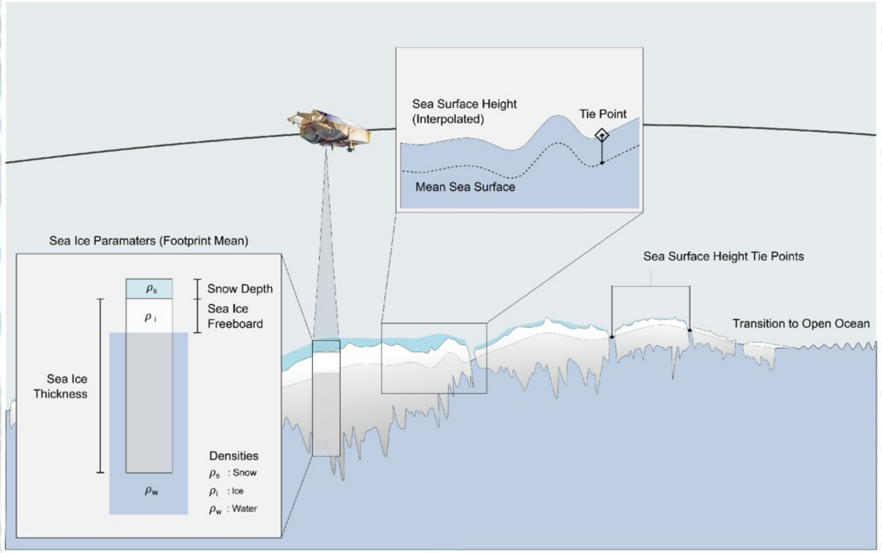
CRISTAL Mission – the key requirements

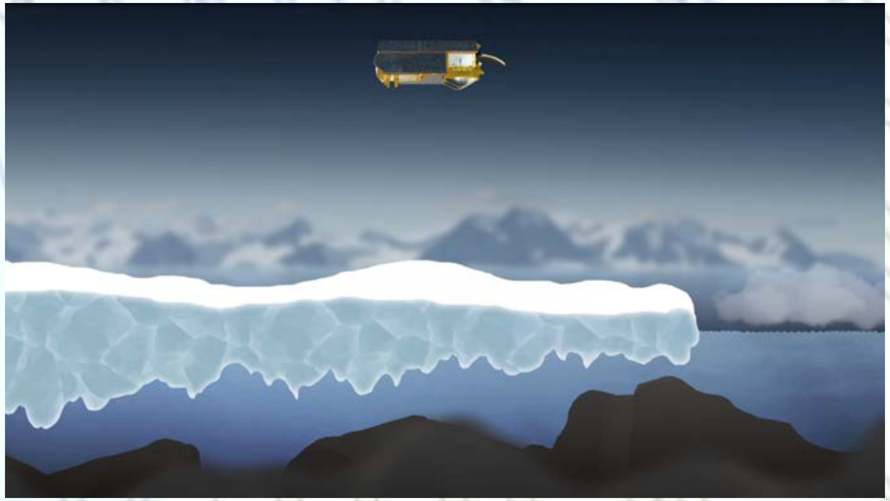
CRISTAL performance and latency requirements:

Applications / Geophysical Products	Measurement uncertainty	Latency requirements
Sea ice freeboard	< 3 cm over segments ≤ 25 km	6 hours
Sea ice thickness	< 10 cm	24 hours
Snow depth on sea ice	< 5 cm	24 hours
Land ice/glacier elevation	< 2 m	NTC (< 30 d)
Iceberg detection		24 hours
Ocean L2 products	< 3.5 cm (for 1-Hz SSH NTC)	NRT (< 3 h) STC (< 48 h) NTC (< 30 d)
Ocean L1 products		STC (< 48 h) NTC (< 30 d)

Most Products **already validated** (CryoSat-2) and **further enhanced** with **higher accuracies.**

New products for **Snow depth** and **Iceberg detection**





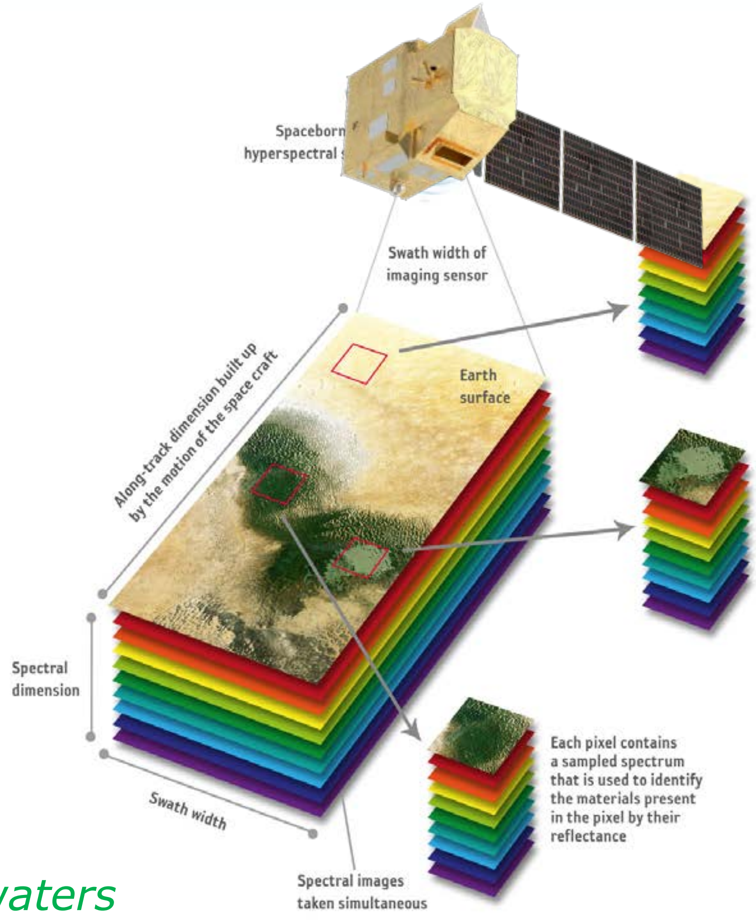
Copernicus Hyperspectral Imaging Mission for the Environment (CHIME)

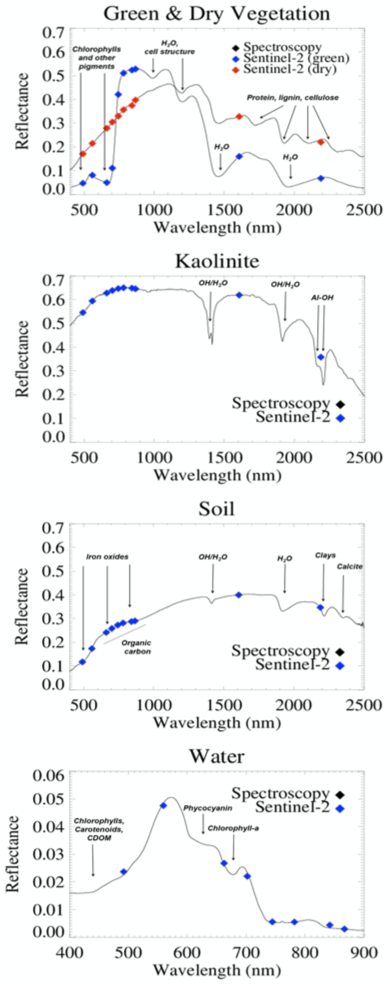
Mission objective:
Provide routine hyperspectral measurements in support of EU- and related policies for the management of natural resources & assets

Primary applications: food security, agriculture, raw materials, soil properties

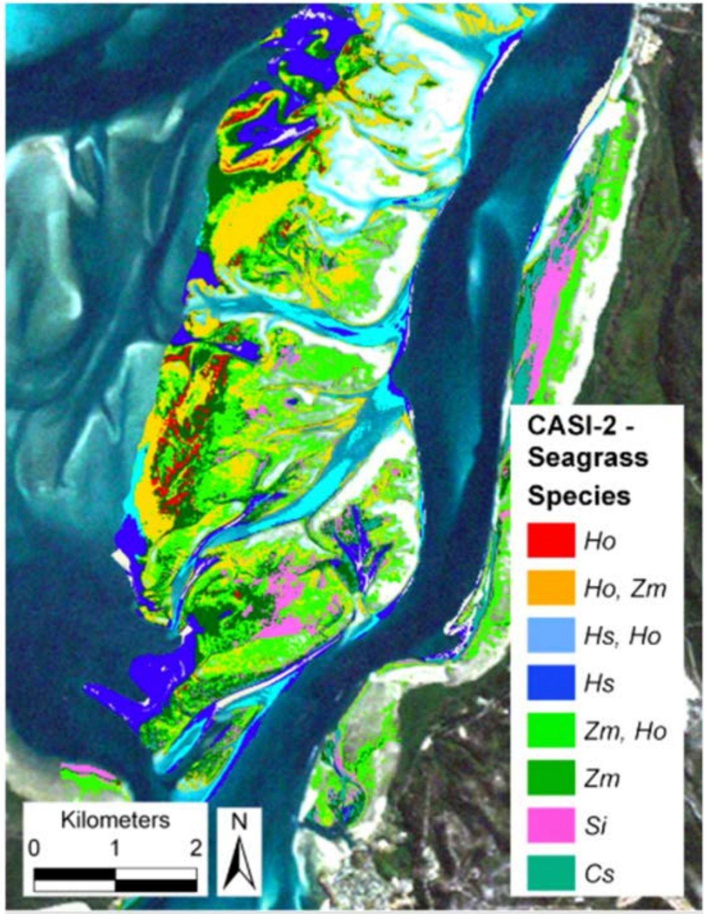
Secondary Applications: biodiversity, forestry management, environmental degradation, lake/coastal ecosystems and water quality, snow grain size/albedo, snow impurities

- *Routine hyperspectral observations* 56S to 84N
- *Sun synchronous orbit (LTDN 10:45)*
- *Revisit ≤ 12.5 days (for 2 satellites, swath >100km)*
- *Nadir view covering land surfaces, inland- and coastal waters*
- *Spectral range: 400 – 2500 nm*
- *Spectral bandwidth ≤ 10nm*
- *SSD: 30m*





CHIME in the Coastal Zone and Inland Waters

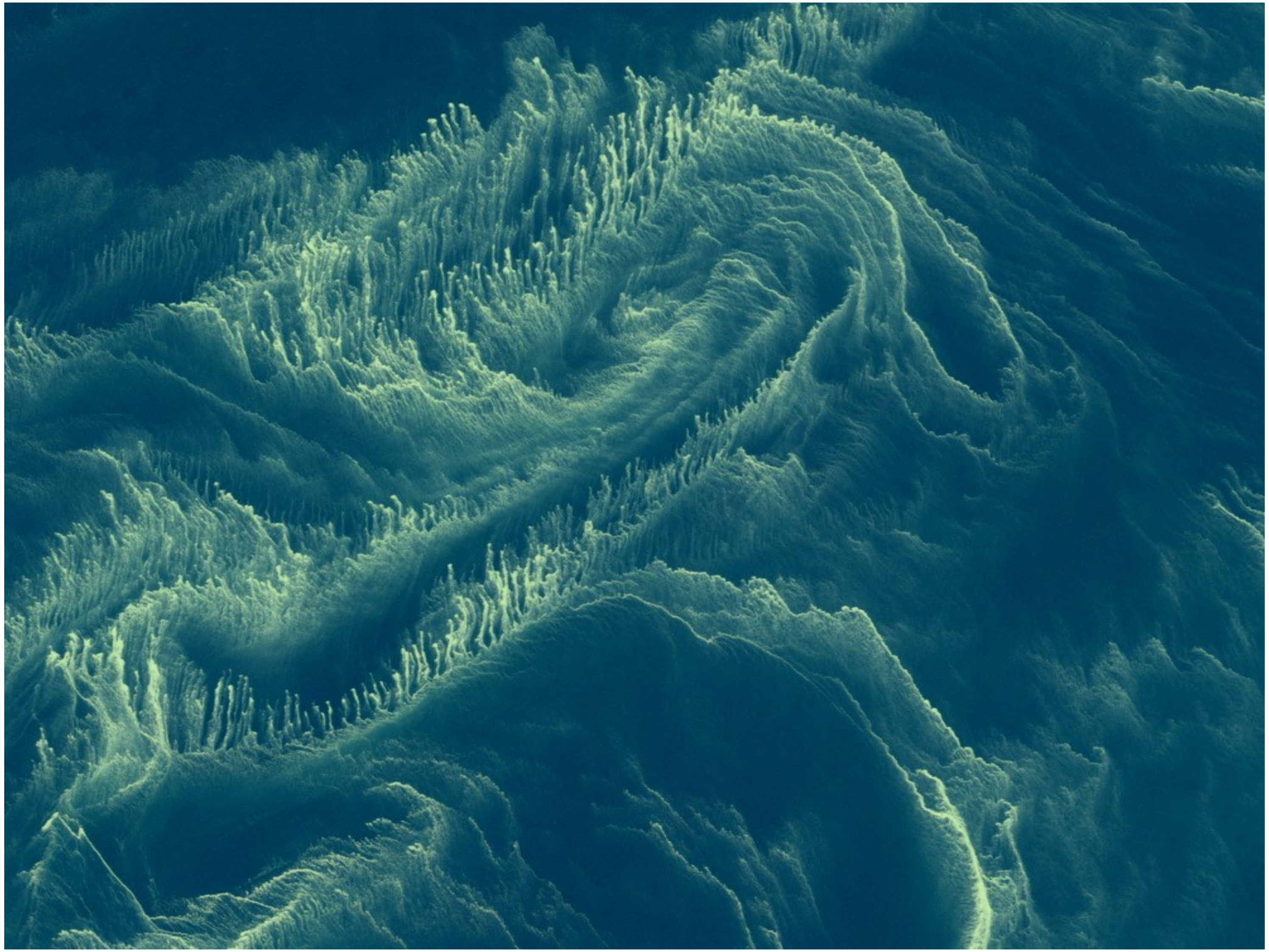


Seagrass species maps to 3.0 m depth (Eastern Banks in Moreton Bay, Australia) derived from CASI-2 data.

- **Hyperspectral information is expected to provide more accurate assessments of:** turbidity and transparency measures, chlorophyll, suspended matter and coloured dissolved organic matter concentration

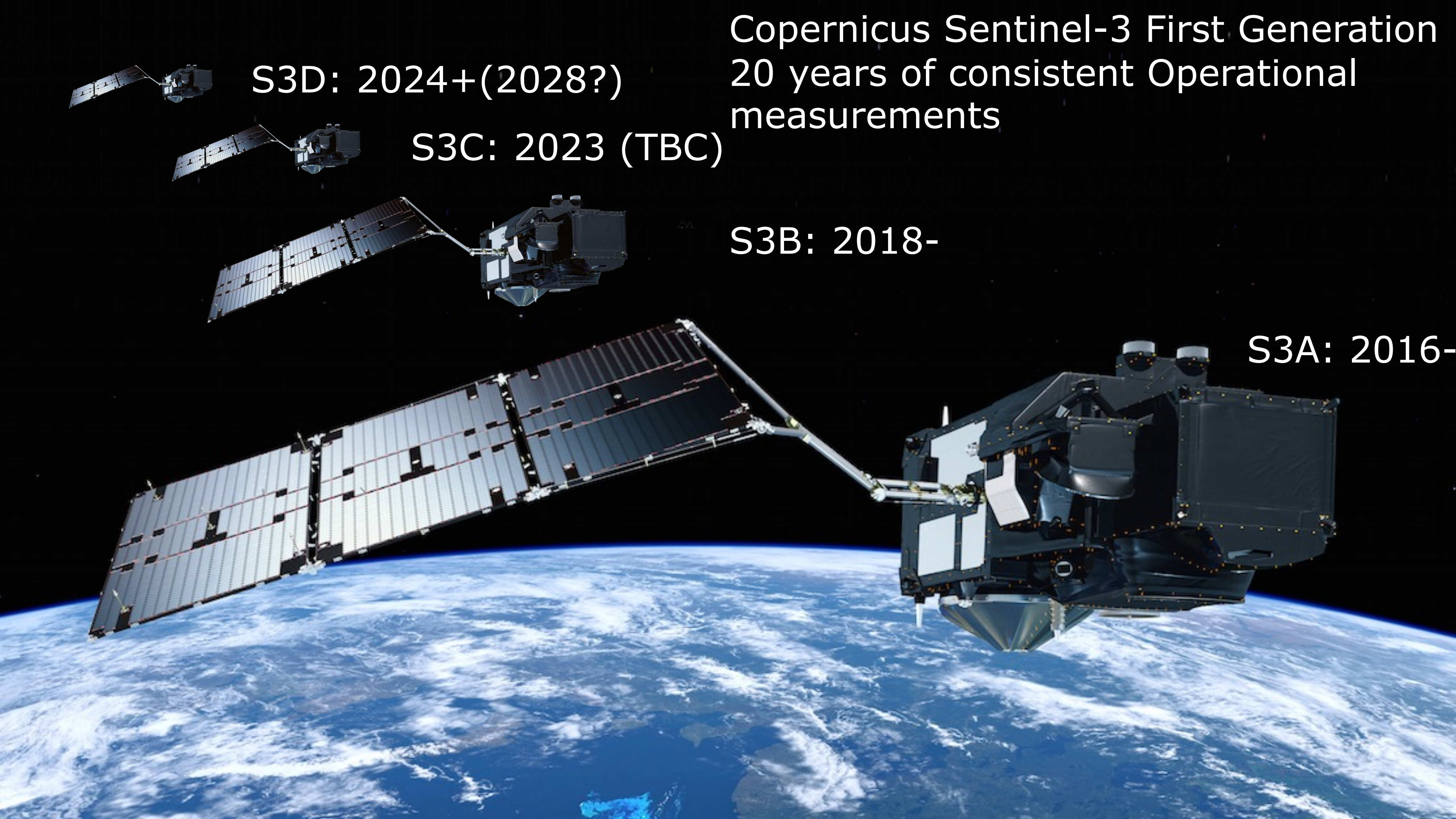
- **More sophisticated products:** particle size distributions, phytoplankton functional types and pigments, harmful algal blooms, distinguishing sources of suspended and coloured dissolved matter, estimating water depth and mapping heterogeneous substrates and cover types.

