

Annual Report for Period:10/2009 - 09/2010

Submitted on: 08/23/2010

Principal Investigator: Scatena, Frederick N.

Award ID: 0722476

Organization: U of Pennsylvania

Submitted By:

Scatena, Frederick - Principal Investigator

Title:

CZO: Luquillo Critical Zone Observatory

Project Participants

Senior Personnel

Name: Scatena, Frederick

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Brantley, Susan

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: White, Art

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Johnson, Arthur

Worked for more than 160 Hours: Yes

Contribution to Project:

Oversees research in surface soil biogeochemistry and coordinates the establishment and maintenance of the LCZO soil network. Supervises 2 PhD students

Name: Plante, Alain

Worked for more than 160 Hours: Yes

Contribution to Project:

Oversees research in soil carbon quality and dynamics. Supervises 1 PhD student and co-supervises 1 post-doc. Has established collaborative carbon research with Christina CZO.

Name: Jerolmack, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Oversees research related to sediment transport and fluvial processes. Established 3 sediment transport monitoring stations and co-supervises a PhD student.

Name: Silver, Whendee

Worked for more than 160 Hours: Yes

Contribution to Project:

Professor Silver is responsible for studies in soil biogeochemistry and soil oxygen dynamics. Supervises 1 PhD student and was responsible for installing soil oxygen nodes in study watersheds

Name: McDowell, William

Worked for more than 160 Hours: Yes

Contribution to Project:

Responsible for analysis of LCZO water samples and for conducting studies in the riparian zones of the main research areas.

Name: Buss, Heather

Worked for more than 160 Hours: Yes

Contribution to Project:

USGS Geochemists responsible for USGS-LCZO coordination and the development of the 3 observation wells

Name: Scholl, Martha

Worked for more than 160 Hours: Yes

Contribution to Project:

USGS Hydrologist/Geochemists responsible for isotopic studies to determine flow paths of water. Is conducting weekly rainwater sampling.

Name: Shanley, Jamie

Worked for more than 160 Hours: Yes

Contribution to Project:

USGS research hydrologist responsible for Mercury studies and WEBB hydrologic sites.

Name: Dmochowski, Jane

Worked for more than 160 Hours: No

Contribution to Project:

Director of UPENN Undergraduate programs in Earth and Environmental Science, was involved in developing CZO-REU program proposal, and has been working with Scatena, An, and students on developing LCZO based education materials for undergraduates.

Post-doc

Name: Bedison, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Initiated soil carbon quality studies and development of Luquillo CZO soil network. Was funded for 9 months by USFS grant

Name: Clark, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Coordinated and managed summer soil survey with Professor Johnson and will manage the processing of the soils. Partly supported by a grant from the USFS

Graduate Student

Name: Hall, Steven

Worked for more than 160 Hours: Yes

Contribution to Project:

Graduate student at UC Berkeley who is working with Professor Silver on soil oxygen dynamics

Name: Jimenez, Rafael

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN student in Masters of Applied Geoscience program who spent 5 weeks in Puerto Rico assisting the drilling of the 3 observation wells. He is also working with McDowell on a capstone project on the biogeochemistry modeling of LCZO riparian zones

Name: Nawl, Cindy

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN student in Masters of Applied Geoscience program who is writing her capstone project on potential Mercury contamination of the Luquillo CZO. Shanley is outside-reader. LCZO funded 2 week field survey.

Name: Phipps, Colin

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN PhD student working with Jerlomack and Scatena on sediment transport and exports of Luquillo streams.

Name: Moore, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Masters Student from University of Southern Mississippi, spend 3 months in field survey canopy sites for LIDAR and assisting in soil surveys.

Name: Nagy, Suzzane

Worked for more than 160 Hours: Yes

Contribution to Project:

Brown University Masters student who assisted in the entire summer soil survey and who will be using soils as part of her Masters thesis.

Undergraduate Student

Name: Leung, Shirley

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN undergraduate work study student who assista in managing hydrologic and climate data and LCZO Ozone monitoring system. Worked several days per week for academic year.

