CLIMATE OF THE KHIBINY MOUNTAINS

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Abstract: The paper presents the analyses of vertical distribution of the net radiation of the underlying surface, air temperatures, precipitation, humidity, wind and fogs using data of the meteorological measurements in the Khibiny Mountains (the Kola Peninsula, Russia).

Keywords: *ICAM, mountainous area, mountain climate, Khibiny Mountains*

1. INTODUCTION

The Khibiny Massif, Khibiny Mountains or Khibiny is one of the two main mountain ranges of the Kola Peninsula, Russia.

The Khibiny massif is of oval shape of about 1,300 sq. km. and it occupies the central part of the Kola Peninsula at a relative elevation of 900-1000 m above the surrounding plain. The highest point is 1200 m. The peaks are of plateau type, with steep slopes, with glaciers, icefields and snowfields in some places. The mountain valleys and lower slopes part (below 450-600 m asl) are occupied by forest (fir-wood and birch wood). The upper part slopes and plateaus are occupied by moss and lichens tundra and rocky tundra.

The Khibiny Mountains massif deserves attention because of small horizontal sizes and its compact location in the middle of the plain. The small massif does not cause any blocking of air mass, cyclones and anticyclones and the forming of difference climates before massif, inside massif and beyond the massif. That is, the Khibiny Mountains is not the boundary of various climatic zones. For this reason we can focus on the vertical distribution of the meteorological characteristics.

2. DATA AND METHODS

The meteorological observations in the Khibiny Mountains began in 1936 (in foothills from 1900). In this study we used data of measurements at meteorological stations “Lovchorr” (1091 m asl), “Yukspor” (902 m asl), “Khibiny mount” (761 m asl), “Khibiny” (135 m asl), “Apatity” (132 m asl), “Apatitovaya gora” (360 m asl), “Vostochnaya” (210 m asl), “Kirovsk” (349 m and 400 m asl). At present, there are 2 meteorological stations which are located in the mountain massif (“Kirovsk”, “Lovchorr”) and a few stations in the foothills (“Apatity”, “Vostochnaya”). The station on the Lovchorr Mountain is located on one of the highest and dominating tops and its measurement describes the upper level of the Khibiny Mountains.

3. RESULTS

3.1 Net radiation of the underlying surface

The annual accumulated radiance decreases with altitude no more than 6% (Fig. 1). The net radiation of the underlying surface decreases more significantly (Fig. 1). During winter the difference of the radiation balance of the underlying surface between foothills and mountain tops is small. In June the difference in balance have the maximal value because of the snow cover is kept on plateaus and it is absent in mountain valleys.

The radiation balance of the underlying surface in the Kola Peninsula has a negative sign during six months.

3.2 Air temperature

The mean annual temperature in the foothills of the Khibiny varies from about -0.3 °C to -0.5 °C. The mean annual temperature varies insignificantly with altitude in the layer below 300-400 m. The temperature

above 400 m decreases by approximately 0.58 °C for each 100 m increase in height so that, the upper part of plateaus has the annual mean temperature of about -4.9 °C.

The duration of period, when the mean daily temperature exceeds 0°C, varies from 170-175 days in the foothills to 110 days at plateaus.

The vertical temperature distribution in the Khibiny and foothills in the different seasons are presented in Fig. 2.

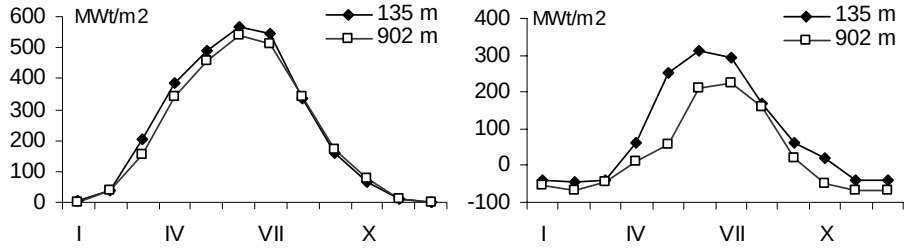

Figure 1. Accumulated solar radiation (left) and net radiation of the underlying surface in the Khibiny Mountains at the different altitudes.

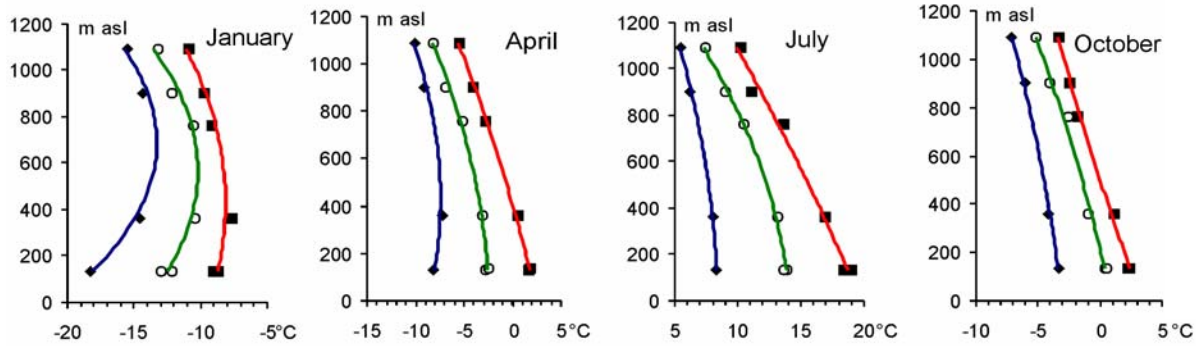

Figure 2. The vertical distribution of the average monthly values of the mean (green), mean minimal (blue) and mean maximal (red) daily temperatures in the Khibiny Mountains in different seasons.

