MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

SOUTH AMERICAN BIOMASS BURNING ANALYSIS:
Brazilian perspectives

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Ricardo Siqueira, Madeleine Sanchez,
Fernando Cavalcante, Megan Bela, Márcia Yamosoe, Alexandre Correa

http://meioambiente.cptec.inpe.br

ciência para sustentabilidade

Grupo de Modelagem da Atmosfera e Interfaces
Modeling of the Atmosphere and its Interfaces Group

Ministério da Ciência, Tecnologia e Inovação

GOVERNO FEDERAL
BRASIL
PAÍS RICO É PAÍS SEM POBREZA

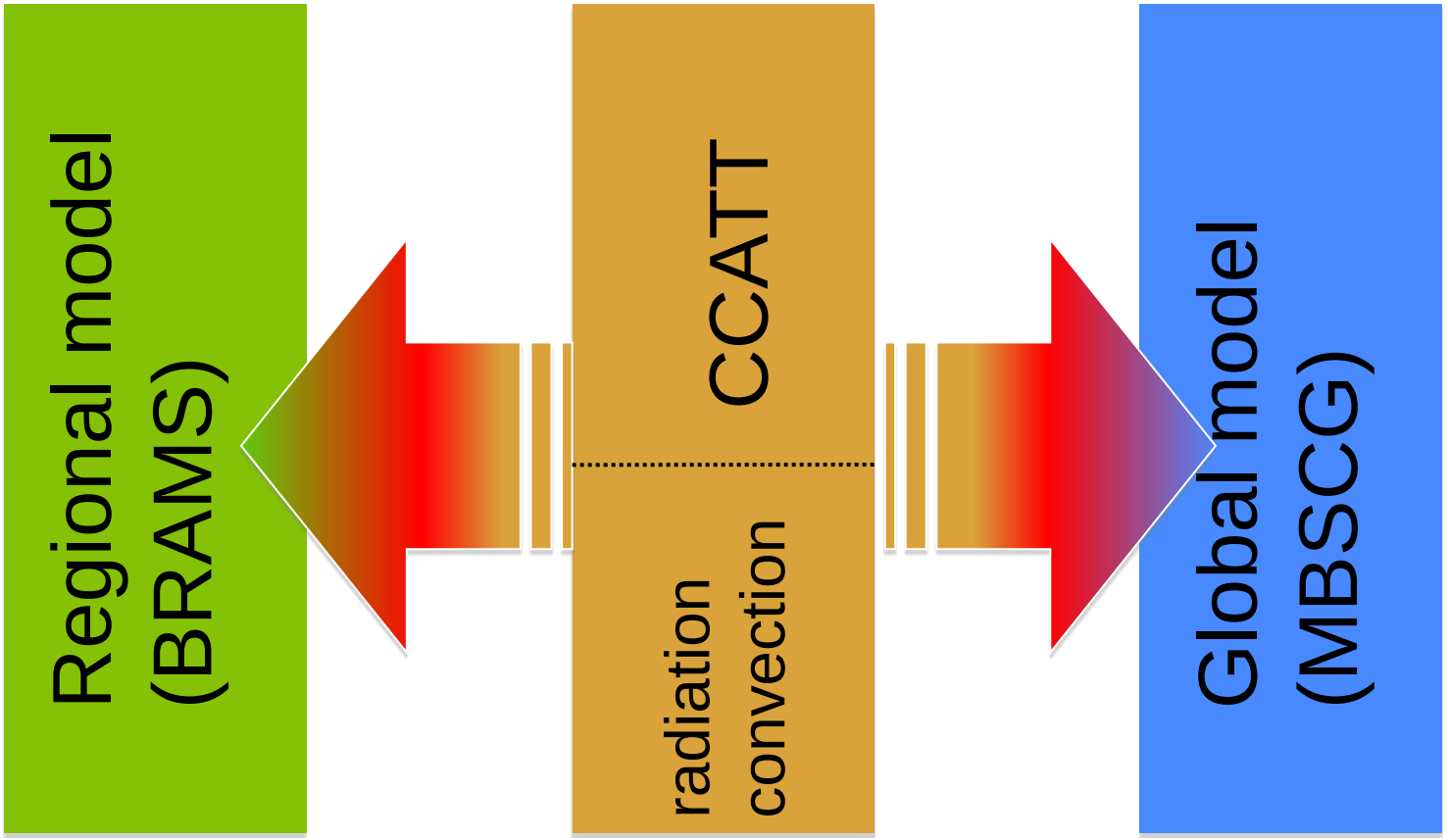
Main goals

Improve our understanding of the impact of biomass burning on the chemical composition of the atmosphere (aerosols/ gases), cloud formation and the energy balance of the atmosphere;

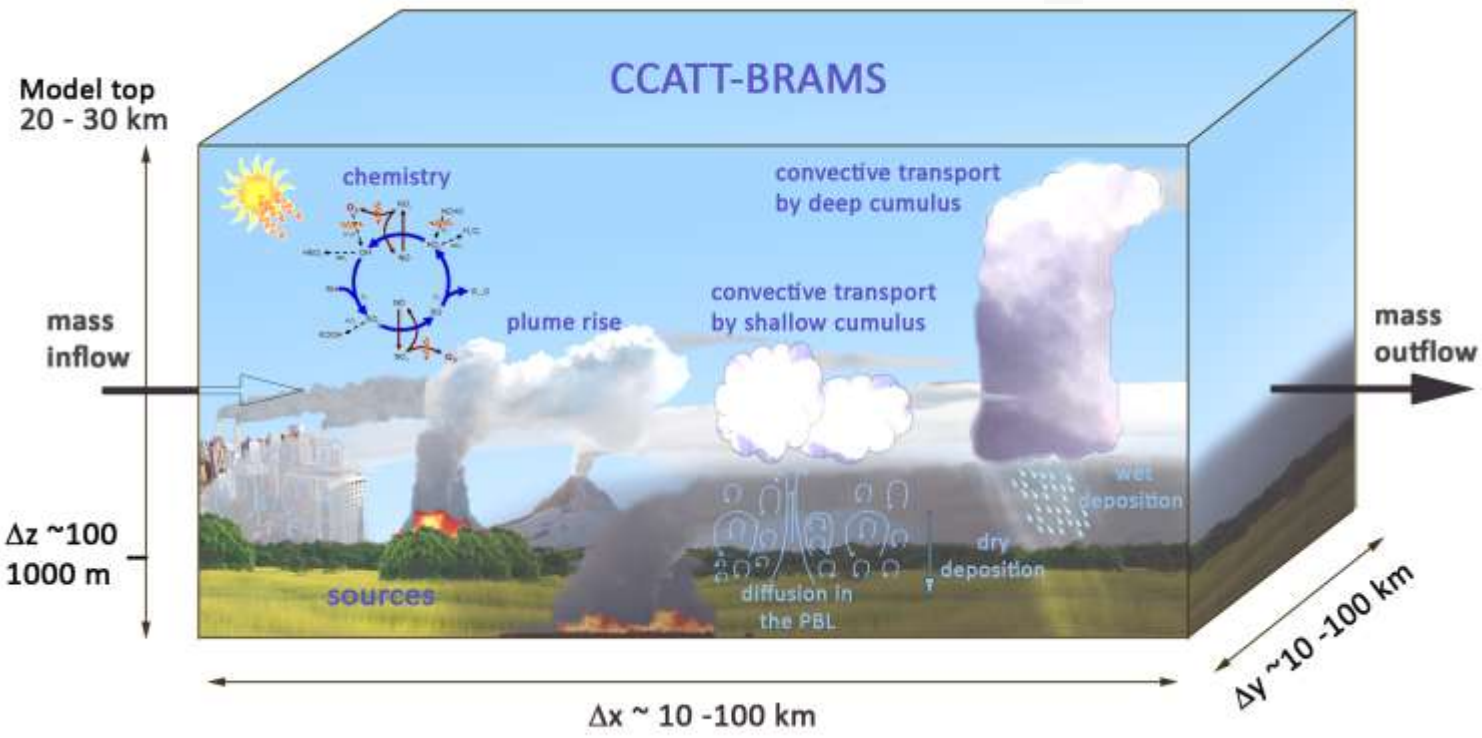
Development and evaluation of INPE's atmospheric chemistry transport models suitable for local, regional and global scales: **CCATT-BRAMS & MBSCG**

Assess the impact of burning emissions on air quality, weather and climate;

Common chemistry module for both regional (CCAAT-BRAMS) and global (MBSCG) models



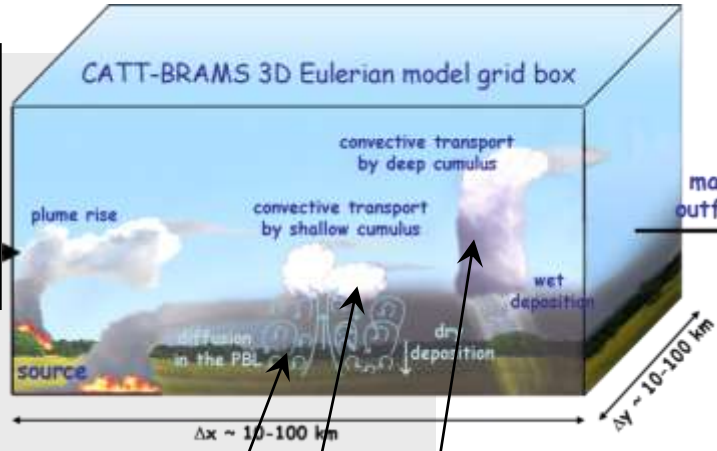
Numerical Developments



Coupled Chemistry-Aerosol-Tracer Transport model to the Brazilian developments on the RAMS: CCATT-BRAMS

Mass Continuity Equation solved by CCATT-BRAMS

$$\underbrace{\frac{\partial \bar{s}}{\partial t}}_{\text{mixing ratio tendency}} + \underbrace{\bar{u}_i \frac{\partial \bar{s}}{\partial x_i}}_{\text{grid-scale advection term}} = \underbrace{-\frac{1}{\rho_0}\left(\frac{\partial \rho_0 \overline{u_i' s'}}{\partial x_i}\right)}_{\text{sub-grid transport by the un-resolved flow}} + \underbrace{\overline{Q_s}}_{\text{forcing}}$$



