

Toward a family of SAR ARD products

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Introduction: Why joint ESA and DLR product?



Definition CEOS Analysis Ready Data (ARD):

*“[...] data that have been processed to a minimum set of requirements and organized into a form that allows **immediate analysis** with a minimum of additional user effort and **interoperability** both through time and with other datasets.”* (<http://ceos.org/ard>)

Main benefits of an ARD product:

- No need for larger data preprocessing by users
- Align gridding and projections of different datasets
- Considering requirements of users

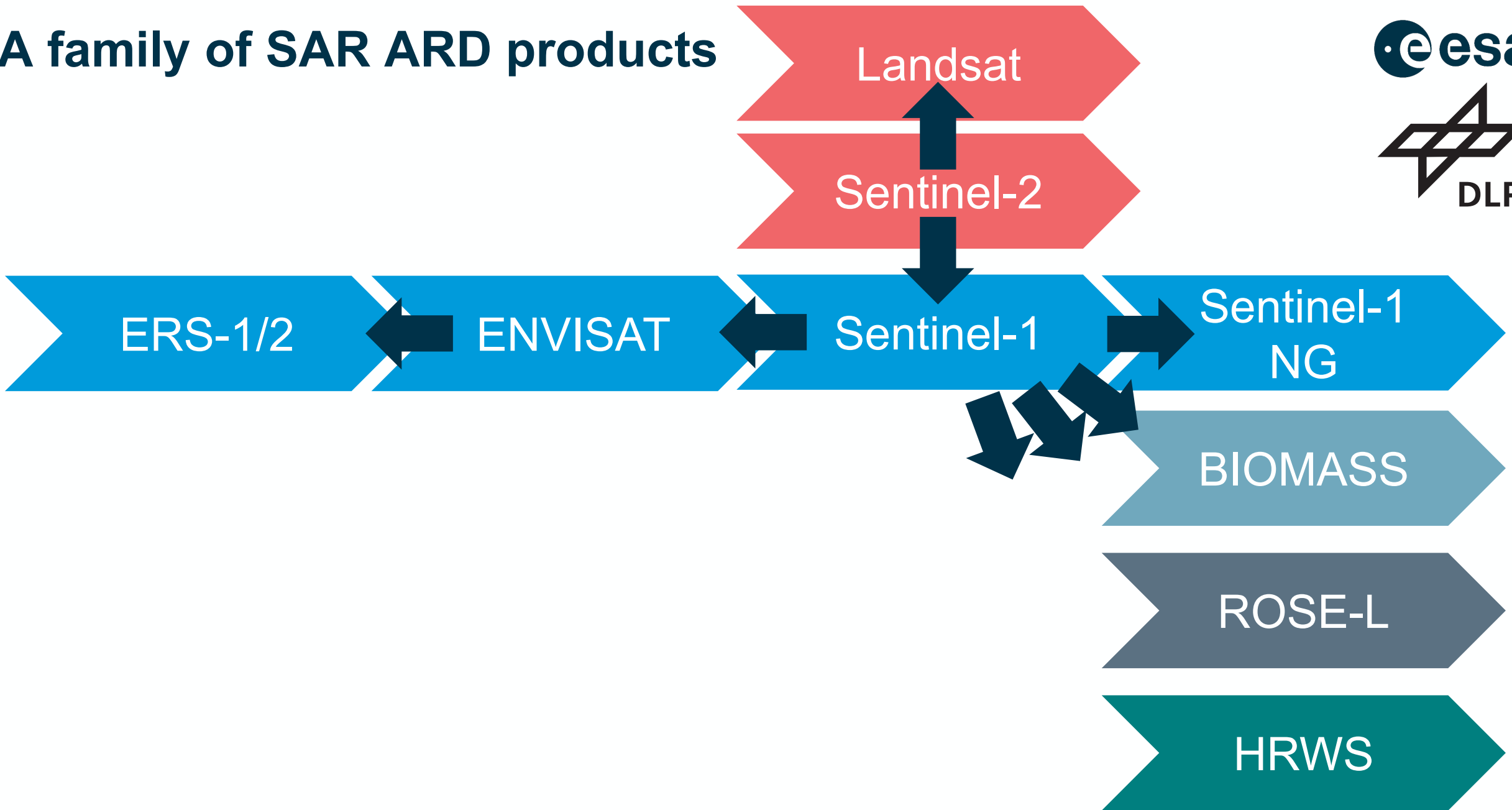


Joint DLR and ESA Sentinel-1 ARD Normalized Radar Backscatter (NRB) product:

