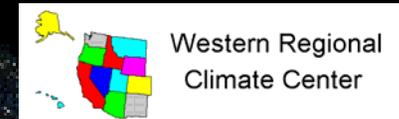
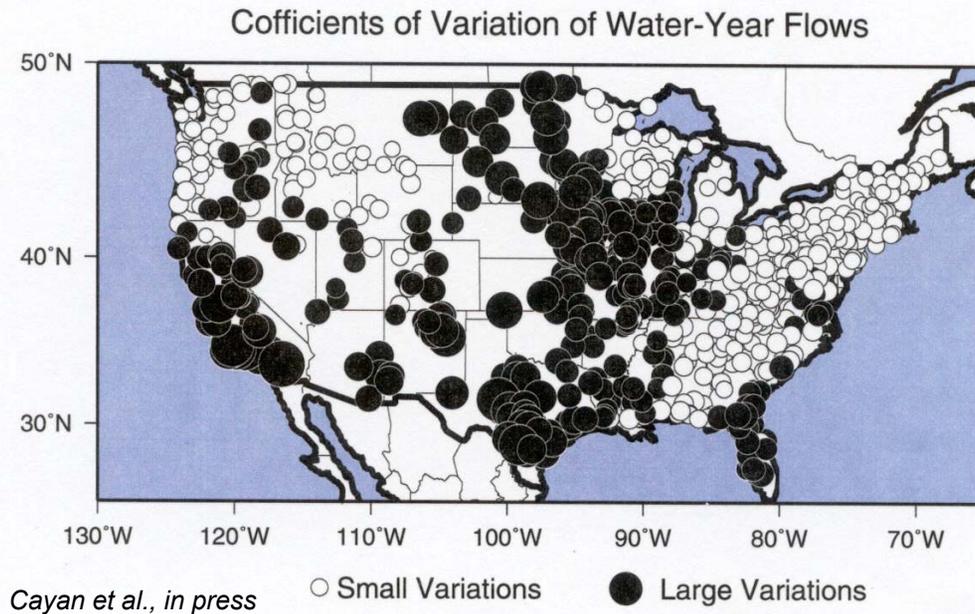


# OVERVIEW OF RECENT HYDROCLIMATIC RESEARCH AT YOSEMITE NATIONAL PARK

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Brian Huggett<sup>6</sup>  
Jessica Lundquist<sup>1</sup>  
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David Peterson<sup>4</sup>  
Kelly Redmond<sup>7</sup>  
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- 2. US Geological Survey, La Jolla*
- 3. U.S. Geological Survey, Denver*
- 4. U.S. Geological Survey, Menlo Park*
- 5. CA Department of Water Resources*
- 6. Yosemite National Park*
- 7. Western Regional Climate Center*



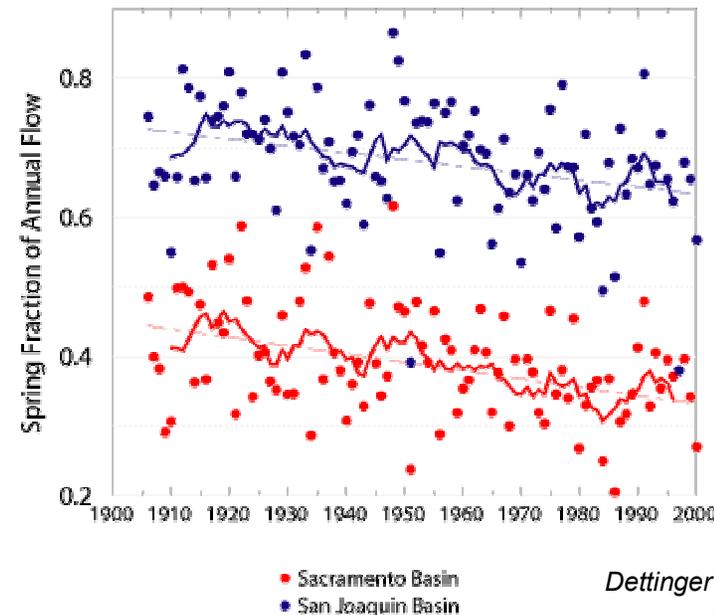


California's hydroclimate and hydrology are notable for their interannual and longer term variability.

Meanwhile, climate change--or a pretty good analog--is upon us in the Sierra Nevada.

To keep up with climate effects, new and widespread models & measurements will be needed in sensitive high-altitude areas.

How much of the Year's Flow is Occurring during Snowmelt Season?  
April-July Full-Natural Flows/Water-Year Full-Natural Flows

