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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observations of relative humidity effects on aerosol light scattering in the Yangtze River Delta of China" *by* L. Zhang et al.

Anonymous Referee #1

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1 General comments

Zhang et al. investigate in their manuscript the effect of relative humidity on the aerosol light scattering for a rural site in the Yangtze River Delta in China. The results of a one-month campaign are presented, which includes measurements of the scattering enhancement factor f(RH), the particle chemical composition and absorption properties in addition to standard meteorological parameters. The relative contribution of inorganic to organic mass fraction was found to be the main parameter determining the magnitude of the scattering enhancement. The results were further analysed using a trajectory analysis and estimating the effect on the direct radiative forcing.

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The findings are of general interest to the scientific community since only few measurements of f(RH) exist from that region of the world. The manuscript is plausibly structured and the results are presented in an appropriate way. However, there is still room for improvement by clarifying specific comments, by removing some redundancies, and by additional editorial work (spelling and grammar mistakes). Currently, some needed instrumental and calibration details are missing in the manuscript. An optical closure study using Mie theory would help to put the measurements on a more trustworthy basis. Overall, I recommend the paper to be published in ACP after the following comments have been answered satisfactorily (**major revisions**).

2 Specific comments (in arbitrary order)

- Sect. 2.2 (Measurement system):
  - Please state the mean and STD of the RH inside the DryNeph. There are also some inconsistencies within the text concerning the RH which has been regarded as dry (30% or 40%?), please precise.
  - The RH-cycle of 1 hour seems quite fast. Have other (longer) scan times been tested?
  - Where exactly was the RH measured within the humidified nephelometer? Have the authors performed a calibration of the humidified nephelometer using a known hygroscopic substance (e.g. ammonium sulphate)?
  - Since there were concurrent particle size distribution measurements at the site, I strongly recommend that the results are being compared to Mie calculations using the chemical composition and size distribution measurements. This will put the results on a more trustworthy basis (see Zieger et al. (2013) for more details).

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  - Page 2861, Line 10 and Figure 1: Figure 1 does not contain a real information content and could be removed. The agreement between the two nephelometers can be described within the text (e.g. by stating the result of the linear regression). Has the small difference between the two nephelometers been accounted for when calculating f(RH)?

- Page 2855, Line 28: Can the authors shortly elaborate further on how the properties of the gas and particulate matter have "changed dramatically" since 1999 at the site?

- Page 2856, Line 20: Particles could also experience reconstruction at elevated RH (see e.g. Tritscher et al, 2011) and thus f(RH) could in theory also be slightly below 1. I suggest to rephrase, e.g. by stating "usually above 1".

- The wavelength of the MAAP is slightly different (637 nm instead of 670 nm) than the manufacturer states (see Mueller et al., 2011).

- Page 2862, Line 20: One should not interpolate linearly to calculate f(RH)-values at different RH. The parameterizations discussed in Sect. 3.6.1 and 3.6.2. should be used instead. Generally, I think it would improve the reading if Sect. 3.6.1 and 3.6.2. are moved to the front, where the observations of f(RH) are discussed first.

- Figure 3: Why is RH=91 % highlighted by a black line? Is this the maximum or set RH? In addition, add the RH inside the DryNeph to panel (a). Please add the wavelength to the graph or the caption.

- Page 2865, Line 26: What is special about the "3 h"? This information could probably be removed.

- Page 2867, Line 16: It is not clear to the reviewer what the difference between the two affected areas are (2.8 vs. 0.27 million square kilometers). Please clarify.

