Report for project 854 "Erdsystemmodellevaluierung"

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Analysis and evaluation of CMIP6 results

The Coupled Model Intercomparison Project (CMIP) Phase 6 is an opportunity to automatize wellestablished aspects of model evaluation so that they can be made available to model analysts and developers more quickly and with less effort than in previous phases of CMIP. The Earth System Model Evaluation Tool (ESMValTool) has been further developed particularly for this purpose as part of the BMBF funded project CMIP6-DICAD, the European Union's Horizon 2020 project CRESCENDO and the third phase of the ESA CCI CMUG.

This new version 2.0 of the ESMValTool (Righi et al., Eyring et al., Lauer et al., Weigel et al.) is now used for a comprehensive evaluation of the CMIP DECK and historical experiments. Results are made available to the modeling groups to support further model improvements on a website hosted at DKRZ as one of the ESGF super nodes (http://cmip-esmvaltool.dkrz.de/). These results are visualized with the Freie University evaluation system (FREVA) as part of collaborations within CRESCENDO and CMIP6-DICAD and provide measures of uncertainty in CMIP DECK and scenario simulations. As an example, figure 1 shows observed and simulated temperature anomalies from CMIP6 models from 1850 to 2014.



Figure 1 Observed and simulated time series of the anomalies in annual and global mean surface temperature. All anomalies are differences relative to the 1850-1900 time-mean of each individual time series. The reference period 1850-1900 is indicated by yellow shading. Single simulations for CMIP6 models (thin lines); multi-model mean (thick red line). Observational data (thick black lines) are Hadley Centre/Climatic Research Unit gridded surface temperature data set 4 (HadCRUT4), and are merged surface temperature (2 m height over land and surface temperature over the ocean). All models have been subsampled using the HadCRUT4 observational data mask. Inset: the global mean 2m temperatures (absolute values) for the reference period 1961-1990 of the subsampled fields. Figure produced with ESMValTool v2.0 recipe_flato13ipcc.yml.

Another example from the ongoing analysis and evaluation of CMIP6 results with the ESMValTool is first results for the equilibrium climate sensitivity (ECS). ECS is a commonly-used measure of a climate model's response to greenhouse gas forcing, which approximates the change in global mean surface air temperature associated with doubling of CO₂ concentrations in the atmosphere. Initial results show that while for several CMIP6 models ECS is similar to their CMIP5 counterparts (from about 6 years ago), some have a

higher ECS (figure 2). At this point it is too early to make definitive statements about the reasons for the increase in ECS seen in some of the models, and it is also too early to say how this will affect the overall multi-model projections of future climate change under different forcing scenarios. However, new methods are developed and observations implemented that can help to further constrain uncertainties in key climate feedbacks and projections.



Figure 2 Equilibrium Climate Sensitivity (ECS) from different CMIP6 models. Figure produced with ESMValTool v2.0 recipe_ecs.yml.

ESMValTool version 2.0 that will be used for the evaluation of CMIP6 models will be described in four publications: a technical overview with a particular focus on the new preprocessor (Righi et al., in review), the large-scale diagnostics (Eyring et al., submitted), emergent constraints und diagnostics for future projections (Lauer et al., in preparation) and regional diagnostics such as extreme events (Weigel et al., in preparation).

References

- Eyring, V., Bock, L., Lauer, A., Righi, M., Schlund, M., Andela, B., Arnone, E., Bellprat, O., Brötz, B., Caron, L.-P., Carvalhais, N., Cionni, I., Cortesi, N., Crezee, B., Davin, E., Davini, P., Debeire, K., de Mora, L., Deser, C., Docquier, D., Earnshaw, P., Ehbrecht, C., Gier, B. K., Gonzalez-Reviriego, N., Goodman, P., Hagemann, S., Hardiman, S., Hassler, B., Hunter, A., Kadow, C., Kindermann, S., Koirala, S., Koldunov, N., Lejeune, Q., Lembo, V., Lovato, T., Lucarini, V., Massonnet, F., Müller, B., Pandde, A., Pérez-Zanón, N., Phillips, A., Predoi, V., Russell, J., Sellar, A., Serva, F., Stacke, T., Swaminathan, R., Torralba, V., Vegas-Regidor, J., von Hardenberg, J., Weigel, K., and Zimmermann, K., ESMValTool v2.0 Extended set of large-scale diagnostics for quasi-operational and comprehensive evaluation of Earth system models in CMIP, Geosci. Model Dev. Discuss., submitted, 2019.
- Lauer, A., Eyring, V., Bock, L., Gier, B. K., Lorenz, R., Righi, M., Schlund , M., Senftleben, D., and Weigel, K., ESMValTool v2.0 – Diagnostics for emergent constraints and future projections from Earth system models in CMIP. Geosci. Model Dev. Discuss., in preparation.
- Righi, M., Andela, B., Eyring, V., Lauer, A., Predoi, V., Schlund, M., Vegas-Regidor, J., Bock, L., Brötz, B., de Mora, L., Diblen, F., Dreyer, L., Drost, N., Earnshaw, P., Hassler, B., Koldunov, N., Little, B., Loosveldt Tomas, S., and Zimmermann, K.: ESMValTool v2.0 – Technical overview, Geosci. Model Dev. Discuss., doi: 10.5194/gmd-2019-226, in review, 2019.
- Weigel, K., Eyring, V., Gier, B. K., Lauer, A., Righi, M., Schlund, M., Adeniyi, K., Andela, B., Arnone, E., Berg, P., Bock, L., Corti, S., Caron, L.-P., Cionni, I., Hunter, A., Lledó, L., Mohr, C.-M., Pérez-Zanón, N., Predoi, V., Sandstad, M., Sillmann, J., Vegas-Regidor, J. and von Hardenberg, J., ESMValTool (v2.0) – Diagnostics for extreme events, regional model and impact evaluation and analysis of Earth system models in CMIP. Geosci. Model Dev. Discuss., in preparation.