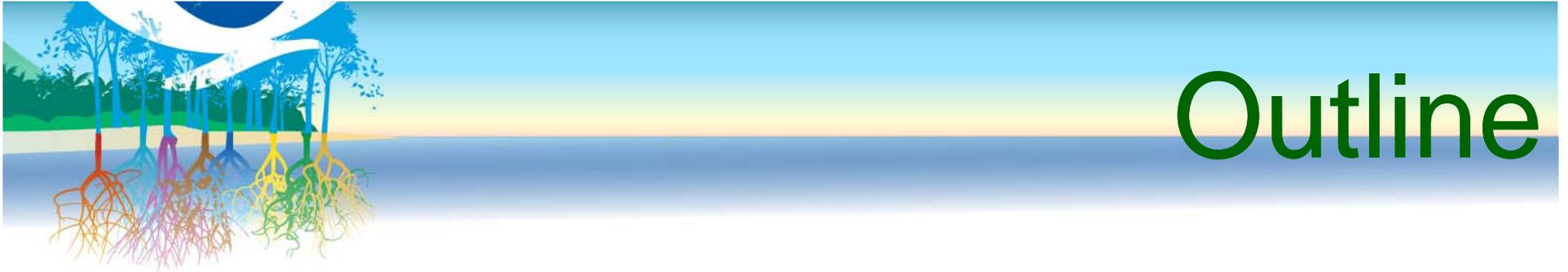


NOAA Water Supply and Water Resources

Drought Monitor Forum
Austin, TX



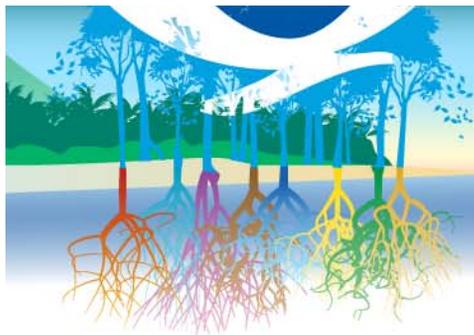
$SM^{5/8} \text{€} - fi^{5/8} \Gamma_R - 5/8 \Gamma_R$
 $- 5/8 \Gamma_R \text{€} \text{€} 1/8^{5/8} - 11 \Gamma_R^{3/8} \text{€} - 1/3 N_L \text{€} 1 -$
 $\dagger R s^{3/8} \Gamma_R^{10/00} 1^{\text{M}} \text{€} L_F N_L$
 $- 10/00^1 \Gamma_R^{1/3} 3/8^1 - 1/3 L_F \text{€} - \square \bigcirc -$
 $\blacksquare 1/8 N_L^{12/3} 5/8 \Gamma_R \text{€} \text{€} 1/2^{aa} \alpha$



- 🌐 River Forecast Center Overview

- 🌐 Water Supply / Water Resources Outlook Project:
 - 🌐 Overview and History
 - 🌐 Current Capabilities
 - 🌐 Future Plans

- 🌐 Other Drought Stuff



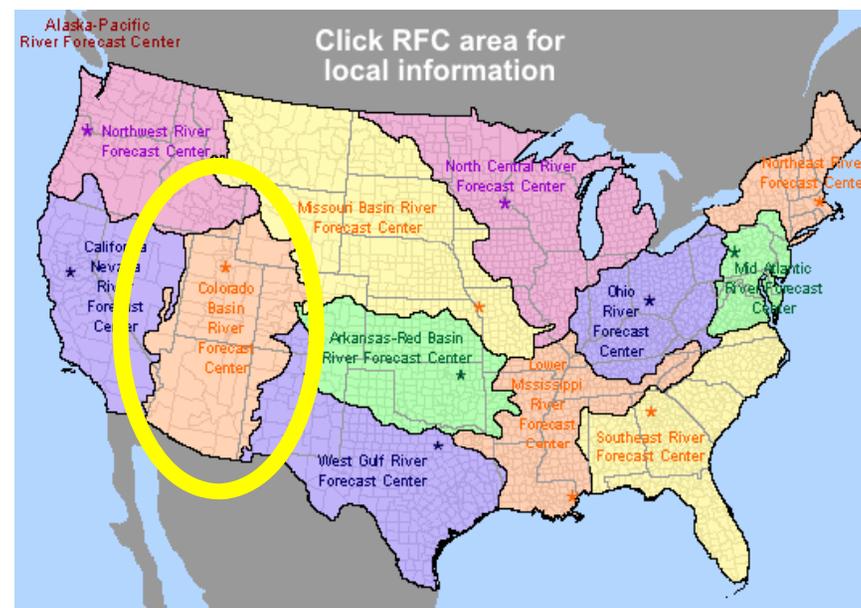
Colorado Basin River Forecast Center

One of 13 River Forecast Centers

Established in the 1940s for water supply forecasting

Three primary missions:

1. Seasonal **Water supply forecasts** for water management
2. **Daily forecasts** for flood, recreation, water management
3. **Flash flood warning support**

