



PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE  
CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION

**STM Product Evolution for Processing Baseline 2.24**



*Mission  
Performance  
Centre*



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## 1 Introduction

This document is a technical note prepared by CLS as part of the “Preparation and Operations of the Mission Performance Centre (MPC) for the Copernicus Sentinel-3 Mission” project, ESA contract 4000111836/14/I-LG led by ACRI-ST, France.

### 1.1 Scope of the document

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The purpose of this document is to provide an overview of the evolutions of the Sentinel-3A Surface Topography Mission (STM) products since the deployment of the STM Processing Baseline 2.24. It complements the Products Notices (PN) for SRAL L1 and L2 products (Available @ <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-altimetry/document-library>) that have been issued along with the deployment of the Processing Baseline.

The evolutions are presented per surface and parameters to highlight the main improvements introduced by this new ground-processing version.



## 2 Processing Status

The summary of the ground processing is recalled below:

Processing Baseline	
<b>Processing Baseline</b>	<ul style="list-style-type: none"><li>IPF Processing Baseline: 2.24</li></ul>
<b>IPFs version</b>	<ul style="list-style-type: none"><li>SR_1 IPF version: 06.12</li><li>MW_1 IPF version: 06.04</li><li>SM_2 IPF version: 06.10</li></ul>
<b>Product Format Specification</b>	<ul style="list-style-type: none"><li>The applicable Product Format Specification (PFS) document is version 2.9.</li></ul>

Current Operational Processing Baseline		
IPF	IPF Version	In OPE since
SR1	06.12	<b>Land Centres:</b> NRT mode: 13/12/2017 08:35 UTC NTC mode: 13/12/2017 08:35 UTC
MW1	06.04	<b>Land Centres:</b> NRT mode: 07/06/2017 12:00 UTC NTC mode: 07/06/2017 12:00 UTC
SM2	06.10	<b>Land Centres:</b> NRT mode: 13/12/2017 08:35 UTC NTC mode: 13/12/2017 08:35 UTC



## 3 Evolutions affecting all surfaces

This section is dedicated to the changes of product format, evolutions of quality flags that are generic and used over all surfaces.

It is important to note that the baseline collection number in the products filename changed from 2 to 3 to reflect the major evolutions introduced by this Processing Baseline. As an example, the filename for STC products will be labelled as O\_ST\_003.SEN3 instead of O\_ST\_002.SEN3

### 3.1 New parameters in the products

---

The following parameters have been added in the L2 products:

- ❖ **A flag related to the type of orbit used in the L2 processing.** This is of interest mainly for the NRT products so that users can discard all observations that were not processed with the GPS orbits or with the Doris orbits.

Below an extract of the L2 product (reduced, standard and enhanced datasets):

```
byte orbit_type_01(time_01);  
    orbit_type_01:_FillValue = 127b;  
    orbit_type_01:long_name = "Orbit type flag : 1 Hz Ku band";  
    orbit_type_01:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b;  
    orbit_type_01:flag_meanings = "osf fos navatt doris_nav gnss_roe pod_moe salp_moe pod_poe  
salp_poe";  
    orbit_type_01:coordinates = "lon_01 lat_01";
```

- ❖ **A flag related to the quality of the waveforms over land ice.** This is of interest mainly over land ice to discard data that have corrupted waveforms.

Below an extract of the L2 product (standard and enhanced datasets):

```
byte waveform_qual_ice_20_ku(time_20_ku);  
    waveform_qual_ice_20_ku:_FillValue = 127b;  
    waveform_qual_ice_20_ku:long_name = "Ice waveform quality check status : 20 Hz ku band";  
    waveform_qual_ice_20_ku:flag_mask = 0b, 1b, 2b, 4b, 8b, 16b, 32b;  
    waveform_qual_ice_20_ku:flag_meanings = "waveform_ok total_power_test_failed  
noise_power_test_failed variance_test_failed leading_edge_test_failed low_peakiness_test_failed  
high_peakiness_test_failed";  
    waveform_qual_ice_20_ku:coordinates = "lon_20_ku lat_20_ku";
```

❖ **Three additional parameters to facilitate the connection between the 1 Hz and 20 Hz fields (3 for Ku-band and 3 parameters for C-band).**

