Project: **834**

Project title: **HD(CP)2 M (Modelling)**

Project lead: Björn **Stevens,** Rieke **Heinze (MPI)**

Panos **Adamidis**, Joachim **Biercamp**, Kerstin **Fieg (DKRZ)**

Reporting period: **01.01.2017 - 31.10.2017**

Report 2017

1. Computing time

For 2017 the WLA granted nearly 2.4 Mio node*h to the Verbundprojekt HD(CP)2, which is nearly 30% of the total amount of computing time available for BMBF projects on *Mistral*. This reflects ambition of the HD(CP)2 Project of being one of the "Lighthouse projects" for the German Climate Research Community.

From this share, 70% of the computing time was assigned to subproject bm0834 (Modul M) and devoted to perform agreed model runs of importance for the whole the HD(CP)2 community.

2. Storage resources

In total, the WLA granted 2.3 Mio GiB Lustre work, 2.4 Mio GiB HPSS arch and 26000 GiB HPSS doku to the HD(CP)2 Verbundprojekt. THE bm834 share counts for 2.17 Mio GiB Lustre work, 2.17 Mio GiB HPSS arch and 14000 GiB HPSS doku.

1. Experiments performed successfully by M Module

The following 14 days are computed and finalizes between Jan and Oct 2017 at *Mistral*:

26.04.2013
28.05.2013
17.06.2014
29.07.2014 (2x)
14.08.2014 (3x)
15.08.2014
17.06.2015 – 18.06.2015 (without restart between the days)
04.07.2015 – 05.07.2015 (without restart between the days)
05.07.2015

2. Justification of used Resources

2.1 Compute Resources

We calculate 70000 node*h for a successful and complete simulation day, broken down into

- Simulation of the day: 60000 node*hours
- Reading input / Restart: 5000 node*hours
- Writing output (dependent on requirements) 5000 node*hours

Summary

- 11 dates mentioned above were performed successfully
- 2 days had to be repeated once (29.07.2014) or twice (14.08.2014) after careful analysis of the output. Errors in the ICON-LEM software or experiment setup were found and fixed.
- 4 experiment days stopped due to hardware / software failure without generating useful output.
- Approximately 2% of resources were used for bug-fixing (e.g. wind bug issue tracker no. #7825, testing of online diagnostics, developing HDCP2 TA setup)
- Approximately 1 % of the resources were used to prepare the initial and boundary conditions for each experiment
- Approximately 2 % used for post processing and visualisation of output data

The more detailed documentation of the experiment setups and the scientific backgrounds can be found in the reports of the S projects attached as well as the impressing list of papers related to the project (http://hdcp2.eu/index.php?id=4203).

Summary:

14 community agreed days with ICON-LEM (a 70000 Node*h)	**980.000 Node*h**
Resources used for unsuccessful attempts	**190.250 Node*h**
2 % of resources were used for bug-fixing	**26.700 Node*h**
1 % of resources were used for experiment setup and data preparation	**13.350 Node*h**
2 % of resources were used for post processing and visualisation	**26.700 Node*h**
Expired resources in Q1 (stop of production due to evaluation and bug fixing)	**98.000 Node*h**
	1 335.000 Node*h

2.2 Storage

It is agreed among the project modules M, S1 – S6, and O, that all project scientists can and should access the project output from storage resources of subproject bm0834. Thus, here they expect to find the results from all experiments performed at *MISTRAL* and performed at *JuQueen*. They are explicitly asked not to copy the data to their local resources.

The Data Management Plan (DMP) attached to the application describes in detail the amount of data stored for the individual experiments on */work* and */archive* resources.

As a summary:

1. */work*:

In the 2017 proposal we got granted 2.17 PB by WLA and used 2.47 PB, which is 113%.
The main reason is, that the evaluation procedure done by the S Modules is about to reach its peak and the scientists are depended on the fast access to all data for post processing of the complete set of HD(CP)2 experiments.

2. /archive

The appropriate directory structure of */archive* is agreed and the output data in original time resolution is transferred into */archive*. According to agreement of the community only the output in 5 min resolution was kept on */work*.

Project: **838**

Project title: **High Definition Clouds and Precipitation for Climate Prediction - PDF cloud schemes**

Project lead: **Johannes Quaas**

Report period: **1.1.2017 – 31.12.2017**

In the report period, we have conducted the planned simulations with the ICON and ECHAM6-HAM2 model systems in preparation and in support of the HD(CP)² high-resolved simulations with (1) perturbed cloud condensation nuclei (CCN) and (2) perturbed atmospheric carbon dioxide concentrations.

The results of this have been highly useful to inform the set-up of the (computationally much more expensive) high-resolved simulations, and also to put the results from these short integrations into context.

An example is shown in Fig. 1 (taken from Nam et al., submitted), where the impact of a strong CO2 perturbation and its temporal development is assessed, as a joint diagram for top-of-atmosphere radiation budget change and surface temperature change.

