Stable Isotopes From A High Elevation Tropical Tree Line Environment: Spatial And Temporal Variability

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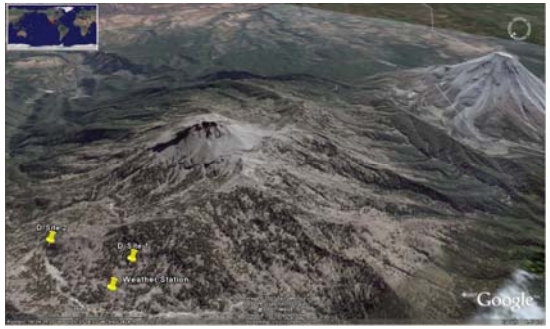
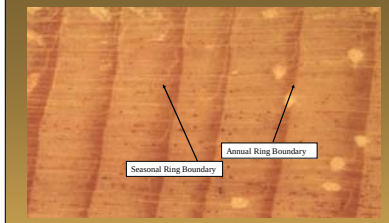
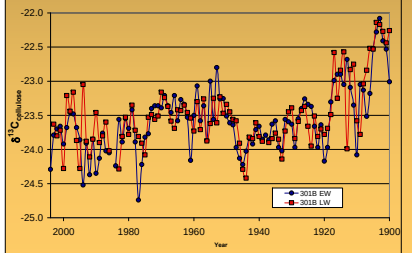


Introduction

Carbon and oxygen isotopic ratios of tree rings were examined at daily to monthly resolution in a tropical treeline environment to study environmental influences on tree growth. We focused on Mexican mountain pine (*Pinus hartwegii*), which grows on mountain tops in Mexico and Central America under a climatic regime dominated by the North American Monsoon system. Stable isotopes of carbon ($^{13}C/^{12}C$) and oxygen ($^{18}O/^{16}O$) during 2000-2004 followed distinct patterns. High (more enriched) oxygen isotopic ratios occurred at the latewood/earlywood boundary, which marks the transition between annual growing seasons, and corresponds to the months of October through March. Maximum carbon isotopic ratios occurred at the earlywood/latewood boundary, which is formed during the growing and summer monsoon season. The oxygen isotopes point to an evolving source of moisture during the monsoon, while the carbon isotopes suggest moisture stress both early and late during the growing season. Using detailed observations of atmospheric, soil, and tree size parameters, we developed a model of wood formation in response to climate variables. This model is compared to a seasonal resolution, century-long record of tree ring cellulose from the site and can be used to reconstruct climatic parameters beyond the length of instrumental records.

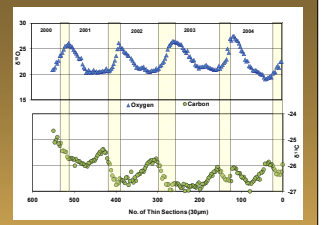
Isotopes in Tree Rings

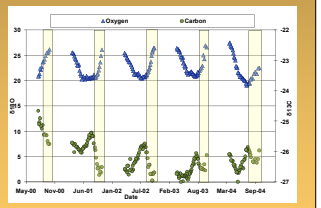




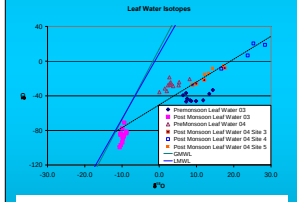
The dendrometers show clear seasonal growth starting in April coincident with increasing temperatures and sustained growth continuing with increased water availability during the Monsoon. Cessation of growth appears to be in October, coincident with the end of the Monsoon and the beginning of the tropical cyclone and winter precipitation regime.