Below an extract of the L2 product (standard and enhanced datasets):

```
short index_1hz_meas_20_ku(time_20_ku);
```

```
    index_1hz_meas_20_ku:_FillValue = 32767s;
```

```
    index_1hz_meas_20_ku:long_name = "Index of the 1Hz measurement : 20 Hz ku band";
```

```
    index_1hz_meas_20_ku:units = "count";
```

```
    index_1hz_meas_20_ku:coordinates = "lon_20_ku lat_20_ku";
```

```
    index_1hz_meas_20_ku:comment = "Index of the 1-Hz measurement associated to the 20-Hz measurement, zero index corresponding to the first 1-Hz measurement of the dataset.";
```

```
short index_1hz_meas_20_c(time_20_c);
```

```
    index_1hz_meas_20_c:_FillValue = 32767s;
```

```
    index_1hz_meas_20_c:long_name = "Index of the 1Hz measurement : 20 Hz C band";
```

```
    index_1hz_meas_20_c:units = "count";
```

```
    index_1hz_meas_20_c:coordinates = "lon_20_c lat_20_c";
```

```
    index_1hz_meas_20_c:comment = "Index of the 1-Hz measurement associated to the 20-Hz measurement, zero index corresponding to the first 1-Hz measurement of the dataset.";
```

```
int index_first_20hz_meas_01_ku(time_01);
```

```
    index_first_20hz_meas_01_ku:_FillValue = 2147483647;
```

```
    index_first_20hz_meas_01_ku:long_name = "Index of the first 20Hz measurement : 01 Hz ku band";
```

```
    index_first_20hz_meas_01_ku:units = "count";
```

```
    index_first_20hz_meas_01_ku:coordinates = "lon_01 lat_01";
```

```
    index_first_20hz_meas_01_ku:comment = "Index of the first 20-Hz measurement associated to the 1-Hz measurement, zero index corresponding to the first 20-Hz measurement of the dataset.";
```

```
int index_first_20hz_meas_01_c(time_01);
```

```
    index_first_20hz_meas_01_c:_FillValue = 2147483647;
```

```
    index_first_20hz_meas_01_c:long_name = "Index of the first 20Hz measurement : 01 Hz C band";
```

```
    index_first_20hz_meas_01_c:units = "count";
```

```
    index_first_20hz_meas_01_c:coordinates = "lon_01 lat_01";
```

```
    index_first_20hz_meas_01_c:comment = "Index of the first 20-Hz measurement associated to the 1-Hz measurement, zero index corresponding to the first 20-Hz measurement of the dataset.";
```

```
short num_20hz_meas_01_ku(time_01);
```

```
    num_20hz_meas_01_ku:_FillValue = 32767s;
```

```
    num_20hz_meas_01_ku:long_name = "Number of 20Hz measurements : 01 Hz ku band";
```

```
num_20hz_meas_01_ku:units = "count";  
num_20hz_meas_01_ku:coordinates = "lon_01 lat_01";  
num_20hz_meas_01_ku:comment = "Number of 20-Hz measurements associated to the 1-Hz  
measurement.";  
short num_20hz_meas_01_c(time_01);  
num_20hz_meas_01_c:_FillValue = 32767s;  
num_20hz_meas_01_c:long_name = "Number of 20Hz measurements : 01 Hz C band";  
num_20hz_meas_01_c:units = "count";  
num_20hz_meas_01_c:coordinates = "lon_01 lat_01";  
num_20hz_meas_01_c:comment = "Number of 20-Hz measurements associated to the 1-Hz  
measurement.";
```

## 3.2 Change of content definition for some parameters

---

The content of the following parameters has been changed in the L2 parameters:

- ❖ The ocean sigma0 parameter is now corrected from the atmospheric attenuation
- ❖ The flag related to the manoeuvre has changed values. They are now set to "1=ongoing\_manoeuvre" (previously 5) or "no\_manoeuvre=0" (previously 4). The fields impacted by the evolution are flag\_man\_pres\_l1b\_echo\_sar\_ku and flag\_man\_pres\_l1b\_echo\_plrm in SRAL L1 product and flag\_man\_pres\_20\_ku and flag\_man\_pres\_20\_c in L2 product.

## 3.3 Change of product format for some parameters

---

The following product format have been applied without any change to the scientific values:

- ❖ The attributes of the units related to the fields ("UTC\_sec\_01", "UTC\_sec\_20\_ku", "UTC\_sec\_20\_c") that was changed from "seconds in the days" to "seconds". Below an extract of the L2 product (standard and enhanced datasets) for parameter UTC\_sec\_01 :

```
double UTC_sec_01(time_01);  
UTC_sec_01:long_name = "Second in the day UTC : 1 Hz";  
UTC_sec_01:units = "s";
```



- ❖ The variable previously called **filtered\_range\_ocean20\_ku** in the L2 products has been renamed **interpolated\_c\_band\_range\_ocean20\_ku** to better reflect the content of this parameter. Below an extract of the L2 product (standard and enhanced datasets):

```
int interpolated_c_band_range_ocean_20_ku(time_20_ku);

    interpolated_c_band_range_ocean_20_ku:_FillValue = 2147483647;

    interpolated_c_band_range_ocean_20_ku:long_name = "C-band filtered
corrected \'ocean\' altimeter range : 20 Hz Ku band";

    interpolated_c_band_range_ocean_20_ku:units = "m";

    interpolated_c_band_range_ocean_20_ku:quality_flag =
"range_ocean_qual_20_c";

    interpolated_c_band_range_ocean_20_ku:add_offset = 700000.;

    interpolated_c_band_range_ocean_20_ku:scale_factor = 0.0001;

    interpolated_c_band_range_ocean_20_ku:coordinates = "lon_20_ku
lat_20_ku";

    interpolated_c_band_range_ocean_20_ku:comment = "C-band altimeter
range value used to compute the Ku-band altimeter ionospheric
correction (iono_cor_alt_20_ku) ";
```

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## 4 Evolutions over Ocean and Coastal Areas

The Processing Baseline 2.24 is a major change for product quality over ocean, both for open ocean and coastal areas.

