DLR

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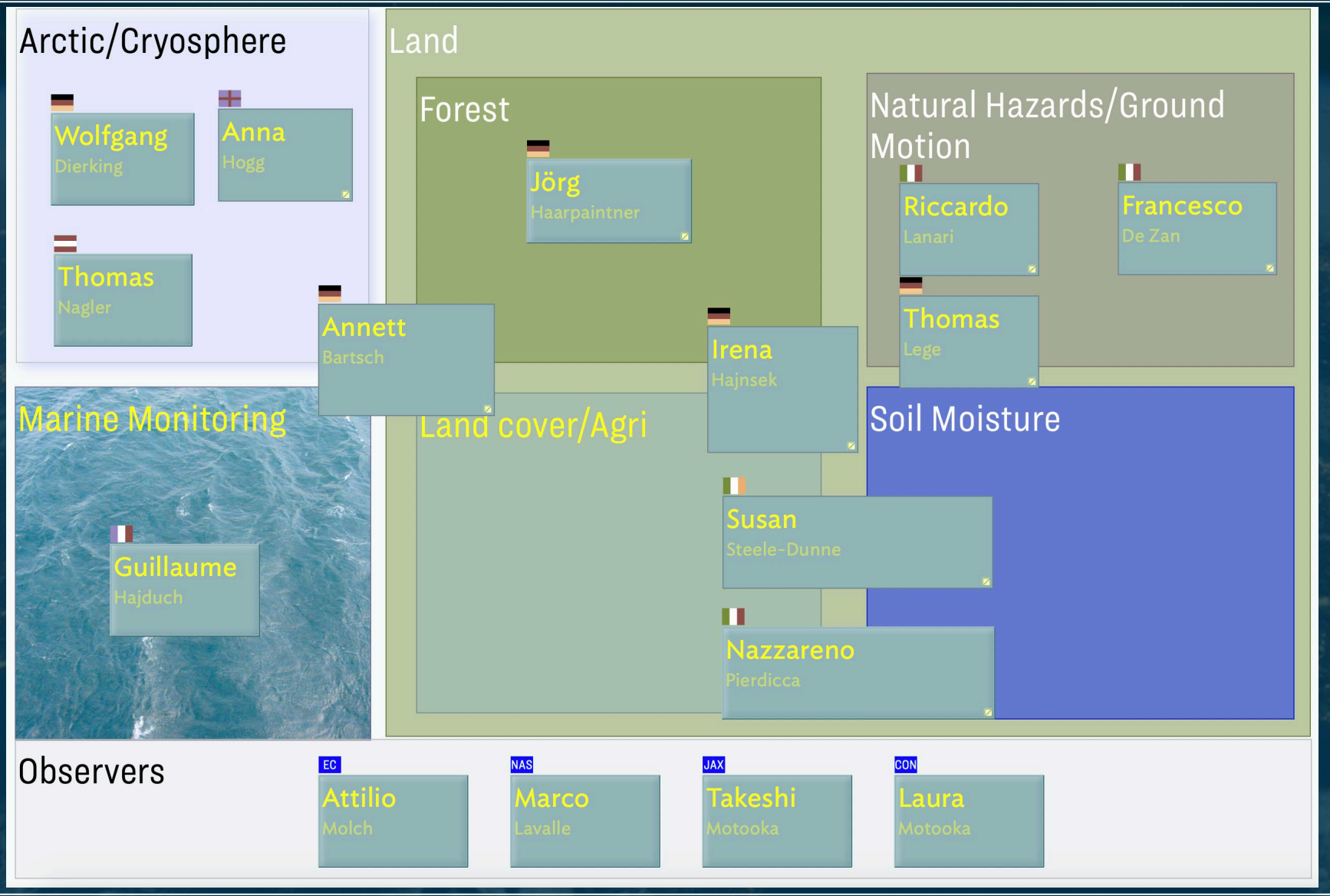
TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

