Jet Propulsion Laboratory
California Institute of Technology

Results from Independent Calibration and Validation of the Sentinel-6A Michael Freilich Mission

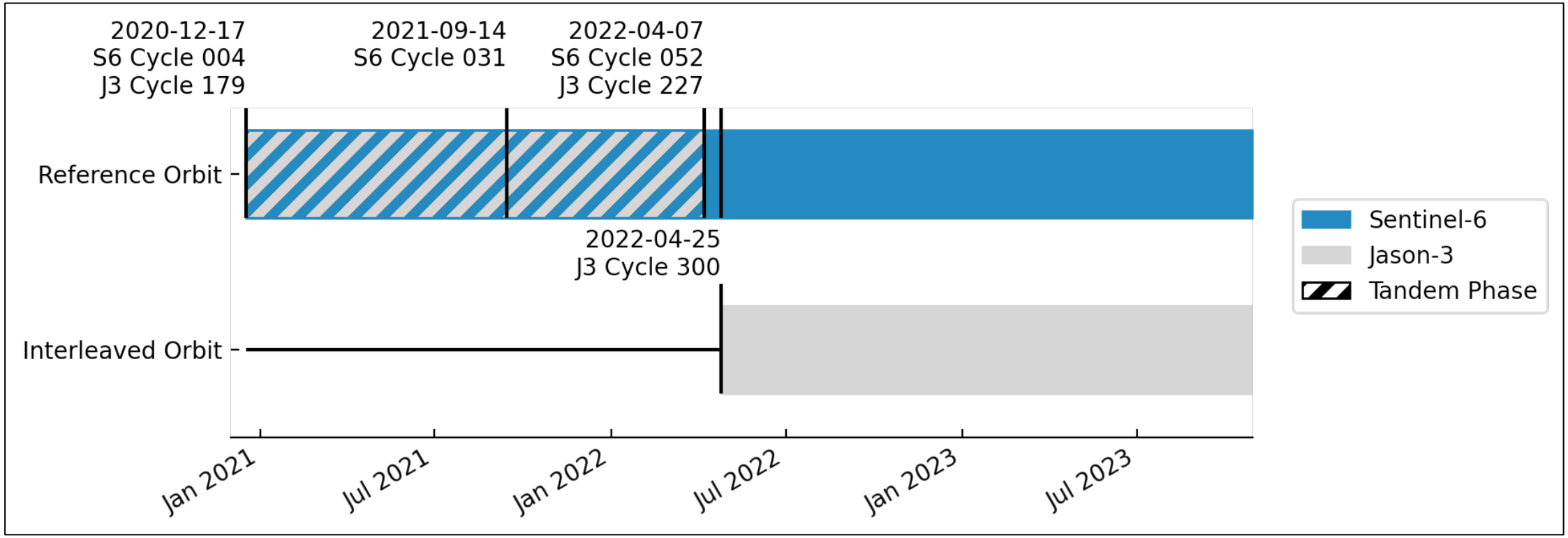
Linda Forster,
Johan Nilsson,
Jean-Damien Desjonquères,
Shailen Desai

Jet Propulsion Laboratory, California Institute of Technology Pasadena, CA

OSTST San Juan, Puerto Rico, 2023

Sentinel-6A Michael Freilich Mission

- Sentinel-6 has been collecting sea level measurements along the historical reference ground track since December 2020.
- Took over as the new reference mission in April 2022 when Jason-3 was moved to the interleaved orbit.



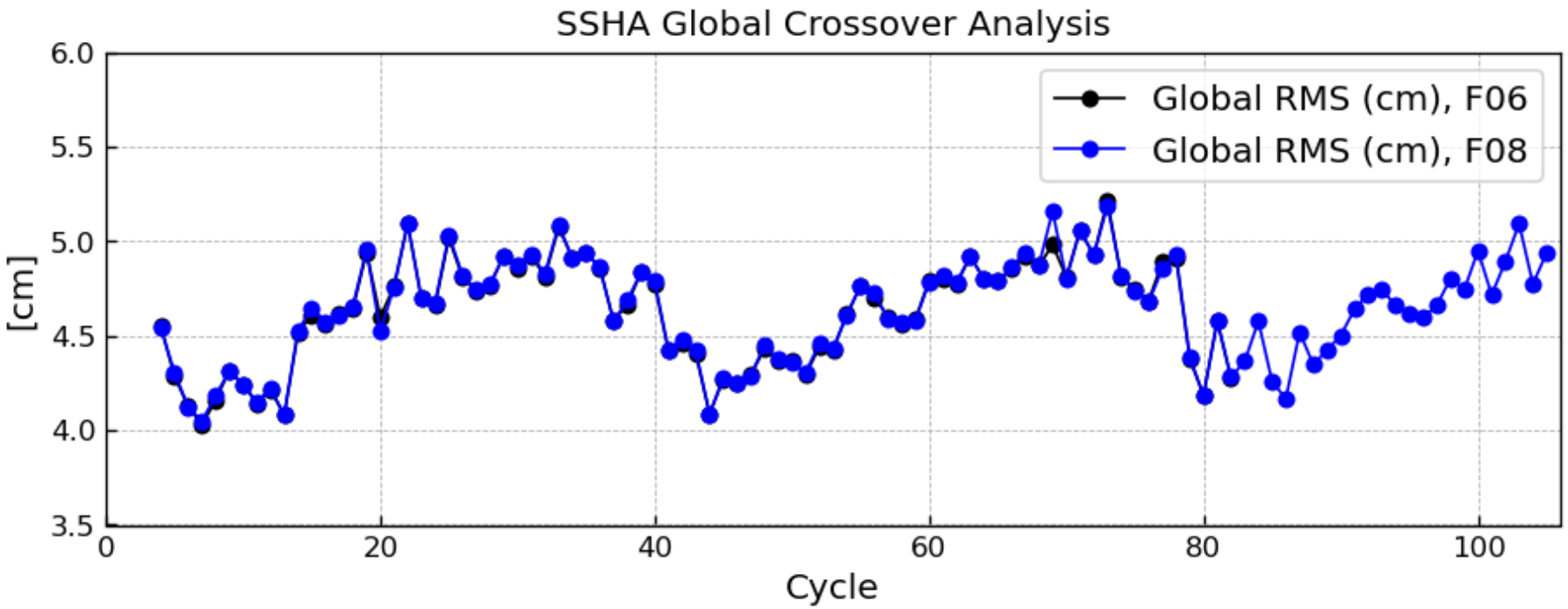
Updates from Sentinel-6A F06 to latest F08 baseline

1. **Numerical Retracker (NR) retrieval in addition to MLE-4**
   → NR is provided for Ku-band products at low resolution (LR).
   → Direct use of measured Point Target Response (PTR) accounts for potential altimeter drift.

2. Ku-band **antenna aperture angle** updated from 1.33° to 1.34°
   → Reduces mis-pointing and has small impact on sigma0.

3. **Updated AMR calibration**.

