CANVAS: Calibration and Validation for SAR

Albert Rabaneda[1], Giuseppe Griecco[2], Marcos Portabella[3], Federico Cossu[3] , Morten Hansen[1] ,Eirik Malnes[4], Temesgen Yitayew[4]

[1]MET Norway, [2]CNR-ISMAR, [3]CSIC-ICM, [4]NORCE

Intro

Aim: To create a Quality Assessment framework for SAR instruments, in a wide perspective, for past, present and future SAR.

This includes L1 and L2 products (over land and ocean) for which we will:

- Definition of Cal/Val procedures
- Create a Guidance for Uncertainty Metrics (GUM)
- Define Fiducial Reference Measurements (FRM)
- Create an open-source software for SAR Cal/Val
- Demonstrate the tool capabilities

As L2 products we consider:

- Soil Moisture (SSM)
- Wet Snow (SWS)
- Ocean Surface Vector Wind (OSVW)
- Significant Wave Height (SWH)

EDAP & EDAP+ legacy

Data Provider Documentation Review		
Product Information	**Metrology**	**Product Generation**
Product Details	Sensor Calibration & Characterisation	Image Formation & Calibration Algorithm
Availability & Accessibility	Geometric Calibration & Characterisation	Geometric Processing
Product Format, Flags & Metadata	Metrological Traceability Documentation	Retrieval Algorithm
User Documentation	Uncertainty Characterisation	Mission-Specific Processing
	Ancillary Data	

Detailed Validation					
Measurmenet	Absolute Radiometric Calibration Method	Radiometric Stability Method	Sensitivity Validation Method	Polarimetric Accuracy Method	Interferometric Accuracy Method
	Absolute Radiometric Calibration Results Compliance	Radiometric Stability Results Compliance	Sensitivity Validation Results Compliance	Polarimetric Accuracy Results Compliance	Interferometric Accuracy Results Compliance
Geometric	Spatial Resolution Method	Geolocation Accuracy Method			
	Spatial Resolution Results Compliance	Geolocation Accuracy Results Compliance			

Missing L2 land and L2 ocean products

EDAP & EDAP+ legacy

Quality assessment undertaken during EDAP+ project

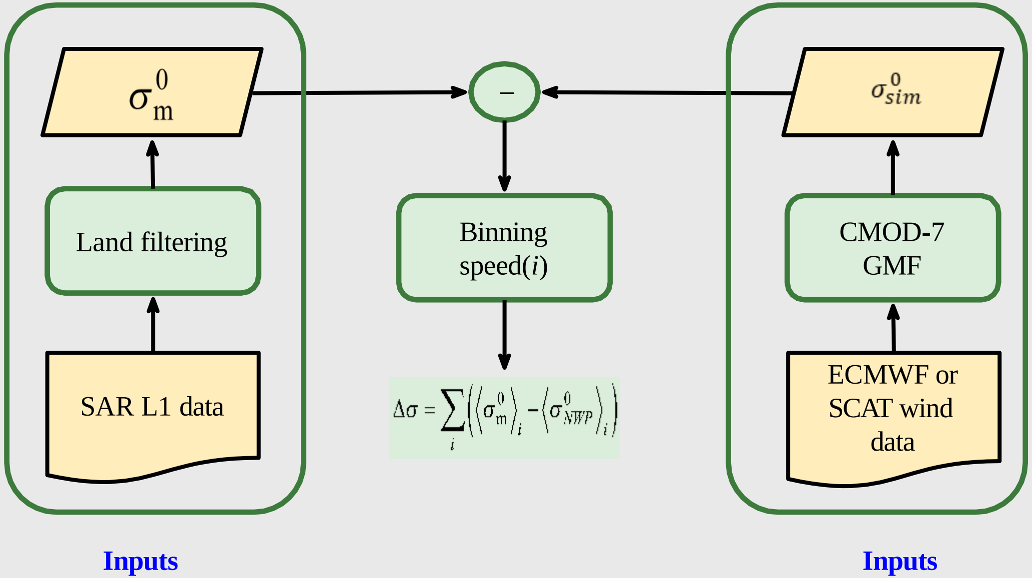
The SAR Calibration Toolbox (SCT) includes a tool for each of the quality parameters

