A turbulence library for asynchronus coupling of meso and microscale models

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Abstract

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To realistically model a collection of turbines that comprise a wind farm, we need to extend the range of spatial and temporal scales represented in a model from 10's of meters to 100's of km's and time scales of few seconds to days. These scales in the atmosphere are represented by either mesoscale or microscale models, which have different characterizations of various dynamical and physical processes. Setting time varying turbulent inflow boundary and initial conditions for a microscale simulation that is designed to produce an internal boundary layer is a key challenge. Improper inflow turbulent conditions could lead to transient conditions near the inlet (or inflow) boundary that persist several boundary layer depths into the model domain. The inflow conditions that are necessary for stimulating the LES simulation of wind fields over a region include the mean velocity profile, profile of turbulent kinetic energy and a measure of the turbulence kinetic energy.

Here we present a framework for building a library of precursor simulations for representative boundary conditions and then using the library to couple the evolution of atmosphere across WRF-ARW (mesoscale) to WRF-LES (microscale). The challenge here is the generation of a library of simulations that could be useful for most frequently encountered meteorological conditions that would influence the PBL development at the microscale. As an initial test of the approach, we will mostly focus on regions away from coast and terrain changes that could have a significant influence on the internal PBL development. Simulations are performed and evaluated for selected flow conditions at the SWIFT site in Northeastern Texas by developing an ensemble around the selected case studies. Our ensemble approach addresses two potential sensitivity cases (a) atmospheric stability states and (b) issues concerning with the time and spatial resolution of the precursor runs. For each stability case the three key variables are the mean wind fields, surface roughnessnd surface heat fluxes. The second key issue for implementing the library is about the spatial resolution of the LES model and the frequency of saving the model outputs. The initial library building exercise will use a range of ratios by the vertical grid size to horizontal grid resolution. We will present an initial construction of the library for selected boundary conditions and results from test simulations using the asynchronous model coupling concept. We will also discuss the computational performance of the coupling strategy.