PROGRAM MCITY BRAZIL

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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)

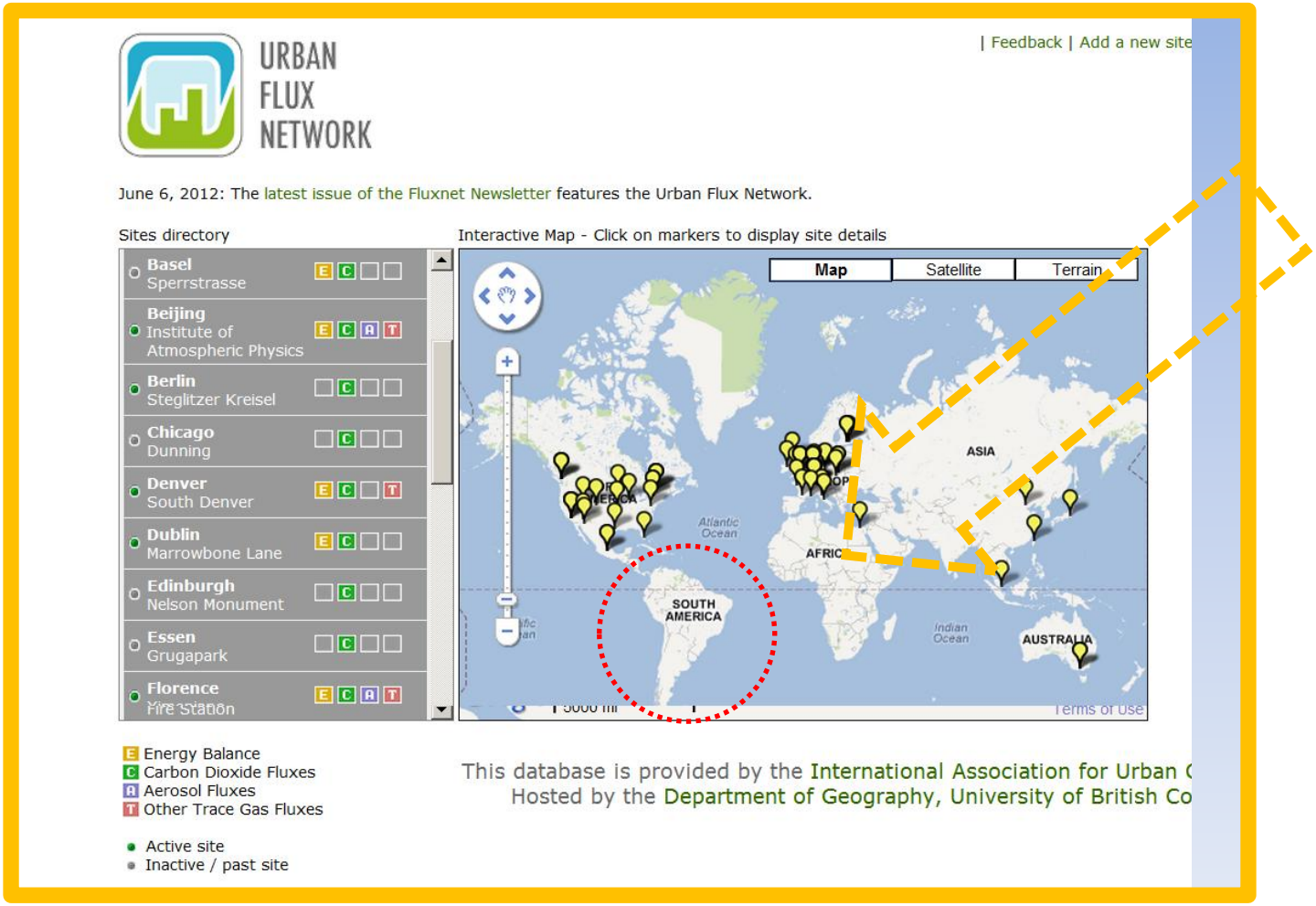
Motivation

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

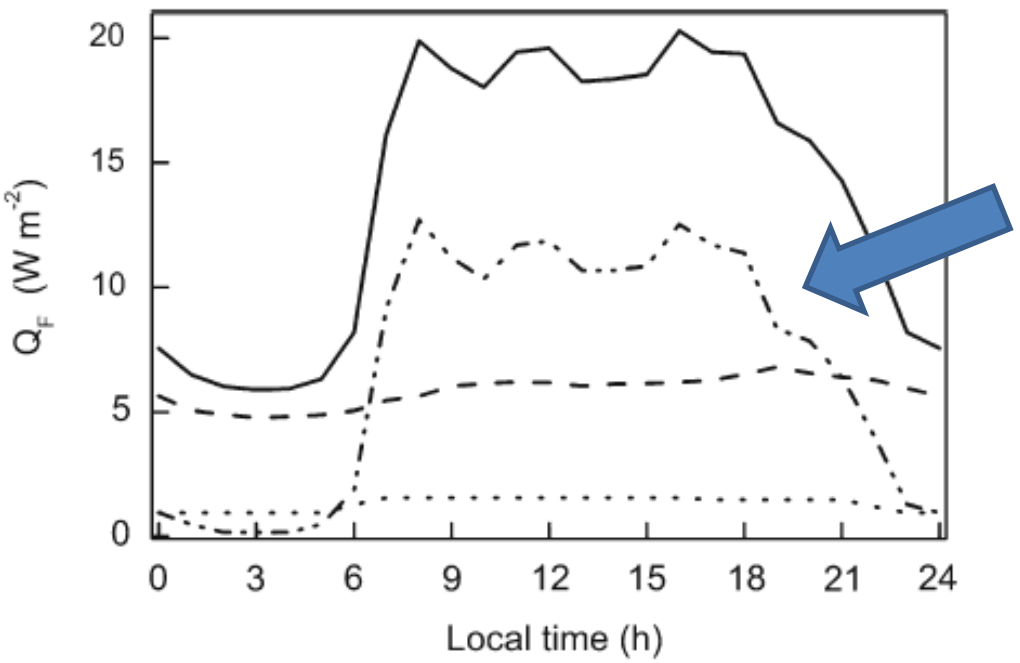
Most of the Brazilian cities are facing environmental problems that may agravate if the IPCC predictions are confirmed.

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)



