ESA’s prospective on interface observations

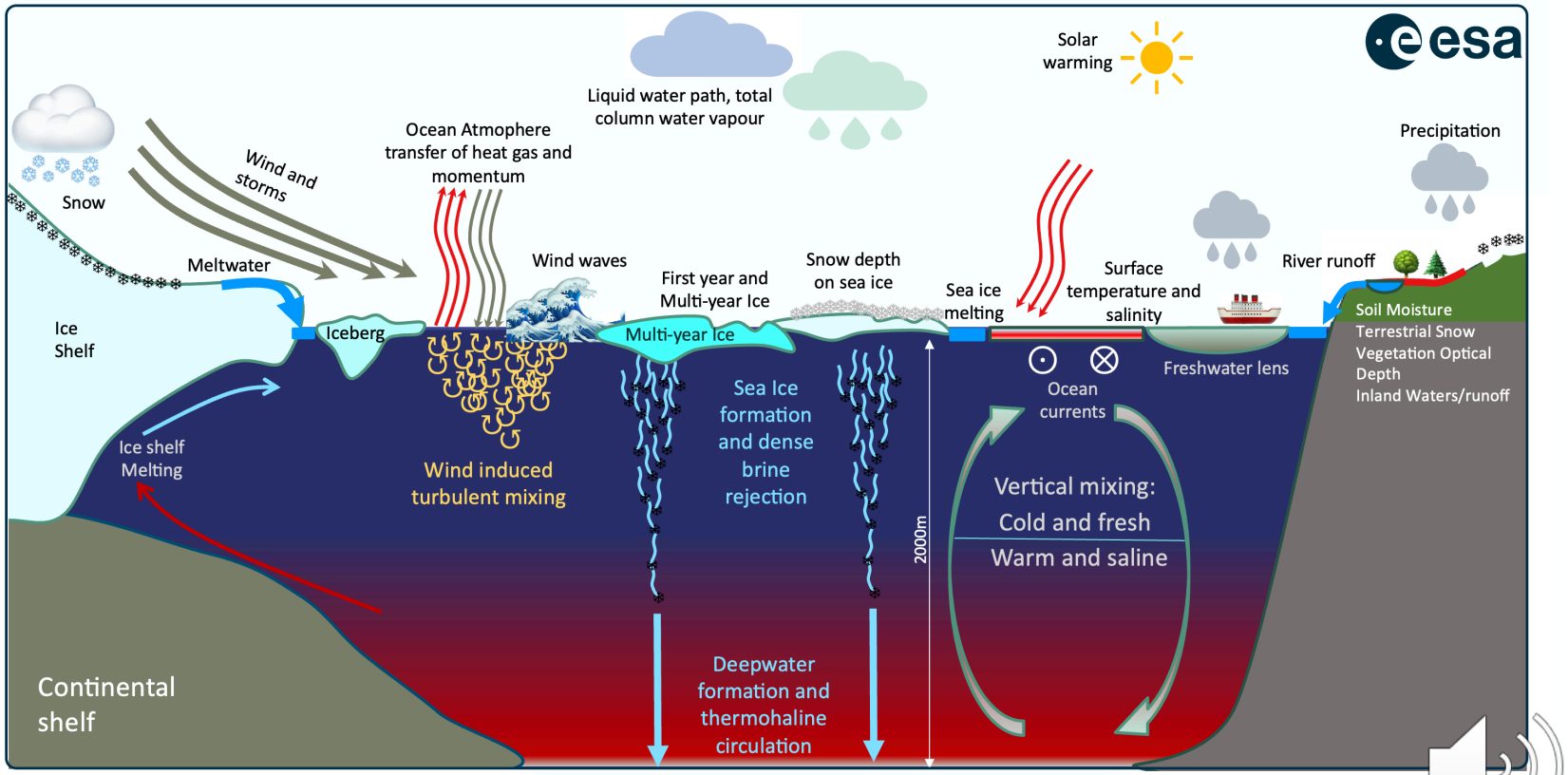
Filomena Catapano (TEC-EFW) & EOP-GMQ Team at ESA-ESRIN

19/11/2024

Earth satellite sensed interface observations

"Interface observations refer to observations that are sensitive to multiple Earth system components, including atmosphere, land, sea ice, snow, and the ocean. "

https://events.ecmwf.int/event/420/



ESA EOP vision: Science Strategy

New ESA Science strategy through 2040

On the steps ESA can take to address the environment, the climate crisis,and societal and economic impacts. Scientific knowledge and understanding gained from new satellite technologies and growing volumes of data provide the basis for decision-making and action, and for preparing a better tomorrow.

The new ESA Science Strategy includes **six major thematic objectives**:

- the water cycle,
- the carbon cycle and chemistry,
- energy fluxes,
- ecosystem health,
- extremes and hazards,
- and **interfaces and coupling in the Earth system**.

https://esamultimedia.esa.int/docs/EarthObservation/ESA_Earth_Observation_Science_Strategy_issued_Sept_2024.pdf

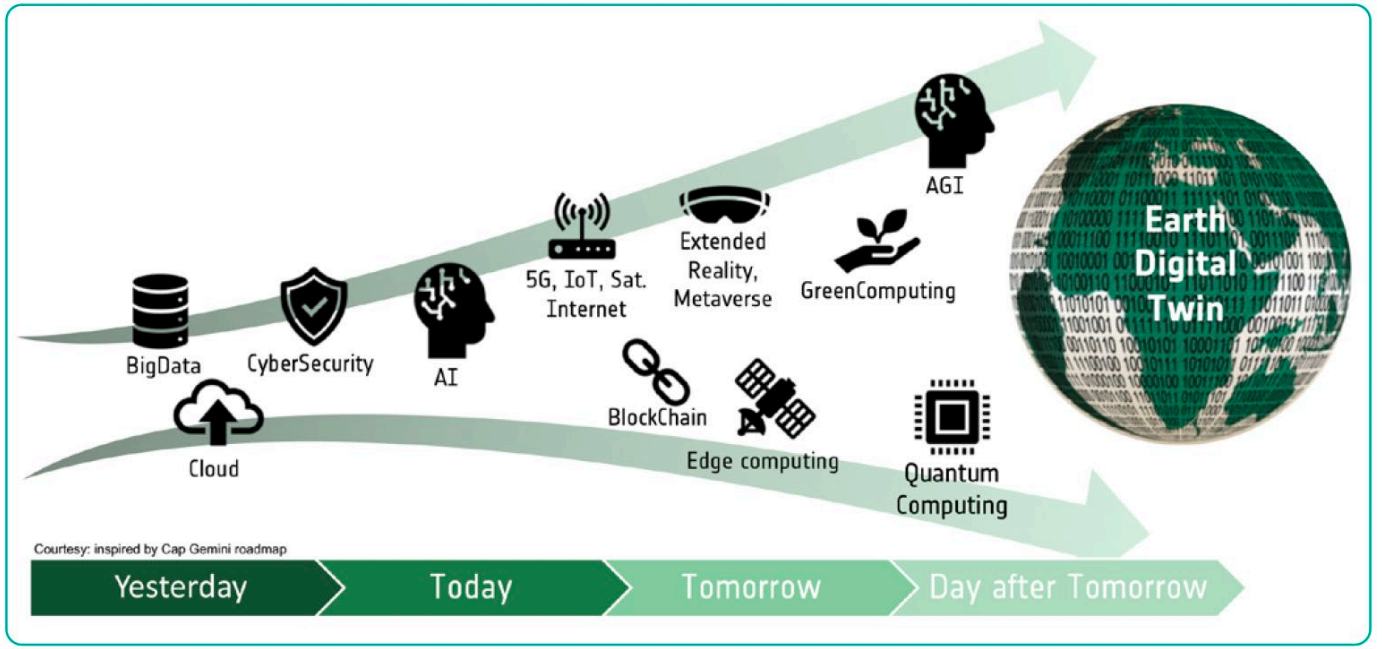
ESA EOP vision: DestinE

Destination Earth is a flagship initiative of the European Commission to develop a **highly-accurate digital model of the Earth** (a digital twin of the Earth) to model, monitor and simulate natural phenomena, hazards and the related human activities.

DestinE unlocks the potential of digital modelling of the Earth system at a level that represents a real breakthrough in terms of accuracy, local detail, access-to-information, speed and interactivity.

By **pushing the limits of computing and climate sciences**, DestinE is an essential pillar of the European Commission's efforts towards the Green Deal and Digital Strategy.

ESA EOP vision: DestinE



DestinE Timeline

DestinE will be developed through the following key milestones:

Implementation

By 2024

All the components of the system (DestinE Platform, Data Lake, Digital Twin Engine) have been developed. The DestinE Platform and Data Lake will be transferred into operation. Demonstration of the first two digital twins on Weather-Induced Extremes and Climate Change Adaptation and the open core platform.

Enhancement

By 2026

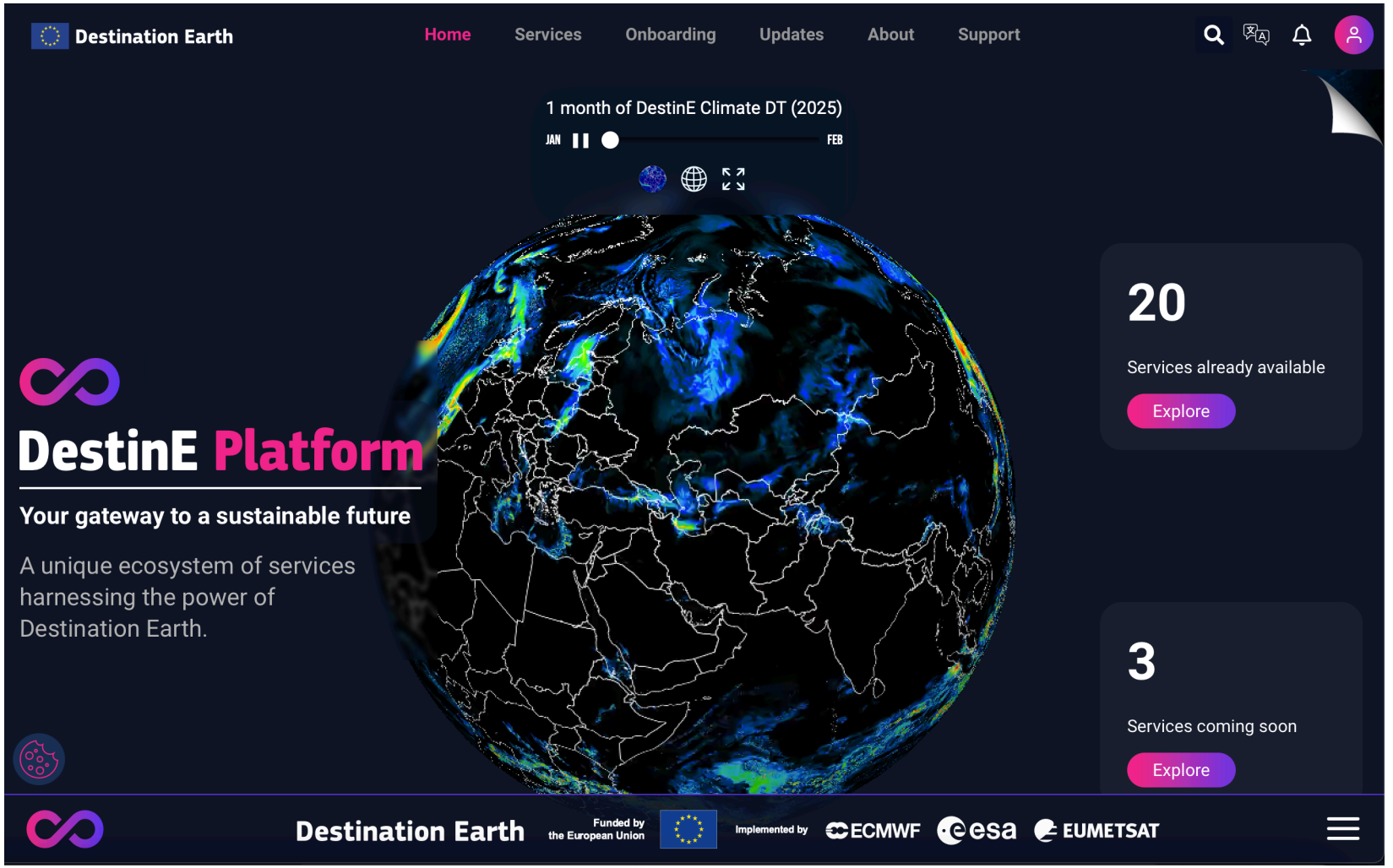
Further enhancement of the DestinE system and integration of additional digital twins and related services.

