EGU General Assembly 2021

OS4.3

Ocean Remote Sensing

First Results from the Sentinel-6 Mission

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Sea Level rise projections

Primary Extremes by 2100:
Ocean Heat Content: +0.35m
Greenland Ice Sheet: +0.28m
Antarctic Ice sheet: +0.28m
Glacial Mass loss: +0.27m

Extreme sea level:
+1.2m by 2100
+5.5m by 2300

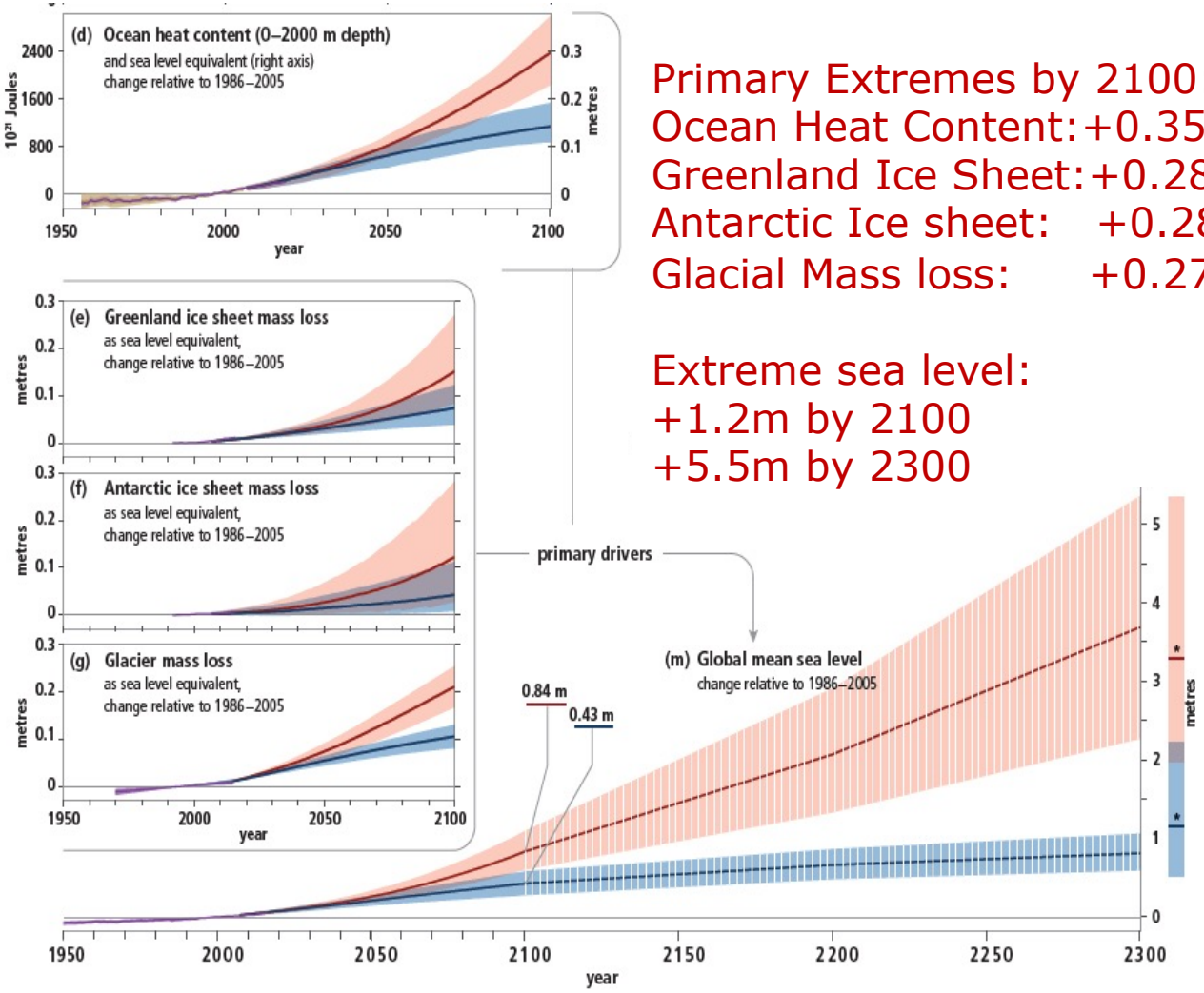
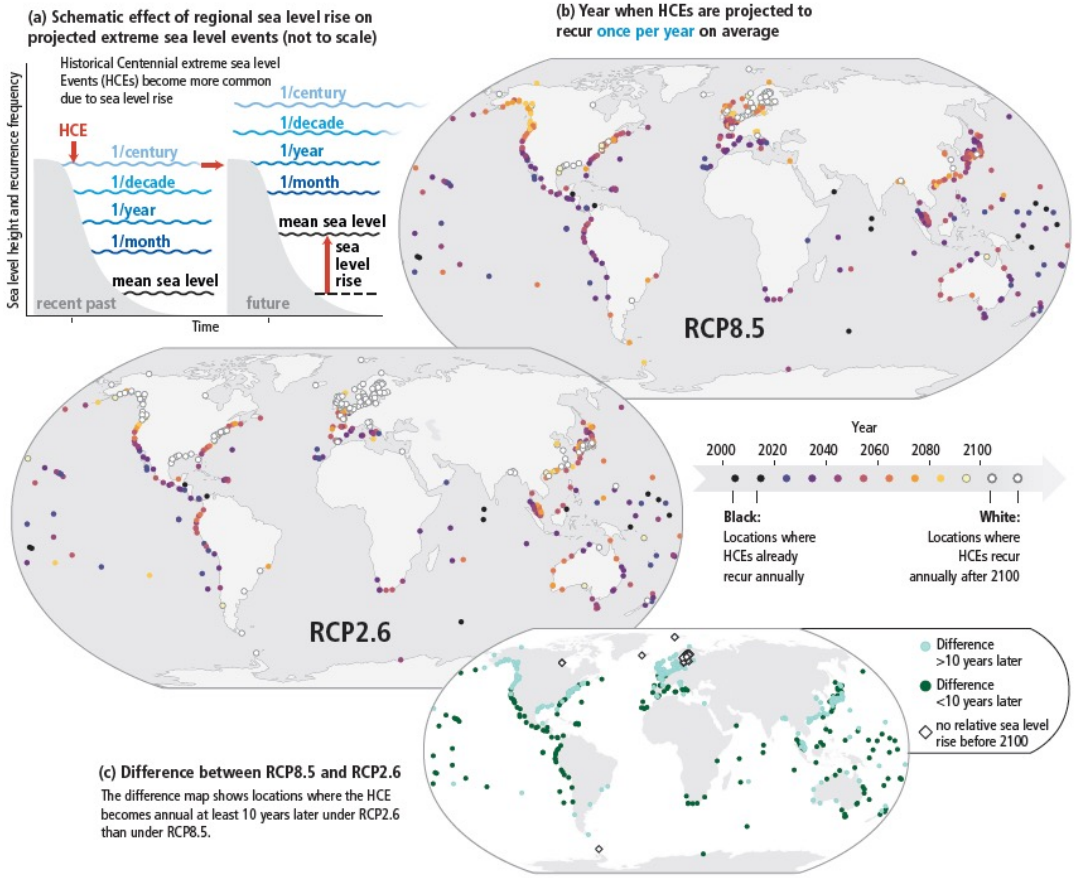


