National Aeronautics and Space Administration

Global Cross-Calibration of the Jason-3 and Sentinel-6 Michael Freilich Missions during their Tandem Period

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Introduction

Here, we present results from the cross calibration of measurements from the Sentinel-6 NTC (F06) and Jason-3 GDR-F products. In particular, we focus on the overall statistics of the measurements from the altimeter (both Ku- and C-band) and radiometer. This includes range, significant wave height, backscatter, and wet troposphere delay. We also investigate the overall system performance and the effects of different orbits solutions on sea level height measurements over the tandem period.

Crossover and Collinear Analysis

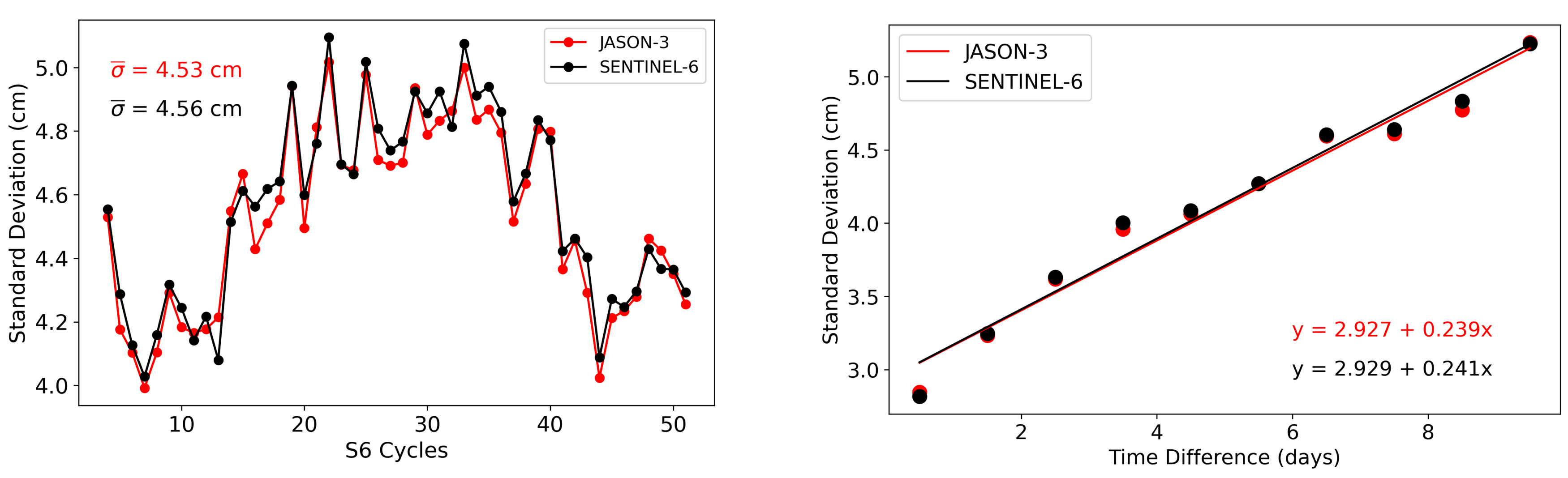


Figure 1. Standard deviations of Sea Surface Height Anomaly (SSHA) differences for Jason-3 (GDR-F) and Sentienl-6 (NTC-F06) over the tandem period from crossover differences of ascending and descending passes. Left figure shows the temporal evolution of the standard deviation of the SSHA crossover differences. Right figure shows standard deviation of SSHA crossovers as a function of time between measurements (1-day bins) and a fitted function to obtain the system noise level at dt = 0 (intercept). Both missions show close agreement in performance.

