# The ALES+ SAR Service for Cryosat-2 and Sentinel-3 at ESA GPOD

M. Passaro[1], M. Restano[2], G. Sabatino[3], Carla Orrú[3] and J. Benveniste[4]

[1] DGFI-TUM , Arcisstraße 21, 80333 Munich, Germany
[2] Serco c/o ESA-ESRIN, Largo Galileo Galilei 1, 00044 Frascati, Italy,
[3] Progressive Systems/ESRIN, Frascati, Italy,
[4] ESA-ESRIN, Largo Galileo Galilei 1, 00044 Frascati, Italy

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# Summary

- The ALES+ SAR retracker
- Validation Activity - Area of Interest & Available Data
- Methodology
- Results
- Conclusions & the ALES+ SAR in GPOD

# The ALES+ retracker

- Water level from sea ice-covered oceans is particularly challenging to retrieve with satellite radar altimeters due to the different shapes assumed by the returned signal compared with the standard open ocean waveforms. Valid measurements are scarce in large areas of the Arctic and Antarctic Oceans, because sea level can only be estimated in the openings in the sea ice (leads and polynyas). Similar signal-related problems affect also measurements in coastal and inland waters.

- In Passaro et. al 2018, the ALES+ retracking strategy, based on a sub-waveform retracker that is able to adapt the fitting of the signal depending on the sea state and on the slope of its trailing edge, was presented. The algorithm modifies the existing Adaptive Leading Edge Subwaveform retracker originally designed for coastal waters (Passaro et. al, 2014), and was applied to ENVISAT and ERS-2 missions.

- In the frame of the current ESA Baltic+ SEAL project (http://balticseal.eu/), the ALES+ retracker has been further developed and extended to all the missions considered (ERS-2, ENVISAT, Jason-1/2/3, SARAL/AltiKa, Cryosat-2, Sentinel-3A/B).

# The ALES+ SAR retracker

In particular,

- **ALES+ for LRM** is based on the Brown-Hayne (Brown, 1977; Hayne, 1980) functional form that models the radar returns from the ocean to the satellite.

- **ALES+ for SAR** adopts a simplified version of the Brown-Hayne functional form as an empirical retracker to track the leading edge of the waveform. This empirical application of the Brown-Hayne model implies that ALES+ cannot estimate a physical value of SWH and of $\sigma 0$. Nevertheless, the retracker is fully able to track the mid-point of the leading edge.

It is important to underline that in the original SAR altimetry products, the Sea State Bias correction is either missing (Cryosat-2) or computed using the Jason model.

In the Baltic+ SEAL Project instead, a first SSB model is computed specifically for the ALES+ SAR retracker.

More information on the ALES+ retracker can be found in the Algorithm Theoretical Baseline Document (ATBD) of the Baltic+ SEAL project.

# Validation Activity

# Area of Interest & Available Data

# Area of Interest & Available Sentinel-3A Data

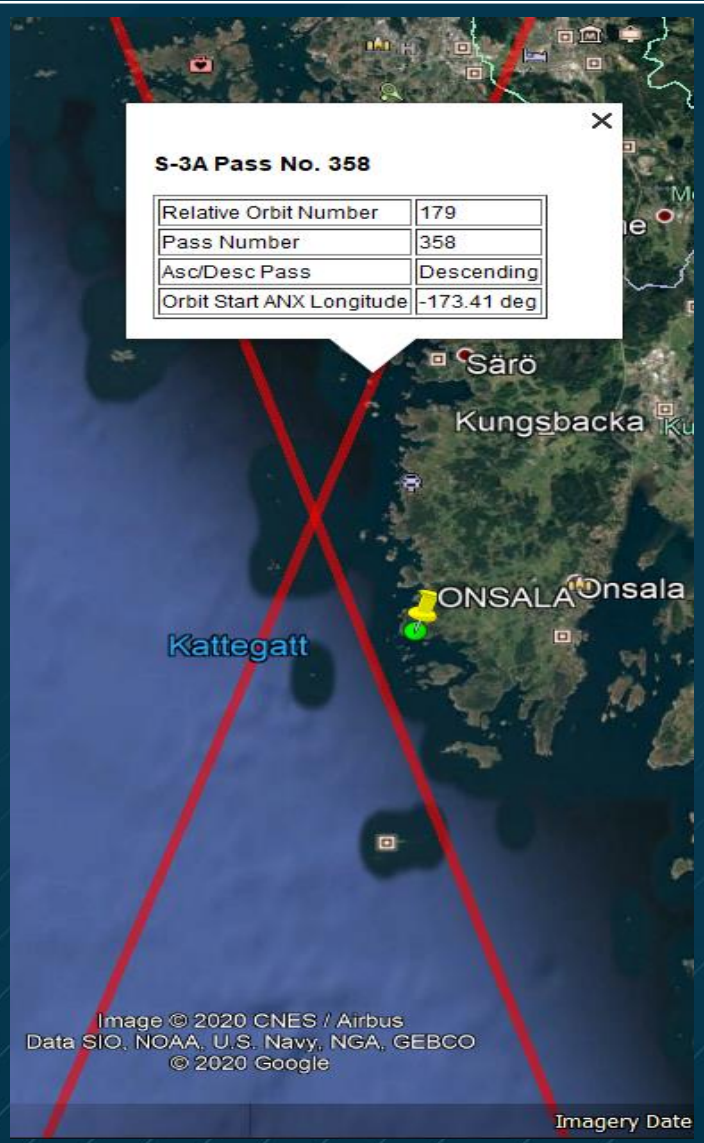
- Onsala
- TG providing hourly data.

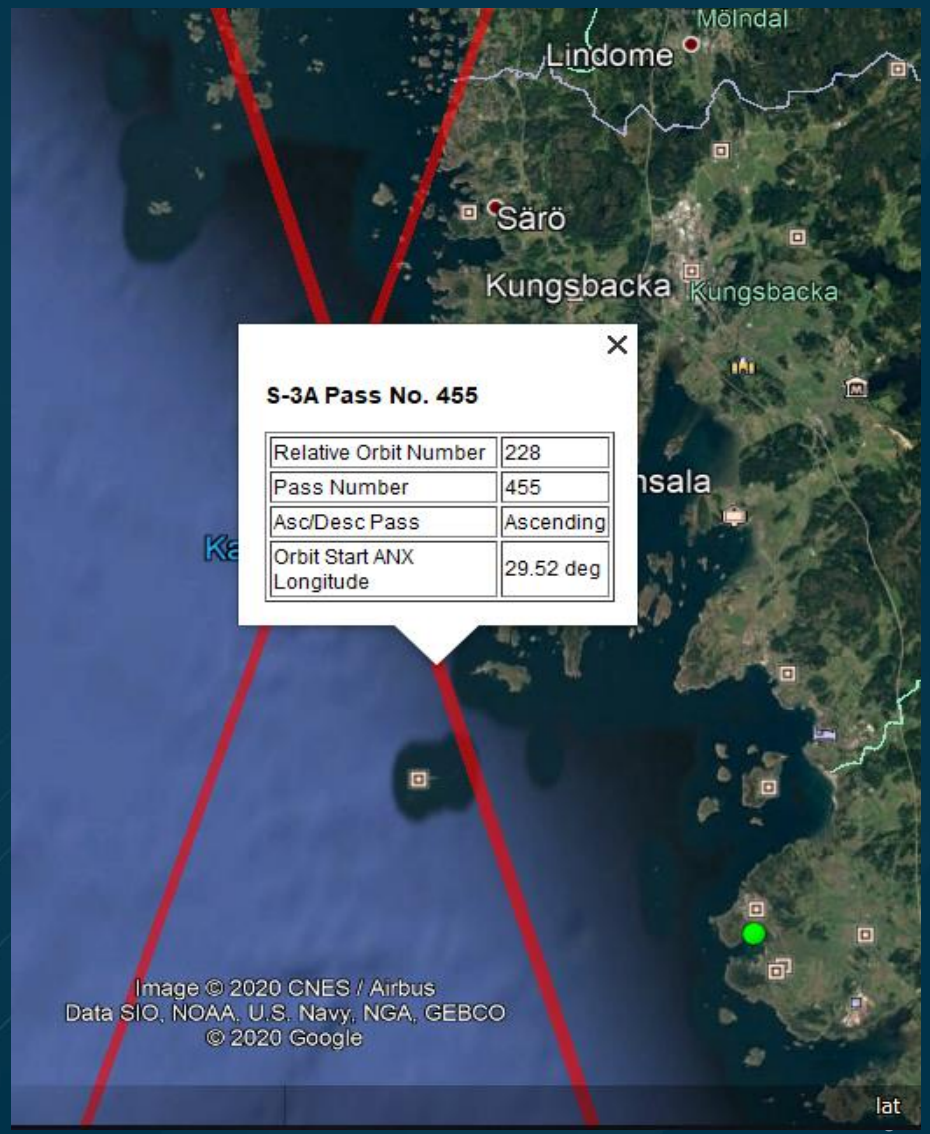
- 2 orbits available (179,228)

- 33 tracks (ascending)
- 33 tracks (descending)

- B+S ALES+ SAR & TG data correctly downloaded from the Project website.

- Validation data downloaded from the ESA GPOD SARvatore for Sentinel-3 online & on demand processing system.



# Area of Interest & Available Data (2)

- ESA GPOD SARvatore for S3A data have been processed using the "Coastal Zone" processing profile and the SAMOSA+ analytical retracker.

