Deliverable 5 Appendix C: Initial Capability Gaps Estimates by Measurement

Atmospheric temperature (column/profile)	12
Wind profile (horizontal)	25
Wind profile (vertical)	30
Atmospheric specific humidity (column/profile)	33
Cloud liquid water (column/profile)	48
Precipitation Profile (liquid or solid)	54
Cloud ice (column/profile)	59
Aerosol Extinction / Backscatter (column/profile)	63
CH4 Mole Fraction	68
CO2 Mole Fraction	77
CO Mole Fraction	85
NO2 Mole Fraction	89
Cloud type	94
Cloud cover	101
Cloud top height	110
Cloud top temperature	118
Precipitation intensity at the surface (liquid or solid)	123
Downwelling (Incoming) solar radiation at TOA	133
Upward short-wave irradiance at TOA	139
Upward long-wave irradiance at TOA	144
Aerosol effective radius (column/profile)	150
Cloud drop effective radius	154
Cloud optical depth	157
Downward short-wave irradiance at Earth surface	162
Downward long-wave irradiance at Earth surface	167
Short-wave Earth surface bi-directional reflectance	173
Upwelling (Outgoing) long-wave radiation at Earth surface	177
Air temperature (near surface)	182
Wind speed over sea surface (horizontal)	187
Wind vector over sea surface (horizontal)	196
Sea surface temperature	202
Sea level	215
Ocean chlorophyll concentration	221

Ocean suspended sediment concentration	228
Color dissolved organic matter (CDOM)	233
Sea Surface salinity	237
Ocean surface currents (vector)	241
Sea-ice cover	246
Sea-ice type	258
Sea-ice surface temperature	264
Sea-ice sheet topography	269
Snow cover	273
Snow water equivalent	284
Glacier motion	287
Glacier topography	291
Land surface temperature	295
Normalized Differential Vegetation Index (NDVI)	310
Leaf Area Index (LAI)	316
Fraction of Absorbed PAR (FAPAR)	322
Fire fractional cover	328
Land cover	338
Land surface imagery	350
Land surface topography	373
Geoid	385
Gravity field	388
Gravity gradients	396
Sea-ice thickness	402
Wind stress	407
Earth surface albedo	409
Water vapour imagery	424
Soil moisture in the roots region	428
Vegetation Canopy (cover)	431
Vegetation Canopy (height)	435
Ice sheet topography	439
Snow surface temperature	444
Lake level	448
Chlorophyll Fluorescence from Vegetation on Land	451
Lake Area	456
Sea-ice motion	459
Upwelling (Outgoing) Short-wave Radiation at the Earth Surface	462
Above Ground Biomass (AGB)	466
CH4 Total Column	473
CO2 Total Column	474

Coastal sea level (tide)	477
Dissolved inorganic carbon (DIC)	479
Ocean salinity	481
Ocean subsurface dissolved oxygen concentration	483
Ocean temperature	485
Ocean velocity	490
Sea surface heat flux	493
Fire radiative power	496
Lake Surface Temperature	500
Evapotranspiration	504
Surface Water Extent	507

Atmospheric temperature (column/profile)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Atmospheric Temperature Fields

Category description: *With humidity, atmospheric temperature profile data are a core requirement for weather forecasting and are coordinated within the framework of CGMS (The Coordination Group for Meteorological Satellites). The data are used for numerical weather prediction (NWP), for monitoring inter-annual global temperature changes, for identifying correlations between atmospheric parameters and climatic behaviour, and for validating global models of the atmosphere.*

Measurement definition: *Vertical profile of the atmospheric temperature - Requested from surface to TOA (layers: LT, HT, LS, HS&M) - Physical unit: [K] - Accuracy unit: [K].*

CEOS Database entry for Atmospheric temperature (column/profile): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=1

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/13

Related Candidate Science Questions

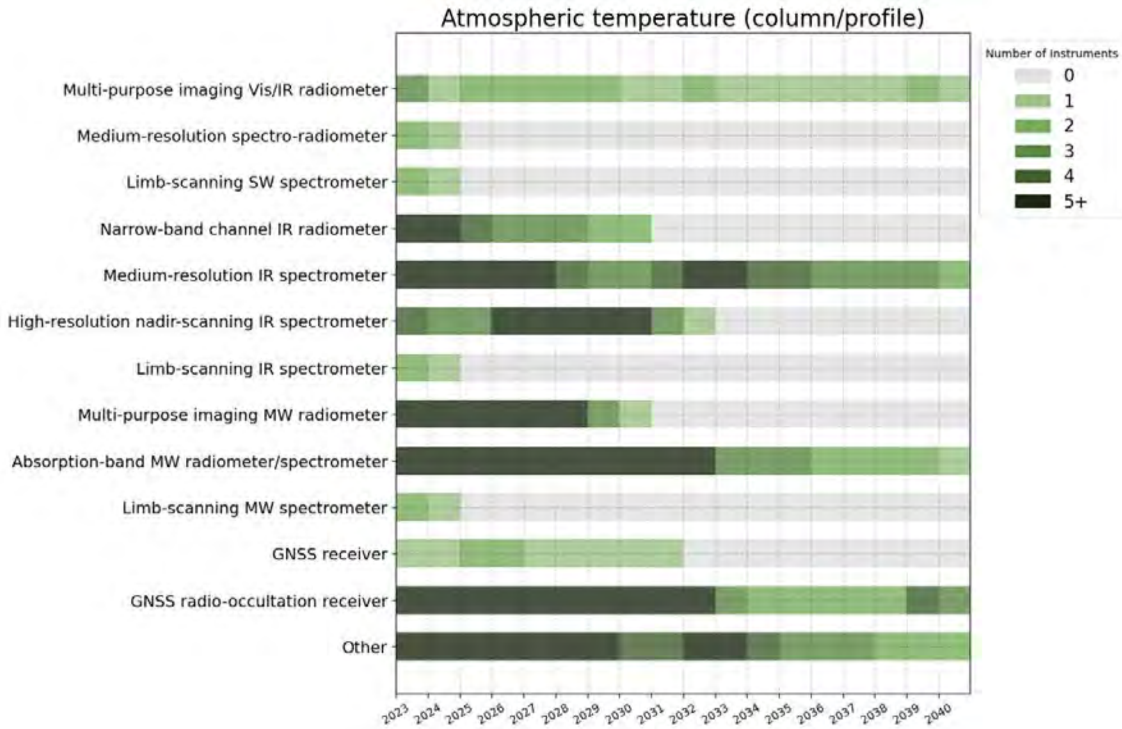
ID	CSQ	KAO	Priority Level
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Critical
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Critical
43-B	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	2). Quantify role of surface and UTLS forcings in ABL processes: - role of sensible and latent energy and water exchanges at the Earth's surface versus within the atmosphere (i.e., horizontal advection and upper troposphere - lower stratosphere (UTLS) exchanges)	Critical

45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for	Critical

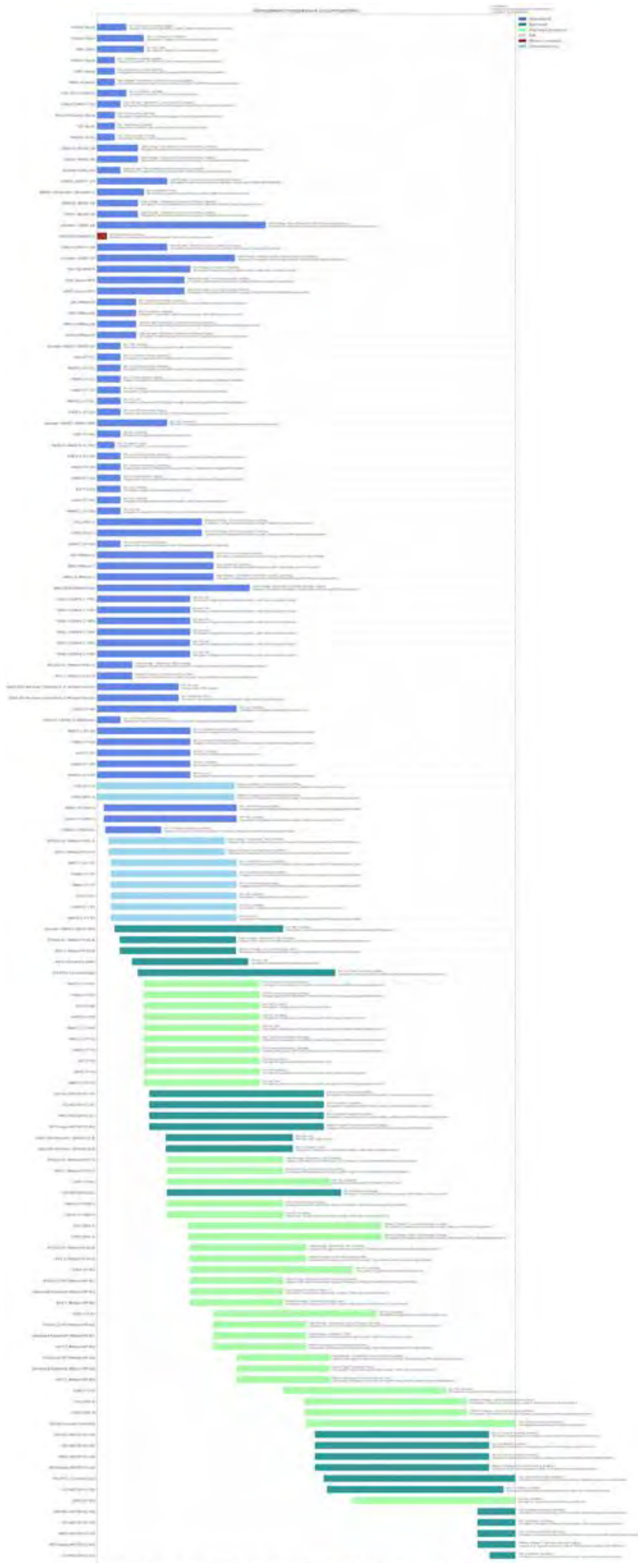
	surface temperature response and climate sensitivity, as well as	Earth system variability and change	
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth’s surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth’s system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	140
2031 (8 years from now)	140
2033 (10 years from now)	140
2038 (15 years from now)	140


Atmospheric temperature (column/profile)
Multi-purpose imaging Vis/IR radiometer
Medium-resolution spectro-radiometer
Limb-scanning SW spectrometer
Narrow-band channel IR radiometer
Medium-resolution IR spectrometer
High-resolution nadir-scanning IR spectrometer
Limb-scanning IR spectrometer
Multi-purpose imaging MW radiometer
Absorption-band MW radiometer/spectrometer
Limb-scanning MW spectrometer
GNSS receiver
GNSS radio-occultation receiver
Other
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Number of instruments
0
1
2
3
4
5+

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Atmospheric temperature (column/profile)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MLS (EOS-Aura)	High Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=126
IASI	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
GRAS	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=306
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
Sounder	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
HIRS/4	High Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
IRAS	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
MWRI	High Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
MTVZA-GY	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673

ACE-FTS	High Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
IKFS-2	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
IKFS-3	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
MTVZA-GY-MP	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
RO	High Utility	METOP-SG B1, METOP-SG A2, METOP-SG A3, METOP-SG B2, METOP-SG B3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1628
TROPICS	High Utility	TROPICS Pathfinder, TROPICS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1770
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
CrIS	General Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=325
TES	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=349

HiRDLS	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=351
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
SMR	General Utility	Odin	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=743
ROSA	General Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=899
Advanced Radiomet	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1570
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
GNSS-RO Receiver	General Utility	Sentinel-6 B, Sentinel-6 A Michael Freilich	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1785
AWS Instrument	General Utility	AWS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1959
TOR	General Utility	TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2054
ATMS	Potential Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
SSM/IS	Potential Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=454
METimage	Potential Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
SAGE-III	Potential Utility	SAGE-III-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1598
MWS	Potential Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1663
OSIRIS	Marginal Utility	Odin	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=662

MWTS-2	Marginal Utility	FY-3H, FY-3I, FY-3C, FY-3E, FY-3F, FY-3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=668
HIRAS	Marginal Utility	FY-3H, FY-3I, FY-3F, FY-3D, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=670
Sounder (INSAT)	Marginal Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=789
GPSRO (Terra-SAR)	Marginal Utility	TerraSAR-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1553
ASI	Marginal Utility	FY-3I, FY-3F, FY-3H, FY-3D, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1616
GNOS	Marginal Utility	FY-3I, FY-3F, FY-3H, FY-3RM-2, FY-3RM-1, FY-3D, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1619
MWHS-2	Marginal Utility	FY-3F, FY-3I, FY-3H, FY-3D, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1621
GNSS POD Receiver	Marginal Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1720
TGRS	Marginal Utility	COSMIC-2 FM2, COSMIC-2 FM3, COSMIC-2 FM4, COSMIC-2 FM5, COSMIC-2 FM6, COSMIC-2 FM1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1725
GIIRS	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1779

Wind profile (horizontal)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Atmospheric Winds

Category description: *Measurements of atmospheric winds are of primary importance to weather forecasting, and as a variable in the study of global climate change. Upper air wind speed and direction is a basic element of the climate system that influences many other variables.*

Measurement definition: *Vertical profile of the horizontal vector component (2D) of the 3D wind vector - Requested from surface to TOA (layers: LT, HT, LS, HS&M) - Physical unit: [m/s] - Accuracy unit: [m/s] intended as vector error, i.e. the module of the vector difference between the observed vector and the true vector.*

CEOS Database entry for Wind profile (horizontal): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=5

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/179

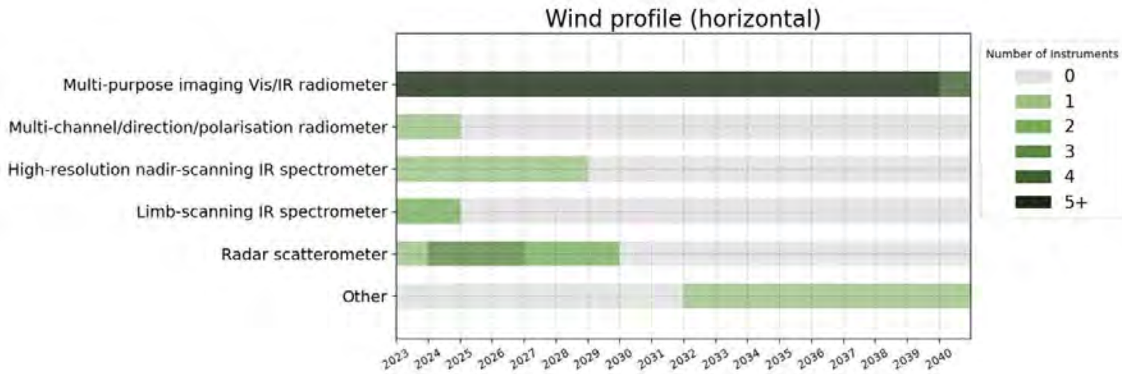
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between	Critical

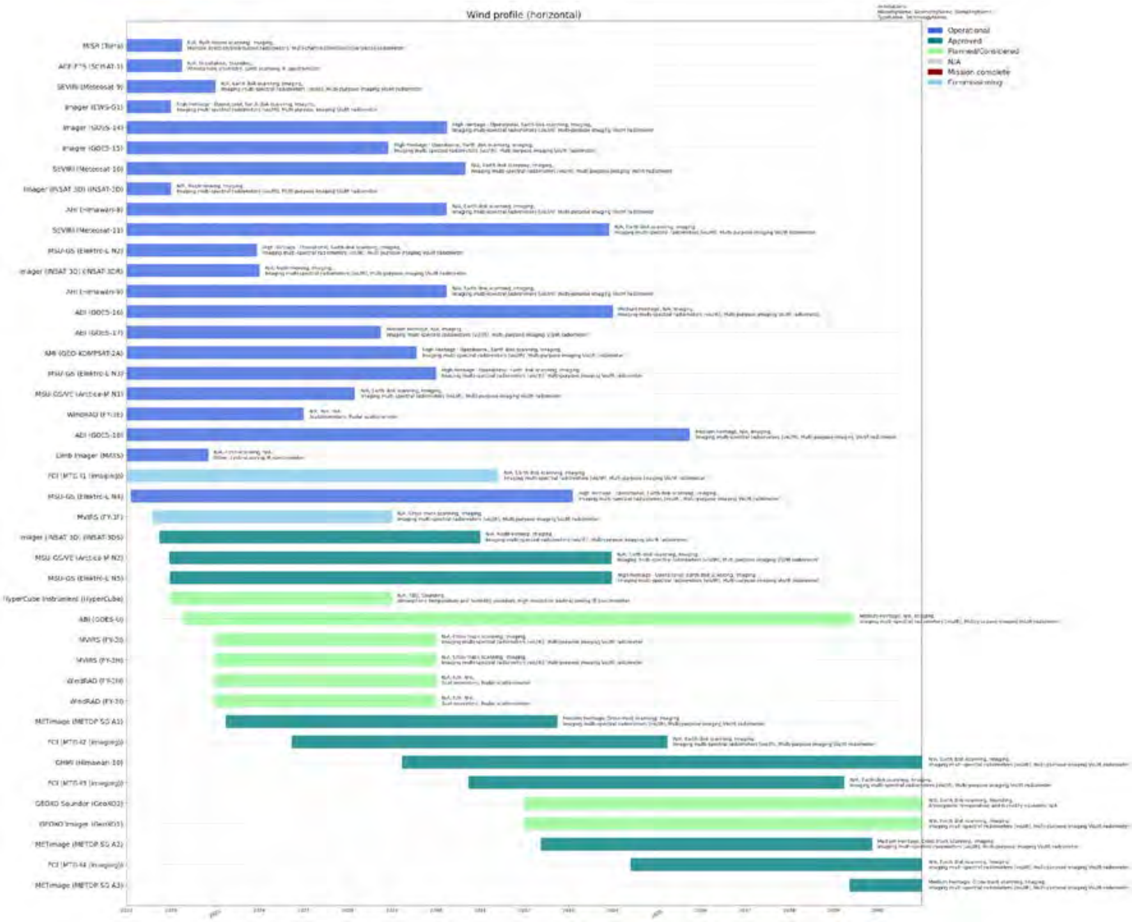
	advancements can we achieve for research and monitoring on weather and climate patterns?	components of the Earth's system (ocean, atmosphere, cryosphere, land)	

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	38
2031 (8 years from now)	37
2033 (10 years from now)	38
2038 (15 years from now)	38



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Wind profile (horizontal)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
Imager	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784

METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
AMI	High Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
WindRAD	High Utility	FY-3H, FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1625
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
HyperCube Instrument	General Utility	HyperCube	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2036
Limb Imager	General Utility	MATS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2041
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
ACE-FTS	Marginal Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
Imager (INSAT 3D)	Marginal Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=788

Wind profile (vertical)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Atmospheric Winds

Category description: *Measurements of atmospheric winds are of primary importance to weather forecasting, and as a variable in the study of global climate change. Upper air wind speed and direction is a basic element of the climate system that influences many other variables.*

Measurement definition: *A series of wind direction and wind speed measurements taken at various levels in the atmosphere that show the wind structure of the atmosphere over a specific location.*

CEOS Database entry for Wind profile (vertical): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=9

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/180

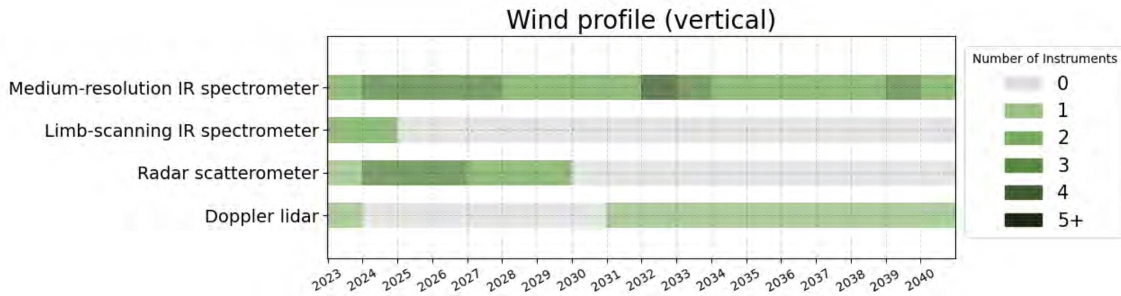
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's	Critical

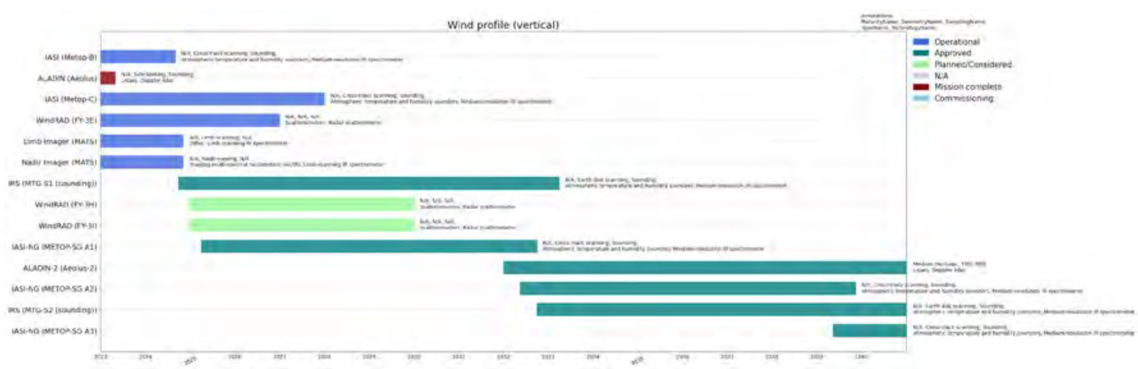
	achieve for research and monitoring on weather and climate patterns?	system (ocean, atmosphere, cryosphere, land)	

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	7
2031 (8 years from now)	5
2033 (10 years from now)	6
2038 (15 years from now)	5



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Wind profile (vertical)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
IASI	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305

WindRAD	General Utility	FY-3H, FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1625
IASI-NG	General Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
Limb Imager	General Utility	MATS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2041
Nadir Imager	General Utility	MATS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2042
ALADIN-2	General Utility	Aeolus-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2050
ALADIN	Potential Utility	Aeolus	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=375

Atmospheric specific humidity (column/profile)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Atmospheric Humidity Fields

Category description: *The observations for water vapour (atmospheric humidity) are a core requirement for weather forecasting and are largely dealt with in the framework of the Coordinating Group for Meteorological Satellites (CGMS). The 3-dimensional field of humidity is a key variable for global and regional weather prediction (NWP) models that are used to produce short- and medium-range forecasts of the state of the troposphere and lower stratosphere.*

Measurement definition: *Vertical profile of the specific humidity in the atmosphere - Requested from surface to TOA (layers: LT, HT, LS, HS&M) + Total column - Physical units: [g/kg] for profile, [kg/m2] for total column - Accuracy unit: [%] for profile, [kg/m2] for total column.*

CEOS Database entry for Atmospheric specific humidity (column/profile): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=13

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/355

Related Candidate Science Questions

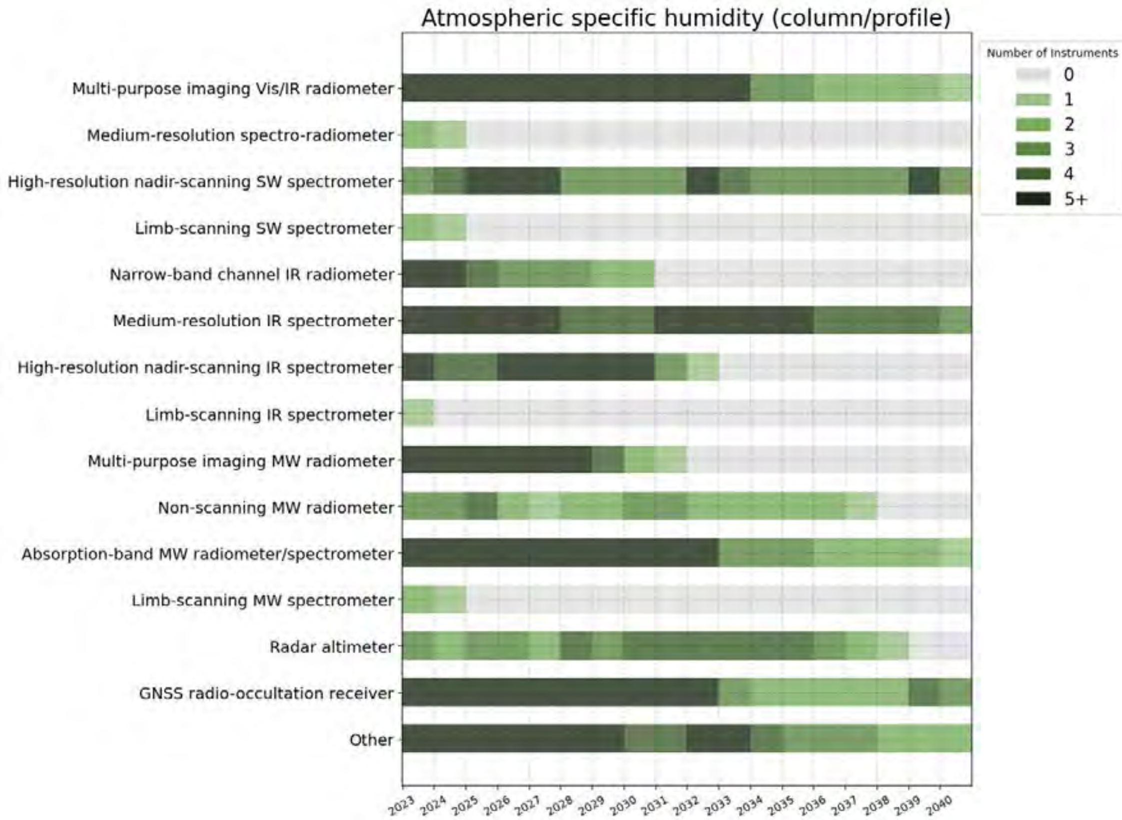
ID	CSQ	KAO	Priority Level
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	Critical
43-B	What are the main coupling determinants between Earth's	2). Quantify role of surface and UTLS forcings in ABL	Critical

	energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	processes: - role of sensible and latent energy and water exchanges at the Earth's surface versus within the atmosphere (i.e., horizontal advection and upper troposphere - lower stratosphere (UTLS) exchanges)	
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from	Study the impact and causality of impacts of a changing Earth energy imbalance over time on	Critical

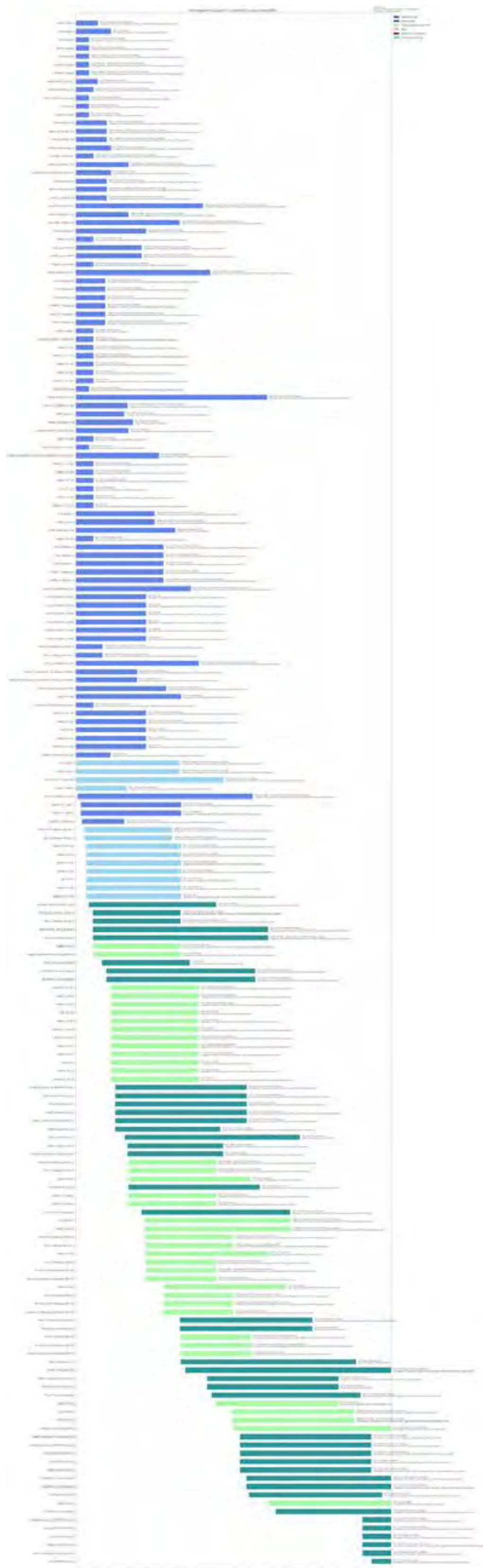
	this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	planetary warming and associated implications for Earth system variability and change	
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	105
2031 (8 years from now)	68
2033 (10 years from now)	60
2038 (15 years from now)	50


Atmospheric specific humidity (column/profile)
Number of Instruments
0
1
2
3
4
5+
Multi-purpose imaging Vis/IR radiometer
Medium-resolution spectro-radiometer
High-resolution nadir-scanning SW spectrometer
Limb-scanning SW spectrometer
Narrow-band channel IR radiometer
Medium-resolution IR spectrometer
High-resolution nadir-scanning IR spectrometer
Limb-scanning IR spectrometer
Multi-purpose imaging MW radiometer
Non-scanning MW radiometer
Absorption-band MW radiometer/spectrometer
Limb-scanning MW spectrometer
Radar altimeter
GNSS radio-occultation receiver
Other
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Atmospheric specific humidity (column/profile)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MLS (EOS-Aura)	High Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=126
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
MHS	High Utility	NOAA-19, Metop-C, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=304
IASI	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
Sounder	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
HIRS/4	High Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564
IRAS	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
MWRI	High Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
MTVZA-GY	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673

		Meteor-M N2-4	
MAESTRO	High Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=702
SMR	High Utility	Odin	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=743
IKFS-2	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
AMR	High Utility	Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=882
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
IKFS-3	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
MTVZA-GY-MP	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
SAGE-III	High Utility	SAGE-III-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1598
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
RO	High Utility	METOP-SG B1, METOP-SG A2, METOP-SG A3,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1628

		METOP-SG B2, METOP-SG B3, METOP-SG A1	
AMR-C	High Utility	Sentinel-6 A Michael Freilich, Sentinel CRISTAL-A, Sentinel CRISTAL-B, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1719
TROPICS	High Utility	TROPICS Pathfinder, TROPICS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1770
AMR-S	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1786
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
GRAS	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=306
GOME-2	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=307
CrIS	General Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=325
HiRDLS	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=351
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
AMSR-E	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664
GMI	General Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
MSU-GS	General Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784

AMSR2	General Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
UVN	General Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=949
Advanced Radiomet	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1570
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
MSU-GS/VE	General Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
GNSS-RO Receiver	General Utility	Sentinel-6 B, Sentinel-6 A Michael Freilich	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1785
AMSR3	General Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804
AWS Instrument	General Utility	AWS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1959
IRIS	General Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
HyperCube Instrument	General Utility	HyperCube	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2036

TEMPEST	General Utility	STP-H8-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2044
TOR	General Utility	TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2054
GHMS	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2068
ATMS	Potential Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
SSM/IS	Potential Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=454
UVNS (Sentinel-5 precursor)	Potential Utility	Sentinel-5 precursor	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=942
UVNS (Sentinel-5)	Potential Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
MWS	Potential Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1663
TES	Marginal Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=349
HSB	Marginal Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=442
MWTS-2	Marginal Utility	FY-3H, FY-3I, FY-3C, FY-3E, FY-3F, FY-3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=668
HIRAS	Marginal Utility	FY-3H, FY-3I, FY-3F, FY-3D, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=670
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
Sounder (INSAT)	Marginal Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=789

AltiKa	Marginal Utility	SARAL	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=931
MWRI	Marginal Utility	HY-2E, HY-2A, HY-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=967
GPSRO (Terra-SAR)	Marginal Utility	TerraSAR-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1553
ASI	Marginal Utility	FY-3I, FY-3F, FY-3H, FY-3D, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1616
GNOS	Marginal Utility	FY-3I, FY-3F, FY-3H, FY-3RM-2, FY-3RM-1, FY-3D, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1619
MWHS-2	Marginal Utility	FY-3F, FY-3I, FY-3H, FY-3D, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1621
TGRS	Marginal Utility	COSMIC-2 FM2, COSMIC-2 FM3, COSMIC-2 FM4, COSMIC-2 FM5, COSMIC-2 FM6, COSMIC-2 FM1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1725
GIIRS	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1779

Cloud liquid water (column/profile)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud particle properties and profile

Category description: *A key to climate modelling is to observe and understand the global distribution of clouds, their physical properties, such as thickness and droplet size. Whether a particular cloud will heat or cool the Earth's surface depends on the cloud's radiating temperature – and thus its height – and on its albedo for both visible and infrared radiation, which depends on the number and details of the cloud properties.*

Measurement definition: *Vertical profile of atmospheric water in the liquid phase (precipitating or not). Requested in the troposphere (assumed height: 12 km), and as total column - Physical unit: profile [g/kg], total column [kg/m2] - Accuracy unit: profile [%], total column [kg/m2].*

CEOS Database entry for Cloud liquid water (column/profile): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=18

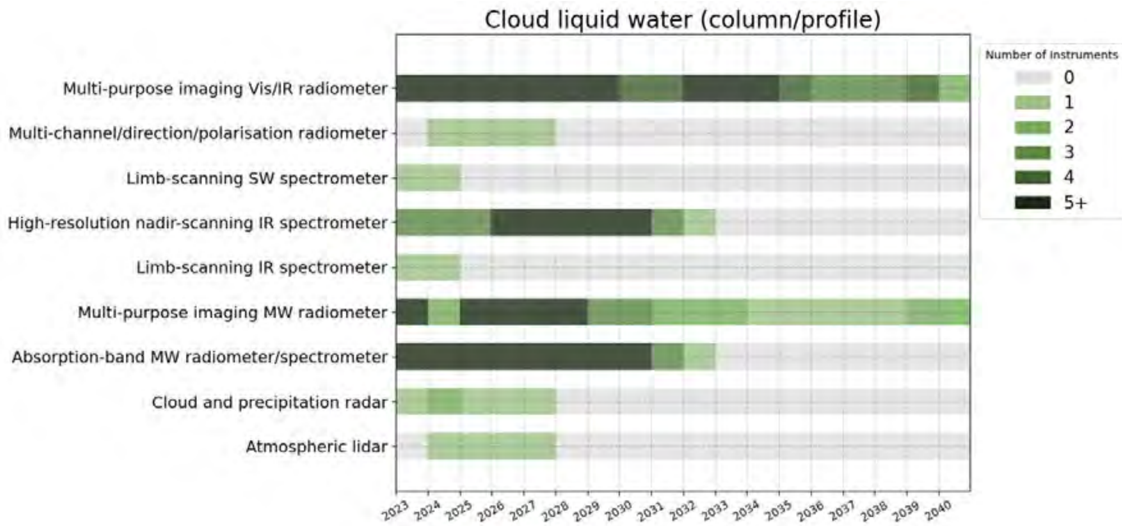
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/32

Related Candidate Science Questions

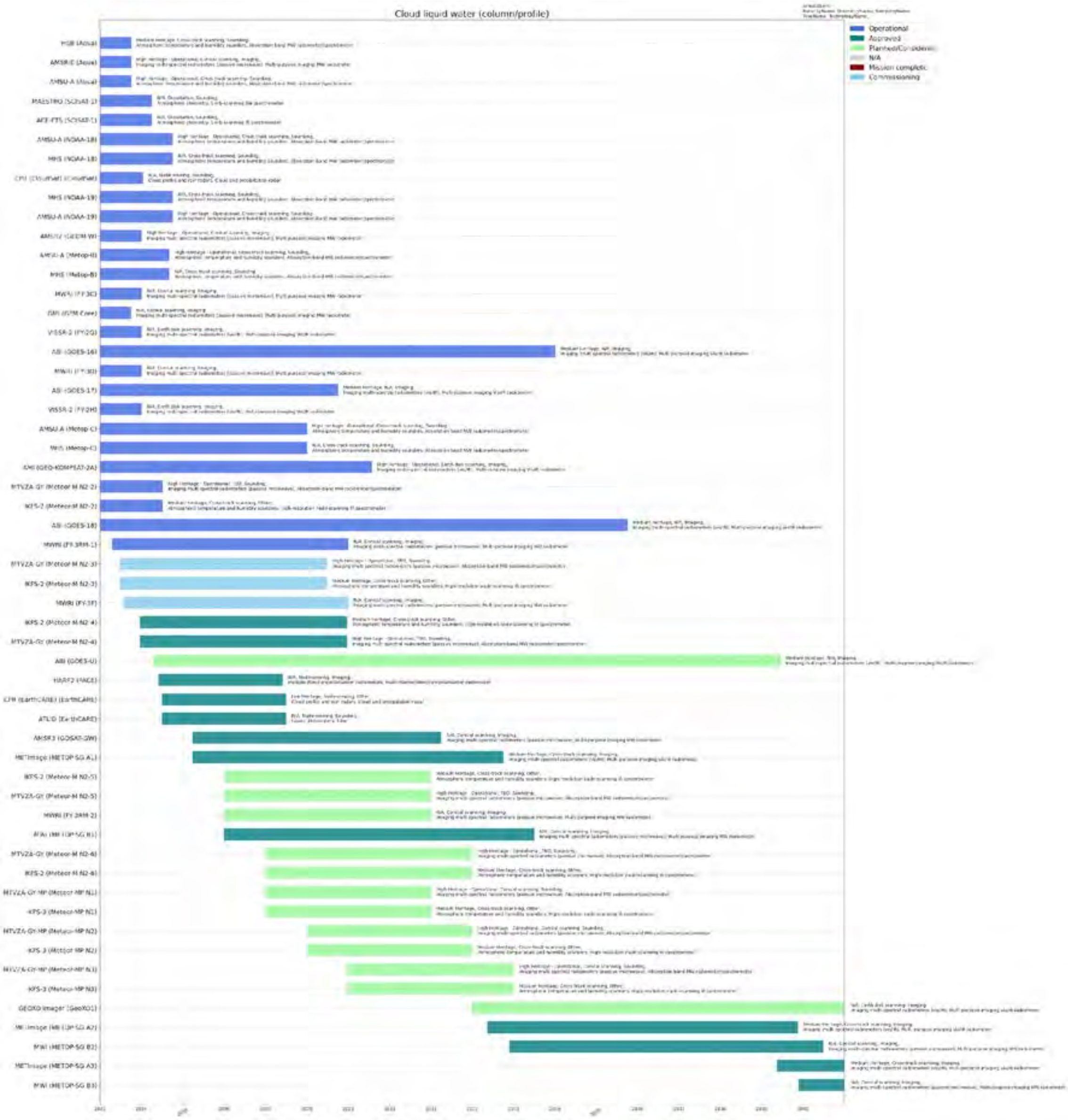
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	29
2031 (8 years from now)	18
2033 (10 years from now)	12
2038 (15 years from now)	10



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud liquid water (column/profile)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MHS	High Utility	NOAA-19, Metop-C, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=304

AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
CPR (EarthCARE)	High Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
MTVZA-GY	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673
GMI	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
MTVZA-GY-MP	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
MWI	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
ATLID	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=374
AMSR-E	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664

ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
AMSR2	General Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
AMSR3	General Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
IKFS-2	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
METimage	Potential Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
IKFS-3	Potential Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
HARP2	Potential Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1899
HSB	Marginal Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=442
MWRI	Marginal Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672

ACE-FTS	Marginal Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
MAESTRO	Marginal Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=702

Precipitation Profile (liquid or solid)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud particle properties and profile

Category description: *A key to climate modelling is to observe and understand the global distribution of clouds, their physical properties, such as thickness and droplet size. Whether a particular cloud will heat or cool the Earth's surface depends on the cloud's radiating temperature – and thus its height – and on its albedo for both visible and infrared radiation, which depends on the number and details of the cloud properties.*

Measurement definition: *Vertical profile of the precipitation rate - Physical unit: [g×s-1×m-2] (vertical flux of precipitation water mass) - Accuracy unit: [%].*

CEOS Database entry for Precipitation Profile (liquid or solid): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=21

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/127

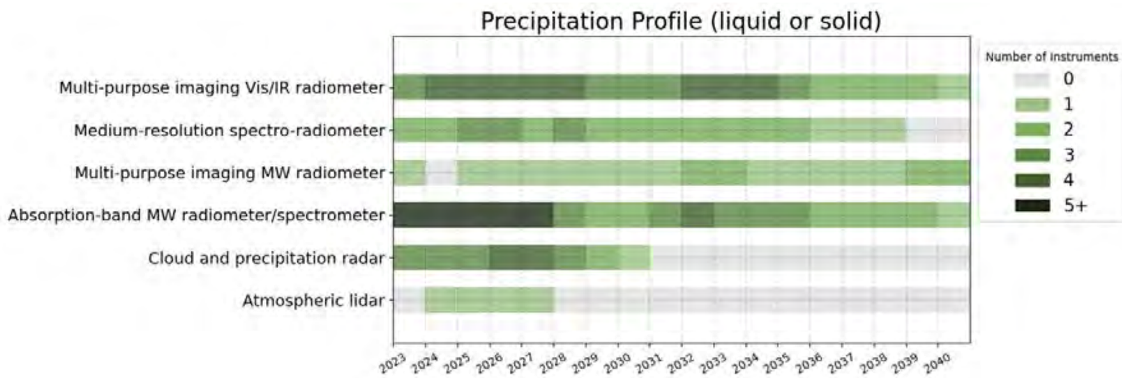
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring	Supporting

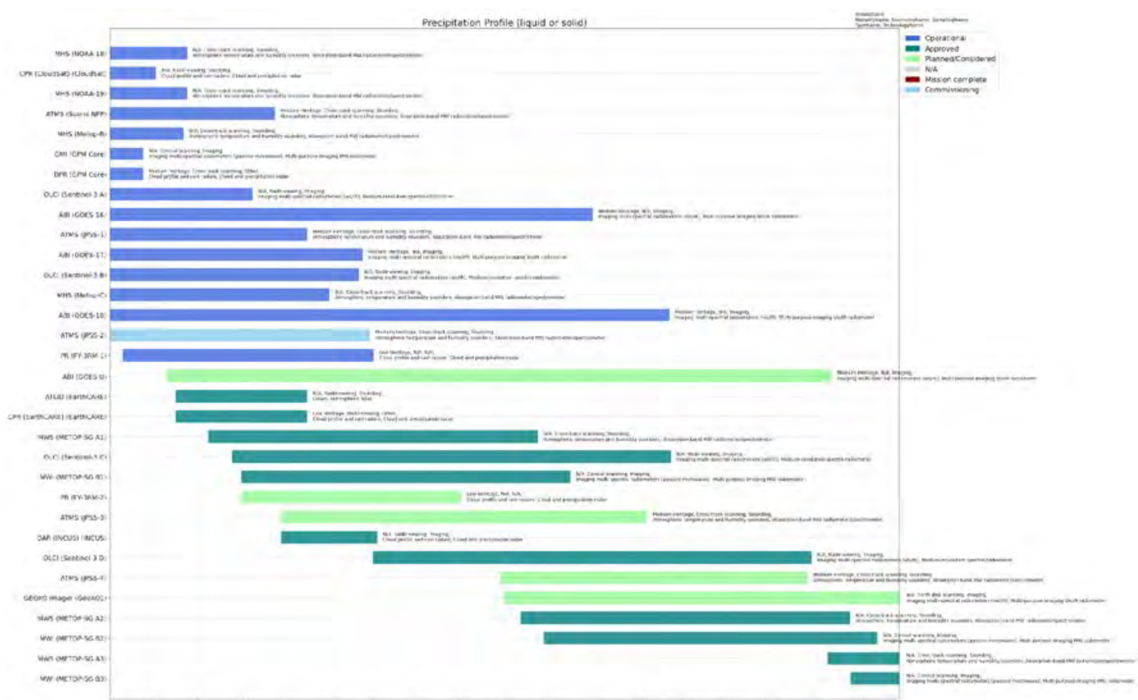
		disturbance frequency and recovery rates over time	

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	16
2031 (8 years from now)	15
2033 (10 years from now)	17
2038 (15 years from now)	13



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Precipitation Profile (liquid or solid)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CPR (EarthCARE)	High Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
CPR (CloudSat)	High Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
GMI	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
DPR	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=774
MWI	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
DAR (INCUS)	High Utility	INCUS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1993
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
ATLID	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=374
MHS	Potential Utility	NOAA-19, Metop-C, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=304
ATMS	Potential Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
ABI	Potential Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
OLCI	Potential Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
MWS	Potential Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1663
PR	Marginal Utility	FY-3RM-2, FY-3RM-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1761

Cloud ice (column/profile)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud particle properties and profile

Category description: *A key to climate modelling is to observe and understand the global distribution of clouds, their physical properties, such as thickness and droplet size. Whether a particular cloud will heat or cool the Earth's surface depends on the cloud's radiating temperature – and thus its height – and on its albedo for both visible and infrared radiation, which depends on the number and details of the cloud properties.*

Measurement definition: *Vertical profile of atmospheric water in the liquid phase (precipitating or not). Measured in the troposphere (assumed height: 12 km), and as total column - Physical unit: profile [g/kg], total column [g/m2] - Accuracy unit: profile [%], total column [g/m2].*

CEOS Database entry for Cloud ice (column/profile): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=24

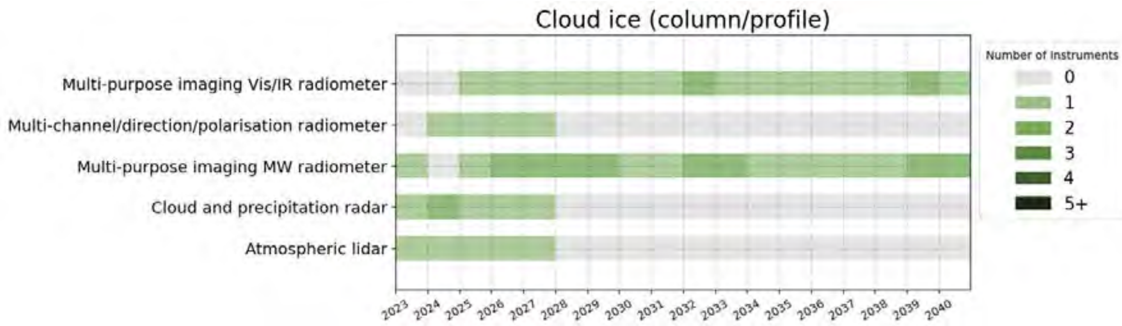
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/29

Related Candidate Science Questions

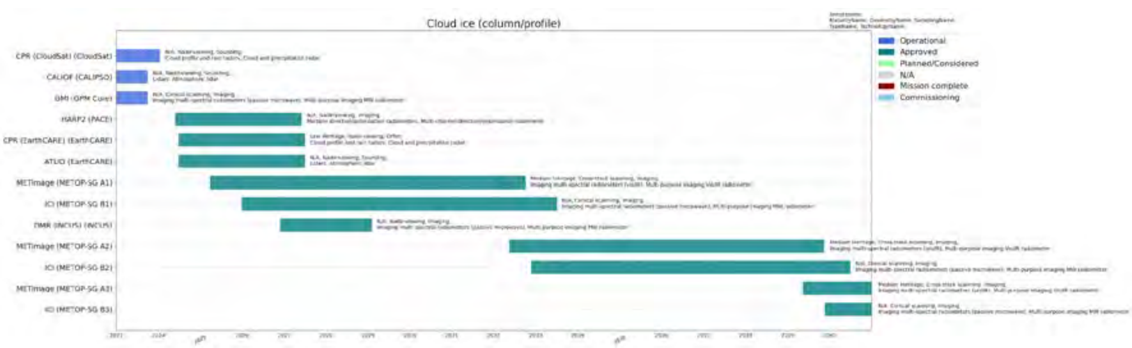
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	6
2031 (8 years from now)	6
2033 (10 years from now)	6
2038 (15 years from now)	6



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud ice (column/profile)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CPR (EarthCARE)	High Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
GMI	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
CALIOP	High Utility	CALIPSO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=820
ICI	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1662

DMR (INCUS)	High Utility	INCUS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1994
ATLID	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=374
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
METimage	Potential Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
HARP2	Potential Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1899

Aerosol Extinction / Backscatter (column/profile)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Aerosols

Category description: *Aerosols are tiny particles suspended in the air, with the majority derived from natural phenomena such as volcanic eruptions, thought it is estimated that some 10–20% are generated by human activities such as burning of fossil fuels. The majority of aerosols form a thin haze in the lower atmosphere and are regularly washed out by precipitation, with the remainder found in the stratosphere where they can remain for many months or years.*

Measurement definition: *3D field of spectral volumetric extinction cross-section of aerosol particles - Measuring Units m-1, Uncertainty Units m-1*

CEOS Database entry for Aerosol Extinction / Backscatter (column/profile): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=29

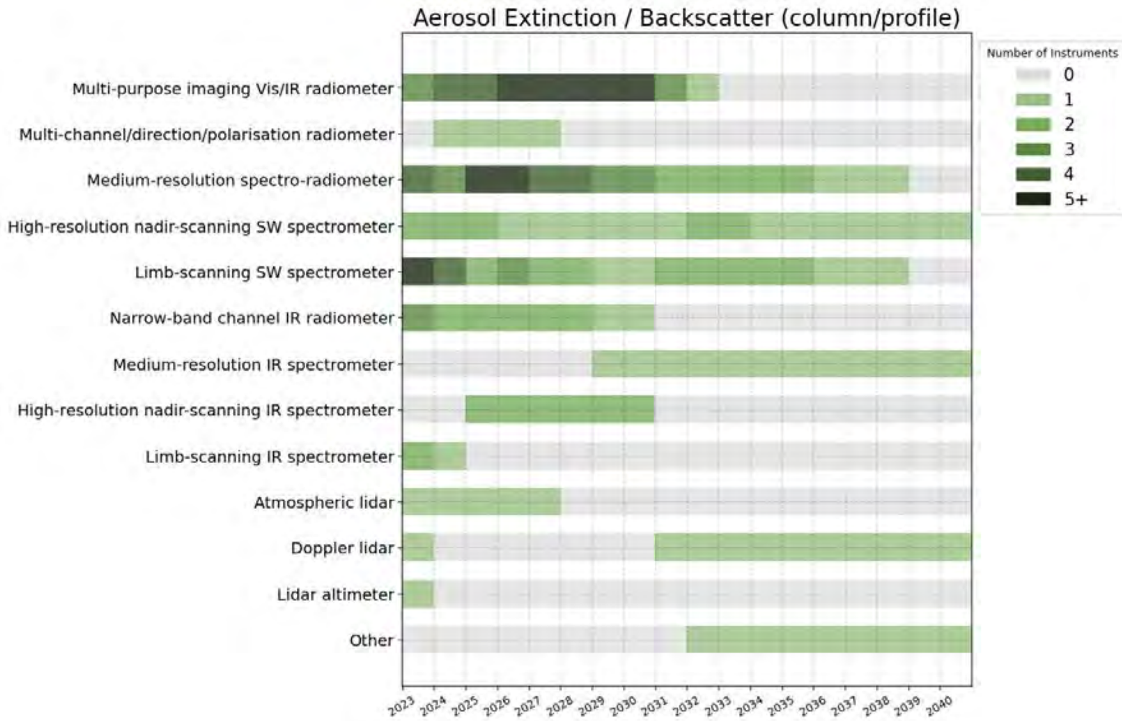
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/4

Related Candidate Science Questions

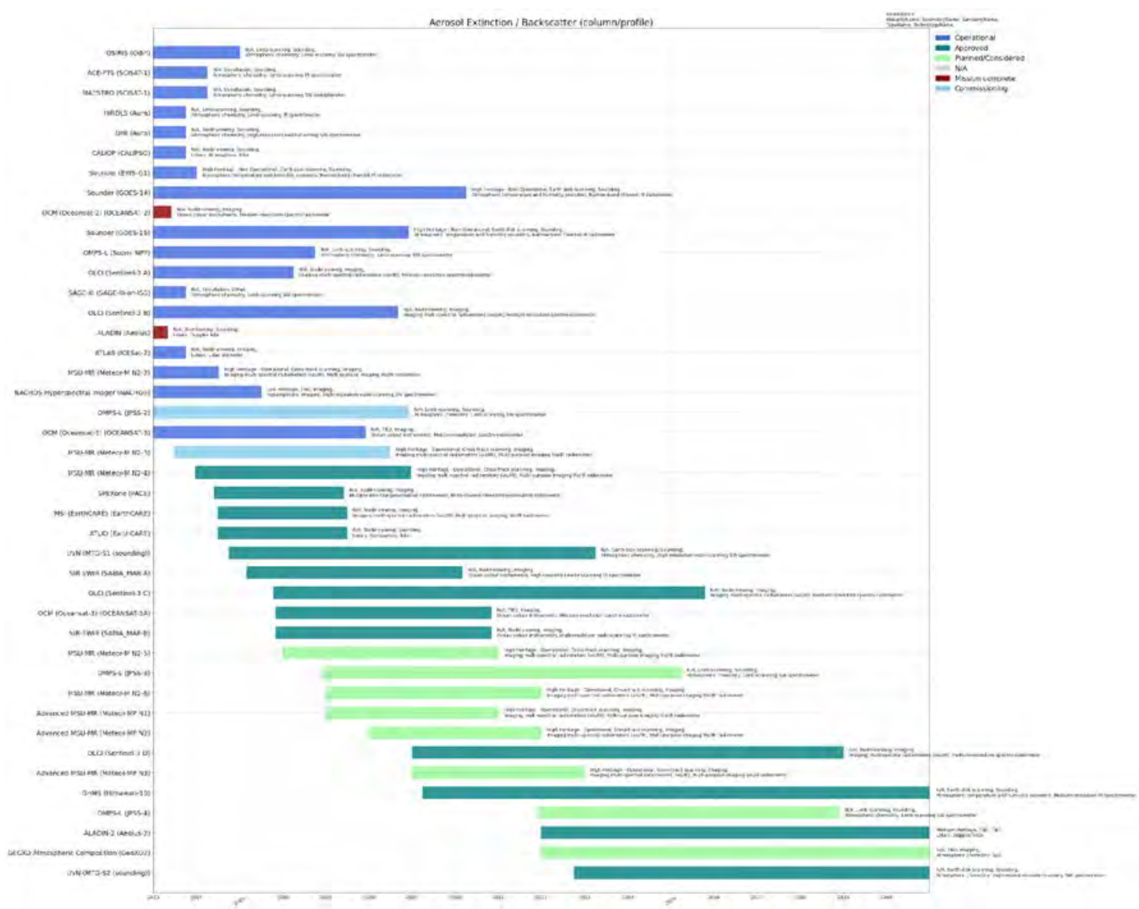
ID	CSQ	KAO	Priority Level
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	28
2031 (8 years from now)	27
2033 (10 years from now)	29
2038 (15 years from now)	27



