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Climate of the Past Discussions

Interactive comment on "The global ocean circulation on a retrograde rotating earth" *by* V. Kamphuis et al.

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We thank the referee for the thoughtful comments and suggestions and all points have been addressed in the revision of the manuscript.

Specific comments

Indeed, model dependence is an issue and therefore we added more cautious remarks throughout the text. The differences between PRO and RETRO in precipitation and SST in the North Atlantic and North Pacific are much larger (about three times) than the largest error in the fields of CCSM3 with respect to observation based climatologies. In Collins et al. [The Community Climate System Model Version 3 (CCSM3),

J. Climate, 19, 2122–2143, 2006] the largest errors in precipitation between CCSM3 and the GPCP data set [Adler et al. (The Version-2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979–Present), Journal of Hydrometeorology, 4, 1147–1167, 2003)] in the North Atlantic and Pacific are from +0.5 to -1.0 mm/day while the difference in stable precipitation between PRO and RETRO is +1.5 to -3.0 mm/day above 30°N. The errors in CCSM3 with respect to data in the tropics are much larger, as is the case in many OAGCMs. However in this area we see hardly any change from PRO to RETRO and therefore this is of minor importance for the problem addressed in the paper.

The fact that PRO2 is forced by climatology and not by CCCSM3 boundary conditions like RETRO2 was a matter of convenience. The bifurcation for the climatology forcing was readily available, and moreover, extensively described in literature. As the forcing fields do not differ too much in the large scale features (taking into account the coarser grid of the steady-state model), we expect that the bifurcation diagrams will not be substantially different for both cases. This has now been explicitly mentioned in section 4.1.

The ocean transport of salinity was not described in detail, because of the very different nature of the circulation. There is reason to believe that the net freshwater inflow due to the overturning (the so called M_{ov} or Σ, e.g. de Vries and Weber [The Atlantic freshwater budget as a diagnostic for the existence of a stable shut-down of the meridional overturning circulation, Geophysical Research Letters, 32, L09 606, 2005] and Dijkstra [Characterization of the multiple equilibria regime in a global ocean model, Tellus A, 59A, 695–705, 2007] are important to determine the stability of the AMOC. However, these quantities only make sense in the presence of a vigorous AMOC. Also, the gyre transport was too different because of the reversed direction; these changes are a study in itself and a more detailed data analysis of these aspects are outside the scope of this paper. For example, the transport of salt from the Indian to the Atlantic ocean is not reversed in the sense that there is Agulhas leakage into the Indian Ocean,

rather there is an inflow from the Indian to the Atlantic due to the reversed ACC.

We have tried to clarify the views (i) and (ii) in more detail and the text has changed into

(i) There is only one possible equilibrium circulation pattern in the ocean under the atmospheric surface forcing and continental geometry. Multiple equilibria do not play a role and the Atlantic-Pacific salinity contrast is set by these external forcing asymmetries.

(ii) Out of a number of possible equilibria, the present-day weak external forcing asymmetries induce a strong preference for the Conveyor state, with a strong Atlantic-Pacific salinity contrast, due to the positive salinity feedback.

We have added relevant references to the introduction.

Technical corrections

Thank you. Suggestions followed.

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