SCA values on left represent the fraction of the pixel that was detected by the satellite as being snow covered.
Resolution of SCA pixels is 500 m.
Red polygons are hydrologic basin boundaries.

Data used:
- Snow covered area (SCA) from satellite
- Ground measurements of temperature, precipitation, snow water equivalent (SWE), snow depth, snowmelt

SCA fraction-March 31, 2008:
- 0.75 - 1
- 0.5 - 0.75
- 0.25 - 0.5
- 0.15 - 0.25
How well do we know how much rain & snow fall in the parks, or any region of the Sierra Nevada?
Kaweah basin precipitation estimates compared with LiDAR and SWE reconstructions – spring 2010

LiDAR provides a spatial “ground truth” estimate of snow accumulation, which for this area, above about 2100 m elevation, should equal accumulated precipitation.

Rice et al values indexed to snow pillows, masked by satellite data.

Precipitation remains poorly measured across the Sierra Nevada.

*Kirchner et al., in preparation*
At a broad scale, temperature varies consistently with elevation, with some month-to-month differences in slope. Local-scale differences may be quite important for snow & biota.

Note 14.6 °C max – min difference at Lodgepole vs 11.6 at Grant Grove.
Local-scale differences in temperature – Onion Creek

10 sensors in wireless network spread over 1-km distance

Max - min
Day: 1-2 °C
Night: 5-10 °C
Satellite data show persistent snowcover through much of the Parks in early spring.
Example application: Giant Sequoia groves – areas having greater fall vegetation wetness are correlated with greater snowcover persistence

Each point on the graph is a giant sequoia grove
NDWI (vegetation wetness index) is high in a narrow band of high transpiration.

- Lower elevations are too dry in summer – rain versus snow dominated.
- Higher elevations are too cold in winter – snow dominated.

Black polygons are Giant Sequoia groves.
Topographic variability & soils are also important
Giant Sequoia Groves tend to be wetter than adjacent areas – combination of snow, topography, soils

Median & 95% confidence interval of 30 x 30 m LANDSAT pixels
Example application: snowmelt & runoff

Graphs show fraction of total snowmelt originating from each elevation range.

2°C of warming will reduce melt in 2100 m elevation band; & reduce melt at higher elevations w/ further warming.

Most snowmelt comes from elevations above most measurement of precipitation or snowpack.
Snowmelt will also be earlier with climate warming

Earlier snowmelt means
- Earlier growing season
- Drying of soils earlier in summer
- Lower summer baseflow in streams
- Greater moisture stress in forest
- Loss of storage for downstream water users

Error bars represent interannual variability
Downstream water users could benefit from more information on precipitation & snowpack.
Some recurring questions from downstream water managers

1. What will be the water yield from Sierra Nevada forests w/ climate warming, vs. today?

2. What was the water yield prior to fire suppression?

3. How different were forests prior to fire suppression vs. today?

4. Given changes in climate & land use, can we take forests back to pre-fire-suppression conditions?

5. What are indicators of a healthy forest?
1. Snowpack supports high evapotranspiration across a wide swath of mixed conifer forest
2. Resiliency in the snow zone to water stress – combined snowpack & soil-water storage
3. Higher water yield in snow zone owing to shorter growing season – climate vulnerable
4. Research is critically needed on several basic hydrologic & management questions around forests, snow & water
5. Water management translates into managing ecosystem services
6. Adapting to climate change also means managing ecosystem services