HDCP2_S1_WP4: Response of Mixed-Phase Clouds to Aerosol Perturbations

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Abstract

HD(CP)² (High Definition Clouds and Precipitation for Climate Prediction) is a BMBF funded German-wide research initiative to improve our understanding of cloud and precipitation processes and their implications for climate prediction. It has been externally reviewed by BMBF both for the first phase (2013-2016) and the second phase (2016-2019).

The first funding period of HD(CP)² focused on the the optimization of the ICON (Icosahedral non-hydrostatic general circulation) model for Large-Eddy simulation (ICON-LES) with very high-resolution (horizontal spacing of 100 m) and on the improvement of ground, in situ and satellite based observations of cloud and precipitation events. The second phase, which started in April 2016 and focusses on six different scientific questions related to cloud formation. The first of these questions, „How do clouds respond to pertubations in their aerosol environment?“, is addressed in synthesis project S1, lead by Johannes Quaas (Uni Leipzig). In this project, several different workpackages cover different aspects of the response of clouds to aerosol perturbations. In workpackage 4 (WP4), the focus is on mixed-phase clouds. WP4 will be carried out at the Karlsruhe Institute of Technology (KIT) in close collaboration with the other S1 partners.

A perturbation in CCN and IN distributions may strongly impact the thermodynamic phase of a cloud. If the perturbation involves more IN, and in particular if the ice number concentration is enhanced through ice multiplication processes, a supercooled cloud might glaciate at higher temperatures (<0°C; “glaciation effect”, Lohmann, 2002). In turn, if the perturbation involves more CCN and smaller individual cloud droplets, more water might be lofted to colder temperatures. The goal of this workpackage is a more realistic representation of these effects in the microphysical scheme of the ICON-LES, a thorough evaluation of these effects in the model, and an assessment of the effects in comparison of the two sensitivity simulations. In particular, we will implement a new microphysical scheme into ICON-LEM. This new scheme adresses the problem that especially for mixed-phase clouds, but also for pure ice clouds, the classical bulk formulation of microphysical schemes that distinguishes hydrometeor classes on the basis of a size gap between cloud- and precipitation particles becomes difficult. The microphysical scheme within ICON-LEM involves four solid hydrometeor classes (cloud ice, snow, graupel, hail), three of which are precipitating and are distinguished mainly by their densities. An alternative approach does consider only one solid hydrometeor class, but introduce additional bulk properties as prognostic variables (Morrison and Milbrandt, 2015). This approach allows for a smooth transition between ice hydrometeor types.