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Fog Dynamics in Tbilisi

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Abstract

The aim of this paper is to study regimes of fog in urban areas and to determine its variation. It is used 5 years (2012-2016) of meteorological bulletins (SYNOP and METAR) from two meteorological stations (MS): Tbilisi (WMO code 37545) (403 m.s.l.), and Tbilisi airport (ICAO code UGTB) (495 m.s.l.). It is analyzed the following characteristics of fog: quantity of foggy days per months, duration (hours), periodicity of foggy days in different dates, fog gradation, and number of occurrences of fog. For a determination of changes in these characteristics, we compared 2012-2016 data to the mean of 1936-1965.

Key words: Fog dynamics, Meteorological station, SYNOP and METAR, Tbilisi.

Introduction

Fogs represent one of an important climateforming factor. Together with such dangerous geophysical phenomena as earthquakes, eruptions of volcanoes, landslides, mudflows, avalanches, mountain collapses; strong wind (storms, hurricanes, tornadoes, blizzards, etc.), intensive or long precipitation (rain, snow, hail), thunder-storms, high level of ultra-violet radiation, extreme air temperatures, droughts, etc.; floods, sea storms, typhoons, tsunami, intensive drift of ices, etc.; magnetic storms, falling of meteorites, cycles of solar activity, etc. the fogs frequently bring essential harm to the living environment of people [1-4].

Current changes in the global climate, mainly expressed by warming tendency effects on climate systems, is also undergoing significant changes of its cause and effect components. Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased [5-8].

Fogs represent not only an important climateforming factor, but also a sensitive indicator of climate change. Therefore, in Georgia, where almost all kinds of climate are encountered, the investigations of fogs have always carried a particular importance. A detailed analysis of the variability of the number of fog days per year N and some reasons of variations of N in different locations of Georgia is given in Amiranashvili et al. [9-15].

For example, trends of the mean number of fog days per year to one meteorological station in Eastern Georgia, Western Georgia and Georgia in 1936-1990 are negative and are satisfactorily described by the nonlinear equations of the third order. In Eastern Georgia in comparison with Western Georgia the decrease of the number of the fog days per year in 1936-1990 occurred less intensively [9-11]. In different localities of Georgia the mainly reasons of variations of number of fog days per year are different. However, for some regions (for example Senaki, Sukhumi) variations of number of fog days are weakly connected with variations of the meteorological parameters and air pollution. In Tbilisi, Anaseuli and Tsalka the mainly reasons of changeability of N are air pollution. In Telavi the mainly reasons of variation of N is atmospheric pollution and air relative humidity. However the share of air pollution in the N variations is 2.6-6.9 times higher than share of the air relative humidity (respectively in Tbilisi 4.5 times, Anaseuli – 6.9 times, Telavi – 2.6 times) [12].

In [13] the detailed statistical analysis of number of days with the fog (N), duration of fogs (T), number of days with the haze (P) and duration of haze (Q) in Dusheti (Georgia) in 1941-1990 are present. Thus, for all four indicated parameters the autocorrelation has a significant effect on the value of the standard error of annual average. The correlation relationships between T and N, Q and P, P and N, Q and T are obtained. The long-term variations of monthly, year and half year values of N, T, P and Q are studied. In particular, the clearly expressed trend of the N, T, P and Q is not observed. However, as a whole in 1941-1990 there is a tendency of the decrease of the number of days with the fogs and duration of fogs. An increase in the number of days with the haze and the duration of haze at the same time is observed.

The aerosol pollution of atmosphere has a definite effect on fogs and haze duration. With an increase in the pollution of atmosphere the duration of fogs during the week-days and weekends becomes identical, whereas the duration of haze during the week-days becomes less than into the weekends. With an increase in the air pollution for the week-days the duration of fogs does not change, but during week-days it is increases. For the haze duration another picture is observed. During the week-days the duration of haze is decreases, but during week-days it is does not change [15].

In [16] results of an analysis of the influence of fogs on air pollutions in Tbilisi (the capital of Georgia) in December – February 2009-2011 at the windless weather are presented. In particular it is obtained, that in cases with fog in comparison with cloudless atmosphere the mean values of radon content in air and sub-micron aerosol concentration increase by 14 and 116 %, bat values of small ions and ozone concentration - decrease by 17 and 69 % respectively (air in the fogs is dirtier than in the cloudless weather).

This work is a continuation of the mentioned investigations and concerns the investigation of fog regimes in and around Tbilisi.

