Level-3 product : 2 km vs 250 m

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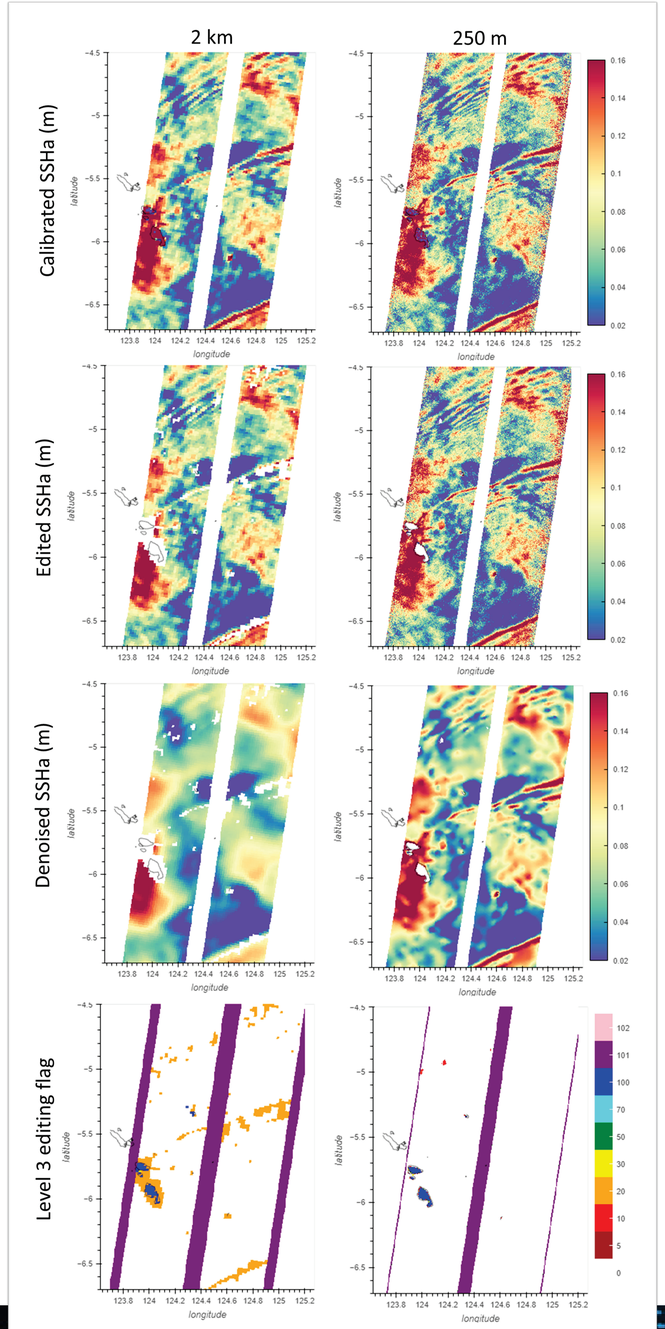
Introduction & Context

The Sea Surface Height Anomaly (SSHa) SWOT product is impacted by spurious pixels and noise. The quality flag available in the Level-2 product does not properly capture obvious anomalies such as heavy rain cells or sea-ice. The objective of the Level-3 product is to better flag them. After this step, the denoising step is necessary for user who want to access the currents and the relative vorticity because the derivatives quickly amplify the noise . This poster presents the last algorithms available in the Level-3 SWOT product at 2 km resolution (version v1.0) and at 250 m resolution (version v0.1). The Level-3 product is part of SWOT Science Team DESMOS project led by P-Y Le Traon.



Editing 2km

List of flag available :

- Flag #102: No SSHa values available
- Flag #101: Pixels over land using a shoreline mask
- Flag #100: Edges of swath. Only values between 10 to 60 km to the nadir are considered as valid data.
- Flag #70: Pixels impacted by spacecraft events (e.g. eclipses transition, maneuvers...)
- Flag #50: Abnormally high SSHA values (|SSHa| > 3 m)
- Flag #30: SSHA pixels out of the expected statistical distribution
- Flag #20: Suspected sea-ice pixels based on quality flag and ice concentration
- Flag #10: Suspected coastal pixels based on quality flag and distance to coast
- Flag #5: SSHA pixels out of the local distribution
- Flag #0: Valid data

They can be activated or not, depended on the applications.

Approximately, **7 % of pixels are considered as invalid** in the nominal 10-60 km. 3 to 4 % are due to eclipse transition. More details in Dibarboure et al (2024).

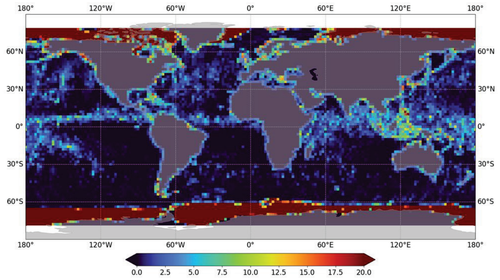


***Figure** : Percentage of data edited (flag < 70)*

Editing 250 m

List of flag available :

- Flag #102: No SSHa values available
- Flag #101: Pixels over land using a shoreline mask.
- Flag #70: Pixels impacted by spacecraft events (e.g. eclipses transition, maneuvers...)
- Flag #50: Abnormally high SSHA values (|SSHa| > 3 m)
- Flag #30: SSHA pixels out of the expected statistical distribution
- Flag #20: Suspected sea-ice pixels based on sigma0 and ice concentration
- Flag #10: Suspected coastal pixels based on sigma0 and distance to coast
- Flag #5: SSHA pixels out of the local distribution
- Flag #0: Valid data

As for the 2km product, they can be activated or not, depended on the applications.