Name: An, Grace

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN undergraduate work study student who has assisted in data management and in the development and testing of LCZO based homework assingments for undergraduates. Worked part time during Spring and summer

Name: Karaman, Joanne

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN undergraduate summer soil field crew member

Name: Lim, Swee

Worked for more than 160 Hours: Yes

Contribution to Project:

UPENN undergraduate summer soil field crew member and assisted in laboratory during academic year. Will do a senior thesis using soil data collected this summer

Technician, Programmer

Name: Leon, Miguel

Worked for more than 160 Hours: Yes

Contribution to Project:

Information manager, responsible for web site and data management

Name: Estrada, Carlos

Worked for more than 160 Hours: Yes

Contribution to Project:

USFS Hydrologic technician responsible for managing Bisley Watersheds and Luquillo Climate stations

Name: Salgado, Jean-Carlos

Worked for more than 160 Hours: Yes

Contribution to Project:

LCZO technician responsible for weekly water sampling and maintenance of field sites and equipment

Name: Figueroa, Manuel

Worked for more than 160 Hours: Yes

Contribution to Project:

USGS Technician responsible for USGS gaging stations. Assists USGS researchers and students in the field and in collecting samples

Other Participant

Research Experience for Undergraduates

Organizational Partners

US Geological Survey

The USGS Water, Energy, and Biogeochemical Budgets (WEBB) program:

- ? Provided direct financial support of approximately \$ 100,000 to drill and instrument three deep observations wells.
- ? Provide basic research and transportation costs for 4 Research Scientists (Buss, Scholl, White, Shanley) and several local hydrologists (J. Rodriguez, M. Figueroa)
- ? Provide direct financial support in upgrading stream gages and in collecting hydrologic information for the Iacos and Guaba watersheds.

USFS International Institute of Tropical

USDA-Forest Service International Institute of Tropical Forestry

- ? Provide basic research support for the participation of three Research Scientists (Gould, Gonzales, Heartsill-Scally) and three hydrologic technicians (Estrada, Moya, Torrens). Dr. W. Gould, Research Ecologist participated in the LIDAR planning and providing access to existing remote sensing data. He will also co-supervise future graduate student in remote sensing of the LCZO site. Dr. G. Gonzales, Research Ecologist, participated in the planning of the LCZO soil network and has provided access and data from series of permanent vegetation plots that span the Luquillo elevational gradient.
- ? Provided direct financial support to re-open and improve the Bisley Road after it was closed by landslides in April 2010.
- ? Provided direct financial support in upgrading and maintaining hydrologic equipment in the Bisley Experimental Watersheds and associated climate stations at Sabana and East Peak.
- ? Provided direct financial support to upgrade the Sabana Field Station laboratory and housing facilities, which will be completed in 2011.

Other Collaborators or Contacts

During the past year the LCZO has has the following collaborations:

Brown University

- ? Collaborations with Asst. Professor Stephen Porter, Post-Doctoral Researcher Steve Goldsmith, and Masters Student Suzie Nagy. The LCZO is collecting water and rock samples for their NSF supported studies on the weathering of granitic rocks. Master degree Student S. Nagy also participated in the entire July 2010 soil dig and will be using some of the samples for her Masters thesis on soil phosphorous.

Boston University

- ? Associate Professor Andrew Kurtz & graduate student Ken Takagi attended the May LCZO Science meeting and the LCZO has agreed to help them with the hydrologic sampling for a project on silica cycling in the Bisley watersheds. The LCZO also wrote them a letter of support for a NSF grant they submitted in July.
- ? Dr. Crystal Barker Schaaf, Research Professor in the Center for Remote Sensing of the Department of Geography has submitted a proposal to NASA to undertake some ground based lidar measurements of the Luquillo forest canopy. The LCZO has written a letter of support and agreed to allow them access to the long-term vegetation plots and LCZO study areas.

University of Puerto Rico

? Professor Olga Mayol; The LCZO is coordinating and providing climate measurements with her NSF funded project on the influence of African Dust on Luquillo precipitation. Scatena and Mayol also taught a short course to UPR students on the Climate, Hydrology and Critical Zone processes in the Luquillo Mountains in May and June 2010.

? Luquillo LTER Site (Luq-LTER) and El Verde Field Station; Weekly water sampling and information management has been coordinated with the Luq-LTER group, LCZO researchers have also stayed at the El Verde field station and participated in LUQ-LTER summer seminars.

University of Bristol,UK

? Dr. Heather Buss, the LCZO-WEBB coordinator, was a Visiting Researcher in the Department of Earth Sciences from March to August 2010. During this visit she developed a novel biogeochemical multi-tracer using Mg and Li isotopes. A large dataset is being generated by analyzing LCZO samples and be used to demonstrate the potential of the multi-tracer technique and to advance the models of biogeochemical cycling currently being developed for the Luquillo site.

