Improving the small SWH characterization over ocean for the Jason-3 mission

Improving the small SWH measurements for Jason-3 mission

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Background

- Jason-3 has been more than 5 years in the reference orbit and serving as the reference altimetry mission for the global mean sea level measurements.
- Sentinel-6A has become the next reference altimetry mission, one major evolution is the introduction of negative SWH measurements. For cross-mission consistency reasons, identifying and reducing processing differences between Jason-3 and Sentinel-6A is a key challenge.

Context

Negative SWH values have no physical meaning. Yet, the behaviour of previous baselines forcing negative values to 0 introduces a non-physical discontinuity. Each SWH estimation is the center of an associated distribution, and the smaller the estimation the less precise the distribution.

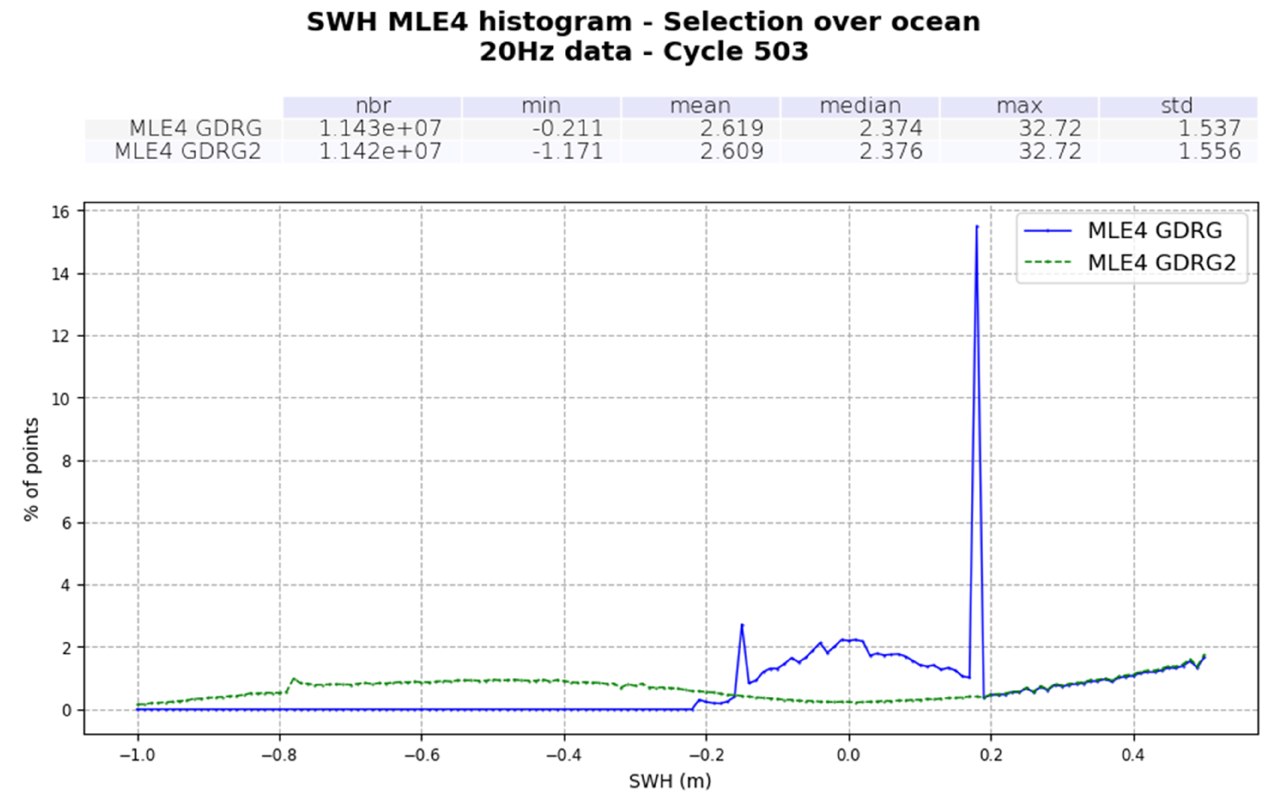
Empirical biases are used to finetune the cross-mission coherence. The SWH bias previously applied to Jason-3 added 18cm to all null and very small measurements, leading to an artificial peak around 18cm.