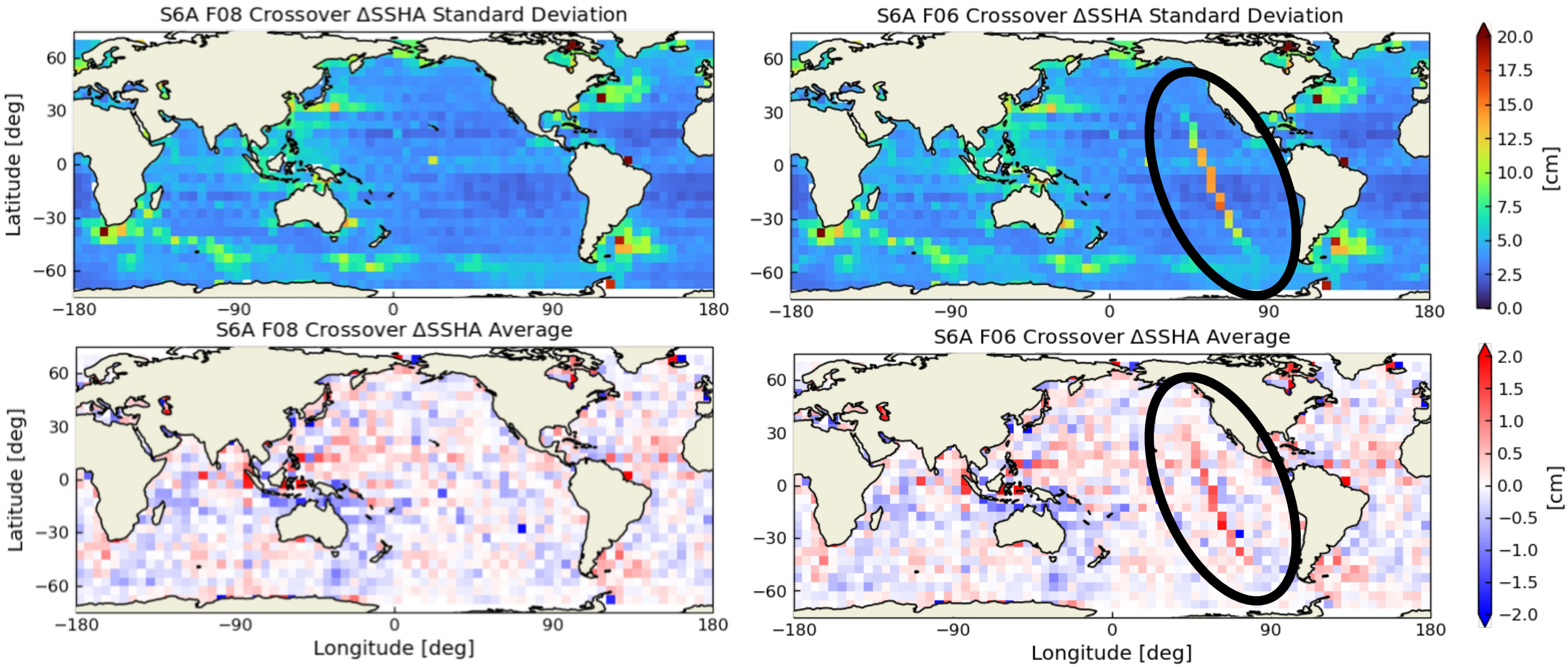
Sentinel-6A SSHA Crossover Statistics



- F08 and F06 are in line in terms of performance.
- Measurement noise is meeting requirements (3.2 cm for LR mode).

Sentinel-6A SSHA Crossover Statistics

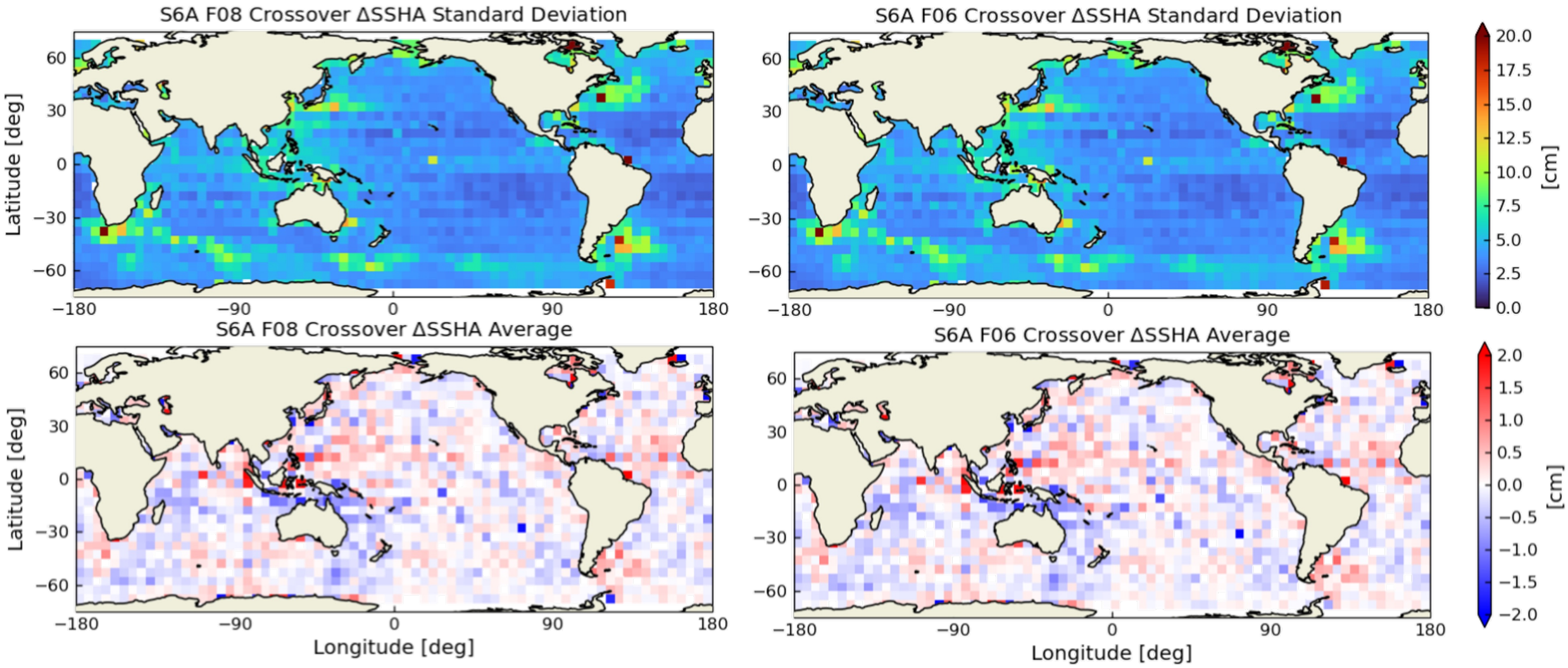
5-degree bins



Anomaly for cycle 20 due to erroneous platform mispointing in the ancillary data. Passes 182 and 183 have been corrected manually in the reprocessing.