### 4.1 Evolutions for the ocean SRAL parameters

---

The sea level observations have been improved thanks to the following changes introduced in SRAL L1 and L2 processing:

- ❖ Exploitation of all the useful beams in the stack during the SRAL L1 processing
- ❖ Extension of the averaging time window for the SRAL calibration average processing (for Ku-band parameters only)
- ❖ Implementation of the SAMOSA 2.5 ocean retracker, following recommendation from the CP40 project.

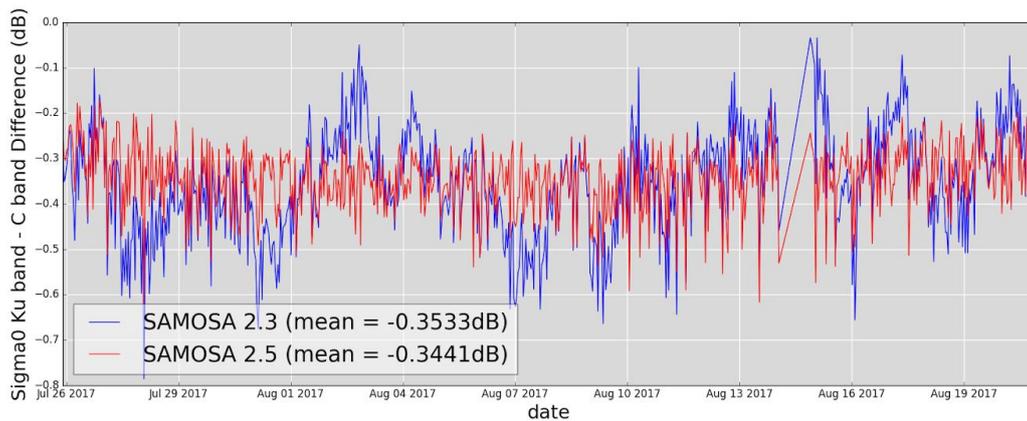
This results in several impacts on the scientific parameters retrieved with the ocean retracker.

The use of a longer averaging window for the SRAL Ku-band calibrations decrease the variations that were observed from pass to pass for the waveform mispointing (available for PLRM processing) and for the SARM Ku band backscatter coefficient. Figure 1 shows the improvement for the Ku band sigma0 that is observed when looking at the difference between Ku band and C band sigma0 for the old version and the new version. The new processing baseline does not show anymore the jumps on the backscatter coefficient.

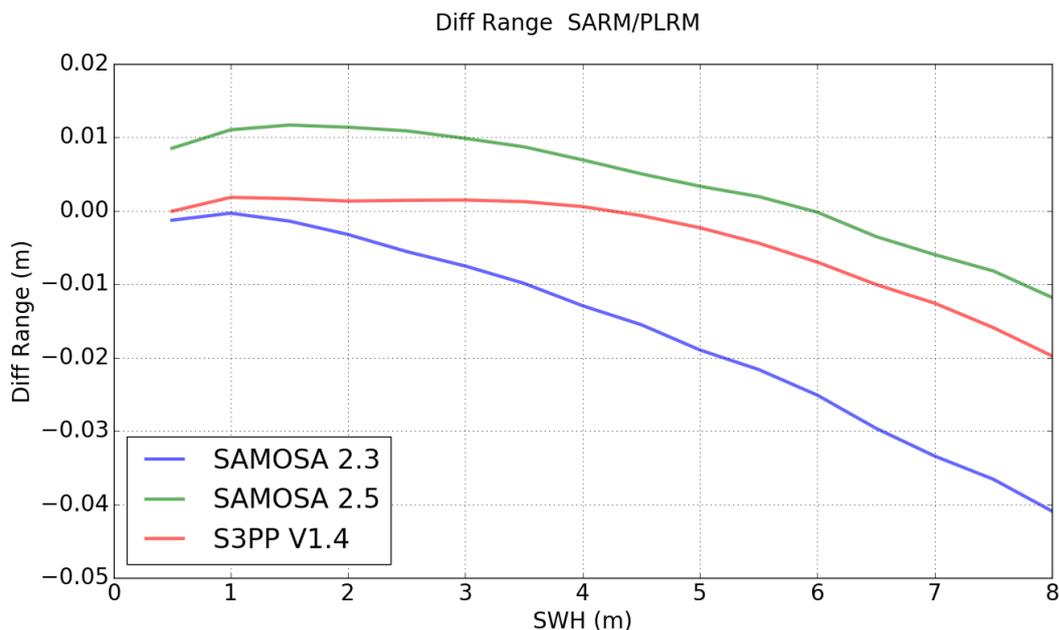
The most impacting evolution is the implementation of the SAMOSA 2.5 retracker. The main achievements are summarised below:

- ❖ The SARM range dependency with SWH is decreased as shown on the Figure 2. We observe now a discrepancy reduced to 0.3% SWH for waves greater than 4 m, compared to PLRM. Note that the SSB correction has not yet been tuned for Sentinel-3A and contains Jason-2 SSB solution. With this new version of the retracker, the results are very similar to the ones obtained with the CNES prototype (which is a completely independent processing), except for a constant bias of 1 cm between both processing.
- ❖ The SARM SWH values are decreased by 14 cm in average as shown on the Figure 3, which provides values closer to the PLRM mode, but also to the ECMWF model and to the Jason-3 altimeter (not shown). The dependency wrt to SWH is also improved for the stronger waves greater than 5 m. With this new version of the retracker the results are also very similar to the ones obtained with the CNES prototype, except for a constant bias of 7 cm between both processing.
- ❖ The SARM backscatter coefficient showed an error correlated with the altitude in the previous version, that is now reduced to 0.1 dB in the regions where strong radial velocities dominate