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Aerosol Extinction / Backscatter (column/profile)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
Sounder	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
CALIOP	High Utility	CALIPSO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=820
SAGE-III	High Utility	SAGE-III-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1598
NIR-SWIR	High Utility	SABIA_MAR-A, SABIA_MAR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1638
OMPS-L	High Utility	JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1718
ATLID	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=374
OCM (Oceansat-2)	General Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=464
OSIRIS	General Utility	Odin	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=662
MSU-MR	General Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
MSI (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=938
UVN	General Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=949

GEOXO Atmospheric Composition	General Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2048
ALADIN-2	General Utility	Aeolus-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2050
NACHOS Hyperspectral Imager	General Utility	NACHOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2053
GHMS	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2068
HiRDLS	Potential Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=351
ALADIN	Potential Utility	Aeolus	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=375
MAESTRO	Potential Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=702
Advanced MSU-MR	Potential Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
SPEXone	Potential Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1898
OMI	Marginal Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=630
ACE-FTS	Marginal Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
OCM (Oceansat-3)	Marginal Utility	OCEANSAT-3A, OCEANSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=935
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998

CH4 Mole Fraction

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Trace gases (excluding ozone)

Category description: *Trace gases other than ozone may be divided into three categories: greenhouse gases affecting climate change; chemically aggressive gases affecting the environment (including the biosphere); and, gases and radicals impacting on the ozone cycle, thereby affecting both climate and environment. Measurements include the concentration of trace gasses, column totals and integrated column measurements, and profiles of gas concentration.*

Measurement definition: *3D field of amount of CH4 (Methane, expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) - Resolution Units km, Measuring Units molecules.cm-2, Uncertainty Units %*

CEOS Database entry for CH4 Mole Fraction: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=39

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/23

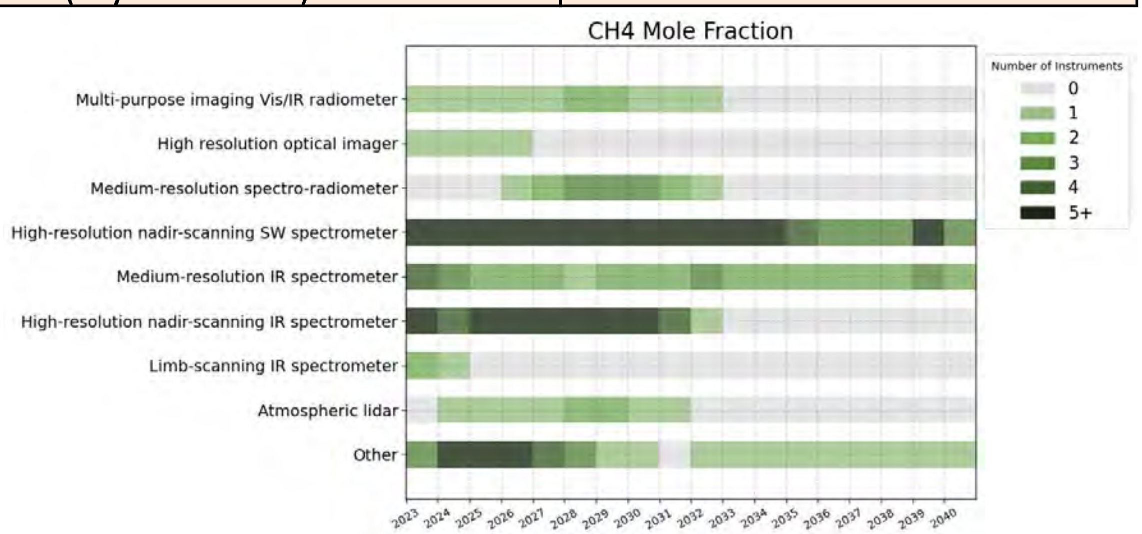
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO2 and CH4 emissions from both anthropogenic and natural sources and CO2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	Critical
1-B	What anthropogenic and natural processes are driving the global carbon cycle?	Distinguish intense anthropogenic CO2 and CH4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	Critical

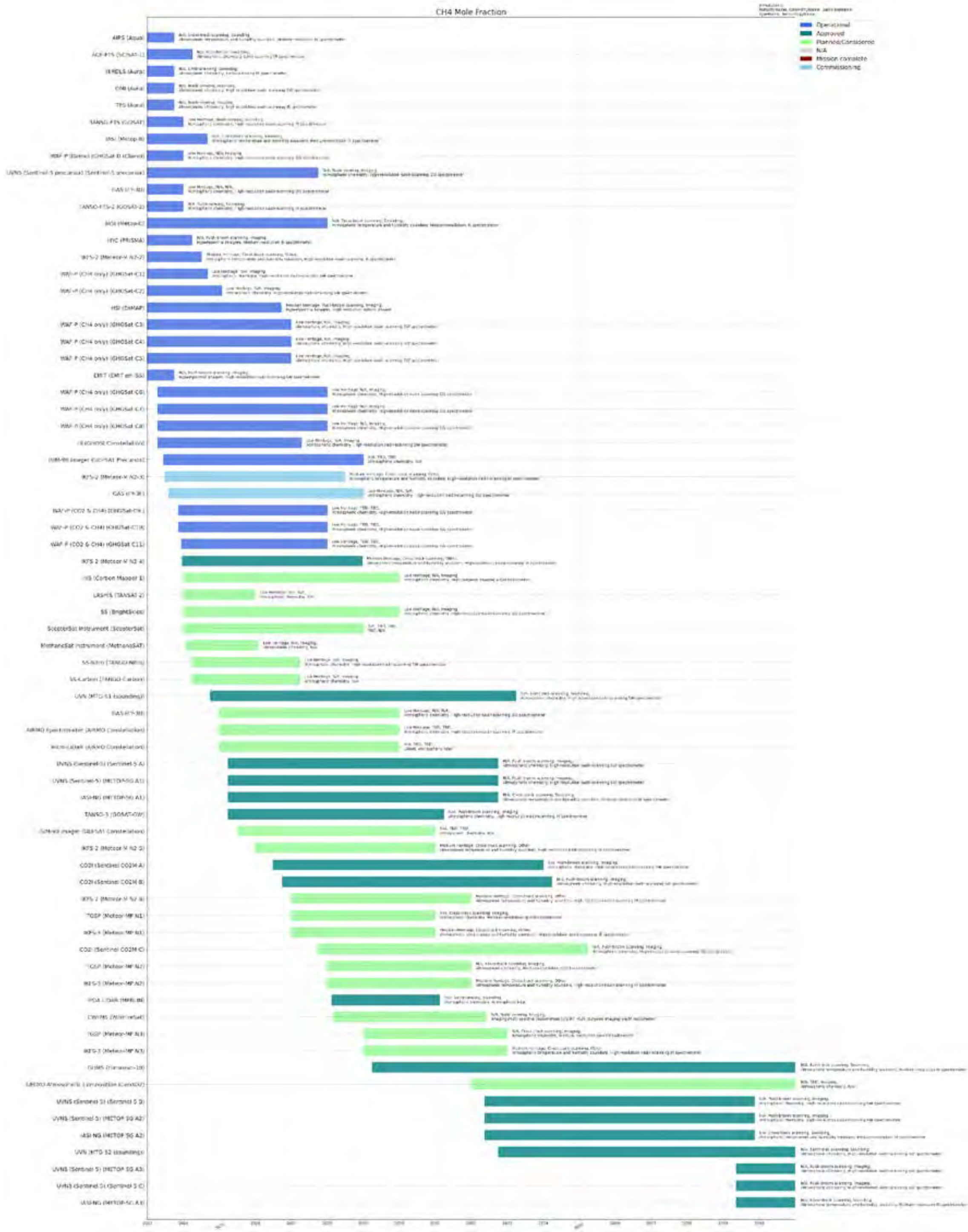
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	51
2031 (8 years from now)	49
2033 (10 years from now)	47
2038 (15 years from now)	46



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring CH4 Mole Fraction

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ACE-FTS	High Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
IKFS-2	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
IKFS-3	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
IPDA LIDAR	High Utility	MERLIN	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1590
TANSO-FTS-2	High Utility	GOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1655
Scanning Spectrometer (GeoCarb)	High Utility	GeoCarb	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1784
TANSO-3	High Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1805
CO2I	High Utility	Sentinel CO2M-B, Sentinel CO2M-C, Sentinel CO2M-A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2012
IASI	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
TES	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=349
HYC	General Utility	PRISMA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=705
TANSO-FTS	General Utility	GOSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=905
UVN	General Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=949
HSI	General Utility	EnMAP	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=964

TGSP	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1573
GAS	General Utility	FY-3H, FY-3D, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1618
IASI-NG	General Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
EMIT	General Utility	EMIT-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1901
HI	General Utility	GHOSt Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1935
SS-Nitro	General Utility	TANGO-Nitro	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1938
GEOXO Atmospheric Composition	General Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2048
iSIM-90 imager	General Utility	GEI-SAT Precursor, GEI-SAT Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2057
Micro-LiDaR	General Utility	AIRMO Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2058
ScepterSat Instrument	General Utility	ScepterSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2059
WAF-P (CO2 & CH4)	General Utility	GHGSat-C9, GHGSat-C10, GHGSat-C11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2066
GHMS	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2068
AIRMO Spectrometer	General Utility	AIRMO Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2069
HiRDLS	Potential Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=351

UVNS (Sentinel-5 precursor)	Potential Utility	Sentinel-5 precursor	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=942
UVNS (Sentinel-5)	Potential Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
AIRS	Marginal Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
OMI	Marginal Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=630
WAF-P (CH4 only)	Marginal Utility	GHGSat-C8, GHGSat-C7, GHGSat-C1, GHGSat-C3, GHGSat-C4, GHGSat-C5, GHGSat-C6, GHGSat-C2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1919
WAF-P (Demo)	Marginal Utility	GHGSat-D (Claire)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1921
MethaneSat Instrument	Marginal Utility	MethaneSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1923
HIS	Marginal Utility	Carbon Mapper 1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1924
LASHIS	Marginal Utility	TANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1925
Bluefield Satellite Instrument	Marginal Utility	Bluebird	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1928
SS	Marginal Utility	BrightSkies	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1936
SS-Carbon	Marginal Utility	TANGO-Carbon	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1937

CO_2 Mole Fraction

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Trace gases (excluding ozone)

Category description: *Trace gases other than ozone may be divided into three categories: greenhouse gases affecting climate change; chemically aggressive gases affecting the environment (including the biosphere); and, gases and radicals impacting on the ozone cycle, thereby affecting both climate and environment. Measurements include the concentration of trace gasses, column totals and integrated column measurements, and profiles of gas concentration.*

Measurement definition: *3D field of amount of CO_2 (Carbon dioxide, expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) - Resolution Units km, Measuring Units molecules.cm-2, Uncertainty Units %*

CEOS Database entry for CO_2 Mole Fraction: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=44

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/39

Related Candidate Science Questions

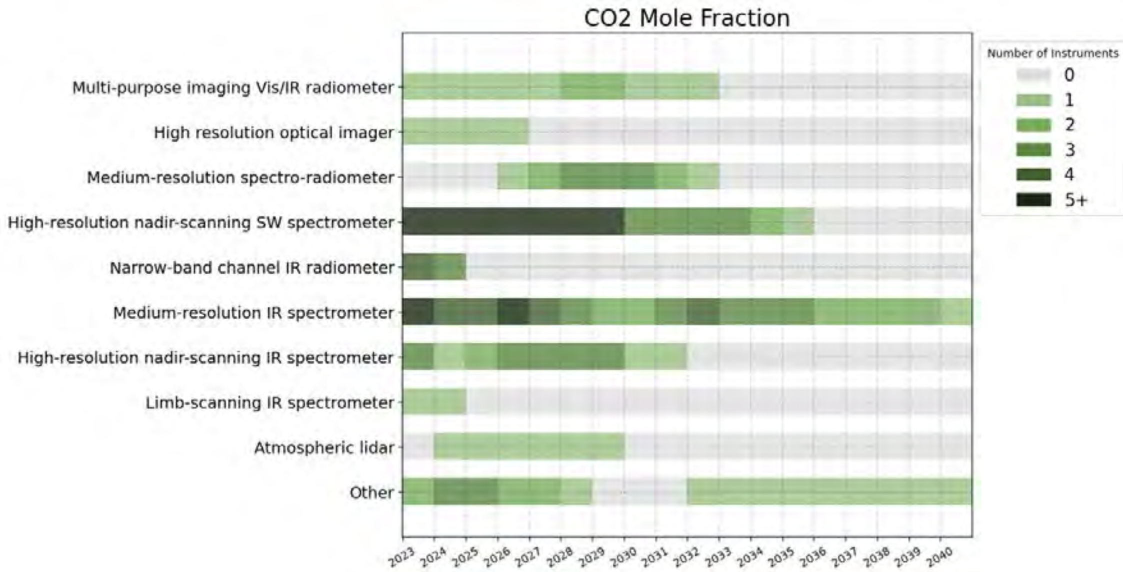
ID	CSQ	KAO	Priority Level
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO_2 and CH_4 emissions from both anthropogenic and natural sources and CO_2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	Critical
1-B	What anthropogenic and natural processes are driving the global carbon cycle?	Distinguish intense anthropogenic CO_2 and CH_4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	Critical

1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO_2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Supporting
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Supporting
3-A	How has the ocean carbon cycle responded to anthropogenic CO_2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO_2 associated with changes in atmospheric CO_2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-B	How has the ocean carbon cycle responded to anthropogenic CO_2 and climate change?	How is the Southern Ocean CO_2 sink responding to climate perturbations and long-term climate change.	Critical

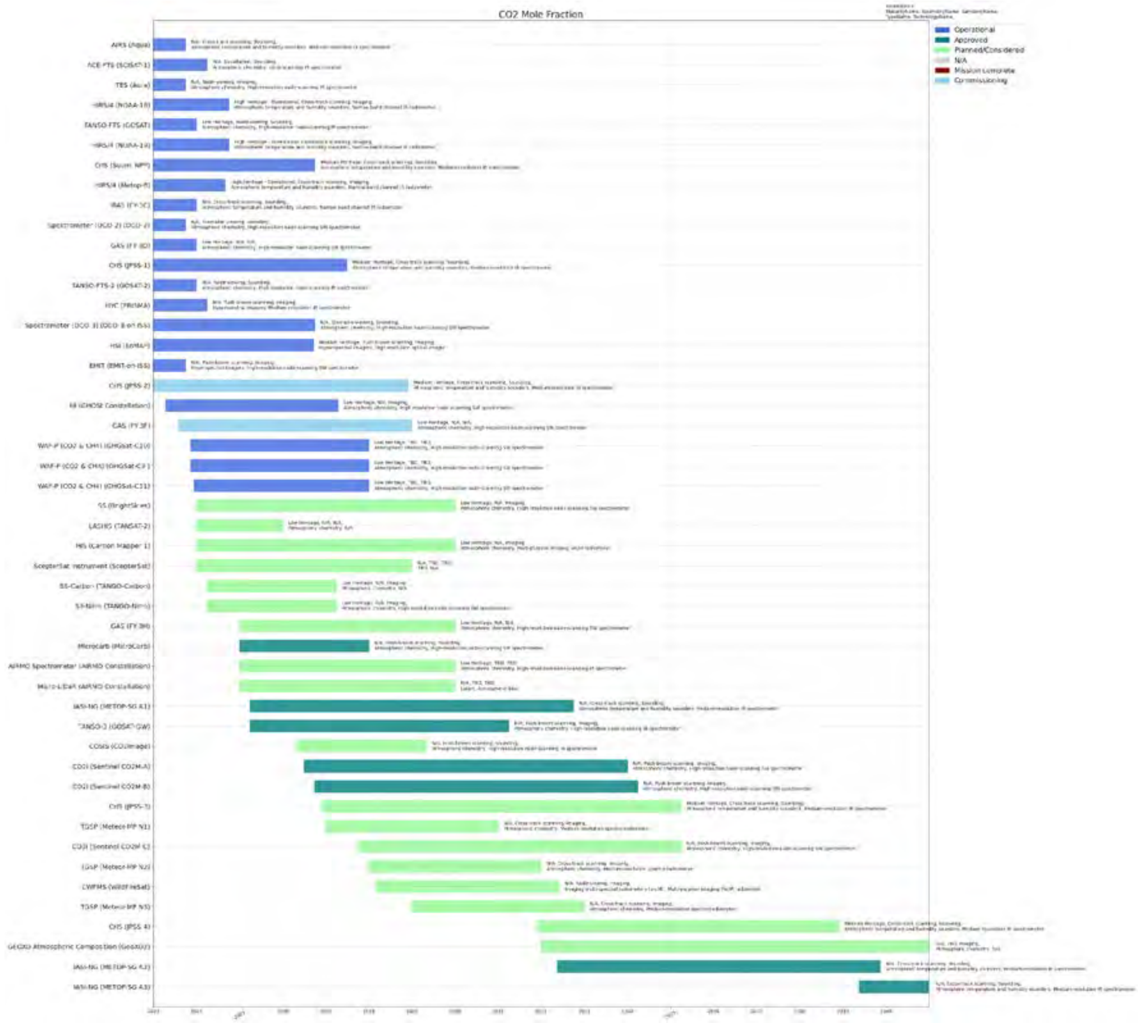
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	22

2031 (8 years from now)	14
2033 (10 years from now)	11
2038 (15 years from now)	7



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring CO2 Mole Fraction

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
Spectrometer (OCO-2)	High Utility	OCO-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1558
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
TANSO-FTS-2	High Utility	GOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1655

Spectrometer (OCO-3)	High Utility	OCO-3-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1671
Scanning Spectrometer (GeoCarb)	High Utility	GeoCarb	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1784
TANSO-3	High Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1805
COSIS	High Utility	CO2Image	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1960
CO2I	High Utility	Sentinel CO2M-B, Sentinel CO2M-C, Sentinel CO2M-A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2012
CrIS	General Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=325
TES	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=349
HIRS/4	General Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564
IRAS	General Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
HYC	General Utility	PRISMA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=705
TANSO-FTS	General Utility	GOSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=905
HSI	General Utility	EnMAP	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=964
TGSP	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1573
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
EMIT	General Utility	EMIT-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1901

Bluefield Satellite Instrument	General Utility	Bluebird	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1928
HI	General Utility	GHOSt Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1935
SS-Nitro	General Utility	TANGO-Nitro	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1938
GEOXO Atmospheric Composition	General Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2048
Micro-LiDaR	General Utility	AIRMO Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2058
ScepterSat Instrument	General Utility	ScepterSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2059
WAF-P (CO2 & CH4)	General Utility	GHGSat-C9, GHGSat-C10, GHGSat-C11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2066
AIRMO Spectrometer	General Utility	AIRMO Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2069
ACE-FTS	Potential Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
AIRS	Marginal Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
GAS	Marginal Utility	FY-3H, FY-3D, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1618
Microcarb	Marginal Utility	MicroCarb	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1799
HIS	Marginal Utility	Carbon Mapper 1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1924
LASHIS	Marginal Utility	TANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1925
SS	Marginal Utility	BrightSkies	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1936

SS-Carbon	Marginal Utility	TANGO-Carbon	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1937

CO Mole Fraction

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Trace gases (excluding ozone)

Category description: *Trace gases other than ozone may be divided into three categories: greenhouse gases affecting climate change; chemically aggressive gases affecting the environment (including the biosphere); and, gases and radicals impacting on the ozone cycle, thereby affecting both climate and environment. Measurements include the concentration of trace gasses, column totals and integrated column measurements, and profiles of gas concentration.*

Measurement definition: *3D field of amount of CO (Carbon monoxide, expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) - Resolution Units km*

CEOS Database entry for CO Mole Fraction: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=49

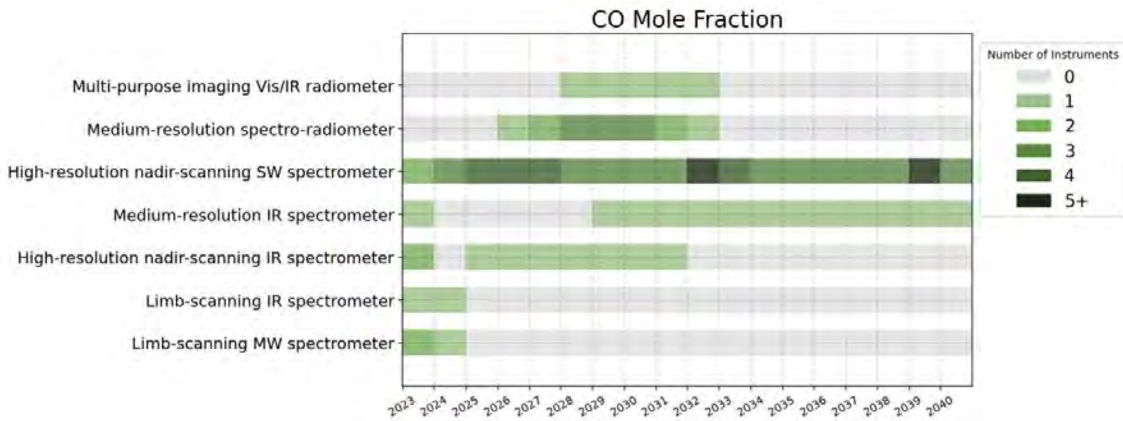
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/38

Related Candidate Science Questions

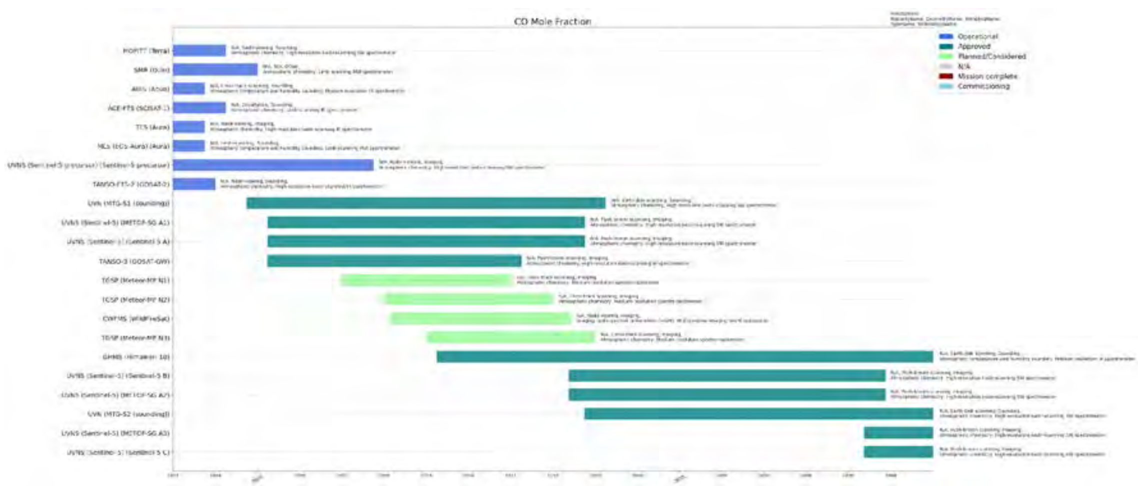
ID	CSQ	KAO	Priority Level
1-B	What anthropogenic and natural processes are driving the global carbon cycle?	Distinguish intense anthropogenic CO2 and CH4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	Critical
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO2 and CH4 emissions from both anthropogenic and natural sources and CO2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	9
2031 (8 years from now)	9
2033 (10 years from now)	6
2038 (15 years from now)	5



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring CO Mole Fraction

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MOPITT	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=119

MLS (EOS-Aura)	High Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=126
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
ACE-FTS	High Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
TANSO-FTS-2	High Utility	GOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1655
Scanning Spectrometer (GeoCarb)	High Utility	GeoCarb	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1784
TANSO-3	High Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1805
TES	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=349
SMR	General Utility	Odin	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=743
UVN	General Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=949
TGSP	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1573
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
GHMS	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2068
UVNS (Sentinel-5 precursor)	Potential Utility	Sentinel-5 precursor	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=942
UVNS (Sentinel-5)	Potential Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504

NO2 Mole Fraction

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Trace gases (excluding ozone)

Category description: *Trace gases other than ozone may be divided into three categories: greenhouse gases affecting climate change; chemically aggressive gases affecting the environment (including the biosphere); and, gases and radicals impacting on the ozone cycle, thereby affecting both climate and environment. Measurements include the concentration of trace gasses, column totals and integrated column measurements, and profiles of gas concentration.*

Measurement definition: *3D field of amount of NO2 (Nitrogen peroxide, expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) - Resolution Units km CO2 = Carbon dioxide. Requested from surface to TOA (layers: LT, HT, LS, HS&M) + Total column - Measuring Units molecules.cm-2, Uncertainty Units %, Physical unit [ppm], Accuracy unit: [%]*

CEOS Database entry for NO2 Mole Fraction: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=74

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/105

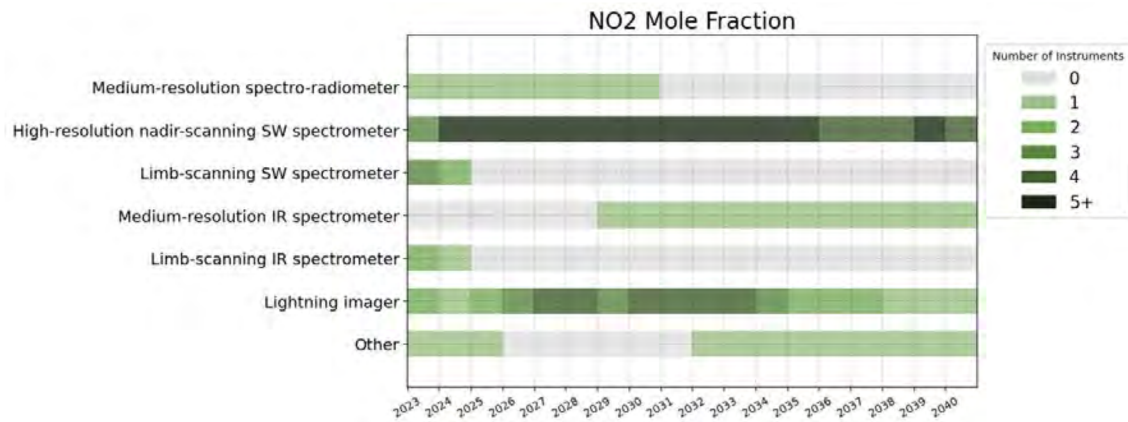
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-B	What anthropogenic and natural processes are driving the global carbon cycle?	Distinguish intense anthropogenic CO2 and CH4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	Critical
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO2 and CH4 emissions from both anthropogenic and natural sources and CO2 removals from natural sinks on spatial scales from individual facilities or field plots to	Supporting

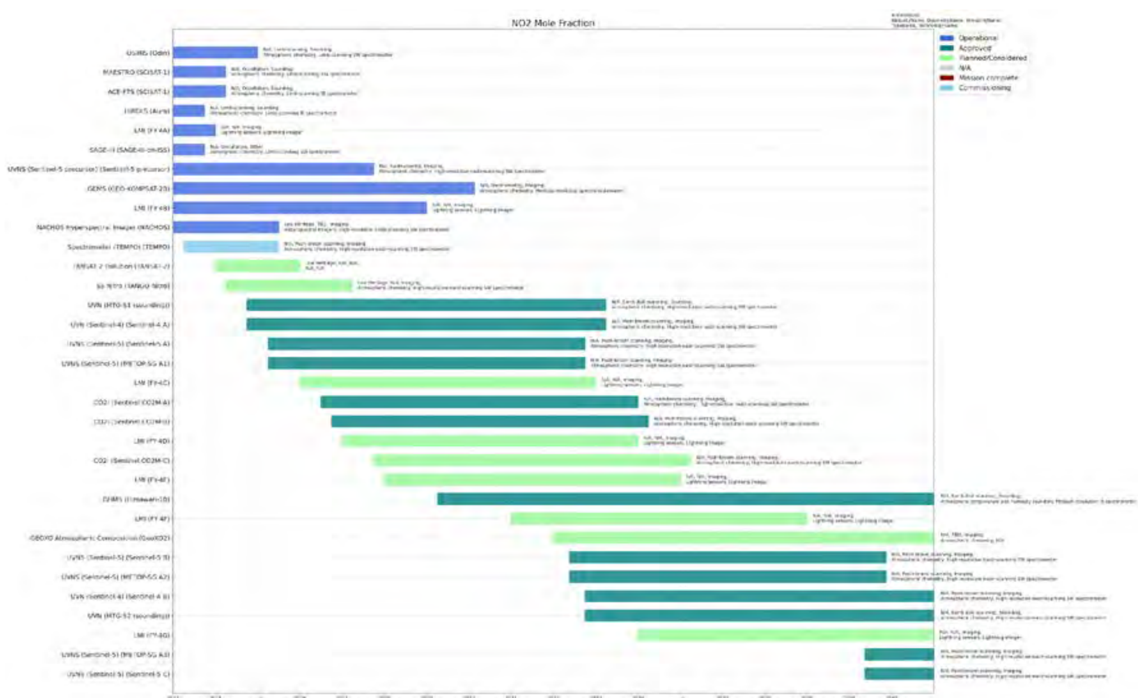
		regional and global scales on seasonal time scales.	

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	12
2031 (8 years from now)	12
2033 (10 years from now)	14
2038 (15 years from now)	7



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring NO2 Mole Fraction

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ACE-FTS	High Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=701
MAESTRO	High Utility	SCISAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=702
GEMS	High Utility	GEO-KOMPSAT-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1583
SAGE-III	High Utility	SAGE-III-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1598
Spectrometer (TEMPO)	High Utility	TEMPO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1672
CO2I	High Utility	Sentinel CO2M-B, Sentinel CO2M-C, Sentinel CO2M-A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2012
OSIRIS	General Utility	Odin	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=662
UVN	General Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=949
GEOXO Atmospheric Composition	General Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2048
NACHOS Hyperspectral Imager	General Utility	NACHOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2053
GHMS	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2068
HiRDLS	Potential Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=351
UVN (Sentinel-4)	Potential Utility	Sentinel-4 A, Sentinel-4 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=941

UVNS (Sentinel-5 precursor)	Potential Utility	Sentinel-5 precursor	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=942
UVNS (Sentinel-5)	Potential Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
LMI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=891
TANSAT-2 Pollution	Marginal Utility	TANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1926
SS-Nitro	Marginal Utility	TANGO-Nitro	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1938

Cloud type

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud type, amount and cloud top temperature

Category description: *The study of clouds, their location and characteristics, plays a key role in the understanding of climate change. Low, thick clouds primarily reflect solar radiation and cool the surface of the Earth. High, thin clouds primarily transmit incoming solar radiation, but at the same time they trap some of the outgoing infrared radiation emitted by the Earth and radiate it back downward, thereby warming the surface. Parameters include temperature and moisture profiles, fractional cloud cover, cloud top height, cloud top pressure, surface temperature and surface emissivity.*

Measurement definition: *Result of cloud type classification - Accuracy expressed as number of classes. Actually [classes-1] is used, so that smaller figure corresponds to better performance, as usual.*

CEOS Database entry for Cloud type: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=110

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/37

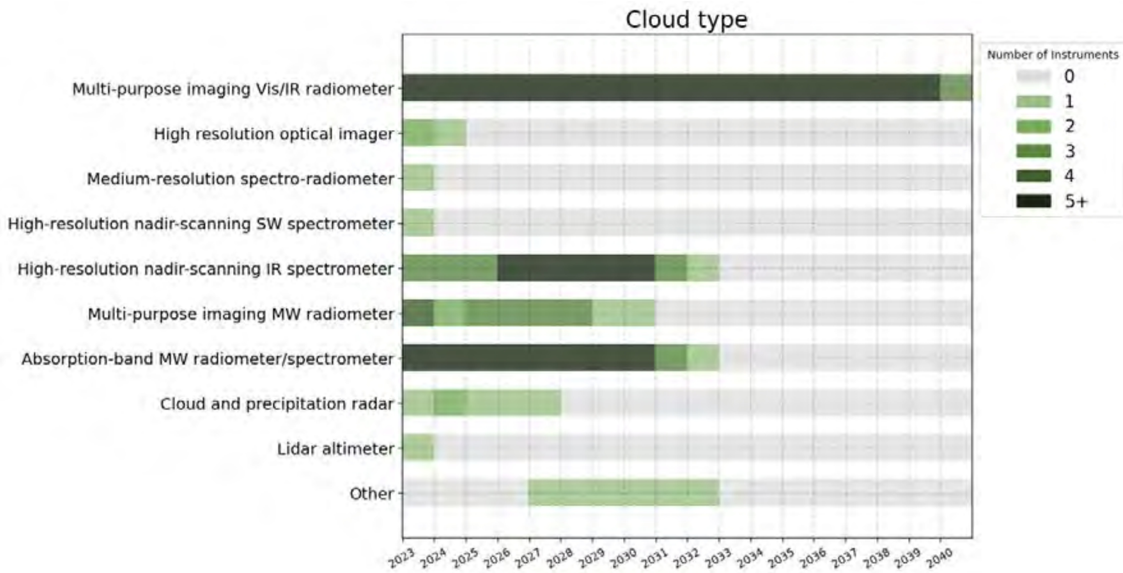
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Critical
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

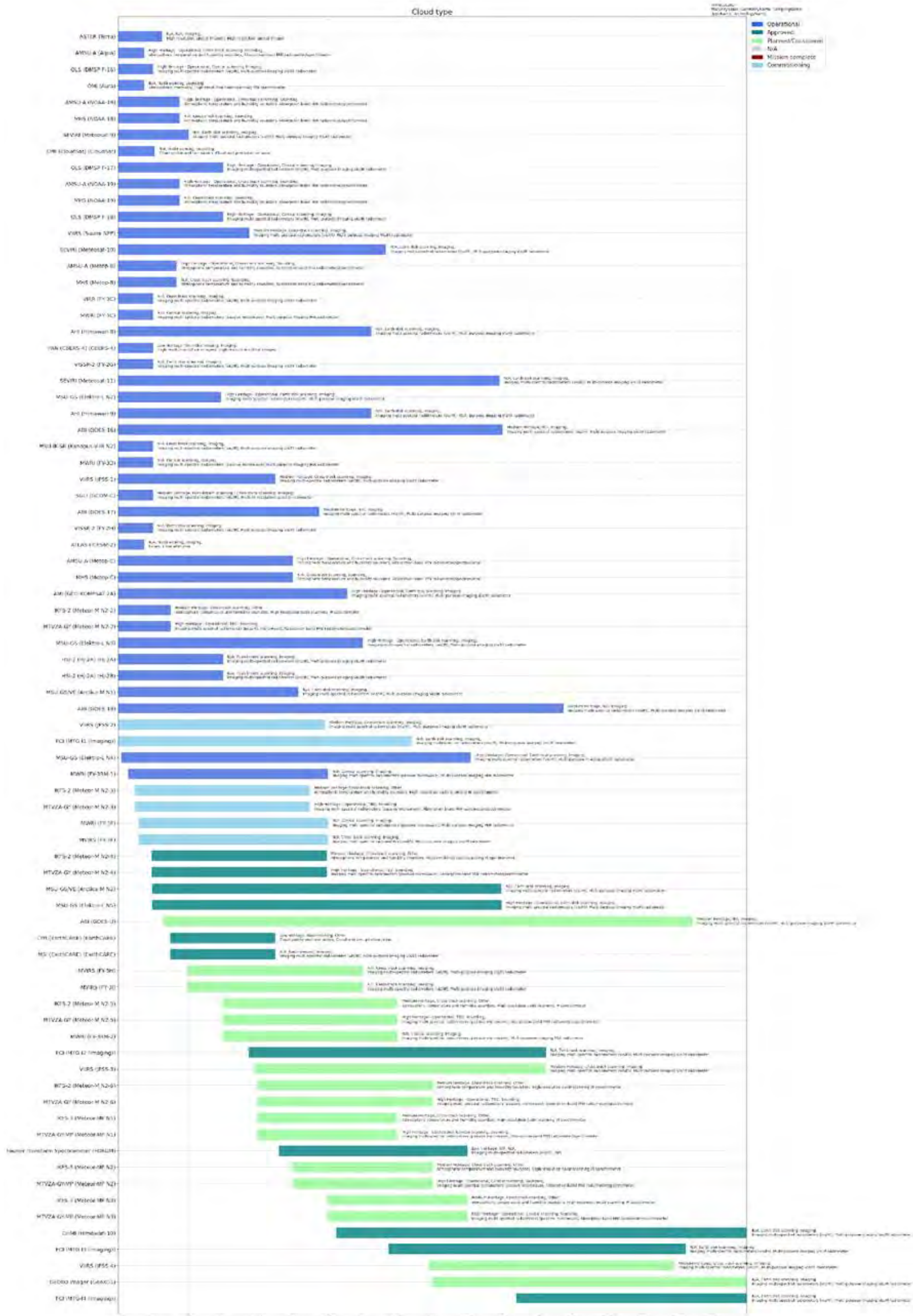
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	43
2031 (8 years from now)	26
2033 (10 years from now)	20

2038 (15 years from now)	13



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud type

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
OLS	High Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=450
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
MWRI	High Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
VIRR	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=684
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
AMI	High Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
MHS	General Utility	NOAA-19, Metop-C,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=304

		Metop-B, NOAA-18	
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MSI (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=938
IKFS-3	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
MSU-IK-SR	General Utility	Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1692
Fourier Transform Spectrometer	General Utility	FORUM	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2026
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
CPR (EarthCARE)	Potential Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
MTVZA-GY	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673

		N2-3, Meteor-M N2-6, Meteor-M N2-4	
IKFS-2	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
MTVZA-GY-MP	Potential Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
ASTER	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
OMI	Marginal Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=630
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
PAN (CBERS-4)	Marginal Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=867
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Cloud cover

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud type, amount and cloud top temperature

Category description: *The study of clouds, their location and characteristics, plays a key role in the understanding of climate change. Low, thick clouds primarily reflect solar radiation and cool the surface of the Earth. High, thin clouds primarily transmit incoming solar radiation, but at the same time they trap some of the outgoing infrared radiation emitted by the Earth and radiate it back downward, thereby warming the surface. Parameters include temperature and moisture profiles, fractional cloud cover, cloud top height, cloud top pressure, surface temperature and surface emissivity.*

Measurement definition: *3D field of fraction of sky filled by clouds - Physical unit [%], Accuracy unit [%]*

CEOS Database entry for Cloud cover: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=111

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/27

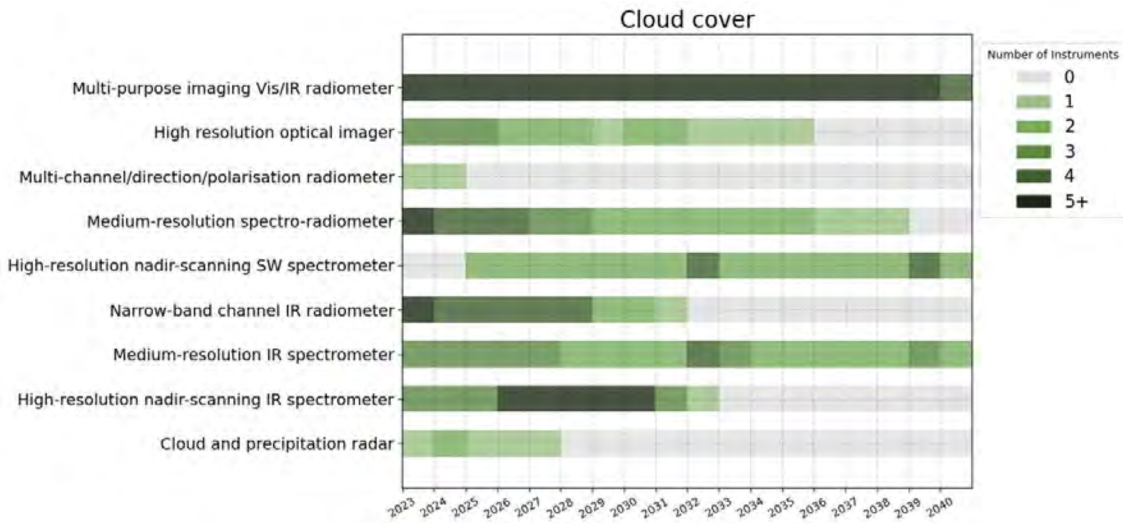
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO2 and CH4 emissions from both anthropogenic and natural sources and CO2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	Supporting
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to	Study of cumulative regional cloud feedbacks, weighted by the global ratio of	Supporting

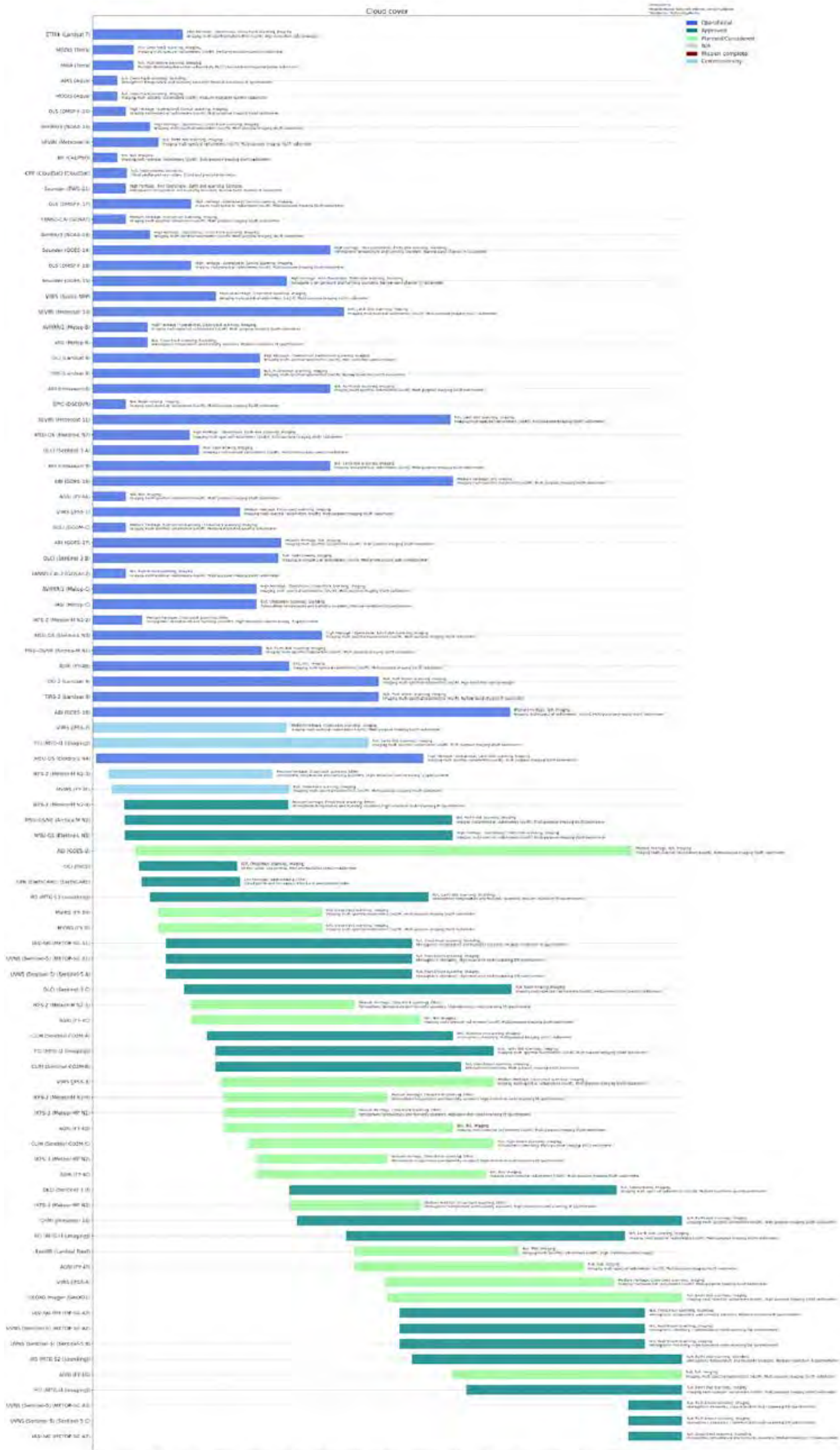
	major uncertainties for equilibrium climate sensitivity evaluations?	fractional coverage to evaluate the global cloud feedback	
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	46
2031 (8 years from now)	33
2033 (10 years from now)	28
2038 (15 years from now)	16



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud cover

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
IASI	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
Sounder	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
OLS	High Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=450
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
TANSO-CAI	High Utility	GOSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=904
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
TIRS	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524

IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
TANSO-CAI-2	High Utility	GOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1654
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
TIRS-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896

SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
UVNS (Sentinel-5)	General Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
IKFS-3	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
OCI	General Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1597
EPIC	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1615
CLIM	General Utility	Sentinel CO2M-B, Sentinel CO2M-C, Sentinel CO2M-A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2011
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
CPR (EarthCARE)	Potential Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
IKFS-2	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778

		Meteor-M N2-6, Meteor-M N2-4	
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
IIR	Marginal Utility	CALIPSO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=696
AGRI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=892

Cloud top height

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud type, amount and cloud top temperature

Category description: *The study of clouds, their location and characteristics, plays a key role in the understanding of climate change. Low, thick clouds primarily reflect solar radiation and cool the surface of the Earth. High, thin clouds primarily transmit incoming solar radiation, but at the same time they trap some of the outgoing infrared radiation emitted by the Earth and radiate it back downward, thereby warming the surface. Parameters include temperature and moisture profiles, fractional cloud cover, cloud top height, cloud top pressure, surface temperature and surface emissivity.*

Measurement definition: *Height of the upper surface of the cloud - Physical unit: [km] - Accuracy unit: [km].*

CEOS Database entry for Cloud top height: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=113

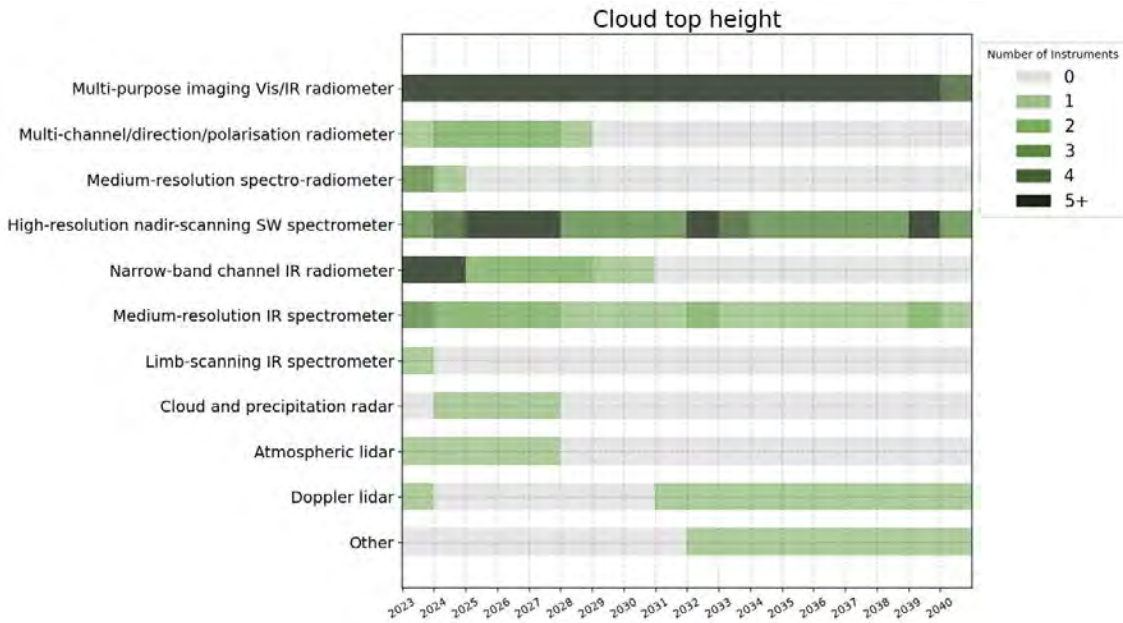
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/35

Related Candidate Science Questions

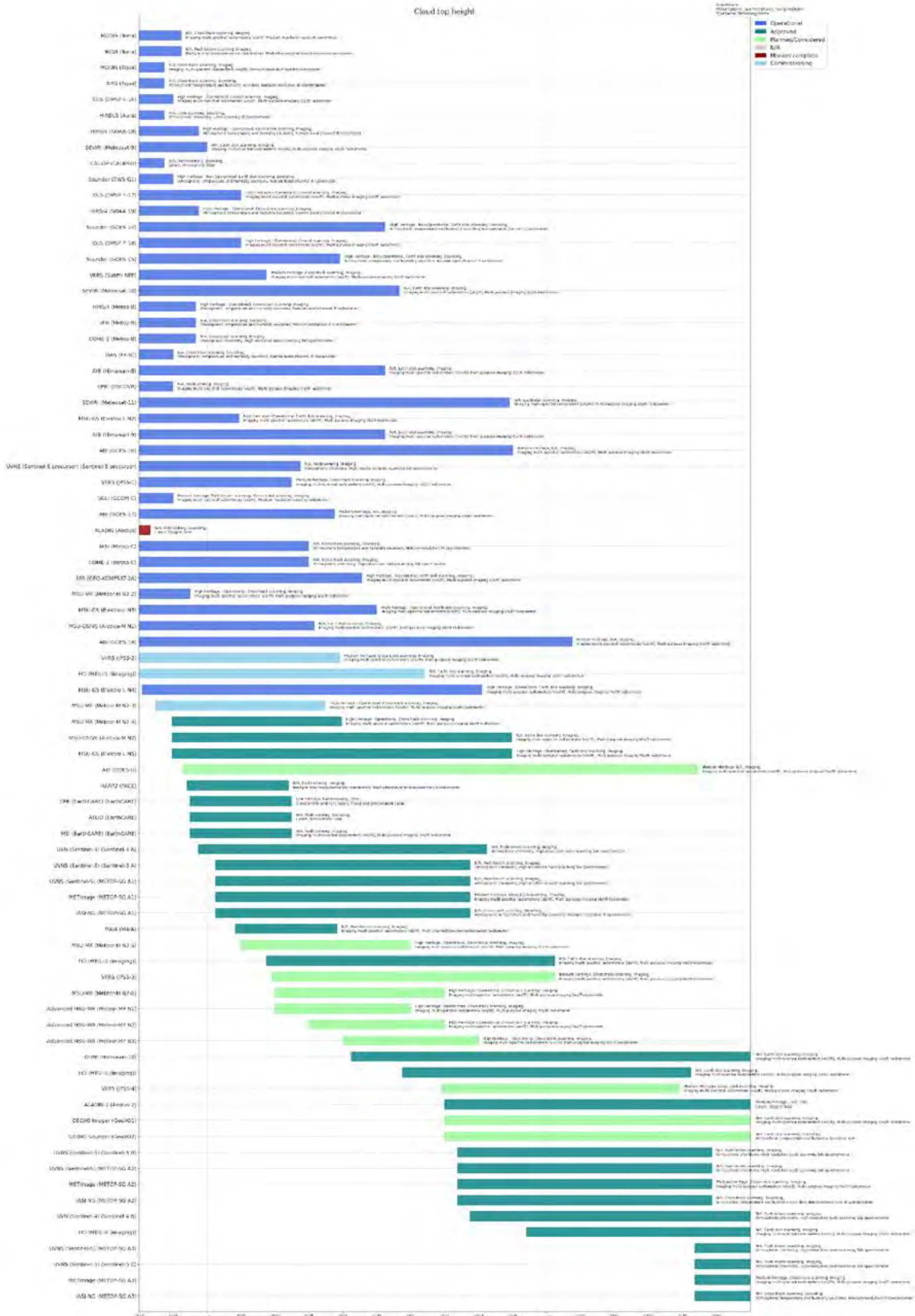
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	32
2031 (8 years from now)	21
2033 (10 years from now)	21
2038 (15 years from now)	13



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud top height

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
GOME-2	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=307
Sounder	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
OLS	High Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=450
HIRS/4	High Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
CALIOP	High Utility	CALIPSO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=820
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965

Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
IASI	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
ATLID	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=374
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MSI (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=938

AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
EPIC	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1615
MAIA	General Utility	MAIA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1768
ALADIN-2	General Utility	Aeolus-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2050
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
HiRDLS	Potential Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=351
CPR (EarthCARE)	Potential Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
ALADIN	Potential Utility	Aeolus	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=375
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
UVN (Sentinel-4)	Potential Utility	Sentinel-4 A, Sentinel-4 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=941
UVNS (Sentinel-5 precursor)	Potential Utility	Sentinel-5 precursor	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=942
UVNS (Sentinel-5)	Potential Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
HARP2	Potential Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1899
IRAS	Marginal Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666

Cloud top temperature

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud type, amount and cloud top temperature

Category description: *The study of clouds, their location and characteristics, plays a key role in the understanding of climate change. Low, thick clouds primarily reflect solar radiation and cool the surface of the Earth. High, thin clouds primarily transmit incoming solar radiation, but at the same time they trap some of the outgoing infrared radiation emitted by the Earth and radiate it back downward, thereby warming the surface. Parameters include temperature and moisture profiles, fractional cloud cover, cloud top height, cloud top pressure, surface temperature and surface emissivity.*

Measurement definition: *Temperature of the top of the cloud (highest cloud in case of multi-layer clouds) - Physical unit [K], Accuracy unit [K]*

CEOS Database entry for Cloud top temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=114

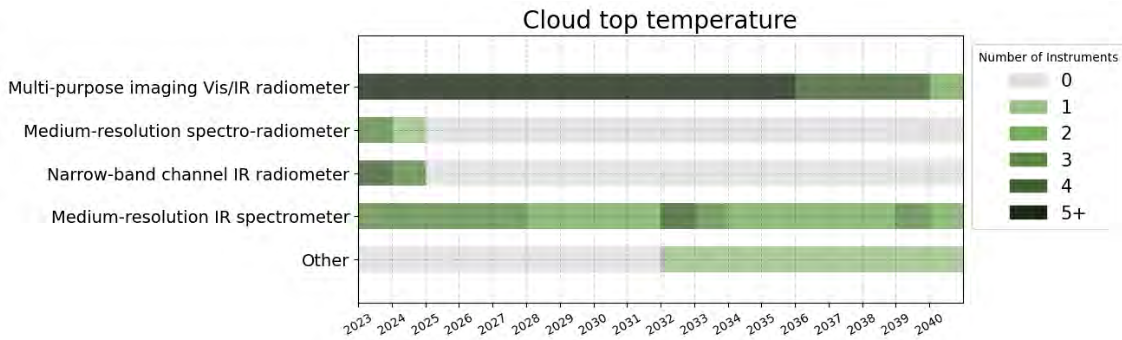
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/36

