NARROWING THE UNCERTAINTIES ON AEROSOL AND CLIMATE CHANGES IN SAO PAULO STATE
NUANCE-SPS

08/58104-8
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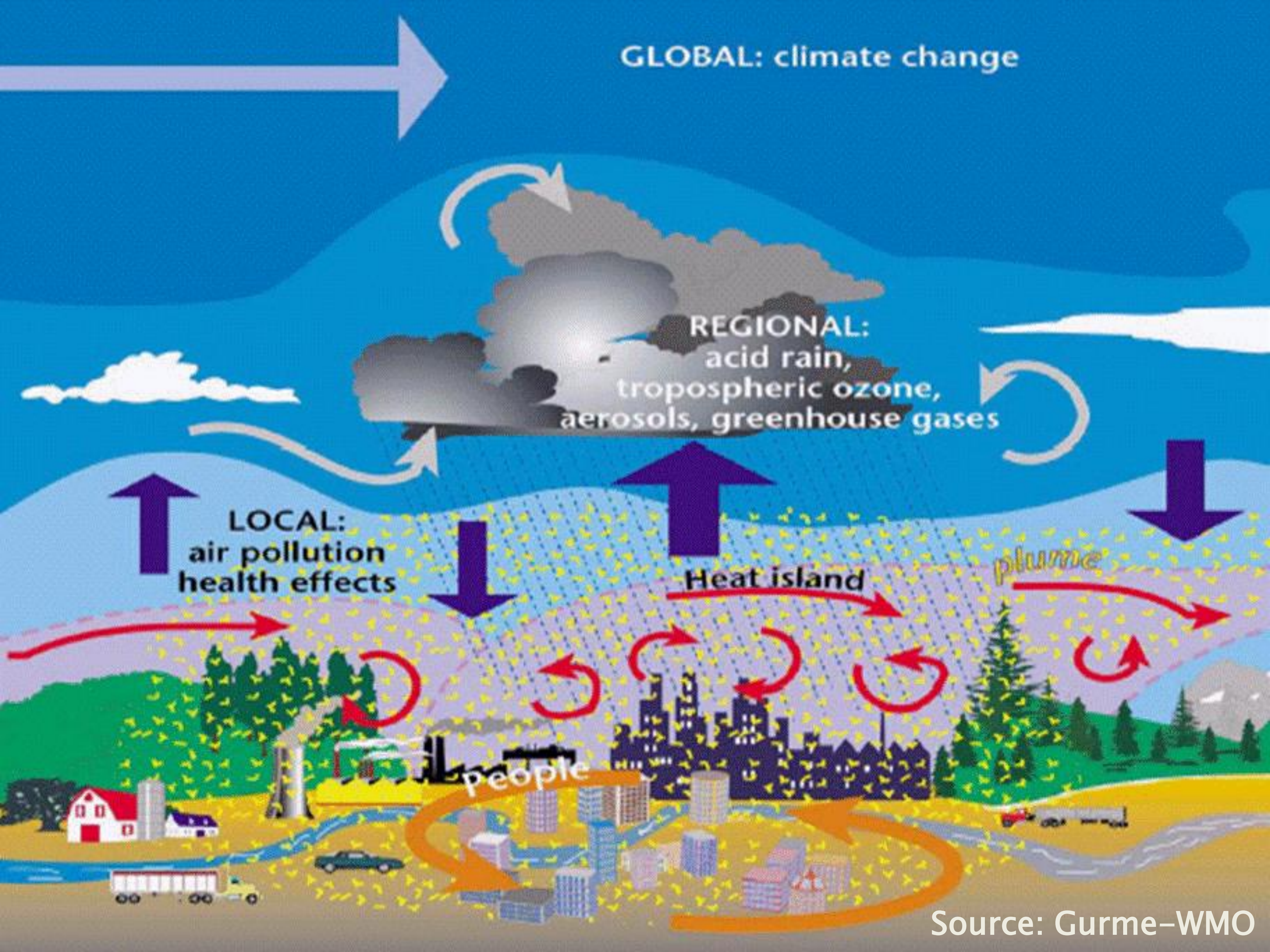
Motivation

The urban areas emissions impact on climate

I

II

And the climate change impacts the cities:
Among many other, the air quality is a important driver



Source: Gurme-WMO

Mega-cities impacts

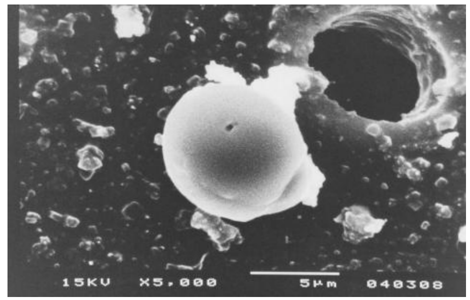
- Urban pollutants
  - CO, NOx, SO_2, PAN, Ozone
  - Particles: sulfate and Carbon
- Green House Gases
  - CO_2
  - N_2O
  - O_3
  - CFC

Changes in soil use

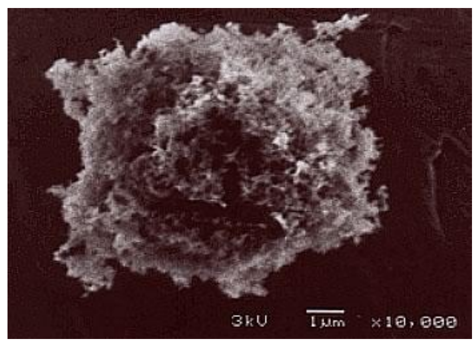
Changes in Energy Balance

Emitted/ formed pollutants in urban areas with global impact

Atmospheric Aerosol



Sulphate



Black Carbon

Ozônio

COV

NOx

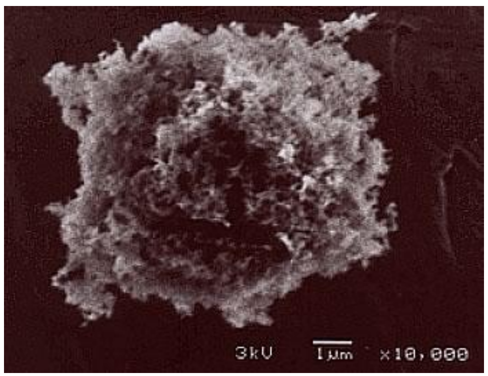
→ O_3

Black carbon climate danger “underestimated”,

Black carbon, is very important in a global scale,

Studies showed that Black Carbon can be the second major responsible for the global warming, being behind only for CO_2.

Ramanathan &Carmichael
Nature Geoscience 1, 221 (2008)



CLIMATE CHANGE

Aerosols heat up

NATURE|Vol 448|2 August 2007

Peter Pilewskie

Solid particles suspended in the atmosphere have long played second fiddle to greenhouse gases as agents of climate change. A study of atmospheric heating over the Indian Ocean could provoke a rethink.

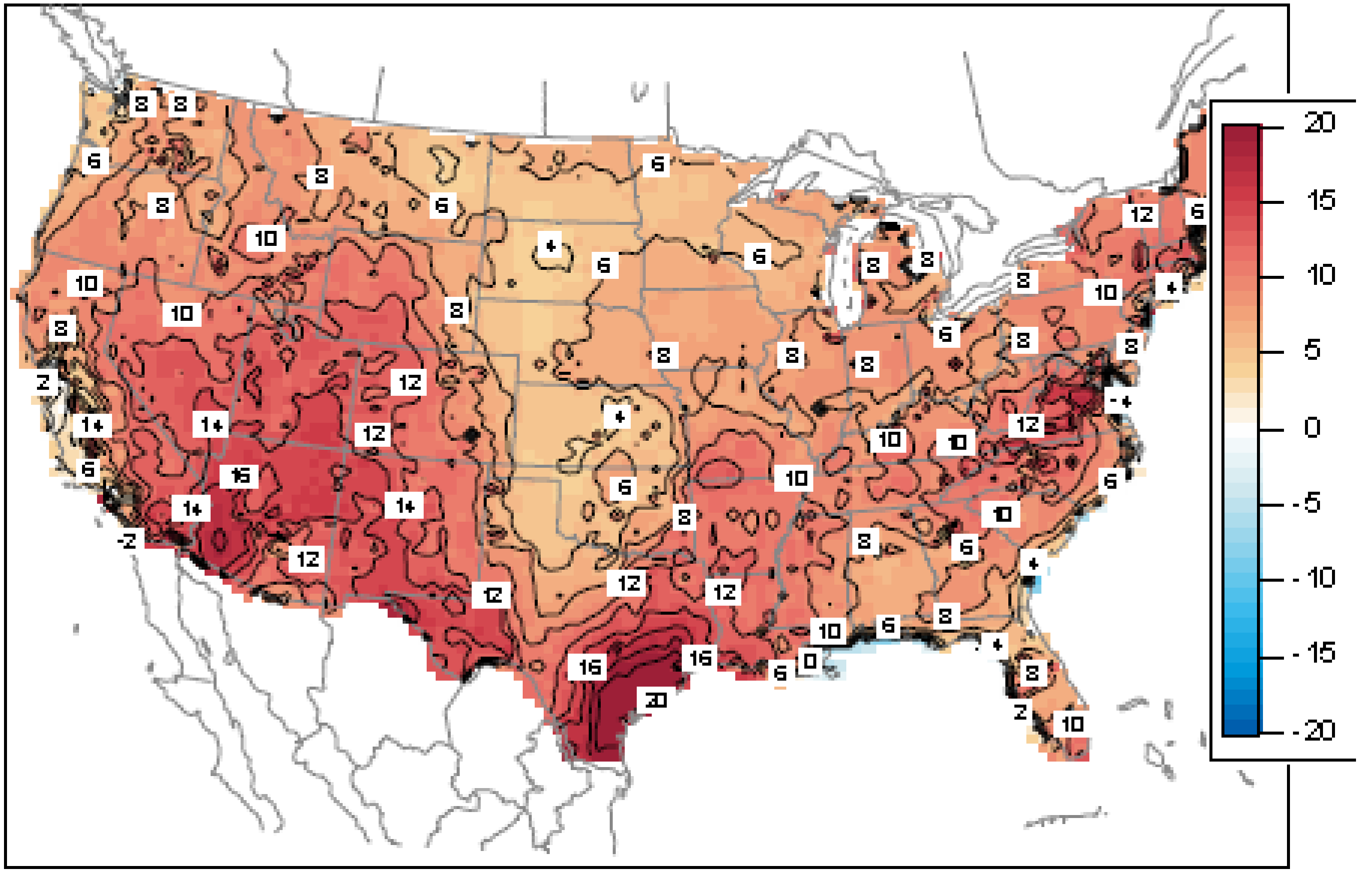
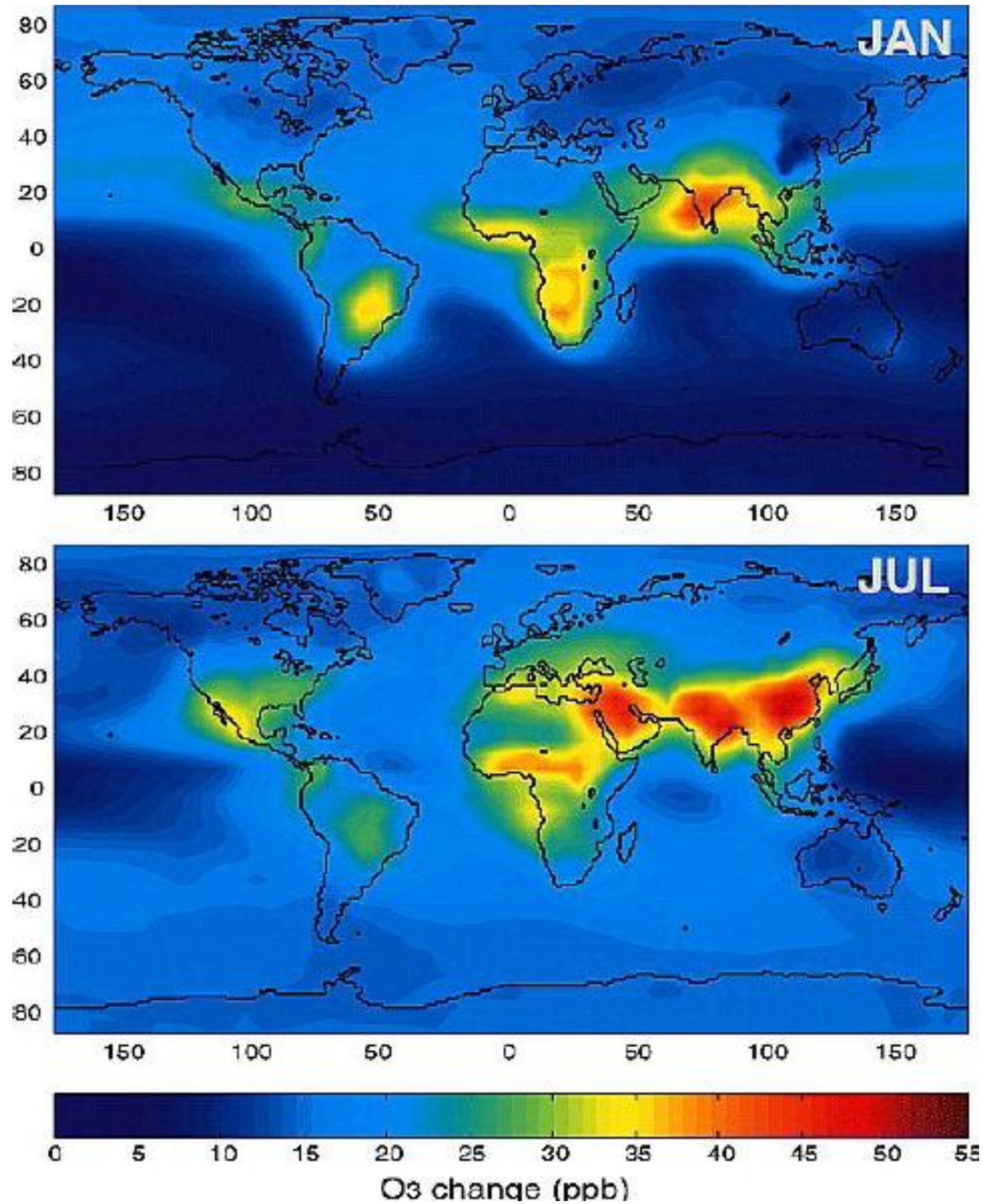


