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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "On the vertical distribution of smoke in the Amazonian atmosphere during the dry season" *by* F. Marenco et al.

F. Marenco et al.

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We wish to thank the reviewer for his or her appreciation of our work and for the careful review. We address here the points raised by the reviewer:

Figures: we will address this issue partly by improving the figure files that we submit to ACP and partly by working with typesetters to ensure that figures are not compressed excessively to small parts of the page, when the paper is edited in final format.

P. 31747 L. 22. Thanks for this suggestion. We will amend the plots to show the reference ranges used.

P. 31749 L. 1-3. Thanks for this feedback. We believe that the figure was reproduced too small and we will work with typesetters to have it printed on a full A4 page, possibly improving the symbol/character size if needed to make it more readable.

P. 31754 L. 8-13. Thanks for spotting this error. It is correct that the plume predicted by ECMWF-MACC is too high. We will therefore correct this description.

P. 31755 L. 2. The MetUM actually displays a large gradient of extinction coefficient along the track, with very large values on the left of the graph and smaller values to the right. We will reword our description to better match the model plots.

P. 31757 L. 12. Ok.

P. 31757 last paragraph. The reviewer suggests a more in-depth discussion of the model comparisons: How good do the models need to be? What is the aim of the model simulations? Why are we seeing some differences with the observations? Have we learned anything useful to improve the models?

We believe this comment to be very valuable. Highlighting the potential sources of error and areas of improvement would give more insight and benefit the article. We shall address this in a revised version and we give here a first outline of our thoughts.

To address the first question: How good do the models need to be? This is very much related to the purpose of the simulations. The MetUM SAMBBA limited area model (LAM) wasset up specifically to support the SAMBBA field campaign and the primary purpose was to facilitate flight planning. The purpose of the ECMWF-MACC simulations is somewhat different. This is an operational global model, with forecast charts made available publically on the web on a daily basis, and for which specially zoomed charts can be requested for campaign support. In both cases the simulations are judged to be useful if they provide some skill in predicting the typical vertical distribution of aerosol, the regional distribution and day-to-day variability of aerosol loadings. The results in this paper clearly show some skill in simulating these aspects, even if the fine detail is not always captured. In this sense the simulations have proved to be useful and have served their purpose well.

The LAM simulations were a first attempt at generating forecasts of biomass burning aerosols with the CLASSIC prognostic aerosol scheme, and the LAM simulations provide an opportunity to test this potential advance in the Met Office's operational NWP atmospheric composition modelling capability. Therefore, in this paper we are looking at what benefits the prognostic treatment of biomass burning aerosols offer over an aerosol climatology. The fact that the MetUM can predict regional and vertical variations with some skill is very satisfying and important to document. Aerosol schemes can be sensitive to the host atmospheric model and its configuration (e.g. the grid-resolution, the representation of dynamics and other atmospheric processes). Therefore, it is important to evaluate the scheme with some detailed observations to see if the simulated spatial patterns are realistic when run at high resolution. Some aspects of the LAM aerosol simulations were also evaluated by Kolusu et al. (ACP 2015). They showed that the regional distribution and magnitude of AODs agree well with observations. The current study adds the evaluation of the vertical profile to this assessment. A first objective of our article is thus to highlight the strengths and weaknesses of the models in predicting the vertical structure, which is usually considered a weak point.The fact that biomass burning aerosol emissions needed tuning up by a factor of 1.7 in the LAM, and by 3.4 in MACC is also an interesting result to inform future model development.

A second application of these forecasts is investigation of the impacts of the prognostic BBA on the simulated meteorology. Kolusu et al. 2015 have investigated this with the MetUM, and found large impacts of the biomass burning aerosol on the radiation balance, improvements in forecasts of temperature and RH, and have jighlighted important changes in the representation of the regional hydrological cycle. The vertical profile of the aerosols is important in this respect, for its associated changes to the heating profile.

A third application of the forecasts is the prediction of air quality in Brazil the neighbouring countries, although this was not a focus of the SAMBBA campaign.

For both models, there are various sources of errors and the possible reasons as to why the simulated aerosol does not always provide a good match to the observed profiles:

- Biomass burning aerosol sources as initialized from GFAS: location, intensity, injection height. Note that other fire emissions datasets are also available (e.g. GFED3, FINN1), and their relative strengths and weaknesses are not fully known.
- Vertical transport and turbulent diffusion. The models don't take into account the impact of fire on localized convection or the formation of pyrocumulus clouds. A better representation of these processes is needed.
- Horizontal transport: uncertainties in the underlying NWP model
- Model resolution always places a limit on the representation of atmospheric processes and transport.

Both models use the same biomass burning aerosol emission sources allowing us to concentrate our interpretation of model-model differences on other aspects. For instance, the MetUM forecasts the thin plume observed on flight B733 at 2 km (between 50-200km along the flight track) while ECMWF does not, and the evidence points to the model vertical resolution as a plausible cause. In the ECMWF-MACC model, injection heights are simulated interactively from a plume rise model and this led to some improvements in the vertical profile of aerosol in MACC for flights B741, B742 and B746 (a separate paper on this topic is in preparation): the height of the plume layers is closer to the observations. For flight B742, the MACC simulation is able to simulate two distinct smoke layers that were observed when using injection heights derived from the plume-rise model; otherwise it only simulates one broader layer.

In summary, this study illustrates the application of the observations to modeling applications and opens the door to a series of further studies. Indeed we are already planning to use it in an evaluation of the GFAS inventory (Remy et al, submitted to ACPD) and an evaluation of the UKCA-MODE aerosol scheme in the Met Office climate model (Johnson et al, in preparation).

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 31739, 2015.