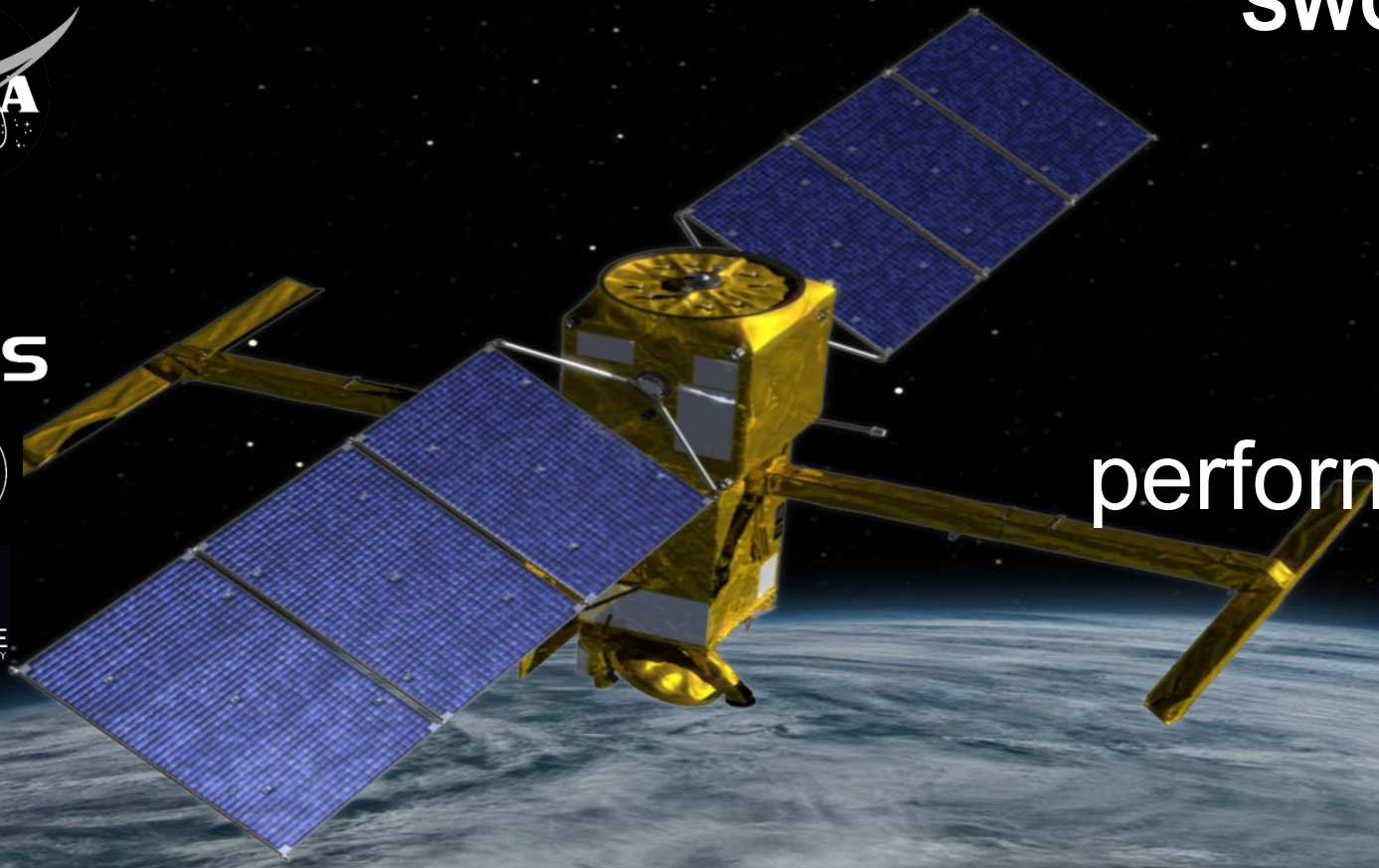
SWOT validation meeting

17-21 June 2024

SWOT nadir Open Ocean performances and validation



CNES and CLS Calval Team

CNES : François Bignalet-Cazalet, Claire Maraldi, Matthias Raynal, Nicolas Picot

CLS : Hélène Roinard, Thibault Pirotte, Nathan Kientz, Alix Nouvel De La Fleche

Noveltis : Alexandre Homerin

Fluctus : Bruno Picard

OUTLINE

- Main CalVal metrics over Open Ocean
- KaRIn / SWOT nadir complementarity
- Benefits from the 1-day orbit configuration

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- **Main CalVal metrics over Open Ocean**
- KaRIn / SWOT nadir complementarity
- Benefits from the 1-day orbit configuration

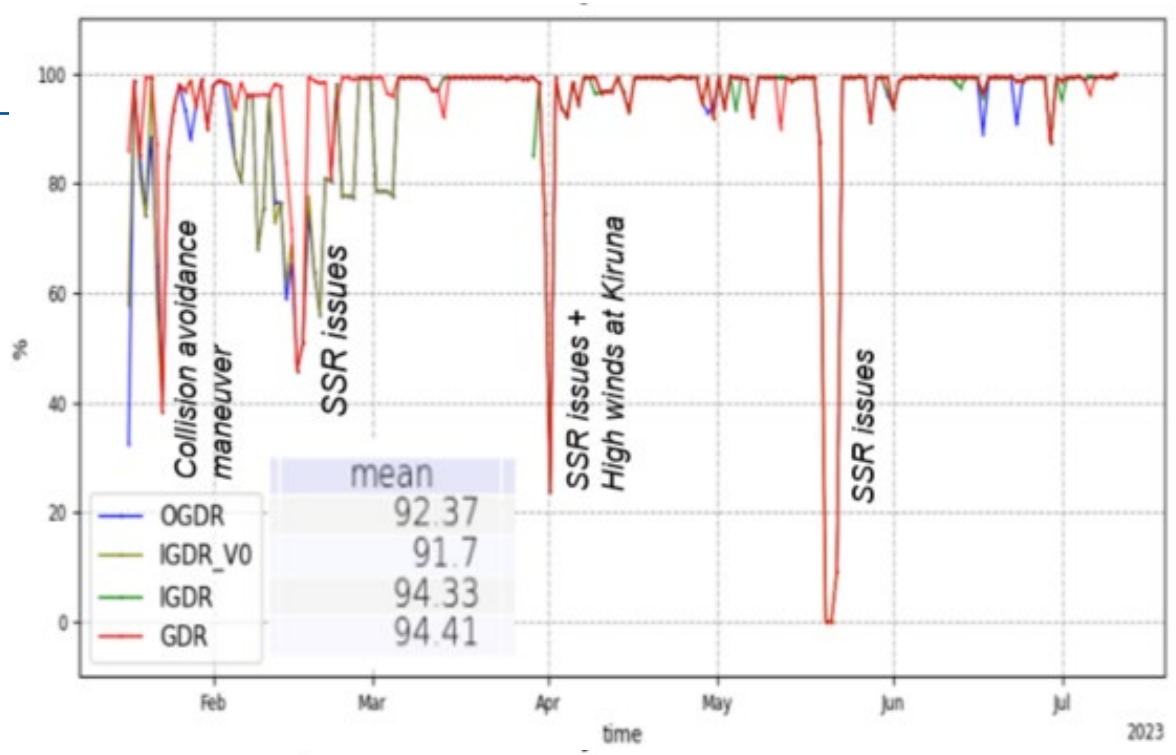
Data availability

- **Excellent data coverage**
  - 94.4% for 1 day orbit
  - 96.2 % for 21 days orbit

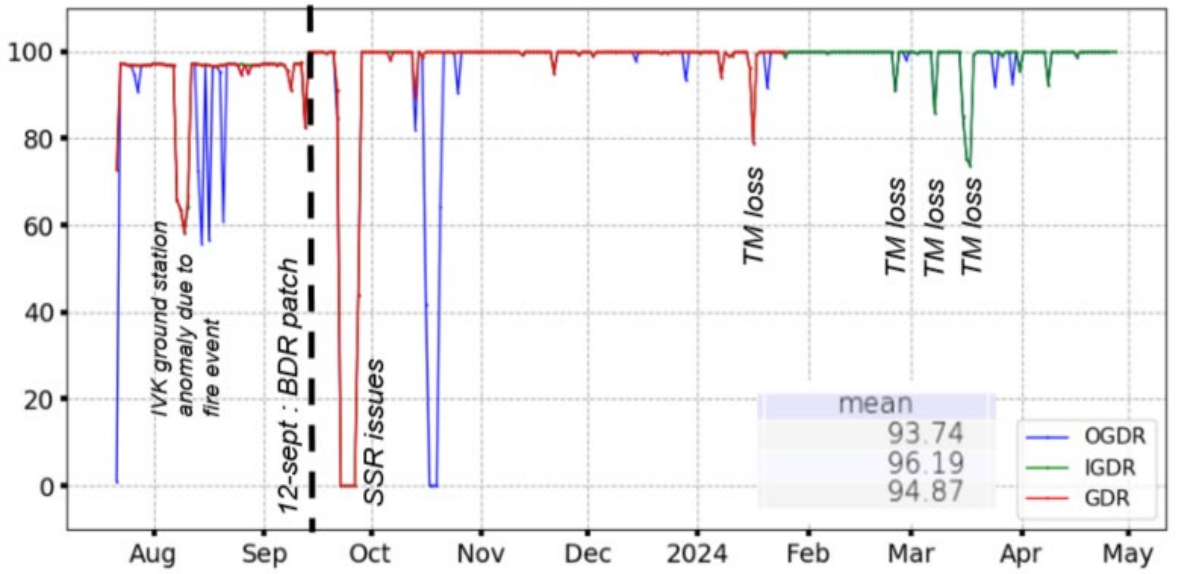
- **Most of the degraded cases are related to**
  - Mission manoeuvers
  - Solid State Recorder issues
  - Ground stations events