Penn State University

? Meredith Ruitz, a UPenn Doctoral student will spend three months (September 2-November 30) working in the lab of the Groupe de G?omorphologie at the Institut de Physique du Globe in Paris, France. Travel costs, approximately \$9,500, are being funded by a NSF Supplemental Grant (EAR 07-25019) to Tim White of the Shale Hills CZO. During her exchange she will work under the supervision of Eric Lajeunesse, a physicist/geomorphologists who has expertise in using small-scale experiments to explore fundamental geomorphic processes. Her research will investigate aspects of the modes and self-organization of sediment transport in braided rivers using both experimental and analytical approaches. She will also learn high-resolution techniques for measuring topography in laboratory experiments that will be applied to LCZO studies.

? Nicol Khan, received travel funds to spend 5 weeks at the Kingsley Dunham Centre's Isotope Lab of the British Geological Survey in Keyworth, Nottingham, UK. A UPenn undergraduate accompanied her with separate supported provided by the UPENN Department of Earth and Environmental Science. During the visit they analyzed 214 LCZO samples for stable carbon isotopes (^{13}C) and C:N ratios. They also were involved in developing a column chromatography based technique to isolate sterols that are commonly found in sewage from sediment samples. This technique will eventually be used to on samples from Puerto Rico to isolate molecular biomarkers and further aid in the distinction of mangrove floral zones. UPENN Undergraduate student Sarah Flacker also accompanied her to the Isotopic lab with separate funding from the UPENN-EES Summer Paleobiology fund and participated in the field work with funding from the LCZO.

? The LCZO wrote a letter of support and has agreed to help with logistical support for a proposal entitled 'A Collaborative Research: Biological Weathering of Deep Regolith at the Luquillo Critical Zone Observatory' that has been submitted to NSF by M. Bruns Associate Professor of Soil Microbiology and Hector Ayala of the University of Puerto Rico Humacao. This proposal will extend previous research on microbial weathering in the LCZO and provide another opportunity to integrate the LCZO with local Universities.

The following organizations also used the facilities and/or participated in LCZO activities:

- ? United Nations Educ. Scientific & Cultural Organization (UNESCO), Hydrology for the Environment, Life and Policy (HELP) program
- ? Groupe de G?omorphologie, Institut de Physique du Globe,France
- ? Kingsley Dunham Centre's Isotope Lab, British Geological Survey
- ? Luquillo Long-term Ecological Research Network
- ? University of New Hampshire; Water Quality Analysis Laboratory
- ? University of Puerti Rico; Institute for Terrestrial Ecosystem Studies, Dept. Geology-RUM, Dept. Biology-Humaco
- ? Turabo University, Puerto Rico
- ? Franklin and Marshall College

The LCZO Advisory Board includes:

- Bras Rafael, Dean and Professor of Hydrology
- Lugo, Ariel, Director of USDA-FS International Institute of Tropical Forestry, Forest Ecologist

Pavich, Milan, USGS Geochemist
Larsen, Mathew, USGS Hydrologist, Director

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings:

As most of the field work was initiated in the summer of 2010, all findings must be considered preliminary. Nevertheless, in addition to the findings mentioned under activities, the following observations can be made:

? Deep observation wells encountered highly weathered saprolite to depths greater than 37 meters. Previous field work has indicated the weathering zone to be approximately 10 meters thick. The observation wells also confirmed that the fracture density and petrology of bedrock under ridges is different than that of valleys and suggest that the entire Bisley watersheds may have been a landslide in the distant past.

Training and Development:

? A short course on 'Climate, Hydrology and Critical Zone Processes of the Luquillo Mountains' was taught by Scatena to 8 University of Puerto Rico graduate students in late May-Early June 2010. The course had a total of 15 hours of contact time and involved having students use LCZO environmental data. UPR Professor Olga Mayol participated in the seminars. Travel support was provided by the University of Puerto Rico.

? Development of LCZO data based homework assignments for undergraduates. These assignments involve doing basic time series analysis on climate and hydrologic data sets collected by the LCZO. The first assignment used LCZO climate data to compare rainfall across the Luquillo Mountains and will be tested in classes this Fall. Future assignments will involve soil and geochemical data.

