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Global ecosystems reveal divergent evapotranspiration response patterns to drought stress

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Abstract: Terrestrial ecosystems, which connect the pedosphere, biosphere, and atmosphere via water and carbon cycles, are increasingly threatened by drought under global warming. Understanding ecosystem drought responses is critical for predicting ecohydrological dynamics and optimizing management, yet existing studies face key limitations: (1) uncertain evapotranspiration (ET) response patterns to drought, (2) lack of process-based resilience quantification framework coupling external climatic stress with internal ecosystem feedback.

Here, we develop a new drought resilience framework—Resilience Index (RI)—and systematically investigated ET responses and drought resilience across diverse ecosystems. Leveraging 57 global eddy-covariance flux sites (covering 11 ecosystem types) and 156 drought events identified using the Standardized Precipitation Evapotranspiration Index, we quantified ET anomaly pattern and constructed RI to reflect the coupling of bio-hydrological processes and physical-hydrological processes in resilience quantification.
Our results showed that the ET responses of different ecosystems to drought could be categorized into four patterns. Across 11 ecosystems, the mean ET anomaly during drought was -0.19 ± 0.39 mm·d^{-1}. ET responses to drought were categorized into four distinct patterns. Forest ecosystems exhibited greater drought resilience than non-forest ecosystems, with evergreen broadleaf forests and evergreen needleleaf forests showing better resilience and having an average RI of 1.03 and 0.96, respectively.
This study's RI framework provides a unified quantitative standard for cross-ecosystem drought resilience assessment, bridging the gap between climatic drivers and ecosystem responses. This finding highlights the dynamic response of the ecosystem to drought, directly reflecting the influence of potential eco-hydrological mechanisms that dominate drought resilience. Our study provides insights into the response mechanisms of eco-hydrological elements under drought stress and contributes to understanding the internal dynamics of ecosystem responses to drought in the context of global change from a new theoretical perspective.

Keywords: *Drought; Evapotranspiration; Ecosystem; Response pattern; Resilience index; Flux observation*

