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## In-situ Measurements and Telemetry of the Snowpack to Improve Hydropower Operations in a Changing Climate



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## Project objective

Offset growing uncertainty in hydropower forecasts owing to a changing climate and growing demands for better forecasts to enhance value of hydropower operations.

Changes in space time patterns Faster snowmelt

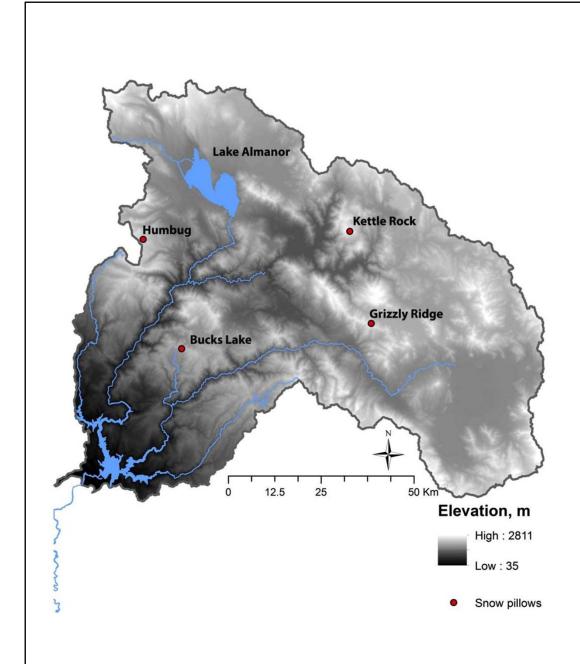
Snow

## Runoff

Changes in seasonality and volume

High uncertainty
Sub-optimal hydro
operations.

Hydro



## North Fork Feather River

Support PG&E's

Hydropower Planning and

Operations

#### **Key priorities:**

- 1. Uncertainty and temporal resolution of forecasts.
- 2. Spatial resolution of snowpack storage and snowmelt.

#### Mountain Meadows Reservoir Hamilton Branch Diversion Dam Hamilton Branch PH N. Fork Feather River Prattville Lake Almanor Tunnel **Butt Valley** PH **Butt Creek** N. Fork Feather River East Branch N. Fork Feather River Three Lakes **Butt Valley** Reservoir Bucks Lake Caribou 1 Caribou 2 **Butt Creek** PH Belden Lower Forebay Bucks Lake Grizzly Oak Flat Milk Ranch Creek Belden **Bucks Creek** Grizzly Rock Creek Forebay Bucks Reservoir Creek PH Rock Creek Cresta Reservoir Cresta Grizzly Creek Legend Poe Dam UNFFR Project Powerhouse UNFFR Project Reservoir Other PG&E Project Powerhouse Other PG&E Project Reservoir/Dam Lake Oroville

## North Fork Feather River

Support PG&E's

Hydropower Planning and

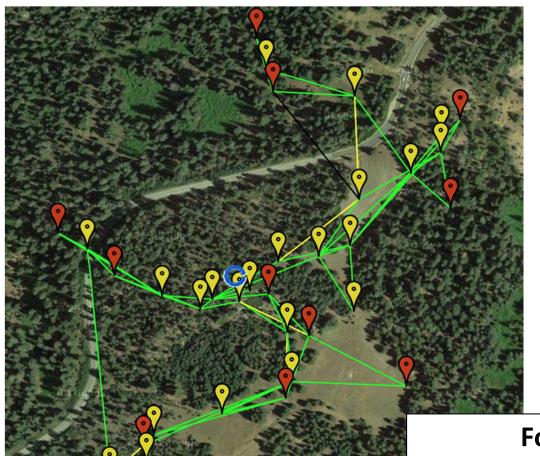
Operations

#### **Key priorities:**

- Uncertainty and temporal resolution of forecasts.
- 2. Spatial resolution of snowpack storage and snowmelt.

