

Interactive comment on “Earth’s energy imbalance and implications” by J. Hansen et al.

J. Hansen et al.

jhsansen@giss.nasa.gov

Received and published: 29 November 2011

The general comment that the paper tends toward excess verbosity and may be a bit too tutorial is related also to the following specific comment about the style "Figure X shows. . .". We agree with Referee 1 that we can save words by avoiding that style, thus minimizing repetition between text and figure captions, so we have made that change throughout the manuscript. As for the tendency to be "a bit tutorial", we have aimed for a compromise between making the matter clear to a broad range of readers and a terse style that would be sufficient for the expert. Given the broad importance of the topic and its implications, we hope this compromise can contribute to a more widespread understanding.

Referee #1 and Referee #2 both point to inappropriate material in the abstract. We apologize for failing to notice that our Introduction was inadvertently included as part of

C12481

the Abstract (because we did not name and number the Introduction as Section 1, as it should be in ACP style). We have corrected this. The Abstract and Introduction are now succinct, well within ACP style.

P2: The first three specific comments for this page all relate to our failure to number the Introduction and have been dealt with via the above revisions.

P5, L6-9: o.k., we have omitted use of grandchildren in the discussion and thus their names.

P6: Yes, the long time scale albedo feedback is mostly from change of continental ice area, so that clarification has been added.

P8: The requested sentence describing the Russell ocean model has been added, specifically: The Russell ocean model conserves water and salt mass, has a free surface with divergent flow, uses linear upstream scheme for advection, allows flow in and out of 12 subresolution straits, and is used here with 13 layers at $4^\circ \times 5^\circ$ resolution.

P11-P12: We have added reference to Dutay et al. (2002), Gent et al (2006), and Griffies et al. (2009). The Dutay and Griffies papers are multi-model comparisons, showing a wide range of mixing rates among the models, although a frequent tendency for excessive mixing into the deep Southern Ocean. The Gent paper concerns only the NCAR model, but is particularly relevant because of the comparison that we have of response functions for these two models.

Section 9: Yes, the recent Church et al. (2011) paper also includes discussion of all of the significant terms in the energy and sea level budgets for the period 1961-2008, often with different data sources or analyses than ours, so we make several comparisons. In general there is consistency between our conclusions and theirs. One of the periods (1993-2008) that they tabulate results for coincides with the period used for our Fig. 10a, so we are able to make precise comparisons.

P21: We have added references to the Gouretski and Koltermann (2007) and Levitus

C12482

et al. (2009) papers.

P22: The new Barker et al. (2011) paper and its implications re systematic measurement biases are now noted here and elsewhere in the paper. The data quality controls employed by Von Schuckmann and Le Traon (2011) should reduce the impact of the pressure sensor drift bias, but the effect of this and any possibly undiscovered biases cannot be eliminated.

P24: We added a sentence noting the possibility that additional data for the deep ocean, beyond that employed by Purkey and Johnson (2010), might provide a useful indication of recent heat storage in the deep North Atlantic. (But given the volume of water there, we would not expect the global heat storage to be modified much.)

P26: We now include mention of the relevance (to possible excessive mixing in ocean models) of the multi-model comparisons with observations of transient tracers, with references to the Dutay et al. (2002), Gent et al. (2006) and Griffies et al. (2009) papers.

P27: We have added reference to the recent Nerem et al. (2010), Roemmich and Gilson (2011), and Llovel et al. (2011) papers, which address ENSO effects on global sea level.

P38: Yes, we agree that the issue of potential biases in Argo data, as raised by Barker et al. (2011), should be mentioned again at this point in our paper, and we have now done so. [We believe that effects of such biases are reduced in the von Schuckmann and Le Traon (2011) analysis.]

P39: We agree that it is worthwhile to point out again that there are several ocean model/data comparisons that provide support for the interpretation that the models' response functions may be slower than the real world. This is the third point in the paper where this is mentioned, so in this case we make the point without explicitly listing the several references again.

C12483

P40: The apparent conflict in the topic sentences for the first and second paragraphs of section 13.5 (now section 14.5, with the Introduction now numbered as section 1) has been removed, as suggested, by clarifying that the 3mm/year rate of sea level rise is an average over a longer period.

P41: We agree that it is useful to comment on the role of La Nina in the recent slowdown of the rate of sea level rise. We have added the comment: Although the effect of La Nina on the vertical distribution of temperature in the ocean (Roemmich and Gilson, 2011) should be captured in the analysis of thermal expansion based on Argo data, the water storage on continents during La Nina as a consequence of heavy rainfall and floods (Llovel et al., 2011) could account for much of the temporary slowdown of sea level rise.

Figures 8-11, & 14: Referee #1 suggests that we try to include error bars on some of these estimates, if possible. We agree that is a desirable objective, and have made the following changes. In Fig. 9 we have added the error bars estimated by von Schuckmann and Le Traon (2011). In Fig. 10 (b) we include the error estimated by von Schuckmann and Le Traon (2011) for their 2005-2010 analysis, but for Fig. 10(a) we have shown the range from Lyman et al. (2010) to Levitus et al. (2009), because that range is larger than their formal error estimate. In Fig. 11 we have added the error estimates of von Schuckmann and Le Traon (2011). Fig. 14 now includes error estimates of von Schuckman and Le Traon (2011) and Purkey and Johnson (2010).

Technical corrections: We agree with these and have made the suggested changes.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 27031, 2011.

C12484