ECO-HYDROLOGY AT THE CZO: LINKING PLANTS, WATER AND GEOLOGY

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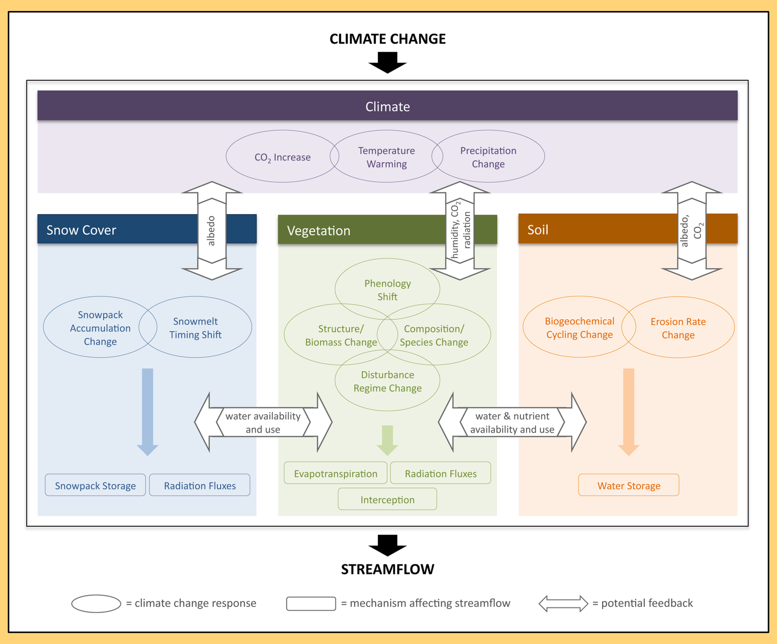
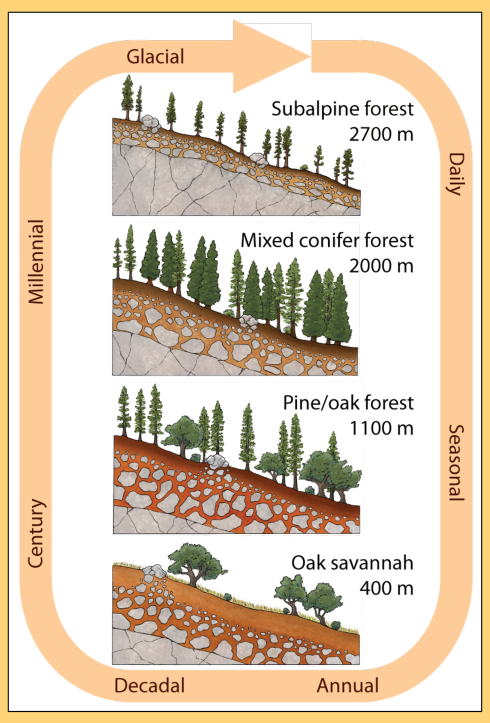


Eco-hydrology is a broad and growing research area that investigates interactions between vegetation (its structure and composition) and the cycling of water. The multi-disciplinary, multi-measurement CZO's are well situated to support advances in eco-hydrologic research. In particular, the strong geologic focus of the CZO's offers a unique opportunity to investigate how soil and landform development interact with eco-hydrologic processes and how these interactions influence responses to climate and land use change. Some examples from the Southern Sierra CZO demonstrate some important linkages between soil and landform properties and eco-hydrologic processes at diurnal to geologic temporal scales and pore to watershed spatial scales.

