American Journal Of Applied Science And Technology
(ISSN – 2771-2745)
VOLUME 04 ISSUE 07 Pages: 46-55
OCLC – 1121105677
Crossref doi Google Scholar WorldCat MENDELEY

Publisher: Oscar Publishing Services

Journal Website: https://theusajournals.com/index.php/ajast

Research Article

MODEL OF SPATIAL DISTRIBUTION OF DUST AND SAND EMISSION

Submission Date: July 21, 2024, Accepted Date: July 26, 2024,
Published Date: July 31, 2024
Crossref doi: https://doi.org/10.37547/ajast/Volume04Issue07-07

G'iyosiddin Rustamov
Research Institute of Environment and Nature Conservation Technologies, Bunyodkor Avenue 7-A, 100043, Tashkent, Uzbekistan

ABSTRACT

The environmental problem of the Aral Sea has had a significant impact on Central Asia in the last fifty years, as a result, the most important factor of the emergence, spread of dust and sand storms and the spread of polluting particles in the regions leads to negative changes in climate indicators. The formation of dust and sand storms is directly related to various climatic elements such as heat, rain, wind formation conditions, pressure, air humidity and solar radiation. As a result of the occurrence of the above conditions, the level of drought in the regions will increase, causing a change in temperature, a change in wind speed, and an increase in the direction of the wind, which will lead to an increase in dust and sand storms. It is observed that the formation of dust and sand storms in the conditions of climate change on the earth, changes in the distribution conditions increase the range of negative effects and lead to other unexpected consequences.

The construction of mathematical models of the processes of formation and diffusion of pollutants into the atmosphere is carried out under certain conditions, restrictions and assumptions that do not contradict the physical nature of these processes and the basic laws of conservation of energy, momentum and mass. it also meets the required accuracy of solving specific theoretical or practical problems.

Therefore, as in many other areas, the optimal way to solve this problem is to use mathematical modeling methods.

KEYWORDS

Insular region, Atmospheric shell, hydrometeorological data, mathematical modeling of salt-dust aerosol dispersion process, Hybrid Single-Particle Lagrangian Integrated trajectory model of hybrid single-particle Lagrangian.

INTRODUCTION

When solving various tasks related to the analysis and control of the ecological situation, experts need accurate information about the distribution of the concentration of particles of pollutants (pollutants) in the environment. To obtain such data, it is necessary to have a fairly dense network of observation points, regular and frequent sampling, as well as to know the results of the measurement history. In addition, the data of automatic atmospheric air monitoring stations reflect its actual condition only at specific measurement locations. That is, they determine the consequences of pollution, while its causes and the general picture of the ecological state of the atmosphere in the neighboring area remain hidden.

Therefore, as in many other areas, the optimal way to solve this problem is to use mathematical modeling methods. Construction of mathematical models of processes of emission, transmission and diffusion of pollutants into atmospheric air is carried out under certain conditions, restrictions and assumptions that do not contradict the physical nature of these processes and the basic laws of conservation of energy, momentum and mass. it also meets the required accuracy of solving specific theoretical or practical problems.

The development of the methodology of mathematical modeling of the processes of the transfer and spread of harmful substances into the atmosphere is a topic of interest to many researchers in far and near foreign countries and Uzbekistan. To date, they have achieved significant results of a theoretical and practical nature.

The existence of many approaches to modeling the process of spreading pollution in the atmosphere is due to the lack of some general physico-mathematical model that takes into account all possible factors and disturbances affecting the studied process. The choice of one or another approach is determined by the exact statement of the problem, the accuracy of the modeling and the requirements for the quality of the model in general [21].

The classification of existing models can be based on various features: the dispersion mechanism, the coordinate system used, the consideration of physical processes, the mathematical apparatus used, etc. Many researchers tend to separate the existing set of atmospheric dispersion (Fig. 1.7). mixtures are divided into three main types [22-25]:

statistics,

deterministic;

physicist.

