Maximum river runoff regime in The North Caucasus under the influence of recent climate change

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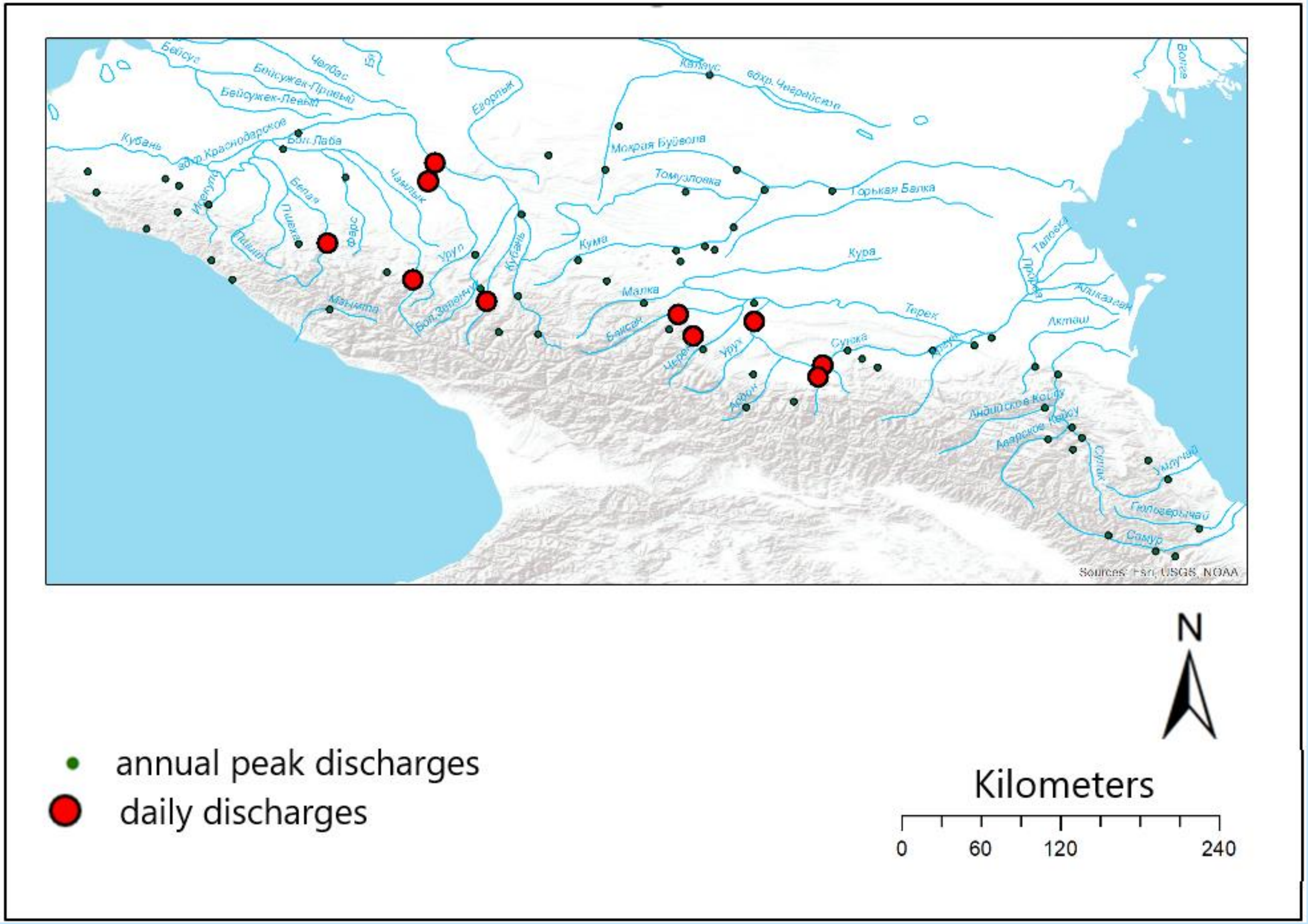
Goal:

Analyzing the spatio-temporal changes in the characteristics of the maximum runoff and the factors that determine them.

