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Sentinel-2 and Related Missions: Status Update

29 May 2024

Ferran Gascon
Sentinel-2 Mission Manager

ESA-DEVELOPED EARTH OBSERVATION MISSIONS

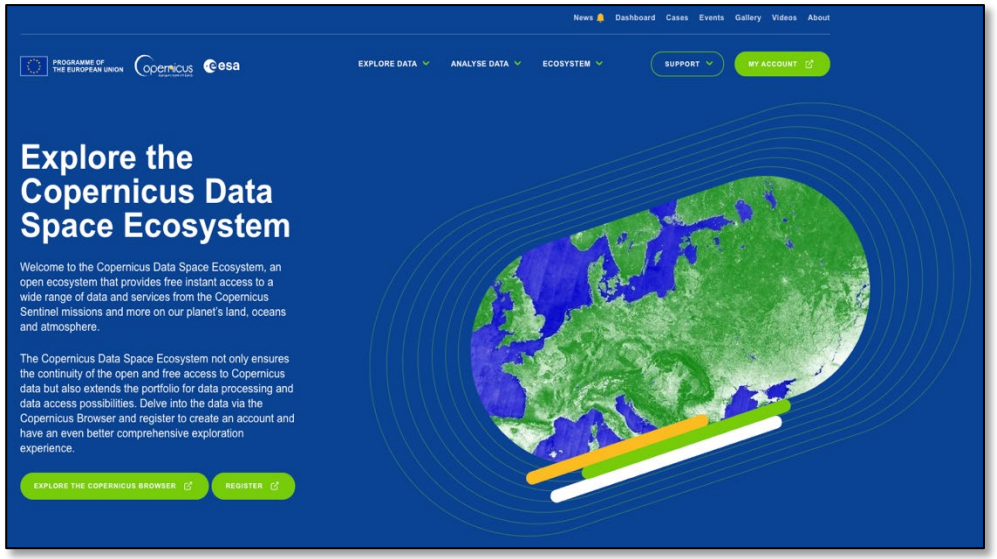
Science esa | Copernicus | Meteorology EUMETSAT

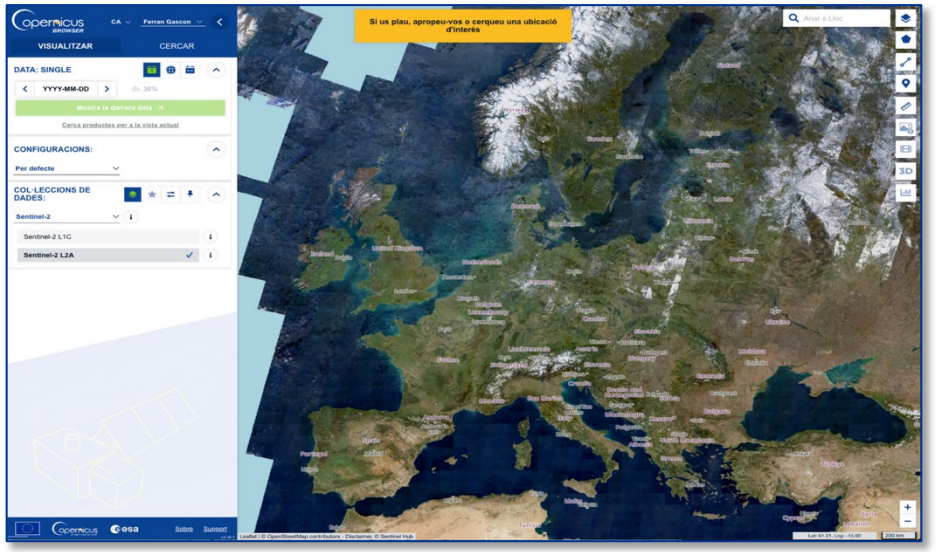
S2 Mission Status Highlights

- Nominal mission operations and good health status of both satellites.
- On-going distribution of Sentinel-2 Collection-1 re-processed products through the https://dataspace.copernicus.eu
- Steady improvement of products data quality (e.g. usage of Copernicus DEM at 30m horizontal resolution).
- Copernicus Sentinel-2 Global Reference Image (GRI) has been made available to all users as a free and open product.
- Extended observation scenario being acquired systematically, plus ad-hoc acquisition campaigns performed.

Mission Products

Product	Description	Spatial Extent	Temporal Extent	Available in Ecosystem from
Level-1B	TOA radiance in sensor geometry	World	Last two weeks	Q2 2024
Level-1C	TOA radiance in cartographic geometry	World	Jul 2015 – Present	Jan 2023
Level-2A	Surface Reflectance	World	March 2017 - Present	Jan 2023
Level-3 Quarterly Mosaics	Surface Reflectance mosaics	World	Jan 2022 - Present	Nov 2023





https://documentation.dataspace.copernicus.eu/Data/SentinelMissions/Sentinel2.html

S2 - Landsat Harmonised and Fused Products

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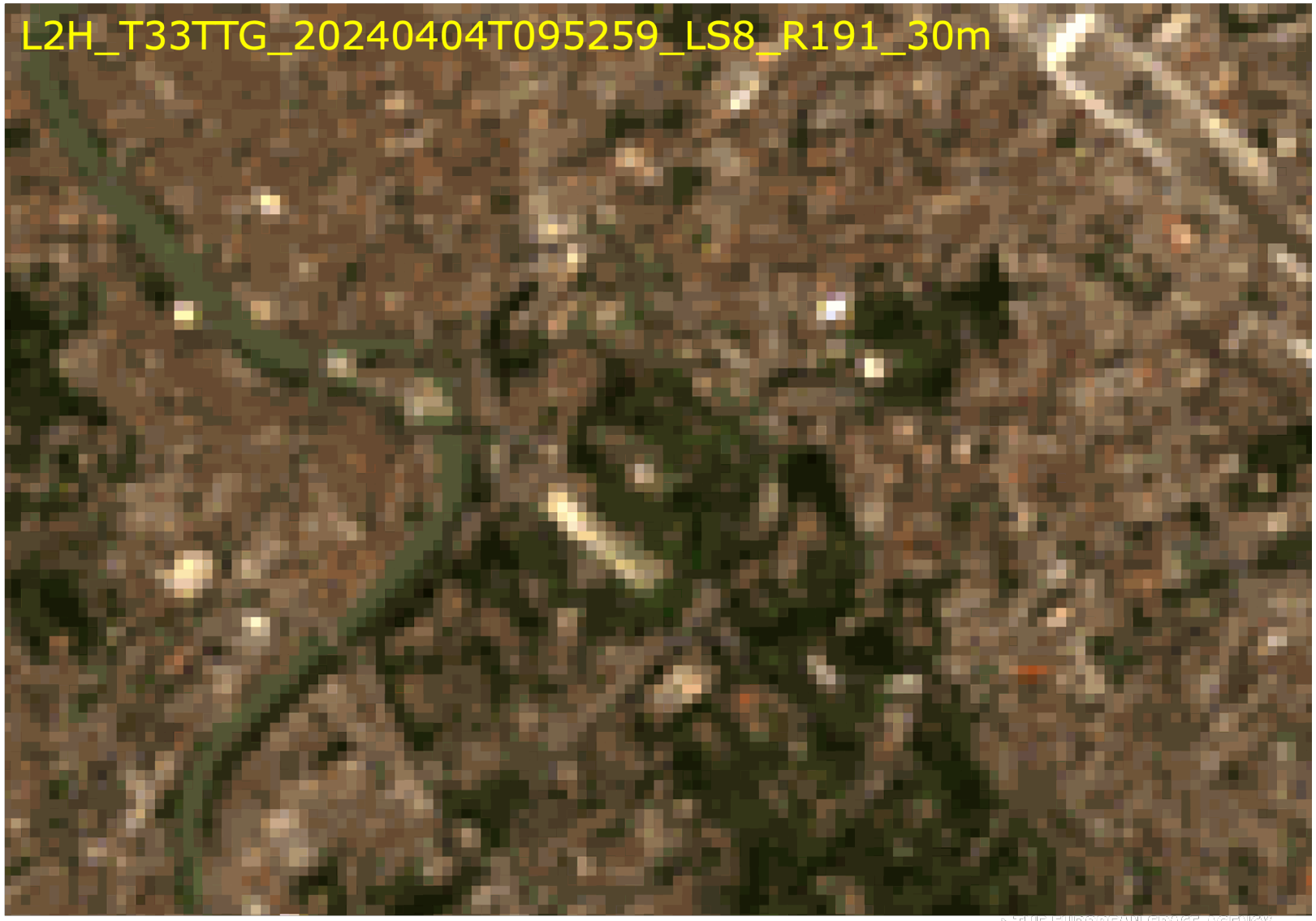
Pilot Products

