SENTINEL-6 PDAP PRODUCTS ASSESSMENT OVER OCEAN
(MISSION PERFORMANCE SERVICE)

Wednesday, November 02 2022
OSTST

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Major evolutions in L2 since last OSTST (2020)

- **Switch to Side B (Oct. 19th 2021)**
- **S6A-MF became the reference mission (April 2022)**
- **Operational Processing Baseline Upgrades**
  - F04 (Nov 9th 2021)
  - F05 (Mar 8th 2022)
    - POE-F v2
  - F06 (May 31th 2022)
    - Reduce doppler beams 448->322
  - F07 (Aug 17th 2022)
    - HRMR in WTC ; ECHO CAL as CAL1
- **Full reprocessing (Baseline F06)**

Missing Data
Valid Data

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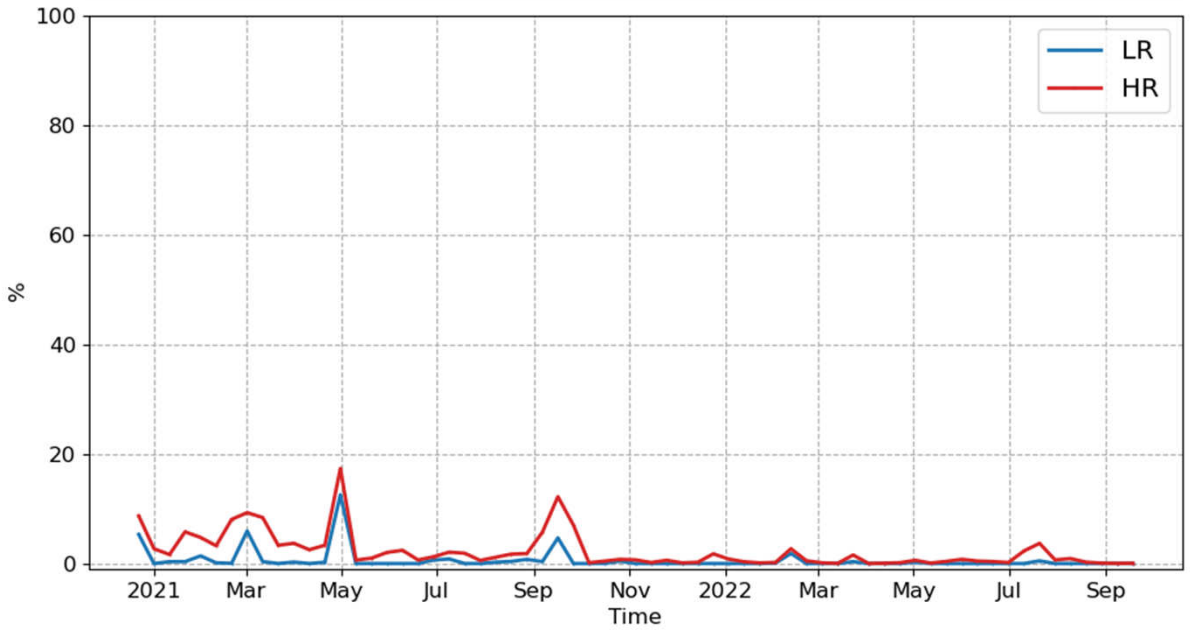
Missing Data

- Missing Data are measurements not present in the product wrt theoretical track
  - Less than 0,6% of missing data in LR
  - Around 2,2% of missing data in HR, but aligned to LR since the end of Mask Mode

Percentage of missing data over ocean per cycle

	nbr	min	mean	med	max	std
LR	65	0	0.5891	0.003302	12.54	1.873
HR	65	0.01701	2.263	0.8153	17.34	3.233



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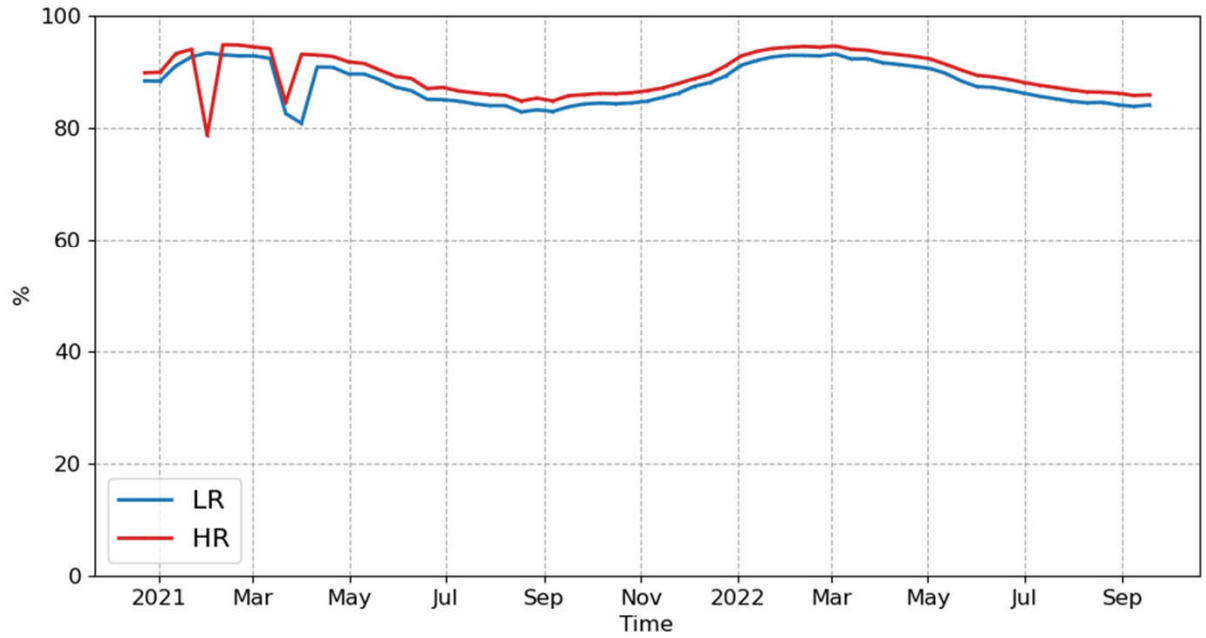
Valid Data

- Editing removes any measurement that is considered erroneous. It helps refining the metrics.
  - Ice-Flaggued : Removes approx 1 to10 % of measurements (seasonal behavior)
  - Out of control thresholds : Removes approx. 5 to 8 % of measurements
  - Mean LR validity : 87,9 %
  - Mean LR validity : 89,6 %

Percentage of valid data over ocean per cycle

	nbr	min	mean	med	max	std
LR	65	80.85	87.88	87.42	93.42	3.567
HR	65	78.68	89.6	89.23	94.88	3.594



Range

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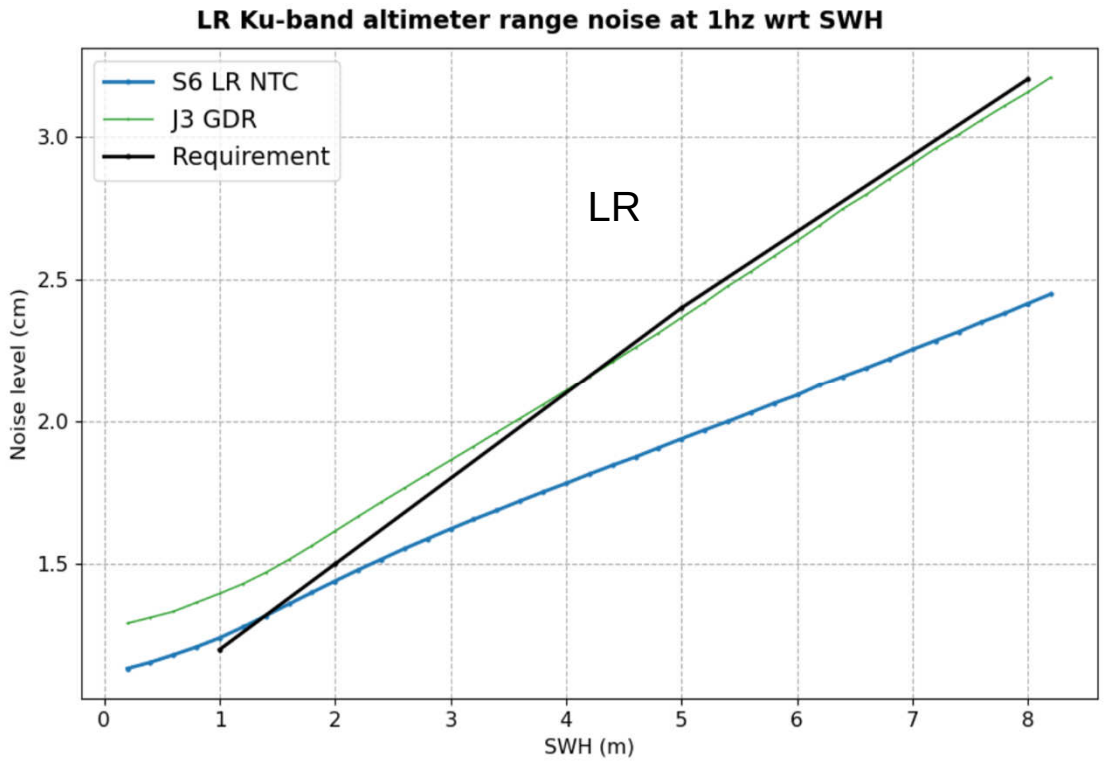
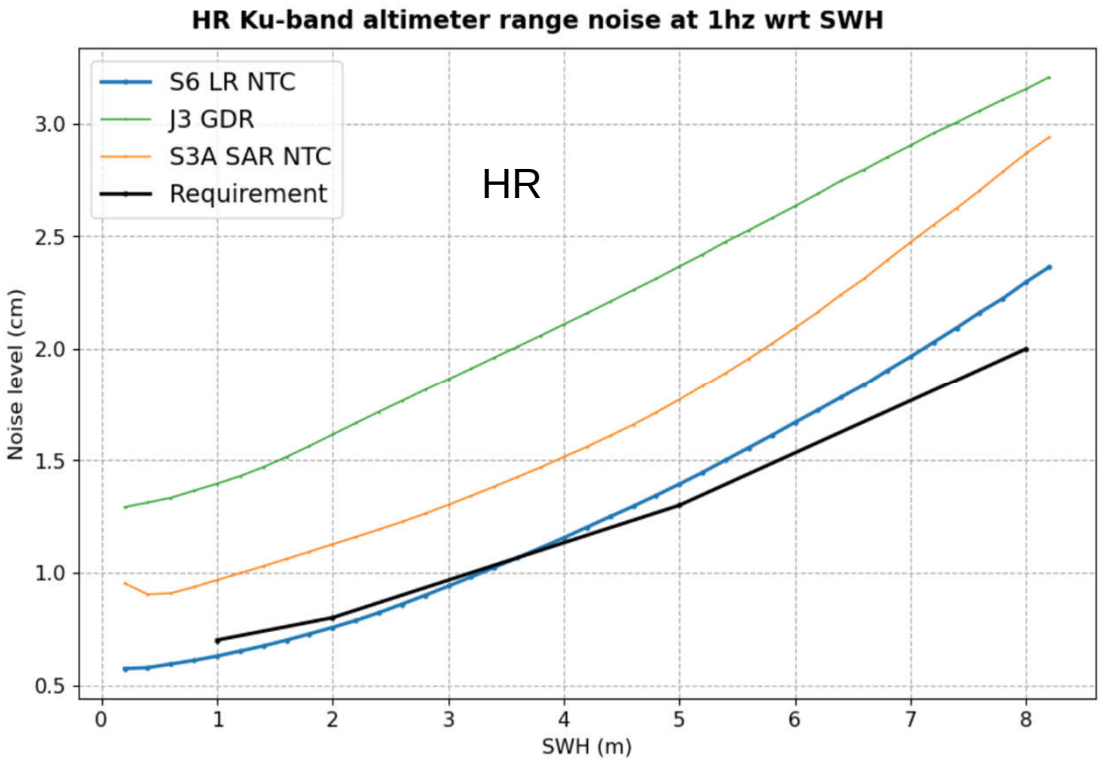
Range

- Noise
  - S6A range noise level is well below Jason-3 and Sentinel-3A level





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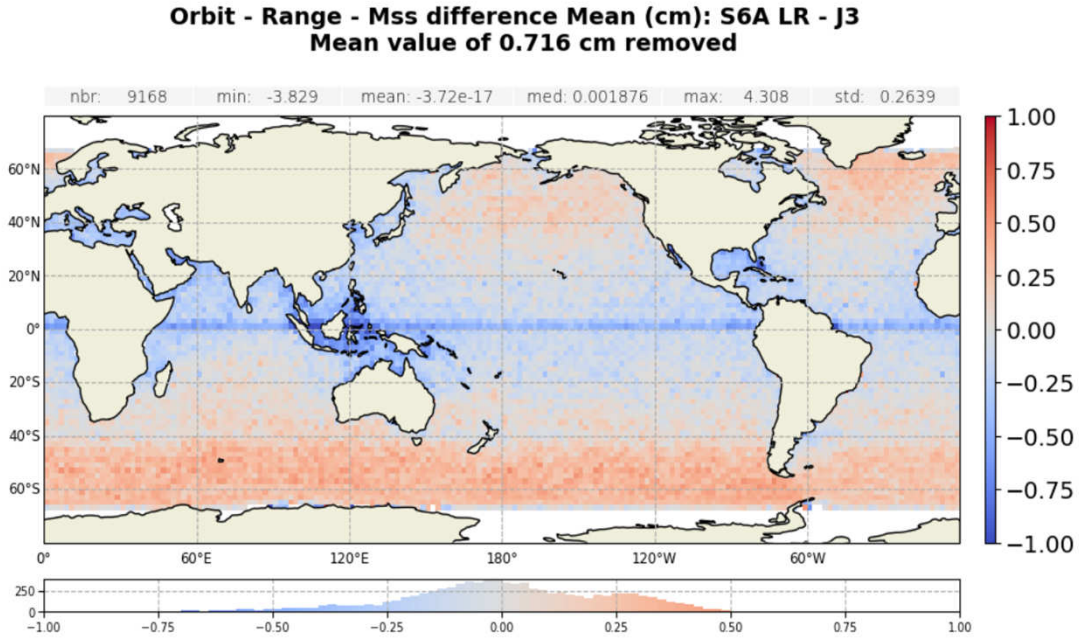
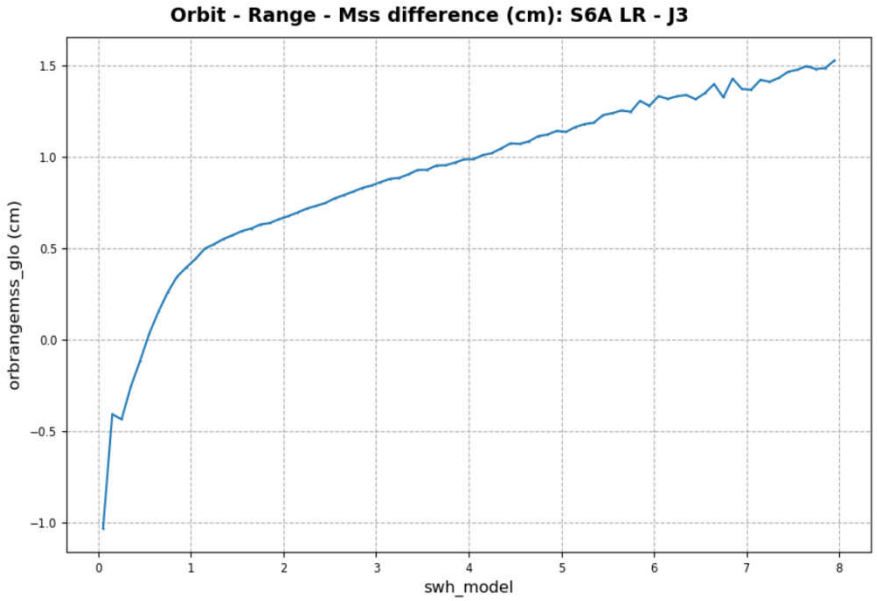
Range

- S6 LR / J3
  - Bias of only 0.76 cm
  - No more hemispheric patterns thanks to POE-F orbit updates
  - Equatorial band. First investigations have shown that this behavior is most likely coming from Jason-3. Still under investigation
  - SWH dependency of the bias (~1cm) . *Will be improved with S6 LR numerical retracking (PB F08)*





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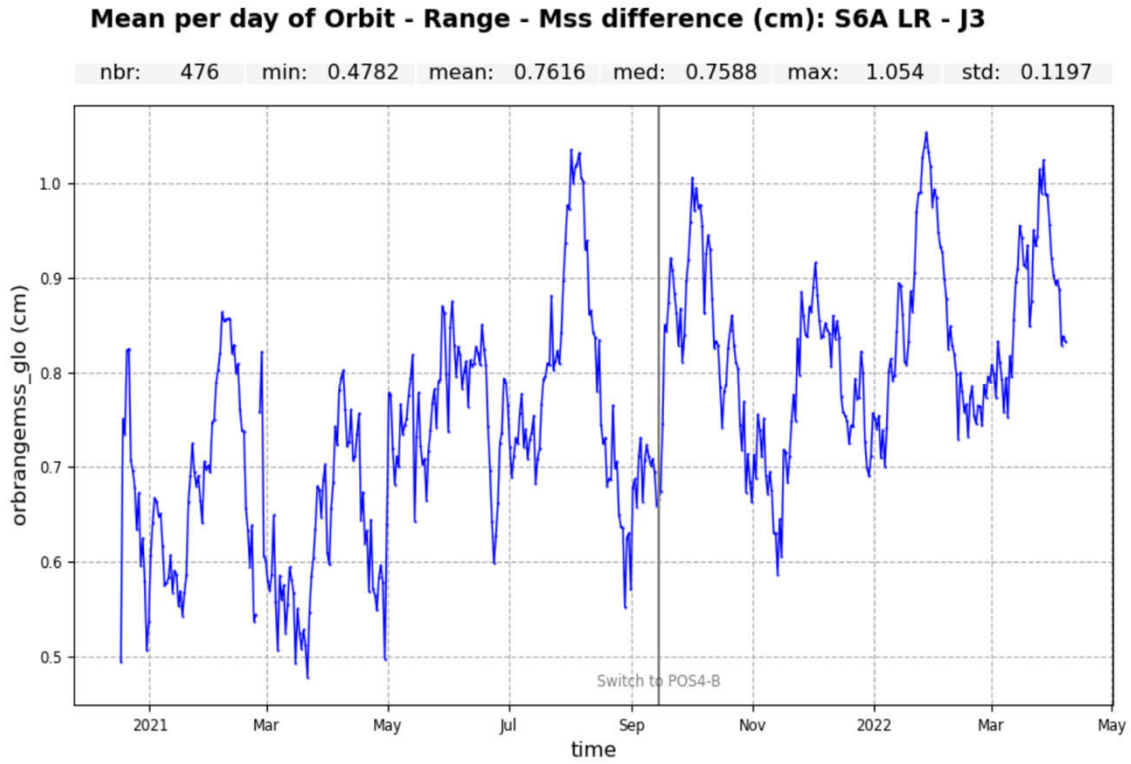
Range

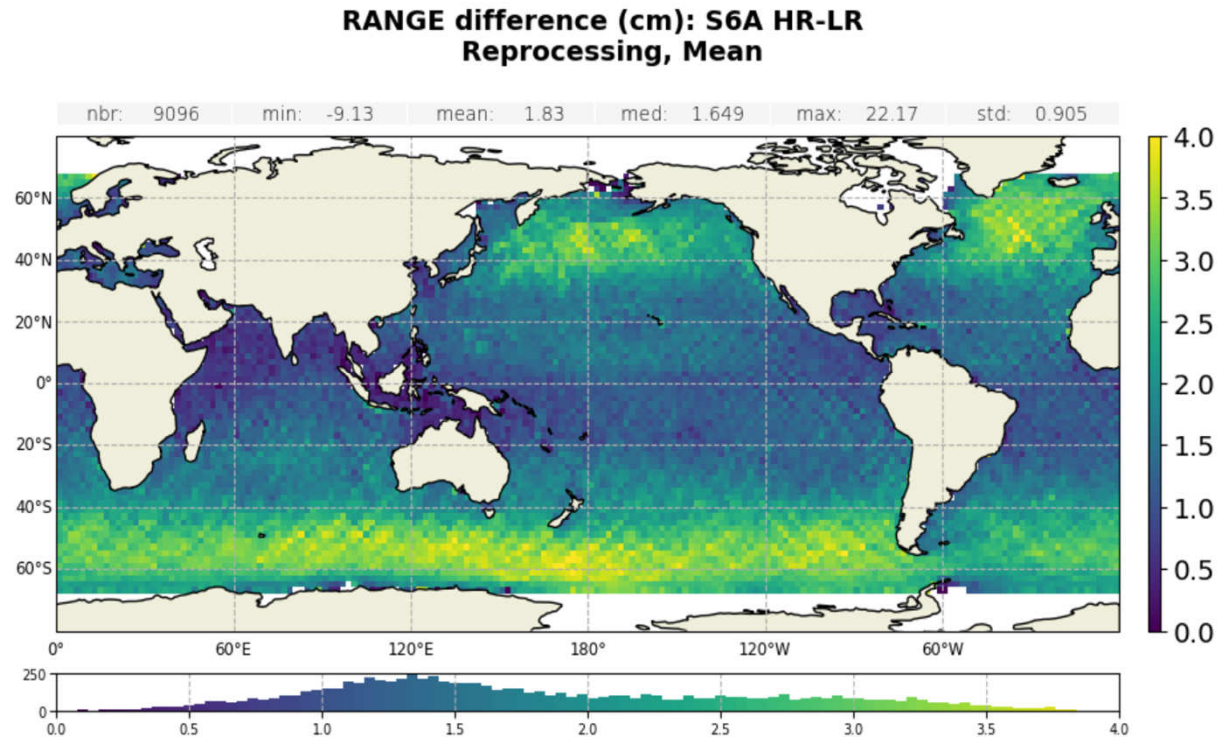
- S6 LR / J3
  - Little slope ?
  - Waiting for LR numerical retracking (PB F08)