Often there is a hybridization of different types of models and modeling approaches. The most common are: Gaussian models of impurity dispersion; Eulerian models of turbulent diffusion are based, in particular, on K-theory; Lagrangian models; computational fluid dynamics models based on full or Reynolds-averaged Navier-Stokes equations [26-29].

Today, many studies are aimed at the study of the spatial distribution of dust and sand storms, but they cannot offer clear solutions due to the fact that the results are tied to empirical expressions and it is impossible to compare them with experimental results.

Research object. The Aral Sea was a large saltwater lake located in the Central Asian lowlands [1]. In addition to supporting large fisheries in the region, the sea served as one of the most important routes for

American Journal Of Applied Science And Technology
(ISSN – 2771-2745)
VOLUME 04 ISSUE 07 Pages: 46-55
OCLC – 1121105677
Crossref doi Google Scholar WorldCat MENDELEY
Publisher: Oscar Publishing Services

regional transportation [2]. The Aral Sea was the fourth largest inland lake on Earth until 1960, with an estimated surface area of 68,000 km2. Also, image analysis in 1990 showed an increase of 29,000 km of dry bottom of the Aral Sea. As a result, new sources of dust have been identified on the southeast coast of the Big Island and on the east coast of the Small Island based on research.

The width of the dry belt of the southeast coast of the Aral Sea reached 30-50 km. In 1975, according to the first estimates of the volume of dust transported during the research, it was 45 million tons per year on average, and in 1990, this figure doubled to 90 million tons per year. Large-scale irrigation projects in many parts of the transboundary watershed, mainly the sea, have caused catastrophic drying of the Aral Sea and ecological crises since the second half of the 20th century [47]. This is mainly the result of the unsustainable expansion of irrigation, which has dried up two tributaries of Amudarya and Syrdarya and seriously damaged their deltas [3].

The studied area is located in the western part of Central Asia, until Arol - the lower reaches of Amudarya, the main agricultural products are cotton, wheat and rice. About 10.4 thousand km2 of land can be irrigated in the region. The only source of water is the Amudarya and its hierarchical network channels, as well as a number of small rivers (Figure 3.1).

The Aral Sea was a large saltwater lake located in the Central Asian lowlands [1]. In addition to supporting the region's large fisheries, the sea served as one of the most important routes for regional transportation. Since 1960, the Aral Sea has rapidly dried up and become salinized [2].

This is mainly the result of the unsustainable expansion of irrigation, which has dried up the two tributaries of the Amudarya and Syrdarya and seriously damaged their deltas [3]. The processes of salinization and desertification in the Aral Sea basin have intensified. At the same time, the problem of water resources in the regions exacerbates the ecological crisis in the sea basin and poses a threat to the environment and human health [6]. Therefore, revealing the trends and causes of ecological changes in this region is an important task and importance [7,8].

