Origins and Pathways of the Merced Water Supply

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1. Measuring the Sierra snowpack
2. Tracking the snowmelt runoff
Part 1. The Sierra snowpack
Our ability to accurately answer the question “How much snow is out there?” is very limited.

Two problems:
- Very few measurements
- Measurements not spatially representative
In the Upper Merced River basin (1,755 km²), snow depth & snow water equivalent (SWE) are only measured daily at only 3 points & monthly at 2 additional locations.
Gin Flat snow pillow
Point SWE measurement problem

- Snow pillow & snow course measurements provide limited information on spatial distribution patterns.
- Sites are not representative of the terrain & thus fail to represent basin-wide snow depth or water equivalent.
Snow course & snow telemetry sites

- Established as index sites to estimate seasonal runoff using statistical models – located at sites with persistent snowcover
- Point measurements of snowpack – not quantitative measures of basin-scale snow water equivalent
UC Merced research

Develop daily snow cover information from satellite (cloud free days)
Design ground-based measurement approaches that provide better spatial coverage
Blend these data with advanced modeling tools
Tuolumne

Merced

DOY 133 – May 12

% SCA
76-100
51-75
26-50
1-25
DOY 133 – May 12

Upper Merced
UPPER MERCEDE

DOY 134 – May 13

% SCA

76-100
51-75
26-50
1-25
DOY 135 – May 14

Upper Merced

% SCA
76-100
51-75
26-50
1-25
DOY 61 – March 1

Upper Merced
DOY 63 – March 3

Upper Merced

% SCA
1-25
26-50
51-75
76-100
Snow cover in the Western U.S.

- exhibits considerable interannual variability
- occurs on only a small fraction of the landscape
- yet it sustains the streamflow & groundwater recharge of much of the west
Jul-Aug-Sep temperature outlook
April 2005

Lack of anomaly
Snow cover & climate change

– Western snowpacks hold less water than 50 years ago
– They are also melting earlier
– Result is earlier runoff & drier summer soil
– These trends should continue as climate warms further
Climate change

There are 3 important points on which the science community agrees:

– global warming is occurring
– fossil fuel consumption contributes to the warming
– if we fail to act now to reduce greenhouse gases it will get worse

Many government & private sector planners consider climate change in:

– planning infrastructure
– evaluating investments
– protecting public health, welfare & natural resources
Snowpack decline in Cascades

April 1 snow water equivalent (SWE) in Pacific NW has declined up to 60% since 1950.

Mote et al., GRL 2
Estimating influence of possible +6ºC on SNOW vs RAIN

"Great things are done when men & mountains meet." -- William Blake

Derived from UW’s VIC model daily inputs, 1950-1999

Dettinger, unpublished
Estimating influence of possible +6°C on SNOW-SEASON LENGTH

Derived from UW’s VIC model daily inputs, 1950-1999

Dettinger, unpublished
Estimating influence of possible +6°C on RAIN-FLOOD STORMS

Derived from UW’s VIC model daily inputs, 1950-1999

Dettinger, unpublished
The combined effects of climate change, population growth, land-use change & landcover changes are placing increasing stresses on mountain environments & on the imbalance between water demand & supply.
Research directions: snow hydrology

- Satellite remote sensing
- MODIS fractional SCA
- 9 Mar 2004
- fractional SCA
- SWE estimation
- Tokapah
- canopy corrections
- energy balance
- ground measurements
- hydrologic modeling
Research directions: integrating water & biogeochemical cycles

- Snow distribution
- Melt timing
- Partitioning
- Infiltration
- Runoff
- ET
- Recharge
- Evapotranspiration
- Precipitation
- Snowmelt
- Infiltration
- Sublimation
- Runoff
- Ground & surface water exchange

Wireless pod for snow depth
Snow: the way forward

Demonstrate usefulness of satellite remote sensing products to research & applications communities
  – hydrologic forecasts
  – water resources decisions
  – biogeochemistry

Create new demands for satellite snow products

Integrate ground & space measurements for snow estimation

Enhance dialog between research & applications communities on topics of snow measurement & modeling
Concluding thoughts

Current ability to quantitatively estimate water fluxes & reservoirs in mountains is woefully inadequate (also ecological & biogeochemical linkages)

Economic value of & societal demand for new knowledge & tools for mountain hydrology is very large

Advances will require sustained investments in new measurements & infrastructure, including data & information systems (plus research)

Measurement strategies will rely heavily on remote sensing — need complimentary ground-based systems