Project: **1143**
Project title: **FORCES**
Principal investigator: **Johannes Quaas**
Report period: **2022-11-01 to 2023-10-31**

Our planned works unfortunately in all four aspects did not proceed as fast as planned, or didn't so as high in resolution as initially planned, so that much less computing time so far was consumed than granted.

**(1) Hemispheric contrast of clouds:** we performed simulations using a coarser resolution (R2B7) in order to allow for quicker turnover. The results are currently being written up in a publication (Henkes et al.).

**(2) Decadal trends in aerosols, clouds and the Earth energy budget:** The project post-doc, Dr. Hailing Jia, left Leipzig University for a new permanent position at the Netherlands Institute for Space Research. Thus, the planned new simulations were not yet conducted. However, the paper on the previous ones is now almost ready for submission (Hodnebrog et al.).

**(3) Calibration of clouds in kilometre-resolution ICON using an emulator:** Fewer simulations than planned have been conducted since so far only one parameter (autoconversion scaling parameter) is tested. The outcome of a systematic exploration using top-of-atmosphere net radiation as the objective function is shown in Fig. 1. Currently, an emulator is trained to objectively identify the optimal autoconversion setting. The results feed into the PhD thesis of Marie Eichholz.

**(4) Identification of cloud regimes for process understanding and model evaluation:** The analysis could rely on available simulations from NextGEMS. At the time of writing the computing time proposal, it was not clear to us that all required diagnostics were available. In light of this, the planned simulations were not necessary. An example of the results is shown in Fig. 2, where cloud types are objectively classified on the basis of diagnosed cloud bulk quantities. This results feeds into the PhD thesis of Julien Lenhardt, and a paper is in preparation.

**Figures**

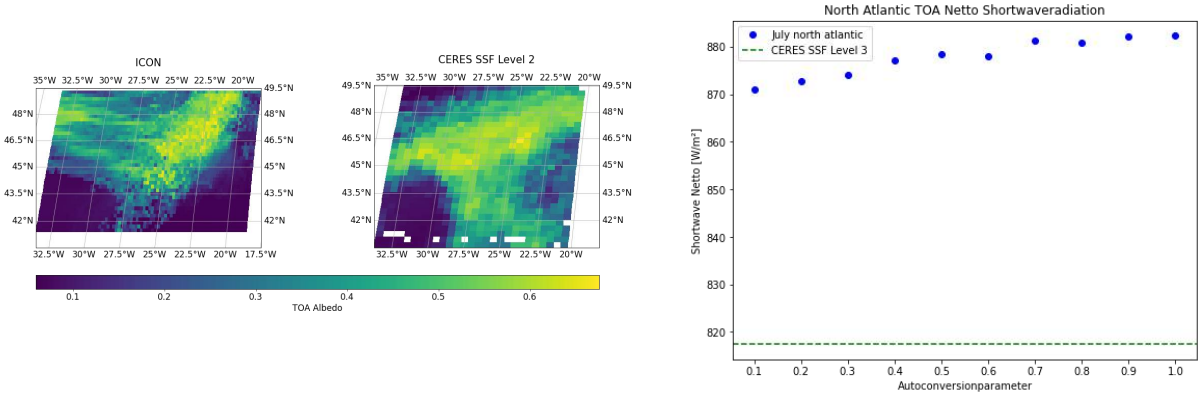


Fig. 1. Calibration data from limited-area ICON kilometer-resolution simulations as input to the emulator. Left: top-of-atmosphere albedo as simulated by the default ICON model (left) and as retrieved by the CERES satellite instrument (right). Right: A range of simulations using varying autoconversion scaling is conducted and the objective function is the field-mean top-of-atmosphere net radiation to be evaluated using satellite retrievals. Solar net absorbed radiation is an almost monotonic function of the autoconversion scaling parameter, but for this weather situation, the ICON model is too far off reality to calibrate the cloud albedo properly.

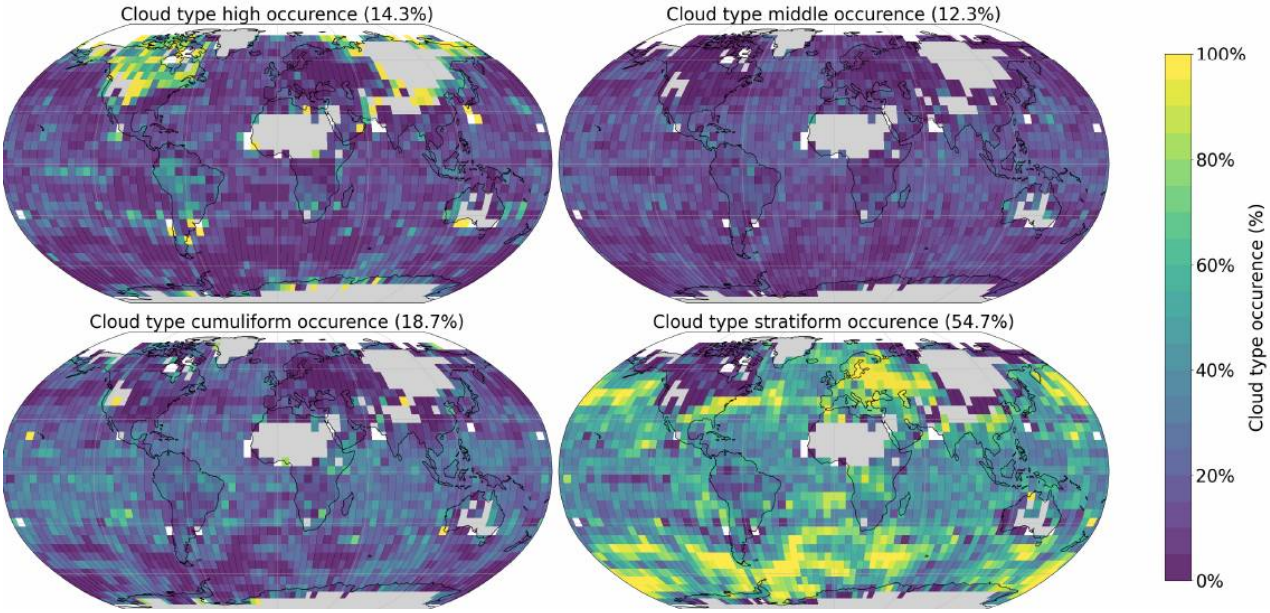


Figure 2. Cloud type identification and occurrence in the NextGEMS ICON simulations (interpolated to a coarser 5°x5° grid). A machine learning algorithm is used to learn cloud types on the basis of bulk cloud quantities, supervised using ground-based observations.