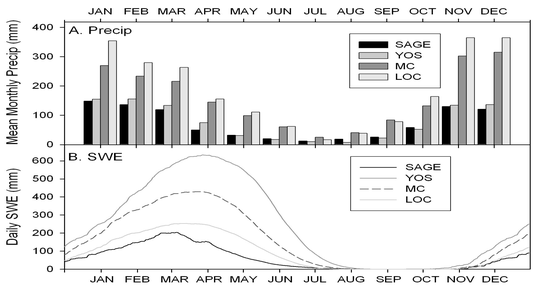
How plant accessible water storage interacts with changing snowpacks in Mediterranean environments

Christina (Naomi) Tague[1], Christopher Heckman[1], Alan Flint[2]
1 Bren School of Environmental Science and Management, University of California, Santa Barbara, CA 93106
2 U.S. Geological Survey, Placer Hall, Sacramento, CA 95819

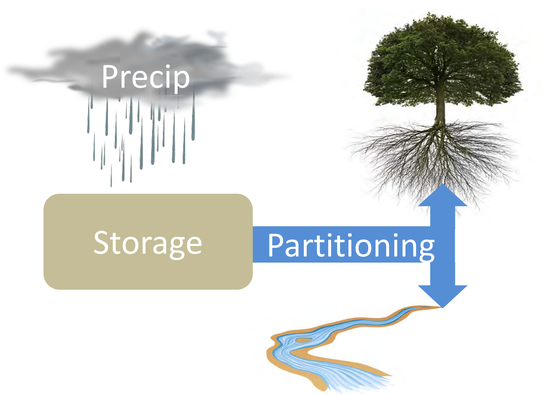
DONALD BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT
UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Motivation:

Forest water use is an important indicator of ecosystem health and forest vulnerability to fire and drought. How much water forests use also influences the amount of water that reaches streams and groundwater aquifers. As the climate warms forests water use is predicted to increase, however this relationship is complicated by California's Mediterranean climate. In this research we explore how a range of plant accessible water storage capacities (PAWSC) can mediate vegetation's response to a decreasing snowpack, under climate change.

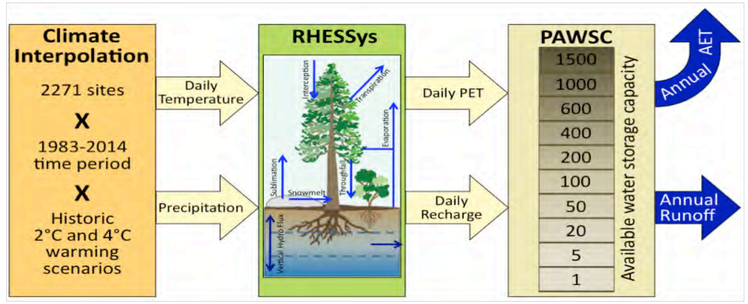


California's Mediterranean climate, where almost all of the precipitation occurs in the winter, places significant importance on the mechanisms that delay winter precipitation to when vegetation water demands increase in summer.



Storage, in the form of snowpack and soil water storage, plays a significant role in delaying winter precipitation input into the soil and therefore the partitioning of water between runoff and evapotranspiration. Since vegetation water use occurs during the summer, large snowpacks and deep soils allow for more water to be available in the late summer producing a longer growing season. On the other hand, winter precipitation in places with smaller storage capacities will result in a shorter growing season and more runoff.

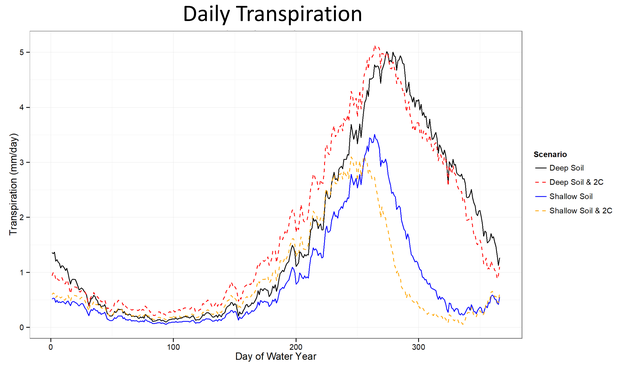
Methods:



