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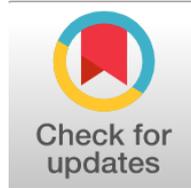
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Bioclimatic Resources and Their Consideration for Tourism Development in Selected Destinations of Uzbekistan

Sumber Daya Bioklimatik dan Pertimbangannya untuk Pengembangan Pariwisata di Destinasi Terpilih Uzbekistan

Bakhtiyar Makhamatjanovich Kholmatjanov, bkhol@mail.ru, (1)
Hydrometeorological Research Institute , Uzbekistan

Yuriy Vasilevich Petrov, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Farrukh Ilkhomjon ugli Abdikulov Abdikulov, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Farrukh Ilkhomjon ugli Abdikulov Abdikulov, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Mokhichekhra Rustam kizi Abdikulova, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Zafariddin Fakhriddin ugli Saypiddinov, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Mukhammadismoil Mukhitdinovich Makhmudov, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Farkhod Makhamatjanovich Khalmatjanov, bkhol@mail.ru, (0)
National University of Uzbekistan, Uzbekistan

Firuz Bakhrametdinovich Safarov, bkhol@mail.ru, (0)
Hydrometeorological Research Institute , Uzbekistan

[1] Corresponding author

Abstract

Taking into account bioclimatic conditions of a territory is one of the necessary elements for the tourism industry. In order to assess the bioclimatic conditions of selected settlements of Uzbekistan, such as Samarkand, Dagbit, Tashkent and the Chimgan mountain recreation zone, a thermohygrometric coefficient of air aridity is used. It is shown that the coefficient has a good response to changes in temperature and humidity and a clearly defined tendency in its annual and daily course. Based on the statistical processing of the data series of standard observations of air temperature and dew point at Samarkand, Dagbit, Tashkent Observatory and Chimgan meteorological stations for the period of 2009-2018 the spatial-temporal features of distribution

of thermal comfort conditions are revealed.

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Introduction

Address by the President of the Republic of Uzbekistan Shavkat Mirziyoyev to Oliy Majlis on January 24, 2020, emphasizes that "... we should turn the tourism industry into a strategic sector of the economy." In order to address the task, the President of the Republic of Uzbekistan Shavkat Mirziyoyev held a meeting on tourism development, further popularization of physical education and sports affairs on January 28, 2020. It was noted at the meeting, that 6.7 million tourists visited Uzbekistan in 2019. The State Committee for Tourism Development of the Republic of Uzbekistan was tasked with increasing the foreign tourists' traffic upto 7.5 million in 2020, and upto 10 million in 2022 and upto 12 million in 2025.

Uzbekistan objectively has all prerequisites for the intensive development of domestic and foreign tourism: features of its geographical position and topography, favorable climate, rich natural, historical, cultural and tourist-recreational potential. Acquaintance with the listed tourist potential usually takes place within natural and climatic conditions. In this case, the weather has a great impact on the physiological state of a person. First of all, it is its thermal comfort, which is a condition when as much heat is removed from a person as his body produces. Figuratively speaking, a person does not feel either cold or overheating.

To date, the number of works devoted to studies of bioclimatic conditions is insignificant. They are mainly carried out in some CIS countries (*Garabatyrov*, 2004; *Andreev*, 2011; *Perevedentsev and Shumikhina*, 2016). These studies give an evaluation of the bioclimatic conditions of various territories based on the analysis of a large number of biometeorological indices applied to tourism, medicine, urban planning, etc. In foreign countries, such studies are carried out by scientists from different countries of the world (*Höppe,* 1999; *Matzarakis,* 2014(a), 2014(b); *Daneshvar et al.,* 2013; *Çalişkan et al.,* 2013; *Lin and Matzarakis,* 2008; *Akinbobola et al.,* 2017). The studies are based on the use of Physiological Equivalent Temperature (PET) proposed by P.R. Höppe (1999). The above studies assessed the bioclimatic conditions of several European countries, such as Greece and the countries of the Balkan Peninsula, Taiwan and Nigeria for tourism purposes. This method is especially extensively used in Iran and Turkey. In connection with the Olympic Games in Tokyo in 2020, the method was also applied to the conditions of Japan (*Matzarakis*, 2019).

