Project: **1036**

Project title: **ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms, (AC)³ – University of Leipzig contribution**

Project lead: **Johannes Quaas**

Report period: **1.1.2018 – 31.12.2018**

This reports about the new results in AC3 sub-project D02, for which we performed the simulations in the reporting period.

The goal of D02 is to better understand and represent in GCMs the role of aerosol-cloud interactions for the Arctic climate change. A prerequisite for this is a simulation of clouds in the models that is as realistic as possible. As in the Arctic, surface-based networks are sparse, and passive satellite remote sensing suffers from severe biases (e.g. Zygmuntowska et al., 2012), the best choice is active remote sensing. Here we make use of the Cloud-Aerosol Lidar and infrared Pathfinder Satellite Observations (CALIPSO) GCM-oriented cloud product (GOCCP, Chepfer et al., 2010) that is tailored to be used for GCM model evaluation. In the model, we make use of the on-line diagnostics of the Cloud Feedback Model Intercomparison Project (CFMIP) Observational Simulator Package (COSP, Bodas-Salcedo et al., 2008; Nam and Quaas, 2012) that emulates the signals as the GOCCP dataset would see it in observations. In the newest version we implement, the cloud phase is distinguished, too. As shown in Fig. 1, the model largely overestimates the total cloud cover in Arctic winter, in the original model version attributable to an overestimation of the liquid cloud cover.

A key problem in the Arctic are the mixed-phase clouds. In the ECHAM model (Stevens et al., 2013), it is thus the Wegener-Bergeron-Findeisen process that is of key interest. This is parameterised in the model such that for temperatures between -35°C and 0°C, phase transition from liquid to ice occurs rapidly if there is pre-existing ice. A threshold for this is set to γ_{thr} *= 5 mg* m^{-3} *in the standard model setup. In an attempt to improve (i.e., reduce) the cloud cover, this was reduced in a number of sensitivity studies (Fig. 1). As expected, liquid cloud cover is reduced the lower the threshold is. However, there is an unexpected increase in total cloud cover, even as liquid cloud cover decreases. In further sensitivity studies we were able to find the reason (within the cloud cover scheme and the computation of relative humidity with respect to liquid water vs. ice in there) and remedy this problem, too.*

A publication on these results was just submitted (Kretzschmar et al., submitted).

References

Kretzschmar, J., M. Salzmann, J. Mülmenstädt, and **J. Quaas**, Arctic cloud cover bias in ECHAM6 and its sensitivity to cloud microphysics and surface fluxes, Atmos. Chem. Phys. Discuss., submitted.

Bodas-Salcedo, A., M. J. Webb, M. E. Brooks, M. A. Ringer, K. D. William, S. F. Milton, and D. R. Wilson (2008), Evaluating cloud systems in the Met Office global forecast model using simulated CloudSat radar reflectivities, J. Geophys. Res., 113, D00A13, doi:10.1029/2007JD009620.

Chepfer, H., Bony, S., Winker, D., Cesana, G., Dufresne, J.-L., Minnis, P., Stubenrauch, C. J., and Zeng, S.: The GCM Oriented Calipso Cloud Product (CALIPSO-GOCCP), J. Geophys. Res., 115, D00H16, doi: 10.1029/2009JD012251, 2010.

*Nam, C., and **J. Quaas**, Evaluation of clouds and precipitation in the ECHAM5 general circulation model using CALIPSO and CloudSat , J. Clim., 25, 4975-4992, doi:10.1175/JCLI-D-11-00347.1, 2012.*

*Stevens, B., M. A. Giorgetta, M. Esch, T. Mauritsen, T. Crueger, S. Rast, **M. Salzmann**, H. Schmidt, J. Bader, **K. Block**, R. Brokopf, I. Fast, S. Kinne, L. Kornblueh, U. Lohmann, R. Pincus, T. Reichler, and E. Roeckner, Atmospheric component of the MPI-M Earth System Model: ECHAM6. J. Adv. Model. Earth Syst., 5, 146-172. doi:10.1002/jame.20015, 2013.*

*Zygmuntowska, M., T. Mauritsen, **J. Quaas**, and L. Kaleschke, Artcic clouds and surface radiation - a critical comparison of satellite retrievals and the ERA-INTERIM reanalysis, Atmos. Chem. Phys., 12, 6667-6677, doi:10.5194/acp-12-6667-2012, 2012.*