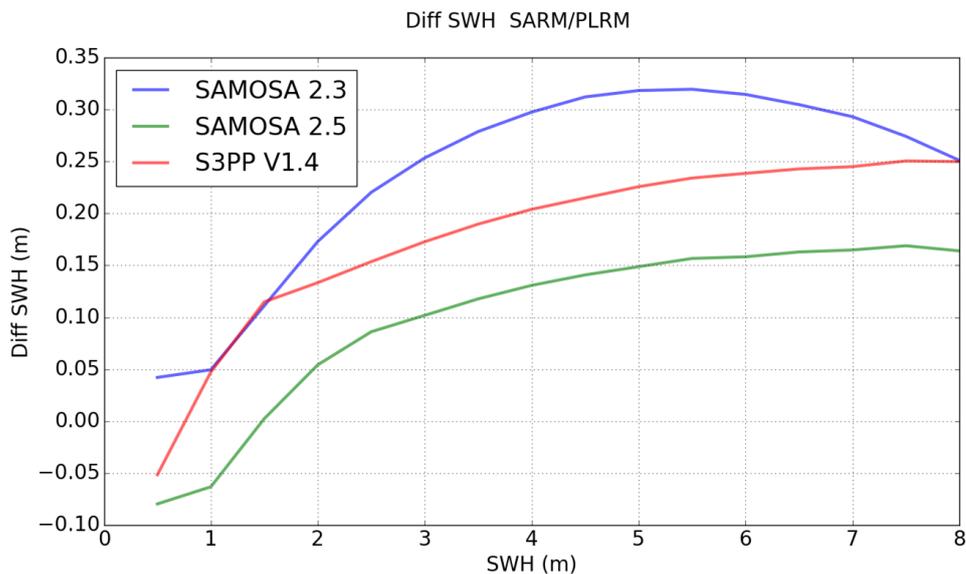
(between 30S and 60S). This is evidenced when comparing the SARM and PLRM backscatter coefficient for both Processing Baseline versions in the Figure 4. Note that this reduction of the error in the SARM sigma0 has only a slight improvement on the resulting altimeter wind speed in SARM. The SARM wind speed bias is reduced by 0.4 m/s in the region below 50S where the error on the SARM sigma0 was the greater (regions of stronger altitude).



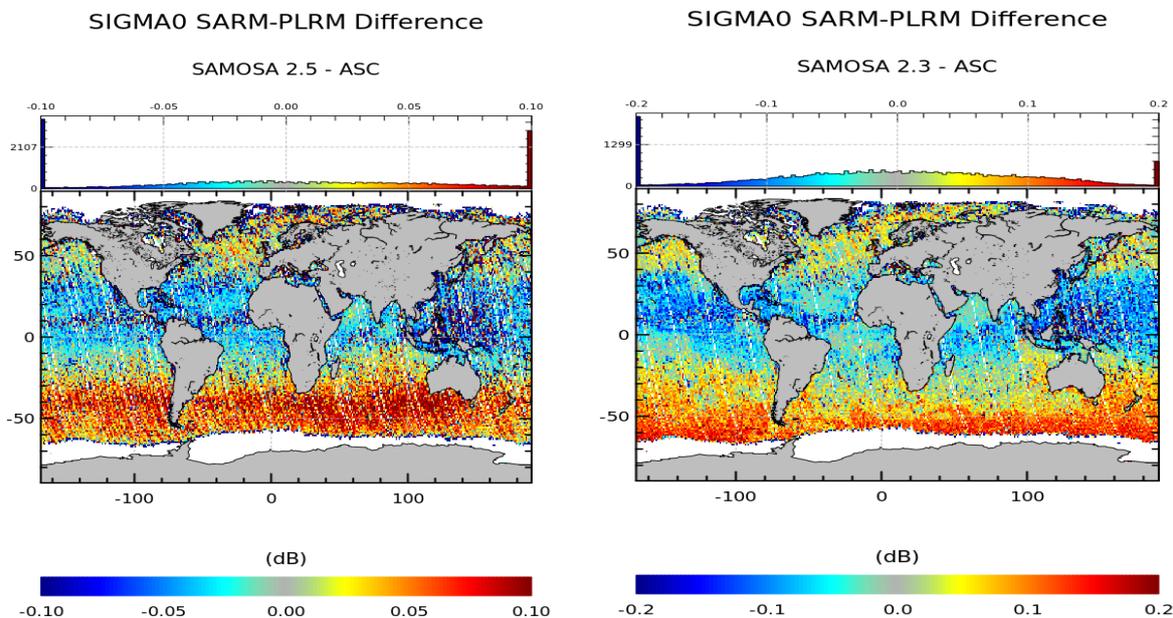
**Figure 1 Mean per pass of the difference between SARM Ku band and C band backscatter coefficient for previous processing baseline (blue curve) and Processing Baseline 2.24 (red curve)**



