EGU24-16801, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-16801
EGU General Assembly 2024
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How the representation of microphysical processes affects the tropical energy budget in a global storm-resolving model

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Cloud microphysics are a prime example of processes that remain unresolved in atmospheric modelling with storm-resolving resolution. In this study, we explore how uncertainties in the representation of microphysical processes affect the tropical energy budget in a global storm-resolving model (SRM). We use the global SRM ICON with a one-moment or a two-moment microphysics schemes and do several sensitivity runs, where we vary one parameter of the applied microphysics scheme in its range of uncertainty. We find that the two microphysics schemes have distinct signatures, e.g., in how condensate is distributed among the different hydrometeor categories or in the intensity distribution of precipitation, but their tropical mean cloud fraction and total condensate profiles are rather robust. Precipitation efficiency sets the amount of condensate in the atmosphere and thereby links microphysical processes to the radiative properties of the atmosphere. Uncertainties in the representation of microphysical processes cause substantial spread in the top-of-the-atmosphere (TOA) energy balance. In agreement with the robustness of the cloud fraction, changes in the radiative balance at TOA are dominated by changes in the radiative properties of cloudy points. A shift towards higher cloud-ice concentrations in simulations with the two-moment microphysics scheme leads to more reflected shortwave radiation that is not fully compensated by less outgoing longwave radiation and results in a slight cooling of the atmospheric column. Overall, microphysical sensitivities at storm-resolving resolution are substantial and resemble part of the inter-model spread of a multi-model ensemble.