- **Nadir IGDR and GDR availability is particularly important for KaRIn L2 products (XCAL computation, Validation, wind & waves estimates currently used in ssb_1 solution)**

1-d

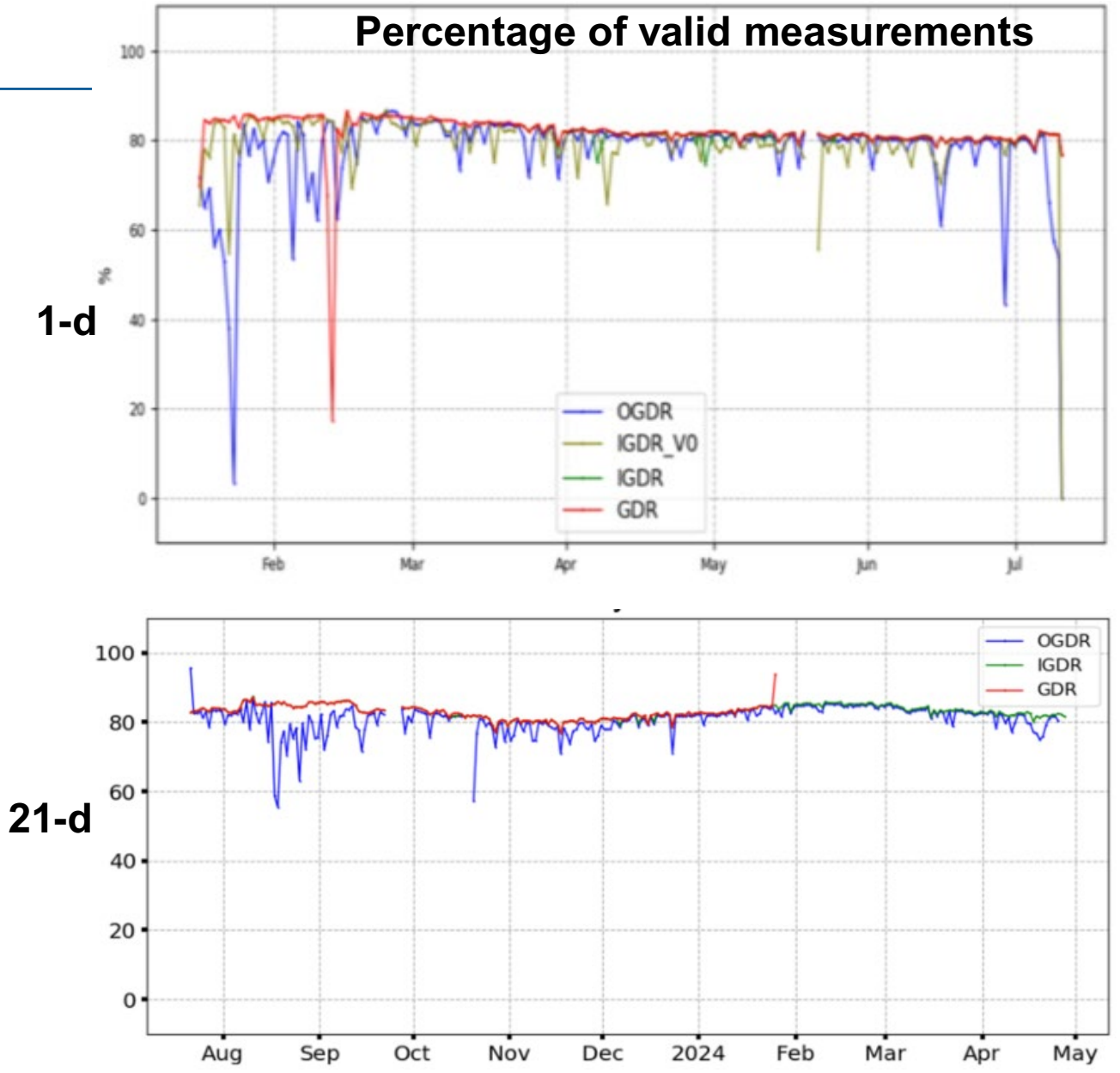


21-d



Valid/corrupted measurements

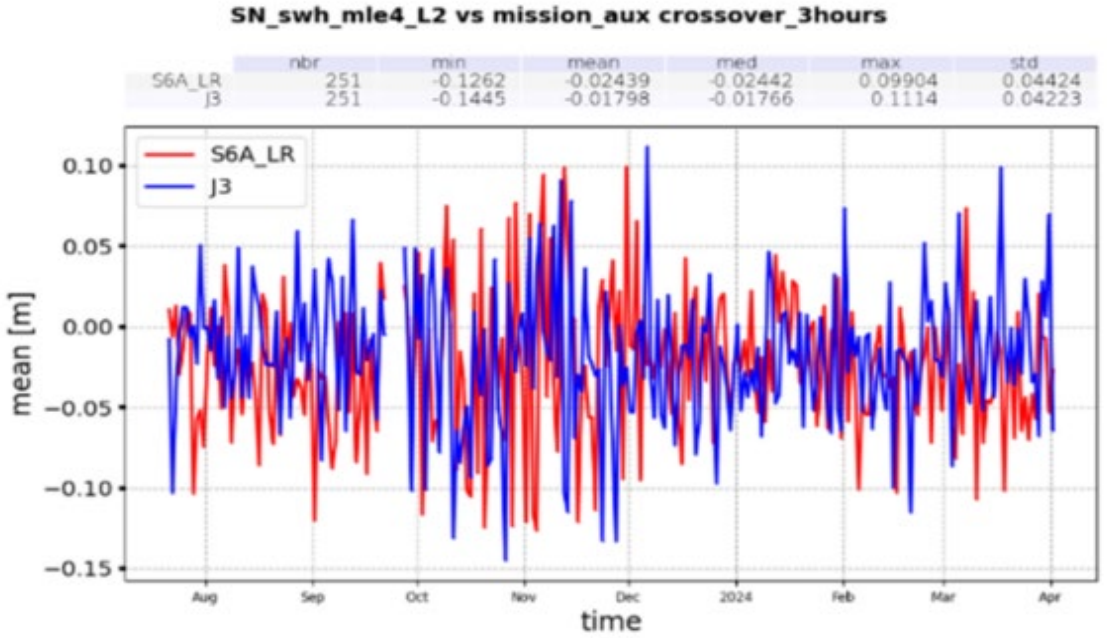
- SWOT nadir editing aims at identifying individual measurements not suited for open Ocean applications
  - See SWOT user handbook for more details (inherited from Jason-2/Jason-3 product handbooks)
- 96% of valid measurements over Ocean (after sea ice editing)
  - Consistent with other nadir missions (Jason-3, Sentinel-6MF)
- Lower percentage of valid measurements for OGDR products (hours latency)
  - Altitude restitution punctually degraded (editing). Anomaly identified, will be solved in a near future.
  - No impact on KaRIn forward production (only the IGDR products are used as inputs)

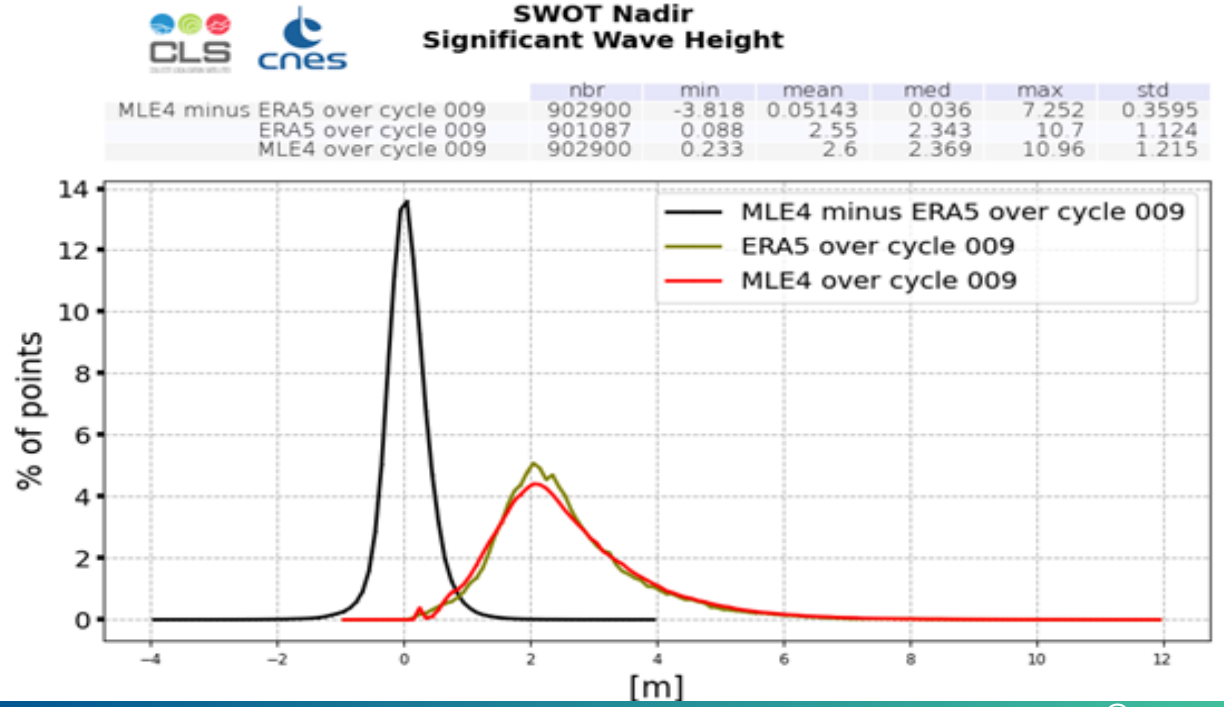


SWH quality

- **Excellent consistency wrt other sensors / model:**
  - **~ 2 cm mean bias wrt Jason-3 / Sentinel-6MF LR SWH**
  - **~ 5 cm wrt ERA5 model**

