4. Urban Effect in Numerical Models and Evaluation with Field Experiment Data: Part II: Mesoscale Aspects

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1. INTRODUCTION

Almost two-thirds of the U.S. population live in urbanized areas occupying less than 2% of the landmass. Similar statistics of urbanization exists all over the world. As a result, the interaction between the urban region and atmospheric processes becomes a very complex problem. Further understanding of this interaction via the surface and/or atmosphere is of importance to improve the weather forecast, and to minimize the loss caused by the weather-related events, or even by the chemical-biological threat.

To this end, Brown and Willaims, (1998) first developed an urban canopy scheme to parameterize the urban infrastructure effect. This parameterization accounts for the effects of drag, turbulent production, radiation balance, and anthropogenic and rooftop heating. Further modification was made and tested in a recent sensitivity study for an idealized case using a mesoscale model (Chin et al., 2000). Results indicate that the addition of the rooftop surface energy equation enables this parameterization to simulate the urban infrastructure impact more realistically.

To further improve the representation of the urban effect in the mesoscale model, the USGS landuse data with multiple resolutions (200 and 30 meters) are used in this study to derive the urban parameters using a look-up table approach. The details of this derivation is shown in a companion paper (Leone et al., 2002). This approach can provide us the key parameters for urban infrastructure (such as urban fraction, roof fraction, building height, and anthropogenic heating) and urban surface characteristics (such as albedo, wetness, and roughness) to drive the urban canopy parameterization with geographic and temporal dependence.

The objective of this study is to validate the urban canopy scheme with the observed measurements, and to quantitatively gauge the contribution of urban infrastructure and urban surface to the overall urban effect in the mesoscale processes for momentum and heat transports.

2. MODEL AND INITIAL CONDITIONS

The Naval Research Laboratory's 3-D coupled Ocean/Atmosphere mesoscale prediction system (COAMPS) is used to study the urban impacts on atmospheric momentum and heat transport, and surface energy budget. COAMPS consists of a data assimilation system, a nonhydrostatic atmospheric forecast model, and a hydrostatic ocean model.

In this study, we use only the atmospheric model, which is composed of a compressible form of the dynamics, nest-grid capability, and parameterizations of subgrid-scale mixing, surface momentum and heat fluxes, explicit ice microphysics, subgrid-scale cumulus clouds, and shortwave and longwave radiation. The terrain-following vertical coordinate is also used to simulate flow over an irregular surface. The reader is referred to Hodur (1997) for further details of COAMPS.

The model domain contains 32 grid points in the vertical, with the grid size varied to maximize resolution at lower levels. The grid spacing of the lowest layer is 4 m, with each successive layer gradually increased to 1 km at the altitude of 5.882 km. Above this level, a uniform grid size of 1 km is used up to the altitude of 8.882 km. Then, the grid size is further smoothly increased to 7.5 km with the domain top residing at 32.132 km. In the horizontal, both zonal and meridional coordinates have 61 grid points for all nested grid domains. A uniform grid size of 36 km is used for the outer coarser mesh with a constant size ratio of three to define the inner nest grids. Constant time steps of 90 and 45 seconds for non-sound and sound wave calculations, respectively, are used in the coarser grids for the time-splitting scheme. The time steps for the finer-grid domains are reduced proportionally to the nest-grid size ratios. The rigid boundary condition is imposed at the vertical boundary. A sponge-damping layer is placed above 12.8 km to minimize the reflection of internal gravity waves off the rigid upper boundary. The Davies (1976) boundary condition is applied to the lateral boundaries with a nudging zone of seven grid points at each lateral boundary. A time filter with a coefficient of 0.2 is applied to control computational instability associated with the leapfrog time approximation in the model.

3. Experiment Design

In this research, we conduct a series of sensitivity experiments using ETA 40-km data. First, simulations with and without the urban effect are performed to gauge the urban influence on the mesoscale processes. Second, simulations with the urban parameters from different resolutions of landuse data (200 and 30 meters, respectively) are used to evaluate the sensitivity of urban parameters to the modeled urban effect. Last, the experiments with varied nest grids (i.e., 3 and 4 nests) are conducted to study the impact of horizontal resolution (4 km and 1.33 km, respectively) on the urban canopy parameterization. To evaluate the performance of this urban canopy parameterization, these simulations are used to compare with the field measurements from the Department of Energy field campaign at the Salt Lake City, October 2000. The intensive observational period

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of IOP-10 occurring on October 25, 2000 is selected in this study as a representative of the high wind case.

