We thank referee #1 for his valuable comments and suggestions. We followed them as explained below.
The reviewers comments are repeated in **bold letters,** our replies are given in *italics,* and text modified or added to the manuscript is given in blue.

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

Done

- 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.

We inserted the citation Kaiser et al.(2012).

- 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).

The frequency of plume height calculations is given in 2.1: "Hourly, for every grid point with an active fire, the values of these variables are transferred to the plume rise model. Within an hour, the input variables are maintained constant."
To clarify this point we modified the text:
Hourly, for every grid point with an active fire, the values of these variables are transferred to the plume rise model in order to calculate the current plume height. Within an hour, the plume height is maintained constant.
And added in section 2.3: Within an hour the emissions are maintained constant.

- 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.

We have rewritten this section and added the proposed references:
Calculating the radiative effect of biomass burning and other aerosol types requires the optical properties extinction coefficient, single scattering albedo, and asymmetry parameter of the aerosol particles at each grid point and each time step. These optical properties depend on the refractive index of the individual compounds, the chemical composition of the particles, their shape, and their size distribution. The refractive index and therefore the optical properties depend on the wavelength.
Insoluble light absorbing particles like soot can be covered by a soluble shell due to physical (coagulation, condensation), and photo-chemical ageing. This increases their mass absorption efficiency (Riemer et al., 2003; Saleh et al., 2014; Bond et al., 2013). That effect needs to be accounted for in fully online-coupled model systems like COSMO-ART. Mie-calculations are the adequate method to determine the optical properties from given size distributions and their

chemical composition (Bohren and Huffman, 2004).These calculations are very time consuming and therefore it is not possible to perform them at each grid point and at each time step. Instead, we have developed a parameterization as described in Vogel et al. (2009). This parameterization is based on simulated aerosol distributions and detailed Mie-calculations ending in mass specific values of the extinction coefficient, single scattering albedo and asymmetry parameter. Moreover, this parameterization takes into account the physical and chemical ageing of soot particles (Riemer et al., 2004; Vogel et al., 2009).Values are delivered for the wavelength bands of the radiation scheme used in COSMO-ART (Ritter and Geleyn, 1992). Fundamental input data for the Mie-calculations are the wavelength dependent refractive indices for the individual compounds. Here, we are using data of detailed measurements performed in the AIDA (Aerosol Interaction and Dynamics in the Atmosphere) chamber (Schnaiter et al., 2003). The disadvantage of this data is that it was obtained for pure diesel soot. But its advantage is the high spectral resolution of the data which is not the case for other lab studies. A comparison of this fundamental input data with data obtained for biomass burning aerosol is difficult for several reasons. Recent studies ended up with bulk data for mostly aged particles or with mass specific values for extinction and absorption coefficients. Consequently, quite different values were found depending on the specific burning conditions and particle compositions. In many cases values were gained for a single wavelength. For that reason it is hard to quantify the errors due to the calculation of the optical properties within COSMO-ART.
Following our parameterization we get a value for the mass extinction efficiency of 9.0 $m^2 g^{-1}$ for the spectral range 0.25 - 0.7 µm and for pure soot particles. For the soot containing Aitken mode we get a value of 5.0 $m^2 g^{-1}$, and for the soot containing accumulation mode a value of 4.0 $m^2 g^{-1}$.
Laser measurements at a wavelength of 0.632 µm suggest a value of 7.8 $m^2 g^{-1}$ for soot with wood origin (Colbeck et al., 1997).
Levin et al. (2010) carried out measurements with biomass burning aerosol of different chemical composition. The geometric mean diameters ranged from 0.2 to 0.57 µm. For those particles they found refractive indices ranging from 1.55 to 1.80 for the real part and 0.01 - 0.50 for the imaginary part. They obtained dry mass extinction efficiency ranging from 1.64 to 6.64 $m^2 g^{-1}$ at a wavelength of 0.532 µm. Hungershoefer et al. (2008) found mass extinction efficiencies in the order of 9.0 $m^2 g^{-1}$ for savanna grass and African hardwood.
From these numbers we would conclude that the optical properties we are using are within the range of literature data.

- 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.'

We regret that our formulation concerning the single scattering albedo gave the impression that we are strongly overestimating the effect of biomass burning aerosol. For that reason we have rewritten section 2.4.

- 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.

