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Climatology of West Antarctic Atmospheric Rivers and their Impacts on Surface Mass Balance

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While Antarctic Ice Sheet (AIS) mass loss is dominated by accelerated ice discharge from the West Antarctic Ice Sheet (WAIS) due to ocean-induced basal melting, surface mass balance (SMB) processes return mass to the WAIS through snowfall. On Thwaites Glacier (TG) in West Antarctica, snowfall is the primary driver for SMB (125 ± 16 Gt snowfall per year), and extreme snowfall events contribute more than 60% of the total snowfall over TG ice shelf, and 30-50% of the total snowfall over grounded TG. Many of these extreme snowfall events are associated with the landfall of atmospheric rivers (ARs). ARs are long, narrow bands of warm and moist air that contribute intense precipitation and surface melting on the AIS, meaning they contribute both positively and negatively to the SMB. Here, we use an Antarctic-specific AR detection tool combined with MERRA-2 and ERA5 reanalyses to develop a climatology of AR events that made landfall over TG and the WAIS from 1980-2020, including their frequency and duration. We quantify the snowfall and surface melt attributed to AR events to determine their impacts on WAIS SMB. Using two case studies of AR events in December 1999 and February 2020, we illustrate the spatial patterns in snowfall and surface melt associated with AR landfall. We then compare the seasonal and spatial patterns in AR-attributed snowfall to the climatology of all snowfall over the WAIS. Finally, we highlight the interannual and decadal variability of West Antarctic AR events and their relationships to large-scale modes of atmospheric variability. Our results enable us to quantify the past impacts of ARs on WAIS SMB and characterize their interannual variability and trends, enabling a better assessment of future AR-driven changes in SMB.