Table 1-1: Parameters for the assessment of SAR data quality

Quality parameter	Metric	Data type	Cal. Sites
IRF	Spatial resolution	Point Target	Mission dedicated sites: Rosamond Corner Reflector Array (California) Surat Basin (Australia)
	Peak-to-Side Lobe ratio	Point Target	
	Integrated Side Lobe ratio	Point Target	
Geometry	Localization	Point Target	
Radiometry	Calibration constant	Point Target	
	Polarimetric imbalance	Point Target	
	Elevation Antenna Pattern	Rain Forest	Amazon, Congo Sahara Greenland
	Azimuth scalloping	Rain Forest	
	Beam-to-beam offset	Rain Forest	
	Equivalent Number of Looks (**ENL**)	Rain Forest, Desert, Ice Sheets	
	Noise level	Low backscatter	Calm sea areas (e.g., Doldrums) Lakes (for small swaths, e.g., Mono Lake - California) Deserts
Interferometry	Coherence	High coherence areas	Salar de Uyuni

*IRF: Impulse Response Function

Numerical Ocean Calibration (NOC)

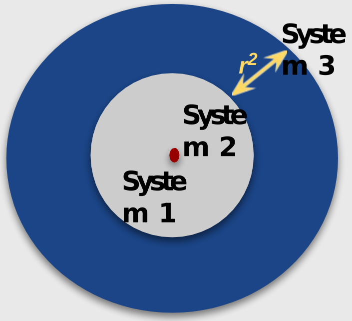


- NOC and possibly Higher-order calibration (HOC) to validate SAR L1 calibration and further correct SAR NRCS to align its behaviour to that predicted by the CMOD7 GMF.

BEC
Barcelona Expert Center

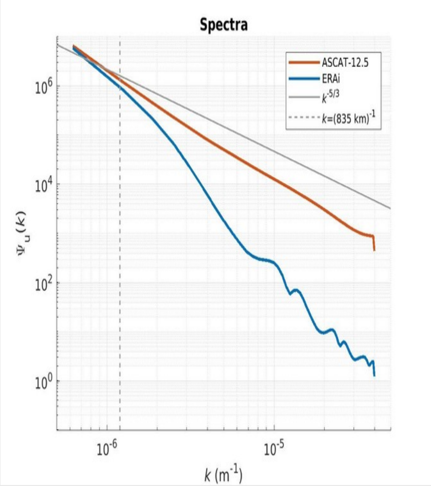
SAR validation over ocean: Triple collocation analysis

- **Aim**: To adapt and validate the triple collocation (TC) method for SAR geophysical product validation
- TC performed over different ocean regions & periods
- Buoy-SAR-ERA for validation of both SAR-derived OSVW & SWH
    - Use of both coastal and open-ocean buoy data
- SAR-SCAT-ERA for validation of SAR-derived OSVW data
- 3 different r2/TC methods will be evaluated
    - Wind spectra
    - Spatial variances
    - Intercalibration
- TC may also be used to validate SAR-derived SMC
    - Use of in situ from International Soil Moisture Networks (https://ismn.earth/en/networks/)

