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An improved WRF for urban-scale and complex-terrain applications

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Simulations of atmospheric flow through urban areas must account for a wide range of physical phenomena. Numerical weather prediction models, such as the Weather and Research Forecating model (WRF), excel at predicting synoptic and mesoscale phenomena. With grid spacings of less than 1 km (as is required for complex heterogeneous urban areas), however, the limits of WRF's terrain capabilities and subfilter scale (SFS) turbulence parameterizations are exposed. Observations of turbulence in urban areas illustrate the local imbalance of TKE frequently found in urban areas, hence the need for improved turbulence modeling. Furthermore, WRF's terrain-following coordinate system is inappropriate for high-resolution runs that include buildings. To address these issues, we are implementing significant modifications to the ARW core of the Weather Research and Forecasting model. First, we are implementing an improved turbulence model, the Dynamic Reconstruction Model (DRM), following Chow et al. (2005). Second, we are modifying WRF's terrain-following coordinate system by implementing an immersed boundary method (IBM) approach to account for the effects of urban geometries and complex terrain. Companion papers detailing the improvements enabled by the DRM and the IBM approaches are also presented (by Mirocha et al. and K.A. Lundquist et al., respectively).

This overview of the LLNL-UC Berkeley collaboration presents the motivation for this work based on observations in Oklahoma City (during Joint URBAN 2003) and some highlights of our progress to date. After implementing an IBM for buildings in WRF, we will be able to seamlessly integrate mesoscale synoptic boundary conditions with building-scale urban simulations using grid nesting and lateral boundary forcing. This multi-scale integration enables high-resolution simulations of flow and dispersion in complex geometries such as urban areas, as well as new simulation capabilities in regions of complex terrain.

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