Independent and intermission validations of Jason-3, Sentinel-6 Michael Freilich and Sentinel-3A/B

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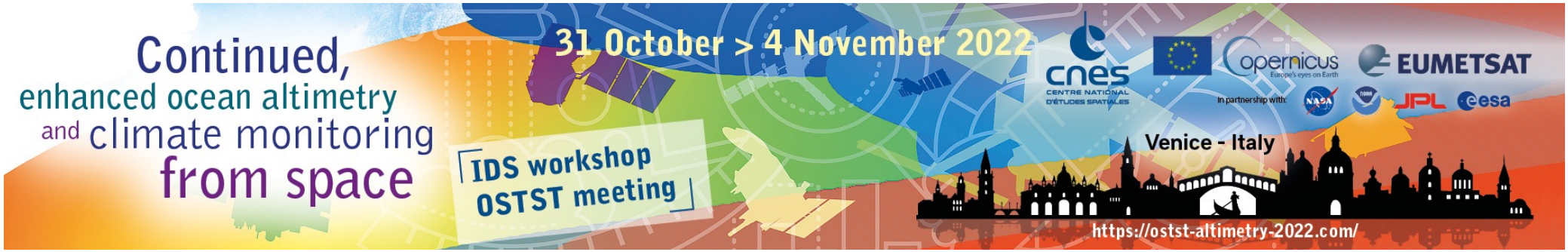
NOAA Laboratory for Satellite Altimetry

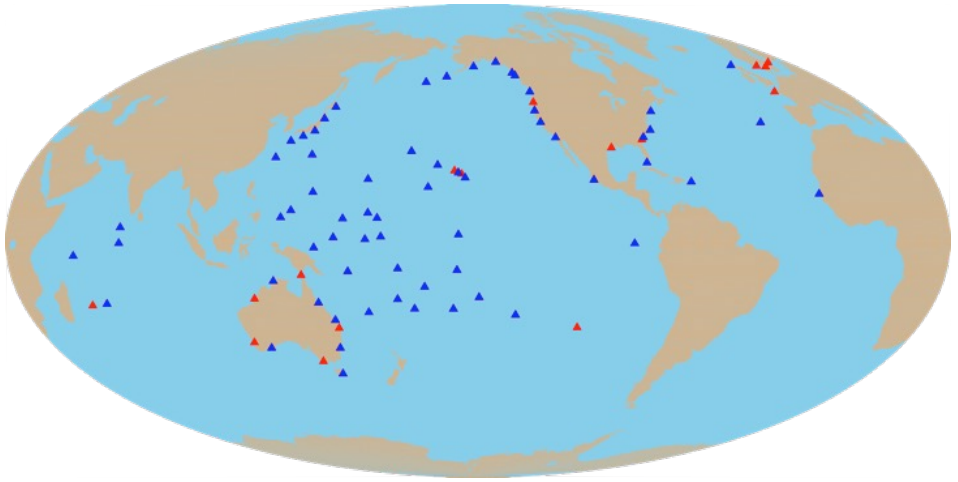


Tide gauge comparisons

NOAA Altimeter/tide gauge comparison system

Methodology

- Modified method of Mitchum [2000]
- Use multiple passes near each gauge, adjust for time/space lags and combine with a covariance weighted least squares
- Vertical land motion estimates from GNSS (NGL) and GIA (A, Wahr, Zhong 2013)
- Updated gauge selection



(blue gauges were selected by Mitchum 2000; red gauges were included in Watson et al. 2015)

Tide gauge comparisons

Gauge data from University of Hawaii Sea Level Center (UHSLC)

Up to 69 gauges

Altimeter data from the Radar Altimeter Database System (RADS)

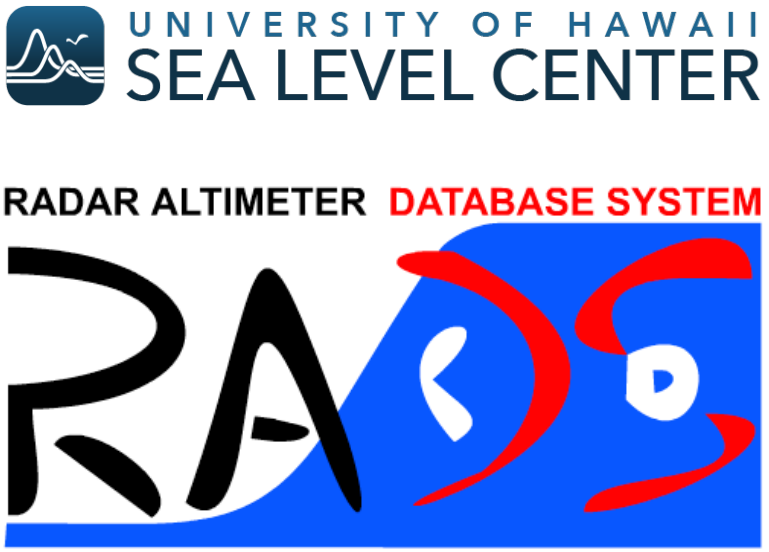
Reference series

Estimate a drift using combination of TOPEX/J1/J2/J3/S6MF (RL06)

Sentinel-3

Comparisons by ½ cycle (13.5 days)