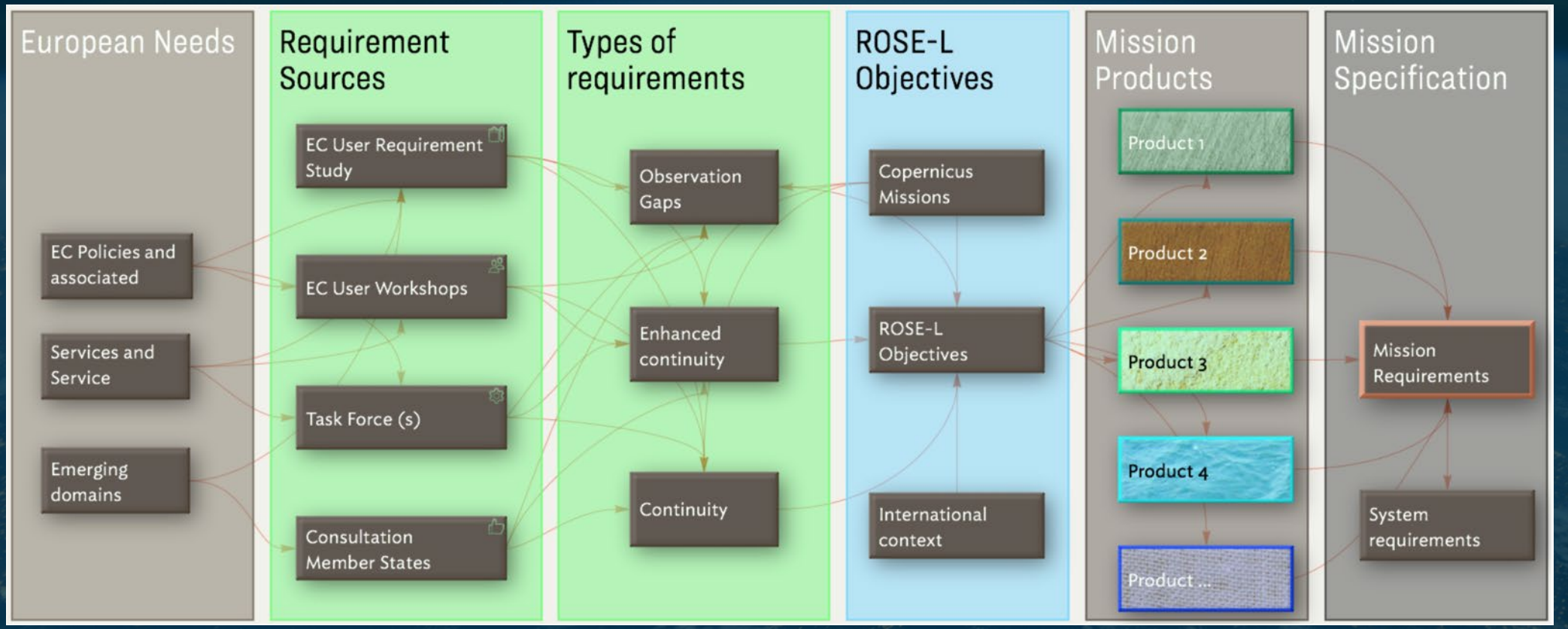
The Copernicus ROSE-L (Radar Observing System for Europe at L-band) mission

27/05/2022

ROSE-L Mission Advisory Group

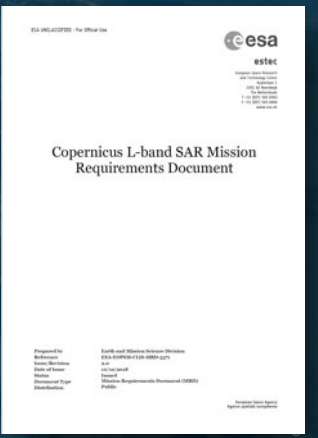


Mission Requirements Formulation Process



Mission Requirements Document available at

https://esamultimedia.esa.int/docs/EarthObservation/Copernicus_L-band_SAR_mission_ROSE-L_MRD_v2.0_issued.pdf



ROSE-L Objectives and Services

CLMS

C3S

CMEMS

EMS

Security

Meteorology and Hydrology Services

National and Local Authorities

Geohazards Monitoring

- **Deformation**
- **Landslides**
- **Urban subsidence**
- **Flooding**

Land Use, Agriculture and Forestry

- **Forest biomass and structure**
- Land over and land cover change
- Agriculture

Soil Moisture

- **High-resolution soil moisture**

Cryosphere and Arctic

- **Sea ice characterization**
- **Ice sheets and glacier velocity**
- **Grounding line**
- **Snow water equivalent**
- Permafrost thawing and extent