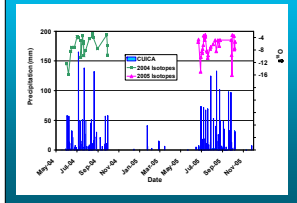
Stable isotopic analyses of the waters show a clear signal of different waters being used by the trees in cellulose formation. Early spring (pre Monsoon) is characterized by a low relative humidity and a high evaporation regime at the leaf surface. Results also show the trees using winter precipitation from relatively deeper soils. Post-Monsoon is characterized by wet soils, high relative humidity, and very little enrichment at the leaf surface. Xylem samples show water use consistent with shallower soils. For isotopic analysis of the cellulose, a high and low resolution approach was used. For the high resolution sampling, small 12mm cores were collected following the growing season in 2004 and sectioned at 30µm increments. Every third sample was run for carbon and oxygen isotopes. For the low resolution sampling, the rings were sectioned at the seasonal boundaries back to 1900. Carbon values are shown here, oxygen values are still being processed.





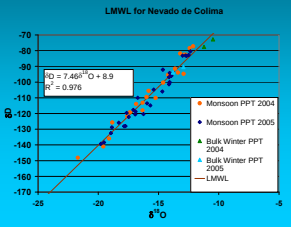
Ecohydrologic Monitoring

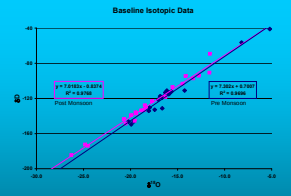




We have been co-monitoring environmental conditions and sampling for isotopes in the ecohydrologic cycle since 2001. To characterize the hydrologic and environmental regime the trees are growing under, two collectors were installed for precipitation chemistry in early 2003 and collection of spring samples has been going on since 2002. We have also carried out four isotopic characterization events, sampling soil, xylem and leaf water from pre and post Monsoon. Waters were extracted from soils and tissues and analyzed for stable isotopic composition. We have also collected weekly and event-based precipitation samples tracing the evolution of the monsoon—at the Universidad de Colima—for the purpose of developing a Local Meteoric Water Line (LMWL).

A weather station and a pair of dendrometer networks were installed just below the tree line at 3770 m (12,370 ft) in May 2001. The weather station is measuring soil and air temperature, soil moisture content, RH, barometric pressure, insolation, wind speed and precipitation amounts. The dendrometer networks consist of point dendrometers and additional environmental sensors measuring tree growth at the same time scale. Each network consists of 7 instrumented trees in a fenced off plot. This monitoring network allows us to track both the environmental conditions the trees are growing under and the isotopes they are incorporating into their matrix.

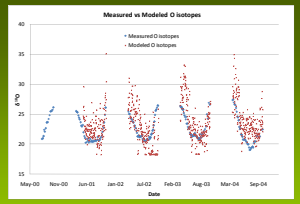


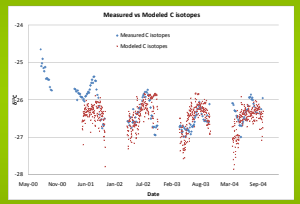


Mexico's forests have shrunk to a quarter of the size they were before the arrival of European colonists. The country has one of the highest deforestation rates in the world, losing about 1.5 percent of its forests and jungles—about 1.7 million acres—every year. The forests that remain are vulnerable to drought and insect attacks. Along with the loss of forests comes a major threat to catchments and watersheds. The protected area around Nevado de Colima is in the headwaters for both the Amería and Naranjo rivers, both important drinking and agricultural water sources in the states of Jalisco, Colima and Michoacán.

Further characterization of the monsoon history will lead to more skillful forecasts of future climate scenarios and the associated ecosystem response. A better understanding of plant water relations will allow for the establishment of rainfall records which go beyond the historic record, using xylem anatomy, dendrochronology, and stable isotope analysis. The combination of different source waters and different evaporation regimes leads to different cellulose isotopic values at the sub annual level. The ring structure, clear early and latewood bands, allows seasonal to sub-seasonal division of the rings for chemical characterization. Cellulose was extracted from ring sub samples and analyzed for ^{13}C and ^{18}O variations within the yearly growth. Modeling efforts have shed light on environmental parameters affecting growth. A better understanding of the Monsoon system—both temporal and physical—will be of great value for understanding hydrologic dynamics in the vast region watered by the North American Monsoon.

Modeling/ Future Work





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