Published in T.R. Karl (ed.), 1999, Proceedings of the 10th Symposium on Global Change Studies, American Meteorological Society, Boston, MA, pp. 161-162.

2B.10 A 400-YEAR TREE-RING CHRONOLOGY FROM THE NORTH AMERICAN TROPICS

Franco Biondi [(1)*], I. Galindo Estrada [(2)], A. Burton [(2)], S.E. Metcalfe [(3)], D.R. Cayan [(1)], and W.H. Berger [(1)]
[(1)] Scripps Institution of Oceanography, La Jolla, California, USA; [(2)] CUICA, Universidad de Colima, Mexico; [(3)] Department of Geography, University of Edinburgh, Scotland, UK

1. INTRODUCTION

Terrestrial climate records for the North American Tropics are needed to understand the interaction between regional and basin-wide phenomena, such as the monsoon and ENSO, respectively. Instrumental records are limited to the last century, and are continuous only at few selected locations. Proxy climatic records of longer duration with annual resolution and exact dating are rare, mostly because tropical tree species often form either unclear or undatable growth rings. In the Mexican tropics, however, trees at the highest elevations experience much stronger seasonality, and form clear growth layers (Arno and Hammerly 1984). We report here on a multi-century tree-ring chronology for *Pinus hartwegii* from Nevado de Colima, at the western end of the Mexican Neovolcanic Belt (Fig. 1).

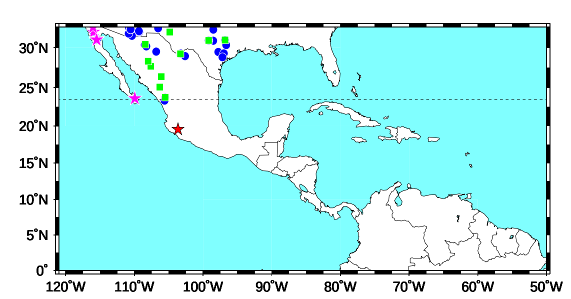

Fig. 1. Nevado de Colima (★) is the southernmost tree-ring site in the North American tropics (different symbols identify tree-ring sites from various datasets).

2. MATERIALS AND METHODS

In April 1997 we collected 128 specimens from 49 *Pinus hartwegii* trees. Despite past logging in the area, we were able to locate pines up to 500 years old. The oldest trees were found at 3600-3700 m elevation, i.e. about 300 m below the present treeline, where sampled pines were less than 100 years old. The tree-ring chronology was calibrated against climatic data from the Comision Nacional del Agua, Colima, and from the Global Historical Climate Network, version 2. Monthly precipitation and temperature records from six stations were compared to those derived from four years (1994-1997) of weather monitoring at 3500 m elevation on the Colima Volcano (Galindo et al. 1998).

3. RESULTS AND DISCUSSION

To date, 41 cores from 19 trees have been visually and numerically crossdated (Stokes and Smiley 1996). Mean segment length is 198 years, allowing the retrieval of interannual-to-interdecadal patterns (Cook et al. 1995). Sample depth (n_t) ranges from 34 to 10 cores back to 1700, and remains $\geq$ 2 cores back to 1600. We prewhitened the chronology by calculating the residuals from an AR(3) model (Box and Jenkins 1976; Fig. 2).

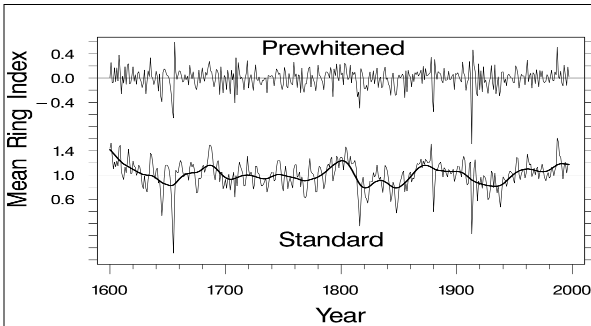

Fig. 2. Annual and interdecadal (thick line) tree-ring chronology (Standard), also shown after removing time-series autocorrelation (Prewhitened).

A few abrupt changes are visible in the chronology. Most trees show extremely low growth in 1913 and 1914 (Figs. 2 and 3), following the January 1913 Plinian eruption of the Volcan de Colima (Simkin and Siebert 1994). Other negative peaks are found in 1816 (Figs. 2 and 4), the 'year without a summer' (Harington 1992), and in 1655 (Fig. 2), but the connection with pre-1900 volcanic eruptions requires additional studies.

Based on data for 1949-1997, annual rainfall averages 800-1000 mm at all elevations, and is concentrated in the summer monsoon season (June-October). Temperature is more varied, with annual averages of about 7°C at the summit and of 23-26°C in the populated areas.

* *Corresponding author address:* Franco Biondi, Univ. of California-San Diego, Scripps Inst. of Oceanography, La Jolla, CA 92093-0215; e-mail: fbiondi@ucsd.edu.

Published in T.R. Karl (ed.), 1999, Proceedings of the 10th Symposium on Global Change Studies, American Meteorological Society, Boston, MA, pp. 161-162.