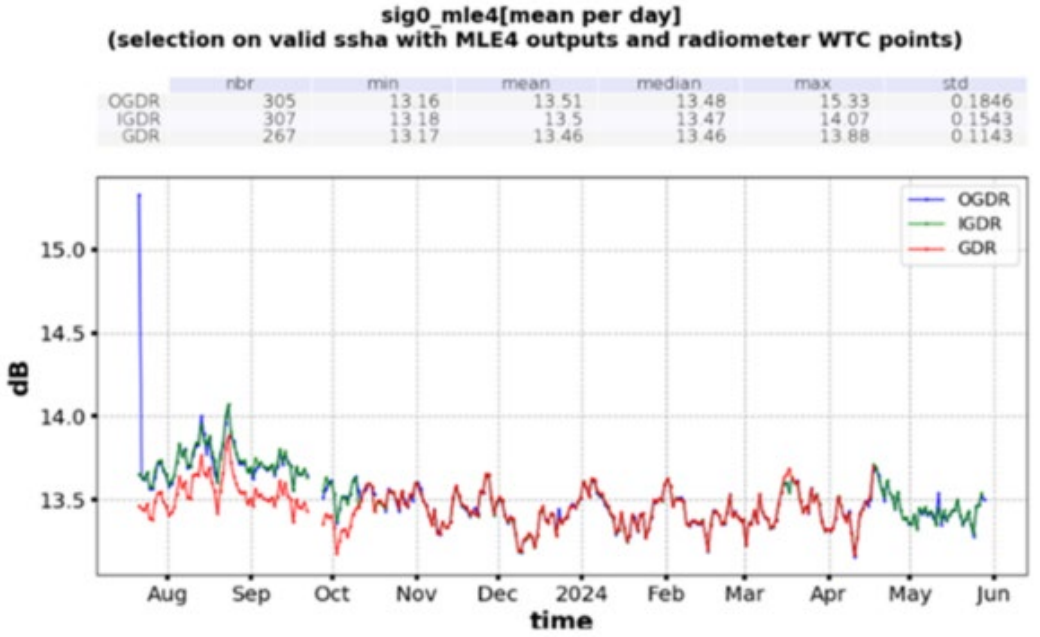
- **SWOT nadir SWH contributes to the CMEMS L4 W&W products since November 2023**

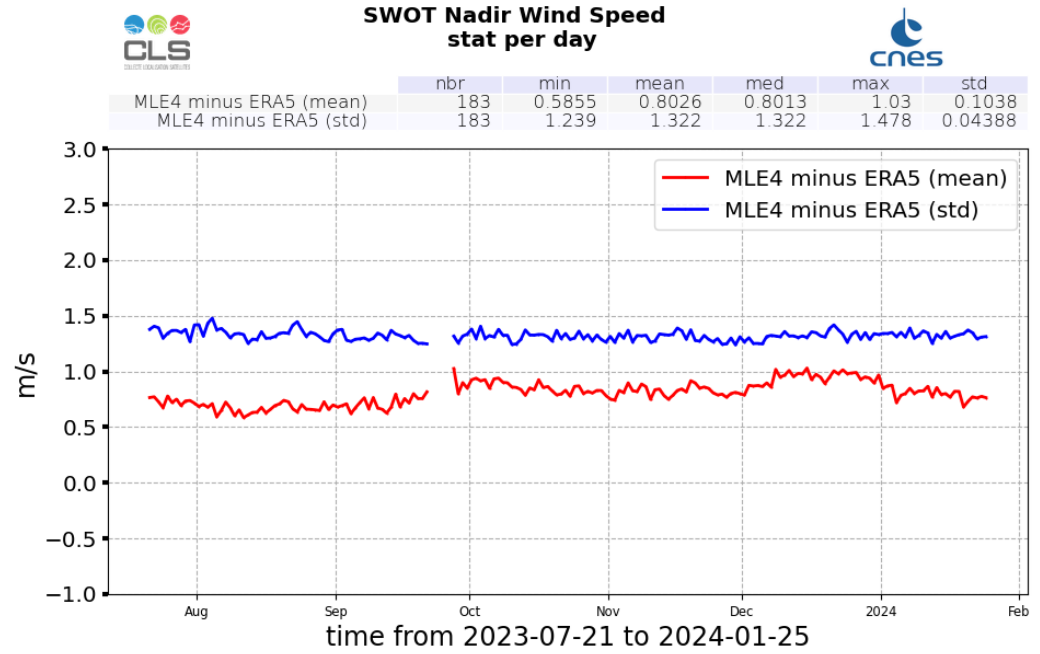




Sigma0 & Wind speed

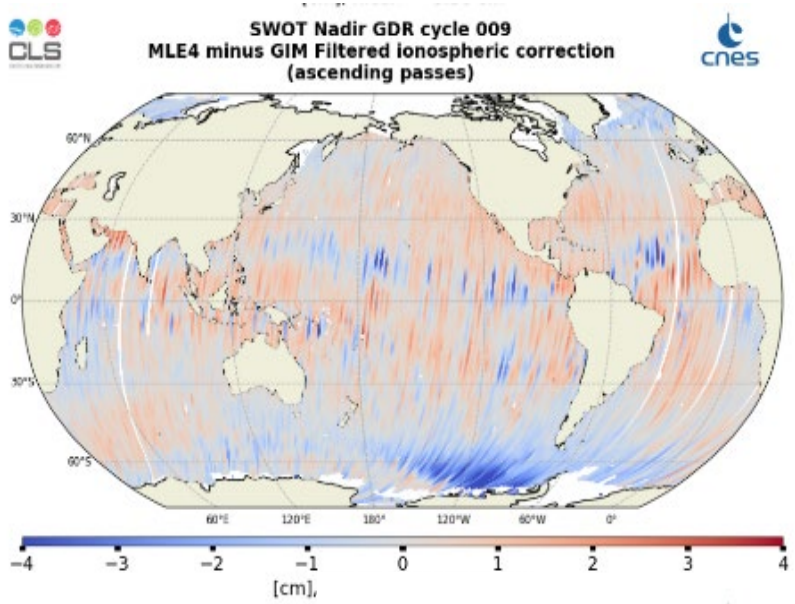
- Sigma0 small discontinuity < 0.2 dB in O/IGDR sigma0 due to ground processing instrumental parameter update on 10th of October 2023 (Update of the antenna aperture angle value)
- Sigma0 same small discontinuity observed in GDR reprocessed products between CalVal & Science orbit (not shown, related to the above feature)
- Slight impact on the Wind speed estimation (IGDR & GDR science phase): over estimation of ~0.7 m/s with respect to ERA5 model.
- Negligeable impact on sea state bias & SSHA < ~0.5 mm
- Bias correction & adjustment planned for next reprocessing