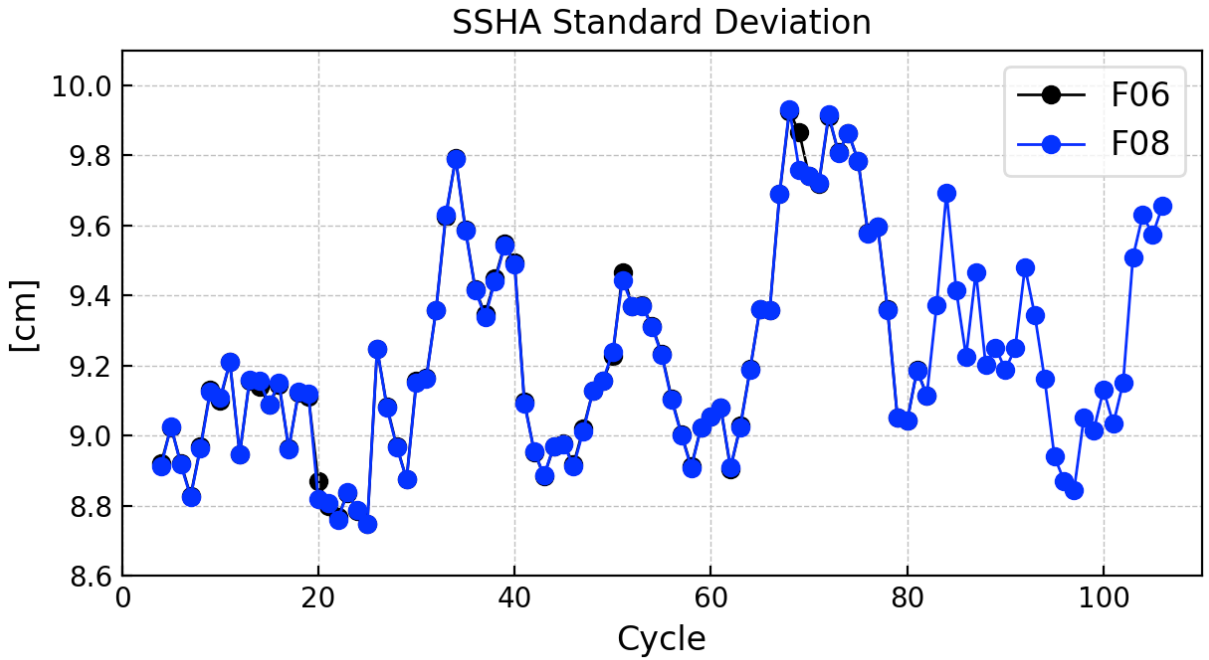
Sentinel-6A SSHA Crossover Statistics

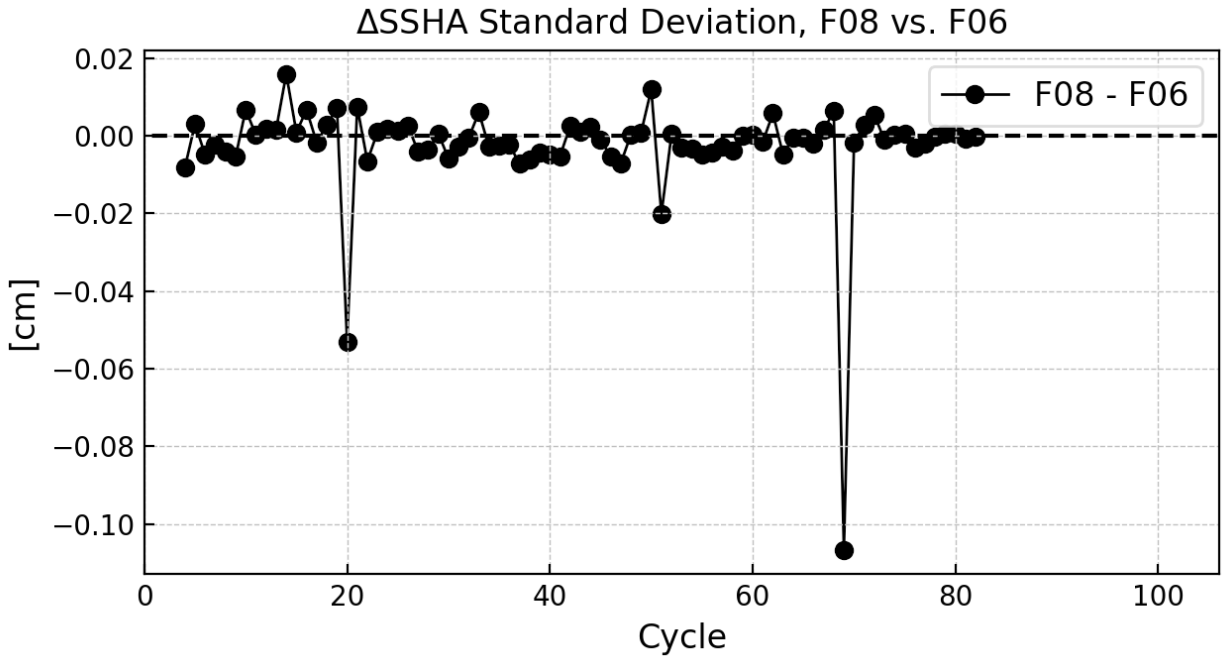
5-degree bins



Sentinel-6A Sea Surface Height Anomaly MLE-4

Time series of Global SSHA Standard Deviation

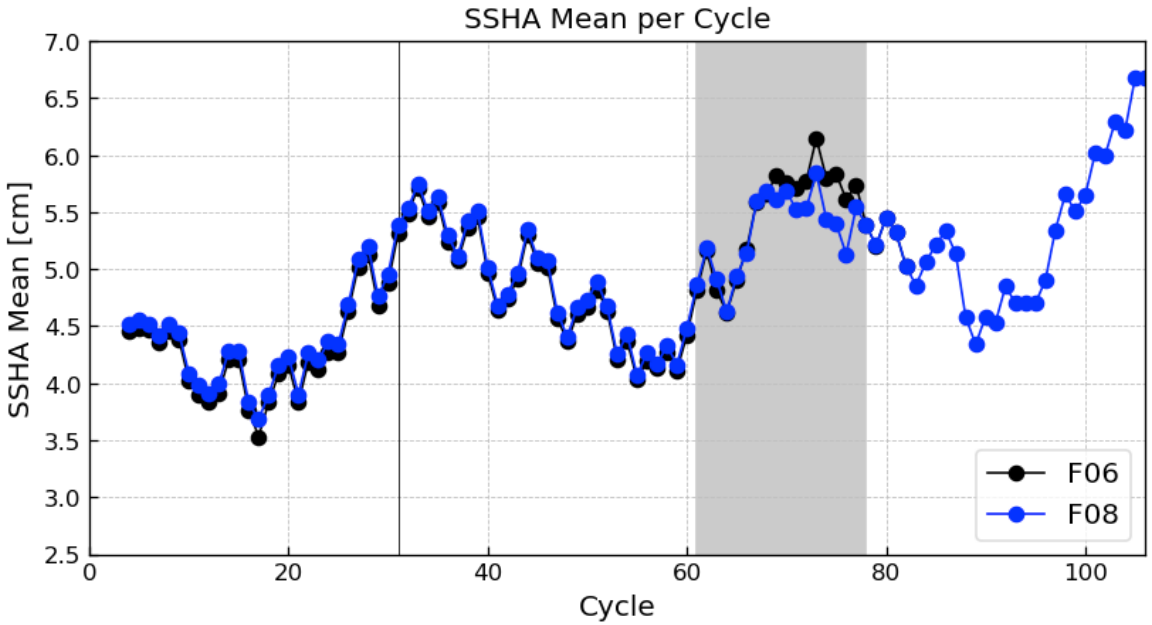


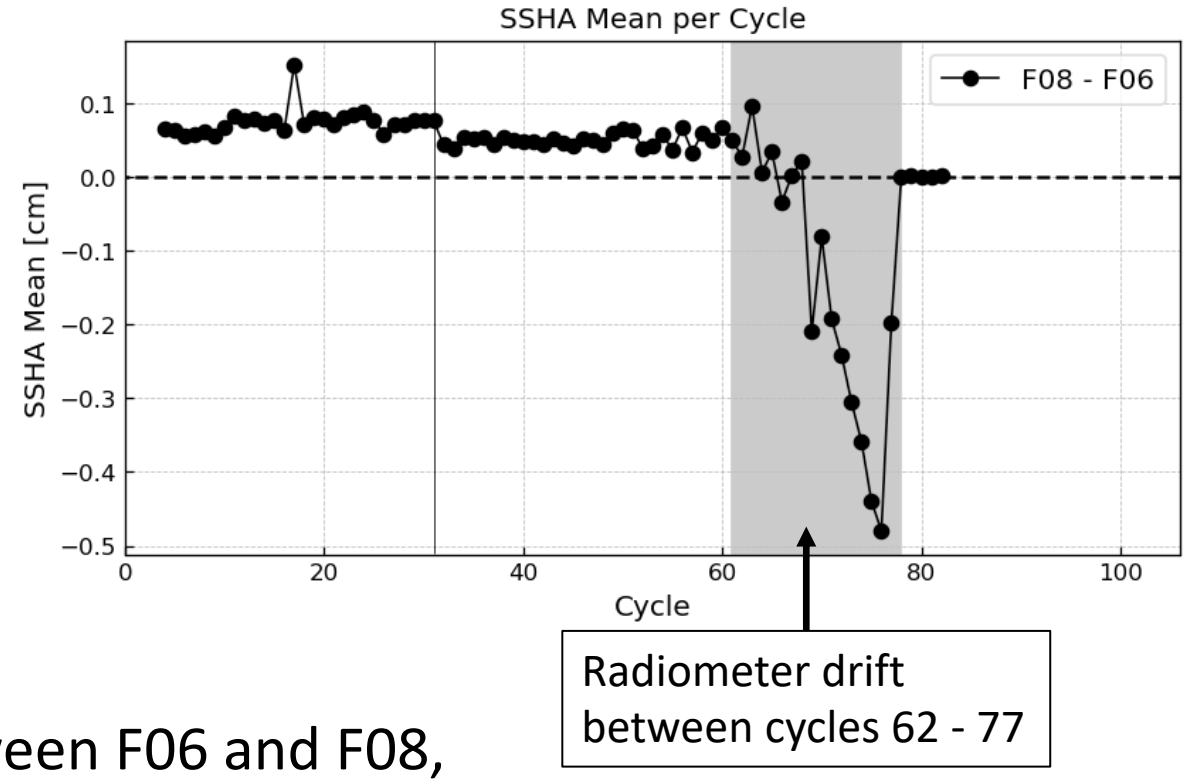


Time series of Global SSHA performance consistent between F06 and F08.