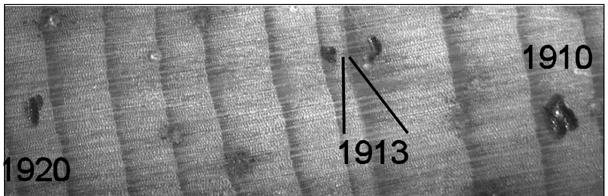

Fig. 3. Tree rings around year 1913, when a barely visible micro ring was formed (width = 0.092 mm). Of 31 measured cores, 12 had no visible ring in 1913.

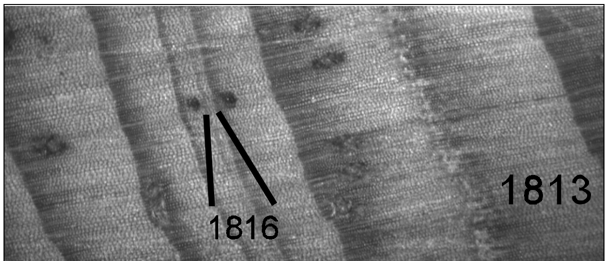

Fig. 4. Tree rings around year 1816, when a micro ring formed by a few rows of fibertracheids was formed (width = 0.127 mm). Also note the frost damage in the latewood of 1813; both of these features are common in many samples.

Temperature at treeline, which has decreased slightly from 1994 to 1997 (Galindo et al. 1998), appears to lead that in the valley. On the mountaintop, May is the warmest month, and December the coldest, while June and January are the corresponding extremes at the base of the mountain. Even at treeline, monthly mean temperature is never below zero, and monthly minimum temperature may fall below zero only in December and January (Galindo et al. 1998).

Climate/ tree growth correlations were not totally consistent when different stations were used, mostly because of trends in the data. Calibration results are reported here between the prewhitened chronology and the Colima station (Fig. 5), which had the longest record and no trends. Monsoon precipitation was the strongest signal, as shown by a significant positive response to June rainfall in the response function (Guiot 1991) for the 1950-97 period. Presumably, June precipitation favors tree growth because it marks the passage from the dry to the wet season, as well as the potential beginning of cambial growth.

Crossdating among annual tree-ring series indicates by itself the existence of an environmental factor that limits tree growth at large spatial scales (Hughes et al. 1982). Although individual years may have been affected by volcanic eruptions, either nearby or far away, average year-to-year variability in the *Pinus hartwegii* chronology is likely to reflect climatic patterns. Given the length of the chronology, and the presence of that tree species on mountaintops from Mexico to Honduras (Perry 1991), there is potential for developing a network of multi-century tropical chronologies. This, in turn, would provide a unique opportunity to uncover interannual and interdecadal patterns of tropical climate.

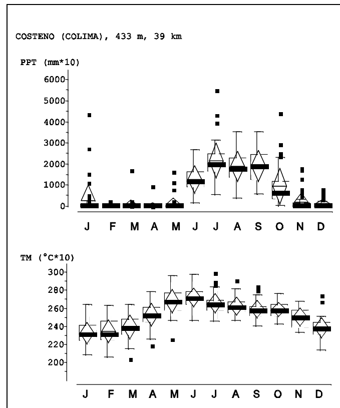

Fig. 5. Box-plot diagram of monthly precipitation and temperature at Costeño (Colima) from 1949 to 1997.

4. ACKNOWLEDGMENTS

We thank the Mexican authorities for permission to obtain tree-ring samples, and Shirley Imsand for help during field collections. Research funding was provided by NOAA Grant NA76GP0492 and NGS Grant 6060-97.

5. REFERENCES

Arno, S.F., R.P. Hammerly, 1984: *Timberline*. The Mountaineers, Seattle, WA.

Box, G.E.P., G.M. Jenkins, 1976: *Time Series Analysis: Forecasting and Control*. Rev. Ed. Holden-Day, Oakland, CA.

Cook, E.R., K.R. Briffa, D.M. Meko, D.A. Graybill, G. Funkhouser, 1995: The 'segment length curse' in long tree-ring chronology development for paleoclimatic studies. *The Holocene*, **5**, 229-237.

Galindo, I.E., A.T. Elizalde, R.S. Barajas, M.C. Calvario,1998: *Climatología del Volcán de Fuego de Colima*. Universidad de Colima, Mexico.

Guiot, J., 1991: The bootstrapped response function. *Tree-Ring Bulletin*, **51**, 39-41.

Harington, C.R. (Ed.), 1992: *The Year Without a Summer?* Canadian Museum of Nature, Ottawa.

Hughes, M.K., P.M. Kelly, J.R. Pilcher, V.C. LaMarche Jr.(eds.), 1982: *Climate from Tree Rings*. Cambridge University Press, Cambridge.

Perry, P.J.Jr., 1991: *The Pines of Mexico and Central America*. Timber Press, Portland, OR.

Simkin, T., L. Siebert, 1994: *Volcanoes of the World*. Second Ed., Geoscience Press, Tucson, AZ.

Stokes, M.A., T.L. Smiley, 1996: *An Introduction to Tree-Ring Dating*, University of Chicago Press.