Geophysical Research Abstracts
Vol. 15, EGU2013-1229, 2013
EGU General Assembly 2013

Univariate versus Bivariate analysis and synthesis of floods to assess the risk of overtopping a dam – a case study for Argentina

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Considering floods as multivariate events allows a better representation of the process generating them. In this work the relevance of multivariate analysis for designing or assessing the risk of overtopping a dam is discussed. Generally, peak flow and volume are two statistically dependent variables; therefore they are used to characterize the flood events. A bivariate statistical frequency analysis is carried out to find a suitable model that adequately represents the data set of flood peak flow and volume. The dependence between the variables is modeled with a copula.

The copula model is used to generate 1000 random pairs of variables characterizing the flood, which are transformed into hydrographs. The shape of the floods is modeled using a Beta distribution function. The synthetic flood events are routed through a reservoir to assess its behavior. The maximum water levels and outflows are computed for all hydrograph and compared to estimations considering peak flow and volume separately. The analysis is carried out using flood peak and volume series observed in the river Agrio basin with a drainage area of 7300 km2, located in the province of Neuquén, Argentina.

The results show that the maximum water levels and outflows obtained based on the bivariate approach are higher compared to the univariate case. If the risk of an existing dam is to be assessed, the bivariate approach would indicate a greater risk of overtopping the dam for a given dam height and spillway geometry. If a dam is to be designed considering the joint behavior of both variables would result in a smaller risk for the structure compared to the univariate case.