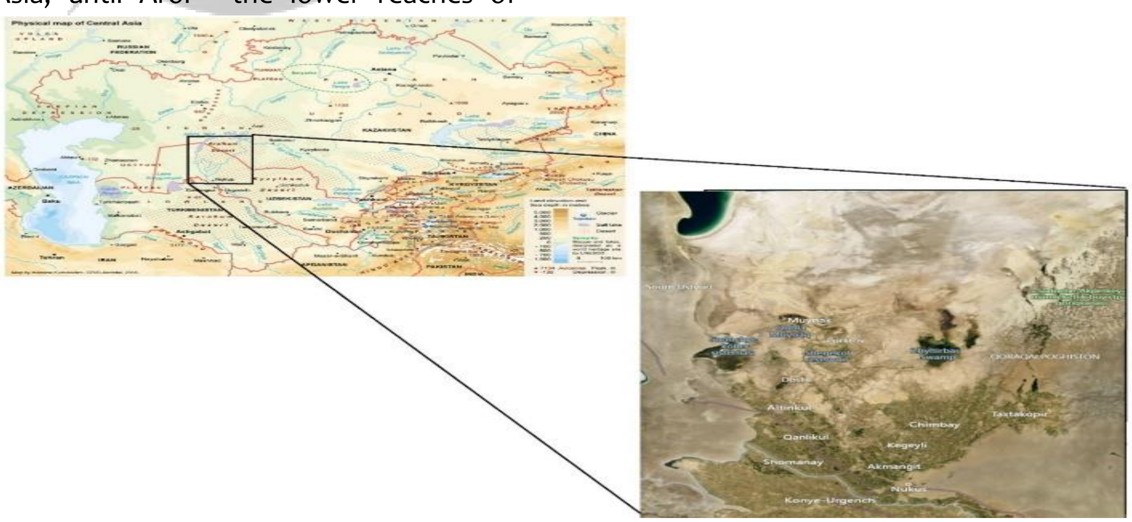


Figure 1. Geographical location of the study area (Source: https://earthexplorer.usgs.gov/)

The rich natural process ecosystems of the Aral Sea region have been greatly damaged. In this case, as a result of the decrease in the level of underground water, the banks of the rivers flowing into the sea suffered a lot of damage, which led to the expansion of the desertification of the sea area [9]. Salts accumulated on the surface of the Aral Sea form layers where almost nothing grows [10]. The situation in the area Since the 1990s, the whole world has become aware of the environmental problem of the Aral Sea, and scientific research on this research has begun [11].

That is why the stage of rapid drying of the Aral Sea began from this period. As a result of the acceleration of desertification processes in the region, a new desert - Orolqum desert appeared [12]. Over the past few decades, the Orolqum desert has become a new "hotspot" of dust and salt storms in the region [9]. Data analysis and research on dust storms and their origins have begun [3].

Special attention was paid to the analysis of land cover changes in the New Orolqum desert [13]. The impact of dust storms rising from the Orolkum desert became more and more intense. The main change in land surface cover is directly related to the significant reduction of vegetation and small water bodies, the significant increase in the area of salt marshes and sandy massifs [14].

