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The vertical structure of atmospheric rivers and their impact in the Atlantic sector of Antarctica from the Year of Polar Prediction observations

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The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) had a special observing period (SOP) from November 16, 2018 to February 15, 2019, during which observational activity during austral summer in the Antarctic was greatly enhanced. More than 2000 additional radiosondes were launched during this 3-month period, roughly doubling the amount from routine programs. Further, several YOPP-endorsed projects contributed to enhanced data collection on various atmospheric and oceanic properties, including the Characterization of the Antarctic Atmosphere and Low Clouds (CAALC) project at King George Island (Antarctic Peninsula) and the Dynamics, Aerosol, Cloud And Precipitation Observations in the Pristine Environment of the Southern Ocean (DACAPO-PESO) field experiment in Punta Arenas (Sub-Antarctic Chile). Here we use the YOPP-SH-SOP observations to investigate the vertical structure of atmospheric rivers (ARs), along with their impact on cloud properties, radiative budgets, and precipitation in the Atlantic sector of Antarctica, including coastal areas of sub-Antarctic Chile, the Antarctic Peninsula and Dronning Maud Land (DML).

ARs can transport anomalous heat and moisture from subtropical regions to the Antarctic, with important impacts on Antarctic surface mass balance. On the Antarctic Peninsula, the surface mass balance can be especially sensitive to AR events during summer, when surface temperatures vary around zero and frequent transitions occur between snow and rainfall. The importance of ARs for the coastal DML is also linked to precipitation events during summer, but is more strongly linked to extreme snowfall events (rather than rainfall), and such events have resulted in anomalously high snow accumulation in DML in recent years.

We will present case studies that demonstrate how combining extensive ground-based observations and radiosoundings from stations in the sub-Antarctic and Antarctic allow for detailed characterization of the temporal evolution of AR events. Analysis of the observations and model sensitivity studies (using Polar-WRF) with additional radiosonde assimilation show the influence of ARs on the Antarctic atmospheric, cloud properties and surface precipitation, as well as the challenges in correctly forecasting conditions during such events. Further, we use SOP enhanced radiosonde programs at Neumayer and Syowa stations to investigate the AR signatures in the atmospheric vertical profiles in the DML coastal areas. The AR events observed during YOPP-SH are put in the context of the longer-term radiosonde observations using 10 years (from 2009 to 2019) of the Integrated Global Radiosonde Archive (IGRA) Version 2 data. The increased frequency of radiosonde observations during YOPP was crucial for elucidating the important contribution these rare events make to the moisture transport towards Antarctica. They also showed an added value in improving the forecast of weather conditions during AR events, which have important consequences for air, ship and station operations in Antarctica.