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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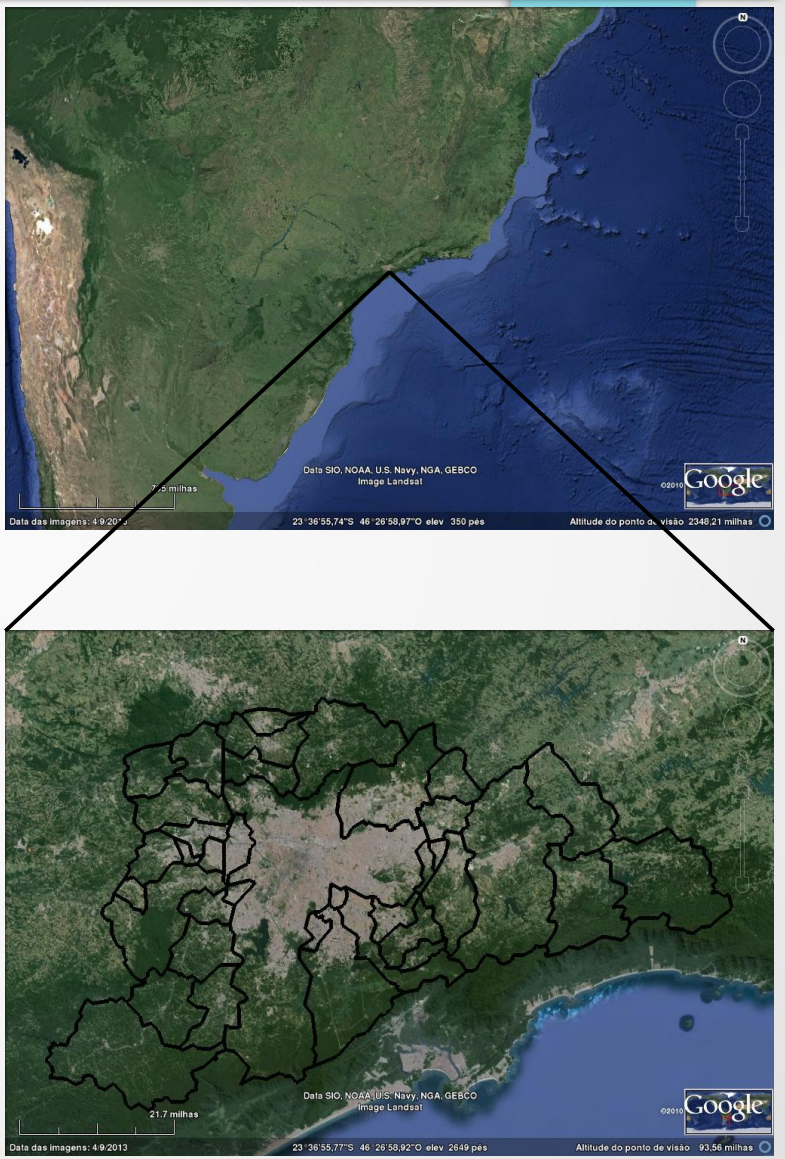
Outline

- UHI in the metropolitan region of Sao Paulo (MRSP)
- Main goals
- Methodology and data
- Results - Spectral analysis and diurnal cycle
- Results - Influence of sea-breeze
- Results - Influence of the dry and warm conditions during Summer 2013/2014
- Conclusions
- References
- Acknowledgment

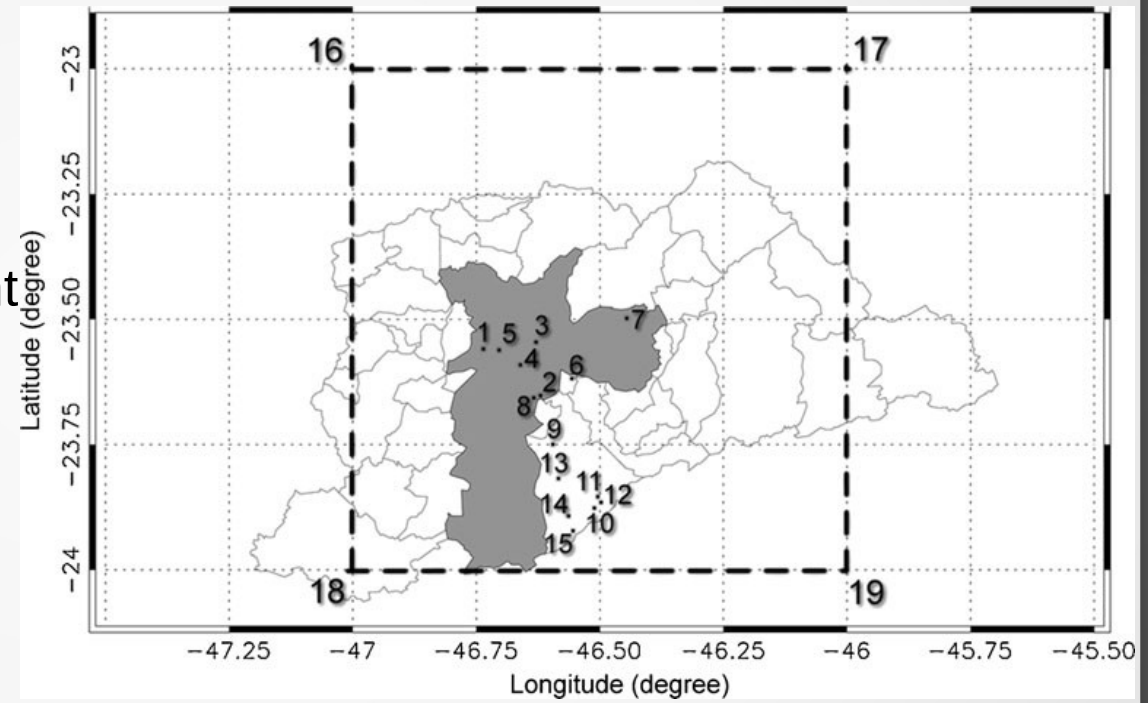
•UHI in the MRSP

- MRSP – 39 cities, including Sao Paulo
- 20 million inhabitants (48% of the population of the state)
- 8000 km^2 area (3% of the area of the state)
- Sao Paulo city (-23° 32' 51'' and -46° 38' 10'') – 1500 km^2 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

