Water information system advances
American River basin

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Opportunities
– Unprecedented level of information from low-cost wireless-sensor networks plus satellite remote sensing can inform a new generation of forecasts, operations & planning
– Current research system provides proof of concept of operational tool for hydrologic forecasting for American River basin, Sierra Nevada & California
– Possible research-applications partnerships
– The foundation for water security in a changing climate and stressed society is better, timely, transparent, accurate water-resources information
Making a water-secure world – the three I’s

**INFRASTRUCTURE**

Better & more-accessible

**INFORMATION**

to store, transport &
treat water

**Ecosystem services**

Stronger & more-adaptable

**INSTITUTIONS**

Better & more-accessible

**INFORMATION**

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
Seasonal runoff forecasts are based on historical observations & have some skill in a stationary climate. Volume forecasts use a few point measurements as indices of snow accumulation. Precipitation forecasts make use of empirical & regression methods. Ground data are used in decision-making processes.
Percent bias of April 1 forecast of annual streamflow

American River at Folsom

Absolute values of percent bias

Bias = \frac{\text{Forecast} - \text{Observed}}{\text{Observed}}

Wet years tend to be under-forecast, dry years over-forecast

Weekly to daily forecasts based on historical data are even more biased

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Some additional points re forecasting

1. We cannot model our way out of this uncertainty
2. Improvements in forecast skill require new observations
3. The technology to support new observations is available
4. This technology has matured over the past 5-10 years
American River basin hydrologic observatory

Platform for research & core element of new water information system
Strategically place low-cost sensors to get spatial estimates of snowcover, soil moisture & other water-balance components

Integrate these sensors with remotely sensed data, forecasting tools & decision support

SNRI/CITRIS, 7-21-15
Goals of American River basin observatory & water-information system

1. Demonstrate basin-scale, real-time intelligent water information system
2. Reduce uncertainty in water-supply forecasts
3. Enable more-flexible operation of dams
4. Enhance hydropower operations
5. Document & forecast impacts of forest management on water
6. Provide information of unprecedented accuracy & scope for current forecasting & decision-support systems
7. Enable more information-intensive forecasting & decision-support tools
8. Provide first core element of broader information system for California
Elevations of installed or planned wireless sensor networks

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On-line data for diagnostics

Map interface to sites

Data from one node & sensor
Zoom to map of individual sensor nodes, Duncan Peak

Nodes placed to capture variability in elevation, slope, aspect, vegetation

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Instead: new generation of integrated measurements

Process research & advanced modeling tools

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Sensor node design

- External 4 dBi antenna
- Snow depth sensor
- Solar radiation shield for: temp/rH Sensor
- Solar Panel
- NEMA Electrical Enclosure with Metronome Systems NeoMote, Li battery, Metronome Systems charge controller

(Buried below ground are 4 soil moisture, temperature, and matric potential sensors)

The wireless data logger housing is built from robust industrial materials to withstand the harsh winters experienced in the Sierra Nevada.
Node construction at Alpha site

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Onion Creek snow water equivalent (SWE)

SWE = depth × density

Daily temperature & daily SWE (mean & standard deviation) – full snow season

Daily & hourly temperature, plus daily SWE, Feb-Apr

Daily & hourly temperature, plus daily SWE – one month

Snow density values from Greek Store, Huysink, CSSL

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Snow depth variability across elevation transect of sensor clusters

March 27 - April 5, 2014

Increasing elevation
Information needs for hydrologic forecasting

Distributed snow sensors → Satellite snowcover → Weather forecast → Met stations

QA/QC & interpolation

Snowpack storage map

Snowmelt model

Daily snowmelt map

Basin water-balance model

Reservoir inflow forecasts

Weather & climate outlooks

Other water-balance products

Forest management, drought planning
Satellite snowcover products complement ground sensors – blended products

Elevations above 1500 m
Divided into approximately 7000 500-m square pixels
1. Technology is sufficiently mature to invest in systems for operational use – harden WSN, blend w/ satellite data
2. American River basin is both research platform & core element of new water-information system
3. Forecasting water supply using spatial data & appropriate modeling could reduce uncertainty due to land-surface fluxes & stores by ~50%
4. Even a few % improvement in high-elevation hydropower would provide significant gains
5. Better information is a critical foundation for water security, especially in a warming & more-variable climate
6. Water information system also provides verification for benefits of sustained forest management