The Copernicus Sentinel-3 Mission: Status

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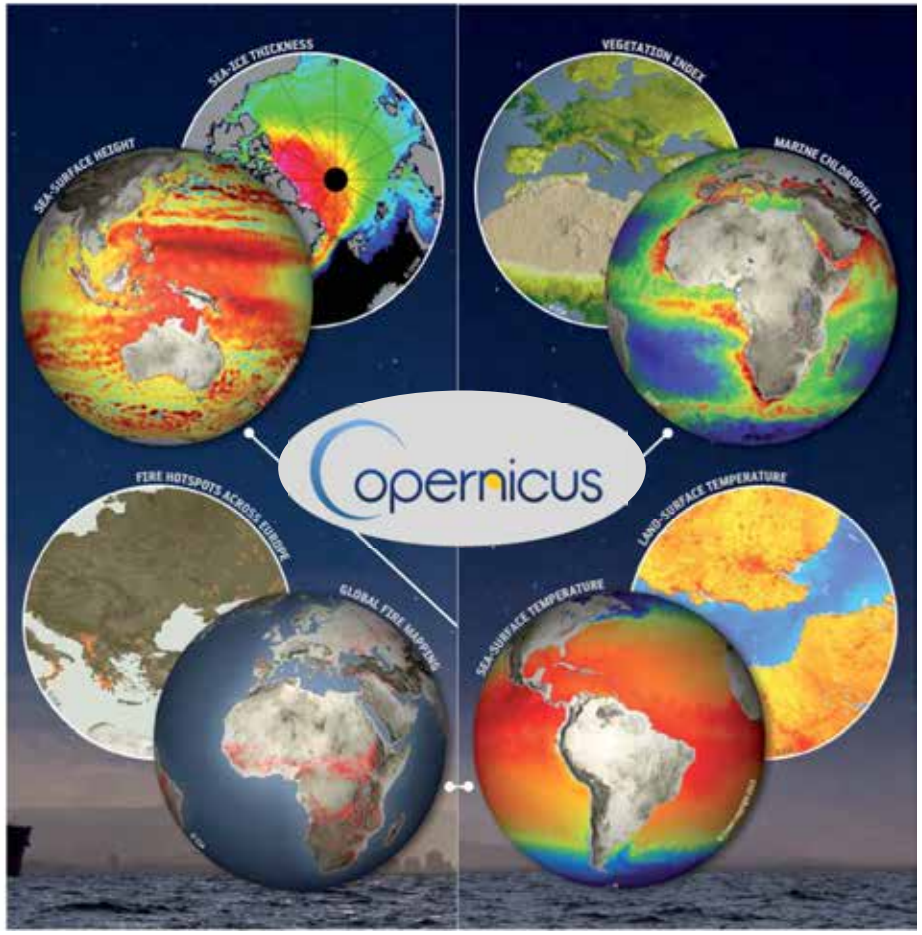
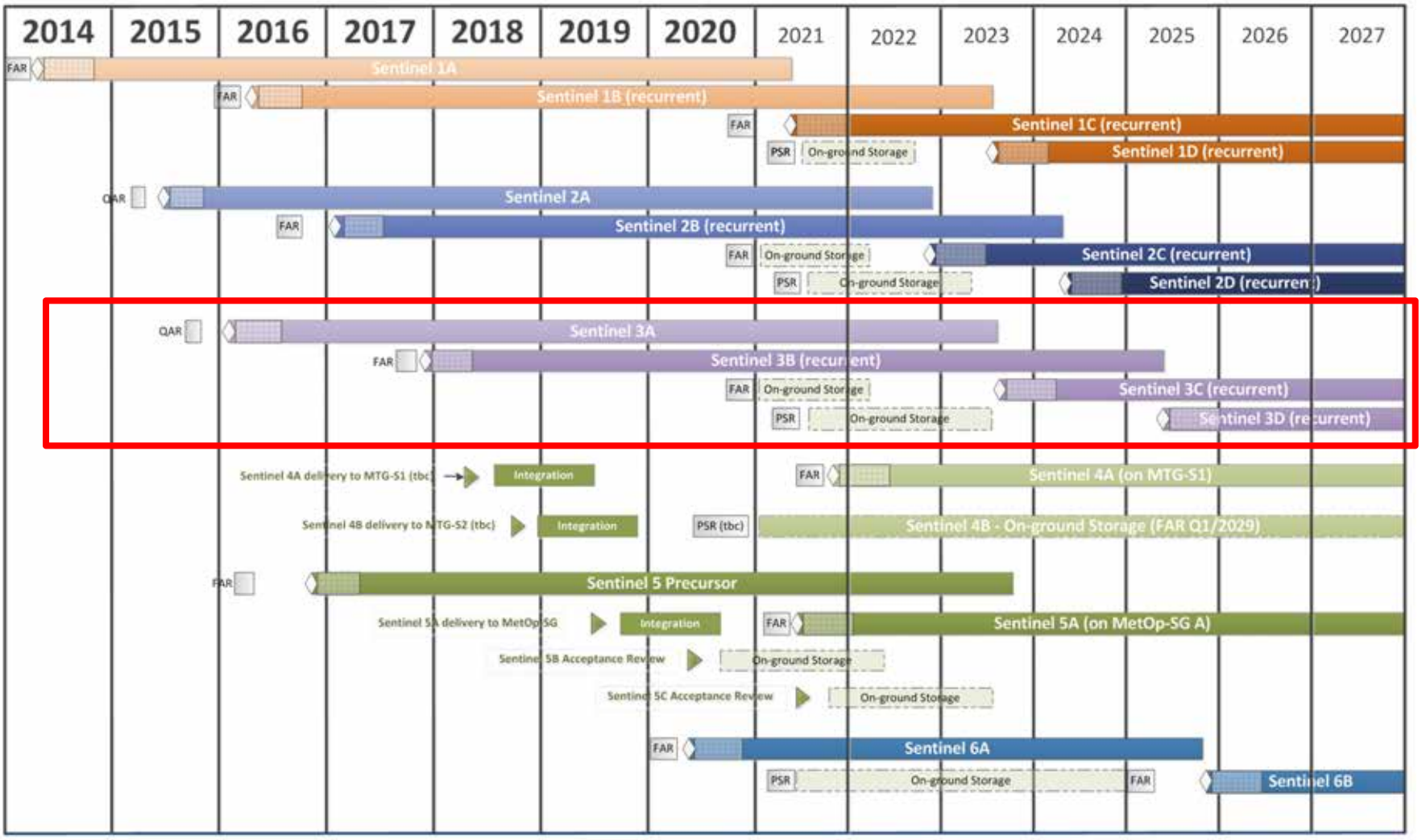
Ocean Surface Topography Science Team Meeting, Miami, USA, 23rd October 2017

Outline

- Copernicus update
- Status of the Sentinel-3A mission
- Status of Sentinel-3B satellite
- Sentinel-3 Tandem flight
- Key upcoming events
- Summary



The Copernicus Sentinel Deployment Schedule



Copernicus Space Component (CSC)

