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Right answers for the wrong Reasons? Testing water use efficiency responses in terrestrial biosphere models

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Water-use efficiency (WUE) quantifies the ratio of CO assimilation to transpiration, reflecting the trade-off between carbon gain and water loss. It therefore provides key information about ecosystems' strategies for dealing with drought, as well as their responses and feedbacks to climate. From an optimality perspective, a robust theory to predict WUE is fundamental for exploring potential adaptations, shifts in vegetation communities, or migration, especially under future scenarios.

Global estimates of WUE, generated by terrestrial biosphere models (TBMs), typically evaluate the accuracy of their predictions using observed fluxes. However, these evaluations often overlook whether the simulated sensitivity of fluxes to environmental drivers matches observed sensitivities, possibly covering flaws in the underlying theory, allowing models to produce "right answers for the wrong reasons".

Here, we assess the sensitivity of WUE simulated by the TRENDY models to environmental variables and compare them against sensitivities inferred from $\delta^{13}C$ isotopes and state-of-the-art remotely sensed datasets derived from machine learning. We found qualitative disagreements (opposite signs) in the sensitivity coefficients of WUE to environmental variables, highlighting gaps in the current theoretical understanding of ecosystem functioning.