LES and KS Applications of Wind Energy in the Atmospheric Boundary Layer

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The Large-Eddy Simulation (LES) became a powerful tool to simulate physical processes in Atmospheric Boundary Layer and for wind farm aerodynamics. The different sub-grid scale (SGS) models are widely used for simulation by different authors. The mathematical model was realized in SOWFA (Simulator for On/Offshore Wind Farm Application) code. SOWFA is an OpenFOAM-based incompressible atmospheric/wind farm LES solver, which is based on finite-volume method, that models wind turbine as actuator lines and actuator disk.

The analysis of fractal dimension for turbulent wakes was performed with the results of numerical simulation by LES and Lagrangian-averaged scale-independent dynamic Smagorinsky, One Eddy Equation ABL turbulence models for a horizontal-axil wind single turbine and two turbines. It is known that such SGS models don't reproduce correctly the energy spectrum for maximum wave number, the normalized time correlation coefficients for velocity modes and sound power spectra comparing with Direct Numerical Simulation (DNS) results.

The stochastic SGS models, such as random forcing models, represent alternatives that could correct the timescales of resolved velocity fields. Kinematic simulations that are limited to SGS motion (or kinematic SGS models) can be used to represent unresolved velocity fields with imposed spatial-temporal statistics.

A kinematic simulation was used to reconstruct the missing-scale motions in isotropic turbulence (Fung et al. 1992) and turbulent shear flows (Ghate & Lele 2015).

Ya & He (Journal of Turbulence, 2009) proposed to use a kinematic simulation (KS) to explicitly construct the unresolved velocity fields with the required statistic properties in both space and time. The kinematic SGS model was used to calculate sound power spectra from isotropic turbulence and yielded an improved result: the missing portion of the sound power spectra was approximately recovered in the LES.

We discuss the procedure of implementation a kinematic SGS model in SOWFA code.

The computational domain as a box of length 2π on each side, where the periodic boundary conditions were applied, was used for verification of different SGS model on different grids.