

Interactive comment on “Aerosol hygroscopic growth, contributing factors and impact on haze events in a severely polluted region in northern China” by Jun Chen et al.

Anonymous Referee #2

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The manuscript studied aerosol hygroscopic growth through sets of measurements made in Xingtai, Hebei province of China, which suffers from very serious pollutions. Using different instruments, including Raman lidar, handheld particle/mass meter for PM₁, PM_{2.5}, aerosol chemical speciation monitor (ACSM), and hygroscopic tandem differential mobility analyzer (H-TDMA), the authors obtained four different quantities representing aerosol hygroscopicity from various aspects. They analyzed the aerosol backscattering enhancement factor [$f(\text{RH})$] (derived from Raman lidar measurement), the aerosol particle growth factor (derived from the H-TDMA), the aerosol acidity and the hygroscopicity parameter (derived from chemical speciation), of a relatively clean case and a pollution case under similar atmospheric relative humidity, and concluded

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that aerosol hygroscopic growth was one of the major factors contributing to heavy haze pollution. The experiment of simultaneous measurements from the four instruments is well designed and the result is important and worth publishing. However I think the manuscript can be improved in writing (English, connection between parts and reasoning), and results can be made more useful if a little more analysis can be done. I recommend publication after addressing the following comments:

1. Add more descriptions or details on the instruments, e.g, what are measured directly and what are derived, uncertainties in their measured/derived quantities.
2. The four variables representing aerosol hygroscopicity from different aspects, namely the aerosol backscattering enhancement factor [$f(RH)$], the aerosol particle growth factor, the aerosol acidity and the hygroscopicity parameter. To what extent are these variables correlated? What are the correlations among $f(RH)$, \ddot{A} and acidity? Under what circumstances? The answers would make the manuscript potentially more useful, e.g. for aerosol modeling. If possible, expand studied RH range, as I understand there is available data (below the selected loft layers and with lower RH) from the measurements.
3. Figure 3 is an important figure for this manuscript, however I find it is hard to read or draw conclusions with it. And the description of Fig 3. is lack of clarity. Why and how the two cases are selected are poorly demonstrated in the text. Consider adding time series of surface water vapor mixing ratio and RH, as PM and chemical composition data are both obtained at the surface, and the authors are trying to draw some relationships between surface RH and these aerosol data.
4. Page 9. Line 4-8, The authors give absolute errors of Raman-lidar-derived relative humidity and water vapor mixing ratio for a relatively dry case ($20\% < RH < 35\%$) in Fig 1 and 2. However boundary layers are generally wetter, and the two case selected for the study both occurred under atmospheric environments with $RH > 80\%$. What is the error of Raman-lidar derived RH for wet environment? It would be more meaningful to

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add a relatively wet case for validation. Also what are other uncertainties from Raman Lidar, e.g, AE, depolarization ratio? Is there any difference in uncertainty lower and higher altitudes?

Other comments:

Page 7. Line 10-11, Please specify if the handheld particle/mass meter (PC-3016A) measures dry mass or total mass (including water uptake).

Page 11. Line 12-13, “When $AV=1.25$, 50% of the total sulfate ions in the atmosphere consists of . . .and 50% consist of . . .” This sounds definite. Isn’t this just a possible combination of different chemical components?

Page 11 line 20, There are two “because” in this sentence, making it awkward.

Page 13, line 3-5 the whole sentence, starting with “To see if this is the true”, reads awkward.

Page 13, line 5-7, “As W in the lower atmospheric layer and the mass concentrations of PM1 and PM2.5 increased, the proportion of organic aerosols decreased, suggesting that the proportion of hygroscopic aerosols increased.” This relationship is not straightforward by looking at Fig 3. Please think of a way of pointing to the readers where to look, maybe by marking these cases. Also in the next paragraph, two cases are selected. Consider adding two vertical lines across Fig a-b-c) so that data can be better visualized.

Page 13, line 8-18, This paragraph is related to Figure 3 and is lack of clarity. “this relationship” in the first sentence needs to be explicitly defined. Line 9 “relatively higher”, what does it compare to? The first sentence implies the two cases are similar because “this relationship was not seen” in the two instances. However reading along, there seems to be differences for the two cases. What are the similarities and what are the differences for the two cases are not clearly stated in this paragraph. Why are they selected as the studied cases?

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Page 14, line 4. How and why are these altitude ranges are selected? I understand that the authors choose RH=80% as the reference RH. Why don't use the whole well-mixed boundary layer, which can give a wider range of RH? I would be curious to see the hygroscopic growths under a wider range of RH. Would the regression relationships between RH and the various hygroscopic growth factors still be valid? If not, how much deviation there would be? Just thinking from aerosol modeling point of view, the result of this paper is potentially applicable in model parameterizations of aerosol hygroscopic growth if a wider RH range can be studied.

Figure 7. If I understand correctly, the reverse of the slopes of fitted lines would be the Acid Value (AV). So maybe consider switch x and y axes for this figure. Then the slopes would be the AV with no need to calculate the reverses.

Page 14, 19-20, "This suggests that aerosol particles were transported to Xingtai from the same source region". Are there local emissions? Can it be excluded?

Page 18. Line 5 "a positive result". Please be explicit.

Page 20, line 2. I think the authors meant relative humidity by "water vapor content". This may have appeared in other places in the draft. Please don't mix use.

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