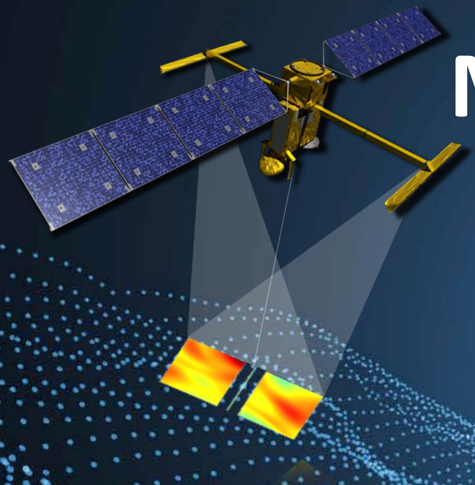

MSS errors & SWOT KaRIn measurements

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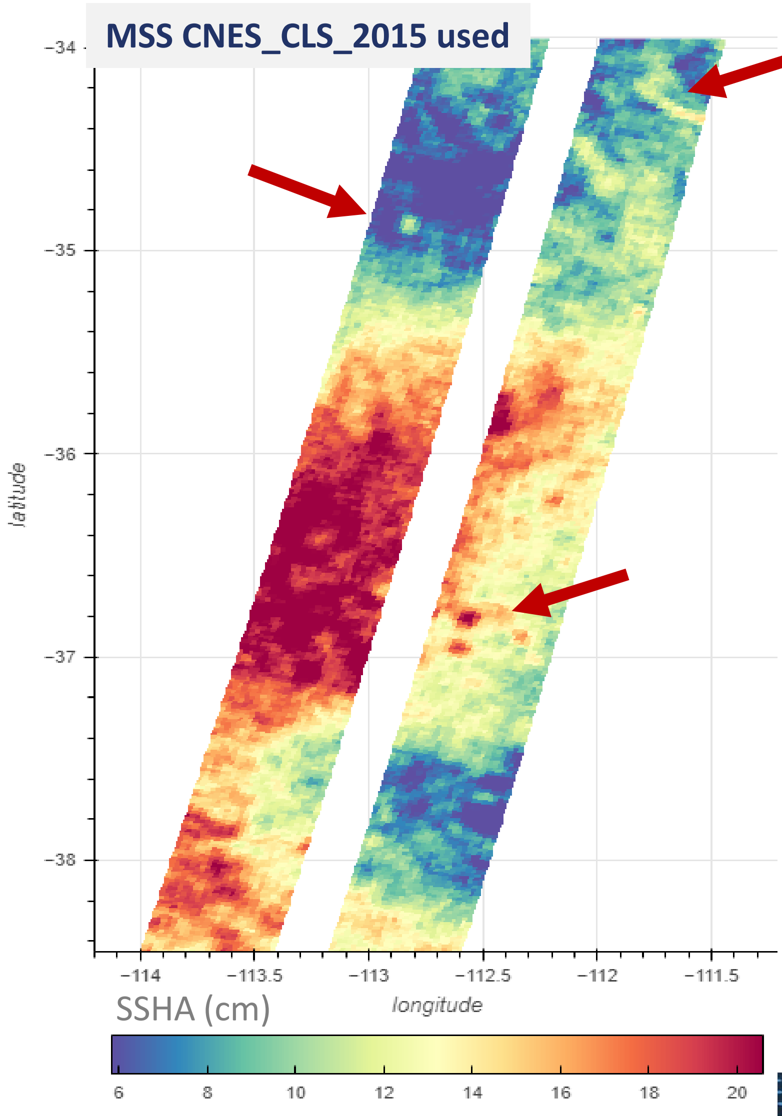
G Dibarboure (CNES)