Funded by the European Union

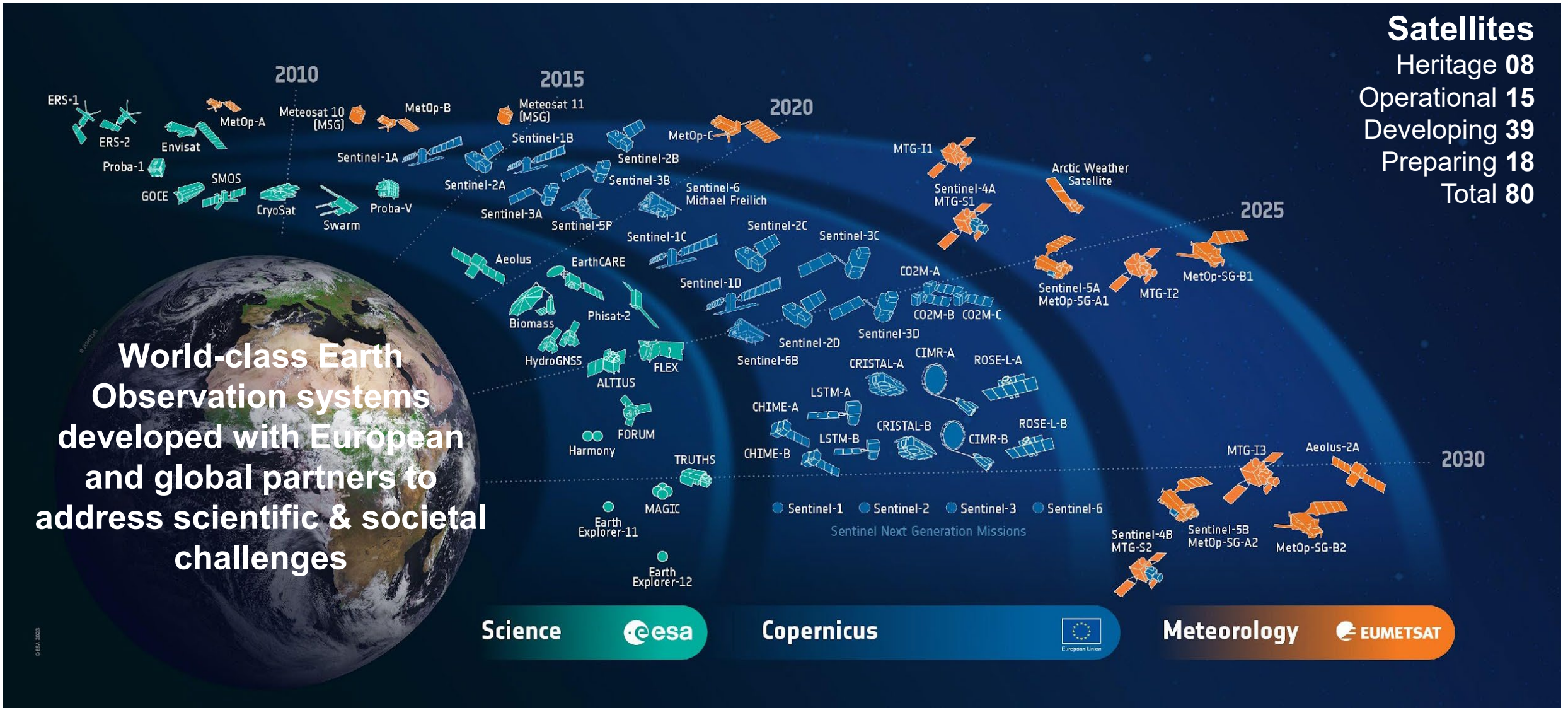
Implemented by ECMWF esa EUMETSAT

ESA EOP vision: DesntinE

platform.destine.eu



ESA EOP vision: EO satellites



ESA EOP vision: EO satellites

5 Satellites (4 Launches in 2024)

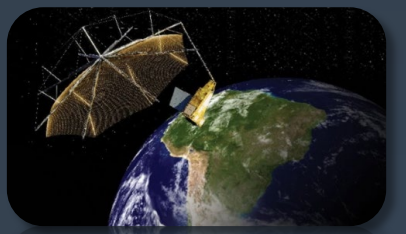
29 May *EarthCARE*

4 September
Sentinel-2C

16 August *Φsat-2* +
Arctic Weather Satellite

Early December
Sentinel-1C

6 Launches in 2025 (TBC)



Q1: *Biomass*

Q1: *HydroGNSS*

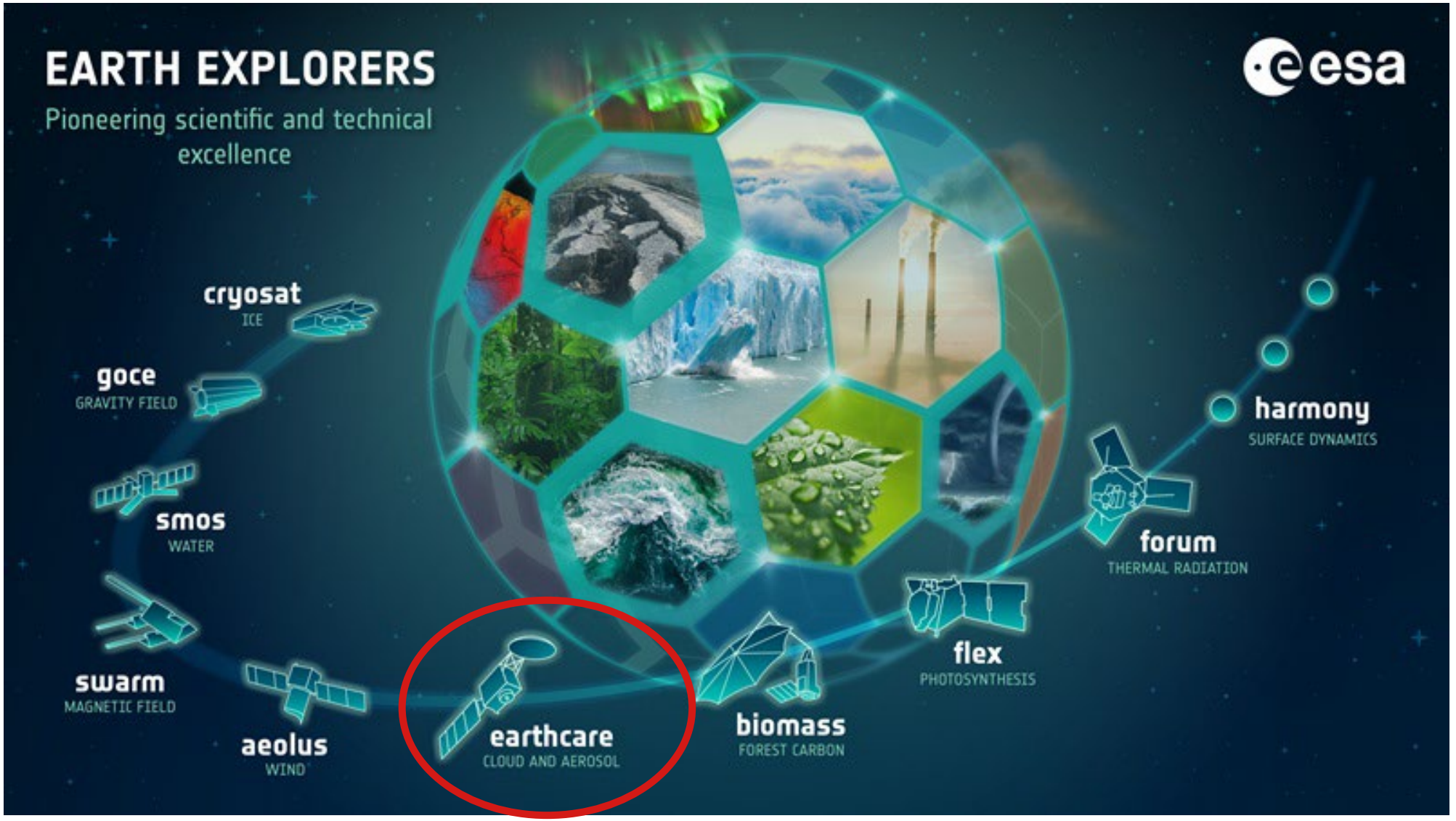
Q3: *MTG-S1*

Q4: *MetOp-SG A1*

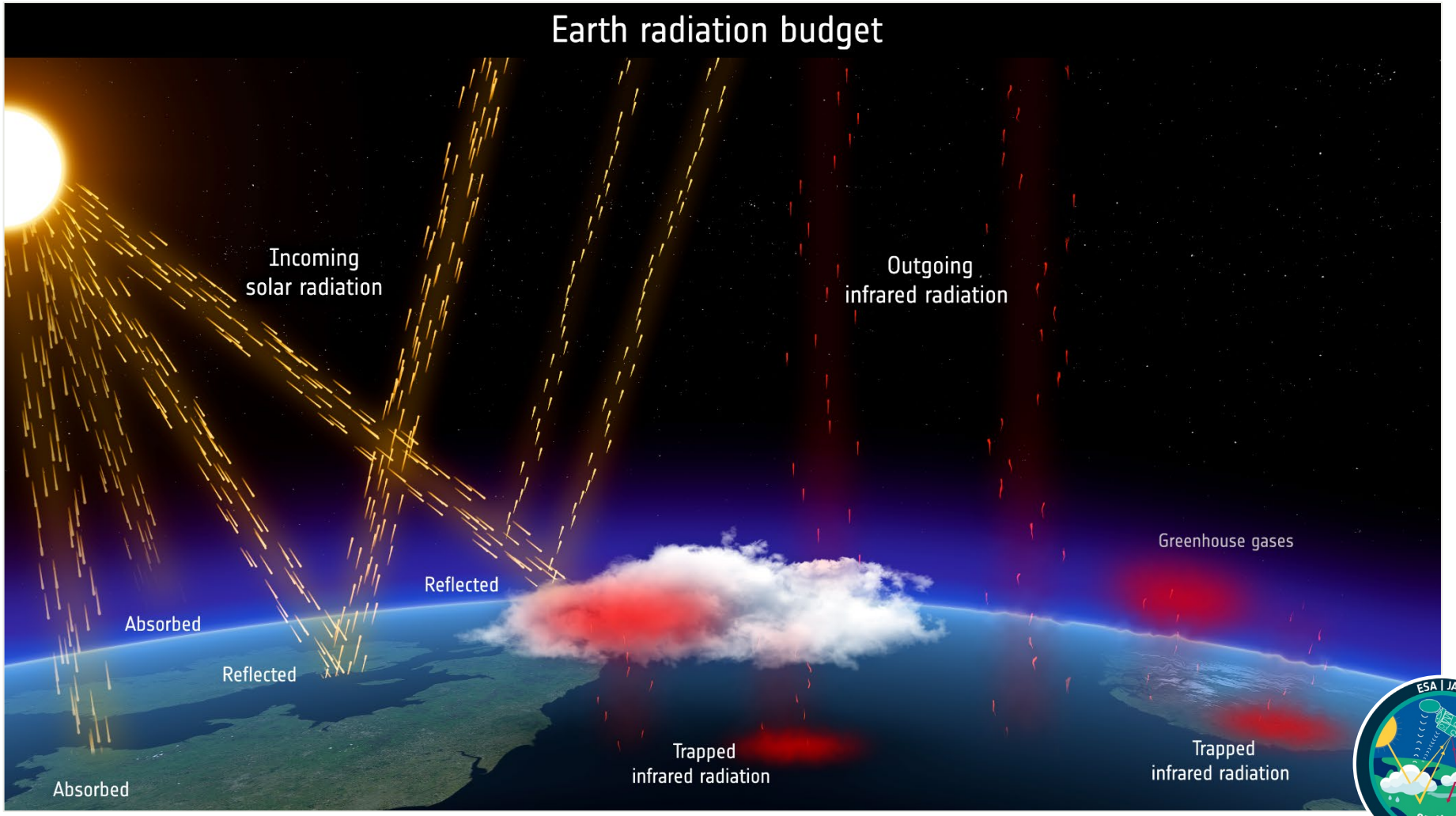
Q2: *Sentinel-1D*

Q4: *Sentinel-6B*

ESA EOP vision: Earth Explorer



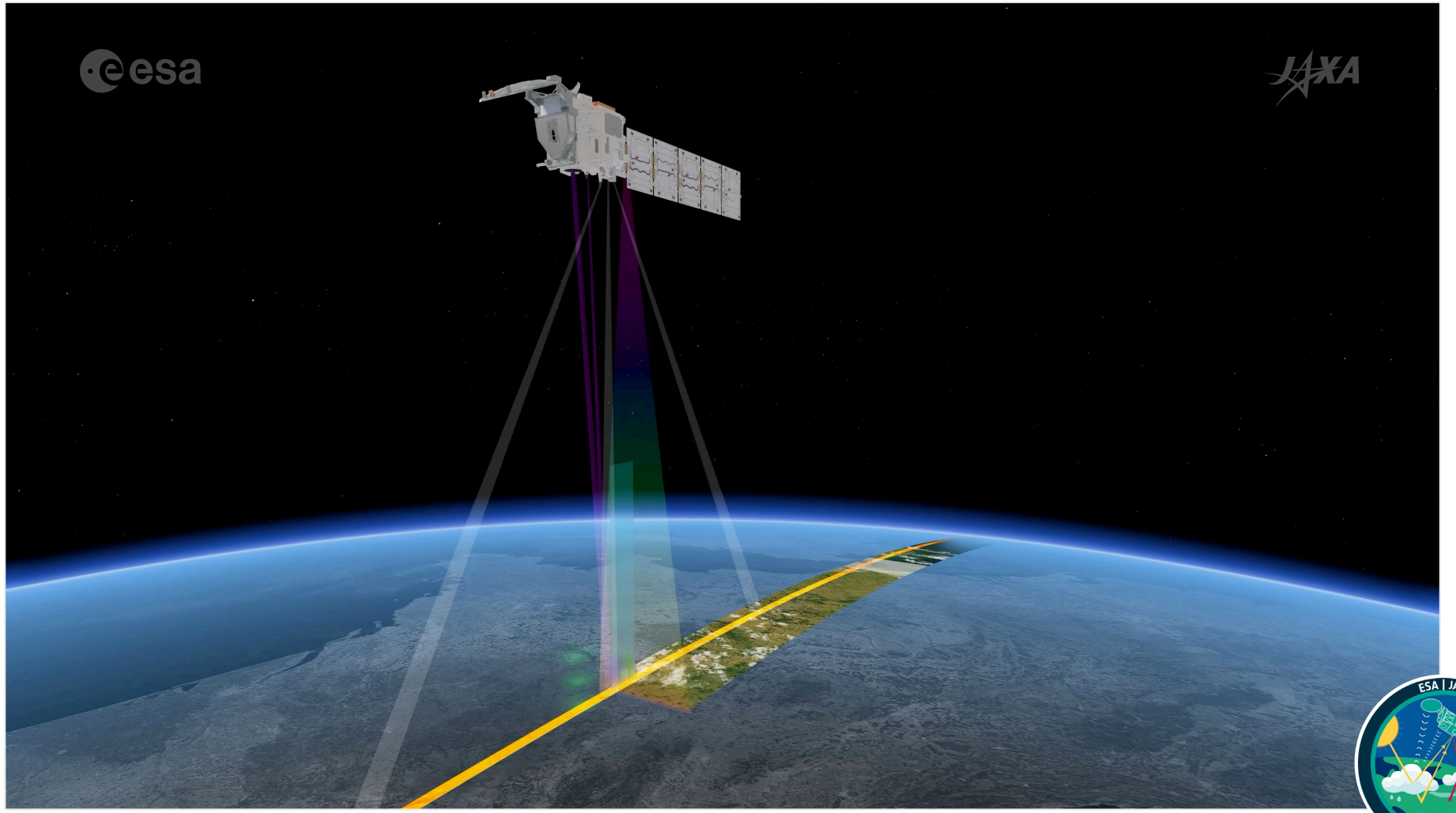
EarthCARE - Mission