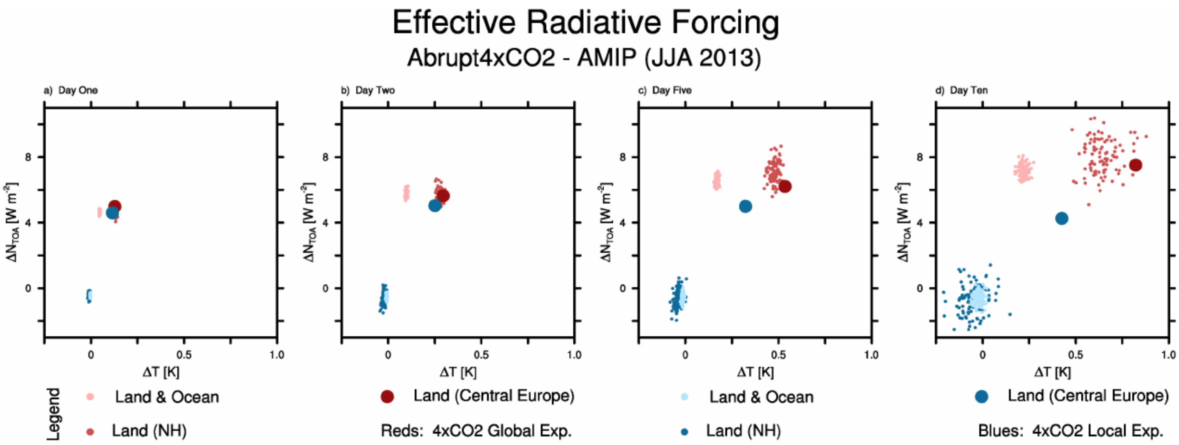

Fig. 1: Net effective radiative forcing at top-of-atmosphere (ΔN_{TOA}) on Days 1 (a), 2 (b), 5 (c), and10 (d). Differences calculated from Global 4xCO2 - AMIP experiments in red, and Local 4xCO2 - AMIPexperiments in blue. From Nam et al. (2017).

References

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Project:	**852**
Project title:	HD(CP)2 **Diagnostics and ice clouds in ICON**
Project leader:	**Dr. Ulrike Burkhardt**
Report period:	**01.01.2017 – 31.12.2017**

1. HD(CP)² - S3 TP4 Einfluss von Konvektion auf Zirrusbewölkung und das Wasserbudget der oberen Troposphäre (Burkhardt b309022, Arka b309120)

We finalized the implementation of the cirrus macrophysical scheme (Burkhardt, 2013) in the Tompkins cloud parameterization (Tompkins, 2002), which was improved and implemented in ICON-GCM by Vera Schemann (Schemann 2014). In particular, we had to overcome challenges, including an instability that caused an unphysically large variance of the total water PDF in the tropopause and stratosphere, which required extensive testing. The stability of the scheme was verified by two 10-year runs. A longer control simulation using the Tompkins scheme without the newly implemented cirrus macrophysical parameterization was also conducted.

The introduction of the cirrus scheme within the Tompkins parameterization resulted, as expected, in a significant reduction of the high cloud cover in comparison to the control run (fig.1). The variance and skewness of the total water PDF are also affected by the cirrus macrophysics, with a higher skewness except in the extratropical UTLS predicted in the scheme using the cirrus parameterization. A higher variance is predicted in most of the upper troposphere, and a decrease is found below. The predicted frequency of supersaturation is comparable to that observed by Lamquin et al. (2012) in the polar regions, but smaller by about a factor of two in the tropical Upper Troposphere. The reasons for this bias will be investigated.

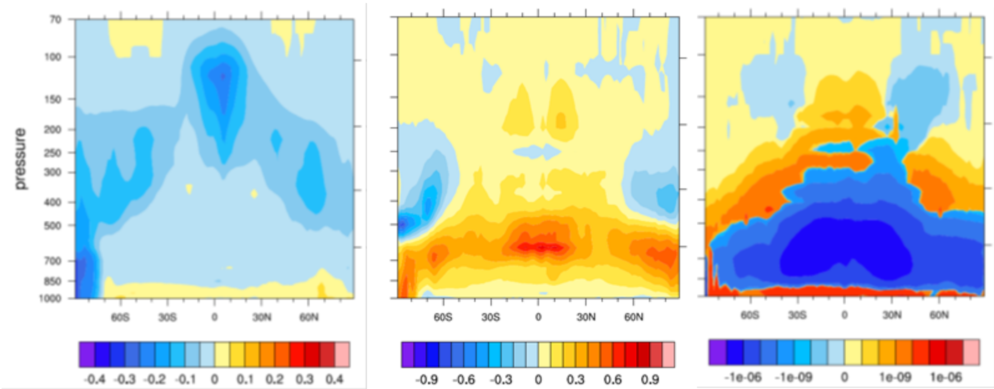

Fig 1*:* Difference between cirrus cloud scheme and control: cloud cover, skewness, variance (yearly means).

13:30 UTC (initialization)	**15:00 UTC** (strong convection)	**18:30 UTC** (thick anvil)	**21:30 UTC** (decay)

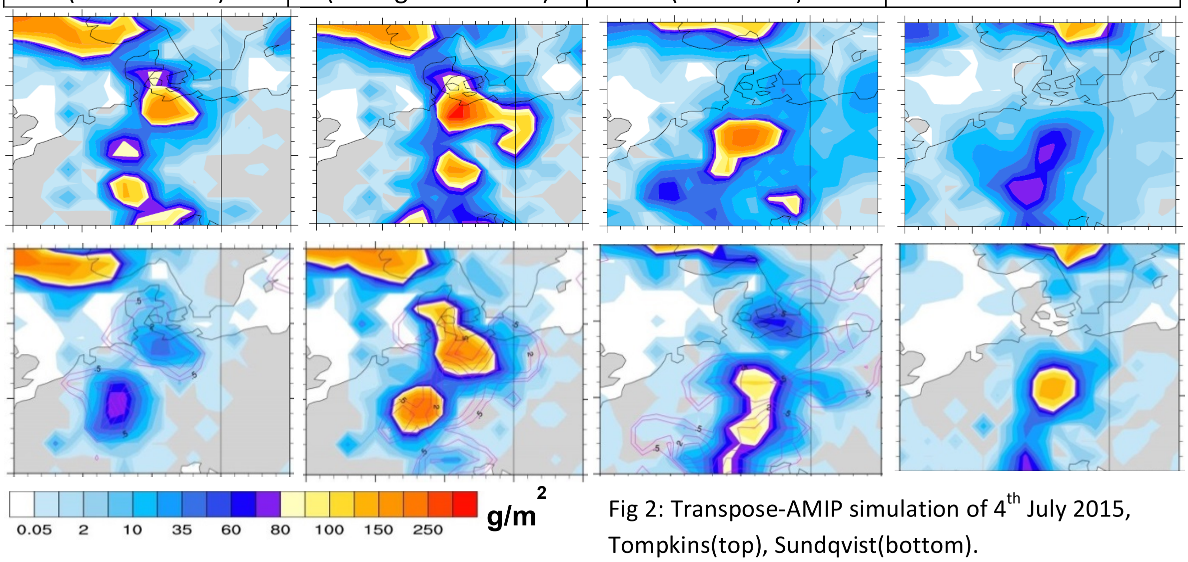

Fig 2: Transpose-AMIP simulation of 4th July 2015, Tompkins(top), Sundqvist(bottom).