Objectives:

- The study of the series of annual peak discharge of the rivers of the North Caucasus
- Analysis of spatial differences in the dynamics of maximum runoff
- The study of modern changes in flood flow in the rivers of the North Caucasus
- Factor analysis of predictors of maximum rainfall flood runoff

Study area and data

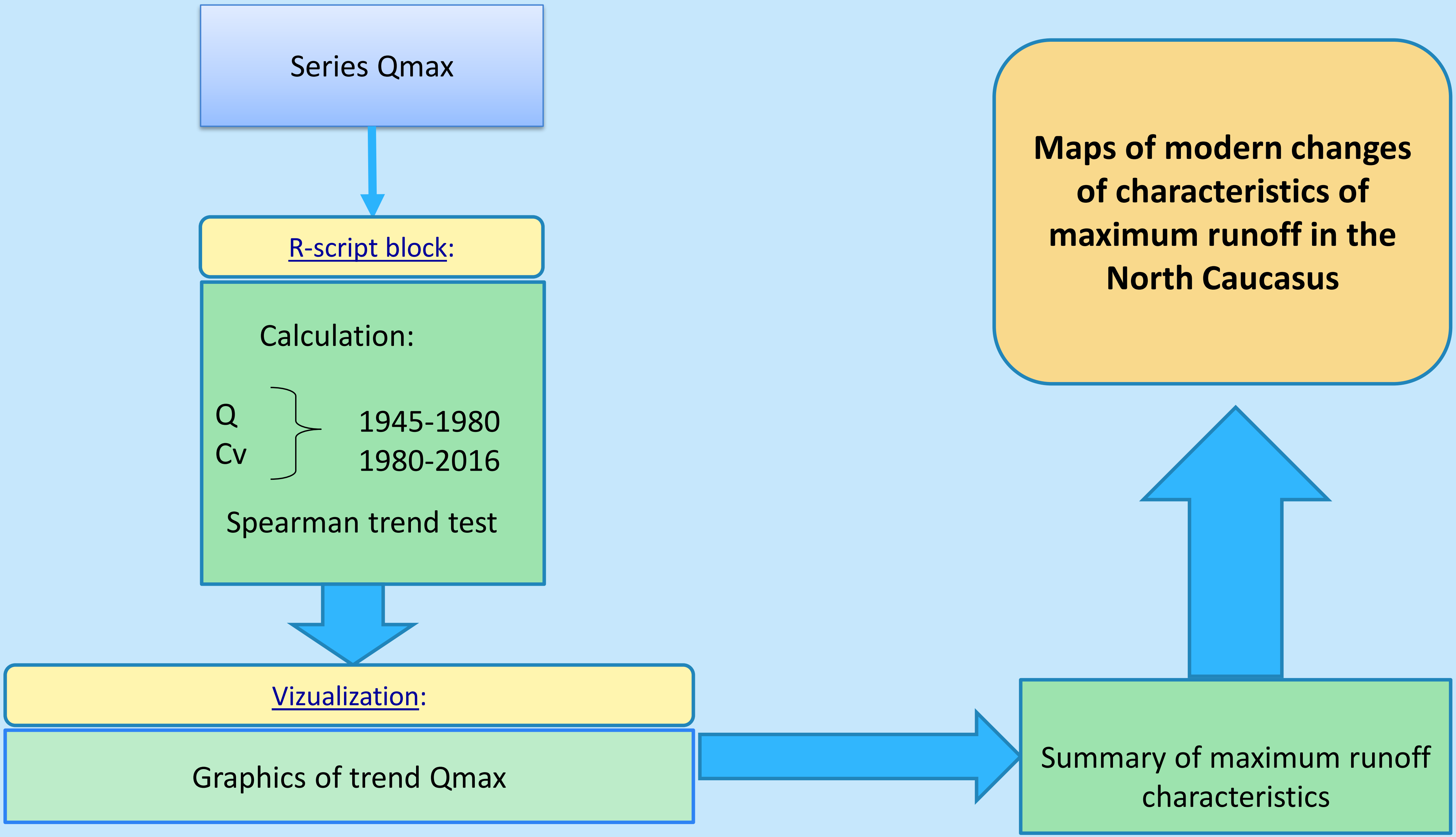


Annual peak discharges series:
76 gauges in North Caucasus river basins.
Observed period around 80 years

