Copernicus Sentinel-1 Mission Status

Nuno Miranda, Pierre Potin

European Space Agency (ESA)

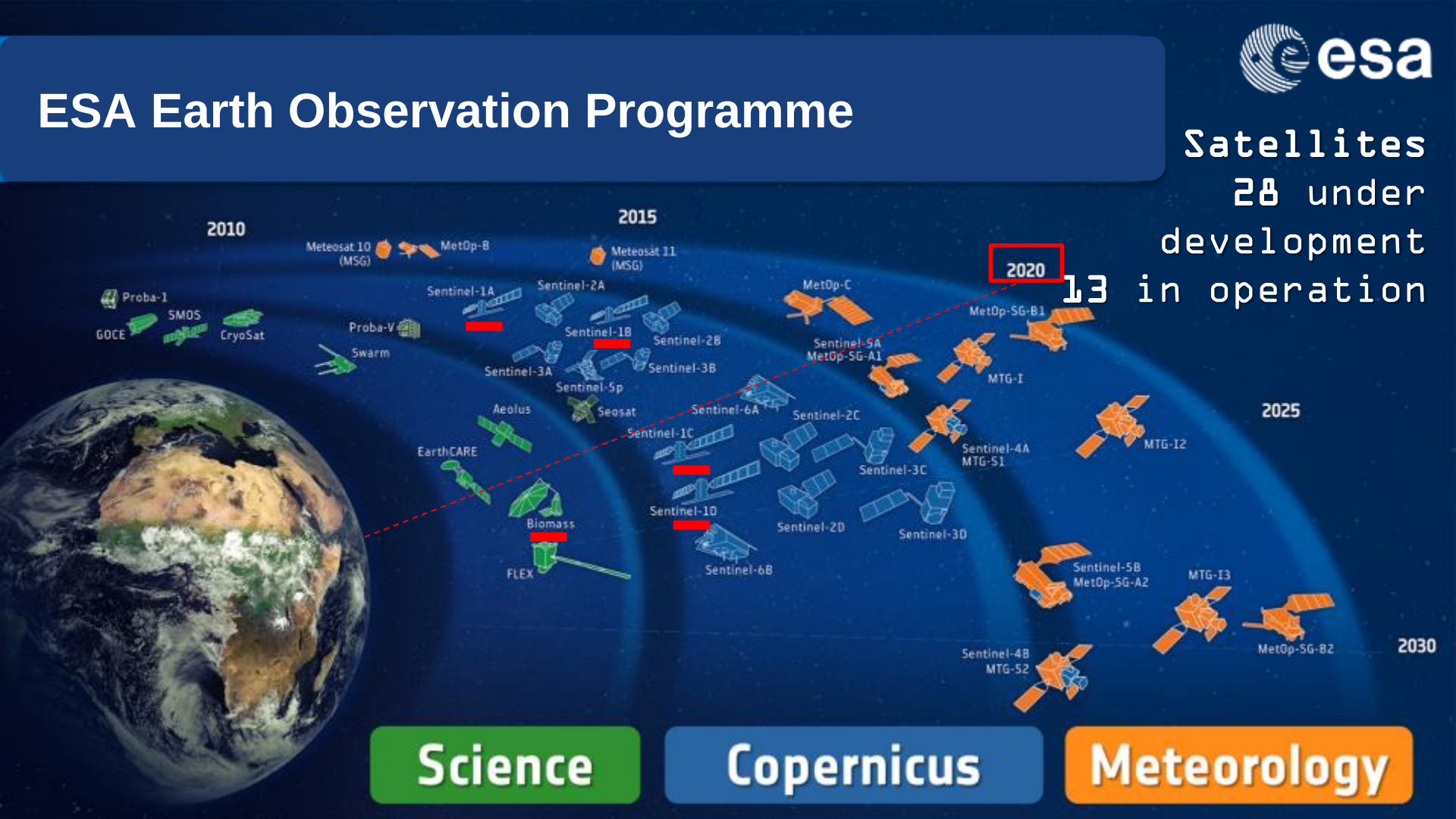
CEOS SAR WGCV / VH-RODA workshop

S-1 Mission Performance Center:

- G. Hajduch, R. Husson, P. Vincent, CLS (FR)
- P. Meadows, A. Pilgrim, BAE Systems (UK)
- D. Giudici, R. Piantanida, Aresys (IT)
- D. Small, A. Schubert, UZH (CH)
- K. Schmidt (DLR)
- A. Mouche, Ifremer (FR)
- H. Johnsen, Norut (N)
- F. Collard, ODL (FR)

ESA UNCLASSIFIED - For Official Use

ESA Earth Observation Programme



Copernicus – The Present

S-1

High Resolution Radar

- A — 3 Apr. 2014
- B — 25 Apr. 2016
- C — 2022 *
- D — > 2024 *

S-2

High Resolution Optical

- A — 23 Jun. 2015
- B — 6 Mar. 2017
- C — 2023
- D — > 2025

S-3

Medium Resolution Optical & Altimetry

- A — 16 Feb. 2016
- B — 25 Apr. 2018
- C — 2023
- D — > 2025

S-4

Atmospheric Chemistry (GEO)

- A — 2021
- B — 2027

S-5P

Atmospheric Chemistry (LEO)

- 13 Oct. 2017

S-5

Atmospheric Chemistry (LEO)

- A — 2021
- B — 2027
- C — > 2027

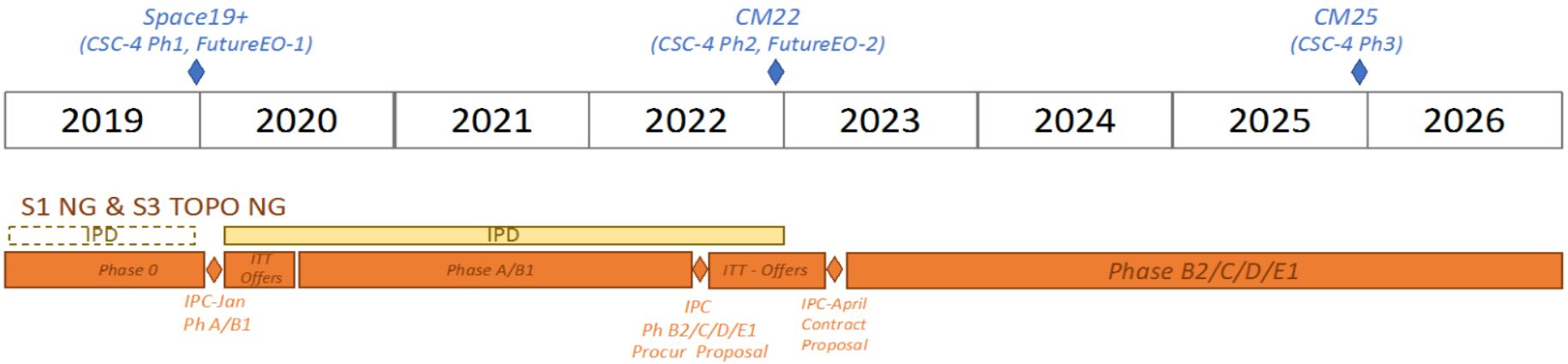
S-6

Altimetry

- A — 2020
- B — 2025

*** Sentinel-1C/D Instrument: Improvements on internal calibration and preliminary verification results**
Francisco Ceba Vega (ESA), Wednesday morning