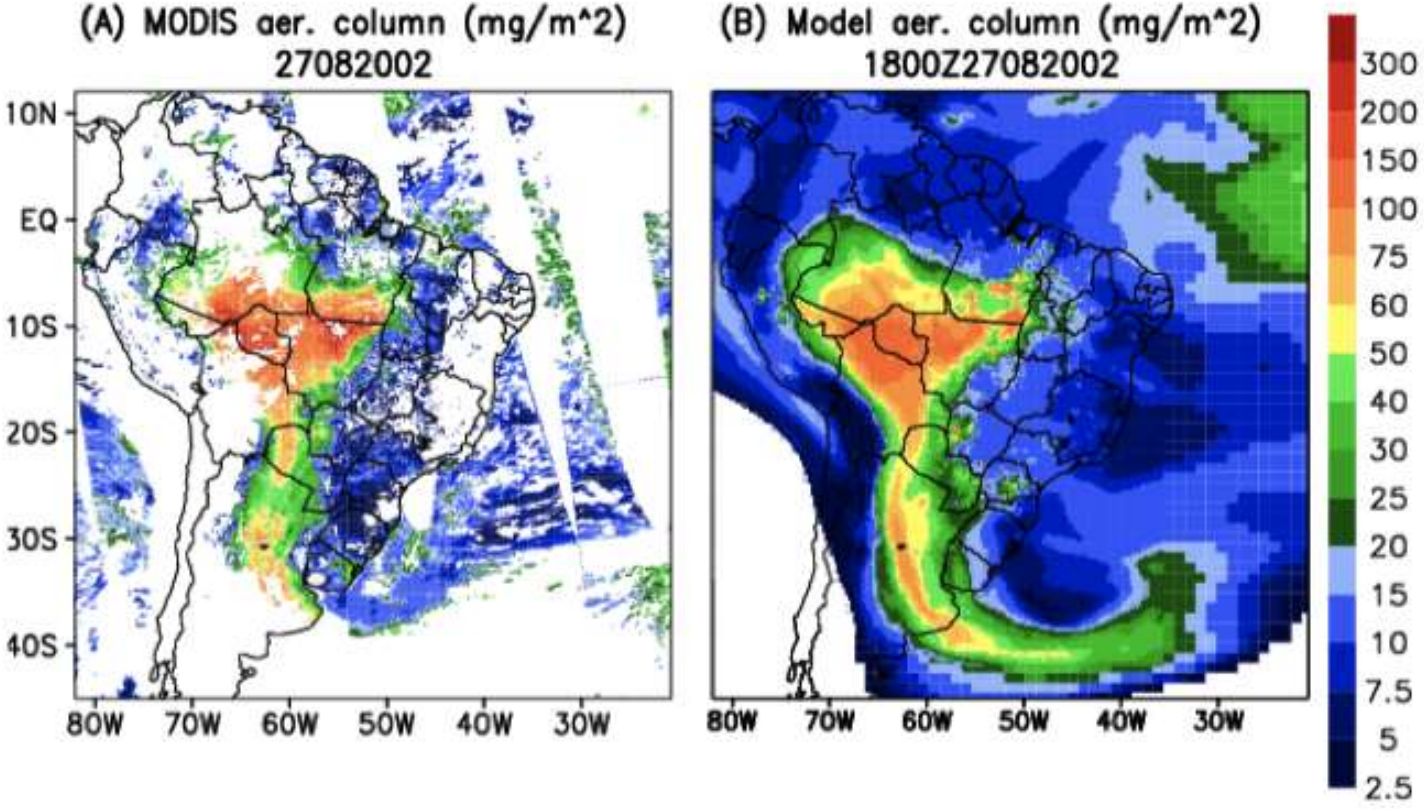
Parameterizations for sub-grid scale transports

(K-theory for diffusion, mass flux for organized convection)

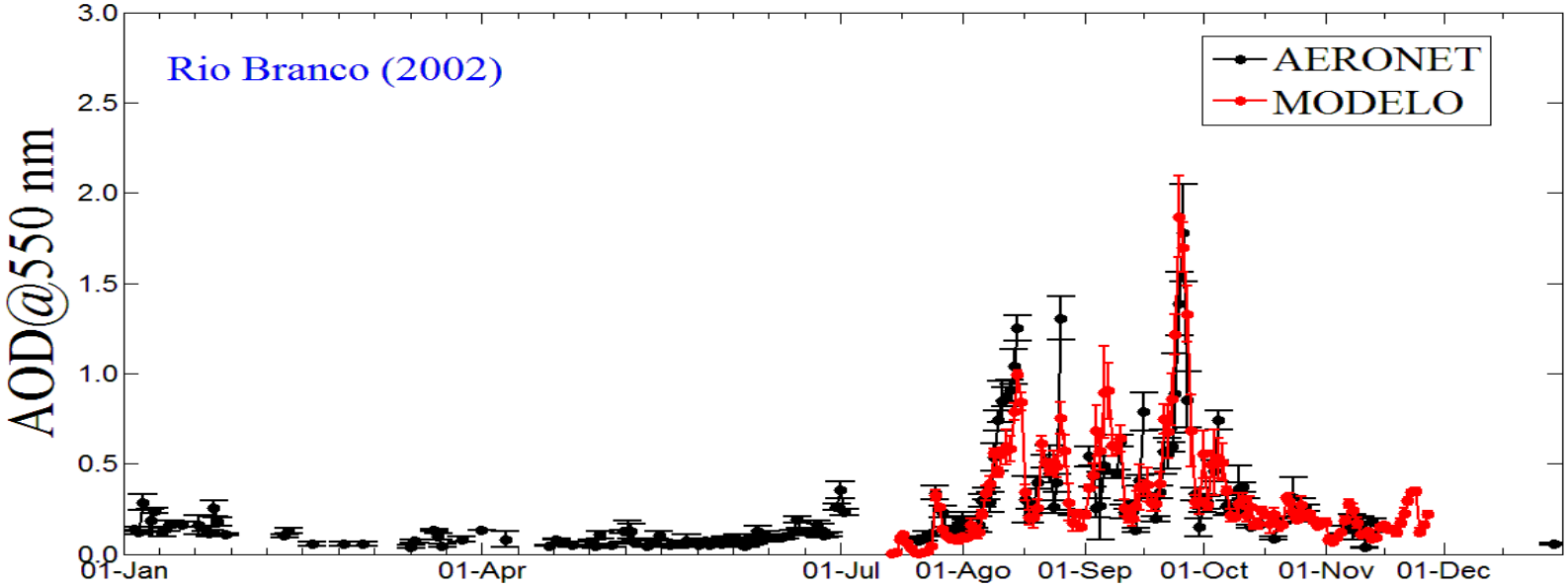
$$-\frac{1}{\rho_0}\left(\frac{\partial \rho_0 \overline{u_i' s'}}{\partial x_i}\right) = \begin{cases} \left(\frac{\partial \bar{s}}{\partial t}\right)_{\substack{PBL \\ turb}} = -\frac{1}{\rho_0}\sum_i \frac{\partial}{\partial x_i}\left(\rho_0 K_{h_i} \frac{\partial \bar{s}}{\partial x_i}\right) \\ \left(\frac{\partial \bar{s}}{\partial t}\right)_{\substack{shallow \\ conv}} = \frac{m_{u,b}}{\rho_0}\left[\delta_u \eta_u \left(s_u - \bar{s}\right) + \eta \frac{\partial \bar{s}}{\partial z}\right] \\ \left(\frac{\partial \bar{s}}{\partial t}\right)_{\substack{deep \\ conv}} = \frac{m_{u,b}}{\rho_0}\left[\delta_u \eta_u \left(s_u - \bar{s}\right) + \delta_d \varepsilon \eta_d \left(s_d - \bar{s}\right) + \eta \frac{\partial \bar{s}}{\partial z}\right] \end{cases}$$

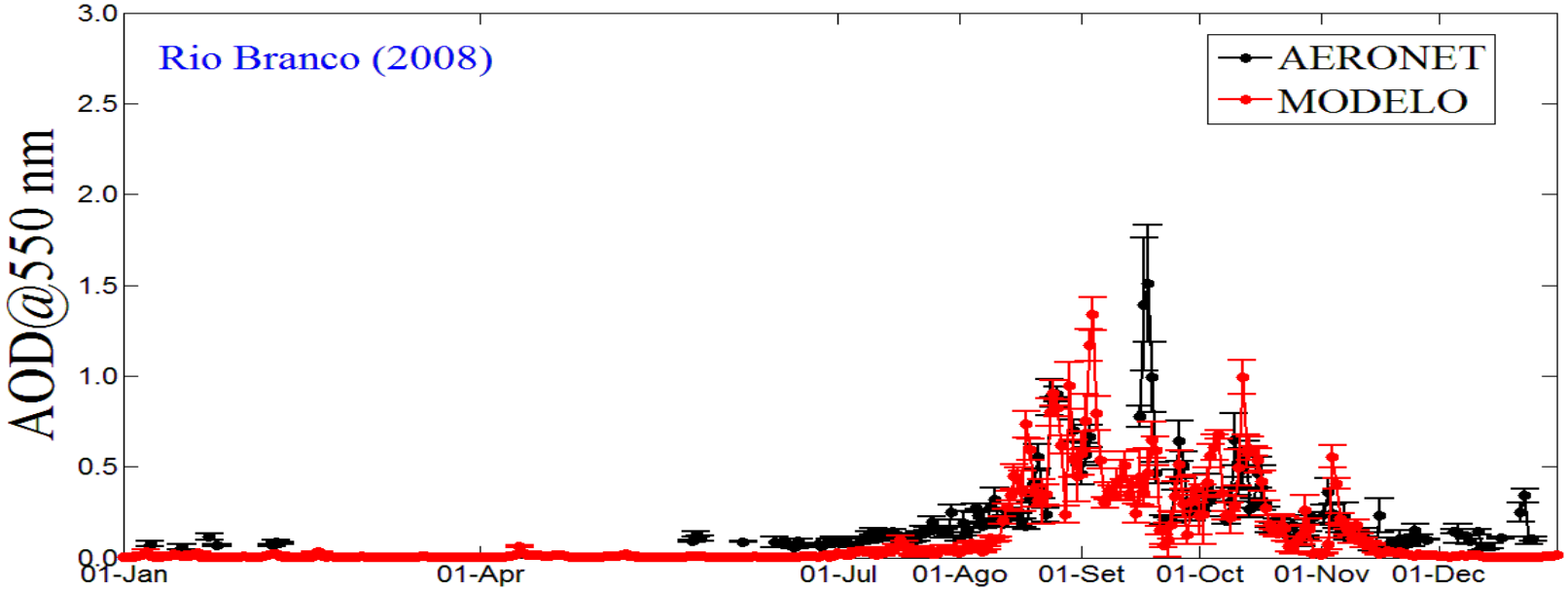
sub-grid scale transport by the un-resolved flows

