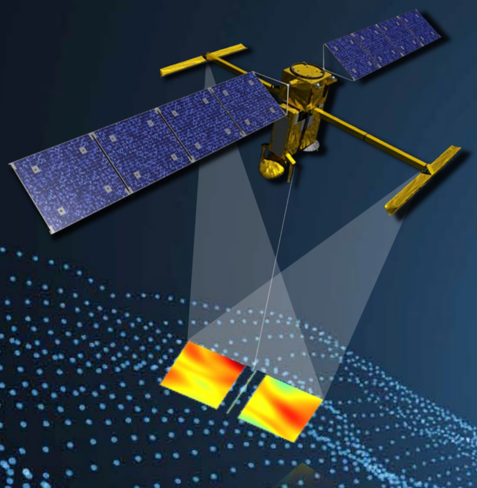

Mean Sea Surface : current quality and future estimation using SWOT-KaRIn

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G Dibarboure (CNES)

SWOT-ST 2024/06

Context

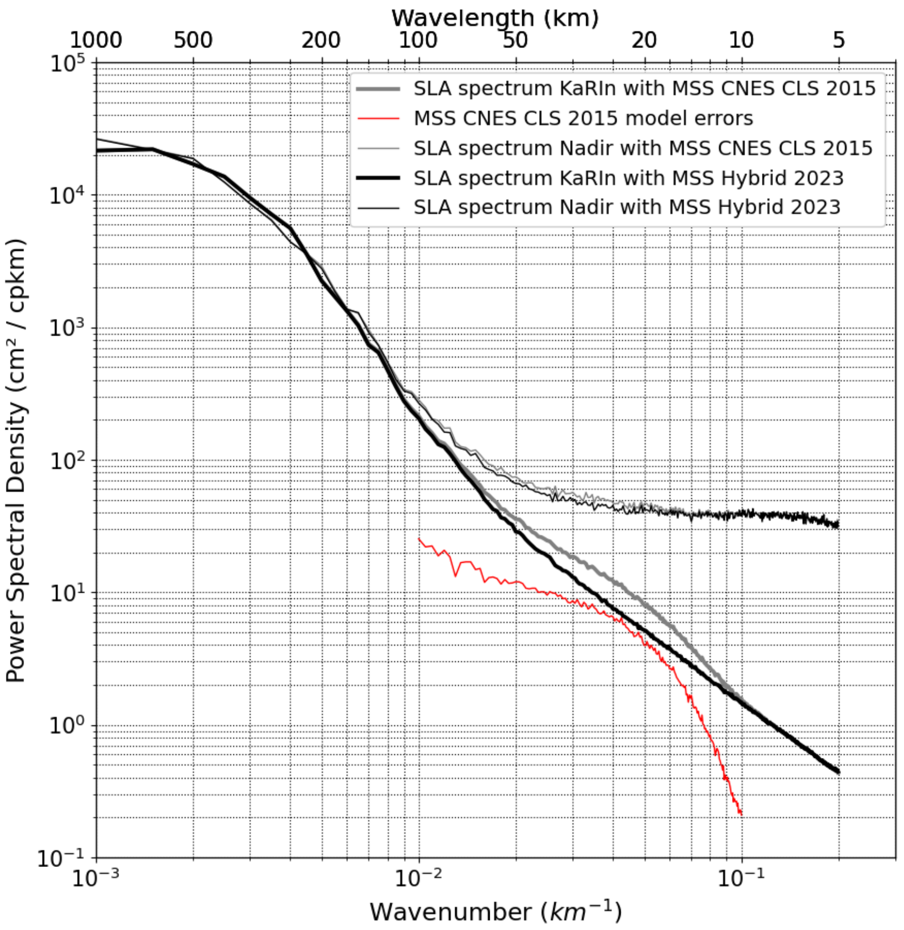
Previous studies underlined the **residual MSS errors at short wavelengths** (e.g. Pujol et al, 2016; Dibarboure et al, 2018)

- MSS error is nearly dominated by measurement noise for conventional LRM nadir measurement
- **MSS become the main source of errors for SWOT-KaRIn at WL < ~100km** (Pujol et al, 2023; Laloue et al, 2024; Dibarboure et al, 2024).

PGC/PIC products currently use the MSS CNES_CLS_2015:

- ➢ Significantly change the SSHA PSD : MSS bump
- ➢ Explains ~40% of the KaRIn SSH variance in the [100, 15km] WL range (Laloue et al, 2024); about 90% around 30-15km.