Level-2H

Harmonised Sentinel-2 + Landsat-8/9 surface reflectances in cartographic geometry > *includes consistent atmospheric corrections (same ATM algorithm), spectral adjustments, BRDF adjustments and re-gridding*

Level-2F

Fused Sentinel-2 + Landsat-8/9 surface reflectances in cartographic geometry > *brings Landsat resolution to* Sentinel-2 *one*



L1C Absolute Geolocation Accuracy

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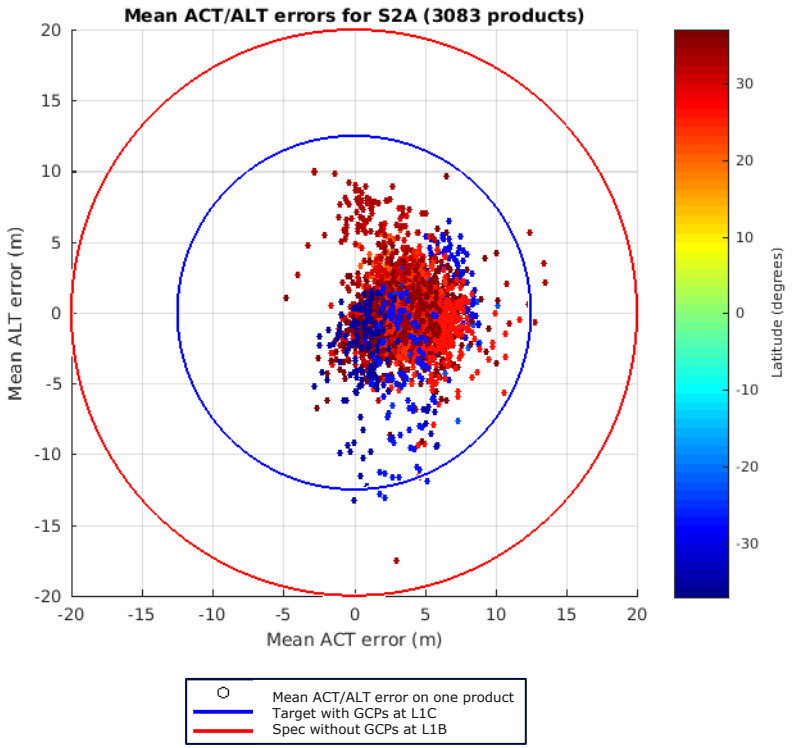
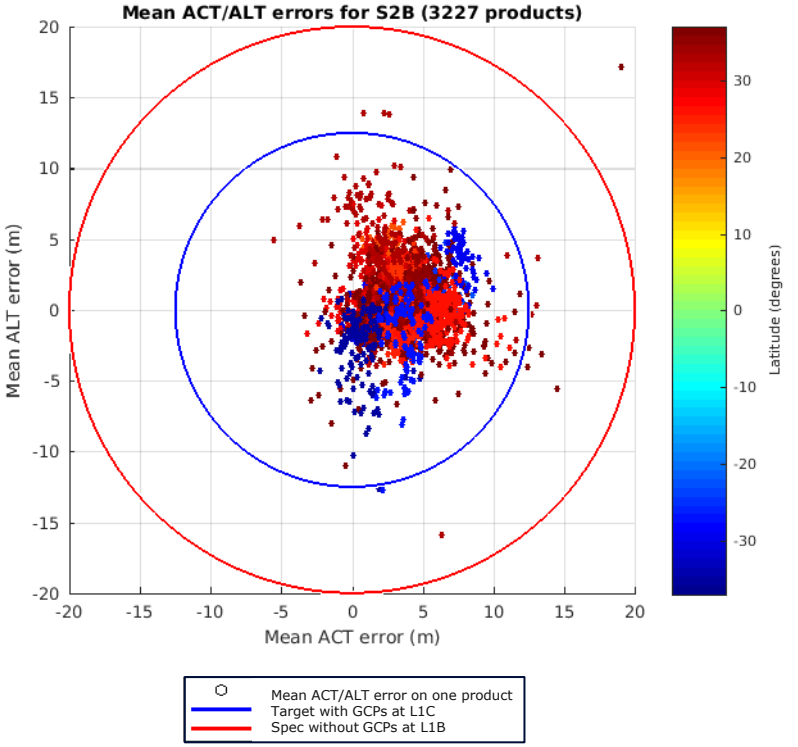
S2A



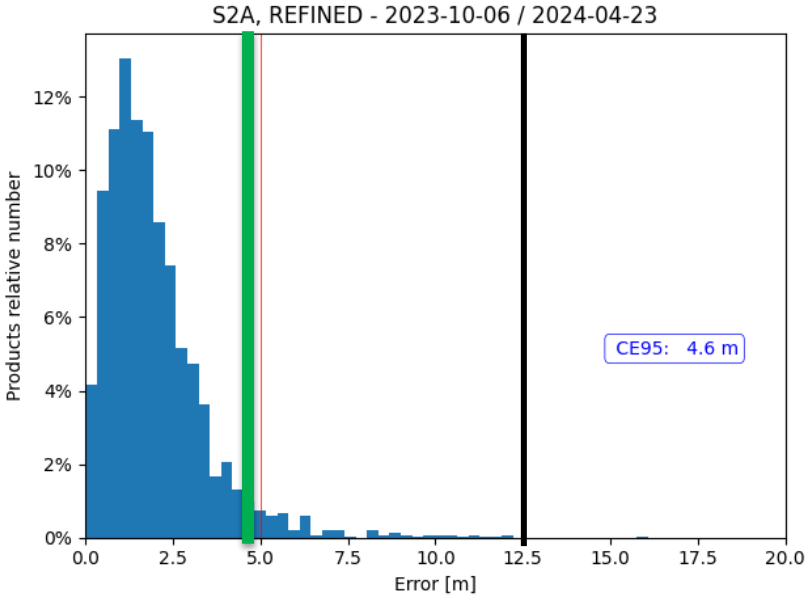
Mean ACT error (m)	3.54m
Mean ALT error (m)	-0.20m
Mean circular error (m)	4.76m
CE95	8.64m

