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Interactive comment on "Modelling the radiative effects of smoke aerosols on carbon fluxes in Amazon" *by* Demerval S. Moreira et al.

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We thank the referee for his(er) insightful and very helpful comments, which contributed to improve the paper. The answers to his(er) questions and comments are below:

Legend: RC: Referee's Comment
AR: Author's response
AC: Author's changes in manuscript

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1. **RC: Unfortunately, the wording is often quite particular (shouldn't the title read ′...in the Amazon region' or similar), despite the English language being overall comprehensible. Examples of such a particular wording which provides wrong spelling, twisted logic as well as unusual usage of words are P5L9 ": : :mixing ratios are diagnosed from the prognostic variables using the saturation mixing ratio with respect to liquid water", P12L6 ": : :fire emissions were not expected to contribute only minorly to CO_2 mixing ratios: : :", or P14L22 ": : : a high GPP for C4 plants, but not high enough to compromise their photosynthesis process". A considerable language editing should therefore be carried out. This can be accompanied with extensive shortenings, particularly towards the end of the manuscript (i.e. P16-20).**

   AR: We changed the title to: 'Modelling the radiative effects of biomass burning aerosols on carbon fluxes in the Amazon region' and the document has been reviewed by a co-author who has English as his first language.

2. **RC: Furthermore, the paper needs more emphasize on the biosphere model. The reader only learns that the JULES model has been used and that it had been evaluated for sites in the Amazon before. What has not been explained in the methodology section is how the model considers direct and diffuse radiation for photosynthesis or how this response depends on plant functional type. It is also important to know how radiation and temperature changes influence simulated respiration (calculating a fixed or variable fraction of photosynthesis being lost as 'growth respiration', exponential temperature dependence on maintenance respiration, allocation shifts regarding exudation or fine root turnover changes the effect decomposition,: : :?).**

   AR: Following this suggestion, we explicitly included a section about JULES and BRAMS as part of section 2.1 and added more information on radiation interception and photosynthesis calculations in JULES, see below

AC: This is the new section on Jules that contains previous text and more information on radiation, photosynthesis and respiration.

Biosphere model: The Joint UK land simulator (JULES)

JULES simulates the exchange of carbon, momentum, and energy between the land surface and the atmosphere. Additionally, it represents subsurface hydrological processes, plants photosynthesis and respiration, and vegetation and soil dynamics (Best et al., 2011; Clark et al., 2011).

Atmospheric aerosols influence ecosystem functioning via effects on GPP from changes in quality and quantity of radiation but also indirectly via temperature effects on GPP but also on plant and heterotrophic respiration. The photosynthesis-radiation scheme, in JULES, accounts for the effects of diffuse radiation on canopy photosynthesis, by splitting direct and diffuse radiation and sunlit and shaded leaves at each canopy layer. Specifically, the multilayer radiation scheme includes an explicit calculation of absorption and scattering of the direct beam and the diffuse radiation fluxes in both visible and near-infrared wavebands, at each canopy layer, using the two-stream approach from Sellers (1985). Additionally, the attenuation of non-scattered incident direct beam radiation (sun flecks) is calculated using the approach by Dai et al. (2004). At each canopy layer, JULES estimates the fraction of absorbed direct and diffuse photosynthetic active radiation (PAR) thus providing a vertical profile of intercepted radiation fields which allows calculation of photosynthesis at each canopy level. At each canopy layer, the fraction of sunlit and shaded leaves is estimated as a function of the canopy beam radiation extinction coefficient (as explained in Clark et al 2011), and it is assumed that shaded leaves absorb only diffuse radiation and sunlit leaves absorb all types of radiation. Photosynthesis at each canopy layer is then estimated as the sum of sunlit and shaded leaf photosynthesis weighed by their respective fraction. Total canopy photosynthesis is estimated as the sum of the leaf –level fluxes in each layer scaled by leaf area of each canopy layer. Temperature effects on photosynthesis are simulated in JULESs via biochemistry, leaf respiration and effects of vapor pressure deficit (VPD) on stomatal conductance in response to the temperature (see details in Clark et al. 2011). The temperature response of leaf respiration is linked to the temperature response of maximum carboxylation activity of Rubisco (Vcmax) in JULES, which is described by a peaked response function. The temperature response of remaining maintenance respiration components is simulated also using the leaf respiration temperature function. Growth respiration is estimated as a proportion of net primary productivity (NPP). Heterotrophic respiration is simulated either using a Q10 temperature function or a RothC temperature function (Jenkinson 1990 as described in Clark et al. 2011).

