Sea Level Stability Monitoring from the NOAA Altimetry/Tide Gauge Comparison System

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Poster #CVL2026_007

Overview

The NOAA Altimetry/Tide Gauge Comparison System provides a calibration/validation framework for radar altimetry missions, including Sentinel-3A and Sentinel-3B, within the multi-mission reference series. The system constructs colocated altimeter sea surface height (SSH) time series at global tide gauge locations and differences them with in situ observations to quantify instrumental bias, drift, and long-term stability.

For Sentinel-3A/B, the NOAA framework applies consistent orbit standards, geophysical corrections, and cross-calibration against the reference altimeter series (e.g., Jason-3 and Sentinel-6 Michael Freilich) to ensure continuity. In parallel, the Radar Altimeter Database System (RADS) provides a flexible, harmonized multi-mission dataset that enables targeted sensitivity studies of geophysical corrections. In particular, RADS allows systematic testing of the impact of individual corrections—such as wet tropospheric delay—on sea surface height stability and drift estimates, offering a controlled environment to assess how processing choices influence long-term performance metrics.

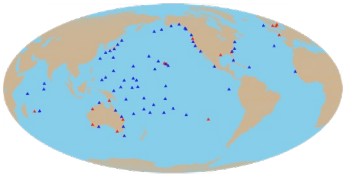
Recent updates incorporate the latest reprocessed Geophysical Data Record baseline G (GDR-G) products for both Sentinel-3 and Sentinel-6MF. These reprocessings include improved retracking algorithms, updated sea state bias corrections, and refined orbit solutions, resulting in reduced sea surface height anomaly (SSHA) noise and improved inter-mission consistency. Comparisons with earlier baselines reveal small offsets at the millimeter to centimeter level, underscoring the importance of continuous monitoring through tide gauge comparisons and correction sensitivity analyses.

RADS

The Radar Altimeter Database System (RADS) is a multi-mission satellite altimetry system jointly maintained by NOAA, EUMETSAT, and Delft University of Technology. At the NOAA/NESDIS Center for Satellite Applications and Research (STAR), RADS provides a harmonized and cross-calibrated archive of sea surface height observations from more than a dozen radar altimeter missions, including TOPEX/Poseidon, Jason-1/2/3, Sentinel-3A/B, and Sentinel-6. By applying a common set of geophysical corrections and maintaining consistent processing standards, RADS enables long-term continuity and inter-mission consistency that are essential for sea level monitoring and calibration/validation activities.

Tide Gauge Network

Tide gauge data are retrieved from the University of Hawaii's Sea Level Center. The global list for the reference mission includes 68 individual gauges; due to the later start of the Sentinel 3 missions, the list for those includes 61 gauges. All data are quality controlled and corrected for vertical land motion.

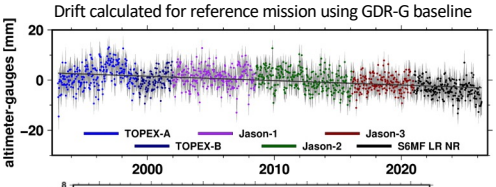


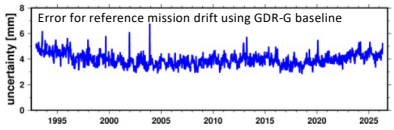
Comparison Methodology

The NOAA Altimetry/Tide Gauge Comparison System combines RADS altimetry data with global tide gauge data to provide an estimate of instrument drift. The method uses multiple altimeter passes near each gauge, shifted according to temporal and spatial lags, and finds the altimeter-tide gauge delta for each individual tide gauge using either standard variance weighting or least squares covariance weighting depending on length of record. An overall weighted global drift is computed over all available gauges. The system has been successfully used for the instruments that make up the reference series (both individually and together), Enivsat, and the Sentinel-3 series, and is currently being extended to the tandem mission (Jason-3 in tandem with Sentinel-6MF), Sentinel-6B, and the Surface Water and Ocean Topography mission (SWOT).