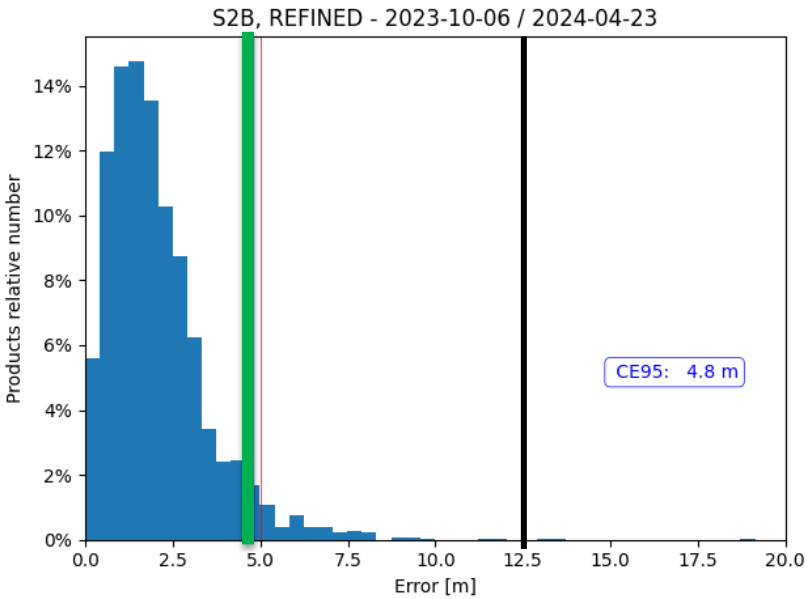
S2B

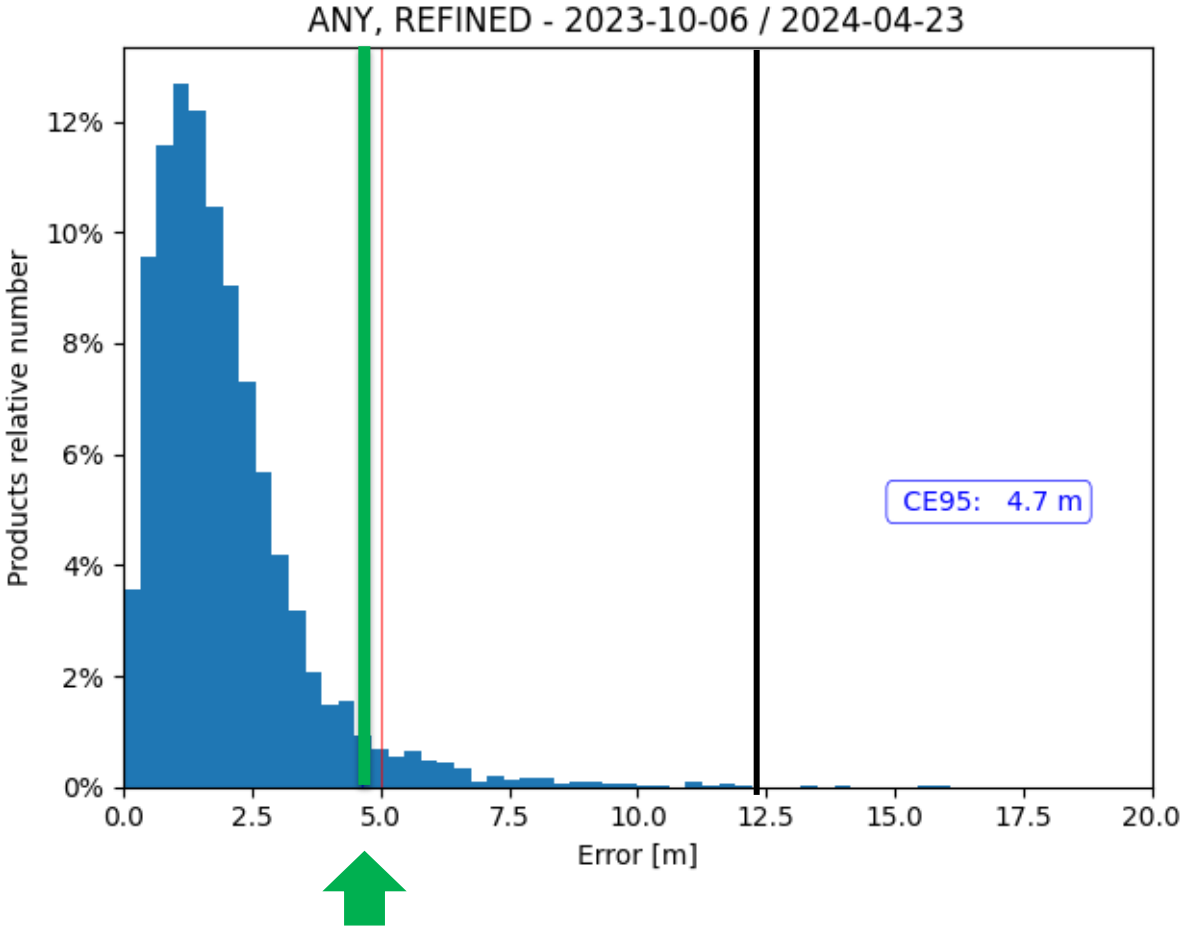


Mean ACT error (m)	3.63m
Mean ALT error (m)	0.54m
Mean circular error (m)	4.72m
CE95	8.21m

L1C Multi-temporal Spatial Co-registration







Multi-temporal accuracy:
<0.5 pixel for refined products

Sentinel-2 GRI: Public Release

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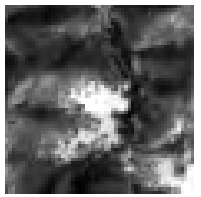
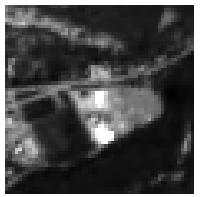
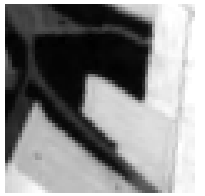
The Copernicus Sentinel-2 Global Reference Image (GRI) is available for download on the Sentinel Online website:

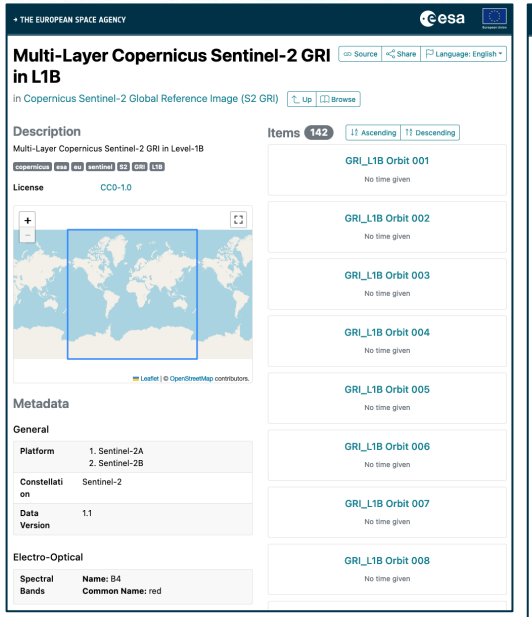
- **Multi-Layer** Copernicus Sentinel-2 GRI in Level-1B (**L1B**);
- **Multi-Layer** Copernicus Sentinel-2 GRI in Level-1C (**L1C**);
- Copernicus Sentinel-2 GRI as **Database of GCPs** in **L1B**;
- Copernicus Sentinel-2 GRI as **Database of GCPs** in **L1C**.

