Supplement to ‘Precipitation processes in an Antarctic moist air intrusion: insights from multi-frequency radar observations over a 1100-km transect’

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S1 Velocity Alignment

A difference in the Doppler velocities measured by the MIRA and BASTA radars first became apparent when attempting to calculate the spectrally-resolved $\mathrm{DFR}_{\mathrm{K_a-W}}$: the velocity offset was large enough that peaks in the MIRA spectra did not overlap with their equivalent peaks in the BASTA spectra. Although the difference in mean Doppler velocity measured at different frequencies (also referred to as the Differential Doppler Velocity, DDV) can provide information on the size of particles (Matrosov, 2011; Meneghini et al., 2003), this relies on the two radars pointing in the same direction to a high degree of accuracy. In the case of vertical-pointing radars, a deviation of one or both radars from vertical can lead to contributions to the measured Doppler velocity from the horizontal wind. Despite efforts to align the radars during installation, small misalignments are not unexpected for the radars in the AWACA OPUs: the compression of the snow underneath the OPU can lead to the whole OPU tilting over time and the inaccessibility of the sites outside of the summer season means that the alignment cannot be measured or corrected over the year.

To re-align the spectra from the MIRA and BASTA, a simple linear model was used to quantify the contribution to the DDV from the horizontal wind. Given two radars misaligned from the vertical direction by small angles θ_1 and θ_2 and pointing at angles ϕ_1 and ϕ_2 clockwise from north (Fig. S1), the contribution to the difference in the mean Doppler velocities MDV_1 and MDV_2 from the horizontal wind is given by

$$\mathrm{DDV} = \mathrm{MDV}_1 - \mathrm{MDV}_2 \tag{S1}$$

$$= (sin\theta_1 \cdot sin\phi_1 - sin\theta_2 \cdot sin\phi_2) \cdot u + (sin\theta_1 \cdot cos\phi_1 - sin\theta_2 \cdot cos\phi_2) \cdot v, \tag{S2}$$

where u and v are the horizontal wind components towards the east and north respectively. Note that there is also a contribution proportional to the vertical wind $(cos\theta_1 - cos\theta_2) \cdot w$ but this is expected to be smaller than the horizontal contributions and is not considered here. Assuming that the angles θ_1, θ_2, ϕ_1 and ϕ_2 can be considered constant over the period of interest, Eq. (S1)

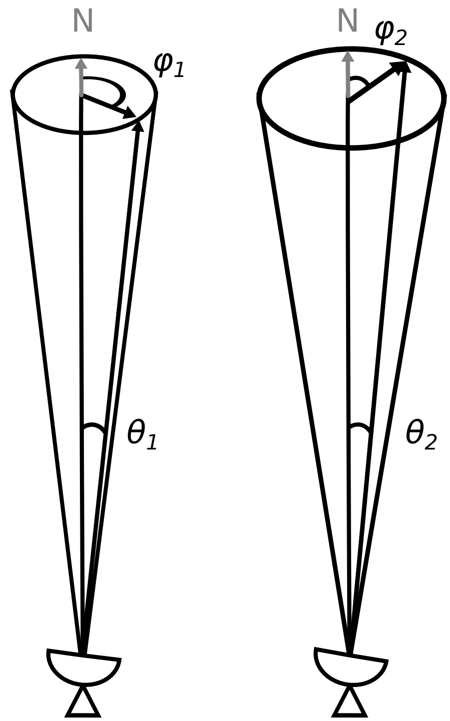

Figure S1. Diagram of two radar misaligned by small angles θ_1 and θ_2 from vertical, causing the radars to point in directions ϕ_1 and ϕ_2 clockwise from North (N) respectively.

simplifies to

$$DDV = A \cdot u + B \cdot v \tag{S3}$$

and the constants A and B can be estimated using multi linear regression.

For the case study in February 2025, A and B were estimated using the horizontal wind components from ERA5 (Fig. S2). The model can largely account for the sign and magnitude of the velocity difference, although some residual remains between the predicted and measured difference. The prediction from the linear model was used as an estimate for the DDV which can be attributed to the misalignment of the radars, a value which varies in time and range. Adding or subtracting this value aligns the velocity measured by one radar to the measurement axis of the other radar. This was used to align the DFR spectrograms in sections 4-8 of the main text (see Fig. S3 for an example). However, it cannot be used to absolutely align the measurements back to true vertical, since Eq. (S1) is not sufficiently constrained to determine the four angles θ_1, θ_2, ϕ_1 and ϕ_2.

Since the velocity cannot be absolutely aligned, a choice has to be made about the direction in which to correct the velocity. In this study, the MIRA was taken as a reference. The configuration of the MIRA antenna means the alignment during installation is more straightforward than for the BASTA. However, tilting of the OPU over time means that it is likely that both radars

