Response to Review #1

Summary: Yin et al. have found a high correlation (0.51) between the early winter haze days in the North China plain and the September-October sea ice in the west of the Beaufort Sea. Further analysis revealed that the sea surface temperature anomalies over the Bering Sea and Gulf of Alaska acting as a bridge that linked the variations of haze days and sea ice. This is interesting, also important for us to understand the causing of the changes of haze pollutions over China in recent years. I recommend it to be accepted by ACP after several corrections.

1. **In recent years, there are increasing works referring to the impact of climate change on the haze pollution over China. The authors should present updating review on these new papers in the introduction.**

Reply:

The impact of climate change on haze pollution in China was a meaningful scientific issue and were paid attentions in recent years. Some related publications were cited now to update the introduction.

Revision:

…For the long-term trend of number of haze days, human activities are the recognized and fundamental driver (Li et al., 2018; Yang et al 2016; Chen et al., 2018; Zhang et al., 2018)…

…By the sensitive experiments, Li et al. (2017) emphasized the impacts of ASI anomalies on haze pollution in North China, but deemphasized the role of ENSO (He et al., 2019)…

Supplemented new papers:

Chen, H. P., Wang, H. J., Sun, J. Q., Xu, Y. Y., and Yin, Z. C.: Anthropogenic Fine Particulate Matter Pollution Will Be Exacerbated in Eastern China Due to 21st-Century GHG Warming, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-761, in review, 2018.

He, C., Liu, R., Wang, X. M., Liu, S. C., Zhou, T. J., Liao, W. H.: How does El

Niño-Southern Oscillation modulate the interannual variability of winter haze days over eastern China? Science of the Total Environment, 651, 1892–1902, https://doi.org/10.1016/j.scitotenv.2018.

10.100, 2019.

Zhang, Q. Q., Ma, Q., Zhao, B., et al.: Winter haze over North China Plain from 2009 to 2016: Influence of emission and meteorology, Environmental Pollution, 242: 1308–1318, 2018.

2. **Line 46: The reference here is not found in the reference list. "2017" may be "2016"?**

Reply:

The error was revised.

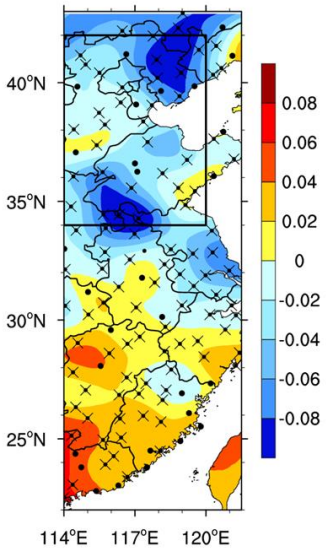
Revision:

…but the rapid ASI decline also contributed to the trend of number of haze days in the North China Plain after 2000 (Wang and Chen 2016)…

3. **Some information for the site observation should be clear. For example, how many meteorological sites used here? as well as the number of monitoring sites for PM2.5. How to deal with the missing values.**

Reply:

(1) The sites used here was shown in Figure 1. The cross (dot) indicated that the HDJ accounted for more (less) than 70% of the total winter haze days.



(2) More information were added. The number of meteorological sites were used to calculated the HDJ_{NCP} was 38, and the number of $PM_{2.5}$ sites were 162.

(3) The sites with missing values >5% was discarded, the others were kept in the datasets.

Revision:

In this study, we focused on the HDJ in the NCP region (HDJ_{NCP}, i.e., mean of the 38 sited HDJ) and its connection with the autumn ASI.

The hourly $PM_{2.5}$ concentration data were provided by the Ministry of Environmental Protection of China, including 162 sites in the North China.

4. The definition of the haze pollution should be clear.

Reply:

The definition of haze was added in the manuscripts.

Revision:

That is, if the visibility was lower than 10km and the relative humidity was drier than 90%, the day was defined as one haze day after filtering the other weather affected visibility (i.e., precipitation, dust, sandstorm, etc.).

5. Line 84-85: This expression here is not correct. Here, just the number of haze days is highlighted, not the synoptic process.

Reply:

The error was revised.

Revision:

The daily maximum of area-mean $PM_{2.5}$ in 2015 is shown in Figure 2b and was above 100 μg/m³. The ~~synoptic processes of haze~~ concentrations of $PM_{2.5}$ were relatively ~~weaker~~lower in January 2016 than those in December but still exceeded the threshold of pollution in China (i.e., 75 μg/m³). On 23 December, the most disastrous haze occurred, and the area-mean

6. Line 90-92: The linear trend here has been deleted or not? It should be clear here as well as in the figure caption.

Reply:

To emphasize the interannual variation, the linear trend was removed.

Revision:

…the correlation coefficients between the HDJ_{NCP} and the September-October sea ice were assessed after removing the linear trend (Figure 3)…

7. Line 105: the "heavy" used here is not correct, as well as in the other places throughout MS.

Reply:

The error was revised throughout the MS.

Revision:

The ~~heavy~~ positive sea ice anomalies, with high albedo, can efficiently reflect solar radiation and restore more fresh water, which could influence the local and adjacent SST. The correlation coefficients between BSISO and the simultaneous and subsequent SST were computed (Figure 5). Because of efficient reflections of the solar radiation, the locally negative SST anomalies, located near the west of the Beaufort Sea (70–81°N, 166°E–138°W), were ~~induced by~~associated with the ~~heavy~~ positive BSISO anomalies in October. In the following two months, these negative SST anomalies could not be sustained, i.e., these anomalous responses disappeared in November. However, the ~~induced~~ positive SST anomalies in the

8. As we all know, the wind is one of key factor that exerts impact on the haze pollution. Compared to the zonal wind, the meridional wind generally performs a greater role on the particulate dissipation. So, the influence of the sea ice on the meridional wind should be checked.