Marine Monitoring

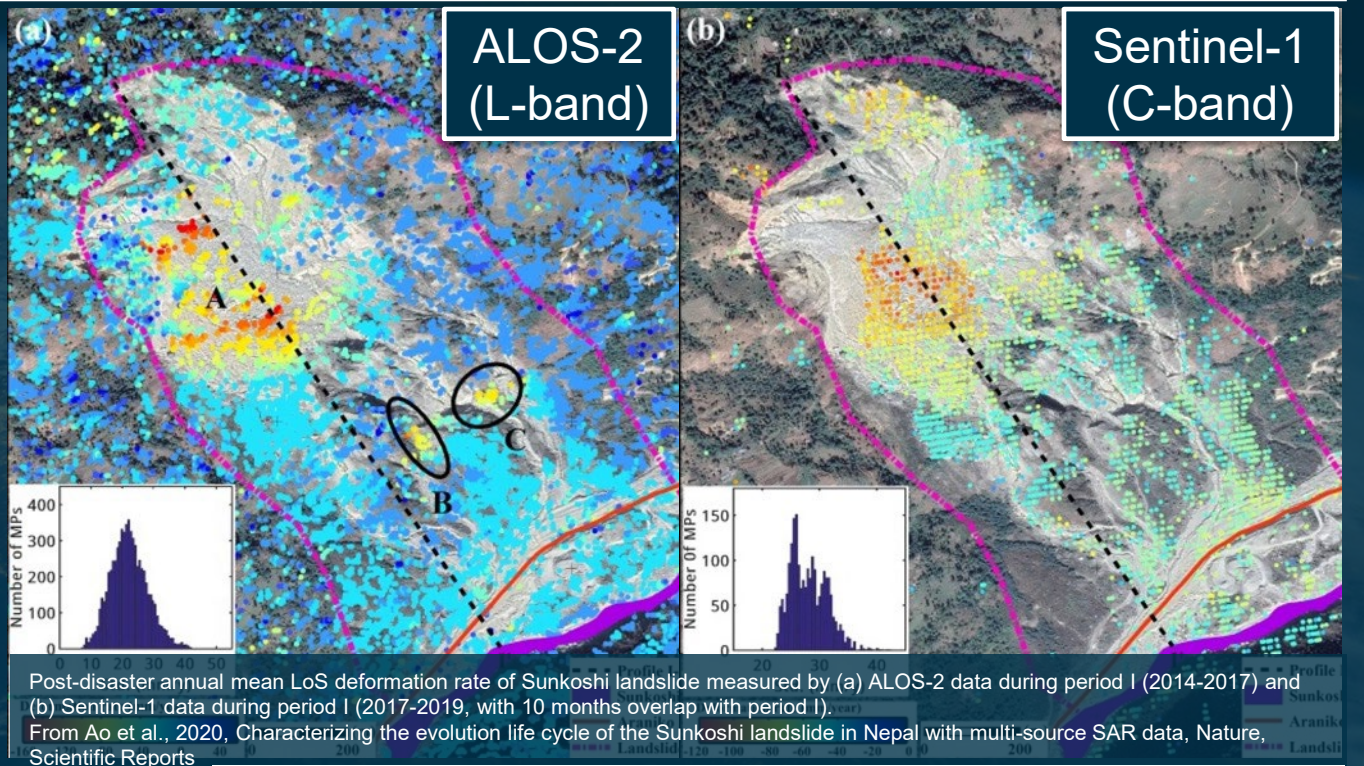
- Ocean surface wind vectors
- Swell properties

Maritime Monitoring

- **Iceberg location, size and drift**
- Vessel location, size and velocity
- Oil spill location and morphology

Geohazards Monitoring – Ground Motion

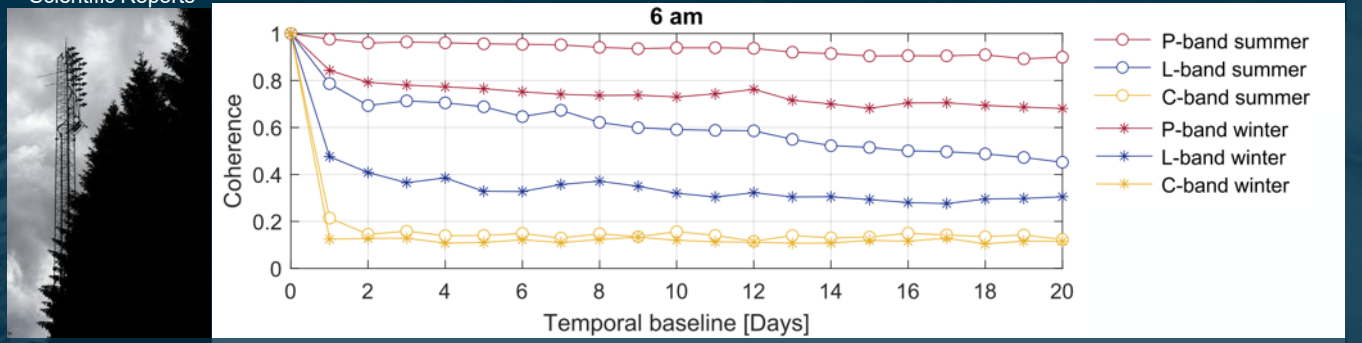
- **Improved coverage** and availability of motion information in **vegetated and snow covered areas**, compared to C-band, mainly due the capability of sensing the ground
- **Enhanced robustness to phase unwrapping** in fast deformation scenarios due to longer wavelengths



Post-disaster annual mean LoS deformation rate of Sunkoshi landslide measured by (a) ALOS-2 data during period I (2014-2017) and (b) Sentinel-1 data during period I (2017-2019, with 10 months overlap with period I).
From Ao et al., 2020, Characterizing the evolution life cycle of the Sunkoshi landslide in Nepal with multi-source SAR data, Nature, Scientific Reports

REQUIREMENTS

- 6 days repeat pass with two satellites
- 50 m2 Resolution for localized displacement
- ASC and DESC acquisitions for EW motion
- Low latency for rapid mapping after event
- Single-mode to guarantee time series



