Seasonality in stream hydrograph of a montane watershed in northern Thailand: Is there a threshold condition that predicts mid-wet-season shift in rainfall-runoff relationship?

*Han Tseng[1], Thomas W. Giambelluca[1], Yin-Phan Tsang[2], Alan D. Ziegler[3]

1. Univ. of Hawai'i at Manoa, Dept of Geography, Honolulu, HI, United States, 2. Univ. of Hawai'i at Manoa, Dept of Natural Resources & Environmental Management, Honolulu, HI, United States, 3. National Univ. of Singapore, Dept of Geography, Singapore, Singapore

In this study, we examined the dynamics of the rainfall-runoff relationship in Mae Sa watershed, a montane catchment with mixed forest, agriculture, and peri-urban land covers in northern Thailand near the city of Chiang Mai. The Asian monsoon and tropical storms produce highly distinct wet-dry rainfall seasonality in this region. Wet season rainfall exhibits a bimodal distribution with peaks in early May and August-September, separated by a relatively dry period (June-July). Wet season streamflow of Mae Sa roughly follows the bimodal rainfall pattern, but the discharge tends to be much higher in the second than in the first rainfall peak, and in many cases, a storm of similar magnitude generates a much larger discharge event after approximately the midpoint of the wet season.
We analyzed daily hydrographs and used runoff coefficients (RCs) as an indicator of the watershed hydrological response to rainfall to examine the seasonal trend and interannual variations and explored the use of simple indices of catchment antecedent conditions to explain such rainfall-runoff dynamics. We obtained the daily time series of discharge measured at the catchment outlet and rainfall observations from the 11-gauge network in the 74.2-km^2 watershed from mid-2004 to 2012. Hourly rainfall records from each of the 11 rain gauges were first adjusted for lag time with respect to the stream discharge, based on the time difference between the peak discharge and the peak rainfall of isolated events at the specific station. The aligned 11 rain gauge hourly records were then spatially interpolated using Thiessen polygon method and integrated into a daily watershed rainfall time series. We separated the quickflow and baseflow components and identified individual quickflow events from the resulting daily rainfall and discharge time series. RCs were then calculated based on both the quickflow component (quickflow-RC = quickflow/rainfall) and the total discharge (total discharge-RC = discharge/rainfall) at the event scale as well as on a daily time step.
Analyses of the hydrograph and RC time series revealed a seasonal pattern where abrupt upward shifts or steep increases in the RCs were observed. The result suggests a “switch-point” in the rainfall-runoff relationship annual cycle, after which similar rainfall events generate higher discharge than earlier. While this switch-point generally occurs in the second half of the wet season, the occurrence and timing varied from year to year during the 8.5 years studied. This inter-annual variability in the occurrence and timing of the switch-point appears to be the related to the difference in annual rainfall amounts and the temporal patterns. For example, the shift in RC in 2007 and 2010, which have average or lower annual RF, are more obvious compared to 2006 and 2011, which have higher total RF and higher RC in the early stage of the wet season. Indices of the watershed antecedent conditions (e.g. cumulative rainfall, baseflow level at time of event) and event characteristics (e.g. rainfall intensity, event duration) were compared with RCs to further explore potential “threshold” conditions that might trigger the change in the watershed hydrological response.

Keywords: rainfall-runoff response, runoff coefficient, tropical monsoon climate, montane forest watershed, watershed hydrology