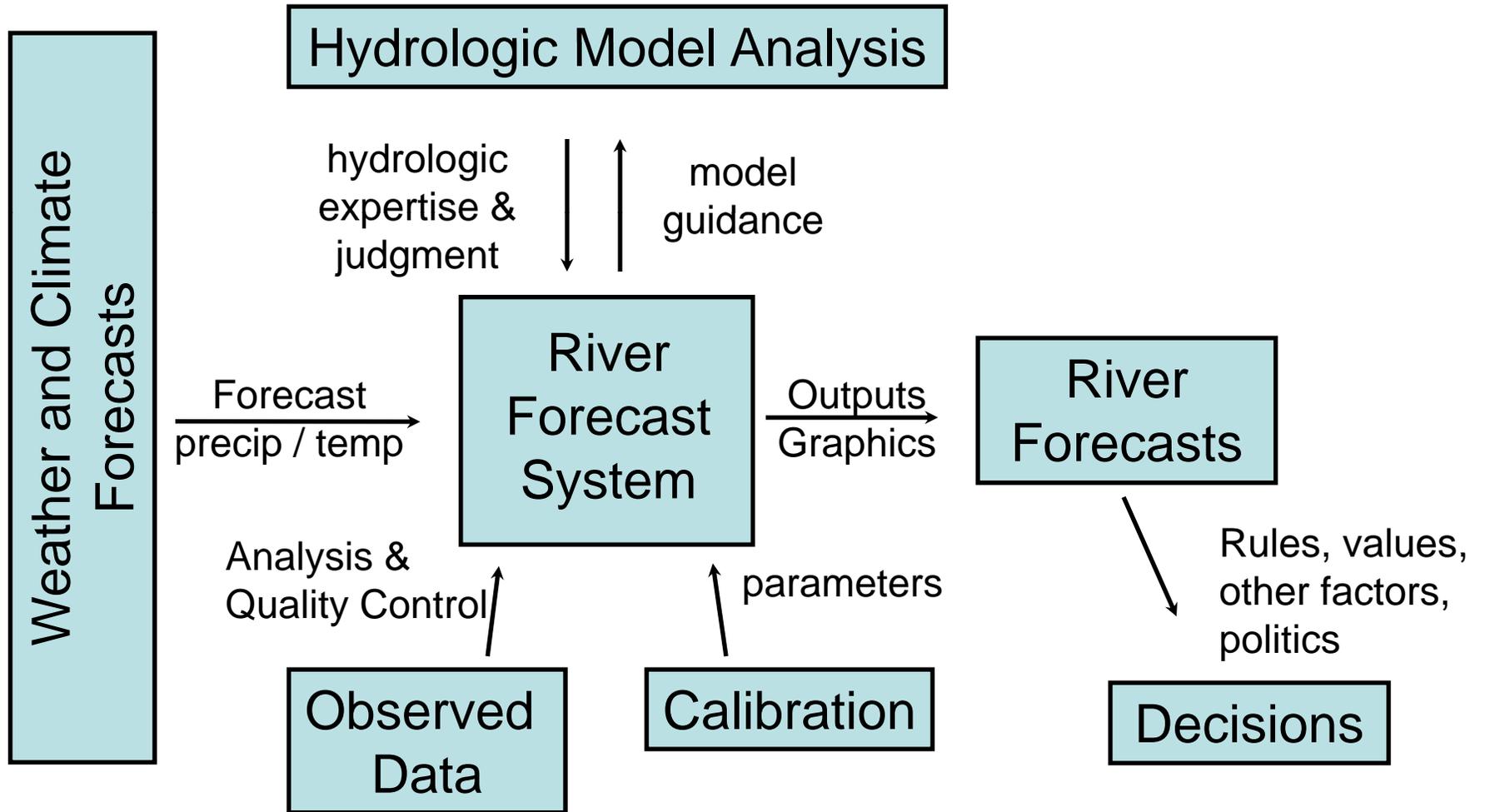


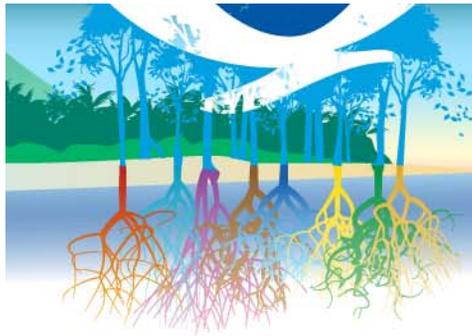
www.cbrfc.noaa.gov





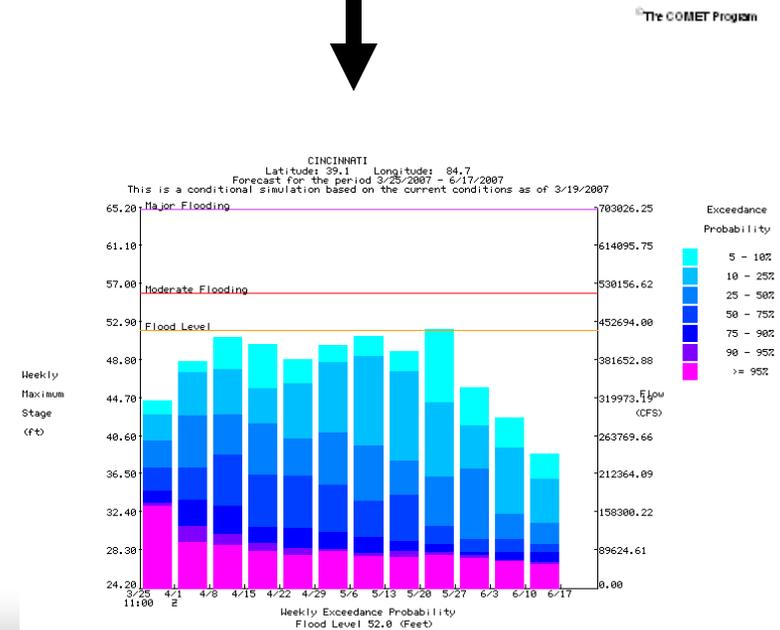
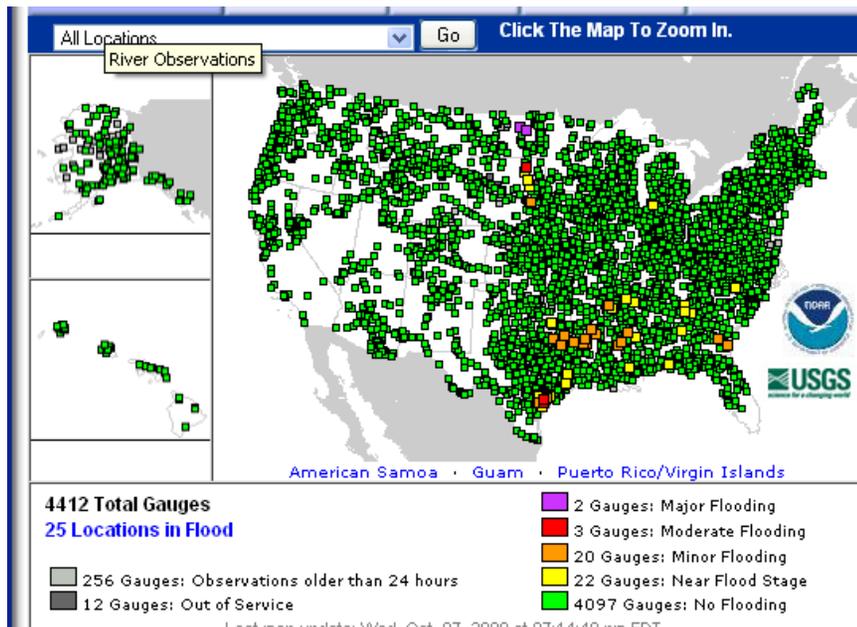
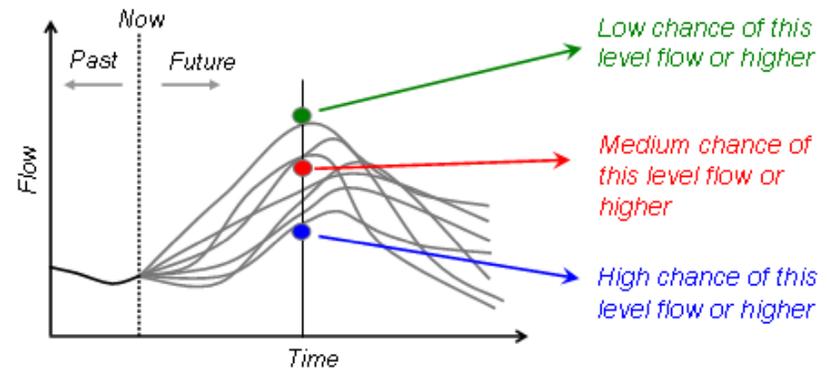
Generalized RFC Forecast Process





RFC Ensemble Streamflow Prediction

RFCs routinely make multi month forecasts integrating initial soil moisture and snow conditions with weather and climate forecasts:





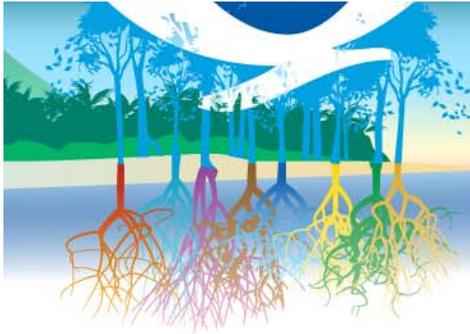
Web Services Project

Goal: Develop “one stop shop” for NWS water supply and water resources forecasts

Milestones (past):

- 📍 April 2005: Working group formed, planning meeting held
- 📍 January 2006: Initial website launched
- 📍 September 2006: Included AB, WG, and MB RFCs in development
- 📍 January 2007: Common database developed
- 📍 September 2007: Move software to NWRFC web farm
- 📍 December 2007: Launched verification and ensemble services
- 📍 May 2008: Partnered with OHRFC to enhance / expand Water Resources Outlook
- 📍 January 2009: Launched “version 3” including google map interface, national water resource outlook, climate variability and change relationships.
- 📍 July 2009: Held organizational meeting in Park City, UT to explore next steps and relationships with RISAs

Current Status: Website Operations



6 Western RFCs

Water Supply
Forecasts

All (13) RFCs

Ensemble Streamflow
Forecasts

Historical Streamflow

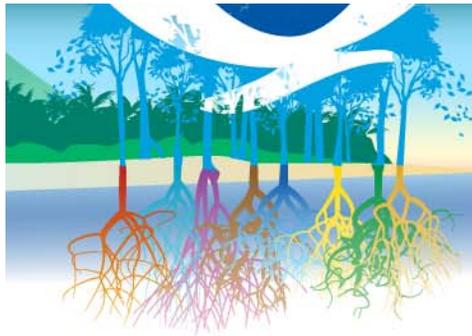
Metadata



Website

NIDIS Web
Services

Central Database

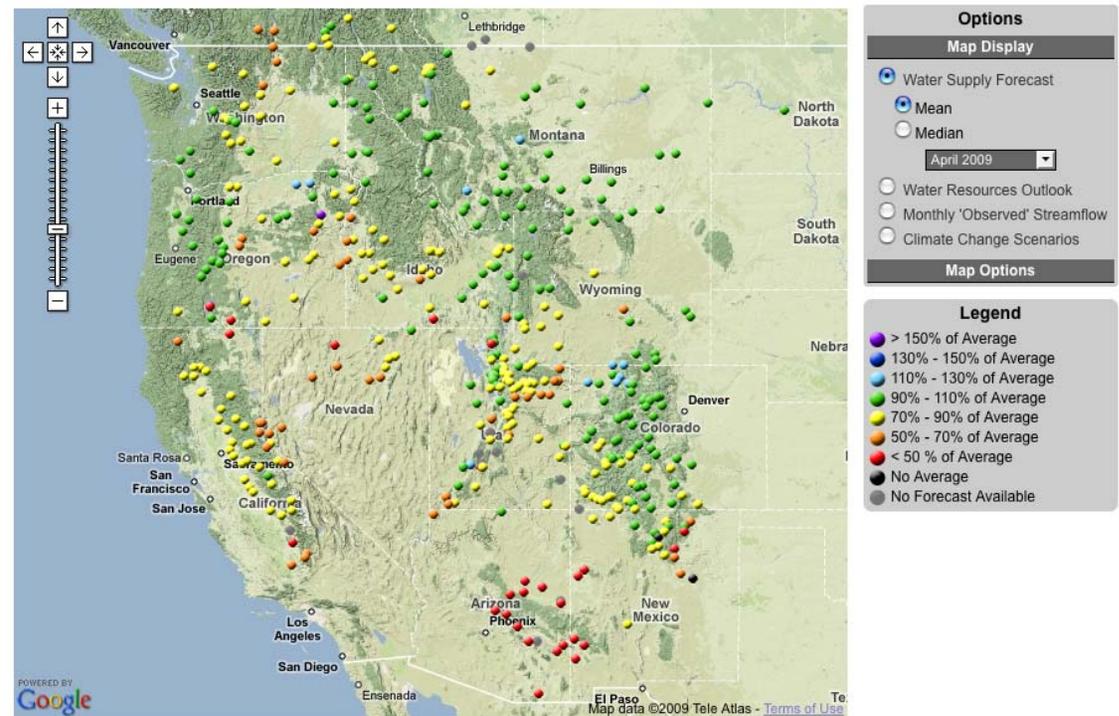


Current Status: Western Water Supply

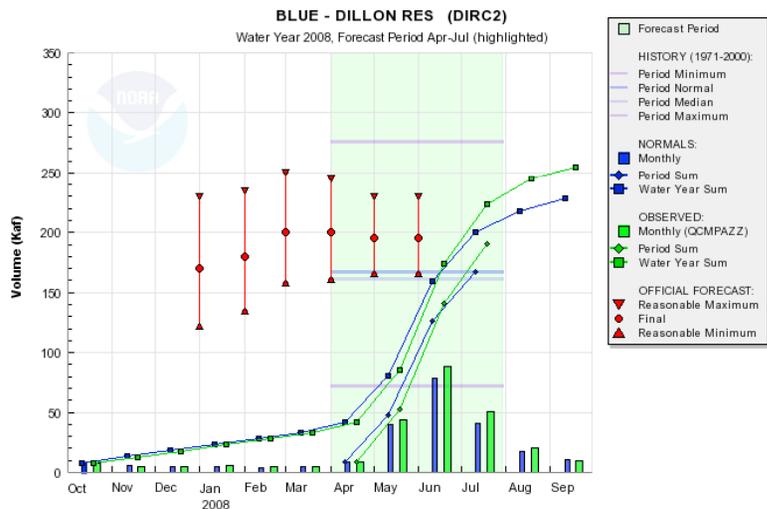
Tools Available:

- Forecast Analysis
- Verification
- Ensemble Forecasts
- Climate Variability Relationships
- Climate Change Scenarios
- Data Access

Water Supply Forecasts Map



Jun 01 2008 Forecast: 195 Kac ft
Range: 166-230 Kac ft (99.4 - 137.7% of normal)



Options

- Water Supply Forecasts
- Ensemble Forecasts
- Observations
- Graph Options

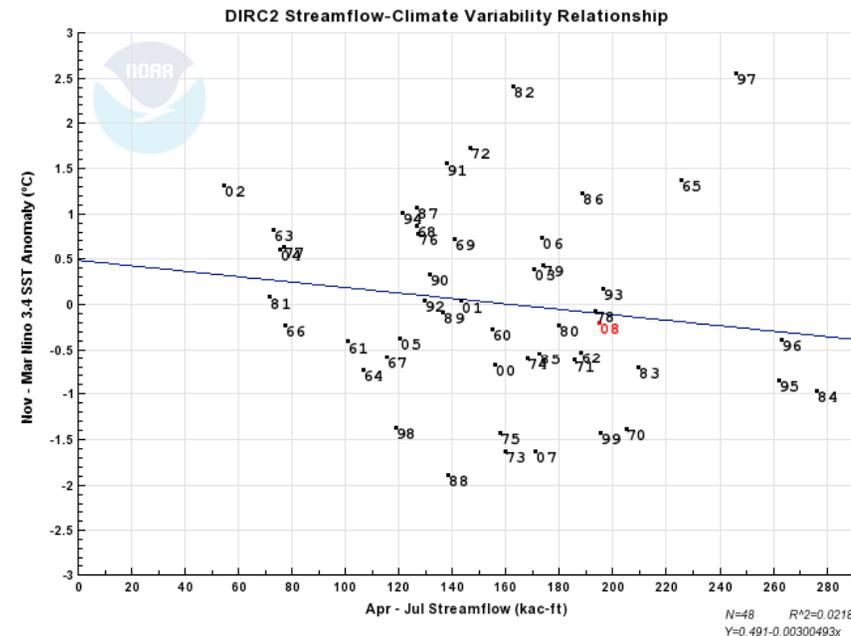
Start Water Year: 2008
End Water Year: 2008
Period: Apr-July

- Period Median
- Period Normal
- Period Maximum
- Period Minimum
- Forecast Period
- Require Maximum
- Grid

CBRFC/NWS/NOAA 11/10/08 17:32:30 UTC

Flow Relationship with Climate Variability

Climate Index: Nino 3.4 SST Anomalies
Index Start: November
Index End: March
Display the Previous: 100 Years



Flow Forecast in context with similar Historic Years (Apr - Jul, 1960 - 2008)

Rank	Year	Flow (kaf)	Percent Normal
Highest (1)	1984	276.13	165.3
10	1978	193.49	115.9
11	2008	190.92	114.3
12	1986	188.57	112.9
13	1962	187.93	112.5
14	1971	185.42	111.0
Forecast	2009	180.00	107.8
15	1980	179.88	107.7
16	1979	173.99	104.2
17	2006	173.65	104.0
18	1985	172.69	103.4
19	2007	170.82	102.3
Lowest (50)	2002	54.56	32.7

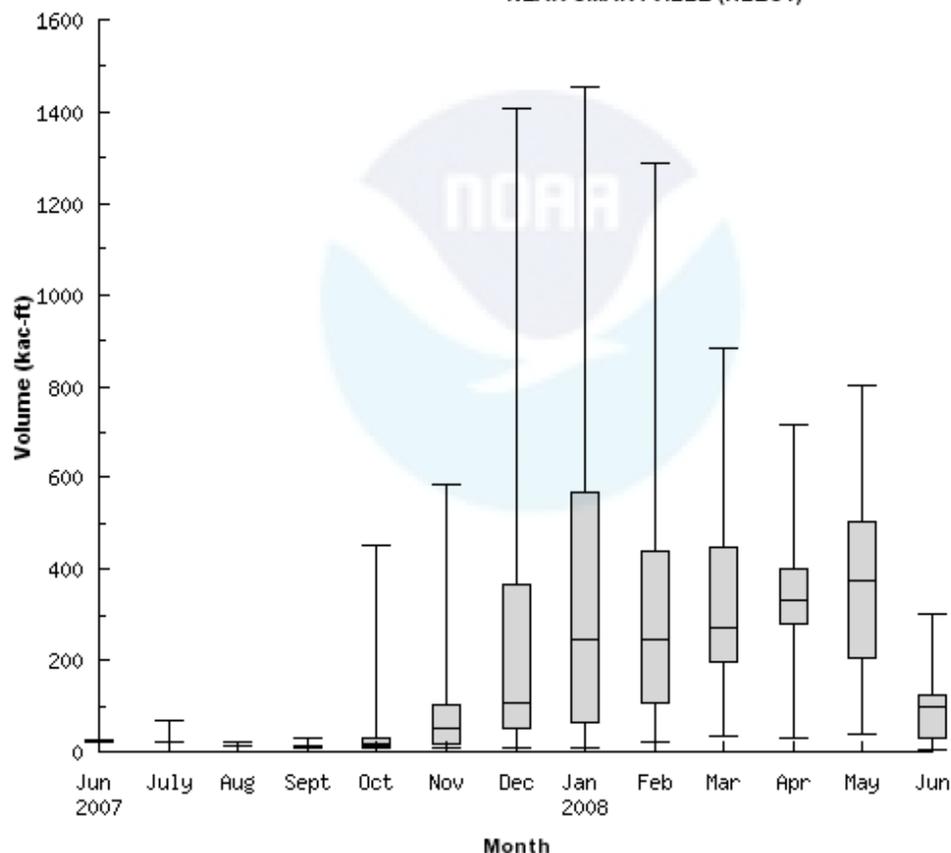
Location: Yuba at Near Smartville, California (HLEC1 - CNRFC)

[change location](#)

[clear location](#)

Ensemble Streamflow Prediction Forecasts

Monthly Streamflow Distribution from ESP Forecast
NEAR SMARTVILLE (HLEC1)



Monthly Ensemble
Jun 2007-Jun 2008

Options

Forecasts

Current Forecast

June 11, 2007

Forcing Year

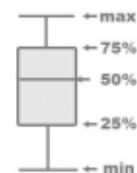
ENSO Conditional Forecast

Archives

Season Options

Graph Options

Disclaimer: ESP forecasts are not coordinated or manually checked by NWS forecasters. Official water supply forecasts are located on map. For questions on ESP usage, please contact the NWS.



Issued: June 11, 2007

About Ensemble Streamflow Prediction

Ensemble forecasts provide range of possible outcomes giving forecast users a measure of forecast uncertainty. Ensemble forecasts may be used to support decision support systems to quantitatively weigh forecast uncertainty against the potential risks and gains associated with decisions. Ensemble forecasts may also support contingency forecasts and qualitative demands for forecast confidence. The methodology

Site Options

Previous 5 Locations Viewed

HLEC1, KRMC2, LUC11, BFFU1, VCRC2

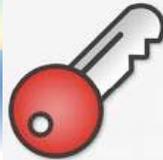
[Print Graph](#)

[Display Raw Data](#)





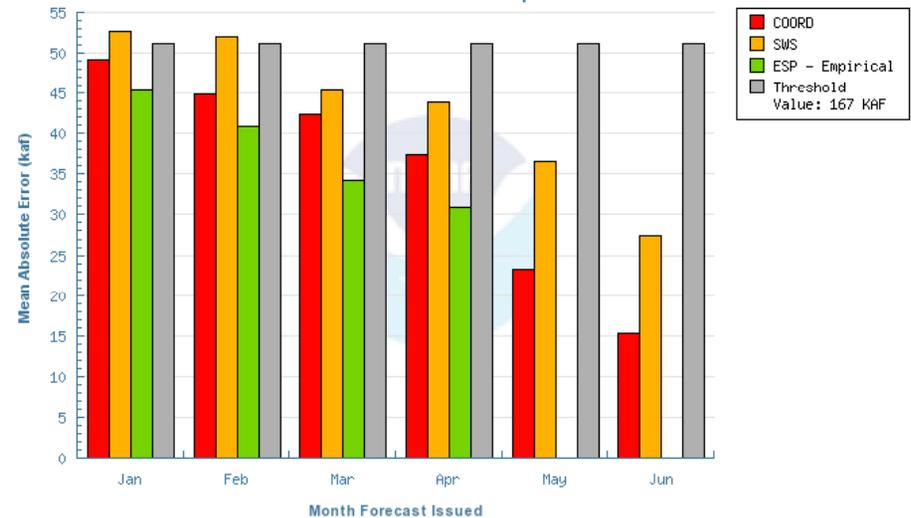
Key Verification Result #1:



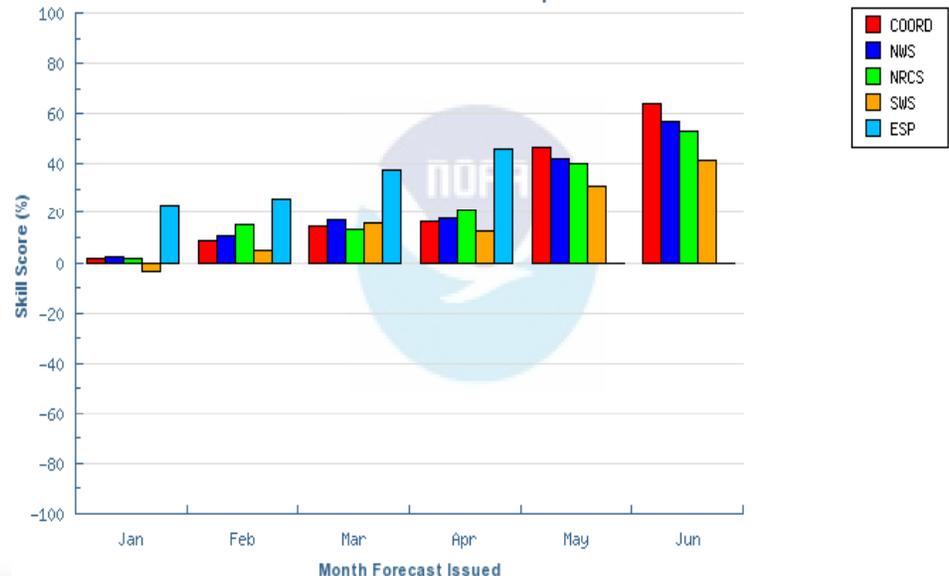
ESP generally outperforms
all other forecasts

- ESP reforecasts made over 1980-2005 with no forecaster intervention
- Compared to archived official forecasts and tools
- Suggests well calibrated continuous RFC models could be the foundation of water supply forecast system
- Important implications for future of water supply forecast process

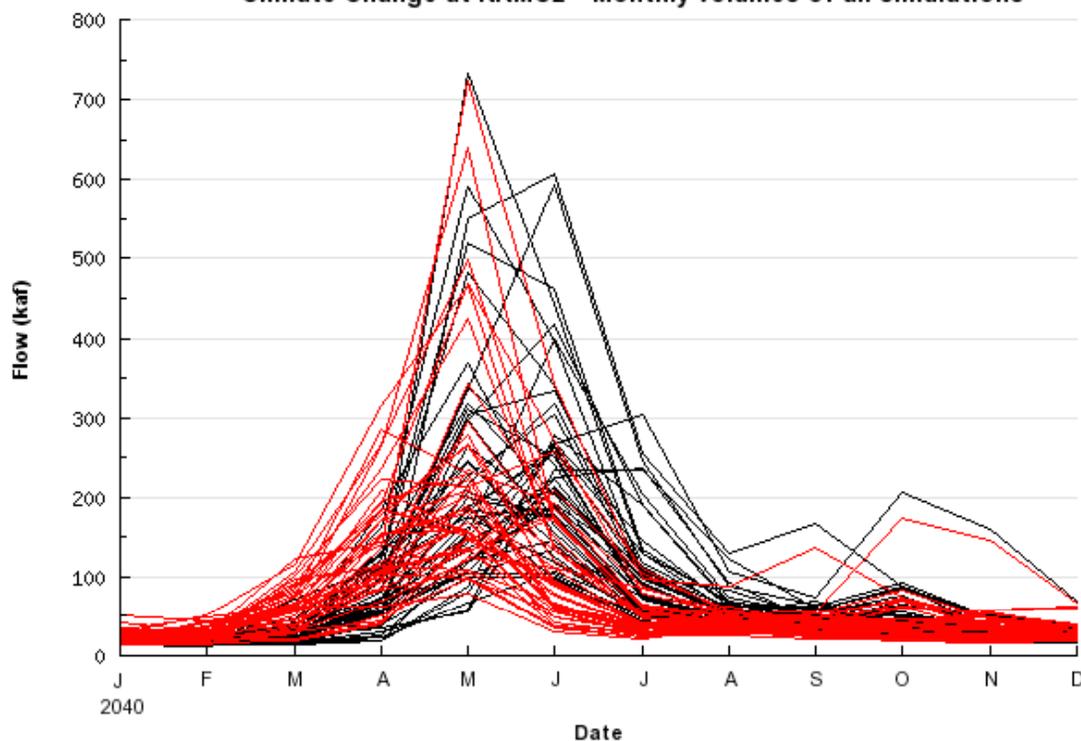
Mean Absolute Error - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



Root Mean Squared Error Skill Score Relative to Threshold - 167 KAF
BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



Climate Change at KRMC2 - Monthly volumes of all simulations



Options

Graph Options

Type:

Scenarios:

Start Year: End Year:

Scenario 1 Options

Scenario 2 Options

Display Graph

About Climate Scenarios

The NWS is testing the feasibility of generating climate change scenarios at select water supply forecast points. Climate change scenarios examine the sensitivity of streamflow to arbitrary perturbations to the temperature and/or precipitation time series in the NWS river forecast system. The baseline time series for temperature and precipitation are the those used to calibrate the NWS streamflow and snow models. Temperature perturbations are linear in time while precipitation perturbations are exponential in time. Scenarios are pre-generated but plots are customizable to examine any combination of scenarios requested by the user.

Scenarios are not intended to be predictions of future streamflow. Instead the scenarios show the impact of specific temperature or precipitation perturbations on the simulated hydrology of the selected basins. It is important to note that while the NWS model computes evapotranspiration at each model time step, it does not currently account for changes in potential evapotranspiration from changes in temperature. Basin scenarios are accessible by following the link on the pop up box that appears when you click on one of the points where scenarios are available.

Site Options

Previous 5 Locations Viewed

[KRMC2](#), [LUC1](#), [BFFU1](#), [VCRC2](#), [DIRC2](#)



Forecast and Observations Data Checkout

<u>Id</u>	<u>Shef</u>	<u>BW</u> <u>Month</u>	<u>EW</u> <u>Month</u>	<u>Cdate</u>	<u>Vdate</u>	<u>Source</u>	<u>Ftype</u>	<u>Dist</u>	<u>e95</u>	<u>e90</u>	<u>e</u>
DIRC2	QCSFAZZ	7	10	2004-01-02	2004-01-01	ESP	R	empirical	99.185	105.81	12
DIRC2	QCMFAZZ	7	10	2004-01-01	2004-01-01	COORD	F		0	205	
DIRC2	QCSFAZZ	7	10	2004-02-02	2004-02-01	ESP	R	empirical	101.632	107.926	11
DIRC2	QCMFAZZ	7	10	2004-02-01	2004-02-01	COORD	F		0	191	
DIRC2	QCSFAZZ	7	10	2004-03-02	2004-03-01	ESP	R	empirical	98.869	104.091	11
DIRC2	QCMFAZZ	7	10	2004-03-01	2004-03-01	COORD	F		0	179	
DIRC2	QCMFAZZ	7	10	2004-06-01	2004-04-01	NWS	O				
DIRC2	QCMFAZZ	7	10	2004-06-01	2004-04-01	SWS	O				
DIRC2	QCMFAZZ	7	10	2004-05-01	2004-04-01	SWS	O				
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP2	R	normal	122.70984	116.46977	106
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP5	R	logweibull	116.64248	110.89159	101
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP3	R	lognormal	120.46293	113.84177	103
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP7	R	loglogisti	305.29809	218.47962	145
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP1	R	empirical	147.97944	108.45392	98.
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP6	R	weibull	116.82679	111.07505	101
DIRC2	QCSFAZZ	8	10	2004-05-01	2004-04-01	ESP4	R	wakeby	142.54127	116.06455	96.

