

NOAA's Colorado Basin River Forecast Center

Climate Outlook for the Colorado River Basin

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Service Coordination Hydrologist

Central Arizona Project Climate Adaptation Workshop



Overview

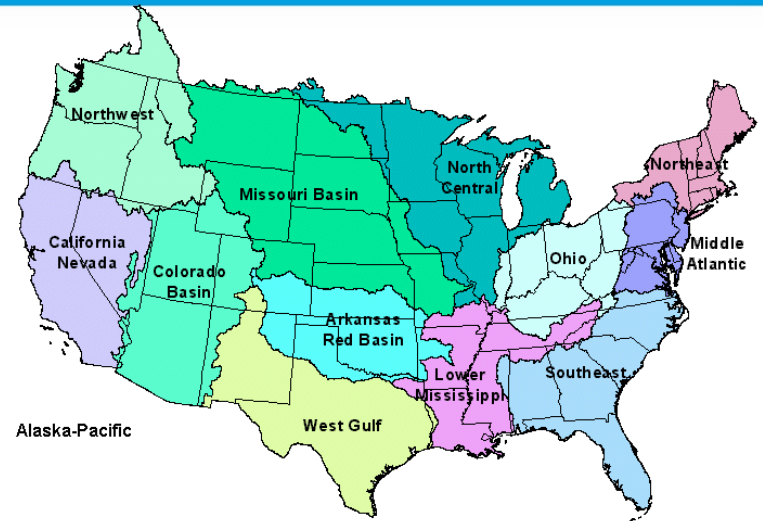
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- Who is the CBRFC and what is our role?
- What does the future climate look like for the Colorado River Basin?
- How does the CBRFC deal with changing climate and uncertainty?





Who Are We?



- Part of NOAA - NWS, one of 13 RFCs nationwide
- An operational field office located in Salt Lake City, UT
- Highly collaborative, reliant on partners and data
- All about decision-support!

Who We Are

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- Work with a broad and diverse set of stakeholders
 - Weather Forecast Offices and Reclamation
 - Municipal and Agricultural Water Users
 - USGS, NRCS, and many other federal agencies
 - State agencies (like CAP!), Academics, NGOs, Tribes
- Receive data from many of these sources



Colorado Basin River Forecast Center

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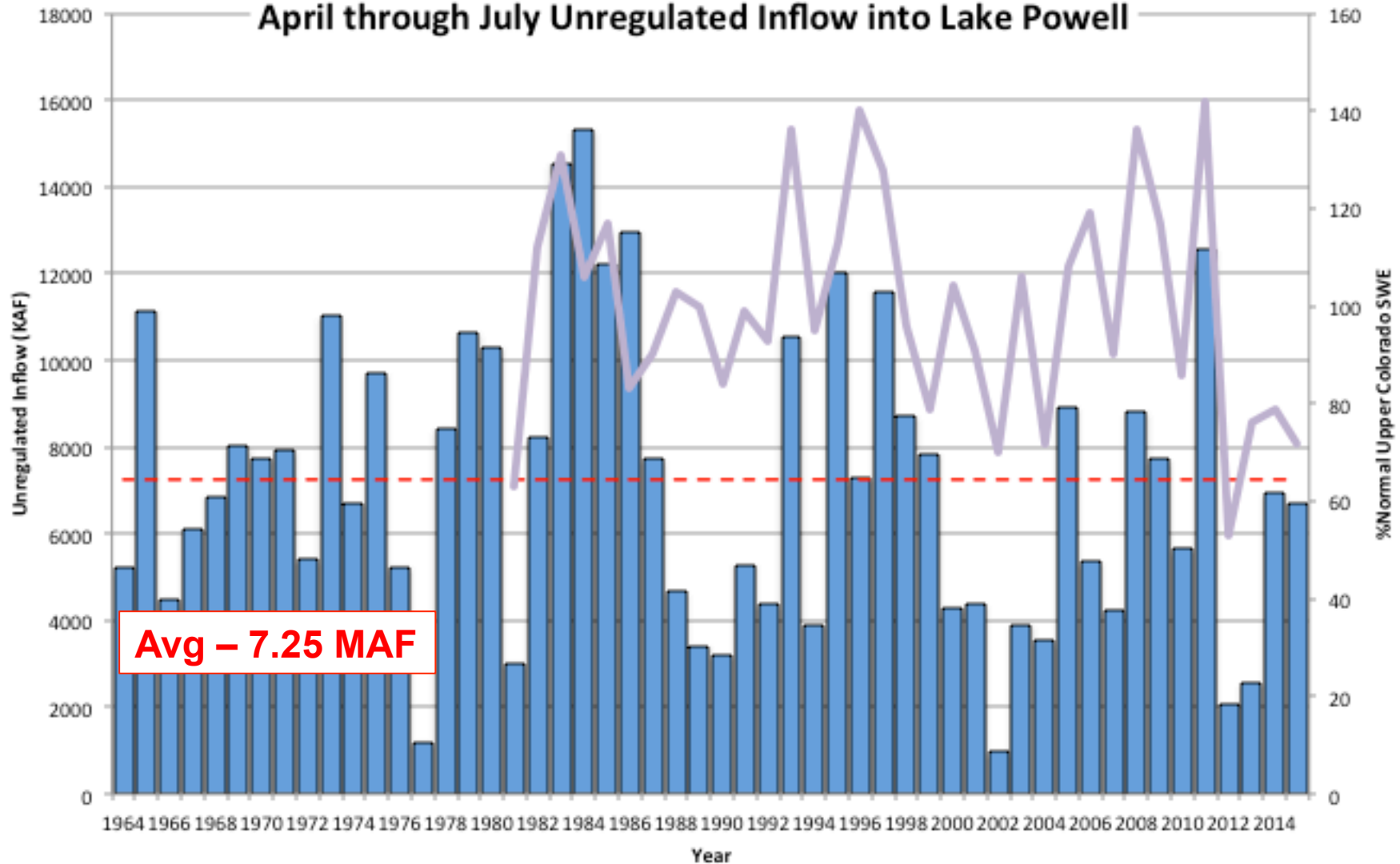
- River Forecast Centers (RFCs)
 - Support for WFOs
 - River levels and flows
 - Reservoir inflows
 - Each RFC is unique
- CBRFC
 - Seasonal Water Supply forecasts, in addition to many other products
 - Most advanced, involved
 - www.cbrfc.noaa.gov



- Weather Forecast Offices (WFOs)**
- Everyday weather
 - Extreme weather
 - Warnings, watches, and advisories
 - Floods, tornadoes, heat, etc...

