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Analysis of the heavy flood at the Kumano River basin in 2011

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Historical heavy flood occurred at the Kumano River basin from August 23 to September 5 in 2011 by the Typhoon 12. The peak discharge of the flood at the Ouga station (2,251km^2), the reference point to develop a flood control plan for the Kumano River basin, was estimated to exceed the design flood 19,000m^3/s. The water level of the flood was far exceeding the past floods, thus the estimated discharge using the rating curve includes uncertainties. In this study, we examined the uncertainty to estimate the largest-ever flood using a distributed hydrologic model with parameter values identified by using the past medium scale floods, and then we estimated the flood discharge using the distributed hydrologic model in terms of rainfall-runoff relationship.

A procedure for the analysis was as follows:

1) A catchment model was developed using a digital elevation model. The flow direction of the catchment was modeled using the 8-direction method, which assumes the flow direction 1-dimensionally to the steepest gradient direction. Each slope unit, determined by the flow direction, was represented by a rectangle formed by the two adjacent nodes of the DEM. The spatial resolution of the topographic data was 250m. The catchment model was constructed as a network of rectangles. Each rectangular unit was used for the element of runoff flow simulation [1][2].

2) The kinematic wave flow model was applied to slope and river flow, to route the water downstream according to the flow direction information. A discharge-depth relationship including soil moisture was introduced to the kinematic wave model [3], which forms a unit of a distributed hydrologic model [4].

3) The study area has several dam reservoirs. The catchment model was sub-divided at the locations of the dam reservoirs and model parameter values were identified for each sub-catchment.

4) The past seven floods at 1990, 1994, 1997, 2001, 2003, 2004A and 2004B were selected. The best fitted model parameter values were identified for each flood using the SCE-UA method [5].

5) Two kinds of rainfall data, the ground-based observation data by the Electric Power Development Co., Ltd. and the Radar/Raingauge-Analyzed Precipitation data by Japan Meteorological Agency were used. The best fitted model parameters were identified for each rainfall data. Then, the past floods were reproduced using the best fitted parameter values identified by other floods.

Through the analysis, we found that the best fitted model parameters related to surface soil characteristics differed according to floods, however the difference of the simulated discharges using these parameters was quite small. This shows the low sensitivities of model parameters because of the large amount of flood discharge than the stored water in the soil layer.

Finally, we estimated the peak discharge of the heavy flood in 2011 at Ouga, which was in the range from 23,115 to 26,098 m^3/s. We should carefully use observed river discharge estimated by a rating curve, especially when the water stage was far exceeding the past floods. To develop a new method to estimate/assimilate river discharge using observation, a hydrologic model and a 2-dimensional river routing model is the next step.

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