

TRENDS AND THREATS OF CLIMATE CHANGE ON THE BAIKAL NATURAL TERRITORY IN RUSSIA

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ABSTRACT

The Baikal natural territory is an interesting object to research for many groups of scientists since from its state the protection of Lake Baikal, which is a natural World Heritage Site depends on. Climate change in the area does not only comply with the general trends, but has its own characteristics due to the highly broken relief and the presence of a large storage of fresh water – Lake Baikal. Drastic changes in air temperature and a significant amount of precipitation can cause emergencies in the region. Temperature rise of air and water, especially in the summer, increases the recreational load and contributes to the emergence of invasive species.

Within the recreation area of Lake Bakoni the prevailing environmental situation (the forced closure of the recreational area for visiting and a ban on bathing because of the manifestations of allergic reactions such as rash and temperature) apparently is the result of a complex chain of dependencies due to the active development of long-term water plant *Elodea Canadensis*, which is invasive for Eurasia. Ecological problems of the beach recreation zone of the city of Severobaykalsk are also associated with the accumulation of a huge mass of decaying algae of *Spirogyra* genus in the coastal waters of Lake Baikal and on the surface of the beach.

Keywords: climate change, environmental consequences, Lake Baikal, Baikal natural territory, Russia

INTRODUCTION

According to researches by many scientific groups global warming is occurring now [11]. This phenomenon affects both the planet as a whole and the individual regions. Climate warming is also observed in the Russian territory. According to the observations and model calculations, the climate in Russia is more sensitive to global warming than the climate in many other regions of the globe. According to the observations, the average rate of warming of the globe is 0.166 °C/10 years for the 1976-2012 period and 0.075 °C/10 years for the 1901-2012 period. For the Russian Federation the rate of warming is 0.43 °C/10 years [9]. Climate change is manifested in varying degrees in different parts of the world [5].

The climate of the Baikal natural territory (BNT) has changed several times over the last century. This is confirmed by the research of Mackay et al. [8], White et al. [14], Shichi et al. [10]. During warm climate periods the lake received the biggest influx of water; as a result, the water level was higher [13].

The aim of this work is to assess the nature of climate warming in the Baikal region. Currently, under the current climate, as recommended by the World Meteorological Organization, refers to "the average values of climatological data calculated for a period of 30 years: 1 January 1961 - 31 December 1990". In this study climatic anomalies are determined relative to this period. To study the temporal and spatial dynamics of climate change on the territory of the Baikal region, we selected 27 meteorological stations regular network ROSHYDROMET. Data were obtained on the official website of the Russian part of World Data Center.

STUDY AREA

The Baikal region includes the Republic of Buryatia, Irkutsk Region, Zabaikalsky Krai. Climate change is important because Lake Baikal is a UNESCO World natural Heritage Site [4]. It is the deepest lake in the world and the largest natural reservoir of fresh water. The water of the lake generally meets international standards on drinking-water quality. The ecosystem of the Baikal region is a unique combination of an outstanding variety of plant and animal species.

Climate of Baikal Natural Territory is sharply continental and associated with large amplitude of annual temperature (near 70°C). Regular winter is frost and clear without precipitation. Average January temperature for different part of the Baikal Nature Territory varies from -21°C to -30°C. Character of winter depends on the development stage of the Siberian High. Most precipitation observed during warm period of the year.

