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Empirical rainfall thresholds and copula based IDF curves for shallow landslides and flash floods

Nejc Bezak, Mojca Šraj, Mitja Brilly, and Matjaž Mikoš
University of Ljubljana, Faculty of civil and geodetic engineering, Ljubljana, Slovenia (nejc.bezak@fgg.uni-lj.si)

Large mass movements, like deep-seated landslides or large debris flows, and flash floods can endanger human lives and cause huge environmental and economic damage in hazard areas. The main objective of the study was to investigate the characteristics of selected extreme rainfall events, which triggered landslides and caused flash floods, in Slovenia in the last 25 years.

Seven extreme events, which occurred in Slovenia (Europe) in the last 25 years (1990-2014) and caused 17 casualties and about 500 million Euros of economic loss, were analysed in this study. Post-event analyses showed that rainfall characteristics triggering flash floods and landslides are different where landslides were triggered by longer duration (up to one or few weeks) rainfall events and flash floods by short duration (few hours to one or two days) rainfall events.

The sensitivity analysis results indicate that inter-event time variable, which is defined as the minimum duration of the period without rain between two consecutive rainfall events, and sample definition methodology can have significant influence on the position of rainfall events in the intensity-duration space, on the constructed intensity-duration-frequency (IDF) curves and on the relationship between the empirical rainfall threshold curves and IDF curves constructed using copula approach.

The empirical rainfall threshold curves (ID curves) were also evaluated for the selected extreme events. The results indicate that a combination of several empirical rainfall thresholds with appropriate high density of rainfall measuring network can be used as part of the early warning system for initiation of landslides and debris flows. However, different rainfall threshold curves should be used for lowland and mountainous areas in Slovenia.

Furthermore, the intensity-duration-frequency (IDF) relationship was constructed using the Frank copula functions for 16 pluviographic meteorological stations in Slovenia using the high resolution rainfall data with 5-minute time step where the data series ranged from 11 to 66 years. Gumbel and Gamma distributions were selected to model annual maximums of rainfall intensities and durations, respectively. Method of L-moments was used to estimate the marginal distributions parameters and method of moments was chosen to estimate the Frank copula parameter. Comparison between ID curves and IDF curves constructed using copula approach was also made.