Improving the Sea Level Data Record for Studying Climate Variability

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Abstract
The University of Colorado has been producing and publishing a time series of global mean sea level (GMSL) since the TOPEX/Poseidon mission, and we continually refine our altimeter data processing and applied corrections. We report on recent improvements to update the processing to the latest, state-of-the-art corrections, including updated microwave radiometer drift parameters, mean sea surface, sea state bias models, orbits, etc., and efforts to test different processing techniques to improve and understand the variability in the long-term global mean sea level record. In past work, we found that choices of processing techniques, such as computing the mean global mean sea level from along-track versus gridded sea surface height anomaly estimates or editing shallow water areas, significantly changes the sensitivity of the GMSL time series to interannual variability, especially during strong El Nino-Southern Oscillation (ENSO) events. We also found that these different processing techniques are responsible for some of the larger interannual differences among the GMSL time series produced by different research institutions. We continue and extend the previous work by exploring modifications and improvements to our altimeter processing and by comparing the resulting sea level climate data records with other climate data records, such as sea level from tide gauges and the Multivariate ENSO Index (MEI). These efforts should help improve our interpretation of the global mean sea level time series as a climate data record and our understanding of linkages between sea level and climate variability.

Comparison of GMSL Estimates

We recently updated the 20-year GMSL estimate (left) to include the Jason-2 radiometer corrections as used on GDR-D. This had the minor effect of increasing the rate of sea level over the Jason-2 era (see tide gauge calibration below). Further improvements to our GMSL estimates using updated GDR-C-class corrections are ongoing.

The differences among five independent GMSL time series after removing the seasonal signals and detrending. CU-GSFC and NOAA-AVISO each have the smallest differences and indicate the similarities between the series because they are derived from the mean of along-track versus gridded SSHA. Residual annual signals in CU-GSFC are most likely due to different outlier removal and included inert water bodies. The T/P era of NOAA-AVISO shows considerable variability compared to the Jason-1/2 era, and this is most likely the result of using different wet tropospheric and sea state bias corrections and the handling of the switch from T/P Side A to Side B altimeters. The long-period signal in the CU/NOAA and CU-AVISO series are due to computing the mean from along-track versus gridded SSHA (as is evident in the opposite figure). The largest differences among all of the series occur at strong ENSO events in 1997-98 and 2010-11, indicating that the choice of algorithm and other constraints plays a large role in determining the sensitivity of each series to interannual signals.

Improving the CU Sea Level Record

The difference of annual means of sea surface height anomalies with respect to the 1993 mean show the regional signals of sea level change and the global increase in sea level. We recently updated the 20-year GMSL estimate (left) to include the Jason-2 radiometer corrections as used on GDR-D. This had the minor effect of increasing the rate of sea level over the Jason-2 era (see tide gauge calibration below). Further improvements to our GMSL estimates using updated GDR-C-class corrections are ongoing. The Multivariate ENSO Index (MEI) right is the unrotated, first principal component of six observables measured over the tropical Pacific (Weller & Timlin, 1993, 1998). To compare the global mean sea level to the MEI time series, we removed the mean, linear trend, and seasonal signals from the global mean sea level estimates and normalized each time series by its standard deviation (right). The normalized values plotted above show a strong correlation between the global mean sea level and the MEI, with the global mean sea level often lagging changes in the MEI.

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Least-squares estimated annual, semi-annual, and trend components of the recomputed CU GMSL time series and the nominal NOAA and AVISO time series.