The 2023 Hybrid Mean Sea Surface

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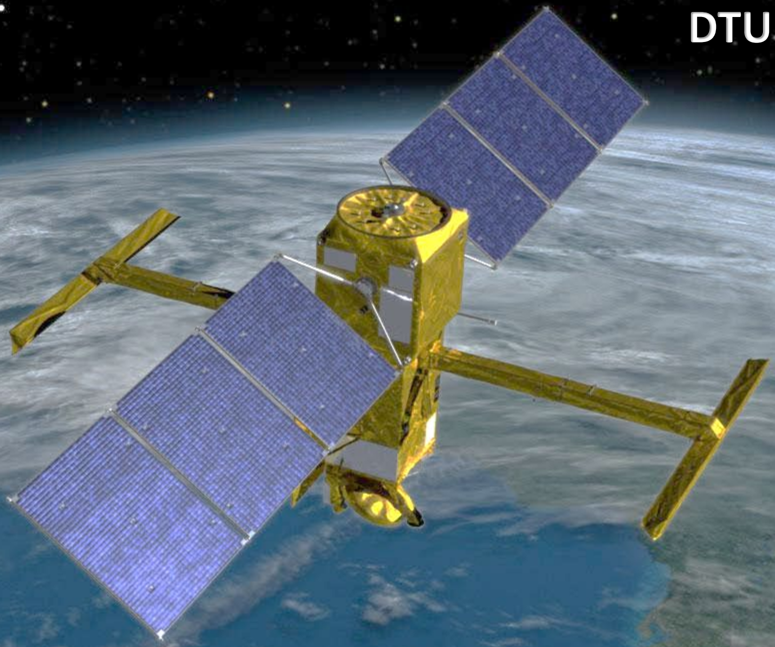


SWOT-ST 2023/09

Hybrid 2023 MSS is the combination of CNES_CLS22, SCRIPPS_CLS22, DTU21 MSS's

	CNES_CLS22	SCRIPSS_CLS22	DTU21
Data used	Mean profiles from LRM 1Hz : TP/J1/J2/J3 (& interleave), E2/EN/AL, GFO HR measurements with **one pass RTK + 5Hz filtering:** C2, AL	Background : Based on CNES_CLS22 MSS for λ > 100 Km HR measurements with **two-pass RTK + 5Hz filtering:** GeoSat, J1/J2, EN, C2, AL, (S3)	Mean profiles from LRM 1Hz : TP/J1/J2/J3 (& interleave), E2/EN/AL, GFO HR measurements with **two-pass RTK + 2Hz filtering:** C2, AL, J1/J2
Observations	**SSH** corrected from oceanic variability (mesoscales & large scales)	**SLOPE** combined with **HEIGTH**	**SSH** (4 parameter estimation of SL variability)
Mapping method	Optimal interpolation + noises budget (white & correlated) + optimal filtering	Biharmonic splines in tension	Optimal interpolation + noises budget

The aims of the combination method

- The goal was to create a new MSS by taking advantage of the best properties of each model.

This work focused on the following points:

- achieving a centimetric accuracy considering the SWOT specification of 1cm/2km,
- while minimizing residual ocean variability,
- and obtaining the most accurate mapping of the finest topographic structures down to wavelengths of less than 10 km.
- Particular attention has also been paid to the Arctic and Antarctic areas.

Differences between CNES_CLS22, SCRIPPS_CLS22, DTU21 MSS

Diff	Nb Points	Mean (cm)	Std (cm) [3σ]
Scripps – CLS	119 439 521	0,06	0,80
CLS - DTU	118 365 843	0,09	1,38
Scripps – DTU	118 861 025	0,02	1,46

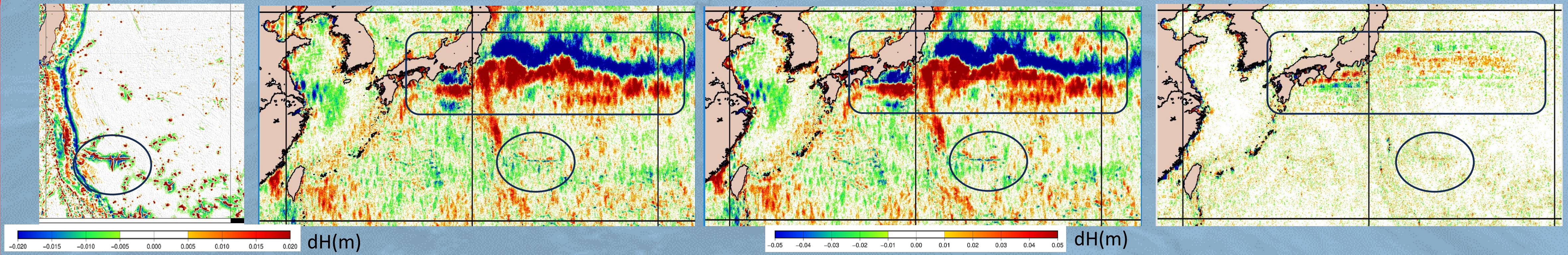
- Differences are calculated on grids at 1 min resolution (~1,8 km/eq).