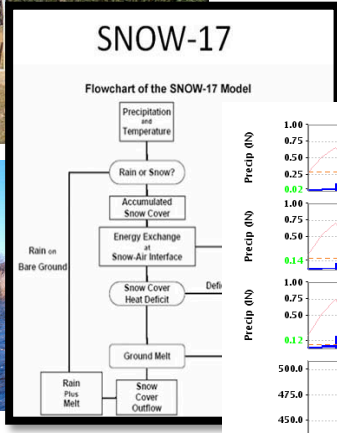
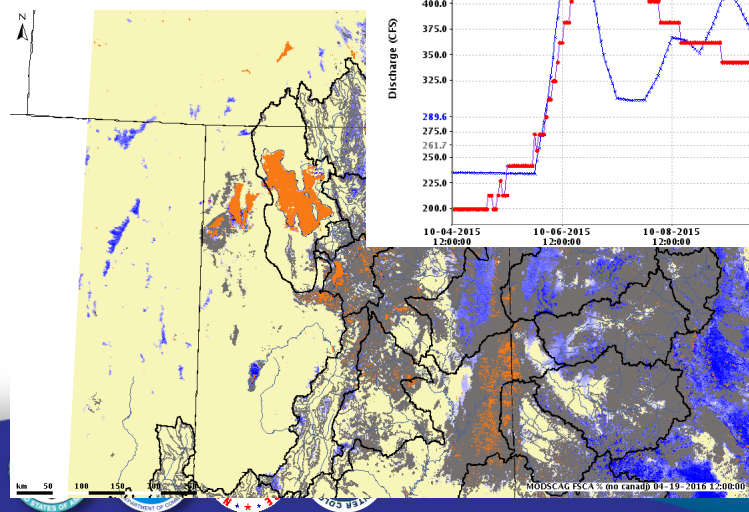
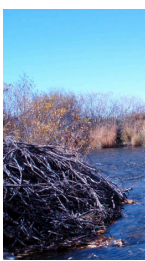


Hydroclimatic Variability over the Colorado River Basin April through July Unregulated Inflow into Lake Powell

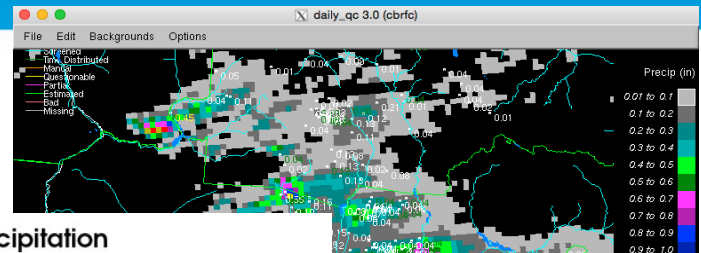


Providing Decision Support

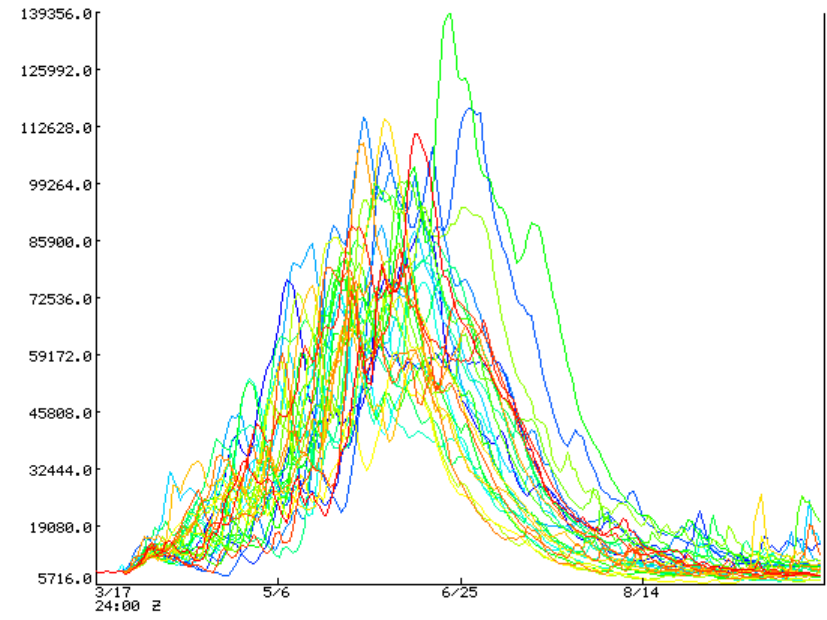
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Evapo- Precipitation



ESP Trace Ensemble of COLORADO - LAKE POWE
 Latitude: 36.9 Longitude: -111.5
 Forecast for the period 3/17/2014 24h - 10/1/2014 24h
 This is a conditional simulation based on the current conditions as of 3/17/2014



Volume (AC-FT)

Quick Update on Current Conditions

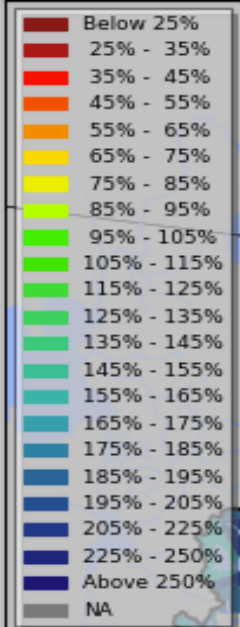
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- Record breaking snowpack in northern portion of the Upper Colorado River Basin, particularly in the Green River Basin
 - Multiple Atmospheric River Events
 - Seasonal snow peaks at some areas attained in February
- Forecasts still generally well above average
- A very warm and dry March and April (so far) have reduced expected volumes some



Upper Colorado April-July Streamflow Volume Forecasts (% of 1981-2010 average)

