Project: **838**

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

Project lead: **Johannes Quaas**

Report period: **1.1.2016 - 31.12.2016**

The goal of the project is the assessment of cloud parameterisations in climate models in the context of the larger HD(CP)² project, i.e. making use of high-resolved model simulations as well as detailed observations.

In the reporting period, this resulted in a publication (Brueck et al., 2016) assessing the relative importance of temperature variability at subgrid-scale, as well as in the submission of a PhD thesis (Brueck, 2016). As an example from the PhD thesis work, Fig. 1 shows the spatial distribution of the cloud fraction, the humidity variability, and the saturation deficit variability in the ICON model in the numerical weather prediction version applying the Eddy Diffusivity-Dual Mass Flux (EDMF) parameterisation for boundary-layer turbulence, shallow convection, and boundary-layer clouds. This involves a probability density function (PDF) describing the diffusive part of the boundary-layer turbulence (PDF_1) and another one describing the convective part (PDF_2). As seen, although the former dominates for cloud fraction and average cloud liquid water, the latter is responsible for generating much of the subgrid-scale variance at least in certain regions.

An evaluation of the model using a new methodology to compare model results of subgrid-scale cloud variability against satellite retrievals (Fig. 2) shows that the ICON implementation of the EDMF-DualM parameterisation tends to show a slight underestimate of the variability, although its spatial variability and order of magnitude is rather well captured.

In another study, based on a Bachelor's thesis, we evaluated the mechanisms by which relative humidity increases or decreases, and thus by which clouds in the model form and dissolve using tendency diagnostics (Heyn et al., 2016). This study revealed in general a balance between large-scale advection and cloud microphysical processes, with little influence from radiation. Further statistical investigations of the model output showed that in general a rather good correlation is found with large-scale dynamics as expressed in terms of the mid-tropospheric vertical velocity.

References

***Brueck, M.**, Evaluation of statistical cloud parameterizations, PhD thesis, Faculty of Physics and Earth Sciences, University of Leipzig, 185 pp., 2016.*

***Brueck, M.**, **J. Quaas**, J.-C. Golaz, and H. Guo, Importance of subgrid temperature variability in cloud parameterizations, Mon. Wea. Rev., submitted (2016).*

***Heyn, I., J. Mülmenstädt, M. Salzmann,** and **J. Quaas**, Effects of diabatic and adiabatic processes on relative humidity in a GCM and implications for the usefulness of the mid-tropospheric vertical wind to classify cloud regimes, Tellus, revised (minor revisions, 2016).*

