Reviewer #1:

Anonymous Referee #1

Received and published: 7 September 2016

This manuscript presents surface aerosol optical properties based on two years of measurements by an Aethalometer and a Nephelometer at an urban site in Nanjing. Authors analyzed their seasonal to diurnal variability and discussed their relationships with relative humidity, wind direction, and visibility. Overall this manuscript is clearly written. Its study provides an important observation-based characterization of aerosol properties over the study area. Meanwhile, manuscript could be further improved in a few aspects as I comment below.

To Referee #1:

Dear reviewer, thank you very much for reviewing the manuscript and providing us the constructive comments and suggestions on our study. We have learned a lot from your advices. With respect to your comments, necessary revisions of the paper have been made. We will response to your comments carefully point by point; details of the revisions can be referred to the revised version of the manuscript.

Relevant changes of the revised manuscript are listed in the last page.

Major comments:

1. The first impression from reading through the manuscript is that it presents so many numbers that readers could easily get lost. It is especially the case when it presents the literature survey in the Line 70 – 91. I would suggest summarize those number in a way that readers can better grab readers's interest, for example, presenting them in a Table. This is also related to my major comment #2 as below.

R: Thank you very much for your suggestion. We agree with you that so many aerosol optical properties here would make readers confuse and it would be more readable by presenting them in a Table. The numbers listed in these lines are mainly aimed at introducing current states and progresses in researching observed based aerosol optical properties over China. In view of most of these numbers are deeply discussed in the text and listed in the table, Line 70-92 have been rephrased and shortened in revised manuscript to avoid duplication.

2. It seems to me the content in the paragraph 345 – 367 closely relates to that in the Line 70 – 91. Why joint them together and put relevant numbers in Table 3?

R: Thank you for your question. As mentioned in comment #1 above, the numbers listed in Line 70-91 are aimed at introducing research progresses of the aerosol optical properties. To make comparisons of the surface aerosol optical properties between urban area of Nanjing and the other sites over China, these numbers as well as the results in this study are listed together in a table to make readers easier to read. And Line 345-367 are the corresponding statements of the table. Meanwhile, Line 70-91 in Introduction have been shorten in the revised version of the manuscript to avoid duplication.

3. Another major comments is about the RH effect on optical properties of hydrophilic particles. While water vapor is an important factor affecting the optical properties, this manuscript tends to overstate its role in the seasonal variability of aerosol optical properties. For example, higher SC, smaller AAE, and SAE in summer season are extensively attributed to the higher RH value. However, the seasonality of surface aerosol property is also influenced by the variability of PBL height, dry/wet deposition, and

aerosol emissions. The roles of these factors are rarely discussed in the manuscript.

R: In summer, both trace gases and particulate matters have lower emission rates as suggested by Zhang et al. (2009). Furthermore, PBL height and precipitation mostly have larger values in this season than those in other seasons. Thus, these three factors would likely result in smaller aerosol loadings in summer. However, SC in summer is larger than that in spring and fall and it was thought to possibly due to the effects of RH. Because: Zhang et al. (2015) indicated that SC and Bsp in YRD would increase by 50% and 25% as the RH increased from 40% to 85% and the increment would become larger if there were considerable amount of nitrate in fine particles. And nitrate in urban area of Nanjing accounts for more than 20% (as much as sulfate) of the total PM2.1 (Zhuang et al., 2014a). Emissions, PBL height and rainfall mainly affect the loadings of the aerosol (subsequently its scattering coefficient) instead of the sizes. Hygroscopic growth of aerosols caused by higher RH would lead to larger aerosol sizes, hence smaller Ångström exponent. Therefore, the RH effect is important in summer. Corresponding statement and discussion above have been included in revised manuscript in Section 3.