Forecasts as of Apr 1
2017



Fontenelle:
1680 KAF / 232%

Flaming Gorge:
2260 KAF / 231%

Yampa-Deerlodge:
1050 KAF / 85%

Colorado-Cameo:
2400 KAF / 102%

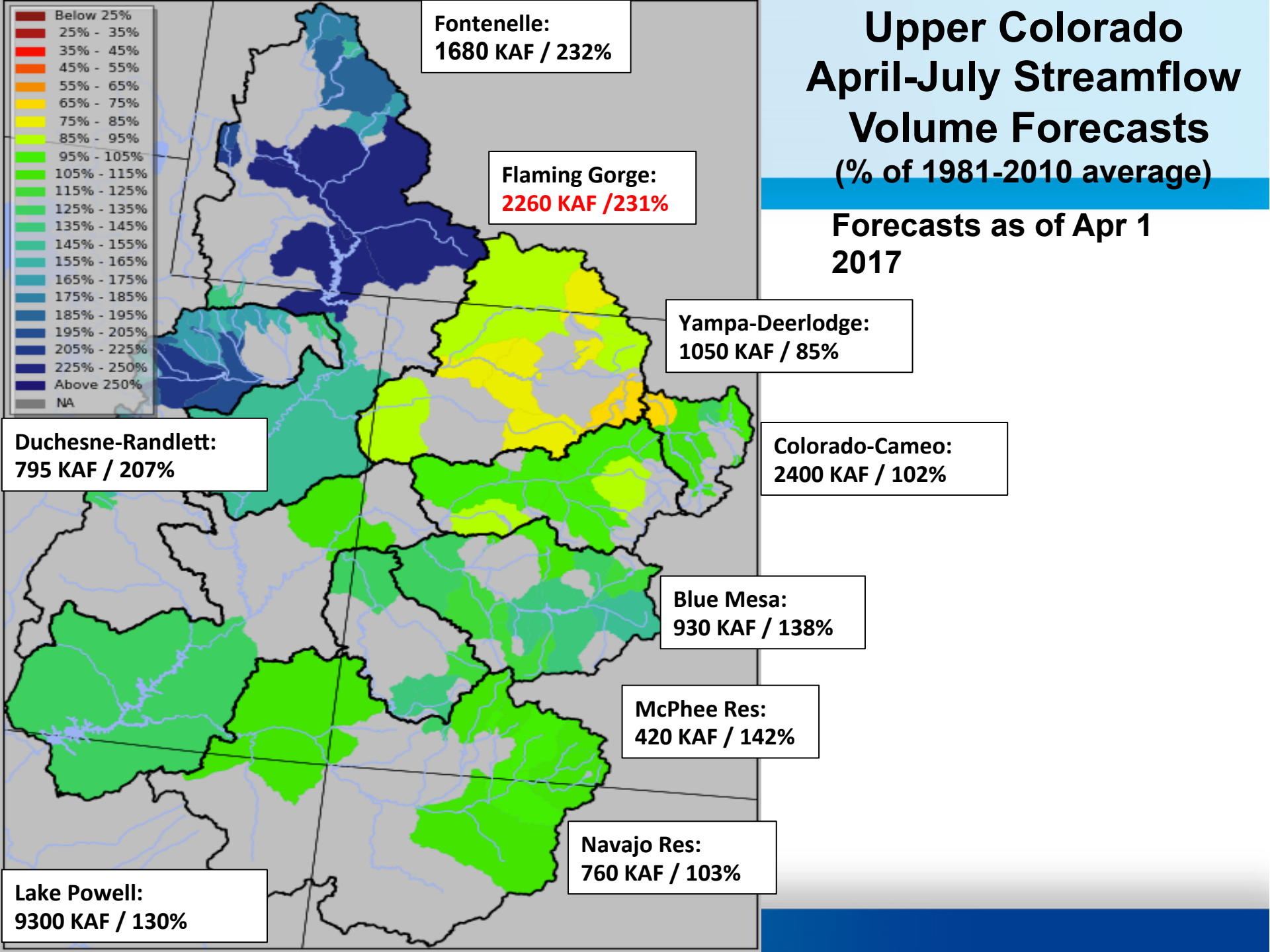
Blue Mesa:
930 KAF / 138%

McPhee Res:
420 KAF / 142%

Navajo Res:
760 KAF / 103%

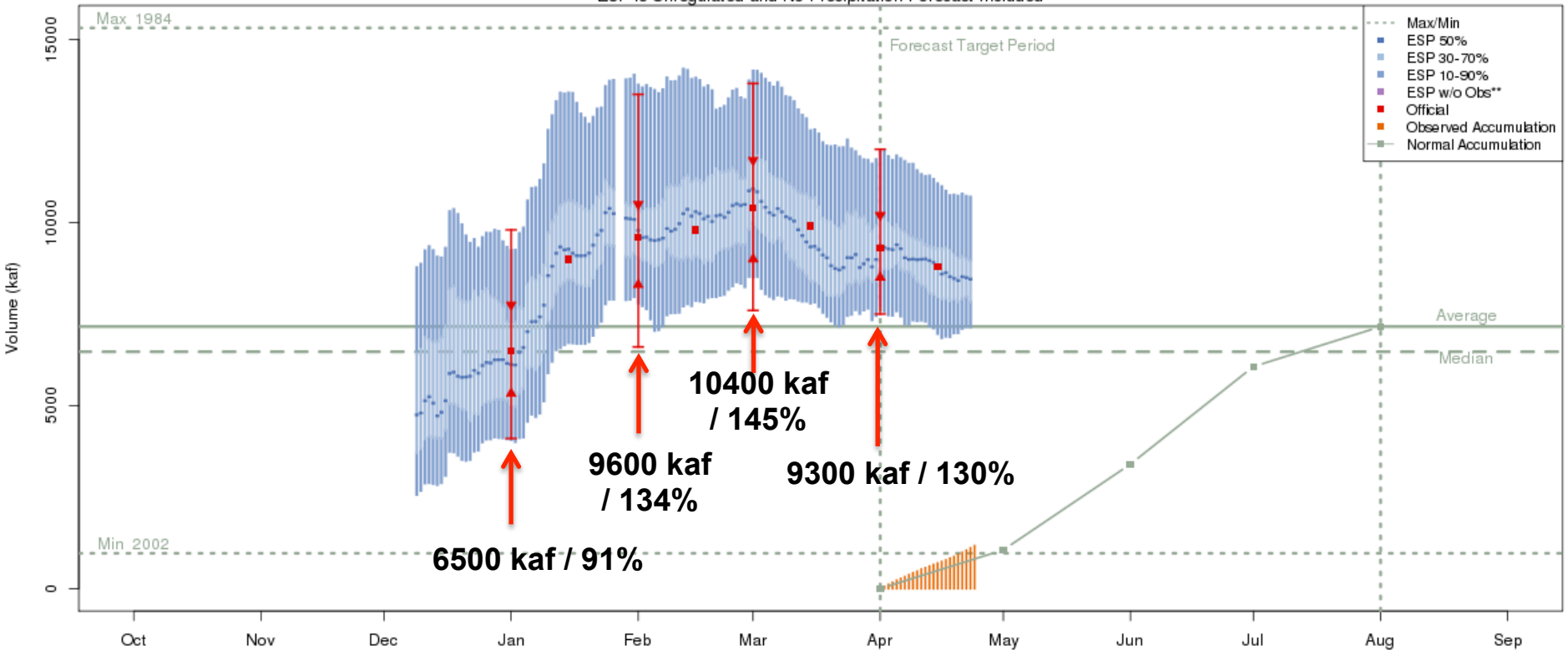
Duchesne-Randlett:
795 KAF / 207%

Lake Powell:
9300 KAF / 130%



Lake Powell Forecast Evolution

Colorado - Lake Powell- Glen Cyn Dam- At (GLDA3)
 2017-04-15 Apr-Jul Official 50% Forecast: 8800 kaf (123% of average)
 ESP is Unregulated and No Precipitation Forecast Included



The most recent (2017-04-23) full period 50% ESP forecast is 8454 kaf.
 Plot Created 2017-04-24 12:44:02, NOAA / NWS / CBRFC
 Forecasts in the forecast target period include observed values.



We Know The Climate Is Changing

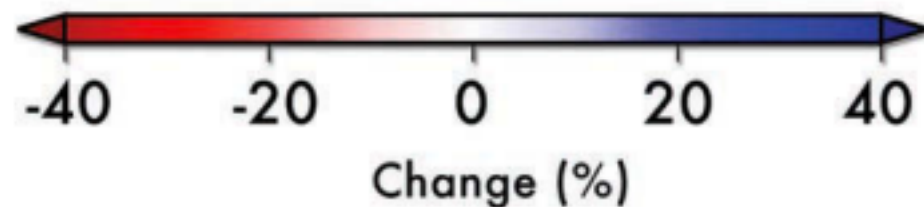
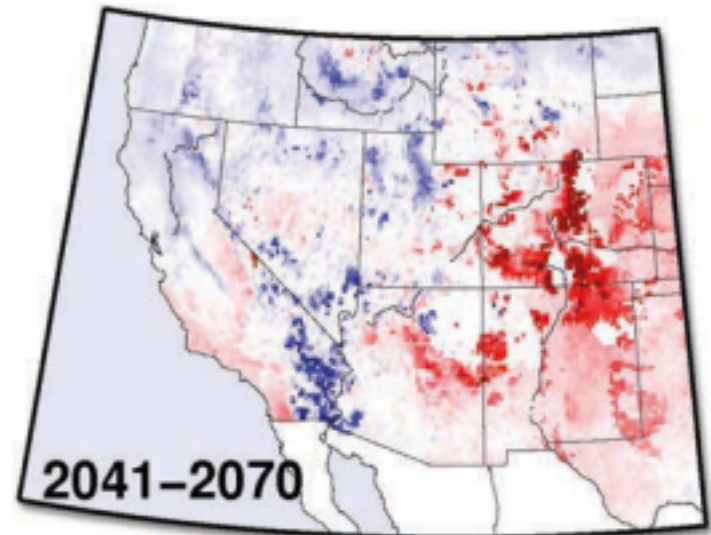
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Temperatures are rising and will continue to rise

Precipitation outlook is uncertain, but we do expect more extreme events

Decreased water supply, particularly for the Southwest and Colorado River Basin

High-emissions scenario



Impacts to the Colorado River Basin

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Droughts have been a part of the natural variability of the Colorado River Basin for decades, but we may expect to see more severe and frequent drought impacts due to climate change in the future

