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Comment on acp-2021-485

Anonymous Referee #1

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-RC2, 2021

The purpose of this study is to assess the importance of including duff in simulation of wildfire impacts on air quality. The authors conduct WRF-Chem simulations for four large wildfire events in the southeastern US using two fire emission scenarios – duff and no duff, as well as a control simulation with no fire emissions. The main findings of the study are:

1) relative to the no duff fire scenario (surface and understory fuels only), the increase in wildfire emissions through the inclusion of duff burning resulted in large increases in simulated surface PM2.5 concentrations near the fire locations (< 300km) and at remote urbans areas

2) while the no duff fire scenario increased regional O3 levels, the impact of additional emissions from duff burning were negligible for O3

3) relative to the control scenario (no fire) both the no-duff and duff fire simulations generally increased agreement between the WRF-Chem simulated PM2.5 and observations at surface air quality monitoring sites in fire impacted areas

4) relative to the no duff fire scenario, inclusion of duff emissions generally improved agreement of the WRF-Chem PM2.5 and observations at surface air quality monitoring sites in fire impacted areas

The authors conclude that modeling of regional air quality in the southeastern US can be improved by adding duff burning emissions to existing fire emission datasets and that emissions from duff burning have much garter impact on PM2.5 than O3.

The topic addressed in this study, contributions of duff and peat burning emissions to regional air quality, is certainly an important and of interest to air quality modelers and atmospheric scientists and is relevant to biomass burning in many regions. However, in the manuscript requires major revisions before it is suitable for publication. The paper is missing key methodological details and a couple important choices in the study design are not well justified. Additionally, the presentation and discussion of results and lacks definition and focus, making it difficult to evaluate the authors' conclusions and the overall broader relevance of the study.

Here I provide my most important concerns regarding the paper, followed by less crucial, specific comments.

1. Estimation of duff consumption by flaming combustion

In Zhao et al. (2019), post-fire field measurements at 4 sites (2 pair: 2 burned, 2 unburned) at the location of the ~11,700 ha Rough Ride Fire, indicated duff depth consumption of 4.5 cm and 4.9 cm. Based on undocumented and unreferenced information, "In fact, whereas a duff layer is typically consumed during the smouldering phase of combustion, the monitoring and images taken during the RRF indicated that a large portion of the duff layer burned during the flaming phase of combustion.", Zhao et al. (2019) assume that nearly all of the duff consumption occurred during flaming combustion in one day. In the current study, the authors use the 4.5 cm duff depth consumed by flaming consumption claimed by Zhao et al. (2019) and apply it to the four fire cases. This choice does not seem justified based on the less than robust information presented in Zhao et al. (2019).

2. Duff PM2.5 emission factors

The study is simulating the impacts of flaming duff consumption on air quality, but they use $PM_{2.5}$ EF factors for smoldering duff (Urbanski 2014; Geron & Hays, 2013). The high $PM_{2.5}$ and VOC emission factors for duff burning result in large part because duff burns primarily by smoldering combustion. The authors should have used a reduced PM2.5 EF to represent flaming combustion.

3. Temporal emissions profile

The authors do not describe how the daily fire emissions were converted into hourly emissions for the WRF-Chem simulation. The appear seems to imply they were not:

L408-409: "The daily variations are different between observations and simulations because the observed fire emission dataset was at daily rather than hourly intervals."

4. Assessment of smoke impacts

It is unclear how the authors define air quality (AQ) observation sites as influenced or not influenced by smoke. Is smoke "influenced" defined from the perspective of the model e.g., air quality monitoring sites that were impacted by a conserved smoke in the WRF-Chem simulation or PM2.5 or CO levels greater than non-fire simulation? Or is smoke influenced defined by AQ observation e.g., PM2.5 > some threshold. The criteria for smoke influenced needs to be clearly defined. And the rational for the criteria explained.

