Comment on acp-2022-542
Anonymous Referee #1

The manuscript presents a method for retrieving BC density and implications for CCN prediction. Since the BC density is difficult to measure, it is worth trying to develop new methods for retrieving accurate BC density from available measured data. It is quite interesting. However, more work needs to be done with the manuscript before it can be accepted.

- It is not clear how the mixing state and the density of BC are retrieved based the description in the methodology section (2.2)?

- The definition of mixing state is especially not clear. What exactly the mixing state is referred to? Internal? External? Do the authors mean the mass size distributions for the internal and external BC?
- The density is calculated by equation 8, so in the calculations, there must be lots of assumptions for the relevant parameters. How each parameter in the equation is determined? Those need to be clearly described. It is obviously not well illustrated in the current version.

- The authors attribute the density fluctuations of the internally mixed BC and the bulk BC to the mixing state and the rapid aging from the variation of emissions (Fig. 3b&c). However, how the changes of emissions affect the parameters contributing to the density remains unexplored. For example, how the parameters in equation 8 are affected by changing the emissions? In addition, it is difficult to discriminate the in-BC and ex-BC in Fig. 3a. It is suggested to change the color of the in-BC to increase the contrast between them.
- Pertinent to comment #2, what factors determine the retrieved BC density? Are they explicit in equation 8? How the correlations between those factors and the BC density?
Can the authors explore more on this?

- The calculation of critical size is based on pure water assumption for the surface tension and water density, which may cause uncertainties. The authors should discuss the uncertainties associated with the assumption.
- In Fig. 5, what is the measured Nccn. What method is this based on? Are they the same for the Nccn in Fig. 5 and Fig. 6? How are the differences between the CCN number concentration predicted based on the retrieved BC density and based on the HTDMA? Can the authors discuss more on this?
- Minor comments: there are a lot of typos, ill-sentences which need to be cleared in the revised version.

- Title: I am not quite sure this is a new method
- L40-41, such an effect
- L44: applying varying BC density, an awkward phrase, please change it
- L50: The light-absorbing capability
- L57: well understood
- L61 and others: While after aging, this is strange since it is just one sentence. There are some more the same issues throughout the manuscript.
- L63: The BC structure.
- L71: the average BC density
- L74: than that internal/ aged BC ..., seems a broken sentence
- L76: internally doesn’t need a hyphen after the word
- L78: climate effect
- L81: particle hygrosopicity
- L85: was found caused by?
- L87: yet accounted for
- L94: reference cited, format is not consistent
- L116: change “Then” to “Subsequently”
- L120: Here, four diameters
- L126: by using, “by” should be deleted. Please check throughout the manuscript
- L128: et al., 2009. I am not sure this can be cited like this way. Please check throughout the manuscript
- L141, where Gf is .... This still belongs to the above paragraph, why it needs to be dented? Check all the occasions.
- L157-158: assumed mixed with the other?
- L158: And thus to “Thus”
- L160: externally mixed
- L174: mass size distributions was modeled as?
- L182: by minus? by subtracting
- L188: is with an assumption of to assumes
- L193-194: which showed an independence on particle size when the Dp >100 nm during the campaign period (Fan et al., 2020), was averaged and applied for the retrieval. It is hard to understand what this sentence means
- L209: in equation (7), no article “the”. Check all occasions
- L219-220: were taken from previous studies
- L221-222: assumed to be
- L222: The values of ... was?
- L235: unlike inorganics, which the hygroscopicity, what is “which” referred to?
- L272: for calculating the ...
- L273: with the assumption of to assuming
- L278: internally and externally mixed
- L280: the atmospheric aging process
- L287: with both those?
L289/303/315: internally mixed
L305: The density of the In-BC during daytime was
L309: The slight decreases
L313: The diurnal cycles in BC density are consistent with those measured
L322: McMurry
L330: Mean probability distribution function (PDF) of the density of bulk and In-BC retrieved by this study is
L332: with a peak value
L333: externally mixed and internally mixed
L338: typical internal mixed BC
L341: A previous study showed that the use of an inaccurate density value of ...
L345: what “it” represents here?
L350: on predicted CCN number concentrations
L360: in the atmosphere),
Section 3.3, use 0.23% instead of 0.2%
L414: would cause
L417-418: by assumption of to assuming
L435: the current assumption