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Comment on acp-2022-324

Anonymous Referee #1

Referee comment on "Projected increases in wildfires may challenge regulatory curtailment of $PM_{2.5}$ over the eastern US by 2050" by Chandan Sarangi et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-324-RC1, 2022

This manuscript presents a modeling investigation of particulate matter ($PM_{2.5}$) changes by the mid-21st century driven by changes in wildfire smoke emissions across North America. Based on simulations with and without wildfire emissions in a coupled fire-climate-ecosystem model (RESFire-CESM), the authors reveal elevated summertime wildfire-induced $PM_{2.5}$ concentrations during 2050s over the entire North America, with most substantial increase in wildfire contribution to the total $PM_{2.5}$ across the eastern United States. The authors further attribute this remote $PM_{2.5}$ enhancement to smoke transport and positive climatic feedbacks on $PM_{2.5}$. While this study provides insights on a timely issue, it seems this study could be improved in terms of its completeness. More specifically, the proposed mechanism underlying the remote effects of wildfire emissions on $PM_{2.5}$ over southeastern US needs further verification or exploration. Therefore, I suggest to return the manuscript to the authors for major revision.

Main suggestions:

- While the authors investigate the thermodynamical feedbacks associated with absorbing aerosols, it looks like neither the dynamical feedbacks or circulation changes under climate change are explored. Intuitively, one would expect the dynamical/circulation features to be important for the long-range transport of smoke; without a thorough analysis on the dynamical aspects, it is hard to believe that the thermodynamical feedbacks are the only or dominant mechanism underlying the projected enhancement of the remote smoke-induced PM_5. I suggest to 1) analyze observational data to identify circulation features that are responsible for long-range transport of western North American smoke to the southeastern US region; 2) evaluate the historical representation of such circulation features in your model; 3) investigate changes in such circulation feature between 2050s and 2000s, with and without wildfire emissions.

- In terms of the currently analyzed climatic feedbacks to smoke, the current interpretation of Figure 5 does not seem to be complete or robust. For example, the authors argue that "lower-tropospheric stability is enhanced by wildfire aerosols in the future", but the changes in AAOD (Figure 5A) or stability (Figure 5C) are only significant in very small and inconsistent areas in the eastern US. In addition, how do you explain the lack of stability changes in western US despite the significant changes in AAOD? Are the changes in stability sensitive to vertical distribution of absorbing aerosols? It is even harder to believe that the changes in AAOD (Figure 5A) solely cause the changes in precipitation (Figure 5D), given their very distinct spatial patterns.
- While the authors focus their analysis on decadal mean changes and spatial distribution of such changes, the temporal variations in PM_5 are worthy of investigation too. A natural question would arise whether we will experience elevated occurrence of extreme $PM_{2.5}$ days. For example, it would be interesting to see something similar to Figure 6 but presenting the spatio-temporal PDF of $PM_{2.5}$ from all grid cells and all days in both the historical and future simulations.
- Does your simulation include multiple ensemble members? Will an ensemble simulation enhance the robustness of your results?
- Finally, while the burnt area does not increase in the southeastern US, it is possible that smoke emission still increases. Does your model account for future biomass increase and possible smoke emission rate increase?

Minor suggestions:

- On line 217-218, the authors attribute the inconsistency between model and satellite-derived PM_5 to the bias in the pristine region, but the scatterplot does not seem to support such bias in the low-value region.
- On line 249, it is also useful to indicate sample size.
- On lines 315-316, please rephrase this sentence, it is not clear what this sentence means.
- On lines 396-398, you can actually test this hypothesis with your simulations, for example by compositing absorbing aerosols in the subsequent days following fire events in Canada.
- Figure 5, what statistical test did you use?
- Around line 450, it is also helpful to report the percentage of grids with seasonal mean PM_5 exceeding 10 μg m^{-3}.