

PROGRAM MCITY BRAZIL



São Paulo - SP

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Objective

To assess the urban effects on the climate of major Brazilian cities and to systematize this procedure of investigation to be extended to other urban areas in Brazil.

BRAZILIAN RESEARCH INSTITUTIONS

- **University of *São Paulo* (USP)**
- State University of *São Paulo* (UNESP)
- Institute of Nuclear Energy Research (IPEN)
- **Federal University of *Rio de Janeiro* (UFRJ)**
- Federal Rural University of *Rio de Janeiro* (URFRJ)
- Federal University of *Minas Gerais* (UFMG)
- Federal University of *Espirito Santo* (UFES)

INTERNATIONAL COLLABORATION

Primoz Mlakar and Marija Boznar (MEIS, Slovenia)

Bob Bornstein (SJSU, USA)

Júlia Hidalgo (Meteo-France, France)

Motivation

In 2020 more than 90% of Brazilian population will be living in urban areas (85% in 2010).

Most of the Brazilian cities are facing environmental problems that may aggravate if the IPCC predictions are confirmed.

There is limited scientific knowledge of urban effects on climate to support any reasonable action from local authorities to mitigate the environmental problems in urban areas.

URBAN FLUX NETWORK (2012)

 URBAN
FLUX
NETWORK

| Feedback | Add a new site

June 6, 2012: The latest issue of the Fluxnet Newsletter features the Urban Flux Network.

Sites directory

Basel	E C	□ □		
Sperrstrasse	□	C	□	□
Beijing	E	C	A	T
Institute of Atmospheric Physics	□	C	□	□
Berlin	□	C	□	□
Steglitzer Kreisel	□	C	□	□
Chicago	□	C	□	□
Dunning	□	C	□	□
Denver	E	C	□	T
South Denver	□	C	□	□
Dublin	E	C	□	□
Marrowbone Lane	□	C	□	□
Edinburgh	□	C	□	□
Nelson Monument	□	C	□	□
Essen	□	C	□	□
Grugapark	□	C	□	□
Florence	E	C	A	T
Fire Station	□	C	□	□

Interactive Map - Click on markers to display site details



Map Satellite Terrain

TERMS OF USE

This database is provided by the International Association for Urban C
Hosted by the Department of Geography, University of British Co

Legend:

- Energy Balance
- Carbon Dioxide Fluxes
- Aerosol Fluxes
- Other Trace Gas Fluxes

• Active site
• Inactive / past site

ANTHROPOGENIC HEAT IN SÃO PAULO

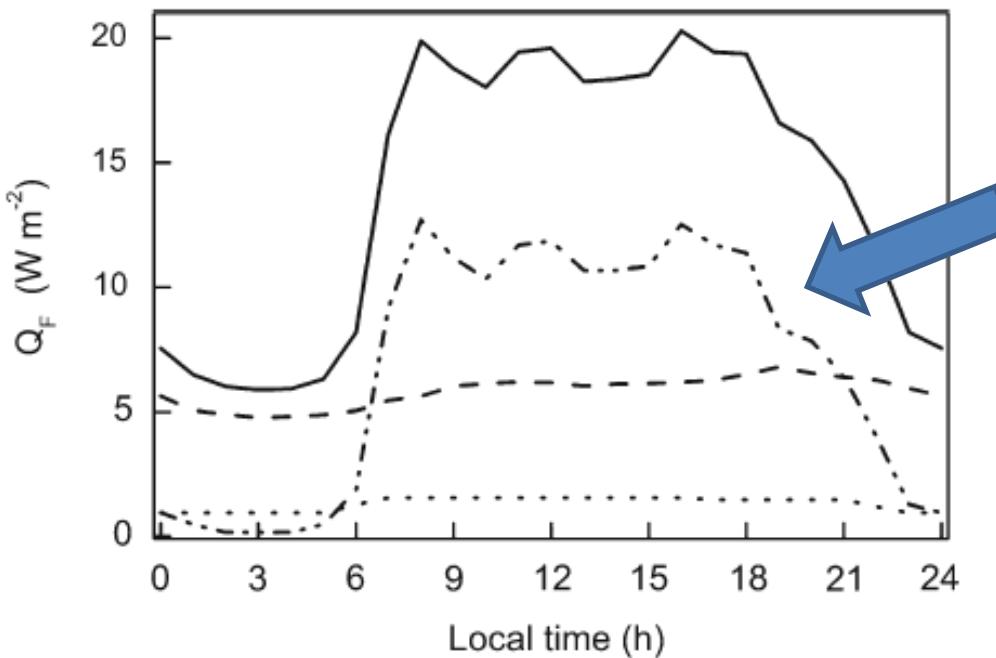
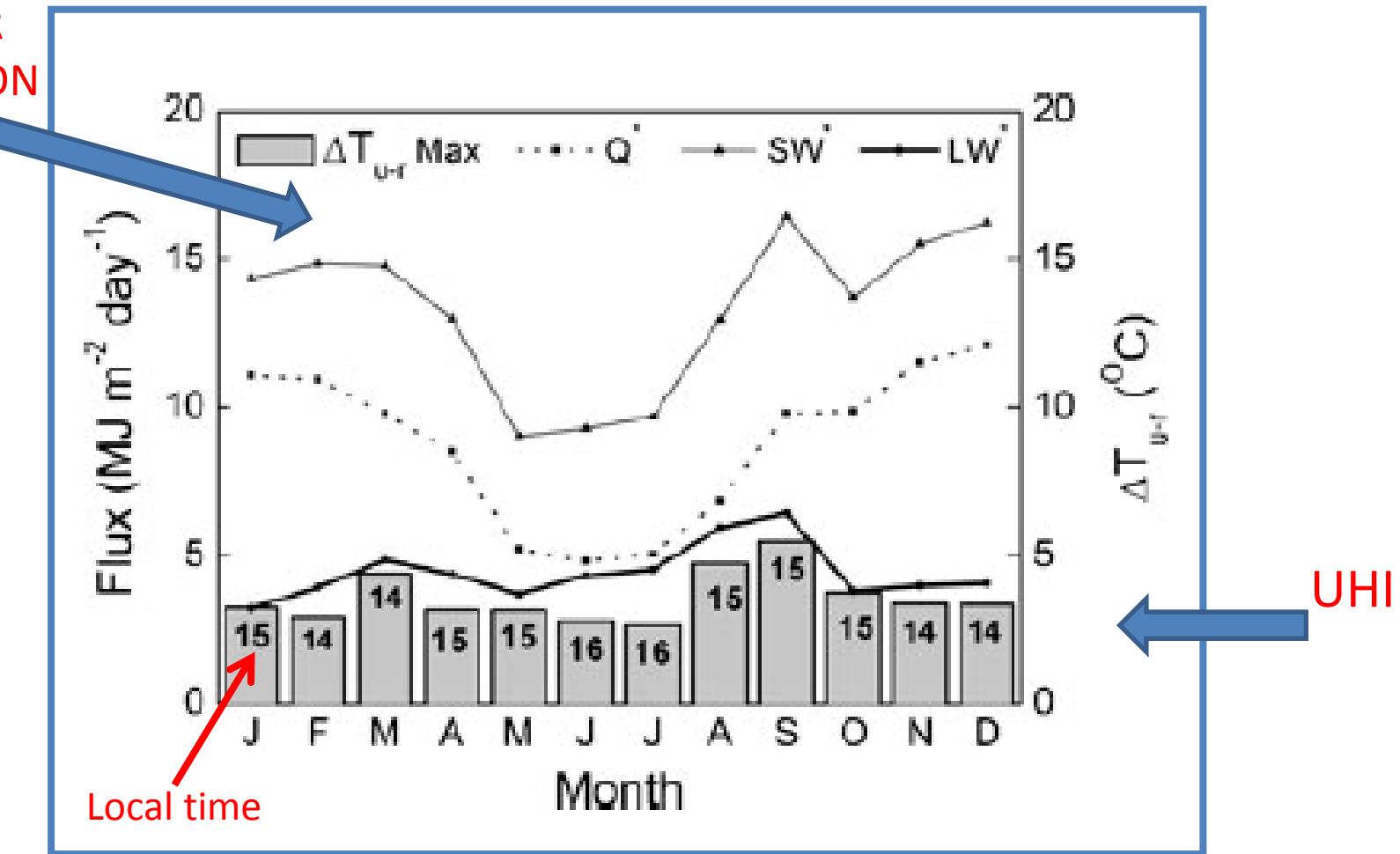


Fig. 6 Diurnal evolution of the anthropogenic energy flux (Q_F) associated with vehicular sources (dashed dotted line), stationary sources (dashed line), human metabolism (dotted line), and total (solid line) for winter (August) in 2007

Ferreira, M.J., Oliveira, A.P. and Soares J., 2011. Anthropogenic heat in the City of São Paulo, Brazil. *Theoretical and Applied Climatology*, **104**, 43-56.

UHI SÃO PAULO: DAYTIME MAXIMUM

NET SOLAR
RADIANTION



Ferreira, M.J., Oliveira, A.P., Soares, J., Codato, G., Bárbaro, E.W., and Escobedo, J. F., 2012: **Radiation balance at the surface in the City of São Paulo, Brazil. Diurnal and seasonal variations.** *Theoretical and Applied Climatology*. 107 (1), 229-246.

ENERGY BALANCE IN SÃO PAULO

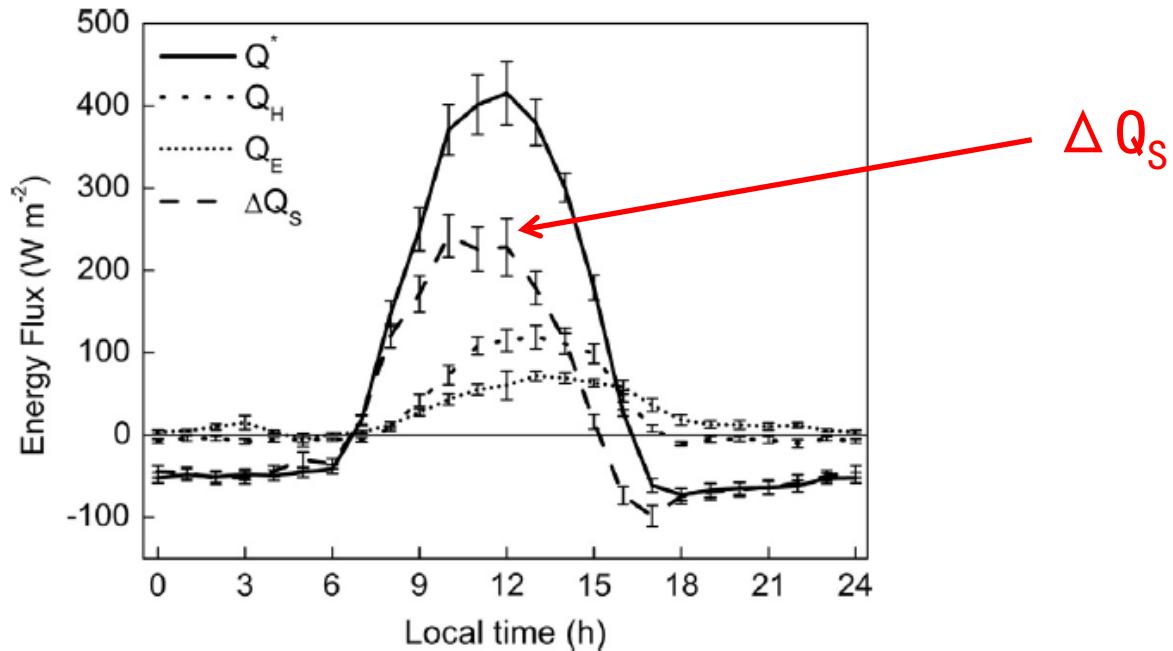


Fig. 4. Diurnal evolution of the main components of the surface energy balance in the city of São Paulo. Average hourly values based on observations carried out during May 18 to June 17 of 2009 at urban Site 1 of Fig. 2. The Q^* is the net all-wave radiation flux, Q_H is the sensible heat flux, Q_E is the latent heat flux and ΔQ_S is the storage energy flux. The vertical bars indicate the statistical error.