Both the Tompkins and the Sundqvist (Sundqvist et al, 1989) scheme including their respective cirrus cloud extensions were used for transpose AMIP simulations of a specific event, during which a large anvil was formed over eastern Germany (4-5th July 2015). The time of initialization of the simulation was varied by +/-2h from 00:00 UTC, July 4th 2015. In all simulations the development of a thick anvil-like structure over eastern Germany is predicted. An example of this can be seen in fig.2.

We were unable to conduct the transpose AMIP simulations at higher resolutions as planned in the last Rechenzeitantrag, because boundary fields were only available for ICON-GCM2.0.00 and in this model version the grid structure and physical parameterizations are changed. The cirrus scheme will have to be transferred into the new version of the ICON-GCM in order for those simulations to be run during the next computing time period.

2. HD(CP)² - S1 TP2 Kondensstreifenzirren(Burkhardt b309022, Verma b309131)

Our aim in this project is to develop a parameterization for contrail cirrus within ICON-LEM. We have implemented a parameterization for contrail ice crystal nucleation (Kärcher et al., 2015). We apply this parameterization currently within natural cirrus to study the impact of air traffic within cirrus on cirrus cloud properties. We initialize fuel and flight distance per grid box (in a first step with air traffic at 260hPa in each grid box) and calculate the number of formed ice crystals depended on the state of the atmosphere. We do two simulations, a control and a perturbed simulation (with contrail ice crystal nucleation). Whereas the total ice water content remains nearly the same after contrail ice crystals nucleation due to limited availability of water vapour, the total number of ice crystals at 260hPa increases drastically (fig. 3).

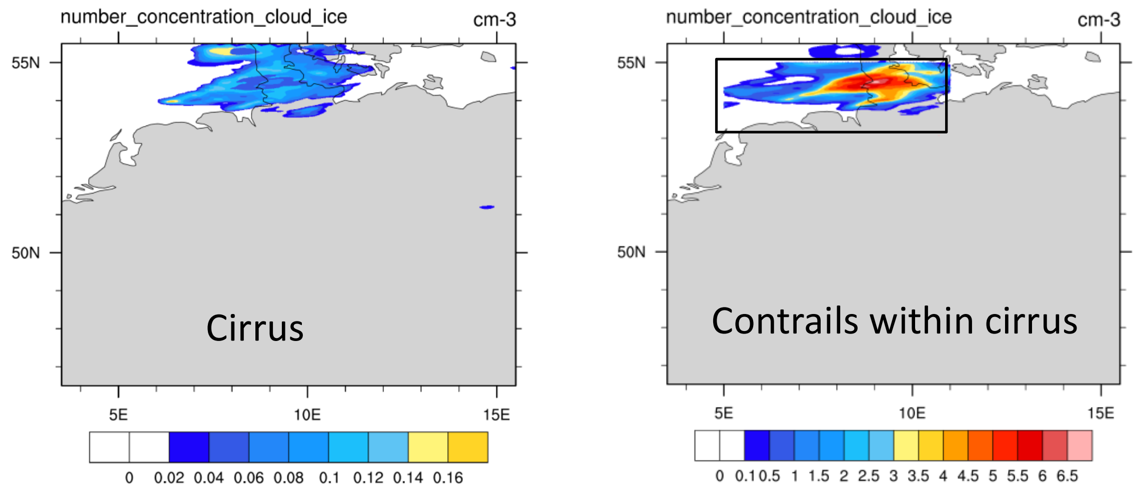

Fig.3 Ice crystal number concentration within cirrus clouds (left) without and (right) with ice crystal nucleation within contrails at the time of the nucleation event. Air traffic flight was initialized within the black box.

Our work is delayed by half a year. The preparation of the boundary data (flight inventory) took longer than anticipated, so that we could only start with the work on the model in the second half of 2017. Therefore, we consumed significantly less computing time but we expect to still use a significant amount in the last quarter of 2017.

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Project: 974
Project title: HD(CP)2 - II S5
Project lead: Rieke Heinze
Report period: 2017-01-01 to 2017-12-31

The formation of shallow cumulus cloud streets was historically attributed primarily to dynamics. Jakub and Mayer (2017) focus on the interaction between radiatively induced surface heterogeneities and the resulting patterns in the flow. The results suggest that solar radiative heating has the potential to organize clouds perpendicular to the sun's incidence angle.
To quantify the extent of organization, a high resolution LES parameter study was performed. They varied the horizontal wind speed, the surface heat capacity, the solar zenith and azimuth angles, as well as radiative transfer parameterizations (1D and 3D). As a quantitative measure a simple algorithm that provides a scalar quantity for the degree of organization and the alignment was introduced. It was found that, in the absence of a horizontal wind, 3D radiative transfer produces cloud streets perpendicular to the sun's incident direction, whereas the 1D approximation or constant surface fluxes produce circular, randomly positioned, clouds. The reasoning for the enhancement or reduction of organization is the geometric position of the cloud's shadow and the corresponding surface fluxes. Furthermore, when increasing horizontal wind speeds to 5 or $10\,\mathrm{m\,s^{-1}}$, the development of dynamically induced cloud streets was observed. If in addition, solar radiation illuminates the surface beneath the cloud, i.e. when the sun is positioned orthogonal to the mean wind field and the solar zenith angle is larger than 20°, the cloud-radiative feedback has the potential to significantly enhance the tendency to organize in cloud streets. In contrast, in the case of the 1D approximation (or overhead sun), the tendency to organize is weaker or even prohibited because the shadow is cast directly beneath the cloud. The radiative feedback on surface heterogeneities is generally diminished for large surface heat capacities. We therefore expect radiative feedbacks to be strongest over land surfaces and weaker over the ocean. Given the results of this study we expect that simulations including shallow cumulus convection will have difficulties producing cloud streets if they employ 1D radiative transfer solvers or may need unrealistically high wind speeds to excite cloud street organization.

