Climate Center 4-10715 Progress Report:
Field trip, laboratory progress and preliminary results.

Date of the report: 30th April 2010

Project title: "Dendrochronological potential of *Polylepis* and *Espeletia* in the high-altitude ecosystems of the Colombian Central Cordillera, South America"

Climate Center Proposal: 4-10715.

CoPis: ***Dr. Laia Andreu Hayles,*** Postdoctoral Research Fellow, Tree Ring Lab, LDEO; ***Daniel Ruiz Carrascal***, Graduate Student, Department of Earth and Environmental Sciences; Graduate Research Assistant, International Research Institute for Climate and Society, LDEO; ***Dr. Kevin Anchukaitis***, Doherty Associate Research Scientist, Tree Ring Lab, LDEO.

Objectives: The main aim of this proposal is to assess the dendrochronological potential of plant species inhabiting the high-altitude ecosystems of the central region of the Colombian Central Cordillera. These activities represent the first step forward of our long-term research interests on reconstructing, through ring-width or isotope chronologies, the past climate variability in these environments with annual resolution for the Holocene.

Field trip period: 11 days from the 21st of February, 2010 to the 3rd of March, 2010.

Itinerary:

- Sunday Feb 21st: Flight from New York City to Medellín, Colombia.
- Monday Feb 22nd: Medellín (meeting, see summary below).
- Tuesday Feb 23rd: Trip from Medellín to Chinchiná (meeting, see summary below). Overnight in Manizales.
- Wednesday Feb 24th: Trip from Manizales to Los Nevados Natural Park, El Cisne base camp.
- Thursday Feb 25th: Los Nevados Natural Park (field work).
- Friday Feb 26th: Los Nevados Natural Park (field work).
- Saturday Feb 27th: Los Nevados Natural Park (field work).
- Sunday Feb 28th: Los Nevados Natural Park (field work). Trip back to Manizales. Overnight in Manizales.
- Monday March 1st: Trip from Manizales to Medellín.
- Tuesday March 2nd: Flight from Medellín to New York City.
- Wednesday March 3rd: Arrival to New York City.

Researchers involved in the field trip:

Dr. Laia Andreu Hayles (TRL-LDEO, Columbia University); Daniel Ruiz Carrascal (IRI, Columbia University; School of Engineering-Antioquia (Colombia), EIA); Cathy Vaughan (IRI, Columbia University), Maria Elena Gutiérrez Lagoueyte and Paula Andrea Zapata Jaramillo (School of Engineering-Antioquia (Colombia), EIA).

Brief summary of the meetings:

During the first days of our trip, we held several meetings with different institutions and Colombian researchers in order to introduce our research. Main topics included our professional background, the Climate Center proposal and our future research in long-term context. All our meetings were productive and we successfully established good relationships for developing our tree-ring research in the future. The meetings were specifically with:

- Colombian National Natural Parks Unit - UAESPNN. Location: Medellín. Appointment: February 21st 2010 at 10 am.
  Personnel: Juan Carlos Troncoso, Forestal Engineer, and Carlos Mauricio Herrera, Biologist and M.Sc. in Conservation Strategies.

- Paleoecology Group, National University of Colombia. Location: Medellín. Appointment: February 21st at 3 pm.
  Researchers: César Augusto Velásquez, Biologist, Ph.D in Paleoecology (Director); Luis Norberto Parra, Geologist, Ph.D in Paleoclimatology; Gonzalo Abril, Agronomy Engineer, M.Sc. in Paleoentomology; Yvonne Castañeda, Agronomy Engineer.

- Dendrochronology Lab, National University of Colombia. Location: Medellín. Appointment: February 22nd at 5 pm.
  Director of the Tree Ring Laboratory: Professor Ignacio del Valle Arango, Agronomy Engineer, Ph.D in Dendrochronology.

- Coffee International Research Center (http://www.cenicafe.org/). Location: Chinchiná. Appointment: February 23rd at 3 pm.
  Researchers: Fernando Gast Harders, Biologist, Ph.D in Biogeography (Director); Néstor Miguel Riaño Herrero, Agronomy Engineer, Ph.D in Agronomy (Researcher, level 3, Vegetal Physiology); Álvaro Jaramillo Robledo, Agronomy Engineer, M.Sc. in Agroclimatology (Researcher, level 3, Agroclimatology).