Ferreira, M.J., Oliveira, A.P., Soares, J., 2013: **Diurnal variation in stored energy flux in São Paulo city, Brazil.** *Urban Climate*. (DOI:10.1016/j.uclim.2013.06.001).

MCITY BRAZIL CHALLENGES

OBSERVATIONAL (LONG TERM AND SPATIAL REPRESENTATIVENESS)

1. SURFACE ENERGY AND RADIATION BUDGET
2. URBAN HEAT AND COOL ISLANDS
3. URBAN BOUNDARY LAYER

MCITY BRAZIL CHALLENGES

MODELING (SCIENTIFIC INVESTIGATIONS AND OPERATIONALLY)

1. WRF (UHI, UCI, URBAN BOUNDARY LAYER)
2. LANDUSE INVENTORY (BUILDING INFORMATION)

STARTING POINT METROPOLITAN REGIONS OF SÃO PAULO AND RIO DE JANEIRO CITIES

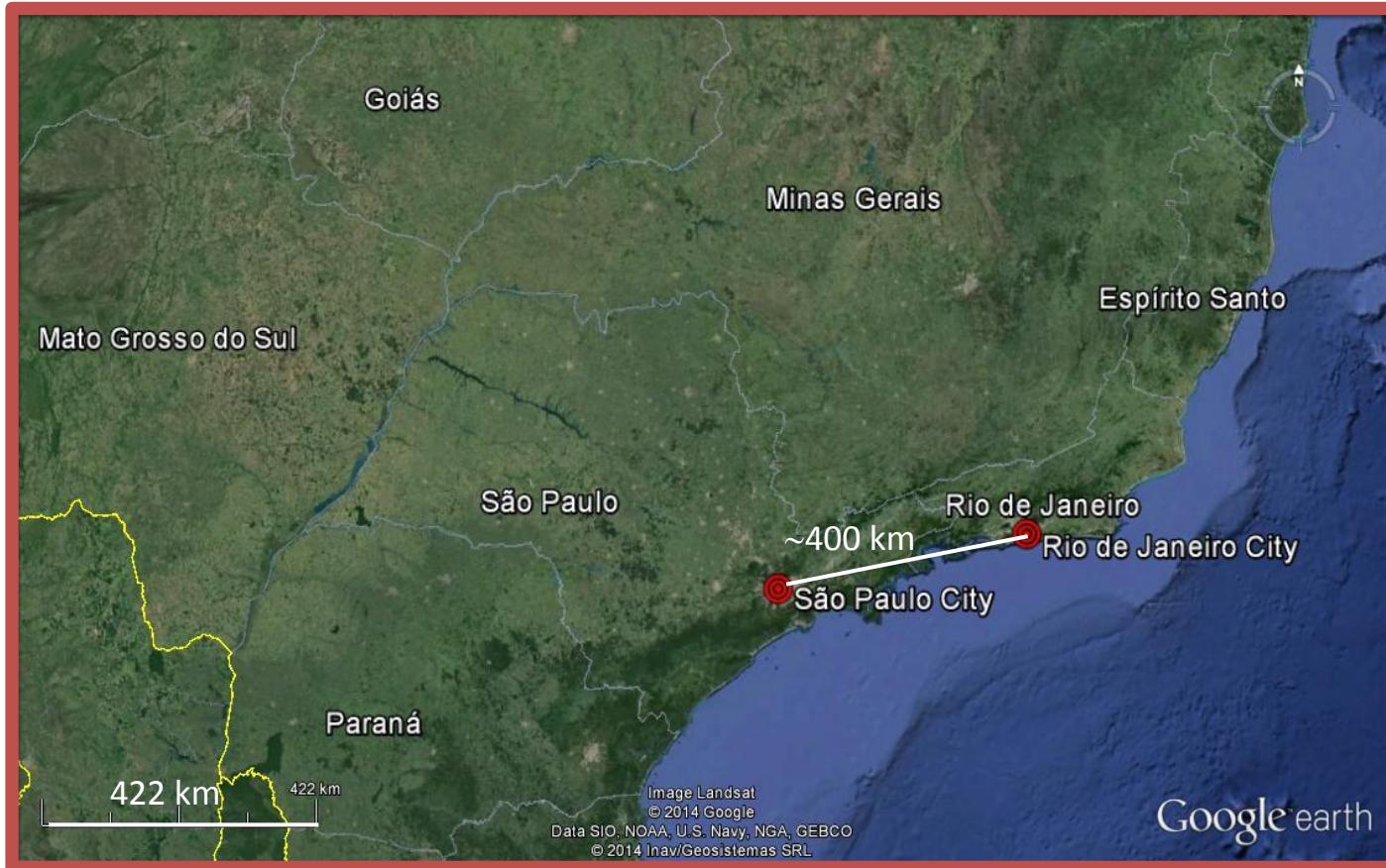
METROPOLITAN REGIONS OF SOUTHEAST STATES OF BRAZIL				
Description	São Paulo	Rio de Janeiro	Belo Horizonte	Vitória
Number of cities	38	20	34	7
Area (km ²)	7.944	5.682	9.468	2.318
Population*	19.672.582	11.875.063	5.152.217	1.685.384
Vehicles**	6.900.000	3.630.678	1.880.608	502.022

Source: (*) IBGE (2013); (**) Detran-SP (2010), Detran-RJ (2010).

