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A high performance finite element model for wind farm modeling in forested areas

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Wind energy has grown significantly during the past decade and is expected to continue growing in the fight against climate change. In the search for new land where the impact of the wind turbines is small several wind farms are currently being installed in forested areas. In order to optimize the distribution of the wind turbines within the wind farm the Reynolds Averaged Navier Stokes equations are solved over the domain of interest using either commercial or in house codes. The existence of a canopy alters the Atmospheric Boundary Layer wind profile close to the ground. Therefore in order to obtain a more accurate representation of the flow in forested areas modification to both the Navier Stokes and turbulence variables equations need to be introduced.
Several existing canopy models have been tested in an academic problem showing that the one proposed by Sogachev et. al gives the best results. This model has been implemented in an in house CFD solver named Alya. It is a high performance unstructured finite element code that has been designed from scratch to be able to run in the world's biggest supercomputers. Its scalabililty has recently been tested up to 100000 processors in both American and European supercomputers. During the past three years the code has been tuned and tested for wind energy problems. Recent efforts have focused on the canopy model following industry needs. In this work we shall benchmark our results in a wind farm that is currently being designed by Scottish Power and Iberdrola in Scotland. This is a very interesting real case with extensive experimental data from five different masts with anemometers at several heights. It is used to benchmark both the wind profiles and the speed up obtained between different masts. Sixteen different wind directions are simulated. The numerical model provides very satisfactory results for both the masts that are affected by the canopy and those that are not influenced by it.