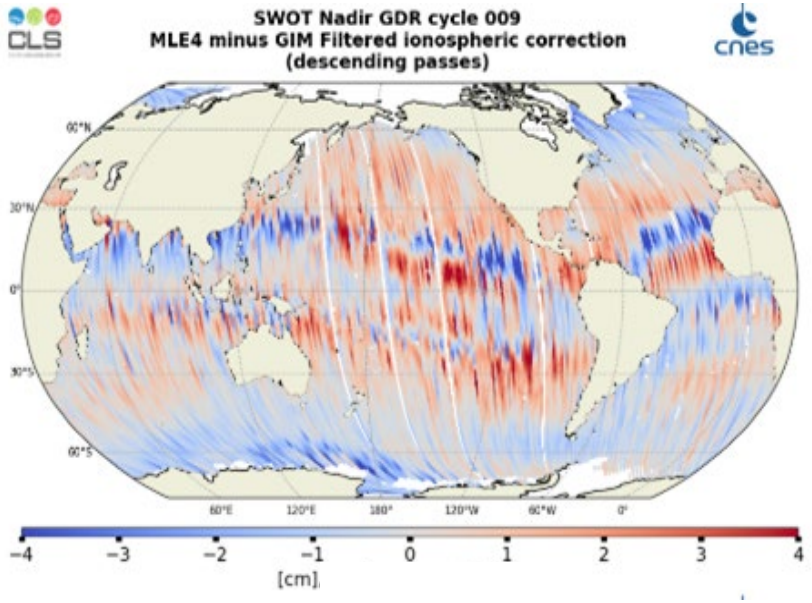




Dual-frequency ionosphere correction

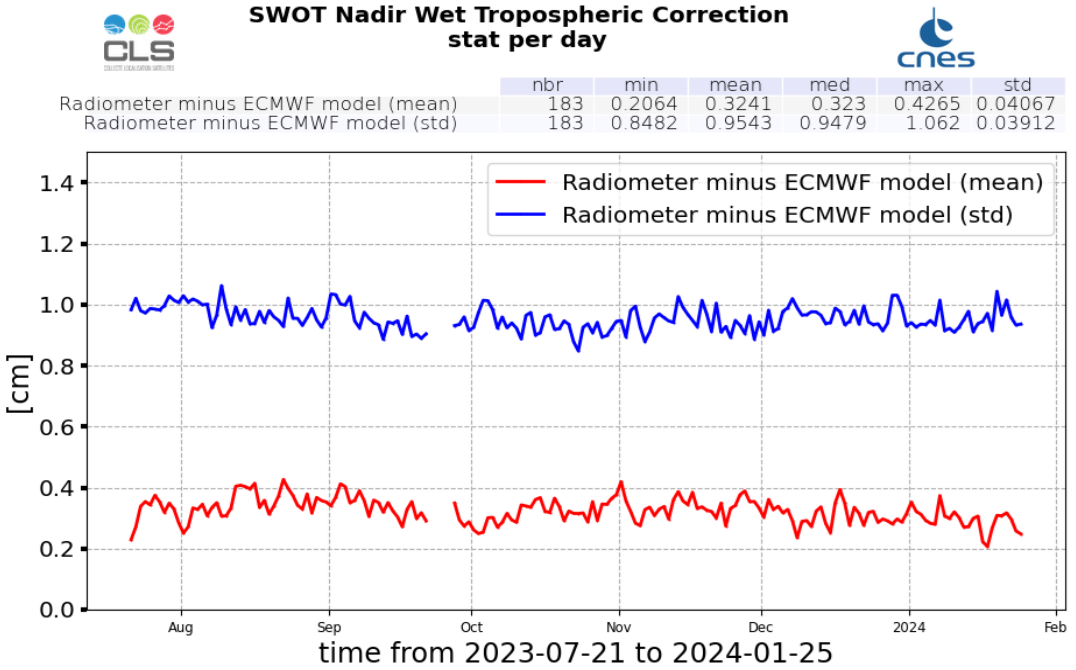
- Mean bias of ~7mm +/- 1cm
- Similar performances as for Sentinel-6MF
- Part of these small biases correlated with TEC / local hours. Related to scaling limitations in the model estimates (see Dettmering et al., 2022) and accuracy of the GIM correction

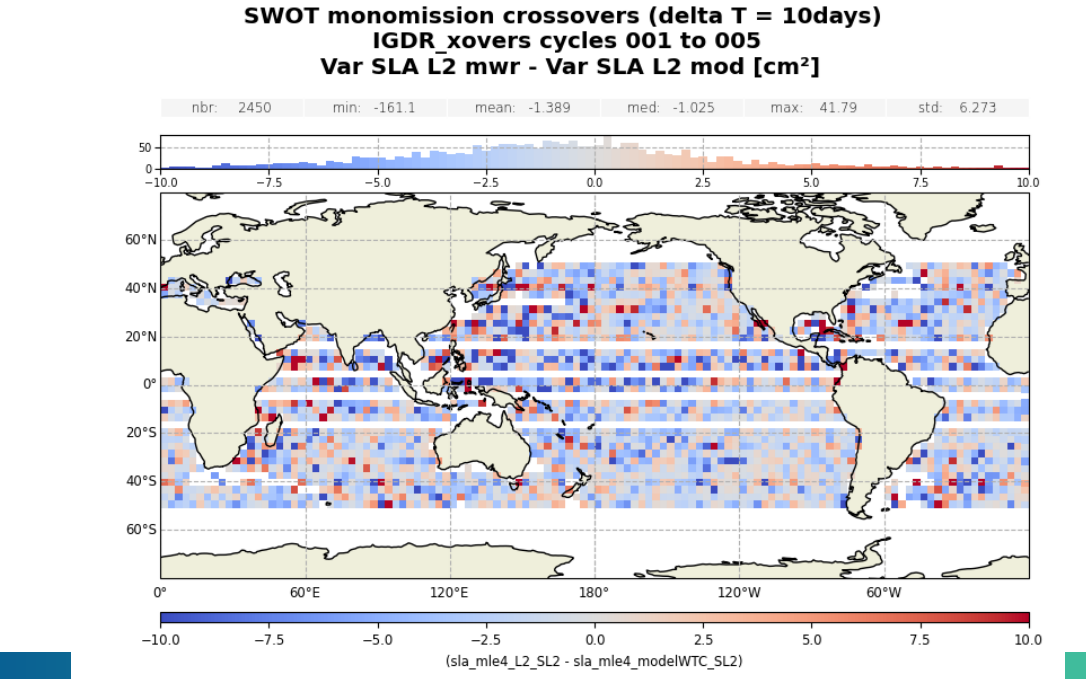




AMR Wet Troposphere correction

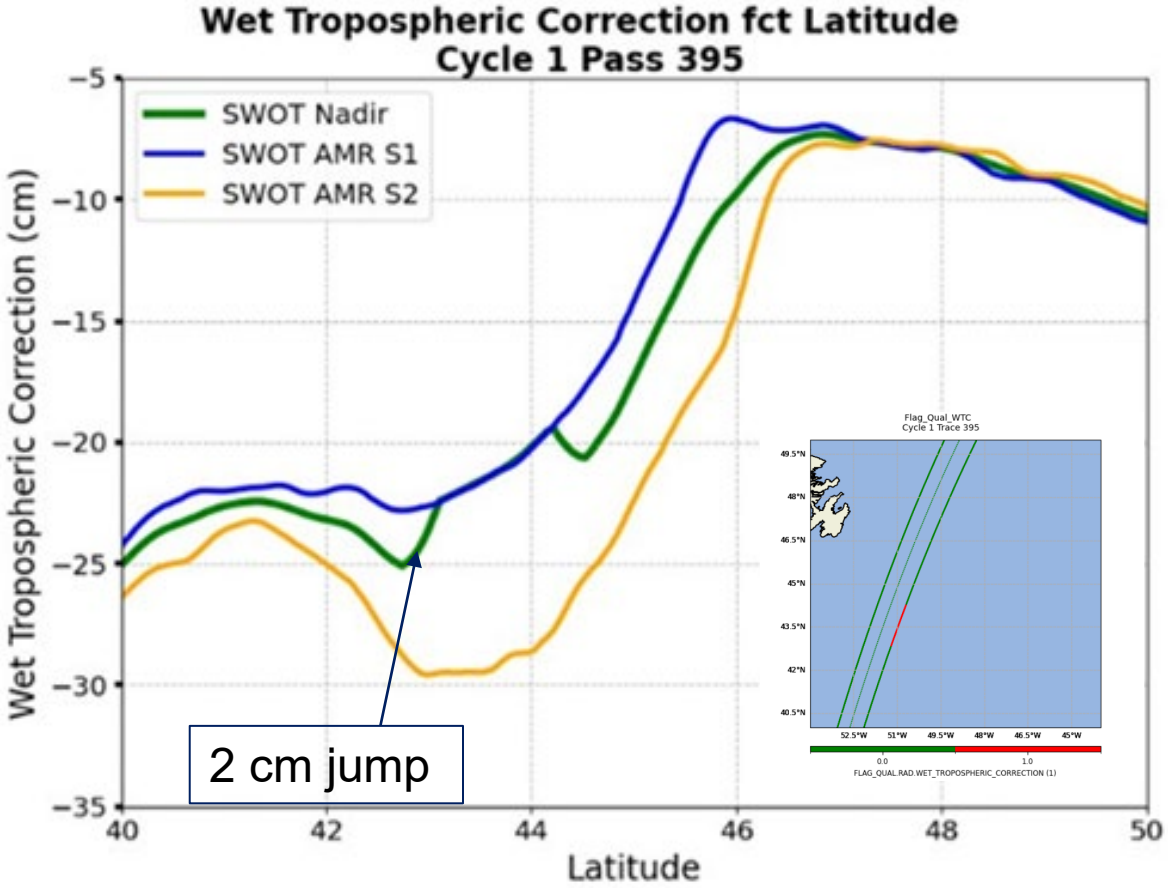
- **Reminder:**
  - 2 AMR beams located ~at center of each KaRIn swaths
  - Interpolation algorithm to retrieve the WPD at nadir
- **Global comparison wrt ECMWF model shows excellent performances**
  - 0,3 cm bias +/- 1 cm
  - 1.4 cm² of SSHA variance reduction very closed / consistent with S6MF metric.



