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Research Article

Perennial Characteristics of Fog Forming in the Absheron Peninsula

N. Sh. Huseynov*, H. V. Mammadova

Department of Azeraeronavigation Air Traffic, University in Baku, Baku, Azerbaijan

ABSTRACT

In this article, we investigate the frequency of foggy days in the Absheron Peninsula and archipelago from 1991 to 2020. While some climatologists have previously addressed this issue, the categorization of fog recurrence in the aquatorium during this period has been lacking. Therefore, we thoroughly examine the repetition of foggy days in the Absheron aquatorium based on preliminary data from hydrometeorological stations in Baku, Sumgait, Mashtagha, Pirallahi, Chilov, and oil rocks. The research findings reveal that fog in the Absheron aquatorium primarily occurs during the colder months of the year, with the highest recurrence observed in March and April. Notably, the number of foggy days has decreased due to climate change. Additionally, the frequency of fog increases from the peninsula towards the archipelago throughout the year. The outcomes of this fog research hold significant implications for the future operational efficiency of various transportation sectors, particularly aviation. They contribute to our understanding of fog dynamics in the region and can guide decision-making processes in managing potential fog related risks.

Keywords: Hazardous atmospheric phenomena; Fog; Meteorological visibility distance; Air temperature; ArcGIS; Aquatorium

INTRODUCTION

Hazardous atmospheric events, including hail, lightning, fog, landslides, floods, and torrential rains, pose significant risks to both human populations and ecosystems. Among these phenomena, fog stands out as a potential danger due to its impact on meteorological visibility. Fog is defined as a decrease in visibility to below 1000 meters. It poses a major risk in transportation, with thousands of traffic accidents occurring annually as a result. Aviation is particularly affected by reduced visibility, necessitating higher quality horizontal visibility distances for takeoffs, landings, and maneuvering on runways. Failure to meet the visual distance limits of an airport can lead to temporary suspension of aviation operations.

Previous studies by A.D. Ayyubov, G.K. Gul, N.Sh. Huseynov, S.H. Safarov, and R.N. Mahmudov have examined the occurrence of fog on the Absheron Peninsula. However, these studies have not extensively analyzed the monthly, seasonal, and multi-year indicators of fog events on the peninsula. Additionally, the increasing statistical significance of fog over time calls for a more precise examination considering contemporary trends. Given the presence of major airports such as Heydar Aliyev international airport, Zabrat airport, and various airfields in Pirallahi, Chilov, oil rocks, and Gunashli fields within the Absheron aquatorium, it becomes essential to conduct continuous fog surveys in these areas that accommodate both large and small scale aviation activities.

MATERIALS AND METHODS

The research utilizes fog observation data from hydrometeorological stations located in Sumgait (-20 m), Baku (2 m), Mashtagha (27 m), Pirallahi (-25 m), Chilov (-17 m), and Oil Rocks (-17 m) under the national hydrometeorological department on the Absheron Peninsula. Additionally, data from their annual periodical publications and statistics on fog were used for the research [1]. The analysis is based on monthly and multi-year data of foggy days from 1992 to 2020. Mathematical-statistical and cartographic methods were employed to monitor the distribution characteristics of foggy days throughout different periods of the year on the peninsula. Microsoft excel was used to

Correspondence to: N. Sh. Huseynov, Department of Azeraeronavigation Air Traffic, University in Baku, Baku, Azerbaijan; E-mail: nazimmet@mail.ru

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generate diagrams, ArcGIS for mapping, and the stock stat program for assurance curves. Given the proximity of the stations to each other, their shared physical-geographical positions, and the moderating effects of the Caspian sea, the stations were grouped into two categories: The peninsula (Mashtagha, Sumgait, and Baku) and the islands (Pirallahi, Chilov, and oil rocks).

The purpose of the study: The research aims to study the perennial characteristics of foggy days that pose obstacles and risks to aviation transport on the Absheron peninsula (Sumgait, Baku, Mashtagha) and the Absheron Archipelago (Pirallahi, Chilov, and oil rocks) from 1991 to 2020. The study examines the long term dynamics of fog and re-evaluates their recurrence throughout the year.