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- Figure 4 and 8: The Ångström exponent has no unit (please remove ”Å” from the figures).
- Table 5: Factor g from Zieger et al. (2014) is 0.59±0.08 at 550 nm (see Tab. 1 in their publication).
- Figure 6: The panels (b) and (c) are repetitive and seen in the first panel. I suggest to just show panel (a).
- Figure 7: Please mark which pie chart belongs to which trajectory.
- Figure 9: Please check the fit method, since the slope of inorganic and organic (inorganic mass fraction $= 1-$ organic mass fraction) are not similar (the slope of the organic mass fraction should be -1 times the slope of the inorganic mass fraction). Has an orthogonal or weighted fit been used?
- The discussion of the steepness of the humidograms should be a separate section (following 3.6.3.). It is not really clear, if real deliquescence behaviour (so real and obvious jumps at a sudden transition from solid particle to liquid droplet) has been observed or if just the steepness increased with increasing inorganic mass fraction. Please clarify. As shown in Fig. 12b, the normalization or calculation of f(RH) using the scattering coefficient at RH=40% could increase a bias in the results, since the particles could still change their water content below 40%. As mentioned above, an optical closure study using Mie theory will help to give more confidence in the measurement results.
- The sensitivity on the direct aerosol radiative forcing is a useful exercise. However, the chosen RH of 67% as the campaign average is a bit arbitrary since the effect will be much larger at increased RH. The authors could add a figure showing the difference in radiative forcing for the entire RH range for the four cases (see e.g. Figure 8 in Fierz-Schmidhauser et al, 2010).

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- The conclusions should be rewritten to really focus on the main findings. Currently, it is a repetition of sentences from the main discussion. Comparison to other findings with a literature discussion (e.g. sentence on Page 2875, Line 14-15) should be moved to the discussion of the results.

3 Technical corrections

I strongly recommend a second proof-reading regarding the English grammar. The reviewer is unable to correct all the typos, missing articles and grammar mistakes.

- Page 2857, Line 4: Define ”SD” at its first appearance.
- Page 2858, Line 27: Replace ”activated” by ”active”.
- Please be consistent on how to capitalize instrument names (sometimes it is Nephelometer, sometimes nephelometer).
- As a symbol for the Ångström exponent, one usually uses α as a symbol. I suggest to replace by α.
- Page 2859, Line 26: Add the Ångström-exponent symbol at the end of the sentence.
- Page 2859, Line 23: The definition of the hemispheric backscatter fraction is a repetition and can be removed.
- Page 2863, Line 12: Verb missing.
- Page 2867, Line 13: Suggest to replace ”to produce hygroscopic compounds.” by ”leading to an increase in the particle’s hygroscopicity.”

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- Page 2868, Line 6 and 7: Please add a ”the” before ”dust” and ”Ångström”.
- Please add the wavelength to the captions in Tab. 1, 4, 5, 6, and 7 and as well to all figures were optical parameters are shown.
- Figure 1: Replace ”pentagram” by ”star”.

References

Fierz-Schmidhauser R., Zieger P., Gysel M., Kammermann L., DeCarlo P., Baltensperger U., and Weingartner E., Measured and predicted aerosol light scattering enhancement factors at the high alpine site Jungfraujoch, *Atmos. Chem. Phys.*, 10(5), 2319–2333, doi:10.5194/acp-10-2319-2010, 2010.

Müller T., Laborde M., Kassell G., and Wiedensohler A., Design and performance of a three-wavelength LED-based total scatter and backscatter integrating nephelometer, *Atmos. Meas. Tech.*, 4(6), 1291–1303, doi:10.5194/amt-4-1291-2011, 2011.

Tritscher T., Jurányi Z., Martin M., Chirico R., Gysel M., Heringa M.F., DeCarlo P.F., Sierau B., Prévôt A.S., Weingartner E., et al., Changes of hygroscopicity and morphology during ageing of diesel soot, *Environmental Research Letters*, 6(3), 034026, 2011.

Zieger P., Fierz-Schmidhauser R., Weingartner E., and Baltensperger U., Effects of relative humidity on aerosol light scattering: results from different European sites, *Atmos. Chem. Phys.*, 13(21), 10609–10631, doi:10.5194/acp-13-10609-2013, 2013.

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