Creating a Washington DC Urban Morphology for use in RAMS/TEB

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Introduction and Motivation

In military and civilian operations today, output from mesoscale weather models are critical input to a number of follow-on decision applications which are extremely sensitive to atmospheric boundary layer values. Examples include air quality and dispersion modeling systems (e.g. Pentagon Shield, Warner et al., 2007) and the Air Force’s Target Acquisition Weapons Software (TAWS).

Mesoscale models are starting to incorporate urban boundary layer schemes to improve performance in urban areas; however, these models need urban morphologies to operate properly. This work reports on my effort to create an urban morphology as part of coupling a mesoscale weather model (the Regional Atmospheric Modeling System, RAMS) to an urban parameterization scheme (Town Energy Balance model, TEB; Masson, 2000).

Methodology: Creating the Morphology

The Washington DC morphology was calculated over a 36X34km area (Fig 1.) at a resolution of 1km. To construct the morphology, three primary resources were used: A series of USGS 1:24,000 maps, a series of high altitude photographs, and the book “Above Washington” (Cameron, 2000). The data in each of these references dated mostly from 1978-1984 giving a morphology that matched well with the dates of the RAMS/TEB Simulations.

Basic Process: Fig 2 shows a nominal example of the process used. The USGS maps had a 1km grid on them that formed the grid cell layout. An overlay of 16 smaller grids was placed over each 1km square in both the USGS map and high altitude photo. Land use (including both morphology and vegetation) was then estimated for each 1/16th and entered into a spreadsheet for aggregation. Cameron’s book was used to provide finer detail where available.

Derived Parameters: In addition to morphology elements that could be estimated directly from photos, several were derived. Albedo and emissivity were varied by estimating the relative ratio of light to dark roofs and assigning a weighted value. A similar technique was used for roads by estimating the relative ratio of asphalt vs concrete. Finally, anthropogenic terms were varied by total road area and approx density of buildings. (Details for these parameters will appear in my Dissertation.)

Background

- 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.
- TEB expects the ‘morphology’ variables listed in table 1.
- RAMS/TEB simulations were conducted over Washington DC for dates in 1984.
- No existing morphology for Washington DC from this time could be found.
- Creating a detailed morphology (instead of a simple city wide approximation) would allow testing of RAMS/TEB sensitivity to morphology details.

Results

The aggregated result is a 1km resolution morphology database. 3 of the 1224 grid cells are shown as an example.

Figure 2: Examples of a) USGS map, b) High Altitude Photo, and c) Photo from “Above Washington”. The red square in the map identifies the 36X34km area selected for the urban morphology database. In all 1224 1km grid cells were databased.

Table 1: Morphology (or non-meteorological) values required for the TEB urban parameterization scheme. Values in red are those derived as part of this morphology exercise, and thus were different for each grid cell. The remaining ones were estimated from literature and did not vary by grid cell.

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Figure 3: Photos of the four different residential neighborhoods: a) & b) ’Gridded-10’, c) & d) ’Gridded-7’, e) & f) ’Sub-Urban Mature’ and g) ’Sub-Urban’ (no color picture). Table 2 has the details.

Table 2: Description and Characteristics of the four residential categories.

References