➔ A better MSS model is required for an optimal use of the SWOT-KaRIn measurements



PSD of the KaRIn (thick solid line) and Nadir SSHA (thin solid line) when it is based on the CNES/CLS2015 MSS (grey); and when a more accurate MSS (here Hybrid 2023 model) is used instead (black). MSS CNES_CLS_2015 (red) estimated errors

Current MSS error estimation

- Recent MSS error was recently quantified by Laloue et al. (2024) using independent Sentinel-3A (SAR) and SWOT-KaRIn measurements (CalVal phase) for global ocean; Icesat-2 in the polar areas

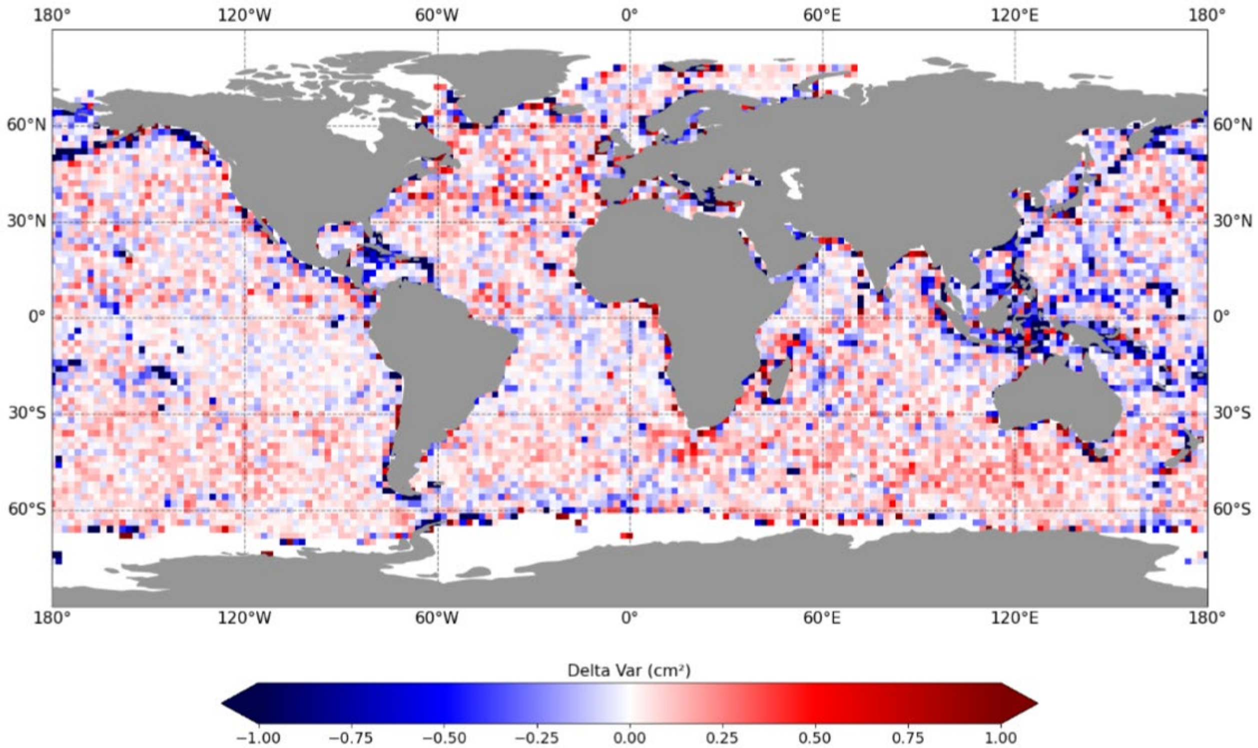
MSS	Sentinel-3A		SWOT KaRIn	
	MSS Error (cm^2)	% of SSHA variance*	MSS Error (cm^2)	% of SSHA variance*
CNES_CLS15	0.31 ± 0.05	31	0.48 ± 0.02	38
DTU21	0.25 ± 0.04	25	0.36 - 0.05/+ 0.08	28
CNES_CLS22	0.18 ± 0.04	19	0.32 ± 0.02	25
SCRIPPS_CLS22	0.15 ± 0.04	16	0.24 ± 0.02	19

MSSs errors estimation over the global ocean for WL ranging [100, 15km]

- CNES_CLS_2015 MSS presents the higher errors at short wavelength (mainly omission errors).
- DTU21, CNES_CLS_2022 and SCRIPPS_CLS2022 present significantly reduced errors, but with some defaults that are specific to each MSS.
- Higher errors estimated with SWOT-KaRIN: mainly due to higher capability to catch fine scale structures thanks to reduced noise level

- Hybrid 2023 : tentative to merge the strength of the different up-to-date MSSs.