Because of safety concerns, fog occurrences are associated with disruptions in air traffic at airports and navigation in marine ports. Unforeseen reductions in airport capacity associated with reduced ceiling and visibility lead to significant cost increments to the large air carriers [17]. For this reason, fog has many times been responsible for the cancellation or postponement of flights, until the weather conditions improve. Fog is formed in almost every part of the earth if given suitable synoptic and geographical conditions. Fog is a limitation of horizontal visibility below

1000 meters, which is caused by the accumulation of condensation and sublimation products of vapor in surface layers. Accordingly, the intensity of fog can be “very strong” (50m.), “strong” (50-150 m), “moderate” (200-500 m), or ”weak” (500-1000 m) [18].

In its genesis fog is both inter air-mass and frontal (figure 1). Fog can be formed by evaporation as well as by cooling of the air. This cooling can be caused by radiation and advection factors. Such conditions are created by the following: central parts of anticyclones; anticyclonic col; small gradient pressure fields; front parts of occlude cyclones; and, warm sectors of cyclones. Fog also can be formed during the invasion of cold air behind cyclones. Fog is also formed by orographic factors (height and form of relief), reservoirs, industry, and urbanization.

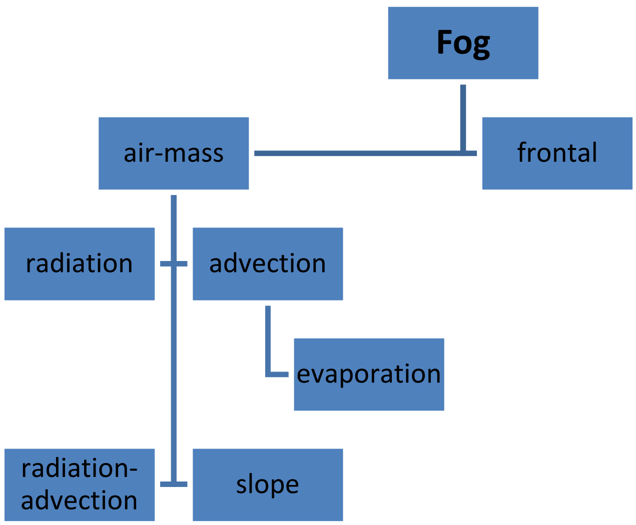


Fig 1. Fog classification scheme.

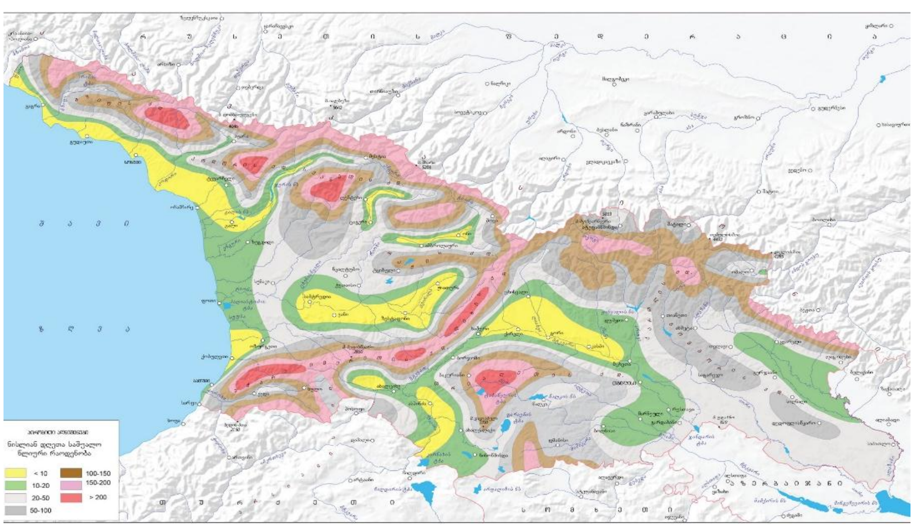


Fig.2. Foggy days in the territory of Georgia (Source: National Atlas of Georgia, 2012) [20].

Distribution of foggy days and its regime are complex in the territory of Georgia. This is caused by the impact of aerosynoptic conditions on the orografic features. Fog is formed throughout the year in Georgia and is characterised by diverse intensity (fig. 2). Fog is prolonged in the Georgian winter period. Foggy days are characterised by high indexes, especially mountainous locations: for instance, on the average, 194 days of fog in Jvari pass (2395 m.); in Mamisoni pass (2854 m.), 223 days; and lastly in Mt.Sabueti (1242 m.) 258 days [19].

