Assessment of Reprocessed TOPEX/Jason/Sentinel-6 Altimetry: Impact on Global Mean Sea Level Estimates

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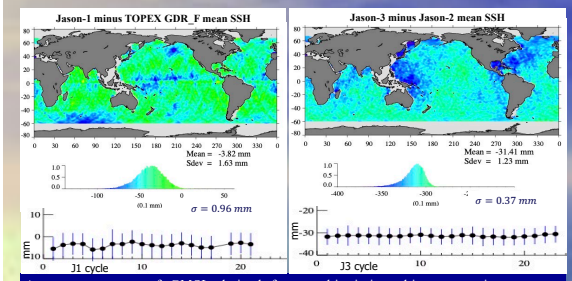
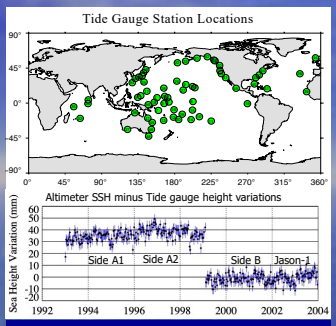
Abstract: Several recent altimeter data reprocessing/recalibration analyses have been completed for both the current Sentinel-6 Michael Frielich (F08 version) mission, and the historical TOPEX/Jason time series including TOPEX/Poseidon retracking and radiometer recalibrations for Jason-2 and Jason-3. The GSFC orbit standard std2006 has also been revised to include updated time variable gravity forward modeling. In this presentation we re-estimate Global Mean Sea Level (GMSL) and assess the accuracy of the revised 30+ year sea surface height time series via tide gauge comparisons and ocean mass budget analyses.

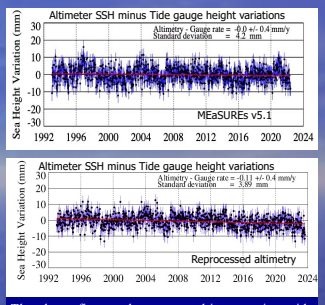
TOPEX GDR_F Verification Results



Accurate measures of GMSL derived from multi-mission altimetry requires accurate estimates of global inter-mission biases. The TOPEX/Jason-1 verification phase mean SSH differences (left figure) show stable per cycle mean biases with a standard deviation less than 1 mm, comparable to the excellent agreement shown in the Jason-2/Jason-3 verification phase comparison (right figure).



TOPEX GDR_F side A1/A2 biases are estimated from mean altimeter minus tide gauge height variations (Mitchum, 2000). TOPEX GDR_F side B/Jason-1 inter-mission bias is computed from verification phase SSH colinear residuals.

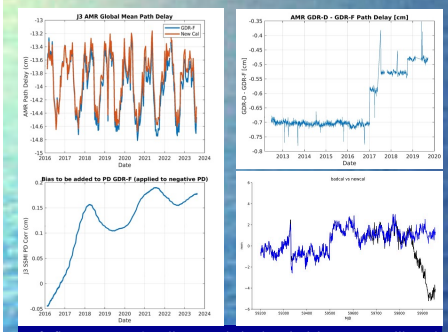


MEaSURES v5.1	Side A	Side B	TOPEX A+B
Drift rate (mm/y)	0.29	-0.88	-0.38
Variance (mm)	4.67	4.00	4.65

Reprocessed	Side A	Side B	TOPEX A+B
Drift rate (mm/y)	-0.02	0.45	-0.23
Variance (mm)	4.40	3.83	4.20

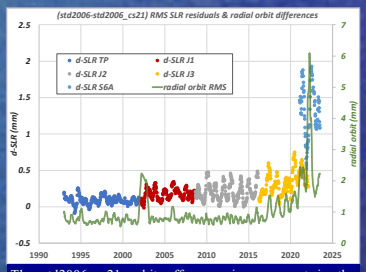
The above figures show mean altimeter minus tide gauge height variations after all inter-mission biases have been applied. The bottom figure shows lower TOPEX drift rates and variance reduction with TOPEX GDR_F data.

Radiometer Derived Path Delay Calibrations



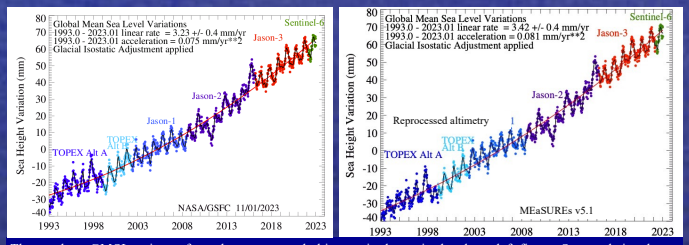
Left figures: Jason-3 radiometer derived path delays are recalibrated against SSMI (Brown, 2023). A trend is observed resulting in an ~ 2mm rise over 8 years. Right Figures: Upper image shows Jason-2 radiometer derived path delay recalibrations (Brown, 2023) that are to be implemented in GDR_F production. Lower panel shows Sentinel-6-MF radiometer path delay calibrations that were in error for a brief period. The correct calibrations were implemented in the current F08 version.