- The European Copernicus system, including the Copernicus Space Component (CSC), is been established as **an extensive and proficient EO system**
- The current Sentinels provide **~10 Tb/day** of world-class data to over **100,000 registered users** – fuelling Copernicus.
- **Service application dependencies** are now in place and there are **great expectations for the future** Copernicus system.
- **User needs and requirements have also evolved** in the new Copernicus paradigm
- **A user-driven Long Term Scenario (LTS) is in development (Extension and Expansion)** in close consultation with the EC, ESA and EUMETSAT
    - This will **define the overall system architecture** for the Copernicus Space Component and its evolution based on user requirements coordinated by the EC
    - **Near-term expansion to address High Priority user needs/gaps in existing observations**

Copernicus High Priority Candidate Missions (HPCM)

- **Potential** Copernicus High Priority Candidate Missions (HPCM) include:
  1. **Anthropogenic CO2 monitoring** Mission
  2. **High spatial-temporal resolution land surface temperature** (LST) monitoring mission (including coastal areas)
  3. **Polar ice and snow topography Mission (See Rob Cullen)**
  4. **Microwave imaging radiometry Mission**
  5. **Hyper-spectral imaging** Mission (including coastal areas)
  6. **L-band SAR** Mission

- **ESA Phase A/B1 studies for all HPCM will start in early 2018 for all HPCM**

- **The EC process of user needs and prioritisation is on-going and will continue in parallel**
- **Final selection of HPCM specific characteristics (e.g. spectral choice, number of satellites etc.) will be determined at the end of Phase A/B1**

Sentinel-3 Mission Status

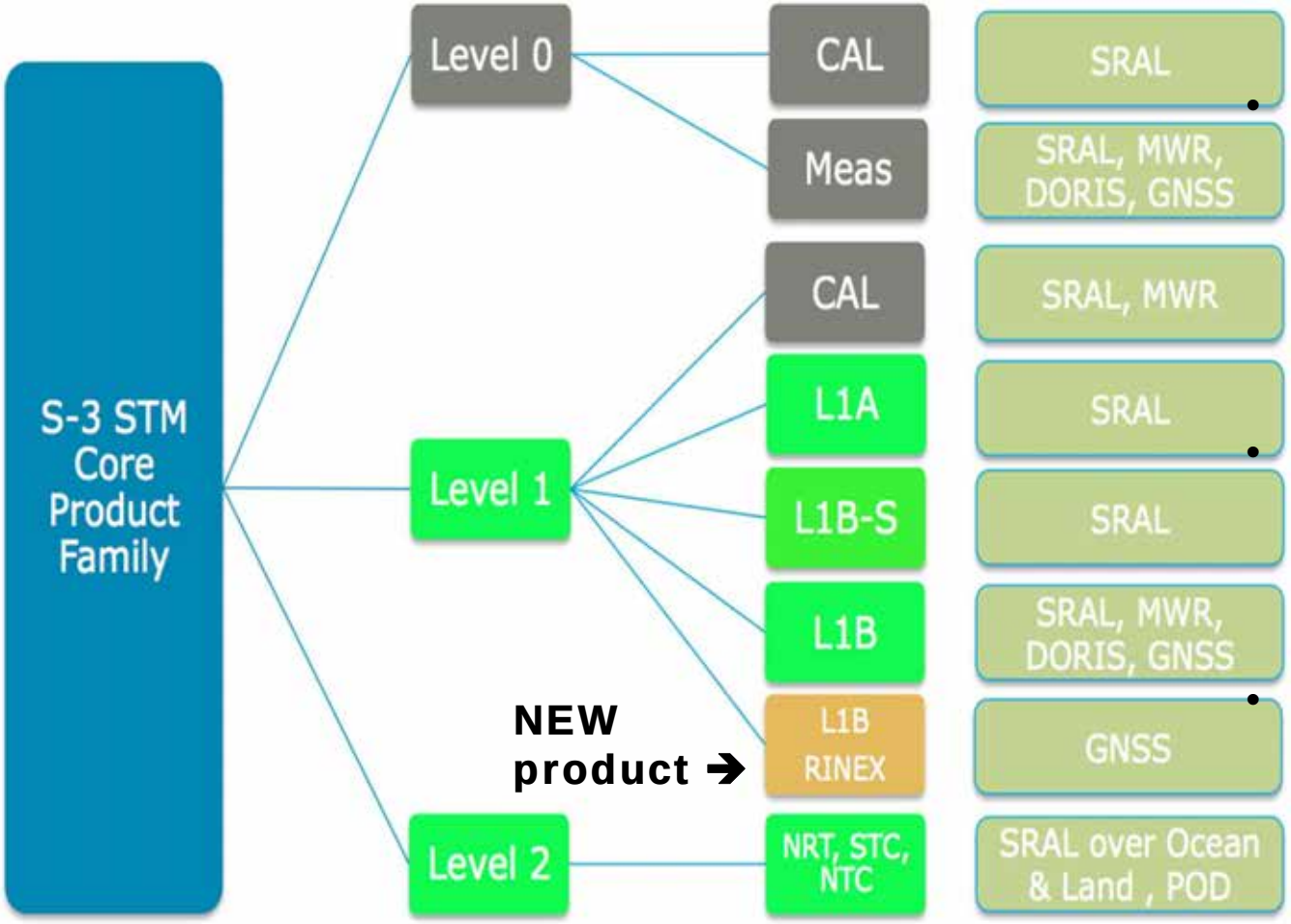
- Sentinel-3A launched in February 2016
- **Nominal operations** of space and ground segment
- Sentinel-3A Routine Operations Readiness Review in October 2017 to **confirmed formal transition into full routine operations**

- **All Level 1 and 2 products have been released to users**
- **Reprocessing** including the commissioning phase
  - SRAL Altimetry: completed and data being made available to all users

SRAL Switch on	**1 March 2016**
Sample L1/L2 data available	**June 2016**
L1B, L2 land and ocean data release	**13 Dec 2016**
L1A, L1BS	**Mid-Feb 2017**

S-3A STM Products Availability

S-3 STM Product Family (Core Products)



Not user product **Officially released** **To be released** (Q4 2017)

- **ALL S-3A STM L1 & L2 products available on line since 15 June 2016** from https://scihub.copernicus.eu/
- **Consistent data set** from 15 June 2015 (Processing Baseline 2.15)
- **Next reprocessing campaign** will include data products BOM, i.e. **from 1 March 2016**

