IMPROVEMENTS OF SENTINEL-6MF PERFORMANCES OVER OCEAN THANKS TO F08 LR NUMERICAL RETRACKER

OSTST 2023

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Major milestones

❖ **S6-MF launch (Nov. 11st 2020)**

❖ **Switch to Side B (Oct. 19th 2021)**

❖ **S6-MF became the reference mission (April 2022)**

❖ **Operational Processing Baseline Upgrades**

➢ F04 (Nov 9th 2021)

➢ F05 (Mar 8th 2022)

➢ F06 (May 31th 2022) + Full reprocessing

➢ F07 (Aug 17th 2022)

➢ **F08 (Feb 18th 2023) + Full reprocessing**
   - Addition of numerical retracker (NR) retrievals in **LR** products for Ku band (allows accounting for the PTR shape evolution)
   - Update of the antenna aperture angle from 1.33° to 1.34°
   - Update of the total electron content (TEC) computation with a more appropriate scaling factor (0.881 instead of 0.925) to align the altimeter-derived TEC with the GPS-derived JPL GIM model

**This presentation focuses on F08 LR MLE4 vs NR differences.**

Bibliography

❖ **Courcol et al. , 2023 , F08 Reprocessing Calval Assessment (SALP-RP-MAO-OP-17710-CN)**

  ➢ https://www.eumetsat.int/media/51160

❖ **Dinardo et al , 2023, Sentinel-6 MF Poseidon-4 radar altimeter: Main scientific results from S6PP LRM and UF-SAR chains in the first year of the mission,**

  ➢ https://doi.org/10.1016/j.asr.2023.07.030.

❖ **Cadier et al, in preparation, Assessment of Sentinel-6MF low resolution numerical retracker over ocean: continuity on reference orbit and improvements**
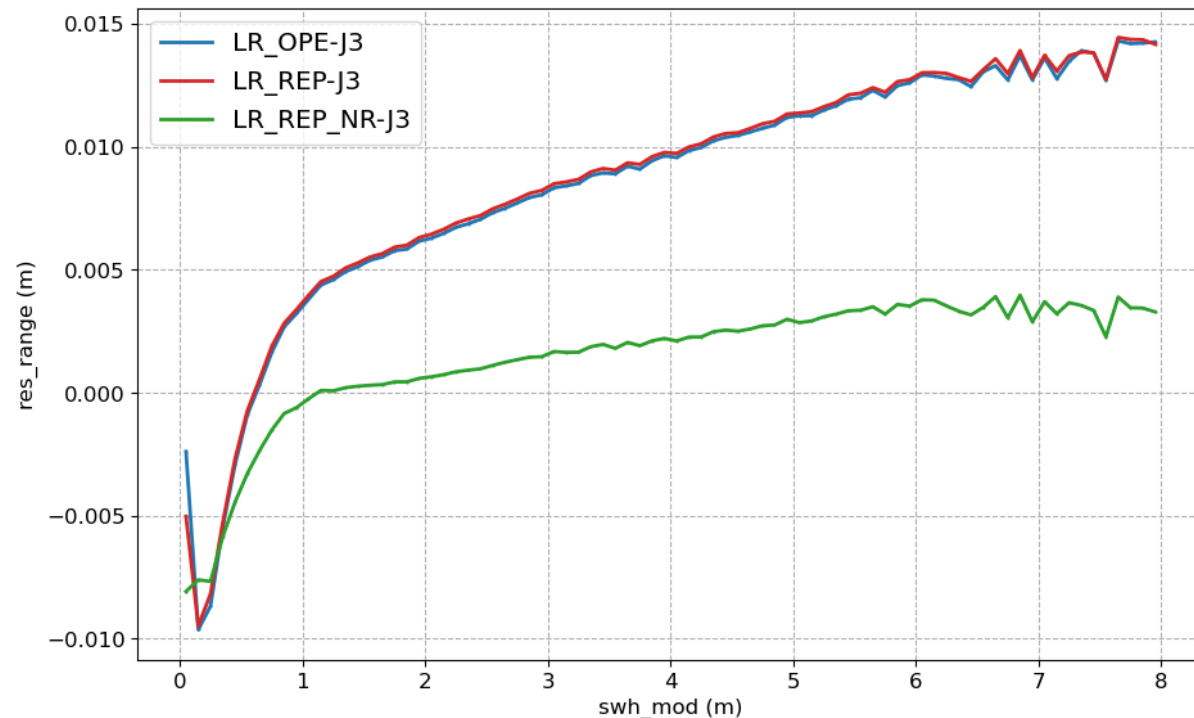
Range

Range

❖ LR MLE4 range dependence to SWH (~1cm coming from LUT) is significantly improved with numerical retracking

❖ Residual NR dependence to SWH coming from Pulse to Pulse correlation

Range difference NR - MLE4 LR F08

| nbr: 9255 | min: -2.86 | mean: 0.5849 | med: 0.5897 | max: 5.54 | std: 0.1277 |
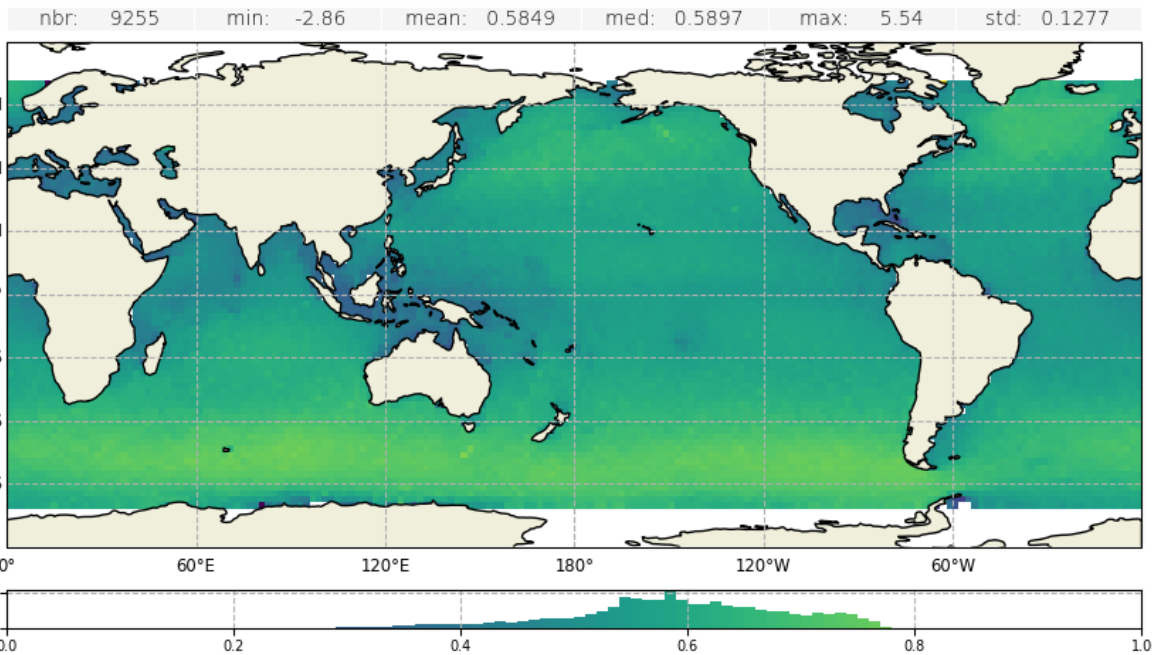
(m) Orbit-range-MSS residuals vs SWH model (mean)

