Dynamical downscaling of future climate change scenarios in urban heat island and its neighborhood in a Brazilian subtropical area

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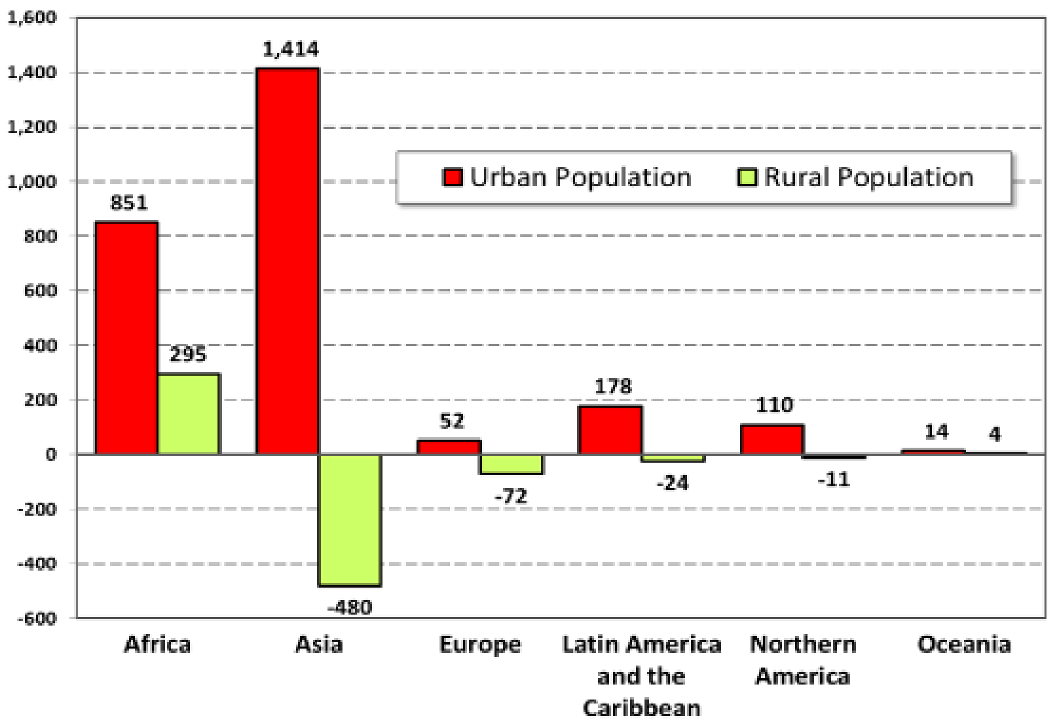
Introduction

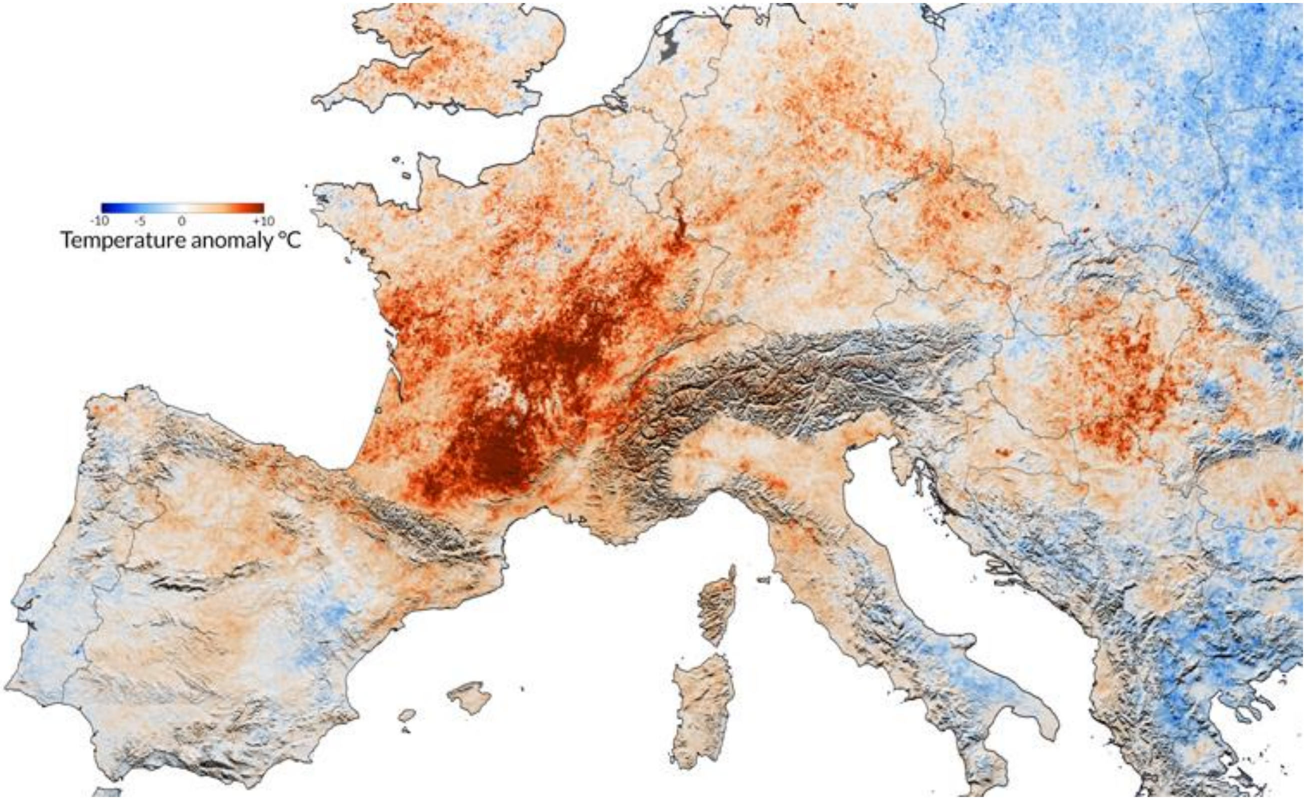
- 50% of world population lives in urban areas.
- And this number is predict to grow



