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Characteristics of Aerosol Changes and Propagation Trajectory Analysis under Three Dust Storms—A Case Study of Gansu Province

Yaqun Cao[1,2,a], Tianzhen Ju[1,2,b,*], Bingnan Li[3,c], Lanzhi Wang[1,2,d], Jiaqi Wang[1,2,e], Jiachen Li[1,2,f], Zhichao Lv[1,2,g]

[1]College of Geography and Environmental Sciences, Northwest Normal University, Lanzhou, China
[2]The Key Laboratory of Resource Environment and Sustainable Development of Oasis, Lanzhou, Gansu Province, China
[3]News and Mass Communication Department, Shaanxi Normal University, Xi'an, 710062, China
[a]2022223101@nwnu.edu.cn, [b]sandstorm608@163.com, [c]bingnanli@snnu.edu.cn,
[d]1780415246@qq.com, [e]2022223083@nwnu.edu.cn, [f]2022213029@nwnu.edu.cn,
[g]2760679951@qq.com
[*]Corresponding author: sandstorm608@163.com

Abstract: *In recent years, environmental concerns related to sand and dust emissions into the atmosphere have gained considerable attention due to shifts in global climate and ecological conditions. To track the spatial and temporal variations of soluble aerosols (UVAI) and particulate matter ($PM_{2.5}$), and to assess their impacts on human health during sand and dust storms of varying intensities, we developed daily scales using UVAI indicators derived from OMI data, complemented by high-altitude $PM_{2.5}$ measurements. The influence of meteorological conditions on the two substances was assessed using a Random Forest model, whereas the HYSPLIT model was employed to trace air mass movement trajectories on two dusty days, thereby identifying the dust sources. The results indicate that: ① During dusty weather conditions, areas with high UVAI are primarily concentrated in the western part of the study area. The relationship between the maximum UVAI values and the proportion of high-value areas is as follows: floating dust > sandstorm > sand lifting.② $PM_{2.5}$ concentration levels markedly increased across all three intensity categories during dust and sand events, with high-value areas progressively expanding from the northwestern region to the central and eastern parts of the study area. ③In our random forest regression model, V-wind speed and air temperature during each of the three dust storms significantly influenced UVAI trends; in contrast, cloud cover and relative humidity had a more pronounced impact on $PM_{2.5}$ trends.④The primary sources contributing to sandy and dusty weather remain largely consistent, primarily including the Taklamakan Desert and the Gurbantünggüt Desert. Secondary sources, however, show minor variations, specifically involving regions such as the Loess Plateau and the Gobi Desert along Mongolia's border, as well as the Qaidam Basin under sand-lifting conditions.*

Keywords: *Dust storms, soluble aerosols, $PM_{2.5}$, backward trajectories*

1. Introduction

Sand and dust storms are catastrophic weather phenomena triggered by specific large-scale atmospheric circulation patterns and meteorological systems, typically occurring under particular geographic and surface conditions. These events primarily occur in desert regions and their adjacent arid and semi-arid areas. Sand and dust storms can be categorized into five types: floating dust, sand lifting, sandstorm, strong sandstorms, and very strong sandstorms[1].Dusty weather can substantially increase the aerosol content in the atmosphere over a short period, leading to significant air pollution. During dust storms, the air becomes heavily laden with fine particles, including those with aerodynamic diameters less than 10μm (PM_{10}) and finer particles with diameters below 2.5μm ($PM_{2.5}$)[2]. It is widely recognized that PM_{10} and $PM_{2.5}$ are the primary pollutants associated with dusty conditions. PM_{10} can be inhaled into the human respiratory system, hence it is referred to as respirable particulate matter. Notably, $PM_{2.5}$ poses the greatest health risk due to its ability to penetrate deep into the lungs and deposit on the surfaces of fine bronchial tubes and alveoli, thereby eliciting considerable public concern[3].