References:

Zhang, Q., Streets, D. G., Carmichael, G. R., He, K. B., Huo, H., Kannari, A., Klimont, Z., Park, I. S., Reddy, S., Fu, J. S., Chen, D., Duan, L., Lei, Y., Wang, L. T., and Yao, Z. L.: Asian emissions in 2006 for the NASA INTEX-B mission, ***Atmos. Chem. Phys.***, 9, 5131–5153, doi:10.5194/acp-9-5131-2009, 2009.

Zhang, L., Sun, J. Y., Shen, X. J., Zhang, Y. M., Che, H., Ma, L. Q., Zhang, Y. W., Zhang, X. Y., and Ogren, J. A.: Observations of relative humidity effects on aerosol light scattering in the Yangtze River Delta of China, ***Atmos. Chem. Phys.***, 15, 8439–8454, 2015.

Zhuang, B. L., Wang, T. J., Li, S., Liu, J., Talbot, R., Mao, H. T., Yang, X. Q., Fu, C. B., Yin, C. Q., Zhu, J. L., Che, H. Z., and Zhang, X. Y.: Optical properties and radiative forcing of urban aerosols in Nanjing, China, ***Atmos. Environ.***, 83, 43–52, 2014a.

Specific comments:

52–56: The radiative forcing results should be updated to the latest IPCC report, i.e., the 5th AR.

R: Thank you for your suggestion. The radiative forcing of all aerosols and black carbon aerosol from 5th IPCC have been used in the revised manuscript.

200: Are the measurements from this single site able to represent the “urban area of Nanjing”? Please justify.

R: Thank you for your question. We believe that the site can represent the urban area of Nanjing. Firstly, it's located in the down town area of Nanjing. And more important, it is built on the roof of a 79.3 m-tall building instead of the surface to avoid the local influences (such as: the block) below the urban canopy as far as possible. Second, there almost have no higher buildings around and there are no industrial pollution sources within a 30 km radius around the site. Third, due to its good representation, trace gases (such as: Hg^g, CO_2, CO, O_3, NOx, NOy) and aerosols (such as: Hg^p, BC, PM) in urban areas of Nanjing were well observed regularly and in seriously polluted episodes. Some of them have been published as followed:

Han, Y., Y. H. Wu, T. J. Wang, B. L. Zhuang, S. Li, K. Zhao (2015), Impacts of elevated-aerosol-layer and aerosol type on the correlation of AOD and particulate matter with ground-based and satellite measurements in Nanjing, southeast China, ***Science of the Total Environment***, 532, 195-207, doi: 10.1016/j.scitotenv.2015.05.136.

Han, Y., Y. H. Wu, T. J. Wang, C. B. Xie, K. Zhao, B. L. Zhuang, S. Li (2015), Characterizing a persistent Asian dust transport event: Optical properties and impact on air quality through the ground-based and satellite measurements over Nanjing, China, ***Atmospheric Environment***, 115, 304-316, doi: 10.1016/j.atmosenv.2015.05.048.

Huang, X. X., T. J. Wang, R. Talbot, M. Xie, H. T. Mao, S. Li, B. L. Zhuang, X. Q. Yang, C. B. Fu, J. L. Zhu, X. Huang, R. Y. Xu (2015), Temporal characteristics of atmospheric CO2 in urban Nanjing, China, ***Atmospheric Research***, 153, 437-450, doi:10.1016/j.atmosres.2014.09.007.

Li, S., T. J. Wang, M. Xie, Y. Han, B. L. Zhuang (2015), Observed aerosol optical depth and angstrom exponent in urban area of Nanjing, China, ***Atmospheric Environment***, 123, 350-356, doi: 10.1016/j.atmosenv.2015.02.048.

Zhu, J., T. J. Wang, R. Talbot, H. Mao, X. Yang, C. Fu, J. Sun, B. L. Zhuang, S. Li, Y. Han, M. Xie (2014), Characteristics of atmospheric mercury deposition and size-fractionted particulate mercury in urban Nanjing, China, ***Atmos. Chem. Phy.***, 14, 2233-2244.

