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Role of sea ice cover in controlling the snow accumulation variability and stable isotopic composition of precipitation in coastal Antarctica

Content

The Antarctic surface mass balance, a critical factor in global sea level changes, is largely determined by the precipitation over the continent and regional climate variability. Although increased surface melting has been observed in the coastal areas of Antarctica in response to atmospheric warming, this is hypothesized to be accompanied by an increase in precipitation which would negate some of the melt-induced mass loss. The coastal Dronning Maud Land (DML) in East Antarctica is characterised by synoptically-induced precipitation, leading to highly variable surface mass balance patterns through time and space, which are not well-captured in regional atmospheric models. Annually resolved ice core records from coastal DML offer potential means for understanding such complexities in accumulation variability well beyond the instrumental records. In this study, we analysed snow accumulation rates and stable water isotopic composition variability within two ice cores, measuring 122 m and 50.5 m, from Djupranen and Leningradkollen ice rises from coastal DML. Chronologies were established by annual layer counting using water stable isotopes, visual stratigraphy, and major ion profiles, constrained by volcanic events identified from non-sea-salt sulphate and tritium anomaly records. The average annual accumulation rate is 0.32 m w.e. a-1 (1726 – 2016 CE) at the Djupranen ice rise (elevation – 325 m), whereas it is 0.24 m w.e. a-1 (1868 – 2016 CE) at the Leningradkollen ice rise (elevation – 170 m). The temporal records at the core sites reveal high interannual variability in snow accumulation rates, with a significant declining trend since the 1980s. Back trajectory analysis and sea ice data from 1979 to 2016 suggest that potential moisture sources at the ice core sites are strongly controlled by the seasonal sea ice coverage in the surrounding ocean. The reduced sea ice cover at the source regions yields more enriched isotope values, while increased sea ice cover results in longer transportation and, in turn, more depleted isotope values. Sea ice cover also controls the amount of moisture availability for evaporation and resulting precipitation. Thus, the seasonal and interannual variability of sea ice cover is the dominant factor controlling the variation in snow accumulation and the isotopic composition of precipitation in the ice core studied. The ice core records from coastal DML are, therefore, ideal for the reconstruction of long-term variability in sea ice cover and understanding the driving mechanisms.

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