Assessing the dendrochronological potential of tree species in highland Guatemala

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Introduction

Hundreds of tree-ring width and density chronologies provide a spatially extensive data network for high resolution paleoclimate reconstructions in temperate regions. Because they have annual or seasonal resolution and are exactly dated, these records can be empirically calibrated against existing instrumental data in order to develop quantitative reconstructions of past climatic variables.

Relatively few such tree-ring chronologies, however, have been developed in tropical regions. Despite some notable exceptions (c.f. *Therrell et al.*, 2006; *D'Arrigo et al.*, 2006; *Buckley et al.*, 2007), many trees in the tropics do not develop reliably annual rings whose variability reflects the influence of climate and can be utilized for paleoclimate reconstructions. Even when they form, or appear to form, annual increment bands, patterns of ring width variability may be incoherent between individual trees, making both chronology development and climate signal detection difficult (e.g. *February and Stock*, 1998). As a consequence, high-resolution, long terrestrial proxy climate records from the tropics remain sparse compared to temperate regions (Figure 1).

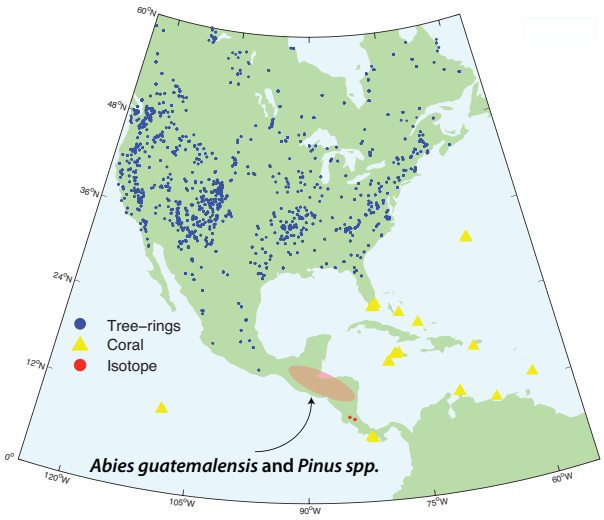

Figure 1: Existing tree-ring and coral chronologies available from the NOAA World Data Center for Paleoclimatology (as of July 2007). Also indicated are two sites in Costa Rica where tropical isotope dendroclimatology record are available. The range of Guatemala fir (*Abies guatemalensis*) and tropical pines (*Pinus*) are shown.

Several strategies are used by dendrochronologists to attempt to overcome these challenges (*Stahle*, 1999). In Mexico, the use of temperate species (*Pseudotsuga menziesii*) growing at high elevations has allowed David Stahle and his colleagues to extend tree-ring reconstructions of climate into the state of Pueblo in southern Mexico (c.f. *Therrell et al.*, 2004).

However, the distribution of *Pseudotsuga menziesii*, the species predominantly used for these studies, does not extend any further into Central America. While in the lowlands, Montezuma Cypress (*Taxodium mucronatum*) holds considerable promise for climate reconstruction, the continued expansion of traditional tree-ring width

dendrochronology into the mountains of Central America will require the evaluation of new species from new sites in the cordillera. There is a considerable need for high resolution, robust reconstructions of both precipitation and temperature in northern Central America, in order to evaluate natural low frequency climate variability, to expand gridded reconstructions of drought (*Cook et al.*, 2004) into Central America, and to test climate model projections that mountain regions will experience larger increases in temperature due to global warming than the lowlands (e.g. *Bradley et al.*, 2004).

My long-term plan is to develop new tree-ring records from the highland regions of Guatemala, Honduras, and Nicaragua. My initial pilot research will focus on the Altos Cuchumatanes Mountains in Guatemala. The highlands of Guatemala have several native species that hold considerable promise for use in dendrochronology, including *Abies guatemalensis* (Guatemalan Fir) and several species of *Pinus* (Pines) and even *Cupressus lusitanica* (Mexican Cypress). Gordon Jacoby found that *Pinus rudis* growing in the coastal volcanic mountain range of Guatemala formed annual rings (*Eckstein et al.*, 1981), and both *Abies* and *Cupressus* form rings in temperate regions.

