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Identifying Dust emission in South Khorasan, South-Western Asia

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ABSTRACT

Atmospheric dust has a significant impact on air quality and human health. Based on visibility, dust events are defined as dusty days and dust storms. South Khorasan, which lies between the Karakum Desert and the Sistan Plain, is affected by dust, and many dusty days have been reported in this area. However, studies on the spread of dust have yet to be conducted. In this study, dusty days and dust storms were determined for six synoptic stations (Birjand, Boshrooyeh, Ferdows, Ghaen, Nehbandan and Tabas) from 2002 to 2018. HYSPLIT model is used to track dust trajectories to determine the main paths from Central Asia and the Middle East. In this study, HYSPLIT is used to analyze dust sources and transport pathways, highlighting the importance of wind patterns and visibility data for classifying dust events. The result shows that dust particles reached South Khorasan from the west of Iran in spring and winter and from the northeast of Iran in summer and autumn. In Nehbandan and summer, most dust storms were reported to rise from Karakum and move to the Sistan plain. The most densely dusty places are located in the northeast and south of South Khorasan. These places are the main entrances and exits for dust in South Khorasan. Finally, dust in South Khorasan is also influenced by the change of seasons. A part of the dust from the Karakum desert enters South Khorasan, and a significant part of the dust raised in South Khorasan moves towards the Sistan plain.

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1. Introduction

Atmospheric mineral dust is composed of materials derived from the weathering of rocks and soils at the Earth's surface. These materials are lifted into the atmosphere by strong surface winds and convection, which create turbulent mixing that allows them to be transported over long distances (Schütz, 1980). Mineral dust is the most extensive terrestrial source of particulate matter in the atmosphere. Once airborne, it degrades air quality and visibility, serves as a nutrient source for remote oceans and ecosystems (Mahowald *et al*., 2005), acts as a surface for heterogeneous reactions of trace gases, and impacts the Earth's radiative budget (Bauer *et al*., 2004). Large dust particles can settle in lung airways, causing tracheobronchial irritation and exacerbating reactive airway diseases (Taylor, 2002). Dust storms are common in arid and semi-arid regions (Cao *et al*., 2015) and can lead to severe ecological and environmental issues (Chen *et al*., 2004; Kwon *et al*., 2002; Park *et al*., 2005). The primary and most persistent dust sources in the Northern Hemisphere are located in the "dust belt," which spans from 20°N to 30°N and has developed under subtropical high-pressure subsidence (Kalderon-Asael *et al*., 2009). This belt includes Central Eurasia, encompassing West Asia and the Middle East, and is recognized as one of the most critical global dust sources (Cao *et al*., 2015).

The Middle East, situated in Central Eurasia, is among the five regions worldwide with the highest dust production (Rezazadeh *et al*., 2013). Previous studies have identified two significant dust sources in the Khorasan region: the Karakum Desert in Turkmenistan at the northern end and the Sistan and Baluchestan region at the southern end. Large areas of southern Turkmenistan, eastern Iran, and western Afghanistan are influenced by the "wind of 120 days," which predominantly blows from late spring to late summer. These winds originate from a relatively low-pressure center in southeastern Iran, along with two high-pressure centers located over the Caspian Sea and the Hindu Kush highlands (Baghi *et al*., 2020; Kaskaoutis *et al*., 2015; Orlovsky *et al*., 2005).

The region of eastern South Khorasan Province and western Afghanistan is a critical area where desertification must be addressed (Ahmadizadeh & Dawoudian, 2016). This area experiences the highest dust emissions, particularly during summer months. Local dust sources are significant due to poor vegetation cover and erosive soils, which contribute to dust generation (Pourhashemi *et al*., 2019; Boroughani *et al*., 2022). A study examining dust particles in Birjand city during summer and autumn 2016 found that these particles originate from alluvial and sedimentary lands, closely resembling minerals from the Sistan Plain and Hamoon Wetland. The analysis suggests that these dust particles likely come from both the Sistan Plain and the "wind of 120 days" (Mosavi & Pourkhabaz, 2017). South Khorasan Province faces significant stress from dust events annually, including wind erosion and damage to biological and economic resources, as reported by the General Department of Natural Resources and Watershed Management. Research on semi-warm dust patterns in South Khorasan indicates that wind flows from the eastern Caspian Sea and Turkmenistan's deserts towards southeastern Iran, generating dust as they traverse drylands and deserts in eastern Iran (Ahmadi *et al*., 2015). Another study using HYSPLIT tracked dust particles from June to September 2017, finding that wind-borne particles primarily originated from Turkmenistan, with a smaller portion coming from Uzbekistan (Baghi *et al*., 2020; Rashki *et al*., 2021).

In southern Iran, HYSPLIT modeling combined with the Normalized Dust Difference Index (NDDI) revealed that major dust storms often originate from Iraq and Syria, driven by northwest winds from regional pressure systems. These storms transport dust into central and southern regions like Shiraz and Bushehr (Khamooshi *et al*., 2016). Recent research confirms Iraq and Syria as primary sources of severe dust storms, with the model showing excellent accuracy in predicting PM10 concentrations (Alzaid *et al*., 2024). In western Iran, specifically Lorestan Province, both international sources (e.g., deserts of Syria and Iraq) and local contributions to dust events have been identified. HYSPLIT back trajectory analysis demonstrated that Mediterranean air masses play a key role in transporting dust into western Iran, where the Zagros Mountains act as a barrier (Borna *et al*., 2021). Using the HYSPLIT model, researchers have identified major dust sources and transport routes for eastern Iran. Up to 90% of dust originates from deserts in Turkmenistan, northwest Afghanistan, and Kazakhstan, transported via northern and northwestern winds. These findings were validated using satellite imagery and synoptic analyses, highlighting the role of atmospheric stability in prolonging dust retention at high altitudes (Yarmoradi *et al*., 2019).

Tracing dust particles in Central Eurasia and Eastern Iran is crucial for addressing environmental, health, and economic challenges. Dust storms degrade air quality, leading to respiratory and cardiovascular issues, and carry harmful substances like heavy metals, posing serious health risks. They also contribute to land degradation, desertification, and infrastructure damage. By identifying dust sources and pathways, effective air quality management, health mitigation, and infrastructure protection strategies can be developed. Additionally, tracing dust facilitates regional cooperation, especially for transboundary dust issues, and helps assess climate change impacts on dust storm frequency and severity, informing adaptation strategies (Akbari & Farahbakhshi, 2015; Soltani-Gerdefaramaezi & Morovati, 2021; Ebrahimi-Khusfi & Soltanianzadeh, 2024).

