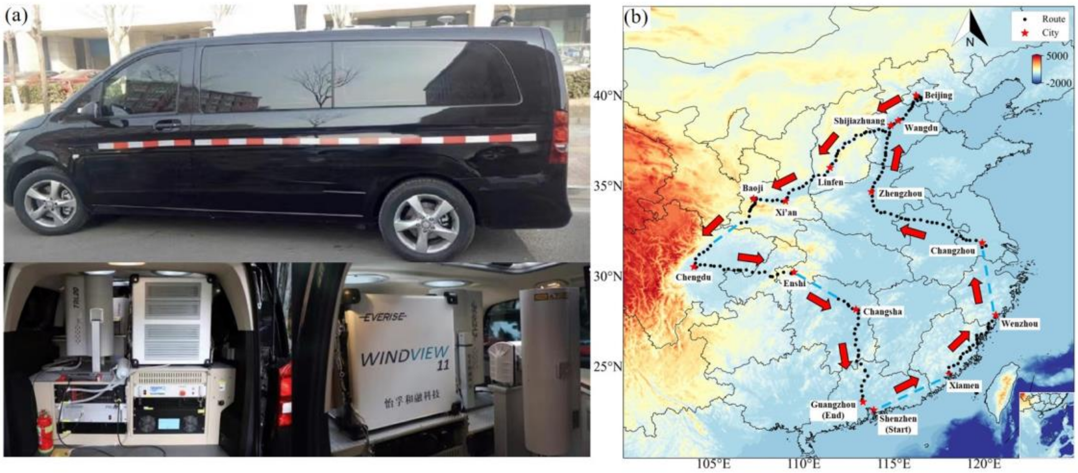
**Reviewer #2**

**Comment [2-1]:** General comments: This study reveal that the T-NPES is a relatively common and important pathway that causes PM2.5 pollution in the surface layer in the plain areas in winter China. Comprehensive mobile-lidar data and surface monitoring data are presented and analyzed to support the conclusion. The mechanism and potential regions of this phenomenon taking place is well demonstrated. Overall, the data presented herein is robust and the mechanism of T-NPES induced nocturnal PM2.5 increase is well explained. It is well suited to *ACP* journal and suggested to be published after addressing my following concerns.

**Response [2-1]: We thank the reviewer for the positive and valuable comments. All of them have been implemented in the revised manuscript. Please see our itemized blue responses below.**

**Comment [2-2]:** Line 43: A comma should be placed before ‘such as’ instead of a period.
**Response [2-2]: Corrected accordingly**

**Comment [2-3]:** Figure 1(b): The label of black dots is suggested to be named as ‘route’.
**Response [2-3]: Thanks. We have revised the name of the label of black dots as ‘route’. The new Figure 1 is shown below:**




**Comment [2-4]:** Section 2.1: In addition to the description of instruments used in this study, in terms of clarification, the method of data processing and QA/QC procedures should be at least briefly presented herein. And I suggest listing all parameters measured by lidar system and other surface station in a table with resolution, uncertainty and other related features for better readability.
**Response [2-4]: Thank you for the suggestion. Quality control of lidar data is always difficult. We have introduced the method of QA/QC procedures in the Section 2.1 as “The quality of the data obtained by the lidar system was checked by the Integrated Environmental Meteorological Observation Vehicle before deployment. The results showed a percentage difference of less than 15% between the lidar system data and the data provided by the Shenzhen Meteorological Tower, demonstrating the high accuracy of the lidar instrument (Xu et al., 2022).” And here we supplied the data processing as the following: “Data during the instrument malfunction, below the blind zone and in rainy weather had been excluded.”. In addition, we have followed your suggestion and**

**supplied more parameters about the lidar system to the Table S1.**

**Table S1.** Detailed parameters for the multi-lidar system

| Lidar | Variable | Wavelength | Spatial and time resolution | Lowest observable altitude |
|---|---|---|---|---|
| 3D visual scanning micro pulse lidar | Extinction coefficient, depolarization ratio | 532 nm | 15 m/1 min | 30 m |
| Doppler wind profile lidar | Wind speed and direction profiles | 1545 nm | 50 m/1 min | 40 m |
| Raman temperature profile lidar | Temperature profiles | 532 nm | 60 m/5 min | 60 m |

**Comment [2-5]:** Line 332~334: What is the reason of the discrepancy between observed PM2.5 and simulated PM2.5 by geoschem? Can the model reproduce the same wind field and temperature as observed one which, as stated above in the manuscript, cause the subsidence of air mass aloft?

