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Discussion

Comment on "Estimating future sea level change from past records" by Nils-Axel Mörner

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We feel compelled to respond to the recent article by Mörner (2004) because he makes several major errors in his analysis, and as a result completely misinterprets the record of sea level change from the TOPEX/Poseidon (T/P) satellite altimeter mission. One major criticism we have with the paper is that Mörner does not include a single reference to any altimeter study, all of which refute his claim that there is no apparent change in global mean sea level (GMSL) [see Cazenave and Nerem, (2004) for a summary]. The consensus of all other researchers looking at the T/P and Jason data is that GMSL has been rising at a rate of 3.0 mm/year (Fig. 1) over the last 13 years (3.3 mm/year when corrected for the effects of glacial isostatic adjustment (Tamisiea et al., 2005)).

Mörner gives no details for the source of the data or processing strategy he used to produce Fig. 2, other than to say it is based on "raw data". Because the details of the analysis are not presented in his paper, we are left to speculate on how this result could have been obtained, based on our years of experience as members of the T/P and Jason-1 Science Working Team. Mörner was apparently oblivious to the corrections that must be made to the "raw" altimeter data in order to make correct use of the data.

As with any satellite data set, calibration and validation of the data must be performed after launch to determine if there are any instrumental errors, find the source of those errors, and evaluate their behavior over time. Satellite altimetry is somewhat unique in that many adjustments must be made to the raw range measurements to account for atmospheric delays (ionosphere, troposphere), ocean tides, variations in wave height (which can bias how the altimeter measures sea level), and a variety of other effects. In addition, the sea level measurements can be affected by the method used to process the altimeter waveforms, and by the techniques and data used to compute the orbit of the satellite. Early releases of the satellite Geophysical Data Records (GDRs) often contain errors in the raw measurements, the measurement corrections, and the orbit estimates that are later corrected through an on-going calibration/validation process defined by the T/P and Jason Science Working Team.

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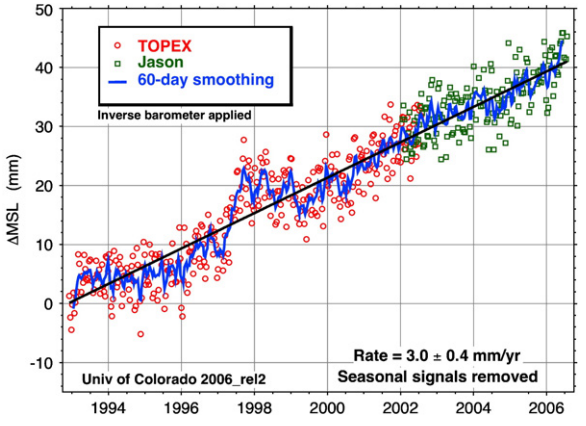

Fig. 1. Global mean sea level variations from TOPEX and Jason altimeter measurements [updated from Leuliette et al. (2004)]. Rate increases to 3.3 mm/year after corrected for the effects of glacial isostatic adjustment (GIA) (Tamisiea et al., 2005).

The original release of the T/P GDRs (as well as some subsequent re-releases) contained several errors that directly affect GMSL change. Based on our experience with these issues, and the shape of Fig. 2 in Mörner's paper, we believe that he used the original release of the T/P GDRs with no attempt to correct for two significant errors. One of the errors is caused by a drift in the TOPEX Microwave Radiometer (TMR). It was first observed in sea level via a comparison to tide gauges (Chambers et al., 1998; Mitchum, 1998), and was verified to be caused by the TMR via comparisons to other orbiting microwave radiometers and radiosondes (Keihm et al., 2000). It caused a drift of nearly −1.2 mm/year in measured GMSL until early 1998, and then a bias of −5 mm. A second major error was introduced when the redundant TOPEX altimeter was turned on in early 1999 due to degradation in the original instrument (Chambers et al., 2003). Since the electronics of the redundant altimeter were different, it caused an apparent bias in the GMSL measurement related to the Sea State Bias (SSB). The sense of the bias was such to cause an incorrect sudden drop in GMSL from the end of 1998 to the beginning of 1999 of nearly 10 mm. This drop is apparent in Fig. 2 of Mörner's paper (and in comparison to tide gauge data (Mitchum, 2000)). This error is removed when an updated SSB model is applied (Chambers et al., 2003). Data with these corrections applied are available from both the U.S. and French processing centers, as well as products to correct the original GDRs.

When care is taken to make these corrections, the rate of sea level change over the entire T/P mission is 3.0± 0.4 mm/year (http://sealevel.colorado.edu), 3.3 mm/year when corrected for the change in ocean volume due to glacial isostatic adjustment (Tamisiea et al., 2005). In light of this, the statement by Mörner that "This means that this data set does not record any general trend (rising or falling) in sea level, just variability around zero plus the temporary ENSO perturbations" is completely false and is based on his erroneous data processing. Mörner's paper completely misrepresents the results from the T/P mission, and does discredit to the tremendous amount of work that has been expended by the Science Working Team to create a precise, validated, and calibrated sea level data set suitable for studies of climate variations. Finally, Mörner ignores substantial other oceanographic (e.g. Levitus et al., 2001; Antonov et al., 2002; Munk, 2003; Willis et al., 2004) and cryospheric (e.g. Dyurgerov and Meier, 2000; Rignot et al., 2003; Krabill et al., 2004; Thomas et al., 2004) evidence of sea level rise which corroborate the altimeter observations.

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