LR_OPE-J3
LR_REP-J3
LR_REP_NR-J3
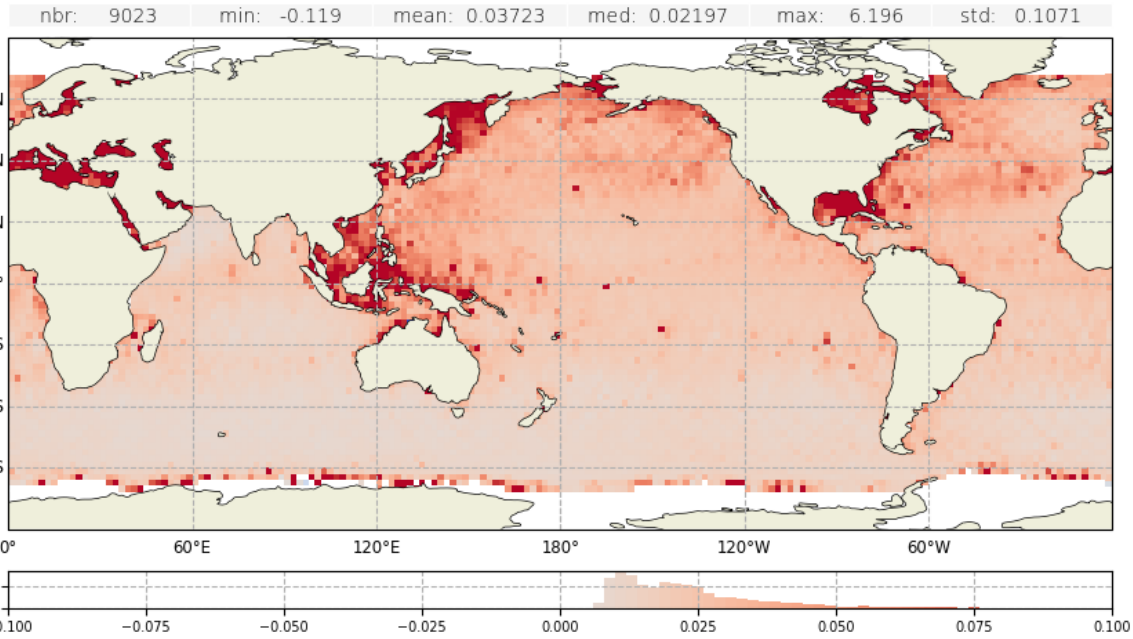
SWH

SWH

❖ F08 reprocessed data are impacted by anomaly AR 2620.

❖ The main impact is that negative measurements of SWH are mapped to their absolute value at 20Hz and mixed to actual positive SWH during compression. 1 Hz NR SWH can be impacted up to 1 meter