**Response [2-5]: The input meteorological data in the GEOS-Chem model is from the Modern-Era Retrospective analysis for Research and Application version 2 (MERRA-2), so the model results are generally similar to the observations and are able to reproduce well wind field and temperature variations similar to those observed by the lidar system. We supplied the comparison of model results with observations in Figure S1 and the following description in Section 2.5: "Figure S1 showed the comparison of model results with observations for monthly mean $PM_{2.5}$, and the correlation coefficients between model and observation were about 0.6, which meant that the model results provided a relatively good reproduction of the observations."**

**The reason for the discrepancy between observed and simulated $PM_{2.5}$ by GEOS-Chem could be due to the relatively low resolution of the model, resulting in a large difference in some of the individual T-NPES cases, which has an impact on the average results shown in the Figure 5.**

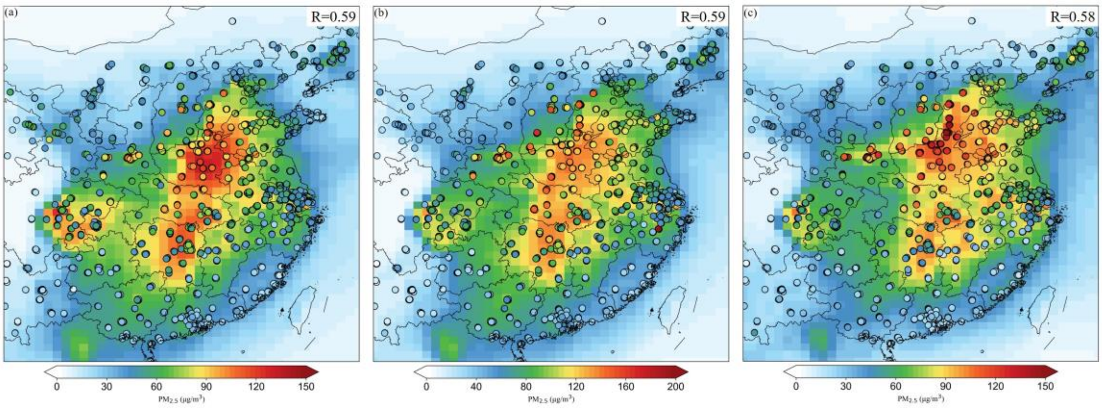



**Figure S1.** The comparison of model results (color map) with observations (color points) for monthly mean $PM_{2.5}$ values and the correlation coefficient (R) between model and observation. (a) 2018.12, (b) 2019.01, (c) 2019.02

**Comment [2-6]:** Line 386: Please change 'shirt' to 'shift'.

**Response [2-6]: Corrected accordingly.**

**Comment [2-7]:** Line 384~404: It seems like the type 4 T-NPES does not follow the same illustrated pattern as the other three and it is also different from the conceptual plot depicted in Fig 6. Maybe more information related to type 4 should be added into Fig 6.

**Response [2-7]: Yes, as we have mentioned in the Section 3.4: "We suggested that the Loess Plateau cities might serve as a crucial transitional zone between the plains and the basin as introduced in Section 3.3." Type 4 is a transition type of T-NPES between the plains and the basins, and the Loess Plateau is at a critical point in terms of the occurrence of T-NPES events, so Type 4 is not identical to the other three types. However, shifts in wind direction and transport of high-altitude $PM_{2.5}$ to the surface, as well as the enhancement of surface $PM_{2.5}$, as described in the conceptual scheme are still observed in Type 4. Therefore, we still classify it as a typical type of T-NPES.**

**We improve the conceptual scheme (Figure 6) as below to better represent the T-NPES events in the plain area, where the T-NPES are more characterized.**