Related Candidate Science Questions

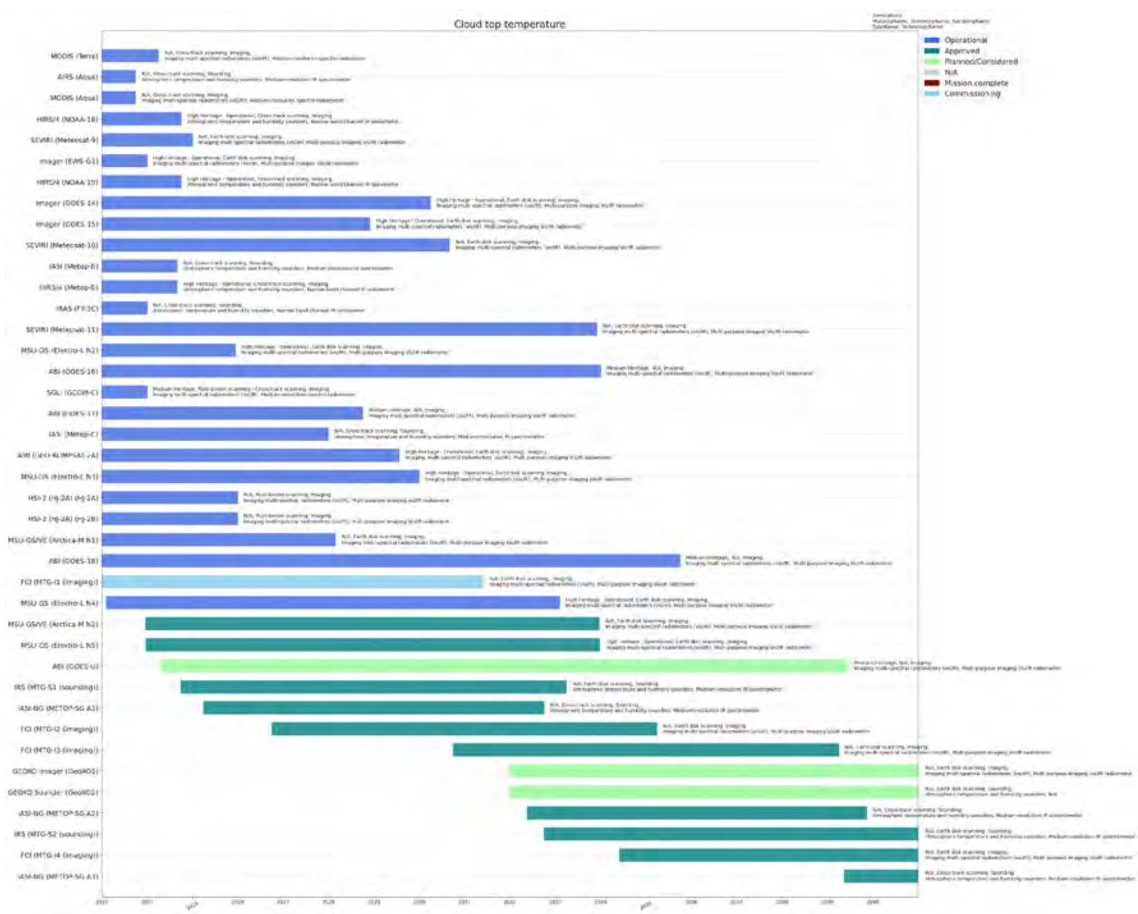
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	18
2031 (8 years from now)	12
2033 (10 years from now)	14
2038 (15 years from now)	7



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud top temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
IASI	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
Imager	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
HIRS/4	High Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
AMI	High Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395

ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
IRAS	Marginal Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Precipitation intensity at the surface (liquid or solid)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Liquid water and precipitation rate

Category description: *Water forms one of the most important constituents of the Earth's atmosphere and is essential for human existence. The global water cycle is at the heart of the Earth's climate system, and better predictions of its behaviour are needed for monitoring climate variability and change, weather forecasting and sustainable development of the world's water resources.*

Measurement definition: *Intensity of precipitation reaching the ground - Physical unit: [mm/h] (if solid, mm/h of liquid water after melting) - Accuracy unit: [mm/h]. Since accuracy changes with intensity, it is necessary to specify a reference intensity. Assumed rate: 5 mm/h.*

CEOS Database entry for Precipitation intensity at the surface (liquid or solid): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=116

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/128

Related Candidate Science Questions

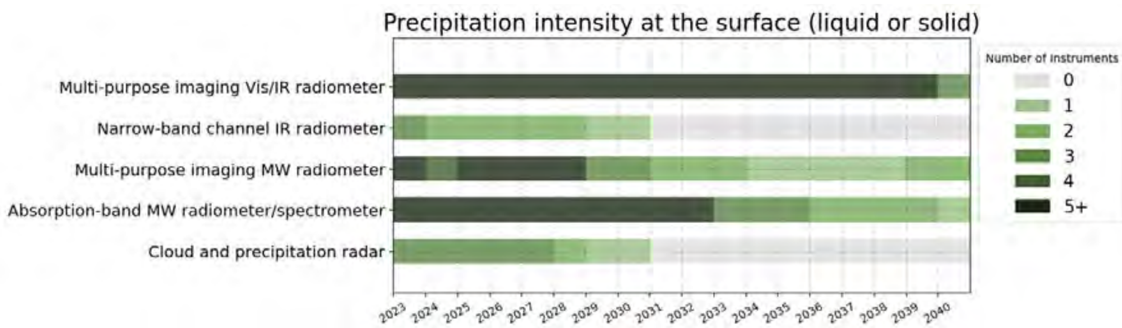
ID	CSQ	KAO	Priority Level
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the carbon sink, including river runoff, upwelling and biological productivity?	Supporting
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Supporting

7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Supporting
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Supporting
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Supporting
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Supporting
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Supporting
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Supporting
44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
44-B	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Detect water management influences: extent to which water management practices and land use changes (e.g., deforestation) modified the water cycle on regional to global scales	Critical

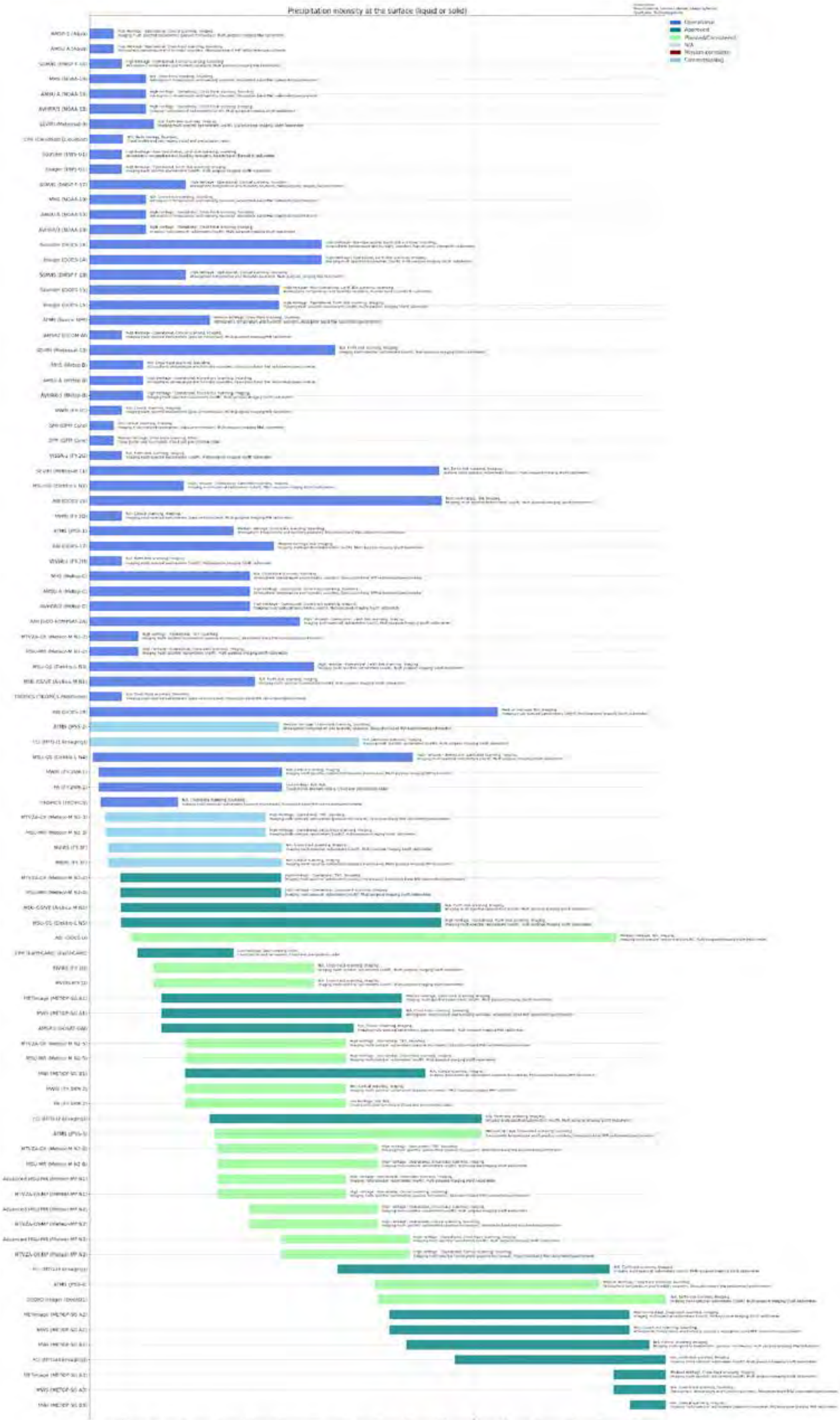
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	44
2031 (8 years from now)	22
2033 (10 years from now)	16
2038 (15 years from now)	8



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Precipitation intensity at the surface (liquid or solid)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MHS	High Utility	NOAA-19, Metop-C, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=304
Imager	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
AMSR-E	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
GMI	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
DPR	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=774
AMSR2	High Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883
MWI	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
AMSR3	High Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
SEVIRI	General Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302

AMSU-A	General Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
SSM/IS	General Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=454
MSU-MR	General Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
AMSU-A	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
CPR (EarthCARE)	Potential Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372
ATMS	Potential Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
MTVZA-GY	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673
MSU-GS	Potential Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
ABI	Potential Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870

FCI	Potential Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
METimage	Potential Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
Advanced MSU-MR	Potential Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
MTVZA-GY-MP	Potential Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
AMI	Potential Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
MWS	Potential Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1663
MSU-GS/VE	Potential Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
TROPICS	Potential Utility	TROPICS Pathfinder, TROPICS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1770
Sounder	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
MWRI	Marginal Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
PR	Marginal Utility	FY-3RM-2, FY-3RM-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1761

Downwelling (Incoming) solar radiation at TOA

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux density of the solar radiation at the top of the atmosphere - Physical unit [W/m2], Accuracy unit [W/m2]*

CEOS Database entry for Downwelling (Incoming) solar radiation at TOA: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=123

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/51

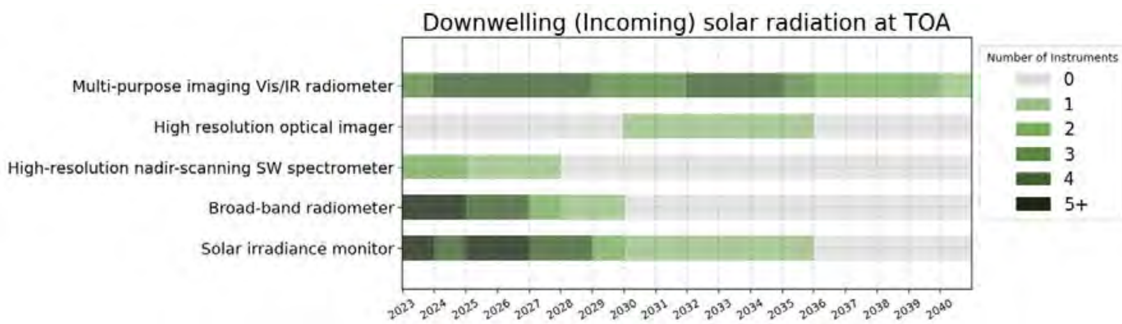
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Critical

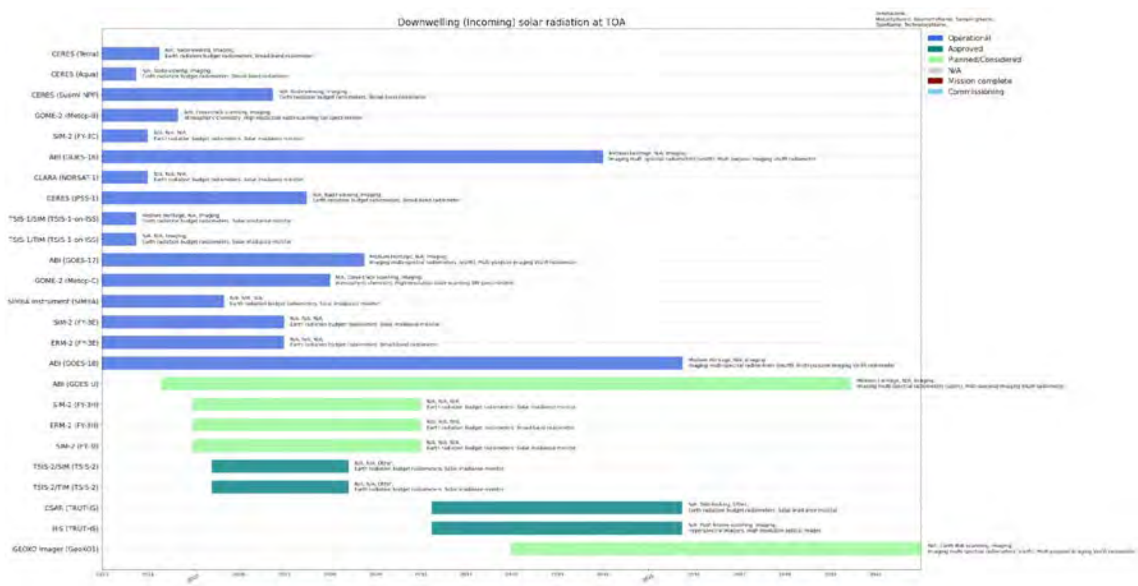
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	22
2031 (8 years from now)	21
2033 (10 years from now)	22
2038 (15 years from now)	20



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Downwelling (Incoming) solar radiation at TOA

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CERES	High Utility	Suomi NPP, JPSS-1, Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=397
TSIS-1/SIM	High Utility	TSIS-1-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=679
TSIS-2/TIM	High Utility	TSIS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1715
TSIS-1/TIM	High Utility	TSIS-1-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1896

TSIS-2/SIM	High Utility	TSIS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1897
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
GOME-2	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=307
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
CLARA	General Utility	NORSAT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1701
CSAR	General Utility	TRUTHS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1953
HIS	General Utility	TRUTHS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1954
SIMBA Instrument	General Utility	SIMBA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2040
ERM-2	Marginal Utility	FY-3H, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1617
SIM-2	Marginal Utility	FY-3H, FY-3I, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1632

Upward short-wave irradiance at TOA

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux of the terrestrial radiation in the range 0.2-4 µm (reflected solar radiation) moving to space through the top of the atmosphere - Physical unit [W/m2], Accuracy unit [W/m2]*

CEOS Database entry for Upward short-wave irradiance at TOA: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=124

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/167

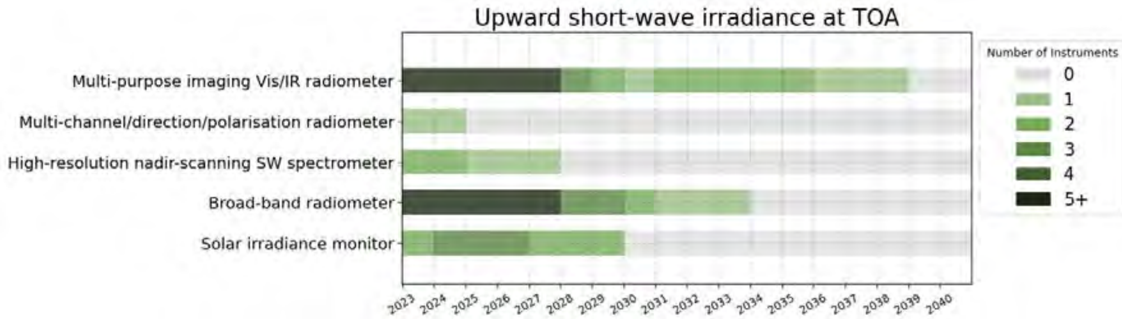
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy	Critical

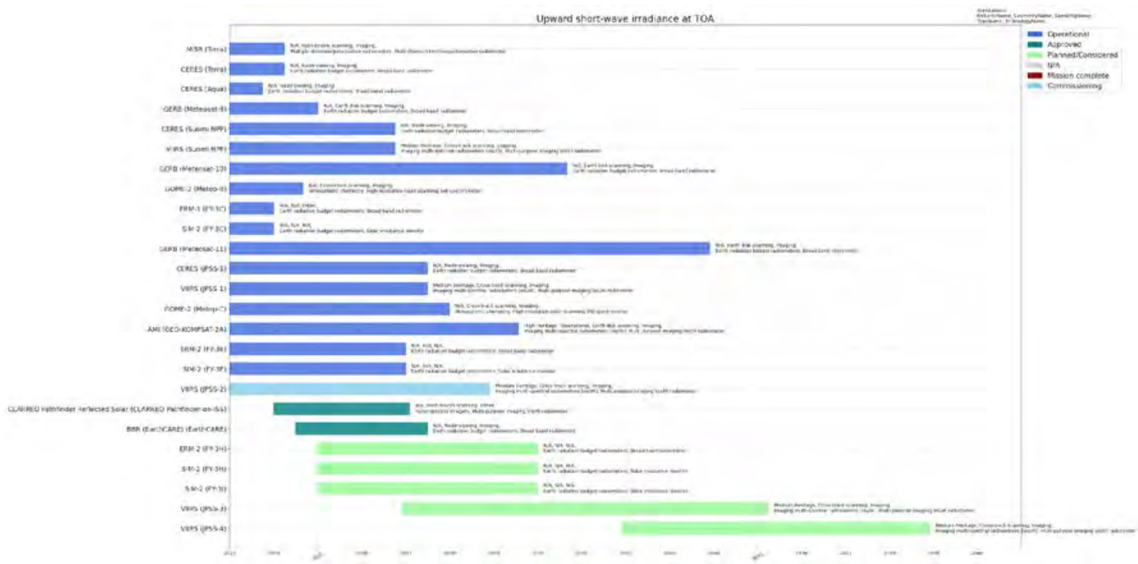
		imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	12
2031 (8 years from now)	8
2033 (10 years from now)	8
2038 (15 years from now)	7



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Upward short-wave irradiance at TOA

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
GERB	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=303
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
CERES	High Utility	Suomi NPP, JPSS-1, Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=397
GOME-2	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=307

BBR (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=937
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
CLARREO Pathfinder Reflected Solar	General Utility	CLARREO Pathfinder-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1736
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
ERM-1	Marginal Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=884
ERM-2	Marginal Utility	FY-3H, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1617
SIM-2	Marginal Utility	FY-3H, FY-3I, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1632

Upward long-wave irradiance at TOA

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux of the terrestrial radiation in the range 4-200 µm (thermal emission) moving to space through the top of the atmosphere - Physical unit [W/m2], Accuracy unit [W/m2]*

CEOS Database entry for Upward long-wave irradiance at TOA: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=125

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/169

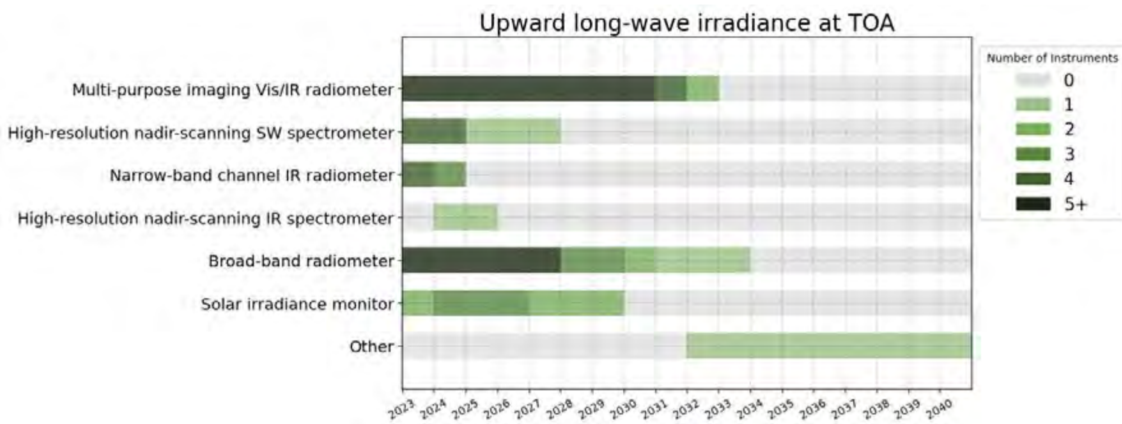
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy	Critical

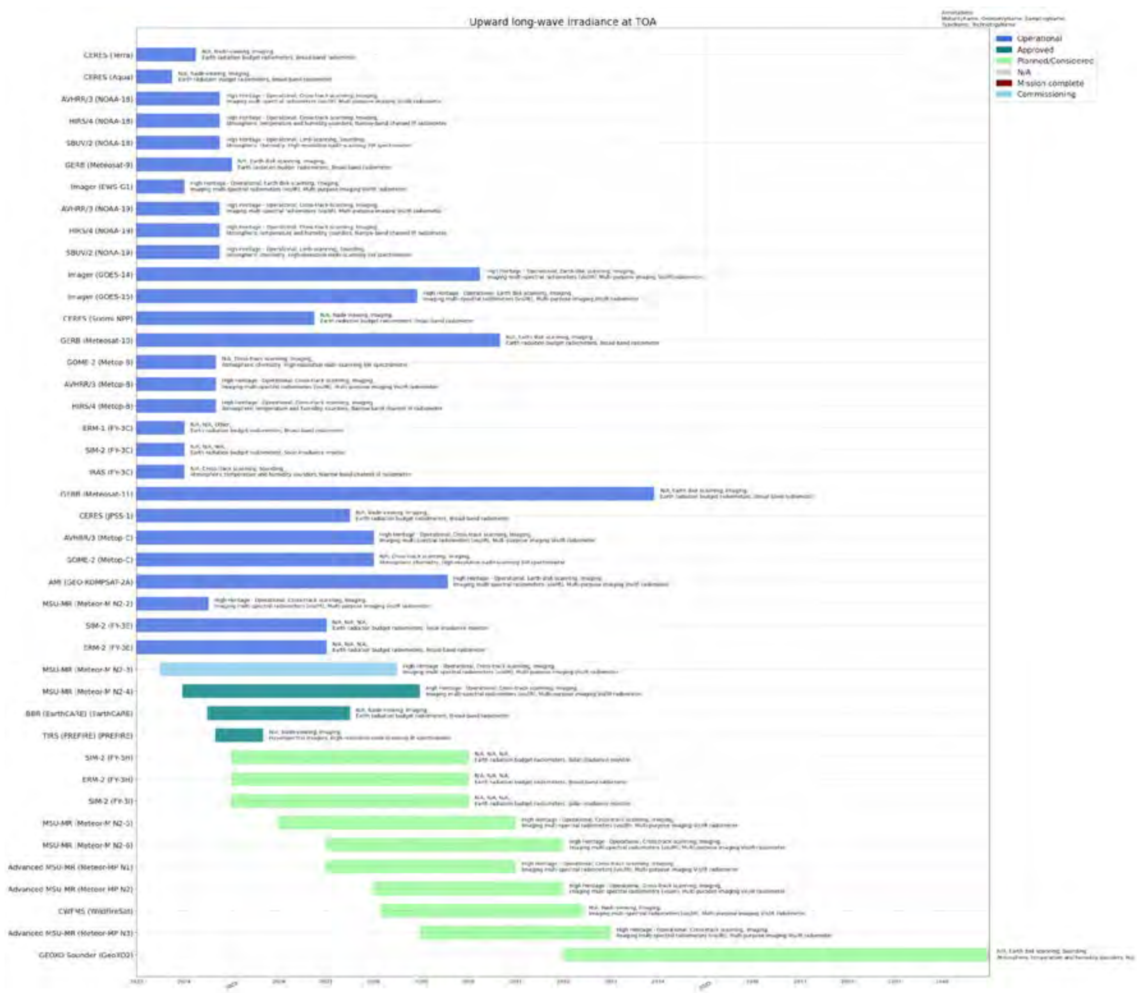
		imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	16
2031 (8 years from now)	6
2033 (10 years from now)	3
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Upward long-wave irradiance at TOA

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
GERB	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=303
CERES	High Utility	Suomi NPP, JPSS-1, Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=397
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
IRAS	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
TIRS (PREFIRE)	High Utility	PREFIRE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1903
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
BBR (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=937
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
HIRS/4	Potential Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564
Advanced MSU-MR	Potential Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
GOME-2	Marginal Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=307
SBUV/2	Marginal Utility	NOAA-18, NOAA-19	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=318

Imager	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
ERM-1	Marginal Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=884
ERM-2	Marginal Utility	FY-3H, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1617
SIM-2	Marginal Utility	FY-3H, FY-3I, FY-3E, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1632

Aerosol effective radius (column/profile)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Aerosols

Category description: *Aerosols are tiny particles suspended in the air, with the majority derived from natural phenomena such as volcanic eruptions, thought it is estimated that some 10–20% are generated by human activities such as burning of fossil fuels. The majority of aerosols form a thin haze in the lower atmosphere and are regularly washed out by precipitation, with the remainder found in the stratosphere where they can remain for many months or years.*

Measurement definition: *Vertical profile of the size distribution of aerosol, assimilated to spheres of the same volume. Requested in the troposphere (assumed height: 12 km) and as columnar average - Physical unit: [mm] - Accuracy unit: [mm].*

CEOS Database entry for Aerosol effective radius (column/profile): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=126

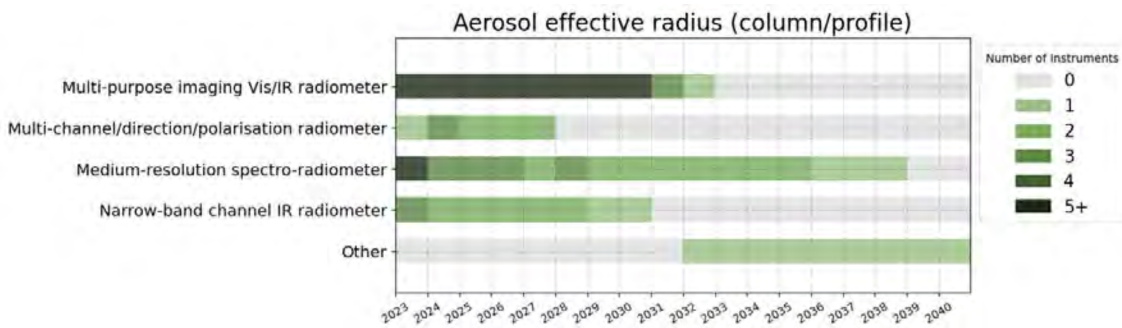
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/3

Related Candidate Science Questions

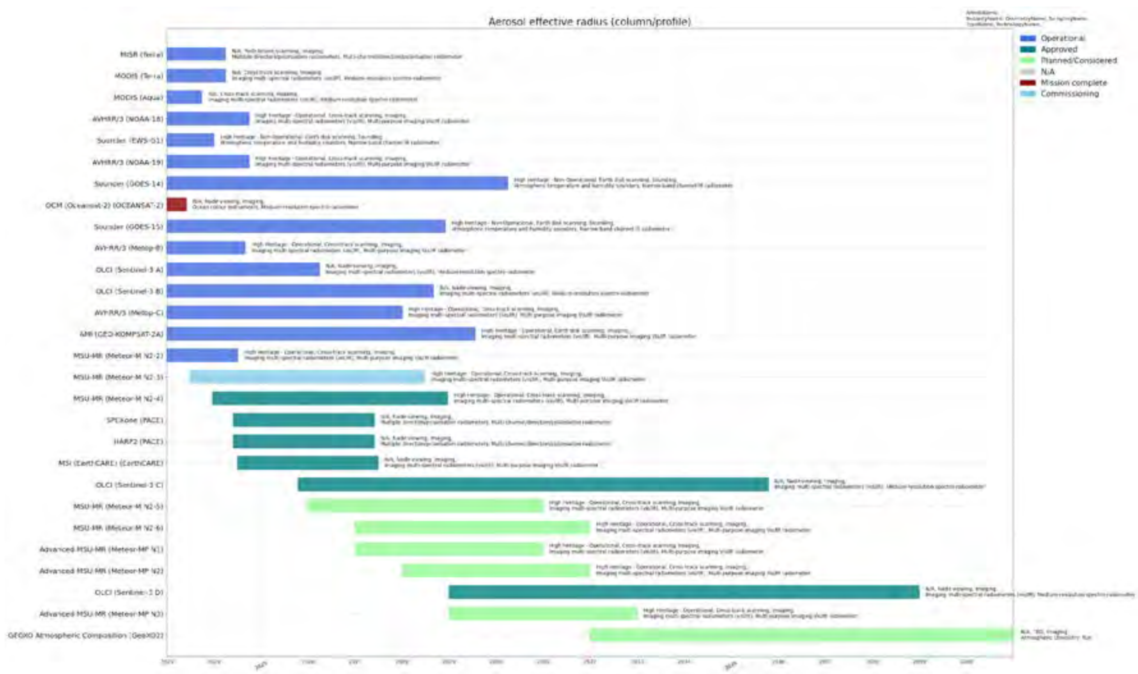
ID	CSQ	KAO	Priority Level
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	11
2031 (8 years from now)	5
2033 (10 years from now)	3
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Aerosol effective radius (column/profile)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
MSU-MR	General Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
GEOXO Atmospheric Composition	General Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2048

OCM (Oceansat-2)	Potential Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=464
Advanced MSU-MR	Potential Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
AMI	Potential Utility	GEO-KOMPSAT-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
SPEXone	Potential Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1898
HARP2	Potential Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1899
Sounder	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
MODIS	Marginal Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
AVHRR/3	Marginal Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
OLCI	Marginal Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
MSI (EarthCARE)	Marginal Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=938

Cloud drop effective radius

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud particle properties and profile

Category description: *A key to climate modelling is to observe and understand the global distribution of clouds, their physical properties, such as thickness and droplet size. Whether a particular cloud will heat or cool the Earth's surface depends on the cloud's radiating temperature – and thus its height – and on its albedo for both visible and infrared radiation, which depends on the number and details of the cloud properties.*

Measurement definition: *Size distribution of liquid water drops, assimilated to spheres of the same volume. Considered as both a 3D field throughout the troposphere and a 2D field at the top of the cloud surface - Measuring Units µm, Uncertainty Units µm*

CEOS Database entry for Cloud drop effective radius: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=127

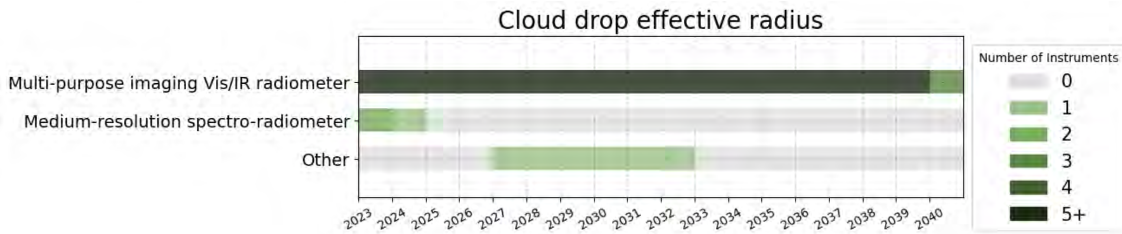
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/28

Related Candidate Science Questions

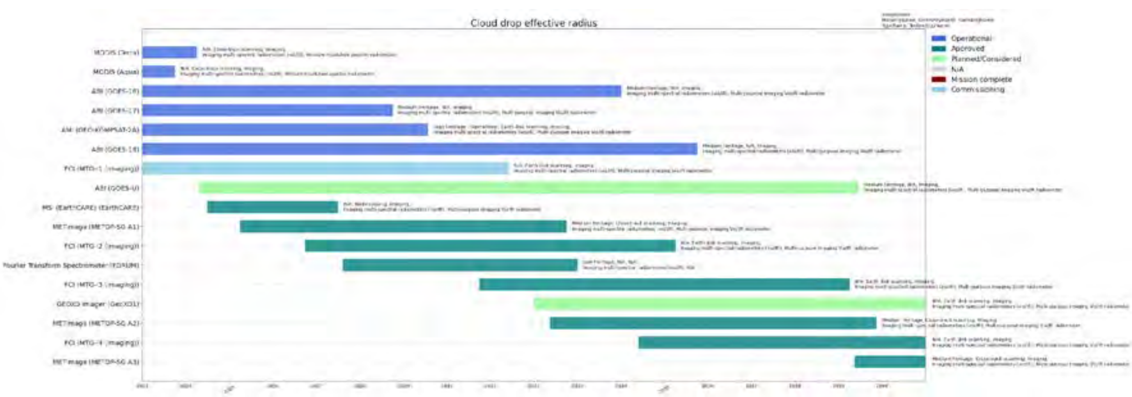
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Critical
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	9
2031 (8 years from now)	8
2033 (10 years from now)	7
2038 (15 years from now)	5



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud drop effective radius

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885

		(imaging), MTG-I2 (imaging), MTG-I3 (imaging)	
MSI (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=938
METimage	General Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
Fourier Transform Spectrometer	General Utility	FORUM	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2026

Cloud optical depth

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Cloud particle properties and profile

Category description: *A key to climate modelling is to observe and understand the global distribution of clouds, their physical properties, such as thickness and droplet size. Whether a particular cloud will heat or cool the Earth's surface depends on the cloud's radiating temperature – and thus its height – and on its albedo for both visible and infrared radiation, which depends on the number and details of the cloud properties.*

Measurement definition: *Impact of the cloud water column on radiation propagation - Physical unit: [dimensionless] - Accuracy unit: [%].*

CEOS Database entry for Cloud optical depth: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=128

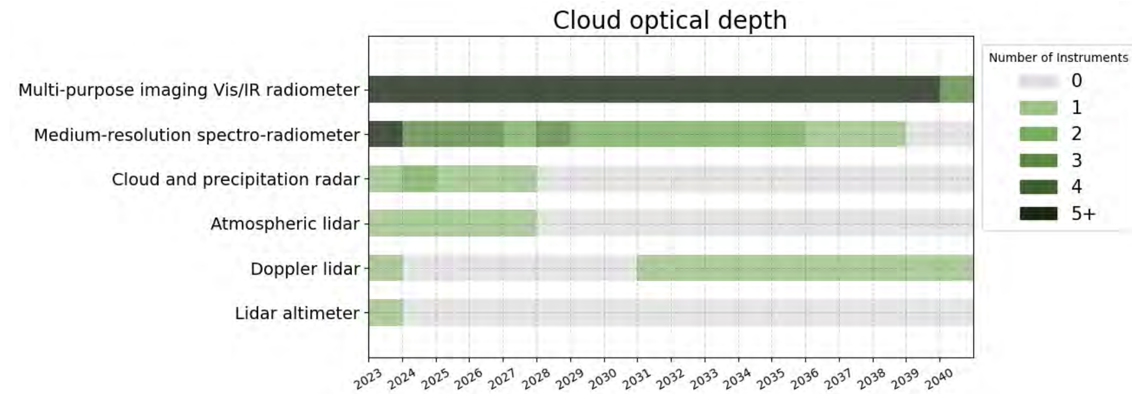
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/34

Related Candidate Science Questions

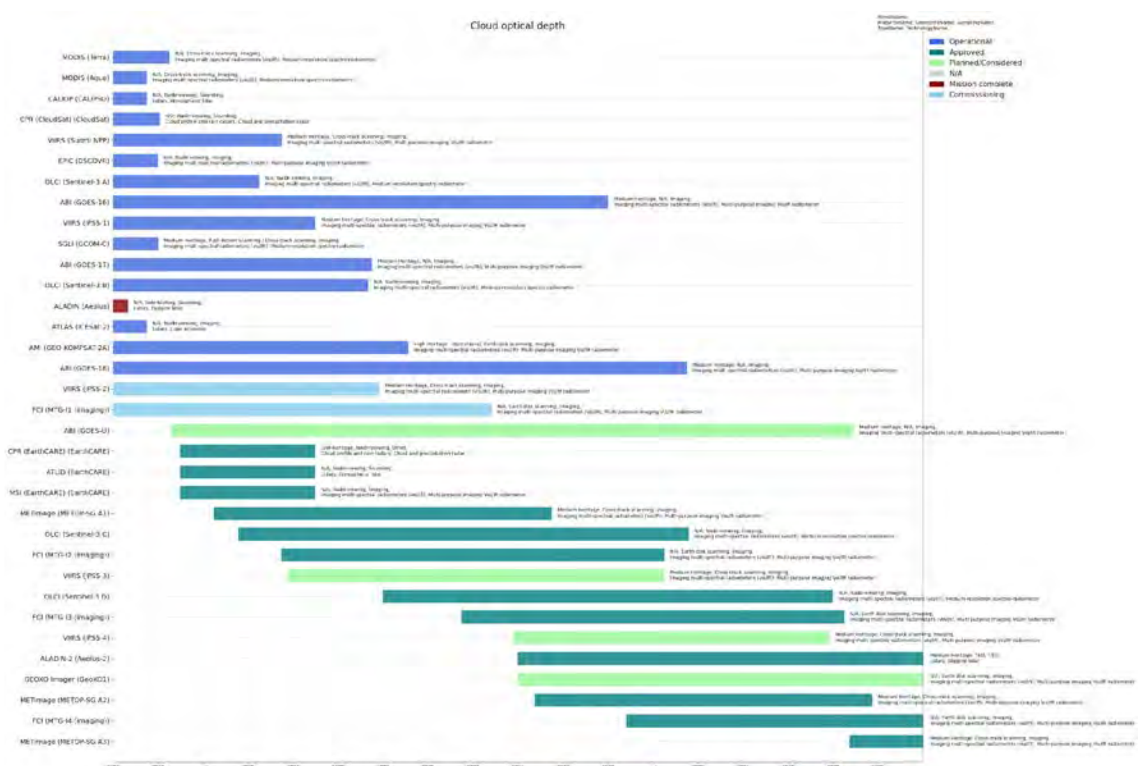
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Critical
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	12
2031 (8 years from now)	11
2033 (10 years from now)	12
2038 (15 years from now)	8



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Cloud optical depth

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CALIOP	High Utility	CALIPSO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=820
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
ATLID	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=374
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MSI (EarthCARE)	General Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=938
METimage	General Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
EPIC	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1615
ALADIN-2	General Utility	Aeolus-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2050
CPR (EarthCARE)	Potential Utility	EarthCARE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=372

ALADIN	Potential Utility	Aeolus	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=375
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998

Downward short-wave irradiance at Earth surface

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux density of the solar radiation at the Earth surface - Physical unit [W/m2], Accuracy unit [W/m2]*

CEOS Database entry for Downward short-wave irradiance at Earth surface: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=131

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/50

Related Candidate Science Questions

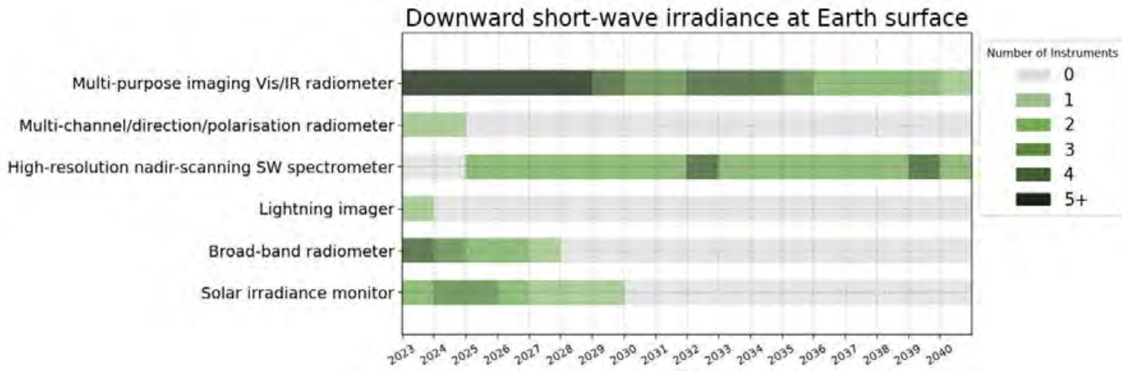
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between	Global budget closure studies for the global energy budget relation linking planetary heating,	Critical

	effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

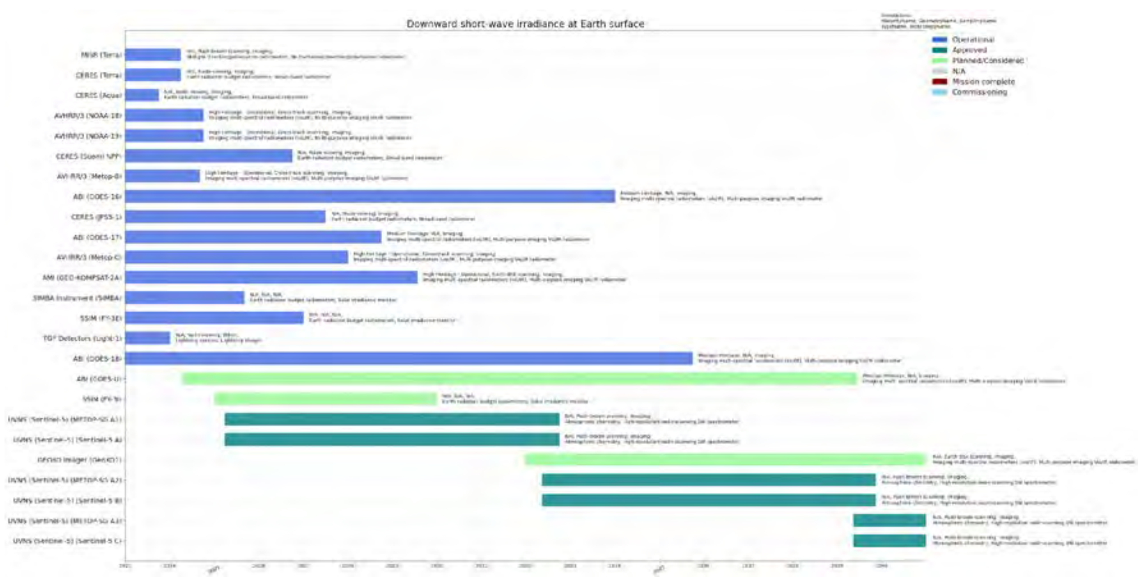
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	10

2031 (8 years from now)	8
2033 (10 years from now)	9
2038 (15 years from now)	7



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Downward short-wave irradiance at Earth surface

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CERES	High Utility	Suomi NPP, JPSS-1, Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=397
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403

UVNS (Sentinel-5)	High Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
MISR	General Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
AMI	General Utility	GEO-KOMPSAT-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
TGF Detectors	General Utility	Light-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1889
SIMBA Instrument	General Utility	SIMBA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2040
SSIM	Marginal Utility	FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1949

Downward long-wave irradiance at Earth surface

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux density of radiation emitted by the gases, aerosols and clouds of the atmosphere to the Earth's surface - Physical unit [W/m2], Accuracy unit [W/m2]*

CEOS Database entry for Downward long-wave irradiance at Earth surface: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=132

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/52

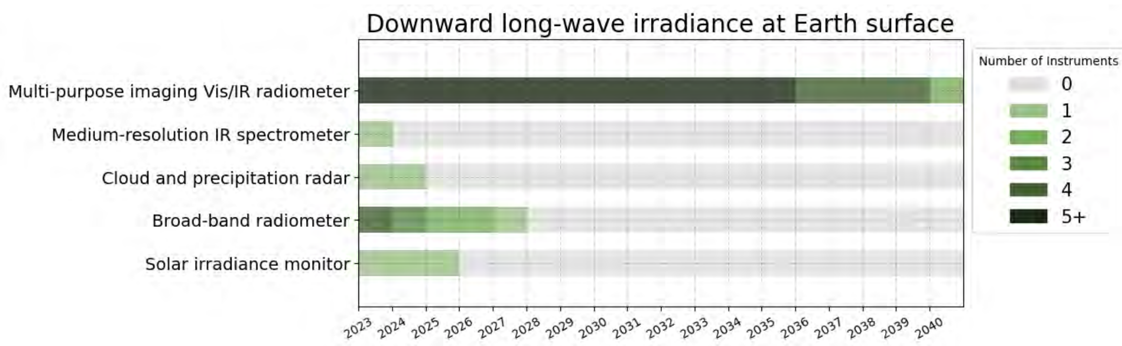
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative	Global budget closure studies for the global energy budget relation linking planetary heating, effective	Critical

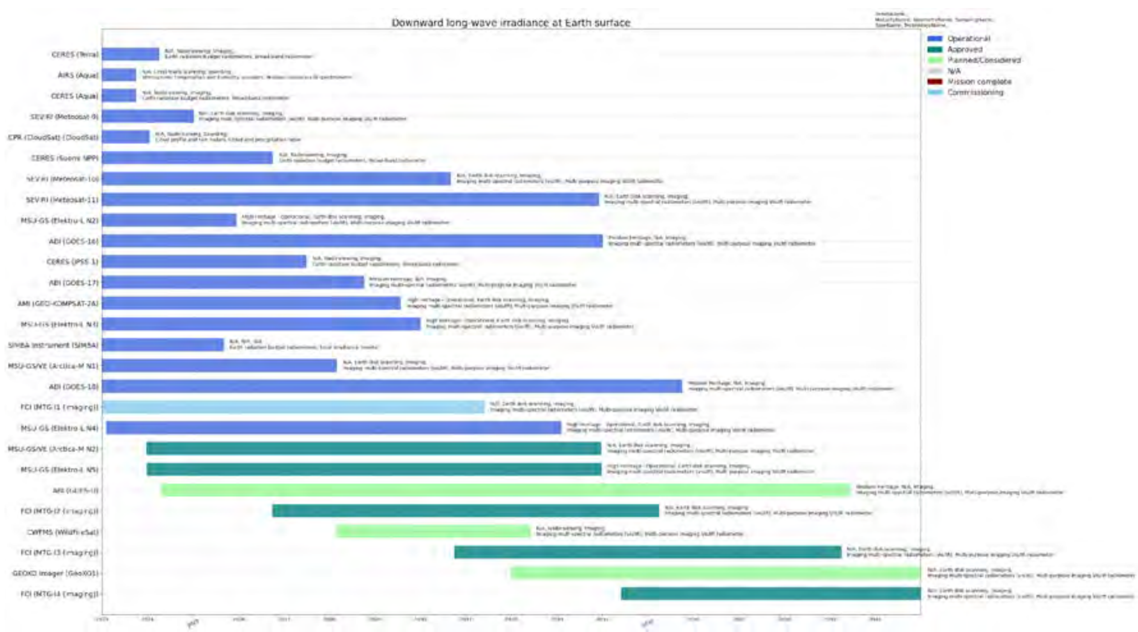
	climate forcing, Earth's surface temperature response and climate sensitivity, as well as	radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	15
2031 (8 years from now)	11
2033 (10 years from now)	10
2038 (15 years from now)	4



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Downward long-wave irradiance at Earth surface

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CERES	High Utility	Suomi NPP, JPSS-1, Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=397
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691

GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
AIRS	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
SIMBA Instrument	General Utility	SIMBA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2040
SEVIRI	Potential Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
CPR (CloudSat)	Potential Utility	CloudSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=649
AMI	Potential Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575

Short-wave Earth surface bi-directional reflectance

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Reflectance of the Earth's surface function of the viewing angle and the illumination conditions in the range 0.4-0.7 µm (or other specific short-wave ranges) - Physical unit: [%] - Accuracy unit: [%].*

CEOS Database entry for Short-wave Earth surface bi-directional reflectance: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=133

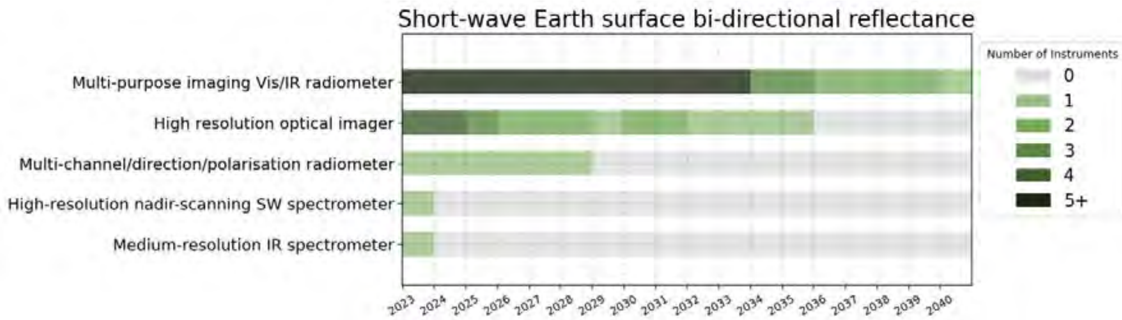
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/55

Related Candidate Science Questions

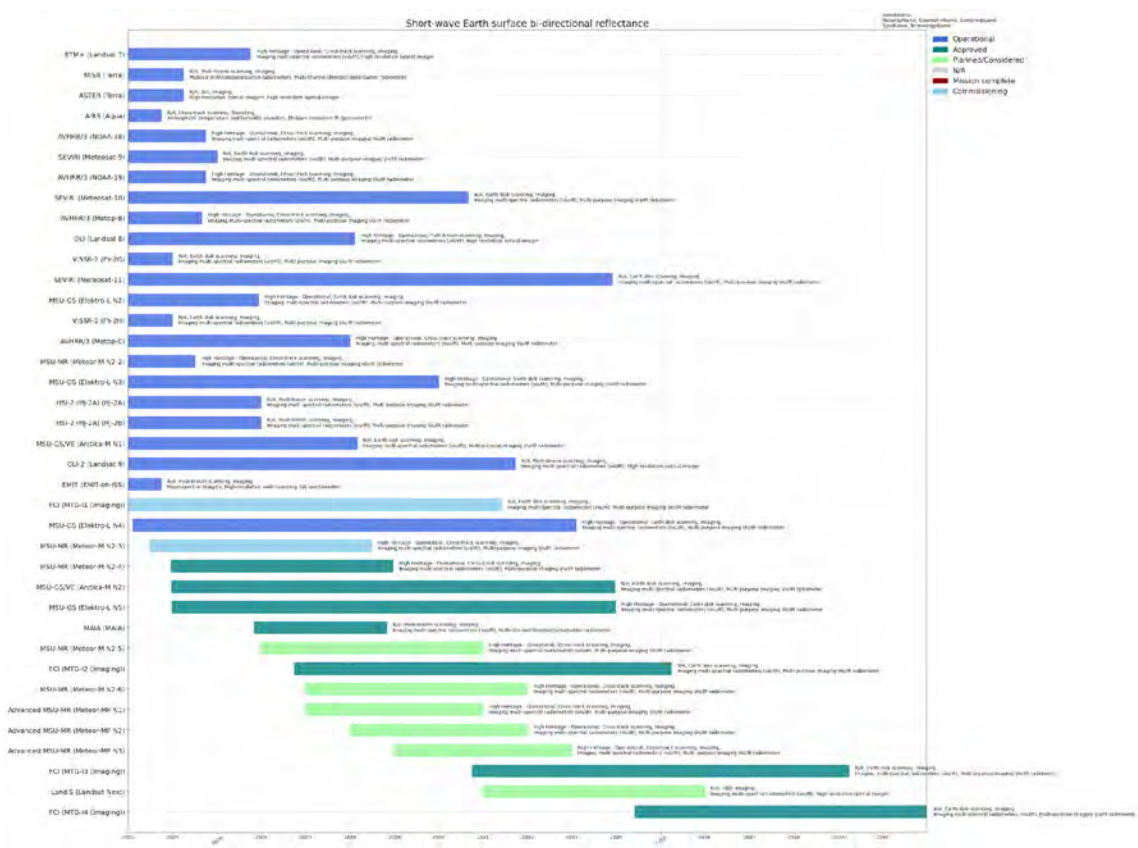
ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO_2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	18
2031 (8 years from now)	12
2033 (10 years from now)	7
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Short-wave Earth surface bi-directional reflectance

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
EMIT	High Utility	EMIT-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1901
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
AIRS	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
MSU-GS	General Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
MSU-GS/VE	General Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691

MAIA	General Utility	MAIA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1768
MSU-MR	Potential Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
Advanced MSU-MR	Potential Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
SEVIRI	Marginal Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
ASTER	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Upwelling (Outgoing) long-wave radiation at Earth surface

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux of thermal radiation from the Earth's surface - Physical unit: [W/m2] - Accuracy unit: [W/m2].*

CEOS Database entry for Upwelling (Outgoing) long-wave radiation at Earth surface: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=134