S2 and S2-NG



Sentinel-2 Next Generation
- future **European wide-swath, moderately to high-resolution, multi-spectral imaging mission**
- **high radiometric accuracy**
- **high revisit frequency** (maximising the number of cloud free acquisitions)
- focus on **land and coastal areas**

- **Continuity with the current S2 generation**
- Towards **long-term availability of consistent high spatial resolution products**
- **Enhancement** of **land** (e.g. land-use / land-cover, LAI) **and water products** (e.g. water color, pigments)


Copernicus Sentinel-3 First Generation
20 years of consistent Operational measurements
S3D: 2024+(2028?)
S3C: 2023 (TBC)
S3B: 2018-
S3A: 2016-

Sentinel-3 NG Optical (Phase 0)

Table 1 AOLCI (G) and (T) sub satellite point spatial sampling requirements applicable ACT & ALT, spectral bands and SNR specification at given radiance levels.

AOLCI									
Band	Resolution Goal	Resolution Trehold	Center Wavelength	Bandwidth	L_{min}	L_{ref}	L_{sat}	L_{max}	SNR@Lref
	@ SSP [m]	@ SSP [m]	λ [nm]	$\Delta\lambda$ [nm]	$Wm^{-2}sr^{-1}\mu m^{-1}$				
1a (G)	100	150	360.00	15 (TBC)	(TBD)	72.2 (TBC)	(TBD)	356 (TBC)	1000 (TBC)
1b (G)	100	150	381.00	15 (TBC)	(TBD)	61.1 (TBC)	(TBD)	381 (TBC)	1000 (TBC)
1 (T)	100	150	400.00	15.00	21.60	62.95	413.50	516.80	2188
2 (T)	100	150	412.50	10.00	25.93	74.14	501.30	501.30	2061
3 (T)	100	150	442.50	10.00	23.96	65.61	466.10	582.60	1811
3a (G)	100	150	473.00	15 (TBC)	(TBD)	61.9 (TBC)	(TBD)	722 (TBC)	1000 (TBC)
4 (T)	100	150	490.00	10.00	19.78	51.21	483.30	604.20	1541
5 (T)	100	150	510.00	10.00	17.45	44.39	449.60	562.00	1488
5a (G)	100	150	532.00	105(TBC)	(TBD)	39.2 (TBD)	(TBD)	651 (TBD)	1000 (TBD)
6 (T)	100	150	560.00	10.00	12.73	31.49	524.50	524.50	1280
6a (G)	100	150	594.00	15 (TBC)	(TBD)	38 (TBD)	(TBD)	624 (TBD)	1000 (TBD)
7 (T)	100	150	620.00	10.00	8.84	21.14	397.90	497.40	997
7a (G)	100	150	631.00	15 (TBC)	(TBD)	19 (TBD)	(TBD)	564 (TBD)	1000 (TBD)
8 (T)	100	150	665.00	10.00	7.12	16.38	364.90	456.20	883
9 (T)	100	150	673.75	7.50	6.87	15.70	443.10	443.10	707
10 (T)	100	150	681.25	7.50	6.65	15.11	350.30	437.80	745
11 (T)	100	150	708.75	10.00	5.66	12.73	332.40	415.50	785
12 (T)	100	150	753.75	7.50	4.70	10.33	377.70	377.70	605
13 (T)	100	150	761.25	2.50	2.53	6.09	369.50	369.50	232
14 (T)	100	150	764.38	3.75	3.00	7.13	373.40	373.40	305
15 (T)	100	150	767.50	2.50	3.27	7.58	250.00	367.70	330
16 (T)	100	150	778.75	15.00	4.22	9.18	277.50	346.80	812
17 (T)	100	150	865.00	20.00	2.88	6.17	229.50	286.80	812
18 (T)	100	150	885.00	10.00	2.80	6.00	281.00	281.00	395
19 (T)	100	150	900.00	10.00	2.05	4.73	237.60	264.00	308
20 (T)	100	150	940.00	20.00	0.94	2.39	171.70	245.30	203
21 (T)	100	150	1020.00	40.00	1.81	3.86	163.70	204.70	152

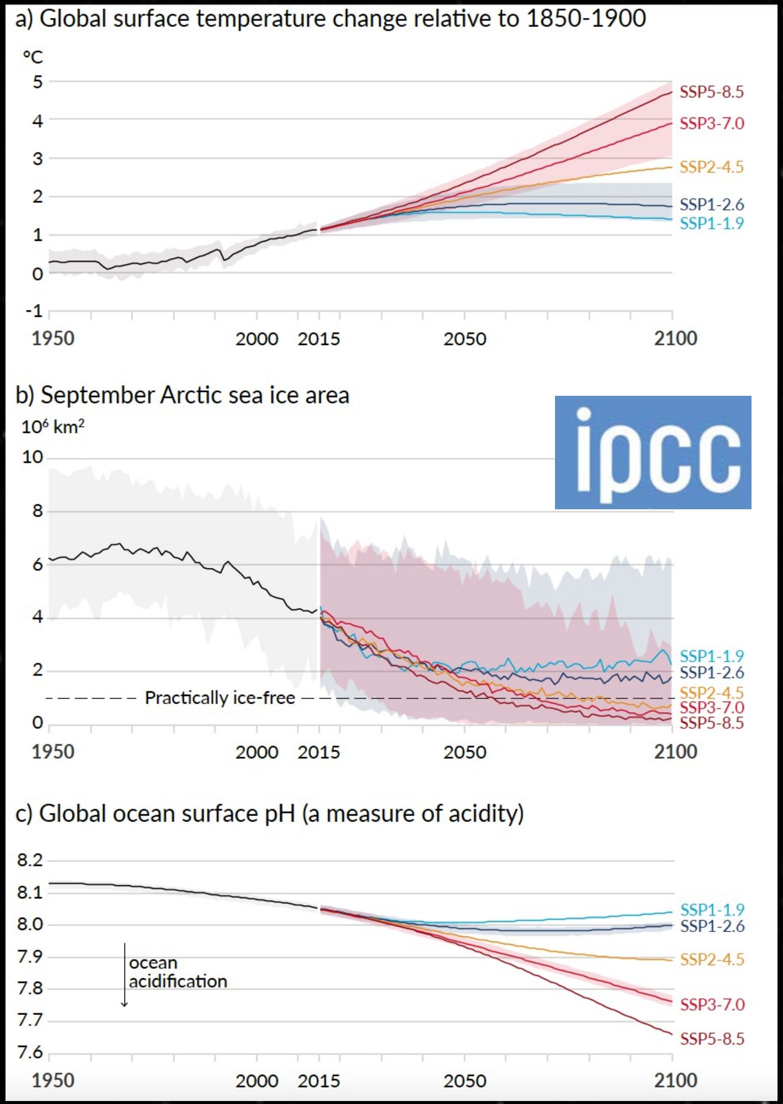
Table 2 ASLSTR spectral channels and characteristics.

ASLSTR									
Band	Resolution	Center Wavelength	Bandwidth	L_{min}/T_{min}	L_{ref}/T_{ref}		L_{max}/T_{max}	SNR/NEDT(1)	
					Low	High		@L_{ref} Low	@L_{ref} High
	@ SSP [m]	λ [µm]	$\Delta\lambda$ [nm]	$mWm^{-2}sr^{-1}nm^{-1}/K^{(2)}$				@Ref SSD	
1a (G)	500	0.440	20	TBD	TBD	TBD	TBD	20	n/a
1 (T)	500	0.555	20	2.92	2.92	n/a	585.0	20	n/a
2 (T)	500	0.659	20	2.43	2.43	n/a	475.0	20	n/a
3 (T)	500	0.865	20	1.53	1.53	n/a	295.0	20	n/a
4 (T)	500	1.375	20	0.58	0.58	6.0	113.1	20	75
5 (T)	500	1.610	60	0.39	0.39	3.8	74.0	20	250
6 (T)	500	2.250	50	0.13	0.13	1.0	24.3	20	110
7 (T)	500	3.740	380	200K	270K	n/a	323K	0.08 (T)/(50mK (G))	n/a
7a (G)	500	3.900	200	200K	270K	n/a	321K	50mK	n/a
7b (G)	500	4.090	200	200K	270K	n/a	321K	50mK	n/a
7c (G)	500	8.700	1000	200K	270K	n/a	323	30mk	n/a
8 (T)	500	10.850	900	200K	270K	n/a	321K	0.05 (T)/(30mK (G))	n/a
9 (T)	500	12.000	1000	200K	270K	n/a	318K	0.05 (T)/(30mK (G))	n/a

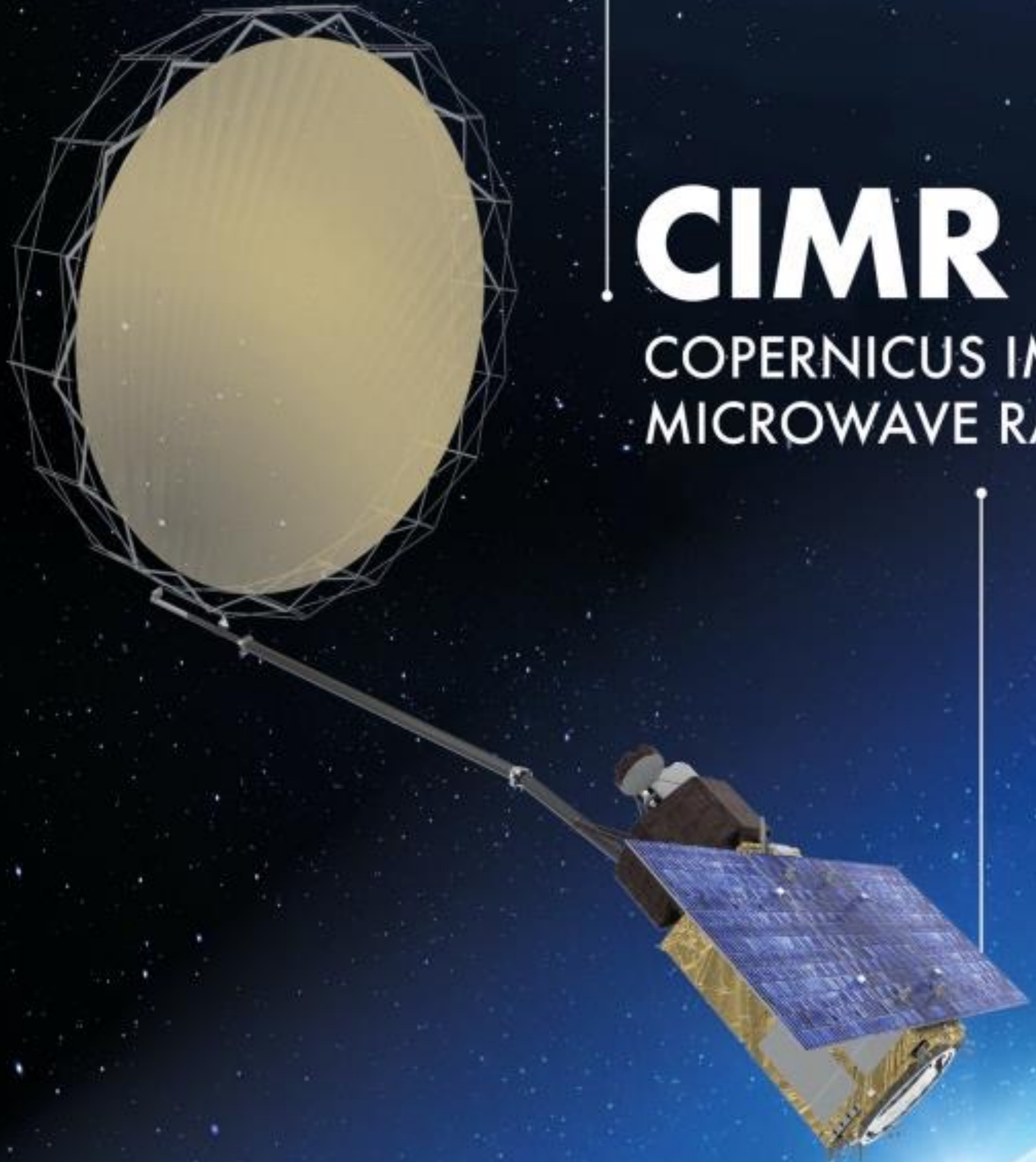
(1) SNR for solar channels, NEDT (K) for IR channels

