Case Study of a 2015 Atmospheric River Impacting East Antarctica

Kristen Cooper [1], Rebecca Baiman [2], Andrew Winters [2]

[1]Department of Earth, Oceanic and Atmospheric Science, Florida State University, [2]Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder

We greatly appreciate the funding support from the National Science Foundation through Grant No. AGS-2150262.

1. Introduction & Methods

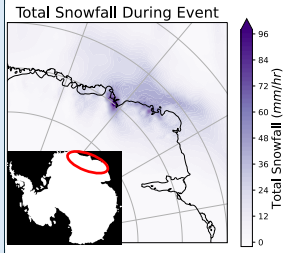


Figure 1: Total snowfall (purple shadings) with an inset of Antarctica showing where the event took place (circled in red).

Between Jan. 16 and Jan. 17 2015, a strong atmospheric river made landfall in East Antarctica.

Atmospheric Rivers (ARs) are narrow streams of enhanced water vapor transport in the atmosphere.

ARs contribute significantly to the annual snowfall over Antarctica and are essential to the growth of the Antarctic Ice Sheet (AIS) [2].

While the AIS is experiencing a net mass loss, it is gaining mass in coastal Dronning Maud Land[1] (circled region). Understanding major AR events in this region is important for understanding this process.

This study uses MERRA-2 reanalysis data and the NOAA HYSPLIT model to identify the main synoptic scale processes responsible for the 2015 event.

4. Sounding & Trajectories

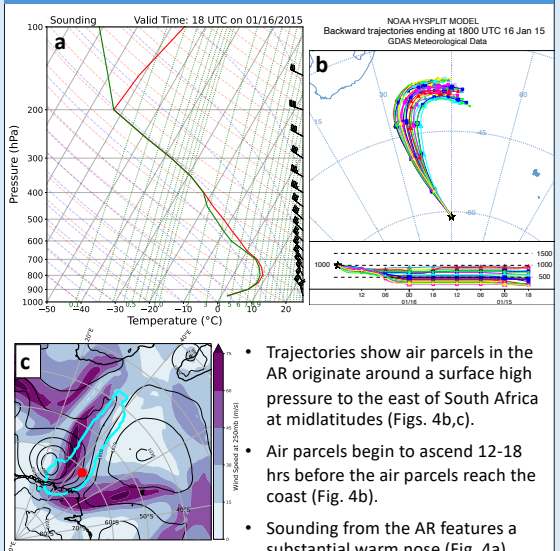


Figure 4: a) Vertical sounding of dewpoint (green line), and temperature (red line) taken in the AR along the warm conveyer belt (red dot in c). b) Backwards trajectories taken from the red dot in c starting at 1000m above ground level (colored lines). c) Location of the sounding/starting point for the trajectories (red circle), 250mb wind speed (fill pattern), sea level pressure (black contours), and AR mask (cyan outline). In both b) and c), the landmass on the top-left is southern Africa.

- Trajectories show air parcels in the AR originate around a surface high pressure to the east of South Africa at midlatitudes (Figs. 4b,c).
- Air parcels begin to ascend 12-18 hrs before the air parcels reach the coast (Fig. 4b).
- Sounding from the AR features a substantial warm nose (Fig. 4a)
- An area of potential instability above the warm nose likely contributes to strong ascent within the warm conveyer belt (Fig. 4a).