Study area, method and data description

The aim of this paper is to study regimes of fog in urban areas and to determine its variation. In our research we used 5 years (2012-2016) of meteorological bulletins (SYNOP and METAR) from two meteorological stations (MS): Tbilisi (WMO code 37545) (403 m.s.l.), and Tbilisi airport (ICAO code UGTB) (495 m.s.l.). Material was downloaded from the website www.ogimet.com. We analyzed each 3 hours SYNOP (Surface Synoptic Observations) for the MS Tbilisi and 00:30 min. METAR (Aviation Routine Weather Report) for the MS Tbilisi airport. Prevailing visibility was used for MS Tbilisi airport (Figure 3). It is worth mentioning that fog was not simultaneously observed in both stations during the investigated period. Even of more interest to note, in the bulletin of MS Tbilisi, fog was not indicated at all. The visibility, as well as other weather phenomena groupings, were not identified in the SYNOP of MS Tbilisi, from 3:00 PM to 03:00 AM [UTC]. This time period is often characterized by a high probability of creating fog. This discrepancy can be explained by two possible reasons: firstly, observation on visibility had not been provided by sensors, and secondly, fog had not been observed at the station.

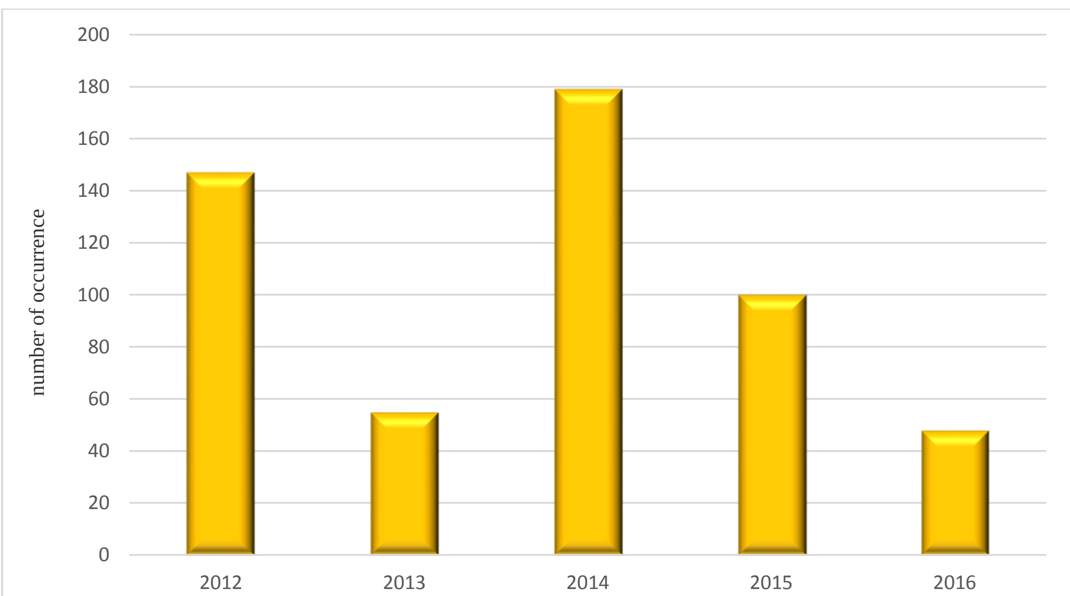


Fig. 3. Number of occurrence of fog in METAR. MS Tbilisi airport.