Options

Data Type

Monthly Observed Streamflow

Seasonal Characteristics

Seasonal Forecast

ESP Forecasts

Monthly Observed Means

Climate Indices

Time Constraints

Output



USGS Home
Contact USGS
Search USGS

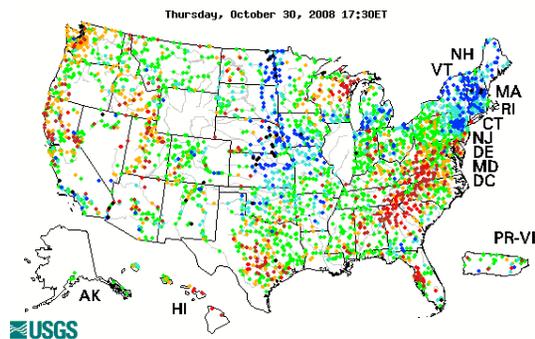
WaterWatch -- Current Water Resources Conditions

Current Maps/Graphs: Flood Watch: Drought Watch: Recent/Historical Maps/Graphs: Search WaterWatch:

Map: United States **Special Features** Contents Additional Information:

WaterWatch -- Current water resources conditions

Map of real-time streamflow compared to historical streamflow for the day of the year (United States)

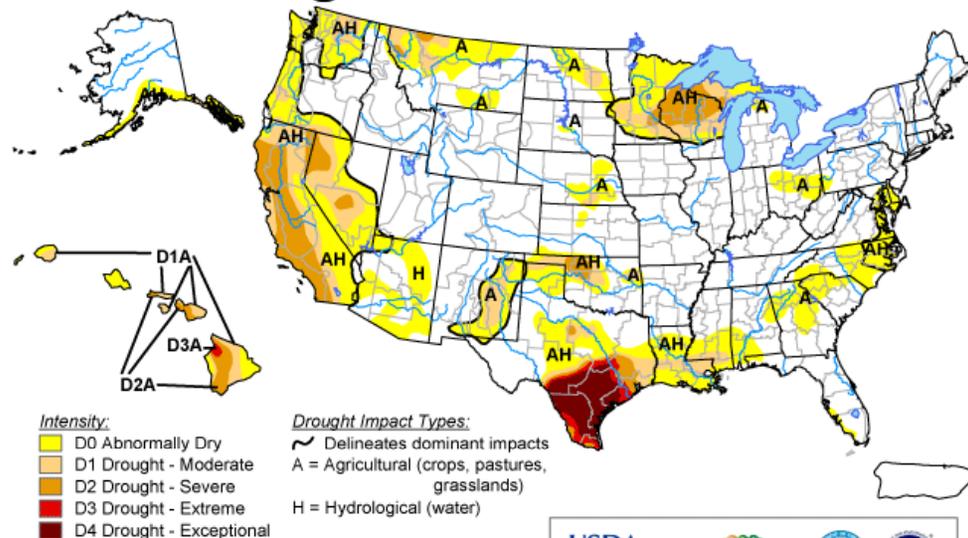


Choose a data retrieval option and select a location on the map
 List of all stations in state, State map, or Nearest stations

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

U.S. Drought Monitor

July 28, 2009
Valid 8 a.m. EDT



Intensity:
 D0 Abnormally Dry
 D1 Drought - Moderate
 D2 Drought - Severe
 D3 Drought - Extreme
 D4 Drought - Exceptional

Drought Impact Types:
 Delineates dominant impacts
 A = Agricultural (crops, pastures, grasslands)
 H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://drought.unl.edu/dm>



Released Thursday, July 30, 2009

Author: Mark Svoboda, National Drought Mitigation Center

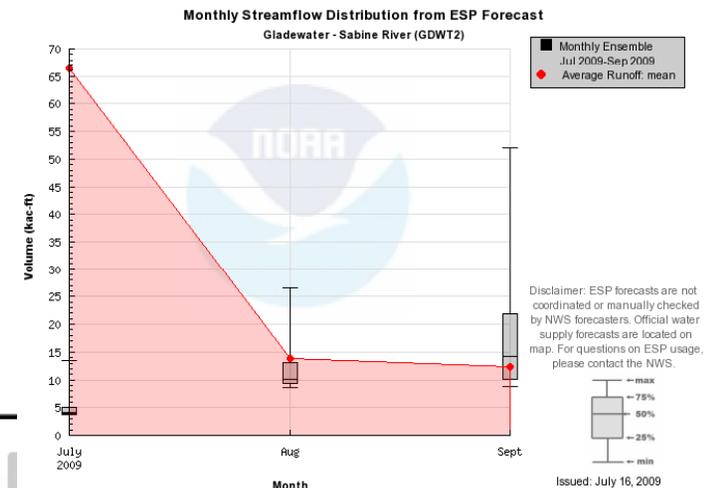
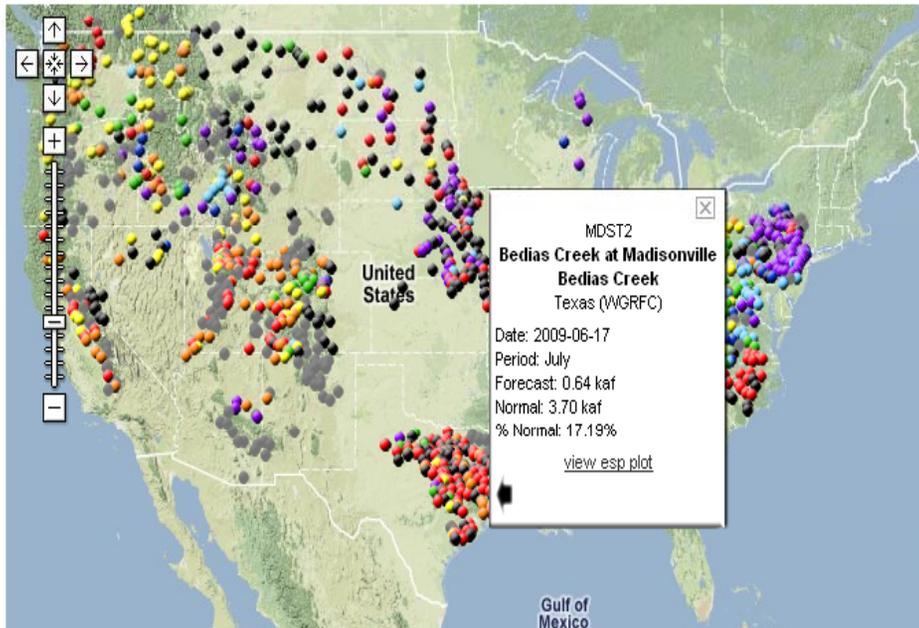


Current Status: National Water Resources Outlook

Tools Available:

-  Ensemble Forecasts
-  Data Access

Water Resource Outlook Map



Map Display

Water Supply Forecast

Water Resources Outlook

August

Monthly 'Observed' Streamflow

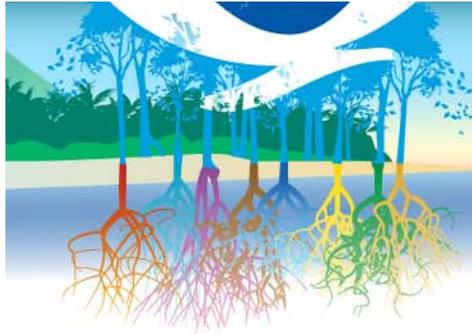
Climate Change Scenarios

Map Options

Legend

- > 150% of Average
- 130% - 150% of Average
- 110% - 130% of Average
- 90% - 110% of Average
- 70% - 90% of Average
- 50% - 70% of Average
- < 50% of Average
- No Average
- No Forecast Available

Future Plans (from July 09 organizing meeting)



- 1. Web Development –** Building “version 4” to address performance issues and simplify first level pages.
- 2. User Interactions –** Partnering with CLIMAS and WWA to develop a “social science toolkit” to systematically collect user feedback. Proposed testing in CO during 2010 and possibly SERFC following.
- 3. Institutional Support –** Working with NWS OSIP process to identify long term maintenance and support.

The screenshot shows the National Weather Service Water Resources Outlook website. The header includes the NWS logo and navigation links: hydro maps, point forecasts, about, data apis, and documentation. The main content area features a text block about the importance of water supply predictions, a search box for water supply points, and a news section with bullet points. A map of the United States is displayed on the right, with state abbreviations and a search overlay. The footer contains four columns of links: Hydro Maps, Point Forecasts, Search for a Water Supply Point, and Legal. The version number 'VERSION 4.0 RELEASE BETA' is also visible.

Water Resources Outlook hydro maps point forecasts about data apis documentation

Predictions of water supply are important for making decisions on water management, recreation, and natural hazards. The tool set provided in this suite of applications provides access to National Weather Service predictions and historical data to assist in making these important decisions.