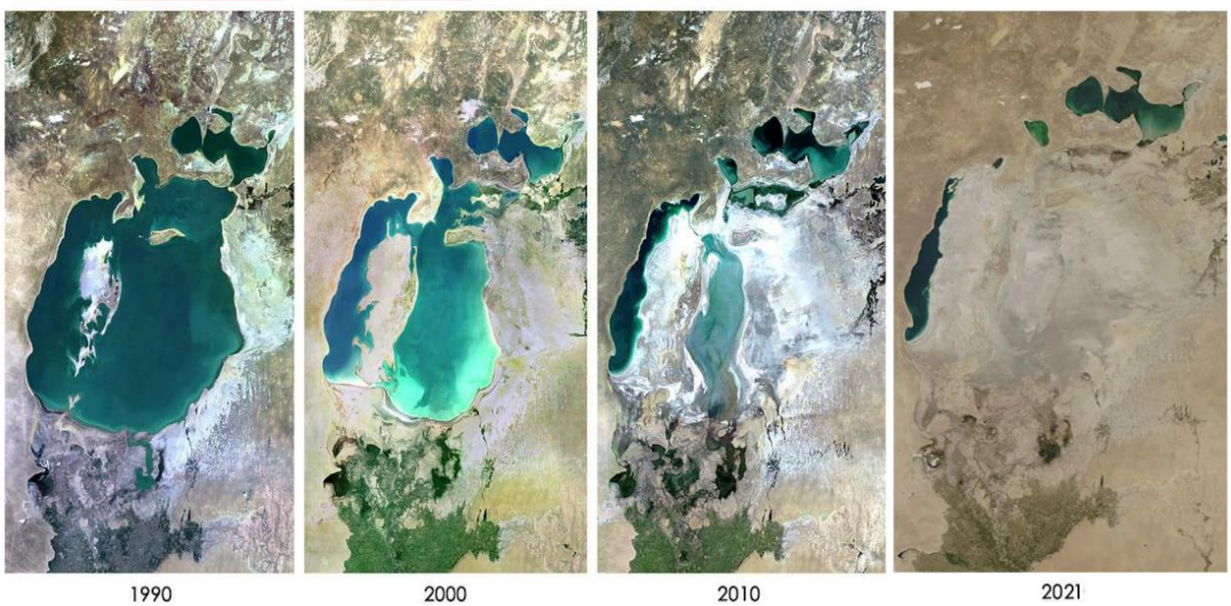


Figure 2. Satellite images showing the shrinking of the Aral Sea from 1990 to 2020 (Manba: http://earthdata.nasa.gov)

One of the unique features of the atmosphere is the dry continental climate circulation in the dry basin of the Aral Sea and the flat landscapes contribute to the formation of dust storms. The territory is mostly occupied by sandy, sandy-gypsum, loess-clay and direct deserts.

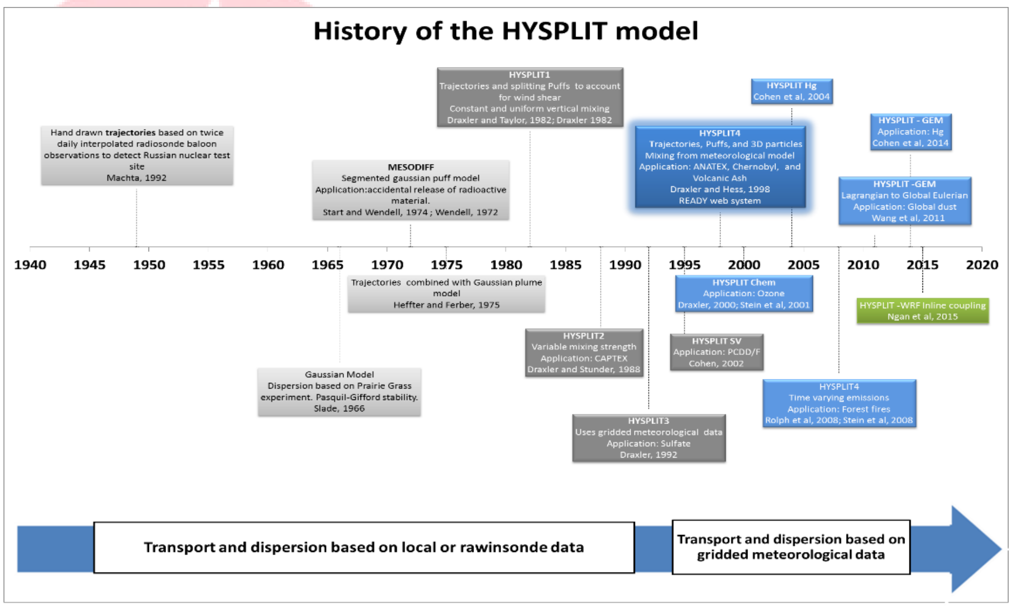
American Journal Of Applied Science And Technology
(ISSN – 2771-2745)
VOLUME 04 ISSUE 07 Pages: 46-55
OCLC – 1121105677
Publisher: Oscar Publishing Services

More than 70% of the study area serves as potential sources of dust in the lower layers of the atmosphere. A long dry season, unstable atmospheric stratification, and frequent strong winds create large amounts of dust in the surface air, and by transporting dust and these pollutants over significant distances from the emission regions, dust and sandstorms here pose a threat to human health. salts and pose significant risks to animals and the environment in general [11].

METHOD

A relatively high accuracy model based on aerological and aerophysical studies is HYSPLIT, Hybrid Single-Particle Lagrangian Integrated trajectory model.

