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Interactive comment on "The Importance of Plume Rise on the Concentrations and Atmospheric Impacts of Biomass Burning Aerosol" *by* Carolin Walter et al.

Anonymous Referee #1

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The authors present the implementation and the application of a documented biomass burning plume rise model in the COSMO-ART regional model, a state-of-the-art meteorological and chemical transport model. The integration of the plume rise model is appropriate for the COSMO-ART modeling system and its inclusion clearly improves the physical description of biomass burning emissions from wildland fires in the model. On the other hand, the plume rise model does contain a set of parameters, e.g., fire size, definition of the plume outflow levels, which still need to be pre-selected. The authors present the results of multiple model simulations from a 10-day period in July 2010 using different assumptions on the height of the emitted biomass burning emission in Canada. They conclude that the application of the plume rise model improves

the model simulations in comparison with satellite and surface observations.

The paper well written; it provides an appropriate review of the available literature and contains a fair amount of detail on the COSMO-ART and the plume rise model. The selected scenario, i.e., the 2010 wildland fires in Canada, fits the purpose to assess the impact of the model performance by including the plume rise model. I recommend to accepted this manuscript for publication in ACP after my minor comments are addressed.

Specific Comments:

- Line 36: Please replace 'they' with 'Konovalov et al., 2015' to clarify the reference.

- Line 136: Please add a reference for the used data set for the fire emissions; I guess Kaiser et al., 2012, would be appropriate when referring to GFAS, but maybe there is a more recent reference available.

- Section 2.3: The time step of the plume model calculations is not clearly stated in this section; I assume the emissions are updated with an hourly time step, but it would be useful to have this stated here (or in Section 3.1 in case the time step is flexible and can be easily adjusted according to the model simulation, similar to the integration time step).

- Section 2.4: The chemical composition and the optical properties of biomass burning aerosol are rather complex; to the best of my knowledge it is still uncertain whether fuel load and/or fire type (i.e, smoldering or flaming) determine the optical properties of the biomass burning aerosol. Hence, certain assumptions on the optical properties of the emitted aerosol have to be made in model simulations such as those presented here. However, please refer to and discuss some references dealing with the study of biomass burning aerosol and its optical properties, e.g., Hungershöfer et al., 2008; Levin et al., 2010; Saleh et al., 2014.

- Line 257 ff: Clearly the use of the single-scattering albedo for diesel soot results in an overestimation of the absorption of the emitted wildland fire aerosol, as correctly stated in the manuscript. Since the improved treatment of the optical properties of the emitted aerosol is not the main purpose of this study, it seems appropriate for the present work to use the aerosol classes available in the modeling system. However, for follow-up studies, in particular studies related to the dynamical feedback of the biomass burning aerosol on the atmosphere through aerosol absorption, this significant limitation of the model systems requires improvement. For the current study, please remove 'may slightly' from the final sentence of this paragraph so that it reads: 'Using the optical properties of diesel soot for our simulations, we overestimate the absorption in layers of dense smoke.'

- Line 272: Please check whether the reference to Kaiser et al.., 2009a, can be replaced by referring to Kaiser et al., 2012, which is a peer-reviewed publication and not a Technical Document.

- Line 275: Please add some more information on the properties of the emitted aerosol particles; e.g., to which modes and composition the emitted aerosol particles are allocated. These classes could maybe be highlighted in Table 1.

- Line 311: What is the frequency of the plume height calculation used to generate Figure 6? Does the plume height represent the hourly emission height (i.e., every fire plume being counted multiple times) or the mean for each fire over a certain period (i.e., every fire counted only once). Please specify.

- Line 324: Please replace 'through' by 'trough'

- Line 353: Please start a new paragraph after '. . .aerosol type.'.

- Line 354 – 382: This paragraph is rather hard to follow; from my perspective it contains too many numbers. The authors might consider to add a table with the corresponding numbers and to substantially shorten this section.

- Line 390 ff: The comparison with the data from the AERONET station at Bratts Lake

is only performed for a single day (15 July). Would it be possible to repeat this analysis for other days, in particular for 16 July when the CALIPSO data are available. Please extend the comparison with available AERONET data from other days in July 2010.

- Section 3.5: Please clearly state at the beginning of this section the limitation of the analysis of the radiative impact of the biomass burning aerosol due to the use of the optical properties from diesel soot instead of biomass burning aerosol.

- Line 430 ff: Please motivate the use of Fort Smith to assess the aerosol impact on surface solar radiation. Obviously it would be very valuable if surface measurements would be available to complement the comparison between the different model simulations. Are there corresponding measurements available at the AERONET site in Bratts Lake?

- Figure 11: It is striking that no temperature change is simulated around 106°W / 58°N, despite the high aerosol loading as shown in Figure 4. Please comment.

- Line 475 / Figure 13: Move this paragraph and the figure towards Fig. 10 and the corresponding text.

References

Hungershöfer et al., (2008), Modelling the optical properties of fresh biomass burning aerosol produced in a smoke chamber: results from the EFEU campaign, Atmos. Chem. Phys., 8, 3427–3439, 2008.

Kaiser, J. W., et al. (2012), Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power, Biogeosciences, 9(1), 527-554, doi:10.5194/bg-9-527-2012.

Levin, E. J. T., et al. (2010), Biomass burning smoke aerosol properties measured during Fire Laboratory at Missoula Experiments (FLAME), J. Geophys. Res., 115, D18210, doi:10.1029/2009JD013601.

Saleh, R., et al. (2014), Brownness of organics in aerosols from biomass burning linked to their black carbon content, Nature Geoscience, 7(9), 647-650, doi:10.1038/ngeo2220.

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