In Uzbekistan a number of studies, carried out in the 60-80s of the last century under the guidance of B.A. Aizenstat (*Aizenstat,* 1973; *Aizenstat and Lukina,* 1982) are known. In the works, on the basis of classical biometeorological indices, bioclimatic conditions not only in some cities of Uzbekistan, but throughout the territory of Central Asia were studied. Taking into account ongoing global climate change and new available evaluation methods, there is currently an objective necessity to study the bioclimatic conditions of various territories of Uzbekistan.

Materials and Methods

The data of standard observations of air temperature and dew point at Samarkand (vn.m. - 666.0 m), Dagbit (vn.m. - 645.1 m), Tashkent-Observatory (vn.m. - 467.7 m) and Chimgan (vn.m. - 1670.0 m) meteorological stations for the period 2009-2018 was served as an information basis for the study. The evaluation of thermal comfort conditions is carried out on the base of the thermohygrometric coefficient of air aridity (K), which reflects the simultaneous influence of temperature and air humidity (*Petrov and Abdullaev,* 2010):

where T is the air temperature in Kelvin, t_d is the dew point temperature, Δ is the dew point temperature deficit.

Being a dimensionless quantity, the coefficient shows how the water vapor far from the saturation state under its given content and under a given air temperature. In this case, an increase in temperature in the case of constant moisture content leads to an increase in air aridity. An increase in moisture content in the case of constant air temperature, in contrast, reduces aridity. It is completely obvious that the value of this quantity depends on many weather factors: amount and type of precipitation, state and type of underlying surface, amount and shape of clouds, etc. Based on the dependence of person's thermal sensations on temperature and aridity coefficient, 6 zones of these sensations have been identified: 1 - very cold, 2 - cold, 3 - comfort, 4 - relative comfort, 5 - hot, 6 - very hot (*Petrov and Akhmedova,* 2019).

Results

The annual distributions of long-term average thermal comfort conditions are obtained for all eight observation periods. As an example, nomograms of the distribution of thermal comfort conditions in the studied settlements for 11 a.m., 2 p.m. and 5 p.m local time are given (Fig. 1, 2).

An analysis of the results shows that at all points the bioclimatic conditions have a pronounced annual course. From the second half of October to the first half of April at all observation times in Samarkand, Dagbit and Tashkent, i.e. on the flat territory discomfort conditions "very cold" and "cold" are registered. During daytime observation