Variable	Mean Side-A	Mean Side-B	Std÷√2 Side-A	Std÷√2 Side-B	Req/Goal
Ionosphere (*) (cm)	0.25	0.32	0.31	0.32	0.5/0.3
Ku-Band SSB (cm)	-0.02	0.06	0.43	0.43	2.0/1.0
C-Band SSB (cm)	-0.03	-0.09	0.55	0.54	N/A
Dry troposphere (cm)	0.00	0.00	0.00	0.00	0.7/0.5
Wet troposphere (cm)	0.00	0.01	0.00	0.01	1.0/0.8
Orbit - Range(Ku) - MSS (cm)	-0.69	-0.81	2.36	2.32	3.2/1.6 (**)
Orbit - Range(C) - MSS (cm)	0.71	0.57	6.78	6.67	N/A
Orbit - Range(Ku) - MSS - SSB (cm)	-0.69	-0.76	2.19	2.10	3.78/2.23 (**)
SSHA (cm)	-1.08	-1.21	2.21	2.16	3.2/2.00
SWH (cm)	1.00	1.36	11.65	11.43	15/10
Ku-Band Sigma-0 (dB)	1.24	1.21	0.10	0.10	0.3/NA
Altimeter Wind Speed (m/s)	-0.04	0.05	0.30	0.30	1.5/1.0

Table 1. Global statistics of 1 Hz collinear differences between Jason-3 (GDR-F) and Sentinel-6 (NTC-F06) over the tandem period. The reported statistics are computed from the average of the cycle mean and associated standard deviation for Side-A/B. (*) Stands for filtered Ionosphere and (**) is RSS or the individual orbit, range and SSB errors respectively. Orbit - Range - MSS (J3-S6) difference show higher standard deviation than SSHA. Applying SSB provides standard deviation inline with SSHA. Ionosphere bias consistent with relative Ku- and C-band range biases (e.g., 0.1798 x (0.69 - (-0.71)) = 0.25 cm.

Altimeter Range Comparison

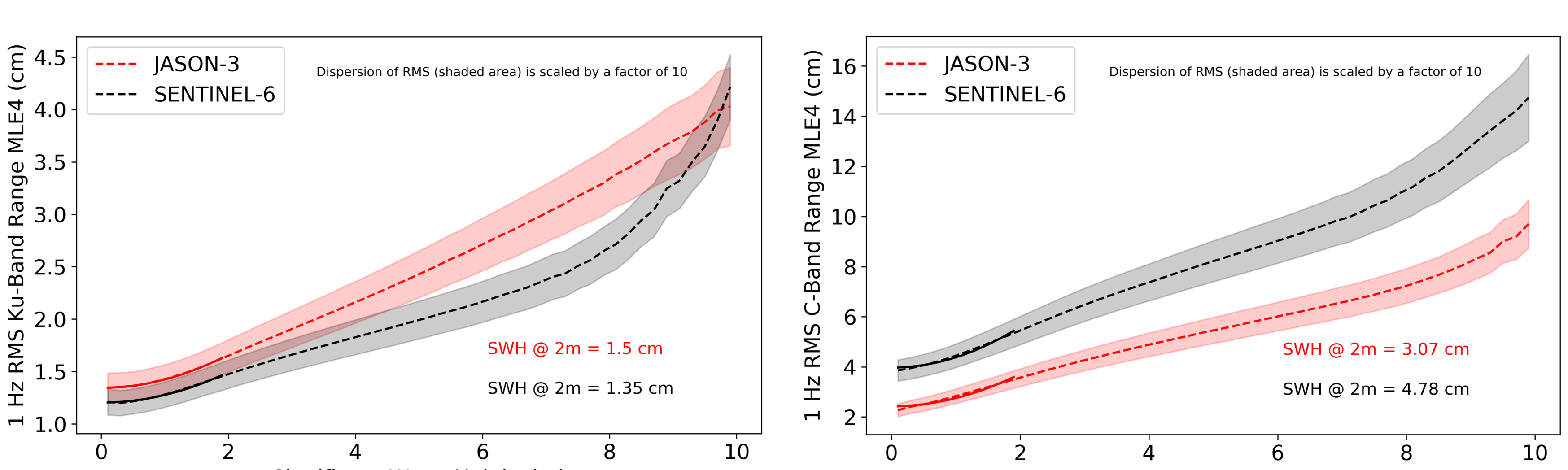


Figure 2. RMS of 20 Hz retracked Range as a function of Significant Wave Height (SWH) for Ku and C-band for Jason-3 and Sentinel-6. A noise model ($y = a + bx^2$) is fit to the RMS (0 < SWH < 2 m) and evaluated at SWH = 2 m. Sentinel-6 shows good overall performance with reference to Jason-3 in Ku-band for all SWH intervals. While for C-band a clear difference in magnitude of the RMS can be observed. Y-axis shows 1 Hz RMS divided by √19.