? Sponsored and coordinate 2 LCZO Project Scientists meetings, one in January 2010 and a second, larger meeting in May 2010. These meetings were attended by approximately 50 participants and were focused on establishing sampling protocols and designs for collaborative projects. Participants from the Luquillo LTER, the University of Puerto Rico, Boston University, the local USGS and USFS attended the meeting. See LCZO web page for details and power points of the presentations.

? As of August 2010, 3 Post-doctoral researchers, 8 graduate students and 6 undergraduates have been recruited to conduct research at the LCZO. All of these individuals will be mentored by several LCZO research scientists and will be actively involved with the LCZO data management system.

Outreach Activities:

Luquillo Critical Zone Observatory Researchers organized the following sessions in professional conferences:

Advances in Critical Zone Research: Interactions among Water, Rock and Life at Earth's Surface. AGU Fall Meeting 2010, USA. Organized by Riebe C. and Buss H.L

Lithologic and Erosional Influences on Critical Zone Processes. Goldschmidt 2010, Knoxville TN, USA. Organized by Buss H.L. and Riebe C.

Waters in the Critical Zones: Major Elements, Trace Elements, and Isotopes as Biogeochemical Tracers. AGU Fall Meeting 2009, San Francisco, CA, USA. Organized by Jin L. and Buss H.L.

Journal Publications

Buss H.L., Mathur R., White A.F., Brantley S.L., "Iron and phosphorus cycling in deep saprolite, Luquillo Mountains, Puerto Rico.", Chemical Geology, p. 52, vol. 269, (2010). Published,

Minyard M.L., Bruns M.A., Liermann L.J., Buss H.L., Brantley S.L, "Bacterial Associations with Weathered Minerals in Deep Tropical Saprolite Formed from Quartz Diorite", *Geobiology*, p. , vol. , (2010). Submitted,

Minyard, M.L., M.A. Bruns, C.E. Martinez, L.J. Liermann, S.L. Brantley, "Occurrence of halloysite nanotubes and bacteria at the interface between saprolite and quartz diorite bedrock, Rio Icacos Watershed, Puerto Rico.", *Soil Science Society of America*, p. , vol. , (2010). Accepted,

Scatena F.N., Gupta A., "Streams of the Montane Humid Tropics", *Treatise on Geomorphology Fluvial Geomorphology Volume*, p. , vol. , (2010). Accepted,

Shanley J.B., McDowell W.H., Stallard R.F., "Long-Term Patterns and Short-Term Dynamics of Solute and Sediment Export from a Rapidly Weathering Tropical Watershed", *Water Resources Research*, p. , vol. , (2010). Submitted,

Books or Other One-time Publications

Minyard M.L., "Microbe-Mineral Associations in Tropical Saprolite and Saprock formed from weathered quartz diorite.", (2010). Thesis, Published

Bibliography: PhD Dissertation. Department of Crop and Soil Science, Pennsylvania State University, 165 pages

Phillips, C., Scatena F.N., "Flashiness indices for urban and rural streams in Puerto Rico.", (2010). Conference proceedings, Accepted
Bibliography: Proceedings of the Tropical Hydrology Specialty Conference of the American Water Resource Association. Rio Mar Puerto Rico, August 29, 2010

Bedison J.E., Scatena F.N., Plante A., Gonzales G., "Spatial controls on carbon quality along an elevation gradient in northeastern Puerto Rico.", (2010). Poster, Published

Bibliography: Poster presented at the 2010 Goldschmidt Conference

Buss H.L., Dessert C., White A.F., Vivit D., Blum A.E., Sak P.B., and Gaillardet J., " Mineral nutrient profiles on differing lithologies at three tropical critical zone sites.", (2010). Abstract, Published

Bibliography: Abstract and oral presentation
at the 2010 Goldschmidt Conference

McDowell W.H., Scatena F.N., Lugo A.E., "Impacts of Hurricanes on Elemental Cycles: Separating short-term and long-term effects on Stream Chemistry.", (2010). Abstract, Accepted

Bibliography: Abstract and Presentation International Association of Limnology meeting in Cape Town, South Africa

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

The project has begun to provide advanced training on Critical Zone Processes to: 3 Post-doctoral researchers, 8 graduate students and 6 undergraduates. We have also given a short course on Critical Zone Processes to 8 students at the University of Puerto Rico.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Web/Internet Site

