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Deterministic modeling the instant discharges of the catastrophic floods at the basins of the small rivers of the Black Sea coast of the Caucasus (Russia)

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Black sea coast of Russia is characterized by increased risk of catastrophic floods due to extreme precipitation which have not been observed before. The assessment of flood characteristics is complicated because of the lack of sufficient hydrometeorological data. The damage and casualties in extreme situations are often the results of the errors at the stage of engineering design.
The study aimed to evaluate the applicability of the hydrological model for estimation of catastrophic flood characteristics at small rivers of the region. It consisted of three main tasks: 1) verify the model at the gauged Tuapse River (351 km2); 2) estimate the characteristics of historical floods at ungauged Tsemes River (82,6 km2) and compare the results with the assessments by standard statistical approach; 3) estimate the characteristics of recent flood (24-26 October 2018) which destroyed railway bridge at ungauged Makopse River (40 km2). We used the distributed deterministic hydrological Hydrograph model.
Tuapse River. The parameters of the hydrological model were assessed and systematized for main landscapes of the basin and continuous simulation of flow formation processes with daily time step was conducted for the period 1966–2013. The median value of the Nash-Sutcliffe efficiency coefficient was 0.60 for the whole period, which allowed evaluating the results as satisfactory. Digitized precipitation data of pluviographs were used to simulate maximum discharges for three outstanding floods (1991, 2005, 2010). Numerical experiments were carried out with the data on spatial distribution of precipitation to simulate maximum discharge for the historical flood in 1991. The values of maximum discharges were estimated for significant flood in June 2005 which caused the debris flow and for which streamflow data is not available. Based on the modeling results, it was concluded that published flow discharges data during the flood in October 2010 was inadequate.
Tsemes River. The maximum discharges at ungauged Tsemes river were calculated for the flood events in 1988, 2002 and 2012 and compared with the discharges of low probabilities obtained on the basis of calculations according to the standard statistical methods used in Russia. The discharges of about 1% probability were observed 2 times over the past 11 years (280 and 360 m3/s in 2002 and 2012). Noteworthy, estimated discharge for the flood in 1988 reached 690 m3/s, which is twice the value of 1% probability estimated with standard methods. This value can be conditionally accepted as PMF as the result of the combination of the most unfavorable meteorological and runoff formation factors.
Makopse River. Using mesoscale atmospheric WRF model data maximum discharge (340 m3/s) of the flood on 24-26 October 2018 on the ungauged Makopse River was estimated. It should be emphasized that such catastrophic flood on the neighboring Kuapse River was not observed.
The results of the study show that using the hydrological model we can calculate the instant discharge for the engineering assessment tasks. The possibility of modeling methods as an approach for assessment of probable maximum flood is discussed.

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