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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Composition, size and cloud condensation nuclei activity of biomass burning aerosol from north Australian savannah fires" *by* Marc D. Mallet et al.

Anonymous Referee #1

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Summary The results provide important data on hygroscopicity of biomass burning smoke using both sub- and super-saturated conditions. This is a region that severely lacks observations of smoke properties and is a globally significant region of biomass burning. The paper is appropriate, well-focused and is publishable in ACP. I recommend a few minor tweaks and thinking about the following comments.

Major Comments on Content Can the authors comment on the mix of fuels in this region beyond the region being a savannah? Perhaps it is or is not well-documented, but any data on the acreage burned in north vs. south Australia and decadal trends? Is wildland fire acreage increasing as in the western US? Vast majority and thousands of fires is a bit squishy when acreage is more atmospherically relevant. The proximity

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to dust sources of Australia, another possible contributor to low hygroscopicity, does this offer any potential influences on the measured properties or does the ACSM not give information on mineral content? This may be of irrelevance considering the sizes under investigation but is worth mentioning. Abstract, Lines 16-18, the photochemical aging leads to somewhat higher Kappa. This is entirely plausible but I don't think fully substantiated (see further below). Any differences on cloudy vs. clear days which might further suggest photochemical processing? P.6, Line 3, influence of distant and local fires. Similarly if the driver of increased kappa is the photochemical aging of the aerosol, some difference may emerge from the smoke from nearby vs. aged smoke from afar. Is there any hints in this comparison? The diurnal trends with larger activation ratios during daytime and small increases in kappa towards the middle of the day is interesting. Does the timing of midday correspond with the peak in photochemical processing? I would expect later in the day, no? As an alternative or contributing factor, could the flaming vs. smoldering nature of the fires (fires flare up during the daytime vs. laying down into smoldering burns at night) perhaps be another contributing variable? This will influence both particle sizing [Carrico et al., 2016] as well as composition potentially. You may be seeing some of this with the ammonium sulfate trends you note in the bulk composition. Also noteworthy is that the flaming burns produce most of their numbers <100 nm (though this increases with aging). The median diameters in this study compared to others corroborates smaller particles as well and diurnally a minimum at the same time. However, with very fresh smoke emissions as suggested by the 10-20 km distances measured for fires, the predominant numbers are likely less than the 100-200nm size fraction examined for composition. Moreover, does the AMS identify potassium as a fragment, as it is a significant contributor to inorganic speciation of biomass burning aerosol? These all lend credence to size resolved inorganic composition as a potential contributor to the kappa trends. Figure 1 is interesting in showing the dominance of burning on CCN properties. How does the acreage burned vs. number of fires play into this relationship or is this information available? Also, the distances in the legend are different than those in the caption.

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Comments on Presentation The paper is well-written and clear. Length is reasonable and it is well illustrated. A few fixes are listed below. The font sizes on the figures are difficult to read on a hardcopy of the paper. P3, Line 8, suggest a new sentence staring at 'This contributes' P3, Line 21, is natural versus 'spontaneous' a better description? I imagine fires erupting without an ignition source beyond the thermodynamics of the forested region. P8, Line 21, "between 80 nm and 100 nm"? P17, Line 6. Although the cited papers are relevant to the study, they are not the most appropriate for discussing the aging of biomass smoke and increasing kappa (e.g. the CMU papers) P20, Line 21, "activation be better modeled"?

Carrico, C. M., A. J. Prenni, S. M. Kreidenweis, E. J. T. Levin, C. S. McCluskey, P. J. DeMott, G. R. McMeeking, S. Nakao, C. Stockwell, and R. J. Yokelson (2016), Rapidly evolving ultrafine and fine mode biomass smoke physical properties: Comparing laboratory and field results, J. Geophys. Res. Atmos., 121, 5750–5768, doi:10.1002/2015JD024389.

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