From UN Report (2012)

Introduction

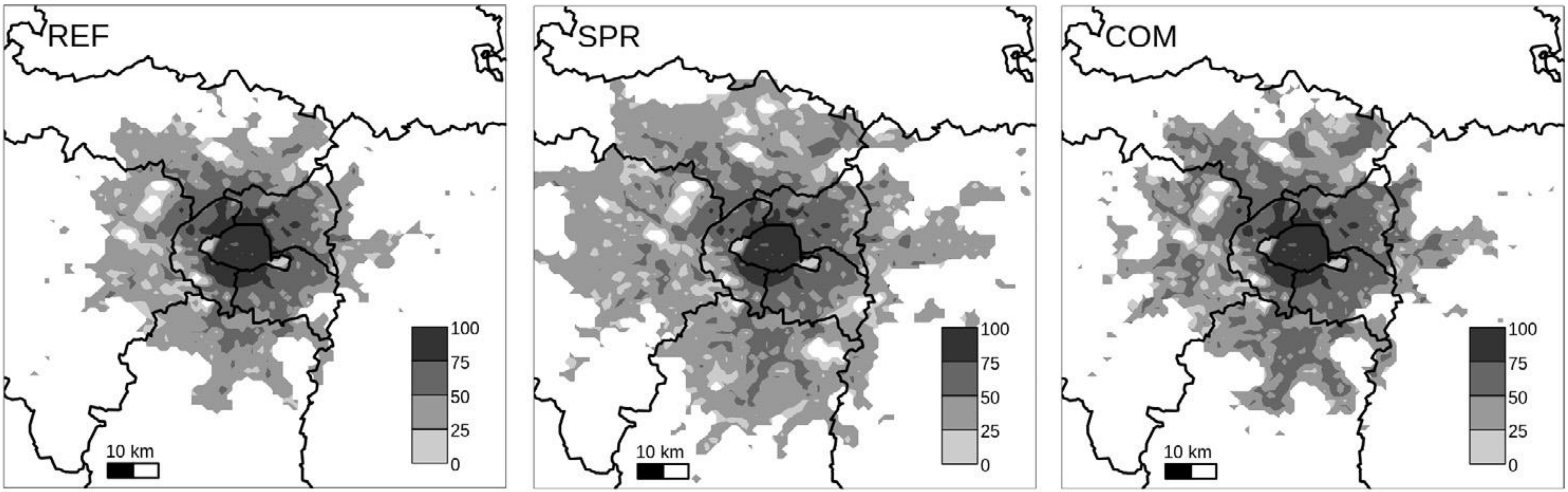
- Extreme events in urban areas
- 2003 heat wave on the west Europe



From Summer (2016)

Introduction

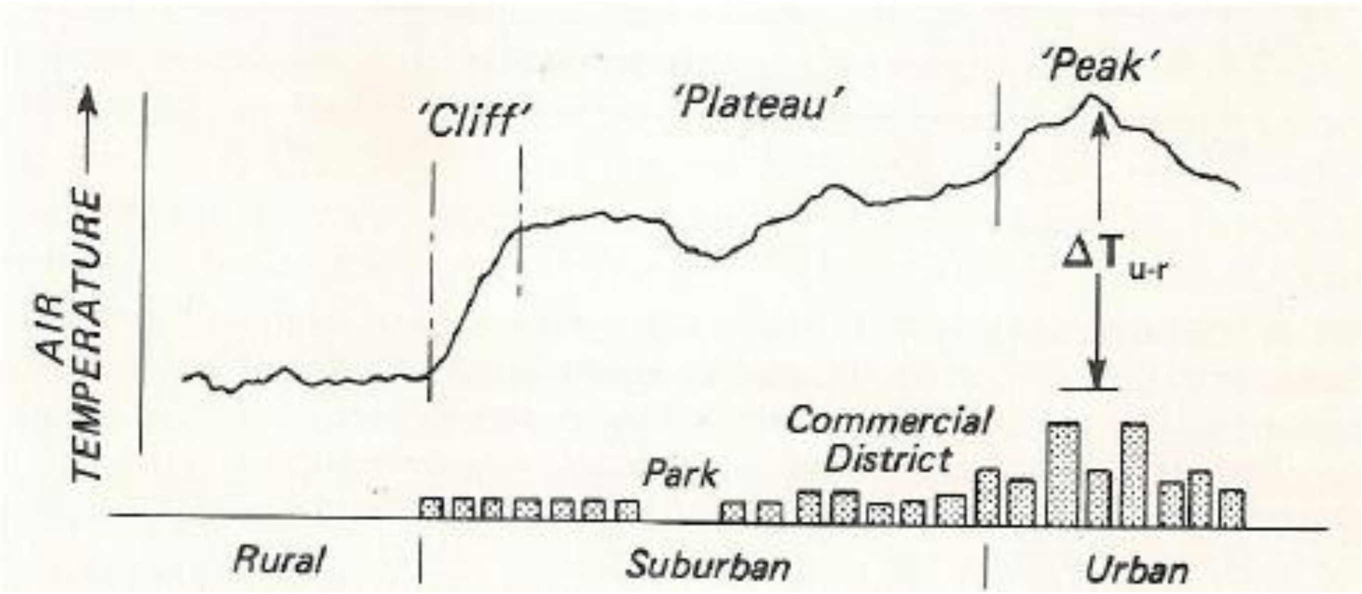
- Urban expansion and urban planning
- Projections
  - Tokyo: increasing the temperature for 4^0C
  - Paris: 1.5 ^{0}C depending on the exposure



Reference, Spread and compact urban expansion projections (Lemonsu et al., 2015)

Introduction

- Urban Heat Island effect: This is a transient feature of urban areas where the air temperature near the surface of the city is higher than the temperature of the surrounding rural areas.