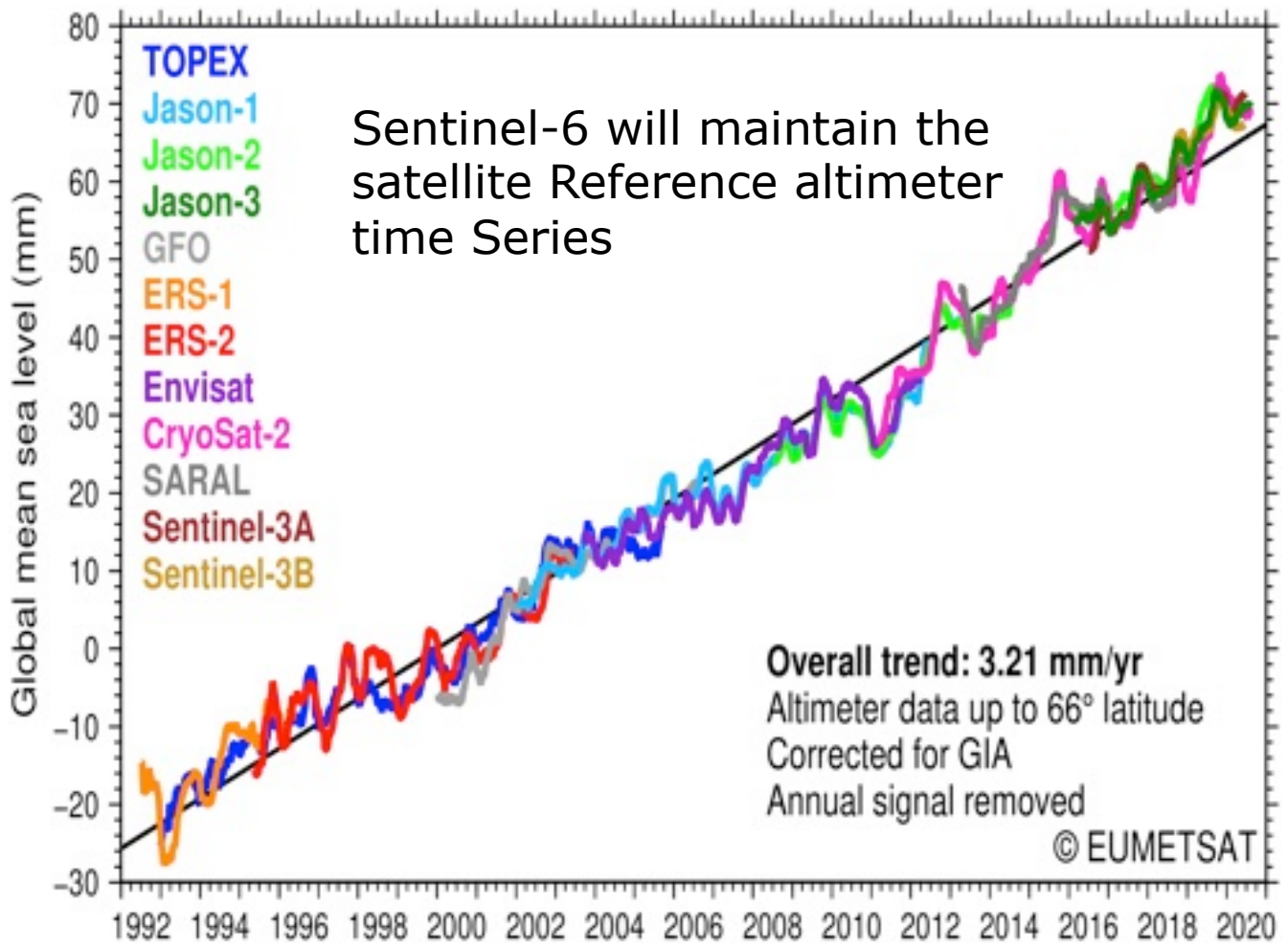
Figure SPM.1 | Observed and modelled historical changes in the ocean and cryosphere since 1950[11], and projected future changes under low (RCP2.6) and high (RCP8.5) greenhouse gas emissions scenarios. {Box SPM.1}

Extreme sea level events

Due to projected global mean sea level (GMSL) rise, local sea levels that historically occurred once per century (historical centennial events, HCEs) are projected to become at least annual events at most locations during the 21st century. The height of a HCE varies widely, and depending on the level of exposure can already cause severe impacts. Impacts can continue to increase with rising frequency of HCEs.