Time Tag Bias from Crossover Analysis

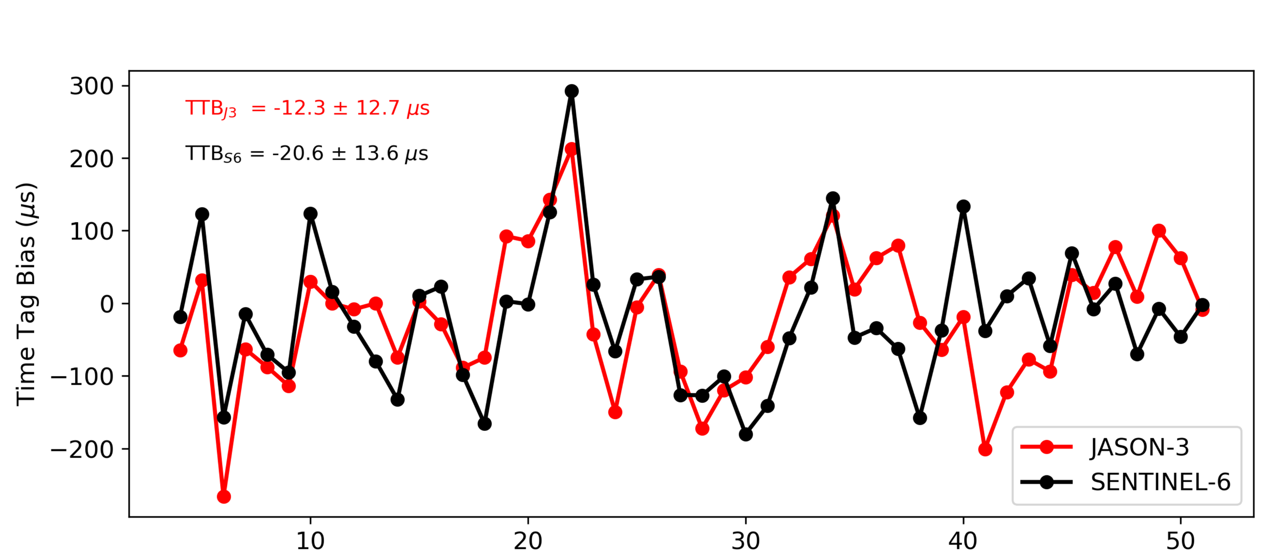


Figure 3. Time tag bias (TTB) estimated from N-1/N/N+1 crossover analysis (dt < 10 days) over the tandem period. Statistics are compute for the entire tandem period in the form of mean TTB and corresponding scaled standard deviation (1σ) Both missions shows good agreement both in magnitude and variability over the tandem period.