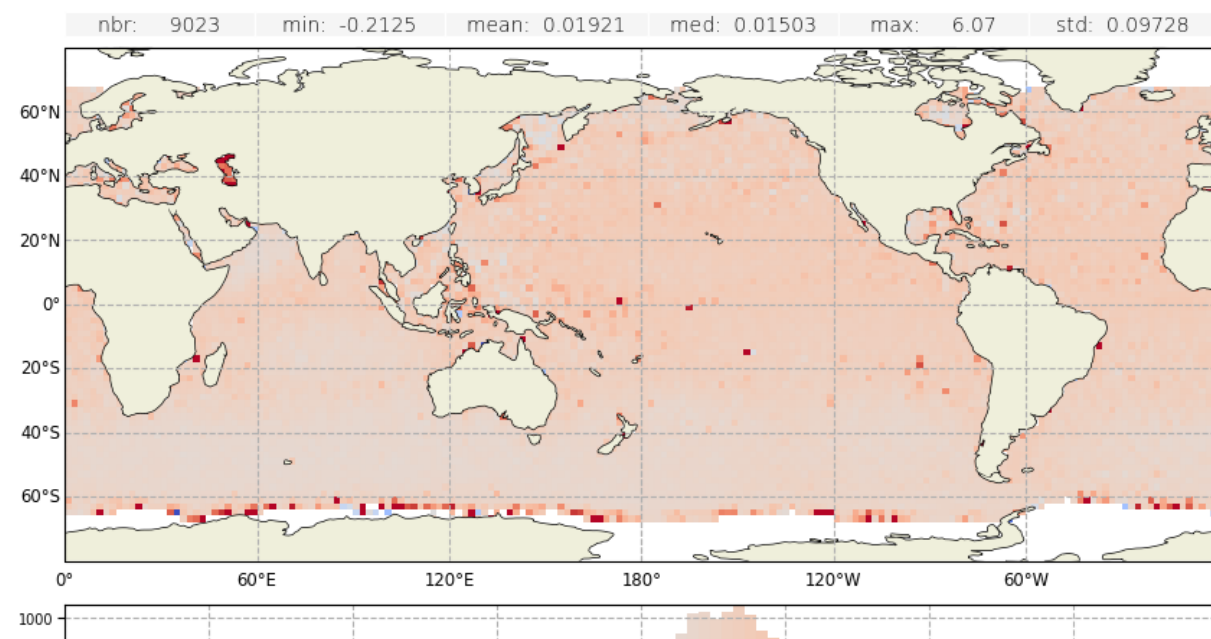❖ A patched version of PB F08 (PDAP 3.8.0) has been deployed in November 2023 for operational data.
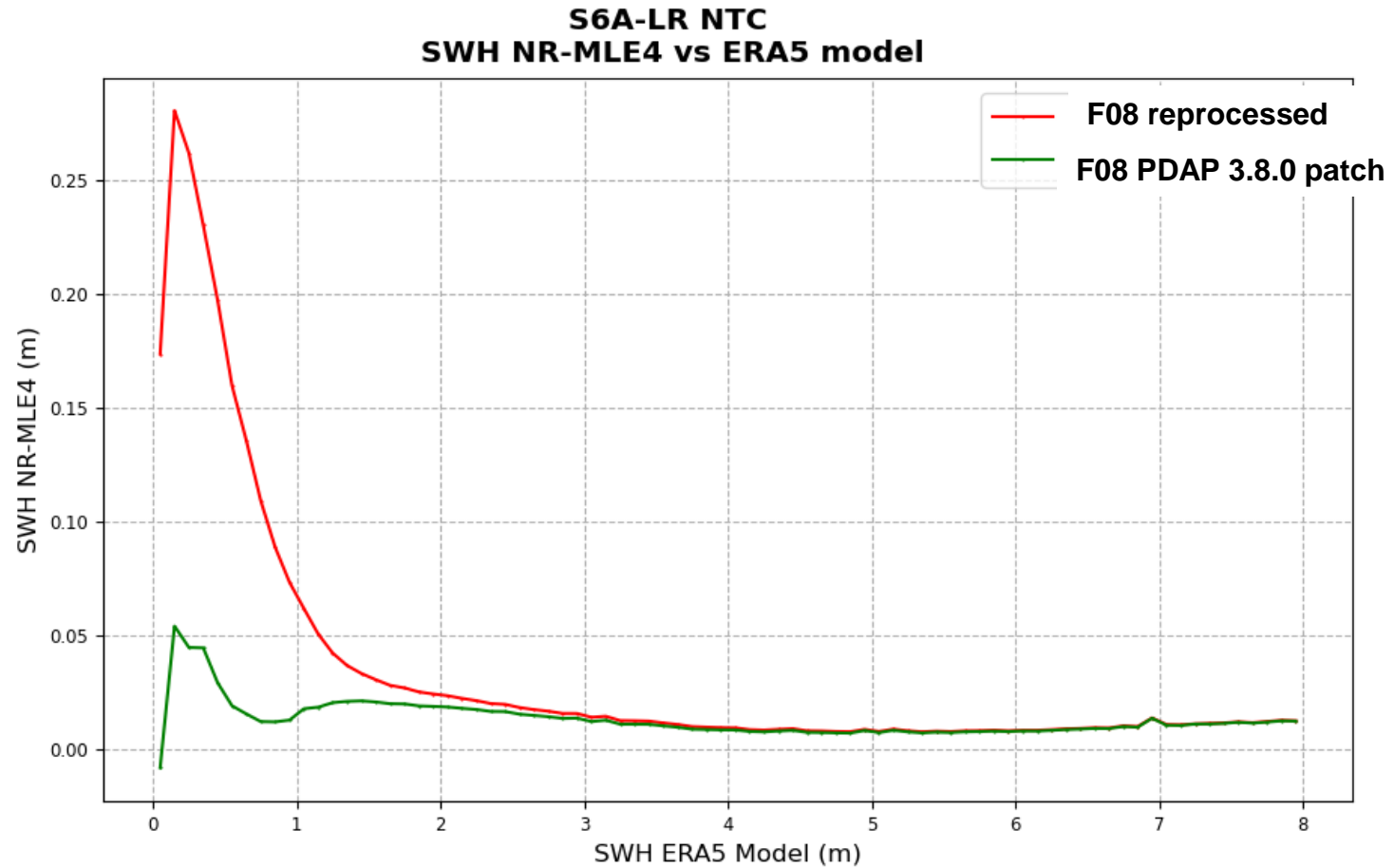

F08 reprocessed : **S6A-LR NTC SWH: NR (OPE) - MLE4**

nbr: 9023 | min: -0.119 | mean: 0.03723 | med: 0.02197 | max: 6.196 | std: 0.1071

F08 PDAP 3.8.0 : **S6A-LR NTC SWH: NR (VAL) - MLE4**

nbr: 9023 | min: -0.2125 | mean: 0.01921 | med: 0.01503 | max: 6.07 | std: 0.09728

F08 reprocessed
F08 PDAP 3.8.0

SWH

❖ After correction, a negligible bias of 1.7 cm between MLE4 and NR

S6A-LR NTC
SWH NR-MLE4 vs ERA5 model

SWH

❖ AR 2620 sligthly impacts SSHA derived from NR (~-5 mm), in low SWH areas due to SWH through SSB (not shown on following slides based on reprocessed F08)


S6ALR_NTC F08_Patch - F08 : SEA_SURFACE_HEIGHT_ANOMALY.ALTI.NR

nbr: 9018   min: -0.0132   mean: -0.0006991   med: -0.000173   max: 0.001732   std: 0.001267   (mm)
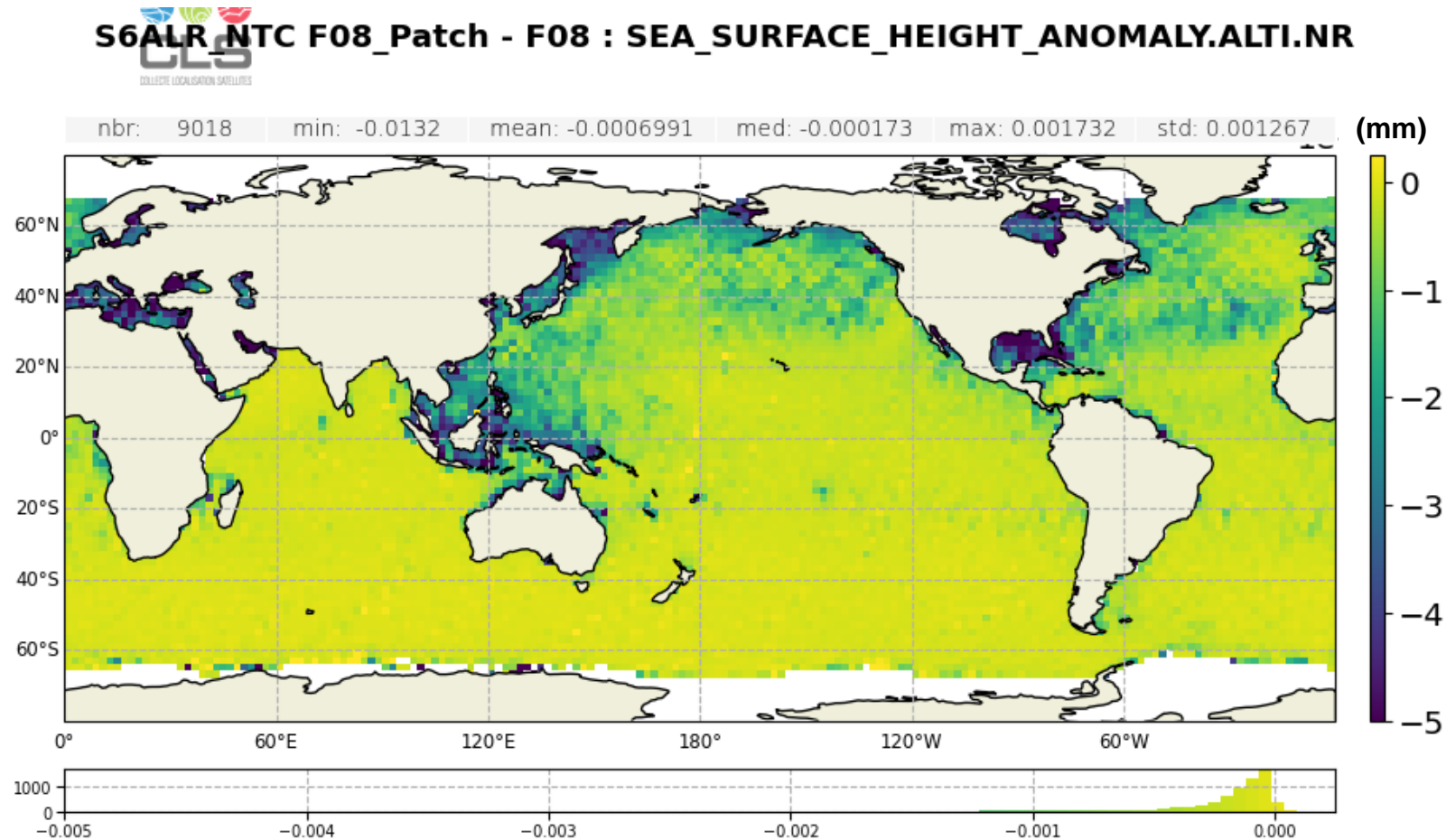
SIGMA0