The model calculation method is a hybrid between the Lagrangian approach, which uses a moving reference system for calculations of advection and diffusion of trajectories or air carriers as they move from an initial location, and is based on the Euler methodology, which uses a fixed three-dimensional grid. This model has evolved over more than 30 years, from a simplified estimation of single trajectories based on radiosonde observations to a system accounting for multiple interacting pollutants that are transported, dispersed, and deposited locally and globally.



3. Picture. History of the creation of the HYSPLIT model

The scientific basis for HYSPLIT's trajectory capabilities dates back to 1949, when the US Weather Bureau's Special Projects Division (SPS) (predecessor to ARL), now NOAA's National Weather Service (NWS), identified a source of radioactive debris from the first Soviet nuclear test. used in an attempt to find and identified by him. Reconnaissance aircraft near the Kamchatka Peninsula. For this purpose, back trajectories were manually calculated based on wind data obtained from twice daily radiosonde balloon measurements. These trajectories were at 500 hPa, assuming a geostrophic wind flow. Although these

American Journal Of Applied Science And Technology
(ISSN – 2771-2745)
VOLUME 04 ISSUE 07 Pages: 46-55
OCLC – 1121105677
Publisher: Oscar Publishing Services

back trajectories were calculated more than 60 years ago, the percentage error between the calculated and actual source location relative to the distance traveled by the trajectories was very low (about 5%). Since then, trajectory calculations have been a cornerstone of ARL research.

In the mid-1960s, Pasquill (1961) and Gifford (1961) described the estimation of the horizontal and vertical standard deviation of a continuous concentration distribution, which provided the basis for Gaussian variance models. One such model was developed based on ARL data. Using this Gaussian approach and assuming a steady state with homogeneous and stationary turbulence, air concentrations were estimated from wind data collected at a single location. Extending this work to handle more realistic (variable) weather conditions in the late 1960s and early 1970s, ARL scientists developed the Mesoscale Diffusion (MESODIFF) model in response to health and safety concerns in Idaho.

By the late 1990s, many new features were added to HYSPLIT version 4, which is the basis for the current model versions. Innovations include an automated method of sequentially using several meteorological networks and calculating the dispersion rate from the vertical diffusivity profile, wind shear and horizontal deformation of the wind field. HYSPLIT allows the use of different types of Lagrangian representations of transported air masses: three-dimensional (3D) particles, aerosols, or hybrids of both.

Over the past 15 years, many updates have been made to HYSPLIT, reflecting the latest advances in dispersion and transport calculations.

Features of using HYSPLIT software. When using the Hybrid Single-Particle Lagrangian Integrated program as HYSPLIT, hydrometeorological data, wind speeds, climate parameters, and terrain relief data are entered.

The possibilities of implementing meteorological data through the HYSPLIT model:

HYSPLIT uses specially formatted meteorological data to estimate the transport and dispersion of atmospheric constituents.

Forecast and archived meeting data are also available NOAA's Air Resources Laboratory converts meteorological model outputs (eg from NOAA Weather Models) to this HYSPLIT format and makes them freely available over the Internet.

Many North American and Global datasets (primarily NOAA-based) are available to run HYSPLIT on. RAMS, etc.) includes conversion programs for conversion.

American Journal Of Applied Science And Technology
(ISSN – 2771-2745)
VOLUME 04 ISSUE 07 Pages: 46-55
OCLC – 1121105677
Crossref doi Google Scholar WorldCat MENDELEY
Publisher: Oscar Publishing Services

