

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2022-170

Anonymous Referee #1

Referee comment on "Sensitivity of NEMO4.0-SI³ model parameters on sea ice budgets in the Southern Ocean" by Yafei Nie et al., Geosci. Model Dev. Discuss.,
<https://doi.org/10.5194/gmd-2022-170-RC1>, 2022

This submission addresses relevant and timely scientific sea ice modelling questions – in particular, how different model parameters, and combinations of model parameters, influence both sea ice budgets in the Southern Ocean as well as comparison with satellite data. The sea ice components of global climate models tend to rely on parameterizations dominated by Arctic studies. This paper is a new look at parameterizations targeting Antarctic sea ice, and recommends ten new combinations of parameters for the NEMO4.0-SI3 sea ice model that would result in better comparisons with satellite-based observations of Southern Hemisphere sea ice area and extent. The paper is well written overall, with methods and assumptions clearly outlined.

The submission will be stronger with some revisions including:

- Set the broader context. This submission explores sea ice parameterizations primarily aimed at reducing RMSE between the model output and satellite observations for total Southern Hemisphere Sea Ice Extent and Sea Ice Area. These are very limited metrics for model performance – e.g. Notz, 2014 and Notz, 2015. The experiments in this paper are thoughtful and provide interesting insight into sea ice models yet the results presented here are not presented within the larger context, and only look at a very limited metric (climatological mean SH SIA, SIE). Other metrics that are valuable include variability, trends, and particularly for the Antarctica regional means, variability and trends. How would the recommended parameterizations, for example, impact (or not) NEMO's future scenario simulations? Do they impact variability and trends? Are the improvements to SH SIA, SIE also seen in all regions or are they regionally different? (or if beyond the scope of this paper some mention and discussion...)
- Some discussion of why these parameterizations are better in the SH and some differences between Antarctic sea ice and Arctic sea ice and why these differences might lead to these different parameterizations (I am assuming current NEMO parameterizations are based on Arctic work).

- These parameterizations are determined from current conditions. Any thoughts as to whether or not they would be expected to be constant and/or changing in a warming world?
- In the first paragraph in the Introduction, the authors discuss how climate models in general do not capture the observed trends in SH sea ice. While this is true, at no point in this paper are the parameterizations discussed in light of the trends! The parameterizations are compared only to the climatological mean SIA, SIE – not the variability or the trends (or regionality). The spread in representation of the mean annual cycle of SIE is quite large between CMIP6 models (e.g. Roach et al., 2020), however there are climate models that capture the climatological annual cycle of SH SIE. Clarify the introduction a bit to match the research and results presented.
- It may be interesting to add three panels to figure 2 showing variability (STD) of each of these as well.....or not if beyond the scope..
- Passive microwave images will lead to underestimates of SIC in thin ice regions. Any thoughts to whether or not this influences how one compares model output to satellite (you only consider areas of SIC 15% and higher. What about regions where model output is > 15% SIC and sea ice thicknesses less than 5 cm or 5-20cm where satellite observations underestimate SIC?

The submission is well written in general however there are some times when it is a bit unclear due to grammar or word choice. I found some minor changes along these lines and I believe the manuscript would benefit from the help of a skilled editor for language word choices, etc. Here are some suggested minor changes:

Line 18 change "sensitivity" to "sensitive"

Line 27 change "association" to "teleconnections"

Line 93 This is confusing. I believe you mean "number of sea ice thickness categories is 5" and I have no idea what "2 and 1 layers of ice and snow" means. How can a 5-thickness categories for sea ice only have 2 layers? Or one? Guessing just 1 layer of snow on top of sea ice?

Line 110 change "marginal regions" to "marginal sea ice regions" (and define "marginal"...15-85% SIC? Or?)

Table 1 jpl = "number of ice **thickness** categories" I believe? Or? And are these set – in other words, do you change not only the number of ice thickness categories but also the category boundaries? Or just the number?

Line 332 change "ice category number" to "number of ice thickness categories"

Line 424. add "SIC" before "CDFs"

References

Notz D. 2014 Sea-ice extent and its trend provide limited metrics of model performance. *Cryosphere* 8, 229–243. (doi:10.5194/tc-8-229-2014)

Notz, D.: How well must climate models agree with observations?, *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, 373, <https://doi.org/10.1098/rsta.2014.0164>, 2015.

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