Sea Surface Height Anomaly Comparison

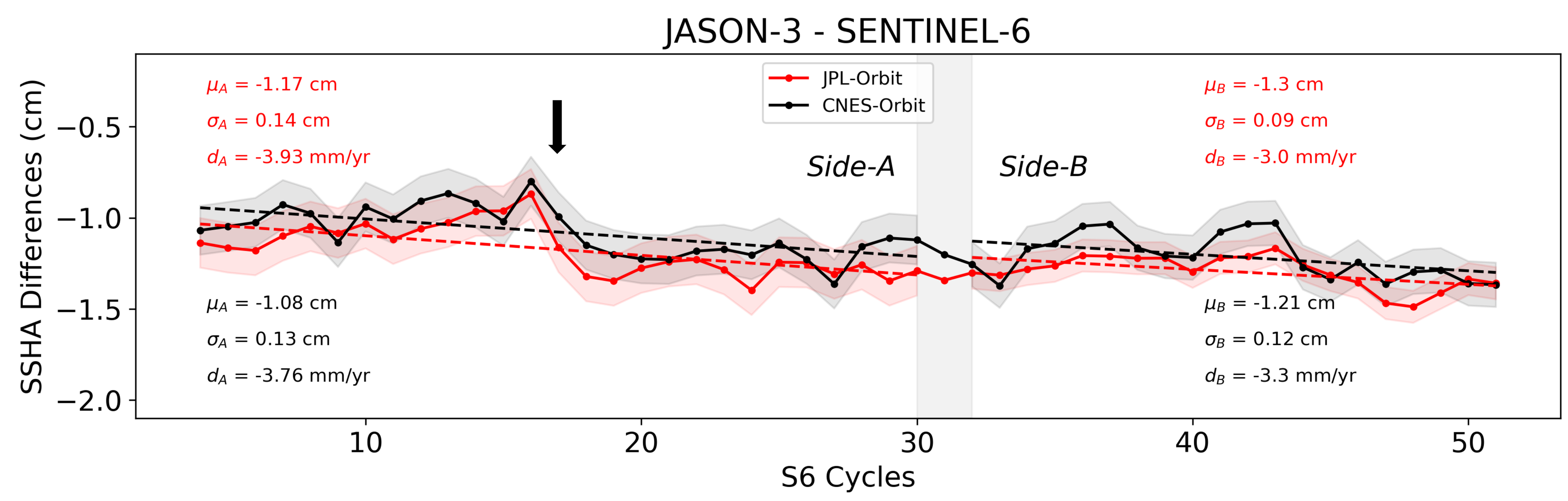
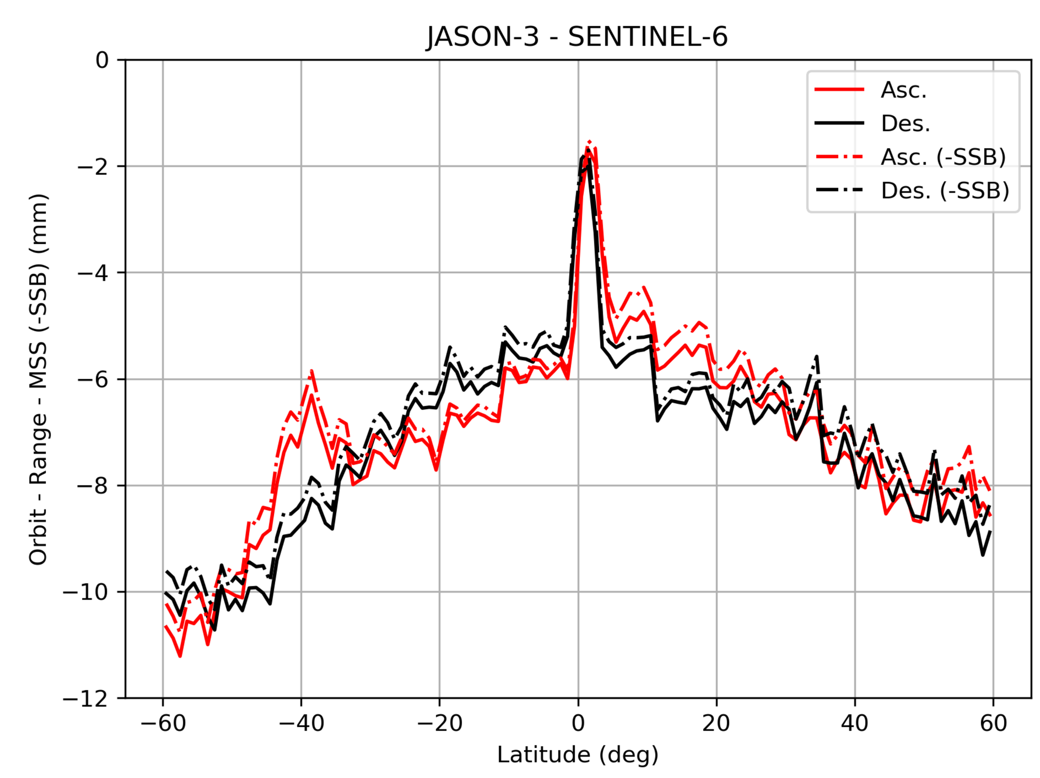
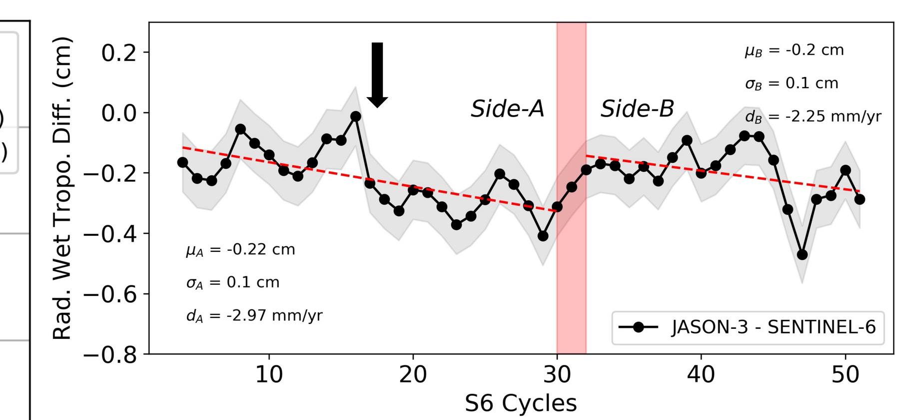


