Large Eddy Simulation of Airborne Wind Energy Systems in the Atmospheric Boundary Layer

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Airborne Wind Energy (AWE) is a novel solution in the field of renewable energy technologies. However, unlike for conventional wind turbines, the effects of AWE systems on the wind environment have not yet been studied in much detail. We have developed a computational framework using Large Eddy Simulation to investigate the interaction between kite systems and the atmospheric boundary layer. Simulations are carried out using the in-house flow solver SPWind developed at KULeuven. For the discretization of the incompressible Navier-Stokes equations, we use a Fourier pseudo-spectral scheme in the horizontal directions and a fourth-order energy-conserving finite difference scheme in the vertical direction. Time integration is achieved using a fourth-order Runge-Kutta scheme. The kite system considered in the study is composed of a tether and a rigid wing. The dynamics of the system are described using a Lagrangian formulation along with an aerodynamic model for the external forces and moments. A lifting-line technique is then implemented in the simulation framework in order to model the effects of the kite systems onto the flow field. A turbulent inflow is generated using precursor methods for fully-developed turbulent boundary layers [1]. In the study, a number of configurations related to different operation conditions of kite systems are considered. We investigate different tip-speed ratios, operation altitudes and operation modes as defined by Loyd in [2]. The objective of the study is to quantify the interaction between the kite systems and the boundary layer in terms of flow induction and wake development. Therefore, we look at instantaneous flow characteristics as well as at time-averaged quantities.

References:

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