# Emission inventories for model intercomparison activity: a case study for the Metropolitan Area of São Paulo (MASP)

Angel Liduvino Vara Vela

Center for Weather Forecasting and Climate Studies
National Institute for Space Research

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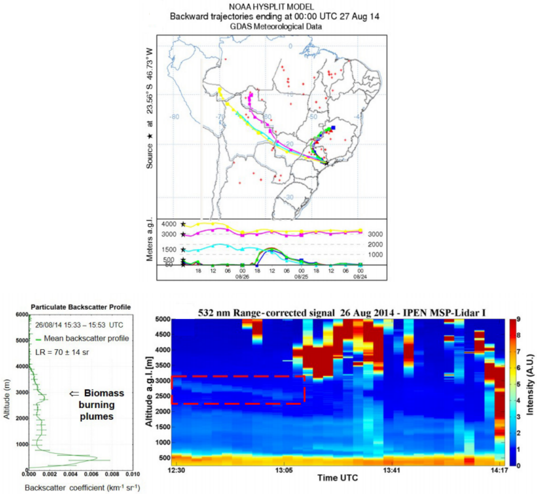
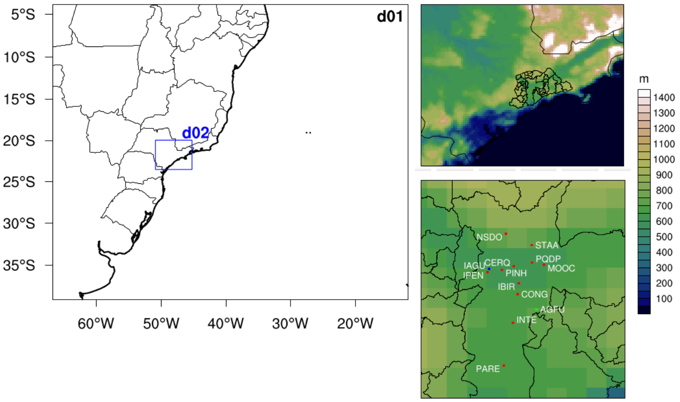



HYSPLIT trajectory and lidar analyses for a day with intrusion of biomass burning aerosols (figure adapted from Souto-Oliveira et al. (2016)).




Double nested domains for WRF-Chem modelling.

Simulation design and evaluation periods.

| Attributes | 7 Aug - 6 Sept 2012 | 19 Aug - 3 Sept 2014 |
|---|---|---|
| Purpose | Quantifying the impact of vehicle emissions on the formation of fine particles, as well as the aerosol impacts on $O_3$ photochemistry. | Quantifying the impact of BB emissions on aerosol loadings and properties, as well as evaluation of aerosol particles to act as CCN. |
| Nesting | 75 - 15 - 3 km | 25 - 5 km |
| Coverage | South-eastern São Paulo State | South-eastern São Paulo State |
| Vertical resolution | 34 layers (surface to 50 hPa) | 34 layers (surface to 50 hPa) |
| Baseline simulation | ICs/BCs from the models GFS 1.0 and MOZART-4/GEOS-5; One-way for downscaling; Emission of gases and aerosols from vehicles and vegetation; Aerosol-rad. feedback turned on; Fine simulation denoted as BASE. | ICs/BCs from the models GFS 0.5 and MOZART-4/GEOS-5; One-way for downscaling; Fire emission module turned off; Aerosol feedbacks turned on; Fine simulation denoted as BASE. |

Simulation design and evaluation periods (continuation).

| Attributes | 7 Aug - 6 Sept 2012 | 19 Aug - 3 Sept 2014 |
|---|---|---|
| First Sensitivity simulation | ICs/BCs and downscaling the same as the base simulation; Emission of gases from vehicles and vegetation; No emission of aerosols; Aerosol-rad. feedback turned on; Fine simulation denoted as NAE. | ICs/BCs and downscaling the same as the base simulation; All emission modules turned on; Aerosol feedbacks turned on; FINN emissions scaled by a factor of 1; Fine simulation denoted as BBE. |
| Second sensitivity simulation | ICs/BCs and downscaling the same as the base simulation; Emission of gases and aerosols from vehicles and vegetation; Aerosol-rad. feedback turned off; Fine simulation denoted as NFB. | ICs/BCs and downscaling the same as the base simulation; All emission modules turned on; Aerosol feedbacks turned on; FINN emissions scaled by a factor of 3; Fine simulation denoted as 3BBE. |
| Statistical evaluation | Model performance: 7 Aug to 6 Sept 2012. | Model performance: 19 Aug to 3 Sept 2014; FEC: 22 Aug - 26 Aug 2014. |