**L1B Processor:**

- **Data Posting Rate**

Flag to set the data posting rate: 20 Hz (canonic posting rate) or 80 Hz (finer posting rate) — 20 Hz

- **Range Walk Correction**

Flag to set the application of the Range Walk on the burst data — No

- **Hamming Weighting Window**

Flag to set the application of the Hamming Weighting Window on the burst data (section 4.4 in REF1) — Apply only in coast

- **Exact Beam-Forming**

Flag to set the application of exact or approximated Doppler Beam Steering (section 4.4 in REF1) — Approximated

- **FFT Zero-Padding**

Flag to operate the Zero-Padding prior to the range FFT (section 4.8 in REF1). Zero-Padding is indicated for coastal zone analysis — Yes, apply Zero-Pa

- **Radar Receiving Window Size**

Flag to select the size of the radar receiving window: 128 range bins (standard) or 128 x N range bins (extended N times). Extended window with N=2 is indicated for coastal zone and sea ice analysis. N>2 may be indicated only for inland water over very steep topographic regions. — 128x2 range bins (

- **Stack Subset**

Subset the Stack to Looks: [100, 120, 140, 160, 180, ALL] — ALL

- **Antenna Pattern Compensation**

Flag to activate the antenna pattern compensation on the Stack Data — No

- **Dump SAR Stack Data in output**

Flag to dump the SAR Stack Data in the output package. Be aware that SAR Stack Data are bulky data products (around 1 GB for single pass); do not process them massively but limit yourself at around 10/20 passes at the time — No

**L2 Processor:**

- **Restrict the re-tracking on specific surfaces**

Flag to limit the processing on open sea or on water (open sea, coastal zone and inland water) or to process the full pass — Process only water

- **PTR width alphap parameter**

Use a LUT (Look-Up Table) or a constant for PTR (Point Tartet Response) alphap parameter — LUT

- **SAMOSA Model Generation**

Flag to select the generation of the SAMOSA model to use in the re-tracking. SAMOSA3 is a truncated version (only zero order term) of SAMOSA2 (REF2), SAMOSA+ is the SAMOSA2 model tailored for inland water, sea ice and coastal zone domain — Use SAMOSA+

Use SAMOSA2
Use SAMOSA3
Use SAMOSA+
Use SAMOSA++

- **Dump RIP in output**

Flag to append Range Integrated Power (RIP) in the output netCDF data product

- **Dump SAR Echo Waveforms in output**

Flag to append the SAR Echo Waveforms in the output netCDF data product

- **Single-look or Multi-look Model**

Flag to set the application of the Model Multilooking (Single-Look or Multi-Look). Single-Look option is indicated for quick look operations while Multi-Look is the most accurate — Multi-look

- **Choose the default Tide Model**

Choose the default Tide model between FES2014b, TPXO8-ATLAS and TPXO9-ATLAS — FES2014b

- **Choose the default Mean Sea Surface Model**

Choose the default Mean Sea Surface Model between DTU18, DTU15 and CLS-CNES15 — DTU18

# Methodology (1) – Evaluation of SLA

- SLAio from Dinardo et al. 2020 has been computed to compare to TG data:

$$\begin{aligned} SSHi = {} & h - R - dry\_tropo - wet\_trop - load\_tide \\ & - iono\_delay - solidearth\_tide - 0.468 \\ & \cdot pole\_tide - ssb \end{aligned}$$

$$SLAio = SSHi - MSS - equi\_tide$$

- The fields in yellow have been extracted from the GPOD SARvatore 1Hz data interpolating on the respective 20Hz latitudes.

R & ssb are taken from the respective datasets.
MSS is from the B+S project (v2)

# Methodology (2) – Evaluation of SLA

**Filtering strategy**:

- 1st : misfit filtering (GPOD data misfit<3, ALES+ SAR ralterr<0.1, as suggested in the B+S user manual) and excluding all points for which |SLAio| > 2 m.

- 2nd: Data are grouped in terms of distance to the TG from 0 to 50km in 5 km sectors and filtered in each sector independently excluding values outside the **median** ± 3 times the standard deviation. The number of accepted points, their median & demeaned values are later calculated for each 5km interval.

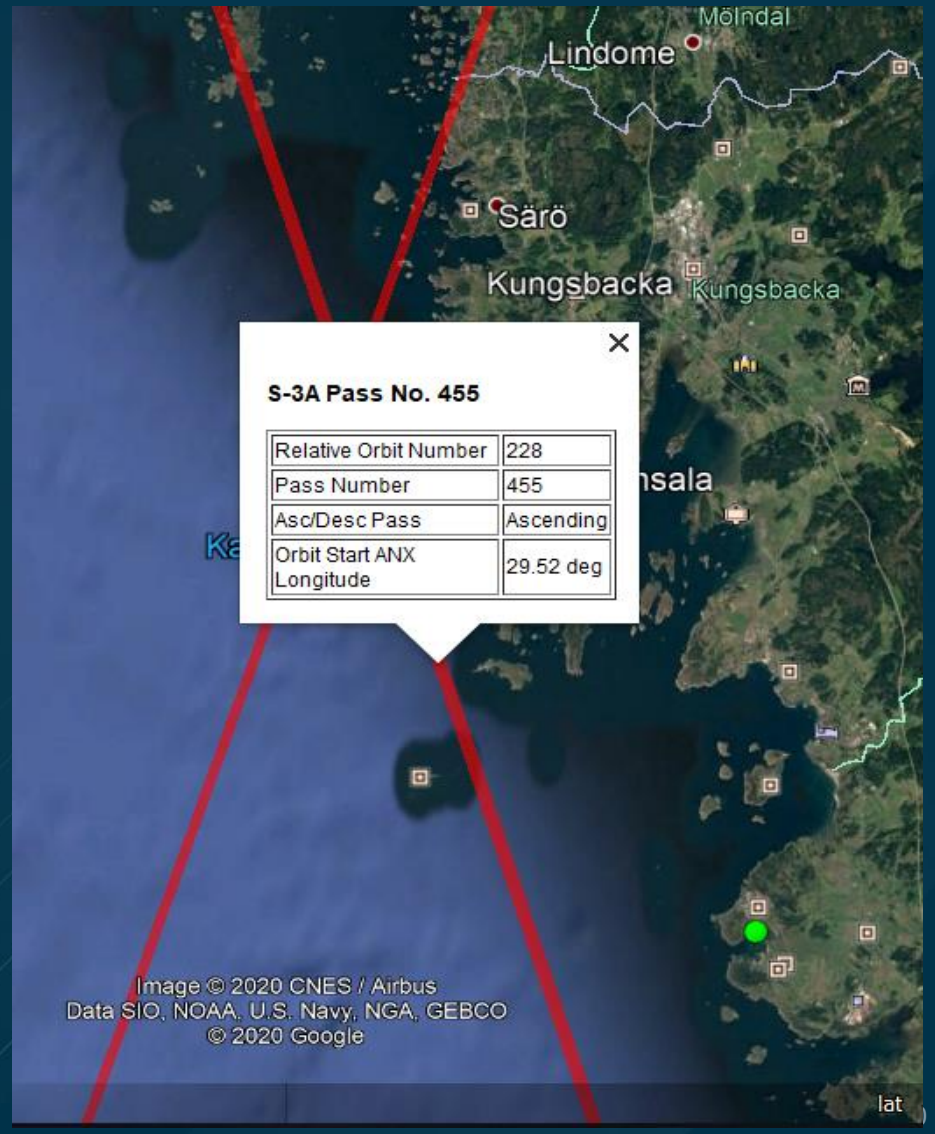
**Validation strategy**:

- Each altimetry pass lasts a few minutes. TG data are sampled hourly which is not optimal.