**Figure 2 Difference between SARM Ku band and PLRM Ku band range wrt SWH for previous processing baseline (blue curve) and Processing Baseline 2.24 (green curve). The curve obtained for the CNES S3 prototype (red curve) is also represented to provide an external reference.**



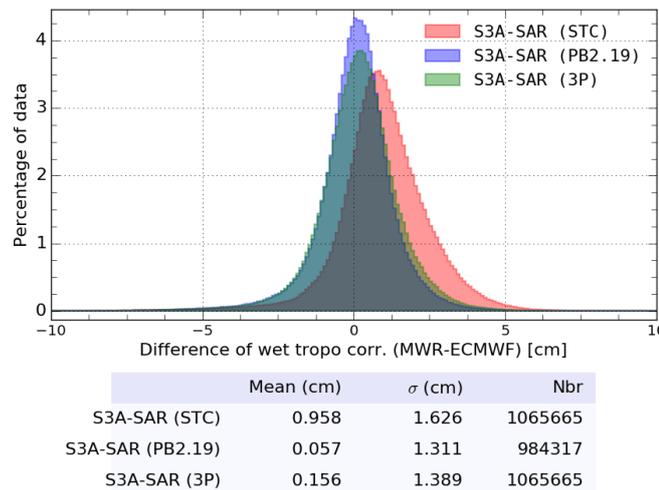
**Figure 3** Difference between SARM Ku band and PLRM Ku band SWH wrt SWH for previous processing baseline (blue curve) and Processing Baseline 2.24 (green curve). The curve obtained for the CNES S3 prototype (red curve) is also represented to provide an external reference.



**Figure 4** Difference between SARM Ku band and PLRM Ku band backscatter coefficient for previous processing baseline (right map) and Processing Baseline 2.24 (left map). The maps display only the ascending tracks to better highlight the finer details of the difference in the maps.

## 4.2 Evolutions for the sea level parameters

- ❖ Implementation of the FES2014 model in replacement of the FES2004 model, for the computation of the solution 2 tide heights.
- ❖ Implementation of two new Mean Sea Surface models for both solutions: CNES-CLS15 and DTU15 models
- ❖ Note that the ssha fields have been updated to reflect these two changes in the geophysical corrections. The FES2014 correction is used for the ocean tide and the DTU15 model used for the mean sea surface. The DTU15 has been selected due to the extended coverage that includes values over some of the large lakes and a small region in the Arctic Ocean whereas the CNES-CLS15 does not provide any value. If users want to compare the performances of the ssha with both MSS models, the change of mean sea surface model can be easily done by subtraction/addition of the mean sea surface fields to the ssha field.
- ❖ Improvement of the radiometer wet tropospheric correction derived with 5 parameters. Figure 5 shows that the new processing baseline provides an improved standard deviation of the difference between radiometer and model correction. This falls now to 1.3 cm instead of the 1.6 cm previously observed. Note that this correction further improves the quality of the sea level observations compared to the use of the classical wet tropospheric correction that uses the MWR brightness temperatures and the SRAL backscatter coefficient (standard deviation is close to 1.4 cm with this correction).

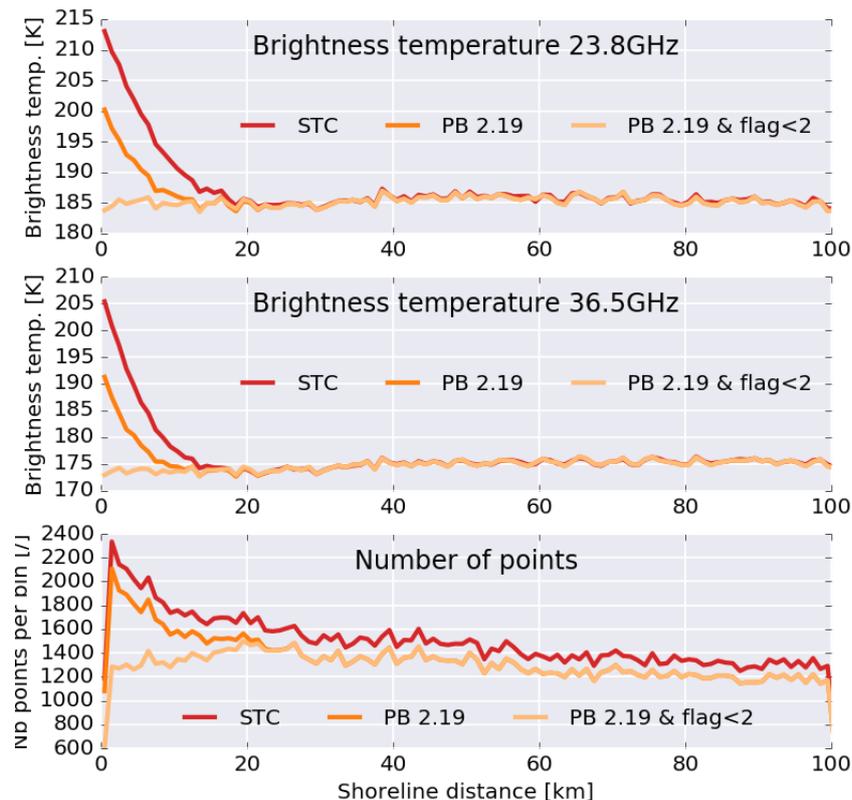


**Figure 5 Difference between 5 parameters radiometer and ECMWF model wet tropospheric correction for previous processing baseline (red) and Processing Baseline 2.24 (blue). The results obtained for the 3 parameter correction is also provided (green histogram)**