- School of Engineering –Antioquia (Colombia, EIA). Location: Medellín. Appointment: March 2nd at 11 am.
  Dr. Carlos Felipe Londono, President; Dr. Olga Lucia Ocampo, General Secretary.

Sampling campaign:

On February 24th we travelled from Manizales to the El Cisne site, in Los Nevados Natural Park (PNN Los Nevados). This place, located at 4000 m asl, was our base camp during our stay in the PNN. We overnighted there and made daily trips for our fieldwork. Our activities included exploring the region, locating potential good sites with GPS and sampling some trees of different species using increment borers.

Development of the specific objectives:

As was described in the proposal, the specific objectives include: (1) to develop a *Polylepis sericea* tree-ring width chronology; (2) to perform a stable isotope pilot study of *Espeletia hartwegiana* and; (3) to explore the dendroclimatic potential of other plant species.

(1) Polylepis sericea.

Three potential sites of *Polylepis sericea* trees were located with a Trimble GPS (see Figures 1 and 2). The trees formed forest patches around 4200 m asl, mainly restricted to steep slopes in most of the cases just below rocky formations (Figure 1, left picture). We sampled 18 cores from 11 living trees at the "Cañon de Termales" site (Figure 2). The extraction of the cores was not easy because the trees had multiple stems, making it really difficult, even impossible in some cases, to find a good place to bore the principal trunk (Figure 2, bottom right picture). These samples are currently being processed at the TRL. They have been glued in wooden mounts and polished successively using different polish papers (80, 320, 400 and 600 grit). The samples have been analyzed under the binocular in a preliminary step. Apparently, tree-ring boundaries do not seem to be clearly defined in this tropical tree species. However, we plan to work further making a finer polish using finishing paper ("Micro-mesh") of 1000, 1200 and 1500 grit, currently not available at the lab but that we already ordered. In this way, we expect to see with more detail the wood anatomical features, and consequently find some clue of the growth pattern of this species in this tropical high altitude environments.

We also sampled 5 cross-sections of 3 dead and 2 living *Polylepis* trees (Figure 3). The cross-sections were obtained using a manual saw from trees that were cut in the past, totally or only one of the secondary trunks. We cut a section from the main trunk when the tree was dead, and a section from the already cut secondary trunk when it was a living tree. The discs looked very promising, and most of them seem to belong to very old trees.

As was described in the proposal, this project is the first attempt to assess the dendrochronological potential of *Polylepis sericea*. Starting with a completely new species, it is highly recommended to have discs or cross-sections because the information on cores is sometimes not enough to determine the growth pattern. This is the reason why the difficulties we experienced when we analyzed the cores at the laboratory (described above) did not surprise us. Discs allow the dendrochronologists to see the growth of the tree for the complete section of the individual, making easier the understanding of the growth pattern. Unfortunately, the five discs collected during the field trip were quarantined and destroyed in the JFK airport when one of the researchers was bringing them to the United States, despite the fact that we had all the legal permits from the "Instituto Colombiano Agropecuario –ICA" and the USDA. Our main conclusion is that the incident was an unfortunate and arbitrary decision of DHS personnel. In order to avoid something like this occurring again, we are holding several meetings with researchers of the New York Botanical Garden to determine the safest way to bring the samples in to the United States the next time. At the same time, due to the scientific value of the discs, our collaborators from the EIA will collect more discs from the same trees in order to replace the lost ones. This new sampling will take place this spring or summer with no extra cost for this Climate Center proposal.

(2) Espeletia hartwegiana

We located a great number of populations of *Espeletia hartwegiana*, whose common name is "Frailejon" (Figure 5), that is endemic to the region. Although it is known that this plant species has a very slow growth, few of its phenology and physiological features have been described yet. Our first work *in situ* was a detailed visual observation of the anatomical structure of this plant. This first exercise was aimed at understanding the pattern of leaves formation, its bloom, trunk structure, etc. Figure 6 illustrates how we performed several of the field observations. We firmly believe that *Espeletia* is a suitable plant to develop the isotope experimental study described in the proposal for several reasons. We confirmed that *Espeletia* keeps most of the dead leaves along its stem or trunk for a very long time (Figure 5, above right picture). Considering that these plants are believed to experience very slow growth, the dead leaves closer to the ground are presumed to have been formed further back in time, and are therefore older than the ones located more close to the top of stem. The isotopic analyses of these dead leaves from the top to the bottom of the stem could give us $d^{13}C$ or d ^{18}O chronosequences that could be suitable for dendroclimatic studies.