Figures

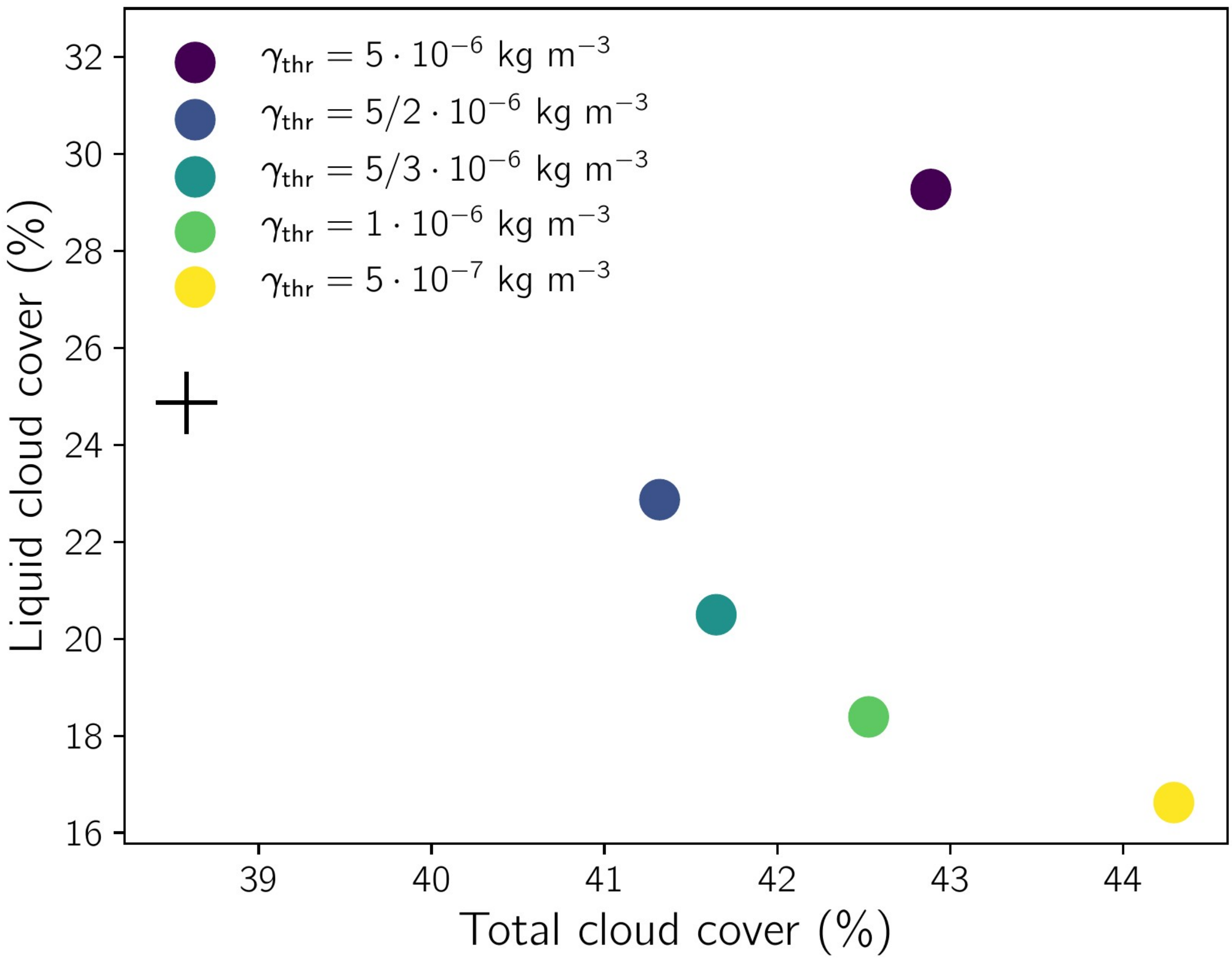

Fig. 1. Exploring the sensitvity of Arctic cloud cover to efficiency of WBF. The cross marks, as an observational reference from satellite data, the liquid- and total cloud cover as derived from the GCM-oriented CALIPSO cloud product (GOCCP, Chepfer et al., 2010). Please see text for the different modelling sensitivity studies. γ_{thr} = 5 mg m^{-3} is the standard choice (purple). The data are averaged over the area 60° to 82°N (82°N is the limit north of which the CALIPSO satellite does not observe due to the tilted orbit), and over the December-January-February period.