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FY21 Q4: Demonstrate moving-grid multi-turbine simulations primarily run on GPUs and propose improvements for successful KPP-2

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ECP WBS	2.2.2.01 ADSE07-ExaWind
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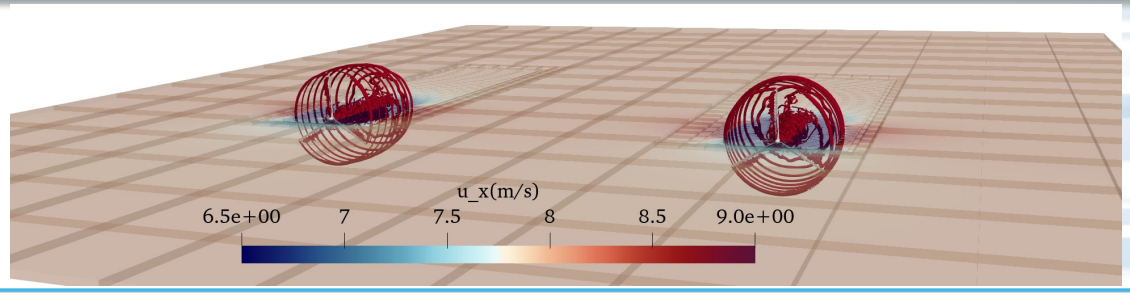
Scope and objectives

- 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.
- FY21 Q4 milestone was to demonstrate a blade-resolved multi-turbine simulation and advance the full software stack for improved performance on GPUs.

Highlight results: Hybrid-solver simulation of two turbines



Isocontours of Q-criterion with velocity visualized in the wake for two NREL 5-MW turbines operating under uniform-inflow wind speed of 8 m/s. Simulation performed with the hybrid-Nalu-Wind/AMR-Wind solver.

Impact

- Milestone accomplishments showed that the AMR-Wind background solver can weakly scale well on GPUs, and that the hybrid solver approach will be critical to ExaWind successfully simulating its challenge problem.
- The ExaWind project and software stack is many faceted, with team members working on multiple areas, including linear-system solvers (Trilinos, *hypre*, AMReX), overset meshes, turbulence modeling, and *in situ* visualization, all with an aim for high fidelity predictions and performance portability. This milestone marks significant improvements on many fronts and provides the team with a pathway to exascale wind farm simulations in FY23.

Project accomplishment

- Demonstrated a two-turbine simulation with the hybrid Nalu-Wind/AMR-Wind solver with a new C++ based driver code.
- Demonstrated Demonstrated a 51.5-billion-gridpoint AMR-Wind simulation of the turbulent atmospheric boundary layer using 24,575 GPUs on Summit.
- Improved time-to-solution and scaling performance of *hypre*, Trilinos, and AMReX linear-system solvers on both CPU-based and next-gen GPU-based systems.
- Improved the Active Model Split turbulence model and implemented in Nalu-Wind a transition model.
- Advanced *in situ* visualization capabilities in AMR-Wind.

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