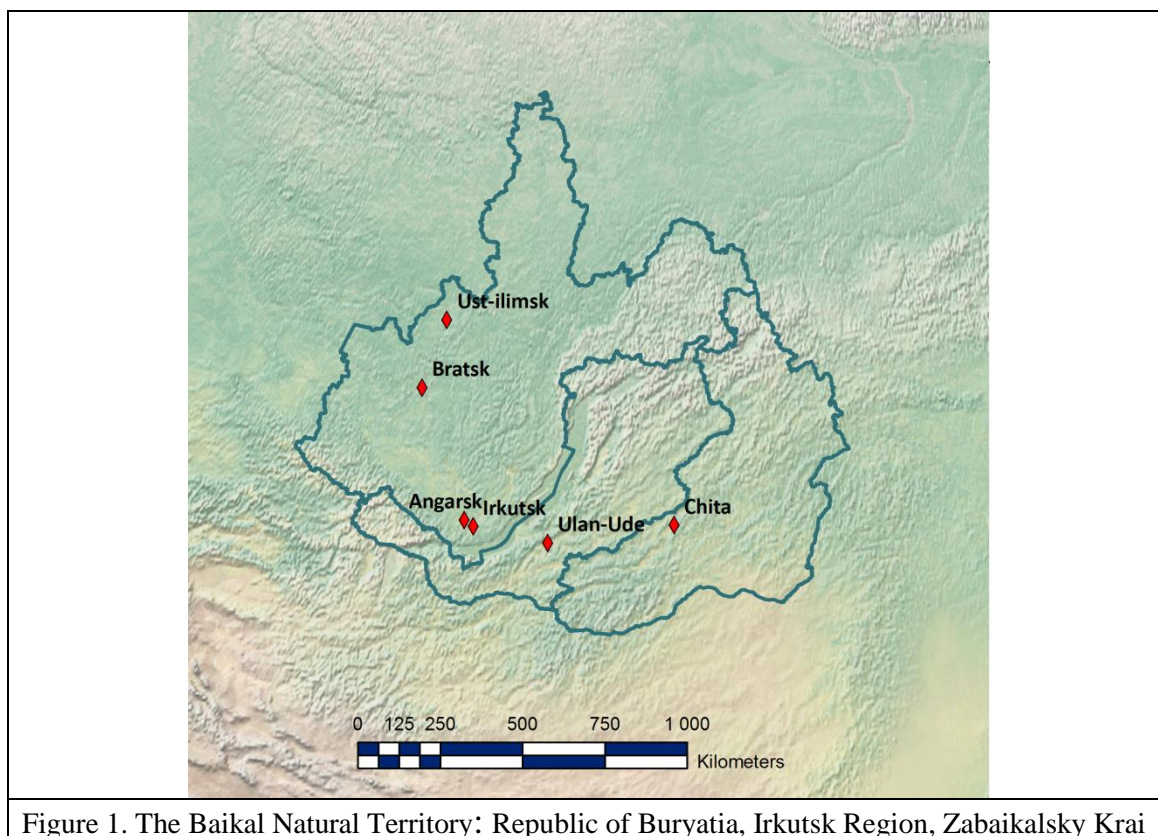


Figure 1. The Baikal Natural Territory: Republic of Buryatia, Irkutsk Region, Zabaikalsky Krai

The key climate feature is that during the cold period of the year here develops a strong north-eastern ridge of Siberian high which occurs in September-October and disappears in April-May [6]. That is why winters in Cisbaikalia and Transbaikalia are characterized by a big number of sunny days and low air temperature. In summer continental polar air dominates in the area. In the second half of the summer southern cyclones often bring marine tropical air into eastern and southern regions of Baikal Natural Territory.

Distribution of precipitation over Baikal Natural Territory is determined by the circulation of the atmosphere (prevalence of north-west air drift) and topographic peculiarities of the area (orientation of mountain ridges from south-west to north-east). That is why on the north-western slopes of the mountain ridges bordering Lake Baikal annual amount of precipitation reaches 500-1,000 mm, on windward slopes it is 400-700 mm, and in central steppe areas – only 200-250 mm.

The climate of this region is formed by a combination of many factors. One of them is Lake Baikal. Due to the fact that the ice on the lake appears only in late winter, Baikal has a warming effect on the region. The reverse effect is observed in the warm season. The relief of the area prevents the spread of the influence of the lake over long distances. Relief features of the Baikal region create conditions for the formation of a number of local winds, such as Barguzin, Sarma and others. This is katabatic winds that could reach the speed of more than 30 m/s.

The weather conditions and ice cover of Lake Baikal were studied with the help of remote sensing [2]. Remote sensing data shows that since 1990 colder winters have occurred with early ice cover formation, later ice melt and longer ice season on the lake [7].

Air temperature increase since 1970s is confirmed by other researchers [12]. Average temperature of Baikal water has grown by 1.21°C since 1946 [3].

METHODS

To study the temporal and spatial dynamics of climate change on the territory of the Baikal region, we selected 27 meteorological stations of regular network ROSHYDROMET. The data were obtained on the official website of the Russian part of World Data Center.

In order to study the spatial features of air temperature anomalies in the Baikal region the 2000–2012 period was chosen. For each year, the maps for temperatures in July and January were made. For mapping the software ESRI ArcGIS Desktop 10.1 was used.