Evaluated Baseline 5



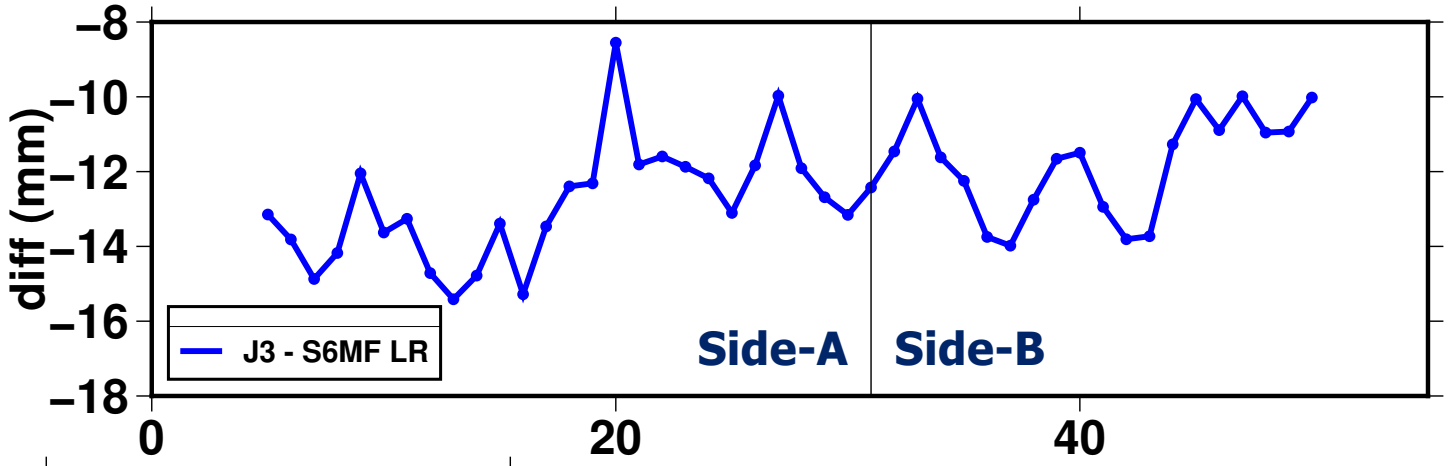
Reference missions

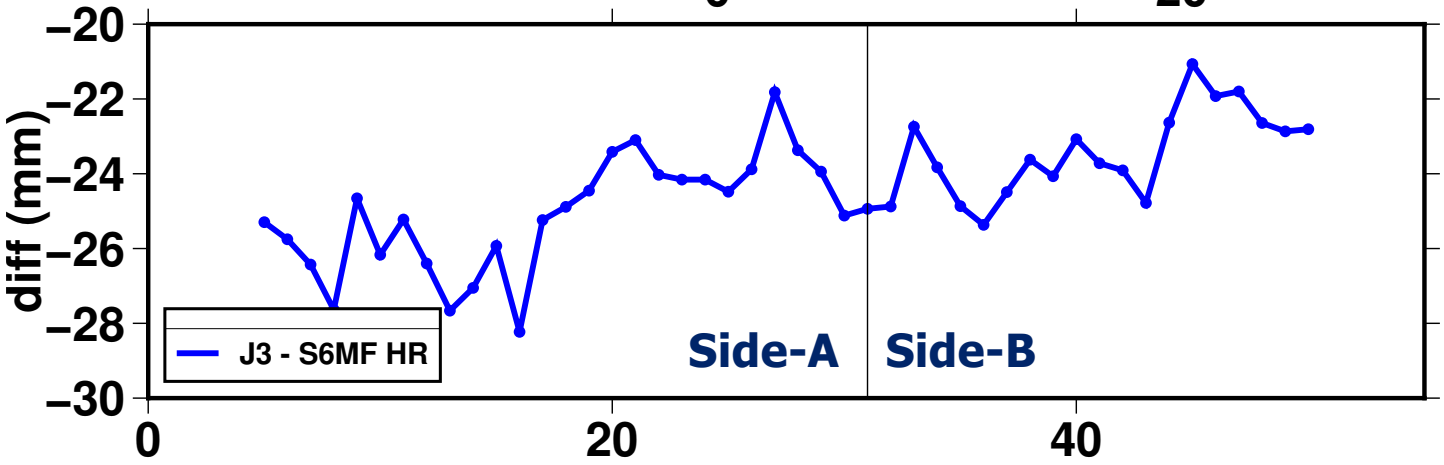
Sentinel-6 to Jason-3 intermission bias

Estimated intermission bias using RADS to determine colinear differences

LR: –12.5 ± 0.5 mm

(95% C.I.; st dev 1.6 mm)



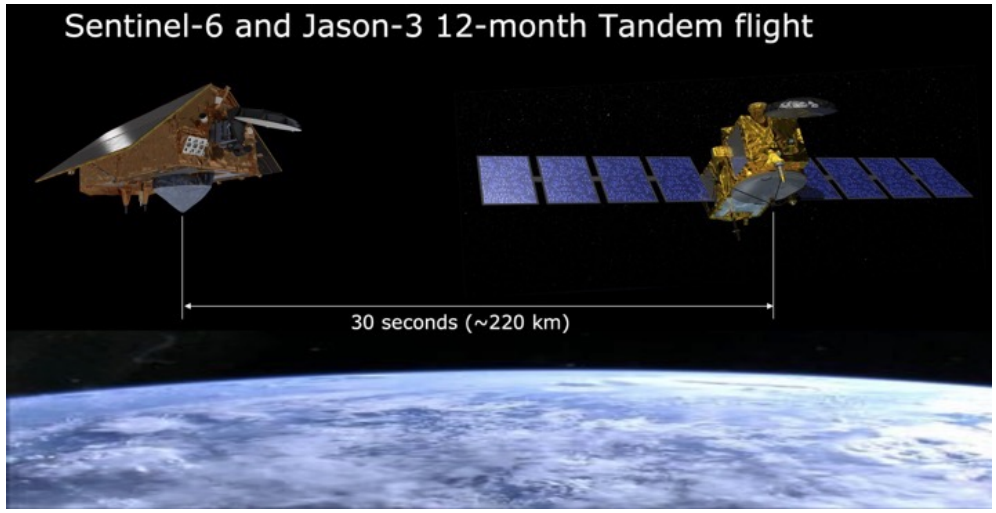


HR: –24.4 ± 0.5 mm

(95% C.I.; st dev 1.6 mm)

Sentinel-6MF to Jason-3 intermission bias

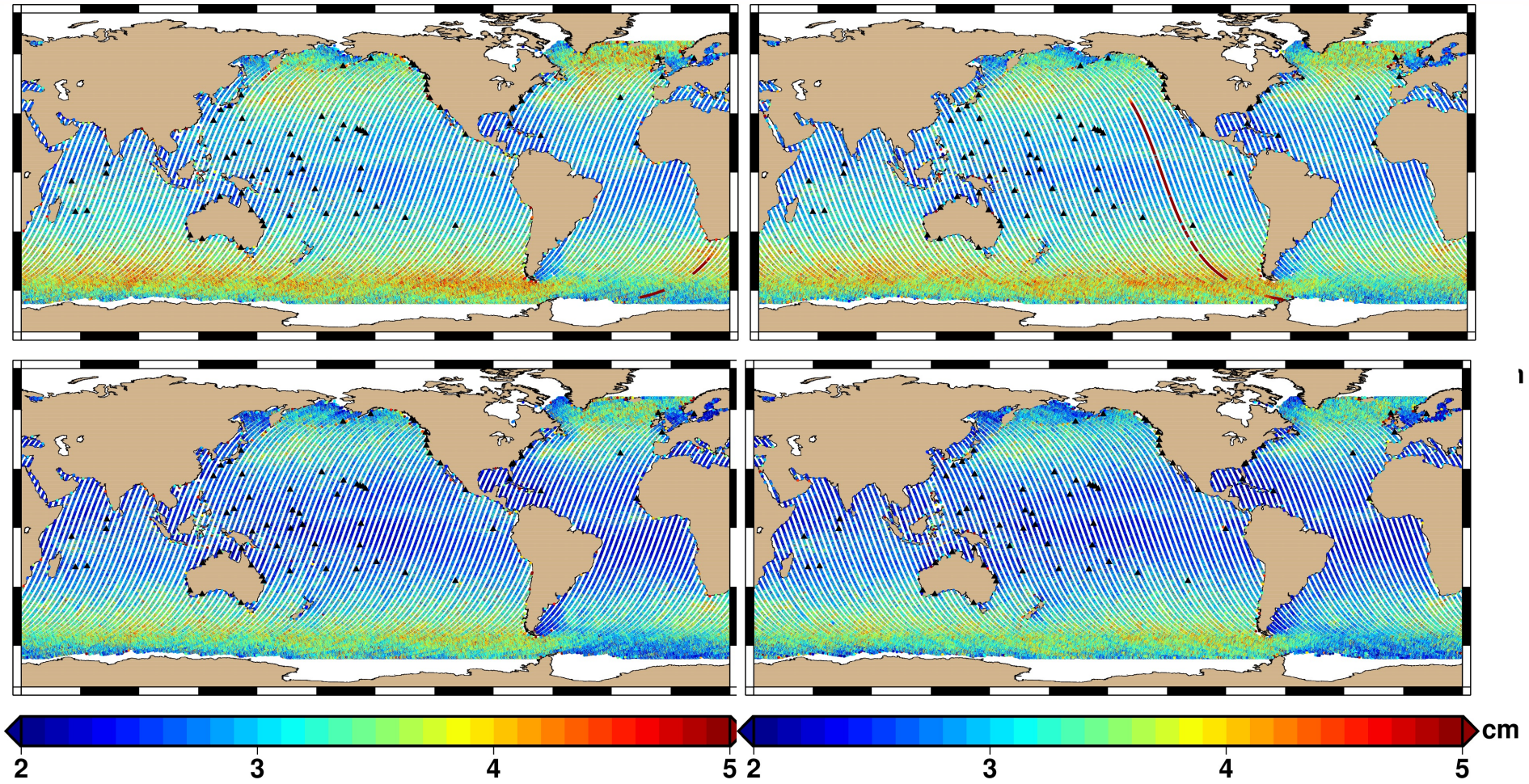
- The global S6MF/Jason-3 biases were withing requirements and stable during the tandem phase, particularly for S6MF side-B.
- However, uncorrected geographically-correlated biases could produce an apparent drift in global tide gauge comparison of the reference series.



