We thank referee #2 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.

General comments:

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.

Unfortunately, this is not possible. We simulated the 10 day period in July 2010. On the MPHP/MPHP2 website there are only datasets available for 2001-2008/01.2008-10.2009. For a global comparison we would need global simulations. This could be done in future work after integrating the plume rise model into ICON-ART.

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.

We added additional text and a new figure to address that point.
To evaluate the horizontal diffusion of the plume the simulated AOD is compared with AOD satellite retrievals, both at 550 nm. In the top of Fig. 8 observations made by MODIS on-board Terra and retrieved with the dark target algorithm are displayed time averaged over 14 and 15 July 2010. Below the AOD averaged over the four overpass times of Terra satellite are shown for the different simulations. The observed maximum of over 3.5 is located around 57.5° N, 112.5° W. From there the increased AOD is spread towards north-east and south-east. In all simulations the maximum is located slightly further in the east compared to the satellite retrieval. The pattern of AOD differs between all simulations in its width, shape, and strength. The southern extension of the plume reaching 50° N, 105° W is best represented by the simulations VARHEIGHT and 800M. Due to the coarse resolution of the satellite retrieval it is not possible to determine the overall best match.

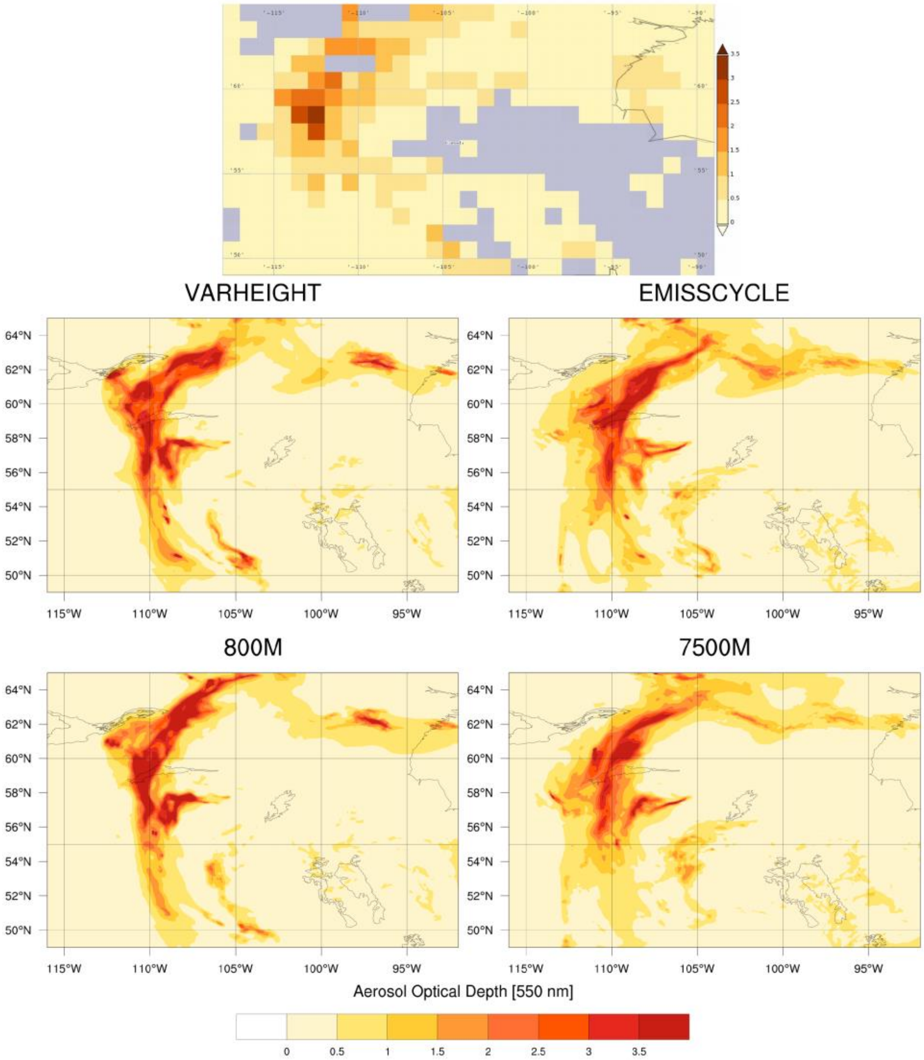

Figure 8. AOD at 550 nm averaged over 14-15 July 2010. Top: Satellite retrieval from MODIS on-board Terra, below: Simulations VARHEIGHT, EMISSIONCYCLE, 800M, and 7500M.

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 figures below allow a comparison of the simulated meteorological parameters and reanalysis from CFS (Climate Forecast System, available at www.wetter3.de) for 2 m temperature and surface pressure. Therefore, simulation VARHEIGHT is used with a lead time of 36 hours. Simulation and reanalysis show reasonable agreement. For both the maximum temperature occurs in the northwestern part of the simulation domain with about 28 °C and a minimum temperature over the Hudson Bay with slightly over 0 °C. The ridge in the central southern part of the simulation domain is indicated by high pressure at the surface of more than 1010 hPa in the simulation and in the reanalysis.