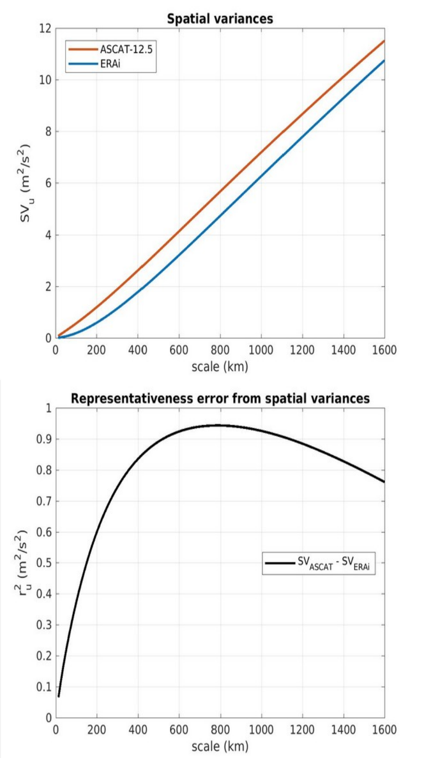


Representativeness error estimation

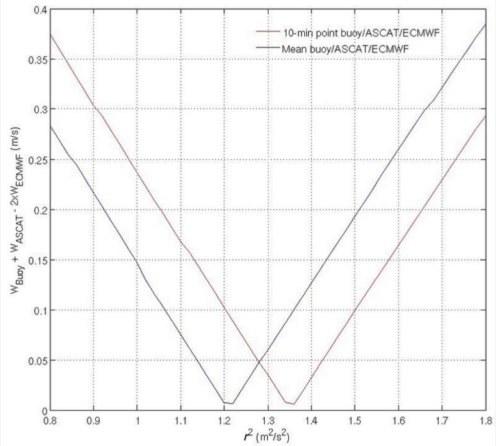
Wind spectra



Spatial variances

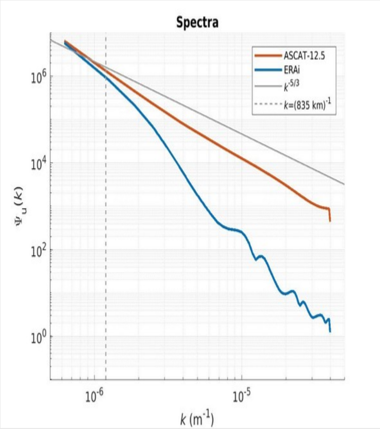


Intercalibration



Additional validation activities

- Spectral and spatial variance analyses to assess the geophysical consistency of the L2 OCN OSVW fields, the presence of noise, and their ability to resolve small-scale wind variance



- Direct comparisons between SAR-derived geophysical products and in-situ measurements

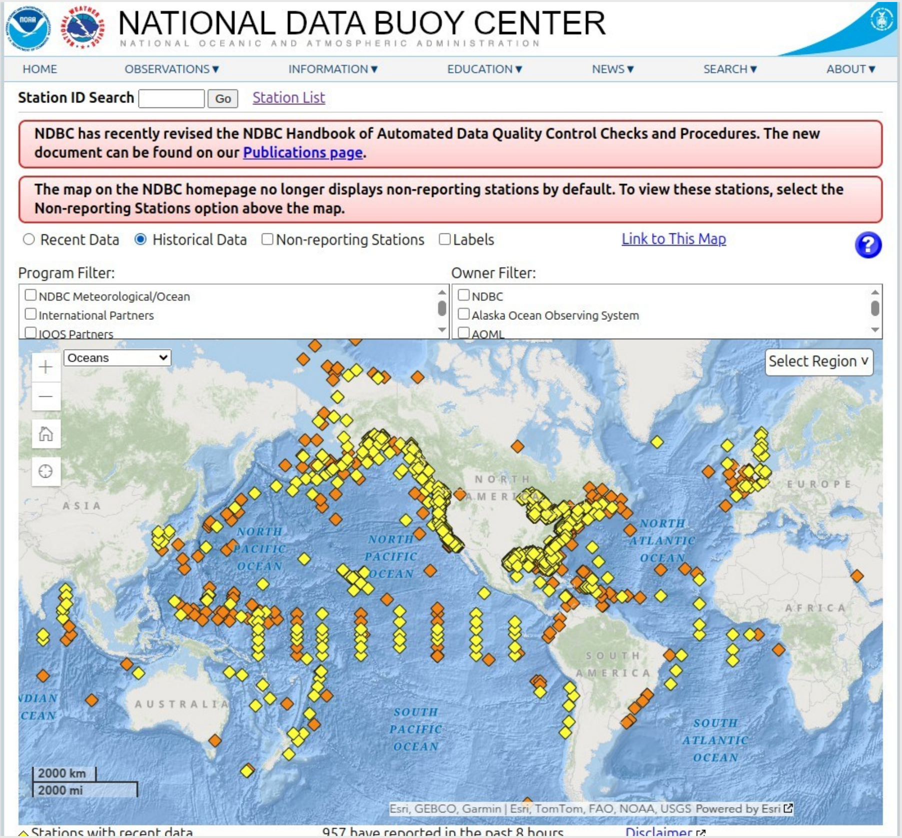
BEC
Barcelona Expert Center

FRM definition and characteristics

- Reference records for Cal/Val of satellite instruments
- Ground-based and airborne measurements (*in-situ*)
- Independent, tailored, and fully characterized measurements
- Ensure accuracy, reliability and consistency in satellite data over time
- Gold standard to assess EO dataset accuracy and quality

[1] Goryl P, Fox N, Donlon C, Castracane P. Fiducial Reference Measurements (FRMs): What Are They? Remote Sensing. 2023; 15(20):5017. https://doi.org/10.3390/rs15205017.