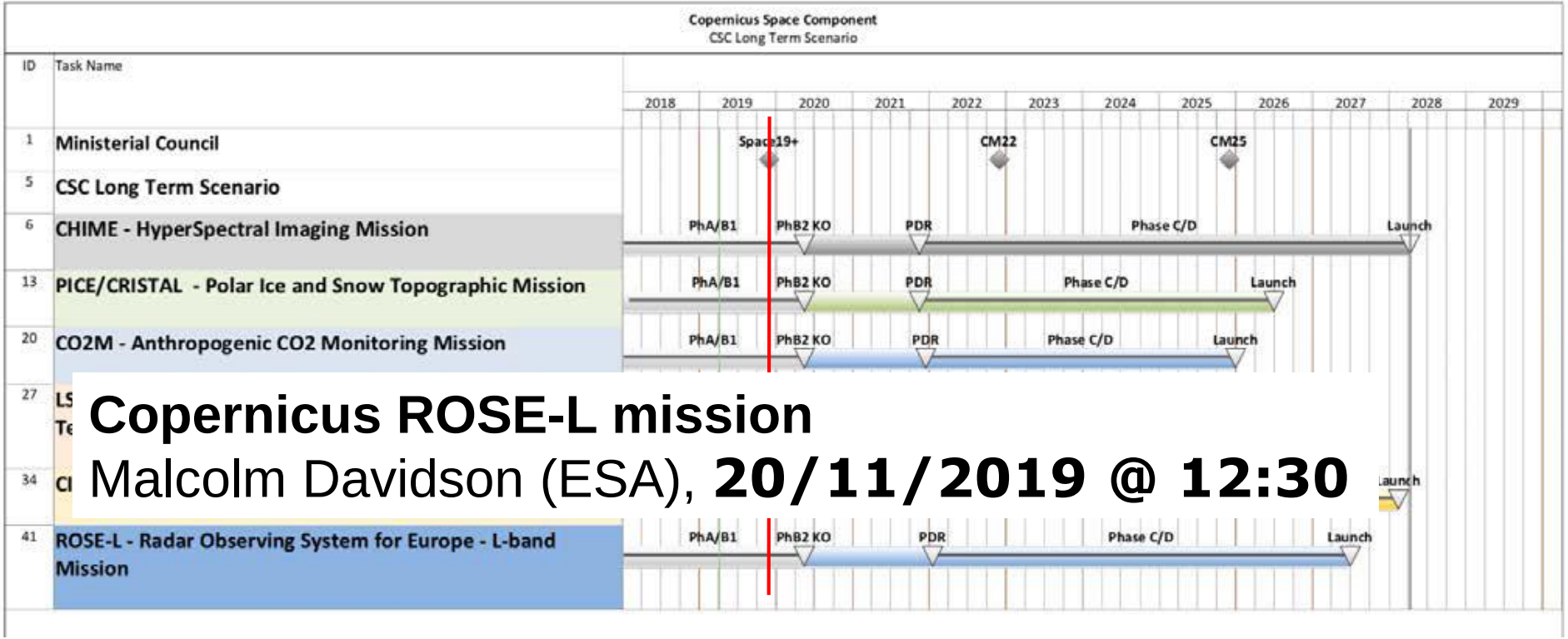
Copernicus – The Next Generation Sentinels



SAR Pointing Calibration for Ocean Surface Radial Velocity Estimation: Challenges and Alternatives, Dirk Geudtner et al, Calibration of Future Missions #1**, 20/11/2019 @ 11:10**

European Space Agency

Copernicus – High Priority Candidate Missions



Copernicus ROSE-L mission

Malcolm Davidson (ESA), **20/11/2019 @ 12:30**

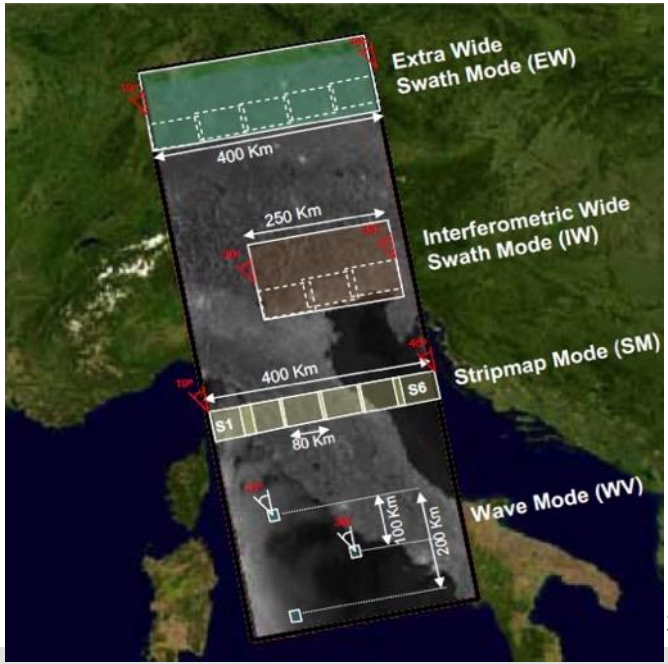
Ref: ESA/PB-EO(2019)10, rev.1 - Long Term Scenario