Sea-Level rise is a societal threat

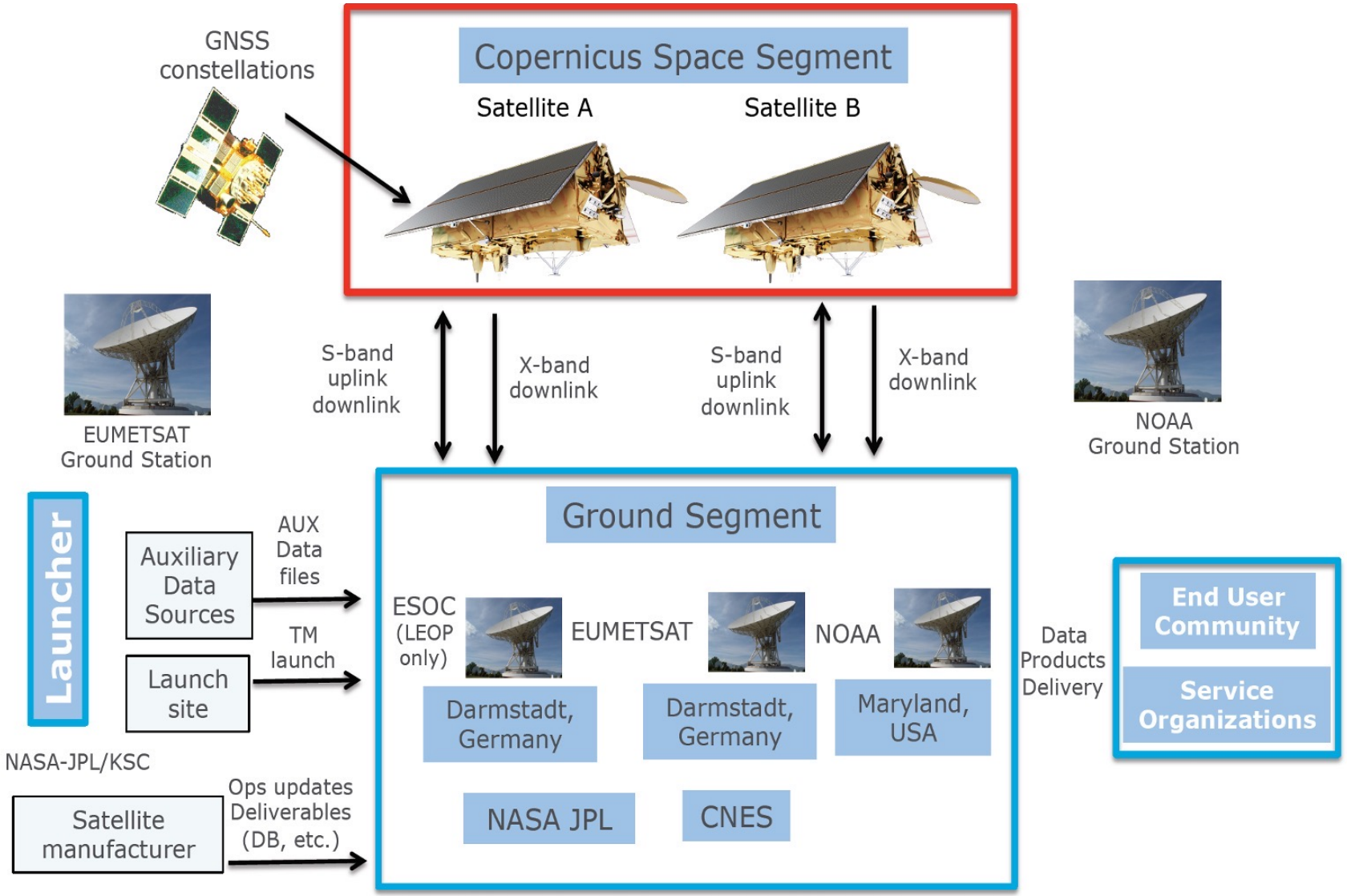


Low-lying coastal zone is home to 680 million people

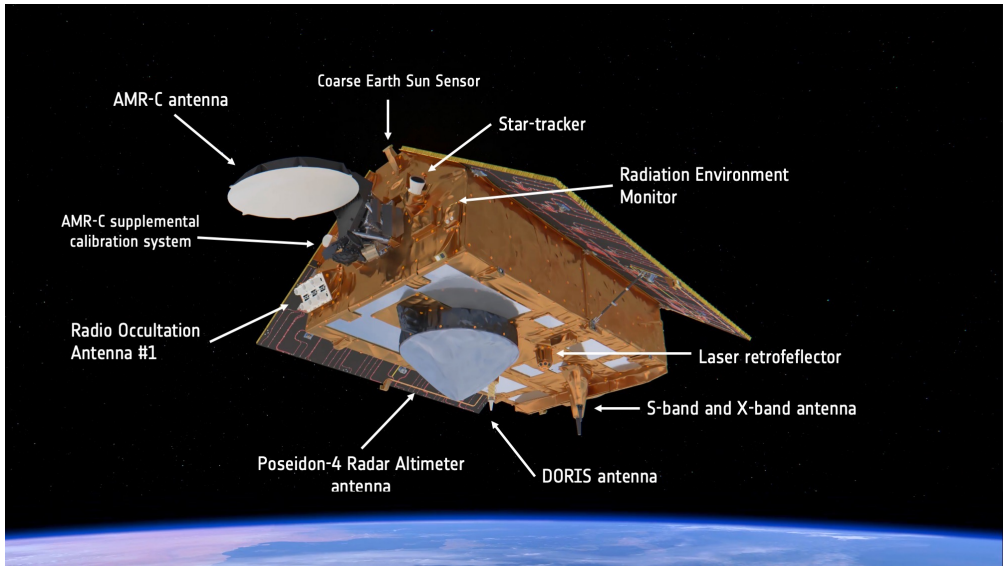
3 million extra people at flooding risk for every cm of sea level rise

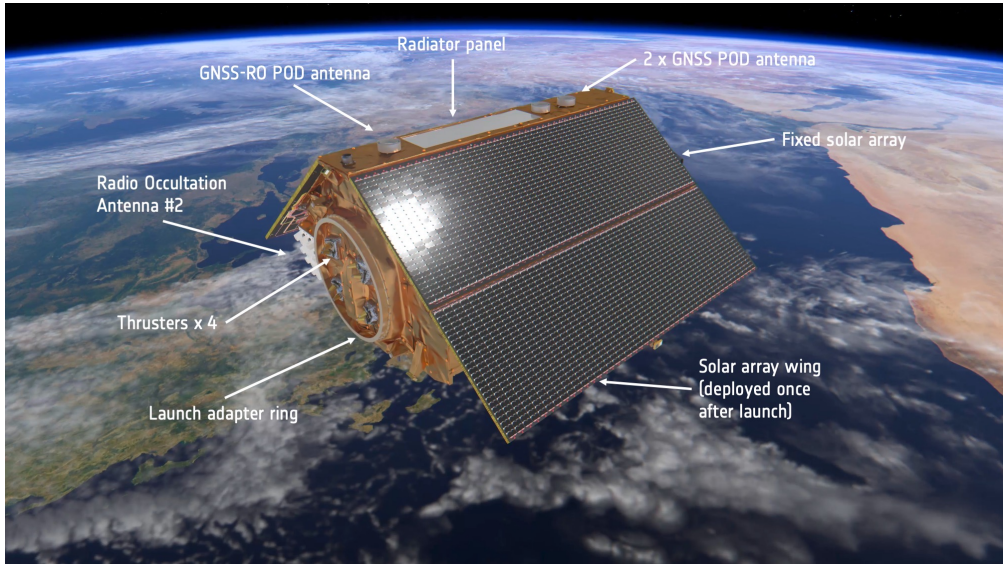
IPCC predictions for 2100 show 0.43 - 0.84 meter increase of average sea levels