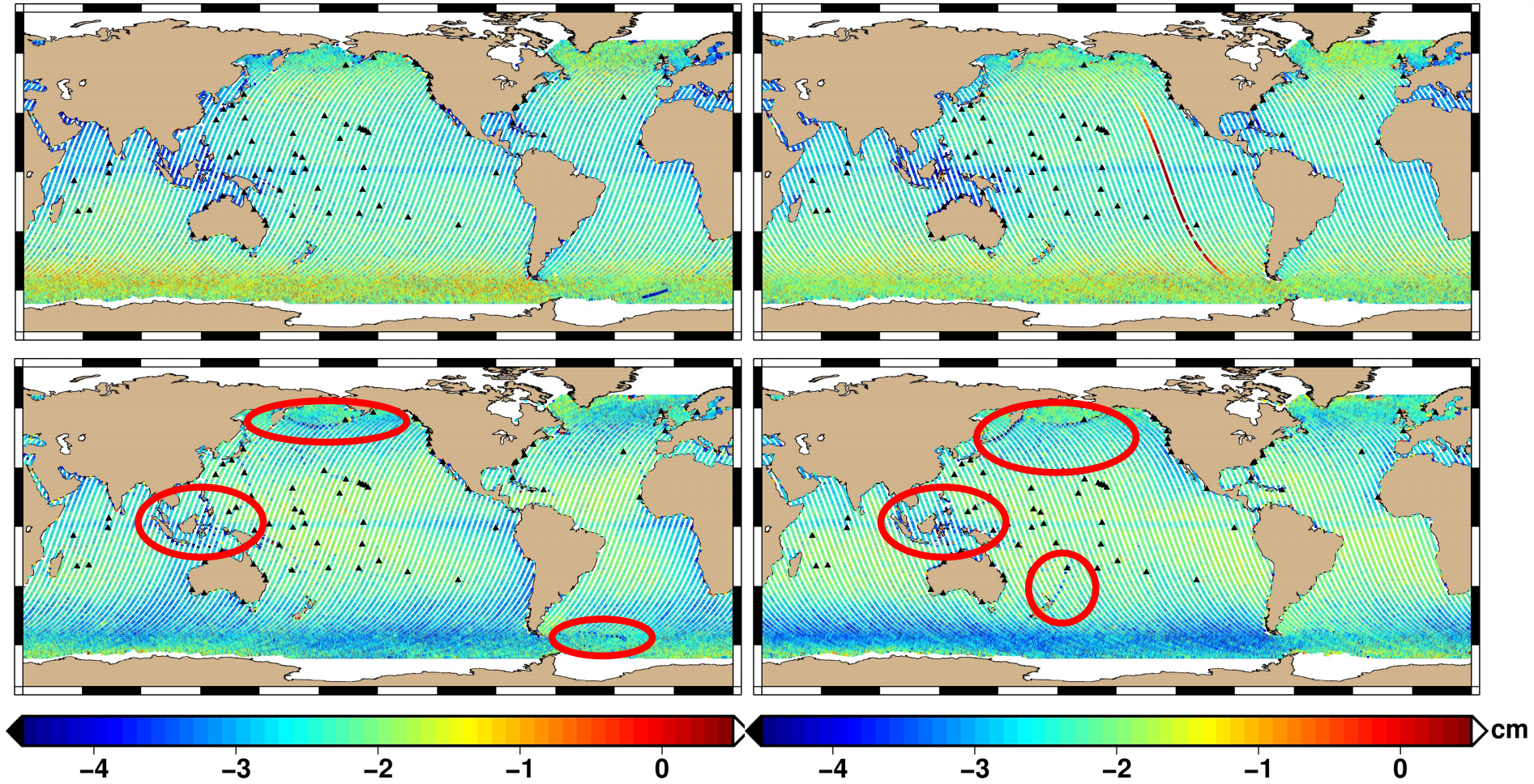
Sentinel-6MF – Jason-3 std. dev. during the tandem phase

LR

HR



Sentinel-6MF – Jason-3 bias during the tandem phase



Along-track slopes from the reference orbit

Along-track slopes from the reference orbit can be estimated from the mean sea surface, geoid, or marine gravity field (Sandwell and Smith).

The S6MF HR – Jason-3 along-track mean biases are 3–4 cm larger at locations of steep slopes in the mean surfaces.

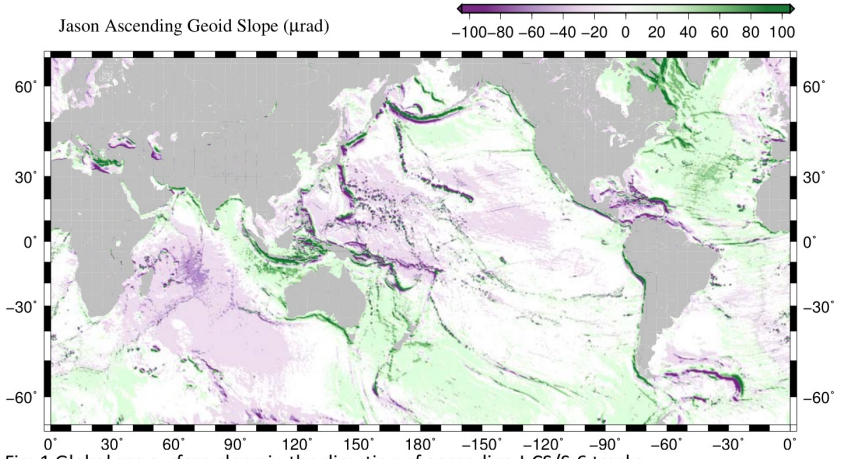


Fig. 1 Global sea surface slope in the direction of ascending J-CS/S-6 tracks.

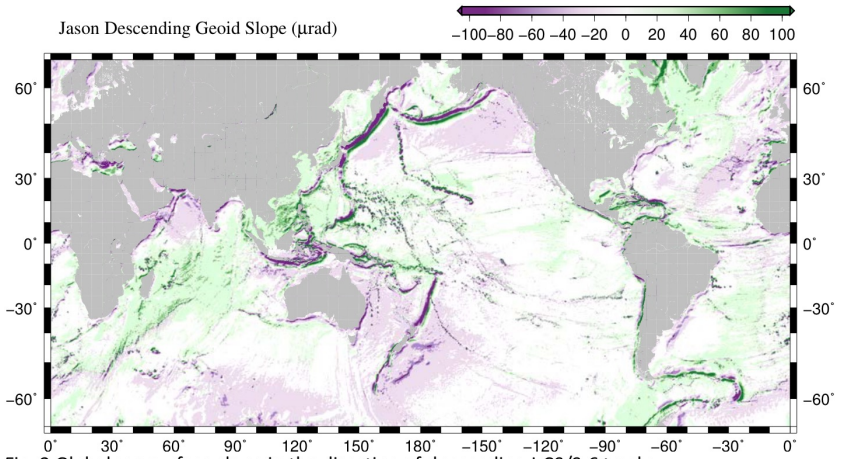


Fig. 2 Global sea surface slope in the direction of descending J-CS/S-6 tracks.