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/170

Related Candidate Science Questions

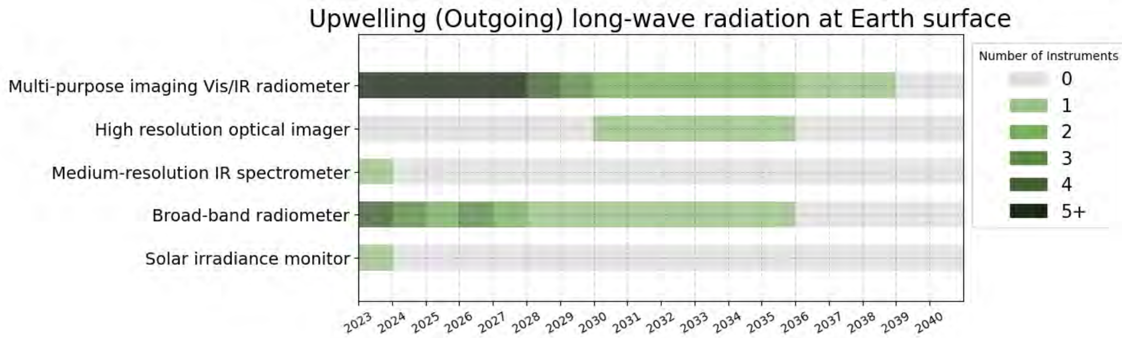
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And	Global budget closure studies for the global	Critical

	what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

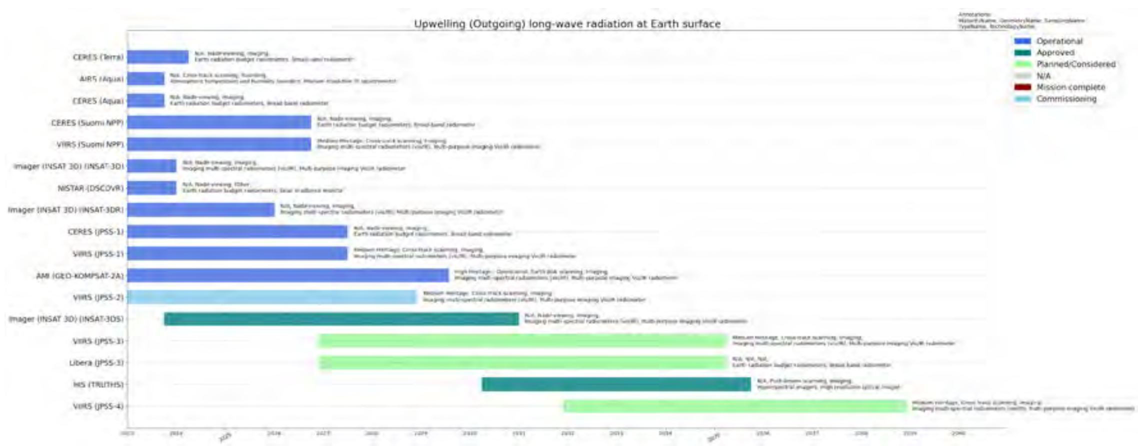
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	6

2031 (8 years from now)	5
2033 (10 years from now)	5
2038 (15 years from now)	3



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Upwelling (Outgoing) long-wave radiation at Earth surface

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CERES	High Utility	Suomi NPP, JPSS-1, Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=397
AIRS	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
NISTAR	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=647
Libera	General Utility	JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1904

HIS	General Utility	TRUTHS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1954
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
Imager (INSAT 3D)	Potential Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=788
AMI	Potential Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575

Air temperature (near surface)

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Atmospheric Temperature Fields

Category description: *With humidity, atmospheric temperature profile data are a core requirement for weather forecasting and are coordinated within the framework of CGMS (The Coordination Group for Meteorological Satellites). The data are used for numerical weather prediction (NWP), for monitoring inter-annual global temperature changes, for identifying correlations between atmospheric parameters and climatic behaviour, and for validating global models of the atmosphere.*

Measurement definition: *Air temperature at a known height above the surface with the height specified in the metadata - Measuring Units K, Uncertainty Units K*

CEOS Database entry for Air temperature (near surface): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=138

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/12

Related Candidate Science Questions

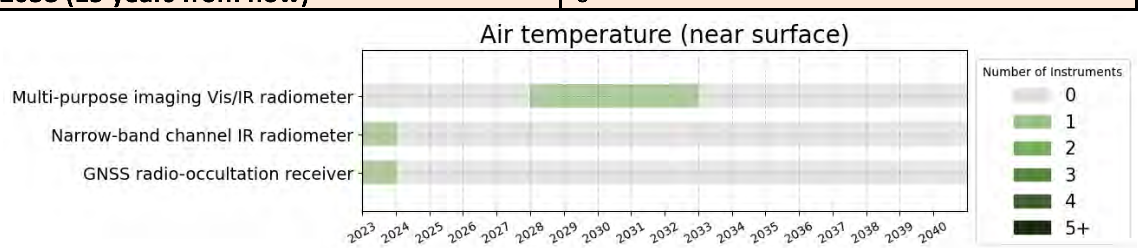
ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Supporting
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Supporting

2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Supporting
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Supporting
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Supporting
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Supporting
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which	Further develop better weather prediction on short time scales (2–12 weeks)	Critical

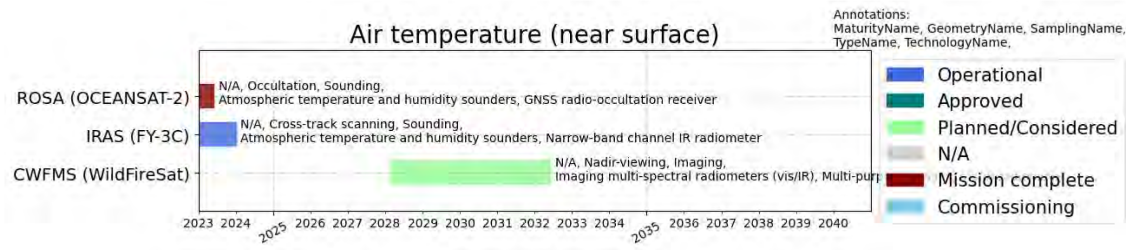
	essential advancements can we achieve for research and monitoring on weather and climate patterns?	aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	1
2031 (8 years from now)	1
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Air temperature (near surface)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
IRAS	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
ROSA	Marginal Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=899

Wind speed over sea surface (horizontal)

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean surface winds

Category description: *High resolution vector wind measurements at the sea surface are required in models of the atmosphere, ocean surface waves and ocean circulation. They are proving useful in enhancing marine weather forecasting through assimilation into NWP models and in improving understanding of the large-scale air-sea fluxes which are vital for climate prediction purposes. Accurate wind vector data affect a broad range of marine operations, including offshore oil operations, ship movement and routing. Such data also aid short-term weather forecasting and the issue of timely weather warnings.*

Measurement definition: *Horizontal vector component (2D) of the 3D wind vector over the sea surface - Physical unit: [m/s] - Accuracy unit: [m/s] intended as vector error, i.e. the module of the vector difference between the observed vector and the true vector.*

CEOS Database entry for Wind speed over sea surface (horizontal): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=141

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/181

Related Candidate Science Questions

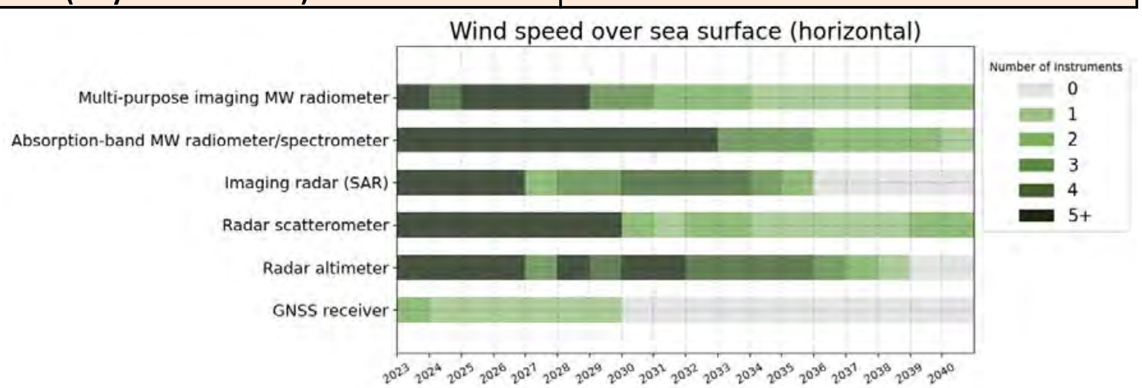
ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-B	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	How is the Southern Ocean CO2 sink responding to climate perturbations and long-term climate change.	Supporting
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes	Supporting

		that regulate the carbon sink, including river runoff, upwelling and biological productivity?	
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Supporting
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Supporting
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Supporting
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Supporting
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Supporting
8-C	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in “Blue carbon” ecosystems, and their resilience to human and climate change pressures in different coastal regions	Supporting
8-D	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in permafrost in the polar coastal ocean, and its resilience to human and climate change pressures in different coastal regions	Supporting
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting

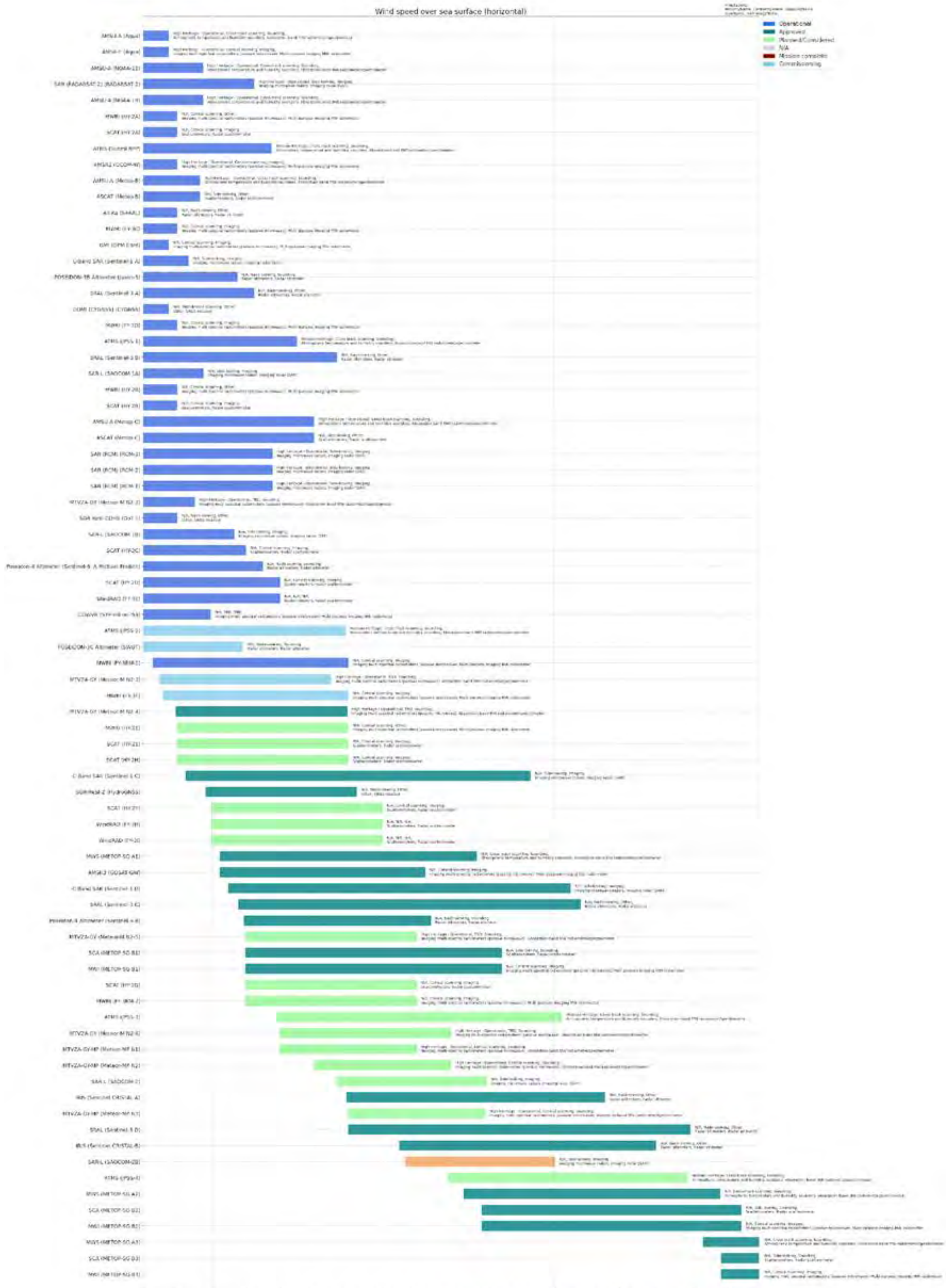
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Supporting
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Supporting
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	53
2031 (8 years from now)	45
2033 (10 years from now)	42
2038 (15 years from now)	37



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Wind speed over sea surface (horizontal)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ASCAT	High Utility	Metop-C, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=308
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
MWI	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
SCA	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1631
POSEIDON-3B Altimeter	High Utility	Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1633
Poseidon-4 Altimeter	High Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1723
SGR-ReSI-Z	High Utility	HydroGNSS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1939
POSEIDON-3C Altimeter	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1961
IRIS	High Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
SAR-L	General Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
GMI	General Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903

C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939
WindRAD	General Utility	FY-3H, FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1625
DDMI (CYGNSS)	General Utility	CYGNSS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1669
COWVR	General Utility	STP-H8-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2043
SGR-ReSI-CDHS	General Utility	DoT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2097
AMSR-E	Potential Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664
MWRI	Potential Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
MTVZA-GY	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673
AMSR2	Potential Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883
AltiKa	Potential Utility	SARAL	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=931
MWRI	Potential Utility	HY-2E, HY-2A, HY-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=967
MTVZA-GY-MP	Potential Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
AMSR3	Potential Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804
AMSU-A	Marginal Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312

ATMS	Marginal Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
SCAT	Marginal Utility	HY-2E, HY-2F, HY-2A, HY-2B, HY-2G, HY-2H, HY-2C, HY-2D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=972
AMSU-A	Marginal Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
MWS	Marginal Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1663

Wind vector over sea surface (horizontal)

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean surface winds

Category description: *High resolution vector wind measurements at the sea surface are required in models of the atmosphere, ocean surface waves and ocean circulation. They are proving useful in enhancing marine weather forecasting through assimilation into NWP models and in improving understanding of the large-scale air-sea fluxes which are vital for climate prediction purposes. Accurate wind vector data affect a broad range of marine operations, including offshore oil operations, ship movement and routing. Such data also aid short-term weather forecasting and the issue of timely weather warnings.*

Measurement definition: *The wind vector represents the motion of the airmass over the ground. It is described by wind speed and the inverse of wind direction. Conventionally measured at 10 m height. For expected performances and in case the measurement is made at a different height or in case it is corrected to 10m, indicate in the comments the exact height of the instrument as well as whether correction to 10 m has been applied. Accuracy is the modulus of the vector difference between measured and true vectors. [Unit of measurement - m/s]*

CEOS Database entry for Wind vector over sea surface (horizontal): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=143

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/183

Related Candidate Science Questions

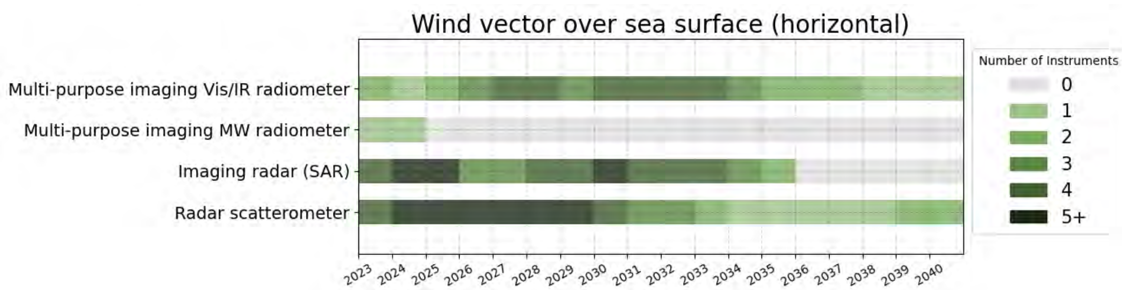
ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-B	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	How is the Southern Ocean CO2 sink responding to	Supporting

		climate perturbations and long-term climate change.	
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Supporting
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Supporting
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Supporting
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Supporting
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Supporting
8-C	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in “Blue carbon” ecosystems, and their resilience to human and climate change pressures in different coastal regions	Supporting
8-D	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in permafrost in the polar coastal ocean, and its resilience to human and climate change pressures in different coastal regions	Supporting
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting
21-B	What physical processes drive ice dynamic variability, and how does	Determine how the dominance of these	Supporting

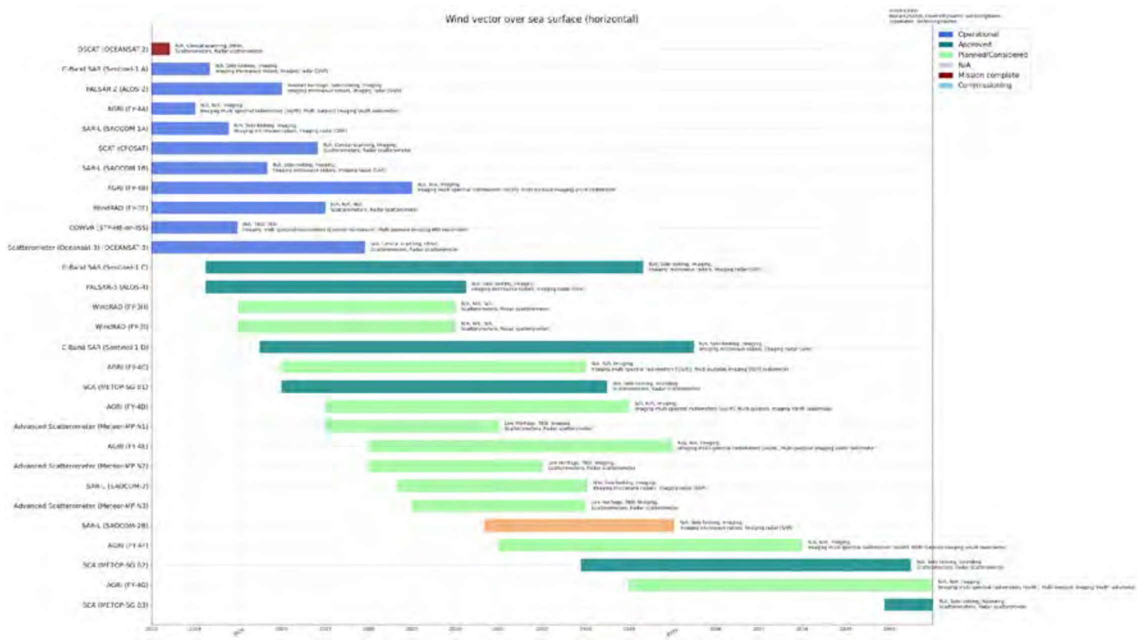
	the dominance of these processes differ between the different Polar regions?	processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Supporting
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	18
2031 (8 years from now)	17
2033 (10 years from now)	17
2038 (15 years from now)	10



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Wind vector over sea surface (horizontal)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
OSCAT	High Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=752
Advanced Scatterometer	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1568
SCA	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1631
SCAT	High Utility	CFOSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1645
Scatterometer (Oceansat-3)	High Utility	OCEANSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1749
SAR-L	General Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939

		Sentinel-1 B, Sentinel-1 C	
WindRAD	General Utility	FY-3H, FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1625
COWVR	General Utility	STP-H8-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2043
PALSAR-2	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
PALSAR-3	Potential Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
AGRI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=892

Sea surface temperature

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Surface temperature (ocean)

Category description: *Ocean surface temperature (often known as 'sea surface temperature' or SST) is one of the most important boundary conditions for the general circulation of the atmosphere. The ocean exchanges vast amounts of heat and energy with the atmosphere and these air/sea interactions have a profound influence on the Earth's weather and climate patterns. SST is linked closely with the ocean circulation, as demonstrated by the El Niño-Southern Oscillation (ENSO) cycle.*

Measurement definition: *Temperature of the sea water at surface. The "bulk" temperature refers to the depth of typically 2m, the "skin" temperature refers to within the upper 1 mm - Physical unit [K], Accuracy unit [K]*

CEOS Database entry for Sea surface temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=144

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/134

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-B	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	How is the Southern Ocean CO2 sink responding to climate perturbations and long-term climate change.	Supporting
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the	Critical

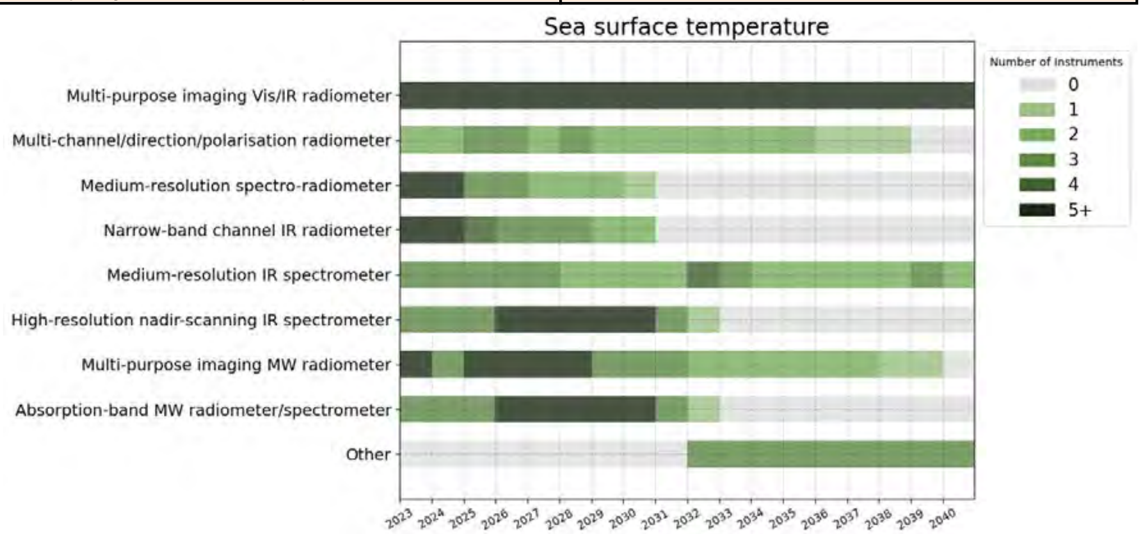
		carbon sink, including river runoff, upwelling and biological productivity?	
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Supporting
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Supporting
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Supporting
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Supporting
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Supporting
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Critical
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Critical
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting

21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Supporting
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Supporting
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth’s surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme	Critical

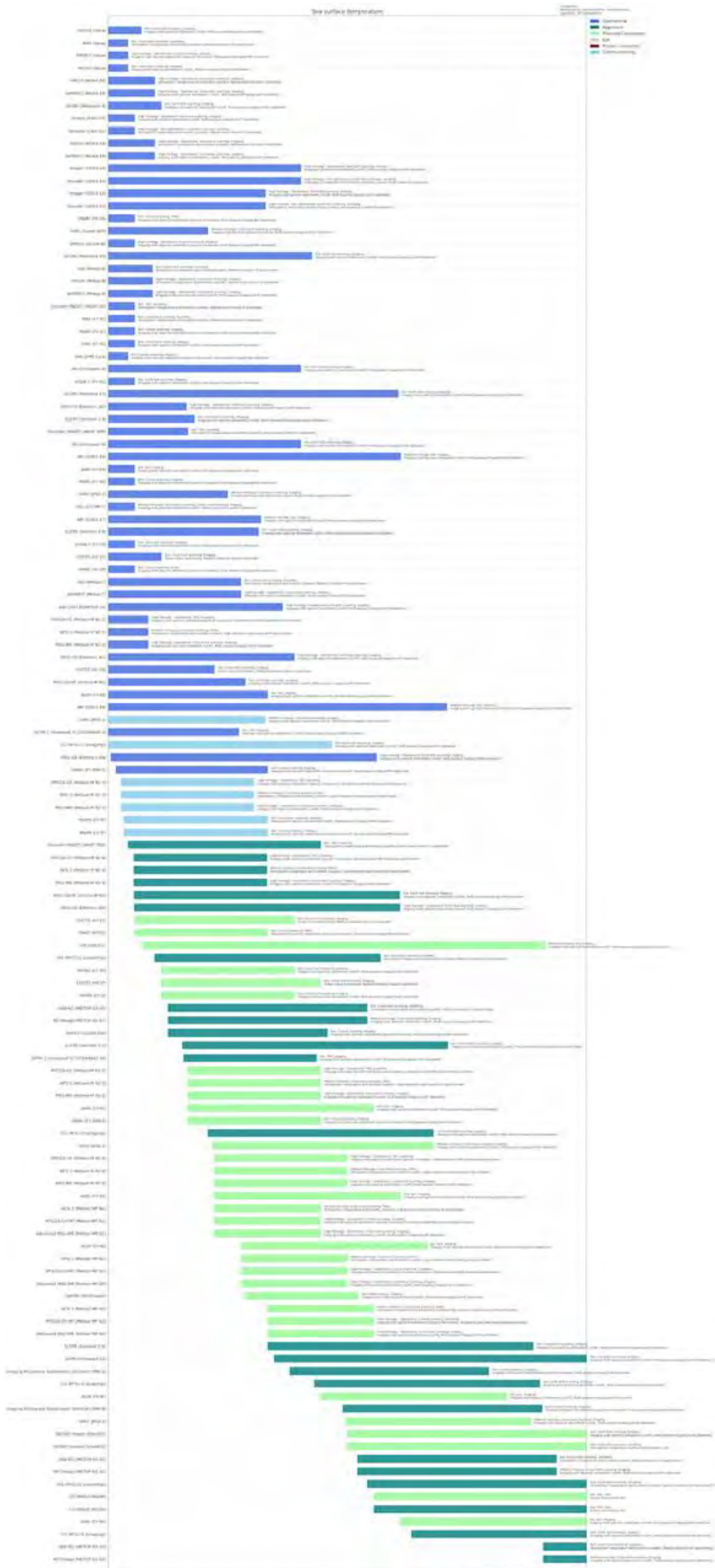
		precipitation, storms and long-term weather.	
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	71
2031 (8 years from now)	45
2033 (10 years from now)	35
2038 (15 years from now)	25



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea surface temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SEVIRI	High Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
IASI	High Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
VIIRS	High Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
AMSR-E	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
VIRR	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=684
GMI	High Utility	GPM Core	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=773
IKFS-2	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
Sounder (INSAT)	High Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=789

ABI	High Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
AMSR2	High Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883
FCI	High Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SLSTR	High Utility	Sentinel-3 A, Sentinel-3 B, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=902
SSTM-1 (Oceansat-3)	High Utility	OCEANSAT-3A, OCEANSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=929
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
IKFS-3	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
AMI	High Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
AMSR3	High Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804

GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
AIRS	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
MTVZA-GY	General Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MTVZA-GY-MP	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
AHI	General Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
Imaging Microwave Radiometer	General Utility	Sentinel CIMR-A, Sentinel CIMR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2014
LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
Sounder	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
Imager	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
HIRS/4	Marginal Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564

IRAS	Marginal Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
MWRI	Marginal Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
COCTS	Marginal Utility	HY-1C, HY-1D, HY-1E, HY-1F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=827
AGRI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=892
MWRI	Marginal Utility	HY-2E, HY-2A, HY-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=967

Sea level

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean topography/currents

Category description: *Ocean surface topography data contain information that has significant practical applications in such fields as the study of worldwide weather and climate patterns, the monitoring of shoreline evolution and the protection of ocean fisheries. Ocean circulation is of critical importance to the Earth's climate system. Ocean currents transport a significant amount of energy from the tropics towards the poles, leading to a moderation of the climate at high latitudes. Circulation can be deduced from ocean surface topography, which may be readily measured using satellite altimetry.*

Measurement definition: *Actual, local sea level inclusive of mean sea level and perturbations (tides, etc.) [Unit of measurement - cm]*

CEOS Database entry for Sea level: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=148

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/49

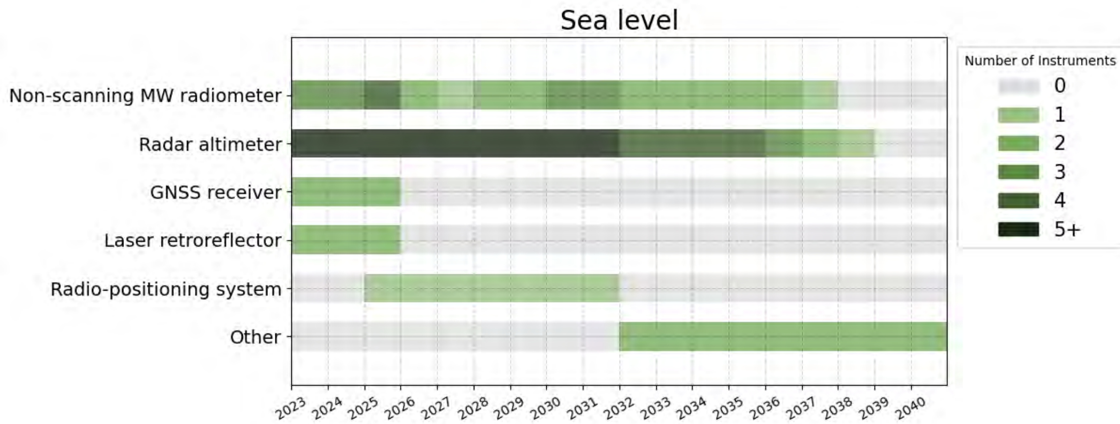
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Critical
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Critical
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical

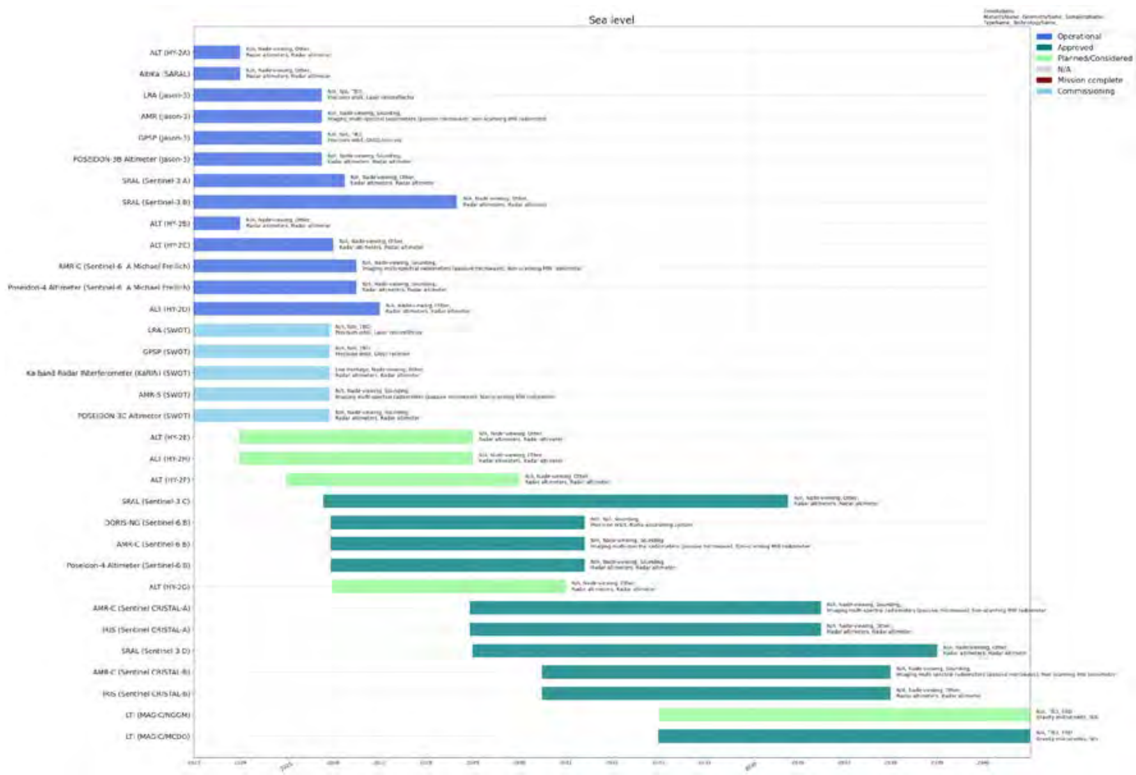
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	16
2031 (8 years from now)	14
2033 (10 years from now)	14
2038 (15 years from now)	9



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea level

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
LRA	High Utility	SWOT, Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=106

DORIS-NG	High Utility	Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=181
AMR	High Utility	Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=882
AltiKa	High Utility	SARAL	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=931
GPSP	High Utility	SWOT, Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=983
POSEIDON-3B Altimeter	High Utility	Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1633
AMR-C	High Utility	Sentinel-6 A Michael Freilich, Sentinel CRISTAL-A, Sentinel CRISTAL-B, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1719
Poseidon-4 Altimeter	High Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1723
AMR-S	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1786
POSEIDON-3C Altimeter	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1961
IRIS	High Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
Ka-band Radar INterferometer (KaRIN)	General Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1541

LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056
ALT	Marginal Utility	HY-2E, HY-2F, HY-2A, HY-2G, HY-2H, HY-2B, HY-2C, HY-2D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=973

Ocean chlorophyll concentration

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean colour/biology

Category description: *Remote sensing measurements of ocean colour (i.e. the detection of phytoplankton pigments) provide the only global-scale focus on the biology and productivity of the ocean's surface layer. Phytoplankton are microscopic plants that live in the ocean, and like terrestrial plants, they contain the pigment chlorophyll, which gives them their greenish colour. Different shades of ocean colour reveal the presence of differing concentrations of sediments, organic materials and phytoplankton. The ocean over regions with high concentrations of phytoplankton is shaded from blue-green to green, depending on the type and density of the phytoplankton population. From space, satellite sensors can distinguish even slight variations in colour which cannot be detected by the human eye.*

Measurement definition: *Indicator of living phytoplankton biomass, extracted from ocean colour observation - Uncertainty is expressed in mg/m3 for a given concentration of 1 mg/m3 - Measuring Units mg/m3, Uncertainty Units mg/m3*

CEOS Database entry for Ocean chlorophyll concentration: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=149

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/110

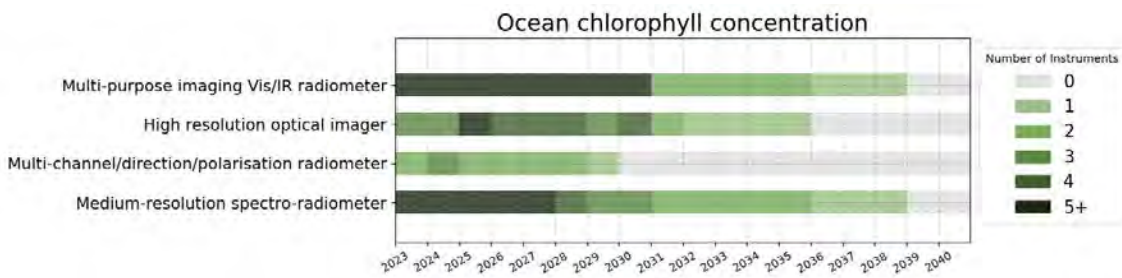
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the carbon sink, including river runoff,	Critical

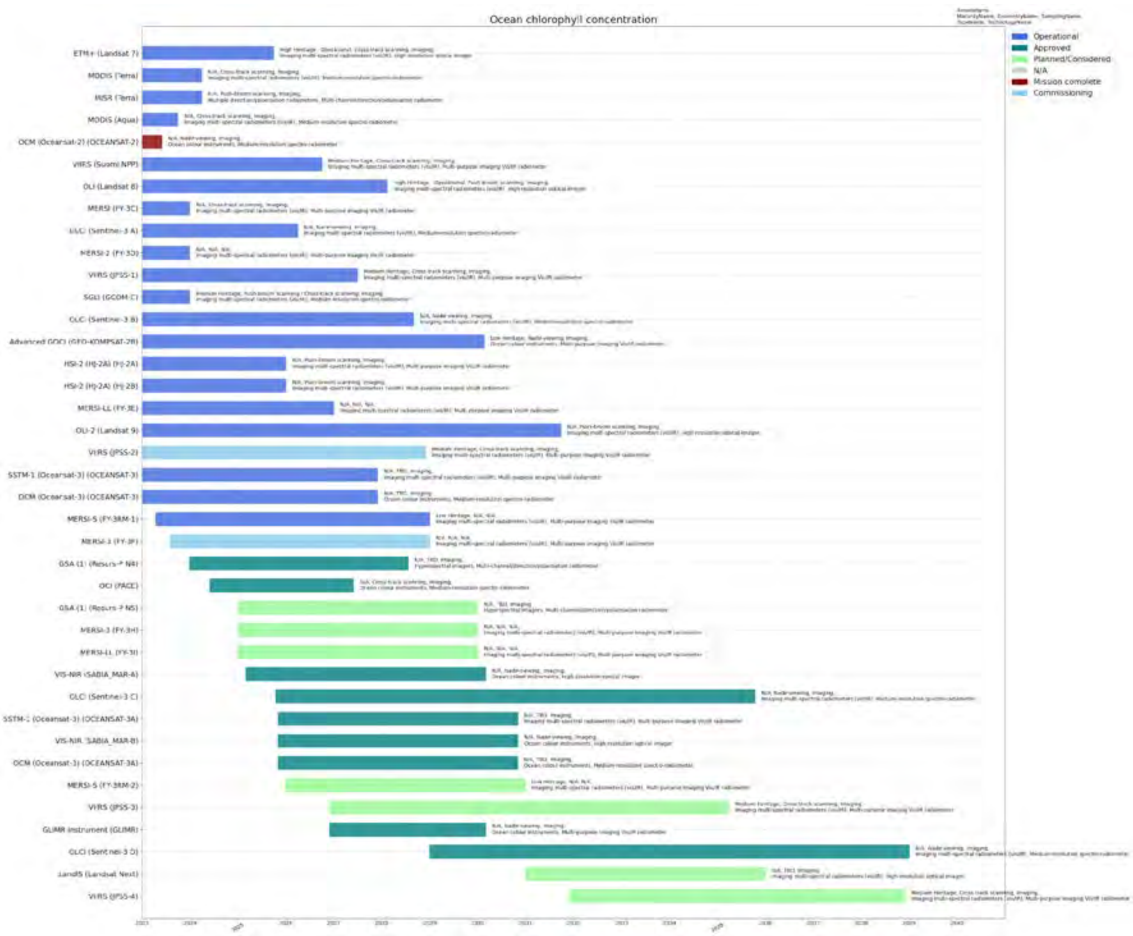
		upwelling and biological productivity?	
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Critical
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Critical
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	22
2031 (8 years from now)	19
2033 (10 years from now)	18
2038 (15 years from now)	15



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Ocean chlorophyll concentration

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
OCM (Oceansat-2)	High Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=464

MERSI	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=893
Advanced GOCI	High Utility	GEO-KOMPSAT-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1574
MERSI-2	High Utility	FY-3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1620
VIS-NIR	High Utility	SABIA_MAR-A, SABIA_MAR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1637
MERSI-S	High Utility	FY-3RM-2, FY-3RM-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1759
MERSI-3	High Utility	FY-3H, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1946
MERSI-LL	High Utility	FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1947
ETM+	General Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
OLI	General Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
OCI	General Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1597
OLI-2	General Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
GLIMR Instrument	General Utility	GLIMR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1902

LandIS	General Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
GSA (1)	Potential Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1686
MISR	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
SSTM-1 (Oceansat-3)	Marginal Utility	OCEANSAT-3A, OCEANSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=929
OCM (Oceansat-3)	Marginal Utility	OCEANSAT-3A, OCEANSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=935
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Ocean suspended sediment concentration

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean colour/biology

Category description: *Remote sensing measurements of ocean colour (i.e. the detection of phytoplankton pigments) provide the only global-scale focus on the biology and productivity of the ocean's surface layer. Phytoplankton are microscopic plants that live in the ocean, and like terrestrial plants, they contain the pigment chlorophyll, which gives them their greenish colour. Different shades of ocean colour reveal the presence of differing concentrations of sediments, organic materials and phytoplankton. The ocean over regions with high concentrations of phytoplankton is shaded from blue-green to green, depending on the type and density of the phytoplankton population. From space, satellite sensors can distinguish even slight variations in colour which cannot be detected by the human eye.*

Measurement definition: *Parameter extracted from ocean colour observation. Indicative of river outflow, re-suspension or pollution of other-than-biological origin. Requested in both open ocean and coastal zone - Physical unit: [g/m3] - Accuracy unit: [%] at a specific concentration (e.g., 2 g/m3).*

CEOS Database entry for Ocean suspended sediment concentration: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=150

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/117

Related Candidate Science Questions

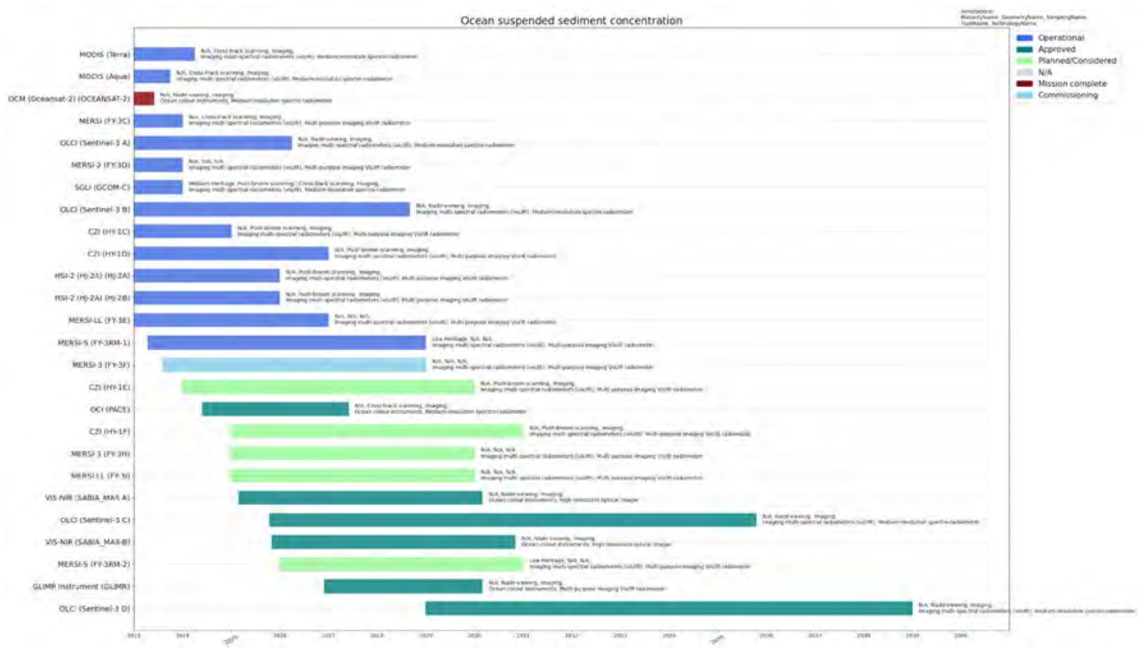
ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the	Critical

		carbon sink, including river runoff, upwelling and biological productivity?	
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Critical
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Critical
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	14
2031 (8 years from now)	6
2033 (10 years from now)	6
2038 (15 years from now)	5

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Ocean suspended sediment concentration

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
OCM (Oceansat-2)	High Utility	OCEANSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=464
MERSI	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=893
MERSI-2	High Utility	FY-3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1620
VIS-NIR	High Utility	SABIA_MAR-A, SABIA_MAR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1637
MERSI-S	High Utility	FY-3RM-2, FY-3RM-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1759
MERSI-3	High Utility	FY-3H, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1946
MERSI-LL	High Utility	FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1947

MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
OCI	General Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1597
GLIMR Instrument	General Utility	GLIMR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1902
CZI	Marginal Utility	HY-1C, HY-1D, HY-1E, HY-1F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=828
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Color dissolved organic matter (CDOM)

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean colour/biology

Category description: *Remote sensing measurements of ocean colour (i.e. the detection of phytoplankton pigments) provide the only global-scale focus on the biology and productivity of the ocean's surface layer. Phytoplankton are microscopic plants that live in the ocean, and like terrestrial plants, they contain the pigment chlorophyll, which gives them their greenish colour. Different shades of ocean colour reveal the presence of differing concentrations of sediments, organic materials and phytoplankton. The ocean over regions with high concentrations of phytoplankton is shaded from blue-green to green, depending on the type and density of the phytoplankton population. From space, satellite sensors can distinguish even slight variations in colour which cannot be detected by the human eye.*

Measurement definition: *Former name: "Yellow substance absorbance". Parameter extracted from ocean colour observation. Indicative of biomass undergoing decomposition processes. Requested in both open ocean and coastal zone - Physical unit: [m-1] - Accuracy unit: [%] at a specific concentration (e.g., 1 m-1).*

CEOS Database entry for Color dissolved organic matter (CDOM): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=151

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/42

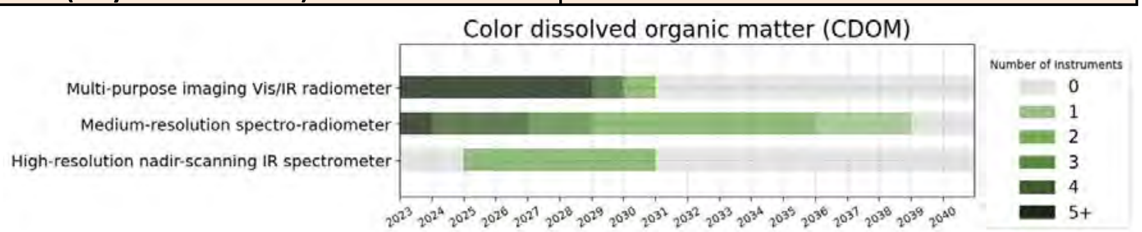
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the	Critical

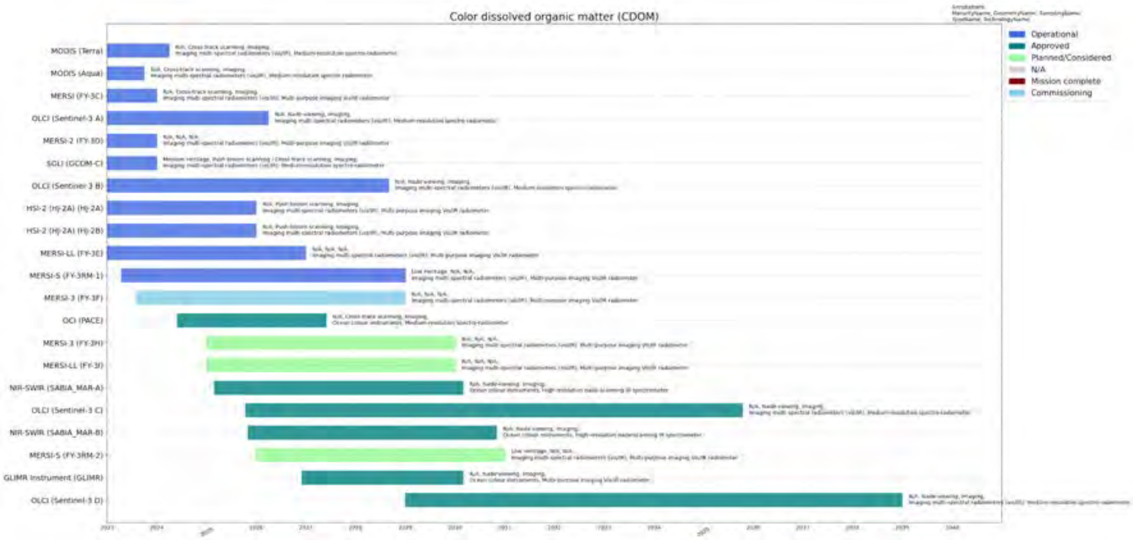
		carbon sink, including river runoff, upwelling and biological productivity?	
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	10
2031 (8 years from now)	2
2033 (10 years from now)	2
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Color dissolved organic matter (CDOM)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MERSI	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=893
MERSI-2	High Utility	FY-3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1620
NIR-SWIR	High Utility	SABIA_MAR-A, SABIA_MAR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1638
MERSI-S	High Utility	FY-3RM-2, FY-3RM-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1759
MERSI-3	High Utility	FY-3H, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1946
MERSI-LL	High Utility	FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1947
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896

		Sentinel-3 C, Sentinel-3 D	
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
OCI	General Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1597
GLIMR Instrument	General Utility	GLIMR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1902
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Sea Surface salinity

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean Salinity

Category description: *Ocean salinity measurements are important because surface salinity and temperature control the density and stability of the surface water. Thus, ocean mixing (of heat and gases) and water-mass formation processes are intimately related to variations of surface salinity. Ocean modelling and analysis of water mass mixing should be enabled by new knowledge of surface-density fields derived from surface salinity measurements. The importance of the ocean in the global hydrological cycle also cannot be overstated. Some ocean models show that sufficient surface freshening results in slowing down the meridional overturning circulation, thereby affecting the oceanic transport of heat.*

Measurement definition: *Salinity of seawater in the surface layer (upper ~ 1 m if observed in MW). In the open ocean the correct term should be "halinity" with reference of the diversity of salts involved - Measuring Units psu, Uncertainty Units psu*

CEOS Database entry for Sea Surface salinity: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=152

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/133

Related Candidate Science Questions

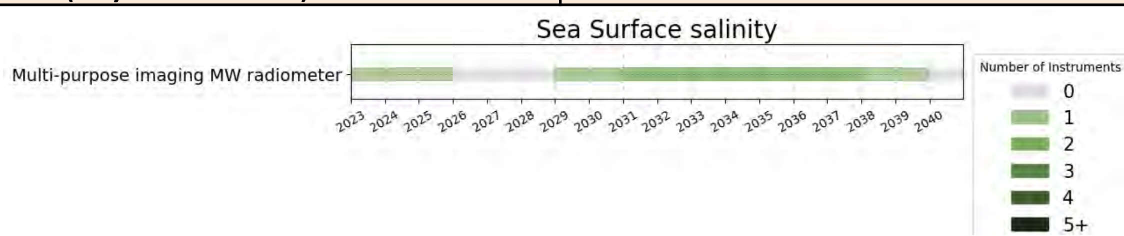
ID	CSQ	KAO	Priority Level
3-A	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	Can space-based measurements track changes in ocean uptake and removal of CO2 associated with changes in atmospheric CO2 concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° resolution over the globe.	Critical
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the carbon sink, including river runoff, upwelling and biological productivity?	Critical

5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Supporting
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Supporting
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Supporting
25-A	How does the cryosphere impact on Polar ecosystems, and how is the	Determine the impact of the cryosphere on Polar ecosystems, such as through	Supporting

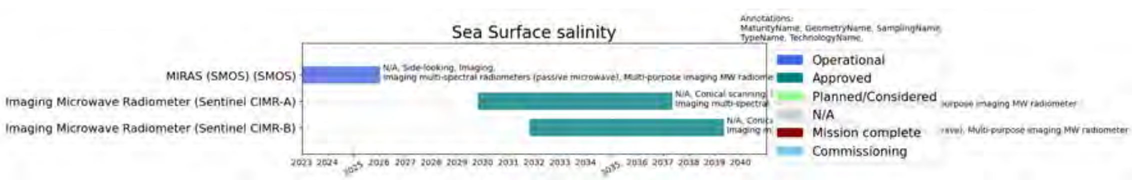
	changing climate altering these feedbacks?	freshwater input to the ocean	
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	1
2031 (8 years from now)	3
2033 (10 years from now)	3
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea Surface salinity

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MIRAS (SMOS)	General Utility	SMOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=689
Imaging Microwave Radiometer	General Utility	Sentinel CIMR-A, Sentinel CIMR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2014

Ocean surface currents (vector)

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean topography/currents

Category description: *Ocean surface topography data contain information that has significant practical applications in such fields as the study of worldwide weather and climate patterns, the monitoring of shoreline evolution and the protection of ocean fisheries. Ocean circulation is of critical importance to the Earth's climate system. Ocean currents transport a significant amount of energy from the tropics towards the poles, leading to a moderation of the climate at high latitudes. Circulation can be deduced from ocean surface topography, which may be readily measured using satellite altimetry.*

Measurement definition: *Water flow on ocean surface - Physical unit: [cm/s] - Accuracy unit: [cm/s] intended as vector error, i.e. the module of the vector difference between the observed vector and the true vector - Measuring Units cm/s, Uncertainty Units cm/s*

CEOS Database entry for Ocean surface currents (vector): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=153

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/116

Related Candidate Science Questions

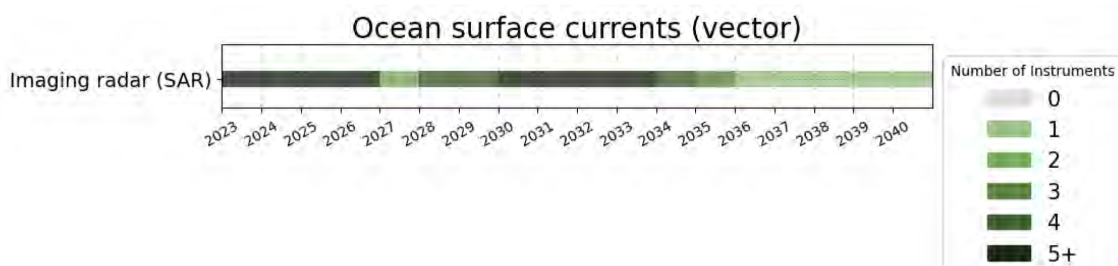
ID	CSQ	KAO	Priority Level
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Supporting
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Supporting
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical

7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
8-C	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in “Blue carbon” ecosystems, and their resilience to human and climate change pressures in different coastal regions	Supporting
8-D	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in permafrost in the polar coastal ocean, and its resilience to human and climate change pressures in different coastal regions	Supporting
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and	Thermodynamic coupling of the Earth’s surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and	Critical

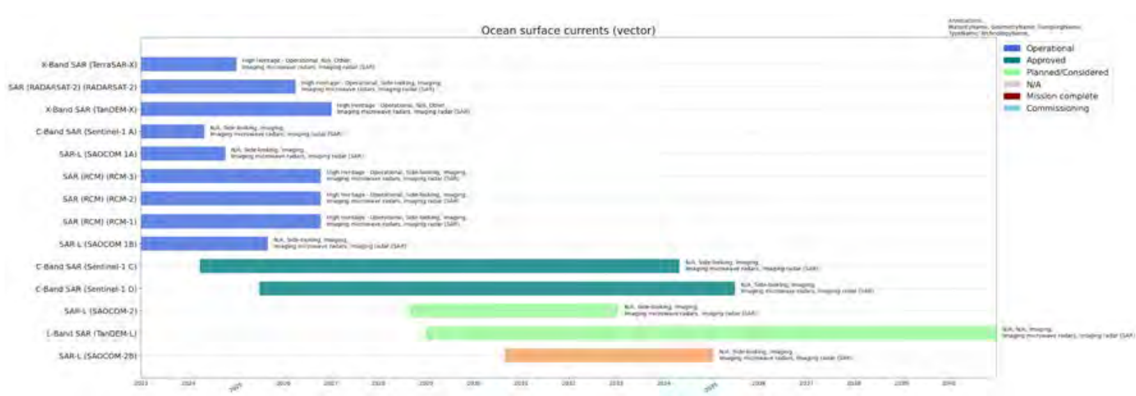
	monitoring on weather and climate patterns?	variations to allow for improved weather and climate predictability	
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	6
2031 (8 years from now)	7
2033 (10 years from now)	7
2038 (15 years from now)	3



