Reviewer #2:

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This manuscript presents a well-conceived and timely contribution to runoff generation modeling by unifying saturation-excess and infiltration-excess mechanisms within a single probabilistic framework. The theoretical development is clearly grounded in the probability distribution modeling traditions, and the application to 181 natural catchments across a range of hydroclimatic regimes demonstrates that the proposed URSSIE scheme can capture essential features of streamflow variability and the shifting dominance of runoff mechanisms from event to annual scales. The organization of results using the aridity index and the phasing between precipitation and evaporative demand is particularly effective in distilling complex process interactions into a small number of interpretable hydrologic regimes.
Response: We thank Reviewer #2 for the positive and encouraging assessment of our work. Point-by-point responses to the reviewer's comments are listed below. For clarity, our responses are color-coded as follows: reviewer comments are in black, our responses are in light blue, the line numbers (corresponding to the clean version) are in red, and the texts excerpted from the manuscript are in brown.

1. The assumed power-law relationship between soil moisture deficit and infiltration capacity should be presented more explicitly as a modeling closure guided by prior experimental and theoretical insights, rather than as a universally validated physical law, with a brief discussion of its implications and its role as an important direction for future empirical testing.
Response: Thank you for your suggestions. We revised the sentence introducing the power-law between soil moisture deficit and infiltration capacity at line 159-160 as follows:
"We represent the point-scale infiltration capacity (f_c) at any unsaturated location in a catchment as a power-law-type function of D:"

2. Similarly, the assumption of a uniform groundwater depth, while consistent with many PDM/VIC-type approaches, would benefit from a short discussion of the hydrogeologic settings where it is most defensible and where caution is warranted.
Response: Thank you for your suggestions. We have revised the manuscript to clarify that the assumption of uniform groundwater depth is most defensible when groundwater tables are relatively deep and exhibit limited lateral variability. (Line 97-99)
"This assumption is reasonable because groundwater table observations are often unavailable, and when the groundwater tables are relatively deep and laterally smooth, spatial differences tend to diminish (Yao and Wang, 2022)."

3. Finally, a concise characterization of those catchments that do not fit the three proposed climate–runoff categories, or where validation performance is weaker, would help delineate the current scope and limitations of URSSIE.

Thank you for your suggestions. We have clarified in the manuscript that the outlier catchments do not exhibit a clear and consistent hydroclimatic pattern and may be influenced by additional local controls such as vegetation dynamics or geological complexity. (Line 316-318)

"These outlier catchments do not exhibit a clear and consistent hydroclimatic pattern, suggesting that additional local controls such as vegetation dynamics or geological complexity may influence their runoff behavior."