Urban heat island in the metropolitan area of São Paulo and the influence of warm and dry air masses during summer

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Outline

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- Main goals
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- Results - Influence of sea-breeze
- Results - Influence of the dry and warm conditions during Summer 2013/2014
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UHI in the MRSP

- MRSP – 39 cities, including Sao Paulo
- 20 million inhabitants (48% of the population of the state)
- 8000 km² area (3% of the area of the state)
- Sao Paulo city (-23° 32' 51" and -46° 38' 10'") – 1500 km² of area and more than 11 million inhabitants
- Dry winter and wet summer
- Predominant NE flow (South Atlantic High), disrupted by cold fronts (SW)
- Influence of sea-breeze
- Mountain-valley circulation when winds are weak and building blocking and channeling when winds are strong
- Average altitude of 700 m ASL
- 60 km distant from the coast (Oliveira et al., 2003)
• **UHI in the MRSP**

• Expected to be more intense at daytime during summer.

• Seasonal variations strongly modulated by urban-rural differences in the moisture content of the soil (Arnfield, 2003).

• Anthropogenic heat plays minor role (20 W m\(^{-2}\)), Ferreira et al. 2011.

• Ferreira et al. 2012→average urban – average suburban; monthly average of hourly values during 2004.

(Figure from Ferreira et al. 2012)
• UHI in the MRSP

• UHI maximum between 1400 LT and 1600 LT, from 2.6 °C (July) to 5.5 °C (September);
• Strong correlation to solar radiation.

(Figures from Ferreira et al. 2012)
• UHI in the MRSP

• Ferreira et al. 2013 → during May and June 2009.
• No clear correlation to stored energy flux.
• Slower change in urban temperatures caused by higher values of urban thermal admittance compared to rural thermal admittance.
• However, inside Sao Paulo city there are differences in land use (parks, water bodies) and temperature.

(Figure from Ferreira et al. 2013)
Main goals

To study:
- the temperature field in the city of Sao Paulo
- the evolution in time of the temperature differences between urban and non-urban sites
- the influence of the sea-breeze in the UHI phenomenon
- the influence of synoptic conditions that may enhance the UHI intensity
Methodology and data

- 2 meteorological stations (MSEast and MSSouth) – suburban sites;
- 1 air quality monitoring station (ES1) – urban.
- Hourly averages from 2004 for MSSouth and ES1 and 2009 for MSEast to 2014.

- The air temperature differences were calculated (urban - suburban):
  - ES1 – MSEast;
  - ES1 – MSSouth.
• Methodology and data

- MSSouth - Suburban site
- MSEast - Suburban site
- ES1 - Urban site
• Methodology and data

• Spectral analysis
  – A periodogram was produces with each data series (ES1 – MSEast and ES1 – MSSouth)

• Diurnal evolution
  – Hourly averages were calculated for each complete data series

• Case study: influence of sea breeze
  – Air temperature and humidity fields at August 6th, 2013, using more air quality environmental stations

• Case study: influence of a warm and dry air mass during the Summer of 2013/2014
  – Monthly averages for the past years compared to the monthly averages of the anomalous Summer
• Results – Spectral analysis

• Most significant periods are 24 h and 12 h.
• Not much contribution of seasonal variations.
• Results – Diurnal Evolution

• Morning Cool Island
• Maximum in the afternoon
• Averaged nighttime intensity greater than daytime
• Influence of sea-breeze
• Results – Sea-breeze

• Case study: August 6th, 2013
  - 9 stations for temperature and 7 stations for relative humidity

Noon (LT)
• Results – Sea-breeze

• Case study: August 6\textsuperscript{th}, 2013 – $\Delta T \sim 10.5 \, ^\circ\text{C}$

1 pm (LT)
Results – Sea-breeze

Case study: August 6th, 2013

2 pm (LT)
Results – Warm and Dry Conditions

- Case study: Summer 2013/2014
- High pressure center
- Higher temperatures
- Less precipitation
- Less cloud formation

Temperature anomalies for (a) January and (b) February 2014. (GREC, 2015)
• Results – Warm and Dry Air Mass

• Case study: Summer 2013/2014

Similar case than September 2004
(Ferreira et al., 2012)
Conclusions

- The UHI in Sao Paulo city is complex (large area, great spatial variation of land use types) and observation are scarce.
  - presence of an Urban Cool Island during morning hours;
  - maximum intensity of the Urban Heat Island at late evening and early nighttime hours, agreeing with previous results (Ferreira et al., 2013);
  - sea breeze circulation influences temperature differences within the Sao Paulo city;
  - larger averaged UHI intensity at nighttime, since the morning cool island compensates the evening heat island when averaging daytime hours;
  - the presence of a high pressure center, creating hot and dry conditions over the MRSP during the austral Summer of 2013/2014, increased the UHI intensity. This result suggests correlation between solar radiation and UHI intensity, agreeing with previous work (Ferreira et al., 2011).


**ACKNOWLEDGMENT**

Fundacao de Amparo a Pesquisa do Estado de Sao Paulo (FAPESP) grant number 2014/04372-2

Conselho Nacional de Desenvolvimento Cientifico e Tecnologico (CNPq) grants number 443029/2014-8 and 204726/2014-0

University of Sao Paulo

Environmental Agency of Sao Paulo (CETESB)

Thank you!

National Center of Atmospheric Research (NCAR)