Evaluation of the skill of JULES in simulating GPP under high direct and high diffuse radiation conditions has been tested against flux sites in the Amazon and in temperate forest sites where direct and diffuse radiation measurements are available. This is shown in Figure 2 of Rap et al. (2015) at Tapajos and French Guyana in the Amazon and at two temperate forest sites in Mercado et al. (2009) (Figure 1). Investigation of the response of photosynthesis to changes in direct and diffuse radiation across relevant plant functional types for the Amazon region is carried out within this study.

3. **RC:The depicted model properties (simplifications) should be used in the discussion to point out the appropriateness of the processes or the need for improvements. One of the reasons why the sensitivity of the model is important is that the importance of the direct and indirect aerosol effects might actually been less important than it looks like. I refer to chapter 3.2 where it is mentioned that the direct aerosol effect (by shading)**

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reaches -100 Wm-2 (Tapajos 80-123 Wm^{-2}), which comes along with a certain amount of cooling. This corresponds to about 460 umol m-2 s-1 global radiation or roughly speaking 230 umol m^{-2} s^{-1} PAR reduction. On the other hand, Fig. 12 shows that the increase of diffuse PAR due to the indirect aerosol effect is from app. 250 to 800 = 550 umol m2 s^{-1}. If direct and diffuse radiation are similarly effective in the model (please explore), the aerosol effect by shading should thus be about half the magnitude of the increase in diffuse radiation. Since it seems to be smaller, the cooling effect (part of direct aerosol effect) seems to compensate for the greater part of the shading. In my opinion this should be discussed in greater detail, using the sensitivity of the model against temperature changes for argumentation.

AR: Under increased biomass burning aerosol concentrations, the maximum reduction in shortwave radiation due to aerosol loading ranges between 50 and 100 W m-2 (Fig 10b) and this corresponds to the maximum reduction of the air temperature near surface, which is of approximately 1 degree Celsius (Fig 10C) . At midday (1600 UTC), this reduction in shortwave radiation corresponds to less than 10% of the maximum radiation, which reaches approximately 900-1000 W m-2 in most places of the Amazon (Fig 10 a). Additionally, according to our DIR+DIF simulations, the highest value of the diffuse fraction attained in the studied region was 0.4. Based on these values, we conducted a sensitivity analysis using JULES in order to investigate the changes in GPP driven by these changes in radiation, temperature and diffuse radiation (Fig S.4 of supplementary document). This sensitivity analysis shows that i) for a 10% decrease in shortwave radiation there are minimal changes in GPP (Fig S.4a), ii) a change in temperature of one degree also did not imply major changes in the simulated GPP (Fig S.4b), and iii) an increase in the diffuse fraction equivalent of 40% increased GPP by 39% , 71%, 4%, and 72%, respectively, in forest, C3, C4 grasses, and cerrado (shrubs) vegetation (Fig S.4c). We conclude from this sensitivity test that in this particular case, the effect of reduction of shortwave radiation and temperature due to the increase of the diffuse radiation had a small effect of on GPP.

4. **RC: P7L4: I don't understand what is meant by 'spin up artifacts'. Usually spin-ups are used to avoid artifacts originating from uncertain initial conditions.**

   AR: Thanks, we rephrased.

   AC: . The model simulations were initialized on 15 August 2010 00:00 UTC and conducted for 45 days. We discarded the first 15 days as spin-up, and restricted our analysis to the month of September to avoid model artifacts related to the initial conditions.