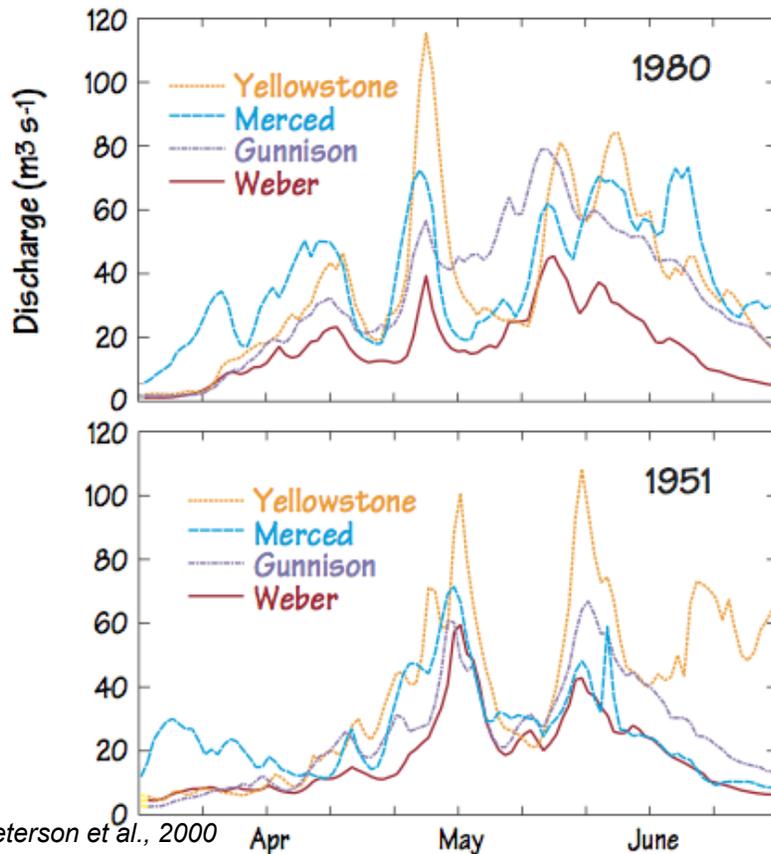


Observed Fractional Flows!!

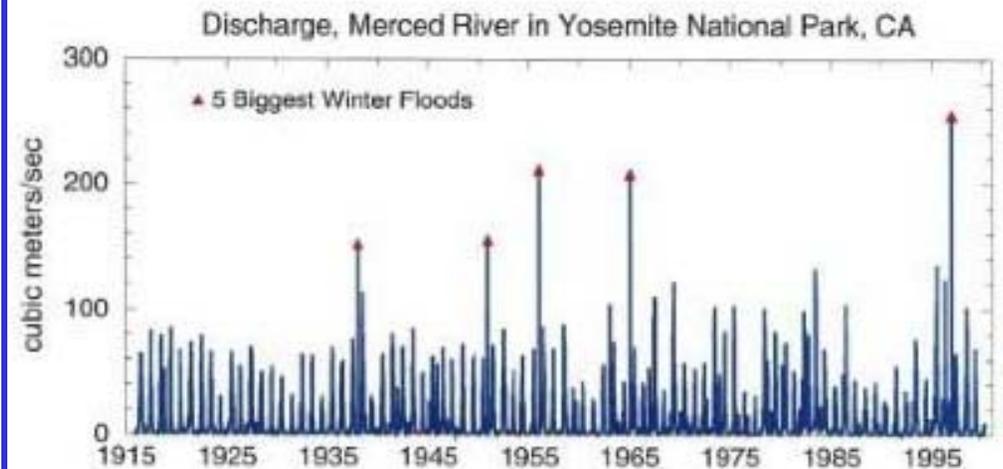
Dettinger and Cayan, 1995;  
Cayan et al., 2001

# Why have we focused in Yosemite?

The Merced & Tuolumne Rivers of Yosemite NP are barometers for stream flow variations across the West, on time scales from days (at least) to decades,...



Peterson et al., 2000



... and, the Merced has one of the longest, pristine high-altitude stream flow records in the West.

# A modeling basis:

In the 1990s, to exploit this broad transfer value, and the Merced's 86-yr record, we developed a detailed watershed model of the basin above Yosemite Valley.



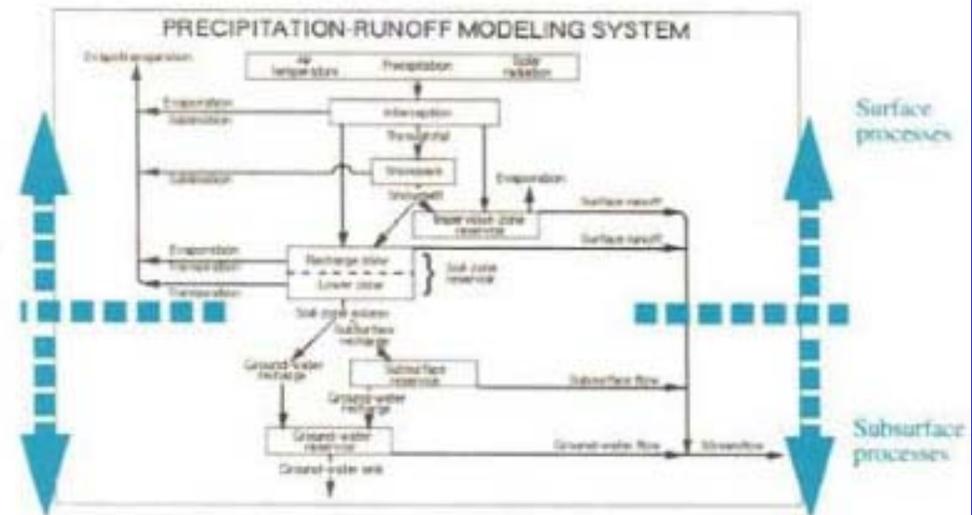
## The US Geological Survey's PRECIPITATION-RUNOFF MODELING SYSTEM (PRMS)