Tague, C.L. and Dugger, A. (2010) Ecohydrology and Climate Change in the Mountains of the Western USA – A Review of Research and Opportunities. *Geography Compass* 4(11): 1648-1663. doi: 10.1111/j.1749-8198.2010.00400.x

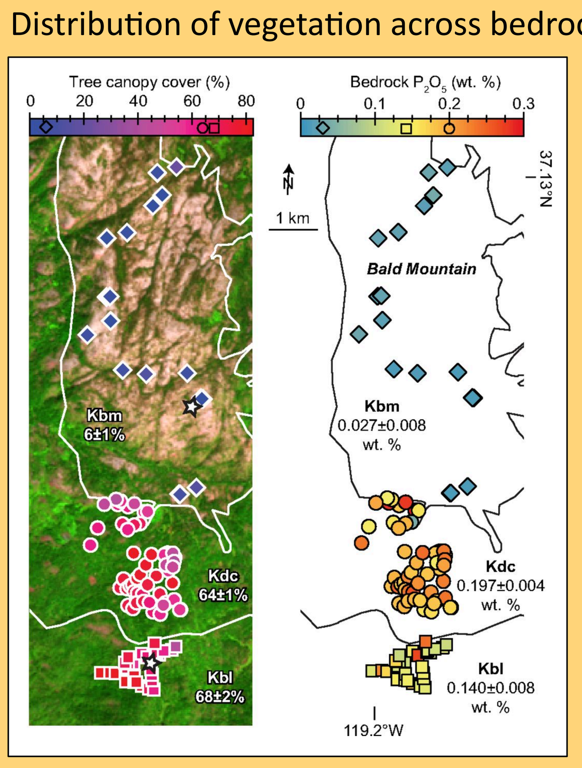
Geologic Time Scale – Regional Space Scale



Maximum weathered saprolite occurs at mid elevations (1100m to 2000m). These elevations also support higher rates of ecosystem productivity (there is a transition between water limitation at lower elevation and temperature limitation at higher elevations) What is the link between gradients of ecosystem productivity and weathering depth?

Do vegetation processes help to generate their water availability (rooting zone depth) at long time scales – eco-optimality?

Distribution of vegetation across bedrock with differing phosphorus content.



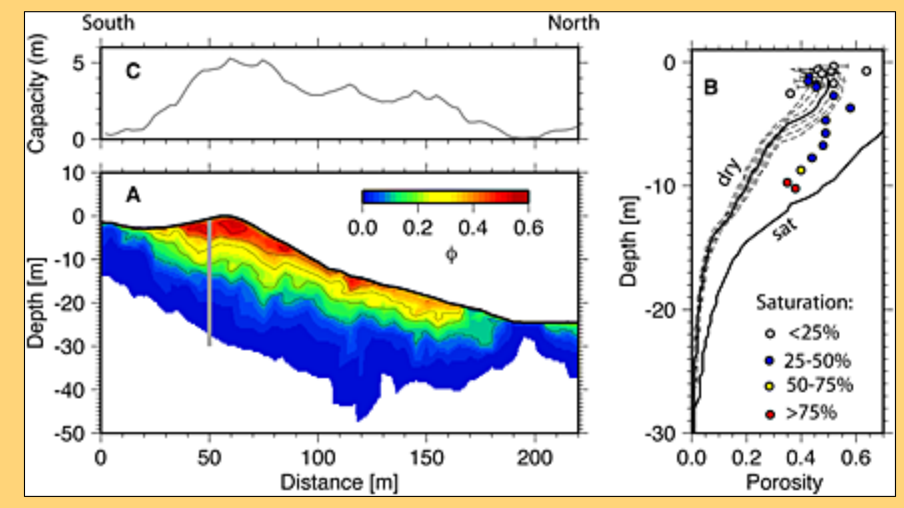
Geology also controls where vegetation can exist: substantial bare rock patches in the Sierra may reflect areas where chemical properties of the rock impeded vegetation (and soil) development:

What are the implications of these geologic controls on vegetation and total water loss as ET at landscape scales?

(*Left*) False-color Landsat image of CZO vicinity with georeferenced bedrock contacts from simplified geologic map *(Right*).

