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### **Dust and sand storms in the Aral Sea region**

Dust and sand storms are common dangerous weather phenomenon in arid and semi-arid regions of Kazakhstan, especially in its southern parts with a great variety of desert types and are a powerful source of mineral and salt aerosols. The dust and sand storms are distributed in Kazakhstan unevenly, depending on the geological structure, wind speed and soil texture.

In this study was used long-term meteorological data on dust storms recurrence and their regional division in Kazakhstan. On the basis of generalization and analyses of the numerous cartographic materials, meteorological observations, we identified the powerful sources of dust storms. The regions in Kazakhstan with the highest frequency of dust and sand storms is Aral Sea region (Aralkum and Kyzylkum deserts). The most active source of dust and sand storms is located in sandy deserts or in areas, which have suffered from human economic activity. They are particularly dangerous for the environment and have a great negative impact on soil conditions.

**Key words:** dust storms, deserts, arid region, Aral Sea.

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### **Арал маңындағы шаңды және құмды дауылдар**

Шаңды және құмды дауылдар өте қауіпті табиғат құбылысы және олар Қазақстанның құрғақ және жартылай құрғақ аудандарында кездеседі. Қазақстанның оңтүстік бөлігінде таралған әртүрлі шөлдер минералды және тұзды аэрозольдердің негізгі ошағы болып табылады. Қазақстанда шаңды және құмды дауылдар аймақтың геологиялық құрылысына, жел жылдамдығына және топырағына байланысты біркелкі таралмаған.

Бұл зерттеу жұмысында шаңды және құмды дауылдардың қайталануы бойынша ұзақ мерзімді метеорологиялық мәліметтер, сонымен қатар олардың Қазақстан территориясында аудандастырылуы туралы мағлұматтар қолданылған. Көпжылдық метеорологиялық бақылау мәліметтерін жалпылау және талдау негізінде шаңды және құмды дауылдардың қуатты ошақтары анықталды. Қазақстан территориясында Арал маңындағы Аралқұм және Қызылқұм шөлдері шаңды және құмды дауылдардың қайталануы (жиілігі) жоғары болатын ошақтар болып табылады. Ең белсенді шаңды және құмды дауылды аймақтар құмды шөлдерде немесе адам әрекеті басым аймақтарда шоғырланған. Шаңды және құмды дауылдар қоршаған орта үшін өте зиян және олар топырақтың жағдайына үлкен кері әсер етеді.

**Түйін сөздер:** шаңды дауылдар, шөлдер, құрғақ аймақтар, Арал теңізі.

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### **Пыльные и песчаные бури Приаралья**

Пыльные и песчаные бури – опасные природные явления, которые распространены в аридных и полупустынных регионах Казахстана. Южная часть Казахстана покрыта пустынями различного типа, которые являются источником солевых и минеральных аэрозолей. В Казахстане пыльные и песчаные бури в зависимости от геологического строения, скорости ветра и почвы распространены неравномерно.

В этих исследованиях были использованы долгосрочные метеорологические данные по повторяемости пыльных/песчаных бурь и их районирование на территории Казахстана. На основе обобщения и анализа многочисленных картографических материалов, метеорологических наблюдений были определены мощные источники пыльных/песчаных бурь. На территории Казахстана Приаралья пустыни Аралкум и Кызылкум являются источниками пыльных/песчаных бурь с их высокой частотой. Наиболее активные источники пыльных и песчаных бурь находятся в песчаных пустынях или в районах, где в большей части доминирует хозяйственная деятельность человека. Пыльные/песчаные бури очень опасны для окружающей среды и имеют большое негативное влияние на состояние почвенного покрова.

**Ключевые слова:** пыльные бури, пустыни, аридные регионы, Аральское море.

## DUST AND SAND STORMS IN THE ARAL SEA REGION

### Introduction

A dust event is a meteorological phenomenon common in arid and semi-arid regions and arises when a gust front passes or when the wind force exceeds the threshold value where loose sand and dust are removed from the dry surface [1-2]. Dust storm sources usually are associated with arid and semi-arid areas of the temperate, tropical and subtropical latitudes, where the mean annual precipitations are below 200-300 mm [1]. According to a large number of researchers dust storms are the result of turbulent wind systems entering particles of dust into the air, when the visibility is reduced to below 1000 m [3-5].