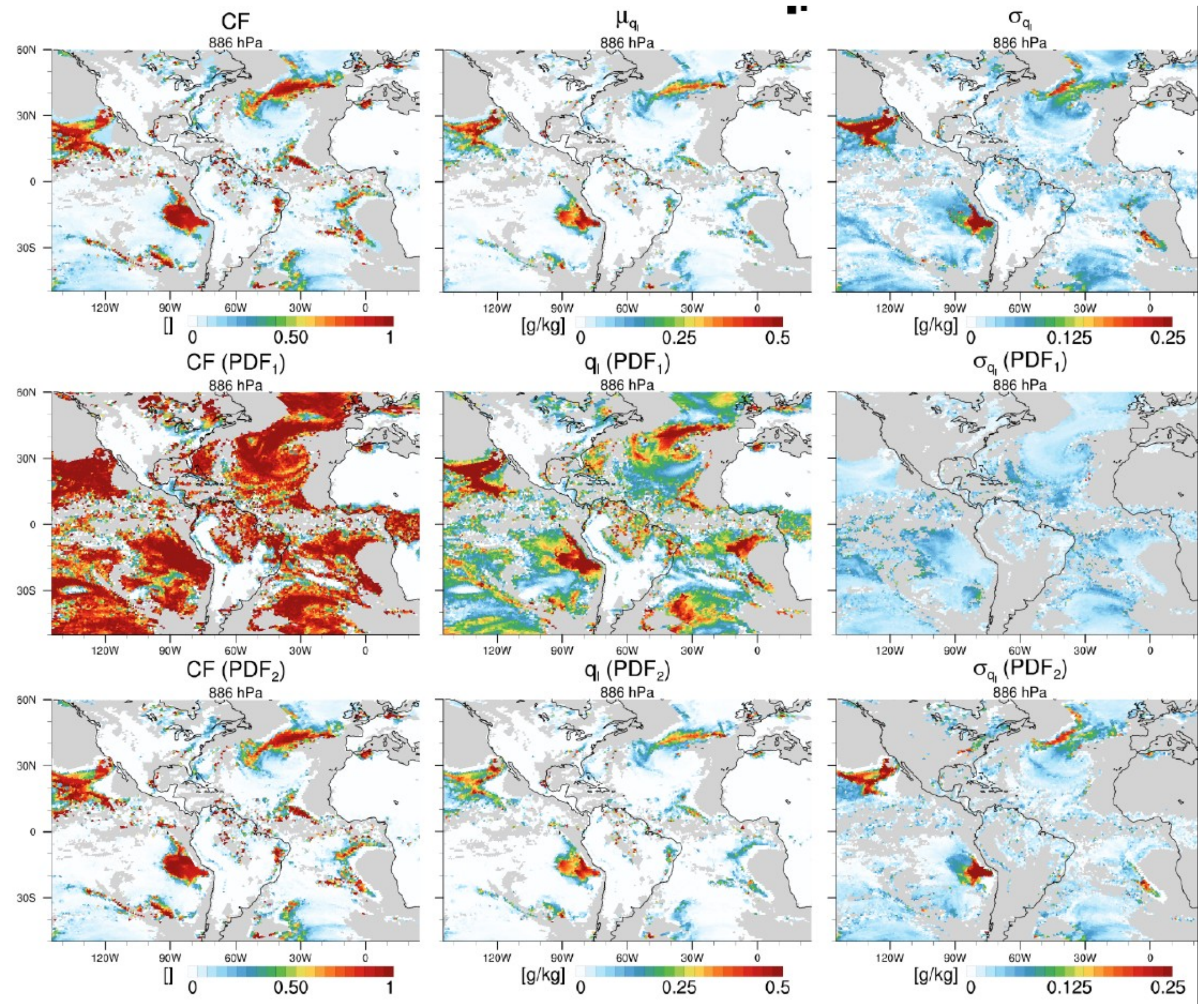

Fig. 1: Geographical distribution of (top left) cloud fraction, (top middle) variance of specific cloud liquid water, and (right) skewness of subgrid-scale distribution of specific cloud liquid water. Middle row: Contribution by the diffusive PDF of subgrid-scale variability to (left) cloud fraction, (middle) specific cloud liquid water, and (right) its skewness. Bottom row: the same, but for the convective PDF (from Brueck, 2016).

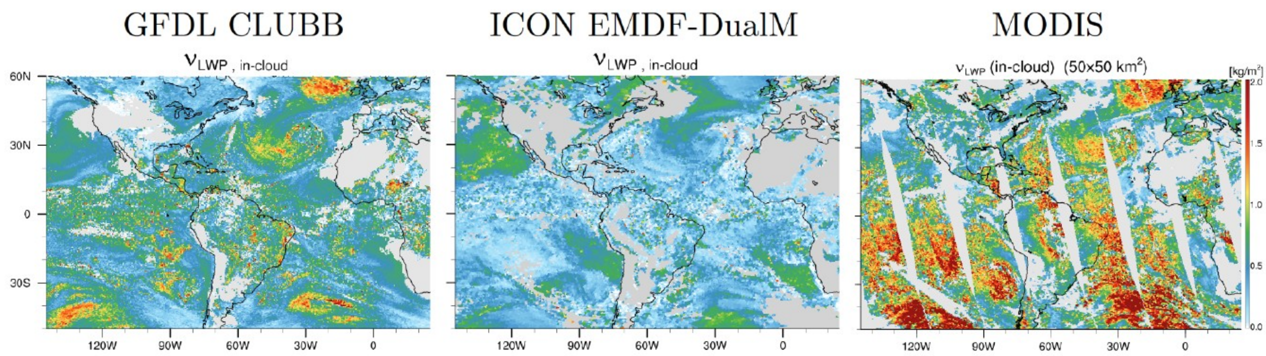

Fig. 2: Evaluation of the relative dispersion (variance of subgrid-scale variability of cloud liquid water path in a layer divided by its mean value) for the GFDL-CLUBB model (see also Brueck et al., 2016), the ICON model in its NWP configuration, and for MODerate Resolution Imaging Spectroradiometer (MODIS) satellite retrievals (from Brueck, 2016).