MODIS x model

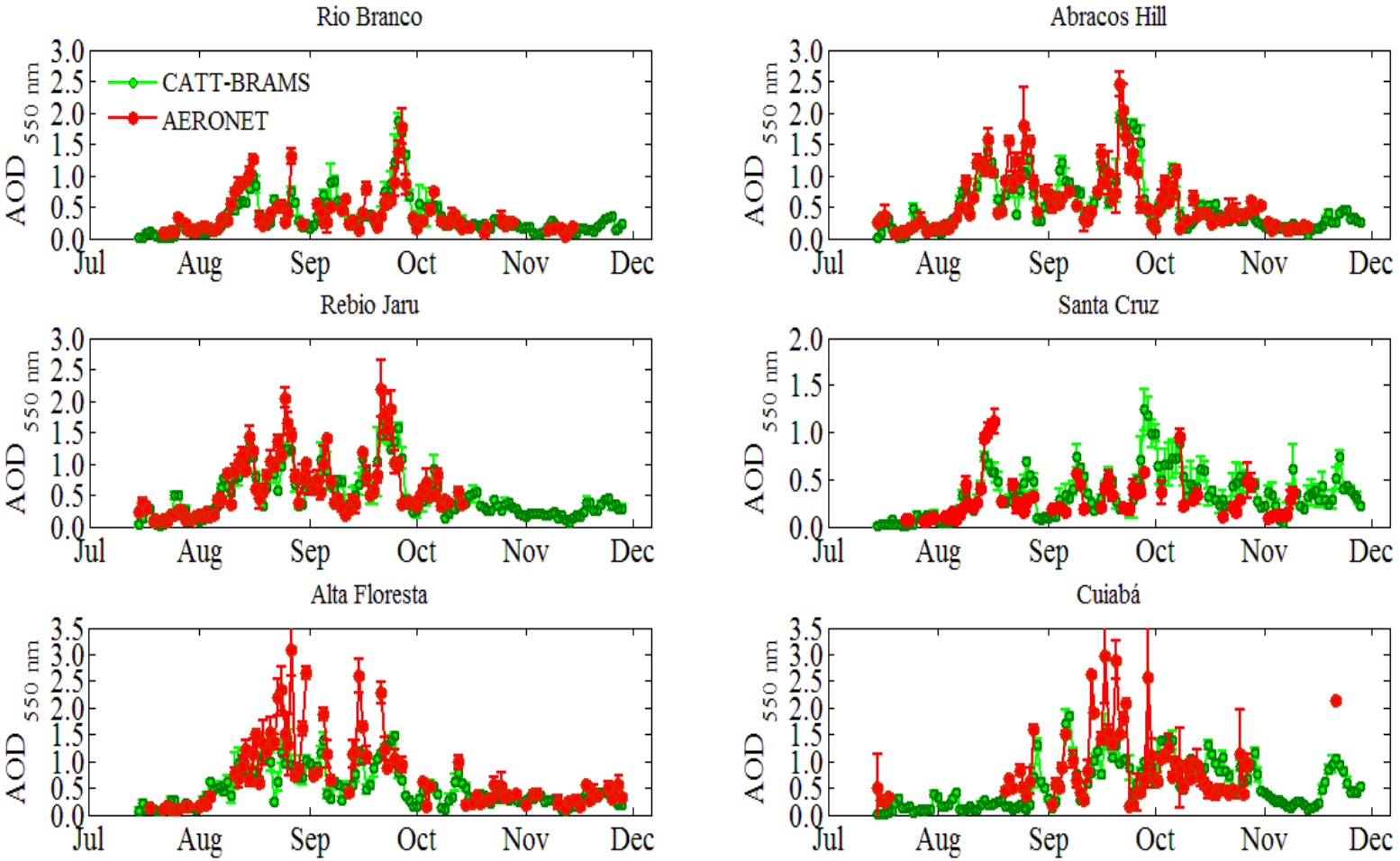


AERONET x model



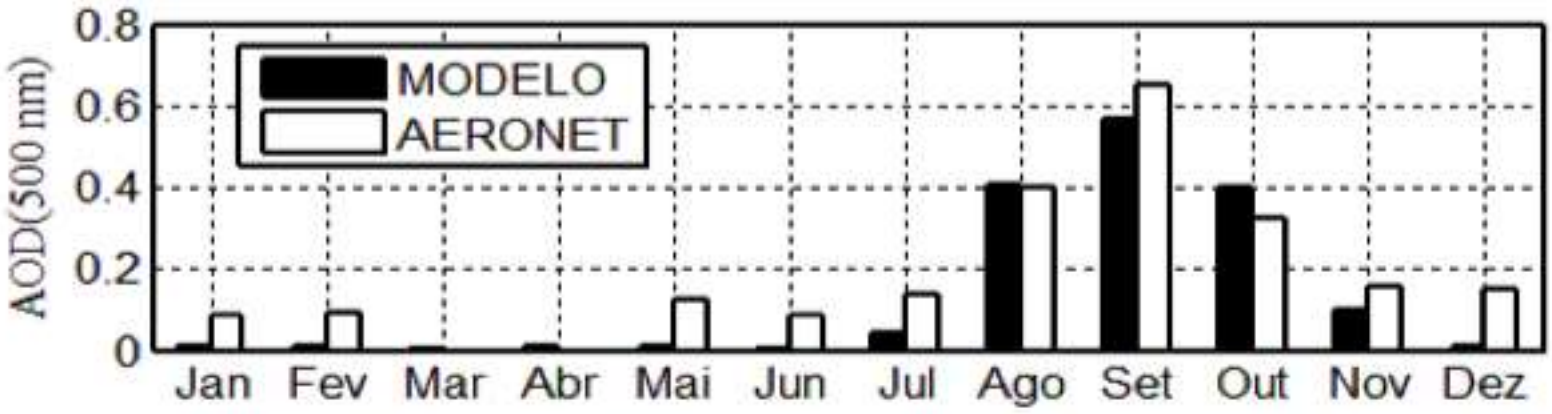


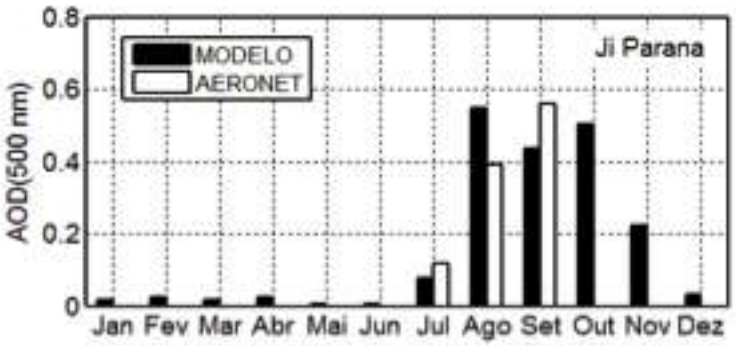
Aerosol optical thickness validation (model x AERONET)

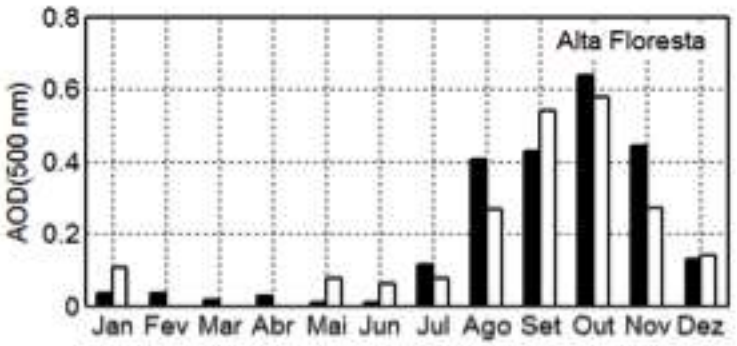


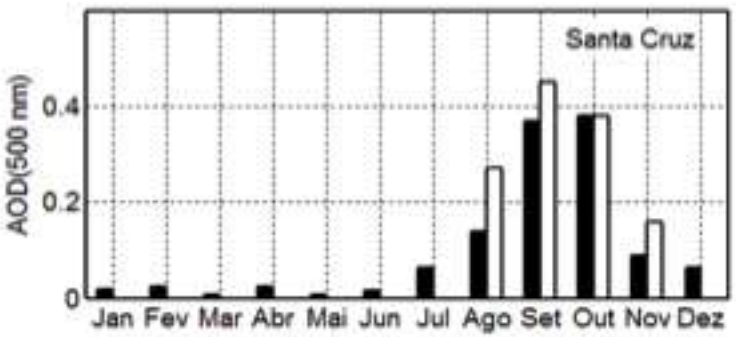
PhD thesis: Rosário, N. E. , USP), 2011.

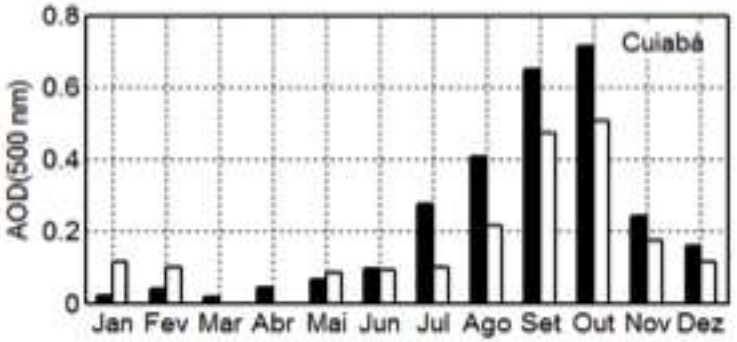
AERONET x model (2008)











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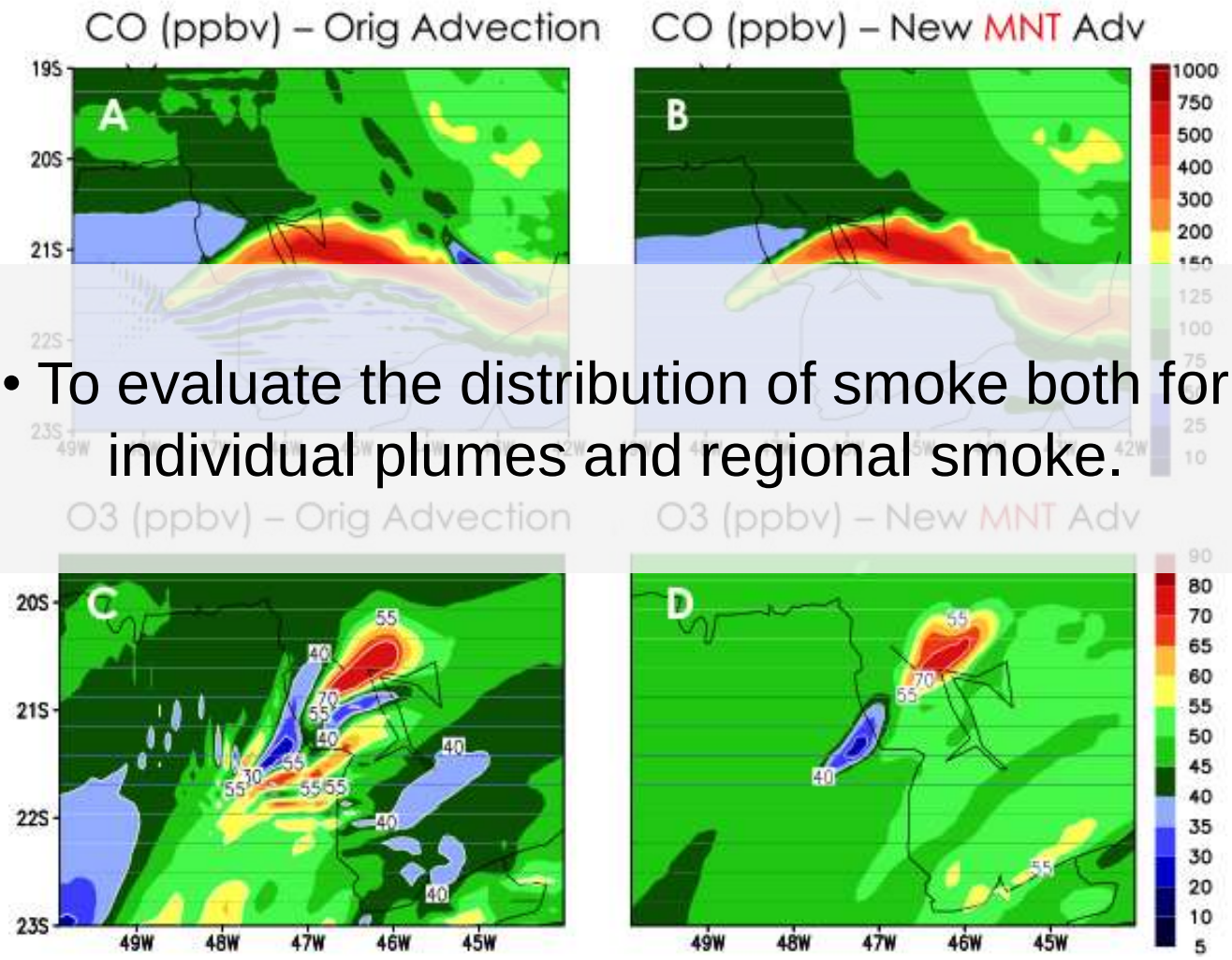
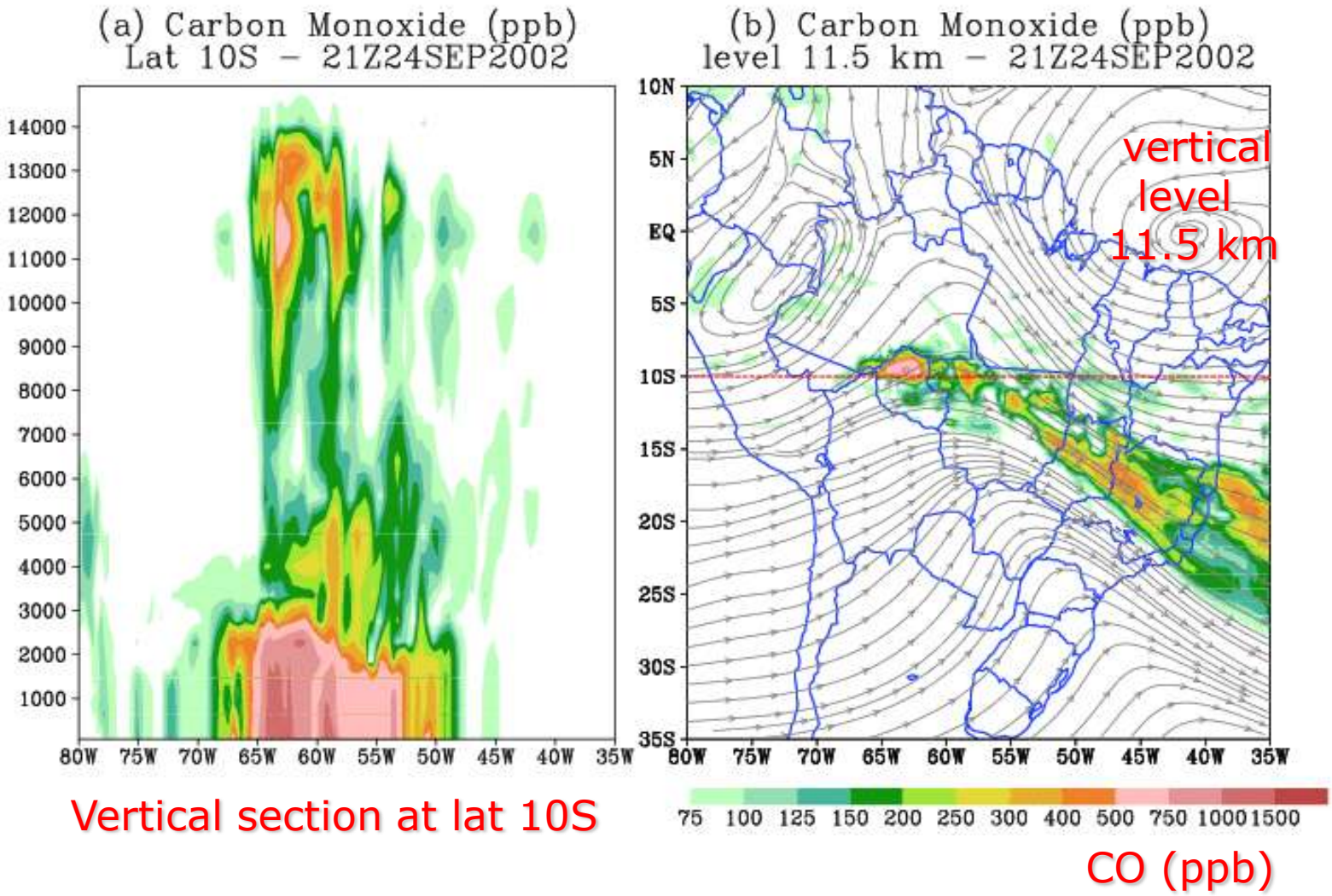
New advection scheme

