Climate effect on the hydrological regime of the kola peninsula rivers

A. V. Semenov[1*], V. N. Ozhigina[1]

[1]Murmansk Hydrometeorology and Environmental Monitoring Administration
Murmansk, Russia
**Corresponding author: leader@kolgimet.murman.ru*

ABSTRACT
Results of statistical estimations of the basic climate and hydrological characteristics for typical river basins (Kola, Ponoi, Umba, Lotta) and weather stations (Murmansk, Kanevka, Umba,) within the territory of the Kola Peninsula, Russia, are presented. For these stations during the period 1961-2006 the rate of change of mean annual air temperature is 0.2-0.4˚C in 10 years. The change of mean temperature varies among seasons, being most explicit in winter and spring. Warming intensity is the highest in winter and the lowest in summer. The second position in the intensity of warming belongs to spring. Positive trends are detected also in the annual precipitation, annual runoff and the flood peak dates time series for the same period.

KEYWORDS
Kola Peninsula, air temperature, runoff, peak date, linear trend.

1. INTRODUCTION
Climate of the Kola Peninsula is exposed to the attenuating influence of surrounding seas, especially of the heat carried from Northern Atlantic by warm currents. As a result, the southwestern part of the Barents Sea remains free of ice even in coldest winters, and air temperatures on the coast in January and February are close to those in areas situated 10° further south (Figure 1). The thermal regime on the southern coast of the peninsula is somewhat harsher, since the White Sea freezes over in winter. As one moves inland, the influence of the seas diminishes rapidly (Yelshin, Kouprijanov, 1970).
The aim of the present study is to determine the effect of climate change in the Kola Peninsula on the hydrological regime of its rivers in the period from 1961 to 2006. The paper considers the relationship between shifts in the dates of flood onset and peaks, and changes in mean spring (April-May) air temperature. Also, correlation between change in annual streamflow and changes in total annual precipitation in the same period was analysed.

2. RESULTS
The spring season is defined according to the classification of seasons worked out by Yakovlev (1961) for the Kola Peninsula. In this classification, winter is from November through March, spring – April and May, summer – June through August, autumn – September and October (Yakovlev, 1961).
Correlations of the dates of flood onset and peak with changes in mean air temperature of the spring season were studied for the rivers belonging to different drainage basins: River Kola – Barents Sea basin, Rivers Ponoi and Umba – White Sea basin, and River Lotta, which flows through western parts of the Kola Peninsula and belongs to the Verkhne-Tulomskoye impoundment reservoir drainage basin. Analysis of temporal variability of mean seasonal air temperatures and total annual precipitation was based on data from weather stations of the Murmansk Hydrometeorology and Environmental Monitoring Administration situated in watersheds of the rivers, i.e. the weather stations Murmansk, Kanevka, Umba and Upstream Lotta, respectively.
Linear trend coefficients were computed for the 1961-2006 period to estimate current tendencies in the change of mean annual air temperature. The computation results are shown in table 1.

Table 1. Linear trend values for mean annual and mean seasonal air temperatures (˚C in 10 yrs.) in the period from 1961 to 2006

Station	Linear trend, ˚C in 10 yrs.				
	Mean annual	Winter	Spring	Summer	Autumn
Murmansk	0.3	0.4	0.3	0.2	0.1
Umba	0.3	0.4	0.3	0.2	0.2
Kanevka	0.2	0.2	0.4	0.1	0.1
Upstream Lotta	0.4	0.5	0.3	0.2	0.2

The rate of change of mean annual air temperature is 0.2-0.4˚C in 10 years. The change of mean temperature varies among seasons, being most explicit in winter and spring. Warming intensity is the highest in winter (linear trend coefficient is 0.2-0.5˚C in 10 years) and the lowest in summer (linear trend coefficient is 0.1-0.2˚C in 10 years). The second position in the intensity of warming belongs to spring (linear trend coefficient is 0.3-0.4˚C in 10 years).
Let us consider the effect of change in mean spring air temperature on the dates of flood onset and peak in the rivers selected. We regard the date of maximum water discharge during the flood as the flood peak.

2.1. River Kola, Murmansk Weather Station

The River Kola acts as the predictor in hydrological forecasts for rivers of the Kola Peninsula. The linear air temperature trend over the spring season at the Murmansk weather station is +0.3° in 10 years.
Figure 1 shows the diagram of flood onset and peak dates plotted for the Kola River for years 1961-2006. One can see a tendency towards earlier onset and peak of the flood: a shift of 1.5 days in 10 years for the onset dates, and 3.2 days in 10 years – for the peak dates. The trend contribution (R^2) to total variation of the flood onset dates is 4.3%, of the flood peak dates – 15.9%.