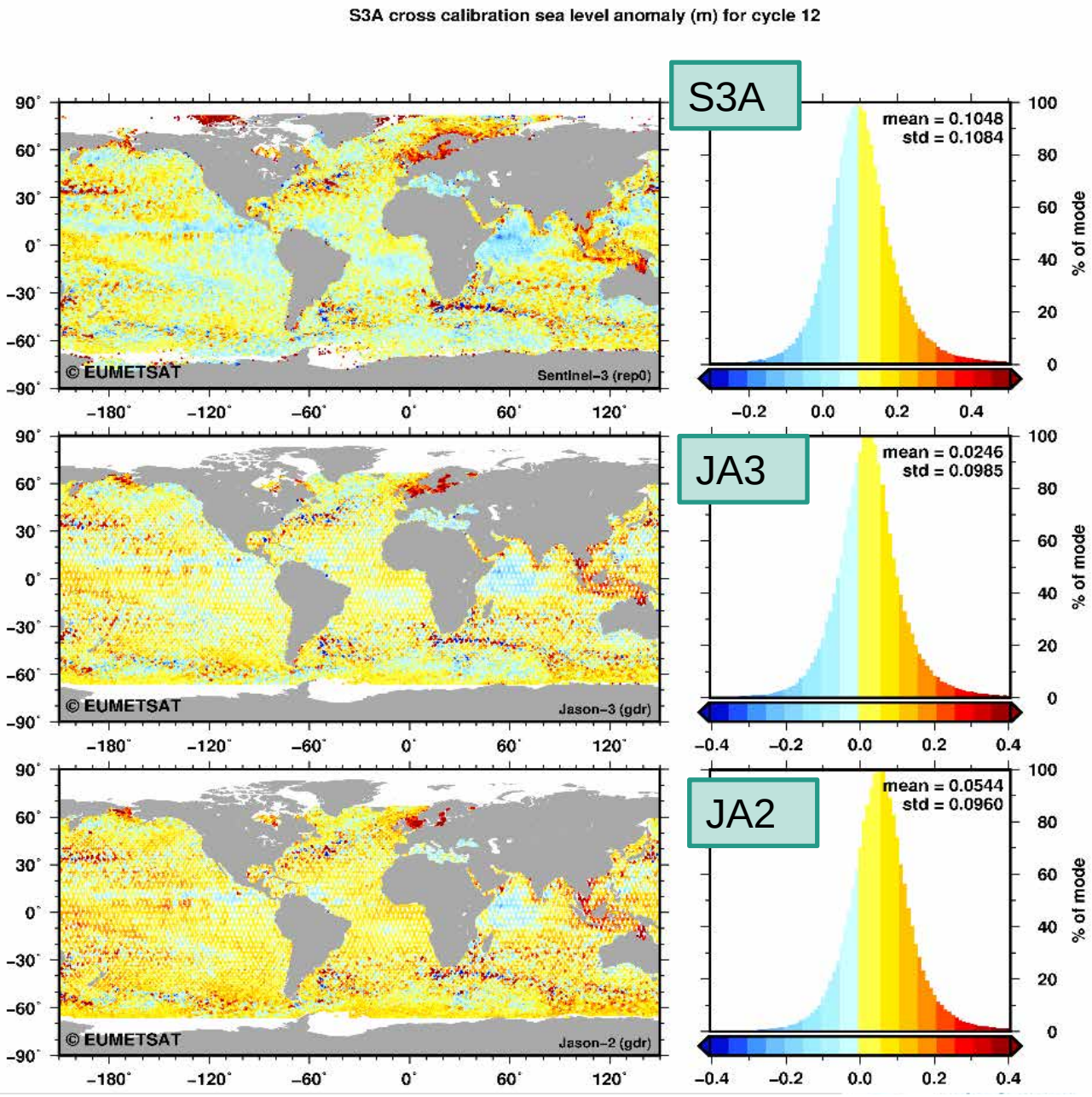
Sea Level – Sentinel-3 / Jason-2 and Jason-3 Intermission biasSLA (Cycle 12)

