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# The impact of anthropogenic heat and surface roughness on an operational weather forecast

**P.A. Makar** (1), S. Gravel (1), V. Chirkov (2), S. Belair (3), K. Strawbridge (1), F. Froude (1)

(1) Meteorological Service of Canada, Toronto, Ontario, Canada, (2) International Institute for Applied Systems Analysis, Vienna, Austria, (3) Meteorological Service of Canada, Montreal, Quebec, Canada (paul.makar@ec.gc.ca / Fax: 1-416-739-4288 / Phone: 1-416-739-4692)

Introduction

Recently, mesoscale models have been used to show the impact of the emissions of anthropogenic heat on local-scale meteorology (Saitoh *et al.*, 1996**,** Fan and Sailor, 2005). Though these results were obtained with high-resolution (~2km) local area models, the impact of anthropogenic heating may be more than local, and it has been suggested in the literature that they should be considered in estimates of global warming (Crutzen, 2004). In operational weather forecast models, such as the Global Environmental Model (GEM) used by Environment Canada for the Canadian weather forecast (Côté *et al.*, 1998) which employ detailed parameterizations for surface exchange processes (Belair *et al.*, 2003), anthropogenic heating and urban impacts are traditionally neglected on account of their poorly resolved scales. In this work, this assumption is reexamined with the inclusion of the flux of anthropogenic heat and a parameterization for urban surface roughness into GEM.

Methodology

Two global (0.04166 degree resolution) databases were used as input for the simulations; an estimate of global anthropogenic heat flux, and a global population database. Anthropogenic heat flux was derived through the use of satellite observations of night-time light emissions as a surrogate for the apportionment of international statistics of anthropogenic heat (Chirkov, 2003). Urban surface roughness was determined through the use of global population data, a parameterization linking typical building height and cross-sectional footprint with surface roughness (Oke, 1978), and a second parameterization linking population density to building height. The last of these was calibrated using high-resolution images of six urban core regions in North America. The resulting population-related surface-roughness field was then combined with the existing natural surface roughness input database for GEM.

The heat flux field was incorporated into GEM's existing ISBA surface process parameterization (Belair *et al*., 2003) as a source term in the surface heating equation, following (Saitoh *et al*., 1996). These and the modifications to the surface roughness field were the only changes to GEM; the remainder of the model was allowed to respond to the new source term and surface roughness values in a dynamically consistent fashion.

GEM is a variable resolution model – here, simulations were performed using GEM's regional forecast configuration, with a resolution of 0.1375 degrees over North America (approximately 15 km) and 58 vertical levels.

Results

While long-range impacts of anthropogenic heating were difficult to assess due to chaotic differences between base-case and modified model runs, strong local perturbations of key meteorological parameters in urban regions were observed. Summer case studies from several North American cities show significant (up to a factor of 5) increases in nightime PBL heights. Surface temperature increases of more than 4 degrees Celsius in urban regions were observed, along with nighttime enhancements of heat and moisture diffusion coefficients by one to three orders of magnitude. Interactions between surface roughness and heat flux were noted. Surface roughness changes alone were found not to have a significant impact on the above meteorological parameters, while heat flux alone was found to perturb the meteorology at urban sites. Simulations with anthropogenic heat fluxes coupled with urban surface roughness were found to have the greatest impact. Observations of lidar-derived and tethersonde PBL heights in an urban region during an air-quality measurement intensive were used for model verification, as were case studies from other measurement programs.

Conclusions

The inclusion of anthropogenic heat into an operational weather forecast model was shown to have a significant effect on predictions of meteorological variables in urban regions. These findings are preliminary, in that comparisons to detailed measurements were only available for one location in the model grid. However, the magnitude of the observed changes and comparisons to observations of typical urban heat islands suggests that the overall model performance may be improved by the modifications, and further testing and verification is warranted.

References


Bélair, S., Crevier, L.-P., Mailhot, J., Bilodeau, B., and Delage, Y., Operational implementation of the ISBA land surface scheme in the Canadian Regional Weather Forecast Model. Part I: Warm Season Results, J. of Hydrometeorology, 4, 352-370 (2003)

Chirkov, 2003: http://www.iiasa.ac.at/collections/IIASA_Research/Research/TNT/WEB/heat/index.htm

Côté, J, S. Gravel, A. Méthot, A. Patoine, M. Roch, and A. Staniforth, 1998 : The Operational CMC-MRB Global Environmental Multiscale (GEM) Model. Part I: Design Considerations and Formulation. *Mon. Wea. Rev.*, 126, p. 1373-1395.

Crutzen, P.J. New Directions: The growing urban heat and pollution “island” effect – impact on chemistry and climate, Atmospheric Environment, 38, 3539-3540, 2004.

Fan, H. and Sailor, D.J., Modeling the impacts of anthropogenic heating on the urban climate of Philadelphia: a comparison of implementations in two PBL schemes, Atmospheric Environment, 39, 73-84, 2005.

Oke, T., Boundary Layer Climates, Methuen, New York, 372 pp., 1978.

Saitoh, T.S., Shimada, T., and Hoshi, H., Modeling and simulation of the Tokyo urban heat island. *Atmospheric Environment*, 30, 3431-3442 (1996).