Figure 4. Collinear differences of SSHA for Jason-3 - Sentinel-6 with corresponding statistics (offset, standard deviation and drift) separated for Side-A and Side-B for both the CNES and JPL orbits. Notable decrease in SSHA difference around Cycle-16 of ~4 mm and a 60-day cycle in the CNES orbit. The ~4 mm differences is a combination of changes in the the radiometer wet troposphere correction (2 mm as shown below) and the retracked range (2 mm as shown below).





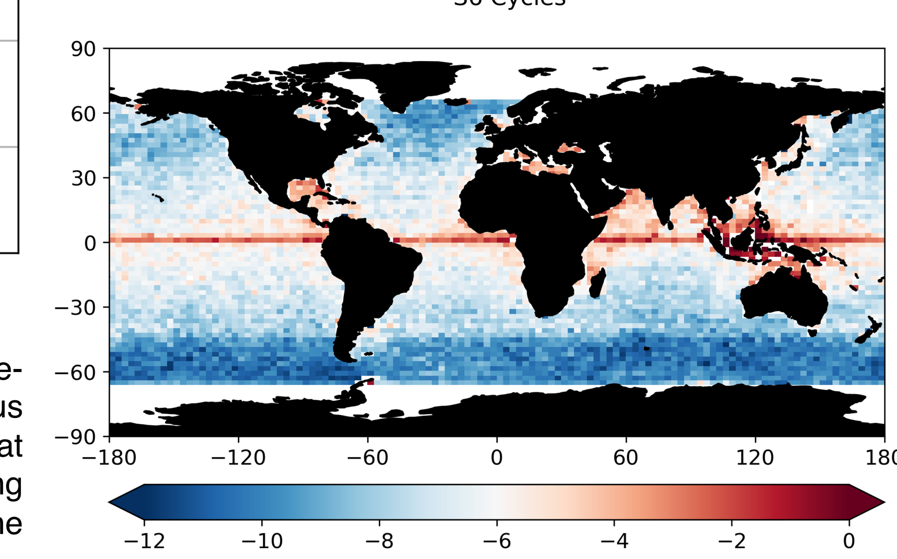


Figure 5. Jason-3 – Sentinel-6 collinear differences of Orbit-Range-MSS and minus SSB as a function latitude for Ku-band. Anomalous long-wavelength latitudinal variation in differences. 4 mm bumps at equator for both ascending and descending, and 40S for ascending only. The equatorial signal is clearly evident in spatial pattern of the differences of the combined A/D passes.