Fig. 10. Difference plot of summer averaged daily maximum 8 h averaged (DM8H) ozone mixing ratios (ppbv) (future case minus base case).

The effects of global changes upon regional ozone pollution in the United States.
J. Chen1,*, et al., Atmos. Chem. Phys. Discuss., 8, 15165–15205, 2008

Example I

Evaluation of a superficial ozone concentration increase For 2000 to 2100



Prather et al., GRL 2003

Example II

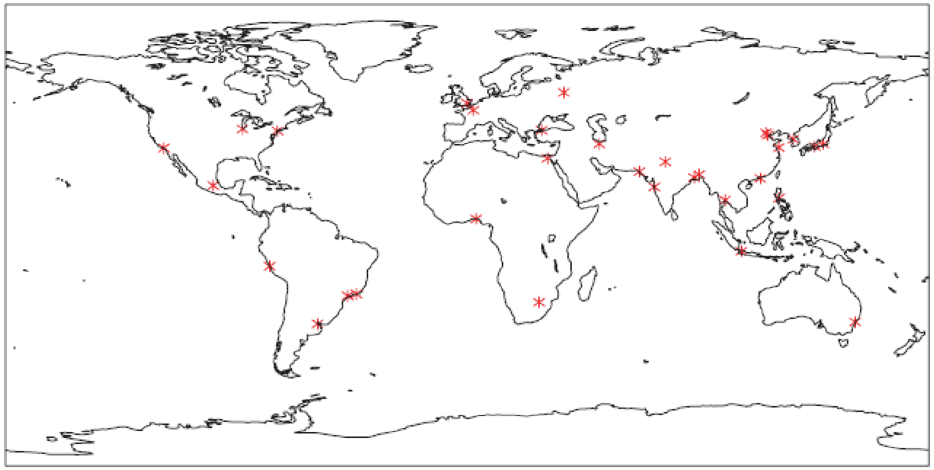


Fig. 1. Locations of the 'megacities' considered in this study, shown in red.

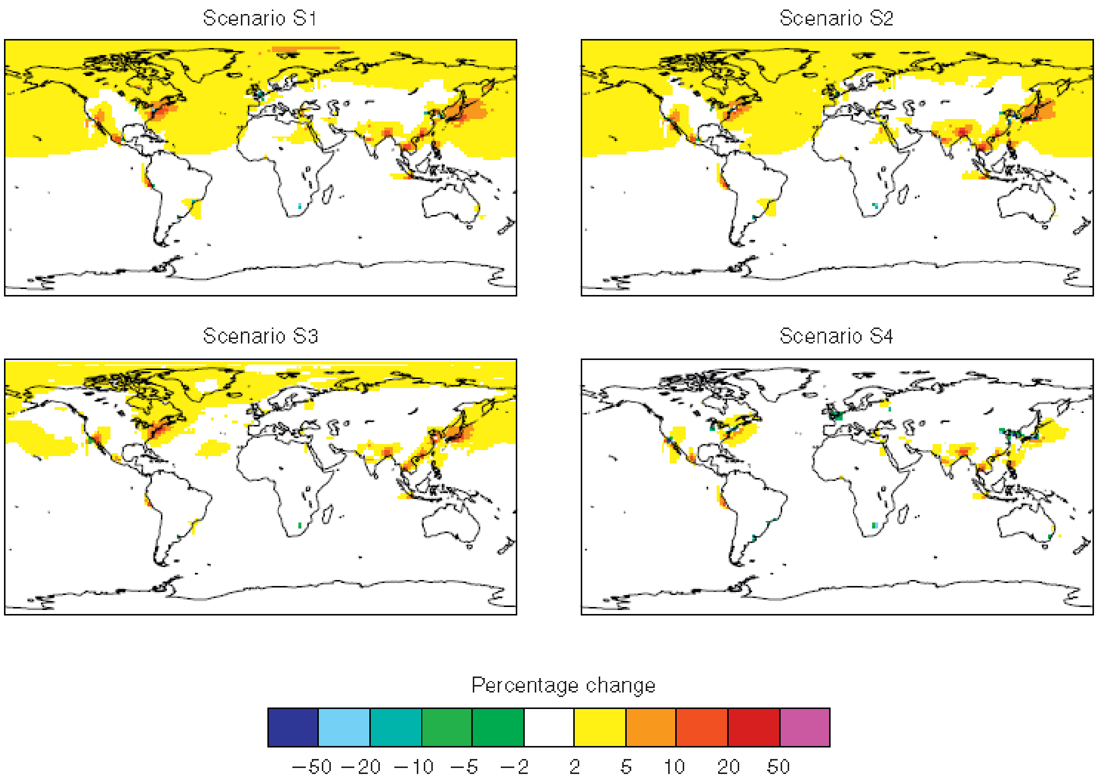


Fig. 3. The percentage change in the global surface July O_3 mixing ratio due to megacity emissions under all scenarios.

Global impact from the increase of pollutants emissions by the megacities.

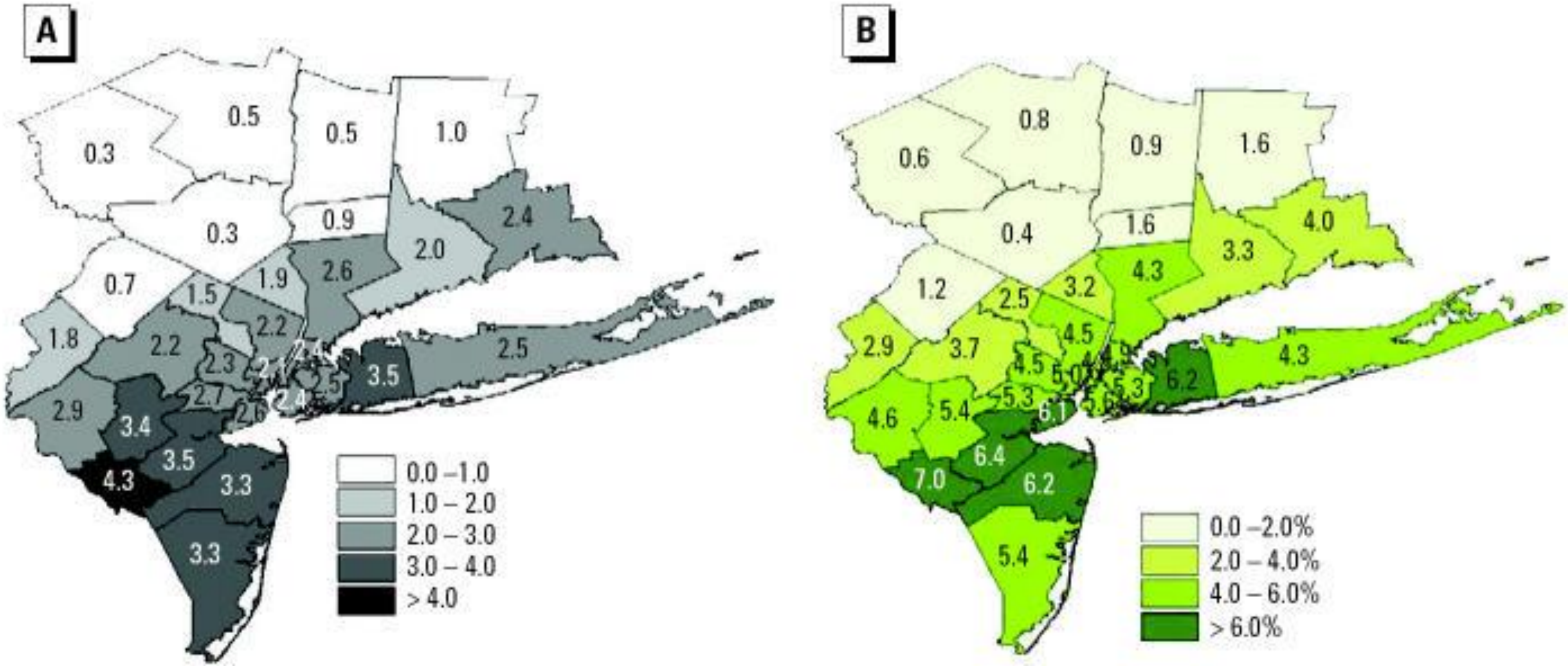
Mega-cities impact on ozone concentration

The influence of megacities on global atmospheric chemistry: a modelling study

Timothy M. ButlerA,B and Mark G. LawrenceA

Environ. Chem. ***2009, 6, 219–225.***

Climate change impact on ozone concentrations and health effects



Estimated changes in O_3 and associated summertime mortality in the 2050s compared with those in the 1990s for M1, where climate change alone drives changes in air quality. (*A*) Changes in mean 1-hr daily maximum O_3 concentrations (ppb). (*B*) Percent changes in O_3-related mortality.

