ESA POLAR SCIENCE CLUSTER
EO SCIENCE FOR SOCIETY

Copernicus Space Component – Evolution

PROGRAMME OF THE EUROPEAN UNION

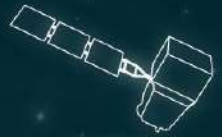
co-funded with esa

CHIME
Copernicus Hyperspectral Imaging Mission for the Environment

soil properties
crop health
raw materials
biodiversity
water quality

ROSE-L
L-band Radar Observing System

geohazards
polar ice
forest management
food security
maritime surveillance



LSTM
Land Surface Temperature Monitoring

sustainable agriculture
water resources management
drought
urban heat islands

Food Security and Water Management

Monitoring Land and Natural Resources

sea-ice concentration
sea-surface temperature
polar maritime security
global ocean and cryosphere
soil moisture and vegetation

CIMR
Copernicus Imaging Microwave Radiometer

CO2M
Copernicus Anthropogenic Carbon Dioxide Monitoring

carbon dioxide and methane from human activity

Combatting Climate Change

Copernicus Sentinel Expansion Missions

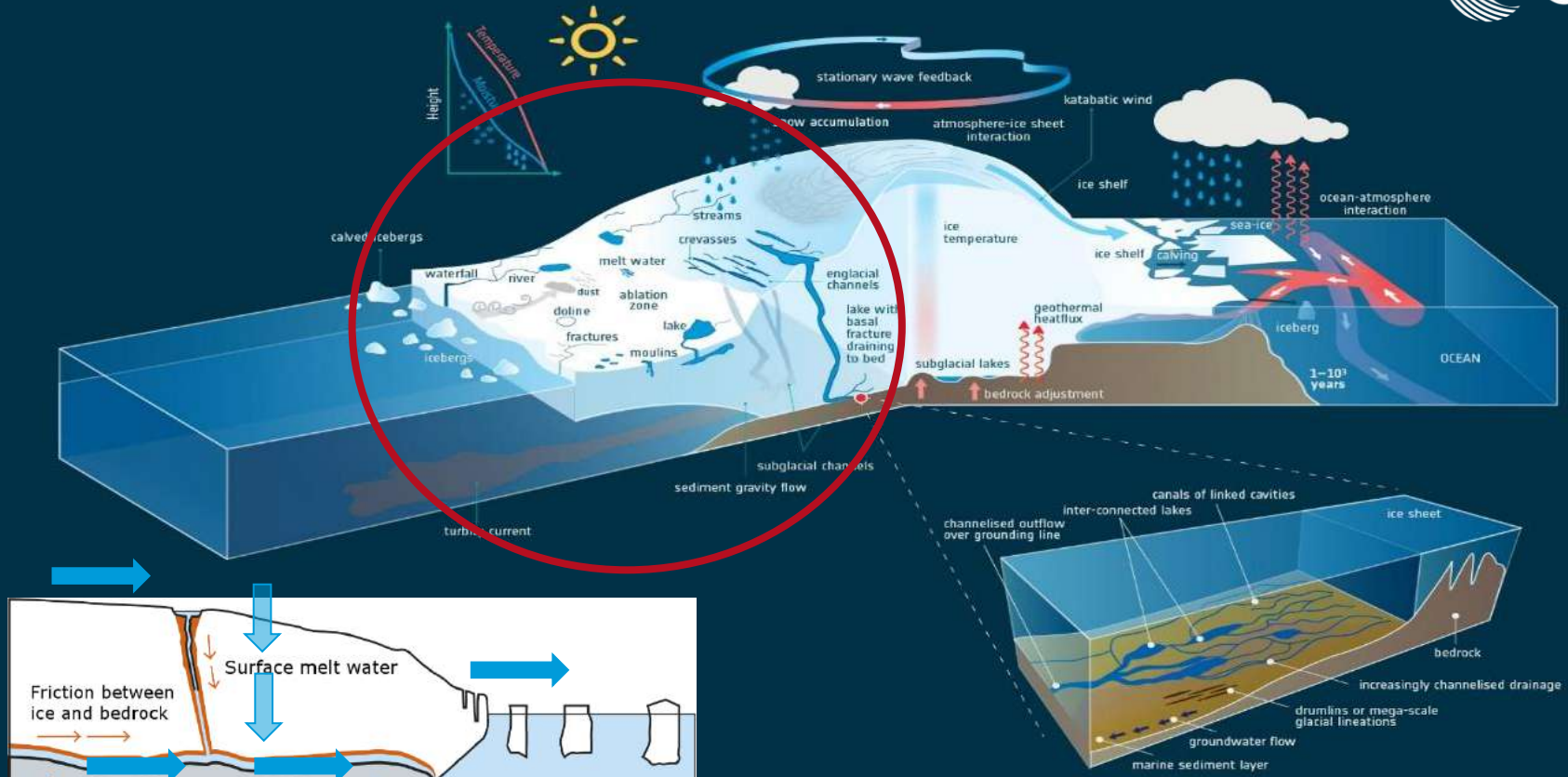
Safeguarding the Arctic

coastal and inland waters
polar oceanography
ice sheets and glaciers
snow
sea-ice thickness

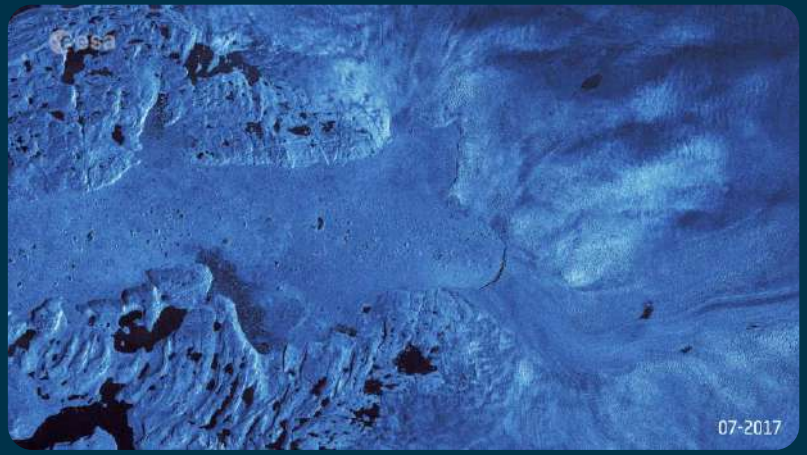
CRISTAL
Copernicus Polar Ice and Snow Topography Altimeter

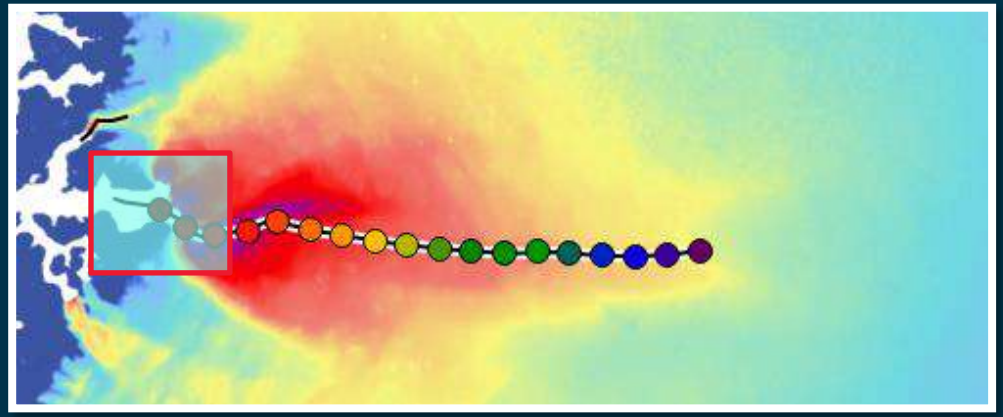
→ THE EUROPEAN SPACE AGENCY

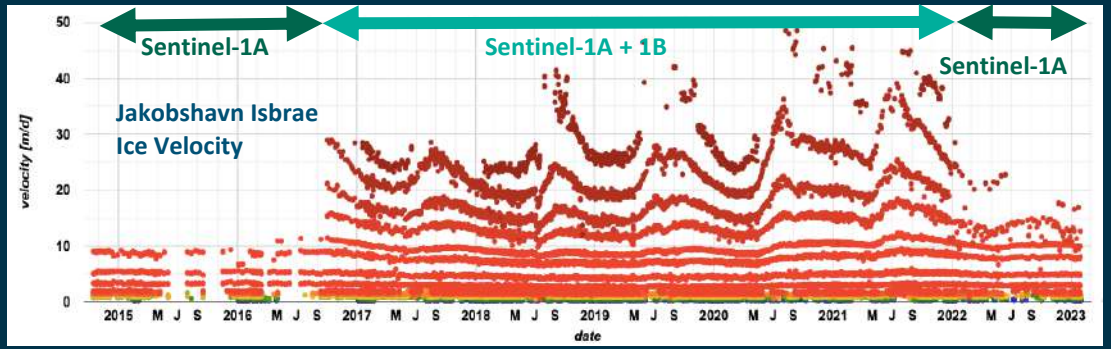
An integrated assessment of the hydrological cycle…

