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THE ROLE OF AIR TEMPERATURE AND DEW POINT DURING FOG RECURRENCES ON THE ABSHERON PENINSULA (AZERBAIJAN)

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The article focuses on the characteristics of air temperature and dew point changes observed during repeated fog events in the Absheron Peninsula in 2000...2022. For this purpose, continuous observation data of Heydar Aliyev International Airport was used. Here is an analysis of all types of fog by month of occurrence. The limits of total fog, Meteorological Optical Range ≤ 500 m. and 501...1000 m. are considered in the analysis. Repeating such criteria, attention was paid to the recorded air temperature and dew point indicators for I...III, IV...VI and X...XII months of the year. The analyzes show that the fogs observed in the peninsula are mostly recorded at a temperature of 6...8 ^{0}C. The most commonly observed dew point temperature ranges of 0,0...0,3 ^{0}C and 1,0...1,2 ^{0}C at all ranges of MOR in fog repeats. The results of the research are of particular importance for the planning of the work of all transport areas and the forecast of fogs.

Keywords: fog, meteorological optical range (MOR), air temperature, dew point temperature, automatic weather station, physical-meteorological analysis.

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INTRODUCTION

Recurrence of fog events is observed with decreasing Meteorological Optical Range (MOR) (Huseynov N.Sh.,2011, Guliyev H.I. et al, 2004). This atmospheric phenomenon poses a threat to agriculture and transport. Reduced visibility creates difficulties in driving a vehicle, and as a result, accidents are inevitable (Tanriverdiyev X.K. et al, 2015, Mehdiyev A.S. et al, 2008). The area of transport where fog events pose a greater threat is air transport. Loss of horizontal visibility paralyzes the operation of air transport. This violates the minimum visibility of aircrafts, does not allow them to take off and land on the runway, free movement and approach to the stop (Tanriverdiyev X.K. et al, 2015, Huseynov N.Sh., 2011, Mehdiyev A.S. et al, 2008). On 27.03.1977, which went down in history as the «Tenerife airport tragedy», the failure to track the movement of two aircrafts on the runway resulted in the tragic loss of 583 passengers on both aircrafts. There are many such facts in the history of air transport (Mammadova G.A., 2017). For this reason, the constant repetition and study of fog events is important for the safety of transport.

The phenomenon of fog is characterized by the loss of meteorological visibility due to the accumulation of sublimation and condensation products in the atmospheric layer near the surface of the earth in calm weather conditions, at certain temperature and dew point limits. The warning received by the Civil Aviation Authority due to the reduction of the horizontal visibility distance (SPECİ) is issued when the limits of 1000, 850, 550, 300, 150, 75 m are exceeded. At this time, the control body and the staff controlling the aircraft, according to the accepted criteria, make an important decision for the flight with the help of the equipment.

In order to study the occurrence of fog, its physical properties are studied. The dependence of fog on other meteorological parameters, the change of its appearance and other meteorological elements in its different extremes are constantly attracting attention.

A. M. Shikhlinski, A. J. Eyyubov, H. I. Guliyev, N. Sh. Huseynov, R. N. Mahmudov and other scientists played a great role in the investigation of various features of fog phenomena across the country. In such studies, attention was paid to the theoretical basis of fog, microphysics,

theoretical basis of fog, microphysics, distribution of foggy days throughout the year in space and time.

The extensive study of the effects of fog on air transport in the country belongs to N. Sh. Huseynov. N. Sh. Huseynov extensively studied the physical and geographical features of the recurrence of fog events at the airports of Azerbaijan, and focused on the role of other meteorological factors in their formation. However, the conducted research should be constantly updated and modernized. The increase in the number of observations, the development of scientific and technological tools for the statistical registration of fogs makes it necessary to take such steps (AAR-ANS-008 Meteorological service to air traffic, Mammadov R.M., 2013).

MATERIALS AND METHODS

The fog monitoring data of the H. Aliyev International Airport (-7 m) operating on the Absheron Peninsula covering the years 2000...2022 were used in the research. The research was conducted on the basis of mathematical and physical-statistical methods. The observational data used in the study are based on the regular fog registration of the most modern transmissometers installed in the automatic meteorological stations. During the analysis, the occurrences of fog recurrence at different thresholds of air temperature and dew point recorded in the observations of all types of fog were investigated. They are grouped by I...VI and X...XII months according to the recurrence characteristics of fog events (Tanriverdiyev X.K. et al, 2015, Mammadov R.M., 2013).

