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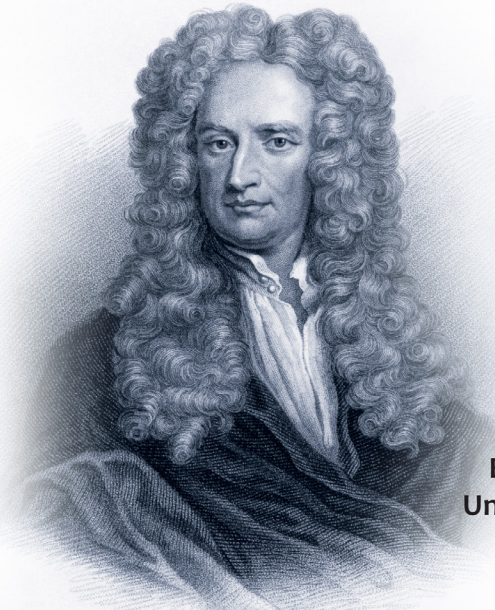

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SOME RESULTS OF MONITORING THE TEMPERATURE REGIME IN THE ALTITUDE ZONE OF THE BARGUZIN RIDGE (NORTHERN BAIKAL REGION)

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Abstract. The monitoring of temperature in the territory of the Barguzinsky reserve was organized. On a high-altitude transect of a key section of the Barguzinsky ridge, information is collected on the temperatures of the air column and on the surface of the earth. Research is carried out using thermochrons of the DS1921G type and the M-03 automatic meteocomplexes. The temperature regime of the Barguzinsky ridge was specified taking into account altitudinal zonation. The vertical gradient of the surface and elevated air temperatures was calculated. The estimation of mountain temperature inversions is given. Peculiarities of changing the thermal regime of altitudinal zoning by the seasons of the year are noted.

Keywords: Barguzinsky ridge, altitudinal zonation, temperature, thermochrons, temperature inversion.

Introduction

Monitoring the temperature regime of local territories is a necessary condition for their characterization and forecast of future climatic changes. The studies were conducted on the territory of the Barguzinsky State Natural Biosphere Reserve, located in the middle part of the western macro slope of the ridge of the same name. The study of the temperature regime of high-altitude vegetation zones of the Barguzinsky ridge has so far been limited to brief information from the work of the scientific staff of the reserve N.P. Ladokhina (1948), N.P. Ladokhina and A.M. Turcan (1948) for the period 1934-1945, V.K. Timofeeva (1948) from observations at the weather station "Sosnovka" in 1933-1937, T.L. Ananina (2008) on a high-altitude profile in the Davsha River Valley in the period 1989-1990.

Regular observations of changes in meteorological parameters on the coast of Lake Baikal have been carried out since 1955 at the 8-urgent meteorological station of the second category of the Barguzinsky Reserve UGMS. The following are recorded: air thickness (average, minimum, maximum), soil temperature, soil temperature at depths of 5, 10, 15, 20 cm, etc. The results of the analysis of long-term climate observations were published in (Ananin, Ananina, 2002, 2018; Ananina, Ananin, 2013, 2017). The data obtained do not cover the mountainous part of the Barguzinsky ridge and do not reflect the climatic features of the entire territory of the reserve. Poor knowledge of the problem initiated us to organize monitoring of the thermal regime of high-altitude vegetation zones of the Barguzinsky ridge.

The climate of the study area is sharply continental with marine features. Its formation is greatly influenced by the huge volume of water (about 23 thousand km^3) concentrated in the Baikal depression and the mountainous terrain (Ladokhin, Turcan, 1948). Accumulating heat in the summer, Baikal gives its surrounding area in the fall. On the contrary, in the spring, absorbing heat during the period of ice melting, the lake cools the surrounding air. The Barguzinsky ridge, located on the path of air currents, retains moisture evaporated from the surface of Lake Baikal, which falls here on the territory of the reserve in the form of various precipitation, while its eastern slope remains in the rain shadow (Timofeev, 1948).