(2) TOA radiance for solar channels, brightness temperature for thermal channels

esa



copernicus
Europe's eyes on Earth

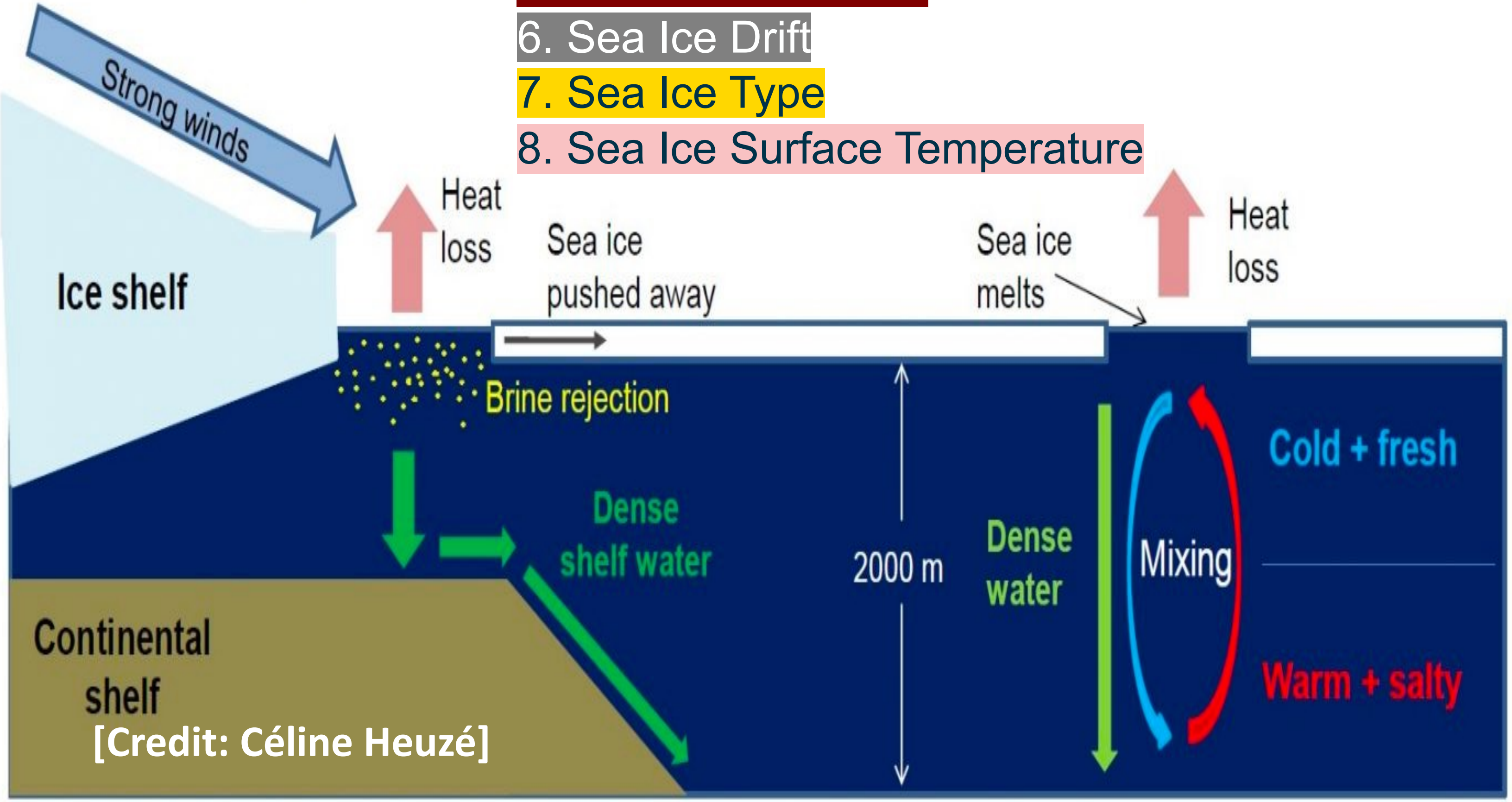


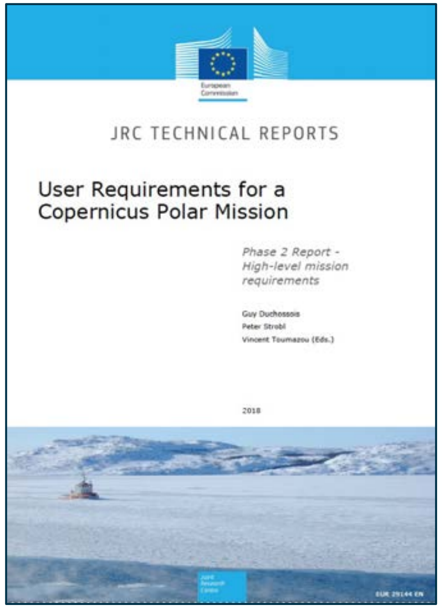
CIMR

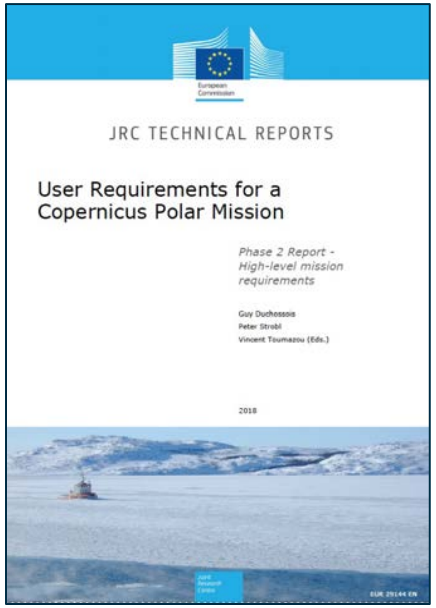
COPERNICUS IMAGING MICROWAVE RADIOMETER

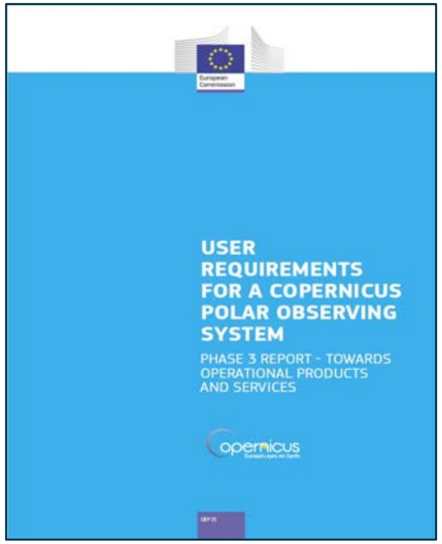
Cryosphere-ocean-atmosphere processes

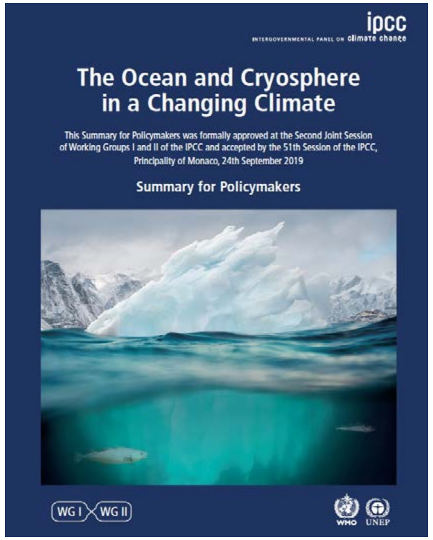
1. Sea Ice Concentration
2. Sea Surface Temperature
3. Sea Surface Salinity
4. Surface Winds
5. Sea Ice Thickness
6. Sea Ice Drift
7. Sea Ice Type
8. Sea Ice Surface Temperature



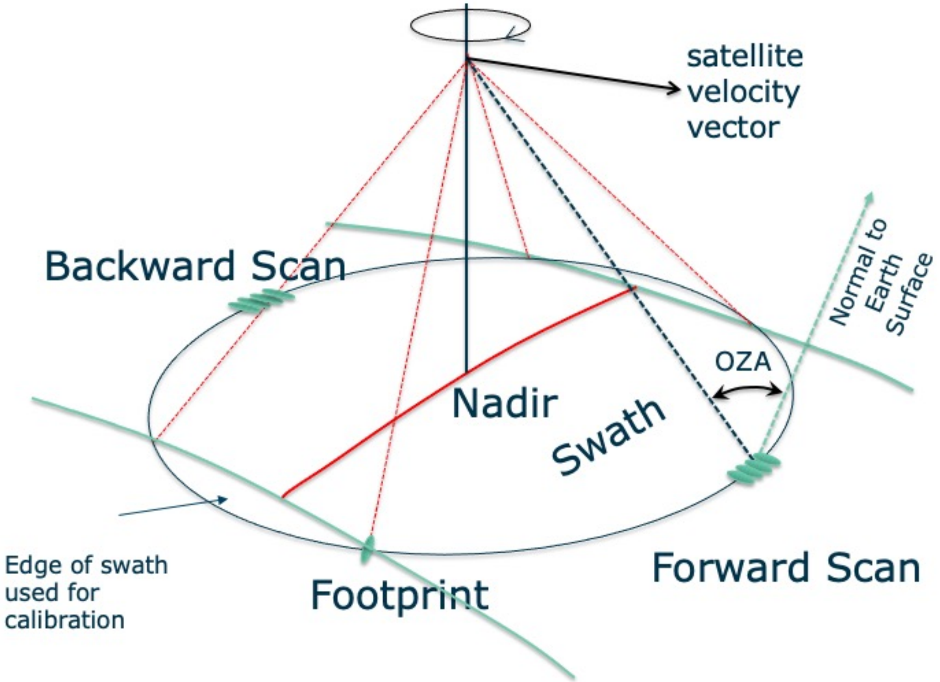




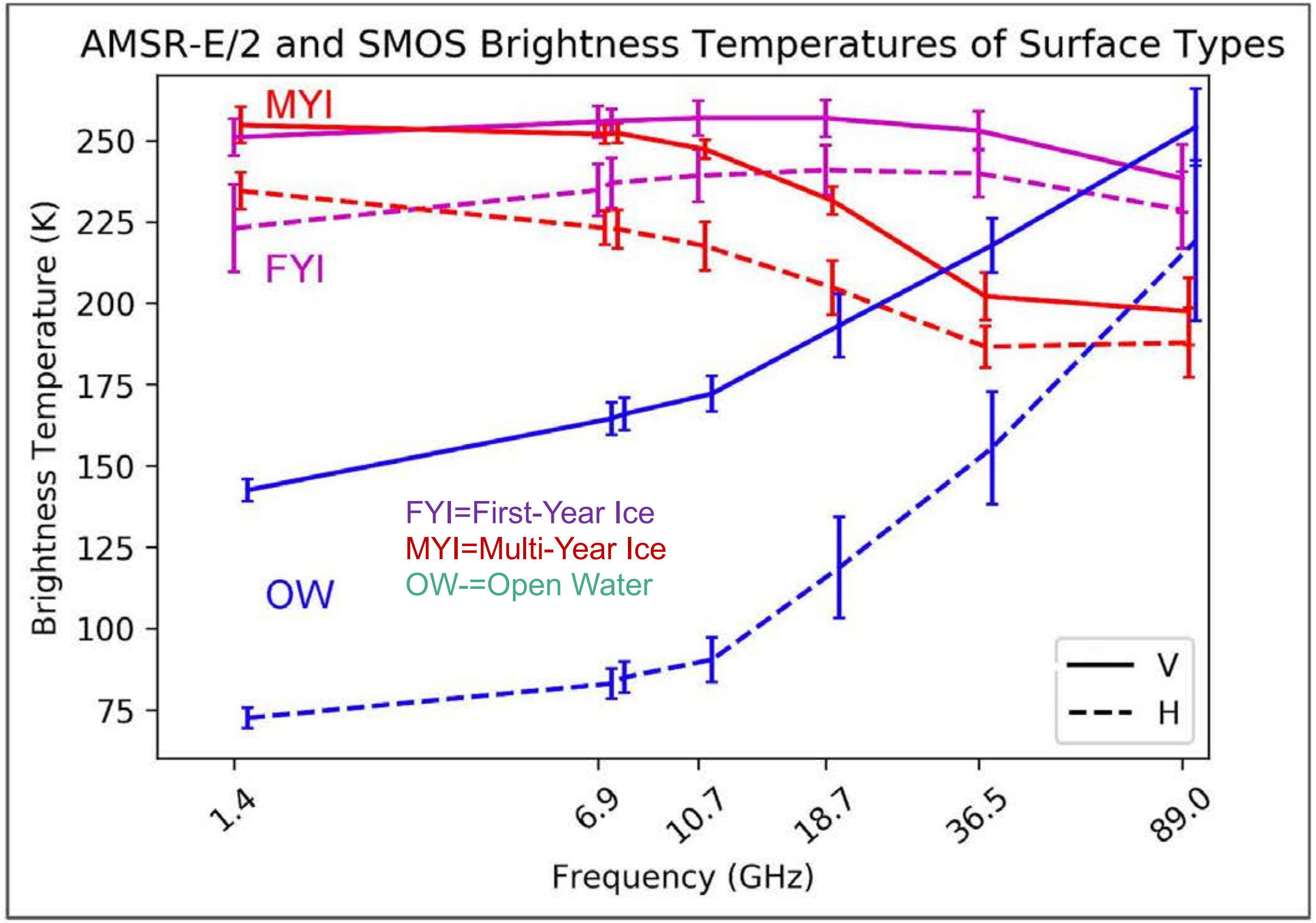




CIMR conically Scanning, L-, C/X, K/Ka-bands (H,V, 3rd Stokes)

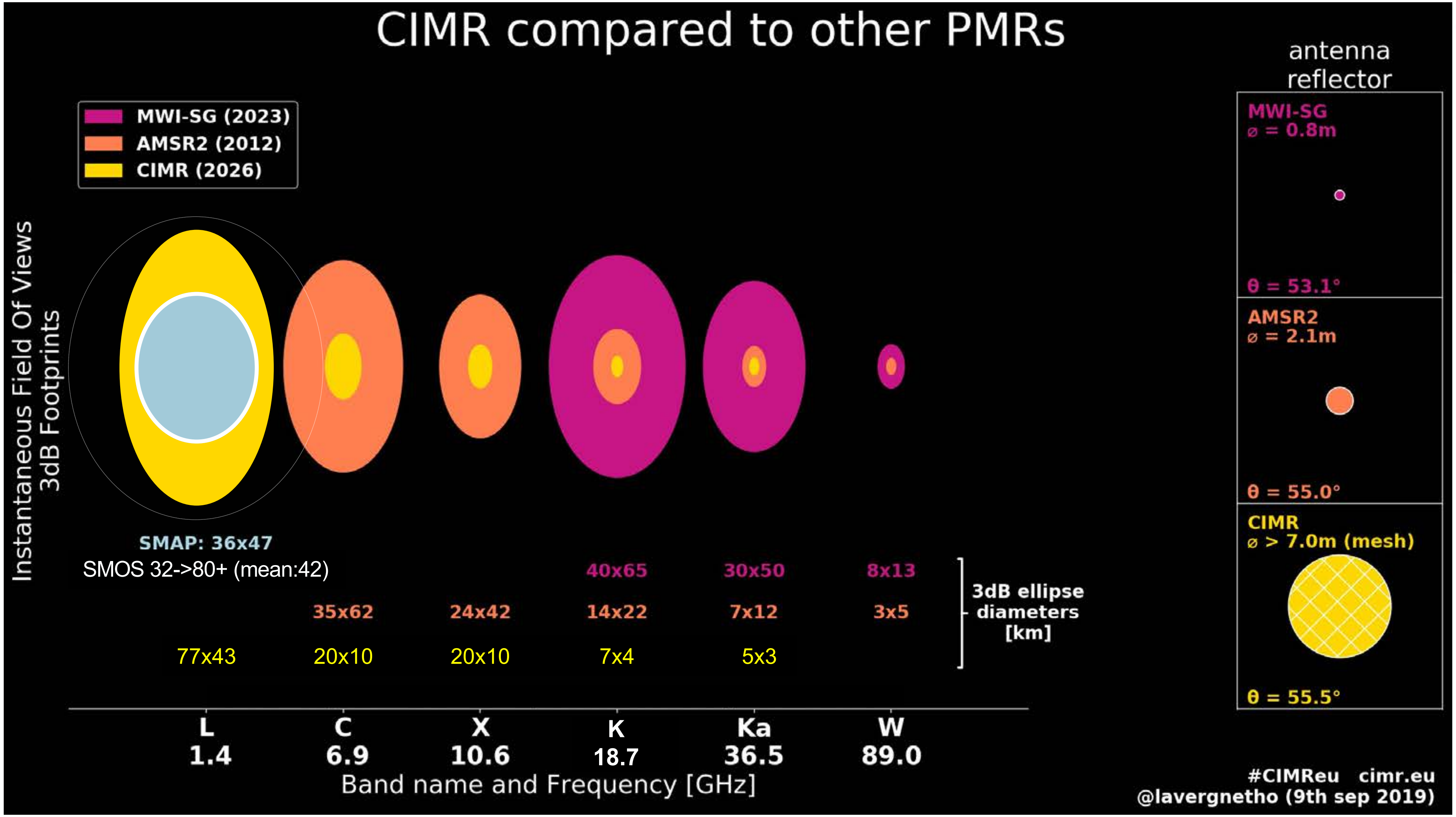


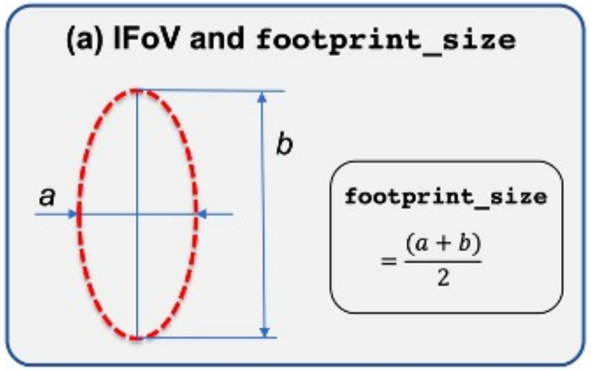
Donlon, Craig; Vanin, Felice (2019): Scanning Geometry of the CIMR instrument. Figshare https://doi.org/10.6084/m9.figshare.7749398.v1



Lu, J. and Heygster, G.: AMSR-E/2 and SMOS Brightness Temperatures of Surface Types, , doi:10.6084/m9.figshare.7370261.v2, 2018.

