

This study discussed the effect of Eurasian snow cover on December haze days. Recently, severe haze occurs in the broad area of China, and the discussion of the relationship between Eurasian snow cover on December haze days is helpful to understand the mechanism modulation the formation of haze. The topic is interesting and I have a few questions listed below:

1. **Line 124: The authors said “In contrast, the associated vertical velocity at the surface was upward, indicating an ascending motion near the surface.” I think the downward vertical velocity favors the haze formation due to weak dispersion conditions. The authors published a paper in 2017 (Atmos. Chem. Phys.,17, 11673–11681, 2017 <https://doi.org/10.5194/acp-17-11673-2017>), and in Figure 7, the omega was positive, and the authors stated that “Under their influence, there was a descending motion from 30 to 55\_ N (Fig. 7),” and claimed this condition support the severe haze. Thus, the statement regarding the vertical motion in this study is somewhat contradicts with the previous study.**

***Reply:***

We have corrected the discussions about the vertical motion.

1. There was significant **upward motion near surface (Figure 5a), indicating weak convergences of the aerosols discharged in the circumjacent regions.** Actually, in winter, the weak convergence near surface was a classical synoptic situation resulting in severe haze pollution. This convergence could transport the aerosols discharged in the surrounding to the CNC area, but cannot disturbed the shallow boundary layer. **The converging and local aerosols both accumulated and reached a high concentration.**
2. The description of the sinking motion on the **mid-high level** was not precise and has been **deleted** from this manuscript on the premise that the conclusions were not affected. In a recent study, we have found that **the vertical motions below different parts of the anti-cyclonic circulation were also different.** It is inaccurate to simply describe the associated vertical velocity as sinking or ascending motion. Thus, we are going to write a new manuscript to discuss the associated vertical motions.

### **Revisions:**

In “Possible physical mechanisms”

.....The associated vertical velocity at the surface was upward (Figure 5a), indicating weak convergences of the aerosols discharged in the circumjacent regions. However, due to the shallower planetary boundary layer (Figure 5a), the converging and local aerosols cannot be dispersed into the upper atmosphere. The local convergences, combined with the weak surface wind (Figure 5b), easily enabled aerosols to accumulate over the CNC area.....

~~The sinking motion caused by these anti-cyclonic anomalies could lead to the shallower planetary boundary layer (Figure 5a) and the rather weak dispersion capacity of atmospheric particulates. In contrast, the associated vertical velocity at the surface was upward (Figure 5a), indicating an ascending motion convergences of the aerosols discharge in the circumjacent regions. However, near the surface due to the shallower planetary boundary layer (Figure 5a), the converging and local aerosols cannot be dispersed into the upper atmosphere. The local rising air convergences, combined with the weak south surface wind (Figure 5b), easily enabled aerosols to accumulate over the CNC area. Near the surface, the positive SLP anomalies were situated in the east of China and the western Pacific (Figure 5c). The stimulated southerlies overlapped with~~

- 2. References: It is easier to read if a few spaces were left in front of the first line of each reference. Alternatively, a number can be used to separate each reference as well.**

### **Reply:**

The advice was adopted.

### **Revisions:**

~~under Climate Change. Nature Climate Change. doi:10.1038/nclimate3249.~~

~~Chen H. P., Wang H. J. 2015. Haze days in North China and the associated atmospheric circulations based on daily visibility data from 1960 to 2012. J. Geophys. Res. Atmos. 120(12): 5895–5909 DOI: 10.1002/2015JD023225.~~

~~Cohen J.L., Furtado J.C., Barlow M.A., Alexeev V.A., Cherry J.E. 2012. Arctic warming, increasing snow cover and widespread boreal winter cooling. Environ Res Lett 7:014007.~~

~~Cohen J, Barlow M, Kushner PJ, Saito K. 2007. Stratosphere and troposphere coupling and links with Eurasian land surface variability. J Climate, 20:5335–5343.~~

~~Dee D. P., Uppala S. M., Simmons A. J., Berrisford P., Poli P., Kobayashi S., Andrae U., Balmaseda M. A., Balsamo G.,~~

**3. Line 59: “Basing on” should be “based on”**

**Reply:**

The error has been corrected.