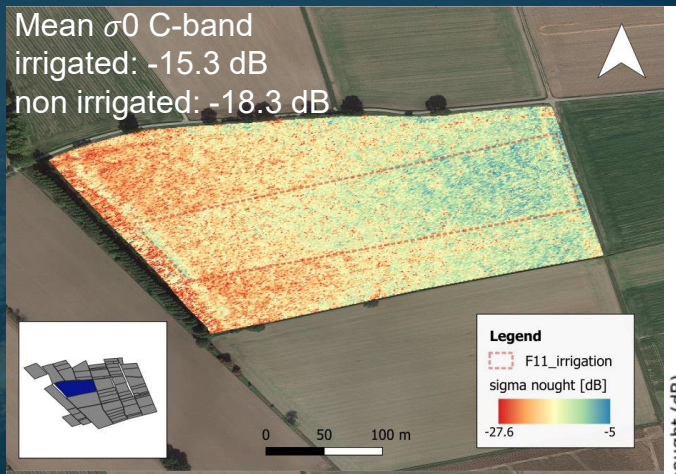
ESA BorealScat experiment. Median temporal coherence over temporal baselines of multiples of one day.
From Monteith and Ulander, TGRS, 2021

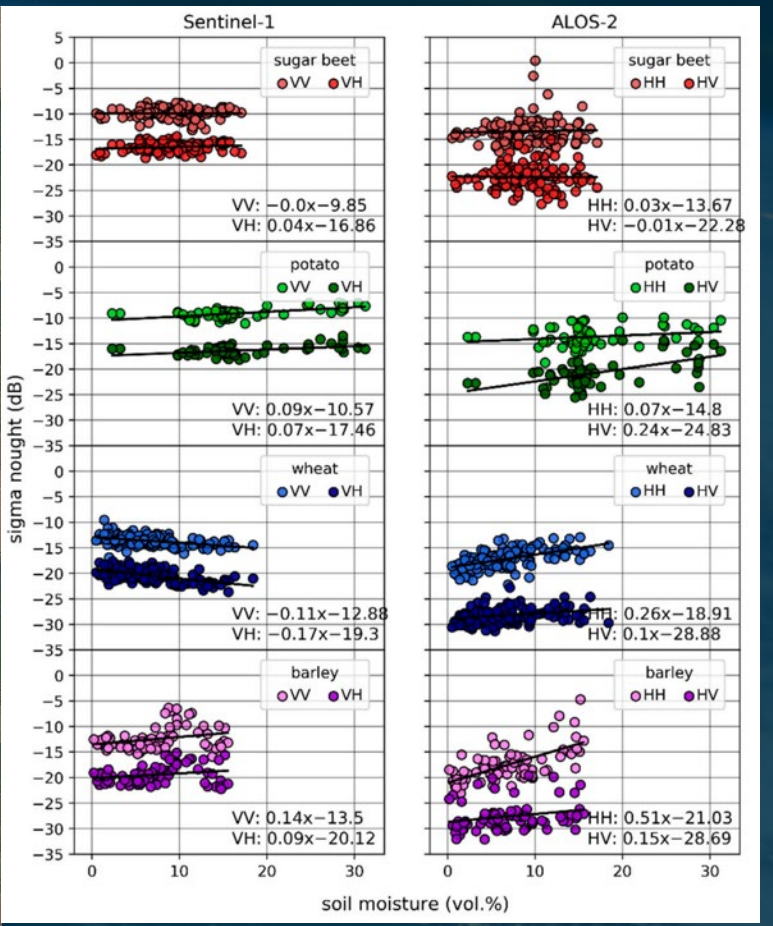
Soil Moisture

- **High-resolution Soil Moisture tracking in a broad range of crops and vegetated land,** complementing Sentinel-1 SSM products that are mainly suitable for bare soils and low vegetation areas.
- Information of **Soil Moisture up to ~5 cm depth** that shall be combined with upper 1 cm layer SSM from Sentinel-1

REQUIREMENTS

- Frequent Revisit (6 days Global, 3 days Europe)
- High resolution
- Low noise level (NESZ, ambiguities)
- Integration (downscaling) with Scatterometers and L-band Radiometers for temporal revisit and accuracy





Results from ESA SARSense air- and space- borne campaign. Acquisitions over Selhausen (DE).
(left) Change in backscatter observed in C- and L-band for irrigated and non-irrigated area (F11), but also range dependent.
(Right) Scatter plots between soil moisture and backscattering signal from co- and cross-polarized channels of C- and L-band satellite data. From Mengen et al., 2021, Remote Sensing

Cryosphere and Arctic

- Support EU Arctic Policy
- Parameters and EO Requirements identified by the Polar Expert Group (PEG)

Key Information Products

- Sea ice type and concentration
- Sea ice drift
- Iceberg detection
- Ice sheets, ice caps and glaciers velocity
- Grounding line
- Snow Water Equivalent

