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CMIP model evaluation with the ESMValTool v2.0

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The Earth System Model Evaluation Tool (ESMValTool) has been developed with the aim of taking model evaluation to the next level by facilitating analysis of many different ESM components, providing well-documented source code and scientific background of implemented diagnostics and metrics and allowing for traceability and reproducibility of results (provenance). This has been made possible by a lively and growing development community continuously improving the tool supported by multiple national and European projects. The latest version (2.0) of the ESMValTool has been developed as a large community effort to specifically target the increased data volume of the Coupled Model Intercomparison Project Phase 6 (CMIP6) and the related challenges posed by analysis and evaluation of output from multiple high-resolution and complex ESMs. For this, the core functionalities have been completely rewritten in order to take advantage of state-of-the-art computational libraries and methods to allow for efficient and user-friendly data processing. Common operations on the input data such as regridding or computation of multi-model statistics are now centralized in a highly optimized preprocessor written in Python. The diagnostic part of the ESMValTool includes a large collection of standard recipes for reproducing peer-reviewed analyses of many variables across atmosphere, ocean, and land domains, with diagnostics and performance metrics focusing on the mean-state, trends, variability and important processes, phenomena, as well as emergent constraints. While most of the diagnostics use observational data sets (in particular satellite and ground-based observations) or reanalysis products for model evaluation some are also based on model-to-model comparisons. This presentation introduces the diagnostics newly implemented into ESMValTool v2.0 including an extended set of large-scale diagnostics for quasi-operational and comprehensive evaluation of ESMs, new diagnostics for extreme events, regional model and impact evaluation and analysis of ESMs, as well as diagnostics for emergent constraints and analysis of future projections from ESMs. The new diagnostics are illustrated with examples using results from the well-established CMIP5 and the newly available CMIP6 data sets.