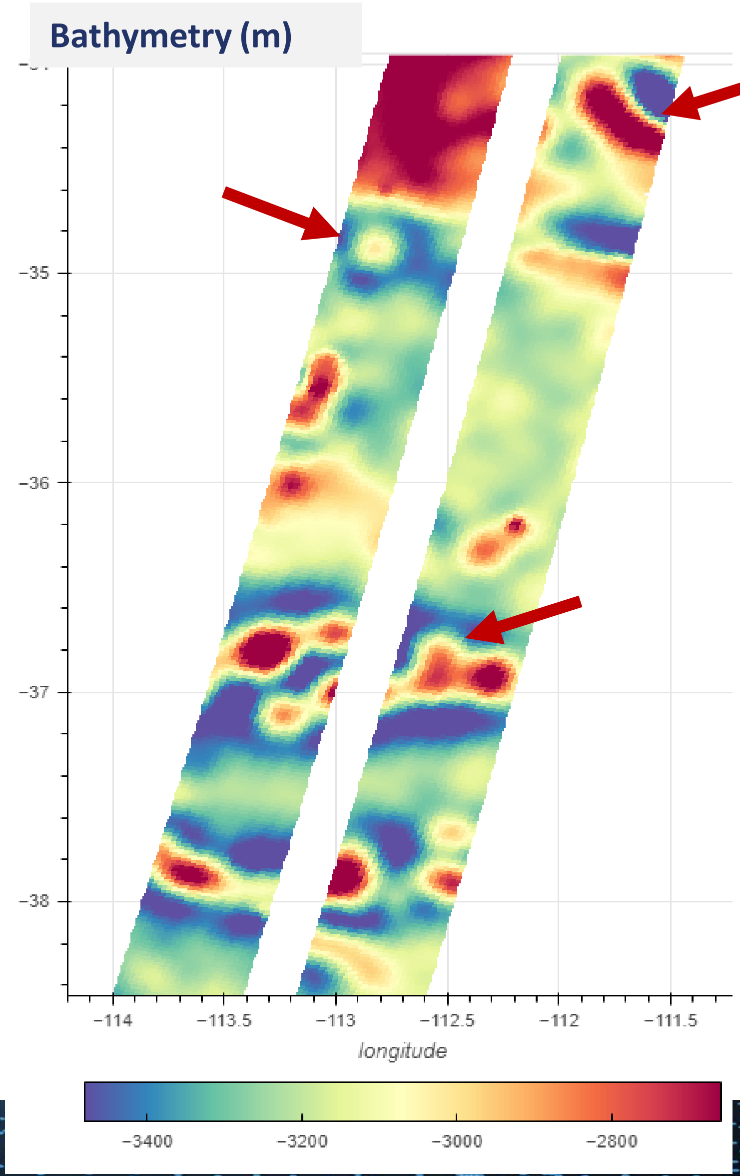
SWOT-ST 2023/09

Example of MSS error signature on SWOT measurements

The MSS is one of the significant error budget for SWOT measurement → necessity to quantify and qualify the MSSs performance at short wavelengths

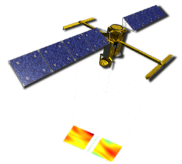


MSS CNES_CLS_2015 used



Bathymetry (m)

Examples of SWOT SSHA (cycle 545) when the MSS CNES_CLS_2015 is used



Methodology for MSSs errors estimation at short WL

- **methodolgy:**
  - Based on SSHA comparison between 2 cycles of measurement
  - Focus on WL ~[15, 100km]

Pujol et al (JGR 2018; https://doi.org/10.1029/2017JC013503*)*
Dibarboure & Pujol (ASR 2021; https://doi.org/10.1016/j.asr.2019.06.018*)*

3 assumptions:

1) There is **no covariance between the SSHA signal and the MSS errors** → We use a mission/period independent from MSS computation: S3PP/CNES Sentinel-3A (20Hz); SWOT KaRIn

2) The **SSHA signal is completely decorrelated between the two cycles considered** → We chose A and B far enough from each other

3) The MSS error is the same whatever the cycle considered → we use a repetitive mission

We consider :

- **H** = SSHA signal including the MSS errors (**e**) and the SSHA signal free from MSS errors (**h**)
- **A** and **B** = two different cycles

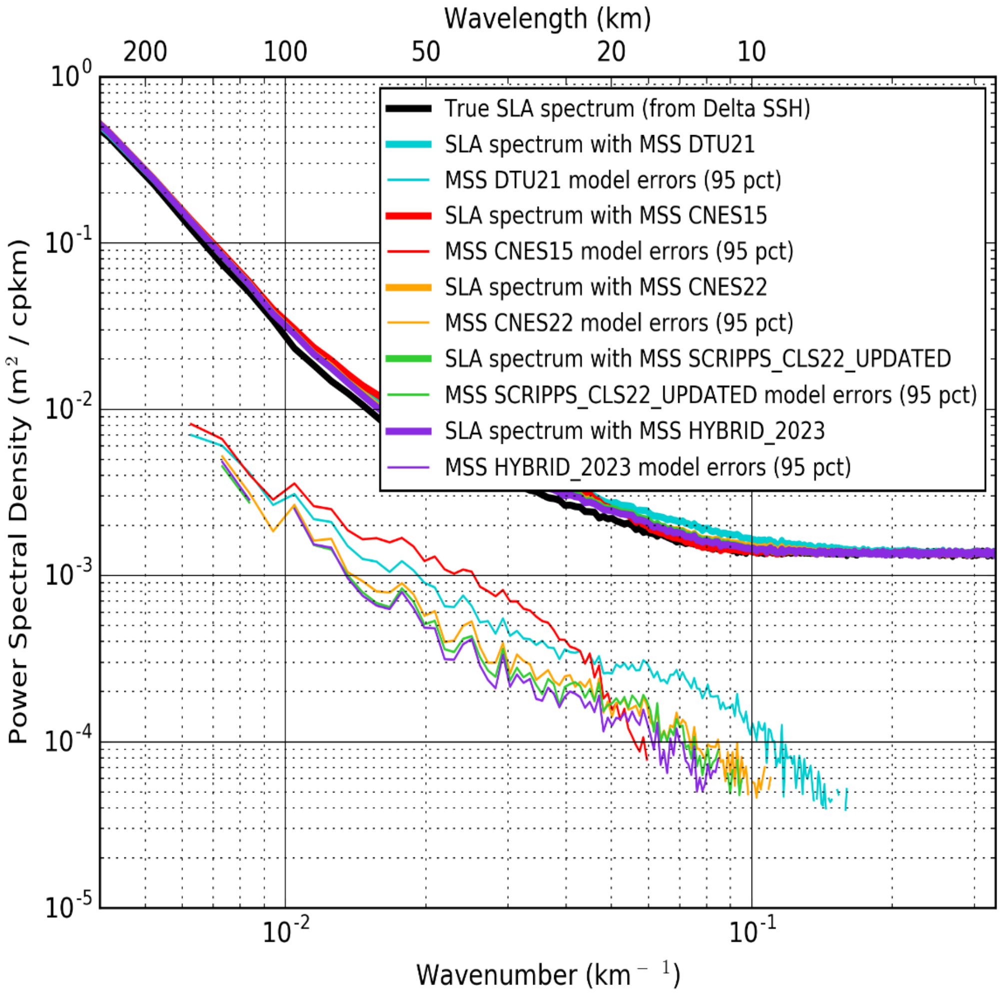
$$\boxed{0.5\,\sigma^2(H_A - H_B) - 0.5\,\sigma^2(H_A + H_B) = 2\,\sigma^2(e)}$$

