

This is an interesting, provocative and important manuscript that should be published after a number of additions and improvements.

The separation of aerosol impacts from meteorological influences is certainly an important task, especially regarding anthropogenic climate influences. However Australian Black Summer wildfires are not in the most need of disentanglement from meteorology. Those fires would have overwhelmed any meteorology. This manuscript is then perhaps an easy case that could provide an example for cases where such entanglement is more of an issue.

This manuscript calls to my attention a great number of unaddressed questions. What was the December-January 2019-20 weather? How typical was that weather? If it was typical then why not simply compare average AOD, Aerosol Index and CALIPSO CCN with that observed during AO fires. Such averages could also leave out atypical years or years with meteorology inconsistent with 2019-20 as was done for ML training. How many of the 15 years (L116) were removed for training due to meteorology and/or wildfires? This would seem to result in a rather small data set (3-14) for the averaging, especially after deliberately leaving 2 additional years out. Or was this removal done at finer time intervals within the examined months? What is the advantage of using a trained model over an historical average with or without meteorological discrimination? Such a comparison would be of fundamental importance. L215 indicates that a simple mean was used for Fig. 4.

More explanation is required about the CALIPSO-derived CCN product. There is an implication (L116) that this is based on real CCN measurements. Was it? Just how aerosol-type was it? Is this one number or a spectrum? Is there an estimate of the supersaturation (critical) value(s) of this product. Conclusions very much depend on the reliability and believability of these CCN estimations.

The ML model baseline description is inadequate. L101 & 150 specifies identical meteorological conditions with no wildfires. How identical? How was the identity decided? Identical within what ranges? Is Table A1 relevant here? Was this identity done on a daily or monthly basis? I take it that only meteorology and aerosol within the months of December and January were considered? Please confirm. Are there some years when one month was ok and the other was not? Are the two months considered together or completely separately. The degree of strictness either compromises the identity or reduces the training data. There is also the fact that the fires (e.g. heat) and subsequent aerosol (e.g. shielding terrestrial and solar radiation) and cloud effects impacted the meteorology during the AU fires. These factors would not have been in effect during the previous years that produced the baseline training. Were and how were these differences accounted for? This is a more important issue with the overwhelming effects of these specific fires. This would be less of an issue in more subtle situations that are more appropriate for unravelling. L128 mentions daytime. Is the analysis and presentation restricted to daylight hours? Is the meteorology restricted to daylight hours?

There is much discussion of the suitability of AOD and Aerosol Index for estimating CCN. It seems that availability CALIPSO CCN would remove this question. Is CALIPSO CCN often unavailable or untrustworthy?

Minor:

L9. Perturbation plural.

L20. Change in to of.

L34-36. These demonstrate that wood fires produce copious CCN;

Rogers, C.F., J.G. Hudson, J. Hallett and J.E. Penner, 1991: Cloud droplet nucleation by crude

oil smoke and coagulated crude oil/wood smoke particles. *Atmos. Environ.*, **25A**, 2571-2580.

Hudson J.G., J. Hallett and C.F. Rogers, 1991: Field and laboratory measurements of cloud forming properties of combustion aerosols. *J. of Geophys. Res.*, **96**, D6, 10,847-10,859.

Hallett, J., J.G. Hudson, and C.F. Rogers, 1989: Characterization of combustion aerosols for haze and cloud formation. *J. Aeros. Sci. and Technol.*, **10**, 70-83.

L37-38. Not a sentence. Removal of Because would make this a sentence. However, not a good sentence. Aerosol-cloud interactions exist even without CCN changes. Variations is a better word. Mediated is not the best word choice.

L37-39. Aerosol-cloud interactions are the largest climate uncertainty but the wildfire component is not necessarily the main reason.

L39-40. CCN is not the reason for the high uncertainty.

L45. Subscript not superscript.

L57. Remove approximately.

L60. For at least 2 reasons this is not a 'natural experiment.' Perhaps inadvertent. Moreover, a number of field projects are often referred to as experiments. Are observations experiments?

L77. Change more to greater. Add ity to sensitive.

L78. Remove information.

L90. Move only after relying.

L96. 15 years is not long term. Furthermore, these are not aerosol and certainly not CCN observations. They are observations of effects of aerosol and perhaps CCN.

L138 & 9. Insert AU before wildfires.

L146. Remove a. Surrogate plural.

L157. Define ensemble member.

L158. Explain with replacement. What are the remaining years? At least the number of such.

L159. How was this uncertainty determined?

L187. Insert vertical before profiles.

L189. Medians singular.

L220. Insert eastward after further. Change to to into the.

L223. Change and undergoes to after.

L238. How is this confirmed?

L268. Change larger to greater. Concentration plural.

L280. Cloud processing, gas-to-particle chemical reactions, coalescence and capture of interstitial material (Hoppel et al.) also affects CCN.

L284. Subscript.

L287-9. Further explain.

L290. Wildfire plural.

L291. Explain phase.

L299. Remove ical. Remove noise.

L302. Insert these before wildfire.

Hoppel, W.A., Frick, G.M. & Larson, R.E. (1986). Effect of nonprecipitating clouds on the aerosol size distribution in the marine boundary layer. *Geophysical Research Letters*, **13**(2), 125-128. <https://doi.org/10.1029/GL013i002p00125>