There are too many figures and the accompanying discussions are difficult to follow. I feel the study would be better served had the authors focused on a handful of days using air quality sites that were smoke impacted, from the simulations' perspective using a clear, well defined definition of smoke impacted (e.g., WRF-Chem conserved smoke tracer, CO levels, etc.)

Specific Comments

5. L9: "The emissions of duff burning were estimated based on a field measurement"

6. L24-26: "Fires contribute 26.9% of total volatile organic compounds (VOC) emissions and 27.5% of PM emissions in the U.S. according to the 2014 US Environmental Protection Agency (EPA) National Emissions Inventory (NEI) (USEPA, 2017)."

The VOC contribution seem high. Please double check.

7. L33-34: "Wildfires produce about 3.5% of global tropospheric ozone production, though ozone production rates of individual fires vary with fuel type, combustion efficiency, etc. (Alvarado et al., 2010; Jaffe and Wigder, 2012)."

Location, time of year, meteorology, and pre-existing atmospheric composition are likely important factors as well.

8. L44-45: "In many regions around the world, including the U.S., wildfires have an increasing trend during recent decades…"

Elaborate on what kind of increasing trend? Frequency of large fires, fire severity, burned area?

9. L49-55: Paragraph needs rewriting. Introductory sentence of the paragraph is about human health impacts of smoke, but two of three following sentences discuss radiative impacts of smoke aerosol. I suggest dropping the radiative impact sentences and added more information on health impacts.

10. L71-72: "Duff typically represents the detritus or dead plant organic materials fallen at the top layer of soil."

This is a good location to define the terms "duff", "peat", and "organic soil". They are often used interchangeably when discussing global wildland fire. For example, a couple sentences down the authors use "organic soil".

11. L82-83: "Besides duff, peat is another burnable organic soil that typically represents the fermentation below the duff layer (Frandsen, 1987)."

See previous comment.

12. L105: *Define "prescribed fire"*

13. L106: *Yokelson et al. (2013) is not a good reference for this statement, more appropriate reference(s) needed*.

14. L115-116: Change to: "…*estimated to account* for approximately 60% of total PM2.5 emitted from the fire."

15. L131: "…temperate forest duff emission factor of nitrogen oxides (NOx) is 0.67 g/kg…" *Citation needed.*

16. L137-142: *This last paragraph of the Introduction needs to provide a better, but still brief, overview of the study (similar to the abstract).*

17. L144: 2.1 Study Region

The authors should provide a map of the study region with polygons of fire perimeters and markers for urban areas of interest in the air quality simulations. Include scale bar. This is necessary for the reader and will allow the authors to streamline this section which reads very rough.

18. L165: 2.2 Fire cases

Maps of each fire subregion region with fire boundary polygons should be provided. Perhaps a three panel – entire study region (see comment above), southern Appalachian region, and the Okefenokee swamp region.

19. L173-185: *It would be interesting if the authors could provide a couple sentences on the fire history of the Okefenokee swamp region. Three large fires in a short period, how does this compare with fire history at the swamp?*

20. L209-210: *Refer reader to figure for domain. Also, I suggest swapping order of Fig S1 and S2. Present model domains first, then time series of OC emissions related to fire activity.*

21. L240-241: "The fire emissions from FINNv1.5 were implemented into WRF-Chem by Pfister et al. (2011a), which contains the daily burned area and emissions of an amount of gas and aerosol species with a spatial resolution of 1 km (Wiedinmyer et al., 2011)."

More explanation is needed here. Did the WRF-Chem installation that you used include FiNNv1.5 fire emissions on an hourly time step that could be included in simulations? I didn't think that was an option. Or did you download FiNNv1.5 fire emissions with MOZART speciation and ingest these emissions into WRF-Chem? If the latter, how did you convert daily emissions of FiNNv1.5 (https://www.acom.ucar.edu/Data/fire/data/README_FINNv1.5_08112014.pdf) into hourly input for WRF-Chem?