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With the implementation of China's "National Sand Prevention and Control Plan (2021-2030)," which aims to enhance the development of sand and dust storm sensing and monitoring systems and increase investment in comprehensive management strategies for sand prevention and control, there has been a significant reduction in the frequency of sand and dust storm events nationwide[4]. However, severe sand and dust storms continue to occur[5]. Northwest China is recognized as one of the regions with a high incidence of sand and dust weather both nationally and globally. Within this region, the Hexi Corridor in Gansu Province is the largest area affected by such storms. This corridor stretches from Turpan and Hami in the west to approximately 1,000 kilometers eastward[6]. The primary sources of dust in northern China and Mongolia include areas such as the Tarim Basin, the Hexi Corridor, and the Mongolian Gobi Desert[7].

In recent years, extensive research has been conducted to investigate the generation and mitigation mechanisms, transport processes, and chemical reactions of sand and dust storms through ground-based observations, satellite remote sensing, and other methodologies[8-9].Sun et al.[10]demonstrated that aerosol uptake properties can be inferred from the inversion of soluble aerosol (UVAI) products derived solely from OMI sensors, utilizing a neural network model. Notably, large aerosol optical depth (AOD) values were observed in the desert regions of northwestern China between 1978 and 2005[11].MODIS remote sensing data revealed that aerosol pollution significantly intensified during sandstorms, with marked increases in PM_{10} and $PM_{2.5}$ concentrations[12]. Furthermore, these sandstorms carried substantial amounts of heavy metals, whose levels far exceeded background values[13]. Aerodynamically, the severity of dusty weather is influenced by both the characteristics of the sand sources and the intensity of meteorological disturbances[14]. The processes of sand initiation, transport, and deposition are intricately linked to large-scale atmospheric perturbations[15-16]. Ren Puhui et al.[17]utilized HYSPLIT to investigate the airflow patterns in Taiyuan across different seasons, revealing significant seasonal variations in the potential source areas of fine particulate matter.Qinget al.[18] utilized HYSPLIT to investigate the primary transport pathways of particulate matter in Lanzhou, identify potential source areas, and quantify the contributions of East Asian sandstorms and dust storms to particulate matter in Lanzhou. Filonchyk[19] provided a detailed analysis of the geographic location, transport mechanisms, particle size, and vertical aerosol distribution during four dust events in northwestern China. Using HYSPLIT simulations, he demonstrated that the main sources of high-altitude aerosol pollution at this site were the desert regions of northern and northwestern China and most of the Mongolian Republic, findings that were consistent with satellite data. Currently, research focuses primarily on the sources of sandstorms, their distribution patterns, and aerodynamic characteristics, while studies on the impact of air quality are predominantly based on ground station data, with limited research on the variation patterns of atmospheric pollutants in high-altitude sand and dust weather. Therefore, it is essential to explore and analyze the variation patterns of multiple pollutants using remote sensing data, as well as the sources of sand and dust for different intensities of sand and dust weather.

In this study, Gansu Province was chosen as the research area, focusing on three distinct levels of dusty weather events that occurred in March 2021, May 2019, and March 2018. The investigation utilized soluble aerosol (UVAI) and particulate matter ($PM_{2.5}$) concentration data obtained from OMI remote sensing to examine the pollution variation patterns during sand and dust storms. A random forest regression model was applied to assess the contribution of meteorological factors to pollutant concentrations, while backward-forward trajectories were analyzed to identify the origins of sand and dust. This study aims to provide a scientific foundation for atmospheric management strategies in response to sand and dust events.

2. Overview of the study area

Gansu Province (32°11′-42°57′N, 92°13′-108°46′E), a provincial administrative region of the People's Republic of China, has its capital city of Lanzhou (see Figure 1). Situated in northwestern China, Gansu stretches from Shaanxi in the east to Xinjiang in the west, borders Sichuan and Qinghai in the south, and adjoins Ningxia and Inner Mongolia in the north, with Mongolia at its northwestern extremity. It covers a total area of 425,800 km² and comprises 14 prefectural and municipal cities. As of the end of 2022, the resident population of Gansu Province was 24,924,200 people. The topography of Gansu is elongated and narrow, characterized by a variety of landforms such as mountains, plateaus, plains, river valleys, deserts, and the Gobi Desert, with the terrain sloping from southwest to northeast. Notably, Gansu Province, particularly the Hexi Corridor region, serves as a primary corridor for frequent sandstorms in China[20].