Biomass burning plume of carbon monoxide (ppbv)



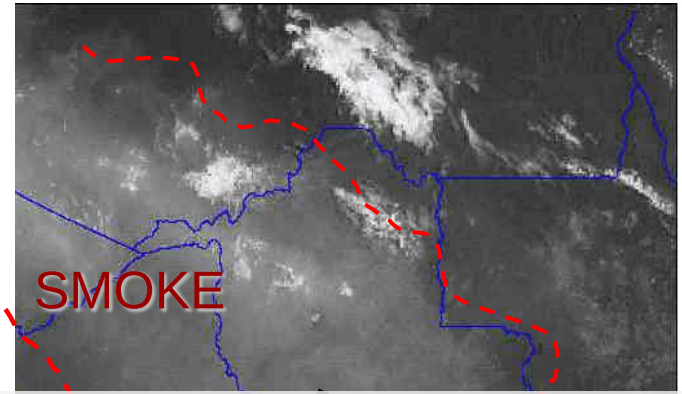
- To evaluate the distribution of smoke both for individual plumes and regional smoke.

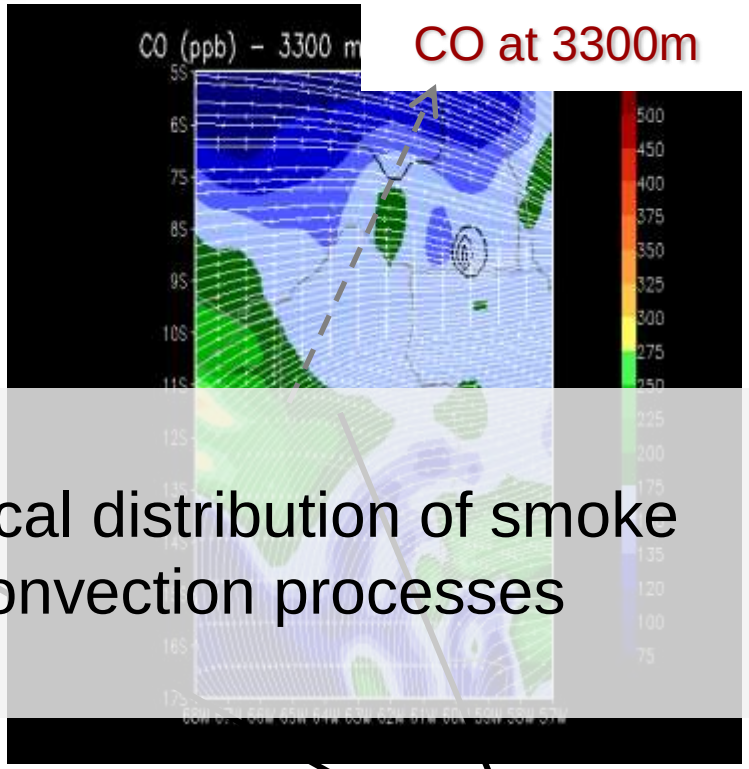
Deep Convective Transport of CO: 21Z 24 Sep 2002 – simulation with CCATT-BRAMS model



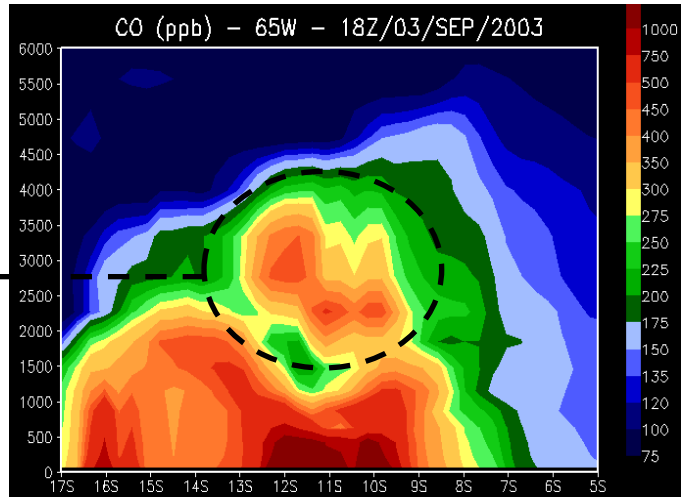
Vertical section at lat 10S

Shallow convective transport
Model simulation for 14-17Z03092003





- To evaluate the vertical distribution of smoke associated with convection processes



shallow cumulus

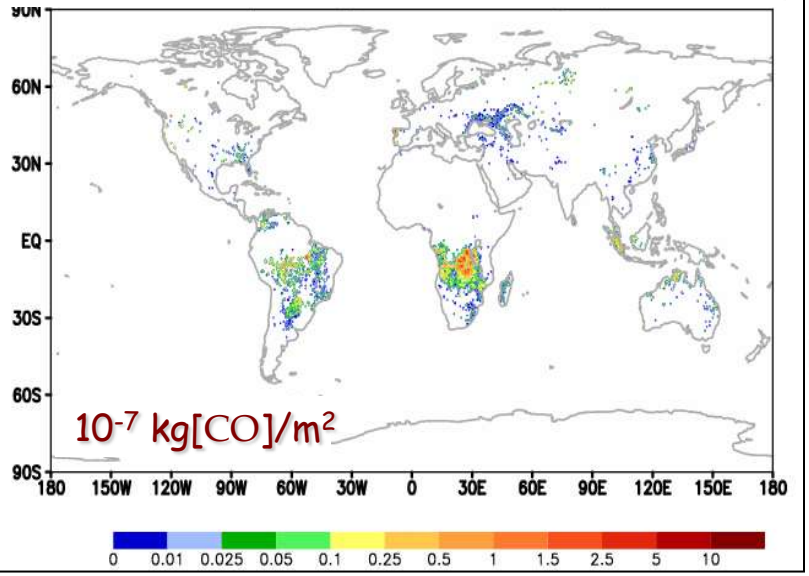
Low troposphere CO

PBL

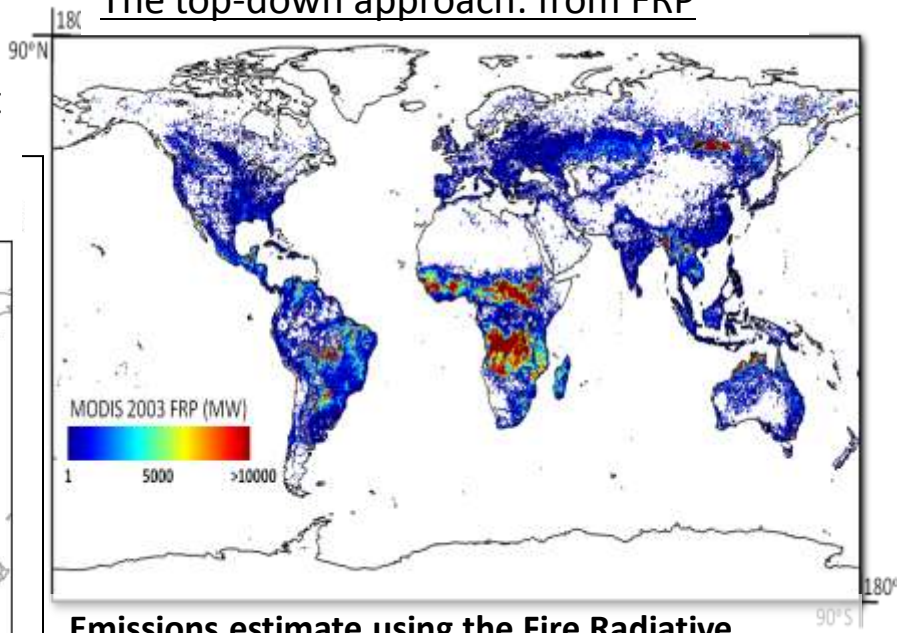
Biomass Burning Emissions Estimation

Brazilian Biomass Burning Emission Model (3BEM): 2 approaches

The bottom-up approach: fire size/burnt area, carbon density, emission and combustion factors.



The top-down approach: from FRP

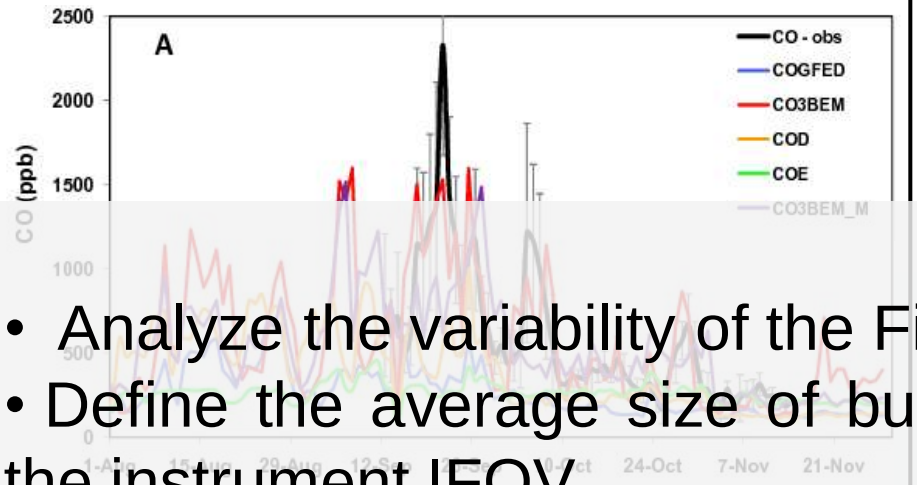


Emissions estimate using the Fire Radiative Energy (FRP) from MODIS, GOES and SEVIRI sensors.