Mean spectral content of the h signal

Mean spectral content of the h+e signal

Estimation of the mean MSS error over the global ocean

Sentinel-3A LRRMC used for validation



MSS errors at WL ranging [100 , 15 km]

MSS	MSS Error (cm²)	% of SSHA variance*
CNES_CLS_2015	0,40	34
DTU_2021	0,34	29
CNES_CLS_2022	0,23	20
SIO_2022	0,21	18
HYBRIDE_2023 (SIO, CNES/CLS, DTU)	0,20	17

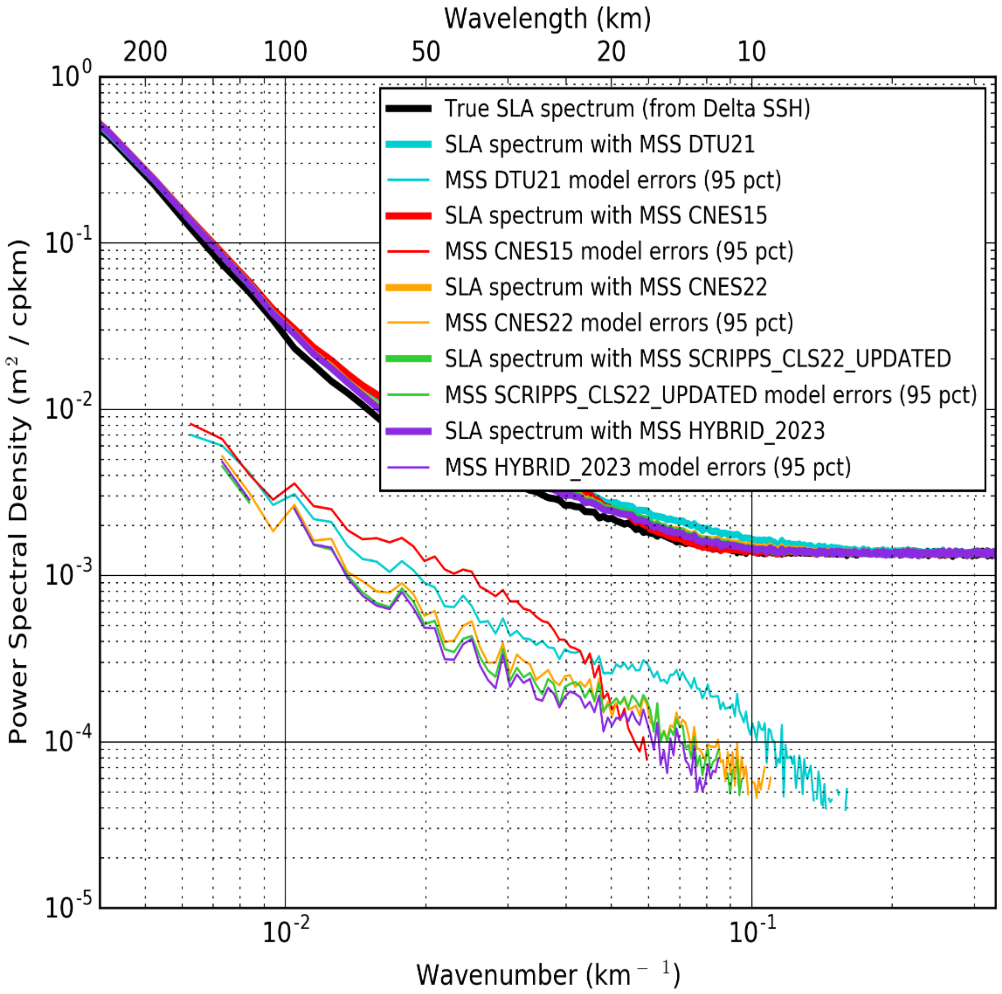
**SSHA "noise free" variance is estimated to 1,16cm²*

Note : assumption 1) not fully respected :

- *S3A measurements used for MSS error estimation cover a temporal period used for MSSs CNES_CLS_2022, SIO_2022 and HYBRIDE_2023 estimation*
- *S3A used in SIO_2022 computation*