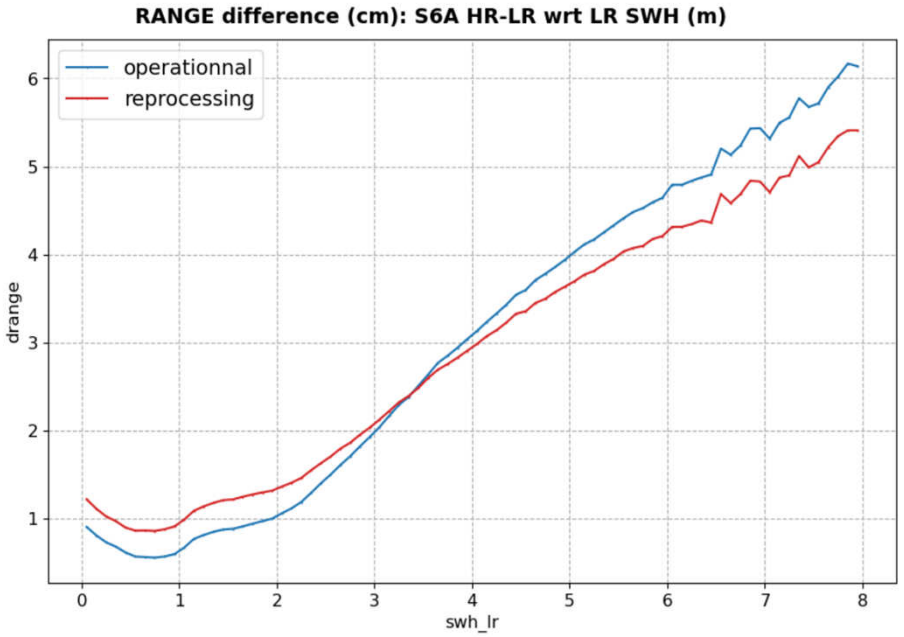


Sentinel-6 PDAP products assessment over ocean

Range

- HR / LR
  - SWH dependency of the bias (~4cm) . *Will be improved with S6 HR numerical retracking (PB F09)*
  - HR & LR Skewness not aligned ; HR skewness needed to reduced LR-HR range differences

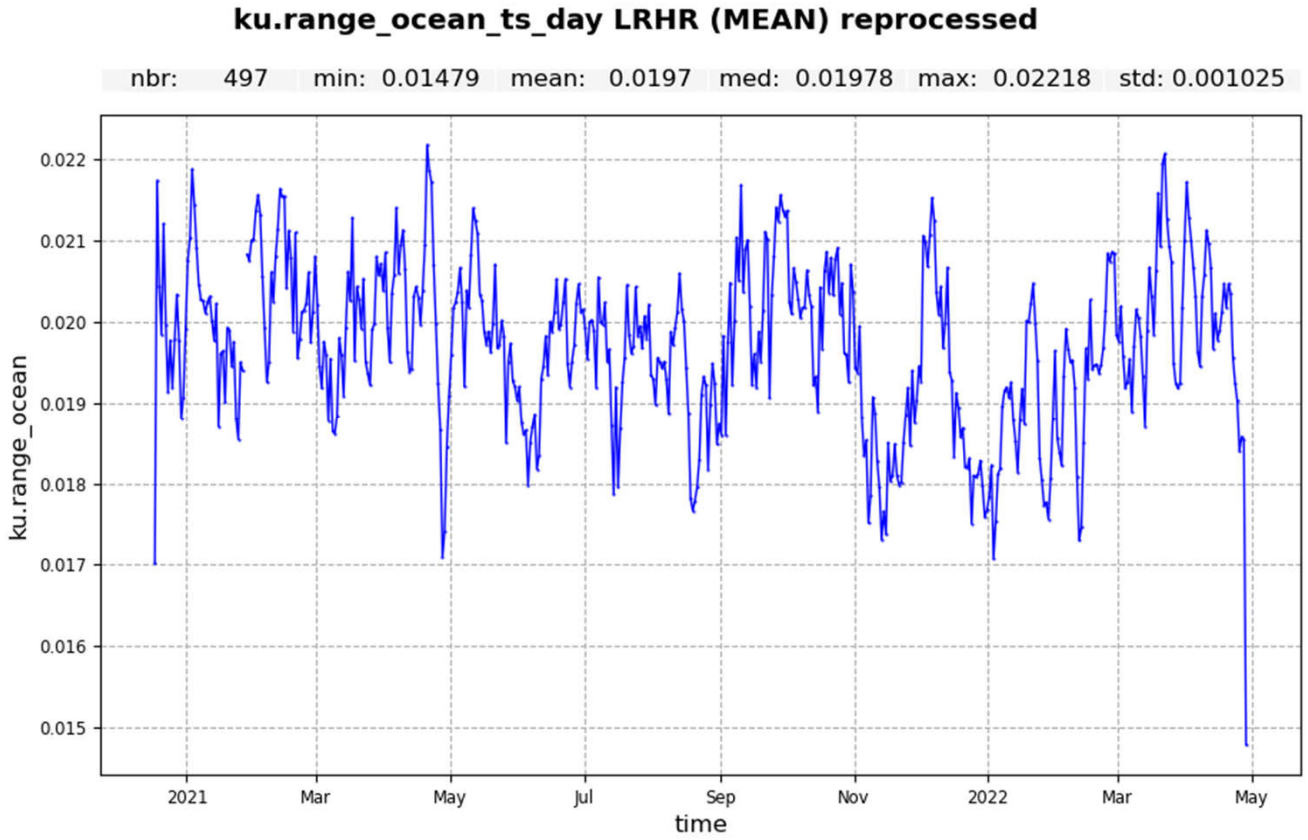




Sentinel-6 PDAP products assessment over ocean

Range

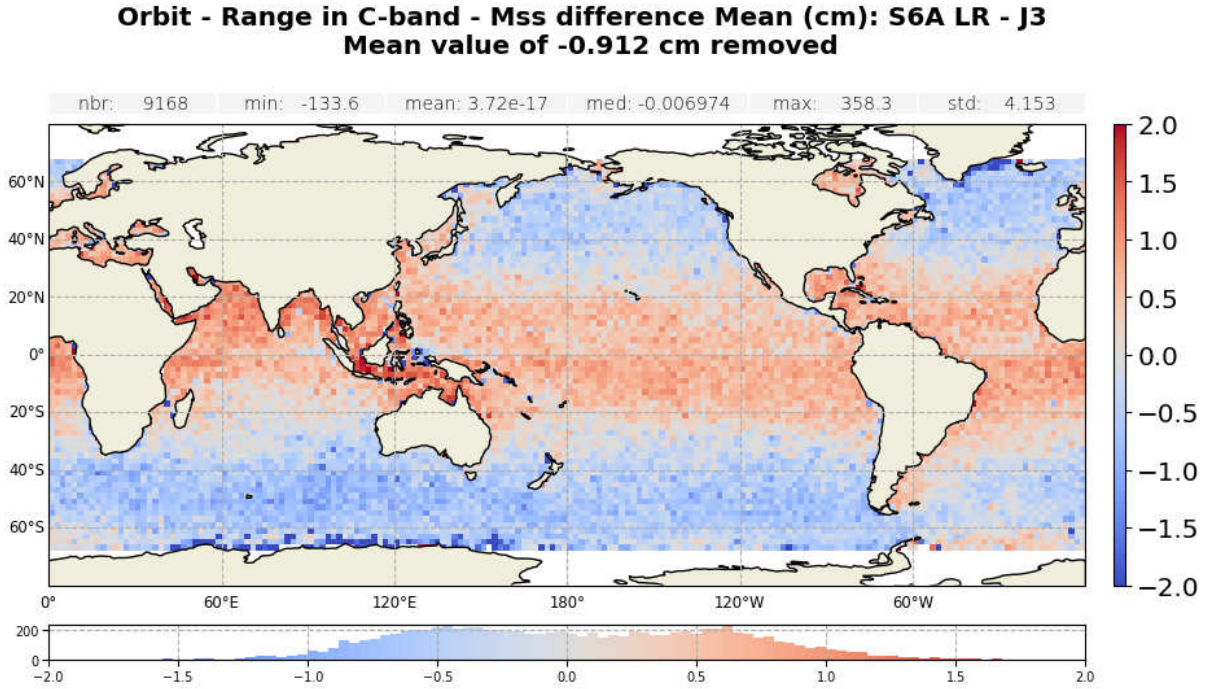
- HR / LR
  - Low bias but still a little drift (few mm/an) due to lack of Range Walk correction (PB F09)

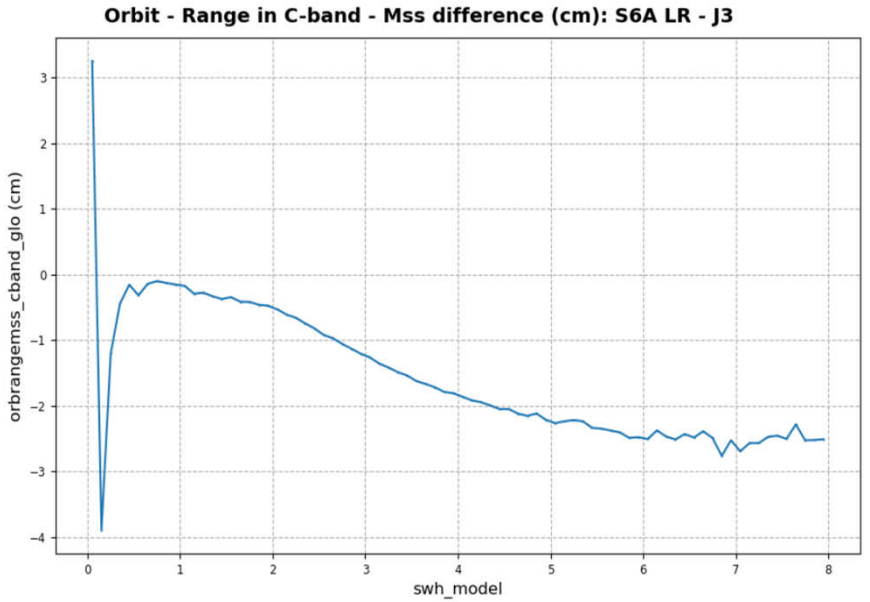


Sentinel-6 PDAP products assessment over ocean

C-Band Range

- S6 / J3
  - correlation is to the total electron content of the atmosphere
    - On going investigation, C-band frequency difference between S6 and J3 may not explain all the difference
  - SWH dependency of the bias : ~2 cm between 2m & 7m



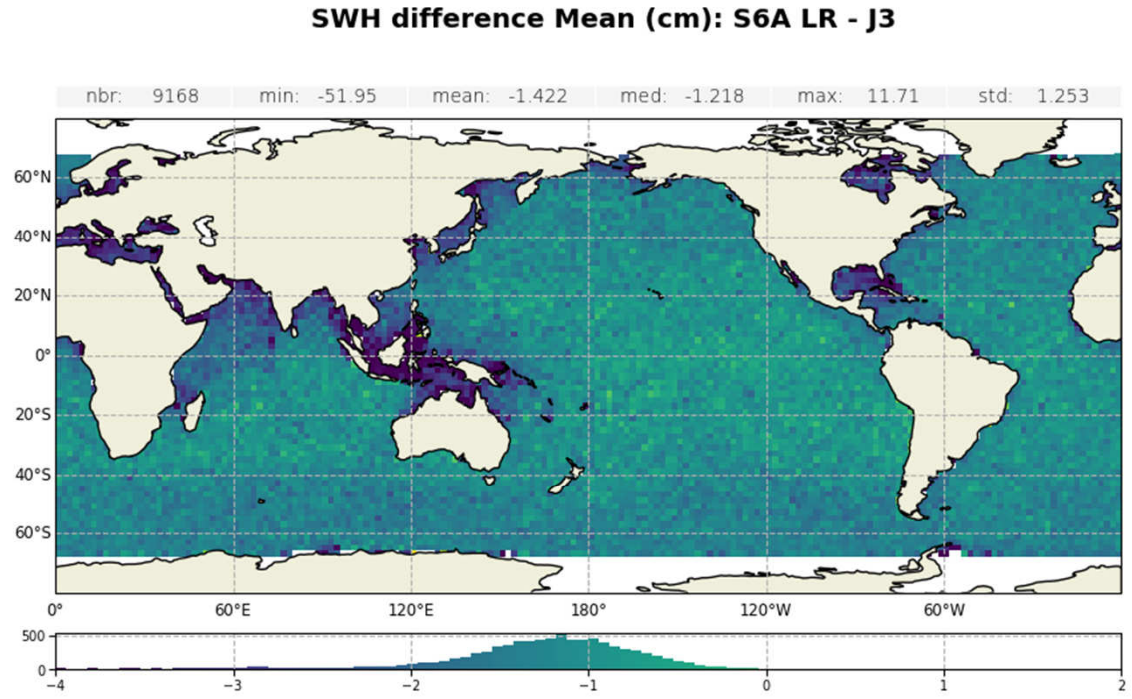


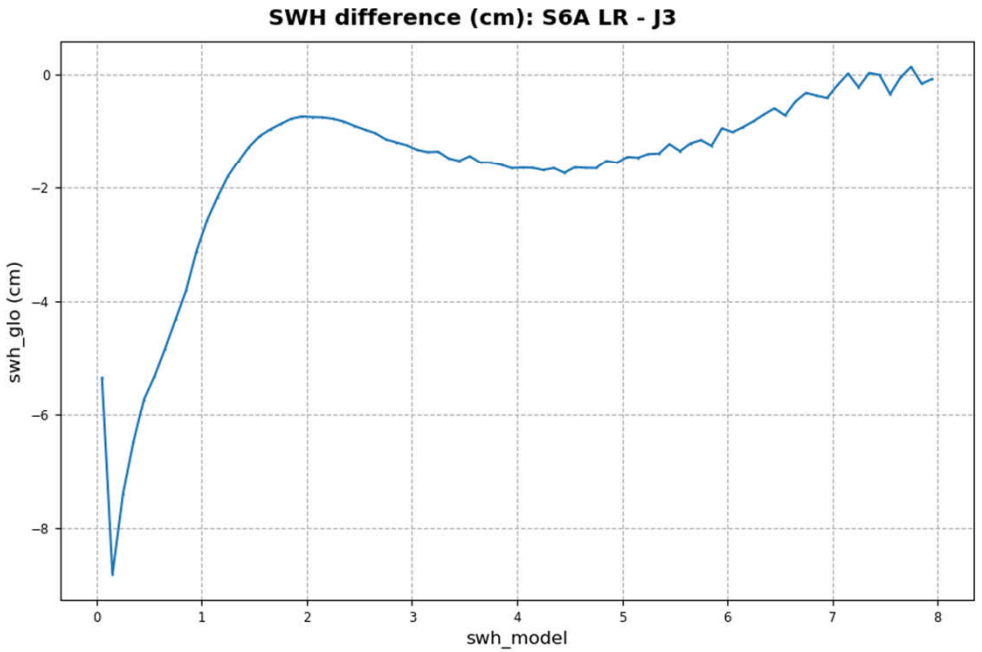
SWH

Sentinel-6 PDAP products assessment over ocean

SWH

- LR/J3 in line
  - bias centered around -1.29 cm
  - No geographical patterns

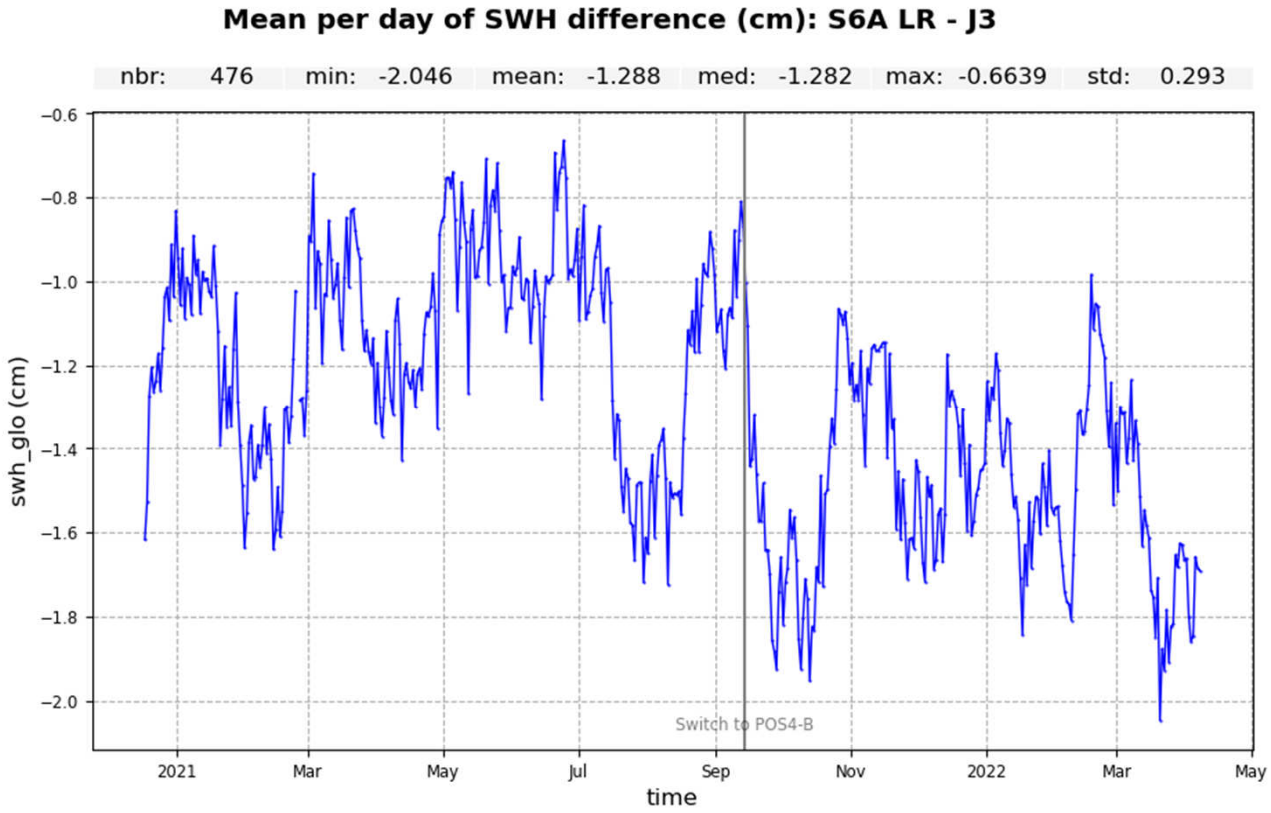




Sentinel-6 PDAP products assessment over ocean

SWH

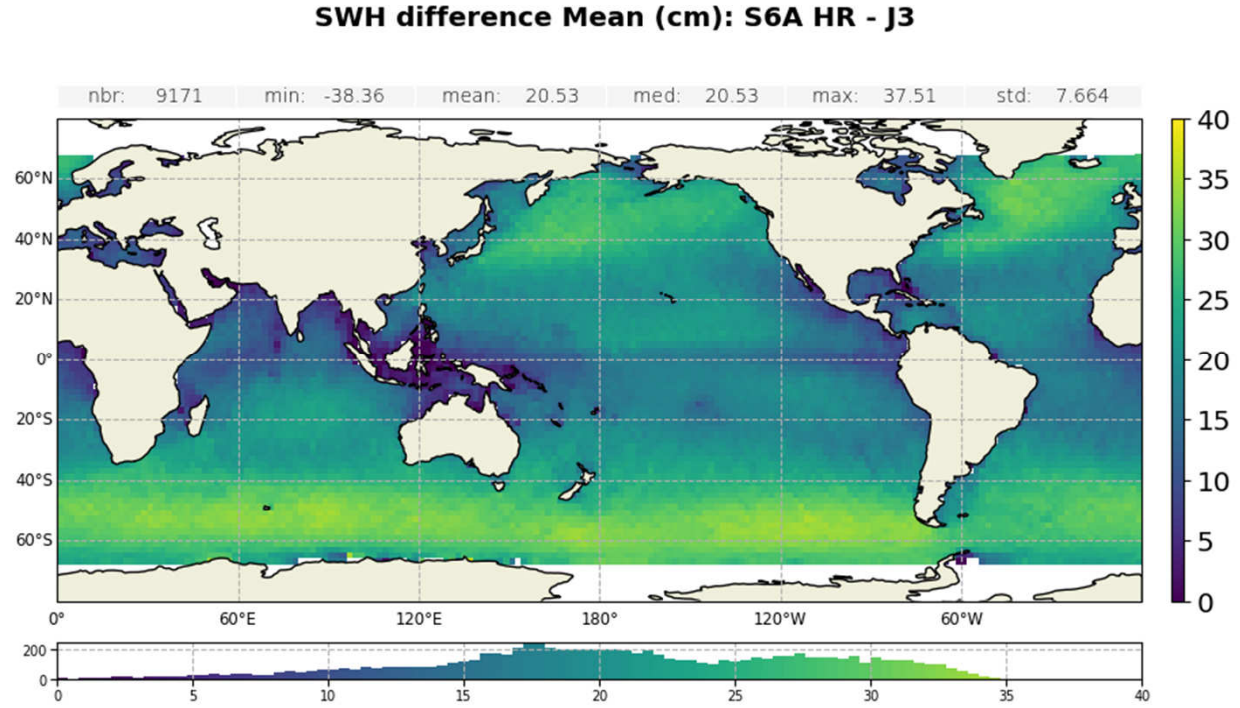
- Negligible difference between POS4-A and POS4-B (-0,36 cm)
  - Hard to conclude yet whether it is due to the switch or simply to sea state condition variations

