EGU21-13794, updated on 02 Aug 2021
https://doi.org/10.5194/egusphere-egu21-13794
EGU General Assembly 2021

Assessing the Turbulence Kinetic Energy Budget in the Boundary Layer Using WRF-LES: Impact of Momentum Perturbation

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Mesoscale-to-Large Eddy Simulation (LES) grid nesting is an important tool for many atmospheric model applications, ranging from wind energy to wildfire spread studies. Different techniques are used in such applications to accelerate the development of turbulence in the LES domain. Here, we explore the impact of a simple and computationally efficient Stochastic Cell Perturbation method (SCPM) to accelerate the generation of turbulence in the Weather Research and Forecasting (WRF) LES model on the Turbulence Kinetic Energy (TKE) budget. In a convective boundary layer, we study the variation of TKE budget terms under the initial conditions of the Scaled Wind Farm Technology (SWiFT) facility located in West Texas. In this study, WRF LES is used with a horizontal grid resolution of 12 m, and is one-way nested within an idealized mesoscale domain. It is crucial to understand how forced perturbation shifts the balance between the terms of the TKE budget. Here, we quantify the shear production, and buoyant production in an unstable case. Since additional production terms are introduced in the SCPM method, we investigate the dissipation term of TKE. In addition, we also study the generation of turbulent transport. Generally, it integrates over height to null in a planar homogeneous case without subsidence, indicating it is positive over some heights and negative over other heights. Furthermore, we also study the variation of the TKE transport term after extending the random perturbation up to a certain height. The findings of this study will provide a better understanding of the contribution of different budget terms in a forced LES simulation.