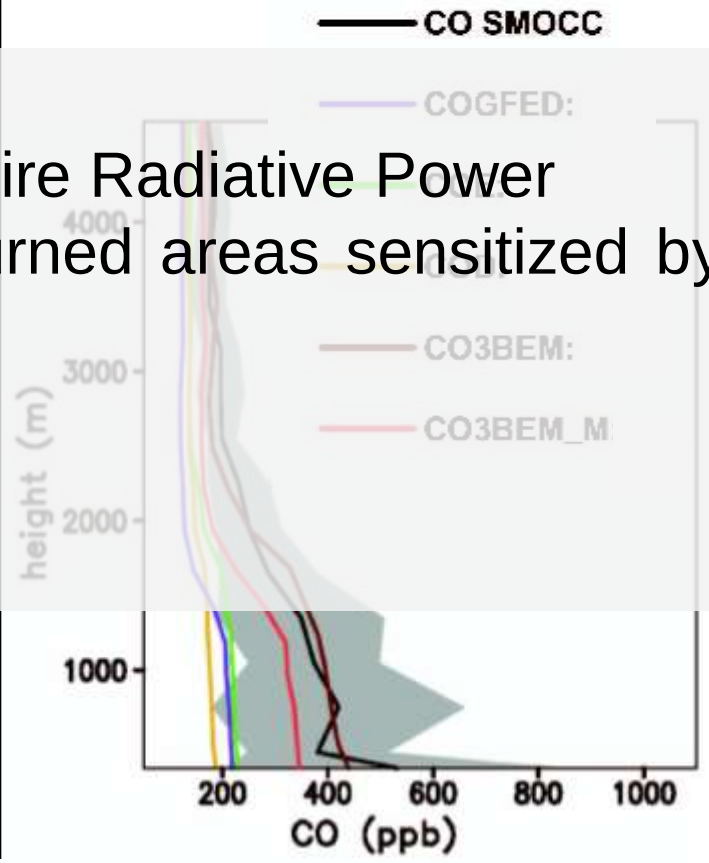
Intercomparison between 4 biomass burning inventories

EDGAR, GFEDv2, D2003, 3BEM

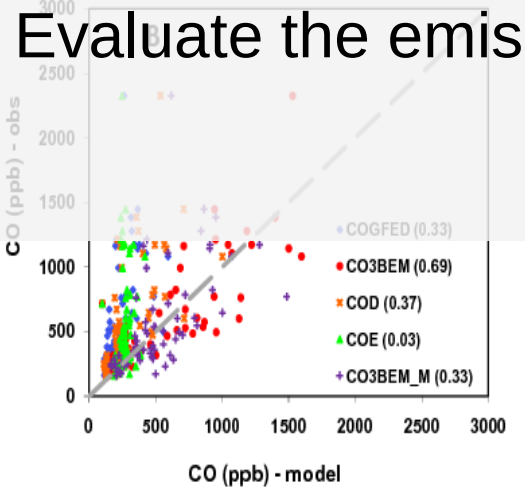
Model evaluation with SMOCC/RaCCI 2002 using near surface measurements



Model evaluation with SMOCC/RaCCI 2002 with airborne measurements (CO)



- Analyze the variability of the Fire Radiative Power
- Define the average size of burned areas sensitized by the instrument IFOV.
- Evaluate the emissions



Including plume rise sub-grid scale transport trough the *"super-parameterization"* concept

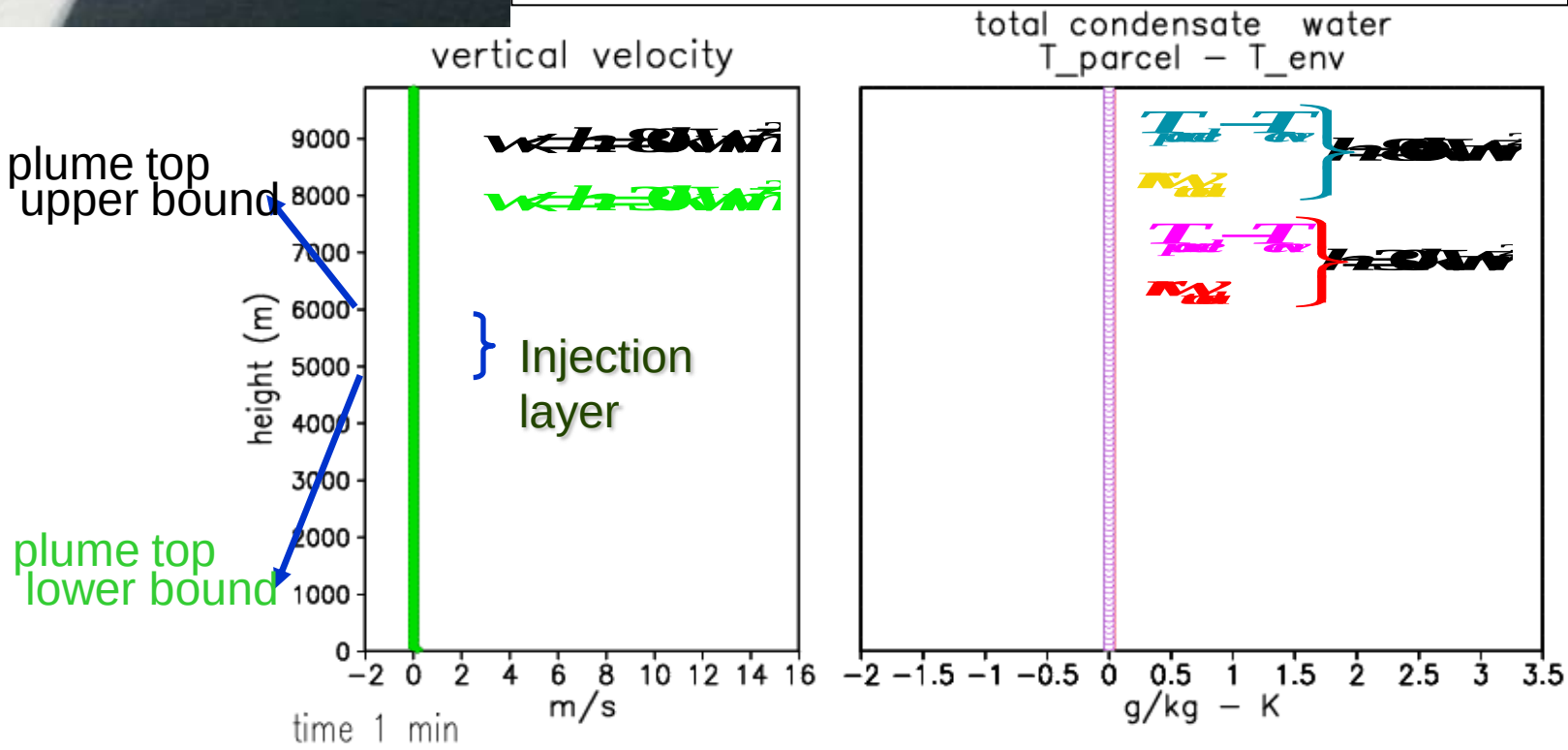
1D plume-rise model for vegetation fires

