

02 October 2013

Dear Editor Dr. Andreas Sterl, dear Reviewer #1, dear Reviewer #2,

Thank you for your careful reading and constructive comments, which greatly improved our manuscript. We have addressed each of reviewer's comments and suggestions, as described in the attached response. In particular, we have rewritten much of the manuscript and reduced the number of figures, to make it shorter and clearer, in line with suggestions from the reviewers.

You will find below a detailed point-by-point response for both anonymous reviewers, and we hope that you find that the paper is suitable for publication in Ocean Science.

Sincerely,

Karina von Schuckmann

Jean-Baptiste Sallée, Don Chambers, Pierre-Yves Le Traon, Cecile Cabanes, Fabienne Gaillard, Sabrina Speich and Mathieu Hamon

## Point-by-point response:

### Reviewer #1:

*1) The manuscript should be completely rewritten (including a title change) to focus on the major point of interest, that consideration of the region around Indonesia is important in closing regional and global ocean heat and sea level budgets on interannual to decadal time scales. Please rework the title, text, and figures to focus on this important point, and condense the rest of the material, which is already discussed in other papers in a more precise fashion, to a much smaller, concise summary supporting the main new result.*

As suggested by this reviewer we have edited the text to make it more concise and straight to the point. We reduced the number of figures from seven to five, and rewrote the abstract. Following reviewer's suggestion, we also re-worded the title to "Consistency of current global observing systems from an Argo perspective".

*2) Overall, the English usage is often poor in the manuscript and needs improvement. There are far too many issues requiring attention than can be pointed out specifically in a review, and they will presumably change with a major rewrite. At any rate, copyediting is not the job of a reviewer. Perhaps the third author should spend a bit of time editing the manuscript for usage after it has been revised, just prior to resubmission.*

We thank the referee for his/her careful reading and apologize for providing a manuscript with poor English usage. All authors carefully reviewed the text and tried to remove most of the typographical errors. In particular the third author (who has English as a first language) spent time to improve language issues.

*3) P924, L14 and following. The units of W/m<sup>2</sup> can be ambiguous. What is the surface area in question? Is it the area of the world ocean, the area of the world ocean between 60°S and 60°N, or the surface area of the Earth? Any of these are plausible, and the latter is widely used in climate studies which consider top-of-the-atmosphere balances. Please consider using TeraWatts instead, or specify the surface area used in the calculation.*

Surface area used for the calculation of GOHC is now clearly mentioned.

*4) P924, L16-17. The Indonesian Archipelago is not a "basin", but a region of the ocean.*

We have changed this as we have rewritten the abstract.

*5) This sentence is awkward and ambiguous. What is "the ocean component" of the sea level budget?*

We have excluded this part of the sentence "especially the ocean component". It was related to the Earth's energy budget, but the way it was written led to misunderstanding.

6) P926, L 9-10. Also this assumption relies on nothing changing in the deep ocean below 1500m.

We have added the issue “deep ocean changes” to this sentence.

7) P926, L16-19. Purkey and Johnson (2010) estimate  $0.15 \pm 0.10$  mm/yr sea level rise, and  $0.10 \pm 0.06$  W/m<sup>2</sup> of warming (applied to the surface area of the earth) below the 2000-m sampling limit of Argo.

We have corrected the numbers of Purkey and Johnson, and we apologize for this error.

8) P930, L3-4 & elsewhere. Sentences like "Fig. x shows . . ." and "Blah blah are shown in Fig. 1" duplicate the figure caption and make poor topic sentences. In this instance, one could just delete the first sentence and refer to Figure 1 parenthetically at the end of the second sentence. Those actions would make sure the topic sentence stands out in its rightful place at the start of the paragraph, and eliminate unnecessary duplication of text already in the figure caption that just ruins the flow of the argument anyways.

We have avoided repetition of information already given in the Figure caption.

9) P930, L21-23. This sentence is unclear and confusing. Please rewrite it.

We have rewritten this sentence.

10) P931, L3-5. Is this statement correct? The contribution of haline contraction to sea level, when integrated globally, is almost two orders of magnitude smaller than the contribution of the mass changes associated with it (e.g. Munk, 2003, *Science*). Thus it would seem that accounting for mass changes would be necessary (e.g. Boening et al., 2011, *Geophys. Res. Lett.*) but that halosteric effects should be negligible, at least for global averages.

The sentence was not meant to exclude mass changes, and to shift the halosteric effects as the dominant process of sea level change for this period of intense interannual variability. But we agree, as the sentence is stated, it leads to misunderstanding, and we have hence clarified the statement: “Consistently, it has been found that the slower rate of sea level rise during 2005–2010 can only be reconciled adding steric height variability computed from Argo data that includes salinity to ocean mass changes (Llovel et al., 2011).”

Halosteric effects should be negligible for global averages over long time scale. However, at interannual time scales, the halosteric effect for global averages is not negligible, which is clear in the study of Llovel et al., 2011. The Munk, 2003 paper discusses “the rate of global sea level”, hence, longer time scales. More work is planned on this issue in a future study.