Daily discharges series:
10 gauges in Terek and Kuban river basins.
Observed period:
1960-2016

Temperature and precipitation series from weather stations near gauges from:
http://aisori-m.meteo.ru
Observed period:
1960-2016

Methods: annual peak discharge series processing



Methods: daily discharges processing

GrWat –
program for automatic dissection of the hydrograph using
A) graph-analytical method
B) complex analysis

30
calibrated precision parameters of hydrograph separation

2 – FORTRAN block:

3 Sub programs – Calculation of characteristics of:
- Baseflow
- minimum n-days discharges (n = 5, 10, 30)

Input data .txt

Input **30** calibrated parameters

preliminary calculations

Determination of hydrological year

Separation of seasonal flood

Separation of groundwater

Separation of floods

1 – R-script block:

Building virtual time series t˚, P ***from reanalysis***

1 – Preprocessing:

Time series selection t˚, P
By nearest weather stations

2 – FORTRAN block:

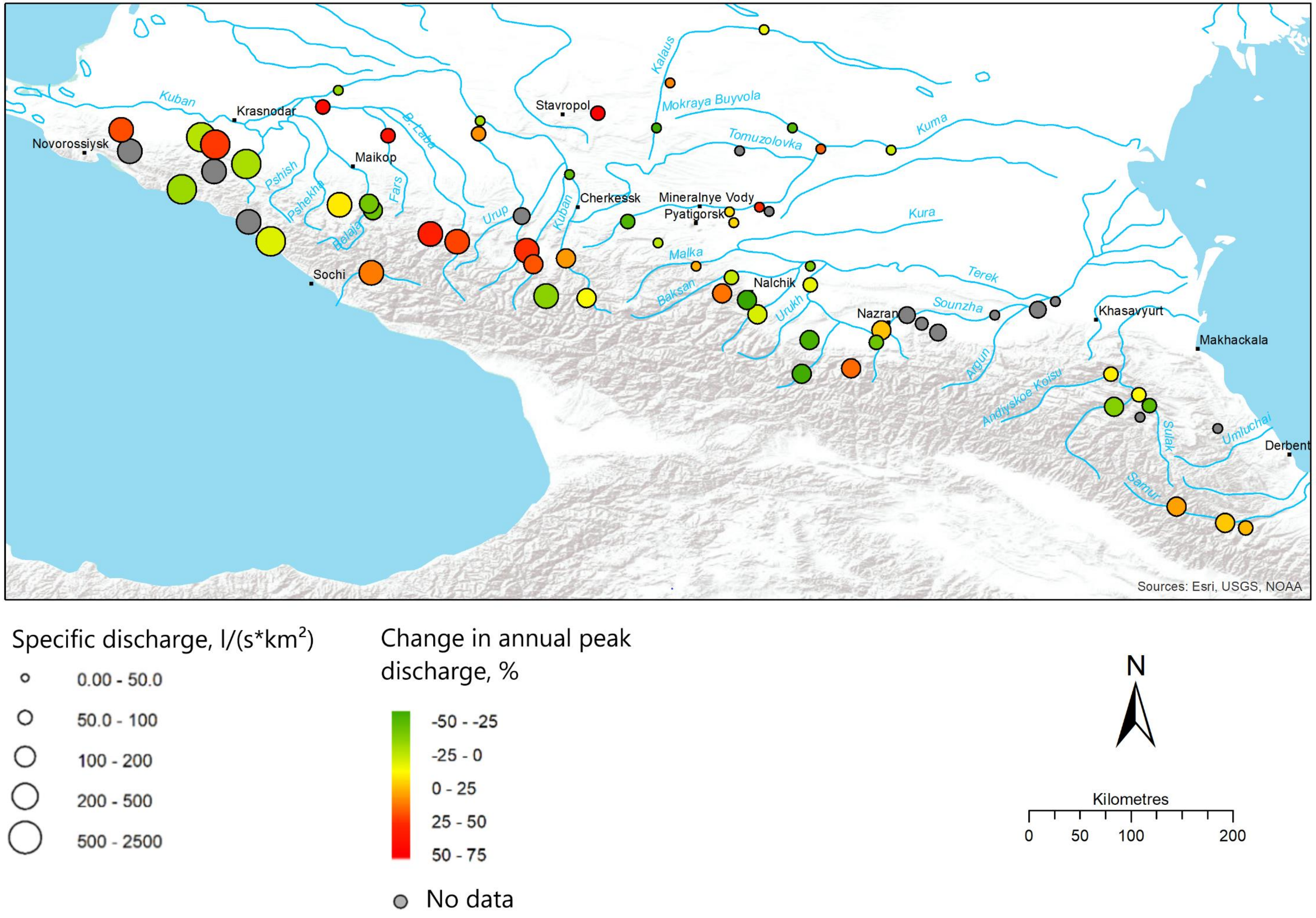
Calculation of seasonal runoff characteristics

