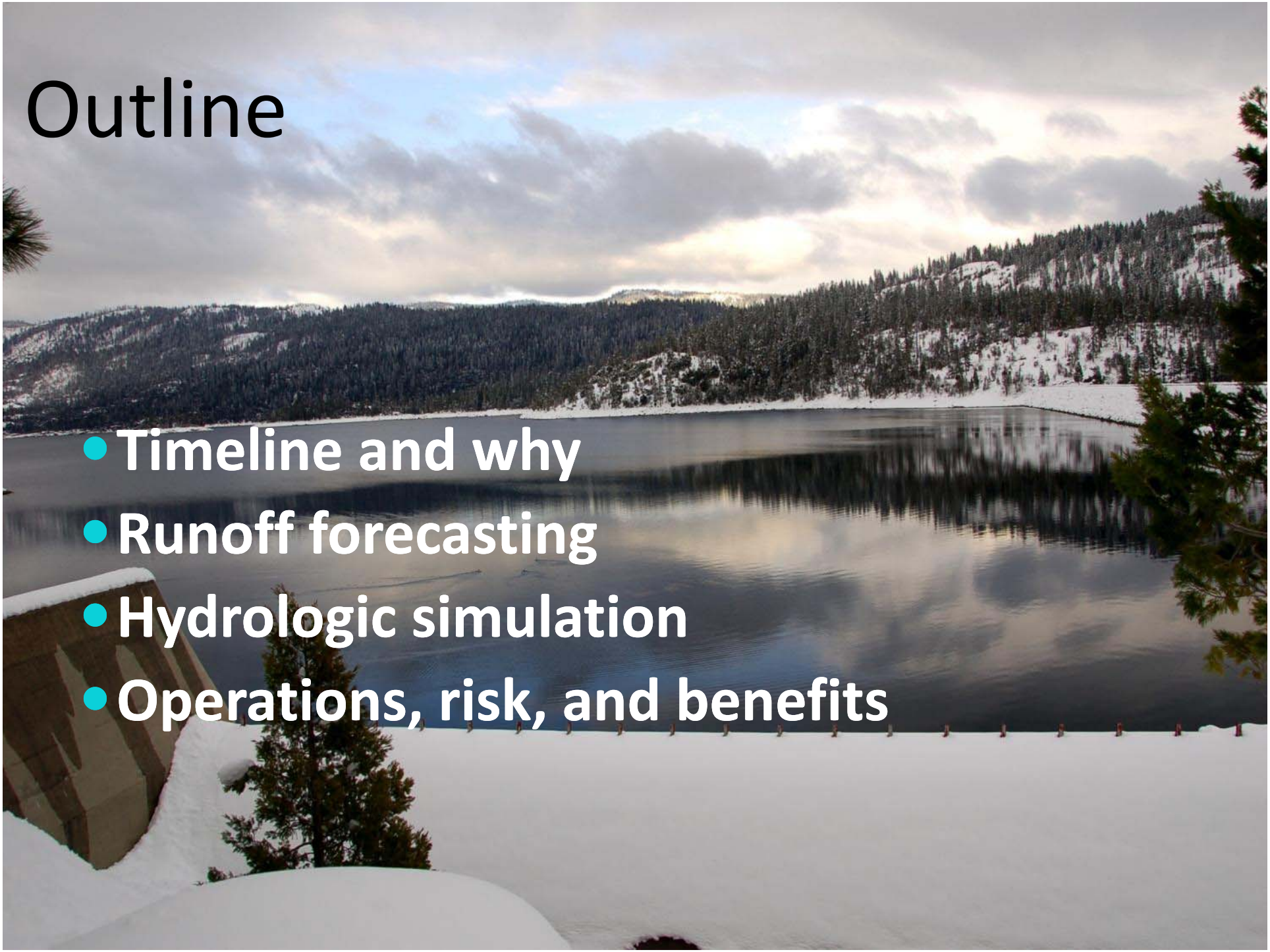
Airborne Snow Observatory

Cal. Cooperative Snow Survey Meeting, Nov. 8-9, 2012

Dr. Tom Painter, NASA JPL, Principal Investigator

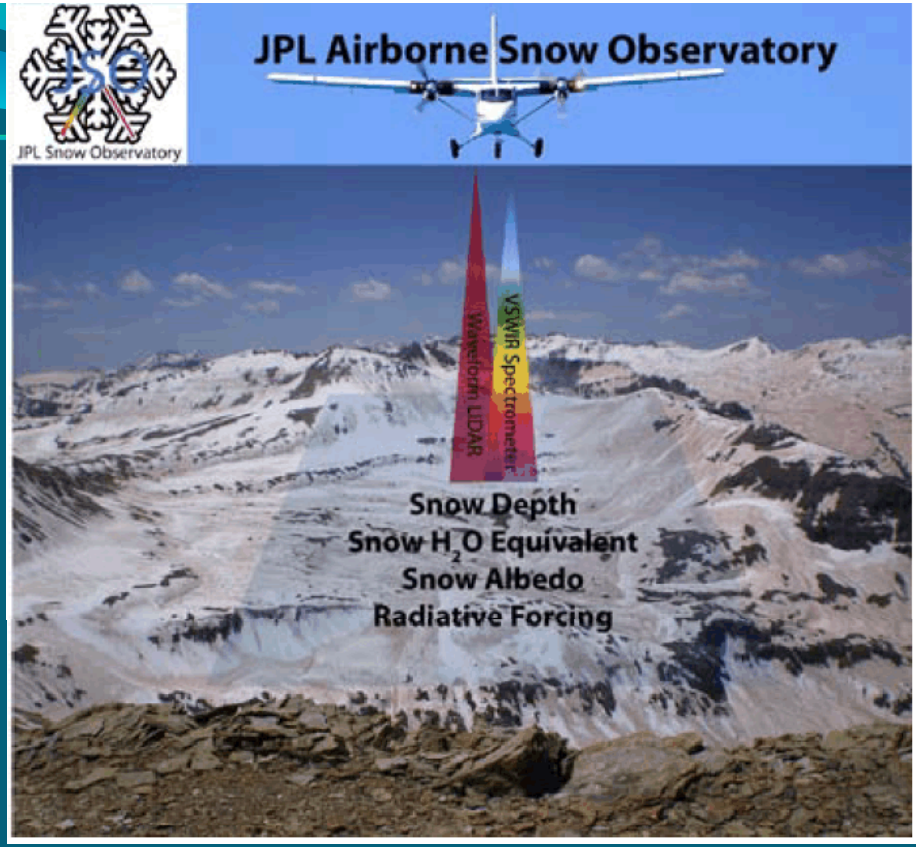
Dr. Bruce McGurk, Principal, McGurk Hydrologic

Outline



- Timeline and why
- Runoff forecasting
- Hydrologic simulation
- Operations, risk, and benefits

