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Change of spring flood parameters in Lithuanian rivers

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The main parameters (flood duration, runoff volume and maximum discharges) of spring flood change over time. A review of the characteristic of spring floods in Lithuanian rivers and the distribution of the different parameters is presented.

The objectives of the current research were the following: assessment of spring flood parameters in a long period for three hydrological districts of Lithuania and trends of spring flood volume change, spring flood peak and spring flood timing during three periods (1922–2003, 1941–2003 and 1961–2003) using the Mann–Kendall test.

Daily discharges from 32 water measurement stations (WMS) were used for this research. Data were analysed for the above three periods (methods of the project "Climate and Energy"). Mann–Kendall tests were carried out for the runoff volume, maximum discharge and spring flood timing trend analysis during the three periods.

In the period 1961–2003, in all Lithuanian territory there were no trends of flood runoff alternation. It means that flood runoff on average was stable. The situation was the same also in the period 1941–2003. There are no trends in all Lithuanian territory, i. e. the runoff is stable from the point of view of average runoff.

Only a long data series (1922–2003) showed that flood runoff had been decreasing in Southeastern Lithuania where WMS had negative trends, i. e. flood runoff volume was decreasing.

The tendency of change of maximum discharge dates is similar in all hydrological districts. Everywhere the trends are definitely negative, i. e. the maximum discharges are observed earlier and earlier (because of warmer winters).

Positive trends were observed in the change of maximum discharges in the period 1961–2003 in rivers of Western Lithuania, i. e. discharges were increasing. In Middle and Southeastern Lithuania, rivers had negative trends during all the three periods, i. e. the maximum flood discharges were decreasing.

Key words: climate change, Mann–Kendall test, rivers of Lithuania, flood volume, maximum discharge, trend

1. INTRODUCTION

Recently hydrologists from the whole world are concerned about climate change and how it impacts river runoff [1–5]. Lithuanian researchers have already noticed the tendency of climate change as well [6–10]. In the last decades of the 20th century, in Lithuania a visible climate change occurred in the atmosphere circulation. This is the reason for warmer winters, decreased long-time frosts, a decreasing contrast among the seasons, etc. [11]. Since 2005, Laboratory of Hydrology of the Lithuanian Energy Institute takes part in the project "Climate and Energy" within North Europe and the Baltic countries. Using the same methodics, change tendencies of the climate elements (air temperature and precipitation) and the main characteristics of river runoff have been studied in all the mentioned countries.

Spring flood is a very significant hydrological regime phase of a river, and its runoff shows an uneven distribution of river runoff within a year. Floods occur every year, but they differ in duration and intensity. Snow melting and rain water are the main sources of river feed as well as the main factors that impact floods.

From the scientific standpoint, floods reflect the general water abundance elements, and flood volume makes a big part of the annual runoff (particularly in Middle Lithuanian rivers). From the practical point of view, maximum discharges of the spring flood belong to the catastrophic phenomena of nature.

The main characteristics of spring flood are flood duration, runoff volume and maximum discharge.

Characteristics of spring flood volume of Lithuanian rivers have been reported in many works [12]. In them, attention was focused on the statistical analysis of maximum discharges and on the practice of different methods of calculation. Flood duration and runoff volume were analysed [12].

Spring flood in Lithuanian rivers is many times greater than the average annual discharge and several hundred times greater than its minimum values. Spring runoff makes up a significant part of the annual runoff (20–90%). Changes of spring flood in Lithuania have been discussed elsewhere [6, 8].

In order to analyse spring floods in Lithuanian rivers, the following flood characteristic were chosen: flood volume, spring flood peak and spring flood timing. Spring floods are very different in all three hydrological regions of Lithuania (Western, Southeastern and Middle). The sources of river feeding in the three regions of Lithuania are precipitation, snow melting and groundwater. The ratio of these sources is differing in the three regions and for long periods. They make up 35% to 50% of the whole runoff.

The main goal of the present research was analysis of spring flood parameters in a long-term period. Floods in three hydrological districts of Lithuania were analysed. The analysis of the trends of spring flood volume change as well as spring flood peak and spring flood timing during the three periods (1922–2003, 1941–2003 and 1961–2003) was performed using the Mann–Kendall test.

2. METHODS

Daily discharges from 32 water measurement stations (WMS) were used for this research. Data from 11 WMS in Western Lithuania, 8 WMS from Middle and Southeastern Lithuania, 2 WMS from the Neris River and 3 WMS from the Nemunas River were analysed.

Data were analysed for three periods: 1922–2003, 1941–2003 and 1961–2003 (methods of the project "Climate and Energy") [2]. Mann–Kendall tests were carried out for the runoff volume, maximum discharge and spring flood timing trend analysis for the three periods [13].