From Oke (1982)

Introduction

- Londrina
  - located in a subtropical region
  - medium sized-city
  - major urban and population growth in recent decades
  - more than 500 thousands inhabitants

- Daytime UHI intensity in Londrina is about 2 ^{0}C for a summer period.

Introduction

- *Objective*

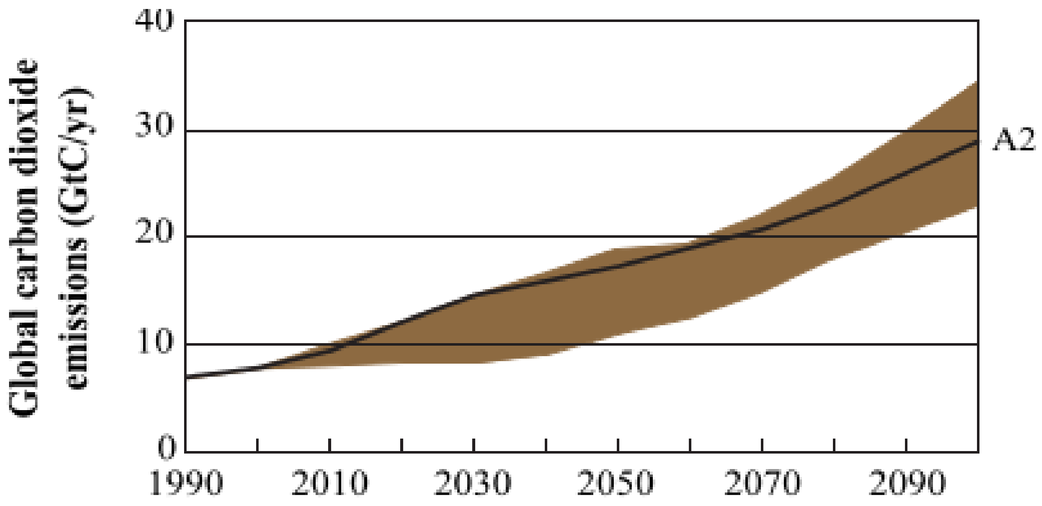
  - To investigate the physics in the UHI formation and intensity on the most extremes future climate change scenarios from the IPCC, A2 and B1.

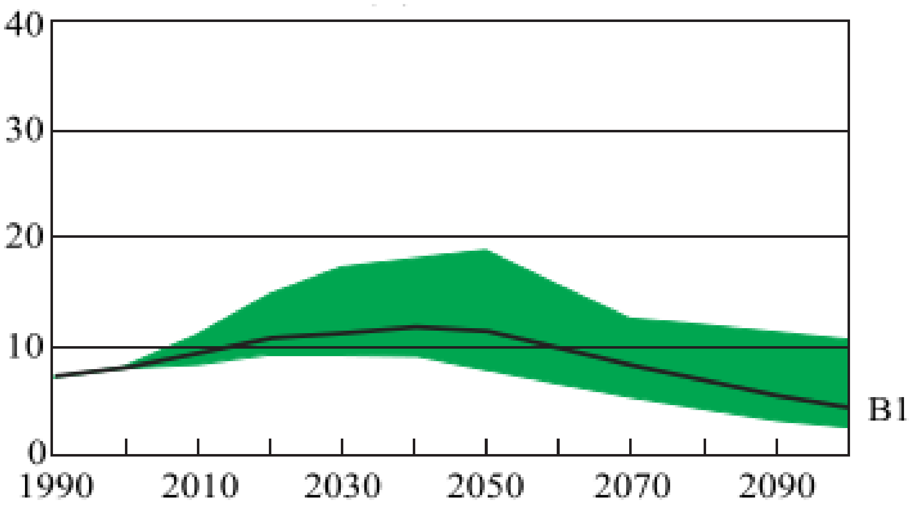
Methodology

- SRES (Special Report on Emission Scenarios - IPCC)
  - describes a series of future scenarios
  - based in different factors that can influence the emissions
    - demography, technology and economy.
  - These scenarios uses a variety of possibilities based on global development,
    - CO_2 sources and sinks,
    - greenhouses gases
    - alternative sources of energy
    - soil land use changes