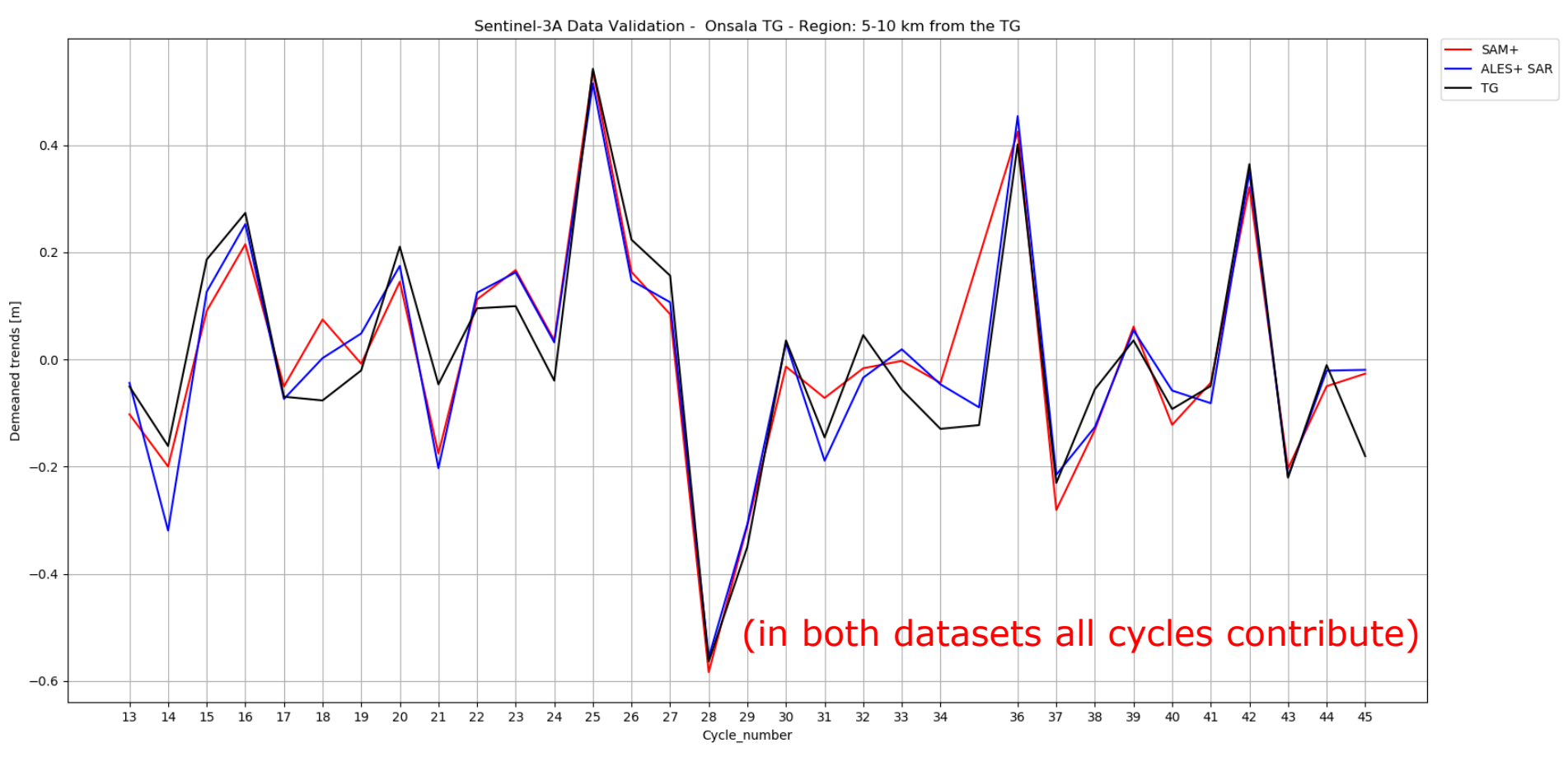
- Following what done in Dinardo et al. 2020: *"**For a given in situ station, the lag in time between in situ and altimeter data is selected to be less than 30 min**."*

- Correlation 'r' and RMSE are evaluated between filtered altimetry data and TG data.

# Results – Multiple Tracks
# 33 Ascending Tracks

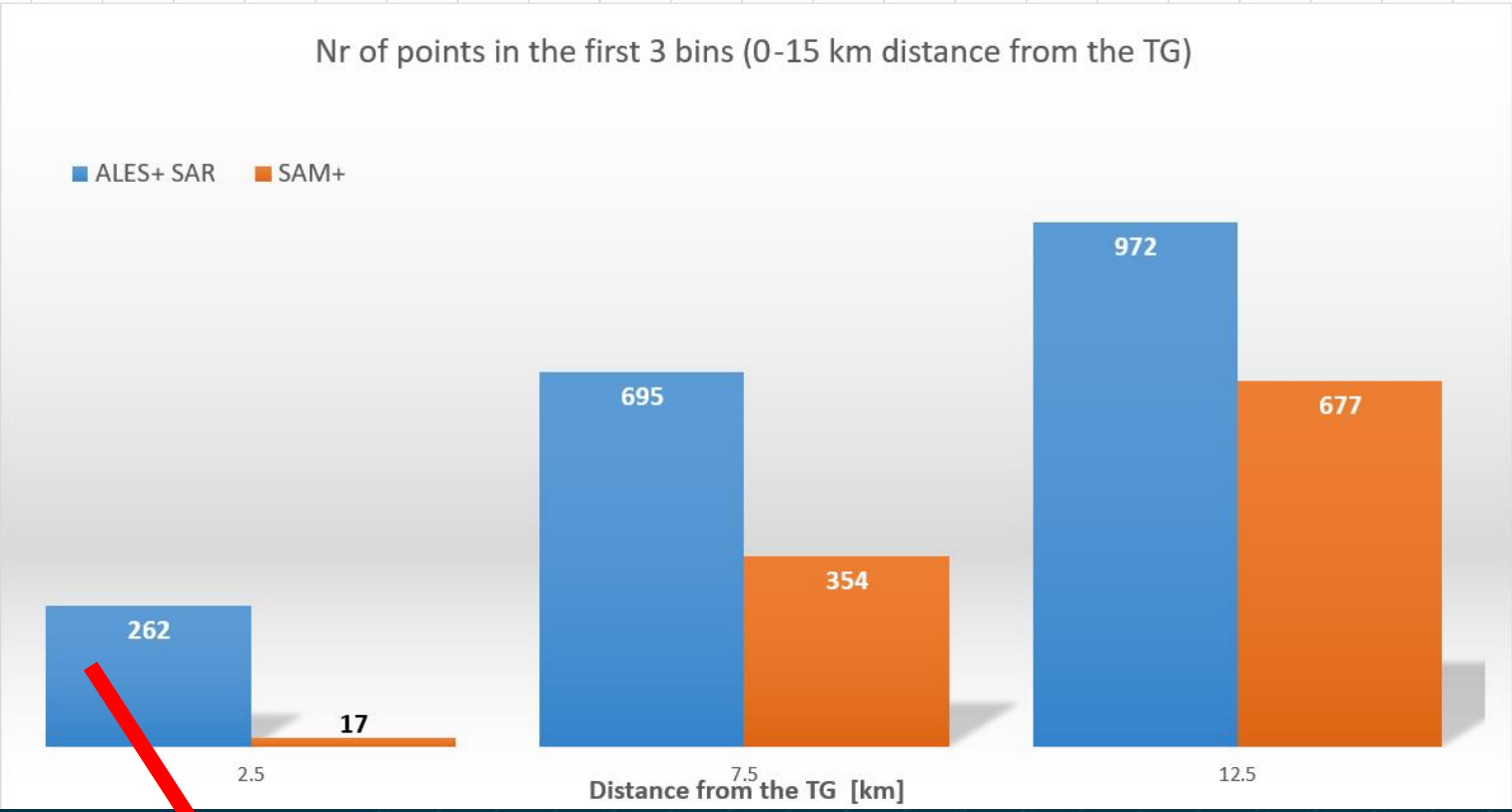


# Results: 5-10Km sector




ALES+ SAR: r= 0.95216 RMSE: 0.06636
SAM+ : r= 0.95222 RMSE: 0.06650

# Results closer to the coast: 0-5Km



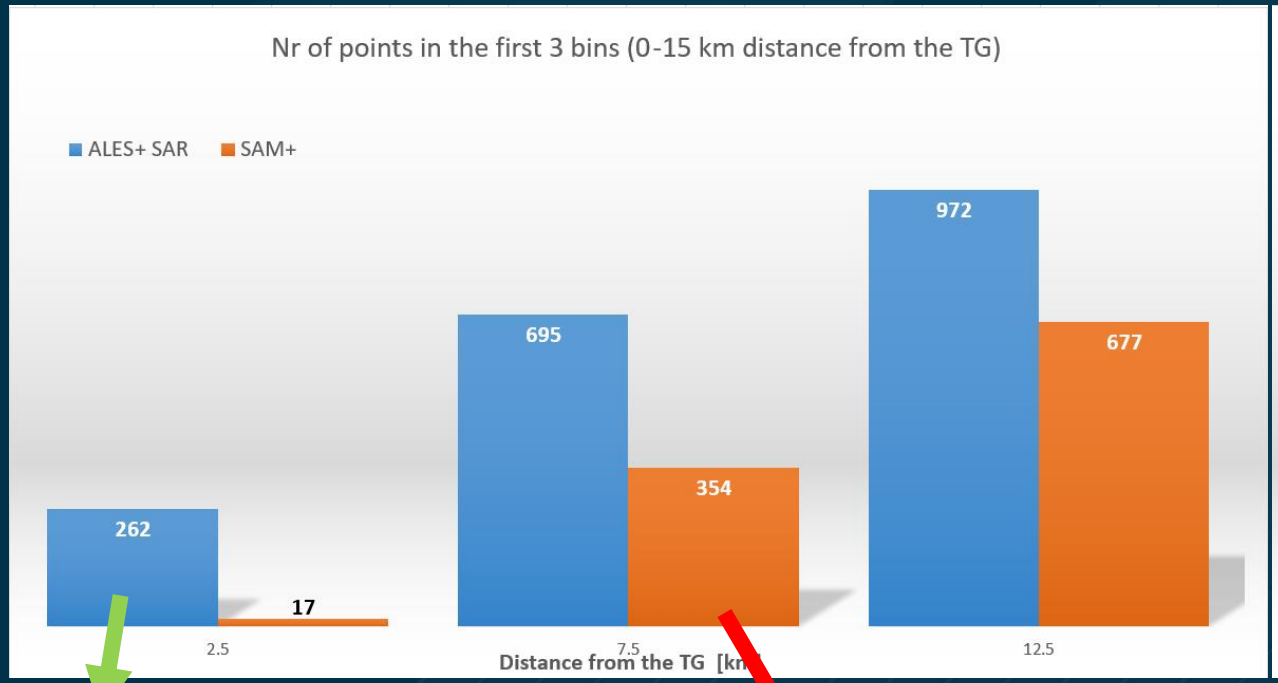

ALES+ SAR: r= 0.780 RMSE: 0.227 m (all cycles)
SAM+ : r= 0.996 RMSE: 0.027 m (4 cycles)

