Referee report for ACP-2015-964 « The Importance of Plume Rise on the Concentrations and Atmospheric Impacts of Biomass Burning Aerosol”

The authors describe how a 1D plume rise model was integrated into the COSMO- ART forecasting system. The extended COSMO-ART was then used, with different assumptions about the vertical distribution of aerosol emisisons, to simulate an intense fire in Saskatchewan in July 2010.

The scientific significance of this work is great, since the injection heights of biomass burning emissions have been shown to be a key source of uncertainty in atmospheric composition forecasts. The implementation of the Freitas plume rise model in COSMO-ART is a notable extension of this system, and this extension was well used in this case study. This case study however doesn't amount to a full validation of the COSMO-ART-PRM system: it would be nice if the authors discuss global comparison against observations such as the MPHP or MPHP2 datasets for an extended period of time (one year or more). If this was not done, then maybe it could be mentioned in the perspective section.

The authors show a good command of the COSMO-ART itself, and of the issues around biomass burning aerosols. The case study is thoroughly investigated in terms of radiative and meteorological impacts. The article gives more emphasis to the impact of the various simulations on the vertical distribution of biomass burning aerosols, compared to remote observations. The impact on the horizontal diffusion of the plume (as compared to MODIS AOD observations, for example) has been less studied: the authors could maybe show a plot to describe this aspect.

This paper allows for a reduction of the uncertainties in biomass burning aerosol forecasts. However, the other sources of uncertainties (turbulent diffusion, transport), etc...have not really been mentioned. While it is a hard job to estimate these sources of error, maybe a comparison of the forecasted meteorological parameters against observations (weather stations, reanalysis or radio-soundings if any radio-sounding is available in this area) could help.

The presentation of the paper is very good and the standard of English excellent. The plots are well chosen and very clear. The new plots 9 and 10 are more readable than before. Maybe plot 13 could also be enlarge as well.

Overall, this is an excellent article and I recommend it to be published with minor corrections.

Specific comments :

- Page 3 line 5 “Additional buoyancy can be gained through release of latent heat”: for large fires latent heat can be an important contribution (pyro-CU and Cb)

- Page 3 lines 10-25: see the review of Paugam et al 2015 : Paugam, R., Wooster, M., Freitas, S., and Val Martin, M.: A review of approaches to estimate wildfire plume injection height within large-scale atmospheric chemical transport models, Atmos. Chem. Phys., 16, 907-925, doi:10.5194/acp-16-907-2016, 2016.

- Page 5 line 19 “To demonstrate the importance of meteorological conditions on the maximum height of the plume top”: indeed, sometimes the meteorological conditions can have more impact on the plume top height than the fire itself. In our experience with a later version of Freitas's PRM, the values for median injection height were sometimes higher with no fire forcing at the base than with fire forcing, which is anomalous (this happened in around 10% of cases with Aqua/Terra pixels). The authors are encouraged to test this kind of occurrence.

- Page 6: Since Freitas's PRM provides a detrainment profile, I don't understand why the vertical distribution of emissions has to be parameterized in such a way. Instead of getting just the lower and upper bounds from the PRM, isn't it possible to get the whole detrainment profile and then interpolate it to COSMO-ART levels? Otherwise, the proposed parameterization seems sensible.

- Page 7, diurnal cycle section: the approach is alright. On this subject you can also refer to Andela, N., Kaiser, J. W., van der Werf, G. R., and Wooster, M. J.: New fire diurnal cycle characterizations to improve fire radiative energy assessments made from MODIS observations, Atmos. Chem. Phys., 15, 8831-8846, doi:10.5194/acp-15-8831-2015, 2015.

- Page 8, Model configuration: There is a new GFAS dataset, GFASv1.2, which includes “mean heights of maximum injection” (the average of the PRM levels where detrainment is above half of the maximum detrainment) and “plume top”, computed by the PRM from Freitas (and updated by R. Paugam) using MODIS observations and ECMWF meteorological profiles. It also includes injection heights computed following Sofiev et al. (2012). It would be interesting for you to compare these data with the plume top that you obtained with the PRM.
- Page 9 Plume heights: Since it is the main subject of the paper, it would be nice to have more information on the plume heights provided by COSMO-ART-PRM, maybe the top and bottom of the plume at some selected locations and times for example, or the emission profiles used in COSMO-ART.