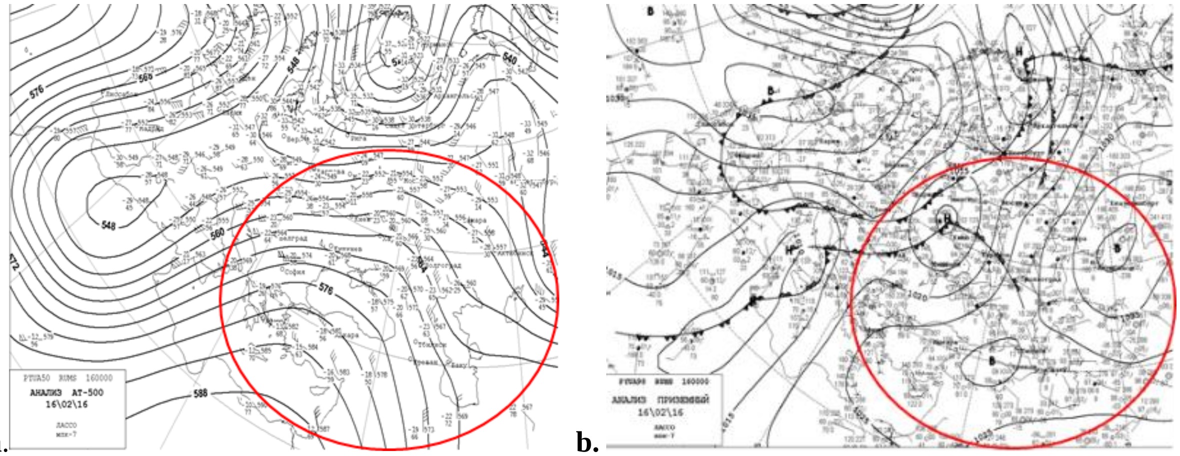
We studied the regime of fog only at the MS Tbilisi airport. We analyzed the following characteristics of fog: quantity of foggy days per months, duration (hours), periodicity of foggy days in different dates, fog gradation, and number of occurrences of fog. For a determination of changes in these characteristics, we compared 2012-2016 data to the mean of 1936-1965.

The area where MS Tbilisi Airport is located is a transitional zone from the outer Kakheti upland to the plains of Kvemo Kartli, adjoining the left side of the steppe of Gardbani [21]. The northern and northeast parts of the airport territory are bounded by rolling hills, which belong to Samgori valley. The surrounding terrain features a complex topographic relief with alternating or merging rolling hills and mountain ridges. Lochini river gorge is situated near the airport. It helps to form and develop fog during agreeable synoptic conditions. According to the long-term data (1936-1965) given in a climatological summary of [19], fog occurs every month of the year except for July, at the MS Tbilisi airport. In our research time range of 2012-2016, fog had only occurred from November to March (5 months). From this period of days, fog duration is characterized best by the months of December, January and February. In March the fog duration was for only a very short period, mainly only 2 days in 2012, totaling 1 hour and 30min, and in 2013 for one day also totaling for 1 hour and 30min. It did not occur in March of 2014 nor in 2015, while in 2016 three days were foggy for a total of 2 hours. As can be seen from our data, distribution of foggy days varies year by year and to determine any trends of periodicity is very difficult.

Results and discussion

Analysis of foggy days weather charts (500 hpa, surface map) revealed that every time when fog occurred at MS Tbilisi airport, the Southern Caucasus had been under the influence of an upper level ridge (figure 4 a), while on surface chart (figure 4 b) anticyclone conditions were shown to have been developed (we present weather maps for 16 February, 2016 because of prolonged fog continuously, 16 hours and 30 min).   Pressure gradients were directed from the east (the Caspian Sea), to the west (the Black Sea), in what we call an “Eastern Circular Process” [22]. Mainly southeasterly direction (130-160°) light breezes (4-6 kt) were blowing. This baric condition makes favorable situations for fog at MS Tbilisi airport, but this does not mean that every time such synoptic conditions occur that fog will be observed. Without doubt one can say that in such synoptic conditions the weather forecaster can state that in cold periods of the year, or in early spring, horizontal visibility can be limited if not by the fog, then by the mist (horizontal visibility form 1000m to 5000m).

In the research period 2012-2016, air-mass genesis-fog (radiation, radiation-advection, advection) had occurred at MS Tbilisi Airport. The fog had developed in the morning time around 22 UTC and lasted until 06UTC. According to the available material of 2012-2016, in most cases before the fog appeared there had been a clear sky. Radiation, cooling, and advection of warm air masses from the south increased condensation products in the air, which was followed by a dropping of air temperature up to dew point and a relative humidity exceeding 95%. This condition resulted in fog at the MS Tbilisi Airport.



a. b.

Fig. 4. Synoptic situation – a. absolute topographic 500hpa chart; b. surface chart (source: www.kcgms.ru/unimas/).