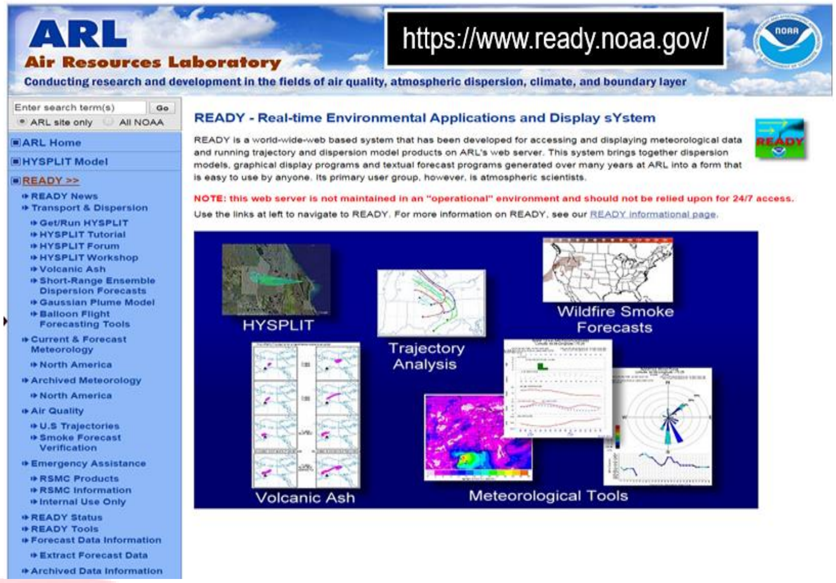


Figure 4. HSPLIT model desktop

The trajectory shows the path of the air parcel following the wind field provided by the numerical weather prediction (NWP) model. Based on this, it will be possible to determine the direction of the wind, and to know the direction of the trajectory of dust and sand particles.

The model notices that the SETUP.CFG file is now present, indicating that one or more advanced settings have been selected.

HYSPLIT can use a variety of meteorological model data from mesoscale to global scale in its calculations.

Thus, the HYSPLIT model was used to study the distribution of particles and the scale of sandstorms during dust and sandstorms on the coast of Arol.

RESULTS

Modeling was done in three stages. At the first stage, a model of atmospheric dispersion during sandstorms observed so far was built. The NOAA model based on the integral Gaussian equation was used in the modeling.

The WRF (Weather Research and Forecasting with Chemistry) module was used to study dust concentration in the atmosphere during dust and sand storms.

American Journal Of Applied Science And Technology
(ISSN – 2771-2745)
VOLUME 04 ISSUE 07 Pages: 46-55
OCLC – 1121105677
Crossref doi Google Scholar WorldCat MENDELEY
Publisher: Oscar Publishing Services