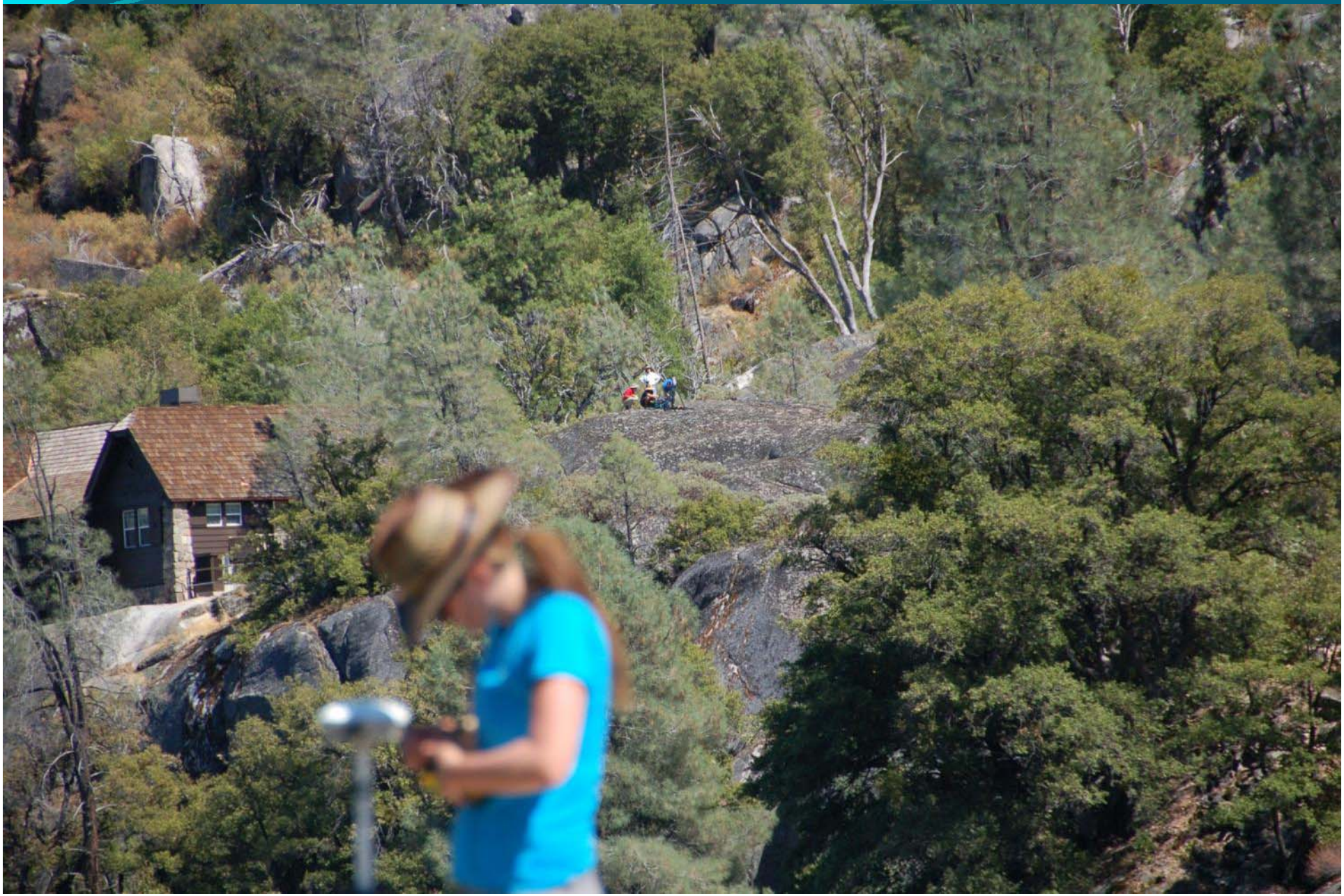
ASO Project Timeline & Goals



- Snow free, August
- Weekly flights – March – June, 2013
- Data processed, PRMS runs
- Forecasted streamflow and basin snow water volume supplied to HHWP
- Better SWE information and modeling allows for better reservoir operation
- Benefits = full pond, more generation, flow control