Dust, sand and salt storms are common events that occur in the arid and semi-arid regions of Kazakhstan and Central Asia. Central Asia and the Southern Kazakhstan is a region with a high frequency of dust, sand and salt storms. The region is characterized by strong winds, scarcity of vegetation cover, continental climate with long and dry summers, frequent of soil and atmospheric droughts. Many Kazakhstan drylands are represented by sandy and solonchak deserts of natural and anthropogenic origin, which are the powerful source of mineral and salt aerosols [6-7]. Sandy deserts and other types of deserts identified like active source areas of dust and sand storms. A powerful source of dust and salt aerosols is the dried bottom of the Aral Sea, which for millions of years was the receiver of the salts of the Aral basin [8-10].

The deflation process as a sand and dust storms are dominate in the Aral Sea region with solonchak, gray-brown, takyrs, takyrs like and sandy soils. Starting with the intensive development of irrigation in the Aral Sea basin at the beginning of the 1960s and irrational use of water resources, significant areas of secondary saline soils and anthropogenic solonchaks have been appeared. These areas are source of salt transfer and these salts have negative affect on the environment and living conditions of local population. White or salt storms are formed as a result of the deflation of the solonchak, salt deposits, and other loose rocks that saturate the air by dust particles. Salt is an indispensable component and companion of dust [9, 11]. Salt/dust transfer and their deposits affect the air and soil surface quality, ground water including drinking water, quality

of agricultural and livestock products. By 2000 42.000 km<sup>2</sup> of theseabed was exposed resulting in a new Aralkum Desert (Man-Made Desert) became activepowerful source of dust/salt storms and transfer during last two decades of the 20<sup>th</sup> century. The desiccated seafloor is a huge open often bare surface rich in salt. The amount of salts from the exposed bottom of the Aral Sea reached 15-75\*10<sup>6</sup> t p/year and raised considerable concerns of the impact on human health [12].

For better understanding of soil/land degradation and deflation processes, it is necessary to reveal the regional divisions in the Aral Sea region, which are mostly prone to the dust/sand/salt storms. The aim of this study is the detection of dust/sand/salt storms sources, finding the causes of this phenomenon, based on consideration and analysis of numerous cartographic materials, data from weather stations hence providing the accurate picture of frequency of dust and sand storms in the Aral Sea region.

### Study area

Aeolian sand and dust transportation is a natural process. Its intensity and impact can be amplified in regions where anthropogenic components are added. This is especially, the case in the Aral Sea basin, located mostly in the Central Asian countries of Kazakhstan and Uzbekistan. The basin

is characterized by natural sandy deserts like the Pre-Aral Karakum, Kyzylkum and Karakum, and the Usturt Plateau (Fig. 1). Annual precipitation is less than 100 mm in the central lowlands near the Aral Sea and in the Kyzylkum and Karakum deserts [13-14]. Unlike many other arid areas, the Aral Sea basin is also intensely cultivated.

The climatic conditions of the Aral Sea region are mainly governed by relatively low elevation [15]. Based on a variety of synoptic processes, rainfall patterns, annual and inter-annual temperatures, the Kazakhstan part of the Aral Sea belongs to the northern climatic province, which is characterized by cold and dry continental patterns of a Central Asian climate. Mean annual temperature is between 5 and 11 °C. Total rainfall varies between 80-200 mm [16]. Chemical composition of the soil is sulfate-chloride [9], formed on the sandy and loam maritime soils.

Most parts of the Aral Sea region are predominantly covered by fine sands and soils, which is highly prone to wind erosion and the formation of aeolian landforms [17]. Grain sizes average from 90–160 µm on the desiccated seafloor, and are smaller in young territories (desiccation 1980, 1990, 2000) and larger in old ones (1960, 1970). Adjacent desert areas (former coastal dunes, former islands, sandy deserts) have an average particle size of 170–270 µm, which make them highly susceptible to wind transportation, especially across long distances [17-18].



