Project: **854**

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

Principal investigator: **Axel Lauer**

Report period: **2021-01-01 to 2021-08-31**

1. ESMValTool development

Within project 854, the new version of the Earth System Model Evaluation Tool (ESMValTool version 2) has been developed, tested and released. During the reporting period, the last of four articles documenting the new ESMValTool version has been published in Geosci. Model Dev. (Weigel et al., 2021). As an example of the new diagnostics implemented into the ESMValTool and described in Weigel et al. (2021), Figure 1 shows a summary plot of 12 temperature and 3 precipitation indices.

The ESMValTool is continuously being improved and tested within this project. The current release version 2.3 (July 2021) includes several new and improved diagnostics and support for new observational datasets.

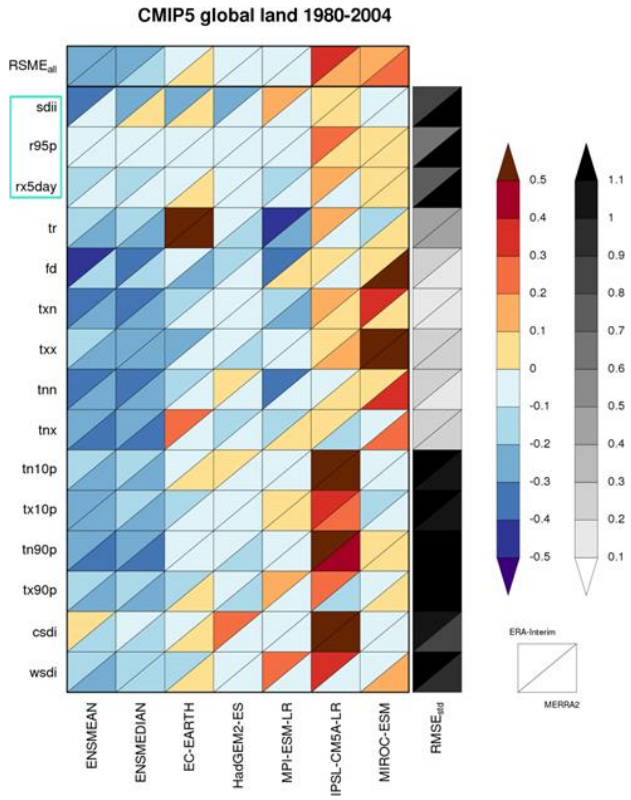

Figure 1 "portrait" diagram showing relative spatially averaged root mean square errors (RMSE) in the 1981-2000 climatologies of 12 temperature and 3 precipitation indices simulated by CMIP5 models (x-axis) with respect to the two reanalyses ERA-Interim (upper triangle) and MERRA2 (lower triangle). The RMSEs are spatially averaged over all land grid points. The top row (RMSEall) indicates the mean relative RMSE across all indices for the CMIP5 ensemble mean (first column) and median (second column) and each model individually. Blue (red) colors indicate that a model performs better (worse) than the ensemble mean error compared to the respective reanalysis dataset. The gray shaded column at the right-hand side indicates the median RMSE normalized by the spatial standard deviation of the index climatology in the reanalyses (RMSEstd). From Weigel et al. (2021).

2. Analysis and evaluation of CMIP6 results

The ESMValTool has been used to analyse results from the Coupled Model Intercomparison Project Phase 6 (CMIP6). The work focused on (a) analysis of climate model projections from the Scenario Model Intercomparison Project (ScenarioMIP) of CMIP6. This study has been published in Tebaldi et al. (2021). (b) Evaluation of the cloud climatologies from CMIP6 models (Lauer et al., in prep.) and (c) contributions to chapter 3 of the IPCC AR6 WGI: Human influence on the climate system.

The ESMValTool has also been used within this project for evaluating stratospheric ozone and water vapour changes in CMIP6 models (Keeble et al., 2021). The study by Schlund et al. (2020) on assessing the robustness of emergent constraints for effective climate sensitivity when applied to CMIP6 data introduced in the 2020 report has now been published in Earth Syst. Dynam.

This report shows exemplary results from the above mentioned analysis of CMIP6 climate model projections from ScenarioMIP (Tebaldi et al., 2021).