European Space Agency

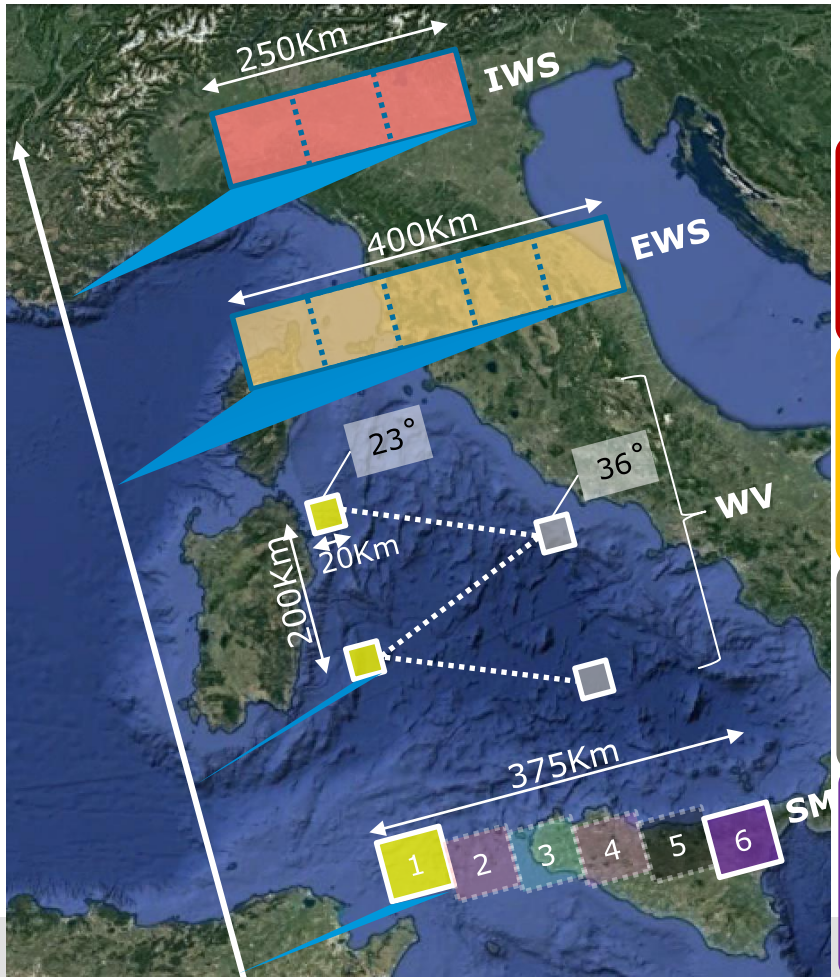
Sentinel-1A/B System Baseline

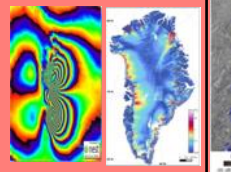
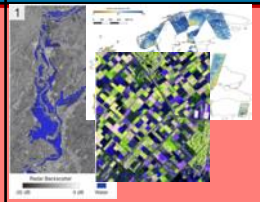
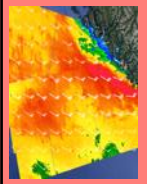
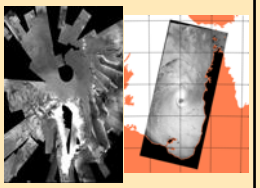
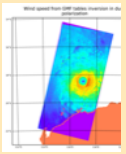
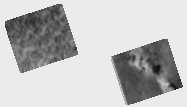
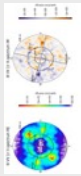
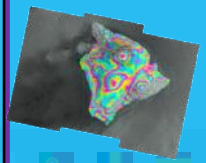
- Constellation of two satellites (A&B) launched on 3-Apr-14 and 25-Apr-16
- C-Band SAR Payload at 5.405 GHz
- Near-Polar, sun-synchronous (dawn-dusk) orbit at 698 km
- 6 days repeat cycle for the constellation
- Four Dual-Pol SAR Modes of Operation
- Data downlink of 520 Mbps (2x260) in X-Band with 3 Ground Stations (Svalbard, Matera, Maspalomas)
- and via Laser (EDRS)

- Rad. Stability better than 0.6dB (3σ)
- Rad. Accuracy better than 1.0dB (3σ)
- NESZ better than -22dB



Sentinel-1 core products



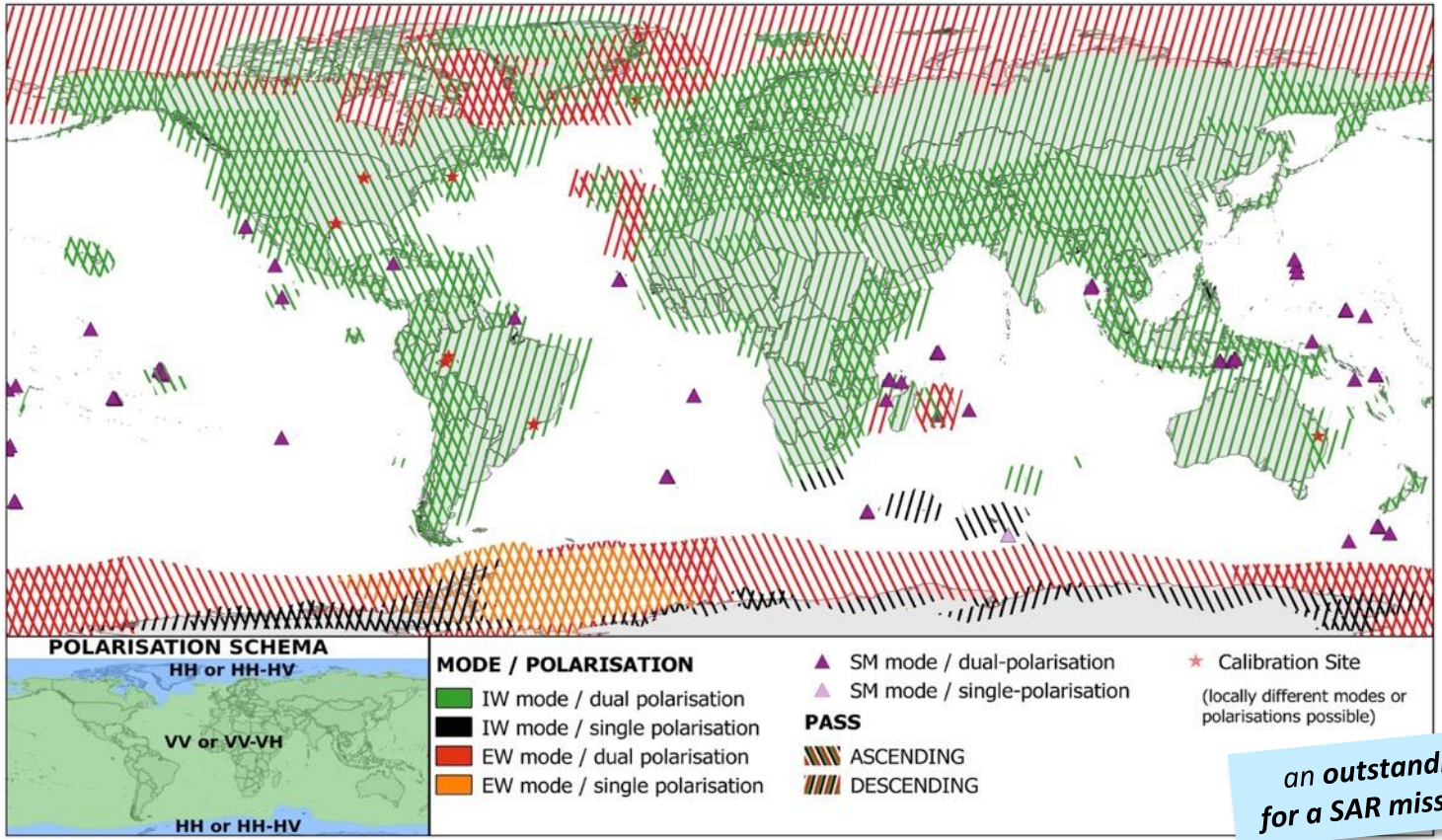
	L1 SLC	L1 GRD	L2 OCN Wind	L2 OCN Swell	L2 OCN Vel
IW				N/A	Not qualified...YET
EW	Not generated			N/A	
WV		Not generated	Cal/val		
SM			Mainly Cal/val		

Sentinel-1 Constellation Observation Scenario: Mode - Polarisation - Observation Geometry

sentinel-1

validity start: 05/2019

esa



Updated Baseline Map , starting May 2019

This map is related to SAR High Rate modes only. Wave mode operated by default over open oceans (not shown)