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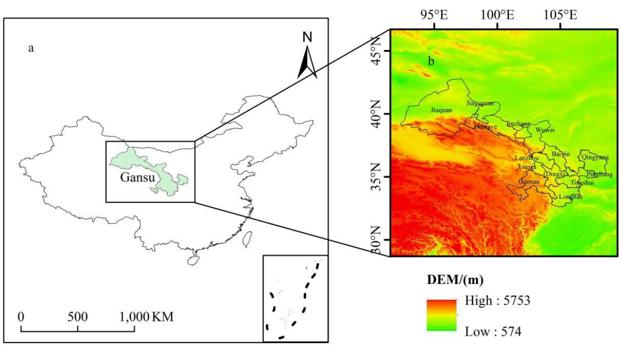

Figure 1: Overview of the Study Area: (a) Geographic Location Map of the Study Area; (b) Topographic Map of the Study Area.

3. Data and research methods

3.1 Data sources

The high-altitude particulate matter data utilized in this study to investigate the distribution of particulate matter during dusty weather conditions are sourced from the China Atmospheric Pollutants (CHAP) dataset. This dataset is renowned for its long-term, comprehensive coverage, high resolution, and high quality, specifically focusing on ground-level atmospheric pollutants in China. For this research, $PM_{2.5}$ monitoring data from 14 prefecture-level cities in Gansu Province were obtained from the National Urban Air Quality Real-Time Dissemination Platform (NUAQRDP) of the China General Environmental Monitoring Station (CGEMS)[21], to assess the impact of dusty weather on human health.

The ultraviolet absorbing aerosol index (UVAI) data presented in this paper were acquired from the Ozone Monitoring Instrument (OMI) sensor on board the Aura satellite, which is part of the Earth Observing System (EOS) managed by the National Aeronautics and Space Administration (NASA) of the United States. As a dedicated scientific research satellite, Aura's OMI functions as a broad-band, low-orbit, near-ultraviolet to visible spectrometer. It measures within a spectral range of 270-500 nm, featuring an average spectral resolution of 0.5 nm, a swath width of 2600 km, a nominal ground pixel size of 13 km×24 km at nadir, and provides global coverage once daily. For this study, the daily atmospheric pollutant data from 12-20 March 2021, 11-19 May 2019, and 25 March-2 April 2018 were extracted from the Level 2 data product of OMI.

The backward trajectory data utilized in this study are meteorological data from the Global Data Assimilation Systems (GDAS), provided by the National Centers for Environmental Prediction (NCEP) of the United States, covering the relevant time periods. These data can be directly applied to the subsequent transport path analysis without requiring any pre-processing steps. By leveraging the meteorological data from NCEP to analyze the transport pathways of air masses at key locations within the study area, this research aims to offer a valuable approach for the prevention and control of atmospheric pollution.

3.2 Research methodology

3.2.1 Random Forest Regression Model

Random forests, a tree-based machine learning method for classification, were initially proposed as an extension of classification and regression trees (CART) in the 1980s[22]. Breiman[23]further developed this concept by introducing a randomized decision forest approach[24], building upon Ho's (1992) work at Bell Labs. This approach combines multiple classification trees into a single model, known as a random forest, which enhances computational efficiency while maintaining high prediction accuracy. In this study, we utilize Python modules such as GDAL, Pandas, Numpy, Scipy, Sklearn, and Jupyter for data processing and matrix computations, and present our findings.

4. Results and analysis

Based on the reported wind speed and visibility data from the day of the dusty weather events, it was

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determined that a sandstorm occurred from 15 to 17 March 2021, a sand-lifting event took place on 15 May 2019, and a floating dust condition was observed on 29 March 2018. For each of these dusty weather events, a total of nine days before and after were selected as the study intervals. The spatial distributions of UVAI and $PM_{2.5}$ in the study area were then plotted on a day-by-day basis for each of the three dusty weather periods.