- Developed at DLR (terabyte) and ESA (COPA)
- Coordinated definition of SAR ARD products and same processing steps
- Applied on existing missions like Sentinel-1, ERS-1/2, and ENVISAT
- Extended to future missions like Sentinel-1 NG, HRWS, Tandem-L, ROSE-L, BIOMASS

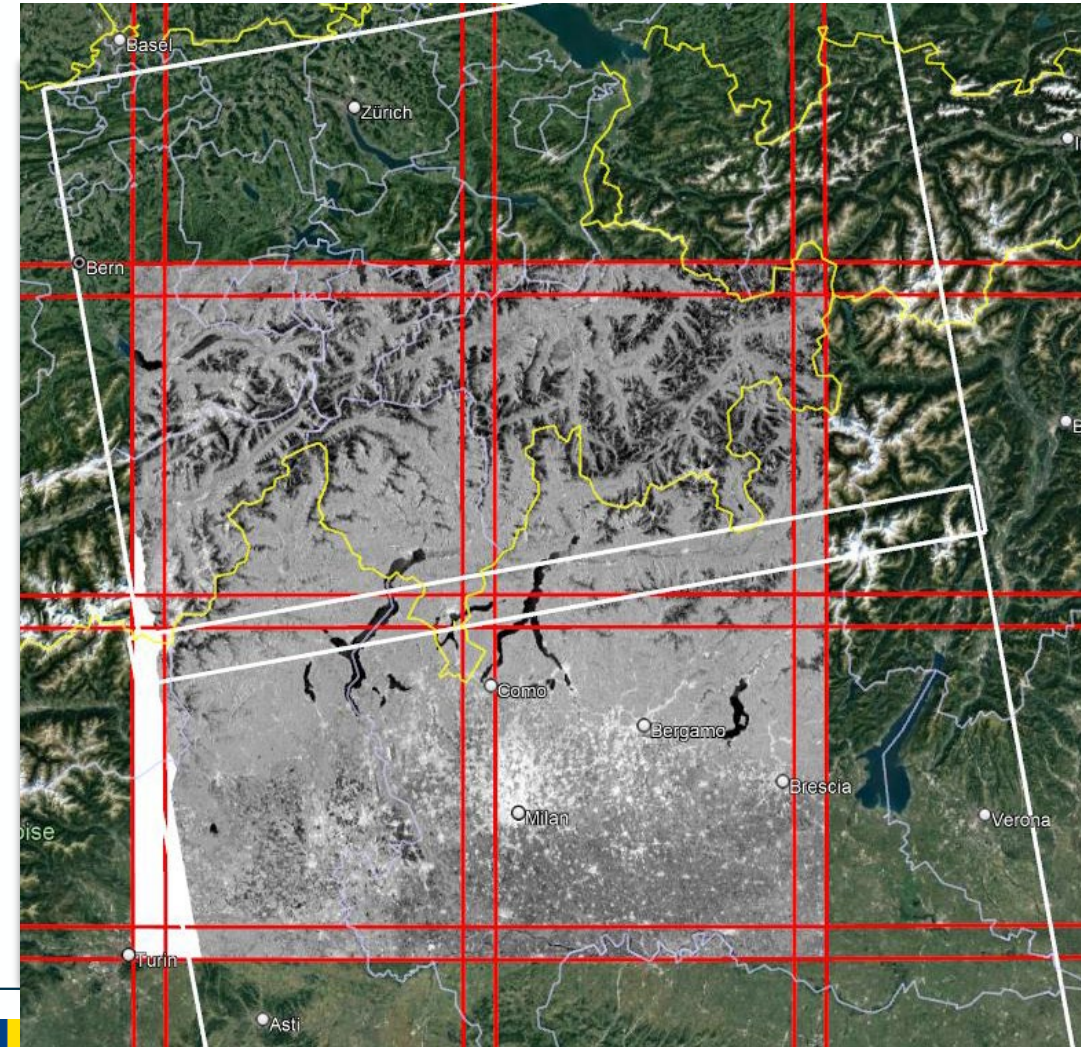
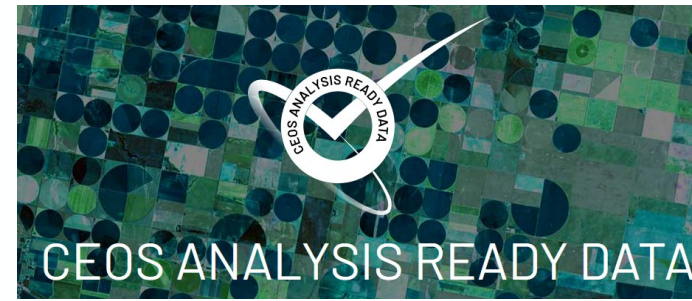


