6.4 Implementation and evaluation of a three dimensional PBL parameterization for simulations of the flow over complex terrain.

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Current computational resources make possible the use of WRF at a wide range of grid spacings from tens of kilometers to meters. However, all the twelve planetary boundary layer (PBL) schemes implemented in WRF are based on the assumption that turbulent motions are statistically homogeneous in horizontal planes over a grid cell. Under this assumption of horizontal homogeneity the PBL parameterizations only account for one-dimensional (1D) mixing resulting from vertical gradients in turbulent fluxes. Arguably, this representation of atmospheric turbulence is justified at grid spacings larger than several kilometers, but it breaks down for smaller grid spacings. The potential benefit of fine grid spacing over complex terrain regions is limited due to the assumption of horizontal homogeneity. We therefore implemented a fully three-dimensional (3D) PBL scheme that accounts for horizontal and vertical gradients in turbulent fluxes.

The 3D PBL scheme is based on the algebraic turbulence model developed by Mellor and Yamada (1982). The development proceeds in steps from an algebraic model that includes an equation to diagnose the turbulent kinetic energy (TKE) to a higher-level model with a prognostic equation for TKE. At each step of development we compare the performance of the 3D PBL scheme to existing 1D PBL parameterizations as well as large-eddy simulations (LES). The validation uses data from 1) a field study in Idaho carried out in 2010 and centered over an isolated mountain, the Big Southern Butte; and 2) an undergoing field campaign over the Columbia River Gorge supported by the Wind Forecast Improvement Project 2. Nested mesoscale simulations are carried out using the innermost grid spacing of 111 m with both 1D and 3D PBL schemes while nested WRF-LES are carried with grid spacing of ~50 m. The results of this analysis are used to assess the performance of the new 3D PBL schemes in complex terrain where the assumption of horizontal homogeneity is violated.