Material and methods

Since 2011, at various points on the territory of the Barguzinsky Reserve, air temperature is recorded by automatic DS1921G thermochrons programmed to record the temperature after 4 hours. Thermochrones allow you to record the air temperature in hard-to-reach places throughout the calendar year, including under a layer of snow. At present, 31 thermochrons are operating: in the valleys of the Davsha river - 19 and the Bolshaya river - 6, in the vicinity of the Davsha field base - 6. The thermochrones are installed in a weather box or fixed with tape on a tree trunk at a height of 2 m, and near the ground surface from the north side.

Replacement of thermochrons is done twice a year, as a rule, before the establishment and after the snow cover has melted. Information is read to a computer and entered into the database. In 2015, automatic weather complexes M-03 (AM-M-03) were acquired in the reserve (developed by the Institute for Monitoring of Climate and Ecological Systems SB RAS, Tomsk, manufactured by Inflay LLC, Tomsk, author of the development S. A. Kurakov). These automatic weather stations (Badmaev et al., 2017) are designed to measure the amount of liquid precipitation

(rain), measure the temperature and humidity of air on the soil surface and a height of 2 m, atmospheric pressure, deep soil temperature, wind speed and direction, snow depth. Information is recorded every 20 minutes, removed once a year on a flash card. In 2018, the automatic weather complex in Davsha was configured to transmit measurements from the drive, automatically, via the Internet to the website of the Institute for Monitoring of Climatic and Ecological Systems of the SB RAS with a limited access mode. The information base was the data of average daily temperatures of the air column and minimum temperatures on the surface of the earth for the period of 2011-2016. Thermochrones are established in 12 characteristic biotopes of a high-altitude transect of a key section of the Barguzinsky ridge in the Davsha valley. Here for a long time the population of birds, large and small mammals, insects, forest pathological and phenological observations have been monitored. A 30 km long transect crosses all high-altitude vegetation zones from the shore of Lake Baikal to high mountains (Fig. 1).

The terrain is characterized by a relatively gentle rise in the low-mountain part of the transect (at 535–721 m), steeper to the upper border of the forest (1407 m), and by a sharp rise to the watershed ridge of the Barguzinsky ridge (1667 m).

Automatic weather stations were installed in 2015 on the coast of Lake Baikal in Davsha settlement (468 m above sea level) and 30 km from the coast on a mountain pass - the watershed of the Davsha and Praviy Tarkulik rivers (1667 m above sea level).

To assess the intra-annual changes in the temperature regime, according to the climatic features of the north-eastern Baikal region, the phenological seasons of the year are indicated: *winter* (cold period, 13 decades) - **X-3** - **III-3**, *summer* (warm period, lasts 9 decades) - **VI-1** - **VIII-3,** *spring* (9 decades) - **IV-1 - V-3**, and *autumn* (5 decades) - **IX-1 - X-2** (transitional periods of the year). The timing of the onset of the seasons of the year is determined according to climatic criteria proposed by K.P. Filonov (1978). The beginning of *winter* is determined by the date of snow cover establishment, *spring* - by the date of the final transition of maximum air temperatures above 10°C, *summer* - by the date of steady transition of minimum air temperatures above 5°C, and *autumn* - by the date of transition of minimum air temperatures below 0°C.

For the convenience of analysis, high-altitude sections are indicated: *the coast* - 458-517 m above sea level BS, *the lower part of the mountain belt* - 518-721 m, *the upper part of the mountain belt* - 722-1004 m, *the subalpine belt of vegetation* - 1005-1667 m.

