PREP-CHEM-SRC VERSION 1.8: improvements to better represent local urban and biomass burning emissions over South America

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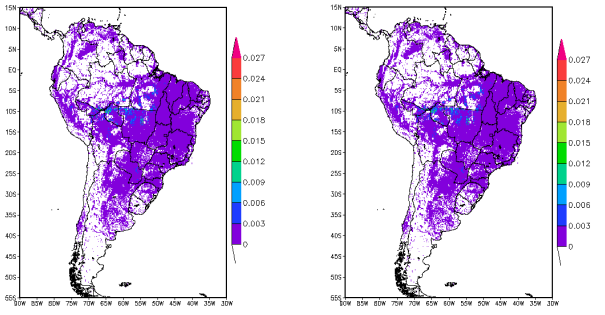
1. Introduction

Atmospheric composition studies with numerical simulations have been widely conducted, motivated by the increasing computational resources and improvements in the representation of atmospheric-chemistry models (Freitas et al. 2011). The spatial and temporal distribution of emissions has a strong role in air quality forecast and is crucial information for numerical models. Better emission representation helps improving the skill of atmospheric–chemistry models as well as the global inventories commonly used to represent the most important primary atmospheric trace gases and aerosols. Since 2003, many improvements have been applied to the Air Quality Forecast System (AQFS) of the Center for Weather Forecasting and Climate Studies of the National Institute for Space Research in Brazil (CPTEC/INPE), which has the Brazilian developments on the Regional Atmospheric Modeling System (BRAMS) as the main component, resulting in successful air quality forecasts for South America. CPTEC/INPE develops the emission pre–processor called PREP-CHEM-SRC, a tool that provides emissions fields of trace gases and aerosols for the BRAMS-AQFS, as well as for other regional and global atmospheric chemistry models (Freitas et al. 2011). PREP-CHEM-SRC has been updated with improvements and implementations according to user needs. All implementations available in previous versions were merged in the new version called PREP-CHEM-SRC 1.8. In addition, new improvements were also developed. In this paper we present PREP-CHEM-SRC version 1.8 and discuss the main improvements available in this version, including updated Emission Factors (EFs) for biomass burning used in the Brazilian Biomass Burning Emission Model (Longo et al. 2010, 3BEM) and updates in urban emissions for Metropolitan Areas of São Paulo (MASP) and Rio de Janeiro (MARJ), following the methodology proposed by Alonso et al. (2010).

2. Biomass burning emissions

EFs of different chemical species were updated in the PREP-CHEM-SRC version 1.8 emissions code with specific information for South America. To this end, we proceed with the review, update and computation of EFs in spreadsheets. A wide bibliographic search regarding these parameters was carried out. The updated EFs were based in Andreae and Merlet (2001), Andreae (personal communication, 2016) and Yokelson et al. (2013). Finally, the estimated EFs were included in the source code of PREP-CHEM-SRC. The PREP-CHEM-SRC categories updated with EFs specific for South America (mainly Brazil) were: tropical forest, savanna, pasture/agricultural area and agricultural residues. Categories like extratropical forest, biofuel and charcoal burning were updated with EFs values of the world literature due to the lack of values for South America.

PREP-CHEM-SRC 1.8 was run by operating with fires detected by remote sensing information from the Geostationary Operational Environmental Satellite (GOES) data, Moderate Resolution Imaging Spectroradiometer (MODIS) and data operationally produced by the Division of Satellites and Environmental Systems (from the acronym in Portuguese for Divisão de Satélites e Sistemas Ambientais - DSA) at CPTEC/INPE from August through October 2015. The results indicated that both estimated total emissions of carbon monoxide (CO), nitrogen oxides (NOx) and methane (CH4, Figure 1a) for South America did not change from previous versions compared with PREP-CHEM-SCR version 1.8 (Figure 1b), indicating the new version is functional. Experiments were also carried out using version 1.8 operating with fires and new EFs for the global scale, which generated equivalent results.



(a) (b)

FIG. 1. Comparison between CH_4 (kg/m^2) emissions from PREP-CHEM-SRC versions a) 1.6 and b) 1.8.