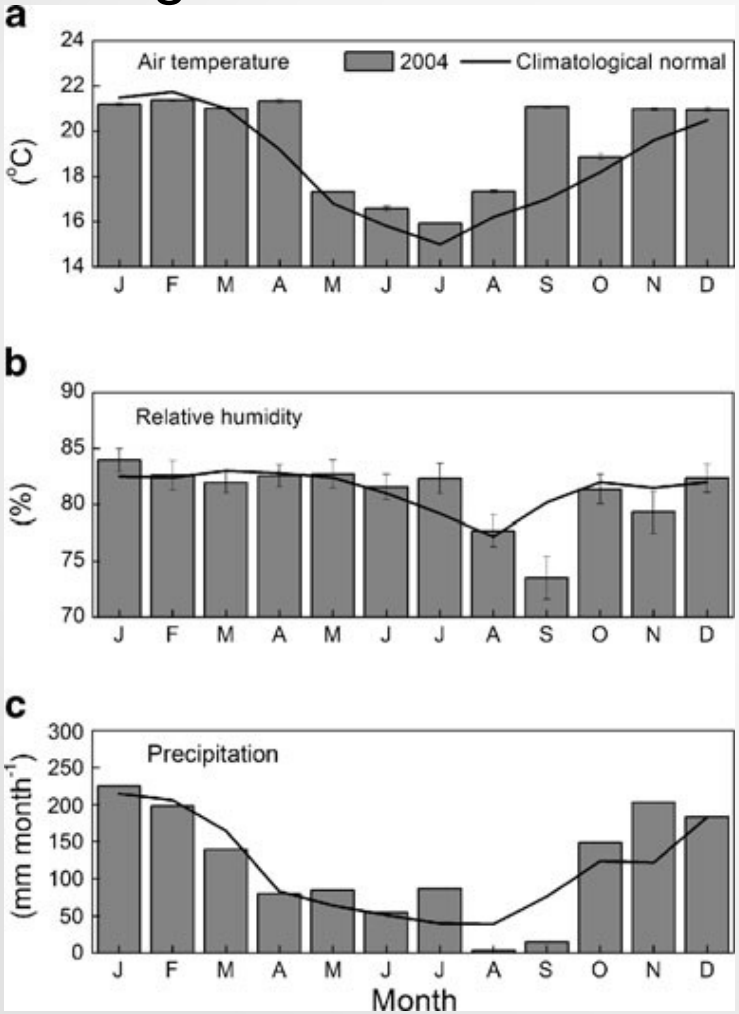
- Expected to be more intense at daytime during summer.
- Seasonal variations strongly modulated by urban-rural differences in the moisture content of the soil (Arnfield, 2003).
- Anthropogenic heat plays minor role (20 W m^{-2}), Ferreira et al. 2011.
- Ferreira et al. 2012 → average urban – average suburban; monthly average of hourly values during 2004.

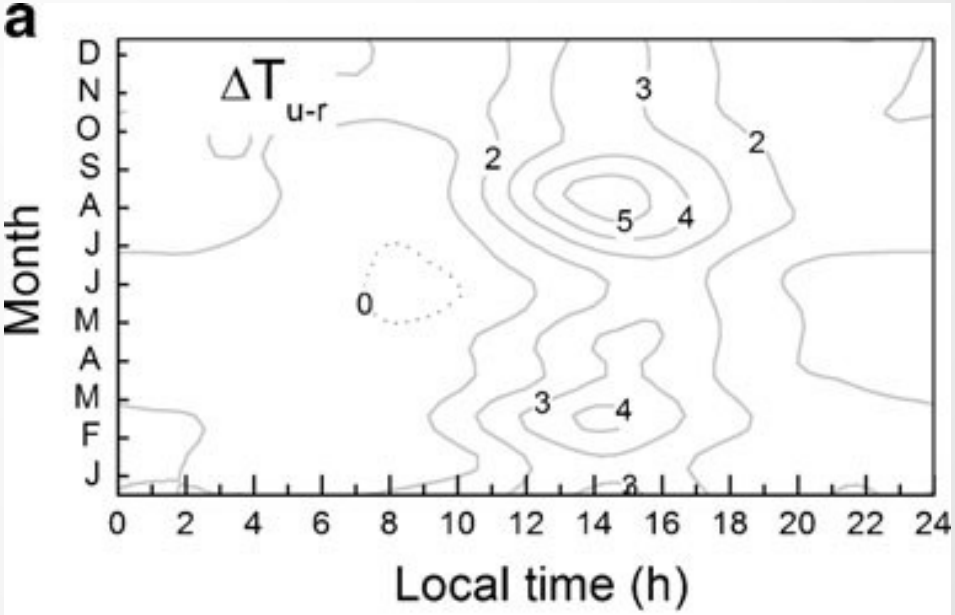


(Figure from Ferreira et al. 2012)

•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.