The purpose of the study

Determining the recurrence characteristics of fog events at different extremes of air temperature and dew point throughout the year. For this purpose, the characteristics of their recurrences in several gradations of air temperature and dew point recorded during fogs recurring in multi-year seasons in 2000...2022 are investigated.

DISCUSSION AND RESULTS OF THE STUDY

The Absheron Peninsula is the most important region in terms of aviation operations in the country. In addition to small aviation, in order to increase the activity of international and local air flights, the safety of flights must be ensured first.

The Absheron water area has a complex physical-geographical position (Andersen H. et al, 2020, AAR-ANS-008 Meteorological service to air traffic). Cold, dry, humid air masses coming to the area from the north, south and east throughout the year and the Caspian Sea determine the synoptic conditions of this area (Tanriverdiyev X.K. et al, 2015, Kanchan, L. et al, 2022). Also, during the transitional periods of the year, fog formation occurs in this region in clear weather conditions and with the intervention of southern air masses in the region. Depending on the type of fog that occurs on the Absheron Peninsula, depending on the conditions of its formation, it sometimes lasts for several days and slows down the traffic (AAR-ANS-008 Meteorological service to air traffic, Hydrometeorological Atlas of the Caspian Sea...2014).

Fogs are divided into advective, radiative and mixed types according to the conditions of formation (Tanriverdiyev X.K. et al, 2015, Huseynov N.Sh., 2011). The formation of fogs on the Absheron Peninsula coincides with the cold period of the year. The main factors that play a role in the formation of fogs are air temperature and dew point (Tanriverdiyev X.K. et al, 2015, Ayyubov A.C. et al, 1984). That is why, the role of air temperature and dew point in their repetition was investigated in the research work on the months of the year.

During fog events, the repetitions of air temperature and dew point in different gradations are distributed differently. Thus, during the years 2000...2022, in repeated fog events in January, February and March, 28 % of the cases where the meteorological optical range was ≤ 500 m were 6...8 ^{0}C, 24 % were 4...6 ^{0}C, 14 % were 0...2 ^{0}C, 12 % occurred in air temperature conditions of 2...4 ^{0}C. At this MOR threshold, 1 % each occurred in the intervals -4...-2 ^{0}C (3 %), -2...0 ^{0}C (5 %), 10...12 ^{0}C and 14...16 ^{0}C, and 3 % at 22...24 ^{0}C. Summarizing the result, the main part (97 %) of repeated fogs was recorded in the range of 0...12 ^{0}C, especially 2...10 ^{0}C (85 %), and a small part (13 %) was recorded in the air temperature range of -4...0 ^{0}C, 10...12 ^{0}C, 22...24 ^{0}C.