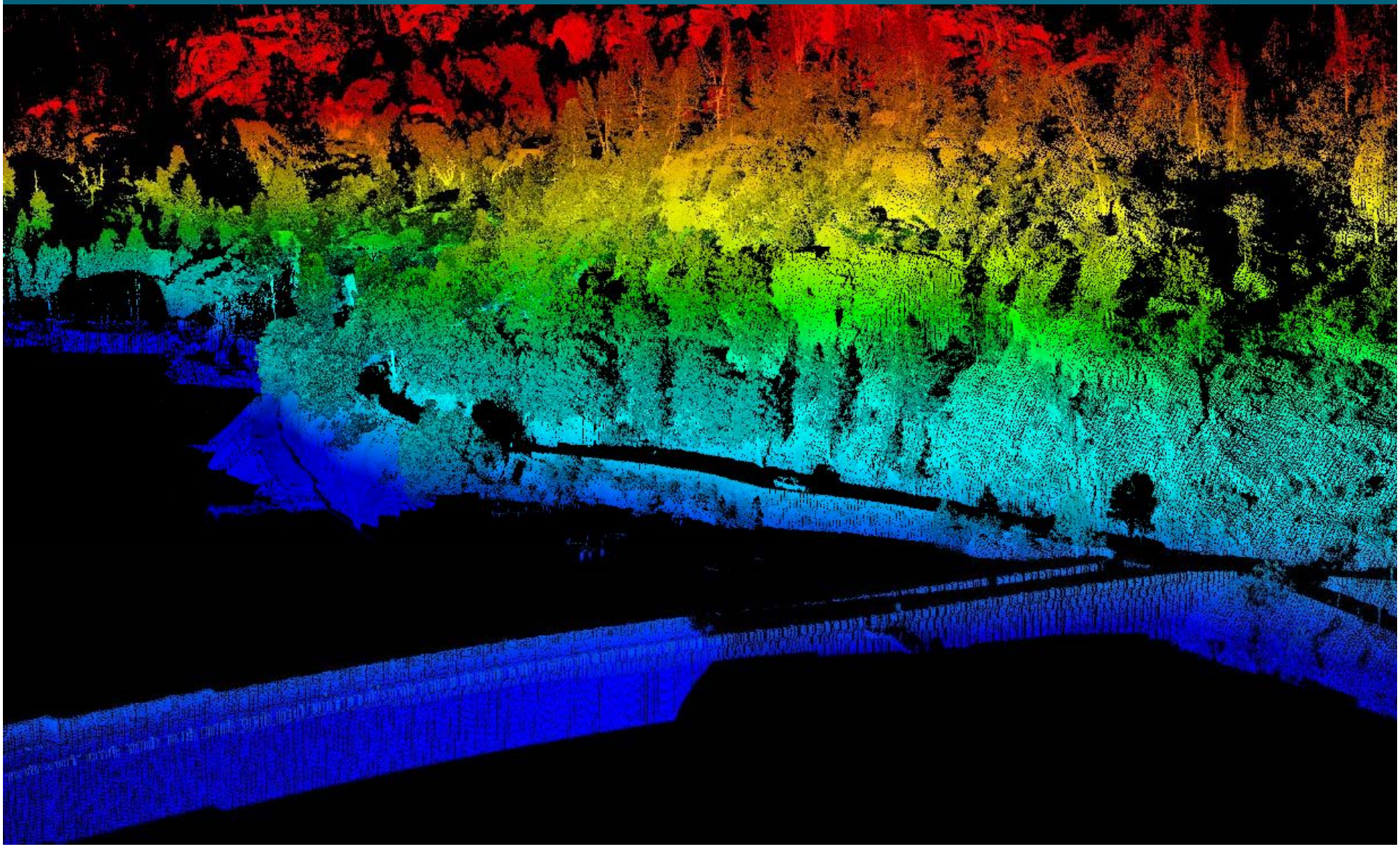
LiDAR at HH

LiDAR at HH

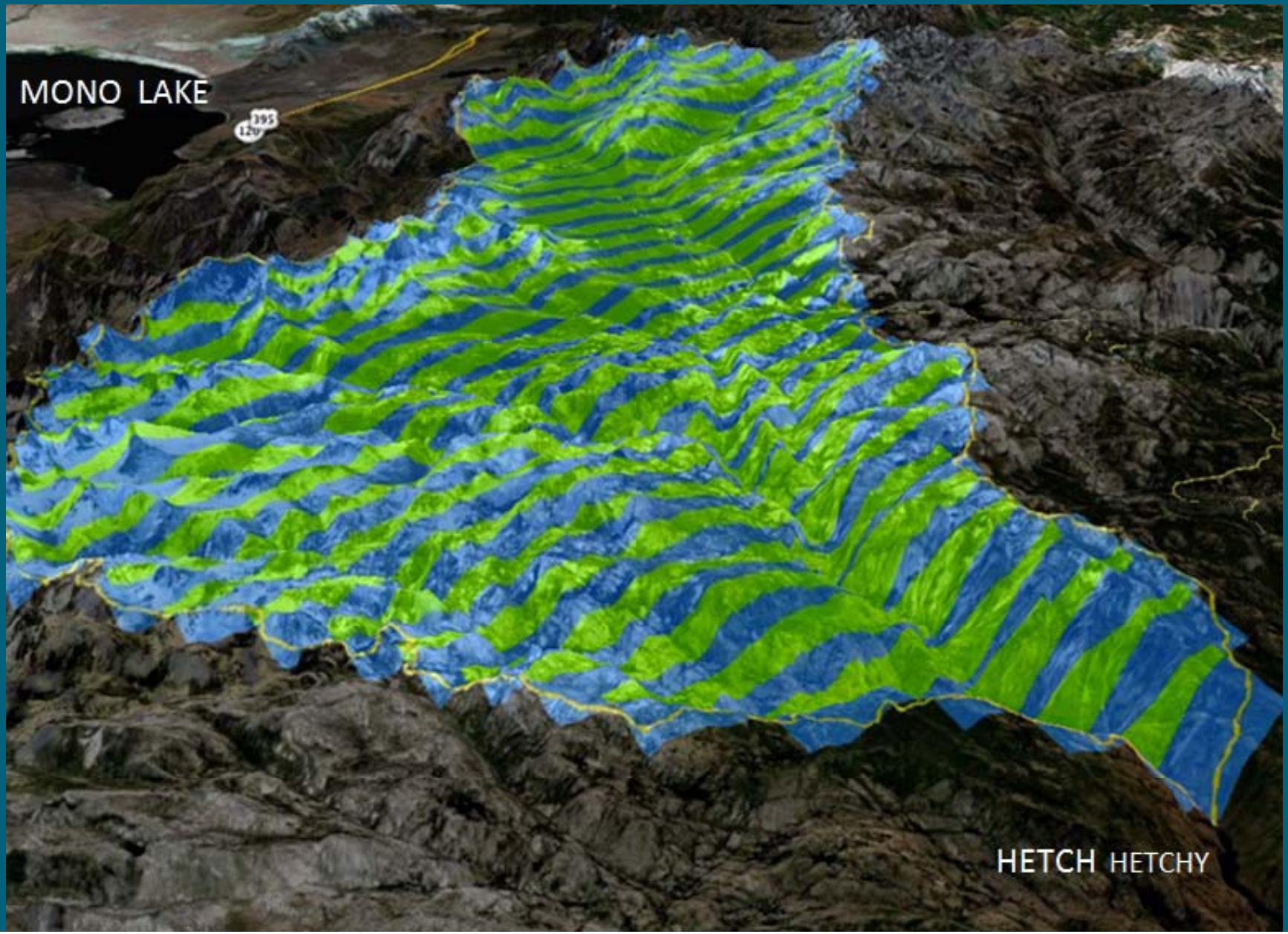


LiDAR at HH, 8 Aug. 2012

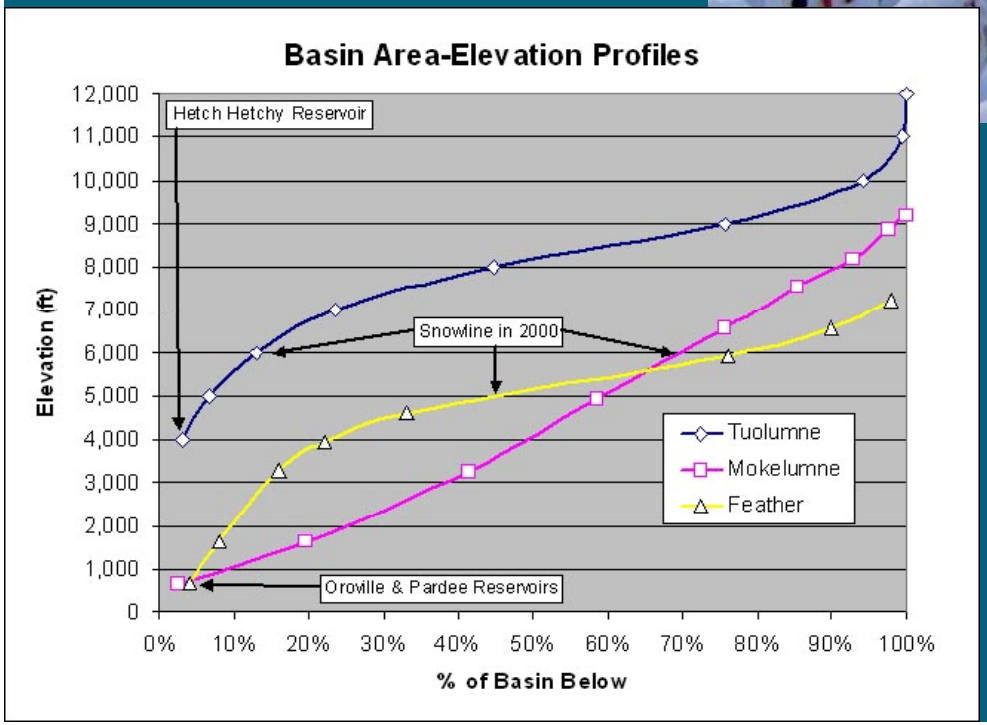
Height at HH – Boat Ramp



Winter Data Collection - Weekly

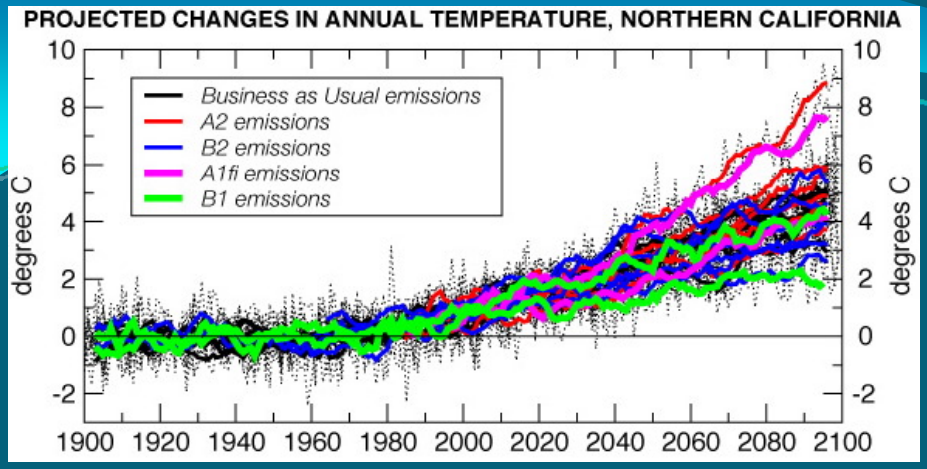


Why?
What do we need?



History of Runoff Forecasting - T

- 1946 – Bartell – Graphical - Combined seasonal precip & annual runoff at LaGrange to predict inflow at HH, EL, CH
- 1960's – CA DWR – Monthly regression equations, used snow courses, prior year runoff, remaining median precip, AJRO and monthly estimates
- 1985 – Water Supply Forecasting Model – PC, weekly, uses snowcourses, temperature, precip, AJRO and monthly estimates
- 2006 – VISTA Daily Forecast Model, simulates snowpack in three zones, adds 5-10 day forecast to current condition to forecast 5-10 days of reservoir inflows

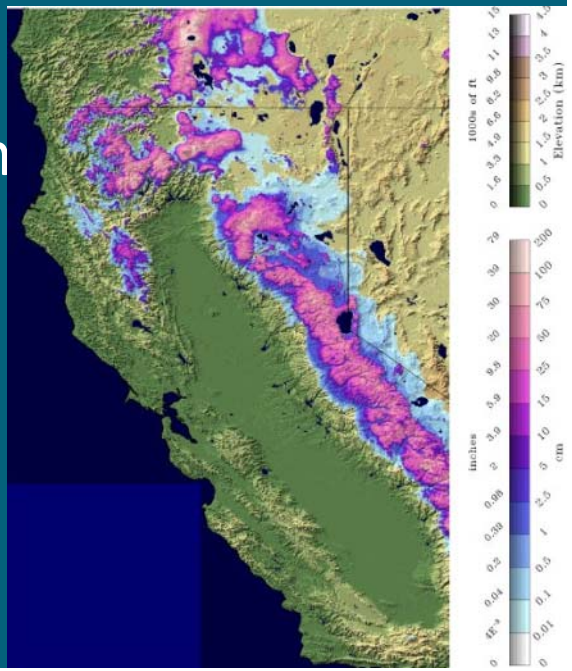


Forecasting and Climate Change

- Current HHWP forecast tools use statistical relationships between snow and runoff from 40-year period
- Trends and relationships appear to be shifting since 2000
- Reducing GHG emissions worldwide appears to be failing
- Adaptation to new regional climate pattern is now considered necessary
- Current statistical tools will have reduced accuracy by 2025, worse by 2050
- Without better tools, only response is HEDGING

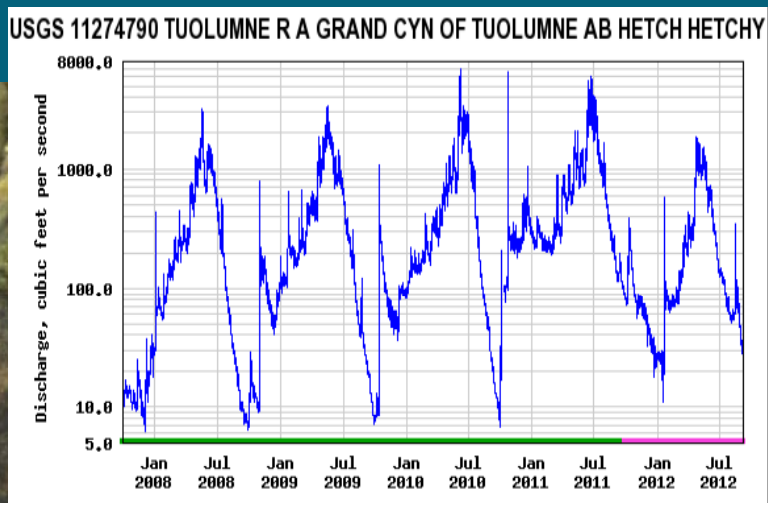
Data Availability Changing

- Current network of climate and SNOTEL stations offers hourly or daily info: temp, precip, snow depth, SWE, rad
- Satellite data on snow cover and snow extent available weekly or better (MODIS), though typically lagged
- Several modeled snow cover, density, and SWE products are available, but have 1 km or larger grids and no verification.