@Laloue et al , 2024



CNES_CLS_2022 better

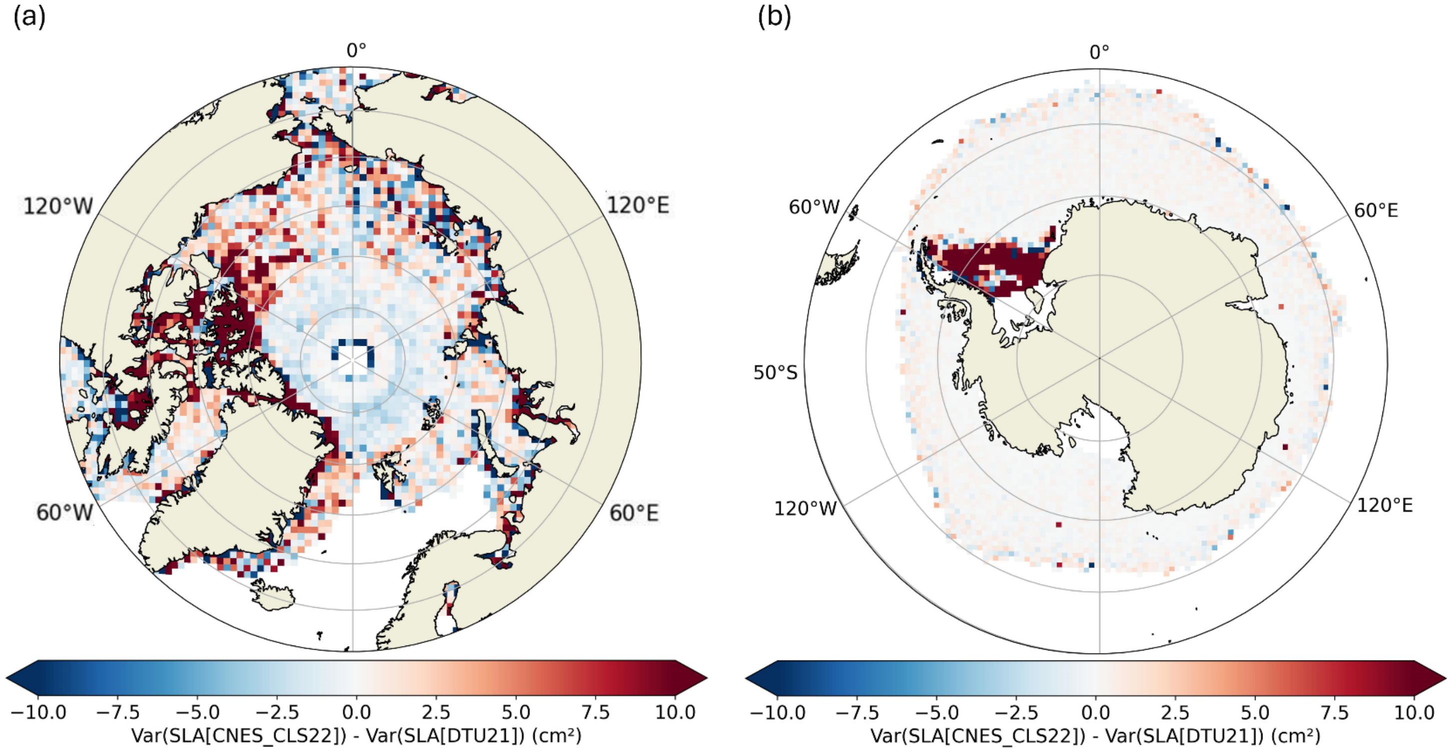
SCRIPPS_CLS2022 better

Differences between the variance of errors estimated for the CNES_CLS22 MSS and the SCRIPPS_CLS22 MSS for wavelengths ranging from 15 to 100 km along S3A tracks