Comparison with J3 and J2

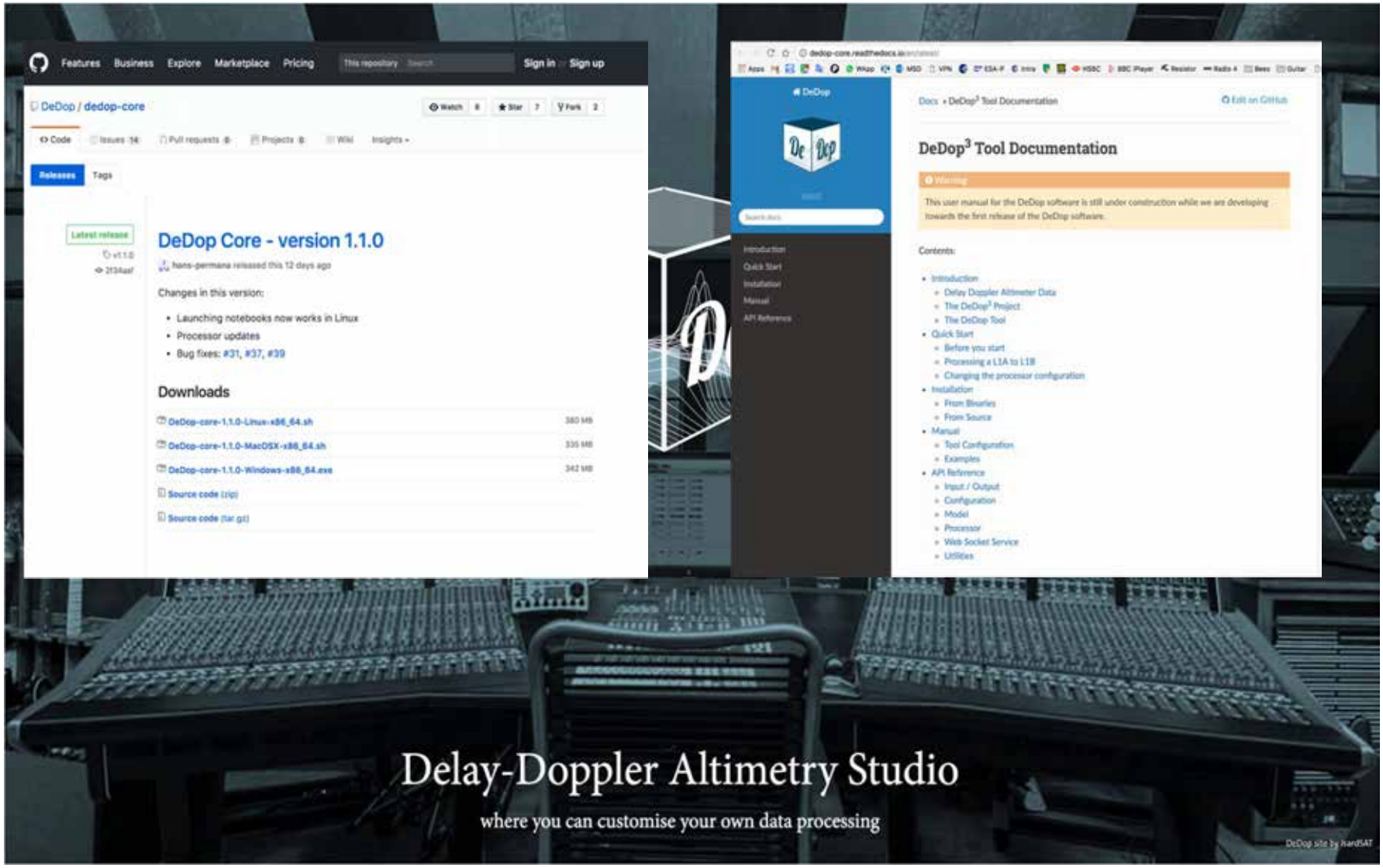
Inter-mission biases

+80 mm

+30 mm

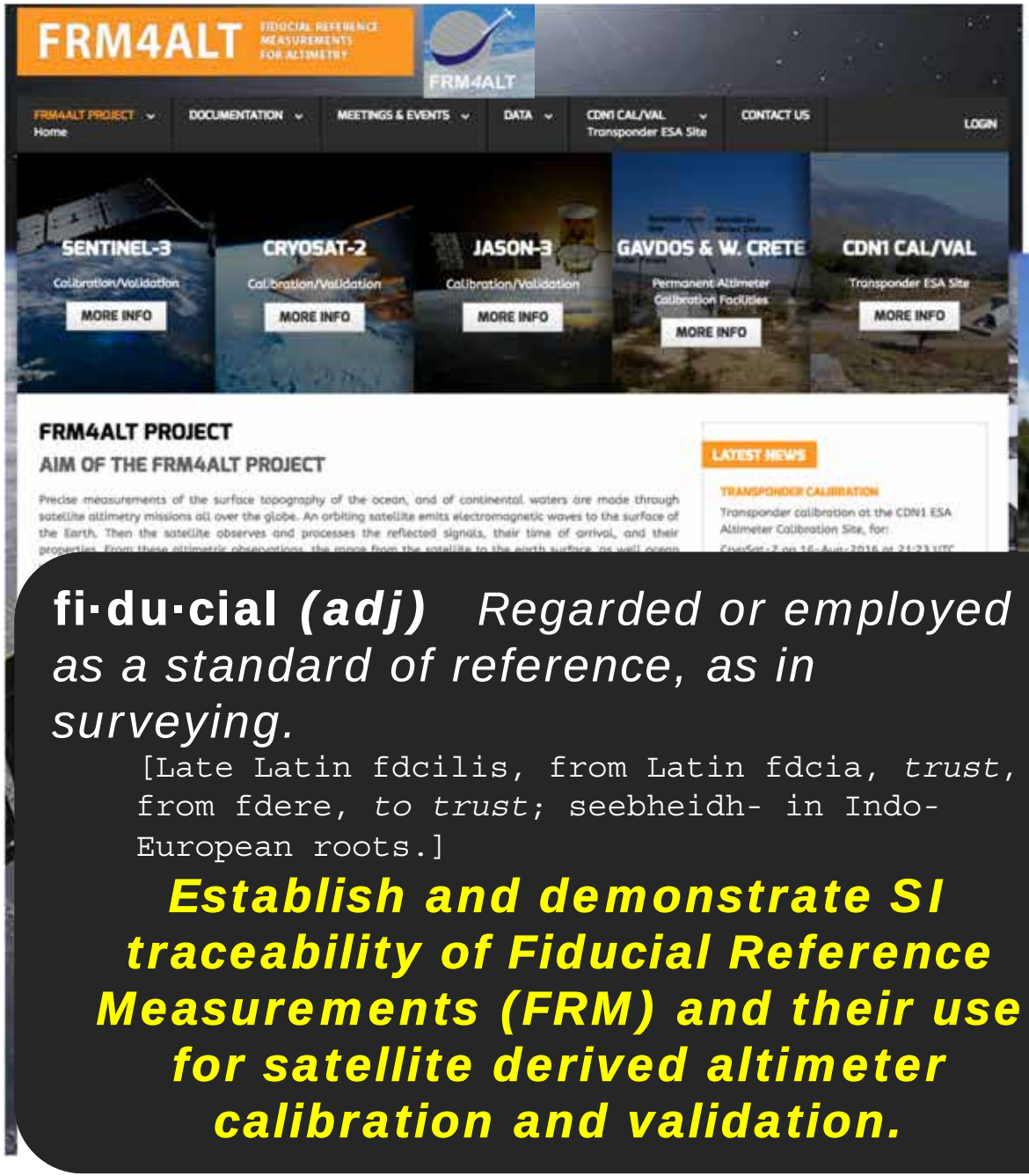


ESA DeDop: Open source code to process SRAL L1a → L1b data



Code, examples, manual etc. at http://DeDop.org

Sentinel-3 OLCI/SRAL synergy over internal waves using SEAScope : 1 Hz vs. 20 Hz along track SSHA (+-30cm)



EUMETSAT esa

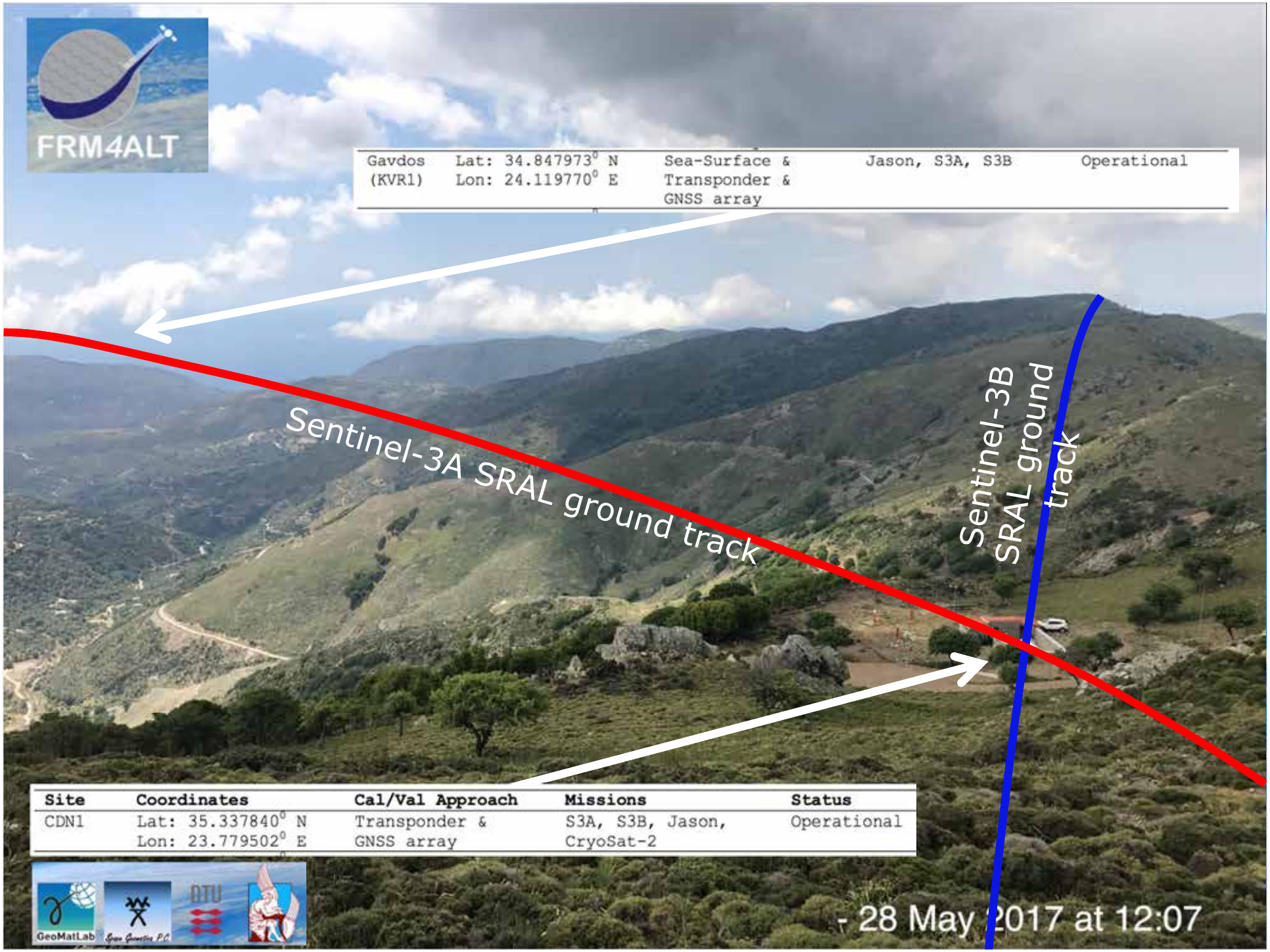
http://www.frm4alt.eu

fi·du·cial *(adj)* *Regarded or employed as a standard of reference, as in surveying.*

[Late Latin fdcilis, from Latin fdcia, *trust*, from fdere, *to trust*; seebheidh- in Indo-European roots.]