periods, the thermal comfort zone includes periods from the second half of September to the first half of October and from April to the first half of May. In the remaining periods of the year (late spring - early autumn), according to long-term average evaluation, the conditions of zone 5 and 6 - "hot" and "very hot" —are practically not observed (Figs. 1, 2a).
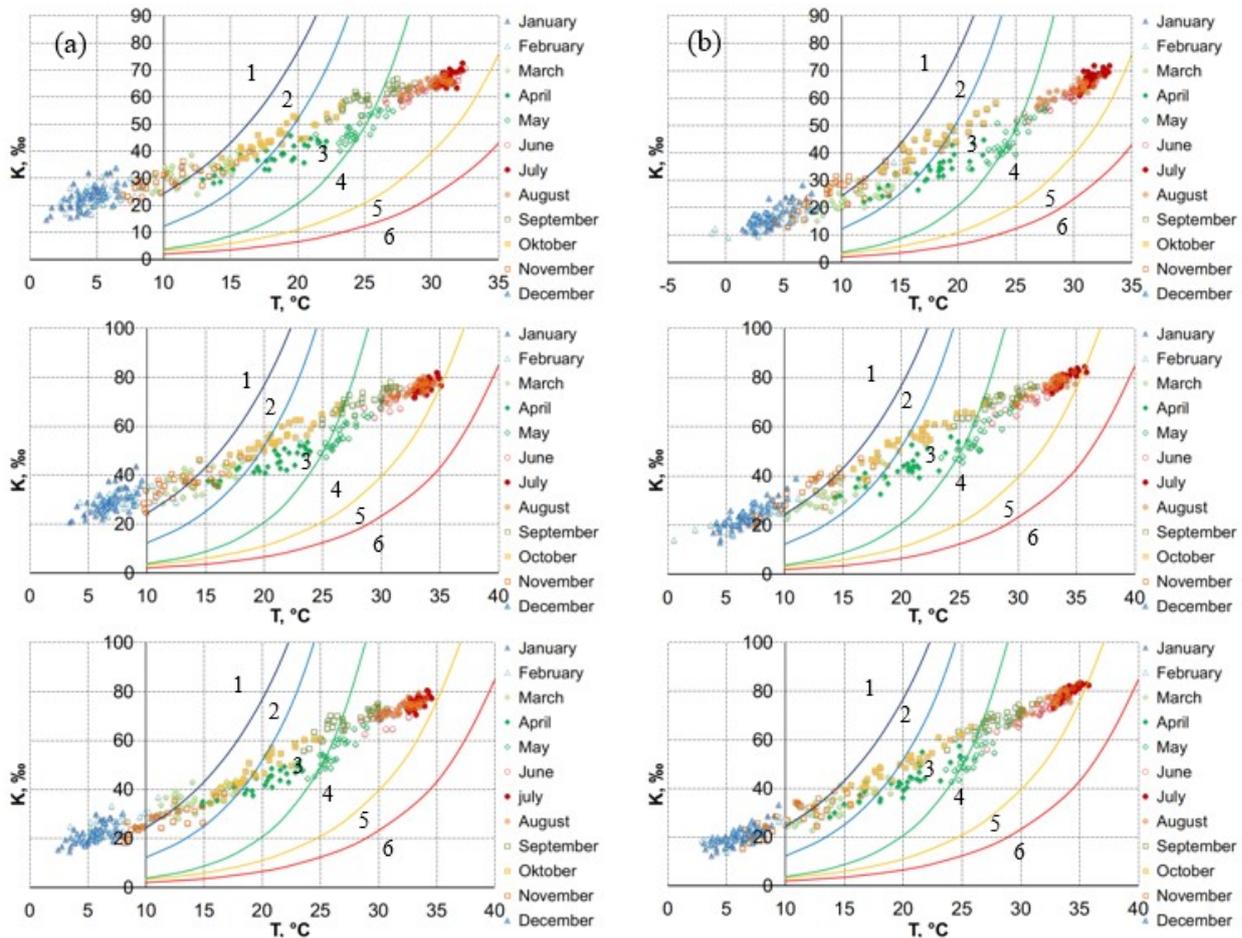

Figure 1. *Long-term average annual distribution of bioclimatic zones in Samarkand (a) and Dagbit (b) at 11 a.m., 2 p.m., 5 p.m*

1 - very cold, 2 - cold, 3 - comfort, 4 - relative comfort, 5 - hot; 6 - very hot

Completely different bioclimatic conditions are formed in mountainous regions. In summer, in Chimgan, at all day time observations, the conditions of thermal comfort are noted (zone 3). Here in the first half of the day (11 a.m.) in May, the conditions of zone 2 are set (cold), and at the rest of the year - the conditions of zone 1 (very cold). At 2 p.m. and 5 p.m. in May and September, the conditions of zone 2 are observed, and in other periods, the conditions of zone 1 are observed (Fig. 2b). Thus, the coefficient used by us quite adequately takes into account the altitudinal zonality of changes in biometeorological conditions.

Let us consider daily changes in thermal comfort conditions based on the analysis of long-term medium-term values of *K.* As an example, we give graphs of the distribution of thermal comfort conditions in the middle months of the seasons - January, April, July and October (Figs. 3, 4).