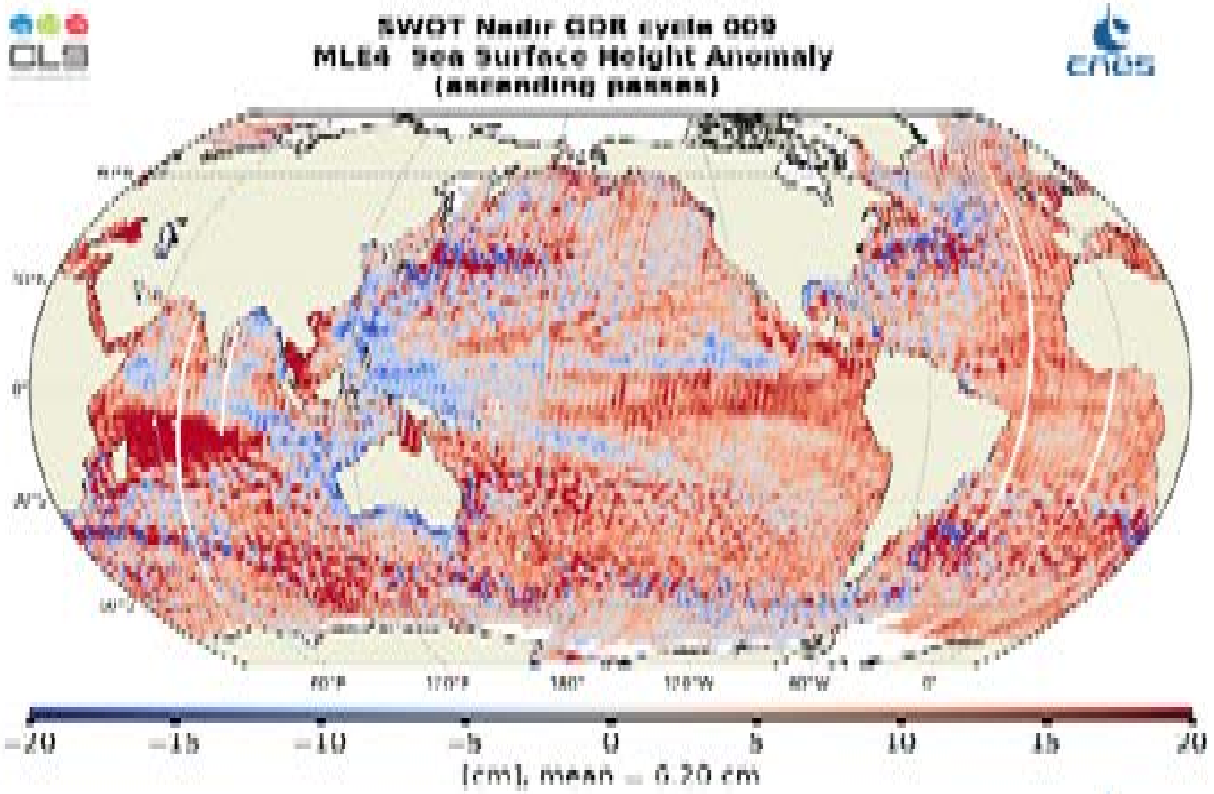


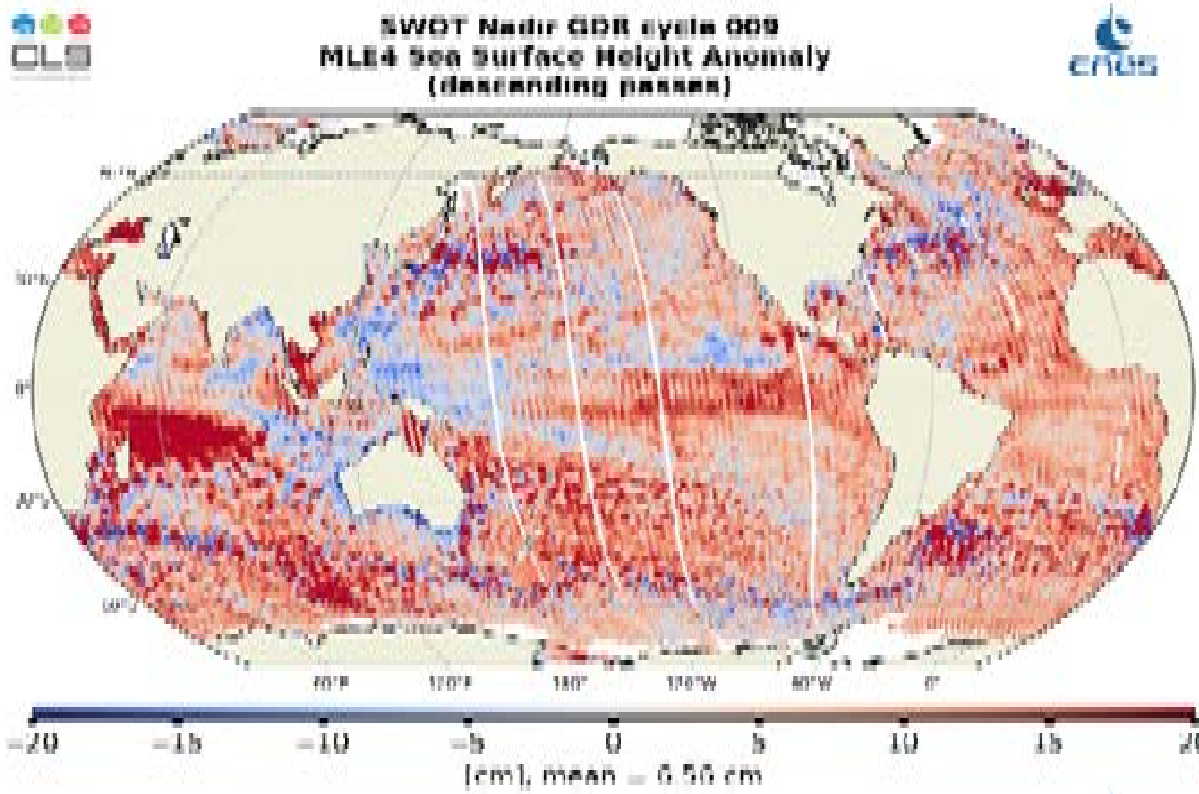
AMR Wet Troposphere correction

- Degraded situations observed when 1 over 2 AMR beam is flagged as invalid (mainly occurs on rain events, land contamination)
  - The nadir correction jumps from averaged value to available off-nadir estimation.
  - 1-2 cm observed locally on both WTC / SSHA
- About 1.3% of occurrences over open Ocean
- Study ongoing to improve the nadir interpolation



SSHA



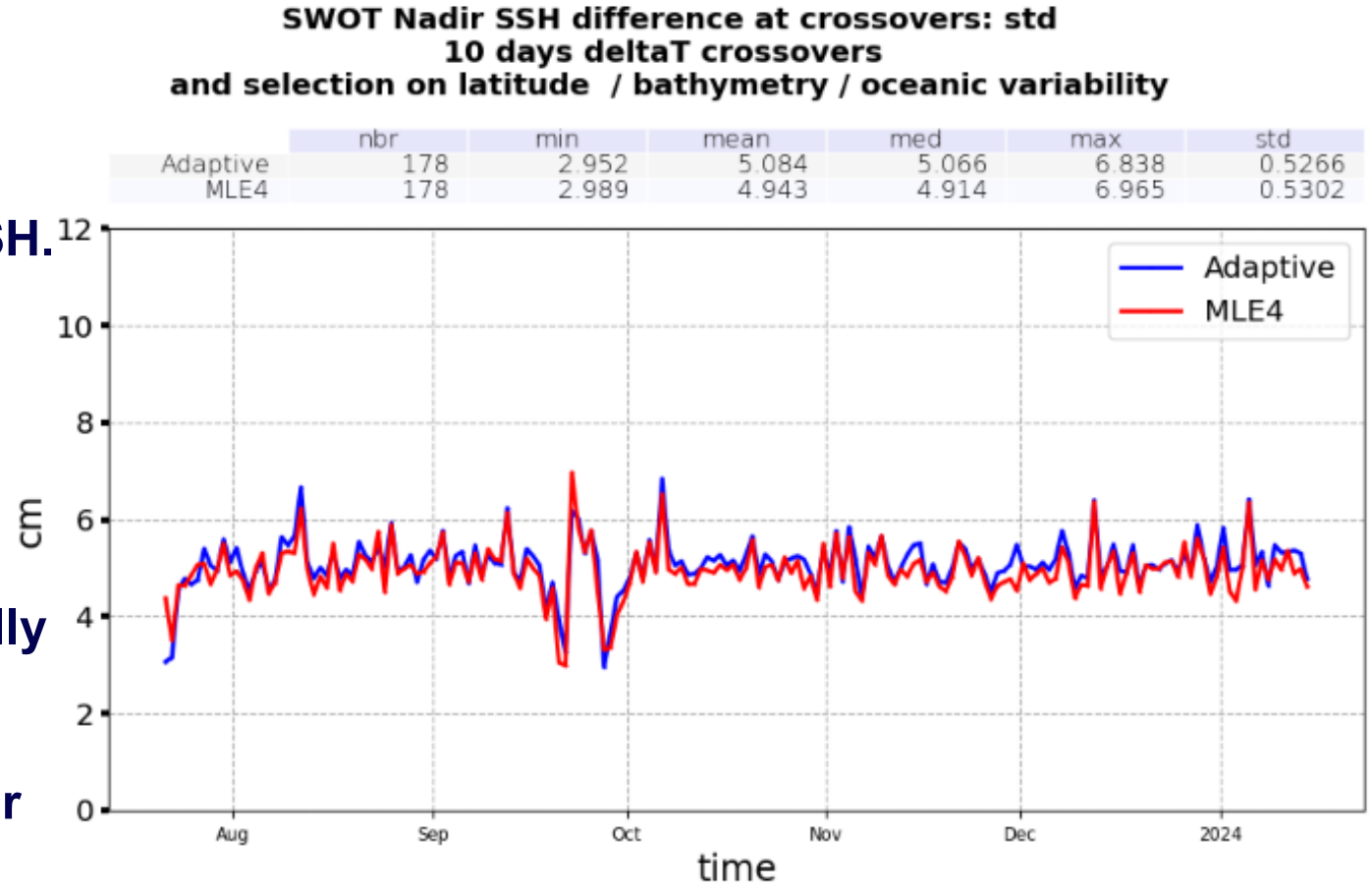


- **At first order, excellent consistency between ASC/DSC passes, with other missions**