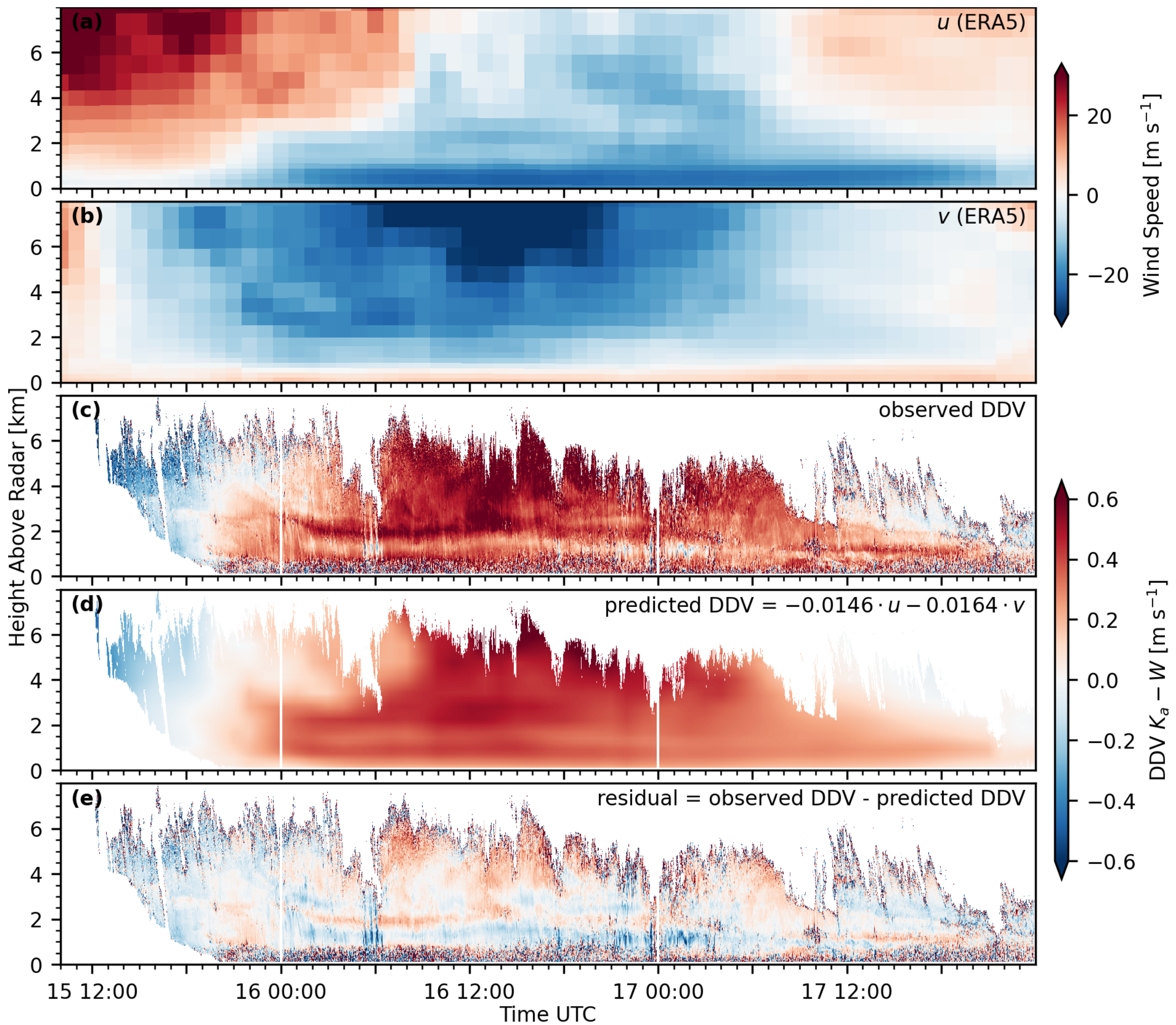

Figure S2. Illustration of the velocity-alignment procedure for D17. The zonal (u) and meridional (v) horizontal winds from ERA5 are used to build a linear model of Differential Doppler Velocity (DDV) between the MIRA and BASTA radars.

are slightly misaligned. We tested aligning the velocity to either the BASTA or MIRA axis (not shown). The small difference between the two 'final' velocities, although significant for aligning spectra, would not lead to a difference in micro-physical interpretation.

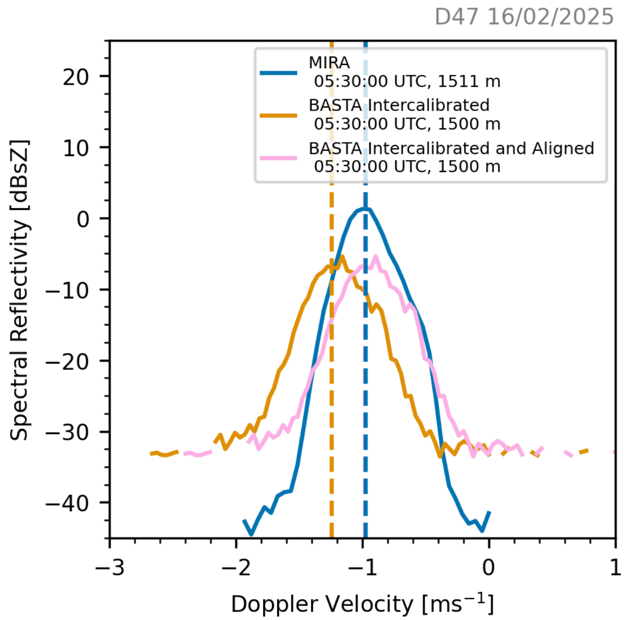

Figure S3. An example of the velocity alignment between the MIRA and BASTA radars for one range and time at D47. The vertical dashed lines show the mean Doppler velocities.

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