RESULTS AND DISCUSSION

Various factors contribute to the formation and existence of fog on the Absheron Peninsula. These factors include the peninsula's physical and geographical position, its coastal location, the influence of cold air masses from the North and warm air masses from the southeast, geographical latitude, and other related features [2]. Fog on the Absheron Peninsula is classified into three types: Radiation fog, advective fog, and advective radiation fog. Radiation fog occurs when there is a sharp temperature difference between the surface and the lower layer of the troposphere, causing the surface to heat more during the day and cool rapidly under clear-sky conditions in the evening. Advective fog occurs due to the sharp difference between warm air masses from the southeast and arctic continental air masses from the north, interacting with the air temperature in the area. The mixed type results from the combined influence of both factors. The formation of fog throughout the year on the peninsula is attributed to the significant temperature difference between the sea and land surface during the cold period, as warm air masses enter from the Southeast [3].

Multi-year observations (1991-2020) indicate that the average recurrence of fog on the Absheron Peninsula was 1.7 times lower compared to the islands in the aquatorium. During this period, there were 759 foggy day occurrences on the peninsula and 1257 occurrences on the islands of Pirallahi, Chilov, and oil rocks (Table 1). Analyzing the distribution of foggy days throughout the year reveals that fog recurrence on the peninsula (Sumgait, Mashtagha, and Baku) is observed between September and May, while on the islands (Pirallahi, Chilov, and oil rocks), it occurs between November and June. The analysis demonstrates that the number of foggy days increases with decreasing air temperature, starting from September on the peninsula and November on the islands. The recurrence intensifies in January, reaches a peak in.

Table 1: The number of days when the fog recapitulates in the Absheron aquatorium.

Station	Month (%)												Yearly (case)
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Baku	17	15	22	13	7	2	0	1	1	3	8	10	224
Sumgait	12	14	29	9	10	3	0	0	3	5	5	9	235
Mashtagha	13	9	23	13	10	1	0	3	3	7	10	7	270
Pirallahi	11	19	24	16	10	2	0	1	1	3	5	8	297
Chilov	10	12	26	18	14	5	1	1	1	2	5	6	485
Oil rocks	8	11	23	22	21	6	1	1	1	1	2	6	475
Peninsula	14	13	25	12	9	2	0	2	3	5	8	9	759
Islands	9	13	24	19	16	5	1	1	1	2	4	7	1257

As of April, with the increase of the average monthly air temperature, it decreases again until June in the peninsula and July in the sea. In June, July, August, and September, fog is rarely repeated. In the summer months, the meteorological phenomenon is formed immediately after the dusty air masses coming from East Asia and, in exceptional cases, the cold air masses coming from the north, which have undergone rapid transformation. If we pay attention to the recurrence of fog in various stations, it can be seen that more foggy days are observed in the months of March-April in the entire aquatorium. It was determined that the highest frequency of fog in a month was in March at Sumgait station, and in Chilov for a perennial period.

Seasonal indicators of fog recurrence have different characteristics. Thus, during the year, much fog is observed in

the Absheron aquatorium in spring. The least recurrence of fog events in the aquatorium occurs in the summer season (Figure 1). The role of temperature indicators in the year-round distribution of fog is great. Subsequently, according to the average seasonal air temperature in the aquatorium, it is 6°C in winter, 12°C in spring, 25°C in summer, and 17°C in autumn. At higher values of air temperature, the recurrence of fog occurs less often. However, in spring, with the average monthly air temperature in the range of 11°C-13°C, fog recurrences reach a higher level.

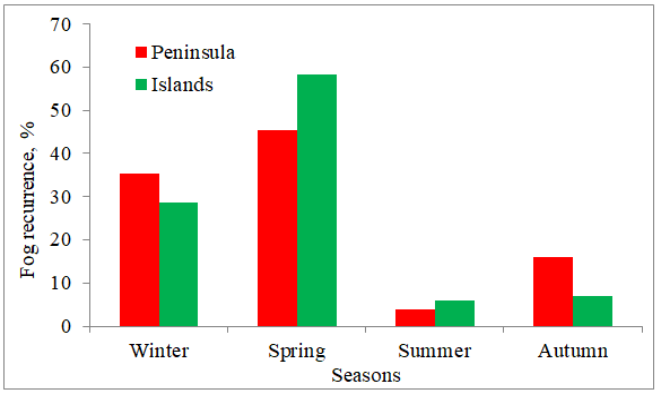

Figure 1: Seasonal recurrence of fog conditions in the Absheron aquatorium.