5. **RC: P7L7ff: From Fig. 12 it is apparent that diffuse PAR is about 250 umol m2-s-1 under conditions of AOD = 0 (clear sky conditions). I guess that this is about 5 percent of the total radiation even if AOD is actually 0. It seems likely that some clouds are even increasing this fraction. On the other hand the DIR-AER scenario seems to exclude this part of the radiation, which causes a bias that underestimates radiation and thus photosynthesis. Can you comment on this?**

   AR: As described in P5L25, the data presented in Figure 1 passed by a filter that removed the days with clouds, so when AOD=0, the parameter "d" of equation 1 gives the diffuse fraction due to the scattering by atmospheric gases, not clouds. The CARMA radiation parameterized only the direct component of the solar radiation. Thus, the solar radiation that reaches the surface (rshort) was divided into a direct ($rshort * (1 - D)$) and a diffuse component ($rshort * D$). In the DIR+DIF scenario the diffuse fraction (D) was obtained by equation 1 and sent to JULES, where the fraction of absorbed direct and diffuse radiation at each canopy layer is estimated On the other hand under the DIR-AER and NO-AER scenarios, a diffuse fraction of zero was prescribed, therefore JULES receives all incoming radiation as direct radiation and zero diffuse radiation, i.e. this guarantees that there is no underestimation of the radiation.

6. **RC: P8L6ff: Equations 5 and 6 seem superfluous to me. A short description in the text should suffice**

   AR: We agree.

   AC.1: The lines P8L4:P8L9 were removed from the text (The contribution of the direct ... definitions in Eq. 2, 3, and 4, respectively.)

   AC.2: P17L29:P17L35: The contribution of the diffuse radiation effect to NEE ($\Delta NEE_{diff}/\Delta NEE_{tot}$) versus AOD, for each biome, is depicted in Figure 18 along with its fitting functions. Over forest, the percentage of the diffuse radiation effect on CO_2 uptake decreases exponentially ($[\Delta NEE_{diff}/\Delta NEE_{tot}]_{forest} \approx e^{-0.9AOD}, R^2 = 0.7$) from 100% to 50% with the increase of aerosol loading, reaching a balance of 50% - 50% between the diffuse and direct effect, for AOD above 0.5. For C3 grass and *cerrado*, as expected, the contribution of the diffuse radiation effects tends to zero with the increase of AOD ($[\Delta NEE_{diff}/\Delta NEE_{tot}]_{cerrado,C3} \approx 0.7e^{-4AOD}, R^2 = 0.7$). While for C4 grass type, the contribution of the diffuse radiation to NEE exponentially increases with AOD ($[\Delta NEE_{diff}/\Delta NEE_{tot}]_{C4} \approx e^{AOD}, R^2 = 0.9$), the C4 photosynthetic pathway does not rapidly saturate with the amount of light received.

   AC.3: P48: The contribution of the diffuse radiation effect to NEE ($\Delta NEE_{diff}/\Delta NEE_{tot}$) as a function of AOD in the LBAR, but separated with different colors for different types of vegetation. The model data were filtered for cloudiness and precipitation. Additionally, only model points with the same soil water factor within all the three experiments, and soil moisture difference below 0.001 m^3m^{-3} were included. The fitting functions of the $\Delta NEE_{diff}/\Delta NEE_{tot}$ versus AOD for each biome are also shown in the figure.

7. **RC: P8L26/28: Why are there two different algorithm numbers (3B42 and as**

3B43)?

AR: The correct is 3B42, 3B43 was a typing error. Thank you.

8. **RC: P10L22: What is meant by ’several precipitation systems’?**

   AR: The phrase was modified to become clearer.

   AC: However, one must take into account that the measurement stations are very scarce in this region, and for this reason, part of the precipitation occurred in the region may not have been computed in the monthly accumulated data from ground based measurements .

9. **RC: P10L27ff: The description of the soil moisture is a bit confusing. I would like to know how the soil is considered and initialized in the model (soil depth, number of layers, stratification of potential water content).**

   AR: In P6L11:P6L113 we described that the model was initialized with the soil moisture estimation from the operational product developed by Gevaerd and Freitas (2006) and available at CPTEC/INPE. However, we in fact did not describe the soil depth, the number of layers and the soil type. In the new version, a more complete description was included in P6L11.

   AC: Data from the RADAMBRASIL project (Rossato et al., 1998) was used for the soil type in Brazil and data from FAO (Zobler, 1999) was used outside Brazil. The model was run with seven soil levels: 0.10, 0.35, 1.0, 2.25, 4.25, 7.25 and 12.25 m below the surface. Soil moisture was initialized with...

   References:

   Rossato, L., Alvalá, R. C. S., and Tomasella, J.: Distribuição geográfica da capacidade de armazenamento de água e das propriedades físicas do solo no Brasil, in: X Congresso Brasileiro de Meteorologia/VIII Congresso da FLISMET, Brasília, DF, Brazil, 1998 (in Portuguese).