Biome: Forest

Time duration: 50 mn

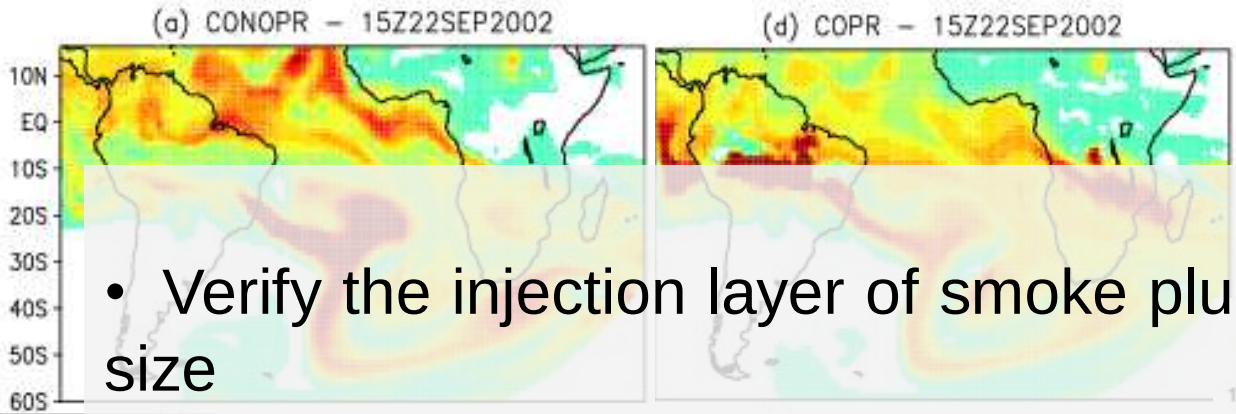
Fire size: 20 ha

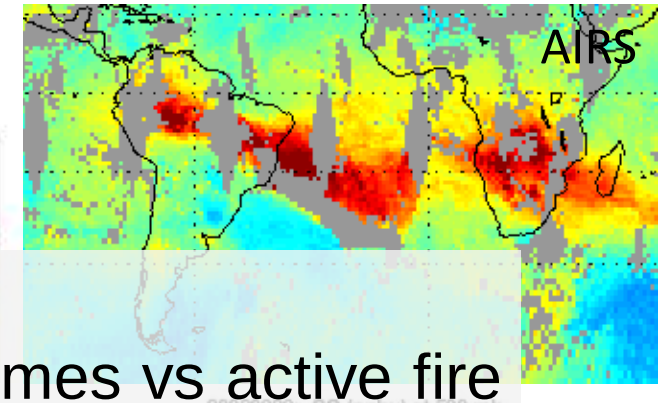
Heat flux: 80 kWm^{-2} / 30 kWm^{-2}



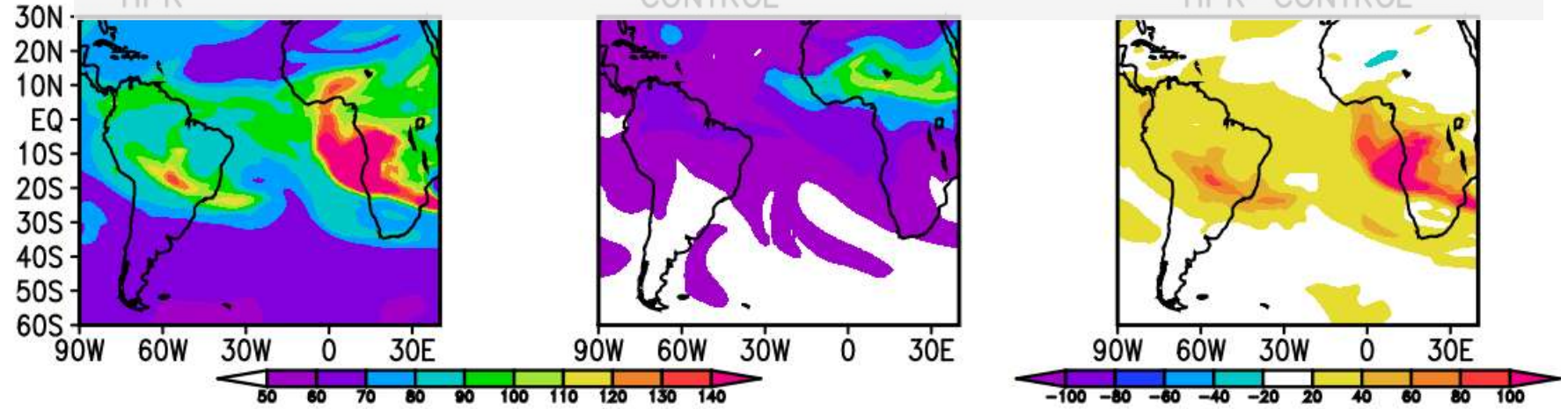
Model x AIRS

CCATT-BRAMS

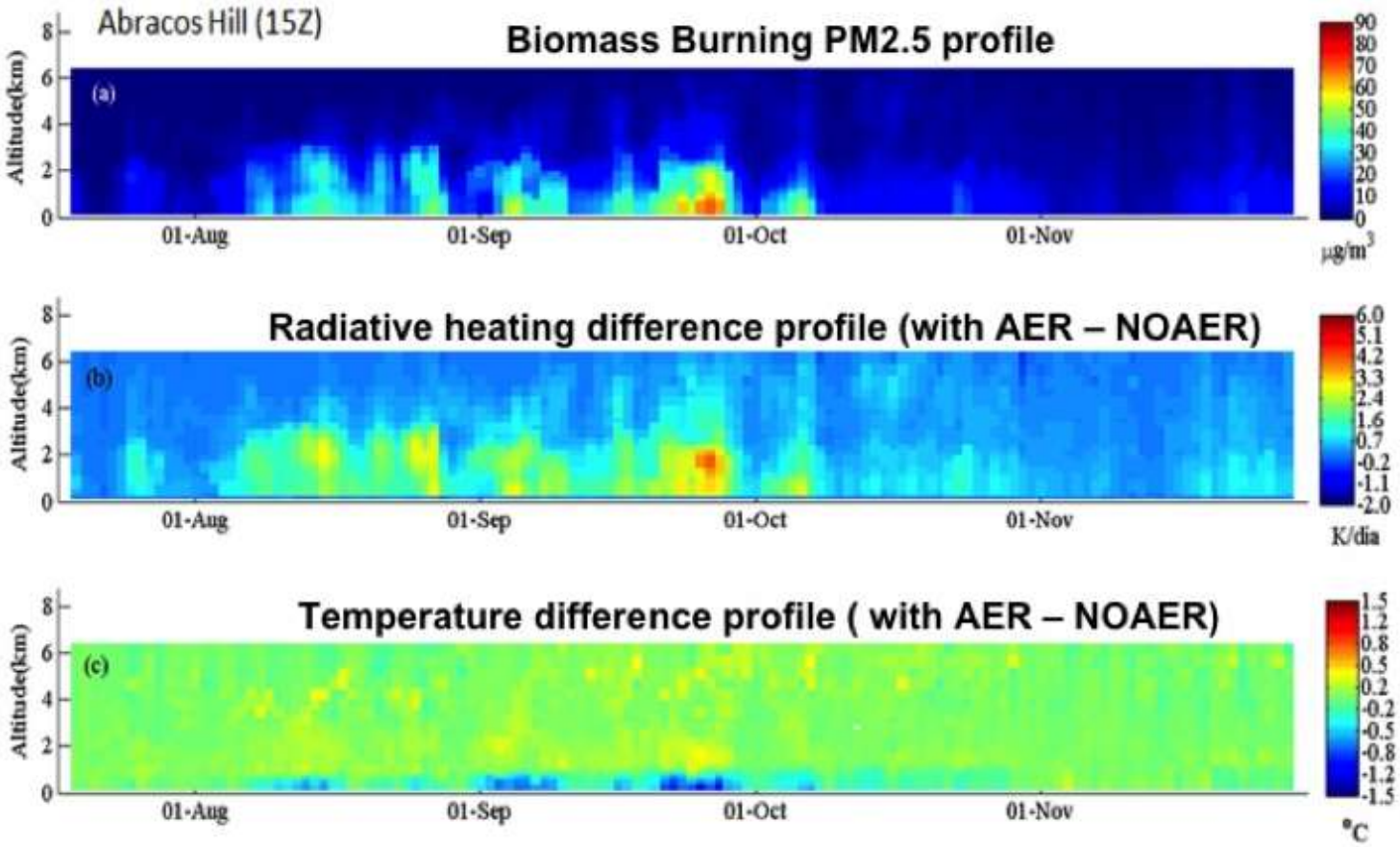




- Verify the injection layer of smoke plumes vs active fire size



Semi-direct radiative effect



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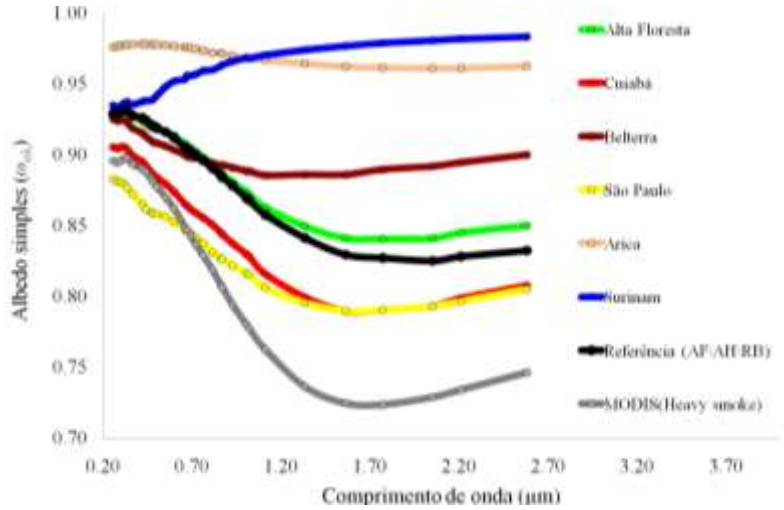
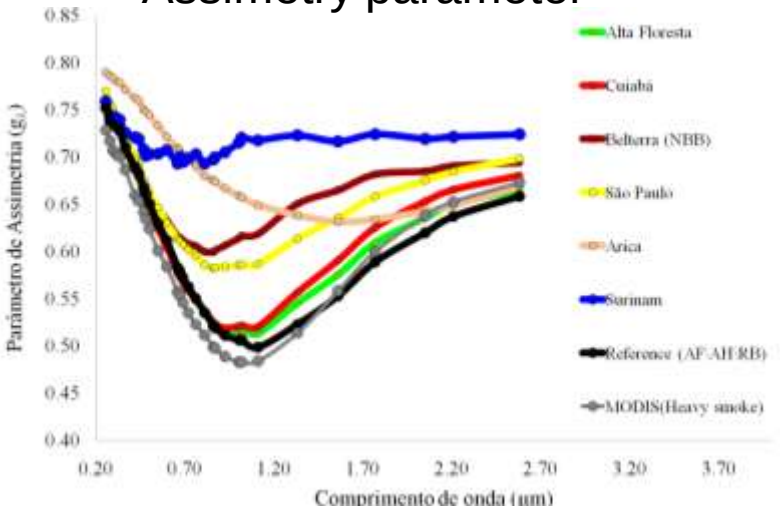
Aerosol optical properties in SA

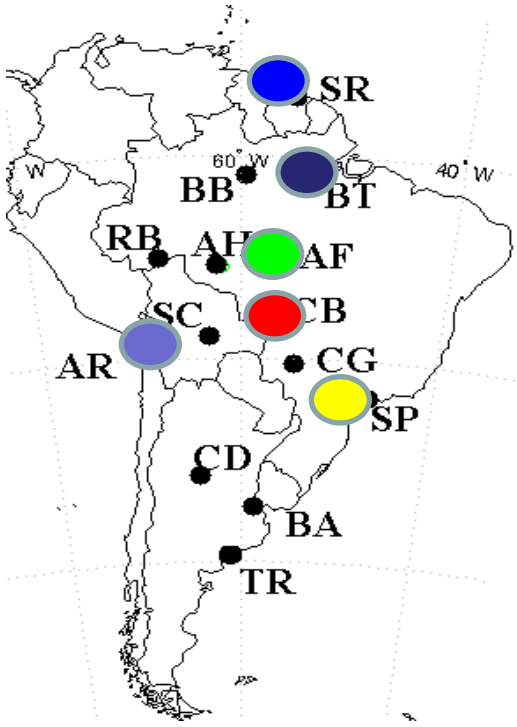
Single scattering albedo



Assimetry parameter

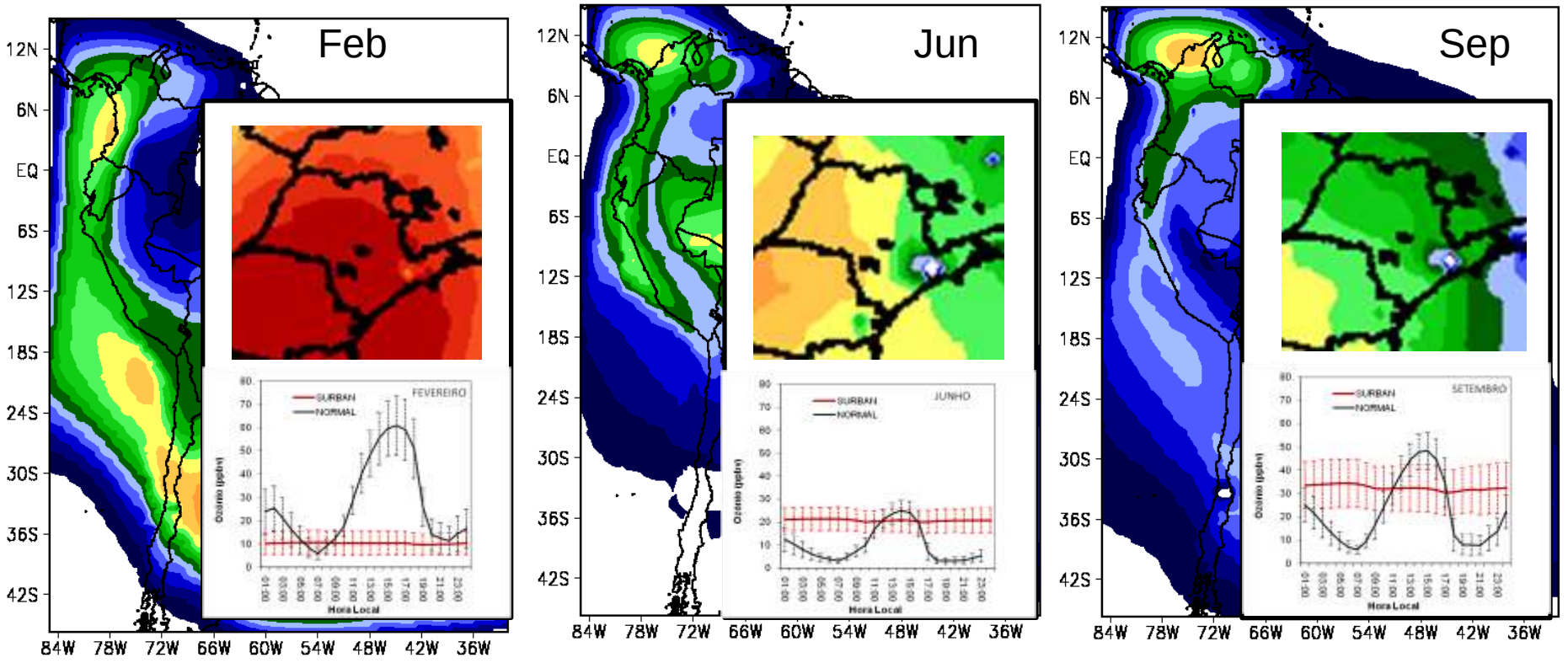


AERONET sites

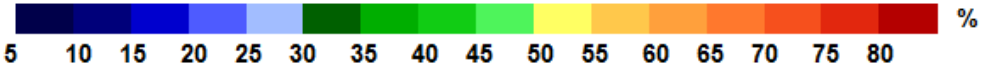


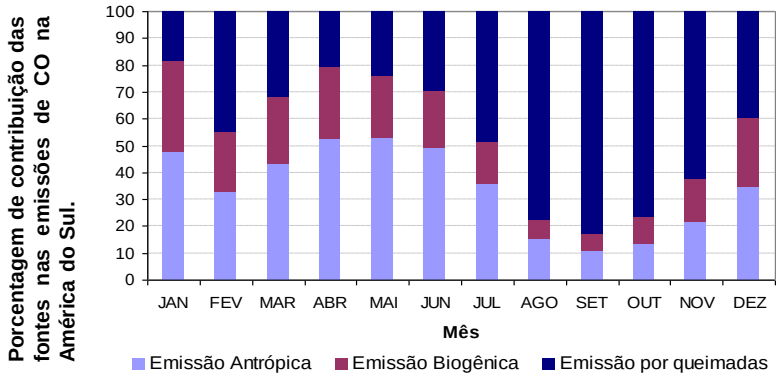
PhD thesis: Rosário, N. E. , USP), 2011.