RESULTS AND DISCUSSIONS

For the Baikal region is a common tendency to increase in surface air temperature. Since 1970, the average increase in temperature was 1°C. However, it should be emphasized that the temperature increase is made up of a plurality of different directions fluctuations. We construct the graphs to analyze the dynamics of average monthly temperature of the warmest (July) and coldest (January) month of the year. The average January temperature varies considerably, but a clear trend of increasing or decreasing the temperature does not add up. That is, the positive and negative anomalies

cancel each other out. In the mean monthly temperature anomalies in July observed trend of temperature increase. Since 1970, the July temperature rose on average by 1.2°C. Since 1990, anomalies have only positive sign for most of the stations. It can be concluded that the warming in the territory of the Baikal region is due to the increase in summer temperatures. Also worth noting is that the anomalies in summer temperatures modulo smaller anomalies winter on average three times. Annual range of temperatures in the study region is increased, the climate becomes more contrast.

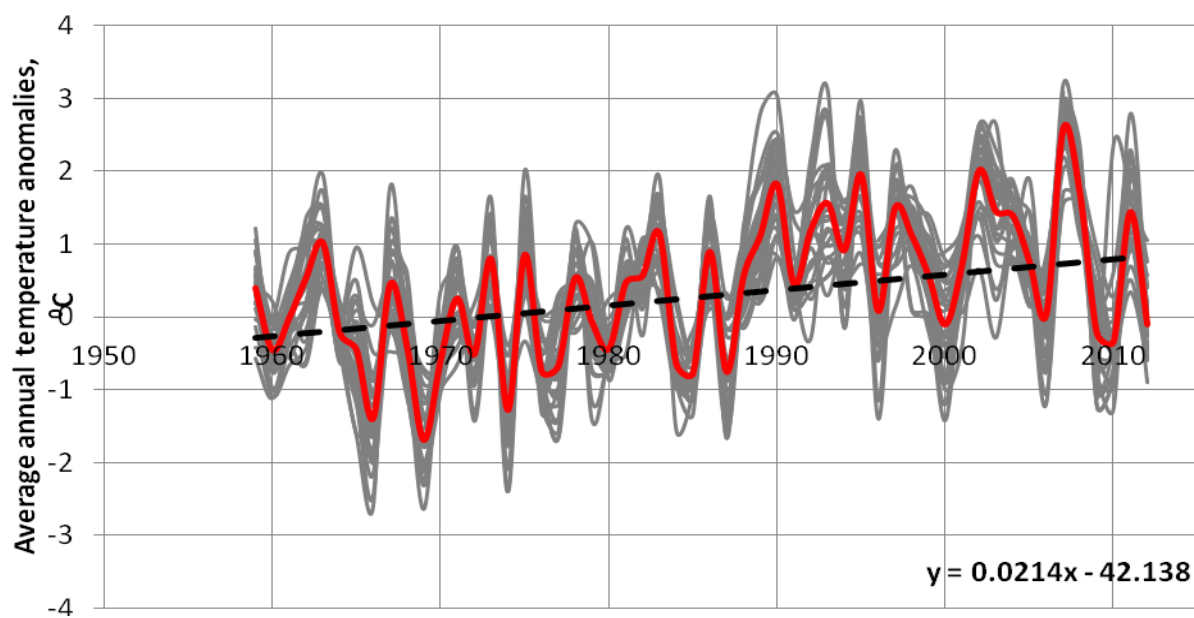


Figure 2. Grey lines – Annual temperature for each meteorological station in region. Red line - Average temperature anomaly for BNT. Black dotted line – linear trend for average temperature for whole BNT

