

Interactive comment on “Modeling South America regional smoke plume: aerosol optical depth variability and shortwave surface forcing” by N. E. Rosário et al.

Response to Interactive comment from P. Colarco Referee #1

First, we would like to thank the referee for his thoughtful comments and suggestions.

Referee #1 General Comments:

1- First, it needs a thorough read for English and grammar, starting I think with the title. “Modeling the South American regional smoke plume: Aerosol optical depth variability and shortwave surface forcing” reads better than the original title. There are numerous sentence fragments that need restructuring. The clarity of the paper really suffers for this.

Authors: The paper went through a careful English revision in order to improve its reading. We appreciated and accepted the suggestion for the title.

2- There isn't really a key result that I can see in the paper, except to say that the model doesn't do a particularly good job under high AOT events or at the Cuiaba site.

Authors: The modeling of the dynamics of the South American regional smoke plume is still a challenging task. We see the improvements in the simulation of the chain of processes (emission, transport, removal) that contribute to the spatial and temporal variability of the regional smoke aerosol optical depth over the continent as an important result. We understand that it will allow a more accurate assessment of the impact of biomass burning activity on the regional climate and its effect on air quality. Nevertheless, the emphasis on the model shortcomings over Cuiaba and Alta Floresta is an acknowledgment that studies are still needed to improve our understanding of regional smoke dynamics in order to provide a more accurate evaluation of the mentioned impacts.

3- I think the paper would be much improved if these deficiencies were addressed more. They suggest some of these deficiencies are related to errors in the satellite based emissions used. While I'm sure there are errors there I'm not convinced those are the sources of the error. For example, without any comparison of events to satellite observations it is not clear that the transport of the plume (here I mean local plumes) is very good. So it could be that these high AOT events are missing not due to errors in emissions but because they are local and either not adequately resolved in the model or else just misplaced in the model.

Authors: We agree that the deficiencies could be addressed more. We've started it following the referee 2 suggestion and it turned out that divergence between the model and observation for Cuiaba is very likely related to events with high contribution of coarse mode (see next query reply and reply to query 3 from referee 2). Regarding deficiencies associated with high AOD events, we attempted to address the issue focusing on the major divergences between the model and observations observed between August 24 and 29 over the Alta Floresta site. We'll include both analyses in the revised manuscript.

We performed a comparison analysis between MODIS AOD events and the modeled results in order to evaluate the quality of the predicted spatial distribution of AOD (additional supplement, pdf file). In regional terms, the main features of the spatial distribution are captured by the model. Locally important differences are observed, even after a correction to minimize the MODIS well known tendency to overestimate AOD over the southern of Amazon basin and cerrado (Hoelzemann et al., 2009; Levy et al., 2010). Sharp gradients in MODIS AOD fields indicate local sources contribution, which indeed is a challenge to the modeling and may play a significant role on the divergences. Two critical aspects during this period were high frequency of problematic MODIS geometry over the main burning area and cloudy scenario related to the presence of a frontal system affecting the central region of Brazil and the southern Amazon basin, which could have prevented fire spots detection. These aspects are going to be discussed in the manuscript. This behavior for this particular period seems consistent with the hypothesis associated with the lack of emissions.

4- Likewise I think there needs to be more explanation for what is wrong with the Cuiaba site other than that the AERONET observations are not the highest quality there. Fine, but I get a hint that it is a different kind of site at least due to the vegetation burned. How does that tie back into errors in the emissions or difficulties in modeling that particular site?

Authors: Indeed, Cuiaba is a different site in terms of vegetation (cerrado, savanna-like), and that is taken into account by the emission scheme, which uses specific emission and efficiency factors for the cerrado vegetation type. Nevertheless, this does not mean an absence of difficulties in this regard. However, the Norm O'Neill SDA product from AERONET (suggested by referee 2) provides new insight into the divergences observed over Cuiaba. Accordingly to this product, major divergences between the model and the AERONET station in Cuiabá are associated with the high contribution of coarse mode to total AOD (see additional supplement, pdf file). An analysis of the Angstrom Exponent (AE) corroborates this finding. A higher contribution of the coarse mode was followed by a decrease in AE. The opposite of the southern region of the Amazon basin, the cerrado region is characterized by large areas of exposed soil, which under windy conditions favor soil dust emissions. Although the magnitude of the observed coarse mode contribution is not very usual, peaks in the concentration of coarse mode aerosol around Cuiaba has been reported previously (SCAR-B experiment, Kaufman et al., 1998.). This new input changes our previous analysis regarding Model x AERONET divergences over Cuiaba. Therefore in the revised paper we rewrite our discussion on this topic taking that into account.

Referee#1 Specific comments:

5- Page 17469: Please restructure the model description. I realize references are given, but some very basic things could be presented. For example, I have no idea what satellite data is used to arrive at the biomass burning emissions. Likewise I don't understand the nature of the aerosol simulation: are you carrying the mass of smoke as a single tracer, or are you simulating the particle size distribution? You imply in section 2.1 that at one point you tried the full CARMA mechanism but that it was too costly, so it would be useful to know what aerosol mechanism you are using. Also, please provide a reference for the global model providing boundary conditions. What is the spatial resolution of the global model?