Chemical weather forecasting for South America: relative impact of urban emissions in the local and regional scales



Relative contribution of urban emission for the ozone near surface level (2 km).

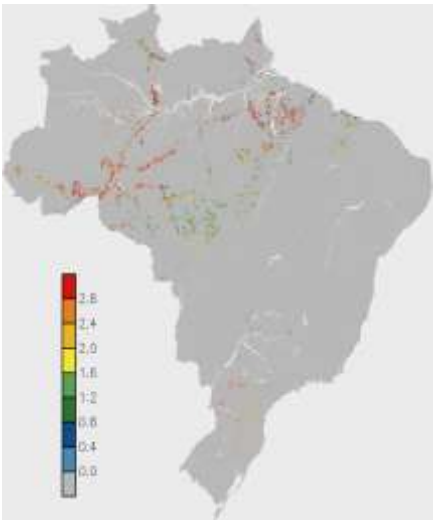




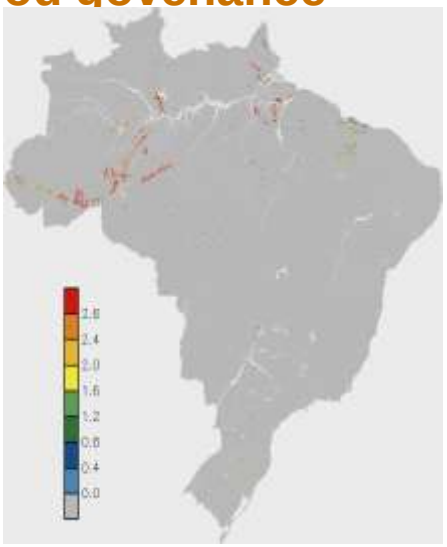
PhD thesis: Alonso, M. F. , INPE), 2011.

Spatial Emission Distribution

Control Scenario: business as usual



Low Carbon Scenario: good governance



Deforestation 2007-2030

Emission [ton/(ha year)] 2007-2030

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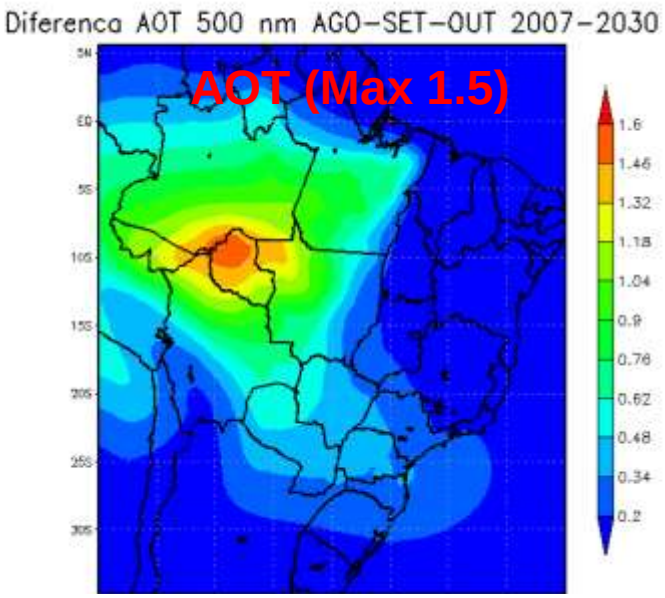
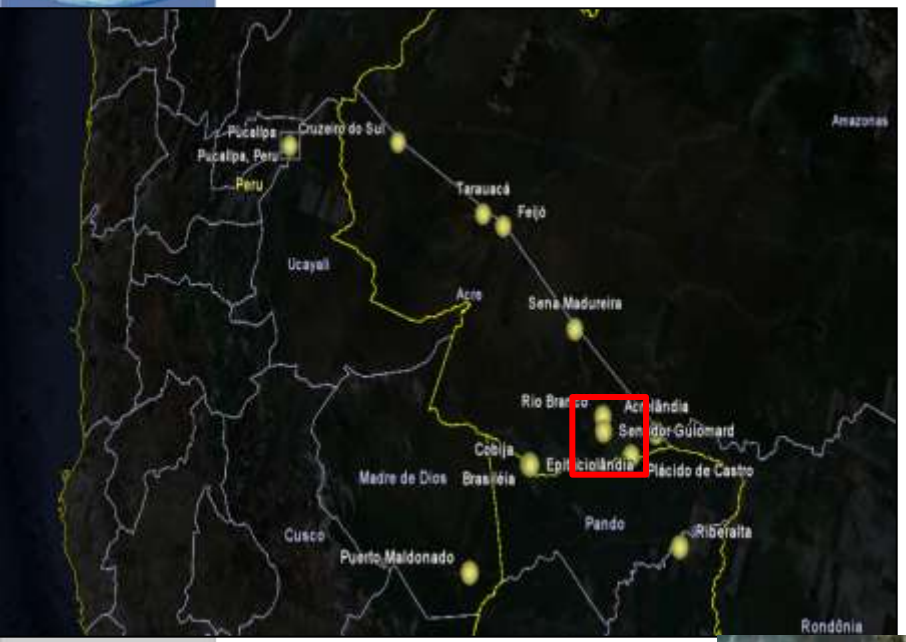
Impacts : reference x low carbon scenarios (Months: AUG-SEP-OCT)



Difere

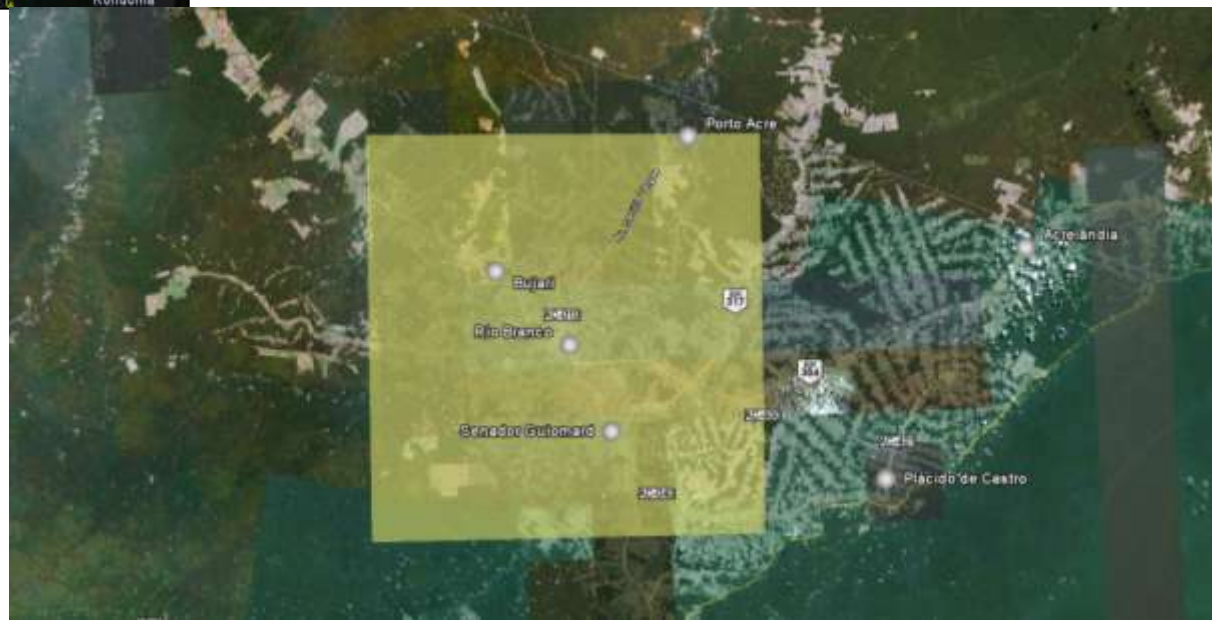
Acre



Population → 733.559 hab

Total area → 164.122 km^2

Density → 4,5 hab/km^2



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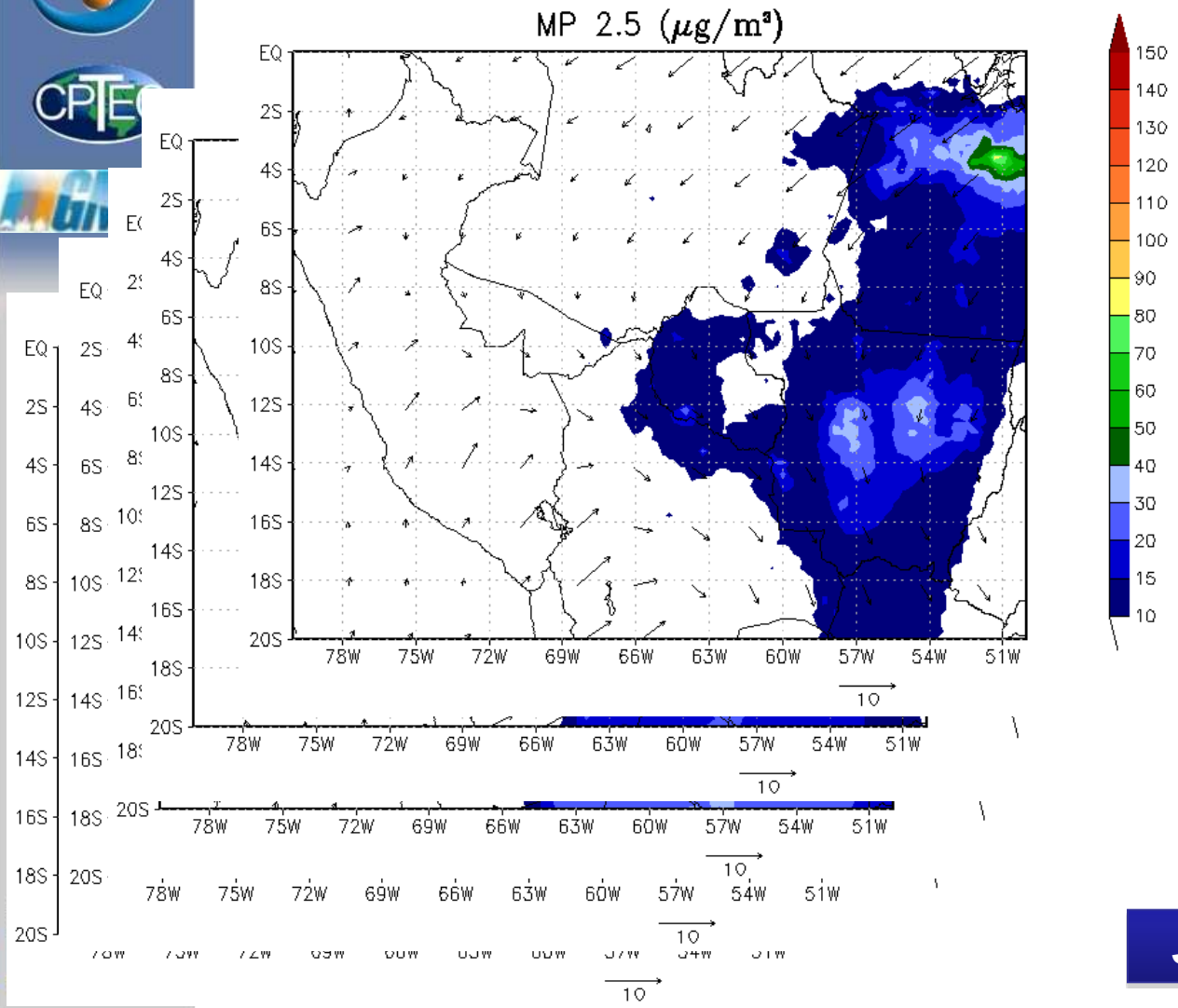
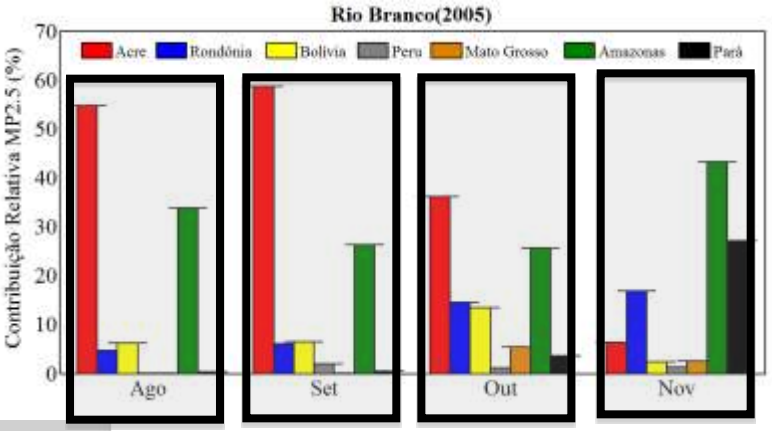
Concentração média mensal de MP_2.5μm para o ano de 2005