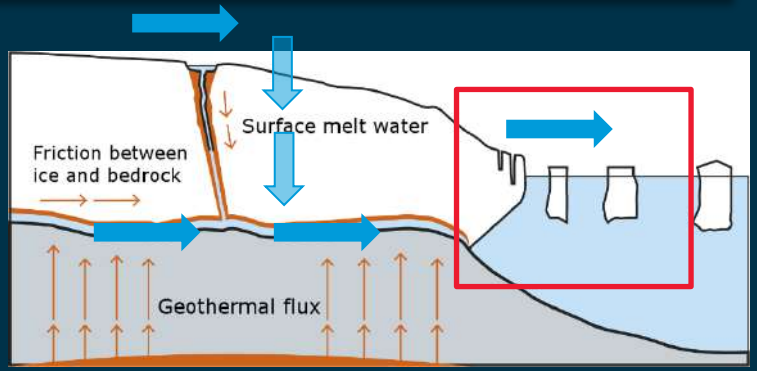


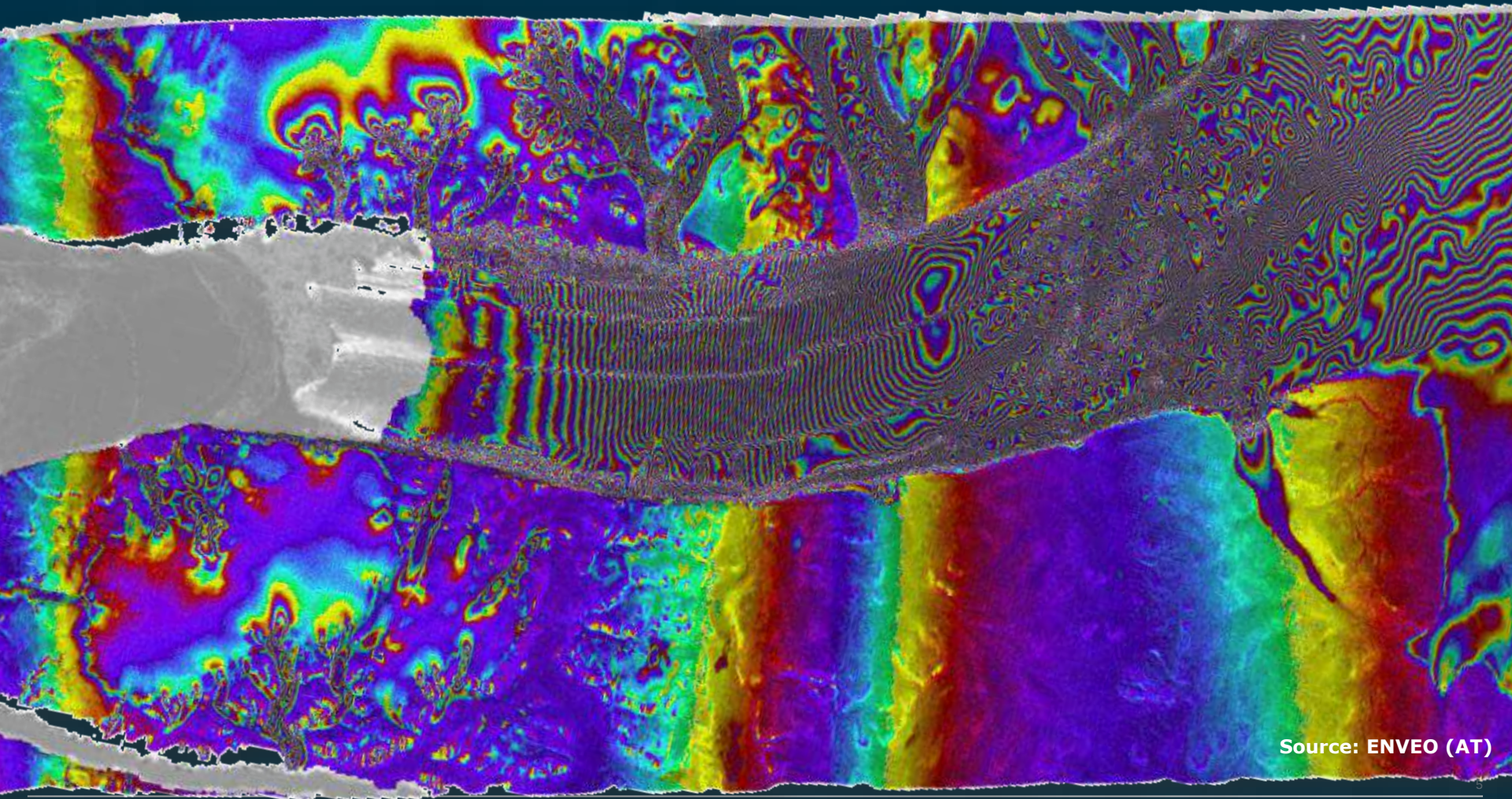
SAR Sentinel 1 glacier velocity (Source: ENVEO)





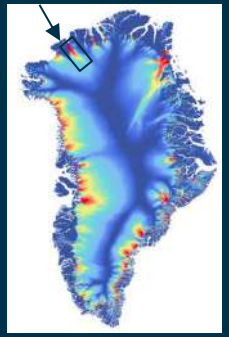




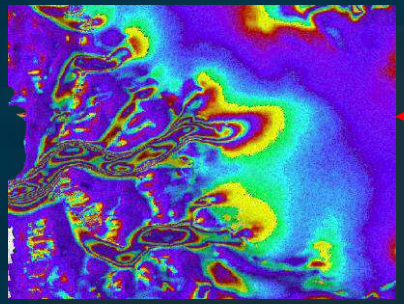

Source: ENVEO (AT)

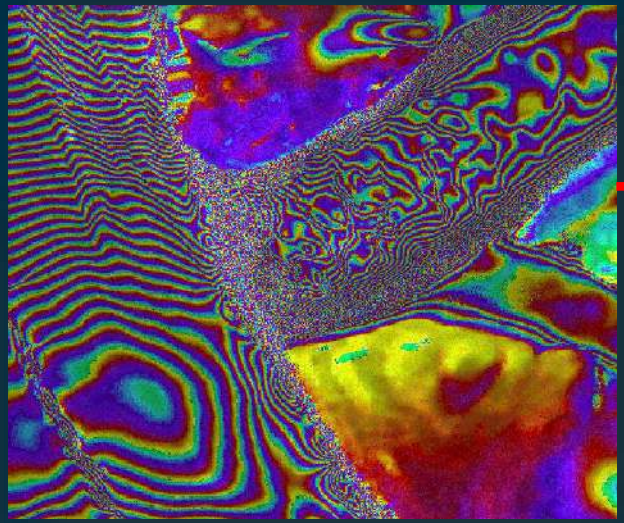
IV from L-Band SAR in preparation for ROSE-L

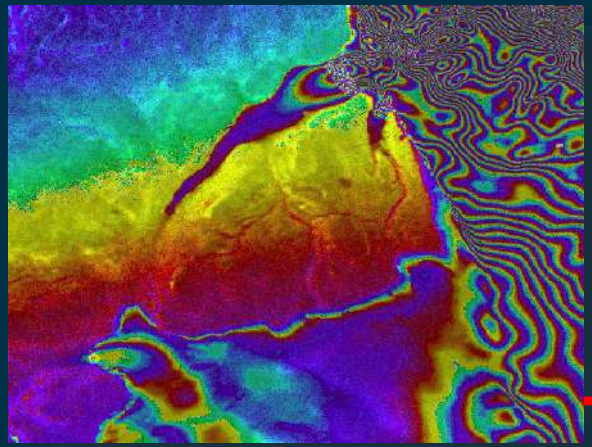
Source: ENVEO (AT)

