

Review result of "Spatiotemporal patterns of temperature inversions and impacts on surface PM_{2.5} across China" (egosphere-2025-4751)

Response to Reviewer #2:

reviewer's comments are given in blue,

our responses are given in deep red.

The authors have answered most of my questions properly, while there are some issues still exist. Please see below:

1. Line 18, it is hard to understand this revised sentence.

Response: Thank you for pointing this out. We realize that the phrasing "significantly stronger 1.3 °C higher" in the previous revision was grammatically incorrect and confusing.

Revised text (Line 17-18): "Distinct regional patterns emerge: SBIs dominate in northern China, whereas EIs prevail in eastern China. Overall, SBIs are 1.3 °C stronger than EIs."

2. The response for my question no. 3 contains "???"?

Response: Thank you for your careful review. We sincerely apologize for this oversight. The "???" was a placeholder used during our drafting process to mark line numbers that were subject to change, and we regret missing it in the final check. We have confirmed that the revised text regarding specific weather systems is located at Line 39-40 in the current manuscript.

3. Line 47, duplicated ‘.’.

Response: Thank you for pointing out this detail. We have removed the duplicated period in the revised manuscript.

4. The results shown in Fig. S1 are questionable. When you calculate the distance, did you use degree as the unit rather than km?

Response: Thank you for this comment. We apologize for the confusion and revised to provide the following clarifications:

Calculation Unit (km): We confirm that all distance thresholds and calculations in Fig. S1(a) are strictly in kilometers (km). As mentioned in our previous response, we used the Haversine formula to compute the physical distance between stations based on their coordinates. The distance between the radiosonde station and the air quality monitoring stations was calculated as the great-circle distance using the Haversine formula, assuming a spherical Earth with a mean radius of 6,371 km. This method accounts for the curvature of the Earth, ensuring accurate distance measurements across different latitudes.

Given the latitude and longitude of two points as (ϕ_1, λ_1) and (ϕ_2, λ_2)

ϕ : latitude, in radians.

λ : longitude, in radians.

R : Earth radius, typically taken as 6,371 km.

Step1: Calculate the semi-positive vector value (a)

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos\phi_1 \cdot \cos\phi_2 \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$$

Step2: Calculate the central angle (c)

$$c = 2 \cdot \arctan2(\sqrt{a}, \sqrt{1-a})$$

Step3: Calculate distance (d)

$$d = R \cdot c$$

where R is the Earth's radius, 6371 km.

Nature of Fig. S1(b): The inset panel (b) is a schematic diagram designed to illustrate our station matching algorithm, rather than a map of actual geographical coordinates.

Red star: Represents a successful match where an air quality station falls within the search radius (r) and is the nearest one.

Black star: Represents an isolated radiosonde station (e.g., in plateau areas) with no air quality stations nearby.

Blue star: Represents a case where candidate stations exist but are beyond the maximum distance threshold ($r > 10$ km), and are thus excluded.

The green circle indicates that the nearest site (air monitoring station) has not exceeded the threshold range; red circle indicates that the nearest site has exceeded the threshold range.

Revision: To prevent further misunderstanding, we have: Updated the figure caption to state: "Panel (b) is a schematic illustration of the nearest-neighbor matching method within a defined radius, rather than a map of actual geographical coordinates."