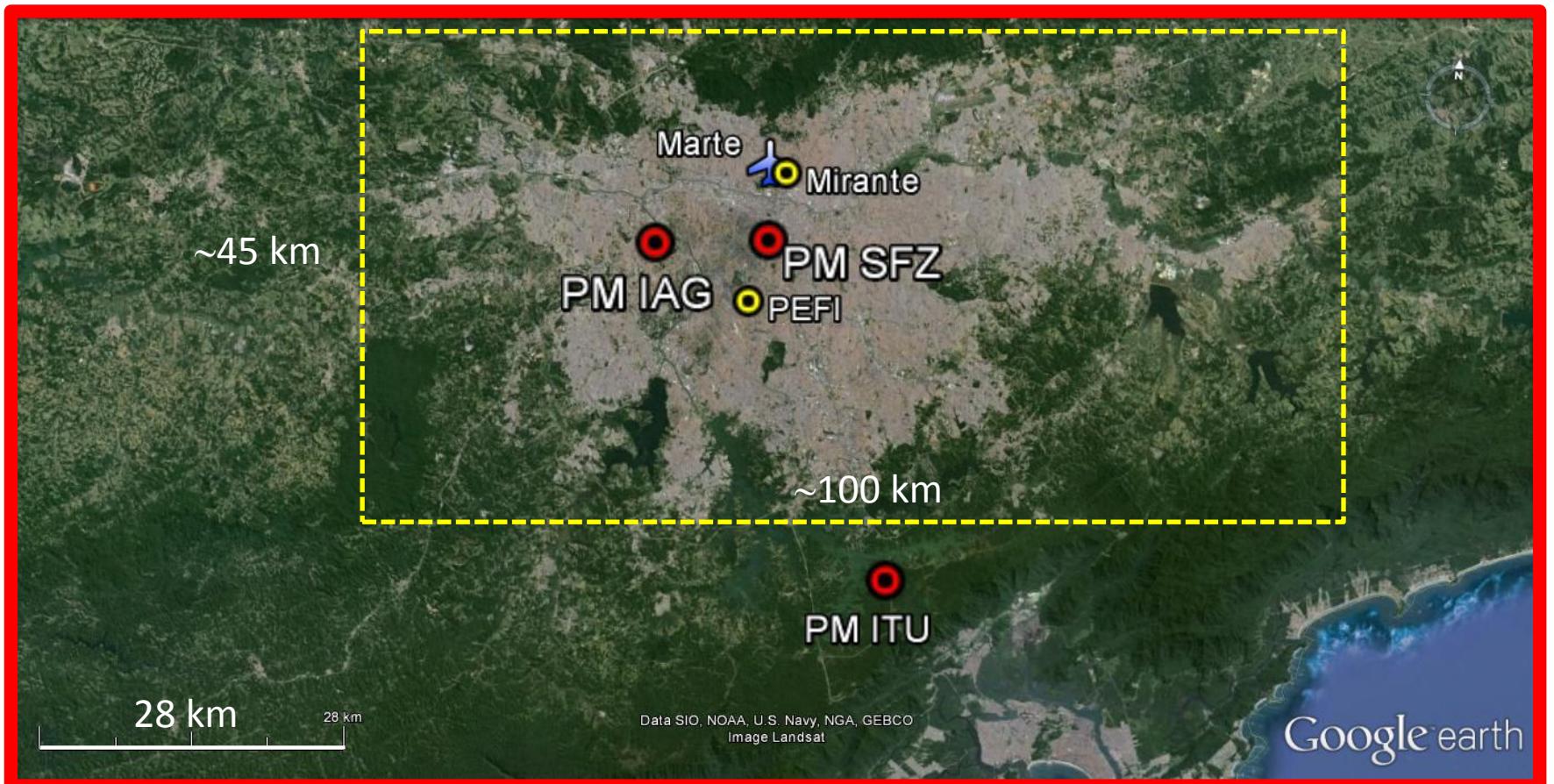
40 million

10 million

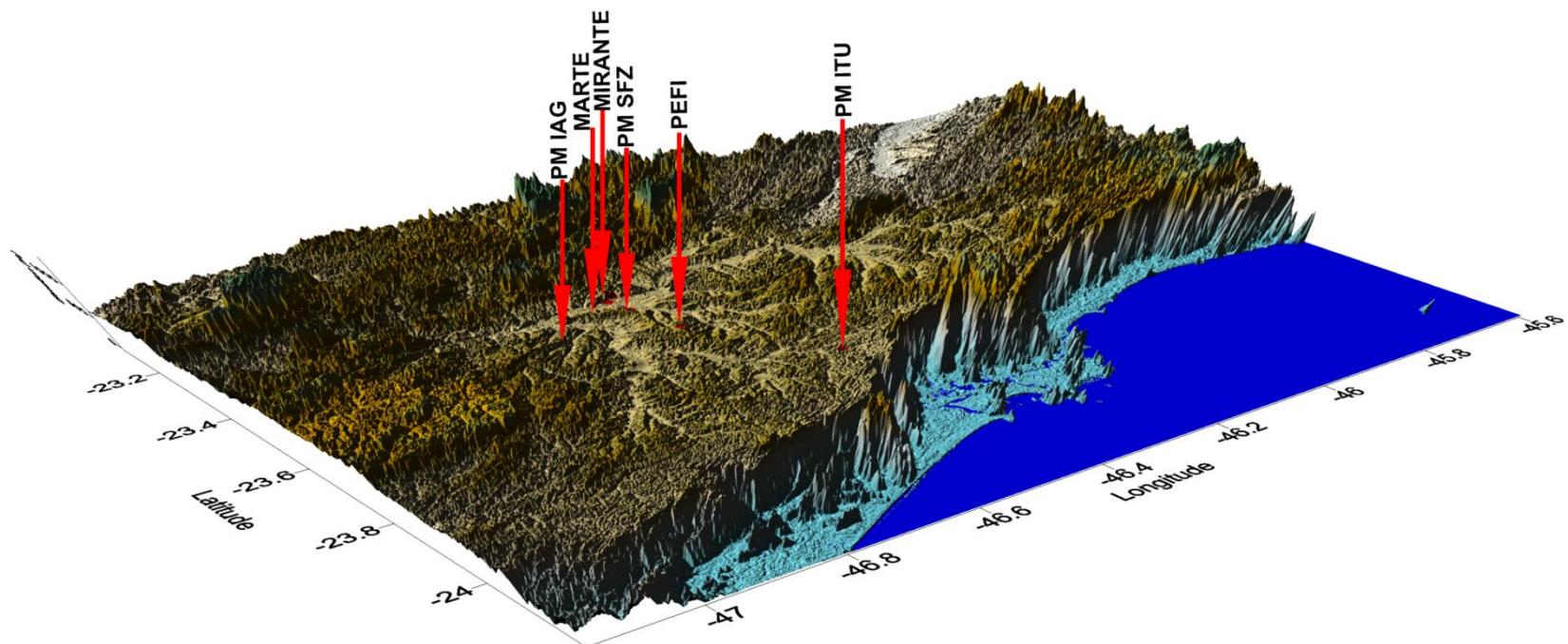
SÃO PAULO AND RIO DE JANEIRO



METROPOLITAN REGION OF SÃO PAULO



TOPOGRAPHY OF MRSP



MICROMETEOROLOGICAL TOWERS METROPOLITAN REGION OF SÃO PAULO

PM IAG



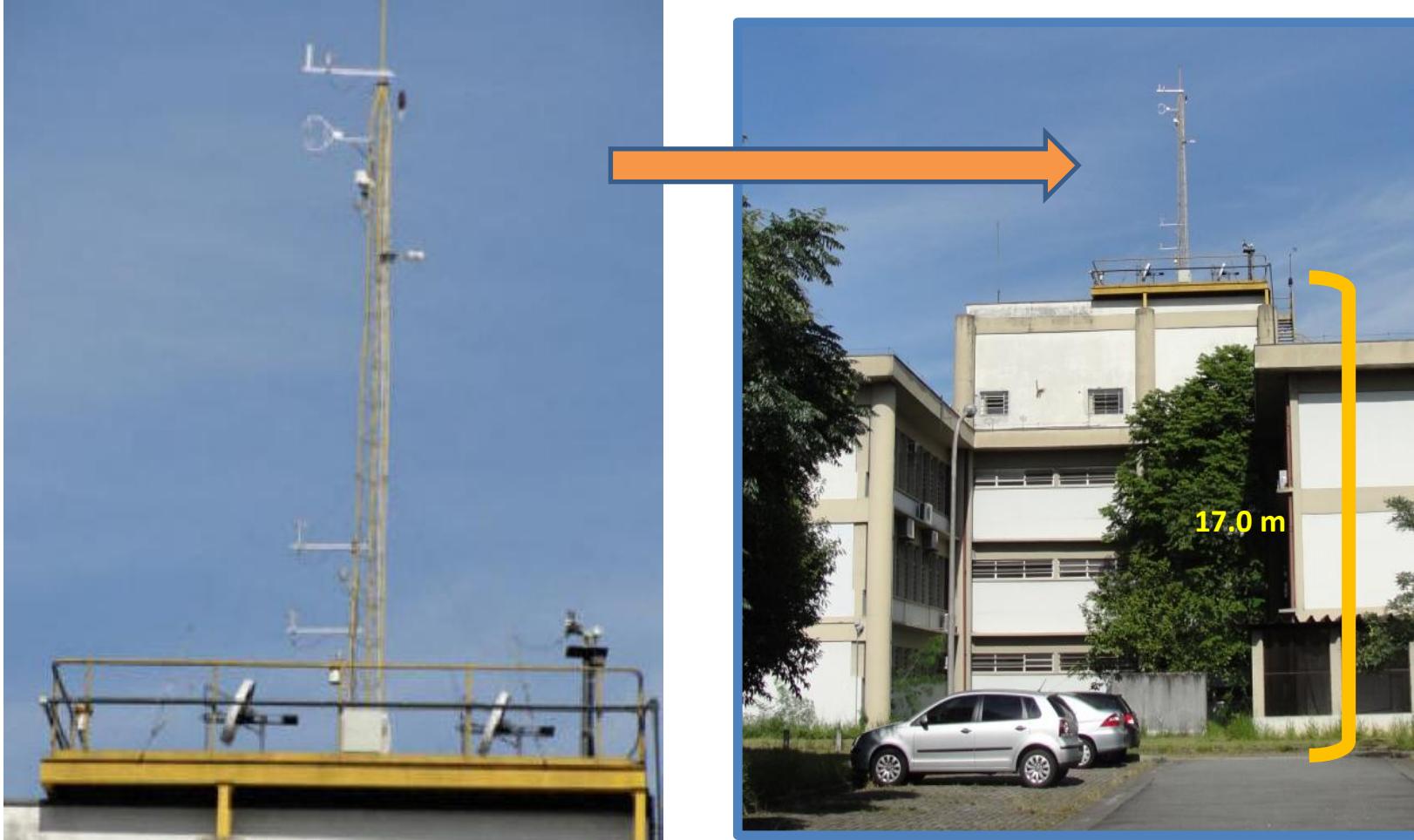
PM ITU



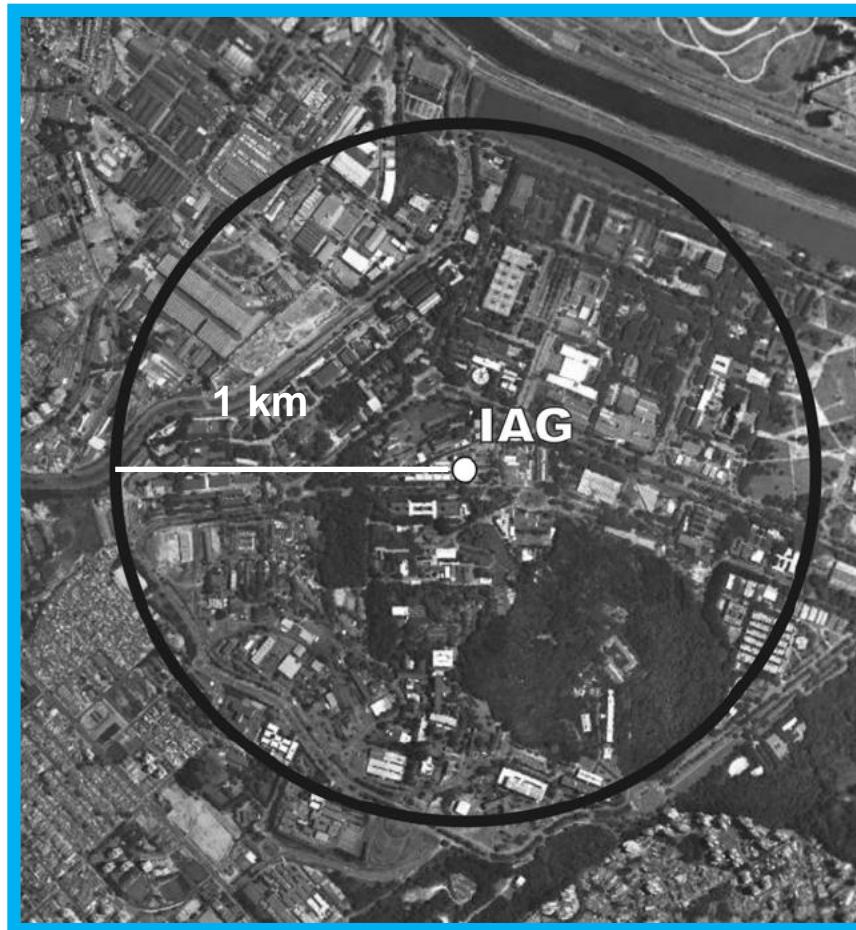
PM SFZ



PM IAG – SÃO PAULO CITY – UNIVERSITY CAMPUS – 4-STORE BUILDING (17 M)