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Zobler, L.: Global Soil Types, 1-Degree Grid (Zobler), data set, available at: http://www.daac.ornl.gov from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA, last access: 7 December 2012, doi:10.3334/ORNLDAAC/418, 1999.

10. **RC: P11L10: The number of fire needs a reference. It seems to be considerable higher what is given in Chen et al. 2013 (Biogeosciences, Vol. 118, P495ff).**

    AR: The references to burned area are described in P6L20:P6L28. The domain area of the simulation is approximately 2200 Mha. In Figure 2 of Chen et al., 2013, one can observe that the number of active fire for the month of September 2010 in the “Eastern” region is ∼150/Mha. Therefore, extrapolating this fire density for the entire area of the model domain we will have around 330,000 fires, which is about the same order of magnitude of the 439,297 fires reported in the archives of the GOES WF-ABBA and INPE. Also, it can be seen in Figure 1 of Chen et al., 2013 that the “Eastern” region encompasses an area with a low index of fires (northwestern of this region), which justifies the difference between Chen et al. 2013 and ours.

11. **RC: P11L19ff: I don’t see any connection between the CO concentration and the biosphere model (but I may be wrong), which would mean that the DIR-AER and DIR+DIF scenarios should result in very similar concentration distributions. Is this correct? The simulation of CO concentrations seems to serve primarily for showing that the physical processes involved are correctly represented in the atmospheric model. This should be highlighted.**

    AR: You are right, we have included in the manuscript a sentence explaining this.

    AC: The CO concentration varies as a function of fire source, horizontal and vertical transport and deposition. It was not coupled with the biosphere model.

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Therefore, the DIR-AER and DIR+DIF scenarios have similar concentration distributions.

12. **RC: P12L8ff: I think it should be clearly articulated that the model fails to represent the CO_2 concentrations. Model results are clearly not 'in an acceptable range' for most of the sites and periods. The reasons seem not to be clear but I am sure that some of the most likely ones can be depicted instead of blaming a 'complex myriad of physical processes'. I would differentiate between uncertainties in transport and biosphere exchange processes. If the authors render air chemical reactions as important despite the relative small reactivity, they might include them too. It should be noted, however, that blaming biosphere process uncertainties (including uncertainties in soil drought determination) means to question GPP and NEE results. Overall, I would suggest clearly arguing that the model is not sensitive to the CO_2 concentration within the given range (app. 385-395) and that therefore the model problems should not have a major effect on final results.**

    AR: We agree that there is, in fact, a limitation on the model representation of punctual CO_2 mixing ratios, especially in the lower levels. However, we must have pointed out that the model reproduced reasonably well the mean diurnal cycle of CO_2 observed in Santarem tower (Figure 9), and has at least the correct order of magnitude of the airborne observations depicted in Figure 7. We agree that the major uncertainties in the CO_2 are related with convective transport and fresh biomass burning plumes and not with the biosphere processes. The simulation of the exact location and time of convection is a well known limitation of atmospheric model in general. Moreover, thanks for pointing out that the model problems on reproducing CO_2 punctual observation should not have a major effect on the final carbon fluxes results. We totally agree with this observation and we included a comment about that in the manuscript.

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AC: The major uncertainty of the CO_2 mixing ratios is probably most strongly related to the vertical transport and fresh biomass burning plumes and uncertainty in the forest NEE. For example, the misplacement of convective systems of few grid cells, very acceptable for a low-resolution atmospheric model, can produce huge variations in the CO_2 values near the surface. In addition, the timing of the convection in tropical region is a well known limitation of atmospheric models in general. Nonetheless, the CO_2 scatter plots (Figure 7, bottom - right) evidenced a much higher variability of both observed and modeled values compared to CO, as well as a poorer model representation values close to the ground compared to the upper levels. The low-level behavior is likely to be associated with local convective processes but could also have a minor contribution from fresh biomass burning plumes, both venting CO_2 and changing locally the diffuse fraction of solar radiation. By contrast, the model tends to better represent the upper levels in terms of observed CO_2, which is due to the fact that air circulation is more intense and mainly controlled by the Carbon Tracker boundary conditions, and fire emissions contribution becomes even less significant. However, the model is not sensitive to the CO_2 concentration within the given range and therefore the model problems reproducing micro scale observations should not have a major effect on the final results.