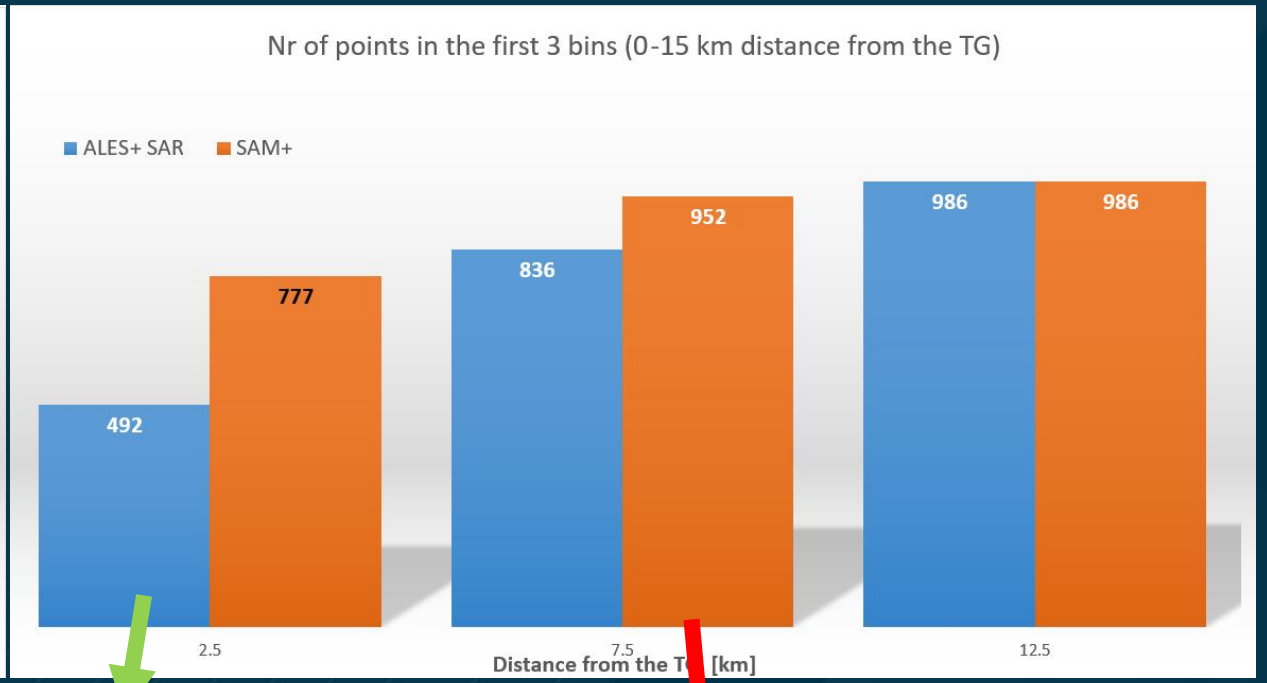
| ALES RMSE | | | |
|---|---|---|---|
| Cycle Nr. | Pass Nr. | 0-5 km | 5-10km |
| 13 | 455 | 0.098 | 0.167 |
| 14 | 455 | 0.371 | 0.142 |
| 15 | 455 | 0.470 | 0.088 |
| 16 | 455 | 0.055 | 0.087 |
| 17 | 455 | 0.097 | 0.064 |
| 18 | 455 | 0.116 | 0.072 |
| 19 | 455 | 0.541 | 0.102 |
| 20 | 455 | 0.344 | 0.127 |
| 21 | 455 | 0.338 | 0.306 |
| 22 | 455 | 0.354 | 0.143 |
| 23 | 455 | 0.209 | 0.059 |
| 24 | 455 | 0.210 | 0.156 |
| 25 | 455 | 0.718 | 0.069 |
| 26 | 455 | 0.238 | 0.125 |
| 27 | 455 | 0.092 | 0.102 |
| 28 | 455 | 0.266 | 0.060 |
| 29 | 455 | 0.079 | 0.094 |
| 30 | 455 | 0.061 | 0.110 |
| 31 | 455 | 0.392 | 0.124 |
| 32 | 455 | 0.400 | 0.070 |
| 33 | 455 | 0.363 | 0.063 |
| 34 | 455 | 0.378 | 0.109 |
| 35 | 455 | 0.142 | 0.157 |
| 36 | 455 | 0.116 | 0.101 |
| 37 | 455 | 0.158 | 0.074 |
| 38 | 455 | 0.234 | 0.049 |
| 39 | 455 | 0.501 | 0.067 |
| 40 | 455 | 0.296 | 0.120 |
| 41 | 455 | 0.350 | 0.203 |
| 42 | 455 | 0.087 | 0.065 |
| 43 | 455 | 0.428 | 0.051 |
| 44 | 455 | 0.144 | 0.073 |
| 45 | 455 | 0.451 | 0.088 |

| SAM+ RMSE | | | |
|---|---|---|---|
| Cycle Nr. | Pass Nr. | 0-5 km | 5-10km |
| 13 | 455 | nan | 0.125 |
| 14 | 455 | nan | 0.047 |
| 15 | 455 | 0.026219 | 0.075 |
| 16 | 455 | 0.07409 | 0.095 |
| 17 | 455 | nan | 0.059 |
| 18 | 455 | nan | 0.089 |
| 19 | 455 | nan | 0.033 |
| 20 | 455 | nan | 0.075 |
| 21 | 455 | nan | 0.025 |
| 22 | 455 | nan | 0.162 |
| 23 | 455 | nan | 0.086 |
| 24 | 455 | nan | 0.068 |
| 25 | 455 | nan | 0.088 |
| 26 | 455 | nan | 0.096 |
| 27 | 455 | 0.043293 | 0.085 |
| 28 | 455 | nan | 0.027 |
| 29 | 455 | nan | 0.141 |
| 30 | 455 | nan | 0.160 |
| 31 | 455 | nan | 0.109 |
| 32 | 455 | nan | 0.039 |
| 33 | 455 | nan | 0.040 |
| 34 | 455 | nan | 0.047 |
| 35 | 455 | nan | nan |
| 36 | 455 | 0.062058 | 0.107 |
| 37 | 455 | nan | 0.098 |
| 38 | 455 | nan | 0.080 |
| 39 | 455 | nan | 0.048 |
| 40 | 455 | nan | 0.137 |
| 41 | 455 | nan | 0.080 |
| 42 | 455 | nan | 0.071 |
| 43 | 455 | nan | 0.056 |
| 44 | 455 | nan | 0.094 |
| 45 | 455 | nan | 0.068 |