CIMR -3dB projected IFoV and footprint_size





footprint_size:

L: <60 km

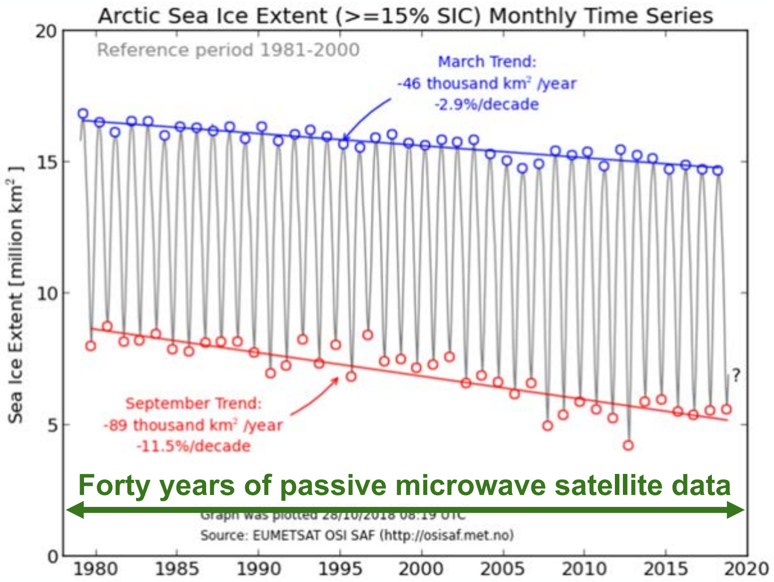
C: ≤15 km

X: ≤15 km

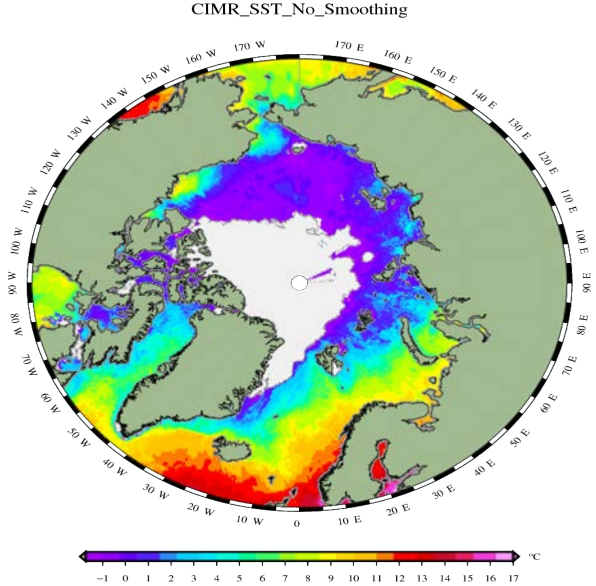
K: ≤ 5.5 km

Ka: ≤5 (g:4) km

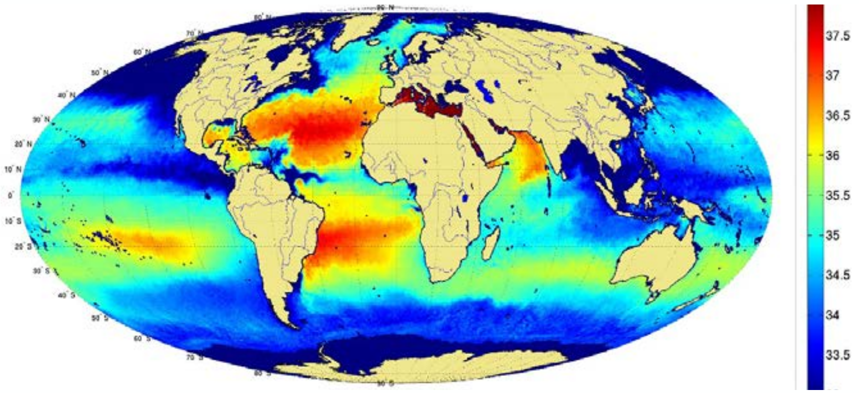
Sea Ice Concentration



Sea Surface Temperature

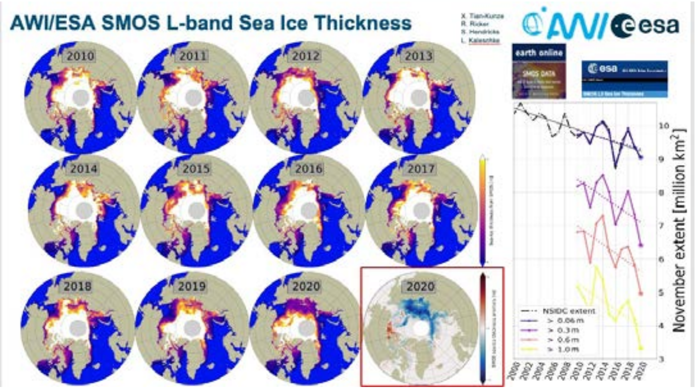


Sea Surface Salinity

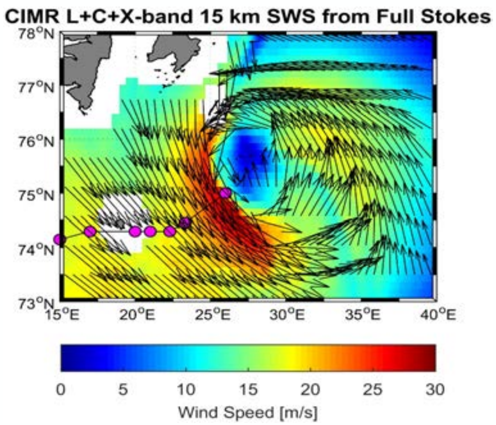


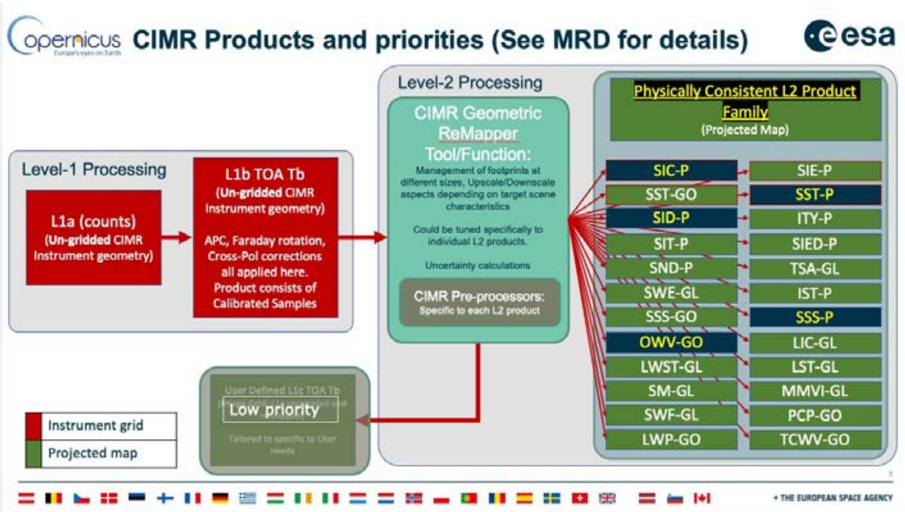
Sea Ice Drft, ice type, snow, soil moisture…

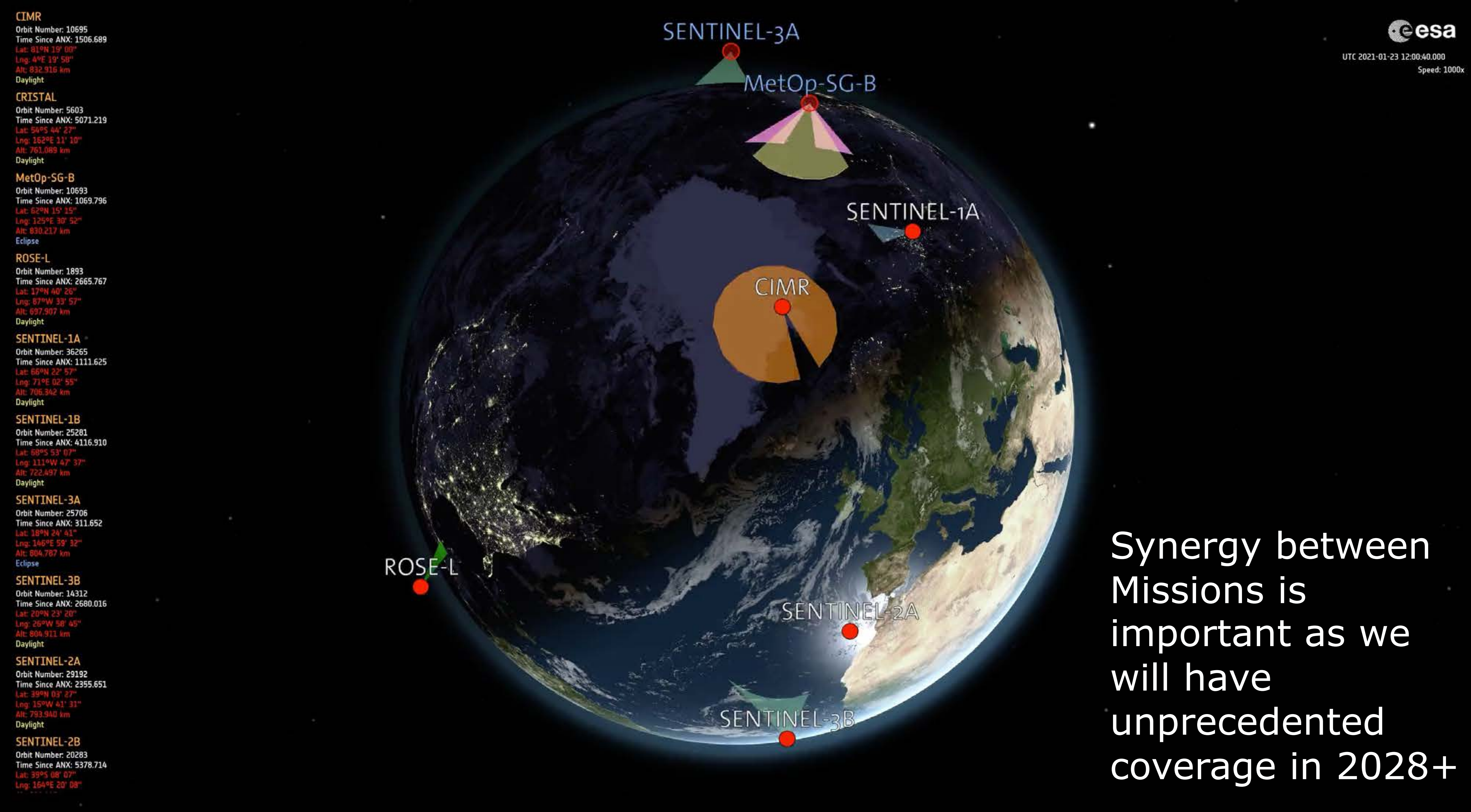
Thin Sea Ice thickness



Surface Wind over ocean





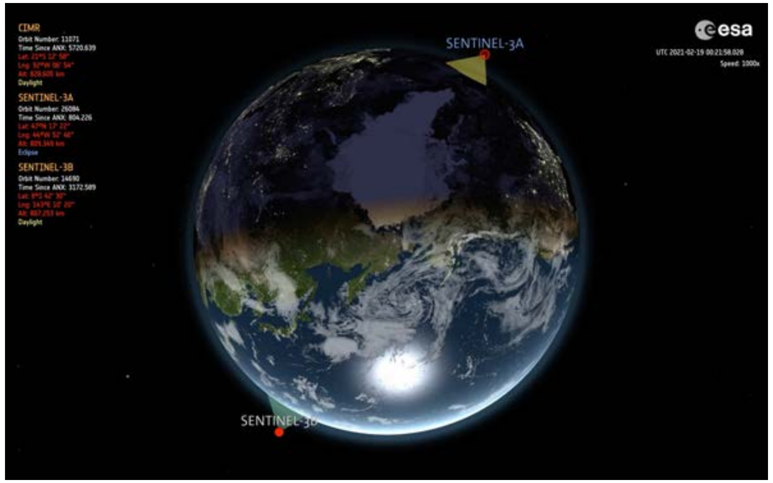


Synergy between Missions is important as we will have unprecedented coverage in 2028+

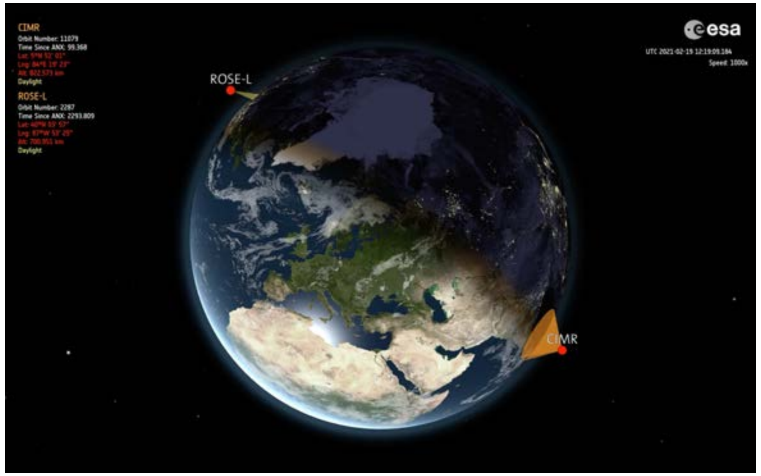
Synergy with Other Missions

CIMR + MetOp-SGB1 SCA and MWI

CIMR + Sentinel-1A and Sentinel-1B

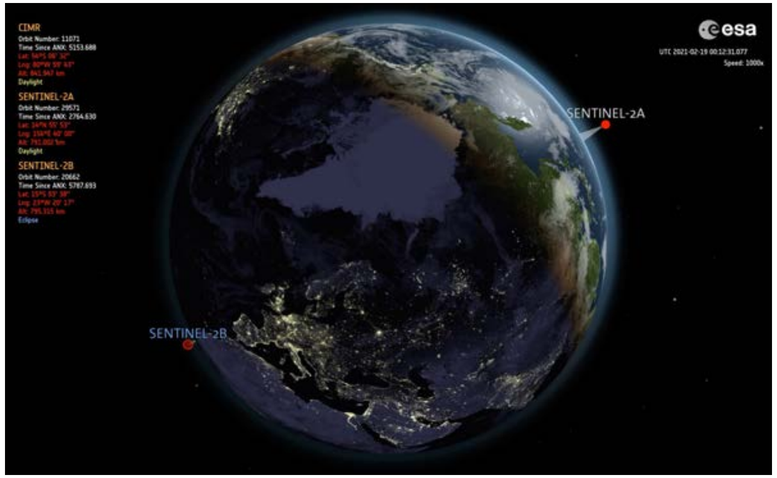


CIMR + Sentinel-3A and Sentinel-3B



CIMR + ROSE-L

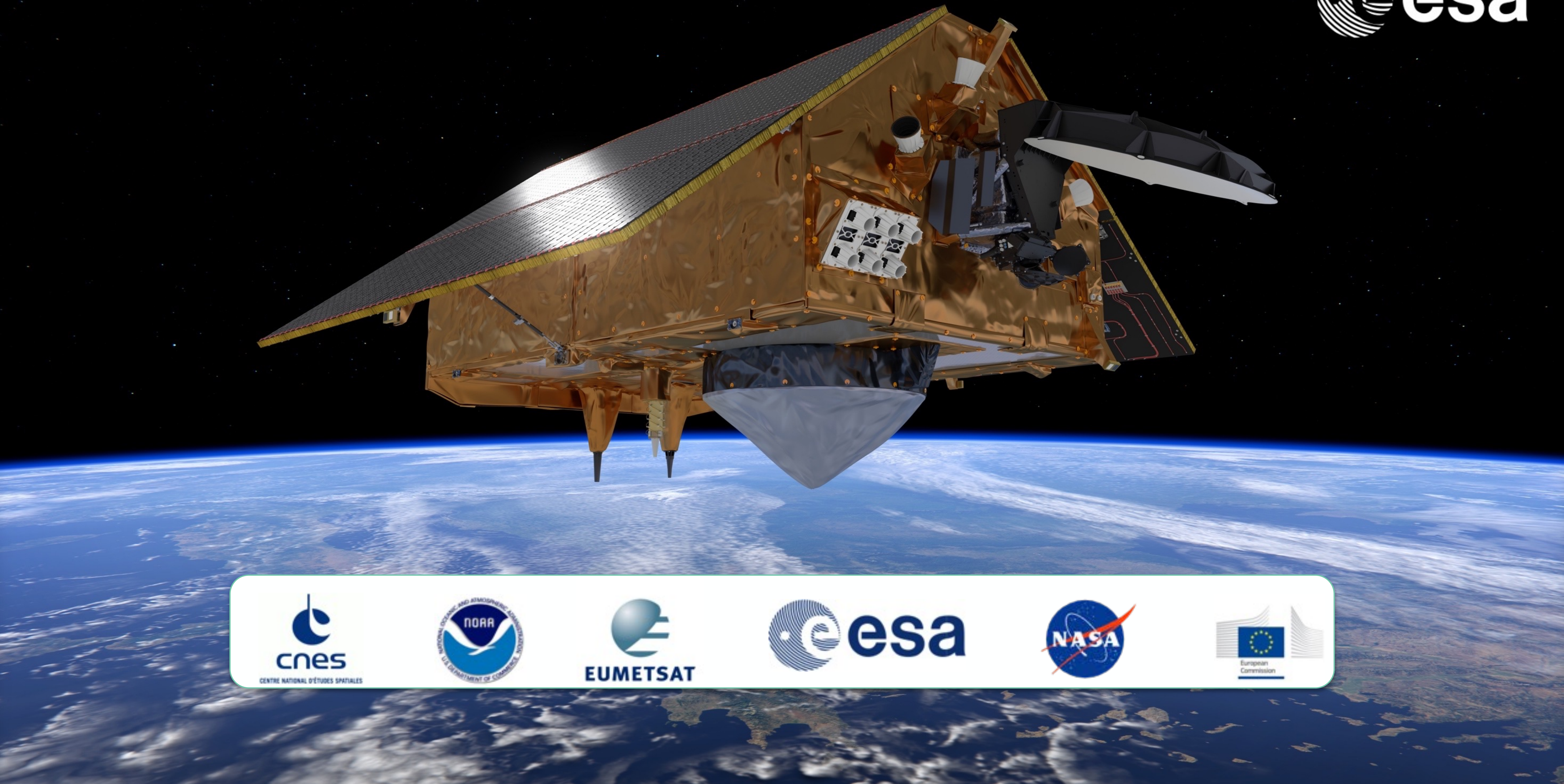
CIMR + CRISTAL



CIMR + Sentinel-2A and Sentinel-2B

Sentinel-6 - dedicated to Sea level rise

esa



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NOAA
EUMETSAT
esa
NASA
European Commission

European Union

6 key facts about Copernicus Sentinel-6

WHAT?