2. Event Overview

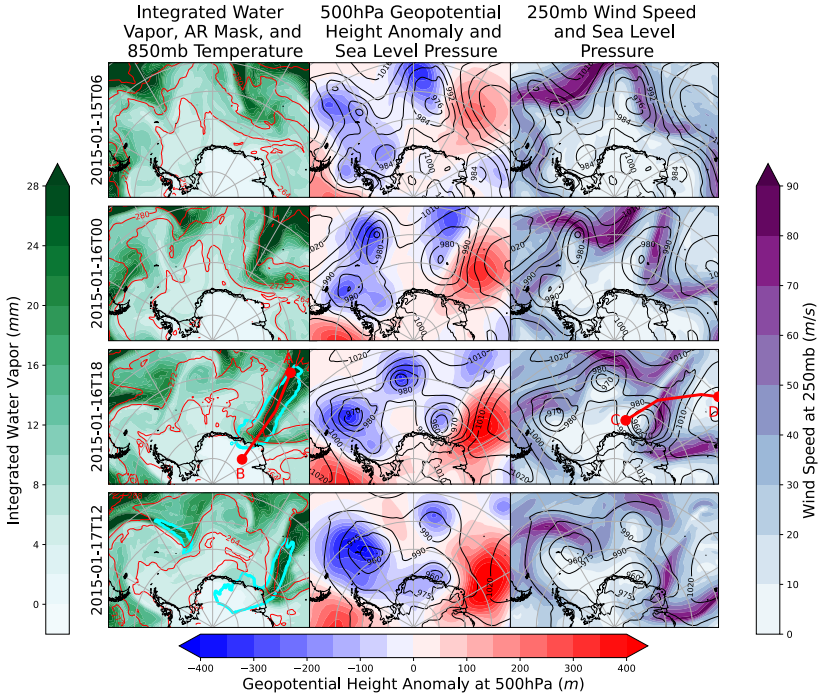


*Figure 2: **Column 1:** Integrated water vapor (green shadings), AR mask outline (cyan), and 850mb temperature (red contours). **Column 2:** 500hPa geopotential height anomalies (red shadings indicate positive anomalies, and blue shadings indicate negative anomalies) and sea level pressure (black contours). **Column 3:** 250mb wind speed (blue/purple shadings) and sea level pressure (black contours). Each row represents a different time leading up to/during the event. The red lines on the 16th at 18Z represent the cross sections shown in Figure 2.*

- The cyclone was favorably positioned beneath an area of divergence induced by two jet streaks.
- This divergence aloft led to cyclone self-development visible between Jan. 16 at 00Z and Jan. 16 at 18Z.
- A blocking high prevented the surface cyclone associated with the AR from moving eastward, allowing moisture to funnel towards the coast.
- The AR originated in the midlatitudes prior to extending towards the Antarctic coast in association with the surface cyclone on Jan. 16.

5. Conclusions

- The moisture from the event came from the midlatitudes around 40°S.
- A blocking high allowed for a low-pressure system and AR to impact Antarctica.
- Two separate jet streaks allowed for cyclone self-development and enhanced lift near the coastline.
- An increase in northerly winds along the coast and topographic lift enhanced rising air within the AR.
- The 18Z sounding on Jan. 16th revealed potential instability along the AR, which likely enhanced the strength of vertical motions in the AR.

3. Cross Sections

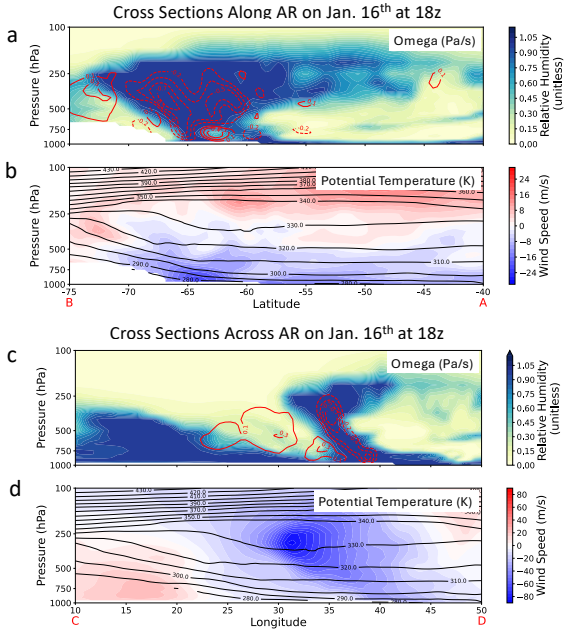


*Figure 3: **(a/c)** Relative humidity (shadings, blue indicates high RH, yellow indicates low RH) and omega (red contours, dashed indicates rising air and solid indicates sinking air) . **(b/d)** Meridional wind speed (shadings, red indicates southerly winds and blue indicates northerly winds) and potential temperature (black contours).*

- High relative humidity (RH) extending throughout troposphere near the coast is indicative of rising air along the cyclone's warm front and AR-induced precipitation (Fig. 3a).
- Sinking air over land may represent cold katabatic winds (Fig. 3a).
- Strong isentropic ascent along the coast is likely a result of orographic lift and the cold katabatic winds (Fig. 3b).
- Strong jet core is present at 250mb immediately above the AR (Fig. 3d).
- A plume of rising air and moisture is located to the east of the jet in its entrance region. The sharp drop in RH and sinking air to the west of the jet represents a tropopause fold (Fig. 3c).

6. References

[1]National Aeronautics and Space Administration Jet Propulsion Laboratory. "Antarctic Ice Loss 2002-2020." https://grace.jpl.nasa.gov/resources/31/antarctic-ice-loss-2002-2020/.

[2]Maclennan, M. L., J. T. M. Lenaerts, C. Shields, and J. D. Wille, 2022: Contribution of Atmospheric Rivers to Antarctic Precipitation. *Geophys. Res. Lett.*, **49**, e2022GL100585, https://doi.org/10.1029/2022GL100585.

[3]Terpstra, A., I. V. Gorodetskaya, and H. Sodemann, 2021: Linking Sub-Tropical Evaporation and Extreme Precipitation Over East Antarctica: An Atmospheric River Case Study. *J. Geophys. Res. Atmospheres*, **126**, e2020JD033617, https://doi.org/10.1029/2020JD033617.