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The Icosahedral Nonhydrostatic (ICON) model: Scalability on Massively Parallel Computer Architectures

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Simulation in numerical weather prediction and climate forecasting has a fast-growing demand for memory capacity and processing speed. For the last decade, however, computer technology has shifted towards multi-core chip designs while at the same time on-chip clock rates have increased only moderately. The parallel implementation of DWD's operational forecast model ICON therefore follows a hybrid distributed/shared memory approach, based on the Message Passing Interface (MPI) and the OpenMP API.
The ICON code couples the different components of the earth system model, e.g. dynamics, soil and radiation, with high-level language constructs. Its communication characteristics and programming patterns take the unstructured triangular grid into account and are designed to meet the main challenges in high performance computing, i.e. load balancing, cache efficiency, and low-latency networking. The implementation employs special domain decomposition heuristics, parallel range-searching algorithms, and makes use of asynchronous I/O servers to deal with the potentially prohibitive amount of data generated by earth system models. This facilitates the ICON code to extract an adequate level of performance on a wide range of HPC platforms, targeting large scalar cluster systems with thousands of cores as well as vector computers.

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