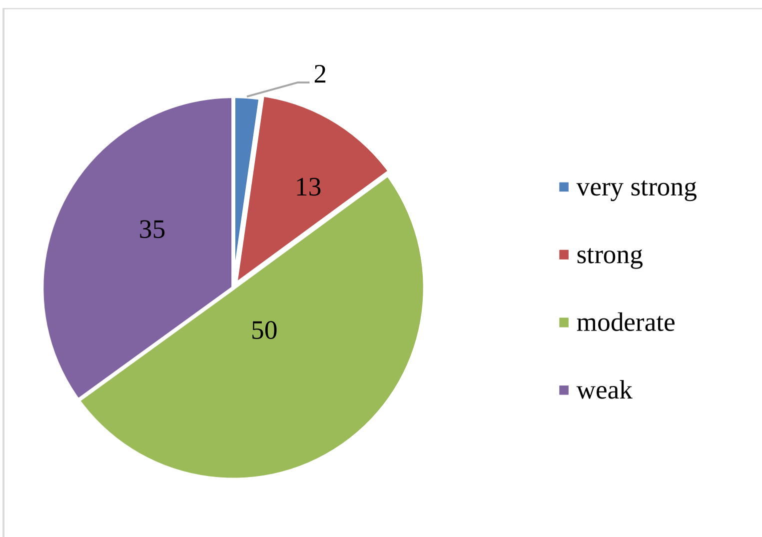


Fig 5. Intensity of fog by percentage, 2012-2016. MS Tbilisi Airport.

We analyzed 529 aviation weather reports (METAR) for this investigation (figure 5). It was revealed that from November to March the lowest index (2%) was concerned with visibility at 50m. The largest index (50%) was focused on moderate gradations (500-1000m).

One of the most important characteristics of fog is its duration (hours), intensity, and its change in time. As an example we give here data of fog which occurred on 8 February 2013 (table 1). From this table below the fog's changing nature can be noted.

Table 1

Visibility indexes of 8 February 2013. MS Tbilisi Airport.

time UTC (+4hr)	visibility (m)
17:30	50
18:00	50
18:30	50
19:00	50
19:30	100
20:00	100
20:30	300
21:00	300
21:30	600
22:00	600

Table 2

Quantity of foggy days. MS Tbilisi Airport, 2012-2016.

Year	November	December	January	February	March	Sum
2012	4	11	9	6	2	32
2013	3		5	4	1	13
2014	3	10	5	2		20
2015	4	1	7	2		14
2016				2	2	2

Table 3

Average Quantity of foggy days. MS Tbilisi Airport, 1936-1965.

Month	Quantity of days
1	7
2	5
3	4
4	1
5	0.3
6	0.2
7	
8	0.1
9	0.2
10	2
11	3
12	7
annual	30

note: figure less than 1 indicates, the fog was not detected every year

As was mentioned above, for a determination of the changeability of the regime characteristics of fog, we compared 2012-2016, and 1936-1965 years data, with each other [19]. It revealed a very interesting picture. Mainly, that fog had been observed only during the 5 months of November through March, in 2012-2016 (table 2), while almost during the full 30 years (1936-1965) fog was observed in every month except that of July, at MS Tbilisi airport, but from May to September it was not detected every year (table 3).

As shown in Table 3 the annual index of foggy days is 30. To detect the dynamics of this parameter we calculated deviations for each year, not from the annual figure, but from those 5 months sum, when fog was detected during 2012-2016 (figure 6). It equaled 26 days during the 5 months recorded. From diagram 6 it is well shown that every year except 2012, the quantity of foggy days was significantly low compared with long-term data. It means that the quantity of foggy days has been decreasing in Tbilisi.

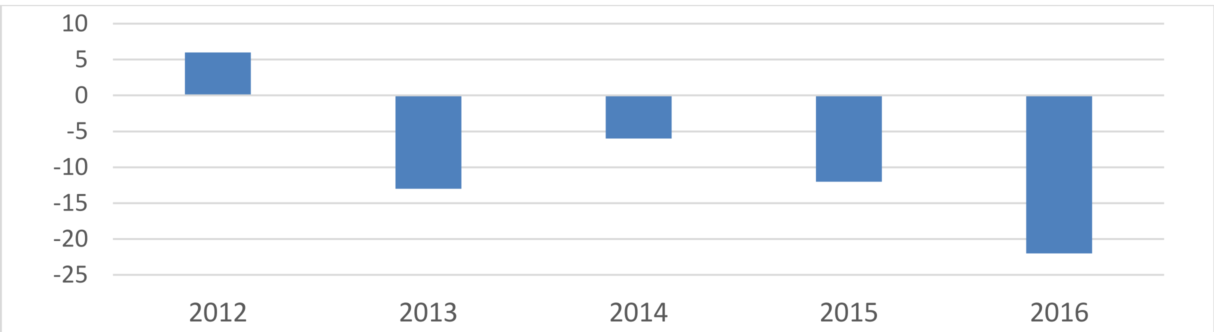


Fig. 6. Deviation of quantity of foggy days from 1936-1965 data (equaled 26) from MS Tbilisi Airport.

