Bumps and Wiggles: Making Sense of Sea Level Climate Record Variability

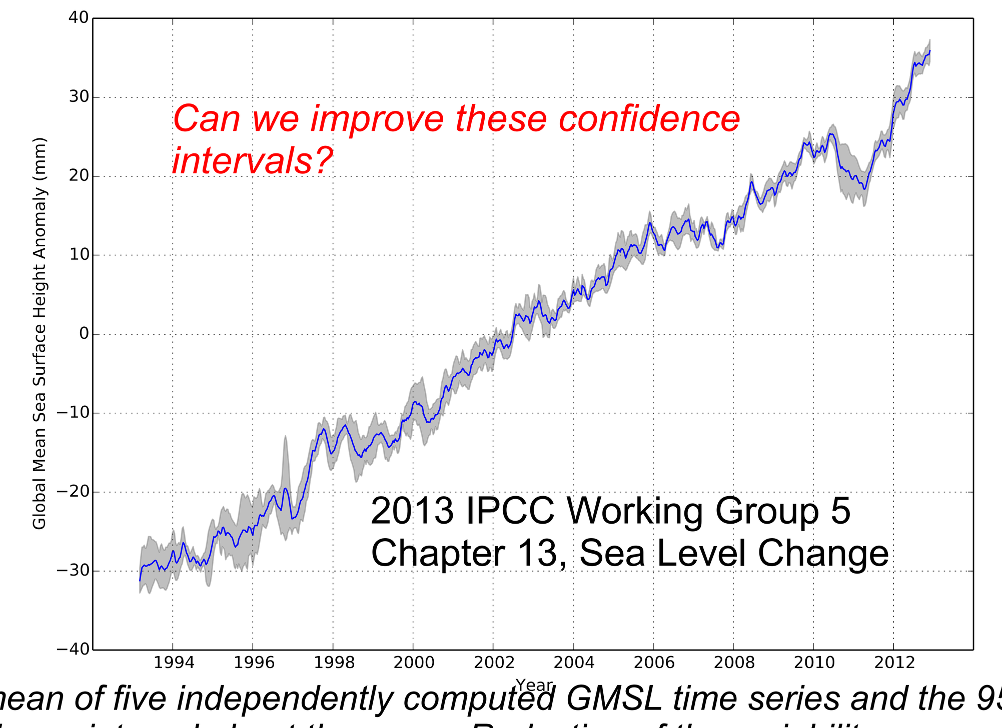
D. Masters, R. S. Nerem, J. Choe

University of Colorado

dallas.masters@colorado.edu

Abstract

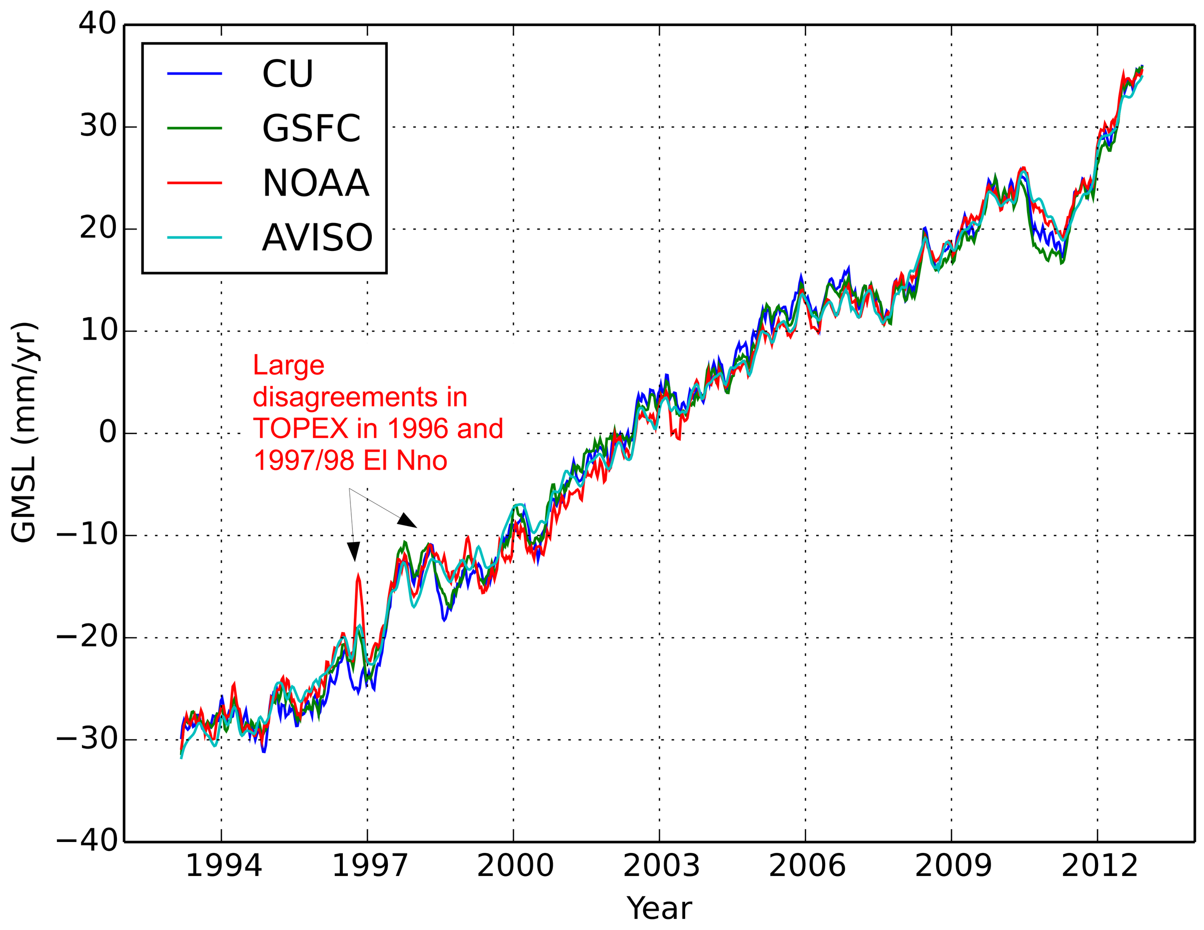
The 20-year global mean sea level (GMSL) climate record made possible by the TOPEX and Jason altimeter missions is an important indicator of climate change. It is being increasingly relied upon for determining evidence of changing rates in the climate system (both accelerations and decelerations). Therefore, understanding the variability within the GMSL time series and also among the different estimates produced by various institutions is becoming more important. Decomposing the record into a long-term and seasonal components leaves a signal with variability on different time scales, from seemingly random short fluctuations to interannual and possible decadal periods. Previous work (Masters et al., 2012) showed that the differences among the GMSL time series produced by various institutions are mainly due to processing methods, such as employing shallow water editing and different averaging techniques (gridding versus non-gridding of the sea surface anomalies). Since then, some institutions have revised their time series to correct errors and improve the ancillary data that go into the sea surface anomaly calculations. In this work, we summarize new processing at the University of Colorado and its effects on the estimated GMSL time series. We also repeat the comparison of the different institutional time series and investigate the remaining causes of discrepancies between them. In order to further understand climate system signals reflected in the time series, we investigate the variability of derived rates of sea level change over interannual and decadal time scales and look at their possible causes.



The mean of five independently computed GMSL time series and the 95 percent confidence interval about the mean. Reduction of the variability among the time series would improve confidence in the GMSL as a climate data record.

Recomparison of GMSL Estimates

Masters, D., R. S. Nerem, C. Choe, E. Leuliette, B. Beckley, N. White, and M. Ablain. "Comparison of Global Mean Sea Level Time Series from TOPEX/Poseidon, Jason-1, and Jason-2." Marine Geodesy (2012): 120830133821002.