Sentinel-6A Sea Surface Height Anomaly MLE-4

Time series of Global SSHA Average

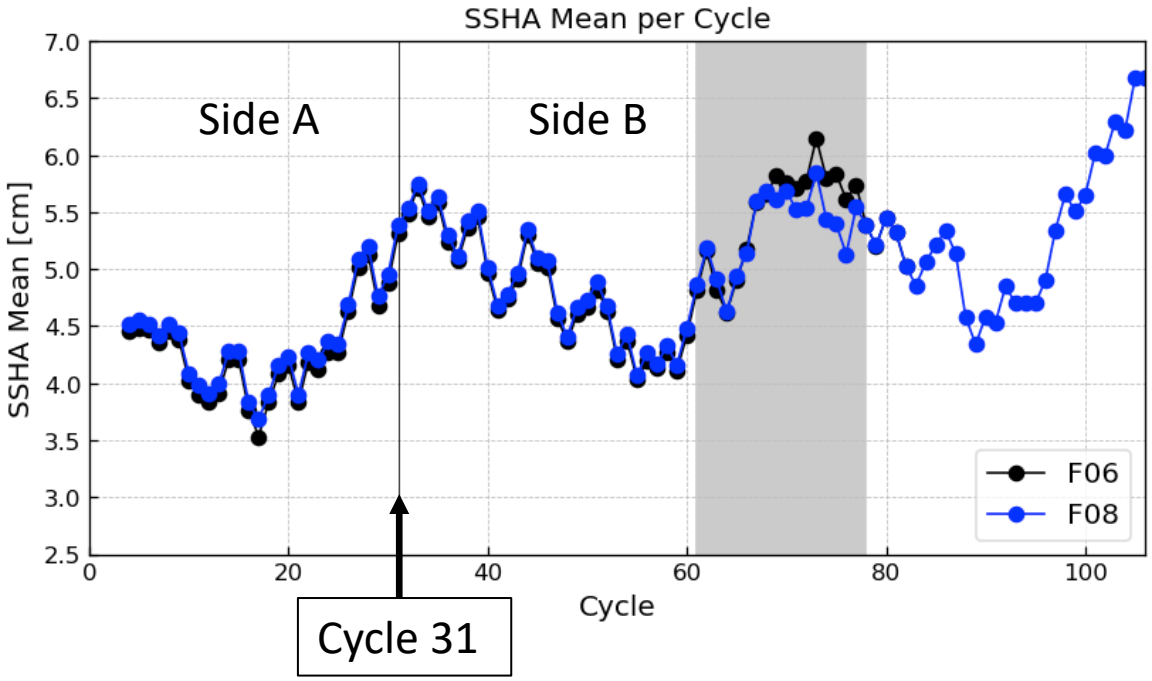


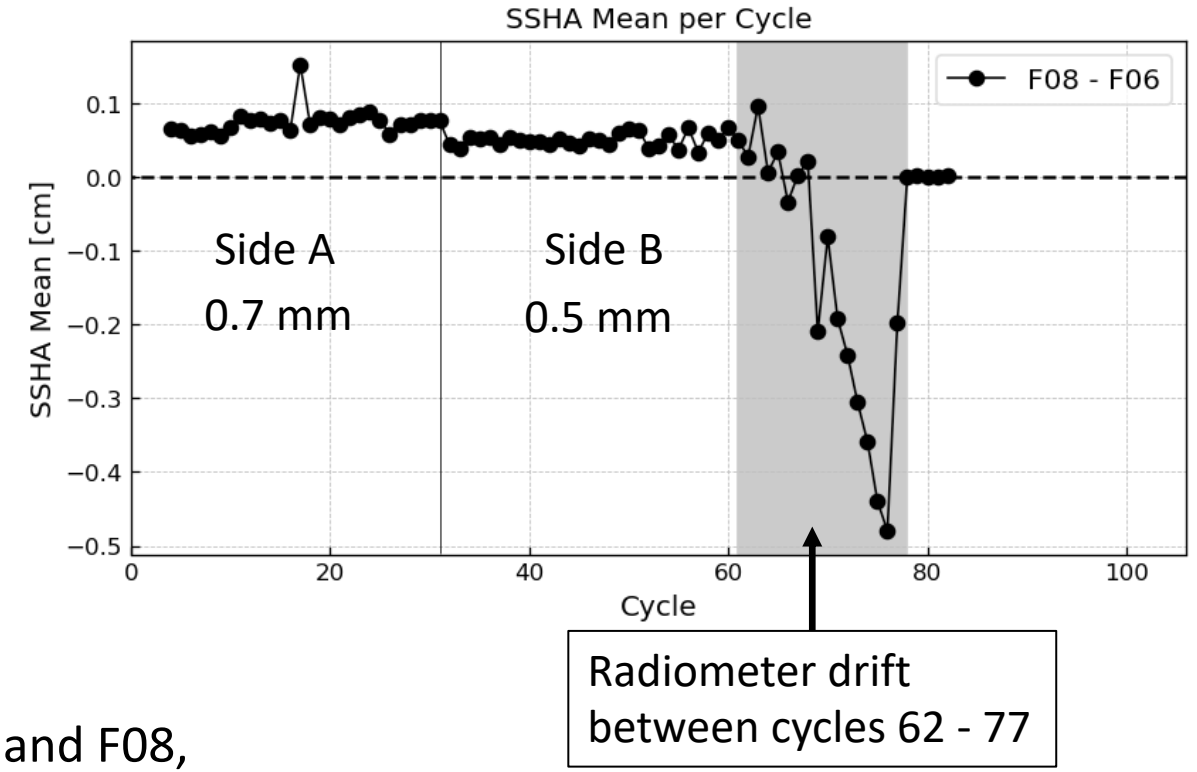


- Time series of average SSHA consistent between F06 and F08, except during cycles affected by radiometer calibration error in F06.