ANTHROPOGENIC HEAT IN SÃO PAULO



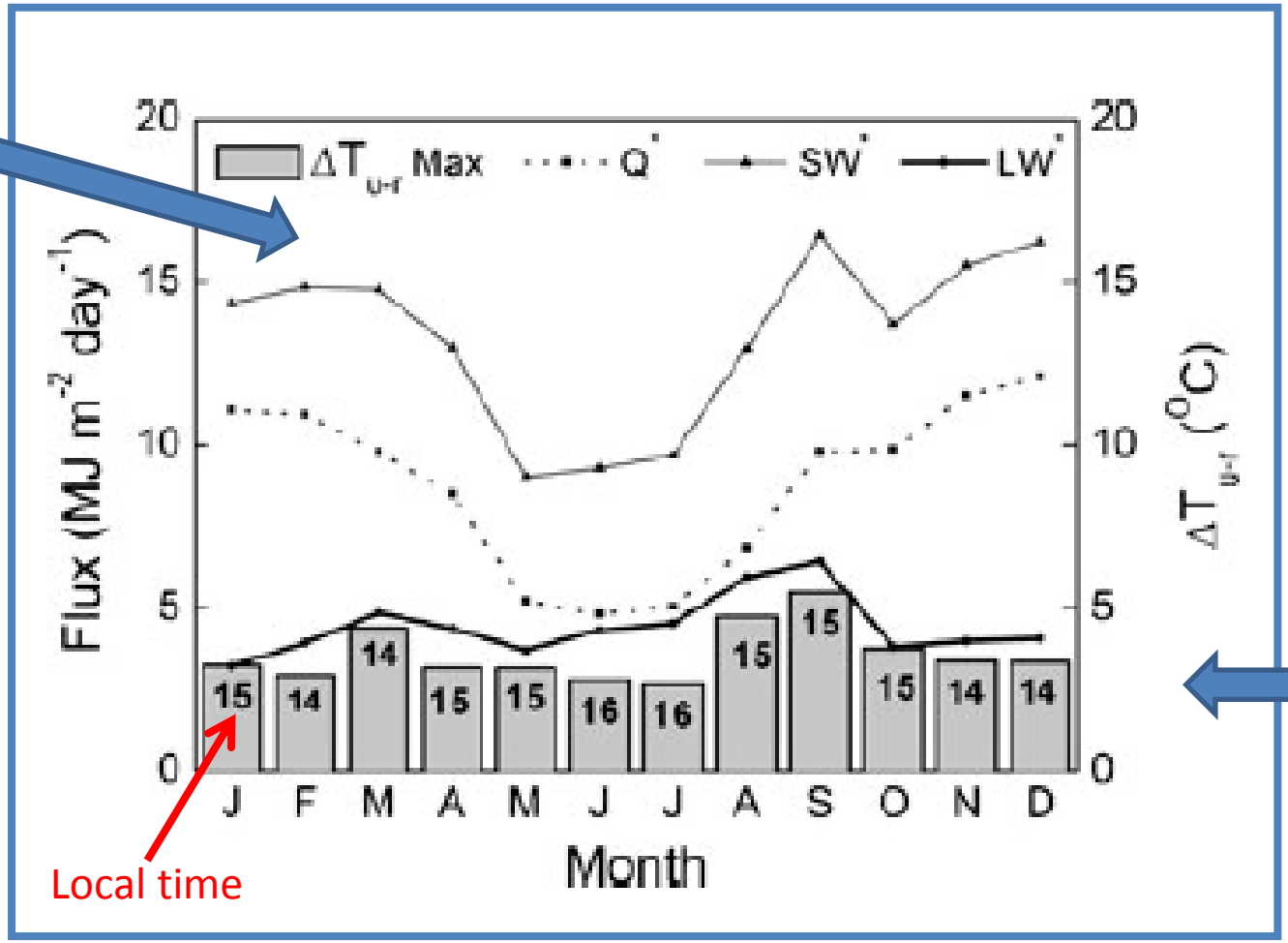
Vehicular

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

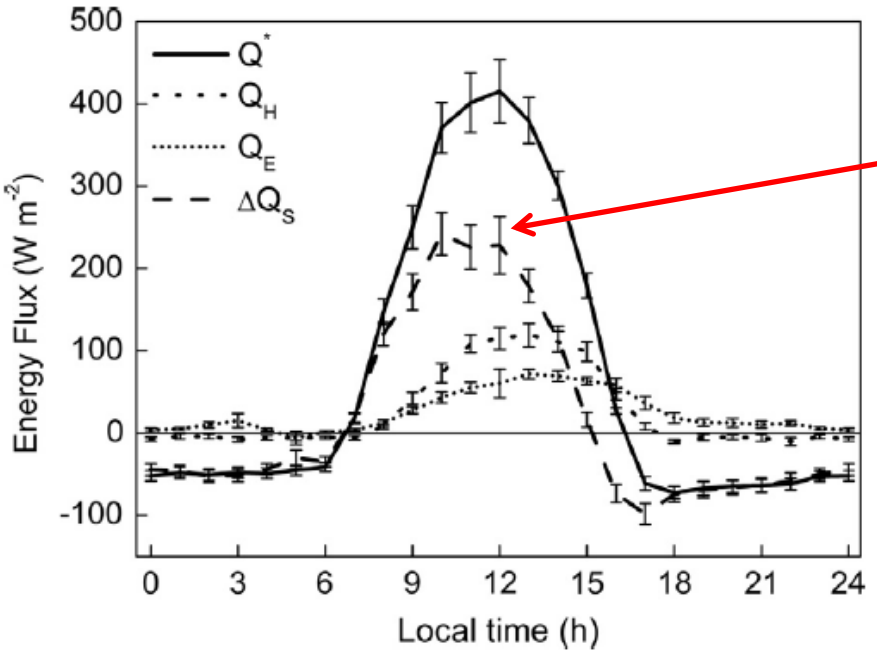


Fig. 4. Diurnal evolution of the main components of the surface energy balance in the city of São Paulo. Average hourly values based on observations carried out during May 18 to June 17 of 2009 at urban Site 1 of Fig. 2. The Q^* is the net all-wave radiation flux, Q_H is the sensible heat flux, Q_E is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

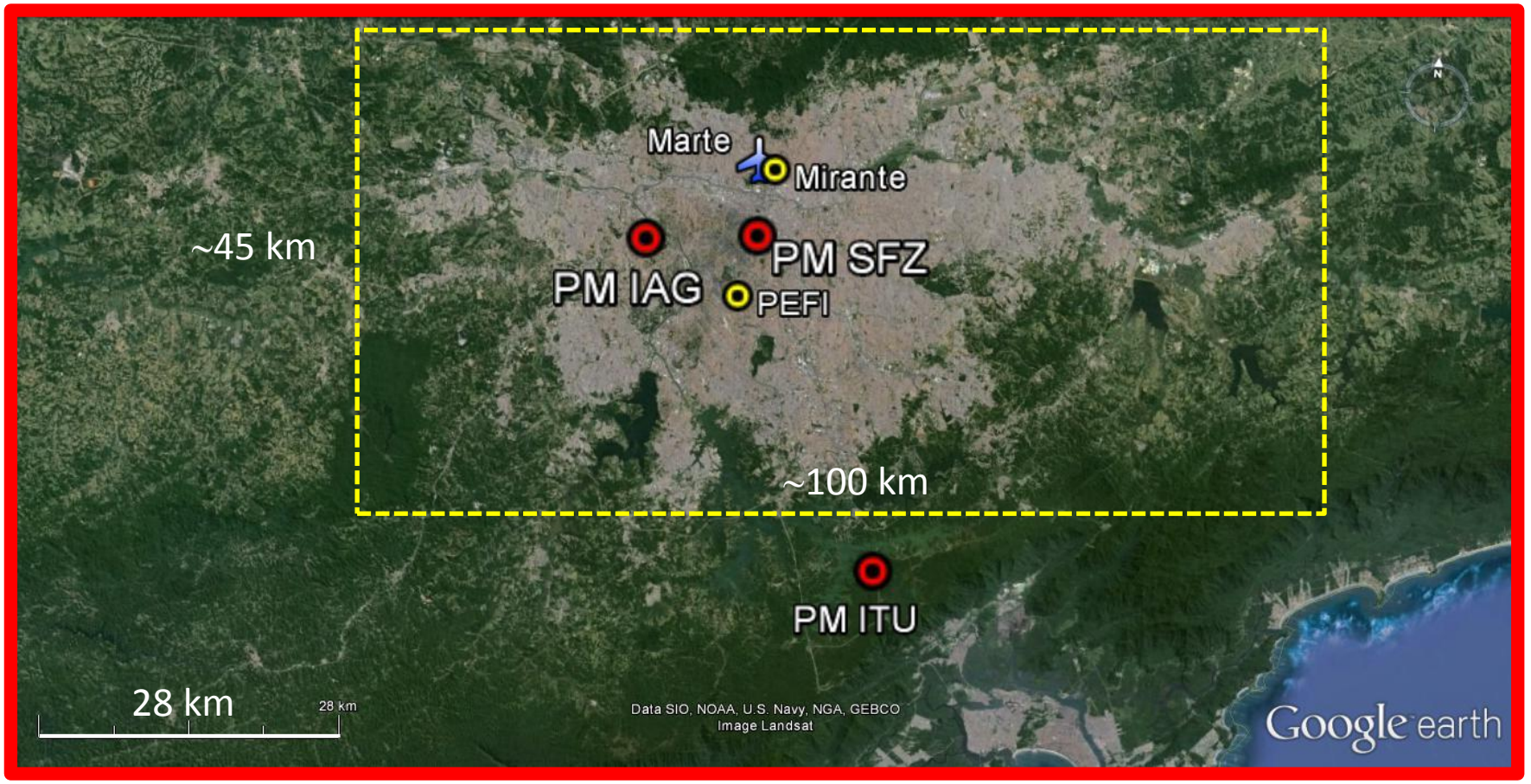
METROPOLITAN REGIONS OF SOUTHEAST STATES OF BRAZIL				
Description	**São Paulo**	**Rio de Janeiro**	**Belo Horizonte**	**Vitória**
Number of cities	38	20	34	7
Area (km^2)	7.944	5.682	9.468	2.318
Population*	19.672.582	11.875.063	5.152.217	1.685.384
Vehicles**	6.900.000	3.630.678	1.880.608	502.022
Source: (*) IBGE (2013); (**) Detran-SP (2010), Detran-RJ (2010).				