To date, no comprehensive research has been conducted to investigate the origins and occurrences of dust. The trend of dust emissions in South Khorasan had not been studied previously.

2. Material and Methods

2.1. Study Area

Central Eurasia (Fig. 1a) is characterized by numerous dust storms occurring in Kazakhstan, Turkmenistan, and Iran (Nobakht *et al*., 2021; OĞUZ, 2020; Rashki *et al*., 2021). South Khorasan (Fig. 1b) is situated at the northeastern edge of Dasht-e-Lut in eastern Iran and connects Turkmenistan with the Sistan Plain (Yousefi *et al*., 2016). This region has six critical synoptic stations that have been operational for many years, providing climatic data and information such as visibility. The variability in climate and landforms in this area is a significant reason for conducting research. Additionally, governmental reports indicate that dust occurrences adversely affect the local population, with these effects increasing over time. Unfortunately, limited research has been conducted in this region, which remains an overlooked aspect of Central Eurasia.

2.2. Dataset

The observational data related to dust events from the synoptic stations of Birjand, Boshrooyeh, Tabas, Ferdows, Ghaen, and Nehbandan were collected for the years 2002 to 2018 from the Iranian Meteorological Organization and the Research Institute of Meteorology and Atmospheric Sciences. According to a report from the World Meteorological Organization, these data are specified in terms of three-hour dust events (DE), based on horizontal visibility and wind speed—two primary variables for dust detection. In the subsequent step, dusty days and dust storms were extracted from dust events according to the classification by Shao and Dong. The Shao and Dong (2006) classification method for identifying dust events and dust storms is based on visibility and wind speed criteria, offering simplicity, wide applicability, and consistency due to its straightforward thresholds and reliance on standard meteorological data. However, it may lack detail by not accounting for factors like particle size distribution or chemical composition, and its dependence on predefined thresholds could lead to misclassification or oversight in varying local conditions. For a more precise evaluation, additional context or direct references to their work would be needed. For this purpose, days when the horizontal visibility at the stations was reported at least once between 1000 and 10000 meters, along with weather codes 6 or 7 in the three-hour observations, were classified as dusty days (DD). Conversely, days with visibility below 1000 meters and meteorological codes ranging from 30 to 35 were classified as dust storm days (DS) (Y Shao & Dong, 2006). In South Khorasan Province, any day when horizontal visibility is less than 10 km at least once during eight recorded times is reported as a dusty day.

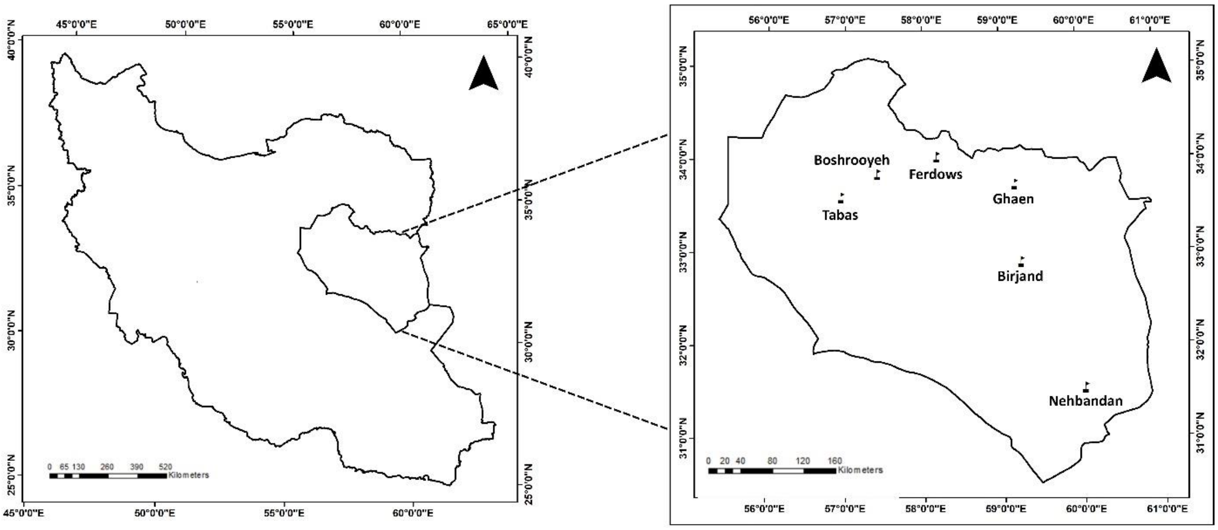

Fig. 1. The location of Central Eurasia (a) and South Khorasan (b).

2.3. Methodology

2.3.1. Windrose pattern

Windrose indicates the frequency of the two-way wind path and provides brief information about the wind speed and the distribution of the dust path in a specific station. The colors in Windrose represent different wind speeds, and 16 directions are displayed in the spherical shape of Windrose (Gopi *et al.*, 2021). In this study, after preparation in PGI Visual Fortran 13.9 software, it was entered into WRPlot View software, and seasonal winds were plotted in all stations.

2.3.2. Dust track of dusty days

One of the methods for identifying dust sources is using the Hybrid single-particle La-grangian integrated trajectory model (HYSPLIT), which can detect the emission path and dust sources with a high approximation. The HYSPLIT is a dual model for calculating the trajectory of dust movement, scattering, and sedimentation simulation using PUFF/particles approaches (Draxler *et al.*, 2009). In this research, the possible path of dust particles at three altitudes of 500, 1000, and 1500 meters has been investigated by HYSPLIT. For this purpose, the backward and forward tracking of dust particles on dusty days with a visibility of fewer than 5000 meters was done in 6 synoptic stations to draw the main routes of input and output gates of dust particles to South Khorasan.

2.3.3. Dust track of dust storms

In the next stage, severe dust storms with a meteorological code of 30 to 35, divided into two categories (dust storms with 200 meters to 1000 meters visibility and dust storms with visibility less than 200 meters (Shao & Dong, 2006) – drew. The dispersion of Backward and Forward trajectories of particles have been tracked 24 hours for dusty days and 72 hours for dust storms before they reached atmospheric heights of 500 meters.