The multi-year changes of fog in the Absheron Peninsula have different features. So, despite the increase or decrease in the number of repetitions in various years, there were no regular changes (Figure 2). Figure 2 (a) plots the multiyear recurrences of fog. If we pay attention to the graph, we can observe a decrease in the trend curves from 1991-2020. Considering that the coefficient of determination of the trend curves is R^2=0.0109 in the islands and R^2=0.0089 in the peninsula, the correlation coefficient is significant at the significance level of 5% (α%) of the student distribution. The calculation of the significance level is determined by the following formula:

$$R\text{-}t_{1\text{-}\alpha}\sigma^{*} \leq R < R+t_{1\text{-}\alpha}\sigma^{*}$$

There, R-indicates the correlation, and $t_{1\text{-}\alpha}$ is the predetermined threshold of the quantile. Here, σ^{*} is determined by the following rule:

$$\sigma^{*} = \sqrt{\frac{1-R^2}{n-2}}$$

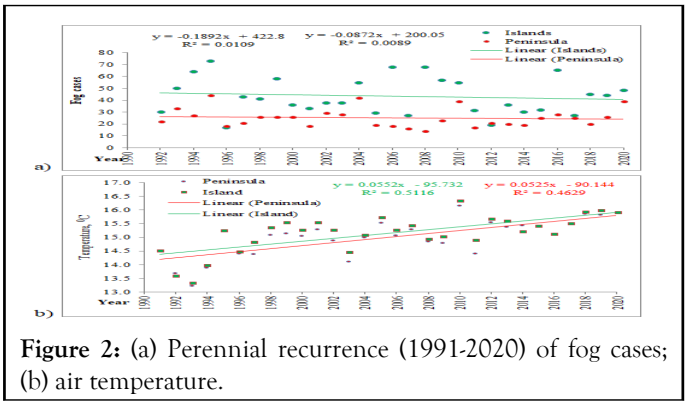

Figure 2: (a) Perennial recurrence (1991-2020) of fog cases; (b) air temperature.

According to this equation, the indicators of the correlation coefficient (R_{island}=0.104 və $R_{peninsula}$=0.094) at the limit of α=5%, the 95% confidence interval is between -26 and +26 in the islands and -13 and +13 in the peninsula.

Graphs of multi-year air temperature dynamics in the Absheron aquatorium are given in Figure 2(b). Analyses indicate that the air temperature increased in all regions of the aquatorium during 1991-2020. The average annual air temperature in this area is 15.0°C on the peninsula and 15.2°C on the islands. Due to regional climate changes, the air temperature in the aquatorium increased by 0.7°C in 1991-2020 and by 1.00°C in 2006-2020 compared to 1961-1990 [4]. A decrease in the number of foggy days was observed with the increase in perennial temperature. This indicates that the occurrence of fog in the area has decreased with the increase in temperature due to climate change.

Based on the perennial observation data of hydrometeorological stations, a distribution map of the average annual indicators of foggy days in the Absheron aquatorium was drawn up in the ArcGIS software. On the map, starting from the western part of the peninsula, where the higher areas are located, and passing through the islands located in the Caspian sea, the frequency of foggy day's increases towards the east. The reason for the increase in the recurrence of fog towards the east in the area is the fact that advective fog caused by air masses that affect the region throughout the year is more prevalent. Thus, during the perennial, an average of 8 days per year is observed in Baku and Sumgait stations, 9 days in Mashtagha, 10 days in Pirallahi, 16 days in Chilov, and 17 days in oil rocks (Figure 3) [5].