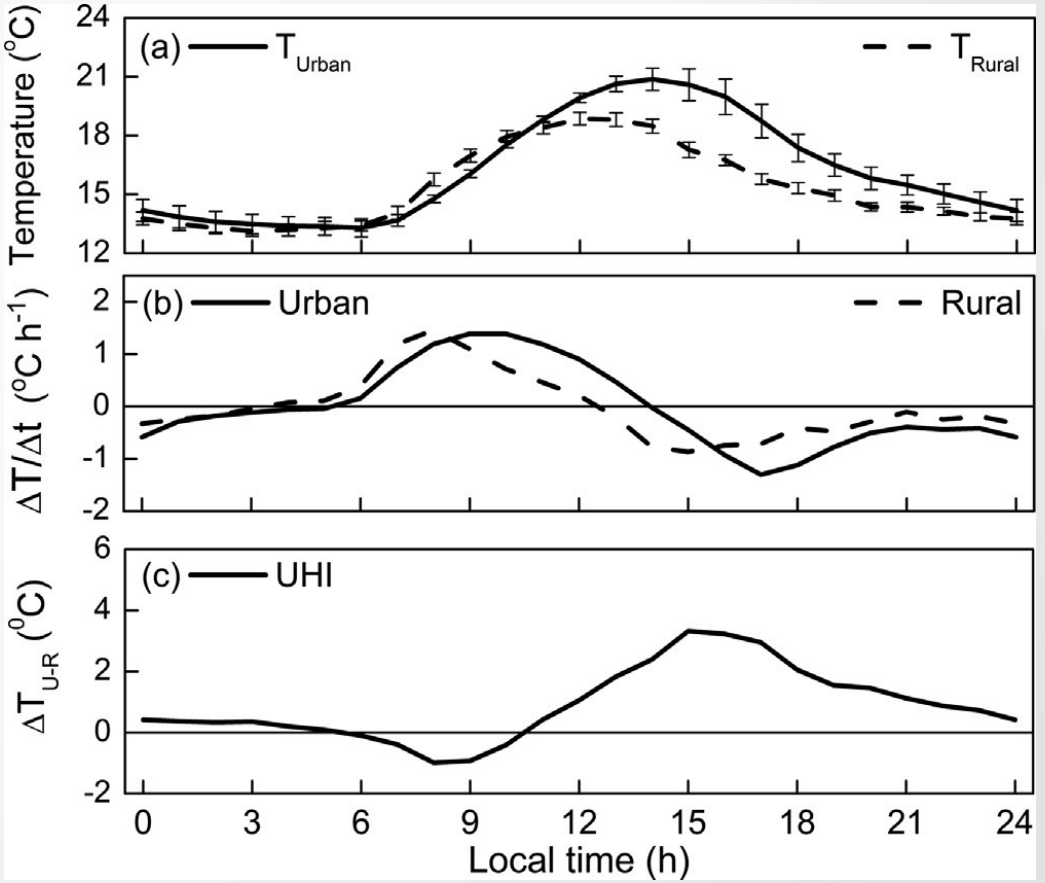




(Figures from Ferreira et al. 2012)

•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)