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Ocean surface currents (vector)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939
SAR (RCM)	General Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
SAR-L	Potential Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
SAR (RADARSAT-2)	Marginal Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703

Sea-ice cover

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Sea ice cover, edge and thickness

Category description: *Sea ice variability is a key indicator of climate variability and change which is characterised by a number of parameters. In addition to monitoring ice extent (the total area covered by ice at any concentration) and concentration (the area covered by ice per unit area of ocean), it is necessary to know ice thickness in order to estimate sea ice volume or mass balance.*

Measurement definition: *Fraction of ice in an ocean area - Physical unit: [%] - Accuracy unit: [%].*

CEOS Database entry for Sea-ice cover: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=156

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/135

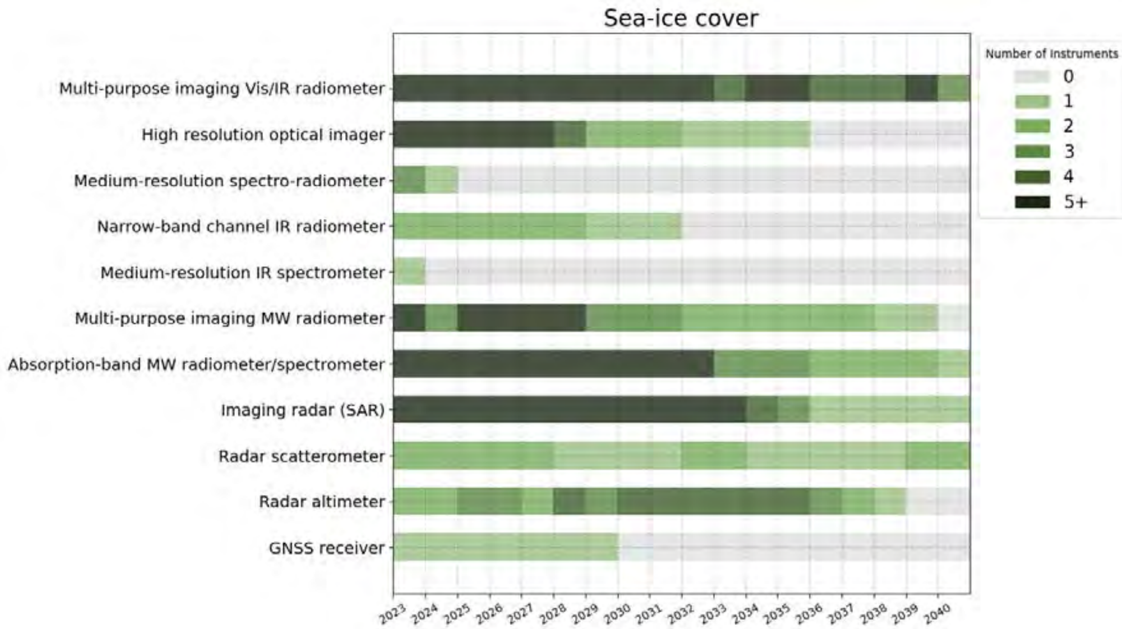
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Critical
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Critical
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Supporting
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical

25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting

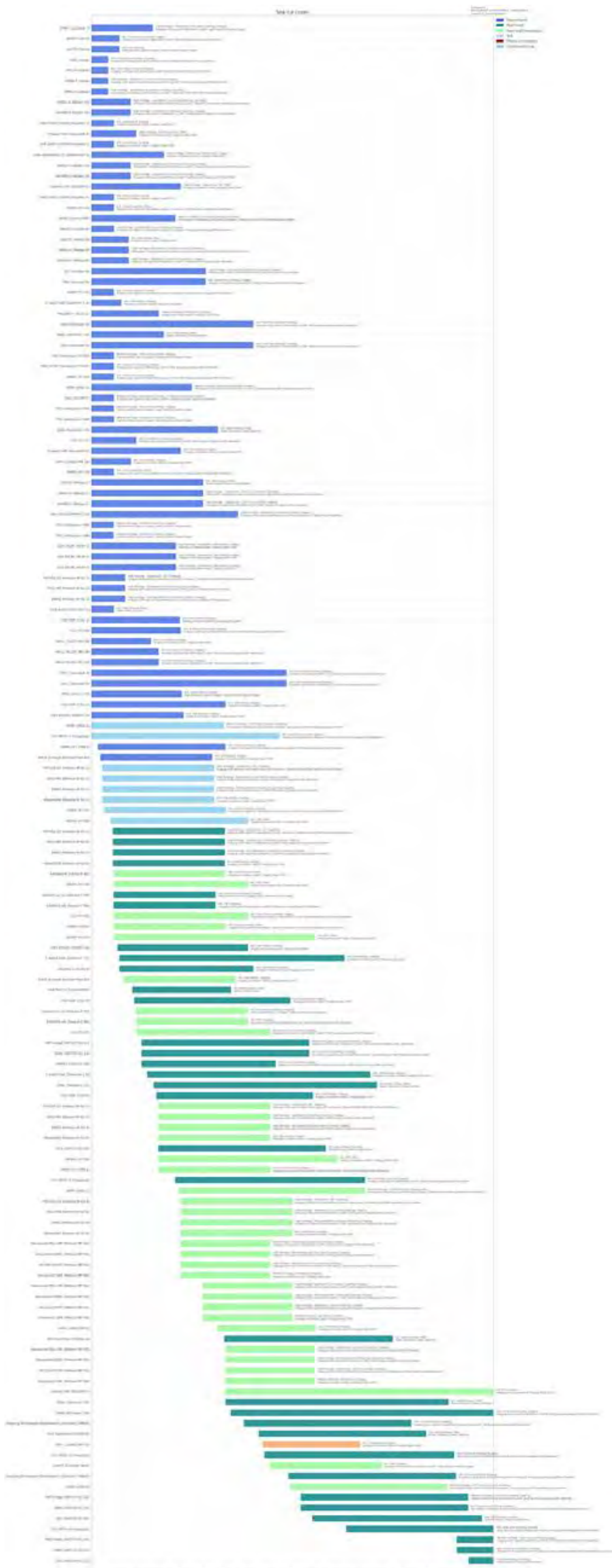
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	80
2031 (8 years from now)	62
2033 (10 years from now)	49
2038 (15 years from now)	37



Sea-ice cover
Multi-purpose imaging Vis/IR radiometer
High resolution optical imager
Medium-resolution spectro-radiometer
Narrow-band channel IR radiometer
Medium-resolution IR spectrometer
Multi-purpose imaging MW radiometer
Absorption-band MW radiometer/spectrometer
Imaging radar (SAR)
Radar scatterometer
Radar altimeter
GNSS receiver
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Number of instruments
0
1
2
3
4
5+

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea-ice cover

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ASCAT	High Utility	Metop-C, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=308
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
AIRS	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
MWRI	High Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
MTVZA-GY	High Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR 2000	High Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
KMSS	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=801

PSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V-IR N2, Kanopus-V N6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=834
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
CSG SAR	High Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
Advanced KMSS	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1565
MTVZA-GY-MP	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
Advanced SAR	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1569
SCA	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1631
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
KShMSA-SR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1693
BRLK S-range	High Utility	Kondor-FKA N1, Kondor-FKA N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1750
Kasatka-R	High Utility	Obzor-R N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1751

OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
S-band SAR	High Utility	NovaSAR-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1797
SGR-ReSI-Z	High Utility	HydroGNSS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1939
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
MeteoSAR	High Utility	Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2060
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
AMSR-E	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664
SAR-L	General Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
AMSR2	General Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939

AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
PALSAR-2	General Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
Geoton-L1 (2)	General Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1684
MSU-IK-SR	General Utility	Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1692
PALSAR-3	General Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
AMSR3	General Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804
Imaging Microwave Radiometer	General Utility	Sentinel CIMR-A, Sentinel CIMR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2014
IRIS	General Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
SGR-ReSI-C DHS	General Utility	DoT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2097
ATMS	Potential Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
SAR (RISAT)	Potential Utility	RISAT-1B, RISAT-1A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=790
TIRS	Potential Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
MWS	Potential Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1663
TIRS-2	Potential Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746

ASTER	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
MBEI	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=794
CZI	Marginal Utility	HY-1C, HY-1D, HY-1E, HY-1F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=828
MWRI	Marginal Utility	HY-2E, HY-2A, HY-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=967
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Sea-ice type

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Sea ice cover, edge and thickness

Category description: *Sea ice variability is a key indicator of climate variability and change which is characterised by a number of parameters. In addition to monitoring ice extent (the total area covered by ice at any concentration) and concentration (the area covered by ice per unit area of ocean), it is necessary to know ice thickness in order to estimate sea ice volume or mass balance.*

Measurement definition: *Parameter convolving several factors (age, roughness, density, etc.) - Accuracy expressed as number of classes. Actually [classes-1] is used, so that smaller figure corresponds to better performance, as usual.*

CEOS Database entry for Sea-ice type: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=157

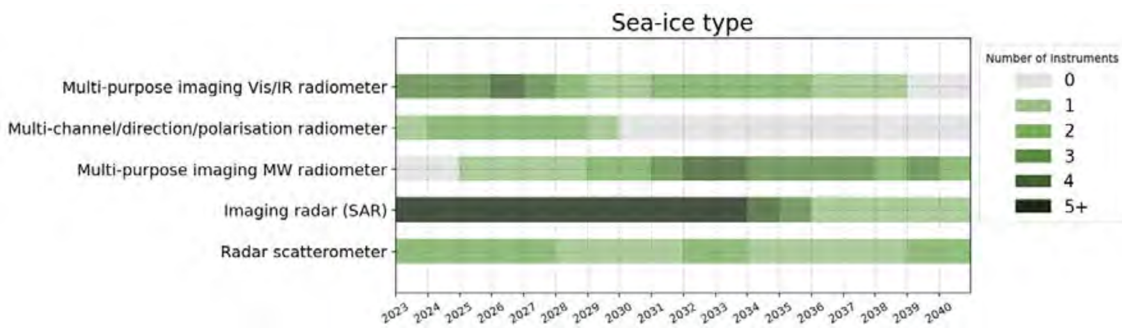
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/139

Related Candidate Science Questions

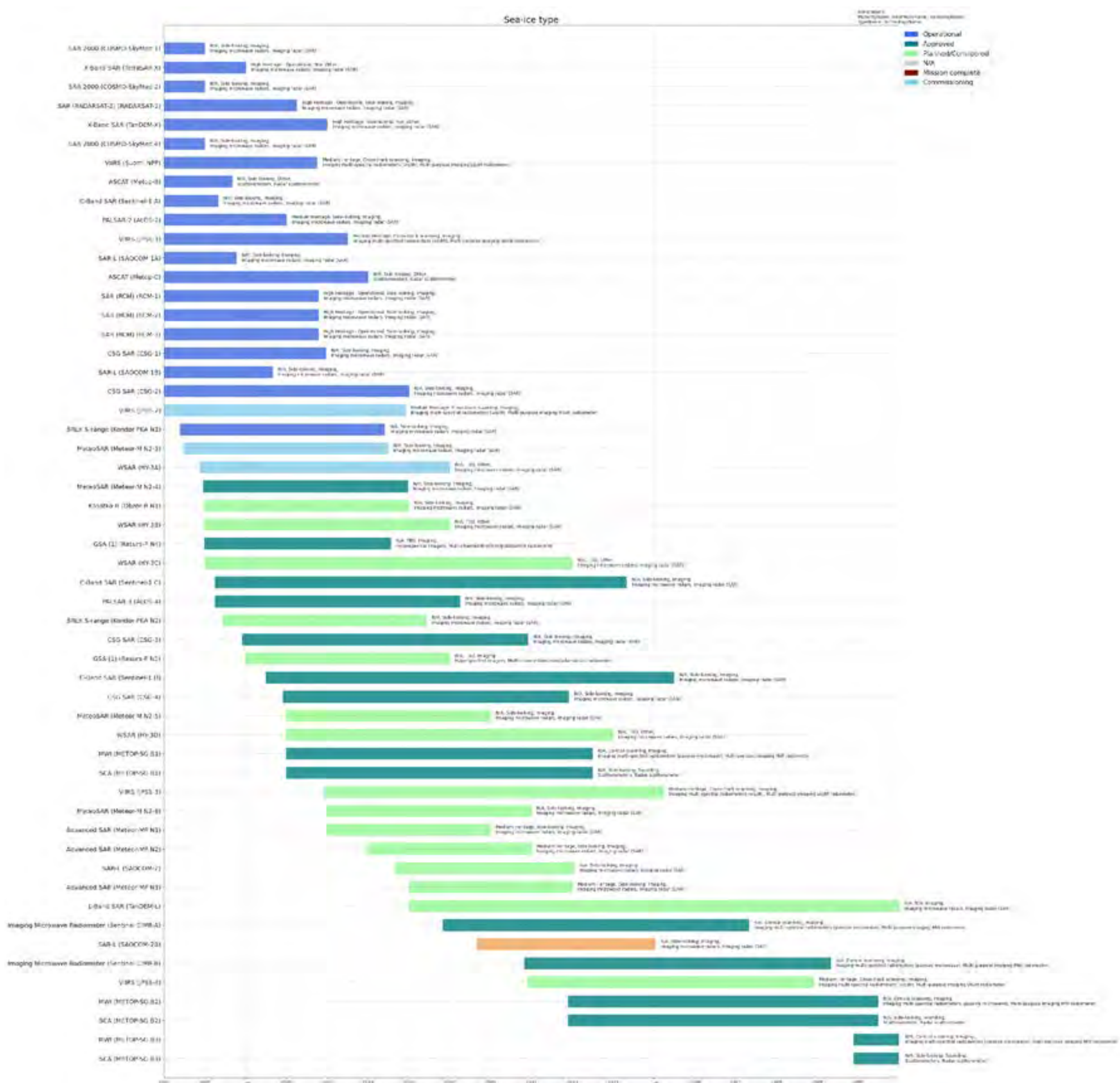
ID	CSQ	KAO	Priority Level
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Critical
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	26
2031 (8 years from now)	18
2033 (10 years from now)	14
2038 (15 years from now)	5



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea-ice type

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ASCAT	High Utility	Metop-C, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=308
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
Advanced SAR	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1569
SCA	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1631
BRLK S-range	High Utility	Kondor-FKA N1, Kondor-FKA N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1750
Kasatka-R	High Utility	Obzor-R N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1751
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
MeteoSAR	High Utility	Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2060
SAR 2000	General Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704
C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939
CSG SAR	General Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519

MWI	General Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
Imaging Microwave Radiometer	General Utility	Sentinel CIMR-A, Sentinel CIMR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2014
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
SAR-L	Potential Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
PALSAR-2	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
GSA (1)	Potential Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1686
PALSAR-3	Potential Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988

Sea-ice surface temperature

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Sea ice cover, edge and thickness

Category description: *Sea ice variability is a key indicator of climate variability and change which is characterised by a number of parameters. In addition to monitoring ice extent (the total area covered by ice at any concentration) and concentration (the area covered by ice per unit area of ocean), it is necessary to know ice thickness in order to estimate sea ice volume or mass balance.*

Measurement definition: *Temperature of the surface of sea-ice - Physical unit: [K] - Accuracy unit: [K].*

CEOS Database entry for Sea-ice surface temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=158

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/137

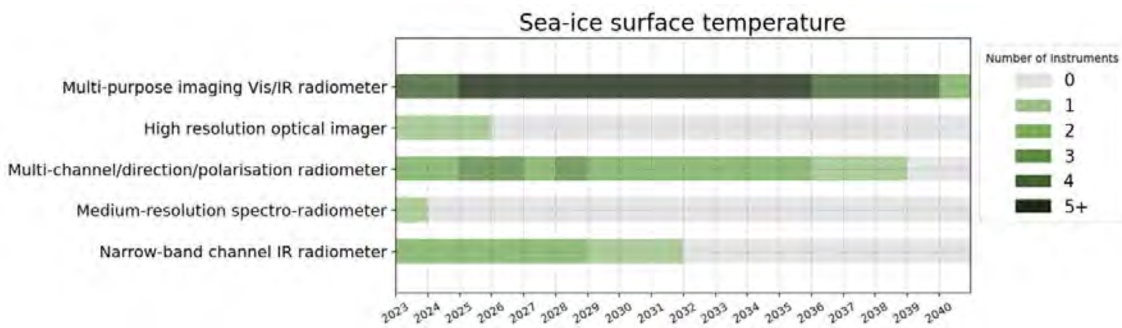
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Supporting
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Supporting

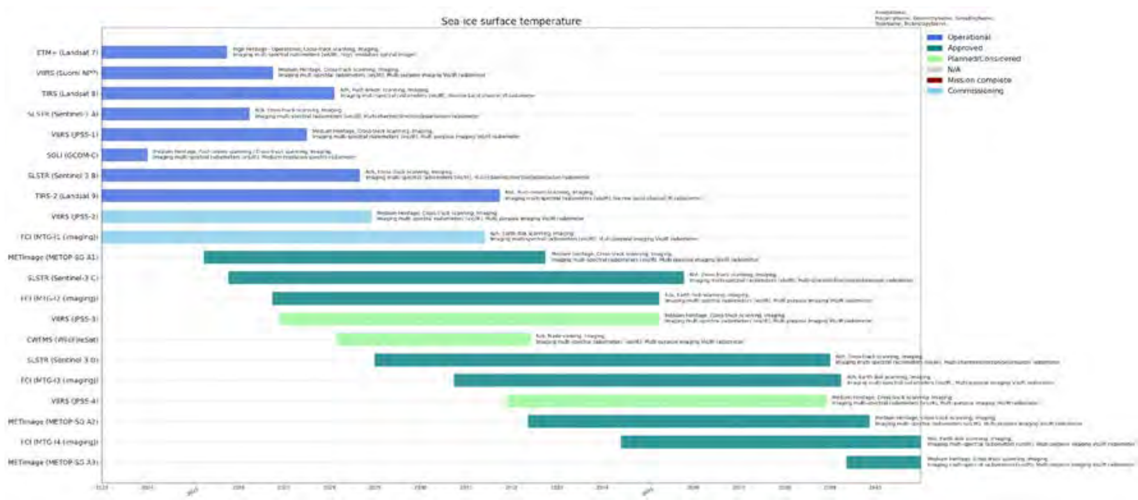
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	10
2031 (8 years from now)	10
2033 (10 years from now)	7
2038 (15 years from now)	5



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea-ice surface temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
TIRS	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
TIRS-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885

SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
SLSTR	General Utility	Sentinel-3 A, Sentinel-3 B, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=902
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
METimage	Potential Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
CWFMS	Potential Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853

Sea-ice sheet topography

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Ice sheet topography

Category description: *The state of the polar ice sheets and their volumes are both indicators and important parts of climate change processes and feedbacks. Consequently, it is important to monitor and study them in order to investigate the impact of global warming and to forecast future trends.*

Measurement definition: *Vertical projection of an area covered by ice sheets in meters.*

CEOS Database entry for Sea-ice sheet topography: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=159

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/136

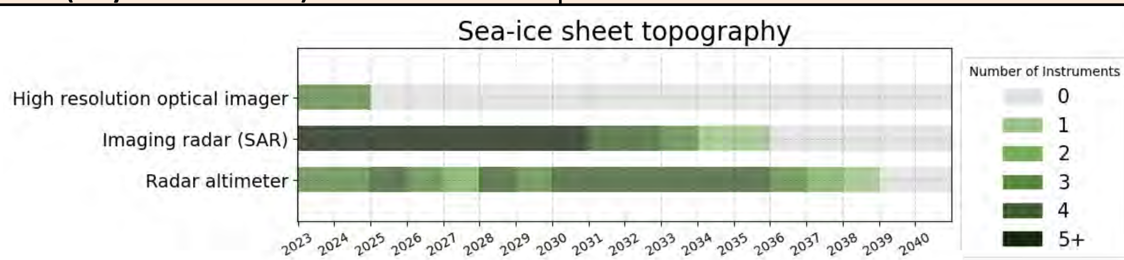
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Critical
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And	Global budget closure studies for the global energy	Supporting

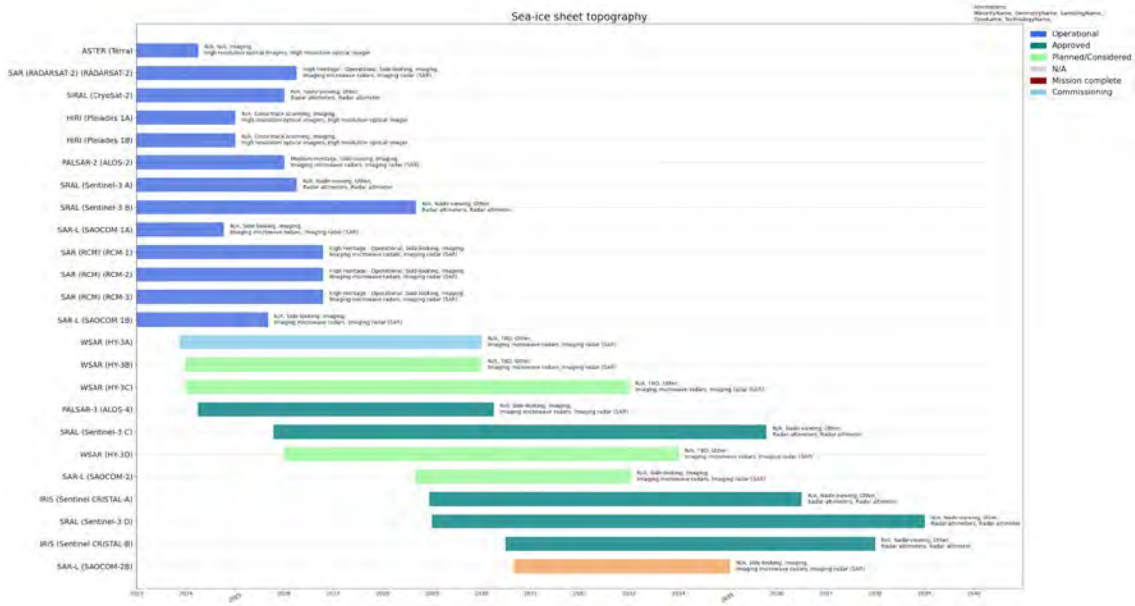
	what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	12
2031 (8 years from now)	11
2033 (10 years from now)	10
2038 (15 years from now)	4



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea-ice sheet topography

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
HiRI	High Utility	Pleiades 1A, Pleiades 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=887
SAR (RADARSAT-2)	General Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
SAR (RCM)	General Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
IRIS	General Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
SAR-L	Potential Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731

PALSAR-2	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
PALSAR-3	Potential Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
ASTER	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
SIRAL	Marginal Utility	CryoSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=688
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988

Snow cover

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Snow cover, edge and depth

Category description: *Regular measurements of terrestrial snow cover are important because snow dramatically influences surface albedo, thereby making a significant impact on the global climate, as well as influencing hydrological properties and the regulation of ecosystem biological activity. Snow forms a vital component of the water cycle. In order to make efficient use of meltwater runoff, resource agencies must be able to make early predictions of the amount of water stored in the form of snow. Snow cover information has a range of additional applications such as detecting areas of winterkill in agriculture that result from lack of snow cover to insulate plants from freezing temperatures. Locally, monitoring of snow parameters is important for meteorology and for enabling warnings of when melting is about to occur – which is crucial for hydrological research and for forecasting the risk of flooding.*

Measurement definition: *Fraction of snow in a given area - Physical unit: [%] - Accuracy unit: [%].*

CEOS Database entry for Snow cover: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=163

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/143

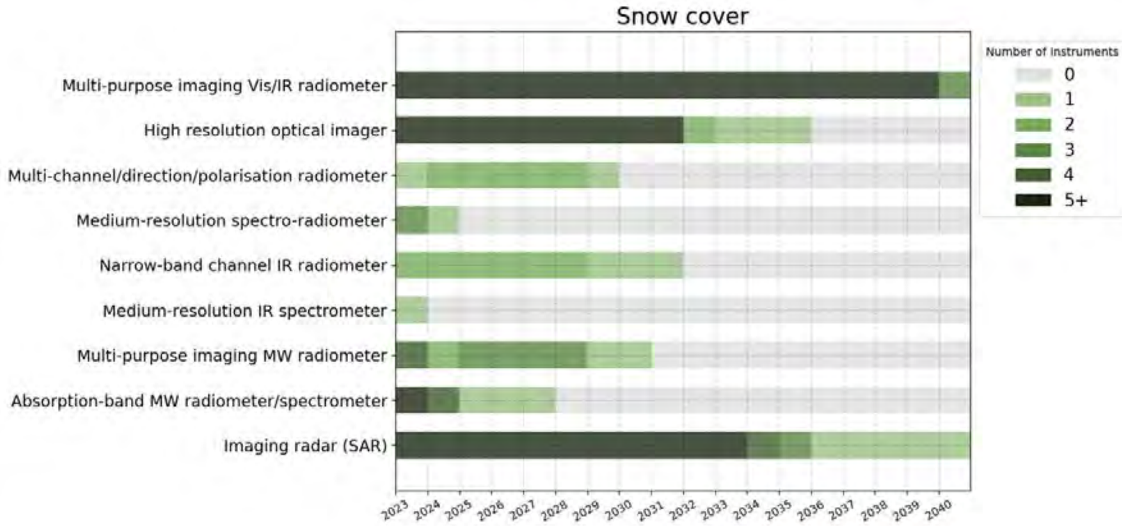
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Critical
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Critical

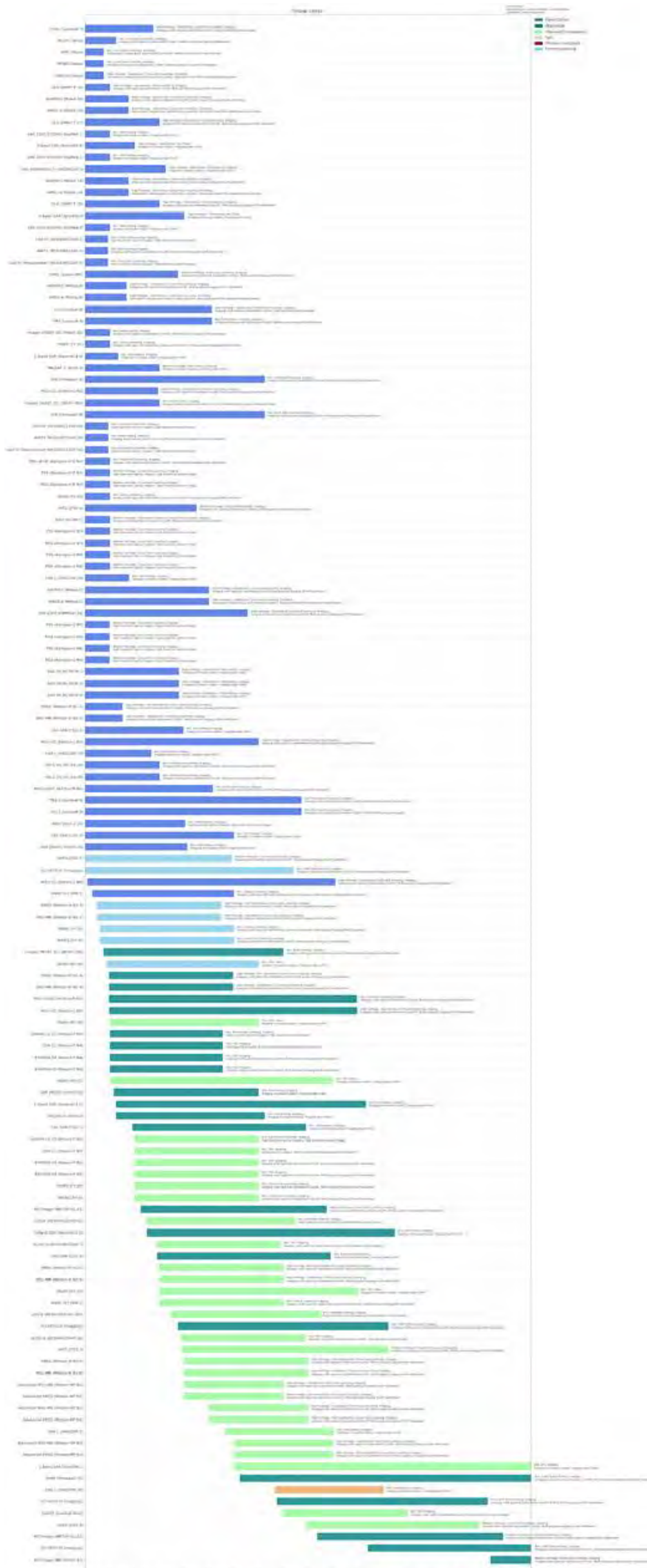
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	73
2031 (8 years from now)	47

2033 (10 years from now)	35
2038 (15 years from now)	25



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Snow cover

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
OLS	High Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=450
MWRI	High Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
KMSS	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=801
PSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V-IR N2, Kanopus-V N6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=834
MSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V N6, Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=835

OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
Advanced KMSS	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1565
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
KShMSA-SR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1693
KShMSA-VR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1694
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
SWIR	High Utility	TRISHNA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1808
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
AIRS	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395

SAR 2000	General Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704
SAR-L	General Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
ALISS III	General Utility	RESOURCESAT-3, RESOURCESAT-3A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=932
CSG SAR	General Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519
SAR-X	General Utility	RISAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1521
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
Geoton-L1 (2)	General Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1684
GSA (1)	General Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1686
MSU-IK-SR	General Utility	Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1692
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
SAR (RISAT)	Potential Utility	RISAT-1B, RISAT-1A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=790
C-Band SAR	Potential Utility	Sentinel-1 A, Sentinel-1 D,	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939

		Sentinel-1 B, Sentinel-1 C	
TIRS	Potential Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
PALSAR-2	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
TIRS-2	Potential Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
PALSAR-3	Potential Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
AWiFS	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=460
LISS-IV	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=461
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
SAR (RADARSAT-2)	Marginal Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
Imager (INSAT 3D)	Marginal Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=788
MBEI	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=794
LISS-III (Resourcesat)	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=934
SAR (RCM)	Marginal Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988
LISS-V	Marginal Utility	RESOURCESAT-3S, RESOURCESAT-3SA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1773
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Snow water equivalent

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Snow cover, edge and depth

Category description: *Regular measurements of terrestrial snow cover are important because snow dramatically influences surface albedo, thereby making a significant impact on the global climate, as well as influencing hydrological properties and the regulation of ecosystem biological activity. Snow forms a vital component of the water cycle. In order to make efficient use of meltwater runoff, resource agencies must be able to make early predictions of the amount of water stored in the form of snow. Snow cover information has a range of additional applications such as detecting areas of winterkill in agriculture that result from lack of snow cover to insulate plants from freezing temperatures. Locally, monitoring of snow parameters is important for meteorology and for enabling warnings of when melting is about to occur – which is crucial for hydrological research and for forecasting the risk of flooding.*

Measurement definition: *Total-column water if snow is reduced to liquid. Linked to snow depth through assumptions or observation on density - Physical unit: [mm] - Accuracy unit: [mm].*

CEOS Database entry for Snow water equivalent: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=165

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/145

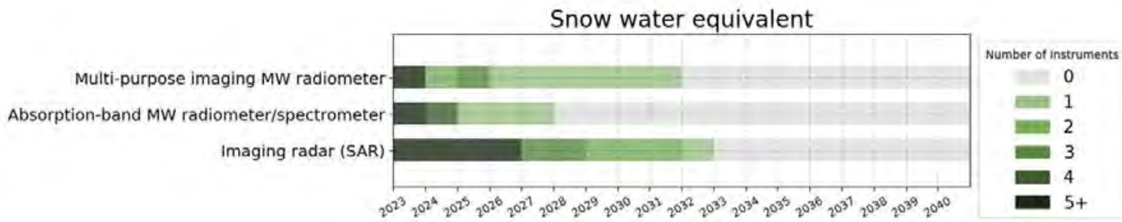
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Critical
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Critical

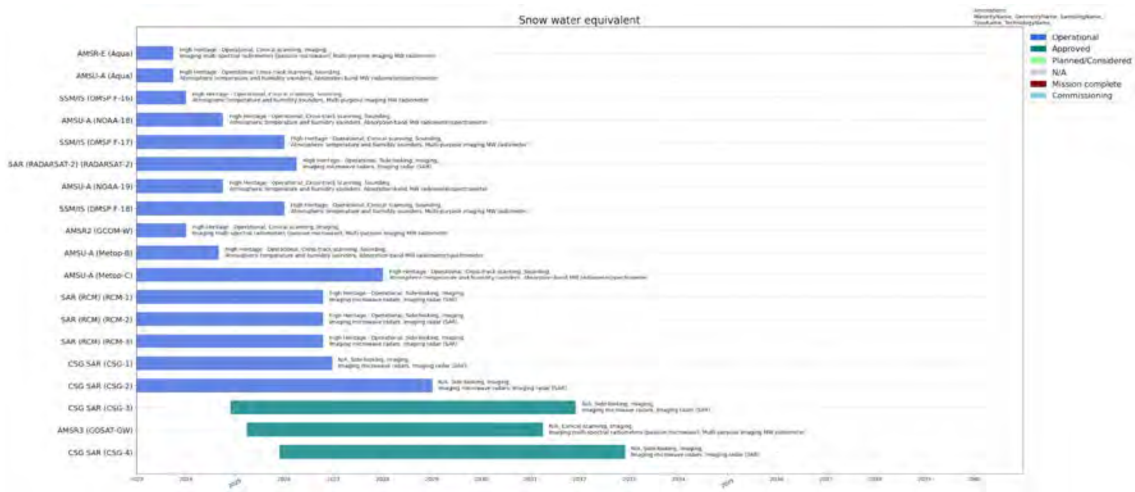
Heat Map Timeline

Year	Number of predicted operational instruments

2028 (5 years from now)	4
2031 (8 years from now)	3
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Snow water equivalent

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
AMSR-E	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=664
AMSR2	General Utility	GCOM-W	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=883

AMSR3	General Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1804
SSM/IS	Potential Utility	DMSP F-17, DMSP F-18, DMSP F-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=454
SAR (RADARSAT-2)	Marginal Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR (RCM)	Marginal Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
CSG SAR	Marginal Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519

Glacier motion

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Sea ice cover, edge and thickness

Category description: *Sea ice variability is a key indicator of climate variability and change which is characterised by a number of parameters. In addition to monitoring ice extent (the total area covered by ice at any concentration) and concentration (the area covered by ice per unit area of ocean), it is necessary to know ice thickness in order to estimate sea ice volume or mass balance.*

Measurement definition: *Variation of glacier boundary in a specific direction. [Unit of measurement -m/y]*

CEOS Database entry for Glacier motion: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=167

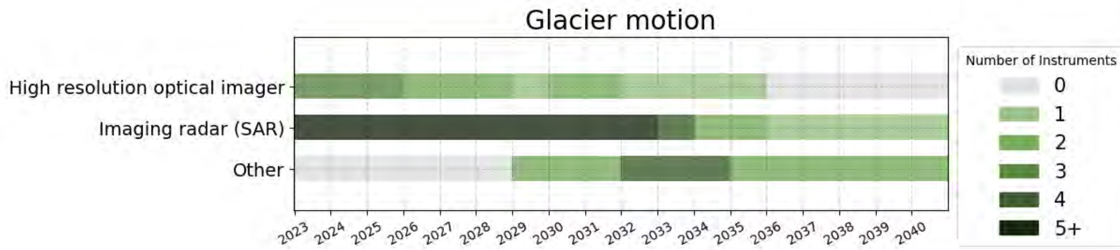
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/70

Related Candidate Science Questions

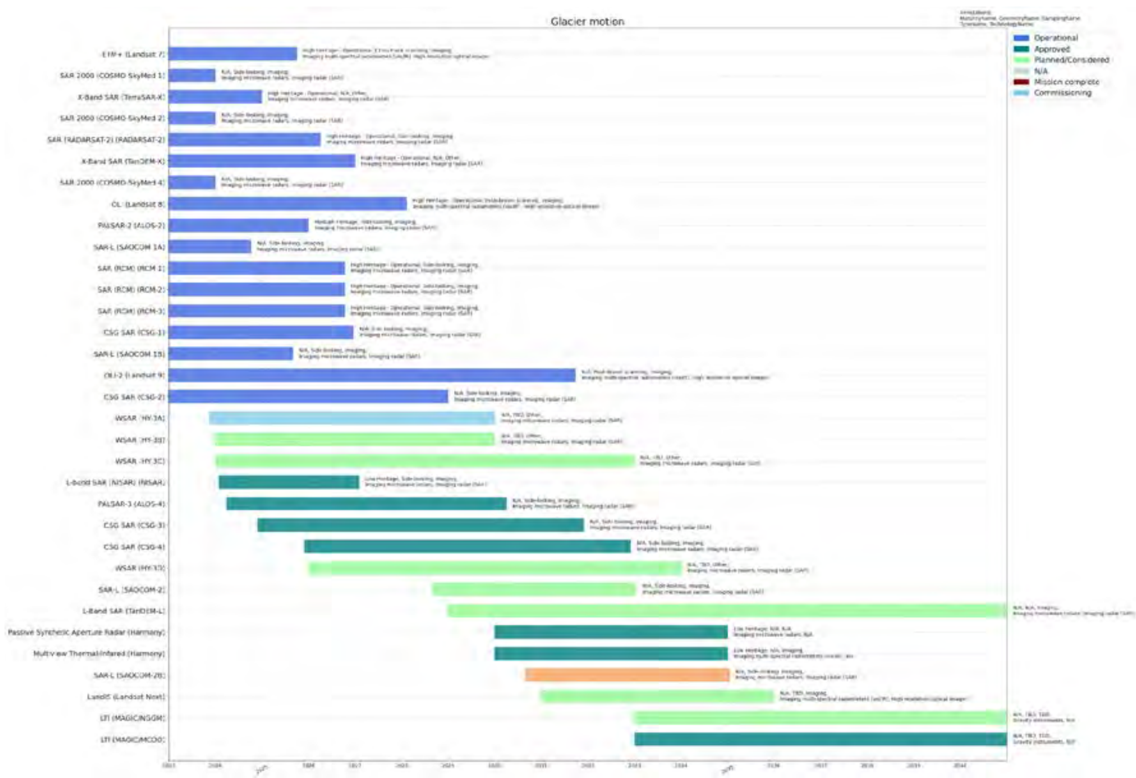
ID	CSQ	KAO	Priority Level
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Critical
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	14
2031 (8 years from now)	12
2033 (10 years from now)	10
2038 (15 years from now)	6



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Glacier motion

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR 2000	High Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704

SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
CSG SAR	High Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519
L-band SAR (NISAR)	High Utility	NISAR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1526
PALSAR-2	High Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
PALSAR-3	High Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
ETM+	General Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
SAR-L	General Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
OLI	General Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
OLI-2	General Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
LandIS	General Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
Passive Synthetic Aperture Radar	General Utility	Harmony	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2020
Multiview Thermal-Infared	General Utility	Harmony	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2021
LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988

Glacier topography

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Multi-purpose imagery (land)

Category description: *The spatial information that can be derived from satellite imagery is of value in a wide range of applications, particularly when combined with spectral information from multiple wavebands of a sensor. Satellite Earth observation is of particular value where conventional data collection techniques are difficult, such as in areas of inaccessible terrain, providing cost and time savings in data acquisition – particularly over large areas. At regional and global scales, low resolution instruments with wide coverage capability and imaging sensors on geostationary satellites are routinely exploited for their ability to provide global data on land cover and vegetation.*

Measurement definition: *Relates to glacier thickness typically found in mid to high latitudes with a volume/area coverage much smaller than an ice-sheet. [Unit of measurement - cm]*

CEOS Database entry for Glacier topography: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=168

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/71

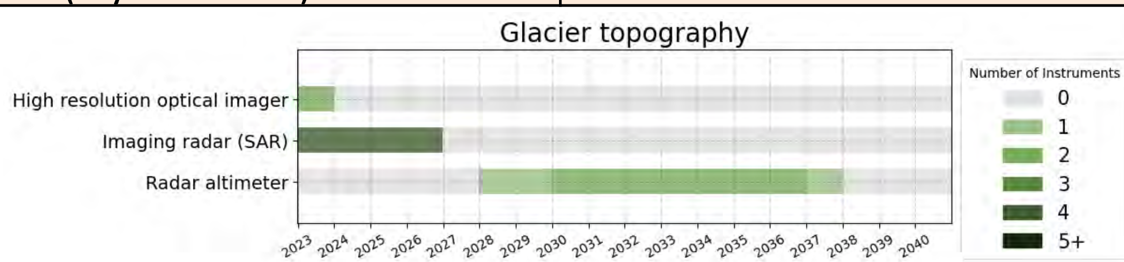
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
33-A	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the long-term GIA signal of the Pleistocene deglaciation in ice sheet elevation and gravity field in regions of present-day ice caps melting, and separate it from contributions reflecting ice sheet imbalance and from GIA responses to the Little Ice Age	Critical
33-B	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the solid Earth visco-elastic response to recent or contemporary ice mass change in glaciated regions associated with low mantle viscosity, such as active plate boundaries	Critical

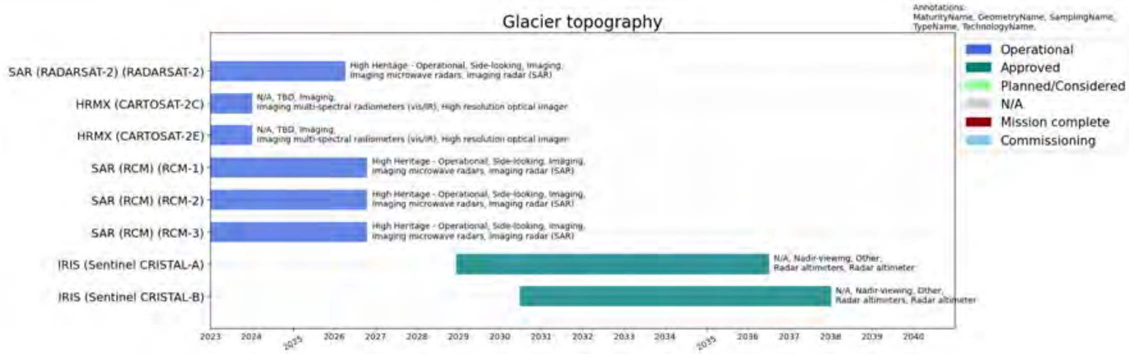
33-C	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Constrain the radial and lateral viscosity structure of the mantle (including in particular low viscosity layers and lateral variations between cratonic and oceanic areas or along hotspot tracks), from data-driven GIA models integrating a broad range of data types. In these models, describe the trade-offs between mantle structure and spatio-temporal evolution of the past ice load	Critical
38-A	How does Earth's crust evolve in interaction with internal geodynamic processes, and how does this reshape the Earth's surface over the long-term ?	Quantify the long-term, present-day changes in Earth's surface and Moho topography due to processes of creation, evolution and destruction of Earth's crust : mountain building, long-term plate subduction, oceanic spreading, extensional tectonics	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	3
2031 (8 years from now)	4
2033 (10 years from now)	4
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Glacier topography

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
HRMX	High Utility	CARTOSAT-2E, CARTOSAT-2C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1603
IRIS	General Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
SAR (RADARSAT-2)	Potential Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR (RCM)	Potential Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946

Land surface temperature

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Surface temperature (land)

Category description: *Land surface temperature varies widely with solar radiation. It is of help in interpreting vegetation and its water stress when the range of temperatures between day and night and from clear sky to cloud cover are compared. On a local scale, surface temperature imagery may be used to refine techniques for predicting ground frost and to determine the warming effect of urban areas (urban heat islands) on night-time temperatures. In agriculture, temperature information may be used, together with models, to optimise planting times and provide timely warnings of frost. Measurements of surface temperature patterns may also be used in studies of volcanic and geothermal areas and resource exploration.*

Measurement definition: *Temperature of the apparent surface of land (bare soil or vegetation) - Physical unit: [K] - Accuracy unit: [K].*

CEOS Database entry for Land surface temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=170

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/96

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Supporting
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America	Supporting

		and Eurasia and identify human activities and climate variations driving these changes	
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Supporting
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Supporting
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Supporting
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Supporting
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales.	Supporting

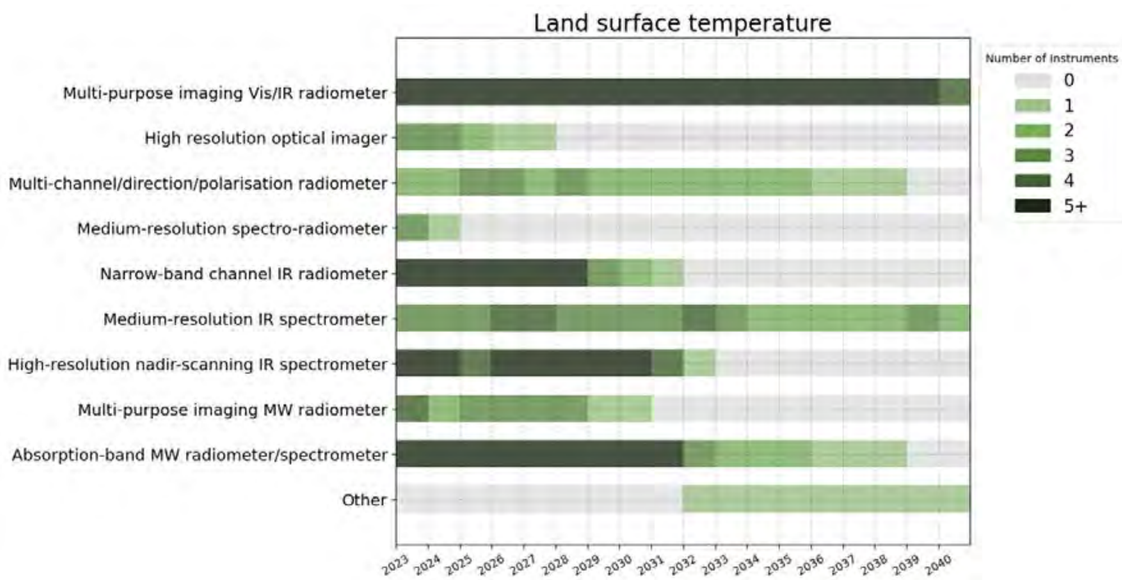
		1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Supporting
43-D	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	4). Quantify land-atmosphere interactions: What are the role of land surface-atmospheric interactions in the water, energy and carbon budgets across spatiotemporal scales?	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing,	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing,	Supporting

	Earth's surface temperature response and climate sensitivity, as well as	surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting

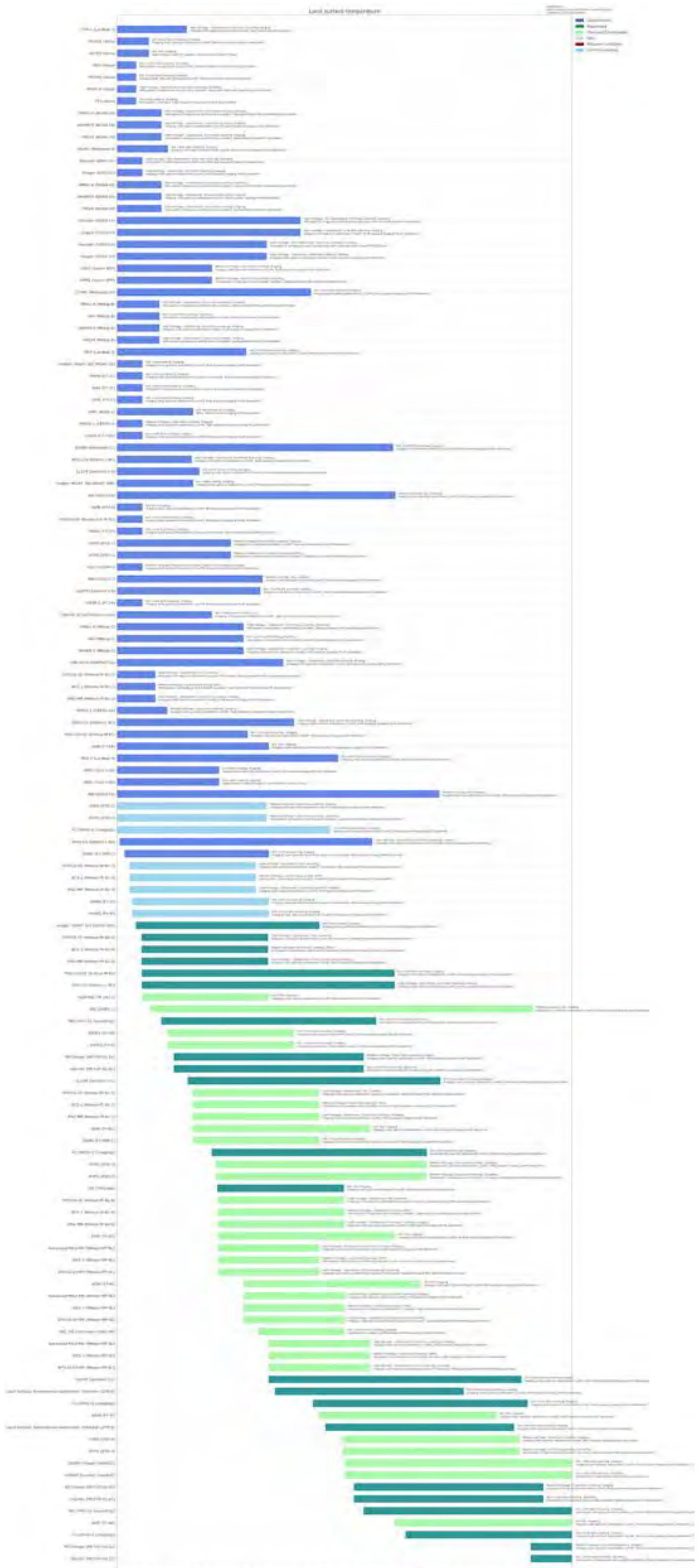
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	70
2031 (8 years from now)	44
2033 (10 years from now)	35
2038 (15 years from now)	23



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Land surface temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
AMSU-A	High Utility	NOAA-18, Metop-C, NOAA-19, Metop-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=312
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
ASTER	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
IRAS	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=666
VIRR	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=684
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
Imager (INSAT 3D)	High Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=788
IRS	High Utility	MTG-S1 (sounding), MTG-S2 (sounding)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=950
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965

TIRS	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
AMSU-A	High Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1555
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
IASI-NG	High Utility	METOP-SG A1, METOP-SG A2, METOP-SG A3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1626
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
TIRS-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
TIR	High Utility	TRISHNA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1810
Land Surface Temperature Radiometer	High Utility	Sentinel LSTM-A, Sentinel LSTM-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2031
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
GEOXO Sounder	High Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2049
SEVIRI	General Utility	Meteosat-9, Meteosat-10, Meteosat-11	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=302
IASI	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
AIRS	General Utility	Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=347
TES	General Utility	Aura	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=349
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395

IKFS-2	General Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=778
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging), MTG-I2 (imaging), MTG-I3 (imaging)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
SLSTR	General Utility	Sentinel-3 A, Sentinel-3 B, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=902
IKFS-3	General Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1566
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
MSU-IK-SR	General Utility	Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1692
PHyTIR	General Utility	ECOSTRESS-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1714
SBG TIR Instrument	General Utility	SBG-TIR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1942
PLATiNO TIR	General Utility	PLT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2039
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
ATMS	Potential Utility	JPSS-4, JPSS-1, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=413
HIRS/4	Potential Utility	NOAA-19, Metop-B, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=564

MTVZA-GY	Potential Utility	Meteor-M N2-2, Meteor-M N2-5, Meteor-M N2-3, Meteor-M N2-6, Meteor-M N2-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=673
MTVZA-GY-MP	Potential Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1567
CIRC	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1666
Sounder	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=330
Imager	Marginal Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
MWRI	Marginal Utility	FY-3F, FY-3RM-2, FY-3RM-1, FY-3D, FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=672
MBEI	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=794
MIRS	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=795
IRMSS-2	Marginal Utility	CBERS-4, CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=866
AGRI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=892
HyperScout-2	Marginal Utility	Federated Satellite Systems	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1891
Phisat-1	Marginal Utility	Federated Satellite Systems	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2101

Normalized Differential Vegetation Index (NDVI)

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *Difference between maximum (in NIR) and minimum (around the Red) vegetation reflectance, normalised to the summation. Representative of total biomass, supportive for computing LAI if not directly measured - Physical unit: [%] - Accuracy unit: [%].*

CEOS Database entry for Normalized Differential Vegetation Index (NDVI): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=172

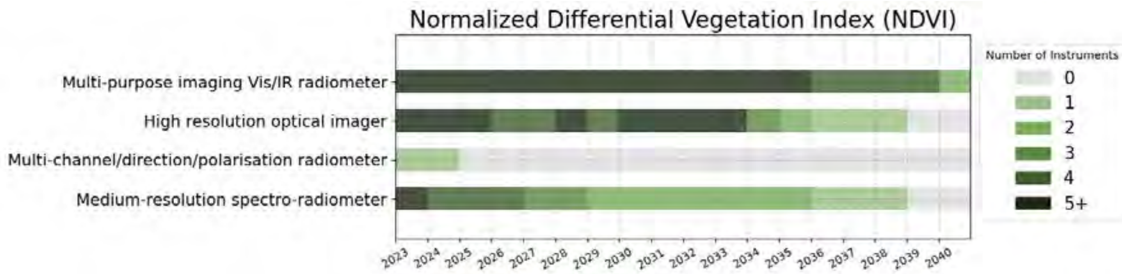
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/107

