CFOSAT AWWAIS V7.0 main evolutions

Upgrade of the L1a processing f for SWIM data acquired in the ”Speckle acquisition mode”

The “speckle mode” of acquisition was designed for specific evaluations of the speckle noise. Since the CFOSAT launch it has been switched on for limited periods of time.

In this specific “Speckle” acquisition mode, the measurement integration time is divided in 3 slots, generating for each SWIM beam, 3 waveforms, instead of one in the nominal acquisition mode. On board, each signal is incoherently integrated over $T_{int}/3$ (corresponding to $N_{int}/3$ samples) where Tint is the integration time in the nominal mode and N_{int} the number of integrated sampled in the nominal mode.

However, it was realized that when the speckle mode acquisition is activated, the on-board processing does not provide the correct power of the integrated signal (mean value corresponding to the $N_{int}/3$ integration). As this cannot be corrected in the on-board processing, a specific routine has to be added in the ground-segment processing to provide the correct power of the integrated waveforms. This addition has no impact on the data acquired in the nominal mode.

This update has been implemented and moving from one acquisition mode to another is transparent for users.

<u>Impacted parameters</u>

The parameters which are modified with this correction, when the instrument is in speckle acquisition mode are:

- echo_l1a_0: Calibrated and geocoded power for nadir beam
- echo_l1a_1: Calibrated and geocoded power for first incidence beam
- echo_l1a_2: Calibrated and geocoded power for second incidence beam
- echo_l1a_3: Calibrated and geocoded power for third incidence beam
- echo_l1a_4: Calibrated and geocoded power for fourth incidence beam
- echo_l1a_5: Calibrated and geocoded power for fifth incidence beam

Upgrade of the L2 processing

- Parasite peaks filtering in the wave spectra

Parasite peaks are observed since the beginning of the mission (New Observations From the SWIM Radar On-Board CFOSAT: Instrument Validation and Ocean Wave Measurement Assessment | IEEE Journals & Magazine | IEEE Xplore). They are non-geophysical peak, generally at wavelengths to the 500m, probably due to either lack of homogeneity over the SWIM footprint, which induces energy at low wavenumber, or remaining presence of noise floor of the slope spectra which is significantly amplified at these wavelengths when converting to wave height spectra.
An algorithm has been designed, tuned and implemented in order to filter these parasite peaks. These peaks are assumed to be isolated random peaks that are particularly higher than their neighbors. They are filtered out (put to 0) if their signal to noise ratio, estimated on their closest neighbors on SWIM 2D elevation spectra, is higher than a certain threshold (see Figure 1) , more specifically:

$$SNR = \frac{\langle E \rangle}{\sqrt{\langle E^2 \rangle - \langle E \rangle^2}}$$

where $\langle E^n \rangle (i,j) = (1/9) \sum_{k=i-1}^{i+1} \sum_{l=j-i}^{j+1} E^n(k,l)$, see also for more details on Figure 1 grid coordinates.

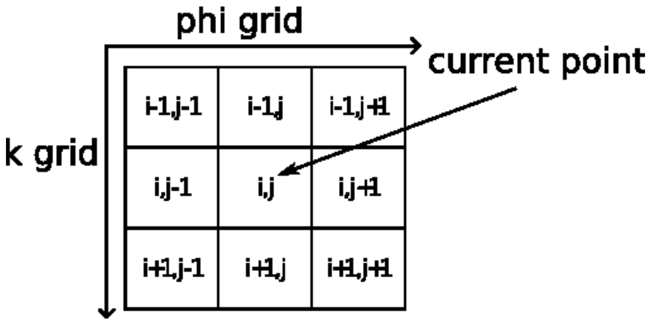


Figure 1 : grid coordinates for SNR estimate at pixel (i,j).

. This threshold varies from beam to beam and has been optimized at global scale.

