CZO Network Meeting

May 29-June 1, 2012
San Juan Puerto Rico
Objectives and Goals

• Prepare for Data Management site visits
• Defining cross-site activities for coming year
• Describe major CZO science achievements
  – “How will the CZ evolve in response to changing climate and land use?”
• Discuss “CZO text book” and identifying 2013 Special Session Participants
• “the Science section of the New York Times is devoted to the CZO.”..2011 Advisory Committee
Advance cross-site science
- “exciting and potentially revealing ways of characterizing the Critical Zone,”
- “An emerging set of hypotheses and principles”

Promote cross-site network integration
- “post-doctoral research fellowships that would be specifically targeted at cross-site studies”

Improve linkage and involvement of broader scientific community
- “Through working groups and workshops along and across CZO theme areas the network should develop synthesis articles and volumes.”
- “A shared vocabulary of data types and consistent format for metadata and ascii format is in progress..."
Broad Agenda

• **Wednesday May 30, 2012: 8:30AM-5:30PM**
  – AM; Network level discussions
  – PM: Data management and Site reports

• **Thursday May 31, 2012: Field Trip to LCZO 8:00AM-6PM**
  – 6:30-8:00AM: Continental Breakfast in Piano Foyer:
  – Mini-Busses will be located near Hotel

• **Friday, June 1, 2012: 9:00AM to 5:00PM**
  – Some participants will leave by 10:30 or 3:00 PM
  – AM: Initial report from Advisory Committee and NSF
  – AM: Discuss 2012/2013 Network activities
  – PM: Finalize report documents and commitments
Luquillo “Science” achievements

• Increased understand of Luquillo Critical Zones
  – Geologic History of Mountains
  – Climate and role of Trade Wind Inversion
  – Identifying “CZ hot-spots” based on interactions of lithology, vegetation, flow paths...
  – Role of microbes; deep weathering, redox...

• Techniques for quantifying CZ
  – Soil network: predict SOM storages..eventually quality
  – Isotopes and tracers: Be/Hg transport, fingerprinting
  – Modeling coefficients; climate, SOM, transport
Self-Organizing Working Groups

- Cosmogenic dating, Be tracers
  - Luquillo, Christina, S. Sierra, Arizona, Boulder
- Graduate Student Lidar Group
  - Needs faculty mentor
- Landform evolution model
  - CHILD
- Fluvial Systems
  - Be tracers; Luquillo, Christina
  - Sediment transport
- Others...
Luquillo Field Trip

• Brief overview of Luquillo Mountains
• Field trip stops and talks
• What we won’t see
• Emerging ideas
Land cover

“lots of people..”

Urban Census Tracks

Population & Forest Cover

Agricultural & biomass

Industrial & Fossil Fuel
Paired and Nested Watershed Design
Climate stations, lysimeters, riparian wells, stream gauges..
Increase P, Decrease ET with Elevation

Clean Maritime Rain
Strong Environmental Gradients

5000 mm/yr
ET << P
Cloud forest

1000 mm/yr
ET > P
Dry Forest

- 1000-5000 mm/yr
- 3+ showers/day
- Interception;
  - 40% to +10%
- “Low” wind speeds
  - Mean Daily = 1.3 m/s
  - Mean Daily Max = 6.4 m/s
Volcaniclastic
Clays & Boulders
Shallow flow paths
Shallow landslides
Higher % SOM...

Quartz-Diorites
Sand & Corestones
Deep flow paths
Deep slope failures
Higher SOM storage
Quartz-Diorite

Volcano-Clastic

Soil % C. Ridges

Soil Ca0-20, Valleys

Tau P, Valleys

Suspended Sediment
Stop 1
Quartzdiorite at 191 Gate

1. Weathering and Deep CZ
   – Orlando, Buss, Brantley, Comas

2. Atmospheric Studies
   – Martha Scholl, Jamie Shanley
   – Gilles Brocard

3. Year of Carbon
   – Bill McDowell, Rich Brereton UNH

4. Soils and Landforms
   – Art Johnson
The architecture of the weathering zone in the Rio Icacos watershed.

Joe Orlando (jjo167@psu.edu); Susan Brantley (sxb7@psu.edu) (both at Penn State); Heather Buss (h.buss@bristol.ac.uk; Univ of Bristol); Xavier Comas (xcomas@fau.edu, Florida Atlantic University);