# With (left) & Without (right) MISFIT filtering:

## Filtering on SLA & Median +/-3*STD is sufficient to obtain good results.

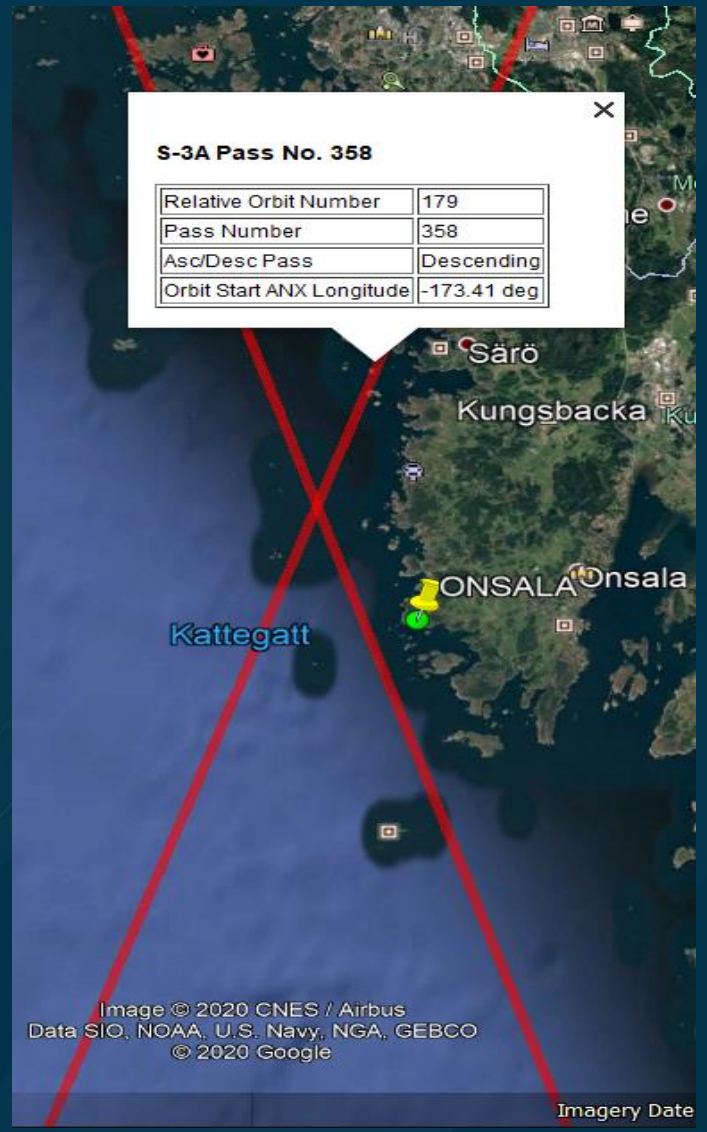


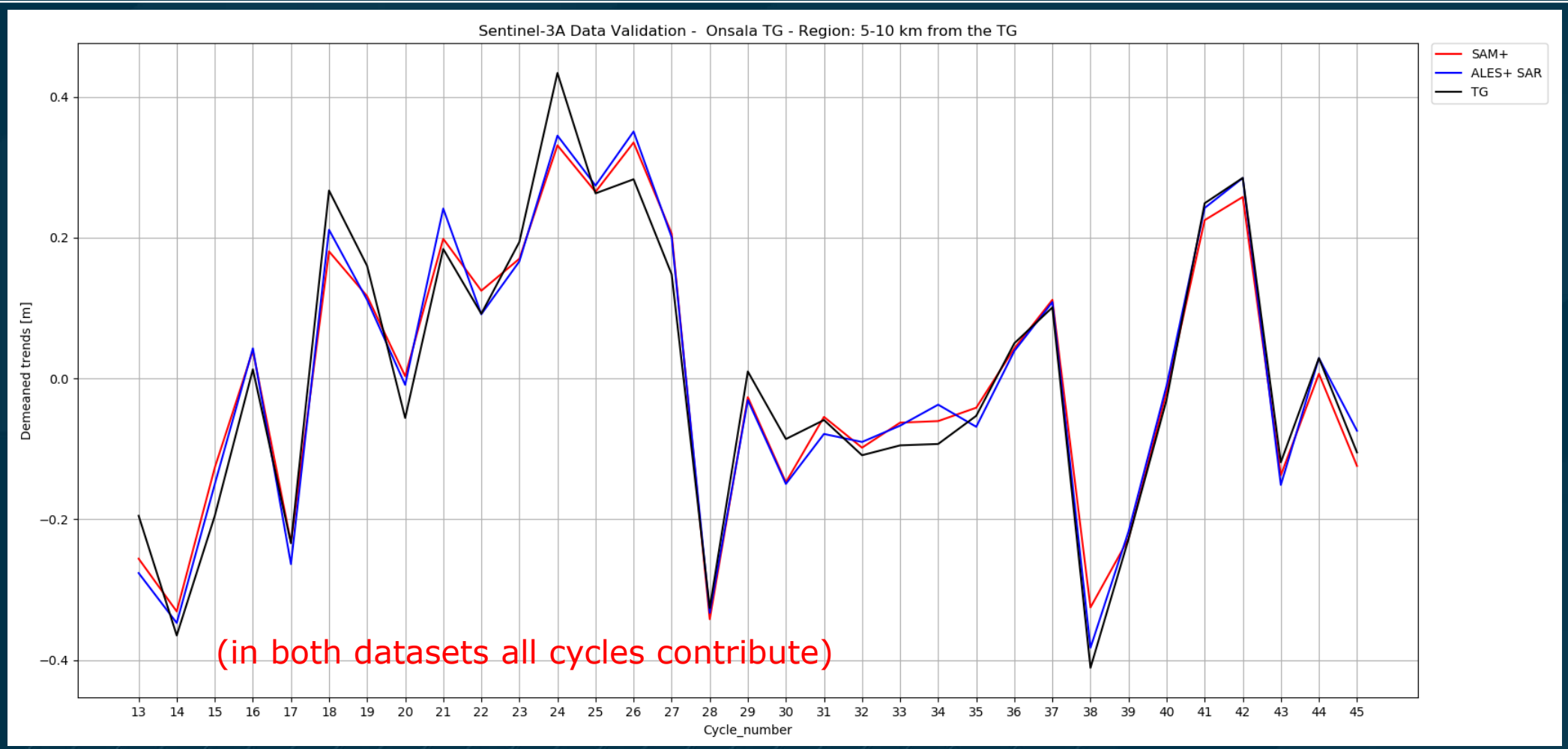

ALES+ SAR: r= 0.780 RMSE: 0.227 m
SAM+ : r= 0.996 RMSE: 0.027 m
ALES+ SAR: r= 0.95216 RMSE: 0.06636
SAM+ : r= 0.95222 RMSE: 0.06650

ALES+ SAR: r= 0.842 RMSE: 0.182 m
SAM+ : r= 0.857 RMSE: 0.160 m
ALES+ SAR: r= 0.9392 RMSE: 0.0767
SAM+ : r= 0.9555 RMSE: 0.0638