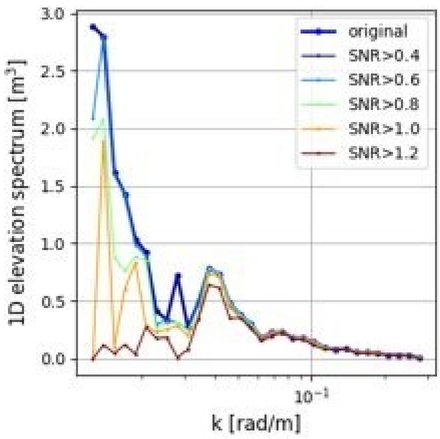


Figure 1: Effect of parasitic peaks filtering on a 1D elevation SWIM spectrum for increasing values of SNR threshold

A careful option has been chosen, i.e. not too large SNR thresholds, so that some wave related signal is not filtered out with parasitic peaks, especially long and low swells in the Gulf of Guinea or in the Eastern Pacific. Correlation with model 1D elevation spectra is improved all over the world, especially in semi-enclosed basins such as the Mediterranean Sea or the Gulf of Mexico, where parasitic peaks are common (see Figure 2).

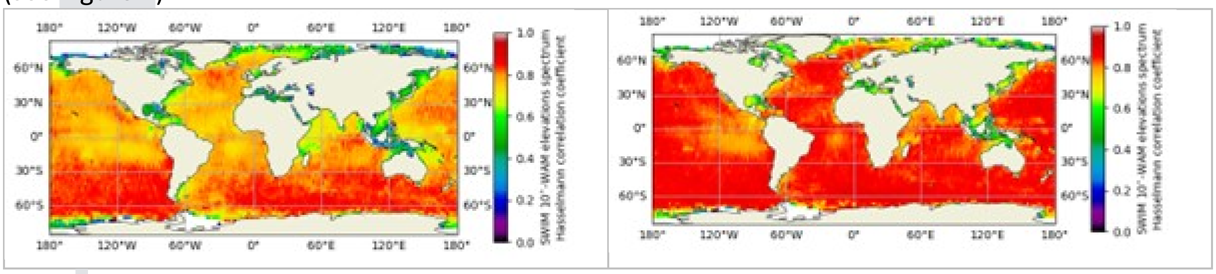


Figure 2 : mean correlation coefficient between SWIM 10° beam and collocated MFWAM 1D elevation spectra over the year 2021 before (left) and after (right) parasitic peaks filtering

This evolution impacts the product as follow:

New parameters:

Filtered are slope and height spectra are provided, in addition to raw spectra.
The filtered variables are name with the extension _fpp w.r.t. raw variables

For instance
pp_mean: “2D mean slope spectrum for all spectral beams” is provided as previously.

Now a complementary variable is provided:
pp_mean_fpp : 2D mean slope spectrum for all spectral beams filtered of parasitical peaks

Here is the full list of complementary variables:

- pp_mean_fpp : 2D mean slope spectrum for all spectral beams filtered of parasitical peaks
- pp_combined_fpp : 2D mean slope spectrum for all spectral beams filtered of parasitical peaks and combining all incidence beams
- f_2d_fpp: 2D symmetrized height spectrum for all spectral beams filtered of parasitical peaks
- f_2d_quality_indicator: Quality indicator of f_2d 2D height spectra corresponding to signal-to-noise ratio"
- f_2d_combined_fpp: 2D symmetrized height spectrum for all spectral beams filtered of parasitical peaks and combining all incidence beams
- f_omni_fpp: Omni-directional height spectrum integrated over azimuth and for all spectral beams filtered of parasitical peaks"

Impacted parameters

On previous version, all parameters were estimated based on raw wave spectra, whereas in this version, several parameters are estimated based on the filtered wave spectra. Thus their values are modified in this product version. Here below is the list of this variables:

mask: Mask of detected partitions on pp_mean

mask_combined: Mask of detected partitions on p_combined combining all incidence beams

mask_combined_nrt: Mask of detected partitions on f_2d_combined combining all incidence beams

wave_param : Wave parameters of the whole spectrum (SWH, peak wavelength, peak direction

wave_param_combined: Wave parameters of the whole combined spectrum (SWH, peak wavelength, peak direction)"

