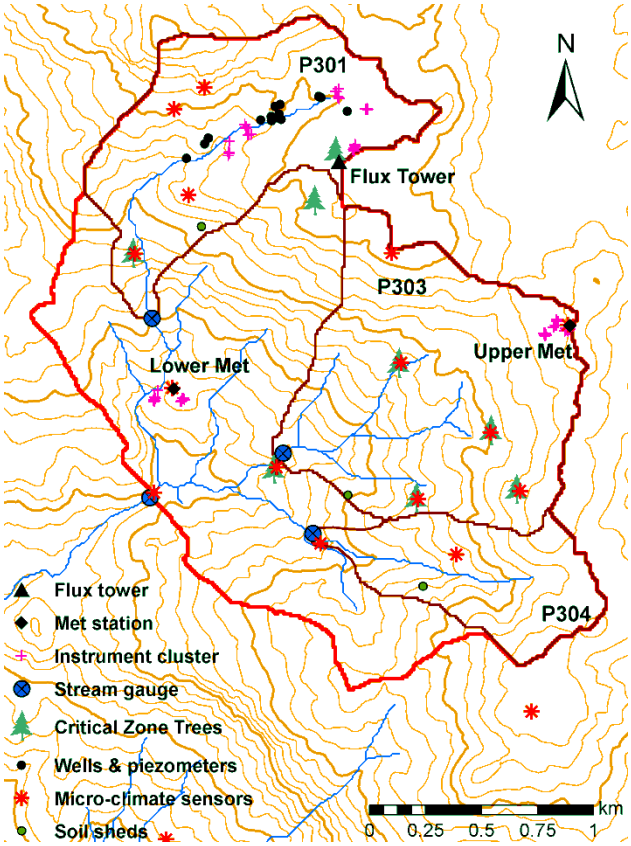
Advances in Measurement Design

Southern Sierra Critical Zone Observatory

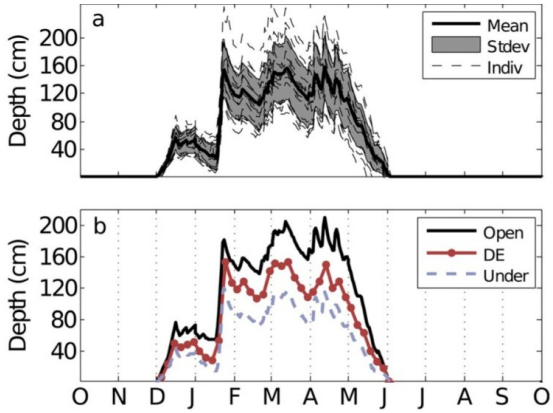
Research challenge. Field observations have always been scale dependent and sampling at more than one scale challenging and expensive. At the Southern Sierra Critical Zone Observatory (SSCZO) we designed a scalable instrument cluster to strategically and accurately measure water reservoirs and fluxes at high temporal and spatial resolution. Prototypes for both the system design and hardware components were previously lacking.

Flexible approach. We designed a series of nested instrument networks at a range of scales, moving from vertical profiles within plots to plots across catchments, to catchments and ecosystem types across a large climate gradient, and ultimately to the entire upper Kings River basin. The deployment of water-balance instrument clusters with several hundred sensors in a single wireless network has provided an unprecedented window on the catchment-scale water cycle.



SSCZO catchments and strategically placed sensors at one of four sites across the elevational gradient.

Wireless-sensor networks. The development of wireless sensor networks allowed the SSCZO to make denser meteorological and hydrologic observations in time and space and over larger areas than had previously been possible. We developed powerful optimal sensor-placement algorithms based on information-theoretic criteria, with significantly better results than expert judgment. This structured network design and strategic sampling facilitated both scaling and robust operation in remote settings. Quantitative comparisons between measurements made with different methods and at different scales show that we can close the water balance at multiple scales.



a) Snow depth from dense sensor network in one SSCZO sub-basin, water year 2010. b) Average snow depth under various canopy covers (open, drip edge, and under canopy),

Water-balance perspective. Snowpack, evapotranspiration, runoff, soil moisture and catchment water yield all vary systematically across the elevation gradient. Our instrument-cluster design captures both the spatial average and spatial patterns over time of water-balance variables. The ability of the wireless sensor network to capture catchment-wide snow depth and soil moisture variability was confirmed by LiDAR data and multiple comprehensive synoptic surveys. The stratified sampling strategy was particularly effective in capturing variability across the complex landscape. This approach is being scaled for optimization of regional water management.

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More information: http://criticalzone.org/sierra/