As has been shown by the data given in Fig. 3 and 4, in the daily course at all studied settlements, January is characterized by cold discomfort conditions corresponding to zone 1 - "very cold". In April, bioclimatic conditions shift to zones 2 and 3 at the plain-foothill territories. However, in the mountainous regions, very cold discomfort conditions still prevail.
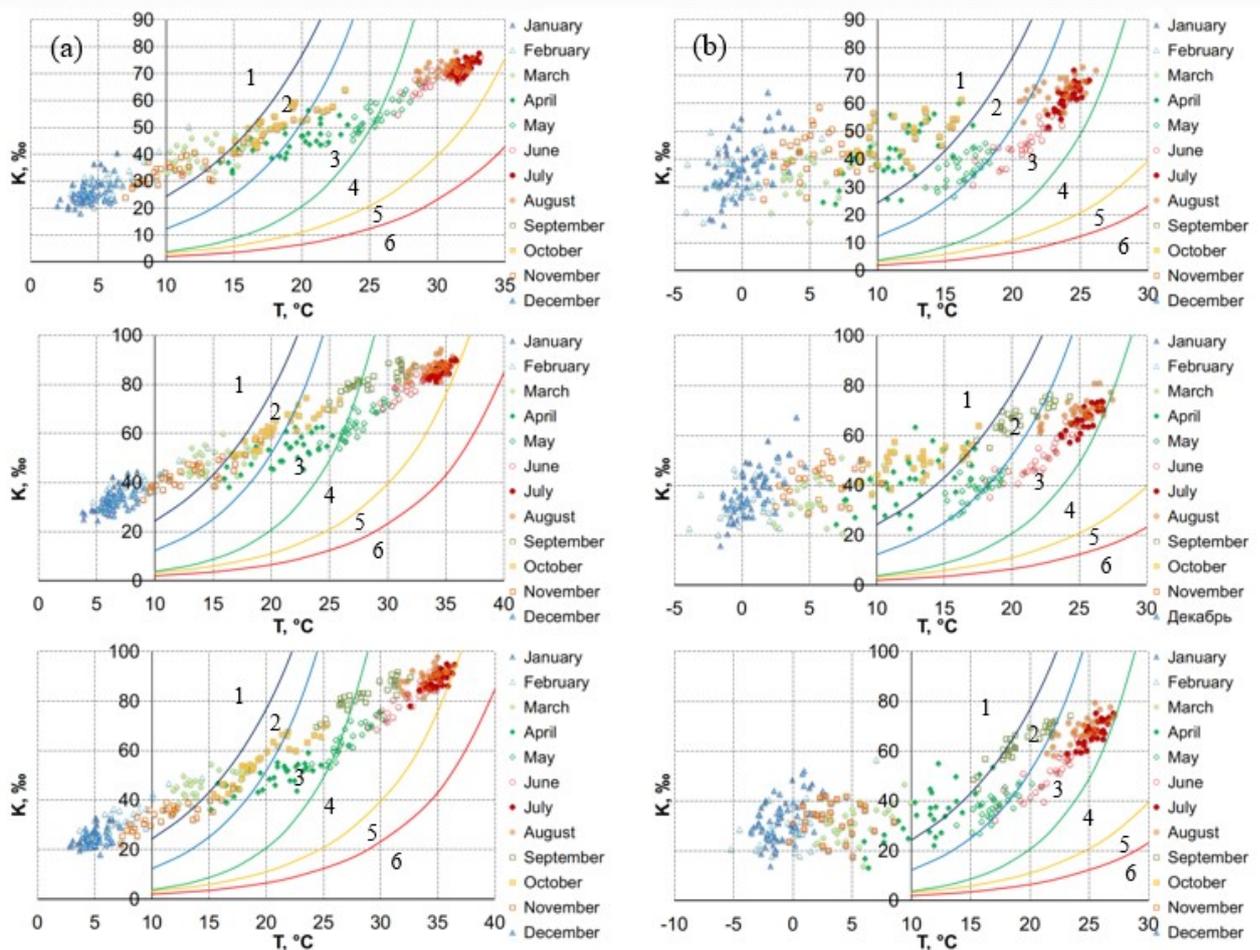
Figure 2. *Long-term average annual distribution of bioclimatic zones in Tashkent (a) and Chimgan (b) at 11 a.m., 2 p.m., 5 p.m*

1 - very cold, 2 - cold, 3 - comfort, 4 - relative comfort, 5 - hot; 6 - very hot