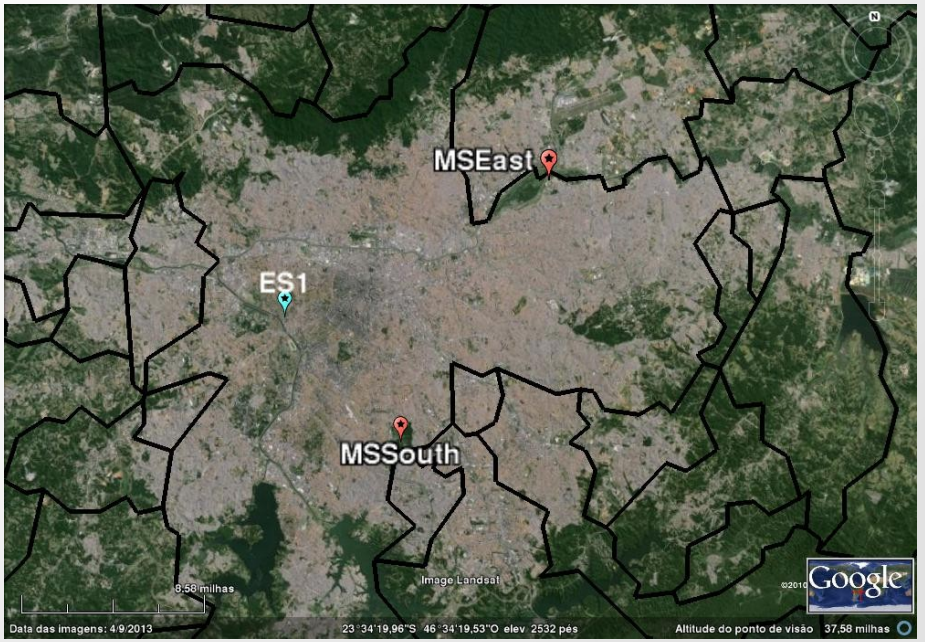
•Main goals

- 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

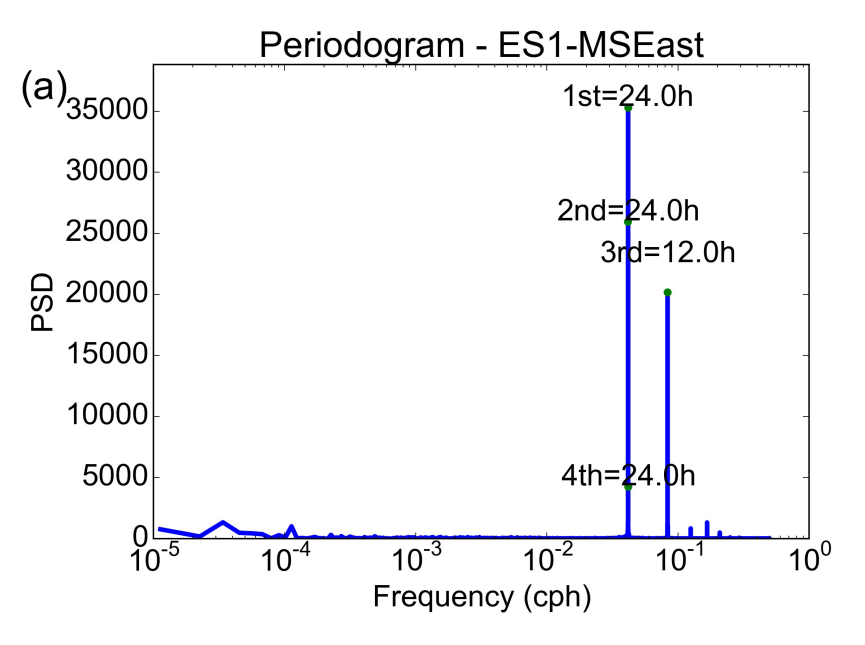
ES1 - Urban site

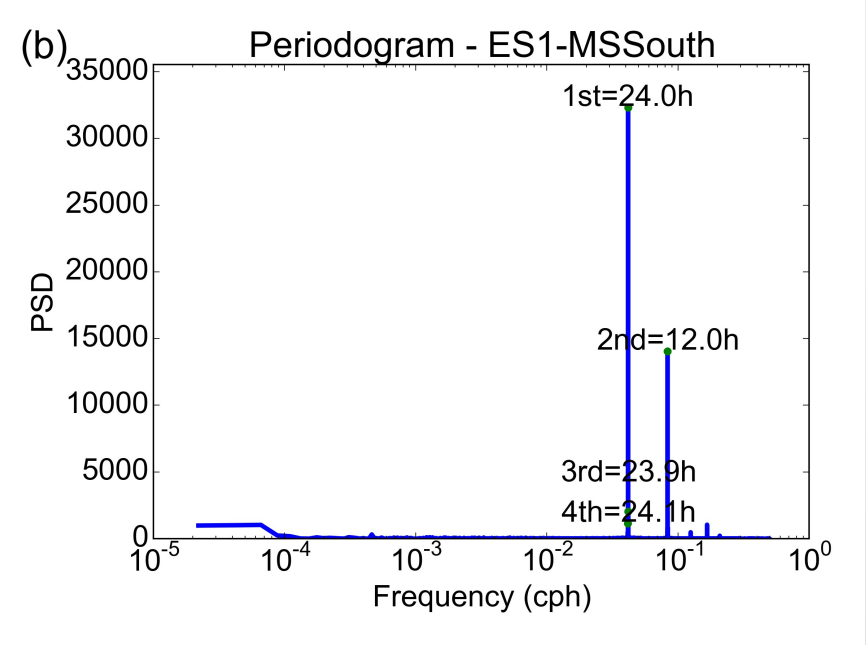
•Methodology and data

- 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

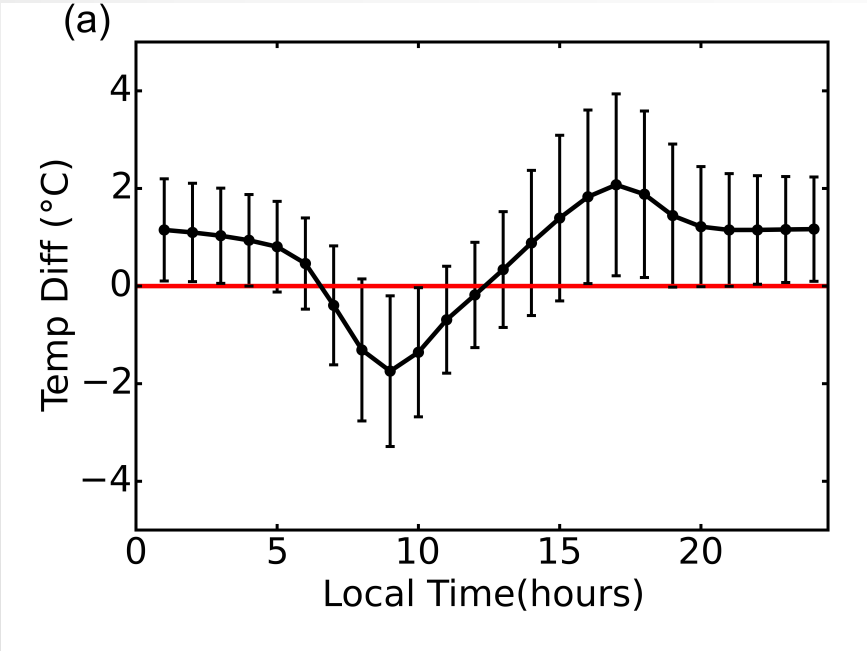
- Most significant periods are 24 h and 12 h.
- Not much contribution of seasonal variations.