Reply:

The arrows in Figure 14a was the influences of the SST_{BA} on the surface wind and has included the meridional wind.

Furthermore, we also plotted the required Figures, but did not repeat it in the manuscript. The SST_{BA} was the bridge to connect the number of haze days and the sea ice anomalies. In the flowing Figure, the surface meridional wind showed significantly positive correlation with the SST_{BA}. The positive correlation indicate enhanced southerly anomalies, which weakened the cold air from the high latitude and make the dissipation conditions poor. Thus, the haze occurred easily.

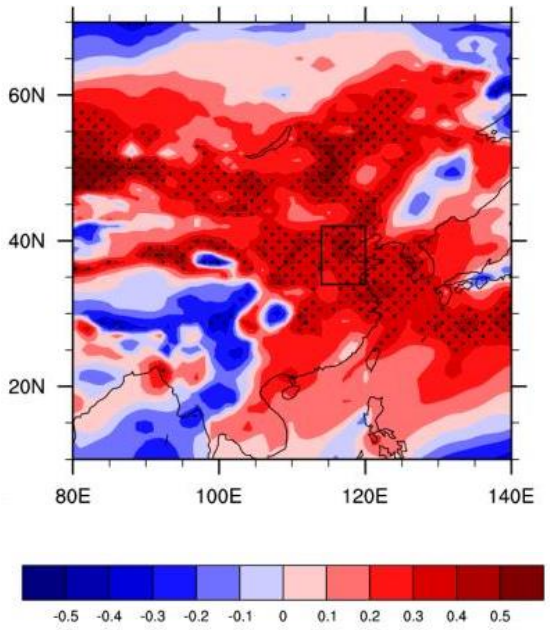


Figure. The CC between the November SST_{BA} and surface meridional wind, the black dots indicate that the CC exceeded the 95% confidence level

Revision:

cold air and ventilation conditions. Compared to the local zonal wind, the meridional wind played more important roles on weakening the horizontal dissipation conditions of the air (Figure omitted). The ~~induced~~ southerly anomalies were located over the coastal area of China and transported moisture to the NCP area (Figure 14a), providing moist air for haze formation.

9. What about the relationship between the local wind speed and Beaufort Sea ice/SST anomalies over the Bering Sea and Gulf of Alaska?

Reply:

We plotted the required Figures as follows. It is obvious that the relationship between the local wind speed and Beaufort Sea ice/SST anomalies over the Bering Sea and Gulf of Alaska was negative, but the relationship was not as significant as the meridional wind. (1) The wind speed anomalies associated with preceding sea ice/SST anomalies were negative. The smaller wind speed indicate poor horizontal dissipation conditions in the air, thus the particulates accumulated efficiently. (2) In weakening the horizontal dissipation, the changed of the meridional wind played more important roles.

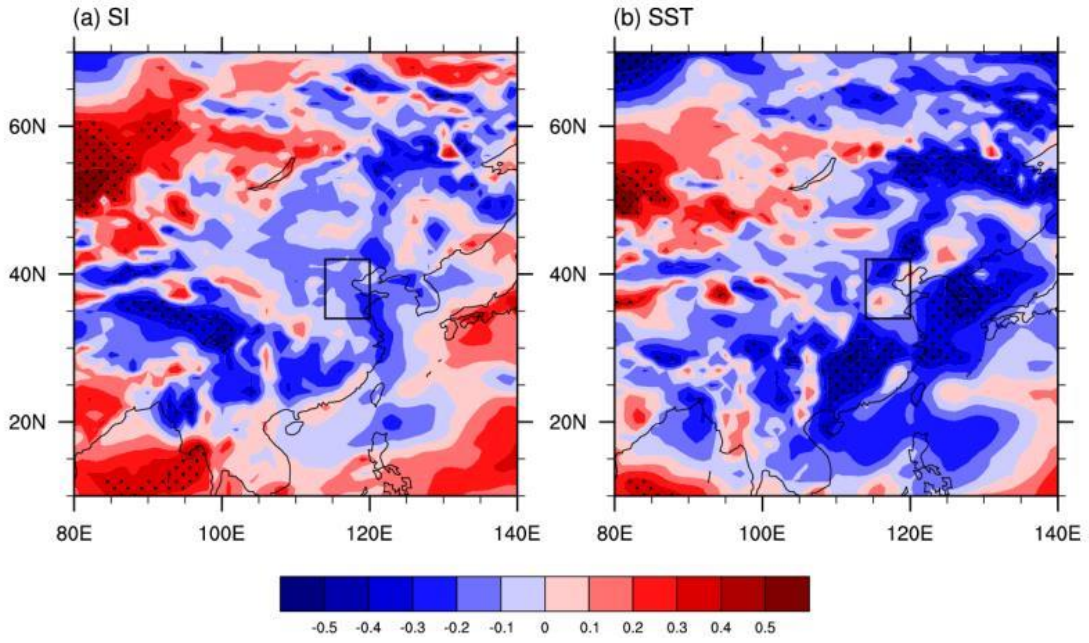


Figure. The CC between the (a) BSISO, (b) November SST_{BA} and surface meridional wind, the black dots indicate that the CC exceeded the 95% confidence level

Revision:

cold air and ventilation conditions. Compared to the local zonal wind, the meridional wind played more important roles on weakening the horizontal dissipation conditions of the air (Figure omitted). The ~~induced~~ southerly anomalies were located over the coastal area of China and transported moisture to the NCP area (Figure 14a), providing moist air for haze formation.

10. The English writing should be further improved.

Reply:

The English has been improved the native speaker.