The Mann-Kendall test is a nonparametric test for a trend in a time series without specifying whether the trend is linear or nonlinear. Consider the annual time series y_t, t = 1,…, N. Each value $y_{t'}$, t = 1,…, N-1 is compared with all subsequent values y_t, t = t' + 1, t' + 2,…, N, and a new series Z_k is generated by

$$Z_k = 1 \text{ if } y_t > y_t' \quad Z_k = 0 \text{ if } y_t = y_t' \quad Z_k = -1 \text{ if } y_t < y_t' \tag{1}$$

in which $k = (t' - 1)(2N - t')/2 + (t - t')$. The Mann–Kendall statistics is given by the sum of the Z_k series:

$$S = \sum_{t'=1}^{N=1} \sum_{t=t'+1}^{N} z_k. \tag{2}$$

This statistics represents the number of positive differences minus the number of negative differences for all the differences considered.

The test statistics for N > 40 may be written as

$$u_c = \frac{S+m}{\sqrt{V(S)}}, \tag{3}$$

$$V(S) = \frac{1}{18}\left[N(N-1)(2N+5) - \sum_{i=1}^{n} e_i(e_i-1)(2e_i+5)\right], \tag{4}$$

where $m = 1$ if $S < 0$ and $m = -1$ if $S > 0$, N is the number of tied groups, and e_i is the number of data in the ith (tied) group. The statistic u_c is assumed to be zero if $S = 0$. Then the hypothesis of an upward or downward trend cannot be rejected at the α significance level if $|u_c| > u_{1-\alpha/2}$, where $u_{1-\alpha/2}$ is the 1-α/2 quantile of the standard normal distribution.

Homogeneity tests were done for the annual, extreme and seasonal data series of all hydrological stations. The Mann–Kendall test with a 5% significance level, recommended by the WMO (1988), was applied for the data series trend analyses. In addition, positive and negative trends significant only at the 30% level were applied.

3. RESULTS

3.1. Conditions of spring flood formation

The beginning of spring flood can be observed by intensively increasing discharges and may be seen in hydrographs. Flood beginning depends on climatic conditions, whereas flood ending depends on many elements (snow reserve in the basin, size, form and slope of the basin, river system).

The course of a spring flood depends on snow reserves in a river basin, the intensity and duration of snow melting, the freezing degree of the soil, air temperature during snow melting time and precipitation during flood time. Sometimes floods in Lithuania are intensive and have one wave. But rather often the water level increases slower and the flood has 2 or 3 peaks (Fig. 1).

Snow reserves depend on snow accumulation in winter. Snowbreaks occurring in winter decrease snow reserves,

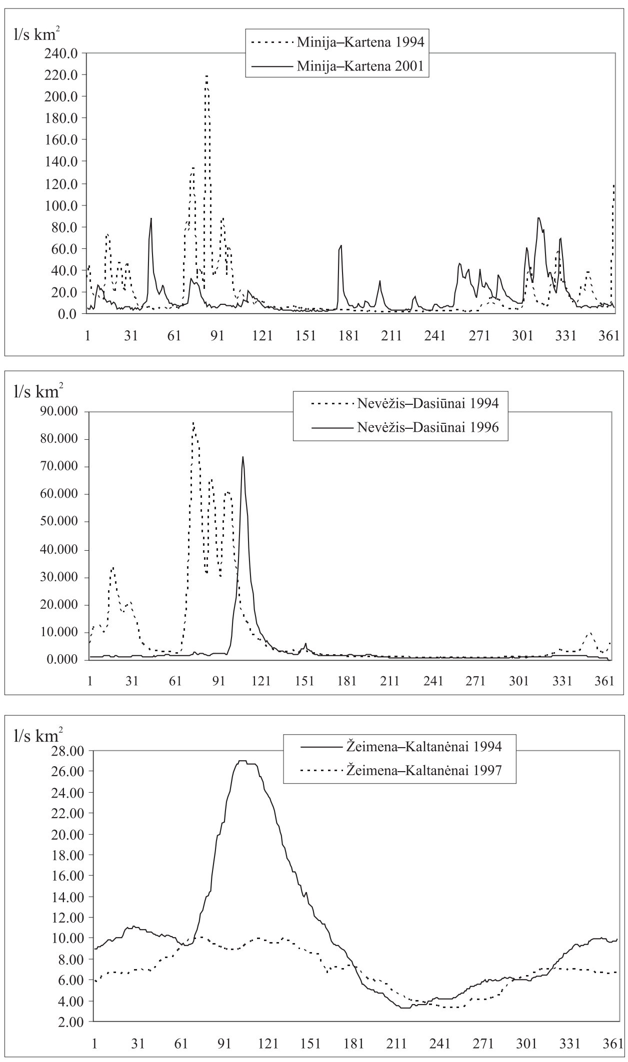

Fig. 1. Flood hydrographs in different hydrological districts (Minija – Western Lithuania, Nevėžis – Middle Lithuania, Žeimena – Southeastern Lithuania)

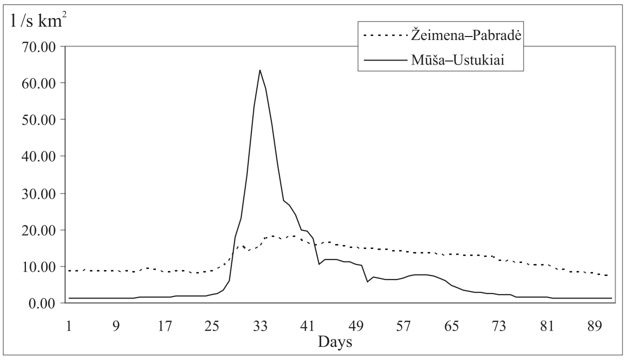

Fig. 2. Course of the spring flood in laky (Žeimena-Pabradė, A = 2580 km²) and unlaky (Mūša-Ustukiai, A = 2280 km²) basins from 1 March to 31 May 1988

especially in Western Lithuania. In Lithuania, the average duration of snow cover is 70 (in the West) to 100 days (in the Southeast). The average thickness of snow cover varies from 15 to 28 mm [12]. It is the main characteristic which determines all quantitative indicators of spring flood.