3 – R-script block:

Interpretation of results

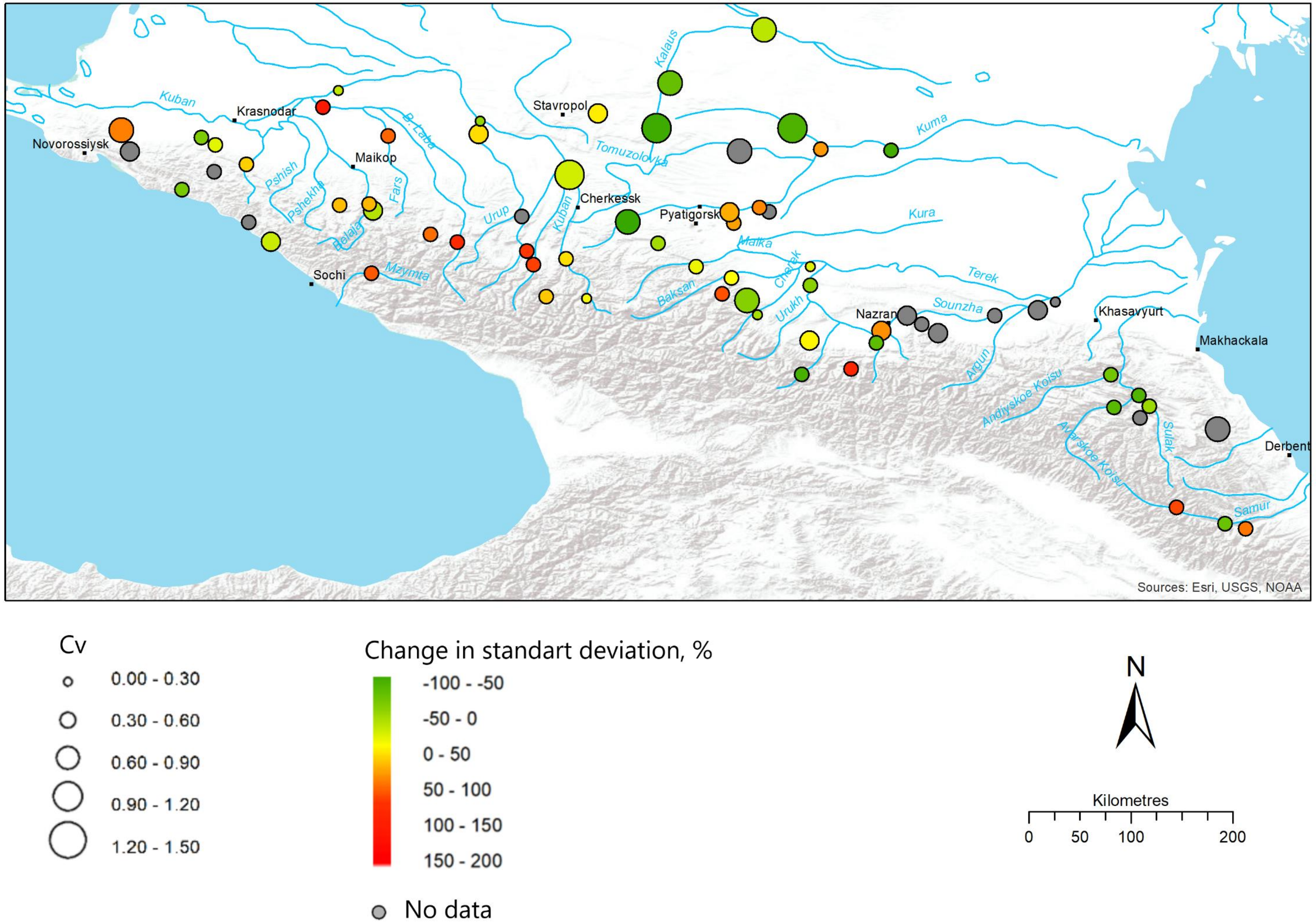
Results: changes in maximum runoff

On half of the rivers of the Terek basin, a negative trend of maximum spending is observed, especially in the mountainous and foothill parts of the basin, including in the foothill areas of Dagestan. The decrease in maximum runoff is 5-50%. In the middle river flow, there are positive trends in maximum runoff. The growth is 30-45%. The highest values of specific discharges are observed in the Kuban basin and on the rivers of the Black Sea coast. Where they can exceed 2000 l / s km^2. Values less than 100 l / (s * km^2) are observed on rivers with a small catchment, as well as in gauges with a large catchment in the lower reaches of the rivers, which confirms the phenomenon of reduction in maximum runoff



Results: changes in coefficient of variation of maximum runoff

The coefficient of variation is characterized by an heterogeneous distribution in the North Caucasus. The spread of values is from 0.24 to 1.5. The highest values are observed in the Kuma basin and the rivers of Dagestan. The smallest values are typical for most large catchments, as well as for rivers of the highlands. Over the past and present period, there was an increase in the spread of values mainly in the middle reaches