Project: **1163**
Project title: **C2Phase: Closure of the Cloud Phase**
Principal investigator: **Corinna Hoose**
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Statistical emulation for untangling microphysical uncertainties in deep convective clouds (Lena Frey et al.)

We are in the process of developing a statistical emulator for real-case model simulations of severe hail storms. The aim of our project is to disentangle the relative contributions from aerosols, microphysics and environmental conditions to the uncertainty in cloud-, precipitation-, and hail parameters.

For the statistical emulator, ensemble simulations will be performed with perturbing multiple parameters simultaneously. In order to identify possible input parameters, we have performed sensitivity simulations with the ICON model (version 2.6.0 and 2.6.2) and also in a coupled configuration with the aerosol module ART on cloud resolving scale with a horizontal resolution of 2 km. For these simulations, we have perturbed different parameters one at a time to test the sensitivity of the model to the selected parameters.

We were able to identify input parameters, which cover the categories microphysics, aerosols and environmental conditions and show all a high sensitivity in the model regarding cloud- and hail parameters. We have chosen five parameters namely: CCN and IN concentrations, the riming efficiency, CAPE and wind shear. Further, we have determined the minimum and maximum range for each parameter with sensitivity experiments and we motivate our selected parameter ranges using reanalysis data and literature.

Two different CCN activation schemes are available in the ICON model, one parameterization based on Hande et al. (2016) and one based on Segal and Khain (2006). The sensitivity of varying CCN concentrations in both schemes have been tested. For the Hande scheme, we used scaling factors between 0.1 and 10 and for the Segal and Khain scheme, predefined optional CCN surface concentrations are available (100, 500, 1700, 3200). Figure 1 shows results from different sensitivity experiments with varying CCN concentrations.

For the IN activation, two different schemes are available in the model configuration without the ART module, one based on Phillips et al. (2008) and the second one based on Hande et al. (2015), and in the configuration with the ART module the scheme by Phillips et al. (2013) is used with ice nucleation by prognostic dust aerosols. We performed sensitivity simulations with varying the IN concentration by using scaling factors between 0.01 and 100 in all three schemes.

An input parameter for the microphysics category is the riming efficiency. For modifying the riming efficiency, we introduced a scaling exponent in the corresponding function with variations between 0.01 and 1.

To influence CAPE in the model, we followed the approach by Barthlott and Hoose (2018) by changing the temperature of the used initial and boundary conditions. The temperature was linearly increased and decreased between the PBL and a height of 12km with a temperature increment of 5K.

Similarly, we changed the wind shear by adjusting the initial and boundary conditions and increased and decreased the wind speed between the surface and a height of 6km.

As a next step in our project, we will start the ensemble simulations for the emulator, the so called training runs. We use the Latin hypercube sampling to distribute the identified parameters well-spaced in the five dimensional parameter uncertainty space.

Swabian MOSES campaign in summer 2021

In summer 2021, the measurement Swabian MOSES was conducted on the Swabian Jura. Model simulations with ICON in the configuration coupled to the ART module have been performed for two selected days, the 20th of June 2021 and the 24th of July 2021. We are in the process of comparing observational data (ground measurements of aerosols, radar and lidar data) with model output from our simulations. We are still testing the final model setup for these reference simulations by using different initial starting times for the simulations and different horizontal resolutions.

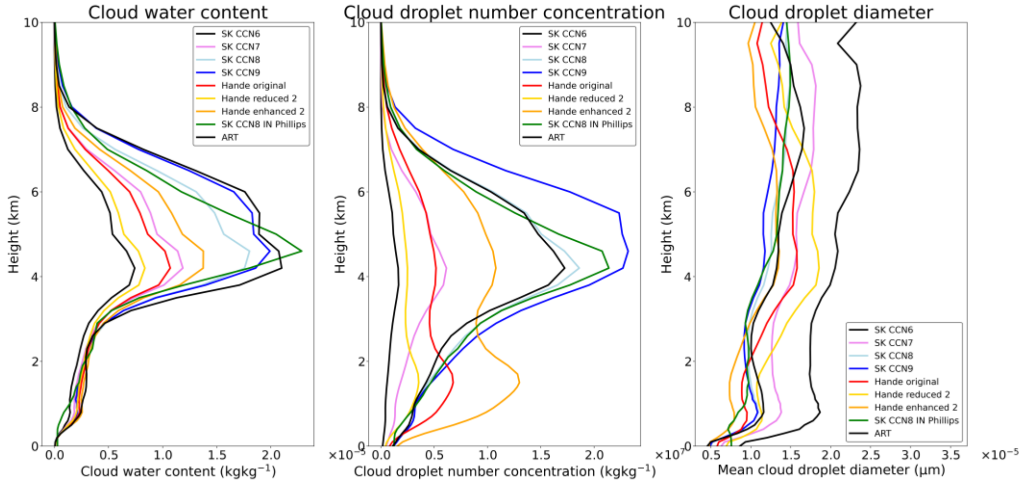

Figure 1: Vertical distribution of cloud water content, cloud droplet number concentration and cloud droplet size for the time and domain mean for a selection of sensitivity experiments with varying CCN concentrations.

Development of secondary ice production parameterizations in the ICON model (Cunbo Han et al.)

In ICON's two-moment cloud microphysical scheme, only the Hallet-Mossop rime-splintering process is included to account for the secondary ice production. We have introduced two other secondary ice production processes into the ICON model, that are droplet shattering upon freezing and collisional breakup of ice particles. The scheme by Sullivan et al. (2018) is used for the droplet shattering process. Two different schemes for collisional breakup are introduced, which are developed by Takahashi et al. (1995) and Phillips et al. (2017). Moreover, a variety of process rates that are related to secondary ice production have been added into ICON's two-moment microphysical scheme.

Preliminary results suggest that secondary ice production processes have a great impact on the cloud microphysics. Collisional breakup is the dominant process in the simulated deep convective clouds. However, the parameterization schemes are still under testing and more simulations are needed to investigate how secondary ice production processes impact on microphysical states and phase distributions of deep convective clouds.

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