Project: **854**

Project title: **Erdsystemmodellevaluierung (DLR-Institut für Physik der Atmosphäre)**

Principal investigator: **Axel Lauer**

Report period: **2021-11-01 to 2022-10-31**

1. ESMValTool development

New versions of the Earth System Model Evaluation Tool (ESMValTool version 2) are developed and tested within project 854 before being released. Within the reporting period, ESMValTool v2.5.0 (March 2022) and v2.6.0 (July 2022) have been released, v2.7.0 is currently being tested. New features include, for instance, diagnostics used for Chapter 3 of the IPCC AR6 report, an extension to read and process native model output from the five Earth System Models CESM2, EC-Earth3, EMAC, ICON, and IPSL-CM6, and improved support for irregular grids such as the spherical icosahedron with triangular grid cells of ICON. As an example of this ESMValTool extension, Figure 1 shows the regridding of native ICON output from the R2B4 grid to a regular 2°x2° grid.

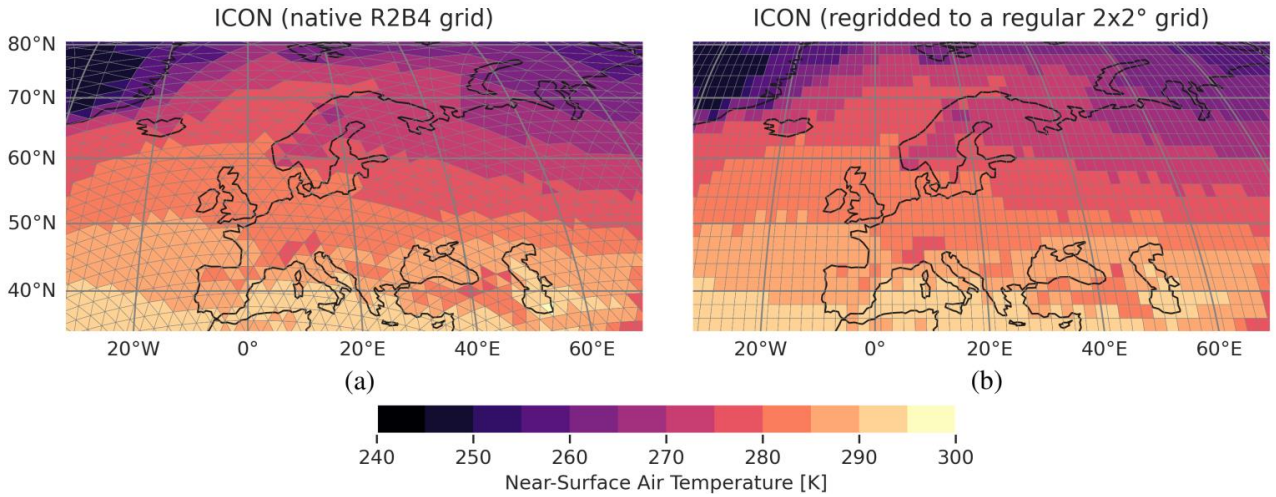

Figure 1. Illustration of the regridding of an unstructured grid using the near-surface air temperature climatology over Europe averaged from 1979 to 2014 as an example. (a) The ICON simulation shown uses a native grid at R2B4 resolution (about 160 km). (b) ICON data regridded to a regular 2°x2° grid using ESMValTool's nearest-neighbor regridding scheme. From Schlund et al. (in review).

2. Analysis and evaluation with the ESMValTool

The ESMValTool has been used within this project in particular for two studies. (a) An evaluation of cloud climatologies from models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6) (Lauer et al., accepted) and (b) a comparison of reanalysis and observational precipitation datasets (Hassler and Lauer, 2021). In the following, an example from the study Lauer et al. (accepted) is shown.