Sentinel-6A Sea Surface Height Anomaly MLE-4

Time series of Global SSHA Average

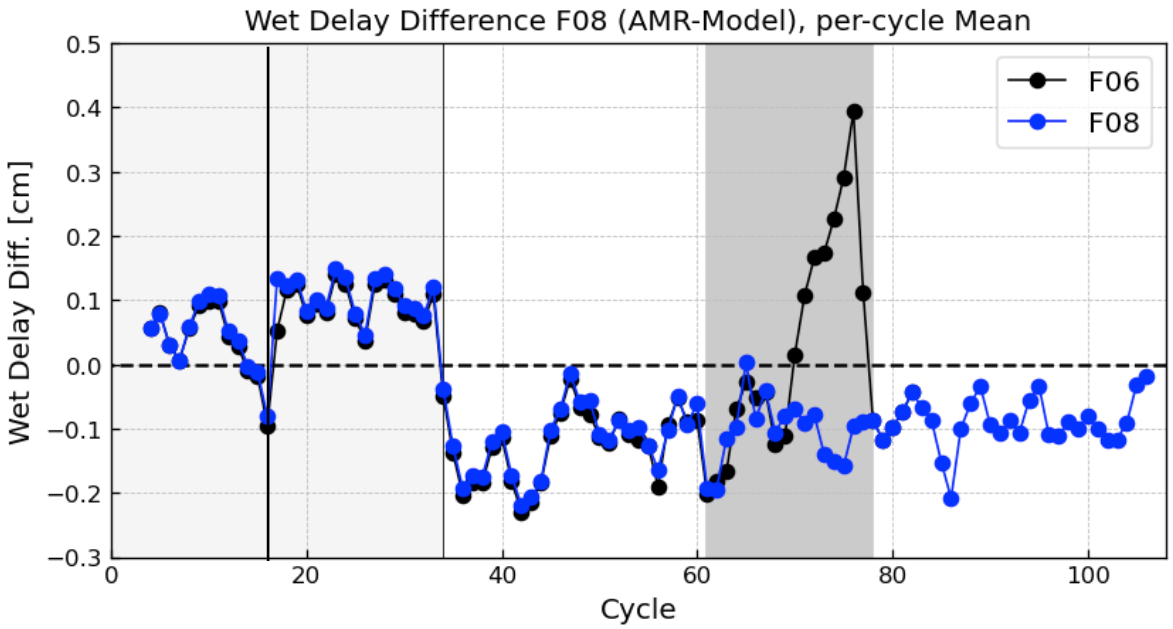


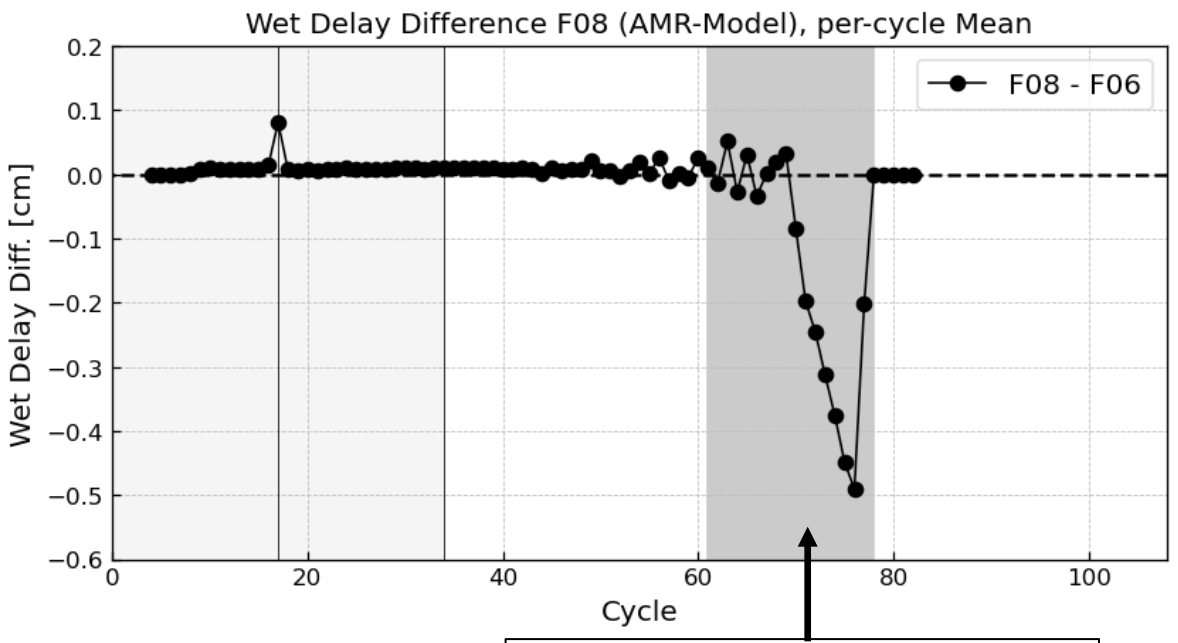


- Time series of average SSHA consistent between F06 and F08, except during cycles affected by radiometer calibration error in F06.
- F08 – F06 SSHA difference is about 0.7 mm for side-A and 0.5 mm for side-B, mostly explained by impact of sigma0 change on SSB.

Sentinel-6A Wet Path Delay Difference AMR – Model

Time series of Global Wet Path Delay Average



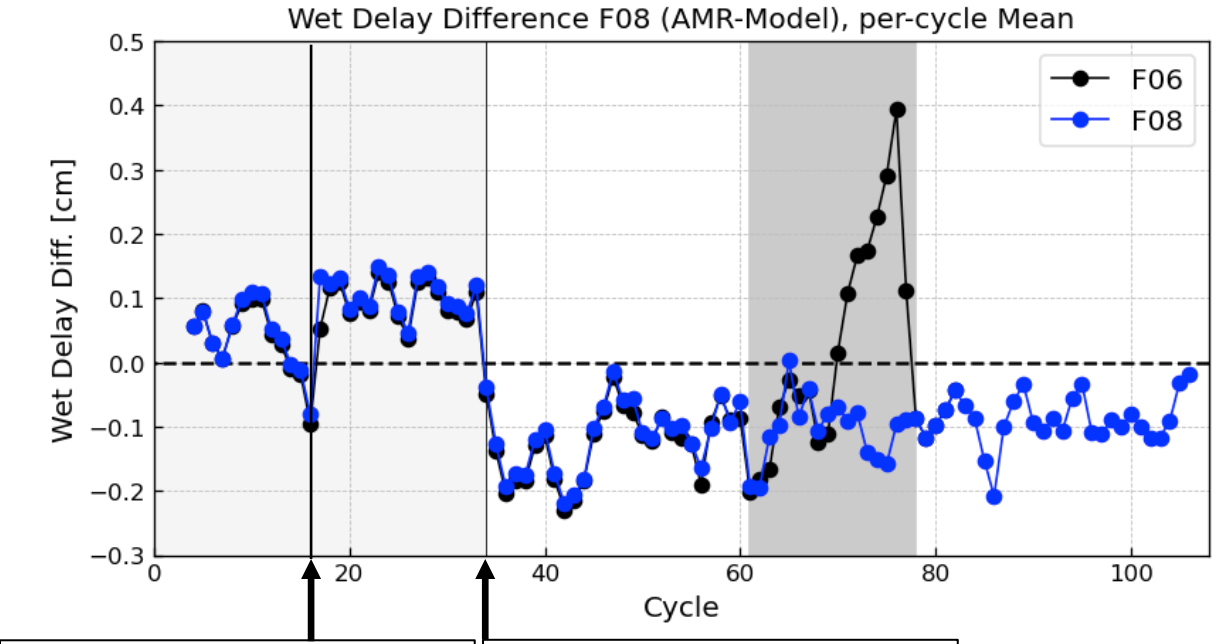


Radiometer drift: Cycles 62 – 77
[22 Apr 2021 to 04 May 2021]

F08 reprocessing fixes an error in the operational AMR calibrations that was present in F06 (cycles 62 – 77).

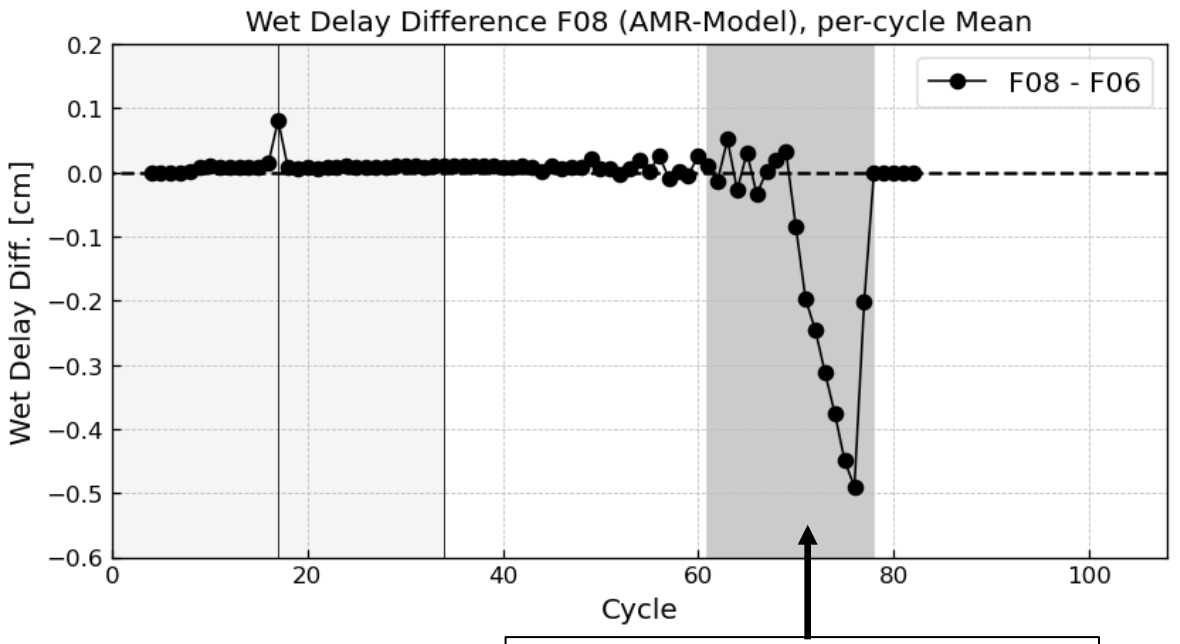
Sentinel-6A Wet Path Delay Difference AMR – Model

