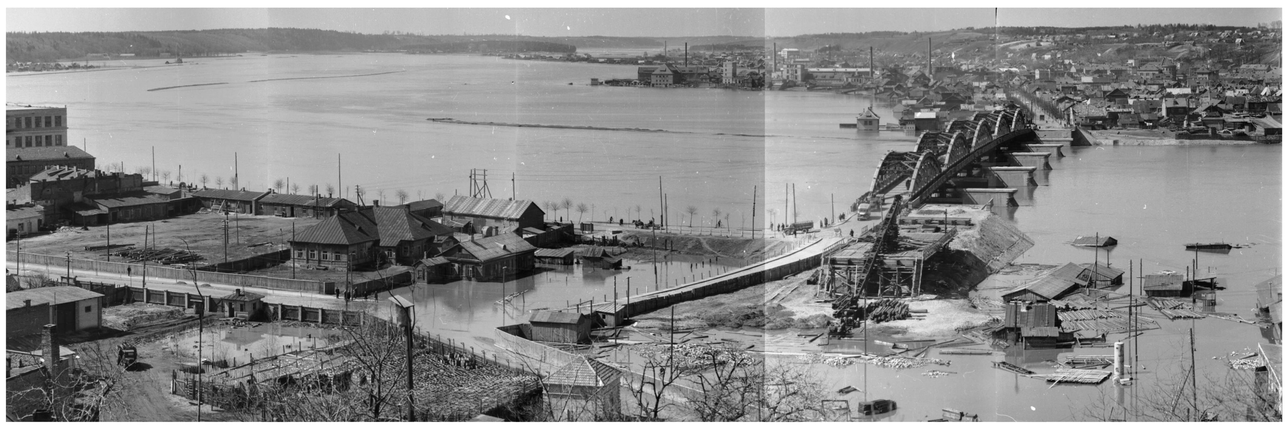
Comparison of Kaunas (Lithuania) street view during the flood of 1958 (left) (photo by Stanislovas Lukošius, Kaunas city Museum Collection) with close to annual average water level in 2017 (right) (photo by Vytautas Akstinas)



The confluence of rivers of the Nemunas and Neris during the flood of 1958 in Kaunas city (photo by Stanislovas Lukošius, Kaunas city Museum Collection)

