HD(CP)^2-II S4 (Land Surface Heterogeneity)

Abstract

HD(CP)^2 – High definition clouds and precipitation for advancing climate prediction is a framework project funded by BMBF. The general target of the project is to advance the understanding of cloud formation and precipitation processes using a very high-resolution model based on the dynamical core of ICON, integrated for short time periods (days) over relatively large domains. The whole project is conceptualized as having three phases: Phase I focused on the development and optimization of the model code and officially ended in September 2015. Building on the development of Phase I, simulations were started on Mistral that allowed for the first time ever to simulate over Germany using a horizontal grid resolution of 150 m for specific days. For Phase II, which will officially start in April 2016, an externally reviewed proposal has been submitted to BMBF which includes an outline of the planned simulations and scientific justifications.

The project S4 of Phase II is about land surface heterogeneities. It will assess and reduce the uncertainties of climate models caused by unresolved subsurface processes, surface heterogeneity and its feedback to the atmospheric boundary layer (ABL) including cloud development and convection initiation. Using the HD(CP)² framework, the project will analyse the true impact of the land including sub-surface, vegetation and anthropogenic structures including its variability and change on the regional climate of central Europe with a focus on cloud and precipitation development, intensity, and distribution. Does land surface heterogeneity influence significantly the statistics of boundary-layer turbulence and even challenge the validity of Monin-Obukhov Similarity Theory (MOST)? What is its impact on cloud and precipitation development? What is the effect of catchment-scale circulations, which evolve in structured terrain, on clouds and precipitation and on the local and regional climate including wind extremes and fog development? How different was our climate before humankind started to dominate the landscape, and what part did related land surface changes ranging from deforestation to water management and urban development actually play in this? The team will answer these questions following an extended validation of ICON-LES for such effects using a range of ICON-simulation with state of the art land models designed to quantify land effects on climate including a consistent representation of the terrestrial water and energy cycle. Finally, appropriate methods will be developed to include these findings in ICON-NWP/GCM. The added realism of ICON-GCM related to a realistic treatment of the heterogeneous lower boundary will be evaluated and improved in order to increase confidence in climate predictions.

The project is divided into six work packages (WPs), which address different aspects of the land surface heterogeneity problem by sets of ICON-LES/NWP/GCM simulations and develop improved parameterizations for sub-surface soil moisture re-distributions, surface fluxes honoring the dynamics of agricultural areas, settlements and cities, ABL turbulence, ABL-lower troposphere coupling, and the effects of surface heterogeneity on larger scale circulations. To these goals, the partners will derive and agree on a set of simulations with different approximations to land surface heterogeneity with the three ICON versions at the start of the project and optimize the setup to achieve the goals with a minimum of extensive simulations in consultation with the M project. Several Tasks of the individual Work Packages overlap to some degree and require close cooperation. Examples are the impact of surface heterogeneity on MOST assumptions (WP1 and WP2), the impact of catchment circulation on

convection initiation (WP3 and WP4), and the improvement of the ICON LSMs (WP2, WP3, and WP5).

Large domain simulations, covering Germany at a horizontal resolution of 150 m, will be covered by the computing resources applied by the M project of HD(CP)^2-II. Here, in this request, we apply for additional computing resources for test and sensitivity simulations on smaller sub-domais, which we will perform independently of the M project. They are necessary for testing new land-surface modules, which have to be implemented into ICON, and for sensitivity experiments with perturbed land-surface conditions. Further, some resources are needed for simulations of idealized diurnal cycles with the LES model PALM, to assess the impact of surface heterogeneities at very small scales (down to 10 m) in WP1.