During winter the temperature lapse rate is small and its sign is unstable. There is the temperature rise in the layer from the ground to the level of 500-600 m asl (300-400 m). The normal temperature decreases begin from 750 m asl.

During November-January in the foothills and October-February on mountain tops the diurnal variations in the air temperature are not shown or the diurnal temperature ranges are less than 1°C.

The diurnal temperature ranges decreases with altitude. However, the time of the minimal or maximal air temperature appearance almost does not change with altitude (the difference is less, than 15 minutes).

The comparison of observations on the top of the Lovchorr mountain with the data from the nearest radiosonde station in Kandalaksha, which is located 50 km south-west, has shown, that the mean temperature differences between the mountain top and free atmosphere were less than 1-2°C. During winter months the average air temperature on the plateau is less by 1.5-2°C than in free atmosphere. In summer the situation is different. The air on the plateau is by 0.5 -1.0°C warmer than air in the free atmosphere in the afternoon and it becomes by 1-1.5°C cool at night.

3.3 Precipitation

The annual precipitation on the tops of the Khibiny Mountains reaches to 1300-1500 mm, while the total average makes 800-1000 mm inside mountain valleys and about 500-600 mm in the surrounding plain (Fig.3). Thus, the total precipitation increases by 2.5-3 times with altitude. At that the duration of precipitation fall on plateau is only 1.5 times greater than ones in the foothills regions (about 3400-3500 and about 2100 hours respectively).

The massif causes not only the increase of total precipitations, but the different seasonal course (Fig.3). In the foothills the annual precipitations maximum is observed in July-August because of the convection rainfall. At the same time, the annual precipitations maximum in mountains shifts to August – October, when the cyclonic action in the region is the most intense. This fact testifies of the importance of an orographic

intensification of frontal-type precipitation. It is not difficult to verify that the precipitation lapse rate in the Khibiny Mountains is not constant throughout the year (Fig. 3).

The mean annual quality of the solid precipitation is about 67-70% from the total precipitation on mountain tops and about 40% in the foothills. Note that the snowfall at altitude of 700 m and higher can be expected in any season.

The annual course of ratio of solid, rain and mixed snow and rain precipitation depending on the altitude is present in Fig. 4.

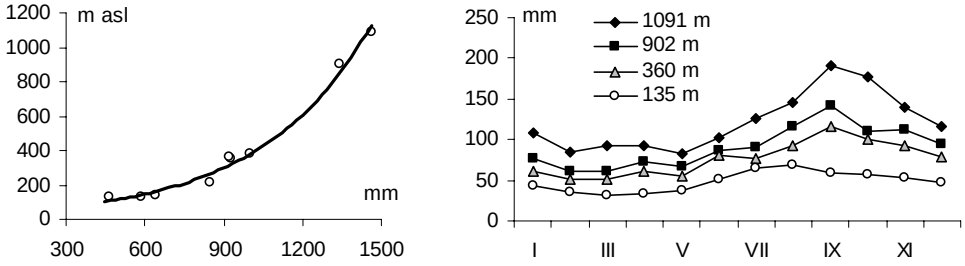

Figure 3. Vertical distributions of annual precipitation (left) and average monthly values of total precipitation (right) in the Khibiny Mountains.

The average annual number of days with snow cover varies from 220 in the foothills (since the third decade of October to the third decade of May) to over than 260 in upper parts of the Khibiny (since the first decade of October to the second decade of June). The wind carries down from 40% to 70% of the falled snow from the plateau. As a result, the snow depth in the mountain valleys exceeds almost than 1m that in the surrounding plain by the end of April (the beginning of snow melt).

The annual cycle of precipitation phase in the Khibiny Mountains presented in fig. 4.

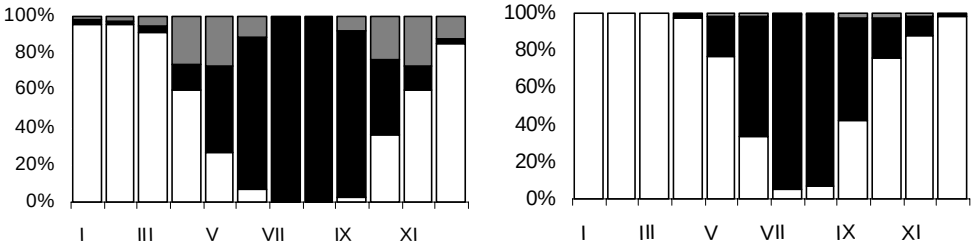

Figure 4. Precipitation phase as a percentage of the total duration of precipitation in the Khibiny Mountains. Left: 135 m asl. Right: 1091 m asl. White is solid, black is rain, gray is mixed precipitation.

