Response to Reviewers - "The characteristics and structure of extra-tropical cyclones in a warmer climate"

Victoria A. Sinclair, Mika Rantanen, Päivi Haapanala, Jouni Räisänen and Heikki Järvinen

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We thank the editor for their comments on our submitted manuscript. We have copied the comments in black here and include our response to each individual comment in blue.

Editor's minor comment

1. Figure 6 shows the difference between SST4 and CNTL for the 900–700 hPa layer mean potential vorticity. There are two maxima, for example in Fig.6c (t=0), the first near the occlusion point (in the northeast sector of the cyclone) and the second near the bent-back front (close to the composite center, corresponding to the vorticity maximum identified by the tracking). However, the corresponding equivalent for precipitation, Fig. 8g (t=0), shows only one maxima, which is in the north-eastern sector of the cyclone. This suggests, that the potential vorticity seen in Fig.6c in the north-eastern sector of the cyclone is formed by enhanced diabatic processes, while the second potential vorticity anomaly near the bent-back front is resulting from enhanced advection. This difference could be explained by the linkage between the cold and the warm conveyor belts. The positive potential vorticity anomaly, which is diabatically generated in the air below the rising warm conveyor belt, is advected by the cold conveyor along the bent-back front, where it contributes to the enhanced potential vorticity gradients (corresponding to higher wind speed near the tail of the bent-back front of the cyclone). When the linkage is accelerated, the first low-level potential vorticity maximum is explained by enhanced diabatic processes and the second by accelerated advection by the cold conveyor belt, resulting in only one maxima in the precipitation pattern but two in the potential vorticity pattern, which is in agreement with the here presented composites (Fig.6 and Fig.8). The linkage between the conveyor belts has been described in an idealized setting in Schemm and Wernli (2014) and is summarised in their Figure 9.

   Schemm, S. and H. Wernli, 2014: The Linkage between the Warm and the Cold Conveyor Belts in an Idealized Extratropical Cyclone. J. Atmos. Sci., 71, 1443–1459, `https://doi.org/10.1175/JAS-D-13-0177.1` (A video that helps to illuminate the linkage is provided at `https://journals.ametsoc.org/doi/suppl/10.1175/JAS-D-13-0177.1`)

Thank you for sharing this insight with us. This does appear to be a plausible explanation but without performing Lagrangian diagnostics we cannot prove that this is certainly the case. However, we have added a comment about this potential mechanism to section 6.5 of the revised manuscript.

2. A couple of suggested additional literature that seems to be in agreement with the findings of the submitted manuscript. Regarding the changes eddy intensity:

   Paul A. O'Gorman 2010: Understanding the varied response of the extratropical storm tracks to climate change. Proceedings of the National Academy of Sciences Nov 2010, 107 (45) 19176-19180; DOI: 10.1073/pnas.1011547107

   O'Gorman, P.A. and T. Schneider, 2008: Energy of Midlatitude Transient Eddies in Idealized Simulations of Changed Climates. J. Climate, 21, 5797–5806, https://doi.org/10.1175/2008JCLI2099.1

   And in agreement with the fact that the large-scale eddies appear to stabilize the tropopshere in a warmer climate:

   Korty, R.L. and T. Schneider, 2007: A Climatology of the Tropospheric Thermal Stratification Using Saturation Potential Vorticity. J. Climate, 20, 5977–5991, https://doi.org/10.1175/2007JCLI1788.1.

   Thanks for these suggestions. We did not include these as these are studies considering the whole atmosphere in an Eulerian framework, rather than in a cyclone relative framework which makes direct comparisons difficult. However, based on the reviewers comments we have added an extra section on the asymmetry of vertical motion to help link to earlier work and we now also compared our results to a wider range of relevant studies in the conclusions.