Copernicus Sentinel-6 is the **next radar altimetry** reference mission dedicated to measuring **changes in global sea level**

WHY?

Since sea-level rise is a key indicator of **climate change**, monitoring the **height of the sea surface** is essential for climate science, policy-making and protecting lives in low-lying areas

WHO?

While Sentinel-6 is one of the European Union's Copernicus satellite missions, its implementation is the result of successful **international cooperation**

esa

EUMETSAT

HOW?

The mission maps 95% of Earth's ice-free ocean every 10 days. It also offers vital information on **ocean currents, wind speed and wave height**

WHAT'S NEXT?

Copernicus Sentinel-6 will continue the **'gold standard'** record for climate studies started in 1992 – extending the legacy of sea-surface height measurements until at least 2030

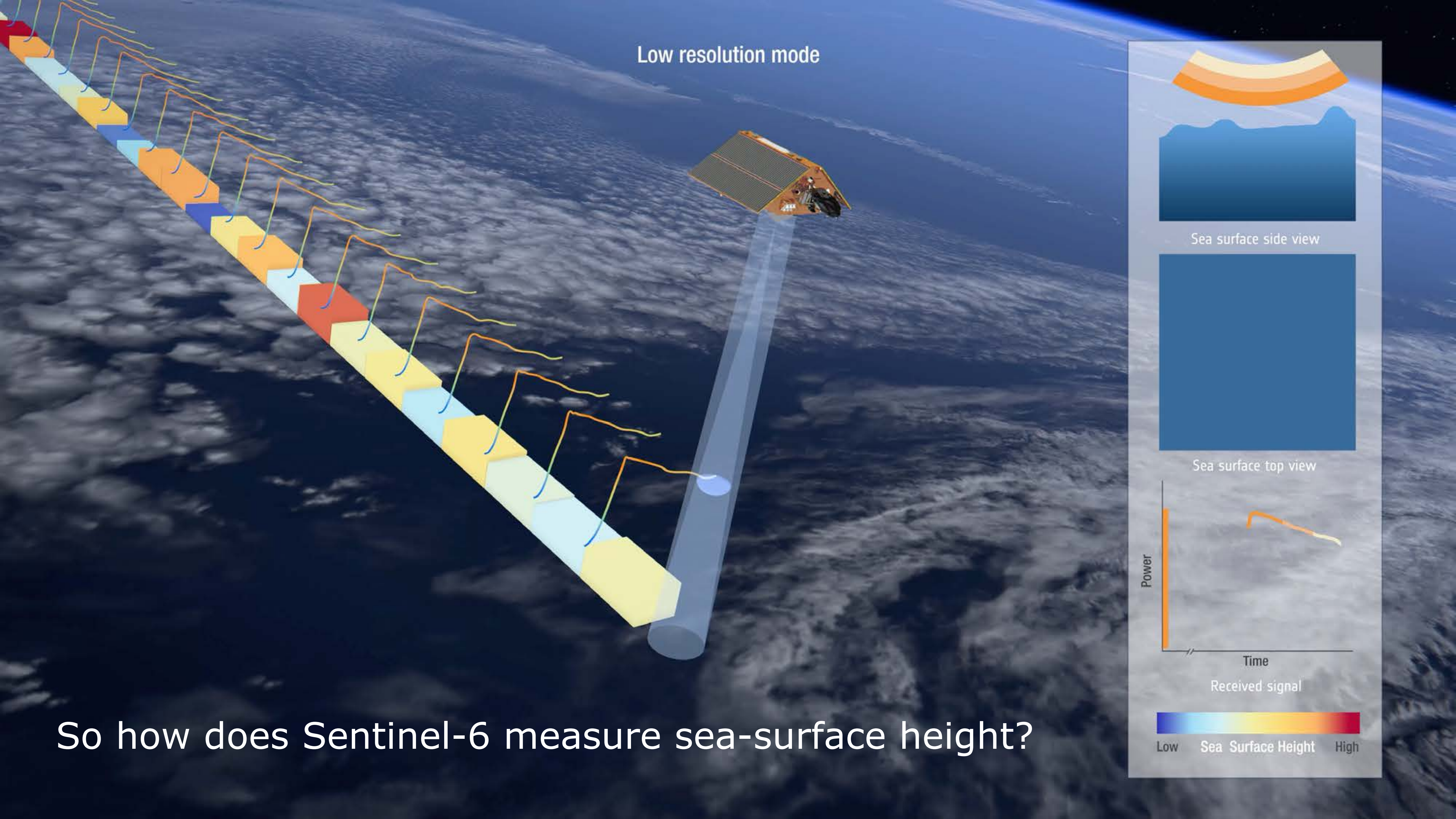
WHEN?

The Copernicus Sentinel-6 mission **comprises two identical satellites** launched five years apart. Firstly, Copernicus Sentinel-6 Michael Freilich on a SpaceX Falcon 9 in November 2020 and then Copernicus Sentinel-6B in 2025

sentinels.copernicus.eu
www.esa.int/Sentinel-6

Copernicus
Europe's eyes on Earth

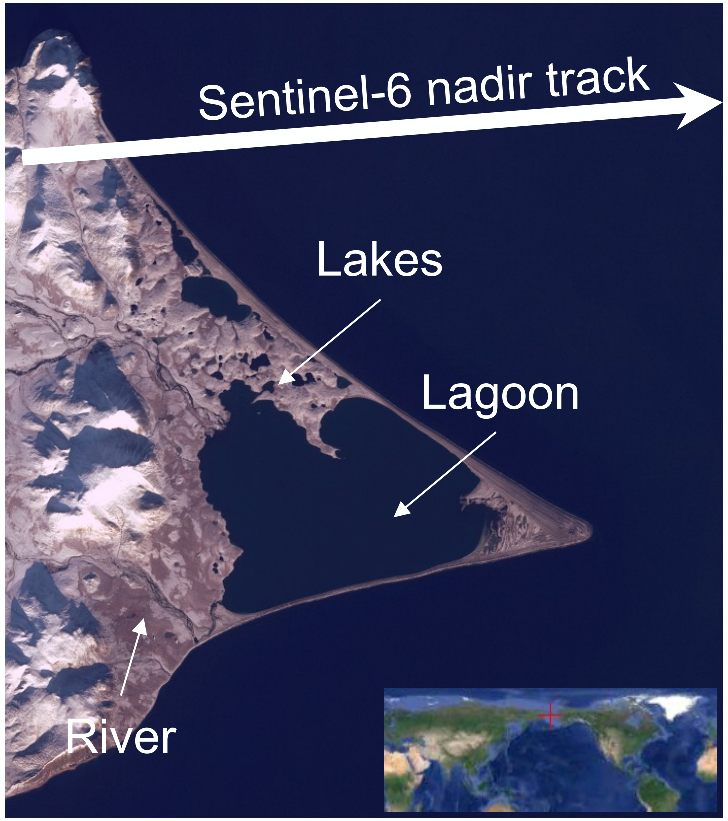
© ESA 2020



So how does Sentinel-6 measure sea-surface height?

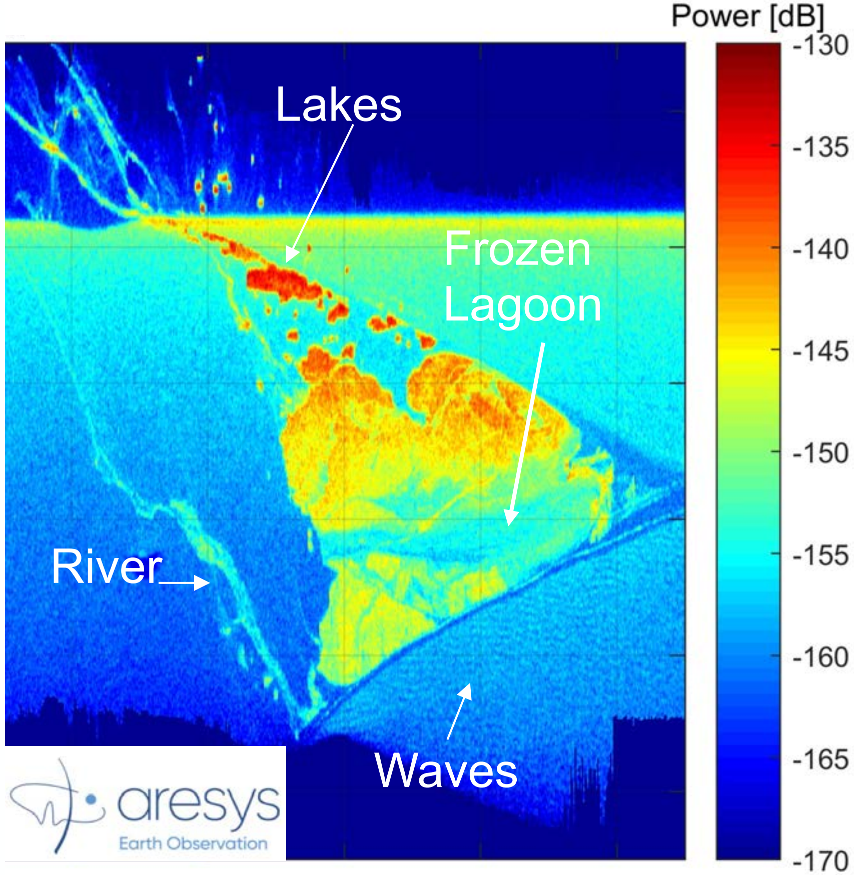
The Beauty of Copernicus: First S6 Cross Track SAR Range Image with Copernicus SAR and Optical data

S6-MF Poseidon-4 altimeter reveals unprecedented detail in the Ozero Nayval lagoon and surrounding river areas. Fully focussed synthetic aperture radar **processing highlights the low noise performance of new digital instrument** architecture. **This will improve sea level rise measurements in marginal sea ice zone.**



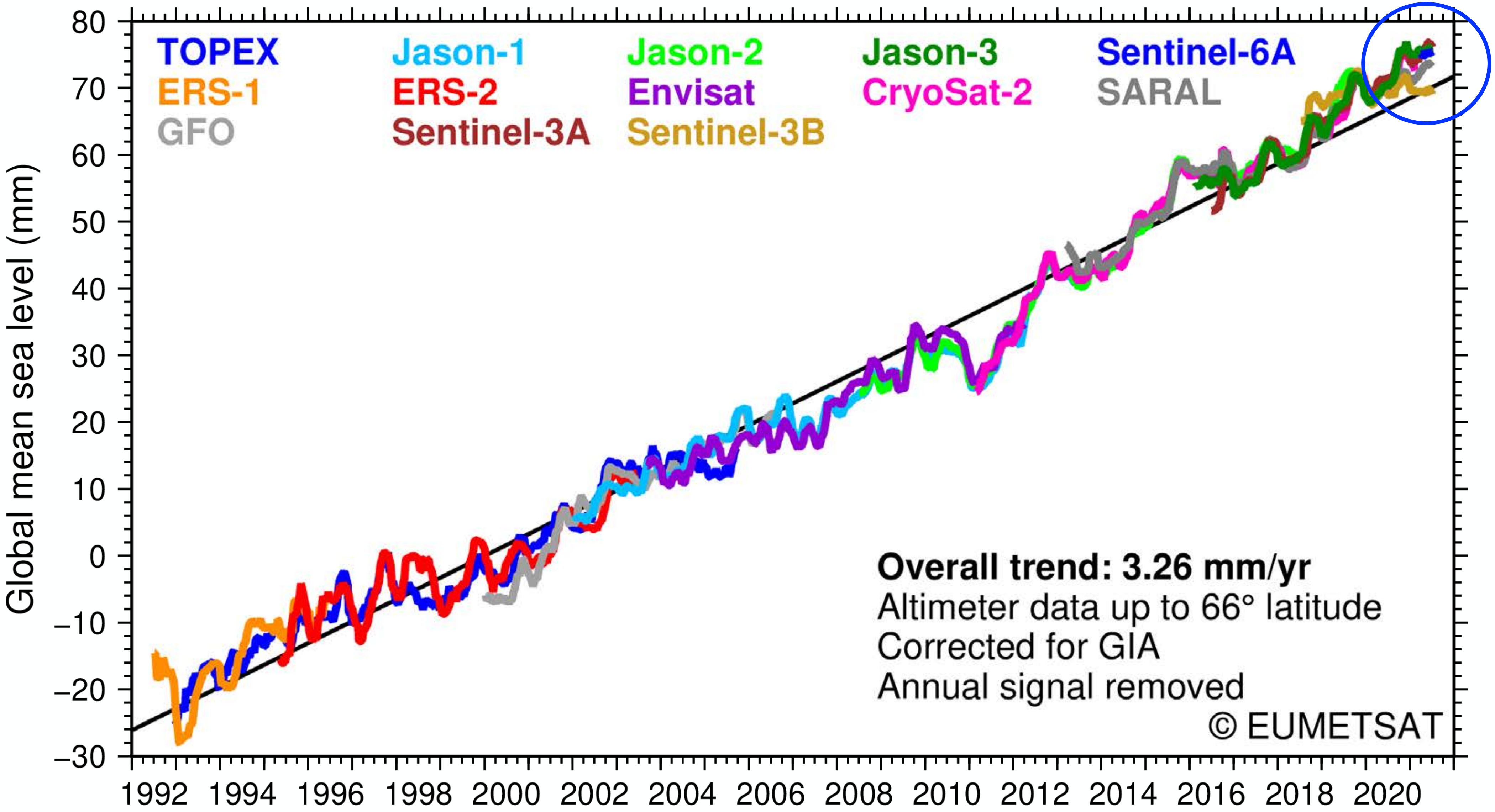
Sentinel-2B (10m) Ozero Nayvak peninsular, Russia, 15 August 2020

