Association of the atmospheric rivers over Southern Ocean/Antarctica with warm conveyor belts

Irina Gorodetskaya1, Annick Terpstra2,1, Tiago Silva3, Harald Sodemann2, Holger Schmithüsen1, Naohiko Hirasawa6

Contact: Irina.Gorodetskaya@ua.pt

February 2011 (Gorodetskaya et al 2014) of total annual (Turner et al 2019); b) IWV during AR

Figure 1: a) # of days of extreme

Introduction

- Intense snowfalls over the Antarctic ice sheet contribute the majority of its surface mass balance (Schlosser et al 2010; Gorodetskaya et al 2014; Turner et al 2019).
- Precipitation over the Southern Ocean and Antarctic is mainly brought by the extratropical cyclones and fronts (Catto et al 2013; 2015; Sinclair and Dacre 2019), with the strongest events being driven by the atmospheric rivers (ARs, Gorodetskaya et al 2014).
- ARs are long, narrow and transient corridors of enhanced horizontal vapor transport typically within the cyclones’ warm conveyor belt (WCB), ahead of the cold front (Ralph et al 2004).
- ARs and their association with WCBs has to be correctly represented in models/analyses and there is a lack of observations for their evaluation especially in Antarctica.
- Intense observational campaigns, such as during Year of Polar Prediction Special Observing Period in the Southern Hemisphere (YOPP-SOP-SH), provide new data for model evaluation.

Data and Methodology

- Frequent (3-4 per day) radiosonde measurements during YOPP-SOP-SH at Neumayer and Syowa stations (DML – Dronning Maud Land, East Antarctica).
- ECMWF reanalyses (ERA-Interim and ERA5) fields are evaluated using radiosonde observations and applied for large-scale analysis.
- LAGRANTO trajectories with WaterSip moisture source analysis (Sodemann et al 2008; 2020)

Atmospheric rivers at Syowa

Key features during YOPP Nov 2017 AR event:
- Near-surface moisture maximum and LLJ higher 900 hPa.
- Different from 15 Feb 2011 case when maximum moisture flux was at higher levels.
- Both ERA5 and ERA-Interim underestimate moisture flux maximum.

10-year AR composites:
- ARs are extreme state compared to median profiles.
- Both ERA5 and ERA-Interim underestimate humidity and wind speed maxima.

Atmospheric rivers at Neumayer

Key features during YOPP Dec 2017 AR events:
- Strong elevated moisture inversion above LLJ.
- Similar to the 15 Feb 2011 case.
- ERA5 is better than ERA-Interim in representing humidity inversion and moisture flux maximum.

10-year AR composites:
- Good representation of moisture profile composite by both reanalyses. Compensation of biases: underestimated LLJ and overestimated humidity inversion.

Figure 2: Radiosonde

Figure 3: Schematic of moisture source diagnostics (Sodemann et al 2008)

Figure 4a: Vertical cross-section through the warm sector of the cyclone: maximum moisture flux (shading, g kg m⁻¹), potential temperature (black lines), K, pink-line=292K, wind speed (yellow lines, m s⁻¹), and specific humidity (blue lines, g kg⁻¹).

Figure 4b: Cross-section at 42-48S (near moisture source): Isentropic upgliding with maximum moisture flux along 292K isentrope from nearly the moisture source ~40ºS to Antarctic coast.

Moist advection is at higher layers and decoupled from the low-level jet.

Loss of moisture by precipitation.

Near the surface: warm air over cold ocean surface; no evaporation => limited moisture in the boundary layer.

Figure 5: Syowa radiosonde profiles

Figure 6a: 5-day trajectories starting on 16 February 2011 at 00:00UTC in DML (only for MT>250 g kg⁻¹ m⁻¹).

Figure 6b: Properties along the trajectories (Fig. 6a) showing mean values (lines) and standard deviation (shading).

Terpstra, Gorodetskaya, Sodemann: Linking subtropical evaporation and extreme precipitation over East Antarctic: An atmospheric river case study. To be submitted to JGR, AR special issue.