**Revisions:**

.....Zou et al (2017) also pointed out that there was close relationship between Eurasia snow and haze in China **based on** the observational and numerical analysis.....

**4. Line 100-103: The authors declared that “during P2, the snow cover with larger interannual variation was distributed widely and zonally”: do you have a figure displaying the distributions of the snow cover? It is hard to tell without a figure how the snow cover was spatially distributed.**

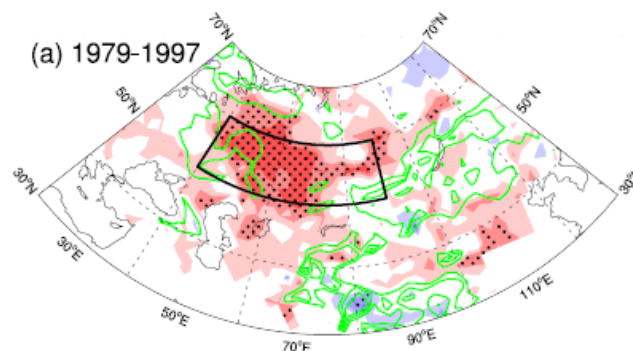
**Reply:**

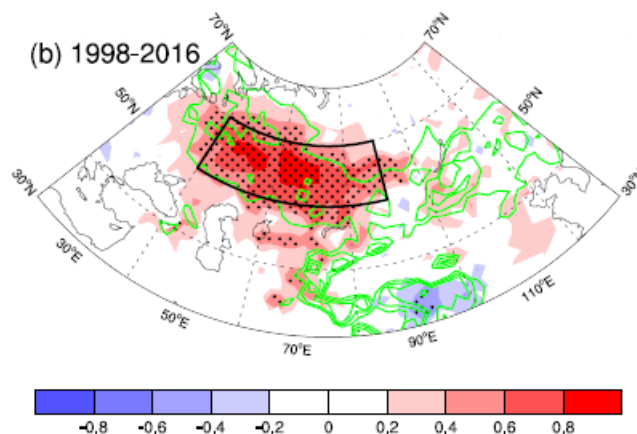
Due to our poor expression, there was some confusion. What we wanted to show was **the intensity of interannual variations**. In the revision, we clarified the intensity of the interannual variations was described by the **standard deviation in Figure 2 (green lines)**.

**Revisions:**

In “Strengthening relationship and associated atmospheric circulations”

.....However, during P1, the CC over the east part of the ES area was insignificant. **The intensity of the interannual variations (i.e., expressed by the standard deviation in Figure 2)** in snow cover over the Tibet Plateau and Mongolian Plateau were evident both during P1 and P2.....





**Figure 2** The CC between the SC<sub>ES</sub> and snow cover (a) from 1979 to 1997 and (b) from 1998 to 2016. The black dots indicate the CC exceeded the 95% confidence level (t test). The black box represents the ES area. The linear trend is removed. **The green lines indicate that the interannual variations in snow cover were obvious in this region.**

5. There are a few places which did not clearly mention the figure number, which makes it hard to follow. For example: Line 145: In the first paragraph of the section 4 “possible physical mechanisms”, the authors should mention **Figure 9** first, so the readers can follow the authors easily. Otherwise, it is hard to know which figure the authors are referring to. Line 176: RL1. . . , this information is from **Figure 11a**, so the authors should point out **Fig. 11a** immediately after the description.

**Reply:**

The error has been corrected. Furthermore, the similar errors were checked and revised throughout the manuscript.

**Revisions:**

In “Possible physical mechanisms”

.....The associated anomalous circulations tended to lead local meteorological conditions (e.g., higher BLH and more obvious surface wind speed) to favor ventilation (**Figure 8**), which was consistent with the 21-yr running CC in Figure 1a (i.e., negative before the mid-1990s).....

.....During P2, the SCES was significantly positively correlated with soil moisture around the Caspian Sea, Balkhash Lake, and Ural Mountains (**Figure 9**, RM1: 50–80°E, 40–60°N).....