4.1 Characteristics of spatial and temporal distribution of soluble aerosols

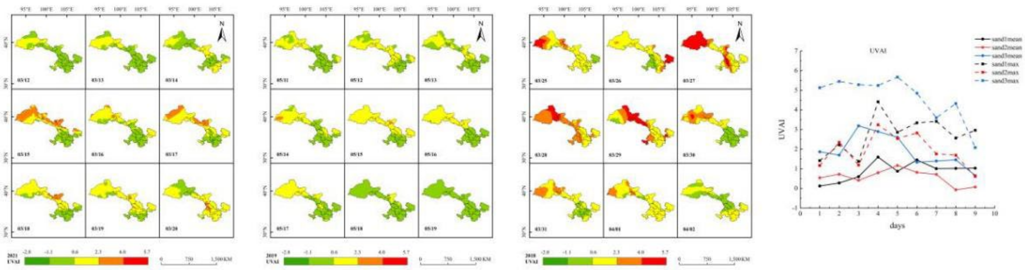

Figure 2: Spatial distribution of UVAI and a fold map depicting the daily mean maximum values of UVAI for three dusty days in Gansu Province.

The daily aerosol values were categorized into five groups, with UAVI values below 0.6 classified as low aerosol concentration and those above 2.3 as high aerosol concentration. As illustrated in Fig. 2, the UAVI values during dusty conditions in the study area are markedly higher in the western regions compared to the eastern parts. Specifically, the high-value areas are predominantly located in the western cities of Jiuquan, Jiayuguan, Zhangye, and Wuwei, which are in proximity to the Taklamakan Desert. This geographical position significantly influences the distribution and size of aerosols due to the presence of sand sources. The line graph indicates that the peak UVAI value during dusty weather was recorded on March 29, 2018, and it is evident that the daily average UVAI values reached their maximum coinciding with the onset of dusty weather.

Specifically, as shown in Figure 2, the spatial distribution of UVAI in the three dust weather events indicates that the floating dust event in 2018 had the largest high-value UVAI area within the study range, covering 72% of the study area on March 28 and affecting an area of 308,679 km². Li Fengshuai et al.[25]analyzed the distribution characteristics of UVAI in China from 2009 to 2018, and their findings indicated that the normal UVAI value in China during the study period did not exceed 0.6. During the floating dust event, the UVAI value exhibited a trend of initially increasing and subsequently decreasing. On March 29 in Zhangye City, the maximum UVAI value reached 5.67, which was 9.5 times higher than the normal value. In 2019, the sandy weather had the largest area in the low-value UVAI region within the study range, while the second and third control areas were almost evenly distributed. The highest UVAI value was 3.24 in Jiuquan City on May 14, which was 5.4 times higher than the normal value. This suggests that the sand-lifting aerosol moved from the northwest to the southeast, with the high-value area first appearing in the northwest of the study area and then spreading to the central part. During the dust storm in 2021, the third-level control area in the study area covered the largest area, followed by the second-level control area. The UVAI high-value areas were primarily concentrated on March 17 and 15, 2021, accounting for 77% and 67% of the region, respectively, with affected areas of 328,254 km² and 284,429 km².

Overall, the UVAI concentration values for the three types of dusty weather were elevated on the dust occurrence days, aligning with the conclusion that in the arid desert regions of northern China, atmospheric aerosols primarily originate from the release of ground dust due to dusty weather processes[26]. Regarding the distribution of high UVAI value areas for the three types of dusty weather, during sandstorms and sand lifting events, the UVAI values were predominantly at the second or third level; however, during floating dust events, the UVAI values were mainly at the fourth and fifth levels. This study concludes that aerosols are closely linked to dusty weather.

