Rainfall Distribution on the Metropolitan Area of Rio de Janeiro

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August 10, 2012
Outlines

- Introduction
- Urban Heat Island of Rio de Janeiro
- Precipitation
- Dengue infectious disease Modeling
- Sea-breeze flow
- Convection associated to the sea breeze
- Hydrological Modeling
- Calibration of solar radiation parameterizations
- Shadows effects in complex terrains
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Complex terrain
Topography of the MARJ

SRTM-NASA
Potential Temperature

Tom Jobim Airport (SBGL)
Specific Humidity

Tom Jobim Airport (SBGL)
Air pressure

Tom Jobim Airport (SBGL)
Lift Condensation Level

Tom Jobim Airport (SBGL)
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UHI along the months of year and hours of day

Marques Filho et al (2009)
Meridional component of the wind

Tom Jobim Airport (SBGL)
Features of the UHI of Rio

- Presence of a diurnal UHI in Rio and São Paulo cities
- The anthropogenic flux is (very) small than the insolation flux
- Insolation is very large in the tropics
- Sea breeze is able to reduce the amplitude of the diurnal UHI in the afternoon and evening
- Meridional component of the sea breeze (S) converges on the northward steep terrain of Serra do Mar, at the north edge of Guanabara bay.
MODIS surface temperature retrieval

Diurnal Urban Heat Island Structure

August 30, 2011
Urban Heat Island (comparison)

Histogram of UHI (°C)

30 Aug 2011, MODIS
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Precipitation

Espatial Structure

GEORIO raingauge network
Cluster Dendrogram

```
dist(data1, method = "euclidian")
```
```
hclust (*, "single")
```
Time series analysis

Comparison of raingauge measurements throughout the network
Rainfall Histogram (for instance)

- Positive skewness

Tail $Q > Q(98\%)$
Cumulative distribution function

Anchieta rain gauge
Distribution of hourly precipitation in Rio throughout the year (mm h\(^{-1}\))

Anchieta rain gauge
Convective delay from summer to fall
The South Atlantic Convergence Zone (SACZ)

Additional factor for severe weather
larger water vapor density
in average depth of the troposphere

SACZ can be correlated with high rainfall amounts in SE part of Brazil (Carvalho and Jones, 2002, 2004)
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Life cycle of *Aedes aegypti*

- **Emergence**
  - CD temperature $> 18^\circ C$
  - Water $> 10$ mm

- **Pupation**
  - CD minimum weight
  - Temperature
  - Water $> 10$ mm

- **Larva**
  - CD temperature $> 13^\circ C$
  - Water $> 10$ mm

- **Egg**
  - CD temperature $> 22^\circ C$
  - Water $> 10$ mm

- **Ovoposition**
Enough water (~10 cm) into the breeding jars will permit the metamorphosis of larvae and pupae.
Infectious Dengue disease Modeling: breeding and survival rates

Mortality rate of eggs throughout the year
Rainwater can accumulate water in urban containers in which the stagnant water is used to eclose eggs, breed larvae and pupae. The density of the larval population and food supply within the breeding water can be critical. This is a basic idea used in our proposed entomological parametrization.
Basic structure of the White's infectious disease model used for dengue fever human population dynamics

J.C.B. Silva et al. (2012, submitted)
Boxplot: seasonal variation of dengue infection notifications

Log_{10} de casos notificados de dengue (indivíduo⁻¹)

Tempo (meses)

× Caso máximo de notificação discrepante
Degree-day correlation

Degree-day (J kg\(^{-1}\)) since July 1st

Degree-day variation (J kg\(^{-1}\) s\(^{-1}\))
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Linear Point Vector Method (LPVM)

Kinematic properties:
- Vertical component of the vorticity vector
- Divergence
- Shearing deformation
- Stretching deformation
Three weather stations (airports)
Conceptual model
Average meridional component of the wind

Average convergence (in blue)
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Convection at the fund of Guanabara Bay

LOCAL TIME
17:45 h
Metar report from SBGL
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Scarp of Serra do Mar

Plainwater Hydrology

Northward of Metropolitan Area of Rio de Janeiro
Topographic Gradient
Uphill Area (Source)
HydroNet of INEA at the NW edge of the Guanabara Bay
Diurnal cycle of the rainfall and river heights

Rainfall

The time scale of the watershed is approximately 3 h

River heights

Average diurnal cycle in the first months of 2011
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Comparing two parameterizations?

Turn on OR turn off the $n$ flags in the model namelist to define the essays of the factorial experiment $2^n$

Other way

Let's sure that every parametrization was calibrated using the same data series (like in the momentum method), yielding *zero bias* (no systematic errors).

Draw up the optimized parameters inline through the code of the mesoscale model.
Multi-parameter optimization

Broadband solar radiation parameterizations useful for complex terrain in the tropics

Brute Force and Simplex methods

"There are less than expected tropospheric aerosols"
Shadows model → SEB
The Urban Heat Island (UHI) in São Paulo (MASP) and Rio de Janeiro (MARJ) is characteristically diurnal, as a response to the large incoming of solar radiation in contrast to the nocturnal UHI in mid-latitude cities, where anthropogenic heat source is determinant.

Sea breeze advection of cold air is enough to reducing the intensity of the diurnal UHI of Rio

A preliminary hourly climatology for precipitation in MARJ was proposed

Stations in the rain gauge network of Rio can be grouped by cluster analysis.

The convective precipitation delays in the afternoon from summer to fall

We have investigated numerically the relationship between precipitation, environment energetics and the dynamics infectious disease Dengue.

Enough amount of accumulated energy in the environment is a condition to ripen female mosquitoes.
Perspectives

1. Modeling

Couple the models: ARPS, TEB, SHADOWS and TOPMODEL

2. Urban fluxes measurements

Radiometric and micrometeorological platform is been placed above the roof at the School of Meteorology in IGEO-UFRJ using a configuration that is twin of the existent at the School of Atmospheric Science in IAG-USP (Marques Filho et al., 2012, project FAPESP-FAPERJ)

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Questions