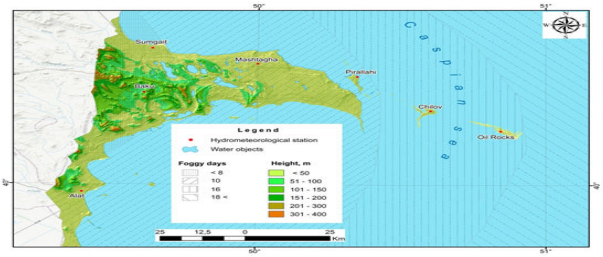

Figure 3: Distribution of annual foggy days in Absheron aquatorium.

Using the three-parameter Weibull distribution (restricted exponential distribution) of the recurrence of foggy days in the Absheron aquatorium, it is appropriate to calculate the recurrence period or assurance of the minimum values of random quantities [6].

The assurance curve is constructed for the Absheron Peninsula and surrounding Islands. The following formula was used to calculate the provision:

$$P = \frac{m}{(n+1)} * 100$$

There, m indicates the threshold calculated during the arrangement of the statistical series thresholds from the largest to the smallest, and n represents the number of thresholds of the sequence. The assurance curve based on multi-year recurrences of fog shows that the assurance of recurrences with 14 days of annual fog days on the peninsula is equal to 97%. This assurance is equal to 17 days in the islands [7]. The recurrence probability of 44 foggy-day cases in the peninsula and 73 foggy-day cases in the islands is equal almost to 3% (Figure 4) [8-13].

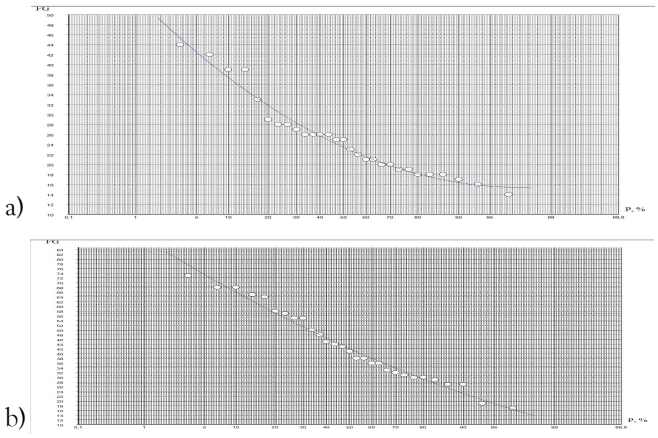

Figure 4: (a) Probability of fog recurrence in Absheron Peninsula, (b) Surrounding islands.

CONCLUSION

As a result of the fog research conducted based on the observation data of the hydrometeorological stations located in the Absheron aquatorium, the following results were obtained:

- Fog in the Absheron aquatorium occurs in the cold period of the year, and its maximum indicators occur in March and April.
- Fog repeats frequently in months with an average monthly air temperature in the range of 11°C-13°C.
- During the years 1991-2020, a decrease in the dynamics of fog is observed with the increase of the perennial air temperature of the region.
- The number of foggy days during the year increases from the west of the aquatorium to the east-towards the islands of the Caspian Sea.
- In the Absheron aquatorium, the probability of perennial fog recurrence of 14 days-17 days is equal to 97%.

The results of fog research conducted in the Absheron aquatorium are of particular importance in stimulating all transport areas in the future. Taking into account the active activity of the country's major airports and airfields in this region, the results obtained from the study of fog can play a special role in streamlining aviation work in the coming days. Prepared maps can be used by forecasters in forecasting.

STATEMENTS AND DECLARATIONS

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of the study. Preparation of material, collection of data, and layout of the map was carried out by Hajar Mammadova. The analysis of the research was carried out by Nazim Huseynov and Hajar Mammadova. The first draft of the manuscript was written by Hajar Mammadova, and the authors commented on earlier versions of the manuscript. All authors read and approved the final manuscript.

DATA AVAILABILITY

The primary data sets analyzed in this study are not publicly available reason why the data is not public as publication is not permitted by law. The data used were obtained based on the request of the author Jamal Huseynov from the National Hydrometeorological service.

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