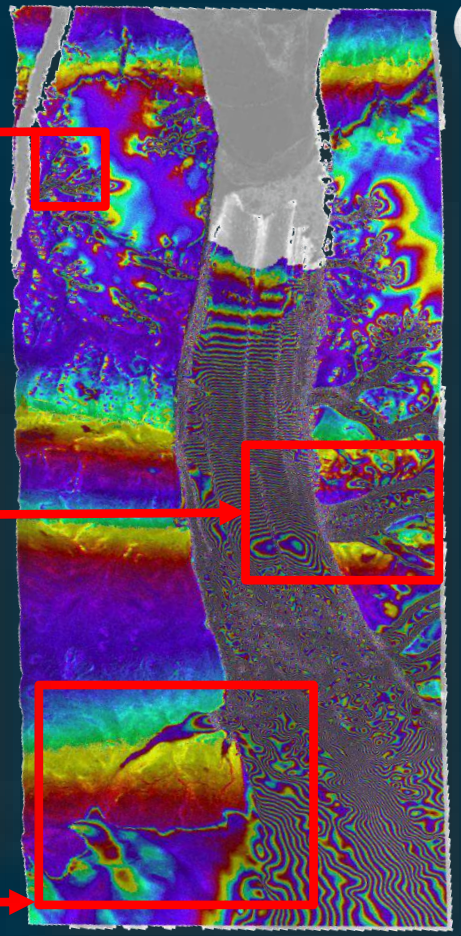


SAOCOM Stripmap
16 Feb – 24 Feb 2022
8 days repeat
Petermann Glacier



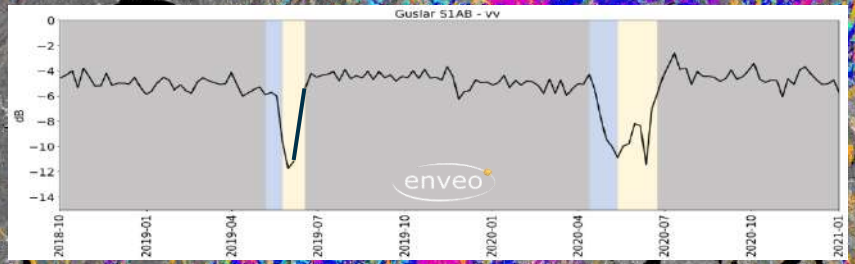


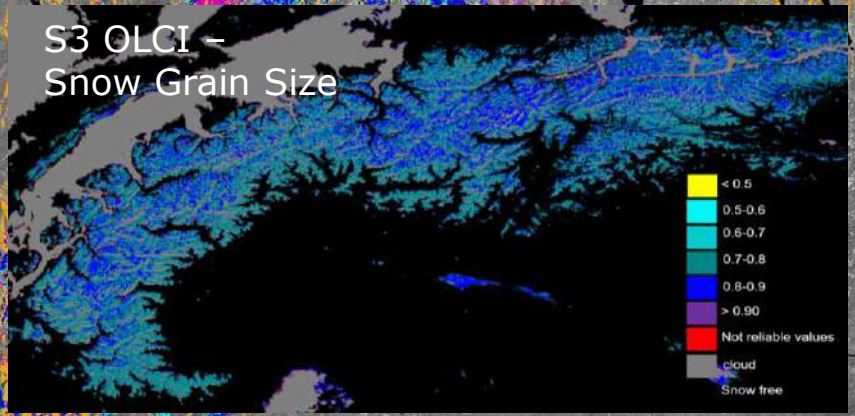




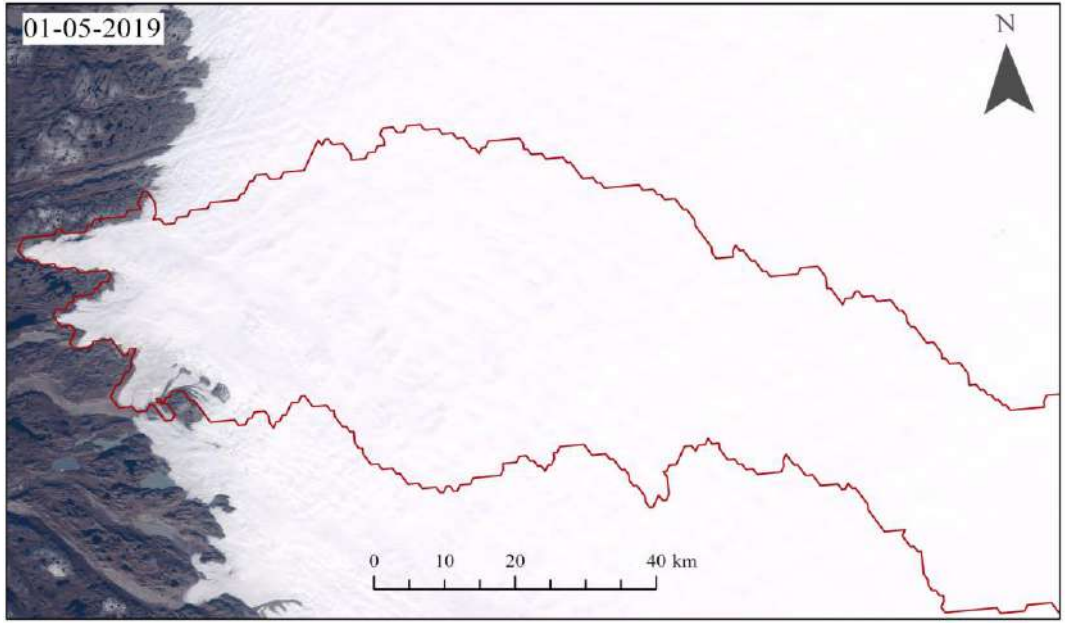
Advancing on physical snow parameters:

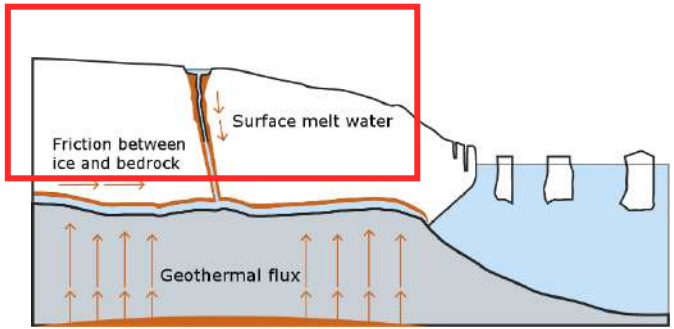
- Snow area extent
- Snow surface albedo & grain size
- Snowmelt area extent & melt phase
- Moving towards Snow water equivalent & snow depth





Supraglacial storage





- **Supraglacial lake extent** were delineated to classify water within S2 images.
- **Lake depths** were calculated using a radiative transfer model.
- **Total lake volume** was calculated by multiplying lake depths by lake area for each individual lake polygon and summing over the basin area. Volume uncertainty was determined via comparison with ICESat-2 transects.

Impacts of run-off on ocean biology

The Cryosphere, 16, 2471–2491, 2022
https://doi.org/10.5194/tc-16-2471-2022
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Article | Assets | Peer review | Metrics | Related articles

24 Jun 2022

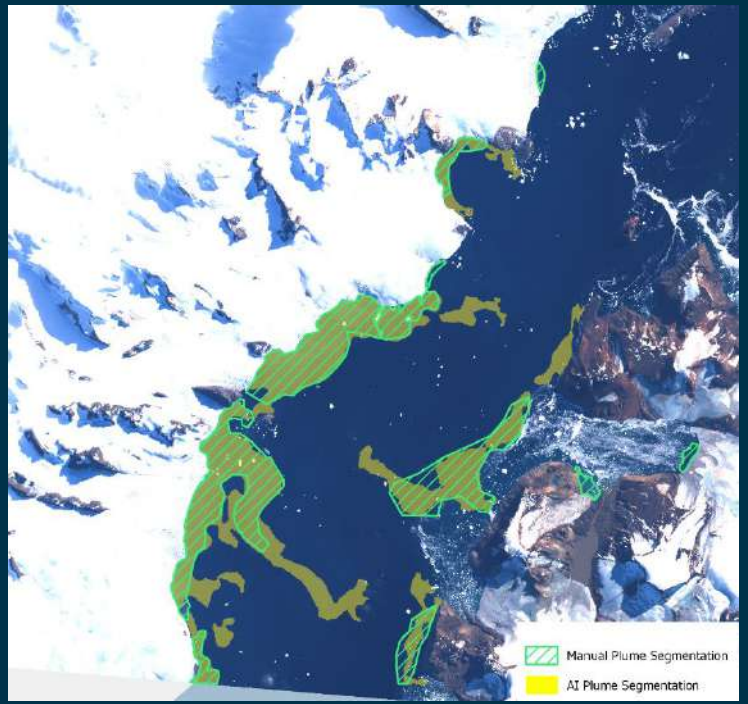
Research article | Highlight paper

Impact of freshwater runoff from the southwest Greenland Ice Sheet on fjord productivity since the late 19th century

Mimmi Oksman[1], Anna Bang Kvorning[1], Signe Hillerup Larsen[1], Kristian Kjellerup Kjeldsen[1], Kenneth David Mankoff[1], William Colgan[1], Thorbjørn Joest Andersen[2], Niels Nørgaard-Pedersen[3], Marit-Solveig Seidenkrantz[4], Naja Mikkelsen[1], and Sofia Ribeiro[1]

[1]Department of Glaciology and Climate, Geological Survey of Denmark and Greenland, Øster Voldgade 10, 1350 Copenhagen, Denmark
[2]Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, 1350 Copenhagen, Denmark
[3]Department of Marine Geology, Geological Survey of Denmark and Greenland, C.F. Møllers Allé 8, 8000 Aarhus C, Denmark
[4]Paleoceanography and Paleoclimate Group, Arctic Research Centre and iClimate centre, Department of Geoscience, Aarhus University, Hoegh-Guldbergs Gade 2, 8000 Aarhus C, Denmark

Correspondence: Mimmi Oksman (mio@geus.dk)



earthwave · The University of Edinburgh · NORCE · British Antarctic Survey · Sorbonne Université · University of Leeds

ESA Earth Explorer Missions

SMOS

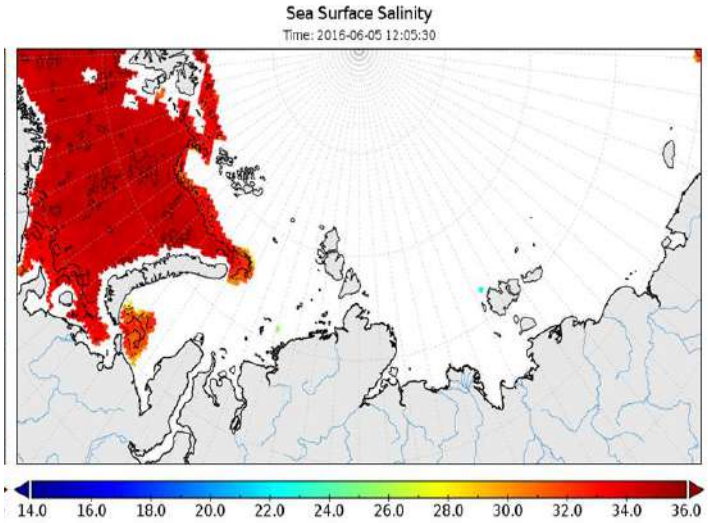
Measuring Soil Moisture and Ocean Salinity

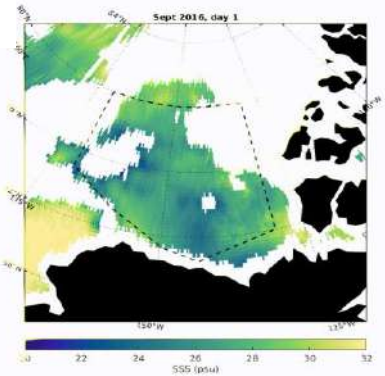
2009-

Study of ocean salinity, thin sea ice, alkalinity and ocean acidification

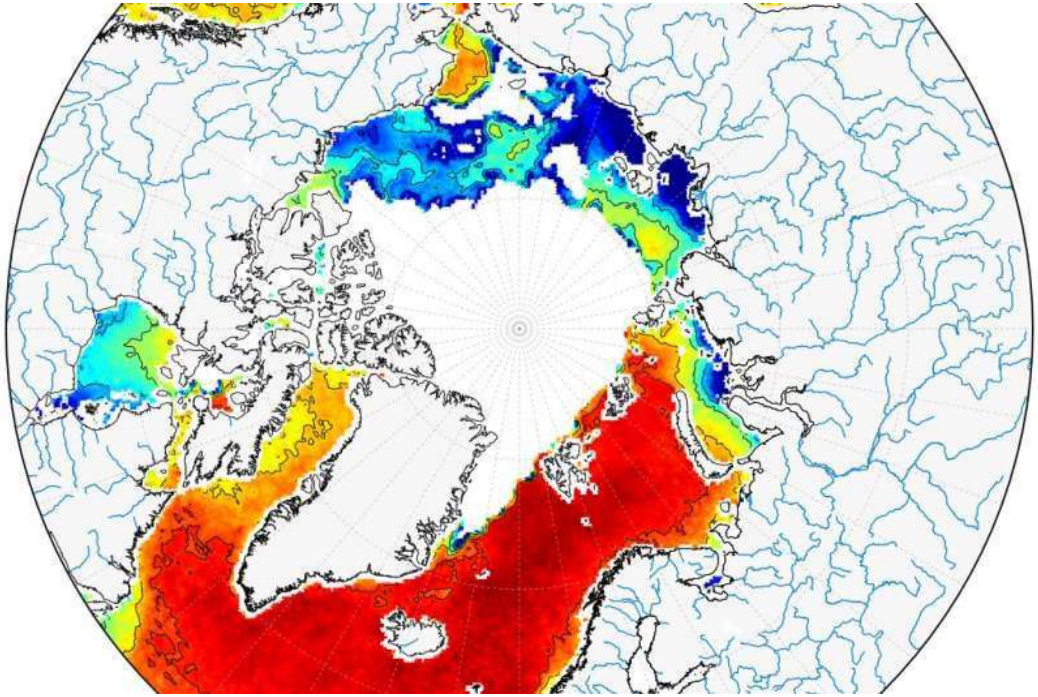
→ THE EUROPEAN SPACE AGENCY

New Arctic Sea Surface Salinity



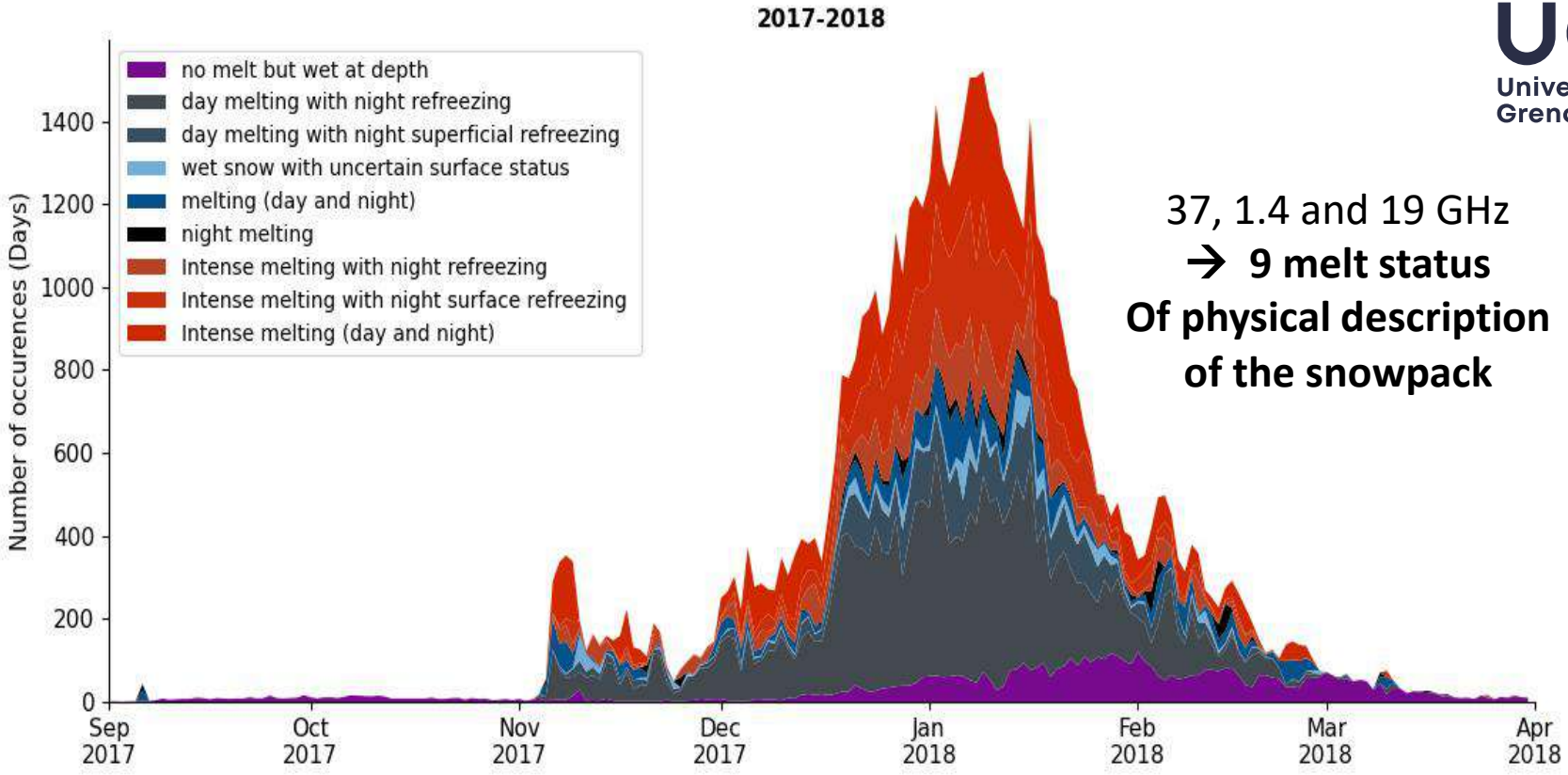


Fresh water inputs from rivers and surface freshwater lenses observed in the new enhanced SMOS salinity product for the Arctic



[Martinez et al. 2022]

Multifrequency passive-microwave snow



37, 1.4 and 19 GHz

→ **9 melt status**

Of physical description of the snowpack

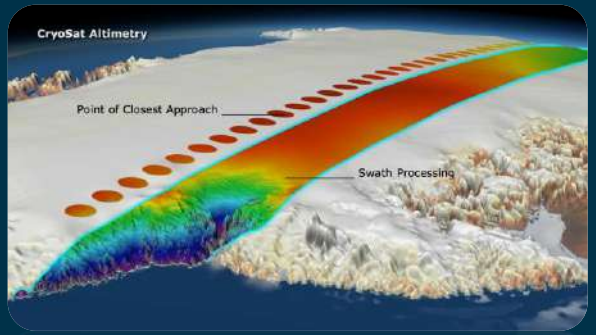
CRYOSAT

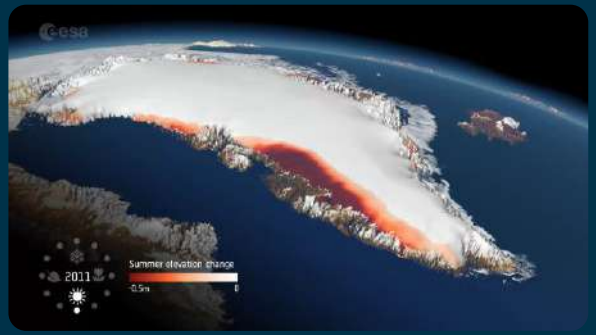
2010-

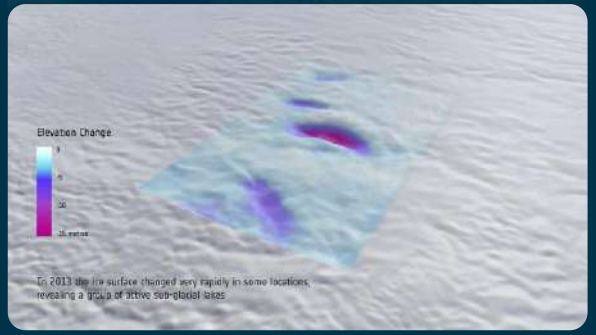
Study of sea ice, ice sheets and ocean surfaces using synthetic aperture radar altimetry.