Time series of Global Wet Path Delay Average



Satellite restart: Cycle 17 [27/28 Apr 2021]

ECMWF model updated: Cycle 34 [13 Oct 2021]

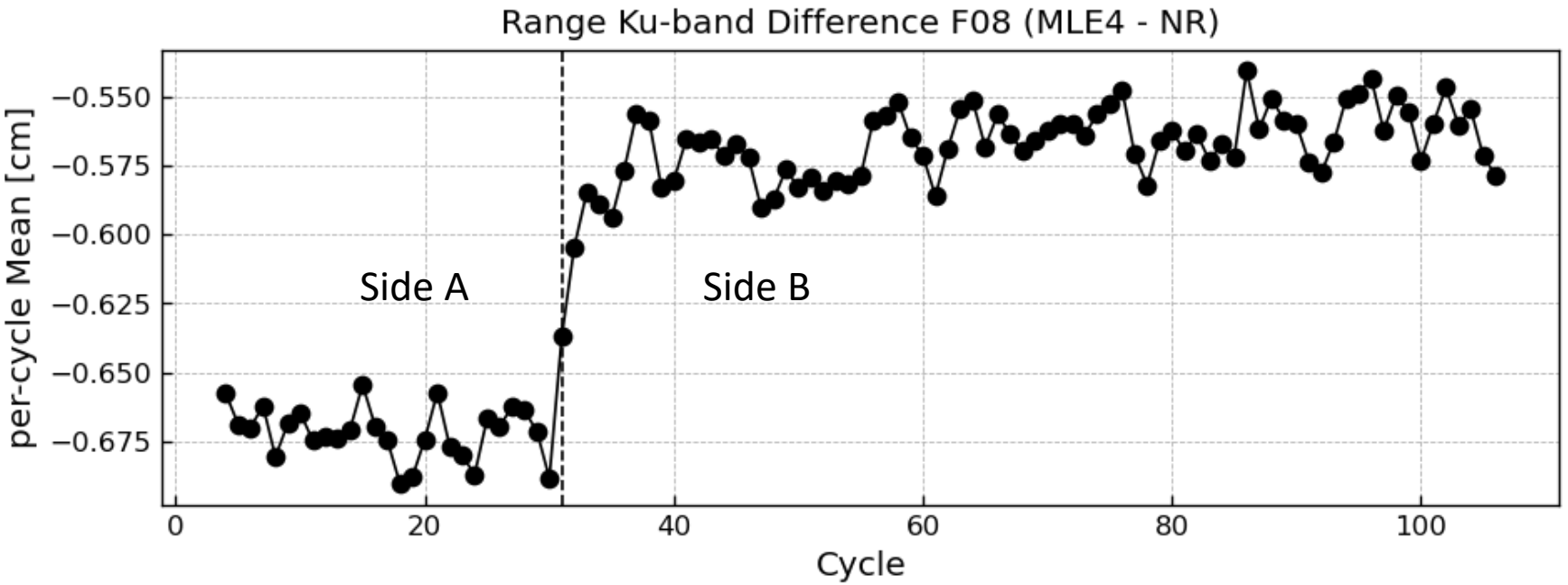


Radiometer drift: Cycles 62 – 77 [22 Apr 2021 to 04 May 2021]

F08 reprocessing fixes an error in the operational AMR calibrations that was present in F06 (cycles 62 – 77).

