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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Size-resolved chemical composition, effective density, and optical properties of biomass burning particles" *by* Jinghao Zhai et al.

Anonymous Referee #3

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This manuscript reports the size-resolved chemical composition, effective density and optical properties of rice straw burning particles using different online instruments including DMA-APM-CPC, single particle aerosol mass spectrometer, and cavity attenuated phase shift (CAPS) spectroscopy. First of all, the focus of this study is unclear and hence the significance and atmospheric implication should be explicitly highlighted in the abstract, introduction and conclusion. Secondly, the results should be discussed in more detail. In particular, the observations regarding particle effective densities and single particle compositions should be better integrated in this manuscript in order to provide a more complete picture on the relationship of particle mixing state, morphology and effective density. Lastly, there is an issue about the data quality in

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Section 3.3.3 (See specific comments) that should be addressed by the authors. The manuscript should be proofread carefully before submission. Overall, I don't recommend this manuscript to be published in Atmospheric Chemistry and Physics in the current format. Below is the specific comments.

Specific comments:

1. Absorption enhancement results (Section 3.3.3 and Figure 5): Figure 1 demonstrated that aerosol particles were pre-treated by a thermodenuder before generating monodisperse particles using a DMA. The size-selected particles were then characterized by a few real-time instruments. Using such experimental setup, the size-resolved absorption enhancement factors reported in Figure 5 are actually not meaningful. The primary reason is that those enhancement factors were not determined by comparing particles with the same original dried-particle diameter. The whole particle size distribution should shift towards the lower particle size after thermal treatment (i.e. removal of coating materials). The original size of heated particles should be greater than that of particles without heating as shown in Figure S7. It is unclear how the shrink factor and transmission efficiency of particles presented in Section 3.3.3 can resolve this fundamental problem. Detail clarification is required to keep the related discussion in the manuscript.

Furthermore, this manuscript emphasizes a few times that aerosol coating can act as a lens to enhance light absorption of aerosol particles in general. Nevertheless, the major conclusion of this work regarding light absorption enhancement (relative to pure BC) is due to the presence of atmospheric brown carbon from biomass burning emissions and without much discussion on the lensing effect. It is recommended to change the tone/wording in the text to avoid any potential confusion to the readers, especially for those are not familiar with this research topic.

2. Figure 2 and Section 3.1.3: Similar to the comment #1, it is essential to highlight in the manuscript that the individual column in Figure 2 is not presenting results obtained

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from particles with the same original dried-particle diameter. The current writing is somewhat misleading. However, the findings observed from this figure is still useful even though direct comparison of plots displayed in the same column is inappropriate.

3. To better organize the discussion of particle effective density, it is recommended to combine Section 3.1.2 and 3.1.4 in the manuscript.

4. Effective density and chemical composition (Section 3.1.3): 1) Lines 358-360: Without quantitative chemical characterization in a single particle basis, it is hard to prove if some BC was externally mixed with other components based on the effective density measurement alone. BC particles with highly fractal structure and thin organic coating can lead to the similar observations, depending on the uncertainty of effective density measurement. 2) Lines 365-378: According to Figure 2, peaks are always observed at around 1.7-1.8 g/cm3 for the heated particles with diameter less than 400 nm. Please comment whether this observation is due to the presence of extremely low volatility organic aerosol materials generated. Furthermore, what are the vaporization temperature of KCl and other potassium salts.

5. Section 3.2 and Figure 3: The authors may over-interpret their observations. The average chemical compositions are not sufficient enough (i.e. they are too similar) to explain the effective densities of the two particle modes presented in Figure 3a (200 nm). Similarly, the first two particle modes in Figure 3b (400 nm) have the very similar average chemical compositions. What are the particle number distributions of each cluster (lines 430-432)? Their particle number distributions should be able to extract from the results of cluster analysis. Estimation of effective densities of some clusters is possible with such additional information. Furthermore, it is unclear how to separate the particle modes in Figure 3 for constructing the pie chart. Please provide sufficient detail.

6. Section 3.3.2, Lines 533-541: What is the particle size for data reported in Table S2? Significant drop of AAE for the thermodenuded particles are observed. Please

comment on the significance and relative contributions of extremely low volatility brown carbon to the total light absorption properties of biomass burning aerosol observed in this study and compare their results with existing literature.

Minor and technical comments:

- Please replace “bi-model” by “bi-modal” throughout the entire manuscript.

- Figure S4: The legend displays the same for both types of effective density. Please correct.

- Please use “low” and “high” to describe density.

- Line 198: Should it be “. . .increased as the size increased. . .”?

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