Assessing Ozone-Related Health Impacts under a Changing Climate. Kim Knowlton,[1] et al. 2004Environ Health Perspect. 2004 November; 112(15): 1557-1563.

The project – approach 1

- ***The megacity of São Paulo will be an example of integrated approach regarding evaluating of the impact of the climate change on its air quality. In this project, MASP will be an observatory of the climate, with special attention to the variation of the meteorological characteristics due to the climate change.***

The project – approach 2

- ***Modeling the impacts of the Sao Paulo megacity emission. That involves the knowledge of the sources of the aerosols and gases (both primary and secondary) and their spatial distribution.***

•***The theme of the project can be summarized as the implementation of a modeling system representing the chemical-physical process in the troposphere and the health impacts at the urban scale.***

The main questions that will be addressed in NUANCE

- Which are the effects of global climate and chemical composition on regional air quality, evaluated through atmospheric models?

- What is the contribution of emissions of the megacity of São Paulo to its surroundings

- What are the couplings and feedback mechanisms among climate change, air pollution and their relationship to the human health?

- How is the physical-chemistry process of aerosol formation and how it influences the energetic balance (urban and sugar cane burning emissions, chemical composition)?
- How is the interaction of the man-made aerosols to the cloud microphysical process?
- What are the relevant chemical, microphysical, and radiative properties, of the aerosols and bio-aerosols emitted and formed in the region?
- What is the aerosol radiative forcing in MASP?

a e r o s o l s

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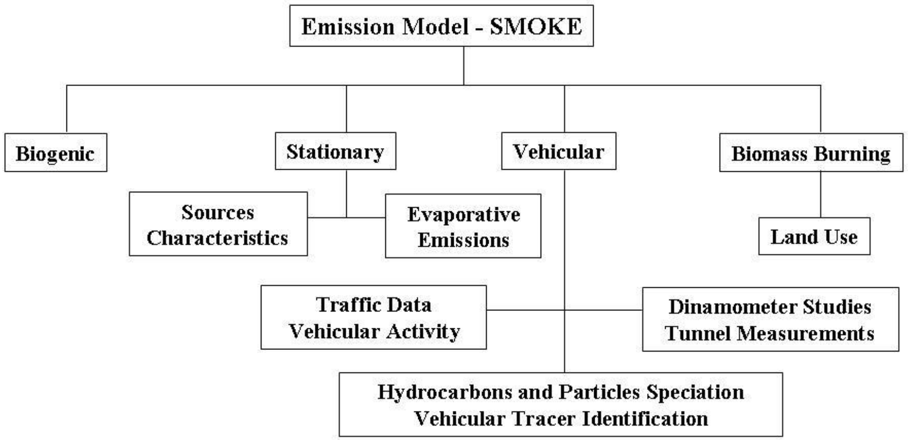
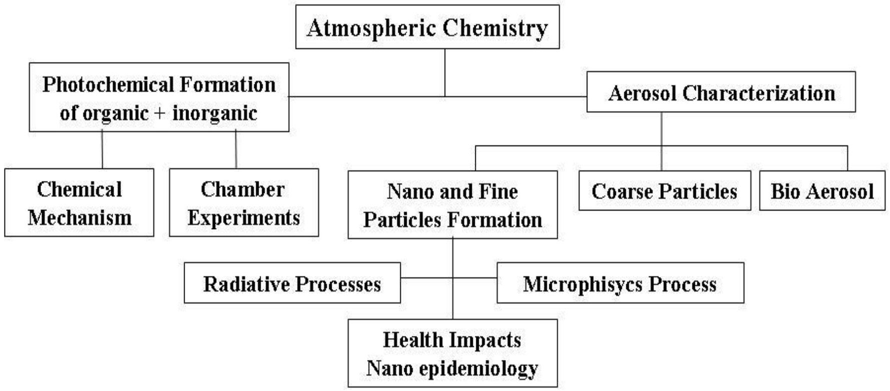
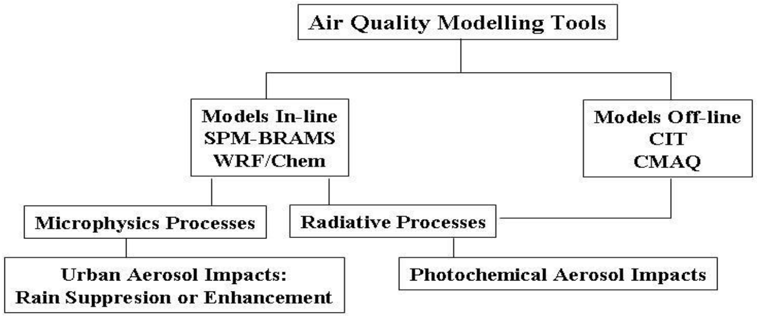
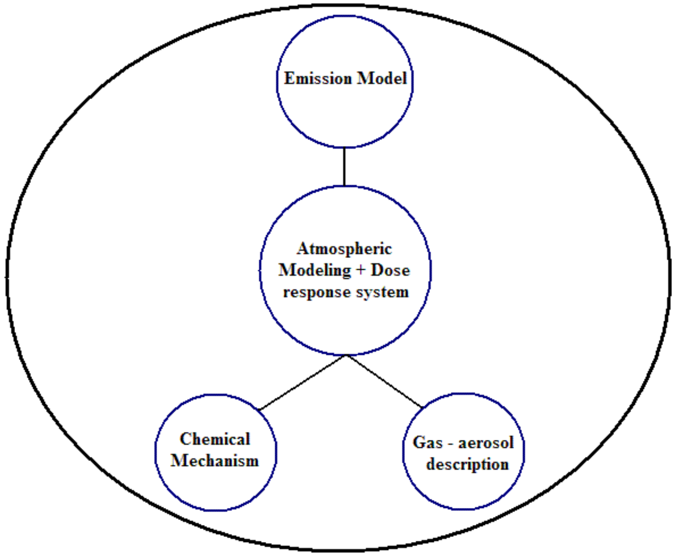




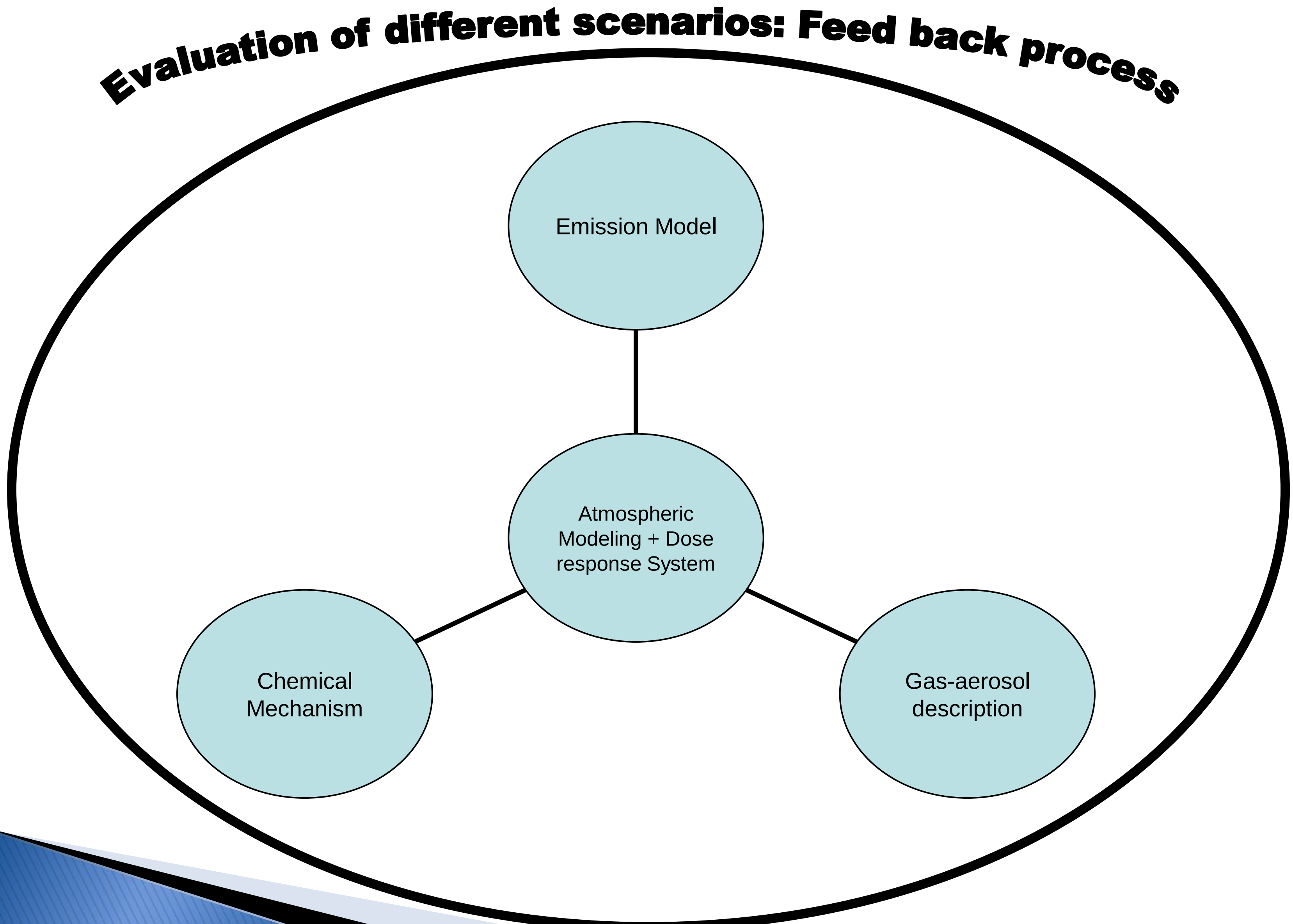


Integrating the modules

Evaluation of different scenarios: Feedback process



Integrating the modules



Modeling approach

SPM-BRAMS, WRF-Chem, CMAq-Models 3

Experimental campaigns

- comprehensive field observations to catalyze efforts in developing a consistent standard for megacity emissions inventory development, which bridges gaps between the needs of local air quality and global climate policymakers.

