FY18-Q1: Deploy production sliding mesh capability with linear solver benchmarking

Scope & 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 plant composed of O(100) wind turbines sited over O(100) km^2 with complex terrain
- FY18 activities are focused on
  - Establishing sliding- and overset-mesh capabilities for operating wind turbines (Q1)
  - Establishing baseline simulation times focusing on Hypre and MueLu/Belos solver stacks, and improving solver performance (Q1, Q2, Q3)
  - Demonstrating simulation of a fully resolved MW-scale turbine on Mira under the ExaWind INCITE award (Q4)
- This milestone is a necessary and critical step in moving towards MW-scale-turbine simulations
  - Establishes baseline performance for a fully resolved sub-MW-scale turbine in an operating configuration
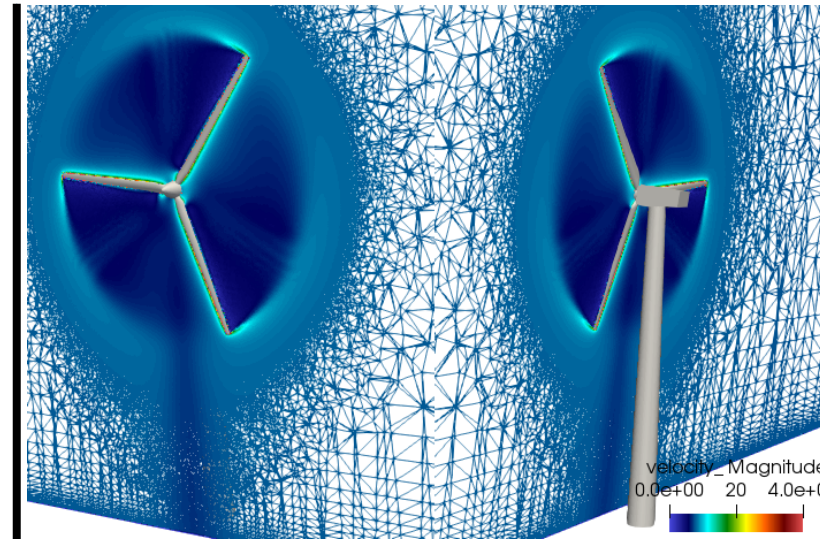
Simulation results for a fully-resolved sub-MW-scale turbine for which the rotor resides in an embedded, rotating "disk" of fluid that is coupled to the surrounding fluid via a sliding-mesh interface. Shown are velocity shadings from the upwind (left) and downwind (right) perspectives.

velocity_Magnitude
0.0e+00   20   4.0e+01

Impact

- The new sliding mesh capability provides a pathway for efficient simulation of rotating meshes in wind turbine simulations
- Simulating a 1.3B element mesh is a milepost on the pathway to the extreme mesh sizes required for MW-scale-turbine simulations
- Coupling of Nalu with Hypre and MueLu provides insight into, and a comparison platform for, two fundamentally different AMG approaches (classic and smoothed aggregation); highlighted areas for future work

Project Accomplishment

- Deployed and verified a design-order hybrid CVFEM/DG sliding-mesh interface for wind turbine simulations.
- Coupled the Nalu CFD solver with the Hypre AMG preconditioner and the TIOGA open-source overset library
- Under the ECP ALCC ExaWind allocation on Cori, established baseline timing results for a fully resolved sub-MW-scale turbine
  - Detailed timing breakdown for MueLu/Belos and Hypre solvers
- Successfully simulated sub-MW-scale fully resolved turbine with 1.3B elements

Exascale Computing Project

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