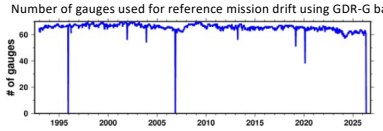
Examples of drifts

Drift calculated for reference mission using GDR-G baseline

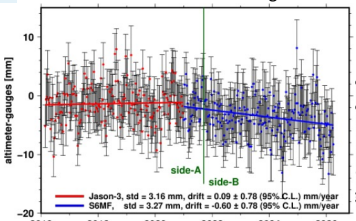




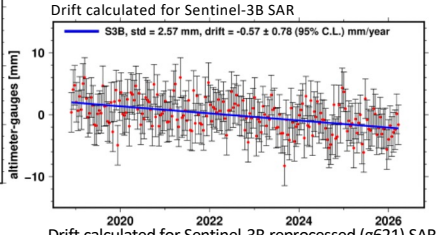
Number of gauges used for reference mission drift using GDR-G baseline



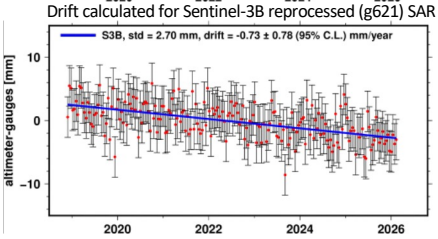
Drift shown for Sentinel-6MF using GDR-G baseline



Drift calculated for Sentinel-3B SAR



Drift calculated for Sentinel-3B reprocessed (g621) SAR



Comparison of calculated drifts

The following lists drift and standard deviation calculated for various altimetric datasets retrieved via RADS. TJ36a refers to the reference mission (TOPEX-Jason-Sentinel-6MF). The drift for the full GDR-G reference mission as of 16 June 2026 is -0.175 mm/yr with a standard deviation of 4.16 mm (see figures above). The table provides the drift for Sentinel 6-MF. Two versions of both Sentinel-3A and Sentinel-3B are presented: standard and the recently reprocessed g621, including both the synthetic aperture radar (SAR) product and the pseudo low resolution mode (PLRM).

Mission and Data Version	Drift ± 95% CI (mm/yr)	Standard Deviation (mm)
s6MF: GDR-F, low rate	-1.31 ± 0.98	3.21
s6MF: GDR-G, low rate	-0.60 ± 0.78	3.27
s6MF: GDR-G, high rate	-0.66 ± 0.78	3.34
s6MF: GDR-G, low rate with numerical retracker	-0.77 ± 0.78	6.60
s3A: nrt1, SAR	-0.73 ± 0.78	3.26
s3A: nrt1, PLRM	-0.91 ± 0.78	3.62
s3A: g621, SAR	-0.73 ± 0.78	3.25
s3A: g621, PLRM	-0.87 ± 0.78	3.46
s3B: nrt1, SAR	-0.57 ± 0.78	2.57
s3B: nrt1, PLRM	-1.00 ± 0.78	3.24
s3B: g621, SAR	-0.73 ± 0.78	2.70
s3B: g621, PLRM	-1.00 ± 0.78	3.21

Value of Approach

The ability within RADS to isolate and evaluate correction impacts provides valuable insight into sources of residual variability and supports refinement of processing standards. Together with NOAA's altimetry/tide gauge comparison system, these approaches support mission requirements for long-term stability monitoring, ensuring that Sentinel-3A/B and Sentinel-6MF meet the precision and consistency needed for sustained altimetric observations.

References

Scharroo, R., E. W. Leuliette, J. L. Lillibridge, D. Byrne, M. C. Naeije, and G. T. Mitchum, RADS: Consistent multi-mission products, in Proc. of the Symposium on 20 Years of Progress in Radar Altimetry, Venice, 20-28 September 2012, European Space Agency Special Publication, ESA SP-710, p. 4 pp., 2013. (https://www.star.nesdis.noaa.gov/socd/lsa/RADS.php)

Caldwell, P. C., M. A. Merrifield, P. R. Thompson (2015), Sea level measured by tide gauges from global oceans — the Joint Archive for Sea Level holdings (NCEI Accession 0019568), Version 5.5, NOAA National Centers for Environmental Information, Dataset, doi:10.7289/V5V40S7W. Fast delivery data retrieved 15 May 2026.

ACKNOWLEDGMENTS Part of this work was performed and funded under **ST133017CQ0050_1332KP22FNEED0042**.