Establish and demonstrate SI traceability of Fiducial Reference Measurements (FRM) and their use for satellite derived altimeter calibration and validation.

Copernicus Europe's eyes on Earth

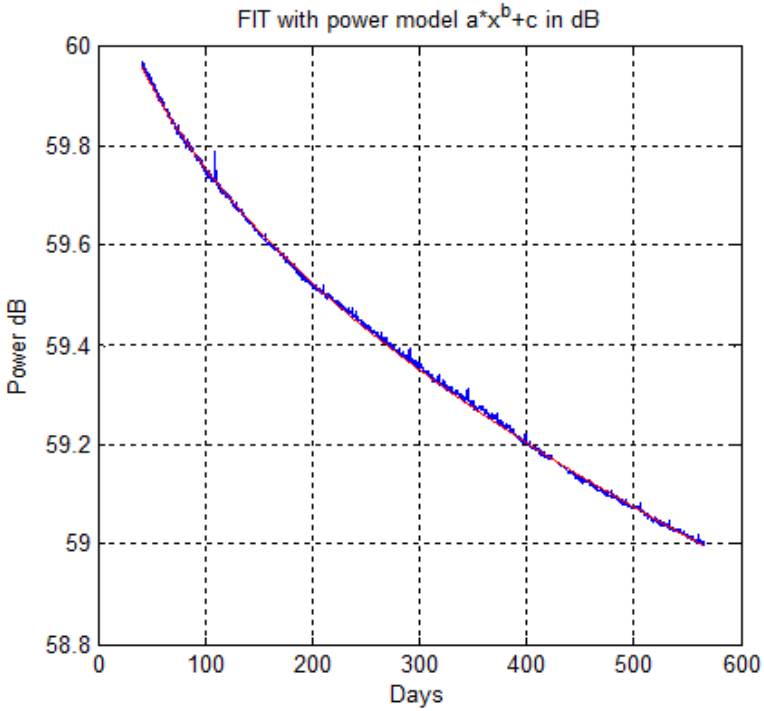

FRM4ALT
Gavdos (KVR1) Lat: 34.847973° N Lon: 24.119770° E Sea-Surface & Transponder & GNSS array Jason, S3A, S3B Operational
Sentinel-3A SRAL ground track
Sentinel-3B SRAL ground track
Site Coordinates Cal/Val Approach Missions Status
CDN1 Lat: 35.337840° N Lon: 23.779502° E Transponder & GNSS array S3A, S3B, Jason, CryoSat-2 Operational
GeoMatLab
DTU
- 28 May 2017 at 12:07

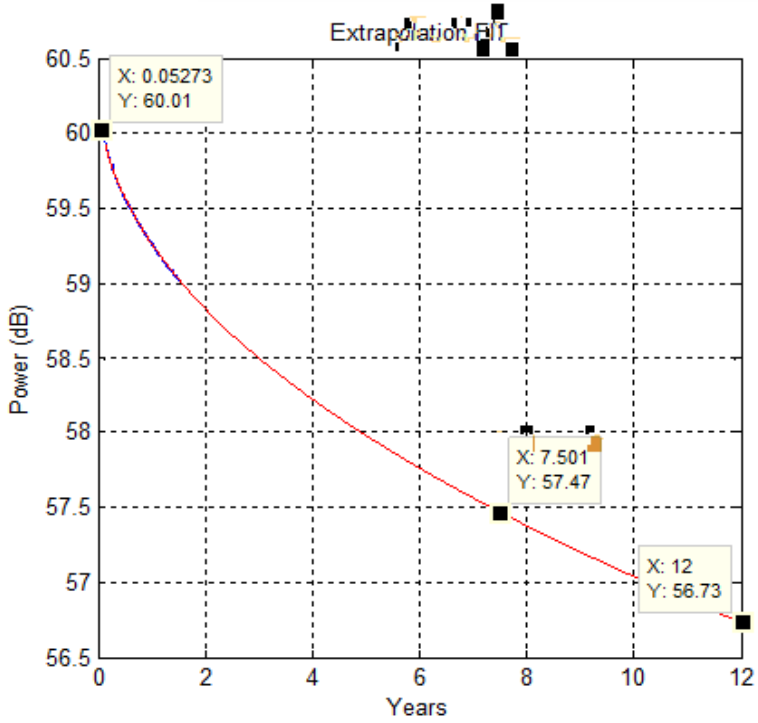
Transponder and sea-surface Cal/Val in Crete

See **Thu, Oct 26 2017, 14:00 - 18:00 - Concerto Ballroom**

- **CVL_001 -** Fiducial Reference Measurements for Satellite Altimetry Calibration
- **CVL_002 -** Multi-mission Calibrations results at the Permanent Facility for Altimetry Calibration in west Crete, Greece attaining Fiducial Reference Measurement Standards
- **CVL_003 -** Sentinel-3 Transponder Calibration Results

SRAL Ku PTR Total power evolution



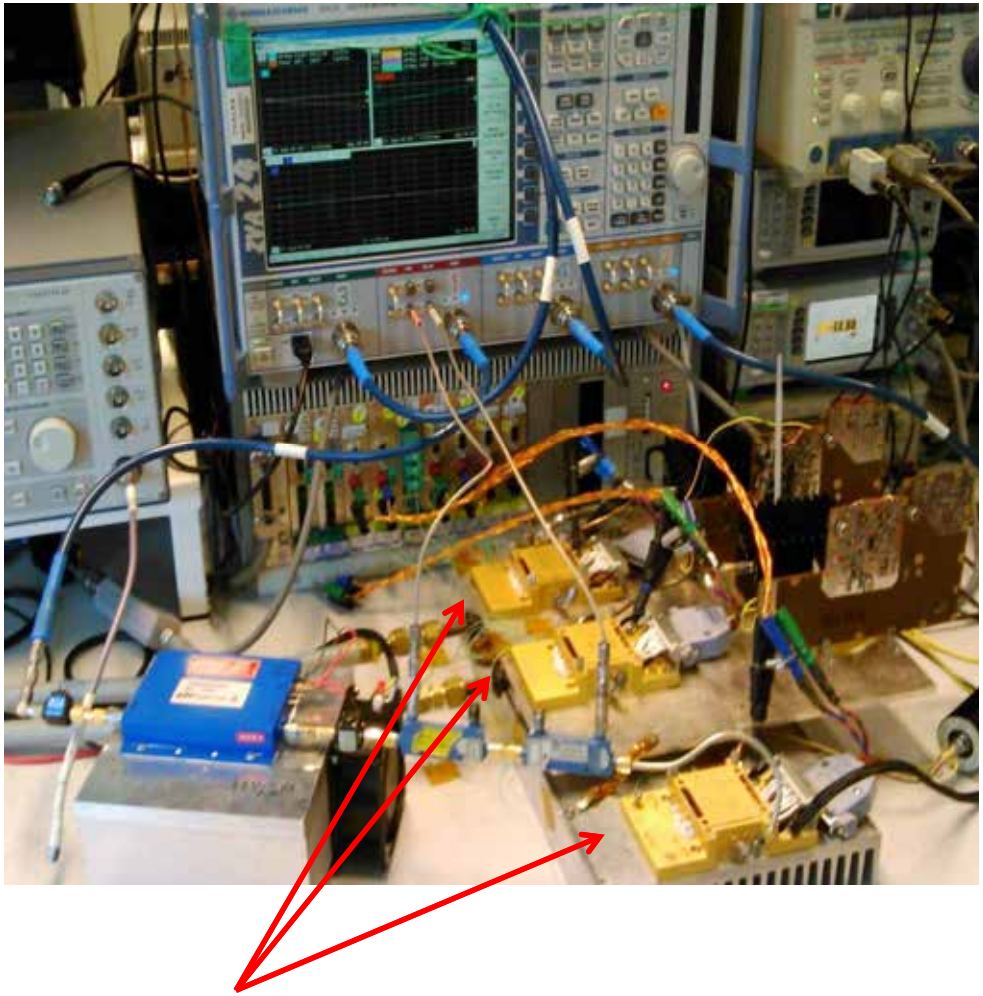


Further analysis of all available flight data (CNES/CLS)