Walter H.F. Smith, memo to the Sentinel-6 Mission Advisory Group, May 2018

Impact on tide gauge comparison

S6MF HR SSH could have small static biases from bin errors in the centroid of the Range Migration Correction, but the S6MF HR – Jason-3 are present both in RAW and RMC cycles.

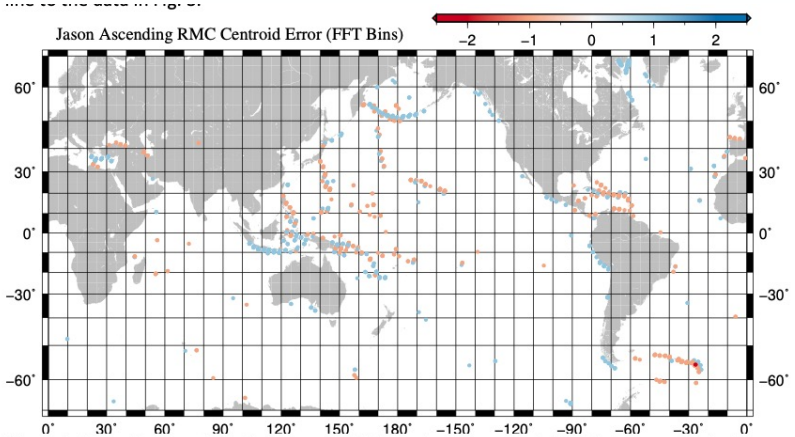


Figure 4. Ascending a-t slope, in Dopper FFT bins, where it exceeds 1/2 bin in magnitude. The largest-in-magnitude effects are near the South Sandwich Islands.

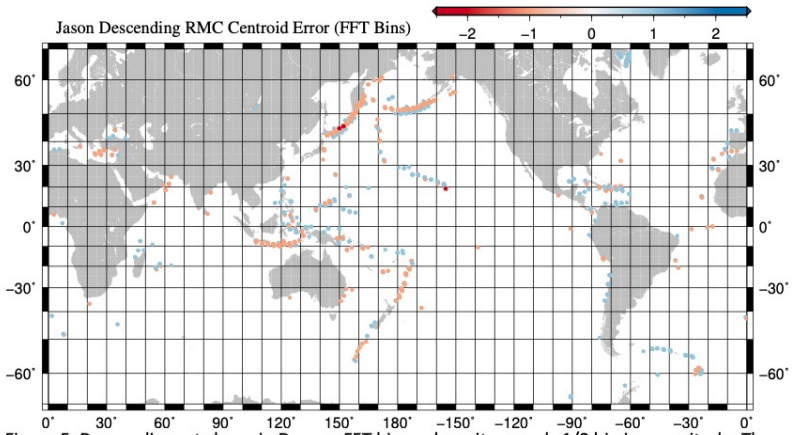
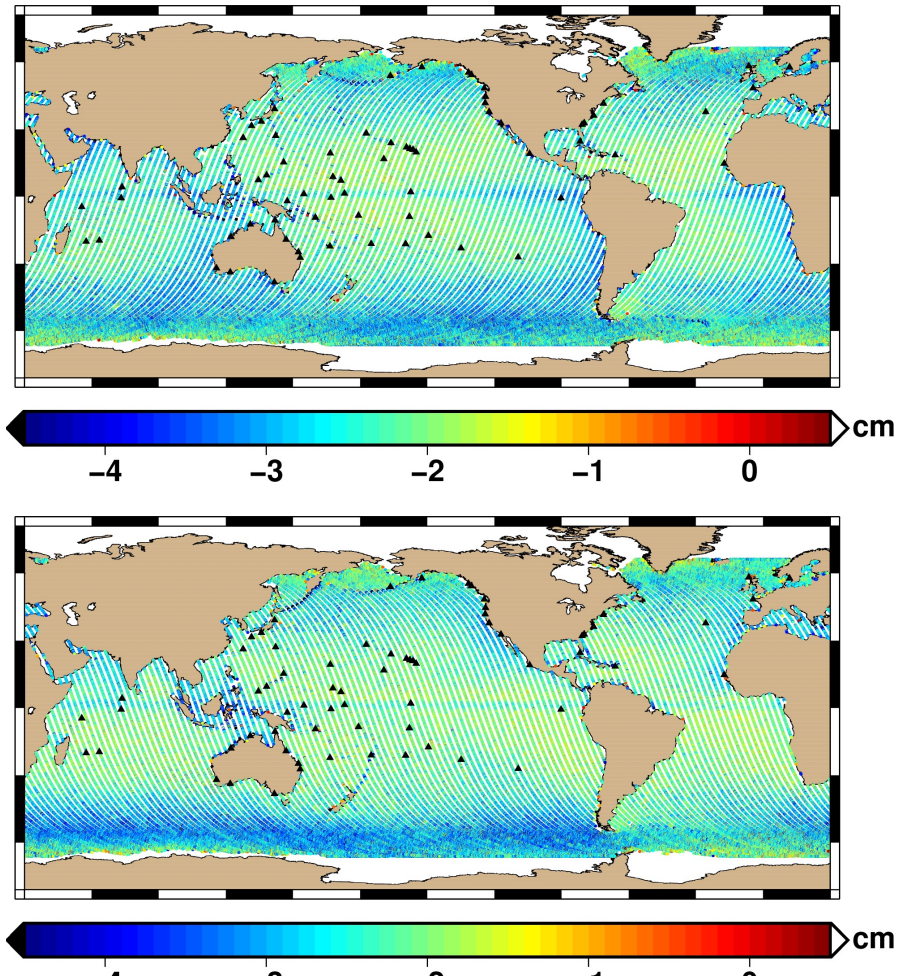


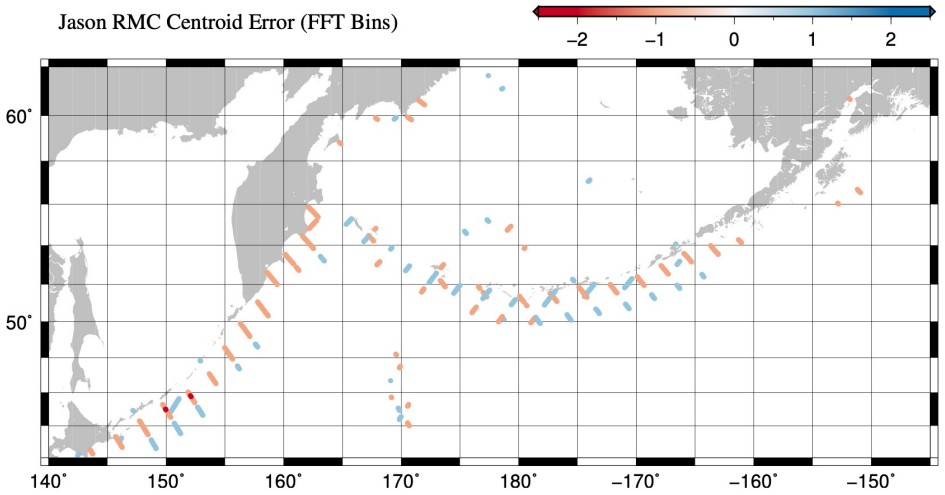
Figure 5. Descending a-t slope, in Dopper FFT bins, where it exceeds 1/2 bin in magnitude. The largest-in-magnitude effects are near Hawaii and the Kuril Trench.