At this point we do not want to replace the reference since the Technical Document better describes the diurnal cycle. But in section 3.1 it is appropriate to replace Kaiser et al. (2009a) by Kaiser et al. (2012). This was done.

- 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.

We added a table which contains the emitted species and their assignment to the existent COSMO-ART classes.
The species are listed in Table 2 together with their assignments and individual weightings, where necessary.

Table 2. Emitted gaseous and particulate species derived from GFASv1.1

original notation	COSMO-ART class
Carbon Monoxide	CO
Nitrogen Oxides $NO_x * 0.9$	NO
Nitrogen Oxides $NO_x * 0.1$	NO2
Sulfur Dioxide	SO2
Ammonia (NH_3)	NH3
Ethane (C_2H_6)	ETH (Ethan)
Methanol (CH_3OH)	HC3 (C_3 to C_5 Alkanes)
Ethanol (C_2H_5OH)	HC3 (C_3 to C_5 Alkanes)
Propane (C_3H_8)	HC3 (C_3 to C_5 Alkanes)
Butanes (C_4H_{10})	HC3 (C_3 to C_5 Alkanes)
Pentanes (C_5H_{12})	HC5 (C_6 to C_8 Alkanes)
Hexanes (C_6H_{14})	HC5 (C_6 to C_8 Alkanes)
Heptane (C_7H_{16})	HC8 (higher Alkanes)
Ethene (C_2H_4)	OL2 (Ethene)
Propene (C_3H_6)	OLT (terminal Alkenes)
Butenes (C_4H_8)	OLT (terminal Alkenes)
Octene (C_8H_{16})	OLT (terminal Alkenes)
Pentenes (C_5H_{10})	OLI (internal Alkenes)
Hexene (C_6H_{12})	OLI (internal Alkenes)
Isoprene (C_5H_8)	ISO (Isoprene)
Terpenes (C_5H_8)n	API (Terpenes)
Toluene (C_7H_8)	TOL (Toluene)
Benzene (C_6H_6)	TOL (Toluene)
Xylene (C_8H_{10})	XYL (Xylene)
Formaldehyde (CH_2O)	HCHO
Acetaldehyde (C_2H_4O)	ALD (Acetaldehyde)
Acetone (C_3H_6O)	KET (Ketones)
Black Carbon	s (pure soot mode)
Organic Carbon $* 0.1$	if (Aitken mode particles, soot free)
Organic Carbon $* 0.9$	jf (Accummulation mode particles, soot free)

- 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.

We clarified this:
Thereby every plume top height calculated by the plume rise model is counted. If the fire is still active the plume is counted again in the next hour with its new height.

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

Done

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

Done

- 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.

We shortened this paragraph, and inserted markers into the figure.
The most prominent features of the observed smoke distribution are marked with dark green circles. Circle A indicates smoke observed by CALIOP between 6 and 7.5 km altitude. This feature is well represented by the simulations 7500M and EMISSCYCLE, moderately represented in VARHEIGHT and 800M fails at this point. Circle B refers to smoke within the lowest 3.5 km. In all simulations the smoke is located a little lower at this position but each of them showing distinct patterns in each case. Circle C and the descending line represent the skewness of the smoke layer between 56 and 50° N. The decline seems to be stronger in the simulations than in the observations. The height is matched by simulation VARHEIGHT and 800M. In EMISSCYCLE the height is slightly overestimated and in 7500M the height is remarkably overestimated.

