Strong Warming over the Antarctic Peninsula during Combined Atmospheric River and Foehn Events

Xun Zou[1], Penny M. Rowe[2], Irina Gorodetskaya[3,4], David H. Bromwich[5], Matthew A. Lazzara[6], Raul R. Cordero[7], Zhenhai Zhang[1], Brian Kawzenuk[1], Jason M. Cordeira[1], Jonathan D. Wille[8], F. Martin Ralph[1], Le-Sheng Bai[5]

1 CW3E, Scripps Institution of Oceanography, University of California San Diego, CA, USA
2 NorthWest Research Associates, Redmond, WA, USA.
3 CESAM - Centre for Environmental and Marine Studies, Department of Physics, University of Aveiro, Aveiro, Portugal.
4 CIIMAR | Interdisciplinary Centre of Marine and Environmental Research of the University of Porto, Porto, Portugal
5 Byrd Polar and Climate Research Center, The Ohio State University, Columbus, OH, USA.
6 Antarctic Meteorological Research and Data Center, Space Science and Engineering Center, University of Wisconsin-Madison, and Department of Physical Sciences, School of Engineering, Science, and Mathematics, Madison Area Technical College, Madison, WI, USA.
7 Department of Physics, University of Santiago de Chile, Av. Bernardo O'Higgins 3363, Santiago, Chile.
8 IGE/CNRS, University Grenoble-Alpes, France.

The Antarctica Peninsula (AP) has experienced more frequent and intense surface melting recently, jeopardizing the stability of ice shelves and ultimately leading to ice loss. Among the key phenomena that can initiate surface melting are atmospheric rivers (ARs) and leeside foehn; the combined impact of ARs and foehn led to moderate surface warming over the AP in December 2018 and record-breaking surface melting in February 2022. Focusing on the more intense 2022 case, this study uses high-resolution Polar WRF simulations with advanced model configurations, Reference Elevation Model of Antarctica topography, and observed surface albedo to better understand the relationship between ARs and foehn and their impacts on surface warming. With an intense AR (AR3) intrusion during the 2022 event, weak low-level blocking and heavy orographic precipitation on the upwind side resulted in latent heat release, which led to a more deep-foehn like case. On the leeside, sensible heat flux associated with the foehn magnitude was the major driver during the night and the secondary contributor during the day due to a stationary orographic gravity wave. Downward shortwave radiation was enhanced via cloud clearance and dominated surface melting during the daytime, especially after the peak of the AR/foehn events. However, due to the complex terrain of the AP, ARs can complicate the foehn event by transporting extra moisture to the leeside via gap flows. During the peak of the 2022 foehn warming, cloud formation on the leeside hampered the downward shortwave radiation and slightly increased the downward longwave radiation.