Methodology

- In this work, opposite scenarios:
  - A2: pessimist
  - B1: optimist



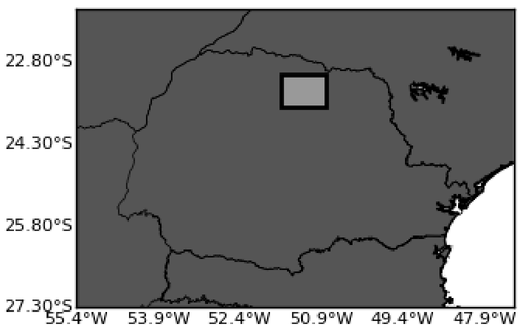


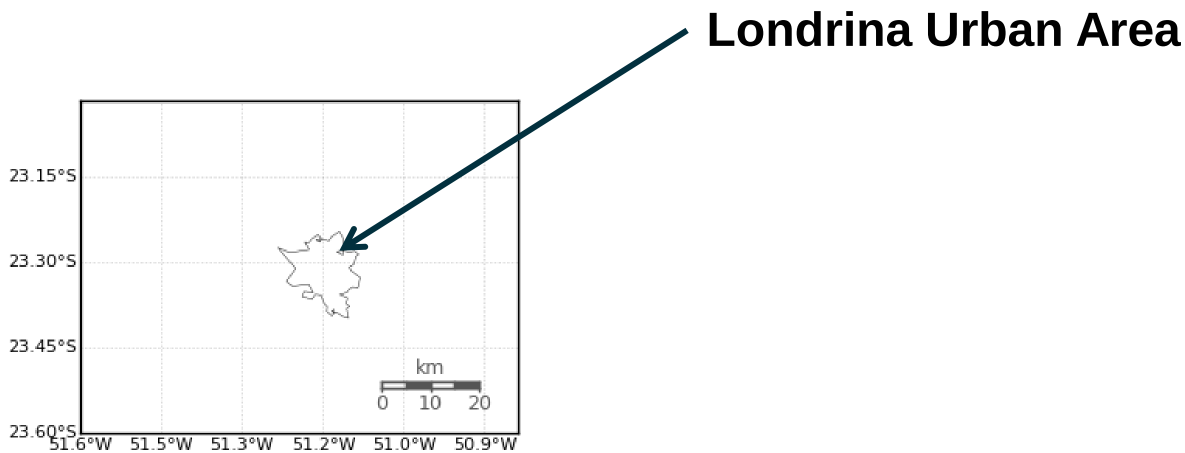
From Nakicenovic (2000)

Methodology

- Numerical Modeling:
  - Weather Research and Forecast atmospheric model (WRF - Version 3.6.1)
    - three nesting grids
    - horizontal homogeneous spacing grid (9, 3 and 1 km)
    - centered in Londrina city (-23.3^0, -51.1^0)
    - from July, 21th to July 25th, 2015 - winter period, with no clouds or rain condition (considered a projection for the IPCC climate scenarios)

Methodology





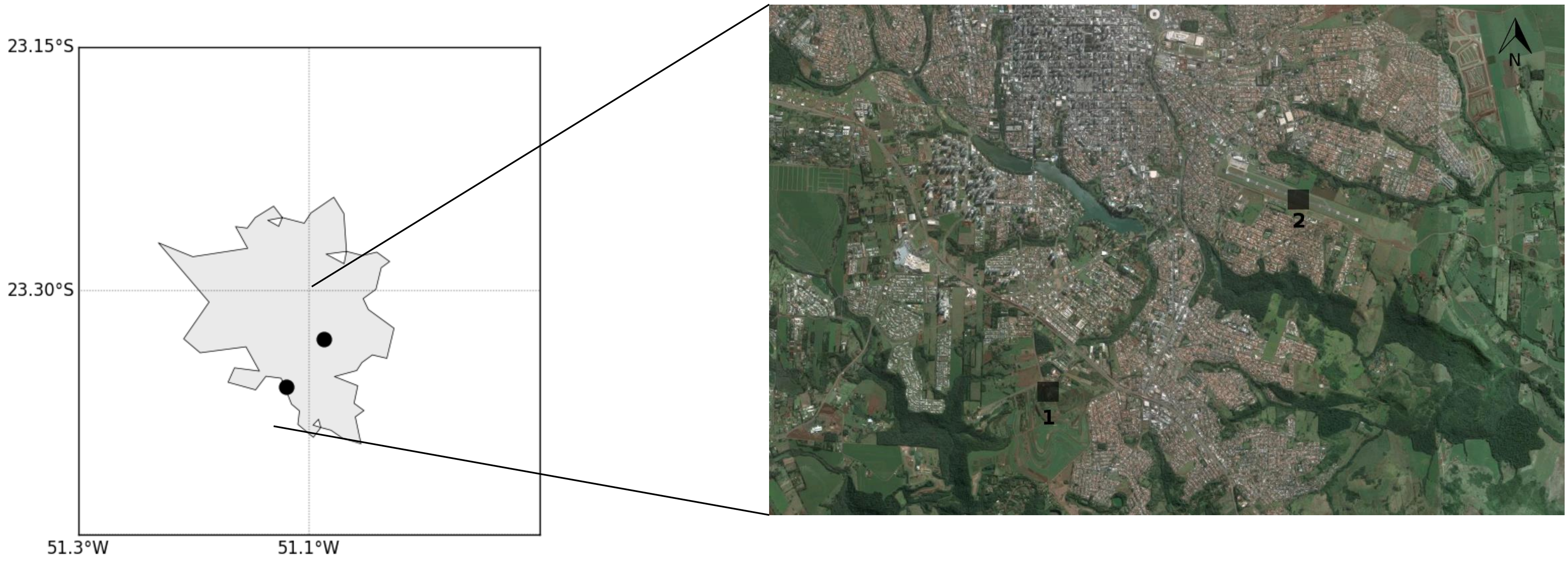
Physics	Schemes
Microphysics	Kessler Scheme
Cumulus	Grell-Freitas
Surface Layer	MM5
Soil-Land	Noah LSM
Urban	UCM
Boundary Layer	Yonsei Scheme
Shortwave Radiation	Dudhia
Longwave Radiation	RRTM

Table 1 – Physical Parameterisation in WRF simulation

Results

- Evaluation of the model: Temperature and specific humidity at 2m.
  - Two surface station for observational data