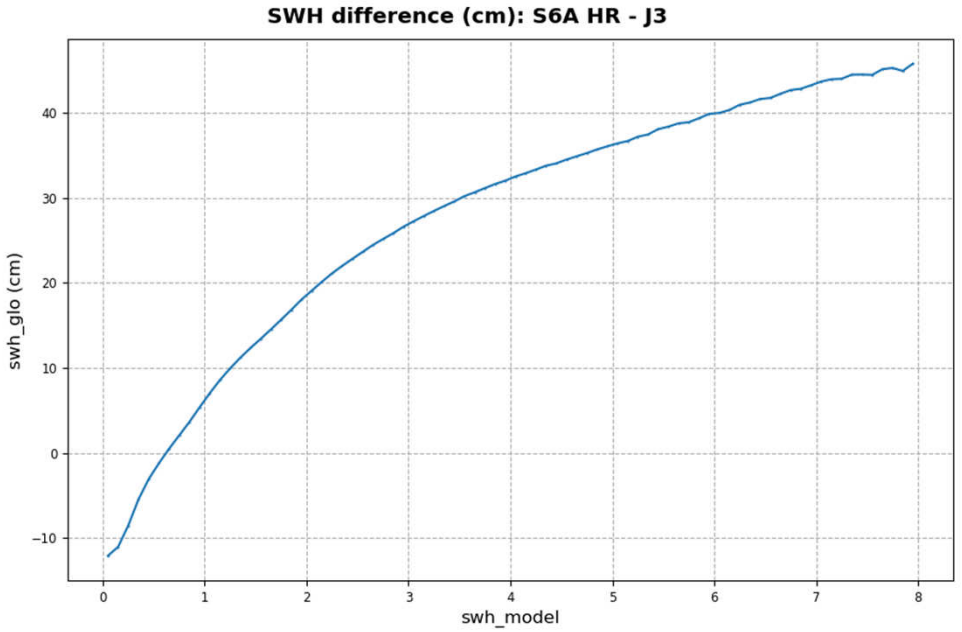


Sentinel-6 PDAP products assessment over ocean

SWH

- HR/J3
  - bias centered around 22 cm
  - SWH dependency : ~25 cm between 2m & 7m
  - Remaining differences will be reduced with VV LUT for SWH estimation (PB F10)

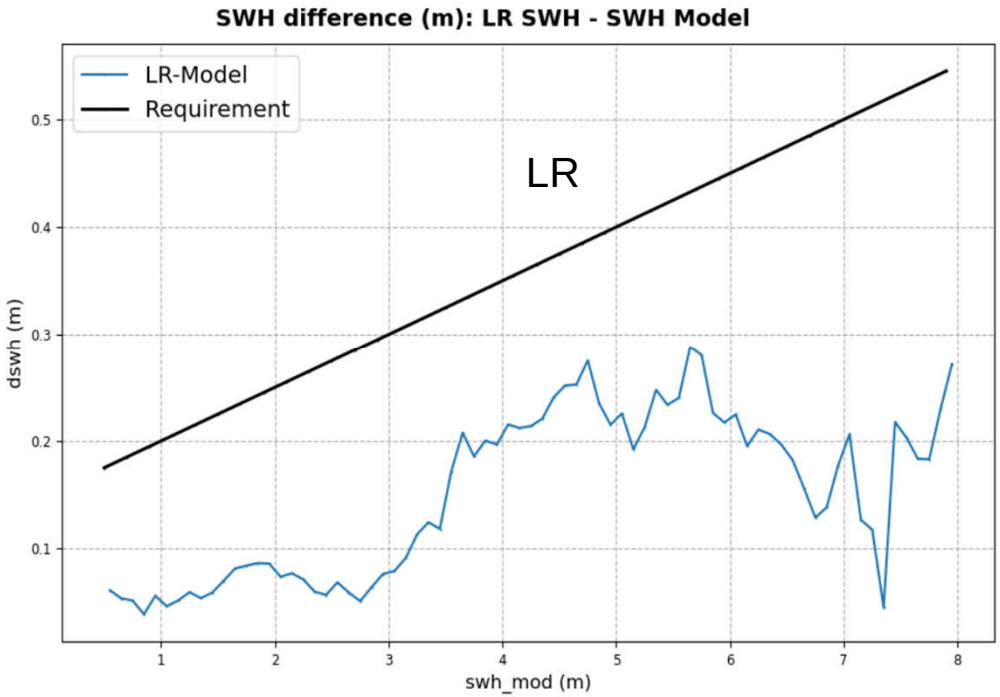


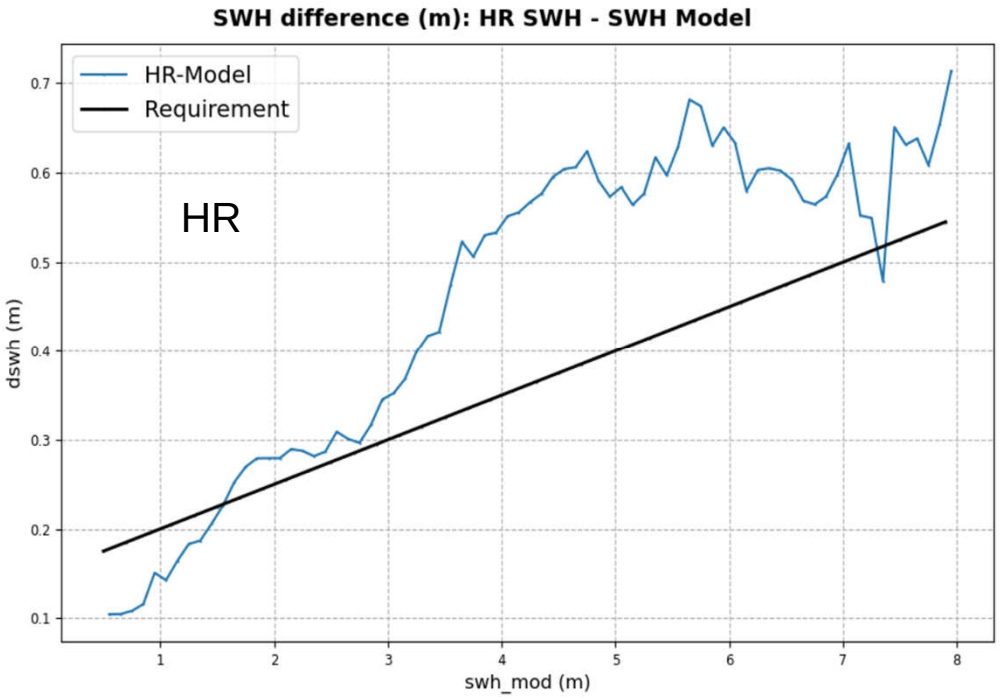


Sentinel-6 PDAP products assessment over ocean

Range

- Noise
  - LR SWH uncertainty is well below requirements (15cm + 5% SWH)
  - HR SWH uncertainty is above requirements (15cm + 5% SWH)

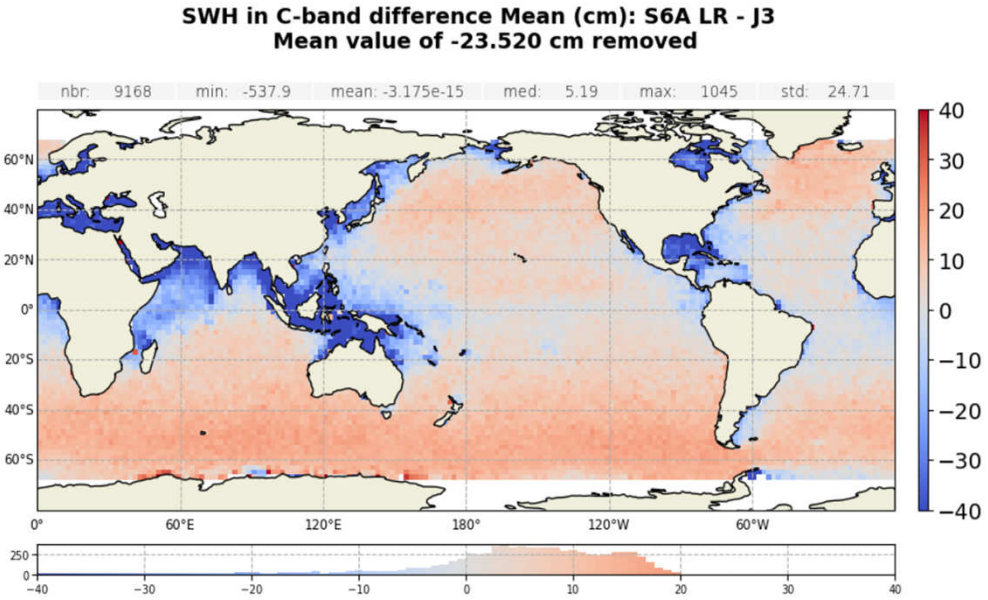


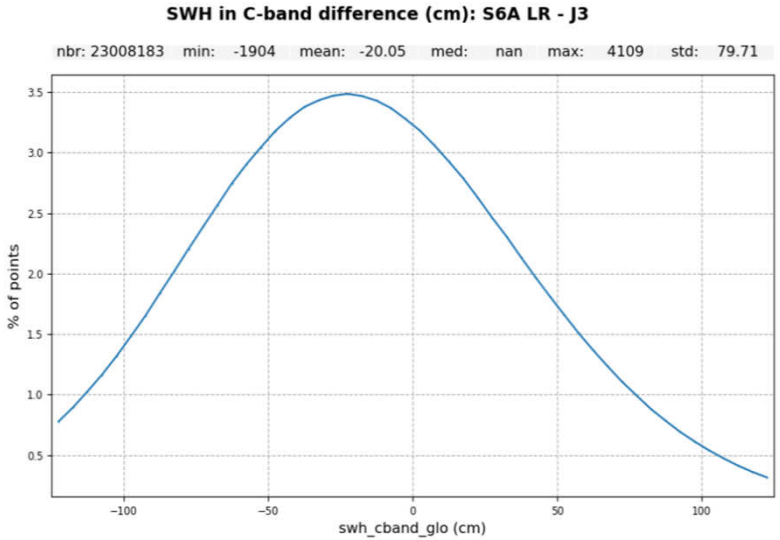


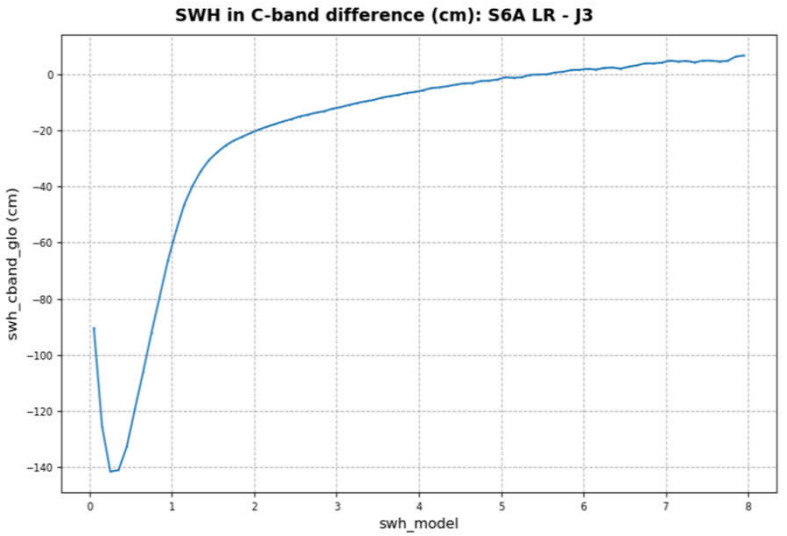
Sentinel-6 PDAP products assessment over ocean

C-Band SWH (Not Used in SSHA)

- LR/J3
  - large bias of -20 cm
  - SWH dependency : ~25 cm between 2m & 7m
  - C-Band SSB uses Ku SWH





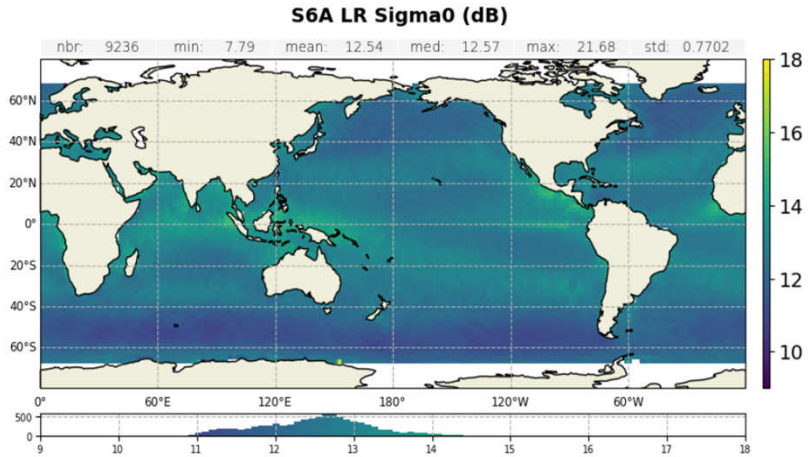


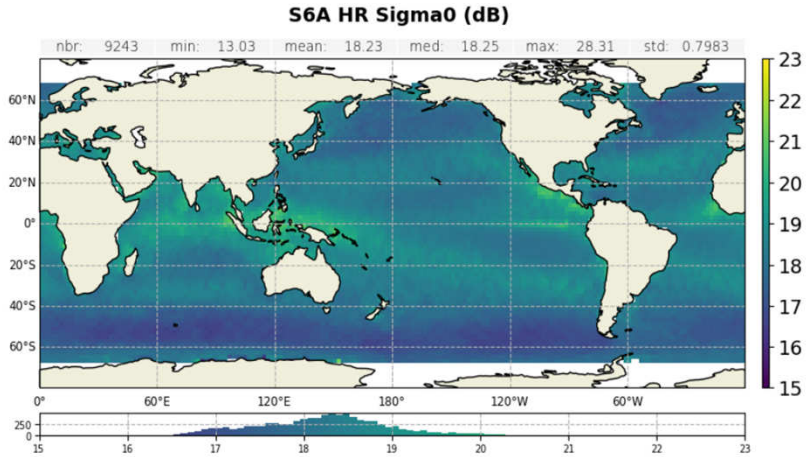
SIGMA0

Sentinel-6 PDAP products assessment over ocean

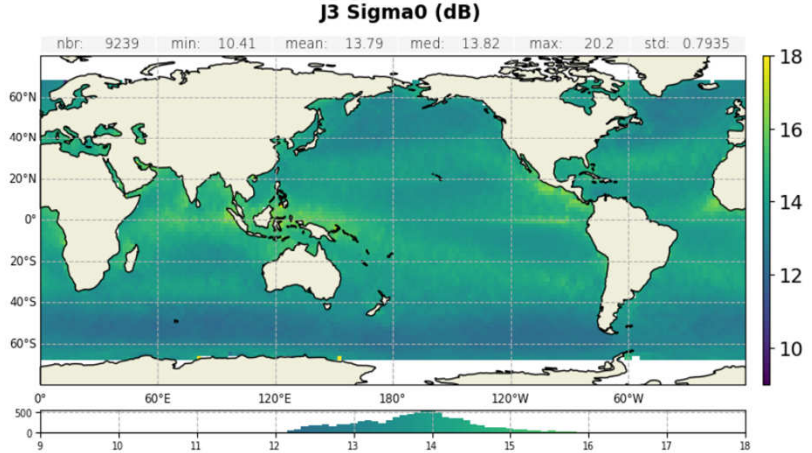
Sigma0

- Same patterns than for J3



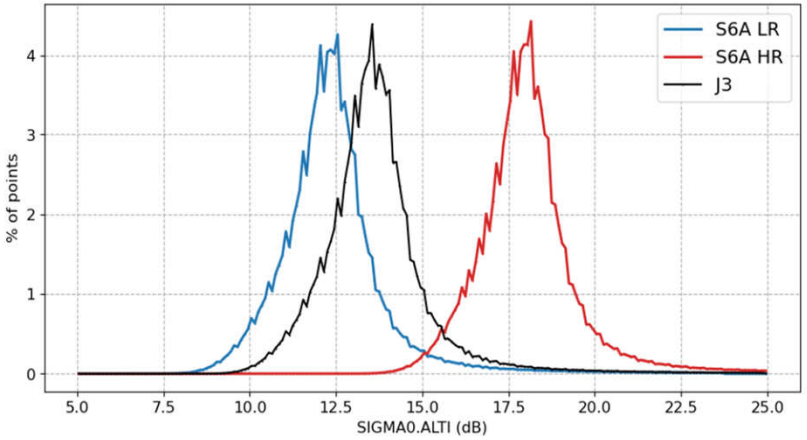


- Different S6 LR / HR / J3 mean value
  - J3 : 13,6 dB
  - LR : 12,4 dB
  - HR : 18,1 dB



Sigma0 histograms (dB)