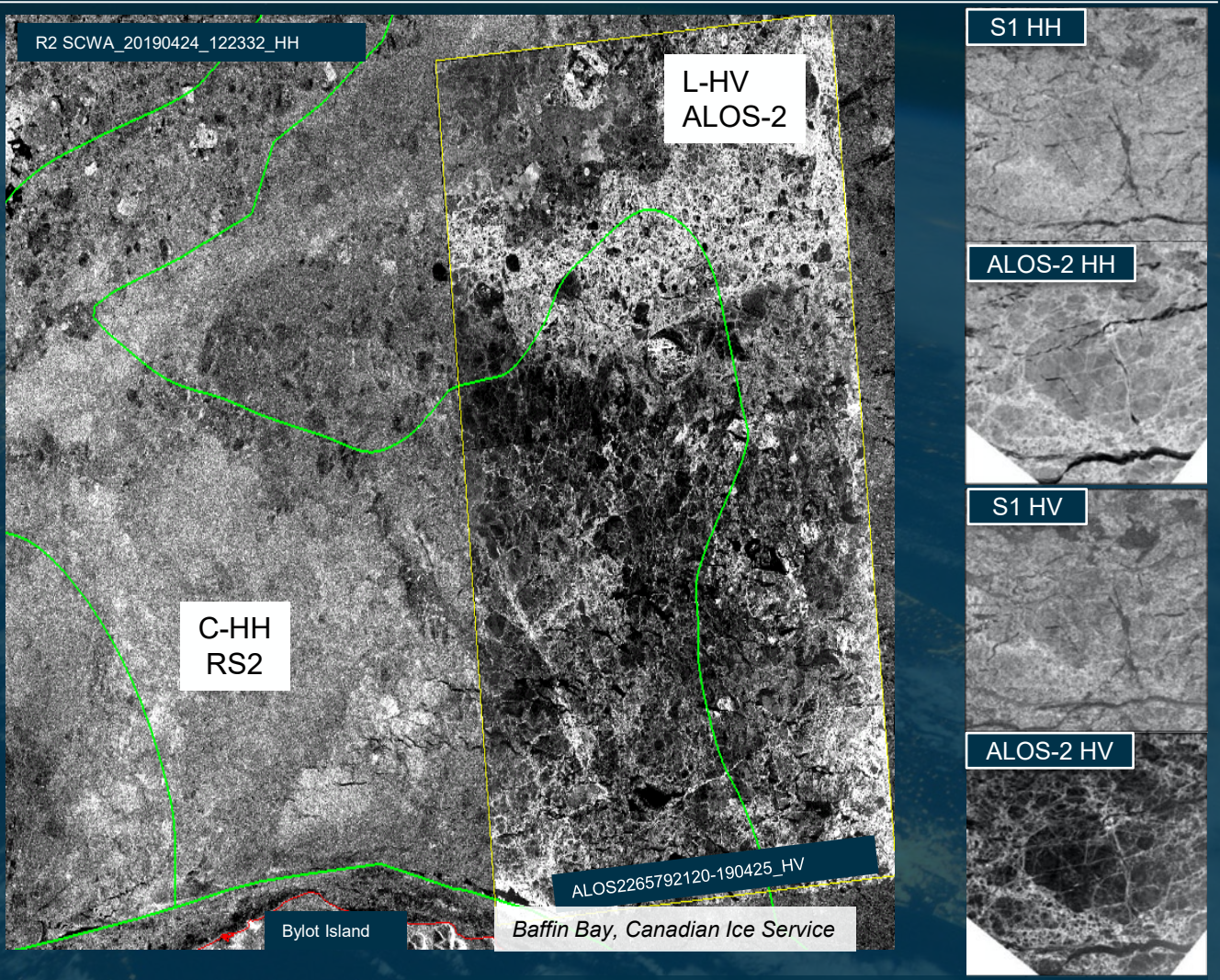
High-priority environmental parameters identified in the Polar Expert Group report (pp 11-12 of Phase-1). Parameters for which L-Band SAR provides unique or gap filling information are identified

Sea Ice Monitoring

- **Daily high-resolution information on hazardous sea-ice and icebergs** for navigation and weather/climate services
- **Enhanced mapping of sea-ice type and concentration,** adding to C-band the L-band sensitivity to large ice structures (e.g. fractures and ridges)
- **Improved mapping of sea-ice drift** by flying in a close formation with Sentinel-1

REQUIREMENTS

- Revisit (<1 day Arctic)
- Low noise level (NESZ, ambiguities)
- High-resolution and wide swath
- Simultaneous acquisitions with Sentinel-1 for sea ice mapping