GSFC std2006_cs21 orbit



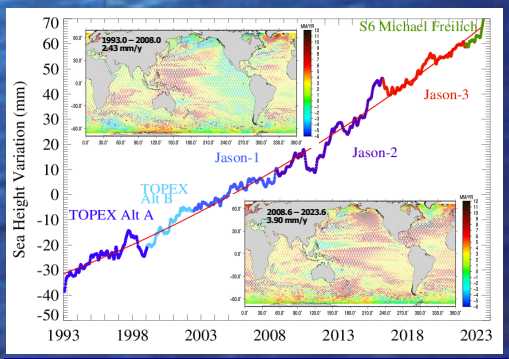
The std2006_cs21 orbit offers an improvement in the GEODYN modelling of the C21/S21 gravity coefficients over the std2006 POD (Lemoine et al., 2023). Upper image shows the 120-day moving average of (std2006-std2006_cs21) SLR RMS differences on the left axis (d-SLR), and the RMS radial orbit differences on the right axis. d-SLR positive indicates improvement for std2006_cs21.

Global Mean Sea Level Estimates

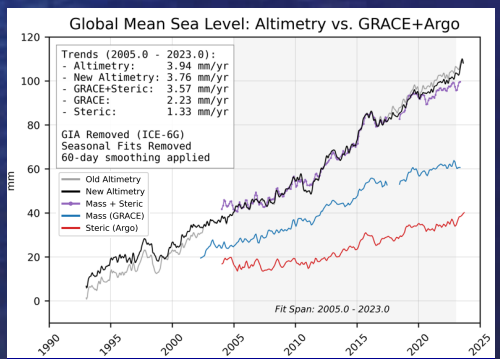


The resultant GMSL estimate from the reprocessed altimetry is shown in the above left figure. Seasonal signals are retained. The linear trend is lowered by 0.2 mm/y due primarily to the reduction in Jason-3 GMSL variations as a result of radiometer path delay recalibrations. This reduces the ocean mass budget misclosure during the GFO era.

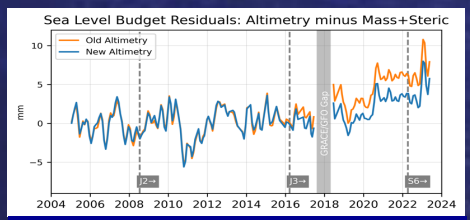
Global and Regional Mean Sea Level Estimates: Ocean Mass Budget



Global mean sea level variations from 1993 to mid 2023 are estimated (*Beckley et al., 2017)* from TOPEX, Jason, and S6-MF (F08) altimetry based on GSFC std2006_cs21 orbits, TOPEX GDR_F data, and radiometer recalibrations discussed above. The red line is the quadratic fit to the SSH variations after removal of annual and semi-annual signal and application of GIA. The linear sea level rate is estimated at 3.24 mm/y ± 0.4 mm/y with an acceleration of 0.077 mm/y^2 ± 0.025 mm/y^2. Regional sea level rates are shown above (left inset) for the first 15-years and last 15-years (right inset) of the TOPEX/Jason/S6-MF sea surface height time series. The revised GMSL reduces the ocean mass budget misclosure during the GRACE Follow-On (GFO) era by ~ 40 % (RMS reduction of 2.2 mm).



GMSL variations based on GSFC std2006_cs21orbits, TOPEX GDR_F data, and Jason-3 radiometer recalibrations are compared to the sum total of ocean mass+steric variations in an accounting towards ocean mass budget closure. The above image shows the total ocean mass variations derived from GRACE GSFC RL06v2 Mascons (*Loomis et al., 2019*) and the steric component derived from the SIO RG climatology (https://sio-argo.ucsd.edu/RG_Climatology.html). A visible mis-closure is evident in the global ocean mass budget post 2017. Recent articles (*Chen et al., 2020* and *Barnoud et al., 2021*) point to possible errors in the altimetry, GRACE Follow On ocean mass estimates, and/or the Argo float derived steric estimates contributing to the mis-closure. The budget misclosure is still present when using thermosteric estimates from Argo, indicating that other sources remain to be found.



Residual differences in GMSL estimates from Altimetry and GRACE+Argo for Measures v5.1 (old) and reprocessed (new) altimetry estimate.

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