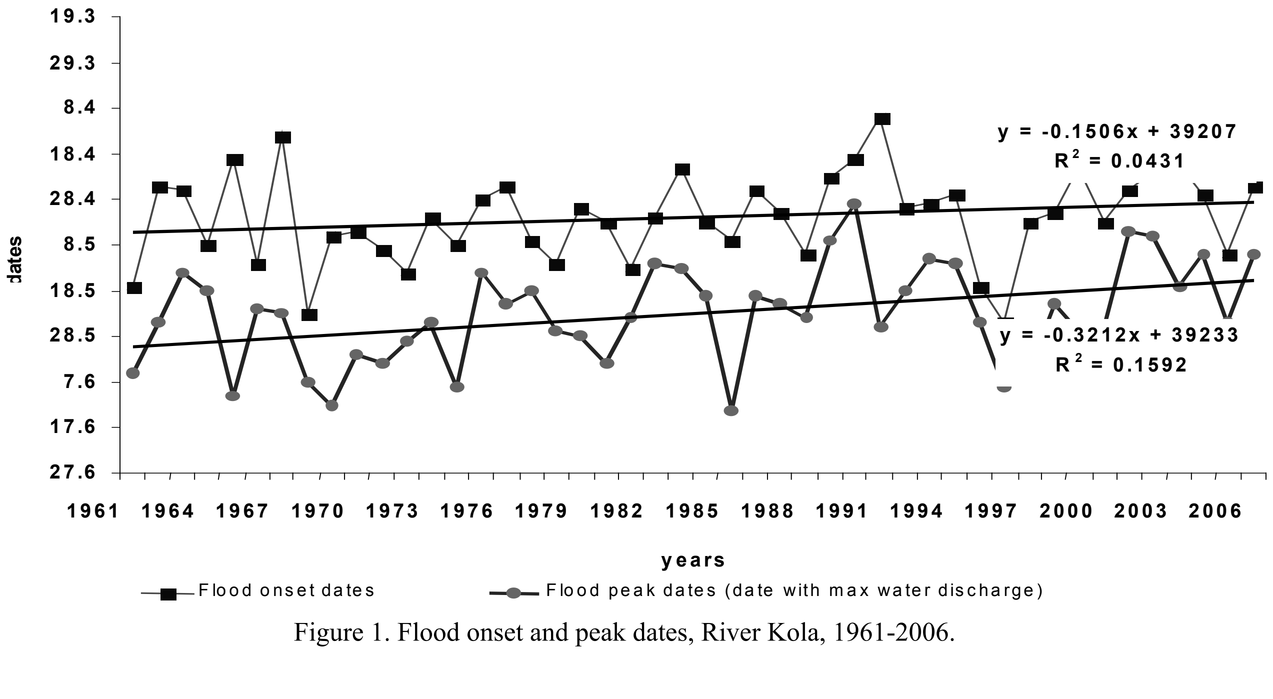

Figure 1. Flood onset and peak dates, River Kola, 1961-2006.

2.2. River Ponoi, Kanevka Weather Station

The River Ponoi is the longest river in the Kola Peninsula (426 km). The river watershed area is 10 200 km^2 (Yelshin & Kouprijanov 1970).