Fundamental learning of SAR ice and ocean altimetry in Sentinel-3,6 and CRISTAL

CRYOSAT OPEN NEW OPPORTUNITIES





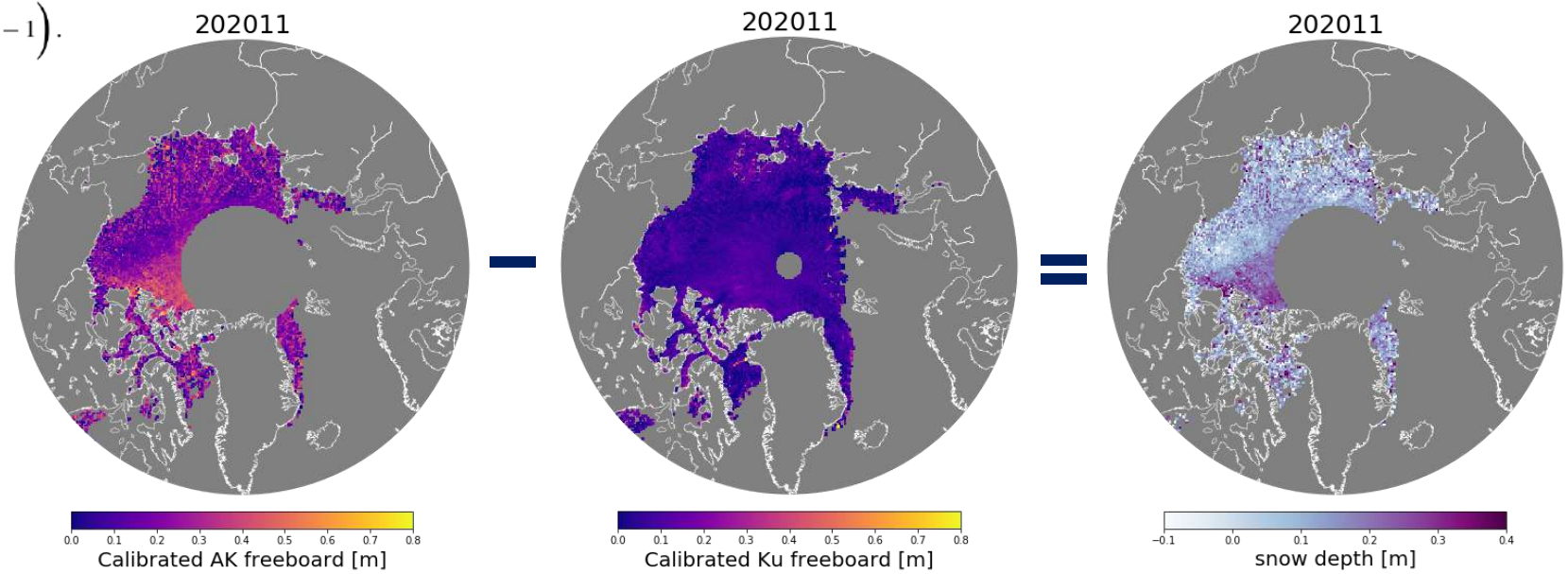


KuKa snow depth

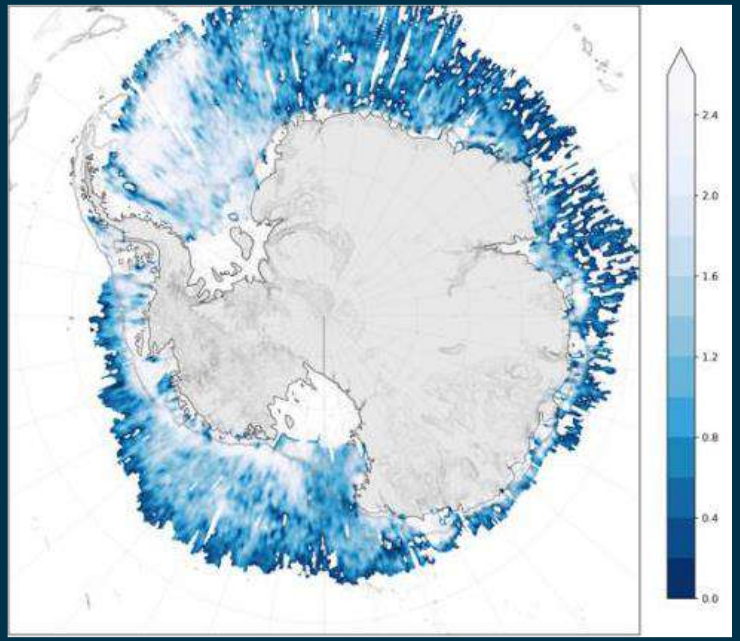
- **KuKa snow depth** = (Calibrated Ka freeboard – Calibrated Ku freeboard) x 0.781

$$f_r = f_i - h_s\left(\frac{c}{c_s} - 1\right).$$

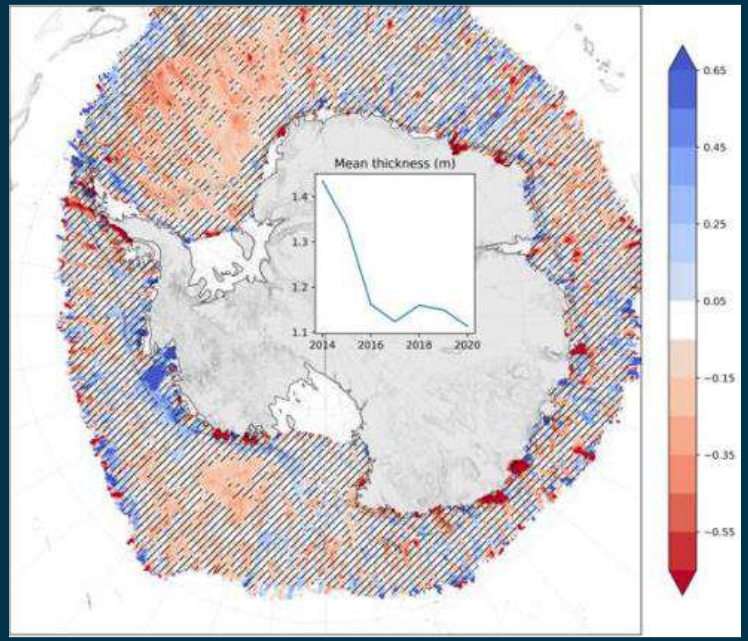
0.781 ×



Antarctica: New circumpolar, sea ice thickness products emerging from ESA Polar Cluster project CSAO…



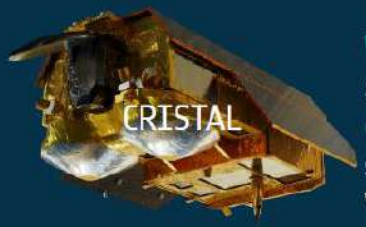
September sea ice thickness (m)



September sea ice thickness trend (m/yr)

Sentinel User Preparation (SUP) ESA EOP Initiative

Activity in collaborative synergy with the EC



WHAT

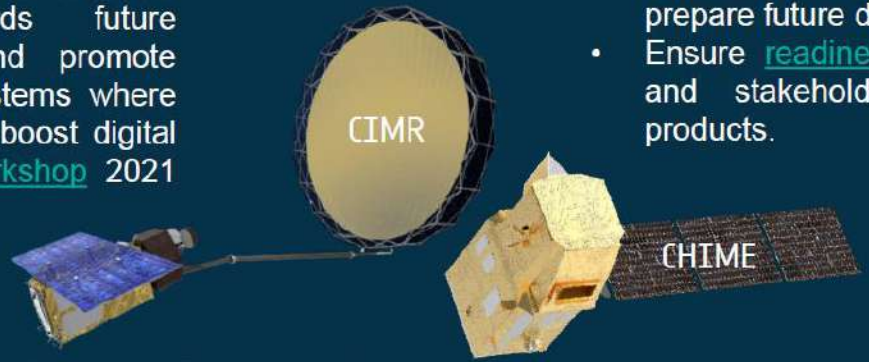
SUP is a preparatory program for the use of Copernicus Expansion/NG data. Strong support by MS and EARSC.
With a multi-mission approach.

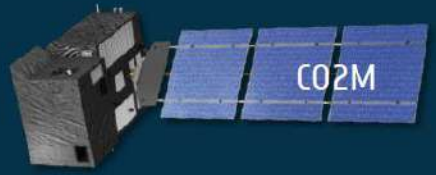
WHY

Supporting the integration of new Copernicus Expansion/NG datasets towards future operational working practices and promote European leadership for space systems where competitors are already active and boost digital commercialisation (ref. EARSC workshop 2021 with D-EOP).

HOW

- Build the necessary expertise in the various science and application domains and sectors (academia, value adding companies) to prepare future downstream services.
- Ensure readiness for rapid uptake by users and stakeholders of derived information products.





EFFECTS

- Readiness of science and downstream analytics to address societal/environmental challenges.
- Act as 'de-risking' factor and incentive for growth to maximise return-on-investment.

SUP Fundamental research and algorithm/products development/validation components

- Consolidate the scientific basis for key algorithms, novel methods and new products addressing innovative aspects beyond the single primary mission objectives and especially focusing on synergistic aspects.

- Generate recommendations with respect to the future Sentinel satellite fleet as a system-of-systems and the development of multi-mission retrieval algorithms and products.

- Build the necessary expertise in both the European science community and downstream industry sectors with respect to the new instruments and their exploitation both for science and applications.

SUP Fundamental research and algorithm/products development/validation

- **ITT (~600KEuro) - SWOT Data analysis and synergistic study for S3NG preparation:** Assessment SWOT capabilities (imaging interferometer dedicated) in preparation for S3-NG and exploration of synergies with SAR nadir altimeters. Data will be available at Launch + 9 months. This study will access and process SWOT mission data in synergy with other datasets to investigate the scientific content of the measurements available and develop innovative approaches to exploit the measurements for ocean, inland waters, cryosphere (sea ice) and other new scientific domains. Q4, 2024

- **ITT (~800KEuro) Polar Science Multi-mission Foundational Experiment (S1, ROSE-L, CMIR, CRISTAL)** explore opportunities and advance fundamental understanding of the interactions of different frequencies with snow, ocean and ice under different conditions for the development of advanced synergistic products and investigate the interplay between sea ice extend, sea ice deformation and sea ice thickness (snow on sea ice). Q4 2024.

- Projects will include a combination of campaigns for dedicated in-situ data, exploitation of proxi-datasets from existing missions, simulated data, including the potential to use/develop a community model based on open source modular approaches to enhance ocean, sea-ice and snow multi-mission simulations..