SSHA

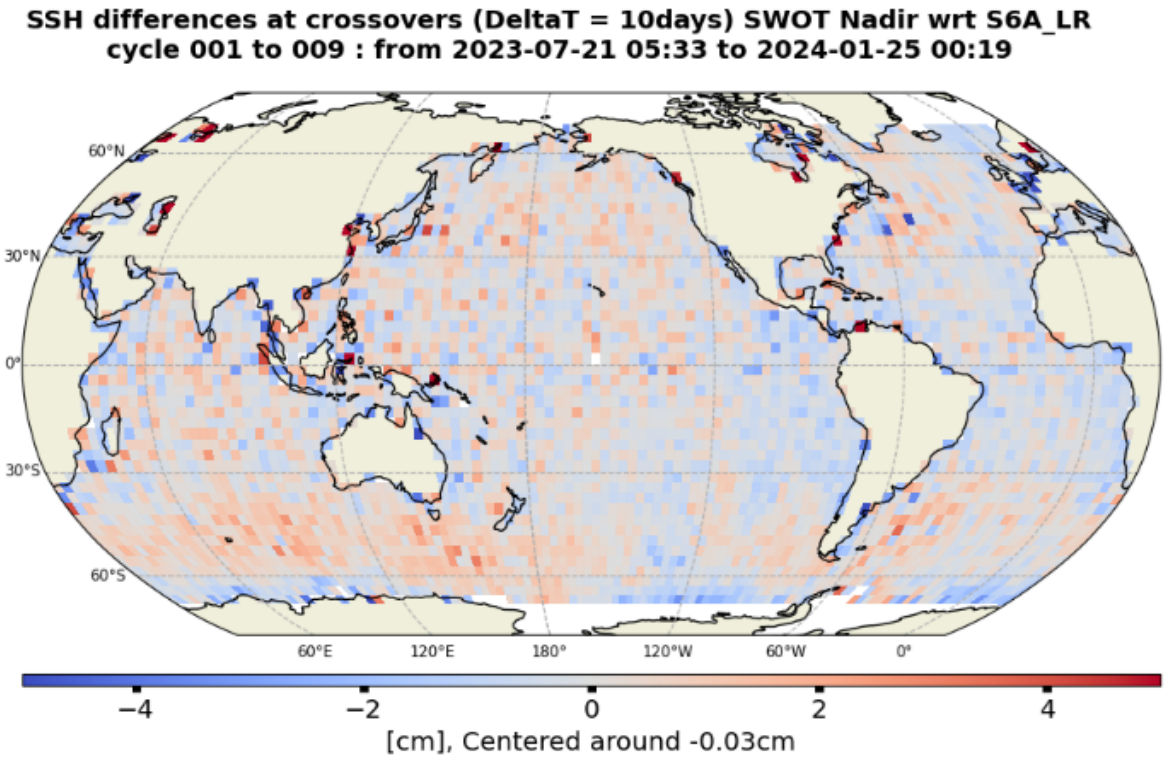
- **Std of SSH differences at crossovers show excellent performances**
  - **5 cm rms in average**
  - ** ~3.5 cm error for the SWOT nadir SSH.**

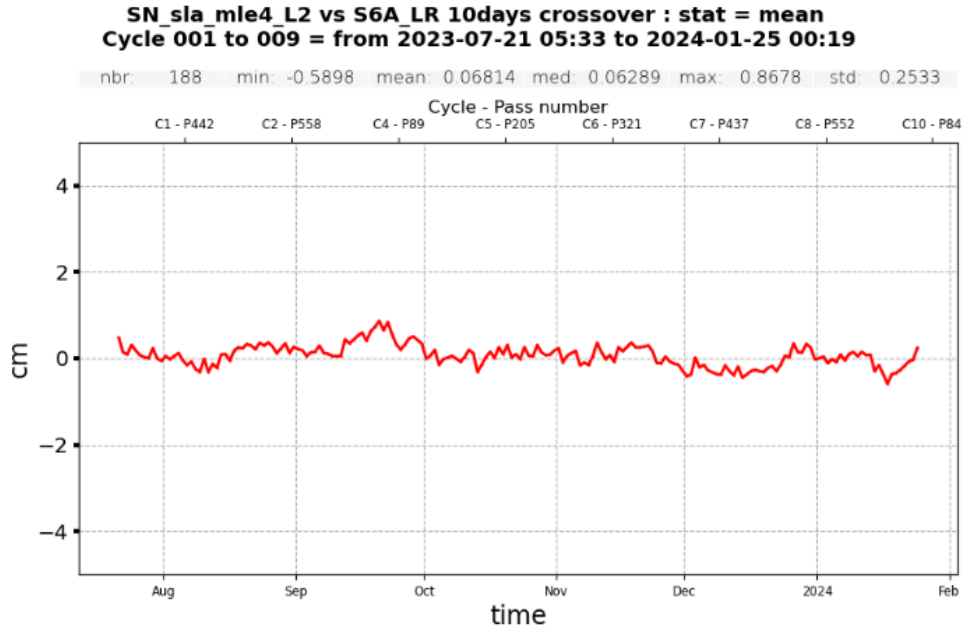
- **Note that this metric:**
  - **includes part of the natural oceanic variability (time lag <= 10d)**
  - **Does not include long term correlated errors (above 10 days) nor geographically correlated errors**
  - **Does not include MSS errors**
  - **Limits the impact of the HF random error**



SSHA

- **Comparison with S6MF shows an excellent agreement**
  - **Aligned mean SSHA**
  - **Very small geographical biases ranged ~[-2;2] cm**
  - **Excellent stability over time**



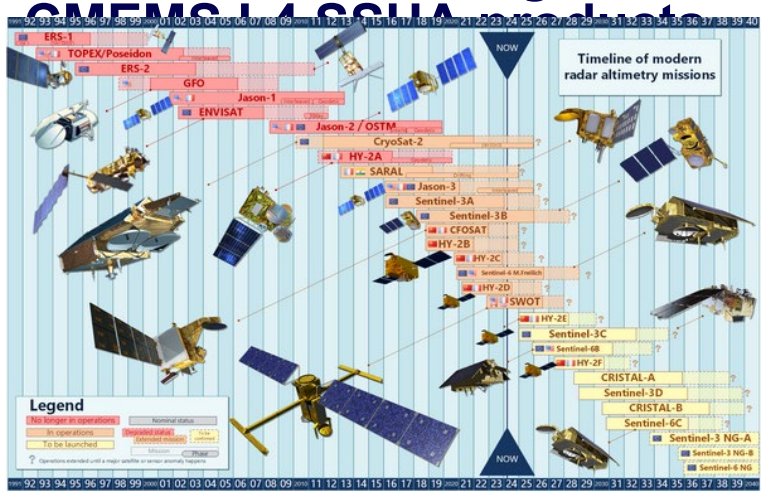


SWOT nadir & the nadir constellation

From Maxime Ballarott

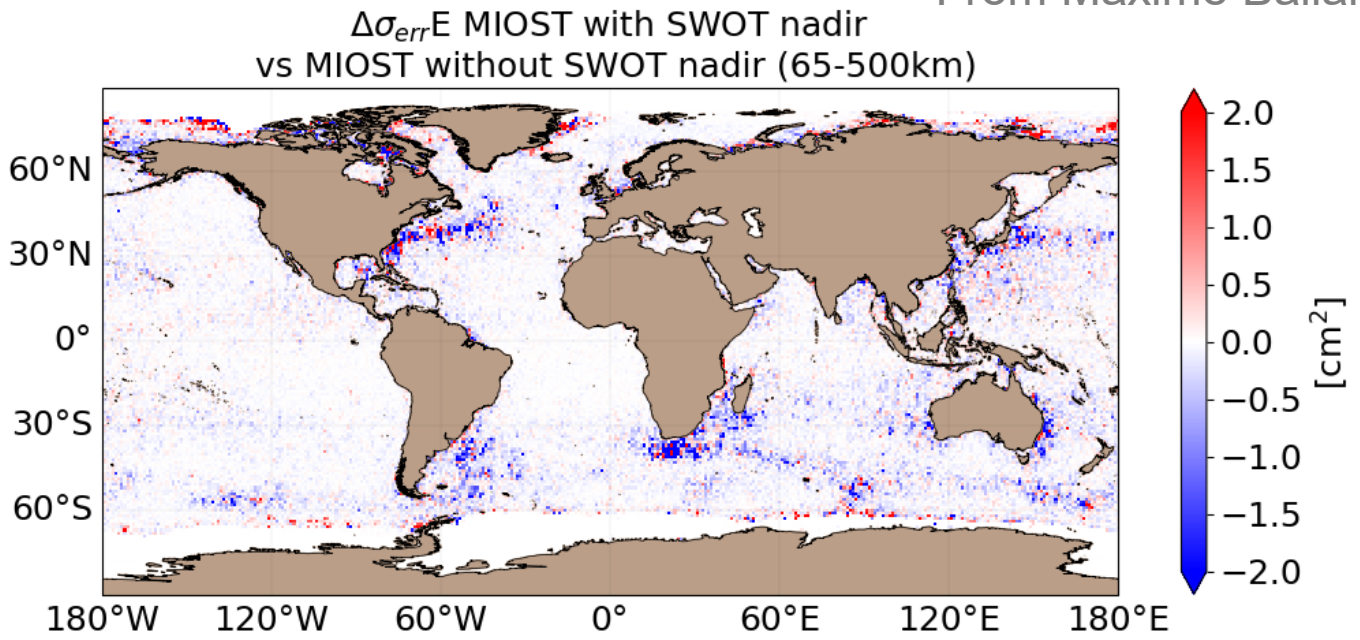
- **Positive impact of SWOT nadir data in the multi-mission SSHA products**

