Southern Sierra CZO update
Roger Bales, UC Merced

Science directions
Infrastructure update
Research highlights
SSCZO team
Data
Next steps

Research focus: water balance, nutrient cycling & weathering across the rain-snow transition – soil moisture as integrating variable
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Conceptual model: bi-directional links between landscape/climate variability & water/material fluxes across the rain-snow transition
How is the response of soil moisture to snowmelt & rainfall controlled by variability across the landscape, & how do these responses both reflect & constrain streamflow & evapotranspiration?
What is the process linkage between soil moisture & topographic variability, soil formation & weathering?
How does vegetation/ecosystem distribution & function (species, plant functional type, production) vary with climate (elevation); & what physiological mechanisms are controlling?
How do vegetation attributes influence land-atmosphere exchange & catchment cycling of water, energy, CO₂?
What is the link between soil heterogeneity, water fluxes & nutrient availability?
Southern Sierra CZO is located at elevations 1750-2100 m, across the rain-snow transition, in a very productive mixed-conifer forest, with extended measurement nodes at elevations 400-2700 m.
CZO measurements are centered around the Kings R. basin, N fork
Wolverton catchments, 2100-2700 m, lies in the snow zone, above the 1750-2100 m elevation Providence catchments.
Providence Creek – main CZO instrument cluster

3 headwater catchments w/stream gauges & water-quality measurements
2 met stations
60-m tall flux tower
60-node wireless embedded sensor network
214 EC-TM sensors for volumetric water content
113 MPS sensors for matric potential
57 snow-depth sensors
Meadow piezometers & wells
Sap-flow sensors
Flux towers along an elevation gradient, 400-2700 m, extend the core CZO instrument cluster from water-limited to temperature-limited ecosystems

4 towers in place now, 3 more planned under NEON (2 co-located)
San Joaquin Experimental range

Elev 400 m
$T_{\text{ave}}$ 14.4º C
Annual rain: 0.5 m
0 dy snow
6 mo growing, water limited

Oak/Pine savannah – Gray pine & live oak w/ exotic grasses
Soaproot saddle

Elev 1200 m
T_{ave} 10.9^\circ C

Annual precip: 0.9 m
11 dy snow
Possible long growing season & high productivity

Dense mix of smallish Ponderosa pine & oak, w/ many shrubs
Site may be recovering from logging/fire/beetles
Elev 2100 m
$T_{ave} 8.9^\circ C$
Annual precip: 1.0 m
130 dy snow
12 mo growing season – neither cold nor drought limited

White fir w/ sugar & other pines, incense cedar & patchy, dense shrubs
Elev 2700 m
$T_{ave}$ 4.1$^\circ$C
Annual precip: 1.1 m
184 dy snow
~5 month growing season – cold limited

Mostly Lodgepole pine w/ scattered western white pine & red fir
Very high annual & summer ET at P301

High summer values depend on deep root extraction of water.

Happy elev for trees – T & precip just right.

Soils hold snowmelt over summer.
How much water can soils hold vs. elev?

Little rain, 5/09-10/09

730 mm Et, 10/08-10/09
430 mm Et, 5/10-10/10
Total profile soil water storage – upper vs. lower met
(soil texture effect)

Lower – finer soils
Upper – coarser textured soils
Physiographic controls over snow distribution

Snow depletion links w/ soil drying at multiple scales

Snowpack & snowmelt control the timing of soil drying
Climatic, physiographic & vegetation controls on water yield

Mean elevations for 8 catchments Modeling in progress

Decreasing temperature
Increasing snow fraction
Decreasing LAI
Coarser soils
Tracking of soil moisture & sap flux

Change in Soil Moisture vs. Sap Flux

- ET decreasing from 1 to 0.5 mm/d
- ET decreasing towards 0.1 mm/d
- ~ 20 cm precip

Putting these together w/ tower data in progress
Do changes in the timing of water availability affect microbial community structure & annual rates of biogeochemical cycling in mountain soils?

Reduced snowcover on S facing apparently not a factor in decomposition rate?

P = 0.001 in one-way ANOVA
Nutrient hot spots

Hot spots, i.e. statistical outliers, common for inorganic species in both O horizon & mineral soil

Infiltration of nutrient-rich runoff in preferential flowpaths creates the hot spots

Runoff through O horizon occurs due to lack of roots

Hotspots in mineral soil not co-located with hotspots in overlying O horizon

Hotspots increase litter decomposition rates?
Providence erosion rates

- Sediment basin
- Headcut

![Map of Providence erosion rates with labels for P304, rock glades, and locations marked with 'N' and 'G'.]

![Graph showing estimated sediment delivery rate (t km⁻² yr⁻¹) with data points from Dixon et al. 2009 and range of rates for bare granite from cosmogenic nuclides.]

- Dixon et al. 2009
- Range of rates for bare granite from cosmogenic nuclides
- Sediment yields from sediment traps

![Image of a stream with a headcut and sediment basin.]

Soil moisture & sap flux measurement design using RHESSys & cluster analysis – catchment P300

Model vs. initial measurements – qualitative agreement

Initial plots mainly in 1-3
Added plots in 4-6
Prototype embedded sensor network, 2008-present

Randomized channel-hopping protocol
Self-assembling redundant mesh
Near 100% transmission w/ RSSI > -73 dBm, i.e. spacing of ≤ 100 m

Received signal strength (RSSI), log scale
Packet delivery ratio
Wireless network layout & equipment

- Sensing node
- Hopper node

Node w/ antenna

Embedded base station
SSCZO Co-PIs & students from 8 campuses; many more collaborators

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Data availability through digital library

Level 2 data from core field measurements made available by water year: snow, soil moisture, temperatures, flux tower
Current-year level 1 data available by request
Investigator-specific data available as per CZO & NSF data policy
Next steps

– End of yr 3 – some mature research & some data streams just initiated
– Most students started in yr 2
– Several papers submitted or close
– Fall AGU: 16 abstracts
– LIDAR products – spring 2011
– Single-tree experiment replicated this summer
– Instrument cluster – basis for developing broader water information system in Sierra Nevada

http://snri.ucmerced.edu/CZO