The organization characteristics of shallow precipitating convection are investigated and the mechanisms leading to cloud organization with a focus on boundary layer turbulence are explored. High-resolution and large-domain simulations were necessary to accurately capture the complexity of the precipitating shallow convection regime (Seifert and Heus, 2013; Schemann and Seifert, 2017). Therefore, the LES simulations were designed with an isotropic grid having a mesh size of 25 m covering a large domain of 50 x 50 x 6 km. As it demands a huge computational time, MicroHH, a newly developed efficient LES model is chosen for the numerical experiments (van Heerwaarden et al., 2017).
To investigate the impact of precipitation and the associated organized motions on the second order moments, idealized LES experiments are designed using the Rain in Cumulus over the Ocean (RICO) field experiment data (Rauber and coauthors, 2007). Two idealized LES simulations were carried out using MicroHH-LES with different initialization approaches, one with initial profiles identical to the RICO inter-comparison study (defined as Std case) and another experiment (termed as Moist), with a modified humidity sounding (vanZanten et al, 2011). In addition, a LES simulation, defined as Control, was carried out for reference. Different test simulations were conducted to implement and verify the second moment budget equations for scalars and vector quantities in the LES model.

The research work investigated the feedback of precipitation and associated cloud organization on the evolution of higher order moments such as variances and covariances. For this, second order budget equations for variances and fluxes were implemented and tested in MicorHH-LES. Using the simulated LES data for precipitating shallow convection, the terms in the second order budgets of scalar and vector quantities were analyzed (example, see figure 1 for Std case). From the figures, it is evident that the variances and covariances of scalar quantities are largely influenced by the microphysical effects. Further research is going on to understand the different mode of organization of precipitating shallow convection and its impact on the higher order moments.

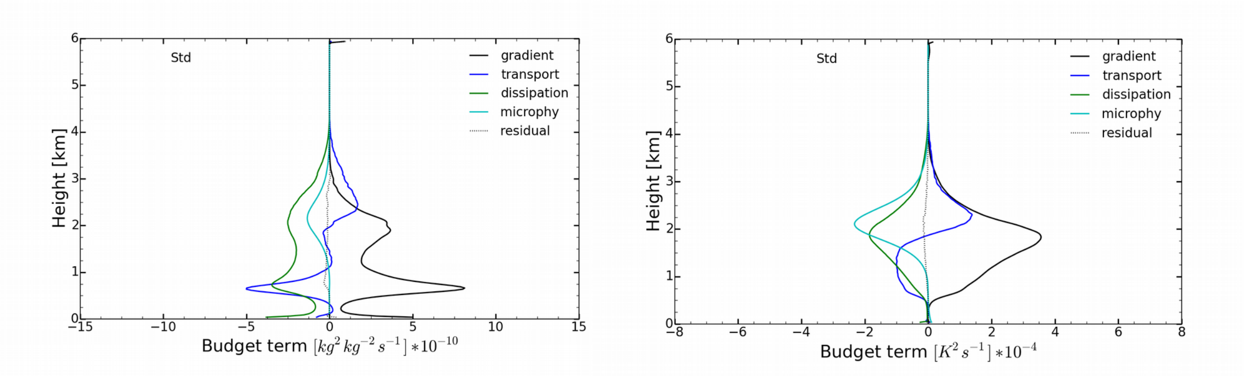

Figure 1: Budget of total water variance (left) and budget of liquid water potential temperature variance (right).

About 87000 node hours (21 % of the granted computing time) expired in the course of 2017. The main reason for this loss is the absence of Rieke Heinze due to parental leave until August 2017. Thus, the work about the inhibition of organziation could not be performed.

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Project: **982**
Project title: **HD(CP)2-II S4 (Land Surface Heterogeneity)**
Project lead: **Christopher Moseley**
Report period: **2017-01-01 to 2017-12-31**

For 2017, an amount of 221700 node hours was granted for DKRZ project bm0982 for the use of S4. In the reporting period, the following simulations have been performed on this computing account:

1. An ensemble of idealized simulations with ICON-LEM, coupled to TERRA, was performed with both homogeneous and heterogeneous soil moisture initializations. The simulations were analyzed with respect to the question how catchment-scale circulation impact on the boundary-layer development.
2. Multiple nested runs with ICON-LEM up to a resolution to 300 m focusing on domains and days with convective activity were performed with IFS forcing. These days were determined by analyzing flash data over several years, and by looking on wind-speeds in ERA-Interim data. The model output was analyzed with special interest on surface heterogeneity and its influence to vertical exchange between the boundary layer and the free troposphere.
3. Small-domain simulations with ICON-LEM with 3 nests and a target grid spacing of 150 m were performed to study the statistics of the boundary layer turbulence profiles. The model output was evaluated with high-resolution lidar observations for the HOPE 2013 campaign. Higher-order moments of potential temperature, humidity and vertical wind from ICON-LEM output were compared with measurements of temperature from a rotational Raman lidar, differential absorption lidar and Doppler lidar. The impact of land use and soil properties on the model derived fluxes were investigated by comparing the model results with four energy balance station measurements.
4. Idealized cases were performed with the LES model PALM on very high resolutions, to study fundamental exchange processes between atmosphere and soil on the turbulent scale. New results for the interaction of Land-Surface models with LES were achieved. These were presented at the EMS2017 conference and a publication is in preparation.
5. Sensitivity experiments with changed land covers (afforestation experiments) were performed with ICON-LES, to study the impact of land use changes on surface fluxes, near-surface temperature, humidity, wind, and on convection. Simulations were performed for entire Germany on 600 m resolution, and smaller domains over urban areas with resolutions down to 150 m.
6. A down-scaling experiment from 5 to 1 km was conducted using ICON-NWP for Germany wide DE domain for multiple days covering the ICON-LEM simulations

