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FLUID STRUCTURE INTERACTION FOR NEXT GENERATION HORIZONTAL AXIS WIND TURBINES (HAWT)

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Abstract. This work deals with the development of computational models and appropriate numerical methods to give an answer with a good compromise between performance and precision for the design of next generation 15 MW horizontal axis wind turbines. The most important factor for increasing the productivity of wind turbines is to have the necessary technology for using longer blades and higher towers. This factor is driving research and development towards the construction of more powerful, efficient, durable and profitable turbines. All these added to other innovations that make the manufacturing of turbines easier and cheaper: e.g. wind turbines that collect and interpret data in real time to act mechanically and manage the flow, maximizing the harvest of energy and taking care of the most risky situations where the stoppage is imminent. Optimal design of wind turbines and wind energy farms requires a comprehensive understanding of the physics of multi-scale wind flows, structural mechanics and materials performance, among other things. A first requirement is knowledge of isolated phenomena on different scales and a number of individual components. However, wind turbines and wind energy farms are complex systems involving close interactions of various phenomena (fluid, structural, mechanical, electrical) on multiple temporal and spatial scales. Although longer and slender blades are able to collect more energy, it is well known that they experience large deflections compromising the efficiency of the installation in addition to its structural integrity. On the other hand, these changes in their design make the problem more complex due to the great disparity of flow conditions that exist between the tip of the blades with respect to the central zone. Regarding the technical aspects of the simulation, besides the varying flow conditions along the blades, we face a problem because the rotation combined with the deformation of the blade make the geometry time varying and the mesh must be adapted accordingly. On the other hand, the movement of rotation of the blades and their deformation depend strongly on the coupling between the fluid and the blades themselves, all these added to a requirement of fine enough spatial and temporal discretization to capture the turbulent effects and the coupling itself. In this work in progress, we present the advances in the fluid-structure coupling for horizontal axis wind turbines using the commercial codes StarCCM+ for the fluid dynamics (CFD), with sliding meshes and morphing for the mesh dynamics, and Mecano for the mechanical behavior of the blades. Algorithms and interfaces to manage the co-simulation are presented, using in all cases parallel architectures to exploit scalability.