- Ku PTR total power **continues to fall following switch on of SAR mode**
- The coefficients of the degradation model fit continue to evolve slightly.
  - The EOL prediction for S3A SRAL is now 2.53 dB loss
- **But this less than 3.2 dB extended life (12 year) requirement – so the instrument remains compliant with specification.**
- **OK… But what is going on?**

SRAL Ku PTR Total power evolution

- Investigations on the **High Power Amplifier** (HPA) die.
- HPA die are common to many Altimeter designs in flight and those now in preparation.
- Accelerated tests of the HPA die on the bench to try and reproduce the effect seen on SRAL 3A
- **Good progress with initial results suggesting a potential link to high-PRF SAR mode pulsed signals (TBC).**
- Investigation on-going.



HPA die under test (F. Vanin, ESTEC)

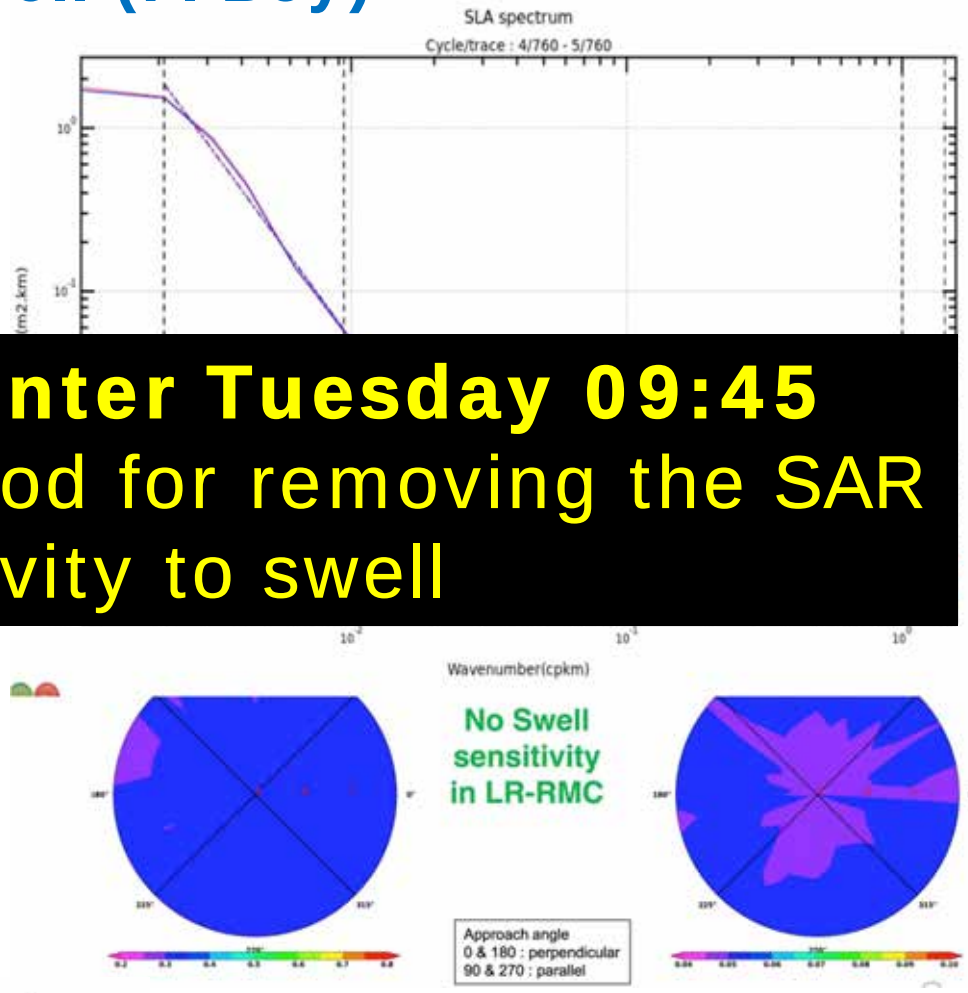
New stacking method for removing the SAR sensitivity to swell (F. Boy)

Alternative stacking process in SAR mode: ***Low Resolution** with **Range Migration Correction (LR-RMC)***

LR-RMC offers a high level of performances over open ocean:

S
s
potentially a good signal though…)

Inst. Proc. Splinter Tuesday 09:45
New stacking method for removing the SAR sensitivity to swell

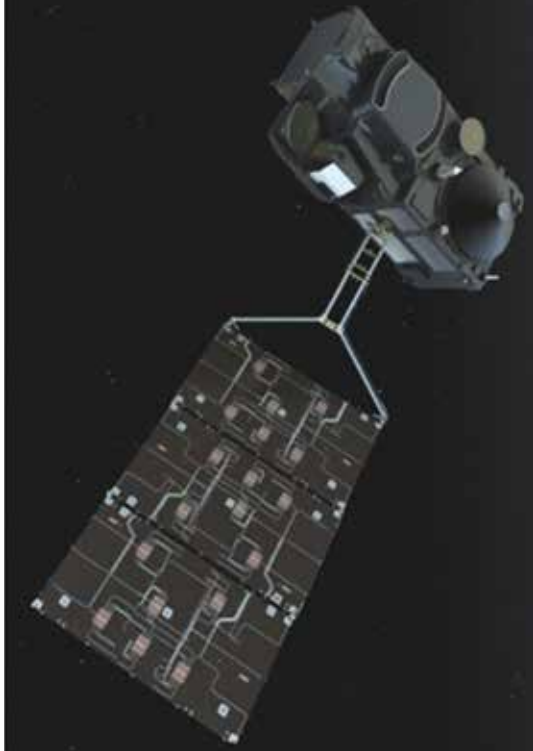


Global analysis:

- SAR spectrum is largely impacted by swell between [scales < 50km]
- LR-RMC spectrum is cleaner despite a very low filtering effect at 20km (antenna footprint)

