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ESM-Tools: A common infrastructure for modular coupled earth system modelling

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Earth system and climate modelling involves the simulation of processes on a large range of scales, and within very different components of the earth system. In practice, component models from different institutes are mostly developed independently, and then combined using a dedicated coupling software.

This procedure not only leads to a wildly growing number of available versions of model components as well as coupled setups, but also to a specific way of obtaining and operating many of these. This can be a challenging problem (and potentially a huge waste of time) especially for unexperienced researchers, or scientists aiming to change to a different model system, e.g. for intercomparisons.

In order to define a standard way of downloading, configuring, compiling and running modular ESMs on a variety of HPC systems, AWI and partner institutions develop and maintain the OpenSource ESM-Tools software (<https://www.esm-tools.net>). Our aim is to provide standard solutions to typical problems occurring within the workflow of model simulations such as calendar operations, data postprocessing and monitoring, sanity checks, sorting and archiving of output, and script-based coupling (e.g. ice sheet models, isostatic adjustment models). The user only provides a short (30-40 lines) runscript of absolutely necessary experiment specific definitions, while the ESM-Tools execute the phases of a simulation in the correct order. A user-friendly API ensures that more experienced users have full control over each of these phases, and can easily add functionality. A GUI has been developed to provide a more intuitive approach to the modular system, and also to add a graphical overview over the available models and combinations.

Since revision 2 (released on March 19th 2019), the ESM-Tools were entirely re-written, separating the implementation of actions (written in Python 3) from any information that we have, either on models, coupled setups, software tools, HPC systems etc. into nicely structured yaml configuration files. This has been done to reduce maintenance problems, and also to ensure that also unexperienced scientist can easily edit configurations, or even add new models or software without any programming experience. Since revision 3 the ESM-Tools support four ocean models (FESOM1, FESOM2, NEMO, MPIOM), three atmosphere models (ECHAM6, OpenIFS, ICON), two BGC models (HAMOCC, REcoM), an ice sheet (PISM) and an isostatic adjustment model (VILMA) as well

as standard settings for five HPC systems. For the future we plan to add interfaces to regional models and soil/hydrology models.

The Tools currently have more than 70 registered users from 5 institutions, and more than 40 authors of contributions to either model configurations or functionality.