A Review of the Manuscript

"A comparison of the atmospheric response to the Weddell Sea Polynya in AGCMs of varying resolutions."

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This study evaluates the atmospheric response to a Weddell Sea Polynya (WSP) in the austral winter of 1974 using a somewhat idealized experimental setup of AGCMs at low- and high-resolutions. The experimental setup of the present study tries to isolate the response of a WSP by looking at the differences between atmospheric responses in experiments with and without WSP by modifying the boundary conditions in ERA5 sea ice and SST fields. Their findings show that the atmospheric responses in all the simulations are restricted to the immediate vicinity of the WSP in the horizontal and boundary layer in the vertical, primarily driven by the ocean to atmospheric turbulent heat flux. The impact of changing resolution is seen in the magnitude of the response at low levels, with high-resolution simulations having a more significant response. These results are expected, given that Weijer et al. 2017 reached similar conclusions using a fully-coupled GCM with an atmospheric model component resolution of 25km.

Major Comments:

The study has mainly suffered from the experimental setup since the varying resolutions apply only to the atmosphere. However, the ocean and sea ice forcing data remain the same in resolution (ERA5 data standard 31km horizontal resolution). It should have been evident to the authors that given the numerous high-resolution studies on the mechanisms of WSPs, to look at just the atmospheric response of the WSPs, one would need to use atmospheric models much higher than 25 km horizontal resolution despite the size of the WSP (the great WSPs of 1974-1976 remained ice-free throughout the austral winter with an ice-free region of ~ 250,000 sq. km). It would have been valuable for the authors also to consider high-resolution fully-coupled modeling studies that have simulated and investigated the cause/effects of realistic open ocean polynyas in the Southern Ocean (Dufour et al. 2017; Kaufman et al. 2020; Gutjahr et al. 2018; Stössel et al. 2015; Chang et al. 2020; Kurtakoti et al. 2021; Weijer et al.). It might help the authors to see how the representation of the WSP changes with resolution in coupled climate simulations and how the atmosphere responds to the WSPs. In those above fully-coupled studies investigating open ocean polynyas, Weijer et al. 2017 exclusively looked at the atmospheric response to WSPs, and their atmospheric model component was configured at 25km horizontal resolution. To improve the manuscript, the authors may want to investigate how the clouds characteristics, radiative fluxes change and/or modify the cloud radiative effects over the WSP in these simulations.

Minor Comments

Lines 18-20: Please explain this further.

Line 34: “perhaps having only occurred once per century”.

The exact frequency of WSP in the past is not known. Studies have shown a strong link between the southern hemisphere westerlies, SAM index and WSP formation (Cheon et al. 2017; Gordon et al. 2007; Gordon 2014). Gordon et al., 2007 mentions “Gordon (1982) reports that two hydrographic stations obtained by the Argentine ship San Martin in 1961 reveal the absence of the warm deep water, similar to conditions encountered in the 1977 Islas Orcadas stations. The SAM index indicates a prolonged negative SAM in the decade prior to the possible polynya in the winter of 1960. Furthermore, except for the 5-yr period centered on 1910, a negative or neutral SAM index persisted from the 1890s into the first three decades of the twentieth century. Might the Weddell Polynya have been common then?”

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