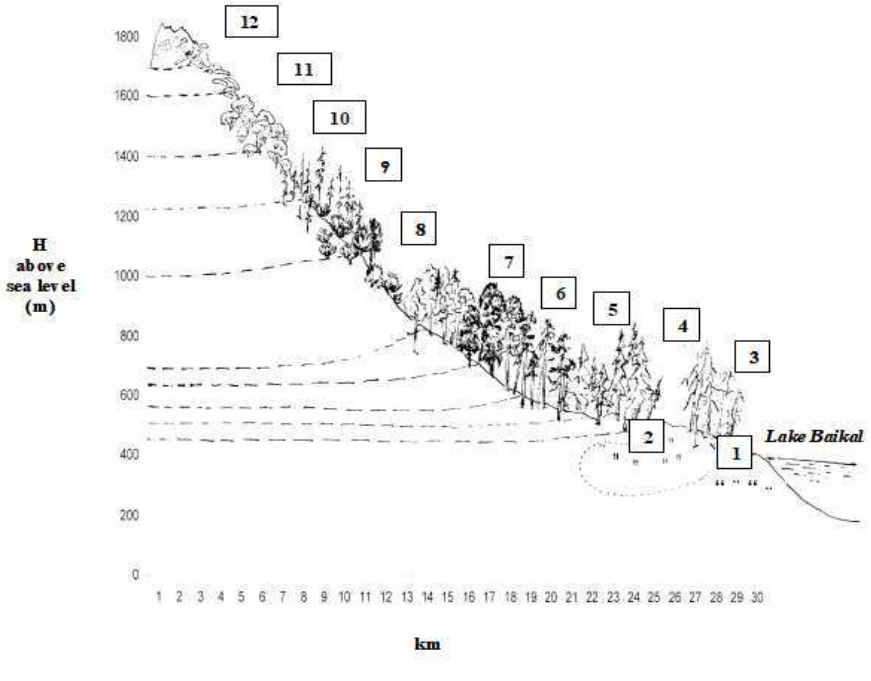


Fig. 1. Location of thermochrons on a key section of the Barguzinsky ridge in the Davsha river valleys

Designation of biotopes:
1 - shrubby meadow (468 m above sea level),
2 - grass meadow (517 m),
3 - blueberry larch (518 m),
4 - sedge spruce (517 m),
5 - lingonberry pine (535 m)
6 - badan pine cedar (635 m),
7 - badan aspen (721 m),
8 - cedar elfin (1004 m),
9 - blueberry fir (1278 m),
10 - park birch (1407 m),
11 - blueberry tundra (1637 m),
12 - lichen tundra (1667 m)

Results and discussion

In the Northern Baikal region, the winter season lasts 13 decades, unlike the summer - only 9 decades. Spring, as a rule, is long - 9 decades, unlike the short autumn season - 5 decades. The cold winter and spring seasons have a greater influence on the formation of the temperature regime of the Barguzinsky ridge than the summer and autumn seasons. The temperature characteristics of the seasons of the Barguzinsky ridge, obtained according to thermochrons, are presented by the following indicators (Table 1). The results of observations of the temperature regime of the Barguzinsky ridge for the seasons of the year are shown in Fig. 2 and Fig. 3.

The temperature gradient of the altitude transect does not remain constant. Due to the topography of the Barguzinsky ridge, microclimatic inversions of air temperature are observed. In winter, the cold air flowing from the highlands stagnates in depressions - in the park birch forest and cedar dwarf forest, where low temperatures of the air column remain. The warmest remain elevated sections of the transect with good conditions for the flow of cold air - blueberry tundra, blueberry fir and aspen. In the summer season, under the influence of the influx of solar radiation, the air warms up better in well-lit biotopes - lichen tundra, in a grassy meadow, aspen badan (Fig. 2 A). Ground temperatures in summer are higher in the mountain belt (Fig. 2 B).