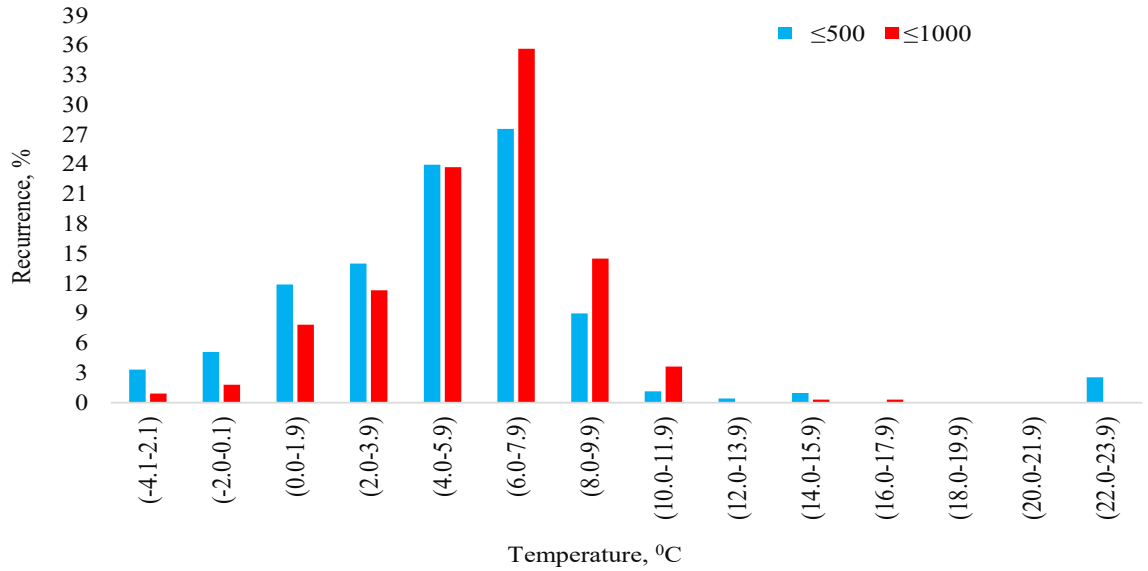

Fig. 1. *Air temperature changes during fog events in months I...III*

36 % of fog recurrences in the range of 501...1000 m of MOR are 6...8 ⁰C, 24 % are 4...6 ⁰C, 15 % are 8...10 ⁰C, 11 % are 2...4 ⁰C, 8 % -i occurred in the range of 0...2 ⁰C. At this visibility limit, 7 % of the total fogs were repeated in the range of air temperature -4 ... -2 ⁰C (1 %), -2...0 ⁰C (2 %), 10...12 ⁰C (2 %). It appears that regardless of the MOR threshold, recurring fog events in January, February, and March were mostly recorded in the 6...8 ⁰C air temperature range. In addition, 94 % of the total reproduction occurred in the air temperature conditions of 0...10 ⁰C. In the study, different thresholds of the dew point observed during the fogs that occurred in the I...III months were calculated. Analyzes show that 51 % of fogs in cases where MOR is ≤ 501m are formed under 0 ⁰C, 27 % at 0,1...0,3 ⁰C, 14 % at 1...1,2 ⁰C, and 5% at 0,4...0,6 ⁰C dew point deficiency. In the range of 501...1000 m of MOR, 42 % of fogs occur when there is a dew point deficit of 0 ⁰C, 25 % of 0,1...0,3 ⁰C, 18 % of 1...1,2 ⁰C, and 7 % of 0,4...0,6 ⁰C. At each of the other dew point deficiency thresholds, fog repeats are no higher than 2 % for both appearance criteria (Table 1).

Table 1

Variation of MOR in fogs in months I...III depending on dew point

MOR	0	0,1…0,3	0,4…0,6	0,7…0,9	1,0…1,2	1,9…2,1	2,8…3,0	4,0…4,2	Cases
≤ 500	51	27	5	1	14	0	1	0	1647
≤ 1000	42	25	7	1	18	2	2	1	662

If we focus on the different air temperature thresholds recorded during fog recurrences in April, May and June, in the phase when MOR is below 500 m, 24 % of total recurrences are 8...10 ⁰C, 21 % are 10...12 ⁰C, 20 % 6...8 ⁰C, 11 % 12...14 ⁰C, 8 % 16...18 ⁰C, 7 % 4...6 ⁰C. At other extremes of air temperature, fog recurrences are not higher than 3%, and this accounts for 9 % of the total cases. However, at MGM ≤ 501 m, 91 % of the total fog events in the 4...14 ⁰C range were repeated (Figure 2).

In April, May, and June, 24 % of repeated fog events within ≤1000 m of MOR were observed at temperature limits in the range of 8...10 and 10...12 ⁰C, 23 % were 6...8 ⁰C, 12 % were 12...14 ⁰C, 6 % were 14...16 ⁰C. In the range of 2...6 ⁰C (5 %) and 16...22 ⁰C (6 %), fog recurrences accounted for 11 % of all cases. However, 89 % of the total replication occurred in the 6...16 ⁰C range.