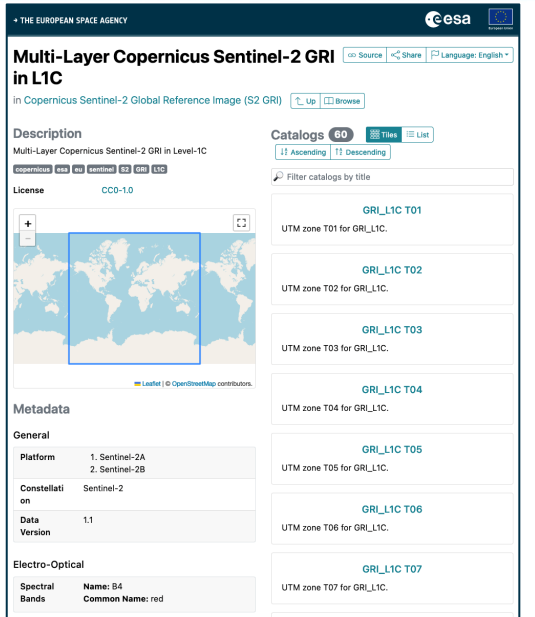
+ related Documentation (Product Handbook & Validation Report)

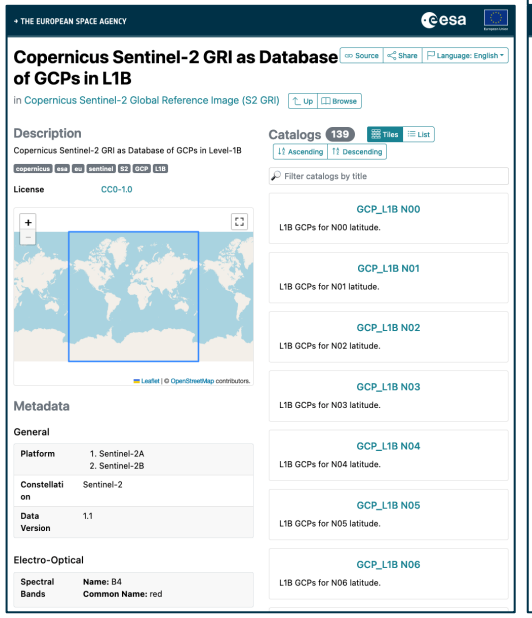
- No Copyright: Free & Open
- Same accuracy as the current GRI version
- Perennial & robust to seasonal effects
- Same performance as achieved by the current GRI version
- Coverage: worldwide
- Usage of Copernicus DEM @30m

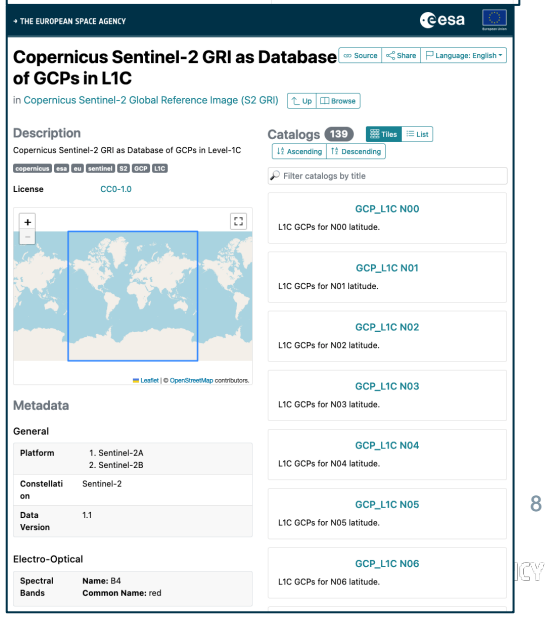










Sentinel-2 Collection-1

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What's new in Collection-1

- ✓ **Improved Geometric Performance**: Geometric Refinement using the GRI and usage of the Copernicus Digital Elevation Model (DEM) at 30m resolution.
- ✓ **Harmonized radiometry** aligning Sentinel-2B to Sentinel-2A.
- ✓ **Radiometric and Geometric Calibration Update**: Optimization of the applicability along-time of the successive radiometric and geometric calibrations.
- ✓ **Quality Mask** in raster format and improved masks for radiometric saturation.
- ✓ **Improved L2A processing algorithms** for scene classification and surface reflectance.
- ✓ **Identification of defective pixels from missing instrument source packets** in the L2A Scene Classification layer.
- ✓ **Compliance with the CEOS Analysis Ready Data (CEOS ARD) for Land** specifications for Level-2A surface reflectance product.

CEOS ANALYSIS READY DATA

CEOS

Mission Observation Scenario

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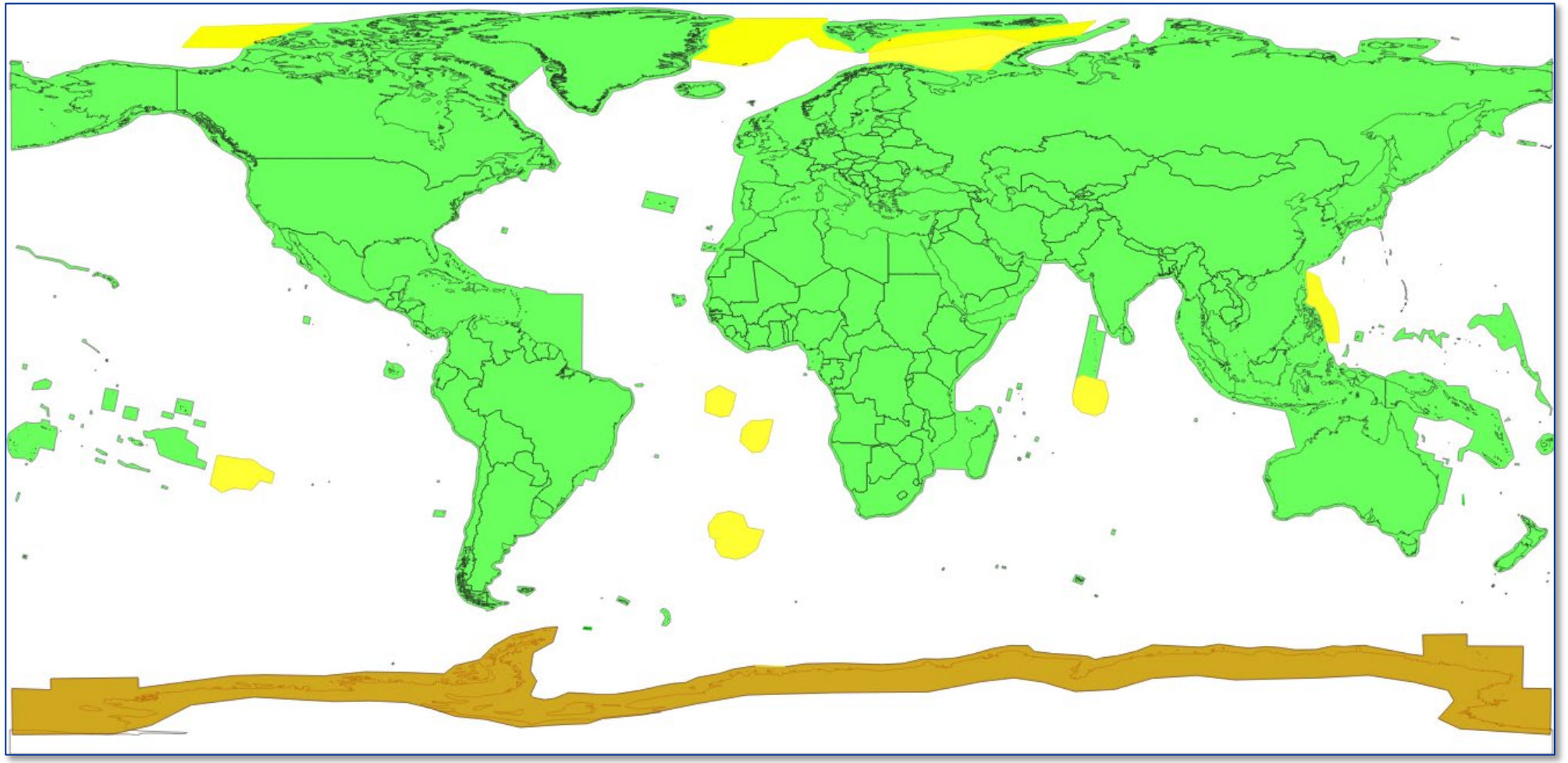
- Observation scenario reaching maximum capacity with current mission configuration.



