Coupling the RAMS Mesoscale Model to an Urban Parameterization Scheme

Major Timothy Nobis
DoD Center for Geosciences/Atmospheric Research, CIRA/Colorado State University, Fort Collins CO

INTRODUCTION AND MOTIVATION

In military operations today, output from mesoscale weather models are critical input to a number of Tactical Decision Aides (TDAs). Examples of such TDAs include the Air Force's Target Acquisition Weapons Software (TAWS), the Army's acoustical decision aide, and the Joint Forces Joint Effects Model (JEM). All of these models are sensitive to the accuracy of the boundary layer parameters provided by the weather model, and inaccuracies could lead to incorrect tactical decisions.

This work reports on progress of coupling a mesoscale weather model (the Regional Atmospheric Modeling System, RAMS) to an urban parameterization scheme (the Town Energy Balance model, TEB) in an effort to improve the model's capability to simulate the urban boundary layer, thereby improving input to the TDAs in urban areas.

COUPLING RAMS-TEB

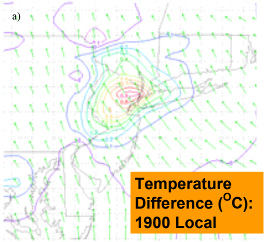
- The TEB model combines a user provided morphology database, meteorological forcing from the parent model, and urban canyon geometry theory to provide a realistic handling of surface radiation processing and building wind effects in urban areas.
- It is a "pseudo-slab" approach… the TEB model ultimately provides surface heat, moisture, and momentum fluxes, plus albedo to the surface input of the parent mesoscale model.
- Primary coupling is to the LEAF2 surface vegetation model within RAMS. During execution, the LEAF2 routine calls the TEB scheme whenever a grid cell contains a percentage of urban land cover.
- TEB is also coupled to the radiation scheme, ensuring consistent handling of surface radiation whenever the radiation scheme is called.
- The user provided morphology array is constructed in such a way to allow the user to vary most of the morphology variables from grid cell to grid cell. This allows for very accurate morphology representation.

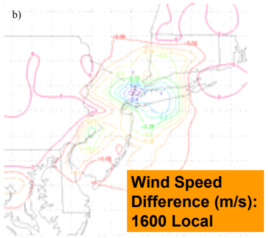
NY TEST/SENSITIVITY RUNS

The RAMS-TEB coupled system was tested using a code testing run provided with the RAMS model. The run is a small domain, 24hr simulation (07L-07L) with two grids centered on NY City. Grid one has 15 grid cells each with dimensions of 40km while grid two has 10 cells with 10km dimensions. The domain is shown in Figure 1

Figure 1: Domain of the two grids used in the test simulations around NY City.

Figure 2 shows that the test simulation was able to reproduce many of the so called "classic" Urban Heat Island signatures, including the increased temperature, decreased winds during the day due to roughness effects, and increased winds during the night due to stability effects.





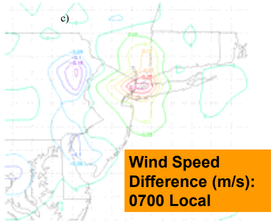


Figure 2: Differences between simulations with and without TEB at the first model level (48m) for
a) Temperature at 19L (note how the low level winds are advecting the UHI to the NW of the city center); b) Wind Speed at 16L (note the reduction in daytime winds); and c) Wind Speed at 07L (note the increase in overnight/morning winds).

Further sensitivity runs suggest:

- The "cost" of TEB in terms of additional simulation time is on the order of 4% for every 10% of grid cells in the domain that have urban land class.
- Grid cell dimensions of 20km or less are generally needed to properly handle the simulation of the UHI.

Perhaps the most interesting result of the test runs was the generation of a gravity wave which permitted the influence of the UHI to extend far upstream. Figure 3a below shows that the wind signature of the UHI at 16L (seen in figure 2), breaks into a dipole relationship at 19L (suggesting a gravity wave) just as the UHI temperature perturbation reaches its maximum. By the final hour of the simulation, convection which the model generated in the NW corner of the domain has been influenced by this gravity wave activity as evidenced by the temperature difference in 3b. It is not known if this activity is real

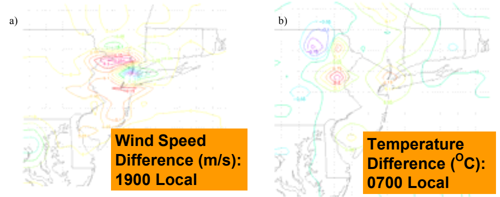


Figure 3: a) Difference in wind between TEB/no TEB at 19L suggesting gravity wave generation at the time of max heat island intensity. b) The TEB/no TEB temperature difference at the 24th hour (07L). Note the appearance of temperature anomalies in NE Pennsylvania, far from any urban area, likely due to the influence of gravity waves on convection that developed there.

CONCLUSIONS AND FUTURE EFFORTS

The RAMS model has been successfully coupled to an Urban Parameterization (The TEB Model) and has reproduced many "classic" UHI signatures in test runs. This coupled system will be used to simulate the Washington DC UHI and validate against a 1984 dispersion data set.