

## ***Interactive comment on* “Theoretical investigation of process controls upon flood frequency: role of thresholds” by I. Struthers and M. Sivapalan**

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We thank the reviewer for the comments provided. The major concerns raised by the reviewer relate to:

1. The simplicity of the model; that the model is incapable of accounting for physically-observed runoff-generation mechanisms, and is therefore unsuited for long-term simulations.
2. The lack of model validation; that the model used in the study has not been demonstrated to reproduce observed discharge.
3. The realism of model behaviour; that the results presented in this paper are merely artefacts of model structure and assumptions.

Regarding the first concern, this manuscript has been submitted to a Special Issue concerned with threshold behaviour, and as such deals primarily with the contrast between non-threshold- and threshold-impacted hydrological response, and attempts to describe behaviour in general terms with respect to parameter values and parameter groupings. In an exploratory study such as this, there is a strong desire to use a model which is catchment- and climate-independent (i.e. a “general” model, with a small total parameter set). This is the rationale for choosing simple catchment and climate models; only with such simple models is it possible to arrive at generalised understandings of resultant behaviour. Similar modelling methods, with a similar degree of parsimony, are common in literature (eg. Milly, 1994, and other works by Milly). For the modelling of flood frequency specifically, it is of similar complexity to the lumped HBV model (as used in Merz and Blöschl, 2004, and Sivapalan et al., 2005), and may be regarded as more physically realistic in certain respects than various empirical loss coefficient methods previously published (eg. Blöschl and Sivapalan, 1997, Muzik, 2002). The rainfall model employed in this study was also chosen for parsimony; primarily, it does not account for correlation between the duration and average intensity of a given storm (which requires, at a minimum, an additional 4 parameters). The impact of this assumption has previously been examined by Cameron et al. (1999), and indeed it does have some impact upon the statistical accuracy of the generated precipitation dataset. While this may quantitatively alter the resultant rainfall and flood frequency curves, we contend that the qualitative features of the resulting behaviour, as summarised in Figure 5, will remain valid.

The issue of model validation is crucial in the assessment of models intended for predictive application. For studies such as this, where the primary objective in applying the model is to facilitate the development of clear insights into the impact of thresholds upon hydrological response behaviour for a generalised and simplified parameterisation of climate and landscape, model validation is not especially important, provided the behaviour of the model is intuitively reasonable. This is explicitly discussed in the manuscript (Section 2):

"The various simplifications employed in this study make this methodology unsuitable for accurate flood prediction, but have the over-riding benefit - given the study objectives - of permitting the derivation of a relatively clear explanatory framework for the resulting flood frequency behaviour in terms of dominant climate and landscape properties."

Regarding the final concern, it is indeed the case that results (i.e. model response behaviour) are artefacts of model structure and model assumptions - although this observation is synonymous with modelling itself! Especially in the case of simple models, the scope for emergent patterns in response behaviour is relatively limited, and a large degree of model behaviour can be readily inferred from the model structure and assumptions themselves. Nonetheless, the present study is successful in identifying parameter groupings (eg.  $r_A$ ,  $r_B$ , and  $\alpha$ ) which characterise the impact of the two soil moisture storage thresholds ( $S_b$  and  $S_{fc}$ ) upon altering flood frequency behaviour relative to the baseline case. While alterations to the model structure and relaxation of model assumptions will lead to changes in the exact nature of this characterisation, it is our contention that the basic process (landscape and climate) controls upon threshold-impacted flood frequency identified in this study will remain valid.

The reviewer identifies specific weaknesses; namely the lack of surface runoff at storages below the catchment storage capacity (due to infiltration excess and partial saturation mechanisms, presumably). With regards to partial saturation, the manuscript considers only the limited case of "decreasing soil depth towards the stream"; the consideration of additional organisations may be warranted, but will have to be considered against the additional insight gained (and additional length of the manuscript). With regards to infiltration excess, this was excluded from consideration primarily due to the difficulty in accounting for it parsimoniously except through a simple fixed infiltration capacity, which would provide little additional insight. It is also questionable whether infiltration excess is a significant surface runoff mechanism at the catchment scale, due to runoff in high-infiltration regions of the soil surface between the point of infiltration

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excess generation and the stream channel. The impact of infiltration excess (as well as other aspects of spatially-variable catchment properties and hydrological response) may be a subject of future work.

The reviewer provides further comments, relating to the use of the term “theoretical” in the manuscript title. We accept that this terminology may be misleading, given the conceptual nature of models employed in this study, and the suggested rewording of the title to "A conceptual investigation of process controls upon flood frequency: role of thresholds" will be implemented in the revised manuscript.

The calculation of evapotranspiration by the model does, indeed, need to be more explicitly described. Given that seasonality is ignored for a majority of the manuscript, the value of potential evaporation is fixed so as to give the constant values of  $r_A$  and  $r_B$  (as given in Table 1) for a given simulation. In Figure 6, which incorporates seasonality, the potential evaporation rate is also seasonally variable; this needs to be incorporated into the description in Section 3.7 as well as Table 1.

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