Sentinel-1B Interferometric Wide Swath, 29 Nov 2020

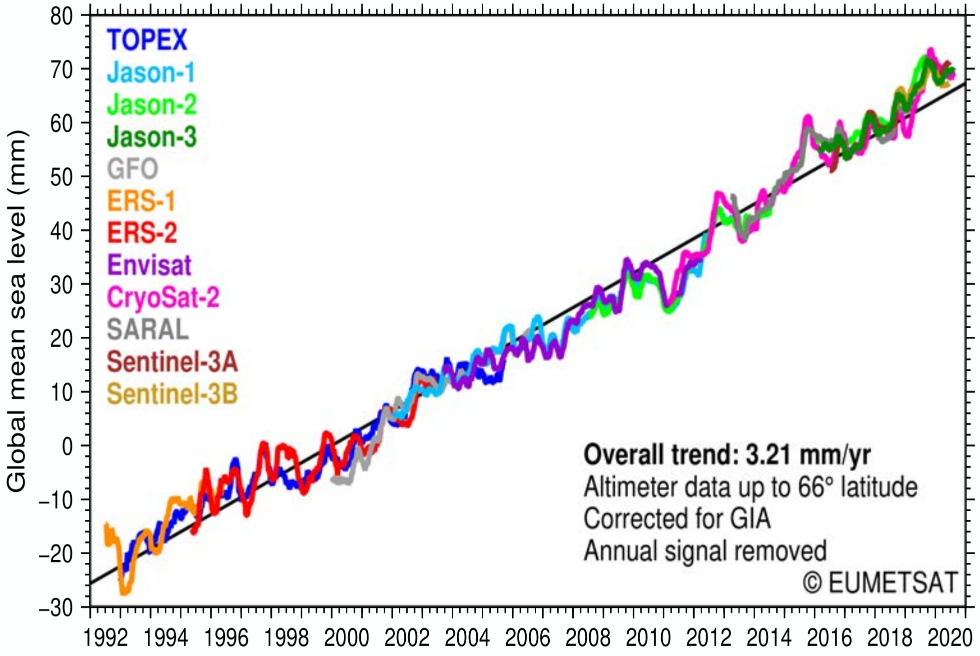


Sentinel-6MF (a) LRM (b) Fully Focussed SAR Range image, 30 Nov 2020

The satellite sea level rise time series

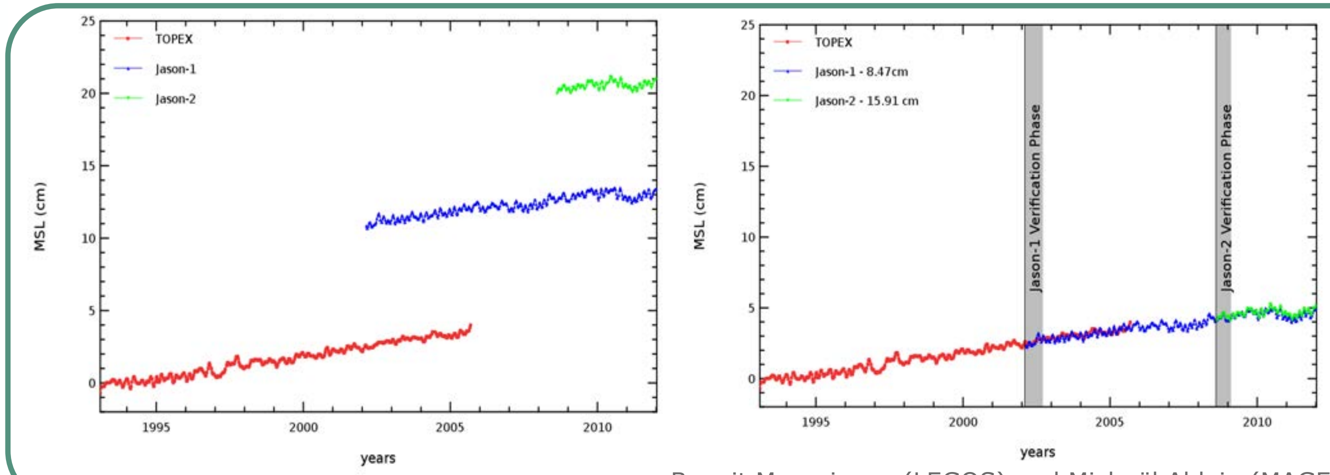


Tandem Calibration Phase and Mean Sea Level Rise Stability. (ESA ASELSU Study M. Ablain and Team)



Sentinel-6 *Michael Frielich* will fly a 12 month Tandem with Jason-3 separated by 30s in time to assure stability in the reference altimeter time series.

- **Link successive missions together**
- **Detect and mitigate geographic biases**



Benoit Meyssignac (LEGOS) and Michaël Ablain (MAGELLIUM)

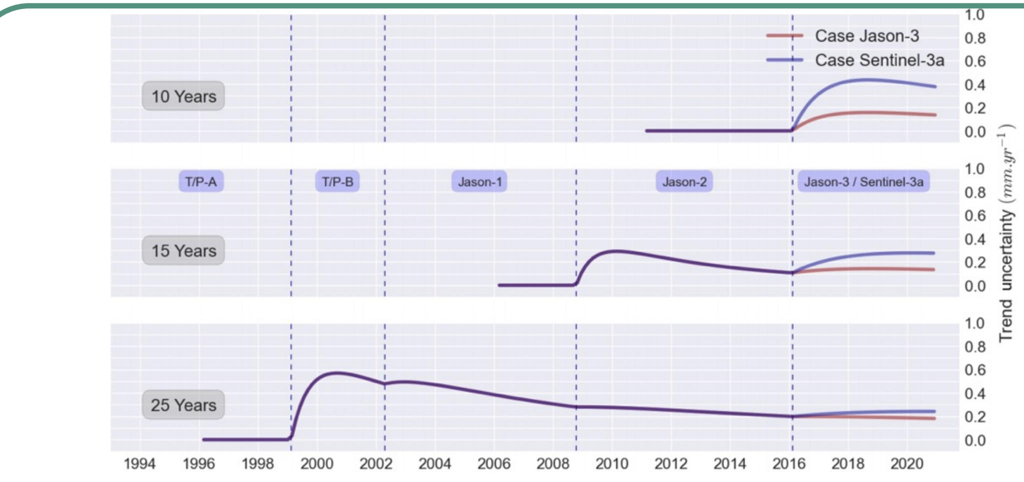
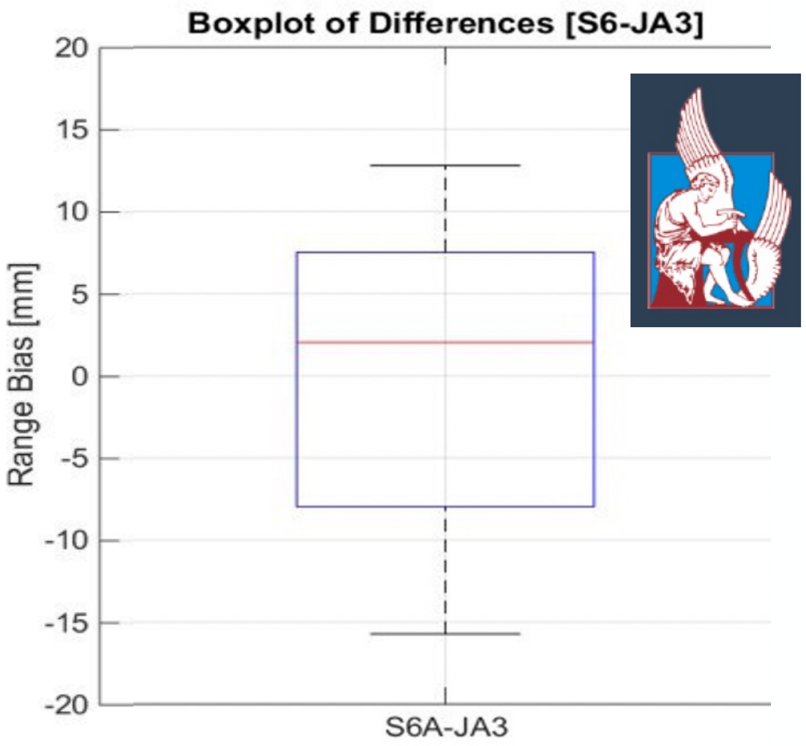


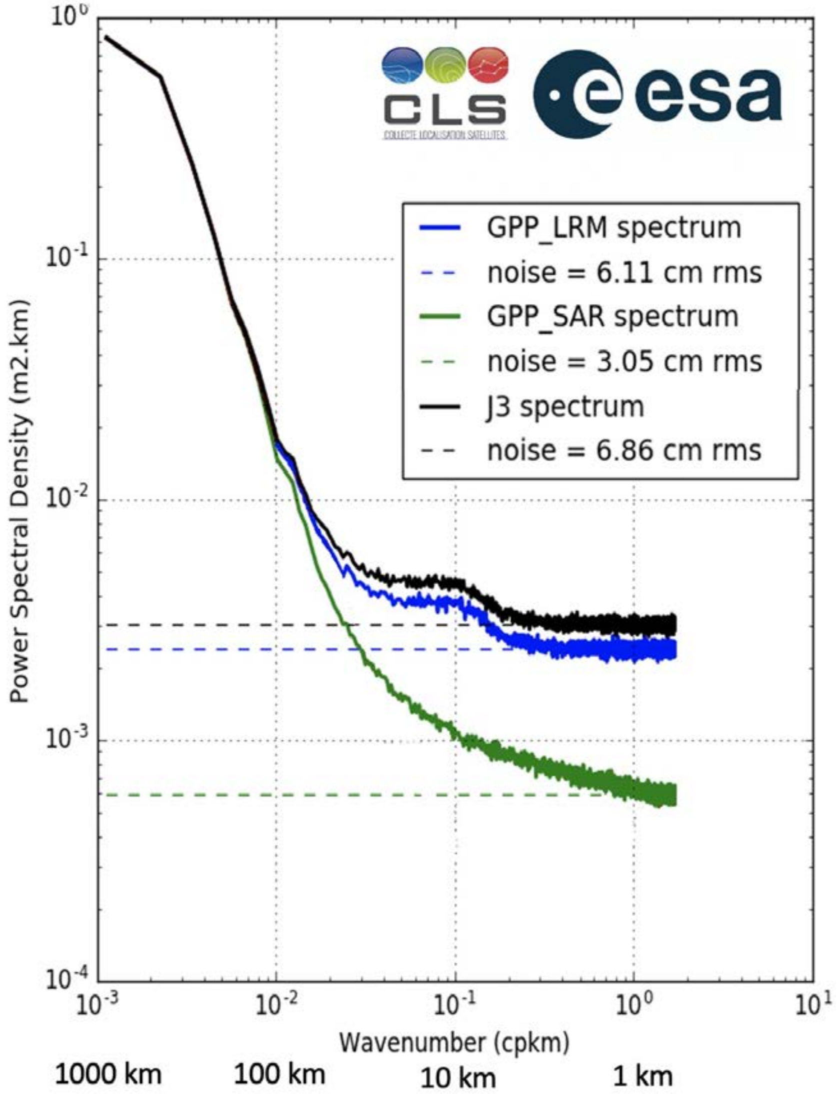
Figure 1. Impact of global mean sea level inter-mission linking bias uncertainties on the estimation of the MSL trend over 10 years (upper panel), 15 years (middle panel), and 25 years (lower panel), in the cases of Jason-3 and Sentinel-3a.

Zawadzki, L. and Ablain, M.: Accuracy of the mean sea level continuous record with future altimetric missions: Jason-3 vs. Sentinel-3a, Ocean Sci., 12, 9–18, https://doi.org/10.5194/os-12-9-2016, 2016.

Differences between Sentinel-6 and Jason-3



- The median difference between Sentinel-6 and Jason-3 Altimeter range over the Crete Transponder is <2 ±12mm
- The differences are monitored every 10 days.



Power spectral density of Sentinel-6 and Jason-3 Sea Level Anomaly measurements for Cycle-9.

S6 SAR HR data (green line) has a noise floor half of LRM (J3 black, S6 blue) and is likely approaching the geophysical limit imposed by ocean surface roughness.

The Arctic Weather Satellite (AWS)

- Small satellite (120 kg) in sun-synchronous orbit aimed at improving Arctic and global weather forecasts.
- **Cross-track scanning microwave (MW) radiometer with temperature and humidity sounding capabilities**
- **Traditional 54 and 183 GHz bands, complemented with a new channel set in the 325 GHz humidity band (for** enhanced information on humidity and ice clouds)
- Prototype for a **potential future constellation**, to complement the backbone core observing missions such as EPS-SG or JPSS. Brings higher temporal sampling from MW sounding instruments for Numerical Weather Prediction

Planned launch: 2024

Mission lifetime: 5 years

Satellite:

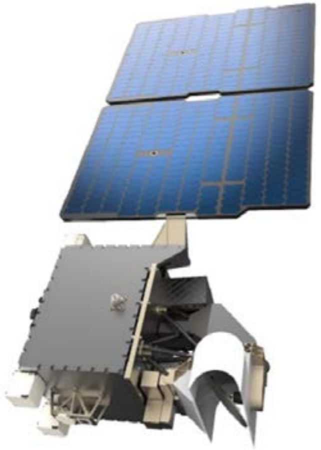
Three-axis stabilised, 120 kg, 1.1 m x 0.7 m x 0.8 m

Power consumption: 120 W (deployable, fixed-angle solar arrays)

Electric propulsion for orbit control

Orbit: 595 km, sun-synchronous, ECT tbd

Mission control: Tromsø and Svalbard (NO)



Applications

Key application areas for AWS and the AWS constellation are:

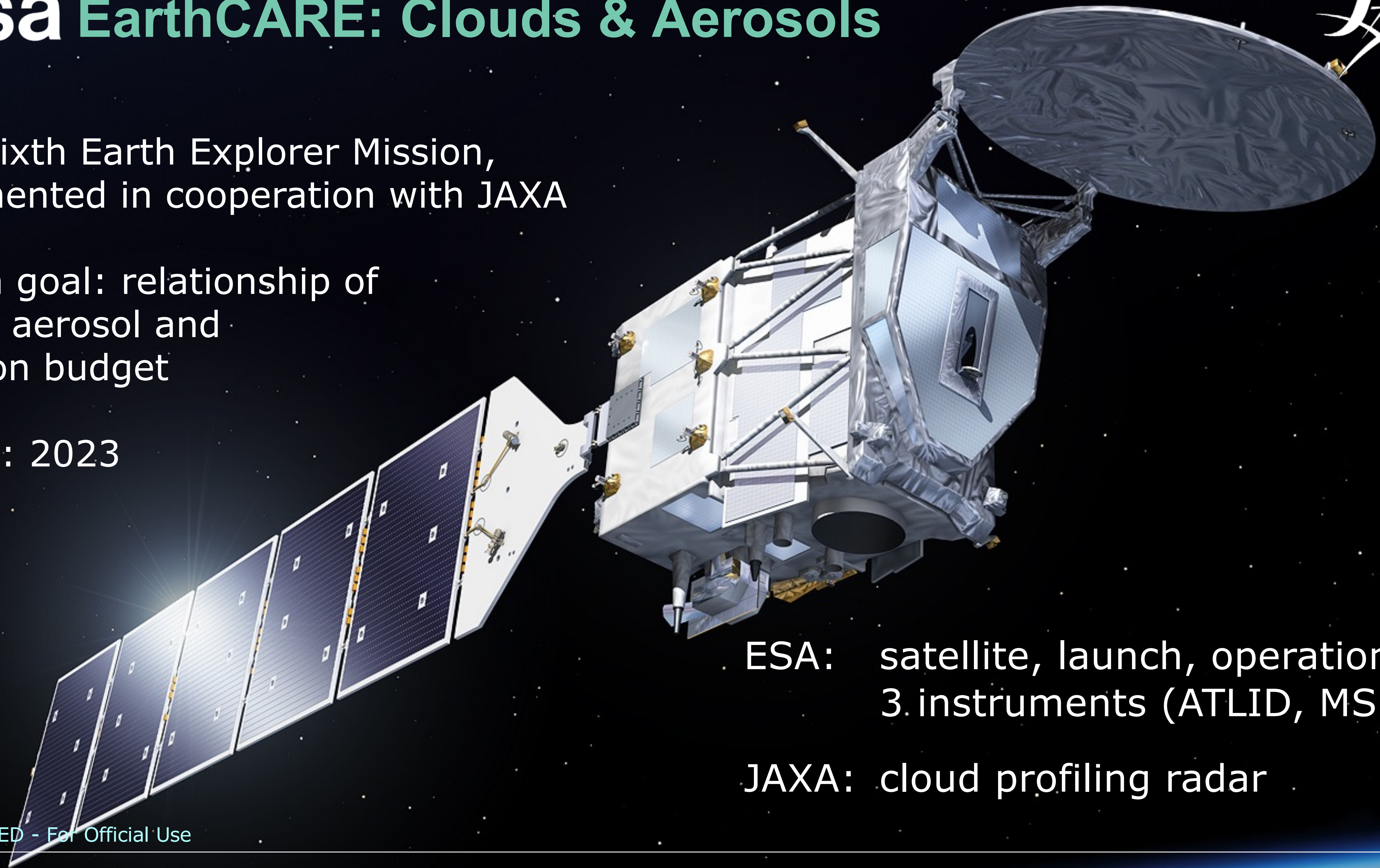
- **Numerical Weather Prediction**, in global and regional systems: These show continued benefit from further all-weather sounding capabilities such as the ones provided by AWS. The AWS constellation will not only improve the representation of temperature, humidity and clouds, but by supplying frequent observations it will also add information on winds by enabling tracing of humidity or cloud structures.
- **Nowcasting:** The high-temporal resolution of the AWS constellation will revolutionise nowcasting in the polar regions.
- **Climate:** AWS observations will also support research into climate change, which occurs at a higher pace in the Arctic compared to other parts of the world.

