Atmospheric River Events in the 64th Japanese Antarctic Research Expedition

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Atmospheric River (AR), defined as a narrow, filamentary structure of water vapor flux, plays a significant role in moisture transport from mid to high-latitude regions. ARs are generally associated with extra-tropical cyclones with the frontal system. Typical ARs are located ahead of the cold front and intrude into warm conveyor belts. ARs are constructed by low-level jets and moisture-laden and warm air in the warm sector of extra-tropical cyclones. As a result, temperature and humidity increase in the ARs. It is crucial that ARs-transporting moisture sometimes intrudes into Antarctica. In Antarctica, ARs are indicated to be related to extreme snow accumulation events (Gorodetskaya et al.,2014) and extreme rainfall events (Wille et al., 2021). Moreover, ARs are associated with the melting ice shelves in the Antarctic peninsula due to foehn wind caused by the mountains. Water vapor contained in ARs is concentrated in the lower troposphere and lifted by the warm conveyor belt or orographic effect. However, AR features in the Southern Ocean (SO) are not well-known. We focused on the AR behaviors over the SO using observations obtained by RV Shirase during the 64th Japanese Antarctic Research Expedition (JARE64) from December 2022 to March 2023.

During the cruise, eight low-pressure systems with the filamentary structures of clouds, identified by MODIS visible bands images, approached and/or passed over the ship, potentially categorized as AR events. The temperature profiling by a shipboard microwave radiometer (MWR) indicated that every event has a rapid temperature increase within the troposphere. Therefore, we investigated whether each event was identified as an AR event using an AR detection method (Zhu and Newell, 1998) and the Japanese 55-year Reanalysis (JRA-55) (Kobayashi et al., 2015). Because the eight events were identified as AR, we compared them with AR climatological features in the SO, such as AR length, width, and size. The AR climatology was calculated using the JRA-55 data over 41 years between 1980 and 2020.

Figure 1 shows the frequency distribution of the climatological AR features for 41 years (blue bars) and the observed eight ARs (red and orange arrows). Most corresponded to the normal ARs in size and the vertically integrated water vapor (IWV) (red arrows); however, one AR was extended more than 7000km in length, broader than 1000km in width, and larger than 40 mm in mean IWV, which is considered a relatively rare event (orange arrow). When this AR moved eastward and passed over the ship on 22nd February, two radiosonde observations were made. The specific humidity profile has an inversion layer of about 700hPa, rapidly increasing from 3.0 g/kg in the lower layer to 4.0 g/kg maximum at about 650hPa. The temperature profile also has the same feature as the inversion. There was wind shear across the inversion layer from the northeast in the lower layer to the northwest above. Therefore, the air mass in the middle of the troposphere was considered a primary source of IWV. This AR structure differs from the common ARs detected in mid-latitudes (Ralph et al., 2017). The characteristics of clouds and precipitation of this event will be shown in detail in the presentation.

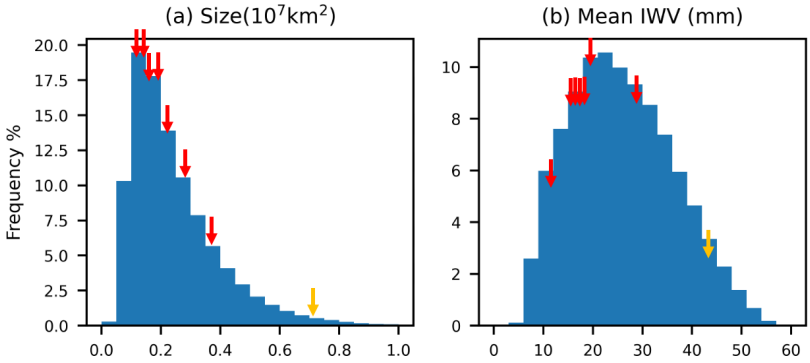

Figure 1 Blue bars indicated the frequency distribution of climatological AR: (a) area size and (g) area mean of the vertically integrated water vapor (IWV). Red and orange arrows indicated the observed ARs.

References

Gorodetskaya, I. V. et al. (2014). The role of atmospheric rivers in anomalous snow accumulation in East Antarctica, Geophysical Research Letters, 41(17), 6199-6206.

Kobayashi, S. et al. (2015). The JRA-55 Reanalysis: General Specifications and Basic Characteristics, J. Meteorol. Soc. Jpn., 93, 5-48.

Ralph, F. M. et al. (2017). Dropsonde Observations of Total Integrated Water Vapor Transport within North Pacific Atmospheric Rivers. J. Hydrometeorol. 18, 2577–2596.
Wille, J. D. et al. (2021). Antarctic Atmospheric River Climatology and Precipitation Impacts. J. Geophys. Res. Atmospheres 126, 8, e2020JD033788.
Zhu, Y., and Newell, R. E. (1998). A proposed algorithm for moisture fluxes from atmospheric rivers. Monthly Weather Review, 126(3), 725–735.

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