    - Particles and Gaseous compounds
    - Optical properties

Experimental campaigns

Aircraft observations to assess how variability in urban plume transport

Experimental campaigns to develop emission data from mobile and other sources

Experimental Measurements to determine the vertical profiles: LIDAR, Soundings, etc.

Surface measurements

This study isolates the role of transportation as a key sector responsible for the majority of interurban variability across the region.

Supersites Sampling

Pico do Jaraguá Station (new station that will be installed): Continous monitoring of SO_2, NOx, O_3, PM_{10}, $PM_{2,5}$, PAN, CO, COVs, Green House Gases (CO_2, CH_4 and N_20), NH_3.

Ibirapuera Station – To complete the present station (historical air quality station from CETESB) : $PM_{2,5}$, PAN, CO, COVs.

Examples

Emission Factor Evaluations

- Measurements inside traffic tunnels
  - Experiments are being developed since May 2, 2011.

Emission factors – light-duty fleet (μg/km)

Species	EF ($\mu g\ km^{-1}$)
S	405,3$\pm$ 1,11
Cu	786,6$\pm$ 0,05
Zn	695,8$\pm$ 0,14
Br	15,6$\pm$ 0,05
Pb	87,0$\pm$ 0,05
BC*	17,0 $\pm$0,05

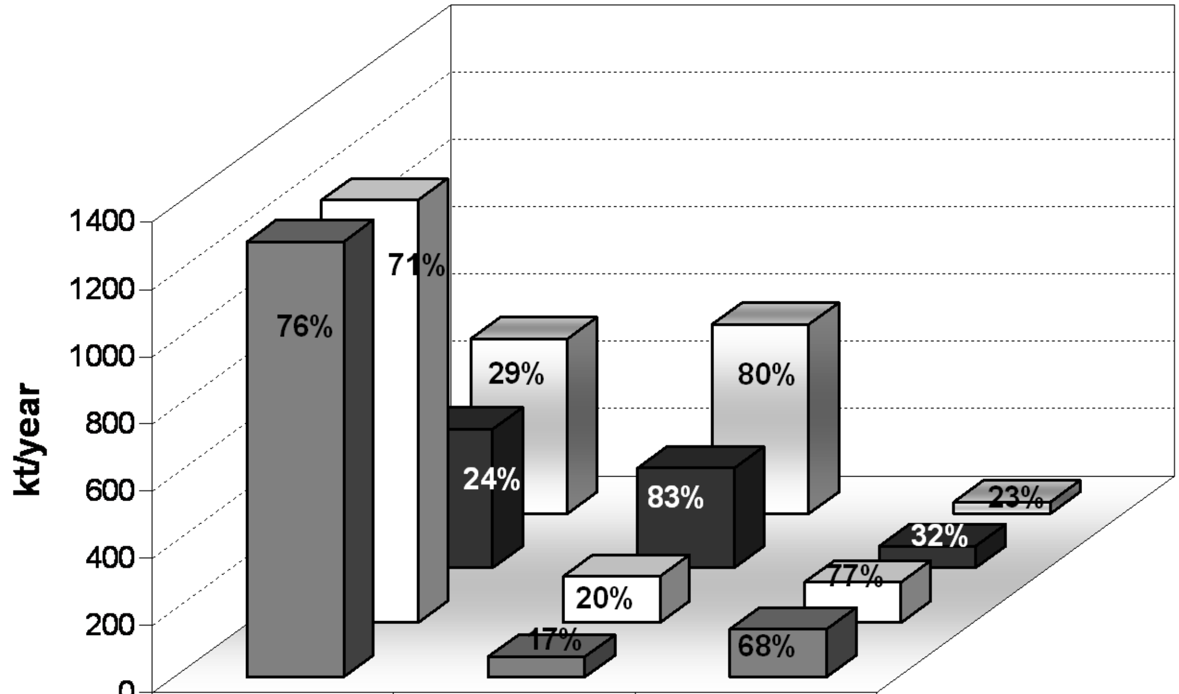
***Black carbon (BC) in mg km^{-1}**

Measurements performed in 2004 in-tunnel

Emission factors (and standard deviation) in-tunnel JQ and MM (mg km^{-1}), EF ration between heavy and light fleet for 2004.

	BC ($mgkm^{-1}$)	PM_{10} ($mgkm^{-1}$)	$PM_{2.5-10}$ ($mgkm^{-1}$)	$PM_{2.5}$ ($mgkm^{-1}$)
Tunnel JQ Light-duty vehicles	**16 (5)**	**197 (118)**	**127 (67)**	**92 (20)**
Tunnel MM Heavy-duty vehicles	**462 (112)**	**754 (401)**	**715 (585)**	**588 (364)**
Ration Heavy/Light	**27**	**3**	**5**	**4.8**

Heavy-duty vehicles emitted much more BC, PM_{10}, $PM_{2.5-10}$ and $PM_{2.5}$ than light-duty vehicles.



	CO	NOx	HC exaust
CETESB light-duty	1293	61	142
Tunnel light-duty	1256	138	120
CETESB heavy-duty	414	296	66
Tunnel heavy-duty	521	564	35

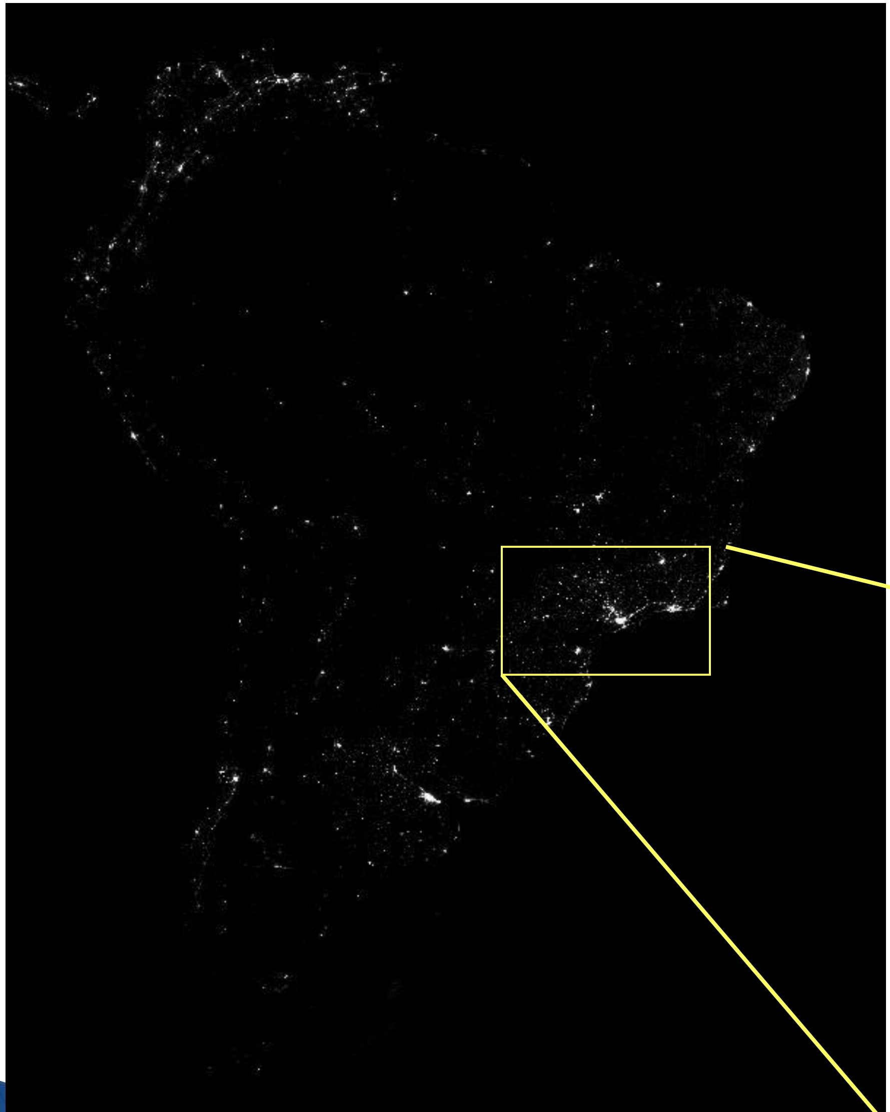
Comparison of annual vehicular emission and of the contribution of light-duty and heavy-duty fleet for CO, NO_x and HC, obtained in this study and by CETESB in 2004