Hahm, W.J., et al. (2014) Bedrock composition regulates mountain ecosystems and landscape evolution. *PNAS* 111(9): 3338-3343, doi: 10.1073/pnas.1315667111

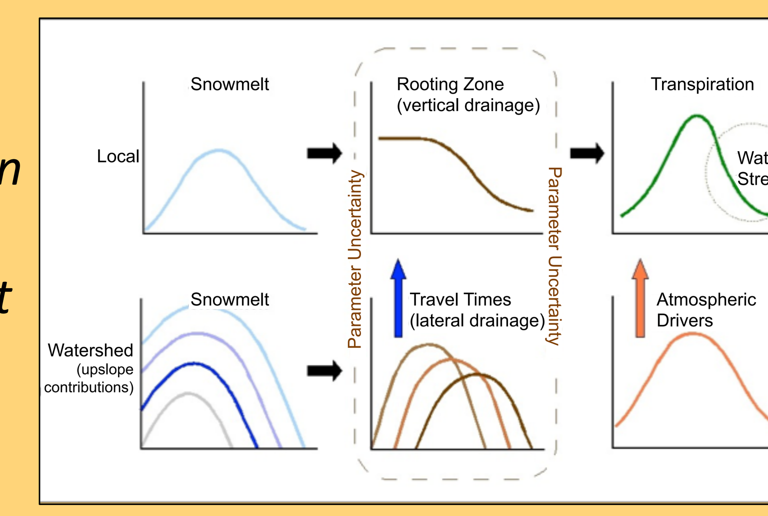
Annual Time Scale – Watershed Space Scale

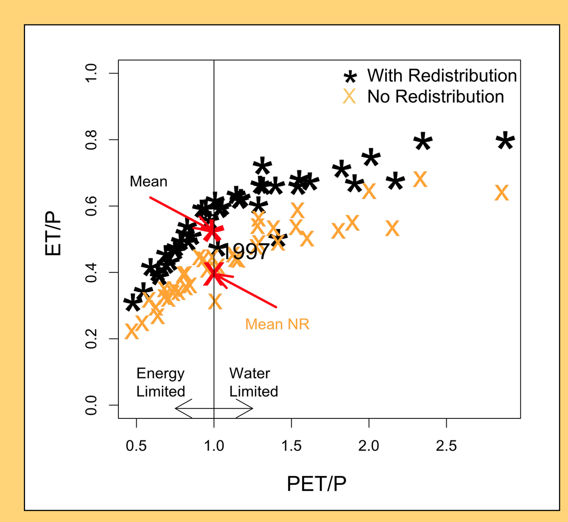


Interpretation of geophysical data provides insight into flowpaths and hillslope profiles of water availability.

Holbrook, W.S., et al. (2014) Geophysical constraints on deep weathering and water storage potential in the Southern Sierra Critical Zone Observatory. *Earth Surf. Proc. Landforms* 39: 366–380, doi: 10.1002/esp.3502

What are the implications of redistribution and hillslope scale patterns of hydrologic drainage and storage properties for forest water use and streamflow?