Any Product

Contributions: To Any within Discipline

Contributions: To Any Other Disciplines

Contributions: To Any Resources for Research and Education

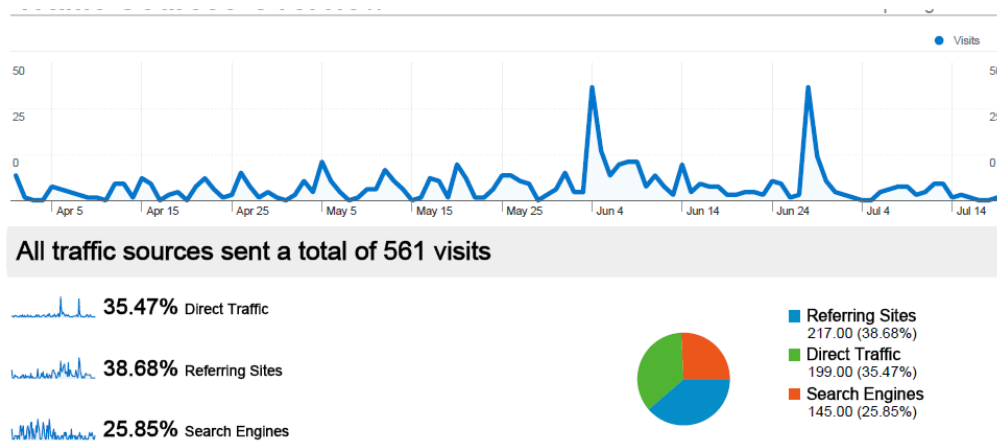
Contributions: To Any Beyond Science and Engineering

Any Conference

Luquillo Critical Zone Observatory Activities 2009/2010

Information Management

- Established a searchable LCZO web page and data management system (<http://www.sas.upenn.edu/lczo/index.html>.) The system allows individual investigators to update their data files and documentation. As of July 29, 2010, 20 project descriptions that contain a total of 66 data files were online.
- Between April and July 2010 the LCZO web page had independent 561 visits from 26 countries. Pages on the site were viewed 3964 times



- The LCZO Information Manager, Miguel Leon, participated in a CZO Data Management meeting in Denver and had numerous meetings with other CZO, LTER, and ULTRA information managers. The LCZO web site is now compatible with the major features of these other NSF supported information management systems.
- The LCZO Information Manager, Miguel Leon, has developed and deployed a web-based system for generating standardized meta-data that will enable the aggregation of all LCZO related data by the Spatial Information Systems Laboratory at the San Diego Supercomputer Center. This system was deployed in late July 2010 and is being currently being tested.

LCZO Surface Soil Studies and Soil Network

- Eight students, plus UPenn Professor Art Johnson and Post-Doctoral Researcher John Clark spent the month of July 2010 establishing and sampling a network of soil pits across the LCZO site. Total of 180 pits were sampled in a stratified random design that can be used to compare soil forming factors by bedrock geology, elevation/climate, forest type, and topographic position. Approximately 800 pounds of soils were collected and

are currently being processed and archived for further use by collaborators. The soils collected will be analyzed as part of a Master's thesis at Brown University, a PhD thesis at UPenn, and several other student related projects.

The students who participated in the entire 6 day per week-4 week dig included; 2 UPenn-Masters of Applied Geosciences students, 2 UPENN Undergraduates; 1 Brown University Masters Student; and 1 University of Southern Mississippi Masters Student. Additional participants included 2 UPenn Professors, 2 UPenn PhD students and 1 Research Associate from Franklin and Marshall College.

- In accordance with hypothesis 4 of the proposal, 24 Prenart Super Quartz tension lysimeters and accompanying soil oxygen probes were installed at various locations in the LCZO. After an initial calibration period, surface soil redox conditions will be manipulated and the response of greenhouse fluxes and soil solution chemistry will be quantified. This project is part of a PhD thesis by Stephen Hall of UC Berkeley that is being supervised by Professor Silver. The samples will be analyzed at the Water Quality Laboratory of the University of New Hampshire under the supervision of Professor W. McDowell, who is an external advisor to the graduate student.

LCZO Weathering Studies and Deep Observation Wells

- With additional financial support of the USGS WEBB program, three deep observation wells were drilled and sampled in the LCZO during July 2010. These wells will be used to sample deep water and rocks for geochemical studies of weathering. The primary goal of the project is to answer longstanding questions about lithology, bedrock fracture networks, and the bedrock-regolith interface in previously inaccessible subsurface areas. The subsurface lithology of all wells was sampled and one is currently being equipped with a water sampling system. One well was drilled to 37 m, the second to 27 m, and the third to 10 m. Four USGS Scientists (Buss, White, Johnson, Rodriguez) and 1 UPenn Masters student (Jimenez) were directly involved with the drilling and logging of the wells. The most surprising observation to date is that highly weathered saprolite extends to a depth of 37m in some areas.