THE PERCEPTION OF CATASTROPHIC FLOODS IN THE NEMUNAS RIVER BASIN

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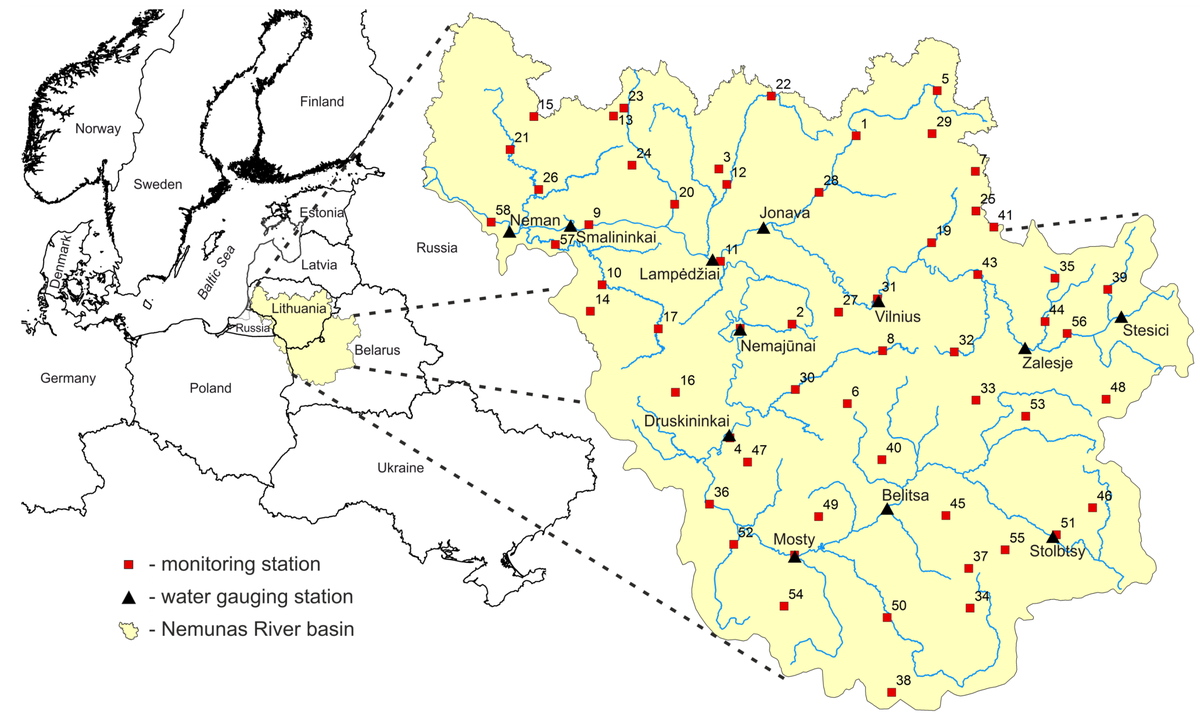
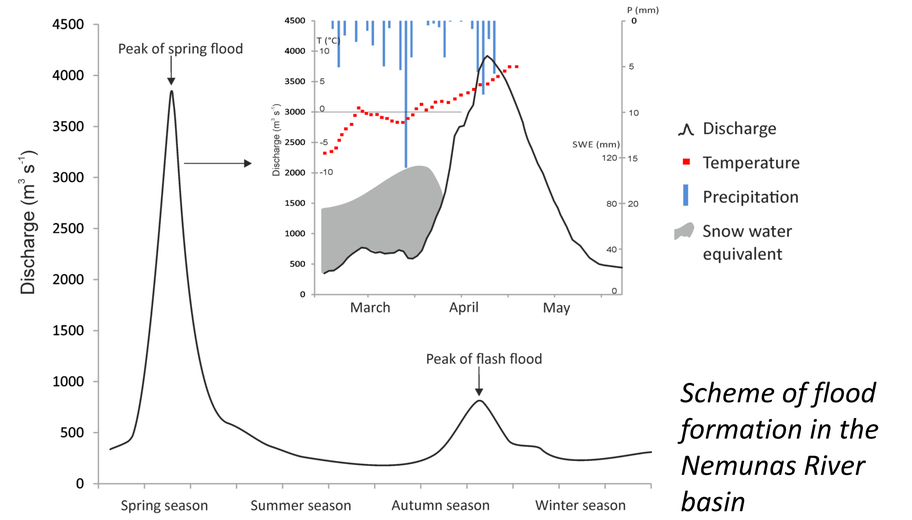
This research concentrates on two catastrophic floods. One of them (1958) occurred before the construction of Kaunas Hydro Power Plant (Kaunas HPP), the second one – after (1979). The flood of 1958 (one of the biggest floods in this basin of the last 200 years) affected large territories and covered three countries, reached a historical peak discharge (6580 m^3/s at Smalininkai WGS in Lithuania). The flood peak in 1979 (the last biggest in this basin after the flood in 1958) reached 5300 m^3/s (at Neman WGS in Russia) and made a lot of damage as well. In 1959, Kaunas HPP (227 km from the mouth of the Nemunas River) was set in to operation and, since then, the flood of the magnitude like in 1958 has not been observed. HPP significantly changed hydrological regime of the river and conditions of the floods formation below the HPP dam.



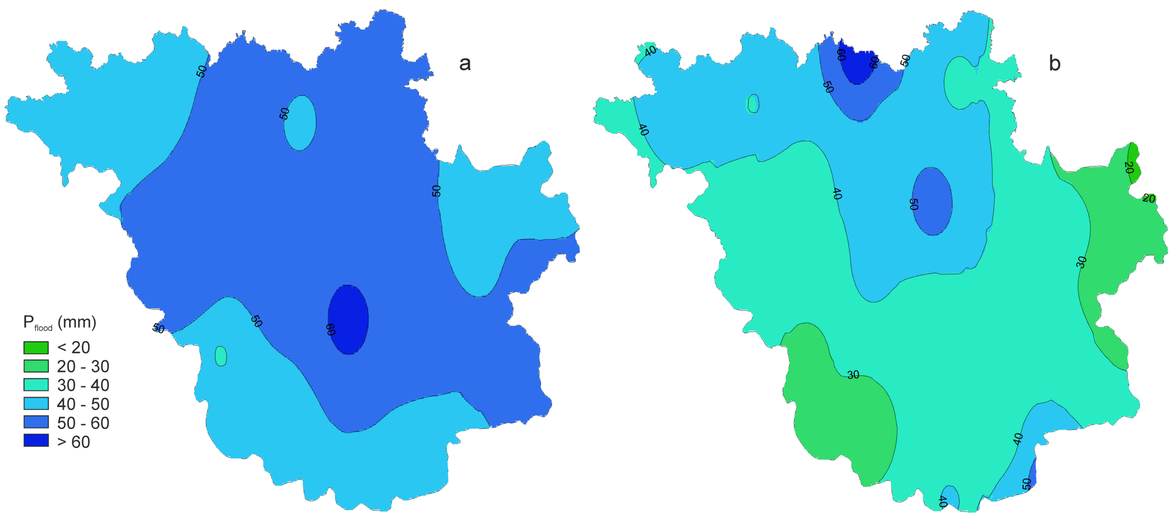
Location of the Nemunas River basin and spatial distribution of the monitoring stations of meteorological parameters (MS) and water gauging stations (WGS)