Broad Range of Applications

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CLMS
Copernicus Land Monitoring Service – Global and Pan-European Components

- Hot Spot Monitoring for EU field projects and international policies
- Global Mosaics
- Inland waters Turbidity
- Inland waters Total Suspended Matter
- Biophysical products
- Land cover products

CMEMS
Copernicus Marine Environment Monitoring Service

- Sea-ice charting
- Coastal waters Turbidity
- Coastal waters Total Suspended Matter

CEMS
Copernicus Emergency Management Service

- Emergency response to rapid mapping (burnt area, flood, landslides, volcanoes)
- Risk recovery (e.g. crop change, floods)
- Validation (e.g. fires, floods, landslides)
- EFFIS/GWIS (Burned area mapping, fire severity and vegetation recovery

CSS
Copernicus Security Service/ Copernicus Maritime Surveillance Service/ European Maritime Safety Agency/ CleanSeaNet/ Support to External Action

- Oil spill detection and polluter identification (CleanSeaNet)
- Maritime surveillance (e.g. ship detection, search and rescue, anti-piracy)
- Up-to-date background information
- Integration with very high-resolution imagery
- Feature of interest extraction

C3S
Copernicus Climate Change Service

- Glaciers mapping
- Glaciers flow velocities

Methane Emissions Monitoring

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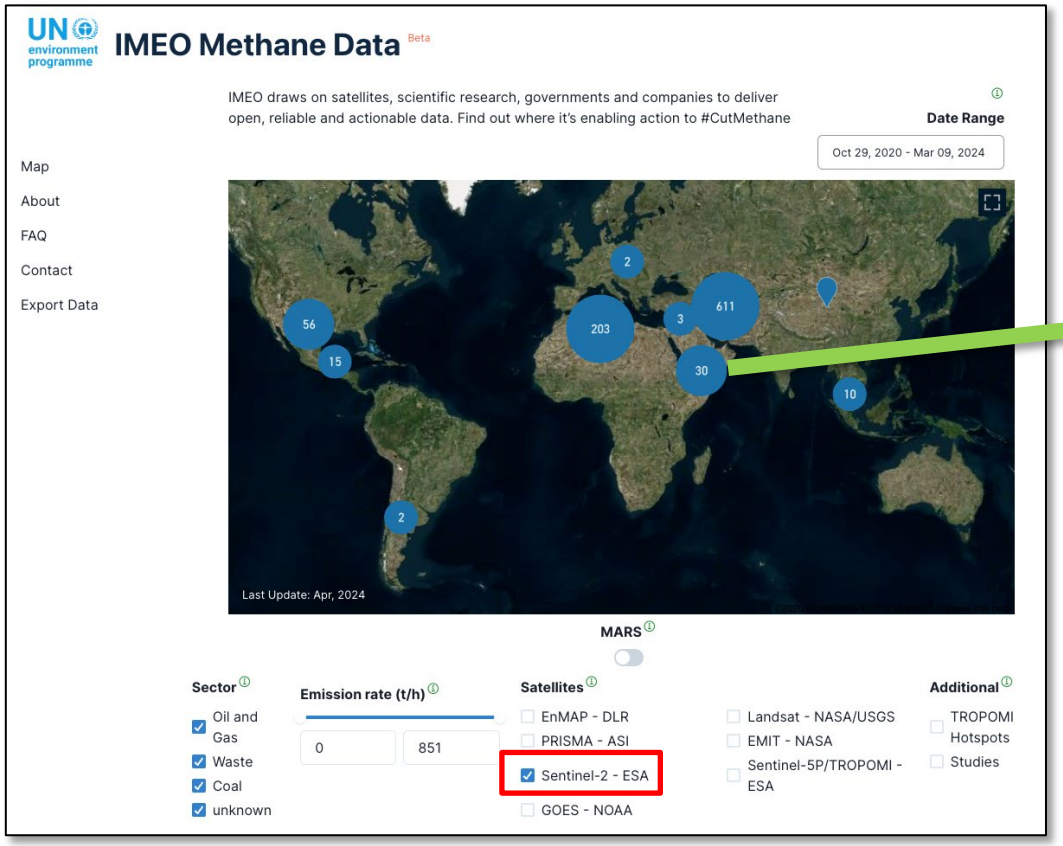
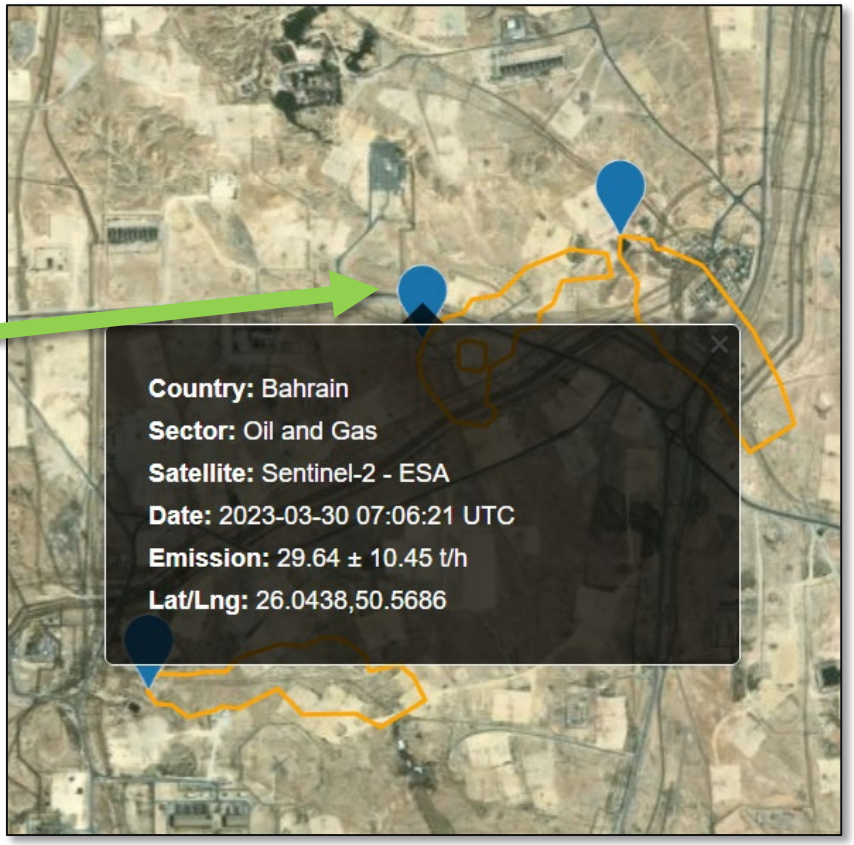
Sentinel-2 is a major workhorse for the International Methane Emissions Observatory (IMEO)

IMEO draws on satellites, scientific research, governments and companies to deliver open, reliable and actionable data.

Sentinel-2 is the top satellite data provider feeding IMEO, becoming a key asset for UN global methane monitoring.





UN environment programme

On 10 April 2024, the EU Parliament adopted a provisional political agreement with EU countries on a new law to reduce methane emissions from the energy sector.

The new regulation is the first piece of EU legislation aimed at cutting methane emissions and covers direct methane emissions from the oil, fossil gas and coal sectors, and from biomethane once it is injected into the gas network.