Representation at surface:

100m x 100m Hydrologic-Response Units



MERCED RIVER, YOSEMITE NATIONAL PARK



Representation at depth:

Subbasin-scale subsurface flow reservoirs (covering 500 km<sup>2</sup>)

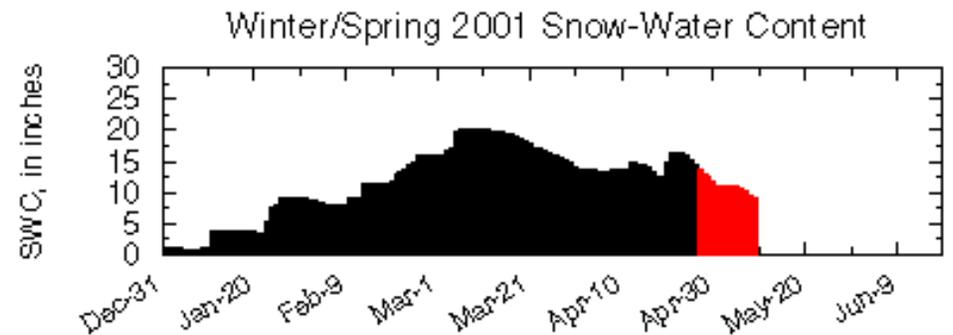
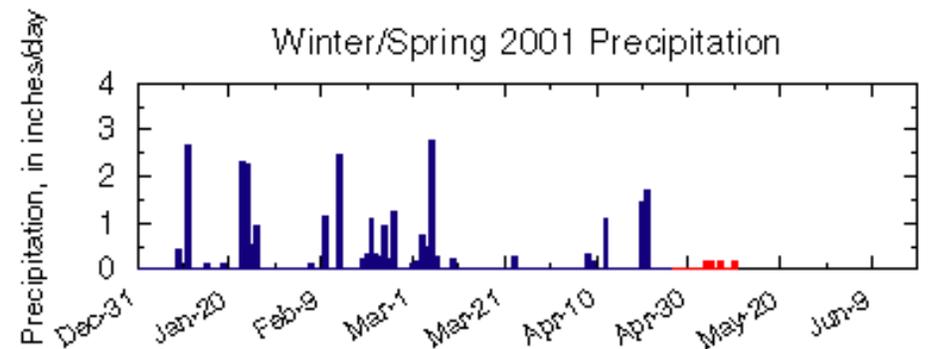
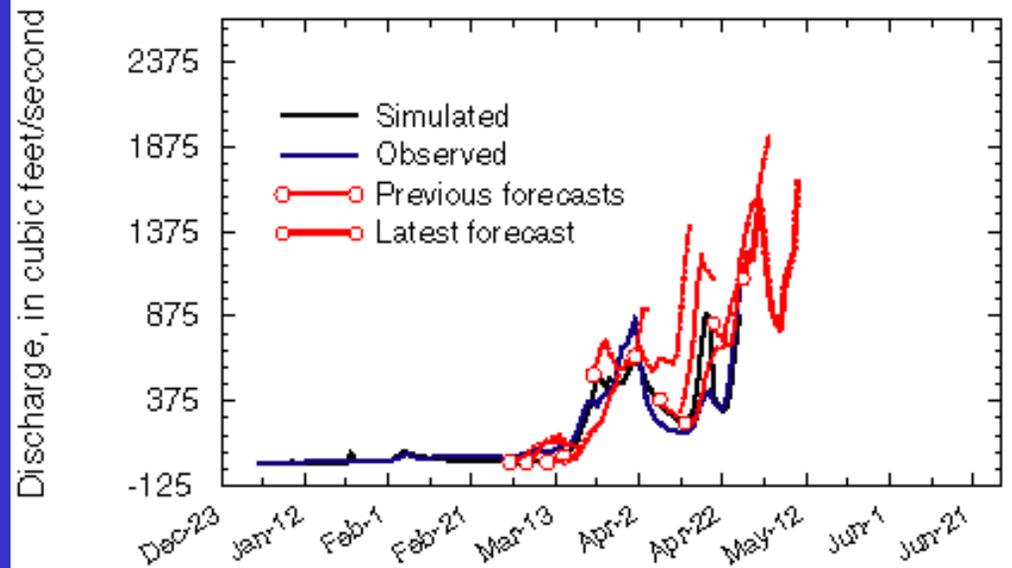


The model has been used to explore the predictability of daily flows, seasonal flows, and major floods of the Merced,...



