Theme 1: Wind Resource, Wind Farms and Wakes

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Dynamic mesh adaptation to capture wind turbine wakes during LES simulations

According to the current energetic and environmental challenges, maximizing the electric power generated in windfarms is a societal concern. A better understanding of the flow physics around turbines in farms become important to achieve this goal. Since experimental data on actual windfarm scales are not affordable and given the constant growth of computational resources, high order numerical simulations tend to be a promising approach [1]. Nonetheless, simulation predictability and reliability still need to be improved.

Large-eddy simulation (LES) consists in explicitly resolving the large scales of the fluid motion and modeling the influence of the smallest scales. LES can today be used to study realistic wind turbines with complex geometries [2]. To perform valid LES, the mesh has to adequate to capture wake meandering and instabilities. Indeed, such unsteady effects are critical issues in wind farms as this oscillatory motion of the wakes increases fatigue loads on downstream machines and impacts their power production. Thus, a compromise between computational cost and wake accuracy must be found. By following this tenet, dynamic mesh adaptation is applied to adapt the mesh based on flow characteristics [3].

Dynamic mesh adaptation goal is to generate a mesh that best matches the flow physics at every fluid iteration. Based on large velocity gradients as a refinement criteria, the mesh follows large scales movements and wind turbine wake. With turbulent wind, tracking the wake is not trivial. A wake meandering detection algorithm [4] is therefore used. Gaussian shape circular mask is convoluted on transverse planes with velocity deficit. This algorithm locates the convolution's maximum and thereby the wake centering. The wake envelope is then compared to the one of the previous fluid iteration. If the difference exceeds a given threshold, the dynamic mesh adaptation is triggered ; otherwise, the simulation continues. Its robustness enable to correctly capture the wake centerline even with turbulent wind injection or yaw misalignment configurations.

The dynamic mesh adaptation metodology will be calibrated on a laminar wind non-yawed DTU10MW wind turbine wake study. Cases where grid adaptation would reveal its potential, i.e. with turbulent wind and yawed wind turbine, will be tested. The rotor modeling is performed using an Actuator Line Method [5] (ALM), coupled to the low Mach-number massively-parallel finite-volume Large-Eddy Simulation (LES) flow solver on unstructured meshes, called YALES2 [6,7]. Global quantities will be compared, such as averaged power and thrust coefficient. This will be followed by local characteristics analysis including velocity and turbulent intensity profiles as well as wake scan downstream of the turbine.

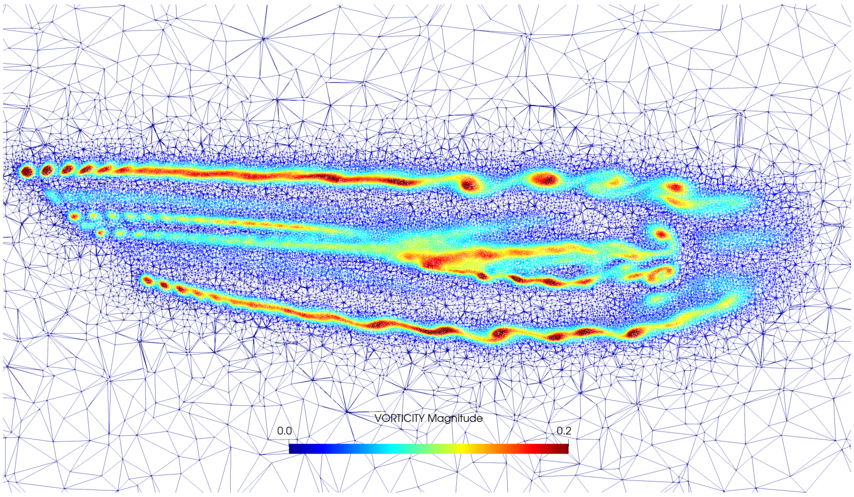

Figure 1: Illustration of mesh adaptation on NREL 5MW wind turbine flow under dynamic yawing condition

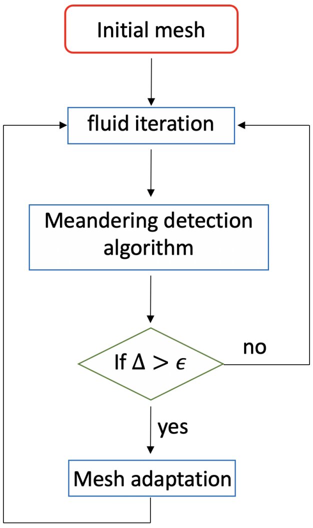

Figure 2: dynamic mesh adaptation algorithm diagram

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Keywords :dynamic mesh adaptation - Wake - LES - turbulence - YALES2