40 million

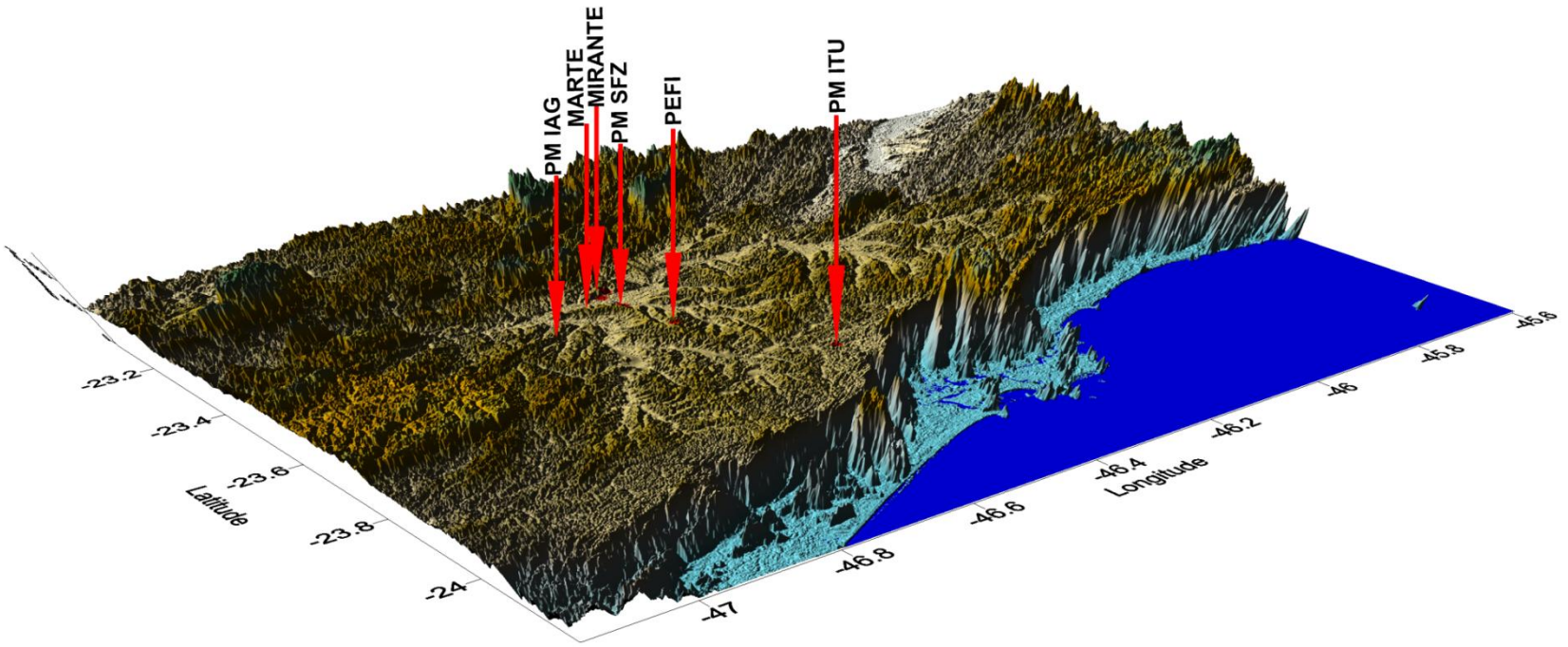
10 million

SÃO PAULO AND RIO DE JANEIRO

METROPOLITAN REGION OF SÃO PAULO



TOPOGRAPHY OF MRSP



MICROMETEOROLOGICAL TOWERS METROPOLITAN REGION OF SÃO PAULO

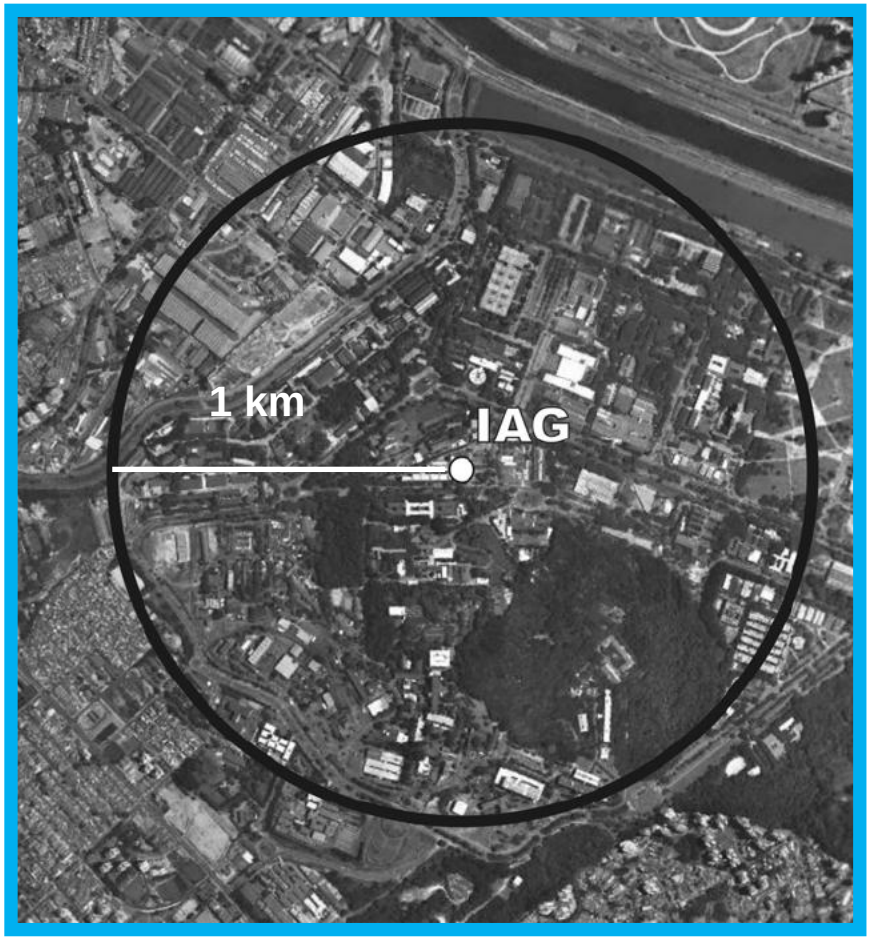
PM IAG

PM ITU

PM SFZ

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

PM IAG: SUBURBAN SITE



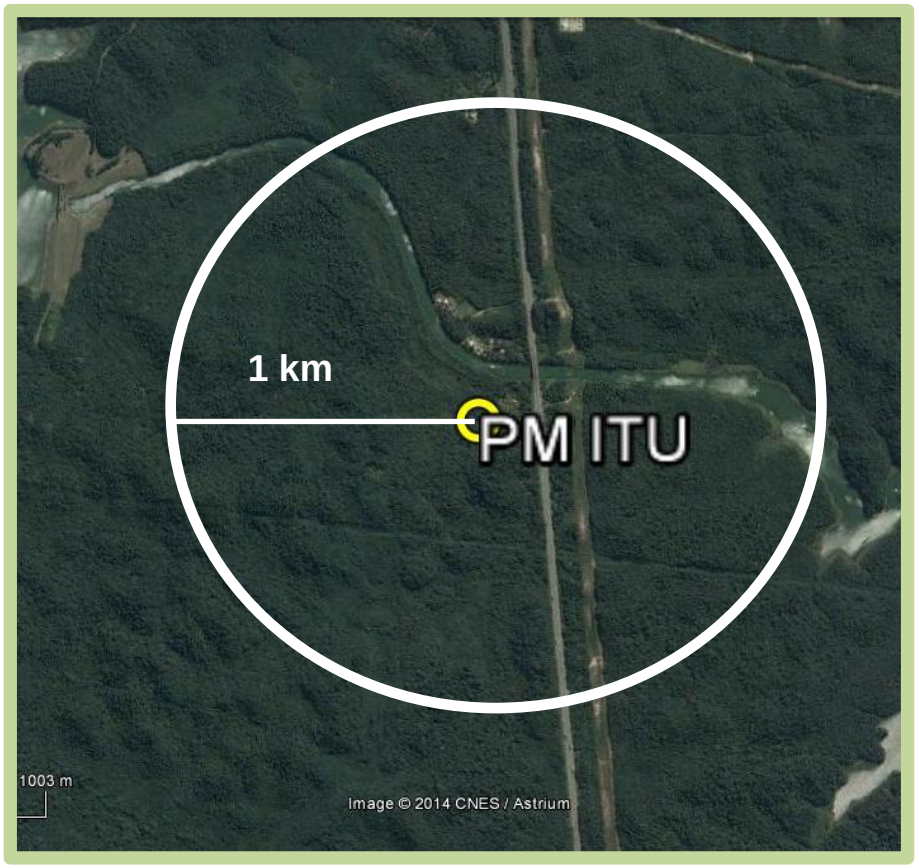
Surface type	Cover fraction (%)
Tree canopy	25.4
Grass and herbaceous ground cover	6.6
Impervious building (roof)	15.1
Impervious road and street	49.0
Water	2.3
Soil and bare ground	0.9
Shrub and Scrub	0.7
Total value	**100**

PM ITU – 10 M

PM ITU (ITUTINGA PILÕES)

