FY20 Q4: Demonstration and performance testing of extreme-resolution simulations with static meshes on Summit

ECP WBS	2.2.2.01 ADSE07-ExaWind
PI	Michael Sprague, NREL
Members	NREL, SNL, ORNL, UTA

SAND2020-11997R

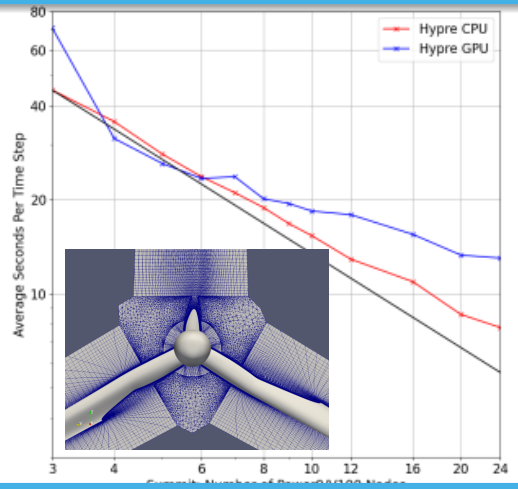
2020 Oct 30

Scope and objectives

- ExaWind Objective: Create a computational fluid and structural dynamics platform for exascale predictive simulations of wind farms.
- Challenge Problem: Predictive simulation of a wind farm composed of O(100) wind turbines sited over O(100) km^2 with complex terrain.
- FY20 milestone activities are aggressively moving as much of the software stack as possible to GPUs, including the equation assembly & linear system creation, preconditioner setup, and linear-system solves.
- Additional efforts are establishing AMR-Wind (built on AMReX) as a structured-grid background solver.

Highlight results: GPU vs CPU Strong Scaling

For a blade-resolved simulation of an operating turbine, examined multiple linear-solver configurations (between Trilinos and *hypre*) for the equation sets (pressure, momentum, scalar transport). The best performance (in time to solution) on both CPUs and GPUs was found with *hypre* for all equations.



Impact

- Further demonstrated the viability and optimality of a novel hybrid-solver approach wherein the near-turbine flow is resolved with an unstructured grid (Nalu-Wind) and the background flow is resolved with a structured grid (AMR-Wind)
- Established new performance benchmarks on GPUs and CPUs for wind energy problems (blade-resolved simulations with moving meshes)
- Established updated list of areas needing performance improvements
- Accomplishments here place ExaWind on track for completing challenge problem

Project accomplishment

- Made huge gains in converting Nalu-Wind kernels and the Nalu-Wind hypre assembly to Kokkos
- Addressed a number of algorithmic issues with the new AMS turbulence model and performed validation for wind-relevant problems
- Performance testing of Nalu-Wind for actuator-line simulations
- Performance testing of the new AMR-Wind structured-grid solver for atmospheric boundary layer simulations

Milestone Team: Ananthan, Williams, Overfelt, Vo, Sakievich, Smith, Hu, Berger-Vergiat, Mullowney, Thomas, Henry de Frahan, Melvin, Moser, Brazell, Sprague

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. This report followed the Sandia National Laboratories formal review and approval process (SAND2020-XXXX O).

EXASCALE COMPUTING PROJECT