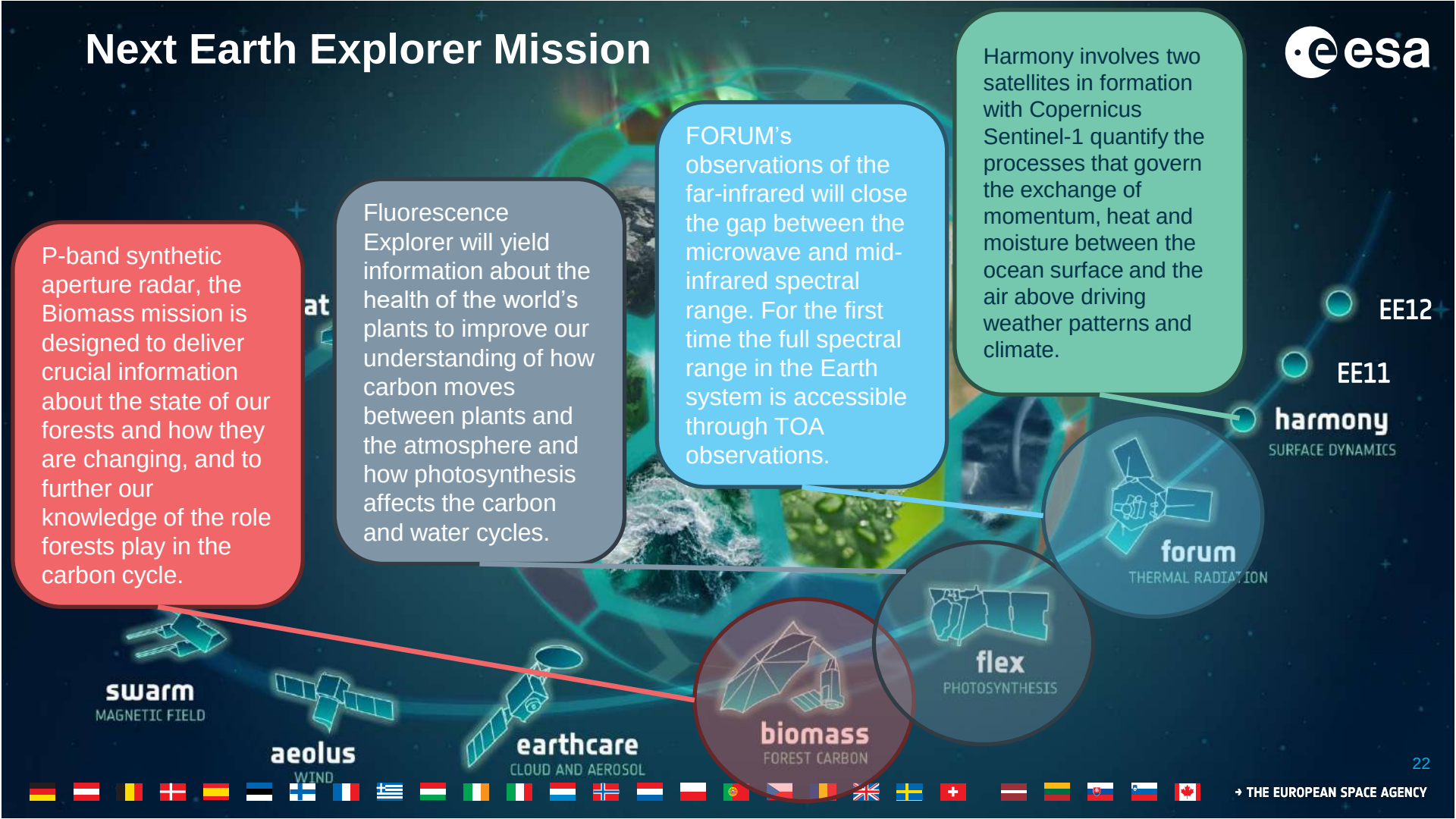
SUP Fundamental research and algorithm/products development/validation

ITT (Budget: 2-2.5MEuro) – SAR SUP: Set of parallel studies to support early development of advanced algorithms and products with focus on SAR multi-frequency synergic aspects and advanced polarimetry studies (recommendations from POLINSAR, SeaSAR, FRINGE) including C-band SARs, L-band SARs (SAOCOM, NISAR, ALOS PALSARs), SARs in other frequency bands (ESA Earth Explorer BIOMASS, NovaSAR-1 S-band, X-band new space sensors etc.).

Topis will include also Polar related domains: e.g.,

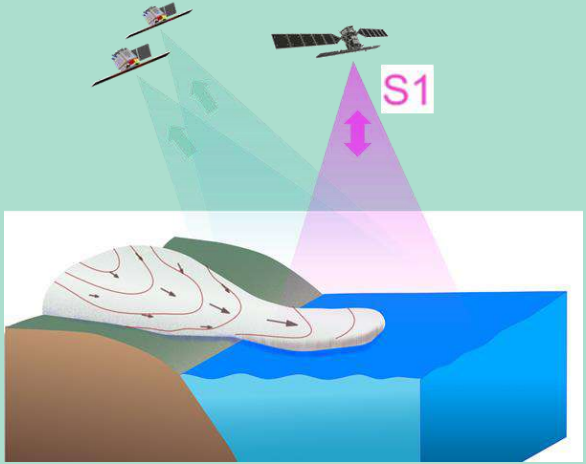
- **Glacier** velocity and processes characterisation;
- Multifrequency SAR **snow products** including dry/wet extend, liquid water content at different depths, snow density, snow depth and related products: including SWE
- Novel synergic opportunities for **SAR ocean retrievals** with focus on synergistic sea state, wave, winds and currents also in Polar regions…

Next Earth Explorer Mission

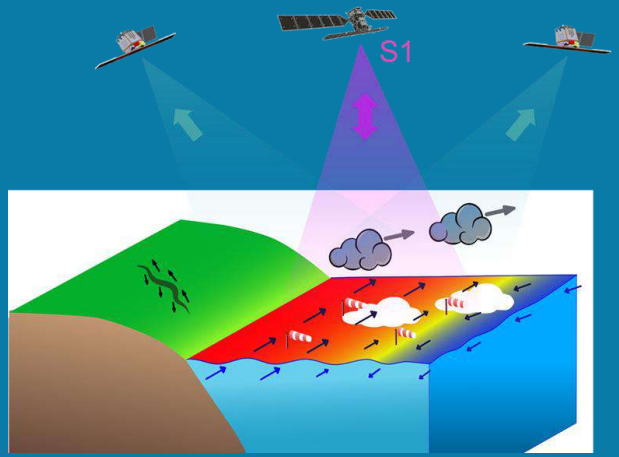


Harmony in a nutshell

Harmony is ESA's Earth Explorer 10 mission, comprised of two companion satellites in a loose convoy with Sentinel-1D (along-track separation ~350 km)
Its payload suite consists of a passive SAR and a multi-view TIR instrument



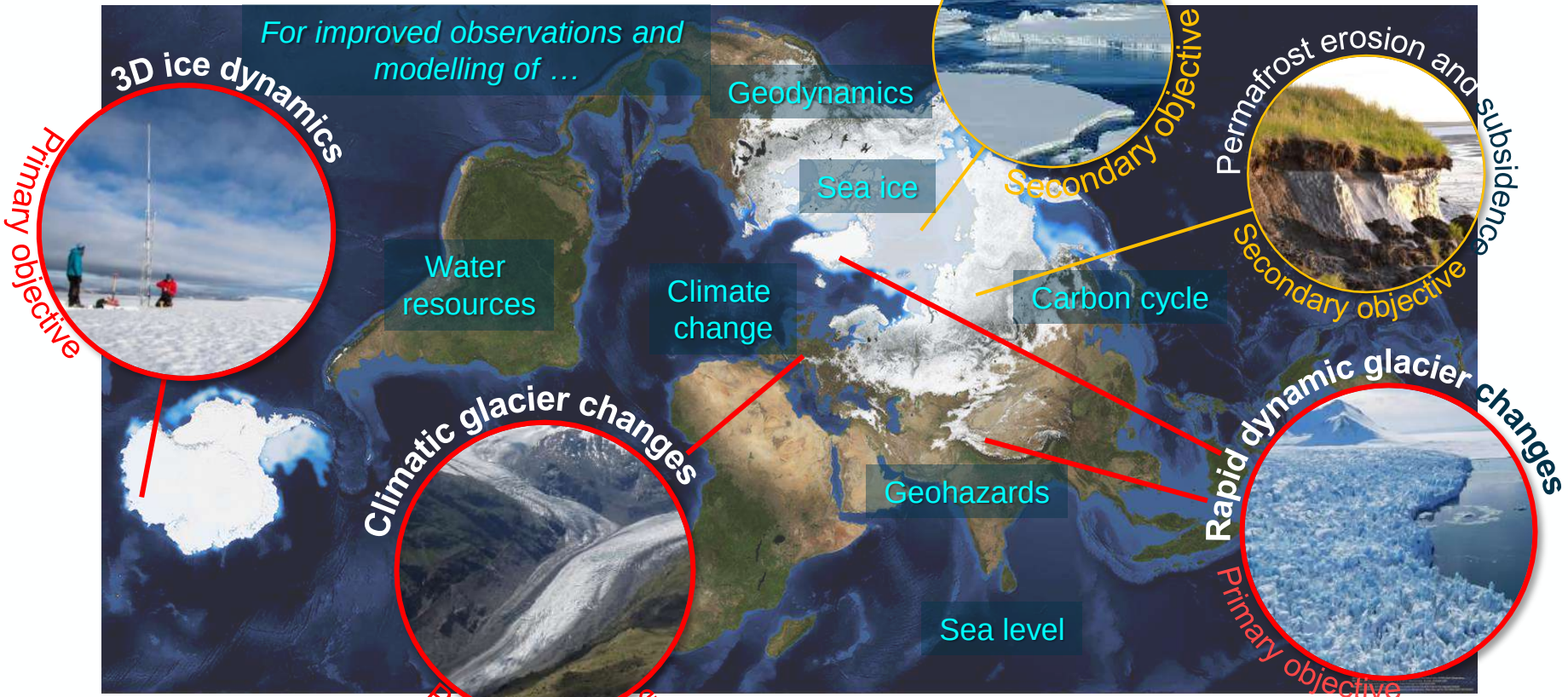
Cross-track Interferometric phase covering land applications like glaciers, permafrost, volcanoes.