A family of SAR ARD products



Sentinel-1: Product definition

- Based on **CEOS CARD4L** NRB guidelines
- **Input data:** Sentinel-1 SLC and Copernicus DEM
- **Mandatory output:**
 - Measurement (Gamma Naught RTC)
 - Local incidence angle
 - Data mask (few MB)
 - Acquisition id (few hundreds kB)
- **Product organisation and name convention:** according to COPA Product Specification
- **Target geometric accuracy:**
 - « Output product sub-sample accuracy should be less than or equal to 0.1-pixel radial root mean square error. »
- **Gridding:** Same tiling system as Sentinel-2 (MGRS)
- **Cloud-Optimised:** GeoTIFF, VRT, XML, and STAC



Sentinel-1: Processing steps

Apply Orbit Files

using available orbit file (precise or restituted)

Thermal Noise Removal

using algorithm of ESA Specification or Park et al.

Radiometric Calibration

converting DN to radiometrically calibrated backscatter

Terrain Flattening

correct terrain-influenced radiometry (gamma naught)

Terrain Correction

using Copernicus DEM (1 arc seconds)

DLR processor for Sentinel-1



Processor Multi-SAR System:

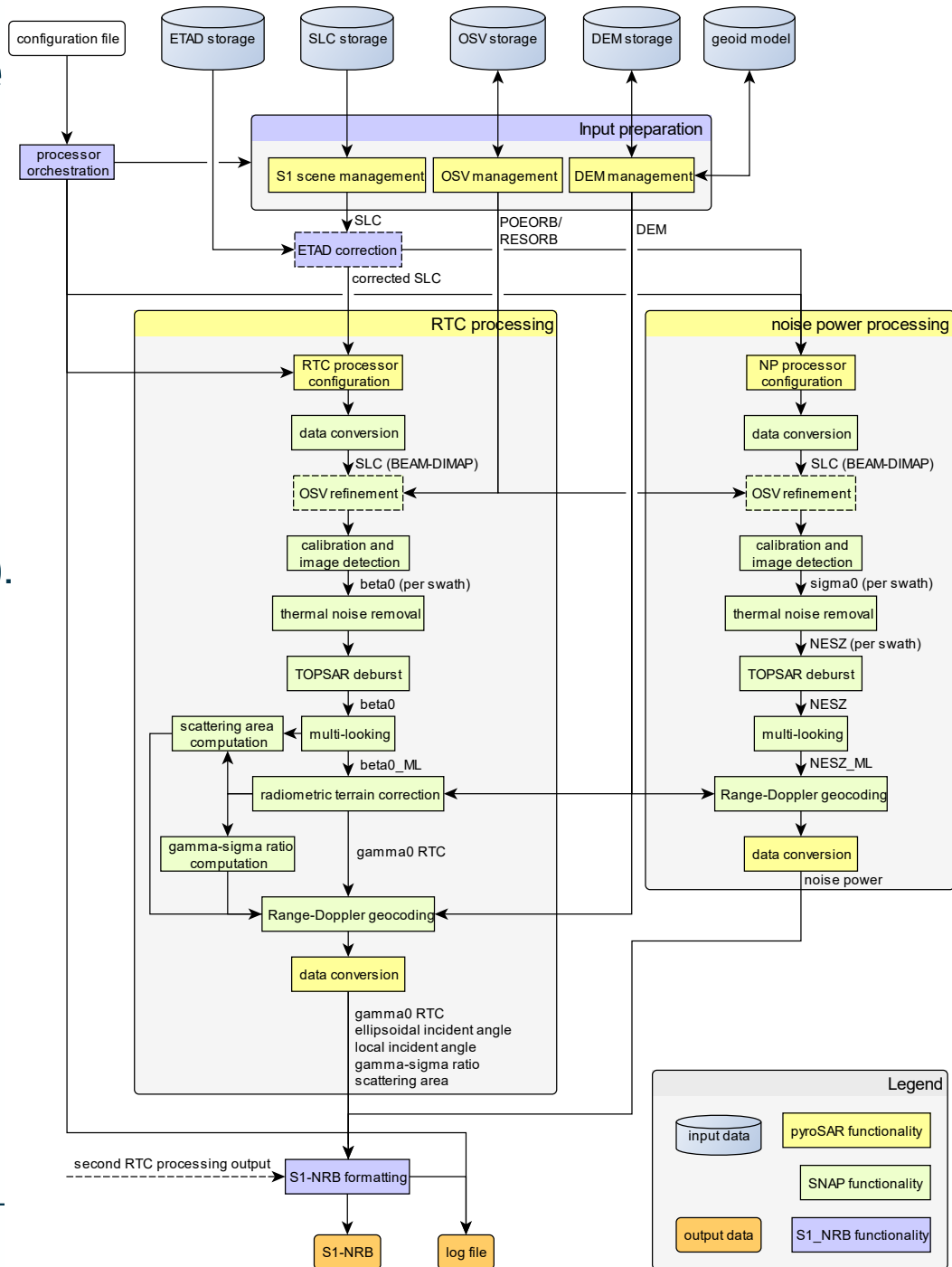
- Processor developed at DLR (based on C/C++)
- Pre-processing system for all SAR data from level 1 to level 2