Coastal and Sea Level Rise Studies

- In accordance with the objectives of Hypothesis 7 in the proposal, two UPenn Graduate students, 1 UPenn post-doctoral researcher, 1 UPenn undergraduate, Dr. Ben Horton of UPenn and Dr. Chris Vane of the British Geological Service establish sampling transects in coastal mangroves of Volcanoclastics and Grandioritic watersheds. During late May of 2010, the team conducted detailed topographic surveys of the coastal zone and collected a total of 214 samples (92 core samples, 73 surface sediment samples, 15 litter bag samples, and 34 vegetation samples). During the summer all the samples were prepped and analyzed for stable carbon isotopes ($\delta^{13}\text{C}$) and C:N ratios at the Kingsley Dunham Centre of the British Geological Survey. Analysis of all sediment samples for microfossils (foraminifera) will occur at Penn in the upcoming year. Samples will also

be sent for Cs-137 and Pb-210 dating to establish an age-depth model for core stratigraphy.

Fluvial and Aquatic Studies

- In accordance with the objectives of Hypothesis 6 of the proposal, 4 stream reach research sites where cobbles to boulders were tagged with electronic tracers were established in early June of 2010. A total of 425 rocks were tagged and surveyed. Sites were re-surveyed to detect movement 2 to 3 times during the summer of 2010. These sites will be surveyed annually and become part of at least 2 UPenn PhD theses. The initial survey indicated that head size boulders can move as far as 60 m in a moderate size storm.
- Started weekly sampling of water from climate and stream nodes for different isotopic studies being conducted by Research Hydrologist M. Scholl of the USGS, Graduate student Simona Balan of the University of California at Berkeley, and Post-doctoral Researcher Steven Goldsmith of Brown University. Rain and stream water sampling efforts in the LCZO were also coordinated with the USGS, the Luquillo LTER program, and the University of New Hampshire. Weekly samples are taken every Tuesday AM and are being processed in the Sabana Field Station Laboratory.
- An automated water conductivity probe was installed on the Icacos stream gage. Additional sensors will be added to the Bisley watersheds this fall.

Other Research Activities

- Mercury contamination testing. As a follow up to a recently published paper that documented high mercury levels in Luquillo water, Cindy Nawal a UPenn Masters student surveyed historic mine sites using a hand-held XRF that was calibrated to detect Mercury contamination. This sampling is being developed into a capstone research project and fortunately indicated that the historic placer mines are not zones of elevated Mercury.
- LIDAR ground-verification: Under the direction of Dr. Wei Wu, Brian Moore, a Masters Degree student from the University of Southern Mississippi surveyed approximately 150 locations to provide ground truth data for the LCZO-LIDAR overflight. Using a protocol developed by the CZO network, canopy height, LAI, % cover, basal area, and stand composition were measured at each georeferenced point. Most of the points were also sites where soil samples were collected as part of the LCZO soil network.
- Transpiration measurements: Dr Wei Wu and 2 graduate students from the University of Southern Mississippi (Moore and Frey) instrumented 24 trees with sap-flow sensors to measure transpiration in the summer of 2010. The trees were located in the focal research areas of Bisley and Guaba and the effort will provide the first detailed measurements of transpiration in the Colorado forest type.

Improvements to physical infrastructure:

- Replaced climate tower at the East Peak climate station and upgraded several sensors.
- Conducted safety inspection of the Bisley climate towers and repaired guy wires. Both towers were deemed safe by the USFS Safety officer but the upper tower base needs to be upgraded.
- Re-opened and improved the Bisley Road following landslides in April 2010.
- Renovation of Sabana Field Station laboratory and office spaces was completed in August 2010. Building of the new sleeping quarters was initiated in August and is planned for completion this Fall. These renovations were paid for by the USFS-IITF.
- Purchases equipment that can be used by all LCZO researchers, including a portable water quality sensor (i.e. Hydrolab), Trimble GPS unit, multiple climate station sensors, electronic tracking equipment to record boulder movement, and soil coring equipment.