of the Kuban, where the growth amounted to 177%. A decrease in the standard deviation is observed at some gauges in the highlands of the Terek. It decreased up to 71%. In the Kuma basin and the rivers of Dagestan, most rivers are also characterized by a decreasing in standard deviation.



Results: correlation of flood characteristics

	Qmax	ΔVol	ΔQ	t_rise	Vol	t_full
Qmax	1	0.53	0.67	0.21	0.53	0.3
ΔVol	0.53	1	0.87	0.55	0.78	0.65
ΔQ	0.67	0.87	1	0.55	0.72	0.61
t_rise	0.21	0.55	0.55	1	0.74	0.84
Vol	0.53	0.78	0.72	0.74	1	0.94
t_full	0.3	0.65	0.61	0.84	0.94	1

Baksan - Zayukovo

	Qmax	ΔQ	ΔVol	Vol	t_rise	t_full
Qmax	1	0.89	0.48	0.57	0.23	0.26
ΔQ	0.89	1	0.6	0.59	0.31	0.38
ΔVol	0.48	0.6	1	0.9	0.71	0.84
Vol	0.57	0.59	0.9	1	0.72	0.8
t_rise	0.23	0.31	0.71	0.72	1	0.85
t_full	0.26	0.38	0.84	0.8	0.85	1

Belaya - Kamennomostskiy

The most closely related is the relationship between the maximum discharge of rain floods and its Excess over the Seasonal flood base component (ΔQ). The correlation coefficient was 0.67-0.99. There is also a close relationship with the flood volume without a base component (ΔVol) (0.37-0.79) and the total flood volume (0.47-0.69). A weak connection is expressed with the rise time and the duration of the flood. The indicators are almost equally expressed for foothill (Belaya) and mountain (Baksan) rivers

