CLS new denoising algorithm succeed to remove KaRIn noise efficiently, better than ever

Ref paper

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Introduction & Objectives

Current denoising applied on 2km SWOT LR L3 products is creating biases and other artefacts in strong waves conditions. We managed to mitigate these phenomenom by improving our training process. We evaluate the quality of our results on a new comparative benchmark we have developed.

Methodology Overview & Data

Main modifications of training process :

- Smaller dataset
- Smaller batches
- Smaller learning rate

Main modifications of training data :

- No more style-transfer on noise, its amplitude is modulated by wave level and cross-track distance
- Real L3 editing mask is applied to simulated swath

Artefacts and biases mitigated :

In V2.0.1 :

Degradation of oceanic structures in high variability regions
+ Creation of artefacts and biases in strong waves regions

In V3.0 :

No more degradations, biases, or artefacts

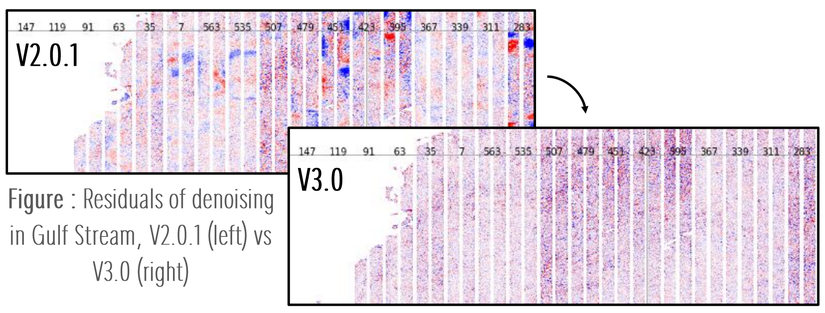


Figure : Residuals of denoising in Gulf Stream, V2.0.1 (left) vs V3.0 (right)

In V2.0.1 : absorption of short-wavelength signals

In V3.0 : more of small-scale variability is restored

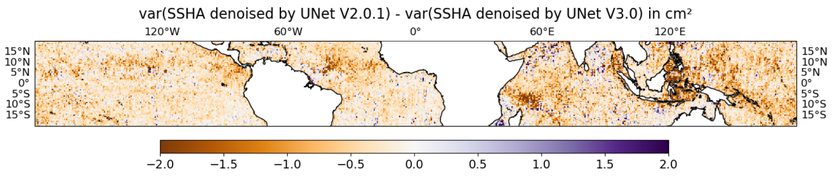


Figure : Spatial difference in variance (in cm²) between SSHA denoised by the UNet in V2.0.1 products against SSHA denoised by UNet in V3.0

Results of V3.0 denoising on the comparative benchmark

To evaluate the quality of the denoising, we created a comparative benchmark against which any new method can compare its performance. We aim to enhance to the benchmark with new metrics with comparison to other satellites or in-situ data. Here we focus on three metrics (more details with the QR code associated above) :

Visual validation :

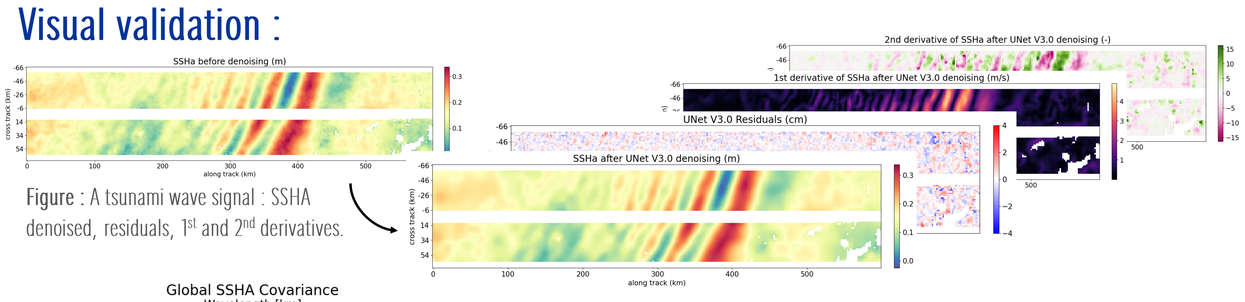
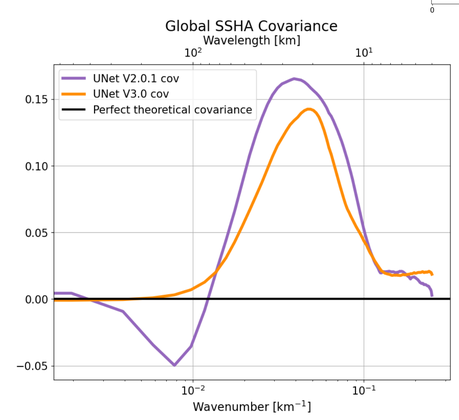


Figure : A tsunami wave signal : SSHA denoised, residuals, 1st and 2nd derivatives.