References

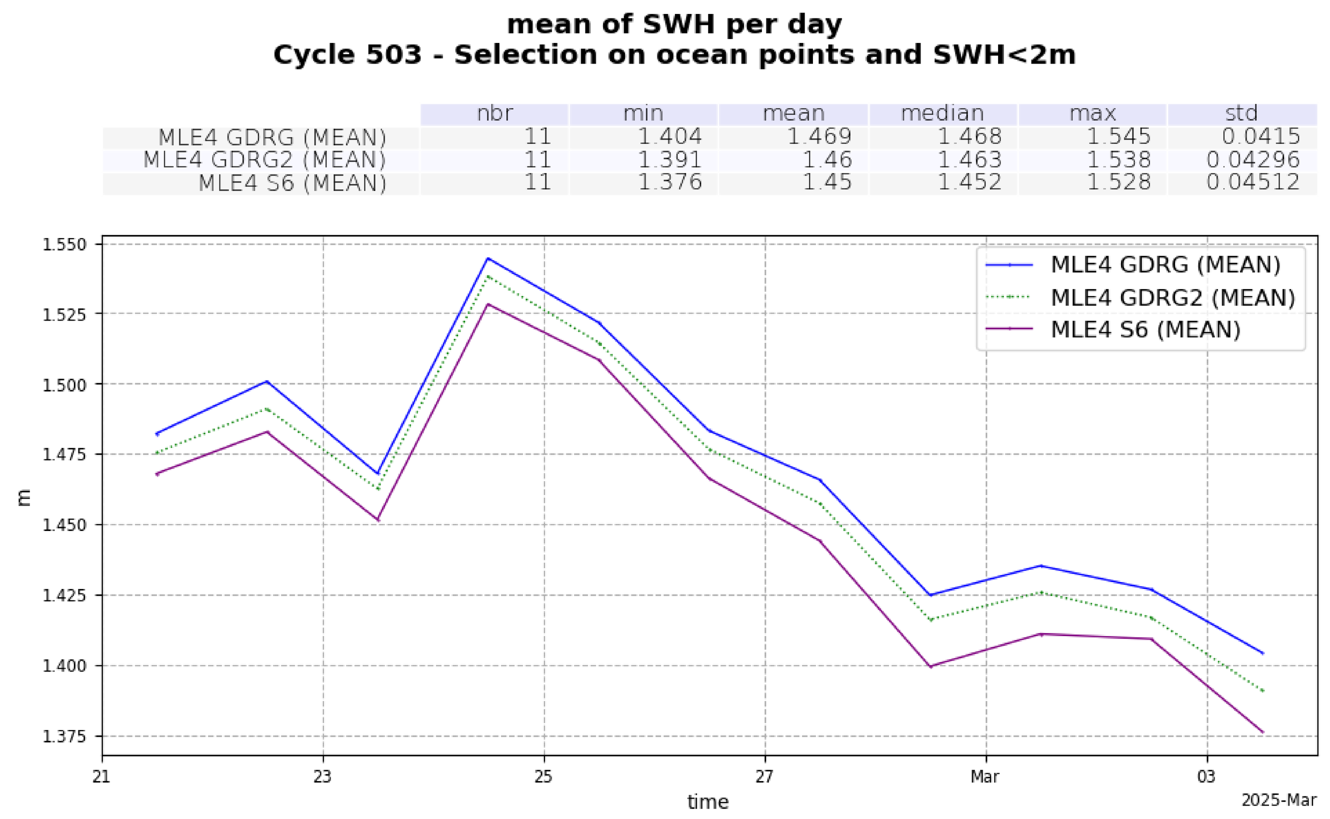
[1] Flamant B. et al, Jason-3 Annual Report 2025.
[2] Flamant B., Analyzing the S6A / Ja3 second tandem phase, OSTST 2026
[3] Dinardo et al., Sentinel-6 MF Poseidon-4 radar altimeter: Main scientific results from S6PP LRM and UF-SAR chains in the first year of the mission. Adv. Space Res. 2024, 73, 337–375.
[4] EUMETSAT, 2021. Sentinel-6/Jason-CS ALT Level 2 Product Generation Specification (L2 ALT PGS). July 2022, EUM/LEO-JASCS/SPE/17/901321, EUMETSAT Darmstadt, Germany.

