Foehn Warming over the Antarctic Peninsula Amplified by Strong Atmospheric Rivers

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The Antarctica Peninsula (AP) has experienced more-frequent and intensified warm events in the past few decades. Foehn events (strong, warm downslope winds) are major contributors to surface melting on the leeside of the AP, and contributed to the collapse of the Larsen A and B ice shelves in 1995 and 2002. When atmospheric rivers (ARs) propagate over the AP mountain barrier, strong leeside foehn warming can occur due to latent heat release via precipitation on the upwind side; foehn cloud clearance, which allows strong downward shortwave radiation (DSR) to reach the surface; and enhancement of sensible heat transfer from the upper foehn flow to the surface. The detailed mechanisms and their strengths vary from case to case, affecting the magnitude of warming.

Here we present an analysis of two extreme surface warming/melting cases over the AP, occurring in 2018 and 2022, with the goals of improving our understanding of the relationship between ARs and foehn warming and the impact of clouds on the surface energy balance (SEB). High-resolution Polar WRF (PWRF) V4.3.3 with modified P3 scheme, Reference Elevation Model of Antarctica (REMA) high-resolution topography, and surface observed MODIS albedo are used to identify and quantify the contribution of each physical mechanism. Observations, including radiosoundings and broadband radiation, are used to contextualize the SEB and validate model results. Radiative transfer calculations are used to quantify the radiative contribution and cloud forcing. Both 2018 and 2022 cases were characterized by extensive leeside foehn warming and strong AR impacts. With heavy precipitation on the upwind side, we find enhanced DSR due to foehn clearance to be the major driver for warming over the northeastern AP during the daytime (DSR > 750 Wm-2). Peak warming occurred at night, when the sensible heat flux was found to be the dominant contributor.