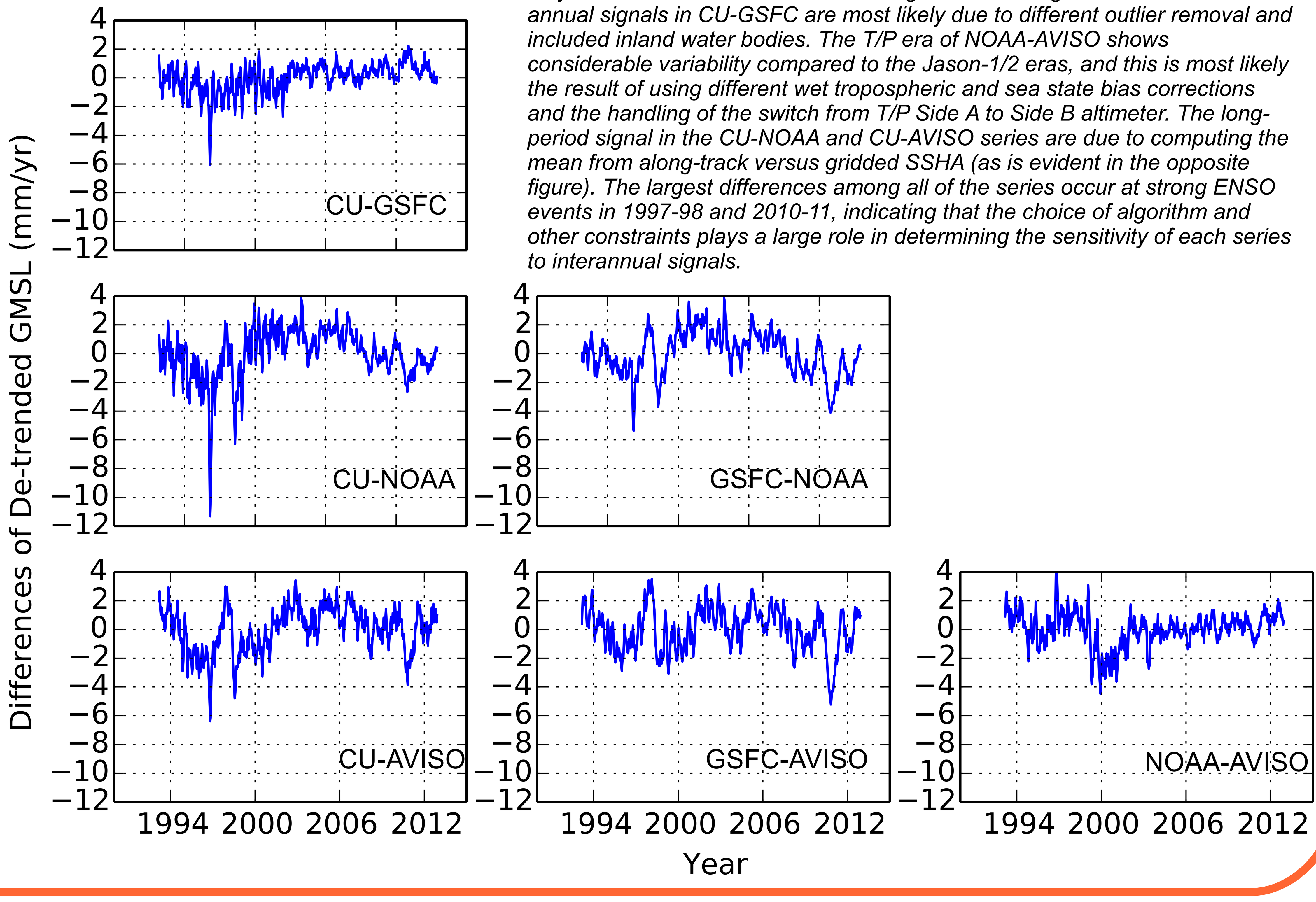


Our original investigation noted the differences in the GMSL time series and concluded that most of the differences can be attributed to processing technique (CU and GSFC do not grid the SSH anomalies, while NOAA and AVISO do) and shallow water editting (CU and GSFC less than 120 m).

Since then, CU has corrected an error in the application of the GOT tide model to TOPEX data (resulting in reduction of TOPEX-era variance). Additionally, AVISO corrected an error to the application of Jason-1 JMR corrections (resulting in better agreement in the Jason-1 to Jason-2 transition and trend).