Sentinel-3 is a multi-Satellite mission

Sentinel-3A: 2015-

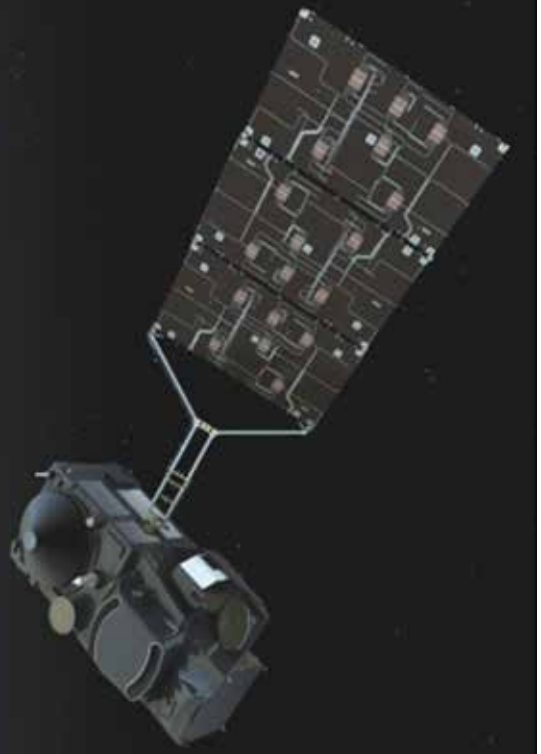


To meet Mission Requirements

The Sentinel-3 Mission is composed of two identical satellites

Flown together in the same orbital plane separated by 140°

Follow-on Satellites (Sentinel-3C and Sentinel-3D) are now being procured.



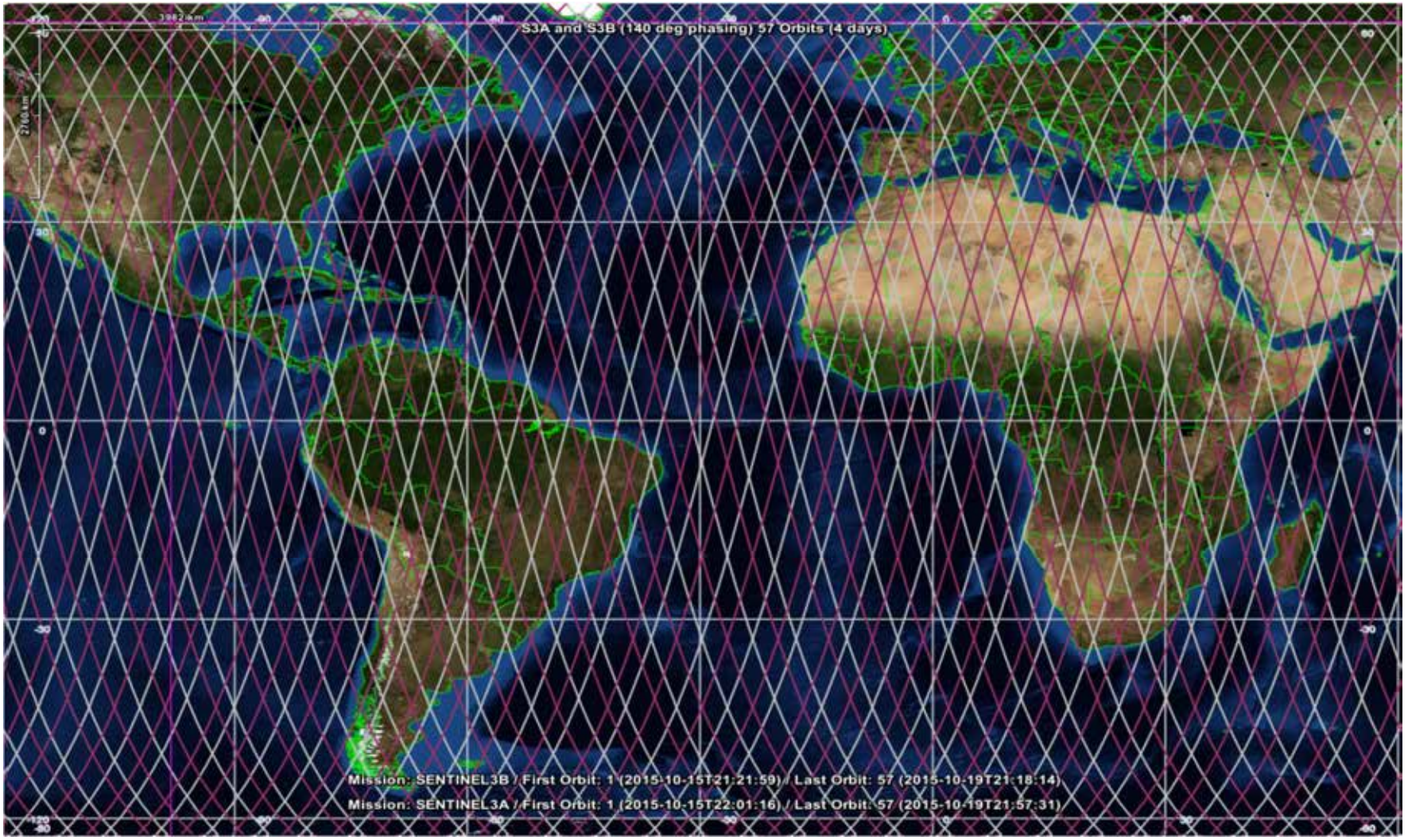
Sentinel-3B: 2018-


European Commission
esa
European Space Agency
Sentinel-3B is coming soon...

Sentinel-3B: status

- Satellite is now completing final Assembly, Integration and Testing.
- Flight Acceptance Review – starts 27th October 2017 to complete 12th December.
- Sentinel-3 is compatible for launch on either a Rockot (Plesetsk) or a Vega (Kourou).
- Actual launch provider is still in discussion - waiting for the final outcome.
- Launch expected early 2018.
- With two satellites on orbit, the mission will attain full operational capacity.

Optimizing the Constellation: Sentinel-3B phasing to 140° (instead of 180°) after 4 days



Sentinel-3 Tandem Rationale

conditions at all latitudes will give the statistical power to characterise relative calibration to the precision required.

- We can run S3A and S3B instruments in different modes
- We are interested in new science aspects of the Tandem phase.

Sentinel-3 Tandem Implementation

Launch S3B higher than S3A. The Launch of S-3B will already initiate the drift to arrive close to S-3A.

