METEOROLOGICAL OBSERVATIONS AT THE MOUNTAINTOP STATIONS IN THE KHIBINY (THE KOLA PENINSULA, RUSSIA) AND REGIONAL CLIMATIC CHANGES

Demin V.I.[1], Zyuzin Yu.L.[2]

[1] Polar Geophysical Institute, Apatity, Russia
[2] Center of Avalanche Safety „Apatit“ JSC, Kirovsk, Russia
E-mail: *demin@pgi.kolasc.net.ru*

Abstract: The results of climatic change study in the Khibiny Mountains using the glaciological, landscape and meteorological observations are presented. If time series analysis is restricted by the period from 1962 to 2006 only, there is a significant positive temperature trend. At the same time, no statistically meaningful difference in air temperatures for periods of 1937-1967 and 1976-2006. It is shown that air temperature variations in the region have oscillatory character, so that it is impossible to make a conclusion on the irreversibility of the modern warming.

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

1. INTRODUCTION

The analysis of weather observations at the ground stations around the globe indicates that surface temperature has increased by ~0.6°C over the last century (IPCC, 2001). At the same time, the regional and global pictures of climatic changes are not often coincident. In this paper the analysis of the climatic changes in the Khibiny Mountains (the Kola Peninsula, Russia) is presented.

2. INDICATIONS OF CLIMATE CHANGES IN THE KHIBINY MOUNTAINS

The glaciological, landscape and meteorological observations in the Khibiny Mountain massif were used as indicators of climate changes.

2.1 Glaciological indications

There are 4 glaciers in the Khibiny Mountains, which area varied from 15000 to 30000 m^2.

The length of glacier nr.3 (according to the Catalogue of glaciers of the USSR) was about 350 m, the width ~ 40-90 m, the ice depth reached 6.5 m according to measurements of September, 1 1958.

The length of the glacier nr. 3 reduced to 270 m between 1958 and 2004. The modern glacier area is 35% of its total area in 1958 (Fig. 1). The length of glacier nr. 4 reduced by 45 m between 1959 to 2004.

The area of permanent snow patches also rapidly decreased.

2.2 Landscape indications

Some areas of tundra vegetation in the Khibiny Mountains have been replaced with forest-tundra, and forest-tundra with the forest. For example, the valley around lake Malyi Vudyjavr was occupied with tundra vegetation according to the results of studies of vegetative and soil covers in the 1930s. At that time, the valley looked like “a wide plain licked of trees, which was covered with lichen, dwarf birch and reindeer moss”. At present, the valley is overgrown with birches. There are no signatures of tundra.

The upper tree-line limits have risen in the Khibiny Mountains (Fig. 2). This is another evidence of higher present-day summer temperatures compared to previous centuries.

2.3 Meteorological data

Meteorological observations had been carried out on Yukspor mountain (902 m asl) between 1936 and 1982. Since 1962 meteorological observations have been performed on Lovchorr mountain (1091 m asl).

As one can see from Fig. 3, there are pronounced positive anomalies in the annual temperature since 1989 to the present time, except for 1998.

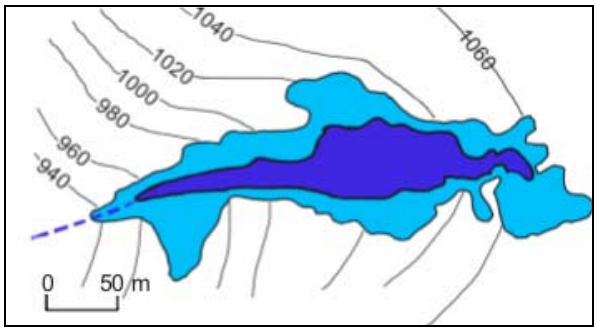

Figure 1: Pattern of glacier nr. 3; the location of the glacier is marked blue for September, 1 1958 and dark blue for August, 26 2004.