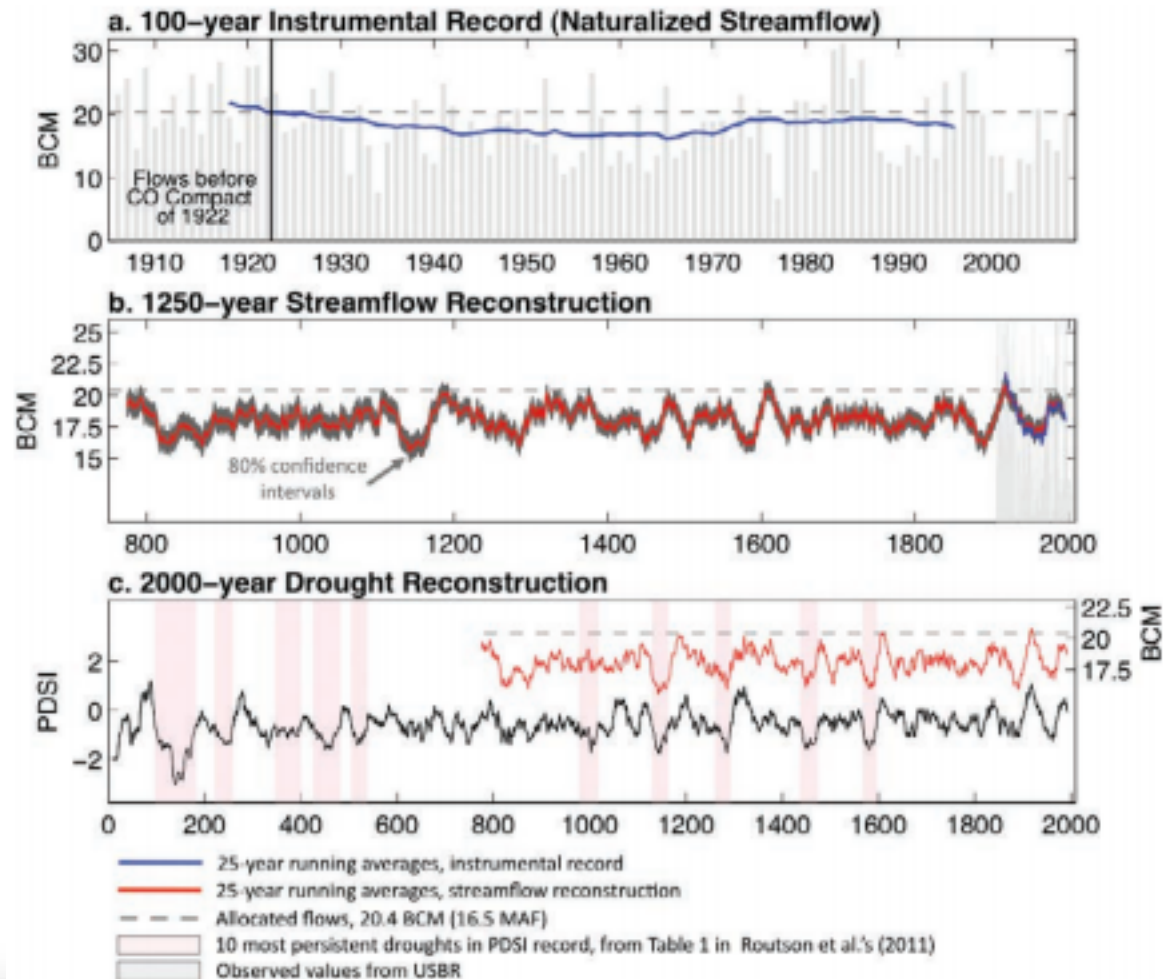


Figure from: Vano, J. et al. 2014. Understanding Uncertainties In Future Colorado River Streamflow. Bulletin of the American Meteorological Society.

Impacts to the Colorado River Basin

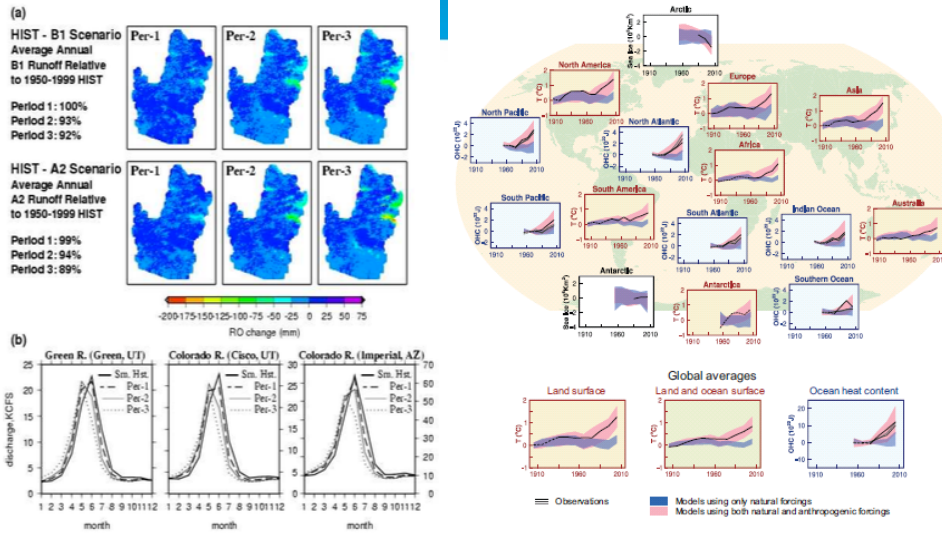
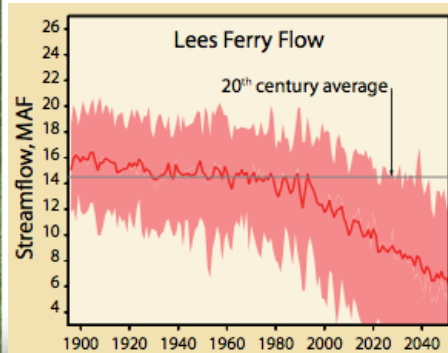
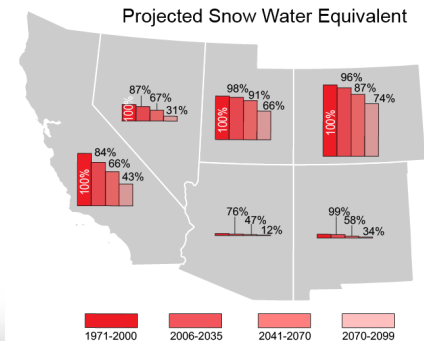
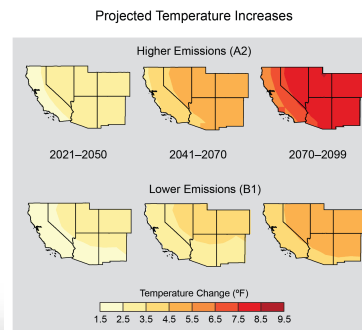
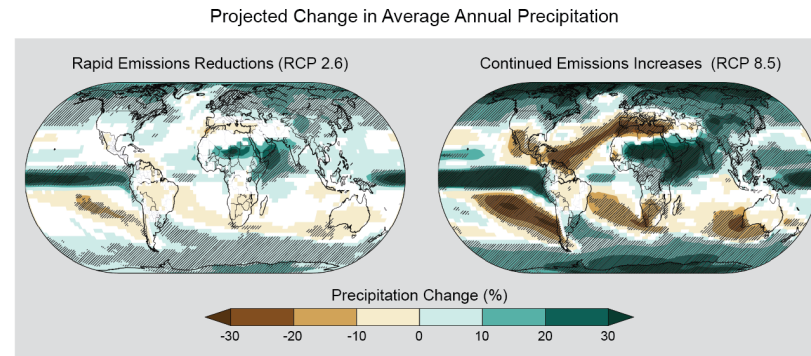
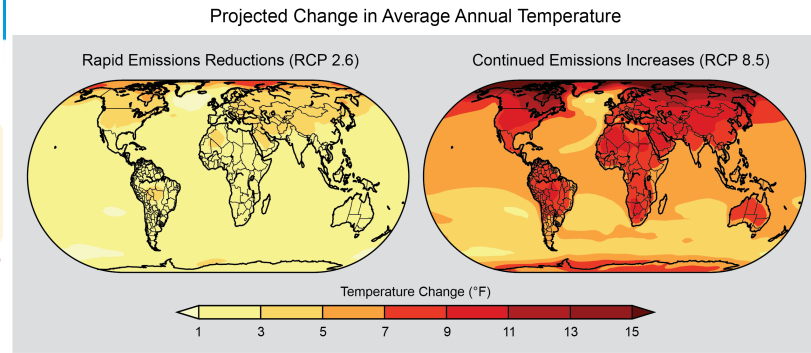
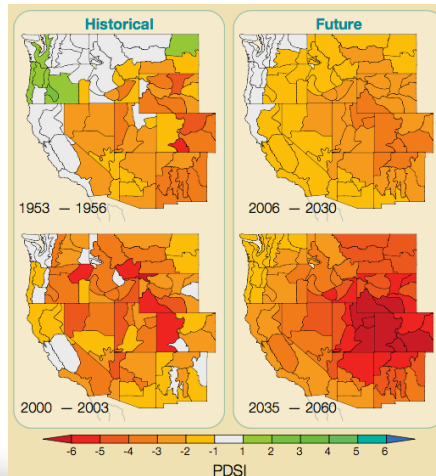