The first point of the benchmark is to verify denoising results on a subset of interesting ocean dynamics swaths, tricky to denoise.



Covariance of denoised SSHA and its residuals

We aim to minimize the covariance between denoised swaths and their residuals.
A negative covariance means that the denoising has created nonexistent signal. We can see clear improvement from V2.0.1 to V3.0.

Figure : Covariance of denoised SSHA and the associated residuals computed from power spectral densities (V3.0 in orange, V2.0.1 in purple)

Comparison at cross-overs points with S3A 20Hz

We consider S3A as an independent satellite to measure the quality of denoising. We make the assumption that for a small enough delta in time, S3A and SWOT are seeing the same true oceanic signal (The bluer, the better on the figure).

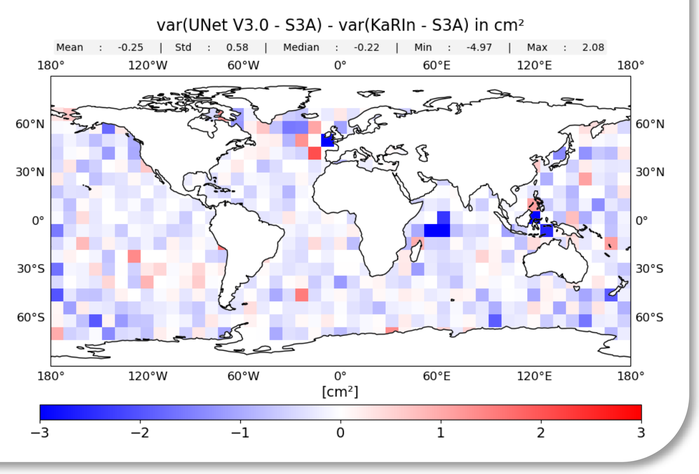


Figure : Spatial difference of variance (in cm²) between noisy SSHA against SSHA denoised by Unet in V3.0

Does the network is reproducing the ocean dynamics of the training simulated model ?

The network learnt on eNATL60 dataset with a noise modulated by wave level and the distance cross-track. To ensure we are not reproducing the dynamics of eNATL60, we infered the model on a MITgcm dataset. Power spectral densities are highlighting the capability of the network to remove only the noise degradation, without damaging the SSHA even in regions it has never seen before.

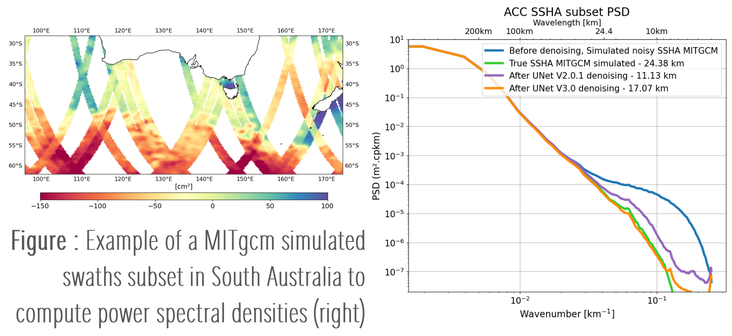


Figure : Example of a MITgcm simulated swaths subset in South Australia to compute power spectral densities (right) between versions of denoising

Future denoising for SWOT LR L3 250m in V4.0 of products

We are currently working on a new version of denoising of SWOT LR L3 250m. We can now see fine-scale signals, even in gradients, that are unseen in 2km products.

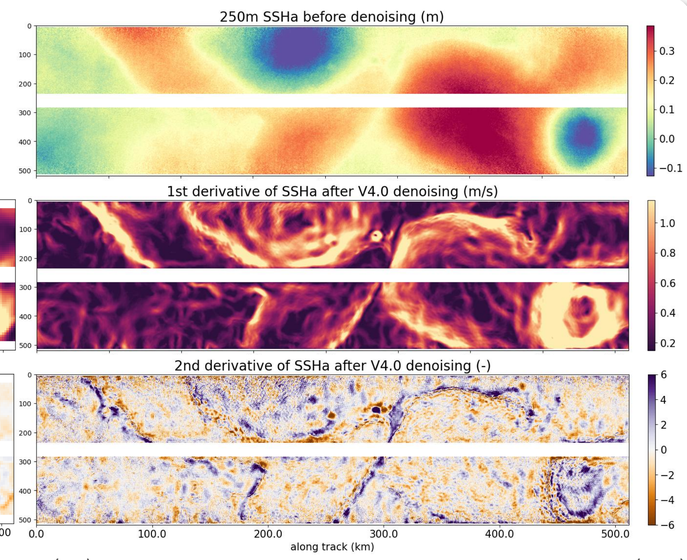


Figure : Example of 1st and 2nd gradients, for 2km SSHA denoised in V3.0 (left) and 250m SSHA denoised by experimental denoising for V4.0 (right)

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DUACS SWOT LR L3 denoising improvements

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