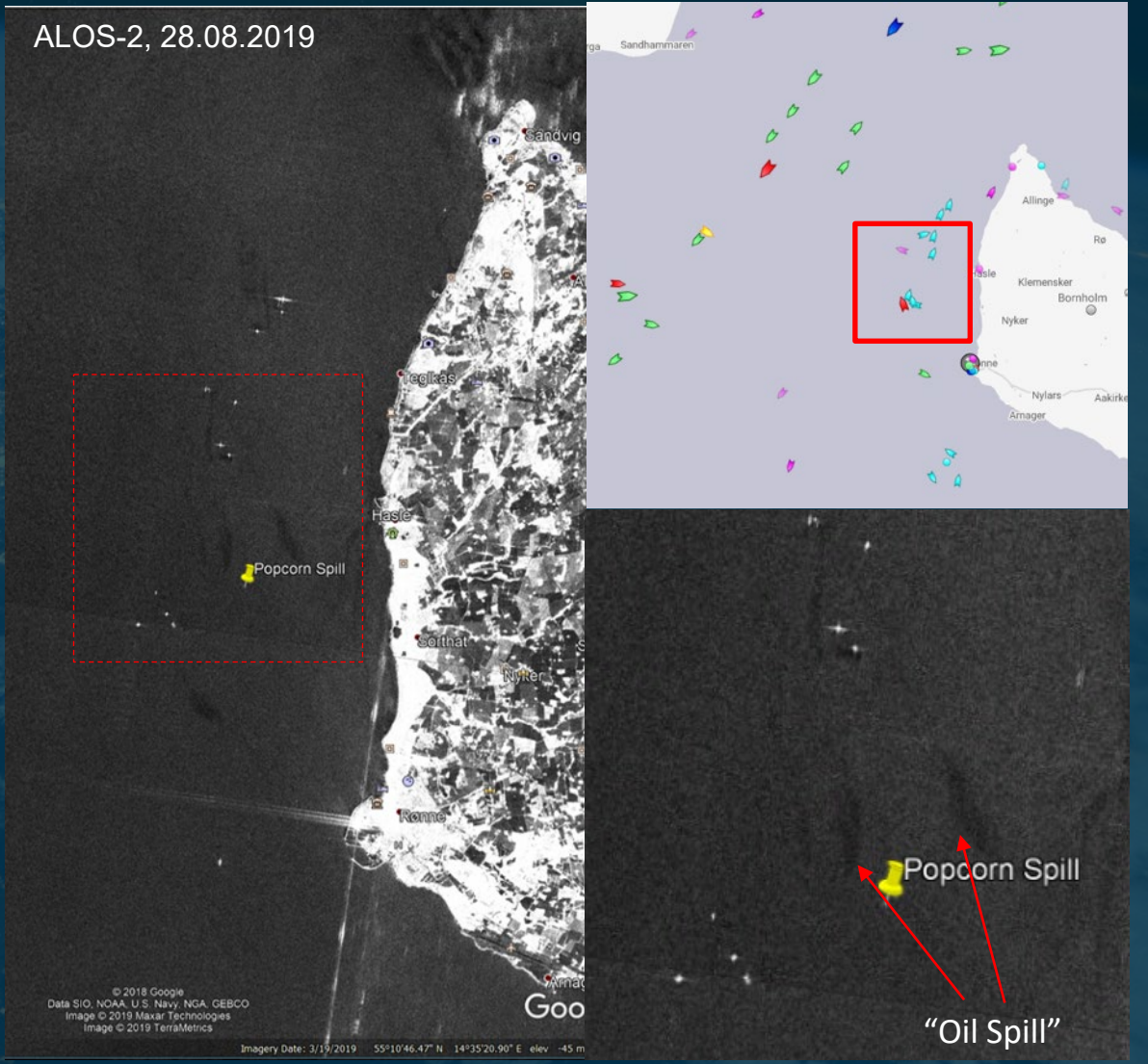
Sentinel-1 Extra Wide Swath and ALOS-2 PALSAR-2 Wide Beam images acquired at HH- and HV polarization over Fram Strait, on Dec. 9, 2019. The PALSAR-2 images were aligned to the Sentinel images. By courtesy of Johannes Lohse, UiT. From Dierking et al., 2022, IGARSS

Maritime and Marine Monitoring

- **Added value in vessel detection** for maritime surveillance due to reduced sensitivity of sea backscatter at lower wind
- **Improved detection of icebergs** thanks to a better sensitivity of L-band to large ice structures
- **Added value in extreme events (e.g. tropical cyclones)** as high winds do not saturate the signal
- **Enhanced continuity for oil spills detection and CMEMS services**, favored by shorter revisit and complementarity with higher frequencies

REQUIREMENTS

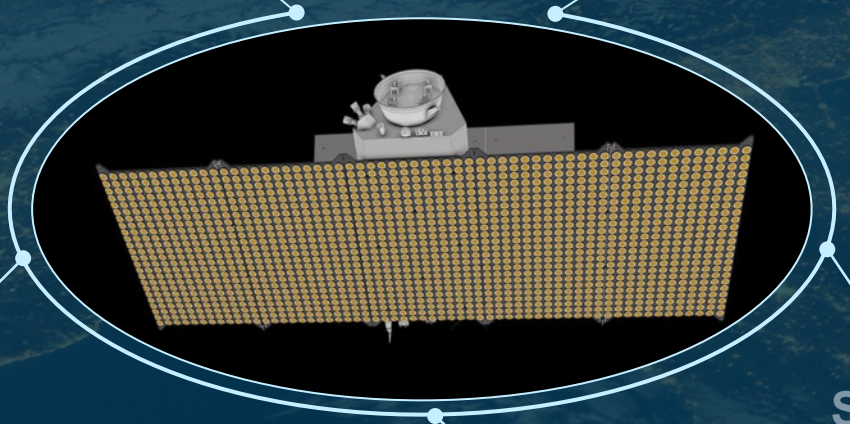
- Wave mode
- Revisit (1 day Arctic, 3 days Europe, 6 days Global)
- Low latency for European waters (< 10 minutes)
- Low noise level (NESZ and ambiguities)
- High-resolution, wide swath



