Atmos. Chem. Phys. Discuss., 15, C2270–C2279, 2015
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Atmospheric Chemistry and Physics Discussions

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15, C2270–C2279, 2015

Interactive Comment

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

L. Zhang et al.

1990zhlu@163.com

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Comments from Referee #2 The contribution contains original measurements, taken in China. I suggest minor revisions.

Thanks for reviewer's suggestions. We have revised the manuscript accordingly.

1. Abstract should contain the goal of the paper, the techniques used, and the main results. The techniques applied are missing.

Following the reviewer's suggestion, we have added the techniques applied in our study and rewritten the second sentence in the abstract as: "To achieve a better understanding of the effect of aerosol hygroscopic growth on light scattering properties and radia-

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tive forcing, the aerosol scattering coefficients at RH varying from 40% to ∼90% was measured using the humidification system (consists of a nephelometer and a humidified nephelometer) in the Yangtze River Delta of China in March 2013. In addition, the aerosol size distribution and chemical composition were measured."(see Line 21-25 in the revised marked-up manuscript).

2. Page 2856, line 20: larger than one, (greater is frequently used in the paper, but larger is appropriate).

We asked help from native English co-author. The suggestions are: "Greater" and "larger" are two words we should pay attention to. Usually, "greater" is used when referring to values, and "larger" (or "bigger", of course) when referring to the size of entities (whether physical or abstract). So, we revised the manuscript accordingly. For example, there are places we have misused "greater" (Line 26 of p.2871; Line 9 and 17 p.2872), we have changed them to "larger" in the revised marked-up manuscript (Line 544 and 555).

3. Page 2858, line 9: So, you humidify the aerosol from very dry conditions to RH 40% (for neph #1) and then to the elevated RH (for neph #2)? Please clarify!

The aerosols pass through an aerosol dryer, enter the DryNeph, and then WetNeph. The measured RH inside DryNeph was always below 20% RH (see Fig.1 [also shown in Fig. 2 in the revised marked-up manuscript]). There is a humidifier between DryNeph (neph #1) and WetNeph (neph #2), which controls the RH of aerosols entering the WetNeph (neph #2). The humidifier set point is stepped from ∼40% to ∼90% RH during the first half hour, and back to ∼40% RH during the last half hour (see Fig.1 [also shown in Fig. 2 in the revised marked-up manuscript]). For example, at 03min, the RH set point was 40%, the aerosols were humidified directly from <20% to 40% RH; at 30min, the RH set point was 90%, aerosols were humidified directly from <20% to ∼90% RH. Each minute correspond to a different RH set point, so that a RH cycle was obtained.

4. Page 2862, line 9: 20 to 1000 Mm-1 corresponds to 4-200 km visibility, and not to 0.1 to 23.7 km as in Fig 4b. Please clarify!

Yes, you are right if it was the ambient scattering coefficient. However, the scattering coefficients were measured were under dry conditions, while the visibility was measured under ambient conditions. There was an automatic regenerating adsorption aerosol dryer at the inlet to provide dry air for all the instruments. The scattering coefficients, number size distribution and the masses of chemical compositions were all measured under dry conditions. We have added “under dry conditions” at Line 263 in the revised marked-up manuscript to make it clear.

5. Page 2863, paragraph, line 3-16: What about the impact (changes)... when the particles are dried and when they get wet again, ... Does that not also influence the determination of the enhancement factor? Could be discussed?

Transport losses, thermophoresis, coagulation, evaporation, and irreversible chemical reactions and so on can differentiate the particles from the original ones, and thus impact the f(RH). However, drying and humidifying is necessary. For one thing, measuring aerosol properties at dry conditions can make the data comparable; for another, only if the particles are dried and humidified can we get the scattering enhancement factor f(RH) since it is defined as f(RH)=σsp(RH)/ σsp(dry). In that case, we have made an effort to retain the aerosol property. For example, the transport path was made as short and straight as possible, particle-free air was diluted to the aerosol stream to reduce coagulation, and lower RH and higher heater temperature was avoided as it will result in semi volatile compounds like weak organic acids and nitrates evaporating from the aerosol.

6. Table 5 According to the old work of Haenel in the 1980ies and subsequent work, c and g is in the range from 0.4-0.9 and g from about 0.6-0.9. But you find c=1.000? and g below 0.3? Can you discuss that? Furthermore, one can compute gamma from c and g (see Haenel, 1984), and he found values of gamma around 0.4, but you get

rather low gammas below 0.2? How can one explain that?