Martins, 2006

Spatial distribution of sources

- Traffic models
- Distribution of mobile sources

Source distribution Noturn Light DMSP-OLS

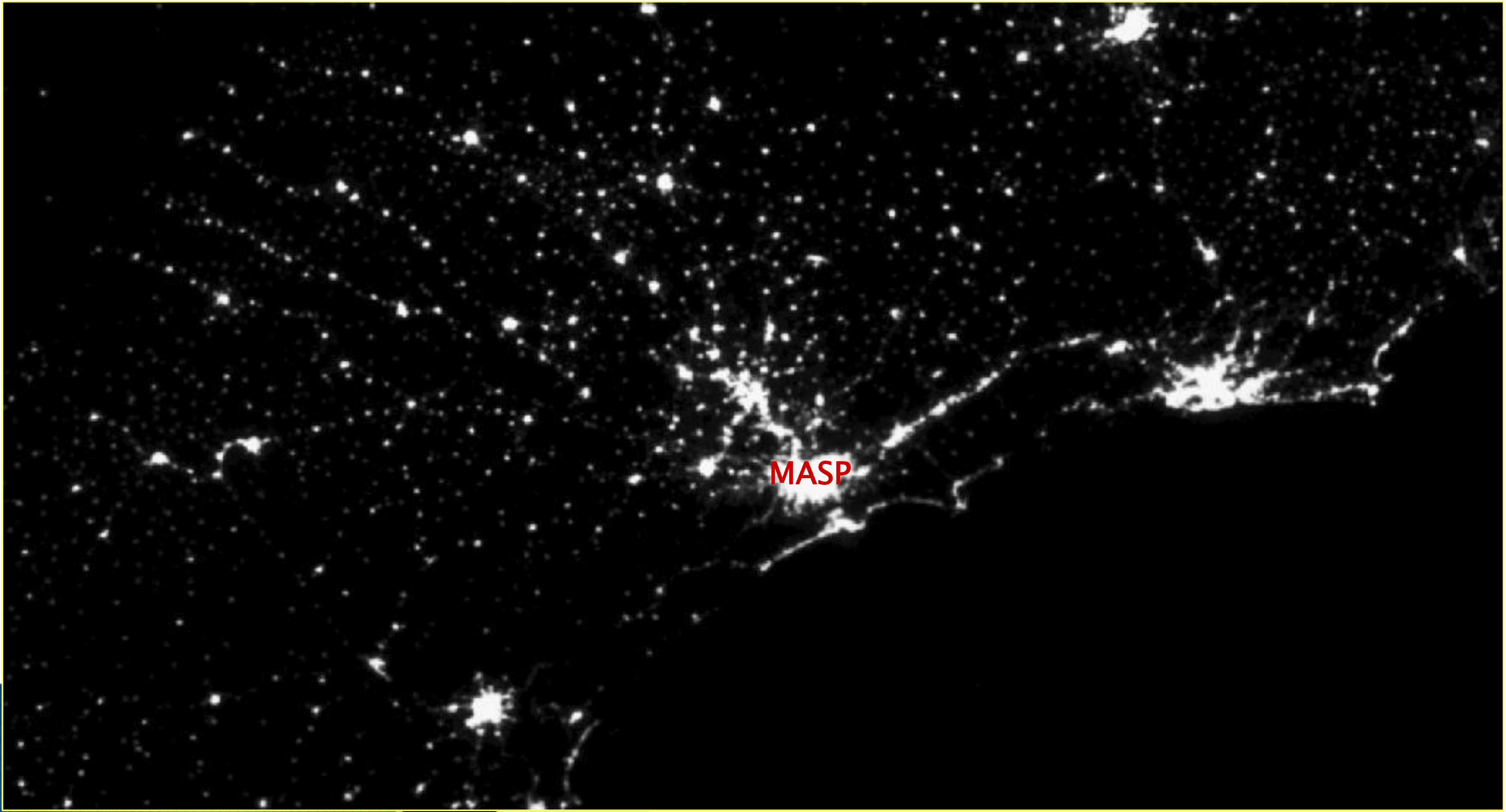


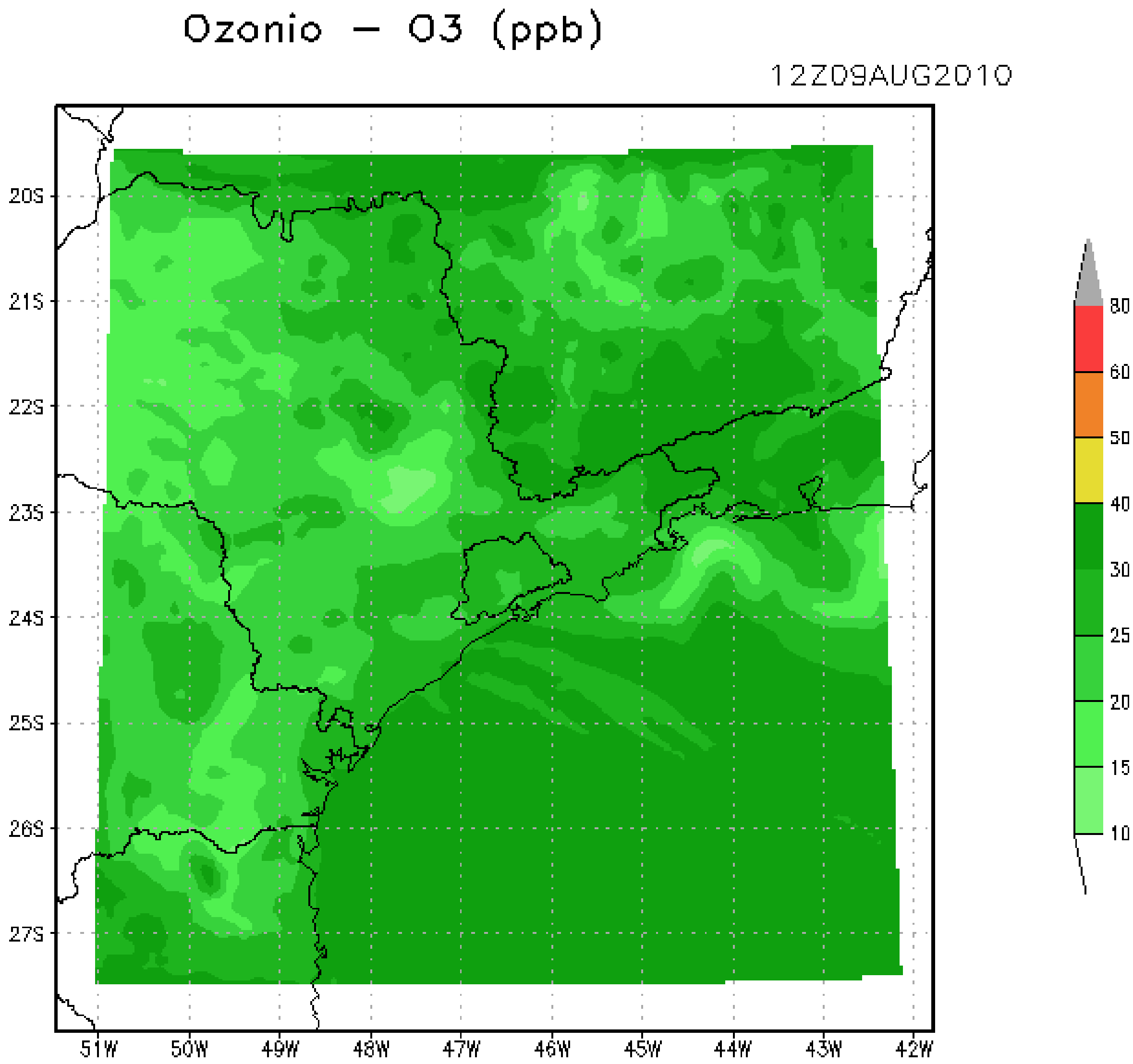
Source distribution

Grid points with 30 seconds resolution from -180° to 180° longitude and -65° to 65° latitude

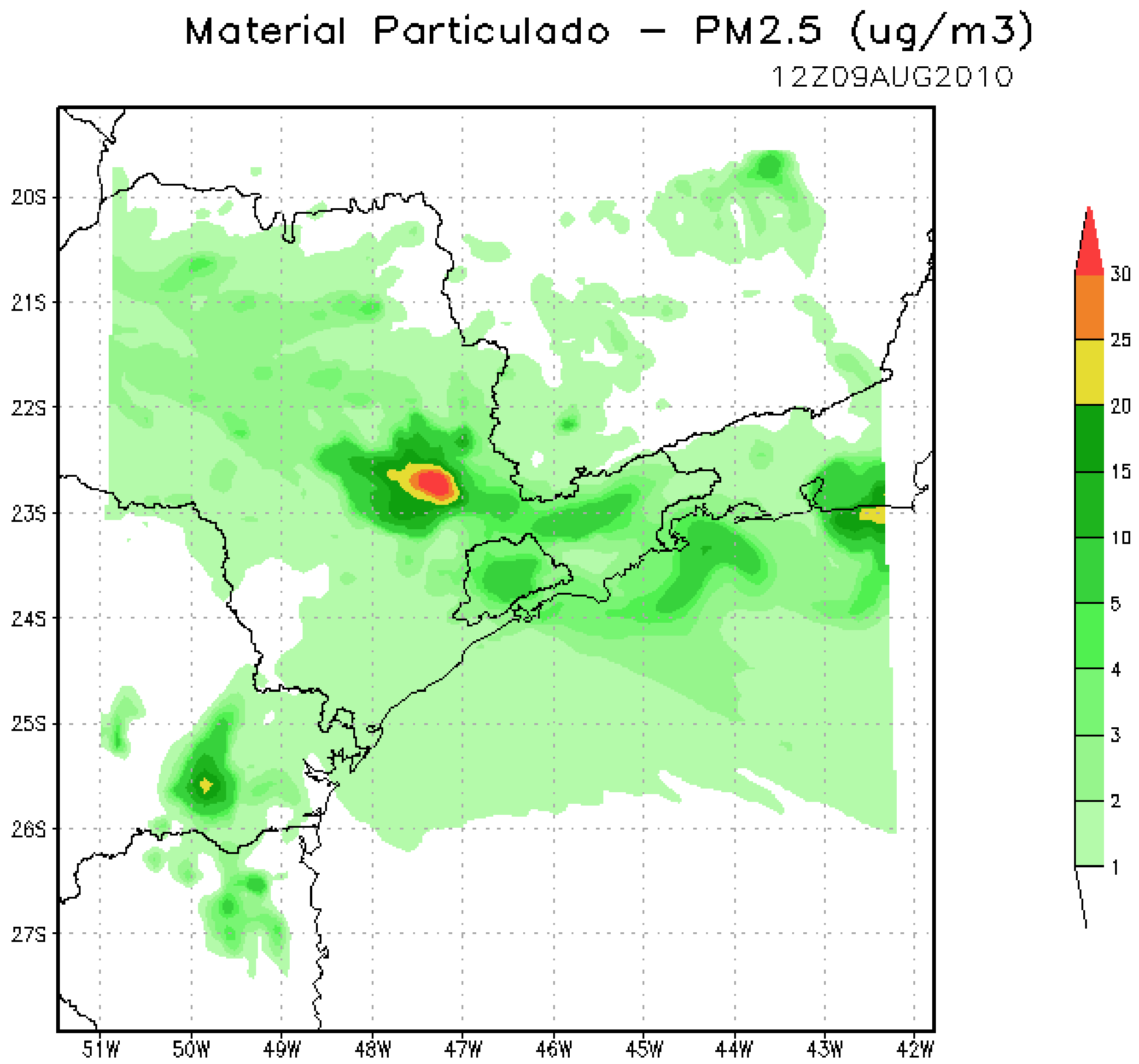
Image and data from NOAA's National Geophysical Data Center.

