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Drought legacy effects on ecosystem productivity across eddy-covariance FLUXNET sites

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The frequency and severity of droughts are expected to increase in the wake of climate change in many regions. Droughts not only cause concurrent impacts on the ecosystem carbon balance, but also result in legacy effects during the following seasons and years. These legacies result from, for example, drought-driven hydraulic damage or adjustments in carbon allocation. To understand how droughts might affect the carbon cycle, it is important to consider both concurrent and legacy effects. Such effects likely affect the interannual variability in carbon fluxes, but are challenging to detect in observations, and poorly represented in land surface models. Therefore, the understanding of patterns and mechanisms inducing legacy effects of drought on ecosystem carbon balance need to be improved.

In this study, we analyze the seasonal dynamic of gross primary productivity (GPP) from the FLUXNET dataset and detect legacy effects from past droughts. We predict the potential GPP in legacy periods based on a trained data-driven model using data in non-legacy periods and infer legacy effects from the difference between actual and potential GPP in legacy periods. We find that the drought-induced lagged GPP reductions are overall of similar magnitude to the concurrent GPP reductions in many sites. We further explore how drought legacy effects depend on drought intensity, vegetation type, and climate zone. These results have the potential to improve our understanding of the mechanisms of recovery and resilience of GPP to drought, thereby drought impacts on the ecosystem carbon cycle.