Analysis of climate model projections from ScenarioMIP of CMIP6

In this study, global averages and spatial patterns of change for surface air temperature and precipitation from CMIP6 simulations are analyzed. In addition, results from CMIP6 projections are compared to CMIP5 results. The range of future temperature and precipitation changes by the end of the century (2081-2100) encompassing the Tier 1 experiments based on the Shared Socioeconomic Pathway (SSP) scenarios spans a larger range of outcomes compared to CMIP5. This is due to both the wider range of radiative forcing that the new CMIP6 scenarios cover and the higher climate sensitivities in some of the new models compared to their CMIP5 predecessors. Spatial patterns of change for temperature and precipitation averaged over models and scenarios have familiar features, and an analysis of their variations confirms model structural differences to be the dominant source of uncertainty. Central estimates of the time at which the ensemble means of the different scenarios reach a given warming level might be biased by the inclusion of models that have shown faster warming in the historical period than the observed. Those estimates show all scenarios reaching 1.5°C of warming compared to the 1850-1900 baseline in the second half of the current decade. The warming level of 2°C of warming is reached as early as 2039 by the ensemble mean under SSP5-8.5 but as late as the mid-2060s under SSP1-2.6. The highest warming level considered (5°C) is reached by the ensemble mean only under SSP5-8.5 and not until the mid-2090s. This study has been published in Tebaldi et al. (2021). As an example, Figure 2 shows global average temperature and precipitation changes until 2100 obtained from CMIP6 models for the different SSPs.

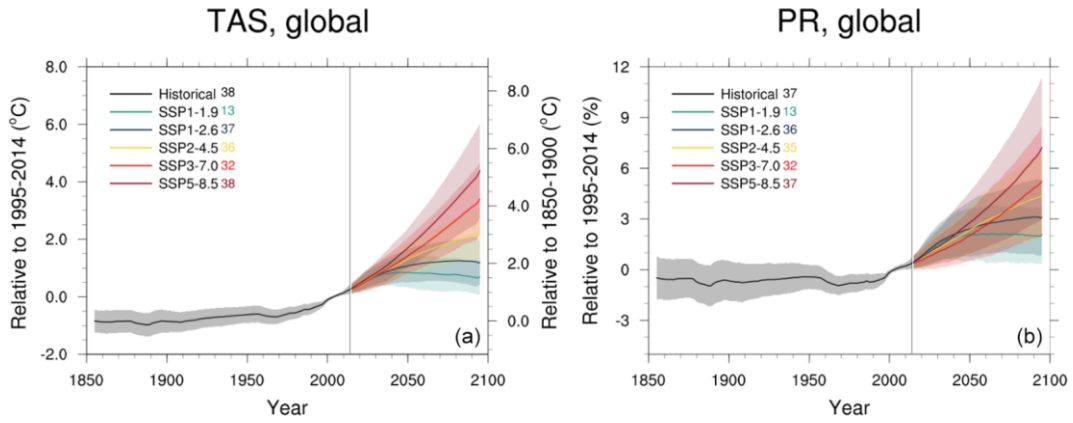

Figure 2 (a) Global average temperature time series (11-year running averages) of changes from current baseline (1995-2014, left axis) and pre-industrial baseline (1850-1900, right axis, obtained by adding a 0.84°C offset) for the different SSP scenarios. (b) Global average precipitation time series (11-year running averages) of percent changes from current baseline (1995-2014) for the different SSP scenarios. Thick lines are ensemble means (number of models shown in the legends). The shading represents the ±1.64σ interval, where σ is the standard deviation of the smoothed trajectories computed year by year. From Tebaldi et al. (2021).

Recent publications related to project 854

Keeble, J., Hassler, B., Banerjee, et al.: Evaluating stratospheric ozone and water vapour changes in CMIP6 models from 1850 to 2100, Atmos. Chem. Phys., 21, 5015-5061, doi: 10.5194/acp-21-5015-2021, 2021.

Schlund, M., Lauer, A., Gentine, P., et al.: Emergent constraints on Equilibrium Climate Sensitivity in CMIP5: do they hold for CMIP6?, Earth Syst. Dynam., 11, 1233-1258, doi: 10.5194/esd-11-1233-2020, 2020.

Tebaldi, C., Debeire, K., Eyring, V., et al.: Climate model projections from the Scenario Model Intercomparison Project (ScenarioMIP) of CMIP6, Earth Syst. Dynam., 12, 253-293, doi: 10.5194/esd-12-253-2021, 2021.

Weigel, K., L. Bock, B. K. Gier, et al.: Earth System Model Evaluation Tool (ESMValTool) v2.0 – diagnostics for extreme events, regional and impact evaluation and analysis of Earth system models in CMIP, Geosci. Model Dev., 14, 3159-3184, doi: 10.5194/gmd-14-3159-2021, 2021.