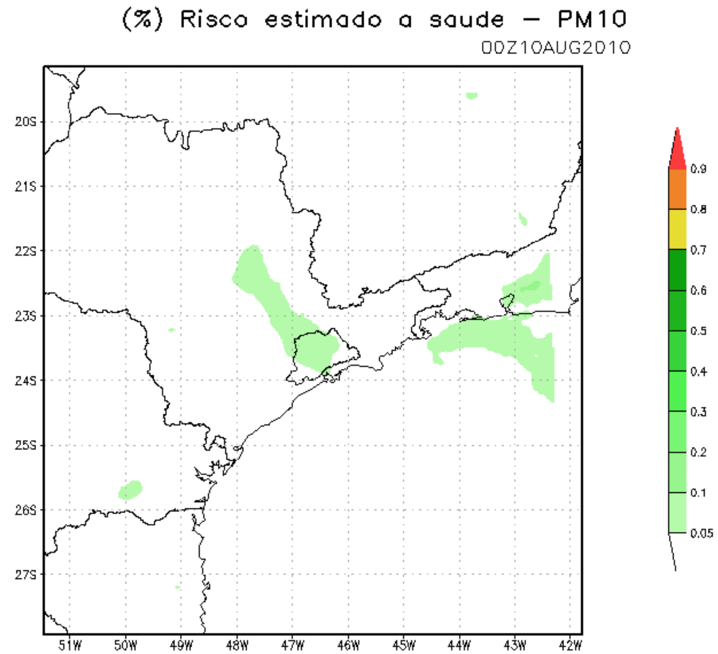
Grid for MASP Metropolitan Area of São Paulo

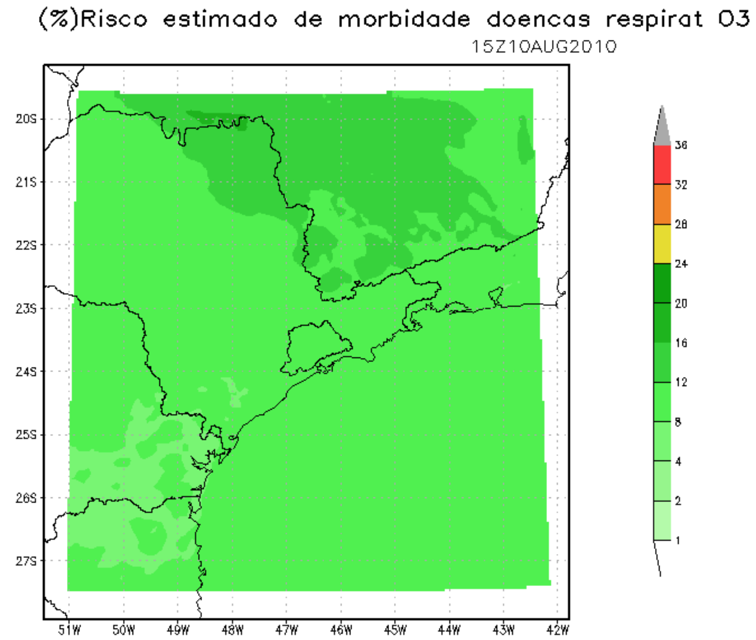


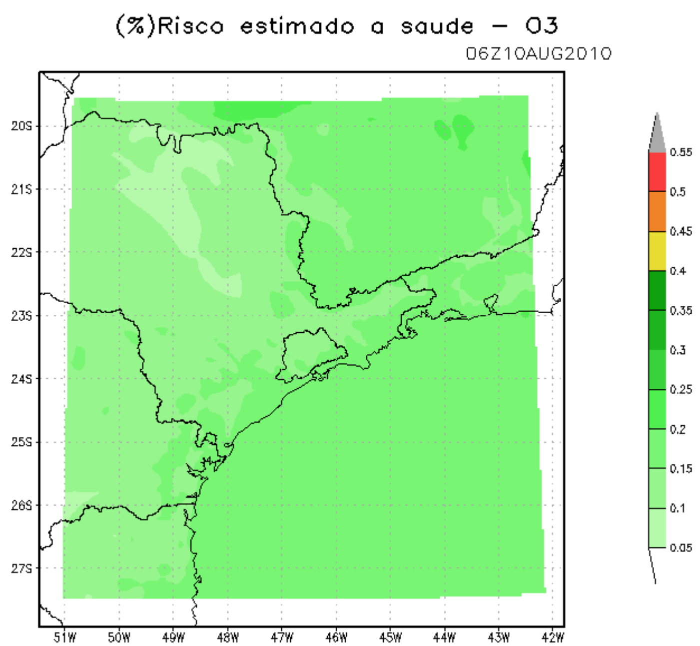


Ozonio - O3 (ppb)
12Z09AUG2010
20S
21S
22S
23S
24S
25S
26S
27S
51W
50W
49W
48W
47W
46W
45W
44W
43W
42W
80
60
50
40
30
25
20
15
10


Material Particulado – PM2.5 (ug/m3)
12Z09AUG2010
20S
21S
22S
23S
24S
25S
26S
27S
51W
50W
49W
48W
47W
46W
45W
44W
43W
42W
30
25
20
15
10
5
4
3
2
1







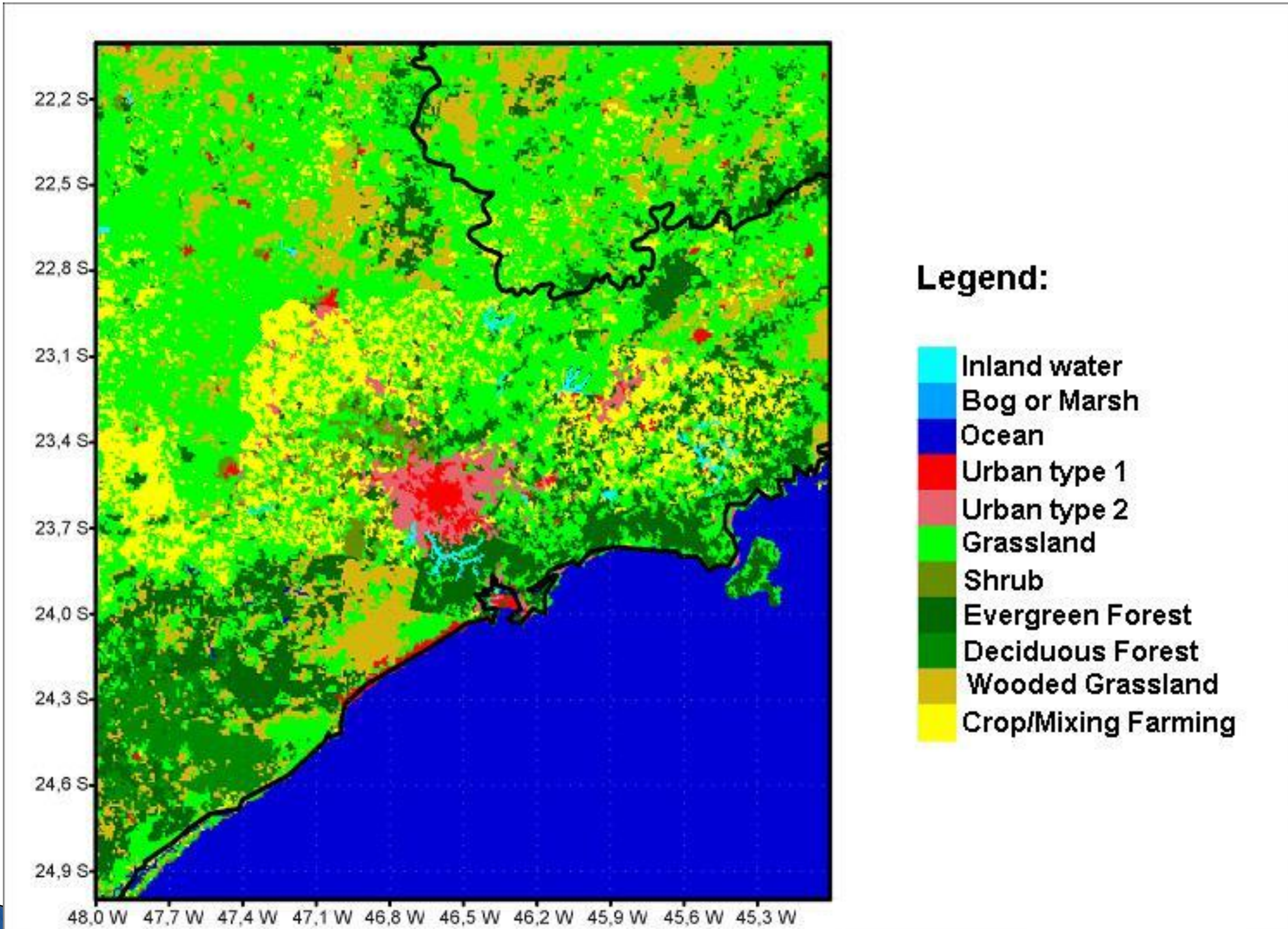
Mortality and morbidity risk associated to ozone and particles concentration