In July, at night (2 a.m., 5 a.m. and 11 p.m.), the conditions of thermal comfort (zone 3) are established in the lowland foothill territories, and the conditions of relative comfort are observed in the remaining periods (zone 4). In the mountains, during these periods, the conditions of zone 2 are established, and at the rest of the day, the conditions of thermal comfort are noted (zone 3). In autumn season (October), bioclimatic conditions shift in the opposite direction, i.e. towards cold discomfort. At this time, on the plain, only at daytime hours in the initial dates of the month conditions of thermal comfort are observed, and in the remaining periods the conditions of zone 2 - "cold" are set (Fig. 3 and 4a). In this season, the mountainous regions already have bioclimatic conditions of zone 1 (very cold) (Fig. 4b). Thus, firstly, the index introduced by us has a good response to diurnal changes in temperature and humidity. Secondly, completely identical bioclimatic conditions are formed in the all studied flat-foothill points, i.e. the theory of altitudinal zoning of climatic conditions distribution is confirmed.

Evaluation of the seasonal repeatability of thermal comfort conditions based on statistical analysis of daily observation data has a great practical importance from the point of view of organizing tourism events (Fig. 5).

Long-term average daily distribution of bioclimatic conditions in Samarkand
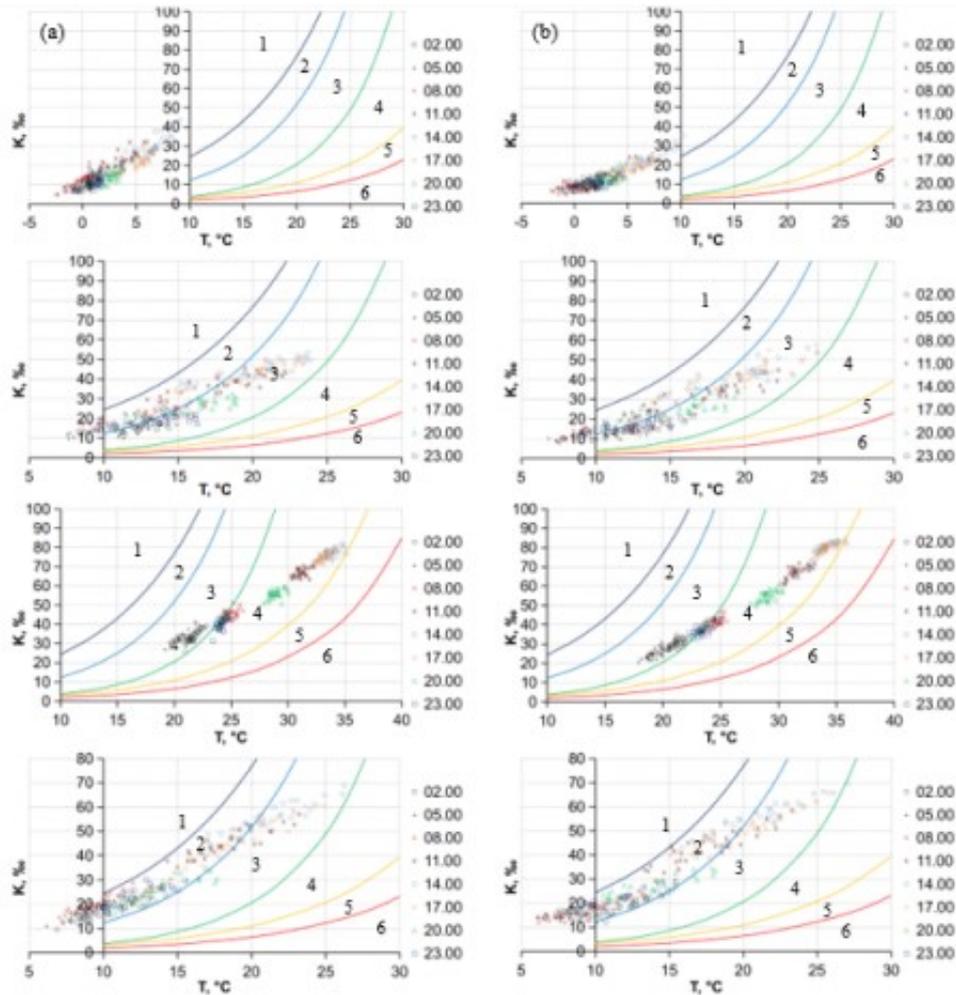
Figure 3. *(a) and Dagbit (b) in January, April, July and October*