Largest uncertainty in projections of the future climate, to be addressed in order to improve numerical weather prediction and climate modelling, comes from cloud, aerosol and radiation interactions.

How do aerosols and clouds, heat or cool the Earth?

EarthCARE – Mission Objective

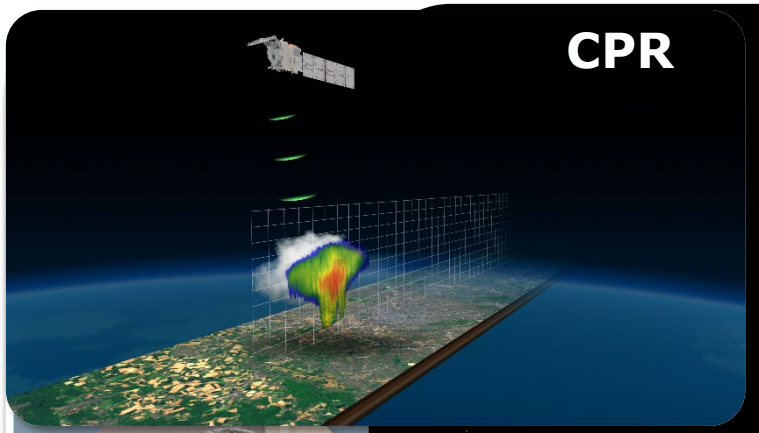


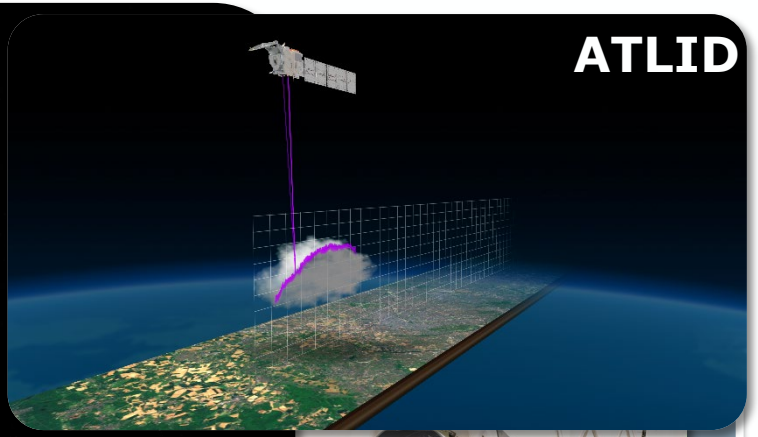
Systematic provision of vertical profiles of clouds and aerosols, collated with measurements of solar and emitted thermal radiation.

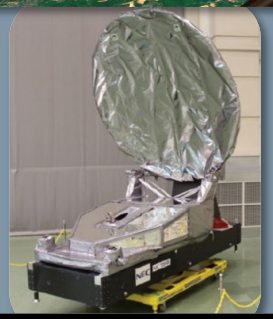
How do aerosols and clouds, heat or cool the Earth?

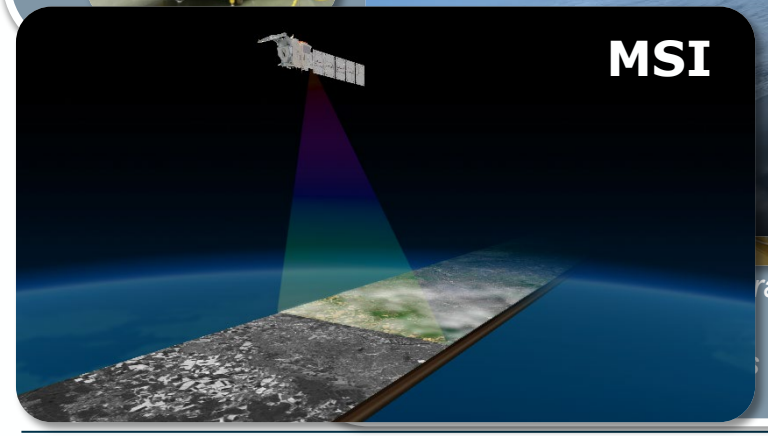
Direct verification of impact of clouds and aerosols on atmospheric heating rates and radiative fluxes.