Results: characteristics of flood runoff

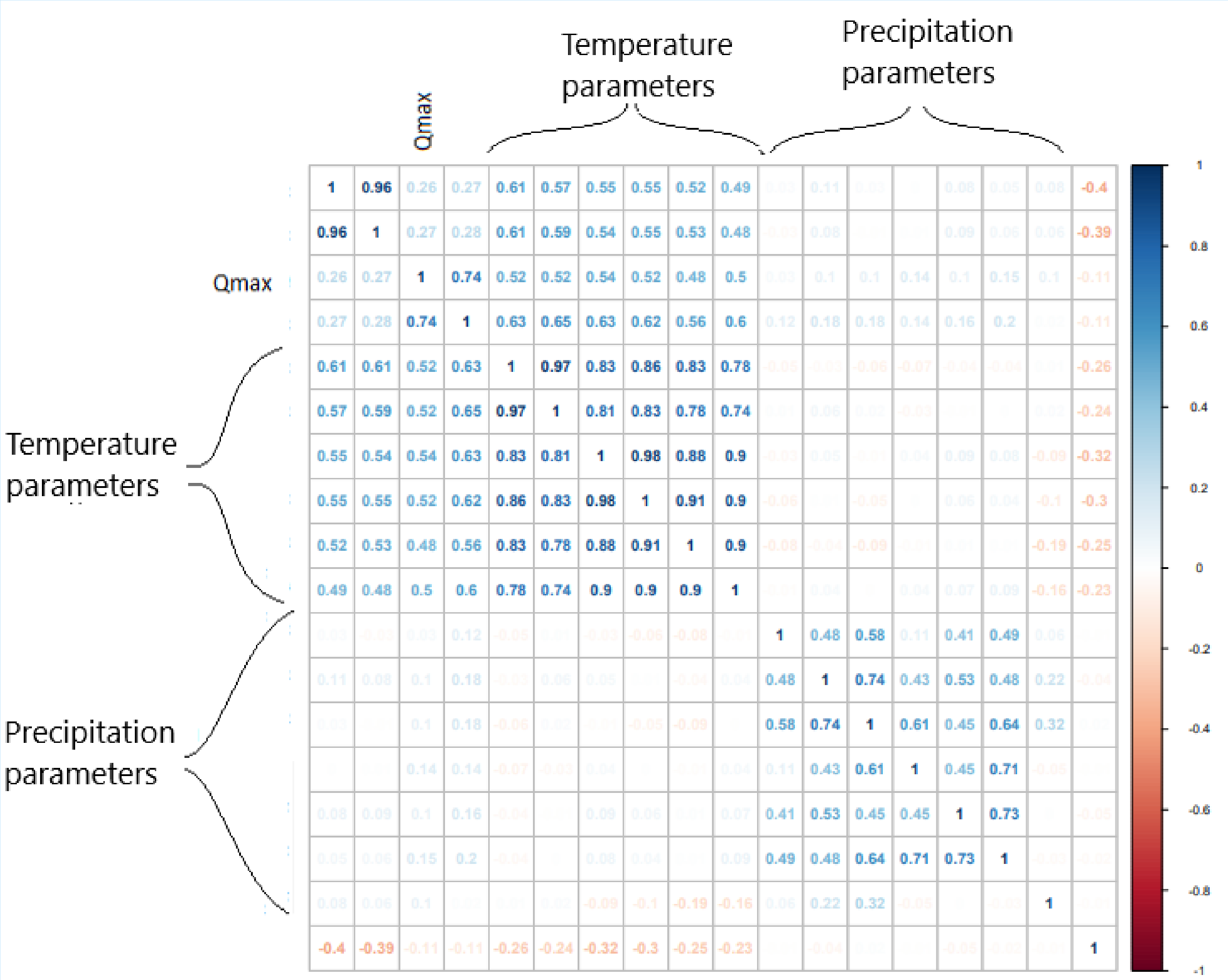
In the warm period, there is an increase in maximum spending in the western part of the study area by 11-13%. Also characterized by the increase in variances in flood volume, their duration and rise time by 29-202%. At the same time, a statistically significant increase in the maximum flood discharge and its Excess over the Seasonal flood base component is also observed in the western rivers, which is already associated with a change in the conditions for the formation of precipitation due to the influence of the sea. In mountain areas, almost no changes

