Technical ESMValTool Workshop

Workshop Summary

A workshop on the technical development of the **Earth System Evaluation Tool (ESMValTool)** was held at the Ludwig-Maximilians-Universität München (LMU) in the Department of Geography from 3-4 March 2015. The workshop invitations were restricted to that subgroup of the ESMValTool Development Team that works on general technical issues and the structure of the tool, as well as the planned coupling of the tool to the Earth System Grid Federation (ESGF). A total of 17 participants from 8 institutions (7 from Europe, 1 from the US) from the Earth system Model Bias Reduction and assessing Abrupt Climate change (EMBRACE), ESA Climate Change Initiative (CCI) Climate Model User Group (CMUG), and other projects came together to define the required steps and a timeline ahead towards the submission of a first ESMValTool documentation paper and a corresponding public release as open-source software. The workshop was also of particular importance for the technical development of diagnostics of the ESA CCI datasets and their integration into the ESMValTool.

Tuesday morning started with an overview session on the present status and future perspectives of the ESMValTool and its relation to international activities. The ESMValTool is developed as a community system, open to both users and developers, hence encouraging open exchange of evaluation methods and results. This will facilitate and improve ESM evaluation beyond the state-of-the-art and aims at supporting model evaluation and development activities at individual model centers and within CMIP. It is envisaged to run the tool routinely on model output submitted to the Coupled Model Intercomparison Project (CMIP), utilizing observations available through the ESGF in standard formats (obs4MIPs/ana4MIPs) or provided by the user.

The core functionality of the ESMValTool is based on open-source software that is either available in the main Linux distributions, or can be readily installed by the user. The core dependencies for running the ESMValTool, excluding packages and dependencies that might be needed for specific diagnostics, are: (1) Python version 2.7.x for running the Python wrapper script „main.py" and diagnostics, (2) NCAR Command Language (NCL, 2014) version 6.1 or higher to run the quality and reformat routines processing all input data files and the majority of the current diagnostics implemented, and (3) Input files in netCDF-format with appropriate attributes and dimension names. A schematic overview of the ESMValTool structure is shown in Figure 1. It was decided that for the release conda will be used to manage the installation, and the need for common interfaces was identified. An application programming interface (API) should allow for flexible integration of diagnostics across different tools, usage of different backends / frontends, and usage of different programming languages. A recommendation was made that interfaces are further discussed and defined within international panels, in particular the Working Group on Numerical Experimentation (WGNE) / Working Group on Coupled Modelling (WGCM) climate model metrics panel, and the WGCM Infrastructure Panel (WIP). The ESMValTool Development Team will continue to reach out to related efforts (e.g., Climaf, PCMDI) to foster international collaboration of diagnostic tool efforts in support of CMIP.

Throughout the remaining sessions, discussions supported by talks and breakout groups took place to conclude on the way ahead regarding the following questions:
* What technical improvements can be made that would facilitate broad community development and usage?
* How to simplify ESMValTool integration with existing data repositories and the ESGF infrastructure?

- What are necessary steps towards a roadmap for ESMValTool enhancement for CMIP6 and beyond?
- How to prepare the software release and what is an appropriate license?

It was agreed that the submission of a first ESMValTool documentation paper is planned for end of June and the corresponding release of the software by mid-October, in time for the final EMBRACE meeting, the 18th Session of the WGCM, and the 'CMIP5 Model Analysis and scientific plans for CMIP6' workshop that will all be held in the week of 18-23 October in Dubrovnik, Croatia. Specific timelines, open issues and responsible parties that will support a timely submission and release were defined for the quality control and testing of the trunk version, the coupling to ESGF including I/O, the inclusion of the conda package, automated testing, visualization, license, and the creation of a reformat template for using the output of individual models directly with the ESMValTool. GFDL implements the ESMValTool in their evaluation workflow and uses an in-house wrapper to convert the raw data into a CMOR-ish format supported by ESMValTool. The implementation in the GFDL workflow will provide valuable feedback for the ESMValTool functionality before the release, since the support of individual modeling groups with the tool is a major goal of the software development. A long-term vision is to fully merge the ESMValTool with Auto-Assess and Iris to avoid duplication of work and to enhance the ESMValTool capabilities through a joint development of both efforts. The ESMValTool development team will also further align its efforts with the development of the PCMDI metrics package.

For the coupling to the ESGF, the current log file (see Figure 1) will be extended to improve provenance and reproducibility. It will additionally include the creation date, the version number of the ESMValTool, a list of all model files that have been used + Tracking ID (if available read from metadata and include the absolute and relative (DRS) path), list of all observations the tool has used, and checksums. In addition, the file naming convention needs to be revised to allow for automated management of output data and an easier creation of plots. The observations for automated testing and for scientific applications are hosted by DLR and in addition by DKRZ and BADC to be able to run the tool alongside the ESGF. They will be organized in Tiers:
- **Tier 1:** obs4mips, ana4mips
- **Tier 2:** other freely available datasets
  - automated download available
  - manual download required
- **Tier 3:** restricted datasets

The observations will not be distributed with the tool, but Tier 1 data are freely available for download and for Tier 2 and 3 data links and helper scripts will be provided, so that the observations can be easily retrieved and processed by the user. The ESMValTool can consider observational uncertainty in different ways, e.g. through the use of more than one observational dataset to directly evaluate the models, by showing the difference between the reference dataset and the alternative observations, or by including an observed uncertainty ensemble hat spans the observed uncertainty range (e.g. available for HadCRUT4 surface temperature and RSS MSU/AMSU Atmospheric Temperature). Often the uncertainties in the observations are not readily available. Reliable and robust error characterization/estimation of observations is a high priority throughout the community, and obs4MIPs and ESA CCI should push for the inclusion of such uncertainty estimates as part of each dataset.