Search for a Water Supply Point

Enter a Location, River, or ID

Water Resources Outlook News

- Water Resources Outlook v3 now released!
- June 2009 observations have now been added for select points
- Mid-month forecast has been issued by four (4) RFCs
- We are now soliciting feedback on the new website design and functionality

HYDRO MAPS
Water Supply Map
Water Resources Map
Observed Flow Map
Climate Variability Map

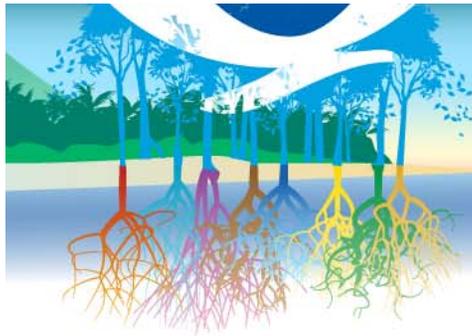
POINT FORECASTS
Forecast Evolution
Ensemble Streamflow
Forecast Verification
Climate Variability

SEARCH FOR A WATER SUPPLY POINT

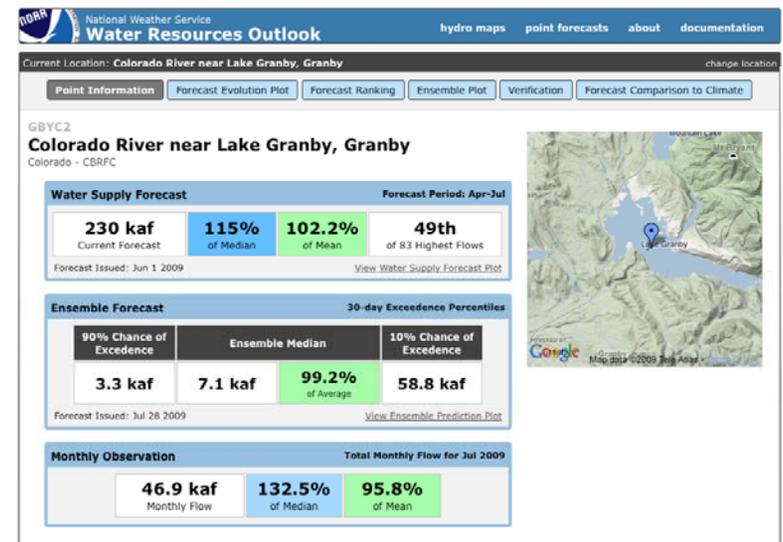
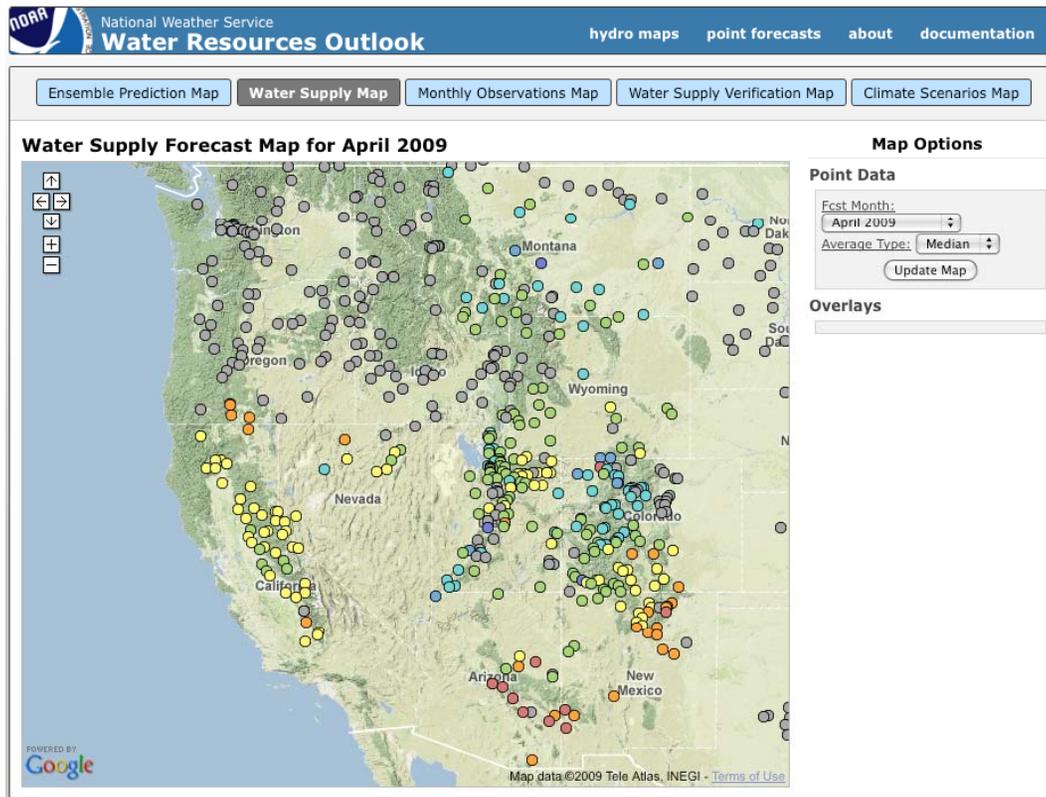
LEGAL
Disclaimer
Information Quality
Credits
Glossary
Privacy Policy
Freedom of Information Act
About Us
Career Opportunities

United States Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
1325 East West Highway
Silver Spring, MD 20910

VERSION 4.0 RELEASE BETA



Coming Soon: Version 4

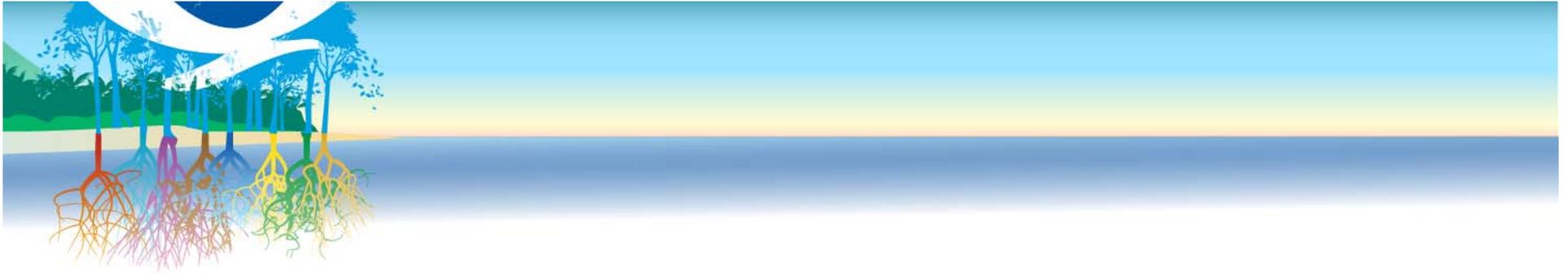


Improved performance

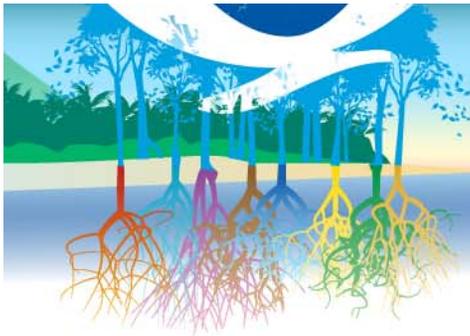
Improved visualization

Web services

GIS

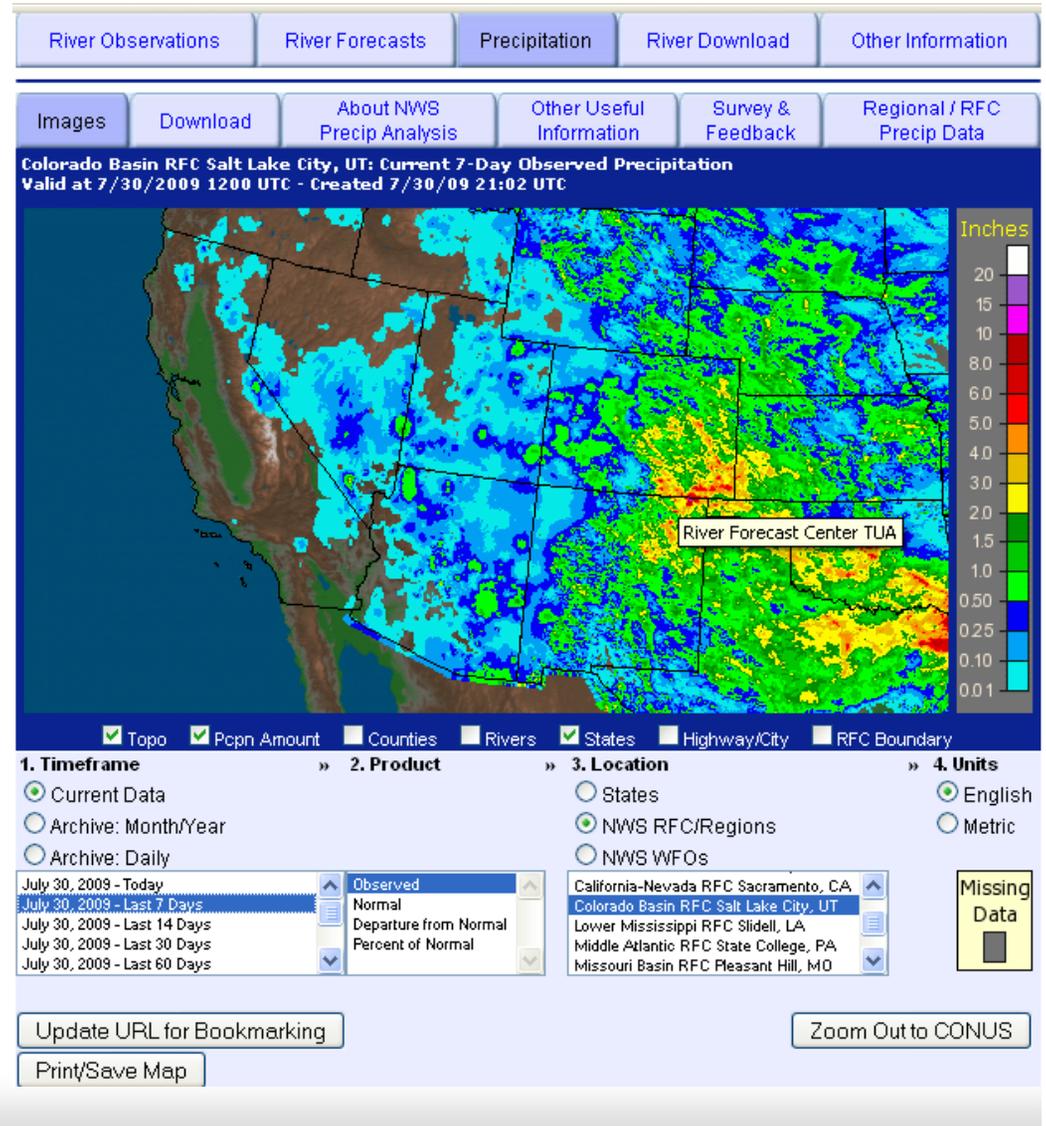


Tangent: Other RFC – Drought Related Products



Precipitation

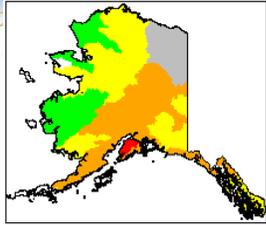
- High quality precipitation **analyses** and forecasts are key to RFC operations
- RFC staff quality control precipitation from gauge reports and radar and satellite estimates.
- Precipitation estimates for specific locations, spatially gridded, and basin averages are produced hourly to monthly.
- Weather and climate **forecasts** are also used in the forecast process



