**Dear Editors,**

We are happy to submit our manuscript entitled ***“Regional Base-Flow Index in Arid Landscapes Using Machine Learning and Instrumented Records”.*** for consideration in Journal of Hydrology: Regional Studies. This work presents a novel integration of streamflow observations and machine learning to characterize base-flow dynamics across diverse physiographic and climatic regions in Arizona, USA.

Dryland regions face critical water challenges yet are often underrepresented in hydrologic analyses due to sparse monitoring networks and unique hydrogeologic characteristics. Our study addresses this gap by (1) analyzing long-term base-flow index (BFI) trends from 205 instrumented streamgages, and (2) using the eXtreme Gradient Boosting (XGBoost) algorithm to predict long-term BFI in ungauged catchments. The resulting spatial patterns and model insights contribute to improved understanding of groundwater–surface water interactions in water-limited environments.

In response to reviewer feedback (Manuscript Number EJRH-D-25-00805), we revised the manuscript throughout to improve clarity and expand explanations where appropriate. We appreciate the thoughtful comments provided by you and the reviewers. We strengthened the justification for our methods, refined the discussion of key results, and expanded interpretation in response to reviewer requests. We have carefully addressed each point raised, and believe the manuscript is substantially improved as a result. Below we outline the major revisions made in response to reviewer and editor feedback.

**Model Performance and Validation – Editor & Reviewer 1**

**Concern:** The model validation and sensitivity analysis lacked sufficient detail. The model testing and verification needed clarification. Additional model comparisons were requested, especially against simpler methods such as interpolation.

**Response**:

* We clarify that the model was trained on annual BFI values and applied to estimate annual BFI which was then aggregated to long-term BFI. A new sentence in the Methods explains this alignment (Section 2.4, paragraph 1).
* We added performance metrics from two baseline comparison models: a simple linear model and inverse distance weighting (IDW) interpolation. These are now included in Section 2.4, paragraph 5, where we compare RMSE and Nash–Sutcliffe efficiency across methods.
  + The IDW model was constructed using leave-one-out cross-validation to simulate out-of-sample prediction, and the performance metrics were computed using the same evaluation criteria as the XGBoost model. These results are described in the Methods and summarized in the revised text.
  + A new short paragraph explicitly compares the three approaches, demonstrating that XGBoost outperformed both alternatives by 42–43% in terms of RMSE and NSE, providing clear justification for the ML approach.

**Regional Comparisons and External Validation – Reviewer 1 & 2**

**Concern**: The discussion of how findings relate to other BFI studies was repetitive and required better organization.

**Response**:

* We reorganized the relevant paragraphs in the Discussion to streamline the comparison with previous BFI studies (Section 4, paragraphs 7-8).
* We removed repetitive phrases and clarified how each cited study (Beck 2013, Ayers 2022, Santhi 2008) aligns or diverges from our findings.

**Mechanistic Understanding, Further Relevance – Reviewer 3**

**Concern**: The discussion lacked sufficient depth regarding hydrologic mechanisms of baseflow drivers. Reviewer 3 asked for more attention to expanded transferability.

**Response**:

* We added a new paragraph (Section 4, paragraph 3) explaining the mechanistic basis of observed BFI patterns, including hydrogeologic context, orographic precipitation, land cover, and recharge dynamics. This connects predictions more clearly to physical processes.
* We added a short subsection (Section 4, paragraph 9) addressing the transferability of this modeling approach to other regions, including its strengths and limitations in under-instrumented dryland settings.

**Additional Revisions per Reviewer Requests**

* We now provide a clearer explanation of our reduction of the predictor set and discuss the tradeoffs between interpretability and completeness. A new paragraph (Section 4, paragraph 6) outlines how future models might incorporate subsurface hydrology, snowpack, soil moisture, and anthropogenic stressors to improve performance.
* We expanded the Base-flow Separation section to include brief commentary on the choice of hydrograph separation filter and clarified the physical basis of base flow.
* The manuscript was revised throughout for clarity, tone, and consistency.

We believe our manuscript is a strong fit for Journal of Hydrology: Regional Studies, as it provides new insights into regional hydrologic processes, with direct applications for managing water resources under climate and land-use pressures. Our interdisciplinary approach combining hydrologic analysis, climate data, and machine learning is aligned with the journal’s emphasis on region-specific solutions, modeling, and translational science.

We confirm that neither the manuscript nor any part of its content is currently under consideration for publication elsewhere or has been previously published. All authors have approved the manuscript and agree with its submission to Journal of Hydrology: Regional Studies.

We hope that the revisions address the reviewers’ and editor’s concerns. Thank you for your consideration. We look forward to the opportunity to contribute to your journal.

Sincerely,  
**Caelum Mroczek** (corresponding author)  
on behalf of all co-authors