Sentinel-6MF HR/SAR – Jason-3 bias



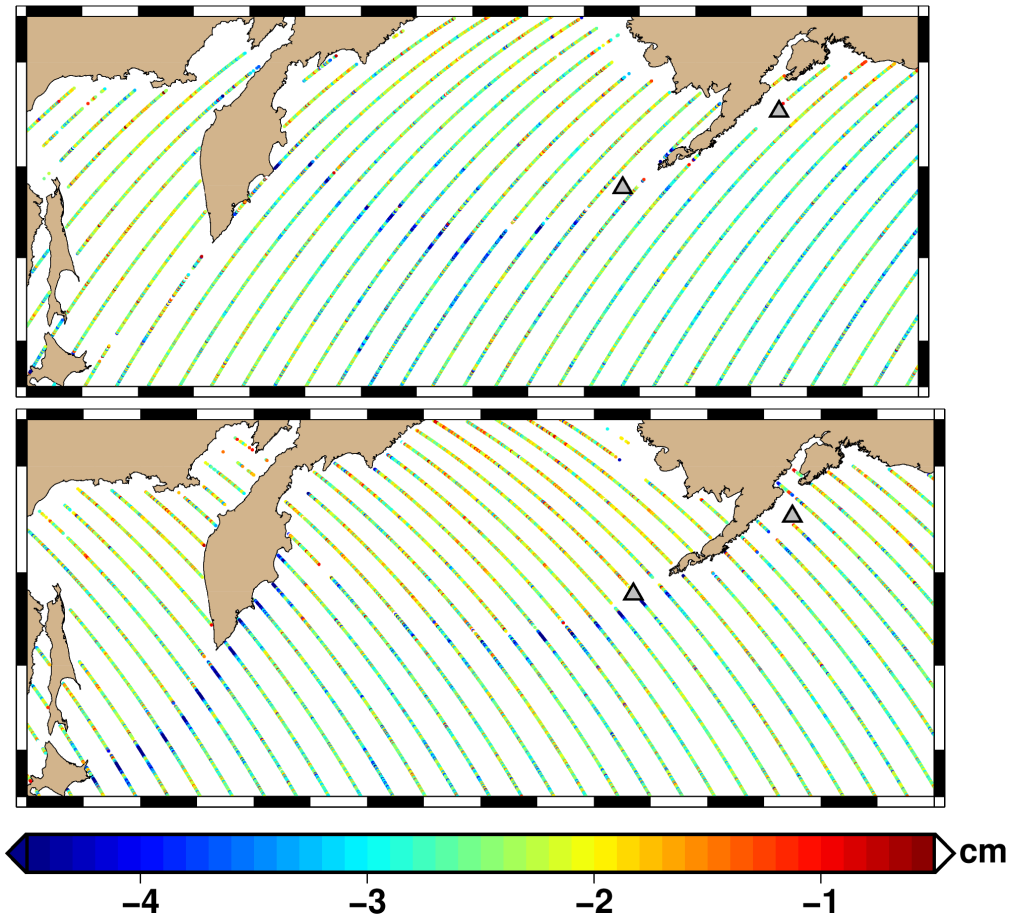
Impact on tide gauge comparison: Aleutian and Kuril trenches

North Pacific Trenches and Seamounts



Many of the tide gauges are on islands where the slope problem would be expected to be large.
One example is Dutch Harbor, Alaska.

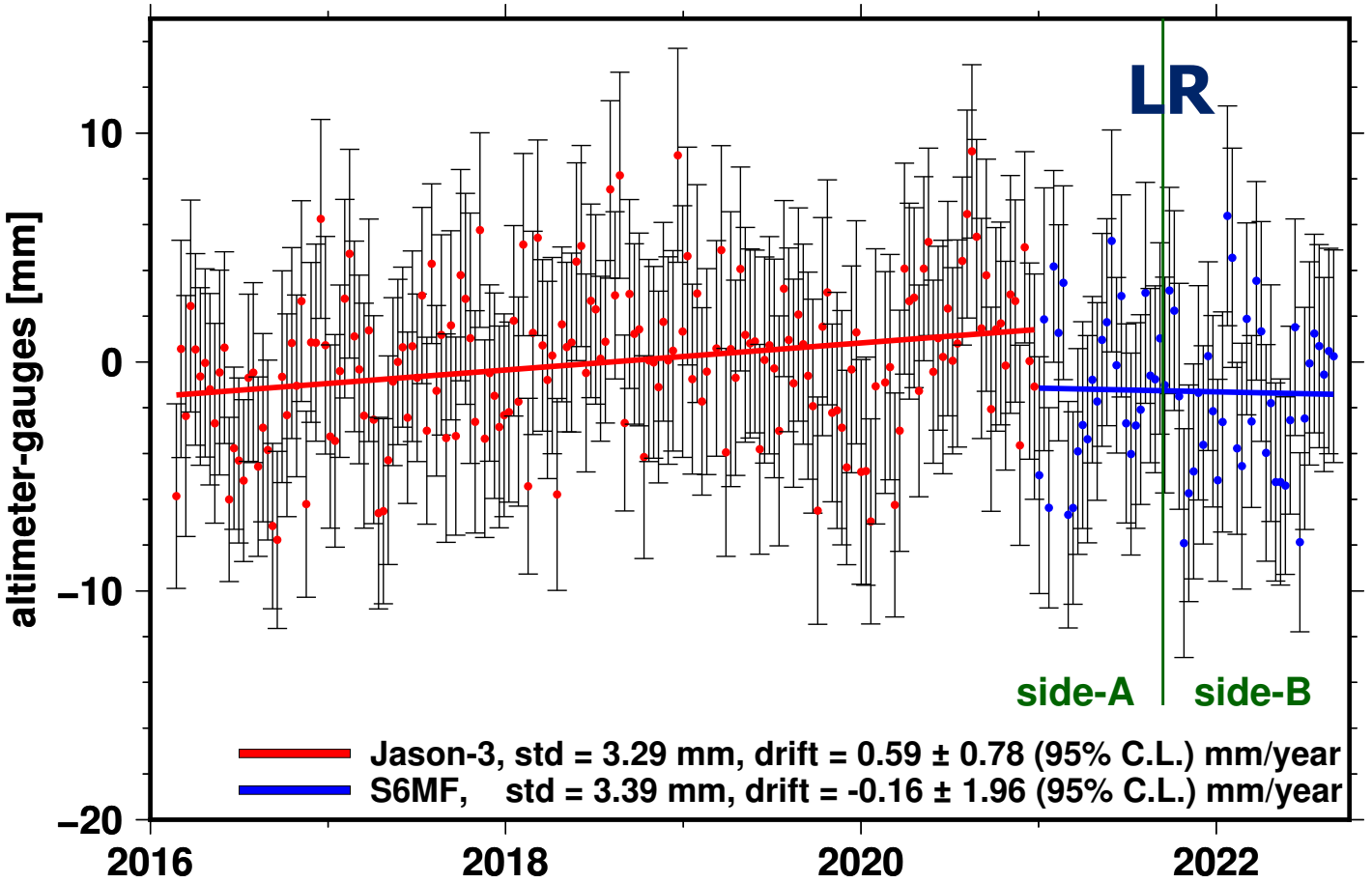
Sentinel-6MF HR/SAR – Jason-3 bias



Tide gauge comparison: Jason-3 and Sentinel-6MF (LR)

No significant drifts in Jason-3 or S6MF LR.