Authors:

Model description will be divided by topics in order to improve it. The model used fire database is a combination of the Geostationary Operational Environmental Satellite - Wildfire Automated Biomass Burning Algorithm (GOES WF ABBA product (cimss.ssec.wisc.edu/goes/burn/wfabba.html; Prins et al., 1998), the Brazilian National Institute for Space Research (INPE) fire product, which is based on the Advanced Very High Resolution Radiometer (AVHRR) aboard the NOAA polar orbiting satellites series (www.cptec.inpe.br/queimadas; Setzer and Pereira, 1987), and the Moderate Resolution Imaging Spectroradiometer (MODIS) fire product (modis-fire.umd.edu; Giglio et al., 2003). We'll extend the emission description in order to provide further details in the revised manuscript. The model carries aerosol mass loading (Mo; accumulation mode), which is converted to number concentration (No) in the optical-radiative module assuming a prescribed particle density ($\rho_o=1.35 \text{ g.cm}^{-3}$, Reid et al., 1998). The total numeric concentration is size distributed based on climatological fine particle size distribution parameters taken from AERONET sites. Therefore we are not simulating particle size distribution or processes related to its evolution, we are assuming a climatological one. Regarding the CARMA mechanisms, I'm referring to optical properties calculations. The code treatment considering bin size distributions by species, internal mixture and on-line Mie calculations was replaced by a straightforward representation which uses prescribed optical properties, specifically, efficiency factor, single scattering albedo and asymmetry parameter spectrally distributed in accordance with the radiative transfer code spectral bands.

For the atmospheric initial and boundary conditions, the 6 hourly CPTEC T126 (100x100 km) model analysis fields of horizontal wind, geopotential height, air temperature and water vapor mixing ratio were used for the model initialization. CPTEC T126 is the operational model from the Brazilian Center for Weather Forecast and Climate Studies.

6- Page 17470, lines 16 - 17: *In this section you seem to be describing the solution to the radiative transfer equation, and not the aerosol mechanism itself. I think the proper reference for this is Toon et al. (1989), same as used later in the text, and not the references given here.*

Authors: Correction accepted.

7- Page 17471, line 10: *For use by other models could you please include a table of the particle size distribution and refractive index parameters used in your simulations.*

Authors: A manuscript discussing the variability among the sites here analyzed and describing climatological optical models and the correspondent particle size distribution and refractive index parameters is being prepared for submission (Rosário et al., 2012) in order to make the mentioned parameters available.

8- Page 17472, line 24: *Please include a reference for the MODIS aerosol products.*

Authors: Included

9- Page 17473, line 3: *AERONET level 2.0 data is not available for the Cuiaba. You use this as a rationale later to exclude Cuiaba from the analyses presented. Maybe that lack of post field calibration means the AERONET data is not good, but are there perhaps other reasons that this site is not useful? It's a different ecosystem (Table 1) and so the assumptions of the emission properties may be very different, for example.*

Or maybe there is something about the environment (terrain?) that makes modeling distributions here difficult. Please elaborate.

Authors: (Please see reply to query 4)

10- Page 17473, line 16: *Your grid size is 35 km, but you consider a window 90 x 90 km² centered at each AERONET site as an averaging area. Do you actually mean something that is a multiple of your grid box? And how do you arrive at this particular window size (about 3 x 3 grid boxes)?*

Authors: Using AERONET site coordinates (lat, lon) as reference we averaged AOD (on grads) assuming a box defined by $lat \pm \Delta lat$ and $lon \pm \Delta lon$ where value of Δlat and Δlon was equivalent to a radius of 45 km.

11- Page 17475 - 174766: *You attribute most of the discrepancy between the simulated and observed AOT to emission errors. Certainly that plays a part, but what about the role of transport? Without showing satellite data it is hard to know if the model is even putting the plumes in the correct locations.*

Authors: (Please see reply to query 3):

12- Page 17478, line 1: *Please clarify that what you are calling the “independent empirical estimate” is what is labeled as “Observed” on Figure 8.*

Authors: Clarification provided in the revised manuscript

13- Page 17478, line 13: *You refer to “major differences” between the two figures in Figure 9. I can tell the figures are different, but they don’t really look very different to me. What should I be seeing? Maybe you could put a box around the region where you see major differences. Or else you could add a third plot which is the difference between the two realizations.*

Authors: Over AERONET sites located in and downwind of Central Brazil, such as Cuiaba, retrieved smoke aerosol single scattering albedo is systematically lower than values retrieved by AERONET sites in the southern Amazon Basin. When one prescribes a regional climatology of single scattering albedo for the South American regional plume that takes into account this spatial gradient (north-south) it should be able to obtain a stronger radiative flux perturbation over Central Brazil and the downwind areas when compared with prescription of a fixed regional average aerosol single scattering albedo. That was the goal of both figures. We’ll include a highlighting over that region.