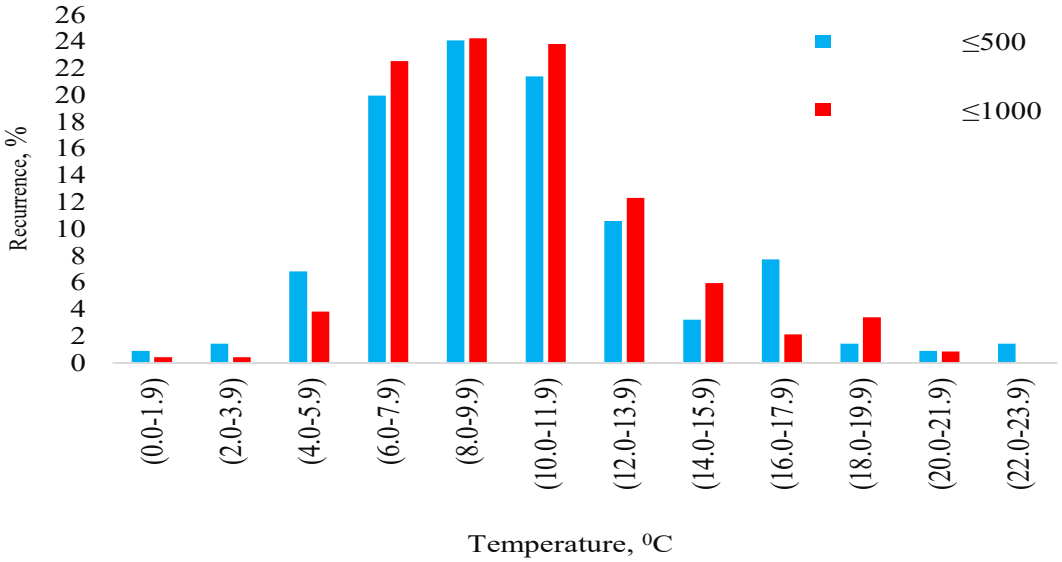

Fig. 2. *Dependence of air temperature on dew point during fog events in IV...VI months*

For both MOR thresholds, the highest fog recurrences occur in the temperature range of 6...12 ⁰C. The analysis of dew point thresholds observed during fogs during these months is also of interest. The analysis shows that more fog cases (57 %) were recorded at 0.0 ⁰C or closer to the MOR visibility limits below 500 m. During fog, the visibility distance of less than 500 m was repeated in 25 % of cases in the range of 0,1...0,3 ⁰C, and in 9 % of cases in the range of 1...1,2 ⁰C. Fog recurrences at other dew point thresholds did not exceed 3 %. 91 % of the total repeatability was recorded in the range of 0...0,3 ⁰C and 1,0...1,2 ⁰C, and 9 % in other dew point ranges.

Table 2

Variation of MOR in fogs in IV...VI months depending on dew point

MOR	0	0,1…0,3	0,4…0,6	0,7…0,9	1,0…1,2	1,9…2,1	2,8…3,0	4,0…4,2	5,0…5,2	5,9…6,1	Cases
≤ 500	57	25	3	0	9	1	2	1	1	1	556
≤ 1000	53	27	11	2	5	0	0	1	0	1	235

53 % of this visibility threshold is observed at 0 ⁰C, 27 % at 0,1...0,3 ⁰C, 11 % at 0,4...0,6 ⁰C, and 5 % at 1,0...1,2 ⁰C dew point thresholds during the MOR threshold in the range of 500...1000 m. Only 4 % of the occurrence of the total ≤1000 m MOR limit occurred in the dew point ranges of 0,7...0,9 ⁰C, 4...4,2 ⁰C, and 5,9...6,1 ⁰C. 96 % of cases where MOR is below 500 m are recorded in dew point cases of 0...0,6 and 1...1,2 ⁰C.

During fog in October, November and December, 15 % of cases of MOR below 500 m have air temperatures of 6...8 ⁰C, 13 % of 12...14 ⁰C, 12 % of 2...4 ⁰C, 8...10 ⁰C and 10...12 ⁰C, 9 % were recorded in the range of 4...6 ⁰C, 7 % in the range of 0...2 ⁰C and 14...16 ⁰C, and 6% in the range of 16...18 ⁰C. In the range of -2...0 ⁰C, 18...20 ⁰C and 20...22 ⁰C, 7 % of the total cases of MOR below 500 m are repeated. The general repeatability shows that 93 % of cases where MOR is ≤ 500 m during fog occur in the air temperature range of 0...16 ⁰C, especially in the range of 6...12 ⁰C (52 %).

In these months, 18 % of the cases of MOR observed at ≤1000 m during fog were 6...8 ⁰C, 16 % 2...4 ⁰C, 14 % 8...10 ⁰C, 12 % 12...14 ⁰C, 9 % 4...6 ⁰C, 9 % 12...14 ⁰C, 9 % 14...16 ⁰C, 6 % 0...2 ⁰C, 5 % 18...20 ⁰C. In the temperature range of -2...0 ⁰C, 16...18 ⁰C and 20...22 ⁰C, this indicator is only 5 % of the total repeatability. However, 95 % of the repetition of this appearance threshold was found to occur in the range 0...16 ⁰C, especially in the range 6...12 ⁰C (44 %).