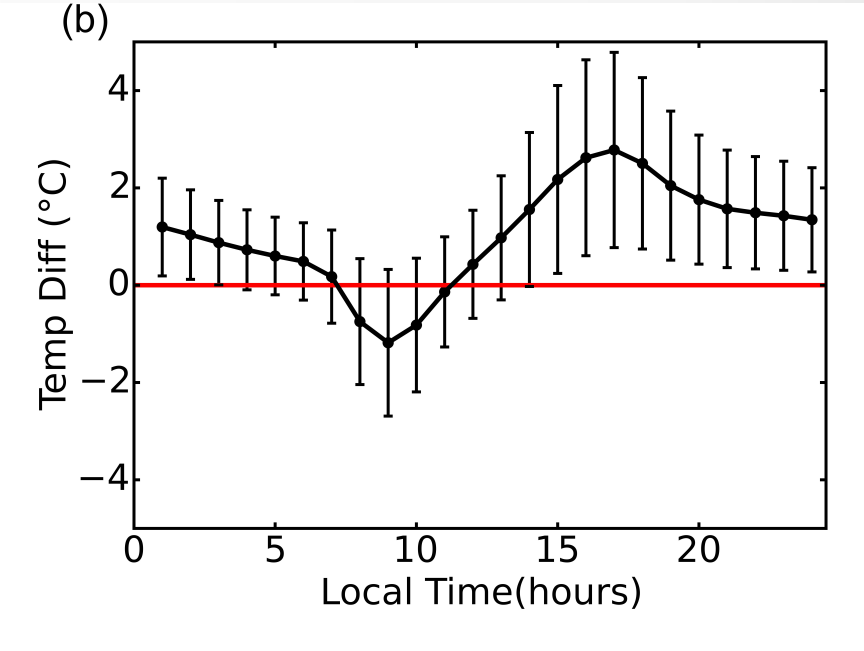




•Results – Diurnal Evolution

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

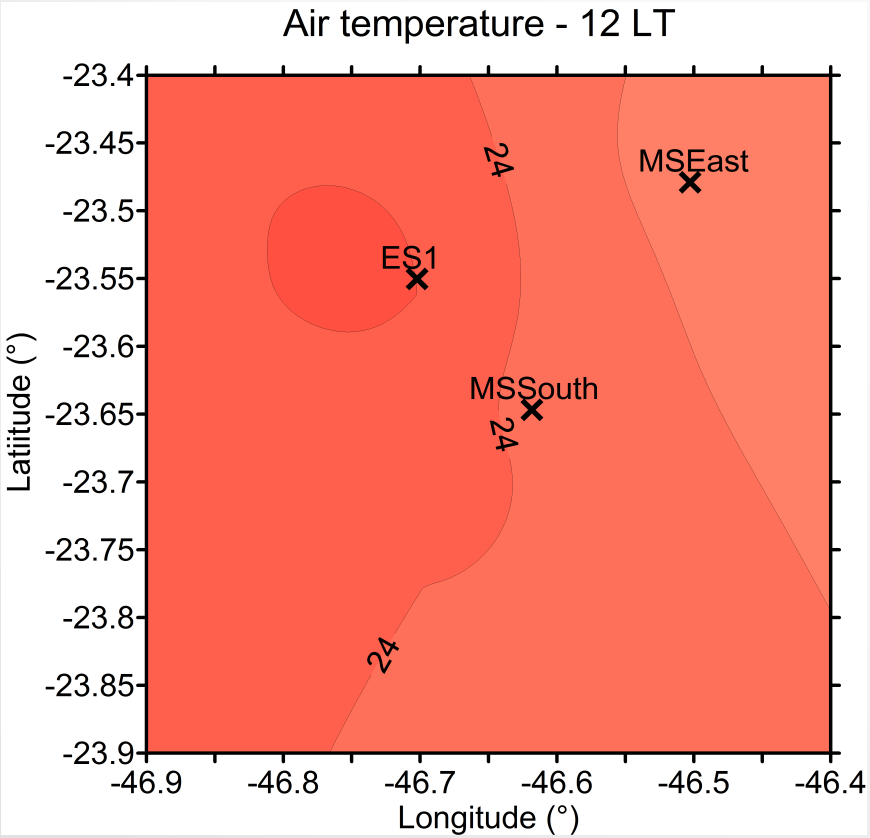


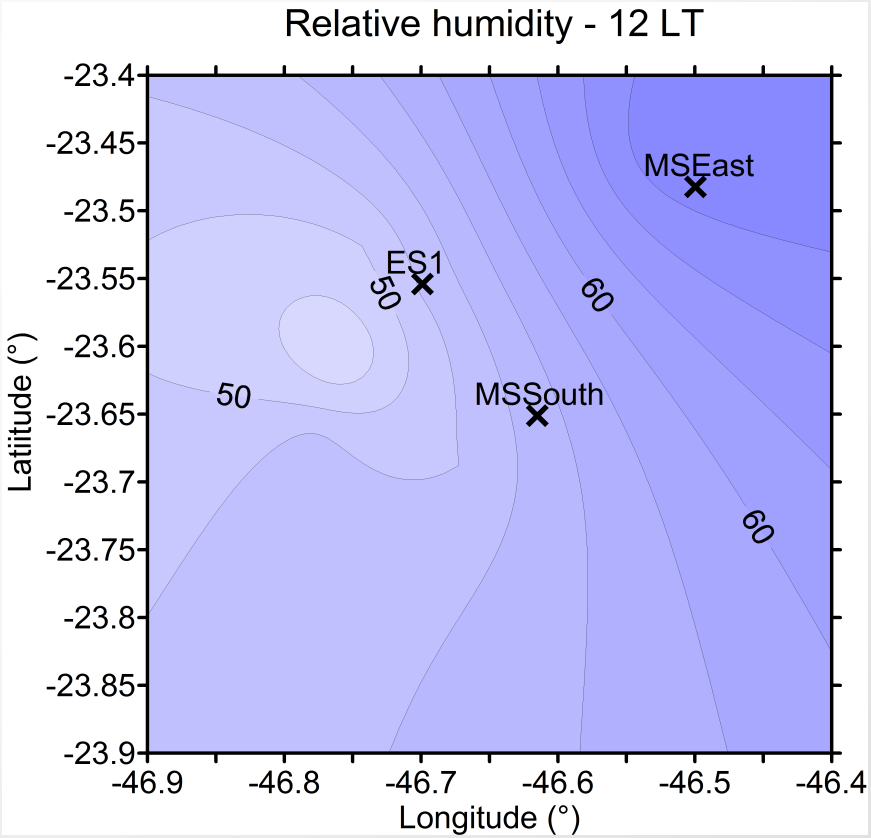


•Results – Sea-breeze

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

Noon (LT)

