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Atmospheric River Climatology of Antarctica

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To properly understand the future Antarctic surface mass balance (SMB) requires a complete understanding of the factors that influence SMB today. Atmospheric rivers, broadly defined as a narrow yet long bands of high precipitable water, provide a sub-tropical connection to the Antarctic continent and are observed to significantly impact the affected region's SMB over short, extreme events. Over coastal Dronning Maud Land, East Antarctica, Gorodetskaya et al. (2013) observed that 4-5 atmospheric rivers contributed to 74-80% of the region's SMB during 2009 and 2011. When an atmospheric river reaches the Antarctic continent, their signature is clearly observed in increased downward longwave radiation, cloud liquid water content, surface temperature, snowfall, surface melt, and moisture transport.

Using an atmospheric river detection algorithm designed for Antarctica and applied to multiple reanalyses, we find that while atmospheric rivers that make landfall are a rare occurrence, they have had significant impacts on the SMB from 1979-2017. During the study period, atmospheric rivers to make landfall have the largest snowfall signature across Dronning Maud Laud where they account for nearly 40% of snowfall in some interior locations. In addition to snowfall, atmospheric rivers are responsible for a majority of the summer surface melt on interior portions of the Ross Ice Shelf and low elevation portions of Marie Byrd Land. Currently melt events across these regions are rare, however a slight surface temperature increase would on average lead to melting conditions when an atmospheric river makes landfall. Atmospheric rivers are also a crucial component of winter surface melting on the Wilkins, Bach, and Larsen ice shelves along the Antarctic Peninsula.

Within most reanalyses, there is a small yet significant increase in atmospheric river activity from 1979-2017. Whether an atmospheric river reaches the Antarctic continent is dependent on the degree of upper-level atmospheric blocking. Atmospheric rivers are associated with significant positive geopotential height anomalies across all regions of Antarctica with the highest anomalies occurring around the Amundsen-Bellingshausen Sea and Adélie Land. Our results suggest that atmospheric rivers should play a significant role in the Antarctic SMB, and that any future changes in atmospheric blocking or tropical-polar teleconnections may have significant impacts on future SMB projections.