3.4 Humidity

The mean monthly values and vertical distribution of the water vapor pressure are presented in Fig. 5.

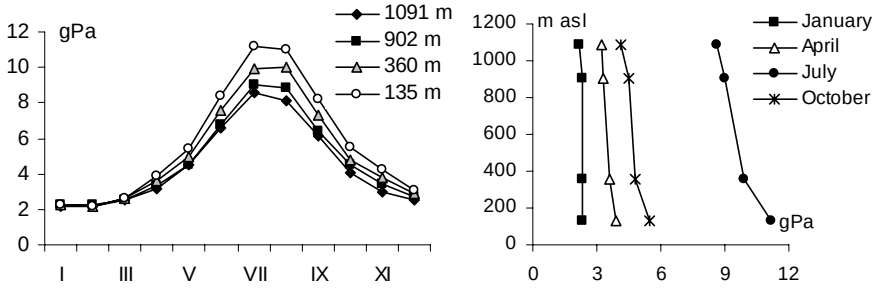

Figure 5. Average monthly values (left) and vertical distribution (right) of the water vapor pressure in the Khibiny Mountains**.**

It is not difficult to verify the lapse rate of water vapor pressure is very small during the greater part of year, when snow cover occupies the slopes of mountain and has the highest values in summer.

3.5 Wind

The average monthly wind speeds on the plateau and in foothills are presented in Fig. 6.

The wind speeds on plateau during the winter are higher, than in the summer months as the cyclonic activity is the most intensive during the cold half year. The wind speed at stations in the valleys and stations, which are located in the foothills changes significantly throughout the year. Thus, the annual variations in the wind speed on mountain tops and in the foothills have different character.

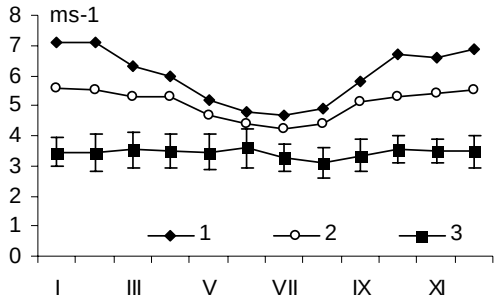

Figure 6. Average monthly wind speed in the Khibiny Mountains (1- Lovchorr (1091 m asl), 2- Yuksporr (902 m asl), 3- mean values and root-mean-square deviations of the wind speed in the foothills (135-390 m asl).

3.6 Clouds and fogs

The cloudy days in the Khibiny are characteristic features of the Khibiny Mountains. The average cloudiness makes more than 6 tenths. In this reason the duration of sunshine in the foothills varies between 30 and 40% of its maximum possible value even during the Polar day period.

The increase of total fog duration and the fog days with altitude is the highest in the layer below 600-700 m asl. This is a layer of low clouds (stratiform clouds). Thus, the longer fog duration on plateaus and slopes is caused by low clouds with cloud base below the level of mountain tops.

4. CONCLUSION

The meteorological observations in the mountain areas requires the special attention as the Alpine mountain systems exhibit particular sensitivity to the climate change (possible effects of climate changes in the mountain regions concentrate over small area).

For example, there have been manifested positive anomalies in the mean annual temperature in the Khibiny Mountains since 1989 to the present time, except for 1998 (Demin et al, 2006, 2007). The mean annual temperature between 1991 and 2007 is 0.7°C higher than the average in the period of 1961-1990. On the based of presented data on vertical distribution in the annual temperature this increase is equivalent to about 100 m descent. This warming can cause a significant response in the dynamics of the mountain landscape zones, if the increases of annual temperatures would take place in the growing seasons rather than in the winter months.

The presented paper provides only a brief description of some climatic characteristic of the Khibiny Mountains (the vertical distribution in the radiation balance, air temperature, humidity, precipitation and wind speed) using the data of meteorological observation at meteorological stations, which are located at different attitudes between 349 and 1091 m in the mountain areas and closely surrounding stations.

Note, the most of meteorological observations in the Khibiny have been carried by the Center of Avalanche Safety of „Apatit“ JSC and the observation data were not presented in the literature in the past.

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REFERENCES

Demin V.I., Zyuzin Yu. L., 2006: On climatic variations in the Khibiny Mountains. *Physics of Auroral Phenomena: Proceeding of XXIX Annual seminar*, Apatity, 2006. pp. 281-286

Demin V.I., Zyuzin Yu. L., 2007: Meteorological observation at the mountaintop station in the Khibiny (the Kola Peninsula, Russia) and regional climatic changes. (This issue)