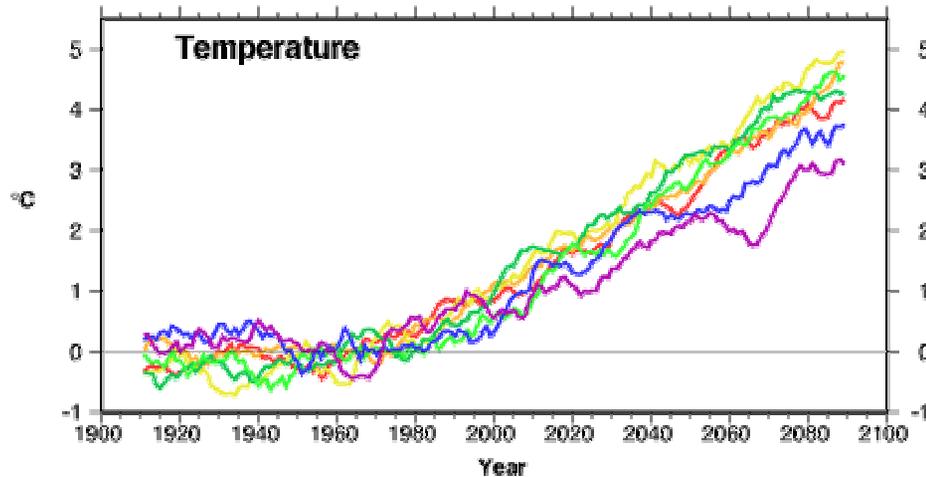
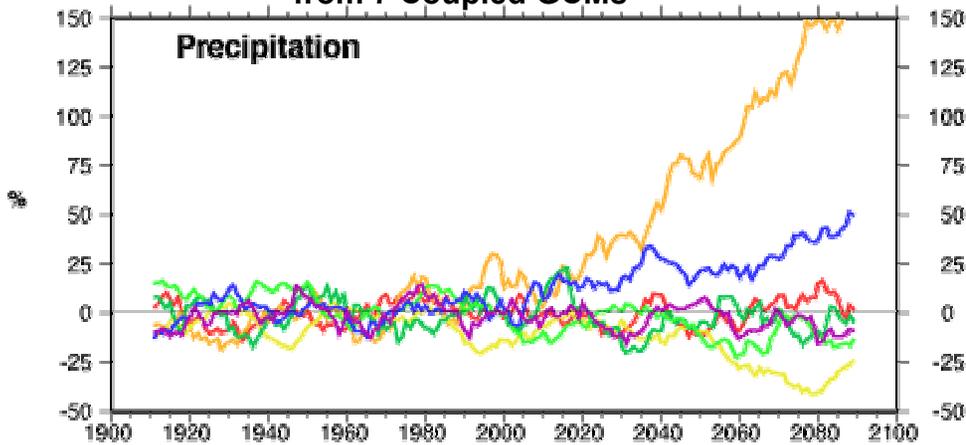
## MERCED RIVER AT HAPPY ISLES

Winter-Spring 2001 Flows (Latest MRF Update: 4/26/01)



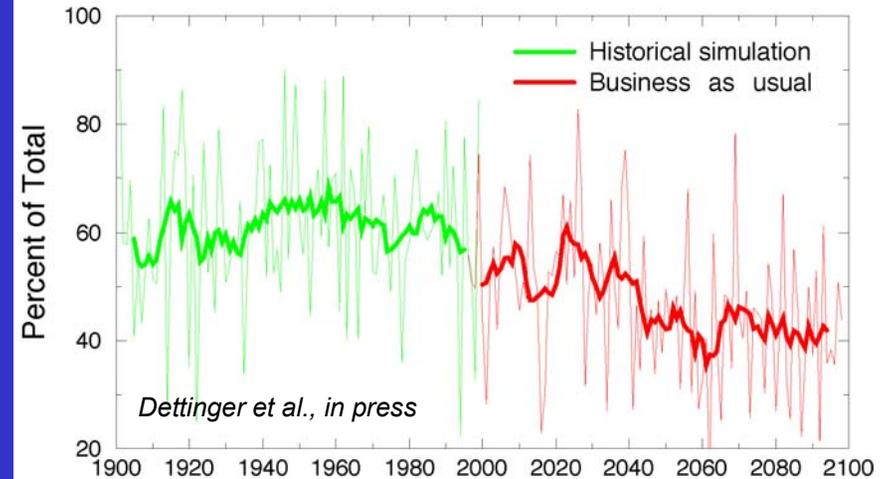
# ... and to project global-change impacts.

**NORTHERN CALIFORNIA  
Climate-Change Projections  
from 7 Coupled GCMs**



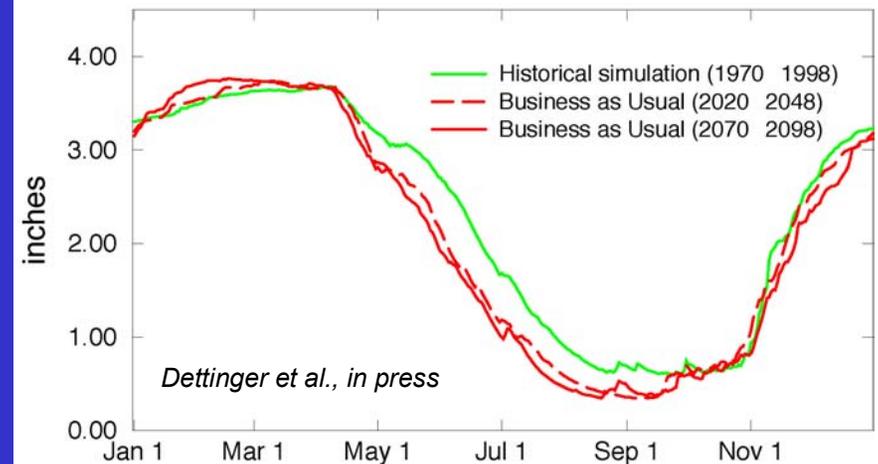
## Dramatic reductions in the "useful" fraction of annual flows

