Supplementary Information for

Interactive effects of aridity and catchment position on blue-green water partitioning across river networks

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The PDF file includes Supplementary:

Supplementary Results

Group-Level Tests of Partitioning by Region and Network Position

Using the group-level tests described in Materials and Methods, we evaluated Great Plains (GP) versus eastern basin (East) contrasts separately for headwaters (HW) and higher-order (MS) reach-catchments across components ($\hat{B}$, $\hat{M}$, $\hat{C}$, $\hat{I}$, $\hat{T}$, $\hat{E}_{soil}$, $\hat{E}_{surf}$). In headwaters, GP shows consistently larger $\hat{B}$, $\hat{C}$, $\hat{T}$, $\hat{E}_{soil}$, and $\hat{E}_{surf}$ than East ($\Delta > 0$ with $\Pr(\Delta > 0) \approx 1$), while $\hat{M}$ is markedly lower in GP ($\Delta < 0$ with $\Pr(\Delta > 0) \approx 0$), indicating stronger routing to green water fluxes (*B, C, T*) and weaker bypass *M* fluxes in the GP headwaters. In MS reach-catchments, GP–East differences attenuate: $\hat{B}$ remains positive and $\hat{T}$ is modestly positive; $\hat{C}$ is small and near zero; $\hat{E}_{soil}$, $\hat{E}_{surf}$, and $\hat{I}$ are indistinguishable from zero, consistent with downstream convergence in partitioning (Table s2).

To assess whether these regional separations could arise from random labeling while holding network position fixed, we conducted block-preserving permutations. For each posterior draw, we formed a combined statistic by averaging the headwater and mainstem contrasts, $S_{draw,row}$, and then averaged over draws to obtain the observed test statistic S_{obs}. Under the null, we shuffle GP/East labels within headwaters and within mainstems only, recompute $S_{draw,row}$ and S_{obs}, and obtain two-sided empirical p-values from the permutation distribution. For each component, the combined HW+MS statistic yielded p=0.0005, indicating that the observed GP–East separations are far larger than expected under random labels.

Distributional diagnostics align with these summaries. ECDF panels show right-shifted GP curves for $\hat{B}$, $\hat{C}$, and $\hat{T}$ (and modest shifts for $\hat{E}_{soil}$ and $\hat{E}_{surf}$) in headwaters (fig. S5A), and shift-function plots localize the largest differences to mid–upper quantiles, with notably weaker or null shifts in MS (fig. S5B). Overall, despite the wide, overlapping posteriors at the reach-catchment scale, the grouped evidence indicates systematic GP–East differences in headwater partitioning that diminish downstream, supporting the interpretation that climate–landscape controls imprint strongly in headwater catchments and attenuate with downstream river-network position.

MRB Climate-Landform Combinations

We quantified representativeness as the fraction of possible climate–landform combinations represented in the Mississippi River Basin, considering Köppen–Geiger climate groups B–D[1] (excluding tropical and polar climates) and the nine EarthEnv geomorphological landform classes[2]. The total possible combinations are therefore 27 (3 climate groups × 9 landforms), and coverage is computed as the fraction of these combinations present at least once within the basin.

Supplementary References

1. Peel, M. C., Finlayson, B. L. & McMahon, T. A. Updated world map of the Köppen-Geiger climate classification. *Hydrol. Earth Syst. Sci.* **11**, 1633–1644 (2007).
2. Amatulli, G. *et al.* A suite of global, cross-scale topographic variables for environmental and biodiversity modeling. *Sci. Data* **5**, 180040 (2018).