# Results – Multiple Tracks
# 33 Descending Tracks



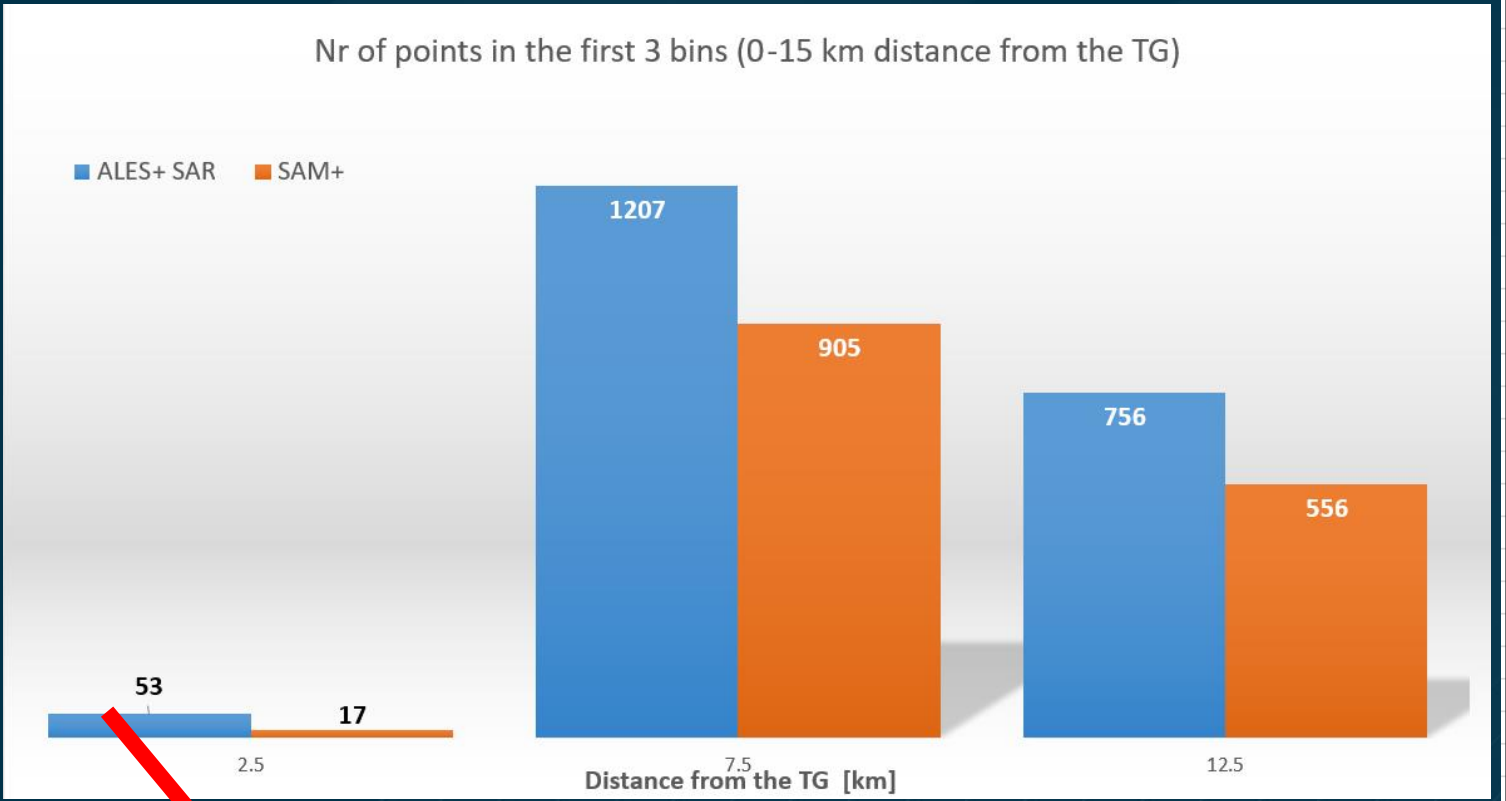
# Results: 5-10Km sector




ALES+ SAR: r= 0.9807 RMSE: 0.03972

SAM+/++ : r= 0.9786 RMSE: 0.04247

# Results: 0-5Km sector



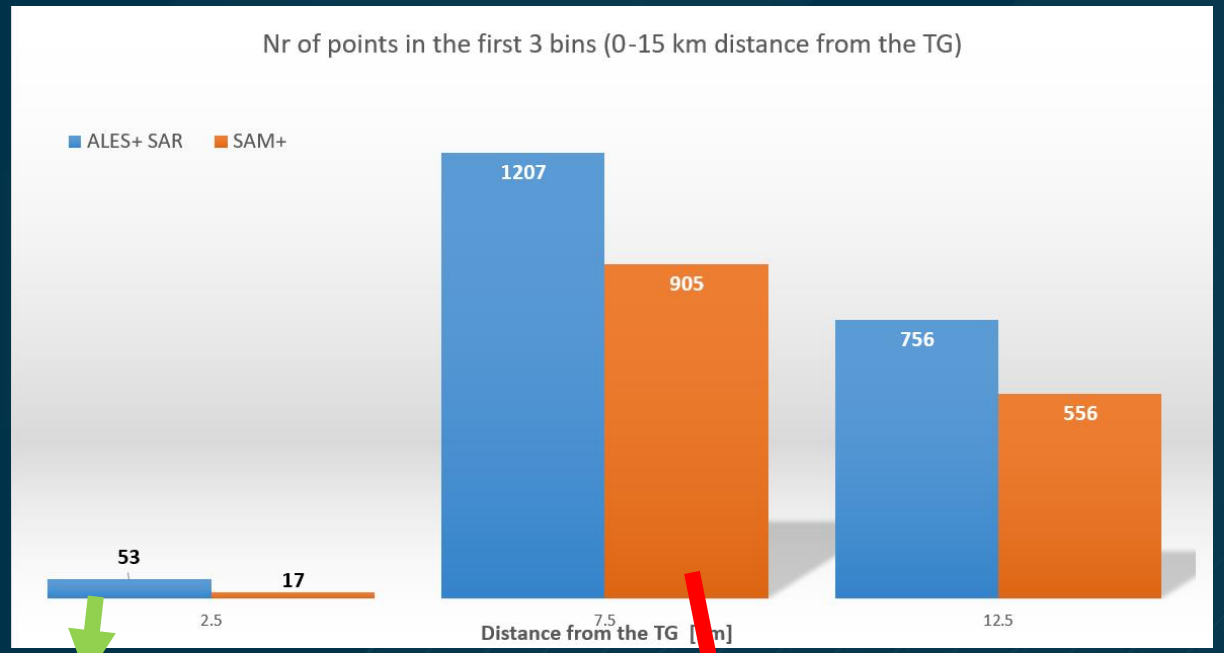

ALES+ SAR: r= 0.9792 RMSE: 0.042 m (7 cycles)
SAM+ : r= 0.9632 RMSE: 0.062 m (5 cycles)

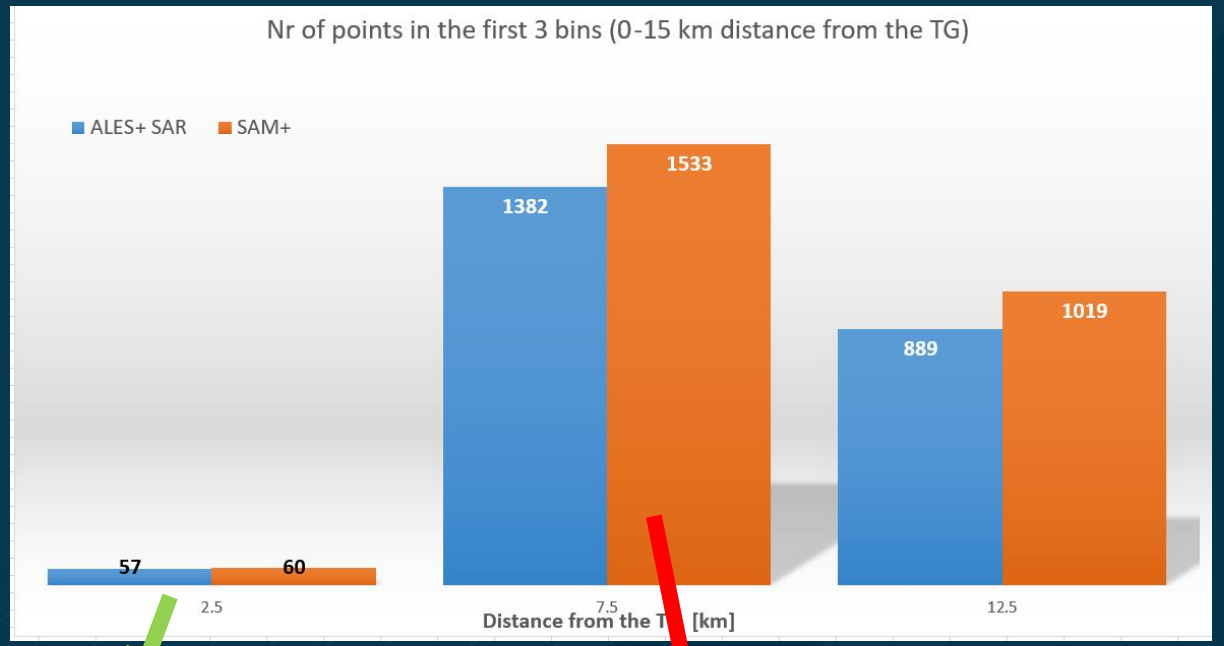
| ALES RMSE | | | |
|---|---|---|---|
| Cycle Nr. | Pass Nr. | 0-5 km | 5-10km |
| 13 | 358 | nan | 0.027 |
| 14 | 358 | nan | 0.034 |
| 15 | 358 | nan | 0.030 |
| 16 | 358 | 0.049 | 0.040 |
| 17 | 358 | nan | 0.042 |
| 18 | 358 | nan | 0.062 |
| 19 | 358 | nan | 0.039 |
| 20 | 358 | nan | 0.037 |
| 21 | 358 | nan | 0.062 |
| 22 | 358 | 0.035 | 0.089 |
| 23 | 358 | nan | 0.043 |
| 24 | 358 | nan | 0.060 |
| 25 | 358 | nan | 0.062 |
| 26 | 358 | 0.006 | 0.158 |
| 27 | 358 | nan | 0.043 |
| 28 | 358 | nan | 0.040 |
| 29 | 358 | 0.076 | 0.036 |
| 30 | 358 | nan | 0.059 |
| 31 | 358 | nan | 0.053 |
| 32 | 358 | nan | 0.046 |
| 33 | 358 | nan | 0.039 |
| 34 | 358 | nan | 0.048 |
| 35 | 358 | 0.052 | 0.066 |
| 36 | 358 | nan | 0.054 |
| 37 | 358 | nan | 0.040 |
| 38 | 358 | nan | 0.075 |
| 39 | 358 | 0.041 | 0.083 |
| 40 | 358 | 0.015 | 0.051 |
| 41 | 358 | nan | 0.041 |
| 42 | 358 | nan | 0.053 |
| 43 | 358 | nan | 0.029 |
| 44 | 358 | nan | 0.043 |
| 45 | 358 | nan | 0.034 |

| SAM+ RMSE | | | |
|---|---|---|---|
| Cycle Nr. | Pass Nr. | 0-5 km | 5-10km |
| 13 | 358 | nan | 0.038 |
| 14 | 358 | nan | 0.034 |
| 15 | 358 | nan | 0.055 |
| 16 | 358 | 0.080052 | 0.059 |
| 17 | 358 | nan | 0.037 |
| 18 | 358 | nan | 0.075 |
| 19 | 358 | nan | 0.050 |
| 20 | 358 | nan | 0.050 |
| 21 | 358 | nan | 0.071 |
| 22 | 358 | nan | 0.066 |
| 23 | 358 | nan | 0.052 |
| 24 | 358 | nan | 0.068 |
| 25 | 358 | nan | 0.070 |
| 26 | 358 | 0.01004 | 0.045 |
| 27 | 358 | nan | 0.044 |
| 28 | 358 | nan | 0.056 |
| 29 | 358 | 0.015181 | 0.057 |
| 30 | 358 | nan | 0.048 |
| 31 | 358 | nan | 0.038 |
| 32 | 358 | nan | 0.049 |
| 33 | 358 | nan | 0.047 |
| 34 | 358 | nan | 0.038 |
| 35 | 358 | 0.075338 | 0.092 |
| 36 | 358 | nan | 0.059 |
| 37 | 358 | nan | 0.045 |
| 38 | 358 | nan | 0.113 |
| 39 | 358 | 0.064609 | 0.071 |
| 40 | 358 | nan | 0.056 |
| 41 | 358 | nan | 0.075 |
| 42 | 358 | nan | 0.072 |
| 43 | 358 | nan | 0.049 |
| 44 | 358 | nan | 0.061 |
| 45 | 358 | nan | 0.050 |

# With (left) & Without (right) MISFIT filtering:

## Filtering on SLA & Median +/-3*STD is sufficient to obtain good results.




ALES+ SAR: r= 0.9792 RMSE: 0.042 m
SAM+ : r= 0.9632 RMSE: 0.062 m

ALES+ SAR: r= 0.9807 RMSE: 0.03972
SAM+ : r= 0.9786 RMSE: 0.04247

ALES+ SAR: r= 0.9766 RMSE: 0.0415 m
SAM+ : r= 0.9810 RMSE: 0.03213 m

ALES+ SAR: r= 0.9811 RMSE: 0.03934
SAM+ : r= 0.9781 RMSE: 0.04260

# Conclusions for the 5-10km range from the TG

In the range 5-10 km from the TG:

- With the approach based only on the MISFIT, we obtain comparable results for ALES+ retracker in the range 5-10km from the TG (r>0.94, RMSE:0.07 (asc) & 0.04 (dsc) m.
- SAMOSA+ results are aligned with ALES+ SAR results retracker in the range 5-10km from the TG. GPOD MISFIT filters more data than the ALES+ SAR misfit.
- SLA & Median +/-3*STD play a major role in correctly filtering the data.

# Conclusions for the 0-5km range from the TG

In the range 0-5 km from the TG:

- Descending tracks: good results have been obtained for both retrackers. ALES+ SAR allows considering some more data points/cycles.
- Ascending tracks: ALES+ allows having more points (all cycles contribute to the ascending pass, but results are not as good as SAMOSA in which the MISFIT filters more data).
- SLA & Median +/-3*STD play a major role in correctly filtering the data.