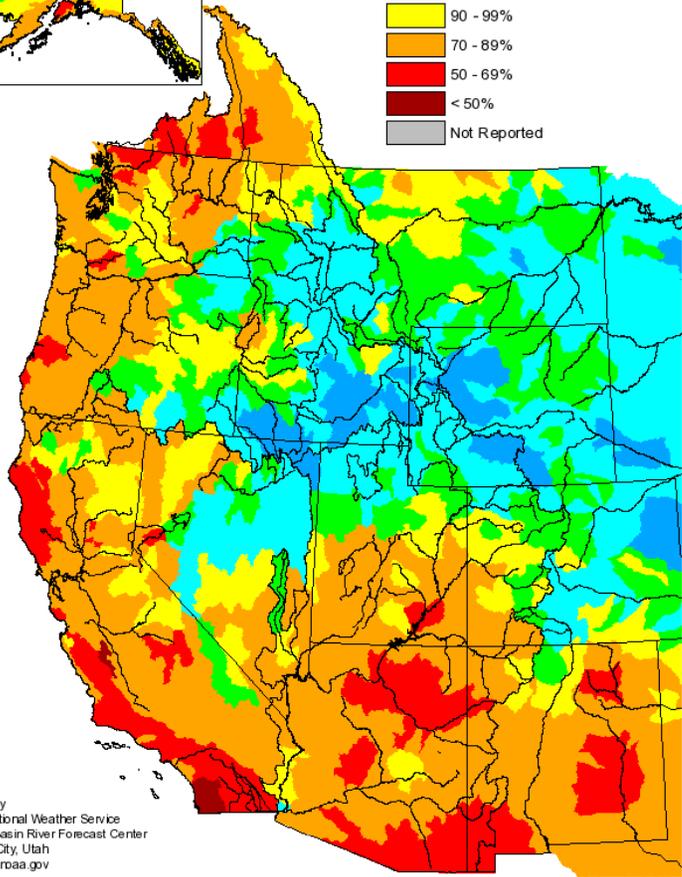
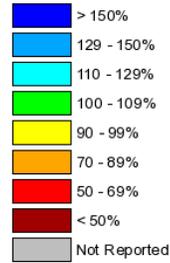


Seasonal Precipitation, October 2008 - August 2009

(Averaged by Hydrologic Unit)



% Average



Prepared by
NOAA, National Weather Service
Colorado Basin River Forecast Center
Salt Lake City, Utah
www.cbrfc.noaa.gov

Source: www.cbrfc.noaa.gov



[River Observations](#) |
 [River Forecasts](#) |
 [Precipitation](#) |
 [River Download](#) |
 [Other Information](#)

[Images](#) |
 [Download](#) |
 [About NWS Precip Analysis](#) |
 [Other Useful Information](#) |
 [Survey & Feedback](#) |
 [Regional/RFC Precip Data](#)

Colorado Basin RFC Salt Lake City, UT: June, 2009 Monthly Percent of Normal Precipitation
 Valid at 7/1/2009 1200 UTC - Created 7/1/09 22:48 UTC

Source: water.weather.gov



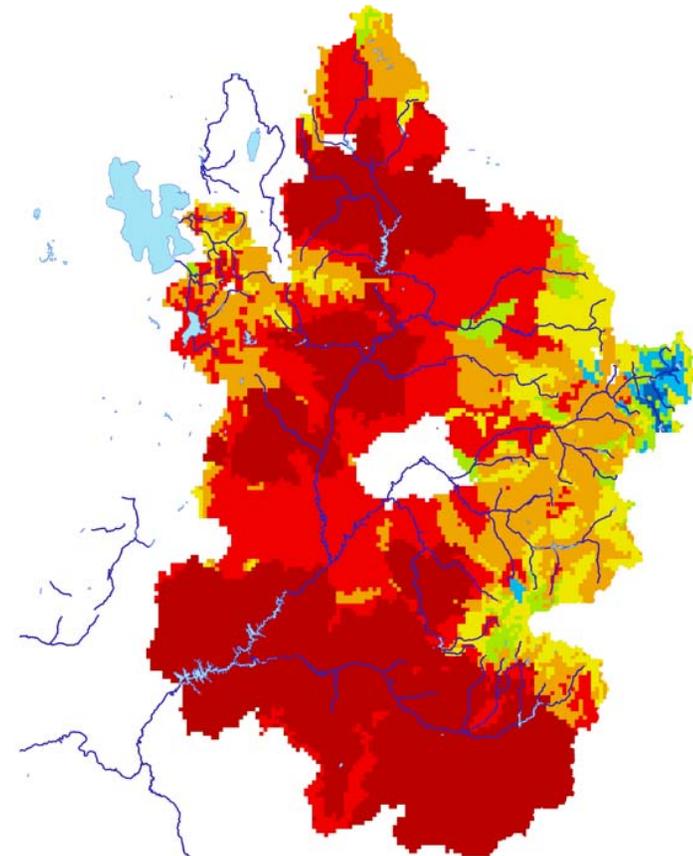
Soil Moisture

Soil moisture and snow states initialize hydrologic models

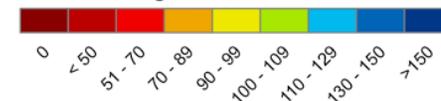
RFCs continually adjust simulated model states to force models to match observed streamflow

Traditional RFC models are basin scale. However, new generation of models is spatially gridded