Reservoir Ops More Challenging

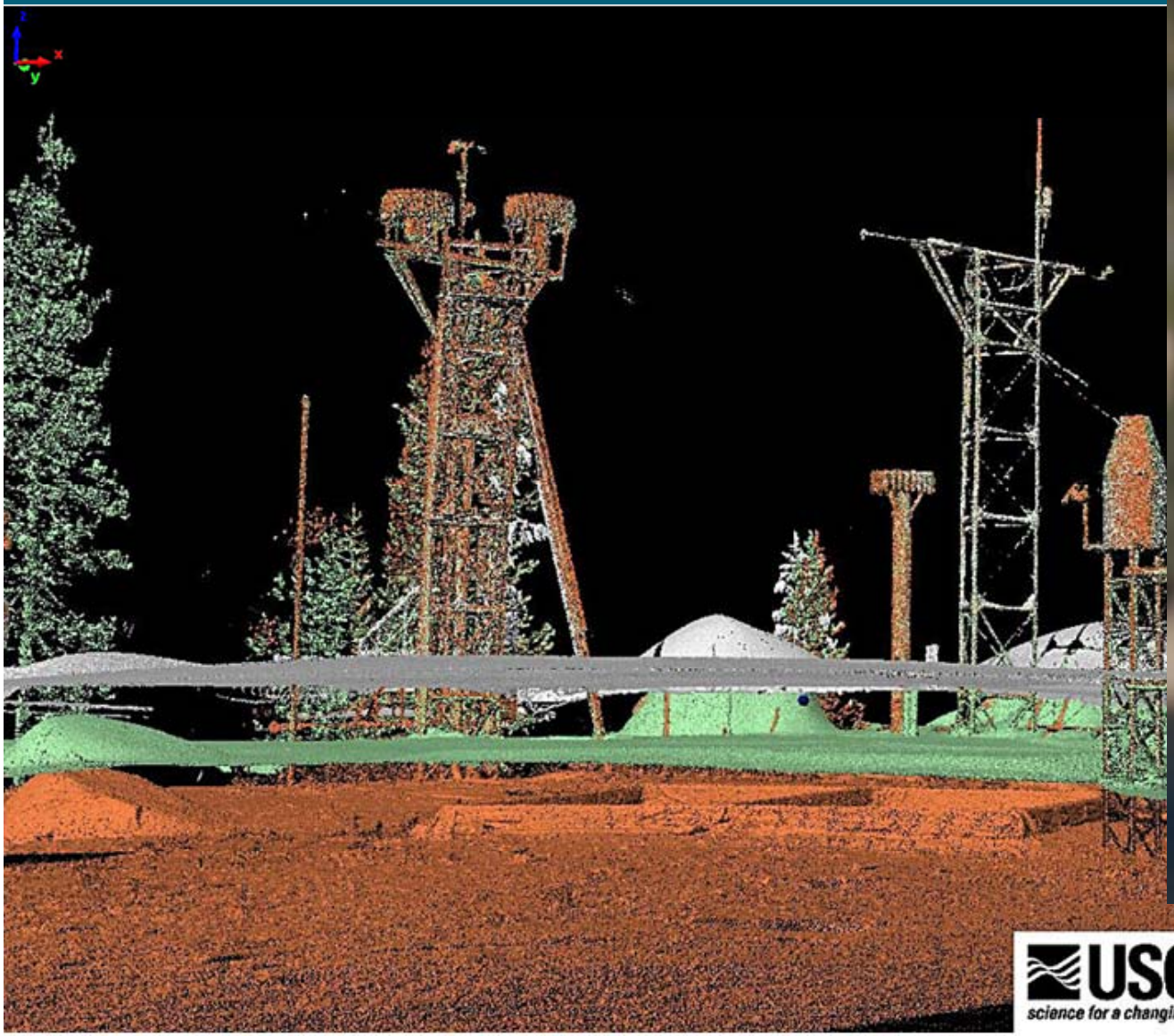
- Operational goals vary by type of operator
- For water supply, full as late as possible is the goal
- Spill release regime is complex when geomorphic and fisheries goals are included:
  - High flows needed in early runoff season – can endanger fill
  - No high flows wanted in late runoff season – frog eggs
  - Increasingly variable inflow quantity and quality due to weather patterns increases risk



NextGen Runoff Forecasting

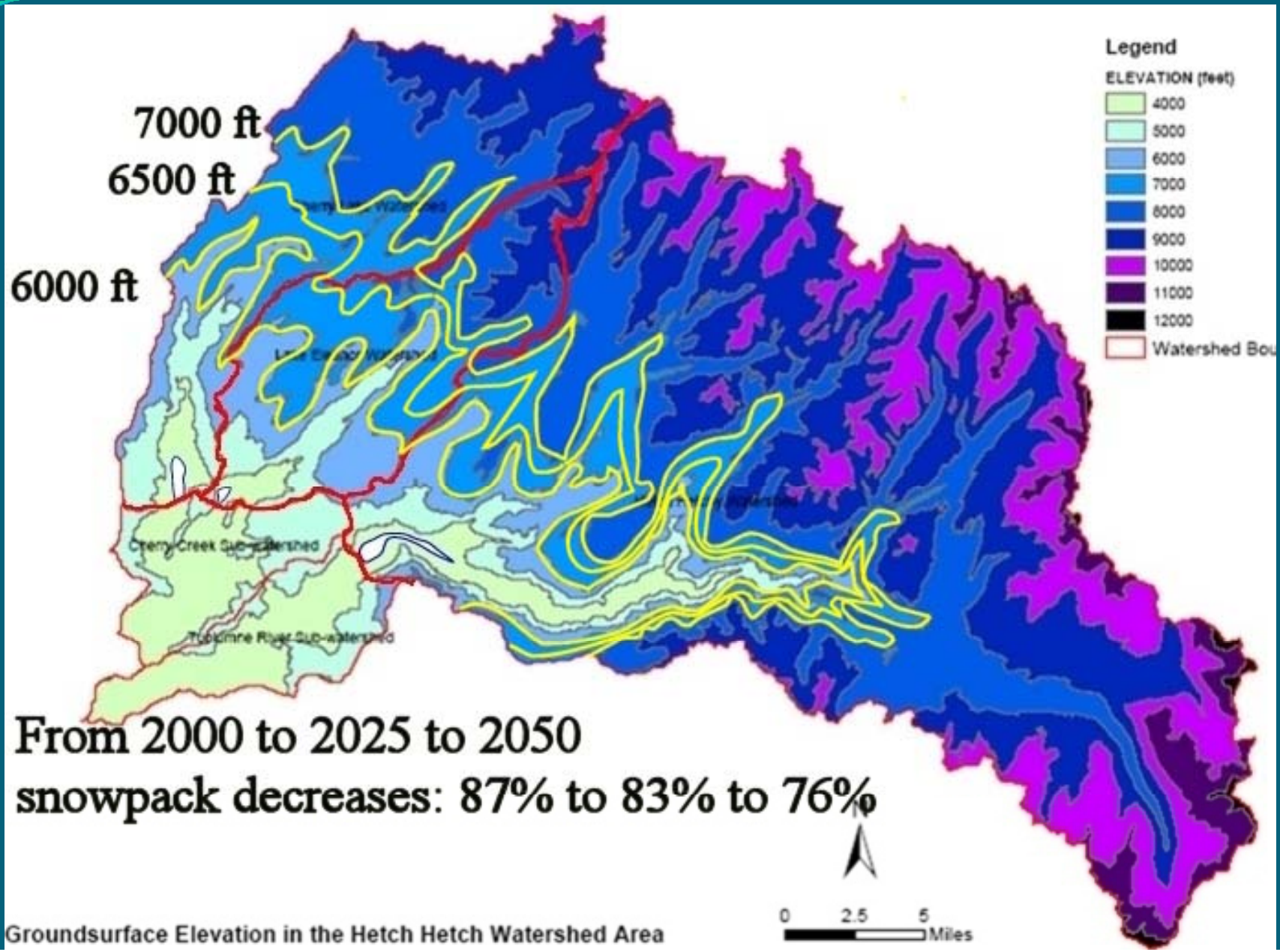
- New forecast models use current and forecast data
- New models are distributed – hundreds (or more) polygons in the watershed, site specific data used
- Data comes from smart networks, satellite, or aircraft
  - Critical parameters are snow depth, density, extent, albedo
  - Small polygons incorporate veg and topo complexity
  - Frequent ground truth events improve/update model states
- Simulation models incorporate physics of snow accumulation and ablation – no longer statistical