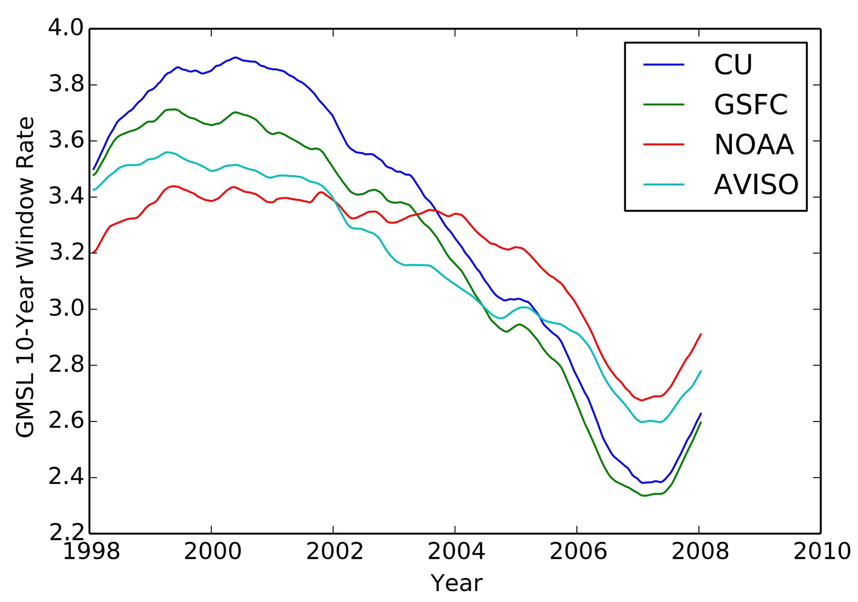
But some large differences still remain of interest, such in 1996 and the El Nino of 1997/98 during TOPEX. While not a cause of trend disagreement, they should be resolved.

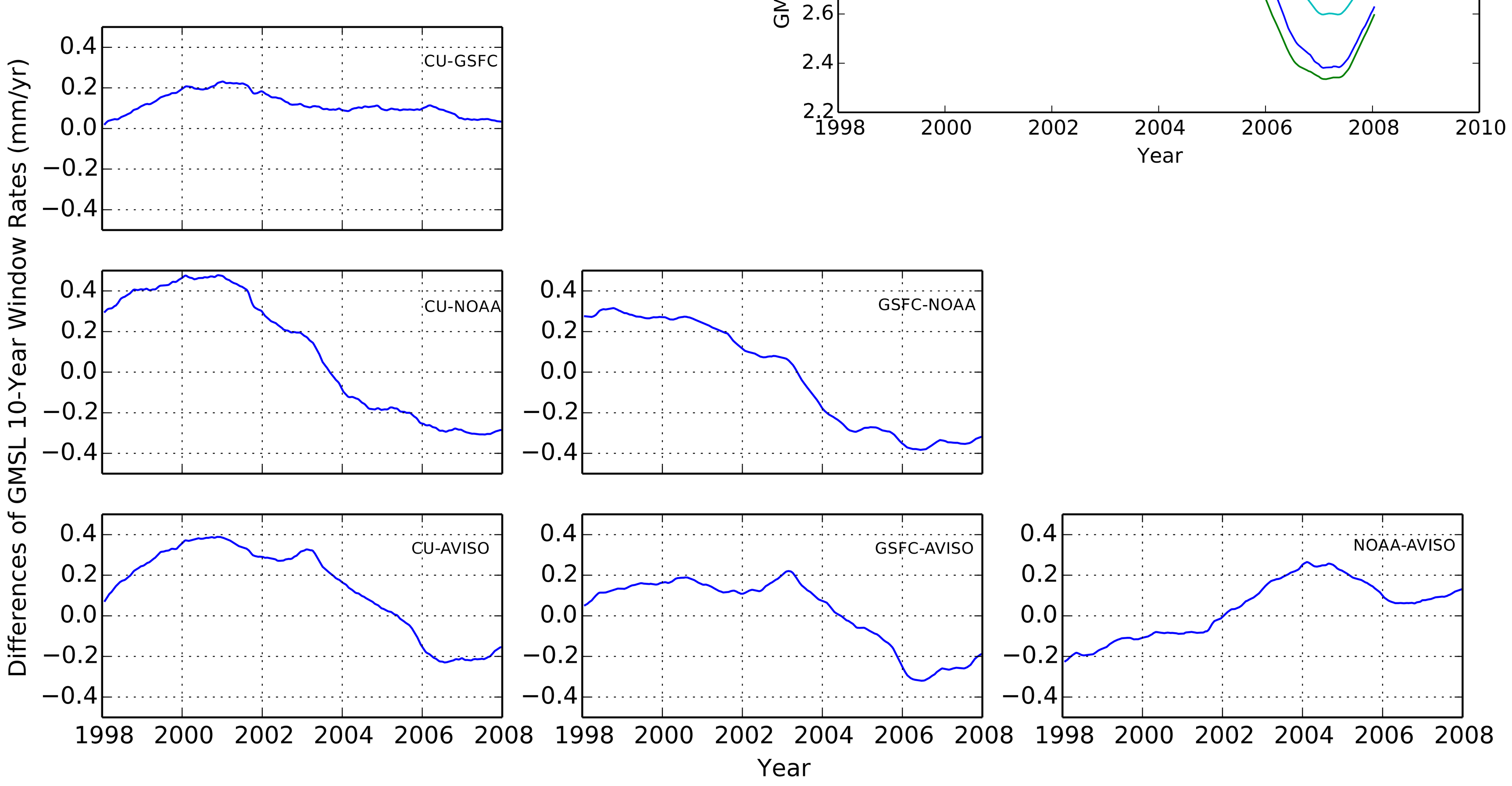
The differences among five independent GMSL time series after removing the seasonal signals and detrending. CU-GSFC and NOAA-AVISO each have the smallest differences and indicate the similarities between the series because they are derived from the mean of along-track versus gridded SSHA. Residual annual signals in CU-GSFC are most likely due to different outlier removal and included inland water bodies. The T/P era of NOAA-AVISO shows considerable variability compared to the Jason-1/2 eras, 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 altimeter. 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.