- ➢ The low values of the averages imply that these MSS are "centered" and therefore consistent in term of Sea Level Rise.
- ➢ The standard deviation values show that these MSSs are close in terms of high-resolution content.

➢ In the open ocean: the standard deviation of differences between SCRIPPS_CLS22 and CNES_CLS22 is less than 1 cm (cf. specifications for SWOT 1cm/2km).

Differences in Kuroshio current

Short wavelengths of SCRIPPS_CLS22 (λ<15km) | DTU21 – CNES_CLS22 | DTU21 – SCRIPPS_CLS22 | SCRIPPS_CLS22 – CNES_CLS22



- ➢ DTU21 has slightly lower amplitudes on certain structures (probably due to the 2 Hz filtering applied to data compared to the 5 Hz used by SCRIPPS & CLS).
- ➢ SCRIPPS_CLS22 shows a residual effect of ocean variability in areas of strong ocean currents.

Hybridization

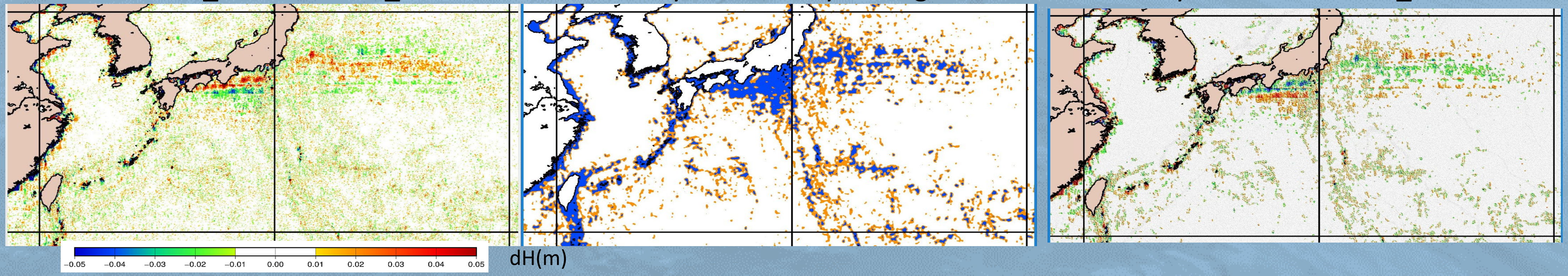
The method is based on the calculation of the RMS of the difference between two MSS which is calculated every 1 minutes in ~10 km boxes of influence (5*5 pixels=25 pixels).
Then the algorithm searches for the boundaries of all zones corresponding to these criteria.

<u>More in detail:</u>

- **Step 1:** Calculation of statistics of the difference between two MSS (Avg,Std,RMS)
  - ➢ this is only done if the difference between 2 MSS is greater than 1 cm
  - ➢ statistics are calculated if there are at least 9 pixels out of the total of 25.
  - ➢ The rms of the corresponding pixel is saved if -and only if- it is greater than 1.5 cm.
- **Step 2:** Determining the boundary corresponding to pixels with RMS greater than 1.5 cm.
- **Step 3:** Filtering the boundary area with size lower than 50 Km (in open ocean)
- **Step 4:** Remove the first MSS and replace it by the second one