Table 5 in this manuscript shows the fitting parameter (c and g) of f(RH) with equation f(RH)=c(1-RH)-g. The parameters c and g both determine the magnitude of f(RH). The larger the g and c parameters are, the larger the f(RH) will be. The parameter g determines the curvature of humiograms (f(RH)-RH curve). The larger g is, the bigger the curvature will be. Figure 2 show how the f(RH) varies with the parameter c and g. As is shown, the influence of g on the magnitude of f(RH) is more important than that of c. The parameter c and g in this study was ∼0.9 and ∼0.3, respectively, since the f(RH) value (e.g. f (80%) = 1.44±0.12) was comparably lower than most of the f(RH) values obtained in Europe, USA, the Arctic and so on. The value of c and g of LinAn was similar to these obtained by Gasso (2000) during a dust event with the f(RH) value f(80%) = 1.33±0.07. Hänel (1984) found the empirical models of f(RH) for background aerosols were f(RH)=(1-RH)-0.4364 (RH<70%) and f(RH)=0.6130*(1-RH)-0.6118 (70%<RH<99.9%), for urban aerosols were f(RH)=(1-RH)-0.2053 (RH<70%) and f(RH)=0.7008*(1-RH)-0.7317 (70%<RH<99.9%). The relatively larger value of parameter g at higher RH indicates the rapid increase of f(RH) with RH increase (as shown in Fig. 3), while the humidograms in our study were different, the f(RH) values were not as large as those obtained by Hänel (1984). In conclusion, the parameter c and g are dependent on the humidogram (both its curvature and the magnitude of f(RH)), the relatively low g value obtained in our study indicates the f(RH) is lower in this study, which is determined by the aerosol chemical composition, particle size distribution and so on.

7. Figure 1, I see a green star!

We have changed the word “ pentagram”to “star”.

8. Figure 3, a (as very thin green line) and b in one plot may help, but separately plotted, Figure 3a makes no sense, can be skipped.

We want to show the performance of our humidification measurement system on the

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RH control, which is a very important part of our experiment. In order to shown more information in this figure, we have added the RH inside the DryNeph to panel (a) and added the ratio of σsp,wet/ σsp,dry (f(RH)raw value) as panel (c) (see Fig.1 [also shown in Fig. 2 in the revised marked-up manuscript]). Hope this will make this figure more meaningful.

9. Figure 4 contains the essential results. This figure must be large! Is the information on wind useful? Otherwise leave out. And all periods which are discussed in more detailed should be highlighted in the plot (grey shading or so).

According to the reviewer's suggestion, we have redrawn this figure. We have enlarged the size of the figure and used larger font size (see Fig. 4 [also shown in Fig. 3 in the revised marked-up manuscript]). We have classified the whole month period into three episodes: the locally-polluted period, the northerly-polluted period and the dust-influenced period. The criteria of the classification were the wind direction, back trajectory and weather phenomenon. We have thought about highlighting the three periods, however, there are cases when the northerly-polluted period only last for several hours, and then changed to the locally-polluted period, if we highlight them all, the figure would be a little messy. So we have not highlighted the three periods in the plot.

10. Figure 6: The found histogram (FoO) in (a) has no Gaussian shape, why do you then show, in addition, Gaussian curves?

Yes, the distribution of the occurrence of f(85%) was not an exact Gaussian distribution. But as Pearson once said, "I can only recognize the occurrence of the normal curve - the Laplacian curve of errors - as a very abnormal phenomenon. It is roughly approximated to in certain distributions; for this reason, and on account for its beautiful simplicity, we may, perhaps, use it as a first approximation, particularly in theoretical investigations". In our study, Gaussian curves captures the main characteristics of the distribution of the occurrence of f(85%, 450nm), f(85%, 550nm) and f(85%, 700nm) with R2 of 0.98, 0.94 and 0.92, respectively. Besides, we use the Gaussian fitting curve as a representation of the data so that we could put the three lines together to make the comparison more clearly.

References in the author's response:

Gasso, S., Hegg, D., Covert, D., Collins, D., Noone, K., Öström, E., Schmid, B., Russell, P., Livingston, J., and Durkee, P.: Influence of humidity on the aerosol scattering coefficient and its effect on the upwelling radiance during ACEâĂŘ2, Tellus B, 52, 546-567, 2000. Hänel, G.: Parameterization of the influence of relative humidity on optical aerosol properties, Aerosols and Their Climatic Effects, 117-122, 1984. Zieger, P., Fierz-Schmidhauser, R., Gysel, M., Ström, J., Henne, S., Yttri, K. E., Baltensperger, U., and Weingartner, E.: Effects of relative humidity on aerosol light scattering in the Arctic, Atmos. Chem. Phys, 10, 3875-3890, doi:10.5194/acp-10-3875-2010, 2010.

(We have attached the revised marked-up manuscript, the revised manuscript and a pdf version of this response in the supplement.)