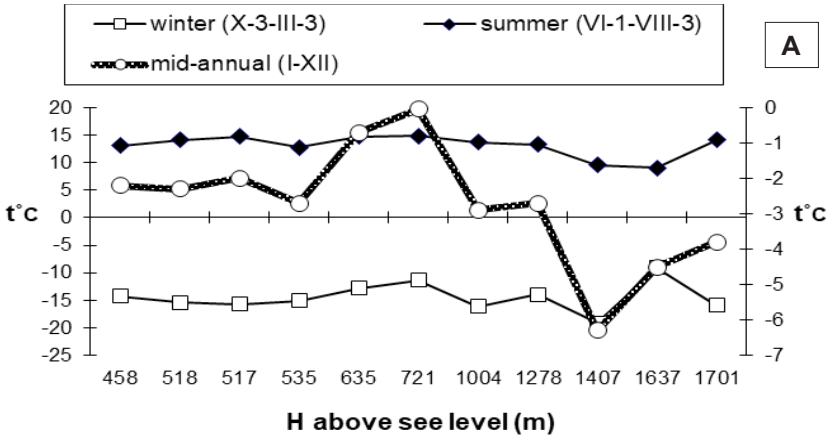
Table 1.
Temperature characteristics of the seasons of the high-altitude transect of the Barguzinsky ridge for the period 2011-2016.

Seasons	Winter	Spring	Summer	Autumn	Average annual
Average t° C	-14,4	+1,7	+14,4	+3,1	-2,7
Ground minimal t° C	-7,1	-1,6	+7,4	-0,8	-1,6

In the transitional seasons of the year, a normal vertical distribution of the average temperature of the air column is observed - it decreases with increasing height. The average air temperatures during the off-season are minimum in the subalpine belt, and maximum in the low-mountain zone (Fig. 3 A). Soil temperatures in the transitional seasons of the year depend on the timing of the establishment of snow cover in the fall and its destruction in the spring. The establishment of snow cover on the Barguzinsky ridge begins with a loach belt, and its destruction - from the coast of Lake Baikal. The first snow in the highlands can fall and melt already in the

second half of August. In September and October, up to 20.6% of the total amount of solid precipitation already arrives there, at which time the snow cover has not yet been established on the coast. In November and December, intense soaring of Lake Baikal continues, northwestern winds carry moisture to the east coast, causing frequent and heavy snowfalls (26.8% and 25.4%) (Ladeishchikov et al., 1977). In the upper and especially in the middle heights, snow still covers the melt. The soil does not freeze to low values, and sometimes the temperature has plus values (Fig. 3 B). This creates favorable conditions for wintering of small animals and plants (Filonov, 1978).

Calculations of the vertical gradient of air temperature on a high-altitude transect in the valley of the Davsha River revealed that the average annual air temperatures decrease with distance from Baikal and with increasing height: in the warm season - by 0.33°C/100 m, in the cold - by - 0.26°C/100 m. On the contrary, average annual ground temperatures increase with climb: winter - by -1.26°C, summer - by 0.13°C. There is an explanation for this - the large contrast between the temperatures of the air mass and on the surface of the earth in winter is due to the thickness of the snow cover, the period of snow accumulation, the periods of its establishment and destruction at different altitude levels (Ananina, Kozulin, 2018). The duration of snow cover is always longer in the upper parts of the macrorelief, since its establishment always starts from the loach belt, and its destruction from the coast. In the cold season, the ground temperatures on the transect are always higher in the alpine zone, and in the warm season, in the low altitude zone (Fig. 2 B, Fig. 3 B).



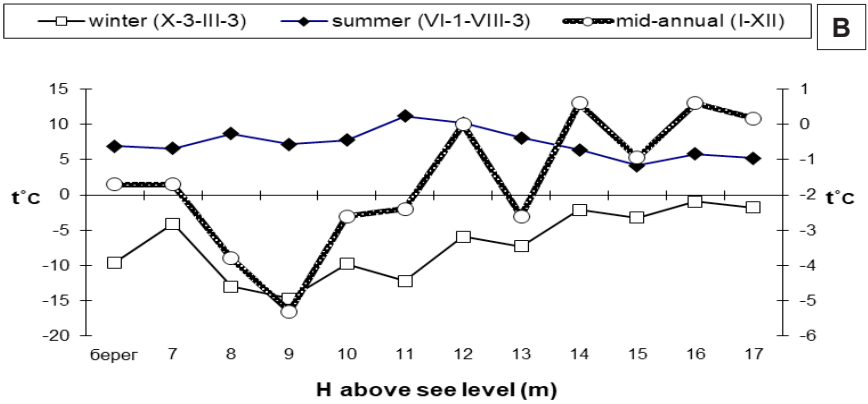


Fig. 2. Temperature characteristics of the air column and on the surface of the earth in the winter and summer seasons of the year on the high-altitude transect of the Barguzinsky ridge (2011-2016)

A – average annual, average winter and average summer temperatures of the air column;

B – average annual, average winter and average summer minimum air temperature on the soil surface.

Thus, the temperature regime of the Barguzinsky ridge is influenced by a complex of factors: altitude, Lake Baikal, mountain landscape, plant associations, slope angle and exposure, and duration of the seasons. With an increase above sea level and a distance from Baikal, the thermal regime of the Barguzinsky ridge changes significantly. However, phenological events do not fit into the diagram with the ordinates of "distance from Baikal" and "altitude above the lake." Thus, the highest average annual temperatures of the air column and on the surface of the earth are observed in the lower part of the mountain belt, where the zone of climatic optimum passes. Temperatures decrease when moving up from the low mountains to the alpine belt and down to the coast of Lake Baikal.

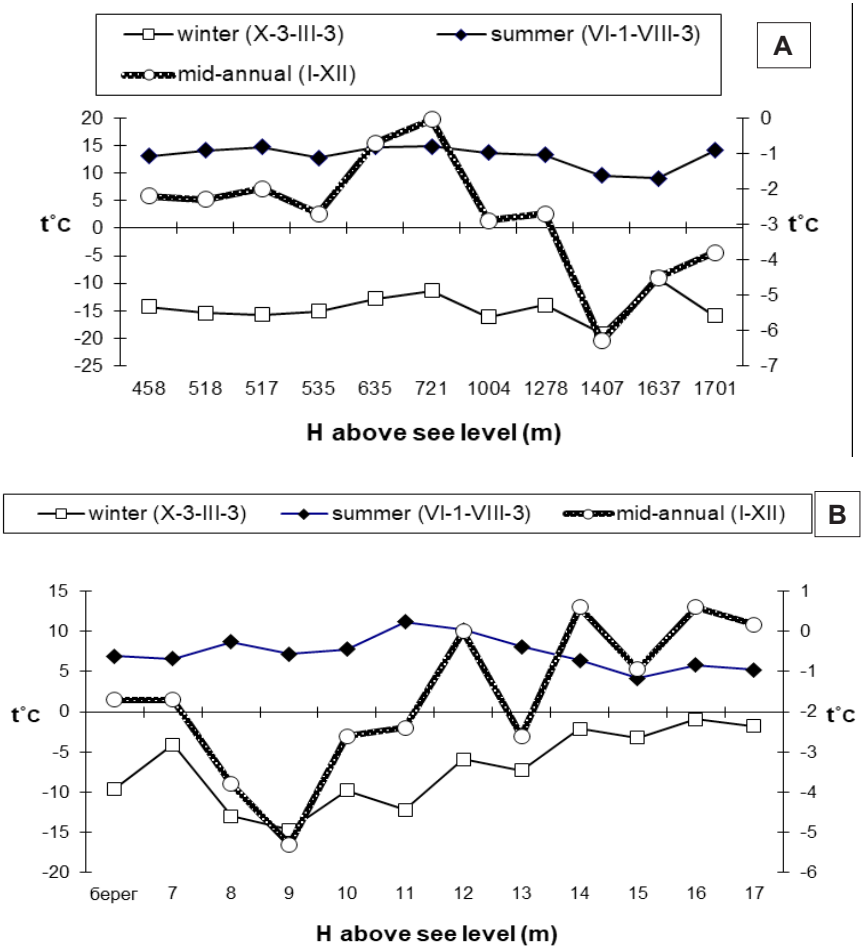


Fig. 3. Characterization of air temperature during the transition periods of the year (spring, autumn) on the high-altitude transect of the Barguzinsky ridge (the Davsha River valley) in 2011-2016

A, B - designations see fig. 2.

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