## 2.3 Development of a multiscale modeling framework for urban simulations in the Weather Research and Forecasting model.

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Downscaling meteorological simulations from the mesoscale (Δx  2km) to the microscale (Δx 100m) is a difficult challenge requiring research and model development in multiple areas. Here, we develop a multiscale framework within the WRF model that enables concurrent multiscale simulations of flow around urban terrain using realistic time-varying lateral boundary conditions nested down from mesoscale simulations. A five domain set-up is used spanning horizontal resolutions of 6.05 km on the outer domain to 2 m on the innermost domain, where the urban terrain is explicitly resolved.

The version of the WRF model used here has been developed specifically for multi-scale simulations and includes two major modifications. First, the ability to refine the vertical grid between concurrently run nested domains is used here to control grid aspect ratios and achieve a high-quality grid on each domain. Second, an improved immersed boundary method (IBM) based on similarity theory has been developed and is used to solve for flow around urban terrain. This improved IBM algorithm can be applied to a domain nested within a traditional WRF domain that uses a terrain-following coordinate. This framework enables the WRF-IBM model to be used for investigations into downscaling and multiscale modeling over complex topography, such as urban terrain.

Validation of the WRF-IBM model has been performed using data from the first continuous tracer release of IOP-3 in the Joint Urban 2003 Field Campaign in Oklahoma City. Performance metrics evaluating model skill show improvements using the new IBM algorithm versus previously published WRF-IBM simulations. Furthermore, the WRF-IBM multi-scale framework enables investigation of meteorological effects on microscale urban simulations that are traditionally simulated using CFD models with idealized lateral boundary conditions.