National Data Buoy Center

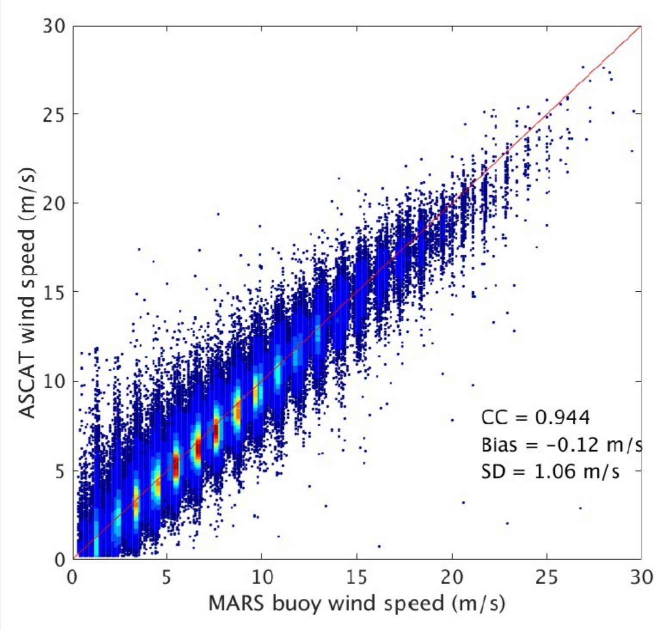


- OSVW
- Wave spectra (→ SWH)
- Ancillary information to compute stress-equivalent winds
- Several programs: NDBC, TAO, etc. covering the entire globe
- Availability of historical data
- Quality Control (NDBC Technical Document 09-02)
- Available also from ECMWF-MARS archive

(https://www.ndbc.noaa.gov/)