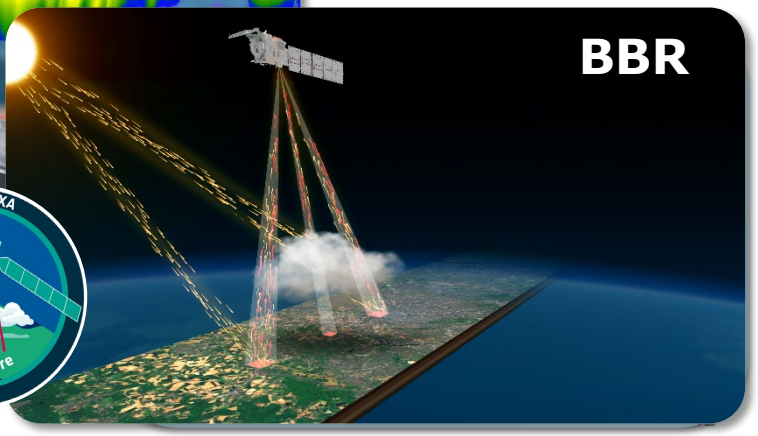
EarthCARE – Space Segment





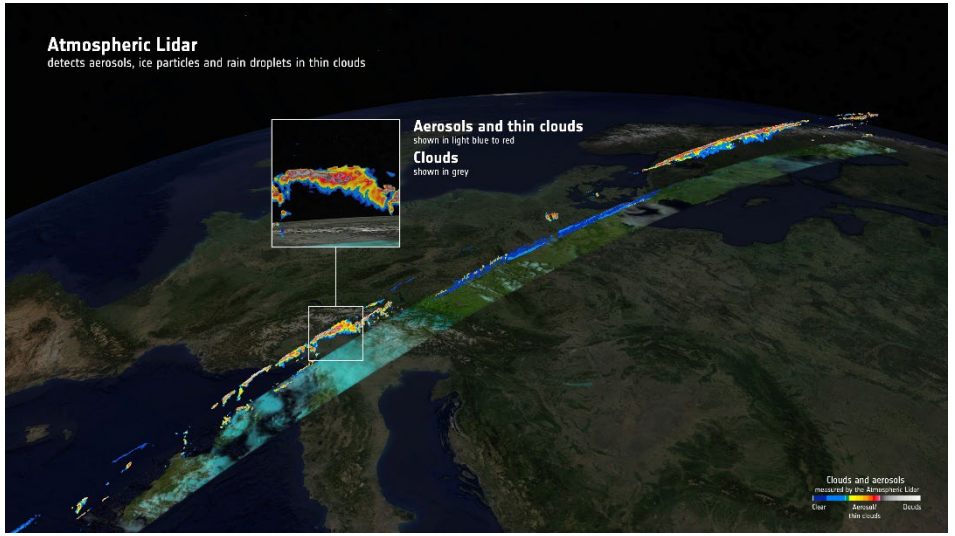


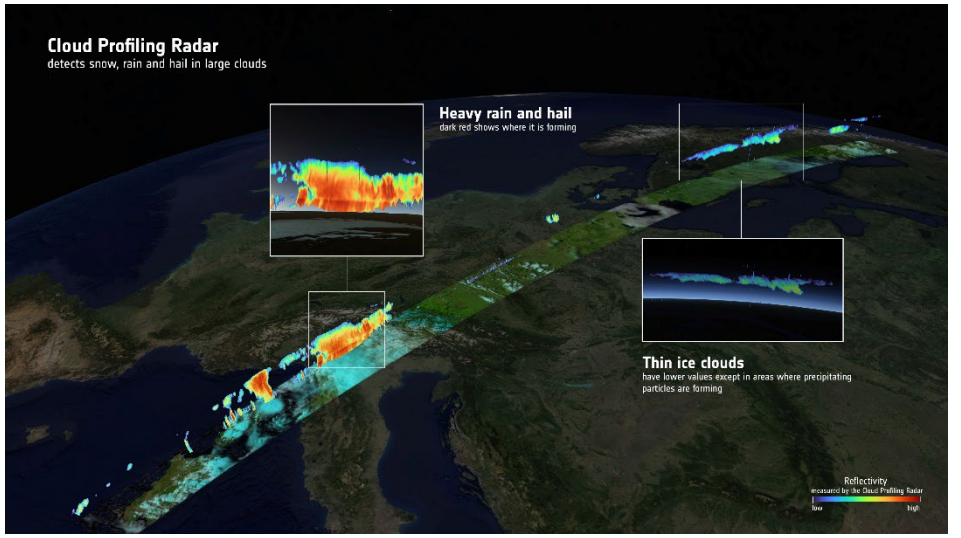




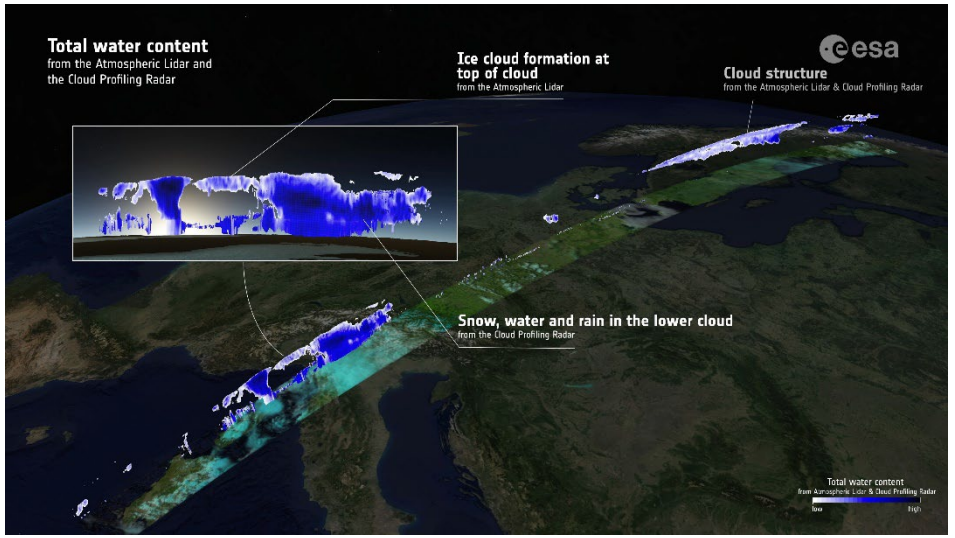
EarthCARE Synergy First Light

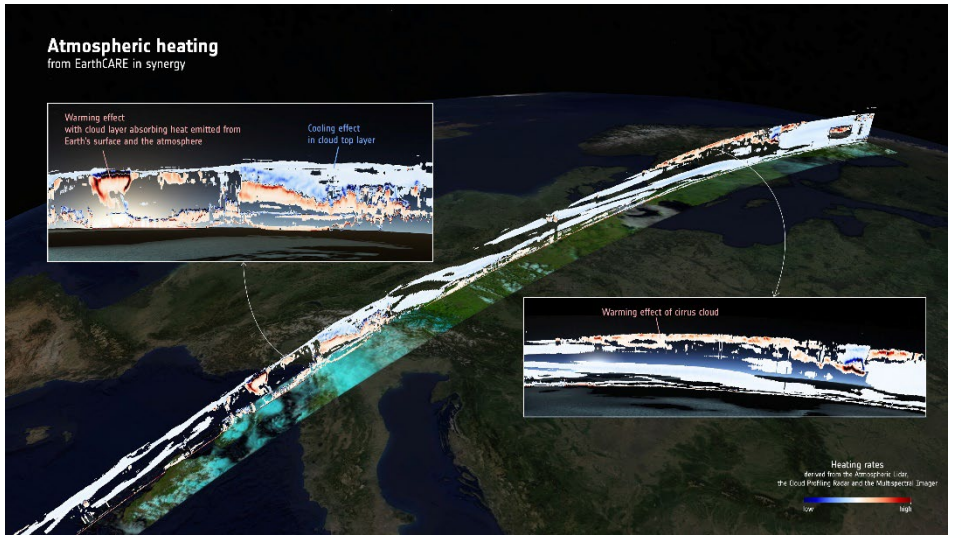
Single Sensor





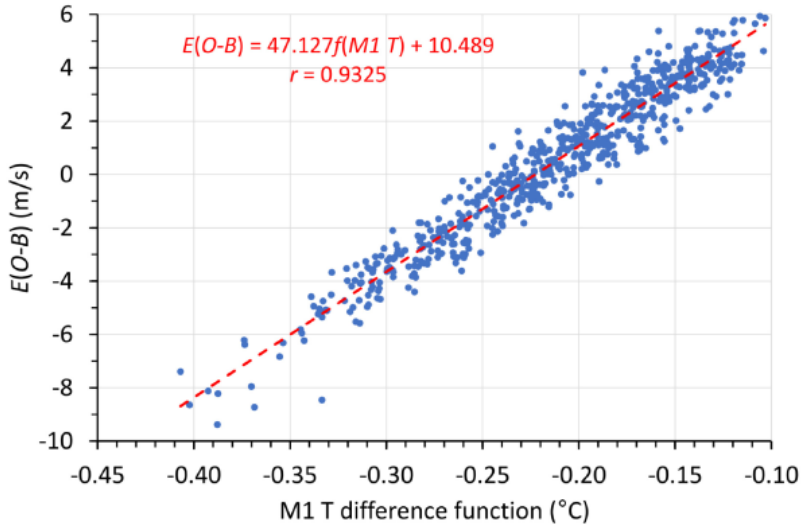
Synergy





EarthCARE links to NWP

The Aeolus mission (as for others before) revealed the power of NWP monitoring for investigating systematic instrument anomalies and significant improvement of the Mission Data Quality

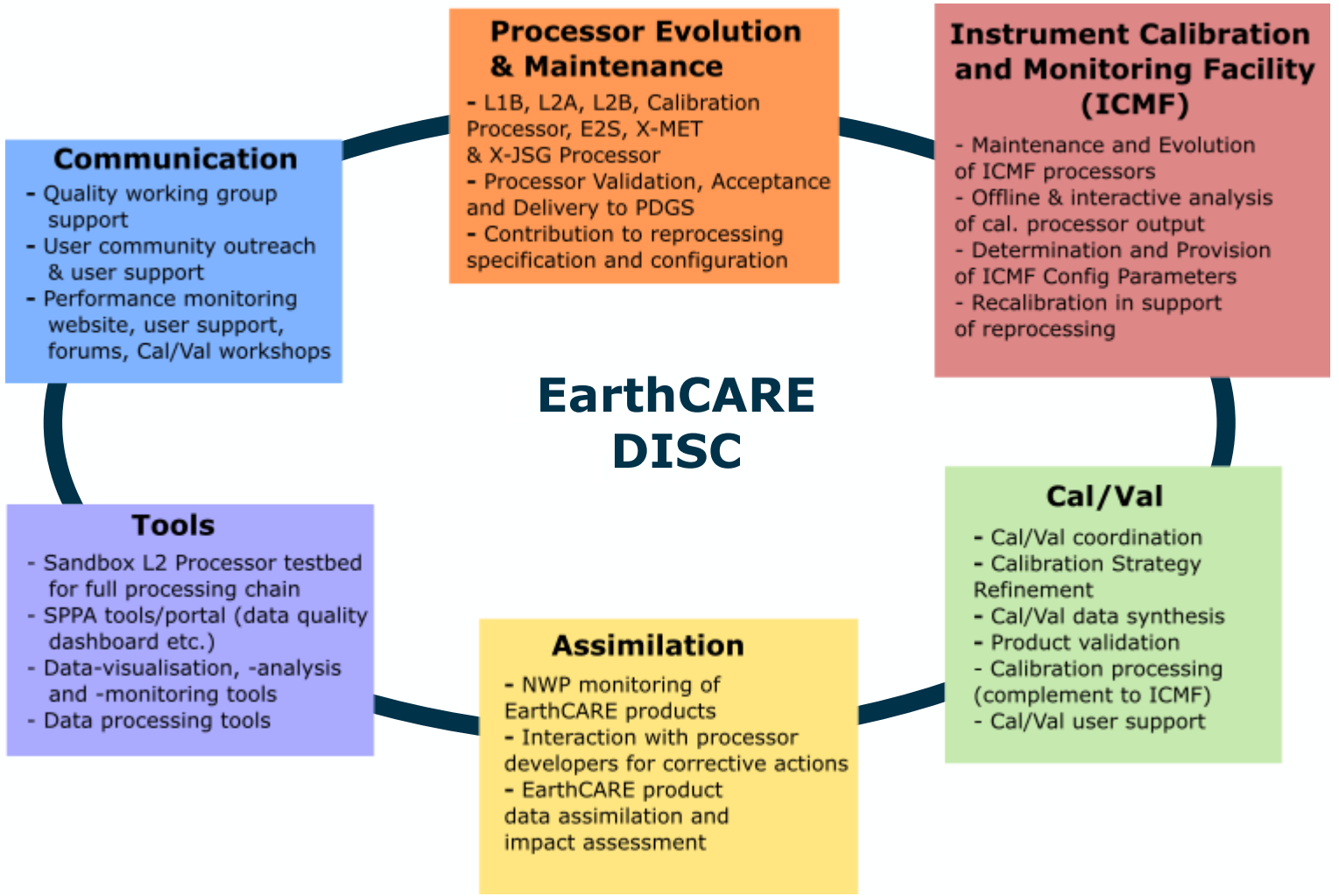


- Identification of instrument anomalies by correlation with NWP models.
- Major achievement by Mike Rennie (ECMWF) to find linear correlation between wind bias and M1-Temperature gradient (outer – inner T)