GRP by Xavier Comas, Florida Atlantic University

Figure 5: GPR profile using 200 MHz unshielded antennas across a 30 m outcrop with presence of corestones and rindlet zones. The reflection record shows rindlet zones as characterized by continuous reflections and corestones characterized by reflection attenuation.
Boulder size & Distribution & Stream Chemistry

Weathering zone ≠ Channel profile

Micro-porosity

Channel

Bedrock

Soil

Bedrock

Weathering zone
Long-term landscape evolution of the Luquillo Mountains: Gilles Brocard, Jane Willenbring

600 Meter ????

Cloud Base
Forest type transition
Coresstone distribution
Landscape Terraces
Stop 1
Quartzdiorite at 191 Gate

• Weathering and Deep CZ

• **Atmospheric Studies**
  – Martha Scholl, Jamie Shanley
  – Gilles Brocard

• Year of Carbon

• Soils and Landforms
Isotope Hydrology Research in the Luquillo Critical Zone Observatory

Daily Orographic, Easterly waves, TS, Hurricanes
What are relative inputs ???

“Emerging View for Precipitation”

~ 29-35% Daily Orographic Rains
(Baseflow, Coastal Plain land use)

~ 30% Easterly Waves, Lows
(NAO, N. Atlantic ..)

~ 10% Hurricanes
(SST, Africa..)

~ 5% Northern fronts

Scholl et al 2009 WRR
Mercury Inputs & Exports
Old mines, Lithology, Be/HG Tracers

Shanley et al

Hg in wet deposition

Annual Loading, $\mu g \, m^{-2}$

- West: 4.4
- Northeast: 7.2
- Midwest: 7.8
- Mid-Atlantic: 10.4
- Gulf Coast and Florida: 19.5
- Luquillo Mns., PUERTO RICO: 27.9
“Year of Carbon”

Carbon, nitrogen, and solute export from high-elevation watersheds in the Luquillo CZO

Richard L. Brereton, Univ. of New Hampshire
rich.brereton@unh.edu
William H. McDowell, Univ. of New Hampshire
bill.mcdowell@unh.edu

Figure 1. Cross-sectional view of Rio Icacos tributary well field, with groundwater N chemistry.
Stop 1
Quartzdiorite at 191 Gate

• Weathering and Deep CZ
• Atmospheric Studies
• Year of Carbon
• Soils and Landforms
  – Art Johnson, S. Porder,
3 slope positions, 3 forest types
2 bedrocks; 3 elevations per forest combinations; 3 replicates ~ 247 pits
Accumulation patterns vary with Forest type and Depth “80 cm zone”

Surface ~ forest type, C/N of inputs

Depth ~ bedrock, soil turnover
Parent material and topography drive soil P status across the Luquillo Mountains.

Stephen Porder PI (stephen_porder@brown.edu), Susanna Mage (susanna_mage@brown.edu).

Parent material explains ~ 49-66% of variance on P
Hillslope position ~ 0-14%

Hillslope Position
VC = 14%
QD = 1%

Catena Position

VC have 2x more P
VC Valleys 3.0 X QD ridges
Emerging view of relative importance of Soil Forming Factors
Landscape Multivariate Modeling

- **Lithology & Landscape Metrics (slope, curvature, rainfall..)**
  - +/- 20-30% of variance in landscape storage (0-80cm kg/ha)
  - < influence for SOM, N..., > influence for P, Fe...

- **Forest Type, Stand Age & Structure, Hillslope Position**
  - +/- 60-70% of variance in SOM, Cations
  - Biotic influence increases with precipitation; reduced decomposition

Ridges: Lithology & Stand Age
Valleys: Water/Redox & Stand Age

Hall & Silver
Lunch

• USFS Facilities
• Advisory Group with Graduate Students
• Interactions with LCZO Pi’s
Stop 2: Puente Roto Bridge
“off the mountain to the coastal plain”

• “Storm chasing”
  – J. Willenbring, Marcia Occhi, ....