3. Results and Discussion

3.1. Windrose patterns

Wind rose patterns for spring, summer, autumn, and winter were created for all stations. In Birjand, the predominant wind direction in spring was primarily from the east and southeast, with wind speeds often being high during this season. In autumn and winter, the wind mainly blew from the east, with additional contributions from the southeast and northeast. The only notable differences between wind direction in autumn and winter in Birjand were the higher wind speeds in autumn compared to winter and a greater prevalence of northerly winds in autumn. However, these differences were minimal. In summer, the wind direction shifted to include northeast as a primary direction, distinguishing this season from the others. Wind speeds were also significantly higher in summer than in spring, autumn, and winter.

In Boshrooyeh, the prevailing wind direction in spring was from the north and northwest. Similarly to Birjand, the main wind direction in summer was northeast. In autumn and winter, the wind predominantly came from the north; however, in autumn, it also included a northeastern component similar to summer. It is important to note that in Boshrooyeh, wind speeds were higher in spring and summer than in autumn and winter.

In Ferdows, the wind direction in spring was mainly between east and south, with southeast being considered the primary direction for this season. During summer, the dominant wind direction shifted to northeast, although east and southeast were also noted. Wind speeds increased in summer compared to spring but were lower in autumn and winter than in spring. In autumn, the wind predominantly came from the southeast and east, while in winter it was primarily from the east. Notably, only during spring did the wind direction significantly shift to the south.

In Ghaen, the main wind directions during spring and autumn were predominantly from the east. This dominance was more pronounced in autumn; however, some winds shifted to southwest during spring, which was less common at previous stations. Similar to Birjand, Boshrooyeh, and Ferdows, Ghaen experienced northeast winds during summer. Nonetheless, a key distinction at Ghaen compared to other stations is that during winter, winds primarily blew from the southwest and generally towards the west. This sets Ghaen apart from other stations during winter and across different seasons.

In Nehbandan, the wind direction during spring was mainly from the east, northeast, and southeast. In summer, wind speeds were significantly higher than those recorded in other seasons at all stations. The predominant wind direction shifted to north before transitioning to east and southeast. The patterns of wind direction in autumn and winter were very similar in Nehbandan, with winds mainly coming from the northeast; it is worth noting that wind speeds were higher in autumn than in winter.

In Tabas, the wind direction pattern during spring indicated that it was difficult to identify a specific dominant direction; however, winds were generally more oriented towards east, southeast, and northeast. The highest wind speeds were associated with winds blowing from the west, northwest, and north. During summer, like Nehbandan, Tabas did not predominantly experience northeast winds; instead, it mainly had winds coming from east or southeast. The patterns of wind direction in autumn and winter were similar as well; winds primarily came from the north with a subsequent shift to east in autumn and northeast in winter (Fig. 2).

3.2. Backward Trajectories in dusty days

Seasonal tracking of backward trajectories on dusty days with visibility of less than 5000 meters revealed that in spring and summer, dust particles predominantly entered the Birjand station from the northeast and southwest. In autumn, dust particles primarily entered Birjand from the south, while in winter, most trajectories indicated that dust particles came from the southwest. The altitude of the moving particles varied, with lower altitudes observed in autumn.

The detection of dust particles entering Boshrooyeh showed similar entry patterns in spring and winter compared to summer and autumn. In spring and winter, dust particles mainly entered Boshrooyeh from the southwest. Conversely, during summer and autumn, dust particles were observed to enter from the northeast. However, due to the limited number of trajectories analyzed, confirming the specific direction of dust particle entry into Boshrooyeh remains challenging. The height of dust particles was particularly low in winter.

Detection of dust particles entering Ferdows indicated that they primarily came from the southwest, east, and northeast during spring. In summer, dust particles entered Ferdows mainly from the northeast, with additional contributions from the south. In autumn, it is anticipated that particles will primarily enter Ferdows from the south; however, the number of trajectories is quite small. In winter, dust particles predominantly arrived from the southwest. The predicted trajectory heights, especially to the south of Ferdows, were low, suggesting that the dust particles were likely moving towards Ferdows at lower altitudes.

Analysis of dust particles entering Ghaen indicated that in spring and winter, they primarily originated from the south. However, a significant number of trajectories in summer showed that particles entered Ghaen at low altitudes from the north, suggesting a large influx of dust from northern South Khorasan and Turkmenistan. Additionally, it is expected that during this season, some dust particles entered Ghaen from the northeast at higher altitudes. In autumn, dust particles may have also entered Ghaen from both the southwest and northeast.

Tracking of dust particles entering Nehbandan during autumn and winter revealed that in autumn, particles mainly arrived from the northeast at high altitudes, while in winter they came from the south at low altitudes. In contrast, tracking during spring and summer indicated two distinct directions: in spring, particles entered Nehbandan from the south and southeast at low altitudes, while in summer they came from the north at high altitudes.