Rennie et. al (2021), QJRMS

- EarthCARE data quality will be continously monitored and assessed by ECMWF NWP models
  - Cloud radar observations, Cloud lidar observations
  - Aerosol lidar observations
- Integral part of the Data Quality Framework for the EarthCARE

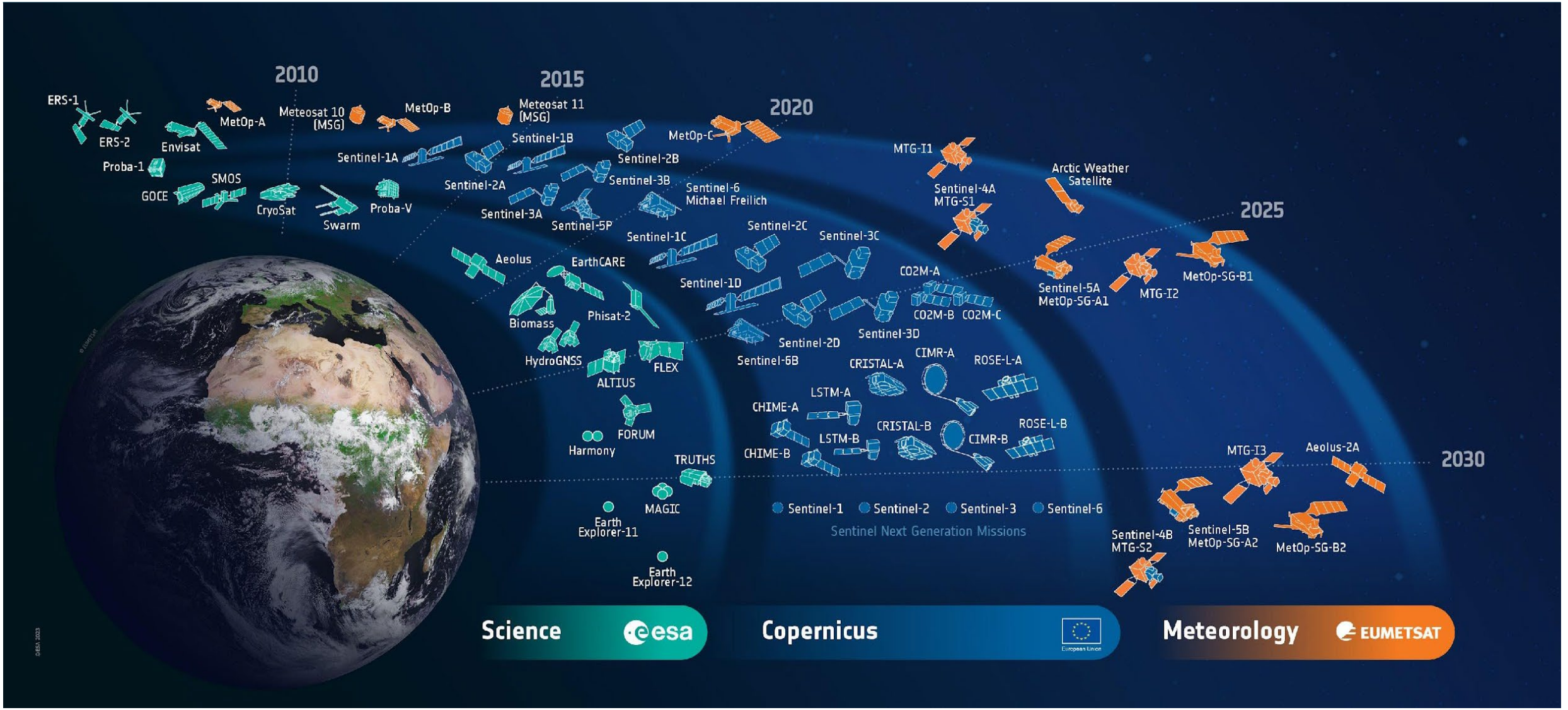
EarthCARE links to NWP - DISC



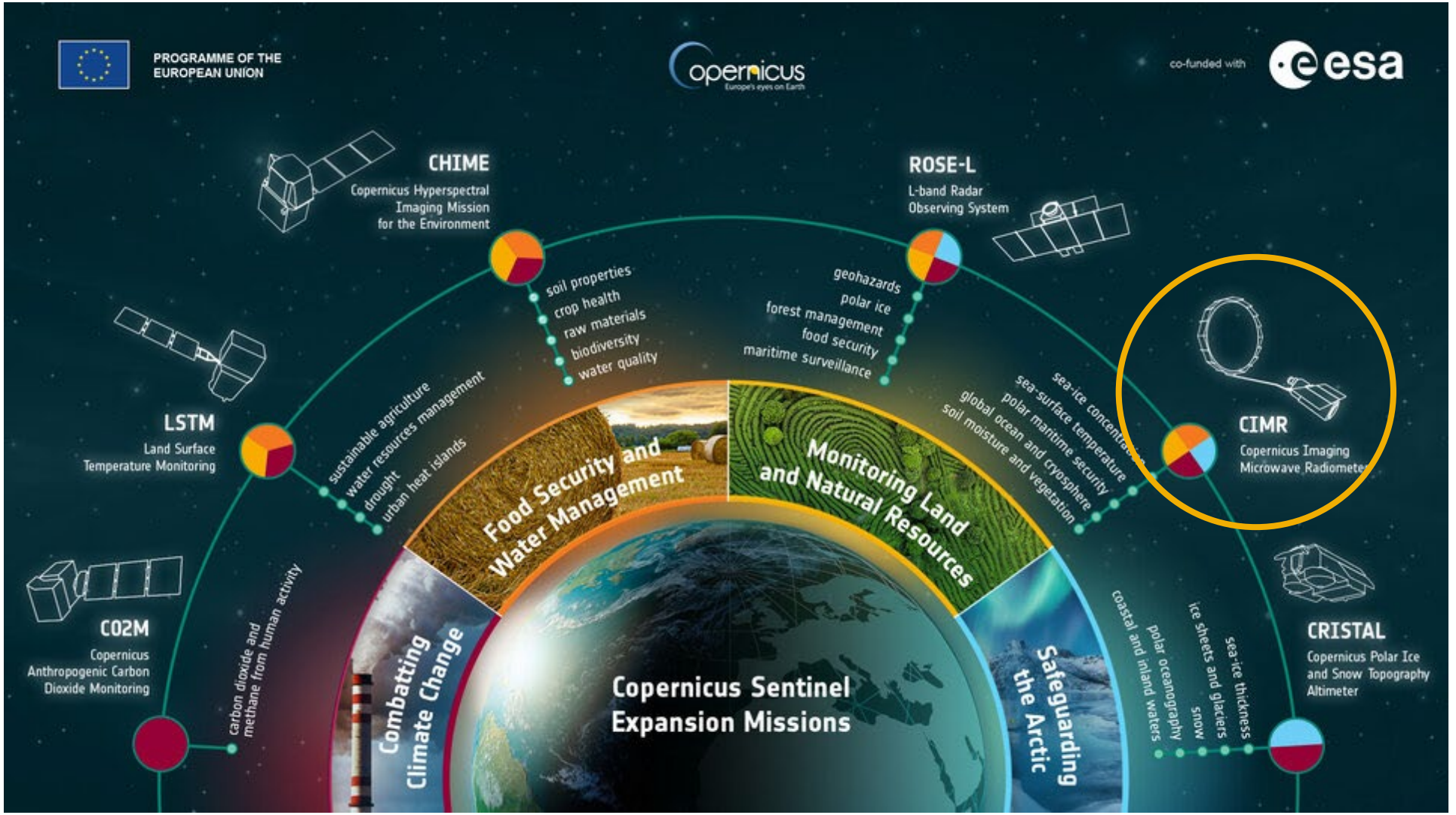
- Continuous improvement of EarthCARE product over the mission lifetime
- Algorithm and processor evolutions
- Data Quality Monitoring
- Cal/Val Synthesis
- EarthCARE product assimilation in NWP models
- Support and Interaction with User

DISC: Data Innovation and Science Cluster

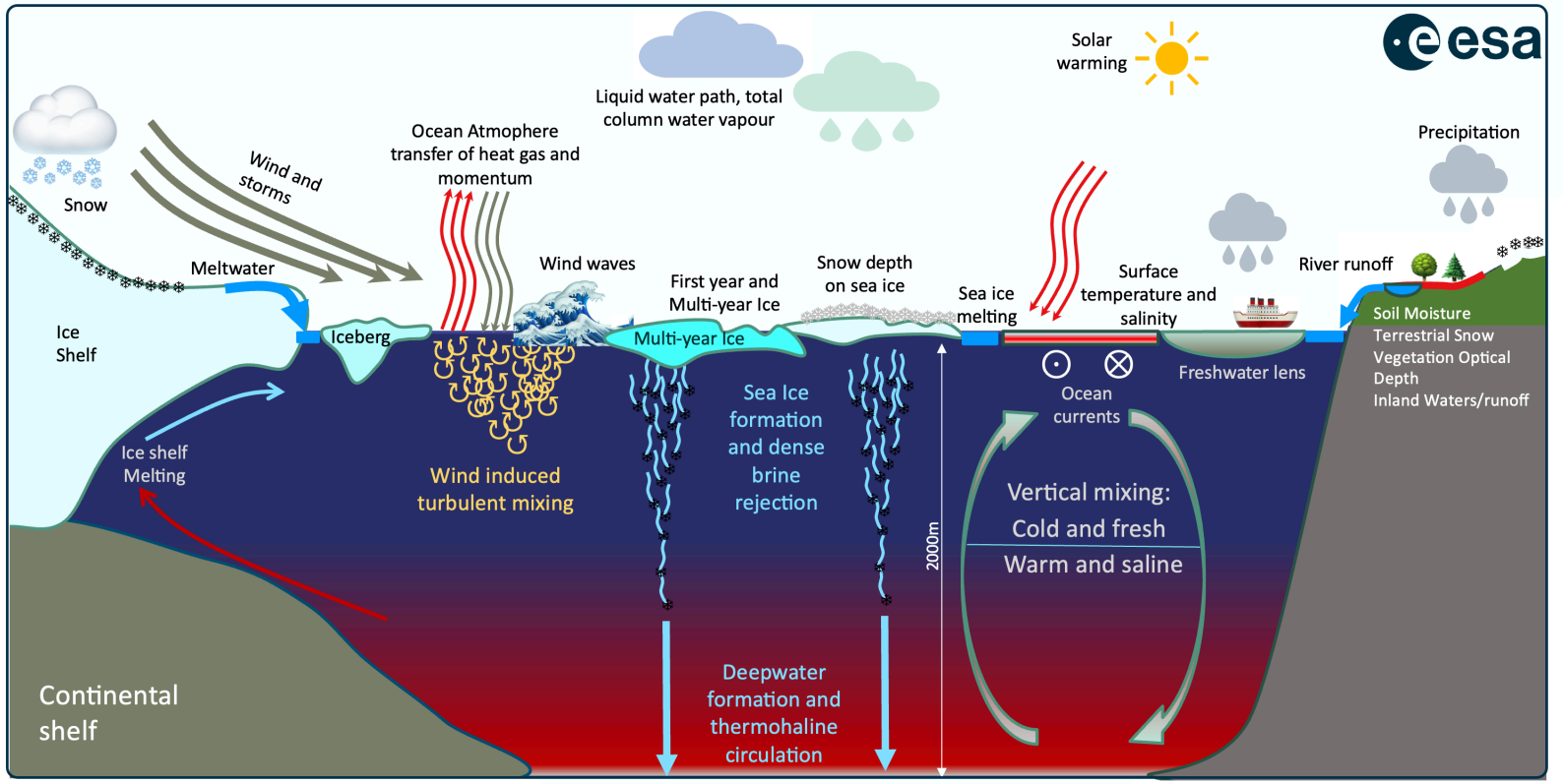
ESA EOP vision: Copernicus



ESA EOP vision: CopEx



Copernicus Imaging Macrowave Radiometer (CIMR)



