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Title: Impacts of Atmospheric Circulations on Aerosol Distributions in Autumn over East China: Observational Evidences
Author(s): Xiao-Yi Zheng et al.
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MS Type: Research Article

Response to the reviewers

We are grateful to the Editor and the two Reviewers for their precious times in reviewing our manuscript. The comments and suggestions of the Reviewers are very helpful and valuable. The issues raised by the reviewers have been addressed (in blue color) in the revised manuscript. Kindly find a point-by-point reply to the issues as follows (presented in blue color).

by Yunfei Fu
July 23, 2015

Reviewer #2:

Major concerns:

1. The patterns of circulation are not clear to me although it is stated that each type represents specific weather pattern associated with lower and upper atmospheric circulation. The authors should add some schematic highlights (arrows or other indicative marks in Figures 4, 5, and 7-15, so that the readers can identify easily the differences between the patterns listed in Table 1.

   Response: Thank you very much for your important suggestion. According to your suggestion, the schematic diagram which clearly show the general circulation characteristics of nine types are presented in the revised manuscript, the indicative marks in different colors represent for the weather system at different layer in the corresponding figure which is named as Figure 17.

2. Accumulation of air pollutants depends on the convergence of winds and the stable atmosphere that does not favor the outflow of air pollutants. The manuscript lacks such information in their analyses.

   Response: Many thanks for your crucial suggestions. Based on your request, the vertical cross section of vertical velocity and divergence of wind have added in the revised manuscript (Figure 1, Figure 5-6, Figure 8-16) to address the vertical movement of air flows and convergence of winds on each level. The results show

uniform descending flows prevails in the East China, moreover, the degree of the pollutant accumulation in the lower atmosphere is determined by the intensity of downward flows. Therefore, the divergence of wind field at different layer plays a key role in determining the column AOD. In the revised manuscript, the corresponding discussions can be found in Section 3 and 4.

Minor concerns:

1. Line 9 of Page 3287: There should be a '." after 'factors'.

   Response: Thank you for your nice reminder. We have corrected in the revised manuscript.

2. Line 12 of Page 3287: It is not right to say that meteorological parameters are under the control of circulation. For example, atmospheric circulation is influenced by temperature gradient.

   Response: Thank you for your reminder. We have corrected in the revised manuscript that meteorological parameters are closely associated with the circulations.

3. Last paragraph of Page 3287: The authors chose to study for October. Some background information should be given here: Usually what are the most polluted months among a year based on the measurements from other approaches? Is October the worst month or a relatively clean month? How about relative humidity in October since AOD is examined in this work.

Response: Thank you for these important suggestions.

(1) Due to the ground-based observational data in most area of East China are unavailable, we take Anhui Province in East China as an example to show the pollution level of each mouth based on the measurements from 80 meteorological observation stations. According to Yang et al (2013), the occurrence of haze, i.e. the frequent of haze, reached the maximum in October. Besides, according to Fig. 1A (1b), the visibility in October haze day (5.4km) is the lowest during the autumn. Consequently, October is a relative worse month. Since we focus on the season of autumn, October is undoubtedly selected as a representative month for investigation. The above discussion has been added in the last paragraph of the first section in the revised manuscript.

(2) We have added the information of relative humidity in Figure 2b in the revised manuscript. In Figure 2b, the relative humidity is around 55% for all years except 2001 and 2009, namely, the variation of the relative humidity is not evident.

Furthermore, as demonstrated by Twohy et al (2009), the elevated relative humidity can cause an increase of the AOD owing to its impacts on hydrophilic aerosols, whereas the correlation efficient between relative humidity and AOD is -0.4 during the study time and is not significant at the 0.1 significance level.

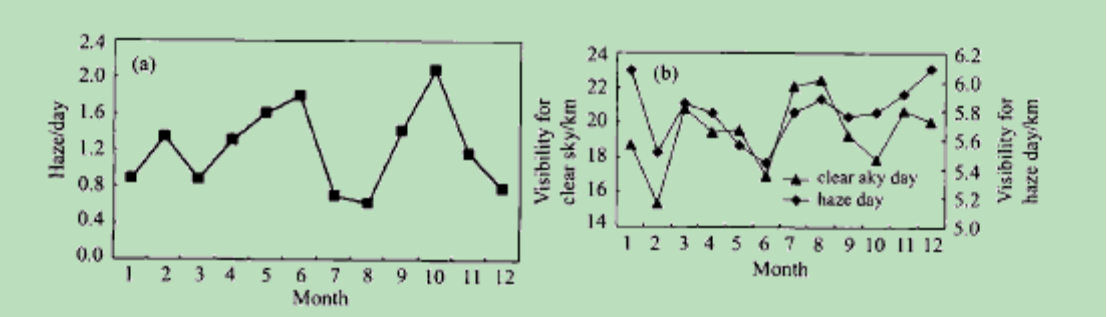

Fig 1A: The (a) number of haze day and (b) visibility for clear/haze day in each month averaged from 2001 to 2009 (From: Yang et al, 2013)

References:

1. Xin, J. Y., Zhang, Q., Wang, L. L., Gong, C. S., Wang, Y. S., Liu, Z. R. and Gao, W. K.: The empirical relationship between the PM 2.5 concentration and aerosol optical depth over the background of North China from 2009 to 2011, Atmos. Res., 138, 179-188, 2014.
2. Twohy, C. H., Coakley, J. A. and Tahnk, W. R.: Effect of changes in relative humidity on aerosol scattering near clouds, J. Geophys. Res., 114, D05205, doi:10.1029/2008JD010991, 2009.

