Contribution ID: **64** Type: **not specified**

Study on Microphysics of Stratiform Precipitation Based on Dual-Polarization Radar and Airborne Observations

Friday 21 March 2025 09:30 (15 minutes)

Understanding the microphysical properties of stratiform precipitation is crucial for advancing weather prediction models and deepening our understanding of atmospheric processes. This study integrates advanced techniques in dual-polarization radar and airborne observations to conduct a comprehensive analysis of stratiform precipitation microphysics.

First, a variational approach to optimize drop size distribution (DSD) retrieval, attenuation correction, and rainfall estimation using polarimetric radar measurements (horizontal reflectivity factor Z_H, differential reflectivity Z_{DR}, and differential phase shift Φ_{DP}. Our approach employs radial B-spline filtering and azimuthal Kalman filtering to ensure the spatial continuity of rain and mitigate random errors in Z_{DR} and Φ_{DP}. Validation includes simulated experiments and real-case observations from mobile C-band and operational S-band polarimetric radars in South China, demonstrating that our method achieves more accurate attenuation correction and rainfall estimates compared to conventional methods.

Furthermore, we investigate microphysical structures and processes in precipitating stratiform clouds using joint observations from an aircraft and the optimized estimates from an X-band polarimetric radar. A case study conducted over North China on May 21, 2018, reveals enhancements in Z_{DR} and specific differential phase K_{DP} above 7 km altitude, indicating the presence of dendrites and platelike ice crystals. Above the melting layer (ML), aggregation processes increase Z_H and decrease Z_{DR}, as confirmed by aircraft observations showing an increase in volume-weighted mean diameter (D_m) and a decrease in total number concentration (N_t). Within the ML, melting particles exhibit complex behaviors, with aggregation dominating the upper part and breakup processes prevailing in the lower part, influencing particle size and concentration. Below the ML, microphysical processes exhibit minimal variation with altitude, indicating a near balance in nearly saturated air.

These findings significantly contribute to our understanding of stratiform precipitation microphysics and provide valuable insights for improving microphysical parameterization in numerical weather prediction models, emphasizing the integration of advanced radar techniques and airborne observations.

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Session

Enhancing Process Understanding: New observations for modeling and parameterization development

Preferred Contribution Type

Oral Presentation

VAT

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