LiDAR & Snow Depth – Jan 3 & 7, 2008

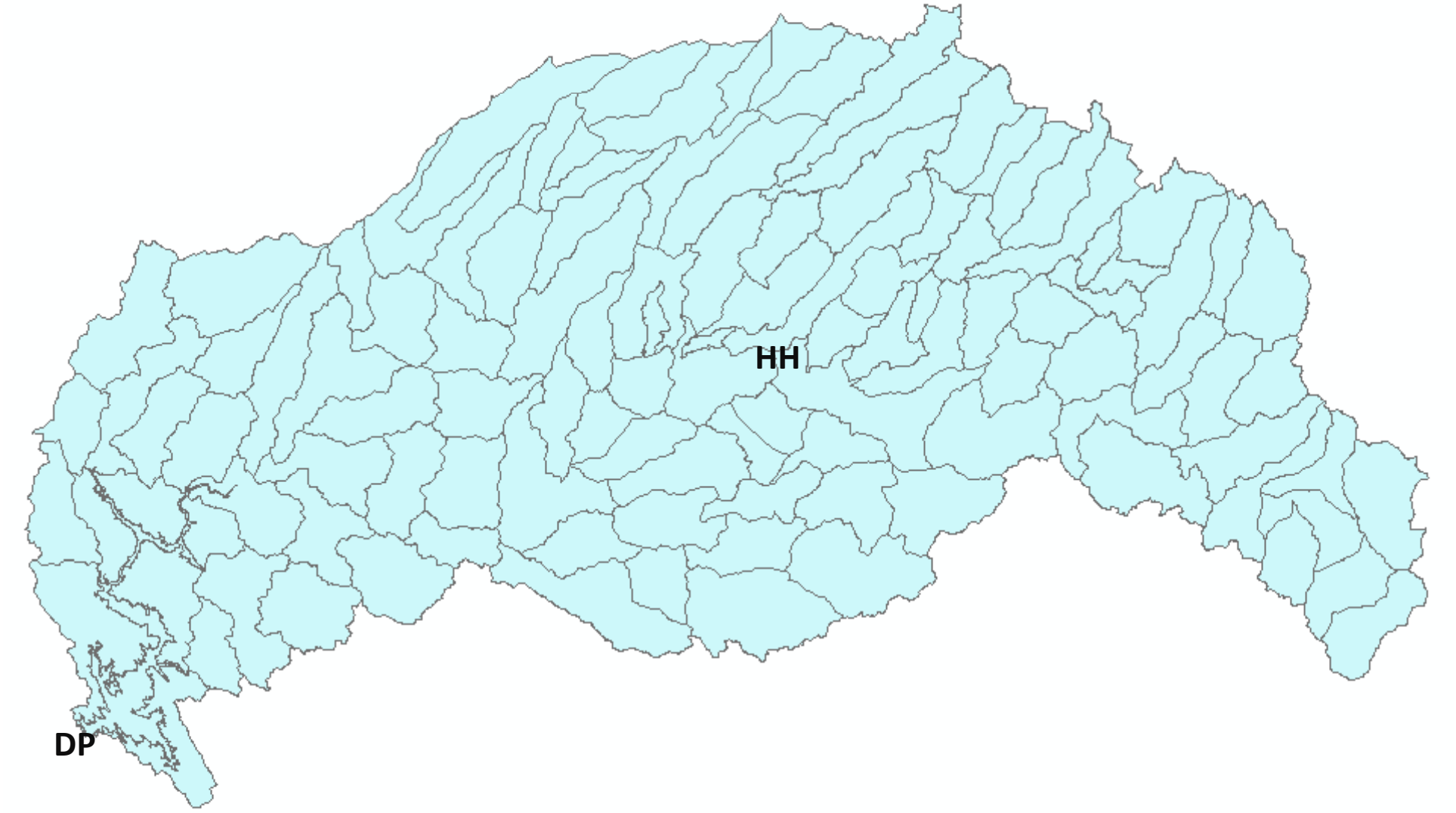


USGS
science for a changing world

Tuolumne Upper Basin

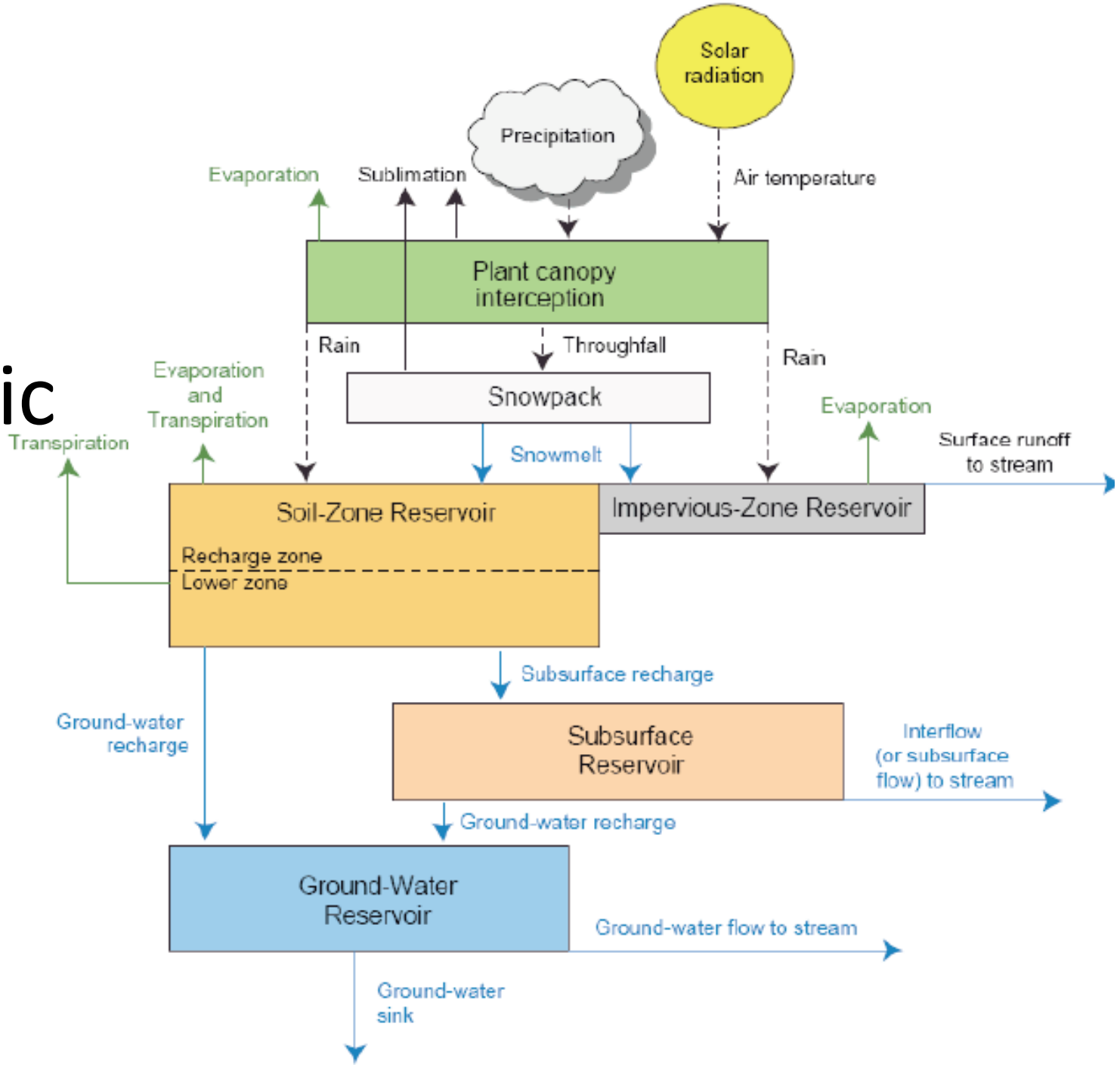


USGS PRMS Model - Tuolumne

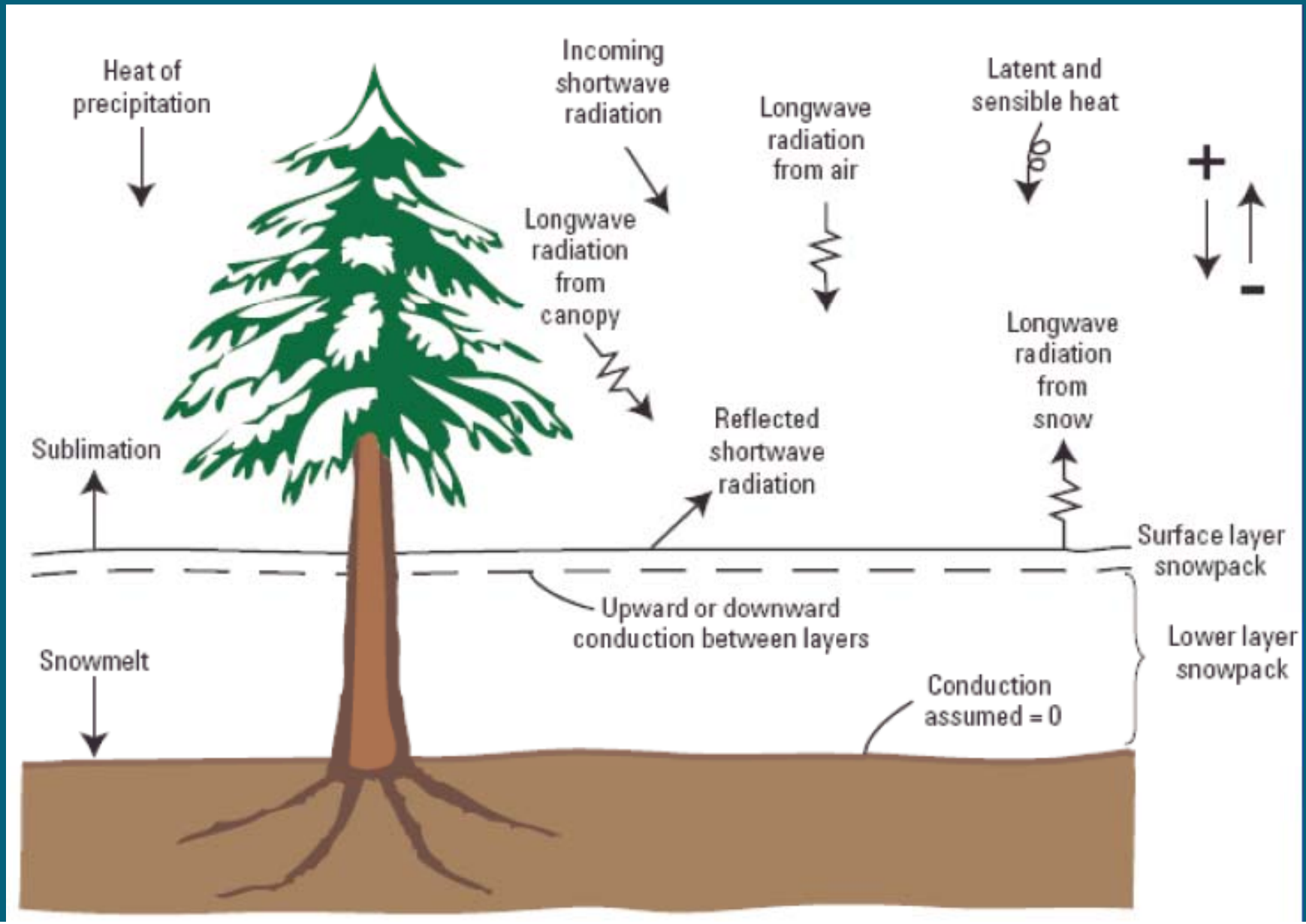


USGS PRMS Model – HH Basin

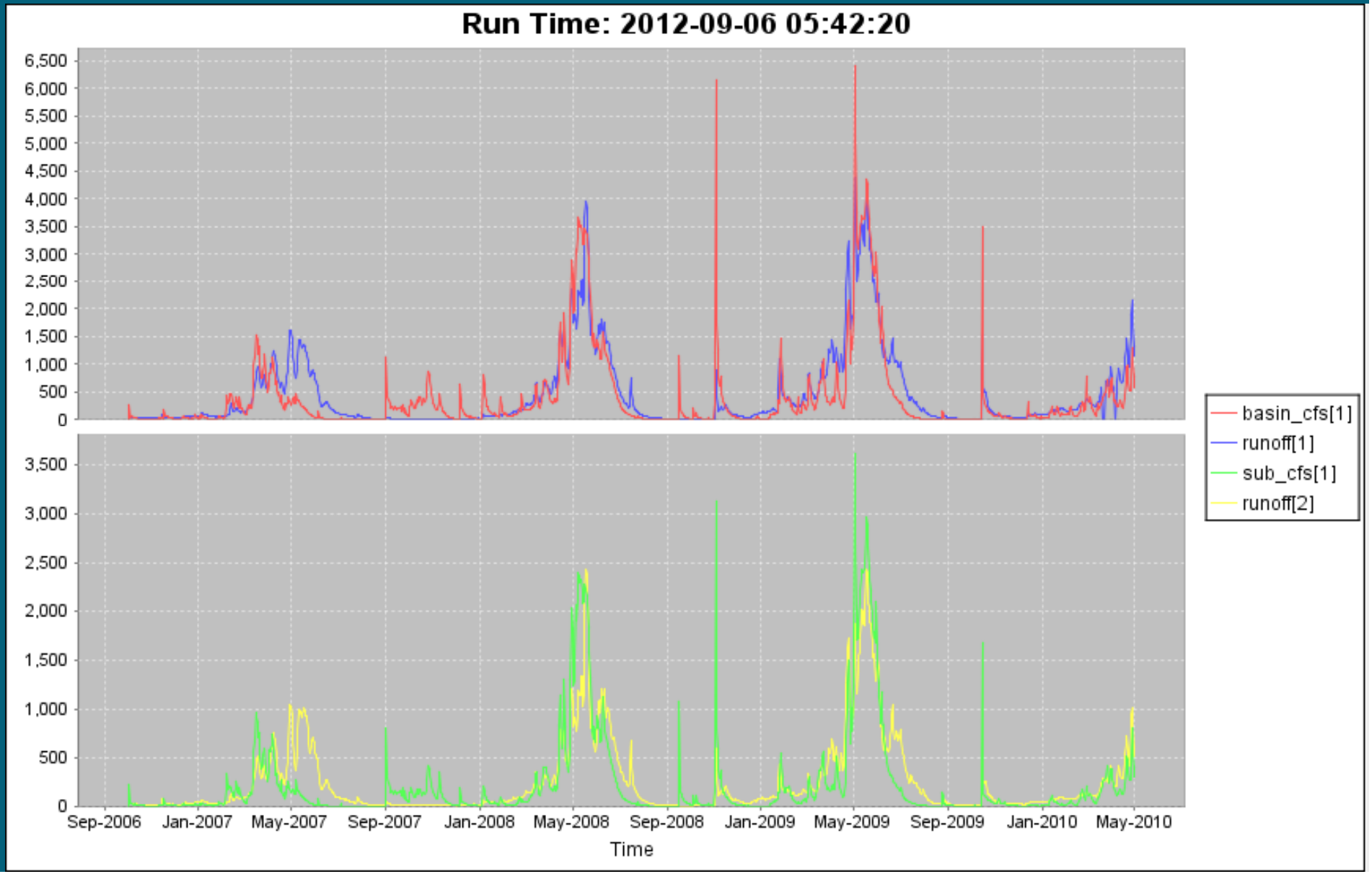