CIMR must measure inter-related but fundamental parameters to monitor the Arctic regions but also, some with Global Coverage

Sea Ice Concentration, Thickness, Drift, Type, Ice Sheet Melt, Permafrost

Sea, Land, Snow and, Ice Surface Temperature

Sea Surface Salinity and Soil Moisture

Ocean Vector Winds

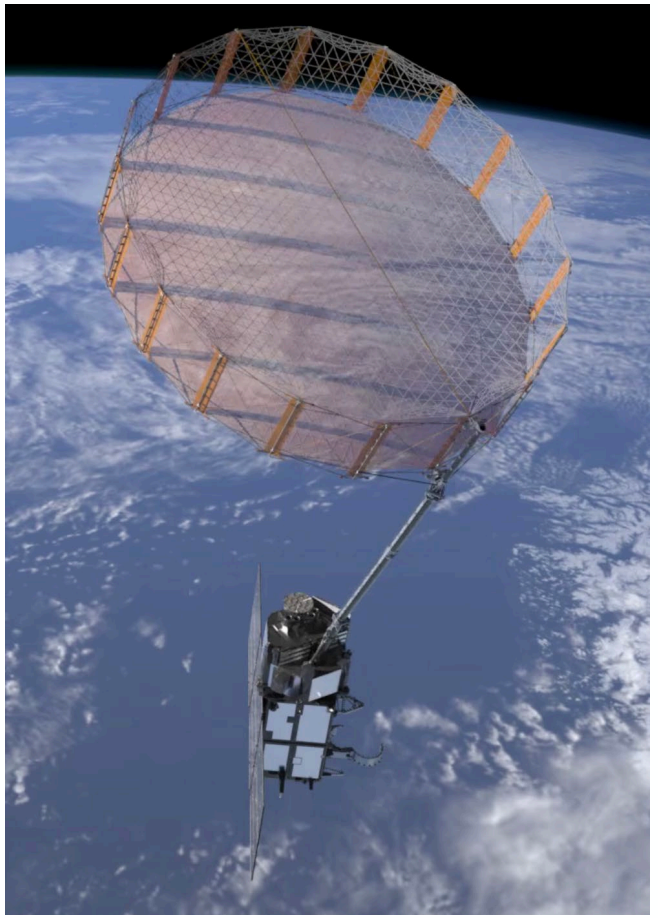
Snow Extent, Snow Depth, Snow Water Equivalent

Vegetation Optical Depth, Vegetation Indices

Total Column Water Vapour, Liquid Water Path, Precipitation

CIMR Mission

Mission aim:
Provide high-spatial resolution microwave imaging radiometry measurements and derived products with global coverage and sub-daily revisit in the polar regions and adjacent seas to address Copernicus user needs.



Polar Regions are fundamental to understanding the global environment

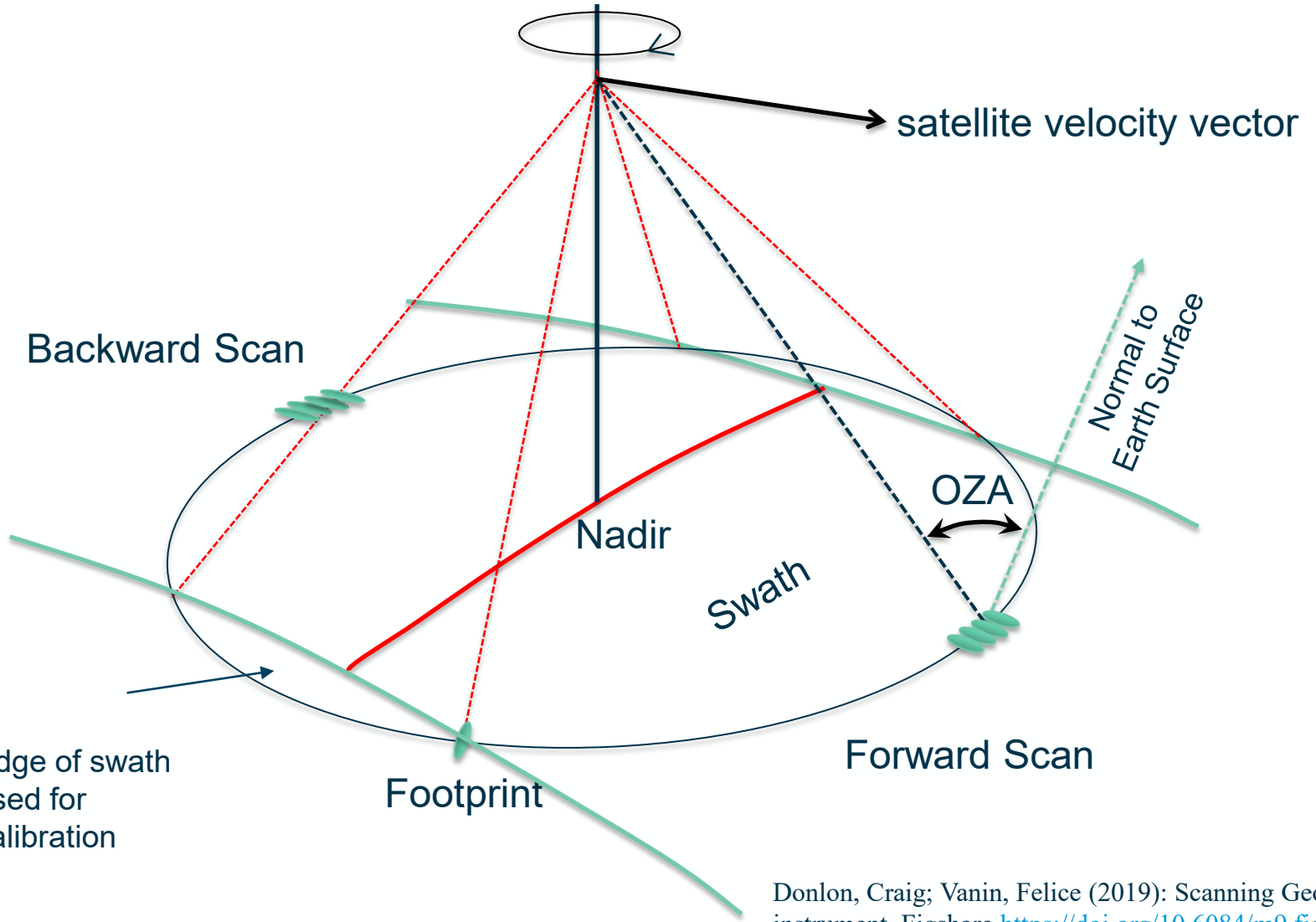
CIMR is designed to:

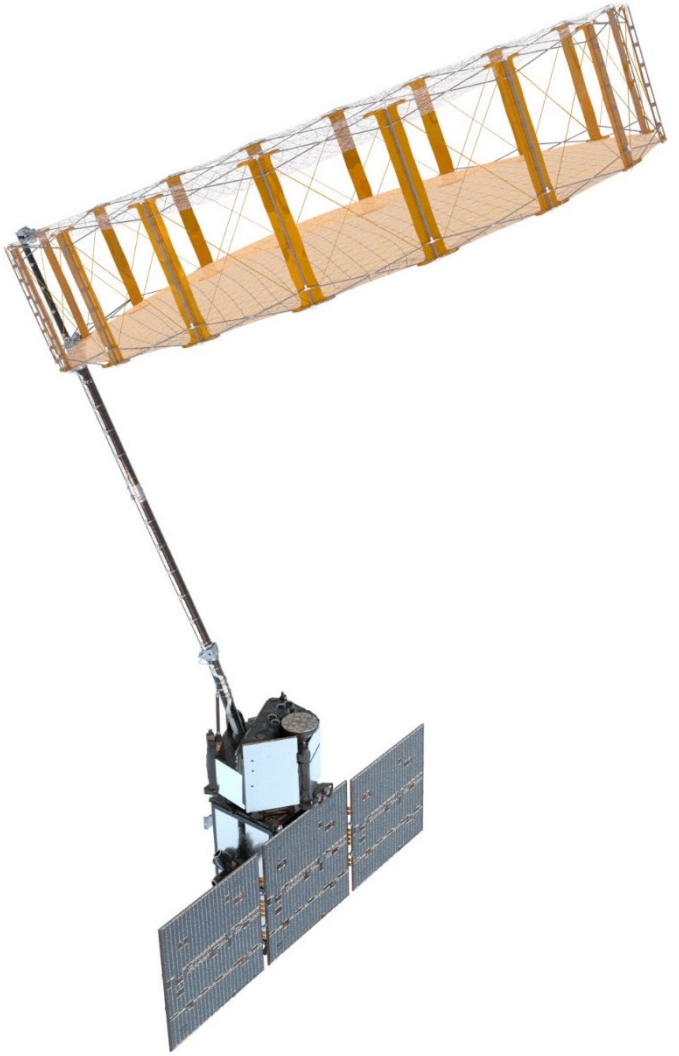
- **Prevent the anticipated Gap in capability**
- Low frequency/High Spatial resolution (5–15 km)
- **Measurements every ~6 hours** in the Polar regions, no hole at the pole
- 95% global coverage every day for **application in all Copernicus Services**
- Directly addresses the EU Arctic Policy.