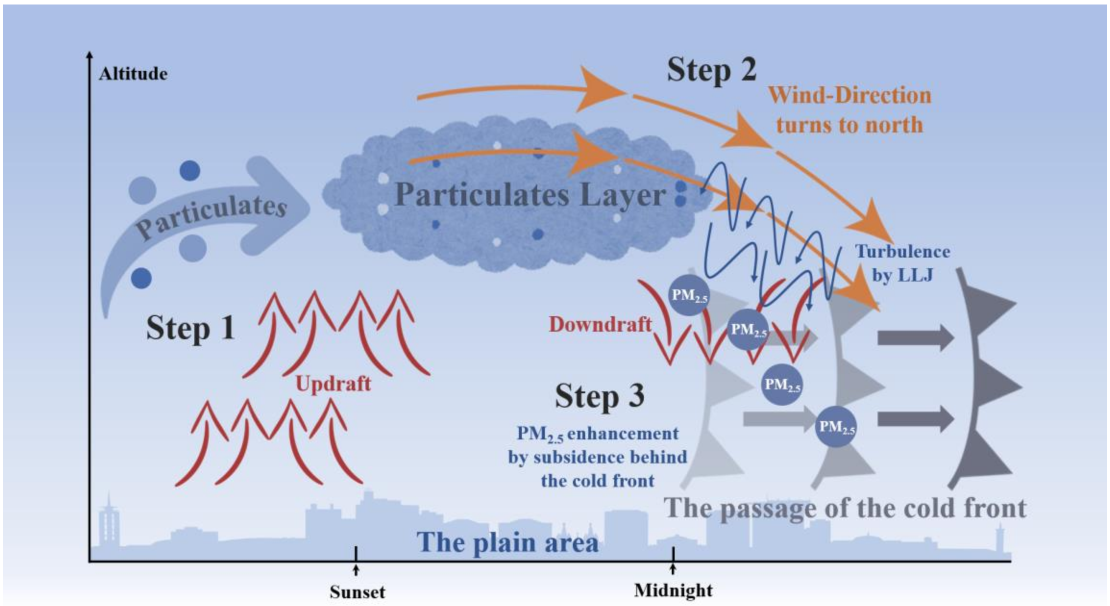



**Figure 6.** Conceptual scheme of the T-NPES events

**Comment [2-8]:** Although the authors presented several case studies to elaborately explain the pattern of T-NPES and its contribution on the increase of nocturnal surface PM2.5 concentrations, as stated in the text, the percentage of occurrence of this phenomenon was less than 20%. In that way, it comes to me that there should be some cases with increasing nocturnal PM2.5 in the surface during non-T-NPES condition, or with typical T-NPES event not causing increasing nocturnal PM2.5 in the surface. I suggest making some comparison among these three different cases, which might help to better illustrate the features and significance of T-NPES on PM2.5 pollution.

**Response [2-8]: Thanks for your suggestion. This is an aspect we had not well considered. Here we further take Wangdu and Changzhou as the representative cities to conduct a comparison among these three different cases, we highlight that the T-NPES make a large contribution to the nocturnal PM2.5 enhancement and partly responsible for the pollution event, while we should note that the**

**T-NPES event not always cause pollution, we also show that the event can also clean away the aerosol by a fast-north wind, this may be explained by the fast wind shifts and the north wind speed is high to remove aerosol quickly before the increase in surface $PM_{2.5}$ is observed. Here we added the discussion in the Section 3.3 as following:**

**Line 409: "To look insights into the mechanism of nocturnal $PM_{2.5}$ enhancement, we systematically documented instances of nocturnal $PM_{2.5}$ enhancement during the winter of 2018 in Wangdu and Changzhou according to the surface $PM_{2.5}$ observation. We identified 48 such events in Wangdu and 27 in Changzhou, with proportions of T-NPES events of 37.5% and 40.7%, respectively. The results implied that T-NPES represents merely one among multiple pathways contributing to the nocturnal $PM_{2.5}$ enhancement. We checked the nocturnal $PM_{2.5}$ enhancement events that not caused by T-NPES in Wangdu, the dominant wind field distributions within the ABL were southerly or characterized by static light wind, which indicated that the nocturnal $PM_{2.5}$ enhancement might result from either horizontal transport from polluted regions in the southern areas or the local accumulation of particulates in the stable ABL. In the nocturnal $PM_{2.5}$ enhancement events of non-T-NPES condition in Changzhou, higher wind speeds in the ABL and predominantly from the northern and southwestern, which indicated the nocturnal $PM_{2.5}$ enhancement might result from horizontal transport from the NCP (Huang et al., 2020) or caused by other reasons. For example, from the perspective of chemical formation, the nocturnal atmospheric oxidation may elevate the nighttime aerosol concentration (Wang et al., 2023; Yan et al., 2023). In addition, we found the T-NPES event not always cause nocturnal $PM_{2.5}$ increase, in a few cases, the strong north wind following the cold front play a role in remove the aerosol. In summary, the T-NPES just represents one vertical transport mechanism that can collectively contributes to the enhancement of nocturnal $PM_{2.5}$ with other physical and chemical processes (Zhao et al., 2023). Further understanding of the coupling effect of transportation as well as the chemical formation to the nocturnal $PM_{2.5}$ enhancement is thus highly needed."**

**References:**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