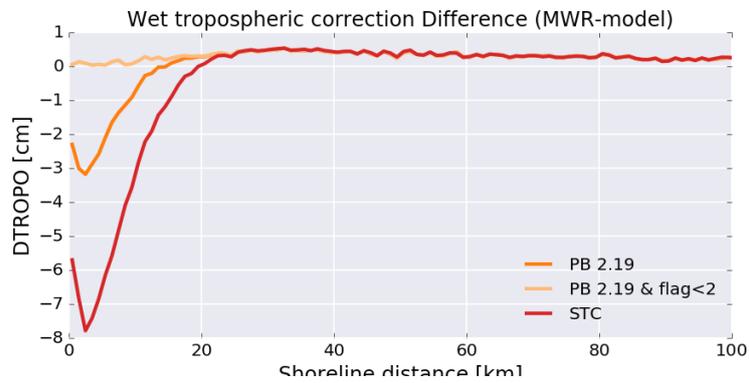
❖ Improvement of the MWR parameters over coastal areas.

A new algorithm was implemented for the interpolation of brightness temperature at altimeter time tag. This algorithm impacts only coastal areas while it does not change the performance over open ocean. Over coastal areas, this new algorithm selects only the non-contaminated data for the interpolation. If none can be found in the averaging, thus the latest non-contaminated is extrapolated up to the coast. Finally, if the latest non-contaminated data is too far from the measurement, then the interpolation is performed with all the data available. The along-track averaging flag provided in the product allows the user to determine which configuration characterizes the measurement. The along-track flag set to 0 stands for nominal interpolation (ie over open ocean and when non-contaminated data are found within the averaging window), set to 1 stands for extrapolated configuration (the latest non-contaminated data is used), set to 2 stands for degraded configuration (interpolation with contaminated data), set to 3 when no interpolation is performed due to missing or invalid MWR/SRAL measurements.

The brightness temperatures profile approaching the coast along with the derived wet tropospheric correction are improved by this new algorithm as shown by Figure 6 and Figure 7.



**Figure 6: Interpolated brightness temperature as a function to the shoreline distance for previous processing baseline (red) and Processing Baseline 2.24 (orange). The light orange curve shows the result when selecting configuration with along track averaging flag < 2 (nominal or extrapolated), the interpolated brightness temperature is no longer impacted by the land contamination, but the number of points is reduced.**



**Figure 7: Difference MWR-model Wet Tropospheric correction as a function to the shoreline distance for previous processing baseline (red) and Processing Baseline 2.24 (orange). The light orange curve shows the result when selecting configuration with along track averaging flag <2 (nominal or extrapolated), the interpolated brightness temperature is no longer impacted by the land contamination.**

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## 5 Evolutions over Sea Ice

The Processing Baseline 2.24 improved the product quality over sea ice, through:

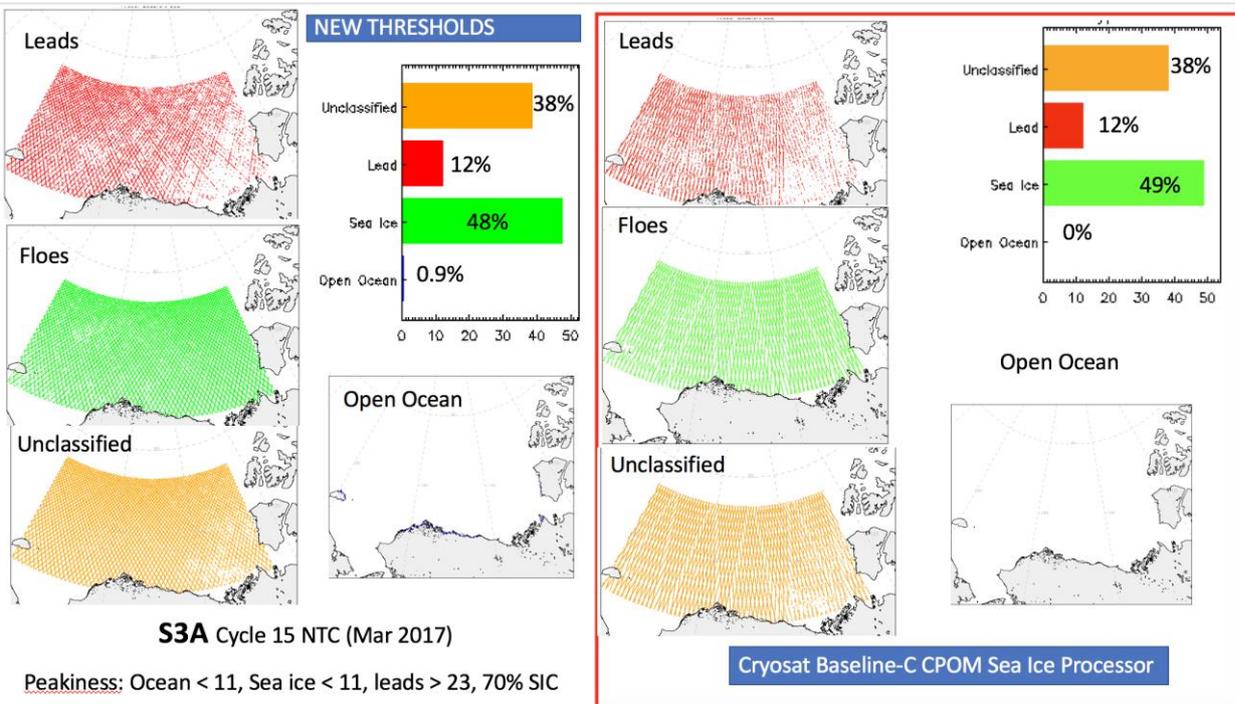
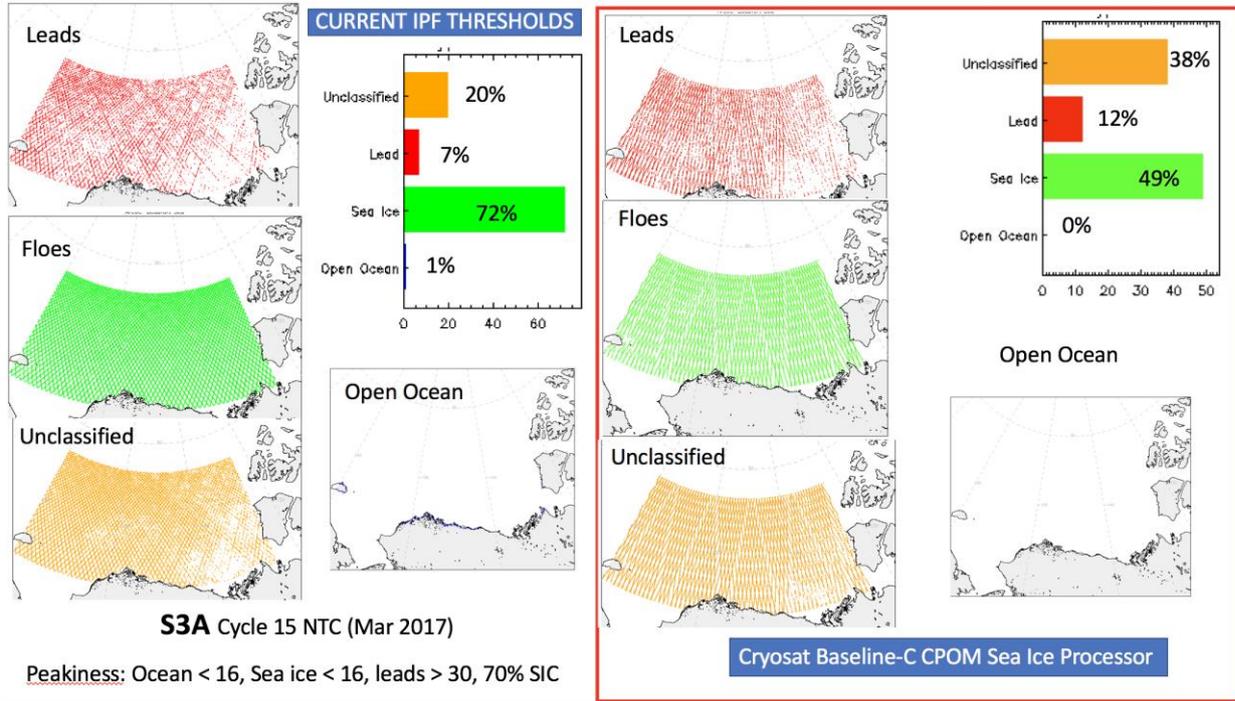
- ❖ the availability of the GIM ionospheric correction in STC products. The systematic coverage now available for this correction allows retrieving the expected values of the sea\_ice\_ssha parameters.
- ❖ the use of the DTU15 Mean Sea Surface model in the sea\_ice\_ssha parameters because this model performs better over the Arctic Ocean.
- ❖ the evolution of the sea ice classification parameter (surf\_type\_class\_20\_ku).

A study of available cycles of Arctic winter L2 SR\_2\_WAT NTC data from IPF v6.0.7 over the Arctic winter of 2016/2017 showed that the key sea ice discriminator algorithm was identifying too many floes and too few leads as compared to results from Cryosat results and it therefore requires further tuning of its thresholds.

A statistical comparison was performed over the Beaufort Sea area of the Arctic, comparing and tuning the discriminator results from 3 cycles of S3A data from different periods during winter 2016/2017.

The results were compared with discriminator statistics for the same periods and area from the ESA Cryosat-2 L2i Baseline-C and from the validated Cryosat-2 CPOM Sea Ice processor data used in the CPOM Cryosat NRT sea ice thickness web portal processor ([www.cpom.ucl.ac.uk/csopr](http://www.cpom.ucl.ac.uk/csopr)). A typical result from cycle 15 using current S3 IPF discriminator thresholds is shown below, indicating that S3 is discriminating too few leads and too many floes as previously found.

The S3 thresholds were tuned to repeatedly match the Cryosat results to within 1% on average over all cycles tested during the winter season of 2016/2017, as shown below for cycle 15.