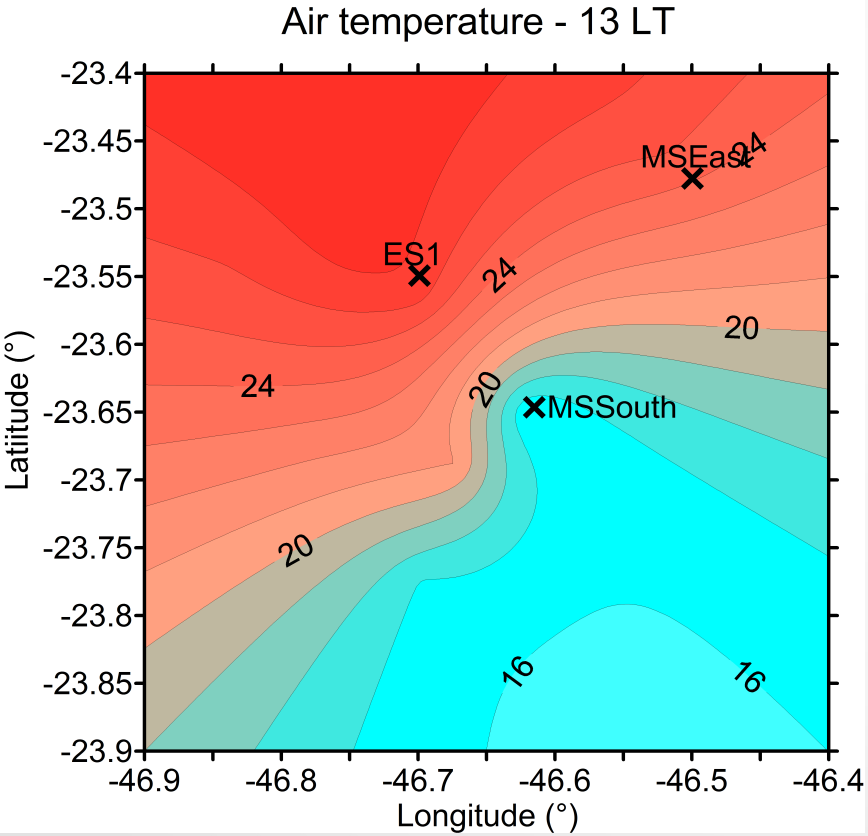


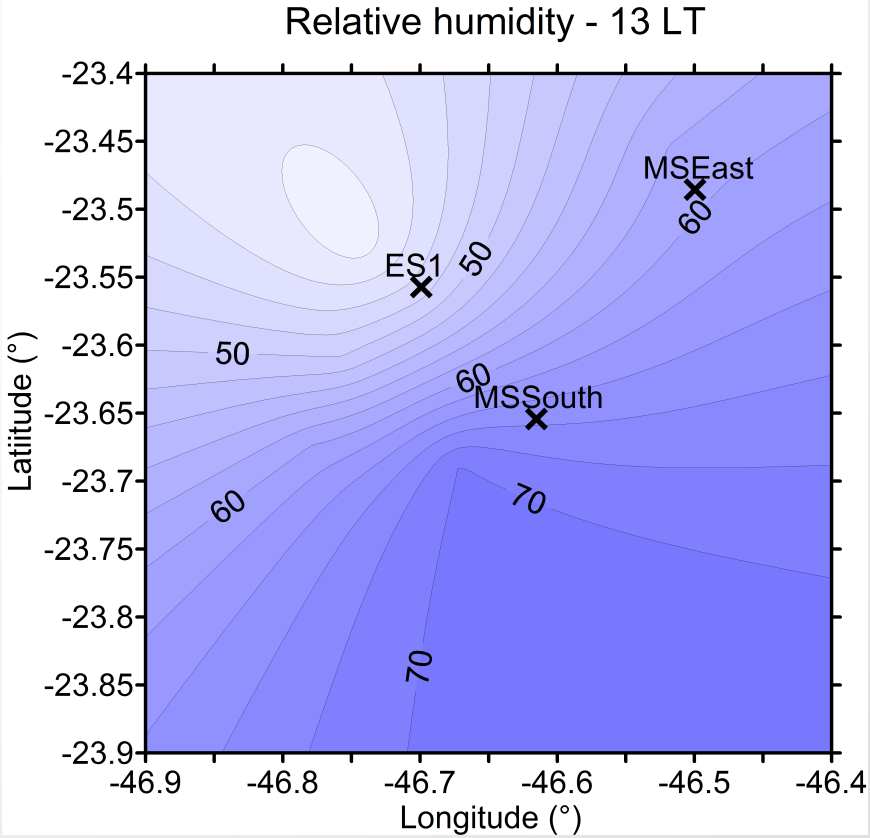


•Results – Sea-breeze

- Case study: August 6th, 2013 – ΔT ~ 10.5 °C

1 pm (LT)