4.2 Characteristics of spatial and temporal distribution of particulate matte

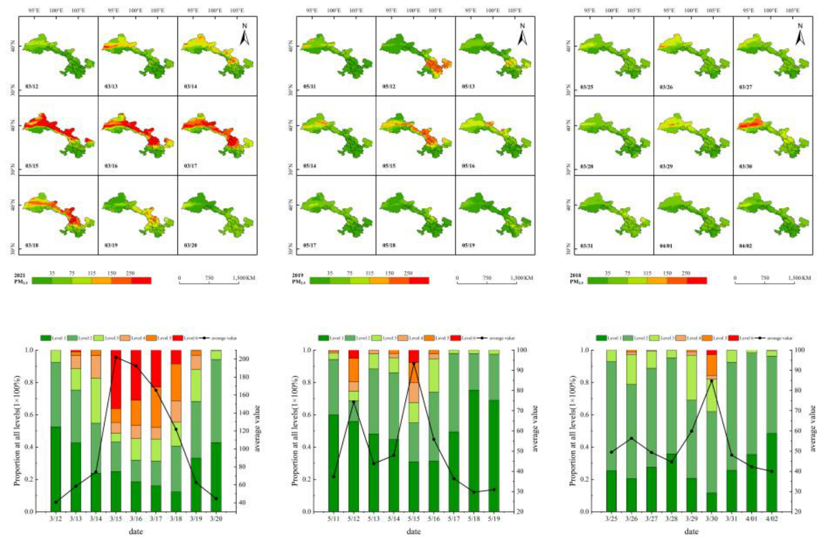

Figure 3: Spatial distribution of $PM_{2.5}$ ($\mu g/m^3$) and daily fluctuations in the percentages of various $PM_{2.5}$ levels and the daily mean value of $PM_{2.5}$ during three dusty weather events in Gansu Province, China

According to the Air Quality Index (AQI), the daily value of $PM_{2.5}$ is categorized into six levels: excellent, good, mildly polluted, moderately polluted, heavily polluted, and severely polluted. As shown in Figure 3, prior to the sandstorm, the area experiencing $PM_{2.5}$ levels above moderate pollution expanded gradually from the northwest of Gansu Province towards its central and eastern regions, with the proportion of areas exceeding moderate pollution levels steadily increasing. During the sandstorm, the study area was predominantly under the influence of concentration levels three and above, comprising over 50% of the region. From March 15 to 17, the proportion of areas with moderate pollution and above continued to rise, and following the dust event, the study area gradually reverted to concentrations below mild pollution, aligning with pre-dust conditions. The daily mean variation chart also indicates that the daily average $PM_{2.5}$ concentration during this sandstorm exhibited an initial increase followed by a decrease, with the lowest recorded value being 41μg/m³on March 12 and the peak value reaching 202μg/m³on March 15.

During sand-lifting weather, the high concentration of $PM_{2.5}$ was predominantly observed in the northwest and central regions of Gansu Province, decreasing gradually from northwest to southeast. A minor peak in $PM_{2.5}$ concentration was noted on May 12, with elevated levels primarily concentrated in Lanzhou, Baiyin, Dingxi, Tianshui, Pingliang, Qingyang, and the Linxia Hui Autonomous Prefecture. On May 15, coinciding with the sandstorm, the highest $PM_{2.5}$ concentration was recorded, and the area exceeding grade 3 concentration control standards was the most extensive, comprising 33% of the region. Following the cessation of the sandstorm, the proportion of areas with $PM_{2.5}$ concentrations above grade 3 progressively diminished, eventually stabilizing at concentration levels of one or two. The daily mean change chart illustrates a wavelike fluctuation trend in $PM_{2.5}$ concentrations during sand-lifting weather, with the lowest daily mean value reaching 30μg/m³on May 18 and the highest daily mean value peaking at 93μg/m³on May 15.