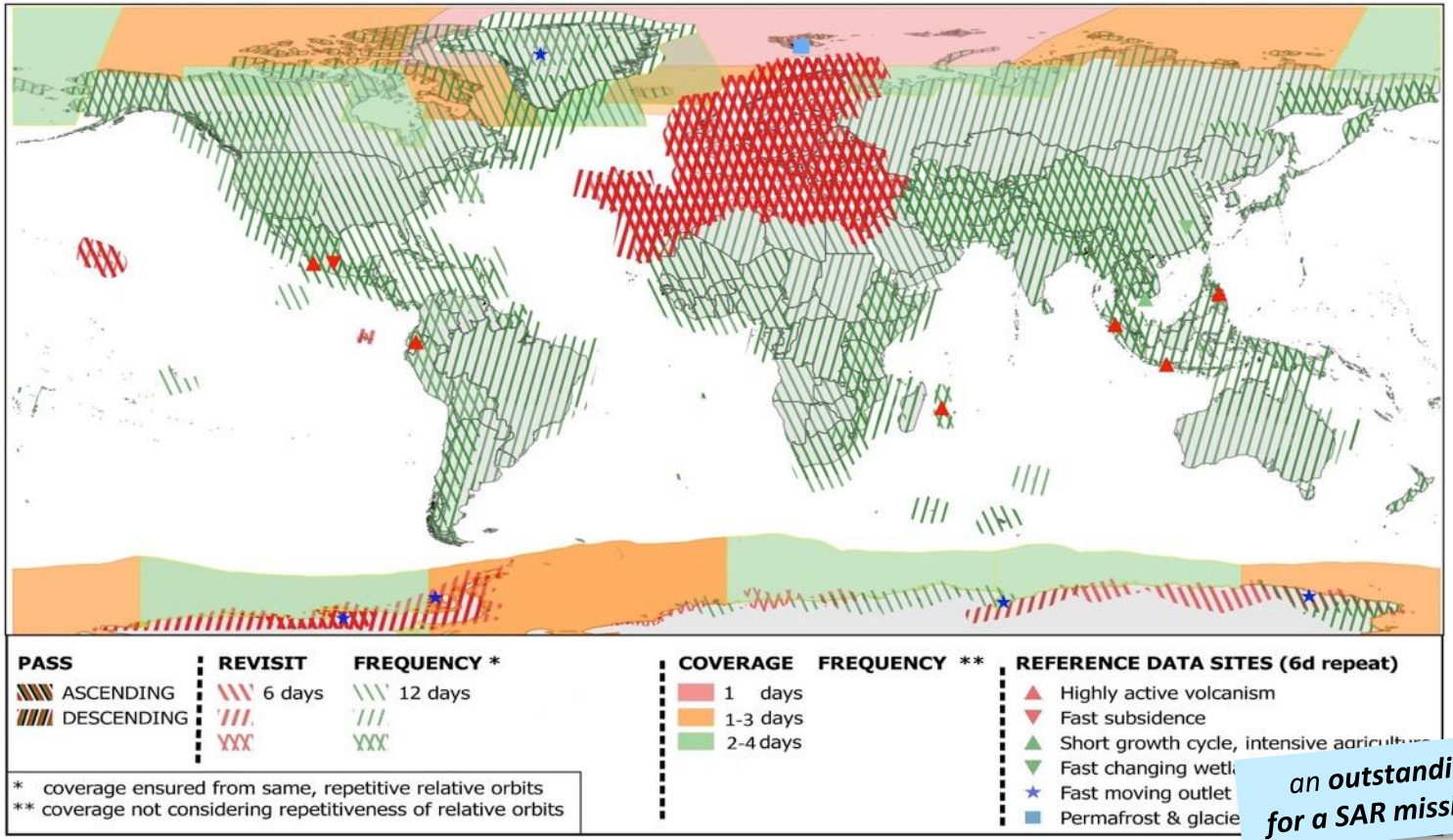
*an **outstanding coverage achievement** **for a SAR mission,** predictable and reliable!*

Sentinel-1 Constellation Observation Scenario: Revisit & Coverage Frequency

sentinel-1

validity start: 05/2019

esa



Updated Baseline Map , starting May 2019

This map is related to SAR High Rate modes only. Wave mode operated by default over open oceans (not shown)

*an **outstanding coverage achievement** **for a SAR mission,** predictable and reliable!*

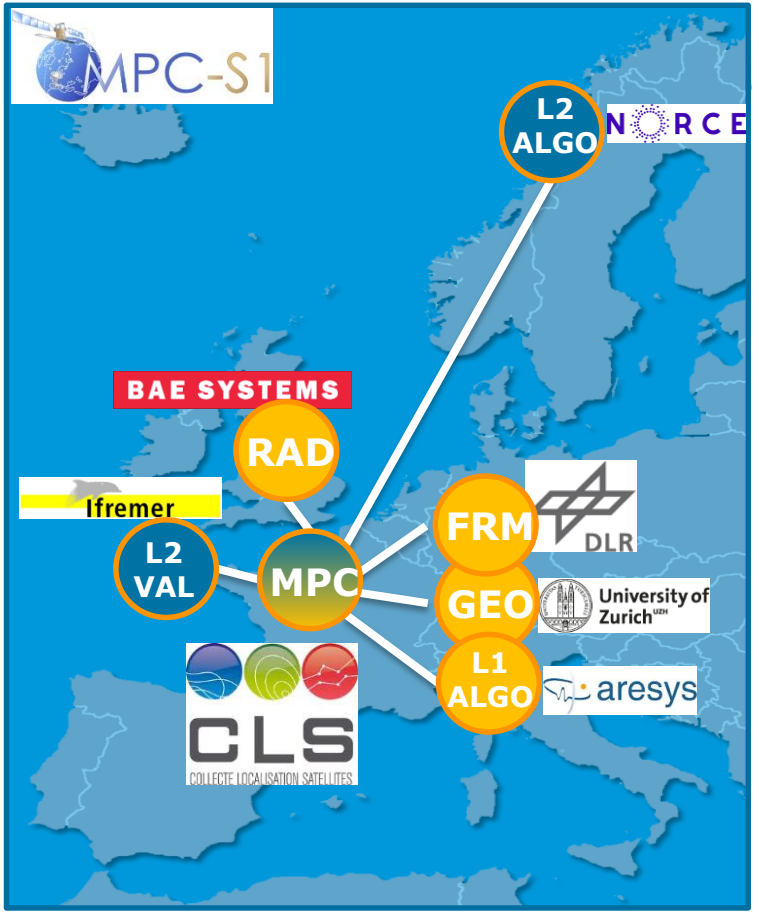
Cal/Val organization during Phase E2

The cal/val and algo development activites are procured through a dedicated service contract – Mission Performance Center – taking over after Phase E1.

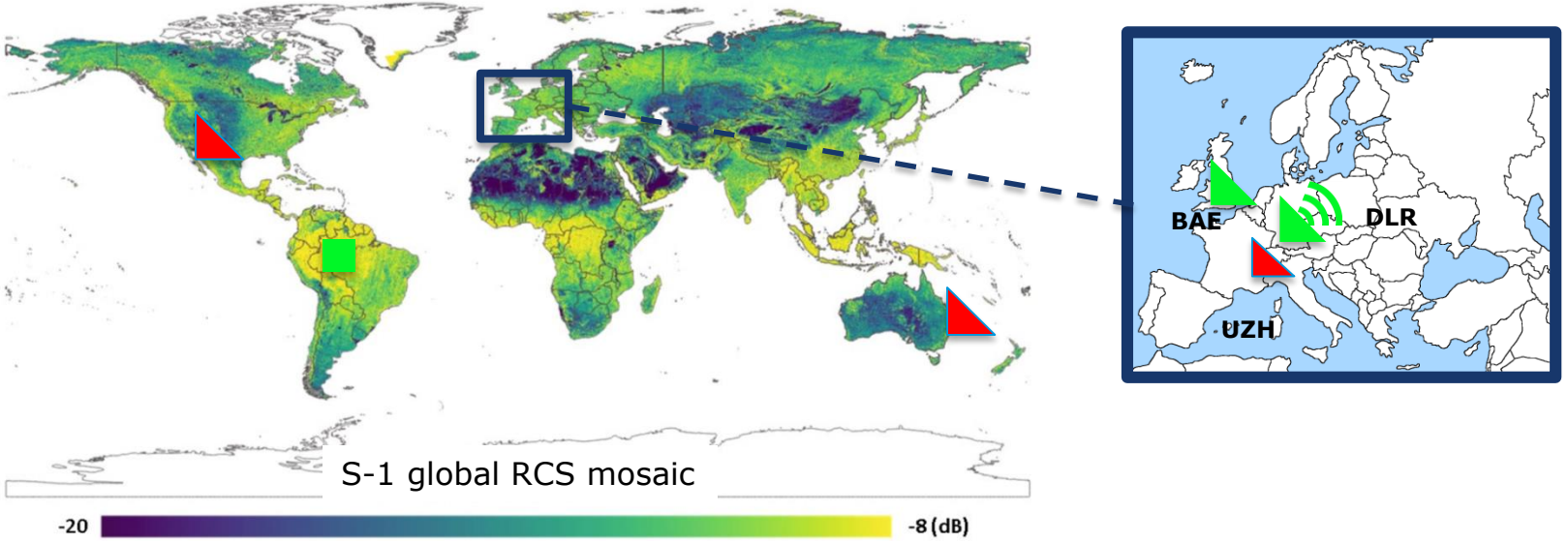
The scope of the MPC is to maintain and improve the product performance and calibration during the phase E2

