IFCES2: Cloud Microphysics Application Case

In the BMBF-funded project IFCES2 (SCALEXA funding line), novel methods of parallel execution, communication and dynamic load balancing for the Earth system model ICON will be explored, implemented and optimized. Future high-performance computing architectures, which will be characterized by massive parallelism and large hardware heterogeneity, pose a particular challenge for the efficient execution of Earth system models. Therefore, in the project IFCES2, special attention is paid to replace existing parallelization concepts with temporally sequential execution of the respective model components by functional concurrency (*functional concurrency*). On the one hand, the applied techniques are a necessary prerequisite for the efficient use of future exascale computers, since they can intelligently distribute computationally intensive operations over a very high number of available, heterogeneous computer components. On the other hand, they enable an increase in the level of detail of Earth system models and thus contribute to reducing the uncertainties of future climate projections. Furthermore, the computational grids of current Earth system models are statically divided into partitions for parallel computation. As a result, process models that describe localized and time-varying atmospheric phenomena (such as clouds) in great detail experience uneven load distributions between partitions, leading to unwanted efficiency losses in parallel execution. Therefore, in order to use exascale systems efficiently, dynamic load balancing methods for these process descriptions must be developed for use.

The proposed project contributes as one of the IFCES2 application cases to the development of new algorithms for improved parallelizability and scalability of complex cloud microphysical calculations as part of ICON atmosphere. The application case "cloud microphysics" is symbolic for the level of complexity to be gained in future ESMs. One of the IFCES2 objectives is creating a unique scientific dataset on the development of a tropical storm over the Atlantic Ocean. To achieve the objectives, reference simulations of temporal developments of different tropical storms (e.g. Hurricane "Paulette" in 2020) need to be generated and compared with different simulation methods, and continuously tested for highest scientific quality and evaluated with a multitude of observational data, especially with the help of modern satellite measurements.