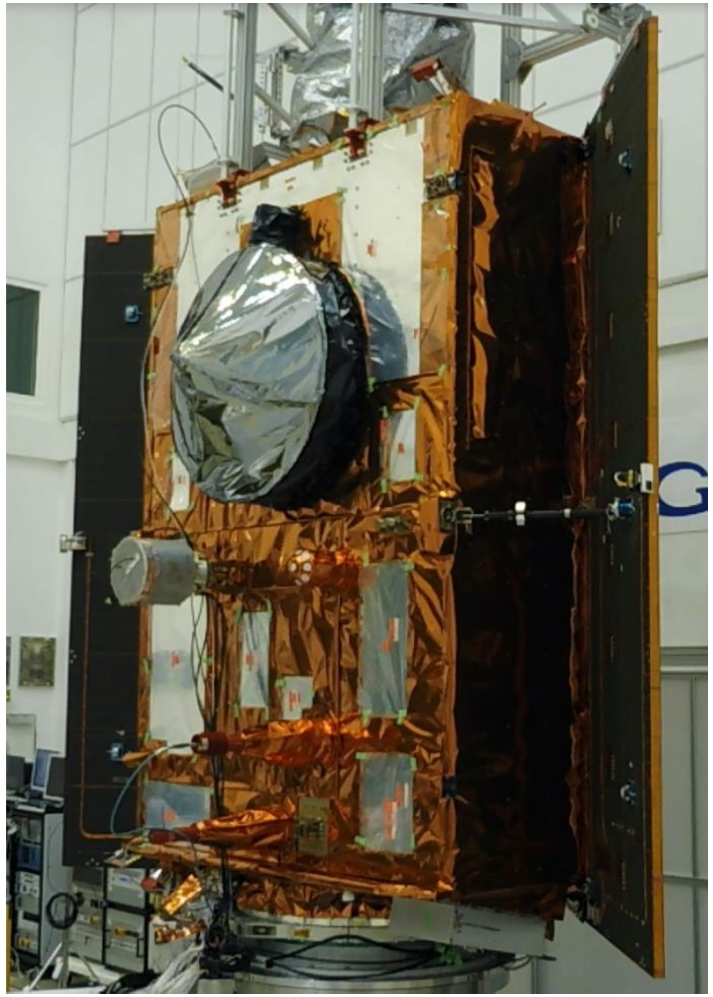
The Sentinel-6 system



Sentinel-6 Main Features



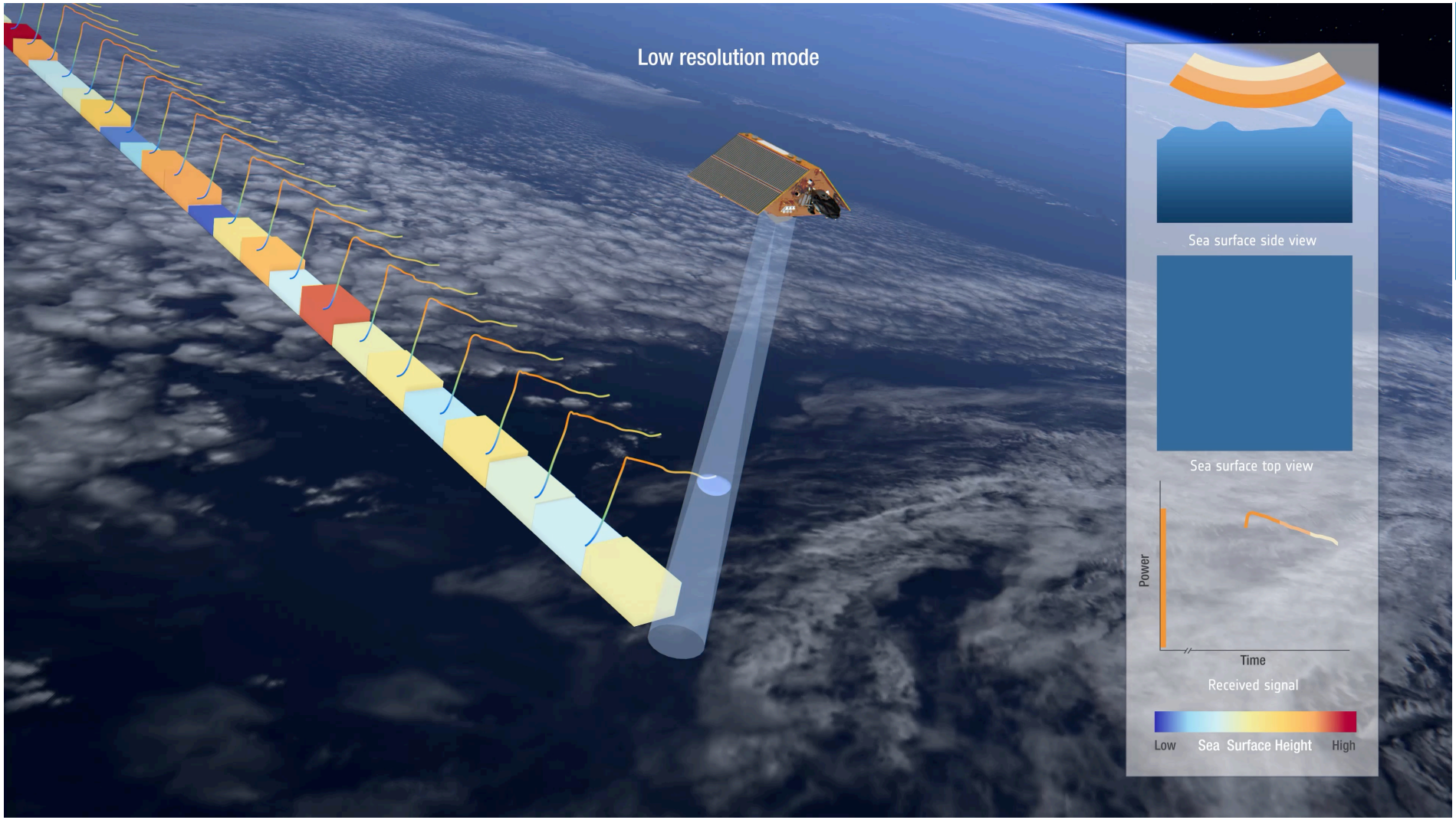


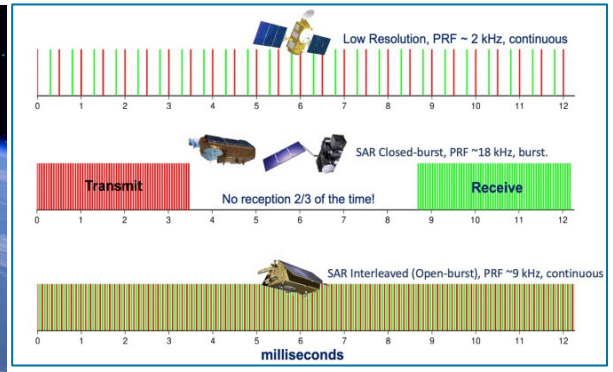


Sentinel-6 Michael Freilich satellite during tests at IAGB facilities, Germany

Sentinel-6 Poseidon-4 altimeter

Video at https://www.youtube.com/watch?v=OXf4Mf4TQeI



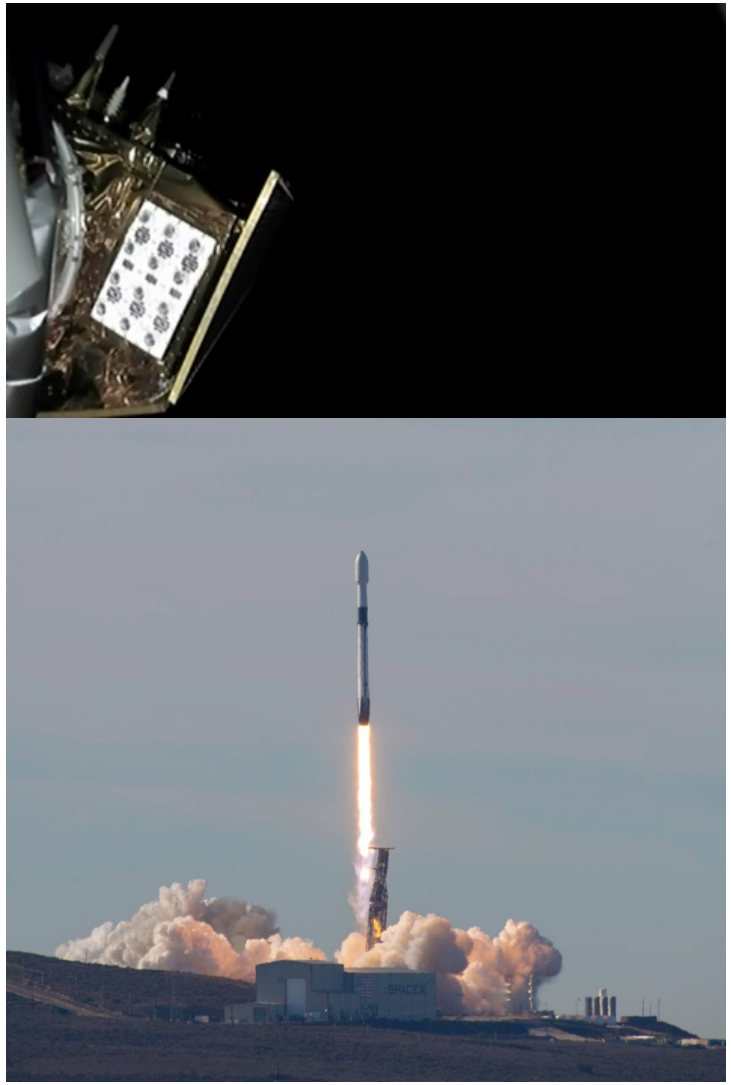


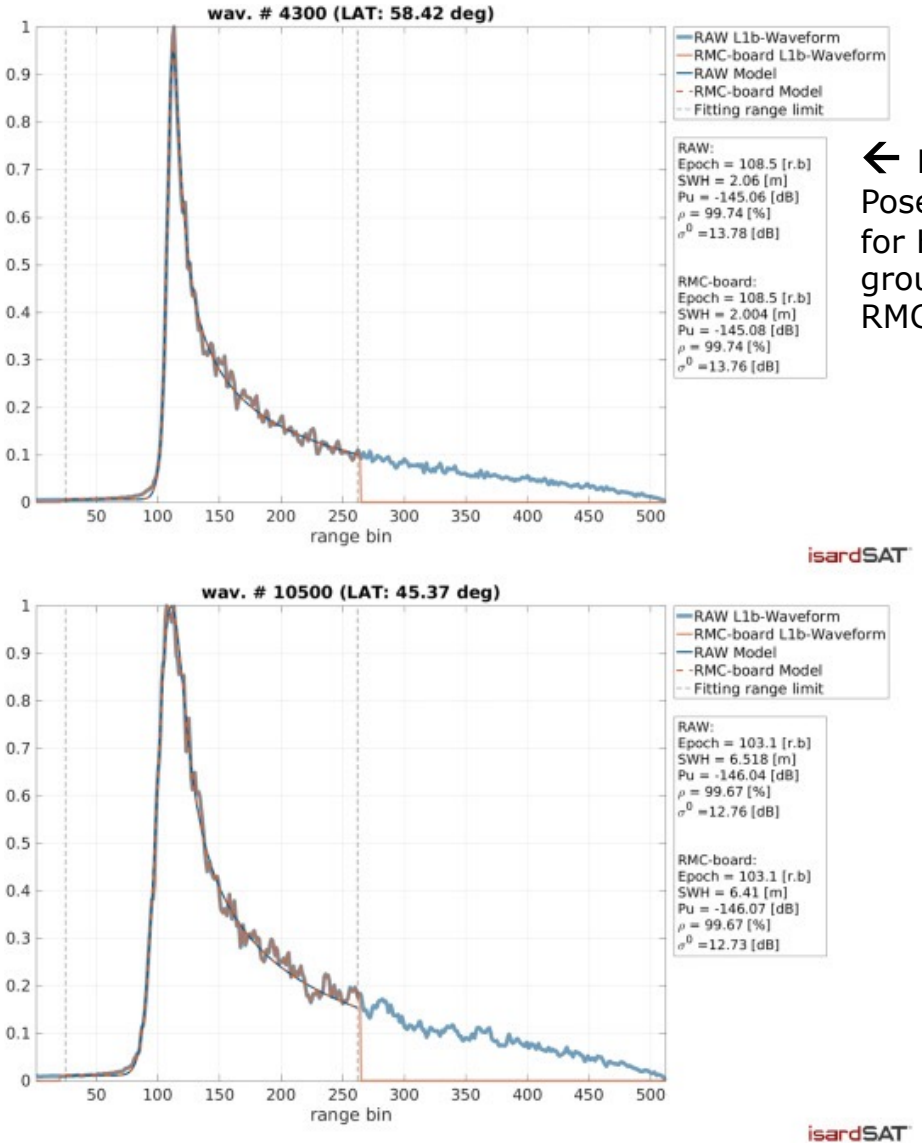
Poseidon-4 uses a new interleaved chronogram allowing simultaneous LRM and SAR acquisition

