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FLOOD PATTERN CHANGES IN THE LITHUANIAN RIVERS

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Introduction. Estimation of both the frequency and variation of spring floods is a key issue for the assessment and management of flood risks. In order to avoid or mitigate flood damage it is important to predict the time of its occurrence and magnitude of flood height, as well as ensure the reliability of various hydro technical structures. This analysis should neither underestimate nor overestimate magnitude of such an event. To make reliable estimates of expected extreme flood events, flood frequency estimation techniques are used: series of observed events are analyzed to assume a probabilistic behavior, which is then extrapolated to provide estimates of the likely magnitude of future extremes.

The aim of this research is to analyze and to compare the patterns of spring flood data in the selected Lithuanian rivers from different hydrological regions applying trend analysis and estimating the best fitted probability distribution for the data series of the selected periods.

Data and methods. Lithuania covers relatively small area, although hydro-meteorological differences across the country are significant. The territory of the Lithuania is divided into three hydrological regions: 1) Western Lithuania (W-LT), which is close to the Baltic Sea, belongs to the marine climate zone and the main source of river feeding here is precipitation; 2) South-eastern Lithuania (SE-LT), the continental part, where rivers have prevailing snowmelt and subsurface feeding and rather equally distributed annual discharge; 3) Central Lithuania (C-LT) is transitional part and rivers here have more individual character.

Daily discharges from 32 water measurement stations (WMS) were used for trend and flood frequency analysis in Lithuanian rivers. The water measurement stations are distributed in the three mentioned hydrological regions. Additionally the hydrological data from 5 WMS which are on the biggest rivers of Lithuania (the Nemunas and the Neris) were investigated. Duration of the discharge data observations is different and ranges from 38 to 92 years. The data of discharge of the Nemunas River in Smalininkai WMS exists from 1812. These data series are among the longest time series in Europe and are very valuable.

The calculation of trend statistics of spring flood data series was based on the nonparametric Mann-Kendall test. This procedure is used since missing values are allowed and the data do not need to conform any particular distribution. In this study the significance of trend was tested by using $\alpha=0.05$ level of significance.

In this research a comparison of 5 commonly used probability distributions was performed. Gumbel (EV1), generalized extreme value (GEV), log-Pearson type 3 (LP3), lognormal (LN) and three-parameter lognormal (LN3) were selected to be the best in representing the statistical characteristics of observed flood data of Lithuanian rivers.

Results. The spring flood in Lithuania usually is a combination of snow melt and rainfall, with a dominant snow melt contribution. The trend analysis of spring floods is performed for three periods (1941–2012, 1961–2012 and 1991-2012).The spring flood trend analysis (Table 1) shows the negative trends during periods of 1941-2012 and 1961-2012. No trend was detected in the last (1991-2012) period. Spring floods are getting smaller and earlier evidently due to increasing winter air temperature. The higher air temperature influences decrease of the water equivalent of snow and the numbers of days with snow as well.

Table 1. **–** Number of WMS with different trend tendencies in the periods of 1941–2012, 1961–2012 and 1991-2012 (“-” – negative trend, “0” – no trend, “+”– positive trend)

Period	1941-2012			1961-2012			1991-2012		
Trend tendencies	–	***0***	+	–	***0***	+	–	***0***	+
W-LT	2	2	-	4	8	-	1	11	-
C-LT	4	-	-	5	4	-	-	5	-
SE-LT	6	-	-	9	2	-	-	12	-

For flood frequency analysis spring data of the hydrological regions were grouped into the following periods: 1961-1990 (used as the reference period), 1961-2012, and 1991-2012. The summing-up of the ranks given for the best fitted probability distributions defined that for 1961-1990 data series LP3 best fitted for water measurement stations of the Western region and GEV – for the rest of water measurement stations; for the period of 1991-2012 GEV was the probability distribution, that received the highest ranks in all regions; and for the data of 1961-2012 LP3 revealed the best fitting in Western and South eastern rivers, whereas LP3 and GEV had the same ranks in the rivers of Central Lithuania. LN and EV1 probability distributions seemed to be the least suitable for the modelling of the analyzed spring flood data.

Goodness of fit tests of the Nemunas and the Neris flood discharge data revealed that for the all described periods GEV probability distribution showed the highest similarity to the observed data.

Estimation of probability distribution is necessary in order to forecast the change in frequency of flood events in the future. The analysis of flood data showed the best match of generalized extreme value distribution for the empirical spring flood data in all hydrological regions (as well as in the biggest rivers) in 1991-2012. Therefore it can be concluded that recently, in the period of significant climatic changes, this probability distribution is the most suitable distribution for flood frequency analysis and for prediction of flood maximum discharges in Lithuanian rivers.

Changes of statistical parameters of spring flood data reflects in changes of probabilistic behavior of simulated flood discharge data. Spring flood data in the Nemunas at Smalininkai were best characterized by extreme value distribution. Fig.1 displays the theoretical cumulative distribution functions for the different observation periods. Cumulative distribution function for the data of the last period diverges the most.

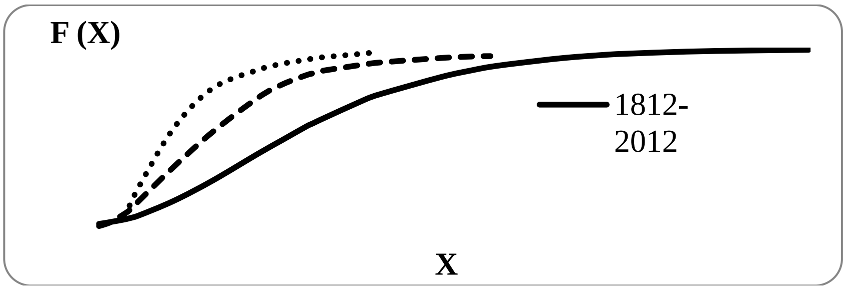

Figure 1. – *The theoretical cumulative distribution functions of the fitted distribution for the flood data of the Nemunas for the different observation periods*

Conclusions

1. Trend analysis of maximum annual discharges showed no significant differences in spatial patterns among the different groups of rivers, but indicated the obvious changes in their temporal behavior, i.e. a decrease of spring floods in the selected studied rivers in the period of 1941-2012.

2. In 1961-1990 (reference period) log-Pearson type 3 probability distribution best fitted actual data of spring flood in the Western region and GEV – for the Central and South eastern regions. Recently, in the period of significant climatic changes (1991-2012), GEV probability distribution is the most suitable distribution for flood frequency analysis and could be used to predict the flood maximum discharges in Lithuanian rivers. This probability distribution could also be used for simulating of flood frequency distribution in ungauged rivers. LN and EV1 probability distributions seemed to be the least suitable (out of the five studied) for the modelling of the analyzed spring flood data.