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Emergent constraints on global carbon-climate feedbacks from regional atmospheric aridity

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The vulnerability of terrestrial carbon sequestration to increases in fossil fuel emissions is one of the most important feedbacks in the Earth System. However, the relative importance of temperature and moisture controls on regional terrestrial CO2 fluxes varies substantially and yet critical to unraveling their roles in carbon-climate feedbacks. Here, we employ the Hierarchical Emergent Constraint (HEC) to quantify an emergent relationship between spatially- explicit sensitivities of carbon fluxes to atmospheric aridity across an ensemble of Earth System Models (ESMs) and the long-term sensitivity of tropical land-carbon storage to atmospheric aridity. Our results show that interannual fluctuations in atmospheric aridity, as an important driver of atmospheric water demand for plants, substantially impact the terrestrial carbon sink. However, this analysis, which is conditioned on observations, leads to a substantially lower feedback than predicted by ESMs alone. Furthermore, we show that a relatively small number of regions have an out-sized impact on global carbon climate-feedbacks. These findings underscore the role of both water and temperature on carbon-climate feedbacks while the regional attribution provided by HEC points to areas for further process-based research.