As we expected, we also confirmed that the stem is empty inside because this plant does not have secondary growth (figure 7, left picture). Anatomically, *Espeletia* leaves are long and hairy with a woody base, once the first layer of tissue is removed (Figure 8). This woody base seems to be very suitable to perform stable isotope analyses. However, we found some methodological problems when we attempted to sample the leaves as describe in the proposal. The leaves are disposed in a dense spiral pattern also known as "rosette" (Figure 7, right picture) which made extracting individual leaves in vertical sequence more difficult than anticipated. In botany, a "rosette" is a circular arrangement of leaves, with all the leaves at a single height, and this rosette morphology is particularly common in the family Asteraceae, to which *Espeletia* belongs. The main problem was that any attempt to sample the leaves along a line from the top to the base of the plant was not simple because the integrity of the plant was in danger due to the shallowness of the its roots. *Espeletia* is a protected species, so currently we are working to find a strategy to sample the leaves without damaging the entire plant. It is not straightforward, but if it works, it could bring an innovative approach to work in environments where trees do not seem to form annual rings. Another approach using radiocarbon has been considered after this first experience in the field. We plan to select three very tall individuals and make measurements of radioisotope ^{14}C from four different bunches of leaves extracted from four different heights. Because the leaves at the top of the plant are the newest and those at the bottom are the oldest, analyzing leaves at different heights will allow us to determine if there is an age trend in the plant material extracted along the stem of *Espeletia harwegiana*.

(3) Other tree species

We found species including "Guayabo Negro", "Acuapanto" and *Gynoxis* sp, that, though they do not look to be as long-lived as *Polylepis,* showed a big trunk and enough height to be considered good candidates for dendrochronological work. We took 9 cores from 5 trees ("Guayabo negro" and "Acuapanto)" from an area called "Salto de la Cueva" (Figure 4), outside the limits of the Natural Park. Near to this site we found an apparently old forest of "Guayabo Negro" with old living trees, as well as many stumps of large diameter (Figure 4: bottom right picture), the result of past management activities in the area. This place could be good site to sample in the future. The samples collected will be analyzed in the following weeks at the TRL.

Complementary research

Complementary activities conducted by the International Research Institute for Climate and Society - Columbia University in partnership with the School of Engineering in Antioquia (Colombia) include:

- Correlation analysis between all-type cloud amounts observed over the El Ruiz - Tolima volcanic massif where Los Nevados Natural Park is located and sea surface temperature anomalies (SSTa) observed in the Niño 3.4 region, as well as the first principal components of SSTa observed in the tropical belts of the Indo-Pacific and Atlantic oceans.
- Exploratory (temperature thresholds) and homogeneity analyses (analysis of changes in the mean, changes in the variance, and long-term historical trends) of minimum temperatures on the coldest days, maximum temperatures during the warmest days and mean near-surface temperatures, observed in the network of meteorological stations deployed in the surroundings of the El Ruiz- Tolima volcanic massif.
- Wavelet-frequency analysis of minimum monthly temperatures on the warmest days, average minimum monthly temperatures, minimum monthly temperatures on the coldest days, and day-to-day standard deviation of minimum temperatures, gathered at four nearby weather stations with the longest historical time periods.
- Analysis of the annual cycles of near-surface dew point, relative humidity, and ambient temperature recorded by the temperature/relative humidity data loggers recently installed in El Cisne base camp and its surroundings.

Future proposals

As a result of this Climate Center proposal, the researchers from the School of Engineering in Antioquia (Colombia) and Columbia University have been invited to participate in the submission of a full proposal to the MacArthur Foundation. We will work in collaboration with several international institutions under the leadership of the Inter-American Institute of Global Change Research (IAI). This full proposal will be submitted at the end of May as a requested by the MacArthur Foundation after reviewing the letter of intent. This new project is entitled "*Impacts of climate change on biodiversity in the Tropical Andres: climate-related vulnerability assessments and improved decision making processes for conservation and land use planning in two Andean biodiversity hotspots*". Activities will be conducted in two binational transboundaries areas spanning elevation gradients of approximately 4500 m asl in the Pacific slope of the Northern Andres (between Colombia and Ecuador) and in the Amazonian slope of the Central Andes (between Bolivia and Peru). This new proposal for the MacArthur is an important result of this Climate Center seed funding and represents the first step for our long-term research interest in South America. We hope to apply for more proposals during the following years to the NSF and other North American Institutions.