- **SWOT nadir will be the eighth mission contributing to the CMEMS L4 SSHA products**



- **Integration planned in July 2024.**

Science orbit



Error reduction including SWOT nadir in the L4 constellation (%)	offshore (> 200km) high var (> 0.02m2)	offshore (>200km) low var (<0.02m2)
all_scale	-3.83	-0.79
65-500km	-6.34	-2.29
65-200km	-5.33	-2.08

Evolutions planned for next version (GDR-S2)

GDR-S2 (after)	GDR-S (current)
MDT CNES/CLS22	MDT CNES/CLS18
Surface type anomaly correction	Bug identifified locally in the grid
MSS CNES/CLS2023/SCRIPPS/DTU (Hybrid)	CNES/CLS2015
Equatorial band error correction	O (mm) error
WS & Sigma0 biases correction	Discontinuities + 80cm/s bias
WTC nadir provide identification of degraded interpolation cases	1-2 cm jumps in WTC & SSHA

OUTLINE

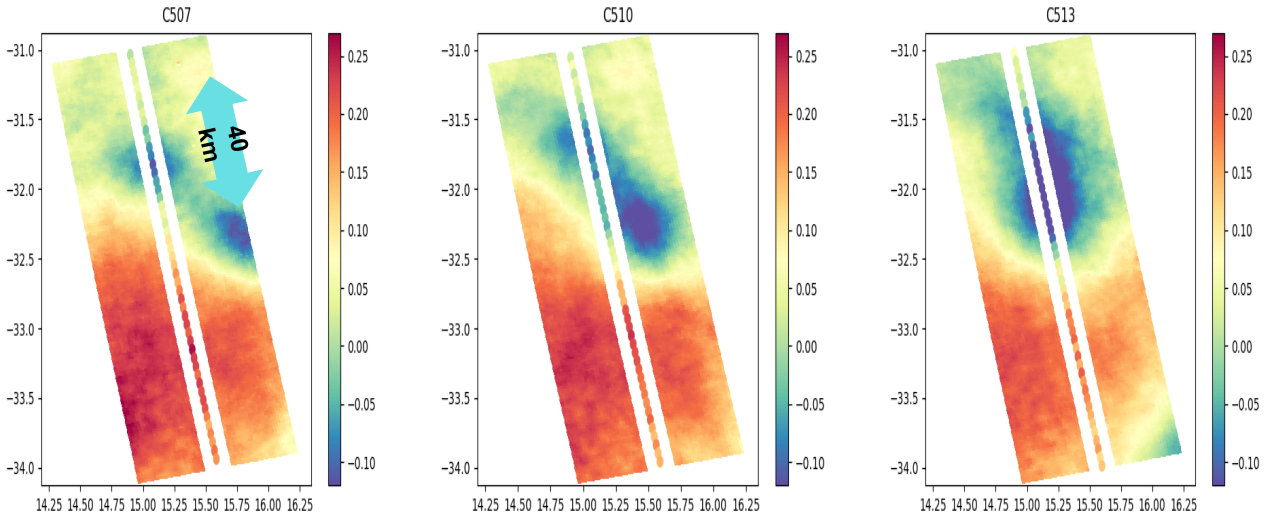
- Main CalVal metrics over Open Ocean

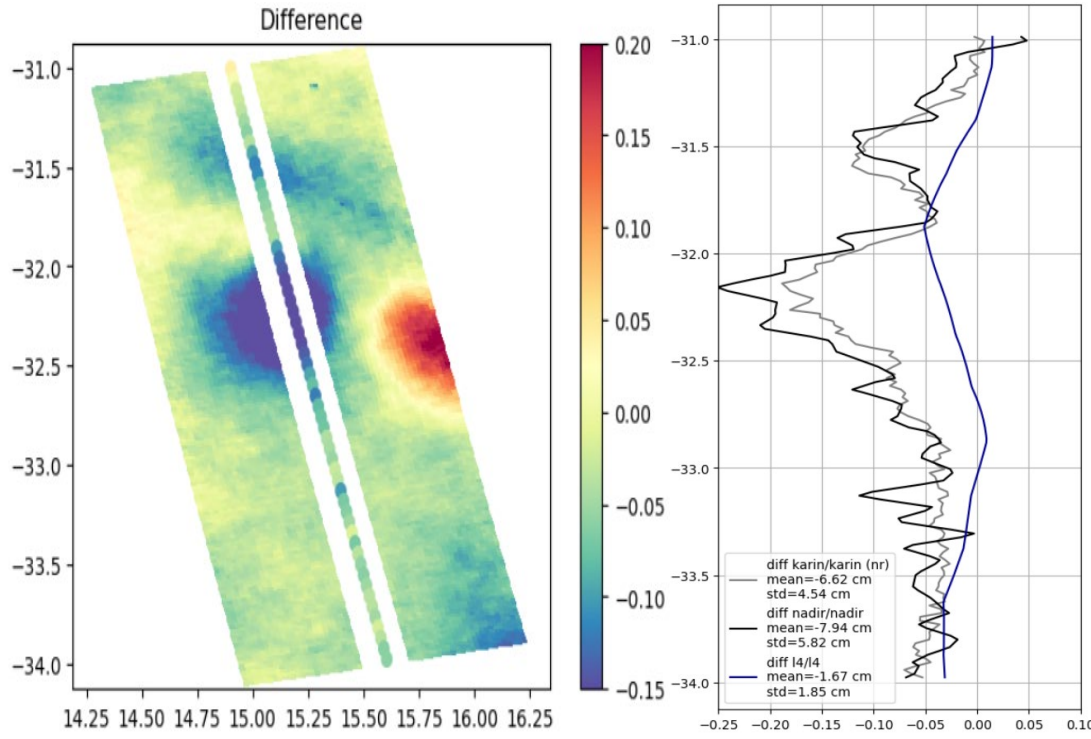
- **KaRIn / SWOT nadir complementarity**

- Benefits from the 1-day orbit configuration

KaRIn & SWOT nadir

- The SWOT nadir altimeter is an undeniable asset for validating KaRIn measurements (in open ocean)
- It has been massively used to validate / confirm the structures observed in KaRIn measurements
  - Use of L4 products often limited by the spatial/temporal resolution
  - Use of crossovers with other nadir altimeters from the constellation is limited by time delay, and coverage
- Successfully used to discriminate the origin of the error (geophysical signal versus instrument/processing) when unexplained features have been observed in KaRIn data.





