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Cloud base vertical velocity statistics – A comparison between AROME and CloudNet observations

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Calculation of cloud droplet number concentrations (CDNC) using parameterizations for aerosol activation is critical for model-based estimates of aerosol indirect effects. Cloud activation of aerosols is strongly influenced by the maximum supersaturation reached in a cloud layer, which usually takes place near the cloud base. Cloud base vertical velocity is one of the key parameters controlling the in-cloud supersaturation.

In the current study, vertical velocity statistics are compared between the mesoscale numerical weather prediction model AROME and CloudNet remote sensing datasets. The comparison is conducted using two domains: Atmospheric Radiation Measurement (ARM) programme Southern Great Plains (SGP) observation site at central Oklahoma, and a ground based remote sensing measurement site in Lindenberg, Germany. Months of January and June are included in the analysis. For model data, output from AROME runs covering the year 2008 at a horizontal resolution of 2.5 km is used. For observations, remote sensing data are provided on a time-height grid with temporal resolution of 30 s. The height resolution of the observation grid is approximately 30 m at Lindenberg and 90 m at SGP. To provide robust statistics, the observation datasets cover several years (2004-2009).

While determining the cloud base vertical velocity from model data is quite straightforward using the grid point values (a threshold of 0.5 was used for fractional cloudiness to detect cloud base), some special attention must be paid to the observations. Cloud radar Doppler velocity measurements are used as a surrogate for the vertical velocity of air, and are vulnerable to biases caused by the fall speed of large atmospheric particles (such as rain and drizzle). Therefore, a radar reflectivity threshold of -30 dBZ is used to filter out particles with significant fall speeds.

We find that the standard deviation of the vertical velocity distribution in AROME is significantly underestimated when compared to the observations. At Lindenberg, the standard deviations for AROME are smaller than observed, by up to a factor of 10. At SGP the underestimation is smaller, but still by a factor of 2 to 5. Conclusion of this study is that if kilometer-scale models such as AROME are used for studies of aerosol-cloud interactions, a subgrid vertical velocity parameterization should be included in these models, as has been done with climate models.