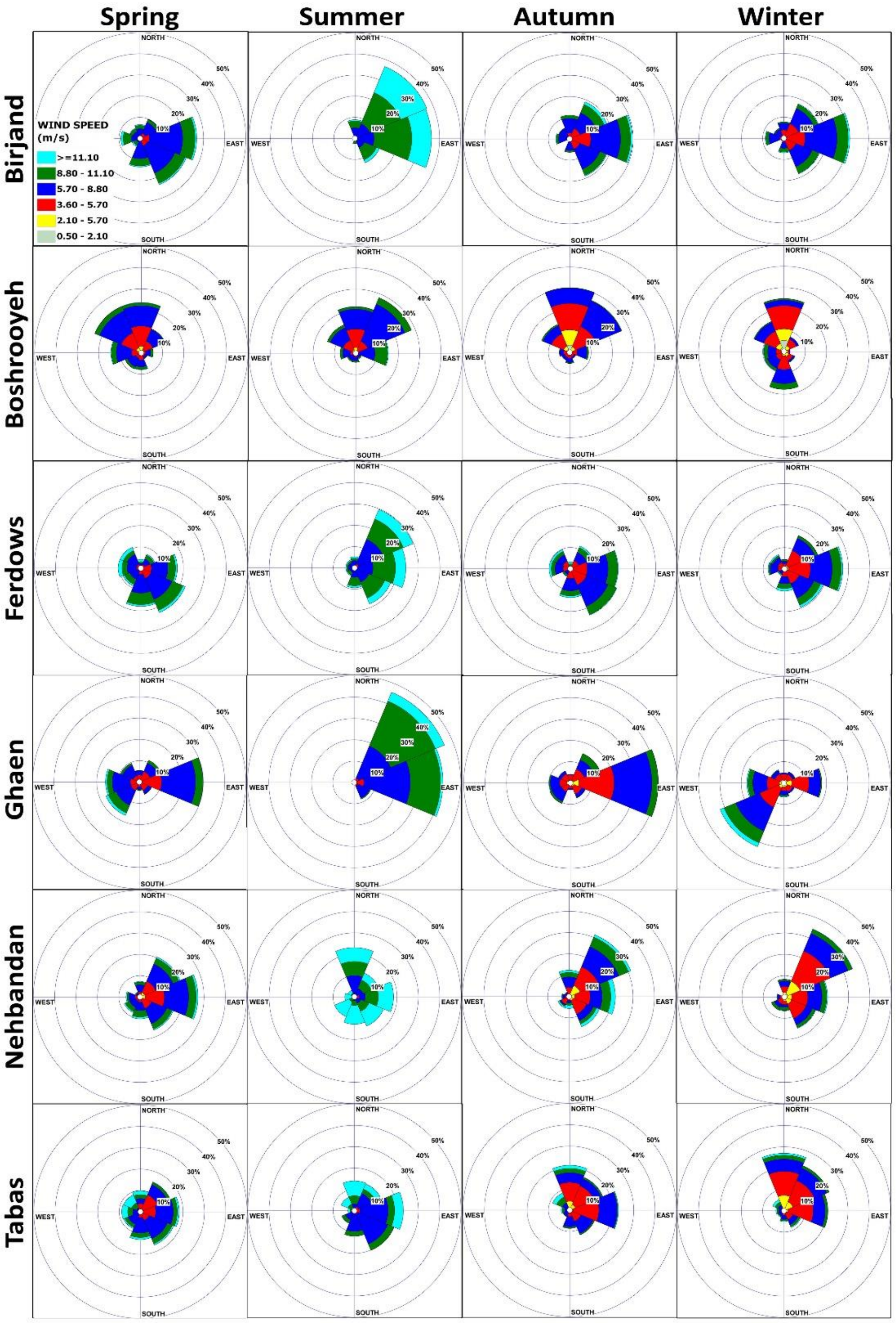

Fig. 2. Windrose in different stations from 2002 to 2018.

Tracking of dust particles entering Tabas demonstrated a very similar movement pattern in spring and winter; in both seasons, dust particles primarily entered Tabas from the west and southwest. Additionally, as one moves further south, the altitude of displaced particles tends to decrease. However, particle tracking in summer indicated that dust mainly entered Tabas from the northeast and east. In autumn, the pattern became clearer: particles entering Tabas from the east were primarily at low altitudes, while those moving from the west reached Tabas at higher altitudes.

Dust tracking conducted in South Khorasan illustrates relatively consistent paths of dust dispersion. An analysis of dust particle motion indicates that during spring and winter, particles are predominantly imported from the southwest and west into South Khorasan. In summer, most dust particles are sourced from the northeast regions of South Khorasan and Turkmenistan; whereas in autumn, they are mainly transferred from the east to South Khorasan (Fig. 3).

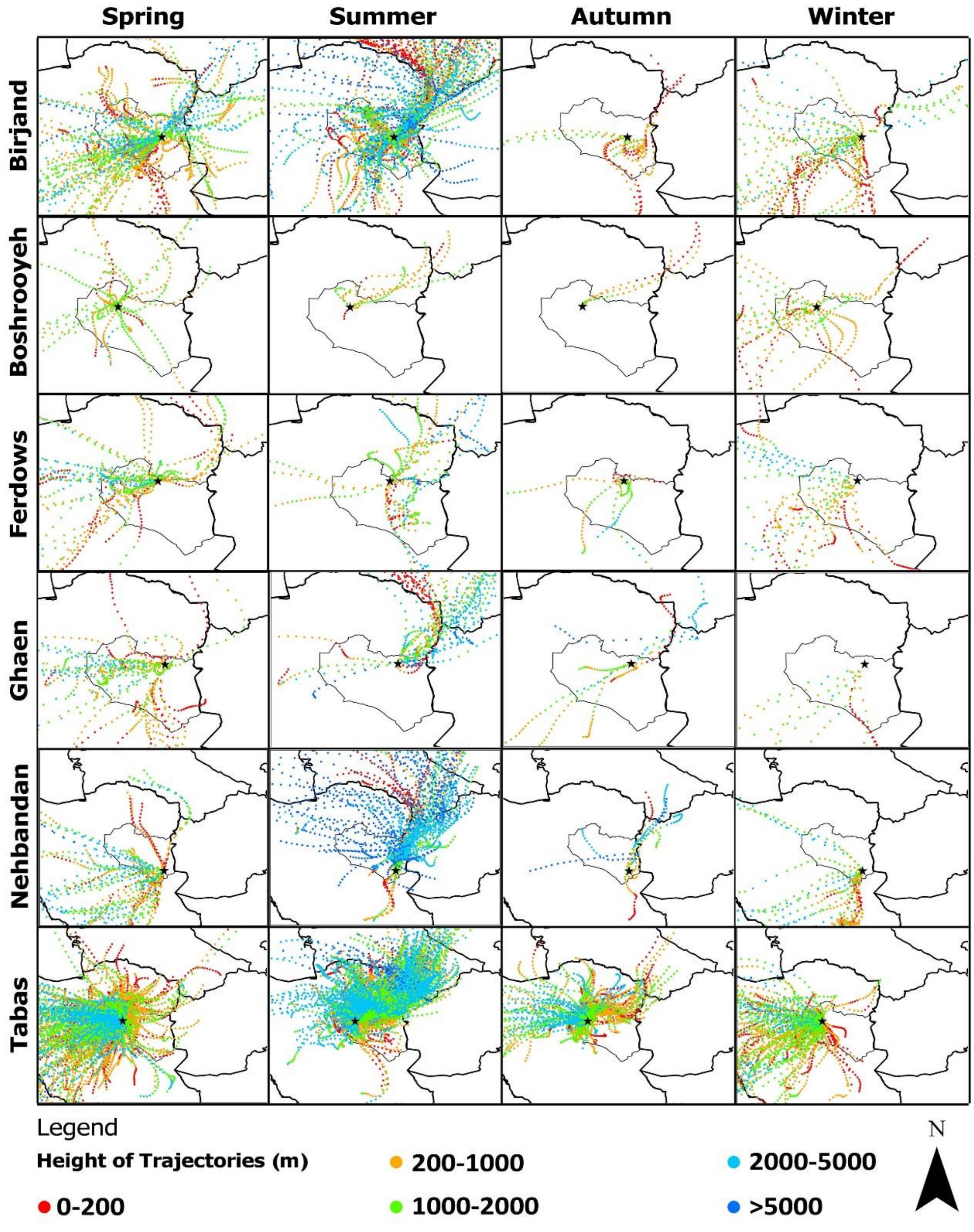

Fig. 3. Backward Trajectories in synoptic stations

3.3. Forward Trajectories in dusty days

Detecting dust particles in a forward manner in Birjand revealed that the particle movement patterns in spring, summer, and winter are almost the opposite of those observed in backward particle tracking. Specifically, particles detected in Birjand moved to the northeast in spring, southwest in summer, and east and northeast in autumn and winter. The height of particle movement to the south of Birjand was predominantly low, while the detected particles in the northeast and east generally moved at higher altitudes.

