Project: **new project**

Project title: **High Definition Clouds and Precipitation for Advancing Climate Prediction – Microphysics and Convection**

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Allocation period: **1.1.2017 - 31.12.2017**

Project Abstract

This request is for the contribution of Deutscher Wetterdienst to the BMBF-funded project "High Definition Clouds and Precipitation for Advancing Climate Prediction" $HD(CP)^2$, specifically for the contribution to the sub-project S3. $HD(CP)^2$ performs cloud- and large-eddy-resolving simulations at the scale of Germany. Sub-project S3 aims at an improved understanding of the cirrus formation and moisture transport due to deep convection.

We will develop an innovative Monte-Carlo Lagrangian particle microphysics scheme that predicts the growth of snowflakes due to depositional growth, aggregation and riming. In contrast to the commonly used bin or bulk microphysics schemes the Lagrangian particle scheme predicts the detailed evolution of individual particles by random sampling of the (multidimensional) particle size distribution. The advantage of this simulation technique is twofold. First, we can predict multiple properties of the ice particles, like the mass, particle density, and composition (e.g. the fraction of solid ice vs rimed ice in an individual particle). In contrast, common bin or bulk microphysics schemes make use of a limited number of particle categories with fixed predefined properties. Second, by following the individual trajectories we can trace back the particles to their origin and have full knowledge of their history. This will allow us to provide more detailed insights into the importance of, for example, different nucleation modes or different growth mechanisms and develop a deeper understanding of the processes.

The Lagrangian microphysics scheme is first developed within an idealized framework and will then be implemented in a three-dimensional atmospheric model (e.g. ICON). We apply for computing time to develop and test this Lagrangian microphysics scheme. Especially convergence studies to understand the dependency on the number of simulation particles are computationally demanding, but such studies are crucial to quantify the model error.

The second part of our work focuses on how the precipitation generation in convection impacts the resulting outflow of cloud. The goal will be an improvement of the parameterization of convection and it's outflow in NWP and climate models. To do that we will start by evaluating ice cloud cover and ice water content in ICON simulations and different resolutions using observations and forward operators. We will then use the ICON-LEM output to evaluate in more detail the moisture and stability errors in ICON-NWP and ICON-GCM in terms of mean profiles and their horizontal variability with focus on the convective anvil. It is crucial at this stage to identify systematic errors in convective parameterization in terms of water transport into the anvil.

We will calculate trajectories, to investigate the physics of moisture transport in deep convection within ICON-LEM. Issues that need to be investigated within this framework include entrainment, precipitation generation and the amount of turbulence in the detrainment of cloudy air. We will attempt to improve moisture transports and equilibrium stability profiles within the parameterizations of turbulent and convective transports to provide accurate inputs for the cloud parameterization. For that investigation a large ICON-LEM dataset (several days) is necessary to derive robust statistics.

We will analyze the influence of improvements of and sensitivity to the microphysics in convection and cloud as developed in collaboration within S3 on mean profiles of moisture and stability, detrainment volume and ice content. This task attempts to evaluate improvements of the description of moisture transports and microphysics within the convective parameterization framework.