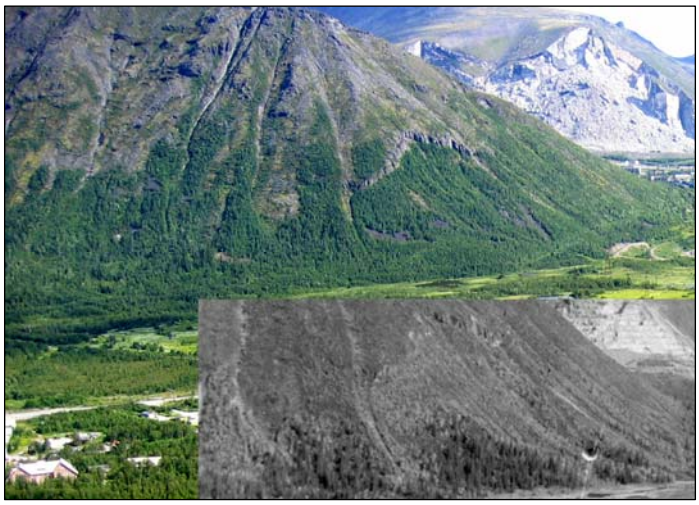

Figure 2: The south-west slope of the Yukspor mountain (a picture of August, 2006). The same area in 1936 is shown in the inset. The modern upper tree-line limits are risen by about 100 m in comparison with 1930s.

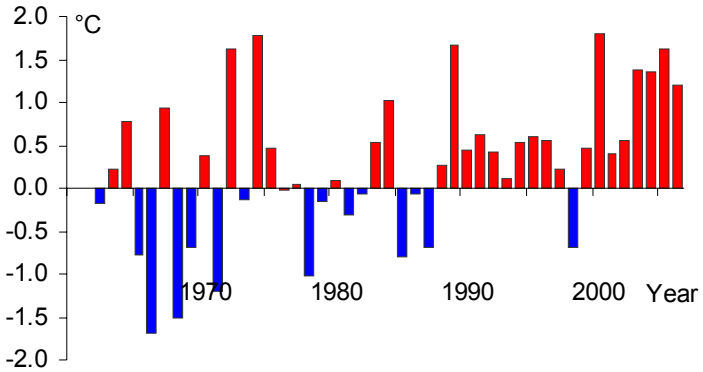

Figure 3: Anomalies of the mean annual air temperature on Lovchorr mountain (from the 1962-1990 average)

The increase in the mean annual temperature on Lovchorr mountain was 0.28°C/decade in the period of 1962-2006. Note, that in other parts of the Kola Peninsula the increase in the annual temperature varied between 0.22 and 0.45°C/decade (Semenov, 2006).

All seasons exhibit a positive temperature trend, but the contribution of the linear trend to the total dispersion is small in spring, in summer and in autumn (3-5%). This implies that the trend can be a result of scare measurements. The analysis shows that only winter and annual temperature trends are statistically meaningful. The trends in other seasons have not any statistical significance.

The annual precipitation in the Khibiny Mountains has been decreased. The decrease in total precipitation was due to the winter (solid) precipitation decrease (Fig.4). At same time, the summer precipitation changed insignificantly.

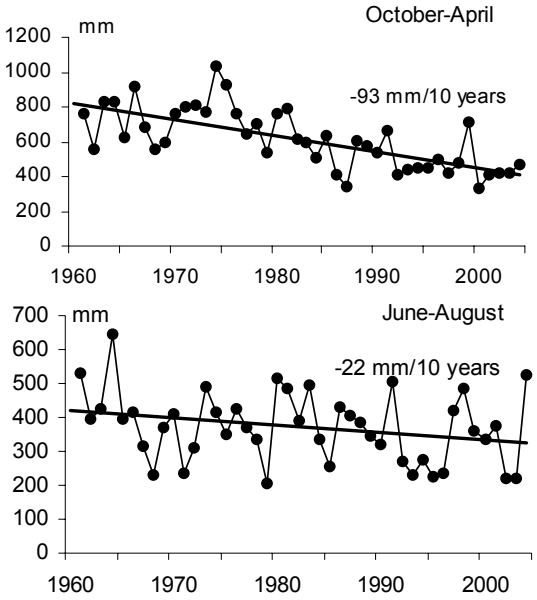

Figure 4: Total summer and winter precipitation and linear trends on Lovchorr Mountain.

It is important that the sign of annual precipitation trend over greater part of the Kola Peninsula is positive, though the trend is small (Semenov, 2006).

3. DISCUSSION

The glaciological, landscape and meteorological observations indicate that a change of climate in the region exists. However, we can not conclude that the present-day climate warming has an irreversible character.

As shown above, the glaciological environment in the Khibiny Mountains is reducing. However the glacier melting is not caused by warming of the second half of the 20th century! The Khibiny glaciers are the relic of the last mountain glaciation. They are situated below the modern climatic snowline by more than 500 metres. Under such conditions the glaciers melting is a natural process. This is a result of global increase of temperature in the interglacial period. The warming of the second half of the 20th century and the solid precipitation decrease only intensified this process. Even if sign of the temperature trend will changes, the glacier melting in the Khibiny will continued as the glaciers are situated below the climatic snowline.

