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Interactive comment on "Multidecadal Preconditioning of the Maud Rise Polynya Region" *by* René M. van Westen and Henk A. Dijkstra

Anonymous Referee #2

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Manuscript to review: Multidecadal Preconditioning of the Maud Rise Polynya Region

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Reviewer decision: Accepted with Major Revisions.

The manuscript presents a study of the preconditioning mechanisms of Maud Rise Polynyas (MRPs) in a high-resolution CESM simulation. The four MRP events occur roughly 20-25 years apart. The polynyas' periodicity is attributed to the Southern Ocean Mode (SOM), a mode of ocean heat content (OHC) variability that is not validated with observations or theory. The study attributes the polynyas to be singularly preconditioned by the SOM, where they suggest that a positive phase of the SOM then leads to positive subsurface OHC anomalies in the South Atlantic ocean, which then

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enters the Weddell gyre over ten years and causes deep convection over Maud Rise. The study is interesting, but the fundamental hypothesis is not backed up with a plausible physical explanation, nor do the authors justify why SOM is a unique mode to consider.

Major comments

1. What is the Southern Ocean Mode? There are very few modeling studies that even consider it. Do the authors consider it to be a different mode from the Southern Annular Mode (SAM)? However, one of the definitions of SAM index is the difference between normalized zonally mean sea level pressure between 40S and 65S (Gong and Wang 1999). (SAMindex = P*40S – P*65S) whose Atlantic sector encompasses the region used in the definition of SOM. The authors do not provide an explanation as to why the SOM index is an independent mode. The Southern Annular Mode could in fact influence the Temperature anomaly over 0-50W;35-50S. It would be very helpful if the authors can show that the SOM index is different from the SAM index. It is really not clear why this is a better metric or how this region behaves as an independent influence on the preconditioning of the polynyas over Maud Rise.

2. The authors do not present a robust justification for using only the SOM and not looking at any of the important factors that play a role in preconditioning such as the structure and strength of the Weddell gyre (Cheon et al. 2015) , the SAM index (Gordon et al. 2007), or the presence of stratified Taylor columns over Maud Rise (de Steur et al. 2007; Alverson and Owens 1996). Previous literature (Hirabara et al. 2012) suggests that the preconditioning and formation mechanism of these MRPs are related to several contributing factors that involve the interaction of large- and small-scale ocean/atmospheric circulation. The authors here do not provide a clear physical connection on how the SOM can in turn influence these other contributing factors for polynya formation. The lack of a physical mechanism clearly linking the SOM to the MRPs is a major weakness in this publication.

3. The loosely connected interpretation of figures 5,6 and 7 suggests that particles released over the MRP box and backtracked for 8 years end up in specific regions in the Weddell gyre that are correlated to parts of the SOM region. However, correlation does not imply causation.

4. If the subsurface OHC anomalies from the SOM region propagate along the Weddell gyre to the MRP box in ten years, one should be able to see a pattern in the correlation between SOM and H1000 in which the SOM leads H1000 in steps of 12-24 months (similar to figure 5d but in steps where SOM leads H1000 in 24, 48, 72, 96 months). It would help readers to see the intermediate steps of SOM leading H1000 by 12-24 months between figures 5c and 5d in which the propagation should be evident if such connections exist.

Minor comments

1. The mapping projection in figure 5 is not consistent with figures 6-7. Please be consistent with the mapping projections.

2. The authors mention 3 MRP events observed in 1973-1977,1994 and 2016-2017 to suggest a periodicity of 20 years between MRP events. They did not include the MRP event of 1980 (Comiso and Gordon 1987). The observations do not suggest a periodicity of 20 years. The polynyas of the late-70s were extremely large Weddell Sea Polynyas that begin over Maud Rise and spread westward into the Weddell Sea and have not been observed since.

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