PRMS Hydrologic Budget



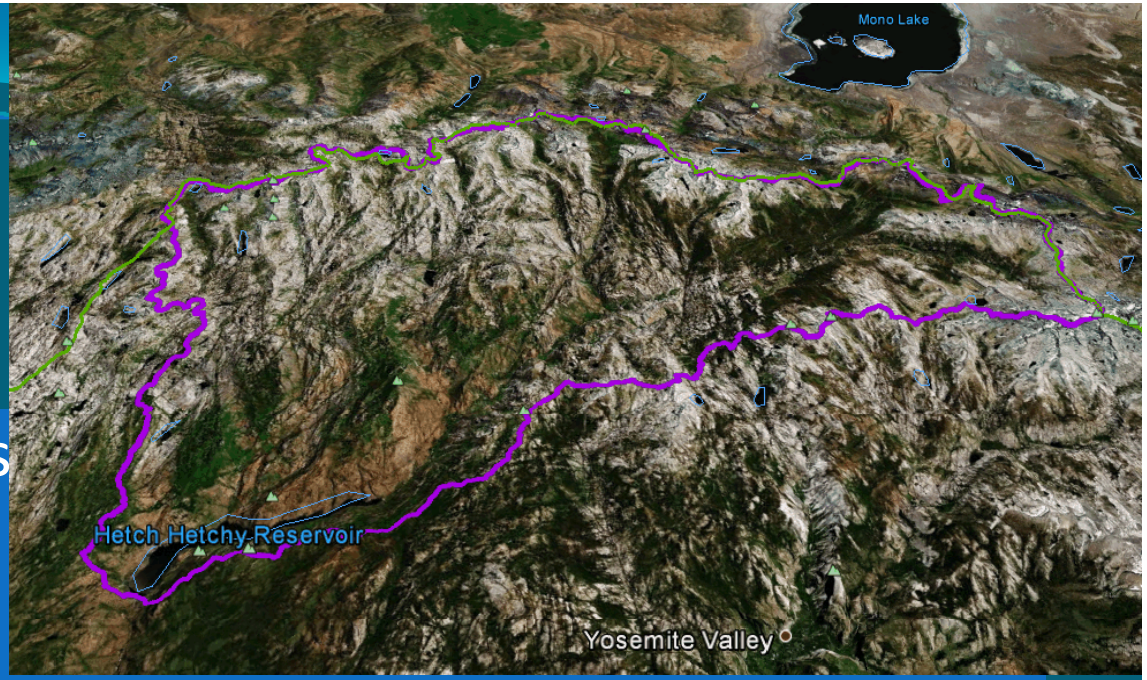
PRMS Energy Budget



PRMS Simulation Output



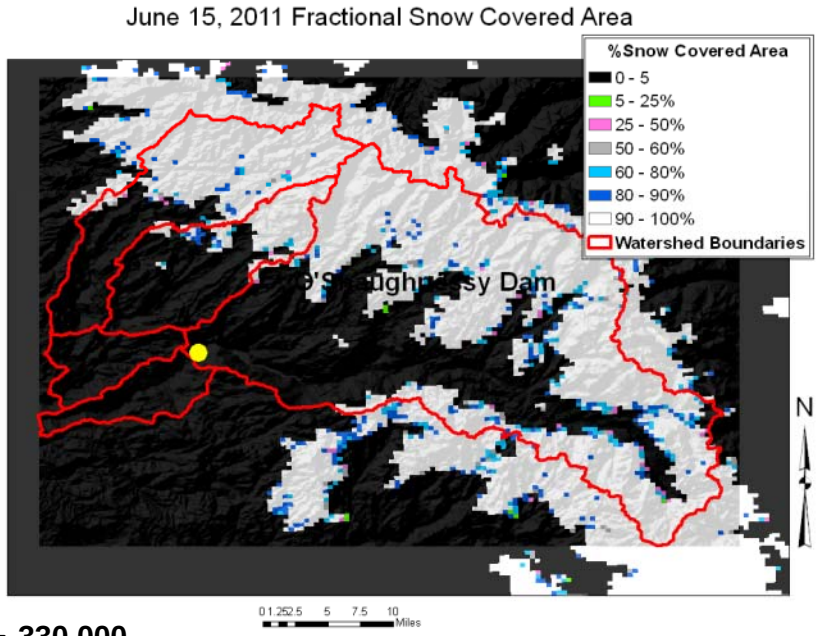
BASIN SWE

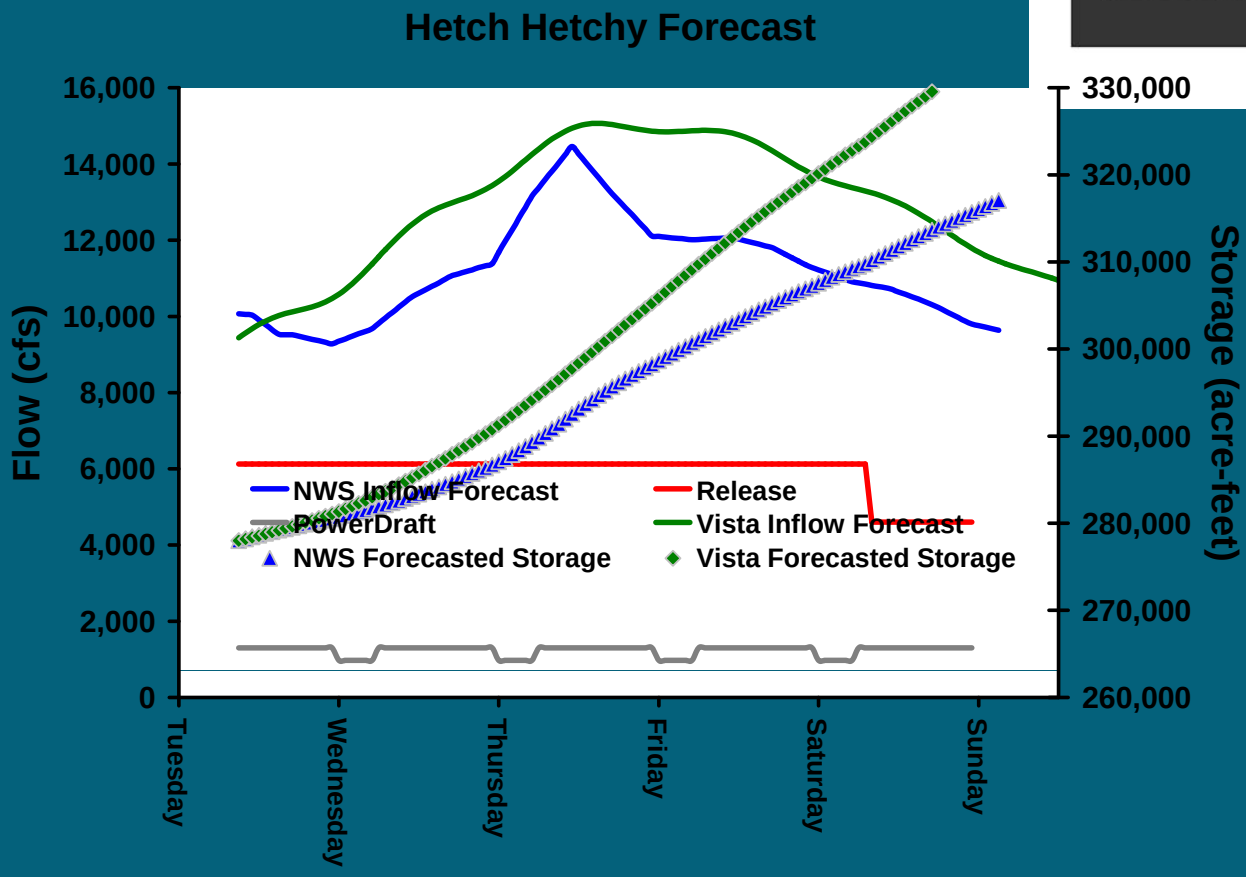


- ASO imagery provides
  - Hi-res depth
  - Albedo
  - Snow extent
- Calculate density field from ground stations
- Calculate volumetric SWE for basin/subbasins for the week
- Difference prior week's basin SWE, compare to reservoir inflow – estimate weekly losses
- Predict melt and runoff for coming week, **REPEAT**

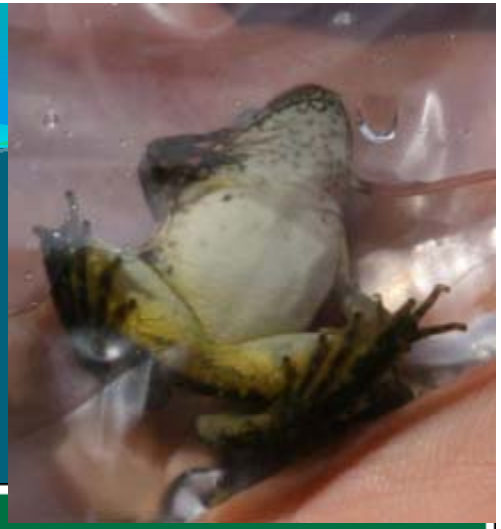
Current Ops

(from A. Mazurkiewicz)