- SCRIPPS_CLS22 shows the better performances in open ocean
- But less performant in coastal areas → CNES_CLS_2022 preferred
- And specific striae anomalies well visible in high variability areas

@Laloue et al , 2024

CNES_CLS_2022 vs DTU21



CNES_CLS_2022 better

DDTU21 better

Differences in variance of sea level anomalies calculated from the CNES_CLS22 MSS and the DTU21 MSS in 50-km boxes. (a) In the Arctic ice-covered region using ICESat-2 data and (b) in the Southern Ocean ice-covered region using S3A data

- DTU21 globally shows the better performances in coastal polar regions

@Laloue et al , 2024

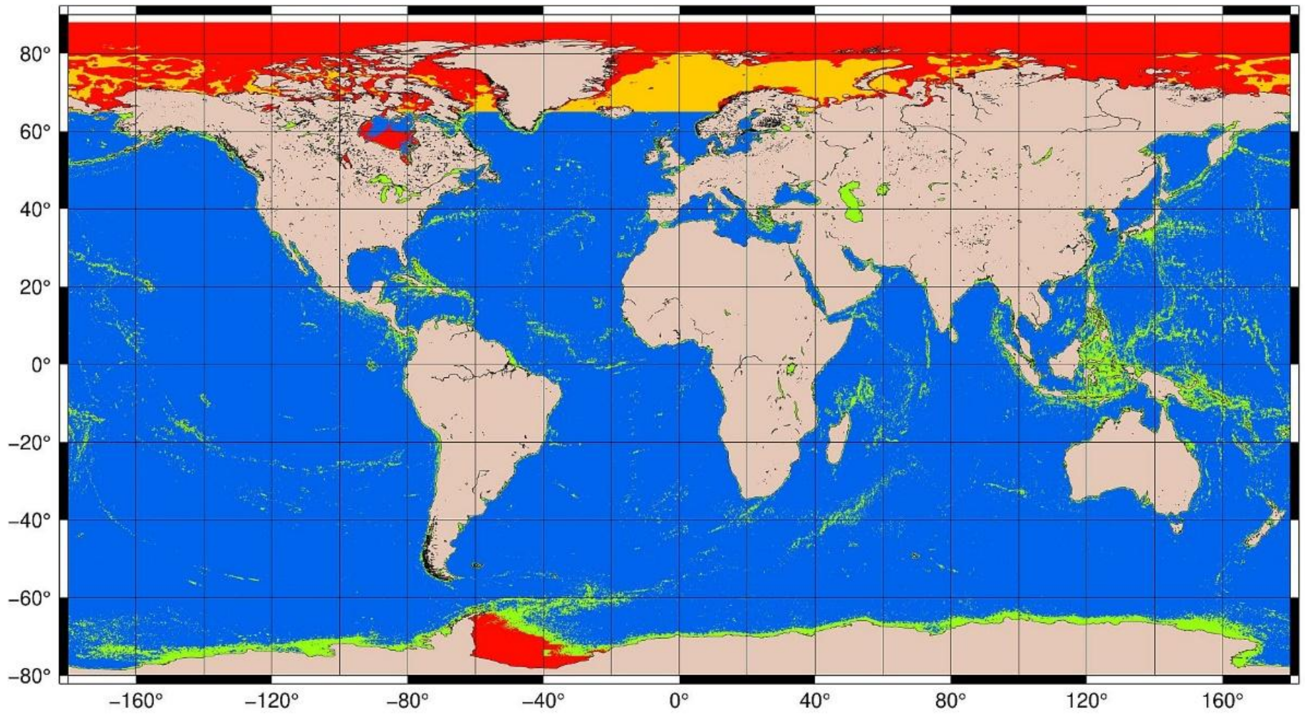
MSS Hybrid 2023

- SCRIPSS_CLS2022 used in the main part of the ocean
- CNES_CLS_2022 used near the coast, in high ocean variability areas and over some geodetic structures
- DTU21 used in high latitude areas

Blending method designed for the SWOT accuracy specification of 1cm/2km

Different conditions required to define the “patch” for the different MSSs :

- MSS replaced by another solution where the differences are significant (> 1cm in a given bubble)
- Patches need to reach a minimal size
- Transition need to be ensured in areas were the difference between MSS doesn’t exceed a defined threshold