.....this was denoted as RS1 (70–100 °E, 38–58 °N) and was mountainous (**Figure 11c**). In contrast, the regions that had significant and negative CCs and net longwave radiation were smaller and over the Pamir Mountains (**Figure 11a**, RL1: 67.5–90 °E, 36–45 °N). By contrast, the significant correlated regions with net longwave radiation (**Figure 11b**, RL2) and net shortwave radiation (**Figure 11d**, RS2) were the same and nearly overlapped with the ES area during P2, which was wider and had a zonal distribution.....

**6. Line 180: if there was more SCES, the absolute value of the net longwave radiation and net shortwave radiation would both be smaller. The signs of the correlations between SCES and net longwave radiation, SCES and net shortwave radiation are opposite. I am not sure why the absolute value of the net longwave radiation and net shortwave radiation would both be smaller when there was more SCES**

*Reply:*

**The upward radiation is positive.** Shown by the Figure below, the net surface short wave radiation was globally negative. However, the net surface long wave radiation was globally positive. Thus, the more significant positive correlation with short wave radiation and negative correlation with long wave radiation both meant the radiation reduced, i.e., the net shortwave and net longwave radiations were both reduced.

To make the analysis clearer, the writing was improved both in the section “dataset” and in the section “physical mechanism”.

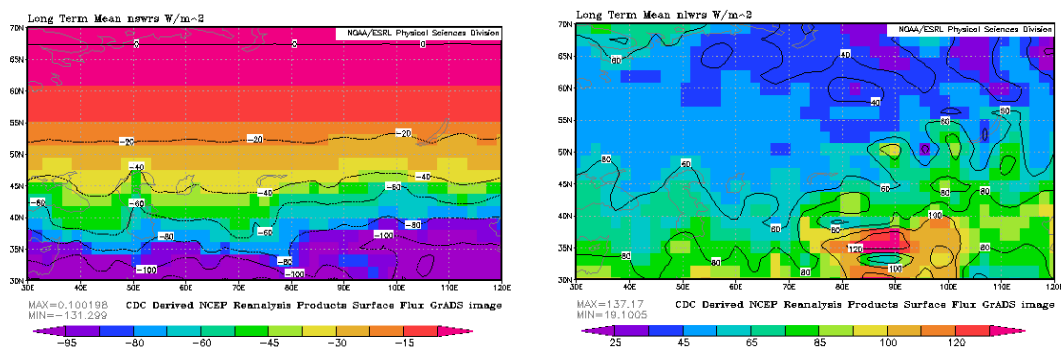


Figure the net surface short wave radiation (left) and net surface long wave radiation (right) in December, directly plotted by the website of NOAA/NCEP PSD

**Revisions:**

In “Datasets and methods”

.....the vertical wind, the **surface** net longwave radiation and the **surface** net shortwave radiation (**upward radiation is positive**) data were downloaded from.....

In “Possible physical mechanisms”

.....As a feedback, the outgoing longwave radiations emitted by the cooler land surface were weakened and had radiative cooling impacts on the atmosphere (Zhang et al. 2017). **That is to say: the absorbed shortwave and outgoing longwave radiations were both reduced.....**

.....According to the above analysis, if there was more SC<sub>ES</sub>, the net shortwave and net longwave radiations were both reduced, i.e., the absolute value of the net longwave radiation and net shortwave radiation would both be smaller.....

**7. Line 197: EAJS was shifted significantly northward Without a base location, how can this shift be identified?**

**Reply:**

The climatic distribution of U200 was showed below. The location of EAJS was around 30°N. In Figure 3, the U200 anomalies were negative near 30°N, but positive northward. Thus, EAJS was shifted significantly northward. If, we plotted the climatic distribution of U200 in the Figures of the manuscript, the Figures should become too complicated and take up too much space. After careful thought, the climatic distribution of U200 was still omitted.

