Geophysical Research Abstracts
Vol. 21, EGU2019-12413, 2019
EGU General Assembly 2019

A Physical Interpretation for Peak Flow Scaling of Rainfall-Runoff Events in Nested River Networks with Implications on Peak Flow Regionalization

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Diverse empirical (data-driven) and theoretical (model-driven) studies have shown that the peak flows associated to a probability of exceedance or a specific rainfall-runoff event scales with respect to drainage area. This hydrologic feature is well-known as flood scaling and it has been widely used by the hydrologic community in peak flow regionalization. In theoretical ideal conditions with spatial and temporal uniform fields of soil moisture and rainfall, the flood scaling seems to hold perfectly, however the actual heterogeneities of these fields create new peak flow variabilities that cannot be explained just with drainage area. This study investigates the actual variabilities of rainfall fields, soil moisture fields, and river network structure in the peak flow scaling of 52 rainfall-runoff events that were observed in the Iowa River Basin. The spatial and temporal variability of the rainfall and soil moisture were quantified using radar and satellite data respectively, and the river network structure was described through Width Function Descriptors. We demonstrate that these variabilities can be used to improve regional peak flow regressions using a physics-driven by providing justification for the inclusion of explanatory variables to be used on regionalization studies. Finally, we connect the results of rainfall-runoff events with peak flow quantiles, showing that regional regression of peak flow quantiles can be improved as well.