13. **RC: P15L14: Here it is firstly indicated that the investigated year might not be representative for the general conditions ('a relatively drier and smokier year'). This should be discussed further. To which degree differs the year from others? Which effect might this have on the overall results?**

    AR: In fact, 2010 was an atypical year, with the total number of fires being one of the tops in the last decade, after only 2004. However, the main objective of this article is to show the effect of the aerosol in the CO_2 fluxes. So, this year was chosen to better see this effect. We agree that it is important to point out that the extrapolation is valid for the years when the fire activity is most intense but it is

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not representative of an average year. We included a comment about that in the manuscript. We are currently working on a longer term model simulation and will include this annual comparison in a future application where we will explore the individual and combined aerosol and cloud effects during a full seasonal cycle.

14. **RC: P15L21-24: I have the impression that for this analysis, it is decisive to evaluate the difference of respiration (and other fluxes) between scenarios. The variability in soil conditions that is certainly influencing the absolute magnitude seems to be less important.**

    AR: The table 4 and Figure 16 show the differences in GPP, R_P and R_H between the three scenarios.

15. **RC: P18L15ff: I recommend refraining from an additional summary like it is done with the 'Final remarks' section and instead create a 'conclusions' section that points out what has been learned from the analysis and what should be considered in future research.**

    AR: We actually disagree. This is a quite extense manuscript and the "Final remarks" section mean to help the readers to summing at up the work. And we believe the main conclusions are actually included in this section. On the other side, we agree that would be important to further explore the future research in this section. So, we included a paragraph describing how this work has been evolving.

    AC:

4 Conclusions and Final remarks

We conducted a modeling study during the peak of the burning season in Amazonia to assess the ability of a current state-of-the-art integrated in-line numerical atmospheric modeling system to simulate the CO_2 fluxes in Amazonia. A set of three different modeling experiments, first totally disregarding aerosol biomass burning effect, then considering only the direct aerosol effect, and, finally, also adding the aerosol effect on the diffuse fraction of radiation. The model results allowed us to assess and quantify the impacts of biomass burning aerosols on CO_2 fluxes in the Amazon Basin during the dry season. Moreover, the relative role of the main soil/vegetation and atmosphere interaction processes controlling the carbon cycle in Amazonia was weighed, and the aerosol effect on each of them was measured separately.

Consistent with previous studies (Freitas et al., 2005, 2009, and 2016; Longo et al., 2010, 2013; Rosário et al., 2013; Moreira et al., 2013), BRAMS performed well while modeling the meteorology and aerosol biomass burning emission, transport and removal processes in Amazonia, which has resulted in accurate simulation of the major features of AOD variability associated with the regional biomass burning plume over South America. The model results for surface temperature, rainfall and AOD were once again in agreement with observations for the 2010 dry season case study, representing the main characteristics of the spatial distribution and the diurnal cycle of temperature and precipitation. BRAMS was also evaluated on its performance to simulate CO and CO_2 mixing ratios using measurements acquired from air samples collected using light aircraft over the Amazon during 2010 and 2011 burning seasons. Typically, the model tends to slightly underestimate the CO mixing ratio, particularly in the lower levels, in regions affected by fresh biomass burning and haze biomass burning layers. Previous studies had already indicated an underestimation of the biomass burning emissions database used in this work (3BEM, Longo et al., 2010) of about 20% (Andreae et al., 2012), mainly related to fire omission and misrepresentation of the vegetation and carbon maps used (Pereira et al., 2016). For CO_2 mixing ratios, the comparison between model and observation is highly scattered, again especially in the lower levels, though in this case more likely related to convective activity pumping CO_2 to the upper layers of the atmosphere and inaccurate modeling of surface carbon net fluxes (NEE). In both cases, model inaccuracies are to be, at least partially, related to the lower model resolution (20 km), suggesting that further sensitivity studies on model resolution would be helpful. Nevertheless, although the 20-km model resolution was not capable of capturing CO_2 point measurements in Amazonia, the order of magnitude of the CO_2 mixing ratio has been in general well represented. Moreover, the diurnal cycle of CO_2 measured above the canopy of the *Tapajós* forest was represented in the model with differences of only about -0.9% and +1.4% between model results and observations during the time of minimum and maximum values, respectively.