1 - very cold, 2 - cold, 3 - comfort, 4 - relative comfort, 5 - hot; 6 - very hot

Taking into account the fact that the bioclimatic conditions of Samarkand and Dagbit are similar to Tashkent, we conduct a comparative analysis of these conditions for the plain-foothill and mountainous territories based on observations from the Tashkent-Observatory and Chimgan meteorological stations. The results show that in the all presented observation periods (at 11 a.m., 2 p.m., 5 p.m.) in Tashkent from November to March, conditions of cold discomfort prevail (zones 1 and 2) (Fig. 5a). The repeatability of these conditions varies between 70-90%. In mountainous regions (Chimgan), the time limits for cold discomfort are wider - from September to April. At that, the conditions of zone 1 (very cold) have a repeatability of 50–85% (Fig. 5b).

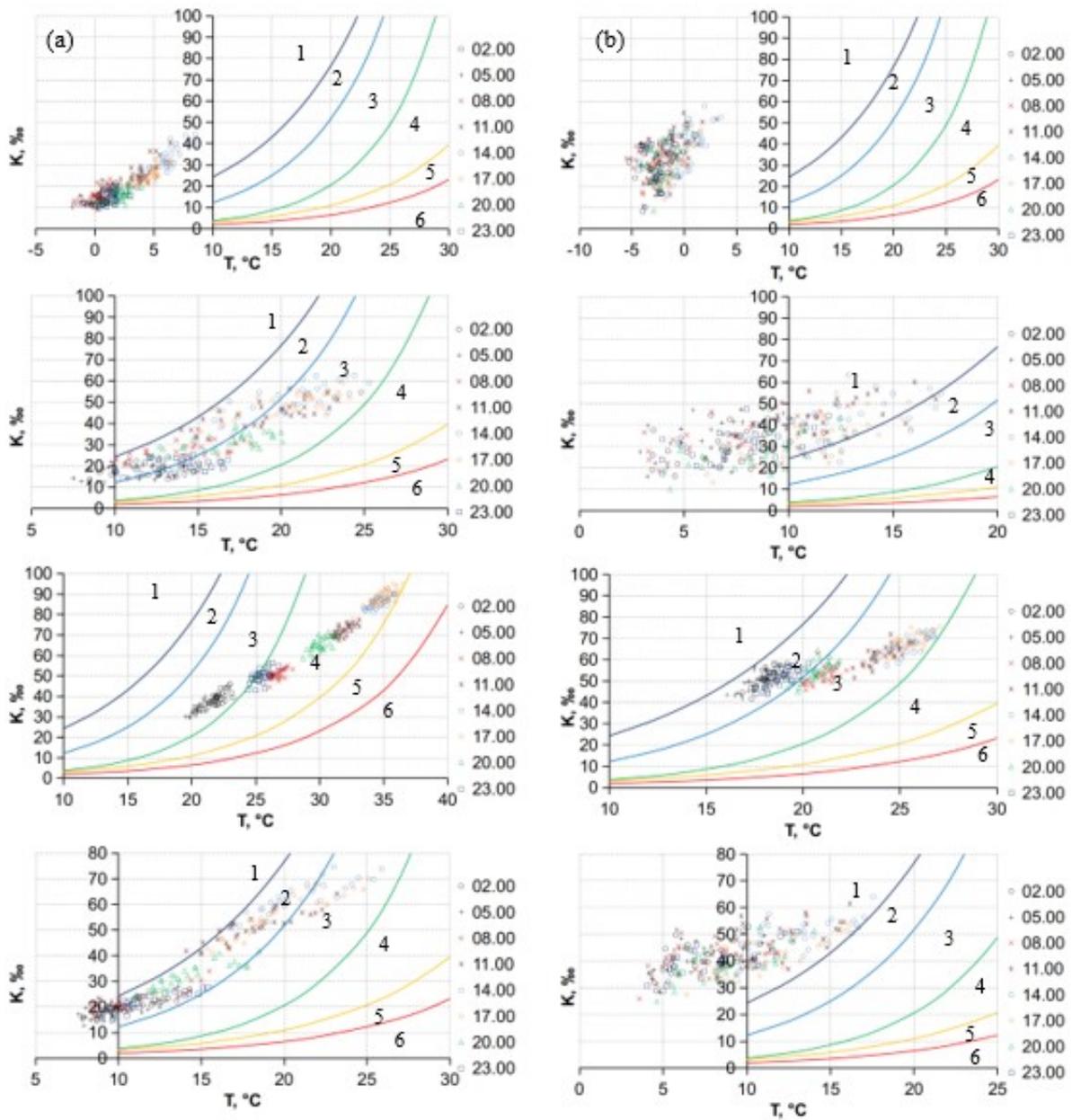Long-term average daily distribution of bioclimatic conditions in Tashkent