Atmosphere (CAMS) | Marine (CMEMS) | Land (CLMS) | Climate (C3S) | Emergency (EMS) | Security

A ‘Game Changer’ for Copernicus

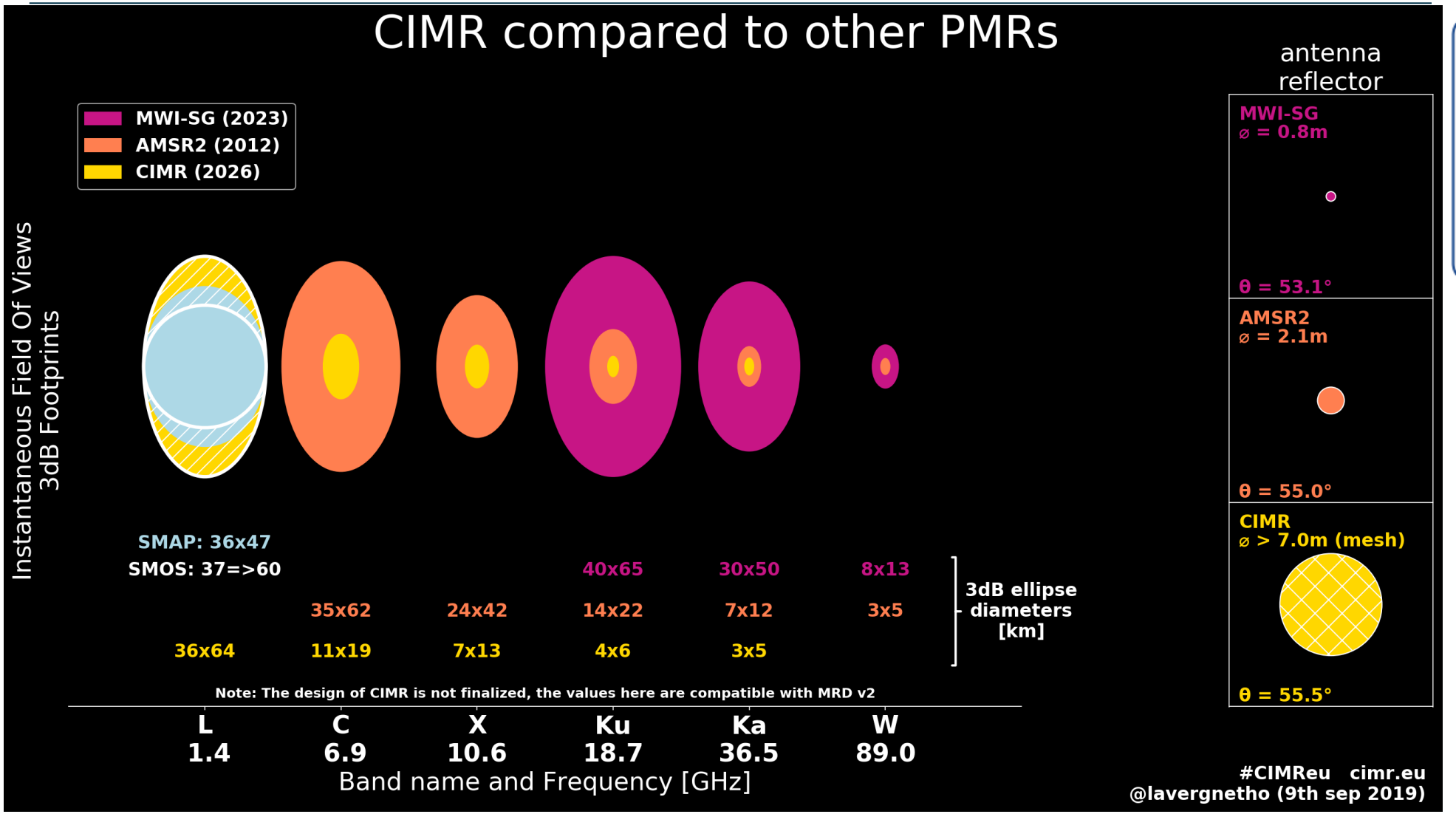
CIMR general architecture

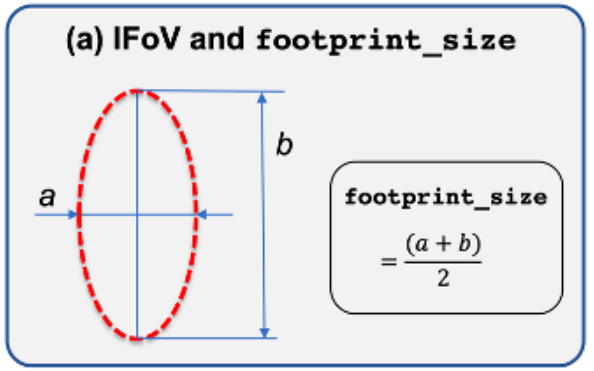




Donlon, Craig; Vanin, Felice (2019): Scanning Geometry of th instrument. Figshare https://doi.org/10.6084/m9.figshare.7749398.v1

CIMR: a game changer





`footprint_size`:

L: <60 km

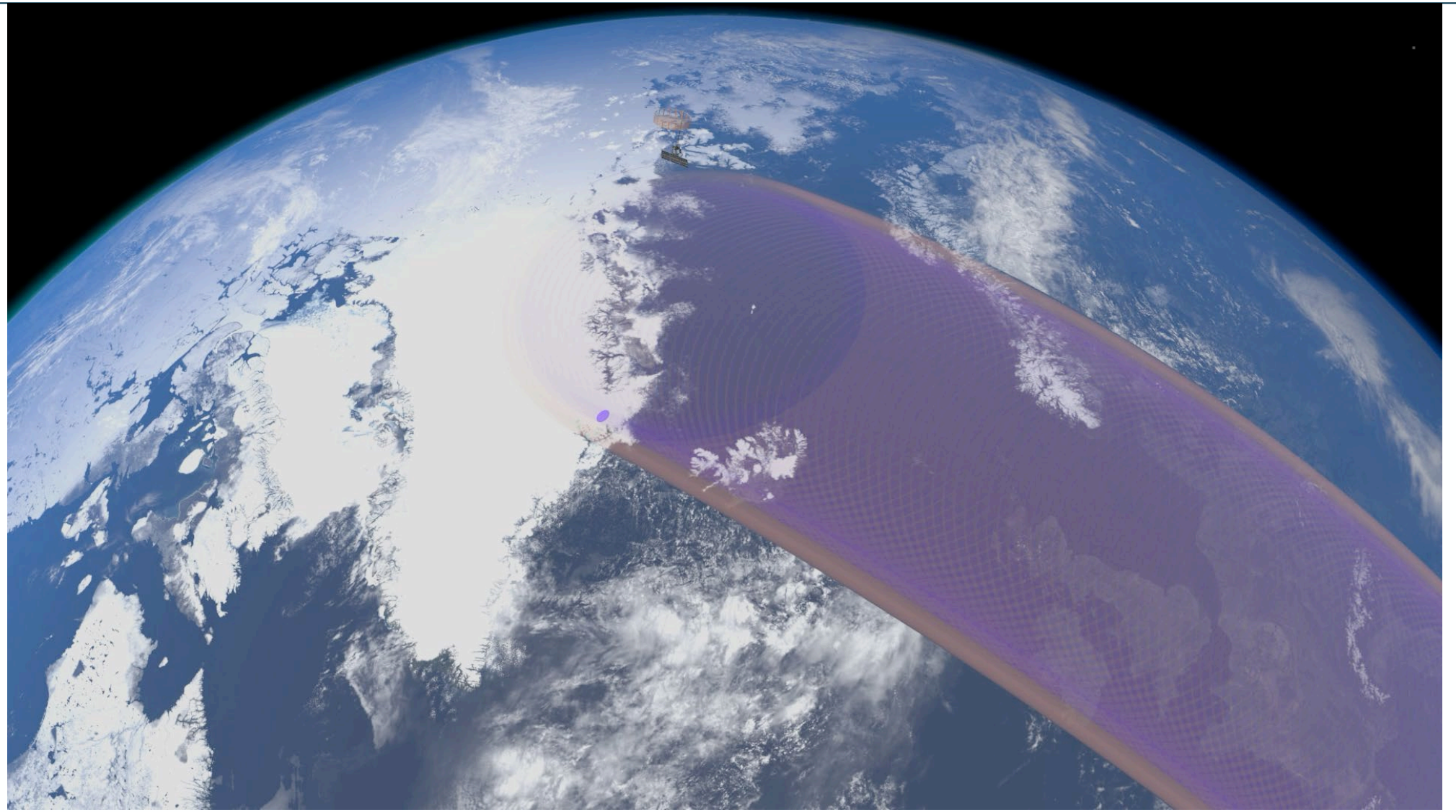
C: ≤15 km

X: ≤15 km

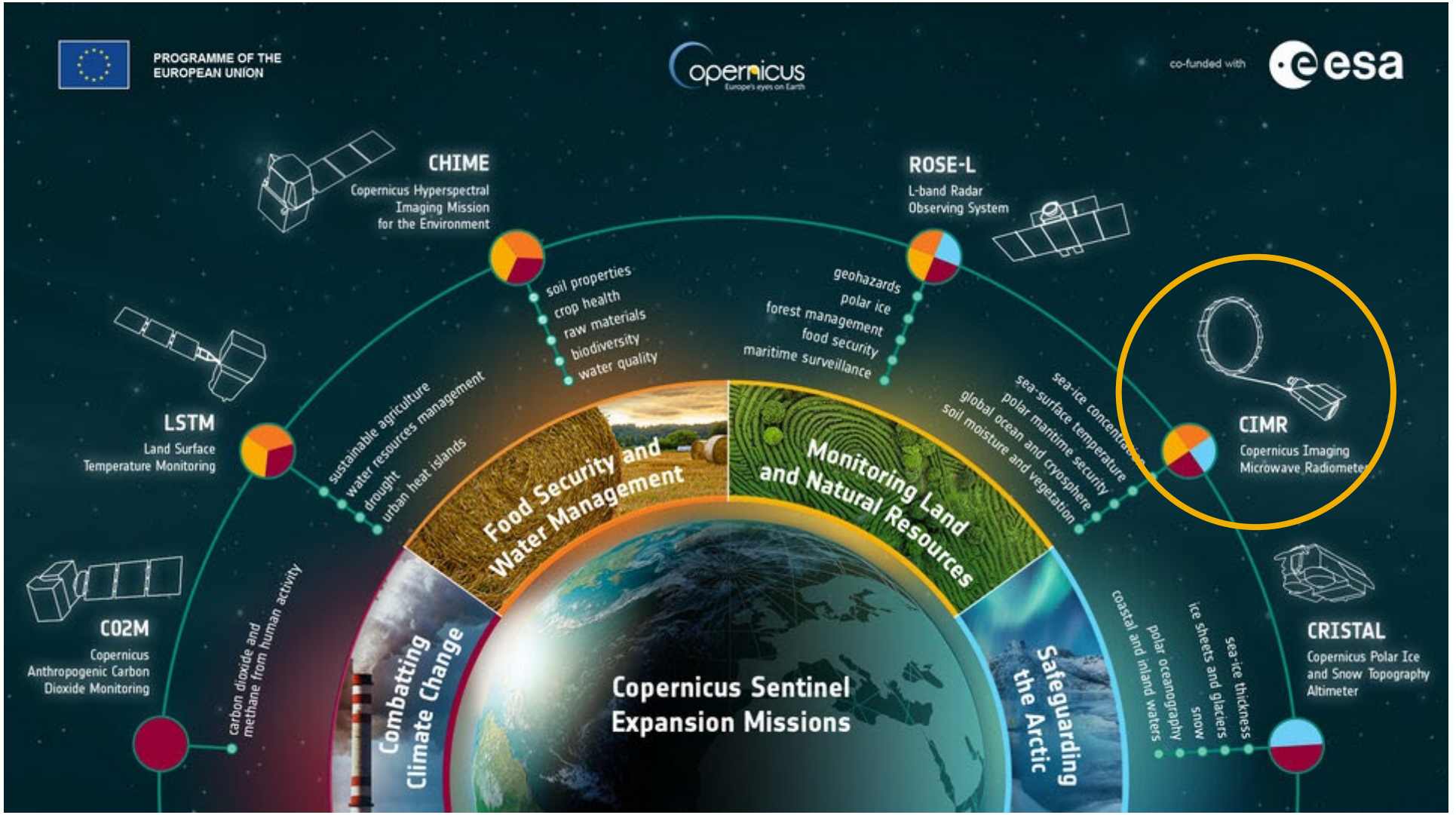
K: ≤ 5.5 km

Ka: ≤5 (g:4) km

CIMR: a game changer



ESA EOP vision: CopEx



CRISTAL: Copernicus polaR Ice and Snow Topography ALtimeter

Aim of CRISTAL Mission

to obtain high-resolution sea ice thickness and land ice elevation measurements including the capability to determine the properties of snow cover on sea ice so as to provide Copernicus' operational products and support services of direct relevance to the polar zones.

