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Project leader: **Dr. Ulrike Burkhardt**
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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 cloud water budget, and in particular TIWP, simulated by the high-resolution global simulations performed in the DYAMOND project and compared to two versions of the lower-resolution NWP (DWD ICON) and ERA5 reanalysis data. Moreover, we evaluated the models with active remote sensing data (2C-ICE and DARDAR) and passive remote sensing data. Models display large variability in TIWP but also in cloud top height and the vertical distribution of the cloud ice and water mixing ratios (Figure 1). While most DYAMOND models produce cloud tops around 17.5 km, NICAM simulates much higher tops near 19 km due to a boundary layer parametrization that leads to larger moisture fluxes from the ocean into the atmosphere. Consequently, NICAM is expected to generate stronger longwave radiative effects connected with convection. The large inter-model variability in the simulated TIWP originates from differences in the microphysical schemes, differences in the convective de- and entrainment and/or the moisture flux out of the boundary layer both controlling the total water path (Ćorko et al., 2025).

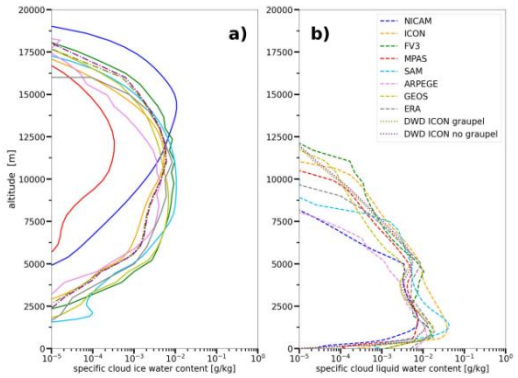


Figure 1: Vertical profiles of mean tropical mixing ratio of (a) cloud ice and (b) cloud water over tropical oceans (30° S - 30° N) for August/September 2016 simulated by DYAMOND models, NWP DWD-ICON models and ERA5 reanalysis on 0.1° grid, Ćorko 2026

Studying the connection between the total ice water path and precipitation and evaluating against active (2C-ICE and DARDAR) and passive remote sensing data shows that kilometre-scale GSRMs substantially improve upon NWP and traditional GCM simulations. However, TIWP remains underestimated in weak convection and aged systems (Figure 2; Ćorko, 2026), even relative to passive observations. A comparison of the simulations with ICON-Sapphire, studying the sensitivity to the sedimentation speed of ice crystals which was run within the MONSOON project, the mean tropical TIWP improves even further, but the bias in the distribution of the total ice water content over convective systems with different strength persists. Increasing ice sedimentation slightly increases TIWP in strong convective systems but further lowers the already underestimated ice water content in weak systems and the cloud tops. In contrast, global warming simulations show reduced TIWP across all precipitation bins relative to the control run. The persistent underestimation across

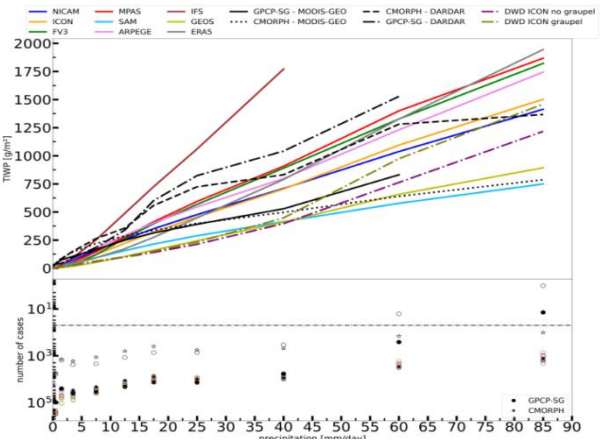


Figure 2: Daily mean partitioning between precipitation and TIWP over the tropical oceans for August/September 2016 simulated by DYAMOND models, DWD (NWP) ICON models, ERA5 reanalysis and combination of observed precipitation and passive and active remote sensing. The bottom panel displays the number of grid points (cases) contributing to each precipitation bin, Ćorko 2026

simulations likely reflects overly rapid conversion of cloud ice into falling hydrometeors, shortening anvil lifetime and highlighting the ongoing challenge of capturing the full convective life cycle at kilometre-scale resolution. We plan to still publish these findings.

References

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