Lakes and the sandy coverage of the basins have the biggest impact on the volume and duration of floods. These elements regulate the runoff, decreasing the maximum discharges and flood height and prolonging runoff duration (Fig. 2).

The impact of wetlands is small. Possibilities of water accumulation in wetlands are minor in the beginning of the flood. Wetland coverage is minor in basins on the Lithuanian territory (~8%).

Similarly, forests prolong the process of snow melting, because they accumulate melting water in the soil. So they decrease maximum discharges and prolong flood duration. A large part of Lithuanian forests grow in districts with sandy coverage.

Table 1. **Characteristics of the spring flood average**

	River	Water measurement station (WMS)	Basin area A, km²	Flood duration t, days	Maximum discarges Q_{max}, m³/s	Height of the flood runoff layer h, mm	Part of the flood runoff in the annual runoff %	Observation period
Western Lithuania	Rešketa	Gudeliai	84,1	38	8.87	111	28	1947–1999
	Šyša	Jonaičiai	174	36	16.0	82	22	1960–1999
	Akmena	Paakmenės	314	40	46.2	111	27	1955–2003
	Veiviržas	Mikužiai	336	33	44.0	97	22	1954–1999
	Bartuva	Skuodas	621	37	76.5	95	25	1957–2003
	Jūra	Pajūris	876	37	128	112	25	1946–1999
	Minija	Kartena	1230	38	139	98	24	1922–2003
	Venta	Papilė	1570	43	99.1	71	35	1948–2003
	Jūra	Tauragė	1690	39	223	116	29	1922–2003
	Šešuvis	Skirgailiai	1880	40	181	91	35	1939–2003
	Venta	Leckava	4060	46	236	78	33	1949–2003
Middle Lithuania	Alsa	Paalsys	49,0	31	6.84	75	32	1957–1999
	Aguona	Dirvonakiai	63,0	36	8.56	92	42	1961–1999
	Lėvuo	Kupiškis	307	42	25.9	83	45	1955–1999
	Šušvė	Josvainiai	1100	41	89.4	72	41	1940–1999
	Dubysa	Lyduvėnai	1070	42	71.4	75	32	1933–2003
	Dubysa	Padubysys	1900	43	134	75	33	1930–1999
	Mūša	Ustukiai	2280	43	135	63	44	1958–2003
	Nevėžis	Dasiūnai	5530	46	285	71	39	1961–2003
Southeastern Lithuania	Šešupė	Kalvarija	444	41	14.5	52	25	1954–2003
	Ūla	Zervynos	679	40	21.0	45	20	1960–2003
	Verknė	Verbyliškės	694	40	35.9	59	26	1952–2003
	Žeimena	Kaltanėnai	752	67	11.3	66	28	1961–2000
	Žeimena	Pabradė	2580	70	48.2	74	29	1954–2003
	Šventoji	Anykščiai	3600	58	152	86	38	1952–2003
	Merkys	Puvočiai	4300	43	116	48	20	1946–2003
	Šventoji	Ukmergė	5440	59	238	87	37	1922–2003
The biggest Lithuanian rivers	Nemunas	Druskininkai	37110	59	755	58	33	1945–2003
	Nemunas	Nemajūnai	42800	63	933	64	33	1922–2003
	Nemunas	Smalininkai	81200	63	2251	73	33	1922–2003
	Neris	Vilnius	15200	55	474	67	30	1923–2003
	Neris	Jonava	24600	37	794	72	32	1922–2003

Flood duration depends on climatic conditions in the territory of a river basin. Typical hydrographs of spring flood in three hydrological districts are shown in Fig. 1.

3.2. Spring flood runoff volume and its fluctuation

The volume of spring flood runoff has been analysed on the basis of data provided by 32 WMS in 23 Lithuanian rivers (Table 1). The volume of the flood runoff was characterized by:

1. Flood duration, days.
2. Flood runoff volume V (mill. m^3).
3. Flood runoff height h (mm).
4. Relative part of flood runoff in the annual runoff (%).

Flood runoff could be analysed as flood volume V (mill. m^3) and runoff height h (mm), and they are often used in hydrological practice ($h = Qt / 1000A$, where A is the basin area, km^2). The flood volume V is the total volume of water that flows per particular time (day, month, season, year), and Q is the volume of water that passes a given location within a given period of time.