The evaluation of impact of hydrological and meteorological parameters on formation of catastrophic floods was carried out by analysing and comparing data of both selected floods. Long-term series of daily discharge data were applied from 12 WGS, as well as data of daily precipitation (*P*, mm), monthly air temperature (*T*, °C) and decadal snow water equivalent (*SWE*, mm) from 58 MS.

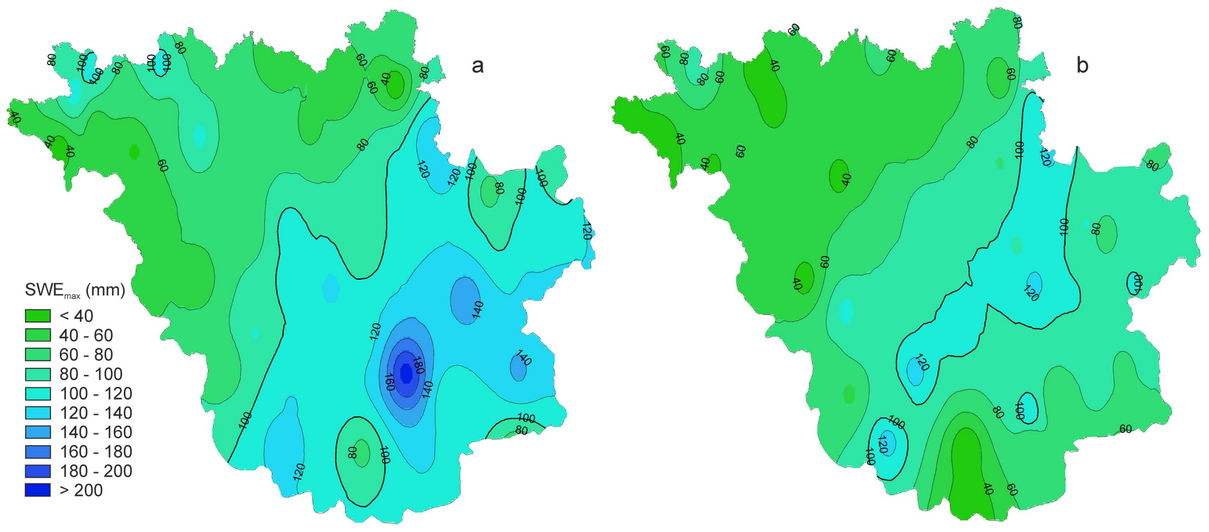


Scheme of flood formation in the Nemunas River basin

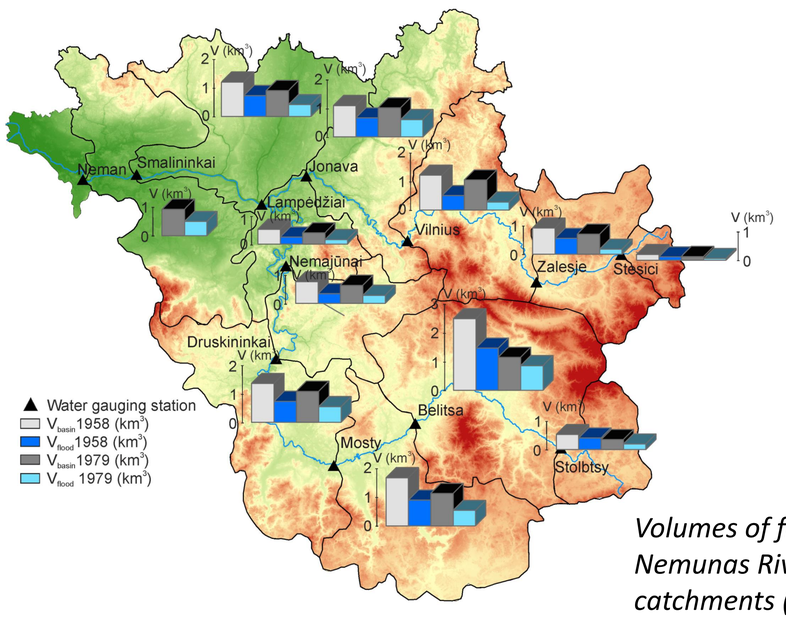
For the investigation of conditions of the catastrophic floods, ArcGIS (ArcMap, version 10.5) and SWAT (Soil and Water Assessment Tool) Baseflow Filter (BF) were used. The calculations of the maximum snow water equivalent (SWE_{max}, mm), precipitation amount during the flood (P_{flood}, mm), volume of catastrophic flood (V_{flood}), volume of water resources in the basin (V_{basin}) and runoff coefficients (η) were carried out for the evaluation of two catastrophic floods.