BEC
Barcelona Expert Center

Scatterometer-derived winds

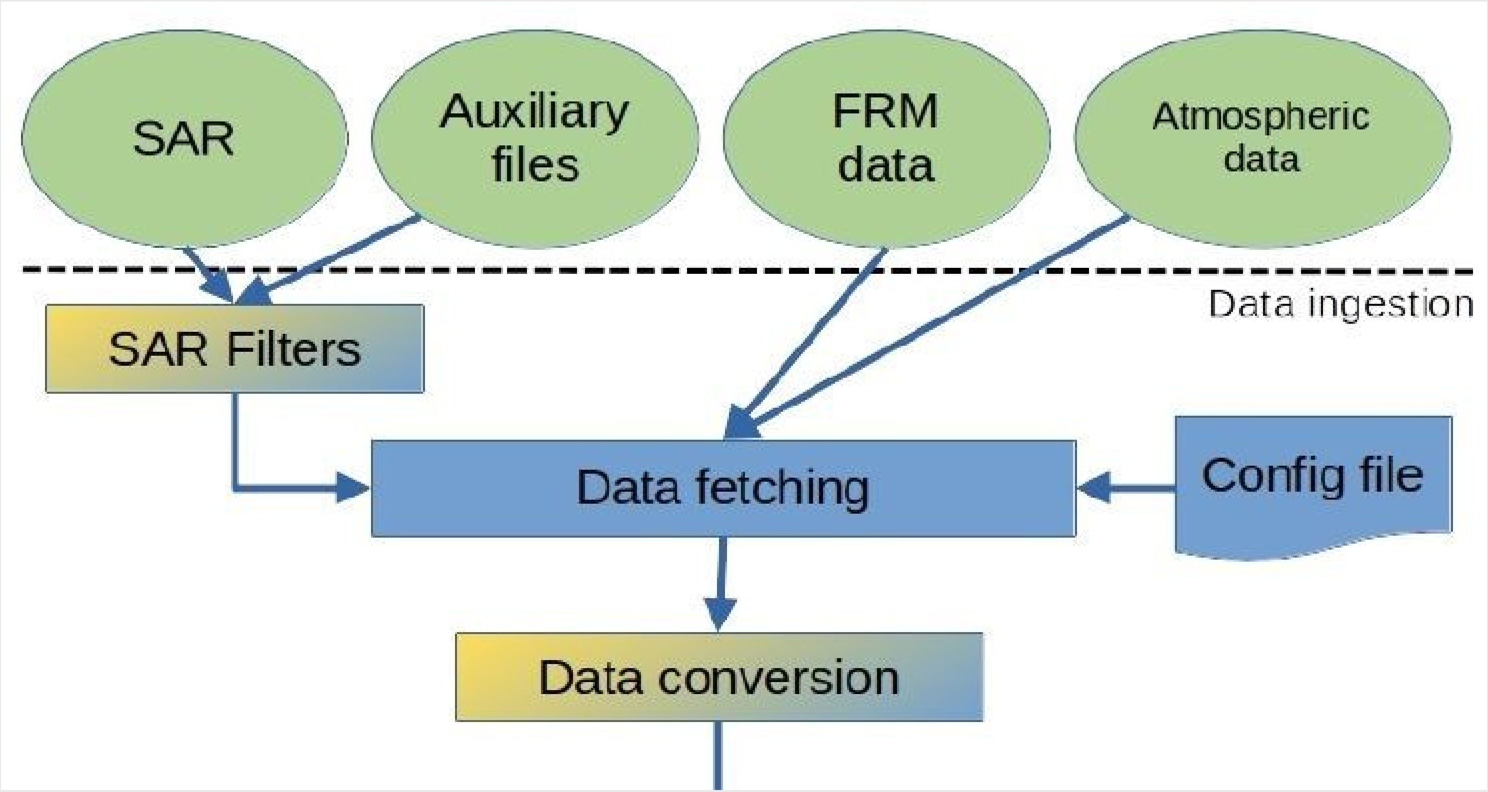


Scatter–density plot of ASCAT U10S wind speed versus MARS buoy U10N wind speed. The scores of the CC, the bias, and the SD of the speed differences are shown in the legend. A total of 300,000 collocations are shown over the period 2009-2014. [4]

- Accuracy: ±1 ms^{-1}, ±20^{o}
- Accuracy stability over decades
- Large constellation: 8 scats
- Collocated with ECMWF U10S winds
- Period: 2007-present
- Data available @ ICM-CSIC

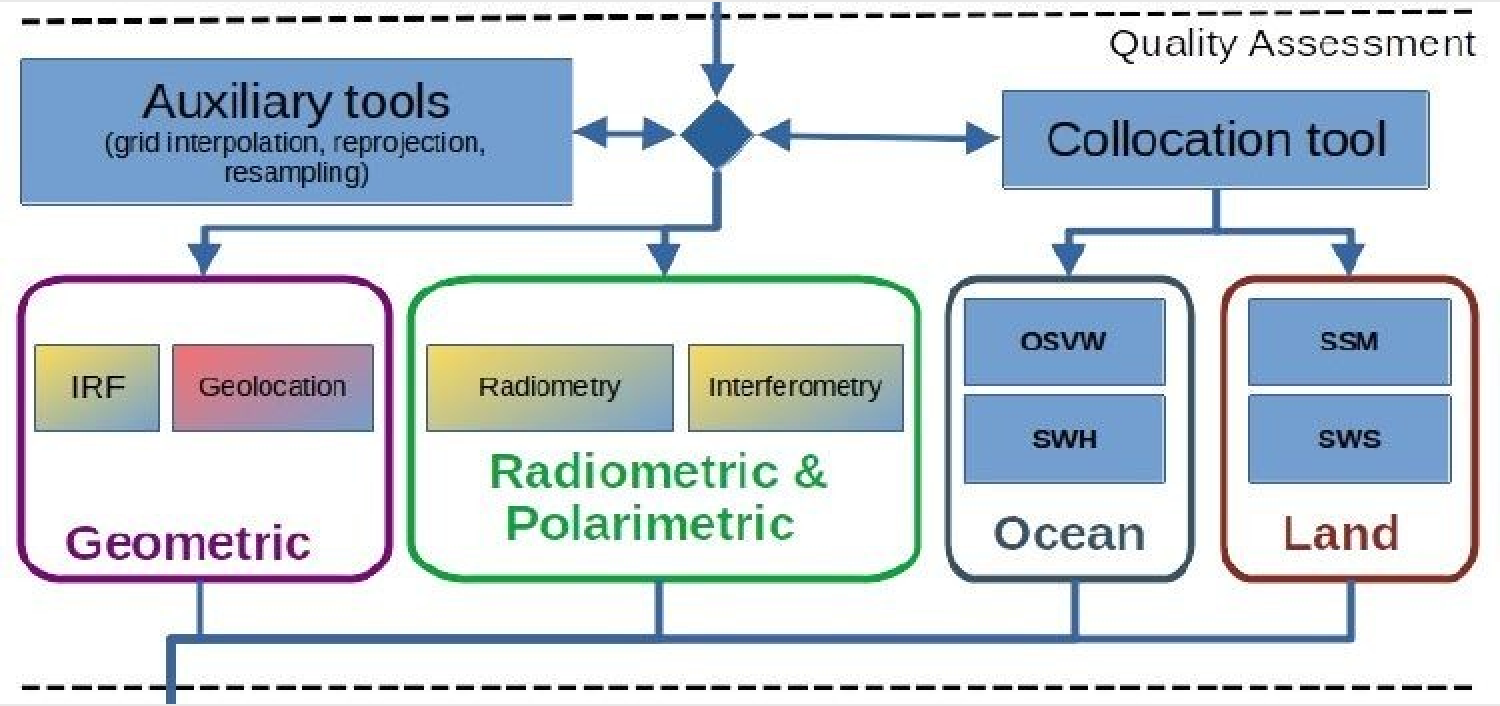
[4] F. Polverari et al., ”On High and Extreme Wind Calibration Using ASCAT,” in IEEE Transactions on Geoscience and Remote Sensing, vol. 60, pp. 1-10, 2022, Art no. 4202210, doi: 10.1109/TGRS.2021.3079898.

