PUSHING THE LIMIT OF SUNWAY TAIHULIGHT FOR FULLY IMPLICIT SIMULATIONS OF ATMOSPHERIC DYNAMICS

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The rapid development of supercomputers and the growing needs of extreme-scale applications pose grand challenges in the design of highly efficient and scalable parallel algorithms. It is of crucial importance to adapt the parallel algorithm with the architectural features so that the potential of the supercomputers can be fully unleashed at the extreme scale. In this talk, I will present our recent efforts on designing highly scalable fully implicit solvers that can take full advantage of state-of-the-art many-core based heterogeneous supercomputers. In particular, we proposed a highly efficient hybrid domain-decomposed multigrid preconditioner with a geometry-based pipelined incomplete LU factorization for solving the overlapped subdomain problems. On top of the solver, we performed systematic optimizations on different hardware levels to achieve best utilization of the heterogeneous computing units and substantial reduction of data movement cost. The fully implicit solver successfully scaled to the entire system of the Sunway TaihuLight supercomputer with over ten million cores and sustained an aggregate performance of 7.95 DP-PFLOPS. Remarkably, the simulation capability of the fully implicit solver at the full system scale is nearly two orders of magnitude better than a highly optimized explicit solver with an aggregate performance of 23.66 DP-PFLOPS. To finish the talk, we will also present some other examples to show the potential of the fully implicit solver when applying to other types of applications that also demand extreme-scale simulation capabilities.