PM IAG: SUBURBAN SITE



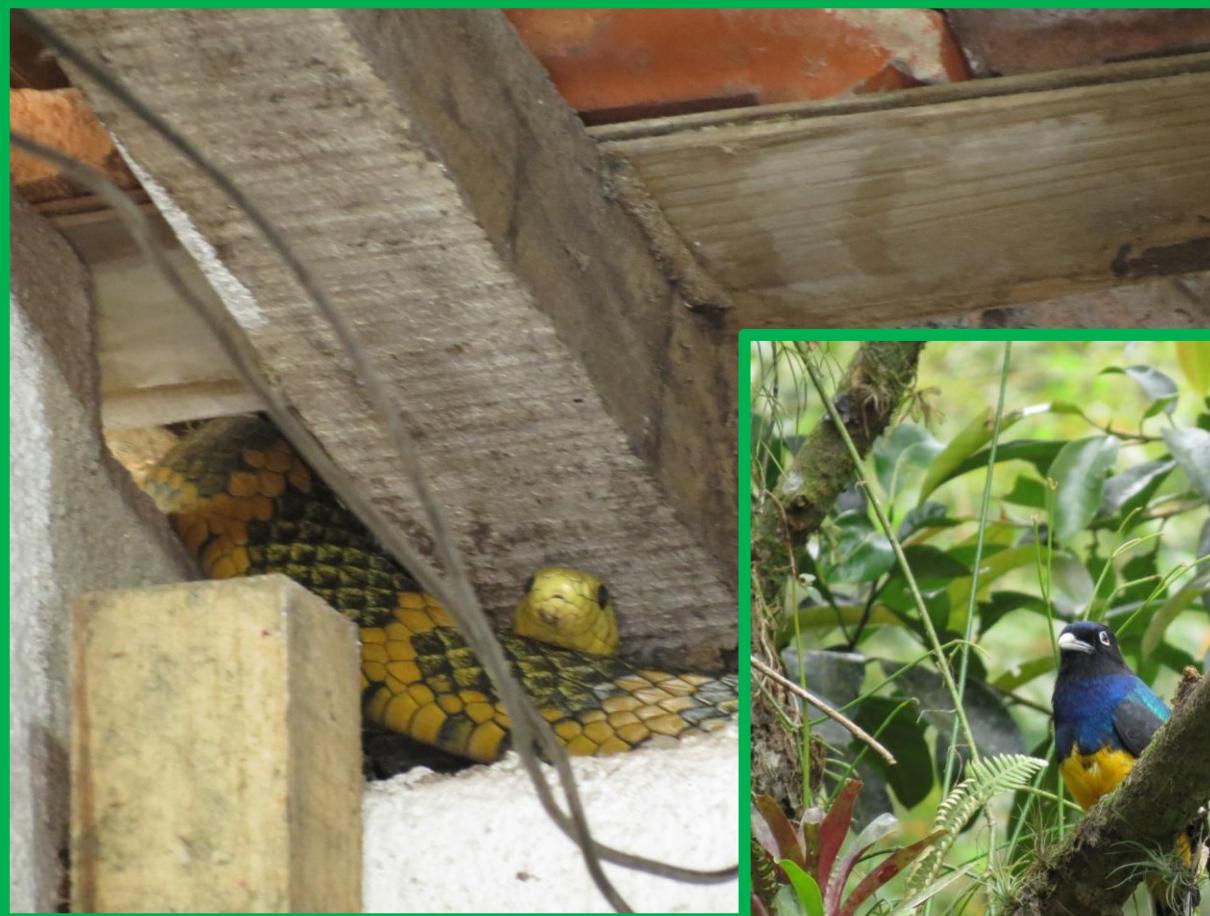
Surface type	Cover fraction (%)
Tree canopy	25.4
Grass and herbaceous ground cover	6.6
Impervious building (roof)	15.1
Impervious road and street	49.0
Water	2.3
Soil and bare ground	0.9
Shrub and Scrub	0.7
Total value	100

PM ITU – 10 M

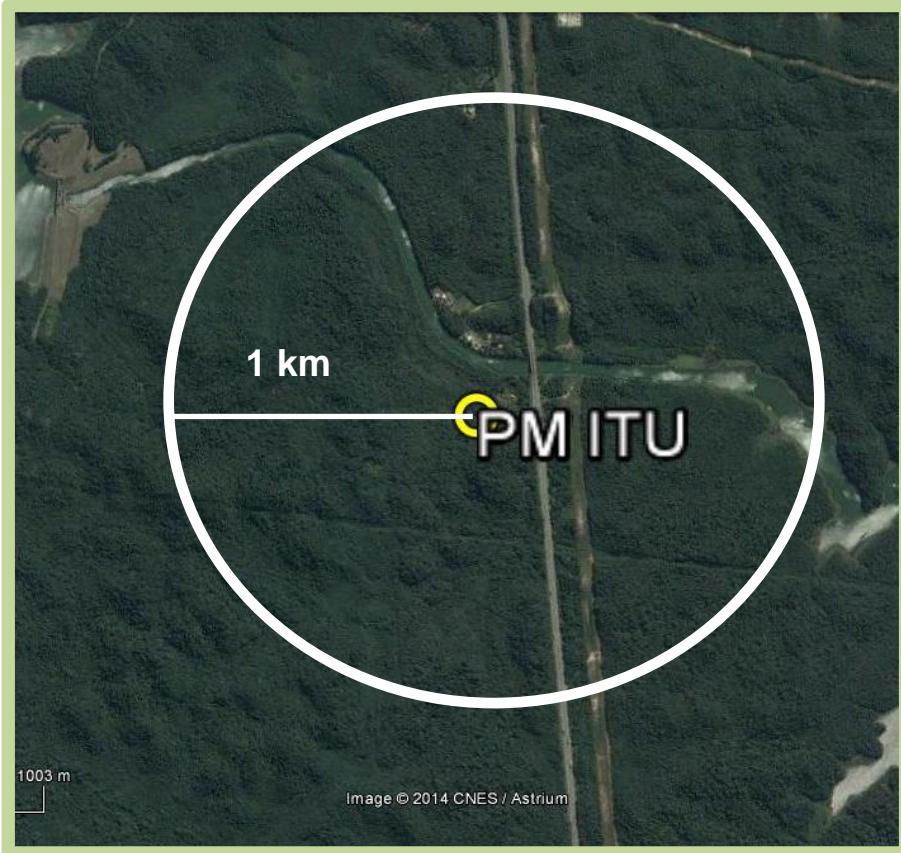


PM ITU (ITUTINGA PILÕES)

ATLÂNTIC FOREST
REFORESTATION
RESERVE



PM ITU: RURAL SITE

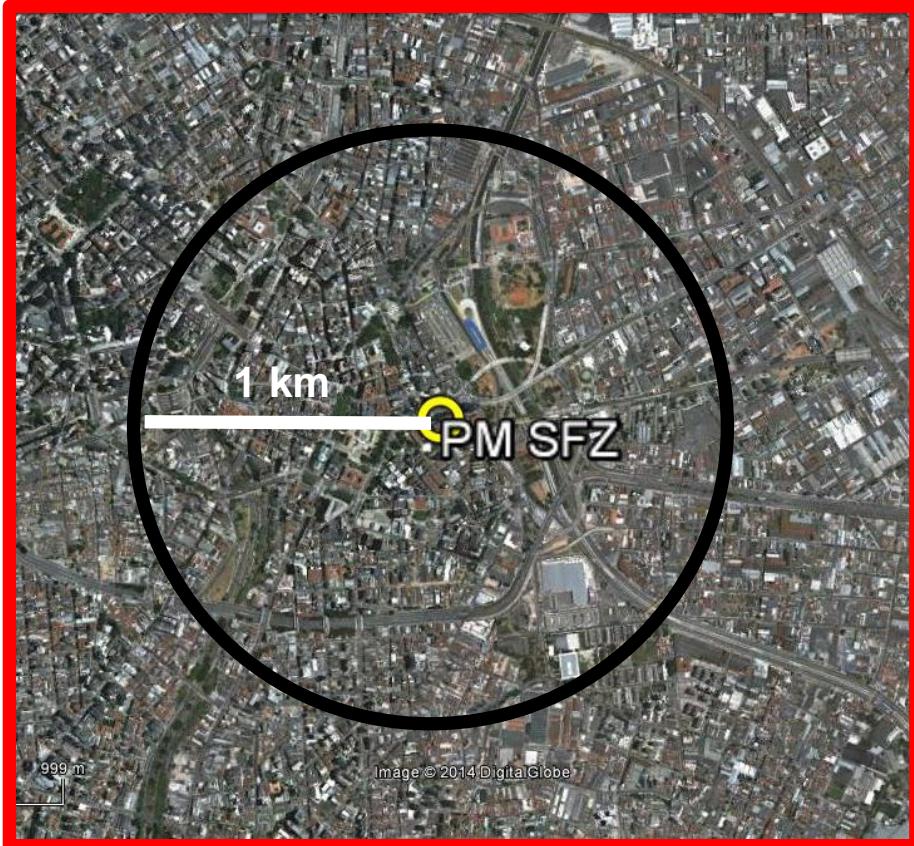


Surface type	Cover fraction (%)
Tree canopy	87.6
Grass and herbaceous ground cover	2.0
Impervious building (roof)	0.4
Impervious road and street	1.6
Water	4.5
Soil and bare ground	1.0
Shrub and Scrub	2.9
Total value	100

PM SFZ – SÃO PAULO CITY (18 STORE BUILDING DOWNTOWN)



PM SFZ: URBAN SITE



Surface type	Cover fraction (%)
Tree canopy	5.6
Grass and herbaceous ground cover	3.6
Impervious building (roof)	45.2
Impervious road and street	43.4
Water	0.9
Soil and bare ground	1.3
Shrub and Scrub	0.0
Total value	100

