The Cryosphere Discuss.,
doi:10.5194/tc-2016-81-AC1, 2016

The Cryosphere
Discussions
Open Access
EGU

Interactive comment on "Impacts of Antarctic runoff changes on the Southern Ocean sea ice in an eddy-permitting sea ice-ocean model" *by* V. Haid et al.

V. Haid et al.

v.haid@web.de

Received and published: 22 September 2016

R. STEVENS:

GENERAL COMMENTS

Numerical models are the ideal tool for undertaking experiments on complex natural systems when attempting to understand the mechanics of the system and how it might change into the future. This paper presents the results of a set of numerical model experiments on one of Earth's major state changes, i.e. the freezing in autumn and winter of the Southern Ocean adjacent to the Antarctic Continent. What is more, Southern Ocean sea ice is baffling in that its extent has been increasing even as global air temperatures have increased. This paper investigates how much of the expansion of sea ice extent is caused by increased freshwater runoff from the Continent. The paper is therefore of interest not only for scientific reasons but also because of the politics surrounding global warming and this "poster child" for climate change sceptics. The paper is well written and easy to understand. The investigation into how the spatial distribution of fresh water input changes sea ice is interesting. That there could exist a maximum freshwater input for sea ice extent increase (and above which extent decreases) is also an interesting result.

SPECIFIC COMMENTS

I think the experimental method is reasonable and the choice of NEMO/LIM is a good one. My major question relates to the authors' choice of LIM version 2 rather than version 3. I realize that LIM2 is favoured by ocean modellers because it is more economical on computer time but this research is focusing on sea ice (and the waters that interact with it) rather than the ocean generally. In this application LIM version 3 seems to offer some advantages over the earlier version. The most important of these is accounting for ice rafting and also frazil ice growth. Both of these processes are important for Southern Ocean sea ice (and less so for Arctic Ocean sea ice). The paper reports that one of the consequences of increased runoff is thinner, more mobile ice. Rafting is common, possibly ubiquitous, in thin Southern Ocean sea ice (Worby et al, 2008) and can occur in relatively mild convergent conditions compared to those encountered by sea ice impacting land, ice shelves, or land-fast ice. The results show that the most thickening of ice from ridging occurs in highly convergent regions, e.g. western Ross Sea. It is possible that the model underestimates dynamic ice thickening in other regions because of the lack of rafting in LIM2. It may have been interesting to run a simulation where increased freshwater is added to all the Southern Ocean, i.e. approximating increased precipitation. This would isolate the thermodynamic contribution of increased freshwater to the ice extent increase. However, I realize that these suggestions would require re-running the model and so are not feasible. It would be

Printer-friendly version

Discussion paper

desirable to explain why LIM2 was preferred to LIM3. The simulated winter ice concentration is higher than that of satellite observations as seen in the supplementary material. The model will report high ice concentration of very thin ice while the passive microwave observations will have problems distinguishing very thin ice from open water. However, thin ice also melts more quickly in spring and summer so I am not sure that the authors' argument is correct, i.e. that the higher winter ice concentration in the simulation accounts for the larger spring/early summer sea ice extent that the model produces. Extent includes open water south of the ice edge so maybe total ice area would give a better comparison? Using total ice area has its own problems of course. Also in the supplementary material the authors state that the quarter degree resolution is sufficient to capture most of the important aspects of atmosphere, ocean and thus the sea ice. I would agree with them in most respects but I wonder if they looked at how well the atmospheric forcing captured the katabatic winds which are so important for the formation of latent heat polynyas and therefore bottom water production?

AUTHORS:

We agree with the referee that a more sophisticated sea ice model might have been more suitable for a model study focused on sea ice properties and their variability. We do also agree that the new features of LIM3 sea ice model might make it a better choice than LIM2, to a great extent. More than based on computational cost, our decision to remain on the "old" but well-tested LIM2 was motivated by the state of the LIM3 code at the time we started the research project that includes the simulations presented here (second half of 2014). Our modelling group at CMCC, as part of the NEMO system team, was aware of weaknesses of the LIM3 code available since 2009 (Vancoppenolle et al. 2009a,b) that might have a large impact on the Southern Ocean sea ice and water masses (as saltÂărejection during ice formation). The group closely followed the evolution of the new LIM code toward the updated version by Rousset et al. 2015. This new code has been released in July 2015, integrated into the most-recent stable version of NEMO (version 3.6). Tests, tuning and then analysis of the LIM3 performances in comparison to LIM2 have been conducted, starting from the coarse 1-degree global configuration (see Uotila et al., in review) and, only later, for the eddy-permitting configuration. Following the development of the NEMO code, we do plan to continue our modeling study of the Antarctic sea ice and runoff effect using the more complete NEMO3.6 which includes the new LIM3 sea ice model, but also modules for iceberg and ice shelf cavities.

Rousset C., M. Vancoppenolle, G. Madec, T. Fichefet, S. Flavoni, A. Barthélemy, R. Benshila, J. Chanut, C. Levy, S. Masson, and F. Vivier: The Louvain-La-Neuve sea ice model LIM3.6: global and regional capabilities. Geosci. Model Dev., 8, 2991–3005, 2015. doi:10.5194/gmd-8-2991-2015

Uotila, P., Iovino, D., Vancoppenolle, M., Lensu, M., and Rousset, C.: On the influence of sea-ice physics in multi-decadal ocean-ice hindcasts, Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-187, in review, 2016.

Vancoppenolle, M., Fichefet, T., Goosse, H., Bouillon, S., Madec, G., and Maqueda, M. A.: Simulating the mass balance and salinity of Arctic and Antarctic sea ice: I. Model description and validation, Ocean Model., 27, 33–53, 2009a.

Vancoppenolle, M., Fichefet, T., and Goosse, H.: Simulating the mass balance and salinity of Arctic and Antarctic sea ice: II. Sensitivity to salinity processes, Ocean Model., 27, 54–69, 2009b

R. STEVENS:

TECHNICAL CORRECTIONS Poor grammar in places, e.g. page 8 lines 1: “In the central and eastern Weddell Sea, the fresh water addition causes the ice to thickened thermodynamically in S3.” I think that “thickened” should be either “thicken” or “be thickened”.

AUTHORS:

We apologize for the mistakes. We carefully checked the text and hope to have corrected and eliminated all typographical and grammatical errors.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-81, 2016.