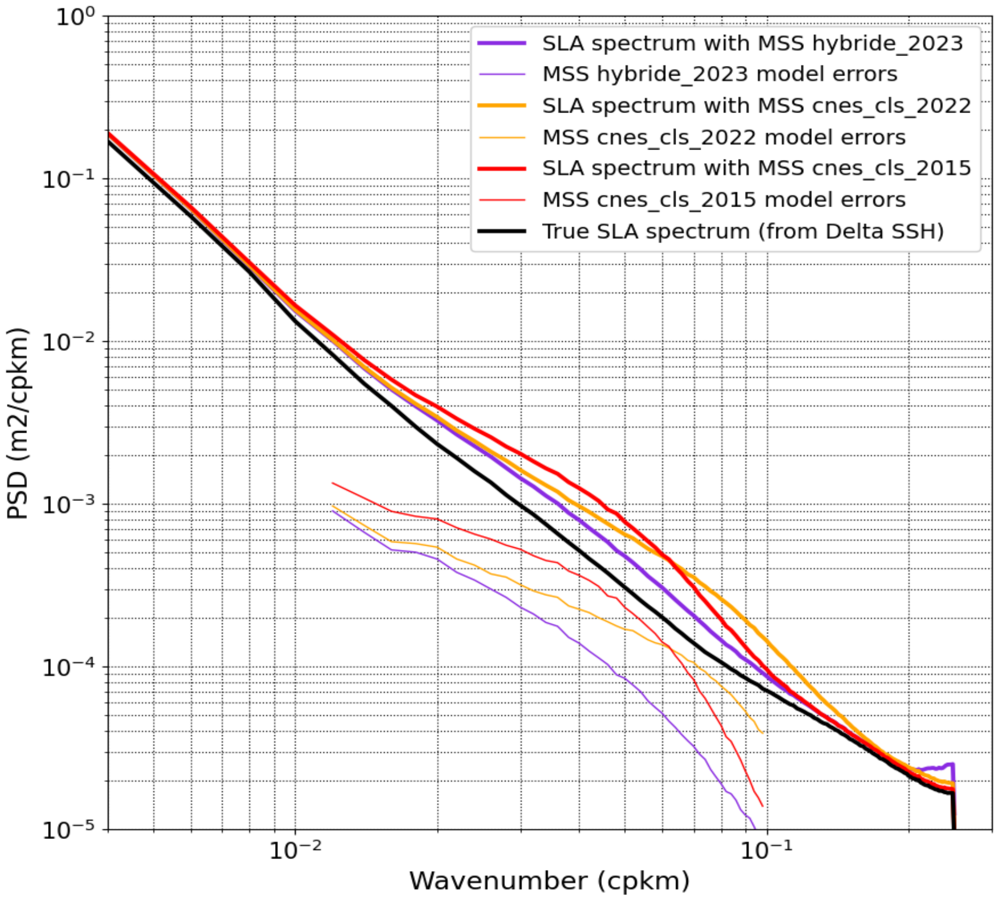
Estimation of the mean MSS error over the global ocean

