ESM-Tools Version 5.0: A modular infrastructure for stand-alone and coupled Earth System Modelling (ESM)

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During the last two decades, modern societies have gradually understood the urge to tackle the climate change challenge, and consequently, a growing number of national and international initiatives have been launched with the aim of better understanding the Earth System. In this context, Earth System Modelling (ESM) has rapidly expanded, leading to a large number of research groups targeting the many components of the system at different scales and with different levels of interactions between components. This has led to the development of increasing number of models, couplings, versions tuned to address different scales or scenarios, and model-specific compilation and operating procedures. This operational complexity makes the implementation of multiple models excessively time consuming especially for less experienced modellers.

ESM-Tools is an open-source modular software written in Python, aimed to overcome many of the difficulties associated to the operation of ESMs. ESM-Tools allows for downloading, compiling and running a wide range of ESM models and coupled setups in the most important HPC facilities available in Germany. It currently supports multiple models for ocean, atmosphere, biochemistry, ice sheet, isostatic adjustment, hydrology, and land-surface, and six ocean-atmosphere and two ice-sheet-ocean-atmosphere coupled setups, through two couplers (included modularly through ESM-Interface). The tools are coded in Python while all the component and coupling information is contained in easy-to-read YAML files. The front-end user is required to provide only a short script written in YAML format, containing the experiment specific definitions. This user-friendly interface makes ESM-Tools a convenient software for training and educational purposes. Simultaneously, its modularity and the separation between the component-specific information and tool scripts facilitates the implementation and maintenance of new components, couplings and versions. ESM-Tools team of scientific programmers provides also user support, workshops and detailed documentation. The ESM-Tools were developed within the framework of the project Advance Earth System Model Capacity, supported by Helmholtz Association and has become one of the main pillars of the German infrastructure for Climate Modelling.