4. RESULTS AND SUMMARY

Figures 1 and 2 demonstrate the differences of input urban parameters derived from varied resolutions of USGS landuse data. The 200-m data set has a total of 37 landuse categories, where seven of them belong to the urban categories. On the other hand, its counterpart in the 30-m data set has 21 categories in total, and only three of them cover high and low density residential, industrial and commercial regions. The primary urbanization categories are not represented in this high-resolution data set. As a result, the low-resolution data exhibit larger urban roof fraction and spatial coverage, and drier urban surface near the populate areas. However, both data sets show a clear improvement at the surface properties near the populated and Utah Lake regions as compared to their counterparts without using the landuse data. These differences would influence to the model simulations to certain degree. Detailed results of these comparisons and their validation with field measurements will be shown to assess the overall performance of this urban canopy parameterization.

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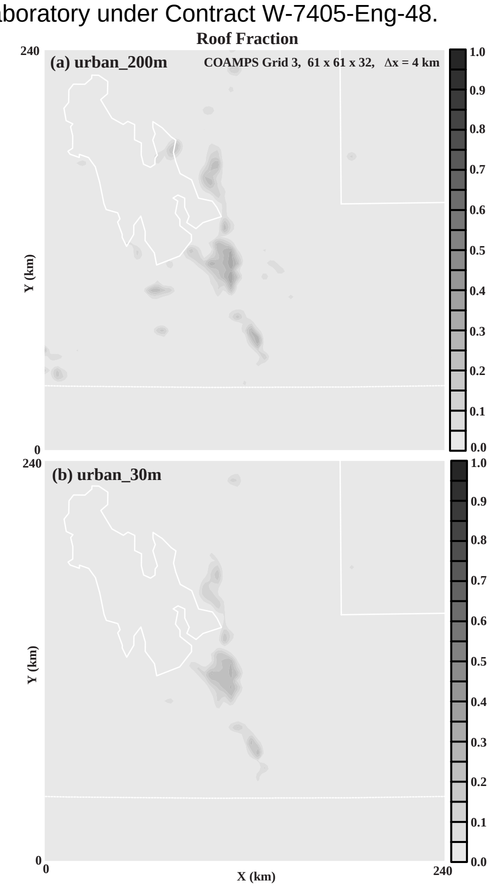

Fig. 1. Horizontal cross-sections of urban roof fractions derived from USGS landuse data. (a) for 200-m resolution, and (b) for 30-m resolution.

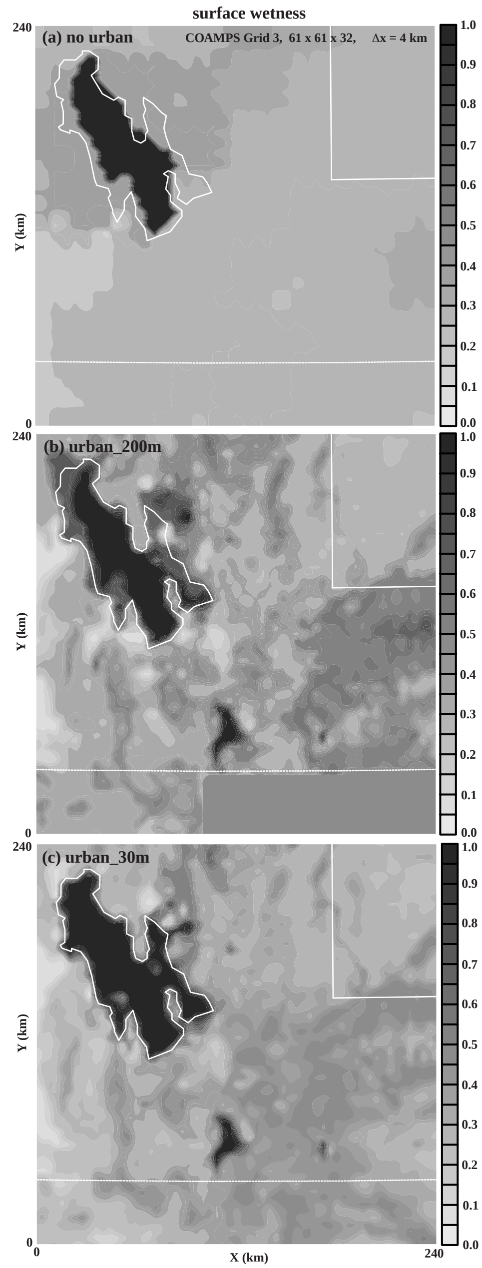

Fig. 2. As in Fig. 1, except for the surface wetness. (a) without urban data (b) for 200-m resolution, and (c) for 30-m resolution.

5. REFERENCES

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