Dear Editor,

We greatly thank the reviewers for their detailed review. Many valuable comments and suggestions were provided, for which we are grateful. Point-by-point responses addressing all the comments were uploaded (and also attached to this file). The manuscript has been revised and improved accordingly.

Best Regards

Chunsheng Zhao

Answers to Referee #1's comments and suggestions:

1) Page 3 line21-28, could author explain more clear about the difference (or definition) between haze and fog ? Hazy or foggy days are judged by human naked-eye observation or by RH value? If the hazy and foggy data were judged by same unified standard (or definition) over the 30 year?

Thank you for these questions. Fog events mostly occur during early morning, rarely lasting until 14 LT. Therefore, a day was defined as a foggy day if the occurrence of fog was recorded at any time during the day. Fogs were recorded according to the Chinese operational standard of RH>90% and visibility<1 km. The same standard has been used during1981-2010 in the area of our study.

Low visibility events (days with visibility at 14 LT below 10 km) that were not associated with fog, precipitation, dust storm, smoke, snow storm etc. were defined as haze events.

The same standards has been used over the entire time range for the determination of haze events, posing no influence on our trend analyses. To make this clearer, we added the above information to the manuscript.

2) Page 9 line 3, could author give more evidences that the low wind speeds are caused primarily by the Taihang Mountains?

Pan et al. (1991) studied the wind resource in the in the Taihang Mountains. The wind speed significantly decreases from west to east in the Taihang Mountain region, which sufficiently proves that the low wind speeds near the eastern edge of the mountain is caused primarily by the Taihang Mountains.

3) Page 9 line 30 : 8 am should be 8 a.m.

Thank you for the suggestions. To use unified time formats, we changed all 8 am to 8h (LT).

4) Page 9 at section 3.3.2: the author just give out the 1000 hPa wind field during a continuous fog event that occurred between the 9th and 19th Dec 2002 to explain the impact of wind on fog, and mention the wind convergence is the important factor, the question is the wind convergence

occurred just in this specific case or is this usually events in the North China Plain? It seems the section 3.3.2 is not sufficient to explain the impact of wind on fog.

We appreciate this valuable comment. The orographic wind convergence line is a common phenomenon for fog events. To prove that this is not a special case, we selected 58 fog days in the time range of Jan 2009 to Feb 2010, during which over 10 stations reported the occurrence of fog, and averaged the according 8h (LT) 1000 hPa NCEP final analysis wind field. The result is displayed in the revised figure 5, as is shown below:

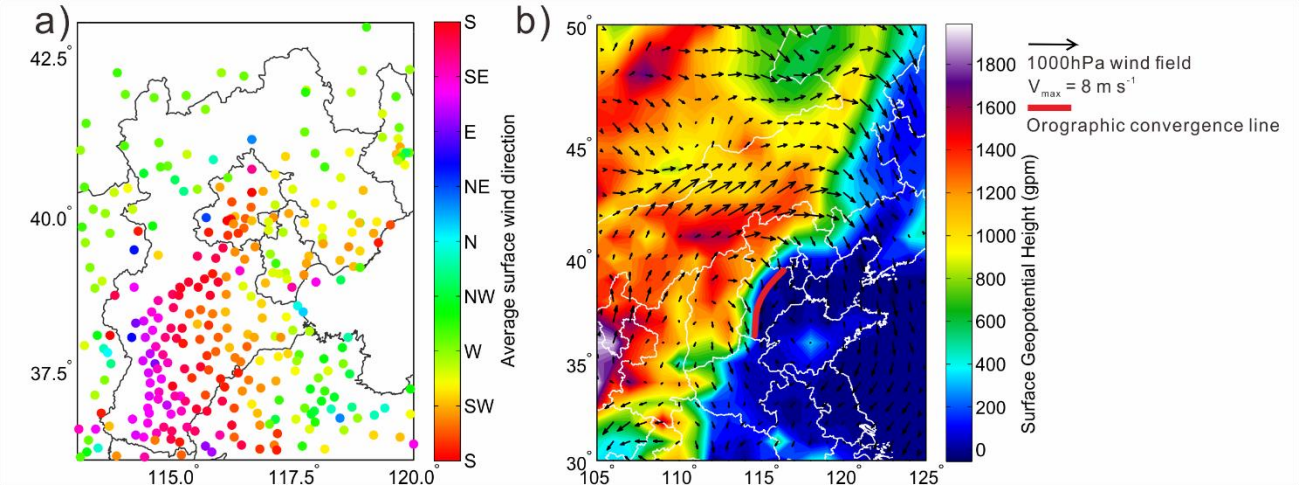

Figure 1 a) Averaged 14h surface wind direction during May-Dec 2009 given by 307 AWS stations. b) The orographic geopotential height above sea level (shading), the average 8 a.m. (LT) 1000 hPa NCEP final analysis wind field (black arrows) and orographic convergence line (red line) of 58 fog days during Jan 2009 - Feb 2010.

Similar to our case study in the former manuscript, the average wind field of the 58 fog days also clearly shows the wind convergence line, which supports our conclusions. The discussion on Figure 5 in the revised manuscript was accordingly altered.