PREP-CHEM-SRC version 1.8 also takes into account the estimation of tracers and aerosols from biomass burning emissions by using the Fire Radiative Power (FRP) methodology available in version 1.6 (Pereira et al. 2009, 2016). The FRP is considered an indicator of the amount of biomass consumed or the emission rate of trace gases and aerosols released into the atmosphere at a burning event (Pereira et al. 2009). In order to compare differences between FRP and 3BEM emission estimation methods available in PREP-CHEM-SRC VERSION 1.8, a climate simulation with BRAMS version 5.2

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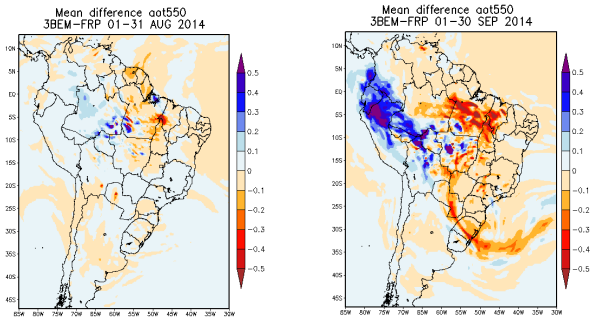
(Freitas et al. 2017) with 20km grid-spacing was carried out for August-September 2014, during the dry season in South America. Comparative differences are made to show how BRAMS Aerosol Optical Depth (AOD) simulations are sensitive to FRP and 3BEM emissions (Figure 2). As discussed in Pereira et al. (2016), FRP better represents smoke particle loading in the eastern region of Amazon forest compared with 3BEM, as well as in transition areas of Amazon rainforest and Brazilian savanna, like in central Brazil and west portion of Northeast Brazil both in August (Figure 2a) and September (Figure 2b). However, due drier conditions climatologically observed during September, such characteristics are highlighted. It is observed overestimation of AOD specially in central Brazil, and underestimation in western part of Amazon rainforest considering emissions estimated by FRP methodology (Figure 2).



(a) (b)

FIG. 2. Difference between Aerosol Optical Depth simulations using a) 3BEM and b) FRP emissions generated by PREP-CHEM-SRC version 1.8.

3. Urban emissions

With public policies adopted in the São Paulo State aiming the reduction of pollution in urban areas, it has been observed decreasing emissions by vehicular fleet in MASP. Values applied in previous versions of PREP-CHEM-SRC were based on reports from the Environmental Company of the São Paulo State (CETESB) of 2005/2006.

In order to update the database for local urban emissions both in MASP and MARJ, the annual vehicle emission up to 2030 was determined for NOx and CO species for each city of the metropolitan areas using different scenarios. Geographic distribution of emissions was carried out using information of types of roads and traffic information for 2015 available in the National Department of Traffic (DENATRAN) website. Emission scenarios for NOx and CO in MARJ were extracted from Rosa (2011), while the values of total vehicular emission of pollutants for MASP municipalities were estimated from CETESB technical report published in 2015.

The methodology considered the analysis of the fleet by municipalities, determining the percentage that represents vehicles of the automobile category in each of the 39 municipalities of MASP and 92 municipalities in MARJ in relation to the total number for 2015. These information allowed the use of total annual emissions to weight emissions by municipalities in the regions according with the local fleet. By multiplying the value of the total annual vehicular emission of each species by the weight determined with the procedure described, an approximate annual vehicle emission value per municipality was obtained for each species. We selected automobile category considering that it has the largest number of units and exert important role on urban emissions. The method allowed the incorporation of the local emission data, making a homogeneous distribution by municipalities in MASP and MARJ. To include the industrial contributions to the emissions, the global datasets RETRO (REanalysis of TROpospheric chemical composition) and EDGAR-HTAP (Emission Database for Global Atmospheric Research) were used. Biogenic contributions took into account information from MEGAN (Model of Emissions of Gases and Aerosols from Nature) model.

4. Concluding remarks

The PREP-CHEM-SRC version 1.8 is presented. Emission factors for different biomes of South America were updated using bibliographic information. The methodology to estimate biomass burning emissions based on Fire Radiative Power is available in the present version. In addition, an update of urban emissions of Metropolitan Areas of São Paulo and Rio de Janeiro was included in PREP-CHEM-SRC version 1.8. Such improvements and new developments are of fundamental importance to better represent emissions in local and regional scale and add value to integrate databases of emission sources specially in areas with lack in local inventories. Better representation of emissions provide predictive skill on air quality forecasts. PREP-CHEM-SCR version 1.8 and previous releases are available on BRAMS homepage (http://brams.cptec.inpe.br/).

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