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C2270/2015/acpd-15-C2270-2015-supplement.zip

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 2853, 2015.

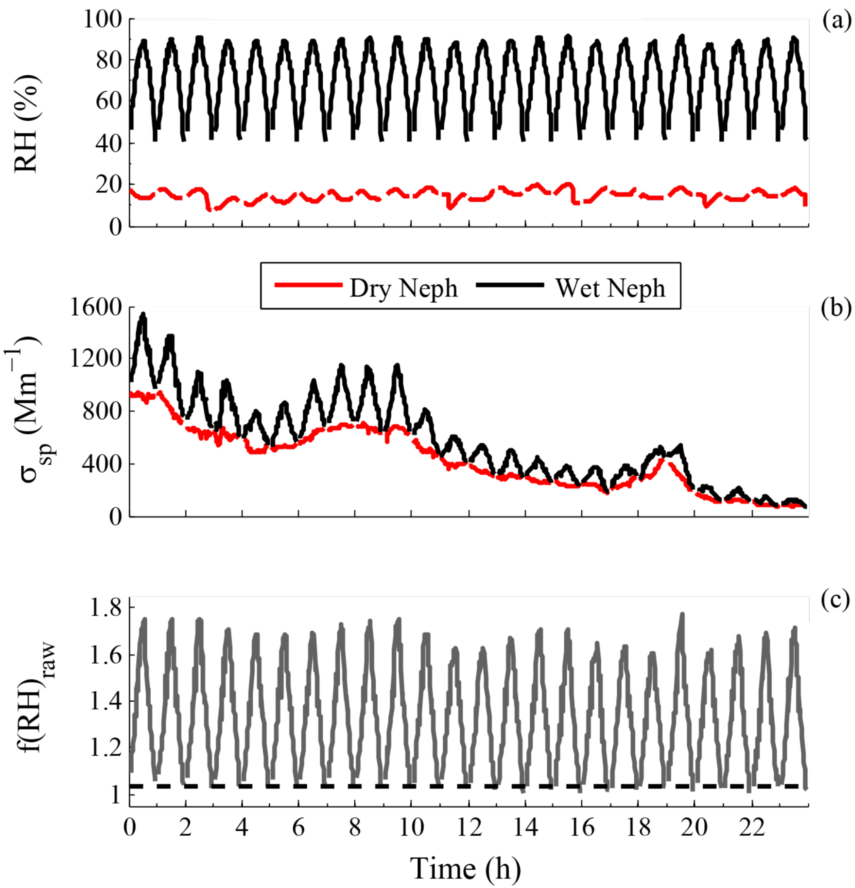

Fig. 1. Example of recorded data on 17 March 2013

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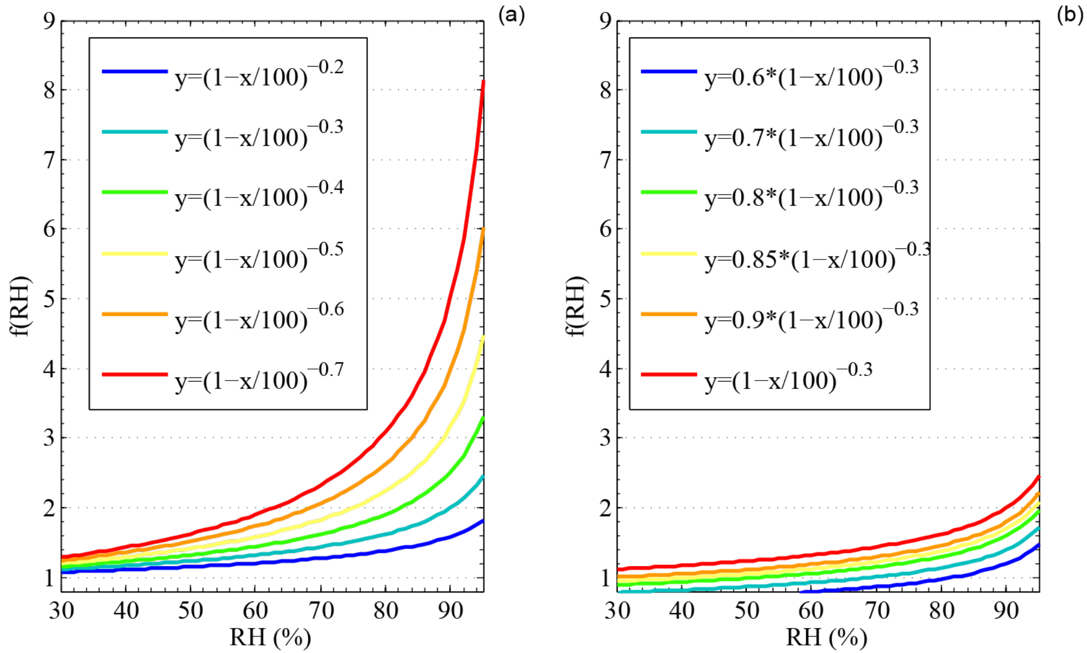

Fig. 2. Sample curves of f(RH)=c*(1-RH)-g with various c and g.