WRF-Chem options.

| Attributes | | 7 Aug to 6 Sept 2012 | 22 Aug to 3 Sept 2014 |
|---|---|---|---|
| Physics | Longwave rad. | RRTM | RRTMG |
| | Shortwave rad. | Goddard | RRTMG |
| | Surface layer | Monin-Obukhov | Revised Monin-Obukhov |
| | Land surface | Noah | Unified Noah |
| | Boundary layer | YSU | YSU |
| | Cumulus clouds | Grell 3D | MSKF |
| | Microphysics | Lin | Morrison 2-moment |
| Chemistry | Gas phase | RADM2 | CB05 |
| | Aqueous phase | | Sarwar et al. (2011) |
| | Aerosol | MADE/SORGAM | MADE/VBS |
| | Photolysis | Fast-J | F-TUV |
| Emission | Anthropogenic | Andrade et al. (2015) | HTAPv2.2 and Andrade et al. (2015) |
| | Biogenic | Guenther | MEGAN |
| | Fire | | FINN |
| | Plume rise | | Freitas et al. (2007) |

## Anthropogenic emissions

- HTAPv2.2 (EDGARv4.3)

  7 sectors of human activities

  Monthly

  0.1° spatial resolution

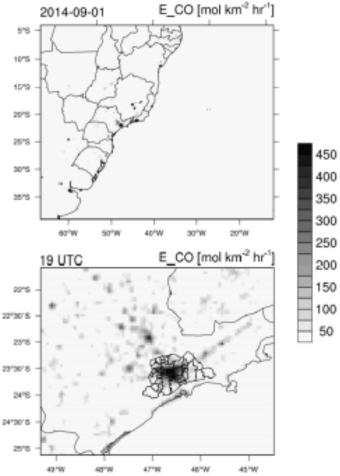
  anthro_emis

- Andrade et al. (2015)

$$E^{p}_{i,j,t} = [\sum_{v} N^{v}_{i,j} \times EF^{p}_{v} \times IU_{v}] \times EP^{p}_{t}$$

  Road maps from GEOFABRIK

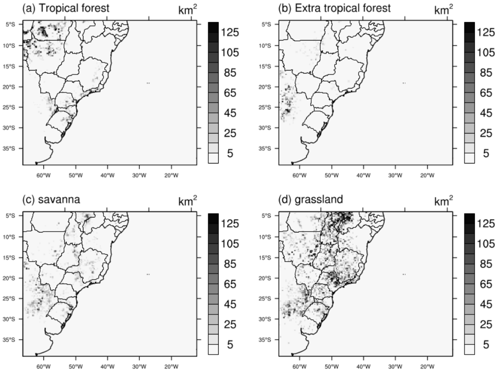
  AAS4WRF




Spatial distributions of CO emission rates in the 25 km (top) and 5 km (bottom) modelling domains.

## Fire emissions

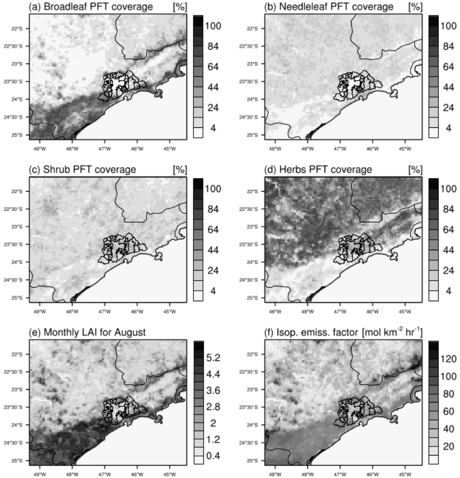
- FINN
- Active fires, land cover and emission factors
- Daily
- global at 1 $km^2$
- Plume rise
- fire_emis




Spatial distribution of the total burned area in the 25 km modelling domain during the period from 22 August to 26 August 2014.