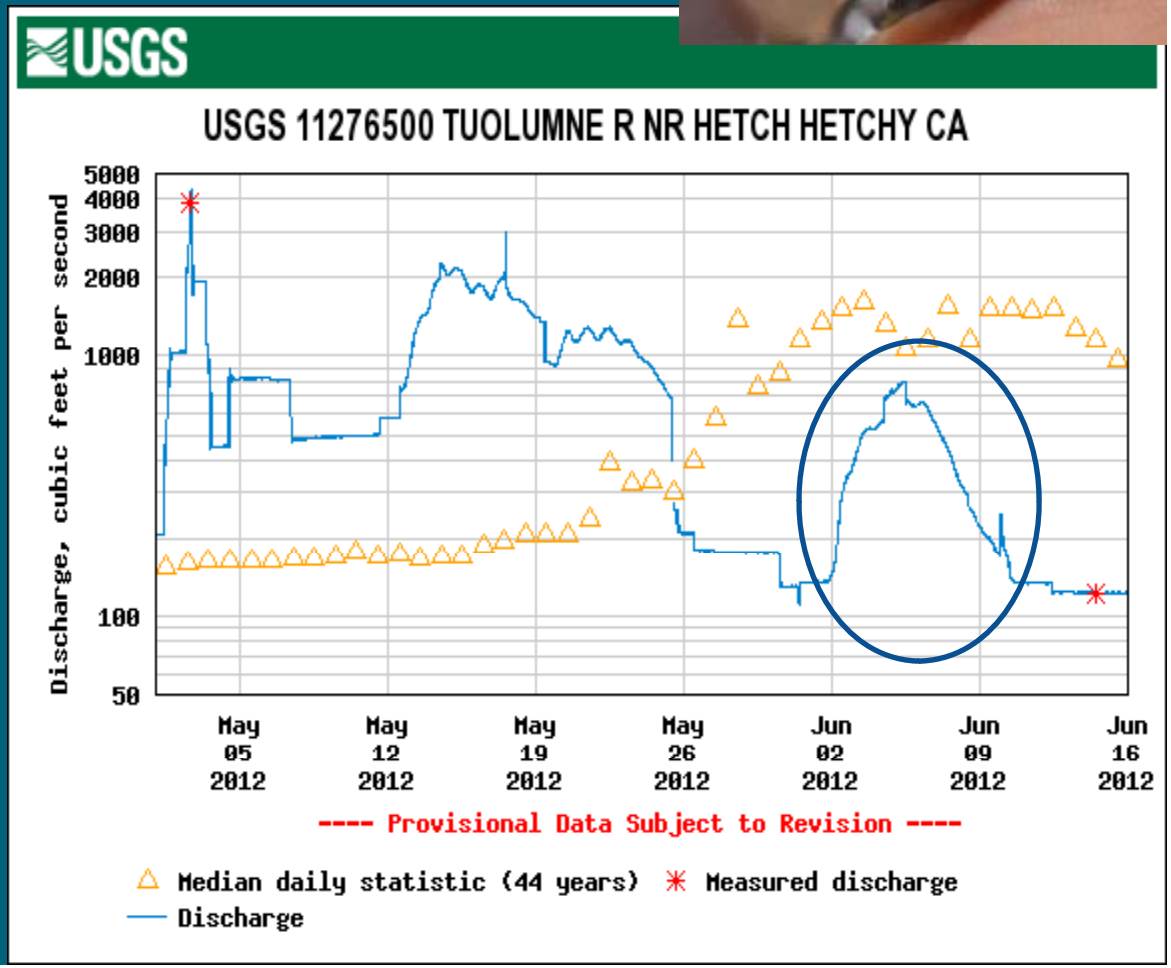




When does more info help?

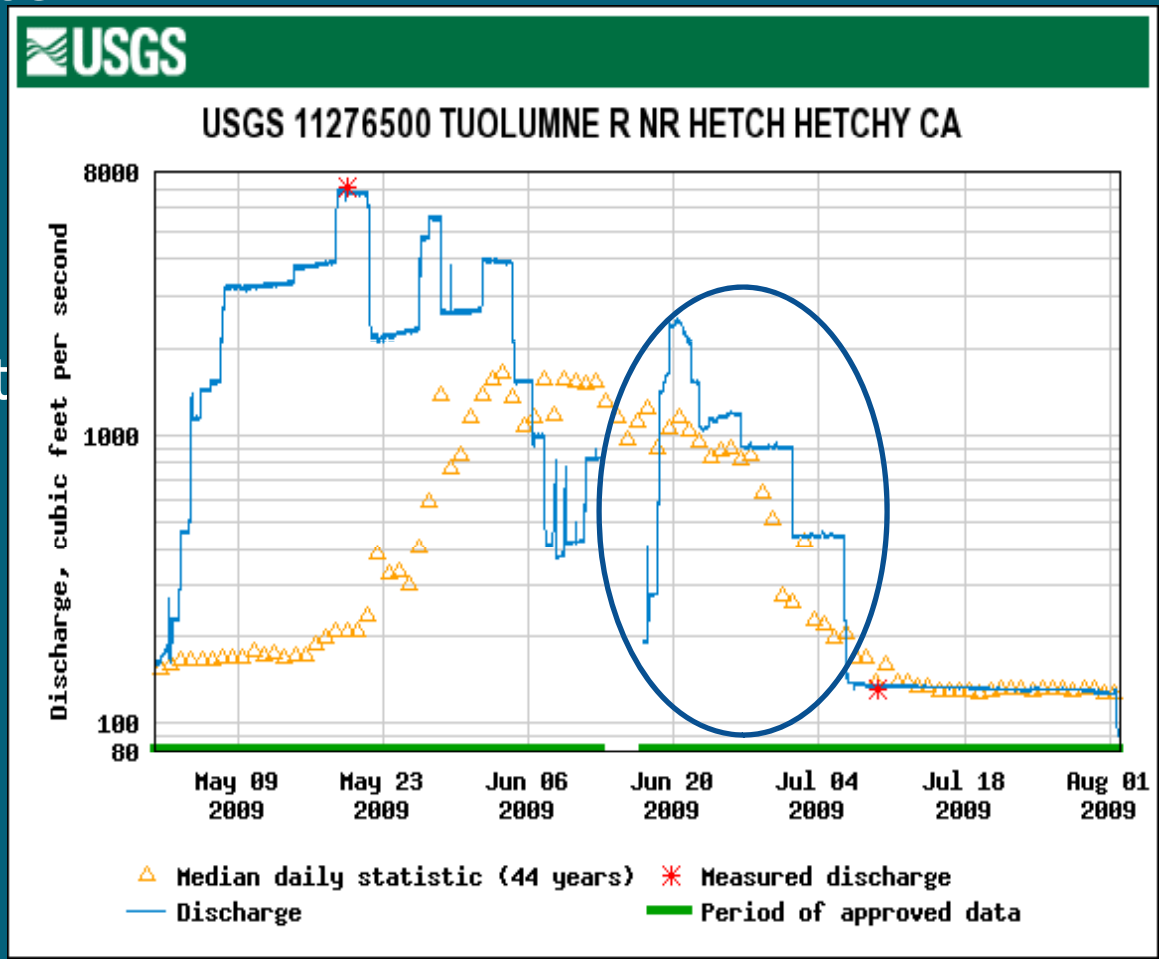


- Dry years – 2011
- Inflow = 50%
- Geomorph pulse OK
- Spills OK
- June pulse might have been avoidable
- If used for power, value was $84K



More info?

- Moderate years – 2009
- Inflow = 83%
- Geomorph OK
- Spill OK
- June-July pulse might have been avoidable
- If used for power, value was $960K



Earlier and more accurate info?

- PUC policy mandates no additional generation until there is over 90% certainty that “excess” water exists
- A 30-60 TAF “buffer” is often used while forecasting, and HH AJRO inflow is 600 TAF – 5-10% **HEDGE**
- With more accurate and earlier SWE data, KPH and HPH could start earlier in below-normal years and run longer – and still fill
- Potential power revenue = $$$$
- ASO/SWE + PRMS reduces risk

ASO & PRMS: A New Way....

Old Way

- New Way

Hetch Hetchy measure swamped by voters

John Wildermuth and John Coté

Updated 12:07 a.m., Wednesday, November 7, 2012

- San Francisco voters overwhelmingly rejected Proposition F, a plan that would have taken the first steps toward draining Hetch Hetchy Reservoir and drastically revamped the way much of the Bay Area gets its water.
- Defeated 75% to 25%
- Proponents maintain they “won a lot” – HUH?

Thank you! Questions?

Horvath, 2009