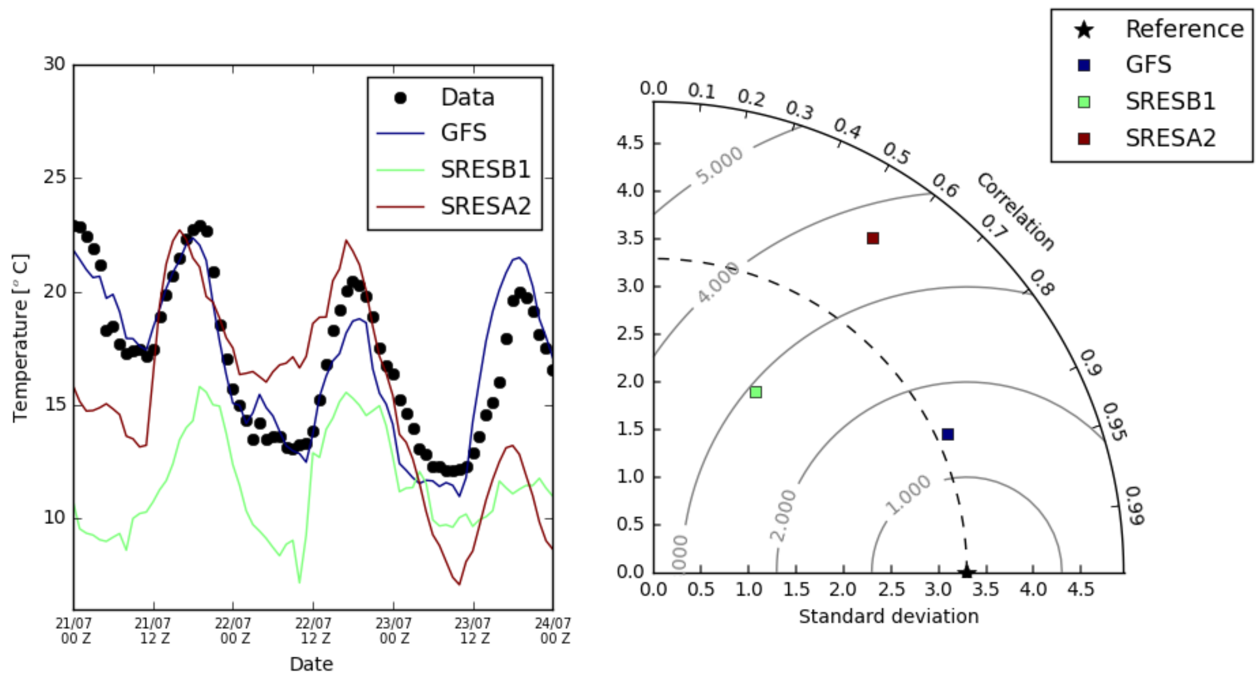
1. SIMEPAR (-23.36^0, -51.1647^0)
2. METAR (-23.33^0, -51.14^0)