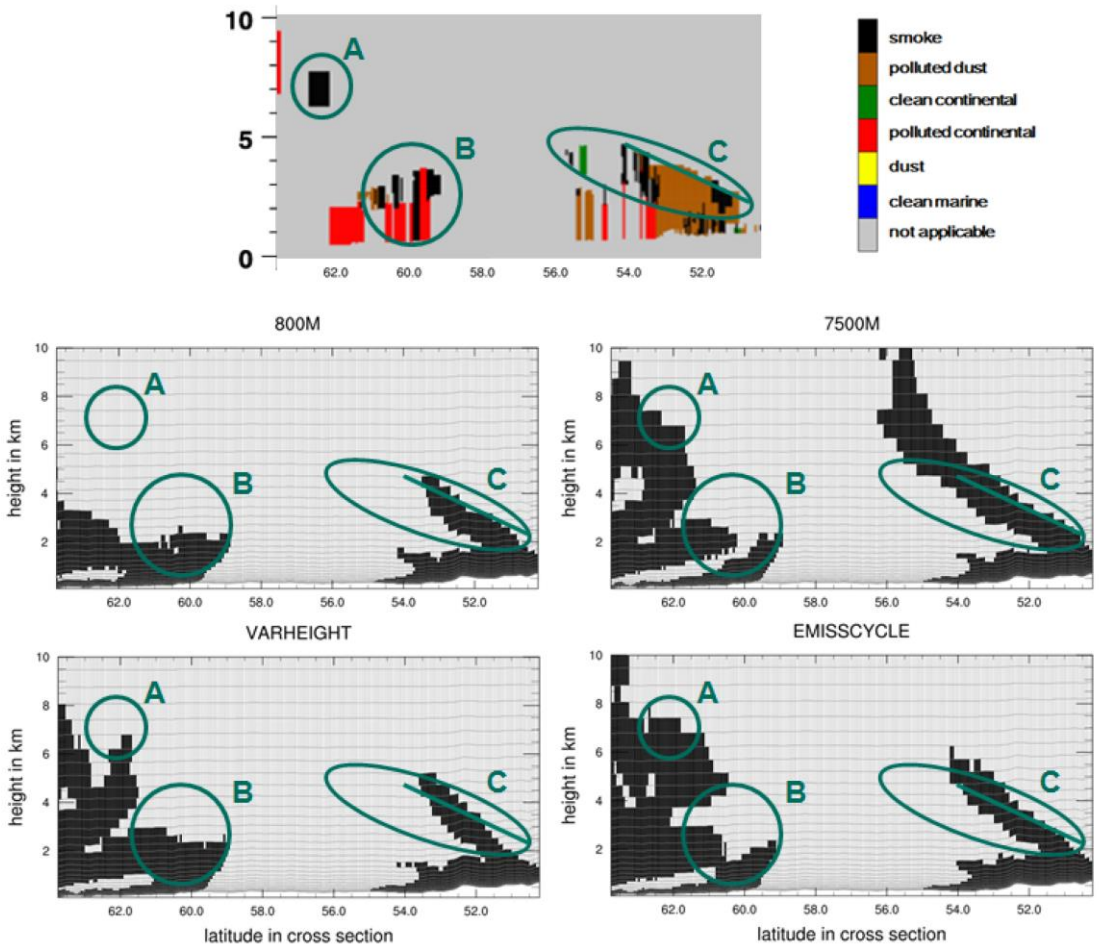

Figure 9. Cross section of aerosol subtypes of CALIPSO overpass at around 9:20 UTC 16 July 2010 (a). The black colour coding denotes the presence of smoke; brown, green, and red represents polluted dust, clean continental, and polluted continental, respectively. Cross section along the same CALIPSO track for simulations 800M (b), 7500M (c), VARHEIGHT (d) and EMISSCYCLE (e), here only soot concentrations greater than 0.01 $\mu g\ m^{-3}$ are displayed.

- 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.

The smoke passes the AERONET station at Bratts Lake only on 15 July. None of the few other stations in the simulation domain observe any smoke of this event.

- 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.

We added:
Uncertainties in the radiative impact of biomass burning aerosol are determined by the uncertainties in the description of its optical properties.

- 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?

We now included measurements of the global solar radiation at the station Fort Smith:
Observations of the global solar radiation at Fort Smith (60.01° N, 111.57° W, Meteomanz.com) do support these simulations. On 15 July 2010 at 6 UTC the station reports 1115 J cm^{-2} during the last 24 hours. The simulation VARHEIGHT which includes the fire emissions yields 1029 J cm^{-2} for the same 24 hour period, whilst the simulation NOFIRE results in 2222 J cm^{-2}. This is a typical value for cloudless, smoke-free days. For example on 11 July 2010 a value of 2168 J cm^{-2} was reported at that station.
Unfortunately such measurements are not available for 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.

We added this explanation:
The lack of a cooling region is due to advection of heated air by cloud dissipation upstream the fires.

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

Done

References:

Bohren, C. F. and D. R. Huffman, 2004: Absorption and scattering of light by small particles. Wiley, New York.

Bond, T. C., et al., 2013: Bounding the role of black carbon in the climate system: A scientific assessment. J. Geophys. Res.-Atmos., 118 (11), 5380–5552.

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