Source: Upper North Fork Feather River Hydroelectric Project

## Real-time wireless sensor networks



Sensor node

Repeater node

### **Four key locations**

**12 sensor nodes** for each location **8 to 12 Ha** spatial resolution (20 to 30 ac).

## Sensor node

15W solar panel

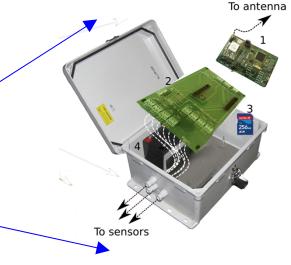
Network antenna

Solar radiation sensor

Ultrasonic snowdepthe sensor

Soil moisture & temperature

Temperature/humidity sensor inside shield



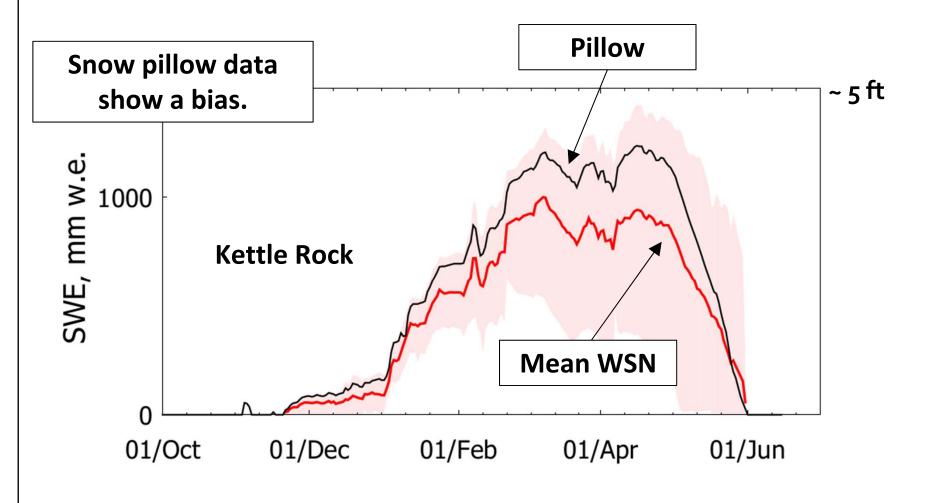
- 1. NeoMote
- 2. Interface
- 3. SD card
- 4. Li-ion battery



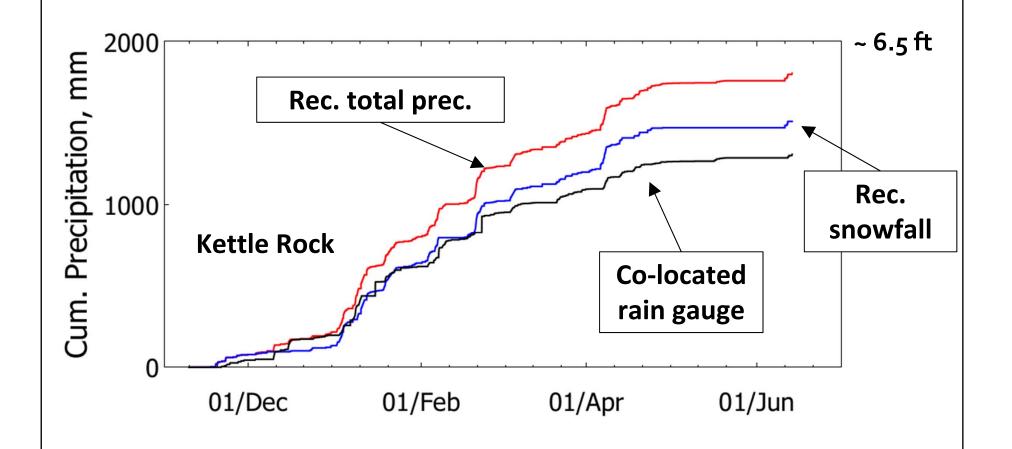
# The 2016/17 snow season



Wireless sensor networks track representative patterns of water content based on physiographic variables.

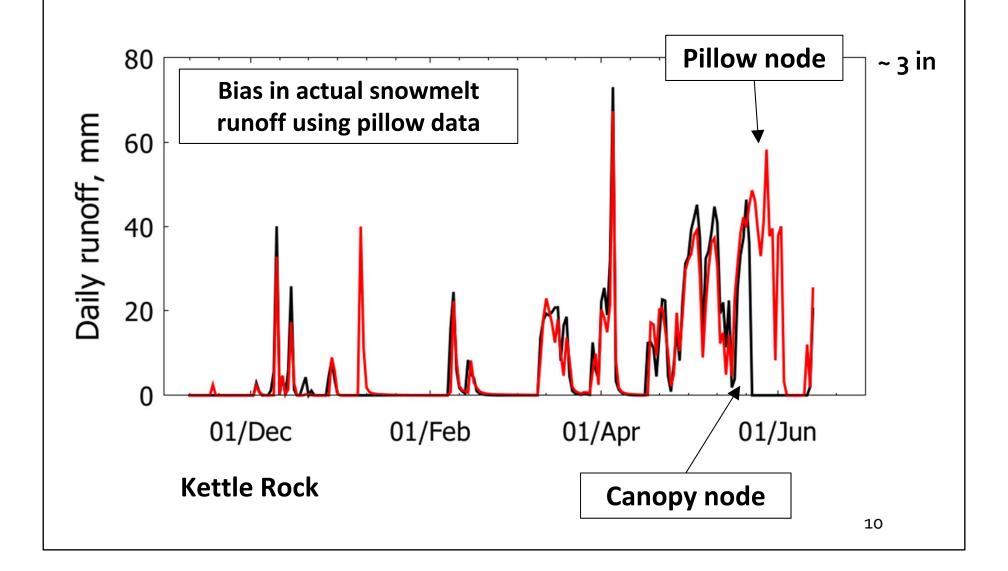


Wireless sensor networks can estimate undercatch of rain gauges and partitioning between rain and snow.



Snow depth and rain gauge data can be blended to better estimate actual precipitation.

Combined with mass-balance models, the networks reconstruct snowmelt runoff inputs to the hydrologic system.



## Summary

We are developing <u>core elements</u> of a **next generation hydrographic data network.** 

The network can support hydropower decision makers in real time with more information about the snowpack state.

The project is successful if the products **enhance hydropower value to utilities** and **ratepayers** through lower uncertainty