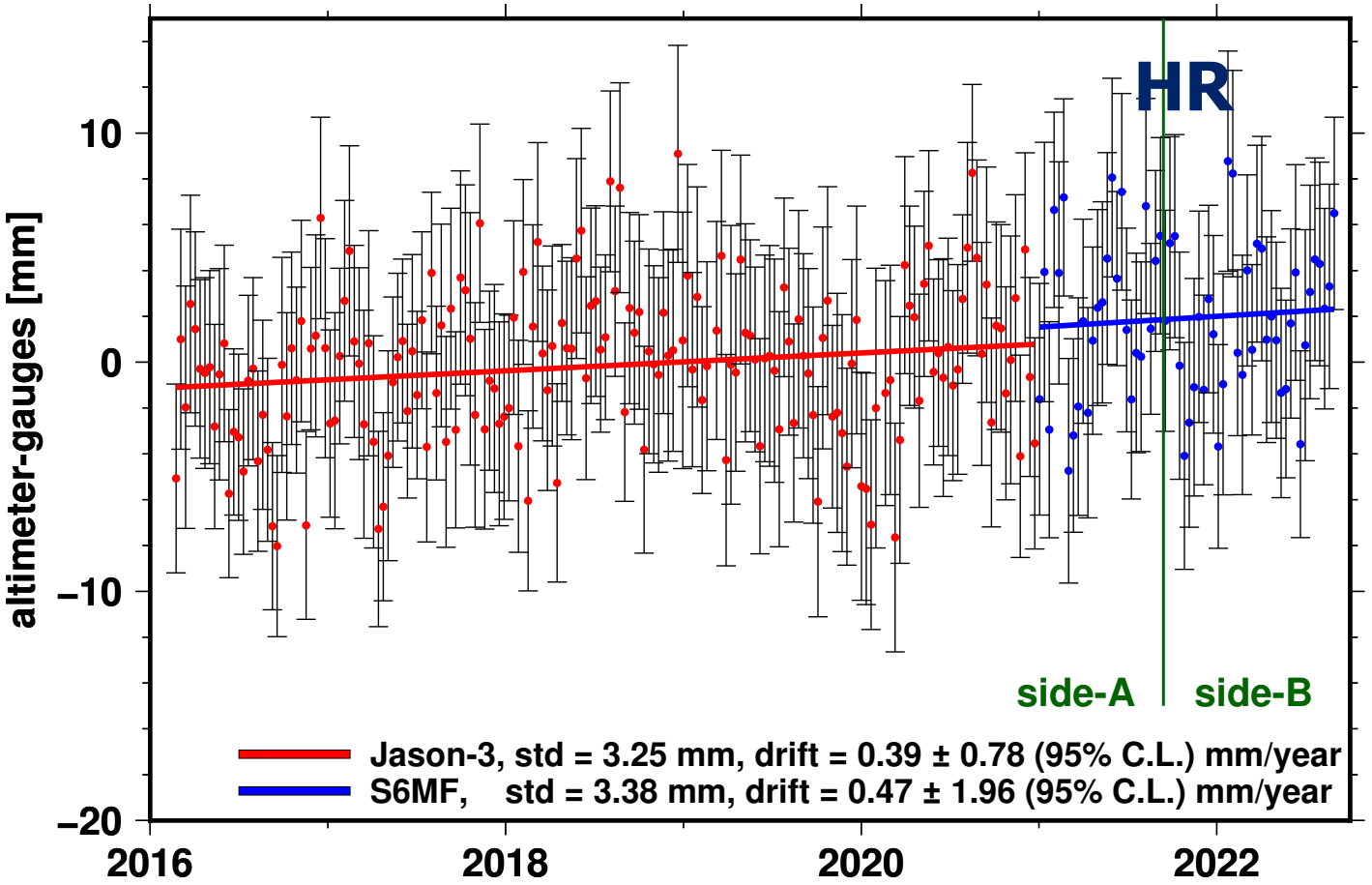
The Jason-3 drift is consistent with a possible wet troposphere drift proposed by Barnoud et al. 2022, *EGUSphere*



Tide gauge comparison: Jason-3 and Sentinel-6MF (HR)

The gauge comparison suggests that the error in the intermission biases between S6MF HR and LR with Jason-3 estimated by all along-track points is 1 to 2 mm.

The geographically-correlated errors may have a limited effect on the gauge comparison.

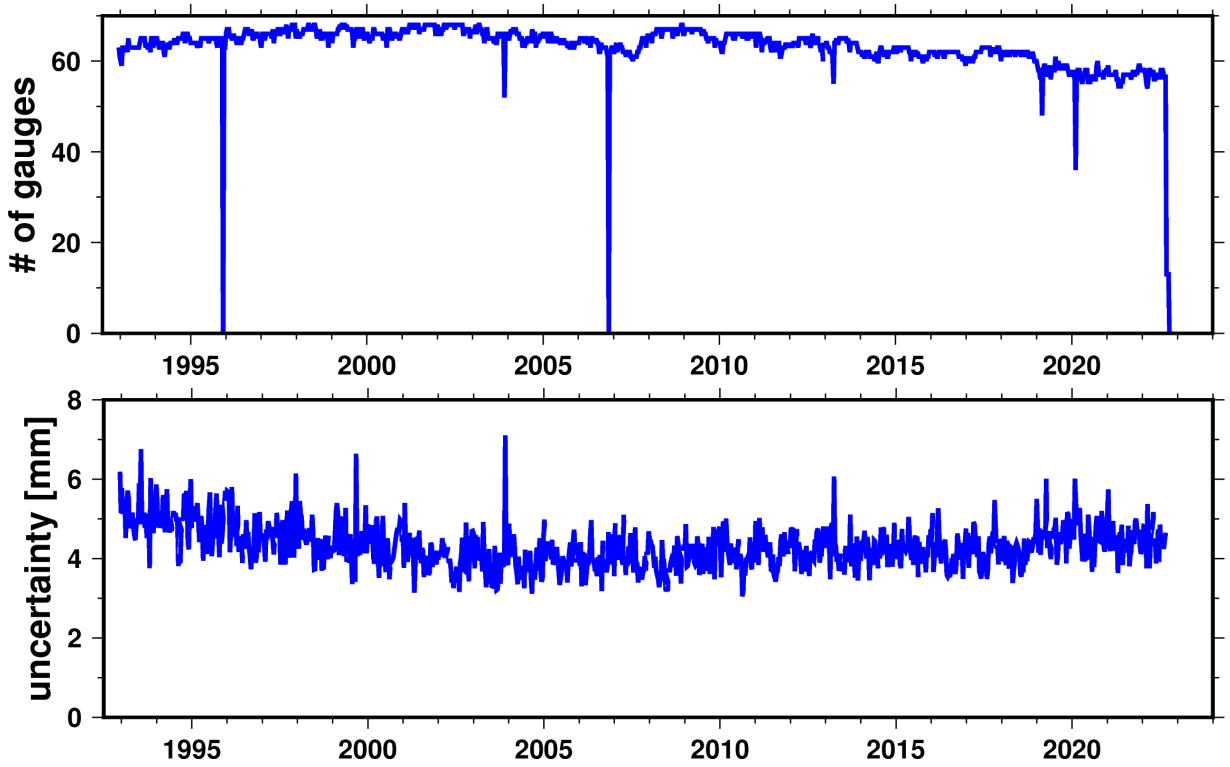


Gauge availability and comparison errors

The number of our selected gauges with available data has been dropping since the 2010 with a decline in 2019.