- Supports data from ERS-1/2, Envisat ASAR, RADARSAT-1/2, ALOS PALSAR-1/2, TSX, and Sentinel-1
- Adjustments and extensions for Sentinel-1 ARD processing

Processing environment HPDA (High Performance Data Analytics) terrabyte:

- Cooperation between DLR Earth Observation Center (EOC) and Leibniz Supercomputing Center (LRZ)
- Cloud/HPC-based data processing environment with 36 Pbyte storage
- Data processing:
 - Global up-to-date processing to ARD
 - User-specific systematic and individual processing
- Data storage: Sentinel, Landsat, MODIS, etc.
- Data management: Cloud-optimized data formats, SpatioTemporal Asset Catalog (STAC) metadata

ESA Sentinel-1 ARD prototype

- Current activity aims at developing a prototype processor and validate it through a test dataset over a few use cases.
- Further operationalisation of this processor, and integration in the Sentinel-1 ground segment is targetted for end of 2024, in order to have a **systematic generation** of this product (**with NRT**).
- ESA is considering a non-copy left type of open-source licence (Apache 2) for the operational processor.
- Based on SNAP and PyroSAR.
- Currently not optimised.
- Prototype processor available for on the fly data generation on the Coastal Thematic Exploitation Platform (C-TEP).



