Estimation of Catchment Averaged Extreme Rainfall in Kinu River

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The Kinu river, which is a tributary of the Tone river, runs from Tochigi prefecture to Ibaragi prefecture. The Kinu river basin was devastated by the 2015 Kanto-Tohoku torrential rainfall. Heavy rain continued along narrow area between the typhoon 17 and the extratropical cyclone reduced from typhoon 18 and the cumulative rainfall reached 500mm at upstream of the basin. This heavy rain caused a breach at the left bank in Joso city and then devastating inundation. Rescue activities with helicopters were broadcasted many times.
This paper shows extreme analysis on several durations of catchment averaged rainfall at Ishii reference point of the Kinu river. While Annual Maximum Series(AMS) analysis has been usually employed so far, the author also uses Peaks Over Threshold(POT) analysis. POT with a threshold large enough can be analyzed with generalized Pareto distribution(GP) which includes Exponential distribution(Exp) as its special case of shape parameter is equal to zero. Generalized Extreme Value distribution(GEV) and Gumbel distribution which is a special case of GEV with shape parameter is zero for AMS correspond to GP and Exp for POT. When AMS and POT are compared, the Poisson process is assumed for the occurrence of POT.
Rainfall data of 15 rain gages of both Ministry of Land, Infrastructure, Transport and Tourism and Japan Meteorological Agency in and around the Kinu river basin are used to calculate the catchment averaged hourly rainfall. The data from 1979 to 2015 were collected and processed with Thiessen poligons. Analyzed rainfall durations are 6, 12, 18, 24, 48, 72 hours and 1, 2, 3 days. In order to check stationarity in AMS of all durations, Mann-Kendall test was employed and the result showed all time series are stationary with significant level of 5% but slightly in increasing trend.
Several methods for selecting threshold have been proposed. One of them is to use Sample Mean Excess Function(SMEF) which is based on the characteristics that the mean of threshold excess of Exponential distribution is constant for varying threshold. Thus the thresholds of POT of every duration were set to 48, 64, 75, 80, 85, 98, 67, 80, 94mm respectively with drawing SMEF. The sample size of POT with these thresholds became 69, 77, 78, 82, 96, 88, 86, 95, 88 and more than twice of AMS except for 6h. The parameters of the four distributions were estimated with L-moment method. The estimated Exp and Gumbel have almost same return levels in the extrapolating range while three parameter distributions such as GEV and GP shows different extreme estimations.
When these four distributions are compared with each other, several points should be noted that 1)POT uses just threshold excess and does not care about smaller data than threshold which may appear in AMS, 2)three parameter distribution such as GEV and GP uses skewness but two parameter distribution Gumbel and Exp does not, that is, the former will bend(with upper bound or with thick tail) on Gumbel probability paper but the latter will be in straight line.
The patterns of estimated distributions are classified as 1)for short durations such as 6h and 12h, Gumbel, Exp and GP have almost same extrapolations but just GEV has upper bound, 2)for 18h and 1 day, Gumble, Exp and GEV are almost same but just GP has thick tail, 3)for other durations, Gumbel and Exp are almost same but GEV and GP have thick tails.
The event of 2015 is the historical record from 1979 in the time series of AMS for each duration except for 6h and 12h,. However, corresponding plots are located around estimated distributions on the Gumbel probability paper and not unprecedented, namely “outlier”. Their return periods are estimated to be 50 to 100 years. Comparing to the result for 1979 to 2014, some of fitted GEV changed from having upper bound to having thick tail. The 100 year return levels of Gumbel for each

durations are about 30mm larger than that of 1979 to 2015.

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