from the M-project to investigate the effect of grid resolution on boundary layer evolution.

7. The effect of the error in the momentum flux calculation (see Proposal for 2018) was examined on two days ICON-LEM run at 600 m resolution. These simulations are done in consultation with the M-project to improve the understanding of this error.

Justification of expired computing time:

- Expiration of 1984 node hours in March 2017: In the first quarter of 2017, a new version of ICON-LEM was released. Therefore, some work packages needed to change their setup, so that some simulations were delayed.
- Expiration of 2765 node hours in June 2017: In June, mistral had longer down times so that computing was partly not possible in the second quarter of 2017.
- In the third quarter of 2017, which ended in September, no computing time expired.

Project: 992
Project title: HD(CP)2 - II S5, TP6
Project lead: Rieke Heinze
Report period: 2017-01-01 to 2017-12-31

In 2017 computing time on Mistral was used to improve a fast forward operator for visible satellite images. Due to their high resolution and excellent coverage, satellite observation in the visible spectral range can provide valuable information for model evaluation purposes. For the HD(CP)² model evaluation study (Heinze et al. 2017) a forward operator based on MFASIS, a one-dimensional radiative transfer (RT) method developed at LMU München, was used. Only due to the high efficiency of MFASIS (which is 4 orders of magnitude faster than standard methods) it was possible to process the large amounts of data generated by the HD(CP)² ICON runs.

While 1D RT results are sufficient, e.g., to determine cloud size statistics, significant errors related to 3D RT effects have to be expected for other useful statistical quantities like reflectance histograms. Therefore, computationally efficient parameterizations for 3D radiative effects have to be included to improve the accuracy of the operator. One of the most important 3D RT effects is the variation of the reflectance with the inclination of the cloud top surface. To take this effect into account we have developed a fast 3D correction method that is based on the solution of a modified 1D RT problem in a rotated frame of reference (in which the cloud top is not inclined). This method contains a tuning parameter that has to be determined from comparison with full 3D Monte-Carlo RT reference computations. For this purpose and also to detect other operator deficiencies related to 3D RT effects, we computed synthetic satellite images for idealized scenarios and for HD(CP)² ICON runs using the 3D-Monte-Carlo code MYSTIC included in the libRadtran libray.

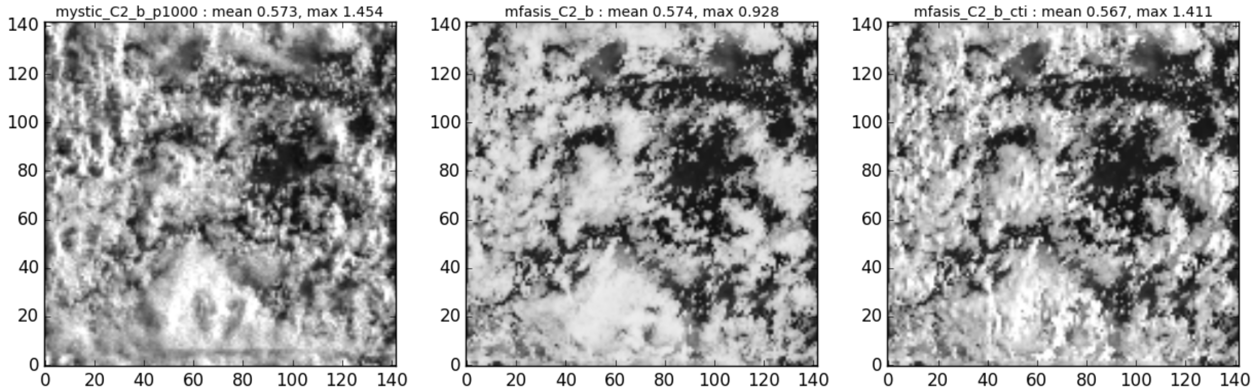

Fig. 1: MYSTIC (left), MFASIS (middle) and MFASIS-3D (right) images computed for a 360km x 360km region from the HD(CP)² run for 2014 August 15. A solar zenith angle of 65° was assumed.

Synthetic MFASIS images computed with the optimized 3D correction (see Fig. 1, right panel, for an example) show significantly more structure and are more similar to MYSTIC results (Fig. 1, left panel) than MFASIS images computed without the 3D correction (Fig. 1, middle panel). Moreover, also the reflectance histograms are much more similar to the ones obtained with MYSTIC (Fig. 2). These reflectance histograms indicate also that there is a discrepancy between 1D and 3D RT results for lower reflectances (<0.6 for the example in Fig. 2) that should be investigated further.