S-1 MPC is composed by pan European value adding companies and, institutions providing expertise in SAR and S-1 in particular:

- **CLS brest (F)**: Prime, L2 algo
- **BAE Systems (UK)**: Radiometric Cal.
- **UZH (CH)**: Geometric Cal.
- **Aresys (IT)** : L1 algo & Instrument
- **Norut (N)**: L2 algo
- **Ifremer (F)**: L2 Validation
- **DLR (G)** : FRM and L1 calibration



S-1 calibration sites



- Several calibration sites are used for radiometric, polarimetric and geometric calibration:
  - DLR calibration sites (transponders and Corners)
  - BAE CR radiometric calibration
  - UZH, JPL & GA CR for geometric calibration
  - Amazonian Rain-Forest for the verification of the range dependent corrections

Spoiling some results…

Sentinel-1 A/B @ CEOS WGCV

Sentinel-1 Radiometric and Geometric Calibration — Tuesday

Peter Meadows (BAE Systems Applied Intelligence)

Mutual interferences between C-Band SAR: Prediction of occurrences identification of sources

Hajduch Guillaume (CLS)

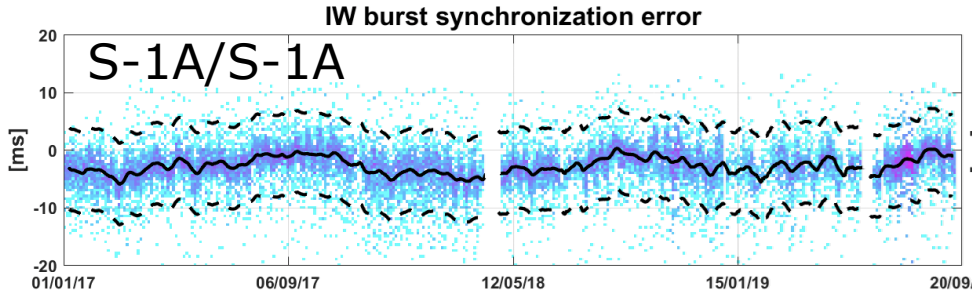
Cross-Sensor Calibration of Sentinel-1 Noise Level

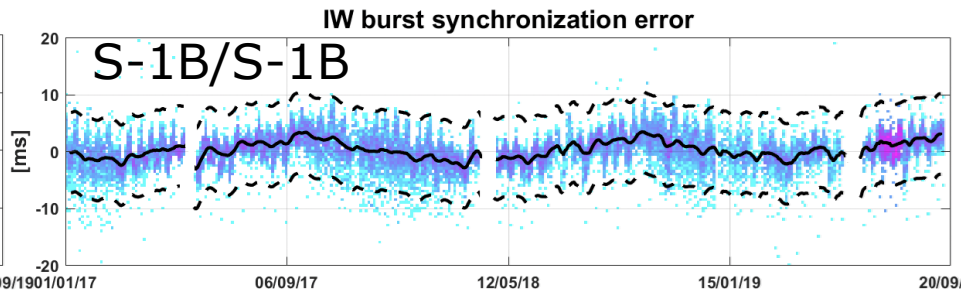
Niccoló Franceschi (Aresys)

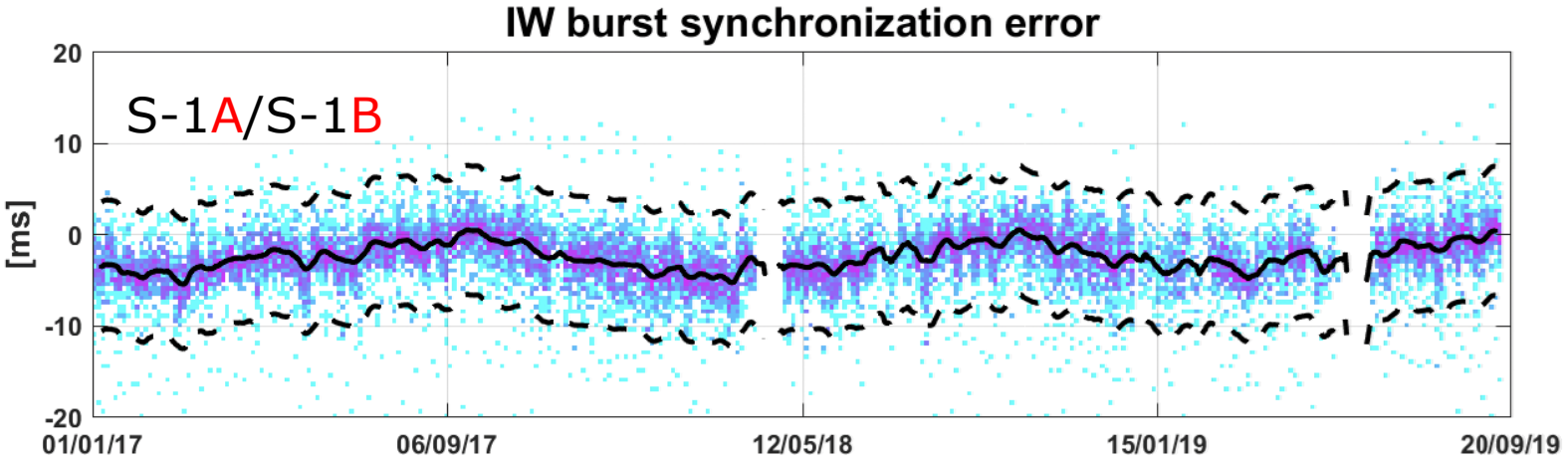
Towards Operational SAR Imaging Geodesy: An Extended Time Annotation Dataset for Sentinel-1 Image Products — Thursday

Christoph Gisinger (DLR)