Tree-ring chronologies from Guatemala may potentially provide important information about past climate conditions in the heart of the Maya empire, and will provide baseline data about natural climate variability in neotropical mountains. In the Cuchumatanes themselves, past 'droughts' alluded to in colonial records of the 16th and 17th centuries may be confirmed by tree-ring reconstructions of precipitation. Success in Guatemala will set the stage for further expansion of dendrochronology south along the Central American cordillera.

Research Plan Reconnaissance and widespread pilot sampling will take place in the first half of 2007 at sites identified by Matthew Taylor (University of Denver) and Michael Steinberg (The University of Alabama). Dr. Taylor and Dr. Steinberg have extensive experience over the last decade in Guatemala (c.f. *Steinberg and Taylor*, 2002), most importantly in the remote Cuchumatanes (see attached letters of support). The research will also involve collaboration with Guatemalan scientists and foresters. We will collect pilot samples from *Abies*, *Pinus*, and *Cypress*, as well as highland species of oak. The goals will be to establish that robust crossdating is possible and to evaluate the climate signal in pilot chronologies from these species.

The results from this pilot study will be used to support a collaborative grant for major funding to the National Science Foundation or the National Oceanic and Atmospheric Administration.

Budget

RT Airfare, New York to Guatemala City	$800.00
'HOBO' Data logging station (www.onsetcomp.com)	$1,226.00
Rental 4x4 including full insurance and diesel (14 days x $130)	$1,820.00
Per Diem (lodging, meals) (16 days x $40)	$640.00
Permits, expert guide and site access fees	$250.00
Shipping of samples and equipment	$200.00
excess baggage fee	$75.00
Total Requested from Climate Center	$5,011.00

Budget Justification The requested funds will be used to support a two week reconnaissance and extensive sampling campaign in the Altos Cuchumatanes, as part of team which will include Dr. Matthew Taylor and Dr. Michael Steinberg. Costs for room, boarding, food, and transportation are based on their recent experience planning fieldwork in the region, and reflect the need to access remote regions on marginal roads (necessitating a good rental vehicle and appropriate insurance). Permits and access fees, as well as the services of *guardabosques* (forest rangers) and collaboration with local foresters, also reflect their experience in the area and the important conservation status of the forests from which we wish to sample.

The installation of an automated HOBO-type weather logging ministation (at a secure site located by Drs. Taylor and Steinberg), with the capacity to collect temperature, relative humidity, solar radiation, and precipitation data, is important for evaluating the climate response of trees growing in the Altos Cuchumatanes. Early data will help assess the relationship between the seasonal cycle of tree-ring formation and climate conditions. Long-term monitoring will allow us to evaluate the climate signal in tree-ring chronologies and relate local climate variability to more distant but longer instrumental data from lower elevations. The importance of establishing climate monitoring locations in tropical mountains in particular has received increased attention in recent years (*Bradley et al.*, 2004).

References

Bradley, R. S., F. T. Keimig, and H. F. Diaz (2004), Projected temperature changes along the American cordillera and the planned GCOS network, *Geophysical Research Letters*, *31*(16), doi:10.1029/2004GL020229.

Buckley, B. M., K. Palakit, K. Duangsathaporn, P. Sanguantham, and P. Prasomsin (2007), Decadal scale droughts over northwestern Thailand over the past 448 years: links to the tropical Pacific and Indian Ocean sectors, *Climate Dynamics*, *29*(1), 63–71.

Cook, E. R., C. A. Woodhouse, C. M. Eakin, D. M. Meko, and D. Stahle (2004), Long-term aridity changes in the western United States, *Science*, *306*(5698), 1015–1018.

D'Arrigo, R., R. Wilson, J. Palmer, P. Krusic, A. Curtis, J. Sakulich, S. Bijaksana, S. Zulaikah, and L. O. Ngkoimani (2006), Monsoon drought over Java, Indonesia, during the past two centuries, *Geophys. Res. Lett.*, *33*, 4709, doi: 10.1029/2005GL025465.

Eckstein, D., J. Ogden, G. C. Jacoby, and J. Ash (1981), Age and growth rate determination in tropical tres: the application of dendrochronological methods, in *Age and growth rate for tropical trees: new directions for research*, edited by F. H. Bormann and G. Berlyn, School of Forestry and Environmental Studies Bulletin 94, Yale University.