https://methanedata.unep.org

NO_2 Emissions Monitoring

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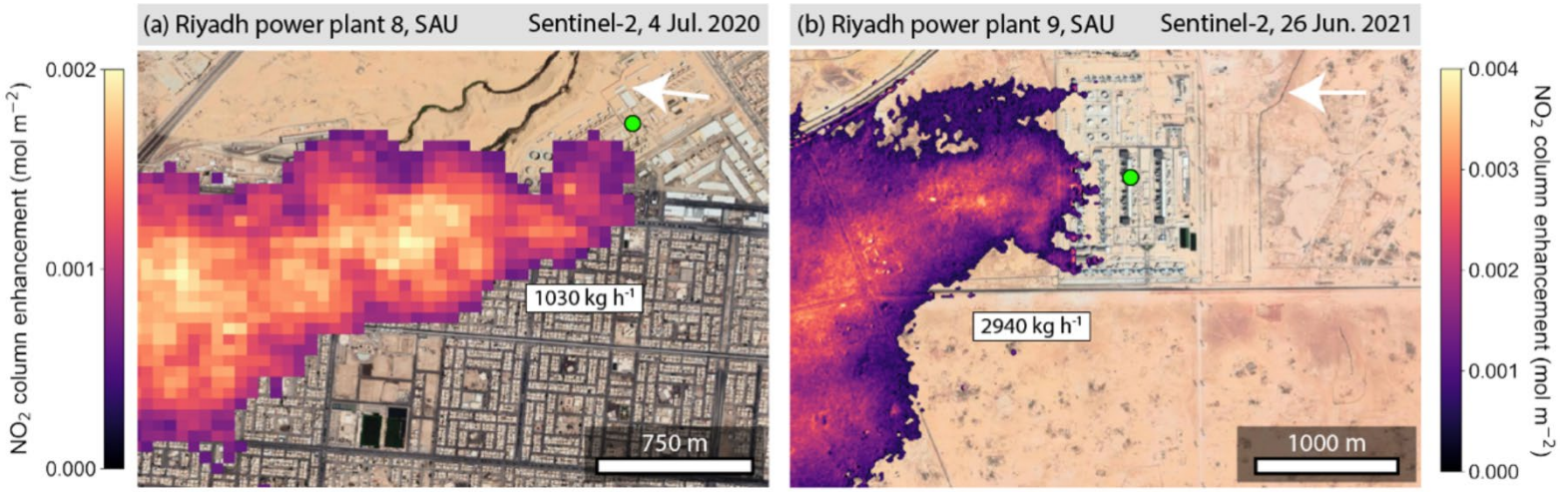
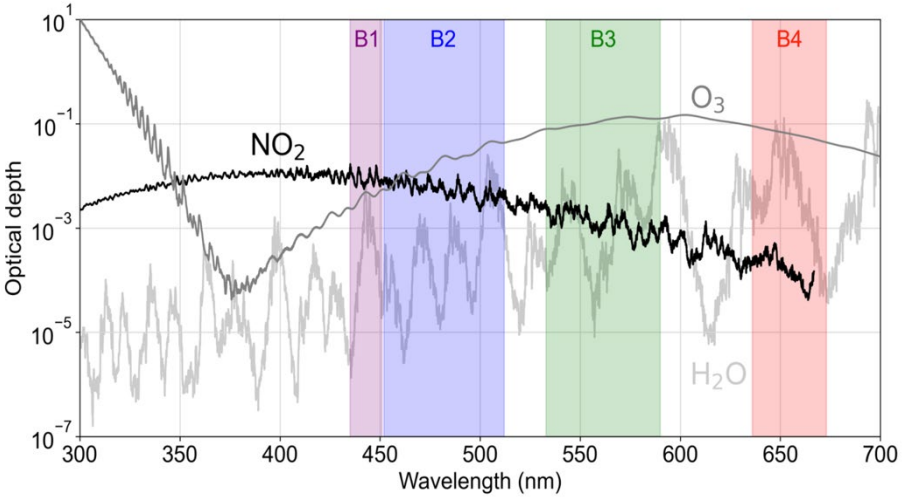
- Atmospheric nitrogen oxides (NOx) are air pollutants with important implications for air quality, climate, and the biosphere.
- Satellites have mapped atmospheric NO_2 concentrations since the 1990s, but with spatial resolution generally too coarse to resolve individual point sources such as power plants.
- Sentinel-2 satellites can monitor NO_2 plumes from large point sources (>500 $kg.h^{-1}$) using their blue and ultra-blue bands.
- The fine pixel resolutions of Sentinel-2 enable separation of individual point sources and stacks, including in urban background, and archive records enable examination of emission trends.



Sample Sentinel-2 and Landsat 8 retrievals of NO2 plume column enhancements from five power plants in Saudi Arabia.



https://www.varon.org/research

Sentinel-2 bathymetry

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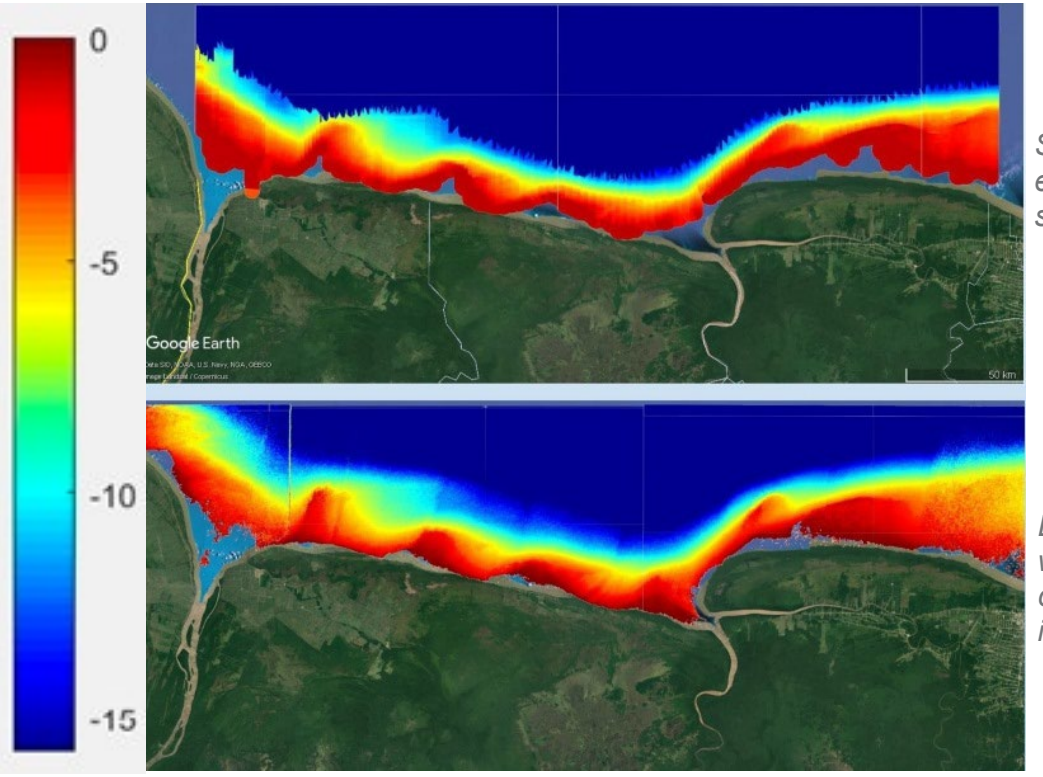
Mapping dynamic ocean depth is useful for marine geology researchers, tide modelling and prediction, coastal management and navigation

Sediment discharge of the Amazon River congregates into mud banks captured by Sentinel-2. Sediments are migrated by forces of waves and currents westward along the northeast South America coastline.
Copyright: Contains modified Copernicus Sentinel data (2023), processed by ESA.



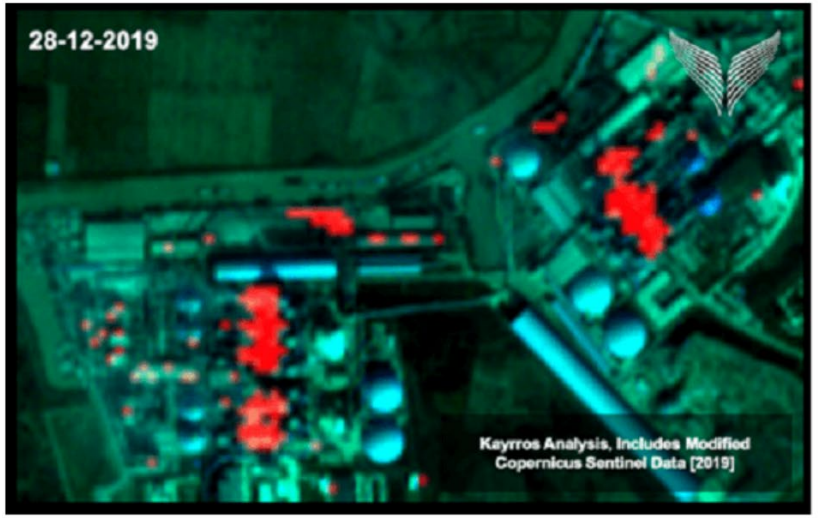
Single-beam echo sounding survey

Bathymetry derived with Sentinel 2, composite of all images 2017-2022

Copyright: Contains modified Copernicus Sentinel data (2017-22), processed by R.Abileah (jOmegak Consulting).