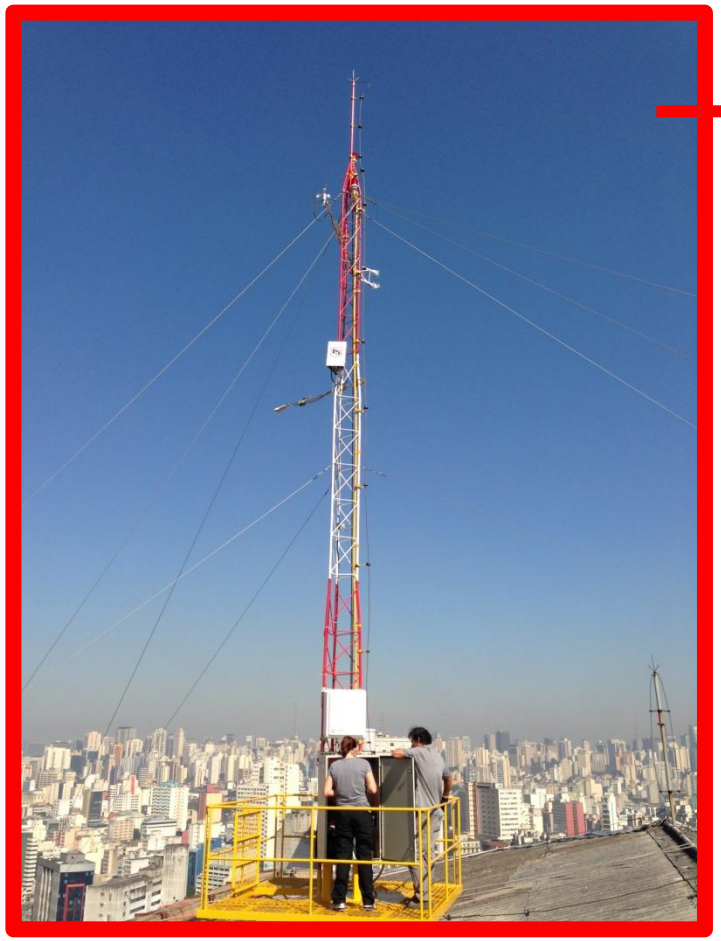
ATLÂNTIC FOREST REFLORESTATION RESERVE

PM ITU: RURAL SITE

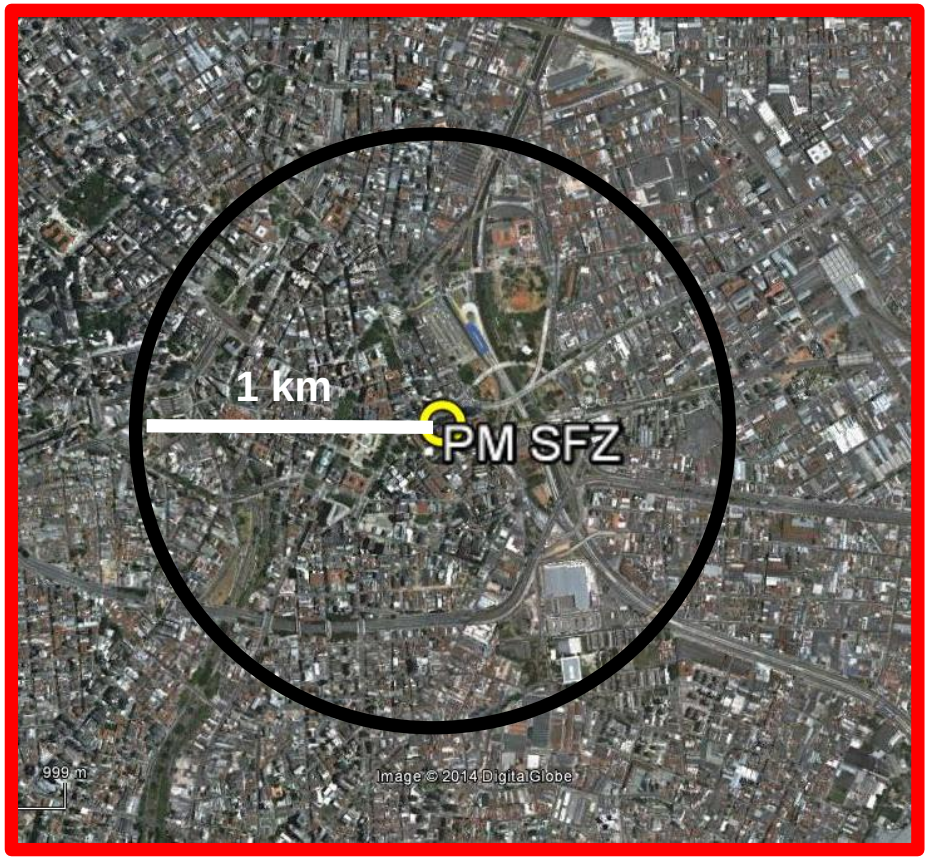


Surface type	Cover fraction (%)
Tree canopy	87.6
Grass and herbaceous ground cover	2.0
Impervious building (roof)	0.4
Impervious road and street	1.6
Water	4.5
Soil and bare ground	1.0
Shrub and Scrub	2.9
Total value	**100**

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



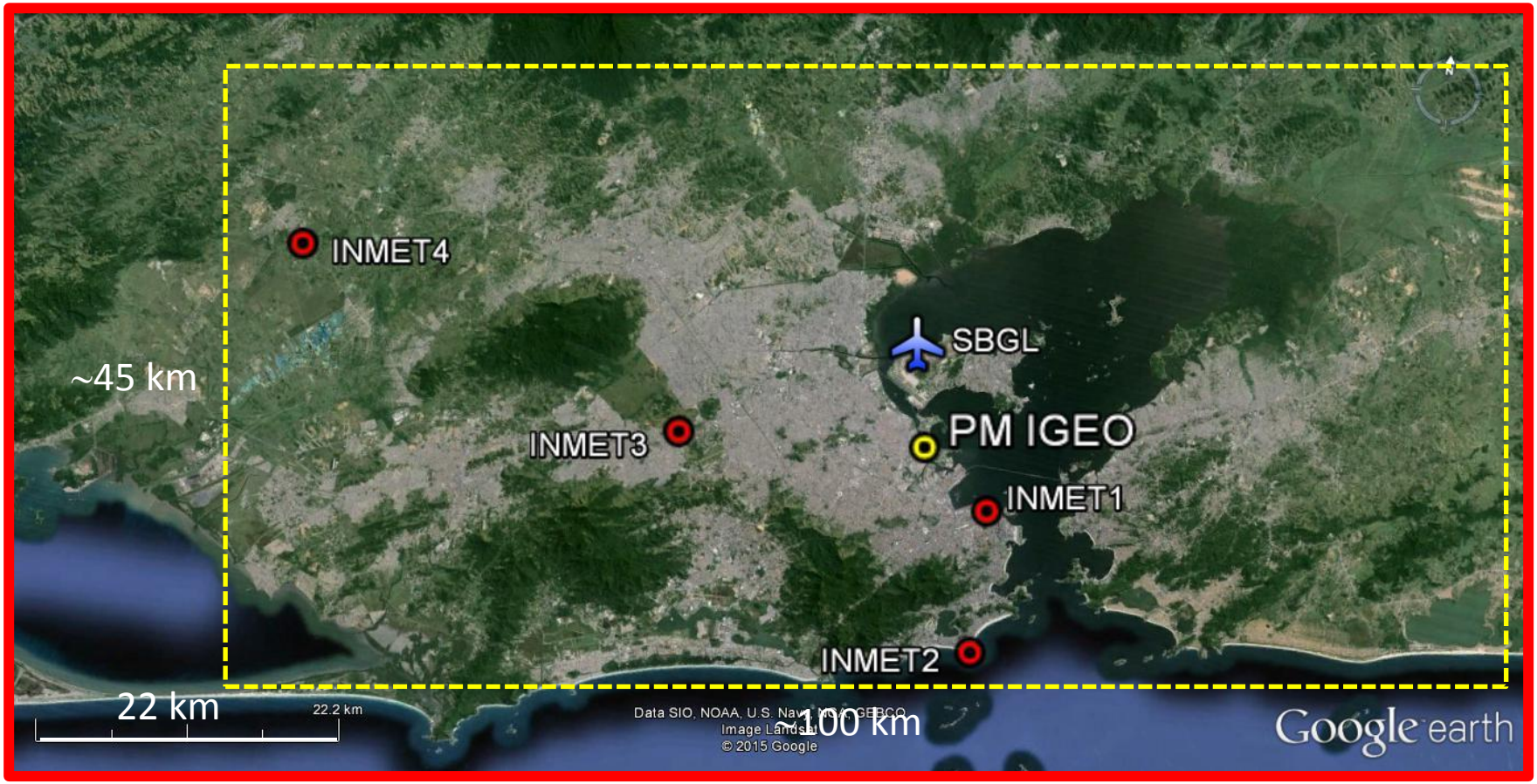
PM SFZ: URBAN SITE



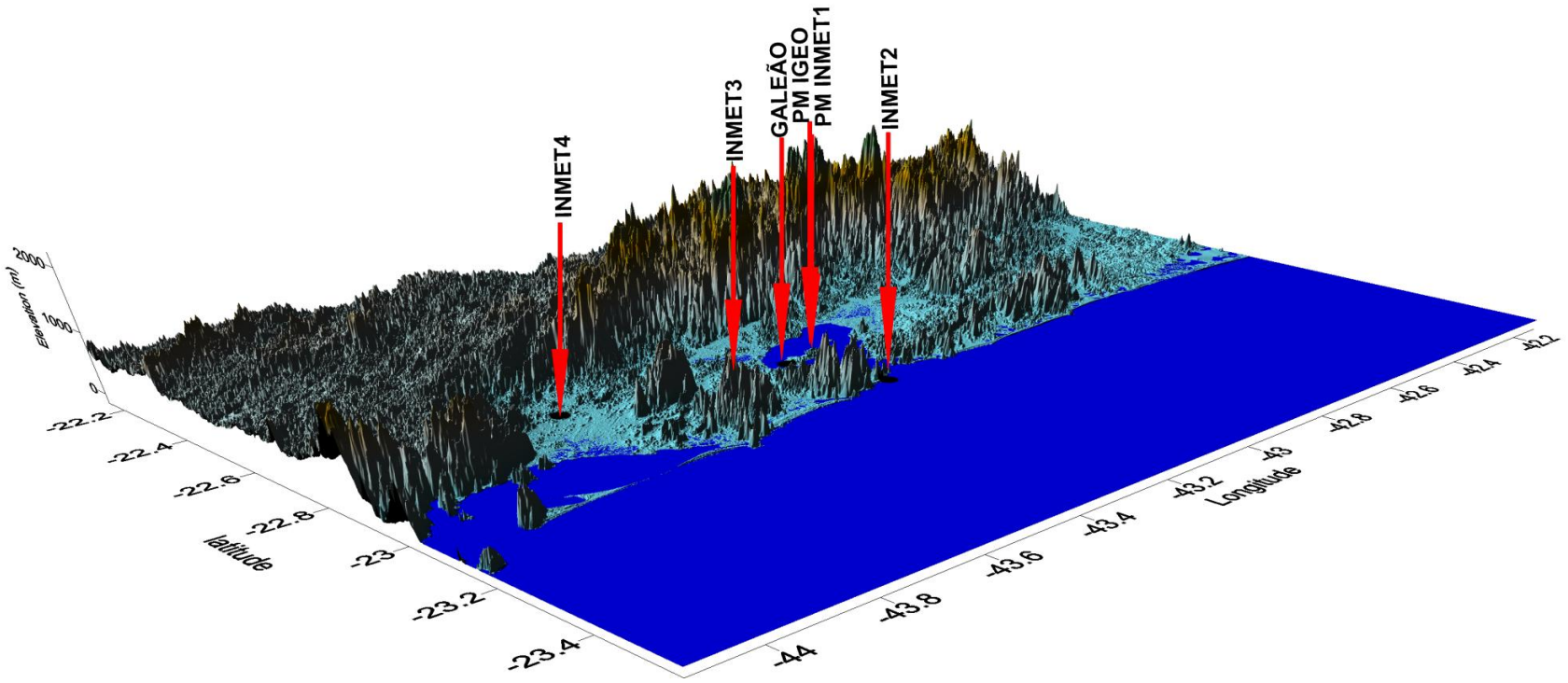
Surface type	Cover fraction (%)
Tree canopy	5.6
Grass and herbaceous ground cover	3.6
Impervious building (roof)	45.2
Impervious road and street	43.4
Water	0.9
Soil and bare ground	1.3
Shrub and Scrub	0.0
Total value	**100**