Sentinel-6A Range Ku-band: F08 MLE4 vs. NR

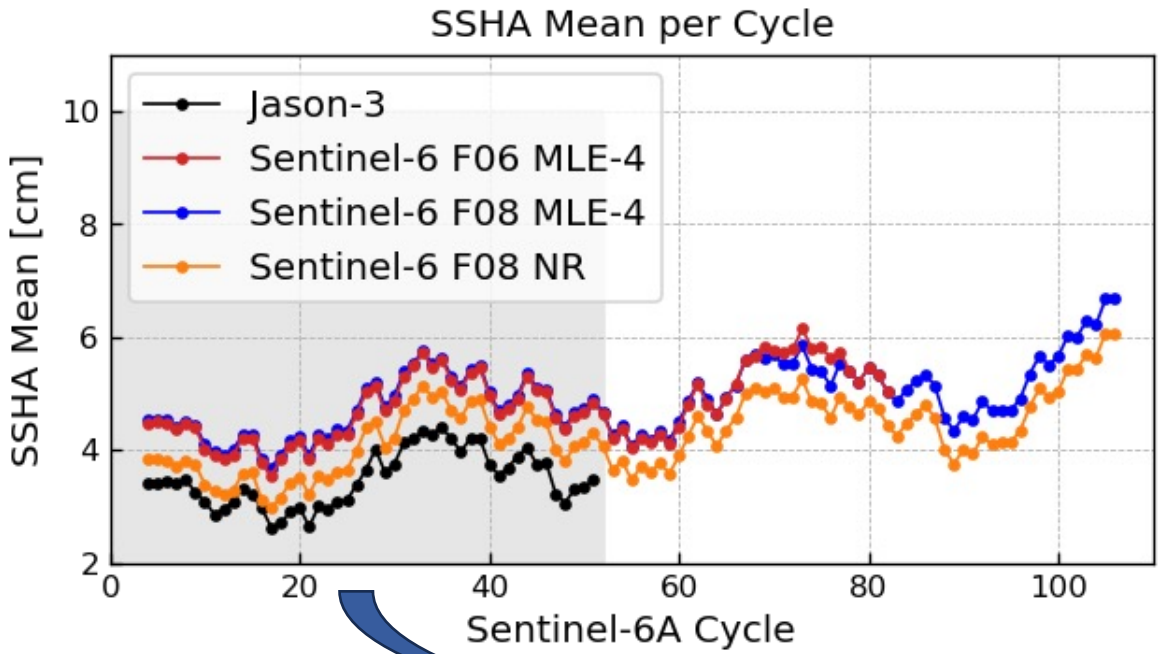
Time series of Ku-band Range Average

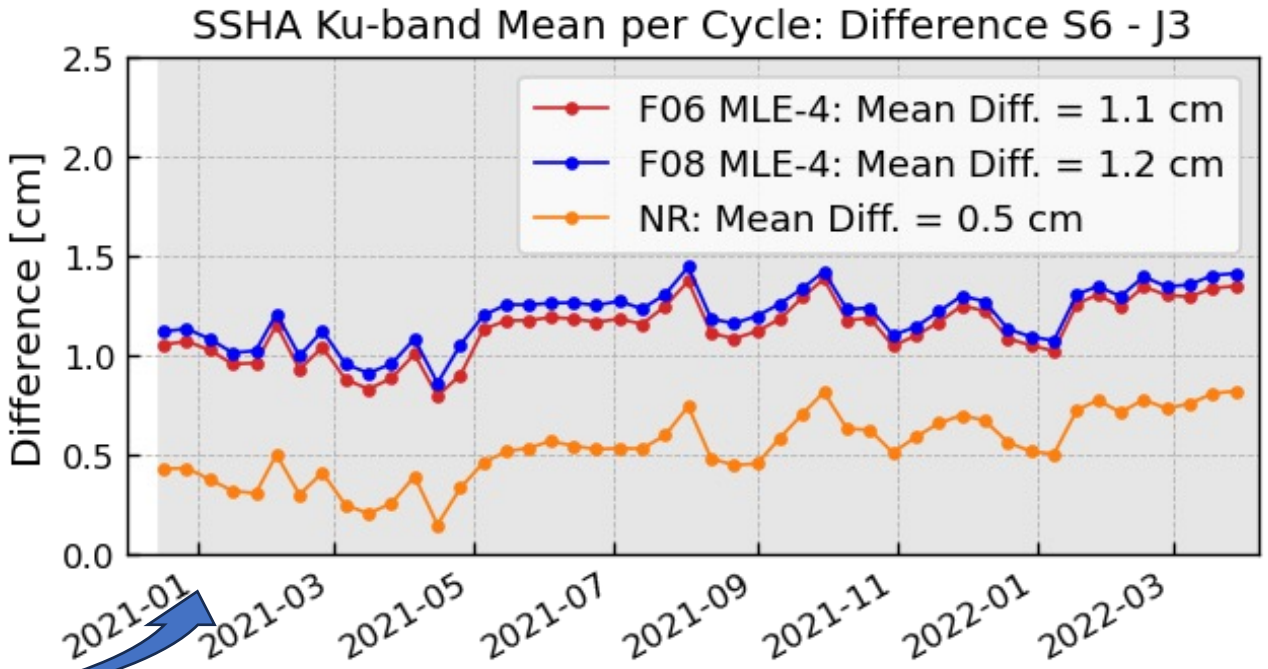


- No significant drifts between MLE-4 and NR for both altimeter sides.
- MLE-4 ranges are shorter than NR ranges: bias of 6.6 mm for side A, 5.6 mm for side B.