Sigma0

❖ Bias of 0,9 dB between MLE4 and NR

❖ Correction of AR 2621 in F09 (total power computation) should align S6 et J3 sigma0.

Sigma0 in Ku band for S6A side B

|	nbr	min	mean	med	max	std
LR_OPE	27798524	7	12.39	nan	23.79	1.581
LR_REP	27803387	7	12.3	nan	23.73	1.579
LR_REP_NR	27878996	7	13.19	nan	24.6	1.604
J3	41026002	7.15	13.64	nan	25.01	1.613
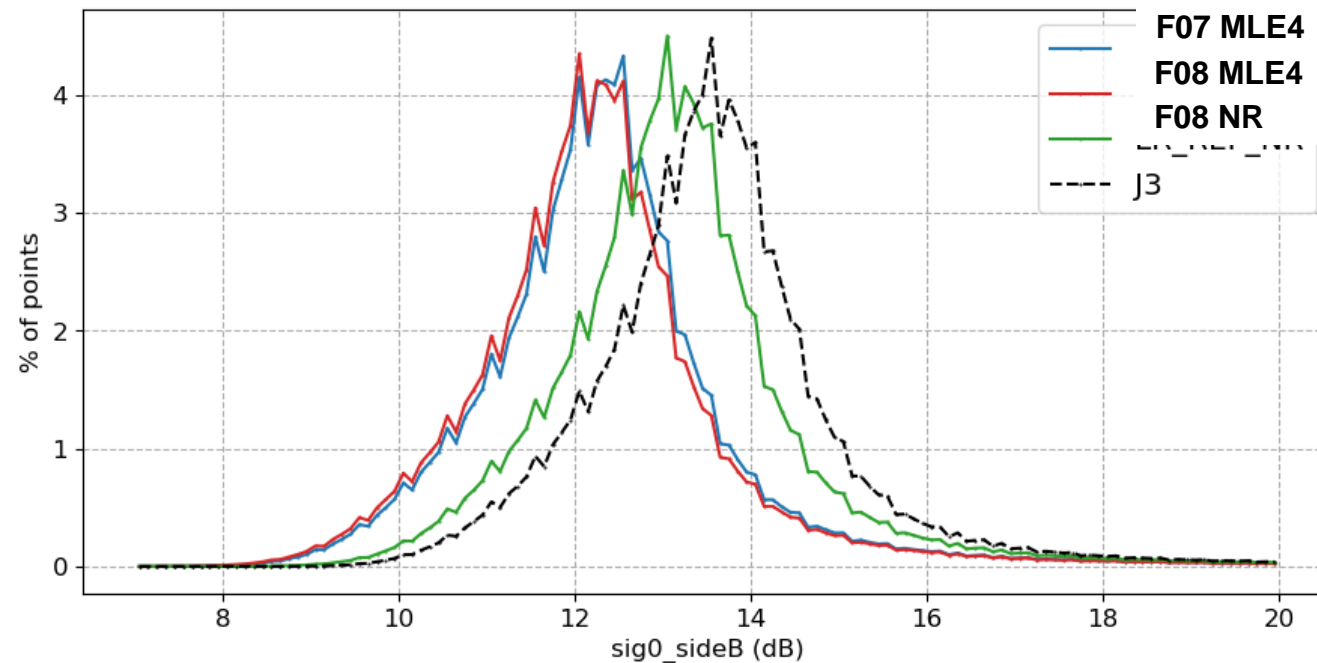
Sigma0

❖ A drift of very small amplitude can be observed (+0.003dB on the entire side B) -> left plot.

