Efforts to implement and optimize nonlinear solvers within DOE's Accelerated Climate Model for Energy (ACME)

Katherine Evans, Oak Ridge National Laboratory

A recently implemented Newton-Krylov (NK) implicit time-stepping method within ACME's spectral element atmosphere model component shows good potential for accuracy and efficiency gains. The degree of gains depends on the separation of scales, spatial resolution, and other configuration and solver parameters. Results for an implicit solver option in the simpler, shallow water dynamical core achieves greater efficiency by leveraging the required data copies to transfer the solution update to the solver library to move the data to the GPU when running the model on hybrid CPU-GPU computing platforms. A scalable, block-structured preconditioner provides almost no increased iteration count with problem size for relevant problem sizes, and we show that understanding and optimizing the large number of parameters provides additional speed and robustness. We have extended the implicit solver to the full atmosphere hydrostatic component, and it shows stable convergence for a range of time step sizes. There are computational cost savings and increased

robustness when additional, previously subcycled dynamics is included within the nonlinear residual of the hydrostatic equations, and a time step size matching the larger tracer advection time step is used. As expected, the NK method applied to hydrostatic CAM experiences a stronger growth in the iteration count for a given problem size associated with the increased nonlinearity and multiscale nature of the system, which highlights the need for scalable preconditioning in this configuration as well.