Example in Kuroshio current

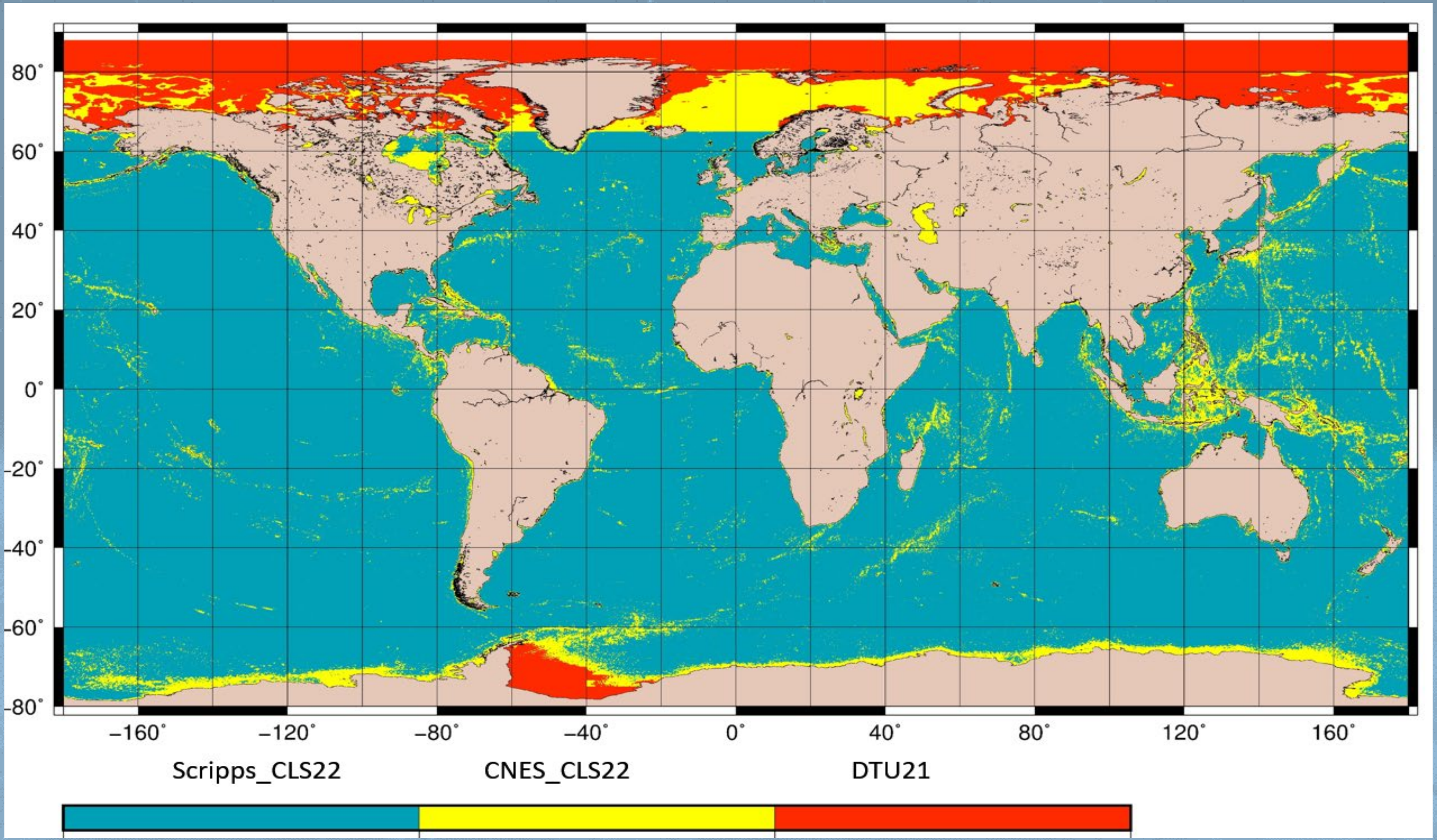
SCRIPPS_CLS22 – CNES_CLS22 | Boundary detected by the algorithm | Hybrid23 – SCRIPPS_CLS22



➢ The "blue" part is the part removed from one MSS to be replaced by the other.

➢ The difference related to residual variability between SCRIPPS_CLS22 and CNES_CLS22 (left map) is the opposite of the difference between Hybrid23 and SCRIPPS_CLS22 (right map), indicating that most of the residual variability has been effectively removed.