A significant spring flood runoff is typical of Western Lithuanian rivers. There, floods usually start on the 15–16th of March and the average flood duration is 33–46 days. The rivers of this coast hydrological district experience a significant change of flood runoff volume, caused by frequent winter snowbreaks every year. For example, in the basin of the Veiviržas river h varied from 24 to 228 mm and in the Almena basinfrom 20 to 237 mm. This variation is more intensive in the basins of small rivers. In the Venta basin, *h* varied from 30 to 160 mm. Its part in the annual runoff comprises only 22–35%. During the summer–autumn time, floods influenced by rainfalls are bigger than summer floods. The seasonal distribution is more equal in these rivers.

Flood runoff is less in Middle Lithuania (60–90 mm) than in Western Lithuania, but still it composes a significant part (32–45%) and in smaller rivers up to 50–70% of the annual runoff. There, floods start on the 15–16th of March and the average flood duration is 33–46 days. The factors of runoff regulation (lakes, sandy soils, rain highwater) have a less impact on the natural runoff, so the annual distribution of the runoff is very uneven. The change of the flood runoff volume is strong, particularly in small basins. For example, in the Agluona river basin it ranges from 10 to 231 mm (Fig. 3) and in the Alsa river basin from 4 to 174 mm.

In Southeastern Lithuania, floods start sometimes later, and especially in laky basins they start on 18–24 March. Their average duration is 40–70 days.

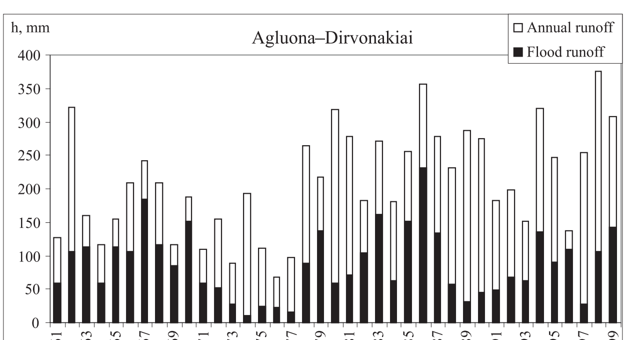

Fig. 3. The part of the flood runoff in the annual runoff of a small Middle Lithuanian river ($A = 66.4\ km^2$)

Spring flood duration is longer in the southeastern part of Lithuania, especially in laky basins of rivers (40–70 days). Spring flood runoff varies from 45 to 87 mm in Southeastern Lithuania. This district has many river basins with a thick (10–30 m) layer of sand, which accumulates snow melt and rain water very quickly and the rivers are fed with groundwater during the whole year. There are a lot of lakes in this district, which smooth the runoff distribution during the whole year. In these basins, spring flood runoff makes only 20–25% of the annual runoff, while in basins without natural elements capable of regulating natural runoff, the flood runoff makes 30–38% of the annual runoff.

The correlation coefficients of flood runoff are very high in the district borders and between neighboring districts. The lowest relation was found among rivers in Western and Southeastern Lithuania (Table 2).

Table 2. **Synchronicity of spring flood runoff (h, mm)**

Hydrological districts	Correlation coefficients		
	Western Lithuania	Middle Lithuania	Southeastern Lithuania
Western Lithuania	0.76–0.97	0.59–0.92	0.40–0.84
Middle Lithuania	0.59–0.92	0.60–0.96	0.48–0.86
Southeastern Lithuania	0.40–0.84	0.48–0.86	0.61–0.97

Perennial changes of spring flood runoff are described by chronological sequences (Fig. 4) and their trends are estimated by the Mann–Kendall test.

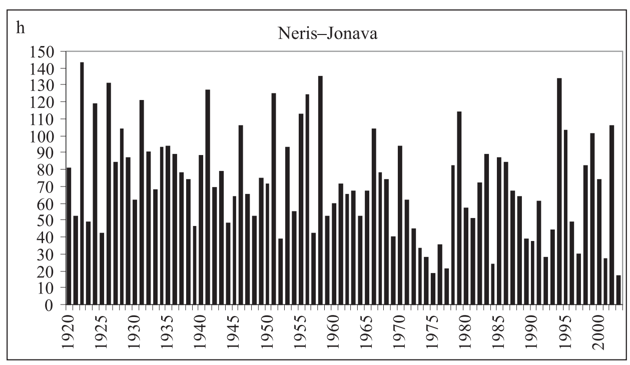

Fig. 4. Chronological sequence layer (h, mm) of the spring flood runoff in Neris-Jonava station

The Mann–Kendall test was used for 32 WMS during three periods (1922–2003, 1941–2003 and 1961–2003) to assess changes of spring flood runoff. Trends of spring flood runoff for three periods are shown in Fig. 5.

According to data of the longest period (1922–2003), a decrease of flood runoff in Southeastern Lithuania has been estimated (one WMS had no trend and three WMS had negative trends). There are no trends of runoff height according to data of 11 WMS for the period 1941–2003, except for one station with a negative trend in Southeastern Lithuania. There are no trends for 1961–2003 over the whole territory of Lithuania, i. e. flood runoff is on average stable.

