EGUsphere, referee comment RC1
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Comment on egusphere-2022-713

Anonymous Referee #1

Referee comment on "Impacts of estimated plume rise on $PM_{2.5}$ exceedance prediction during extreme wildfire events: a comparison of three schemes (Briggs, Freitas, and Sofiev)" by Yunyao Li et al., EGUsphere,
https://doi.org/10.5194/egusphere-2022-713-RC1, 2022

The manuscript presents a study comparing three plume rise parameterizations on their ability to capture observed injection heights, and how they differ in their impacts on air quality and photochemistry on the short and long range. This study represents good contributions to the field and it's within the scope of ACP. I think the paper needs more work before it's ready for publication based on the comments below.

My main comments are the following:

- The section evaluating injection heights is very short and could be greatly improved in many ways, including the addition of more cases that are more representative of the really extreme conditions that happened during this period. Also, the only injection height data used is that from MISR capturing fresh plumes. This does not capture the peak of fire activity that usually happens on the afternoon. For this I recommend including data from CALIPSO. While the chances for CALIPSO to capture fresh smoke are much lower, this event was so massive that most CALIPSO overpasses captured some section of the smoke emitted on a previous day. Thus an analysis could be done for the regional smoke heights rather than for smoke from individual fires, complementing that from MISR. The analysis should move a bit beyond a few study cases and try to capture the whole extend of the fire

- The article could be improved by being more thorough in it's literature review and using reference to better backup some statements. See some examples in the comments by line below

- Some sections of the results were very qualitative on it's description, where I think a better job on being quantitative and using statistical metrics could have been done. More details in the comments below.

Comments by line:

Intro. There have been multiple studies evaluating some of these plume injection height schemes beyond the Ye et al. (2021), so these previous findings need to be summarized. Some that come to mind can be found below, also look for work from Joe Wilkins. This literature review also can be used to motivate this study (i.e., what hasn't been done). Some uniqueness I see from these work include the comparison of these 3 schemes and the type of event studied (record-breaking wildfire season)

-Mallia, D., Kochanski, A., Urbanski, S. & Lin, J. Optimizing Smoke and Plume Rise Modeling Approaches at Local Scales. Atmosphere 9, 166 (2018).

- Wilmot, T. Y., Mallia, D. V., Hallar, A. G., and Lin, J. C.: Wildfire plumes in the Western US are reaching greater heights and injecting more aerosols aloft as wildfire activity

intensifies, Scientific Reports, 12, 12400, 10.1038/s41598-022-16607-3, 2022.

-Sessions, W. R., Fuelberg, H. E., Kahn, R. A. & Winker, D. M. An investigation of methods for injecting emissions from boreal wildfires using WRF-Chem during ARCTAS. Atmos. Chem. Phys. 11, 5719–5744 (2011).

-Roy, A. et al. Effects of Biomass Burning Emissions on Air Quality Over the Continental USA: A Three-Year Comprehensive Evaluation Accounting for Sensitivities Due to Boundary Conditions and Plume Rise Height. in Energy, Environment, and Sustainability 245–278 (Springer Singapore, 2017). doi:10.1007/978-981-10-7332-8_12

- Add a reference to support these statements

95-104. This paragraph is lacking any referencing, please add. Also, the notion that primary organic aerosol is also quite dynamic needs to be included as well.

Section 2.2. A description of how model smoke injection height is derived is missing. Please be specific, e.g., what variable and what threshold is used, how is it mapped to the MISR pixels (location and time). Also include info on how AOD is derived and mapped to VIIRS.

Section 2.3. There are some details missing from the explanations of the injection schemes that could be useful to understand results. For instance, how is the plume

distributed once the injection is computed? Is there a height of the bottom of the plume computed as well or how is it assumed? Is there a fraction of emission placed at the surface (so called "smoldering" emissions as stated in Freitas 2007)? If so, what % for each scheme? Due any of the parameterization consider different parameters for different fuels? Is the FRP used from GBBEPx a daily value? If so, is it applied as constant throughout the day or a given diurnal cycle is specified?

161-162. Please expand a bit more on why the factor of 10 is applied.

167-168. Please add references for this sentence

Section 2.4. VIIRS AOD data was not described. Please include any quality flags applied

- MISR injection heights have the limitation that MISR overpass is in the morning while peak fire behavior (and thus deeper injections) tends to be in the afternoon. This has been highlighted in previous work (paper below for instance). Since this is the only dataset used for evaluation in this work, this needs to be mentioned and taken into consideration when discussing results and deriving conclusions.

Kahn, R. A. et al. Wildfire smoke injection heights: Two perspectives from space. Geophys. Res. Lett. 35, (2008).

Figure 3. Having a visible image (MODIS Terra) including hotspots would help to visualize each scene.

Figure 3. It would also help to have the model boundary layer height as reference to assess boundary layer injections versus into the free-troposphere. Given the range shown by MISR, I would assume it's estimates contains a mixture of boundary layer smoke and injections. But the model doesn't show this variability, so it would be nice to understand why

Figure 3. Are these heights capturing mostly freshly emitted smoke or is here any recirculated smoke from the same or other fires?

Figure 3. I find that evaluating only for 2 snapshots capturing 2 fires during August is a bit insufficient. There are likely many more opportunities during this 2 month period, especially during September where fires in the whole western US were exploding.

Figure 3. Also think in better ways of presenting the data, maybe aggregate MISR to the model resolution to avoid having so many repeated values for the model?

Figure 3. The model resolves the increase of height with distance, so you can do analysis to assess why is this happening. This is a bit counterintuitive as one would expect to earlier plume (i.e., further away) be emitted a lower altitudes. Or are the conditions such that the plume is just rising with time?

191-202. Please be more quantitative. Higher by how much? Show some statistics

206-207 Maybe do statistical testing on the mean o backup this statement?

208-213. Need to better backup these statements. For instance, what were the stability conditions the model used for these fires. Also note Briggs not always shows higher injections.

Figure 4. It would be nice to explore if these trends are also found on observations such at those from IMPROVE sites

Figure 5. It would be good to have a panel showing the average profile for one of the schemes to use it as a reference.

Section 3.3. While VIIRS AOD is included, it doesn't seem to be used in the analysis. Satellite AOD tends to saturate around 5 so retrievals for the very fresh plumes are likely missing. If the model was not screened by these missing values then this likely explain why the model is overpredicting AOD on the locations of the fires. Ones you move away a bit from the fires the bias flip, with models tending to underpredict AOD. This discussion needs to happen before analysis is done comparing model runs.

- Reference Figure 6 to make it clear you are comparing to that figure

- Changes of 70% are described, but the color-scale of Fig 8 saturates at 30%. Exploring a scale that’s not linear (like Fig 5) might work better.

Figure 8. I t would be nice to have a surface PM2.5 map for one of the simulations as a reference to better interpret the differences.

Figure 8. How much of these differences are due to differences in injection height versus assumptions of fraction of emissions placed at surface levels vs injected?

319-331. While 35 um/m3 is the standard, this divides the "Moderate" from "Unhealthy for sensitive groups" categories. However, it would be nice to see how the models in predicting the more extreme categories ("Unhealthy", "Very unhealthy", "Hazardous".) where more authorities might take more stringent measures

319-331. This analysis is based on one day. A way to generalize this analysis could be to show a map or difference maps of the number of days the models predict exceedances.

Minor Edits

191: ACP won’t allow links, convert it to a reference

321-325. A lot of this text is already in Fig 9 caption so no need to repeat.