During the fine dust weather event, areas with elevated $PM_{2.5}$ concentrations were predominantly located in the northwest of the study region. On March 30, level 3 or higher control zones were primarily concentrated in Jiuquan City. Notably, on March 29, the onset of the fine dust weather, a minor portion of these control zones was also observed in Jiuquan City, while the rest of the days were generally classified as excellent or good. The average daily $PM_{2.5}$ concentration exhibited an initial upward trend followed by a decline, reaching its peak at 85μg/m³on March 30 and its nadir at 40μg/m³on April 2.

Overall, the growth in $PM_{2.5}$ concentration values and the trend of dispersion in high-value areas under the three intensities of dust storms exhibited similar patterns: all showed significant increases during dust storms and were positively correlated with the intensity of these events. This finding aligns with Krasnov et al.[27], who reported that both indoor and outdoor air concentrations of $PM_{2.5}$ and PM_{10} increased substantially during sandy and dusty weather. The observation that particulate matter

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concentrations do not decline significantly immediately following a dust storm suggests that these pollutants will continue to impact the environment for an extended period after the storm has ended.

4.3 Analysis of the Impact of Meteorological Variations on UVAI and PM2.5 Levels During Dust Storms

Table 1: Contribution of various meteorological data indicators to UVAI and PM2.5

UVAI	Precipitable precipitation	Air temperature	V-wind speed	Relative Humidity	Cloudiness
sandstorm	6.13%	28.55%	33.78%	19.65%	11.89%
floating dust	4.86%	6.31%	34.51%	13.88%	40.44%
sand lifting	20.21%	38.50%	16.01%	21.38%	3.91%
$PM_{2.5}$	Precipitable precipitation	Air temperature	V-wind speed	Relative Humidity	Cloudiness
sandstorm	13.05%	22.47%	16.37%	15.80%	32.30%
floating dust	21.54%	17.96%	19.02%	21.75%	19.73%
sand lifting	20.20%	18.42%	15.77%	21.91%	23.71%

Based on the significance of the findings from the Random Forest analysis, all the influencing variables selected in this study exert some influence on UVAI and $PM_{2.5}$, including precipitable water, air temperature, V-wind speed, relative humidity, and cloudiness[28-29]. This study further evaluates the impact of each meteorological factor on aerosols and particulate matter based on the results of the Random Forest calculations. As shown in Table 1, the contributions of each variable to aerosol and particulate matter indicate that V-wind speed and air temperature had a more significant impact on the UVAI trend during the three dust storms, while cloudiness and relative humidity had a more pronounced effect on the $PM_{2.5}$ trend.

Specifically, the V-wind speed made the highest contribution to UVAI during the first sandstorm and the second sand-lifting weather event (33.78% and 34.51%, respectively), primarily because higher wind speeds at this latitude facilitate the accumulation of UVAI[30]. As the intensity of the three sandy weather events progressively diminishes, the contribution of the V-wind speed to UVAI also decreases, with the lowest contribution coming from precipitable water (4.86% and 6.31%). This is attributed to the substantial dilution and deposition effects of precipitation on absorptive aerosols[31]. During the third floating dust weather event, the air temperature had the highest contribution to UVAI (38.50%), suggesting that as temperatures rise, air convection decreases, thereby increasing UVAI concentrations[32].For $PM_{2.5}$, under the first sandstorm intensity, cloudiness contributed the most at 32.30%, while precipitable water contributed the least at 13.05%. This is attributed to the heavier settling of atmospheric particulate matter in areas with higher water content[33]. Under the second sand-lifting intensity, the highest contributions to $PM_{2.5}$ were relative humidity (21.75%) and precipitable water (21.54%), which were nearly equal. Under the third floating dust intensity, cloudiness again contributed the most at 23.71%, while V-wind speed contributed the least at 15.77%. This is because higher wind speeds promote the horizontal dispersion of particulate matter, thereby aiding in the dilution and diffusion of air pollutants and contaminants[34].

4.4 Sand and dust transport path analysis

4.4.1 Sand and dust transport paths during Sandstorm

A 72-hour backward trajectory simulation conducted at an altitude of 1,000 meters above the study area yielded four distinct transport pathways.