## Biogenic emissions

- MEGAN2
- Online calculation
- T, RAD, LAI, PFT
- global at 1 km$^2$
- megan_bio_emiss



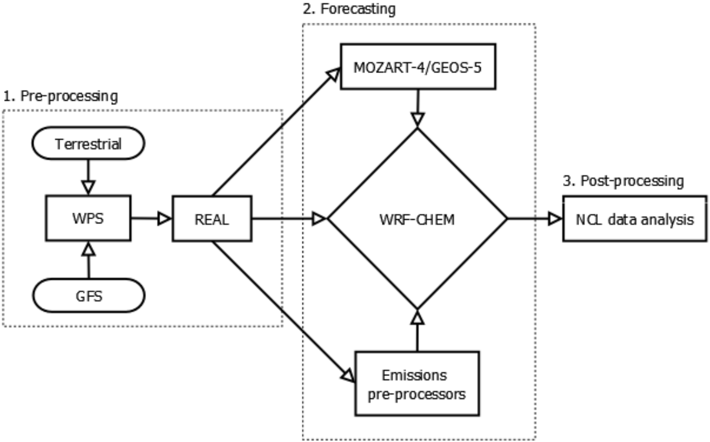

Spatial distributions of MEGAN2 canopy types (panels a, b, c and d), LAI (e), and isoprene emission factor in the 5 km modelling domain.

## The NUANCE-SPS project

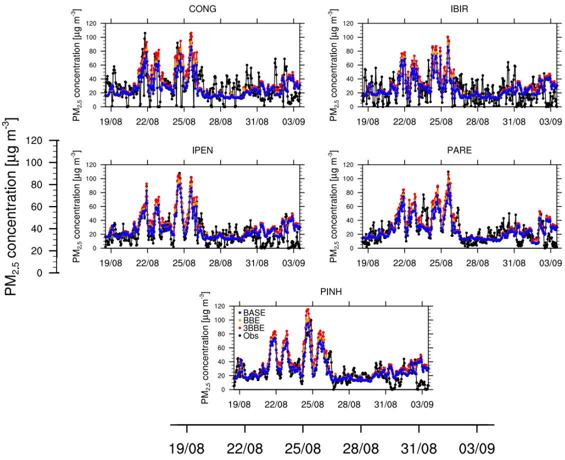
Description of the NUANCE-SPS aerosol sampling campaign performed at the IAGU site and other data sets included in the model evaluation.

| Database | Parameter | freq. | Period | Device |
|---|---|---|---|---|
| NUANCE | Particle mass conc. | 12 h | both | Rotating MOUDI |
| SPS | Particle number conc. | 5 min | 2014 | DMPS aerosol spectra |
| | CCN conc. | 1 sec | 2014 | CCN chamber |
| | $PM_{2.5}$ and $PM_{10}$ conc. | 12 h | 2012 | Dichotomous sampler |
| | EC and OC conc. | 12 h | both | Sunset OC-EC analyser |
| | Aerosol extinction coef. | Daily | 2014 | Raman Lidar system |
| CETESB | $PM_{2.5}$, $PM_{10}$, $O_3$, T, RH, WS and WD | Hourly | both | Various |
| GPCP | Precipitation | Daily | 2014 | |
| MERGE | Precipitation | Daily | 2014 | |
| MODIS | AOD | Daily | 2014 | |

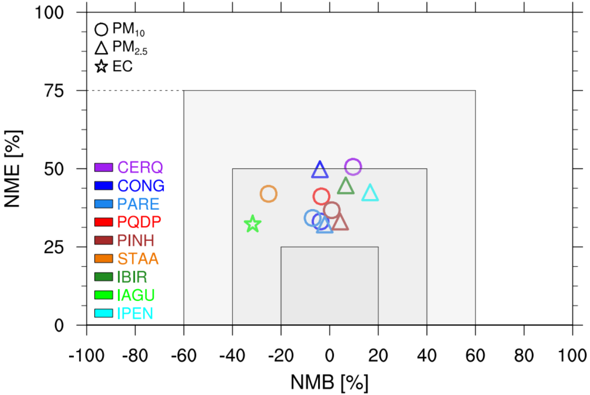
# WRF-Chem simulations flowchart



## $PM_{2.5}$

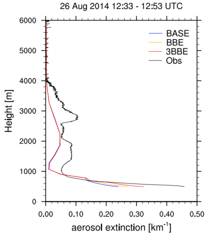


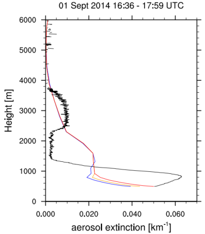

Observed (black) and predicted (blue, orange and red) temporal variations of $PM_{2.5}$ concentrations at some CETESB sites for 5 km modelling domains.

