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Analysis and evaluation of ice clouds in high-resolution simulations (Karol Ćorko b309188, Ulrike Burkhardt b309022)

Within the BMBF Monsoon project we have investigated inter-model variability in the tropical total ice water path (TIWP) simulated by the high-resolution global simulations performed in the DYAMOND project and compared them with ERA5 reanalysis data as well as two versions of the NWP ICON model. Analyzing the data on high spatial resolution, the large positive and negative vertical velocities indicate strong convective systems with positive vertical velocities indicating convective updrafts and negative vertical velocities indicating downdrafts, both connected to large TIWP (Figure 1b). We found that the PDF of daily mean vertical velocity at 500 hPa and the associated TIWP vary significantly among the DYAMOND models (Figure 1a and 1b). The large inter-model variability in the simulated TIWP originates mainly from differences in the microphysical schemes and controlling the total water path (TWP). When two models simulate a similar TWP, the frozen fraction (Figure 1c) indicates that differences in detrainment levels relative to the freezing levels are partly responsible for differences in TIWP.

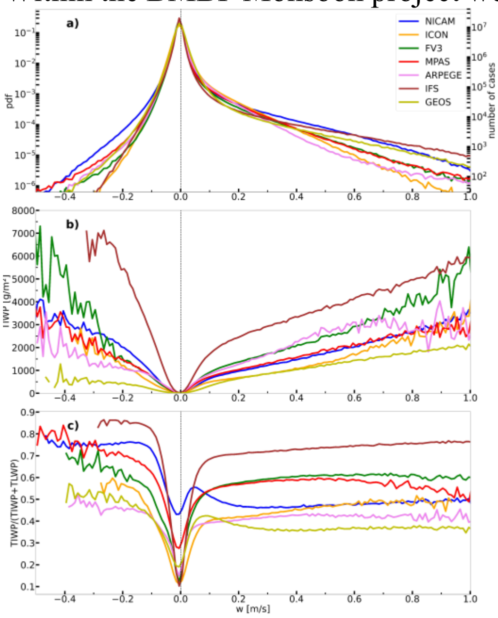

Figure 1: (a) PDF of daily vertical velocity at 500 hPa, (b) TIWP for different daily mean vertical velocity bins (c) the frozen fraction, TIWP/(TIWP + TLWP) in high-resolution DYAMOND models on daily time-scale and 0.1° grid (cca 10 km), Ćorko et al. 2025

The evaluation of the models with active (2C-ICE and DARDAR) and passive remote sensing data showed that relative to the DARDAR and 2C-ICE data, models significantly underestimate the convective ice water path. While the ice water path is satisfactorily simulated by many high-resolution models for strong convection, the large underestimation of the ice water path is evident for weak convective events or aged systems (indicated by medium strong precipitation, Figure 2) relative to active and even relative to passive remote sensing data. The underestimation of the ice water path appears to be caused by a too fast conversion of ice water into falling hydrometeors.

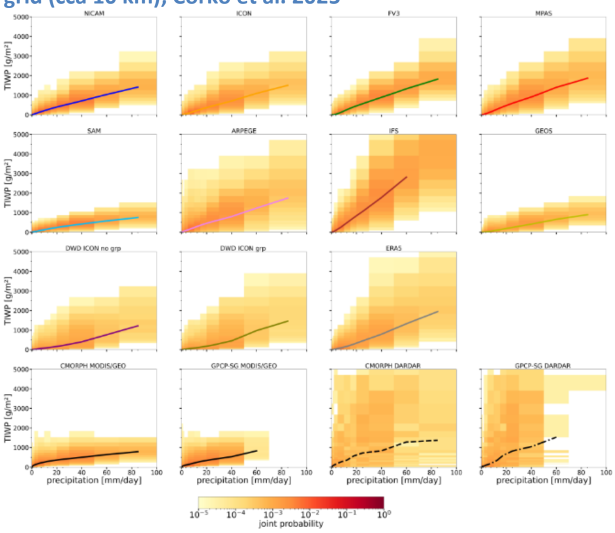

Figure 2: Daily mean joint probability distributions of partitioning between precipitation and TIWP simulated by high-resolution DYAMOND models, low-resolution NWP-ICONs, ERA5 reanalysis and the combinations between observed precipitation and observed TIWP by passive and active remote sensing. The lines on each plot represents mean values for each precipitation bin.

We are currently planning another publication connected with the thesis.

References

Ćorko, K., Burkhardt, U., Ewald, F., & Köhler, M. (2025). Inter-model variability of tropical total ice water path simulated by the convection permitting DYAMOND models. *Journal of Geophysical Research: Atmospheres*, 130, e2024JD041954. **https://doi.org/10.1029/2024JD041954**

PhD Thesis, Karol Ćorko: Tropical Ice Clouds in Storm-Resolving Global Simulations and their Evaluation, awaiting approval