

Tropical urban heat island simulation using the Topographic Vorticity Mesoscale (TVM) model

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Abstract

In this work, a numerical simulation of the Urban Heat Island (UHI) of Rio de Janeiro City is set up using the Topographic Vorticity Mesoscale (TVM) model. At noon, the resulting surface potential temperature presents a strong UHI core across the Fluminense Lowlands (Baixada Fluminense), whereas the specific humidity reaches its lowest values.

Resumo

Neste trabalho, uma simulação numérica da Ilha de Calor Urbana (ICU) da cidade de Rio de Janeiro é feita usando o modelo Topographic Vorticity Mesoscale (TVM). A temperatura potencial resultante mostra ao meio dia uma forte ICU na região da Baixada Fluminense e um mínimo de umidade específica.

1. Introduction

Marques Filho et al. (2009) analysed the Urban Heat Island (UHI) of Rio de Janeiro City, suggesting that UHI's in this tropical city could vary significantly from the patterns observed in mid-latitude cities, with the intensity peak occurring in the morning rather than at night. Here, a numerical simulation of Rio's UHI obtained using the Topographic Vorticity Mesoscale (TVM) model is analysed. This model is based on the non-hydrostatic and incompressible Boussinesq equations in sigma coordinate system, solving vorticity vector components (Thunis and Clappier, 2000). Among the advantages of using vorticity based models are the reduction of truncation errors associated with the integration of non-conservative variables, and the elimination of the pressure from the prognostic equations.

2. Methodology

The TVM model was applied to dynamically adjust the atmospheric flow to Rio's surface conditions (IGBP land cover, Fig. 1a, and SRTM topography, Fig. 1b), with initial conditions at rest in January 1st, integrated over one hour. To avoid the increase of accelerations over the very complex terrain, the grid lengths and the time step were scaled by a factor. The model was run until the wind speed was comparable to the observed one (1-2 m/s). The result is a flow physically consistent with surface conditions.

3. Results

The three outcrops (Fig. 1b) present in the Metropolitan Area of Rio de Janeiro (MARJ) are able to block the sea breeze flow, resulting in high temperatures and low specific humidity over the Fluminense Lowlands (Fig. 2a and 2b). The Turbulent Kinetic Energy and the urban Boundary-Layer height (z_i) reach their maxima in the same area (not shown). The next step is extending the simulation up to 24-hrs.

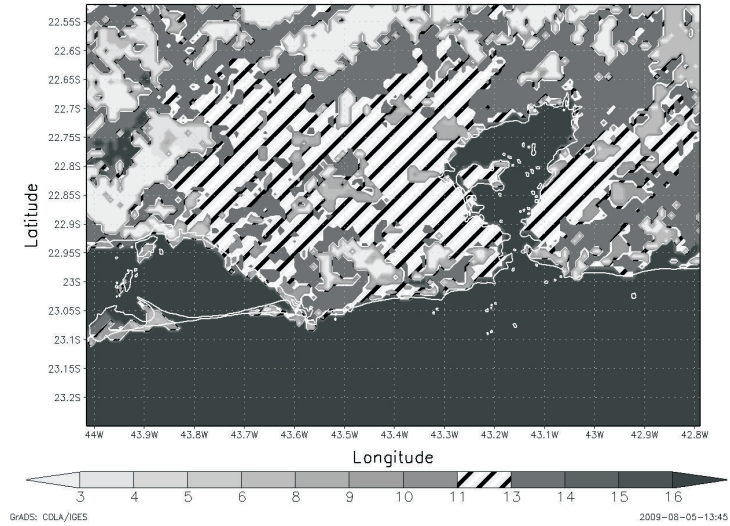
Acknowledgements: The authors acknowledge financial support from CAPES and CNPq.

References

MARQUES FILHO, E. P. et al. Rio de Janeiro's Urban Heat Island. *Quarterly Newsletter of the IAUC*, [S.l.], n. 32, jun. 2009. Disponível em: <<http://www.urban-climate.org>>.