On-board Processing implements Range Migration Compression and significantly reduces data rates

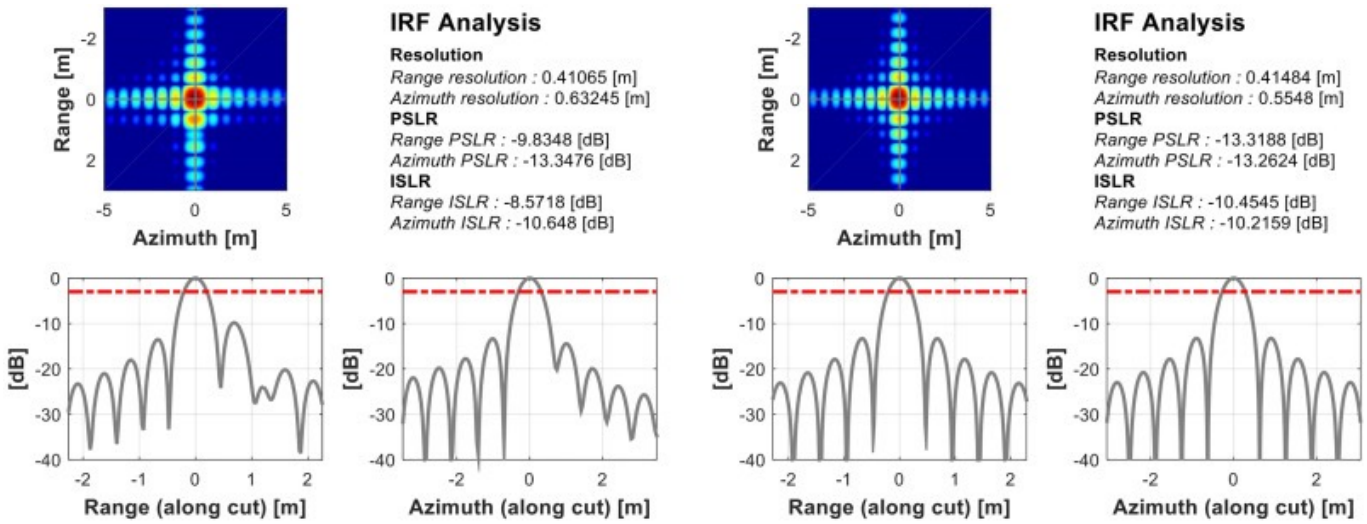
Sentinel-6 Michael Freilich

- Sentinel-6 Michel Freilich was launched from Vandenburg Air force Base on 21st November 2020 at 18 km below the operational orbit as planned.
- A series of manoeuvres were initiated to bring the satellite into a Tandem flight configuration with Jason-3 by mid December 2020 allowing inter-comparison with Jason-3 and maintain stability of the sea level record.
- A full handover of the satellite system from ESA to EUMETSAT took place end Jan after Launch and Early Operations Phase (LEOP) and Satellite In-Orbit Verification (IOV) were completed.
- On November 30th, the Poseidon-4 altimeter instrument was switched on.
- Initial Poseidon-4 altimeter data acquisitions were used to check the instrument while the spacecraft is approaching the operational orbit.
- The following plots reveal the excellent quality of the Posiedon-4 radar altimeter that is the principal payload of the Sentinel-6 mission.
- Of particular note is the low noise floor associated with the new SAR digital architecture flown, for the first time, on Sentinel-6





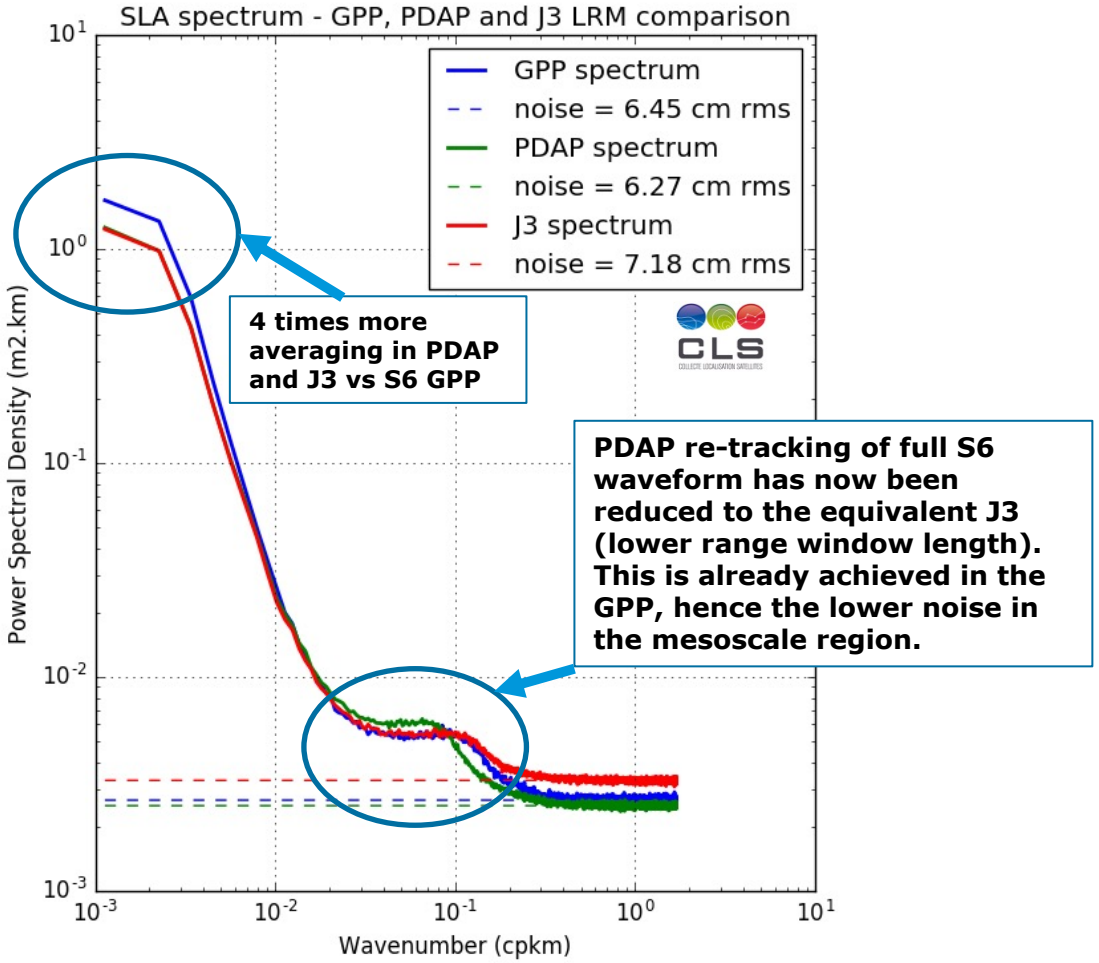
← Example waveforms from S6-MF obtained during the 30 November 2020 Poseidon-4 switch-on highlighting initial measurement performance. Top: Example for Hs = 2 m, Bottom: Example for Hs = 6 m. RAW SAR data were processed on the ground using the ESA Ground Prototype Processor (GPP) and show that the on-board RMC processor is performing within expectations.



