RAMS Simulations Incorporating an Urban Boundary Layer Scheme

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Introduction and Motivation

In military operations today, output from mesoscale weather models are critical input to a number of Tactical Decision Aids (TDA's). Examples of TDA's include the Air Force's Target Acquisition Weapons Software (TAWS), the Joint Forces Joint Effects Model (JEM), and various Army battlefield application such as those used by artillery forces. TDA's such as these are sensitive to the accuracy of the boundary layer parameters provided by the weather model, yet today's military operational weather models do not have the necessary components to incorporate the influence of urban areas on boundary layer processes.

This work reports results from the coupling a mesoscale weather model (the Regional Atmospheric Modeling System, RAMS) to an urban parameterization scheme (Town Energy Balance model, TEB; Masson 2000, Masson et al., 2002) in an effort to improve the model's capability to simulate the urban boundary lay

RAMS - TEB Coupling and Model Setup

- The TEB model combines a user provided morphology database, meteorological forcing from the parent model, and urban canyon geometry theory to calculate surface radiation and roughness effects in urban areas.
- It is a "pseudo-slab" approach… the TEB model uses 3D geometry, but ultimately provides surface heat, moisture, and momentum fluxes, plus albedo to just the surface input of the parent mesoscale model.
- Primary coupling is to the LEAF2 land surface model within RAMS. (Rozoff, 2003)
- This work has improved the original coupling by incorporating TEB into the radiation scheme and permitting morphology to vary by grid point.
- The model set up for simulations was designed to mimic a typical operational setup and so the inner most nest was purposely limited to 5km

Masson, V., Grimmond, C.S.B., and Oke, T.R., 2002: Evaluation of the Town Energy Balance (TEB) Scheme with Direct Measurement from Dry Districts in Two Cities. *J. Appl. Met.*, **41**: 1011-1026.

Masson, V., 2000: A Physically-Based Scheme for the Urban Energy Budget in Atmospheric Models. *Boundary-Layer Meteor.*, **94**: 357-397.

Rozoff, C.M., et al., 2003: Simulation of St. Louis Missouri, Land Use Impacts on Thunderstorms. *J. Appl. Met*, **42**: 716-738.

Results: 26 June 1984 - Primary Model Configuration and Sensitivity Experiments

The RAMS-TEB coupled system initialized at 1200Z (0800L) 26 Jun 1984 and run for 36 hours. The primary simulation consisted of one run with TEB and one without using a 30 meter LULC land surface data set.

Subjective Results: Fig 1 shows fields of TEB minus No-TEB and demonstrates that the TEB simulation is producing characteristics consistent with 'typical' UHI's. Fig 1 a-b are from the time of maximum difference between TEB / no TEB. The run produces an UHI intensity of over 3 degrees C (fig 1a) centered slightly north of the city's urban core consistent with observed southerly winds (not shown). The sustained PBL at (fig 1b) and higher wind speeds at night (fig 1c) are also often observed in UHI's. Fig 1d shows the delayed early morning heating consistent with the effects of urban shadowing.

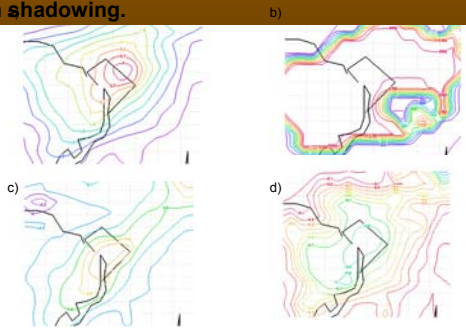

Figure 1: TEB simulation fields - no TEB simulation fields for: A) Temp (C) at 2200L; B) PBL height (m) at 2200L; C) Low level wind speed (m/s) at 0000L; D) Temp(C) at 1000L

Objective Results: The METREX field experiment collected met data as several sites around DC. Fig 2a is a comparison against Reagan International Airport. Both models over forecast the daytime temperature; thus TEB retains too much heat and is too warm through much of the night. However, the TEB run clearly handles the overnight low much better than non-TEB. Fig 2b shows vertical profiles (from a tethersonde) at Gallaudet College (near the center of UHI). Even though the TEB run is too warm, it is maintaining a better vertical profile while the run without TEB is too stable.

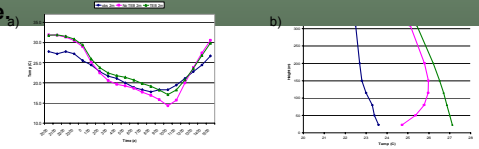

Figure 2: a) Temperature (C) from Reagan Intl as observed and simulated from 1600L 26 Jun thru 1100L 27 Jun b) Vertical temperature profiles at 2200L (0200Z) at Gallaudet College as observed with a tethersonde (blue), simulated without TEB (pink) and with TEB (green).

Sensitivity Runs: Several sensitivity runs were conducted to note the behavior of the UHI. Results from three are reported here. Fig 3a-b shows the strong sensitivity of using a 30 second (1km) land surface data set as opposed to the 30 meter one. The model produces a >30% increase in UHI (fig 3a) and nighttime winds (fig 3b). Fig 3c-d shows results from changing initial soil moisture. UHI strength is decreased in the drier simulation (fig 3c) and increased in the wetter simulation (fig 3d), though the impact is not as great (circa .5 degree C) as the different land surface data set.

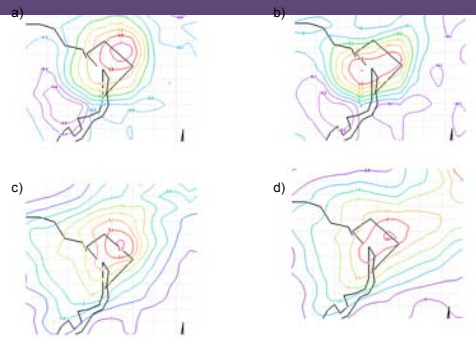

Figure 3: TEB simulation fields - no TEB simulation fields for: A) UHI Temp (C) using 1km land class minus UHI Temp (C) using 30m land class temp (C) at 2300L; B) 1km land class winds (m/s) minus 30m land class winds (m/s) at 0000L; C) UHI Temp (C) of low soil moisture runs at 2200L; D) UHI Temp(C) of high soil moisture runs at 2200L

Conclusions and Future Work

The RAMS model has been successfully coupled to an Urban Parameterization and has reproduced many of the typical urban heat island structures in simulations conducted over Washington DC, June 26, 1984. Comparison to observational data collected during METREX showed the TEB simulations, while too warm, handled the overnight low temperature better and also improved the stability profile (an input critical to dispersion models). Sensitivity studies suggested that choice of land surface data sets is a critical one with changes >30% in UHI. Initial soil moisture also had an impact on UHI strength. Work is on going to analyze results from other sensitivity runs, plus two other days (Nov 7 & Jan 8) representing meteorological conditions less typical of UHI studies.