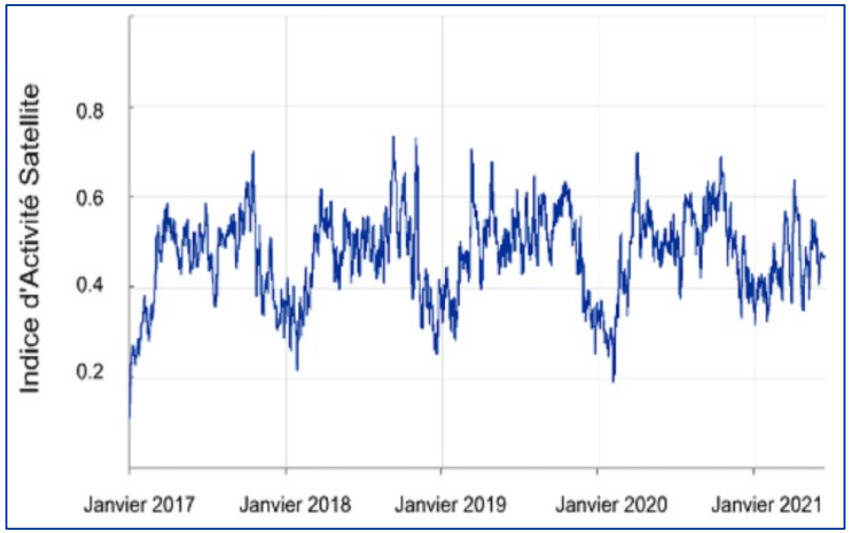
Cement plant activity index

- To monitor the global economy in real-time, satellite detection of heat emitted by active cement plants enables a production indicator.
- This indicator, used in a neural network model to predict construction activity, shows excellent performance compared to reference models and other indicators.



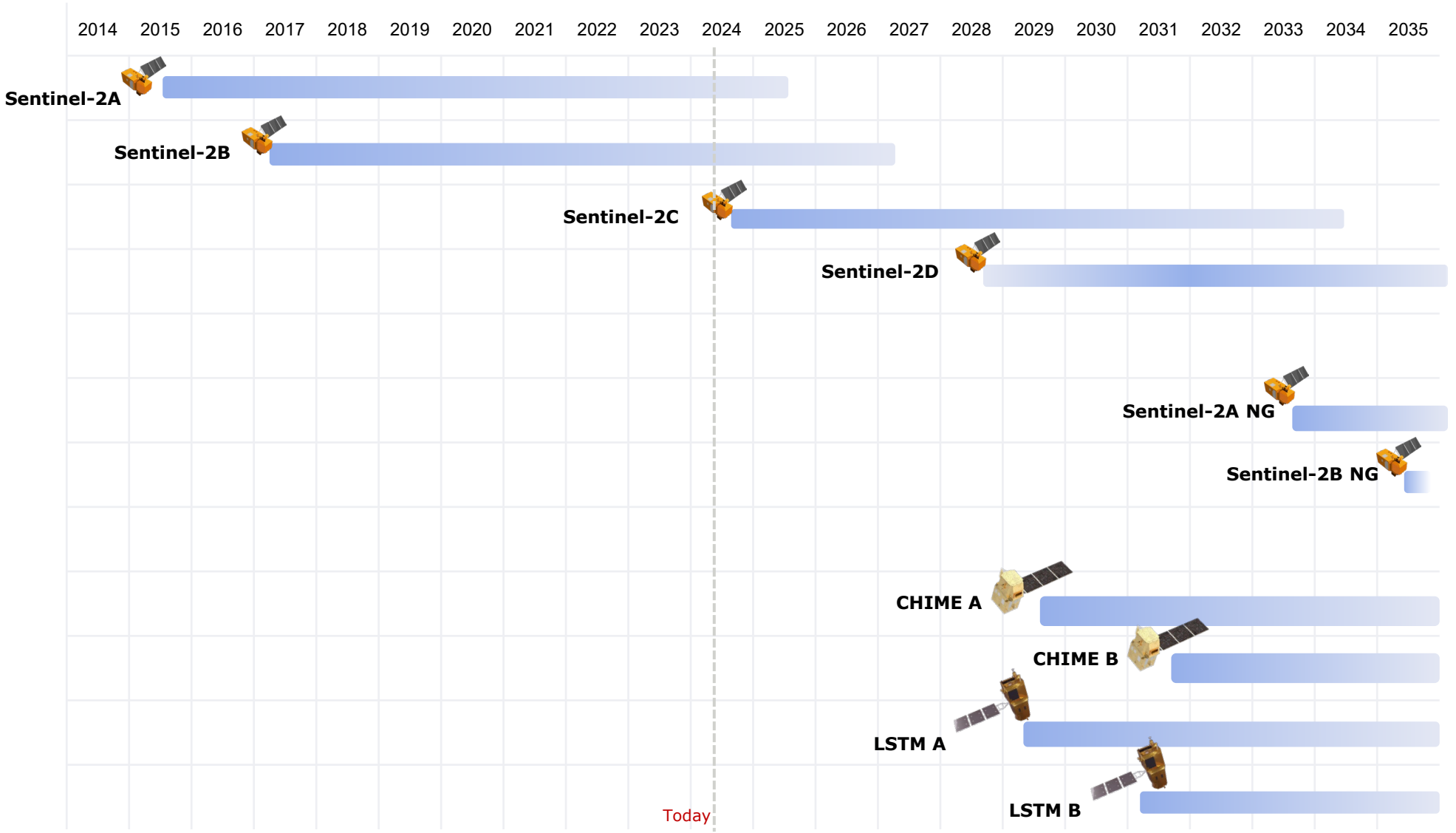
KAYRROS

Sentinel-2 image of a cement factory in China (Before/During Covid-19). Pixels colored red are those for which the algorithm detects the heat of cement kilns.



Cement plant activity index for China generated using Sentinel-2 data. The index represents the utilization rate of a country's production capacity, equal to the average utilization rate of each cement plant, weighted by its capacity.