River	Station	Change in	Qmax	Volume of flood cut from seasonal flood base flow	Full Volume of flood	Duration of rise of flood	Total duration of flood	Excess over the Seasonal flood base component	Number of floods per year
Belaya	pgt Kamenomostskij	Mean, %	**13**	30	21	4	11	12	4
		Variance, %	**29**	**128**	**47**	14	14	**29**	-17
Bolshaya Laba	nizhe Aziatskogo mosta	Mean, %	**11**	22	6	4	6	**20**	4
		Variance, %	19	**47**	**-31**	2	-2	**80**	16
Kuban	Armavir	Mean, %	-1	12	6	22	24	-5	-4
		Variance, %	**-23**	**39**	5	**190**	**202**	**-27**	19
Urup	hutor Steblitskij	Mean, %	11	22	14	0	3	11	0
		Variance, %	**29**	**113**	**84**	**104**	**38**	**43**	13
Maruha	Maruha	Mean, %	-1	23	19	17	16	-13	-8
		Variance, %	8	**130**	**153**	**109**	**111**	-15	95
Baksan	Zayukovo	Mean, %	0	2	-15	-16	-17	-11	-13
		Variance, %	-14	**135**	**-28**	**-57**	**-51**	12	32
Terek	Kotlyarevskaya	Mean, %	6	-6	3	4	2	-9	-10
		Variance, %	-5	-4	3	**102**	**101**	-18	0
Terek	Vladikavkaz	Mean, %	8	0	9	1	2	-3	-2
		Variance, %	**-24**	1	-19	**52**	**36**	**-38**	99
Kambileyevka	Ol'ginskoye	Mean, %	**-14**	-24	-10	5	-4	-23	**23**
		Variance, %	-9	-13	**30**	9	14	-4	41
Nalchik	Belaya rechka	Mean, %	**-20**	**-45**	-21	3	-3	**-31**	-16
		Variance, %	**-38**	**-92**	**-81**	**-39**	**-80**	**-32**	-41

Results: factor analysis of predictors of maximum flood discharge

For mountain rivers, a correlation with temperature characteristics is mainly revealed. The correlation coefficient with them ranges from 0.22 to 0.58, and the relationship is more closer in high mountain regions. But for major floods, the main factor is precipitation. In foothill areas precipitation begins to play a large role. This is due to the high position of the catchment. In the mountainous part, the river feeding is predominantly glacial, in connection with which the bulk of the floods is superimposed on a flood wave, the passage of which is determined by the intensity of melting. In the piedmont part, floods occur not only during seasonal flood, moreover, the proximity of the Black and Azov Seas begins to influence. In this regard, precipitation also becomes a significant factor.

At the same time, the limited choice of weather stations for factor analysis does not allow us to accurately assess all the features of the formation of floods, especially the largest ones.



Terek - Vladikavkaz

Conclusions:

- The spatial variability of the maximum runoff of the rivers of the North Caucasus over the past 70-80 years was analyzed. The results indicate a predominantly negative trend of maximum water discharge in the highlands of the North Caucasus and a positive in the middle reaches of the Kuban. This is consistent with data on the absence of a positive trend in average annual temperatures in the highlands due to lower temperatures in the winter, as well as with an increase in the number of days with heavy rainfall (Toropov et al., 2018). The latter factor determined the almost universal increase in interannual variability of maximum expenditures, which indicates an increase in flood hazard throughout the region

- An analysis of the characteristics of the flood flow showed that the dependence of floods on precipitation in the mountains manifests itself at extreme values, while for all the main factor is air temperature. The maximum discharge of rain floods tends to increase in foothill areas, while no changes have been detected in the mountains.

- The results obtained allow us to conclude that significant changes in the maximum flow in the late 70s and early 80s of the last century. Climatic changes that affected the maximum runoff led to an increase in the number of hazardous floods at the end of the XX – beginning of the XXI centuries, which led to human casualties and great material damage.

Thanks!

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