The isolines of P_{flood} (mm) in the Nemunas River basin in 1958 (a) and 1979 (b)



The isolines of SWE_{max} (mm) before the flood in the Nemunas River basin in 1958 (a) and 1979 (b)



Volumes of floods and water supplies in the Nemunas River basin at different WGS catchments (in 1958 and 1979)

Q_{max}, height of SWE_{max}, P_{flood} and η at catchments of different WGSs during the floods of 1958 and 1979

River	WGS	WGS catchment area (km^2)	Maximum discharge Q_{max} (mm)		Average height of SWE_{max} (mm)		Average height of P_{flood} (mm)		Runoff coefficient η	
			1958	1979	1958	1979	1958	1979	1958	1979
Neris	Stesici	1228	12.2	6.4	113.4	84.1	49.3	22.8	0.59	0.44
Neris	Zalesje	6162	12.4	3.3	103.8	88.5	48.3	28.3	0.61	0.29
Neris	Vilnius	7893	8.4	3.6	106.9	97.8	53.2	40.9	0.51	0.28
Neris	Jonava	9244	7.3	4.7	68.2	67.1	53.1	45.4	0.54	0.39
Nemunas	Stolbtsy	3182	18.3	9.6	119.2	78.1	51.4	34.0	0.78	0.57
Nemunas	Belitsa	13935	12.2	6.8	130.0	94.0	53.8	35.7	0.62	0.50
Nemunas	Mosty	10866	9.7	5.3	109.8	70.8	48.8	36.3	0.59	0.49
Nemunas	Druskininkai	10126	7.4	4.5	86.4	77.5	47.3	30.4	0.58	0.49
Nemunas	Nemajūnai	5113	7.0	4.2	98.4	87.6	55.1	40.3	0.57	0.44
Nemunas	Lampėdžiai	3940	6.4	3.8	79.7	62.5	55.4	39.8	0.55	0.39
Nemunas	Smalininkai	9841	7.0	4.2	72.5	48.8	52.3	45.7	0.61	0.46
Nemunas	Neman	10332	-	5.0	-	53.2	-	38.7	-	0.54

Conclusions

- Analysis of catastrophic flood of 1958 showed significant direct impact of meteorological factors on flood magnitude. The combination of water resources from snow water equivalent (SWE_{max}) and precipitation amount during the flood (P_{flood}) caused large volume of water resources (12.27 km^3 at Smalininkai WGS). The high runoff coefficients η (0.51-0.78) were estimated during the flood and it showed favourable runoff conditions for direct inflow of accumulated water resources into flood volume (7.54 km^3 at Smalininkai WGS).
- In 1979, sudden increase of air temperature together with heavy precipitation in March impacted flood behaviour. The volumes of water resources (9.40 km^3 at Smalininkai WGS) distributed more equally in the whole analysed basin. However, total amount of water resources from SWE_{max} and P_{flood} was less in comparison with flood of 1958. Also runoff coefficients η were lower than in 1958 and fluctuated in wider range (0.28-0.57). All previous mentioned factors caused lower magnitude of catastrophic flood (4.33 km^3 at Smalininkai WGS) of 1979, but still large areas of the Nemunas River basin were inundated.
- The damages during catastrophic floods of 1958 and 1979 in the Eastern Europe (case of the Nemunas River basin) affected huge urban and nature areas as well as artificial structures. Cities of Grodno (BY), Druskininkai (LT) and Kaunas (LT) suffered serious damages in 1958. Meanwhile, during the flood of 1979, only the cities of Grodno and Druskininkai were inundated. In 1979, the mitigation of damages were less, it could be related with hydro-technical constructions (Kaunas HPP, 1959 and Vileika Reservoir, 1976) for cities below the dams.