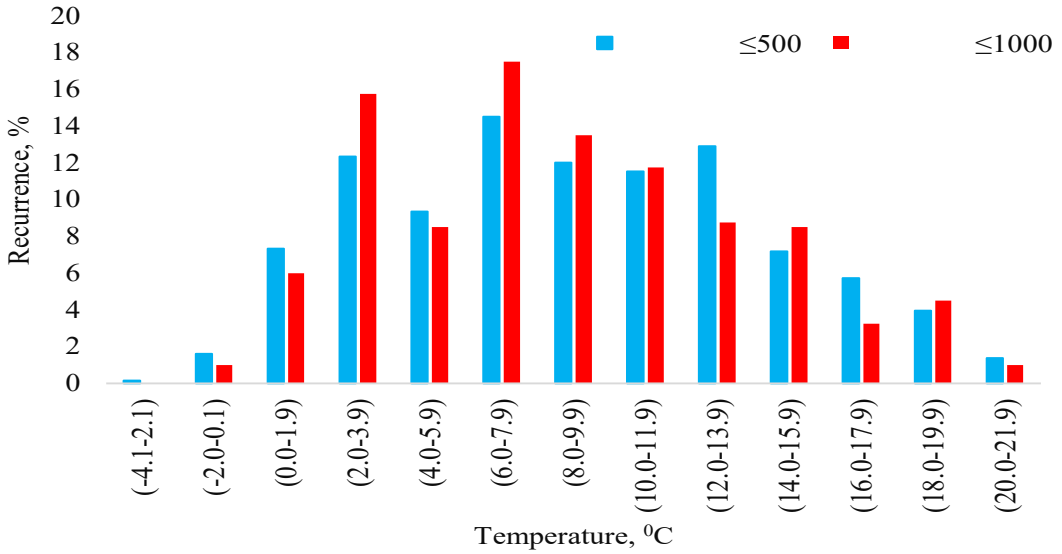

Fig. 3. *Dependence of air temperature on dew point during fog events in X...XII months*

In recurring fogs in October, November, and December, 58 % of cases where MOR was ≤500 m had a dew point of 0 ⁰C, 21 % 0,1...0,3 ⁰C, 13 % 1...1,2 ⁰C, 7 % 0,4...0,6 ⁰C recorded in the interval. Only 1 % of the total cases where this appearance threshold was repeated occurred in other dewpoint cases, 99 % in the 0...0,6 ⁰C and 1,0...1,2 ⁰C dewpoint range, especially in the 0,0...0,3 ⁰C (79 %) dewpoint range. During these months, 48 % of 501...1000 m MOR thresholds recorded during fogs were repeated at 0,0 ⁰C, 20 % at 0,1...0,3 ⁰C, 14 % at 0,4...0,6 ⁰C, and 12 % at 1,0...1,2 ⁰C dew point thresholds. During these months, 48 % of 501...1000 m MOR thresholds recorded during fogs were repeated at 0,0 ⁰C, 20 % at 0,1...0,3 ⁰C, 14 % at 0,4...0,6 ⁰C, and 12% at 1,0...1,2 ⁰C dew point thresholds. 8 % of the total repeatability was found in the dew point ranges of 0,7...0,9 ⁰C, 1,3...3,0 ⁰C and 5,0...5,2 ⁰C. However, 82 % of cases where MOR was ≤ 1000 m recorded dew point thresholds in the range 0...0,6 ⁰C (Table 3).

Table 3

Variation of MOR in fogs in X...XII months depending on dew point

MOR	0	0,1…0,3	0,4…0,6	0,7…0,9	1,0…1,2	1,3…1,5	1,9…2,1	2,8…3,0	5,0…5,2
≤ 500	58	21	7	1	13	0	0	0	0
≤ 1000	48	20	14	4	12	1	1	1	1

In the study, phase I of maximum cases of MOR below 500 m in annual repeated fog events from 2000 to 2022 is located in the range of air temperature 0...10 ⁰C and dew point 0,0 ⁰C (Table 4).

0,1...0,3 ⁰C dew point and 0...10 ⁰C range of air temperature is maximum phase II when MOR ≤500 m is observed during fog. The dew point range of 1,0...1,2 ⁰C and the temperature range of 0...10 ⁰C is phase III where the maximum of MOR is observed below 500 m. A total multiyear MOR of less than 500 m was observed in 3,668 cases.