11) P931, L5-8. Please be more precise with dates and numbers here and throughout. Estimating the trend in SSH from the start of the AVISO series to any given date shows that the trend is  $> 3.4$  mm/yr for end dates between early 2001 and early 2007, but thereafter falling to 3.13 mm/yr by an end date of early 2012, and only partly recovering to 3.17 mm/yr by an end

*date of early 2013. One doesn't need all that detail, but try to be precise with dates and numbers for the detail given.*

Sorry for the confusion. We have clarified this point by adding “from the start of altimeter time series to mid-2013”.

12) P932, L1-3. *If the errors cancel, why would one increase the trend error? Do they add, and not cancel?*

We have changed this sentence to “We account for this in increasing the trend error from the fit with the uncertainty in GIA...” (note that this sentence is now section 2: data and method).

13) P932, L10 & L20. *Again, eliminate poor topic sentences like this one that duplicate parts of the figure captions.*

We have eliminated these sentences (note that this sentence is now in section 3.2).

14) P933, L7-13. *Including some appropriate references to studies that support these statements might be useful for some interested readers.*

We have added some references (note that this sentence is now in section 3.2).

15) P934, L3-4. *Again, the topic sentence is poor and duplicates the figure caption.*

We have removed this sentence (note that this sentence is now in section 3.2).

16) P934, L3-9. *This paragraph is confusing and would benefit from a total rewrite.*

We have re-written this paragraph.

17) P935, L1-7. *Could interannual variability in Labrador Sea Water (LSW) ventilation, or variability in other components of North Atlantic Deep Water, also be a factor?*

We have added this sentence: “Also unaccounted interannual variability in Labrador Sea Water (LSW) ventilation or in other components of North Atlantic Deep Water (e.g. Biastoch, 2008) could also be a factor.” (Note that this sentence is now in section 3.3).

18) P935, L24 - P936, L1. *This portion of the text is not clear at all.*

We have shortened and rewritten this paragraph and hope to be clearer now. (Note that this sentence is now in section 3.4)

19) P937, L1. *The phrase "coarse Argo sampling" is not correct. It is really that shelves are hardly sampled at all by Argo, and the marginal seas are poorly sampled, along with regions of seasonal (and permanent) ice cover.*

We agree that coarse is a subjective word, which can be confusing. We have now removed the word “coarse” from the sentence.

20.) P937, L7. *What are "instrument fail functions"? Perhaps "instrument failure modes" would be more appropriate here?*

Due to re-writing/changes in this chapter, this sentence has been completely removed.

21. P937, L14 - P938, L2. *Detecting small changes as the residual of the difference of two large numbers is almost never a useful exercise. One is never sure if there is some unknown bias error that is small with respect to the signal being measured, but large with respect to the residual being calculated.*

We agree with the reviewer that it is always difficult to detect small changes as the residual of the difference of two large numbers. This is a recurrent problem in many aspects of climate sciences. However, we believe that it is the legacy of climate scientists to extract climate relevant signal, even from residual of large signals, if (and only if) error are properly computed and acknowledged, and if limitations are clearly explained. This is why, we dedicated a large part of our analysis to error treatment and clearly displayed in all figures and number given in the text an estimate of the error.

Any residual signal needs then to be analyzed in terms of physical understanding of the system. This is what we aim at in the present manuscript and conclude that the residuals in the present study are not associated with a climate signal. The sentence the reviewer refers to is about future climate signal that could potentially be detected with longer time series. We clarified our thought by adding this sentence to the discussion: “If systematic errors can be fully resolved (or continue to cancel) and standard errors in the current observation networks stay constant, after 15 years we could detect a the deep steric trend greater than 0.4 mm/year for 15 years at the 90% confidence level. With increasing numbers of Argo floats in the SO, and assuming continued altimetry and gravimetry, we may hope to be able to detect subtle and climatically important deep ocean changes in the future.”

22) P937, L14 - P938, L2. *Deep observations can also be useful for estimating circulation or ventilation changes (e.g. Kouketsu et al., 2011, J. Geophys. Res.; Purkey and Johnson, 2013, J. Climate). Also, one cannot calibrate Argo salinities with confidence without deep shipboard measuerments that are carefully calibrated with bottle salinity data standardized by IAPSO Standard Sea Water.*

We have added these two sentences: “This emphasises once more the importance of deep measurements, such as from ship and from deep Argo probes. Note that the ship casts are vital for deep Argo to work, since one cannot calibrate Argo probes with confidence without deep shipboard measurements that are carefully calibrated with bottle salinity data (IAPSO Standard Sea Water) and precise thermometers. Moreover, deep observations are important for estimating circulation or ventilation changes (e.g. Kouketsu et al., 2011; Purkey and Johnson, 2013).

23) P944. *Change the last sentence to "Error bars include data . . . but not systematic errors."*

We have changed this.

24) P946. *Should read "Same as Fig. 2, . . ." and should be "-0.6\_0.6" (minus sign missing).*

We have corrected this

25) P947. *There must be a better way to tell this story, which is perhaps the main new result detailed in this manuscript. Between the figure and the text, it is hopelessly confusing as it is now.*

We have re-written this part, and hope to be clearer now.

26) P948, *Change "belt" to "band".*

We have removed this Figure from the paper.