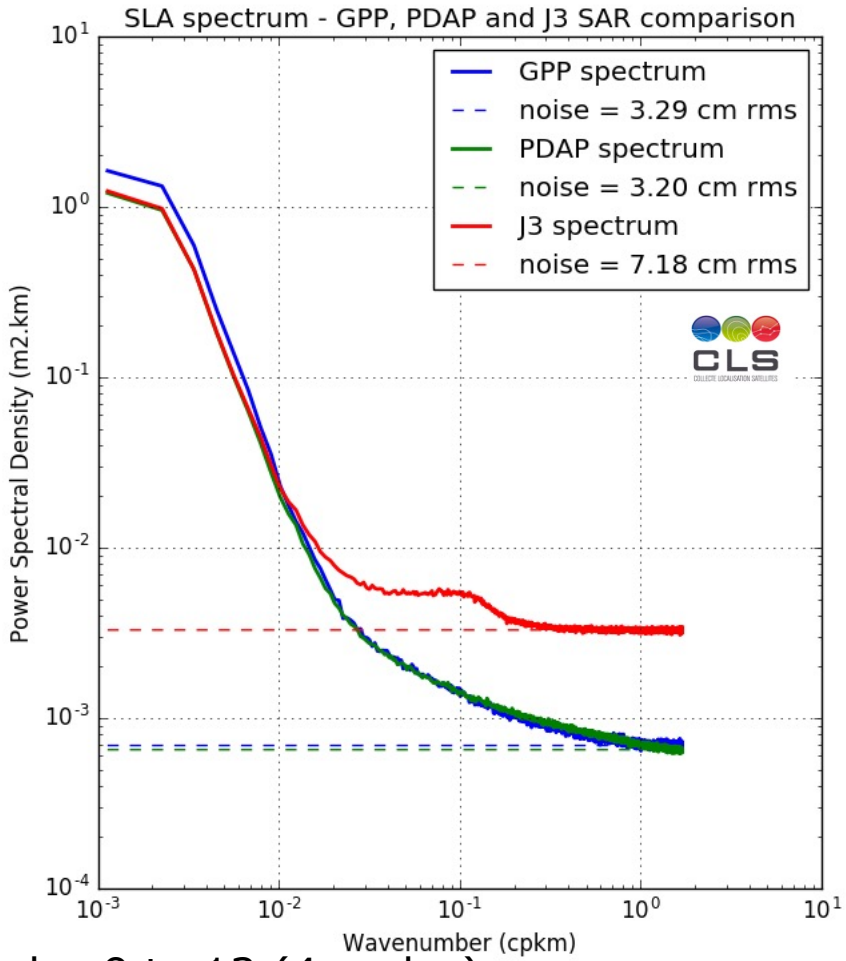
⇧ Fully focussed SAR results from Posiedon-4 for the first PFAC transponder pass obtained on 18th November 2020 immediately after the S6MF tandem orbit configuration was acquired. Right: expected theoretical response. Data processed by the ESA Ground Prototype Processor (GPP).

SLA Spectrum shows equivalence between missions and methods

Low Resolution



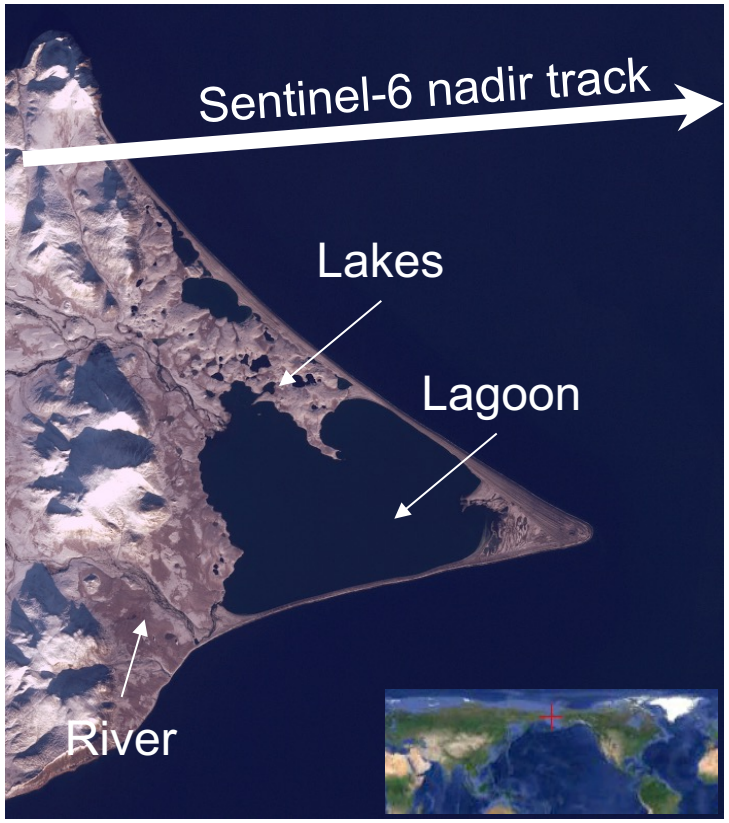
High Resolution



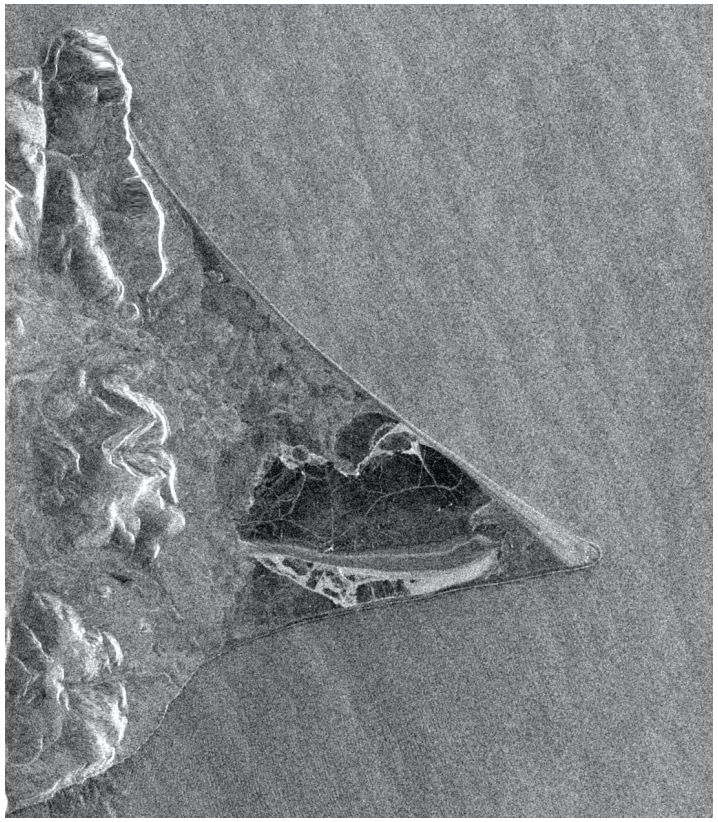
SLA generated for Jason 3 and S6 PDAP computed for cycles 9 to 13 (4 cycles).
GPP reference processing for cycle 9 for comparison with a different processing configuration to PDAP