IW burst synchronisation



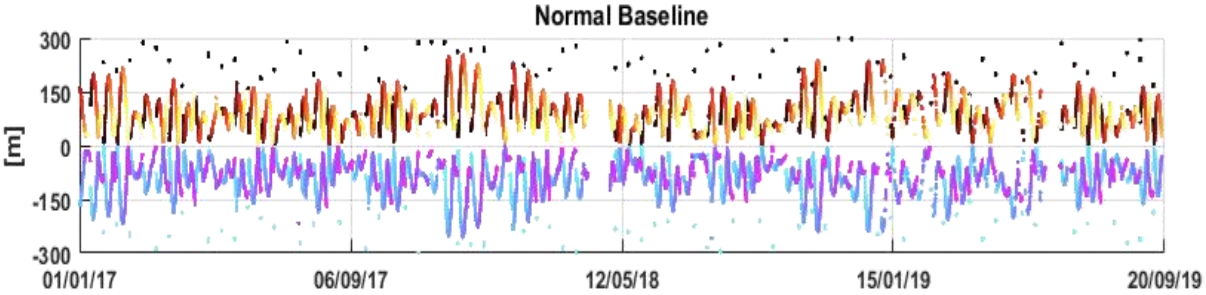




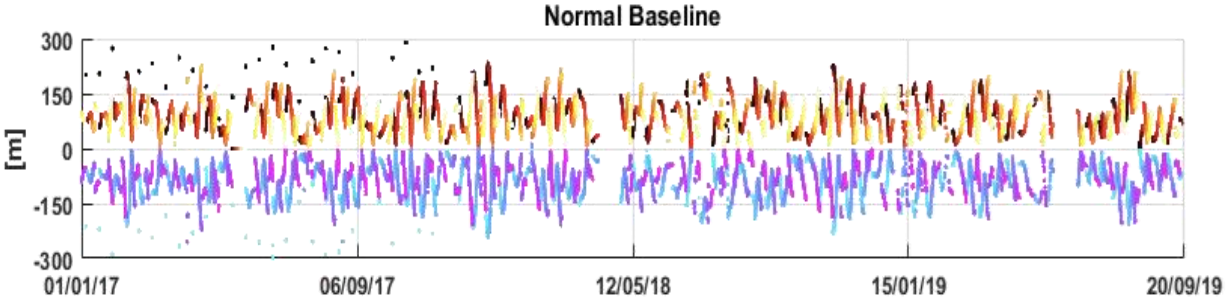
Interferometric baseline

S-1 A and B are controlled in a stringent orbital tube of 200m

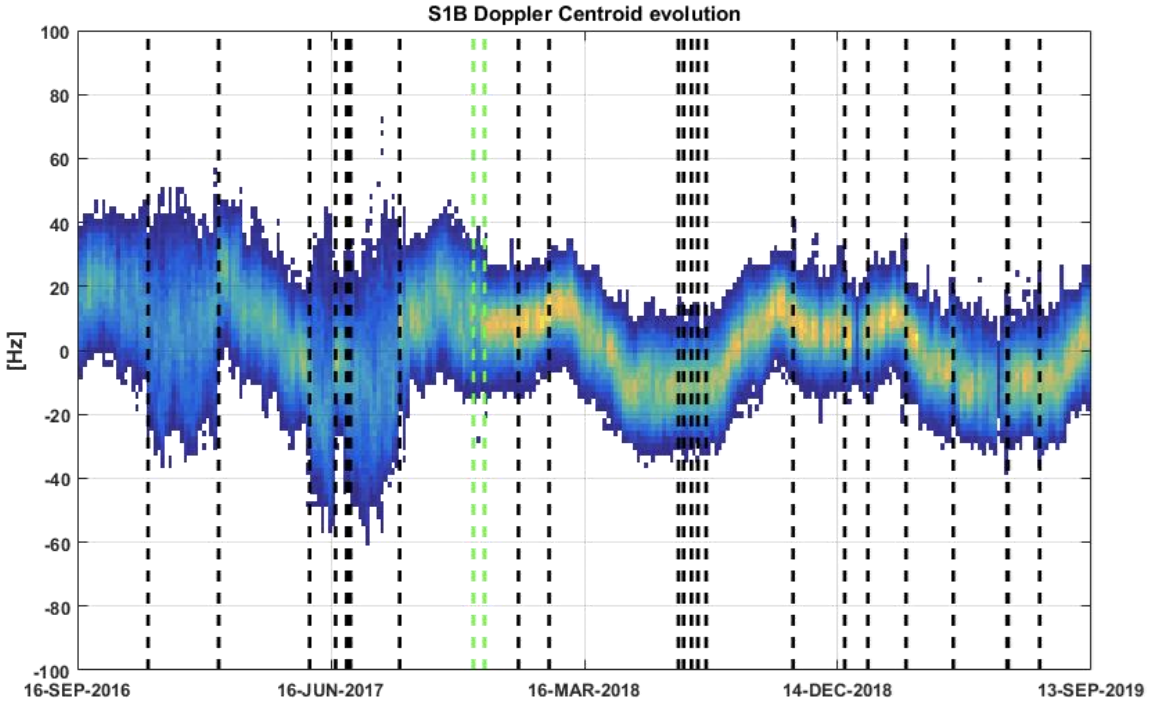
S-1A



S-1B

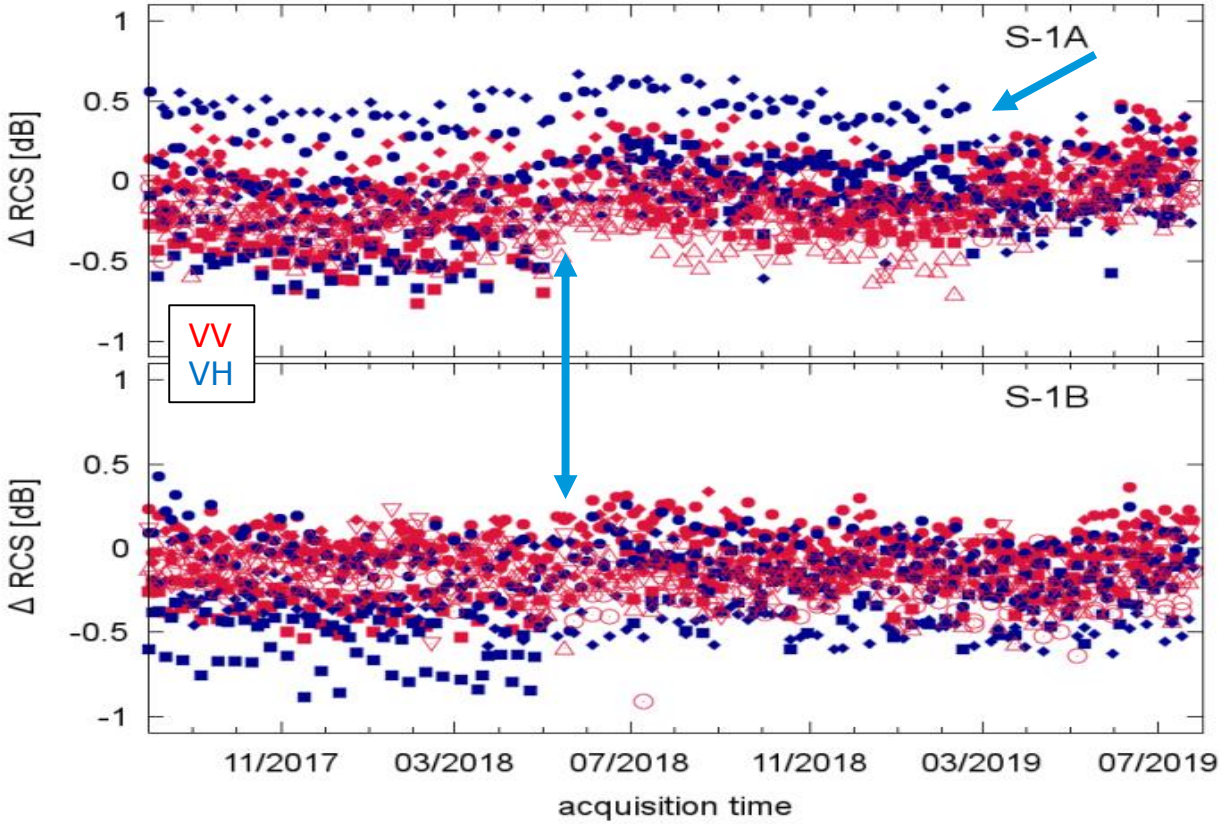


Sentinel-1 Total Zero Doppler Steering improvement



- Long AOCS optimisation campaign put in place to support the RVL retrieval
- As a result, the Doppler centroid frequency stability is below 10Hz!
- Unprecedented for a SAR mission