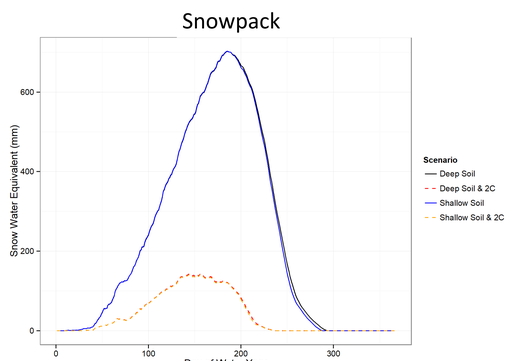
To quantify how soil water storage influences the partitioning of recharge, we combine a spatially explicit climate data product with a mechanistic land surface hydrology model (a modified version of RHESSys). The hydrology model represents well understood relationships among AET and energy availability, precipitation and temperature, snow accumulation and melt. We use this data-model combination to conduct a sensitivity analysis to show how soil water storage interacts with climate drivers for a wide range of environments in the Sierra.

Results: Single site, single year

Daily Transpiration

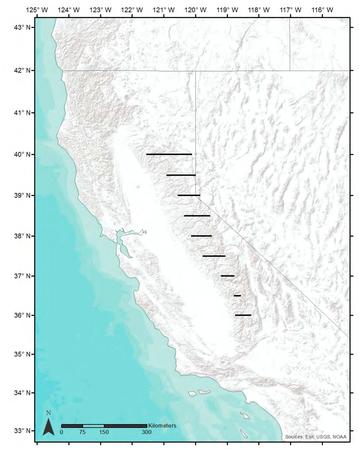


Snowpack

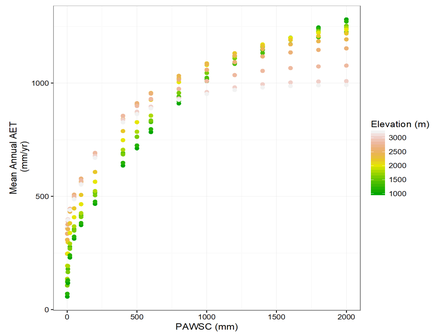


Results: All sites all years

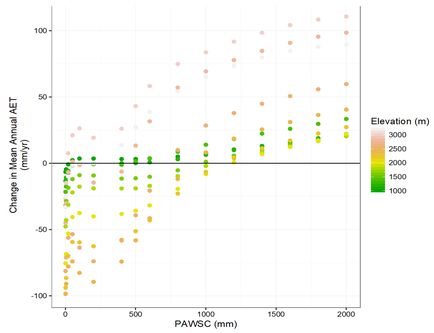
2271 sites along 9 elevation gradients



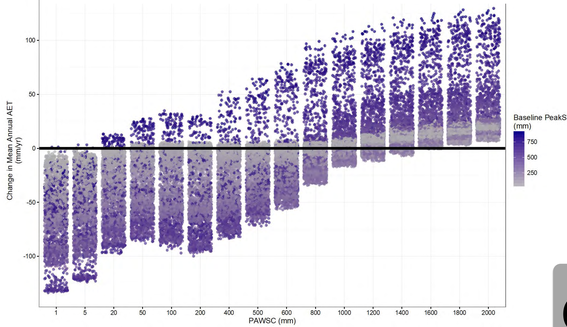
Mean Site Annual AET



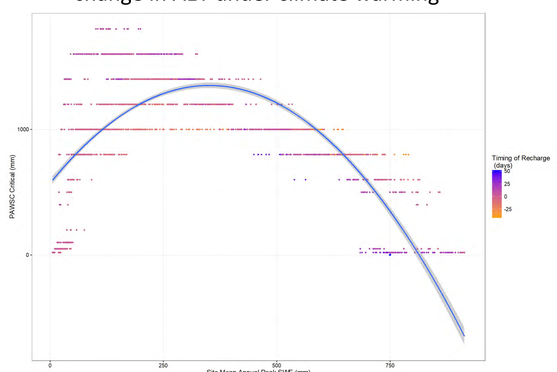
Change in Mean Site Annual AET for 2°C - Baseline



Relationship between peakSWE and change in AET under climate warming



Relationship between timing of recharge and change in AET under climate warming



Conclusions:

- Climate warming typically leads to decreases of AET under low levels of PAWSC and increases with high levels of PAWSC
- Geology matters: the PAWSC is a first order control on the spatial patterns of vegetation water use
- The amount of snow (peakSWE) and the timing of recharge play a significant role in cross site variation

[1] Flint LE, Flint AL, Thorne JH, Boynton R (2013) Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model development and performance. *Ecol Process* 2(1):1–21
[2]Tague CL, Band LE (2004) RHESSys: regional hydro-ecologic simulation system-an object-oriented approach to spatially distributed modeling of carbon, water, and nutrient cycling. *Earth Interactions* 8(19):1–42.