Sentinel-6A in Tandem with Jason-3: F06 vs. F08

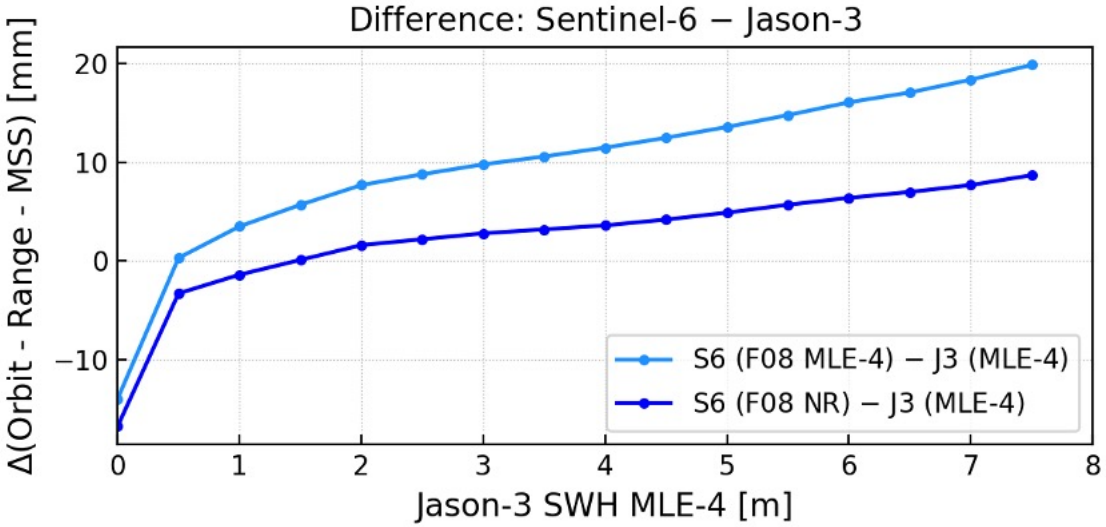
Sea Surface Height Anomaly



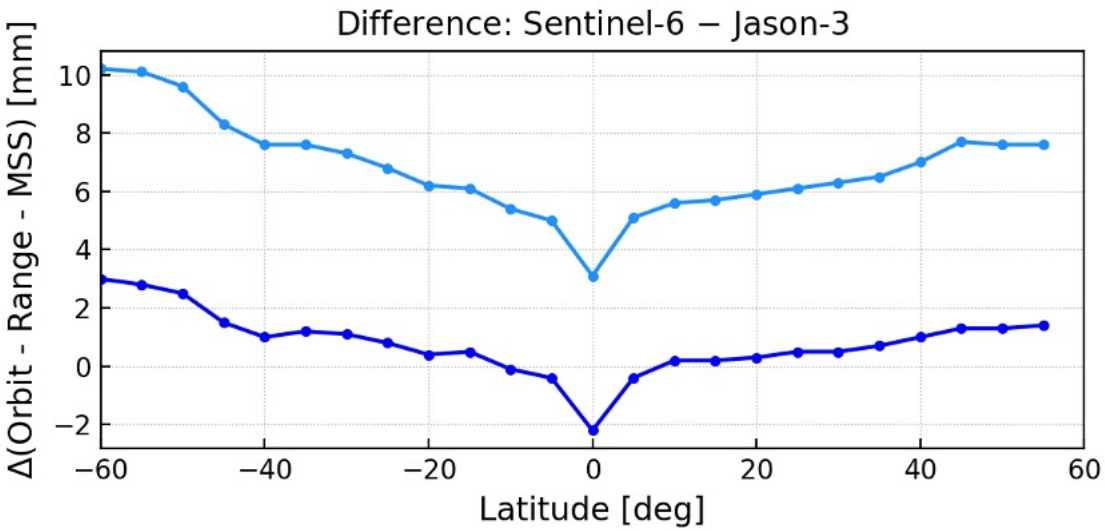


Overall good consistency. NR has smaller bias relative to Jason-3

Sentinel-6A in Tandem with Jason-3: Orbit – Range Ku – MSS



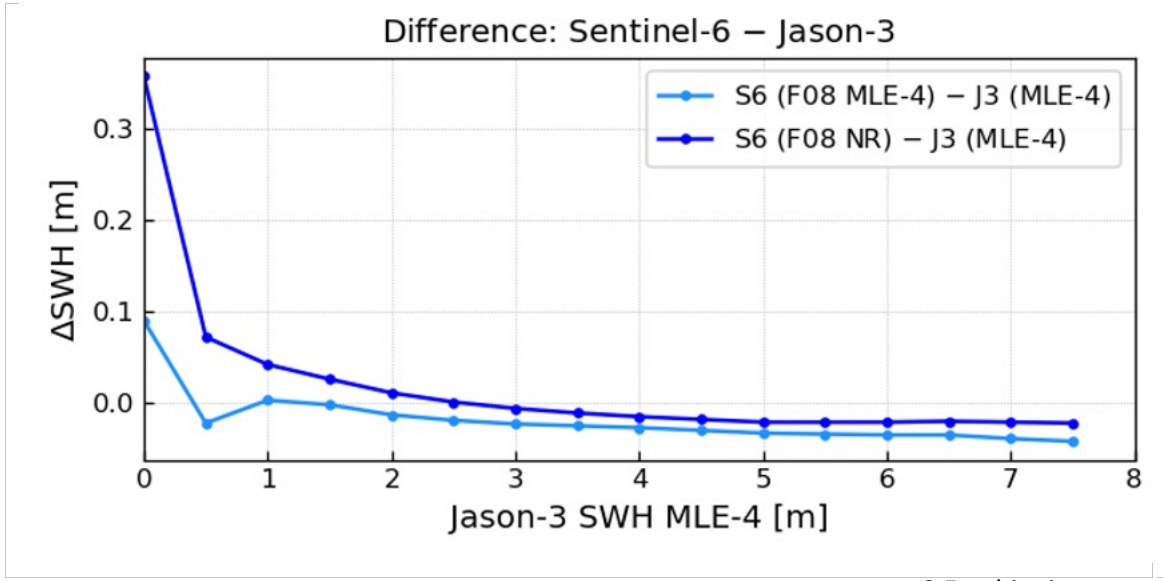
0.5 m binning



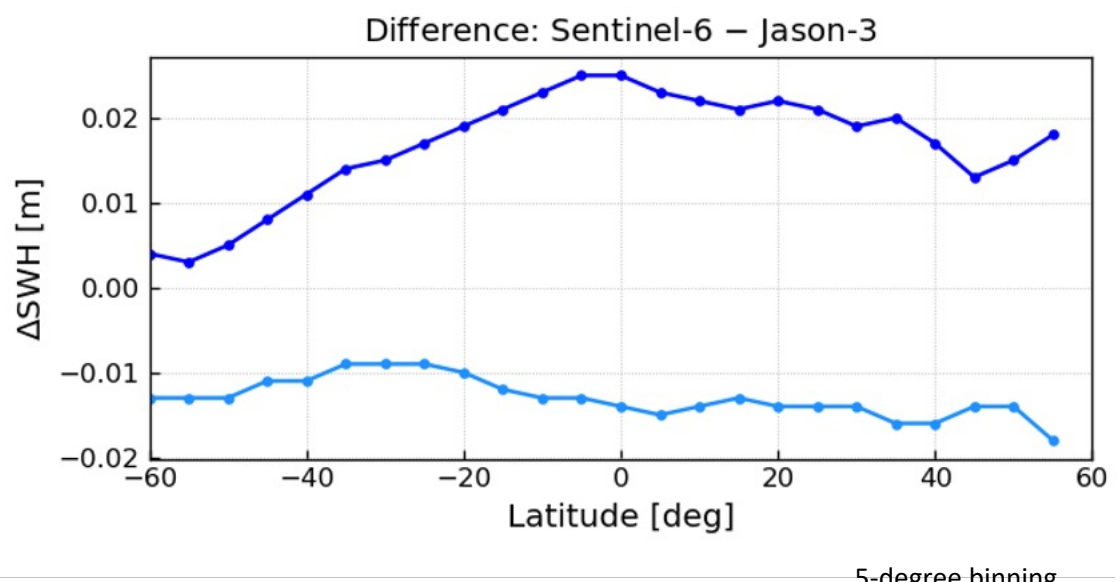
5-degree binning

- NR shows closer alignment with Jason-3 than MLE-4 (2.5 mm vs. 8 mm) and flatter difference both as a function of SWH and latitude.
- Equatorial signal still evident in the difference and is centered around 3 degrees North (believed to come from Jason-3, still under investigation).
- No identifiable difference between F06 and F08 in range (not shown here).

Sentinel-6A in Tandem with Jason-3: Significant Wave Height



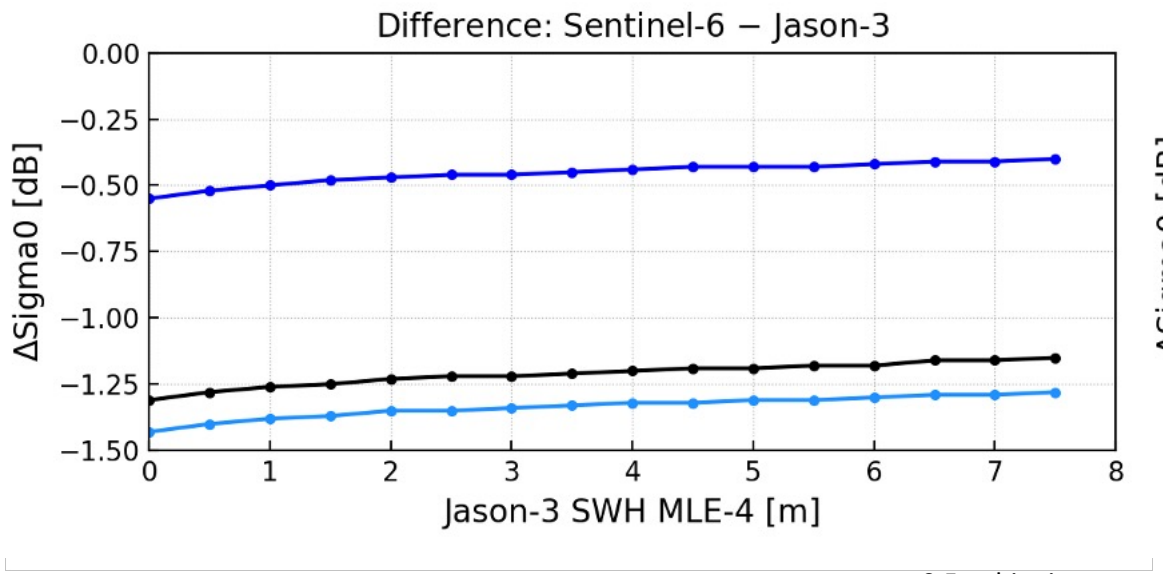
0.5 m binning



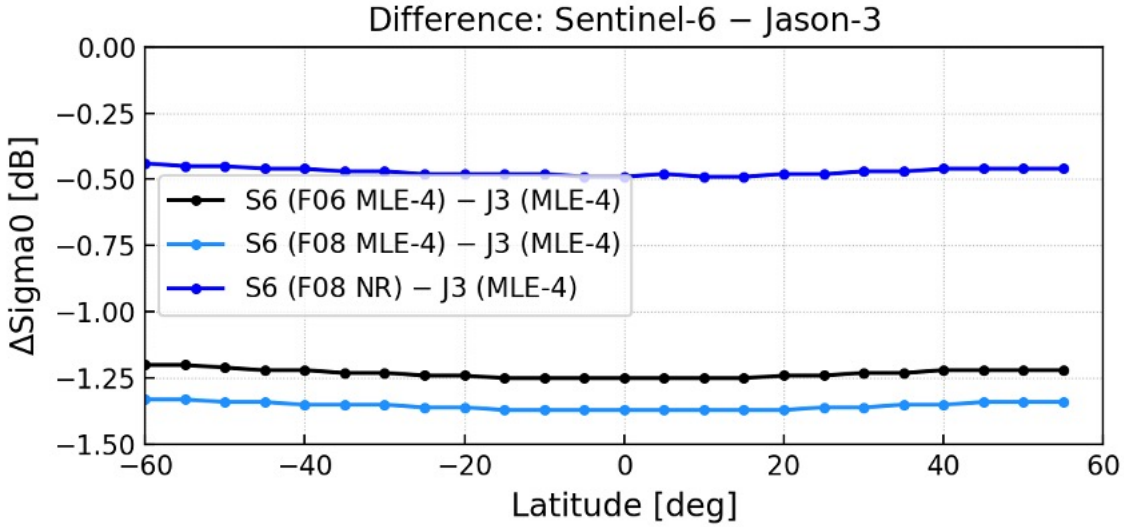
5-degree binning

- Compared to MLE-4, NR shows larger difference with Jason-3 and a larger latitude dependency (due to processing error for S6A F08 in 20Hz to 1Hz SWH compression).
- No difference between F06 and F08 for MLE-4 (not shown here).

Sentinel-6A in Tandem with Jason-3: Sigma0 Ku-band



0.5 m binning



5-degree binning

- Small bias between F06 MLE-4 and F08 MLE-4 products due to updated antenna aperture (about 0.1 dB impact).
- NR is much closer to Jason-3 estimation in terms of bias with similar behavior as for MLE-4.

Conclusions

1. Sentinel-6 comparison F06 vs. F08:
   - **Similar performance** for F06 compared to F08. Overall performances are within requirements when compared to crossover RMS.
   - **SSHA evolution is almost the same**, except a very subtle change due to the antenna aperture update in the retracking
   - **Correction of radiometer calibrations** for AMR **removed drift** in wet path delay w.r.t. ECMWF model. Remaining jump in AMR vs. model difference is due to the model update on 31 Oct 2021 .

2. Sentinel-6 comparison with Jason-3 highlights improvement of NR over MLE-4:
   - **Consistency with Jason-3 is improved by using NR results**.
     (Except for SWH in low SWH conditions due to a known bug in 1-Hz compression).
   - Improved consistency most apparent for comparing MLE-4 vs. NR altimeter parameters as functions of SWH and latitude.