

## Transport Trajectories and Potential Source Regions of Atmospheric Particulate Matter in the Laohugou Area of the Qilian Mountains (Post-print)

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### Abstract

Based on atmospheric particulate matter observation data from the Laohugou Glacier Station in the western Qilian Mountains spanning January 2010 to October 2011, this study investigated the transport pathways and distribution of potential source regions for different particle size fractions (PM<sub>10</sub>, PM<sub>2.5</sub>, and PM<sub>1</sub>) in the Laohugou area using the HYSPLIT-4 backward trajectory model, trajectory cluster analysis, Potential Source Contribution Function (PSCF), and Concentration Weighted Trajectory (CWT) method. The results indicate that:

Airflow trajectories affecting the study area predominantly originate from the westerly direction, with additional influence from the easterly direction during summer. The mass concentrations of the three particulate matter categories exhibit significant seasonal variation, characterized by elevated levels in spring and summer and reduced levels in autumn and winter. PSCF analysis demonstrates that high particulate matter concentrations in spring are closely associated with dust transport from downstream arid and semi-arid regions such as the eastern Tarim Basin and western Hexi Corridor. The formation of high particulate matter concentrations in the study area during summer is primarily influenced by regions to the west, including the periphery of the Tarim Basin, northern Xinjiang, and western Hexi Corridor, as well as regions to the east, including western Inner Mongolia, Hexi Corridor, Ningxia, and even western Shaanxi. High CWT value areas in spring are distributed in the northwest and west directions relative to the study area. In summer, high CWT values receive contributions not only from the westerly direction but also from easterly regions such as the Hexi Corridor.

## Full Text

### Preamble

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The Potential Source Contribution Function (PSCF) and Concentration Weighted Trajectory (CWT) methods were applied to identify source regions of atmospheric particulate matter. The PSCF value is calculated as:

$$\text{PSCF} = \frac{n_{ij}}{N_{ij}}$$

with weighting functions applied as follows: - 1.00 when  $N_{ij} < 80$  - 0.70 when  $20 < N_{ij} \leq 80$  - 0.42 when  $10 < N_{ij} \leq 20$  - 0.05 when  $N_{ij} \leq 10$

The CWT method calculates concentration fields using:

$$C_{ij} = W_{ij} \cdot C_i \cdot \tau_{ij}$$

where  $W_{ij}$  represents the weighting coefficient,  $C_i$  denotes the pollutant concentration at the receptor site, and  $\tau_{ij}$  indicates the residence time of trajectories in grid cell  $(i, j)$ .

## 2. Materials and Methods

### 2.1 Data Collection

Atmospheric particulate matter observations were conducted in the Laohugou area of the western Qilian Mountains. The dataset comprised measurements from a single observation point, with  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ , and  $\text{PM}_1$  concentrations recorded at 5-minute intervals. The data exhibited high validity, with 92.7% of measurements meeting quality control standards.  $\text{PM}_{10}$  concentrations averaged  $126.5 \text{ g} \cdot \text{m}^{-3}$  and  $72.3 \text{ g} \cdot \text{m}^{-3}$  across different sampling periods, while  $\text{PM}_{2.5}$  showed significant temporal variation. The ratio of  $\text{PM}_{2.5}$  to  $\text{PM}_{10}$  indicated substantial fine particle contributions, with  $\text{PM}_{2.5}$  accounting for 31.8% to 60.9% of total particulate mass. During pollution episodes, 62.5% of sampling days exceeded national ambient air quality standards.

### 2.2 Trajectory Analysis and Source Identification

Backward trajectory analysis was performed using the HYSPLIT-4 model to simulate air mass transport pathways. Trajectories were calculated at 200 m above ground level with 72-hour backward simulation periods. The PSCF analysis applied the GB3095-2012 standard thresholds of  $150 \text{ g} \cdot \text{m}^{-3}$  for  $\text{PM}_{10}$  and  $75 \text{ g} \cdot \text{m}^{-3}$  for  $\text{PM}_{2.5}$  to identify potential source areas. Weighted CWT analysis was subsequently employed to quantify the relative contribution of different source regions across seasons.

### 2.3 Seasonal Source Attribution

CWT analysis was applied to  $PM_1$ ,  $PM_{2.5}$ , and  $PM_{10}$  data to characterize seasonal variations in source region contributions. The method incorporated trajectory residence times and measured concentrations to generate weighted potential source contribution fields for spring, summer, autumn, and winter periods.

## 3. Results and Discussion

The HYSPLIT-4 backward trajectory model simulations revealed that the study area was predominantly influenced by westerly jet flow throughout the year, with easterly airflow patterns becoming significant during summer months. Particulate matter concentrations exhibited pronounced seasonal variability, with elevated levels during spring and summer seasons and reduced concentrations in autumn and winter.

PSCF analysis demonstrated that springtime  $PM_{2.5}$  and  $PM_{10}$  pollution was strongly associated with dust transmission from arid and semi-arid regions, particularly the eastern Tarim Basin and western Hexi Corridor. During summer, high PSCF values originated from two primary source directions: (1) western sectors encompassing the Tarim Basin, northern Xinjiang, and western Hexi Corridor; and (2) eastern sectors including western Inner Mongolia, the Hexi Corridor, Ningxia, and western Shaanxi.

CWT analysis corroborated these findings, showing elevated values in north-western and western regions during spring, with additional high-value areas emerging from the Hexi Corridor and eastern regions during summer. This spatial distribution pattern confirms these areas as significant potential source regions for particulate matter affecting the Qilian Mountains.

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**Abstract:** From January 2010 to October 2011, we analyzed characteristics of atmospheric particulate matter based on observed data in the Laohugou area of the western Qilian Mountains. The HYSPLIT-4 backward trajectory model simulated transport patterns and potential source areas of different-sized particles. Results showed that westerly jet flow affected the study area throughout the year, while summer was additionally influenced by easterly airflow. Particulate matter concentrations exhibited significant seasonal variation, with higher levels in spring/summer and lower levels in autumn/winter. PSCF analysis revealed that springtime  $PM_{2.5}$  and  $PM_{10}$  pollution was closely connected with dust transmission from arid and semi-arid areas such as the eastern Tarim Basin and western Hexi Corridor. High PSCF values during summer originated from two primary areas: one from the west including the Tarim Basin, northern Xinjiang, and western Hexi Corridor; and another from the east including western Inner Mongolia, the Hexi Corridor, Ningxia, and western Shaanxi. CWT analysis showed higher values distributed in the northwest and west of the study area during spring, with additional high values appearing from the Hexi Corridor and eastern regions in summer, confirming these as potential source areas of particulate matter.

**Keywords:** particulate matter pollution; cluster analysis; potential source contribution function; concentration-weighted trajectory method; Qilian Mountains

*Note: Figure translations are in progress. See original paper for figures.*

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