Figure from: Christensen and Lettenmaier, 2007. A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin. Hydrology and Earth System Sciences.



Figures from: Hoerling and Eischeid, 2007. Past Peak Water in the Southwest. Southwest Hydrology.

Figure from the IPCC 5th Assessment Report.



Figures from the 2014 National Climate Assessment

Impacts to the Colorado River Basin

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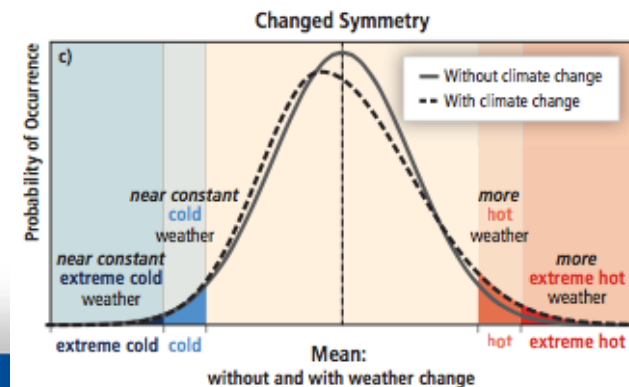
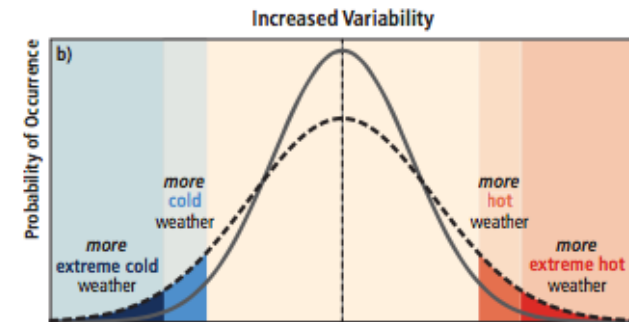
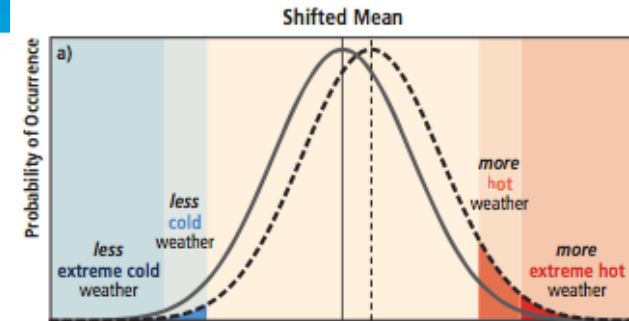
- Temperatures are going to increase
 - About 3 °F to 10 °F over the next 20 – 80 years
 - Southwest is particularly effected
- Precipitation
 - More uncertainty
 - Locally and orographically influenced
 - Southwest could see little change to about a 20% decrease
- Impacts to Streamflow
 - Locally variant, but overall decrease in water supply
 - More rainfall events, less snowfall
 - Earlier runoff
 - Increased evapotranspiration
 - Consensus seems to hover around 8% to 10% decrease over the next 20 – 80 years
 - Extreme events still possible, more likely



The Science Ahead

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- Climate change attribution
 - Can we start to quantify how much climate change contributes to a particular event?
 - Difficult, but the science is rapidly advancing
 - Comparison with the observational record
 - Comparison to model simulations without anthropogenic climate change

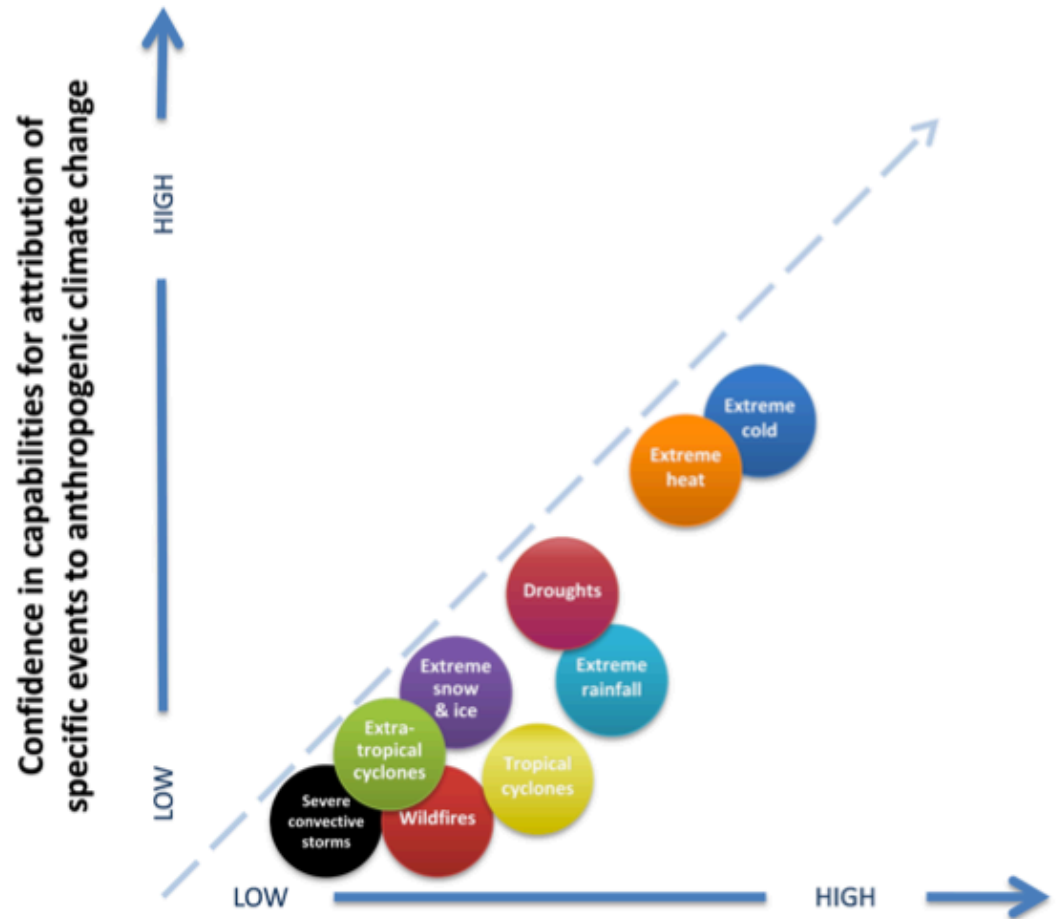


The Science Ahead

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Can attribute temperature changes confidently to climate change, less confidently to other impacts

Figure here and previous slide from National Academy of the Sciences Attribution of Extreme Weather Events in the Context of Climate Change, 2016



Challenges Ahead

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- Climate Change and its Impacts
 - Stationarity is in the past – but it's also how we look forward
 - Extreme Events – persistent drought and intense rains can impact our forecasts, and our stakeholder's ability to manage resources effectively
- Infrastructure and Operations
 - How do we continue to bridge the research to operations gap? AND the operations to research gap?
 - Our model from the 1970s was not built for the data we have access to now, so we have to be innovative
- Outreach
 - Facilitating cooperative and continued decision support
 - Reaching those partners we haven't met yet
 - A diverse area with diverse needs! Great Basin, Lower Basin, Upper Basin... and the users within those areas...



Moving Forward

Sixteen years of drought in the Colorado River Basin: Reality or talking point?

By Guest Columnist

Thursday, May 12, 2016

By Eric Kuhn

I was recently reading an article about Colorado River water when I was seeing for many years now that it was "after 14 years of drought"

May showers bring better outlook for Colorado River, but no miracle



A group of kayakers prepare to head down river while paddling the Black Canyon Water Trail on the lower Colorado River in Lake Mead National Recreation Area on the Nevada and Arizona border east of Las Vegas on Thursday, July 3, 2014. There are 16 routes within the National Water Trail system, and the Black Canyon Water Trail is the first water trail in the Southwest and the only water trail that traverses through a desert. (Jason Bean/Las Vegas Review-Journal)

By HENRY BREAN
LAS VEGAS REVIEW-JOURNAL

It wasn't the "Miracle May" that some observers called it, but a month of rain in Colorado and Utah did provide a significant boost to the outlook for the river.

A terrible year became merely below average.

"Miracle" is probably a bit of an overstatement, but the unusually wet winter did have a significant impact on water supply," said Paul Miller, a senior hydrologist with the Service's Colorado Basin River Forecast Center in Salt Lake City.

Energy and Environment

'Climate change is water change' — why the Colorado River system is headed for major trouble

By Chelsea Harvey August 19



Cutbacks in Arizona Water deliveries possible

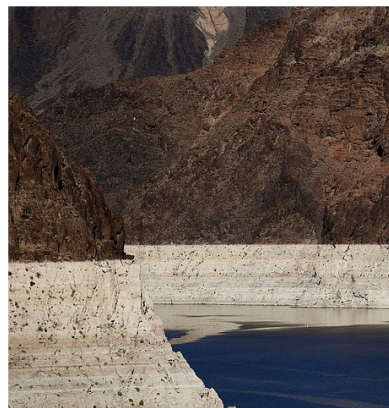
Lake Powell could dry up in as little as six years, study says

By Tony Davis Arizona Daily Star Updated Sep 4, 2016



White marks on the canyon rim are evidence of a once-thriving aquifer that has been depleted by years of drought, with serious consequences for the lake.

Lake Mead shows extent of drought: Feds see 2



Jae C. Hong/The Associated Press, file
A riverboat glides through Lake Mead on the Colorado River at Hoover Dam near

By Ken Ritter, The Associated Press



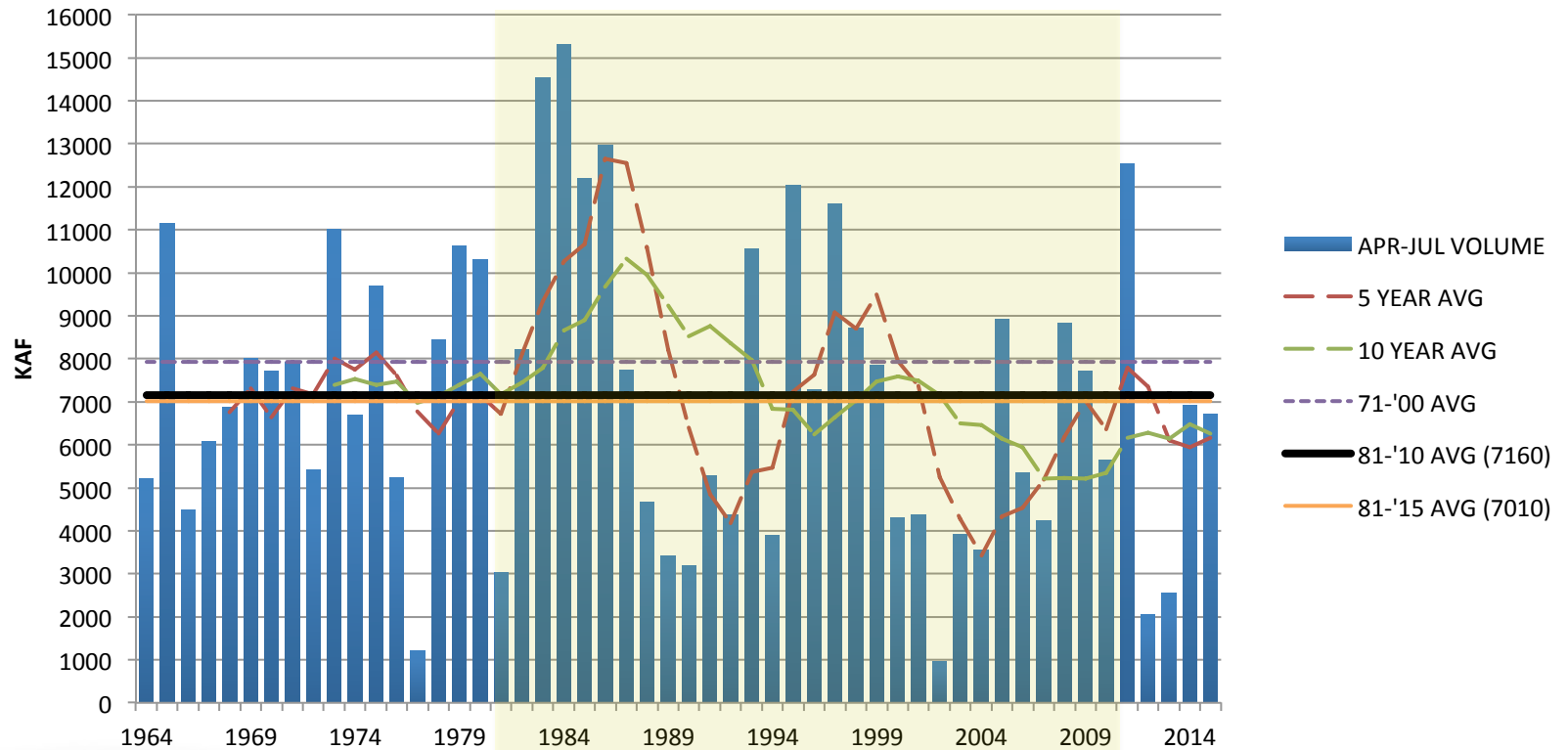
The Rise of Water Optimism

Two new books offer hope for our aquatic future.

By Ben Goldfarb

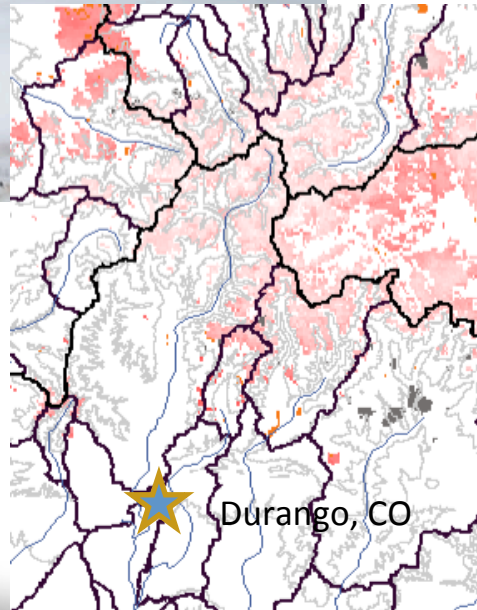
1981-2015 Unregulated Flow

LAKE POWELL APR-JUL UNREG INFLOW



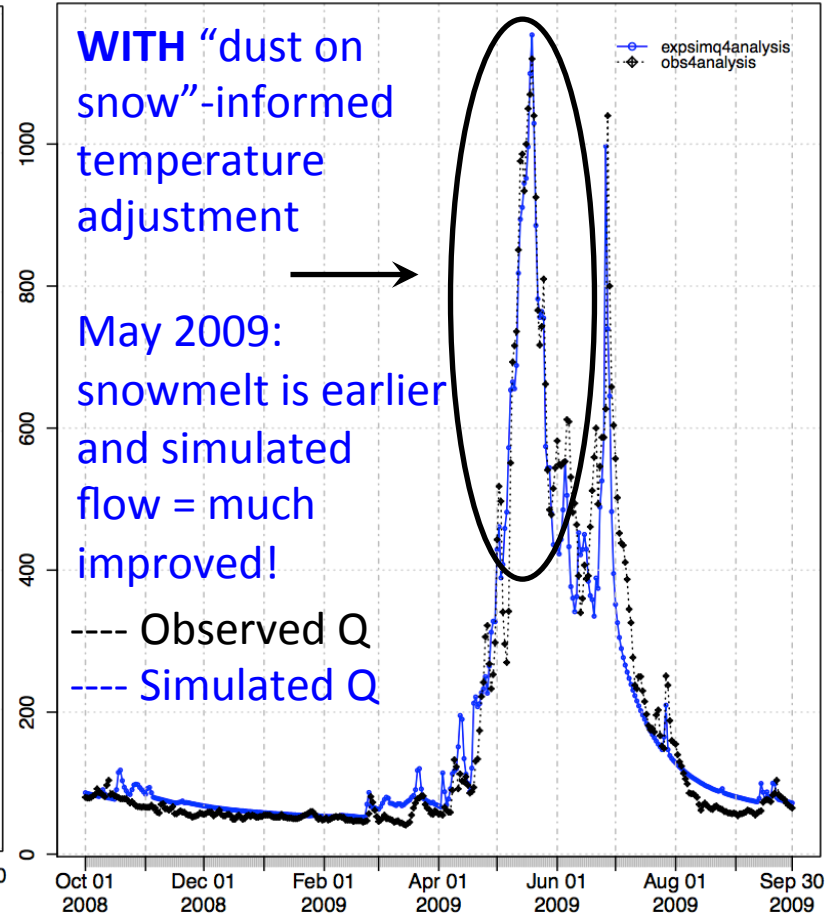
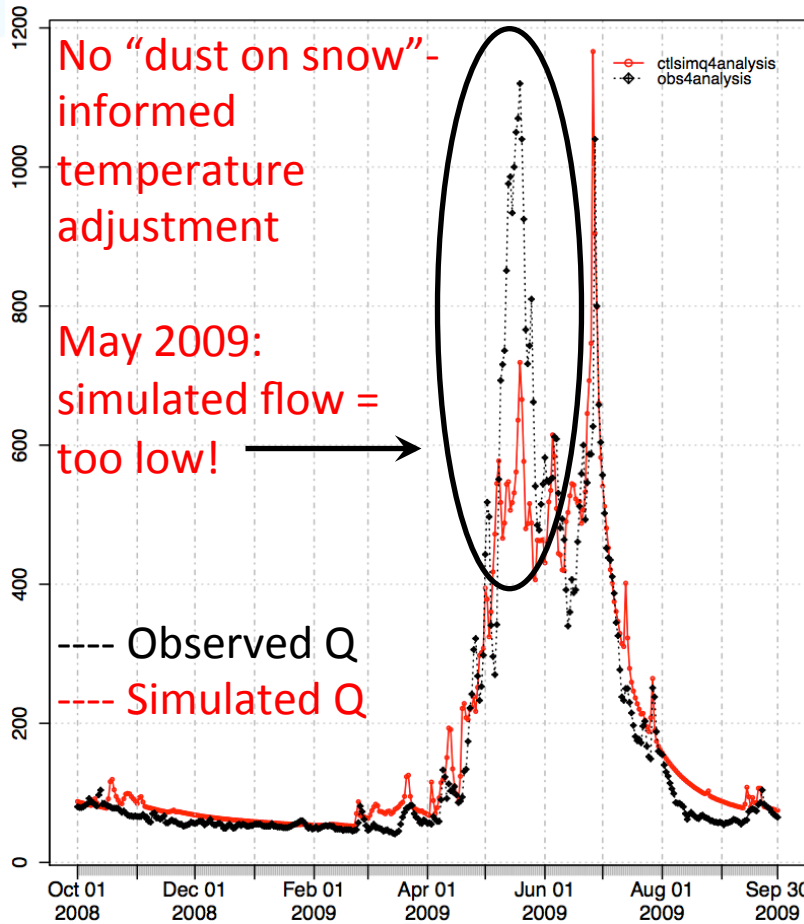
Moving Forward

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- Incorporation of remotely sensed snow information
 - Aerial extent
 - Dust on snow impacts
- An innovative way to get new information into an old model

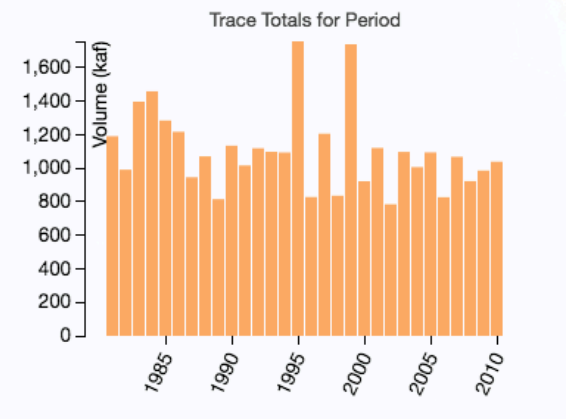
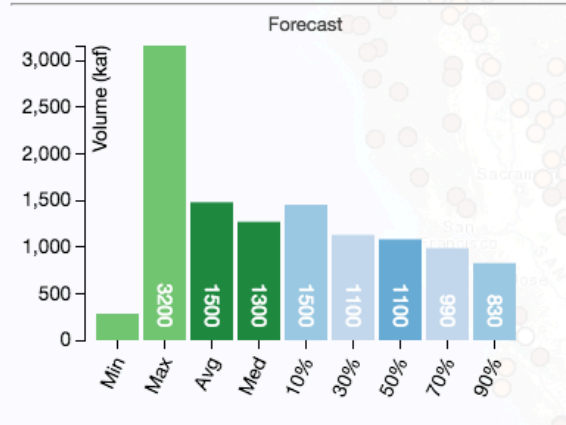
Moving Forward



Moving Forward

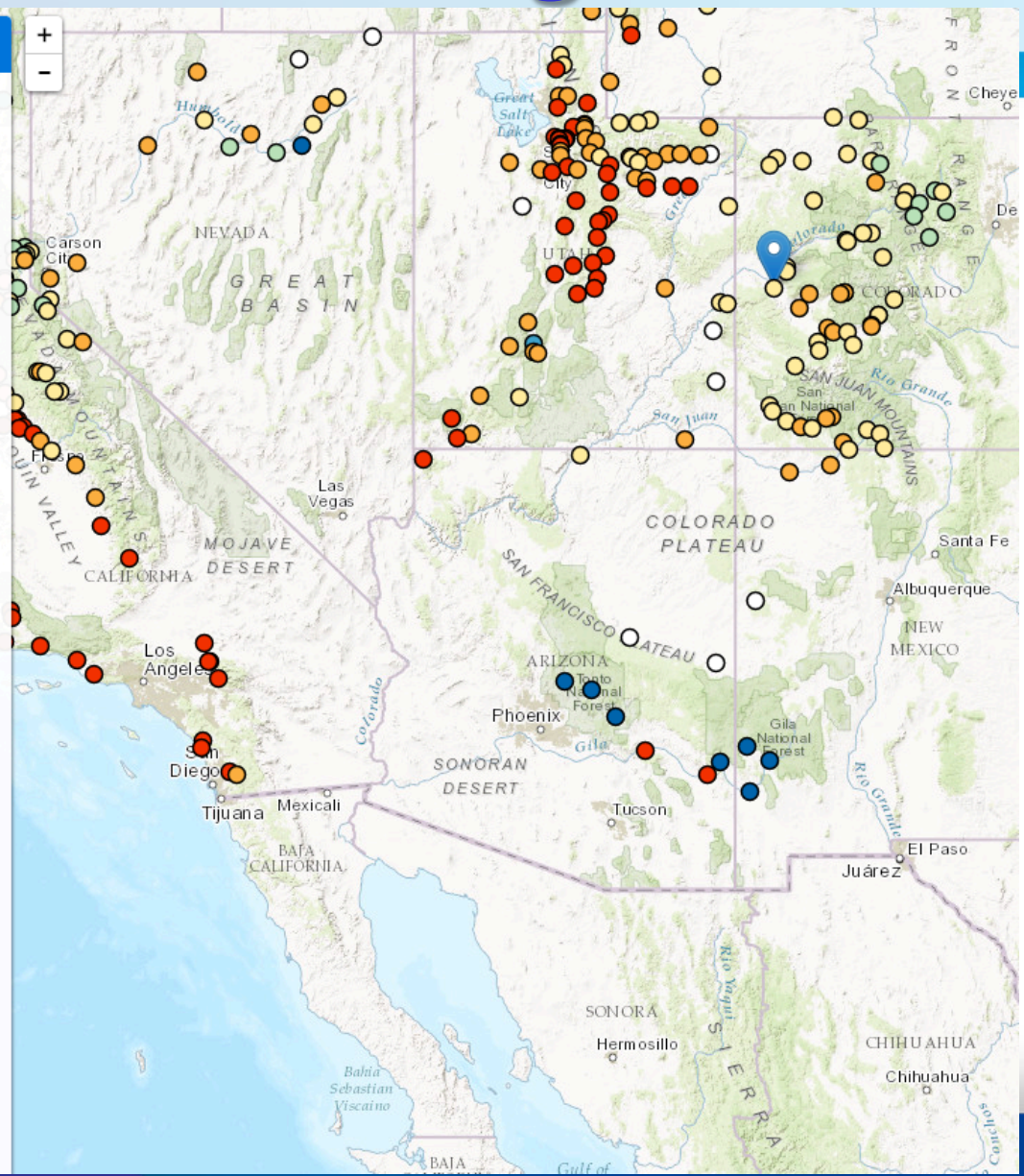
Forecast Point Details

Gunnison - Grand Junction, Nr



[View Forecast Evolution](#)

Station
ID GJNC2
Latitude 38.98
Longitude -108.45



National Water Center



National Water Model Improving NOAA's Water Prediction Services



In August 2016, NOAA took a giant leap forward in its ability to forecast the flow of rivers and streams throughout the entire continental United States with the launch of the

new high resolution National Water Model (NWM).

The NWM will enhance and expand NOAA's water flow forecasts, which to date have been available for approximately 4,000 river locations with stream gauges operated by the U.S. Geological Survey. This new model will expand forecasts to 2.7 million stream locations nationwide. Leveraging the full network of nearly 8,000 U.S. Geological Service stream gauges and NOAA's investment in atmospheric modeling, the NWM will provide high-resolution forecasts of soil moisture, surface runoff, snow water equivalent, and other parameters.

We all recognize that water is an essential component of sustainable and resilient communities. But its also a stressed natural resource and potential threat to life, property, and livelihoods during extreme weather events.

Improved Water Information Services

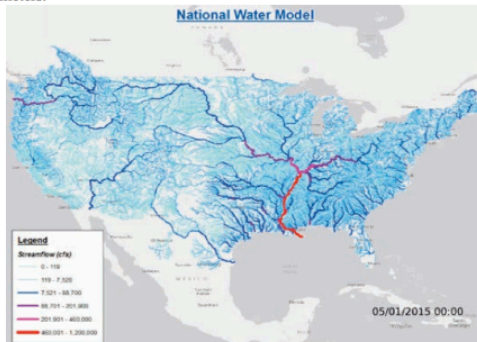
The new NWM improves the National Weather Service's ability to deliver impact-based decision support services nationwide by providing "street level" water information and guidance, as well as serve as the foundation for additional private sector water services. At a minimum, the NWM will immediately provide predictive water information for many locations where none previously existed.

Initially, this new NWM-based information will be particularly useful in headwater areas in support of NOAA's flash flood mission.

How it Works

The NWM simulates the water cycle with mathematical representations of the different processes and how they fit together. This complex representation of physical processes such as snowmelt and infiltration and water movement through the soil layers varies significantly with changing elevations, soils, vegetation types and a host of other variables.

Additionally, extreme variability in precipitation over short distances and times can cause the response on rivers and streams to change very quickly. Overall, the processes are so complex that to simulate it with a mathematical model means that it needs a "supercomputer" in order to run in the time frame needed to support decision makers when flooding is threatening.



National Water Model is a new forecasting tool that will help forecasters predict when and where flooding can be expected.

www.water.noaa.gov

National Water Model Image Viewer

The viewer below has been made available to view the pre-generated imagery depicting output from the National Water Model. For direct access to the imagery shown in the viewer, visit the following location: http://www.noahrs.noaa.gov/pub/staff/keicher/WRFH_ppd/web/static_images/

Dataset: Stream Flow Forecast Type: Long Range

2016-09-09 06:00:00 UTC

2016-09-09 12:00:00 UTC

2016-09-09 18:00:00 UTC

2016-09-10 00:00:00 UTC

2016-09-10 06:00:00 UTC

2016-09-10 12:00:00 UTC

2016-09-10 18:00:00 UTC

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2016-09-11 06:00:00 UTC

2016-09-11 12:00:00 UTC

2016-09-11 18:00:00 UTC

2016-09-12 00:00:00 UTC

2016-09-12 06:00:00 UTC

Questions?

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- www.cbrfc.noaa.gov

