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Development of a parameterization scheme for the scale-adaptive treatment of subgrid mixing in the WRF model

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We present a blending turbulence kinetic energy (BTKE) scheme to describe subgrid mixing in the Weather Research and Forecast (WRF) model. The BTKE scheme is derived from the three-dimensional subgrid turbulent kinetic energy (TKE) equation. It includes two governing equations for subgrid TKE on two scales: one is the generalized three-dimensional subgrid TKE equation suitable for large-eddy simulation (LES) and the other is the one-dimensional subgrid TKE equation suitable for describing vertical subgrid mixing on the vertical scales ranging from the vertical grid scale to the atmospheric boundary layer (ABL) scale. The use of two TKE equations suitable for different scales allows us, in principle, to work across a range of horizontal resolutions. That is, when the size of the horizontal grid spacing is so great that the subgrid mixing is dominant in the vertical direction, the large eddies on the conventional ABL scale, as conventionally simulated by the one-dimensional TKE equation, will do most of the subgrid mixing. On the other hand, as the horizontal grid-spacing approaches the size of the grid spacing currently used for LES, the ABL-scale eddies are resolved and hence only the small eddies on the order of the LES grid spacing or smaller are responsible for the subgrid mixing. A blending function is used in the scheme to ensure that the transition of subgrid mixing between the mesoscale NWP and LES grid-spacing limits can be achieved smoothly as horizontal grid spacing varies.