Sentinel-3A LRRMC used for validation



CNES_CLS_2015
CNES_CLS_2022
HYBRIDE_2023
DTU_2021
SIO_2022

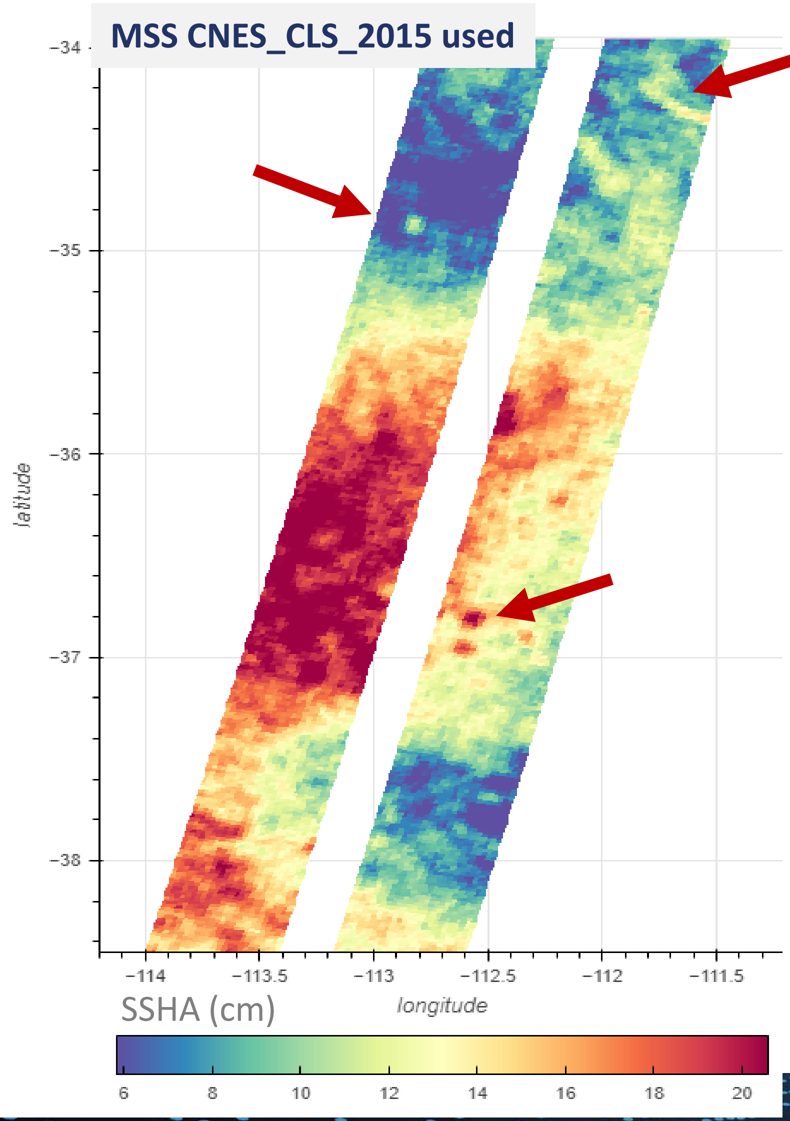
SWOT KaRIn used for validation

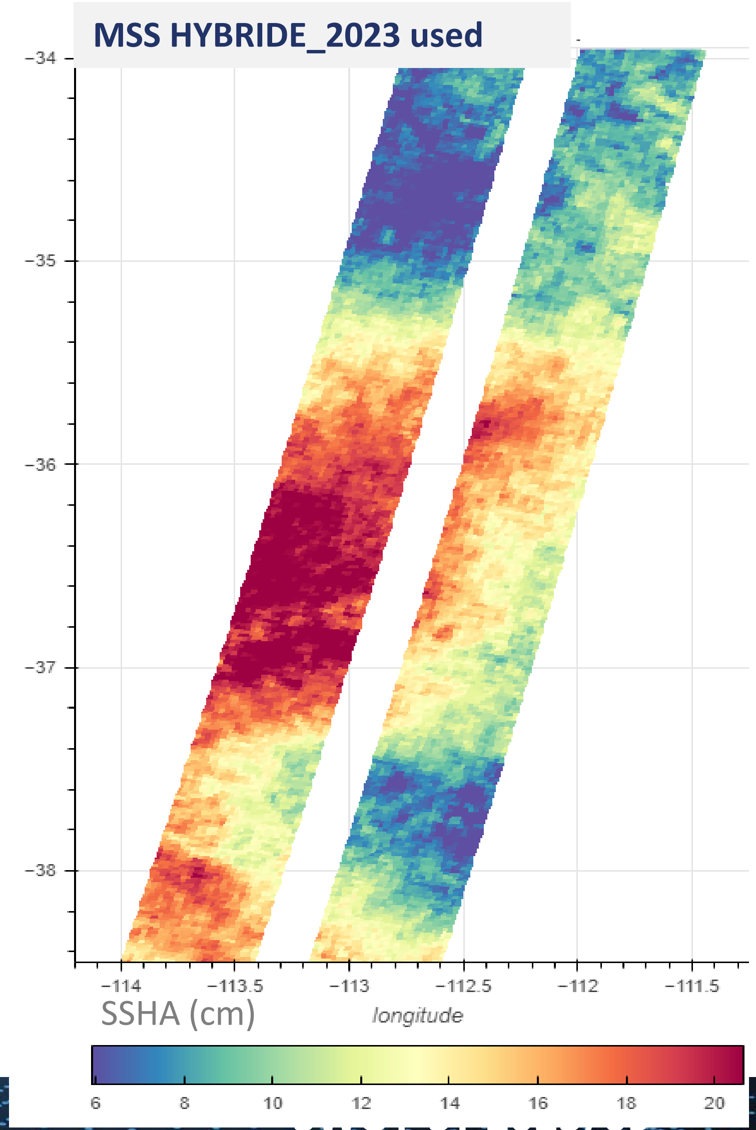


- ➔ Consistent results obtained with SWOT and S3A measurements at wavelengths ranging [70, 20km].
- ➔ Low noise level on SWOT = high potential for error estimation at short wavelengths (< 20km)
- ➔ **Preliminary results with SWOT that need to be consolidated**

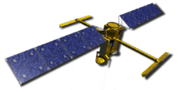
Example of MSS error signature on SWOT measurements

Up-to-date MSSs contribute to reduce the errors on SWOT. But some errors are still visible: the MSS remains a major contributor in the SSHA error (Dibarboure 2023)


MSS CNES_CLS_2015 used


MSS HYBRIDE_2023 used

Examples of SWOT SSHA (cycle 545) when the MSS CNES_CLS_2015 or HYBRIDE_2023 is used



Futures MSSs deduced from SWOT measurements

SWOT can be used to estimate a new MSS below the swath position.

A MSS error model prediction was proposed by Dibarboure et Pujol (2021; https://doi.org/10.1016/j.asr.2019.06.018):

Depends on 3 main parameters :

- The measurement noise level
- The repetitivity of the measurement
- The number of cycles (temporal period) available to compute the MSS

➔ They modulate the commission errors (i.e. residual noise or small-scale ocean variability) in the MSS

	MSS error level at short wavelength (in % of SSHA variance)			
	18% (~error of the up-to-date MSS models)	**9% (half the error of up-to-date MSS models)**	**< 5%**	**<2%**
	MSS SWOT can be used for future SWOT measurements (not used in MSS computation)	*MSS SWOT can be used for future and past measurements*		
SWOT CalVal phase (1-day repeat)			90 cycles (~3 months)	130 cycles (~4,3 months)
SWOT Scientific phase (21-day repeat)	9 cycles (~6 months)	18 cycles (~12 months)	26 cycles (~1,5 years)	52 cycles (~3 years)