22. L265: "The duff burning contributed 60% of the total PM2.5 emission"

Should read: "*The duff burning was estimated to have contributed 60% of the total PM2.5 emission*"

23. L291-295: *The authors should note that the Geron & Hays (2013) was a field study that made in-situ measurements of EFPM2.5 from three different peat fires in coastal North Carolina. Black et al. is a laboratory study that measured EF from peat core samples from two locations in North Carolina. BTW – Black et al. (2016) is missing from bibliography.*

24. L303-305: *Please provide reference for NOx EF or refer reader to Table 2. The authors do not mention Table 2 anywhere in the text. Table 2 should be referenced when discussing EF.*

25. L306-314: *This is a reasonable approach at the Okefenokee fire sites, to estimate duff reduction from previous burns (2007 to 2011, 2007/2011 to 2017).*

26. L322-325: “We did not use the commonly used approach to scale up the FINN emissions because we wanted to understand if the missing duff burning contributed to the underestimate FINN emissions to a certain extent. This FINN emission underestimate would lead to uncertainty in quantitatively estimating the contribution relative to the above-ground fuel consumption.”

This is unclear and must be rewritten.

Section 3.1

27. It is unclear how the authors define air quality (AQ) observation sites as influenced or not influenced by smoke. Is smoke “influenced” defined from the perspective of the model e.g., air quality monitoring sites that were impacted by a conserved smoke in the WRF-Chem simulation or PM2.5 or CO levels greater than non-fire simulation? Or is smoke influenced defined by AQ observation e.g., PM2.5 > some threshold. The criteria for smoke influenced needs to be clearly defined. And the rational for the criteria explained.

28.*Figure S3 is not that helpful in discerning agreement between base simulation (No fire) and AQ observations. A time series like Figure 3 would be far more useful (with smoke influence clearly defined, previous comment).*

29. State how many air quality sites were used in each domain.

3.2 The PM2.5 emission and transport from duff burning

30. L381-382: “Thus, implementing duff burning doubles the PM2.5 concentrations from App16”

Is this statement based on specific AQ site(s)? Please clarify.

31. L384-385: "The total burned area of Oke07 was 5 times more than that of App16. The emissions were larger from Oke07 and correspondingly the simulated PM2.5 concentrations are greater."

Since Oke07 lasted > 2 months, it would be more useful to compare area burned and emissions for the periods of the simulations, perhaps as daily average.

32. L386-388: "In the sim_FINN+duff runs, the simulated fire plume effectively approaches the underestimated regions, but the enhancement is still not enough over some regions."

By approaches, I assume the authors mean the simulated surface PM2.5 in the plume approaches the concentration of the AQ observations showing greatest impact? Please clarify.

33. L408-409: "The daily variations are different between observations and simulations because the observed fire emission dataset was at daily rather than hourly intervals."

I commented on this topic earlier. How did the authors temporally distribute (daily to hourly) the fire emissions for WRF-Chem input? The temporal distribution of fire emissions is critical to getting realistic simulations.

Technical

It would make for a more pleasant read if for URLs the authors provided citations in the text and the links in the bibliography, e.g.:

"(http://www.gatrees.net/forest-management/forest-health/alertsand-updates/Wildfire%20Damage%20Assessment%20for%20the%20West%20Mims%20Fire.pdf, last access: December 3,185 2020)."

L33: "Wildfires produce about…" to "Wildfires account for…"

L49: "…when fire plumes are transported…" to "…when smoke plumes are transported…"

L75-76: "…may provoke each other…" Rephrase, be more specific about the physical processes to which you are referring.

L83: change "swamp" to "wetland", the latter encompasses swamp, bog, march, etc.

L86: "…are also evaluated…" to "have also been evaluated…"

L88: "However, the air quality impacts of emissions from duff fires are very limited…" I don't think this is what the authors intend to state.

L109: Change "springs" to "spring"

L216: Should refer to Fig S2.

Additional English usage / technical corrections needed at: 154, 175-177, and other places