• Sediment Transport & Fluvial Geomorphology
  – D. Jerolmack, K. Litwin, Phillips

• Coastal Studies
  – Ben Horton, Nicol Khan
Lithology & Stream Morphology
“strongest lithologic imprint”

Grain Size by Lithology

- a) Volcaniclastic $n = 15467$
- b) Contact Metamorphic $n = 1602$
- c) Granodiorite $n = 1383$
- d) Mafic Dike $n = 1446$
- e) Alluvium $n = 3284$

Longitudinal Profiles

- Blanco
- Espiritu Santo
- Fajardo
- Mameyes
- Sabana

Slope/Area Plots

- CD
- VC/CM
- AL

Distance from Headwaters (km)
Drainage Area (km²)
Global Average Channel Cross-section Area (width) increase = 2.5 (1.5)
NE Puerto Rico = 1.5 (1.0)

Tropical Storms and Sediment Supply limited Conditions

Channel Change Ratios
Determining the Provenance of Suspended Sediment: Storm Sampling in NE Puerto Rico

Marcie E Occhi*, Dr. Jane Willenbring*, F.N. Scatena*, Dr. Martha Scholl\textsuperscript{a}, Dr. Jamie Shanely\textsuperscript{b}, Dr. Jim Kaste\textsuperscript{c}, Dr. Gilles Brocard*, Hyejung Lee*

*Department of Earth and Environmental Science, University of Pennsylvania, \textsuperscript{a}USGS, Reston, VA, \textsuperscript{b}USGS, Montpelier, VT, \textsuperscript{c}Department of Geology, The College of William and Mary.

Be tracers; Hg and sediment source identification

Multi-investigator storm sampling

![Graphs showing Be tracers in Bisley and Puente Roto](image)

- **Bisley**: $y = 692x + 2.3 \times 10^5$, $R^2 = 0.58$
- **Puente Roto**: $y = 1763x + 6.1 \times 10^5$, $R^2 = 0.82$
The reconstruction of Holocene sea level and paleoenvironmental change

Nicole Khan\textsuperscript{1}, Benjamin P. Horton\textsuperscript{1}, Christopher Vane\textsuperscript{2}, F.N. Scatena\textsuperscript{1}
\textsuperscript{1}Department of Earth and Environmental Science, University of Pennsylvania, USA
\textsuperscript{2}British Geological Survey, Kingsley Dunham Centre, UK

Recent and Holocene rates of Sea Level Change
Uplift vs SLR

Isotopic indices of RSL
Carbon storage change with sea level change

Figure 1. Mangrove zonation related to elevation in the intertidal zone
Stop 3
Volcanoclastic Bisley Watersheds

• Soils and Hillslope:
  – Silver, Thompson, Hall

• Soils Quality and Microbes:
  – Plante, Stone, Wordell

• Weathering and soil production:
  – Buss, Brantley
Soil organic matter quantity, quality and microbial activity in deep soil profiles

Madeleine Stone (madstone@sas.upenn.edu; PhD)
Lydia Ali (prali@sas.upenn.edu; undergraduate)
Alain Plante (aplante@sas.upenn.edu, co-PI)

Differences in soil organic matter quality by biological, chemical and physical fractionation

Elizabeth Wordell (ewordell@sas.upenn.edu; MSAG)
Tsutomu Ohno (ohno@umaine.edu)
Alain Plante (aplante@sas.upenn.edu, co-PI)

Microbes, SOM quality & Stabilization
VS
Depth, geology, forest type
80cm & 600m
Linkages between redox processes and surface soil carbon cycling

Steven Hall and Whendee Silver
UC Berkeley, Dept of ESPM, Ecosystem Science
stevenhall@berkeley.edu, wsilver@berkeley.edu