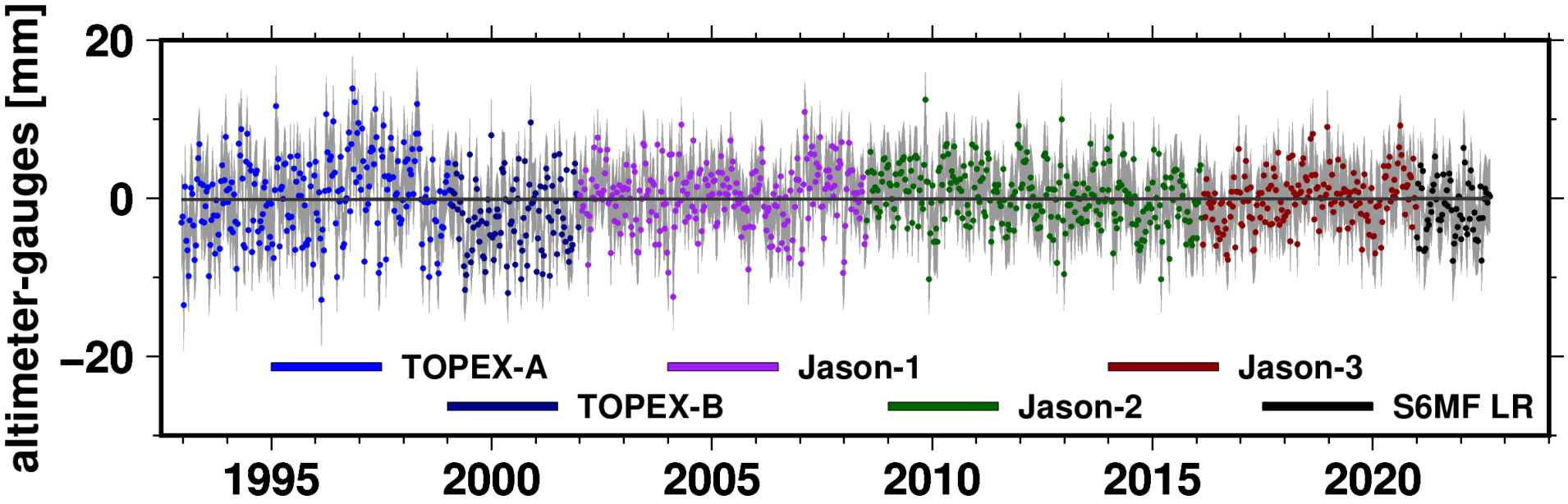
For Jason-1 through S6MF the per cycle uncertainty in the altimeter-gauge bias is ~4 mm.

It has risen slightly since 2019, impacting S6MF comparisons.



30-year reference mission/tide gauge comparison

The residuals from the 30-year reference series record are consistent with no drift (0.0 ± 0.8 mm/year, 95% CI)



Sentinel-3

Baseline 5 available for 2017/2018 and July 2022 to present

Crossover analysis: Sentinel-3A/Jason-3

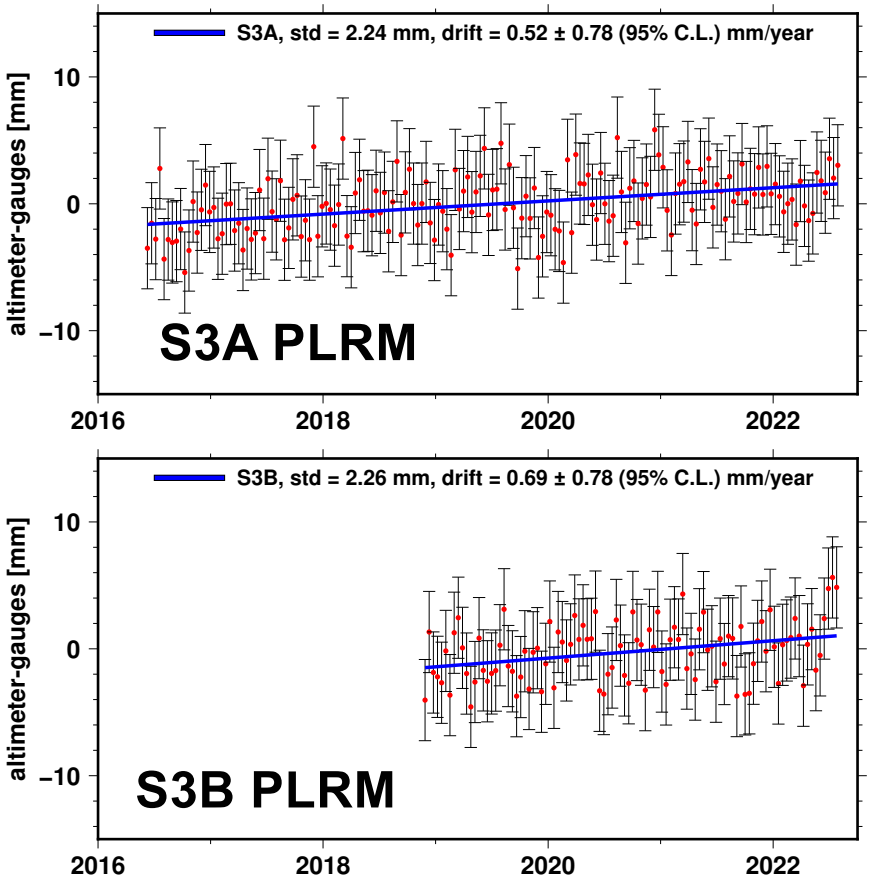
< 2 hr, latitude < 60°, > 100km coast, outliers < 3.5 sigma, 0.5 m < SWH < 8 m