*Upper Colorado
NWSRFS Modeled Lower Zone Soil Moisture*



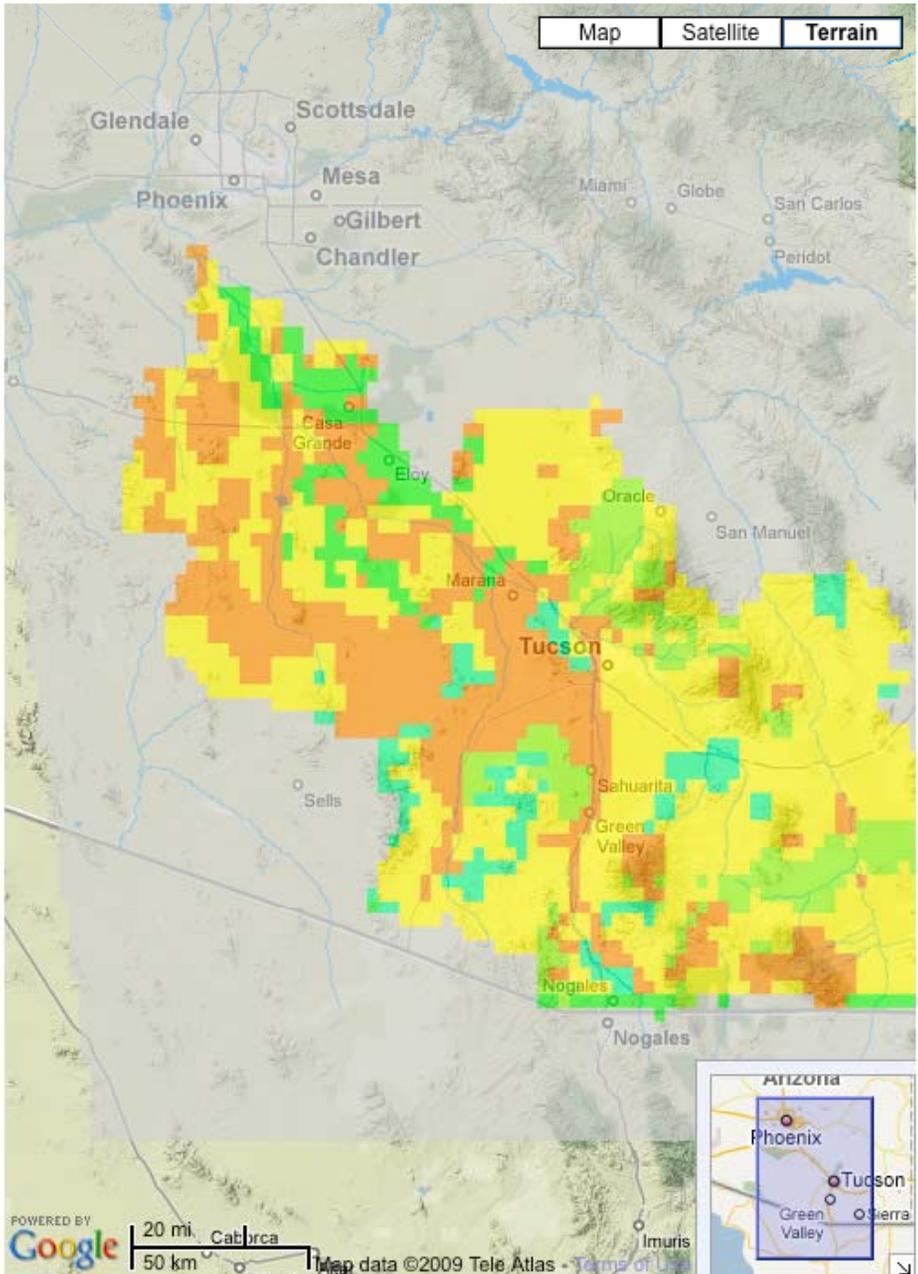
Percent of Avg Nov 1, 2008



CBRFC Grids

Zoom Level: 200km 50km 20km 10km 2km 1km 0.5km 0.2km

Map Satellite Terrain



Data Types

River Snow Water Supply Grids Overlays
 Allow Multiple Data Types

Grid Type

- None
- Precipitation
- Soil Moisture
- Discharge Response
- Surface Response

Choose Date: 1/22/2009

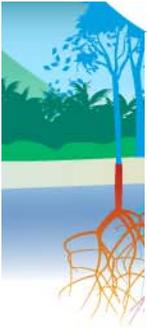
Month:

Day:

Depth: 5 cm

Fractional Water Content

-
-
-
-
-
-
-



POWERED BY Google

20 mi. 50 km

Map data ©2009 Tele Atlas



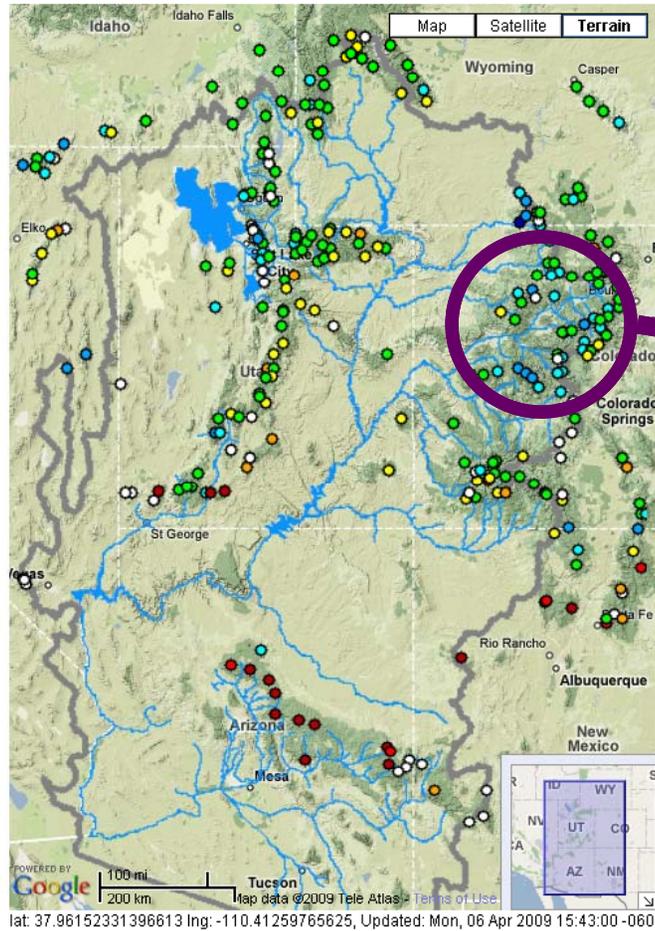
Source: www.cbrfc.noaa.gov



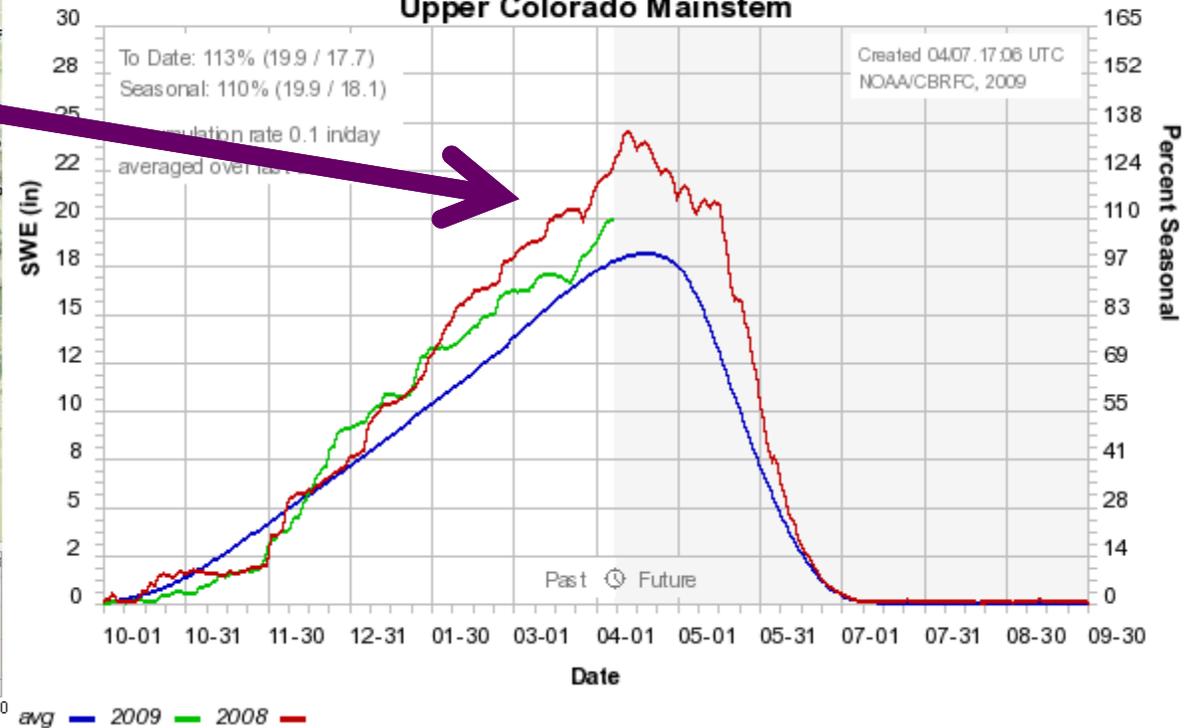
Snow

CBRFC Snow Conditions

Zoom Level: 200km 50km 20km 10km 2km 1km 0.5km 0.2km



Colorado Basin River Forecast Center Upper Colorado Mainstem



April 7th

Currently snow falls between average and 2008.

Web Reference:

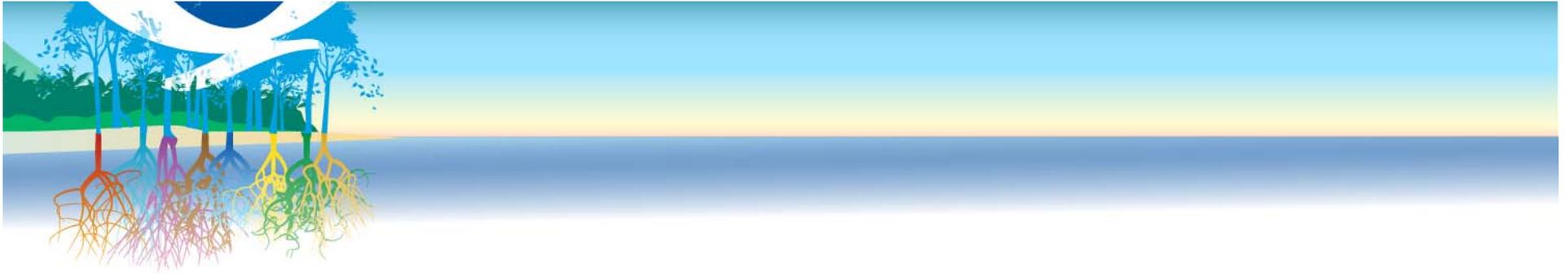
<http://www.cbrfc.noaa.gov/snow/station/sweplot/sweplot.cgi?BLSC2+WLLC2+LKIC2+PHTC2+SCSC2+AROC2+BTSC2+HOOC2+CPMC2+SUMC2+FMTSC2+VLMC2+IVHC2+KLNC2>IDPC2+SOSC2+NLSC2+MESC2-Upper+Colorado+Mainstem?avg.2009.2008>





Closing Thoughts

- River Forecast Centers (RFCs) provide **objective** forecast and guidance products for streamflow (and precipitation, snow, soil moisture) across many lead times
- RFCs in the western United States also provide seasonal water supply forecasts
- RFC interactions with and relevance to drought problems increasing



Kevin Werner

CBRFC Service Coordination Hydrologist

Phone: 801.524.5130

Email: kevin.werner@noaa.gov