Figure 1

- **Figure 1a**: Box plots showing Fe(II) concentration (μg g⁻¹ soil) for ridge, slope, and valley positions.
- **Figure 1b**: Box plots showing fine root biomass (mg g⁻¹ soil) for ridge, slope, and valley positions.
- **Figure 1c**: Scatter plot showing CBH (μmol MIB g⁻¹ soil hr⁻¹) against Fe(II) (μg g⁻¹ soil) with position indicated (Ridge: circles, Slope: triangles, Valley: crosses), and R² = 0.65.
- **Figure 1d**: Scatter plot showing soil carbon (%) against Fe(II) (μg g⁻¹ soil) with position indicated (Ridge: circles, Slope: triangles, Valley: crosses), and R² = 0.71.
Redox cycling and Fe atom exchange in the Bisley Watershed

PIs: Aaron Thompson¹, Christof Meile² and Michelle Scherer³  Post Docs: Brian Ginn¹ and Viktor Tishchenko¹

Grads: Tim Pasakarnis³ and Jared Wilmoth¹

¹University of Georgia (Crop and Soil Sci.); ²University of Georgia (Marine Sci.); ³University of Iowa (Civil and Environ. Engineering)

Bisley Watershed sampling sites

Ridge
Slope
Valley

Luquillo Mountains, Puerto Rico
(volcaniclastics)

Courtesy of Art White
Stable Ridge Tops – Dynamic valleys
Ridges ~ Lithology
Valleys ~ water

Hurricane Structured Stands ~ 110 yr

SOM
Constant Climate
TPI ~ 39%
TPI + Age + Depth ~ 60%

Saprolite thickness // channel

Gap and slide Structured Stands ~ 40 yr

Saprolite / substrate
Surface
Bedrock

Bisley Soils

Ridges ~ Lithology
Valleys ~ water

SOM
Constant Climate
TPI ~ 39%
TPI + Age + Depth ~ 60%

Saprolite thickness // channel

Gap and slide Structured Stands ~ 40 yr

Saprolite / substrate
Surface
Bedrock

Bisley Soils
What we won’t see

• Climate Stations; 8 stations
  – Joint management: USFS, USGS, LCZO, LTER
  – Olga Mayol UPR African Dust Project; NSF
    Atmospheric Chemistry, Bill Keene

• Quartzdiorite Stream

• Coastal Plain Sites

• UPR-LTER field station
  – Vegetation plots
How do the pieces fit?
Boulders!

Deep weathering
Cosmo-dating
Stream Morphology
Sediment Transport

Production & Development
1955-2010; P & PET % change/yr
No change in Stream flow with Reforestation

Slight to no Increase in Precipitation
5%/100 yrs

22% (11-33) to “drastically” after vegetation types

500-1000 yrs
Forest Type

10-20 C4

Larger increase In PET (.15-.3%/yr)
Reforestation

Figure 3: The trend [% yr\(^{-1}\)] from 1955 to 2010 for annual mean (a) P and (b) PET. Significant as well as insignificant trends are shown. The points mark stations with > 20 yr time series of (a) P, and (b) \(T_{\text{min}}\) and \(T_{\text{max}}\) (used to derive PET, see Section 3.4). The numbers represent the last five numbers of the GHCN-D station identification code. Catchments identified by letters (cf. Table 1) and stream gauges by crosses.
Deforestation of Maritime Tropical lowlands
Forest vs. Pasture

Latent Heat

Observed fluxes (W m$^{-2}$)

- $R_n$
- $H$
- $LE$
- $G$

Hr average

Van der Molen et al 2010
Forest to Pasture conversion
Less Convective Rains

Synoptic Systems

Trade-winds
Orographic rains

Energy & Moisture

Land-Sea

Sea Level

Tectonic Uplift

600 m
Landscape Response by Erosion Surface

• Above 600 M knickpoint
  • Resistant to climate and baselevel change
  • Thick soils, Chemical denudation > Physical
  • Carbon accumulation
  • Baseflow, orographic storms

• Below 600-400 m knickpoint
  • Shallow soils
  • Not resistant to climate and baselevel
  • Physical > Chemical denudation
  • Carbon decomposition
  • Tropical storms, floods
Why 600 m
geology, forest type, cloud base, streams

Synoptic Systems
Trade-winds
Orographic rains

Energy & Moisture
Land-Sea

Sea Level
Tectonic Uplift

600 m
Questions ??