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Challenges for Application of the Derived Distribution Approach to Flood Frequency

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Flood estimation in ungauged basins is important for flood design, and for improving our understanding of the sensitivity of flood magnitude to changes in climate and land cover. Flood estimates by current methods (e.g. statistical regression, unit hydrograph) have high uncertainty, even in places with dense observing networks (e.g. +/- 50-100% in the UK). Reductions in this uncertainty are being sought by using alternative methods, such as continuous simulation using hydrological models (spatially-distributed or lumped), and event-scale derived distribution approaches. The very significant challenges for reliable application of continuous simulation models in ungauged catchments are well described in the literature.

The event-scale derived distribution approach also has challenges, which we explore below. The derived distribution approach at the event scale typically combines the following elements: a stochastic rainfall model, an event-scale rainfall-runoff model (including "losses" and a "baseflow" component), and a runoff routing model. In principle, every element of this approach may be considered as a (seasonally varying) random variable. The flood peak distribution is obtained by integrating over joint distributions of the model elements.

First challenge: what is the physical basis for estimating the event runoff coefficient? In the 1970s, this was addressed using infiltration theory, but other runoff generation mechanisms are often more important. How do we connect our knowledge of seasonal water balance and runoff generation processes to the probability distribution of event runoff coefficients, and its seasonal variation? We suggest (i) begin with locations which are dominated by a small number of runoff generation mechanisms (ii) make use of existing theory on links between climate, catchment characteristics and seasonal water balance (iii) adapt relevant simple concepts of runoff generation which link seasonal water balance to runoff generation.

Second challenge: how do we parsimoniously quantify the impacts of within-storm temporal rainfall patterns on the flood hydrograph? Existing approaches use stochastic rainfall models to explicitly generate (hourly) time series of rainfall; since catchments damp out high frequency forcing, we suggest that these rainfall series often contain excessive temporal detail and obscure the most informative interactions between rainfall and catchment response. We propose that we use stochastic models that can generate hydrologically relevant attributes of rainfall events (e.g. intensity/depth/duration, spatial and temporal moments), and then apply rainfall-runoff transformations which operate on rainfall moments, and do not require excess detail in temporal

(or spatial) patterns of rainfall.

Third challenge: What is an event? This is no problem for theoretical models, but it is hard as a data analysis question, and we need data analysis to implement and evaluate the derived distribution method. The event identification methods of engineering hydrology are subjective, require manual intervention and are poorly suited for large sample hydrology! We suggest the answer lies in the catchment's response time.

The underlying conceptual framework to link seasonal climate and hydrology to floods is already available (Sivapalan et al, 2005). What these challenges require is that we integrate and apply more of our existing hydrological concepts and knowledge to implement the process-based theory of flood frequency.