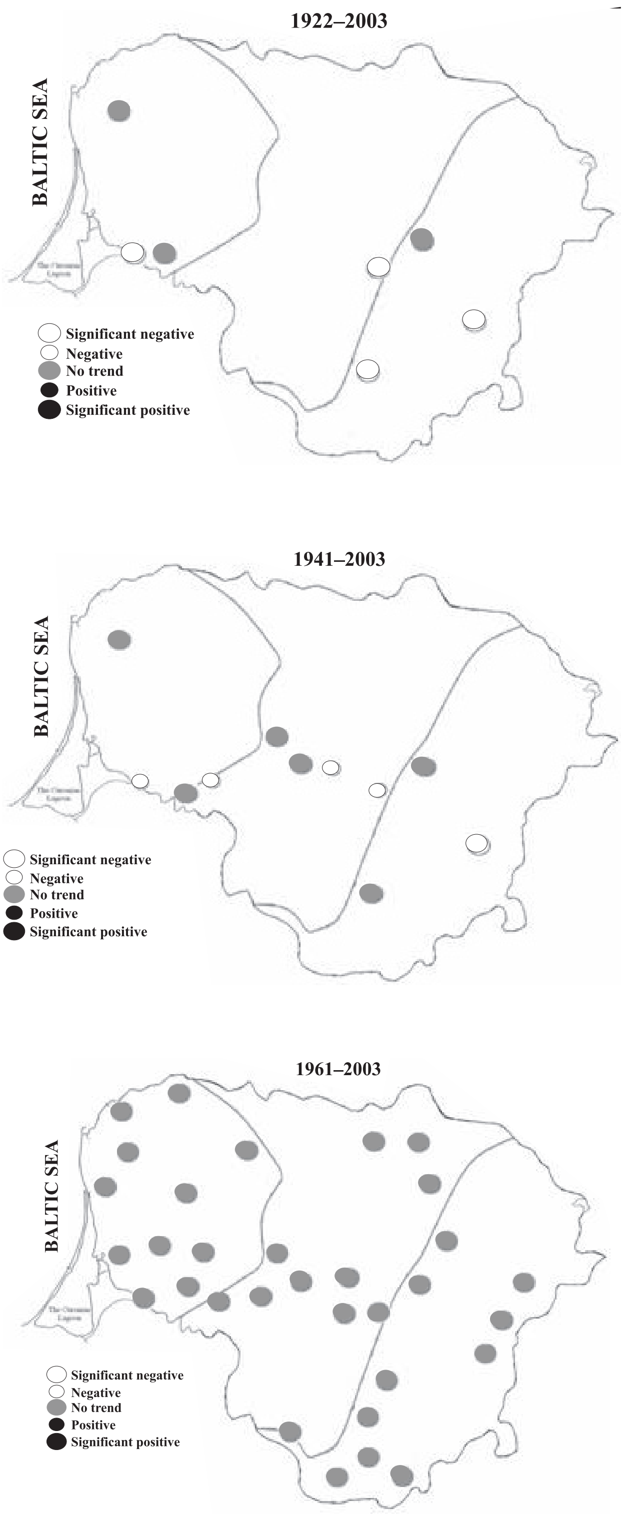

Fig. 5. Trends of the spring flood runoff (h) for different periods

3.3. Maximum discharges of spring flood

Maximum discharges occur when floods in river reach the highest water level. Maximum discharges are many times greater than the average annual discharge volume and several hundred times greater that its minimum annual values. Generally, the most significant differences between the maximum and the minimum discharge parameters are observed in small rivers (Table 3).

Maximum spring discharges in Lithuanian rivers generally take place in March–April, but sometimes this event happens earlier, if strong snowbreaks raise floods. Maximum discharges occur in rivers of Western Lithuania in the first months (January–February) of the year. They comprise ~20% and in the rest of the territory 12–15% of maximum discharges. In the rivers of Nemunas and Neris they comprise only 6–10% of maximum discharges.

Maximum discharges occur often in rivers of Western Lithuania on 25–26 March. In small rivers (basin arena up 100 km^2) discharges are observed 3–4 days earlier.

Maximum discharges in rivers of Middle Lithuania are often observed on 27–28 March. In smaller rivers this process takes place a couple of days earlier. The latest maximum discharges occur in rivers of the hydrological district in Southeastern Lithuania on 27–30 March. For example, the very laky basin of the Žeimena river shows maximum discharges on 6–13 April.

Spring flood timing is the day of the maximum discharge. The chronological sequence of spring flood timing in different parts of Lithuania is shown in Fig. 6. The Minija is a river in Western Lithuania and the Neris is a river in Southeastern Lithuania. The average date of Q_{max} (maximum discharge) of the Minija is 22 March and of the Neris 28 March. According to the Mann–Kendall test, data trends of both river discharges are negative, i. e.floods take place earlier and earlier (particularly in the last two decades).

A consistent pattern of the distribution of maximum discharges is the same as the flood runoff in the Lithuanian territory: the biggest maximum discharge occurs in rivers of Western Lithuania and the least one in rivers of Southeastern Lithuania.