ESA-DLR coordination around 5 axes



1. Joint Sentinel-1 ARD NRB product:

- *Objective to have ESA and DLR product definitions aligned.*

2. Joint ESA and DLR Sentinel-1 ARD NRB processor:

- *Exchanges of modules and code developed.*
- *Share the new modules developed (e.g. file packaging).*

3. Coordination on use cases:

- *Complementary use cases in terms of spatial and temporal coverage, and instruments.*

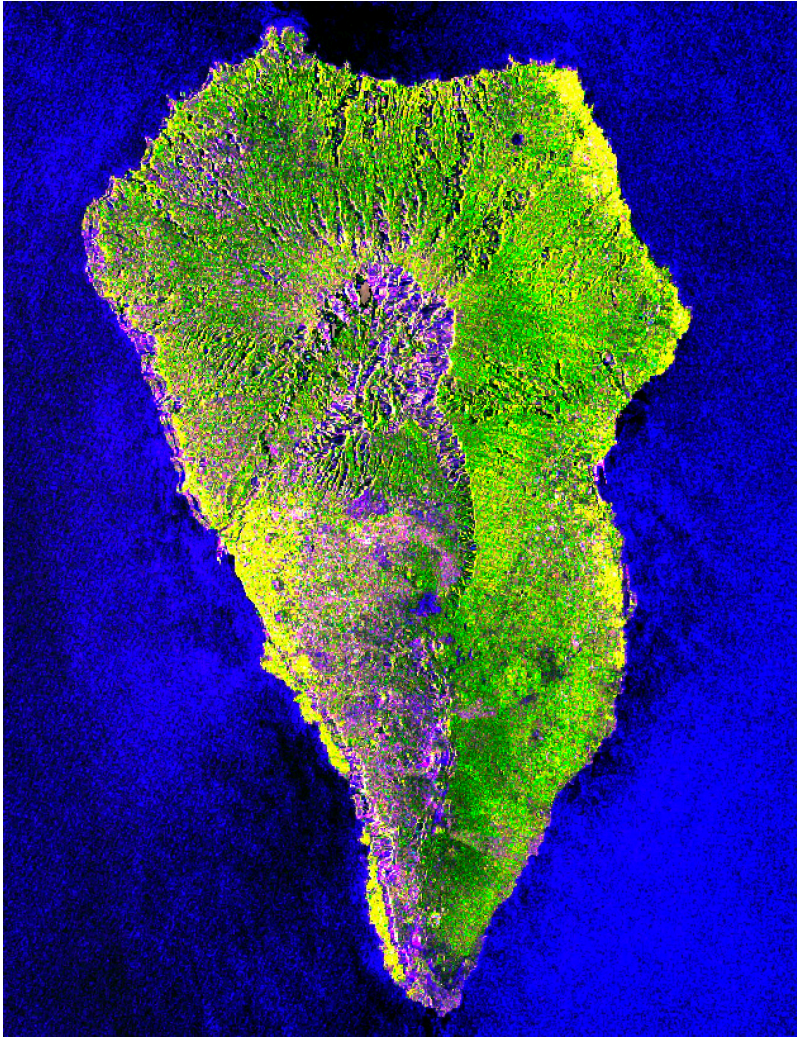
4. Coordination on validation:

- *Complementary validations in term of radiometry, geometry, processing modules, etc.*

