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Postprint of "Study on the long-term variation trends and short-term enhancement events of PM_{10} and $PM_{2.5}$ mass concentrations at Akdala Station"

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Abstract

Based on continuous observation data of PM10 and PM2.5 at the Akdala regional atmospheric background station from 2011 to 2023, this study employed statistical analysis, meteorological correlation analysis, the HYSPLIT-4 model, and methods including the potential source contribution function (PSCF) and concentration-weighted trajectory (CWT) to investigate the temporal trends and source characteristics of PM10 and PM2.5 mass concentrations. The results show that: (1) From 2011 to 2023, the annual mean PM10 mass concentration at Akdala station increased from 12.1 μg · m-3 to 23.2 μg · m-3, and the annual mean PM2.5 mass concentration increased from 7.3 μg · m-3 to 10.8 μg · m-3. The annual mean growth rates were 0.81 μg · m-3 · a-1 and 0.31 μg · m-3 · a-1, respectively, with the growth rate of PM10 exceeding that of PM2.5. (2) PM10 and PM2.5 mass concentrations exhibited a seasonal pattern of higher values in spring and winter and lower values in summer and autumn. The PM2.5/PM10 ratio showed a bimodal distribution (0.4–0.5 and 0.8–0.9), with the lower ratio reflecting contributions from natural sources and the higher ratio reflecting contributions from anthropogenic sources. (3) Air-mass trajectory analysis indicated that PM10 mainly originated from arid regions in eastern Kazakhstan (PSCF values 0.4–0.7), whereas PM2.5 mainly originated from anthropogenic source regions in northern Xinjiang (PSCF values 0.5–0.8). (4) In 2023, four high-concentration PM10 episodes (peak range 681.1–822.6 μg · m-3) and five high-concentration PM2.5 episodes (peak range 294.2–551.4 μg · m-3) were identified. The duration of these episodes was generally less than 1 h, exhibiting a "short-duration, high-intensity" characteristic. (5) In comparison with Lin' an station, PM10 and PM2.5 mass concentrations at Akdala station were characterized by a "low baseline, large fluctuations, and short-duration peaks" : the baseline concentrations were lower than those at Lin' an station, but the

peak concentrations were higher. These findings provide a scientific basis for understanding the characteristics of particulate

Full Text

Long-term Variation Trends and Short-term Elevation Events of PM10 and PM2.5 Mass Concentrations at Akedala Station

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Abstract

Based on continuous observations of PM10 and PM2.5 at the Akedala regional atmospheric background station from 2011 to 2023, this study employed statistical analysis, meteorological correlation analysis, the HYSPLIT-4 model, potential source contribution function (PSCF), and concentration-weighted trajectory (CWT) methods to investigate the variation trends and source characteristics of PM10 and PM2.5 mass concentrations. The results showed that: (1) The annual average mass concentration of PM10 increased from 12.1 $\mu g \cdot m^{-3}$ to 23.2 $\mu g \cdot m^{-3}$, with an annual growth rate of 0.81 $\mu g \cdot m^{-3} \cdot yr^{-1}$, while PM2.5 increased from 7.3 $\mu g \cdot m^{-3}$ to 10.8 $\mu g \cdot m^{-3}$, with an annual growth rate of 0.31 $\mu g \cdot m^{-3} \cdot yr^{-1}$, indicating that PM10 increased faster than PM2.5. (2) Both PM10 and PM2.5 exhibited clear seasonal variations with higher concentrations in spring and winter and lower values in summer and autumn. The PM2.5/PM10 ratio displayed a bimodal distribution (0.4–0.5 and 0.8–0.9), where lower ratios reflected natural source contributions and higher ratios indicated anthropogenic source contributions. (3) Air mass trajectory analysis revealed that PM10 primarily originated from the arid regions of eastern Kazakhstan (PSCF values of 0.4–0.7), whereas PM2.5 mainly came from anthropogenic source regions in northern Xinjiang (PSCF values of 0.5–0.8). (4) In 2023, four high-concentration PM10 events (peak range: 681.1–822.6 $\mu g \cdot m^{-3}$) and five high-concentration PM2.5 events (peak range: 294.2–551.4 $\mu g \cdot m^{-3}$) were identified, with event durations typically less than one hour, demonstrating "short-term high-intensity" characteristics. (5) Compared with Lin' an station, Akedala station exhibited a "low baseline, high fluctuation, short peak" pattern, with baseline concentrations lower than Lin' an but peak concentrations higher. These findings provide a scientific basis for understanding atmospheric background particulate pollution characteristics and transboundary transport patterns in arid regions, contributing to atmospheric environmental quality assessment and regional collaborative governance in Northwest China.

Keywords: PM2.5; PM10; pollution characteristics; temporal variation; re-

gional transport

1.1 Study Area Overview

Akdala Regional Atmospheric Background Station (hereinafter referred to as Akedala station) is situated at the confluence of the Irtysh and Ulungur River basins in northern Xinjiang, representing an important desert-wetland ecological functional area on the Eurasian continent. As the only western plain site among China' s regional atmospheric background monitoring network, Akedala station plays a critical role in regional atmospheric background monitoring. The terrain within a 50 km radius is flat and open, with vegetation dominated by Gobi wetlands and desert grasslands, and anthropogenic emission sources are scarce, making it ideal for investigating regional PM2.5 background characteristics and cross-border transport.

1.2.1 PM10 and PM2.5 Monitoring Data

This study utilized two types of particulate monitors: the Grimm180 environmental particulate analyzer and the TEOM-1405DF particulate monitor. The Grimm180 operates based on the light scattering principle, simultaneously measuring PM10 and PM2.5 with a time resolution of 5 minutes, and complies with European standards EN 14907 and EN 12341. The TEOM-1405DF uses a tapered element oscillating microbalance principle to synchronously measure PM10 and PM2.5 mass concentrations with a measurement accuracy of $±$2.0 $\mu g \cdot m^{-3}$. All instruments underwent rigorous calibration and standardization before use.

1.2.2 Meteorological Data Sources

Meteorological data for Akedala station from 2011 to 2023 were obtained from the station' s automatic weather observation system, including parameters such as temperature, relative humidity, wind speed, air pressure, and precipitation. Data collection utilized standardized meteorological observation instruments from the China Meteorological Administration, with quality control performed according to the "Surface Meteorological Observation Specifications" (GB/T 35221-2017). The PM2.5 mass concentration data were provided by the Atmospheric Sounding Center Database of the China Meteorological Administration.

1.3.1 Data Quality Control and Statistical Analysis

According to the climatic characteristics of the Akedala region, the four seasons were defined as spring (March–May), summer (June–August), autumn (September–November), and winter (December–February). Quality control procedures were applied to the observational data, and statistical analysis methods were employed to analyze the PM2.5 mass concentration data from Akedala station.

1.3.2 Trajectory Simulation and Source Region Analysis

This study utilized the HYSPLIT-4 model to simulate 72-hour backward trajectories, with the initial simulation height set at 100 m. Trajectories were calculated four times daily at 00:00, 06:00, 12:00, and 18:00 UTC. The model input fields were obtained from the Global Data Assimilation System (GDAS) data. Following trajectory simulation

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

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