Radiometric accuracy

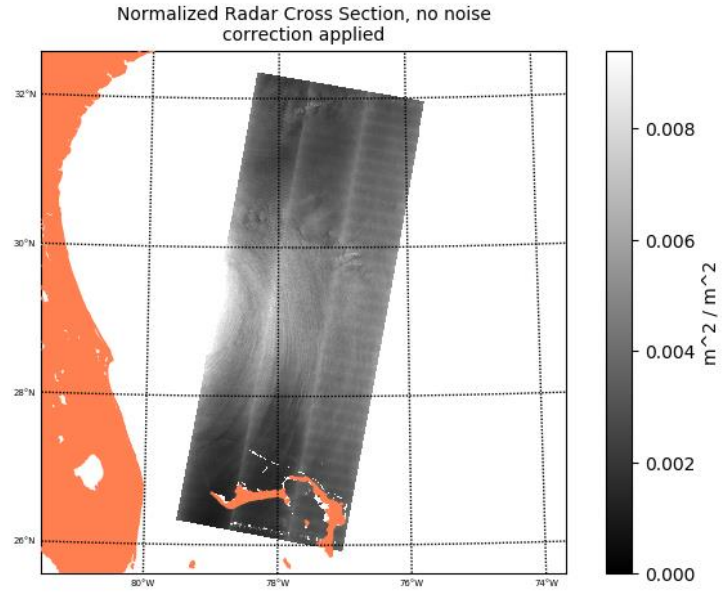


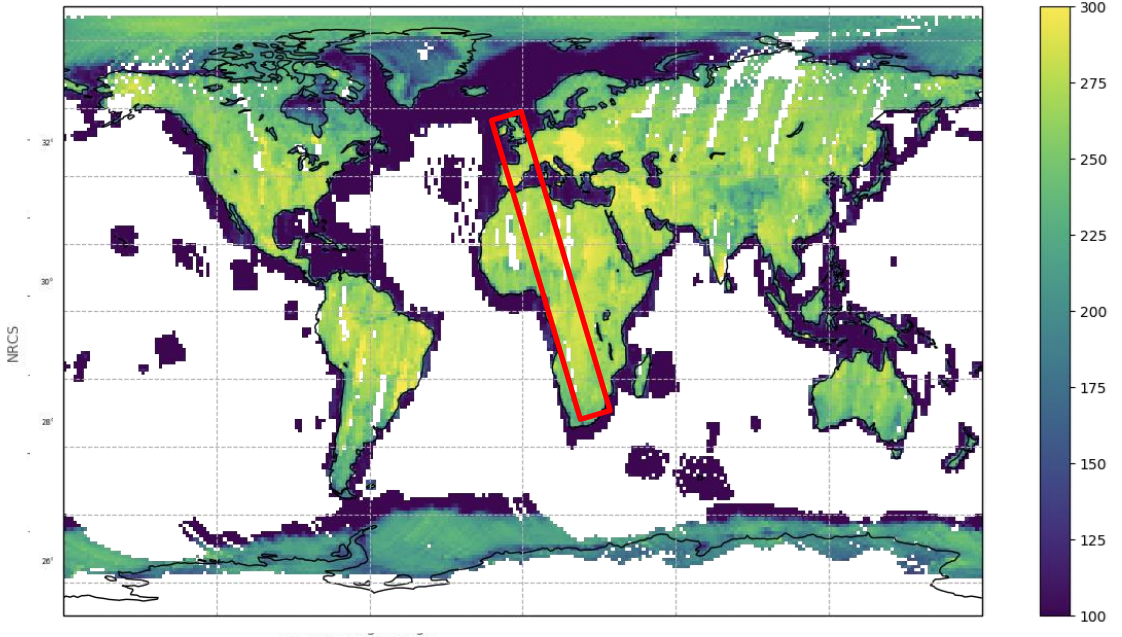
- Measurement over DLR target over the last two years
- Very stable RCS over time
- Changes related to transponder maintenance
- Improvement of EAP
- Seasonal fluctuations

	S-1A RCS [dB] (μ±σ)	S-1B RCS [dB] (μ±σ)
VV	-0.19 ± 0.21	-0.11 ± 0.17
VH	-0.03 ± 0.33	-0.24 ± 0.26

European Space Agency

Improve radiometric accurary under presence of noise

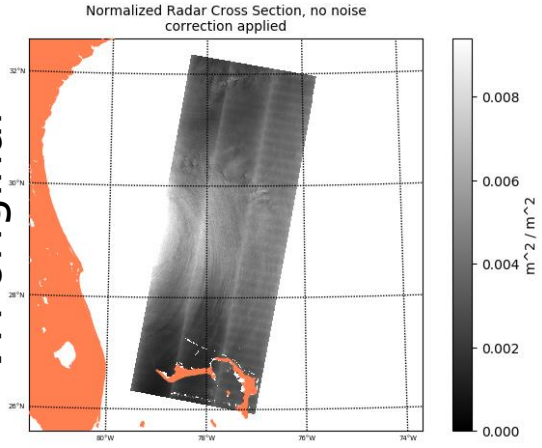




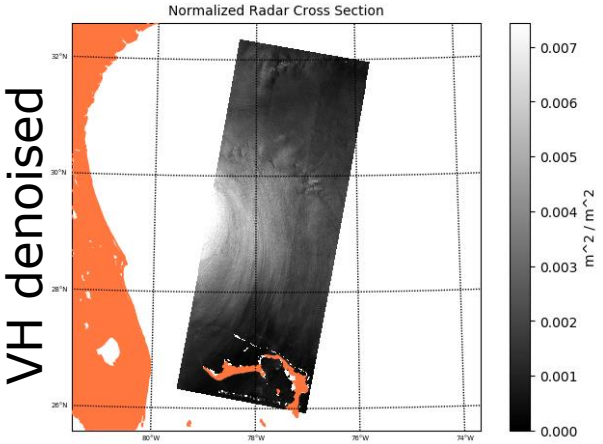
- Improving the sensor NESZ characterisation
- Reviewing the noise handling in the SAR processor
- Tracking the noise power evolution over the data-take

