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Scalability and Efficiency of Earth System Models in the Multi-Core-Age

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Climate and Earth system modeling today is performed with intricate systems of coupled models. Complexity and spatial resolution of these models is limited by computing resources. Necessary and envisaged improvements will require an increase of the computing power available to climate models by several orders of magnitude.
Until very recently the speed of a single CPU (central processing unit) doubled roughly every two years. This has come to an end for technical and physical reasons. The new rule of thumb says that the number of computational cores will double every two years. Climate modelers will have to learn how to use very large numbers of cores in parallel. Modern supercomputer already use thousands of cores. If, with a global atmosphere model, we wanted to achieve 1000 forecast days per day at a horizontal resolution of 1km, we would need to run it on more than 10.000.000 processing units in parallel. Today nobody knows how to program such an application, how to handle the enormous data streams produced by it and how to pay for the power bill of such a machine.
In this talk we will discuss our strategies to scale earth system models to high numbers of processor cores. We will mainly focus on two projects. "ScalES" (Scalable Earth System Models) is a BMBF funded project led by DKRZ which started in January 2009. In this project we will identify bottlenecks which inhibit efficient scaling of typical climate models and will implement prototype solutions in the COSMOS coupled Earth system model. In particular the project will address parallel I/O, load balancing, efficient parallel coupling of component models and efficient use of state-of-the-art computer architectures. "PeAKliM" (Petaflop-Architectures in Climate und Meteorology) is a joint initiative of climate researchers and mathematicians which aims at tackling the question, what kind of architecture is best suited for climate and weather models and to already now investigate into algorithms for future systems.