Comment on acp-2020-823:

The manuscript titled "Atmospheric transmission patterns which promote persistent winter haze over Beijing" attempted to illustrate the relationship between North Atlantic oscillation and persistent haze in winter in Beijing, especially on the intraseasonal time-scale. Although the topic is interesting, many major revision must be revised.

Response: *Thanks for your comments. We have revised the manuscript according to your remarks, and our point-by-point responses to the comments are listed in detail below.*

Major comments:
Title: Possibly, the title is not accurate. From your title, I cannot read any valuable information about the NAO pattern that you focused on. I strongly suggest you to rephrase your title of this manuscript.

Response: *You make a good point here. Yes, this paper highlights the important role of NAO on atmospheric transmission patterns, but this is not reflected in the title. Therefore, we have revised the title of this paper in the revised version to better reflect the focus of this study. The title is now 'Linkages between the atmospheric transmission originating from the North Atlantic Oscillation and persistent winter haze over Beijing'.*

Line 17: "This study focuses mainly on the role of the NAO+ pattern, because the NAO index shows a closer relationship with winter haze frequency, especially after 1999". However, I did not find any physical explanations about this arguments that you emphasized in the Abstract and that seemed to be the reasons why you did this research.

Response: *We appreciate the point you are making here. We have removed this sentence in the Abstract, since we did not explain this relationship. Instead, we now present one of the rationales for this research by adding this "This study mainly focuses on the role of the WNAO pattern, because the WNAO+ pattern acts as the origin of the atmospheric transmission, 8–10 days prior to the persistent haze events."*

Line 18–20: The intraseasonal relationship between North Atlantic oscillation and persistent winter haze in Beijing may be a new finding, although the interannual relationship has been revealed by many previous studies. As you argued, the relationship between NAO and haze is stronger after mid-1990s. Thus, can you composted this relationships using the observations of PM2.5 concentrations? As you known, the PM2.5 concentrations were widely observed since 2014.

Response: *Many thanks for this suggestion. However, there are two reasons why we do not use the PM2.5 concentration in our study. The first is that our study is conducted for the 37-year period of 1980-2016, while quality ground-based PM2.5 data is only available from 2013 (see Xue, W. et al., 2021: Spatiotemporal PM2.5 variations and its response to the industrial structure from 2000 to 2018 in the Beijing-Tianjin-Hebei region. Journal of Cleaner Production,* ***279****, 123742, doi: 10.1016/j.jclepro.2020.123742). Hence these data would overlap our interval for only four years*

(2013-2016). We do not believe that statistically robust conclusions could be reached with this short period. Xue et al. also made use of high resolution PM2.5 data which was derived via a regression algorithm applied to MODIS MAIAC satellite data. This set extended back to 2000 (and hence covered only half the period of interest here). Xie et al. also commented that the set needs to be treated with caution '... because it is limited by the statistical regression model, the estimation and prediction ability of the model still has some deviation, which may lead to certain differences in historical PM2.5 concentrations between satellite observations and the real situation'.

Secondly, we mainly consider the meteorological definition of haze which is defined by relative humidity and visibility. These two meteorological elements are more directly related to atmospheric circulations.

Data and Methods: The details of composite approach should be introduced. For example, how to determine day -10, day 0 and day 4 of a persistent haze events lasting for more than 5 days? and so on……

Response: *Thanks for pointing out the need to introduce this more carefully. We only mentioned "..., where Day 0 denotes the day with the minimum visibility within a persistent haze event". However, we did not make it very clear and mention it in the Data and Method Section. In the revised manuscript, we have added more details about this approach at the end of Section 2.2.*

Line 197–207: What is the differences between the definition of NAO and your LW03 NAO? It should be carefully illustrated and marked on Figures. Furthermore, I cannot understand the large differences of the correlation coefficients when you only change the definition of NAO. If this evident differences existed, the LW03 NAO you defined is still the NAO pattern? or something else?

Response: *We used the NAO index of NOAA/CPC and a modified LW03 NAO index in this study. The NAO index of NOAA/CPC is identified by the Rotated Principal Component Analysis (RPCA) technique. The LW03 NAO index is the difference of zonally-averaged (from 80°W to 30°E) SLP between 35°N and 65°N. One difference of our modified NAO index from the LW03 NAO index is that we do the zonal average from 80°W to 10°W. In the revised manuscript, we name this modified NAO index the Western-type NAO (WNAO) index. This NAO index better reflects the amplitude of a north-south dipole over the North Atlantic, which corresponds to the circulation pattern of the Beijing haze. Thus, it has a higher correlation with the haze frequency. Following the studies of Yao and Luo (2014) and Luo et al. (2014), we also call it a NAO pattern, but a more westward NAO pattern, the WNAO pattern. We have added more explanatios as to why we define this WNAO index in section 2.1.*

Line 207: I did not agreed that the connection between haze and EA/WR pattern is weaker. The correlation coefficients, listed from Line 205 to Line 210, have little difference. In addition, Line 210–219 cannot stand, as you showed decadal changes of connections between NAO/EAWR and haze.

