ESTIMATION OF FLOOD DISCHARGES IN SLOVENIA

STATISTICAL ANALYSIS OF ANNUAL MAXIMUM FLOOD DATA IN SLOVENIA USING L-MOMENTS

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Among different natural hazards in Slovenia, i.e. snow avalanches, landslides, rock falls, or floods, the latter occupy the largest area of all; the total inundated area under high flood events (Q_{100}) is 695 km^2 or 3.5% of the total surface, out of which 25 km^2 are urban areas. In 1989 a catastrophic flood occurred in the Savinja River basin. This was just a prelude to larger floods that affected the greater part of Slovenia in 1990 (late October–early November) and again in 1998 (early November). Both floods inundated more than 500 km^2. Floods caused severe stream bank erosion, destroyed or damaged tens of bridges, several industrial facilities and hundreds of houses; both were accompanied by numerous landslides. Their total damage was estimated at more than 500 Mio € (for 1990 floods) and 170 Mio € (for 1998 floods), respectively. Therefore, from the engineering point of view, it is of high importance for a hydrologist to be able to estimate flood discharges with accuracy as high as possible. This is valid not only for the floods with a 100-year recurrence interval that stands as a standard in torrent control or river engineering works in populated areas, but it is also true for extreme floods with statistically derived return periods as high as 5000 years in the case of nuclear power plants (e.g. NPP Krško on the Lower Sava River).

PURPOSE OF THE STUDY

In Slovenia, for the statistical analysis of flood discharges usually the Log-Pearson III method with central moments is used. It is known that for higher return periods this method gives unrealistically high values. The main reason of the study presented in the paper was to compare the usage of L-moments (Hosking and Wallis, 1997), as proposed in the Flood Estimation Handbook (FEH, 1999), with the existing statistical methods in use in Slovenia for single-site analysis. For this reason, we compared the Pearson III distribution with L-moments with the Pearson III distribution and the Log-Pearson III distribution using central moments. As the data set (a series of annual maximum flood discharges Q_{max}) we used the available data from the Slovenian hydrological network of nearly 300 gauging stations. The data set included some major floods that occurred in Slovenia in the last decade of the 20th century. Even though the WINFAP-FEH as a software platform for this purpose is available, it was found to be inconvenient to be used for the whole Slovenian network (there is no direct support for the Slovenian data). That is why we developed a program in the Excel and Visual Basic environment, supporting different two- and three-parameter statistical frequency distributions using the L-moments and the central moments, and directly using the available files created at the Environmental Agency of the Republic of Slovenia. The output files of this newly created software can be easily used in the Windows Office environment.

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RESULTS

The results obtained using the L-moments were compared for three return periods (50, 500, and 5000 years) with the other two applied methods using central moments in terms of average values, absolute differences, catchment area of the measuring station, and the size of the data set. A sample of these results is given in Fig. 1. After all these criteria the new method with the L-moments proved stable, and the results ranged in-between the results yielded by the other two methods using central moments.

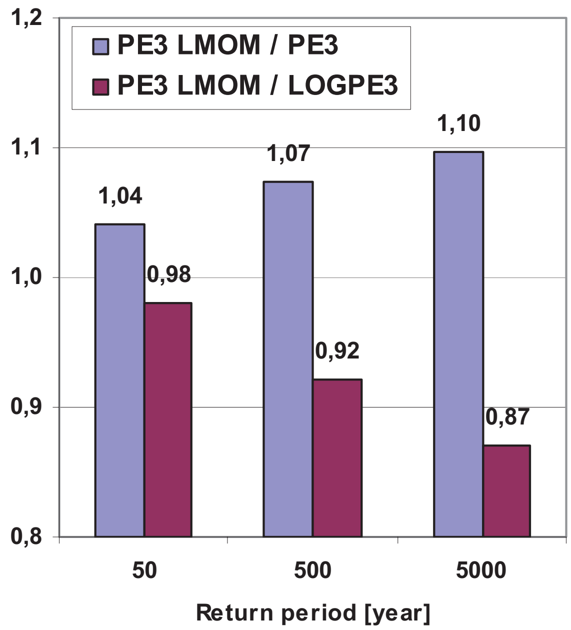

Fig. 1 The average difference between the methods as a function of the return period of a flood (PE3 – Pearson III; LOGPE3 – Log Pearson III; LMOM – L-moments).

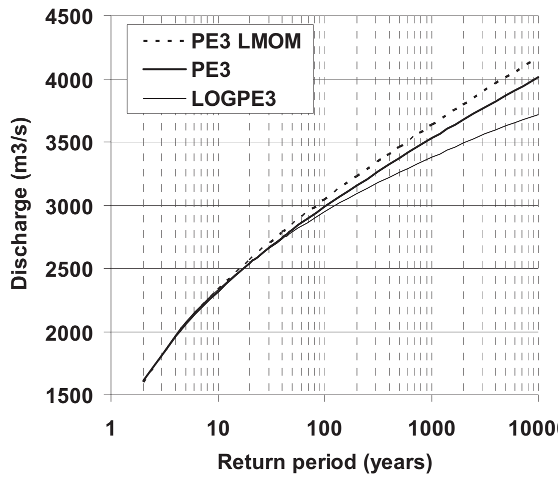

Fig. 2 The computed extreme high flows for the Radeče gauging station (for the data from the period 1945 – 1993) on the Lower Sava River for the 3 methods (PE3 – Pearson III; LOGPE3 – Log Pearson III; LMOM – L-moments). See large differences for higher return periods – i.e. so-called design floods.

The results using the L-moments are on average 8% to 13% lower when compared to Log-Pearson III, and 4% to 10% higher when compared to the Pearson III method.
The differences between the methods increase with longer return periods. For the 50-year return period 85% of all stations are in the ± 10% interval, but with the 5000-year return period the number of such stations drops to only 50%.
The study also revealed that the differences between the methods were on average somewhat larger for smaller rivers, irrespective of the return period.
For shorter return periods and the stations with fewer observations the differences between the methods were smaller when compared to the stations with more observations; with longer return periods the situation was the opposite, the differences were somewhat larger for the stations with less data. These unexpected results should be further investigated.
An example of the comparison between the three methods is given for a selected gauging station: Radeče on the Lower Sava River close to NPP Krško (Fig. 2).
Further study should consider the influence of selected distribution functions and of large observed floods on the results.

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