❖ Leading to a very small drift of Wind Speed (- 1cm/s on the entire side B) -> right plot.
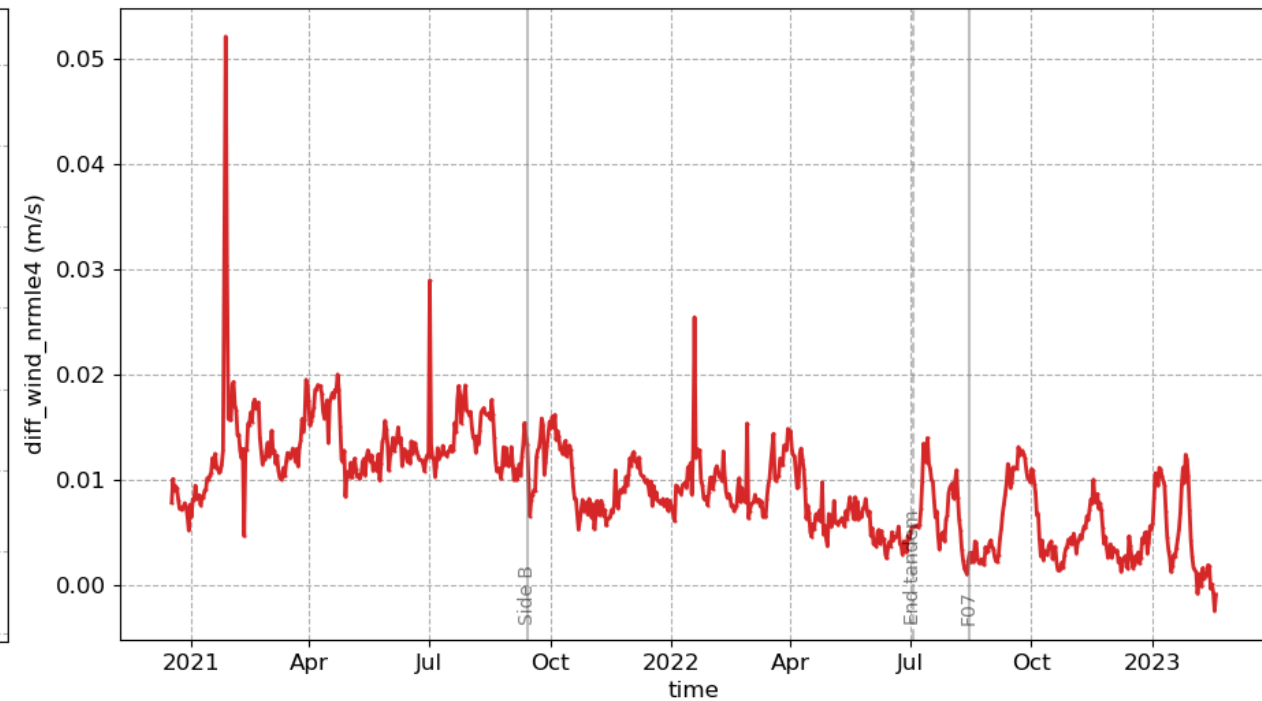

Sigma0 difference NR - MLE4 (mean)

nbr: 794   min: 0.8706   mean: 0.8843   med: 0.8842   max: 0.8883   std: 0.001568
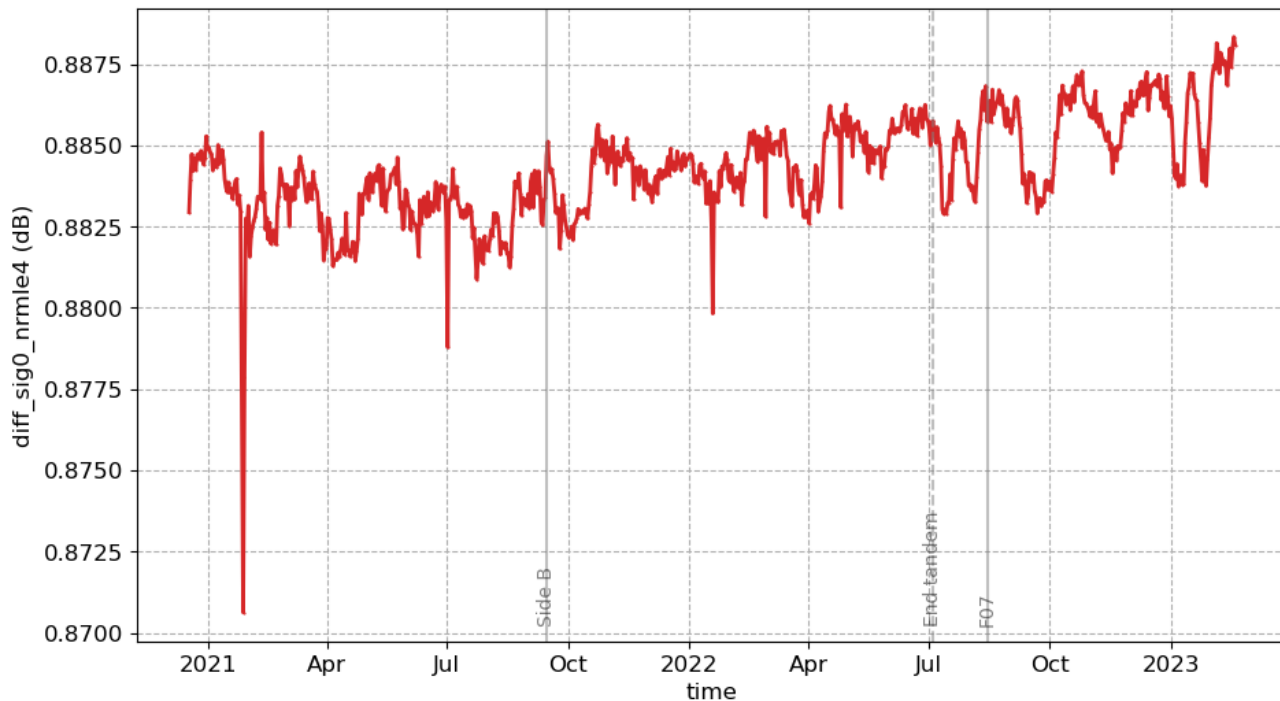
Wind speed difference NR - MLE4 (mean)

nbr: 794   min: -0.002467   mean: 0.009277   med: 0.009389   max: 0.05209   std: 0.004831
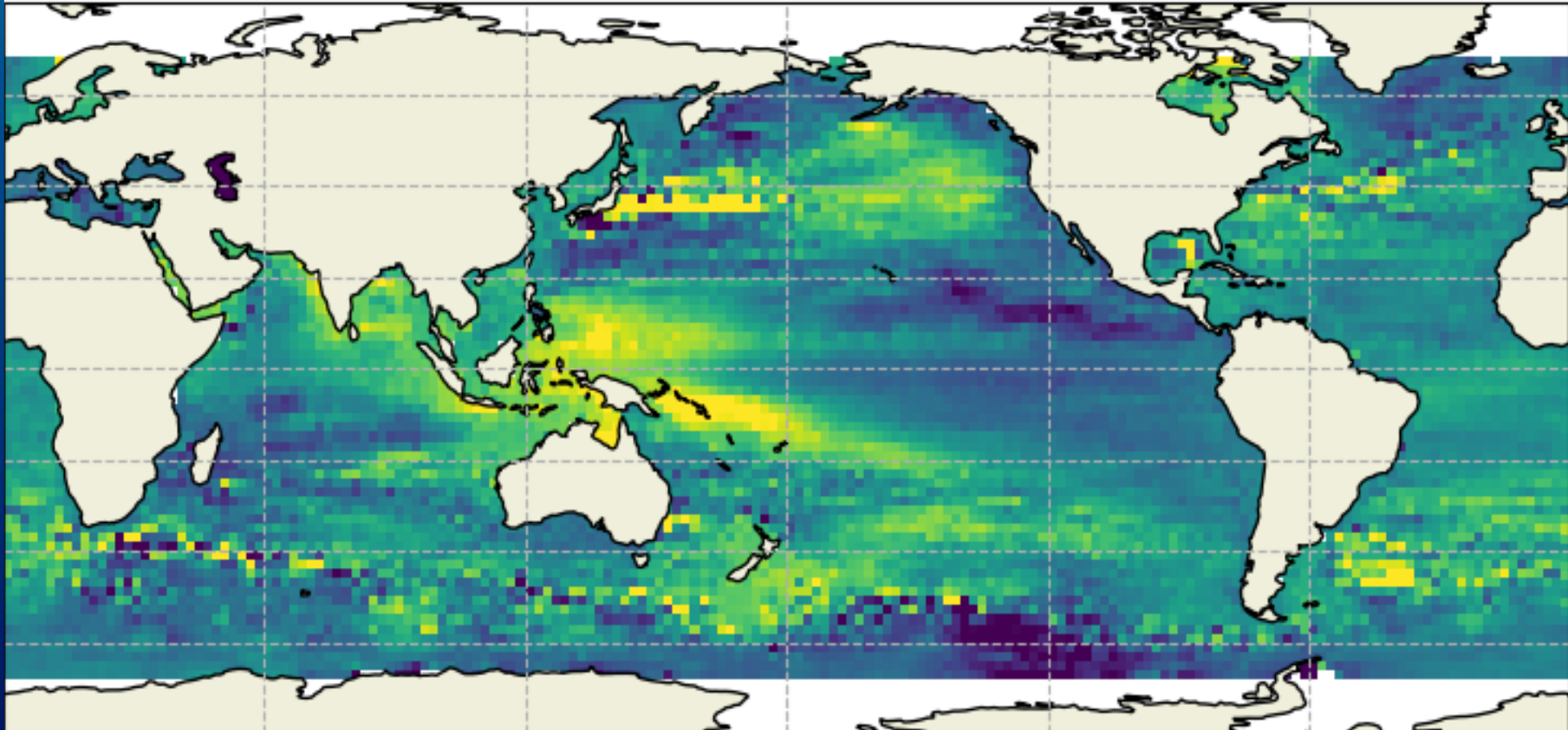
Sigma0

❖ The sigma0 difference map is slightly correlated with high Mean Sea Surface (MSS) gradients, which corresponds to sudden changes in bathymetry. This indicates that both retrackers have different sensitivies to sea surface slopes, however the exact explanation is not yet understood.

❖ Also visible in Wind Speed
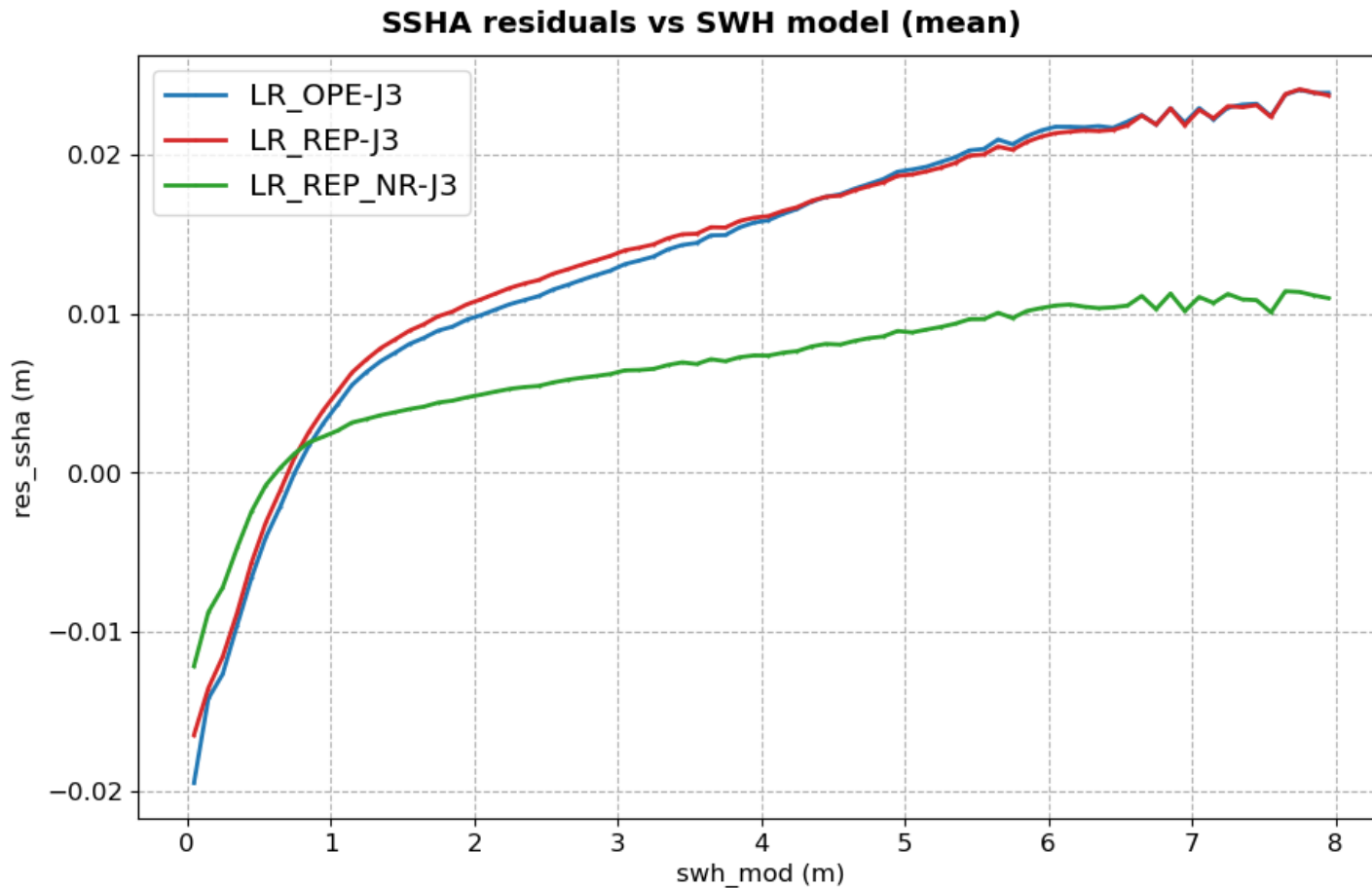

Sigma0 difference NR - MLE4 LR_REP (mean)
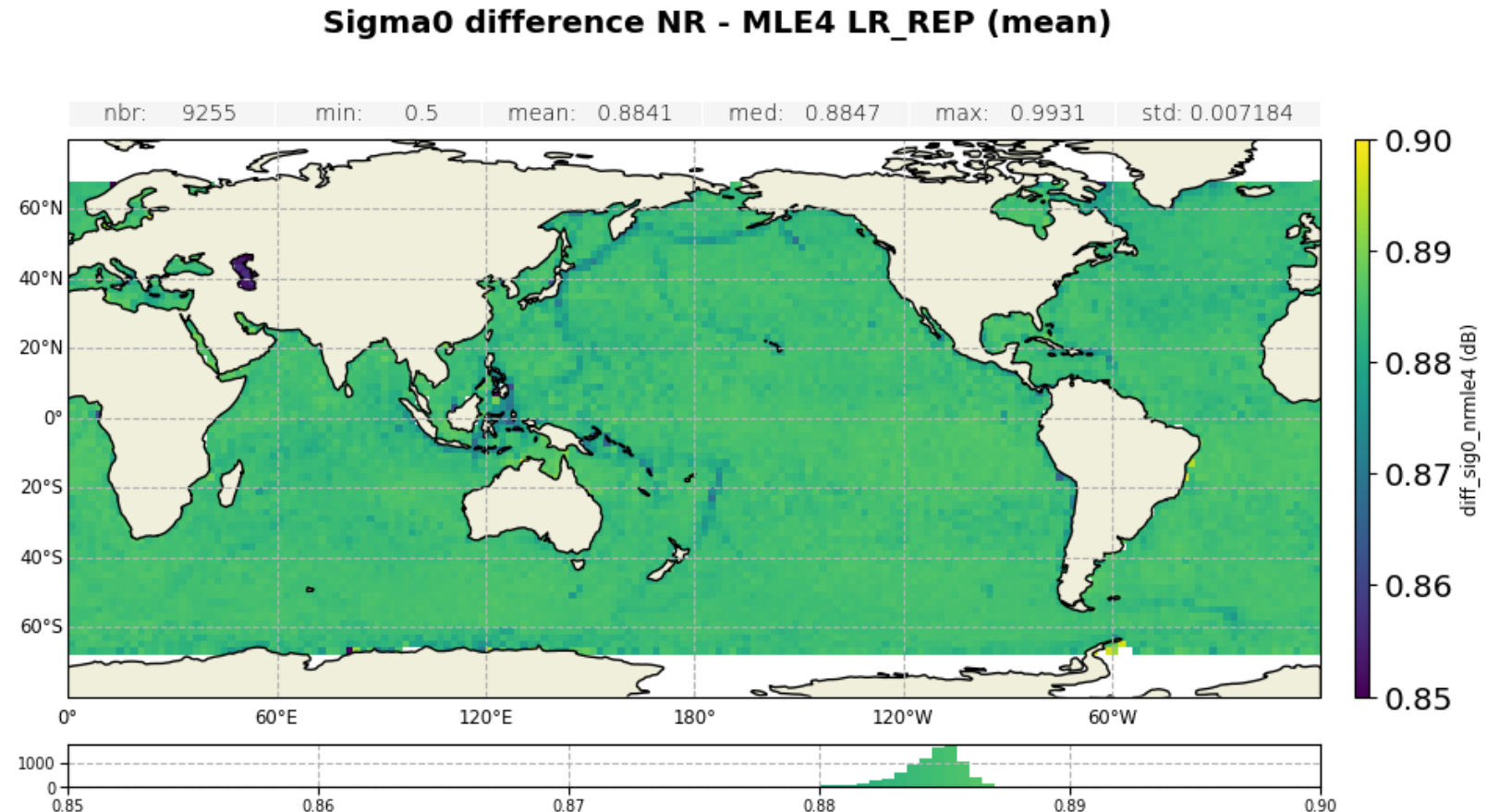
SSHA

SSHA

❖ LR MLE4 SSHA dependence to SWH (coming from range and second order from Iono) is significantly improved with numerical retracking

SSHA residuals vs SWH model (mean)

SSHA

❖ Reduction of the tandem phase J3-S6 bias with numerical retracking

Parameter	S6 MF LR - J3 bias between 1 and 8m-SWH	
	MLE4	NR
Orbit - Ku-band range - MSS	1.1cm	0.4cm
Ku-band SSB	-0.1cm	0.2cm
Altimeter filtered ionosphere correction	-0.7cm	-0.6cm
Sum	1.9cm	0.8cm

The sum is performed as [bias on orbit-range-mss] minus [the sum of the bias on the geophysical correction], as in the SSHA computation.
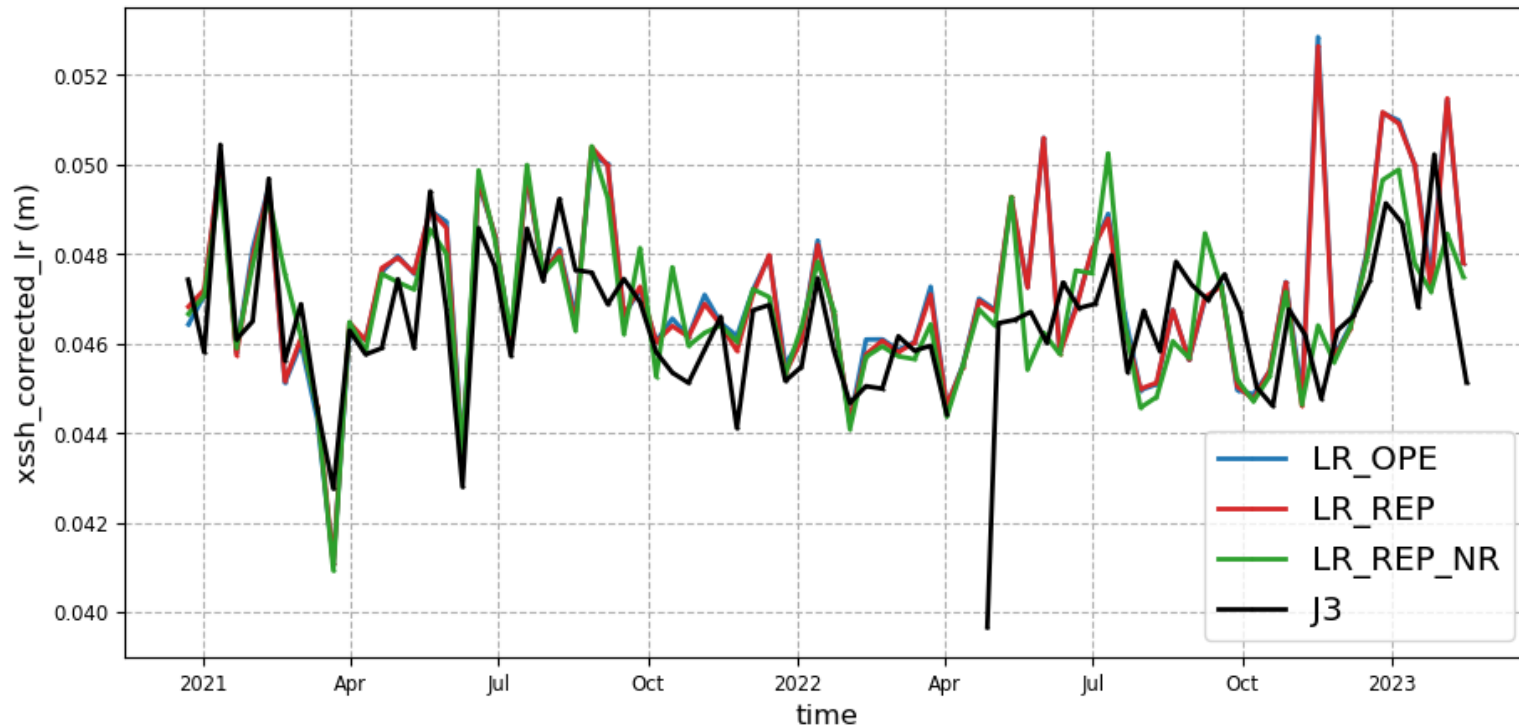
Cross Over Analysis