Schedule Overview



CHIME Overview

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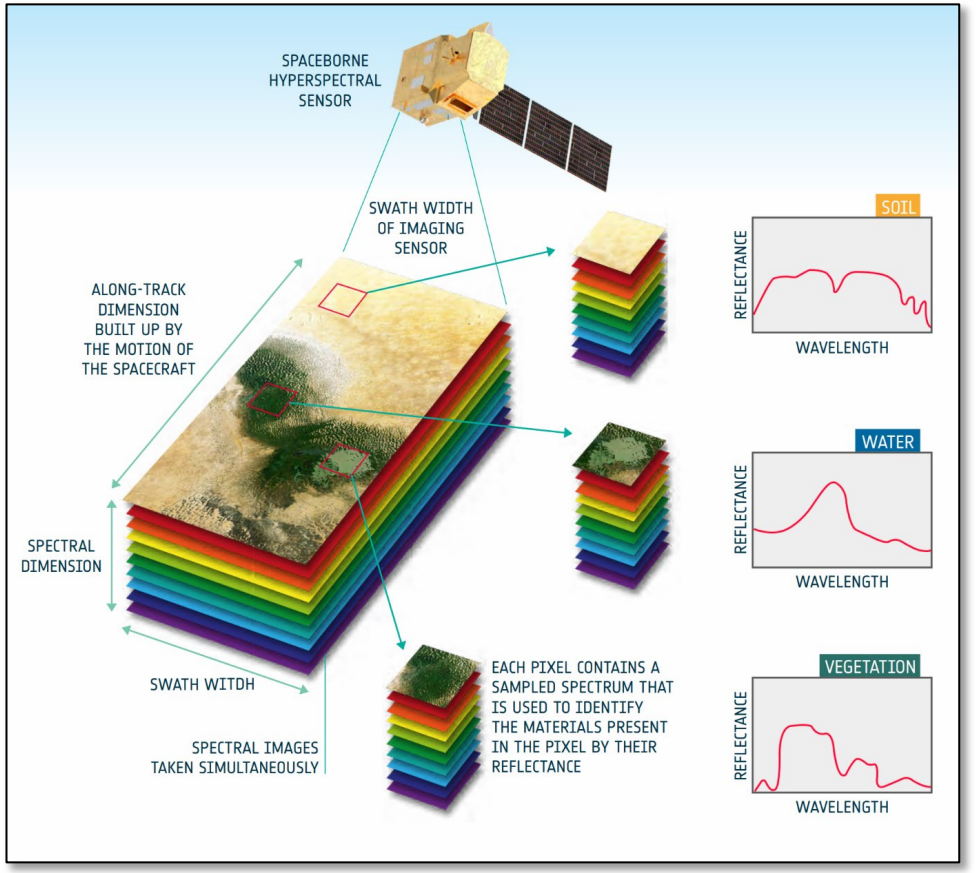
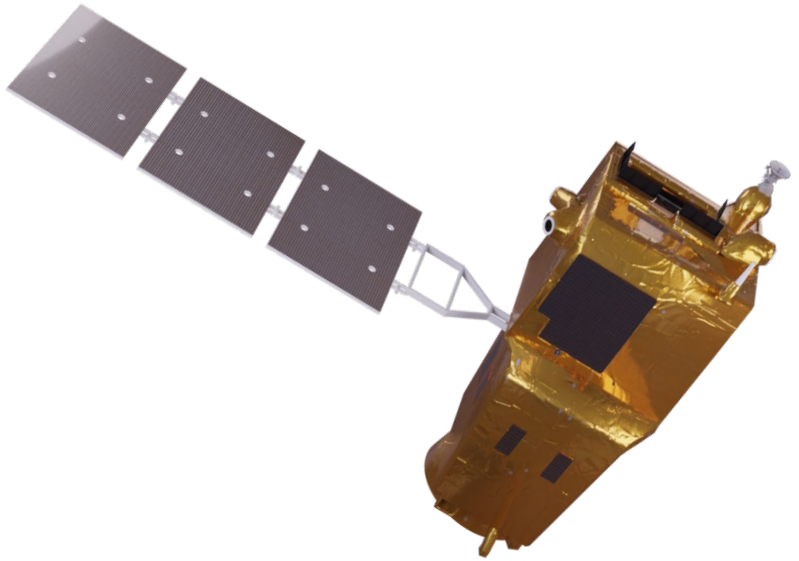
Operational hyperspectral observations of land and coastal areas

- **Spectral range**: 400 – 2500 nm
- **Spectral bandwidth** ≤ 10nm
- **Swath width**: 130 km
- **Ground resolution:** 30 m
- **Local Time**: 10:45 (Equator)
- **Revisit**: 11 days (2 satellites)
- High radiometric accuracy, low spectral/spatial mis-registration
- High SNR matching performance of similar missions (e.g. EnMAP)



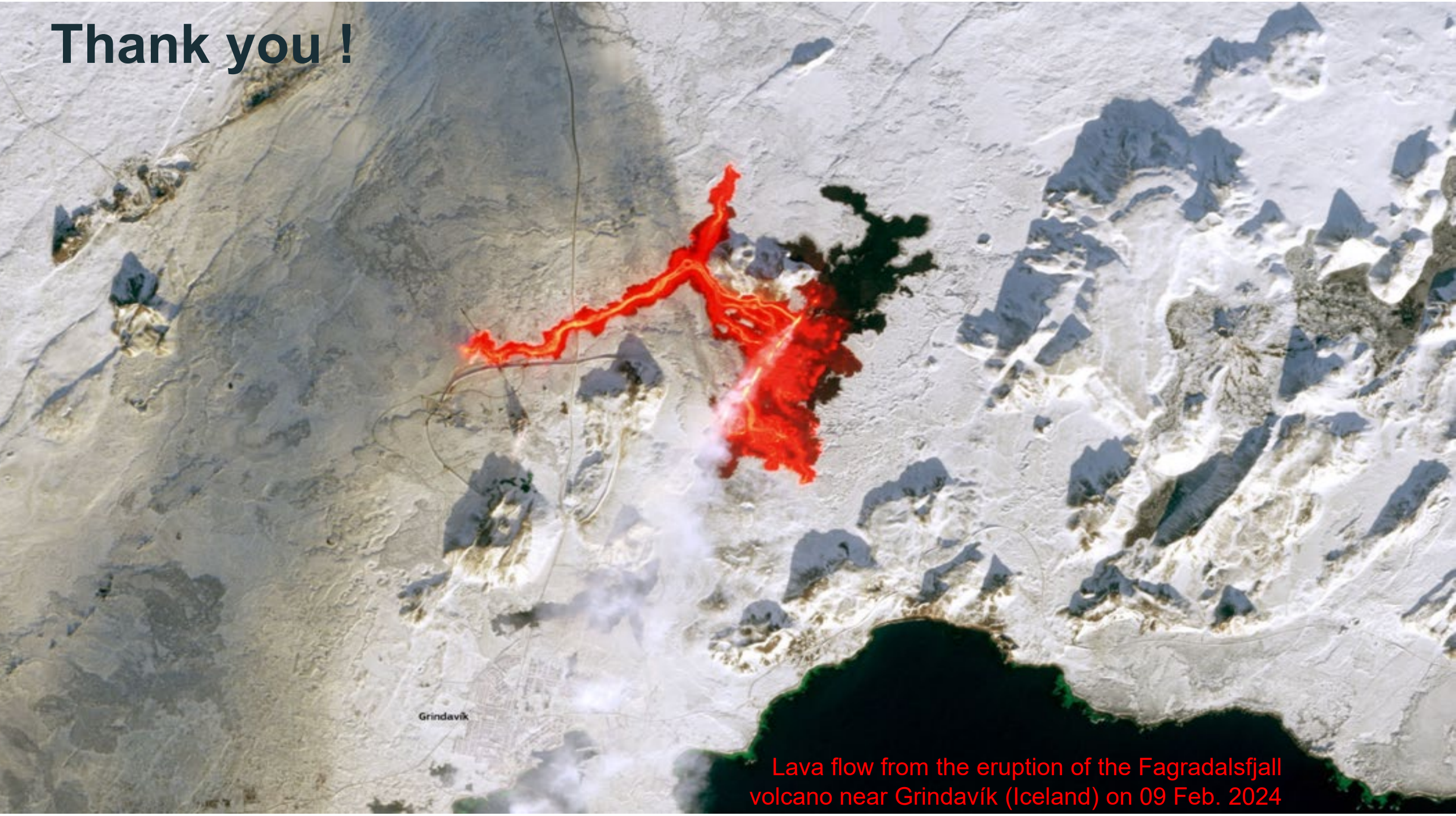
LSTM Overview



A high spatial-temporal resolution thermal infrared sensor to provide observations of land-surface temperature

- **Geometrical revisit**: 2 days (with 2 satellites)
- **Local Time**: 13:00 (Europe) & night observations
- **SSD** (Spatial Sampling Distance): 50 m, (37m at nadir)
- **Spectral Bands**: 5 TIR, 4 VNIR, 2 SWIR
- **Nominal swath**: 687 km
- **Acquisition system**: Whiskbroom scanner

Thank you !



Lava flow from the eruption of the Fagradalsfjall volcano near Grindavík (Iceland) on 09 Feb. 2024