Response: *Thanks for picking these things up. In the descriptions of the correlations between the winter haze days and the atmospheric teleconnections, we have changed 'NAO index' into 'WNAO*

index', since what we focused on is a western type NAO in this study.

Compared with the NOAA/CPC EA/WR index (0.36, $p<0.05$), the NOAA/CPC NAO index (0.27, $p<0.1$) has a weaker correlation with the winter haze days over the time period 1980-2016. However, our modified WNAO index has a higher correlation (0.42, $p<0.01$) with the winter haze days, that is, 0.06 higher than that of the EA/WR index (and a higher confidence level. We agree that to say 'the connection between haze and EA/WR pattern is weaker' is not accurate. Thus, in the revised manuscript, we have stressed out that it is the western type NAO that has a higher correlation with the winter haze days.

Moreover, over the time period 1980-1999, the correlation coefficient for EA/WR index (0.57, $p<0.01$) is much higher than that of the WNAO index (0.08), while over the time period 2000-2016, the correlation for EA/WR index (0.22) is much lower than that of the WNAO index (0.61, $p<0.01$). Both of these teleconnection patterns are essential in inducing the winter hazes, but they act on different time periods. In the revised manuscript, we now present a more objective description to show the comparison of their relationships with the winter haze days.

On the Lines 210–219, our purpose was to show that the WNAO index better corresponds with years with high and low haze days. Please note that we have removed 'the modified LW03 NAO index is better correlated with winter haze days in Beijing' in Line 218.

Section 3.2: the discussion about intraseasonal relationship needed rewrite to be more compact and clearer.

Response: *Thanks, we appreciate the point you are making here. In the revised manuscript, we have stressed the daily-to-weekly timescales instead of the intraseasonal timescale. We have rewritten the daily-to-weekly relationship in the conclusions and discussions. To make it more compact and clearer, we have removed some detailed descriptions on circulation evolutions and added the prediction part of winter haze.*

It might be better to move discussion about the impacts of sea surface temperature and Arctic sea ice Section Discussion, because you did not fully explained associated physical mechanisms.

Response: *Thank you for these very helpful suggestions. In the revised manuscript, we only briefly described the relationships between the SST, SIC and winter haze in Beijing in conclusions. The impacts of SST and SIC in the discussion have been removed. However, since SST and SIC are external forces for atmospheric circulations, we only added some further insights including SSTs and SICs.*

Line 478: the relationship between the subtropical Western Pacific SST and haze over North-Central North China Plain also contributed to the variation in haze of Beijing, as well as the Strengthening Relationship between Eurasian Snow Cover and December Haze Days in Central North China after the Mid-1990s.

Response: *Thank you for your comment. We have cited these two papers and they have enriched our literature research.*

Most of the Figure must be improved. Especially, the country boundaries should be carefully examined.

Response: *Thank you for this feedback on our graphics. We have improved most of the Figures and checked the country boundaries.*

The language must be improved by native speaker.

Response: *Thank you very much, we have asked a native English speaker to help us revise the language of the article.*

References:

Luo D., Yao, Y., and Feldstein, S.: Regime transition of the North Atlantic Oscillation and the extreme cold event over Europe in January-February 2012, Mon. Wea. Rev., 142, 4735–4757, doi:10.1175/MWR-D-13-00234.1, 2014.

Yao Y., and Luo, D.: Relationship between zonal position of the North Atlantic Oscillation and Euro-Atlantic blocking events and its possible effect on the weather over Europe. Sci. China. Earth. Sci., 57, 2628–2636, doi:10.1007/s11430-014-4949-6, 2014.

Xue, W. et al.: Spatiotemporal PM2.5 variations and its response to the industrial structure from 2000 to 2018 in the Beijing-Tianjin-Hebei region. Journal of Cleaner Production, 279, 123742, doi: 10.1016/j.jclepro.2020.123742, 2021.

Yin, Z., and Wang, H.: The relationship between the subtropical Western Pacific SST and haze over North-Central North China Plain, Int. J. Climatol., 3479–3491, doi:10.1002/joc.4570, 2016.

Yin, Z., and Wang, H.: The strengthening relationship between Eurasian snow cover and December haze days in central North China after the mid-1990s, Atmos. Chem. Phys., 18, 4753–4763, doi: 10.5194/acp-18-4753-2018, 2018.