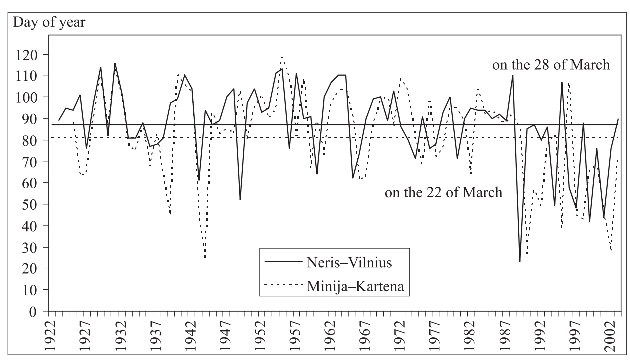

Fig. 6. Chronological sequence of spring flood timing

Table 3. **Typical discharges of four rivers in 1970**

River-WMS	Basin area, km^2	Maximum discharge Q_{max}, m^3/s	Average discharge Q_{vid}, m^3/s	Minimum discharge Q_{min}, m^3/s	$\frac{Q_{max}}{Q_{vid}}$	$\frac{Q_{max}}{Q_{min}}$
Nemunas-Smalininkai	81200	3370	561	186	6	18
Nevėžis-Dasiūnai	5530	625	36.6	2.56	17	244
Šušvė-Josvainiai	1230	204	14.3	1.19	29	582
Alsa-Paalsys	49.0	9.50	0.34	0.001	28	9500

In Western Lithuania, the average annual Q_{max} varied from 9.9 to 236 m^3/s in eleven rivers with a different basin size (84.1–4060 km^2). Changes of maximum discharge in a long time period are very big. For example, maximum discharges in the river Rešketa-Gudeliai (A = 84.1 km^2) are from 2.53 to 25.2 m^3/s, in the river Šyša-Jonaičiai (A = 174 km^2) 1.47 to 37.0 m^3/s, and in the river Jūra-Tauragė (A = 1690 km^2) 63.0 to 491 m^3/s.

In Middle Lithuania, eight rivers with the basin areas from 49.0 to 285 km^2 have been selected for analysis. The average perennial Q_{max} of these rivers ranges from 6.84 to 285 m^3/s and their hydromodules are from 51.6 to 140 l/s km^2. The interval of maximum discharges is very large in a long time period.

In Southeastern Lithuania, 8 rivers with basin areas from 444 to 5440 km^2 have been analysed. Their average perennial Q_{max} is from 11.3 to 238 m^3/s and their hydromodules vary from 15.0 to 51.8 l/s km^2. In this district, maximum discharges show less annual changes (6–12 times), particularly in the laky river of Žeimena (4–6 times).

Q_{max} varies from 303 to 3180 m^3/s in the Nemunas-Druskininkai WMS and from 834 to 6820 m^3/s in the Nemunas-Smalininkai WMS. In the Neris-Vilnius WMS, Q_{max} varies from 123 to 1690 m^3/s and in the Neris-Jonava WMS from 261 to 2090 m^3/s.

Trend analysis of spring flood peak and spring flood timing has been done for three periods (1922–2003, 1941–2003, 1961–2003) (Figs. 7 and 8).

