Flash flood simulation using unit hydrograph and hydrodynamic models (case study of Western Caucasus, Russia)

Pelagiya Belyakova¹, Ekaterina Vasil'eva¹, Andrey Aleksyuk¹,², Vitaly Belikov¹, Boris Gartsman¹, and Andrey Bugayets³

¹Water Problems Institute, Russian Academy of Sciences, Moscow, Russia (pobel@mail.ru)
²Faculty of Mechanics and Mathematics, Lomonosov Moscow State University, Moscow, Russia
³Pacific Institute of Geography, Far East Division of Russian Academy of Sciences, Vladivostok, Russia

In the Russian part of Western Caucasus heavy rainfall episodes frequently occur, leading to flash floods that often cause fatalities and severe damage. As soon as climate change is expected to increase the risk of flash floods it is necessary to improve flood forecasting and flood risk mapping as well as other precautionary measures. For this scope the better knowledge of catchment response on heavy precipitation is needed using rainfall-runoff simulation and further hydrodynamic modelling of inundation of urbanized areas.

There is a number of models used for flash flood simulation. In this study we used an available unit hydrograph model KW-GIUH [1] and a hydrodynamic model STREAM 2D CUDA [2]. KW-GIUH model only schematically describes overland flow over the catchment, nonlinear character of response is introduced via kinematic-wave approximation of the travel time. STREAM 2D CUDA is based on numerical solution of shallow water equations in a two-dimensional formulation according to the original algorithm using the exact solution of the Riemann problem [2], due to which the calculation is performed for the entire catchment without special allocation of the channel network. Models were tested on several flash flood events on the river Adagum (6-7 July 2012, catastrophic flood in the Krymsk town) and the Zapadny Dagomys river (25 June 2015, 24-25 October 2018, Sochi).

Comparison of simulation results was done as the same input data set was used. Input data included DEM HydroSHEDS, measured hourly precipitation and runoff volumes observed on gauges and estimated after high-water marks. Also 10-min water levels from a regional automated flood monitoring system of the Krasnodar Territory were applied. Simulated runoff volumes and peak timing were analyzed. For the Zapadny Dagomys river a forecasting calculation was done using precipitation forecast from COSMO-Ru. For the Adagum river STREAM 2D CUDA allowed to conduct an experiment to assess possible effect from potential reservoir-traps in the tributaries. The results of the rainfall-runoff simulation by the KW-GIUH model can be used as inflow to the boundary of the area for hydrodynamic modeling using STREAM 2D CUDA, also for operational use. Scenario calculations with changing hydraulic conditions at the catchment can be simulated using the STREAM 2D CUDA model itself.
The flood simulation was supported by the Russian Science Foundation under grant №17-77-30006. Data processing from an automated flood monitoring system in the Krasnodar Territory is funded by Russian Foundation for Basic Research and the Krasnodar Territory, grant № 19-45-233007.

References: