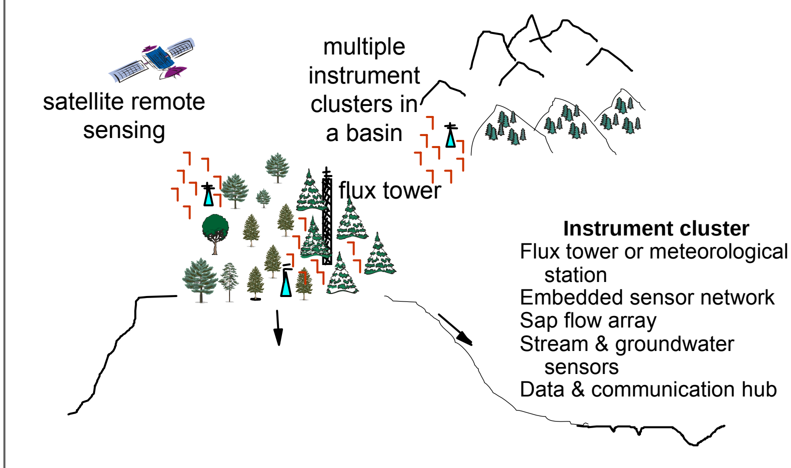
Development of prototype instrument cluster for mountain hydrology, biogeochemistry & ecology

Scope: This project involves developing and deploying a prototype instrument cluster to make comprehensive water-balance measurements across the rain-snow transition in the Southern Sierra Nevada, in support of hydrologic and related research by multiple investigators.

Focus: At the center of the cluster will be an eddy-covariance system (flux tower) for measuring water and carbon exchange with the atmosphere. Micrometeorological measurements and an embedded sensor network to capture the spatial variability of snow depth, soil moisture, air temperature, soil temperature, relative humidity and solar radiation will be clustered around the tower



Conceptual design and deployment of instrument clusters in a mountain basin. Selected instrument clusters are anchored by an eddy-correlation flux tower extending above the forest canopy, with ground measurements extending 1-2 km from the tower. Other clusters would consist of sensors and sensor networks but not a tall tower.

Primary objectives:
- Develop measurement strategies for accurate estimation of snowpack amount, soil moisture, snowmelt and partitioning of snowmelt/rain into runoff versus infiltration and evapotranspiration (ET) in mountain basins.
- Demonstrate the applicability of an integrated satellite and ground-based measurement strategy through deployment of a prototype system employing emerging technologies.
- Provide measurements needed to accurately estimate mountain water fluxes, reservoirs and related biogeochemical cycles, in a representative southern Sierra Nevada basin.

Basic hypothesis: Strategically placed instrument clusters, designed to complement satellite remote sensing information, together with models of climate, surface and subsurface hydrology, and other components of the Earth system, provide the basis for more accurately and efficiently measuring and scaling water balance components, and thence basin-scale fluxes, than does an approach that relies on sparsely distributed measurements of the type now available

Location: The site for the instrument cluster is in the Kings River Experimental Watersheds (KREW) (37.0665°N, 119.1940°W, 1985 m elevation), a watershed-level, integrated ecosystem project for long-term research on headwater streams in the Southern Sierra Nevada. KREW includes 10 instrumented, nested watersheds ranging in size from about 50 ha to 10 km^2, and is adjacent to the Teakettle Experimental Forest, which has 3 additional catchments with long-term instrumentation and an active ecosystem research program. KREW is road accessible year round.

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For more information: https://snri.ucmerced.edu/snho

Mixed conifer forest at KREW

Working hypotheses:

- Increased accuracy in the spatial estimation of snow water equivalent (SWE) at scales of 1-1,000 km^2 is possible with sensors placed to capture the variability in slope, aspect, radiation and landcover.
- Soil moisture patterns will follow the patterns for snowcover accumulation and depletion.
- Soil moisture measurements will also help to discriminate snow versus rain.
- Spatial variations in tree canopy cover are as important as slope and aspect for variability in snowcover and soil moisture.
- Accurate estimates of changes in spatial SWE across a basin can be developed using subpixel satellite snow covered area (SCA) and albedo plus canopy information and distributed energy balance modeling, with only limited ground-based SWE measurements.
- The reduction in uncertainty for a spatial average from additional nodes within a sensor web diminish slowly after a relatively small number of nodes is in place, i.e. measurement saturation will occur.
- Evapotranspiration is a dominant component of the water balance, greater than deep infiltration/runoff. It is greatest following spring snowmelt and is lowest in late summer and fall after the soil dries.
- Evapotranspiration (and carbon exchange) continues through the winter at a significant rate, and increases in response to temperature during the snow-covered season and in response to soil moisture (precipitation) during the snow-free season.
- Measurable groundwater recharge occurs in meadows.

KREW is snow-covered in winter, and receives a mix or rain and snow

Instrumentation is distributed across KREW

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Collaborators:

- Mike Allen, UC Riverside (ecology)
- Martha Conklin, UC Merced (Co-I, groundwater-surface water interactions)
- Mike Goulden, UC Irvine (Co-I, flux tower measurements)
- Jessica Green, UC Merced (ecology)
- Qinghua Guo, UC Merced (flux tower measurements)
- Tom Harmon, UC Merced (water quality & sensor networks)
- Jan Hopmans, UC Davis (Co-I, soil moisture)
- Peter Kirchner, UC Merced (graduate student, instrument deployment)
- Fengjing Liu, UC Merced (groundwater-surface water interactions)
- Joe McConnell, Desert Research Institute (sap flow)
- Norman Miller, Berkeley National Lab (hydrologic modeling)
- Noah Molotch, UC Los Angeles (snow hydrology & measurement design)
- Peggy O'Day, UC Merced (geochemistry)
- Robert Rice, UC Merced (snow measurements)
- Eric Small, U Colorado (Co-I, soil moisture and flux tower)
- Sam Traina, UC Merced (soil chemistry)

Project status: Instrument cluster installation is in progress. Tower construction is planned for 2007.