The Cryosphere Discussions

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# Comment on tc-2022-133

Anonymous Referee #2

Referee comment on "Southern Ocean polynyas and dense water formation in a high-resolution, coupled Earth System Model" by Hyein Jeong et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-133-RC2, 2022

Southern Ocean polynyas and dense water formation in a high-resolution, coupled Earth System Model

Hyein Jeong et al.

The authors investigate dense water and polynya formation in two versions of the Energy Exascale Earth System Model. The manuscript is clearly structured and the results are well presented. Some of the arguments don't seem to be supported by the material and the results need to be expanded upon.

Main comments here:

- Could you give recommendations for development? What are the key improvements needed here (easterlies and Ekman transport)?
- You mention the impact of the overly strong polar easterlies and associated Ekman transport throughout the paper and abstract. However - you do not seem to directly calculate the Ekman transport. Can you do this and compare to observations?
- The mean-state open ocean stratification is important for the formation of open ocean polynya in models. What does the open ocean stratification look like in these models compared to observations? Is it overly weak (explaining the convection in HR model) or overly strong (explaining no convection in the LR model)?
- You mention that the model is fully coupled. The ocean-ice interaction is very important for DSW and presumably the coastal polynya development. Please include a discussion of this.

Minor comments:

Line 18: Are you referring to katabatic winds? If so, please introduce term as you use it again later.

Line 20: Are coastal polynya important for other aspects of the earth system e.g., marine biology or biogeochemical cycles?

Line 20: You may introduce that these are areas of high sea ice production. Also, coastal polynya may form due to oceanic currents.

Line 46: Could add citation to On the Role of the Antarctic Slope Front on the Occurrence of the Weddell Sea Polynya under Climate Change.

Line 55: You may introduce the two types (coastal and open) of polynya in paragraph one.

Line 134: You can have open ocean convection that doesn't form polynya in models (e.g., Dufour et al 2017 and Lockwood et al 2020).

Line 181: Moved westward with an average velocity of 0.013 m s−1 (Gordon 1978, 1982).

Line 193: Episodic open ocean deep convection events in the Weddell Sea have been linked to anomalies in the Southern Annular Mode index (Gordon et al. 2007; Cheon et al. 2014; Francis et al. 2019; Campbell et al. 2019; Cheon and Gordon 2019). Have you considered the representation the SAM in these models?

Line 209: You can have convection and dense water formation without polynya formation (see Dufour et al. 2015 and Lockwood et al. 2020). Please check if the LR model is infact creating dense water and convection, just without polynya formation. Convection can be calculated via. the mixed layer depth (see de Lavenge et al. 2015)..

Lines 258: Although you're correctly taking the transects from the respective areas following Thompson et al 2018 - the Western and Eastern Weddell Sea transects seem very close together. I'd like to see how this model holds in another region of Fresh Shelf (e.g., along the Ross sea). Also, can the LR model capture the hydrography?

Line 295: Could you produce depth average velocities around the full Antarctic ?

Line 325: Have you considered comparing to very high resolution simulations like the MITGCM or LCM-4320?

Figure 6. c-d The vectors are difficult to see in the figures.