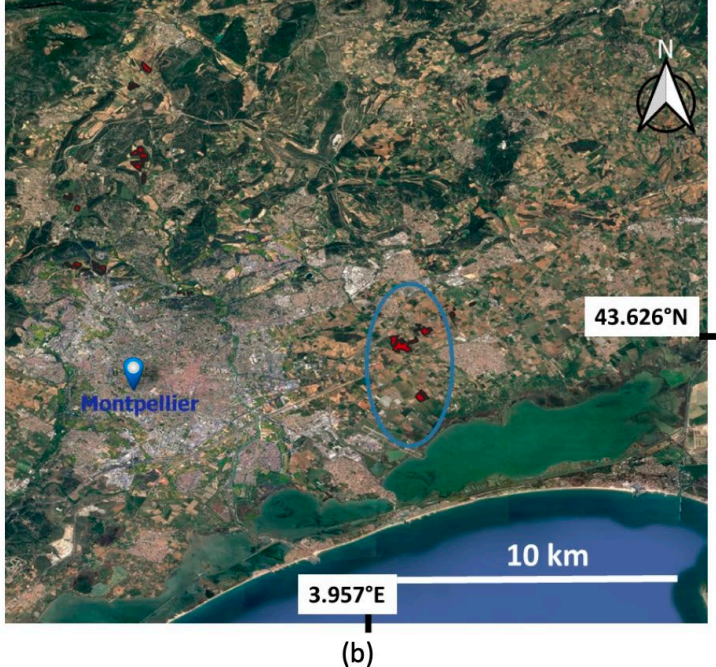
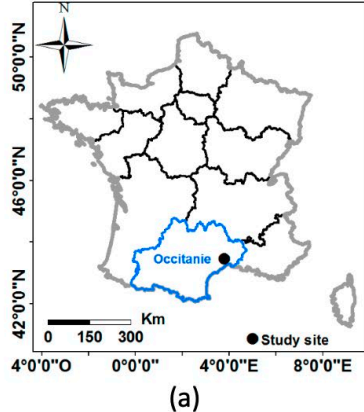
5. Exchange of information related to internal ESA and DLR activities:

- *Monthly coordination meetings.*

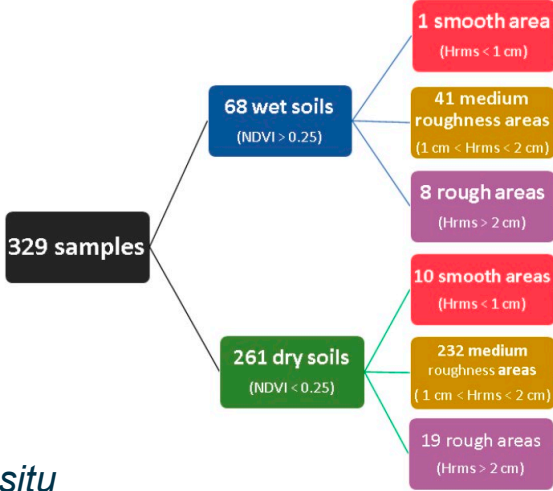
Examples of products and validation



Example of product (La Palma - Spain)



Location of the study site in France (in red, the plots where the in-situ data was collected) and characteristics of the study area database.