Figure 1 – Study area

### Materials and methods

Dust/sand storms appear in the condition of some critical thresholds of wind speed, depending on topography and soil structure when unrelated particles

are less than 250 microns, high soil dryness, and scarcity of the vegetation cover and so these thresholds vary from region to region [5, 18]. Dust storm observations were made at meteorological stations located in particular areas of interest in Kazakhstan.

For the analyses, we used data of the “Dust storm climatology for Kazakhstan database”. Our database is the archive data collections contained in the “Reference Books of Kazakhstan climate (2003)”. This database contained the monthly 39 years average number of days with dust storm for each weather station (30 weather stations) and their frequencies. We have analyzed seasonal frequency of dust storms in different regions in Kazakhstan according to average number of days with dust storms in different months for the period 1966-2003. Long-term (many years) variability of the dust storms frequencies was analyzed using data from 1971-2010.

## Results and discussion

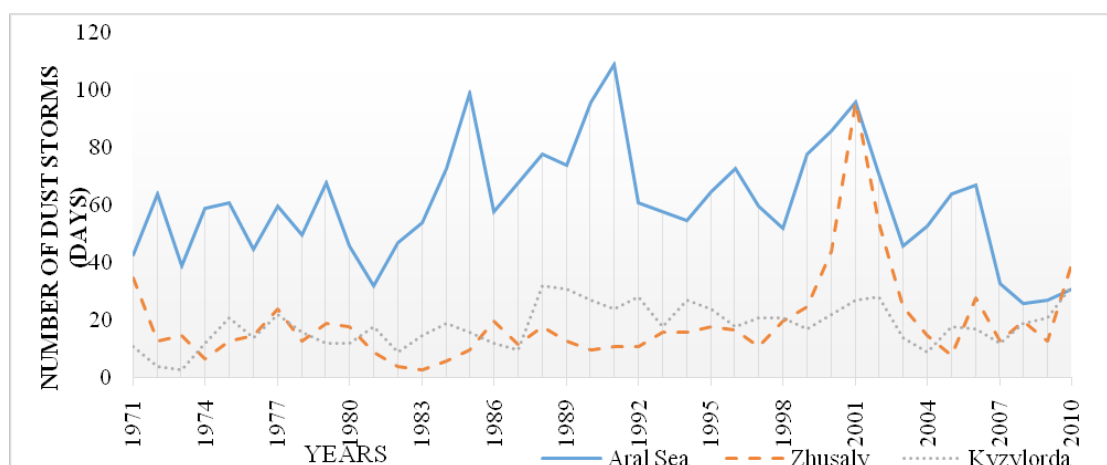
*Aral Sea region is the main dust, sand and salt storm source.* Dust and sand storms are common events in the arid and semi-arid regions of Kazakhstan [18- 19]. According to observations of the meteorological stations, the high wind speed regime and scarcity of vegetation cover, frequent of soil and atmospheric droughts and for the continental climate of Kazakhstan, dust storms are typical for continental climate of Kazakhstan almost all over territory of the republic. However, the distribution and frequency of dust storms in Kazakhstan is heterogeneous and spotty within the territory of Kazakhstan and is characterized by large diversity. Sandy and solonchak deserts such as Naryn, Pre-Aral Karakum, Kyzylkum, Aralkum and Southern

pre-Balkhash in the southern part of Kazakhstan are main source of dust and sand storms.

The high frequency and long duration of dust storms is a feature of arid regions, including the Aral Sea region. Arid climatic conditions and open surfaces with fine grain sizes are quite favorable for the development of dust storms in the region. Formation of dust and sandstorms in the Aral Sea region contribute to unfavorable (adverse) weather conditions and the state of the soil surface. Strong winds are often recorded in the region, with mean wind speeds reaching 6 to - 7  $\text{ms}^{-1}$  at the meteorological stations of the region. In the summer, the maximum wind speeds can reach 20 to - 25  $\text{m s}^{-1}$  [18, 20]. These natural factors determine the high vulnerability of the territory to the development of deflation processes as a dust and sand storms. The frequency of dust and sand events between 1971 and 2010 at three Kazakhstan meteorological stations along the Aral Sea region was shown in Fig.2. Active deflation processes were observed at MS in 1972-1979, 1985-1991, 2001-2005 (Fig.2).

