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Visualization-based Decision Tool for Urban Meteorological Modeling

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- data and terrain elevation data.
- Our system computes urban morphology parameter values suitable for the urban weather simulation.
- The resulting simulation values and city model are visualized by the user (3D renderings, choroplethic maps, etc.).
- **Modeling Urban Weather**
- Based on the canyon model, we adapt and extend the Town Energy Budget (TEB) scheme of Masson [2] to simulate the surface energy fluxes into the atmosphere at the surface of a mesoscale atmospheric model covered by buildings, roads, and other artificial material.



- The fluxes estimated from TEB are combined with those of other surrounding land types (e.g., vegetation, water bodies, etc.) using the LEAF2 land-surface model [4] and then spatially averaged into a single atmospheric model grid in proportion to the space occupied by each land type.
- The overall atmospheric simulation system we use is the Regional Atmospheric Modeling System or RAMS ver 4.3 [1]. RAMS is a well-tested multiscale environmental modeling system that has been applied for a wide range of problems.

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Contributions:

- simulation system.

Calculate Urban Morphology+LULO

Simulation

using high-level editing tools (e.g., greening, introducing parks in the urban landscape, altering roof albedos, etc.). • New urban morphology parameter values are computed and the cycle repeats enabling the exploration and visualization of new city designs and the resulting urban weather.

APPROACH



- From a set of input layers (LULC, population, and terrain) we generate a plausible 3D city model that is qualitatively similar to the actual city. This process is based on [3].
- The following urban morphology parameter values are automatically computed from the 3D model of the city and used by the urban weather simulation
 - Average building height
 - Urban fabric covered by buildings
 - Canyon aspect ratio
 - Roughness and displacement length
 - Albedo

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1. A system to dynamically integrate urban land use planning and high impact/extreme weather mitigation into a unified framework that enables stakeholders to explore the effects of adopting different urban land use and weather/climate assessments. A method to generate 3D city models from land-use, population, and terrain elevation data, and to interactively edit the city model assisted by an integrated urban

A set of algorithms to compute the urban morphology parameters necessary for regional weather simulation and visualization.



We demonstrate our visualization application system over a 1600 km2 area centered on Indianapolis, IN. We compare the results of a control scenario and various "what-if" greening scenarios with the objective of visualizing and understanding how to mitigate the local climate to different configurations.



We explore several altered urban scenarios of the region surrounding Indianapolis, IN. In our examples and during the simulation time frame, the surrounding regional weather (e.g., from state and country level meteorological phenomena) is producing southwest winds over Indianapolis. Also, in general green areas have lower temperatures and higher humidity as compared to dense urban areas, but the weather resulting from large green areas can affect other parts in the city as well as in the surrounding non-urban areas. We present several exemplary results of using our system to help decision makers visually explore the effect of adopting different urban policies.





RESULTS

Cotton, W. R., Pielke, Sr., R. A., Walko, R. L., Liston, G. E., Tremback, C. J., Jiang, H., McAnelly, R. L., Harrington, J. Y., Nicholls, M. E., Carrio, G. G., and McFadden, J. P.: RAMS 2001: Current Status and Future Directions, *Meteorol. Atmos. Phys.*, 82, 5–29, 2003. Masson, V.: A physically-based scheme for the urban energy budget in atmospheric models, Bound.-Lay. Meteorol., 94, 357–397,

Vanegas, C.A., Aliaga, D, Benes, B, AND Waddell, P., 2009. Interactive Design of Urban Spaces using Geometrical and Behavioral

Walko, R.L., L.E. Band, J. Baron, T.G.F. Kittel, R. Lammers, T.J. Lee, D. Ojima, R.A. Pielke, C. Taylor, C. Tague, C.J. Tremback, and P.L. Vidale, 2000: Coupled Atmosphere–Biophysics–Hydrology Models for Environmental Modeling. J. Appl. Meteor., 39, 931–944.

^{2000.}

Modeling, ACM Transactions on Graphics, 28(5), 10 pp.