Related Candidate Science Questions

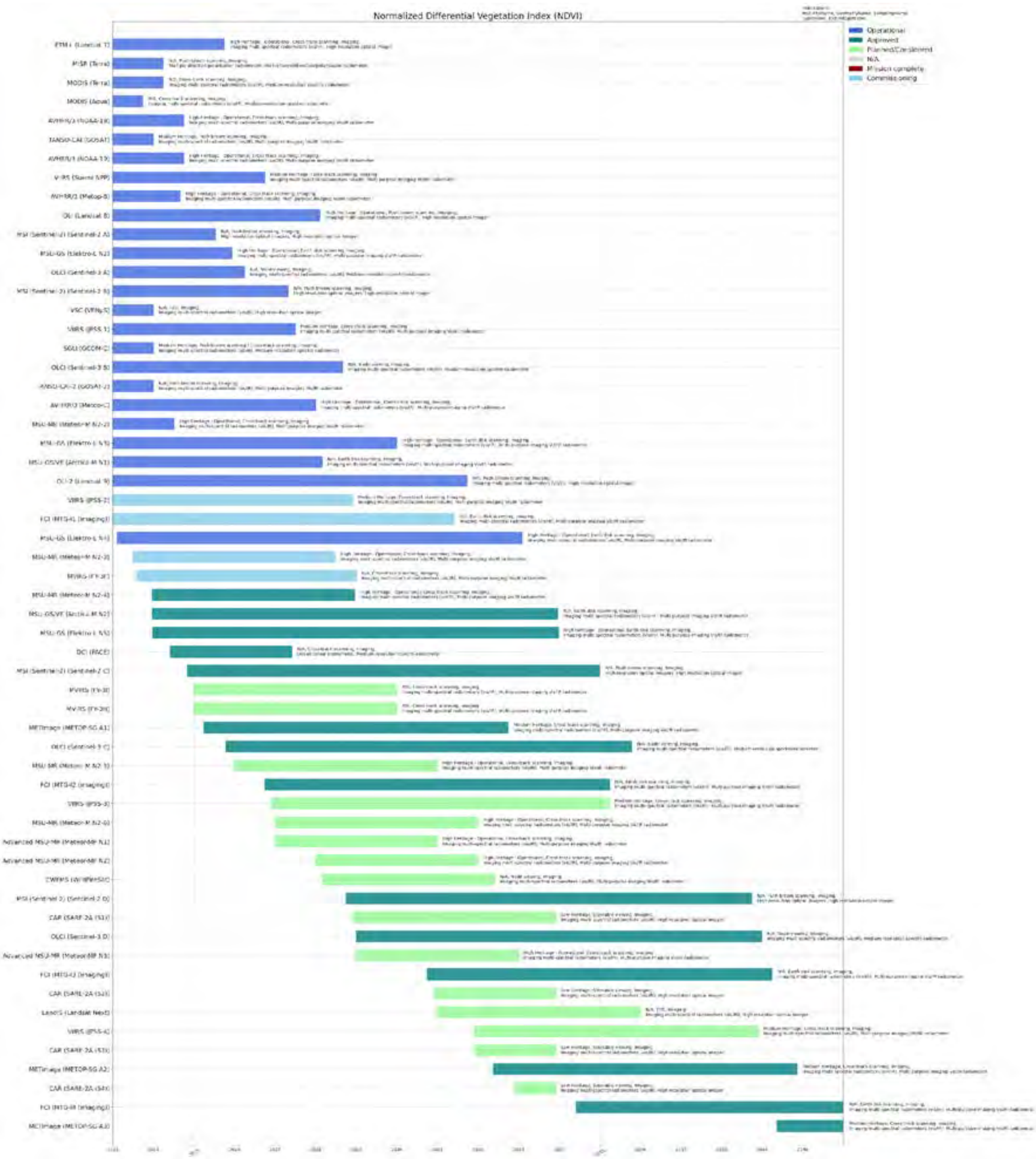
ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	30
2031 (8 years from now)	25
2033 (10 years from now)	20
2038 (15 years from now)	10



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Normalized Differential Vegetation Index (NDVI)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322

MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
VSC	High Utility	VENμS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=966
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
CAR	High Utility	SARE-2A (S2), SARE-2A (S1), SARE-2A (S3), SARE-2A (S4)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1762
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging),	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885

		MTG-I2 (imaging), MTG-I3 (imaging)	
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MSI (Sentinel-2)	General Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
OCI	General Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1597
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
TANSO-CAI	Potential Utility	GOSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=904
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
TANSO-CAI-2	Potential Utility	GOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1654
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671

Leaf Area Index (LAI)

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *LAI is the total one-sided area of photosynthetic tissue per unit ground surface area - Physical unit [%], Accuracy unit [%]*

CEOS Database entry for Leaf Area Index (LAI): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=173

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/98

Related Candidate Science Questions

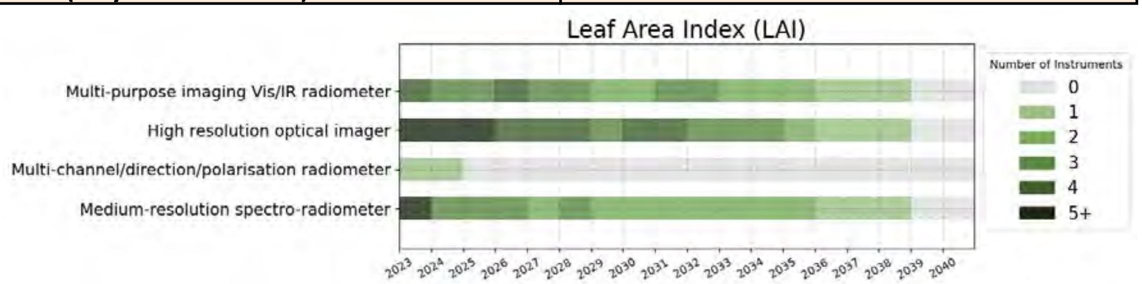
ID	CSQ	KAO	Priority Level
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are	Supporting

		the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	
44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting

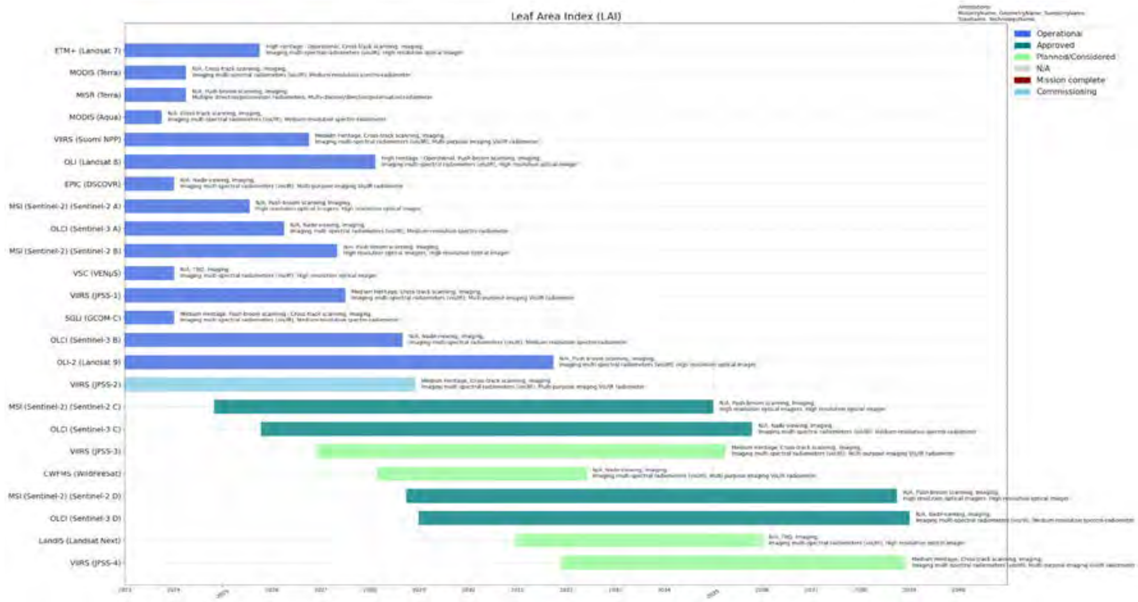
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	9
2031 (8 years from now)	9
2033 (10 years from now)	7
2038 (15 years from now)	3



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Leaf Area Index (LAI)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
VSC	High Utility	VENµS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=966
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395

OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MSI (Sentinel-2)	General Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
EPIC	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1615
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634

Fraction of Absorbed PAR (FAPAR)

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Albedo and reflectance

Category description: *Albedo is the fraction of solar energy that is diffusely reflected back from Earth to space. Measurements of albedo are essential for climate research studies and investigations of the Earth's energy budget. Different parts of the Earth have different albedos. For example, ocean surfaces and rain forests have low albedos, which means that they reflect only a small portion of the Sun's energy. Deserts, ice and clouds, however, have high albedos; they reflect a large portion of the incoming solar energy. The high albedo of ice helps to insulate the polar oceans from solar radiation.*

Measurement definition: *Fraction of PAR absorbed by vegetation (land or marine) for photosynthesis processes (generally around the "red") - Physical unit [%], Accuracy unit [%]*

CEOS Database entry for Fraction of Absorbed PAR (FAPAR): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=175

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/65

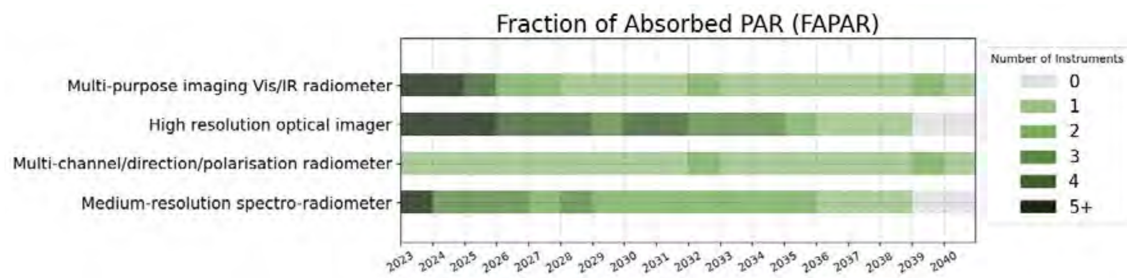
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales.	Supporting

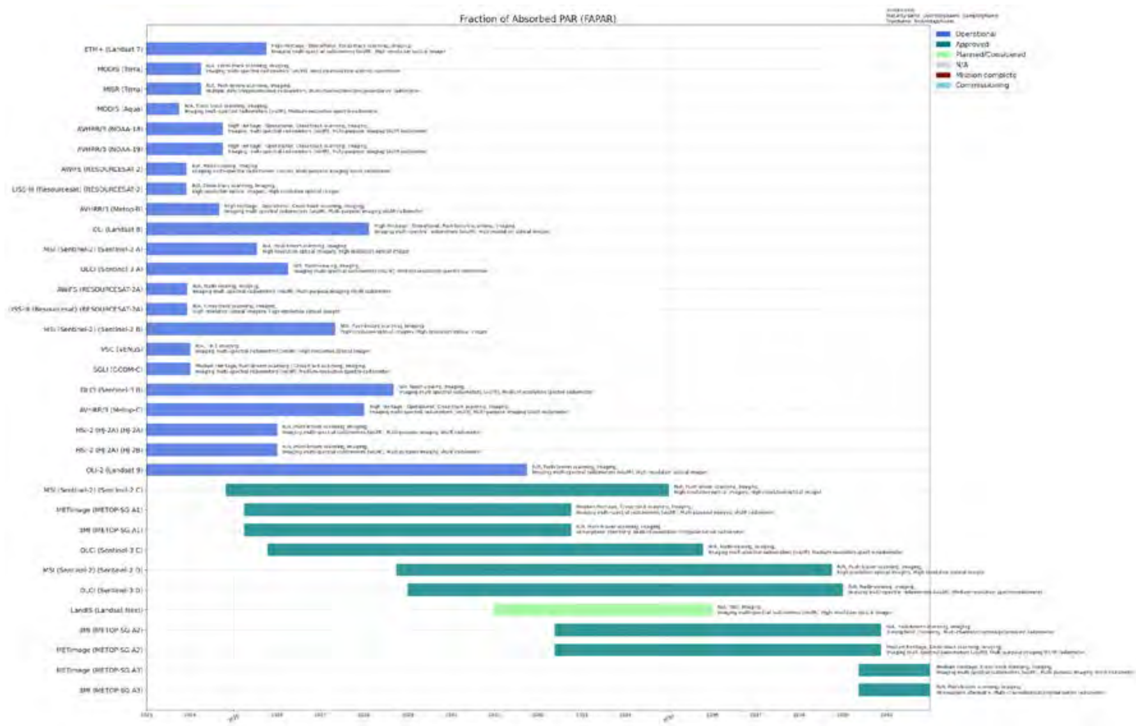
		1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	Supporting
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	8
2031 (8 years from now)	8
2033 (10 years from now)	7
2038 (15 years from now)	4



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Fraction of Absorbed PAR (FAPAR)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
MODIS	High Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396

OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
VSC	High Utility	VENµS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=966
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
MSI (Sentinel-2)	General Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
HSI-2 (HJ-2A)	General Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909
AVHRR/3	Marginal Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
AWiFS	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=460
LISS-III (Resourcesat)	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=934
METimage	Marginal Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
3MI	Marginal Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1627

Fire fractional cover

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Multi-purpose imagery (land)

Category description: *The spatial information that can be derived from satellite imagery is of value in a wide range of applications, particularly when combined with spectral information from multiple wavebands of a sensor. Satellite Earth observation is of particular value where conventional data collection techniques are difficult, such as in areas of inaccessible terrain, providing cost and time savings in data acquisition – particularly over large areas. At regional and global scales, low resolution instruments with wide coverage capability and imaging sensors on geostationary satellites are routinely exploited for their ability to provide global data on land cover and vegetation.*

Measurement definition: *Fraction of a land area where fire is occurring - Physical unit [%], Accuracy unit [%]*

CEOS Database entry for Fire fractional cover: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=177

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/60

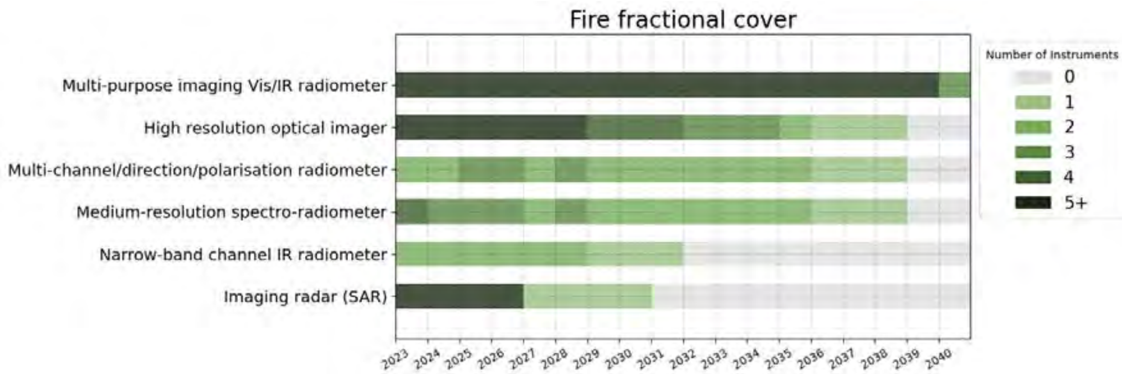
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-B	What anthropogenic and natural processes are driving the global carbon cycle?	Distinguish intense anthropogenic CO2 and CH4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	Supporting
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Supporting

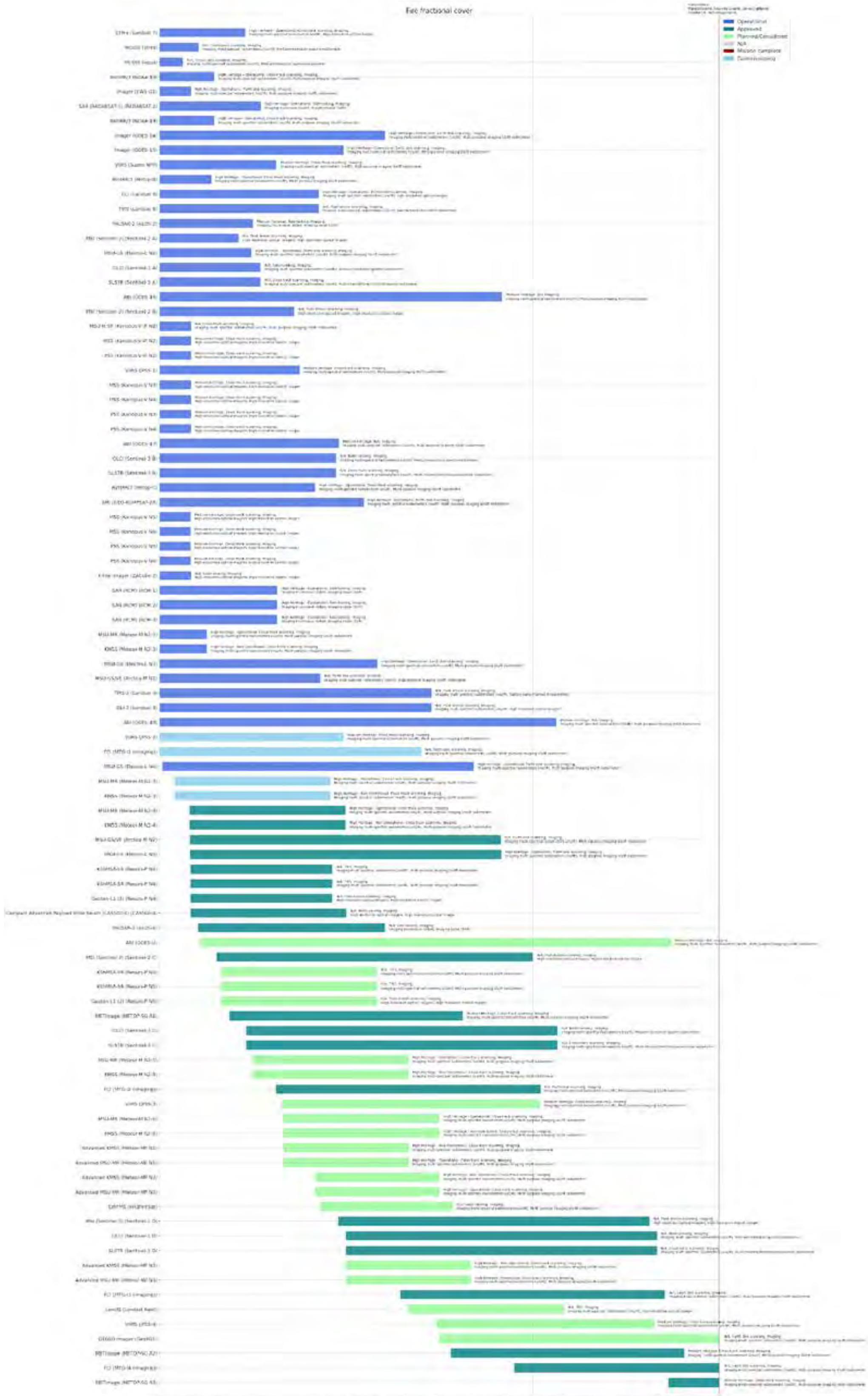
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Critical
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Critical
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	Supporting
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	49
2031 (8 years from now)	30
2033 (10 years from now)	21
2038 (15 years from now)	11



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Fire fractional cover

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
Imager	High Utility	GOES-14, EWS-G1, GOES-15	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=331
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
MSU-GS	High Utility	Elektro-L N2, Elektro-L N3, Elektro-L N4, Elektro-L N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=784
KMSS	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=801
PSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V-IR N2, Kanopus-V N6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=834
MSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V N6, Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=835
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897

SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
Advanced KMSS	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1565
Geoton-L1 (2)	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1684
MSU-GS/VE	High Utility	Arctica-M N2, Arctica-M N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1691
KShMSA-SR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1693
KShMSA-VR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1694
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
Compact Advanced Payload Wide Swath (CAS500-4)	High Utility	CAS500-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1991
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
GEOXO Imager	High Utility	GeoXO1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2045
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
ABI	General Utility	GOES-17, GOES-18, GOES-U, GOES-16	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=870
FCI	General Utility	MTG-I4 (imaging), MTG-I1 (imaging),	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=885

		MTG-I2 (imaging), MTG-I3 (imaging)	
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
SLSTR	General Utility	Sentinel-3 A, Sentinel-3 B, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=902
MSI (Sentinel-2)	General Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
AMI	General Utility	GEO-KOMPSAT-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
MSU-IK-SR	General Utility	Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1692
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
K-line Imager	General Utility	ZACube-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1884
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
TIRS	Potential Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
PALSAR-2	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
TIRS-2	Potential Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
PALSAR-3	Potential Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803

Land cover

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *Processed from land surface imagery by assigning identified cluster(s) within a given area to specific classes of objects - Accuracy expressed as number of classes. Actually [classes-1] is used, so that smaller figure corresponds to better performance, as usual - Physical unit [Classes], Accuracy unit [Classes-1]*

CEOS Database entry for Land cover: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=179

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/95

Related Candidate Science Questions

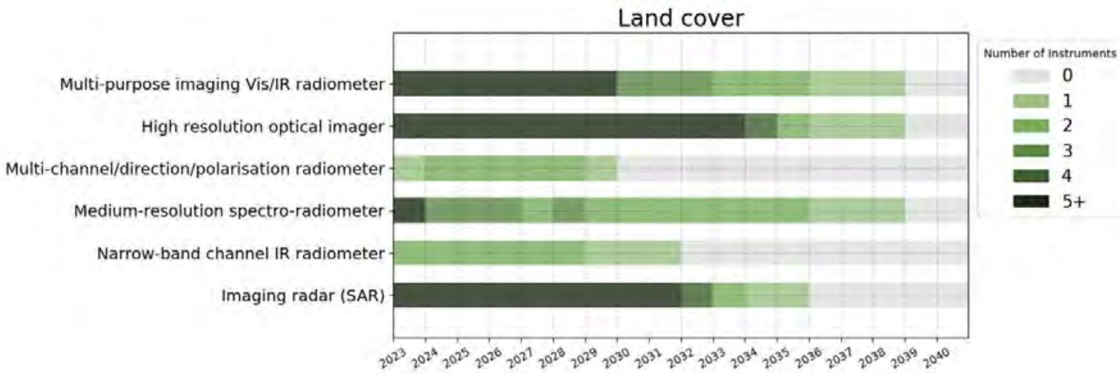
ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and	Critical

		climate variations driving these changes	
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Critical
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Critical
44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And	Study the impact and causality of impacts of a changing Earth energy	Supporting

	what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	imbalance over time on planetary warming and associated implications for Earth system variability and change	
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	Supporting
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

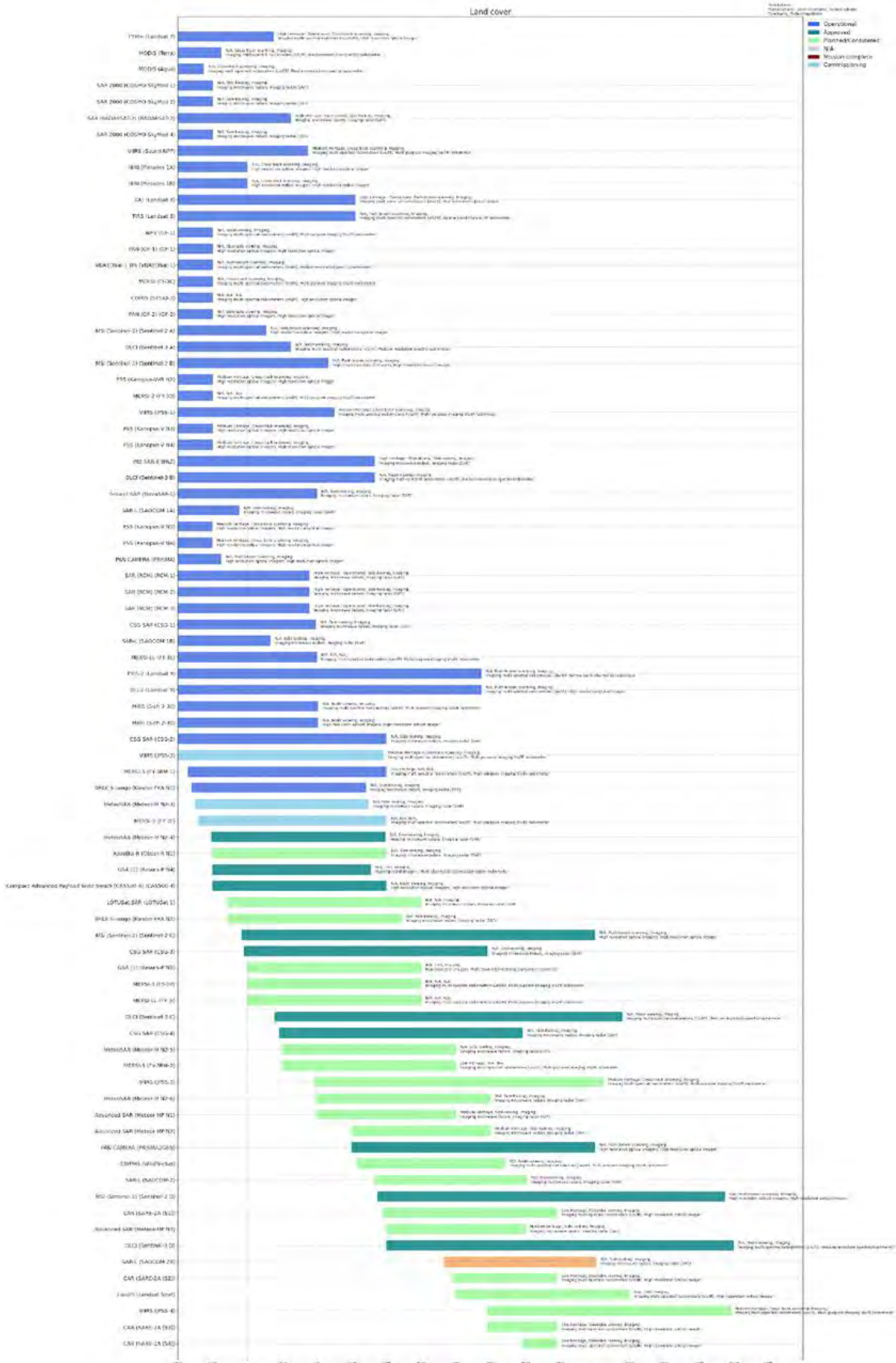
Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	43
2031 (8 years from now)	30
2033 (10 years from now)	22
2038 (15 years from now)	12



Land cover
Multi-purpose imaging Vis/IR radiometer
High resolution optical imager
Multi-channel/direction/polarisation radiometer
Medium-resolution spectro-radiometer
Narrow-band channel IR radiometer
Imaging radar (SAR)
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Number of instruments
0
1
2
3
4
5+

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Land cover

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR 2000	High Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704
SAR-L	High Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
PSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V-IR N2, Kanopus-V N6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=834
HiRI	High Utility	Pleiades 1A, Pleiades 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=887
MERSI	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=893
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
Paz SAR-X	High Utility	PAZ	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1514
CSG SAR	High Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519
Advanced SAR	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1569
MERSI-2	High Utility	FY-3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1620

GSA (1)	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1686
MERSI-S	High Utility	FY-3RM-2, FY-3RM-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1759
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
S-band SAR	High Utility	NovaSAR-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1797
VNIR	High Utility	TRISHNA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1809
MERSI-3	High Utility	FY-3H, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1946
MERSI-LL	High Utility	FY-3I, FY-3E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1947
Compact Advanced Payload Wide Swath (CAS500-4)	High Utility	CAS500-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1991
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
MODIS	General Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
MSI (Sentinel-2)	General Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
LOTUSat SAR	General Utility	LOTUSat 1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1678
VNREDSat-1 MS	General Utility	VNREDSat-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1681

PAN (GF-1)	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1728
PAN (GF-2)	General Utility	GF-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1729
WFV	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1730
COMIS	General Utility	STSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1739
BRLK S-range	General Utility	Kondor-FKA N1, Kondor-FKA N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1750
Kasatka-R	General Utility	Obzor-R N1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1751
CAR	General Utility	SARE-2A (S2), SARE-2A (S1), SARE-2A (S3), SARE-2A (S4)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1762
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
MeteoSAR	General Utility	Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2060
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
TIRS	Potential Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
TIRS-2	Potential Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
MBEI	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=794
MIRS	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=795

PAN CAMERA	Marginal Utility	PRISMA, PRISMA2GEN	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=832

Land surface imagery

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Multi-purpose imagery (land)

Category description: *The spatial information that can be derived from satellite imagery is of value in a wide range of applications, particularly when combined with spectral information from multiple wavebands of a sensor. Satellite Earth observation is of particular value where conventional data collection techniques are difficult, such as in areas of inaccessible terrain, providing cost and time savings in data acquisition – particularly over large areas. At regional and global scales, low resolution instruments with wide coverage capability and imaging sensors on geostationary satellites are routinely exploited for their ability to provide global data on land cover and vegetation.*

Measurement definition: *Level-1 product (not a geophysical parameter). High-resolution imagery covering wavelengths in the range 0.4-1 µm (cloud-affected) or 1-10 GHz (SAR, all-weather) - Accuracy expressed as Modulation Transfer Function (MTF) at the Nyquist spatial wavelength (twice the resolution). Actually [MTF-1] is used, so that smaller figures correspond to better performance, as usual.*

CEOS Database entry for Land surface imagery: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=181

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America	Critical

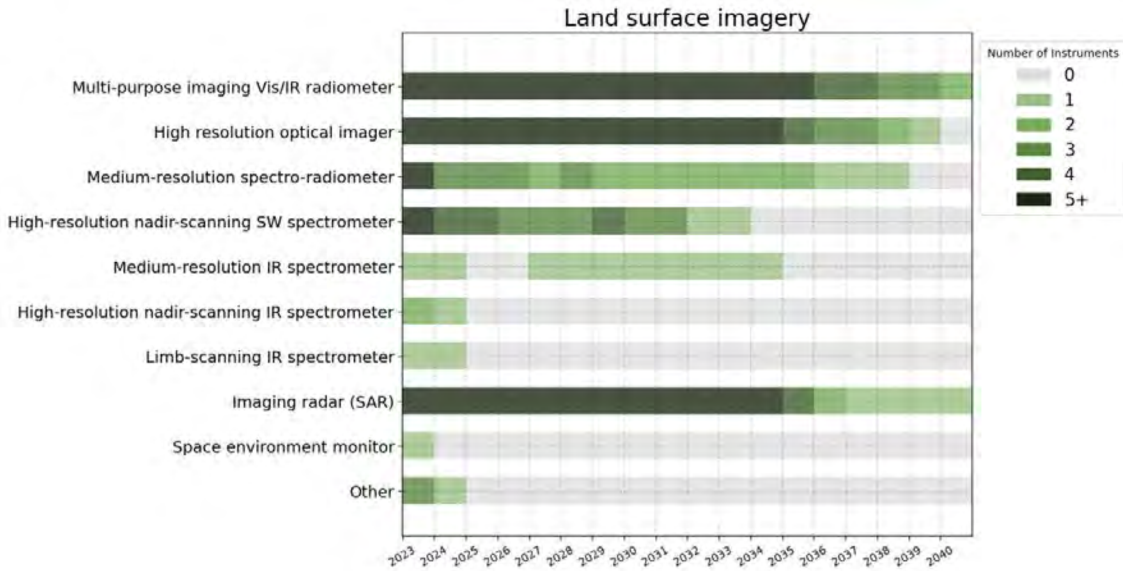
		and Eurasia and identify human activities and climate variations driving these changes	
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Critical
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Critical
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
33-A	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the long-term GIA signal of the Pleistocene deglaciation in ice sheet elevation and gravity field in regions of present-day ice caps melting, and separate it from contributions reflecting ice sheet imbalance and from GIA responses to the Little Ice Age	Supporting
33-B	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the solid Earth visco-elastic response to recent or contemporary ice mass change in glaciated regions associated with low mantle viscosity, such as active plate boundaries	Supporting
33-C	How does the solid Earth deform under present and past ice loads	Constrain the radial and lateral viscosity structure of the mantle (including in	Supporting

	and what does it tell us about its rheology ?	particular low viscosity layers and lateral variations between cratonic and oceanic areas or along hotspot tracks), from data-driven GIA models integrating a broad range of data types. In these models, describe the trade-offs between mantle structure and spatio-temporal evolution of the past ice load	
36-A	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Identify and delineate the locked versus the creeping segments of plate boundaries, and monitor inter-seismic strain accumulation, by accurately measuring the surface deformations of the plates around major boundaries	Critical
36-B	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the spatio-temporal characteristics of transient aseismic events in subduction systems	Critical
36-C	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the possible existence of a short-term preparatory phase for earthquakes	Critical
36-D	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Quantify the co-seismic slip distribution and discriminate between early rupture models	Critical
36-E	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Assess the relative contributions of localized vs distributed deformations at depth along the plates interface and in the surrounding mantle during the post-seismic phase, in	Critical

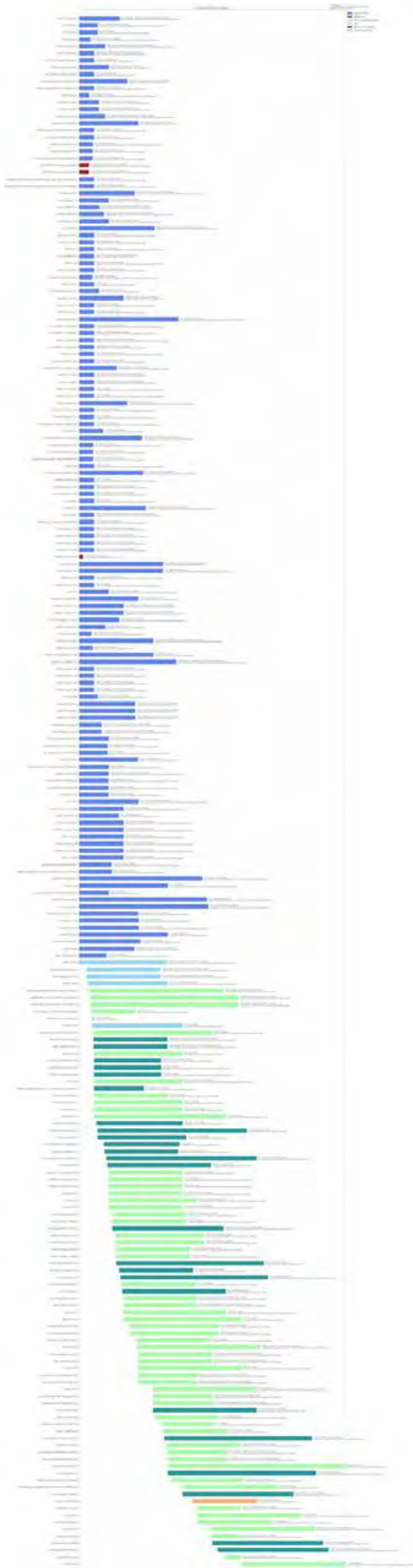
		order to quantify the stress redistribution along plate boundaries after an earthquake	
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	116
2031 (8 years from now)	94
2033 (10 years from now)	81
2038 (15 years from now)	63


Land surface imagery
Multi-purpose imaging Vis/IR radiometer
High resolution optical imager
Medium-resolution spectro-radiometer
High-resolution nadir-scanning SW spectrometer
Medium-resolution IR spectrometer
High-resolution nadir-scanning IR spectrometer
Limb-scanning IR spectrometer
Imaging radar (SAR)
Space environment monitor
Other
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Number of Instruments
0
1
2
3
4
5+

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Land surface imagery

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
ASTER	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
VIRR	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=684
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
SAR (RADARSAT-2)	High Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SAR 2000	High Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704
SAR-L	High Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
MSC	High Utility	KOMPSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=735
MSU-MR	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
KMSS	High Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=801

PSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V-IR N2, Kanopus-V N6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=834
MSS	High Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V N6, Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=835
HiRI	High Utility	Pleiades 1A, Pleiades 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=887
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
SAR (RCM)	High Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
METimage	High Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
VSC	High Utility	VENµS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=966
Paz SAR-X	High Utility	PAZ	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1514
CSG SAR	High Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519
AEISS	High Utility	KOMPSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1522
COSI	High Utility	KOMPSAT-5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1523
Advanced MSU-MR	High Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
Advanced KMSS	High Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1565
NigeriaSat X Remote Sensing	High Utility	NigeriaSat-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1595

(Medium Resolution)			
HRMX	High Utility	CARTOSAT-2E, CARTOSAT-2C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1603
AEISS-A	High Utility	KOMPSAT-3A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1614
PAN (ZY Series)	High Utility	ZY-1-02E, ZY-1-02D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1659
Geoton-L1 (2)	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1684
KShMSA-SR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1693
KShMSA-VR	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1694
SAR (KOMPSAT-6)	High Utility	KOMPSAT-6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1695
High Resolution Optical Sensor (CAS500-1)	High Utility	CAS500-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1740
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
AEISS-HR	High Utility	KOMPSAT-7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1789
CARBONITE-2 Imager	High Utility	CARBONITE-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1796
S-band SAR	High Utility	NovaSAR-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1797
AEISS-HR-A	High Utility	KOMPSAT-7A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1900

High Resolution Optical Sensor (CAS500-2)	High Utility	CAS500-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1990
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
HSI	High Utility	Sentinel CHIME-B, Sentinel CHIME-A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2030
HYC	General Utility	PRISMA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=705
WFI (CBERS-4)	General Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=817
MUX (CBERS-4)	General Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=818
OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
RASAT VIS Panchromatic	General Utility	RASAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=912
RASAT VIS Multispectral	General Utility	RASAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=913
ALISS III	General Utility	RESOURCESAT-3, RESOURCESAT-3A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=932
C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939
MSI (Sentinel-2)	General Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
PALSAR-2	General Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589

WFI (Amazonia-1)	General Utility	AMAZONIA-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1698
MUX (GF-1)	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1726
MUX (GF-2)	General Utility	GF-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1727
PAN (GF-1)	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1728
PAN (GF-2)	General Utility	GF-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1729
WFV	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1730
MUX (CBERS-4A)	General Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1731
WFI (CBERS-4A)	General Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1732
DESIS	General Utility	DESIS-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1734
MIRIS	General Utility	STSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1741
PAN (BJ-2)	General Utility	DMC3, SSTL S1-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1747
MSI (BJ-2)	General Utility	DMC3, SSTL S1-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1748
CAR	General Utility	SARE-2A (S2), SARE-2A (S1), SARE-2A (S3), SARE-2A (S4)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1762
MUX (ZY-3-02)	General Utility	ZY-3-02, ZY-3-03	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1774
MWIR (GF-4)	General Utility	GF-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1775

VNIR (GF-4)	General Utility	GF-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1776
PALSAR-3	General Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
HiRAIS	General Utility	DubaiSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1887
KHCS	General Utility	KhalifaSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1888
SBG VSWIR Instrument	General Utility	SBG-VSWIR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1941
VNIR Camera (SBG-TIR)	General Utility	SBG-TIR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1962
GIS	General Utility	GeoEye-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1963
HiRAIS	General Utility	GEOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1964
X-Band SAR	General Utility	ICEYE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1965
SkySat Camera	General Utility	SkySat-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1974
Vision-1 Imagery	General Utility	Vision-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1975
PlanetScope Camera	General Utility	PlanetScope	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1978
Imager	General Utility	Pleiades Neo 3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1979
Imager	General Utility	Pleiades Neo 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1980

Capella X-SAR	General Utility	Capella X-SAR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1983
WorldView Legion Camera	General Utility	WorldView Legion	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1984
SV-24	General Utility	BlackSky Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2007
Optical Instrument (CO3D)	General Utility	CO3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2008
High-resolution Camera (OPS-SAT)	General Utility	OPS-SAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2034
Pelican	General Utility	Planet Pelican	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2037
PLATiNO X-SAR	General Utility	PLT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2038
Nadir Imager	General Utility	MATS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2042
HYC2	General Utility	PRISMA2GEN	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2061
PLT SAR	General Utility	PLT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2063
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412
SAR (RISAT)	Potential Utility	RISAT-1B, RISAT-1A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=790
NigeriaSat 2 Remote Sensing (Med and High Res)	Potential Utility	NigeriaSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=916
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
MODIS	Marginal Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395

AWiFS	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=460
LISS-IV	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=461
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
MBEI	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=794
MIRS	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=795
CZI	Marginal Utility	HY-1C, HY-1D, HY-1E, HY-1F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=828
TOP (PAN)	Marginal Utility	THEOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=857
TOP (MS)	Marginal Utility	THEOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=858
IRMSS-2	Marginal Utility	CBERS-4, CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=866
PAN (CBERS-4)	Marginal Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=867
AGRI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=892
SGLI	Marginal Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
PAN (Cartosat-3)	Marginal Utility	CARTOSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=917
LISS-III (Resourcesat)	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=934
HSI	Marginal Utility	EnMAP	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=964

WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988
PAN (Cartosat-2A/2B)	Marginal Utility	CARTOSAT-2A, CARTOSAT-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1586
MX (Cartosat-3)	Marginal Utility	CARTOSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1611
HRWS X-Band Digital Beamforming SAR	Marginal Utility	HRWS SAR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1696
WPM	Marginal Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1733
OEK VR	Marginal Utility	Resurs-PM N1, Resurs-PM N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1754
BIK-SD 1	Marginal Utility	Resurs-PM N1, Resurs-PM N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1756
APAN	Marginal Utility	RESOURCESAT-3S, RESOURCESAT-3SA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1772
LISS-V	Marginal Utility	RESOURCESAT-3S, RESOURCESAT-3SA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1773
C-SAR	Marginal Utility	GF-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1787
NAOMI (PAN)	Marginal Utility	THEOS-2 Main VHR Satellite	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1851
NAOMI (MS)	Marginal Utility	THEOS-2 Main VHR Satellite	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1852
HyperScout	Marginal Utility	GOMX4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1890
HyperScout-2	Marginal Utility	Federated Satellite Systems	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1891
CERIA Camera	Marginal Utility	THEOS-2 Small Satellite	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1907

HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909
IRMSS-2 (HJ-2)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1910
WVC-2	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1911
HSI (Intuition-1)	Marginal Utility	Intuition-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1944
Camera (STORK)	Marginal Utility	STORK Constellation	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1945
Phisat-1	Marginal Utility	Federated Satellite Systems	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2101

Land surface topography

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Landscape topography

Category description: *Many modelling activities in Earth and environmental sciences, telecommunications and civil engineering increasingly require accurate, high resolution and comprehensive topographical databases with, indication of changes over time, where relevant. The information is also used by, amongst others, land use planners for civil planning and development, and by hydrologists to predict the drainage of water and likelihood of floods, especially in coastal areas.*

Measurement definition: *Map of land surface heights - Physical unit: [m] - Accuracy unit: [m].*

CEOS Database entry for Land surface topography: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=183

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/97

Related Candidate Science Questions

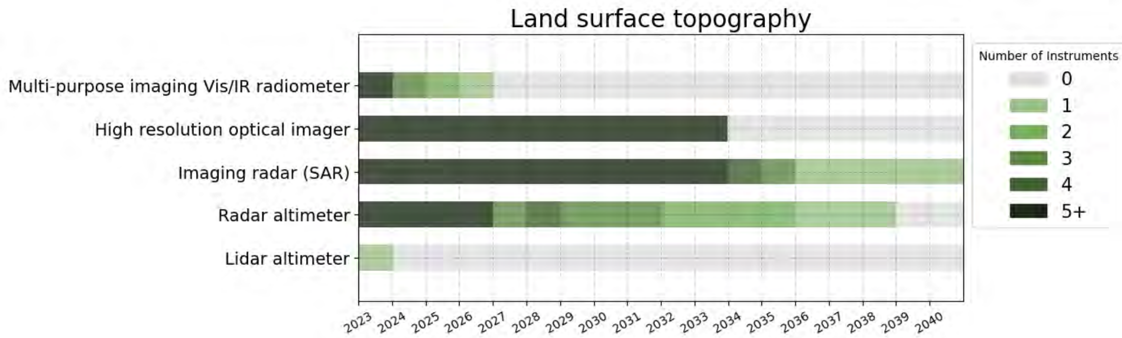
ID	CSQ	KAO	Priority Level
33-A	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the long-term GIA signal of the Pleistocene deglaciation in ice sheet elevation and gravity field in regions of present-day ice caps melting, and separate it from contributions reflecting ice sheet imbalance and from GIA responses to the Little Ice Age	Critical
33-B	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the solid Earth visco-elastic response to recent or contemporary ice mass change in glaciated regions associated with low mantle viscosity, such as active plate boundaries	Critical
33-C	How does the solid Earth deform under present and past ice loads	Constrain the radial and lateral viscosity structure of the mantle (including in	Critical

	and what does it tell us about its rheology ?	particular low viscosity layers and lateral variations between cratonic and oceanic areas or along hotspot tracks), from data-driven GIA models integrating a broad range of data types. In these models, describe the trade-offs between mantle structure and spatio-temporal evolution of the past ice load	
36-A	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Identify and delineate the locked versus the creeping segments of plate boundaries, and monitor inter-seismic strain accumulation, by accurately measuring the surface deformations of the plates around major boundaries	Critical
36-B	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the spatio-temporal characteristics of transient aseismic events in subduction systems	Critical
36-C	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the possible existence of a short-term preparatory phase for earthquakes	Critical
36-D	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Quantify the co-seismic slip distribution and discriminate between early rupture models	Critical
36-E	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Assess the relative contributions of localized vs distributed deformations at depth along the plates interface and in the surrounding mantle during the post-seismic phase, in	Critical

		order to quantify the stress redistribution along plate boundaries after an earthquake	
38-A	How does Earth's crust evolve in interaction with internal geodynamic processes, and how does this reshape the Earth's surface over the long-term ?	Quantify the long-term, present-day changes in Earth's surface and Moho topography due to processes of creation, evolution and destruction of Earth's crust : mountain building, long-term plate subduction, oceanic spreading, extensional tectonics	Supporting
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

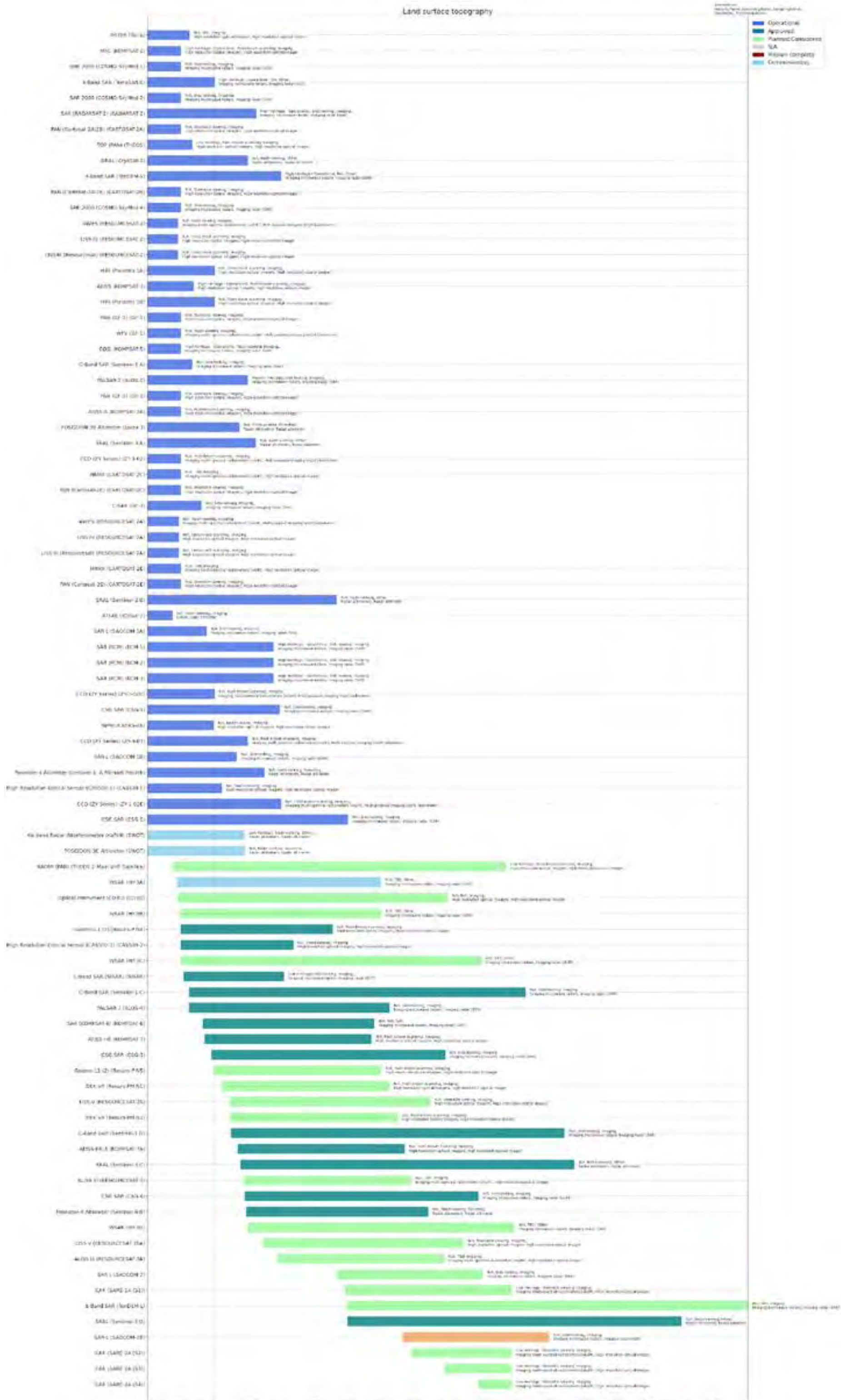
Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	34
2031 (8 years from now)	26
2033 (10 years from now)	19
2038 (15 years from now)	8



Land surface topography
Multi-purpose imaging Vis/IR radiometer
High resolution optical imager
Imaging radar (SAR)
Radar altimeter
Lidar altimeter
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Number of Instruments
0
1
2
3
4
5+

Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Land surface topography

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ASTER	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
SAR 2000	High Utility	COSMO-SkyMed 1, COSMO-SkyMed 2, COSMO-SkyMed 4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=704
SAR-L	High Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
MSC	High Utility	KOMPSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=735
HiRI	High Utility	Pleiades 1A, Pleiades 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=887
CSG SAR	High Utility	CSG-3, CSG-4, CSG-1, CSG-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1519
AEISS	High Utility	KOMPSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1522
COSI	High Utility	KOMPSAT-5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1523
Ka-band Radar INterferometer (KaRIN)	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1541
HRMX	High Utility	CARTOSAT-2E, CARTOSAT-2C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1603
AEISS-A	High Utility	KOMPSAT-3A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1614
CCD (ZY Series)	High Utility	ZY-3-02, ZY-1-02E, ZY-1-02D, ZY-3-03	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1657

Geoton-L1 (2)	High Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1684
SAR (KOMPSAT-6)	High Utility	KOMPSAT-6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1695
High Resolution Optical Sensor (CAS500-1)	High Utility	CAS500-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1740
CAR	High Utility	SARE-2A (S2), SARE-2A (S1), SARE-2A (S3), SARE-2A (S4)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1762
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
AEISS-HR	High Utility	KOMPSAT-7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1789
AEISS-HR-A	High Utility	KOMPSAT-7A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1900
High Resolution Optical Sensor (CAS500-2)	High Utility	CAS500-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1990
SAR (RADARSAT-2)	General Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
ALISS III	General Utility	RESOURCESAT-3, RESOURCESAT-3A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=932
C-Band SAR	General Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939
PAN (GF-1)	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1728

PAN (GF-2)	General Utility	GF-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1729
WFV	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1730
Optical Instrument (CO3D)	General Utility	CO3D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2008
SAR (RCM)	Potential Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
PALSAR-2	Potential Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
PALSAR-3	Potential Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
AWiFS	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=460
LISS-IV	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=461
SIRAL	Marginal Utility	CryoSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=688
TOP (PAN)	Marginal Utility	THEOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=857
LISS-III (Resourcesat)	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=934
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998
L-band SAR (NISAR)	Marginal Utility	NISAR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1526
PAN (Cartosat-2A/ 2B)	Marginal Utility	CARTOSAT-2A, CARTOSAT-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1586

POSEIDON-3B Altimeter	Marginal Utility	Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1633
PAN (Cartosat-2E)	Marginal Utility	CARTOSAT-2E, CARTOSAT-2C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1647
Poseidon-4 Altimeter	Marginal Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1723
WPM	Marginal Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1733
OEK VR	Marginal Utility	Resurs-PM N1, Resurs-PM N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1754
LISS-V	Marginal Utility	RESOURCESAT-3S, RESOURCESAT-3SA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1773
C-SAR	Marginal Utility	GF-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1787
NAOMI (PAN)	Marginal Utility	THEOS-2 Main VHR Satellite	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1851
POSEIDON-3C Altimeter	Marginal Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1961

Geoid

Date generated: 2023-11-24

Measurement Domain: Gravity and Magnetic Fields

Measurement Category: Gravity, Magnetic and Geodynamic measurements

Category description: *The geoid is the surface of equal gravitational potential at mean sea level, and reflects the irregularities in the Earth's gravity field at the planet's surface caused by the inhomogeneous mass and density distribution in the interior. Such measurements are vital for quantitative determination – in combination with satellite altimetry – of ocean currents, improved global height references, estimates of the thickness of the polar ice sheets and its variations, and estimates of the mass/volume redistribution of fresh water in order to better understand the hydrological cycle.*

Measurement definition: *Equipotential surface which would coincide exactly with the mean ocean surface of the Earth, if the oceans were in equilibrium, at rest, and extended through the continents (such as with very narrow channels) - Physical unit: [cm] - Accuracy unit: [cm].*

CEOS Database entry for Geoid: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=184

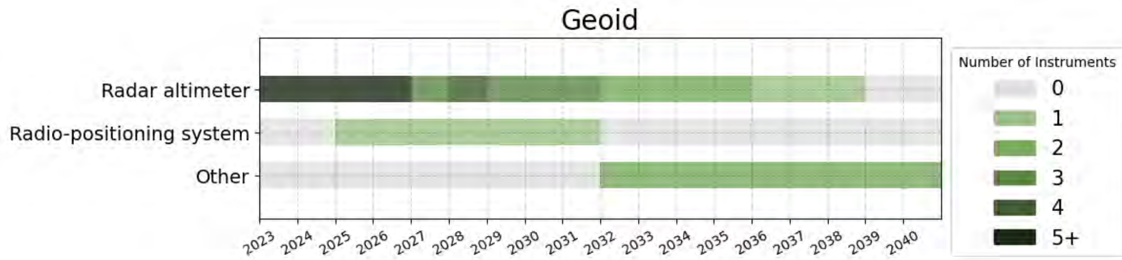
OSCAR Variable page: https://space.oscar.wmo.int/variables/view/68