**Figure 8** Sea ice classification parameters over the Beaufort Sea for Cycle 15 with previous processing baseline (upper left) and Processing Baseline 2.24 (bottom left). Reference coming from the CPOM processor is also provided (right)

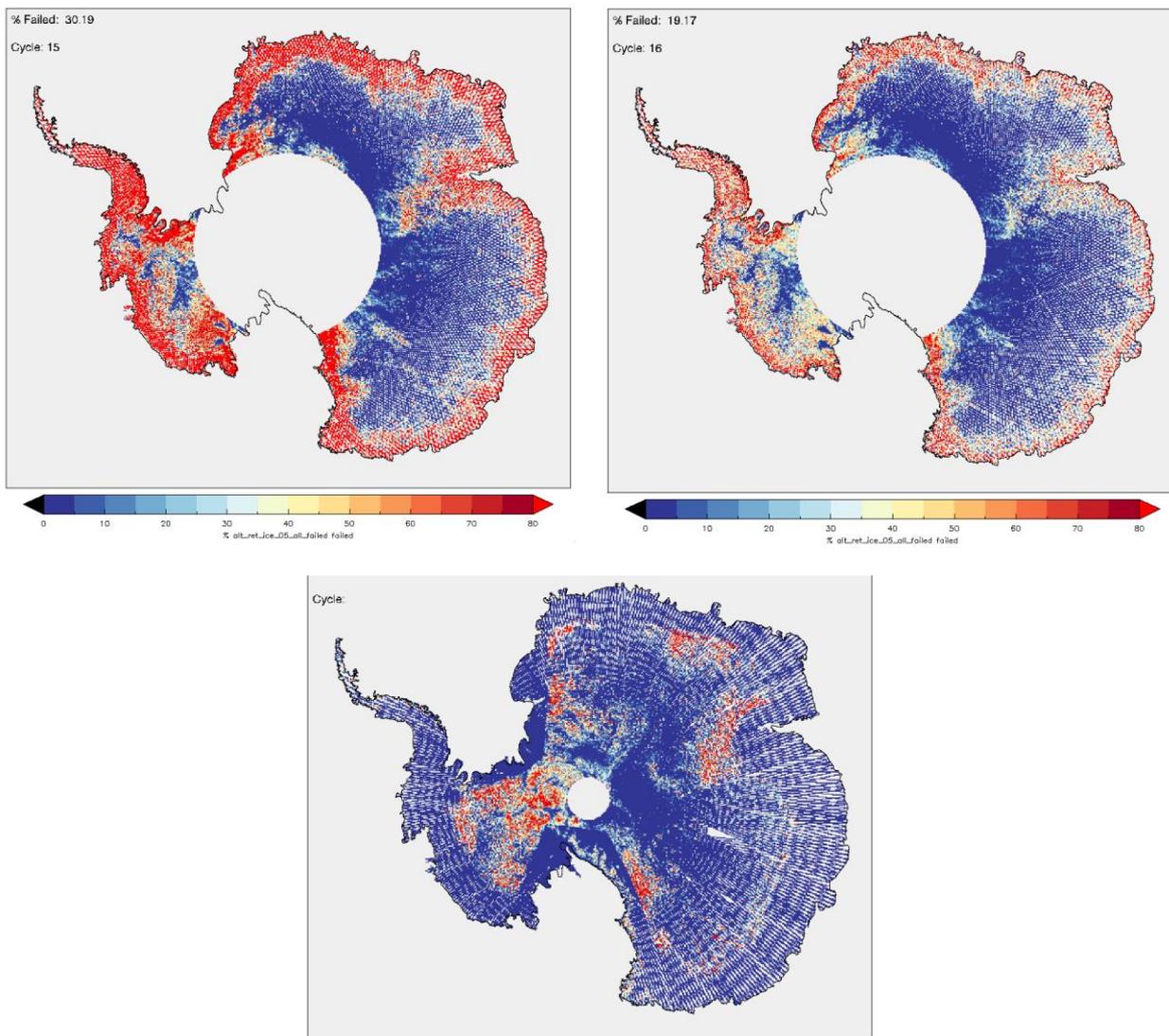
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## 6 Evolutions over Land Ice

The Processing Baseline 2.24 improved the product quality over land ice, through:

- ❖ the addition of new flag providing information on the quality of the waveforms over land ice
- ❖ the increase of the coverage of the outputs of the ice sheet retracker.

Sentinel-3A elevations are affected over areas of the ice sheet with slope  $> 0.3$  degrees (ie the margins of Antarctica and Greenland) where measurement density is particularly low compared to previous missions (Cryosat coverage is shown below for comparison). A first improvement is made with Processing Baseline 2.24 that decreases the percentage of data loss over the margins and it is reduced from 30% to 19% globally over Antarctica. Note that this low density only affects the ice sheet retracker while the density is nominal for the OCOG retracker.



**Figure 9 Percentage of failure over Antarctica of the ice sheet retracker with previous processing baseline (upper left) and Processing Baseline 2.24 (upper right). The percentage of failure with Cryosat-2 mission is also displayed for comparison (bottom). Note that the margins are acquired in SARin mode on Cryosat-2 mission, which explains the very low percentage of failure over this zone.**



## Sentinel-3 MPC

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## 7 Evolutions over Inland waters

The Processing Baseline 2.24 does not aim at improving product quality over inland waters.

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