Improve radiometric accurary under presence of noise

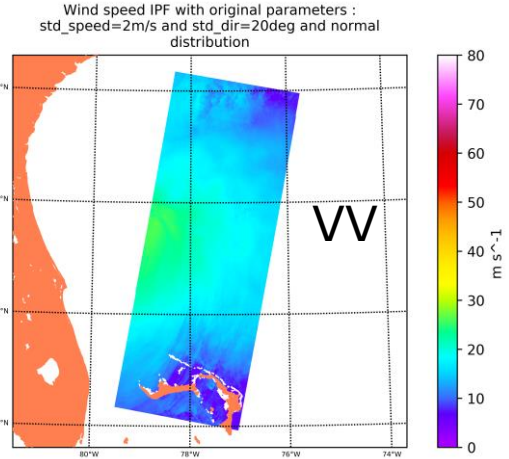
VH original

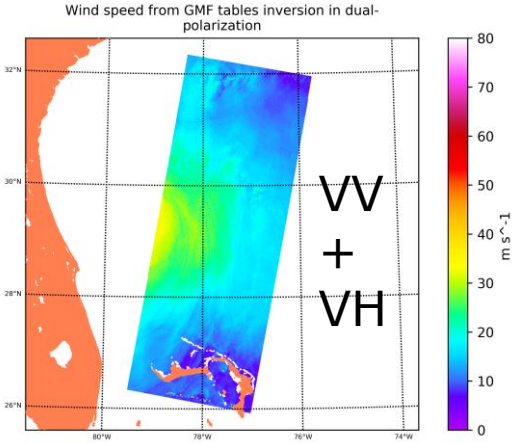


VH denoised



wind speed



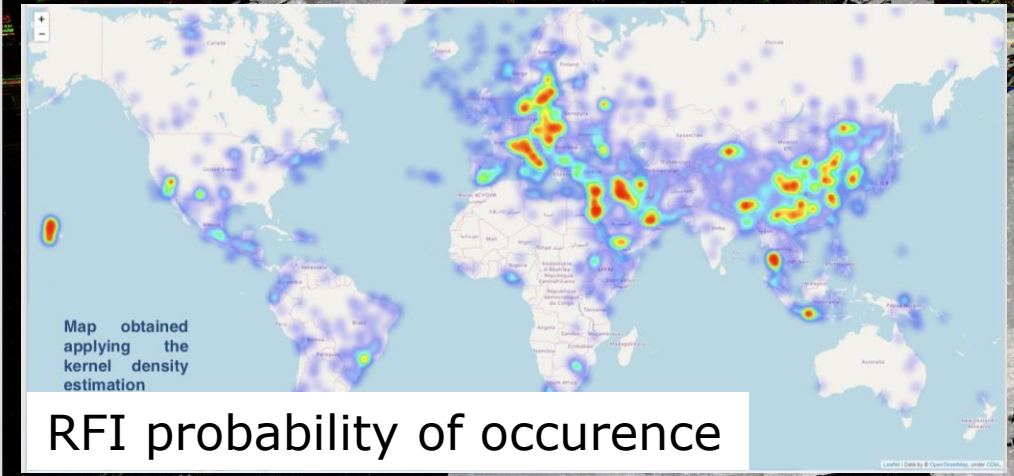


MPC-S1

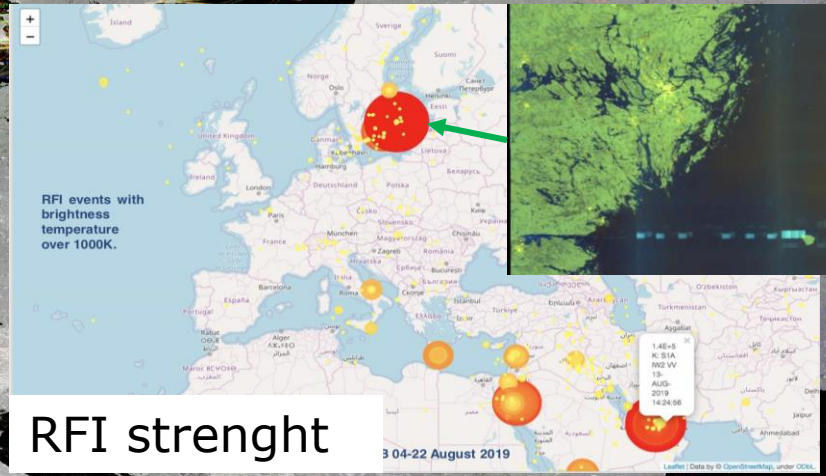
S-1 Mission Performance Centre

Denoising of images generated by the S-1 IPF

Interferences at C-band



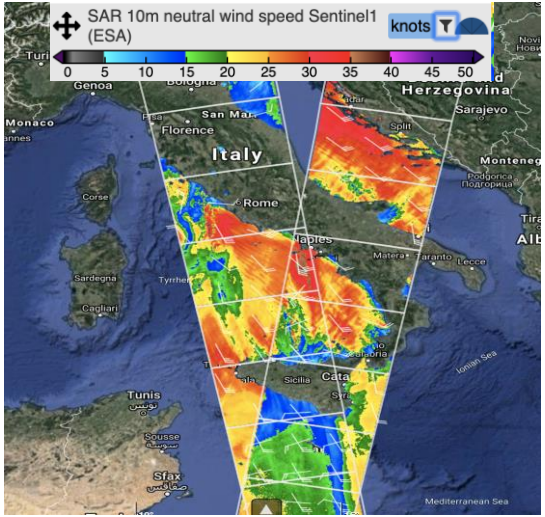
RFI probability of occurence

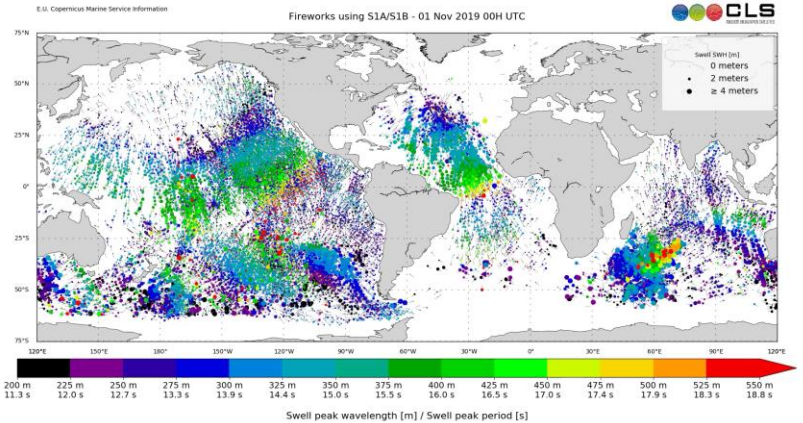


RFI strenght

- RFI has been reported as the major source of disturbance.
- Using noise power globally it is possible to estimate probability and strenght of occurence
- S-1 processor will be updated to mitigate RFIs

Also Level-2 products





- Sentinel-1 is the unique mission providing **validated** ocean geophysical variables for operational services (wind and swell)

- Wind product will be soon update to perform inversion using the cross-pol benefiting for all the efforts made on the noise removal

- Global swell information is assimilated since 2018 in operational weather forecast model.

Taking home messages

- Sentinel-1 A/B satellites are both in very good shape. Sentinel-1 A is approaching is the expected 7y lifetime with no performance degradation

- Senitnel-1 is a unique asset providing systematically global calibrated data over land masses and open oceans allowing to build up very dense time series

- The data quality is being constantly improved through as a result of constant effort in calibration, geophysical validation, algorithm evolutions or changes at spacecraft level

- The outstanding spacecraft, the systematic production, the quality of the data and the free and open data policy makes S-1 a game changer in all domains.