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Antarctic Atmospheric River Climatology and Impacts

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Atmospheric rivers, broadly defined as narrow yet long bands of strong horizontal vapor transport typically imbedded in a low level jet ahead of a cold front of an extratropical cyclone, provide a subtropical connection to the Antarctic continent and are observed to significantly impact the affected region's surface mass balance over short, extreme events. When an atmospheric river makes landfall on 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 regional climate simulations from MAR, we created a climatology of atmospheric river occurrence and their associated impacts on surface melt and snowfall. Despite their rarity of occurrence over Antarctica (maximum frequency of ~1.5% over a given point), they have produced significant impacts on melting and snowfall processes. From 1979-2017, atmospheric rivers landfalls and their associated radiative flux anomalies and foehn winds accounted for around 40% of the total summer surface melt on the Ross Ice Shelf (approaching 100% at higher elevations in Marie Byrd Land) and 40-80% of total winter surface melt on the ice shelves along the Antarctic Peninsula. On the other side of the continent in East Antarctica, atmospheric rivers have a greater influence on annual snowfall variability. There atmospheric rivers are responsible for 20-40% of annual snowfall with localized higher percentages across Dronning Maud Land, Amery Ice Shelf, and Wilkes Land.

Atmospheric river landfalls occur within a highly amplified polar jet pattern and often are found in the entrance region of a blocking ridge. Therefore, atmospheric river variability is connected with atmospheric blocking variability over the Southern Ocean. There has been a significant increase in atmospheric river activity over the Amundsen-Bellingshausen sea and coastline and into Dronning Maud Land region from 1980-2018. Meanwhile, there is a significant decreasing trend in the region surrounding Law Dome. Our results suggest that atmospheric rivers play a significant role in the Antarctic surface mass balance, and that any future changes in atmospheric blocking or tropical-polar teleconnections may have significant impacts on future surface mass balance projections.