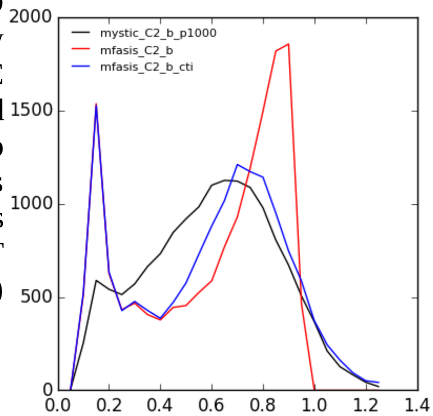

Fig. 2: Reflectance histograms for the images in Fig. 1. Black=MYSTIC, red=MFASIS, blue=MFASIS-3D.

About 4000 node hours (25% of the granted computing time) expired in the course of 2017. This can be attributed to a lack of personnel. It was not possible to commence the planned work about including organization in the closure of a stochastic convection scheme. This work will begin in the fourth quarter of 2017 with the hiring of the post-doctoral scientist in Munich.

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Project: **994**
Project title: **HD(CP)2, S3, TP2**
Principal investigator: **Peter Spichtinger**
Report period: **2017-01-01 to 2017-12-31**

Progress report:

In this project we want to investigate cirrus clouds as driven by the outflow of warm conveyor belts (WCBs). For this purpose, we want to investigate certain cases of WCBs using the ICON model in a coarser resolution (i.e. NWP mode with horizontal resolution of Δx~ 1-10km).

Delays in progress:

Unfortunately, we experienced strong but unforeseen delays in the project progress:

Matthias Voigt, who was project scientist since 01/05/2016 (later start than the whole BMBF project HD(CP)2) left the project at 31/10/2016. it was very difficult to find a successor. Actually, Tim Lüttmer started to work in the project on 01/05/2017. In addition, we had to develop some additional ice microphysics parameterisations in order to address our research questions adequately. This task required only marginal computing time.

These delays in progress lead also to the problem, that we could not consume the computing time as requested in the proceeding project request in October 2016. Thus, we request the same amount of computing time as last period.

Development and extension of ice microphysics scheme:

For addressing the issue of dominant pathways of ice nucleation, the microphysics scheme was extended as follows:

In the existing scheme there is only one class for cloud ice, which can be formed via different pathways; once ice crystals are formed, number and mass concentrations stemming from different sources are just added. We extended the cloud ice class to four classes. Each of them consists of a number concentration nc_{class} and a mass concentration qc_{class}. The classes represent different ice formation pathways, i.e. homogeneous freezing of solution droplets, heterogeneous nucleation of ice crystals, homogeneous freezing of preexisting cloud droplets and secondary ice production due to Hallett-Mossop process (driven by riming), respectively.

First tests of the new ice microphysics scheme

After implementing the new extension of the ice microphysics successfully, first test cases were run with the ICON model. For this purpose we used the implemented Weisman-Klemp test case in 3D. First results are shown in figure 1. Here, the mass mixing ratios of all hydrometeor species are shown. All cloud ice species are collected in the variable qi, as in the usual microphysics scheme.

In figure 2, the different classes of cloud ice are shown. In this representation, the occurrence of cloud ice stemming from different pathways can be seen clearly. Some classes can occur in the same environment and it seems that homogeneous freezing of preexisting cloud droplets is the dominant ice formation pathway in this convective case. However, a more detailed evaluation of different classes will hopefully lead to a better quantification of nucleation pathways under different environmental conditions.

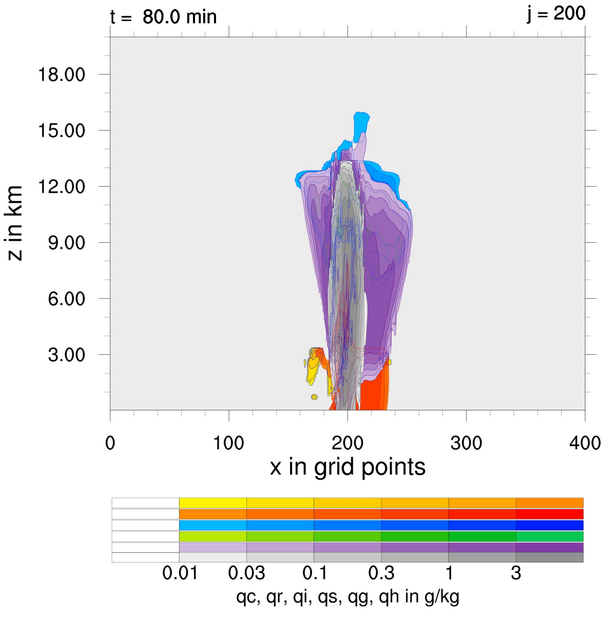

Figure 1: Hydrometeor mass mixing ratios (cloud water, rain water, cloud ice, snowm graupel, hail) for the Weisman-Klemp test case.