Figure 4. *[a] and Chimgan [b] in January, April, July and October*

1 - very cold, 2 - cold, 3 - comfort, 4 - relative comfort, 5 - hot; 6 - very hot

In transitional seasons (April-May, September-October) in Tashkent, the highest repeatability of thermal comfort conditions is observed (zone 3). In the summer months, the conditions of zone 4 (relative comfort) are predominant (Fig. 5a). From May to the second decade of September, the conditions of thermal comfort are established in the mountainous regions (zone 3). Conditions of relative comfort with repeatability up to 30-35% are registered in the hottest month - July only.

The long-term average monthly ten-day repeatability of bioclimatic conditions in Tashkent
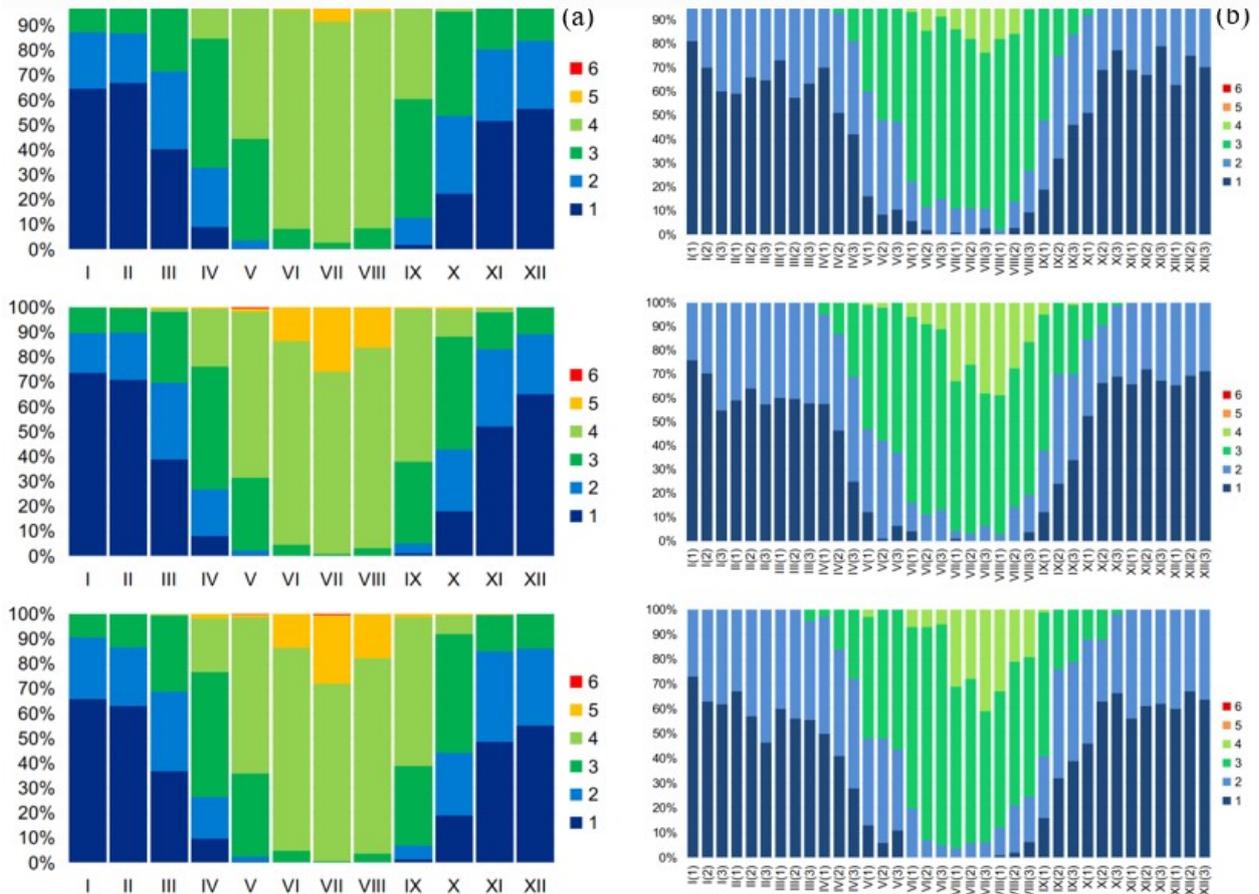
Figure 5. *(a) and Chimgan (b) at 11 a.m., 2 p.m., 5 p.m.*

