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Developing a mechanistic model of tree growth

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Vegetation, especially forest, is an important regulator of atmospheric CO_2 and climate and therefore requires correct representation in models. Despite this, predictions of vegetation responses to environmental drivers by global vegetation models diverge widely from one another. This contributes to major uncertainties in predicting future atmospheric CO_2 and climate. Growth processes, in particular the dominant process of formation of wood, are currently not represented mechanistically in global vegetation models, which are driven primarily by carbon supply through photosynthesis. However, there is substantial evidence that carbon supply is frequently not limiting growth. If true, this would have fundamental implications for our understanding of the role of vegetation in the global carbon cycle.

To address this issue, we are exploring methods for incorporating meristem-led growth into a whole-tree representation of carbon dynamics, with equal attention to supply and demand processes. We are addressing the hypothesis of whether explicit inclusion of growth processes generates more realistic model responses than a purely source-led approach, when compared to data.

Our model includes wood formation, whereby the secondary meristems produce different cells numbers and properties dependent on internal and external factors. It represents different cell types (cambial, enlarging maturing and mature) and their transitions. Running on a daily time step, the model resolves wood structure intra-annually.

Our tree-growth model is tested using weekly microcore observations from a growth manipulation experiment on mature trees (white pine, red oak, and red maple) at Harvard Forest. An outline of the research project and the design of the manipulation experiment is presented in session BG2.2 (Turton et al).

Our model represents a novel approach to representing carbon dynamics within global dynamic vegetation models. In addition, our model has direct application for dendrochronological investigations and fundamental research on tree biology. Importantly, if a balanced approach of growth and photosynthesis proves to be superior to the current source-centric approach, projections of future terrestrial carbon and vegetation dynamics can be improved, with major implications for climate modelling and policy.