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

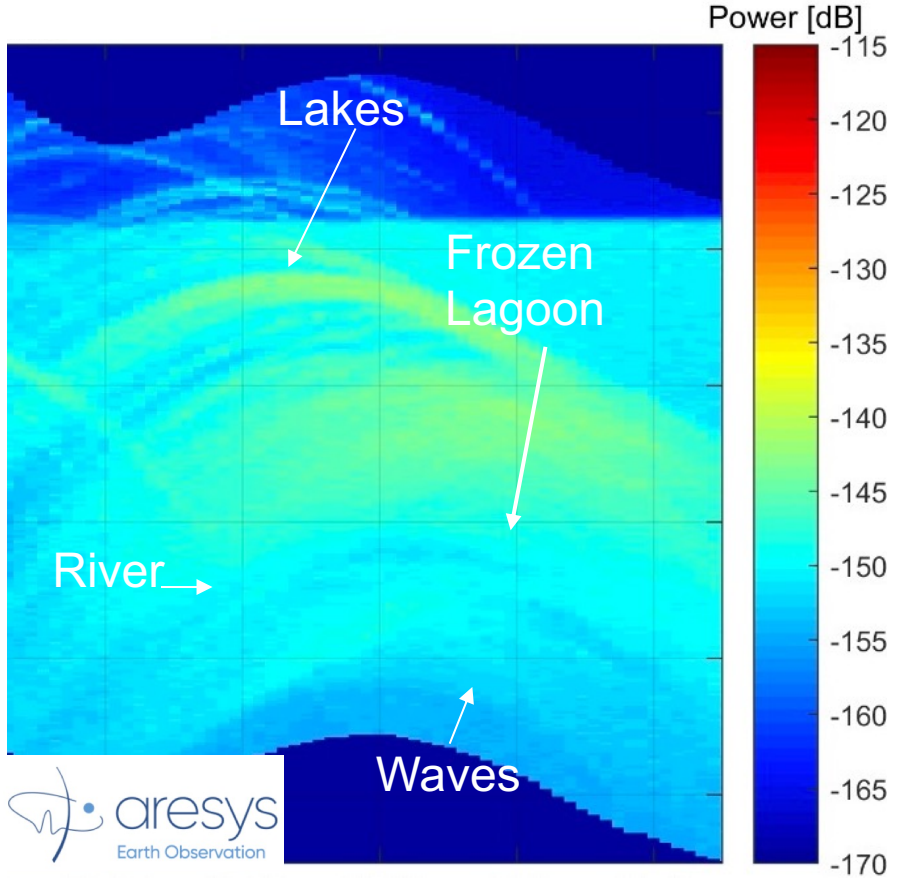
S6-MF Poseidon-4 altimeter reveals unprecedented detail in the Ozero Nayval lagoon and surrounding river areas. Fully focussed synthetic aperture radar **processing highlights the low noise performance of new digital instrument** architecture.



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

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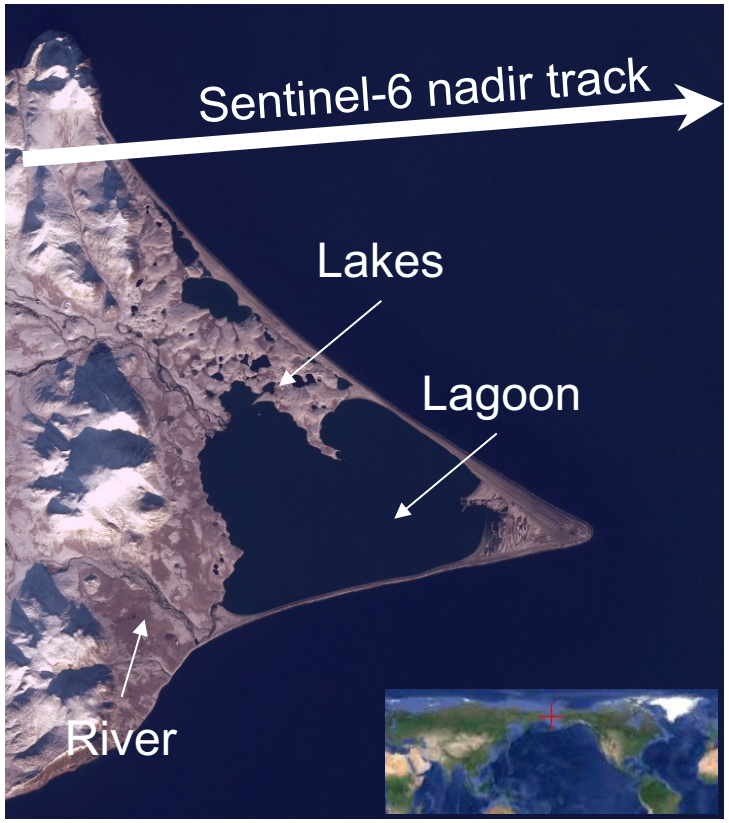
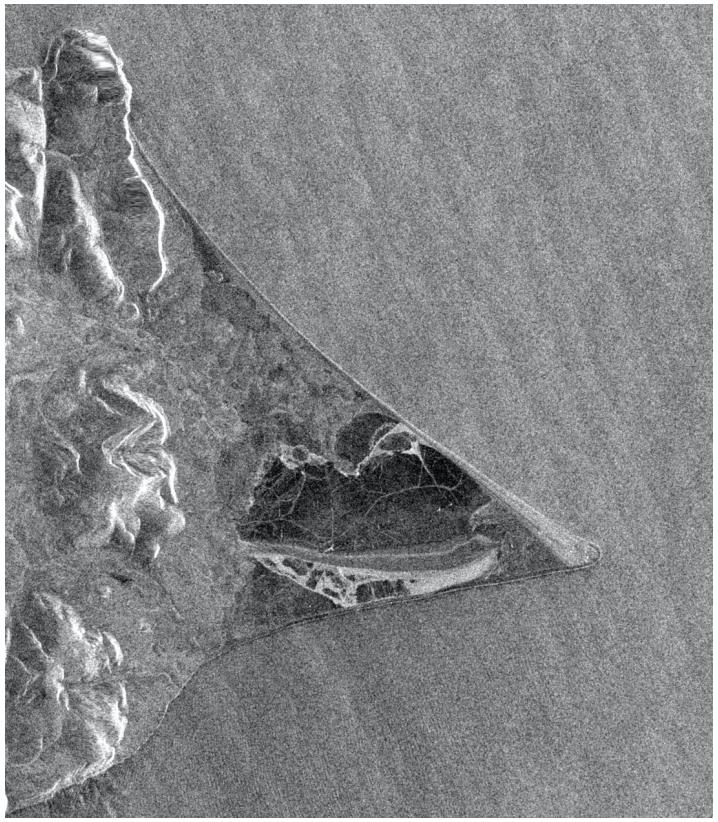
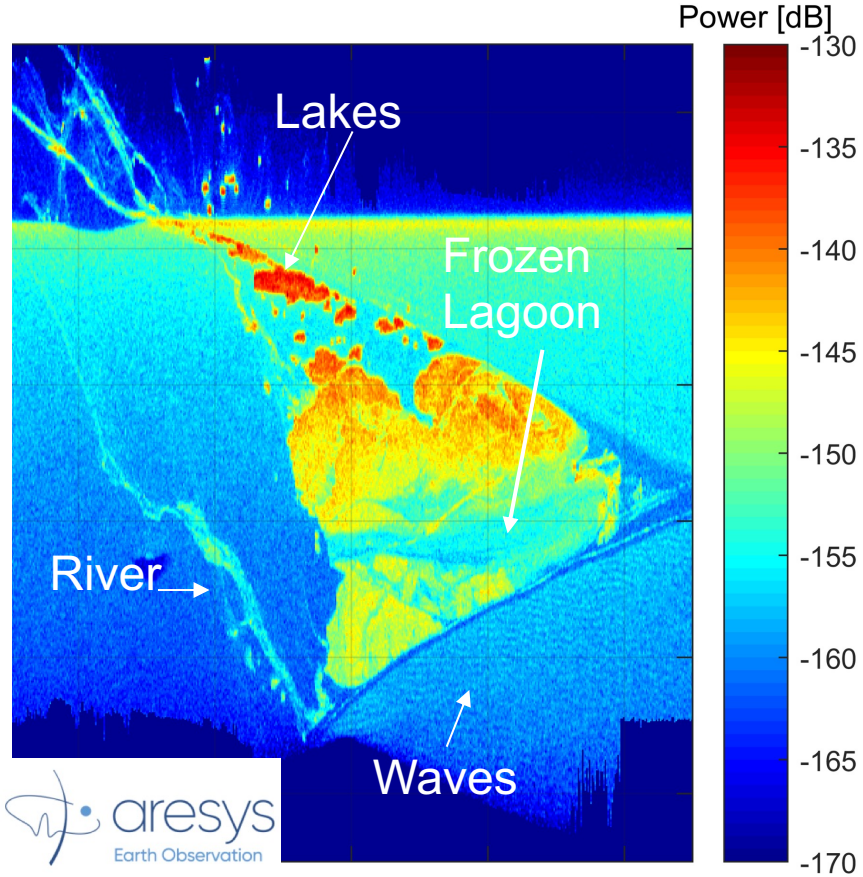