Related Candidate Science Questions

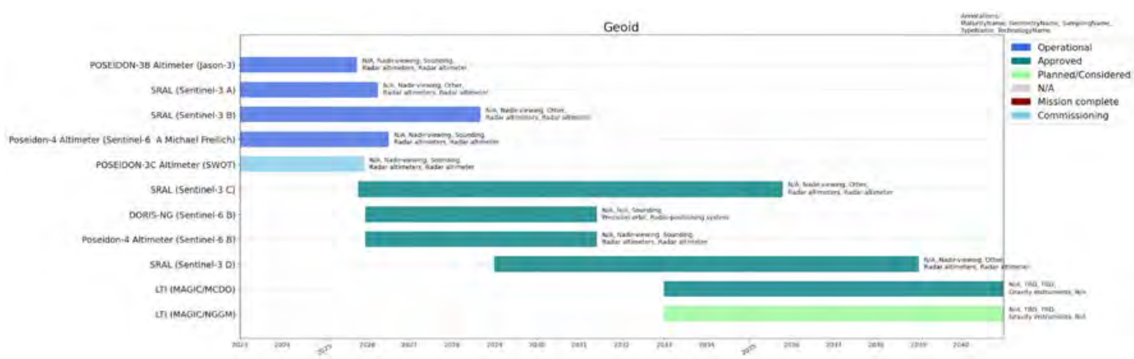
ID	CSQ	KAO	Priority Level
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Critical
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Critical
38-A	How does Earth's crust evolve in interaction with internal geodynamic processes, and how does this reshape the Earth's surface over the long-term ?	Quantify the long-term, present-day changes in Earth's surface and Moho topography due to processes of creation, evolution and destruction of Earth's crust : mountain building, long-term plate subduction, oceanic spreading, extensional tectonics	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	4
2031 (8 years from now)	4
2033 (10 years from now)	4
2038 (15 years from now)	3



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Geoid

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
DORIS-NG	General Utility	Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=181
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056
POSEIDON-3 B Altimeter	Marginal Utility	Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1633

Poseidon-4 Altimeter	Marginal Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1723
POSEIDON-3C Altimeter	Marginal Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1961

Gravity field

Date generated: 2023-11-24

Measurement Domain: Gravity and Magnetic Fields

Measurement Category: Gravity, Magnetic and Geodynamic measurements

Category description: *The geoid is the surface of equal gravitational potential at mean sea level, and reflects the irregularities in the Earth's gravity field at the planet's surface caused by the inhomogeneous mass and density distribution in the interior. Such measurements are vital for quantitative determination – in combination with satellite altimetry – of ocean currents, improved global height references, estimates of the thickness of the polar ice sheets and its variations, and estimates of the mass/volume redistribution of fresh water in order to better understand the hydrological cycle.*

Measurement definition: *Indicative of the statics and dynamics of the lithosphere and the mantle - Physical unit: [mGal] (1 Gal = 0.01 m/s2. i.e. 1 mGal ≈ 10-6 g0 . "Gal" stands for Galileo) - Accuracy unit: [mGal].*

CEOS Database entry for Gravity field: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=185

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/72

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Critical
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Critical
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Critical

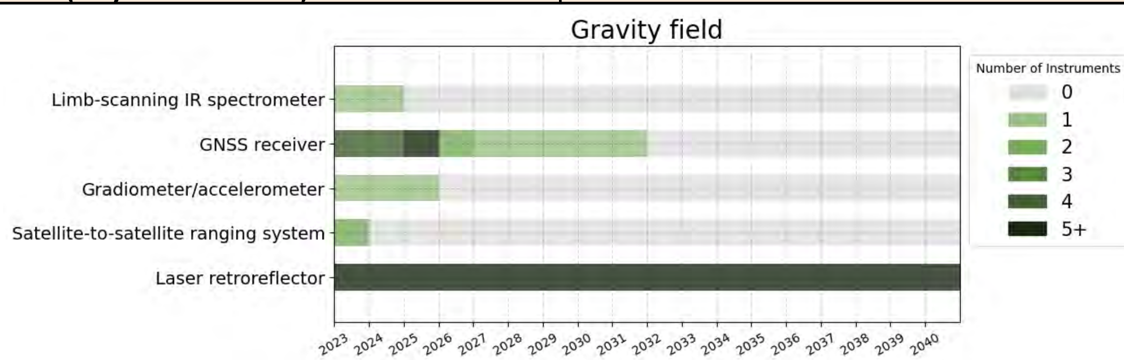
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Critical
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Critical
33-A	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the long-term GIA signal of the Pleistocene deglaciation in ice sheet elevation and gravity field in regions of present-day ice caps melting, and separate it from contributions reflecting ice sheet imbalance and from GIA responses to the Little Ice Age	Critical
33-B	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the solid Earth visco-elastic response to recent or contemporary ice mass change in glaciated regions associated with low mantle viscosity, such as active plate boundaries	Critical
33-C	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Constrain the radial and lateral viscosity structure of the mantle (including in particular low viscosity layers and lateral variations between cratonic and oceanic areas or along hotspot tracks), from data-driven GIA models integrating a broad range of data types. In these models, describe the trade-offs between mantle structure and spatio-temporal evolution of the past ice load	Critical
35-A	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify the long-term present-day sediment discharge to the oceans, and locate modern sedimentation zones, at the mouth of major rivers. An objective could be to resolve accumulations of ~0.5 cm year -1 of sediment at	Critical

		200-km spatial resolution, close to the highest river discharges (Amazon, Ganges-Brahmaputra, Yangtze, ...).	
35-B	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Resolve large variations in sediment discharge following typhoons and El Nino events. So far only accumulated sediment over long time periods could be considered, in order to build up enough mass to be detected by GRACE. With a higher sensitivity, the detection of temporal variations in sediment discharge might be considered.	Critical
35-C	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify sediments loss in mountaneous areas	Critical
36-A	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Identify and delineate the locked versus the creeping segments of plate boundaries, and monitor inter-seismic strain accumulation, by accurately measuring the surface deformations of the plates around major boundaries	Supporting
36-B	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the spatio-temporal characteristics of transient aseismic events in subduction systems	Critical
36-C	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the possible existence of a short-term preparatory phase for earthquakes	Critical
36-D	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to	Quantify the co-seismic slip distribution and discriminate between early rupture models	Critical

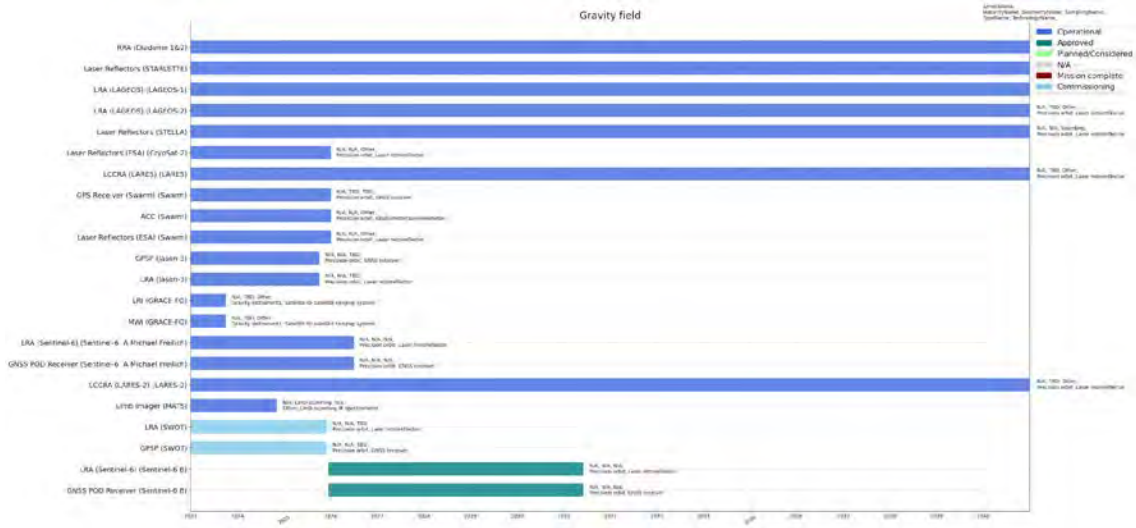
	post-seismic phases and during the inter-seismic phase?		
36-E	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Assess the relative contributions of localized vs distributed deformations at depth along the plates interface and in the surrounding mantle during the post-seismic phase, in order to quantify the stress redistribution along plate boundaries after an earthquake	Critical
38-A	How does Earth's crust evolve in interaction with internal geodynamic processes, and how does this reshape the Earth's surface over the long-term ?	Quantify the long-term, present-day changes in Earth's surface and Moho topography due to processes of creation, evolution and destruction of Earth's crust : mountain building, long-term plate subduction, oceanic spreading, extensional tectonics	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	16
2031 (8 years from now)	16
2033 (10 years from now)	15
2038 (15 years from now)	15



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Gravity field

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
LRI	High Utility	GRACE-FO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1667
MWI	High Utility	GRACE-FO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1668
RRA	General Utility	Diademe 1&2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=766
LCCRA (LARES)	General Utility	LARES	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=772
LRA (LAGEOS)	General Utility	LAGEOS-2, LAGEOS-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1510
LCCRA (LARES-2)	General Utility	LARES-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1948
Limb Imager	General Utility	MATS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2041
Laser Reflectors	Marginal Utility	STELLA, STARLETTE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=29

LRA	Marginal Utility	SWOT, Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=106
Laser Reflectors (ESA)	Marginal Utility	Swarm, CryoSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=767
ACC	Marginal Utility	Swarm	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=863
GPS Receiver (Swarm)	Marginal Utility	Swarm	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=943
GPSP	Marginal Utility	SWOT, Jason-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=983
GNSS POD Receiver	Marginal Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1720
LRA (Sentinel-6)	Marginal Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1721

Gravity gradients

Date generated: 2023-11-24

Measurement Domain: Gravity and Magnetic Fields

Measurement Category: Gravity, Magnetic and Geodynamic measurements

Category description: *The geoid is the surface of equal gravitational potential at mean sea level, and reflects the irregularities in the Earth's gravity field at the planet's surface caused by the inhomogeneous mass and density distribution in the interior. Such measurements are vital for quantitative determination – in combination with satellite altimetry – of ocean currents, improved global height references, estimates of the thickness of the polar ice sheets and its variations, and estimates of the mass/volume redistribution of fresh water in order to better understand the hydrological cycle.*

Measurement definition: *Gradient of the Earth's gravity field measured at the satellite orbital height - Physical unit: [E] , Eötvös (1 E = 1 mGal / 10 km) - Accuracy unit: [E].*

CEOS Database entry for Gravity gradients: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=186

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/73

Related Candidate Science Questions

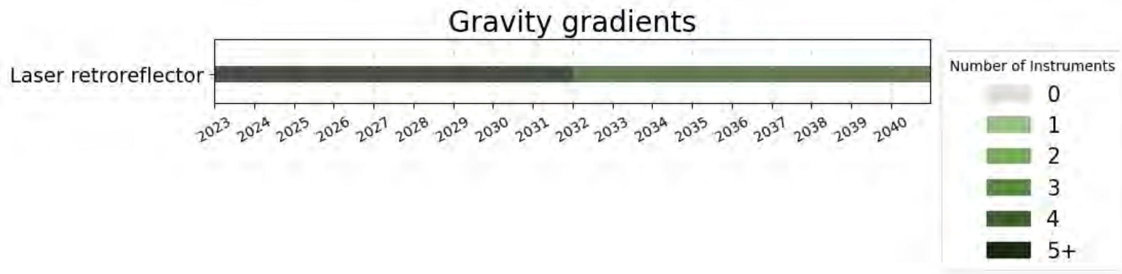
ID	CSQ	KAO	Priority Level
33-A	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the long-term GIA signal of the Pleistocene deglaciation in ice sheet elevation and gravity field in regions of present-day ice caps melting, and separate it from contributions reflecting ice sheet imbalance and from GIA responses to the Little Ice Age	Critical
33-B	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the solid Earth visco-elastic response to recent or contemporary ice mass change in glaciated regions associated with low mantle viscosity, such as active plate boundaries	Critical
33-C	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Constrain the radial and lateral viscosity structure of the mantle (including in particular low viscosity layers and lateral variations between cratonic and oceanic areas	Critical

		or along hotspot tracks), from data-driven GIA models integrating a broad range of data types. In these models, describe the trade-offs between mantle structure and spatio-temporal evolution of the past ice load	
35-A	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify the long-term present-day sediment discharge to the oceans, and locate modern sedimentation zones, at the mouth of major rivers. An objective could be to resolve accumulations of ~0.5 cm year -1 of sediment at 200-km spatial resolution, close to the highest river discharges (Amazon, Ganges-Brahmaputra, Yangtze, ...).	Critical
35-B	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Resolve large variations in sediment discharge following typhoons and El Nino events. So far only accumulated sediment over long time periods could be considered, in order to build up enough mass to be detected by GRACE. With a higher sensitivity, the detection of temporal variations in sediment discharge might be considered.	Critical
35-C	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify sediments loss in mountaneous areas	Critical
36-A	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Identify and delineate the locked versus the creeping segments of plate boundaries, and monitor inter-seismic strain accumulation, by accurately measuring the surface deformations of the plates around major boundaries	Supporting
36-B	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic	Document the spatio-temporal characteristics of transient aseismic events in subduction systems	Critical

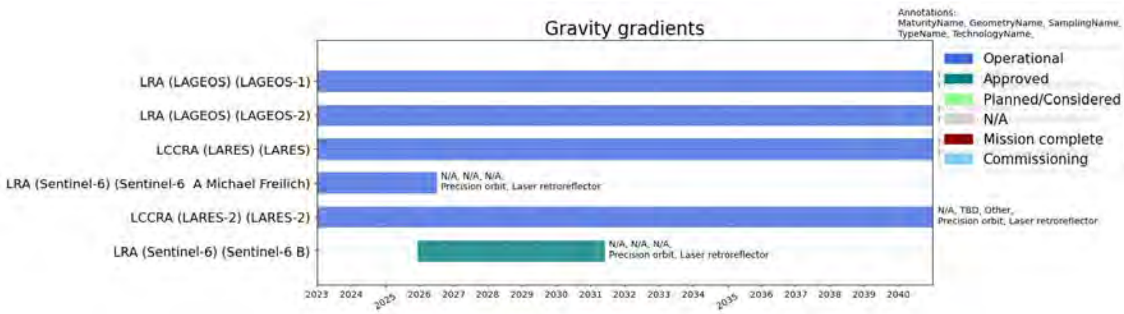
	phases and during the inter-seismic phase?		
36-C	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Document the possible existence of a short-term preparatory phase for earthquakes	Critical
36-D	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Quantify the co-seismic slip distribution and discriminate between early rupture models	Critical
36-E	Can we observe, model and forecast the deformation processes during the seismic cycle at plate boundaries, from pre- to post-seismic phases and during the inter-seismic phase?	Assess the relative contributions of localized vs distributed deformations at depth along the plates interface and in the surrounding mantle during the post-seismic phase, in order to quantify the stress redistribution along plate boundaries after an earthquake	Critical
38-A	How does Earth's crust evolve in interaction with internal geodynamic processes, and how does this reshape the Earth's surface over the long-term ?	Quantify the long-term, present-day changes in Earth's surface and Moho topography due to processes of creation, evolution and destruction of Earth's crust : mountain building, long-term plate subduction, oceanic spreading, extensional tectonics	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	5
2031 (8 years from now)	5
2033 (10 years from now)	4
2038 (15 years from now)	4



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Gravity gradients

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
LCCRA (LARES)	High Utility	LARES	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=772
LCCRA (LARES-2)	High Utility	LARES-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1948
LRA (LAGEOS)	General Utility	LAGEOS-2, LAGEOS-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1510
LRA (Sentinel-6)	Marginal Utility	Sentinel-6 A Michael Freilich, Sentinel-6 B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1721

Sea-ice thickness

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Sea ice cover, edge and thickness

Category description: *Sea ice variability is a key indicator of climate variability and change which is characterised by a number of parameters. In addition to monitoring ice extent (the total area covered by ice at any concentration) and concentration (the area covered by ice per unit area of ocean), it is necessary to know ice thickness in order to estimate sea ice volume or mass balance.*

Measurement definition: *Thickness of the ice sheet - related to sea-ice elevation and density - Physical unit [cm], Accuracy unit [cm]*

CEOS Database entry for Sea-ice thickness: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=193

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/138

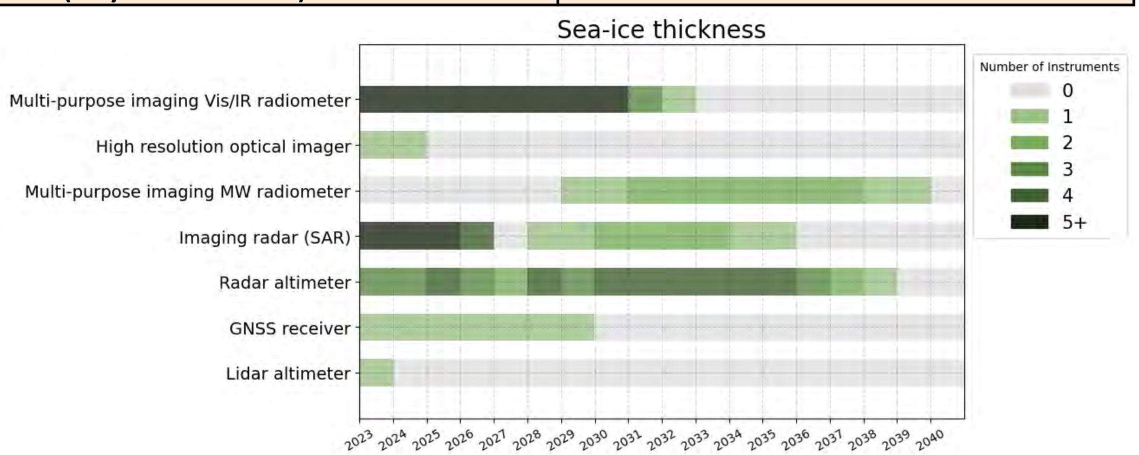
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Critical
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Critical
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting

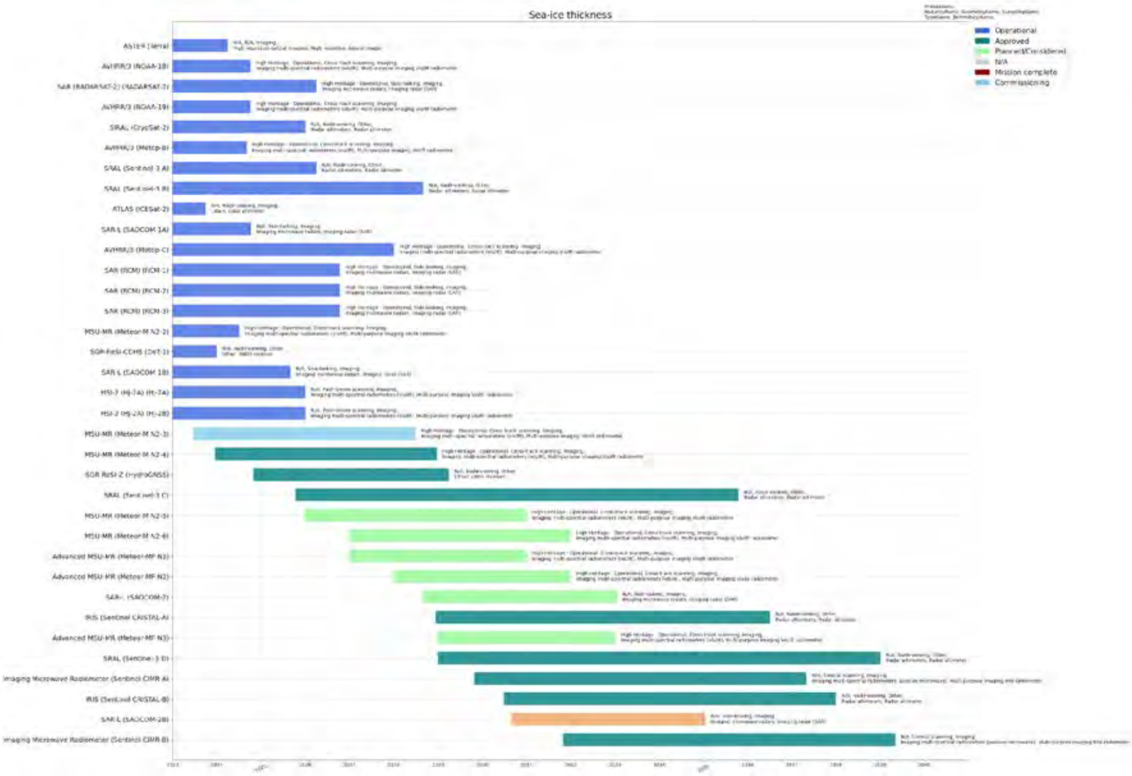
	response and climate sensitivity, as well as		
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	11
2031 (8 years from now)	11
2033 (10 years from now)	8
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea-ice thickness

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
SGR-ReSI-Z	High Utility	HydroGNSS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1939
IRIS	High Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
SRAL	General Utility	Sentinel-3 D, Sentinel-3 A, Sentinel-3 B, Sentinel-3 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=903
Imaging Microwave Radiometer	General Utility	Sentinel CIMR-A, Sentinel CIMR-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2014

SGR-ReSI-CD HS	General Utility	DoT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2097
SAR-L	Potential Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
Advanced MSU-MR	Potential Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
ASTER	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
SIRAL	Marginal Utility	CryoSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=688
SAR (RADARSAT-2)	Marginal Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
MSU-MR	Marginal Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
SAR (RCM)	Marginal Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909

Wind stress

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean surface winds

Category description: *High resolution vector wind measurements at the sea surface are required in models of the atmosphere, ocean surface waves and ocean circulation. They are proving useful in enhancing marine weather forecasting through assimilation into NWP models and in improving understanding of the large-scale air-sea fluxes which are vital for climate prediction purposes. Accurate wind vector data affect a broad range of marine operations, including offshore oil operations, ship movement and routing. Such data also aid short-term weather forecasting and the issue of timely weather warnings.*

Measurement definition: *The shear force per unit area exerted by wind blowing over the sea surface. [Unit of measurement – Pa]*

CEOS Database entry for Wind stress: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=206

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/182

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Critical
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Critical
8-C	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in “Blue carbon” ecosystems, and their resilience to human and climate change pressures in different coastal regions	Supporting
8-D	How are coastal areas contributing to the global carbon cycle, and how	Determine contribution and drivers of change in permafrost in the polar	Supporting

	are they responding to climate change and human pressures?	coastal ocean, and its resilience to human and climate change pressures in different coastal regions	
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Critical
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Critical

Instruments

No instruments recorded in D4 for Wind stress

Earth surface albedo

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Albedo and reflectance

Category description: *Albedo is the fraction of solar energy that is diffusely reflected back from Earth to space. Measurements of albedo are essential for climate research studies and investigations of the Earth's energy budget. Different parts of the Earth have different albedos. For example, ocean surfaces and rain forests have low albedos, which means that they reflect only a small portion of the Sun's energy. Deserts, ice and clouds, however, have high albedos; they reflect a large portion of the incoming solar energy. The high albedo of ice helps to insulate the polar oceans from solar radiation.*

Measurement definition: *Hemispherically integrated reflectance of the Earth's surface in the range 0.4-0.7 µm (or other specific short-wave ranges) - Physical unit: [%] - Accuracy unit: [%].*

CEOS Database entry for Earth surface albedo: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=218

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/54

Related Candidate Science Questions

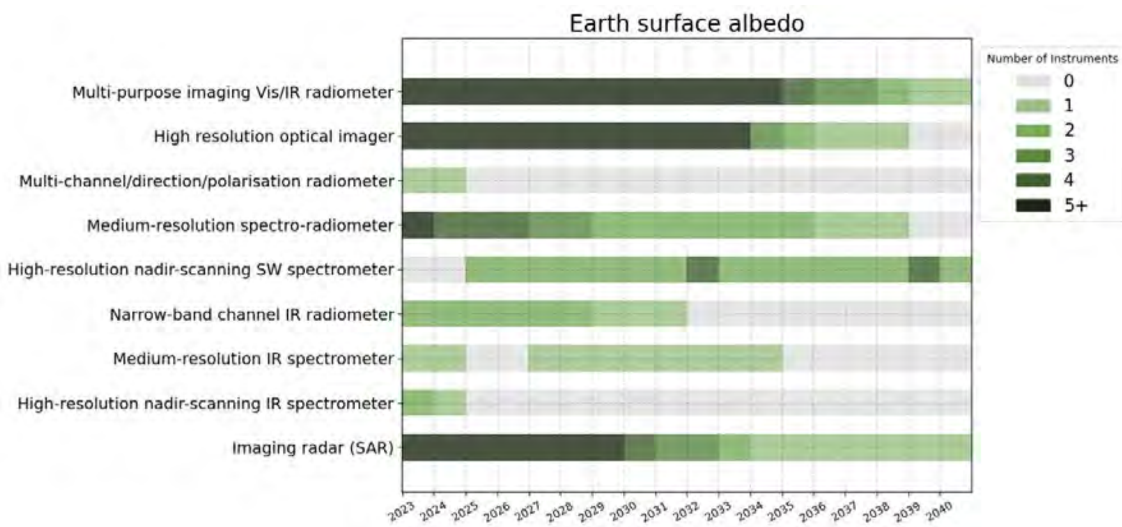
ID	CSQ	KAO	Priority Level
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Critical
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding	Supporting

	different components of the Earth system?	of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	
43-D	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	4). Quantify land-atmosphere interactions: What are the role of land surface-atmospheric interactions in the water, energy and carbon budgets across spatiotemporal scales?	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	Supporting

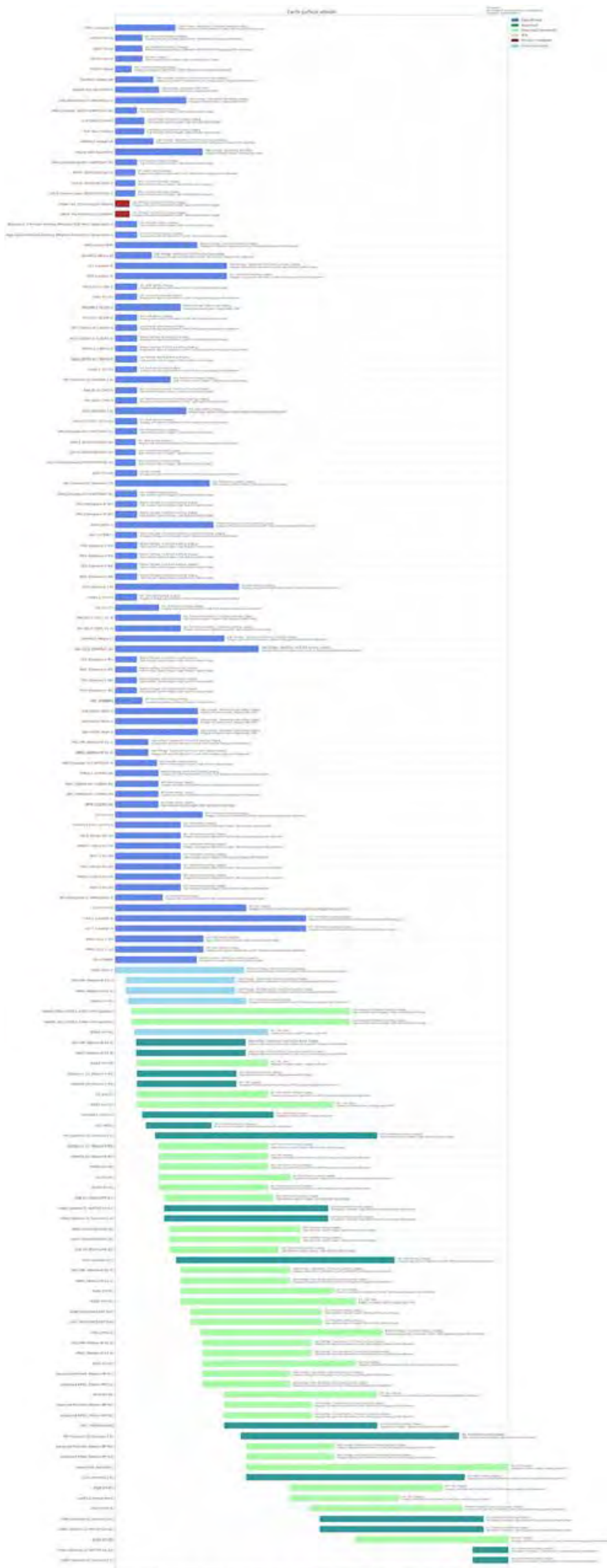
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	53
2031 (8 years from now)	32
2033 (10 years from now)	17
2038 (15 years from now)	7



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Earth surface albedo

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
MISR	High Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=396
AVHRR/3	High Utility	NOAA-19, Metop-B, Metop-C, NOAA-18	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=403
VISSR-2	High Utility	FY-2G, FY-2H	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=665
VIRR	High Utility	FY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=684
X-Band SAR	High Utility	TerraSAR-X, TanDEM-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=697
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
NigeriaSat X Remote Sensing (Medium Resolution)	High Utility	NigeriaSat-X	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1595
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
L-Band SAR	High Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
SWIR	High Utility	TRISHNA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1808
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
HYC	General Utility	PRISMA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=705

OLCI	General Utility	Sentinel-3 B, Sentinel-3 A, Sentinel-3 C, Sentinel-3 D	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=896
RASAT VIS Panchromatic	General Utility	RASAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=912
RASAT VIS Multispectral	General Utility	RASAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=913
UVNS (Sentinel-5)	General Utility	Sentinel-5 B, METOP-SG A2, METOP-SG A3, Sentinel-5 C, METOP-SG A1, Sentinel-5 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1504
Advanced MSU-MR	General Utility	Meteor-MP N1, Meteor-MP N3, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1564
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
OCI	General Utility	PACE	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1597
MUX (GF-1)	General Utility	GF-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1726
MUX (GF-2)	General Utility	GF-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1727
PAN (BJ-2)	General Utility	DMC3, SSTL S1-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1747
MSI (BJ-2)	General Utility	DMC3, SSTL S1-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1748
MUX (ZY-3-02)	General Utility	ZY-3-02, ZY-3-03	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1774
HYC2	General Utility	PRISMA2GEN	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2061
VIIRS	Potential Utility	JPSS-1, JPSS-4, Suomi NPP, JPSS-2, JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=412

MSU-MR	Potential Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=779
KMSS	Potential Utility	Meteor-M N2-2, Meteor-M N2-4, Meteor-M N2-5, Meteor-M N2-6, Meteor-M N2-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=801
MSS	Potential Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V N6, Kanopus-V-IR N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=835
SGLI	Potential Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901
NigeriaSat 2 Remote Sensing (Med and High Res)	Potential Utility	NigeriaSat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=916
MSI (Sentinel-2)	Potential Utility	Sentinel-2 B, Sentinel-2 C, Sentinel-2 D, Sentinel-2 A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=940
Advanced KMSS	Potential Utility	Meteor-MP N3, Meteor-MP N1, Meteor-MP N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1565
HISUI	Potential Utility	HISUI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634
Geoton-L1 (2)	Potential Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1684
KShMSA-VR	Potential Utility	Resurs-P N4, Resurs-P N5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1694
MODIS	Marginal Utility	Terra, Aqua	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=395
ASTER	Marginal Utility	Terra	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=416
AWiFS	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=460

LISS-IV	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=461
MVIRS	Marginal Utility	FY-3H, FY-3I, FY-3F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=671
SAR (RADARSAT-2)	Marginal Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
MBEI	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=794
MIRS	Marginal Utility	Sich 2-30	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=795
WFI (CBERS-4)	Marginal Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=817
MUX (CBERS-4)	Marginal Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=818
CZI	Marginal Utility	HY-1C, HY-1D, HY-1E, HY-1F	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=828
PSS	Marginal Utility	Kanopus-V N3, Kanopus-V N4, Kanopus-V N5, Kanopus-V-IR N2, Kanopus-V N6	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=834
TOP (PAN)	Marginal Utility	THEOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=857
TOP (MS)	Marginal Utility	THEOS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=858
IRMSS-2	Marginal Utility	CBERS-4, CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=866
PAN (CBERS-4)	Marginal Utility	CBERS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=867
AGRI	Marginal Utility	FY-4F, FY-4G, FY-4A, FY-4B, FY-4C, FY-4D, FY-4E	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=892
PAN (Cartosat-3)	Marginal Utility	CARTOSAT-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=917

LISS-III (Resourcesat)	Marginal Utility	RESOURCESAT-2A, RESOURCESAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=934
SAR (RCM)	Marginal Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
HSI	Marginal Utility	EnMAP	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=964
WSAR	Marginal Utility	HY-3D, HY-3A, HY-3B, HY-3C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=988
TIRS	Marginal Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
PAN (Cartosat-2A/ 2B)	Marginal Utility	CARTOSAT-2A, CARTOSAT-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1586
PALSAR-2	Marginal Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
PAN (Cartosat-2E)	Marginal Utility	CARTOSAT-2E, CARTOSAT-2C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1647
WFI (Amazonia-1)	Marginal Utility	AMAZONIA-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1698
MUX (CBERS-4A)	Marginal Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1731
WFI (CBERS-4A)	Marginal Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1732
WPM	Marginal Utility	CBERS-4A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1733
TIRS-2	Marginal Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
OEK VR	Marginal Utility	Resurs-PM N1, Resurs-PM N2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1754
APAN	Marginal Utility	RESOURCESAT-3S, RESOURCESAT-3SA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1772

LISS-V	Marginal Utility	RESOURCESAT-3S, RESOURCESAT-3SA	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1773
PALSAR-3	Marginal Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803
NAOMI (PAN)	Marginal Utility	THEOS-2 Main VHR Satellite	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1851
NAOMI (MS)	Marginal Utility	THEOS-2 Main VHR Satellite	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1852
HSI-2 (HJ-2A)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1909
IRMSS-2 (HJ-2)	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1910
WVC-2	Marginal Utility	HJ-2A, HJ-2B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1911

Water vapour imagery

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Atmospheric Humidity Fields

Category description: *The observations for water vapour (atmospheric humidity) are a core requirement for weather forecasting and are largely dealt with in the framework of the Coordinating Group for Meteorological Satellites (CGMS). The 3-dimensional field of humidity is a key variable for global and regional weather prediction (NWP) models that are used to produce short- and medium-range forecasts of the state of the troposphere and lower stratosphere.*

Measurement definition: *Level-1 product (not a geophysical parameter). Multi-channel imagery covering wavelengths in the range 0.4-14 μm including water vapour bands for atmospheric tracing in clear-air at more levels (e.g., for winds) - Accuracy expressed as Modulation Transfer Function (MTF) at the Nyquist spatial wavelength (twice the resolution). Actually [MTF-1] is used, so that smaller figures correspond to better performance, as usual.*

CEOS Database entry for Water vapour imagery: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=231

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/162

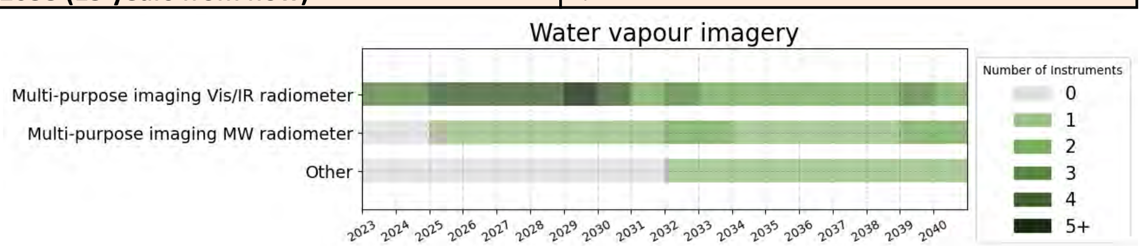
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	Supporting

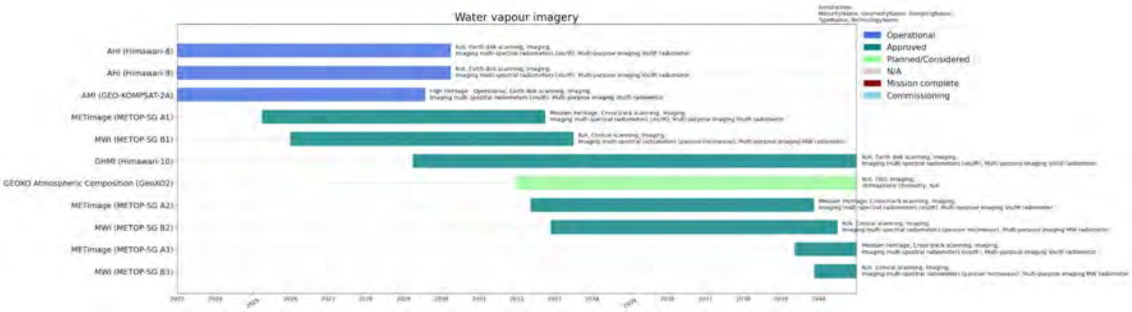
45-B	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study of cumulative regional cloud feedbacks, weighted by the global ratio of fractional coverage to evaluate the global cloud feedback	Supporting
45-C	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Study the causality in aerosol–cloud relationships, particularly for anthropogenic perturbations	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Critical
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	5
2031 (8 years from now)	3
2033 (10 years from now)	5
2038 (15 years from now)	4



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Water vapour imagery

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MWI	High Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
AHI	High Utility	Himawari-8, Himawari-9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1651
METimage	General Utility	METOP-SG A2, METOP-SG A3, METOP-SG A1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=965
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575
GEOXO Atmospheric Composition	General Utility	GeoXO2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2048
GHMI	General Utility	Himawari-10	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2067

Soil moisture in the roots region

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Soil moisture

Category description: *Soil moisture plays a key role in the hydrological cycle. Evaporation rates, surface runoff, infiltration and percolation are all affected by the level of moisture in the soil. Changes in soil moisture have a serious impact on agricultural productivity, forestry and ecosystem health. Monitoring soil moisture is critical for managing these resources and understanding long-term changes, such as desertification, and should be developed in proper coordination with other land surface variables. Applications include crop yield predictions, identification of potential famine areas, irrigation management, and monitoring of areas subject to erosion and desertification, as well as for the initialisation of NWP models.*

Measurement definition: *Sub-soil vertical profile of the fractional content of water in a volume of wet soil. Requested from surface down to ~ 3 m - Physical unit: [m3/m3] - Accuracy unit: [m3/m3].*

CEOS Database entry for Soil moisture in the roots region: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=239

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/148

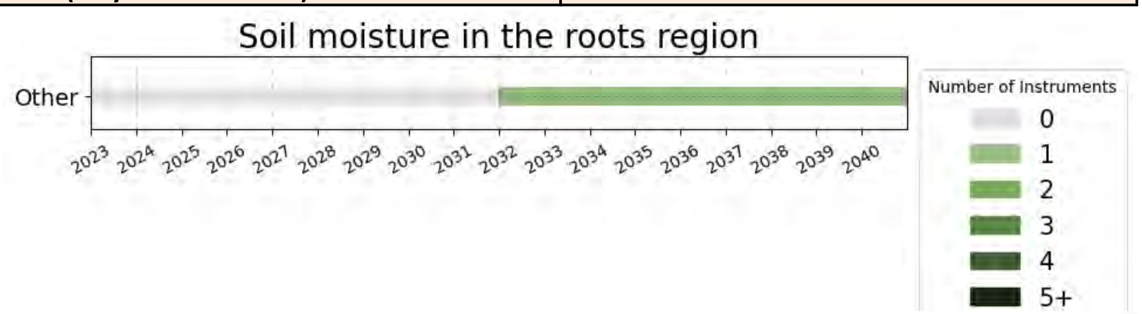
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales.	Critical

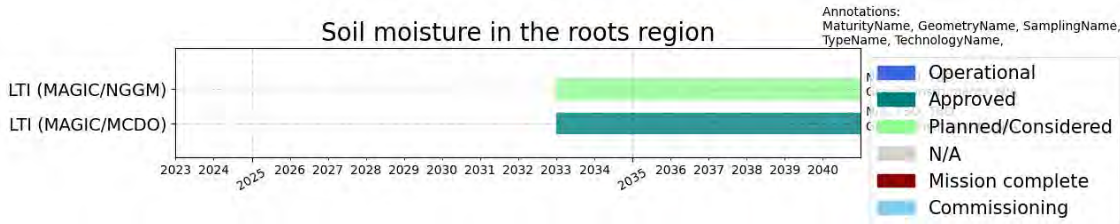
		1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	
44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
44-B	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Detect water management influences: extent to which water management practices and land use changes (e.g., deforestation) modified the water cycle on regional to global scales	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	0
2031 (8 years from now)	0
2033 (10 years from now)	2
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Soil moisture in the roots region

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056

Vegetation Canopy (cover)

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *Fraction of the ground area covered by tree crowns in %.*

CEOS Database entry for Vegetation Canopy (cover): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=240

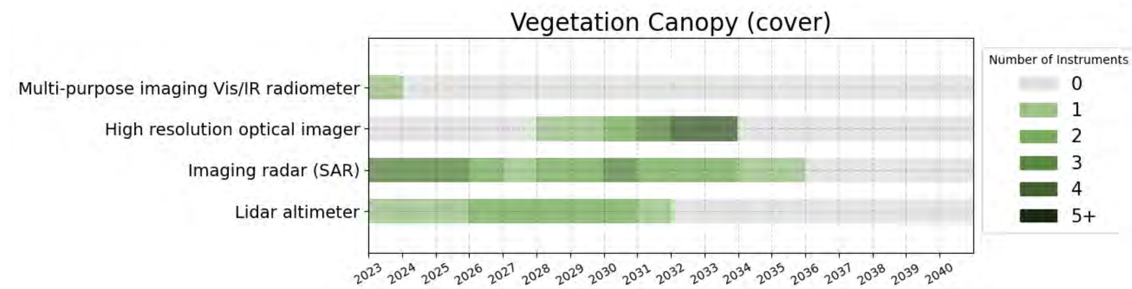
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
2-C	How has the land biosphere responded to human activity and climate change?	Quantify above ground biomass (AGB) in tropical and extratropical forests to the accuracy needed to resolve changes in stocks on sub-decadal time scales	Supporting
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	Supporting
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal	Critical

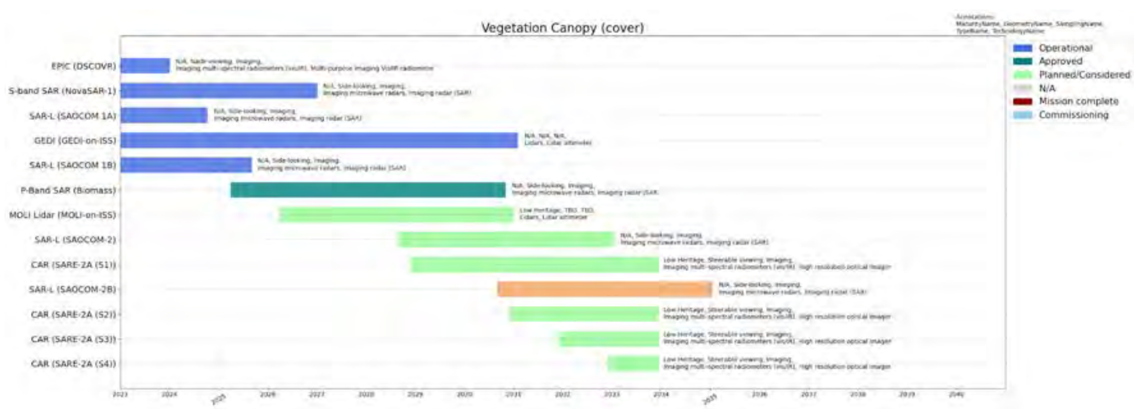
		variation in ecological processes) for improved understanding of ecosystem resilience	
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	5
2031 (8 years from now)	8
2033 (10 years from now)	9
2038 (15 years from now)	3



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Vegetation Canopy (cover)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
S-band SAR	High Utility	NovaSAR-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1797
SAR-L	General Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
EPIC	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1615
GEDI	General Utility	GEDI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1717
P-Band SAR	General Utility	Biomass	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1722
CAR	General Utility	SARE-2A (S2), SARE-2A (S1), SARE-2A (S3), SARE-2A (S4)	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1762
MOLI Lidar	General Utility	MOLI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2052

Vegetation Canopy (height)

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *Vertical projection of an area covered by tree crowns in meters.*

CEOS Database entry for Vegetation Canopy (height): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=241

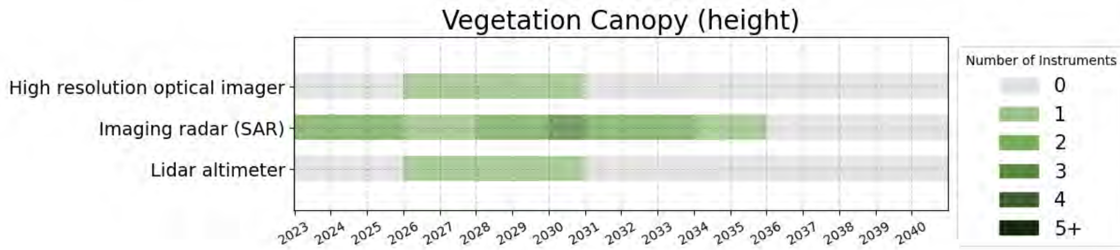
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Critical
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	Critical
43-B	What are the main coupling determinants between Earth's energy, water and carbon cycles	2). Quantify role of surface and UTLS forcings in ABL processes: - role of sensible	Critical

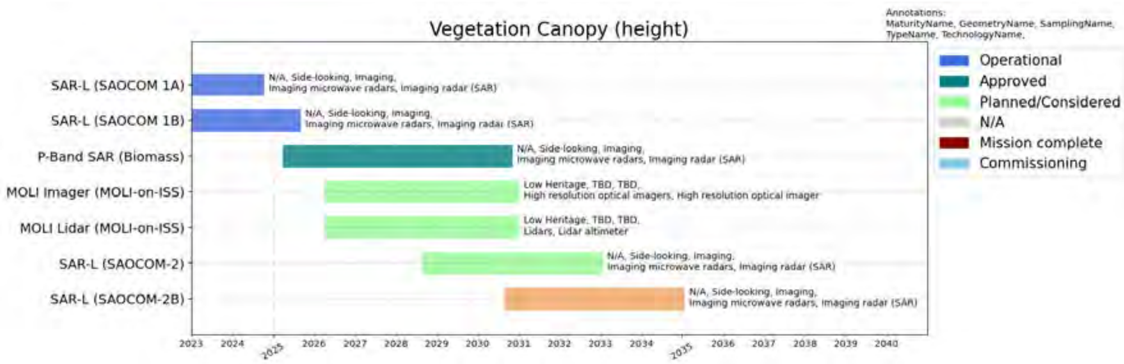
	and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	and latent energy and water exchanges at the Earth's surface versus within the atmosphere (i.e., horizontal advection and upper troposphere - lower stratosphere (UTLS) exchanges)	
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	Critical
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Critical
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Critical
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	4
2031 (8 years from now)	3
2033 (10 years from now)	3
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Vegetation Canopy (height)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SAR-X	General Utility	RISAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1521
P-Band SAR	General Utility	Biomass	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1722
MOLI Imager	General Utility	MOLI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2051
MOLI Lidar	General Utility	MOLI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2052
SAR-L	Potential Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731

Ice sheet topography

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Ice sheet topography

Category description: *The state of the polar ice sheets and their volumes are both indicators and important parts of climate change processes and feedbacks. Consequently, it is important to monitor and study them in order to investigate the impact of global warming and to forecast future trends.*

Measurement definition: *Map of ice sheet heights. Intended over land (for the ocean, see Sea-ice thickness) - Physical unit: [cm] - Accuracy unit: [cm].*

CEOS Database entry for Ice sheet topography: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=243

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/85

Related Candidate Science Questions

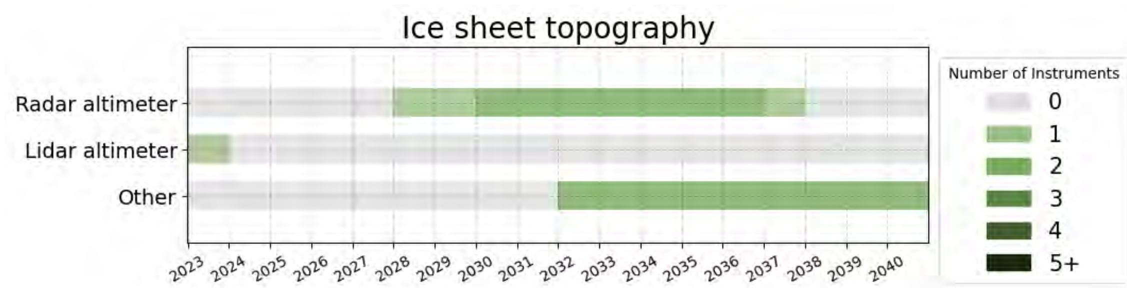
ID	CSQ	KAO	Priority Level
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Critical
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Critical
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Critical
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g.	Critical

		through nutrient cycling and primary productivity.	
33-A	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the long-term GIA signal of the Pleistocene deglaciation in ice sheet elevation and gravity field in regions of present-day ice caps melting, and separate it from contributions reflecting ice sheet imbalance and from GIA responses to the Little Ice Age	Critical
33-B	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Quantify the solid Earth visco-elastic response to recent or contemporary ice mass change in glaciated regions associated with low mantle viscosity, such as active plate boundaries	Critical
33-C	How does the solid Earth deform under present and past ice loads and what does it tell us about its rheology ?	Constrain the radial and lateral viscosity structure of the mantle (including in particular low viscosity layers and lateral variations between cratonic and oceanic areas or along hotspot tracks), from data-driven GIA models integrating a broad range of data types. In these models, describe the trade-offs between mantle structure and spatio-temporal evolution of the past ice load	Critical
35-C	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify sediments loss in mountaneous areas	Critical
38-A	How does Earth's crust evolve in interaction with internal geodynamic processes, and how does this reshape the Earth's surface over the long-term ?	Quantify the long-term, present-day changes in Earth's surface and Moho topography due to processes of creation, evolution and destruction of Earth's crust : mountain	Supporting

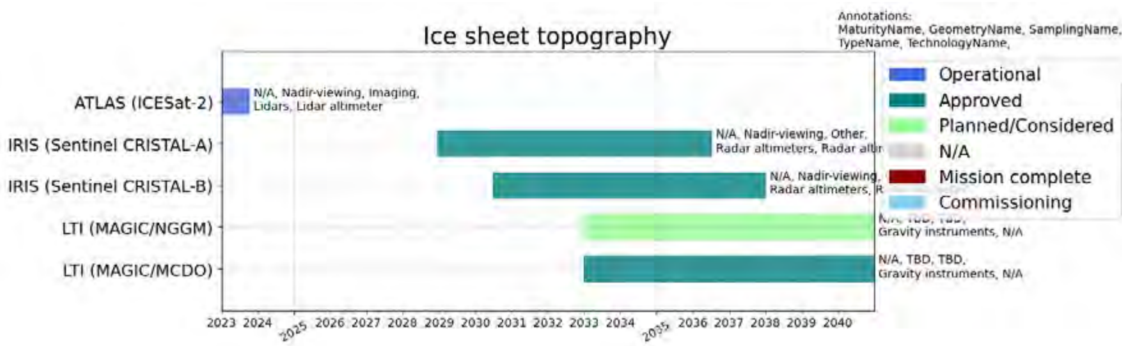
		building, long-term plate subduction, oceanic spreading, extensional tectonics	
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	1
2031 (8 years from now)	2
2033 (10 years from now)	4
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Ice sheet topography

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
IRIS	High Utility	Sentinel CRISTAL-A, Sentinel CRISTAL-B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2015
LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998

Snow surface temperature

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Snow cover, edge and depth

Category description: *Regular measurements of terrestrial snow cover are important because snow dramatically influences surface albedo, thereby making a significant impact on the global climate, as well as influencing hydrological properties and the regulation of ecosystem biological activity. Snow forms a vital component of the water cycle. In order to make efficient use of meltwater runoff, resource agencies must be able to make early predictions of the amount of water stored in the form of snow. Snow cover information has a range of additional applications such as detecting areas of winterkill in agriculture that result from lack of snow cover to insulate plants from freezing temperatures. Locally, monitoring of snow parameters is important for meteorology and for enabling warnings of when melting is about to occur – which is crucial for hydrological research and for forecasting the risk of flooding.*

Measurement definition: *Temperature of the surface of the snow mantle - Physical unit: [K] - Accuracy unit: [K].*

CEOS Database entry for Snow surface temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=246

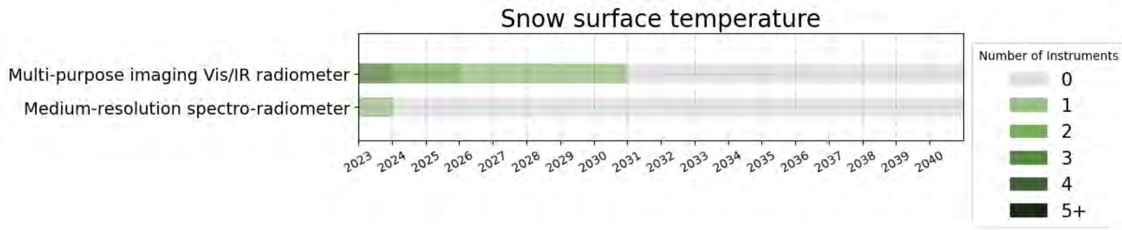
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Supporting

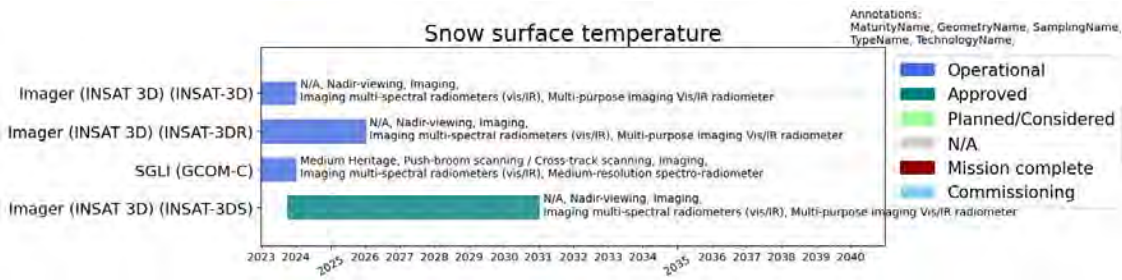
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	1
2031 (8 years from now)	0
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Snow surface temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
Imager (INSAT 3D)	High Utility	INSAT-3DR, INSAT-3D, INSAT-3DS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=788
SGLI	General Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901

