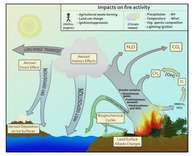
INTEGRATION OF A SMOKE PLUME RISE SCHEME AND 3BEM-FRP EMISSION INVENTORY INTO MPAS-GOCART2G: APPLICATION TO THE 2024 SOUTH AMERICA WILDFIRE SEASON

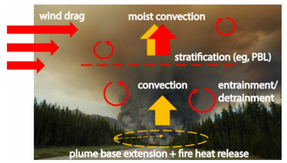
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BACKGROUND

Landscape fires emit large quantities of aerosols into the atmosphere, affecting air quality, atmospheric chemistry, human health, and Earth's radiative budget. Ward et al. (2012)





The plume injection height influences the chemical evolution with formation of secondary compounds, long-range transport and lifetime of fire-emitted trace gases and aerosols.

Paugam et al. (2016)

The ability of atmospheric models to simulate wildfire smoke is critically dependent on the plume injection height parametrization.

Objective

Provide the state-of-science wildfire aerosol module for

MONAN Model for Ocean-laNd-Atmosphere predictioN

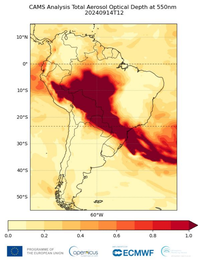
Atmospheric Driver: MPAS-A

Next generation of Earth System numerical modeling for the South America and Caribbean.

1. Implement Freitas et al. (2007, 2010) Plume Rise Model (PRM) within the MPAS-GOCART2G framework to assist the fire emission module with the vertical distribution of the hot smoke;
2. Implement the 3BEM-FRP emissions fields in the MPAS-GOCART2G.

SOUTH AMERICA 2024 WILDFIRE SEASON

The 2024 exceptional and widespread wildfires across South America.



- Most affected areas: Amazon rainforest, the Pantanal and the Cerrado in Brazil.
- Between May and November 2024, more than 350,000 megatons of carbon were emitted by these fires, the highest for these months since 2011.
- In September 2024, more than 340,000 hotspots were identified via satellite imaging, with fire spots mainly in Bolivia, Brazil, Paraguay, and Peru (representing an increase of about 15–20% compared to the period 2012–2024).
- The smoke derived from the wildfires worsened the air quality up to very unhealthy levels in several populated cities, including São Paulo in Brazil and Puerto Maldonado and Pucallpa in Peru.

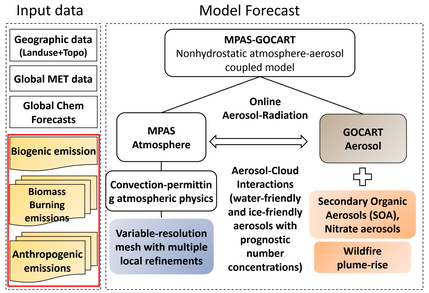


Satellite image of smoke billowing from the blazes in South America acquired on September 3, 2024, by the Earth Polychromatic Imaging Camera imager.

METHODS AND DATA

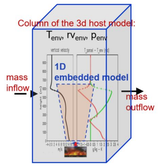
What is MPAS-GOCART2G ?

NSF NCAR's next-generation multi-scale atmosphere - aerosol chemistry global to regional online-coupled system



What is Plume Rise Model (PRM) ?

Parametrization To Estimate Plume Injection Height

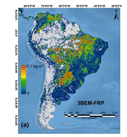


Freitas et al. (2007, 2010)

- 1-D time-dependent cloud-resolving model;
- Based on microphysics and entrainment;
- Solves the vertical momentum, first law of thermodynamics and the continuity equation for water phases;
- Takes in fire information (active fire size and heat flux), besides the atmospheric environment condition;
- The plume-top height: height for which the vertical velocity of the in-plume air parcel is less than 1 ms^{-1}.

What is 3BEM-FRP ?