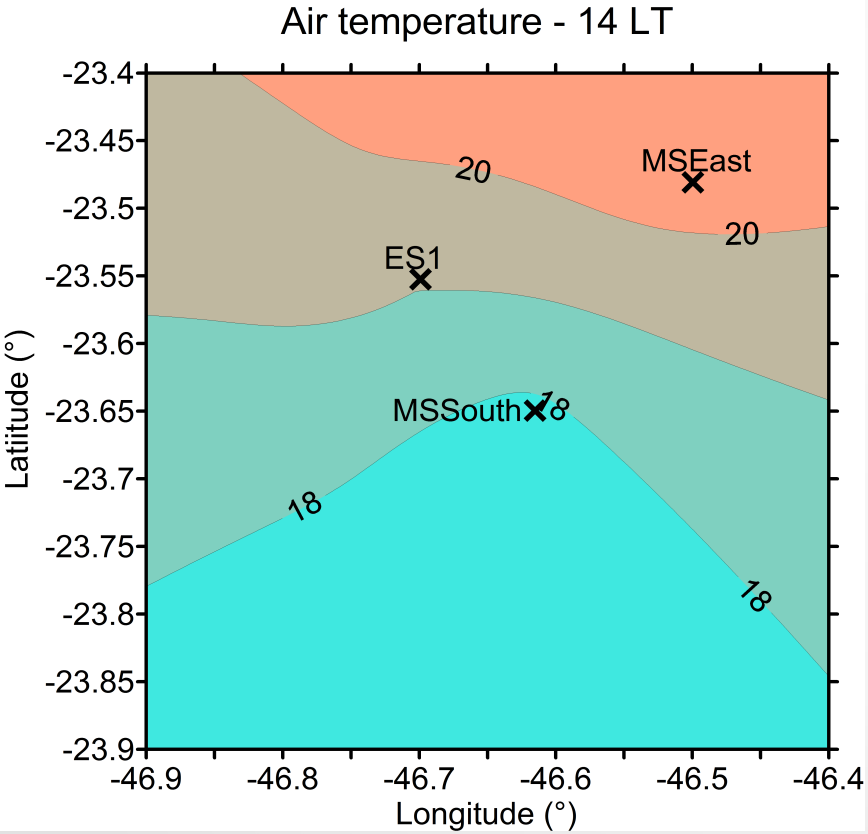


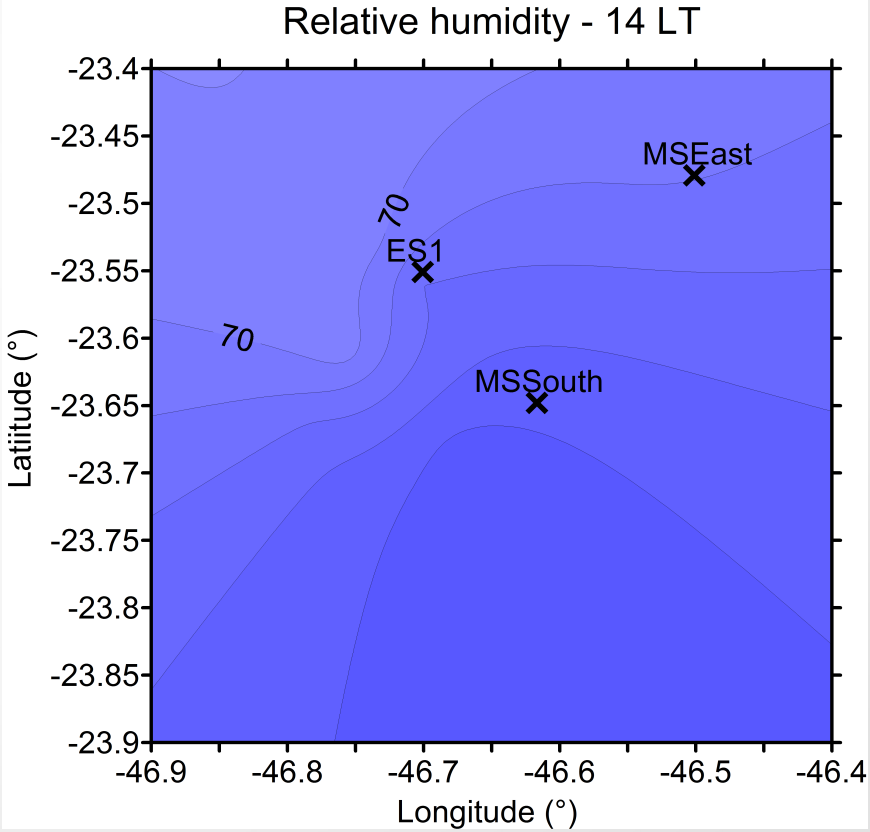


•Results – Sea-breeze

- Case study: August 6th, 2013

2 pm (LT)

