Project: 1154
Project title: Monsoon
Project leader: Dr. Ulrike Burkhardt
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1. Analysis and evaluation of ice clouds in high-resolution simulations (Karol Corko b309188, Ulrike Burkhardt b309022)

During the last year, we have analyzed, within the BMBF Monsoon project, high-resolution global simulations performed within the DYAMOND project and compared them with observational data and the ERA5 reanalysis. Moreover, a comparison between different DWD versions of the ICON model and the ICON model from the DYAMOND project was performed. This should provide us with insights into which modifications could be implemented into the ICON model in order to improve the ICON simulations.

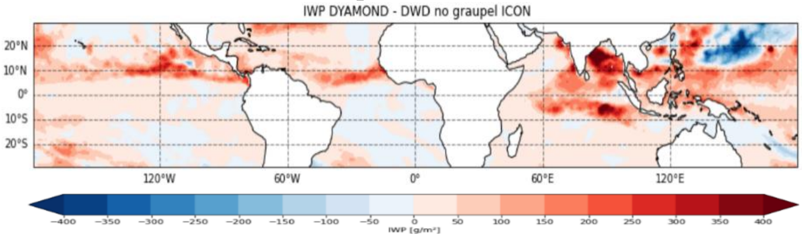

Figure 1: Difference in ice water path between the simulation of the 3.5km resolution DYAMOND version of ICON and the 13km resolution DWD version of ICON in the Tropics. The biggest differences can be found in ITCZ.

Employing a resolution of 5 km or less, DYAMOND models simulate vertical velocities and clouds and precipitation much more successfully (Stevens et al., 2020) and mostly resolve deep convection. Since the water budget in the tropical UT is controlled by convection, we restrict our analysis to the tropical upper troposphere. Figure 1 shows the difference between the ice water path (IWP) from the DYAMOND version of the ICON model and the DWD version, which parameterizes deep convection. The lower resolution DWD version simulates a significantly lower IWP, in particular along the ITCZ.

In order to understand more about the differences in the simulations from different models, we have analysed the connection between the simulated vertical velocity and the IWP and other variables. Figure 2 shows the cloud response to vertical velocity (total IWP (solid lines, circles) and LWP (dashed lines, stars) for the given vertical velocity. In general, higher vertical upward velocities tend to bring more water into the upper troposphere whereas, for downward velocities, IWP is low and liquid clouds can be sustained only in the lower troposphere. Nevertheless, there is a large variability in the connection between the amount of water that is brought into the upper troposphere by convection. In order to find out the reasons behind model differences, we also analyse the response of the individual hydrometeors to vertical velocity. Models convert the water into larger precipitating hydrometeors differently fast. Reasons and effects of those differences in the hydrometeors are not clear. Do models with more cloud ice moisten the upper troposphere more effectively? What determined the partitioning in different hydrometeors and do differences in entrainment, detrainment, clustering or microphysical constants play a crucial role? We will continue to analyse the UT water budget at different spatial and temporal resolutions.

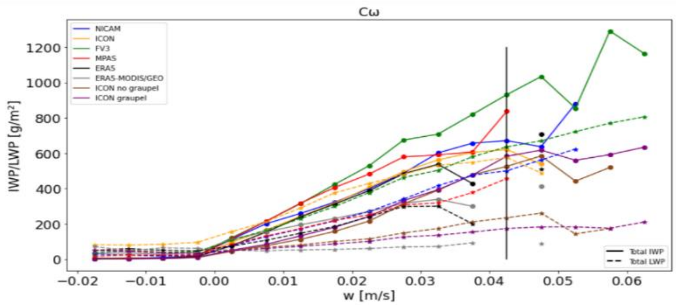

Figure 2: Response of total ice water path (water path of cloud ice + graupel + snow) and liquid water path (water path of cloud water + rain) to vertical velocity at 500 hPA.

2. Test Runs and Debugging (Luis Kornblueh m214089, Reiner Schnur m212005 und Chao Li m221071)

The original plan of the BMBF funded Monsoon project was to port the ICON code to the Chinese top one supercomputer TaihuLight. This was to be used in particular to better structure the ICON code and improve its portability to different computer architectures. A work contract between DKRZ and a Chinese scientist, who is familiar with the TaihuLight supercomputer, had already been negotiated and was ready to be signed. However, due to the restrictions imposed by Covid-19, the candidate had to withdraw his application. At the end of 2020, the project leaders and together with the Chinese collaborators have decided to use other less experimental computer architectures because of the unforeseen and unpredictable Covid-19 pandemic. At the same time, the opportunity has arisen to use CPU-based supercomputer of Tianhe in Tianjin China and also the GPU-based supercomputer of JUWELS Booster at the Jülich Supercomputer Center.

Due to the COVID-19 pandemic, all involved project scientists were not allowed to travel to China as we planned in our proposal. This created a very inconvenient and difficult situation for us to debug the model via internet and virtual meetings. It is an inefficient way to solve software issues in a project like Monsoon-2.0 without personal contact of all involved project scientists. The initial installation and testing ICON on Tianhe supercomputer took much longer than we have planned in our proposal. During the reporting time, we have mainly worked on installing and testing ICON on Tianhe supercomputer from the National Supercomputing Center in Tianjin China. As the internet connection offers only very limited bandwidth, the boundary and initial data had to be transferred by hard disk drive and post. It took considerable time to transfer all required data to Tianhe supercomputer. At meanwhile, the project hired scientist, Lukas Kluft (MPI-M), and the project technical leader, Luis Kornblueh, have spent most of their project time on porting and testing ICON in JUWELS Booster and Tianhe. So far until now, none of the project planned simulations have been accomplished. Hence, we cannot manage to use all of our proposed computing resources because of the changing work plan.

Fortunately, we have made considerable progresses in preparing the Monsoon simulations by this summer. Now all technical problems have almost been solved, the ICON is more or less ready to produce planned simulations for the Monsoon project in JUWELS Booster and also in the Chinese supercomputer Tianhe. We are still planning to do some of the testing and debugging runs on Levante as we proposed. Most of the granted computing resources will be used to improve ICON performance until the end of this year.