# ALES+ SAR IN GPOD

Being the ALES+ retracker very appreciated by the altimetry community, a collaboration has started between the ESA GPOD Team, already hosting the successful SARvatore services portfolio for unfocused SAR & SARin altimetry, and TU Munich to make the ALES+ SAR retracker available both in:

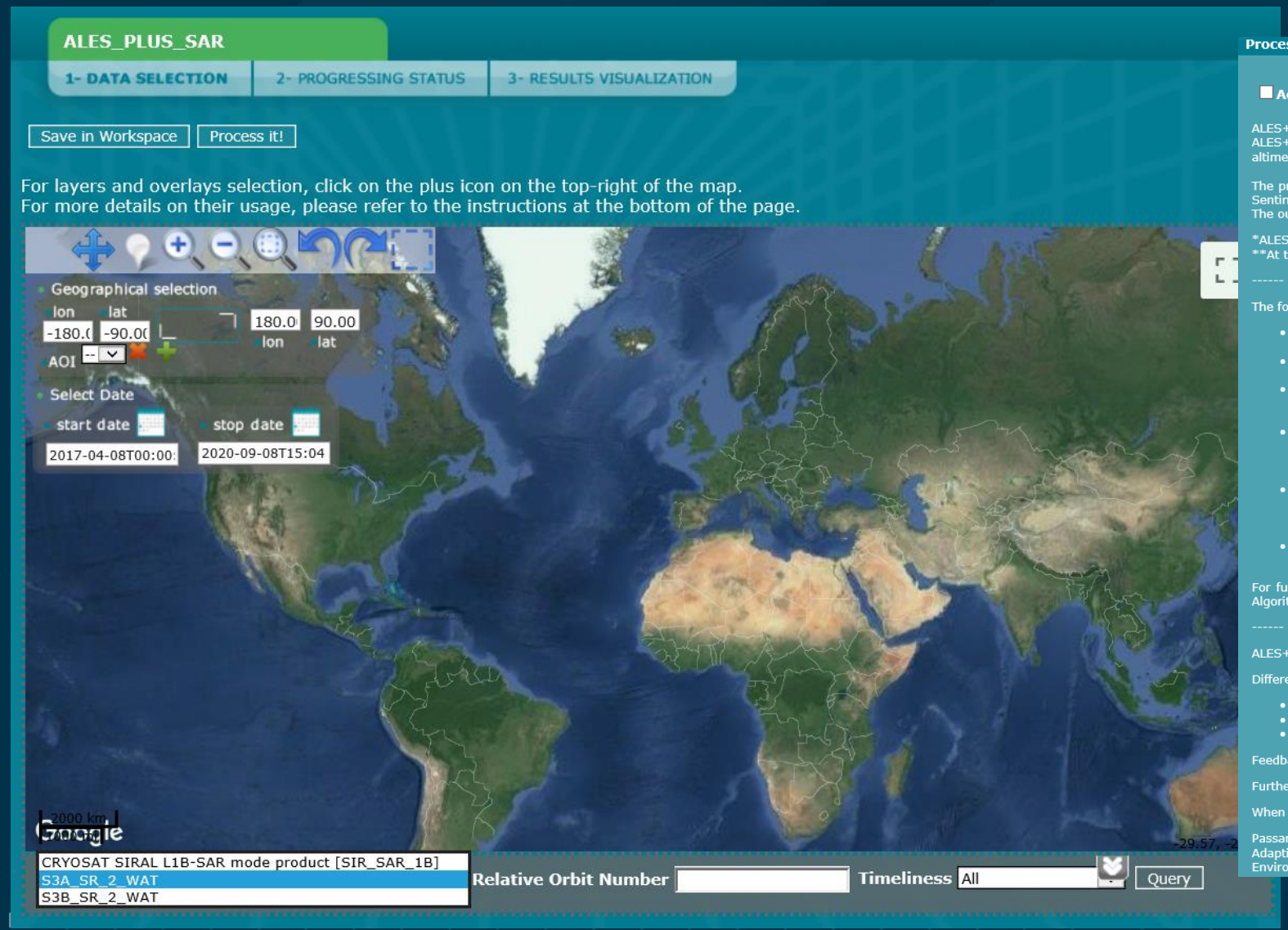
1) Standalone services, with ALES+ SAR applied on official L1b Cryosat-2 & Sentinel-3 SAR waveforms, and

2) SARvatore for Cryosat-2 & Sentinel-3 services, with ALES+ SAR results appended in a separate output folder. The latter will allow GPOD users directly comparing SARvatore SAMOSA retracker outputs to ALES+ SAR results increasing their research possibilities.

The service is open, free of charge and accessible online from everywhere. In order to be granted the access to the service, an EO-SSO (Earth Observation Single Sign-On) ID is needed and can be created at https://earth.esa.int/web/guest/general-registration. Once registered, an e-mail to the G-POD team (eo-gpod@esa.int) shall be sent requesting the activation of the ALES+ SAR & SARvatore services for the created EO-SSO user account.

# ALES+ SAR IN GPOD – STANDALONE SERVICE

# ALES+ SAR IN GPOD




**Processing Parameters**

☐ **Add the input file to the output**

ALES+ SAR is a subwaveform retracker for open ocean and coastal zone SAR altimetry data*.
ALES+ SAR adopts a simplified version of the Brown-Hayne functional form (which is the functional form for pulse-limited altimetry) as an empirical retracker to track the leading edge of the waveform.

The processor uses either official CryoSat-2 L1b products (only CryoSat-2 Baseline D SIR_SAR_L1B data are supported**) or Sentinel-3 WAT L1b products and produces ALES+ SAR L2 NetCDF products including the fields indicated in the section below. The output products will include all the data points of the selected tracks.

*ALES+ SAR is not conceived for the inland water domain, therefore, Sentinel-3 LAN products are not injected into the system.
**At the moment, only data from May 2019 are available in the GPOD catalogue.

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The following fields are produced as output of ALES+ SAR:

- **[lat_20_ku]**: Latitude at 20 Hz in degrees north.
- **[lon_20_ku]**: Longitude at 20 Hz in degrees, in the range [0-360°] or [-180 +180°] according to the selected mission.
- **[range_ales_20_ku]**: This is the altimetric range in meters. It corresponds to the distance between the satellite the satellite-to-surface range (calculated by measuring the time taken for the signal to make the round trip).
- **[range_ales_qual_20_ku]**: This is a 1-0 quality flag based on the fitting quality of the leading edge of the signal. A value of 1 corresponds to a bad quality flag. Note that this flag does not exclude the presence of further wrong retrievals in the product. A careful outlier analysis is strongly suggested.
- **[ssb_ales_20_ku]**: This is the sea state bias correction to be applied to the [range_ales_20_ku] when computing the sea surface height. It is computed empirically based on the proportionality between the wave height and the rising time of the leading edge in the waveform.
- **[time_20_ku]**: time in seconds since 2000-01-01 00:00:00.0.

For further information on the ALES+ SAR retracker and on how Range and Sea State Bias are computed, please check the Algorithm Theoretical Baseline Document of the ESA Baltic SEAL Project, available from http://balticseal.eu/outputs/

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ALES+ SAR is an algorithm under research&development, which is subject to updates.

Different phases of the ALES+ SAR development have been funded by the following ESA Projects:

- Sea Level Climate Change Initiative (ESA Contract No. 4000126561/19/I-NB)
- Baltic+ Sea Level (ESA Contract No. 4000126590/19/I/BG)
- HYDROCOASTAL (ESA Contract No. 4000129872/20/I-DT)

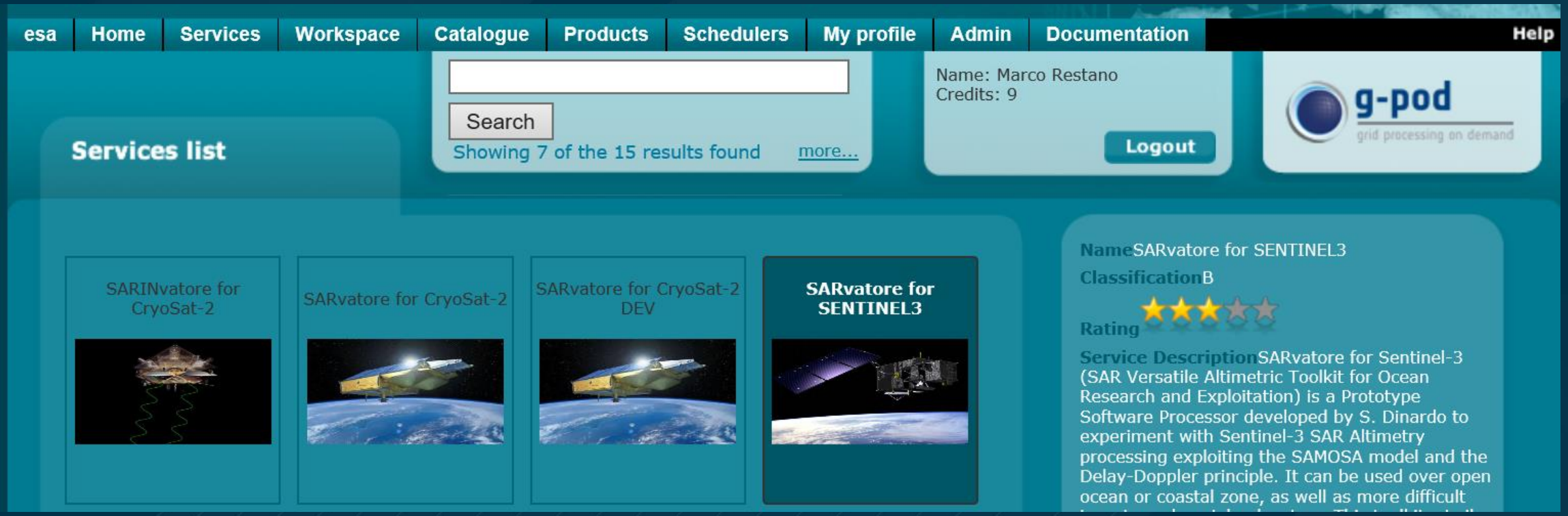
Feedbacks concerning the algorithm can be provided to its author, Marcello Passaro (marcello.passaro@tum.de).