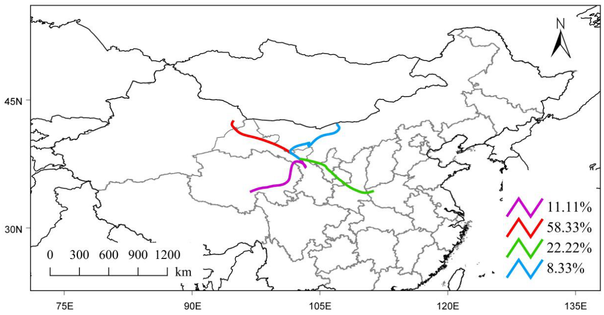

Figure 4: Wuwei City (38.15°N, 102.62°E) was chosen as a representative site for the dust storm event.

The representative point for this sand and dust transmission path study was selected as Wuwei City, where the UVAI value peaked during the March 2021 sand and dust storm. As illustrated in Fig. 4, the predominant transmission path in Wuwei City, accounting for 58.33%, extends from the northwest, traversing the eastern part of the Xinjiang Uygur Autonomous Region and the western part of Gansu Province, with its origin in the Gurbantunggut Desert. The second trajectory, originating from the southeast, passes through Shaanxi Province and the Ningxia Hui Autonomous Region, crossing the Loess Plateau, and constitutes 22.22% of the total.Trajectory 3 originates from the southwest, traversing Qinghai Province and passing through the Kumutag Desert and the Qaidam Basin, representing 11.11%. Trajectory 4 originates from the northeast, passing through the Inner Mongolia Autonomous Region, and crossing the Gobi Desert and the Badain Jaran Desert at the border of southern Mongolia and western Inner Mongolia, accounting for 8.33%. Overall, the predominant transmission direction of sandstorms in March 2021 was northwest, comprising 58.33% of the total, with the primary source being the Gurbantunggut Desert.

4.4.2 Sand and dust transport paths during sand lifting

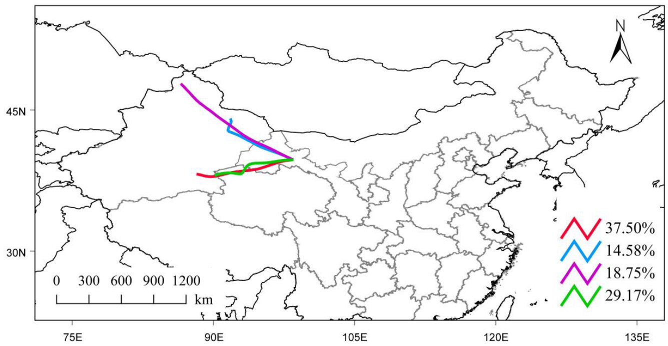

Figure 5: Jiuquan City (39.75°N, 98.52°E) was chosen as a representative site for the sand lifting event.

The representative case for studying the air pollution transmission pathway during this sand-lifting weather event was chosen to be Jiuquan City. As illustrated in Fig. 5, the predominant transmission path in Jiuquan City originates from the southwest, comprising 37.50% of the total, primarily traversing the eastern part of the Xinjiang Uygur Autonomous Region and the western part of Qinghai Province, with the primary source being the Taklamakan Desert. The second trajectory also emanates from the southwest, passing through Qinghai Province and northwestern Gansu Province, accounting for 29.17%. The third trajectory, which covers the longest distance, represents 18.75% of the total, passing through the Xinjiang Uygur Autonomous Region, with the main source being the Gurbantunggut Desert.Trajectory 4 also originates from the northwest, comprising 14.58%. Overall, the predominant directions of air pollution transmission during sandy weather events are the southwest and northwest, accounting for 66.67% and 33.33%, respectively. In the southwest, the primary sources are the Taklamakan Desert and the Qaidam Basin, whereas in the northwest, the trajectory primarily passes through the Xinjiang Uygur Autonomous Region and northwestern Gansu, with the Gurbantunggut Desert being the main source.