ABOVE CANOPY OBSERVATION

NORTH VIEW



SOUTH VIEW



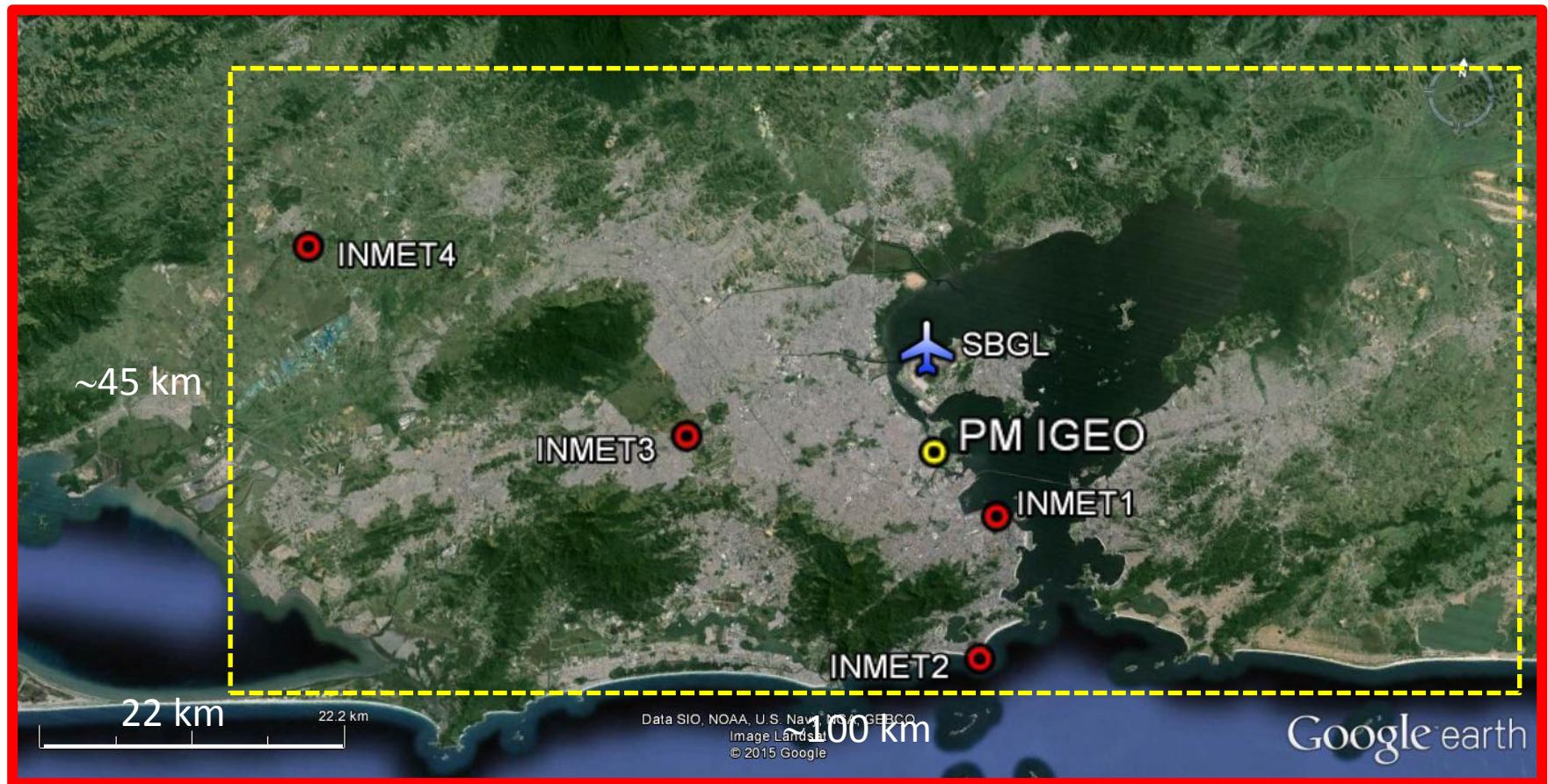
WEST VIEW



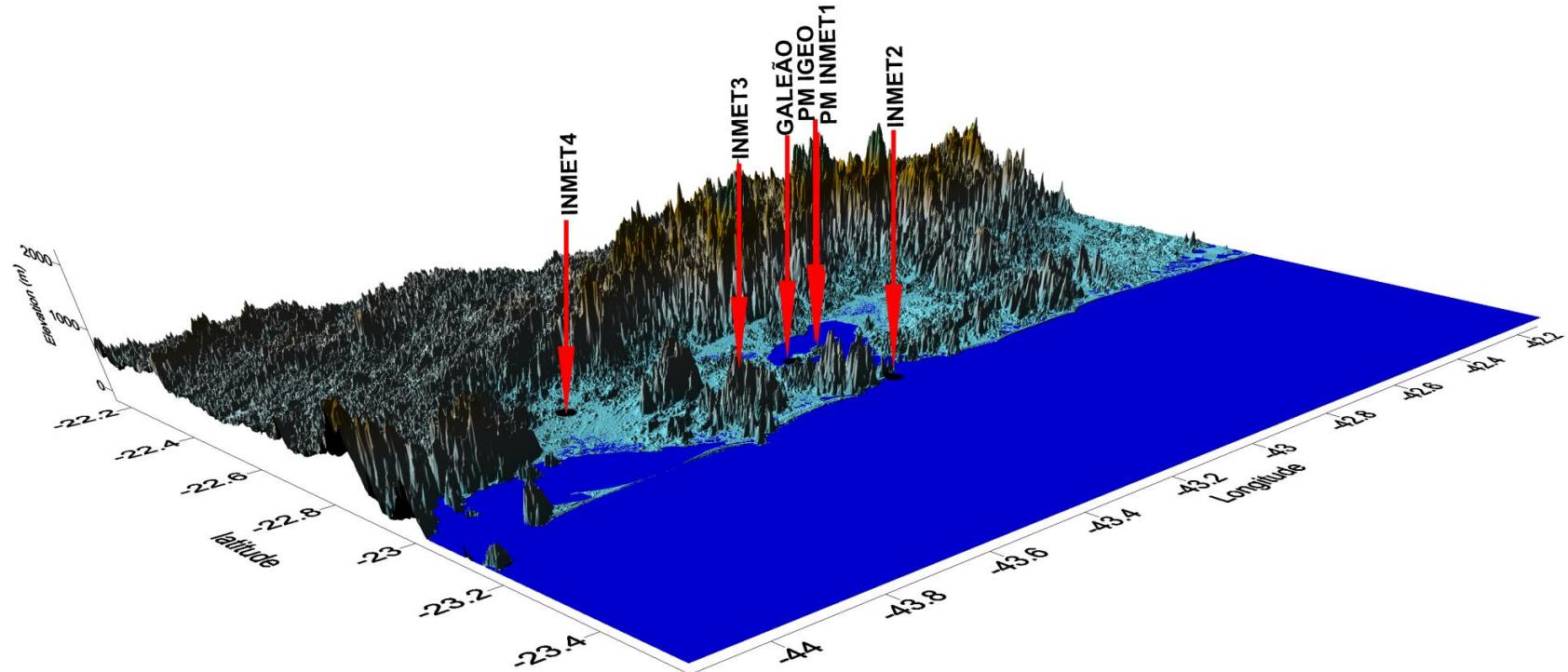
EAST VIEW



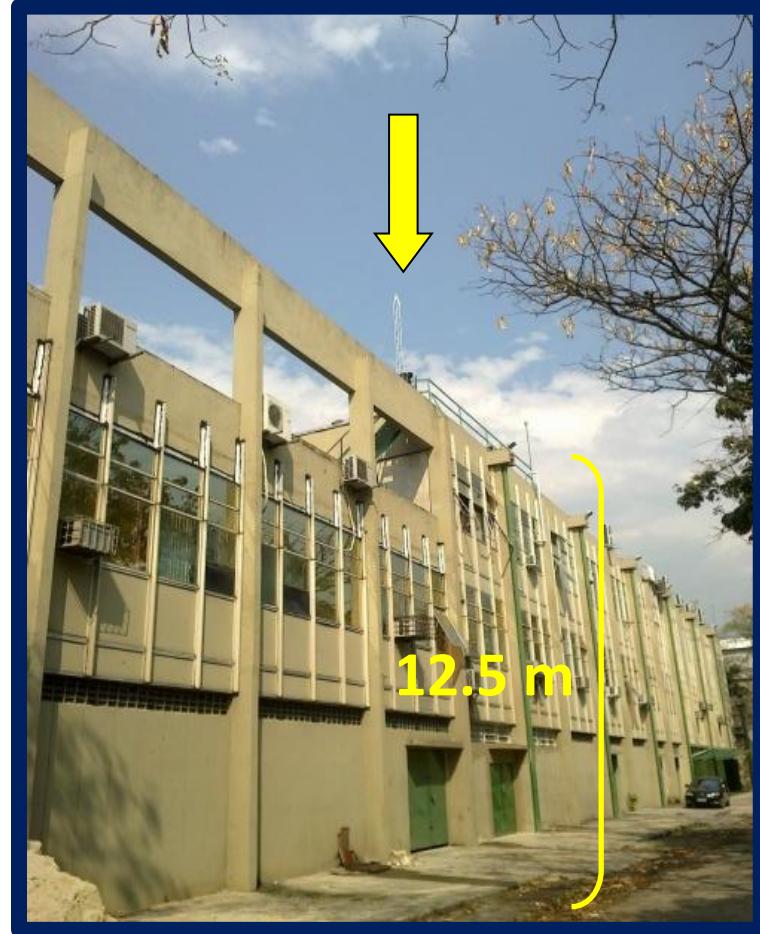
METROPOLITAN REGION OF RIO DE JANEIRO CITY



Topography of Rio de Janeiro



PM IGEO – RIO DE JANEIRO – UNIVERSITY CAMPUS – 3 STORE BUILDING



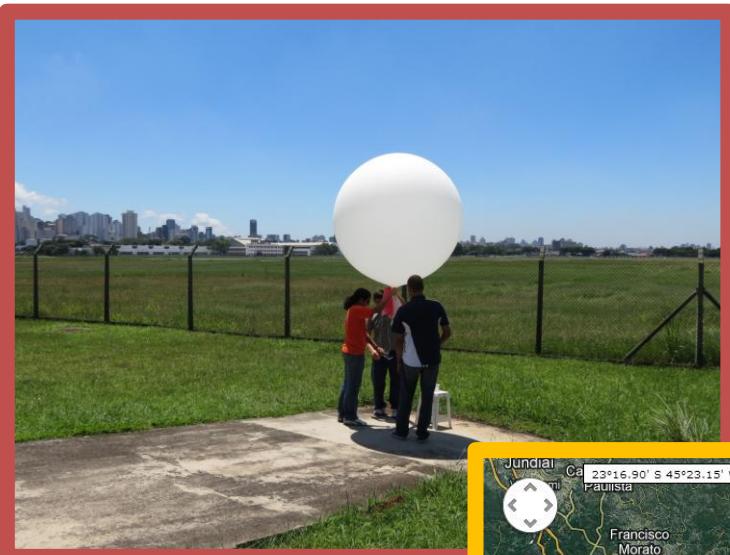
PM IGEO: SURBURBAN SITE



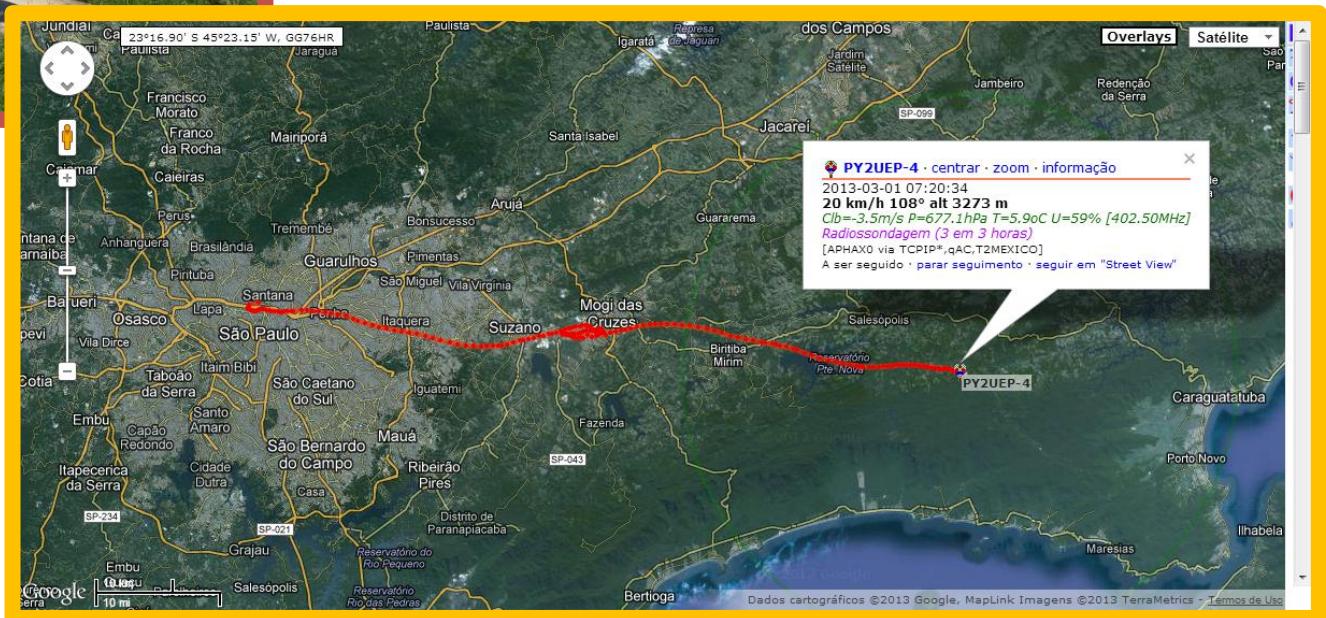
Surface type	Cover fraction (%)
Tree canopy	7.2
Grass and herbaceous ground cover	14.9
Impervious building (roof)	20.8
Impervious road and street	22.6
Water	22.0
Soil and bare ground	8.8
Shrub and Scrub	3.7
Total value	100