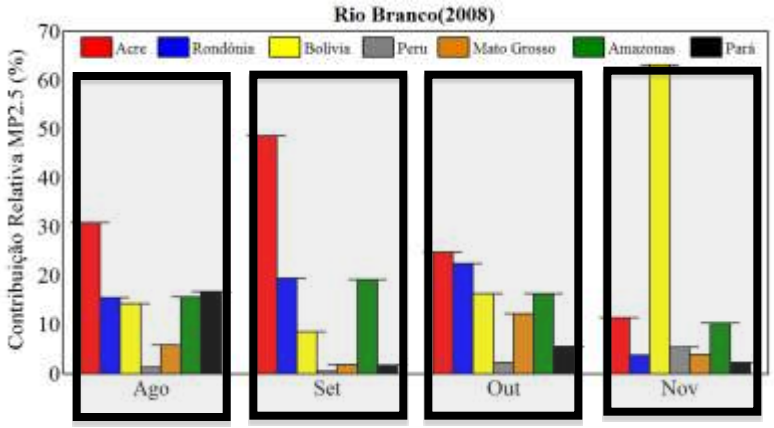


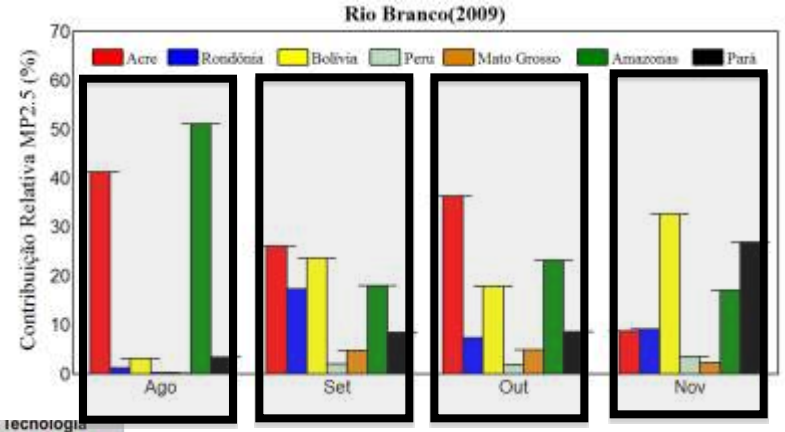
NOVEMBR

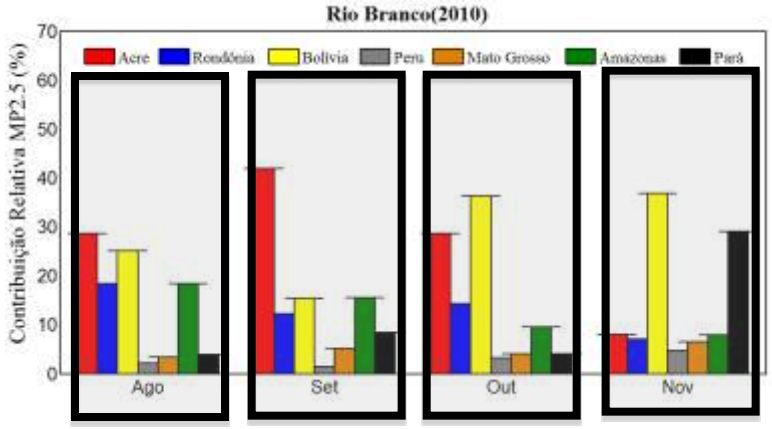
JULHO

Smoke contribution in Rio Branco



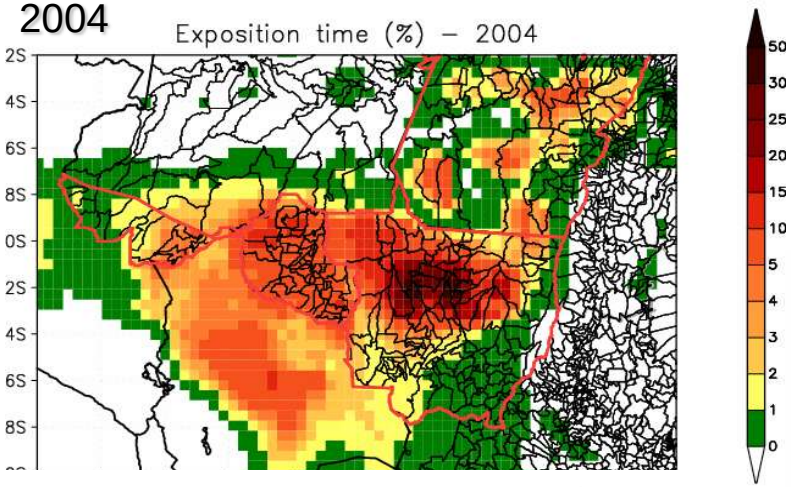




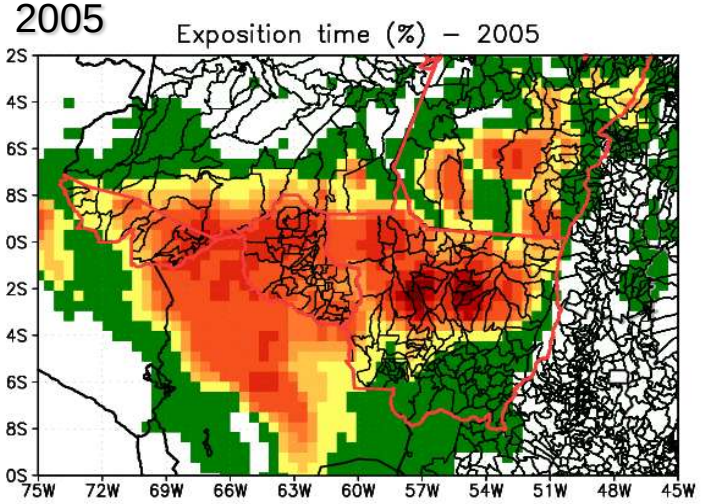


Qualidade do ar e saúde pública

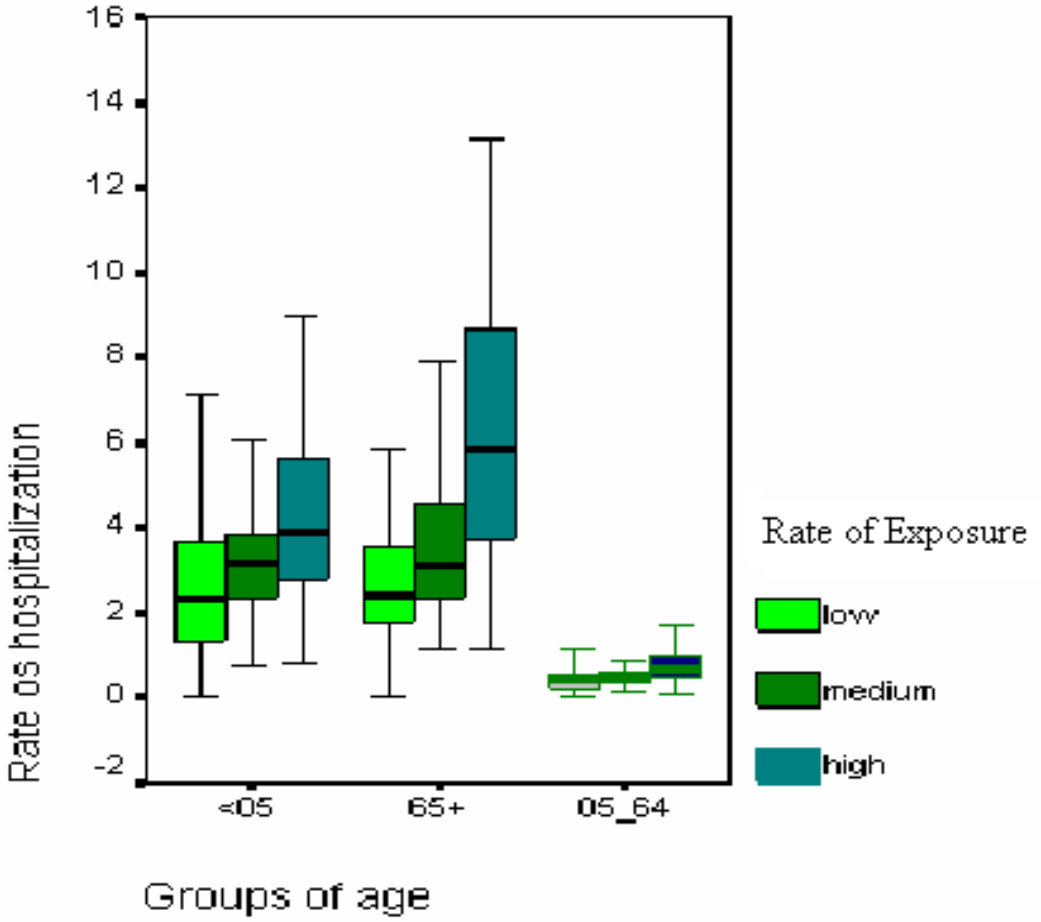
Tempo de exposição (%) 80 μg/m³ 2004



Tempo de exposição (%) 80 μg/m³ 2005



Amazônia Legal e distribuição de queimadas



INPE – FIOCRUZ – UNEMAT

Ongoing thesis work

- Coupling JULES model (soil/vegetation/carbon/VOC) to CCATT-BRAMS
  Demerval Moreira PhD at INPE, with Saulo Freitas

- Aerosol indirect effect on cloud microphysics and cumulus convection
  Ricardo Almeida, PhD at INPE, with Saulo Freitas and Karla Longo

- Nitrogen budget over South America: organic fraction of Nr
  Madeleine Gácita (PhD at INPE, with Karla Longo)

- Biogenic emission in South America: oxidative capacity of the Amazonian atmosphere
  Fernando Cavalcante (PhD at INPE, with Karla Longo and Alex Guenther)

- Chemistry associated with convective clouds
  Megan Bela (PhD at University of Colorado, with Mary Barth and Brian Toon)

Ongoing work

- Implementation of MATRIX in CCATT-BRAMS
  Karla Longo, Nilton Rosário, Luiz Flávio Rodrigues and Saulo Freitas

- New cumulus scheme for nearly cloud resolving resolutions (G3d)
  Saulo Freitas and Georg Grell)

- Implementation of the radiation scheme from UK-MO in CCATT-BRAMS
  Nilton Rosário, Karla Longo, Luiz Flávio Rodrigues and Saulo Freitas

Prescribed fires – FAPESP project (João Andrade)

Google earth

quilômetros 800

km 1000

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