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Ocean Science Discussions



# *Interactive comment on* "A new assessment of global mean sea level from altimeters highlights a reduction of global trend from 2005 to 2008" *by* M. Ablain et al.

**M. Ablain et al.**

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**General Comment**

The main originality of this paper is an exhaustive description of the altimeter errors impacting the MSL. Studies about this subject have been already performed (Nerem et al., 2001; Fernandes et al, 2006). But reprocessed GDRs and updated geophysical corrections are now available, which justifies a new assessment. In addition, another important issue of the paper is the statistical approach to estimate the error with a confidence interval. Finally, this new assessment of the global budget error allows

us to demonstrate that the recent sea level change (1 mm/yr since 2005) is not due to errors from altimetry measurements. In order to better demonstrate the new information presented in the paper are useful, we propose a new release of the paper to take into account all your remarks.

Major Comments

*1. Reviewer 2 is absolutely correct that some important references are missing. First of all, the authors act as if this observation of interannual anomalies in GMSL associated with ENSO is a novel result, whereas it has been documented before in Nerem et al. [GRL, 1998], Chambers et al. [JGR, 2002], and several papers by Cazenave et al. These references should all be discussed in light of the recent several year change, with some comments that this is not unexpected in the record.*

We agree with you remark. In fact, we modified the introduction of our paper to focus on the global budget error, since the main objective here is not to discuss the inter-annual observation.

*2. On page 38, Lines 25, I agree with Reviewer 2 that the statement: "This 1mm/yr trend differences cannot be explained by a physical process.: is a little strong. This assumes that global mean sea level rise is uniformly the same over the global ocean, and we know for a fact this is not true. There are long-term changes in the ocean heating and circulation that is different from one ocean basin to another and from one hemisphere to another. We really do not know what the size of these local*



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*changes180; can be, but a difference of s 1 mm/year is not necessarily unreasonable. It does seem that using a new reference frame makes the trends more uniform, but how well do we know the reference frame?*

We agree with you remark. We improved and better explained this item in the new release of the paper. Indeed physical processes can explained partly the hemispheric trend differences. But it also clear that new reference frame (ITRF2005) change significantly these trends in the same order as the observed signal. Then, the inconsistency observed between each hemispheric trend can legitimately be considered as an source of uncertainty.

*3.1 Section 4.4 is very confusing, mainly because relative bias estimates are so dependent on the sea-state bias model used. I think this section needs to be re-written and clarified. I agree with Reviewer 2 that Chambers et al. [JGR, 2003] should be discussed here. While it is not the SSB model you are using, it does a good job of at least describing the problem and the effect of changing the SSB model on GMSL. Then you can discuss the newer SSB models you use, and the apparent uncertainty in the bias estimate.*

The main objective of this section is not to describe the absolute value of the SSH bias to link together each MSL time data series (TOPEX A / TOPEX-B and TOPEX / Jason-1) but is to evaluate the uncertainty of this bias. Indeed, SSB models significantly impact these SSH biases (we have indeed to discuss the Chambers et al. [JGR, 2003]). For instance and as described in the paper (section 2), using the BM4 model from M-GDR products, the SSH bias between TOPEX-A and TOPEX-B is close to 0.5 cm while using a no-parametric model (Gaspard and Labroue, 2002), the SSH bias becomes 1.17 cm. We tried to better describe this part on the new release of the



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paper.

*3.2 I do think that your estimates of the bias uncertainty is a little high for the TOPEX-A/B switch. For example, Mitchum has computed this in his tide gauge analysis (after fixing the SSB to the Chambers model) and finds a uncertainty of less than 1 mm because of the long time-spans before and after the switch. I don't really follow your reasoning that it is up to 2 mm. Please explain.*

We think 1 mm uncertainty is a little optimistic for the following reasons: - TOPEX A and TOPEX B MSL series are not overlapped, and in the meantime a strong decrease of the MSL evolution occurred (in relationship with "La Nina" 1999). This effect prevents a direct estimation of the SSH bias with an accuracy < 2 mm.
- Using external data as tide gauges to estimate the residual SSH bias (as Mitchum) only reflects SSH behaviour in coastal areas.

*4. Summation of errors. This is where it gets confusing to the reader. Basically, as I follow it, you assume a maximum and minimum error, ignore that some of these may be negatively correlated, and sum them up. I this is so, please state this. After this, I do not understand how you reduced this to 0.6 mm/year based on the "mathematic formulism" of Bretherton et al., 1976. Please summarize what assumptions are made about the individual components to reduce the value.*

We agree to better re-written this section probably not detailed enough. Indeed, the total contribution of errors listed in this paper can be calculated differently: - The sum



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of each error gives a total value close to 0.9 mm/yr. But it is a pessimistic point of view since errors can be correlated and not only additive.
- From a classic way, the quadratic sum of each error leads to a value close to 0.45 mm/yr. This basic method do not allows to take into account the correlation between each error and the no-linearity of the MSL evolution. In addition, the confidence interval of the total error is unknown.
- It is the reason why in this paper, we use a more realist statistical approach (inverse formalism). It allows us to calculate a realist error around 0.6 mm/yr with a confidence interval of 90%. This new budget error is an interesting new conclusion in the paper. We have to better explain its principle in the paper.
The new release has been significantly developed to better described this section.

*5. Finally, you estimate drift by comparing to tide gauges in the next section. Again, I agree with Reviewer 2 that there are problems with this assessment and some things need to be clarified.*

*5.1 First of all, why are the curves offset in Figure 8 if a relative bias has been applied? Is this artificial, or is there some residual bias in your results. If you have offset them artificially, please state this in the caption; otherwise, please explain the bias.*

As the altimeter SLA is the difference between its SSH and the Mean Sea Surface while tide gauges are calibrated together without taking into account this MSS, the difference between both data time series result in an offset for each altimetric mission. The calibration of tide gauges could be offset on the MSS so as not to get some residual bias in the SLA differences.



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*5.2 Also, you mention later that the standard deviation of the tide gauge-altimeter global residuals is 7 cm, which is quite large. Mitchum generally gets residuals closer to 1 cm RMS. It also does not look like your residuals in Figure 8 have a 7 cm RMS. Finally, I am a little surprised that your drift in the TOPEX residuals is so high compared to that in Beckley et al. (or Leuliette et al). These both relied on an analysis my Mitchum and the Chambers TOPEX SSB model. They both showed only a little drift in the TOPEX-tide gauge residuals.*

Results presented in the paper have been filtered and adjusted from periodic signals. The strongest values of standard deviation which are sometimes observed can be related to the measurements number of colocated altimeter and in-situ measurements weaker than expected (due to altimeter or in-situ data incidents). Some other explanations can be given to this relative high number. For example a raise corresponding to the TOPEX orbit change can be observed in September 2002 when the satellite moved over the Jason-1 interleaved track in order to benefit from both altimeter missions in oceanic applications (Jason-1 phase tandem). Moreover, studies from Mitchum, which indeed get residuals closer to 1 cm RMS, are optimized in the way of choosing the most 64 reliable tide gauges in a defined area. Our goal is a little different as it consists in looking for drifts or jumps in altimeter data by using the whole tide gauge dataset and computing global statistic monitoring.

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