CZO contributions to water security in the Western U.S.

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Making a water-secure world – the three I’s

**INFRASTRUCTURE**
- to store, transport & treat water

**HARD**

**INFORMATION**
- Better & more-accessible

**INSTITUTIONS**
- Stronger & more-adaptable

**SOFT**
Making a water-secure world – the three I’s

INFRASTRUCTURE
to store, transport & treat water

Better & more-accessible INFORMATION

Stronger & more-adaptable INSTITUTIONS

Water security: the reliable availability of an acceptable quantity & quality of water for health, livelihoods & production, coupled w/ an acceptable level of water-related risks
Making a water-secure world – the three I’s

**INFRASTRUCTURE**

to store, transport & treat water

**Ecosystem Services**

Better & more-accessible **INFORMATION**

**INSTITUTIONS**

Stronger & more-adaptable
Water is fundamental to sustainable ecosystem services. Water management therefore translates into managing ecosystem services, and must be a fundamental goal of virtually all such efforts.
Much of the water supply for the semi-arid Western U.S. derives from mountain snowpacks

Warming by +2 to +6°C drives significant changes:

– rain-vs-snow storms *
– snowpack amounts *
– snowmelt timing *
– flood risk
– streamflow timing *
– low baseflows
– growing seasons *
– recharge?
– drier soil in summer

Precipitation changes?

Already observed (*)
Water security lies at the heart of adaptation to climate change

Includes both:
- ‘hard’ options to capture & control water
- ‘soft’ tools to manage demand as well as increase supply, e.g. water allocation, conservation, efficiency & land-use planning

General feeling in the water community that soft opportunities will be insufficient

What California is doing:
- Planning for infrastructure
- Collaboration & integration in planning, management
- More information-intensive decision support

Southern Sierra CZO is addressing knowledge gaps in all 3 areas
Critical zone observations are a foundation for water security
Southern Sierra
CZO is located at elevations 1750-2100 m, across the rain-snow transition, in a very productive mixed-conifer forest, with extended measurement nodes at elevations 400-2700 m.
A new generation of integrated measurements

eddy correlation

embedded sensor networks

isotopes & ions

satellite snowcover

lidar

low-cost sensors

sap flow

sediment
Southern Sierra CZO

E-W transect of flux towers

Elev., m

3000
2400
1800
1200
600

San Joaquin Experimental Range 400 m

Soaproot Saddle 1100 m

CZO P301 2000 m

Shorthair Creek 2700 m

Main CZO site

N-S transect of research catchments

NEON to follow same E-W transect as CZO
Increase in water yield with elevation:

Decreasing temperature
Increasing snow fraction
Decreasing LAI
Coarser soils

Implication for 2°C warmer climate: Reduce runoff by 10-40% in mixed conifer forest.
Evapotranspiration (ET) across an elevation transect

- Lower elevation is water limited
- Higher elevation is cold limited
- Highest current ET in rain to rain-snow-transition region of mixed conifer forest – year-round growth
Is ET really this high?

Modeled ET in Yosemite (Lutz et al., 2010)

- Ecological & climate models often have ET values in the 200-500 mm range
- Deficit based in part on 1-m or 2-m soil depth
- Providence precip & streamflow suggest values in the 500-1200 mm per year range

$\text{Precip} = ET + \text{Streamflow}$
Water & temperature limits

Conventional wisdom: short growing seasons, small changes w/ elevation

Observations:
– Water & cold limitation thresholds that kick in at lower/higher elevations
– Sweet spot at mid elevation – only weak water/cold co-limitation

Implications
– Warming alone could cause big change in growing season length
– Ecohydrologic & biogeochemical processes may not be buffered against warming
Some implications of steep elevation gradients in ET & runoff for water resources

Forest management is important for water yield & the timing of snowmelt runoff

Downstream beneficiaries have a stake in upstream watershed management

Better measurement & process understanding are critical to realizing benefits of management actions

SS-CZO is addressing knowledge gaps & stimulating adaptive management
Developing a new water-information system for California & beyond – American R. basin prototype

Scaling CZO results for water, flood & drought management

Strategically place low-cost sensors to get spatial estimates of snowcover, soil moisture & other water-balance components

Network & integrate these sensors, w/ satellite data & modeling, into a single spatial instrument for water-cycle estimates

in progress
Southern Sierra CZO is a multi-campus program & a community resource