Project: **854**

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

Principal investigator: **Axel Lauer**

Report period: **2022-11-01 to 2023-10-31**

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 v2.8.0 (March 2023) and v2.9.0 (July 2023) have been released, v2.10.0 is currently being tested, release is scheduled for late October 2023. New features include, for instance, support of wildcards in recipes, optional usage of the Dask distributed scheduler, which can significantly reduce the run-time of recipes, additional diagnostics used for Chapter 3 of the IPCC AR6 report, a new set of recipes and diagnostics has been included to evaluate cloud climatologies, and a new diagnostic providing a high-level interface to the Python data visualization library seaborn. An example of new diagnostics implemented in ESMValTool is shown in Figure 1.

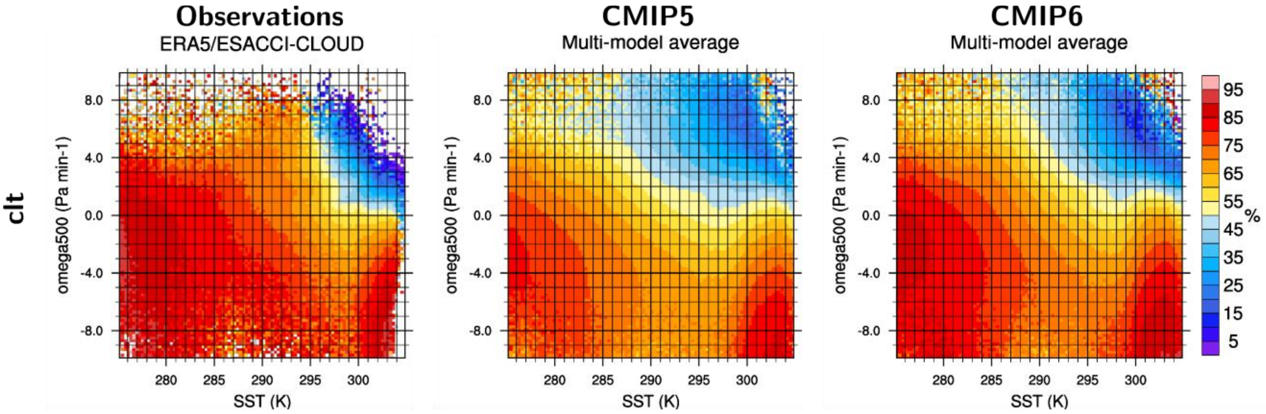

Figure 1. Example of a new diagnostics implemented in ESMValTool v2.8.0 to evaluate cloud climatologies. The figure shows the two-dimensional distribution of average total cloud cover (clt) binned by SST (x axis) and vertical velocity at 500 hPa (ω_{500}; y axis) averaged over 20 years and all grid cells over the ocean. (Left) reference data, (middle) CMIP5 multi-model mean, (right) CMIP6 multi-model mean. From Lauer et al. (2023).

2. Analysis and evaluation with the ESMValTool

The ESMValTool has been used within this project in particular for two studies. (a) Cloud parameters from reanalysis datasets – a comparison with satellite data (Lauer et al., in preparation) and (b) Cloud properties and their projected changes in CMIP models with low/medium/high climate sensitivity (Bock and Lauer, in review). In the following, an example from the study Bock and Lauer (in review) is shown.

Cloud properties and their projected changes in CMIP models

In this study the representation of cloud physical and radiative properties from a total of 51 CMIP5 and CMIP6 models grouped by effective climate sensitivity (ECS) is investigated. Model results from historical simulations are compared to observations and projected changes of cloud properties in future scenario simulations are analyzed by ECS group.

In general, models in the high ECS group are typically in better agreement with satellite observations than the low and medium ECS groups. This is in particular the case for total cloud cover and ice water path in midlatitudes, especially over the Southern Ocean. Notoriously difficult tasks, however, such as simulating clouds in the Tropics or the correct representation of stratocumulus clouds remain similarly challenging for all three ECS groups.

Differences in the net cloud feedback as a reaction to warming and thus differences in effective climate sensitivity among the three ECS groups are found to be driven by changes in a range of cloud regimes rather than individual regions. In polar regions, high ECS models show a weaker increase in the net cooling effect of clouds due to warming than the low ECS models. At the same time, high ECS models show a decrease in the net cooling effect of clouds over the tropical ocean and the subtropical stratocumulus regions whereas low ECS models show either little change or even an increase in the cooling effect. In the Southern Ocean, the low ECS models show a higher sensitivity of the net cloud radiative effect to warming than the high ECS models. As an example, Figure 2 shows the sensitivities of selected clouds parameters from the three ECS groups to warming averaged over different geographical regions.