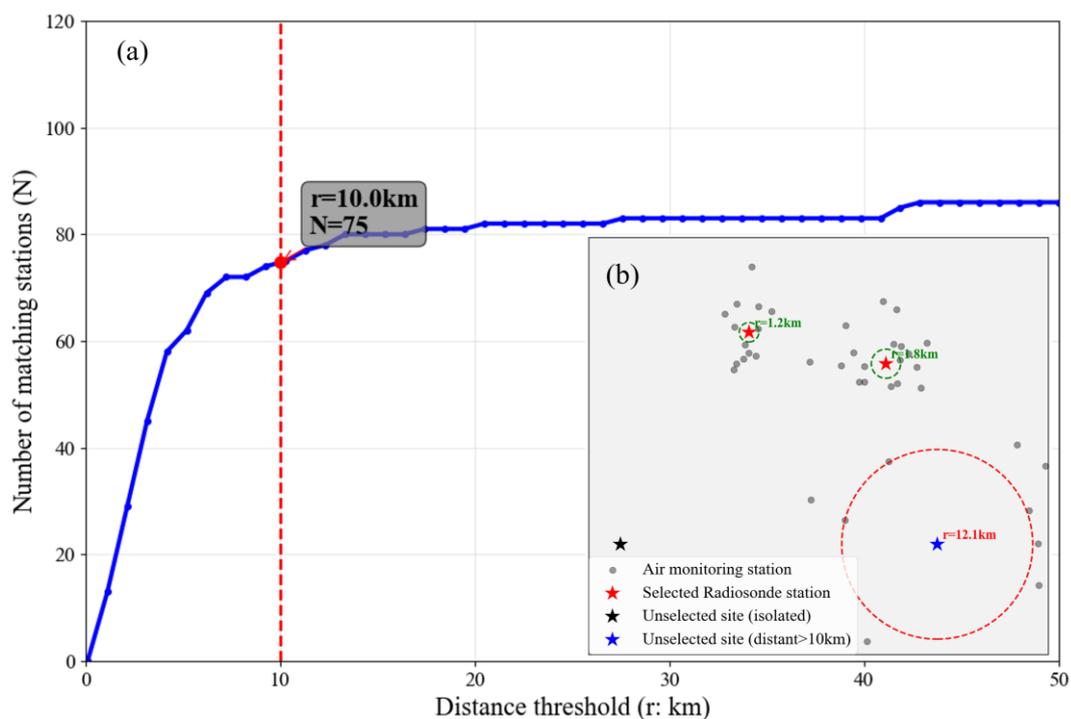


Fig S1. Site filtering method. (a) Relationship between distance and the number of matching stations. (b) Example diagram of site matching process. 'r' represents the distance from the nearest air quality monitoring station to the sounding station. Panel (b) is a schematic illustration of the nearest-neighbor matching method within a defined radius, not a plot of actual station coordinates.

5. The answer to question 26 is not satisfactory. If you select Beijing station as an example, we would be happy to see the original PBLH data first. Then, the correlation of $PM_{2.5}$ and inversion strength when PBLH is below 500 m alone is insufficient to confirm the strong relationship between them.

Response: We sincerely thank the reviewer for this critical insight regarding the coupling of low PBLH and TIs. To isolate the independent role of TIs and provide the "original PBLH data" as requested, we have conducted a comprehensive analysis based on the hourly ERA5 dataset for Beijing (2019).

Characteristics of original PBLH data: As shown in Fig.1, we confirm the reviewer's point that the standard sounding times (08:00 and 20:00 BJT), indeed coincide with the diurnal minima of PBLH in Beijing. This confirms that our primary dataset cover or obtained the most stable atmospheric conditions in the morning and evening.

To address the concern that $PM_{2.5}$ accumulation might be solely attributed to a low PBLH, we integrated the results from Fig.2 and Fig.3. Evidence of independent impact (Fig.2): By categorizing the data into specific PBLH intervals (<200 m, 200–500 m, and >500 m), we "fixed" the geometric volume of the boundary layer. Fig.2 clearly demonstrates that within

the same PBLH bin, the $PM_{2.5}$ concentrations during TI episodes are significantly higher than those during non-TI periods. This sufficiently demonstrates that TIs have an additional suppression effect on pollutant dispersion, and that this effect is independent of PBLH. We further examined on the most critical scenarios where PBLH is below 200 m. As shown in Fig.3, a strong linear correlation ($R^2 = 0.71$, $p < 0.01$) exists between TI strength and $PM_{2.5}$ concentrations. This high correlation indicates that when the "air container" is small suppressed and stable, the thermodynamic intensity of the inversion becomes the primary determinant of pollution severity.

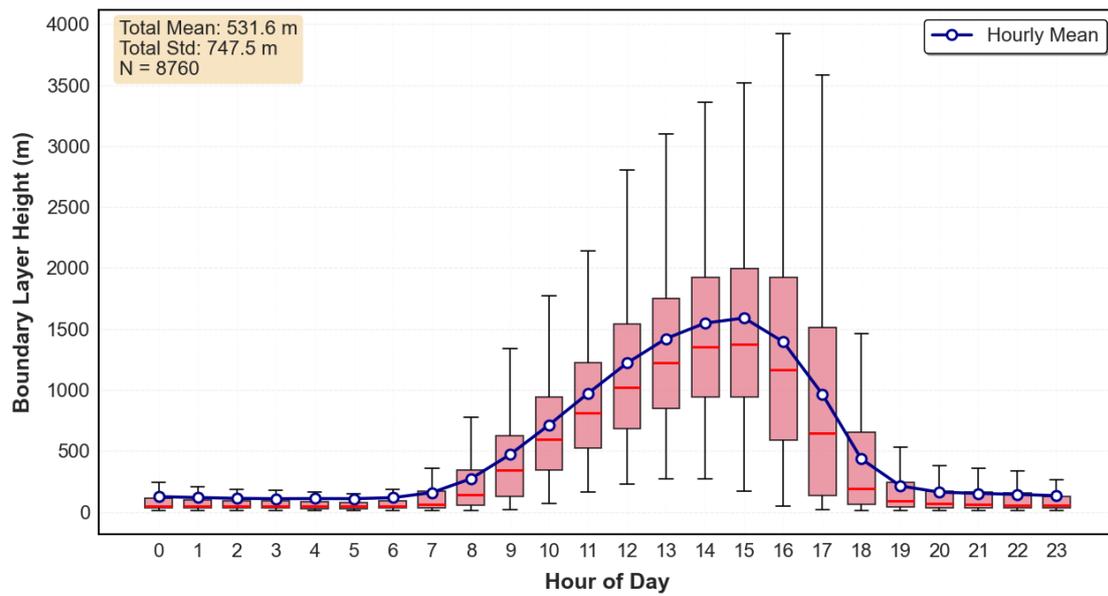


Fig.1 Diurnal variation of hourly mean boundary layer height in Beijing throughout 2019 (Beijing Time).