ROSE-L Mission in Brief

GENERAL

- Constellation of 2 satellites (PFM & FM2) + options under study
- Consortium led by Thales Alenia Space Italy (TAS-I), involving 29 companies from 15 countries



IMAGING

- L-Band – 85 MHz ITU allocated band (1.215-1.300 GHz)
- Dual-Pol and Quad-Pol Imaging Modes
- Wave mode over oceans
- Resolution < 50 m2 (Dual-Pol)
- NESZ < -28 dB
- DTAR < -23 dB
- Swath width > 250 km

COVERAGE

- Coverage of Global Land (excl. Antarctica) and Arctic
- Revisit with 2 satellites :
  - 6 days Global Land
  - 3 days Europe
  - 1 day Arctic
- Repeat cycle of 6 days over Global Land (2 satellites)

PROGRAMMATICS

- Currently reaching end of Phase B2
- Science Plan activities start in 2022
- Launch of PFM expected in 2028
- FM2 delivery expected in 2030

SYSTEM

- Synergic acquisitions with Sentinel-1: co-located swaths + design allows optimized revisit or convoy orbit placement (1 min)
- Low data latency
  - 10 min Europe coastal waters
  - 200 min Global
- Enable companion for single-pass InSAR

Coverage and Operations

Mission Sizing Scenario

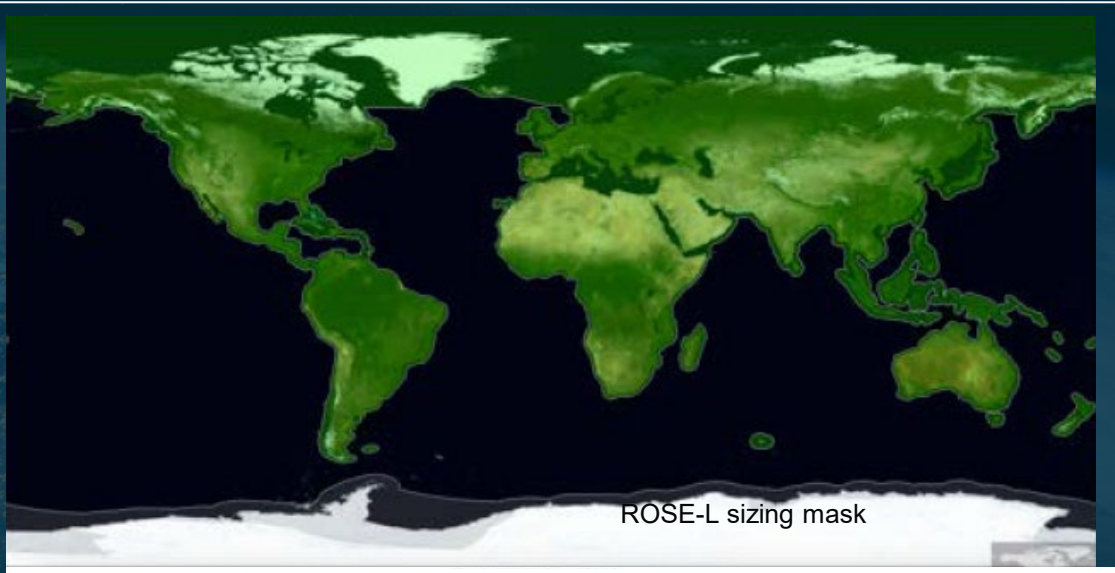
- **“always on"** over *Europe*, *Arctic*, and *coastal Antarctica* in dual-pol SAR or quad-pol mode
- **full coverage** of *remaining landmass* within ***12-day* revisit** time, i.e. ***6-day* global revisit** time for entire constellation
- **Wave mode** over *Open Ocean*