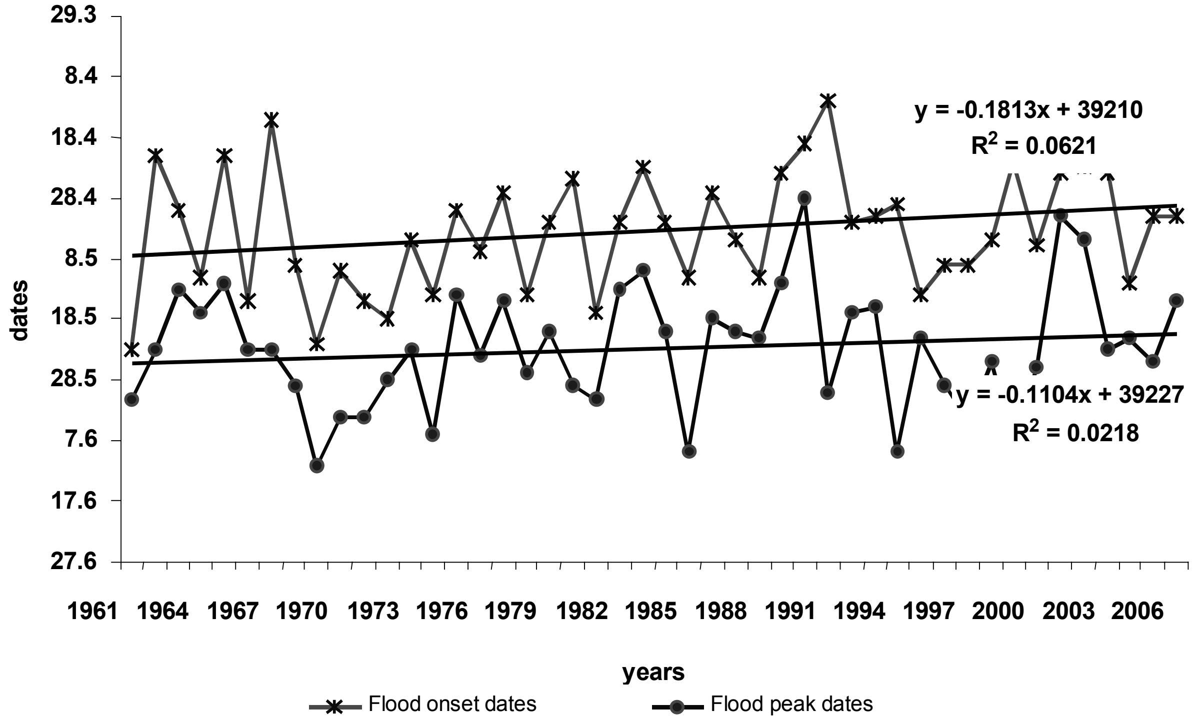

Figure 2. Flood onset and peak dates, River Ponoi – Kanevka station, 1961-2006.

The linear air temperature trend over the spring season at the Kanevka weather station (fig. 2) is +0.4° in 10 years. The shift towards earlier onset of flood is 1.8 days in 10 years, the trend contribution (R^2) to total variation of the flood onset dates is 6.2%. The shift towards earlier flood peak dates is less significant – 1.1 days in 10 years ($R^2 = 2.2\%$).
Similar diagrams were plotted for Rivers Lotta (site – Kallokoski rapid) and Umba (site – Payalka rapid). Results of the calculations are summarized in table 2.

Table 2. Coefficients of the linear trend of air temperature, flood onset and peak dates

River-site, (weather station)	1961-2006 linear trend coefficients for			Reliability of approximation - R^2 (contribution of the trend to total variation, %) for	
	spring air temperature, (ºC in 10 yrs.)	flood onset dates $D_{f.o.}$ (days in 10 yrs.)	flood peak dates $D_{f.p.}$ (days in 10 yrs.)	flood onset dates	flood peak dates
Kola – 1429th km of the Oktyabrskaya railway (Murmansk)	+0.3	-1.5	-3.2	4.3	15.9
Ponoi – vil. Kanevka (Kanevka)	+0.4	-1.8	-1.1	6.2	2.2
Lotta – Kallokoski rapid (Upstream Lotta)	+0.3	-1.7	-2.4	5.9	10.0
Umba – Payalka rapid (Umba)	+0.3	-1.8	-2.2	7.3	12.2

Note: $D_{f.o.}$ *– flood onset dates;*
$D_{f.p.}$ *– flood peak dates (dates of max water discharge).*

Judging by the results of estimating the linear trend of flood onset and peak dates summarized in table 2, the increase in mean spring air temperature by + 0.3 - +0.4º C in 10 years from 1961 to 2006 has told on the timing of flood onset and peak, shifting them towards earlier dates. In the past 46 years, the onset of flood on the rivers has been shifting to earlier dates by an average of 1.5-1.8 days in 10 years, the peak of flood – by 1.1-3.2 days in 10 years. The rate of shift to earlier flood peak dates differs among rivers, the greatest rate observed on River Kola (3.2 days in 10 yrs.), the lowest rate – on River Ponoi (1.1 days in 10 yrs.).

Table 3. Values of the linear trend of total annual precipitation (mm in 10 yrs.) and annual streamflow (km^3 in 10 yrs.) over the 1961-2006 period.