4 FIELD CAMPAIGNS 10 DAYS EACH

3 HOURS RADIOSOUNDING AND LIDAR

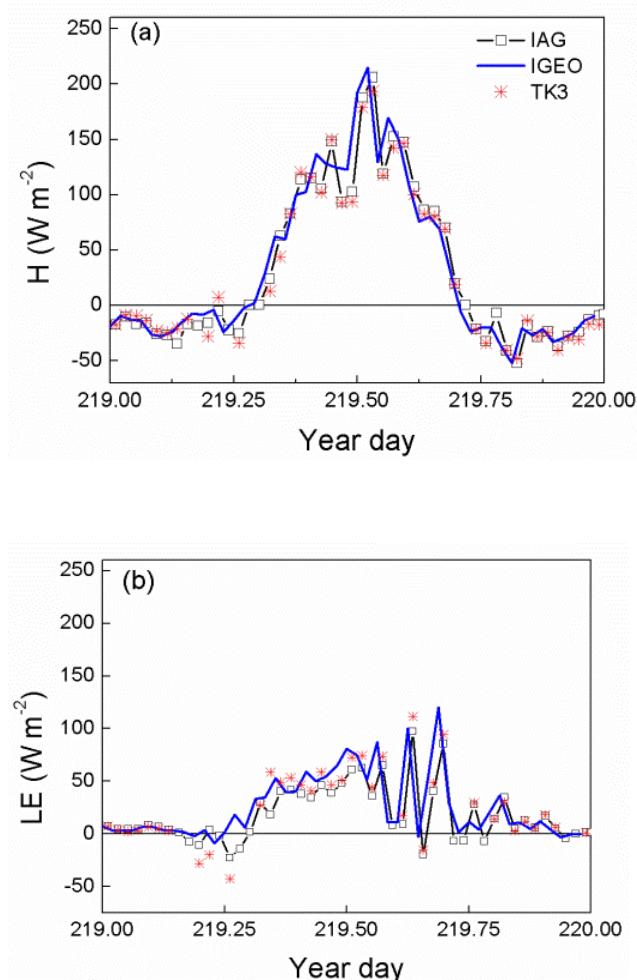


CAMPAIGNS		
1 st	São Paulo	February 2013
2 nd	Rio de Janeiro	March 2013
3 rd	Rio de Janeiro	July 2013
4 th	São Paulo	August

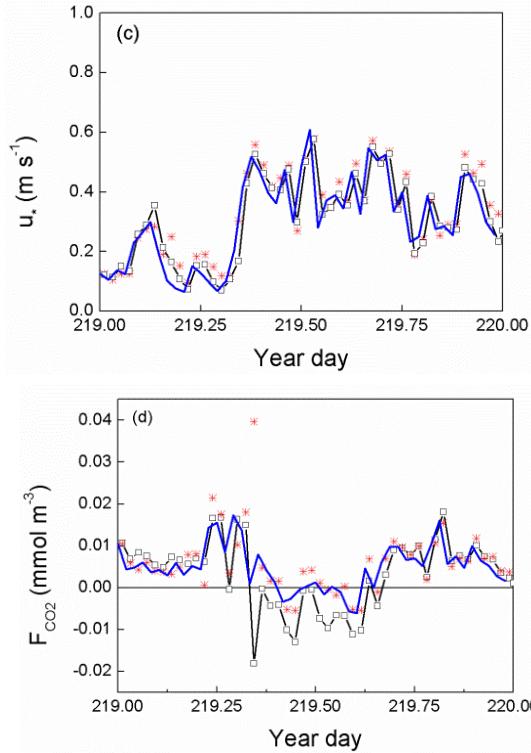


Results

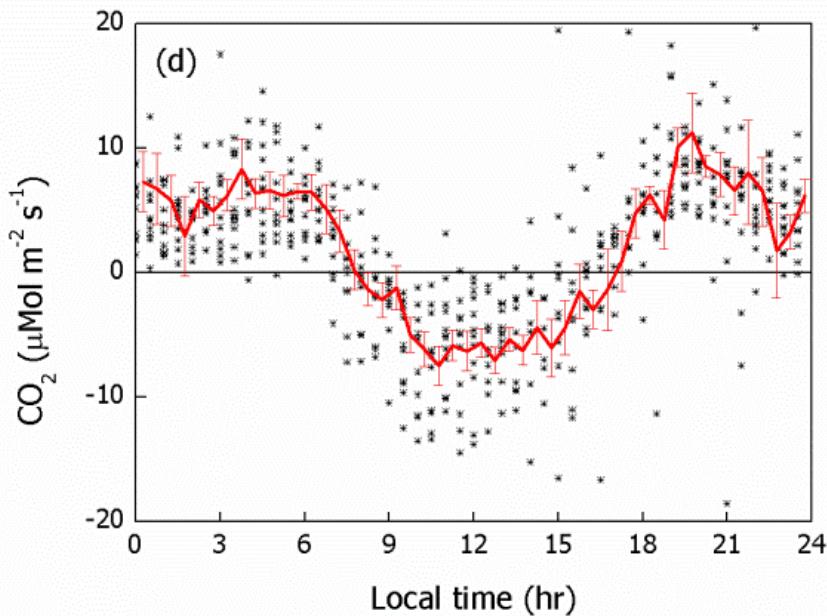
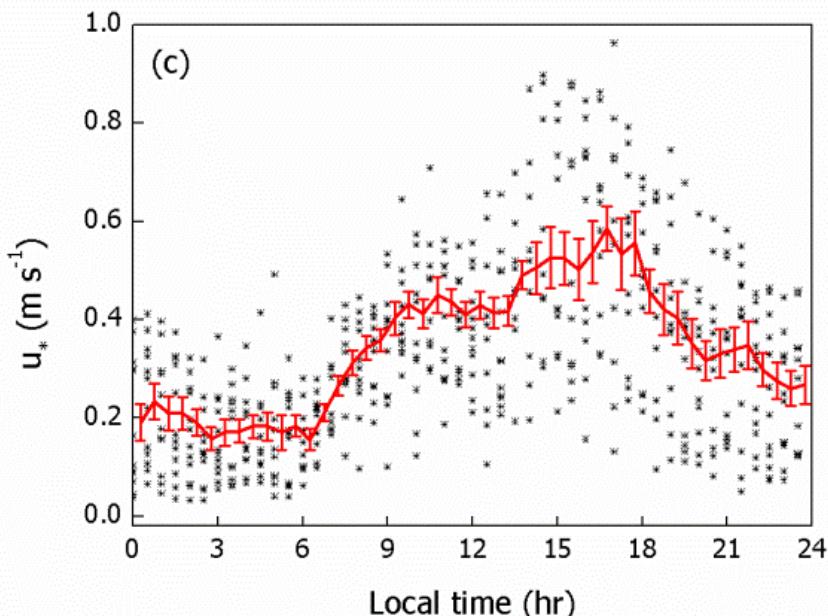
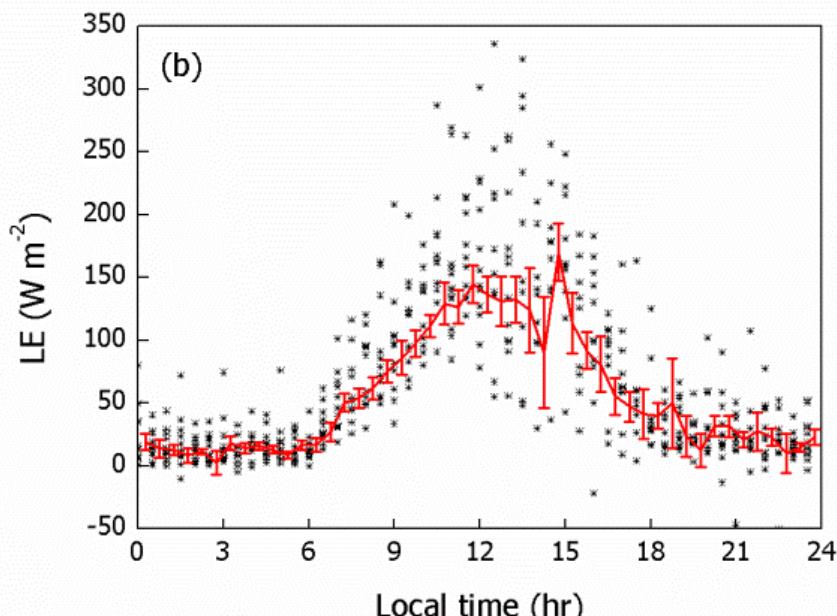
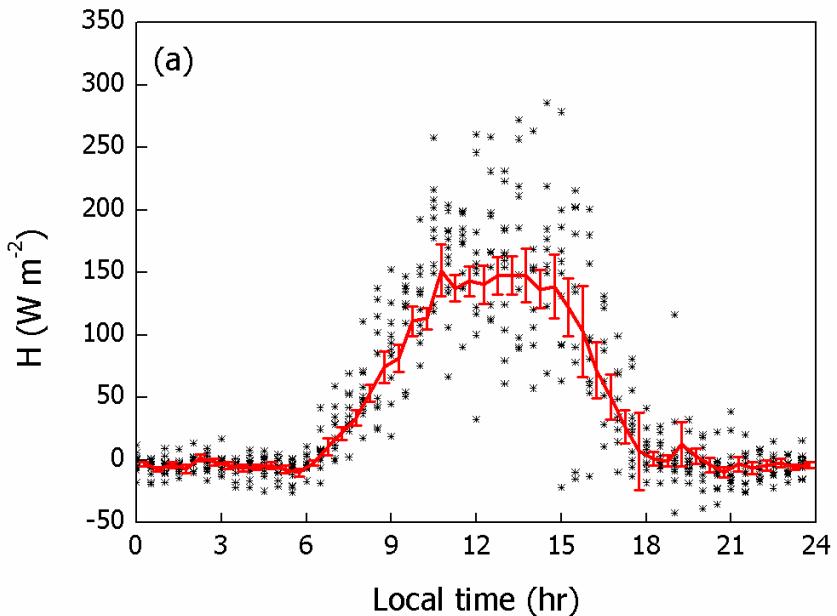
VALIDATION OF EDDY COVARIANCE SOFTWARE USING TK3 (MAUDER AND FOKEN, 2011) AS REFERENCE



