Ocean Science

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Discussions

Interactive comment on "Weighing the ocean with bottom-pressure sensors: robustness of the ocean mass annual cycle estimate" *by* Joanne Williams et al.

Joanne Williams et al.

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Thank-you for your review and encouraging remarks.

1 *About self-attraction and loading: ...Please consider restructuring to begin with a formal description and the introduction of the acronym. SAL could then later be used as a previously defined concept without further explanation.*

Changes are made to section 2 as suggested.

2 *Introduction of p_{ANN} on page 461 – could consider mentioning the explicit connection to p_m by naming it for example p_m^{ANN} .*

Thank-you for this suggestion.

3 *Section 4.3 starts with: "The hydrology and atmosphere model thus provides" tying this section to the previous one. To have a more clear divide between 4.3 and 4.2, one could re-state in a few words the conclusions of 4.2 instead of using "thus". p_h could be introduced earlier (maybe section 4.2) to make the relationship between m_O , p_m (or p_{ANN}) introduced in equation (1) and p_h more clear.*

We've rearranged the first paragraphs of section 4.2 and 4.3 to make this clearer.

4 *On page 460 ECMWF data is used to correct the bottom pressure data. Atmospheric data in section 4.2 comes from NCEP. Does the use of different reanalysis products cause any differences in the end results?*

phase for best sites (6, 10–15, 17) simultaneously with noise added to the bottom pressure records, using both ECCO and NEMO12. NCEP is used for atmospheric pressure instead of ECMWF. 95% of results fall inside the white contour.

We have since calculated the p_a, the global annual cycle of atmospheric pressure over the ocean, over the dates 2001 to 2011 (as used in section 2, p460) from the NCEP reanalysis. p_a from the NCEP reanalysis has amplitude 0.60 mbar, phase $190°$. p_a from the ECMWF reanalysis has amplitude 0.61 mbar, phase $186°$. This is a small change compared to the difference between the two ocean models.

Using the NCEP reanalysis in the full calculation for the "best" sites (6,10–15,17), and combining both ECCO and NEMO 1/12 models, (figure 1 attached, equivalent to Fig. 13 in the paper) leads to an ocean mass annual of 0.96 mbar, peaking at $273°$ (4 Oct), with 95% of results between $0.59 - 1.11$ mbar and $258° - 295°$ (19 Sep–26 Oct). The biggest effect is in slightly focussing the spread when NEMO 1/12 alone is used, and hence creating a slight double-peak when combining the models. The change is within the existing range of estimates listed in Table 2, and more importantly, the estimated 95% bounds are little changed. We feel it is

best not to add to the complexity of the paper by including more combinations of results there.

5   *Section 5.5: What are the major differences in the model implementation (or data assimilated) between GLDAS-1 and GLDAS-2.0?*

We have added further explanation in section 4.5, where GLDAS-2 is first mentioned: "We have also tested the GLDAS-2.0 data (also plotted on Fig. 4c), which uses an updated version of the NOAH model and, more importantly, different meteorological forcing. While the whole GLDAS-1 model time series is forced by a mix of meteorological datasets, over the period of this study the forcing is consistent and includes high quality observational precipitation and solar radiation. The GLDAS-2 uses the Princeton meteorological forcing dataset, which is a bias-corrected reanalysis product." See http://hydro1.sci.gsfc.nasa.gov/data/s4pa/GLDAS/README.GLDAS2.pdf

6   *Why not use GRACE for all of the hydrology instead of using GLDAS that only covers part of the water mass observed?*

We want this study to be as far as possible independent of GRACE, in order to provide an calibration to GRACE measurements of water mass changes. We were obliged to use GRACE for Antarctica and Greenland, but these are relatively small regions in the far-field of our sensors.

The use of global GRACE measurements in this context is a subtle issue, as some model for the low degree harmonics (including geocentre) must be introduced, as investigated for example by Bergmann-Wolf et al, 2014: DOI 10.2478/jogs-2014-0006 | J. Geod. Sci. 2014 4:37–48. By minimizing the use of GRACE data, we characterize our errors in a way which alllows for future optimal combination of BPR and GRACE data.

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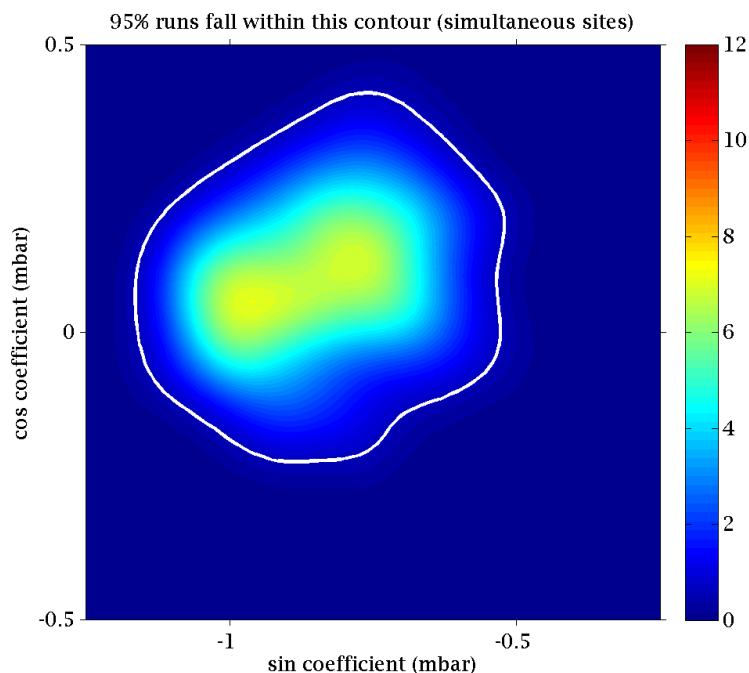
Fig. 1. Prob. dist. fun. of annual amplitude and phase for best sites (6, 10–15, 17) simultaneously with noise added to the bpr, using both ECCO and NEMO12. NCEP is used for p_a instead of ECMWF.

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