During the multi-year period of fog, the first phase in which the cases of MOR recorded at the range of ≤ 1000 m were repeated more often occurred in the conditions of air temperature 0...14 ⁰C and dew point 0,0 ⁰C (Table 5).

The second phase, where this appearance threshold is more repeated, is the temperature range of 2...12 ⁰C and the dew point range of 0,1...0,3 ⁰C. The third maximum phase, in which the limit of MOR ≤1000 m is repeated, coincides with the approximate range of dew point 1,0...1,2 ⁰C and temperature 2...12 ⁰C.

Table 4

Variation of MOR below 500 m as a function of air temperature and dew point in annual replicated fog from 2000 to 2022

MOR	T_d, ^{0}C / T°, C	0	0,1…0,3	0,4…0,6	0,7…0,9	1,0…1,2	Summary
≤ 500 m	-4,1…2,1	1	0	0,2	0,0	0,1	2
	-2,0…0,1	2	1	0,3	0,0	0,3	3
	0,0…1,9	5	2	0,5	0,1	1,4	9
	2,0…3,9	9	3	0,9	0,2	2,7	16
	4,0…5,9	8	4	0,9	0,1	1,9	15
	6,0…7,9	13	5	0,6	0,1	1,4	20
	8,0…9,9	5	3	0,3	0,0	2,8	12
	10,0…11,9	4	2	0,2	0,1	0,9	8
	12,0…13,9	3	2	0,5	0,1	0,2	6
	14,0…15,9	2	1	0,3	0,1	0,1	3
	16,0…17,9	2	0	0,0	0,1	0,4	3
	18,0…19,9	1	0	0,1	0,0	0,3	2
	20,0…21,9	0	0	0,0	0,0	0,1	1
	22,0…23,9	1	0	0,1	0,0	0,0	1
	Summary	56	23	5	1	13	3668

Table 5

Variation of the 501…1000 m threshold of MOR as a function of air temperature and dew point in repeated annual fogs from 2000 to 2022

MOR	T_d, ^{0}C / T, ^{0}C	0,0	0,1…0,3	0,4…0,6	0,7…0,9	1,0…1,2	1,9…2,1	2,8…3,0	4,0…4,2	Sum
≤ 000 m	-4,1…2,1	0	0	0	0	0	0,0	0,0	0,0	0
	-2,0…0,1	0	0	0	0	0	0,0	0,0	0,0	1
	0,0…1,9	3	1	1	0	1	0,2	0,0	0,0	6
	2,0…3,9	6	2	1	0	3	0,5	0,2	0,1	13
	4,0…5,9	7	4	1	0	2	0,2	0,5	0,3	15
	6,0…7,9	13	8	2	0	3	0,2	0,0	0,3	27
	8,0…9,9	7	4	1	1	2	0,0	0,2	0,0	16
	10,0…11,9	4	2	1	0	1	0,2	0,3	0,1	10
	12,0…13,9	2	1	1	0	0	0,0	0,0	0,0	5
	14,0…15,9	3	1	0	0	0	0,0	0,0	0,0	4
	16,0…17,9	0	0	0	0	0	0,0	0,0	0,0	2
	18,0…19,9	1	0	0	0	0	0,1	0,1	0,2	2
	20,0…21,9	0	0	0	0	0	0,0	0,0	0,0	0
	22,0…23,9	0	0	0	0	0	0,0	0,0	0,0	0
	Sum	47	23	10	2	13	1	1	1	1333

A total of 501...1000 m MOR occurred in 1333 cases in the multiyear period. Given the small numbers of repeated occurrences during fog in the tables, it can be said that the main fog occurrences occurred at temperatures of 6...8 ^{0}C and dew points of 0,0 ^{0}C at both analyzed MOR thresholds.

CONCLUSION

The following results were obtained during the study of the dependence of MOR on air temperature and dew point thresholds during repeated fogs in Absheron Peninsula in 2000...2022:

1. In January, February, March, 75 % of cases of MOR below 500 m have an air temperature of 2...10 ^{0}C, in April, May, June, 76 % of cases are 6...14 ^{0}C, and in October, November, December, 60 % It happened in the range of 4...14 ^{0}C.