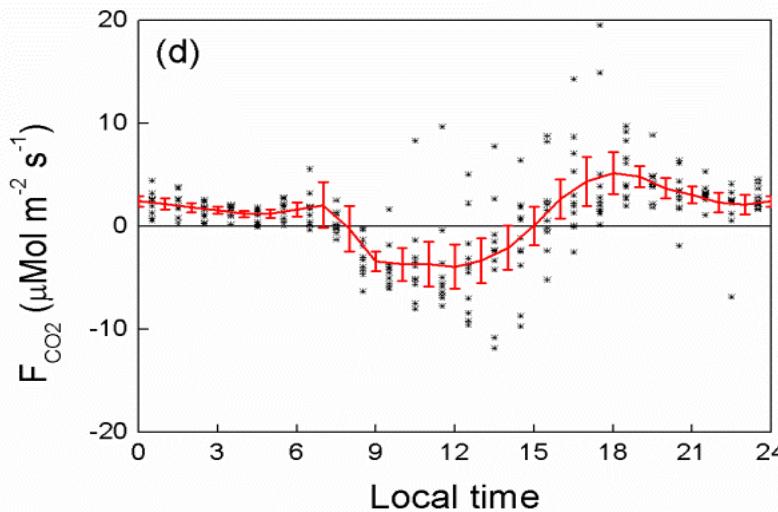
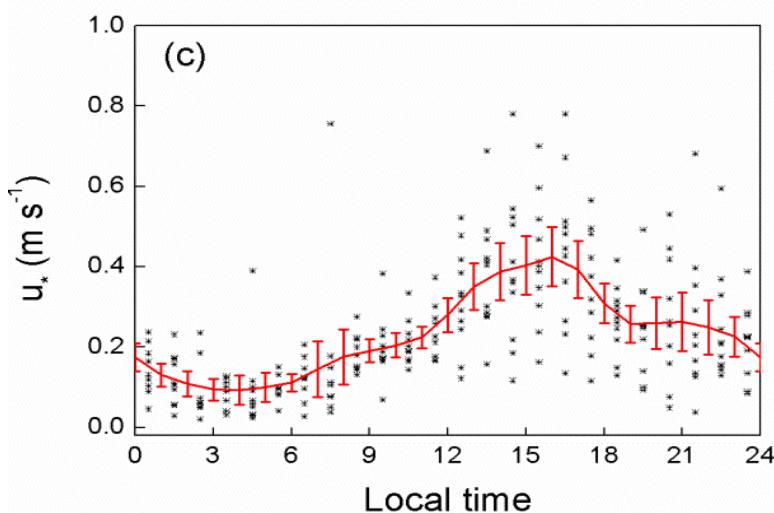
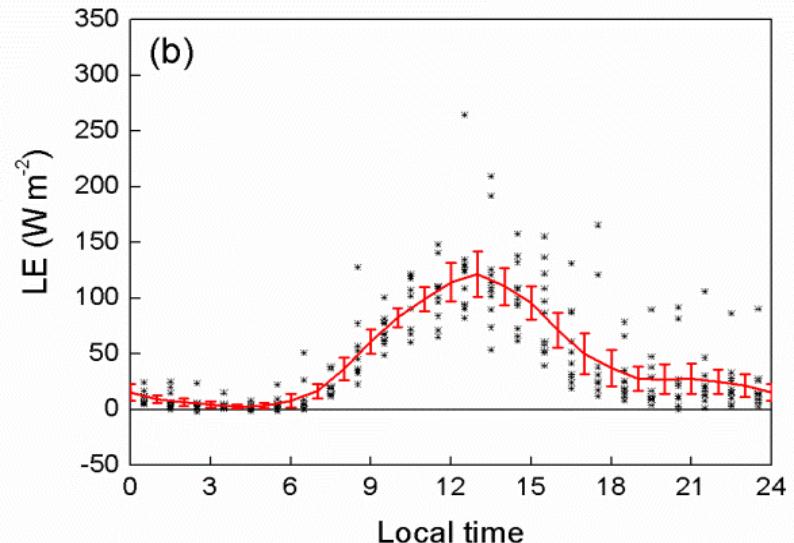
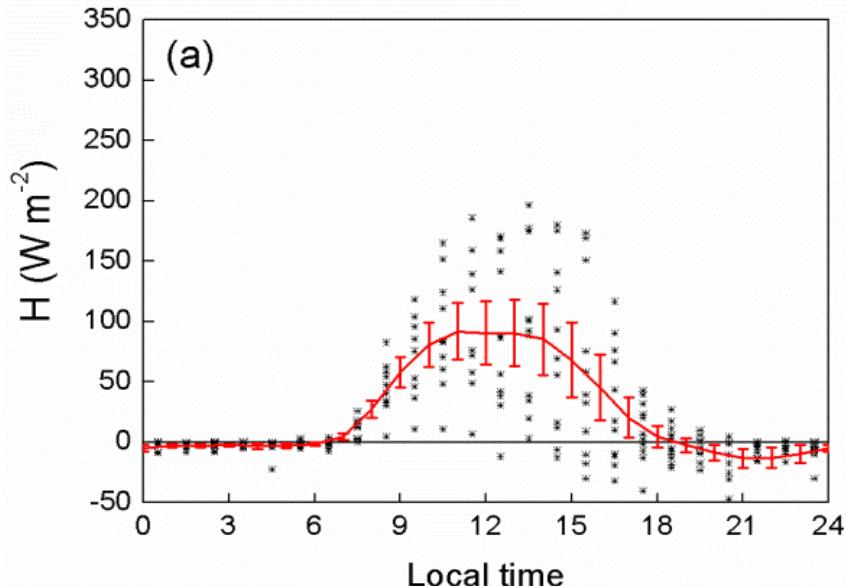
Mauder M and Foken T (2011) Documentation and instruction manual of the eddy covariance software package TK3, Work Report University of Bayreuth, Dept. of Micrometeorology, ISSN: 1614-8916, pp. 46, 58



PM IAG - FEBRUARY 2013 – 1ST CAMPAIGN – SÃO PAULO (10 DAYS)



PM IGE - MARCH 2013 – 2ND CAMPAIGN – RIO DE JANEIRO (10 DAYS)



DAILY VALUES SÃO PAULO AND RIO DE JANEIRO DURING THE FOUR FIELD CAMPAIGNS

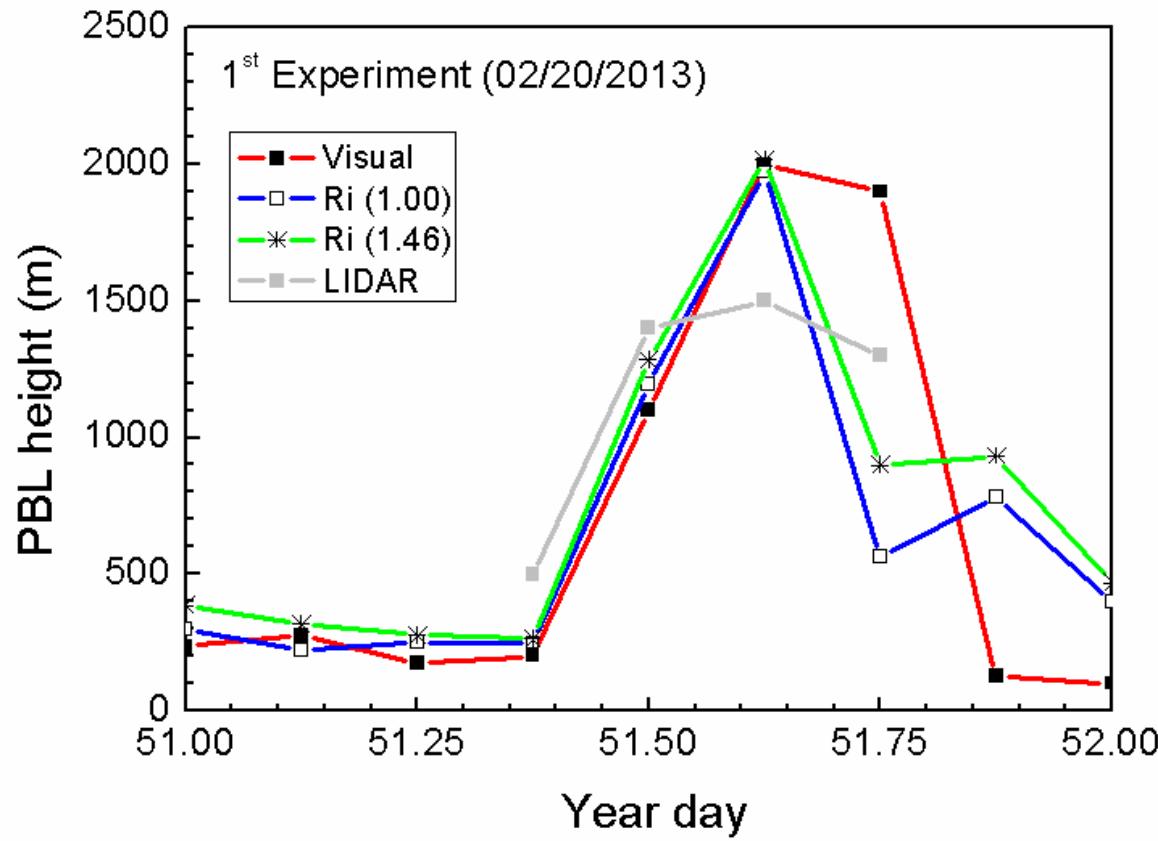
Table 3. Daily values of SEB mean components during four field experiments carried out in February (1st Campaign) and August (4th Campaign) in at the PM IAG at the MRSP and in March (2nd Campaign) and July (3rd) in PM IGEO at the MRRJ.