THUNIS, P.; CLAPPIER, A. Formulation and Evaluation of a Nonhydrostatic Mesoscale Vorticity Model (TVM). *Monthly Weather Review*, Boston, v. 128, p. 3236-3251, sep. 2000.

a)



b)

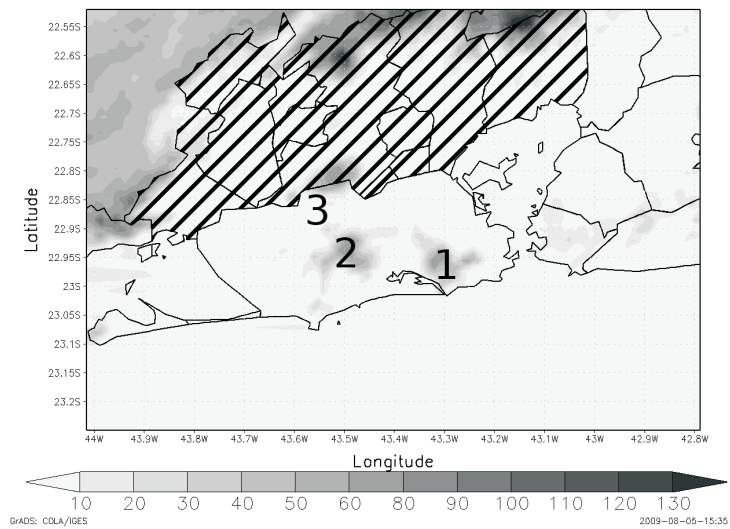
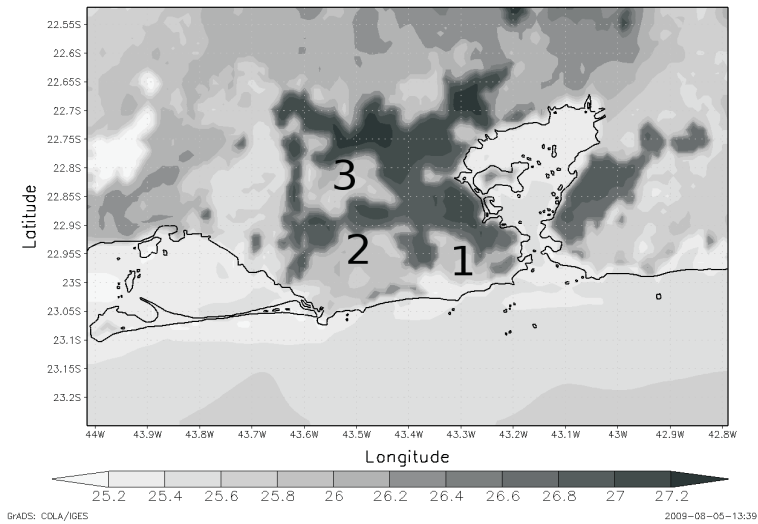


Figure 1. Surface conditions on MARJ. a) land cover types (IGBP) and b) topography (m) (SRTM). The diagonals stripes represents a) the urban areas and b) Fluminense Lowlands municipalities. The numbers are 1) Tijuca, 2) Pedra Branca and 3) Gericinó outcrops.

a)



b)

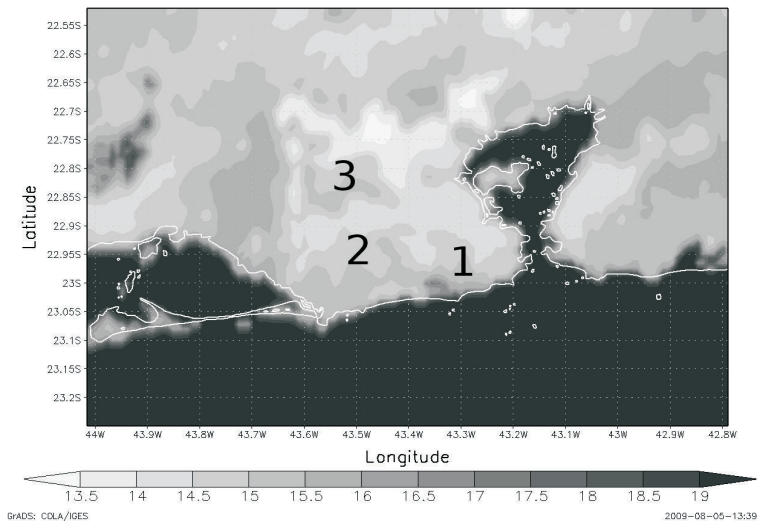


Figure 2. Surface variables on MARJ at noon, Jan 1st. a) potential temperature (°C) and b) specific humidity (g/kg) of the air.