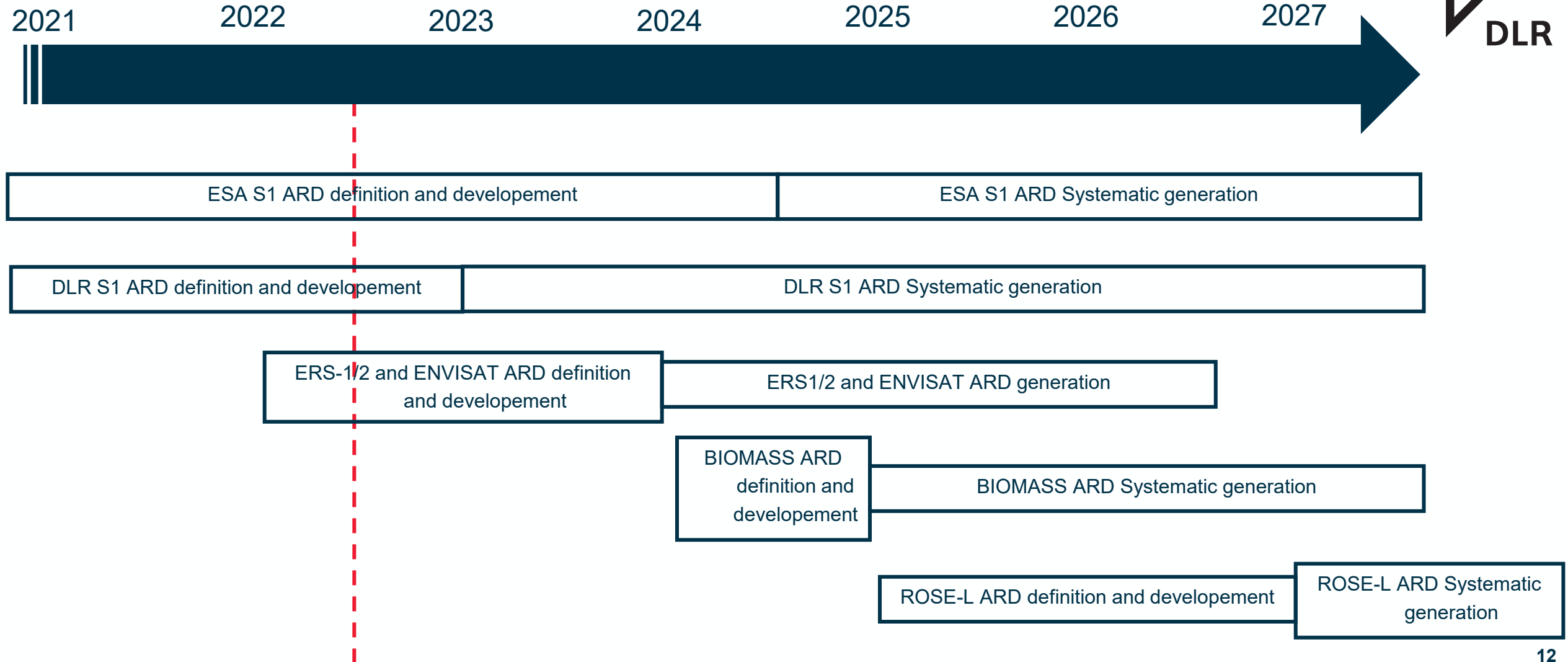
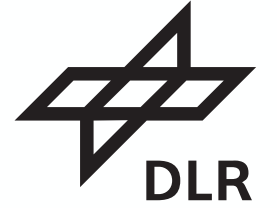
- Comparison of Sigma0 and Gamma0 for soil moisture inversion:
 - gamma naught will give better results than sigma naught if working on small plots or at pixel scale because the radiometric quality of the data will be better with gamma than with sigma.

Other SAR ARD products in development at ESA & DLR



- C-band SAR NRB product for ERS-1, ERS-2 SAR and ENVISAT ASAR.
 - **Poster:** *Tuesday – 24.05.2022 - 05:57 pm - Poster Session Day 2*
Kajal Haria | Telespazio UK
LPS22: B4.01 Heritage Missions and Long Time Data Series: ERS-1/2 SAR and ENVISAT ASAR CARD4L NRB Product Development Project, ID64603
- How can we make Polarimetry Analysis Ready? (Sentinel-1, RADARSAT and TerraSAR-X)
 - **Poster:** *Friday – 27.05.2022 - 01:04 pm - Poster Session Day 5*
Birgit Wessel | German Aerospace Center (DLR)
LPS22: B1.07 Analysis Ready Data: are we there yet?
- SAR ARD products planned for HRWS (High-Resolution Wide Swath) mission
- Potential P-band SAR NRB product could be defined and generated for the BIOMASS mission.
- L-band SAR NRB product requested for ROSE-L in the Mission Requirement Document.

Time schedule and access for users to ARD NRB



Conclusion



Outlook

- The proposed family of SAR ARD products will ease data analysis and exploitation by being « cloud-computing compliant », open SAR data to new communities, and allow interoperability between these products.

Way forward:

- Definition of a SAR ARD product for Ocean (following the CEOS related guidelines).
- Processing of historical Sentinel data (DLR).
- Operational product format and corrections applied could diverge from the prototype.

Related activities under definition:

- Follow-on ETAD activities: Investigation of no-latency geolocation improvement, i.e., with PREORB and (TBC) independent of L1A (or L0)
 - **Poster:** Monday – 23.05.2022 - Antonio Valentino | RHEA for ESA | B1.06 - Towards NRT Sentinel-1 ARD products: model based atmospheric corrections for improved geolocation
- Open, validated, optimised, and documented RTC processor (with D. Small).
- Fundamental Data Record - FDR: Backscatter composites from Sentinel-1 and Radarsat.