Implicit time-integration of an atmospheric model on massively-parallel computing systems.

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In order to increase the resolution, and hence the accuracy and realism, of weather and climate models, they must be able to exploit the massively parallel computing architectures that are becoming available. Current massively parallel computing systems group a large number of nodes O(10,000) each containing O(10) cores. Therefore, a significant amount of the memory is distributed and so message passing is a significant bottleneck. Recent research has shown that models built on icosahedral grids offer significant advantages over latitude-longitude grids and, importantly, can scale well on massively parallel systems. Recently, a number of groups developing atmospheric models on icosahedral grids joined together to identify and address issues affecting parallel performance and scalability under the ICOsahedral-grid Models for EXascale earth system simulations (ICOMEX) project. Research presented here forms part of the ICOMEX project, investigating the possibility of applying an implicit time-integration scheme in the MPAS (Model for Predictions Across Scales) atmosphere model.

Currently, all the models participating in ICOMEX use explicit or HEVI (Horizontally Explicit Vertically Implicit) time integration schemes. Implicit time integration allows significantly longer time steps, and confers advantages in stability and accuracy, but requires the solution of elliptic problems involving significant communication. Previously, it was feared that the additional time spent communicating information during each iteration would result in an overall less efficient solver. However, recent research has shown that multigrid elliptic solvers can be efficient and scale well for massively parallel problems. Furthermore, they are well suited to the icosahedral grid structure. A fully three-dimensional semi-implicit time integration scheme has been formulated for the MPAS-atmosphere fully compressible equation set, based on a multigrid solver for the elliptic problem. This scheme is being implemented within the MPAS-atmosphere code; progress and early results from scalability simulations will be presented.