SSH Cross-Overs

❖ Small improvement of SSH Xovers STD : 4,71 cm for MLE4 ; 4,68 cm for NR

SSH crossover (STD)

	nbr	min	mean	med	max	std
LR_OPE	80	0.0411	0.04712	0.04679	0.05284	0.001942
LR_REP	80	0.04108	0.04709	0.0468	0.05264	0.001945
LR_REP_NR	80	0.04093	0.0468	0.04649	0.05041	0.001669
J3	79	0.03967	0.04647	0.0466	0.05044	0.001644

GMSL

GMSL

❖ The MLE4 and NR GMSL have been estimated over the complete Sentinel-6 MF lifetime.

❖ Over the two periods (POS4-A and POS4-B), no significant drift can be observed between MLE4 and NR (errors are higher than slopes value).

❖ We cannot conclude here on the improvement brought by the numerical retracker on the long term stability of the mission. It will be re-assessed on a longer time series for Side B.

Differences of GMSL from MLE4 and Numerical Retracking (MLE4 - NR)
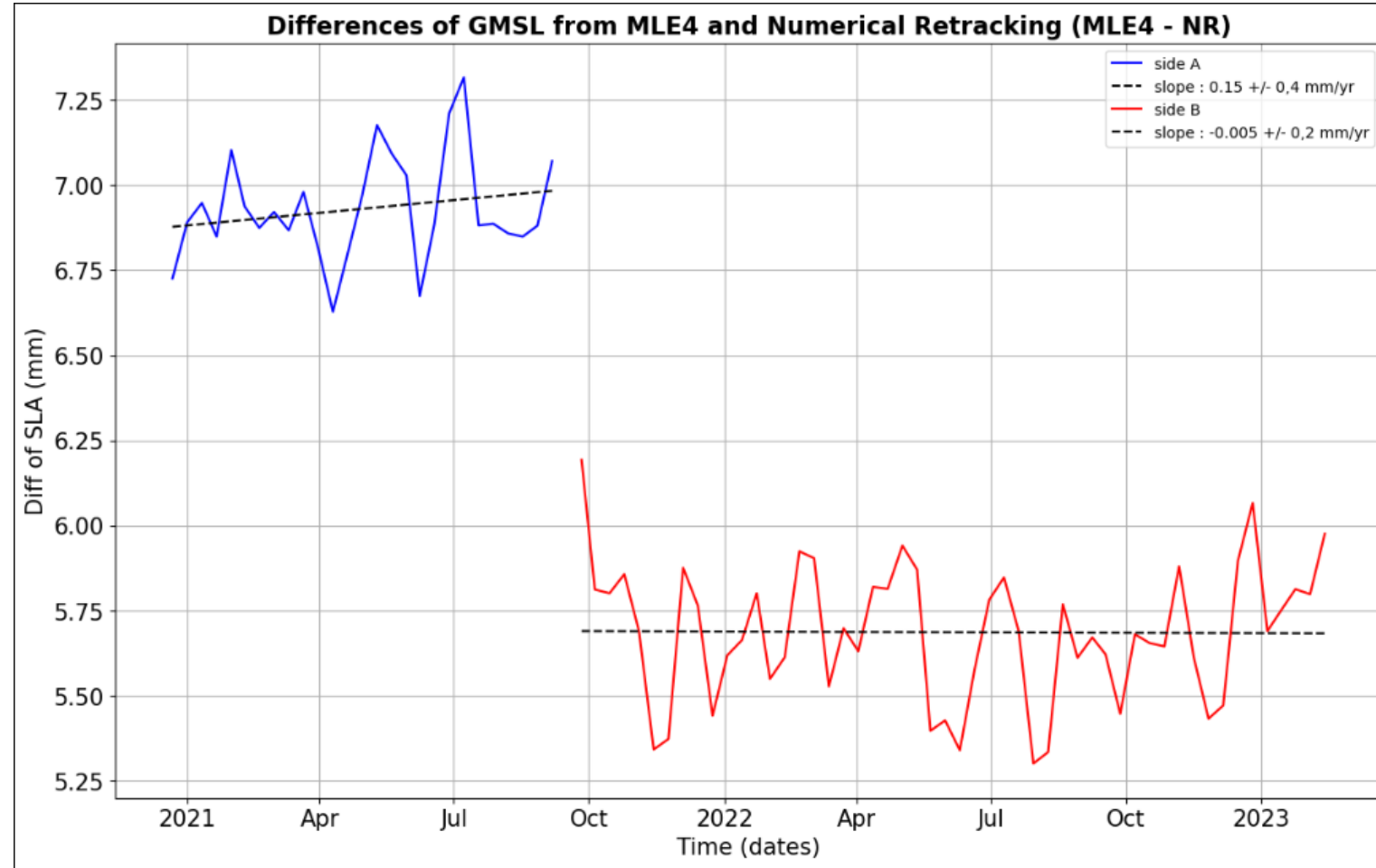
Conclusion

- **F08 reprocessing propose to users both MLE4 and NR for LR retracker**

  - **Significant improvement of LR range/ssha dependence to SWH (~1cm) with NR**

  - **Small improvement of SSH Xovers STD**

  - **Anomaly AR 2620 impacts F08 reprocessed data on low SWH (<1m). A patched version of PB F08 (PDAP 3.8.0) has been deployed the 2 November 2023 and will correct operational data onwards.**

  - **GMSL impact to be re-assessed on a longer time series**

- **NR allows S6-MF mission to be robust for any futur drift of instrumental behavior**

- **On HR, impacts of NR is higher than LR, HR NR will be distributed in F09**