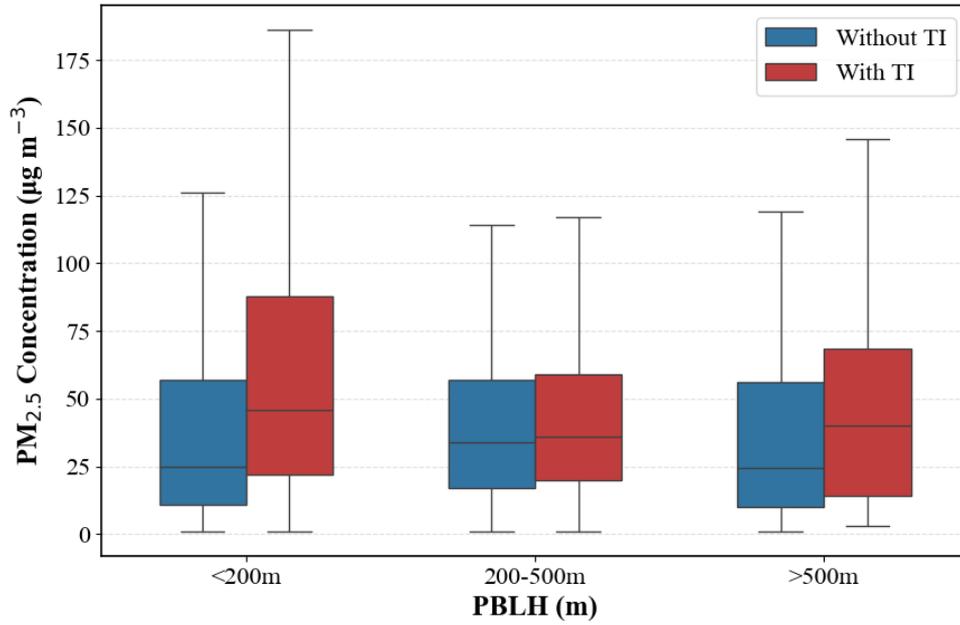


Fig.2 Impact of TI on PM_{2.5} under different PBLH bins.

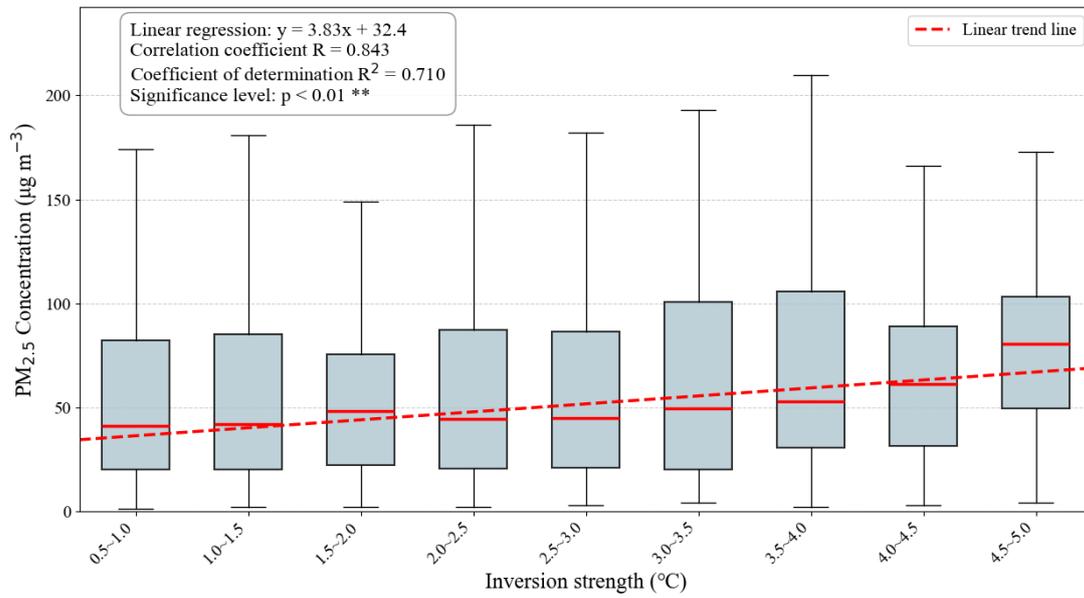


Fig.3 PM_{2.5} concentration distribution across different inversion strength intervals (PBLH < 200 m).