Sentinel-2B (10m) Ozero Nayvak peninsular, Russia, 15 August 2020



Sentinel-1B Interferometric Wide Swath, 29 Nov 2020



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

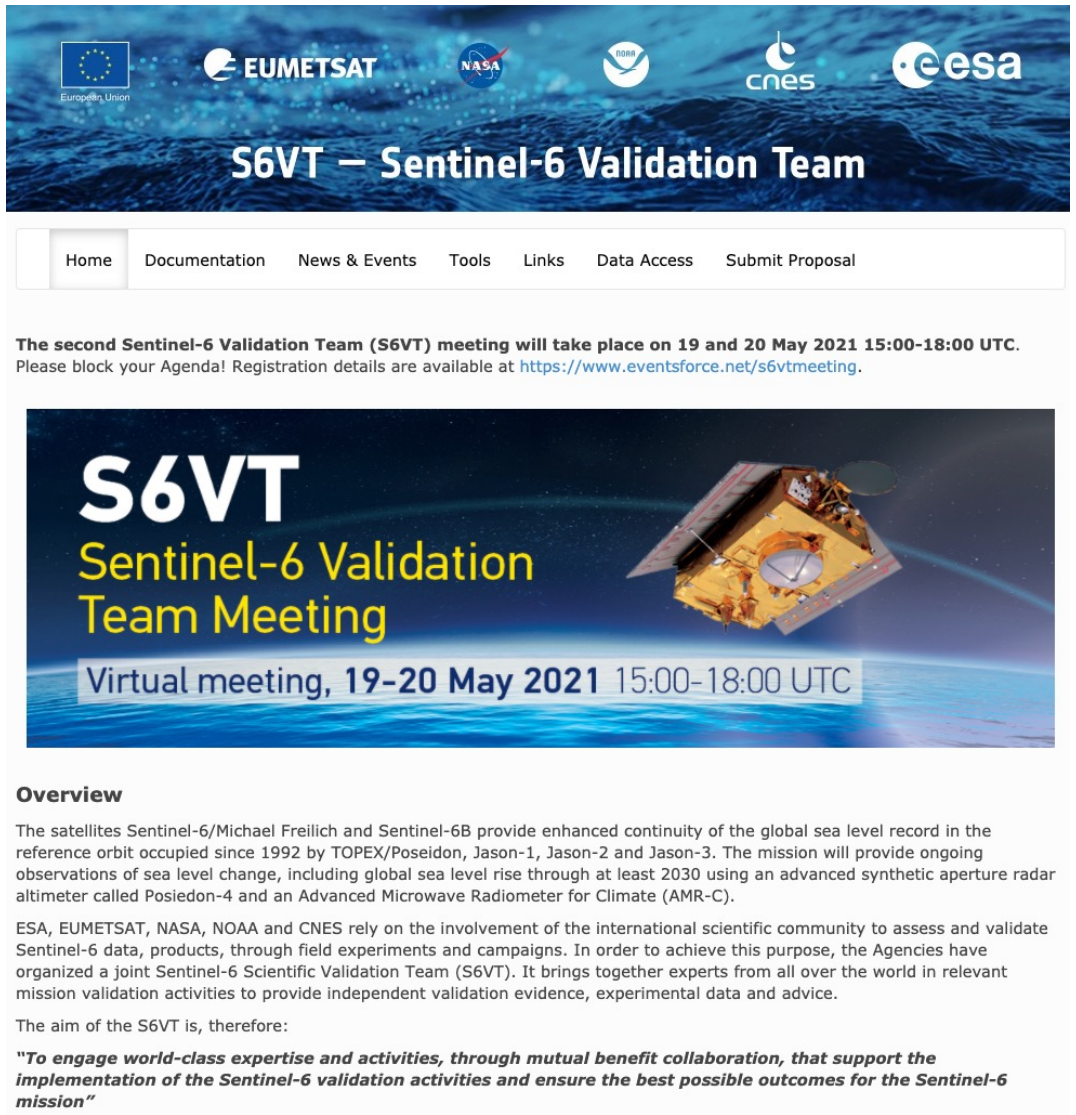
Sentinel-6 Validation Team

- **S6VT provides early access to data – first LRM data now available!!!**

- S6VT is an open to all - Please submit a short proposal at **https://earth.esa.int/aos/S6VT**

- The second Sentinel-6 Validation Team (S6VT) meeting will take place on 19 and 20 May 2021 15:00-18:00 UTC.

- Please block your Agenda! Registration details are available at
- **https://www.eventsforce.net/s6vtmeeting**



Sentinel-6 Overview Paper

Remote Sensing of Environment 258 (2021) 112395

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journal homepage: www.elsevier.com/locate/rse

The Copernicus Sentinel-6 mission: Enhanced continuity of satellite sea level measurements from space

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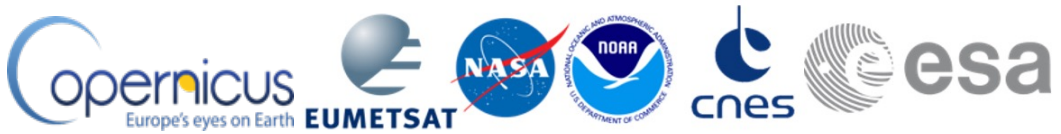
ABSTRACT

Given the considerable range of applications within the European Union Copernicus system, sustained satellite altimetry missions are required to address operational, science and societal needs. This article describes the Copernicus Sentinel-6 mission that is designed to provide precision sea level, sea surface height, significant wave height, inland water heights and other products tailored to operational services in the ocean, climate, atmospheric and land Copernicus Services. Sentinel-6 provides enhanced continuity to the very stable time series of mean sea level measurements and ocean sea state started in 1992 by the TOPEX/Poseidon mission and follow-on Jason-1, Jason-2 and Jason-3 satellite missions. The mission is implemented through a unique international partnership with contributions from NASA, NOAA, ESA, EUMETSAT, and the European Union (EU). It includes two satellites that will fly sequentially (separated in time by 5 years). The first satellite, named Sentinel-6 Michael Freilich, launched from Vandenburg Air Force Base, USA on 21st November 2020. The satellite and payload elements are explained including required performance and their operation. The main payload is the Poseidon-4 dual frequency (C/Ku-band) nadir-pointing radar altimeter that uses an innovative interleaved mode. This enables radar data processing on two parallel chains the first provides synthetic aperture radar (SAR) processing in Ku-band to improve the received altimeter echoes through better along-track sampling and reduced measurement noise; the second provides a Low Resolution Mode that is fully backward-compatible with the historical reference altimetry measurements, allowing a complete inter-calibration between the state-of-the-art data and the historical record. A three-channel Advanced Microwave Radiometer for Climate (AMR—C) provides measurements of atmospheric water vapour to mitigate degradation of the radar altimeter measurements. The main data products are explained and preliminary in-orbit Poseidon-4 altimeter data performance data are presented that demonstrate the altimeter to be performing within expectations.

Summary

- Poseidon-4 **digital architecture**, flown for the first time on Sentinel-6, delivers a **very low noise instrument compared to heritage altimeters**.
- **Ocean profiles are very clean** and highlight the benefit of SAR processing compared to pulse limited LRM, as used by Jason-3.
- **On-board RMC processing is performing as expected**: **initial data shows excellent performance that is equivalent to full SAR high resolution data.** Further analysis is required to confirm the result in other regions dominated by swell waves, for example.
- **The high performance and low noise of Poseidon-4 when processed using ESA developed Fully Focussed SAR techniques reveals exceptional results.**
    - The processor provides an image similar to a SAR imager such as Sentinel-1.
    - An example at a resolution of 1.1m (further multi looked to provide a resolution of ~30m) shows the radar backscatter power coded by colour as a function of across-track range **to provide a surface image** and clearly reveals sea ice and land features: extremely promising for improved sea level measurements in the Marginal Ice Zone
- **Poseidon-4 can measure the elevation of target scene and an across track image, so that for the first time, an operational elevation measurement from the altimeter can be directly interpreted in the surrounding target area from a single set of measurements.**
- Further data are required to investigate the performance of Poseidon-4 in Ocean Swell waves using this approach to reduce the Sea Sate Bias second largest uncertainty (2 cm) in the altimeter measurement system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