Turbulent drag reduction over Liquid Infused Surfaces

Turbulent drag reduction has been the objective of research studies for several decades, but with the possible exceptions of non-Newtonian additives and riblets, all attempts so far have failed to deliver any noticeable effect under realistic flow conditions.

One of the most promising methods for drag reduction is that of Super-Hydrophobic Surfaces (SHS) and Liquid Infused Surfaces (LIS). They consist of a film of air or lubricating oil locked in place by a micro/nanoporous substrate, which reduces the wall shear stress. Direct Numerical Simulations of two superposed fluids in a turbulent channel have been performed. A parametric study varying the viscosity of the two fluids, the shape of the textured surface and the interfacial tension has been carried out to develop design criteria for practical applications. Correlations between the amount of drag reduction and the slip length have been extended to LIS in the case of flat and slippery interface. The dynamics of the interface affects significantly the drag, especially when the substrate presents walls perpendicular to the flow direction. An attempt to reconcile the flow physics of rough walls, SHS and LIS, based on the wall normal velocity fluctuations will be discussed at the seminar.

Power Production Optimization in a wind turbine array

In recent years, the wind energy industry has experienced a considerable technological and economical expansion leading to the design of large and dense power plants. As the turbines are being placed closer together, in order to minimize capital costs, the overall efficiency is being affected by wake interaction between upstream and trailing turbines.

In the last few years we developed a numerical code to study wind turbine arrays. With blade lengths of the order of 70 m, the flow field in a wind turbine array is inherently coupled to unsteady dynamics at the synoptic scale. Therefore, we coupled the Weather Research and Forecasting (WRF) Model, a mesoscale numerical weather prediction model and our in-house LES code to retain the meso-scale variability and resolve, in the limit of LES resolution, the turbine wakes. Results have been validated with LiDAR measurements and SCADA data. In addition, we have implemented an optimization algorithm, Extremum-Seeking Control (ESC), to increase the power production of the farm varying the torque gain and yaw angle of the rotor disk with respect to the wind direction. ESC increases the power of the array of turbines of about 7-10% compared to the baseline case. We also clarified how ESC changes the wake dynamics thus leading to an increased power production.