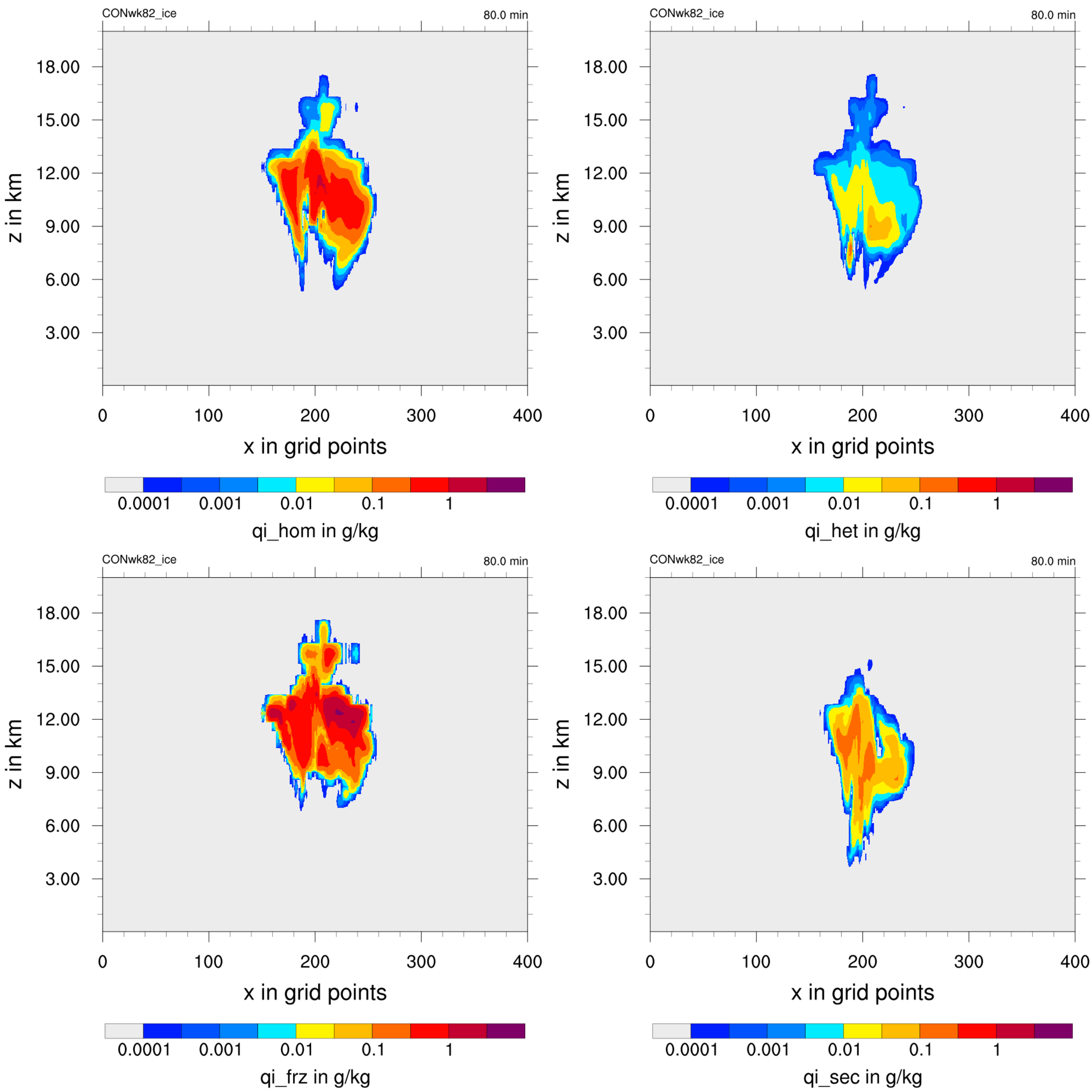

Figure 2: Cloud ice mass mixing ratios for different classes of ice, discriminated by the formation mechanism (top row: left: homogeneous freezing of solution droplets, right: heterogeneous nucleation. Bottom row: left: homogeneous freezing of cloud droplets, right: secondary ice production due to riming)

Project: **1018 - Report for allocation period: 2017-01-01 to 2017-12-31**

Project title: **HD(CP)2 S6 Storm Track Group - Cloud-radiative interactions with the North-Atlantic storm track**

Project lead: **Aiko Voigt**

Project overview and range of planned work from scientific view

see 2017 allocation request

Performed simulations and used resources

We have used the project resources for two purposes: 1) development of the model and the simulation setup, and 2) production runs with the global ICON-DWD model (NWP physics) and with the cloud-locking technique.

1) Development of model and simulation setup

Running ICON-DWD in global mode for climate purposes and with the cloud-locking technique required us to adapt some parts of the model, e.g., output and I/O handling for the cloud-locking techniqe, and to test the simulation setup. This work was performed by the project leader Aiko Voigt and used the following resources until 30 September 2017:

- 1774 node hours

2) Production runs

With the model setup being defined, we have performed production runs with the ICON-DWD model in global mode. These runs were done with prescribed SSTs and in realistic setup, and include "free" and "locked" clouds simulations. The runs were performed by the project member Nicole Albern (PhD student). As of 30 September 2017, we have simulated a total of 220 years and have used the following resources:

- 3674 node hours
- 7275 GiB Lustre work

These runs are currently analzyed and so are not yet uploaded to Lustre arch, which we therefore have not used so far in 2017. We plan to make use of Lustre arch in Q4 of 2017, however.

Comparison to granted resources

In total, we have used the following resources as of 30 September 2017:

- 5448 node hours
- 7275 GiB Lustre work

This compares well to the granted resources, which were 7200 node hours and 8500 Gib Lustre work. In fact, we have been transferred an additional 5000 node hours by the central HDCP2 project in October 2017 that we plan to spend in Q4 2017 for further production runs.

We have not yet used the allocated 11000 GiB Lustre arch but plan to do so in Q4 2017.

In Q3 2017, 1147 node hours expired. This occurred because the PhD student Nicole Albern only started in April 2017, which delayed the production runs. Since then, we have used all our allocated node hours. PhD student George Papavasileou has not yet used HLRE-3, but it is planned that he will start using the resources in 2018 (so far he did work with observational data).

Project: **1023**

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

Project lead: **Axel Seifert**

Report period: **1.1.2017 - 31.12.2017**

Project overview

The BMBF-funded project "High Definition Clouds and Precipitation for Advancing Climate Prediction" HD(CP)2 aims at a better understanding of cloud process with the ultimate goal to improve climate models. Th sub-project S3 aims at an improved understanding of the cirrus formation and moisture transport due to deep convection.

