

STATISTICAL ANALYSIS OF THE NUMBER OF DAYS WITH DUST STORMS IN THE CITY OF NUKUS FROM 1978 TO 2023

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ABSTRACT

This study presents a comprehensive statistical analysis of the frequency, duration, and characteristics of dust storms in the city of Nukus from 1978 to 2023. Drawing on archival data from the Nukus Aviation Meteorological Station and supported by the Karakalpak Scientific Research Institute of Natural Sciences, the research identifies key temporal patterns, wind regimes, and seasonal variations associated with dust storm activity over the 45-year period. Results indicate a significant decline in the number of dust storm days since the 1980s, with spring months showing the highest frequency of occurrences. The analysis also highlights shifts in dominant wind directions and speeds, as well as variations in storm duration, with most storms in recent decades lasting less than an hour. A notable long-duration event occurred in May 2018, lasting up to 17 hours. These findings underscore the evolving nature of meteorological hazards in the Nukus region, their implications for public health and the environment, and the importance of continued monitoring and regional climate analysis.

KEYWORDS: Dust Storms, Air Pollution, Dust Pollution, Environment, Air Quality, Health, Aral Sea, Nukus

INTRODUCTION

Air pollution is a global environmental problem of our time and represents one of the greatest threats to the living conditions and health of the residents of Nukus. The air quality in Nukus is influenced not only by emissions of pollutants caused by anthropogenic factors but also by many natural factors, primarily due to the transformation of various dust-emitting materials in the desert and the occurrence of dust storms. Strong winds are also associated with the natural dispersion of dust.

Strong winds significantly reduce visibility, bringing large amounts of dust and sand into the atmospheric boundary layer. It is necessary to distinguish between a dust storm and a dust event (DS-DE).

- **Dust drift:** An atmospheric phenomenon in which fine dust particles are lifted by the wind to a height of 0.5 m to 2 meters above the ground, without causing significant visibility reduction. This is usually associated with soil particles and may reduce visibility to 1 km or less, but it differs slightly from a dust storm.
- **Dust storm:** An atmospheric phenomenon characterized by a significant reduction in horizontal visibility in a layer several meters above the ground due to the presence of many dust (or sand) particles. (Leukhina et al., 1996)

Essentially, observing a dust storm requires analyzing all atmospheric topographic maps (AT) based on synoptic charts. This article focuses only on the phenomenon of dust storms. This meteorological phenomenon is typical for the Karakalpakstan region, but in Nukus and its surroundings, it was not significantly observed in the periods preceding those examined in this study.

The aim of this research is to analyze the dynamics of dust storms recorded by the Nukus Aviation Meteorological Station in the Republic of Karakalpakstan from 1978 to 2023. The study of dust storm days in the city is based on archival work from the Karakalpak Hydrometeorological Department. Currently, in collaboration with the Hydrometeorological Center, the Laboratory of Environmental Process Modeling at the Research Institute of the Republic of Uzbekistan, Karakalpak Scientific Research Institute of Natural Sciences, has developed a database of meteorological elements for dust storm days. The database was created by Tleumuratova B. and Sultanashov R (2024).

The main results and their analysis, including the speed and direction of dust storms, as well as the current state of data analysis over the years, are presented. Over the past 45 years, the total number of days with dust storms and the situation in the previous period compared to the current period show two differences (Table 1; Figure 1).

In 1978–1988, there were 72 days of dust storms in Nukus; in 1989–1999, there were 24 days. In 2000–2010, there were 34 days; in 2011–2021, 36 days; and in 2021–2023, 7 days, totaling 173 days (Report of the Hydrometeorological Center of the Republic of Karakalpakstan, 1978–2023).