Characterizing impact of keeping negative SWH values

Until baseline GDRG1, the SWH repartition showed an erratic repartition for all SWH below 20cm; The GDRG2 baseline smoothens the repartition: negative values are found continuously between -100cm and 20cm, the 18cm peak disappears, the repartition is the same after 20cm (all this while applying the old empirical bias to both datasets).



	nbr	min	mean	median	max	std
MLE4 GDRG	1.143e+07	-0.211	2.619	2.374	32.72	1.537
MLE4 GDRG2	1.142e+07	-1.171	2.609	2.376	32.72	1.556

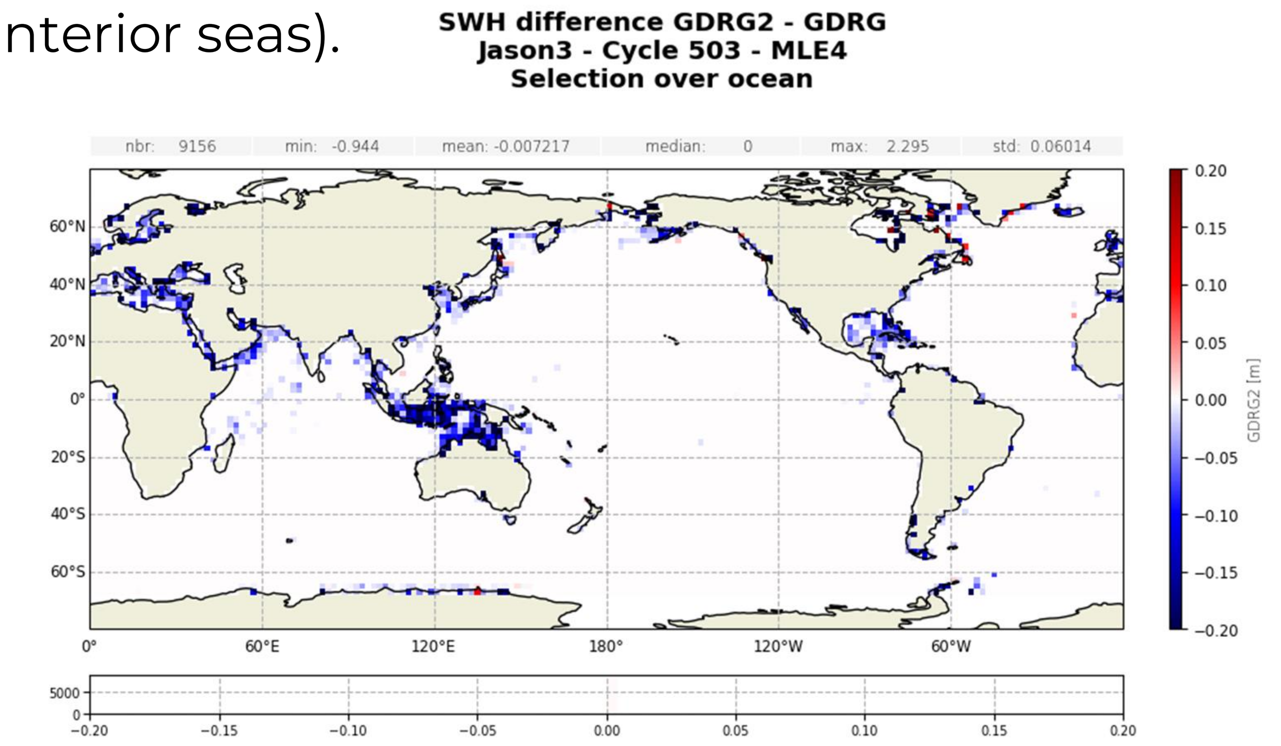


	nbr	min	mean	median	max	std
MLE4 GDRG (MEAN)	11	1.404	1.469	1.468	1.545	0.0415
MLE4 GDRG2 (MEAN)	11	1.391	1.46	1.463	1.538	0.04296
MLE4 S6 (MEAN)	11	1.376	1.45	1.452	1.528	0.04512

Time series show that the GDRG2 SWH values are statistically closer to Sentinel-6A.

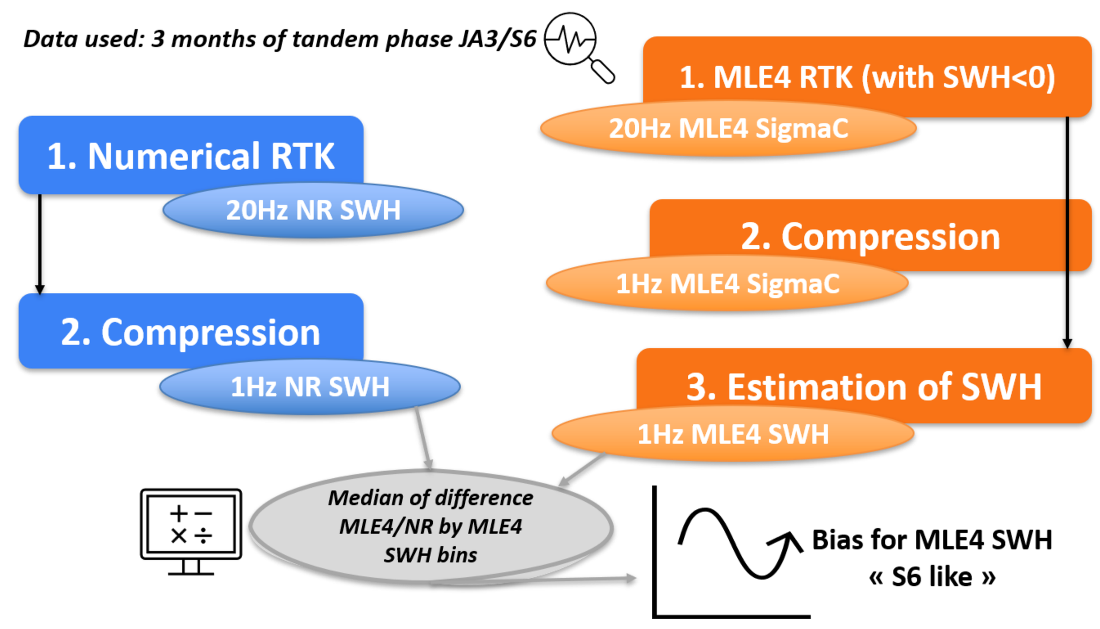
The instrumental bias previously applied does not fit this new SWH repartition.