Brazilian Biomass Burning Emission Model With Fire Radiative Power



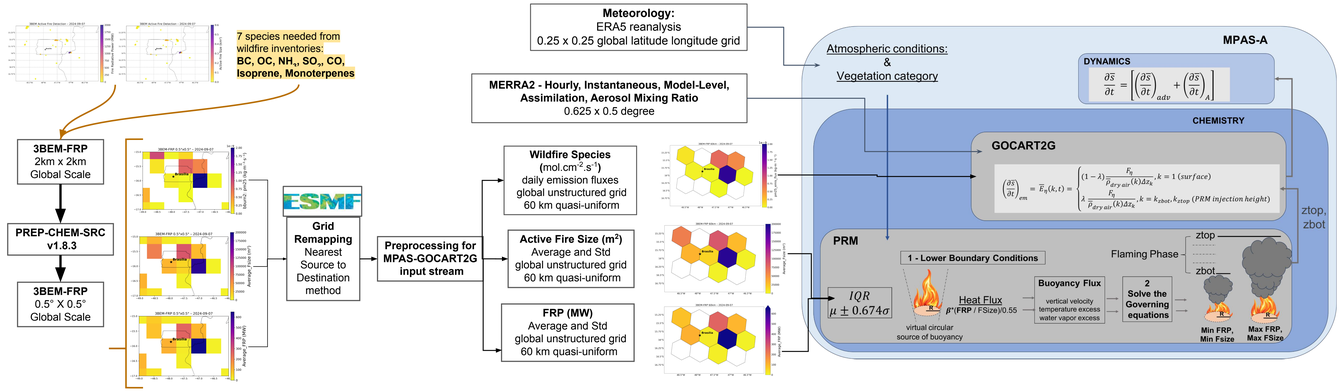
Pereira et al.. (2022)

- Fire Size, FRP and gas and aerosol emissions fluxes;
- Integrates polar-orbit (MODIS 1km, VIIRS 750m) and geostationary (SEVIRI 3km, ABI 2km) satellites' fire-related products;
- Processed on Prep-Chem-Src (Fortran-based tool that provides gridded emissions with flexible spatial resolution, several projections, and is suitable for global models).

TAKEAWAYS

The model captured key features of wildfire plume injection height and demonstrated sensitivity to input data such as Fire Size and FRP. These efforts will improve the description of smoke plume rise and increase the accuracy of wildfire smoke dispersion simulations in MPAS-GOCART2G.

EXPERIMENT CONFIGURATION AND WORKFLOW



Simulation	
Wildfire Event	2024 wildfires across South America
Periodo	September 07 - 14, 2024
Domain Setting	
Horizontal Grid	60 km - global
Vertical Layers	55

Atmospheric Process	
physics_suite	convection_permitting
GOCART2G	
config_gocart2G_toRRTMG config_gocart2G_toMYNN config_gocart2G_toTHOM config_gocart2G_toNTIEDTKE	

PRM Configuration	
config_do_bburnPRM	true
config_heatflux	'FRP'
config_prm_lbc_interval	01_00:00:00
config_prm_interval	00_01:00:00

PRELIMINAR RESULTS

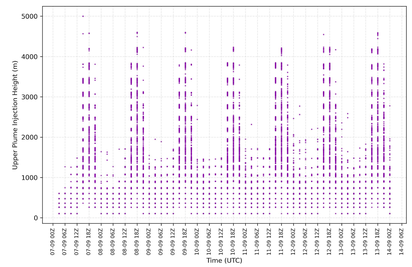


Fig 1. Upper boundary of the plume injection heights simulated by the MPAS-GOCART2G over the South America from September 07 to 14, 2024.

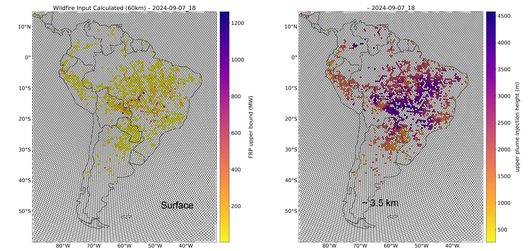
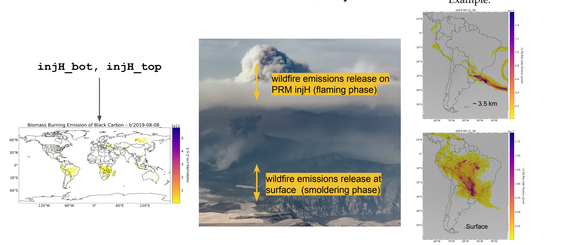


Fig 2. (a) Upper boundary of the FRP (MW) and (b) plume injection height (m) simulated by the MPAS-GOCART2G over the South America at September 07, 2024, 18UTC.

ONGOING RESEARCH

Application of the plume injection height on the biomass burning emissions in the MPAS-GOCART2G system.



ACKNOWLEDGES

This work has been supported by the following Brazilian research agencies: CAPES, CNPq.

We also acknowledge the support of NSF-NCAR, specially MMM and ACOM Labs, as well as the insightful guidance provided by Michael Duda, Laura Fowler and Gabriele Pfister.

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Freitas, S. R., et al. (2007). Including the sub-grid scale plume rise of vegetation fires in low-resolution atmospheric transport models. *Atmospheric Chemistry and Physics*, 7(13), 3385–3398.

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