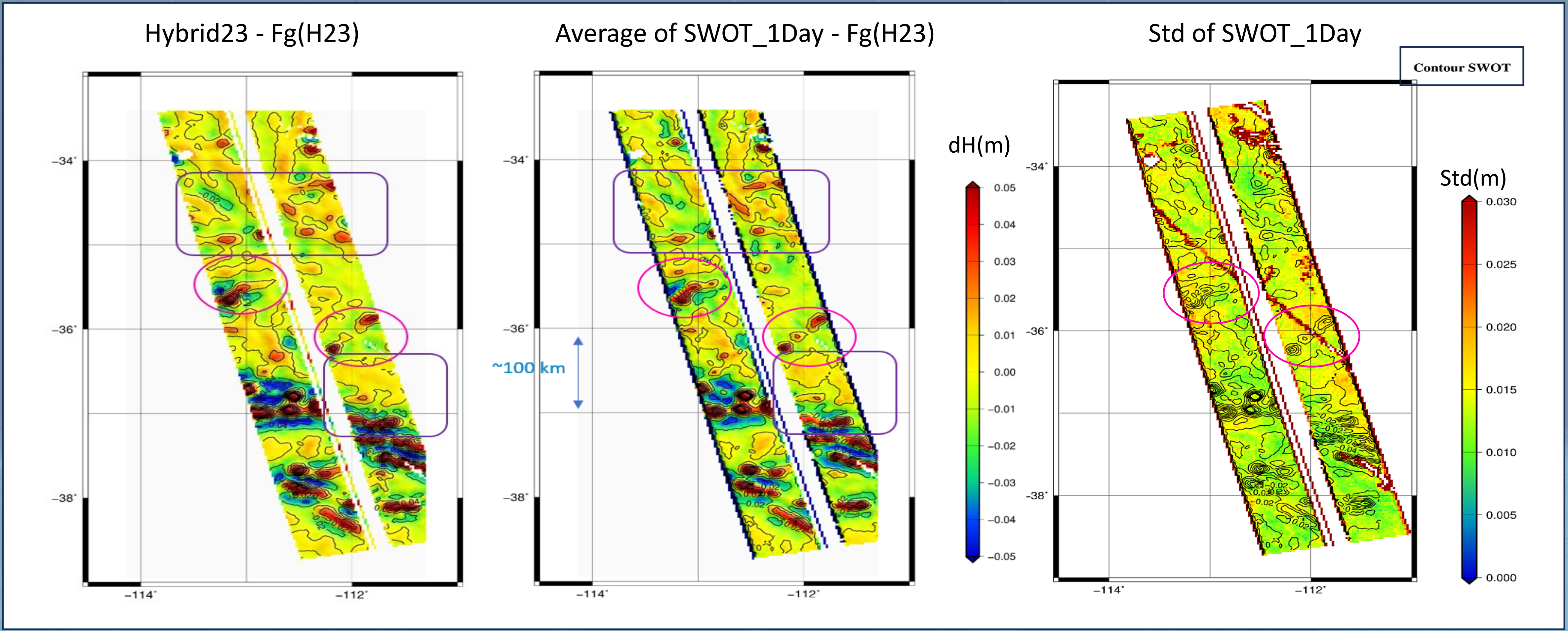
Contribution of the three MSS



The Hybrid23 MSS is the result of the combination of:

- SCRIPPS_CLS22 in the open ocean,
- CNES_CLS22 in regions of strong ocean currents and near the coast,
- DTU21 in polar regions.

Preliminary result using 90 cycles of SWOT 1_Day phase (Pass 26)



- The average of SWOT 1 Day is calculated with 90 cycles (In this case, Flag/Val was not used which explains some erroneous values at the swath border).
- The two maps on the right represent the difference relative to the Hybrid23 MSS filtered for wavelengths smaller than 30 km (FgH23).
- This first preliminary result already shows that SWOT enables us to map new seamounts (magenta circles) of the order of 10 km in size (or even less),
- But, we can see in the purple rectangles that there is still some differences at medium-wavelength (λ>30 km), the cause of which has yet to be analyzed.

➢ See also poster from Yao Yu & David Sandwell “Accuracy and Resolution of SWOT Altimetry: Fondation SeaMounts”

Conclusion

- The method used to create the hybrid MSS allowed us to achieve a level of accuracy that is globally better than the 3 previous solutions. The validation of the Hybrid23 MSS will be presented by Isabelle Pujol "MSS errors & SWOT KaRIn measurements".
- First comparisons with SWOT swaths already show improvement in topographical structures up to sizes of the order of 10 km.
- At the same time, these preliminary results show that SWOT will enable us to improve short-wavelengths of the MSS with a centimeter-level of precision.
- But, before we will use SWOT data to improve the MSS, we need to understand the differences for wavelengths longer than 30 km.
- More details about this Hybrid MSS is presented in the poster "The 2023 Hybrid MSS"