Canvas tool - Data ingestion



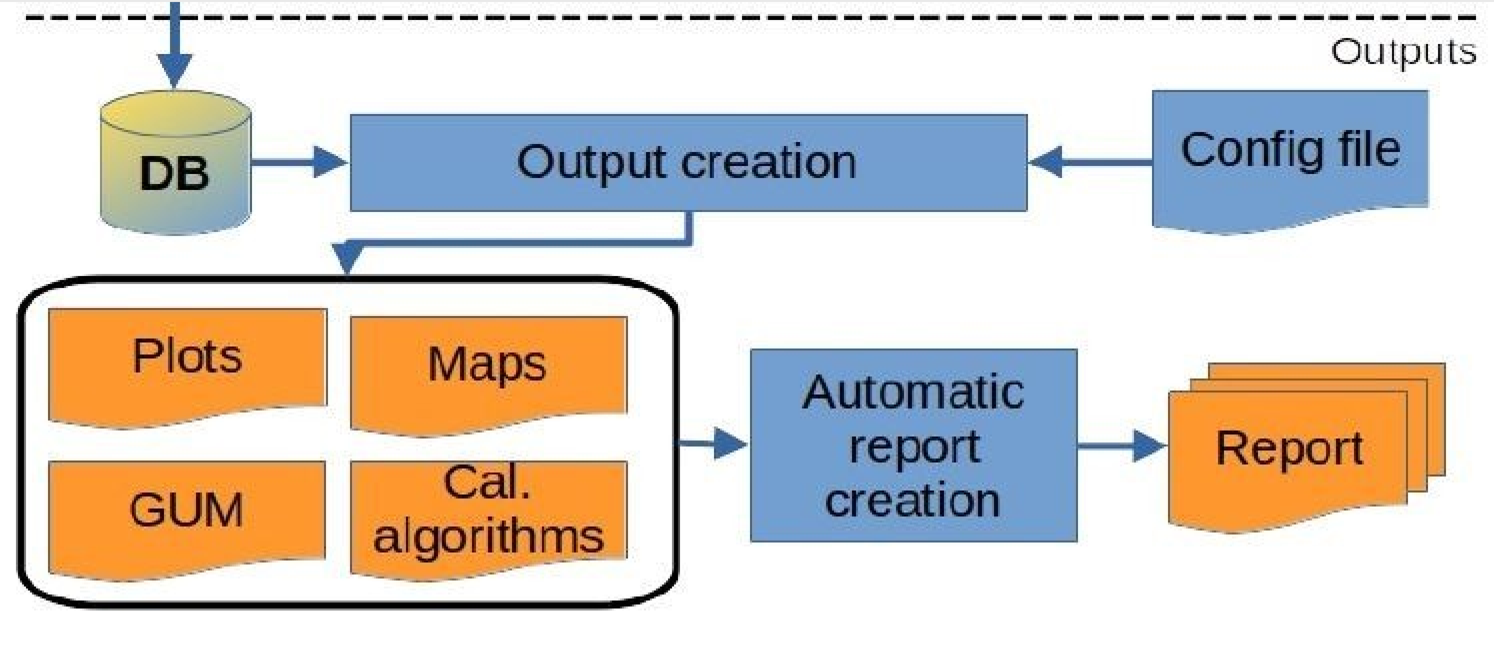
Despite of being developed for SAR, the tool can be used for any other L2 product

Canvas tool - Quality assessment



Despite of being developed for SAR, the tool can be used for any other L2 product

Canvas tool - Outputs



Despite of being developed for SAR, the tool can be used for any other L2 product

Ongoing work

- Review Cal/Val procedures, GUM and FRM
- Development the tool

Future work

- Show-case study for Sentinel-1 (or other)
- Investigate the possibility of SAR cross-calibration and cross-validation between different instruments/missions

Questions?