River-post, weather station (WS)	Coefficient of the linear trend of total annual precipitation (mm in 10 yrs.)	Coefficient of the linear trend of annual streamflow (km^3 in 10 yrs.)	Reliability of approximation - R^2 (contribution of the trend to total variation, %)
Kola -1429th km of the Oktyabrskaya railway (Murmansk)	4	0.05	5.7
Ponoi – vil. Kanevka (Kanevka)	-1	0.10	7.8
Lotta – Kallokoski rapid (Upstream Lotta)	3	0.00	0.4
Umba – Payalka rapid (Umba)	5	0.01	0.2

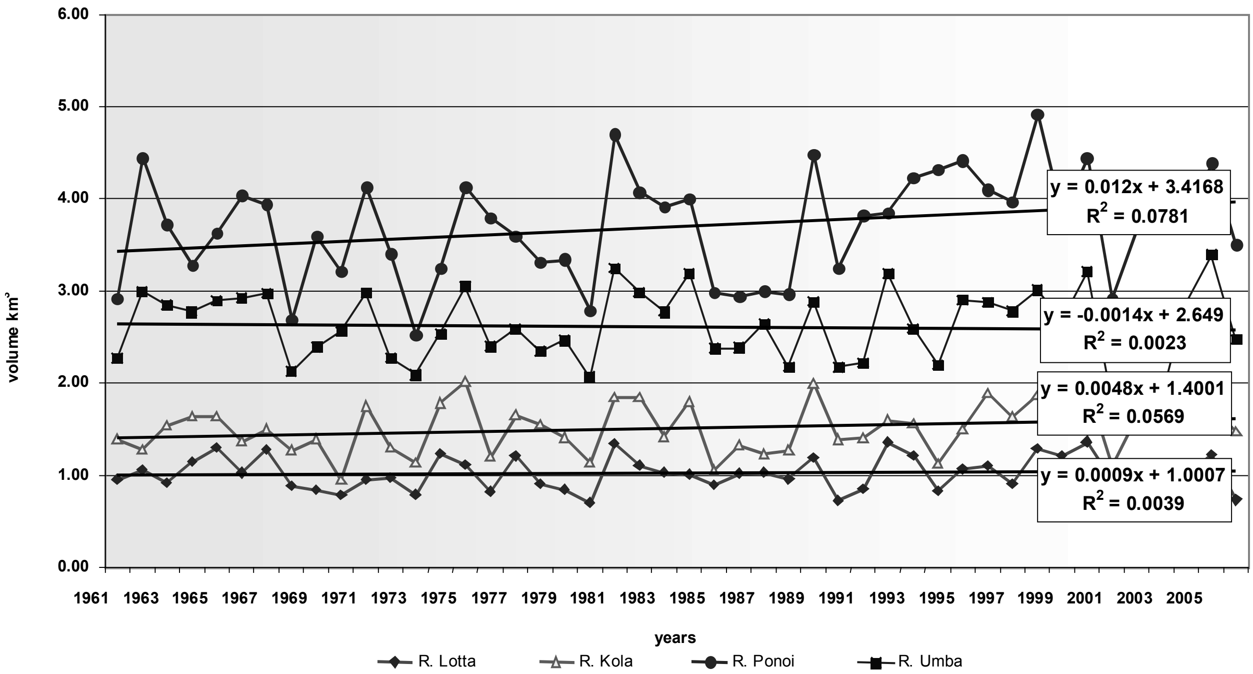

Figure 3. Annual runoff of rivers within the Kola Peninsula

Let us consider the effect of total annual precipitation on annual streamflow.
As seen from table 3, the highest coefficient of the linear trend of total annual precipitation is 5 mm in 10 years (Umba WS), the lowest one is -1 mm in 10 years (Kanevka WS). The linear trend of total annual precipitation is insignificant, and so is the linear trend of annual streamflow, which values vary from 0.0 (River Lotta) to 0.10 (River Ponoi) km^3 in 10 years (Fig. 3). One can conclude from the data in table 3 that precipitation amounts and river water content have changed little over the past 46 years.

REFERENCES

Davydov, A.A. 2001. Changes in the Kola Peninsula air temperature and Barents Sea ice status in the second half of the 20th century. Secular changes in marine ecosystems of the Arctic. Climate, marine Periglacial, bioproductivity. Kola Research Centre of RAS Publishers. Apatity. p. 291-297. [in Russian]

Davydov, A.A., Semyonov, A.V. 2005. Change of the air temperature in the Kola Peninsula and Spitzbergen Archipelago, in the ice status of the Barents Sea in the second half of the 20th century. Proceedings of the International Scientific-Industrial Forum “Great Rivers”. Gidrometeoizdat. St. Petersburg. p. 299-300. [in Russian]

Yelshin, Yu.A., Kouprijanov, V.V. 1970. Surface water resources of the USSR, Vol. I. Kola Peninsula. Gidrometeoizdat, Leningrad. p. 26, 44. [in Russian]

Yakovlev, B.A. 1961. Climate of the Murmansk Region. Murmansk Book Publishers. p. 24-27. [in Russian]