Advantages compared to 2km product : Better precision of the editing for rain cells, coast and sea-ice.

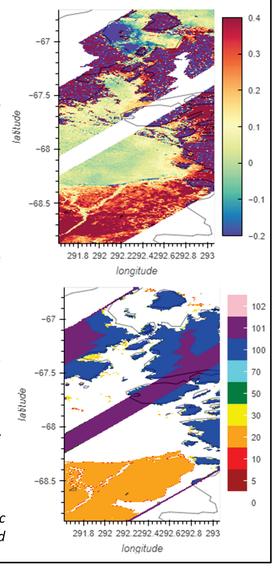


***Figure** : SSHa calibrated (left) in m and the associated Level 3 editing flag (right) near the Antarctic (250m product). For the 2km product, almost all the data are edited*

Scan for **SWOT data** access

Scan for free hosting on **CNES Cloud** & HPC infrastructure
Very fast I/O for SWOT 250-m & 2-km

Denoising 2km

Features of the noise : Correlated and lower than in simulations (order of magnitude : millimetric)

Training dataset : Simulated SWOT data are used based on eNATL60 ocean model with tides (Ajayi et al., 2020; Brodeau et al., 2020). A correlated noise is generated by using the style transfer technique from Gatys et al (2016) (context: simulated SWOT data, style: real SWOT data) to be as realistic as possible.

Model : UNet with 231 000 parameters (Tréboutte et al, 2023)

Results :

- Remove ~ 5 mm RMS from the SSHa
- SSHa spectrum linear from larger scales to 15 km
- Might captures ocean features (internal waves, …)

in addition to KaRIn noise.
More details in Dibarboure et al (2024).

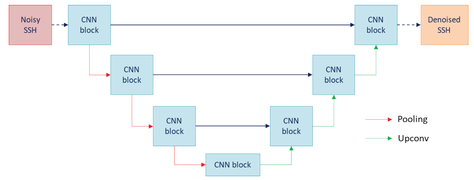


***Figure** : Architecture of the UNet*

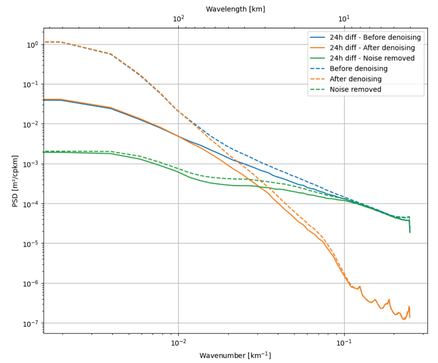


***Figure** : Power Spectrum Density (PSD) of SSHa (2km product) before denoising (dashed blue), after denoising by the UNet (dashed orange) and of the noise removed (dashed green). The plain lines corresponds to 24-hour differences from the 1-day phase*

Denoising 250 m

Features of the noise : White noise – Order of magnitude : centimetric

Training dataset : Simulated SWOT data are used based on eNATL60 ocean model without tides (Ajayi et al., 2020; Brodeau et al., 2020). A random noise is generated with the SWOT simulator (Gaultier et al, 2016).

Model : UNet with 231 000 parameters (Tréboutte et al, 2023)

Results : The UNet remove ~ 2.5 cm RMS from the SSHa on average and it is only random noise.

Advantages compared to 2km product : Small physical structures (internal waves, small eddies...) are not smoothed / removed.

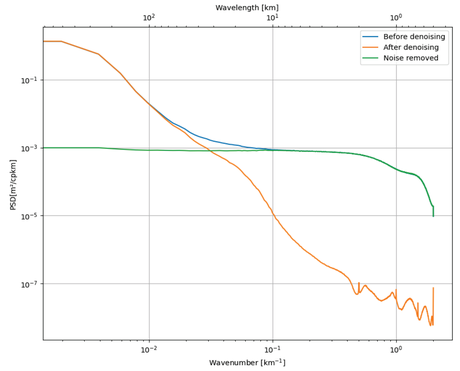


***Figure** : Power Spectrum Density (PSD) of SSHa (250m product) before denoising (blue), after denoising by the UNet (orange) and of the noise removed (green)*

Conclusion & Perspectives

The editing and the denoising at 2km resolution are qualitatively good for most cases. Small structures such as internal waves or small eddies are not well edited and/or filtered. Therefore, some improvements can be done such as training the UNet on global ocean model. Quantitative metrics and comparisons to real in-situ observations are missing in order to better evaluate the denoising. The first version of 250m product shows many advantages compared to the 2km product and can be used for coastal or polar activities.

References : Ajayi et al (2020) https://doi.org/10.1029/2019JC015827 / Brodeau et al (2020) https://doi.org/10.5281/zenodo.4032732 / Dibarboure et al (2024) https://doi.org/10.5194/egusphere-2024-1501 / Gaultier et al (2016) https://doi.org/10.1175/JTECH-D-15-0160.1 / Gatys et al (2016) https://doi.org/10.1109/CVPR.2016.265 / Treboutte et al (2023) https://doi.org/10.3390/rs15082183