The rise of upper tree-line limits indicates that the air temperature in the 20th century is higher than in the 19th century. However, the remains of trees can be found above the modern upper tree-line limits. This suggests that the past temperature was higher. Consequently, the present-day high temperatures in the Khibiny are not exclusion.

Besides, during the last millennium the temperature trend has repeatedly changed the sign. For example, the range of vertical movement of the tree line in the Khibiny Mountains during the last thousand years has been 240-260m, which corresponds to a mean change in the summer temperature of 2°C (Kremenetski et al, 2004).

It is known, that the short-term climate fluctuations have practically no impact on the location of the upper tree-line limits. Only century-long and especially many-century lasting fluctuations cause a destruction or forming of the forest at the border with the tundra phytocenosis (Gorchakovskyi et al, 1985). In this connection, the modern rise of the upper tree-line limits in the Khibiny and the replacement of tundra with forest-tundra are the result of the global and slow temperature increase, which started at the end of «the Little Ice Period». It is unlikely that the observed phenomenon is caused by short-time climate variations as the sign of these fluctuations changed repeatedly even during several decades.

In fact, as shown above, the air temperature has been increasing since 1960s. However, the meteorological measurements are indicative of different sign temperature variations in the 20th century. The

period of warming of 1920-1940s was followed by a period of air cooling between 1950s and 1970s. The modern warming began from the second half of 1980s (see Fig. 5).

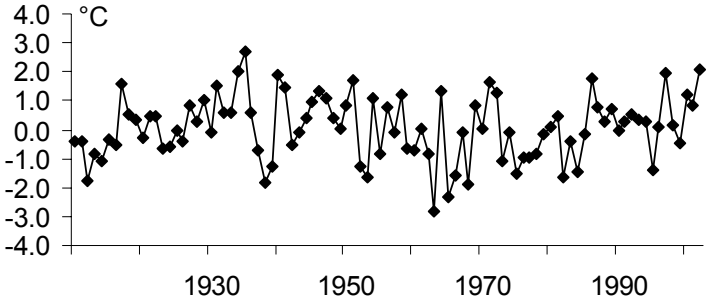

Figure 5: Annual air temperature in Kandalaksha (the Kola Peninsula)

Meteorological observations on Lovchorr mountain have been carried out since 1962. We have continued the time-series back to 1937 using the technique of reduction to a long time series, measurements on Yukspor mountain and regression equation for the period of synchronous records on Lovchorr mountain and Yuksporr mountain (the standard deviation is 0.1°C).

We have detected, that the modern air temperature on Lovchorr mountain does not exceed the values in the period of warming of 1920-1940. Thus, we can conclude that there is a significant positive trend in temperature only if temperature time series is restricted by the period of 1962-2005. At the same time, the difference of the air temperatures is not statistically significant for periods of 1937-1967 and 1976-2005. The climate in the 1930s was approximately as warm as in the 1990s.

The results of our study indicate a complicated character of the modern changes in the Arctic climate. The observed variation can not be explained by the man-made influence only. This question requires further study with using longer time series of meteorological measurements.

4. CONCLUSIONS

The meteorological observations as well as and glaciological and landscape studies are indicative of evident changes of climatic conditions in the Khibiny Mountains (the Kola Peninsula) during the second half of the past century.

However, we have no incontestable reasons to conclude that this process has an irreversible character. During the last thousand years the sign of air temperature trend changed repeatedly.

Significant trends of air temperature were found between 1962 and 2005. However the present-day temperatures in the Khibiny Mountains do not exceed those in the warming period of 1920 -1940.

Acknowledgments. *This study was supported by RFBR, grants No 05-05-64271*

REFERENCES

Semenov A.V. Climate change at the Kola Peninsula in the period 1960-2005. *Proc. of the 3th int. conf. "Avalanche and related subjects"*. Kirovsk. 2006. p. 86-87 (in Russian)

Kremenetski C., Vaschalova T., Sulerzhitsky L. The Holocene vegetation history of the Khibiny Mountains: implications for the post-glacial expansion of spruce and alder on the Kola Peninsula, northwestern Russia. *Paleogeography, Paleoclimatology, Paleoecology.* 2004, 209(1-4), pp. 113-125

Gorchakovskyi P.L., Shijatov S.G. Phitoindication of environmental condition and the natural mountain processes. M. Nauka. 1985. 208 p (in Russian)