Spatial patterns of interaction among climate variability and change, soil water deficit and transpiration in small mountain catchments of Southern Sierra Critical Zone Observatory

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Abstract

In snow-dominated mountain systems, a warming climate alters soil water deficit through changing the timing and magnitude of moisture inputs as precipitation and snowmelt and through changes in the timing and magnitude of evapotranspiration losses. The net effect of climate warming on soil water deficit and associated ecosystem processes ultimately depends on the interaction between changes in inputs and outputs on vegetation, microclimate, and soil properties that control the sensitivity of soil water to changes in inputs/output drivers. In mountain environments, steep spatial gradients result in substantial variation in atmospheric forcing and vegetation and soil properties over relatively short spatial scales, which necessitate providing finer-scale assessment of climate change impact. Measurements of soil moisture and forest response to climate are often made at plot scales but are limited in spatial coverage. Coupled eco-hydrologic models, applied at relatively fine (m) scales provide a method of extrapolating findings from local measurements and exploring hillslope and watershed scale impacts of climate change. Our approach which is using 2 and 4°C temperature warming causes the greatest ET reduction occurs in the snow-dominated watershed (P303), while other sites are more temperature limited. Key question is whether the model can sufficiently resolve these microclimate patterns.

Effect of climate warming on hydrologic response of the CZO watersheds

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Hydrologic Similarity indices

mean and inter-annual variation (expressed as coefficient of variation, CV) of five indices:
(a) number of days of snow melt
(b) day of water year that root-zone soil moisture is fully saturated
(c) day of water year that root-zone soil moisture declines to 70% of saturation
(d) day of water year that root-zone soil moisture declines to 50% of saturation
(e) day of water year that transpiration declines to 50% of its peak growing season value
(F) Combined five indices

Spatial variability of microclimate, soil moisture and transpiration

The relationship among microclimate (VPD), soil moisture and transpiration at the summer season between sites. In the dry sites (P303), Transpiration is correlated with soil moisture and limited by available soil moisture. In the intermediate sites (P203), the transpiration is highly correlated with VPD. However, in the wet site (CZT), the transpiration is non correlated with soil moisture. The net effect on ET varies significantly with upslope areas in the rain-snow transition watershed showing greater reduction of ET and lower elevation in the snow-dominated watershed.

Summary

- Estimates of hydrologic similarity indices using a physical distributed model are used to strategically guide site selection for soil moisture and sapflow measurements.
- Collected soil moisture and sapflux data suggest that microclimate is significant controls on summer and winter transpiration.
- Snow-dominated watershed (P303) is more sensitive to climate warming than snow-rain transition watershed (P303).
- Warming can both increase PET and decrease available water by shifting the timing of water input (snow-rain). The net effect on ET varies significantly with upslope areas in the rain-snow transition watershed showing greater reduction of ET and lower elevation in the snow-dominated watershed.

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