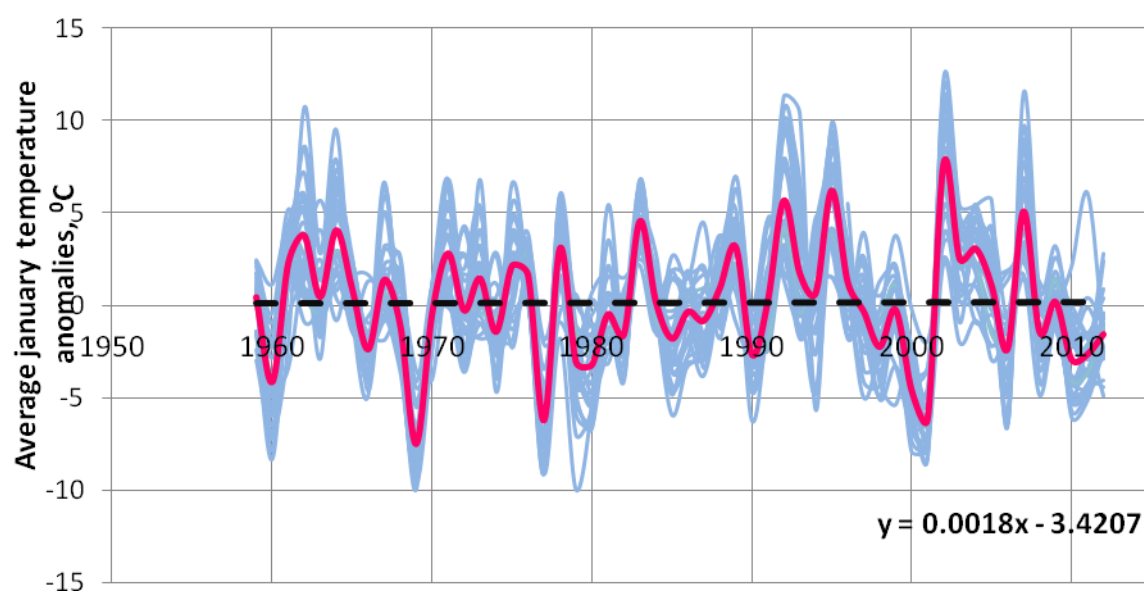


Figure 3. Pink line - Average temperature anomaly for BNT

It has already been noted that the tendency to increase the temperature of the air consists of many divergent fluctuations. One year is characterized as the warmer, the other on the contrary is characterized by a negative anomaly. What a certain year will be like is determined by the change in weather patterns in the region. The development of a strong blocking anticyclone in winter can lead to a long period of frost and a cold winter. Conversely the attenuation of the Siberian High may cause heat and a high temperature.

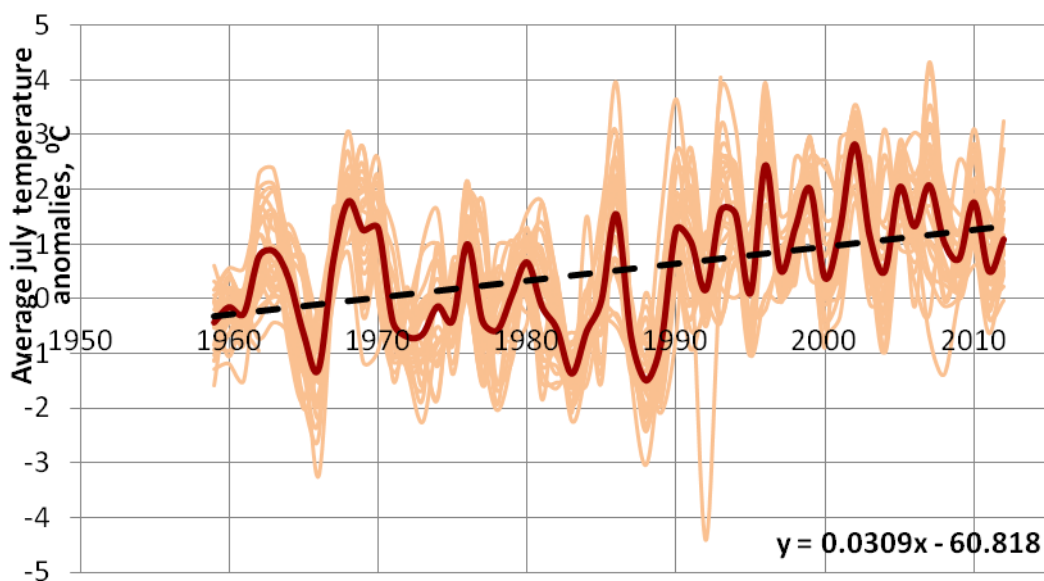


Figure 4. Brown line - Average temperature anomaly for BNT

CONCLUSION

Analysis of the constructed maps of air temperature anomalies for July and January for the period 2000-2012 did not reveal a single spatial feature of formation of anomalies in the region. On some winter maps, the area of Lake Baikal is an area of increased anomalies that can be explained by the increase in the warming effect of the lake as a result of late establishment of ice.

Temperature change can cause negative effect on endemic species. Besides, arrival of invasive species is possible as a result of freeing and emergence of new ecological niches. Recreational pressure on the BNT may grow due to the growth of water temperature and the number of tourists [1].

For example, within the recreation area of Lake Bakoni the prevailing environmental situation apparently is the result of a complex chain of dependencies due to the active development of long-term water plant *Elodea canadensis*, which is invasive for Eurasia. This is forced closure of the recreational area for visiting and a ban on bathing because of the manifestations of allergic reactions such as rash and temperature. Ecological problems of the beach recreation zone "The 8th kilometer" of the city of Severobaykalsk are also associated with the accumulation of a huge mass of decaying

algae of *Spirogyra* genus in the coastal waters of Lake Baikal and on the surface of the beach.

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