**Simulated April - July Fraction of Annual Flows  
Merced River at Happy Isles**

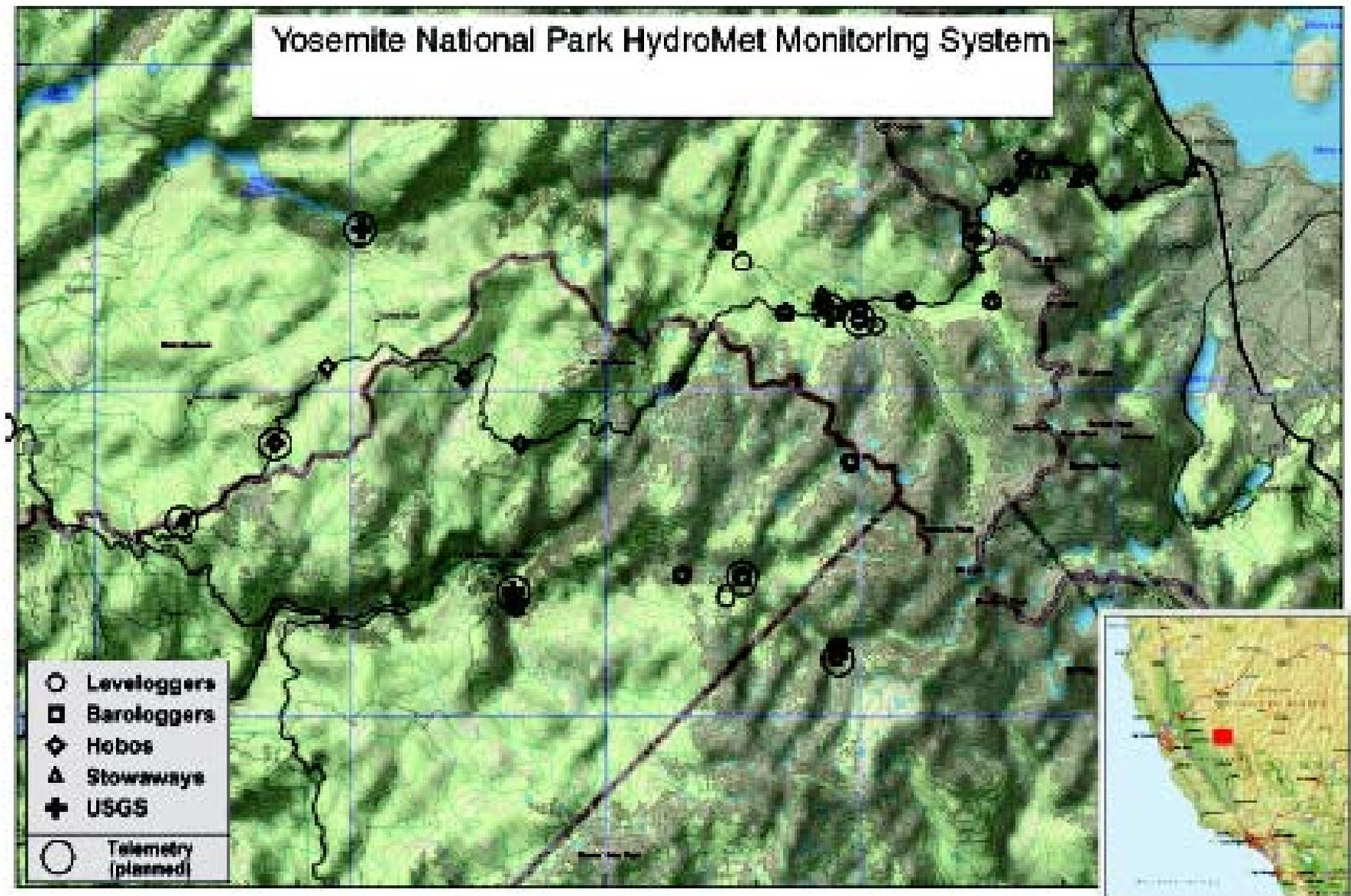


## Dramatic reductions in summertime moisture availability

**Changes in Soil Moisture Seasonality  
Merced River basin abv Yosemite Valley**



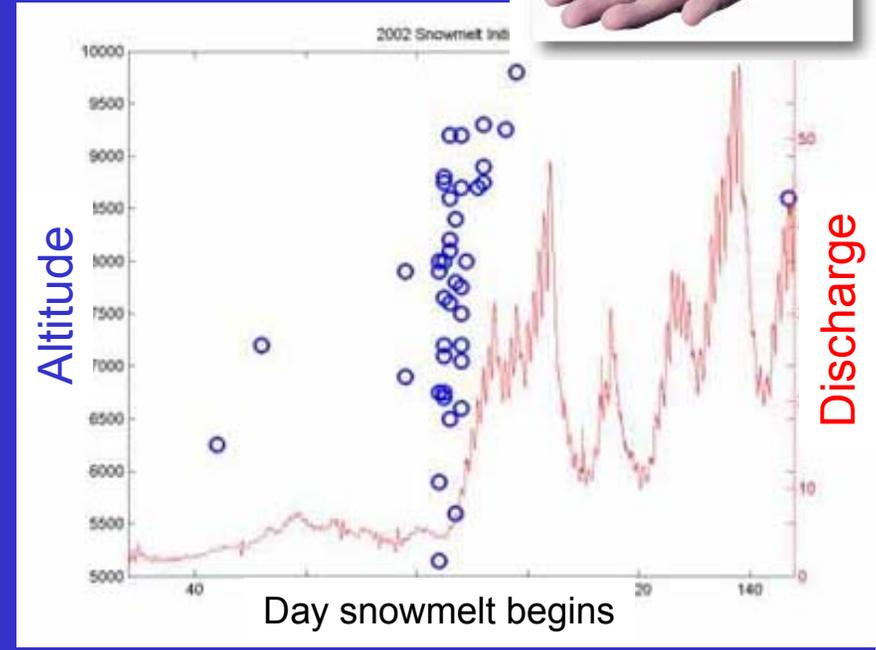
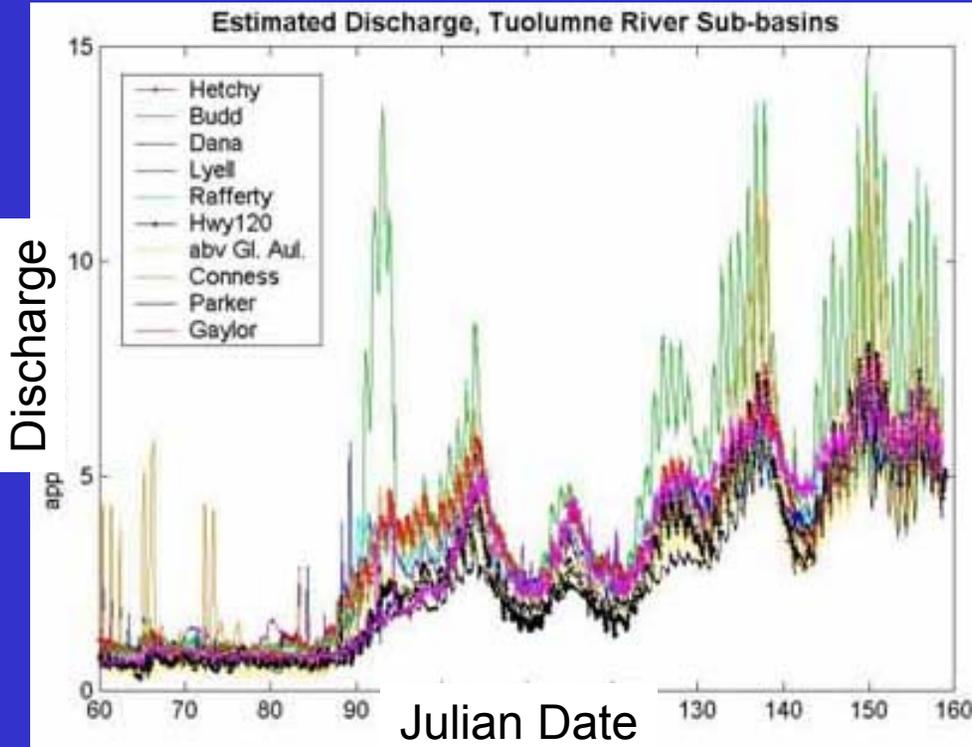