5) Page 11 line 12: Significant increasing trends can be found in the ratio of haze event RH and average RH at all four stations (Figure 9a), the phenomenon is true or not depend on the hazy and foggy data used, only make clear about question 1) can explain the phenomenon.

Thank you for the careful inspection. Since we already explained in question 1) that unified standards were used throughout the 30 years, we believe that this phenomenon really does exist.

6) Page 24 Figure 8 which does not appear in main manuscript? It seems the color scale ruler is not an appropriate unit for RH. Here I suggest to show one more figure of the average RH on foggy days. I guess the distribution of RH maybe better explain the difference distribution between haze and fog as showed in Figure 2 c) and d).

Thank you for pointing this out. We neglected to change the figure caption of Figure 8. Figure 8 displays the distribution of the count of days with RH>70% and the distribution of the count of haze days with RH>70%. We added a paragraph to Sect. 3.4 to discuss Figure8:

"The distribution of the count of days with 14h (LT) RH > 70% and the count of haze days with 14h (LT) RH > 70% are depicted in Figure 8. High RH days most frequently occur in the southeast, where there is a water vapour transport passageway, and along the orographic wind convergence line, which was observed to be favourable for the formation of fog events in Sect. 3.3.2. The distribution of the count of haze days with 14h (LT) RH > 70% (Figure 8b) is similar to that of the count of all days with 14h (LT) RH > 70% (Figure 8a), only with significantly less counts to the east of Shijiazhuang, because haze is not as severe in that region. Compared with the distribution of the total counts of low visibility and haze days (Figure 2b-c), it can be noted that the frequent low visibility events along the southern edge of the Taihang mountain were caused primarily by the heavy aerosol pollution and not by haze events associated with high RH. The low visibility events in the vicinity of Shijiazhuang, however, was not only caused by severe pollution but were also associated with high RH events, indicating that the hygroscopic growth of aerosols plays an important role in the visibility impairment in this region. Although aerosol pollution is not as severe in the south-eastern part of our area of study, a large fraction of haze days are associated with high RH events, suggesting that the high RH in this region is able to impair visibility even if the aerosol concentration is not very high. The hygroscopic growth induced light scattering of aerosols plays a dominant role in the degradation of visibility in this region."

Since we only have the 14h RH data, however, fogs usually appear during nighttime or early morning and that was way it was not possible for us to plot the average distribution of RH during fog events.

7) Here I suggest to add RH analysis on continuous fog event that occurred between the 9th and 19th Dec 2002 at section 3.4.

This is a very good suggestion. However, as was mentioned in question 7), we only have the 14h RH data and not those associated with the fog events. According to our determination standard, fogs were always accompanied by high RH reaching over 90%. Although the super-saturation of water vapour (high RH) is what has directly led to fogs, we were concerned more with what has caused this super-saturation, namely the meteorological and orographic impact on fog formation, rather than how the RH influences individual fog events.

Reference:

Pan, Y. S., Wang, X. Y., Yan, G. B., Song, Y. C., Sun, Z. Q., and Wu, Z.: Observation and Study of the wind power resources in Taihang Mountain area in Hebei Province, Journal of Hebei Agricultural University, 14, 59-64, 1991.

Answers to Referee #2's comments and suggestions:

1) The operational observation standards for foggy and hazy day by China Meteorological administration have changed during the passing decades. As for trends analysis, are there any considerations/treatments to avoid the difference caused by the different standards?

We understand the concern of the reviewer and are grateful that this was pointed out. We confirmed that the operational standard was changed in 2014 for the stations in our study, thus not influencing the time range of 1981-2010. The same standard is applied throughout the entire analysis for determining fog and haze days.

2) Figure 8 does not appear in the main text and the color scale ruler is not consistent with RH Unit. The units of vertical and horizontal axis is also missing in Figure 8, as well as that in figure 5 and figure 6.

Thank you for pointing out our negligence. The units of the figures have been corrected/added and discussions on Figure 8 were added to Sect. 3.4 of the revised manuscript as is given below:

"The distribution of the count of days with 14h (LT) RH > 70% and the count of haze days with 14h (LT) RH > 70% are depicted in Figure 8. High RH days most frequently occur in the southeast, where there is a water vapour transport passageway, and along the orographic wind convergence line, which was observed to be favourable for the formation of fog events in Sect. 3.3.2. The distribution of the count of haze days with 14h (LT) RH > 70% (Figure 8b) is similar to that of the count of all days with 14h (LT) RH > 70% (Figure 8a), only with significantly less counts to the east of Shijiazhuang, because haze is not as severe in that region. Compared with the distribution of the total counts of low visibility and haze days (Figure 2b-c), it can be noted that the frequent low visibility events along the southern edge of the Taihang mountain were caused primarily by the heavy aerosol pollution and not by haze events associated with high RH. The low visibility events in the vicinity of Shijiazhuang, however, was not only caused by severe pollution but were also associated with high RH events, indicating that the hygroscopic growth of aerosols plays an important role in the visibility impairment in this region. Although aerosol pollution is not as severe in the south-eastern part of our area of study, a large fraction of haze days are associated with high RH events, suggesting that the high RH in this region is able to impair visibility even if the aerosol concentration is not very high. The hygroscopic growth induced light scattering of aerosols plays a dominant role in the degradation of visibility in this region."