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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Understanding meteorological influences on $PM_{2.5}$ concentrations across China: a temporal and spatial perspective" *by* Ziyue Chen et al.

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Dear Referee:

Thanks so much for your valuable suggestions. We have fully revised the manuscript according to your suggestions in the revised manuscript. And we are willing to conduct further revision if you have additional requests.

This paper attempts to investigate the meteorological influence on PM2.5 concentrations in China at the national scale using a convergent cross-mapping (CCM) method. This method is somewhat new to the atmospheric chemistry community, but the physi-

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cal mechanism as discussed in this paper is very descriptive and already well-known. Overall I don't feel these results are significant enough to warrant publication in ACP. Here are my major concerns.

R: Thanks so much for pointing this out. Actually, the major aim of this research is to quantify the causality influence of individual meteorological factors on PM2.5 concentrations in 190 monitoring cities across China. The spatial and seasonal variations of meteorological influences on PM2.5 concentrations at a national scale have rarely been examined before. Meanwhile, previous studies for meteorological influences on PM2.5 concentrations at local and regional scale mainly employed the Correlation analysis, which can lead to mirage correlations and unreliable correlation coefficient, due to complicated interactions between different meteorological factors. Thus the use of CCM method has the advantage to remove potential influences from other variables when analyzing the bi-directional coupling between two variables. The comparison and patterns of calculated p value (quantitative causality influence) of individual meteorological factors on PM2.5 concentrations across China are the key findings for this research.

Yes, as you pointed out, the e physical mechanism We did not add the physical mechanism of PM2.5-meteorology relationship in the first version of manuscript. One reviewer in the first stage of ACPD review suggested this , and thus we added a brief discussion. However, in this round review, you and other referees all pointed out that this part was off the structure and was already well known to scholars with relevant background. So in the revised manuscript, according to your suggestions, we have deleted this part. And for other major issues you pointed out, e.g. the lack of multiple year analysis ,we have fully revised this manuscript accordingly and explained as follows. Thanks again for your valuable comments and we would like to make further revision in due stages if you have further requirements.

First, the authors just use the PM2.5 observations in one year, from Mar 2014 to Feb 2015, which is far from sufficient to draw any convincing conclusions. In Figure 2, they

evaluate the influence of 8 different variables on PM2.5 in each season. This means they make these conclusions using only 90 data values, which is far from enough. When the authors prepare this manuscript, observations in 2015 and 2016 should already be available. Why not include a longer time series of observations into this study?

R: This is a very good point. Long-term observation data are more likely to present reliable causality influence of 8 different variables on PM2.5 in each season, as one-year data may be influenced by abnormal meteorological conditions. So according to your suggestions, we managed to collect the PM2.5 and meteorological data from Mar 2014 to Feb 2017. In the revised manuscript, we have added additional two years' data for multiple-year analysis and thus a comprehensive CCM analysis based on three year's analysis has been conducted. Thanks again for pointing this out, as the inclusion of multiple-year analysis made the results more robust.

Second, the discussion of the scientific significance of this work looks very superficial and unprofessional. Throughout Section 5.1, the authors made a lot of descriptive statements with little reference. For example in Line 410-413, the authors claim that rising PM2.5 concentrations prevents the occurrence of winds. Is this true? Can the authors list some references? In my understanding, the effect of aerosols on wind occurrence is much smaller than that from synoptic circulation patterns.

R: Thanks so much for this valuable suggestions. As explained above, we also know that PM2.5-meteorology interactions, as you and another two referees pointed outïijŇ the mechanisms were well-known and may be off the focus of this manuscript. For this reason, we did not add this introduction of this part to the original manuscript. During the first stage of ACPD discussion, a referee kindly suggested that a brief introduction of PM2.5Âň-meteorology relationship can be added, and thus we provided a general introduction of mechanisms in the previous manuscript. In the revised manuscript, according to the suggestions of you and other referees, we have deleted this part to make the aim and key findings highlighted. In addition, according to the comments of

you and other referees, we have added some more in-depth discussion, concerning the potential applications of this research and underlying reasons for the large variations of meteorological influences on PM2.5 concentrations across China, has been added to the revised manuscript.

Although the PM2.5-meteorology interaction part has been removed, we would like to give some explanations on the example you suggested. Yes, we understood that synoptic circulation patterns were the major causes for wind occurrence and we are not claiming that the effects of aerosols were large enough compared with the synoptic circulations. We just pointed out that the potential mechanisms of the negative feedbacks of high PM2.5 concentrations

Yang et al. (2015) observed four haze episodes during Oct to Nov, 2014 and during these four haze episodes in the North China plain, the very high PM2.5 concentrations all led to stagnant condition and weak high-pressure systems, which further led to slowed wind speed and disturbed wind direction. This phenomenon was also observed by Liu et al. (2014) in haze episodes in Beijing in 2013. Very high PM2.5 concentrations induced haze episodes further led to stagnant and stable high-pressure systems, which made megacities serve as obstacles to significantly slow down the wind speed (Yang et al., 2015). Therefore, the effects of aerosols, especially high-concentration PM2.5 concentrations, prevented the wind occurrence mainly through indirect mechanisms.

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Liu, X. G., Li, J., Qu, Y., Han, T., Hou, L., & Gu, J., et al. (2013). Formation and evolution mechanism of regional haze: a case study in the megacity beijing, china. Atmospheric Chemistry & Physics, 13(9), 4501-4514.

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