Evaluation and analysis of clouds from CMIP6 models

As key components of the hydrological cycle and the climate system, an evaluation of clouds from models used for climate projections is an important prerequisite for assessing the confidence in the results from these models. In this study, we compared output from models contributing to CMIP6 with satellite data and with results from their CMIP5 predecessors. We used multi-product reference datasets to estimate the observational uncertainties associated with different sensors and with internal variability on a per-pixel basis. Selected cloud properties such as cloud radiative effect, cloud liquid water and cloud ice water content and cloud fraction were also analyzed by region and by dynamical regime and thermodynamic conditions. Our results show that for parameters such as total cloud cover, cloud water path and cloud

radiative effect, the CMIP6 multi-model mean performs slightly better than the CMIP5 ensemble mean in terms of average bias, pattern correlation and relative root-mean square deviation. The inter-model spread in CMIP6, however, is not reduced compared to CMIP5. Compared with CALIPSO-ICECLOUD data, the CMIP5 and CMIP6 models overestimate cloud ice particularly in the lower and middle troposphere partly due to too high ice fractions for given temperatures. This bias is reduced in the CMIP6 multi-model mean (Figure 2). While many known biases such as an underestimation in cloud cover in stratocumulus regions remain in CMIP6, we find that the CMIP5 problem of too few but too reflective clouds over the Southern Ocean is significantly improved.

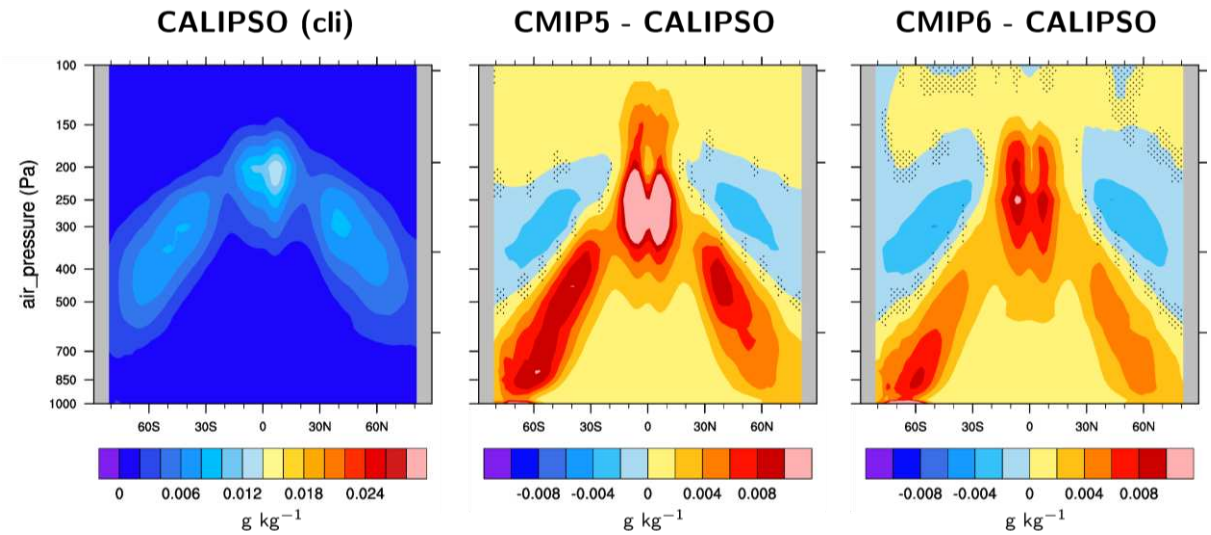

Figure 2. Multi-year annual average of (top row) zonal mean cloud ice water content (cli) in g kg^{-1} from CALIPSO-ICECLOUD (left) and differences of the CMIP5 (middle, 32 models) and CMIP6 (right, 27 models) multi-model mean compared with the CALIPSO data. Stippled differences are not statistically significant at a 95% confidence level. From Lauer et al. (accepted).

Recent publications related to project 854

Hassler, B., and Lauer, A.: Comparison of Reanalysis and Observational Precipitation Datasets Including ERA5 and WFDE5, Atmosphere, 12(11), 1462, doi: 10.3390/atmos12111462, 2021.

Lauer, A., Bock, L., Hassler, B., Schröder, M., Stengel, M.: Cloud climatologies from global climate models - a comparison of CMIP5 and CMIP6 models with satellite data, Journal of Climate (accepted).

Schlund, M., Hassler, B., Lauer, A., Andela, B., Jöckel, P., Kazeroni, R., Loosveldt Tomas, S., Medeiros, B., Predoi, V., Sénési, S., Servonnat, J., Stacke, T., Vegas-Regidor, J., Zimmermann, K., and Eyring, V., Evaluation of Native Earth System Model Output with ESMValTool v2.6.0, Geosci. Model Dev. Discuss. [preprint], https://doi.org/10.5194/gmd-2022-205, in review, 2022.