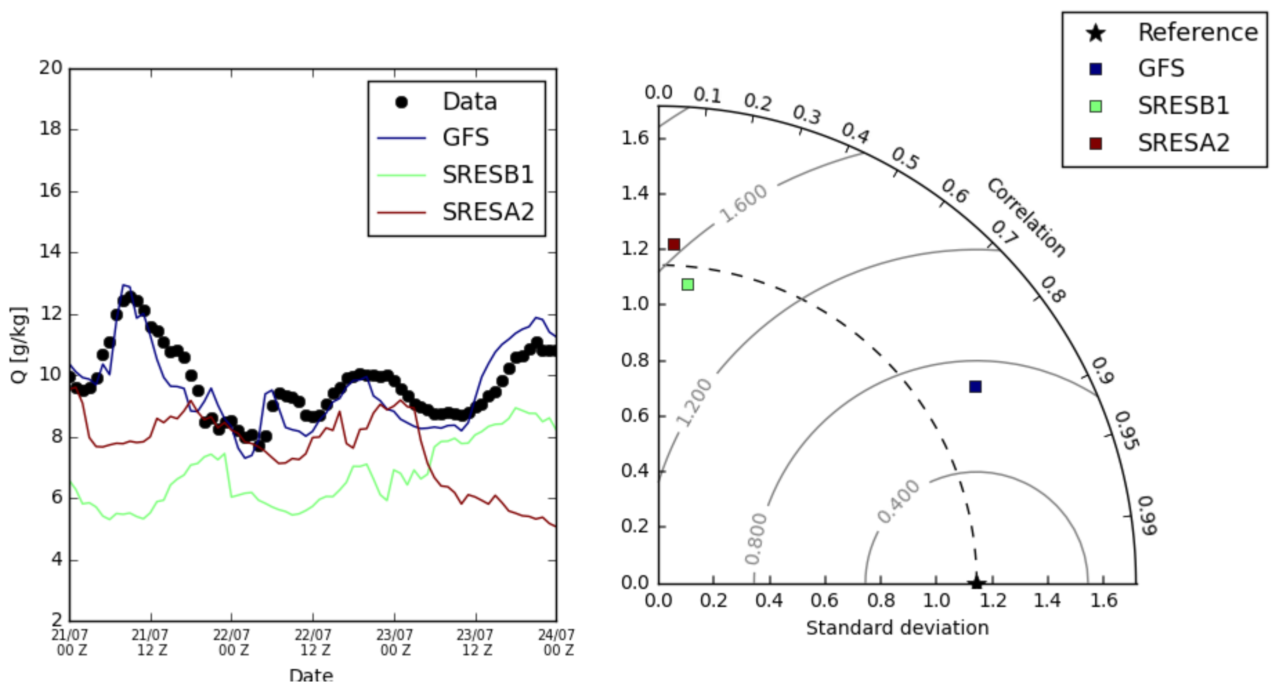
Results

- SIMEPAR

Temperature at 2 m



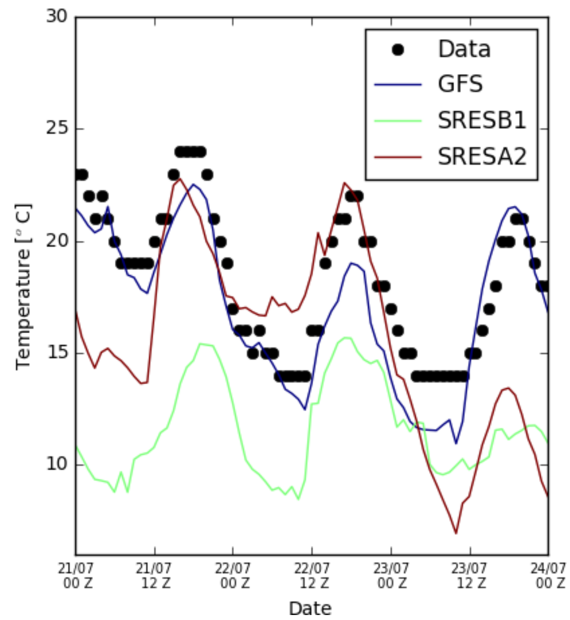
Specific humidity at 2 m

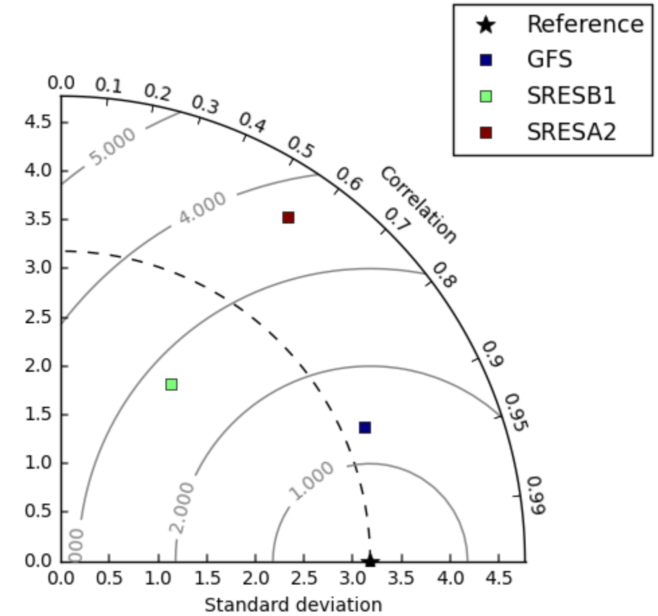


Results

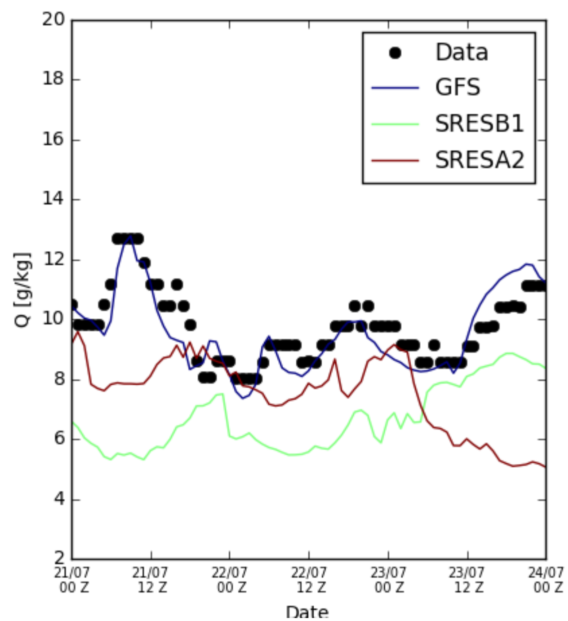
- METAR

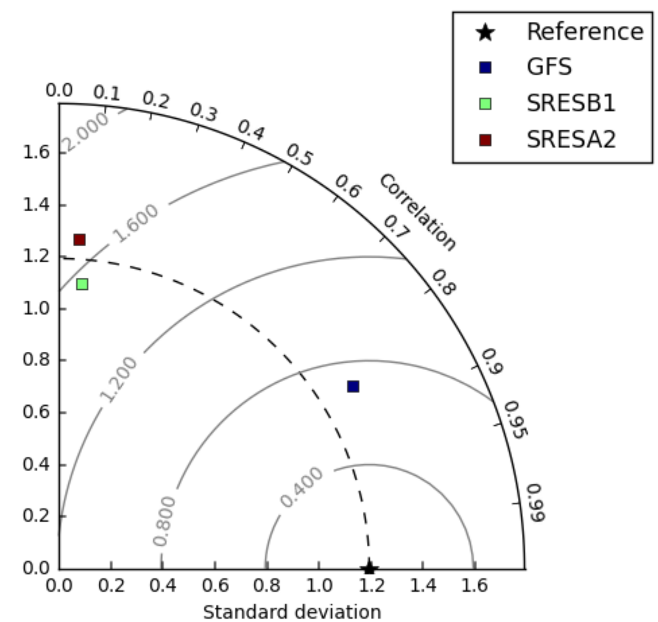
Temperature at 2 m





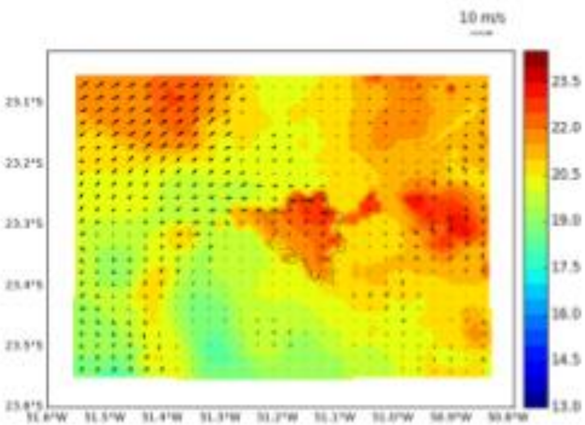
Specific humidity at 2 m*



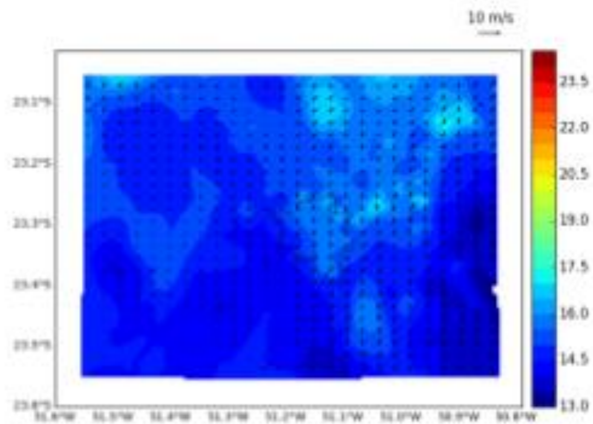