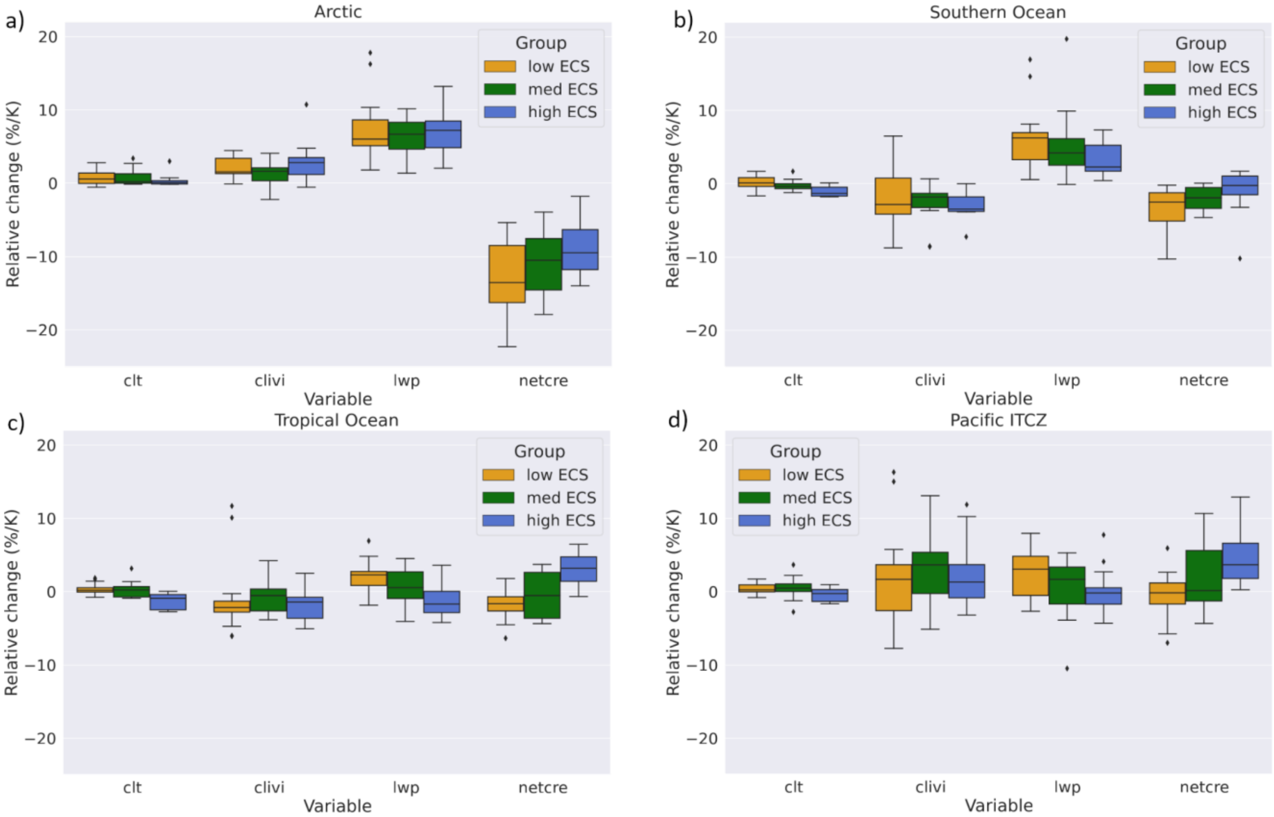

Figure 2. Relative change of total cloud fraction (clt), ice water path (clivi), liquid water path (lwp) and net cloud radiative effect (netcre) per degree warming averaged over selected regions over the ocean: (a) Arctic (70-90°N), (b) Southern Ocean (30-65°S), (c) Tropical Ocean (30°N-30°S) and (d) Pacific ITCZ (0-12°N, 135°O-85°W). In the box plot, a box is created from the first quartile to the third quartile, the vertical line shows the median and the whiskers the minimum and maximum values excluding the outliers. Outliers are generally classified as being outside 1.5 times the interquartile range. From Bock and Lauer (in review).

Recent publications related to project 854

Bock, L., and Lauer, A.: Cloud properties and their projected changes in CMIP models with low/medium/high climate sensitivity, EGUsphere [preprint], doi: 10.5194/egusphere-2023-1086, 2023.

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, 36(2), 281-311, doi: 10.1175/JCLI-D-22-0181.1, 2023.

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., 16, 315-333, doi: 10.5194/gmd-16-315-2023, 2023.