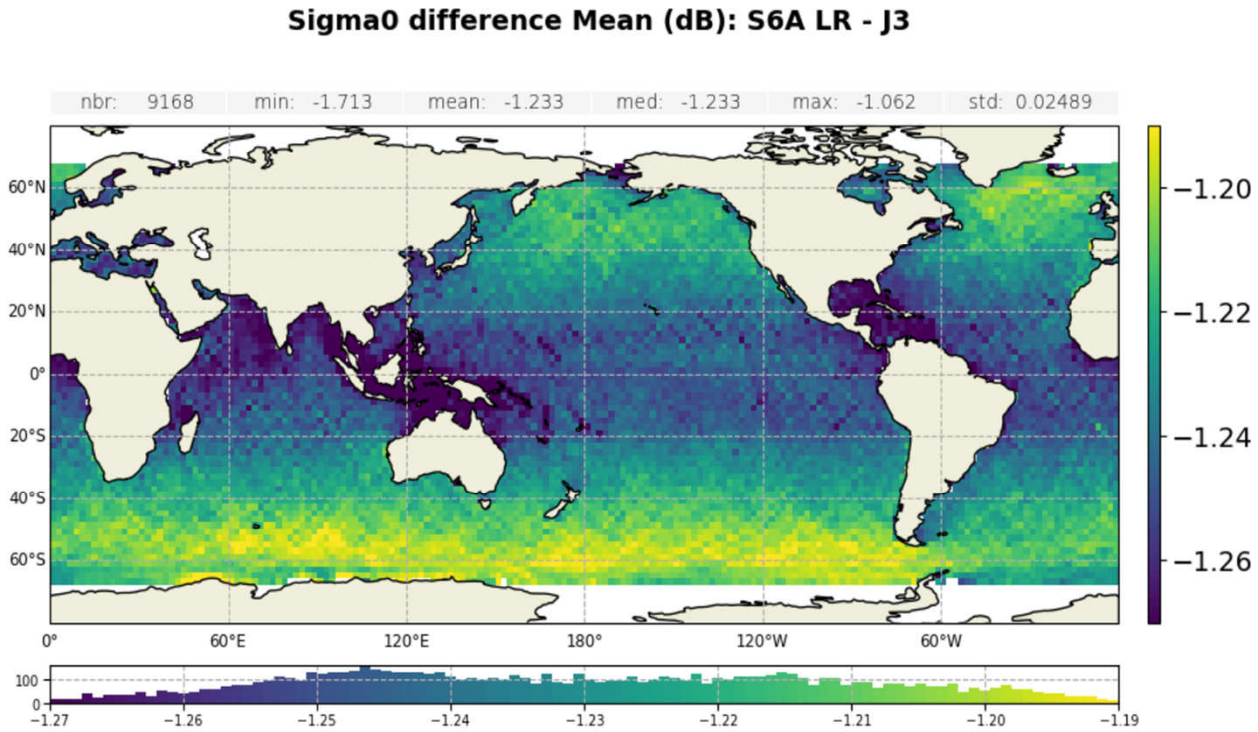
	nbr	min	mean	med	max	std
S6A LR	26651788	7	12.4	nan	23.79	1.594
S6A HR	26519059	10	18.1	nan	29.46	1.653
J3	25525555	7.15	13.64	nan	25.01	1.611

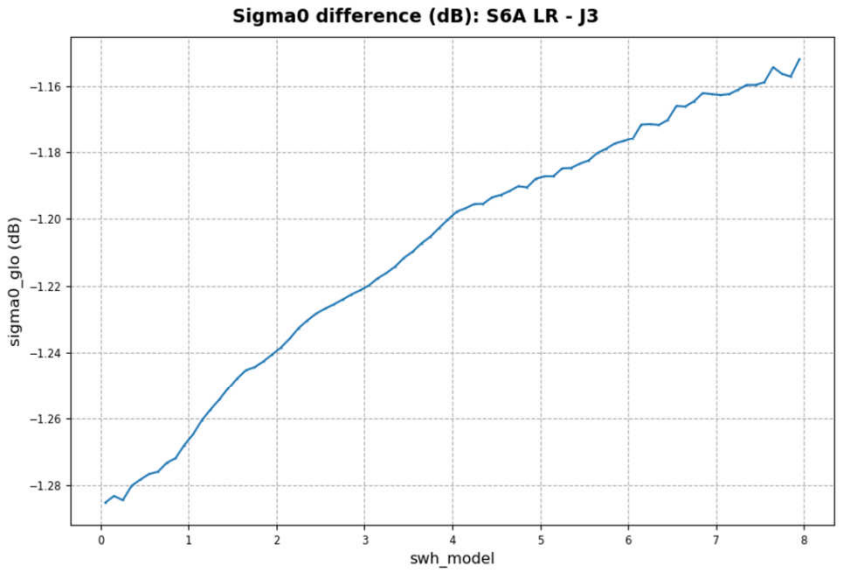


Sentinel-6 PDAP products assessment over ocean

Sigma0

- LR/J3 : Small SWH dependency
  - +0.08 dB between 2 and 7 m wave





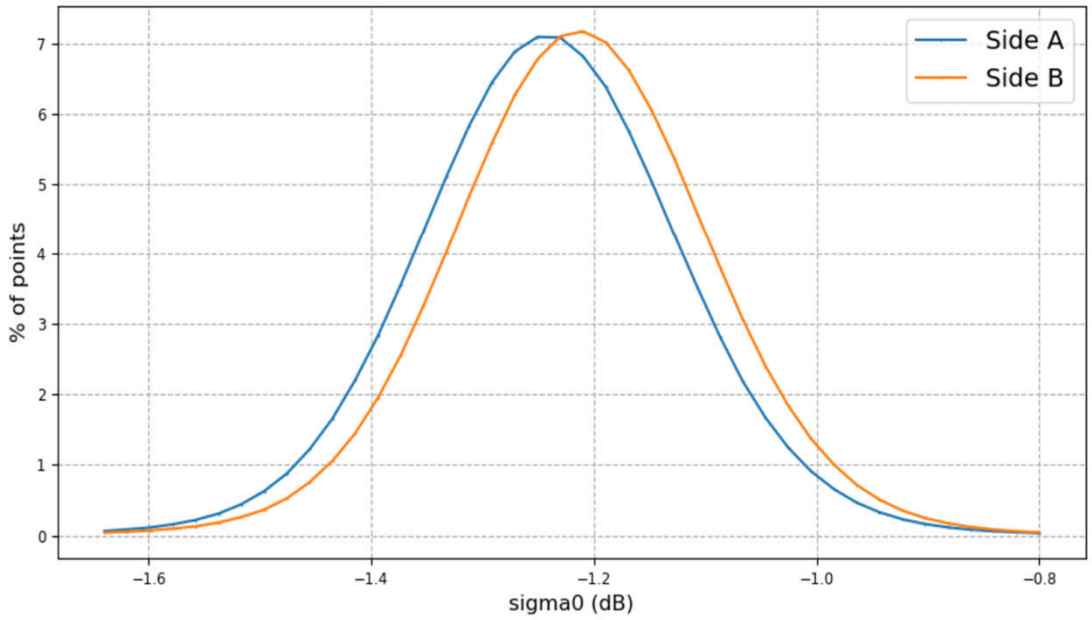
Sentinel-6 PDAP products assessment over ocean

Sigma0

- LR/J3 : Small difference between side-A and side-B
  - +0.03dB

Sigma0 difference (dB): S6A LR - J3

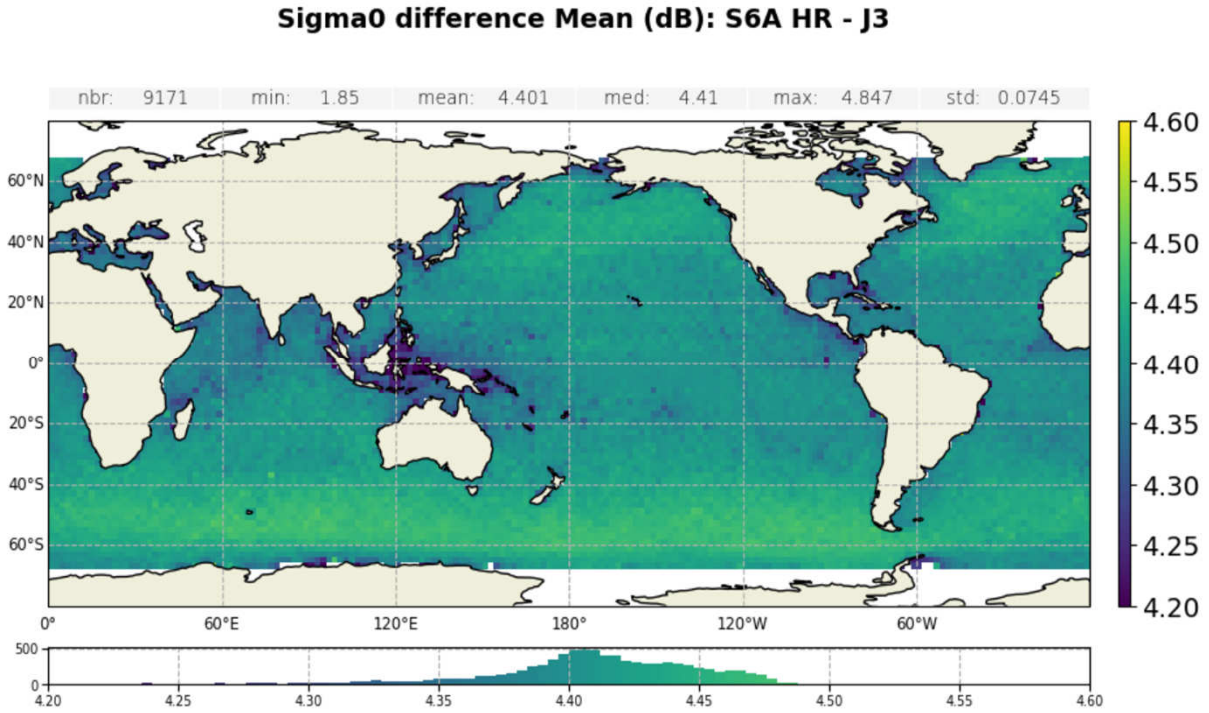
	nbr	min	mean	med	max	std
Side A	12429698	-4.494	-1.241	nan	3.005	0.1257
Side B	9775332	-4.731	-1.213	nan	1.462	0.1234

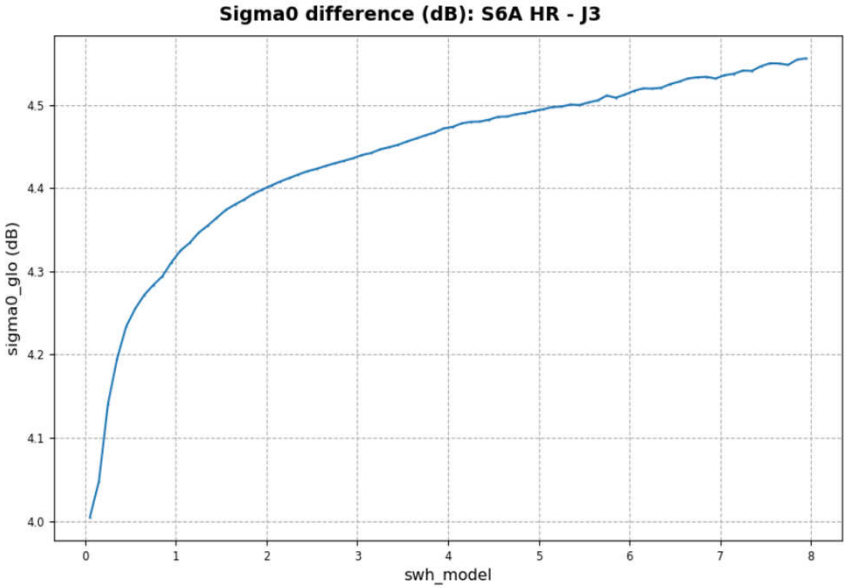


Sentinel-6 PDAP products assessment over ocean

Sigma0

- HR/J3 : Small SWH dependency
  - +0.15 dB between 2 and 7 m wave



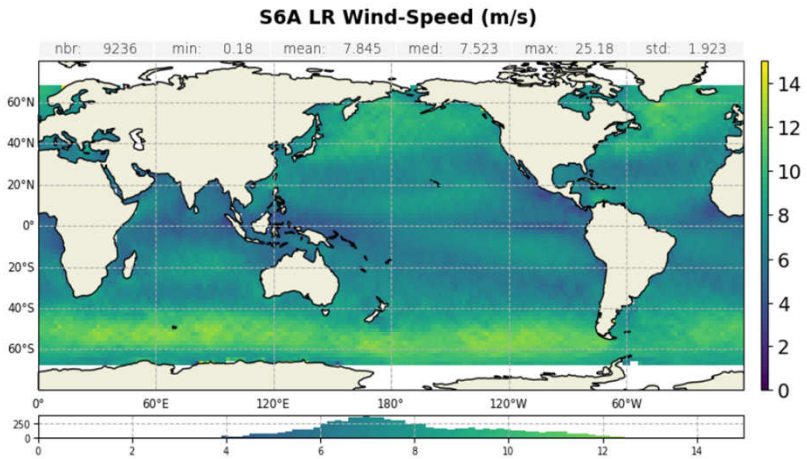


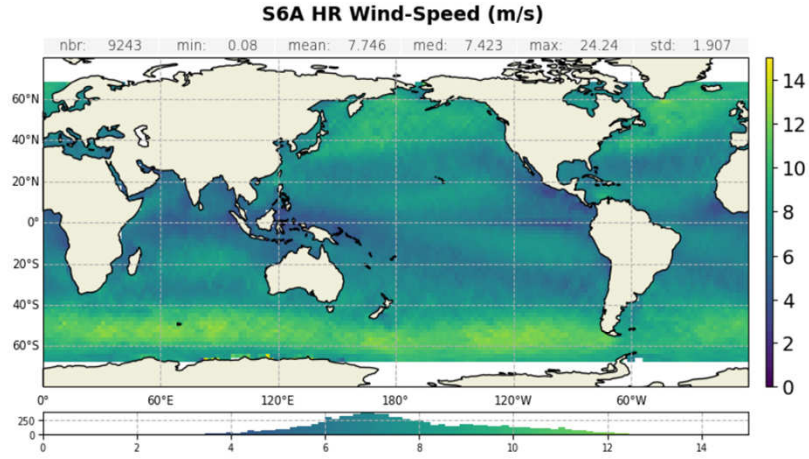
WIND SPEED

Sentinel-6 PDAP products assessment over ocean

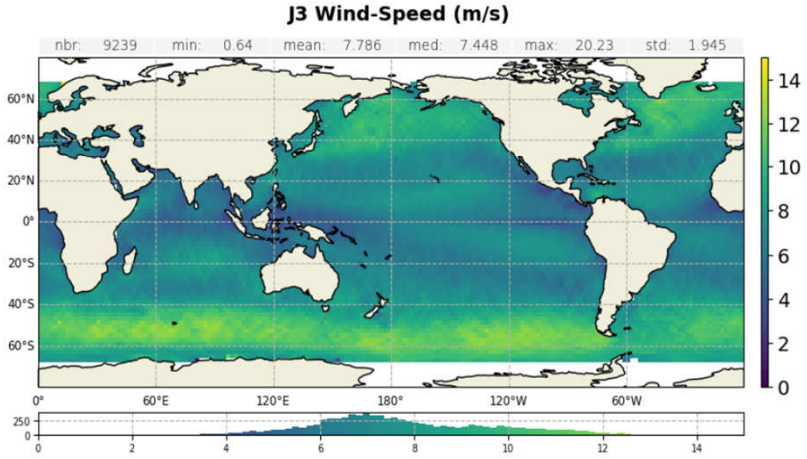
Wind Speed

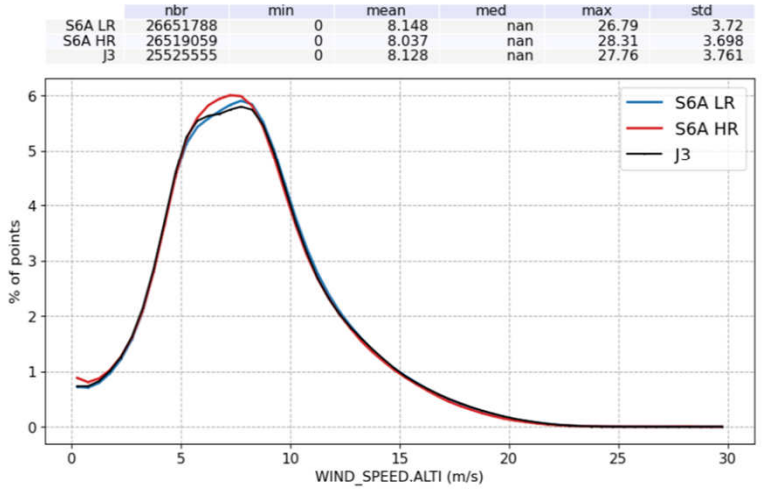
- Same patterns than J3





- Similar S6 LR / J3 mean value
  - Sigma0 Aligned before wind computation

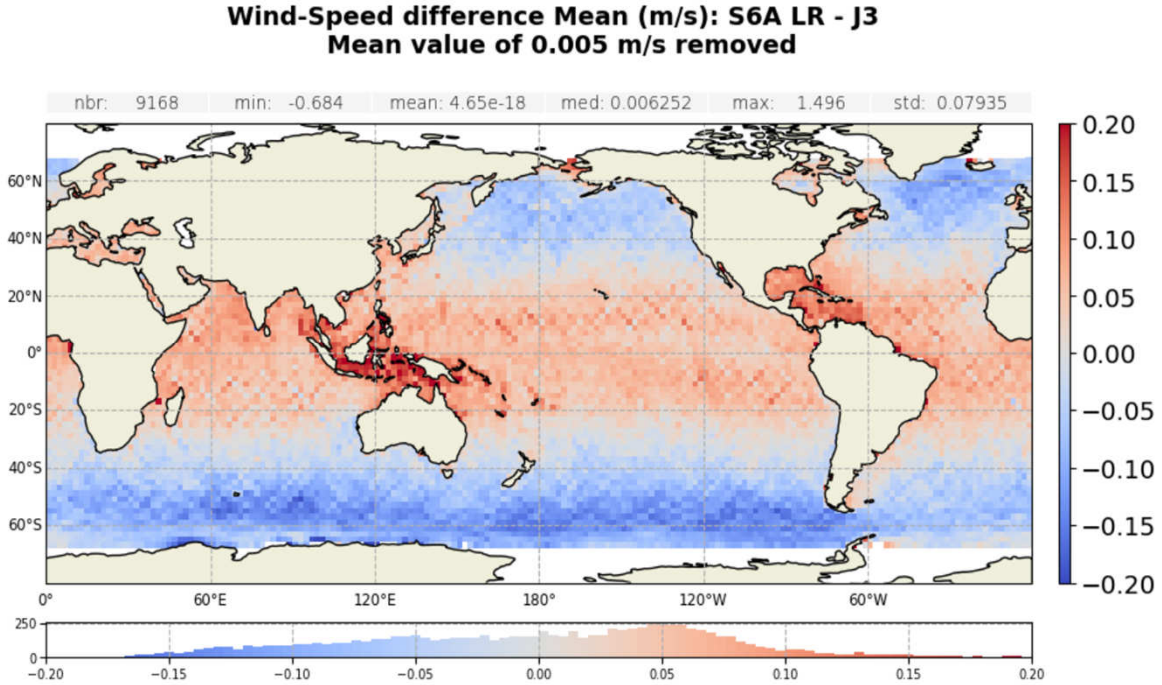


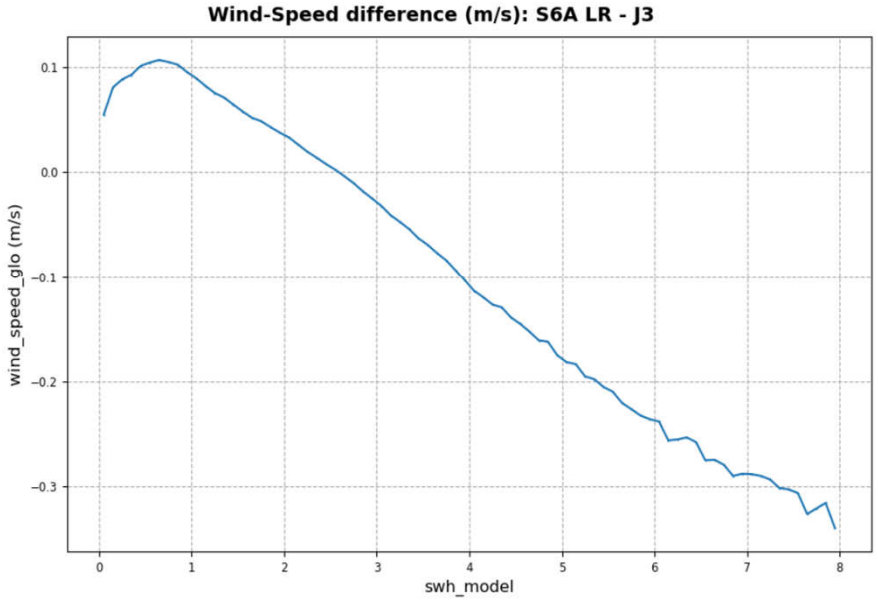


Sentinel-6 PDAP products assessment over ocean

Wind Speed

- LR/J3 : Small SWH dependency
  - -0.31 m/s between 2 and 7 m wave
  - consequence of LR sigma0 analysis