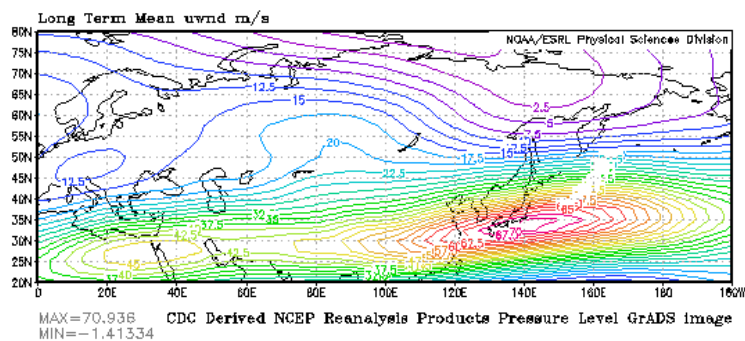


Figure the climatic distribution of U200, directly plotted by the website of NOAA/NCEP PSD

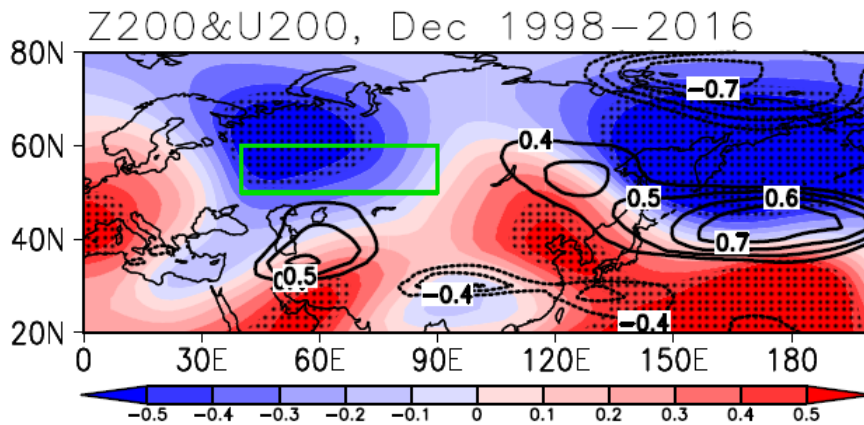


Figure 3 The CC between the SCES and Z200 (shading) and U200 (contour) in December from 1998 to 2016. The black dots indicate the CC exceeded the 95% confidence level (t test). The green box represents the ES area. The linear trend is removed.

**8. The figure qualities and descriptions of captions need to be improved: For example: Figure 1: CCdt, CCOS should be explained in the caption. A figure is in principle can be independent from the paper. Thus, one should get all the information from the figure or caption without searching from the main text.**

*Reply:*

The error has been corrected. Furthermore, the similar errors were checked and revised throughout the manuscript.

*Revisions:*

**Figure 1** (a) the variation of the normalized  $DHD_{CNC}$  (black) and  $SC_{ES}$  (blue) from 1979 to 2016 after detrending and the 21-yr running correlation coefficient (CC) between the  $DHD_{NH}$  and  $SC_{ES}$  before (solid, red) and after (dash, red) detrending. (b) The CC between the  $DHD_{CNC}$  and snow cover from 1979 to 2016 after detrending. The black dots indicate CCs exceeding the 95% confidence level (t test). The black box represents the ES area. **The subscript “dt” and “OS” in panel (a) represented the CC was calculated by the detrending and original sequence.**

**Figure 9** The CC between the  $SC_{ES}$  and soil moisture in (a) October-November and (c) December from 1979 to 1997, and in (b) October-November and (d) December from 1998 to 2016. The black dots indicate the CC exceeded the 95% confidence level (t test). The linear trend is removed. The green boxes (**RM1 and RM2**) are the significantly correlated areas, which were used to calculate the SoilM index.

**Figure 11** The CC between the  $SC_{ES}$  and (a) longwave radiation and (c) shortwave radiation in October-November from 1979 to 1997 and the CC between the  $SC_{ES}$  and (b) longwave radiation and (c) shortwave radiation in October-November from 1998 to 2016. The black dots indicate the CC exceeded the 95% confidence level (t test). The linear trend is removed. The green boxes (**RL and RS**) are the significantly correlated areas, which were used to calculate the  $I_{LS1}$  ( $I_{LS2}$ ).