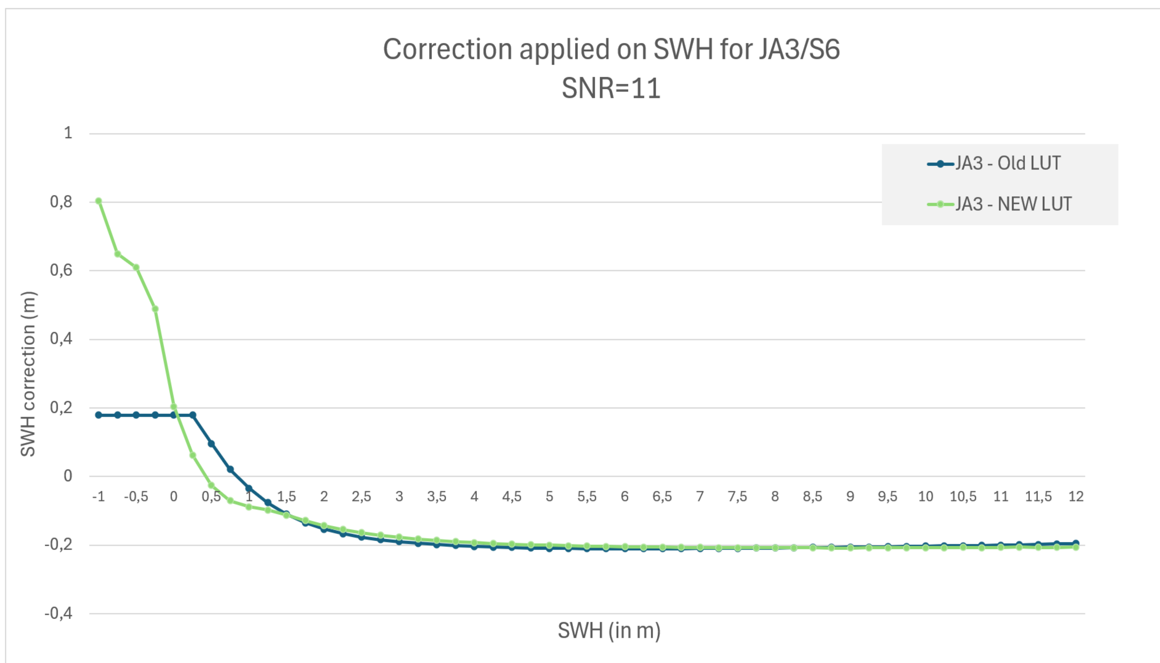
This small change is geographically correlated to known areas of small SWH values (SE Asia, interior seas).