The most frequent storms were observed in the northern Aral Sea region (Aral Sea MS), where their long-term average frequency reached 36 to - 110 days per year, compared to 9 to - 33 days per year in the east (Kyzylorda MS, Zhusalv MS).

The largest dust/sand storm sources were the Pre-Aral Karakum (Aral Sea MS) and Kyzylkum deserts, where dust/sand storms occur from 40 to - 110 days out of the year (Fig.2).



**Figure 2** – Long-term dynamics of dust and sand events in the largest dust storm source of Aral Sea region for period of 1971-2010

Additionally, the Aralkum Desert is the main source of dust, sand and salt storms. The arid climate, open surface with fine grain sizes are

favorable for the development of regular dust, sand and salt storms in the man-made Aralkum Desert. In the Aralkum region the frequency of dust storms

has increased since the 1980s and since 2000 almost all meteorological stations in Central Asia are registering an increase in the dust storm activity [13, 21].

*The seasonal distribution of dust and sand storms in the Aral Sea region.* Kazakhstan is a large region of variability of geographical and climatic features, therefore dust storms activities vary with annual and inter-annual scales. In general, the Kazakhstan dust storms outbreaks are common in the spring and summer seasons. According to

averagenumber of days with dust storms in different months for the period of 1966-2003, we found peak from April-July (Fig. 4). Due to the drastic rise in the temperatures and high wind speed in the spring, the southern deserts surfaces suffer from rapid evaporation of precipitation, which together with strong winds favors the development of dust events. The Kyzylkum, Pre-Aral Karakum are the main regions of Kazakhstan, where dust storms are common, especially during April-October and April through August respectively (Aral Sea MS).

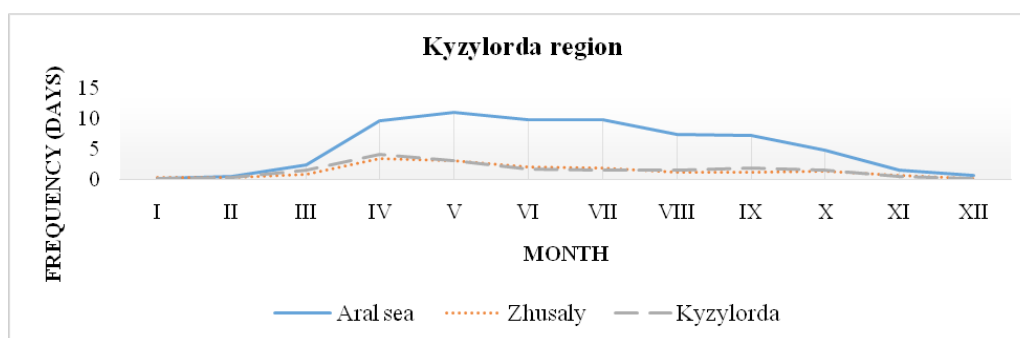


Figure 3 – Seasonal frequency of dust storms in the Aral Sea region for the period of 1966-2003

## Conclusion

The vast expanse of deserts across Kazakhstan and Central Asia experience dust storms of different frequencies, intensities and durations. The frequency of dust events varies over a wide range of 5-146 days of dust storms per year. Aral Sea region is most prone to the dust, sand and salt storms. Human activities have changed the level and volume of the Aral Sea. Syrdarya and Amudarya rivers regulation, provoke land/soil degradation and contributed to the development of intensive deflation and desertification processes. Analysis of the data on

dust and sand storms shows that the northern parts of the Aral Sea region exhibited dust storms more frequently than the eastern parts. Nevertheless, in this region the anthropogenic causes are playing major role in the origin of the dust, sand and salt storms. The Aralkum (Man-Made Desert) and Kyzylkum Deserts became active and main powerful sources for aeolian dust, sand and salt storms and transfer in the Aral Sea basin. The powerful source of aerosols have a great affect on the climate and environmental situation in the Central Asia and Kazakhstan. These aerosols can seriously pollute the air and water lead to the soil salinization and vegetation degradation.

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