Activities and achievements in 2017:

The planned work on

1. Development of a Lagrangian particle ice microphysics scheme
2. Assessment of moisture transport due to deep convection

is delayed for several reasons. First, the trajectory model, which is necessary for both work packages was not yet available until late September 2017. Second, the project scientist of WP1 quit his job and a replacement had to be found. Third, the high-resolution simulations performed for HDCP2 at DKRZ showed some suspicious behavior in the cloud statistics, namely a lack of high supersaturations over ice and an overestimation of ice crystal number densities. It was therefore decided (in agreement with the HDCP2 steering committee) to investigate the model behavior and identify the source of the high ice crystal number. Understanding this problem was urgently necessary due to the fact that the very expensive HDCP2 simulations are affected by this problem, which made their use questionable for all HDCP2 projects aiming at cirrus clouds. A series of sensitivity studies have therefore been performed for the HDCP2-DE domain at 600 m grid spacing. Eventually the deposition mode of the heterogeneous ice nucleation was identified as the source of the unrealistic ice crystal number densities in the upper troposphere. In cooperation with Corinna Hoose of KIT Karlsruhe, who developed this new ice nucleation parameterization in Phase 1 of HDCP2, it was decided to reduce the deposition mode by a factor of 10. The overestimation of the deposition mode could be traced back to an overestimation of upper tropospheric aerosol particle caused by a too strong mixing in the aerosol transport model, which was used to characterize the large-scale transport during the period of interest. With the reduced deposition mode the ice particle concentrations are more realistic, but the statistics of the relative humidity over ice still shows a lack of high supersaturations compared to the long-term climatology.

In the first quarter of 2017 7941 node hours expired in this project. This was due to the problem that the trajectory model was not yet available as mentioned above. In the original computing proposal it was indeed mentioned that most of the simulations would be performed in the 2nd half on 2017.

The work originally planned within the project is currently being performed on the Cray at DWD, because all computing resources within this DKRZ project were spent on the sensitivity studies.

Project: **1027**
Project title: **HD(CP)² S1 TP4: Cloud Adjust**
Principal investigator: **Corinna Hoose**
Report period: **2017-01-01 to 2017-12-31**

Report on resource usage in 2017

As planned, the main simulations in project HDCP2_S1_WP4 were performed at the Steinbruch Computing Center at KIT. Therefore, we applied only for a rather small number of node-hours for test simulations, in particular with small real-case setups for which external data have to be generated. As this was our first DKRZ proposal, the amount of CPUh needed for this was estimated with the help of other users. In addition, some computing time was used for postprocessing and visualization of data from the large HD(CP)^2 simulations. Unfortunately, the required computing time resources were overestimated by a factor of 5-8 (but with low absolute numbers).

Requested computing time for 2017: 500 CPUh
Requested disk space on Lustre: 1000 GiB

Used computing time (until Oct 9, 2017): 55 CPUh (+96 CPUh transferred to project 834)
Used Lustre Work (until Oct 9, 2017): 433 GiB

Report for computing time at HLRE-3 for 2017

Project title: HD(CP)^2 Module S2, WP1 & WP4 – bb1041
Project lead: Vera Schemann and Philipp Griewank
Allocation period: 1.1.2017 - 31.12.2017

Project motivation

Our main aim was to set-up a virtual lab and testing environment for parameterization development based on supersite observations. As a first step this includes running high-resolution simulations with the ICON-LEM and comparisons to observational data. At a later stage this will be combined by including single-column-models. High-resolution simulation provide the information (4 dimension) that are needed for the testing and development of parameterizations. As the ICON-LEM is still a rather new model, we worked towards a good set-up and used the allocated computing time for simulations, sensitivity tests, and evaluation.

High-resolution simulations with the ICON-LEM

We developed a set-up which consists of an outer domain with a diameter if approximately 110 km and a resolution of 624 m. Within this outer domain the resolution can be increased up to 78 m by nesting. When simulating very large domains the computational cost is so high that it is only feasible to simulate selected days. In contrast, with this smaller 110 km set-up we can run longer timeseries or increase the resolution up to 78m or even higher. These simulations can be performed around observational supersites providing information on the synoptic situations and spatial and temporal patterns surrounding the observations. This information is crucial to analyse and put the measurements into context. To evaluate the representation of the synoptic situation in our set-up we have simulated two weeks and confronted the model with observations. For example, the integrated water vapor (see Fig.1) shows that the timing of synoptic systems passing through the domain and over JOYCE agree well with each other. The results of this and other comparisons are very encouraging as we find a good representation of the synoptic situation. We are confident that we can use our newly developed set-up for its intended purpose as part of a virtual lab and parametrization testbed.

Besides this basic evaluation, the computing time was also used to evaluate and test the ICON-LEM itself and perform simulations with a higher resolution to actually represent the observed variability.

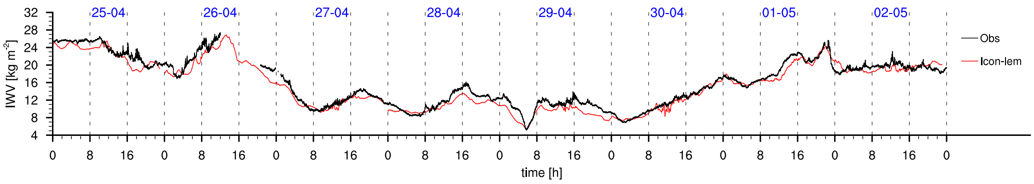

Figure 1: An example of integrated water vapor of the ICON-LEM around Juelich (JOYCE) with a resolution of 624m for a time period in 2013, compared to observed values.

Parameterization development

Our second aim and task is the development of a cloud parameterization for climate and weather models. For this aim we focused on analysing the high-resolution output generated by the ICON-LEM by using the postprocessing capabilities of the supercomputer. Using the ICON-LEM simulations we could study the effects of different resolutions and domain sizes and how they influence our cloud parametrization. Based on this analysis we have managed to test the assumptions on which our cloud scheme is based, and have already found various ways to improve the existing parameterization. Beyond testing and developing the cloud parametrization the analysis of the large data fields also allows us for the first time to quantify the parametrization performance under various conditions.