Tracking dust particles in Boshrooyeh during spring indicated that these particles did not follow a specific direction; some moved southeast, others southwest, northwest, and east. The particles that moved southwest were primarily displaced at higher altitudes. Despite the limited number of trajectories, particle tracking in summer and spring showed that particles moved east and west in summer and west in autumn. However, during winter, the particles predominantly moved eastward.

Detection of dust particles in Ferdows also demonstrated a contradiction between the forward motion pattern and the backward motion pattern. In spring and winter, dust particles mainly moved southeast, east, and south. In summer, they primarily moved southwest and west, with no clear pattern observed in autumn. Particles moving north and east of Ferdows were generally displaced at higher altitudes, while those moving southeast and south were mainly at low altitudes.

Tracking of dust particles in Ghaen indicated that the movement patterns were similar in spring and winter, with particles moving northeast and east. The height of particles moving to the northeast was particularly elevated, especially in winter. However, during summer, dust particles primarily moved to the east and southeast, often at lower altitudes. There was no specific pattern observed in autumn; however, some particles likely moved east while others moved west.

Tracing dust particles entering Nehbandan revealed that, similar to Birjand, Ferdows, and Ghaen, the particle movement patterns in spring and winter were very similar, with particles mainly moving eastward. In summer, as seen at most stations, dust primarily moved south and southwest (Fig. 10). The particle movement pattern in autumn was also similar to that of summer despite a limited number of trajectories; additionally, the height of displaced particles was generally low.

Dust particles detected in Tabas showed that the particle movement patterns during spring and winter were very similar. However, while moving east and northeast, there was a tendency for particles to shift more towards the southeast. The movement patterns during summer and autumn were alike as well; particles predominantly moved south with high concentration. It is predicted that particle motion heights will be greater in summer compared to other seasons. Dust from South Khorasan also predominantly moved to the east and northeast during spring and winter; meanwhile, dust movement during summer and autumn was mainly directed south and southwest (Fig. 4).

A noteworthy observation is the similarity of wind direction patterns across certain seasons and stations with the dust tracking conducted. This pattern similarity is evident in spring, autumn, and winter for Birjand; spring and winter for Ferdows; spring for Ghaen; spring, summer, and winter for Nehbandan; and spring for Tabas. It can be seen that this pattern is most similar during spring. This suggests that although wind direction patterns relate to all days of the year while dust particle tracking pertains to a limited number of days, winds in spring predominantly aligned with the direction of dust particle movement (Fig. 2, Fig. 4).