# A monitoring thrust:



Lundquist et al., in press

# Recent (2002) monitoring results:

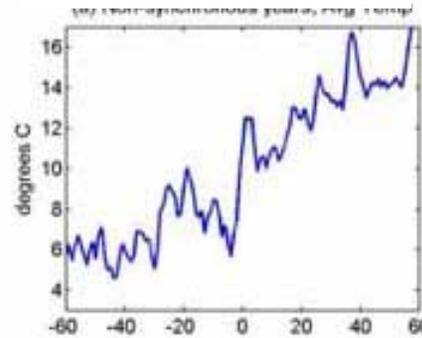
## A surprising synchronicity of snowmelt ...



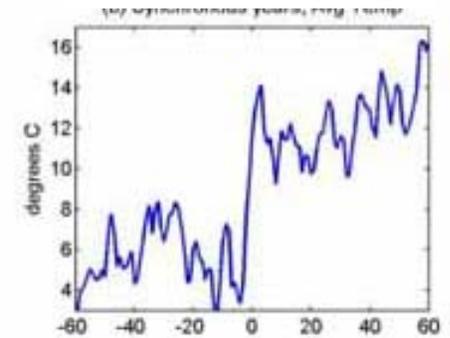
...turns out to be typical of some springs (including several recent ones), & is attributed to a step-onset of spring warmth.