First publication

Just 2 months after receiving the Climate Center funding, a short article has been posted. Cathy Vaughan, from the IRI of Colombia University, has recently posted a brief summary of the research conducted during our field trip on "Climate Matters @ Columbia", the blogs website from the Earth Institute:

http://blogs.ei.columbia.edu/climate/

PICTURE GALLERY

Figure 1. *Polylepis sericea* trees in the trail to "Laguna Verde", Los Nevados Natural Park, Colombia.

Figure 2. *Polylepis sericea* forest outside the perimeter of Los Nevados Natural Park, Colombia. This site is called "Cañón de Termales" and 11 living trees were sampled.

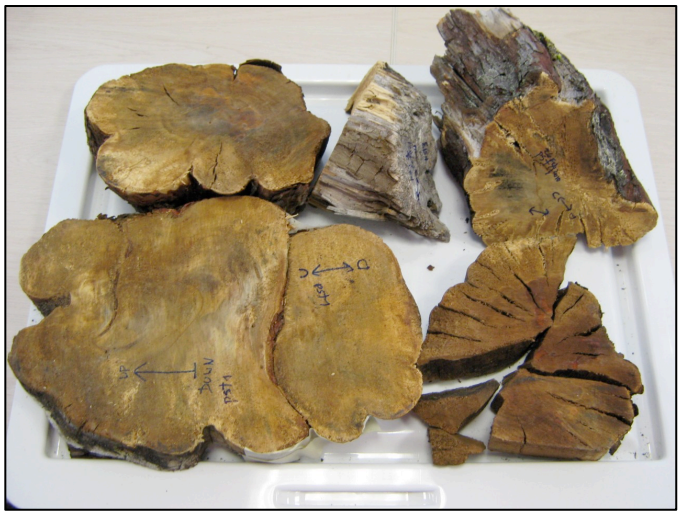

Figure 3. Five cross-sections of *Polylepis sericea*.

Figure 4. "El Salto de la Cueva" site on the two pictures above. Mature forest of "Guayabo Negro" in the surroundings of "Salto de La Cueva" were georreferenced. The bottom left picture shows a "Guayabo Negro" tree. The bottom right picture depicts a stump in the located old "Guayabo Negro" forest.

Figure 5. *Espletia hartwegiana* populations. Note that each individual keeps the dead leaves along the stem. Considering the slow growth of these plants and the great height of some of them, the leaves or even the stem itself may be a suitable proxy for paleoclimatic research.

Figure 6. Observations *in situ* of individuals of *Espeletia hartwegiana*.

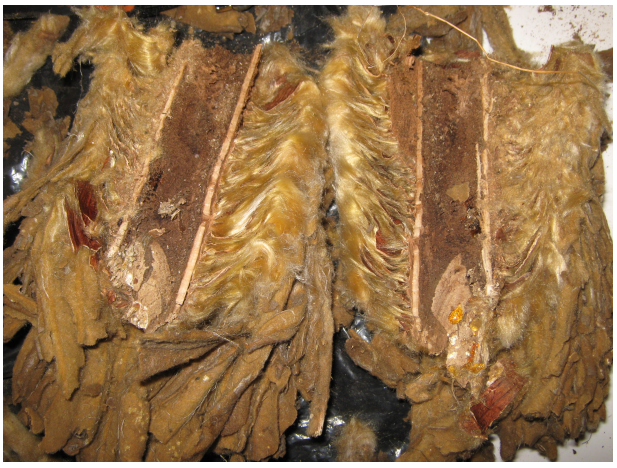

Figure 7. Left: Dissection of *Espeletia hartwegiana* at the laboratory. Note that this plant does not show secondary growth (empty stem). Right: leaves are arranged in dense spiral pattern ("rosseta", see text for more information).

Figure 8. *Espeletia hartwegiana* leaves. Note the hairy and long leaves end in a woody base suitable for isotope analyses.