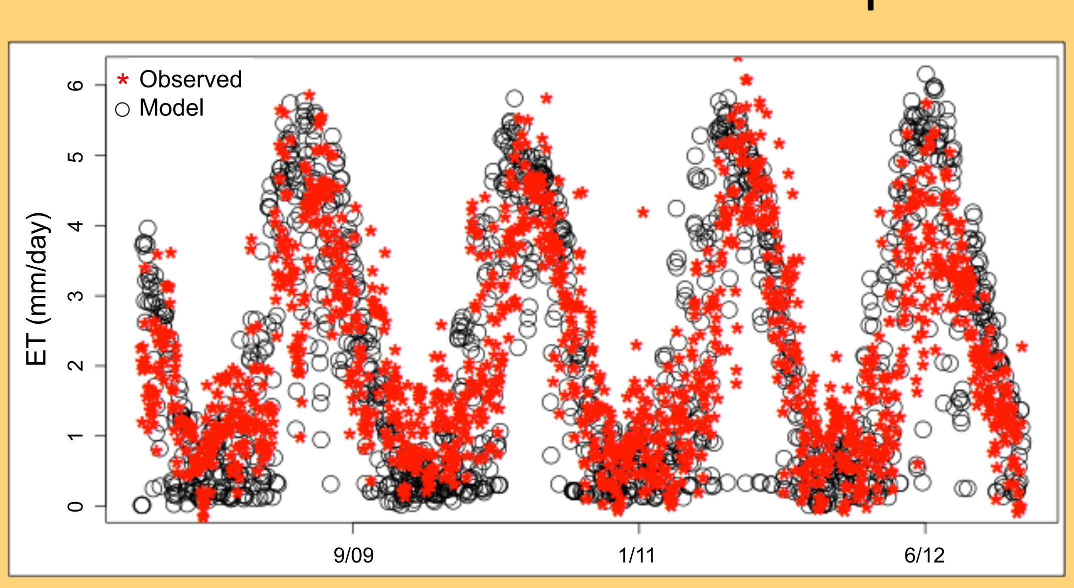




Hydrologic model estimates of ET, with and without lateral redistribution. Lateral redistribution leads to higher ET in riparian and hillslope hollows and a 30% greater estimate of watershed scale ET).

Tague, C., & Peng, H. (2013) The sensitivity of forest water use to the timing of precipitation and snowmelt recharge in the California Sierra: Implications for a warming climate, *Geophys. Res. Biogeosci.* 118: 875–887, doi:10.1002/jgrg. 20073

Seasonal Time Scale – Stand Space Scale



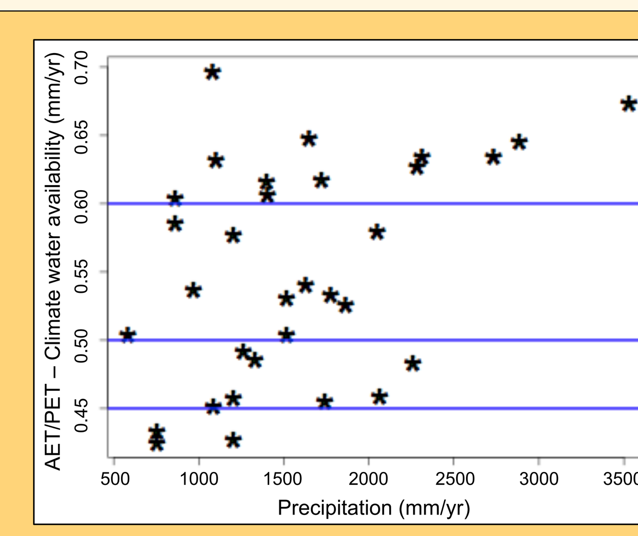
High rates of summer time evapotranspiration (and productivity) observed at mid-elevation CZO flux tower.

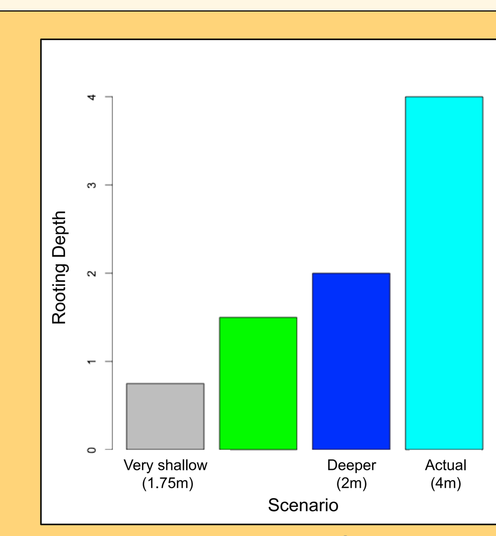
Water balance (Bales et al. 2011) and RHESSys hydrologic model simulations argue that this can only occur for rooting depth > 4.

Bales, R.C. (2011) Soil moisture response to snowmelt and rainfall in a Sierra Nevada mixed-conifer forest, *Vadose Zone J.* 10 (3): 786–799. doi:10.2136/vzj2011.0001

How do spatial patterns of soil properties influence stand-scale for climate warming responses for forests?