February, E. C., and W. D. Stock (1998), An assessment of the dendrochronological potential of two *Podocarpus* species, *The Holocene*, *8*(6), 747.

Stahle, D. W. (1999), Useful strategies for the development of tropical tree-ring chronologies, *IAWA Journal*, *20*, 249–253.

Steinberg, M. K., and M. Taylor (2002), The impact of political turmoil on maize culture and diversity in highland Guatemala, *Mountain Research and Development*, *22*(4), 344–351.

Therrell, M. D., D. W. Stahle, and R. A. Soto (2004), Aztec Drought and the "Curse of One Rabbit", *Bulletin of the American Meteorological Society*, *85*(9), 1263–1272.

Therrell, M. D., D. W. Stahle, L. P. Ries, and H. H. Shugart (2006), Tree-ring reconstructed rainfall variability in Zimbabwe, *Climate Dynamics*, *26*(7), 677–685.

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Dr. Edward Cook, Chair of the Climate Center Committee
The Climate Center
Lamont-Doherty Earth Observatory
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Dear Dr. Cook,

I write this letter in support of the proposal by Kevin Anchukaitis in which he seeks funds to conduct paleoclimate research in Guatemala's highlands using tree-ring chronologies. Very little work, other than that conducted by W. George Lovell, Mike Steinberg and myself explores the Cuchumatán Mountains of Guatemala. Simply, civil conflict over the past 40 years has prevented research in the area.

Mike Steinberg and I have conducted research in the area for over 10 years and thus understand and support the type of work that Kevin is proposing. Quite simply, Kevin's work will provide a vital contribution to our understanding of the evolution of the area, the region, and the Americas in general. Moreover, this is the time to conduct the research before the last vestiges of old-growth forest fall to the axe and fireplace. The work that Kevin proposes will tie in perfectly with a sediment core that Mike Steinberg and I retrieved from a wetland in the Cuchumatanes in 2005. Our initial results suggest that this highland record serves as a "natural" record of climate change over the last 10,000 years, which can be used disentangle human from natural climate and/or vegetation change in the lowlands of Mesoamerica. The HOBO weather station that Kevin proposes is pivotal in establishing relationships between temperature, precipitation, and tree growth. Moreover, this station will be the first and only station in the region and will thus provide an important public service and good baseline information for future research.

We intend to fully collaborate with Kevin on this project. We will bring our years of field experience to the project. This experience includes an extensive network of contacts with local communities, an intimate knowledge of back roads and trails, and the location of appropriate forest stand for coring. Importantly, our experience ensures collaboration with Guatemalan researchers and universities.

Please contact me with any questions.

Sincerely,

Matthew Taylor

Dr. Edward Cook
Chair of the Climate Center Committee
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Dear Dr. Cook:

I write in support of Kevin J Anchukaitis's research in highland Guatemala. Kevin has proposed to conduct new and important climate research that will broaden our understanding of this unique, important, and understudied region.

The Cuchumatanes region, where much of Kevin's work will take place, presents a fascinating landscape anomaly compared with the surrounding areas in highland Guatemala and Mesoamerica in general. For example, this cold and remote plateau lies above the elevation limits of maize production, but supports several thousand rural Guatemalans. Maize cultivation and consumption is synonymous with Maya culture throughout Mesoamerica. Instead, the people of the region rely on sheep and potatoes. In terms of natural flora, the area also presents several anomalies. The highest reaches are dominated by páramo grasslands and scattered groves of juniper, pines, and fir forests found among rock outcrops and karst sinkholes. The páramo in the Cuchumatánes represents the most northern extent of this ecoregion in Central America. The upper reaches were also only one of two areas in Central America that were glaciated during the late Pleistocene, the other being the Cordillerra de Talamanca in Costa Rica. And while this region is unique, little climate or bio-physical data of any kind has been collected or analyzed (either contemporary or paleo-studies). This is remarkable given the uniqueness of this landscape.

I have worked in highland Guatemala for about ten years, know the area well, and have published various articles on the Cuchumatanes Mountains. I look forward to collaborating with Kevin in the future on this important project. I hope your center will be able to offer Kevin any assistance available regarding this research.

Best,

Michael K. Steinberg, PhD
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