ABOVE CANOPY OBSERVATION

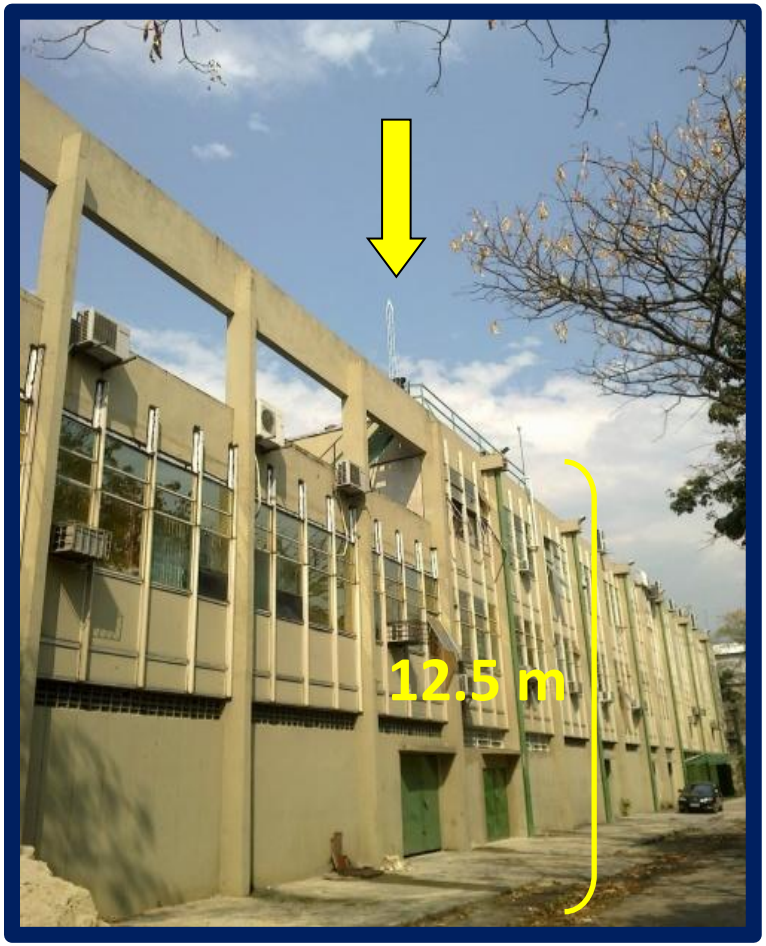
METROPOLITAN REGION OF RIO DE JANEIRO CITY



Topography of Rio de Janeiro



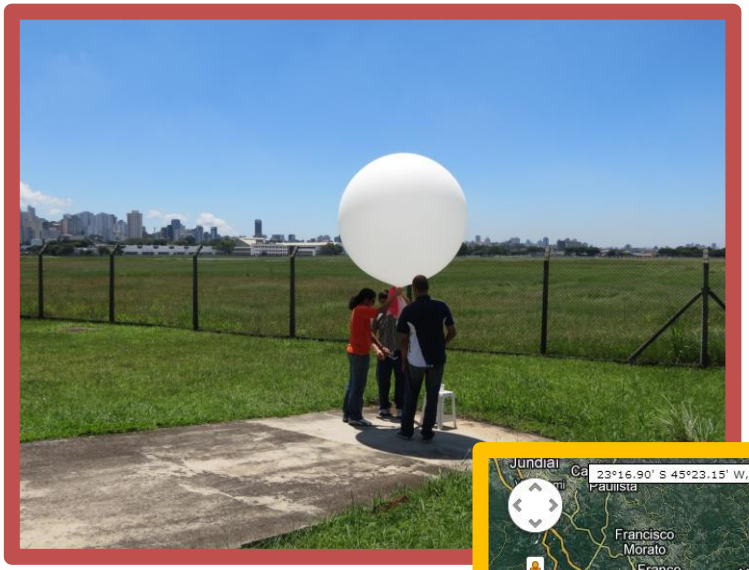
PM IGEO – RIO DE JANEIRO – UNIVERSITY CAMPUS – 3 STORE BUILDING



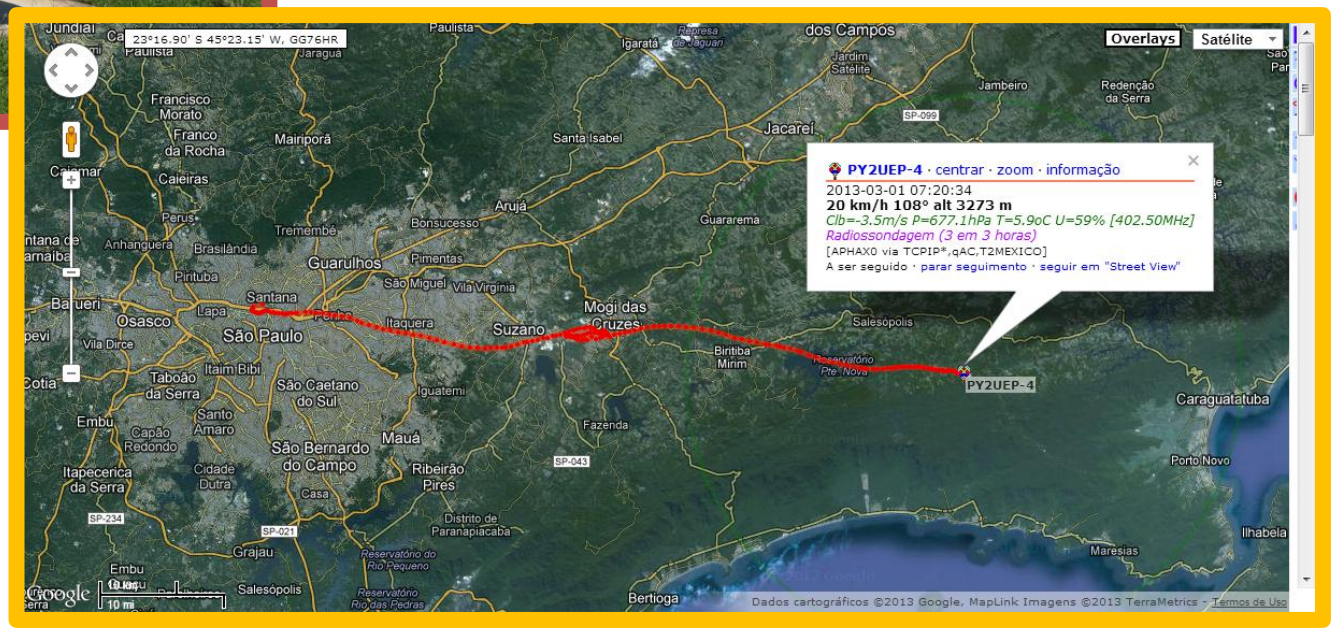
PM IGEO: SURBURBAN SITE

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

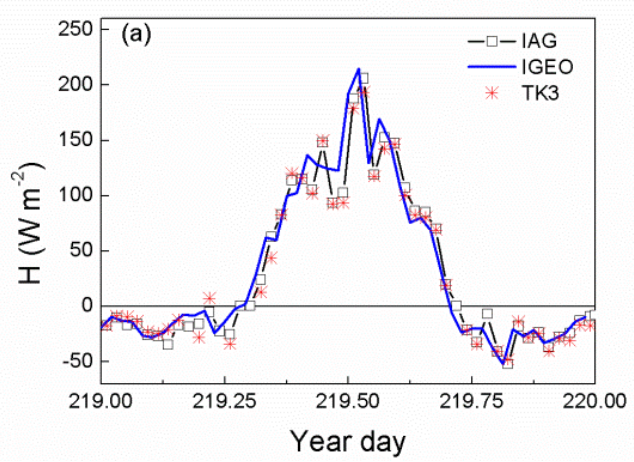


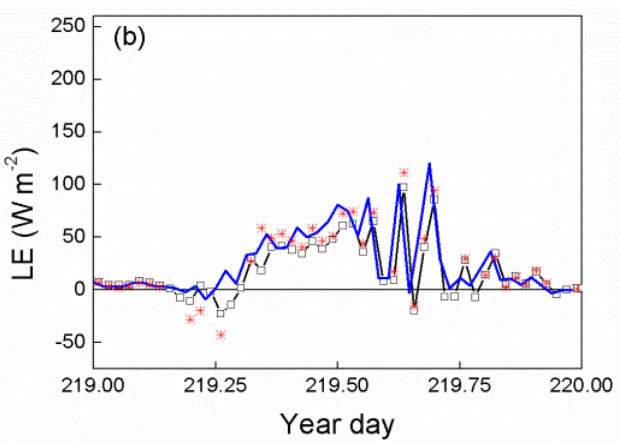
CAMPAIGNS		
1st	São Paulo	February 2013
2nd	Rio de Janeiro	March 2013
3rd	Rio de Janeiro	July 2013
4th	São Paulo	August



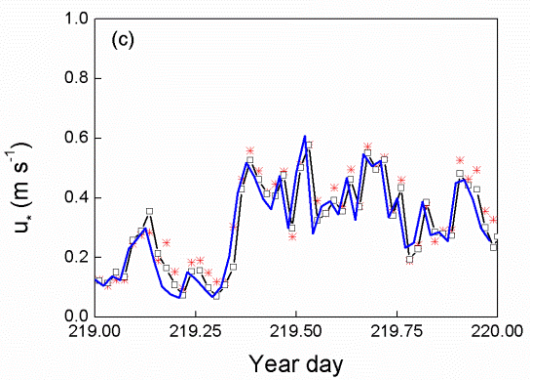
Results

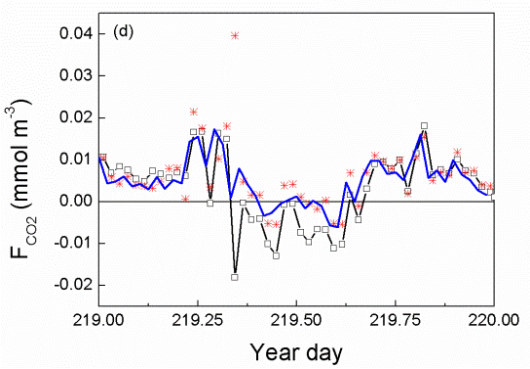
VALIDATION OF EDDY COVARIANCE SOFTWARE USING TK3 (MAUDER AND FOKEN, 2011) AS REFERENCE