www.lapat.iag.usp.br

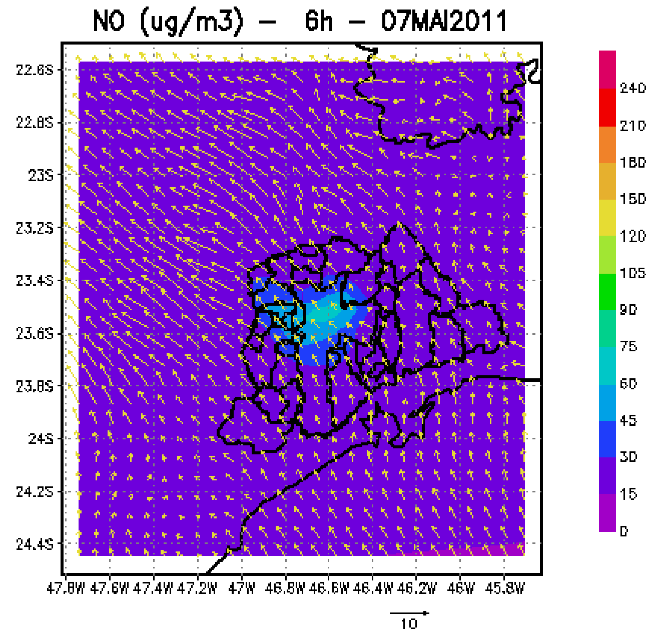
SPM-BRAMS

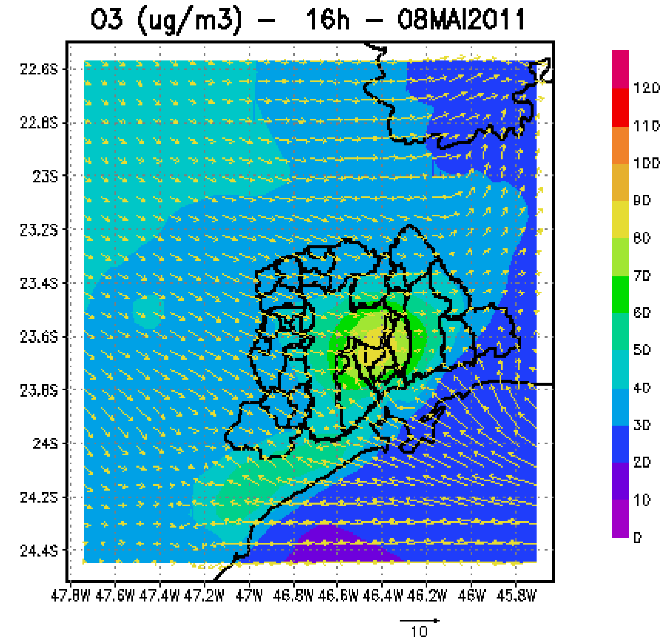
- **Simulation 1**

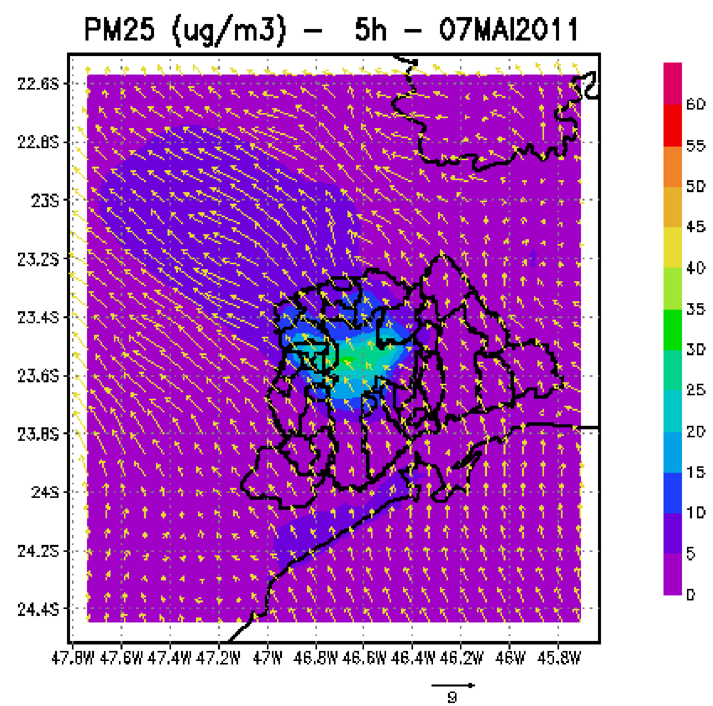
- 2 grids (16 and 4 km of horizontal resolution)
- 72 hours of simulation (02 – 05 Aug 99).
- Initialization: CPTEC/COLA AGCM + observations.
- Time step for chemical reactions 0,5 seconds.
- Diferent emissions for the two urban types (100% for type 1 and 30% for type 2)

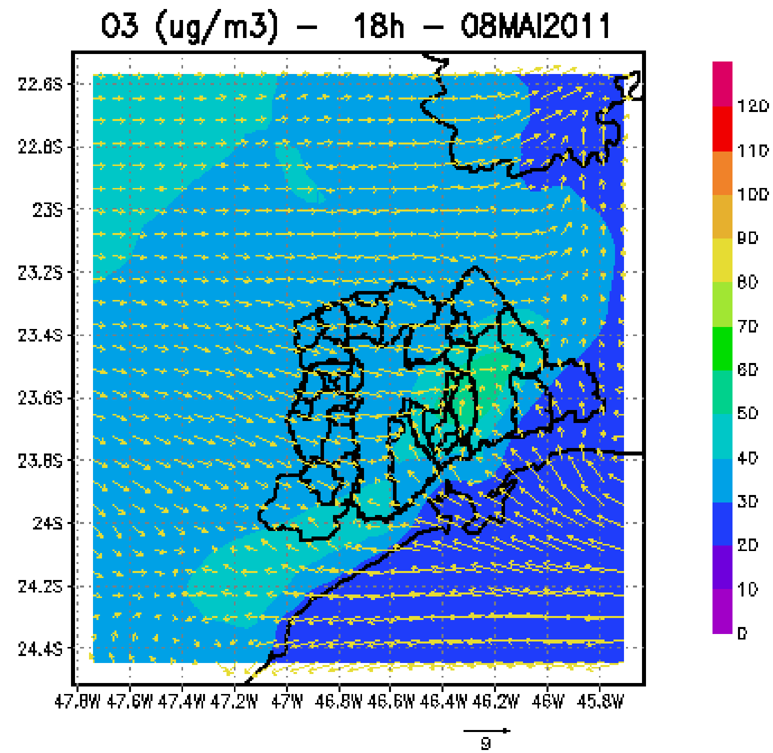

22,2 S
22,5 S
22,8 S
23,1 S
23,4 S
23,7 S
24,0 S
24,3 S
24,6 S
24,9 S
48,0 W
47,7 W
47,4 W
47,1 W
46,8 W
46,5 W
46,2 W
45,9 W
45,6 W
45,3 W
Legend:
Inland water
Bog or Marsh
Ocean
Urban type 1
Urban type 2
Grassland
Shrub
Evergreen Forest
Deciduous Forest
Wooded Grassland
Crop/Mixing Farming

www.master.iag.usp.br

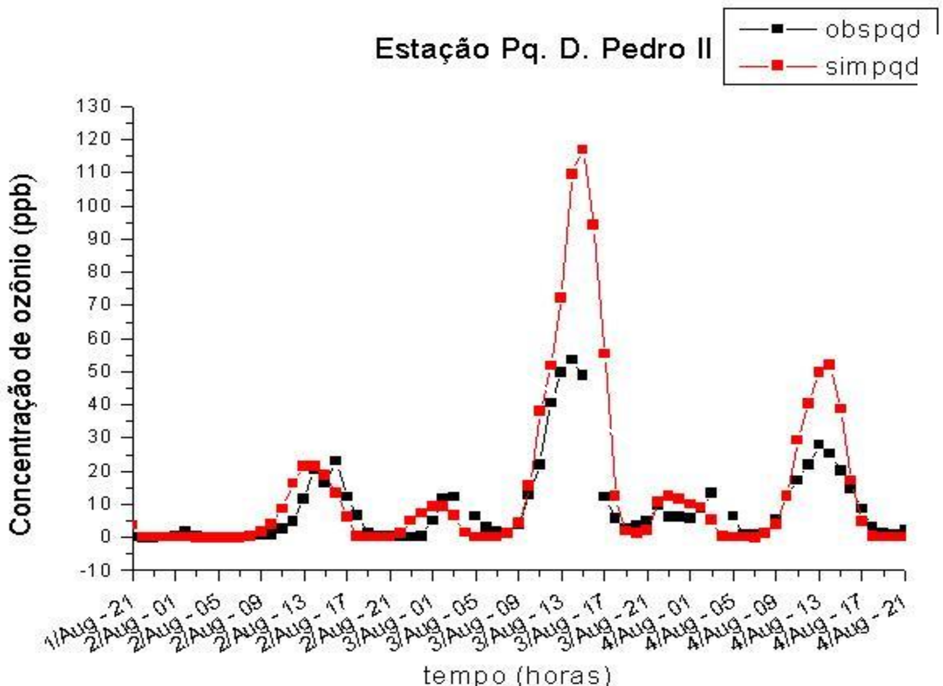


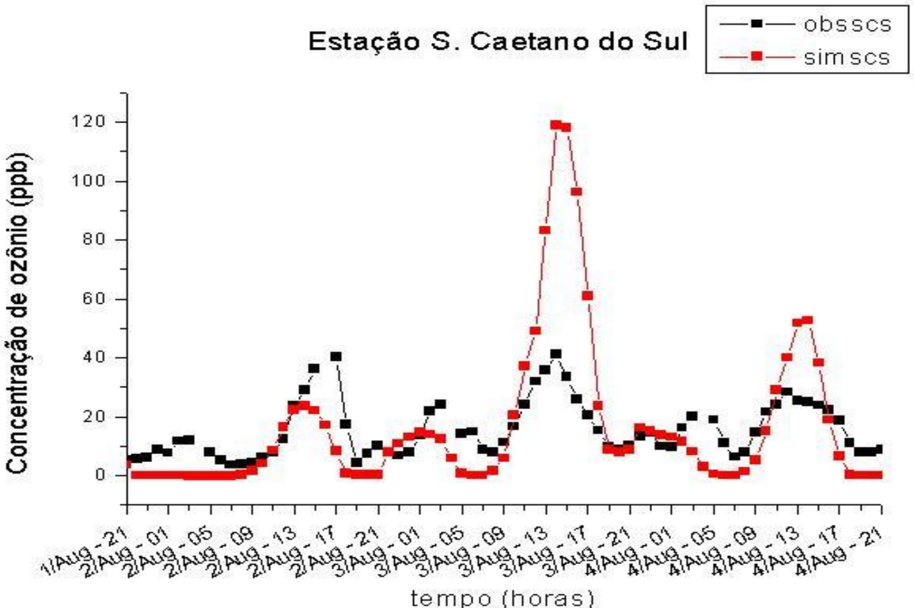


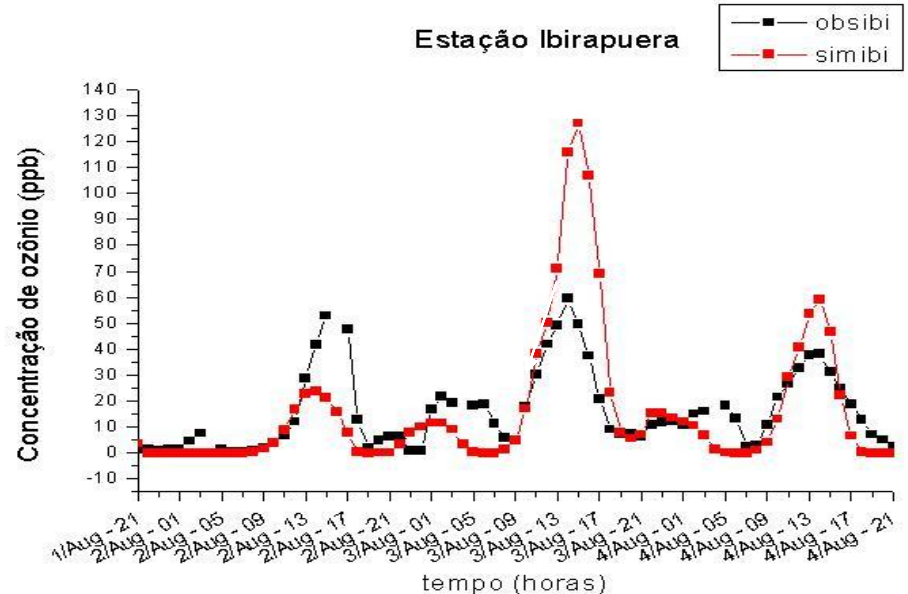




Results (from second grid – 4 km)



