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Exploring climatic and landscape controls of runoff generation through behavioral constraints on runoff volume using the Budyko Curve

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Hortonian overland flow, Dunne overland flow and subsurface stormflow are the three dominant mechanisms contributing to runoff generation in catchments. Dunne (1978) postulated that the occurrence and dominance of these different mechanisms are governed by different combination of climatic conditions, soil characteristics and topography. In this work, the climatic and landscape controls on the partitioning of annual runoff into its various components are assessed quantitatively, from a theoretical/modeling perspective. A relatively simple distributed hydrologic model has been built for this purpose, which is complete enough to simulate the effects of different combinations of climate, soil and topography on the nature of catchment functions that underpin processes of runoff generation mechanisms. The model is driven by a sequence of simple hypothetical precipitation events, for a large set of hypothetical catchments formed as virtual laboratories to be used in the detailed analyses. The outcomes of these model simulations are then pooled together with the use of a small set of dimensionless similarity parameters that are formed from the constituent climatic and landscape properties. The similarity parameters are chosen in such a way as to capture the competition between the wetting, drying, storage and drainage functions underlying the catchment response. Each combination of these dimensionless parameters is feasible in theory, but only some combinations may actually occur in nature. By constraining the runoff predictions of the model with the empirical Budyko curve governing mean annual runoff, these are narrowed down to feasible or "behavioral" parameter combinations, discarding the remaining "non-behavioral" parameter combinations. These analyses revealed clear inter-relationships amongst the "behavioral" climate, soil and topography parameter combinations that made intuitive sense. These results reveal much about how the various components of the landscape could be organized and inter-connected in nature. These results may be seen as initial steps towards developing a unifying framework for exploring these inter-connections, both in the field and through more detailed numerical modeling.