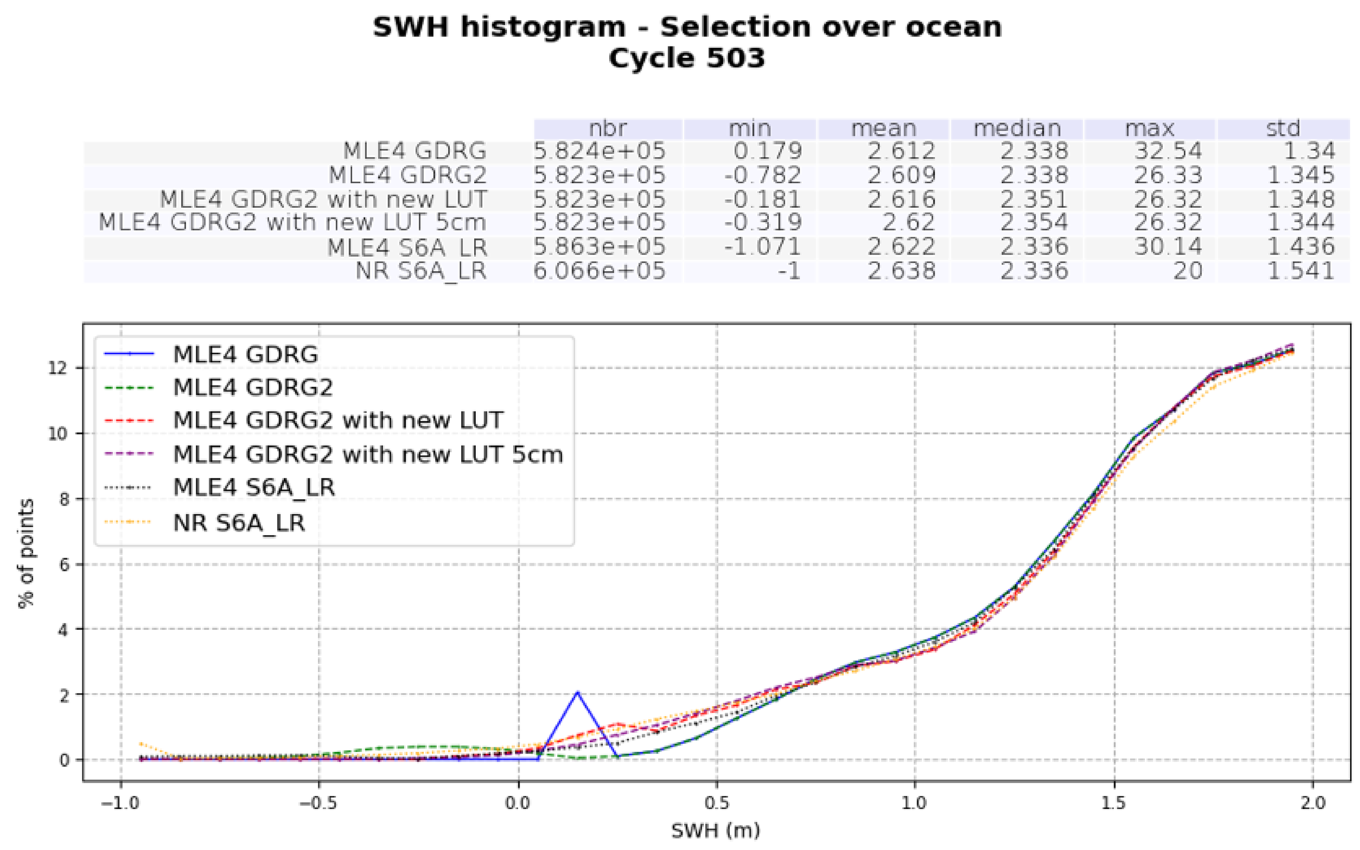
Adjusting instrumental bias

A new instrumental bias was computed using a Numerical Retracking solution for Jason-3 that accounts for the in-flight PTR (without approximation) and forcing the MLE4 bias to align with the NR solution.
The methodology is described in the diagram; the bias is computed from the difference NR/MLE4 by bin of MLE4 SWH.





With this new method, the Look Up Table (LUT) applied to SWH below 25cm is not constant and fits the NR data. Wave heights from -1 to 12m can be corrected. This also corrects the artificial peak at 18cm for all SWH measurements lower.



	nbr	min	mean	median	max	std
MLE4 GDRG	5.824e+05	0.179	2.612	2.338	32.54	1.34
MLE4 GDRG2	5.823e+05	-0.782	2.609	2.338	26.33	1.345
MLE4 GDRG2 with new LUT	5.823e+05	-0.181	2.616	2.351	26.32	1.348
MLE4 GDRG2 with new LUT 5cm	5.823e+05	-0.319	2.62	2.354	26.32	1.344
MLE4 S6A_LR	5.863e+05	-1.071	2.622	2.336	30.14	1.436
NR S6A_LR	6.066e+05	-1	2.638	2.336	20	1.541

This histogram synthetizes the evolutions. The LUT resolution step was also refined from 25 to 5cm smoothing remaining local inhomogeneities.
The final version shows a strong consistency between Jason-3 and Sentinel-6A for both MLE4 and NR.

Conclusion

This processing change and the associated LUT will bring a better cross-mission fit in areas of small SWH. The new Jason-3 Sea State Bias correction currently under development will also benefit from these improvements. All this is part of the GDRG2 processing baseline that should be used operationally by end-2026 before a complete reprocessing of the time series.