

Summary of Current United States Geological Survey Drought Research in the Western States

Earl Greene, U.S. Geological Survey, External Research

Earl Greene is a U.S. Geological Survey Hydrologist with the National Research Program and Chief of External Research. Earl did his graduate work at the University of Idaho. He began his Federal career with the Research Branch of the US Forest Service in 1983 and moved to the USGS as a Research Hydrologist in 1986. Earl's research within the National Research Program is on modeling flow and transport of water in karst and fractured rock terrain. Earl is part of the USGS Senior Staff for Water and serves as the Coordinator for the Water Resources Research Institute Program for the USGS.



Figure 1. Introduction.

Figure 2. Water mission area, which is one of seven mission areas.

Explanation - Percentile classes					
●	●	●	●	●	●
Low	<10	10-24	25-75	76-90	>90
	Much below normal	Below normal	Normal	Above normal	Much above normal

Choose a data retrieval option and select a location on the map
 List of all stations in state, State map, or Nearest stations

Figure 3. Data retrieval options.

Figure 4. Observations: Water watch and drought watch.

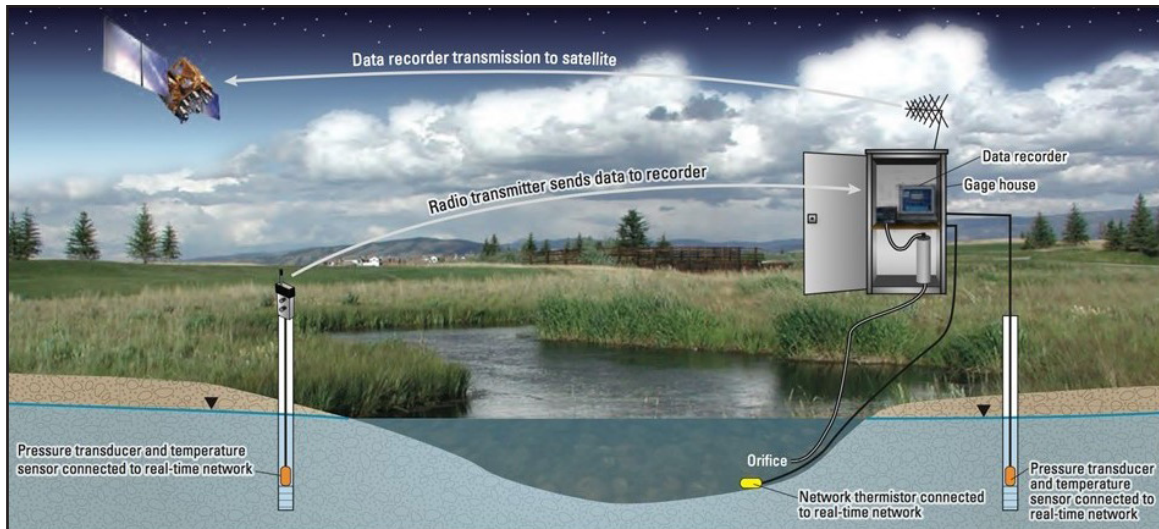


Figure 5. New groundwater streamgages.

- 
 - Scientific Investigations Report 2015-5056
A Water-Budget approach to Estimating Potential Groundwater Recharge from Two Domestic Sewage Disposal Fields in Eastern Bernalillo County, New Mexico
- 
 - Scientific Investigations Report 2014-5153
Hydrogeology, Water Resources, and Water Budget of the Upper Rio Hondo Basin, Lincoln County, New Mexico

Figure 6. Reports available from the New Mexico Water Science Center.

Federal-State Partnership:

- Conducts applied and basic research to help solve State and regional water resource issues
- Technology transfer and dissemination
- Train the next generation of scientists and engineers
- Network of 54 Institutes




Figure 7. Water Resources Research Institute Program.

Basic and Long-Term Research:

- 100 Scientists, 200 support staff
- 3 Research Offices
- Reston, VA
- Denver, CO
- Menlo Park, CA



Figure 8. USGS National Research Program.

- A dozen major reservoirs hold about 1/2 of the water stored in California’s reservoirs. Water storage in the mountain snowpack is just as significant
- Between April 2011 and April 2015, total storage in the major reservoirs declined by 50%
- Value of April snow water contents is usually about 75% of the long-term average total reservoir storage
- Estimate of snow-water content for the state was only 5% of normal

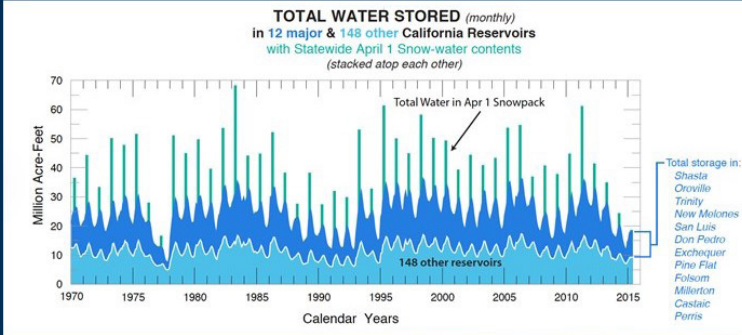
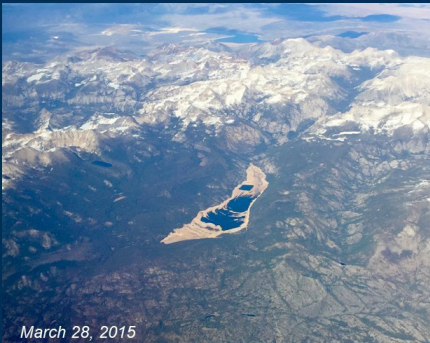


Figure 9. California’s water storage in reservoirs and snowpacks.

- Thomas A. Edison Lake
- Upper San Joaquin River basin
- 125,000 acre reservoir
- 18% of normal
- Basin snowpack was 8% of normal



USGS

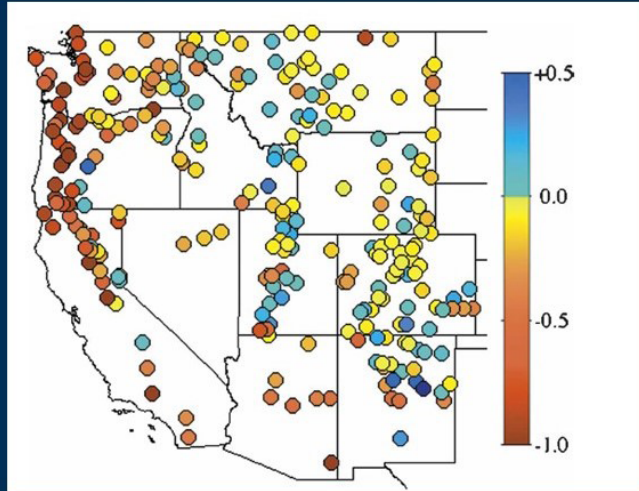
Dettinger and Anderson, 2015

Figure 10. Upper San Joaquin River basin water storage on March 28, 2015.

- Water resources of the western United States depend heavily on snowpack to store part of the wintertime precipitation into the drier summer months.

- WY1949–2004 show spring snow accumulation has declined.

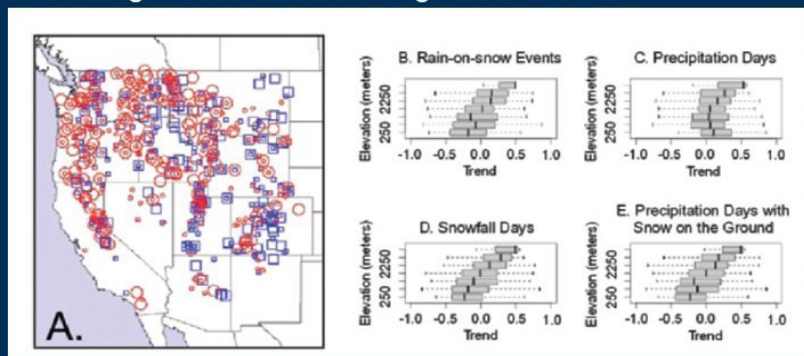
- 75% of the studied stations have experienced snowfall reductions as a result of widespread warming



Knowles and others, Climate, 2005

Figure 11. Western U.S. spring snow accumulation declined from 1949 to 2004.

- Significant flood producing events
- Analyzed rain-on-snow events from 1949-2003
- Red show decreasing events - Blue shows increasing events
- Most significant increasing trends are for the highest elevations



McCabe, Clark, Hays, 2006

Figure 12. Rain-on-snow events from 1949 to 2003 in the West.

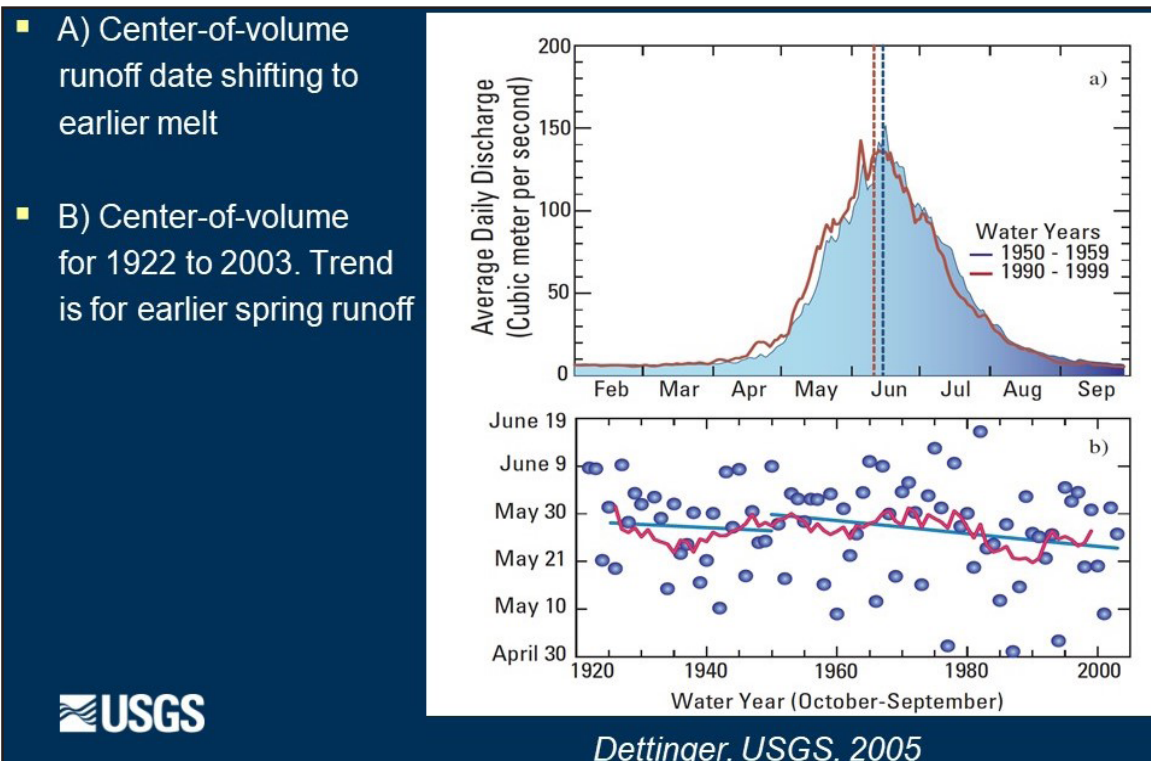


Figure 13. Trends in streamflow runoff in Wyoming for 1922 to 2003.

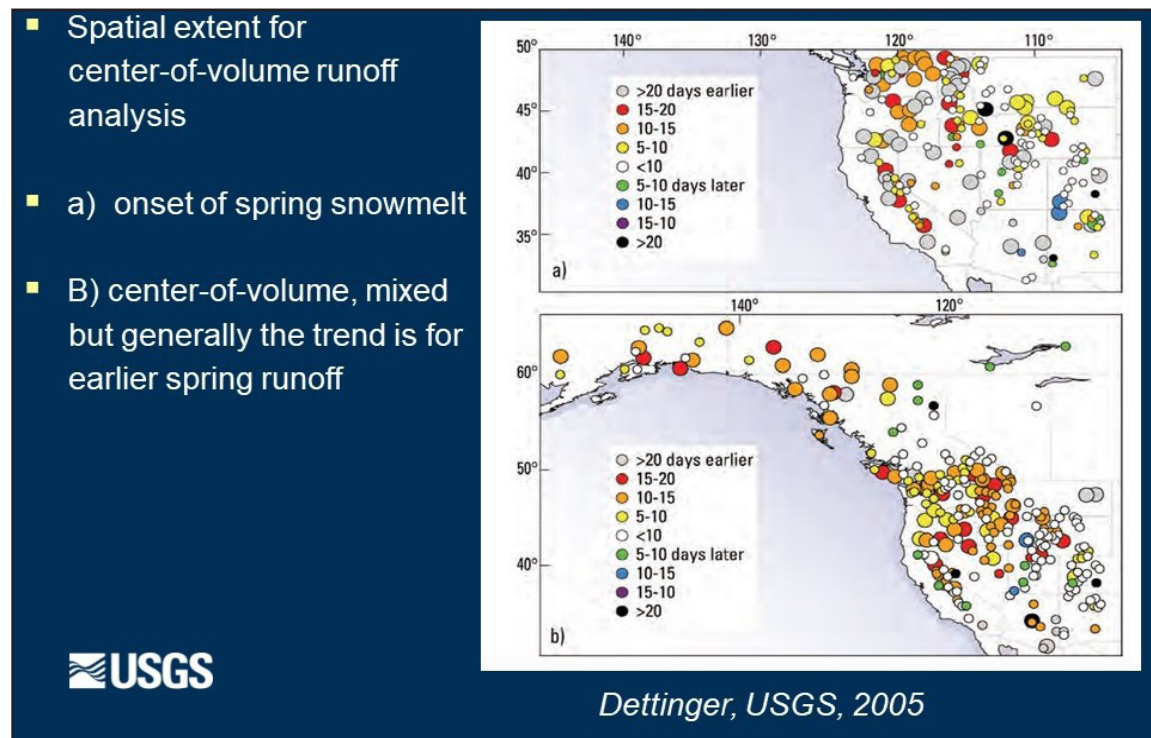


Figure 14. Trends in streamflow runoff across the West.

- Long ribbons of moisture that transport huge amounts of water vapor
- When atmospheric rivers move inland and strike the mountains the air rise and cools, creating heavy rainfall
- Atmospheric rivers are the source of 30-50 percent of precipitation along the US West Coast

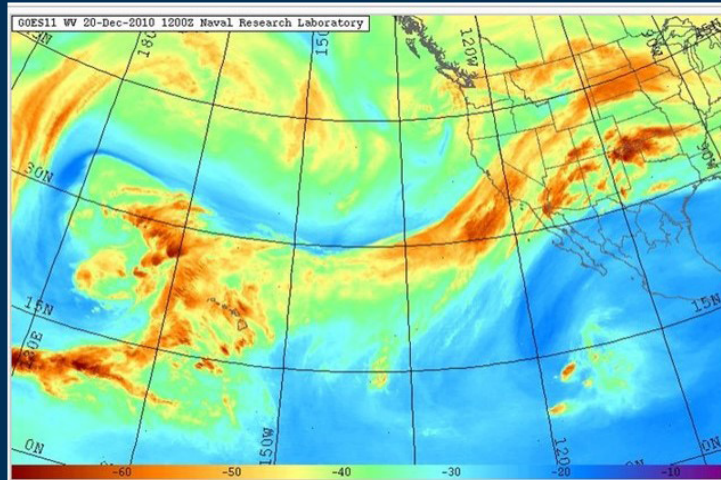
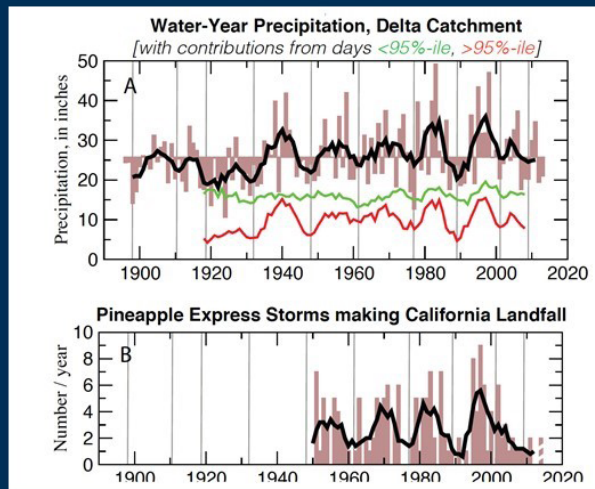



Figure 15. Atmospheric rivers.

- The number of atmospheric rivers making landfall correlate with wet years
- Early 1990s low number of atmospheric river storms - drought years. In contrast, late 1990s high number of atmospheric river storms - wet years




Dettinger and Cayan, Estuary and Watershed Science, 2014

Figure 16. Water-Year Precipitation, Delta Catchment since 1900s.

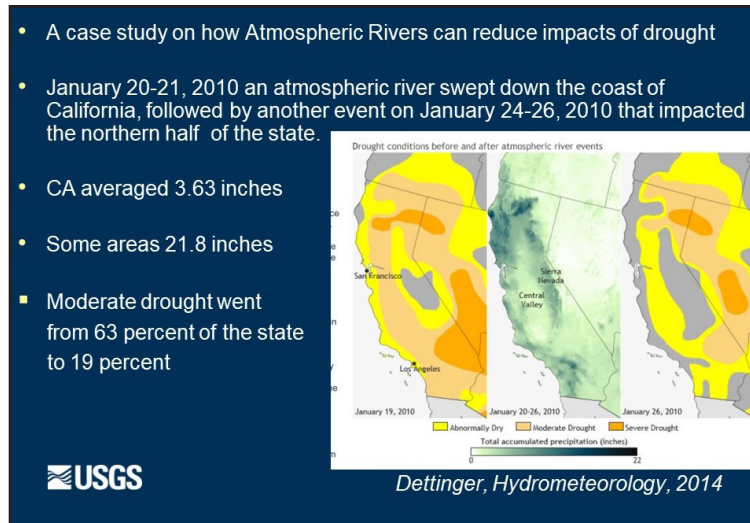


Figure 17. Atmospheric Rivers as drought busters.

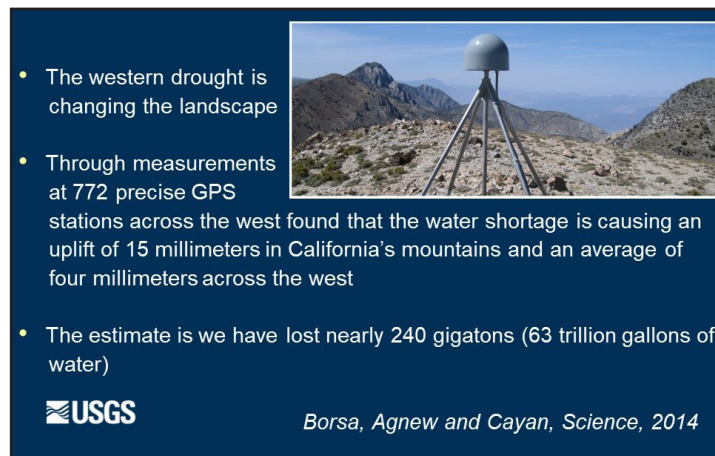


Figure 18. Uplift and quantifying water loss.

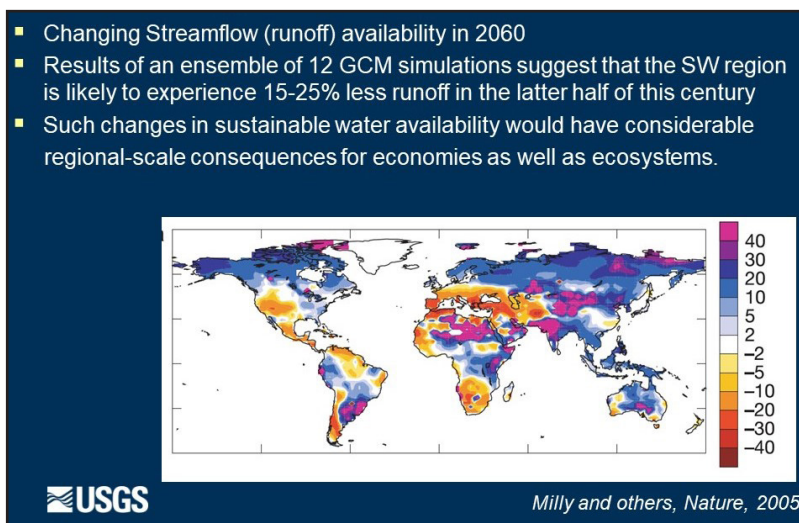


Figure 19. Regional scale forecasts.

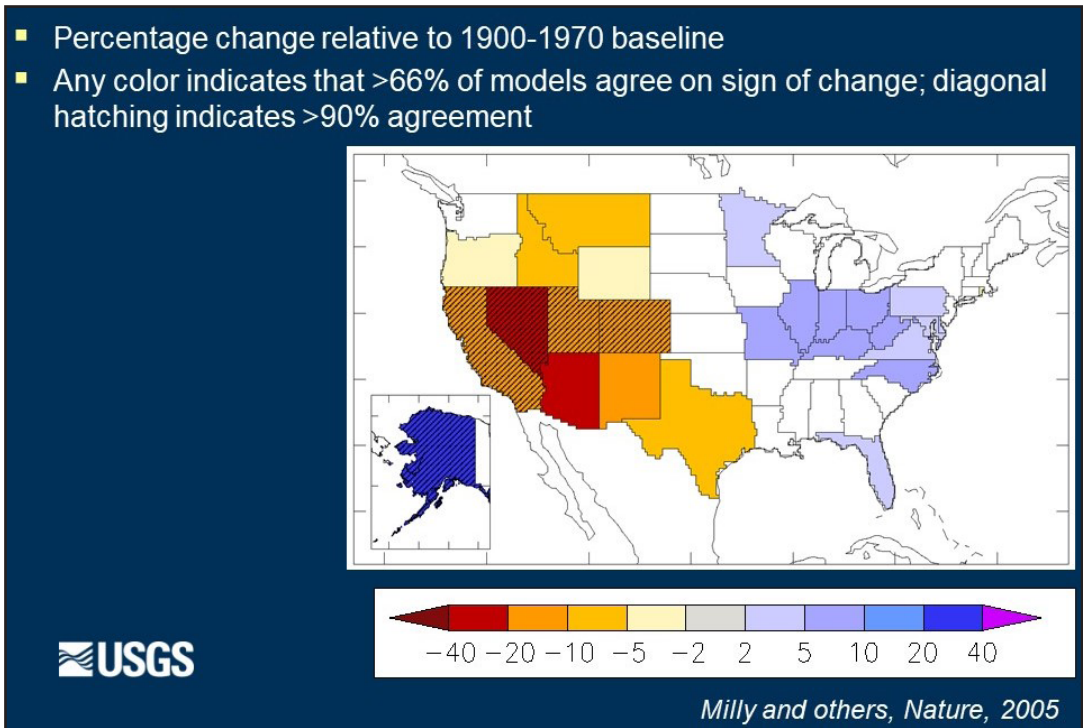


Figure 20. Regional scale forecasts for 2041-2060.

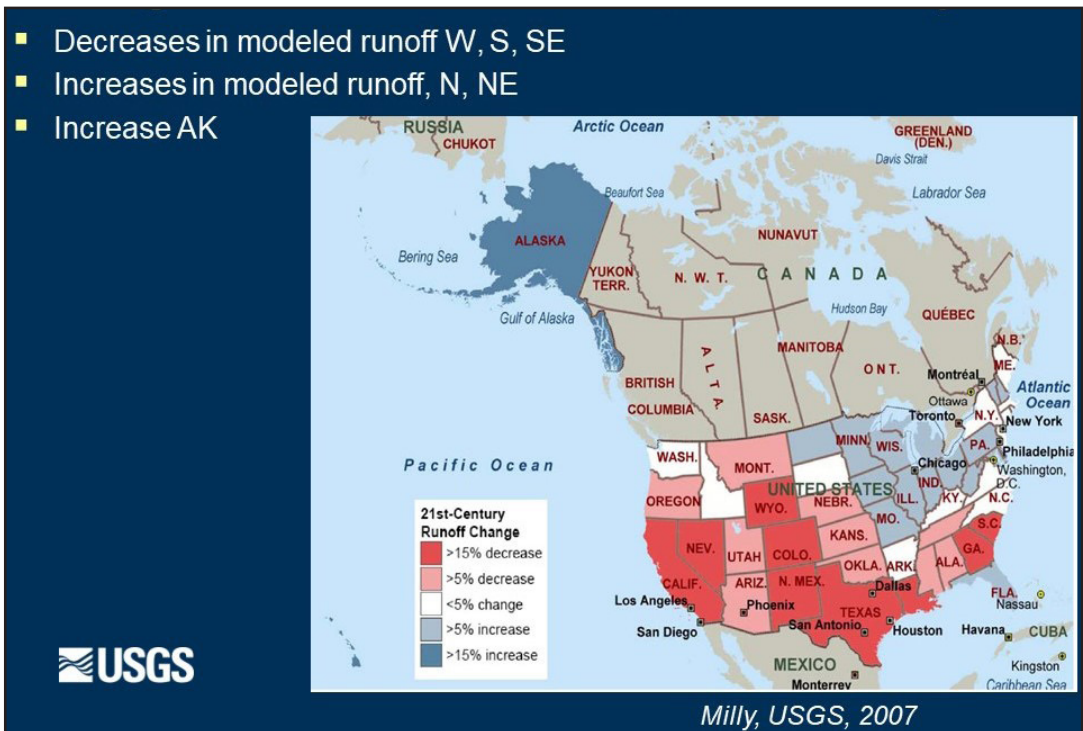


Figure 21. Regional scale forecasts for 21st century runoff change.

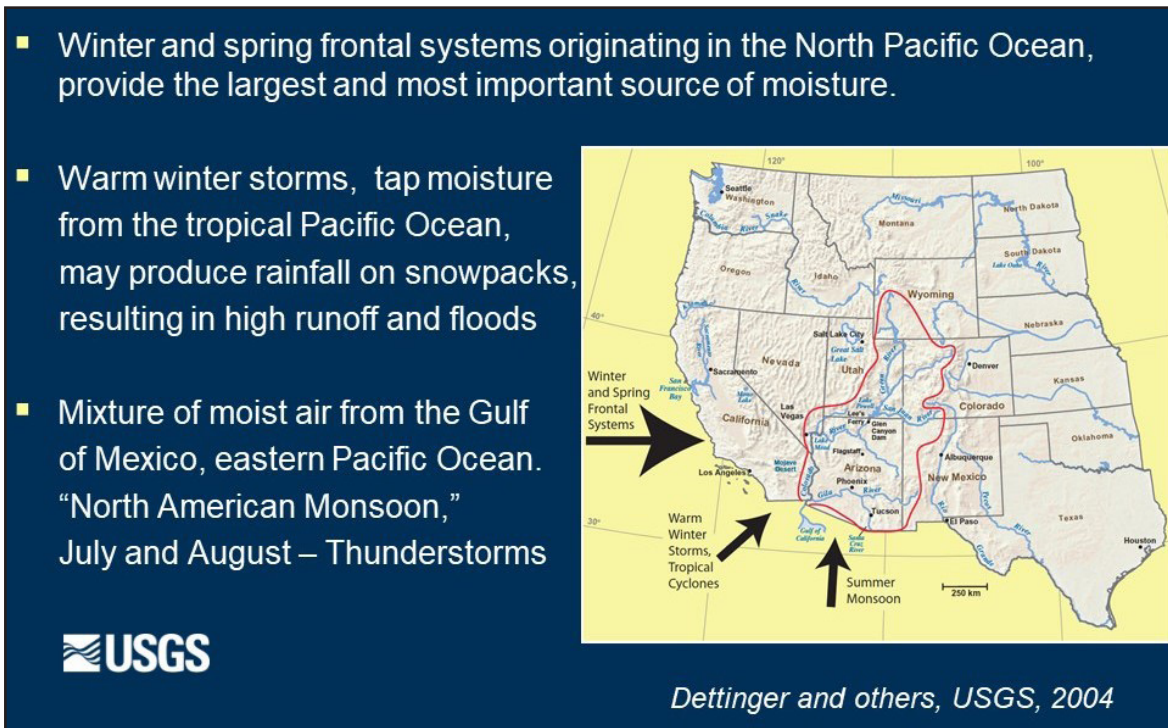


Figure 22. Colorado River Basin - climate controls.

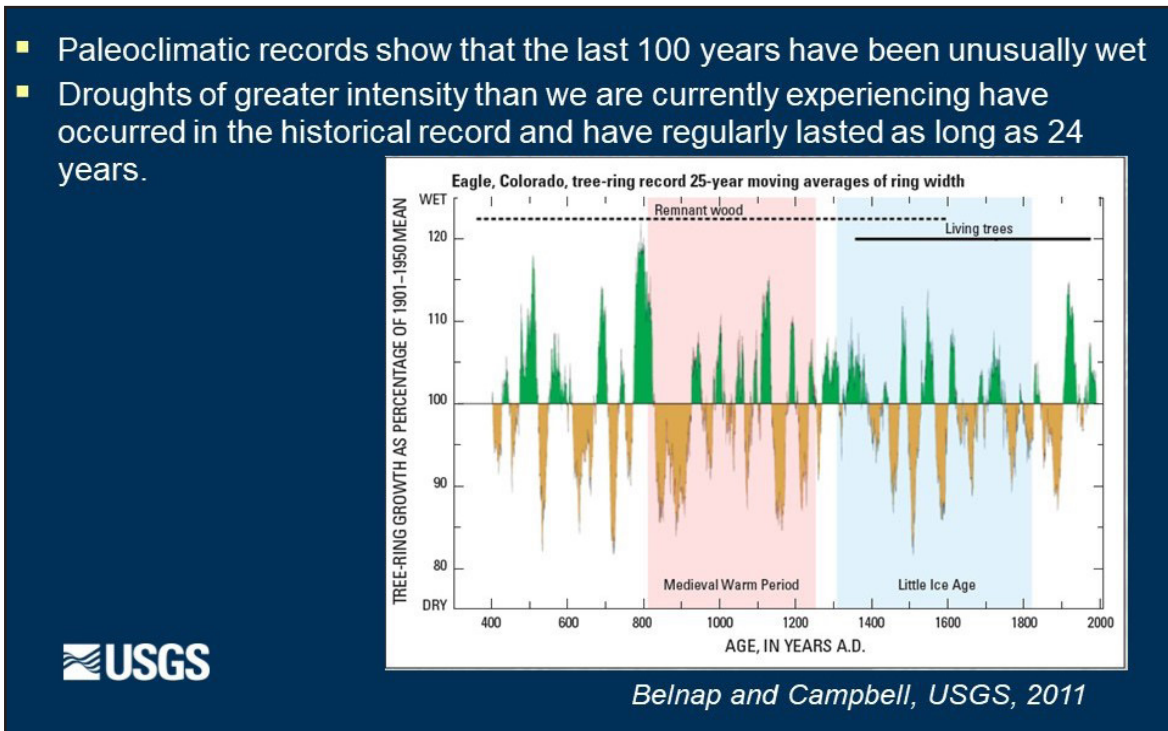


Figure 23. Colorado River Basin - paleoclimatic record.

- Analyses of Colorado River Flows at Lee’s Ferry show recent droughts each lasted from 4 to 11 years
- Tree ring analysis and flow reconstruction can be used to reconstruct the history of drought in the United States for the past 800 years (Gray and others, GRL, 2004) . Since 1226 A.D., nine droughts have occurred lasting 15-20 years and four droughts have occurred lasting more than 20 years.

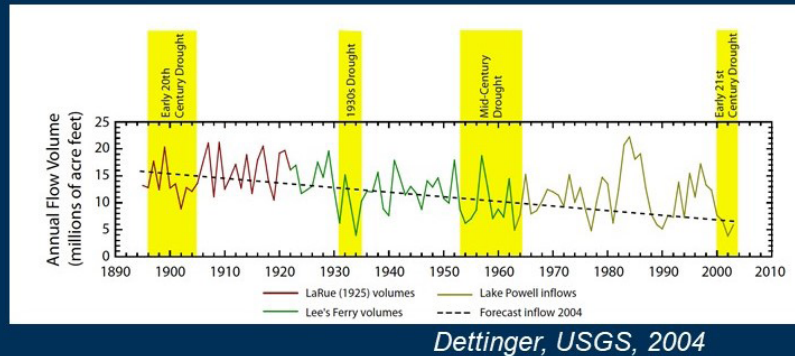


Figure 24. Colorado River Basin - drought duration.

- SW regional drought presents a challenge to the sustainability of our current water use by human and natural systems in the Colorado River Basin
- GCM simulations suggest that the region is likely to become drier and experience more severe droughts
- Model simulations show in the latter half of the 21st century the basin is likely to become drier and experience greater drought activity

Counts of extreme droughts, climate simulations

		Historical 1951–1999	Projected early period 2000–2049	Projected late period 2050–2099
CNRMCM3	SRESA2	5	3	9
	SRESB1	5	2	6
GFDLCM2.1	SRESA2	5	5	13
	SRESB1	5	4	9



Cayan and others, 2010

Figure 25. Future drought in the Colorado River Basin.

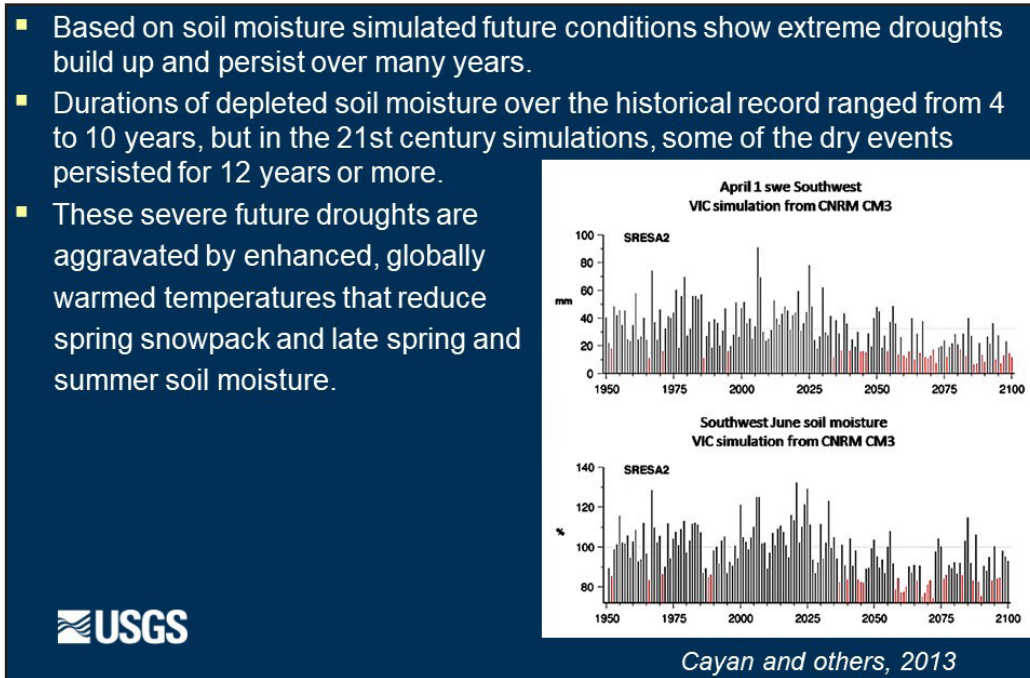


Figure 26. Future drought in the Southwest (cont.).

- With limited rainfall and surface water, the region relies heavily on groundwater to meet demands.
- Basin-scale recharge ranged from less than 0.3 percent of annual precipitation during La Niña conditions to about 16 percent during El Niño conditions. Southern basins were more sensitive to climatic oscillations than those farther north.

Stonestrom and others, USGS, PP-1703, 2008

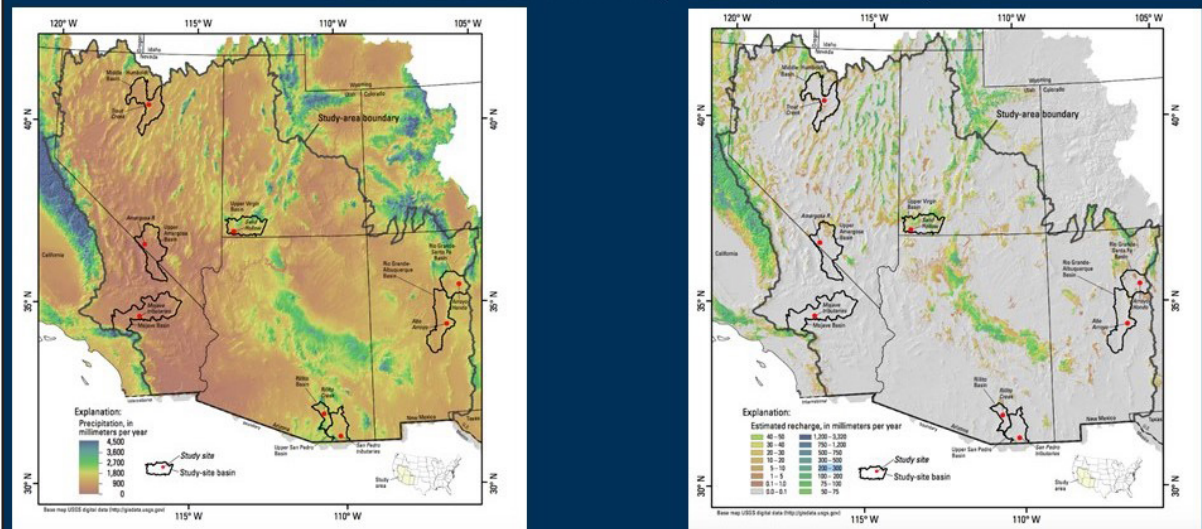
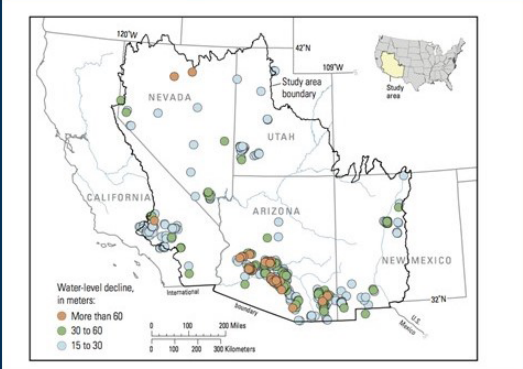


Figure 27. Climate and groundwater recharge in the Southwest.

- The sustainability of groundwater resources, including groundwater-fed habitats, depends on the balance of recharge and discharge, NRP scientists recently developed groundwater to examine the influence of geology, soils, topography, vegetation, and climatic variations have on recharge. Mountain snowpack was found to be critical to recharge.

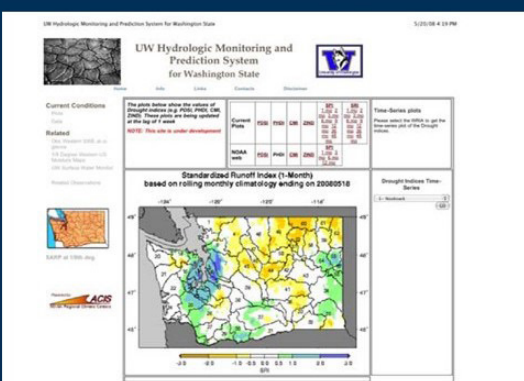


USGS

Stonstrom and others, USGS, PP-1703, 2008

Figure 28. Climate and groundwater recharge in the Southwest (cont.).

- The overall goal of the proposed project is to develop a drought forecast system (DSS) in the western U.S for water managers. WA and TX are the pilot states.
- Develop procedures for assimilating, USGS well data, USGS streamflow, soil moisture data from NRCS, weather data from NOAA, other state networks
- Develop methods for producing probabilistic forecasts of drought persistence recovery.



USGS

Figure 29. Drought forecasting - institute program.