MSS Hybrid2023 hybridation mask

SCRIPSS_CLS22 used

CNES_CLS_2022 used

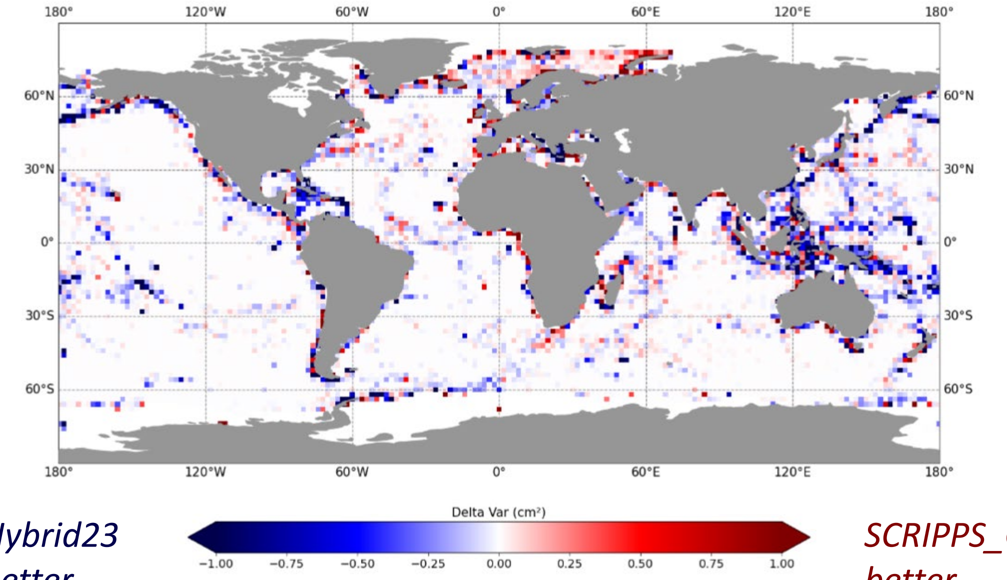
CNES_CLS_2022 and DTU21 used with homogenized interannual content

@Laloue et al , 2024

Hybrid 2023 performances slightly better than SCRIPPS_CLS2022 for the global ocean and DTU21 in the polar areas

MSS	Sentinel-3A		SWOT KaRIn	
	MSS Error (cm^2)	% of SSHA variance*	MSS Error (cm^2)	% of SSHA variance*
Hybride_2023	0.15 ± 0.04	15	0.23 ± 0.02	18

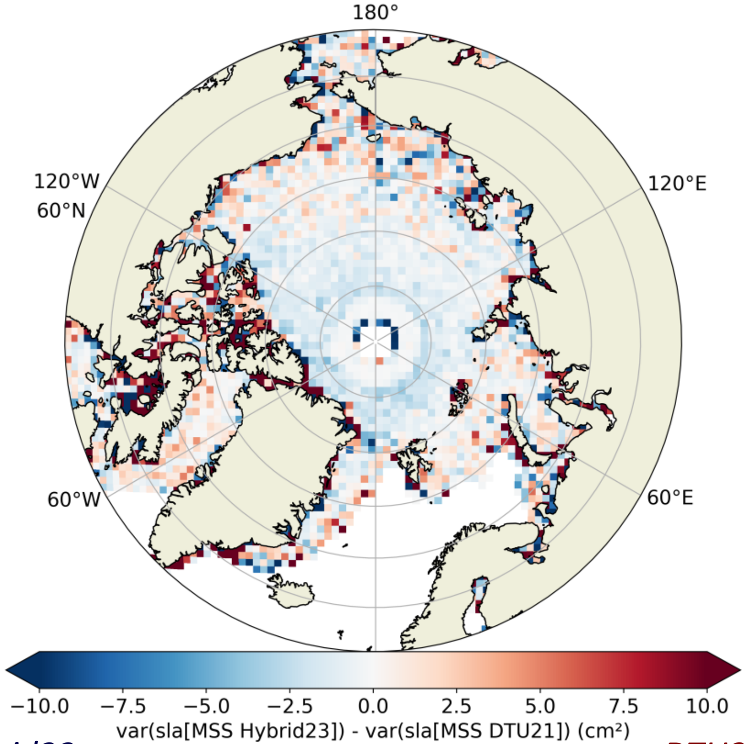
MSSs errors estimation over the global ocean for WL ranging [100, 15km]



Hybrid23 better

SCRIPPS_CLS2022 better

Difference between the variance of errors estimated for the Hybrid23 MSS and the SCRIPPS_CLS22 MSS for wavelengths ranging from 15 to 100 km along S3A tracks.