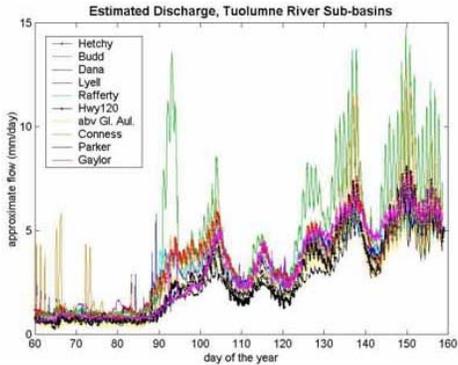
Average springtime Temperatures

Asynchronous springs



Synchronous springs

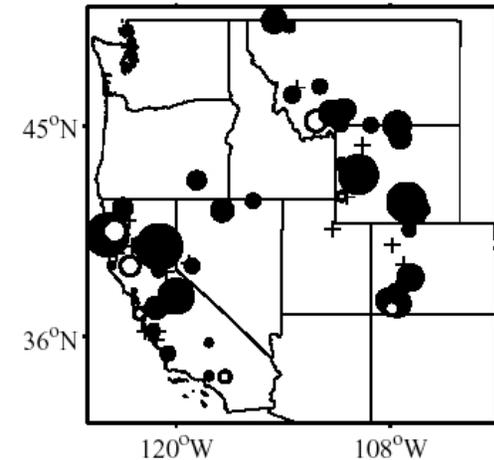




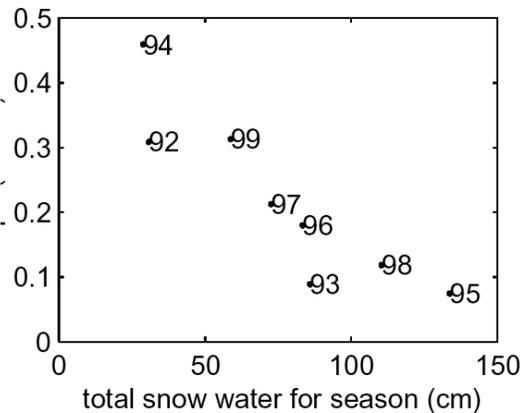
Diurnal flow cycles are allowing us to use **existing** stream networks to determine river-basin conditions that we never could get at before!



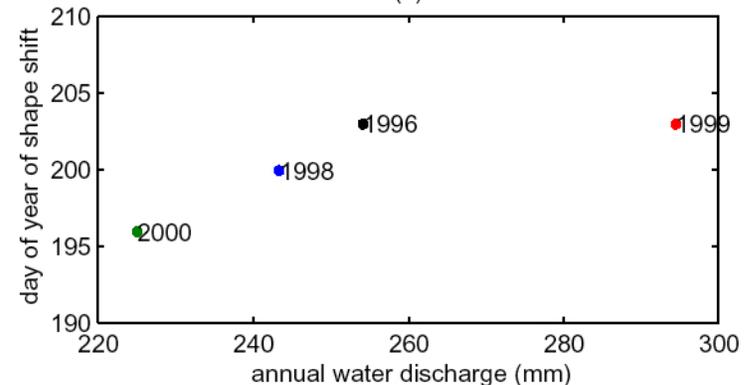
Rates of retreat of snow melt line within basins



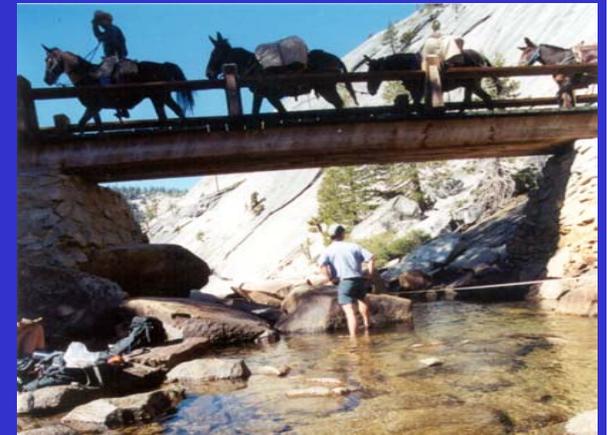
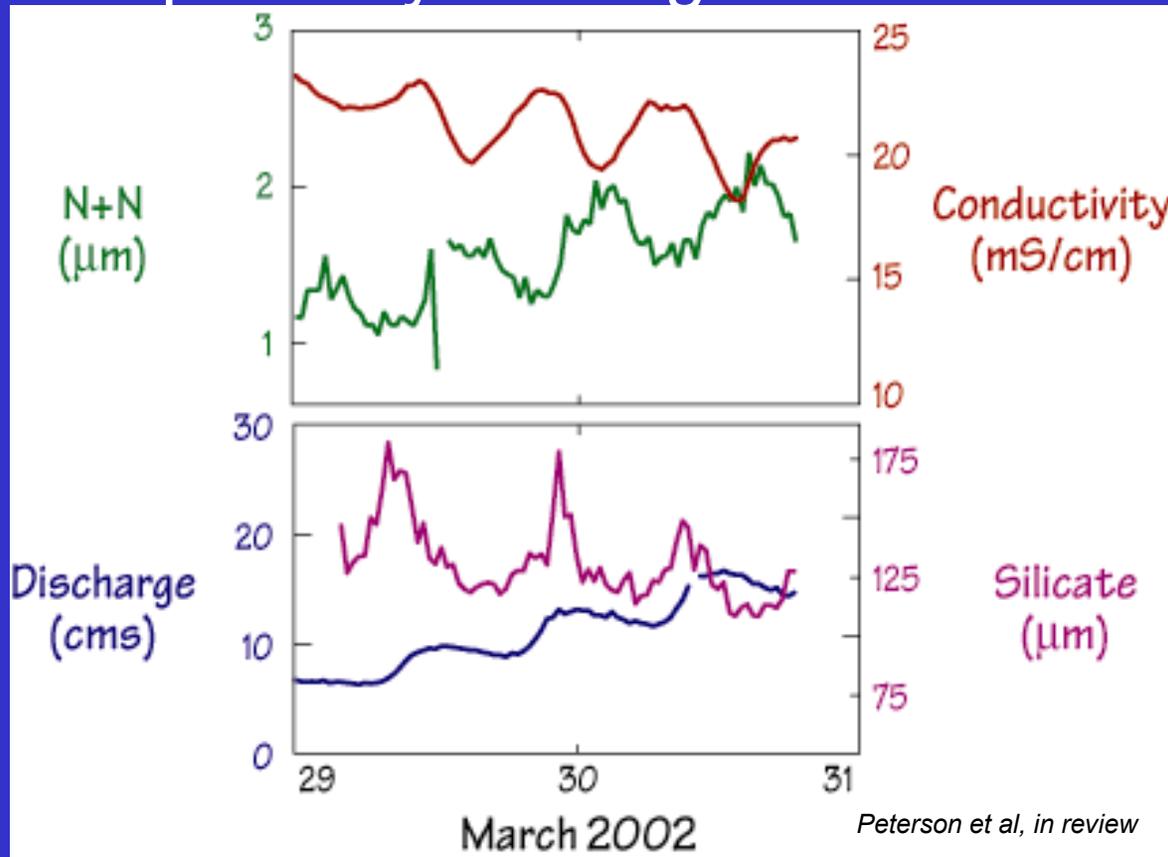
Slow vs fast runoff routes of snow melt