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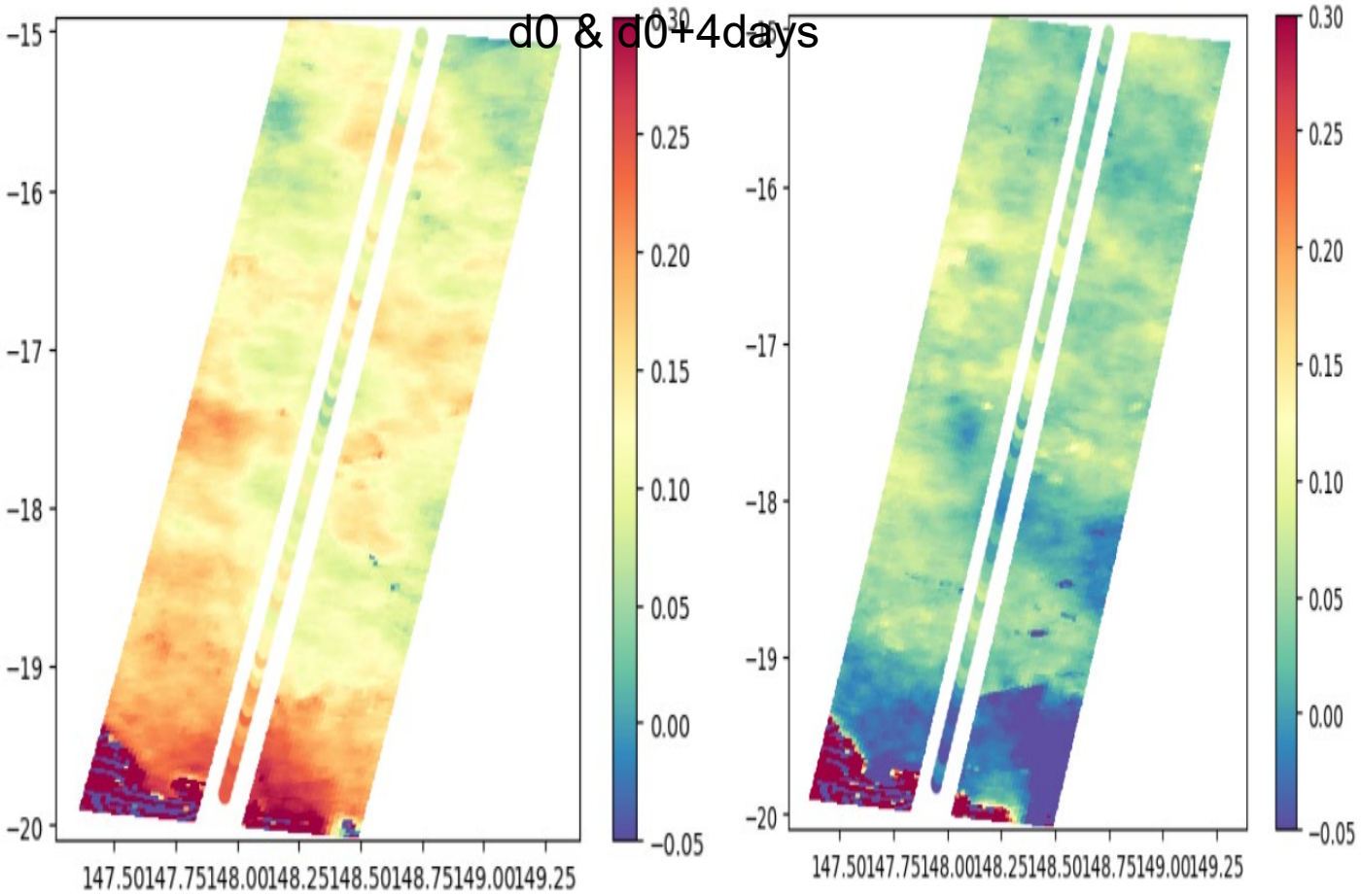
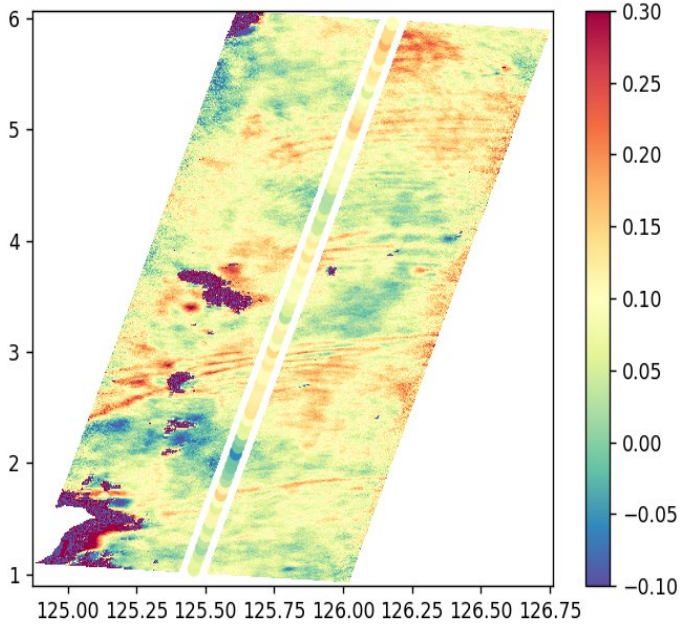
Tide elevation error in North of Australia

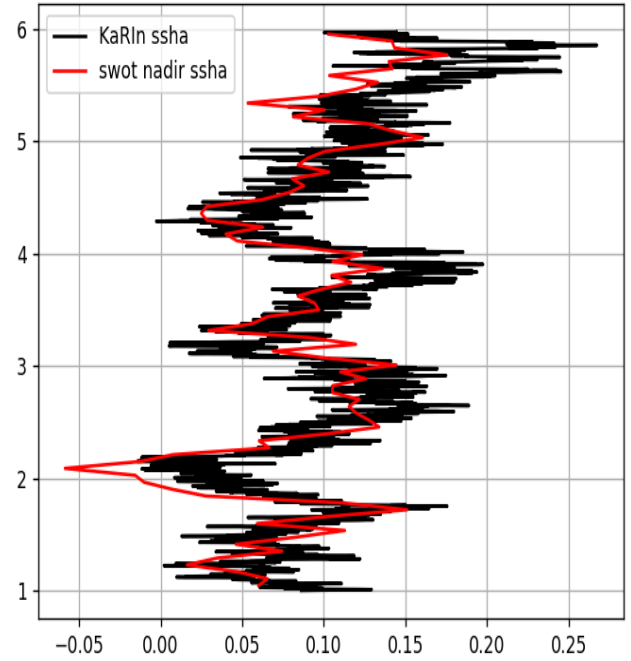
d0 & d0+4days



KaRIn & SWOT nadir

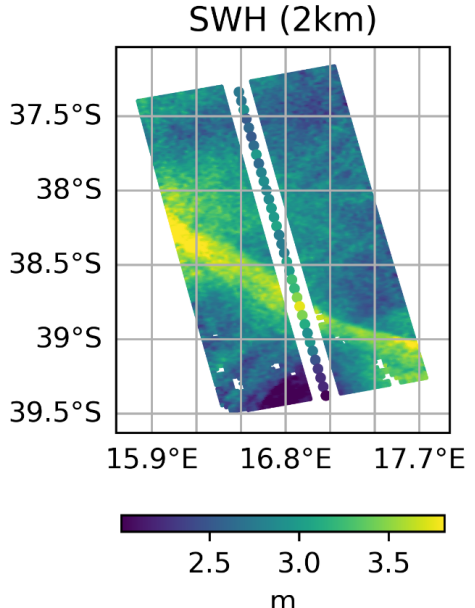
- On the other hand, this complementarity between both instruments should benefit to improve our knowledge of the nadir altimeter signal and provides new opportunity to develop and validate alternative processing.
- Among others :
  - Ongoing studies on the nadir spectral bump using information of heterogeneity within the footprint from KaRIn
  - Ongoing studies on sea ice surfaces to evaluate & improve current retracking models.





Internal tide signatures captured by KaRIn and swot nadir (smoothed)

SWH front observed from both instruments



OUTLINE

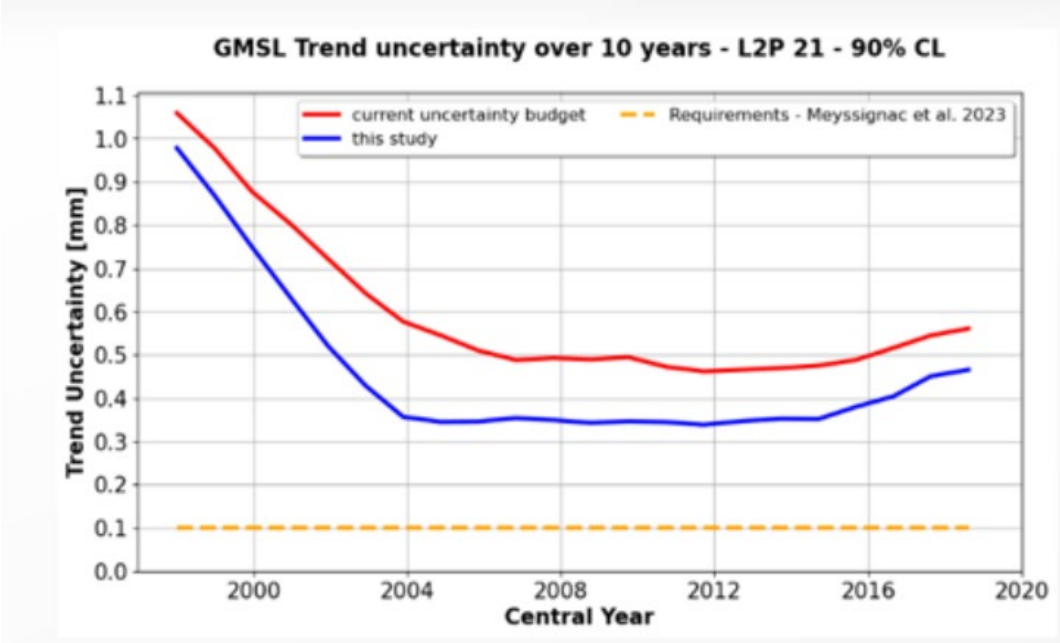
- Main CalVal metrics over Open Ocean
- KaRIn / SWOT nadir complementarity
- **Benefits from the 1-day orbit configuration**

Benefits of the 1day orbit

- First time ever an altimetry satellite has 1 day revisit period (over ~6months for Swot nadir)
- Specific studies have been conducted on various subjects:
  - Autocorrelation and cross-correlation of SSB inputs parameters to optimize the computation of SSB models
  - Study of geoid & rapid mesoscale signals
  - High frequency error contribution for Global Mean Sea Level error budget
  - Daily nadir radargram analysis over rivers

Table 3: Percentages of significant correlations (i.e., falling outside confidence intervals) between sla (corrected and not corrected for SSB) and SSB input parameters at -2 days, -1 day, 0 day, +1 day, and +2 days.

	-2 days	-1 day	0 day	+1 day	+2 days
sla_uncorr x swh_alti	6.2%	9.9%	98.4%	7.6%	6.2%
sla_corr x swh_alti	6.1%	10.9%	31.8%	10.7%	7.9%
sla_uncorr x u_alti	6.0%	11.6%	82.5%	23.1%	8.0%
sla_corr x u_alti	5.9%	7.3%	23.4%	10.2%	7.4%
sla_uncorr x mwp_model	4.9%	22.6%	32.8%	12.0%	6.1%
sla_corr x mwp_model	5.4%	10.2%	22.0%	8.5%	6.7%



Conclusions

- **Excellent quality of SWOT nadir products over Ocean**
  - **Some adjustments to be performed to slightly improve the data quality for next reprocessing.**

- **SWOT nadir integration in CMEMS L4 products expected in July 2024**

- **KaRIn and the 1-day repetitive orbit bring relevant contextual information to further improve nadir altimetry products**

THANK YOU