Further information on this algorithm can be found in http://doi.org/10.5270/esa.BalticSEAL.ATBDV1.1.

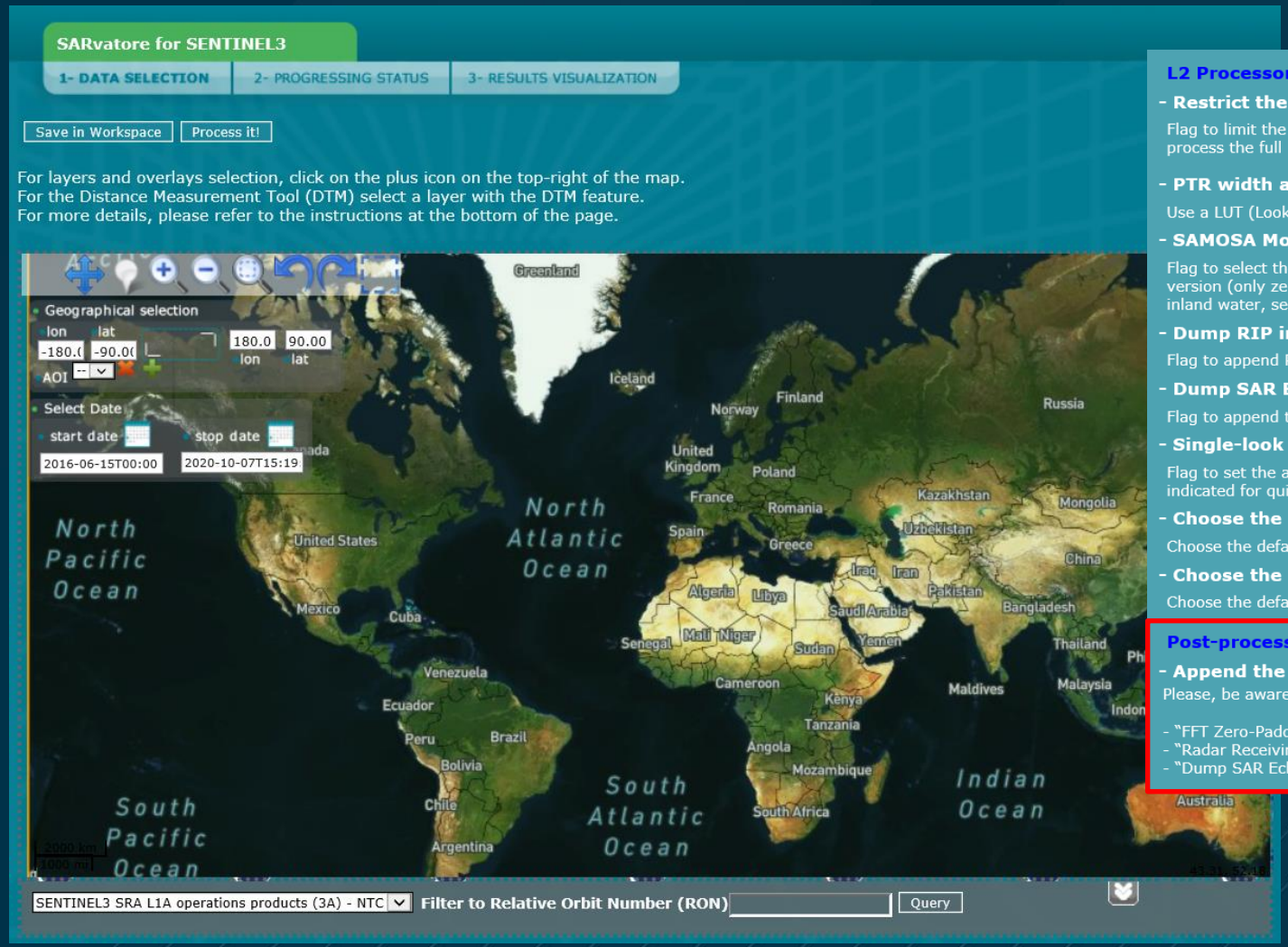
When using the output of ALES+ SAR for any scientific abstract/publication, please also cite Passaro et al. (2018):

Passaro, M., Rose, S. K., Andersen, O. B., Boergens, E., Calafat, F. M., Dettmering, D., & Benveniste, J. (2018). ALES+: Adapting a homogenous ocean retracker for satellite altimetry to sea ice leads, coastal and inland waters. Remote Sensing of Environment, 211, 456–471.

# ALES+ SAR IN GPOD/ SARvatore services



# ALES+ SAR IN GPOD/ SARvatore services




**L2 Processor:**

**- Restrict the re-tracking on specific surfaces**

Flag to limit the processing on open sea or on water (open sea, coastal zone and inland water) or to process the full pass — Process only water

**- PTR width alphap parameter**

Use a LUT (Look-Up Table) or a constant for PTR (Point Tartet Response) alphap parameter — LUT

**- SAMOSA Model Generation**

Flag to select the generation of the SAMOSA model to use in the re-tracking. SAMOSA3 is a truncated version (only zero order term) of SAMOSA2 (REF2), SAMOSA+ is the SAMOSA2 model tailored for inland water, sea ice and coastal zone domain — Use SAMOSA2

**- Dump RIP in output**

Flag to append Range Integrated Power (RIP) in the output netCDF data product — No

**- Dump SAR Echo Waveforms in output**

Flag to append the SAR Echo Waveforms in the output netCDF data product — No

**- Single-look or Multi-look Model**

Flag to set the application of the Model Multilooking (Single-Look or Multi-Look). Single-Look option is indicated for quick look operations while Multi-Look is the most accurate — Multi-look

**- Choose the default Tide Model**

Choose the default Tide model between FES2014b, TPXO8-ATLAS and TPXO9-ATLAS — FES2014b

**- Choose the default Mean Sea Surface Model**

Choose the default Mean Sea Surface Model between DTU18, DTU15 and CLS-CNES15 — DTU18

**Post-processing:**

**- Append the ALES+ SAR output to the output netcdf product** — No

Please, be aware that ALES+ SAR option is not selectable in case:

- "FFT Zero-Padding" is applied in the L1b processing options above.
- "Radar Receiving Window Size" exceeds 128 bins in the L1b processing options above.
- "Dump SAR Echo Waveforms in output" is set to "No" in the L2 processing options above.

# ALES+ SAR IN GPOD/ SARvatore services

**Post-processing:**

**- Append the ALES+ SAR output to the output netcdf product** Yes

Please, be aware that ALES+ SAR option is not selectable in case:

- "FFT Zero-Padding" is applied in the L1b processing options above.
- "Radar Receiving Window Size" exceeds 128 bins in the L1b processing options above.
- "Dump SAR Echo Waveforms in output" is set to "No" in the L2 processing options above.

ALES+ SAR is a subwaveform retracker for open ocean and coastal zone SAR altimetry data*. ALES+ SAR adopts a simplified version of the Brown-Hayne functional form (which is the functional form for pulse-limited altimetry) as an empirical retracker to track the leading edge of the waveform.

ALES+ SAR L2 NetCDF products will be placed into a dedicated output folder and will include the fields indicated in the section below.

*ALES+ SAR is not conceived for the inland water domain.

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The following fields are produced as output of ALES+ SAR:

- **[lat_20_ku]**: Latitude at 20 Hz in degrees north.
- **[lon_20_ku]**: Longitude at 20 Hz in degrees [-180° to +180°].
- **[range_ales_20_ku]**: This is the altimetric range in meters. It corresponds to the distance between the satellite the satellite-to-surface range (calculated by measuring the time taken for the signal to make the round trip).
- **[range_ales_qual_20_ku]**: This is a 1-0 quality flag based on the fitting quality of the leading edge of the signal. A value of 1 corresponds to a bad quality flag. Note that this flag does not exclude the presence of further wrong retrievals in the product. A careful outlier analysis is strongly suggested.
- **[ssb_ales_20_ku]**: This is the sea state bias correction to be applied to the [range_ales_20_ku] when computing the sea surface height. It is computed empirically based on the proportionality between the wave height and the rising time of the leading edge in the waveform.
- **[time_20_ku]**: time in seconds since 2000-01-01 00:00:00.0.

For further information on the ALES+ SAR retracker and on how Range and Sea State Bias are computed, please check the Algorithm Theoretical Baseline Document of the ESA Baltic SEAL Project, available from http://balticseal.eu/outputs/.