Variability in Decadal Trends

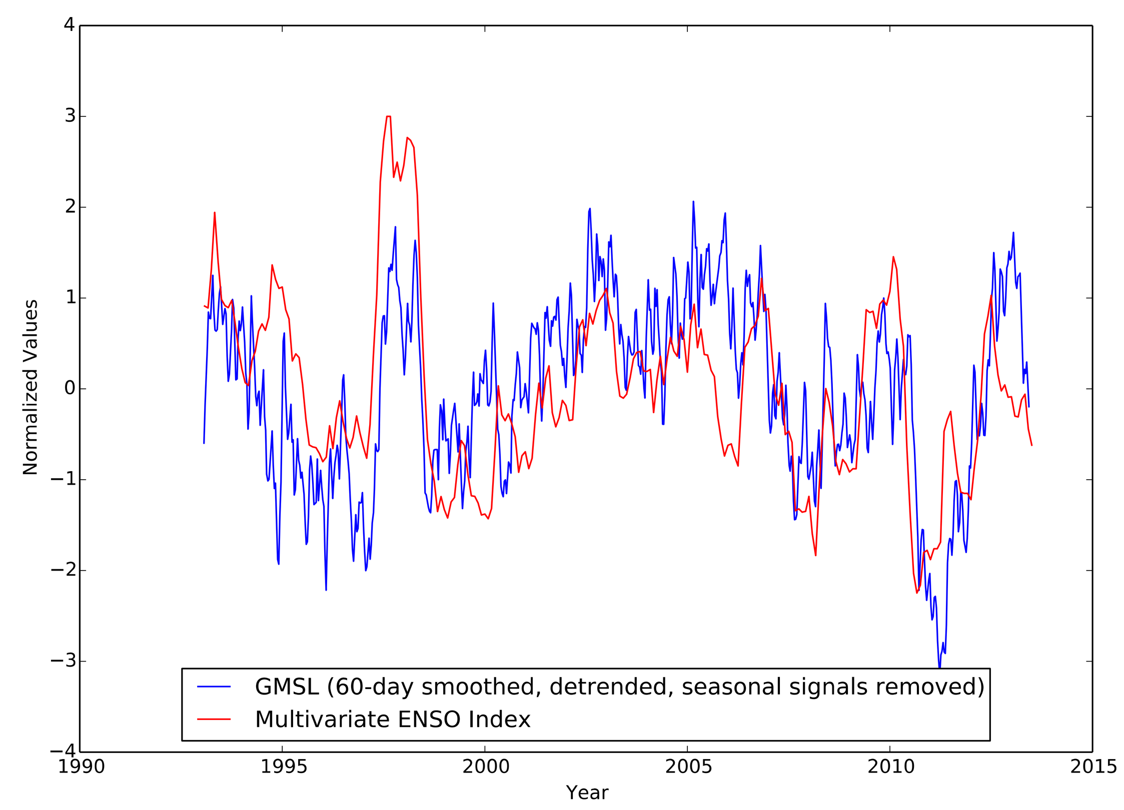
Computation of the decadal trends shows the rate of GMSL was higher in the TOPEX era and has slowed during Jason-1 and Jason-2 (although the rate is again increasing). This "slow-down" in sea level rise is an active area of investigation and a subject of future work..