Zhu, J., T. Wang, R. Talbot, H. Mao, C. Hall, X. Yang, C. Fu, B. L. Zhuang, S. Li, Y. Han, X. Huang (2012), Characteristics of atmospheric Total Gaseous Mercury (TGM) observed in urban Nanjing, China, ***Atmos. Chem. Phys.***, 12, 12103-12118.

Zhuang, B. L., T. J. Wang, J. Liu, Y. Ma, C. Q. Yin, S. Li, M. Xie, Y. Han, J. L. Zhu, X. Q. Yang, C. B. Fu (2015), Absorption coefficient of urban aerosol in Nanjing, west Yangtze River Delta, China, ***Atmos. Chem. Phy.***, 15, 13633-13646.

Zhuang, B. L., T. J. Wang, J. Liu, S. Li, M. Xie, X. Q. Yang, C. B. Fu, J. N. Sun, C. Q. Yin, J. B. Liao, J. L. Zhu, Y. Zhang (2014), Continuous measurement of black carbon aerosol in urban Nanjing of Yangtze River Delta, China, ***Atmos. Environ.***, 89, 415-424.

Zhuang, B. L., T. J. Wang, S. Li, J. Liu, R. Talbot, H. T. Mao, X. Q. Yang, C. B. Fu, C. Q. Yin, J. L. Zhu, H. Z. Che, X. Y. Zhang (2014), Optical properties and radiative forcing of urban aerosols in Nanjing, China, ***Atmos. Environ.***, 83, 43-52.

221: “moisture absorption growing” –> “water-uptake growth” or “hydroscopicity”

R: It has been changed to "hygroscopic growth" in revised manuscript.

273–274: It is neither persuasive nor clear to the reviewer to say “SSA is also large in afternoon possibly because the dilution effect of well developed boundary layer on scattering aerosol is weaker than that on absorbing aerosols.” Please justify or present more clearly.

R: Thank you for your comments. The sentences have been rephrased in the revised manuscript to make them more clearly.

Technical corrections:

17: than –> than aerosols

R: Corrected.

58: is mostly resulted from –> mostly results from

R: Corrected.

61: are corrected based on –> are based on

R: Corrected.

63: among –> among countries in

R: Corrected.

69–70: “Uncertainties in . . . the rest of the world.” –> “Uncertainties of the aerosol radiative forcing and corresponding climate effects in these regions might be much larger than those of the rest of the

world.”

R: Corrected.

188: were directly –> , which were directly

R: Corrected.

201: the scattering aerosols’ optical properties –> aerosol scattering properties

R: Corrected.

207: might be mostly resulted from –> might result from

R: Corrected.

375: 0.87 –> 0.78

R: Corrected.

Relevant changes in revised manuscript:

Author affiliations: #1 and #3 are merged together. The last one is changed to "Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, Michigan, USA"

In third paragraph of Introduction: Introductions on the aerosol optical properties in lines 70-91 in original manuscript are rephrased and shortened to avoid duplication and confusing, based on the reviewers' comments and suggestions.

In first paragraph of Section 3.2: To make the text more readable, frequency values are listed in a new table (Table 3 in revised manuscript) and corresponding statement has been rephrased according to reviewers' comments.

In fourth paragraph of Section 3.4: Add more discussion on the effect of RH on the aerosol optical properties.

In third and fourth paragraph in Conclusion: According to reviewers' comments, discussions on the importance of the aerosol optical properties seasonal and diurnal variations have been added. Additionally, frequency analysis was shortened.

In Acknowledgements: The foundation number was changed in revised manuscript.

References: References listed and recommended in reviewers' comments were cited and listed in References section in revised manuscript.

In Figure captions: Fig. 8's caption was changed according to reviewers' comments.

Tables: Add a new table (Table 3) to summary the frequencies of the aerosol optical properties. Add a table caption in Table captions section. Table 3 in original manuscript is changed to Table 4.

Figures: Redraw Fig. 9b based on reviewers' comments.

Others: Correct the grammar, cite more references and re-organize some sentences throughout the manuscript according to reviewers' comments.