Data Flow

Global science data will be downlinked to Svalbard (NO), processed to level 1b and distributed in near-real-time through Eumetsat's EUMETCast system.

Direct Data Broadcast will also be available for regional particularly time-critical applications.

EarthCARE: Clouds & Aerosols



ESA's sixth Earth Explorer Mission, implemented in cooperation with JAXA

Mission goal: relationship of clouds, aerosol and radiation budget

Launch: 2023

ESA: satellite, launch, operations, 3 instruments (ATLID, MSI, BBR)

JAXA: cloud profiling radar

ESA UNCLASSIFIED – For Official Use

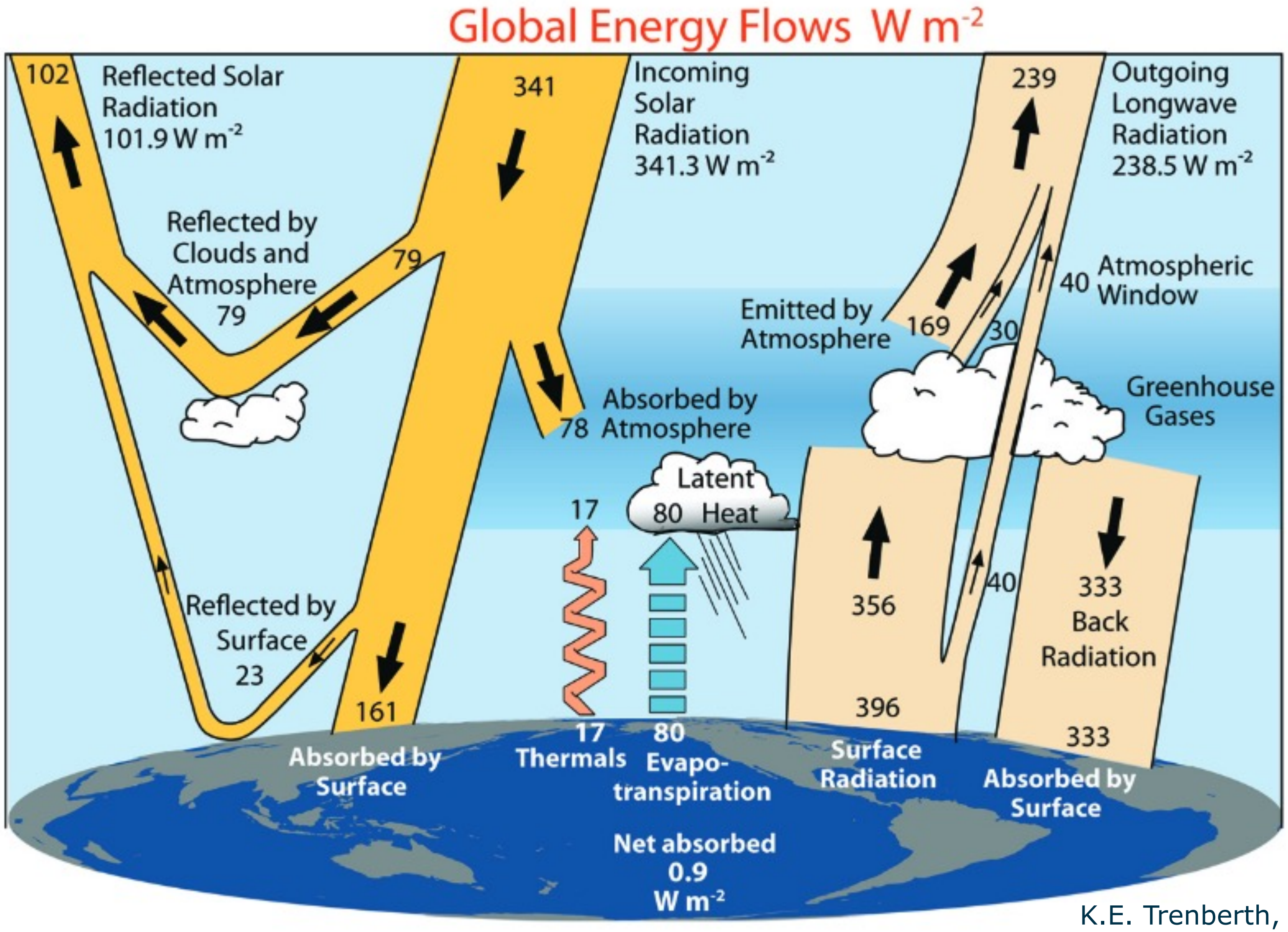
Climate predictability: Clouds, the most significant uncertainty in the atmosphere

Cloud radiative effect: cooling, heating

Climate change & cloud feedback: warming and cloudiness, cloud location & structure?

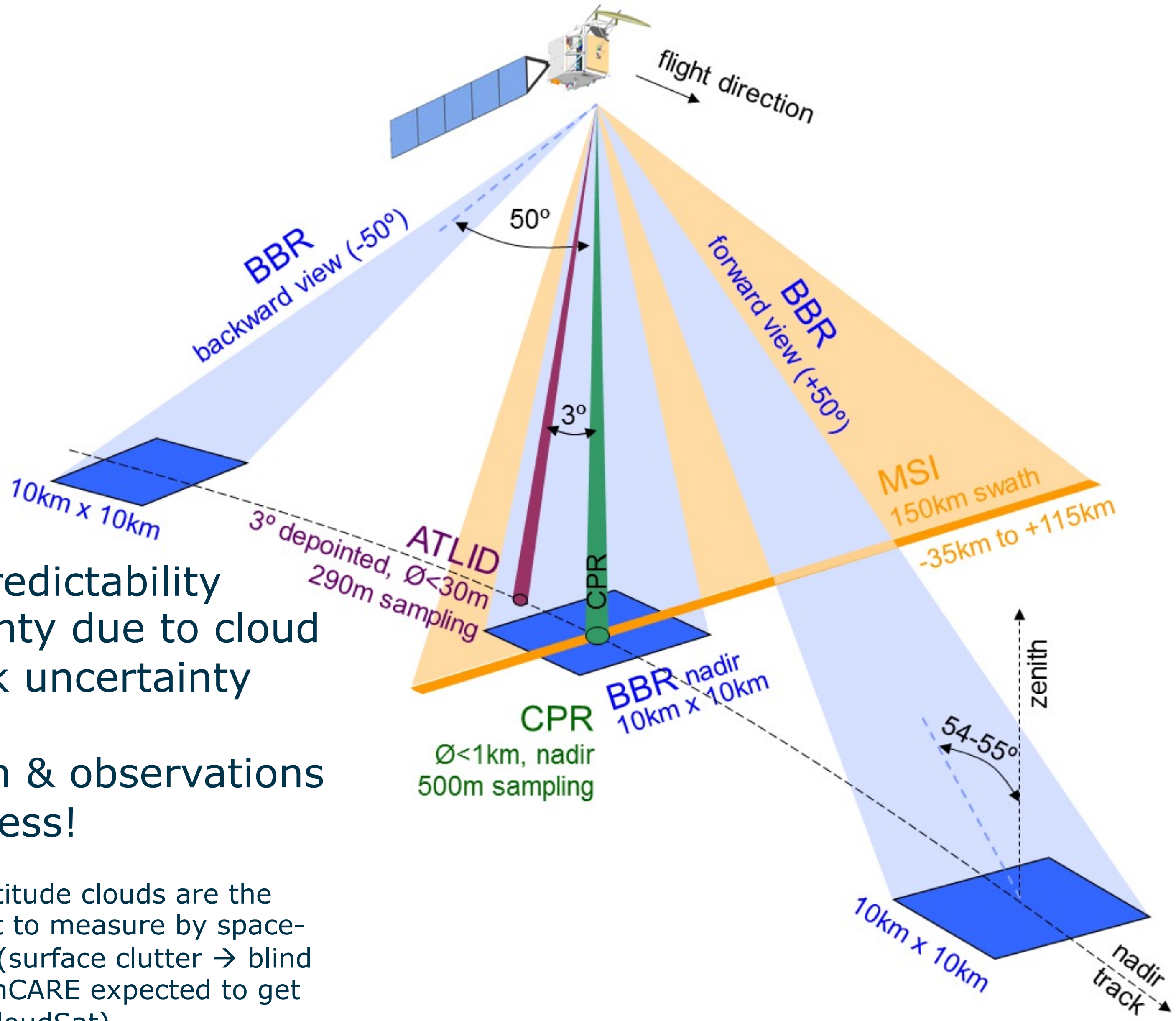
Model predictability uncertainty due to cloud feedback uncertainty

And aerosol:
- direct radiative effect of aerosol (much less significant and less uncertain than clouds, though)
- indirect radiative effect via impact on cloud life cycle



K.E. Trenberth, 2009

EarthCARE
Payload & Level 1 Products



Model predictability uncertainty due to cloud feedback uncertainty

Research & observations → progress!

Note: low-altitude clouds are the most difficult to measure by space-borne radar (surface clutter → blind zone)! (EarthCARE expected to get more than CloudSat)

HSR Lidar

λ=355nm: Rayleigh, Mie, depol. channels

Level 1: attenuated backscatter profiles*

94GHz Radar, with Doppler (JAXA/NICT)

Level 1: Reflectivity* and Doppler profiles

**planned assimilation at ECMWF*

Multi-spectral Imager:

4 solar + 3 thermal IR channels

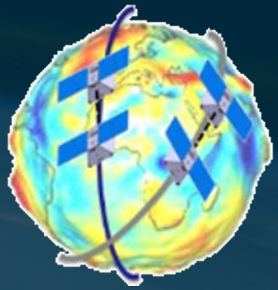
Level 1: TOA radiances and brightness temperatures in 7 spectral bands, 500m nadir spatial resolution.

Broad-band Radiometer:

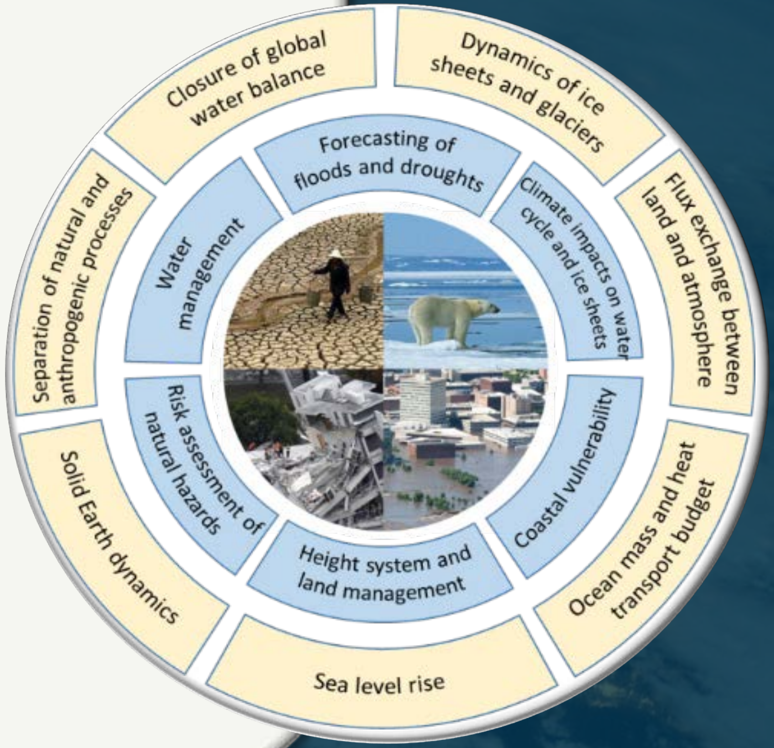
3 fixed FoV

Level 1: Solar and thermal TOA radiances (filtered, unfiltered as Level 2 product)

MAGIC for mass change: the unique cross-cutting variable

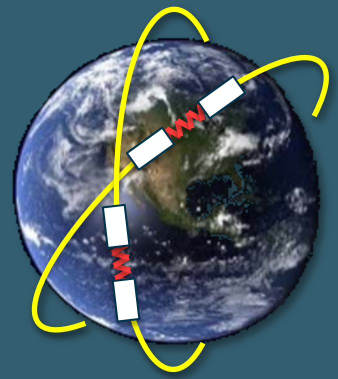


- Continues to provide the global context at short, medium and long term for water related elements in atmosphere, land, ocean, ice, solid earth and thus climate
- Crucial for many water cycle related ECVs as defined by GCOS especially groundwater and total water storage
- Unique in providing ground water information essential for water management and droughts/floods
- Implicitly assumed as available information for multiple Copernicus services (land/hydrology, climate, marine, emergency)
- Novel designed constellation using scientific and technical heritage from GOCE and GRACE with new science and service prospects
- Timely opportunity for a joint cross-cutting ESA/NASA mission enabling a constellation in international cooperation



Future gravity and magnetic mission ideas

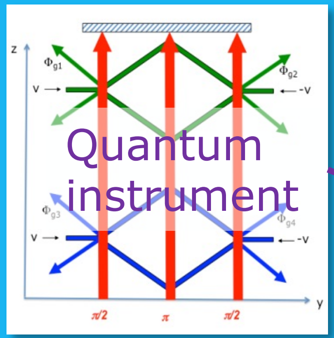
Near-future gravity mission

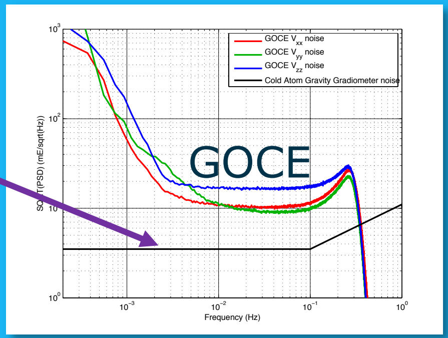


Mass change from gravity changes:
MAGIC (formerly NGGM)

Constellation (ESA/NASA) study in Phase A

Future, future gravity mission?





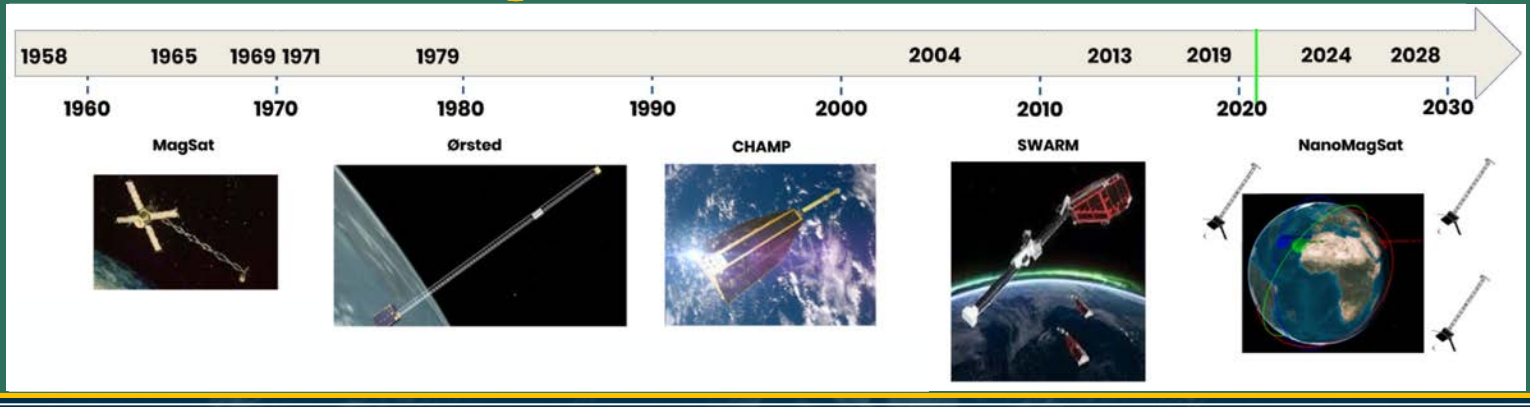
Microgravity Sci. Technol. (2014) 26:139–145
DOI 10.1007/s12217-014-9385-x

ORIGINAL ARTICLE

A Spaceborne Gravity Gradiometer Concept Based on Cold Atom Interferometers for Measuring Earth's Gravity Field

Olivier Carraz · Christian Siemes · Luca Massotti · Roger Haagmans · Pierluigi Silvestrin

Future magnetic field mission direction?