4. Line 16 on Page 3291: What do you mean by 'stable correlation'? Explain.

Response: Thank you for the comment. Sorry for the ambiguous "stable correlation". In the revised manuscript, "close correlation" is used to describe the relationship between the SLP (sea level pressure) and surface meteorological factors.

5. Line 26 on Page 3291: What are the approximate concentrations of PM2.5 that correspond, respectively, to AOD values of 0.6 and 0.4 in October?

Response: Many thanks for your suggestion. As shown by Xin et al (2014), there is a high correlation between the daily observed PM2.5 concentration and aerosol optical depth (AOD) in North China, and the MODIS AOD were valuable and capable of retrieving the surface PM2.5 concentration as the linear regression function. Fig. 2A describes the linear regression function of autumn, and the correlation coefficient square R^2 is 0.57. According to the linear regression

functions of the monthly PM2.5 concentration (y) with the MODIS AOD (x): y = 161.37x + 7.80, when x=0.4, then y=72.34 and when x=0.6, then y=104.62, these two values corresponds to Moderate and Lightly Polluted respectively (as seen in following Table 1A). These also confirm that the definition of the AOD threshold is suitable for our study.

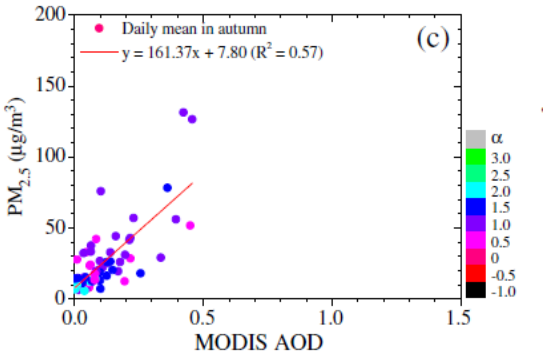

Fig. 2A: The scatterplots and the relationships between the PM2.5 concentration and the MODIS AOD at 550 nm in the autumn. (From: Xin et al, 2014)

AQI	$PM_{2.5}$(ug/m³)	Pollution level
0-50	0-35	Good
50-100	36-75	Moderate
100-150	76-115	Lightly Polluted
150-200	116-150	Moderately Polluted
200-300	151-250	Heavily Polluted
>300	>250	Severely Polluted

Table 1A. Air quality CLASS

References:

1. Xin, J. Y., Zhang, Q., Wang, L. L., Gong, C. S., Wang, Y. S., Liu, Z. R. and Gao, W. K.: The empirical relationship between the PM 2.5 concentration and aerosol optical depth over the background of North China from 2009 to 2011, Atmos. Res., 138, 179-188, 2014.

6. Caption of Figure 1 needs to be rewritten. Otherwise it reads as the mean distribution of (b) SD of AOD.

Response: Thank you for your nice reminder. We have corrected in the revised manuscript.

7. Lines 15-17 of Page 3293: Biomass burning can increase AOD because of the enhanced emissions. Such pollution can be identified from AOD but may not be caused by circulation. Does this influence conclusions from this work?

Response: Thank you very much for the important comment. Generally, temporal and spatial variation of the distribution of the AOD is controlled by synoptic patterns and the distributions of emission sources. In this manuscript, we suggested that the anthropogenic emissions are quasi-stable in the East China based on results issued by Xu et al. (2011) that the anthropogenic emissions of widespread pollutant sources are almost constant during a given season in China. As for the biomass burning generated by rural fires, our studies show that it does not influence the interannual variation of the AOD (Figure. 2b). For nine types concluded in the manuscript, we compared the types with almost same fire numbers to reduce the sudden influences from biomass burning and confirm the impacts of atmospheric condition, which added the in the revised Discussions and Figure 18. So, such pollution caused by the biomass burning in rural areas in the East China does not influence the conclusions from our study.

Reference:

Xu, W. Y., Zhao, C. S., Ran, L., Deng, Z. Z., Liu, P. F., Ma, N., Lin, W. L., Xu, X. B., Yan, P., He, X., Yu, J., Liang, W. D., and Chen, L. L.: Characteristics of pollutants and their correlation to meteorological conditions at a suburban site in the North China Plain, Atmos. Chem. Phys., 11, 4353-4369, doi:10.5194/acp-11-4353-2011, 2011.

8. Line 21 of Page 3292: Fig 1c actually shows clock-wise winds over selected region.

Response: Thank you for your careful reminder. We have corrected in the revised manuscript.

9. For the purpose of this work, it will be more interesting to show interannual variations in Fig 2b by giving daily AOD so that the readers can see year-by-year variation in pollution events.

Response: Many thanks for the valuable suggestion. According to your suggestion, we have changed daily AOD anomaly to the daily AOD in Figure 2a.

10. English needs to be improved; Chinese style English can be seen in many places

throughout the manuscript.

Response: Thank you for your nice reminder. We have corrected in the revised manuscript.