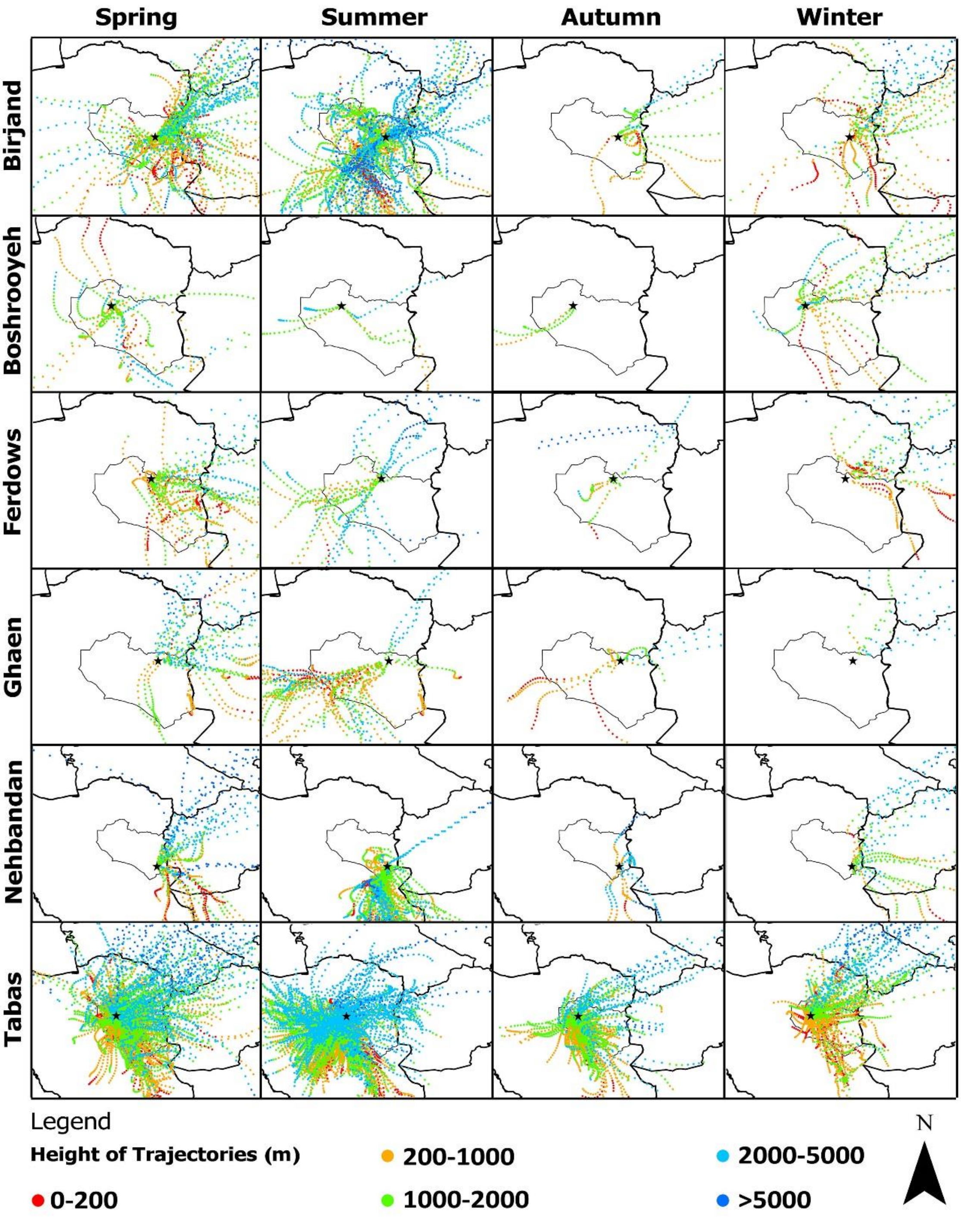

Fig. 4. Forward Trajectories in synoptic stations

3.4. Backward dust storms trace

In South Khorasan, up to 23 severe dust storms have been recorded. During these storms, particles and dust in Birjand mainly entered from the south and northeast in summer, while in winter, they predominantly came from the south. Additionally, the source of the storms in Ferdows was likely from the south in spring. In Ghaen, however, storms have been reported in three seasons: spring, summer, and autumn. Particle tracking indicates that the storms occurring in spring probably originated from the southwest and northeast. The dust entering during summer storms came from the northeast and likely originated in Turkmenistan due to the high altitude of the particles. Particle tracking also showed that the source of particle movement toward Ghaen during autumn dust formations was probably from the southwest.

Dust particles associated with Nehbandan storms in spring were likely traced back to the southwest and southeast. In contrast, tracking summer storms in Nehbandan indicated that they could originate from the north and northeast. However, the pattern of traced particles related to Tabas storms in spring was quite irregular; generally, it can only be stated that they originated from the west of Tabas (Fig. 5). Most of these storms originate at lower altitudes than those found in southwestern Iran and Saudi Arabia but at higher altitudes than those in European countries and Turkmenistan. Almost no storms have originated in eastern Iran; instead, dust particles have primarily come from countries to the west or southwest.

A noteworthy point is that most of these storms originate at lower altitudes than those found in southwestern Iran and Saudi Arabia but at higher altitudes than those in European countries and Turkmenistan. Almost no storms have originated in eastern Iran; instead, dust particles have primarily come from countries to the west or southwest.

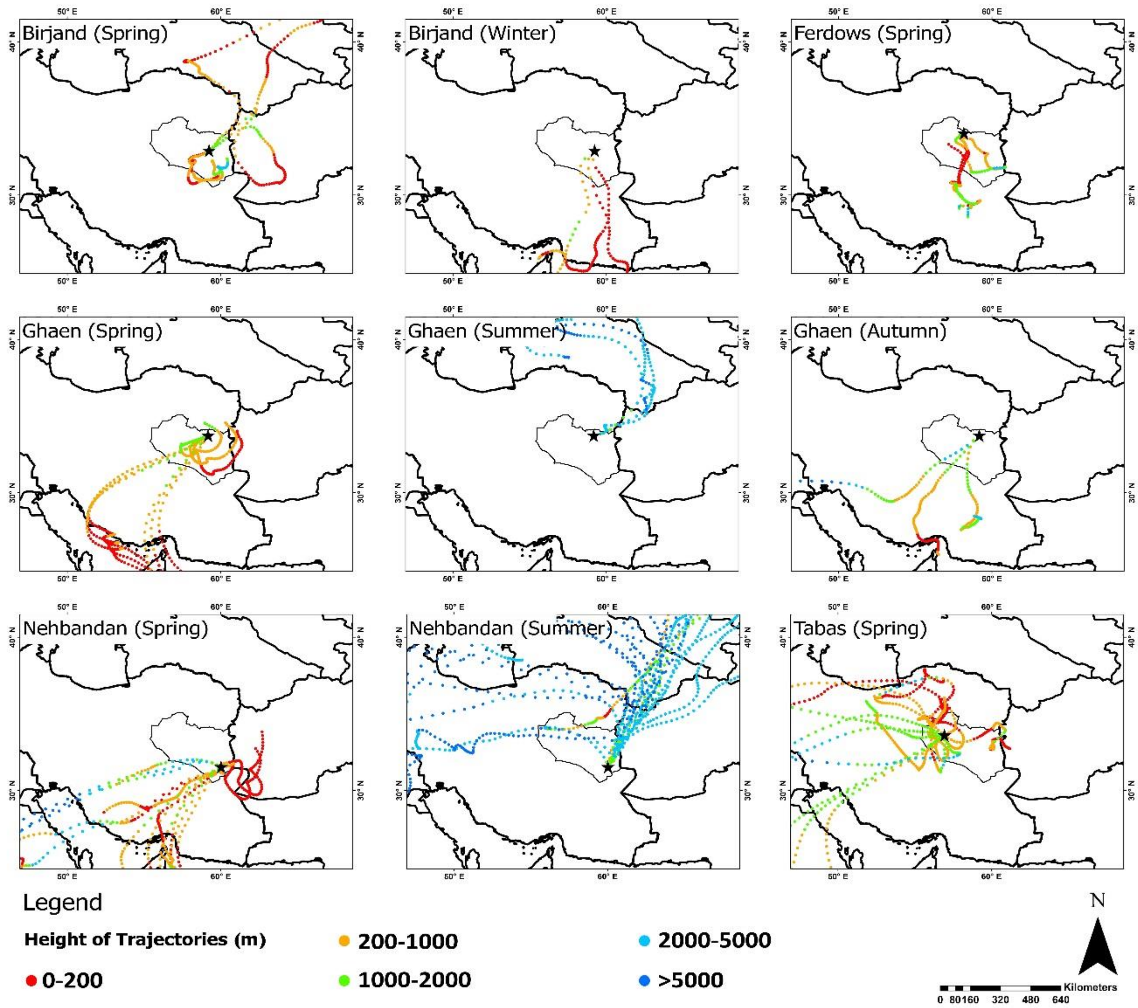

Fig. 5. Backward Trajectories of Dust storms

3.5. Forward dust storms trace

Tracking of storms during the spring of Birjand showed that these particles probably moved from Birjand to the southeast, southwest, and at higher altitudes to the west. Tracing Birjand summer storm also revealed that the direction of particles was moving from Birjand to the northeast. Also, particles and dust related to Hurricane Ferdows, which occurred in the spring, may have moved south. However, the Ghaen dust storms in spring and autumn have moved east and northeast. However, the dust particles of the Ghaen summer storm have shifted South and southwest. Nehbandan spring storms, like Ghaen, were moving east, and dust particles from summer storms were also moving south. Finally, the spring storm of Tabas, like most storms in the spring, moved east from Tabas.

