Earth Syst. Dynam. Discuss., 3, C171–C174, 2012
www.earth-syst-dynam-discuss.net/3/C171/2012/

Earth System
Dynamics
Discussions

Interactive comment on "On the relation between Meridional Overturning Circulation and sea-level gradients in the Atlantic" *by* H. Kienert and S. Rahmstorf

Anonymous Referee #1

Received and published: 11 May 2012

Review of the manuscript "On the relation between Meridional Overturning Circulation and sea-level gradients in the Atlantic" (doi: 10.5194/esdd-3-325-2012), written by H. Kienert and S. Rahmstorf, submitted to Earth System Dynamics Discussions

The aim of this study is to examine the relationship between the sea level change and the change in the strength of the Atlantic Meridional Overturning Circulation (AMOC), which is modulated by three forcing, i.e. CO2 concentration, freshwater perturbation and the Southern Ocean wind, and potential usage of the forcing as the AMOC diagnostic . The topic is important under the on-going climate change and could contribute to our knowledge of the ocean and climate system in a sufficient manner to warrant

eventual publication. However I have some recommendations that I hope will improve the current manuscript.

1. Explicit oceanic eddies are missing in this study and this could be biasing the result. In particular, the response of the Southern Ocean to wind changes has been shown to be markedly different in eddy vs. non-eddy models – the authors should cite studies relevant here: see for example Screen et al., 2009; Meredith and Hogg, 2006; Hogg et al., 2008; Sallée et al. 2008; Spence et al. 2010; Farneti and Delworth, 2010 (papers listed at end of review). Over short time-scales, an adjustment in the Southern Ocean winds generates a change in the horizontal Ekman transport, and in turn the vertical Ekman pumping and the location of fronts. However this adjustment is then pretty much entirely compensated on interannual time-scales by mesoscale eddy fluxes that transfer heat poleward and diffuse density gradients via baroclinic instability (see papers above). The results of the present paper would be entirely different in an eddy-resolving model, because eddy compensation would mitigate much of the response in the Ekman transport. As a result, the linear relationship could be not valid. Of course it would be impossible to run the suite of experiments examined here at eddying resolutions, but the authors need to discuss this shortcoming of their study in some more detail and point out it potential influence on the relationship between the sea level change and the AMOC strength. Similar discussion might be also applied for the freshwater forcing.

2. I think it would be necessary to mention in Section 2 (model simulations) in which exact latitude bands the Southern Ocean wind anomalies are applied.

3. In section 3, the authors conclude that both freshwater forcing and reduction of the Southern Ocean wind stress only result in a localized sea level reaction in the 100-year simulation. However, a total response of the AMOC to these forcing may take much longer time. In recent paper, Wei et al. 2012 found that the full AMOC response to the Southern Ocean wind perturbation takes several centuries ($\sim$ 300 years) in their coupled GCM. What is the response time for both forcing in your specific model setup?

Or some discussion is needed here based on the previous studies. In section 4.2, the authors provide the results from longer integrations. However, only figures from the CO2 experiment are shown. No further analysis or discussion on the longer timescale change of the sea level results from the other two forcing. It would be interesting to see the results from the freshwater and wind forcing experiments, or at least, the authors should have more discussion on it and either support or further explain the conclusion in Section 3.

4. In Fig. 3a, Fig. 4a and Fig. 10b, one can see that the linear relation between sea level change and the AMOC is only valid in when the AMOC strength is larger than a certain value. Is there any threshold for this relation? One can also see that this value may depend on the freshwater amount. For each freshwater amount, the linear relation breaks down in different AMOC strength. In Fig. 13, the AMOC change is quite smooth under CO2 and SO wind forcing, but not the freshwater forcing, especially the last 50 years. I guess it is also related to the response time of different forcing as pointed in comment #3. Meanwhile, what causes the large fluctuation of the AMOC under the freshwater forcing in the last 50 years? Internal variability? Possible feedback? The authors should analyze more in section 5.2 to clarify this point.

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