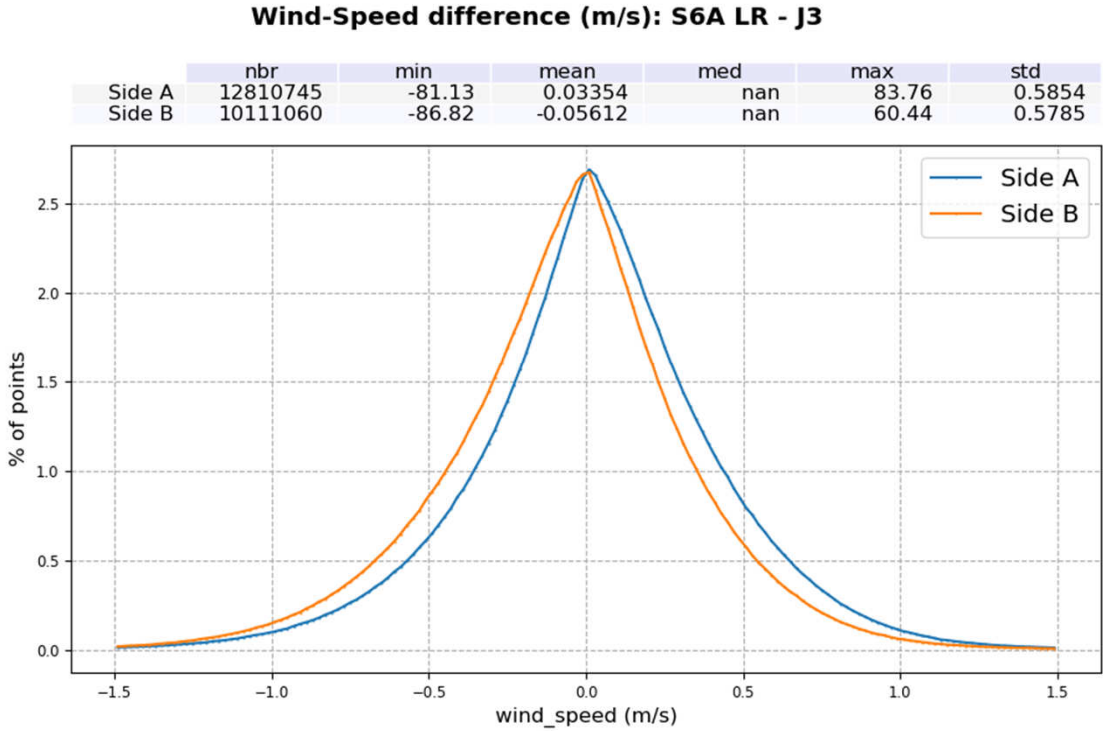




Sentinel-6 PDAP products assessment over ocean

Wind Speed

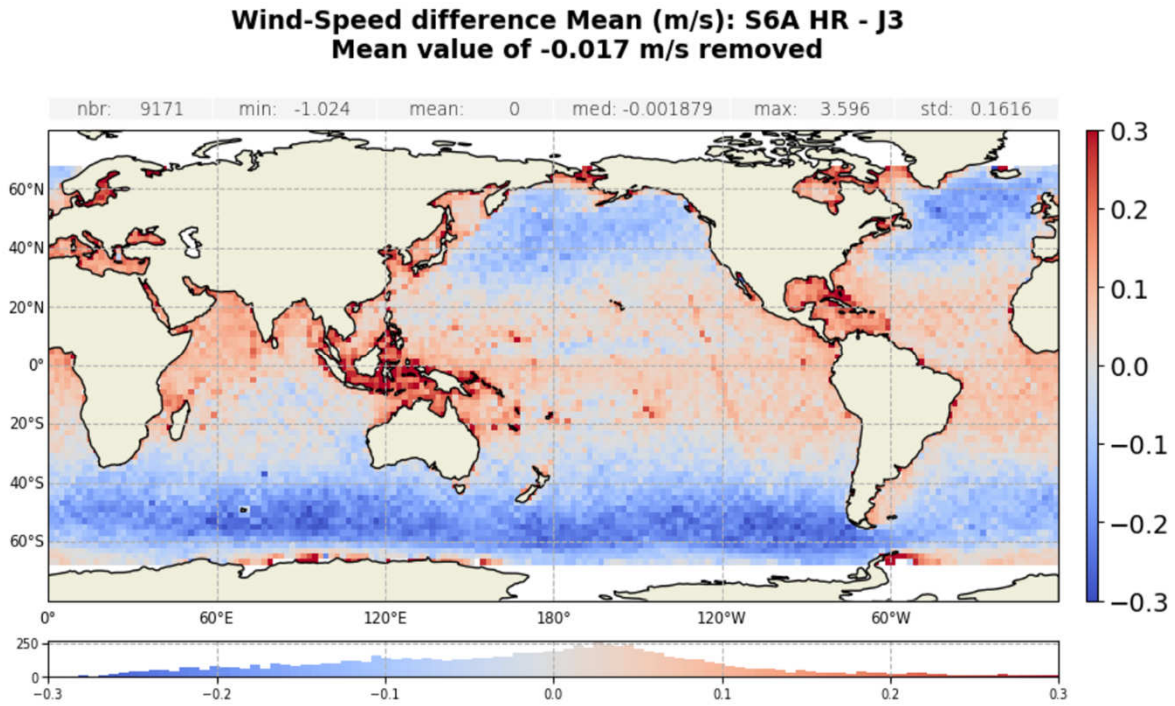
- LR/J3 : different bias between POS4-A and POS4-B (~0,1 m/s)
  - Direct consequence of sigma0. Constant calibration bias applied on sigma0 for the wind speed computation (+1.29 dB) is not fully adjusted for both sides
  - We recommend to use these values for the next S6A reprocessing campaign (computed before echocal F07)
    - for POS4-A : + 1.30 dB
    - for POS4-B : + 1.27 dB

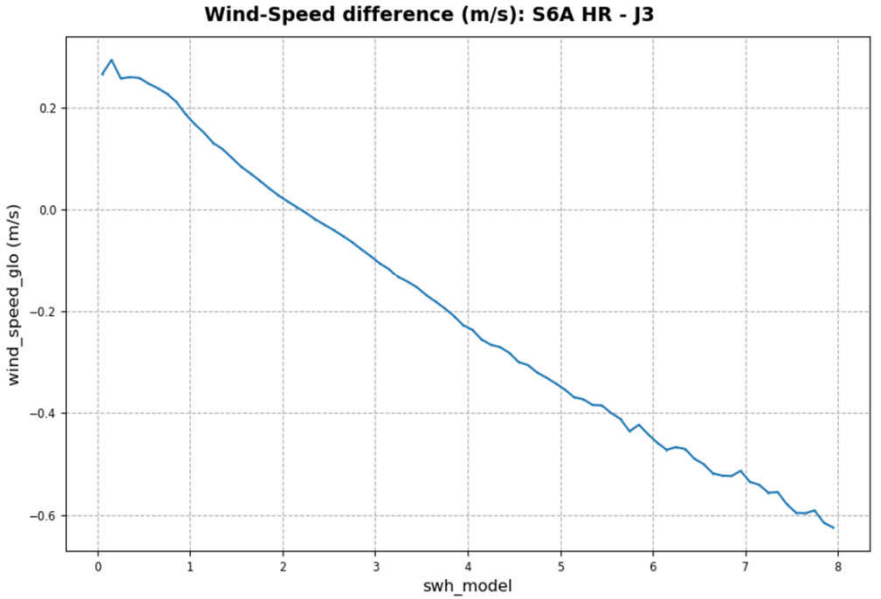


Sentinel-6 PDAP products assessment over ocean

Wind Speed

- HR/J3 : Small SWH dependency
  - -0.5 m/s between 2 and 7 m wave





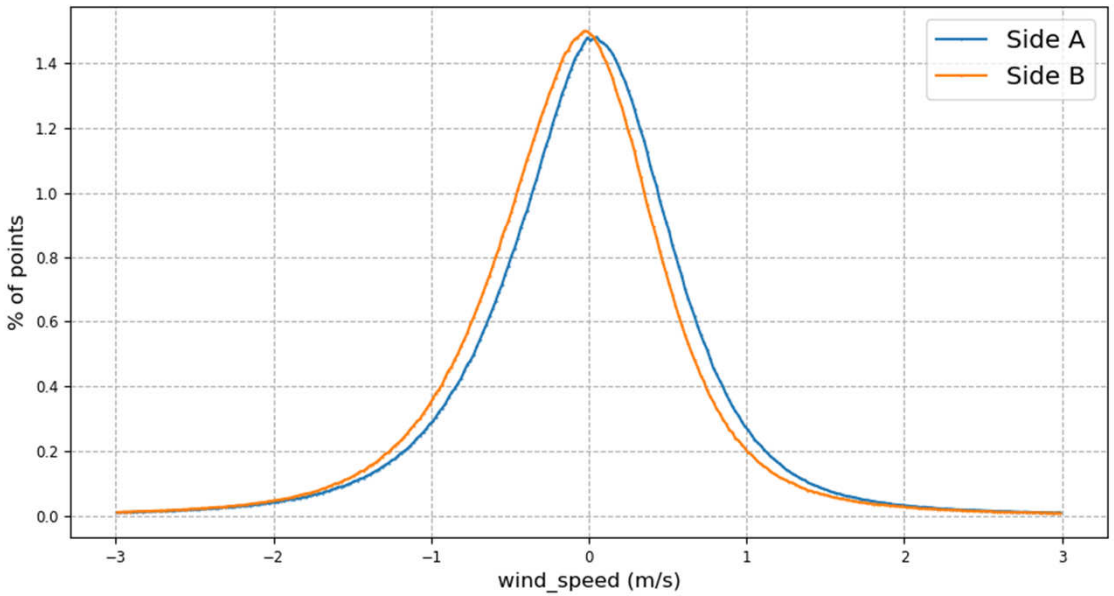
Sentinel-6 PDAP products assessment over ocean

Wind Speed

- HR/J3 : different bias between POS4-A and POS4-B (~0,1 m/s)
  - Direct consequence of sigma0. Constant calibration bias applied on sigma0 for the wind speed computation is not fully adjusted for both sides
  - We recommend to use these values fc the next S6A reprocessing campaign
  - (computed before echocal F07)
    - for POS4-A : -4.34 dB
    - for POS4-B : -4.26 dB

Wind-Speed difference (m/s): S6A HR - J3

	nbr	min	mean	med	max	std
Side A	12453321	-82.57	-0.002676	nan	75.46	0.9014
Side B	10057139	-70.45	-0.1006	nan	94.45	0.8964

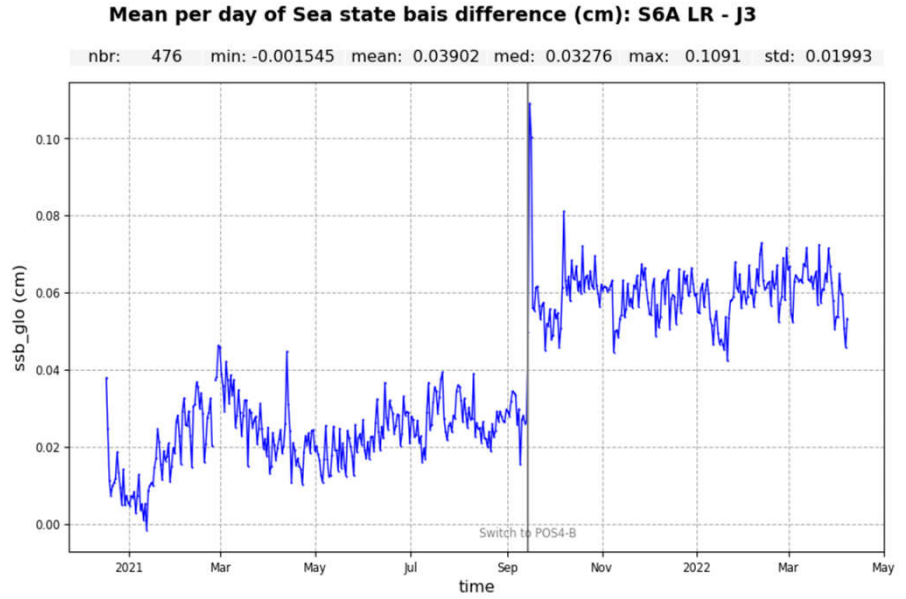


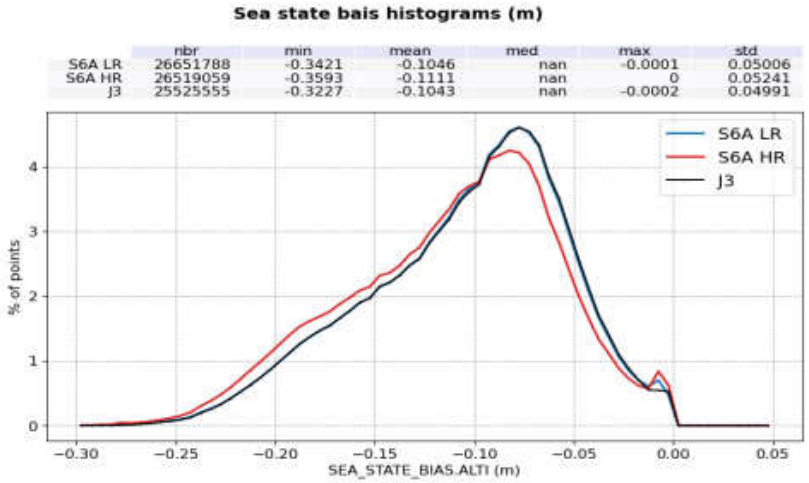
SSB

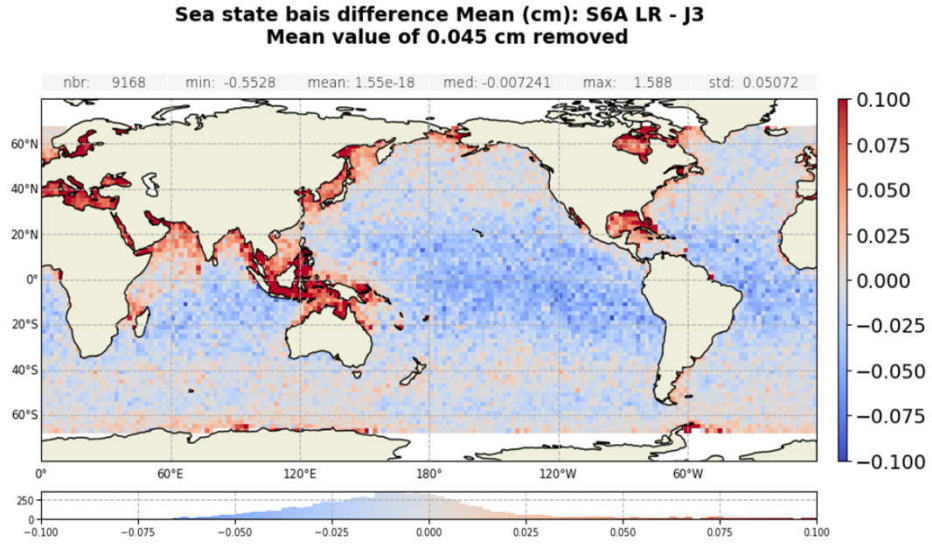
Sentinel-6 PDAP products assessment over ocean

SSB

- LR in line with J3 (same SSB for J3, S6 LR and HR)
  - A jump is visible at the switch to POS4-B due to the change in wind speed, from 0.2 to 0.6 mm in average. Should be fixed with sigma0 bias side-dependency
  - SSB differences are mostly located in low SWH



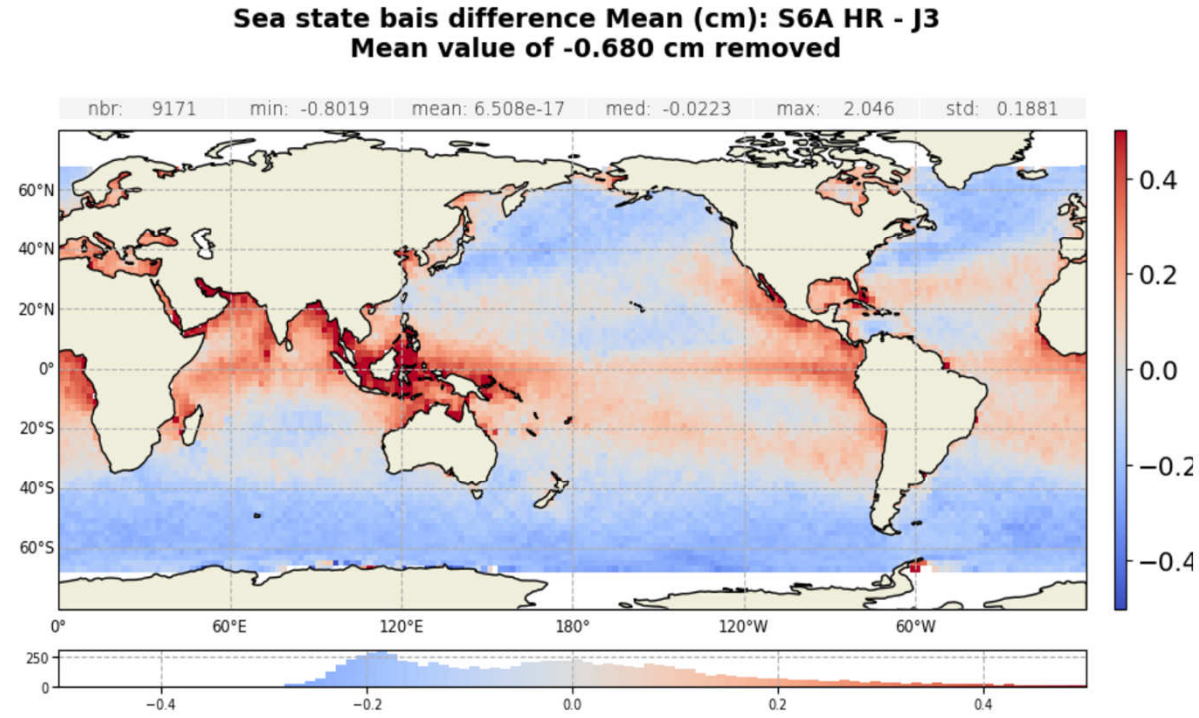


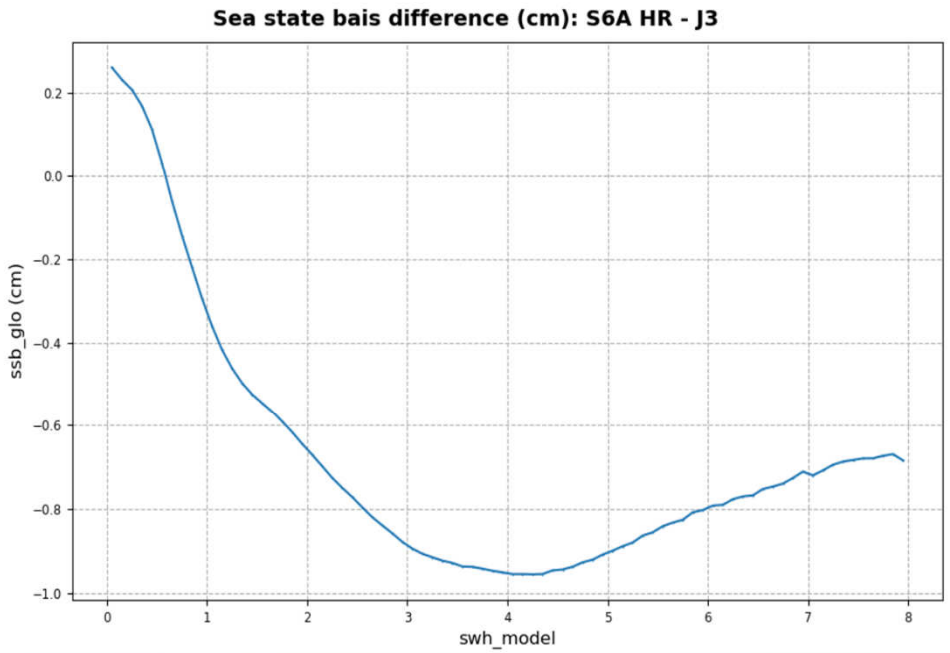


Sentinel-6 PDAP products assessment over ocean

SSB

- HR : Clear correlation to sea state conditions
  - NB SSB algorithm used for HR SSB computation is the same as for LR data, i.e. Jason-3 GDR-F Ku-band algorithm → not adapted to HR data
  - *HR SSB needed?*