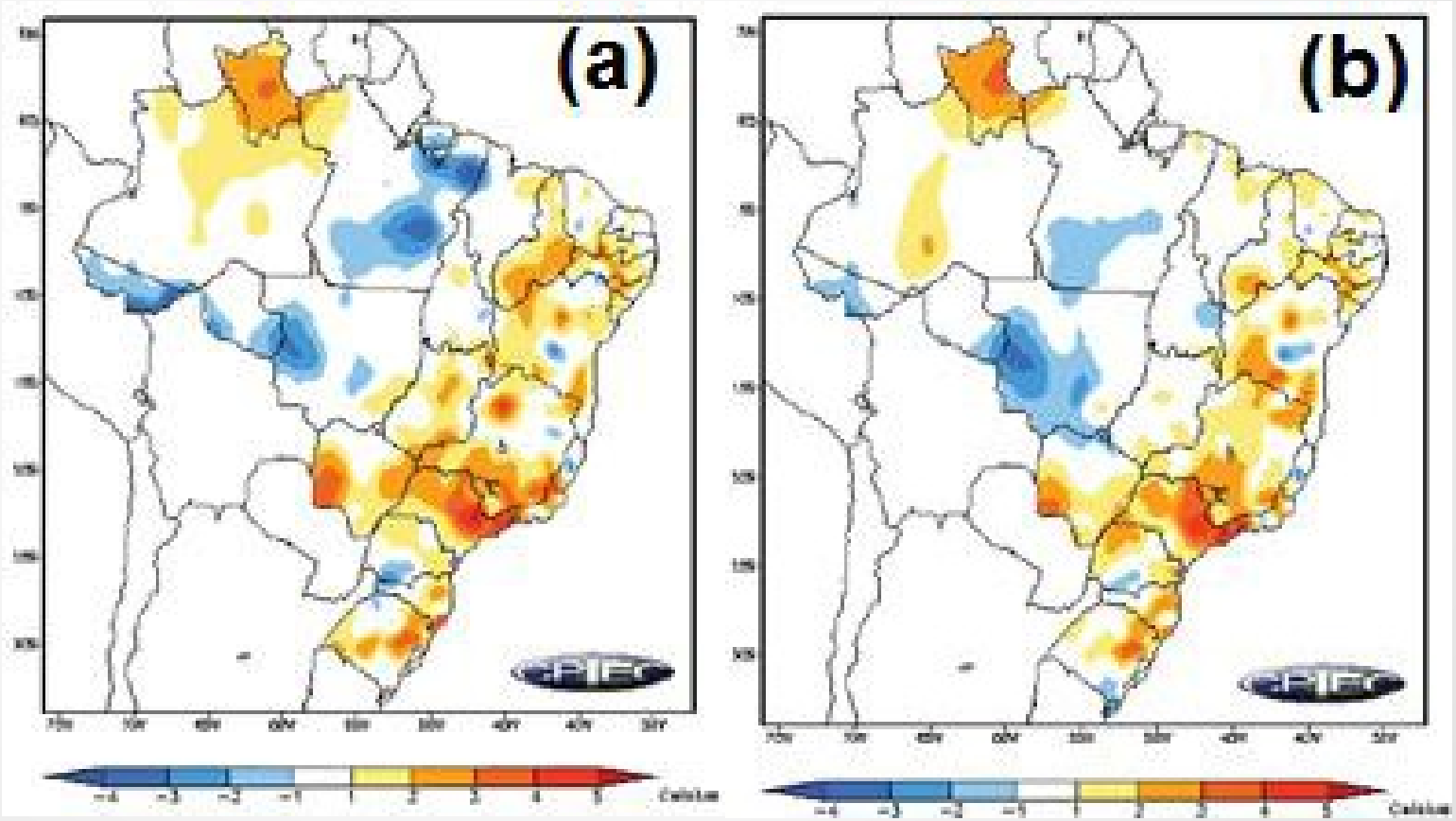




•Results – Warm and Dry Conditions

- Case study: Summer 2013/2014

- High pressure center
- Higher temperatures
- Less precipitation
- Less cloud formation

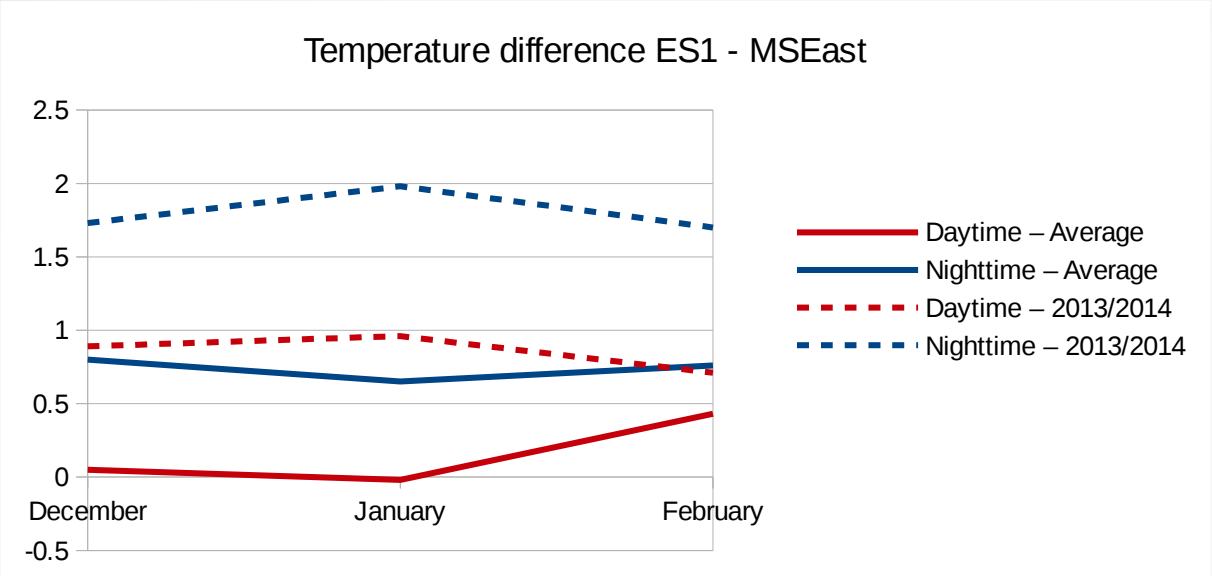


Temperature anomalies for (a) January and (b) February 2014.

(GREC, 2015)

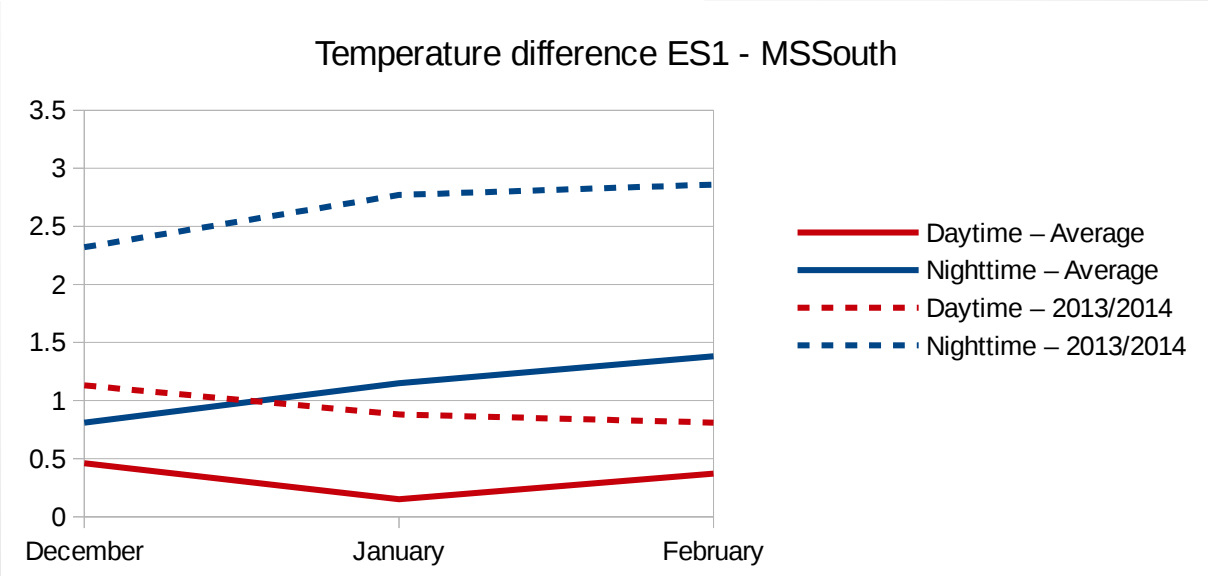
•Results – Warm and Dry Air Mass

- 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).

•References

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Thank you!