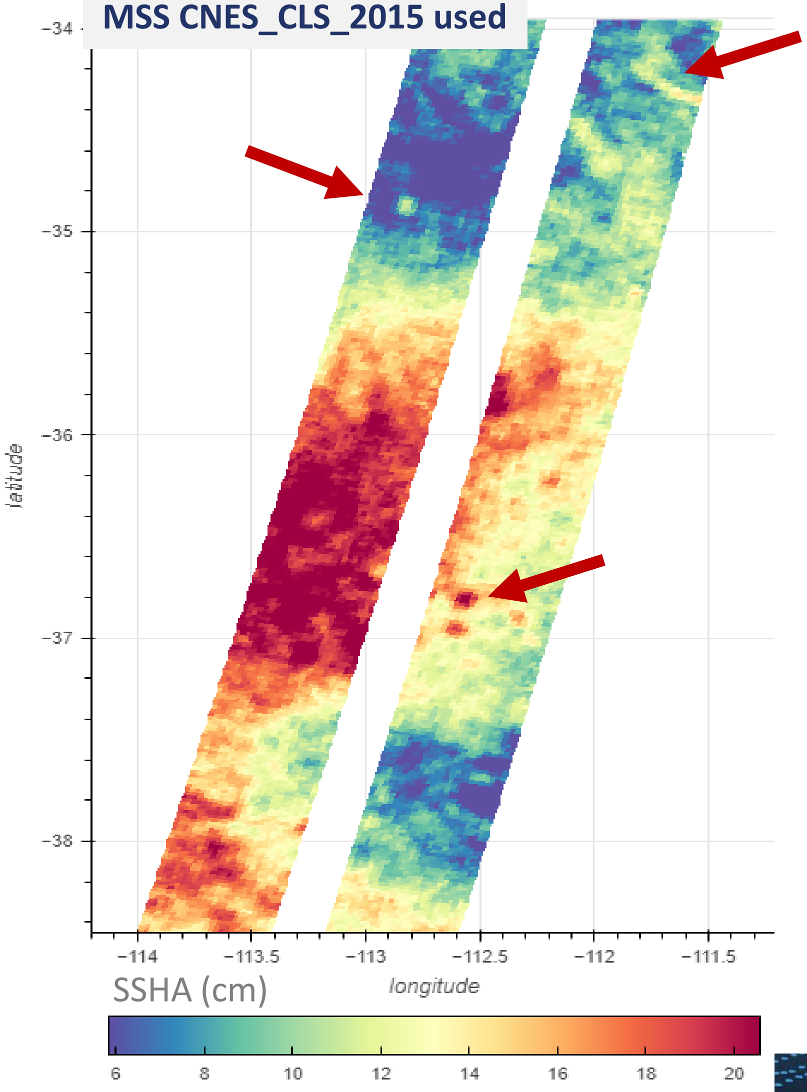
Tab: Temporal period required to reach a defined MSS error level at short wavelength

Example of MSS error signature on SWOT measurements

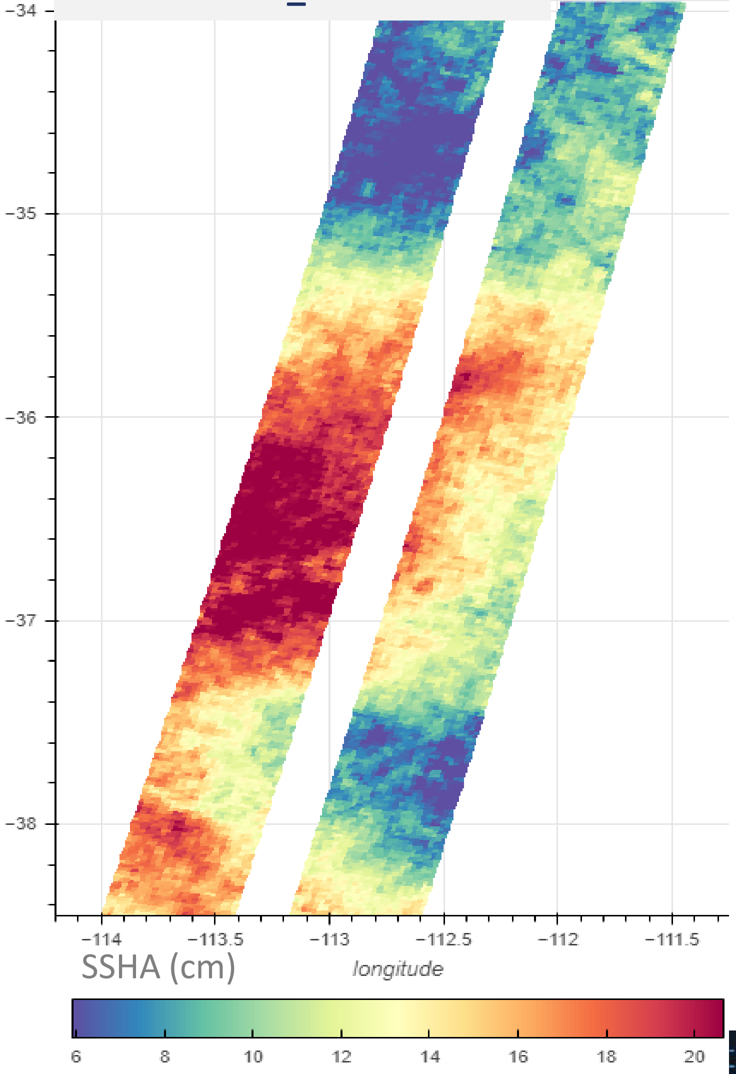
An example of the performances of the future SWOT MSS (preliminary results with 90 cycles of 1-day orbit).