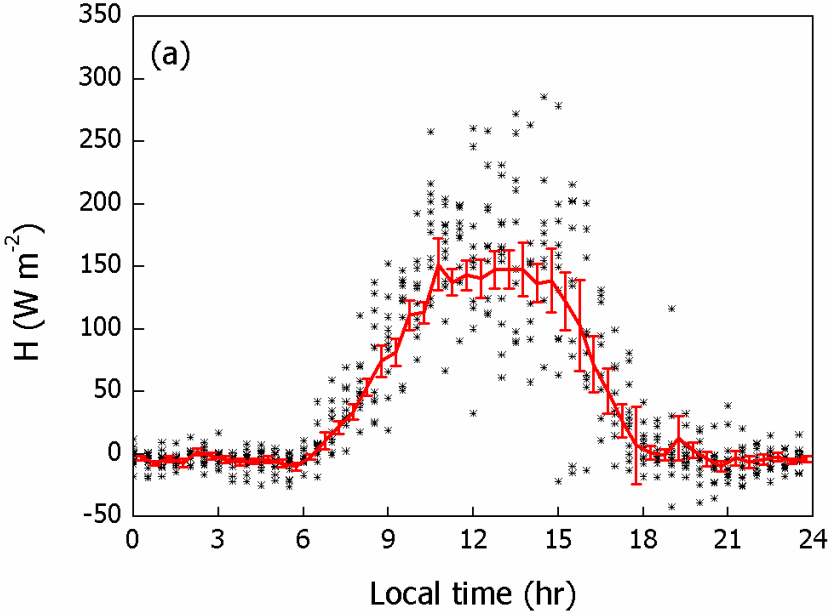


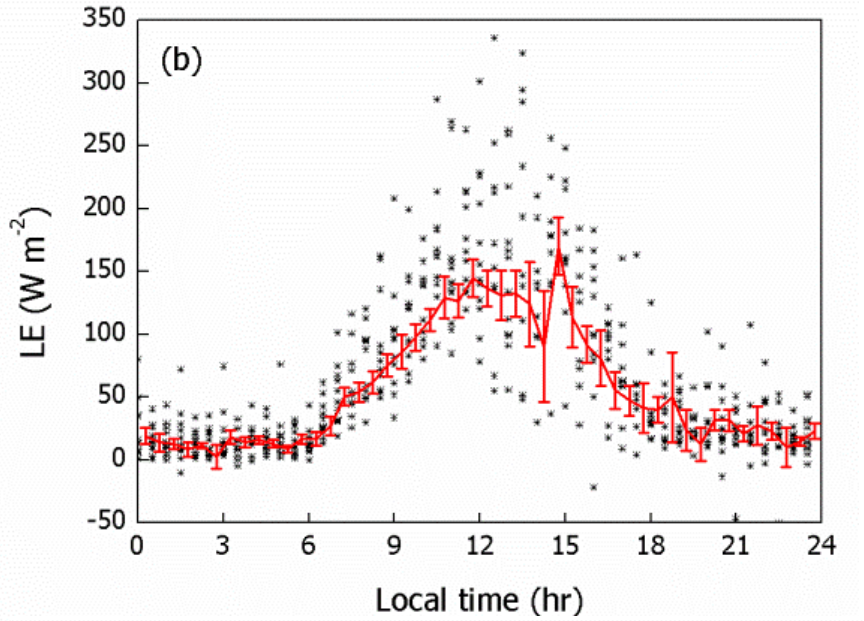
Mauder M and Foken T (2011) Documentation and instruction manual of the eddy covariance software package TK3, Work Report University of Bayreuth, Dept. of Micrometeorology, ISSN: 1614-8916, pp. 46, 58

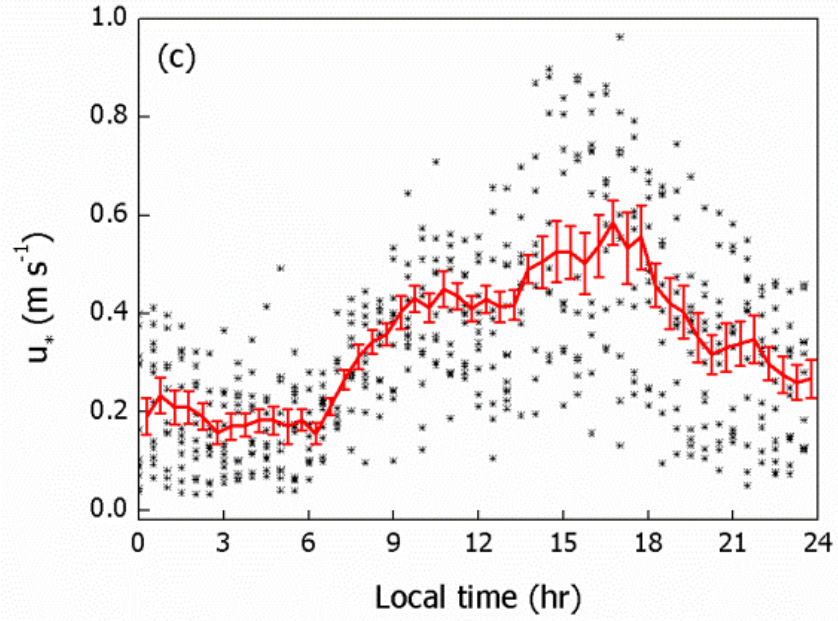


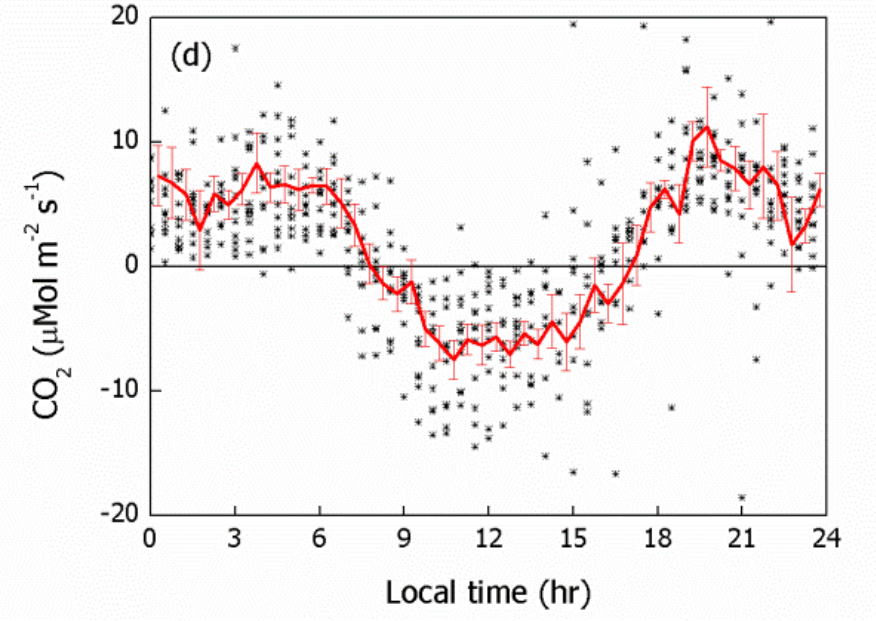


PM IAG - FEBRUARY 2013 – 1ST CAMPAIGN – SÃO PAULO (10 DAYS)