Lake level

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Inland Waters

Category description: *Observations of inland water systems, for example lakes and rivers.*

Measurement definition: *Map of the height of the lake surface. - Physical unit: [cm] - Accuracy unit: [cm].*

CEOS Database entry for Lake level: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=247

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/93

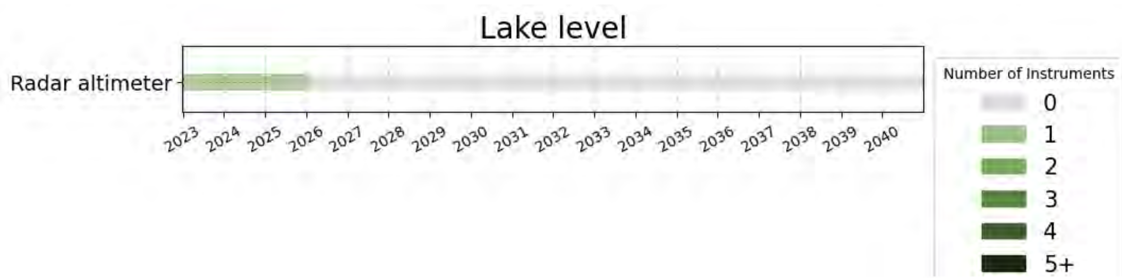
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
35-A	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify the long-term present-day sediment discharge to the oceans, and locate modern sedimentation zones, at the mouth of major rivers. An objective could be to resolve accumulations of ~0.5 cm year −1 of sediment at 200-km spatial resolution, close to the highest river discharges (Amazon, Ganges-Brahmaputra, Yangtze, ...).	Supporting
35-B	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Resolve large variations in sediment discharge following typhoons and El Nino events. So far only accumulated sediment over long time periods could be considered, in order to build up enough mass to be detected by GRACE. With a higher sensitivity, the detection of temporal	Supporting

		variations in sediment discharge might be considered.	
44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
44-C	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify variability and trends of water availability: effects of water and land use and climate changes on the variability (including extremes) of the regional and continental water cycle	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	0
2031 (8 years from now)	0
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline

Instruments

Instruments recorded in ESSFS D4 as measuring Lake level

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
Ka-band Radar INterferometer (KaRIN)	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1541

Chlorophyll Fluorescence from Vegetation on Land

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *Solar induced chlorophyll fluorescence occurs during photosynthesis. It exhibits a strong linear correlation with terrestrial gross primary production (GPP). Direct global space borne observations of the fluorescence emission provide the same or better GPP estimations as those derived from traditional remotely-sensed vegetation indices using ancillary data and model assumptions.*

CEOS Database entry for Chlorophyll Fluorescence from Vegetation on Land: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=250

Related Candidate Science Questions

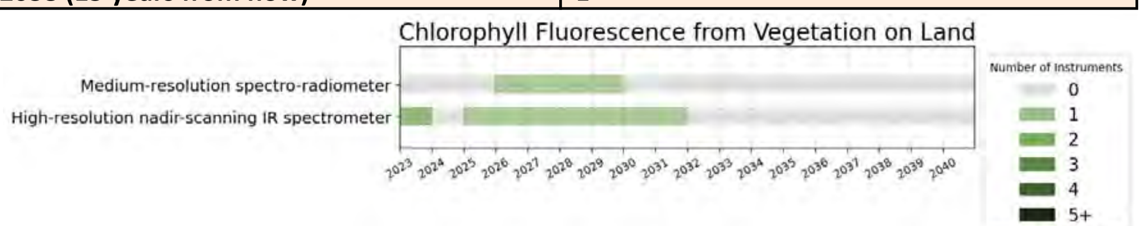
ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Critical

2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Critical
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Critical
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	Critical
43-B	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	2). Quantify role of surface and UTLS forcings in ABL processes: - role of sensible and latent energy and water exchanges at the Earth's surface versus within the atmosphere (i.e., horizontal advection and upper troposphere - lower stratosphere (UTLS) exchanges)	Critical
55-A	What are local patterns of ecosystem structure and composition worldwide?	Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on	Supporting

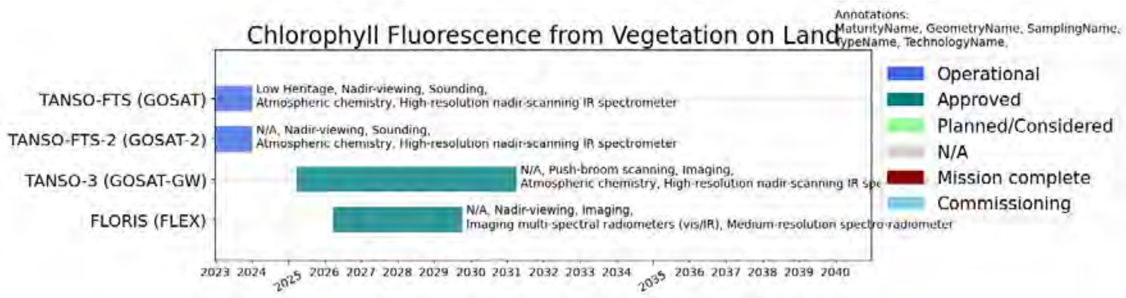
		the ground ecological and forest monitoring networks	
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	2
2031 (8 years from now)	2
2033 (10 years from now)	1
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Chlorophyll Fluorescence from Vegetation on Land

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
TANSO-FTS	General Utility	GOSAT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=905
TANSO-FTS-2	General Utility	GOSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1655
TANSO-3	General Utility	GOSAT-GW	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1805
FLORIS	Marginal Utility	FLEX	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1778

Lake Area

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Inland Waters

Category description: *Observations of inland water systems, for example lakes and rivers.*

Measurement definition: *Area extent of the surface of a lake- Physical unit: [m2] - Accuracy unit: [m2].*

CEOS Database entry for Lake Area: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=254

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/92

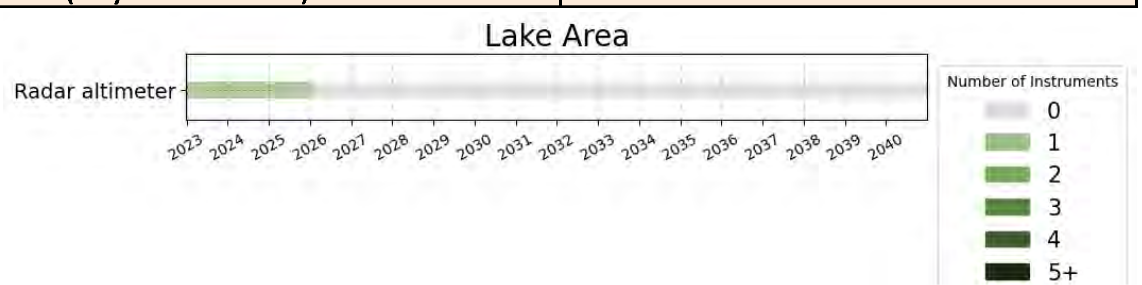
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
44-C	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify variability and trends of water availability: effects of water and land use and climate changes on the variability (including extremes) of the regional and continental water cycle	Critical
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat	Global budget closure	Supporting

	inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	0
2031 (8 years from now)	0
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline

Instruments

Instruments recorded in ESSFS D4 as measuring Lake Area

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
Ka-band Radar INterferometer (KaRIN)	High Utility	SWOT	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1541

Sea-ice motion

Date generated: 2023-11-24

Measurement Domain: Snow & Ice

Measurement Category: Sea ice cover, edge and thickness

Category description: *Sea ice variability is a key indicator of climate variability and change which is characterised by a number of parameters. In addition to monitoring ice extent (the total area covered by ice at any concentration) and concentration (the area covered by ice per unit area of ocean), it is necessary to know ice thickness in order to estimate sea ice volume or mass balance.*

Measurement definition: *Sea ice motion*
*Measuring Units km*d-1*
*Uncertainty Units km*d-1*

CEOS Database entry for Sea-ice motion: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=255

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/198

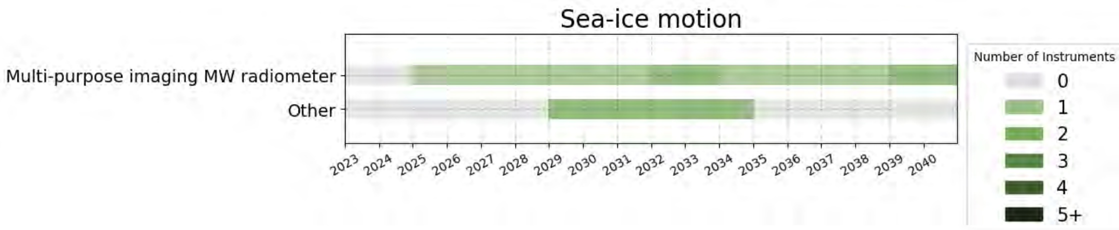
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
21-A	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine what physical processes drive ice dynamic variability	Critical
21-B	What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?	Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets.	Critical
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Supporting

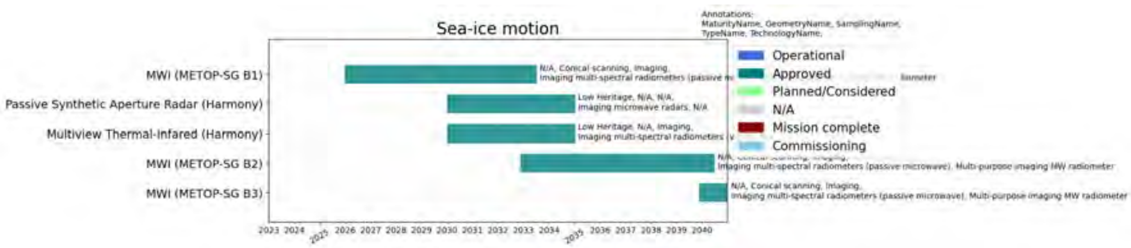
Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	1

2031 (8 years from now)	3
2033 (10 years from now)	4
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea-ice motion

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
MWI	General Utility	METOP-SG B1, METOP-SG B2, METOP-SG B3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1630
Passive Synthetic Aperture Radar	General Utility	Harmony	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2020
Multiview Thermal-Infared	General Utility	Harmony	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2021

Upwelling (Outgoing) Short-wave Radiation at the Earth Surface

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Radiation budget

Category description: *The Earth's radiation budget is the balance within the climate system between the energy that reaches the Earth from the Sun and the energy that returns from Earth to space. The goal of such measurements is to determine the amount of energy emitted and reflected by the Earth. This is necessary to understand the processes by which the atmosphere, land and oceans transfer energy to achieve global radiative equilibrium, which in turn is necessary to simulate and predict climate.*

Measurement definition: *Flux of short-wave radiation from the Earth's surface - Physical unit: [W/m2] - Accuracy unit: [W/m2].*

CEOS Database entry for Upwelling (Outgoing) Short-wave Radiation at the Earth Surface: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=260

Related Candidate Science Questions

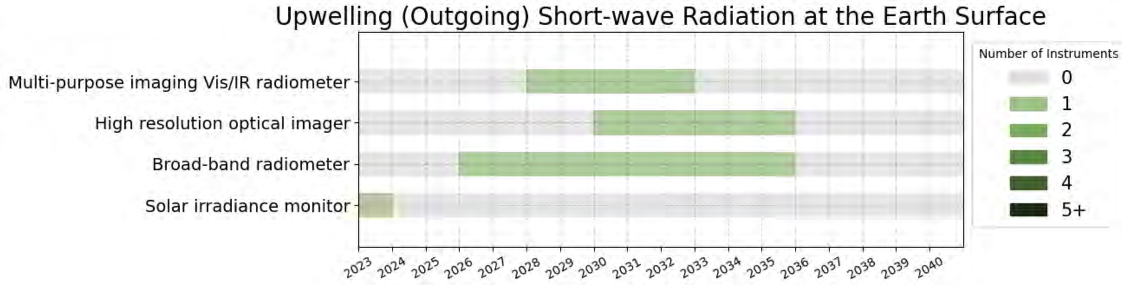
ID	CSQ	KAO	Priority Level
43-C	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	3). Quantify circulation controls: influence of the large-scale circulations of the atmosphere and oceans on exchanges between water, energy and carbon	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from	Global budget closure studies for the global energy budget relation	Critical

	this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Supporting
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Supporting
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Supporting

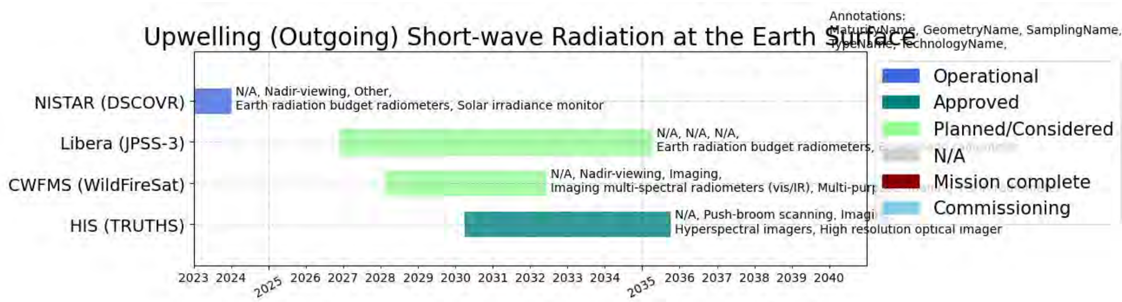
Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	2

2031 (8 years from now)	3
2033 (10 years from now)	2
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Upwelling (Outgoing) Short-wave Radiation at the Earth Surface

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
NISTAR	General Utility	DSCOVR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=647
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
Libera	General Utility	JPSS-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1904
HIS	General Utility	TRUTHS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1954

Above Ground Biomass (AGB)

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Vegetation

Category description: *Changes in land cover are important aspects of global environmental change, with implications for ecosystems, biogeochemical fluxes and global climate. Land cover change affects climate through a range of factors from albedo to emissions of greenhouse gases from the burning of biomass. Deforestation increases the amount of carbon dioxide (CO2) and other trace gases in the atmosphere.*

Measurement definition: *Total amount of vegetation in a reference area - Physical unit: [t/ha (tons/hectare)] - Accuracy unit: [t/ha]*

CEOS Database entry for Above Ground Biomass (AGB): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=268

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/15

Related Candidate Science Questions

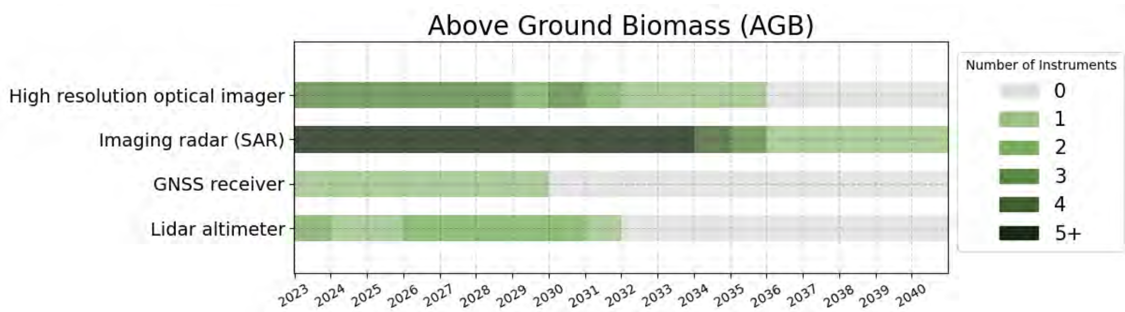
ID	CSQ	KAO	Priority Level
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Critical
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across	Critical

		equatorial Africa, the Amazon basin and Oceania	
2-C	How has the land biosphere responded to human activity and climate change?	Quantify above ground biomass (AGB) in tropical and extratropical forests to the accuracy needed to resolve changes in stocks on sub-decadal time scales	Critical
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Critical
43-A	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	Quantify the inter-relationships between Earth's energy, water and carbon cycles in order to advance our understanding of the Earth system and our ability to predict it across scales. 1). Advance forcing-feedback understanding: What are the main climate forcings and feedbacks formed by energy, water and carbon exchanges?	Critical
43-B	What are the main coupling determinants between Earth's energy, water and carbon cycles and how accurately can we predict the forcings and feedbacks between the different components of the Earth system?	2). Quantify role of surface and UTLS forcings in ABL processes: - role of sensible and latent energy and water exchanges at the Earth's surface versus within the atmosphere (i.e., horizontal advection and upper troposphere - lower stratosphere (UTLS) exchanges)	Critical
55-B	What are local patterns of ecosystem structure and composition worldwide?	Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting

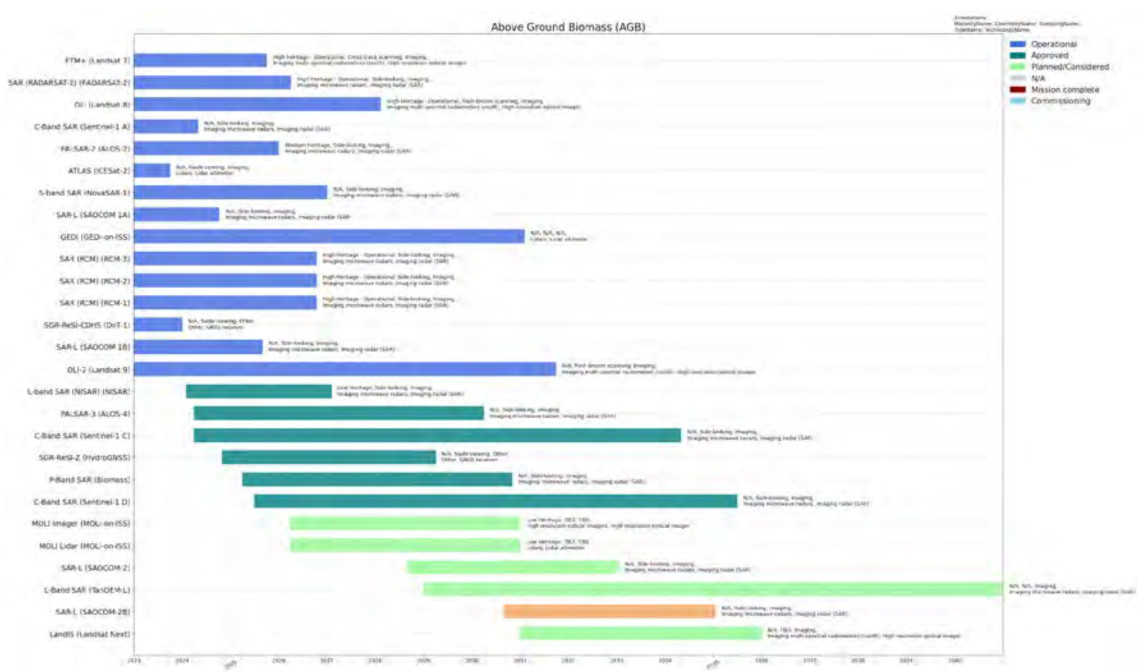
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	11
2031 (8 years from now)	8
2033 (10 years from now)	6
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Above Ground Biomass (AGB)

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SGR-ReSI-Z	High Utility	HydroGNSS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1939
ETM+	General Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
OLI	General Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
OLI-2	General Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769
LandIS	General Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
MOLI Imager	General Utility	MOLI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2051
MOLI Lidar	General Utility	MOLI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2052
SGR-ReSI-CD HS	General Utility	DoT-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2097
SAR-L	Potential Utility	SAOCOM-2B, SAOCOM-2, SAOCOM 1A, SAOCOM 1B	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=731
SAR (RADARSAT-2)	Marginal Utility	RADARSAT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=703
C-Band SAR	Marginal Utility	Sentinel-1 A, Sentinel-1 D, Sentinel-1 B, Sentinel-1 C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=939
SAR (RCM)	Marginal Utility	RCM-1, RCM-2, RCM-3	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=946
ATLAS	Marginal Utility	ICESat-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=998

L-band SAR (NISAR)	Marginal Utility	NISAR	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1526
PALSAR-2	Marginal Utility	ALOS-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1589
GEDI	Marginal Utility	GEDI-on-ISS	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1717
P-Band SAR	Marginal Utility	Biomass	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1722
L-Band SAR	Marginal Utility	TanDEM-L	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1777
S-band SAR	Marginal Utility	NovaSAR-1	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1797
PALSAR-3	Marginal Utility	ALOS-4	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1803

CH4 Total Column

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Trace gases (excluding ozone)

Category description: *Trace gases other than ozone may be divided into three categories: greenhouse gases affecting climate change; chemically aggressive gases affecting the environment (including the biosphere); and, gases and radicals impacting on the ozone cycle, thereby affecting both climate and environment. Measurements include the concentration of trace gasses, column totals and integrated column measurements, and profiles of gas concentration.*

Measurement definition: *2D field of total amount of CH4 molecules per unit area in an atmospheric column extending from the Earth's surface to the upper edge of the atmosphere - Measuring Units molecules.cm-2, Uncertainty Units %*

CEOS Database entry for CH4 Total Column: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=272

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/315

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO2 and CH4 emissions from both anthropogenic and natural sources and CO2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	Critical

Instruments

No instruments recorded in D4 for CH4 Total Column

CO2 Total Column

Date generated: 2023-11-24

Measurement Domain: Atmosphere

Measurement Category: Trace gases (excluding ozone)

Category description: *Trace gases other than ozone may be divided into three categories: greenhouse gases affecting climate change; chemically aggressive gases affecting the environment (including the biosphere); and, gases and radicals impacting on the ozone cycle, thereby affecting both climate and environment. Measurements include the concentration of trace gasses, column totals and integrated column measurements, and profiles of gas concentration.*

Measurement definition: *2D field of total amount of CO2 molecules per unit area in an atmospheric column extending from the Earth's surface to the upper edge of the atmosphere - Measuring Units molecules.cm-2, Uncertainty Units %*

CEOS Database entry for CO2 Total Column: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=274

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/314

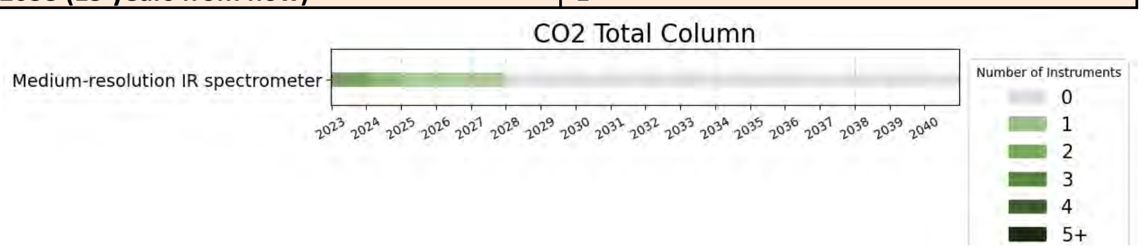
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-A	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO2 and CH4 emissions from both anthropogenic and natural sources and CO2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	Critical
3-C	How has the ocean carbon cycle responded to anthropogenic CO2 and climate change?	What is the impact of human activities and climate change on coastal processes that regulate the carbon sink, including river runoff, upwelling and biological productivity?	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And	Global budget closure studies for the global energy	Critical

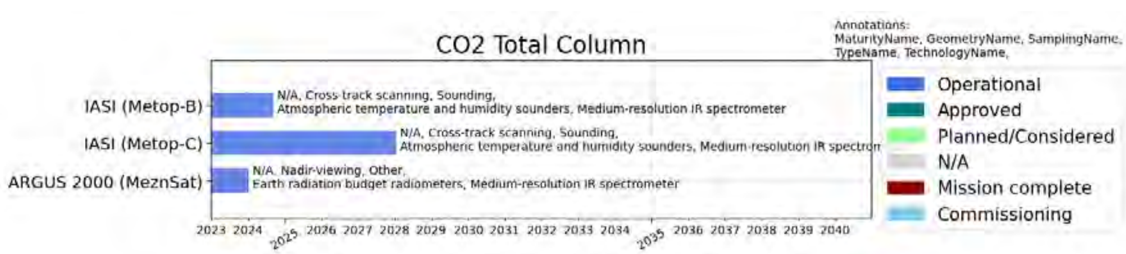
	what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	1
2031 (8 years from now)	1
2033 (10 years from now)	1
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring CO2 Total Column

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
IASI	General Utility	Metop-B, Metop-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=305
ARGUS 2000	Potential Utility	MeznSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1885

Coastal sea level (tide)

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean topography/currents

Category description: *Ocean surface topography data contain information that has significant practical applications in such fields as the study of worldwide weather and climate patterns, the monitoring of shoreline evolution and the protection of ocean fisheries. Ocean circulation is of critical importance to the Earth's climate system. Ocean currents transport a significant amount of energy from the tropics towards the poles, leading to a moderation of the climate at high latitudes. Circulation can be deduced from ocean surface topography, which may be readily measured using satellite altimetry.*

Measurement definition: *Deviation of sea level from local references in coastal zones, caused by local currents and tides (astronomical and wind-induced) - Measuring units cm, Uncertainty units cm*

CEOS Database entry for Coastal sea level (tide): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=279

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/40

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
5-A	What processes drive changes sea level in the coastal ocean?	Reduce uncertainties in observing, modelling and forecasting of water levels in coastal, estuarine and inland water bodies	Critical
5-B	What processes drive changes sea level in the coastal ocean?	Characterise the relative contributions to coastal sea level changes by steric and other physical processes	Critical
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical

7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical

Instruments

No instruments recorded in D4 for Coastal sea level (tide)

Dissolved inorganic carbon (DIC)

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean colour/biology

Category description: *Remote sensing measurements of ocean colour (i.e. the detection of phytoplankton pigments) provide the only global-scale focus on the biology and productivity of the ocean's surface layer. Phytoplankton are microscopic plants that live in the ocean, and like terrestrial plants, they contain the pigment chlorophyll, which gives them their greenish colour. Different shades of ocean colour reveal the presence of differing concentrations of sediments, organic materials and phytoplankton. The ocean over regions with high concentrations of phytoplankton is shaded from blue-green to green, depending on the type and density of the phytoplankton population. From space, satellite sensors can distinguish even slight variations in colour which cannot be detected by the human eye.*

Measurement definition: *The cumulated concentration of inorganic carbon species (dissolved carbon dioxide, carbonic acid, bicarbonate and carbonate) in solution - Units Mol. Kg-1*

CEOS Database entry for Dissolved inorganic carbon (DIC): https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=280

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/47

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
25-A	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Determine the impact of the cryosphere on Polar ecosystems, such as through freshwater input to the ocean	Critical
25-B	How does the cryosphere impact on Polar ecosystems, and how is the changing climate altering these feedbacks?	Measure how change in the polar regions is impacting these feedbacks, e.g. through nutrient cycling and primary productivity.	Critical

Instruments

No instruments recorded in D4 for Dissolved inorganic carbon (DIC)

Ocean salinity

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean Salinity

Category description: *Ocean salinity measurements are important because surface salinity and temperature control the density and stability of the surface water. Thus, ocean mixing (of heat and gases) and water-mass formation processes are intimately related to variations of surface salinity. Ocean modelling and analysis of water mass mixing should be enabled by new knowledge of surface-density fields derived from surface salinity measurements. The importance of the ocean in the global hydrological cycle also cannot be overstated. Some ocean models show that sufficient surface freshening results in slowing down the meridional overturning circulation, thereby affecting the oceanic transport of heat.*

Measurement definition: *3D field of salinity of the ocean Requested in upper and deep ocean - Physical unit [psu], Practical Salinity Unit, close to 1*

CEOS Database entry for Ocean salinity: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=281

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/113

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Critical
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Critical
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Critical
8-A	How are coastal areas contributing to the global carbon cycle, and how	Global inventory of Blue carbon ecosystems, including mangroves, tidal	Supporting

	are they responding to climate change and human pressures?	marshes and seagrass beds	
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Critical

Instruments

No instruments recorded in D4 for Ocean salinity

Ocean subsurface dissolved oxygen concentration

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean colour/biology

Category description: *Remote sensing measurements of ocean colour (i.e. the detection of phytoplankton pigments) provide the only global-scale focus on the biology and productivity of the ocean's surface layer. Phytoplankton are microscopic plants that live in the ocean, and like terrestrial plants, they contain the pigment chlorophyll, which gives them their greenish colour. Different shades of ocean colour reveal the presence of differing concentrations of sediments, organic materials and phytoplankton. The ocean over regions with high concentrations of phytoplankton is shaded from blue-green to green, depending on the type and density of the phytoplankton population. From space, satellite sensors can distinguish even slight variations in colour which cannot be detected by the human eye.*

Measurement definition: *Concentration of dissolved oxygen - Measuring Units Mol. Kg^-1, Uncertainty Units Mol. Kg^-1*

CEOS Database entry for Ocean subsurface dissolved oxygen concentration: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=282

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/114

Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Critical
8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Critical

Instruments

No instruments recorded in D4 for Ocean subsurface dissolved oxygen concentration

Ocean temperature

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Surface temperature (ocean)

Category description: *Ocean surface temperature (often known as 'sea surface temperature' or SST) is one of the most important boundary conditions for the general circulation of the atmosphere. The ocean exchanges vast amounts of heat and energy with the atmosphere and these air/sea interactions have a profound influence on the Earth's weather and climate patterns. SST is linked closely with the ocean circulation, as demonstrated by the El Niño-Southern Oscillation (ENSO) cycle.*

Measurement definition: *3D field of temperature of the ocean Requested in the upper and deep ocean - Measuring and Uncertainty Units K*

CEOS Database entry for Ocean temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=284

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/118

Related Candidate Science Questions

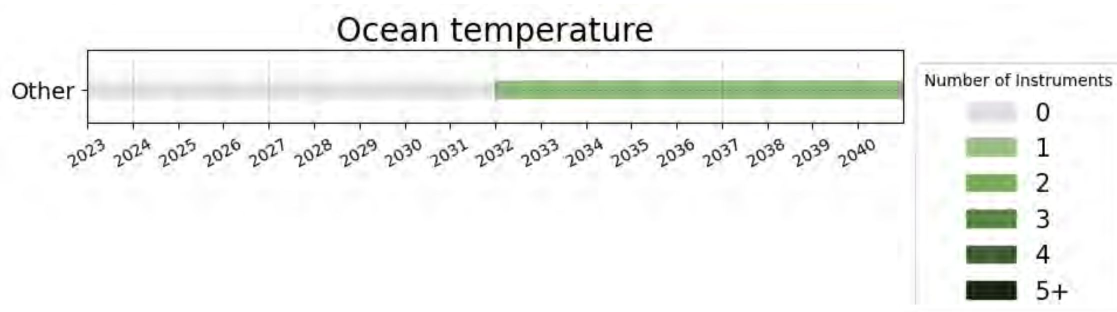
ID	CSQ	KAO	Priority Level
7-A	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the physical processes that control land-air-sea exchanges in coastal regions.	Supporting
7-B	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.	Supporting
7-C	How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?	Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.	Supporting
8-A	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds	Supporting

8-B	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean	Supporting
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice shelves, glaciers and ice caps, sea ice, permafrost and snow cover	Supporting
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Supporting
24-A	What is the impact of the Polar regions on global climate variability?	Determine what impact the polar regions have on global climate variability.	Critical
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting

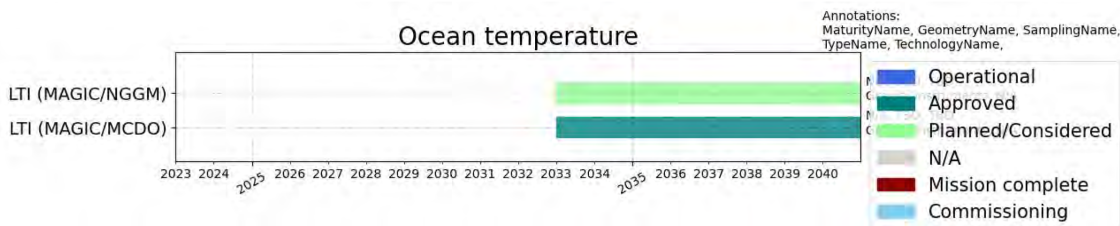
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	0
2031 (8 years from now)	0
2033 (10 years from now)	2
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Ocean temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056

Ocean velocity

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Ocean topography/currents

Category description: *Ocean surface topography data contain information that has significant practical applications in such fields as the study of worldwide weather and climate patterns, the monitoring of shoreline evolution and the protection of ocean fisheries. Ocean circulation is of critical importance to the Earth's climate system. Ocean currents transport a significant amount of energy from the tropics towards the poles, leading to a moderation of the climate at high latitudes. Circulation can be deduced from ocean surface topography, which may be readily measured using satellite altimetry.*

Measurement definition: *Ocean motion measured at various depth levels - Measuring and Uncertainty Units cm/s*

CEOS Database entry for Ocean velocity: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=285

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/119

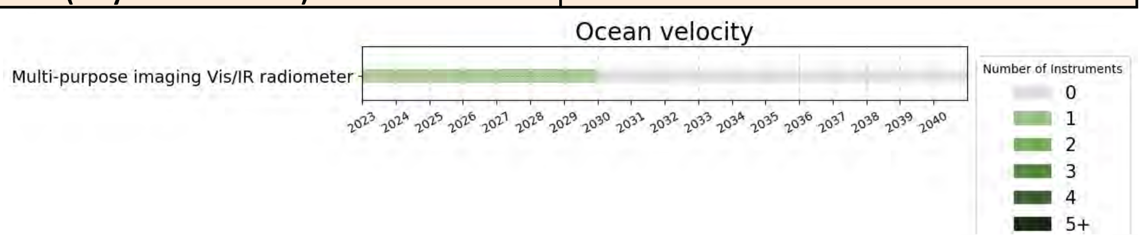
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
8-C	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in "Blue carbon" ecosystems, and their resilience to human and climate change pressures in different coastal regions	Supporting
8-D	How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?	Determine contribution and drivers of change in permafrost in the polar coastal ocean, and its resilience to human and climate change pressures in different coastal regions	Supporting
20-A	What is the mass balance of the cryosphere and how is it changing over time?	Measure the change in the mass balance of all components of the cryosphere system, including ice sheets and ice	Supporting

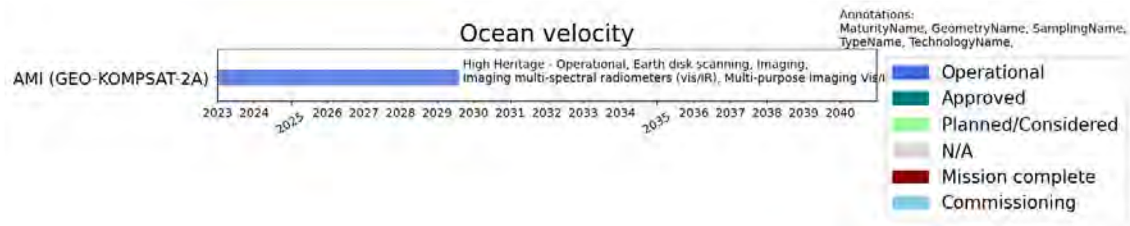
		shelves, glaciers and ice caps, sea ice, permafrost and snow cover	
20-B	What is the mass balance of the cryosphere and how is it changing over time?	Measure the regional pattern of variability in ice mass loss.	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	1
2031 (8 years from now)	0
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Ocean velocity

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
AMI	General Utility	GEO-KOMPSAT-2A	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1575

Sea surface heat flux

Date generated: 2023-11-24

Measurement Domain: Ocean

Measurement Category: Surface temperature (ocean)

Category description: *Ocean surface temperature (often known as 'sea surface temperature' or SST) is one of the most important boundary conditions for the general circulation of the atmosphere. The ocean exchanges vast amounts of heat and energy with the atmosphere and these air/sea interactions have a profound influence on the Earth's weather and climate patterns. SST is linked closely with the ocean circulation, as demonstrated by the El Niño-Southern Oscillation (ENSO) cycle.*

Measurement definition: *Sea Surface Heat Flux - Measuring and Uncertainty Units W/m2*

CEOS Database entry for Sea surface heat flux: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=287

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/192

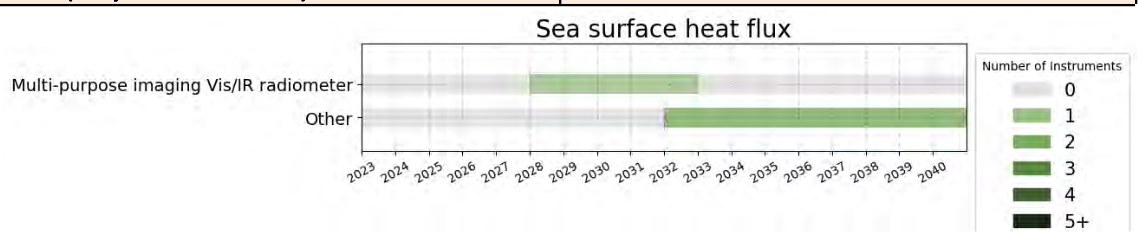
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning	Critical

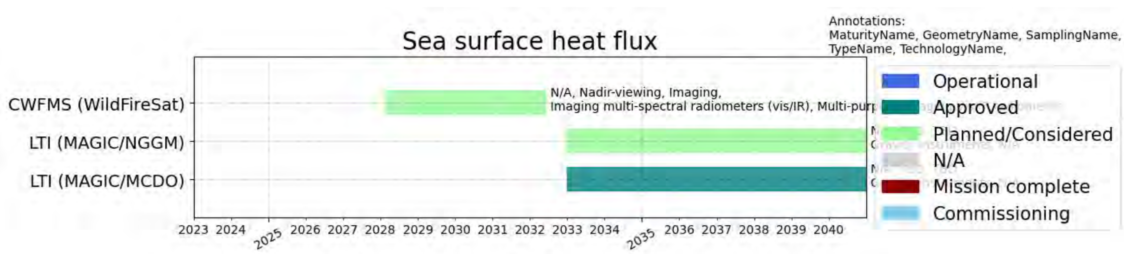
	advancements can we achieve for research and monitoring on weather and climate patterns?	of events such as heat waves and extreme precipitation, storms and long-term weather.	
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	1
2031 (8 years from now)	1
2033 (10 years from now)	2
2038 (15 years from now)	2



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Sea surface heat flux

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853

LTI	General Utility	MAGIC/NGGM, MAGIC/MCDO	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2056

Fire radiative power

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Albedo and reflectance

Category description: *Albedo is the fraction of solar energy that is diffusely reflected back from Earth to space. Measurements of albedo are essential for climate research studies and investigations of the Earth's energy budget. Different parts of the Earth have different albedos. For example, ocean surfaces and rain forests have low albedos, which means that they reflect only a small portion of the Sun's energy. Deserts, ice and clouds, however, have high albedos; they reflect a large portion of the incoming solar energy. The high albedo of ice helps to insulate the polar oceans from solar radiation.*

Measurement definition: *Power radiated by the fire occurring within an area. Physical unit [kW*m-2], Accuracy unit [kW*m-2]*

CEOS Database entry for Fire radiative power: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=288

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/61

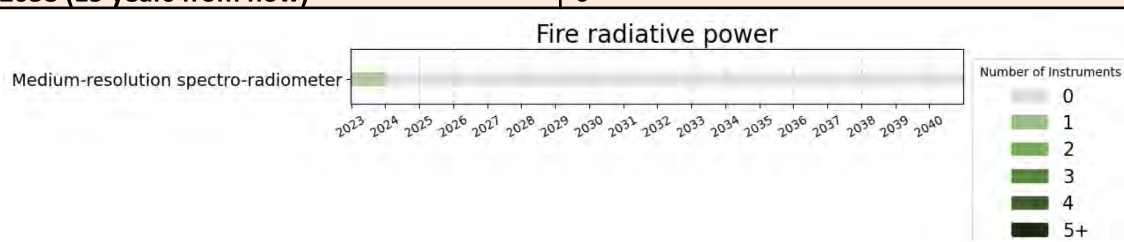
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
1-B	What anthropogenic and natural processes are driving the global carbon cycle?	Distinguish intense anthropogenic CO2 and CH4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	Supporting
1-C	What anthropogenic and natural processes are driving the global carbon cycle?	Quantify emissions and removals (fluxes) of CO2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	Critical
2-B	How has the land biosphere responded to	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical	Critical

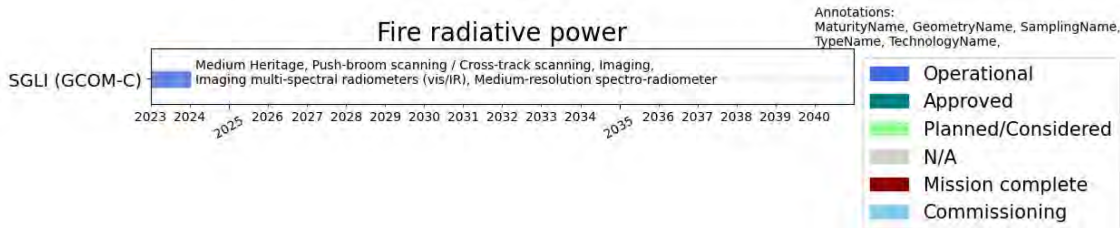
	human activity and climate change?	carbon sink across equatorial Africa, the Amazon basin and Oceania	
2-A	How has the land biosphere responded to human activity and climate change?	Quantify enhancements in the extra-tropical carbon sink over North America and Eurasia and identify human activities and climate variations driving these changes	Critical
2-B	How has the land biosphere responded to human activity and climate change?	Distinguish the relative roles of climate change and disturbances (wildfire and land use change) on the tropical carbon sink across equatorial Africa, the Amazon basin and Oceania	Supporting
2-D	How has the land biosphere responded to human activity and climate change?	Catalogue the impacts of climate change on crop health and forest mortality across the North American Great Plains, Central Europe and South and East Asia	Supporting
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting
56-A	Where and how are ecosystems undergoing critical transitions?	Assessing ecosystems heterogeneity (that is, spatial and temporal variation in ecological processes) for improved understanding of ecosystem resilience	Supporting
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	0
2031 (8 years from now)	0
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Fire radiative power

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
SGLI	Potential Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901

Lake Surface Temperature

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Inland Waters

Category description: *Observations of inland water systems, for example lakes and rivers.*

Measurement definition: *Temperature of the lake surface. - Physical unit: [K] - Accuracy unit: [K].*

CEOS Database entry for Lake Surface Temperature: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=293

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/94

Related Candidate Science Questions

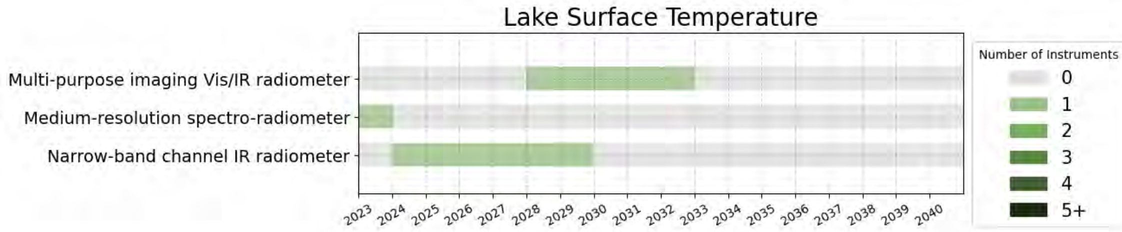
ID	CSQ	KAO	Priority Level
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved observational constraints for climate models	Supporting
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Critical
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take	Supporting

	response and climate sensitivity, as well as	stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Critical
48-A	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Thermodynamic coupling of the Earth's surface and the atmosphere to analyze critical feedback mechanisms, particularly for small-scale processes and variations to allow for improved weather and climate predictability	Critical
48-B	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Further develop better weather prediction on short time scales (2–12 weeks) aiming for advance warning of events such as heat waves and extreme precipitation, storms and long-term weather.	Critical
48-C	How can we improve the monitoring and understanding of planetary heat exchange at regional scale, and which essential advancements can we achieve for research and monitoring on weather and climate patterns?	Study the dynamic coupling for improved understanding of momentum and kinetic energy transfer between components of the Earth's system (ocean, atmosphere, cryosphere, land)	Critical
55-C	What are local patterns of ecosystem structure and composition worldwide?	What is the current state of land ecosystems and their functions?	Supporting

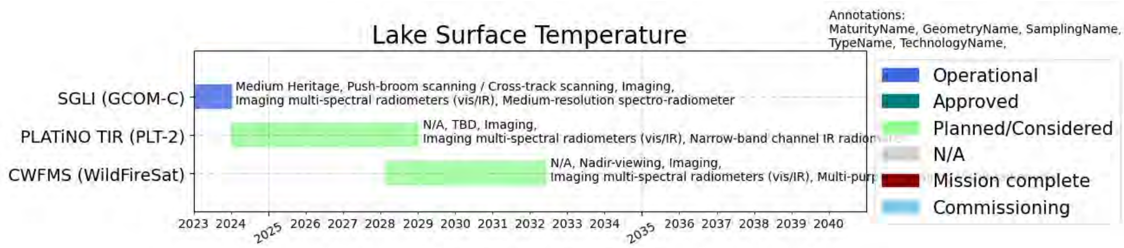
Heat Map Timeline

Year	**Number of predicted operational instruments**
2028 (5 years from now)	2
2031 (8 years from now)	1
2033 (10 years from now)	0

2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Lake Surface Temperature

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
CWFMS	General Utility	WildFireSat	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1853
PLATiNO TIR	General Utility	PLT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2039
SGLI	Potential Utility	GCOM-C	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=901

Evapotranspiration

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Surface temperature (land)

Category description: *Land surface temperature varies widely with solar radiation. It is of help in interpreting vegetation and its water stress when the range of temperatures between day and night and from clear sky to cloud cover are compared. On a local scale, surface temperature imagery may be used to refine techniques for predicting ground frost and to determine the warming effect of urban areas (urban heat islands) on night-time temperatures. In agriculture, temperature information may be used, together with models, to optimise planting times and provide timely warnings of frost. Measurements of surface temperature patterns may also be used in studies of volcanic and geothermal areas and resource exploration.*

Measurement definition: *The vaporisation of water through direct evaporation from wet surfaces plus the release of water vapour by plants through leaf pores. In remote sensing, evapotranspiration can be estimated using land surface temperature measurements.*

CEOS Database entry for Evapotranspiration: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=294

OSCAR Variable page: https://space.oscar.wmo.int/variables/view/187

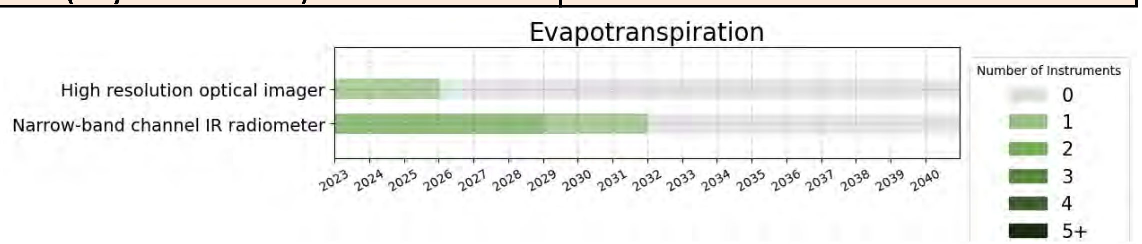
Related Candidate Science Questions

ID	CSQ	KAO	Priority Level
44-B	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Detect water management influences: extent to which water management practices and land use changes (e.g., deforestation) modified the water cycle on regional to global scales	Supporting
45-A	How can we improve estimates of the internal flow of energy within the climate system with respect to major uncertainties for equilibrium climate sensitivity evaluations?	Regional budget closure studies to further unravel regional uncertainties of surface observations, retrieval of energy flux and their parametrisation, and to allow for improved	Critical

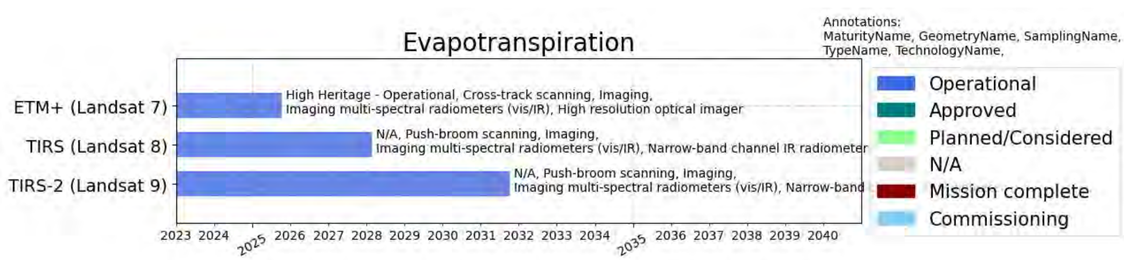
		observational constraints for climate models	
56-B	Where and how are ecosystems undergoing critical transitions?	Comprehensive assessment of ecosystem dynamics including the identification of critical changes in ecosystem resilience directly through monitoring disturbance frequency and recovery rates over time	Supporting

Heat Map Timeline

Year	Number of predicted operational instruments
2028 (5 years from now)	2
2031 (8 years from now)	1
2033 (10 years from now)	0
2038 (15 years from now)	0



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Evapotranspiration

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
TIRS	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524

TIRS-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746

Surface Water Extent

Date generated: 2023-11-24

Measurement Domain: Land

Measurement Category: Inland Waters

Category description: *Observations of inland water systems, for example lakes and rivers.*

Measurement definition: *The spatial extent of water on the surface of the Earth such as in a river, lake, ponds, wetland, or the ocean, as well as inundation due to flooding.*

CEOS Database entry for Surface Water Extent: https://database.eohandbook.com/measurements/instruments.aspx?measurementTypeWMOID=295

Related Candidate Science Questions

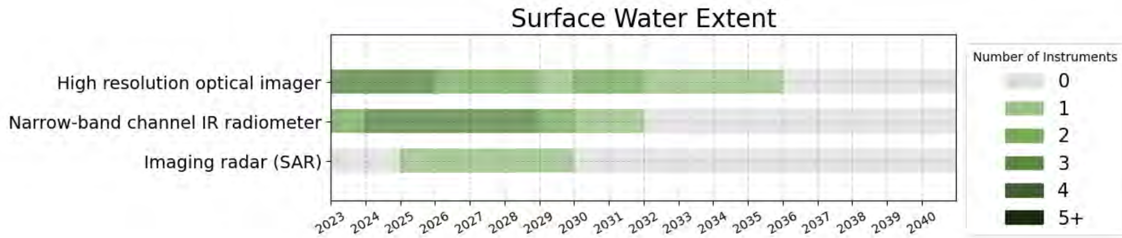
ID	CSQ	KAO	Priority Level
35-A	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Quantify the long-term present-day sediment discharge to the oceans, and locate modern sedimentation zones, at the mouth of major rivers. An objective could be to resolve accumulations of ~0.5 cm year −1 of sediment at 200-km spatial resolution, close to the highest river discharges (Amazon, Ganges-Brahmaputra, Yangtze, ...).	Supporting
35-B	Can we quantify erosional processes of drainage basins and the resulting sediments discharge to the oceans	Resolve large variations in sediment discharge following typhoons and El Nino events. So far only accumulated sediment over long time periods could be considered, in order to build up enough mass to be detected by GRACE. With a higher sensitivity, the detection of temporal variations in sediment discharge might be considered.	Supporting

44-A	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify anthropogenic forcing of continental scale water availability: extent to which the changing greenhouse effect modified the water cycle over different regions and continents	Supporting
44-C	How important are the anthropogenic influences on the water cycle and how accurate can we predict the anthropogenic influences on the water cycle?	Quantify variability and trends of water availability: effects of water and land use and climate changes on the variability (including extremes) of the regional and continental water cycle	Critical
46-A	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Earth heat inventory evaluation to unravel how much and where surplus heat from climate change is going	Supporting
46-B	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Global budget closure studies for the global energy budget relation linking planetary heating, effective radiative forcing, surface temperature response and climate sensitivity to take stock on the long-term change in the Earth energy imbalance, further tackle underlying uncertainties.	Supporting
46-C	How does the Earth energy imbalance and Earth heat inventory changes over time and why? And what can we learn from this for the interplay between effective radiative climate forcing, Earth's surface temperature response and climate sensitivity, as well as	Study the impact and causality of impacts of a changing Earth energy imbalance over time on planetary warming and associated implications for Earth system variability and change	Supporting

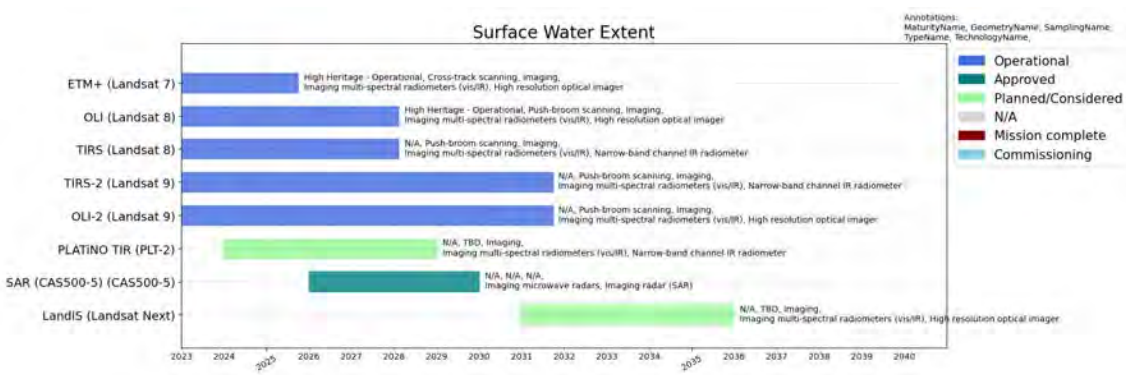
Heat Map Timeline

Year	Number of predicted operational instruments

2028 (5 years from now)	6
2031 (8 years from now)	4
2033 (10 years from now)	2
2038 (15 years from now)	1



Detailed Timeline



Instruments

Instruments recorded in ESSFS D4 as measuring Surface Water Extent

Instrument	Utility (as assessed by agency)	Missions	CEOS DB Entry
ETM+	High Utility	Landsat 7	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=322
OLI	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=897
TIRS	High Utility	Landsat 8	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1524
TIRS-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1746
OLI-2	High Utility	Landsat 9	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1769

SAR (CAS500-5)	High Utility	CAS500-5	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1992
LandIS	High Utility	Landsat Next	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1995
PLATiNO TIR	General Utility	PLT-2	https://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=2039