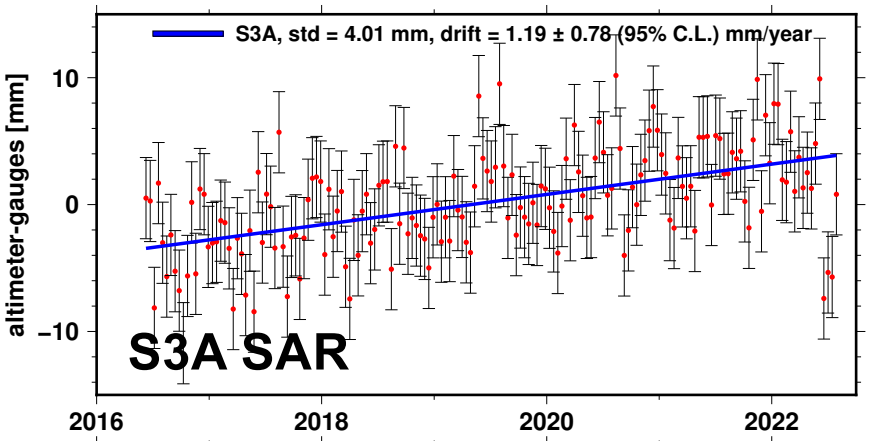
BC4_2021: 20210707 to 20211018

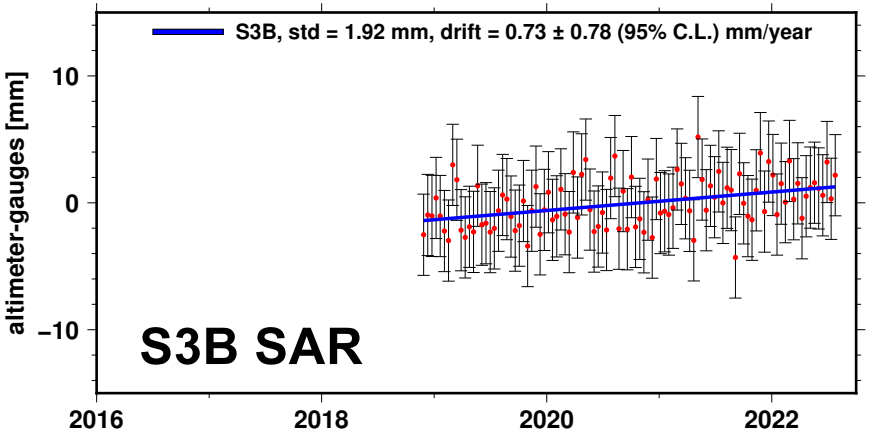
BC5_2022: 20220707 to 20221018

	SSH rms (cm)		SWH rms (cm)	
	BC4_2021	BC5_2022	BC4_2021	BC5_2022
J3/S3A SAR/NRT	4.05	3.58	18.1	19.1
J3/S3A SAR/STC	3.21	3.34	18.2	19.5
J3/S3A SAR/NTC	3.00	3.17	18.1	19.8

Tide gauge comparisons S3A/B (Baseline Collection 4 and 5)





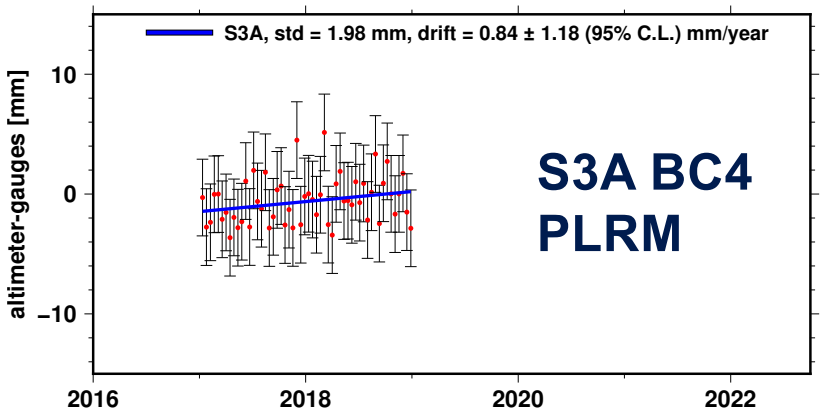


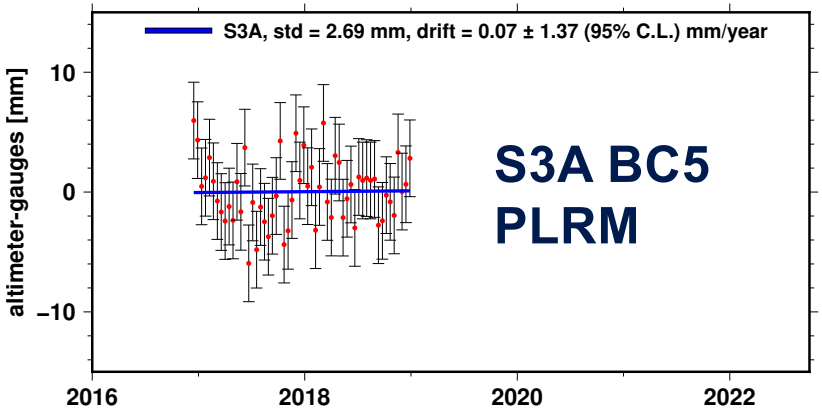
Tide gauge comparisons: Sentinel-3A BC4 versus BC5

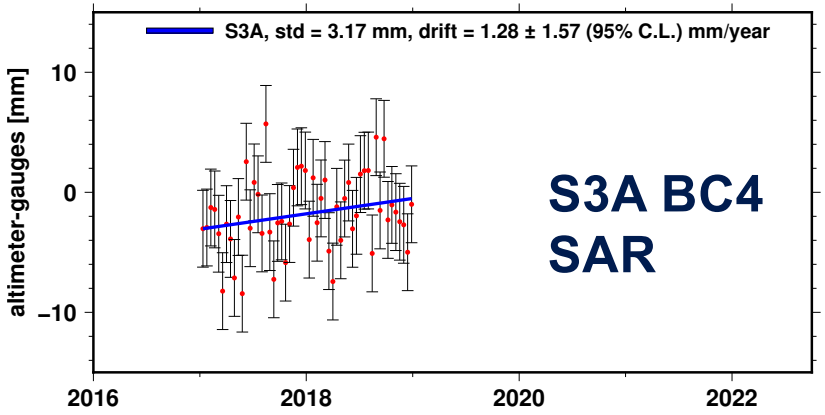
Two years of data is the minimum time span required by our tide gauge comparison system

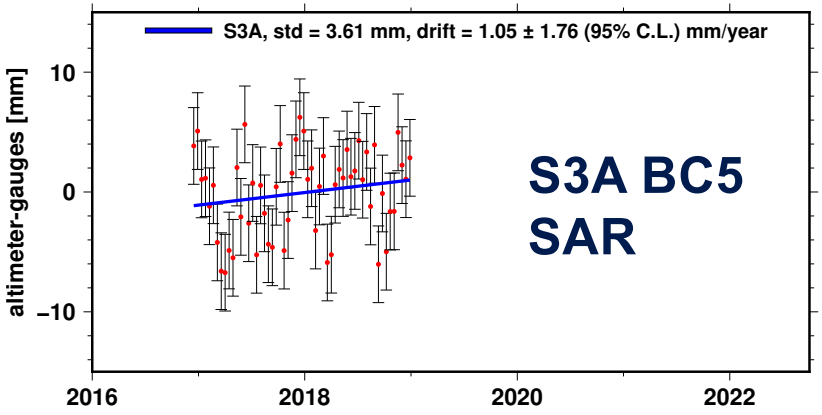
Estimated drifts are not significant

Did not implement GPD+ in the comparison. Could have a significant effect on the comparison by providing more valid comparison points closer to the gauges.









Summary

- **The loss of tide gauges from the network is impacting the altimeter drift estimates.**
- **Jason-3: The tide gauge comparison is consistent with a wet troposphere path delay drift, though it is not statistically significant.**
- **Sentinel-6MF: No significant drifts detectable in the short time series.**
- **The J3/S6MF intermission bias is significant in areas of large surface slopes.**
- **Sentinel-3A: Two years of Baseline Collection 5 is too short for meaningful drift estimates.**
- **Future plans:**
    - Estimate drift for Sentinel-3A/3B full-mission reprocessing
    - Evaluate impact of GPD+ on Sentinel-3 and HRMR on Sentinel-6