Tropical Forests and the Global Carbon Cycle

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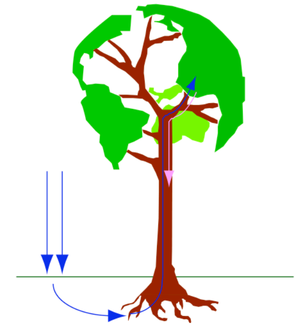
Tropical dendrochemistry



Tropical forests play a key role in the global carbon cycle, encompass diverse ecosystems and are sensitive to extreme events such as El Niño. Despite their importance, they remain poorly characterized compared to other ecosystems on the planet. Central to this shortcoming is the inability to date tropical trees through conventional means of ring counting. Quantifying the age distribution of tropical forest trees is an important step in order to determine long-term ecosystem sensitivity to climate and other disturbances, explore the timeline over which current climate records may be extended back in time, improve our knowledge of tropical carbon cycling and inform foresters of sustainable management practices.

Periodic cambial dormancy (interruption of growth) and the subsequent formation of visible growth rings come as a result of seasonal temperature variations, which are characteristic of temperate latitudes. Consequently, growth rings are uncommon in tropical trees as radial stem growth can occur uninterrupted throughout the year. Over the last century, studies documenting changes in ring widths, density and wood anatomy have reconstructed various facets of climate history of the mid latitudes, leaving tropical forest archives largely untapped (Figure 1).

Although temperatures vary little annually in the tropics, much of the region has distinct seasonal climates, as evidenced through patterns of rainfall and relative humidity (Figure 1). Based on the pulsing between wet and dry seasons, aspects of the wood chemistry may retain seasonal signatures of cambium activity.

Poussart and colleagues demonstrated that high-resolution $\delta^{18}O$ and $\delta^{13}C$ records recovered from ringless tropical trees and dated using bomb-radiocarbon (^{14}C) captured seasonal signals that could be used for age and growth rate reconstructions. Using trees from Indonesia and Thailand, they showed that these signals were reproducible on local and regional scales and in some instances, retained climatic information (Poussart *et al*., 2004, Poussart and Schrag, 2005).

However, because hydrological patterns are spatially heterogeneous, large statistically cross-dated sample sets are required to capture climatically robust signals (as in temperate forests). Current analytical capabilities for cellulose isotopic analysis pose a non-trivial impediment to the replication challenge.

In an article published this September in *Geophysical Research Letters*, Pascale Poussart, Satish Myneni and Antonio Lanzirotti developed a complementary and more efficient approach for reconstructing the age and growth history of ringless tropical trees based on dendrochemistry.

Seasonal variations of trace elements have been observed previously in temperate tree samples with annual growth rings. Using synchrotron X-ray microanalysis at the National Synchrotron Light Source in Brookhaven, Poussart, Myneni and Lanzirotti documented the first record showing Calcium and Zinc cyclical variations on a ringless tropical tree from Thailand. As shown in Figure 2, the calcium age model agrees within ≤ 2 years of bomb radiocarbon age estimates and confirms that the cycles are seasonal. Annual growth estimates are calculated based on the distance covered between two adjacent minima. The technique allows analysis on whole wood samples, requires minimal preparation and measurement time and provides low detection limits and µm-scale resolution for the simultaneous measurement of a range of elements.

The next step involves an assessment of whether seasonal variations of trace elements are common in tropical trees. To this end, Poussart and colleagues are surveying species growing in seasonally dry forests of Brazil, Panama and Indonesia (Figure 1). Poussart is currently evaluating alternatives to the synchrotron with collaborators at WHOI (bench top scanning X-ray fluorescence) and at MIT (Electron Microprobe) for dendrochemical measurements, which could make the analysis of large numbers of samples even more feasible. If this technique finds broad applicability in the tropics, elemental data records will help resolve fundamental controversies on the age of tropical forest trees and provide a baseline for developing sounder management practices.

Poussart P.M., Myneni S.C.B., Lanzirotti A. Tropical dendrochemistry: A novel approach to estimate age and growth from ringless trees. *Geophysical Research Letters*, 33. L17711 (2006).

Schiermeier Q. Bright sparks reveal invisible tree rings. Published online 15 September 2006. http://www.nature.com/news/2006/060911/full/060911-15.html