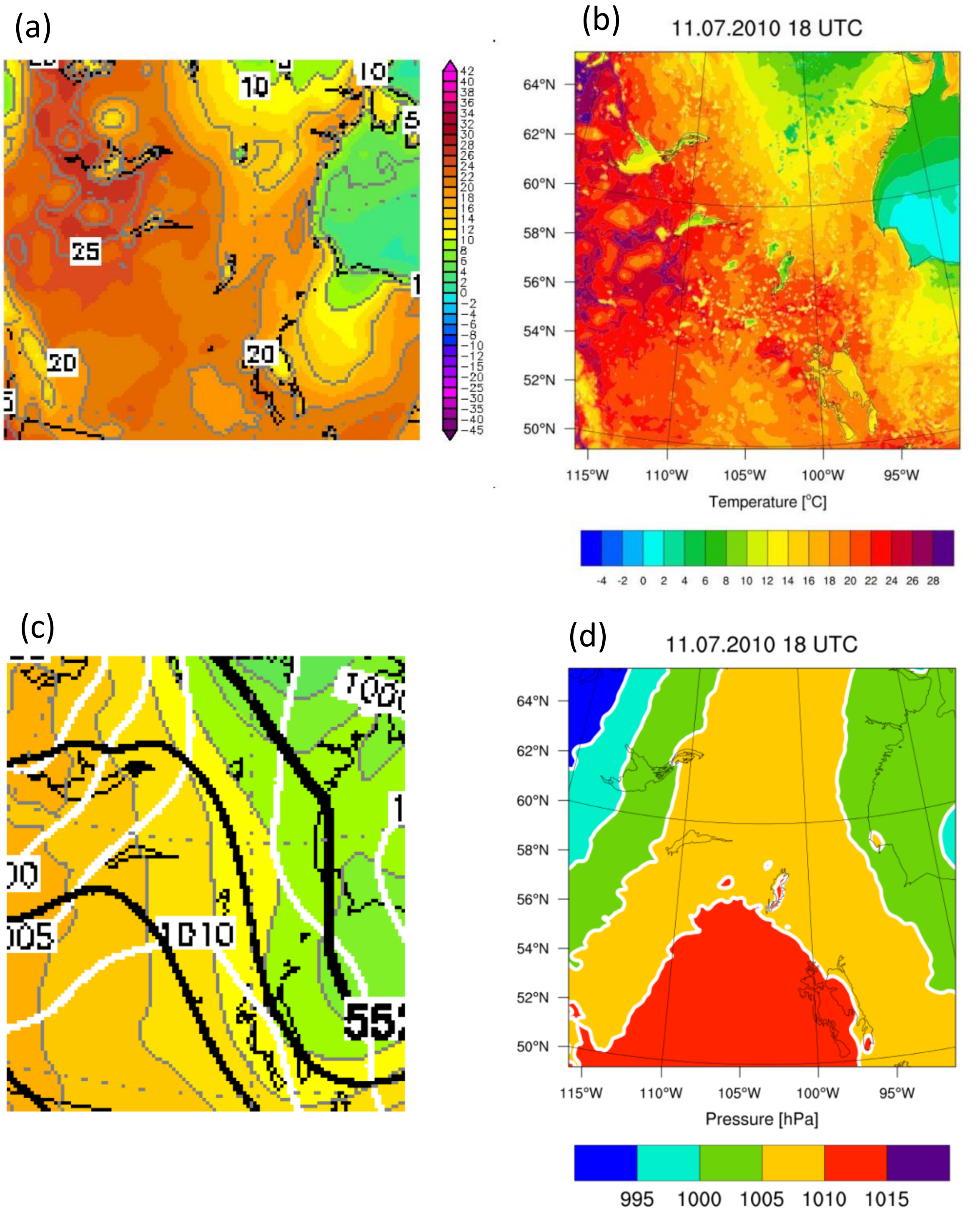

Figure: Comparison of reanalysis from CFS (Climate Forecast System, available at www.wetter3.de) and simulation VARHEIGHT for 11 July 2010 18 UTC and the meteorological variables 2 m temperature and surface pressure. (a) 2 m temperature [°C] denoted by the color coding and grey lines (CFS), (b) 2 m temperature [°C] denoted by the color coding (COSMO-ART), (c) surface pressure [hPa] displayed by the white lines (CFS), and (d) surface pressure [hPa] represented by the white lines and the color coding (COSMO-ART).

Maybe plot 13 could also be enlarge as well.

Done

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)

Here we added:

The release of latent heat from large fires can make an important contribution to the formation of pyrocumulus and pyrocumulonibus clouds (Fromm et al., 2010).

• 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.

We added:

A recent review of the representation of plume injection heights in atmospheric models was performed by Paugam et al. (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.

This is not the case in our version of the plume rise model. When the heat flux is set to zero we obtain zero plume height. We tested it for all plume conditions within our simulation domain and period.

• 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.