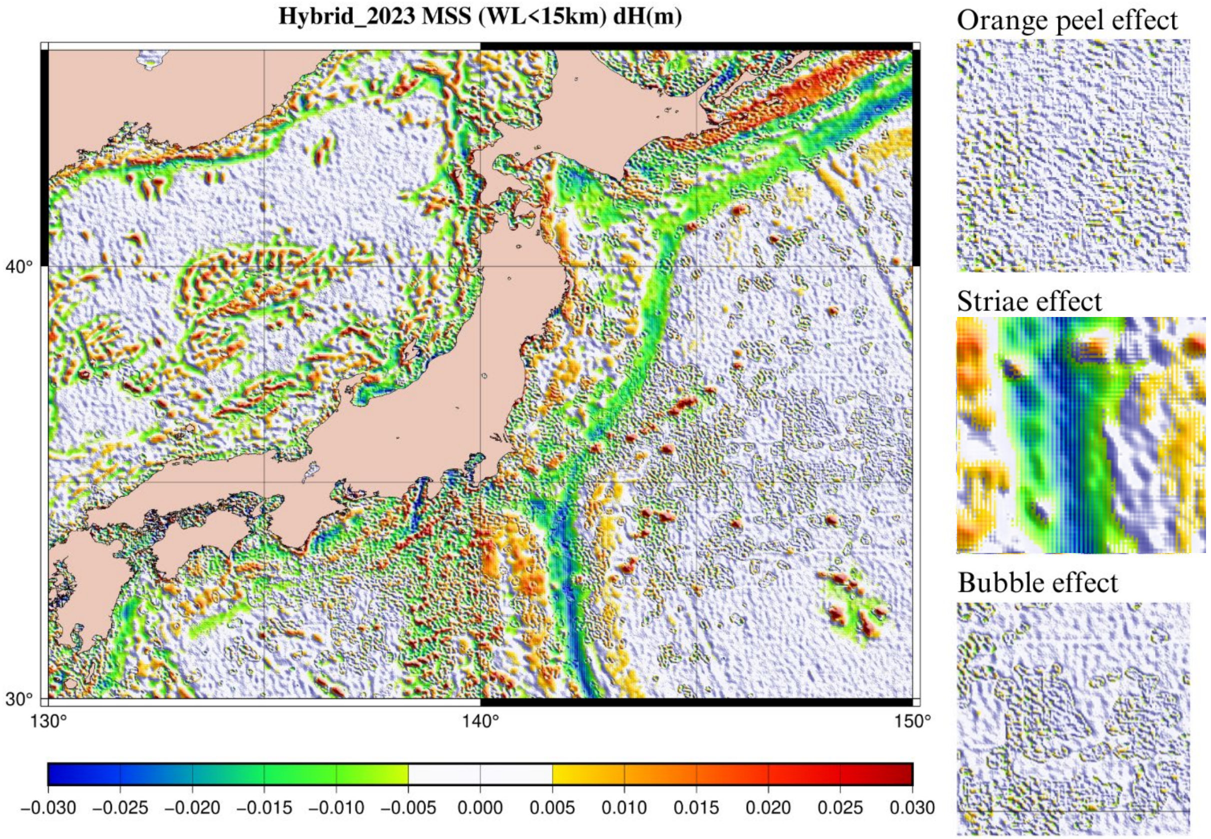
Hybrid23 better

DTU21 better

Differences in variance of ICESat-2 sea level anomalies corrected with the Hybrid23 MSS and the DTU21 MSS in 50-km boxes for the period of October 2018 to June 2020

@Laloue et al , 2024

But some imperfections remains ….