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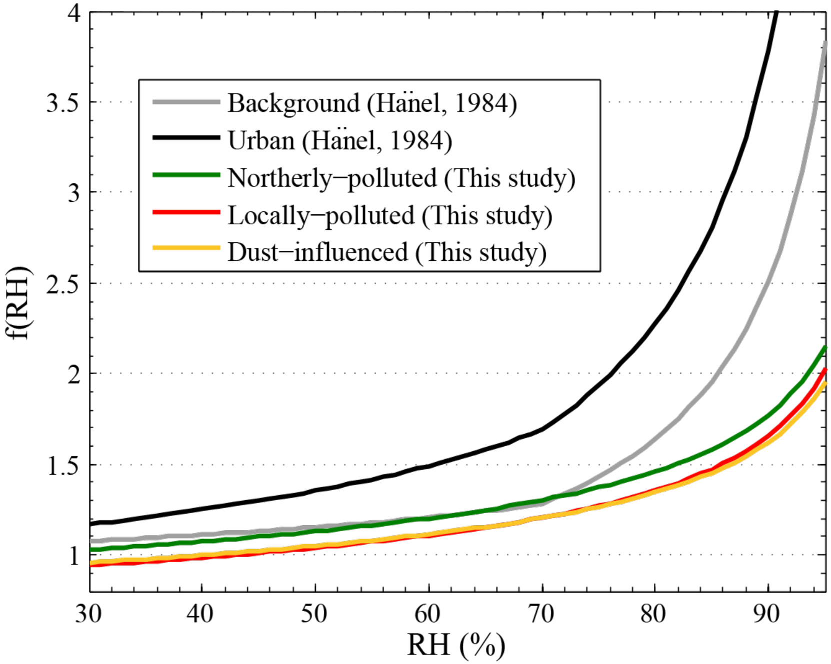

Fig. 3. Fitting curves of humidograms of Hänel and this study.

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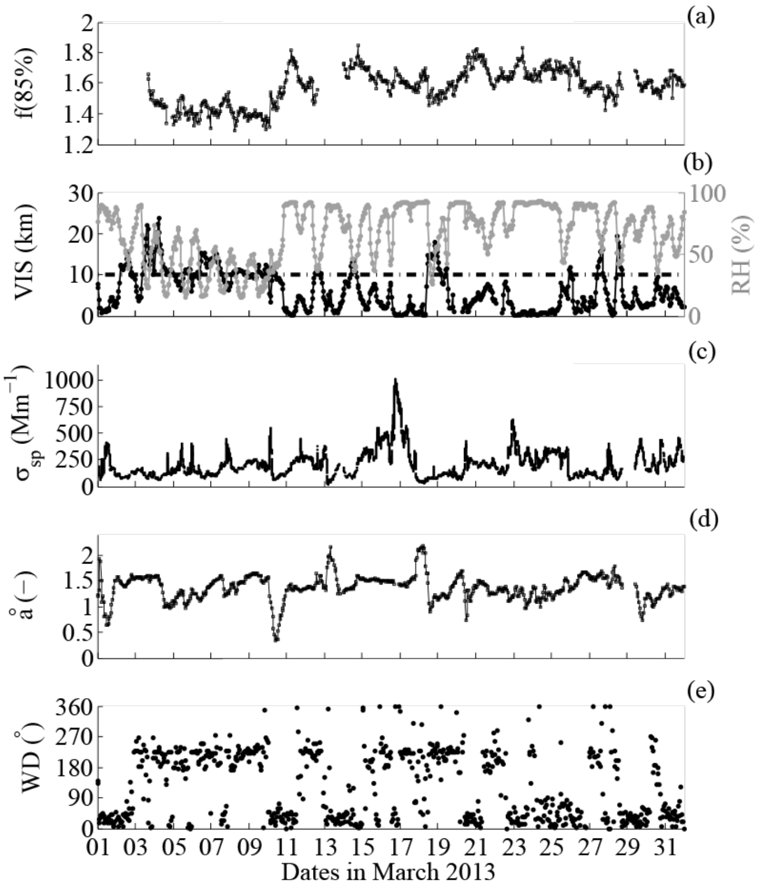

Fig. 4. Time series of measured and derived aerosol variables, as well as the ambient RH and visibility.

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