Our modeling results indicate that during the dry season in Amazonia, regions with lower precipitation do not always have high values of NEE, because the lower soil respiration of a dryer soil can compensate for the deficit of water available for plants [e.g. Saleska, 2003]. Being an equatorial region, Amazonia receives abundant PAR. Therefore, areas with plenty of water availability in the soil have higher GPP compared to dry soil areas. However, after noon local time, when the radiation excess typically occurs, there is a drop in carbon assimilation for all biomes, except for the C4 grass type that has a maximum assimilation coinciding with the peak of PAR.

The presence of an intense biomass burning aerosol layer during the dry season over Amazonia reduces the solar energy reaching the surface, consequently reducing near surface temperature. The model results show this cooling effect contributing to increasing the GPP in regions covered by forest, grass C3 and *cerrado*. However, in addition to reducing the surface energy, the aerosol layer also increases the diffuse fraction of radiation. This is the major effect that contributes to increasing the GPP, and, in this case, including the C4 grass type biome. These two effects altogether increase GPP of about 32%, 30%, 9% and 20% for forest, C3, and C4 type grasses, and *cerrado*, respectively.

In the LBAR, the GPP increased about 27%, reaching 1,113 TgC during September 2010, when the aerosol effects were included. Plant respiration also increased from 510 to 560 TgC, with the aerosol biomass burning effect as a response to the increase of GPP. The more CO_2 the plant assimilates to produce sugar, the more it needs to increase its respiration for energy supply. On the other side, soil respiration dropped from 463 to 449 Tg C. Consequently, the NEE in the LBAR during September 2010 dropped from +101 to -104 TgC when the aerosol effects were considered, mainly due to the diffuse radiation effect. That is, the LBAR during the dry season, in the presence of high biomass burning aerosol loads, change from being a source to be a sink of CO_2 to the atmosphere. These results are also consistent with the observations of Yamasoe et al. (2006), who found no correlation between NEE and aerosol load for low AOD values (< 0.7); however, for AOD > 0.7 NEE values became negative, and for AOD > 1.5-2 NEE started to increase again. Our model results also indicate that the impact of the aerosol on the NEE change is mainly related to the aerosol increasing the diffuse fraction of radiation. For AOD higher than 0.5, the forest reaches a balance of 50% – 50% between the diffuse and direct aerosol effects. For C3 grass type and *cerrado*, as expected, the contribution of the diffuse radiation effect is much lower than for the forest biome and tends to near zero with the increase of AOD. Direct measurements at the *Tapajós* site (Doughty et al., 2010) led to an estimation of the relative aerosol contribution in CO_2 uptake, for high values of AOD, of 80% as a result of increased shaded light in the sub-canopy, related to the effect of aerosol increasing the diffuse fraction of radiation. While only 20% of the aerosol impact on CO_2 uptake was attributed to the decreased of canopy temperature. These same authors, however, do recognize that is “difficult to know whether this proportion is applicable to forest biomes worldwide or limited to tropical forest”. So, based on our model results, we go even further and say that it is difficult to even to affirm that there is a unique rule applicable to the all Amazon forest due to its high diversity of plant and soil charateristics, and microclimates.

Considering that the fire activity in Amazonia typically last for about 3 months, we can estimate as first approximation that, the net impact of the biomass burning aerosols on the carbon cycle in Amazonia is about -820 TgC per year. However, we must say that the fire activity in 2010 was very intense (see Figure S.7 of the Supplementary document), and therefore, this estimation is not likely to be representative of an average year. According to Espírito-Santo et al. (2014), the impact of the natural disturbance in the carbon cycle in Amazonia is approximately 1,300 TgC per year. Thus, the aerosol (negative) impact can be of a similar order of magnitude of the (positive) impact of the natural disturbances in the carbon cycle in Amazonia.

Our model results emphasize the importance of considering the effects of aerosol in numerical models of climate forecasting, especially when investigating the intensification of the greenhouse effect due to the atmospheric CO_2 concentration. In general, the numerical results obtained were in good agreement with observational data, including meteorological, aerosol and trace gases variables, which gives us confidence in the estimation of the carbon fluxes. However, we do recognize that including the effect of cloudiness on the diffuse fraction of radiation is an essential model capability that will allow us to explore the relative impact of the biomass burning aerosol and clouds, as well as the seasonality and the annual variability of the carbon cycle in Amazon. This is a work on development and we will soon report the inclusion of the cloud effect on the diffuse fraction of solar radiation in the model, which is certainly a major effect on the CO_2 budget in Amazonia during the wet season.