Orbit Solution Comparison

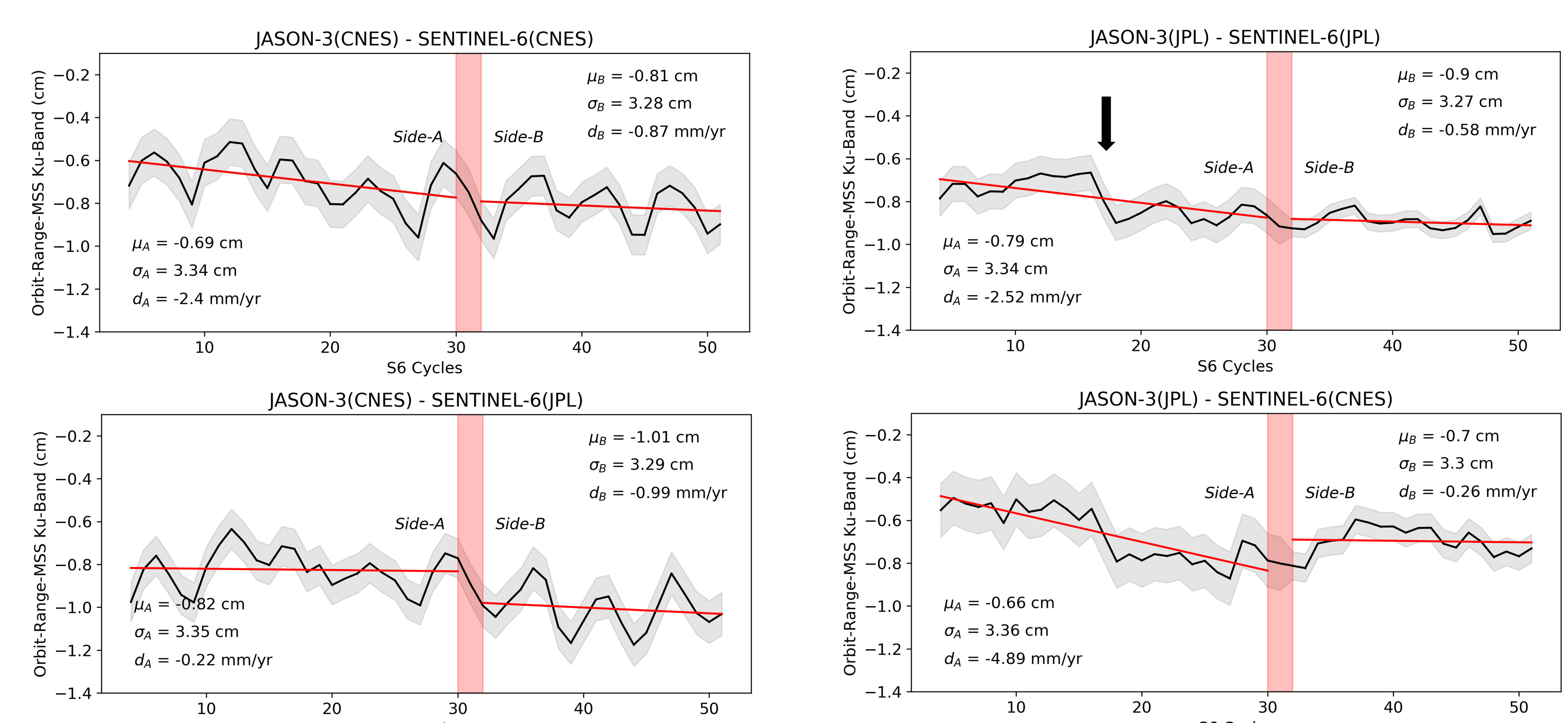


Figure 6. Orbit-Range-MSS of collinear differences using different orbit solutions. 60-day cycle (beta-prime) seen in CNES/CNES differences and can be traced back to the Jason-3 CNES solution. Noticeable is a ~2 mm drop in Orbit-Range-MSS around Cycle-16, which can be seen in the JPL/JPL-orbit comparison, but is masked by the 60-day cycle in the CNES/CNES solution.

Key Take Aways

- ❑ Tandem period suggests Jason-3 and Sentinel-6 are both performing better than their requirements.
- ❑ Anomalous signals observed in "Orbit - Range - MSS" and SSHA differences.
  - ❑ Long-wavelength latitudinal signal, and bumps at the equator and 40S (ascending only).
- ❑ Detected 60-day "Beta-Prime" variation in the Jason-3 CNES orbit (GDR-F POE).
- ❑ Observed jump in SSHA (~4 mm) at Cycle-16 related to changes in AMR (~2 mm) and Range (~2 mm).
- ❑ Global analysis suggest "Orbit - Range - MSS – SSB" is more suitable for comparing Jason-3 and Sentinel-6 differences.

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