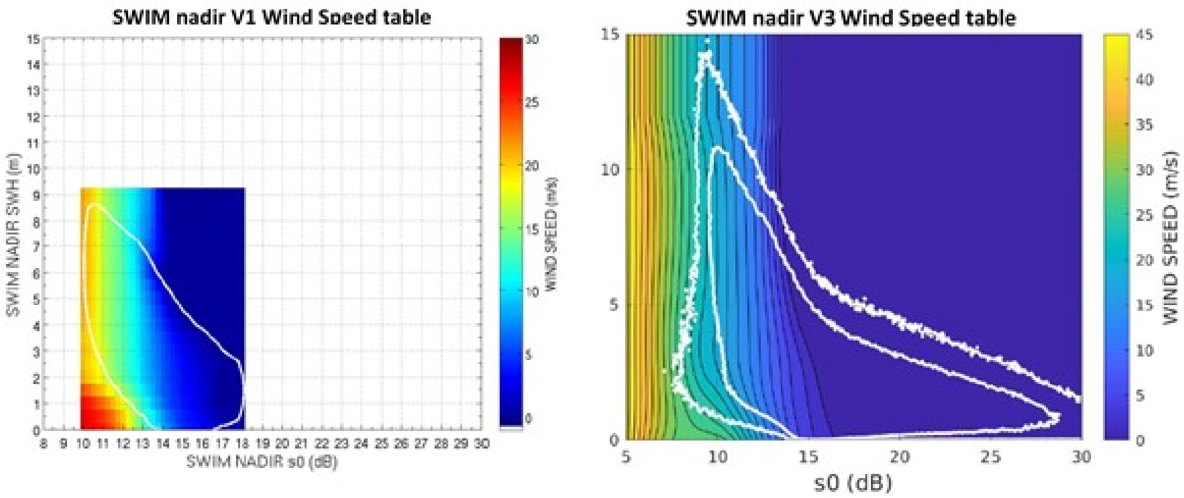
wave_param_part: Wave parameters of each partition (SWH, peak wavelength, peak direction)

wave_param_part_combined: Wave parameters of each partition of the combined spectrum (SWH, peak wavelength, peak direction)

- Wind from Nadir: new Look Up Table to estimate wind speed from sigma0 and SWH

This table is used to derive the nadir Wind Speed (WS) from two other parameters: the sigma naught (sigma0) and the Significant Wave Height (SWH). It is established as a function of 5-Hz native data (sigma0, SWH) with the Feng et al [2010]'s approach (spline based non-parametric estimation). It has been established with the use of ERA5 winds as reference.
The previous operational table issue (V1) was established on the six firsts months' data (cycles 1 to 14). A study was performed to established a new issue (V2) based on data from cycles 8 to 19 and 48 to 63 to avoid RMA anomalies period (cf. §2 of CALVAL_report-V4.2 (altimetry.fr)).
Because of the limited amount of data for this issue it was decided to wait until the availability of a full year dataset. Consequently, this new issue (V3) was established based on the 2022 full year period (cycles 90 to 117).
As shown in fig.1, this allows to enlarge the WS definition domain from [10, 18] dB x [0, 9] m to [5, 30] dB x [0,15] m to obtain altimeter wind speed up to about 40 m/s (extrapolation that is not validated for cyclone conditions).

The computed statistical variables show the closer correlation between the new SWIM WS estimates (v3) and ECMWF data (both forecasts and reanalyzes). We can observe on the histograms comparison (cf.fig.2) that the SWIM WS estimates from this new version (V3) are closer in shape to those observed from ECMWF and CMEMS L4 products, when compared to operational product ouptuts (obtained with V1 table). The scatter plots of nadir wind speed estimates versus ECMWF ones, given in Fig.3, also shows a better performance of V3 table compared to V1, in terms of bias and RMSE, and we also observe an improvement due to the extension of the WS definition domain which suppressed nonphysical cutoff in the estimation.