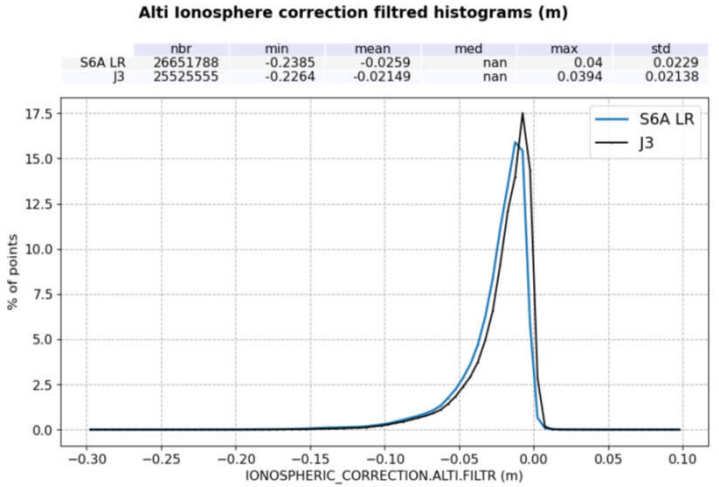


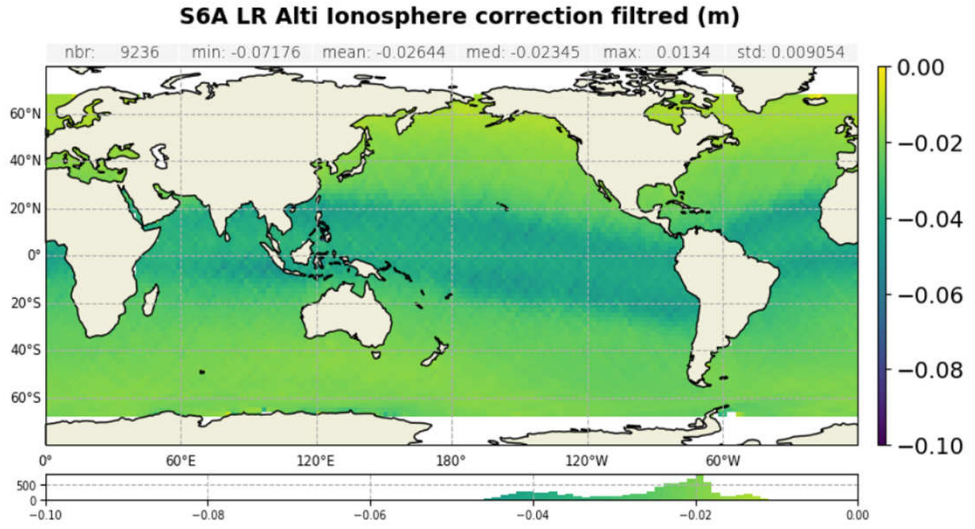
Iono

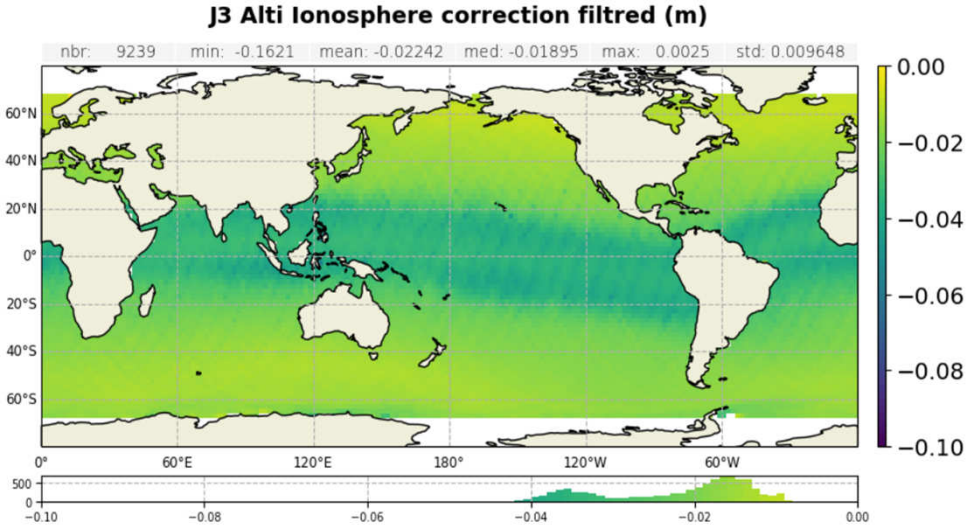
Sentinel-6 PDAP products assessment over ocean

Iono

- LR/J3 : Same patterns
  - Different S6 LR / J3 mean value
    - -2,6 cm S6 LR
    - -2,1 cm J3
  - NB HR Iono copied from LR Iono in products



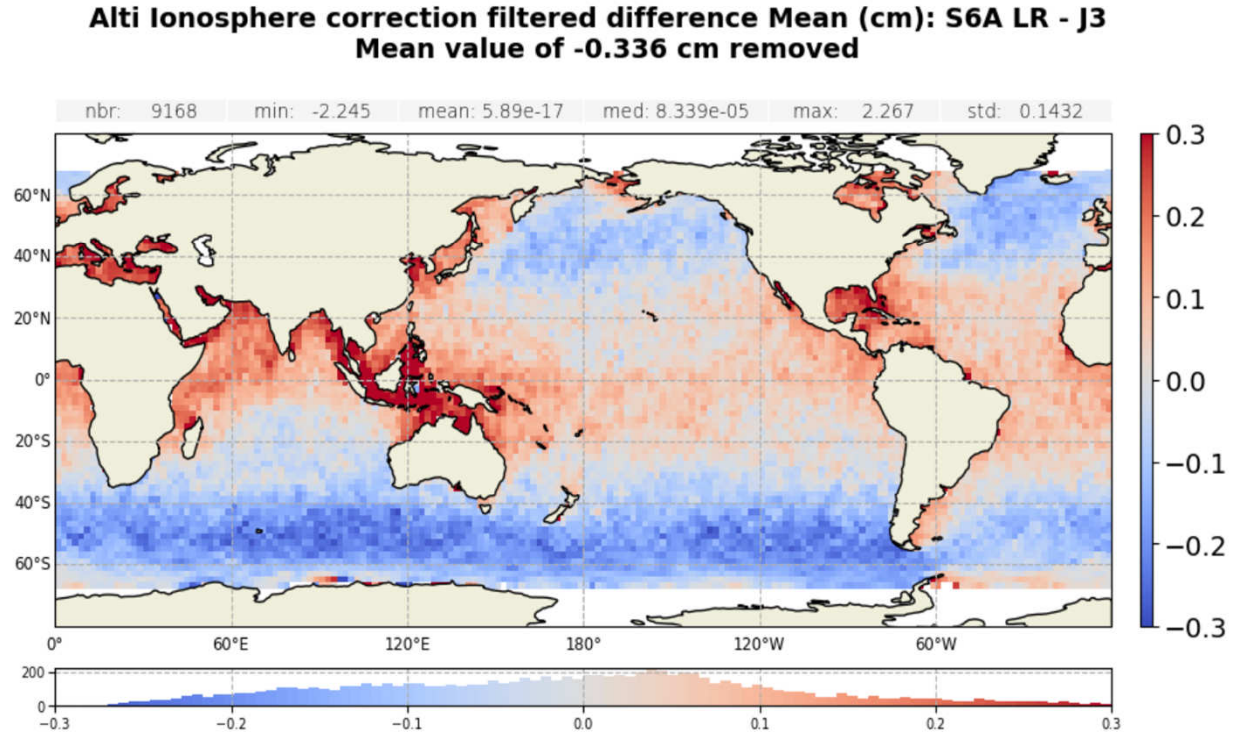


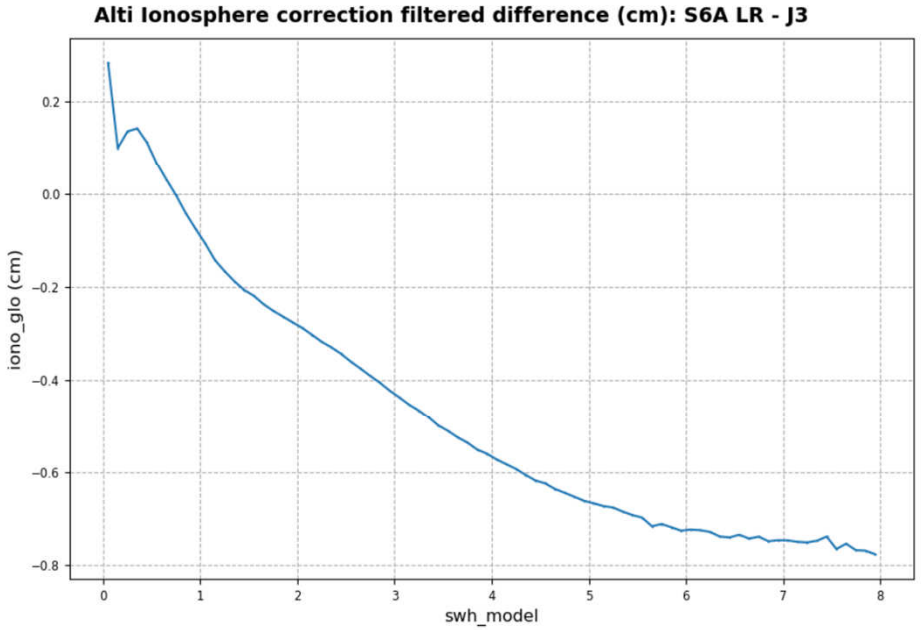


Sentinel-6 PDAP products assessment over ocean

Iono

- LR/J3 difference : Small SWH dependency
  - -5 mm between 2 and 7m wave.





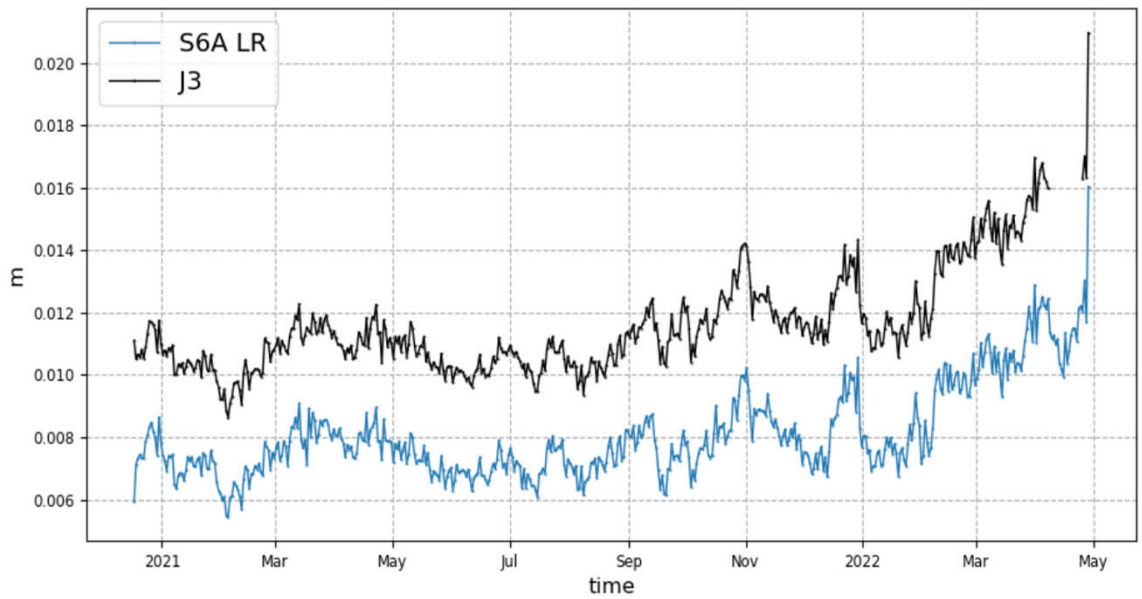
Sentinel-6 PDAP products assessment over ocean

Iono

- LR/GIM : drift (5mm)
  - Linked to solar activity
  - Probably coming from GIM due to its incomplete scaling

Ionosphere correction difference: Altimeter filtred - GIM model (m)
Mean per day

	nbr	min	mean	med	max	std
S6A LR	498	0.005458	0.008099	0.007714	0.01605	0.001469
J3	481	0.008626	0.01159	0.01121	0.02097	0.001621

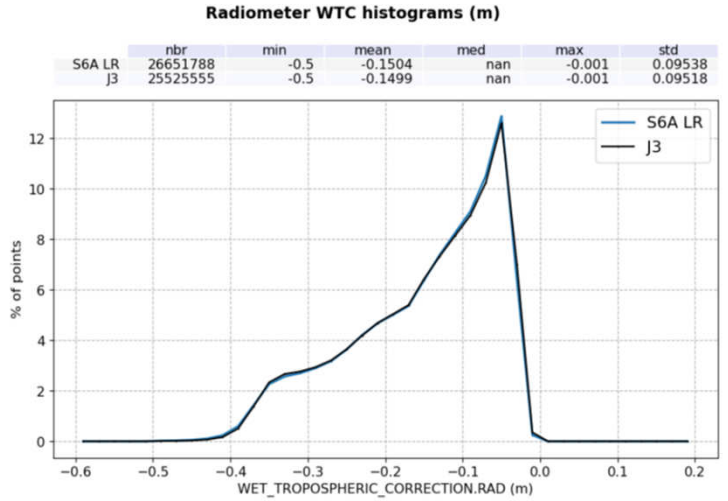


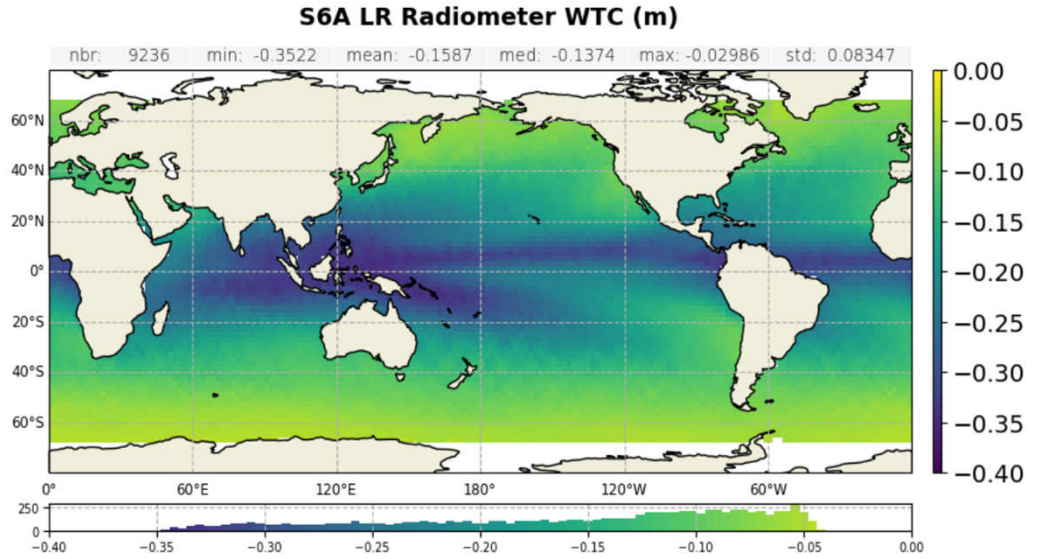
Tropo

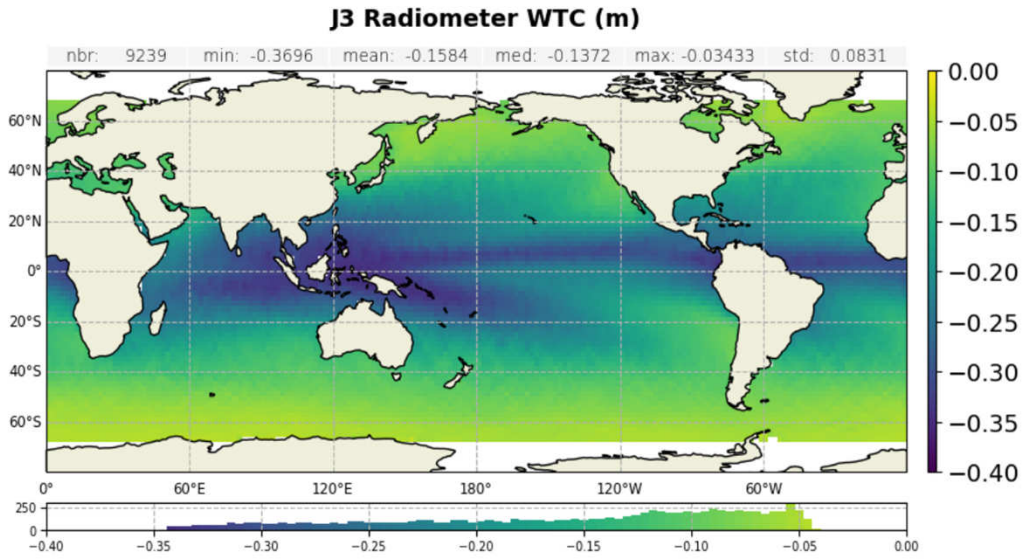
Sentinel-6 PDAP products assessment over ocean

AMR-C Tropo

- S6/J3 : Same patterns



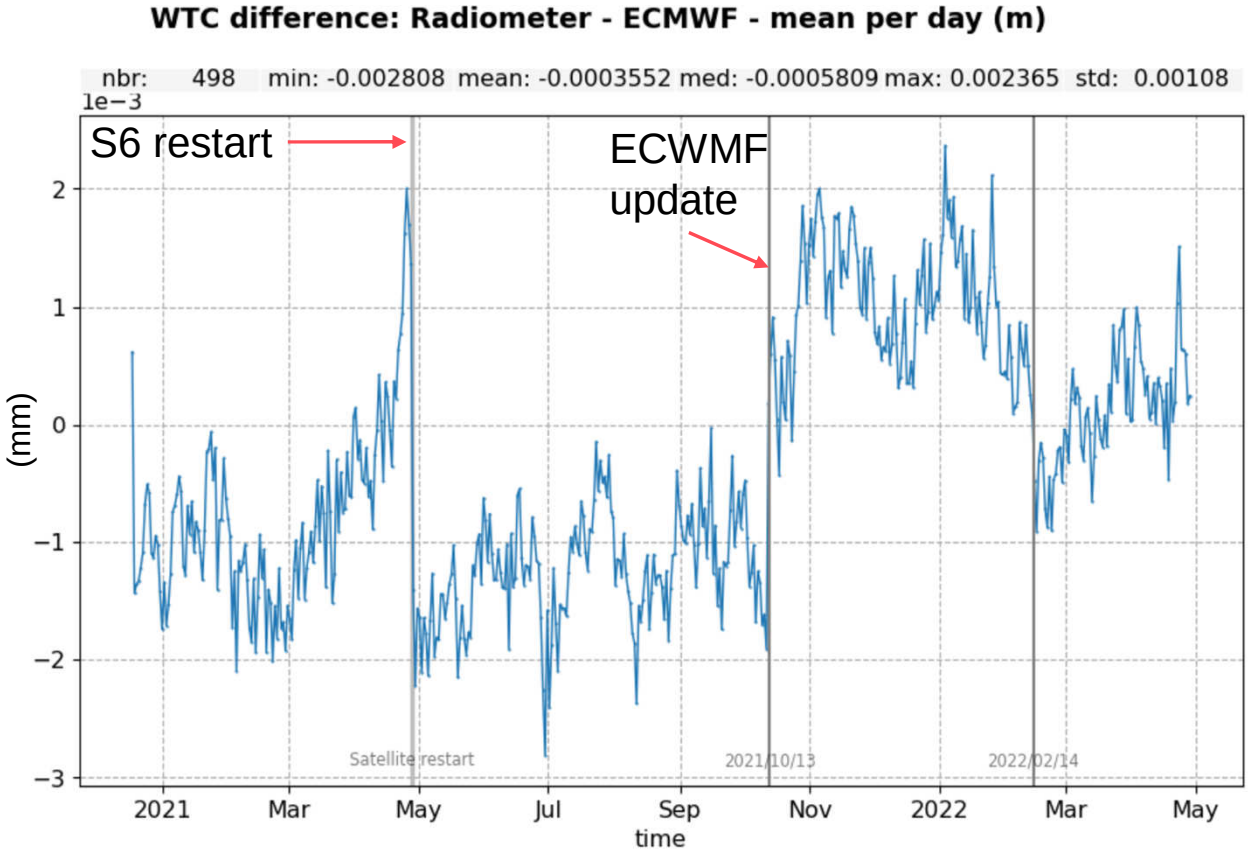




Sentinel-6 PDAP products assessment over ocean

AMR-C Tropo

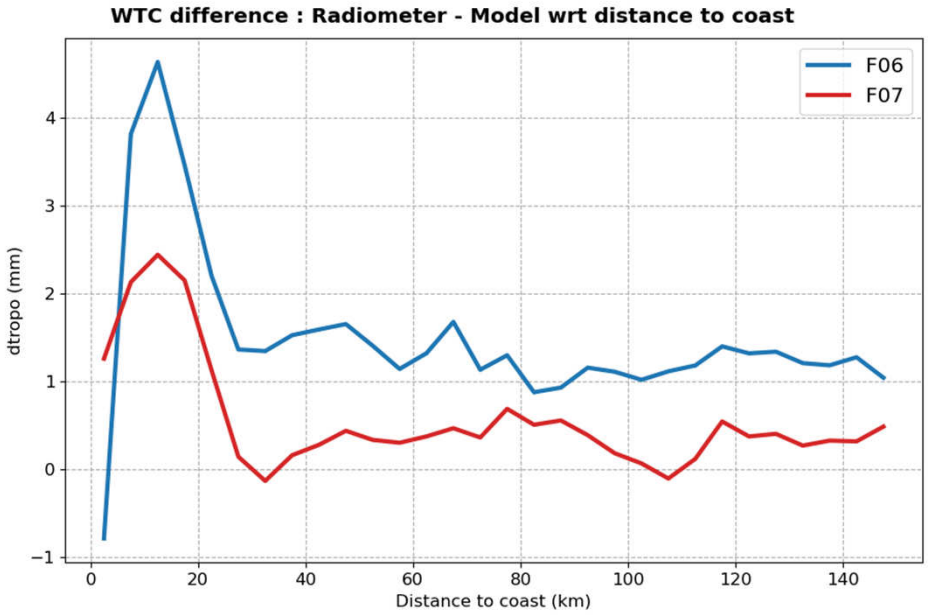
- March-May 2021 : S6 AMR-C seems to drift away before satellite restart (3 mm)
- 13 Oct 2021 : 2 mm jump due to ECMWF update
- Feb 2022 : -1 mm jump ? Under investigation