See also poster from Yao Yu et D. Sandwell : “Accuracy and Resolution of SWOT Altimetry: Foundation Seamounts”

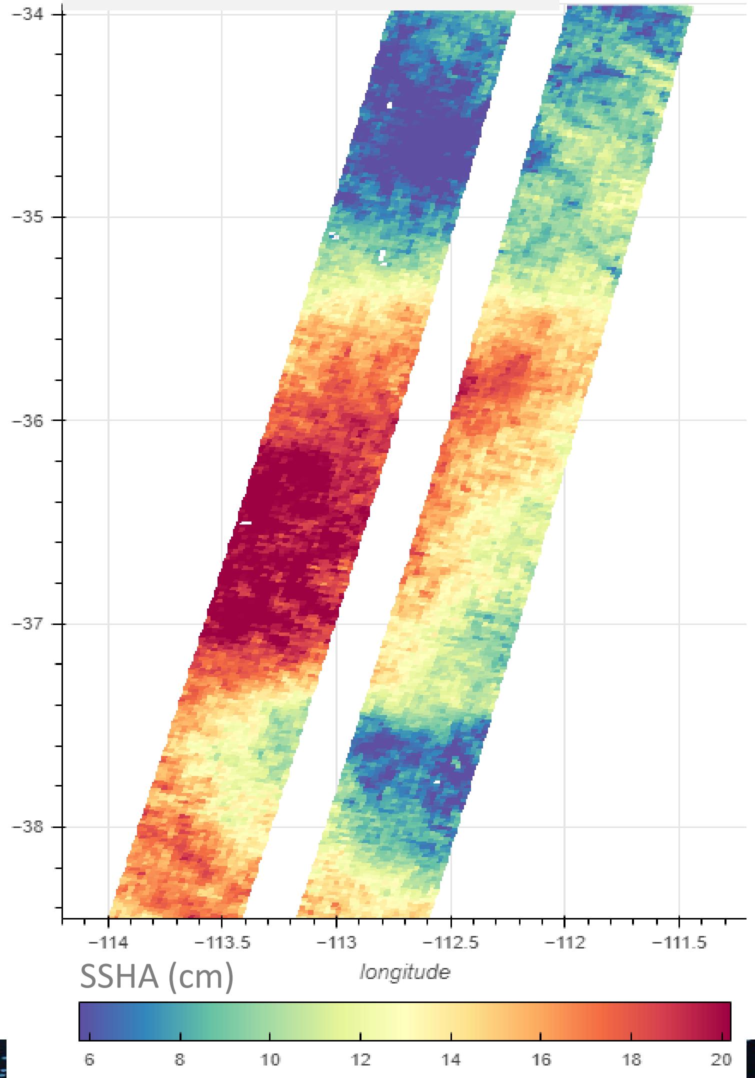
MSS CNES_CLS_2015 used



MSS HYBRIDE_2023 used



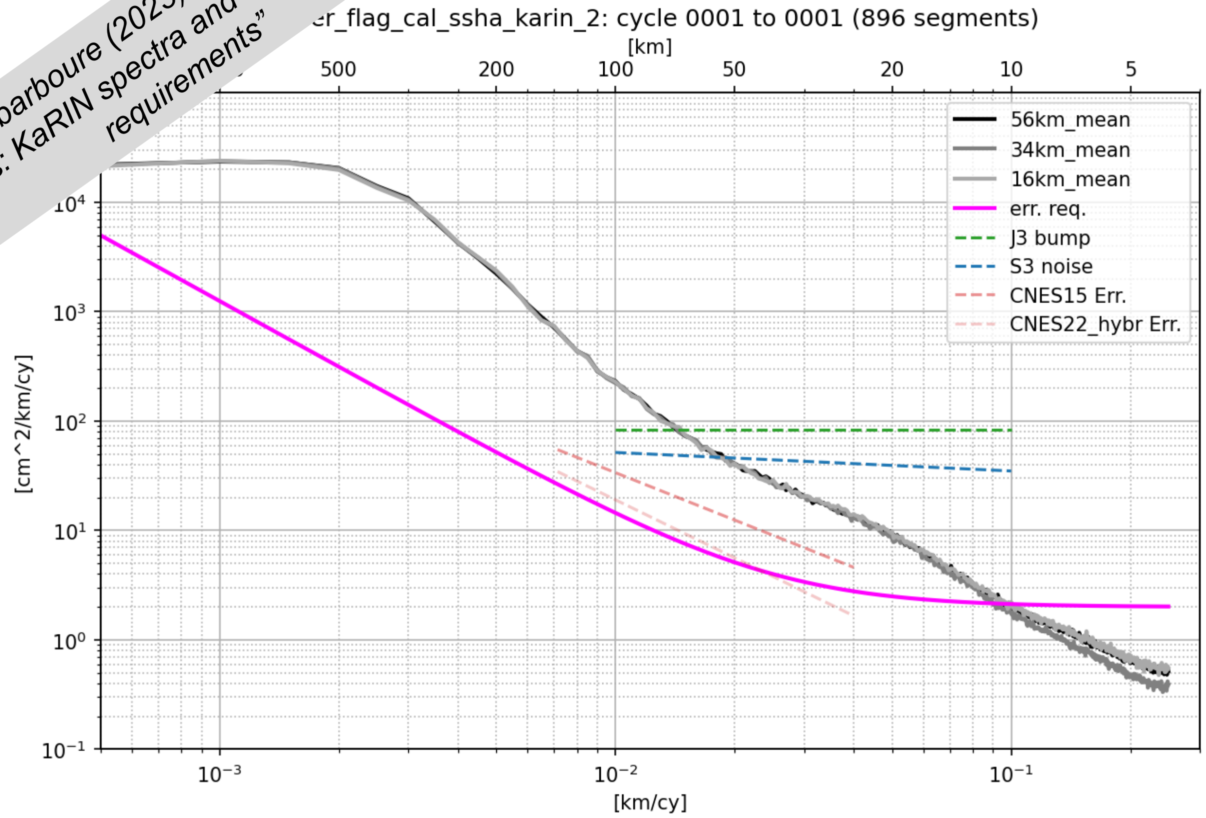
MSS SWOT_1d used



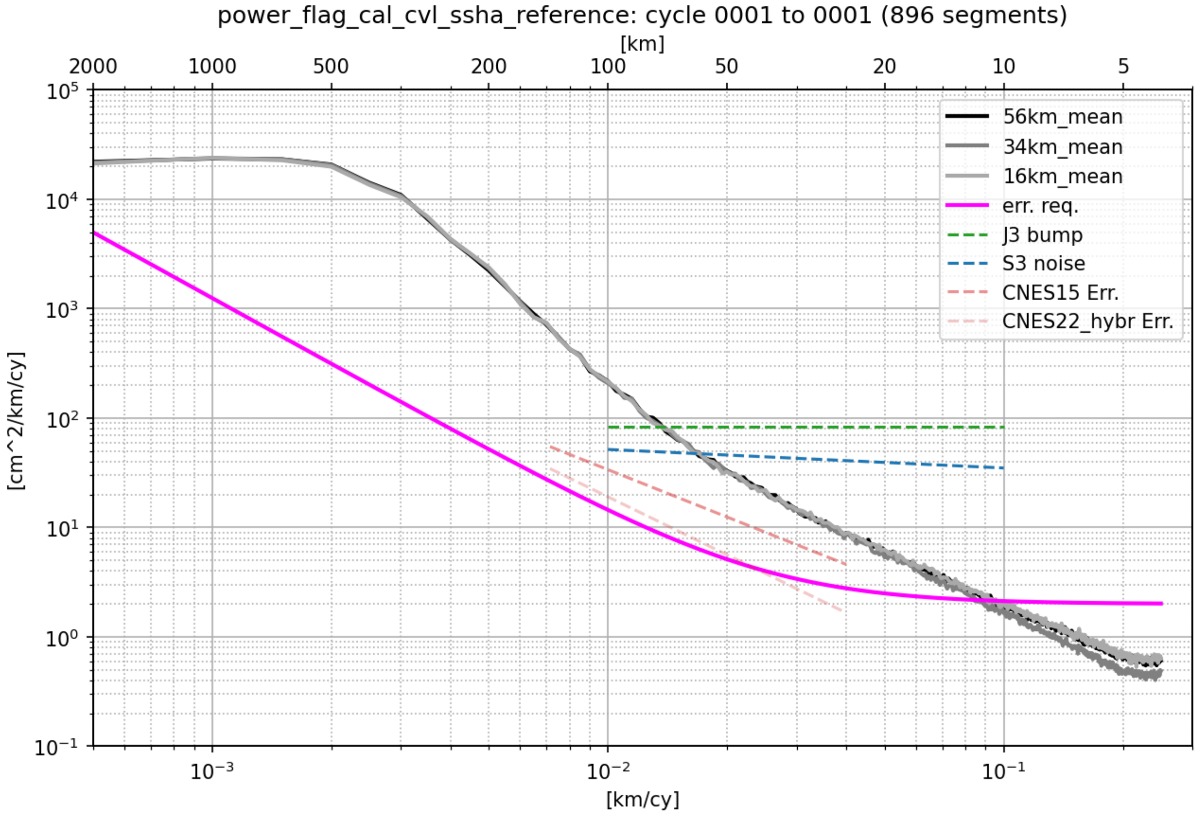
Annexes

From Dibarboure (2023) “SWOT Early E1 Results: KaRIN spectra and Ocean spectral requirements”

Science C A KarIn_2 with MSS model from 2015



Science Orbit (MSS updated 2023H-alpha2)



- Smaller scales of the geoid are poorly known in many regions: the error is correlated (fake eddies are seen in KaRIN SSHA)
- The MSS model is major contributor in the SSHA error ➔ SWOT needs to support geodesy (currently secondary science obj)
- Consequence on SSHA spectra: hump-shaped artifact from 15 to 50 km
- For smaller scales, the geoid error is likely still here but hidden by ocean geophysical signals & errors
- With the most recent MSS model (SIO/CLS/DTU hybrid v2023, in development) the hump disappears (geoid error divided by 3)
- The SSHA spectrum is then perfectly linear and well-behaved