1 - very cold, 2 - cold, 3 - comfort, 4 - relative comfort, 5 - hot; 6 - very hot

Discussion

Analysis of the literature references shows that the applied in the CIS countries methods for assessing bioclimatic conditions are based on a large set of biometeorological indices (*Andreev,* 2011). The authors cite more than 30 names of biometeorological indices. These indices are divided into seven groups: 1 - temperature and humidity indicators; 2 - temperature-wind (cold stress indices); 3 - temperature-humidity-wind (for shady areas); 4 - temperature-humidity-wind (taking into account solar radiation); 5 - indices of pathogenicity and climate variability; 6 - climate continental indices; 7 - indices characterizing the state of the atmosphere. Emphasizing a great scientific value of these studies results, it should be underlined that the information provided cannot be easily understood. In order to interpret the information, end user, in our case, a tourist, should possess certain knowledge in the field of biometeorology. The above make difficult to apply it for the tourism industry. Study results based on usage of Physiologically Equivalent Temperature (PET) are simple, informative, and understandable to everyone (*Matzarakis,* 2014(a), 2014(b)*; Daneshvar et al.,* 2013*; Çalişkan et al.,* 2013*; Lin and Matzarakis,* 2008*; Akinbobola et all,* 2017). However, being a temperature-humidity index, PET only indirectly takes into account the effect of air humidity on thermal comfort. For example, in Europe, thermal comfort conditions are in the range of 18–23°C (*Höppe,* 1999*; Matzarakis et al.,* 2014(a)). For Taiwan, this range is 26-30°C (*Lin and Matzarakis,* 2008), and in Nigeria it is 24-27°C (*Akinbobola et al.,* 2017). According to estimates made on the basis of the thermohygrometric coefficient of air aridity, the conditions of thermal comfort can be observed even at sufficiently low temperatures (10-12°C), when the air contains high moisture. Our proposed methodology for assessing thermal comfort for a particular area based on the thermohygrometric coefficient of air aridity can be applied to any climatic conditions. Unlike foreign analogues, *K* makes it possible in a relatively simple way to simultaneously take into account the influence of temperature and air humidity on the conditions of thermal comfort of the human body. Thus, it is an objective characteristic of the weather and climate of the study area.

Conclusion

Based on the analysis of the obtained results, it is shown that the most favorable months in terms of thermal comfort conditions are April, May, September and October for the arrangement of tourist events in the flat-piedmont areas.

The revealed tendencies of annual and daily course of the coefficient, calculated long-term average monthly and daily characteristics of repeatability of thermal comfort conditions can be applied for organizing of tourist events.

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