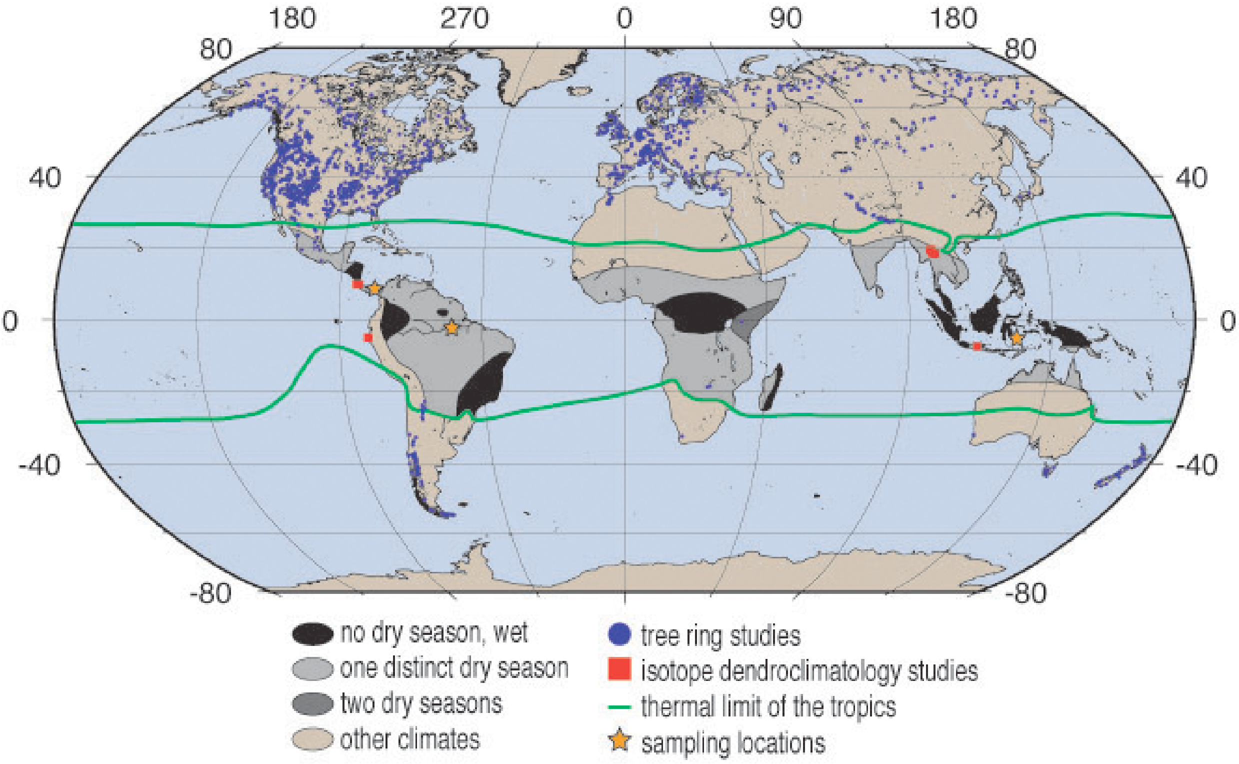


Figure 1: *Global map showing the distribution of tree ring studies (blue circles) as compiled by the World Data Center for Paleoclimatology as of January 2005 (Map created using iGMT). Red squares represent the location of tropical isotope dendroclimatology studies in Costa Rica, Peru, Indonesia and Thailand and yellow stars show the current sampling locations. Regional rainfall seasonality in the tropics is shown as grey and black shaded areas.*

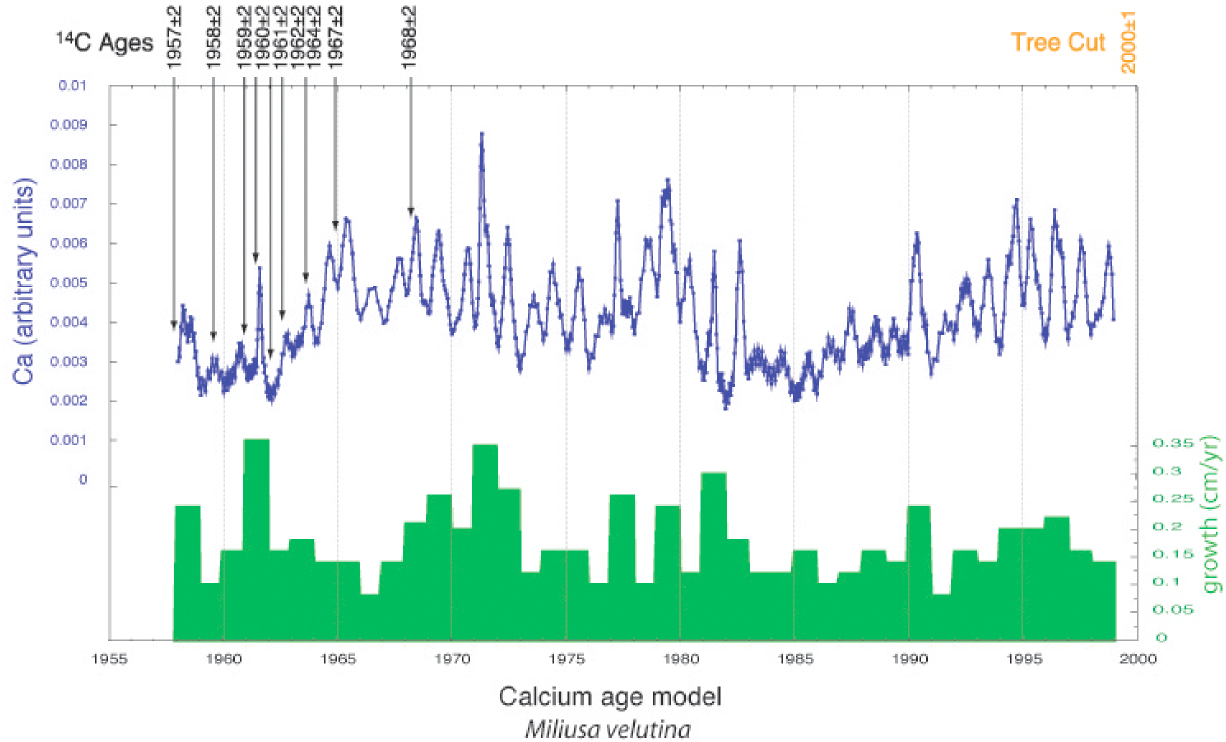


Figure 2: *Calcium age model for Miliusa velutina sample (PK1) from Pangmapa, northern Thailand. The radiocarbon and Ca chronologies agree to within ≤ 2 years and confirm a seasonal timescale of formation. Growth rate estimates based on Ca age model (cm yr^{-1}) are shown as green bars.*