Table 4

Periodicity of foggy days by months in different dates. MS Tbilisi Airport, 2012-2016.

Month / Data	**11**	**12**	**1**	**2**	**3**
1-2			2	1	2
3-4					
5-6					
7-8	1	3	1	3	
9-10	3	1		3	
11-12	2	1	2	2	1
13-14		4		1	
15-16		2		1	
17-18		1	1	3	
19-20	1	3	1		
21-22	3	3	3		1
23-24		2	2		
25-26		1	3	1	1
27-28	2		5	1	
29-31	2	2	4		

The research revealed that the last third of every month is characterized with a frequency of foggy days (Table 4).

One of the main characteristics of fog is its duration by hours. The analysis of research (2012-2016) and long-term (1936-1965) periods by these parameter has revealed that in 5 months of research the period of fog duration expressed by hours was significantly reduced (table 5) compared to long-term data.

Table 5

Average duration of fog (hours). MS Tbilisi Airport.

Months	**1**	**2**	**3**	**11**	**12**
long-term	45	23	15	15	45
2012-2016	22	15	2	6	21

According to the criteria we used from this research period it is worth distinguishing 2 dates, the 21-22nd of January 2015 – when the duration of fog was continuously 14 hours and 30 minutes, and the 16-17th of February 2016 – when the fog duration was continuously 16 hours and 30 minutes. Because of such prolonged fog, some international flights were postponed at Tbilisi International airport. According to long-term data the average duration of fog in January is 44.9 hours, and in February 22.9 hours. As it is seen, those parameters also showed decreases.

Conclusions

Our study of fog regimes for the MS Tbilisi Airport has shown that during the 2012-2016 period the characteristics of this phenomena experienced changes. Mainly, that the quantity of foggy days according to months, as well as its duration (hours), has decreased over this time. Such conclusions were made by the assessment of 529 aviation weather reports (METAR). The research apparently indicates that there are ongoing changes in fog regimes, but without many stations' long-period data evaluation it is very hard to distinguish if this process is similar in other parts of the country, or not. Due to the complicated nature of fog genesis and its development, it is very important to further study this topic, according to data from meteorological stations located in the many different climate zones of Georgia.

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ნისლის დინამიკა თბილისში

ნ.ლომიძე, ნ.სუქნიძე

რეზიუმე

სტატიაში განხილულია ქალაქის პირობებში ნისლის რეჟიმი და დადგენილია მისი ცვლილება. ამოცანის შესასრულებლად გამოყენებულია ორი მეტეოსადგურის - თბილისი ქალაქის (მმო-ს კოდი - 37545) (ზ.დ. 403 მ) და თბილისი აეროპორტის (იკაო-ს ინდექსი - UGTB) (ზ.დ. 495 მ) 5 წლის (2012-2016 წწ.) SYNOP-ისა და METAR-ის კოდით შედგენილი მიწისპირა მეტეოროლოგიური დაკვირვების შეტყობინებები. ნისლის მახასიათებლებს შორის განხილულ იქნა: ნისლიან დღეთა რაოდენობა თვეების მიხედვით, ხანგრძლივობა (საათებში), ნისლიან დღეთა განმეორებადობა სხვადასხვა თარიღებში, ნისლის გრადაცია, ნისლის შემთხვევათა რიცხვი. ნისლის ამ მახასიათებლების ცვლილების დასადგენად 2012-2016 წლის მონაცემები შედარებულია 1936-1965 წლების საშუალო მნიშვნელობასთან.

Динамика тумана в Тбилиси

Н. Ломидзе, Н. Сукнидзе

Резюме

В статье приведены данные изучения режима тумана в условиях города и определены ее изменения. Для исследования были использованы пятилетные (2012-2016 г.г) данные двух метеорологических станций: города Тбилиси (ВМО код - 37545) (высота 403 м. над уровнем моря) и аэропорта Тбилиси (ИКАО индекс - UGTB) (высота 495 м. над уровнем моря). Данные наземных метеорологических наблюдений брались в виде кодов SYNOP и METAR сообщений. Были рассмотрены следующие характеристики туманов: количество дней с туманом по месяцам; их продолжительность (в часах); повторяемость туманных дней в различных датах; градация тумана; количество случаев тумана. Для установления изменений тумана и его характеристик мы сравнили данные, полученные за 2012-2016 годы с усредненными данными, полученными за 1936-1965 годы.