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Dry-season climate drives interannual variability in tropical tree growth

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Tropical and subtropical ecosystems are primarily responsible for the large inter-annual variability (IAV) in the global carbon land sink. The response of tropical vegetation productivity to climatic variation likely drives this IAV, but the climate sensitivity of key productivity components are poorly understood. Tree-ring analysis can help fill this knowledge gap by estimating IAV in woody biomass growth, the major carbon accumulation process in tropical vegetation.

Here, we evaluate the climate responses of woody biomass growth throughout the global tropics. Using an unprecedented compilation of tropical tree-ring data, we test hypotheses that (1) precipitation (P) and maximum temperature (T_{max}) have opposite and additive effects on annual tree growth, (2) these climate responses amplify with increasing aridity and (3) wet-season climate is a more important driver of growth than dry-season climate.

We established a network of 347 tree-ring width chronologies compiled from (sub-)tropical latitudes, representing 99 tree species on five continents and obtained from contributors (n=112) and the International Tree-Ring Data Bank (ITRDB; n=235). Our network is climatologically representative for 66% of the pantropical land area with woody vegetation.

To test hypotheses we re-developed standardized ring-width index (RWI) chronologies and assessed climate responses using SOM cluster analysis (monthly P and T_{max}) and multiple regression analysis (seasonal P and T_{max}). Our results were consistent with hypothesis 1: effects of monthly or seasonal P and T_{max} on tree growth were indeed additive and opposite, suggesting

water availability to be the primary driver of tropical tree growth. In accordance with hypothesis 2, these climate responses were stronger at sites with lower mean annual precipitation or a larger annual water deficit. However, our results contrast those expected under hypothesis 3. Three of the four clusters show a dominant role of dry-season climate on annual tree growth and regression analyses confirmed this strong dry-season role.

The strong dry-season effect on tropical tree growth seemingly contrasts the general notion that tropical vegetation productivity peaks during the wet season but is consistent with studies showing that climatologically benign dry seasons increase reserve storage and xylem growth. We posit that dry-season climate constrains the magnitude of woody biomass growth that takes place during the following wet season, and thus contributes to IAV in tree growth.

By providing field-based insights on climate sensitivity of tropical vegetation productivity, our study contributes to the major task in Earth system science of quantifying, understanding, and predicting the IAV of the carbon land sink.