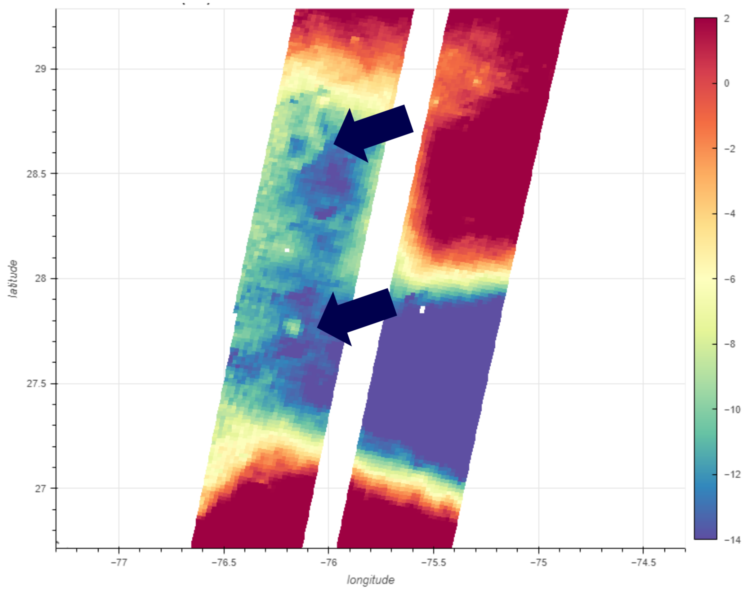
MSS Hybrid2023 at WL < 15km and zoom in specific artifacts

Errors specifics to the individual upstream MSS models:

- Orange peal effect for CNES_CLS_2022
- Striae effect for SCRIPPS_CLS22

Errors specifics to the hybridation methodology:

- Bubbles effect
- Small gradient induced by the hybridation

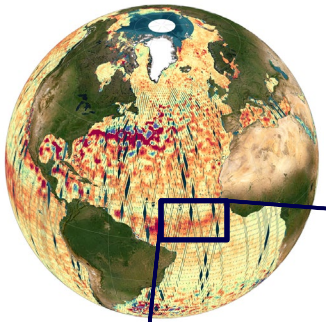


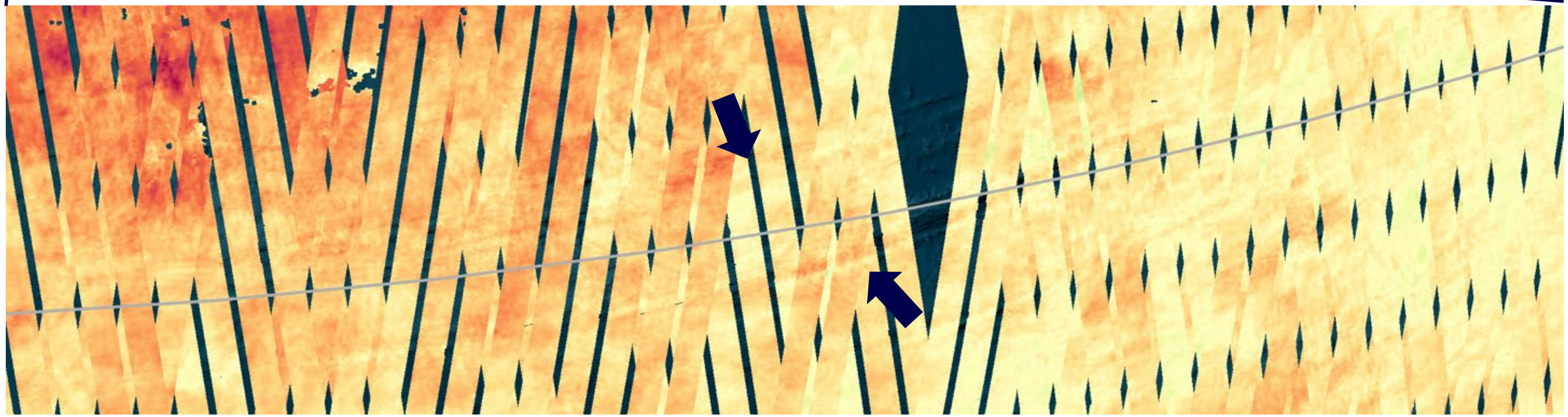
KaRIn SSHA (using MSS Hybrid 2023) along one swath during the Calval phase (unit: cm)

@Laloue et al , 2024

But some imperfections remains ….