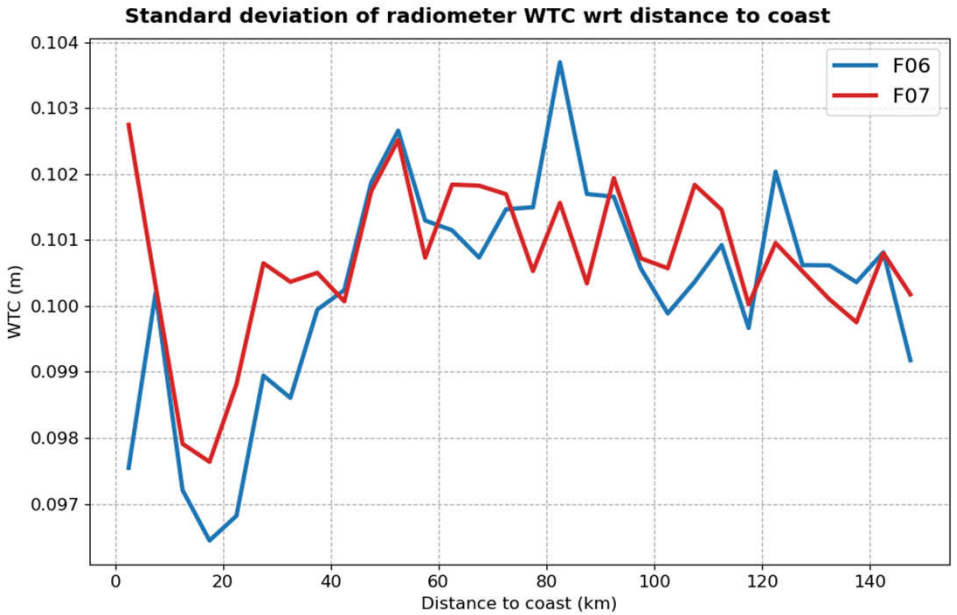


Sentinel-6 PDAP products assessment over ocean

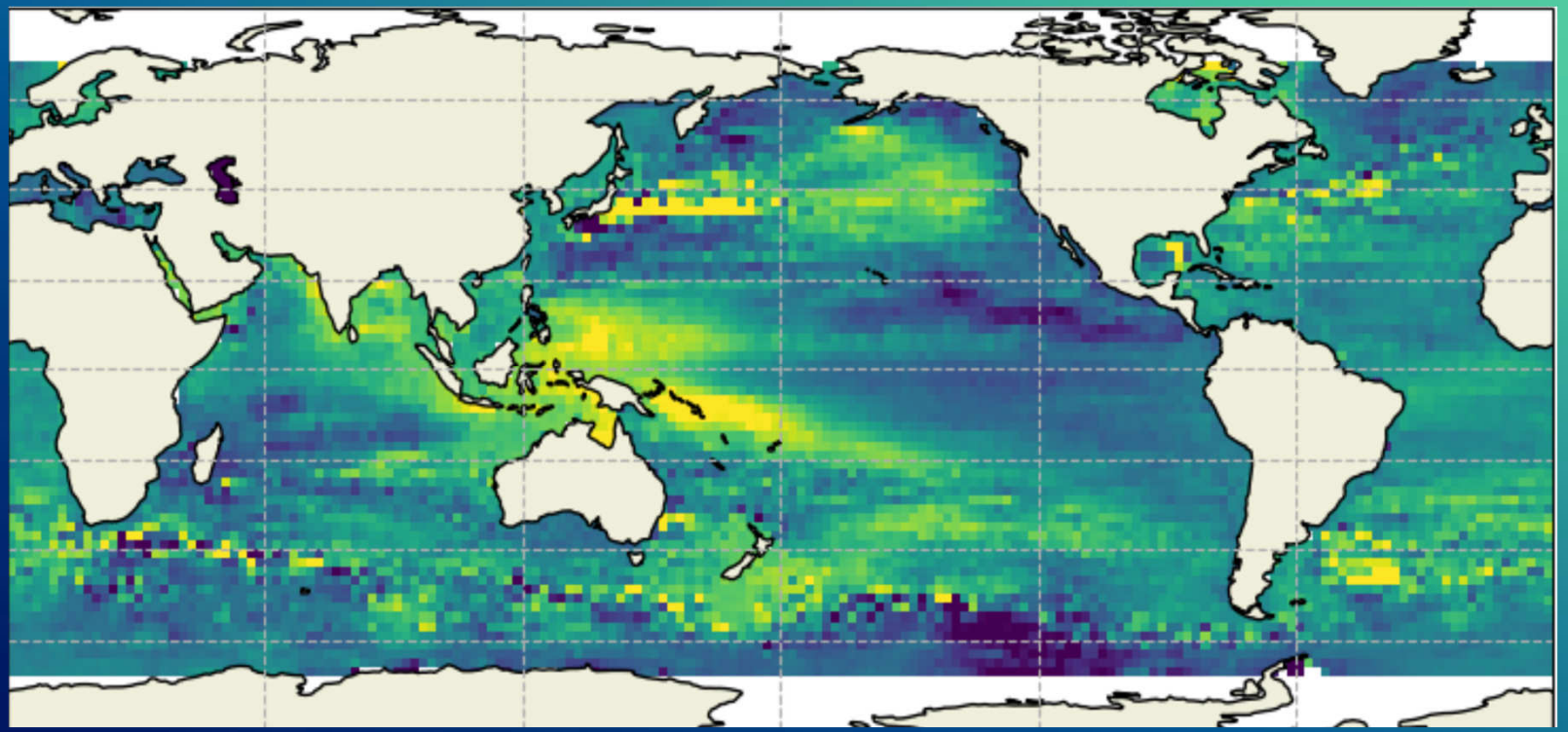
AMR-C Tropo

- Since F07 : Use of HRMR data for WTC computation
  - Improvement in coastal areas





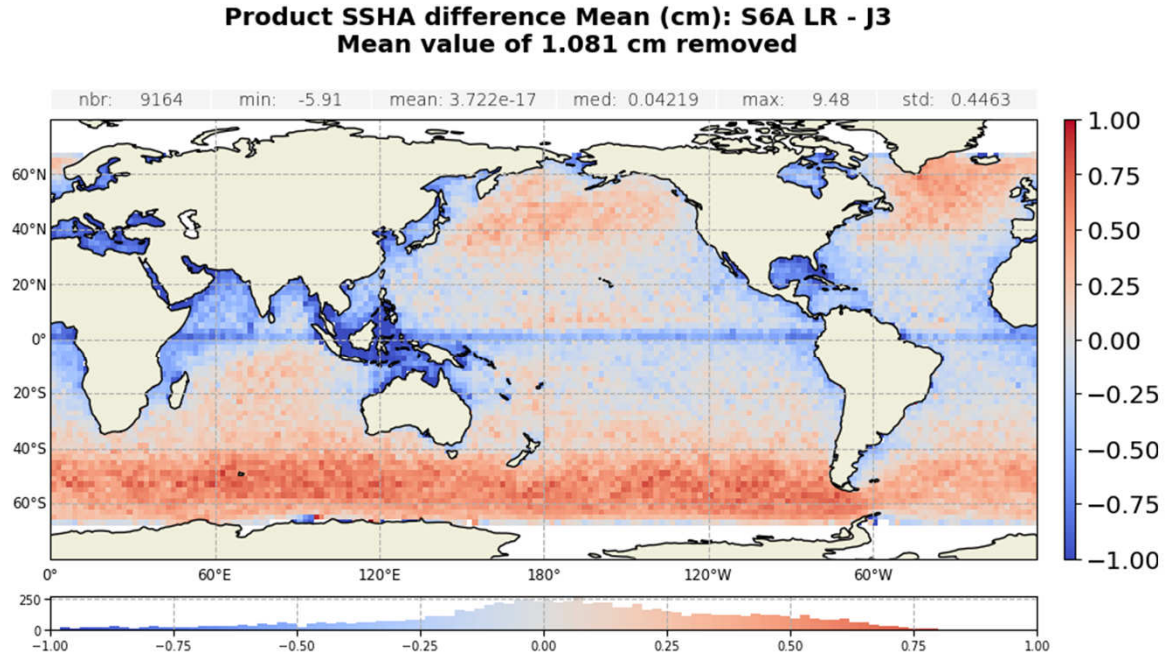
SSHA

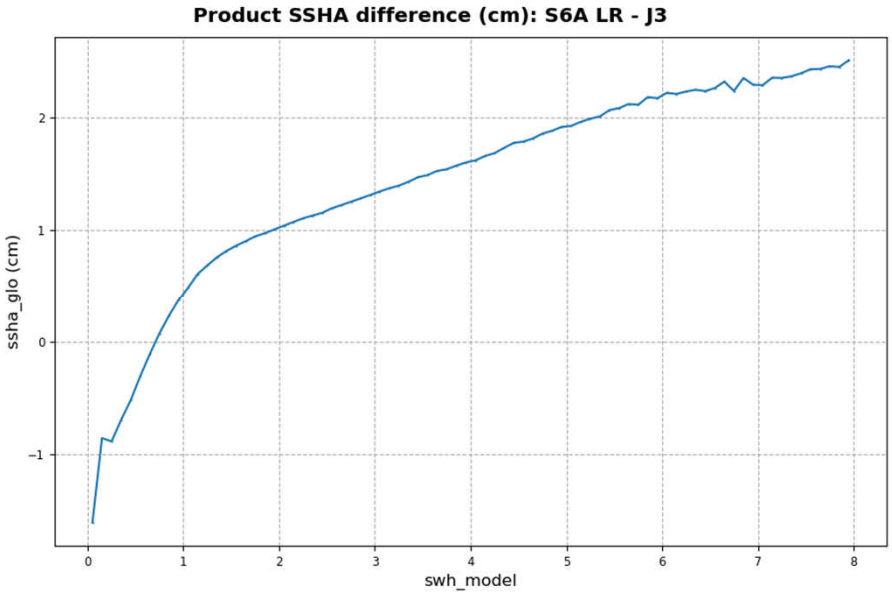


Sentinel-6 PDAP products assessment over ocean

SSHA

- LR in line / J3
  - Average bias is of 1.17 cm
  - *Main contribution to the difference : range & iono*
  - *SWH dependency will be improved with S6 LR numerical retracking (PB F08)*

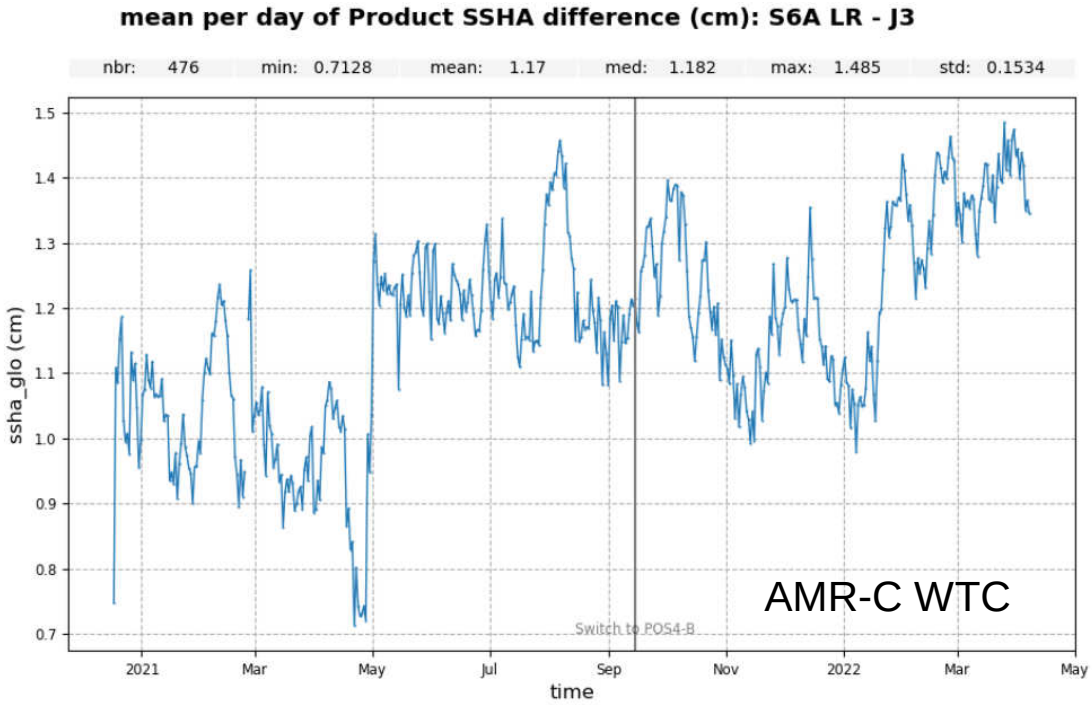


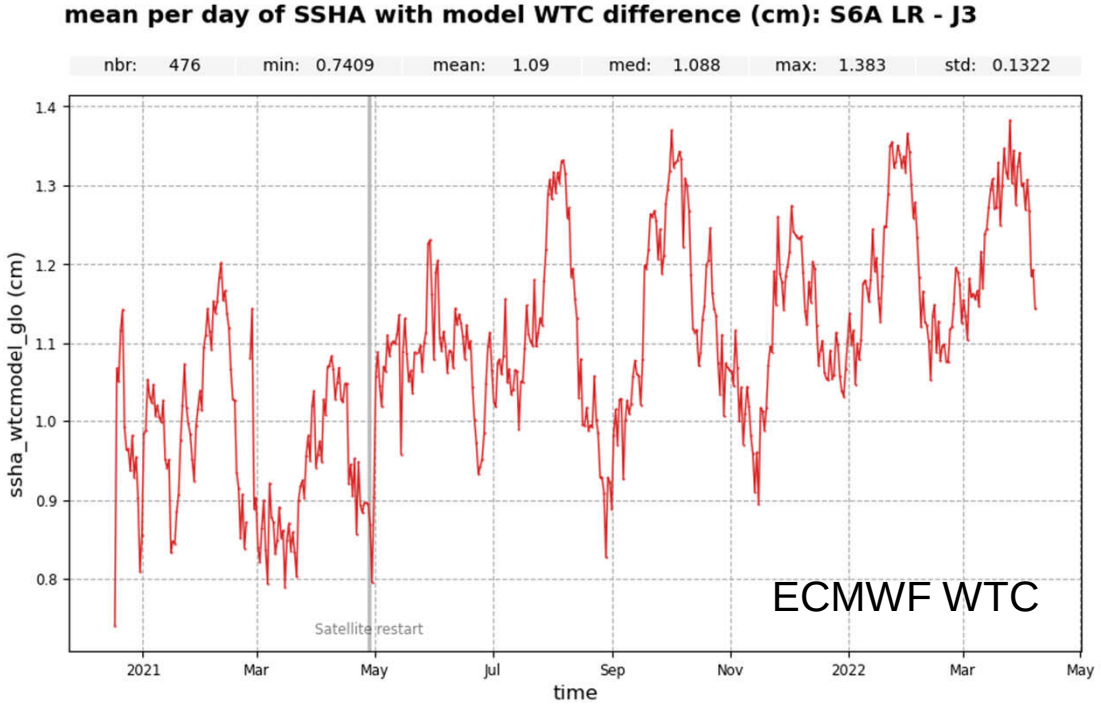


Sentinel-6 PDAP products assessment over ocean

SSHA

- LR in line / J3
  - No jump at the switch between side A and side B
  - A jump of about +3 mm is visible after the satellite restart of 27-28 April 2021. Due to WTC.
  - A second jump in Feb 2022 less visible (but present in HR). *Under investigation*

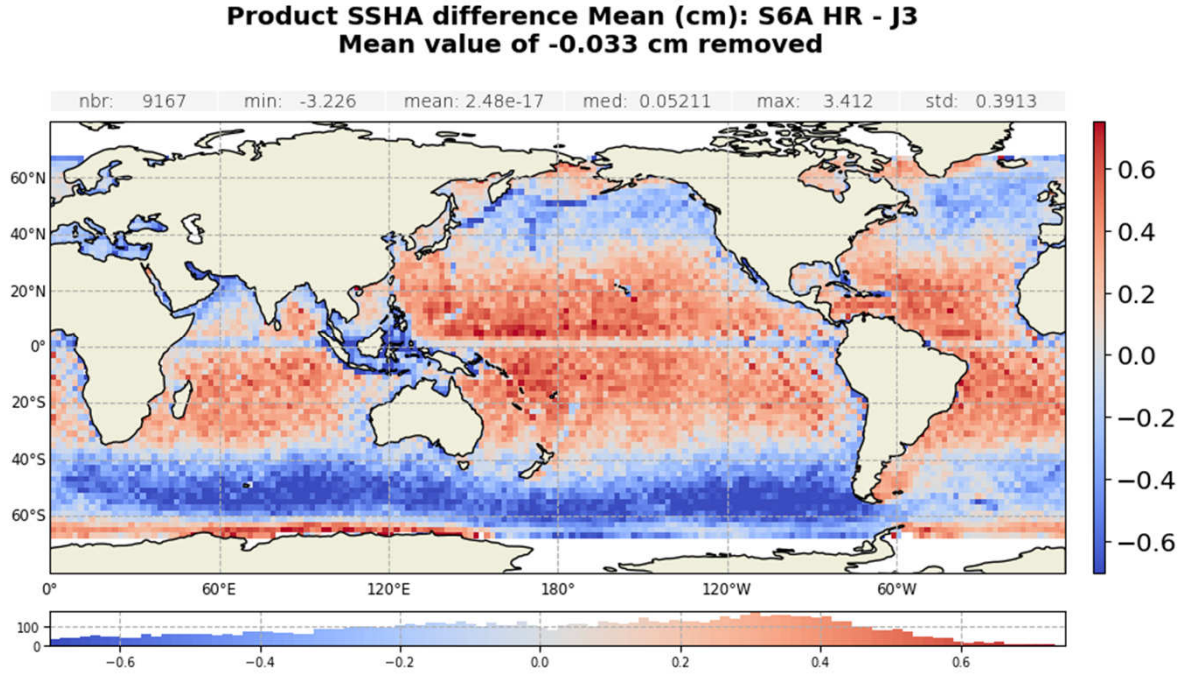


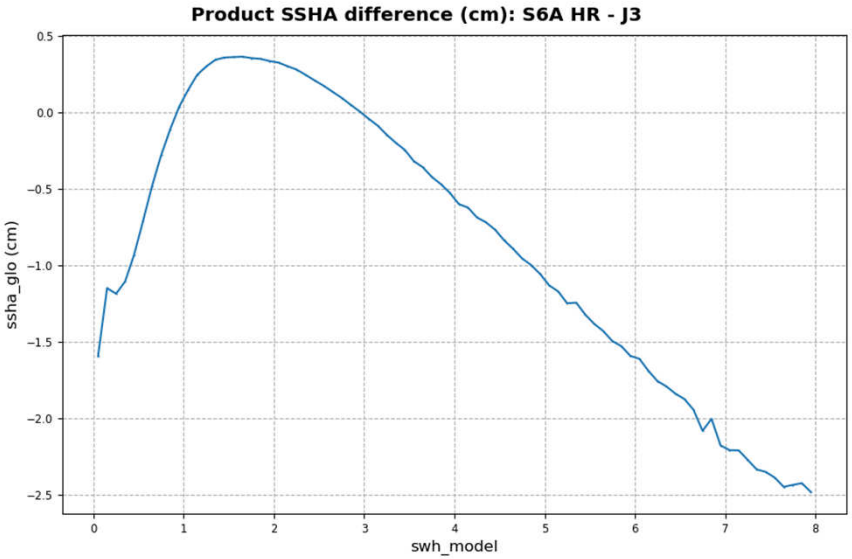


Sentinel-6 PDAP products assessment over ocean

SSHA

- HR / J3
  - *Main contribution to the difference : range & iono*
  - *SWH dependency*
    - *will be improved with S6 HR numerical retracking (PB F09) and VV LUT (PB F10)*
    - *Also need HR skewness*