PRIMARY OBJECTIVES

HR sea ice thickness and **snow depth** measurements in polar regions

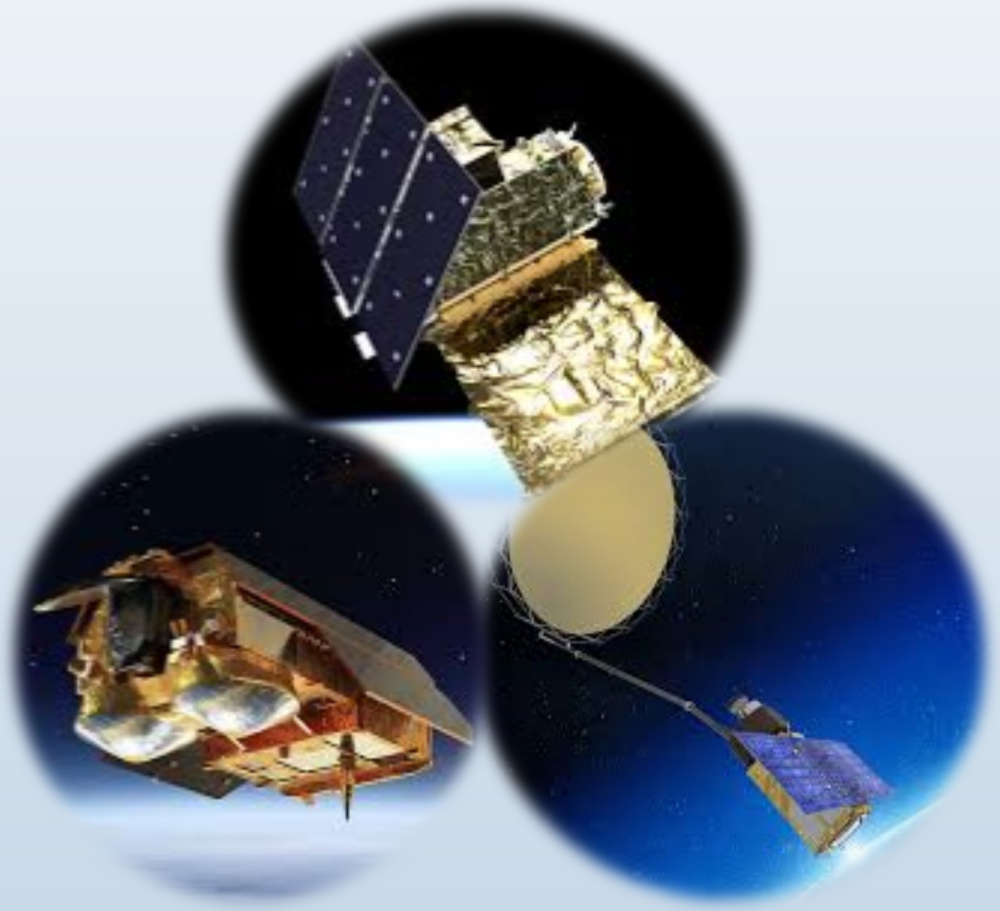
HR ice elevation measurements of glaciers, ice caps and ice sheets

SECONDARY OBJECTIVES

Global ocean topography as a **continuum up to the polar seas**

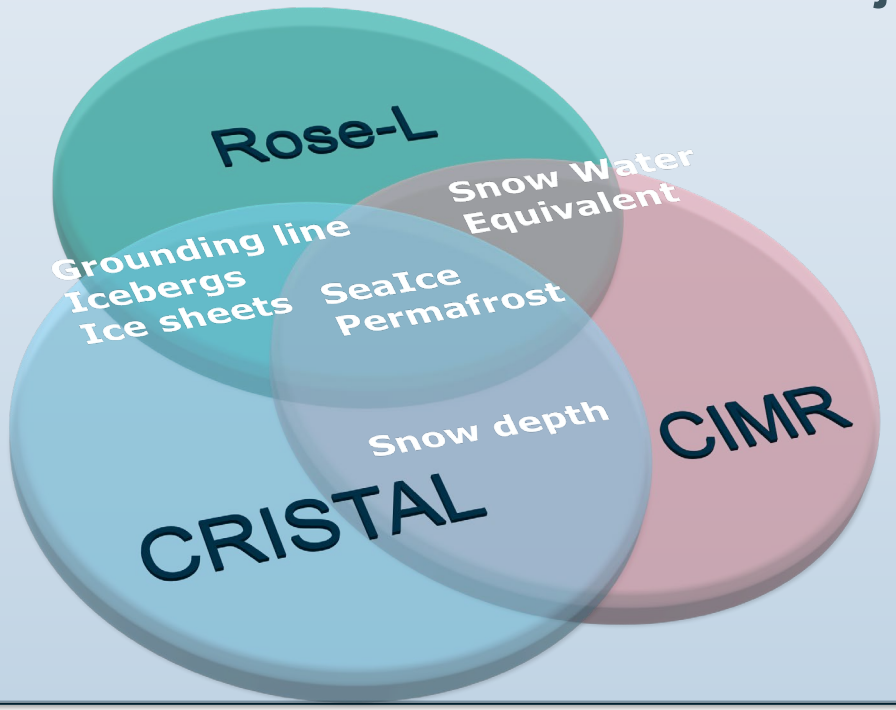
Support applications related to coastal **inland waters**, snow cover and permafrost

Copernicus Expansion Missions: Polar synergies

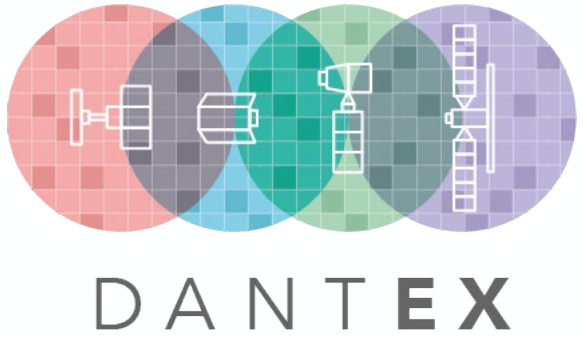


Three Copernicus Expansion missions CIMR, CRISTAL and ROSE-L support the implementation of the EU Arctic Policy allowing enhanced monitoring of the cryosphere

CRISTAL, ROSE-L and CIMR will operate on the same domains and will have common Mission objectives



CRISTAL and CIMR link with NWP



KO yesterday!

3 years project

DN with ECMWF

Main objectives:

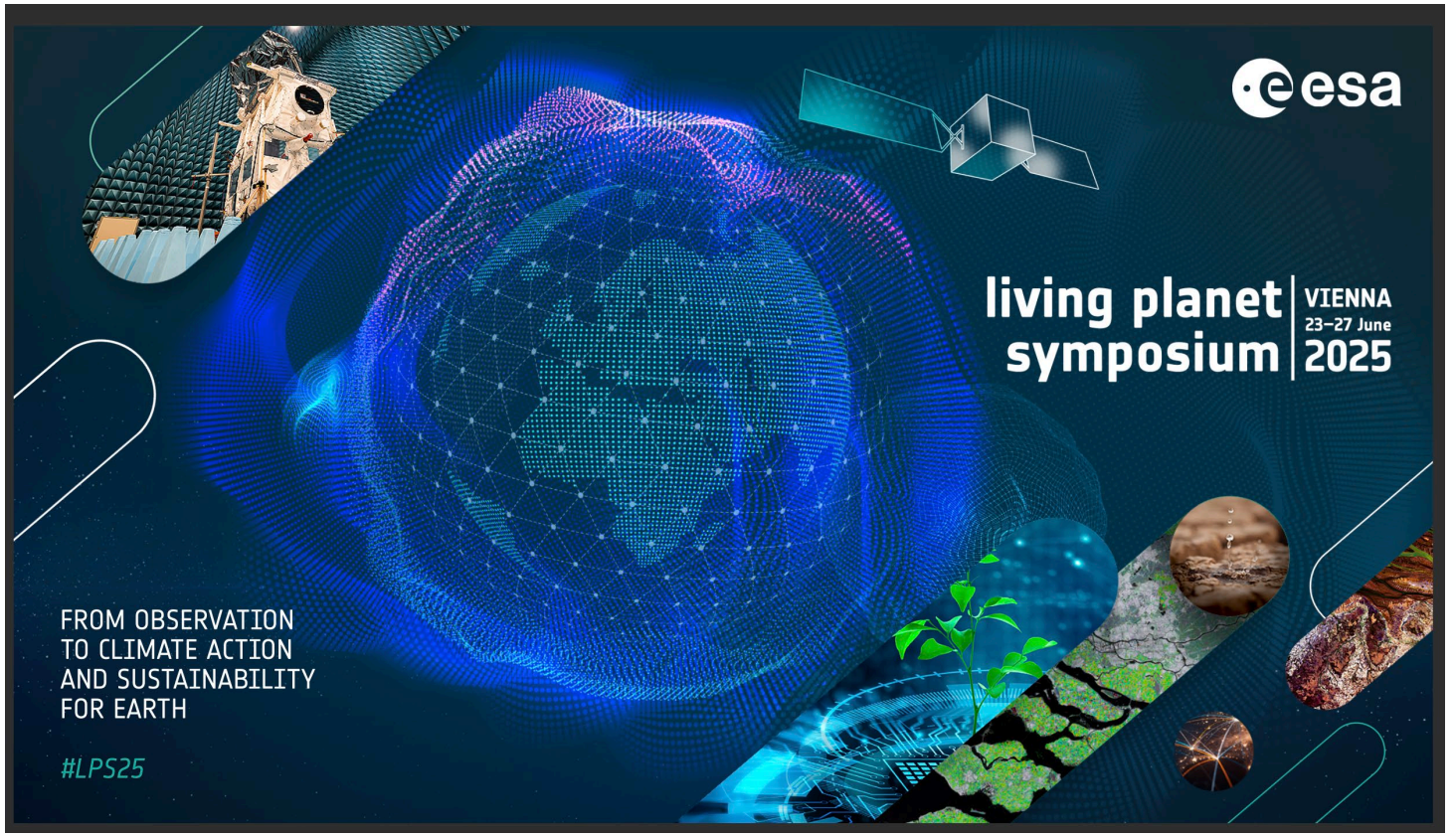
1. Assess the state of the art of **RT models and tools and DA for cryosphere and land domains** and define a roadmap of **evolution supporting the CEMs operational capabilities**.
2. Develop improved RT models and tools and **Coupled DA** techniques and **test these using satellite datasets**.
3. Provide **recommendations on L1 and L2 data** format and content **for CIMR, CRISTAL and LSTM missions.**
4. Provide assessment of Sentinel-1 Synthetic Aperture Radar (SAR) Wave Mode (WV) coupled DA

DANTEX: Data Assimilation and Numerical Testing for EXpansion missions

Conclusion

- ESA vision: the interface observations and coupling are major attention topics

- ESA works in synergy with ECMWF to benefit from NWP in terms of:
  - Data quality monitoring
  - Data validation
  - Model parameters provision for operational data processing



Dedicated sessions at LPS25! (lps25.esa.int)

Deadline: December 1st!

Thank you !

filomena.catapano@esa.int