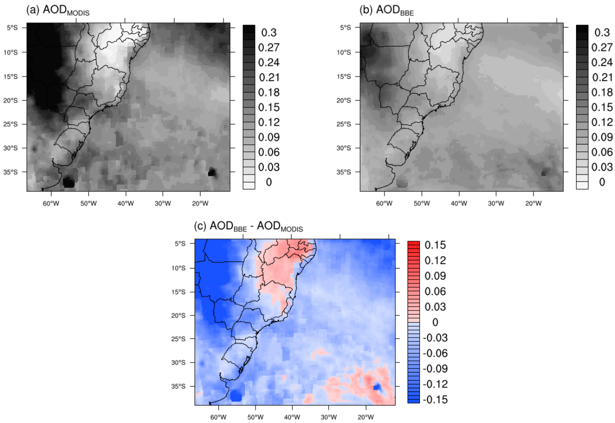


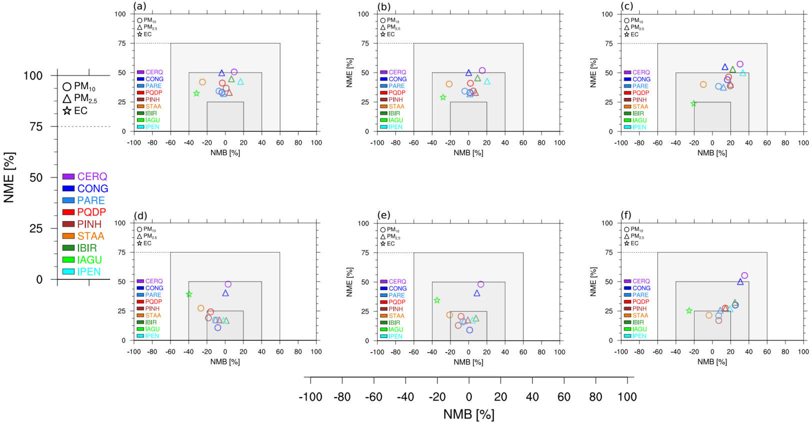

PM model performance for the 3 km (left) and 5 km (right) modelling domains.

## Optical properties






PM soccer plots for the simulations BASE (left), BBE (middle) and 3BBE (right), during the period from 19 August to 3 September 2014 (top) and during the fire emission contribution period (bottom).

- According to model results, biomass burning, on average, accounted for 8-24% (5-15 $\mu$g m$^{-3}$) of $PM_{2.5}$ and for 15-32% (12-26 $\mu$g m$^{-3}$) of $O_3$, suggesting that air pollutant levels depend largely on local emissions.
- The model also revealed that the largest fire impacts on $PM_{2.5}$, with relative differences of 27-72% (10-35 $\mu$g m$^{-3}$), took place northwest and north of the MASP, within the inland portion of the state.
- Despite the fact that small signs of fire emissions were seen over the MASP, we can conclude that the impacts of air pollutants resulting from fire events are dependent on the magnitude of those events, not only for $PM_{2.5}$ and $O_3$ but also for the formation of CCN.

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**Key Points:**
- The fully coupled WRF-Chem model was applied and evaluated for the atmosphere over the metropolitan area of São Paulo
- The WRF-Chem can reproduce observed temporal variations in meteorological conditions and chemical species
- Inclusion of biomass burning emissions improves predictions of aerosol properties

# Modeling of Atmospheric Aerosol Properties in the São Paulo Metropolitan Area: Impact of Biomass Burning

**Angel Vara-Vela[1], Maria de Fátima Andrade[1], Yang Zhang[2], Prashant Kumar[3,4], Rita Yuri Ynoue[1], Carlos Eduardo Souto-Oliveira[5], Fábio Juliano da Silva Lopes[1,6], and Eduardo Landulfo[6]**

[1]Department of Atmospheric Sciences, Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo, São Paulo, Brazil, [2]Department of Marine, Earth and Atmospheric Sciences, College of Sciences, North Carolina State University, Raleigh, NC, USA, [3]Global Centre for Clean Air Research, Department of Civil and Environmental Engineering, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, UK, [4]Environmental Flow Research Centre, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, UK, [5]Geocronological Research Centre, Institute of Geosciences, University of São Paulo, São Paulo, Brazil, [6]Centre for Laser and Applications, Nuclear and Energy Research Institute, São Paulo, Brazil