A nano-satellite candidate scout mission concept for studying fast variations in magnetic field and plasma environment (not selected)

Harmony is the ESA Earth Explorer 10 Candidate Mission, comprised of two companion satellites in a loose convoy with Sentinel-1D (along-track separation ~350-400 km).

- Its payload suite consists of a passive SAR and a multi-view TIR instrument
- Foreseen launch in 2029
- Multi-faceted mission (solid Earth, land ice and ocean)

Harmony will resolve (sub)kilometre scale motion vectors and topography changes associated to dynamic Earth System processes:

- heat, gas and momentum exchanges at the air-sea interface;
- the inner structure of ocean-atmosphere extremes;
- instantaneous sea-ice motions to characterize sea-ice dynamics;
- 3-D deformation vectors associated to tectonic strain;
- topographic change at active volcanoes worldwide;
- gradual and dynamic volume changes of global mountain and polar glaciers.

EE10 Harmony and Cryosphere

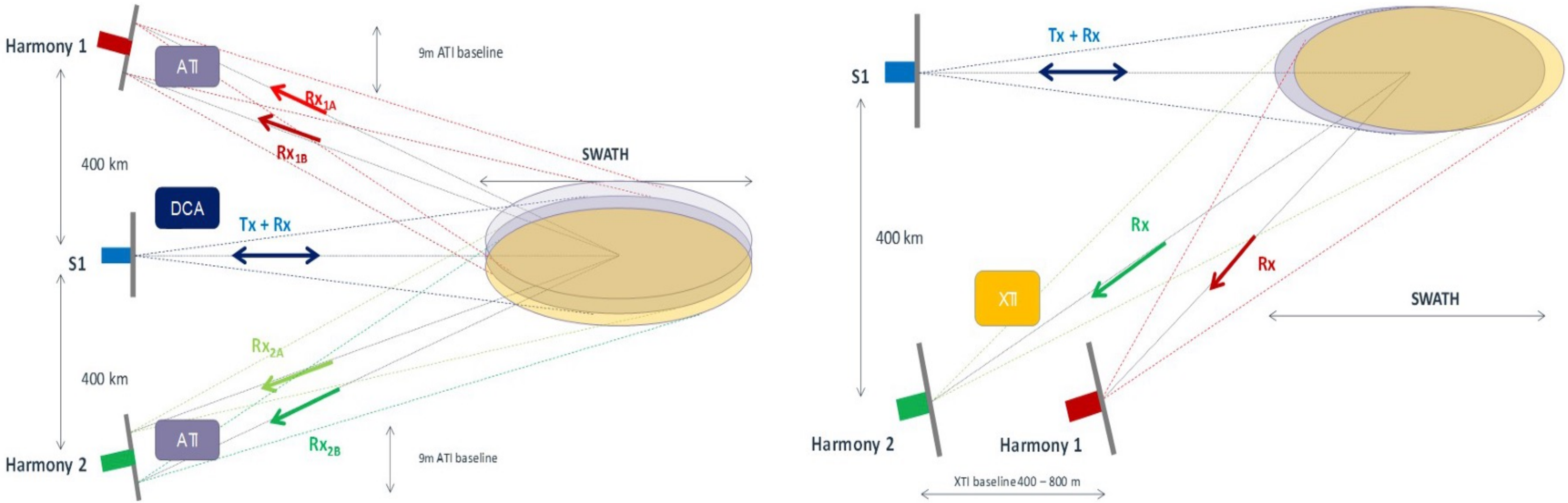
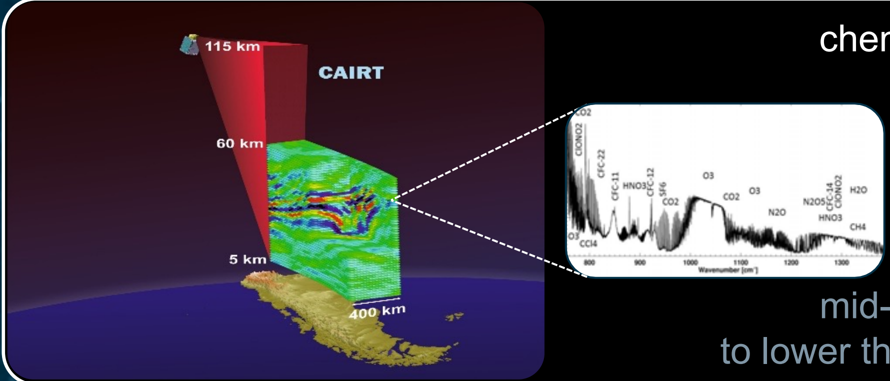


Figure 5.3: (left) stereo and (right) XTI flight configuration. (Concept B)

Earth Explorer 11 Phase 0 mission candidates (1/2)

Cairt

Charting our changing atmosphere in 3D



chemical tracers
temperature
aerosols

from
mid-troposphere
to lower thermosphere

Credits: iss062e005412

Key science and mission objectives

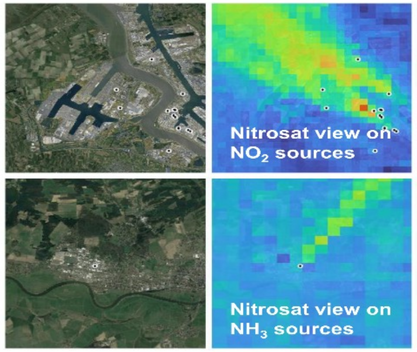
- To observe atmospheric composition, structure and dynamics
- To better understand the processes that couple atmospheric circulation, chemistry, composition and regional climate change

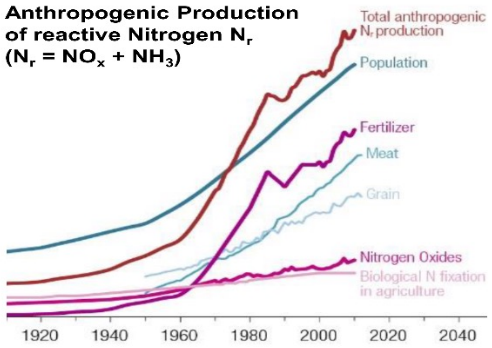
Proposed mission concept

- Infrared limb emission imager (imaging Fourier Transform Spectroscopy)
- Spectral coverage of 710 – 2200 cm^{-1} at 0.1 cm^{-1}
- Tomographic 3D mapping of atmosphere (5-115 km) at 50x50x1 km^3
- Loose formation with MetOp-SG / IASI-NG for synergistic limb-nadir retrievals

Nitrosat

Mapping reactive nitrogen at the landscape scale





Key science and mission objectives

- Detect and characterize individual sources of reactive nitrogen species NH_3 and NO_2 associated with farming industrial complexes, transportation, fires and cities

Proposed mission concept

- Observe atmospheric NH_3 and NO_2 column densities
- with spatial resolution 500 m×500 m
- with high sensitivity to the planetary boundary layer
- Mission lifetime at least 3 years

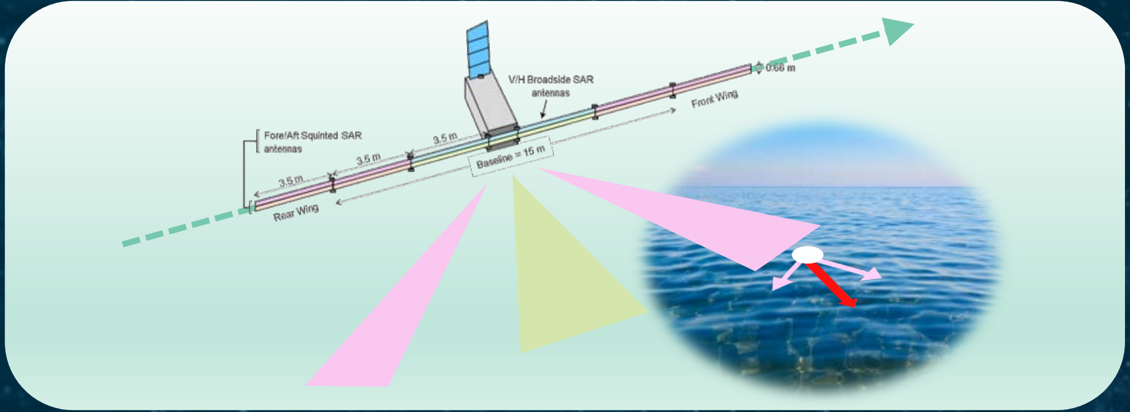
https://www.esa.int/Applications/Observing_the_Earth/Future_EO/Earth_Explorers/Four_mission_ideas_to_compete_for_Earth_Explorer_11

Earth Explorer 11 Phase 0 mission candidates (2/2)

esa

Seastar

Measuring small-scale ocean dynamics



Key science and mission objectives

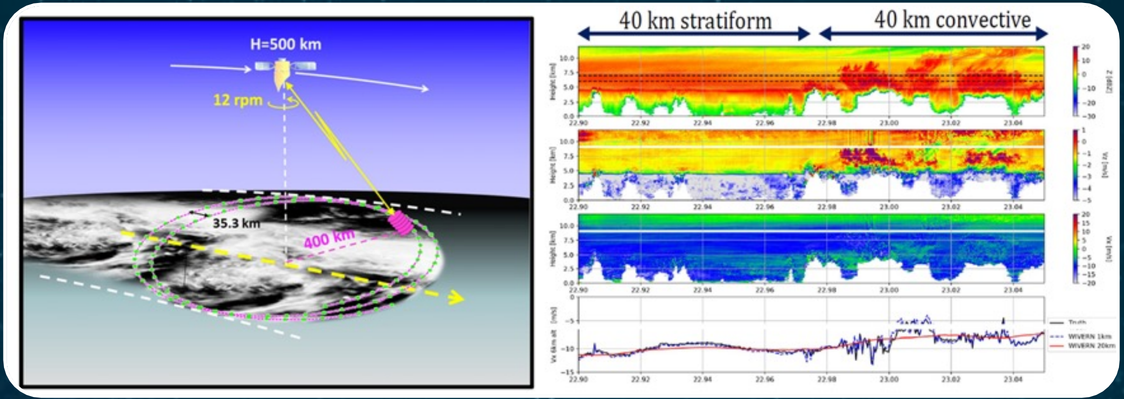
- synoptic high-res observations of currents, winds and waves over coastal and shelf seas, and the Marginal Ice Zone
- infer derivative products such as vorticity, strain and divergence
- contribute to understanding of air-sea interactions, vertical processes and marine productivity
- validate high-resolution models

Proposed mission concept

- Ku-band SAR system for squinted along-track ocean interferometry (ATI) from space, with three beams (fore, aft, broadside) for full 2-D measurements
- Flexible space/time sampling: fast 1-2 day revisit, or all coastal and shelf seas

Wivern

Observing global winds, clouds and precipitation



Key science and mission objectives

- Measure in-cloud horizontal atmospheric motion and microphysical properties
- Extend lead-time and predictive skills of high-impact weather
- Contribute to reanalysis, improve weather and climate model parameterization
- Establish benchmark for precipitation and cloud profiling

Proposed mission concept

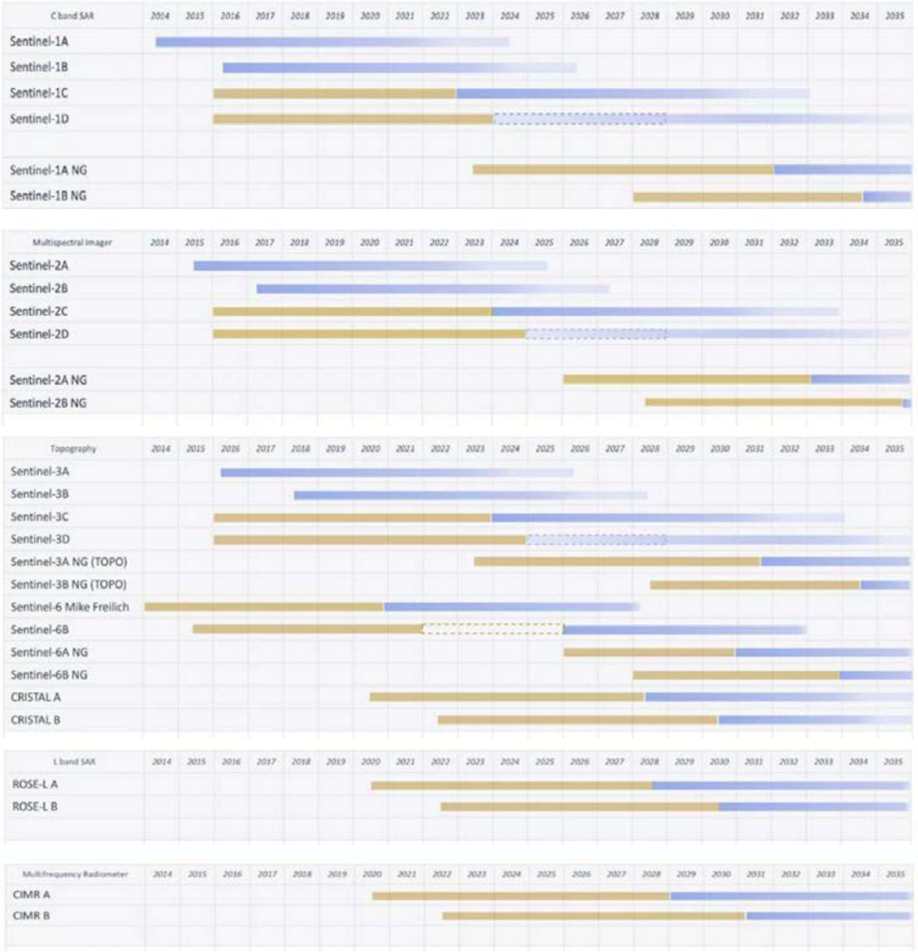
- Conically scanning W-band radar with dual polarization pulse-pair technique
- Sun-synchronous polar orbit with 800 km swath, daily revisit above 50° latitude
- 5-year lifetime

https://www.esa.int/Applications/Observing_the_Earth/Future_EO/Earth_Explorers/Four_mission_ideas_to_compete_for_Earth_Explorer_11

Summary

The main ‘cryosphere’ missions in development/study at ESA are:

- Copernicus Sentinel-1 C and D (Phase D/E)
- Copernicus Sentinel-2C and D (Phase D/E)
- Copernicus Sentinel-3C and D (Phase D/E)
- Copernicus Expansion CIMR (Phase B2+)
- Copernicus Expansion CRISTAL (Phase B2+)
- Copernicus Expansion ROSE-L (Phase B2+)
- Copernicus Sentinel-1 Next Generation (in Phase A/B1)
- Copernicus Sentinel-2 Next Generation (Phase 0)
- Copernicus Sentinel-3 Next Generation Topography (In Phase A/B1)
- Copernicus Sentinel-3 Next Generation Optical (In Phase 0)
- Earth Explorer 10 Harmony (Phase A)
- Earth Explorer 11 SeaStar (Phase 0)
- Arctic Weather Satellite (Planned launch ~2024)



Conclusion

- **Europe is providing an unprecedented and unique Earth Observation Observation Evidence Base** that is supporting an enormous and growing number of applications across **all domains**
- The European Space Agency, together with the European Commission and EUMETSAT, is now preparing to **enhance and extend the Copernicus system**
  - User and Policy driven requirements drive the system evolution
  - Continuity of Copernicus observables is to be guaranteed
  - Enhanced continuity sets next generation targets
- **The ESA Earth Explorer Program** continues to developing new scientific missions to view our planet Earth using **innovative techniques and technologies**.
- **Fundamental challenges remain to exploit satellite measurements in synergy** from the local process-driven perspective to the global climate challenges.
- **We have an extremely rich and growing data archive for reanalyses and climate activities that provides an unparalleled scientific evidence base**
- **These are critical for effective decision making and Policy implementation – and of course our next generation of forecasting and prediction systems**

Thank you
Any Questions?

Contact:
Craig.Donlon@esa.int