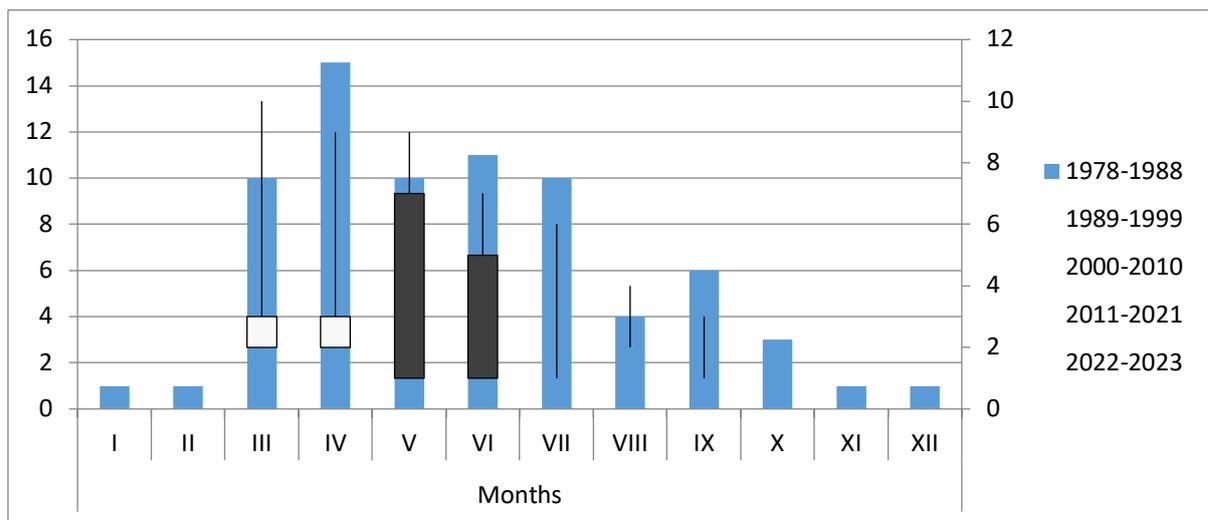
TABLE 1

Number of dust storm days by year for the period 1978–2023.

The interval of years	Months												Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1978-1988	1	1	10	15	10	11	10	4	5	3	1	1	72
1989-1999			2	2	7	5	4	2		1	1		24
2000-2010			10	5	9	5	1	2	1	1			34
2011-2021			6	9	8	7	3		3				36
2022-2023			2	3	1	1							7
Total	1	1	30	34	35	29	18	8	9	5	2	1	173

FIGURE 1

Dynamics of the duration of dust storms from 1978 to 2023 in Nukus.



The maximum number of dust storm days in a year, determined by the number of dust storm days and event duration characteristics for the studied periods, was 72 days in 1987. In the following decade, it decreased to 48 days. In the last two decades, dust storms in Nukus did not exceed 34–36 days.

The analysis of the annual frequency of dust storm days showed that each decade has its own characteristics in terms of percentage distribution (Table 2). In 1978–1988, the highest number of dust storms in Nukus was observed in April and May, accounting for 57% of all dust events. In 1989–1999, over 60% of events occurred during this period. In 2000–2010, the main activity of dust storms was recorded in May–July, with 42% in the spring months (March–April), 29% in September–October, and 19% in April–May. In 2021–2023, 40% of cases were identified in May and 30% in June (Report of the Hydrometeorological Center of the Republic of Karakalpakstan, 1978–2023).

TABLE 2

Main characteristics of the number of dust storm days and event duration in Nukus.

	1978-1988	1989-1999	2000-2010	2011-2021	2022-2023
Total number of days					
nfor the period	74	24	34	36	7
nav/year	5,3	1,6	1,9	1,6	-
nmax/year	16 1980 y.	5 1991 y.	9 2008 y.	5 2017 y. 5 2020 y. 5 2021 y.	-
nmin	2. 1985 y.	1. 1996 y. 1. 1998 y.	n/a 2003, 2004 y.	n/a 2013, 2016 y.	

Note: n/a – years in which this event was not observed.

Thus, in 1978–1988, 53% of all meteorological events occurred in the spring season. In the following decade, it shifted to June. In the last two decades, there has been an increase in activity in spring (Table 2), with the contribution of summer dust storms being 38–43%. In

2001–2010, the most significant change (47%) in dust storm activity occurred in the spring months. The duration of dust storms is a necessary characteristic of the event. Over 45 years, the total duration of dust storms was 318 hours, indicating a low trend in its dynamics over the decades (the total time with dust storms decreased from 69.4 hours to 23.3–13.8 hours). The average annual total duration of events was 5.6 hours. The maximum total duration of 2.3–1.4 hours (t-max per year) corresponded to 1984.