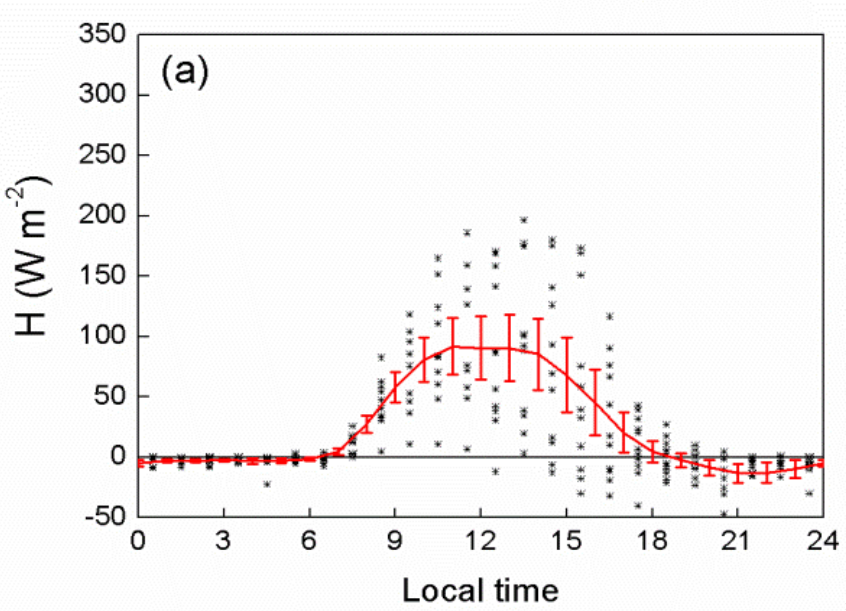


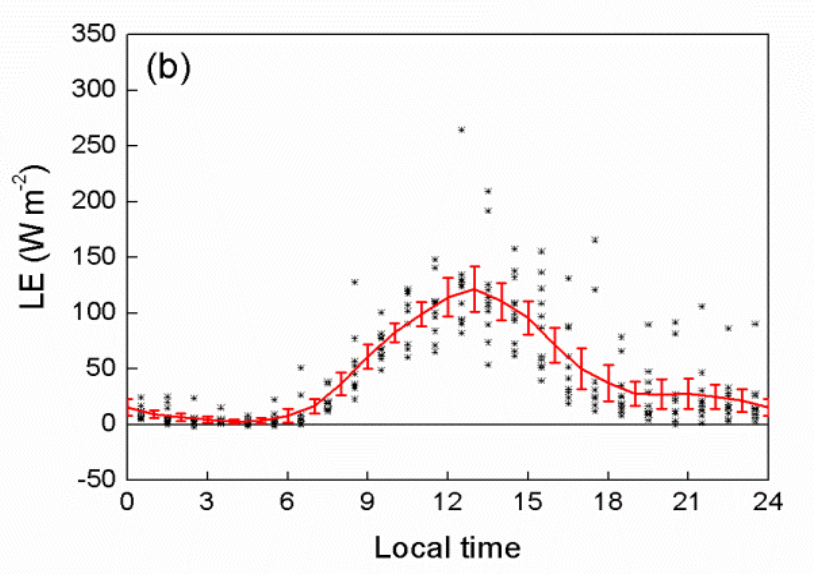


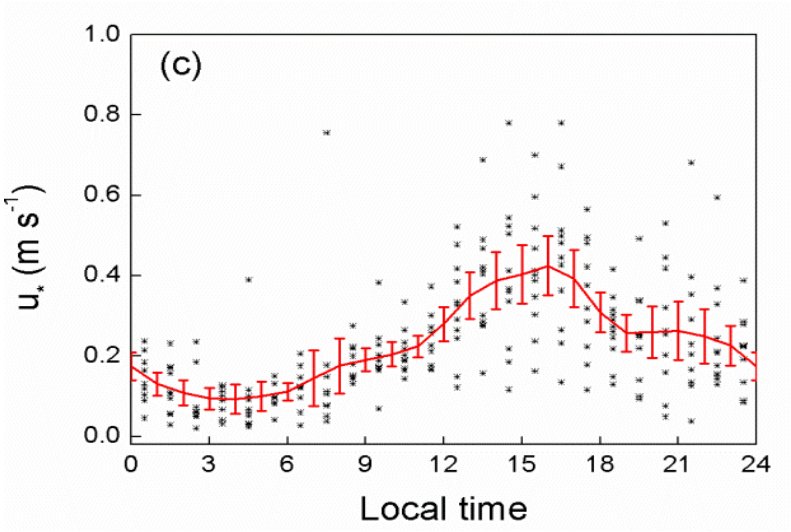


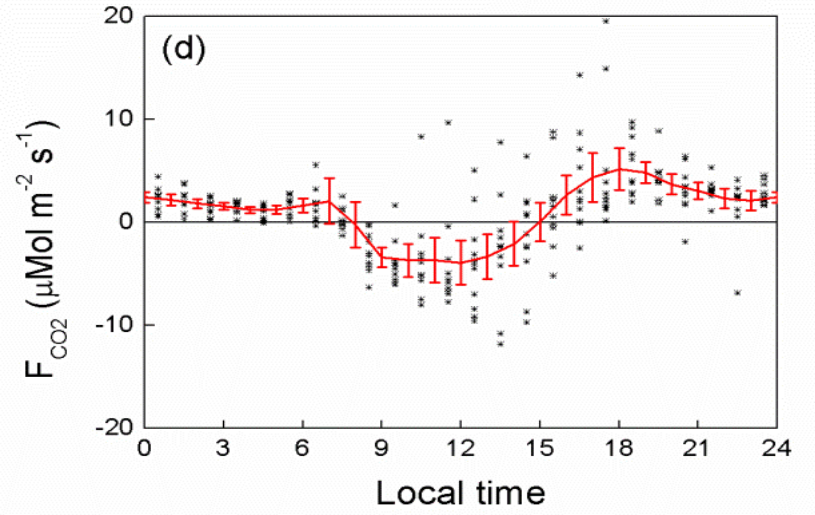


PM IGEO - MARCH 2013 – 2ND CAMPAIGN – RIO DE JANEIRO (10 DAYS)









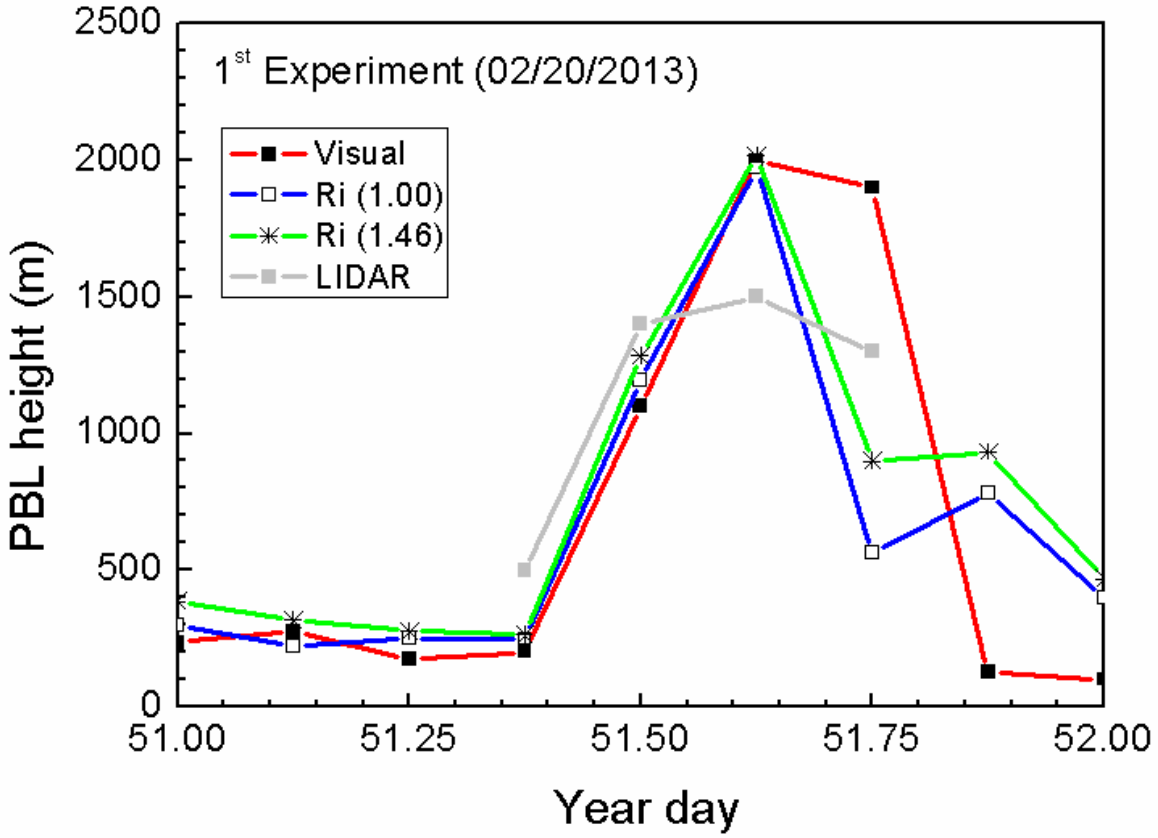
DAILY VALUES SÃO PAULO AND RIO DE JANEIRO DURING THE FOUR FIELD CAMPAIGNS

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.

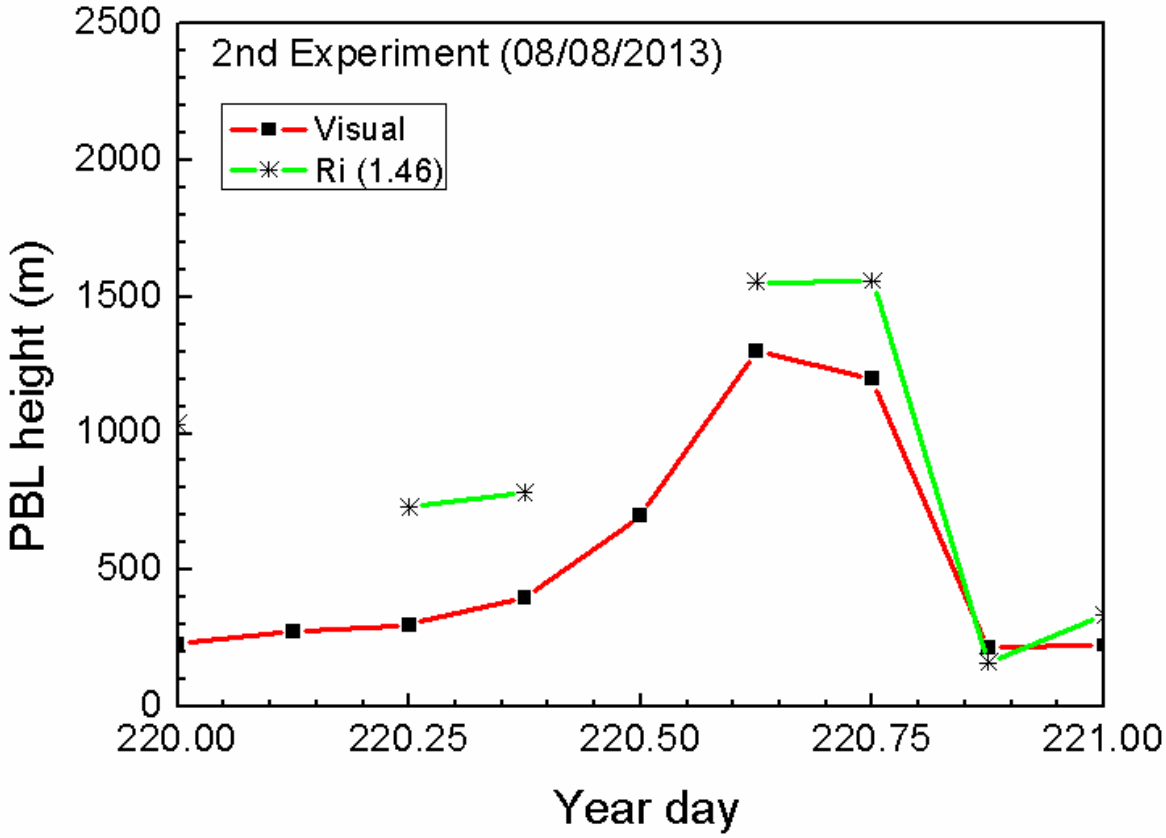
SEB components ($MJ\ m^{-2}\ day^{-1}$)	Campaign			
	1st	2nd	3rd	4th
	February	March	July	August
H	6.10±0.28	2.10±1.74	1.78±0.82	3.16±0.36
LE	4.85±0.41	3.93±1.09	2.64±1.29	1.64±0.27
Bowen ratio	1.38±0.17	0.62±0.57	0.83±0.49	2.25±0.32