SEB components (MJ m ⁻² day ⁻¹)	Campaign			
	1 st	2 nd	3 rd	4 th
	February	March	July	August
H	6.10±0.28	2.10±1.74	1.78±0.82	3.16±0.36
LE	4.85±0.41	3.93±1.09	2.64±1.29	1.64±0.27
Bowen ratio	1.38±0.17	0.62±0.57	0.83±0.49	2.25±0.32

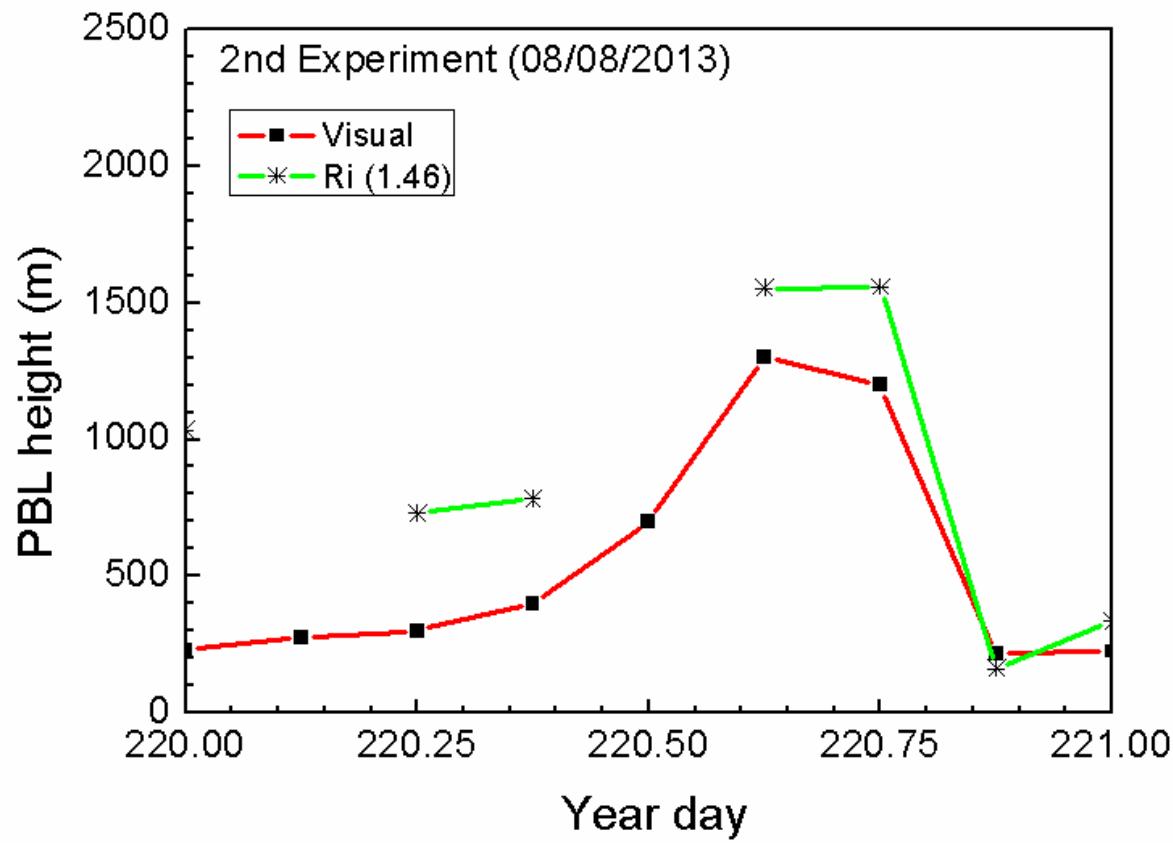
Summer (Wet season)

Winter (dry season)

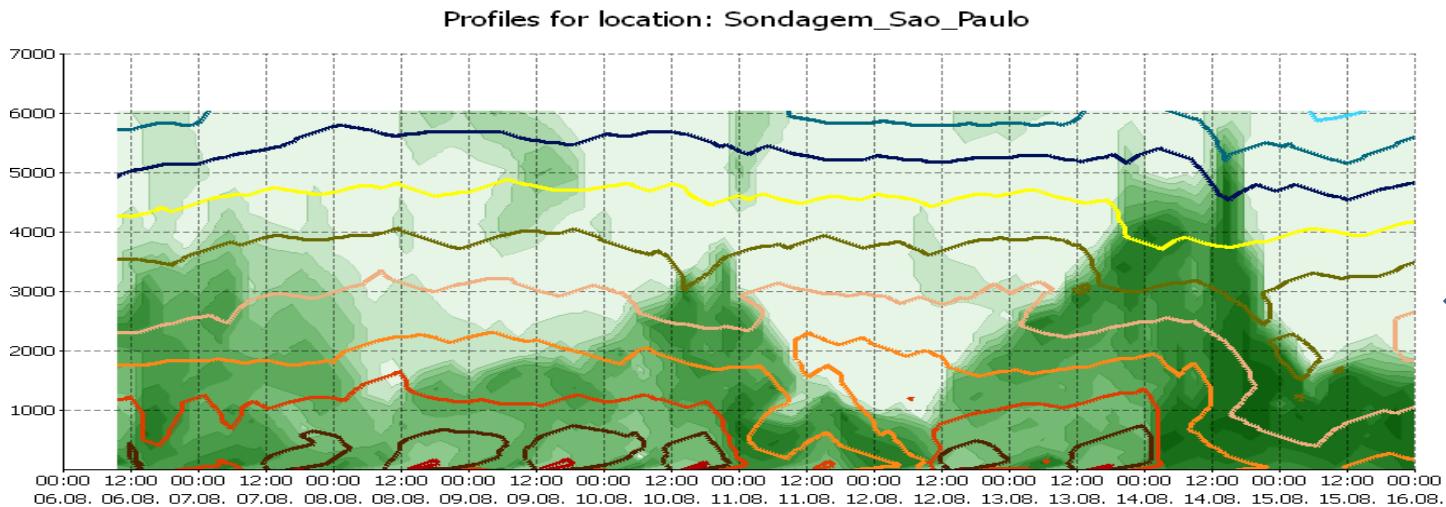
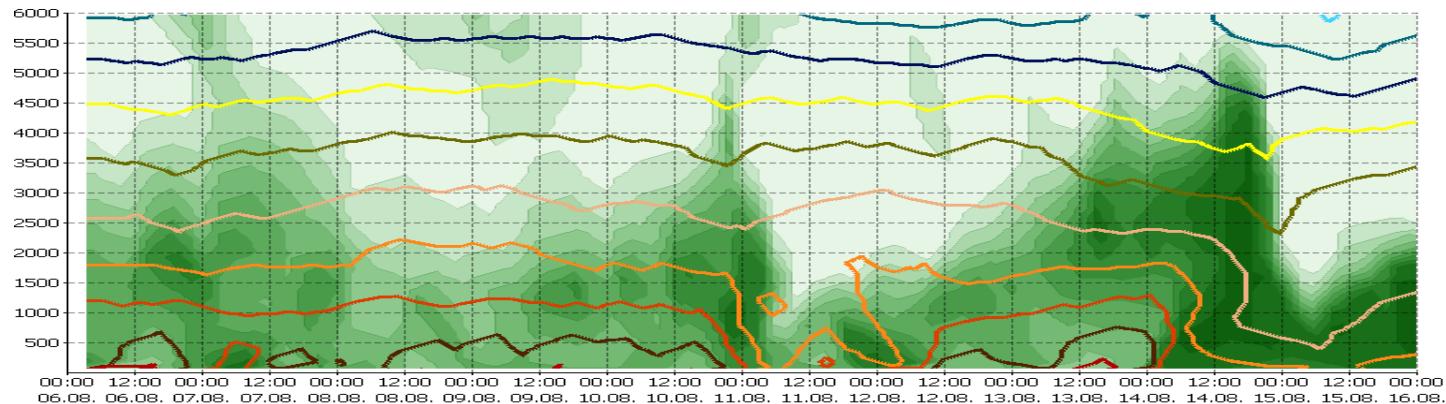
Urban Boundary Layer Summer Campaign – São Paulo



Urban Boundary Layer - Winter Campaign – São Paulo



Numerical modeling using WRF – 10 days during winter campaign São Paulo



WHERE AREWE RIGHT NOW?

METROPOLITAN REGIONS OF SOUTHEAST STATES OF BRAZIL				
Description	São Paulo	Rio de Janeiro	Belo Horizonte	Vitória
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Source: IBGE (2013), Detran-SP (2010), Detran-RJ (2010).



2013
3 Towers



2013
1 Tower



2017
(1 Tower)



2016
(1 Tower)

URBAN FLUX NETWORK

The screenshot shows the Urban Flux Network interface. On the left, a vertical sidebar lists 14 urban sites with their names, locations, and measurement categories. A legend at the bottom defines the symbols: a yellow square for Energy Balance (E), a green square for Carbon Dioxide Fluxes (C), a blue square for Aerosol Fluxes (A), and a red square for Other Trace Gas Fluxes (T). On the right, a world map displays numerous yellow location markers, indicating the global distribution of the network. The map includes standard Google Earth controls (zoom, pan, satellite view) and a copyright notice for NASA imagery.

Sitio	Lugar	Categoría
Oberhausen	Falkensteinstrasse	E C A
Pesaro	Osservatorio Valerio	E C A
Phoenix	West Phoenix	E C A
Rio de Janeiro	Federal University	E C A
Rome	Collegio Romano	C A
Salt Lake City	Murray	E C A
Sao Paulo	University	E C A
Seoul	Seoul Forest	E C A
Seoul	EunPyeong NewTown	E C A T
Singapore	Telok Kurau	E C A
Swindon	BWY	E C A
Syracuse	Center of Excellence	C A
Syracuse	Upper Onondaga	C A

Mapa | Satélite

Reporte de Tela Chica

Imagens ©2015 NASA | Termos de Uso

E Energy Balance
C Carbon Dioxide Fluxes
A Aerosol Fluxes
T Other Trace Gas Fluxes

This database is provided by the International Association for Urban Climate
Hosted by the Department of Geography, University of British Columbia

IAUC

SPSS 2013 (2017)

SPSS 2013 (2017)

São Paulo Spring School on:
"Urban Climate at Tropical Regions:
Observational and Modeling Features"

Lecturers

Robert Bornstein, San Jose State University, California, USA
Matthias Mauder, Karlsruhe Institute of Technology, Germany
Monique Leclerc, University of Georgia, Georgia, USA
Claudia Furlan, University of Padova, Padova, Italy

September 23 to 27, 2013

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UNIVERSITY OF SÃO PAULO, SÃO PAULO, BRAZIL
RUA DO MATÃO 1226, BUTANTÃ CAMPUS

REGISTRATION & ABSTRACT INFORMATION
www.iag.usp.br/atmosfericas/escolaprimavera/
spschool.aca@iag.usp.br

Logos: USP, FAPESP, FAPERJ, CNPq, MCITY



Thank you