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Southern hemisphere extra-tropical cyclones and their influence on the climate of Antarctica

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The major part of southern hemisphere (SH) heat flux (sensible and latent) in the extra-tropical troposphere is associated with transient waves in the synoptic scale. These poleward fluxes have large impacts on the climate of Antarctica. This study investigates the role of changing SH extra-tropical cyclone activity for climate change over Antarctica. Analysis is done for the 20th and 21st century for a better understanding of observed variability and potential future changes.

With respect to the end of 20th century, climate change in the SH is discussed to be influenced by ozone depletion in austral spring and summer. The Southern Annular Mode (SAM) tends to shift towards positive phases in these seasons. To analyse this mechanism, transient and idealised time-slice experiments with the chemistry-climate model EMAC have been performed and analysed. In summer, the time-slice representing the conditions of ozone depleting substances (ODS) of year 2000 shows a significant higher cyclone track density around East Antarctica than undisturbed (year 1960) conditions. In the southern ocean north of 60°S, cyclone activity is reduced with respect to ozone depletion. The signal of surface temperature is consistent with composite studies for different SAM phases, in particular at East Antarctica, where temperature slightly decreases. Positive temperature signals around the Antarctic Peninsula cannot be identified possibly due to the horizontal model resolution.

To examine the climate change signal at the end of the 21st century, a multi-model ensemble of coupled atmosphere ocean general circulation models (AOGCM) from the ENSEMBLES project has been analysed. By the end of the 21st century, the relative change of cyclone track density is in the same order of magnitude in each AOGCM. The multi-model ensemble mean shows a significant poleward shift of cyclone track density with positive changes up to 20% off the Antarctic coast. The atmospheric branch of surface mass balance, i.e. net precipitation (E-P) is given by the divergence of the vertically integrated moisture flux. Transient flux divergence (approximately equivalent to net precipitation due to cyclonic activity) within the Antarctic Circle (66°33') holds more than 90% of the total flux divergence in all model integrations. The climate change signal is subdivided into a part assigned to the change in atmospheric moisture content and a component related to dynamical changes. Net precipitation inside the Antarctic Circle increases in the warmer climate whereas the dynamical part does not show any increase even though there is a poleward shift of cyclonic activity. Here, the specific regions of increasing cyclone track density as well as the different behaviour of strong cyclones play an important role in understanding the influence on the climate of Antarctica.