Summer (Wet season) Winter (dry season)

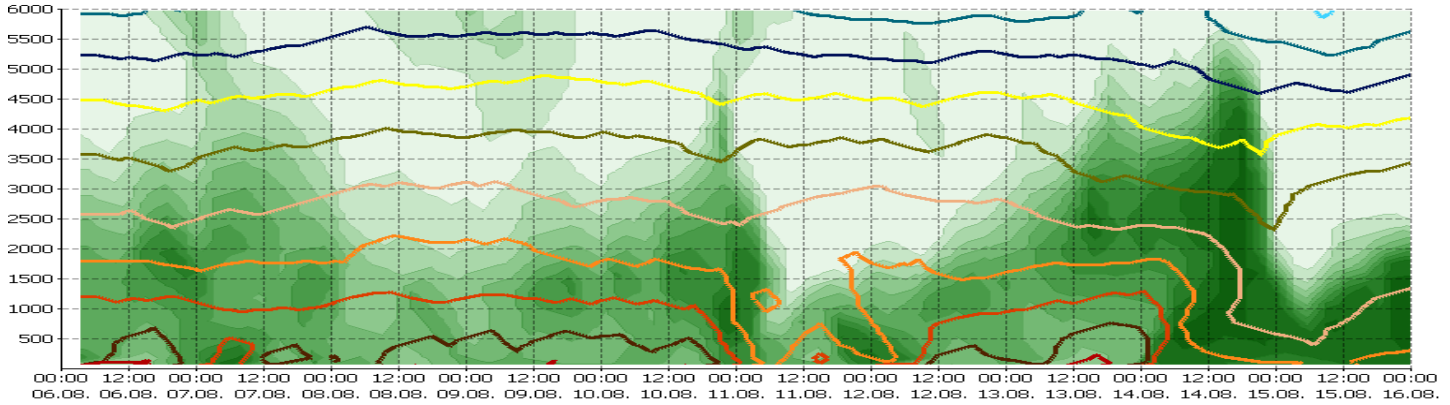
Urban Boundary Layer Summer Campaign – São Paulo

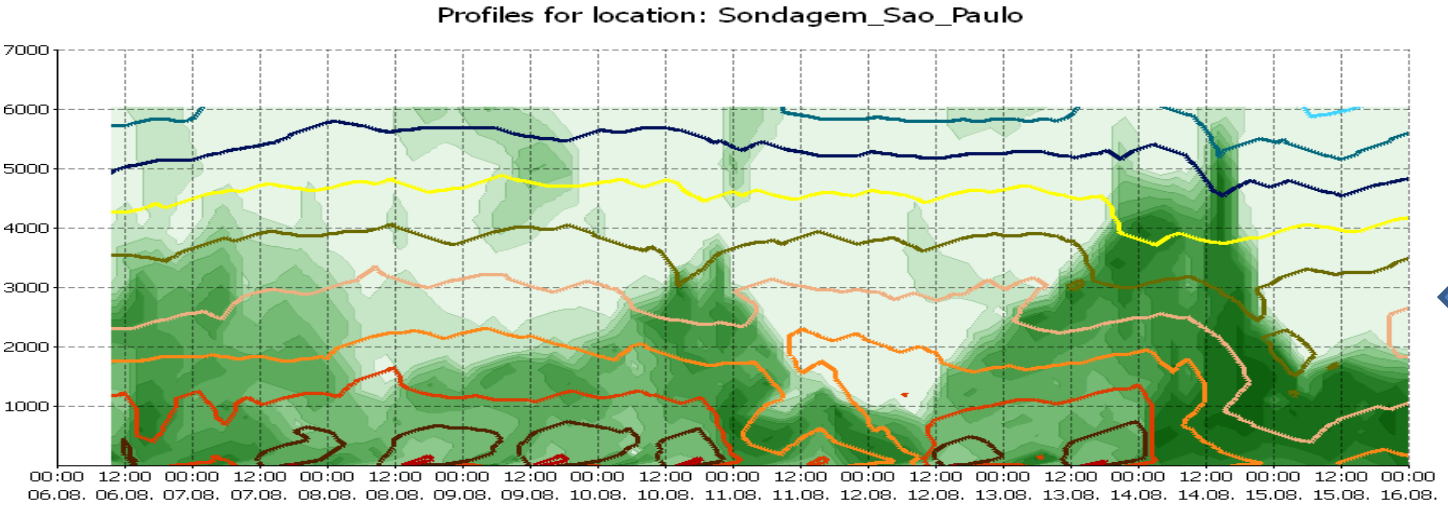


Urban Boundary Layer - Winter Campaign – São Paulo



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





OBS

WHERE AREWE RIGHT NOW?

METROPOLITAN REGIONS OF SOUTHEAST STATES OF BRAZIL				
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Vehicles	6.900.000	3.630.678	1.880.608	502.022
Source: IBGE (2013), Detran-SP (2010), Detran-RJ (2010).				

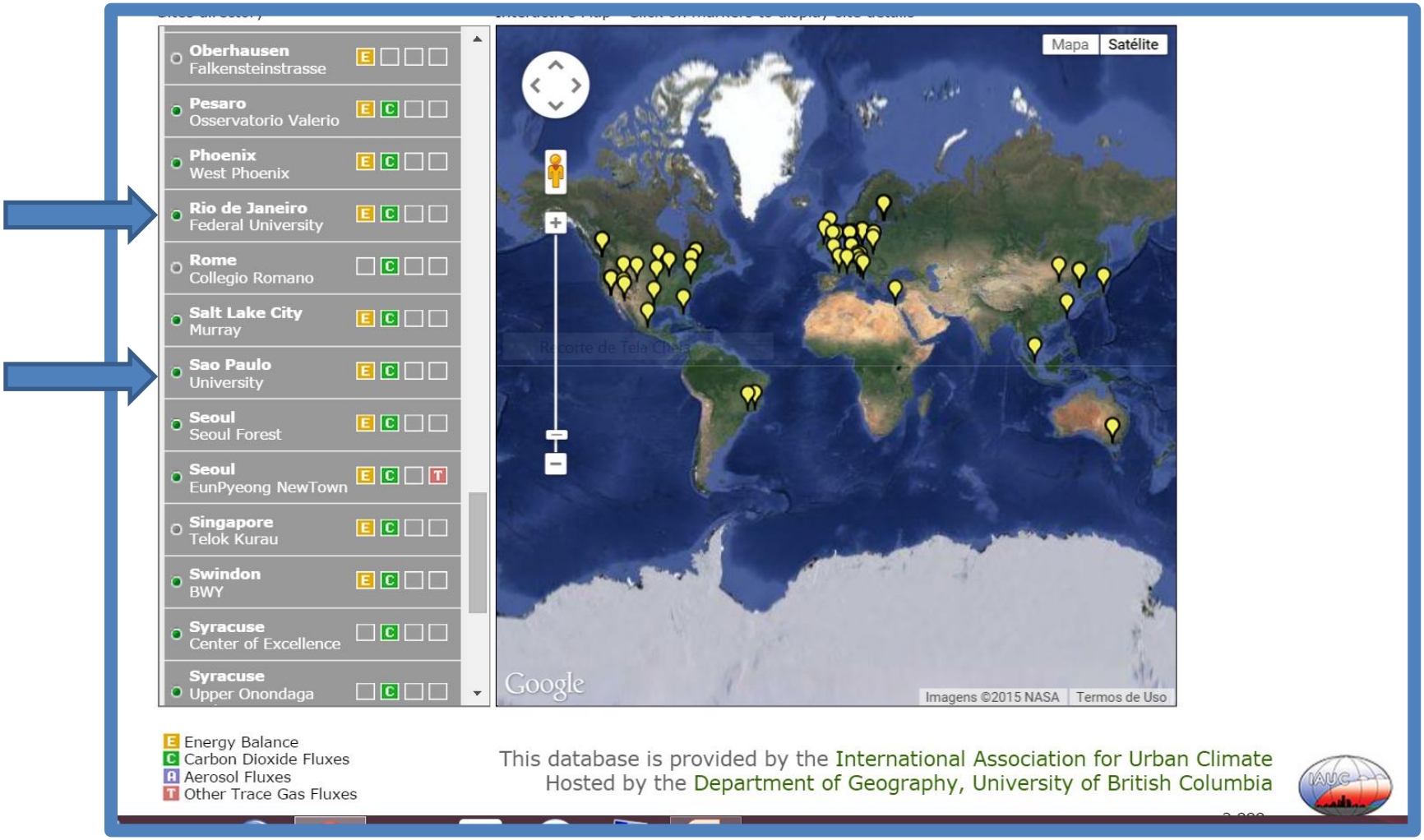
2013
3 Towers

2013
1 Tower

2017
(1 Tower)

2016
(1 Tower

URBAN FLUX NETWORK



SPSS 2013 (2017)

Thank you