*For METAR, the specific humidity was calculated from the dew point temperature and Clausius-Clapeyron equation.

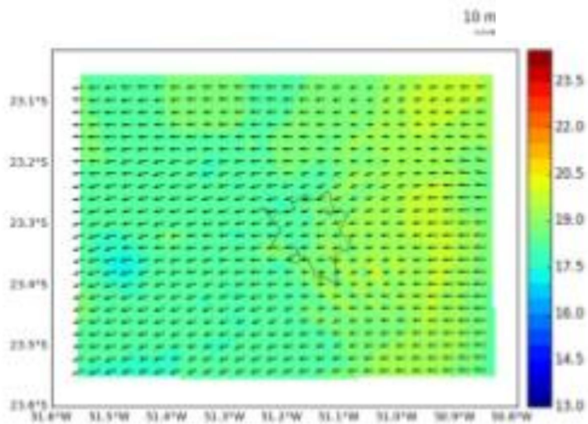
Results



SRESA2



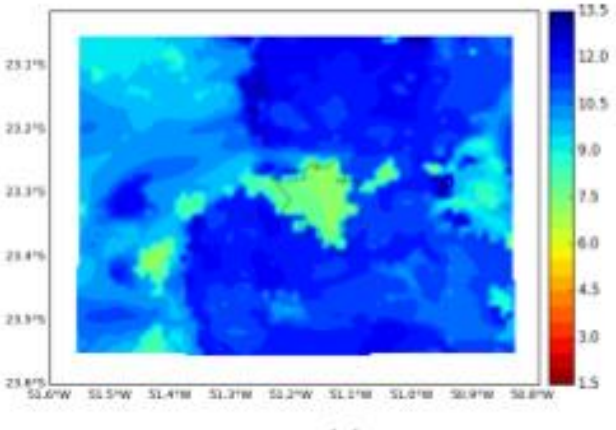
SRESB1



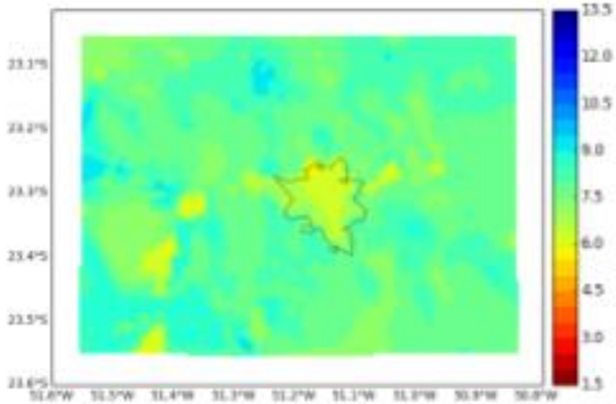
GFS

- 18 Z at 22 July – 2015
  - $\Delta T_{GFS} = 0.5\ ^{o}C$
  - $\Delta T_{SRESA2} = 1.0\ ^{o}C$
  - $\Delta T_{SRESB1} = 2.0\ ^{o}C$
- The wind pattern:
  - SRESB1: south wind
  - SRESA2: west wind
  - GFS: east wind