2. In January, February, March, 85 % of cases of MOR below 501...1000 m air temperature is 2...10 ^{0}C, in April, May, June 83 % is 6...14 ^{0}C, and 67 % in October, November, December It happened in the range of 2...12 ^{0}C.

3. All MOR thresholds for year-round recurring fog occur in the dew point ranges of 0.0 ^{0}C, 0,1...0,3 ^{0}C and 1,0...1,2 ^{0}C.

4. During fog, the maximum repetition of both MOR thresholds occurs at 0,0 ^{0}C dew point conditions with temperatures of 6...8 ^{0}C.

The analyzes of the fogs occurring in the Absheron water area are used for future forecasting, air transportation planning, charting, etc. can be used in the assessment of the logistics interests of the state and in the planned organization of the work of transport types.

In the conditions of modern climate changes, the process of increasing the temperature of the air and decreasing the amount of precipitation continues on the Absheron peninsula. In such conditions, air humidity is also decreasing. Our analysis shows that global warming will weaken the recurrence of fog events on the Absheron Peninsula, leading to internal shifts in its timing. Therefore, it is recommended to give priority to the use of regional forecast models in which the local relief factor is taken into account in fog forecasting.

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АБШЕРОН ТҮБЕГІНДЕГІ (ӘЗІРБАЙЖАН) ТҰМАННЫҢ ҚАЙТАЛАНУЫН АНЫҚТАУДАҒЫ АУА ТЕМПЕРАТУРАСЫ МЕН ШЫҚ НҮКТЕСІНІҢ РӨЛІ

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Мақалада 2000...2022 жж. Абашерон түбегінде қайталанған тұман кезінде байқалған ауа температурасы мен шық нүктесінің өзгеру ерекшеліктері қарастырылған. Бұл үшін Гейдар Әлиев халықаралық әуежайының тұрақты мониторингі деректері пайдаланылды. Талдауда жалпы тұманның шегі, метеорологиялық көріну қашықтығы ≤ 500 м. және 501...1000 м. ескеріледі. Мұндай критерийлердің қайталануы кезіндегі ауа температурасы мен шық нүктесінің I...III, IV...VI және X...XII айларында тіркелген көрсеткіштеріне назар аударылды. Талдаулар түбекте байқалған тұман негізінен 6...8 ºС температурада тіркелетінін көрсетеді. Тұманның қайталануындағы метеорологиялық көріну қашықтығының барлық диапазонында жиі байқалатын шық нүктесінің температурасы 0,0...0,3 ºС және 1,0...1,2 ºС аралығында болады. Зерттеу нәтижелері барлық көлік бағыттарының жұмысын жоспарлау және тұманды болжау үшін ерекше маңызға ие.

Түйін сөздер: тұман, метеорологиялық көріну қашықтығы, ауа температурасы, шық нүктесінің температурасы, автоматты метеостанция, физика-метеорологиялық талдау.

РОЛЬ ТЕМПЕРАТУРЫ ВОЗДУХА И ТОЧКИ РОСЫ ПРИ ОПРЕДЕЛЕНИИ ПОВТОРЯЕМОСТИ ТУМАНА НА АБШЕРОНСКОМ ПОЛУОСТРОВЕ (АЗЕРБАЙДЖАН)

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В статье рассмотрены особенности изменения температуры воздуха и точки росы, наблюдавшиеся во время повторных туманов на полуострове Абашерон в 2000...2022 гг. Для этого были использованы данные постоянного мониторинга Международного аэропорта им. Гейдара Алиева. В анализе учитываются пределы общего тумана, дальность метеорологической видимости (ДМВ) ≤ 500 м. и 501...1000 м. При повторении таких критериев обращали внимание на регистрируемые показатели температуры воздуха и точки росы для I...III, IV...VI и X...XII месяцев года. Анализы показывают, что наблюдаемые на полуострове туманы в основном фиксируются при температуре 6...8 ^{0}C. Наиболее часто наблюдаемые температуры точки росы во всех диапазонах ДМВ в повторах тумана находятся в пределах 0,0...0,3 ^{0}C и 1,0...1,2 ^{0}C. Результаты исследования имеют особое значение для планирования работы всех транспортных направлений и прогнозирования туманов.

Ключевые слова: туман, дальность метеорологической видимости (ДМВ), температура воздуха, температура точки росы, автоматическая метеостанция, физико-метеорологический анализ.

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