Decadal trends are often used to determine if the rate of sea level is changing. The running mean decadal trend rates computed from the GMSL time series also indicate the effects of processing, with the CU and GSFC rates following each other well, and likewise for the NOAA and AVISO rates.

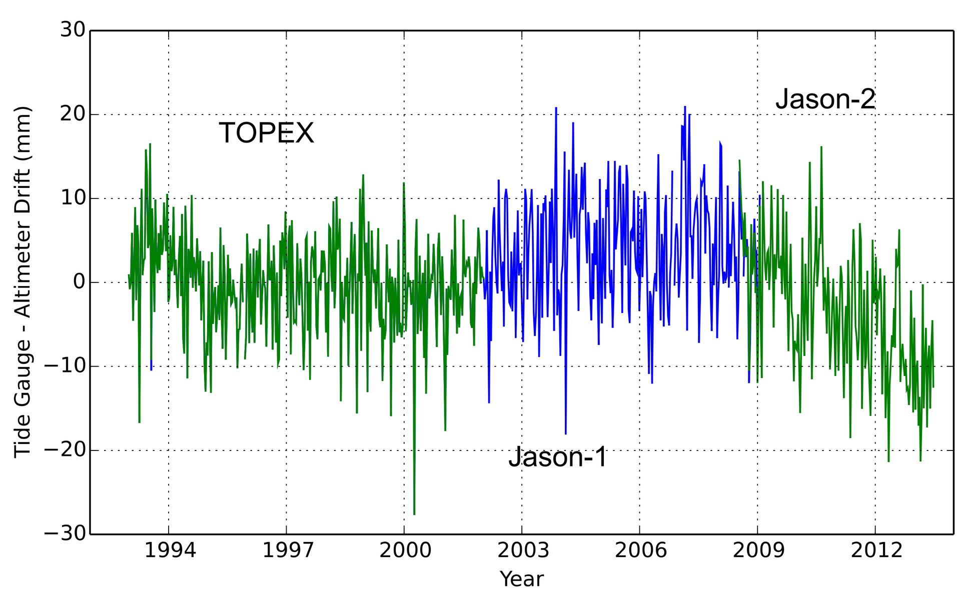
Improving the CU Sea Level Record



The Multivariate ENSO Index (MEI) is the unrotated, first principal component of six observables measured over the tropical Pacific (Wolter & 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 60-day smoothed global mean sea level estimates and normalized each time series by its standard deviation.

Altimeter - tide gauge drift over the 20 year record shows a long-period signal. Efforts to reduce the trend in the Jason-2 drift w.r.t. the tide gauge network are ongoing.

(Tide gauge drift calculations courtesy of G. Mitchum).



This work was supported by two grants from NASA (Ocean Surface Topography Science Team and the MEaSURES Project).