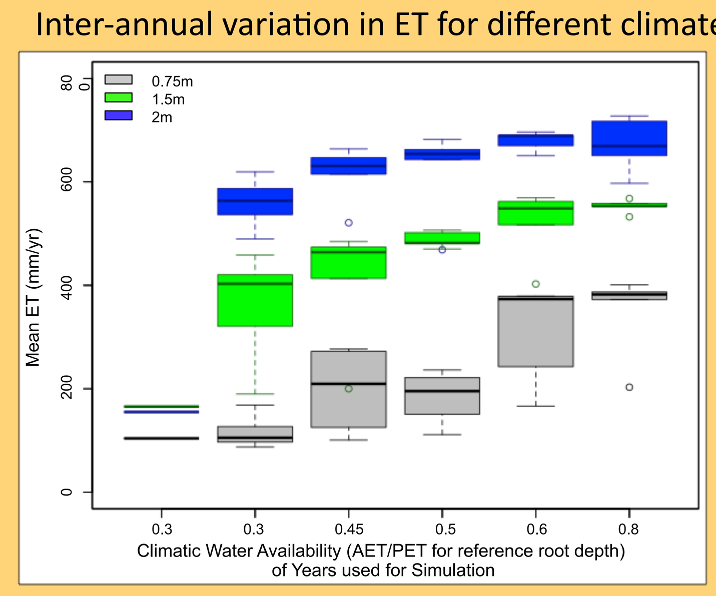
- 30 yr climate sequences generated by resampling from previous years with different relative water availability (AET/PET)
- Ran with different assumptions about subsurface water availability (current, 0.75m, 1.5m, 2m, 4m)



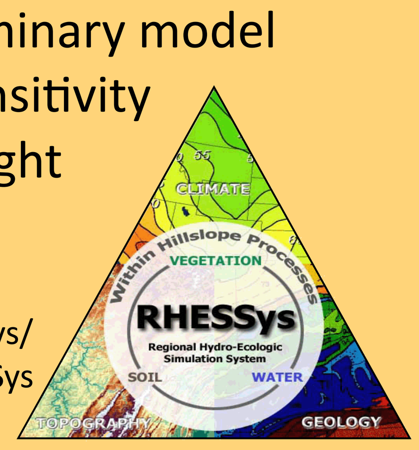


Climate Scenarios X Rooting Depth Scenarios

Inter-annual variation in ET for different climate scenarios (index by mean AET/ PET) - given different rooting depths.