In addition, further model development based on current level of knowledge could still improve the representation of biomass burning aerosol effects in the carbon cycle. As such, model studies that include the reduction of photosynthesis due to the oxidation of plant leaves by high levels of ozone secondarily produced in biomass burning plumes, as well as the indirect aerosol effect on the CO_2 is a work in progress.

16. **RC: Figure 7: Note that observations are generally depicted on the x-axis while simulation results are shown on the y-axis.**

    AR: This has been changed (see below)

17. **RC: Figure 9: I am missing the effect of the scenarios on total/direct radiation.**

    AR: We are not sure we understood your question. In Figure 9.b, the direct effect is very small and the DIR-AER and NO-AER curves are superposing. Anyway, the other reviewer pointed out that the color scale was not visible and so we changed it.

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2016-1147/acp-2016-1147-AC2-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2016-1147, 2017.

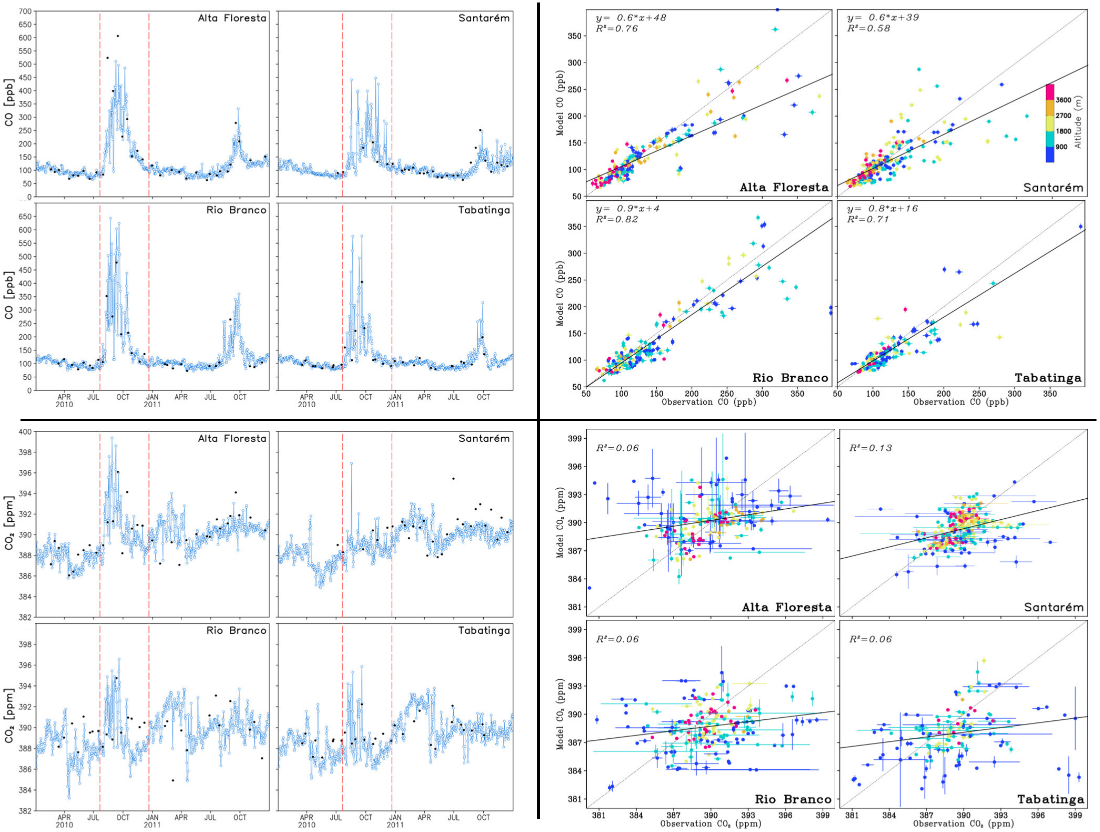

Fig. 1. Figure 7.