Nevertheless, the particles originating from South Khorasan in dust storms, most of their destination in the southeast and south. It can be said that most storms have been to the east (Fig. 6). The pattern of dust storms also indicates that the storms' origin was mainly from the west, and the destination of the storms formed in South Khorasan was the east.

Air pressure pattern changes was different with PM_{10} pattern changes. In July, the lowest air pressure and the highest PM_{10} concentration were recorded. The pattern of changes in air pressure and mean temperature variables were similar to the pattern of changes in PM 10 concentration (Fig6).

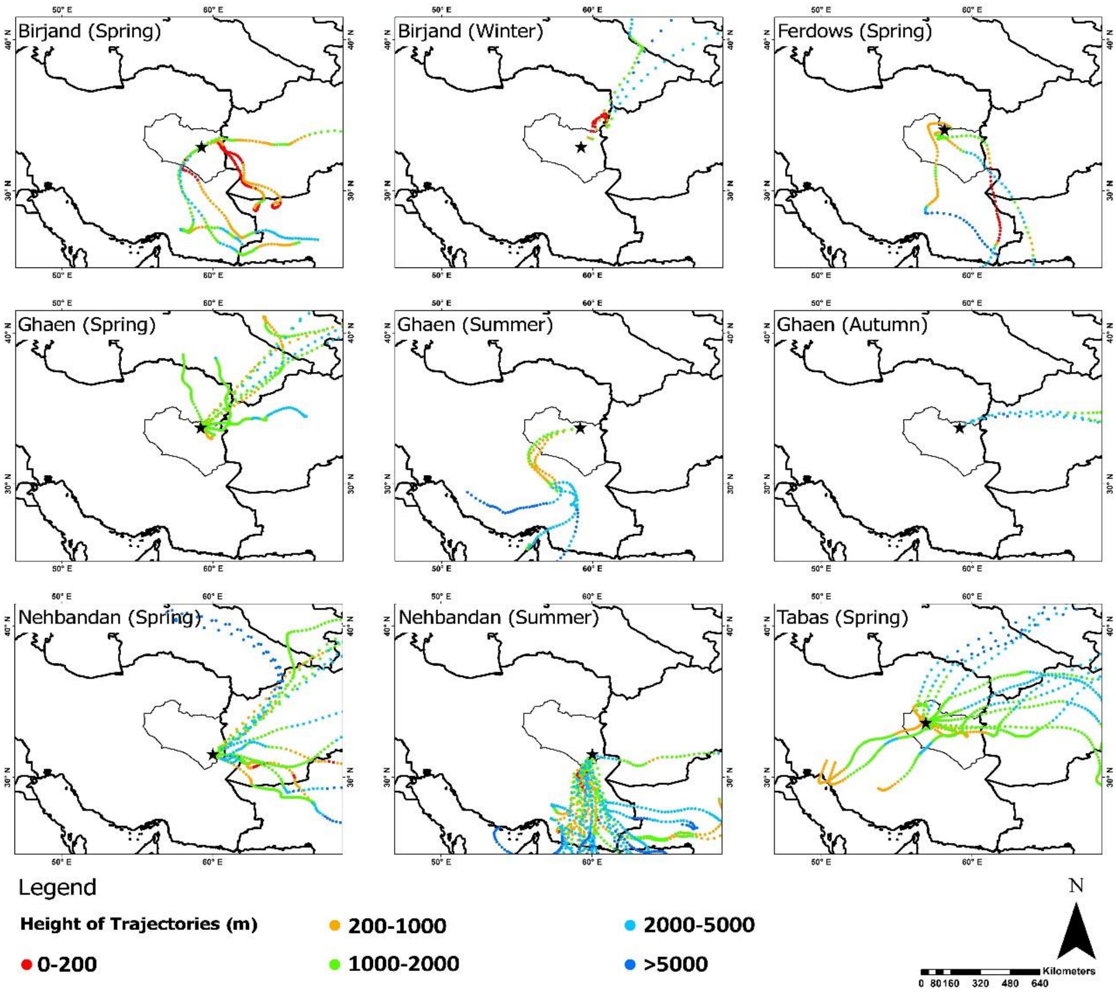

Fig. 6. Forward Trajectories of Dust storms

3.6. Main dust inputs and outputs

Based on backward trajectories on dusty days, Dust particles entered Birjand, mainly from the northeast of South Khorasan and Turkmenistan and Uzbekistan, the center, southwest, and in fewer cases, southeast and west of Iran. In Boshrooyeh, the Tracking of dust particles indicated that particles from the northeast of South Khorasan and Turkmenistan at a higher level and southwest and south at a lower level entered and reported to Boshrooyeh station. Tracking of dust particles entering Ferdows shows that dust particles generally come to Ferdows from Turkmenistan, southwestern and western Iran. Dust particles entering Ghaen have moved to Ghaen from both Turkmenistan and southern Iran. In milder amounts, the particles have come from the west to Ghaen. Tracking dust particles entering Nehbandan indicates many Turkmenistan, Uzbekistan, Tajikistan, and southeastern trajectories. Due to the number of dusty days, Nehbandan's trajectories were considered more than other stations. The study of backward trajectories in Tabas shows that in almost all directions except the southeastern, the dust particles entered was very high. Southwestern and northeastern countries have probably been the most important sources of dust for Tabas.