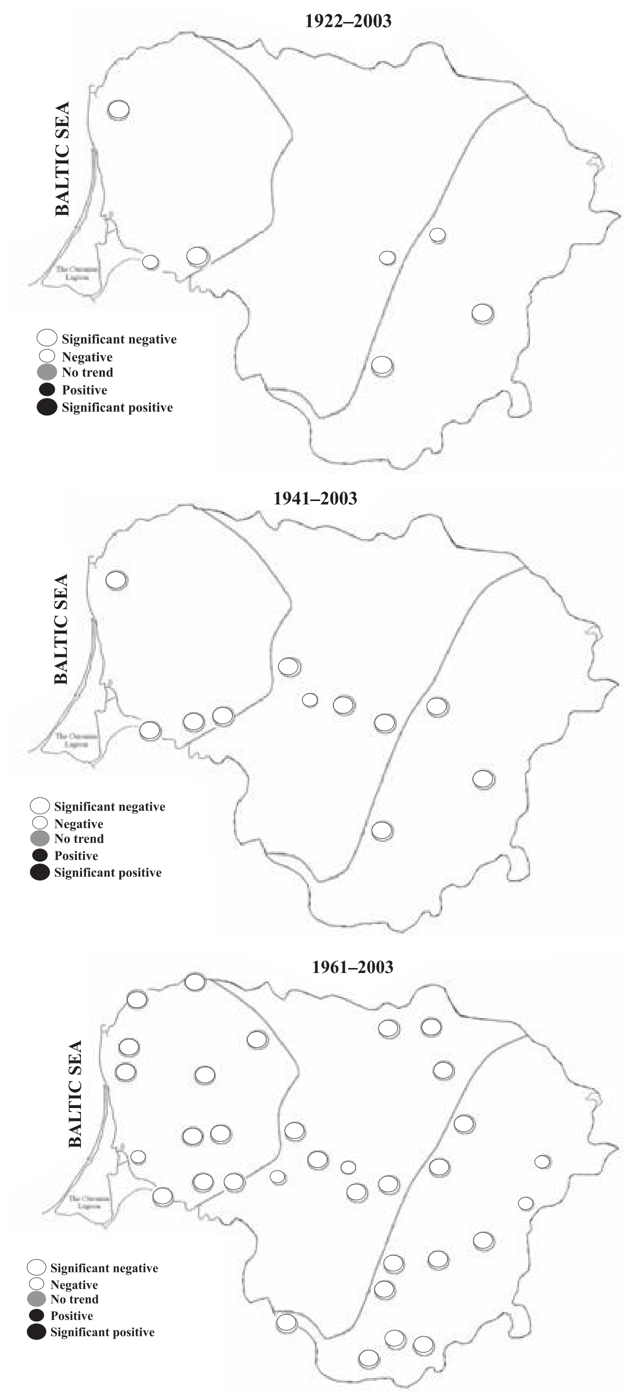

Fig. 7. The distribution of maximum discharges of spring flood timing in Lithuania

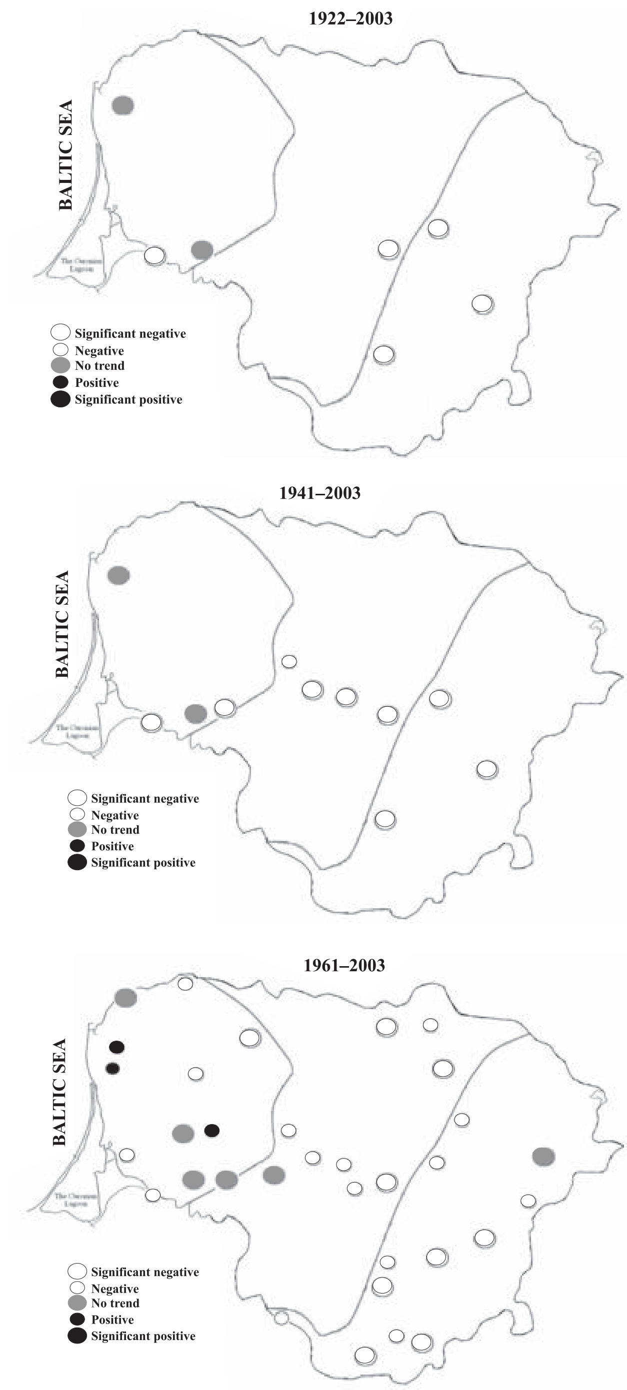

Fig. 8. The distribution of maximum discharges of spring flood peak in Lithuania

The spring flood peak timing magnitude showed the same negative trends in all hydrological regions because of the earlier floods.

In rivers of Western Lithuania, Q_{max} showed no trends for the first two periods and a minor positive trend for the period 1961–2003. The reason is maximum discharges of spring flood in 1994, which in this region was the biggest for the last 80 years. Besides, discharges were very large in 1968, 1970, 1979 and 1985.

In the Middle and Southeastern hydrological districts of Lithuania, trends of maximum discharges are definitely negative for the three periods, and the maximum discharges of flood are decreasing. In these districts, the biggest discharges in the rivers were observed in 1931, 1941, 1951, 1953, 1956, 1958 and 1970.

3. CONCLUSIONS

1. Flood runoff height and hydromodules of maximum discharges are the biggest in the river basins of Western Lithuania.

2. In Middle Lithuanian rivers, the flood runoff volume comprises a larger part (32–45%) of the annual runoff versus 20–35% in rivers of Western and Southeastern Lithuania.

3. In the period 1961–2003, in all Lithuanian territory there were no trends of flood runoff alteration. It means that flood runoff is on average stable. The situation was the same also in the period 1941–2003. There are no trends in the Lithuanian territory, except its southeastern part (basin of the Neris). Only a long data series (1922–2003) has shown that flood runoff has been decreasing in Southeastern Lithuania where one WMS has no trend and three WMS have negative trends. The biggest floods and discharges in this district were observed in 1922–1958.