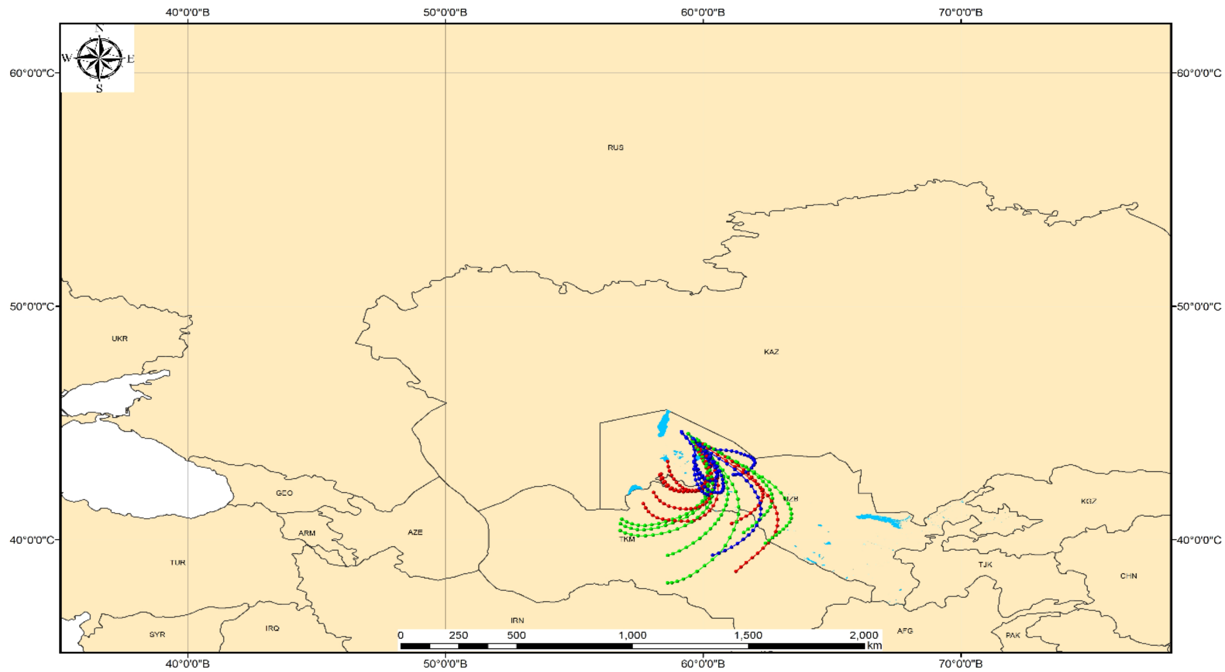


Figure 5. Trajectory of transported sand particles in the atmosphere during a dust and sand storm in the region of the island (27.04.2017).

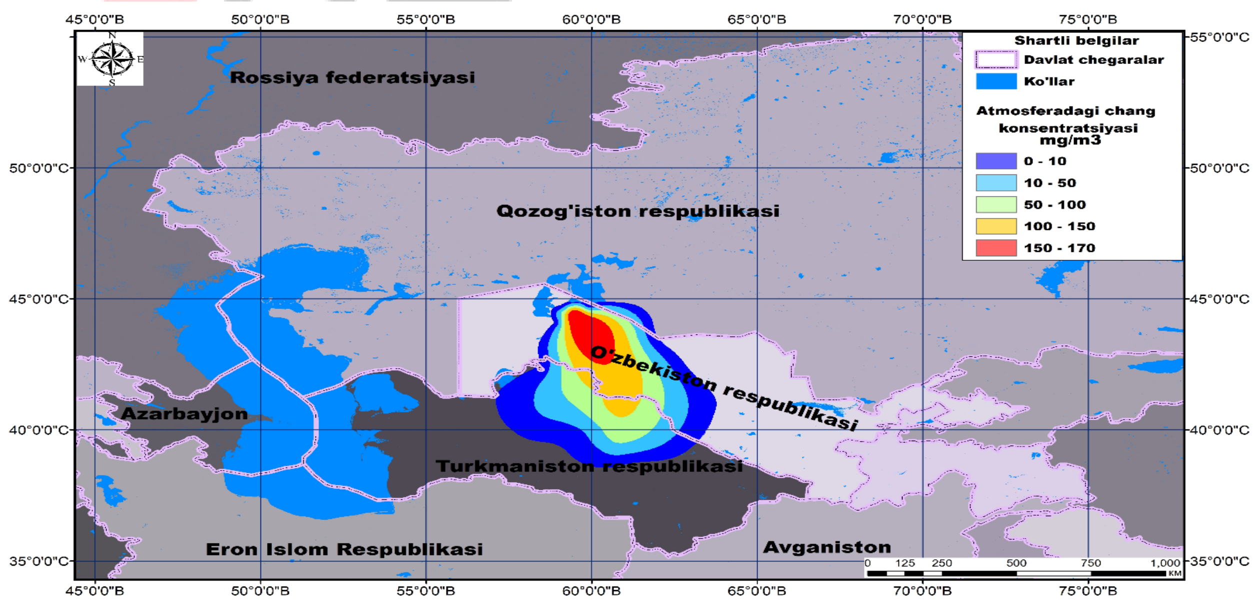


Figure 6. The concentration of transported dust and sand particles in the atmosphere during a dust and sand storm in the region of the island (June 27, 2017).

CONCLUSION

On April 27, 2017, an unprecedented sandstorm occurred in the recent history of Uzbekistan. At around 4:30 am, a strong wind formed in the Volga region and entered Central Asia and a warm front joined the cold front.