It should be noted that in the decade 1981–1990, the total duration and maximum number of dust storm days were recorded in different years, while the maximum number of days for other decades occurred in 1978–1980.

According to the research results, the maximum duration of a dust storm in Nukus from 1978 to 2023 was the most dangerous meteorological event in May 2018, when the dust storm lasted 17 hours per day. Therefore, the frequency of dust storms of varying durations was analyzed (Table 3).

TABLE 3

Durations of dust storms in Nukus from 1978 to 2023.

	1978-1988 years	1989-1999 years	2000-2010 years	2011-2021 years	2022-2023 years
<i>Total duration of Dust Storms (hours)</i>					
t for the period	157	91	85	97	22
t av/year	15	9	8	9	0.2
t max/year	43 1983 y.	44 1991 y.	31 2009 y.	37 2018 y.	22

Short-term dust storms lasting less than an hour accounted for 61% of events. A quarter of the events corresponded to dust storms lasting 1–2 hours (24%), while dust storms lasting 2 hours or more accounted for 15%. The analysis of annual percentage comparisons, considering the gradations of dust storm durations in our republic, allows us to draw the following conclusions: the activity of dust storms in each period has its own characteristics, and the activity observed with the duration of such events is also reflected in the trajectory of the annual process. In all periods, a two-year peak in total monthly duration is observed, and there is a difference in the frequency of temporal gradations of duration. The dust storm on May 26, 2018, lasted 3 hours. From May 27 to 29, the longest dust event was observed, lasting 17 hours. It began at 24:00 Nukus time and continued for 3 hours with decreasing wind strength, occurring at half-hour intervals, and the duration increased until 20:30 on May 27 (Report of the Hydrometeorological Center of the Republic of Karakalpakstan, 1978–2023).

The chemical composition of soil and water-soluble salts was determined in the laboratories of the Karakalpak Branch of Chemistry and the Republican Center for Sanitary and Epidemiological Control of the Academy of Sciences of the Republic of Uzbekistan, the Hydrometeorology Department of the Republic of Karakalpakstan, and the Committee for Ecology and Environmental Protection of the Republic of Karakalpakstan.

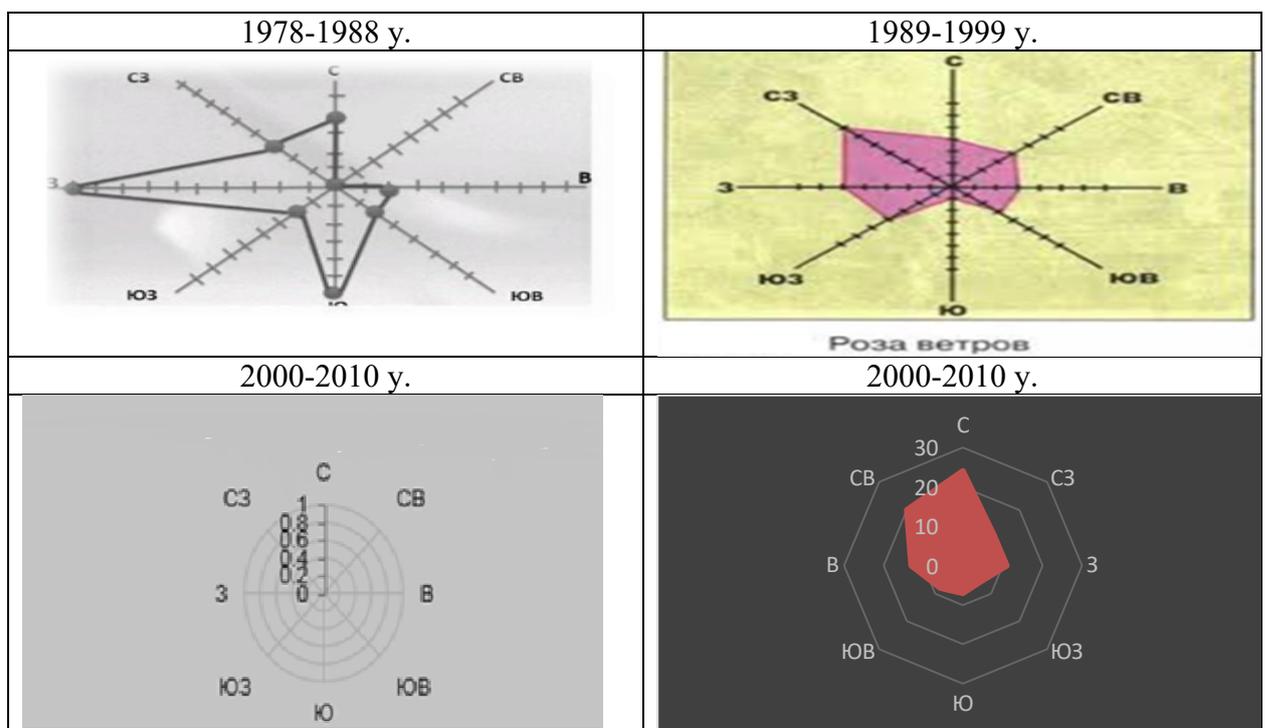
It was found that over the past 45 years, most dust storms (about 90%) began in the afternoon, from 12:00 to 21:00. During 1978–1988, 70% of the time, convective processes actively developed during the day, with 20% of events observed before noon. 8% were observed around 9:00–12:00, and 13% at 21:00.