4. The tendencies of maximum discharge timing are similar in all hydrological districts. Everywhere trends are definitely negative, i. e.maximum discharges are observed earlier and earlier (because of warmer winters).

5. Positive trends are observed in maximum discharges for the period 1961–2003 in rivers of Western Lithuania, i. e. discharges are increasing. In Middle and Southeastern Lithuania, rivers have shown negative trends in all three periods, i. e. their maximum flood discharges are decreasing.

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PAVASARIO POTVYNIO PARAMETRŲ KAITA LIETUVOS UPĖSE

S a n t r a u k a
Pastaruoju metu viso pasaulio hidrologus domina klausimas – kaip klimato kaita veikia upių nuotėkį. Klimato kaitą tiriantys Lietuvos mokslininkai jau fiksuoja nemažai keletą dešimtmečių vykstančių jo kaitos tendencijų. Nuo 2005 metų Lietuvos energetikos instituto Hidrologijos laboratorija dalyvauja bendrame Šiaurės Europos ir Baltijos šalių projekte „Klimatas ir energija“. Šiose šalyse pagal vieningą metodiką ir vienodas laiko eilutes tiriame klimato elementų – oro temperatūros bei kritulių ir visų pagrindinių nuotėkio charakteristikų (metų, sezonų, ekstremalių reikšmių) pokyčių tendencijas. Šiame straipsnyje pateikiami atliktos pavasario potvynio charakteristikų – potvynio tūrio ir maksimalių debitų analizės rezultatai.

Darbe panaudota 32 vandens matavimo stočių pavasario potvynio paros debitai 1922–2003 metais. Jie analizuoti trimis variantais – 1922–2003, 1941–2003 ir 1961–2003 m. laikotarpiais, vadovaujantis projekto „Klimatas ir energija“ metodika. Pavasario potvynio parametrų trijų variantų laiko eilučių trendams įvertinti panaudotas Mann-Kendall testas.

Analizės rezultatai parodė, kad potvynio nuotėkio tūrio sekose 1961–2003 ir 1941–2003 metų laikotarpiais visoje Lietuvoje trendų nėra, t. y. nuotėkis stabilus vidurkio atžvilgiu. Panaši situacija ir 1922–2003 metais – trendų nėra didesnėje teritorijos dalyje, išskyrus Pietryčių Lietuvą, kurioje nustatyti neigiami trendai, t. y. potvynio nuotėkio tūrio mažėjimas.

Maksimalių debitų datų kaitos tendencija visoje teritorijoje vienoda – trendai visur reikšmingai teigiami, t. y. maksimalūs debitai stebimi vis anksčiau, matyt dėl šiltėjančių žiemų.

Vidurio ir Pietryčių Lietuvos upėse per visus analizuojamus laikotarpius maksimalūs potvynio debitai turi neigiamus trendus, t. y. debitai mažėja, o Vakarų Lietuvoje tik 1961–2003 metų laikotarpiu atsiranda teigiami trendai, t. y. fiksuojamas maksimalių trendų padidėjimas.

Raktažodžiai: klimato kaita, Lietuvos upės, trendas, maksimalus debitas

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ИЗМЕНЕНИЯ ПАРАМЕТРОВ ВЕСЕННЕГО ПАВОДКА РЕК ЛИТВЫ

Резюме

В настоящее время гидрологов всего мира интересует вопрос, как происходящее изменение климата действует на сток рек. Климатологи Литвы уже установили достаточно значимые тенденции изменения отдельных элементов климата за последние 3–4 десятилетия.

С 2005 г. Лаборатория гидрологии Литовского энергетического института участвует в международном проекте стран Северной Европы и Балтики „Климат и энергия“. Во всех странах по единой методике и одинаковым временным параметрам изучаются тенденции изменений элементов климата (температуры воздуха и осадков) и основных характеристик стока (годового, сезонного и экстремальных его значений). В данной статье представлены результаты анализа изменения во времени, т. е. тренды характеристик стока весеннего паводка: объема стока, дат и величины максимальных расходов.

Использовались данные 32-х водомерных станций за 1922–2003 гг. Согласно программе анализ данных производился в 3-х вариантах (за 1922–2003 гг., 1941–2003 гг. и 1961–2003 гг.) по методике проекта „Климат и энергия“. Для определения трендов использован тест Манн-Кендала.

Результаты анализа показали, что ряды наблюдений объема стока паводка стабильны по всей территории Литвы за периоды 1941–2003 гг. и 1961–2003 гг. Данные 1922–2003 гг. показали уменьшение стока паводка на территории юго-восточной Литвы.

Даты максимальных расходов паводка на всей территории имеют значимые положительные тренды, т. е. они наблюдаются все раньше, по-видимому, в результате потепления зимнего периода.

В Средней и Юго-Восточной Литве за все исследуемые периоды максимальные расходы рек имеют отрицательные тренды, т. е. расходы сокращаются. Только в Западной Литве в период 1961–2003 гг. выявлены положительные тренды.

Ключевые слова: изменение климата, реки Литвы, тренд, максимальный дебит