After 2 hours, he entered Khorezm region. The scope of the sandstorm covers the northern regions of Turkmenistan, Karakalpakstan, Khorezm and Navoi, and the western parts of Bukhara regions. The concentration of particles in the atmosphere reached 150-170 g/m3 in the center of the storm. Visibility drops to 3-5 meters in some places. After a storm, dust particles remain in the atmosphere for about 1 day.

REFERENCES

1. Aili A, Abuduwaili J, Xu H, Zhao X and Liu X 2021 A Cluster Analysis of Forward Trajectory to Identify the Transport Pathway of Salt-Dust Particles from Dried Bottom of Aral Sea, Central Asia Atmosphere 12 764
2. Xiao F, Zhou C and Liao Y 2008 Dust storms evolution in Taklimakan Desert and its correlation with climatic parameters J. Geogr. Sci. 18 415–24
3. Антонова А М, Воробев А В, Воробев В А, Дутова Е М and Покровский В Д 2019 МОДЕЛИРОВАНИЕ РАСПРОСТРАНЕНИЯ В АТМОСФЕРЕ ЗАГРЯЗНЯЮЩИХ ВЕЩЕСТВ ВЫБРОСОВ ЭЛЕКТРОСТАНЦИЙ НА БАЗЕ ПРОГРАММНОГО КОМПЛЕКСА «SKAT» IZVESTIYA 330 174–86
4. Centre for the Development of Software and Hardware-Program Complexes, Ravshanov N, Sharipov D K, Institute of Mathematics, National University of Uzbekistan, Muradov F, and Samarkand Branch of Tashkent University of Information Technologies 2016 COMPUTATIONAL EXPERIMENT FOR FORECASTING AND MONITORING THE ENVIRONMENTAL CONDITION OF INDUSTRIAL REGIONS Theoretical & Applied Science 35 132–9
5. Indoitu R, Kozhoridze G, Batyrbaeva M, Vitkovskaya I, Orlovsky N, Blumberg D and Orlovsky L 2015 Dust emission and environmental changes in the dried bottom of the Aral Sea Aeolian Research 17 101–15
6. Engelstaedter S, Tegen I and Washington R 2006 North African dust emissions and transport Earth-Science Reviews 79 73–100
7. Twomey S 1977 The Influence of Pollution on the Shortwave Albedo of Clouds J. Atmos. Sci. 34 1149–52
8. Orlovsky N S, Orlovsky L and Indoitu R 2013 Severe dust storms in Central Asia Arid Ecosyst 3 227–34
9. Alfaro S C, Gaudichet A, Gomes L and Maillé M 1997 Modeling the size distribution of a soil aerosol produced by sandblasting J. Geophys. Res. 102 11239–49
10. Marticorena B and Bergametti G 1995 Modeling the atmospheric dust cycle: 1. Design of a soil-derived dust emission scheme J. Geophys. Res. 100 16415–30
11. Gillette D A, Niemeyer T C and Helm P J 2001 Supply-limited horizontal sand drift at an ephemerally crusted, unvegetated saline playa J. Geophys. Res. 106 18085–98
12. Nickovic S, Kallos G, Papadopoulos A and Kakaliagou O 2001 A model for prediction of desert dust cycle in the atmosphere J. Geophys. Res. 106 18113–29
13. Shao Y and Leslie L M 1997 Wind erosion prediction over the Australian continent J. Geophys. Res. 102 30091–105
14. Wiggs G F S, O'hara S L, Wegerdt J, Van Der Meer J, Small I and Hubbard R 2003 The dynamics and characteristics of aeolian dust in dryland Central Asia: possible impacts on human exposure and

respiratory health in the Aral Sea basin Geographical Journal 169 142–57

15. O'Hara S L, Wiggs G F, Mamedov B, Davidson G and Hubbard R B 2000 Exposure to airborne dust contaminated with pesticide in the Aral Sea region The Lancet 355 627–8