We do use the detrainment profile specified in Freitas' PRM. Since the levels of PRM are not infinitely small, it is more accurate to distribute the emissions within COSMO-ART over the height levels instead of interpolating emissions from discrete intervals from PRM to COSMO-ART levels. We just introduce the dimensionless height $z^* \geq 0$ and ≤ 1 instead of the absolute height in this equation.
To clarify this we changed the sentence: The emissions are distributed with a parabolic function defined between the upper and the lower bounds as specified within the plume rise model and according to the following expression.

• 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.

We included the citation.

• 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.

We now show the comparison between the GFAS plume heights and the simulated ones (see comment below).

• 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.

We added a figure which shows the time series for one location having coincidental values for simulated plume height and values within GFAS plume heights datasets.

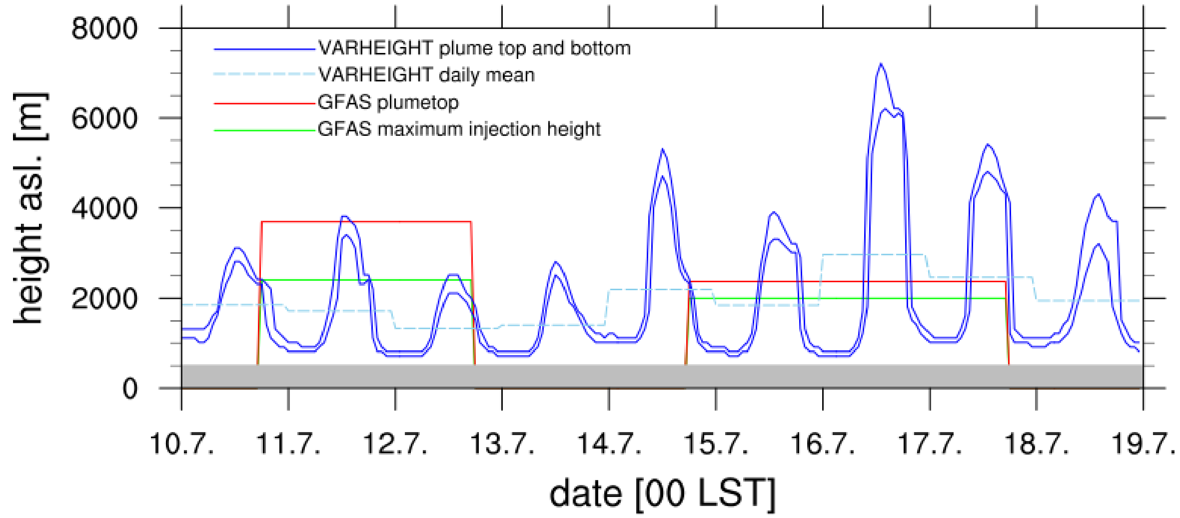

Figure 5. Time series of the plume height at one fire location. The lower and the upper bound of the effective emission layer simulated by the plume rise model within COSMO-ART (blue lines). The dashed light blue line gives the daily mean of these heights. Plume heights specified by GFASv1.2 for two derivations (red and green line).

In section 3.3 we added:

In Fig. 5 the time series of the plume height is shown for one fire location (56.98° N, 106.99° W). The top blue line denotes the plume top and the lower blue line the plume bottom as simulated by COSMO-ART in combination with the plume rise model. Thereby the upper and the lower bound of the effective emission layer are defined. The diurnal cycle is clearly visible. The thickness of the smoke layer is dependent on the meteorological conditions. During night the smoke is located within 1 km above ground. Daytime values range from about 2 – 7 km for the simulation period. A daily mean is calculated over each day (LST) and averaged over plume top and bottom to obtain a quantity comparable to GFASv1.2 plume height derivations. These are namely the height of maximum injection derived by a later version of the plume rise model within C-IFS (Composition-Integrated Forecasting System) and the plume top estimated after a method by Sofiev et al. (2012). In comparison to the plume heights obtained by simulation VARHEIGHT the GFAS plume heights do not have a diurnal cycle. The daily mean plume height of simulation VARHEIGHT agrees with the GFAS heights in the same extend than they do to each other. According to the GFAS plume height derivations two short fire periods occurred during 10. - 19. July 2010 while the fire in simulation VARHEIGHT lasts for ten days.

Literature:

Andela, N., J. W. Kaiser, G. R. van der Werf, and M. J. Wooster, 2015: New fire diurnal cycle characterizations to improve fire radiative energy assessments made from modis observations. Atmos. Chem. Phys., 15 (15), 8831–8846, doi:10.5194/acp-15-8831-2015.

Fromm, M., D. T. Lindsey, R. Servranckx, G. Yue, T. Trickl, R. Sica, P. Doucet, and S. Godin-Beekmann, 2010: The untold story of pyrocumulonimbus. Bull. Am. Meteorol. Soc., 91 (9), 1193.

Paugam, R., M. Wooster, S. Freitas, and M. Val Martin, 2016: A review of approaches to estimate wildfire plume injection height within large-scale atmospheric chemical transport models. Atmos. Chem. Phys., 16 (2), 907–925, doi:10.5194/acp-16-907-2016.