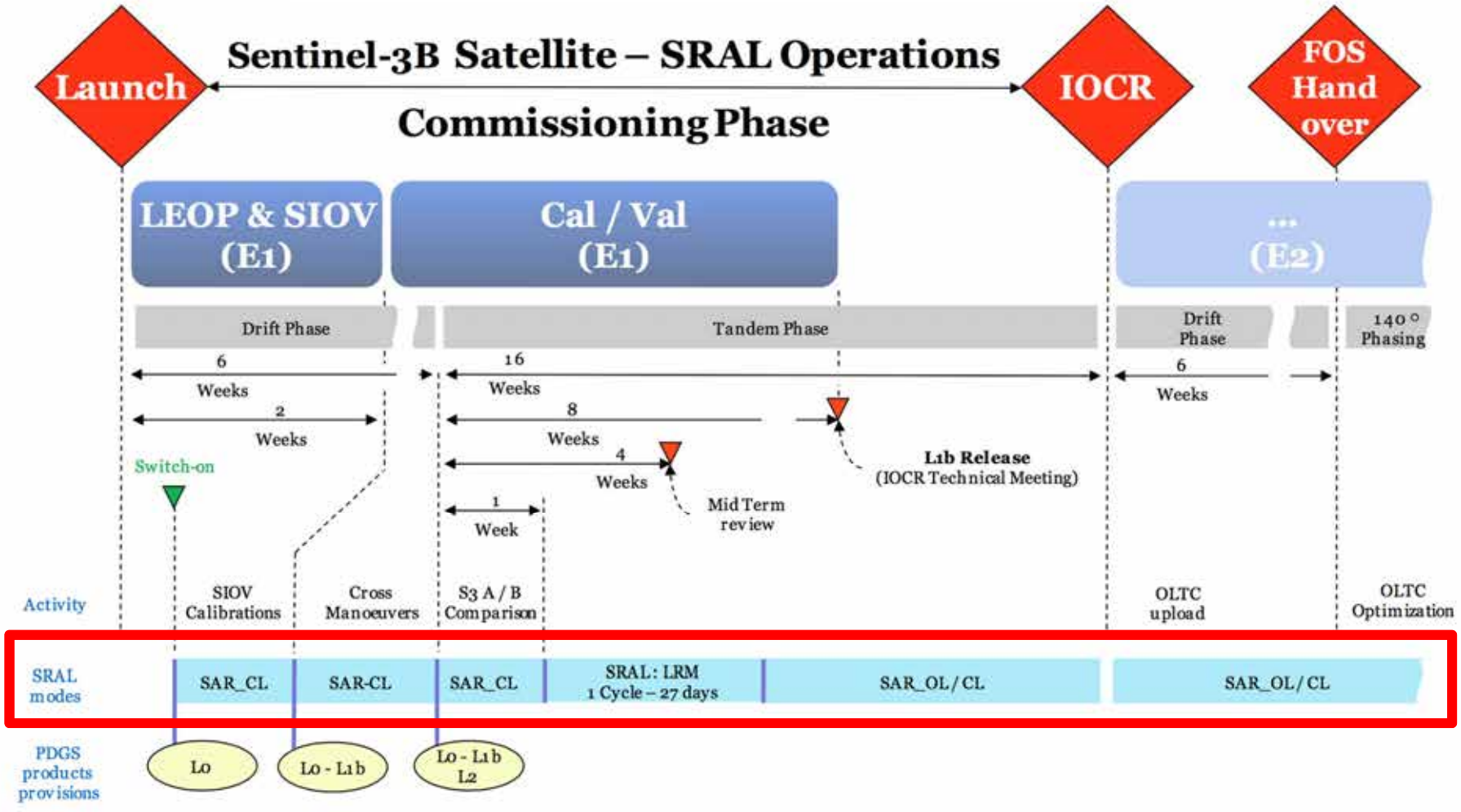
Drift phase1: S-3B to reach S-3A, over 1.5 months. While still in sufficient safety distance from the S-3A position, SIOV/LEOP and commissioning of S-3B command and control can be performed. S-3B data commissioning can start.

Tandem Phase: Once S3-B command and control commissioning is confirmed to be OK, the approach to the actual tandem position will be initiated. A Tandem phase of 4-5 months then follows:

- S-3A maintains normal operations.
- S-3B follows S-3A with a time distance of 30 seconds (separation in position of 210 km)
- S-3B continues commissioning activities

Drift phase2: S-3B to move away from S-3A and arrive at its baseline position at +/- 140 deg to S-3A. Typical duration of this phase ~1.5 months.

Tandem Phase Overview and S3B SRAL commanding

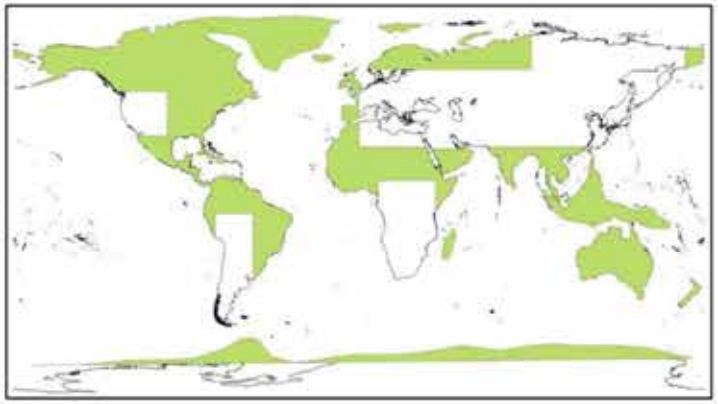


Tandem: SRAL Open/Closed Loop

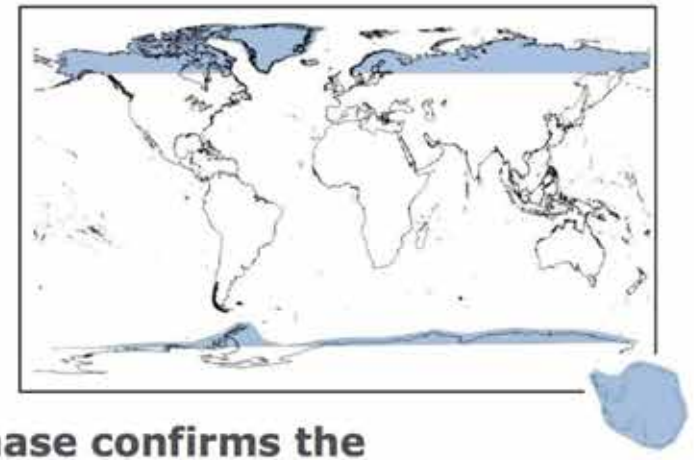
SRAL – S-3B vs. S-3A commanding scheme

- **On S-3A, the OL commanding has improved the measurement return for the surfaces for which the OLTC was correctly defined**
- **Ice margins are meanwhile commanded in SAR-CL**
- **For S-3B, the OLTC coverage has been increased to include all Land area up to +/- 60 deg latitude**

S-3A
white: SAR OL
green: SAR CL



S-3B
white: SAR OL
blue: SAR CL



➔ **If the comparison with S-3A during the tandem phase confirms the improvement of the increased OLTC coverage, it will be recommended to keep it on S-3B and implement it on S-3A**

S-3 S3VT-ALT


S3VT
SENTINEL-3 VALIDATION
TEAM MEETING
12-16 March 2018
Darmstadt, Germany
opernicus
esa
EUMETSAT

Review on International Altimetry Cal/Val Activities and Applications

Venue
Center of Mediterranean Architecture, Chania, Crete, Greece

23-26 April 2018,
Chania, Crete, Greece

GeoMatLab

FRM4ALT

Summary

- **Copernicus is being fully implemented – and expanding**
- **Sentinel-3A now in Routine Operations**
  - **Satellite and payload is fully commissioned**
  - **All ground segment facilities supporting Sentinel-3** at ESA and EUMETSAT are in full operations.
  - SRAL Ku PTR total power decay predicted to remain within specification – on-going investigation underway to establish root cause.
  - New approaches to data processing (e.g. LR-RMC) being developed
  - Validation activities are well advanced and dedicated projects are in place to develop a culture of FRM validation
  - New L1A products available with Open Source tools to read and work with data
- **Sentinel-3B Satellite Flight Acceptance Review in progress**
- **Orbit changes approved for 140Deg phasing of S3A and S3B**
- **Tandem phase in E-1 approved and baselined**
- **Sentinel-3C and -3D Satellites are being built now!**
- **International altimeter Cal/Val Review Chania, Crete 26-23rd April 2018**

- **It's a fantastically busy time! Couldn't be better!**


Thank You –
any Questions
Contact: Craig.Donlon@esa.int