Recent advances in coupling in the GFDL Flexible Modeling System

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Climate models represent a large variety of processes on a variety of

time and space scales, a canonical example of multi-physics

multi-scale modeling. In addition the system is physically

characterized by sensitive dependence on initial conditions, and

natural stochastic variability, and very long integrations are needed

to extract signals of climate change. Algorithms generally possess

weak scaling. Weak-scaling, I/O and memory-bound, multi-physics codes

present particular challenges to computational performance.

Current hardware trends, such as GPUs and MICs, are based on marginal

increases in clock speed, coupled with vast increases in concurrency,

particularly at the fine grain. Multi-physics codes face particular

challenges in achieving fine-grained concurrency, as different physics

and dynamics components have different computational profiles, and

universal solutions are hard to come by.

We propose here one approach for multi-physics codes. These codes are

typically structured as \emph{components} interacting via software

frameworks. The component structure of a typical Earth system model

consists of a hierarchical and recursive tree of components, each

representing a different climate process or dynamical system. These

generally encompass a modest level of concurrency at the highest level

(e.g atmosphere and ocean on different processor sets) with serial

organization underneath.

We propose to extend concurrency much further by running more and more

physics in parallel with each other. Each component can further be

parallelized on the fine grain, potentially offering a major increase

in scalability of Earth system models.

We present here first results from this approach, called

Coarse-grained Component Concurrency. Within the GFDL Flexible

Modeling System, the radiation component has been configured to run in

parallel with the atmospheric dynamics and all other atmospheric

physics components. We will explore the algorithmic challenges

involved in such an approach, and present results from such

simulations. Plans to extend this approach within other components

such as the ocean, will be discussed.