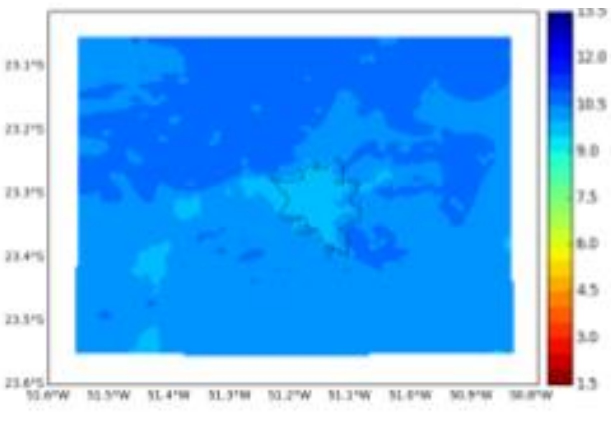
Results



SRESA2



SRESB1



GFS

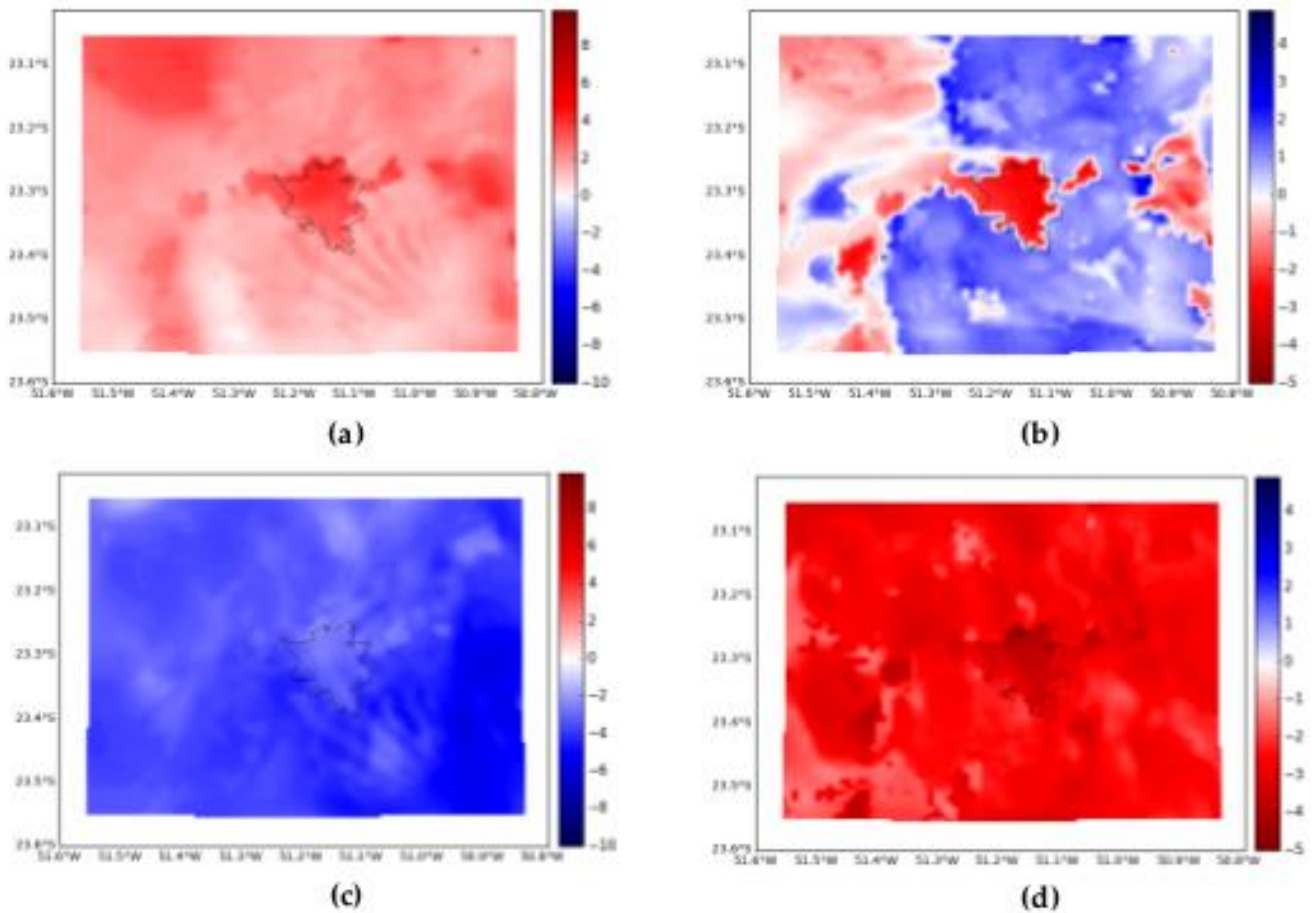
- 18 Z at 22 July – 2015
- Urban Area
  - q_{GFS} = 9.0 g/kg
  - q_{SRESA2} = 7.5 g/kg
  - q_{SRESB1} = 5.5 g/kg

Results

Temperature difference | Specific humidity difference

SRESA2-GFS

SRESB1-GFS



Discussions and Conclusion

- Considering evaluation indexes:
  - temperature at 2 m GFS simulation ≈ SRESA2 simulation
  - specific humidity at 2 m GFS simulation ≈ SRESA2 simulation
  - SRESA2 closer to GFS than SRESB1.
    - Ex.: peak of temperature at 22 th July at 15 Z → temperature values from SRESA2 are closer to than SRESB1 temperature values.

Discussions and Conclusion

- UHI in Londrina urban area in SRESA2 was similar to GFS simulation
  - SRESB1 drier than SRESA2/GFS → influence on the energy budget at surface, confirming the high intensity of the UHI for SRESB1 simulation.

- The decrease on humidity affects directly the formation and the intensity of UHI
  - The higher value in SRESA2 affects the wind pattern at local scale
    - Can influence pollutants dispersion.
    - Greater convergence at urban area can configure a maintenance of high levels of poor air quality.

- The dynamical downscaling of future scenarios is an important tool to analyses the impact of it in a local scale.

Discussions and Conclusion

- Further research...
  - to carry out future simulations (for 2020, 2030, 2040 and 2050), using future projections of urban land use and occupation based on the population and economic projections to study the evolution of UHI in Londrina city.
  - Simulations using the chemical version of the model will also be performed based on projections of vehicle use and industrial emissions.

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