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# Study of Extreme Hydrometeorological Events under Consideration of Climate Change in terms of Flood Protection Design Standard

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A study of Trend and Shift on annual maximum daily data over 500 raingauges with data length of 80 years or longer in the Ohio River Basin U.S. demonstrated a significant increase in variance of the data over time. The area-average increase in standard deviation is 23% for the recent 40 years (1959 - 1998) in comparison with the earlier 40-60 years (1919 or earlier - 1958). This implies that more and more extreme hydrometeorological events such as extreme rainfalls and droughts could be observed in the future years. The centurial flood disaster of August 8-10 2009 in the mid-southern Taiwan caused by Morakot Typhoon and the extraordinary drought lasting from winter 2009 to early summer 2010 wreaking havoc of a vast area of south-west China mainland were two good examples of the extremes. This variation could attribute to climate change. It challenges the hydrologic frequency analysis. Thus, exploration of a robust and reliable approach to precipitation frequency analysis becomes an imminent issue in hydrologic design studies. This paper introduces a novel hydrometeorological approach, the Regional L-moments method (RLM), to rainfall frequency analysis. There are two fatal weaknesses in FA: 1) There is no analytical way to derive a theoretical distribution to best fit the data; 2) The theoretical true value of a frequency such as 50-y or 100-y is unknown forever. The RLM, which is developed based on the order statistics and the concept of hydrometeorological homogeneity, demonstrates unbiasedness of parameter estimates and robust to outliers, and reduces the uncertainties of frequency estimates as well via the real data in Ohio River Basin of the U.S. and in the Taihu Lake Basin of China. Further study indicated that the variation of the frequency estimates such as 10-year, 100-year, 500-year, etc. is not normal as suggested in current textbooks. Actually, the frequency estimates vary asymmetrically from positive skew to negative skew when estimates go through from common frequencies to rare frequencies.

Probable Maximum Precipitation (PMP) is defined as the greatest depth of precipitation for a given duration meteorologically possible for a design watershed or a given storm area at a particular location at a particular time of year, with no allowance made for long-term climate trends (WMO, 2009). The PMP has been widely used by many hydrologists to determine the probable maximum flood (PMF) critical to the design of a variety of hydrological structures and other high profile infrastructures such as nuclear power-generation station with respect to flood-protection, for which a high level safety is required.

What is the impact of climate change on PMP estimation? Actually, in the definition of PMP, there is "no allowance made for long-term climate trends" (WMO, 2009). However, when people are talking about impact of climate change on PMP estimation, two things may be taken into account practically: (1) To affect the precipitable water as a result of increase of SST; (2) Effect on the selection of the transposed storm because more extreme storms would occur due to climate change and more potential candidates to be used for storm transposition. The occurrence of a severe rainfall storm could alter the PMP estimates. A good example is the lashing of the Typhoon Morakot of 8 - 10 Aug. 2009 on Taiwan Island that set up new rainfall picture.

What is the effect of topography on rainfall is another big issue in PMP estimation. Many observations of precipitation in mountainous areas show a general increase in precipitation with elevation. Practically, the effect of topography on rainfall should be taken into account in PMP estimation and implemented by the storm separation technique. The Step-Duration-Orographic-Intensification-Factor (SDOIF) Method, which was developed based on statistics analysis of extreme rainfalls in the storm area, can practically be used as storm separation technique to decouple the Morakot storm rainfalls into two components, convergence component and orographic component. Then, the convergence component can be transposed in a wider area for PMP estimation at a design location in the East Asia region.

At last, this paper provides a clue for the first time on relationship between the frequency analysis and the PMP estimation in terms of hydrologic engineering design studies.