Date of change from snow melt dominance to ET dominance



Continuous stream-chemistry monitoring is allowing us to separate surface and subsurface flow pathways through the Yosemite watersheds.



Point stream-chemistry sampling is allowing us to identify atmospheric-deposition hotspots within the Yosemite watersheds.

# Where We Are Headed:

## *Science issues*

Precipitation: Orographic processes?

Snowmelt: where/when/how?

Linkages: climate–hydrology–**ecosystems**

How will climate change operate?

Nature and significance of chemical change?

## *Technical Goals*

### **Sierra Nevada transects of**

- solar & thermal radiation

- wind

- humidity & vapor transport

- ....-- precipitation

- stream chemistry

- soil moisture

- snowpack thermodynamics

### **Economical, non-intrusive instruments**

- low cost, low power

- miniature, small foot print

### **Real-time Data from wilderness**

- digital cellular

- phone line

- satellite

### **Climate-based index stations**

- long term, climate quality observations

- focus points for a whole multidisciplinary range of observations & surveys



## Some key references:

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- **Cayan, D.R., Dettinger, M.D., Redmond, K.T., McCabe, G.J., Knowles, N., and Peterson, D.H., in press**, The transboundary setting of California's water and hydropower systems--Linkages between the Sierra Nevada, Columbia River, and Colorado River hydroclimates, *in* Diaz, H.F., and Woodhouse, B. (eds.), *Climate and Transboundary Issues*: 25 p.
- **Clow, D.W., Mast, M.A., and Campbell, D.H., 1996**, Controls on surface water chemistry in the upper Merced River Basin, Yosemite National Park, California: *Hydrological Processes*, v. 10, p. 727-746.
- **Dettinger, M.D., Cayan, D.R., Meyer, M.K., and Jeton, A.E., in press**, Simulated hydrologic responses to climate variations and change in the Merced, Carson, and American River basins, Sierra Nevada, California, 1900-2099: *Climatic Change*.
- **Lundquist, J.D., Cayan, D.R., and Dettinger, M.D., 2003**, Meteorology and hydrology in Yosemite National Park: A sensor network application: *Proceedings, 2nd International Workshop at Palo Alto Research Center, Information Processing in Sensor Networks*, 10 p.
- **Lundquist, J.D., and Dettinger, M.D., 2003**, Linking diurnal cycles in river flow to interannual variations in climate: *American Meteorological Society, 83rd Annual Meeting, 17<sup>th</sup> Conference on Hydrology*, Long Beach, CA, J2.4-1 to J2.4-5.
- **Peterson, D.H., Smith, R.E., Dettinger, M.D., Cayan, D.R., and Riddle, L., 2000**, An organized signal in snowmelt runoff over the western United States: *Journal of American Water Resources Association*, 36 (2), 421-432.
- **Peterson, D.H., Smith, R.E., Hager, S., Huber, K., Dettinger, M., and DiLeo, J., in USGS review**, An alpine river chemistry tutorial—Fun with salinity and snowmelt: *U.S. Geological Survey Open-File Report*.
- **Wilby, R.L., and Dettinger, M.D., 2000**, Streamflow changes in the Sierra Nevada, California, simulated using statistically downscaled general circulation model output, *in* S. McLaren and D. Kniveton (eds.), "Linking Climate Change to Land Surface Change": *Kluwer Academic Publishers*, 99-121.

<<**See also** <http://meteora.ucsd.edu/cap/> &  
<http://water.usgs.gov/nrp/proj.bib/peterson.html> >>