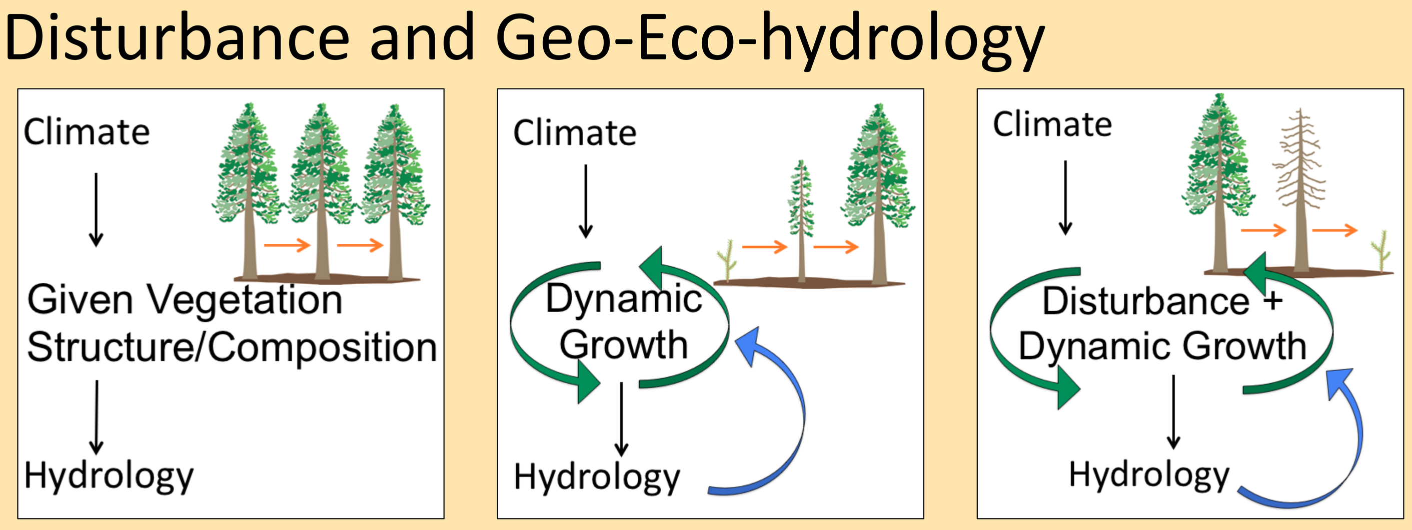


At high-elevations (that are currently temperature limited but have shallow soil) preliminary model estimates suggest much greater sensitivity of forest water use to climatic drought (AET/PET) for these shallower soils.



http://fiesta.bren.ucsb.edu/~rhessys/
https://github.com/RHESSys/RHESSys
http://ecohydrolab.com/

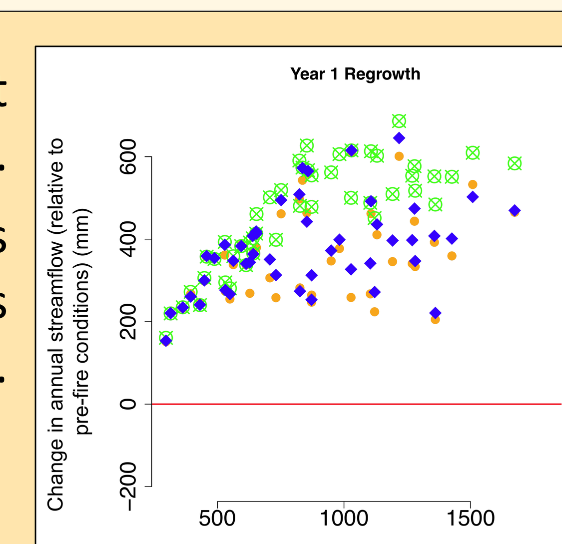
Disturbance and Geo-Eco-hydrology

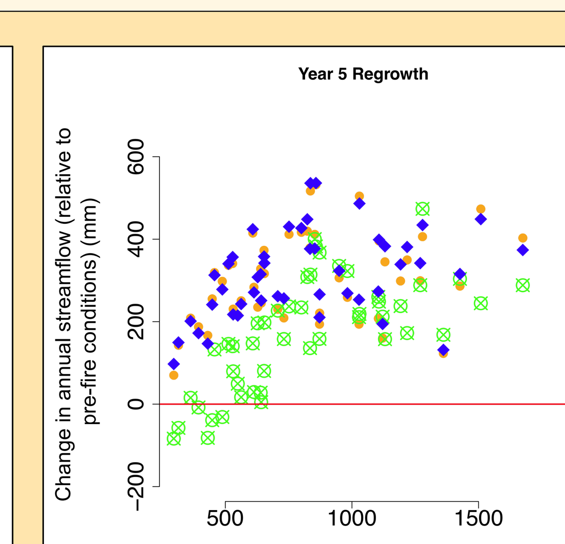


How does the geophysical template influence:
- *vulnerability to disturbance?*
- *hydrologic response after disturbance?*
- *ecosystem recovery after disturbance?*

Modeled hydrologic response during post fire biomass recovery.

Colors denote different assumptions about carbon allocation to roots (preliminary RHESSys estimates).





Garcia, E.S. and Tague, C.L. (in prep) Climate variability's influence on streamflow recovery after disturbance in three Western U.S. basins. Planned submission to - JGR-Biogeosciences.

http://www.fs.fed.us/psw/publications/reports/psw_sciencesynthesis/