- Imprecision of the restitution of some geodetic structures observed with SWOT KaRIn





KaRIn SSHA (using MSS Hybrid 2023) in the mid-Atlantic ocean

Improve the MSS estimation for & with SWOT-KaRIn

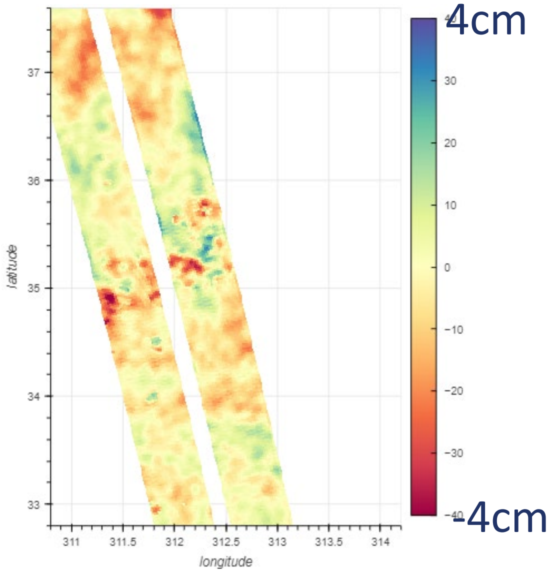
See dedicated poster

Different initiatives on going : CNES_CLS, SCRIPPS, DTU, …

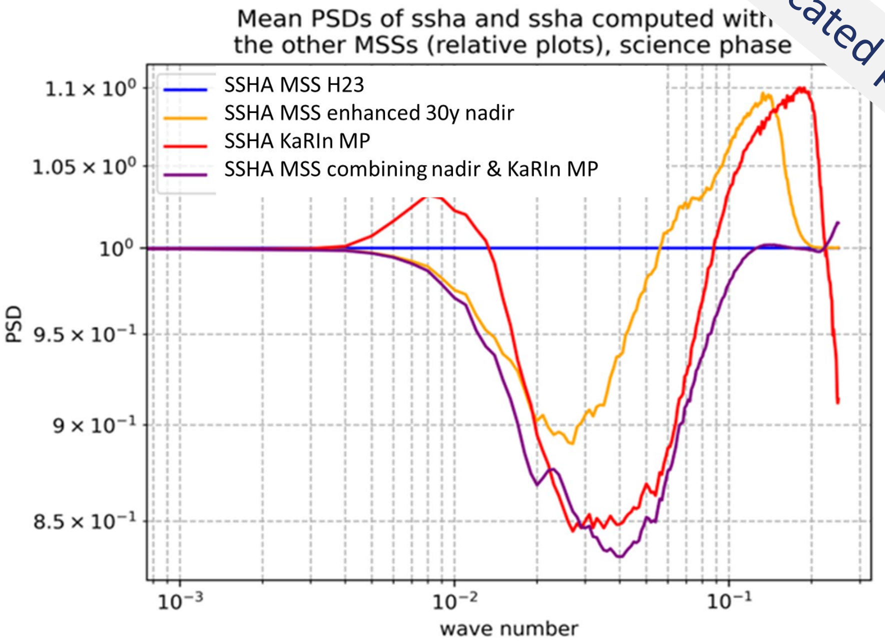
Future CNES_CLS solution using 102 cycles CalVal & 14 cycles Science to better resolve small MSS structures ~[50, 15km] in the swath; Combined with an improved background for longer WL

- ➢ About -15% SSHA variance reduction expected
- ➢ MSS errors reduced by ~65% expected

➔ Expected to be used in a future version of the Level-3 KaRIN products



Example of KaRIn mean profile (CalVal phase)

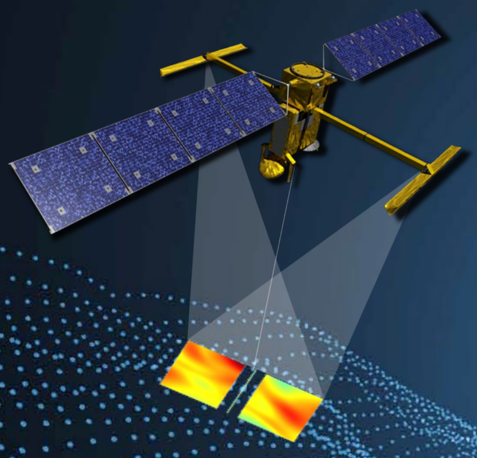


Relative mean SSHA PSDs (cycles independent of the PM and latitude ∈ [-60°; 60°]) obtained with different MSSs. MSS Hybrid2023 used as reference

And probably by 2025 different new MSS solutions available:

→ Assessment of the different MSS solutions

→ Blending of the different solutions ?



Thanks!