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Sensitivity of tropical tree growth to climatic variation: a global meta-analysis of tree-ring data

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Tropical forests are a crucial component of the global carbon cycle and importantly contribute to the global carbon land sink. Stem growth of tropical trees is a key component of carbon dynamics in tropical forests, but our understanding of how this is driven by climatic variation is poor. Such understanding is needed for predictive vegetation modelling of climate change effects.

Here, we help to fill this knowledge gap by conducting a meta-analysis of published tropical tree-ring width chronologies. We compiled >350 tropical chronologies (30°N - 30°S) from all tropical climate zones. We used this data set to explore i) common patterns in the tree-growth responses to monthly rainfall and temperature (Tmax) patterns (cluster analysis), ii) the relative importance of temperature and rainfall in determining tropical tree growth (glm), iii) how these climatic drivers shift along gradients of temperature and precipitation.

Our cluster analysis revealed 6-8 primary types of responses to monthly climate variables. These clusters are associated with mean climate, elevation, or geographic location. The seasonality of growth responses to temperature and rainfall differed clearly among clusters, but the signs of responses were consistent: higher Tmax reduces growth, more precipitation increases growth. Multiple regression analyses of growth responses to seasonal climate further confirmed the negative effects of temperature and positive effects of rainfall. Rainfall during the dry season had the strongest relative importance. Finally, we found that seasonal drivers of tropical tree growth are modified by mean climate. In drier regions, growth sensitivity to temperature increases; in warmer regions, growth sensitivity to rainfall increases. The latter may imply that global warming leads to stronger drought effects on tree growth and possibly enhances mortality risks of tropical trees.

Our meta-analysis shows that tree-ring studies help to improve understanding of climate-driven carbon dynamics in tropical forests. Insights from this study can be used to benchmark global vegetation modelling and to better understand responses of tropical tree species to climate change.