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4.4.3 Sand and dust transport paths during floating dust

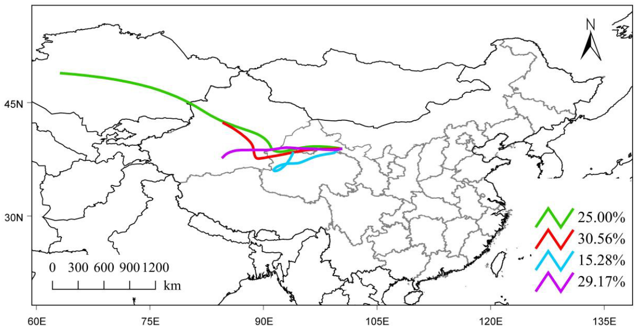

Figure 6: Zhangye City (38.93°N, 100.45°E) was chosen as a representative site for the floating dust event.

Zhangye City was chosen as the representative site for this study on sand and dust transmission pathways. As illustrated in Fig. 6, trajectories 1 and 2, which originate from the northwest, account for 30.56% and 29.17%, respectively, primarily from the Taklamakan Desert in the Xinjiang Uygur Autonomous Region. Trajectory 3, with a longer transmission distance, mainly traverses Kazakhstan and the northwest of the Xinjiang Uygur Autonomous Region, representing 25.00%. Trajectory 4, obstructed by the Qilian Mountains, exhibits a significant turning angle and originates primarily from the Qaidam Desert and Kumtagh Desert in Qinghai Province. Overall, the primary transmission pathways of dusty weather originate from the northwest, with the main sources being the Taklamakan Desert and the Qaidam Desert region.

5. Conclusions

a) From the perspective of pollutant concentration levels and $PM_{2.5}$ particulate matter distribution during sand and dust events, under three different intensities of sand and dust, the relationship between the maximum UVAI value and the proportion of high-value areas consistently follows this order: floating dust > sandstorm > sand lifting. Aerosol distribution in the study area generally exhibits higher concentrations in the western region and lower concentrations in the eastern region. The UVAI value increases with the onset of sand and dust events and decreases as these events subside. In the study area, the $PM_{2.5}$ concentration and the extent of severe pollution both increase with the arrival of sand and dust, and particulate matter continues to exert an impact for some time after the cessation of sand and dust storms.

b) In the random forest regression model, V-wind speed and air temperature significantly influenced the UVAI trend during the three dust storms, whereas cloudiness and relative humidity had a more substantial impact on the $PM_{2.5}$ trend. Specifically, the greatest contributions to UVAI and $PM_{2.5}$ were as follows: during the dust storm intensity, V-wind speed (33.78%) and cloudiness (32.30%); during the sand lifting intensity, V-wind speed (34.51%) and relative humidity (21.75%); and during the floating dust intensity, temperature (38.50%) and cloudiness (23.71%).

c) By analyzing the transmission pathways of three dust storms with varying intensities, it is evident that the primary dust sources for sandstorm weather are the Gurbantunggut Desert, the Loess Plateau region, and the Badanjilin Desert in southwestern Inner Mongolia. The main sources of sand-lifting weather are the Taklamakan Desert and the Qaidam Desert, which are also the principal sources of floating dust weather.

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Author Contributions

Yaqun Cao: methodology, writing-original draft review and editing, data curation, resources, visualization, formal analysis.

Tianzhen Ju: project administration, conceptualization, writing-review and editing, methodology, supervision.

Bingnan Li: writing-review and editing, data curation.

Lanzhi Wang: resources, data curation.

Jiaqi Wang: writing-review and editing.

Jiachen Li: writing-review and editing, investigation, formal analysis.

Zhichao Lv: investigation, formal analysis.

Data availability

The air pollutant data used during this study are from the NASA, and other datasets analyzed are available from the corresponding author on reasonable request.

Ethical Responsibilities of Authors

“All authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors”.

Consent to Participate

This paper does not require consent to participate.

Consent for Publication

The first author and the responsible author agree to publish the paper.

Competing Interests

The authors declare no competing interests.

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