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Comment on acp-2021-485

Anonymous Referee #2

Referee comment on "Duff burning from wildfires in a moist region: different impacts on $PM_{2.5}$ and ozone" by Aoxing Zhang et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-485-RC1, 2021

Review of "Duff burning from wildfires in a moist region: different impacts on PM2.5 and Ozone"

The authors are addressing a much-needed topic in fire emission calculations and air quality modeling. When ground fuels burn they become a large source of trace gases and aerosols into the atmosphere and there is a great lack of data needed to quantify these emissions. This manuscript highlights the need for more information, and how the lack in the current available information hinders air quality analyses. Below I have specific comments designed to help make this analysis more robust.

Specific Comments

Fire Events: Four of the largest wildfire events in the southeastern US were selected for air quality modeling with WRF-Chem for two domains. One domain simulates fires in the southern Appalachian mountains and one domain simulates fires in southern Georgia. The fires ranged from 91K acres to > 500K acres. One thing I found lacking was consideration of the Evans Road and Pains Bay wildfires. They were smaller than the top 4 criteria (41K, and 5K acres respectively), but were significant in terms of the emissions from the burning of organic/ground fuels and subsequent air quality impacts. Rappold et al. 2011 conducted a health impact analysis from the Evans Road wildfire and Tinling et al. 2016 conducted a similar analysis for the Pains Bay wildfire. The first two sentences of the Abstract state that "Wildfires can significantly impact air quality and human health. However, little is known about how duff and peat burning contributes to these impacts." Given the goals of this paper, I would expect these studies/impacts be part of the introduction and also a consideration in this study.

Duff Flaming Phase Emissions: Why only focus on flaming emissions of duff? Smoldering phase emissions are important in terms of air quality impacts (as noted by Rappold et al. 2011 and Tinling et al. 2016). Smoldering of ground fuels does not always occur on a time scale of months to year, it can occur on the scale of hours/days, and while the plumes do not necessarily loft high, during the day they mix near the surface (where people breath) under the mixing height and can be transported further distances. At night they can transport along terrain features often impacting small towns in rural areas closer to the fires. This becomes an environmental justice issue as well. Limiting the work here to only flaming phase duff emissions unnecessarily limits the utility of this study.

Duff Consumption: Related to this is how much duff consumption actually went into each of the scenarios? I see that 4.6 cm of duff burned in the 2016 Rough Ridge fire which went into the App16 case (fuel loading 3.15 kg/m2). How many centimeters of duff burned in the Oke07, Oke11 and Oke17 cases? And was the same fuel loading from App16 (3.15 kg/m2) assumed for the Oke scenarios? The end of section 2.4.2 discusses how regrowth was handled, but again, what actual data went into the scenarios? I recommend adding the duff depth burned and fuel loading estimates to a table. Further, were all duff estimates assumed to burn in the flaming phase? Or were some estimated to burn in the smoldering phase (and thus eliminated if I am interpreting the discussion regarding the focus on flaming phase emissions)?

Duff Emissions: Section 2.4.2 indicates that "we estimated duff emissions and added them to FINN." Was a full suite of trace gas and aerosol species added? Or were only PM2. 5, NO and NO2 species added to the simulations? At a minimum I would expect a full suite of species using default above-ground fuel emission factors would be added to represent the duff fuels, and ideally those emission factors be adjusted based on available literature for duff fuels. Recent studies for the SE in George et al. 2016 and Black et al. 2016 may be useful. They both conducted lab experiments based on peat from North Carolina. Many of these trace gases have implications for ozone and secondary aerosol formation.

VOC-limited: Section 3.3. Is the SE (App16 domain) really in a VOC-limited scenario in the winter (Nov)? I recommend showing estimates to support this.

NOX and Ozone Generation: Much of the discussion focuses on how the duff did not add much ozone to the model simulations, which is attributed to the NO/NO2 emission factors being low. There needs to be more discussion about the variability in NO/NO2/NOX emissions from duff. Yokelson et al. 2013 is just a single experiment and Urbanski 2014 applies an uncertainty of 100% to the data. Studies such as Burling et al. 2010, McMeeking et al. 2009, Selimovic et al. 2018 and Clements and McMahon 1980 are all studies that measured emission factors for ground fuels. NO values range from 0.56 to 2 g/kg, and NO2 values range from 0.23 to 2.7 g/kg. These data argue for perhaps using greater EF values for NO and NO2 and also (especially) sensitivity runs that vary the NOX EF's by more than just 20%. Recommendation: I recommend an additional sensitivity run using 100% per Urbanski 2014 (e.g. 2x duff).

Meteorology/Transport: Section 3.2 discusses the PM2.5 emissions and transport. I recommend making the discussion more robust by including references to support the statement "Both biases in fire emission calculation and smoke transport simulation should be the contributors." I recommend Li et al. 2020 and Garcia-Menendez et al. 2013.

Technical Corrections

Table 1 caption needs to include more information such that the information in the table is understandable independent of the paper. Also, I recommend adding fire size (acres) to the table as well.

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