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A climatological analysis of high-precipitation events in Dronning Maud Land, Antarctica, and associated large-scale atmospheric conditions

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Dronning Maud Land (DML), located in the Atlantic sector of East Antarctica, has become an area of intensive ice core research in recent years. Ice cores are used to study past climatic changes among others. To correctly interpret the ice core information, a profound understanding of the glaciological processes that lead to ice sheet formation as well as of the atmospheric conditions under which snow accumulation occurs is indispensable. Earlier studies showed that in DML especially high-precipitation events complicate the interpretation of ice core data.

The atmospheric conditions leading to high precipitation in DML have been widely investigated, however these investigations tended to focus on individual case studies. Our main objective in this study is to analyse the link between high precipitation in DML and the large-scale atmospheric conditions from a climatological perspective. High-precipitation events are analysed at Halvfarryggen ice dome (71.2°S, 6.7°W), a potential ice core drilling site situated in the relatively wet, low-altitude coastal region of DML, and at Kohnen Station (75°S, 0.1°E), a deep ice core drilling site located in DML's dry, high-altitude interior.

For our climatological analysis, we primarily make use of atmospheric reanalysis data from the ERA-Interim project for 1979-2009; complemented by precipitation data from the Antarctic Mesoscale Prediction System and snow accumulation measurements from automatic weather stations located near Halvfarryggen and Kohnen Station. To describe the large-scale atmospheric conditions, we focus on vertically integrated water vapour transport (IVT), upper level potential vorticity, surface cyclone frequency, and atmospheric blocking frequency.

In line with earlier studies, we find that high-precipitation events in DML are typically associated with amplified upper level waves. This large-scale atmospheric flow pattern is preceded by the downstream development of a Rossby wave train from the eastern South Pacific several days before the precipitation event. At the surface, a cyclone located over the Weddell Sea is the main synoptic "ingredient" for high precipitation both at Halvfarryggen and at Kohnen. Although a blocking anticyclone downstream is not a requirement for high precipitation per se, a larger share of blocking occurrences during the highest-precipitation days in DML suggests an amplification of the IVT into DML when blocking occurs.

We regard the large-scale IVT as one of the most relevant factors in creating high precipitation in DML, in particular over DML's interior. However, we also find that it is important to take into account both the magnitude and the direction of the IVT. Whereas the location of Kohnen Station on the Antarctic plateau allows moisture fluxes from different directions, high moisture fluxes over Halvfarryggen with, for example, an easterly direction do not result in high precipitation in most cases due to the interaction of the moisture flux with the local orography. In other words, high precipitation at Halvfarryggen does not necessarily correspond to high IVT values, but rather corresponds to the IVT with the strongest component perpendicular to the local orography.

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