WIND REGIME

Depending on the difference between wind speed and direction, the presence of dust storms can be determined based on short-term wind and dust storm data. The analysis of wind direction frequency is shown in Figure 2.

From 1978 to 1988, most cases (34%) were identified with westerly winds in the range of 247–292 degrees, 21% with northerly winds (69–112 degrees), and 16% with southerly winds (157–202 degrees). Wind speeds reached 5–11 m/s. From 1989 to 1999, prevailing winds (59%) were in the range of 247–292 degrees (northwesterly winds), with 18% northerly winds (337–22 degrees) and 12% northwesterly winds (292–337 degrees). Wind speeds were 3.6–8.8 m/s in 29.4% of cases. From 2000 to 2010, the largest number of cases (42%) occurred with northwesterly winds (247–292 degrees), and 25% with northwesterly and southwesterly winds, with speeds of 3.6–5.7 m/s in 21% of cases. From 2011 to 2021, 34% of cases were associated with northerly winds (247–292 degrees), and about 35% with southwesterly and northwesterly winds, with speeds of 3.6–5.7 m/s in 31% of cases (Tleumuratova et al., 2024; Chanysheva & Smirnova, 2011).

FIGURE 2



Note. *Frequency of wind directions during dust storms.*

A repeated analysis shows that in all studied periods, northerly and northwesterly winds were most frequently observed. Over the last ten years, the analysis of surface observations of northwesterly winds during dust storms from 1978 to 2023 revealed the following features in Nukus:

Over the past 45 years, the total number of dust storm days has decreased by more than half compared to previous periods, likely due to changes in synoptic processes. The period 1989–1999 was the calmest. In the last 20 years, storms lasting no more than an hour have predominated (2002, 2006, 2009, 2010). Dust storms mainly come from the north at speeds of 10–15 m/s and appear with northwesterly winds. It is appropriate to consider the characteristics of synoptic processes in this case. The problem of air pollution in the city is considered relevant.

To analyze it, it is necessary to study the relationship between dust storms and dust waves and the dangerous hydrometeorological phenomenon—the dust storm of May 26–28, 2018—which affects air quality, the environment, human health, plant growth, and overall biodiversity, having long-term negative impacts (Kublanov & Tleumuratova, 2022).

SUMMARY

Atmospheric dust pollution is a concern for the people of Nukus. The article analyzes the statistical data on dust storms observed at the Nukus hydrometeorological station, based on surface observations for the years 1978-2023.

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