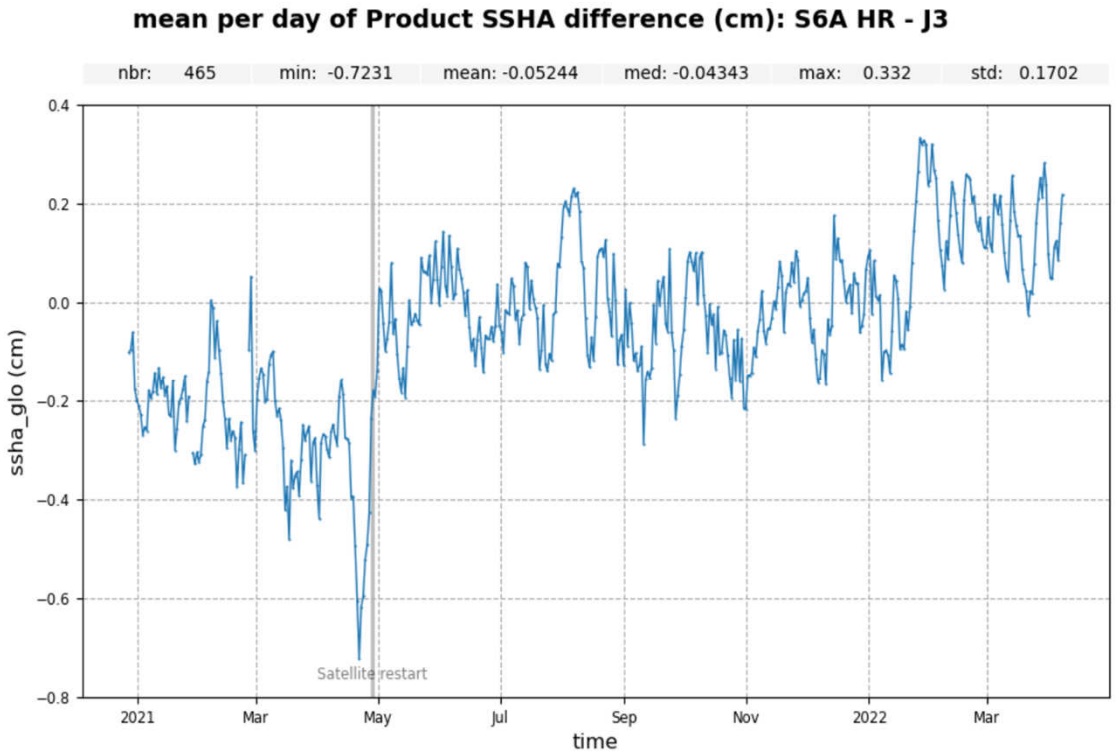




Sentinel-6 PDAP products assessment over ocean

SSHA

- HR / J3
  - No jump at the switch between side A and side B
  - Time monitoring of the difference shows 2 jumps (as in LR)



Cross Over Analysis

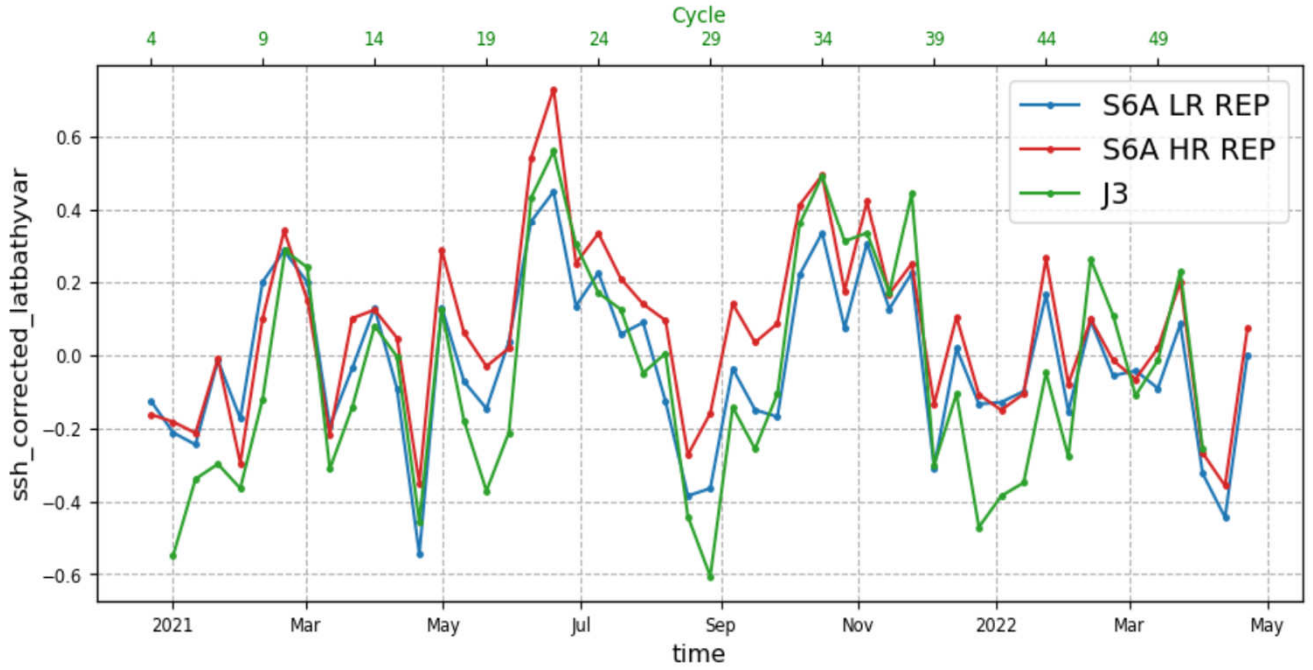
Sentinel-6 PDAP products assessment over ocean

SSH Xovers : mean

- S6 LR < J3 < S6 HR

SSH difference at crossover (cm), MEAN per cycle
for abs(latitude) < 50°, bathy < -1000 m & oceanic var. < 20 cm

	nbr	min	mean	med	max	std
S6A LR REP	50	-0.5446	-0.0184	-0.03663	0.4507	0.2154
S6A HR REP	50	-0.3579	0.06597	0.07989	0.7321	0.2343
J3	47	-0.6053	-0.0475	-0.1057	0.5611	0.3006



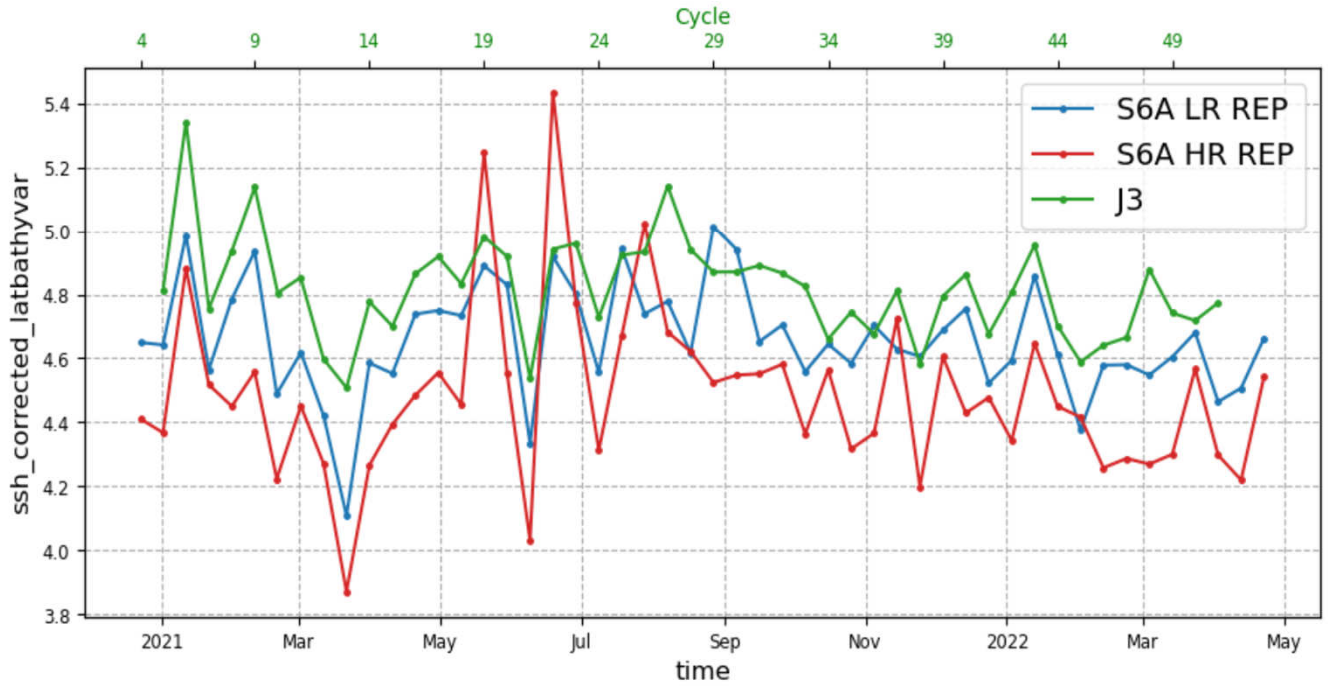
Sentinel-6 PDAP products assessment over ocean

SSH Xovers : STD

- S6 HR < S6 LR < J3

SSH difference at crossover (cm), STD per cycle
for abs(latitude) < 50°, bathy < -1000 m & oceanic var. < 20 cm

	nbr	min	mean	med	max	std
S6A LR REP	50	4.108	4.661	4.643	5.013	0.173
S6A HR REP	50	3.871	4.487	4.454	5.435	0.2647
J3	47	4.508	4.818	4.812	5.342	0.1581

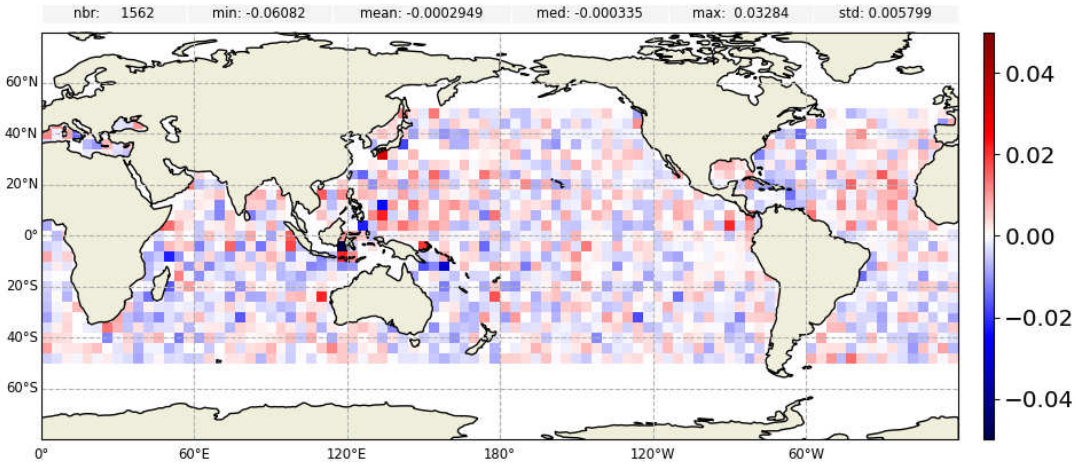


Sentinel-6 PDAP products assessment over ocean

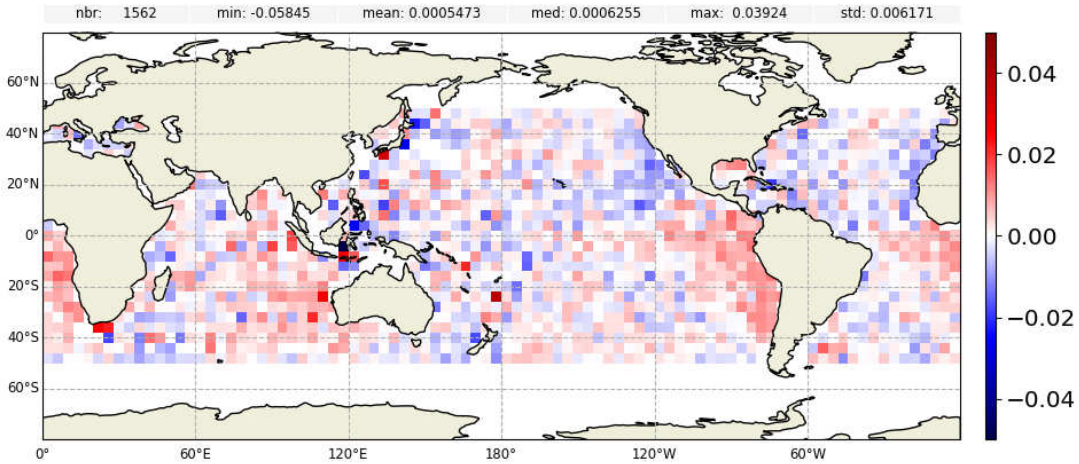
SSH Xovers : mean

- LR : no geographical pattern
- HR : pattern patterns correlated to along track wind (under investigation)

LR



HR

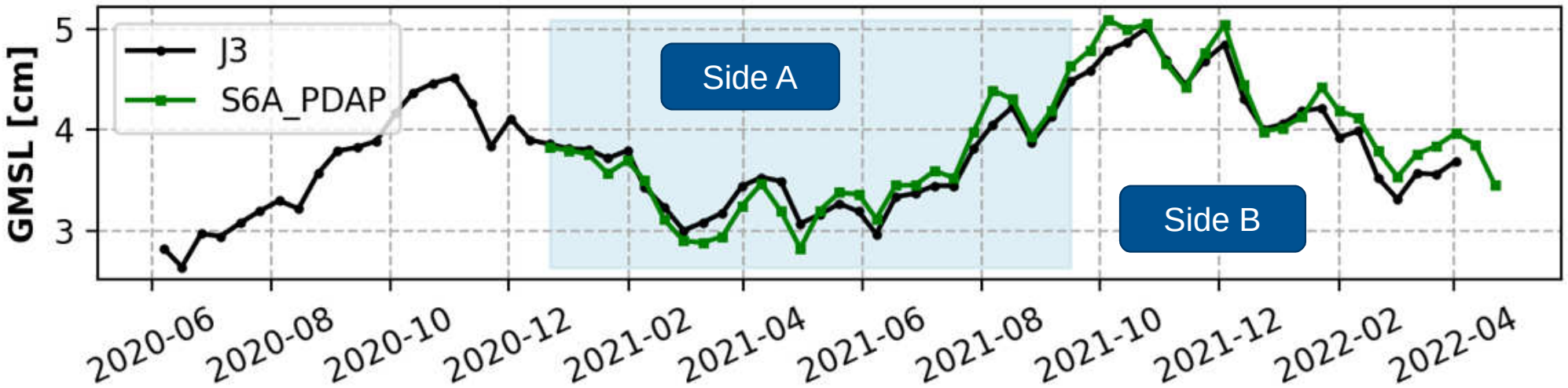


GMSL

Sentinel-6 PDAP products assessment over ocean

GMSL

- short period for GMSL analysis : large uncertainty on trends

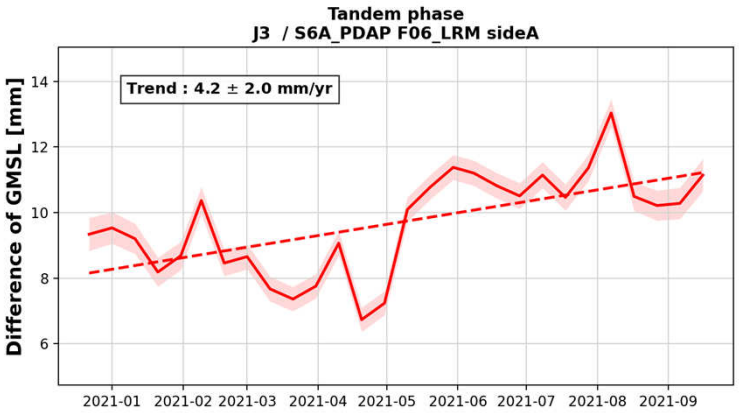


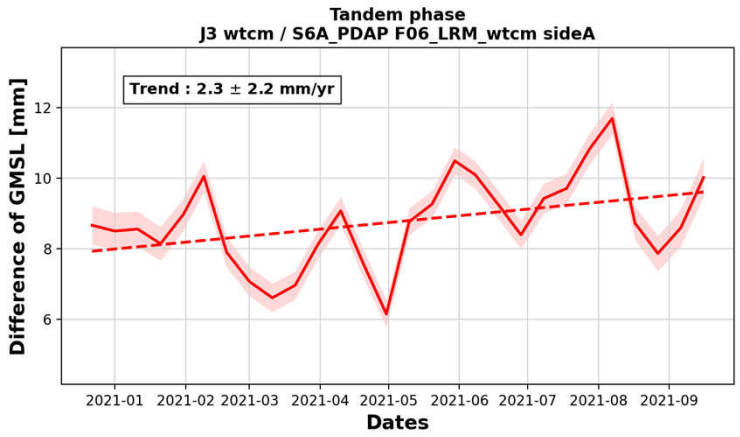
Sentinel-6 PDAP products assessment over ocean

GMSL

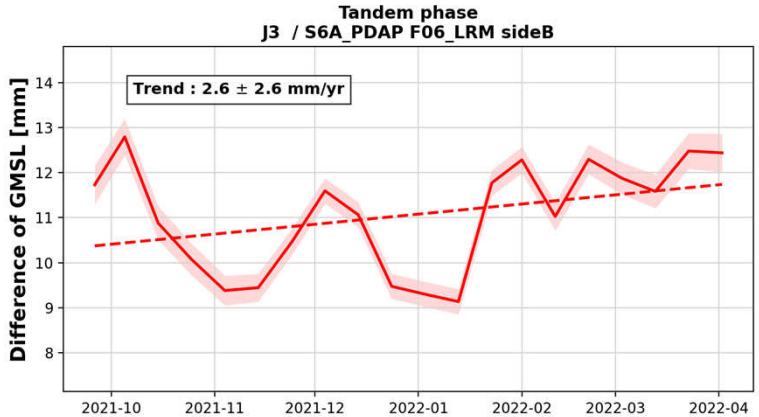
- Side A : Jump at cycle 17 (cf AMR WTC section), thus significant GMSL drift between J3 and S6
  - Biais uncertainty : 0,3 mm (1-σ)
- Side B : No significant drift between J3 and S6
  - Biais uncertainty : 0,2 mm (1-σ)
  - Periodic signal under investigation when using ECMWF WTC

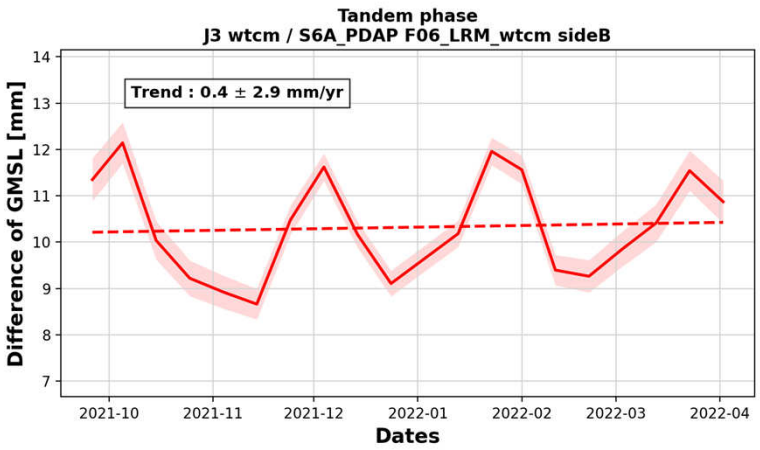
Side A





Side B





Conclusion

- **Since F06 reprocessing the S6 time serie is homogeneous**

- **Excellent LR performances**
  - **Still small range SWH dependency (~1cm) → will be improved with Numerical Retracking (PB F08)**

- **Good HR performances**
  - **Note Range (4cm) and SWH (25 cm) SWH dependency → will be improved with Numerical Retracking (PB F09) , Range Walk (PB F09) and Wave Vertical Velocity LUT (PB F10)**
  - **Need HR Skewness**

- **2 jumps in WTC visible in SSHA time monitoring and GMSL → Under investigation**