High-resolution urban coupled meteorology and air quality model

Jonathan Pleim[1], Jerry Herwehe[1], Roger Turnau[2], David Wong[1], Limei Ran[3]

1 Center for Environmental Measurement & Modeling, USEPA
2 Marine, Earth and Atmospheric Sciences, North Caroline State University
3 Natural Resources Conservation Service, USDA

We have developed a new urban parameterization for coupled WRF-CMAQ modeling at high resolution for large cities. The new urban scheme considers the effects of buildings in dense urban areas through parameterization of street canyons in two directions representing urban street grids. In WRF, the new urban capability is built into the ACMv2 PBL scheme and the PX LSM and is called UACM. The computations of radiation interactions within the building canopy and the effects on wind flow are based mostly on Masson (2000) and Martilli et al (2002). The building morphology is derived from a combination of detailed building data, including building height and plan area, and street data for New York City (NYC). Building effects on air quality include dry deposition to roofs, walls, and ground. Resistances to deposition are derived from the wind speed and momentum fluxes to walls and roofs in each layer within the building canopy.

The WRF-CMAQ with UACM is configured to run on two one-way nested domains of 1.33 km and 444 m grid spacings for WRF coupled with CMAQ operating in the two-way coupled mode on the 444 m grid domain. The online nesting of the 1.33 km and 444 m grids for WRF is necessary to avoid spurious gravity waves propagating into the 444 m grid from the lateral boundaries. The primary effects of the UACM compared to the base model (ACM2/PXLSM) are warmer temperatures at night, reduced wind speeds within the building canopy, and decreased stabilty at night in lowest layers. The greatest effect of the UACM on the air quality is to reduce concentrations, especially aerosols. The high grid resolution allows for detailed assessment of neighborhood variations in air quality.

Martilli, A., Clappier, A., & Rotach, M. W. (2002). An urban surface exchange parameterisation for mesoscale models. Boundary-Layer Meteorology, 104, 261–304.

Masson, V. (2000). A physically-based scheme for the urban energy budget in atmospheric models. Boundary-Layer Meteorology, 94, 357–397.