Stereo phase covering 3-D surface deformation ocean applications: surface motion, surface winds, sea surface temperature, cloud motion.

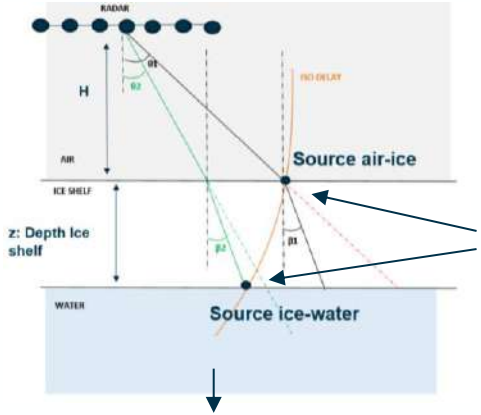
Year 1 | Year 2 | Year 3 | Year 4 | Year 5

Harmony: sensing the cryosphere

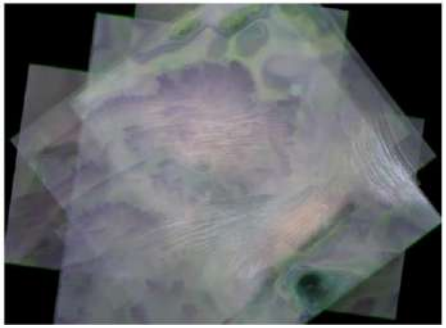


BIOMASS: ICESHELVES BASAL TOPOGRAPHY MAPPING

BIOMASS SYNTHETIC LINEAR ARRAY (7 ACQUISITIONS)



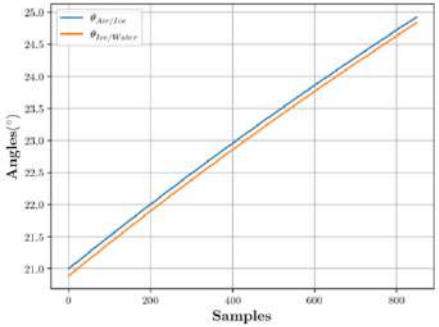
2 scattering sources



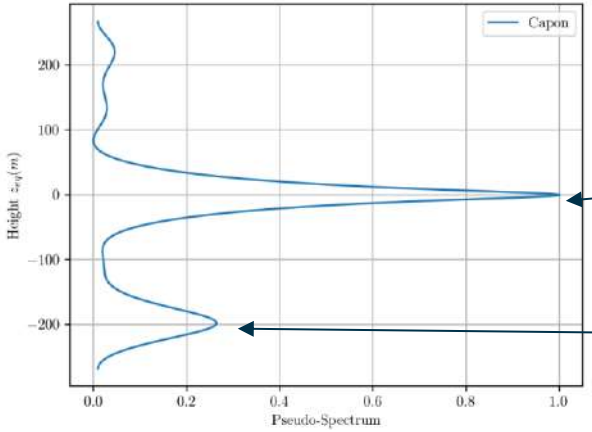
10 km

SAR IMAGE at P-band in Greenland (ONERA measurements [1])

We can exploit the different direction of Arrival from each interface



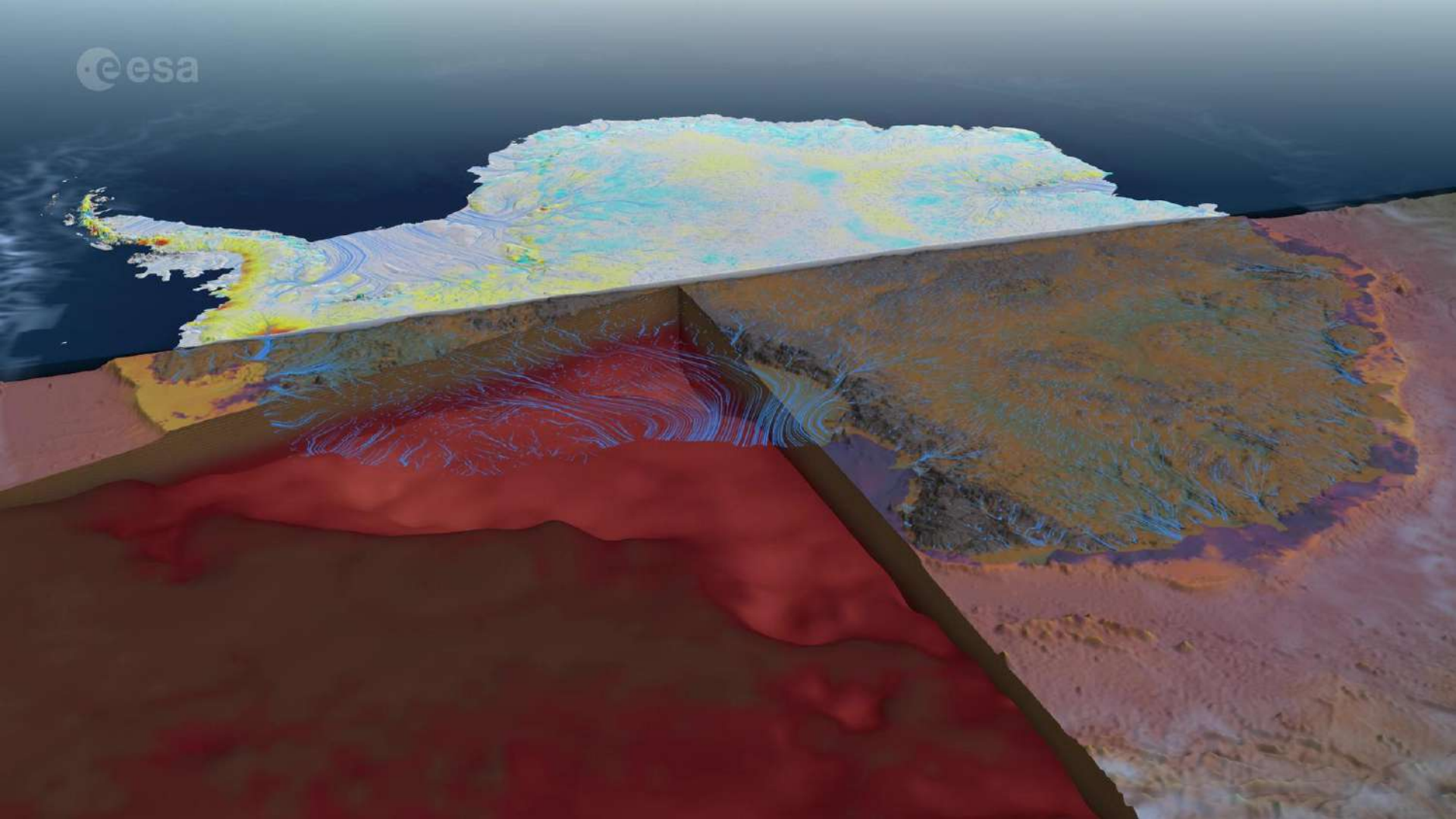
Tomographic processing



Simulated Tomographic reconstruction from 7 acquisitions

interface air-ice

Interface ice-water


esa