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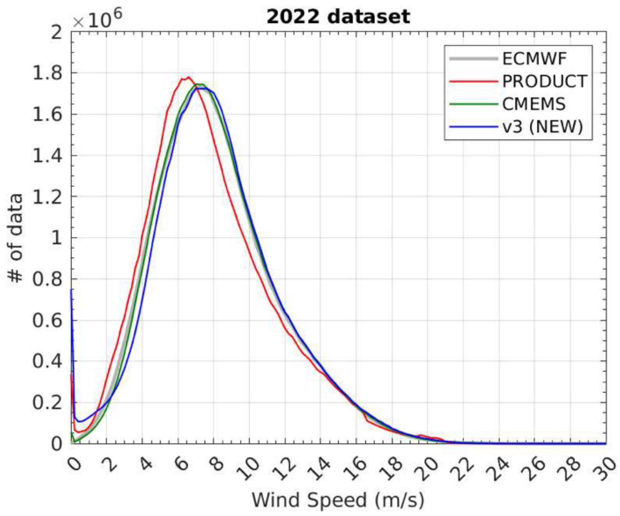
- *Fig.1: SWIM nadir Wind Speed table values. left: V1 table, right: V3 table*



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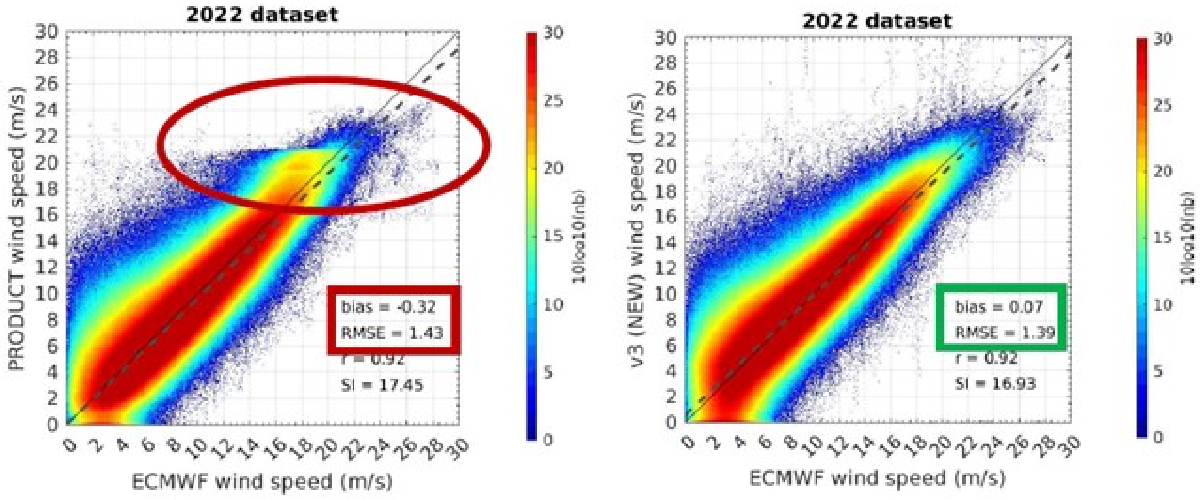
- *Fig.2: Wind Speed histograms from: ECMWF model (grey line), SWIM Product corresponding to V1 WS table (red line), CMEMS L4 product, V3 SWIM WS table (blue line). Wo observe the better consistency of V3 histogram with CMEMS and ECMWF compared to V1 histogram*



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- *Fig.3: SWIM nadir Wind Speed estimates versus ECMWF Wind Speed model scatter plots. Left: V1 Wind Speed table outputs, right : V3 Wind Speed table outputs*

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<u>Impacted parameters</u>

This evolution impacts the wind speed parameters listed hereafter:

- nadir_wind_native : Wind speed value from nadir native processing
- nadir_wind_1Hz: Wind speed value from nadir processing compressed on 1s
- nadir_wind_nsec: Wind speed value from nadir processing compressed on NSEC s
- nadir_wind_box: Wind speed value from nadir processing compressed by box