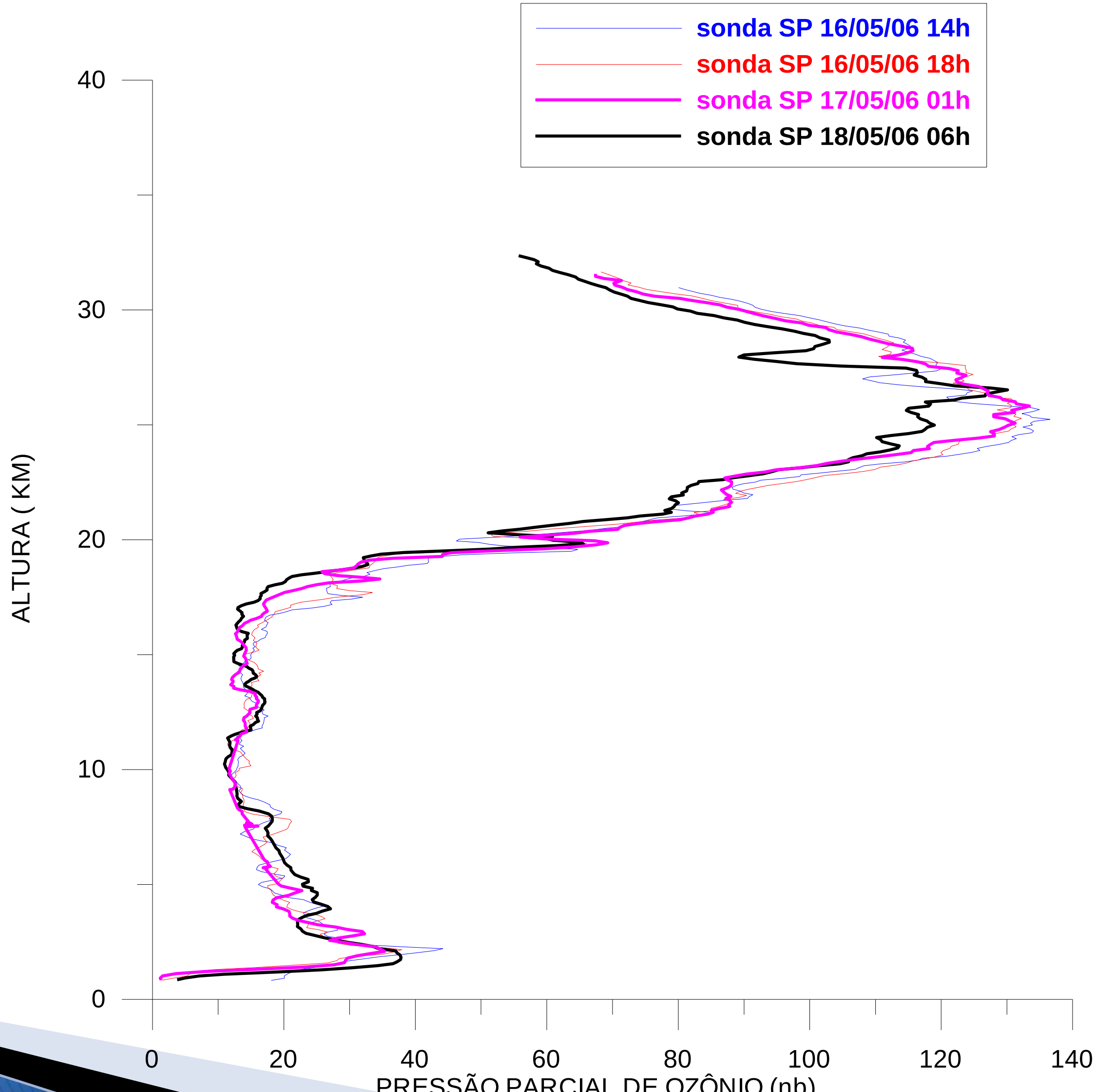


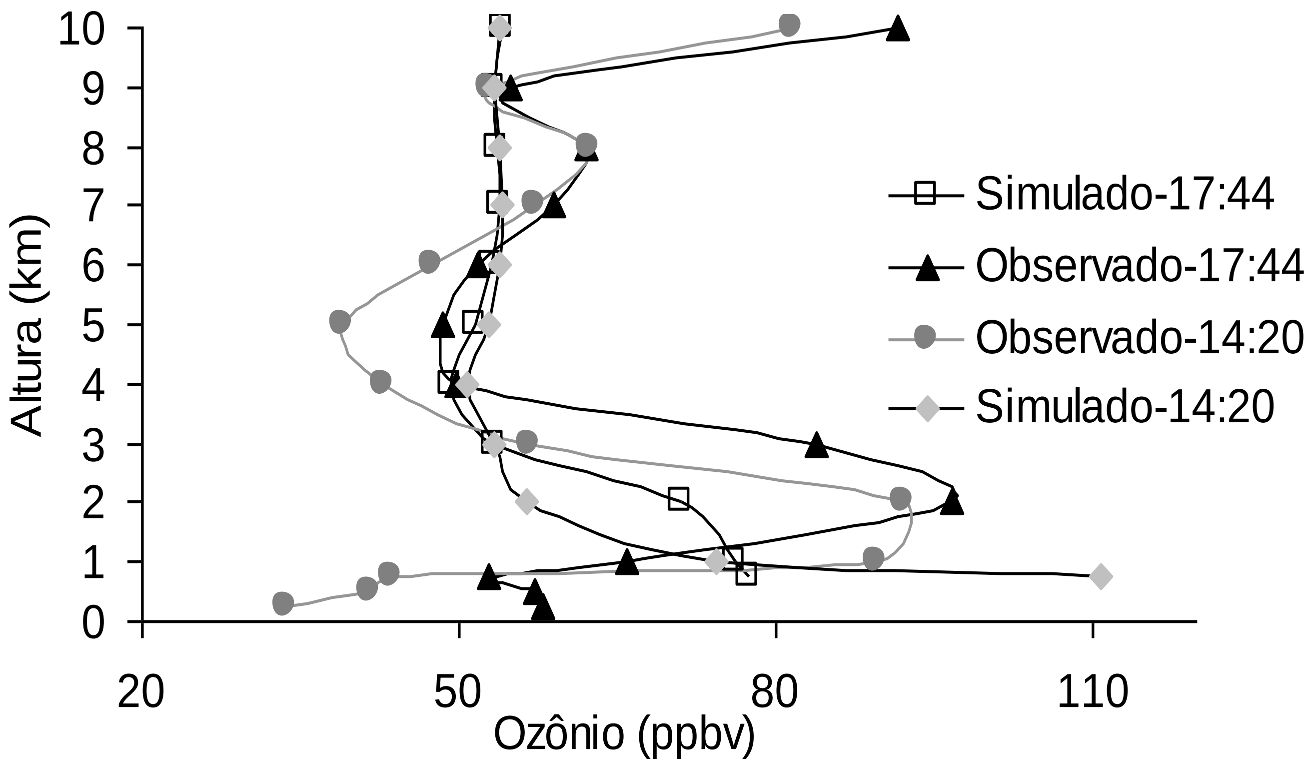


Martins, 2004

Examples vertical profiles

Experimental Data regarding Ozone Sounding in MASP

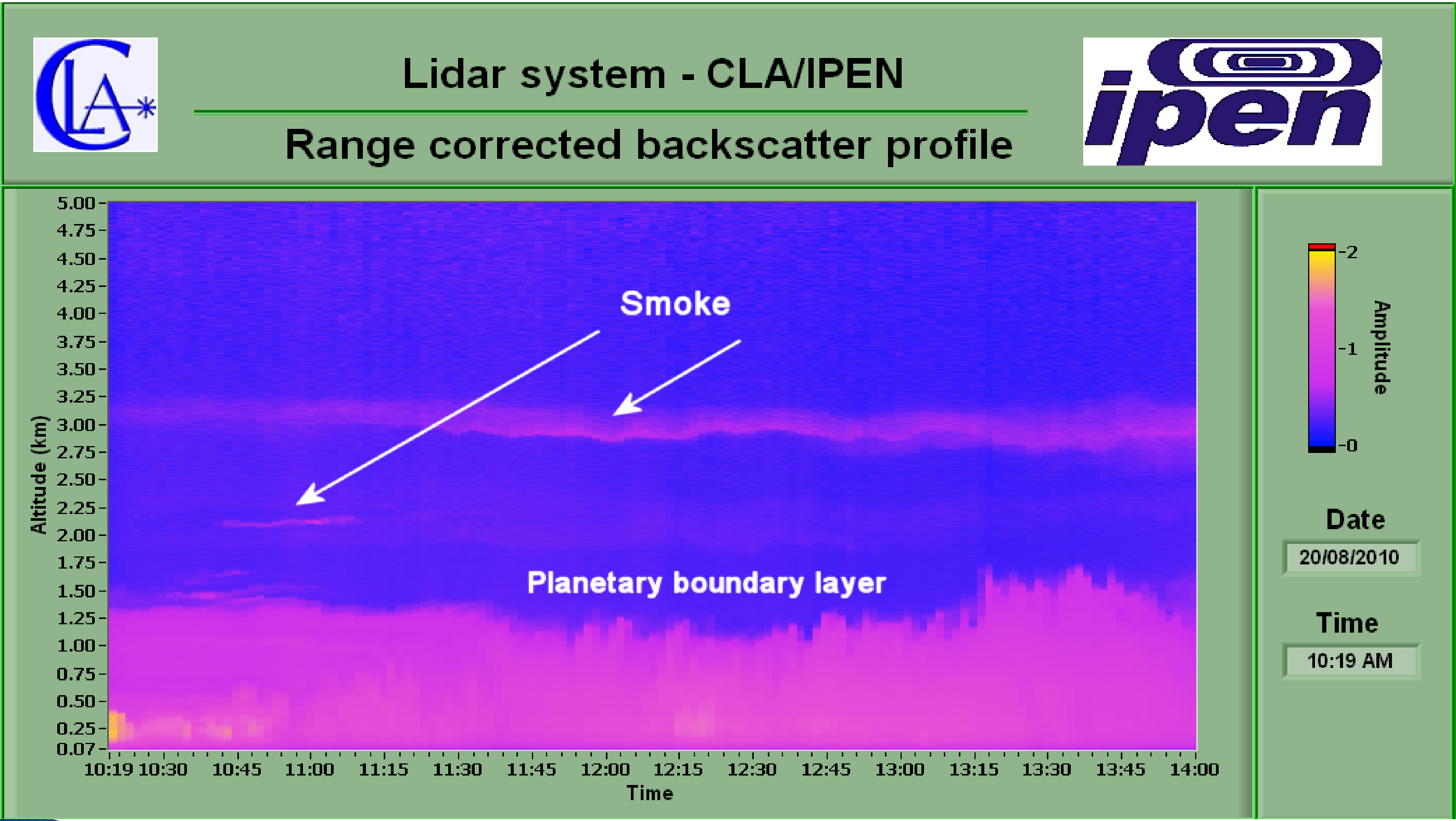




- Comparison between vertical profiles of ozone – November 31, 2006.

- Ozone sounding in colaboration with INPE

  –(first ozone soundings in São Paulo urban area)



Lidar system - CLA/IPEN
Range corrected backscatter profile
Smoke
Planetary boundary layer
Altitude (km)
5.00
4.75
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.07
10:19 10:30 10:45 11:00 11:15 11:30 11:45 12:00 12:15 12:30 12:45 13:00 13:15 13:30 13:45 14:00
Time
Amplitude
2
1
0
Date
20/08/2010
Time
10:19 AM

Acknowledgements