For the backend, it was decided to restrict major technical changes for the first release to those issues that are required for the ESGF coupling. The current structure of separating plots and diagnostic scripts was confirmed and developers are asked to submit their code following this structure.

For the licensing, it was agreed to release the trunk – the ESMValTool Software – mid-October under an APACHE LICENSE, VERSION 2.0. For the ESMValTool Development Software a more restricted license will prevent redistribution and will ensure benefits for ESMValTool developers when their unreleased code is used in publications or presentations. The license for the ESMValTool Development Software regulates the

terms of use within the ESMValTool Development Team who exclusively has access to the ESMValTool development environment. To ensure that coding rules and standards are met responsibilities for the ESMValTool core development team and the ESMValTool developers have been defined.

For the way ahead, it was decided to provide regular releases of new versions of the ESMValTool once major improvements took place and to hold regular users workshops and/or sessions at conferences, coding workshops, and ESMValTool development team workshops. It is also planned to provide video tutorials on the ESMValTool wiki.

The workshop was held under the auspices of the ESA Climate Model User Group (CMUG), the European Commission's 7th Framework Programme, under Grant Agreement number 282672, "Earth system Model Bias Reduction and assessing Abrupt Climate change (EMBRACE) project, the Institute of Atmospheric Physics of the German Aerospace Center (DLR), and the Department of Geography at the Ludwig-Maximilians-Universität München.
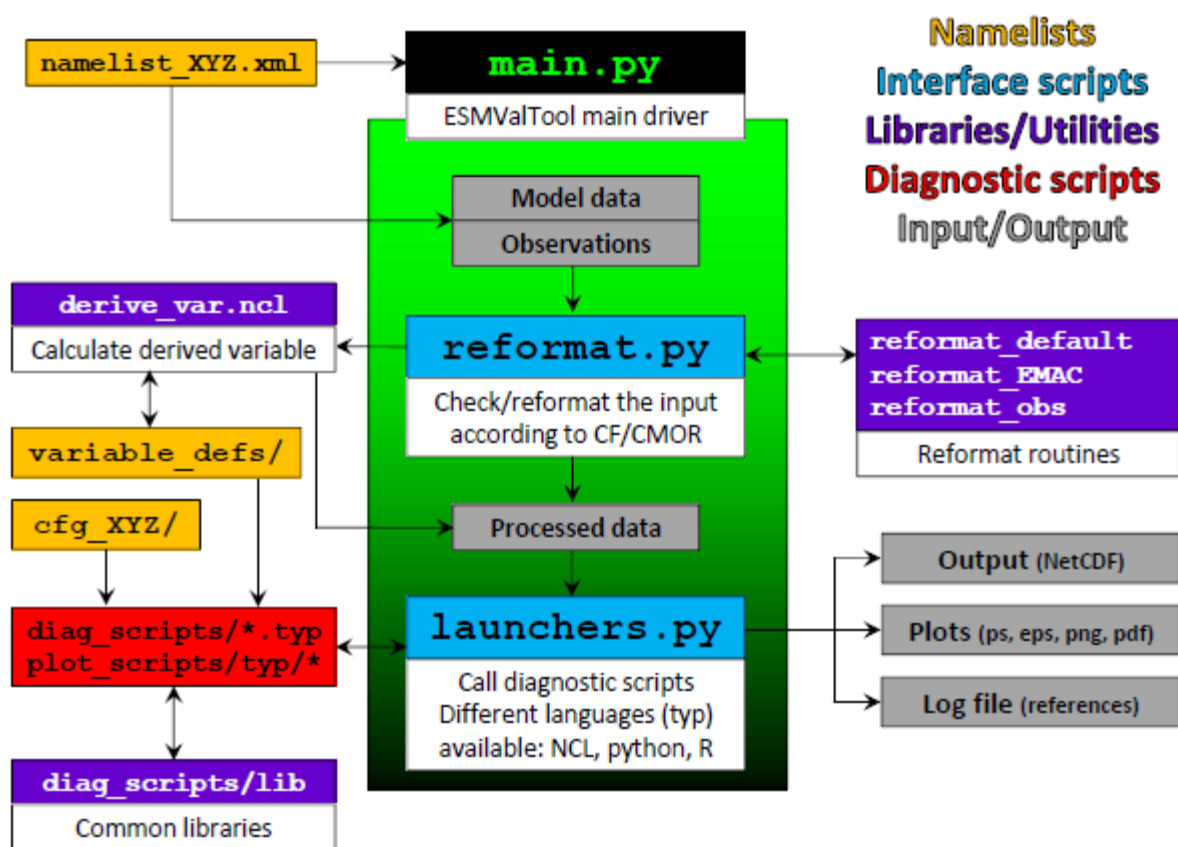

Figure 1. Schematic overview of the ESMValTool structure.