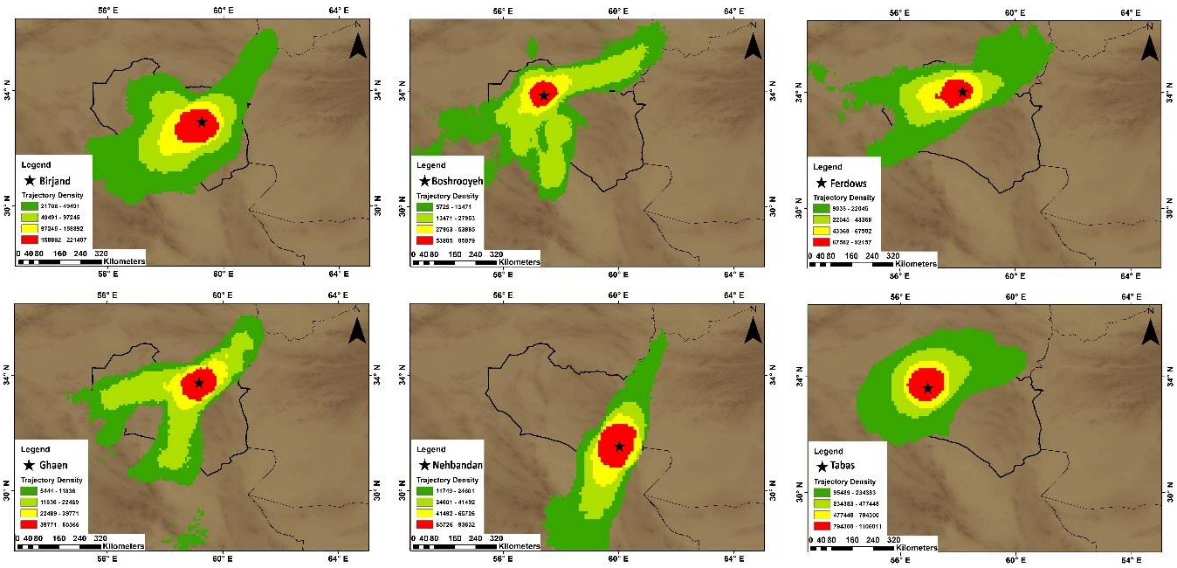

Fig. 7. Density of Input trajectories

The forward tracking of the dust from Birjand indicates that southern Iran, Turkmenistan, and Uzbekistan were probably the destination of the dust. Detection of dust from Boshrooyeh demonstrates that the Forward mode's particle path is almost similar to the Backward model. The difference is that the particles did not move to the west and center of Iran, and when moving to the east of Iran and Afghanistan, they moved in higher altitudes. The dust from Ferdows has moved to the South with high compression. Especially the movement of particles from Ferdows to the southeast is much more impressive. Unlike Birjand, Boshrooyeh, and Ferdows, central and southwestern Iran is the leading destination for dust from Ghaen. The South and southeast of Iran are the destinations of a large volume of dust particles in South Khorasan. This fact was obtained from tracking the dust of Nehbandan and Tabas. Most of the dust from Nehbandan, one of the important stations, probably moved to the South and southeast. Particles from Tabas have also moved mainly to the southeast and scattered to the northeast, center, and southwest of Iran (Fig. 8).

The importance of the South of the study area and Nehbandan is that, like the northeast of the region, the dust source is known there, the source of which may be that according to the traces, these two regions are among the main routes for dust particles to pass in South Khorasan (Fig. 3, Fig. 4). The pressure difference between Afghanistan and Sistan plain and the existence of solid pressure centers in Siberia can be a factor in forming dust particles moving from northeast South Khorasan and moving south and Sistan and Baluchestan (Ekhtesasi & Gohari, 2012).

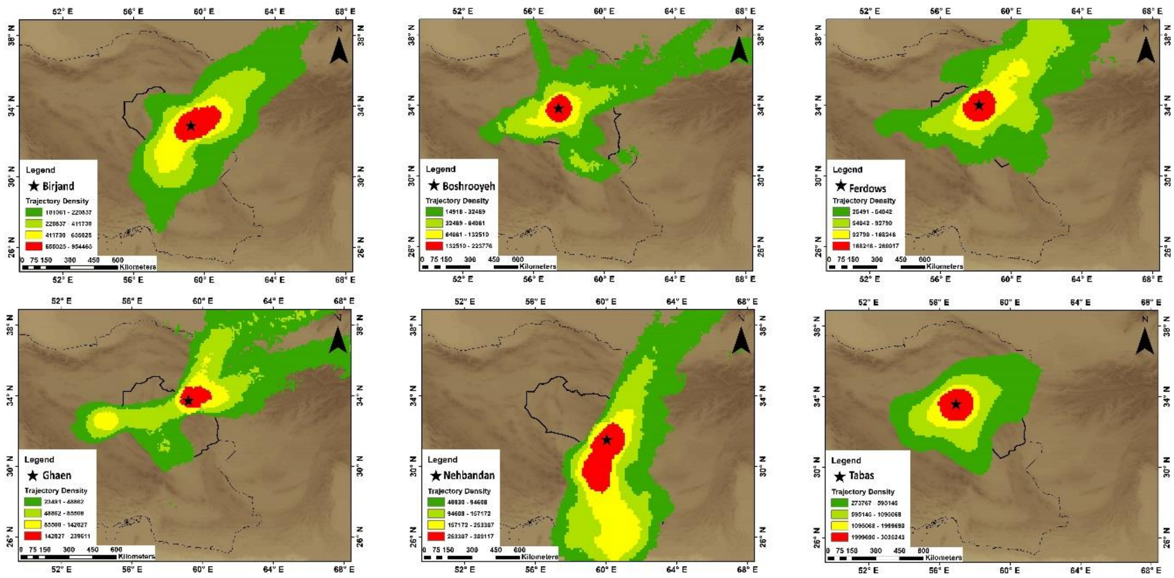

Fig. 8. Density of Output trajectories

4. Conclusion

Dust dispersion in South Khorasan depends on the seasons. Dust enters South Khorasan mainly from the west in spring and winter and mainly from the east in summer and autumn. The forward traces are also mainly in line with the backward traces. For example, in winter and spring, particles entered the province from the west, and according to advanced tracking, particles moved eastward from the stations inside the province. Of course, it should be noted that a large number of particles moved south in the summer and autumn at Nehbandan station. It is worth noting that dust sources forms along the path of dust movement over time. Tackling dust requires government funding. Stopping the formation of new dust sources in arid and semi-arid lands involves a combination of strategies that address both the environmental conditions and human activities contributing to dust generation. So, Strategies to prevent new dust sources focus on vegetation cover, soil stabilization, water management, land use practices, infrastructure improvements, and policy engagement. Planting vegetation, mulching, and using chemical stabilizers or physical barriers help stabilize soil and reduce wind erosion. Water management techniques like irrigation and rainwater harvesting maintain soil moisture, while limiting land disturbance and adopting conservation tillage prevent soil exposure. In construction and industry, dust control measures and enclosed processes minimize emissions. Regulatory frameworks and community education further support sustainable land use and dust prevention efforts, ensuring a comprehensive approach to mitigating dust formation.

Author Contributions

All authors contributed equally to the conceptualization of the article and writing of the original and subsequent drafts.

Data availability

Data available on request from the authors.

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Ethical considerations

The authors avoided from data fabrication and falsification.

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Conflict of interest

The authors declare no conflict of interest.

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