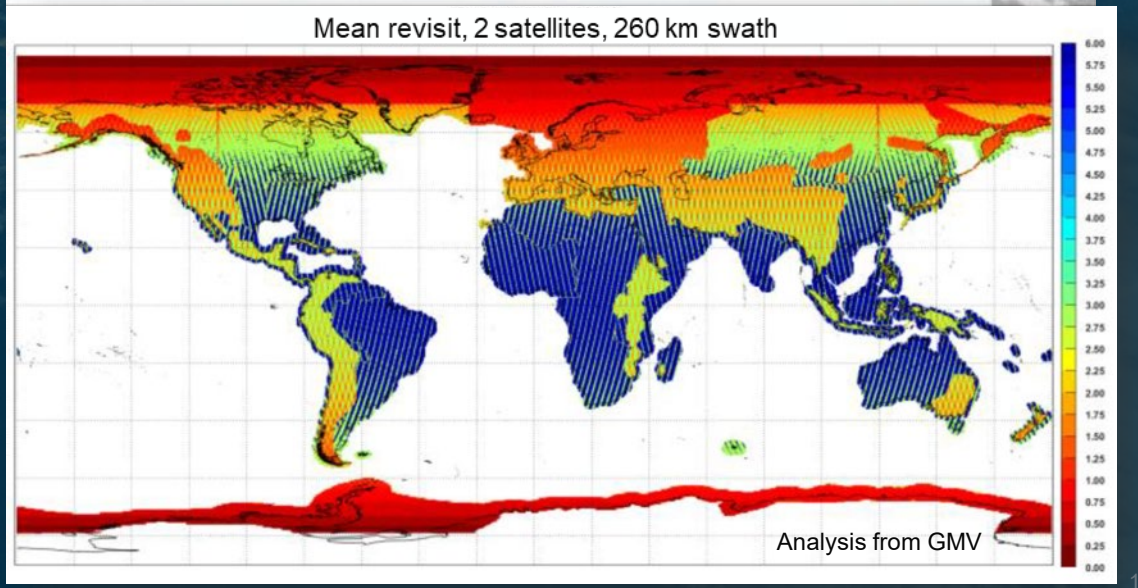
Mission duty cycle

- **38 min <u>average</u> orbit duty cycle** in dual-pol mode (remaining time in *Wave Mode)*
- **56 min <u>maximum</u> orbit duty cycle** in dual-pol mode (remaining time in *Wave Mode)*

Data Rates

- **PHDT: Ka-Band 1822 Mbps x 4 channels**, steerable antenna, 24Tbit Mass Memory
- Approx. 1200-1300 Tb acquired data over a full cycle

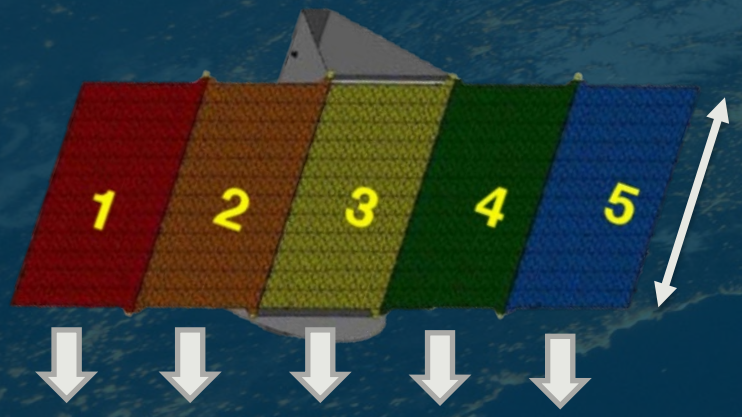

ROSE-L sizing mask



Instrument and Imaging

Antenna

- Airbus design
- Antenna size: 11 x 3.6 m
- Peak power : 9 kW
- A total of 60 TRM (12 elevation x 5 azimuth)



12 TRM for SCORE (SCan On REceive) in elevation

- Needed for gain (NESZ) and ambiguities
- Challenges in calibration and performance assessment

5 Azimuth Channels for on-ground DBF MAPS (Multiple Azimuth Phase centers)

- Individually downlinked and provided in Level-0 product.
- **Unique opportunity** : ad-hoc Level-1 processing and products, e.g. for **ATI**

Baseline Acquisition Modes

- *Dual-Pol & Quad-Pol modes* : **ScanSAR** over Land, coastal and European waters
- Wave mode : **Stripmap** over oceans
- Options for additional modes using selected hardware baseline (e.g. to cover polar gap or improve image quality)

SAR Mode Overview – Key Parameters

	Dual-pol (nominal)	Quad-pol	Wave mode (single pol)
Access	25^0 – 46^0	1 fixed swath within 25^0 – 46^0 e.g. 25^0 – 42.3^0	variable
Swath/ coverage	260 km	260 km	20 km x 20 km (separation of center 100 km)
Resolution (single look)	50 m²	100 m²	50 m²
DTAR	< -23 dB	< -23 dB	< -23 dB
PTAR	< -25 dB	< -25 dB	< -25 dB
NESZ	< -28 dB	< -28 dB	< -28 dB

Conclusions

ESA with industry and together with EC preparing “expansion” of Copernicus SAR missions

ROSE-L Mission at L-band as a Copernicus Expansion mission *to address information gaps* and provide new. information not yet available through current Sentinel missions

ROSE-L bring new and enhanced capabilities

- Two-satellite constellation (PFM and FM2)
- High resolution (50m2 in dual-pol interferometric wide swath mode) and wide-swath
- Low NESZ (-28 dB)
- Wide swath and frequent revisit capability through improved duty cycle (> 37 minutes)
- Same orbit, swath and acquisition geometry as Sentinel-1 (IWS) leading to a an operational dual-frequency system

ROSE-L PFM Expected to launch in 2028 time frame

ROSE-L Industrial Consortium

Prime Contractor

Thales Alenia Space Italy

Payload Prime

Airbus Germany

+ 29 companies from 15 ESA Member State countries