

# NOAA's National Weather Service

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## *The Colorado River Basin Drought*

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***Michelle Stokes***

*Hydrologist In Charge  
Colorado Basin River Forecast Center*

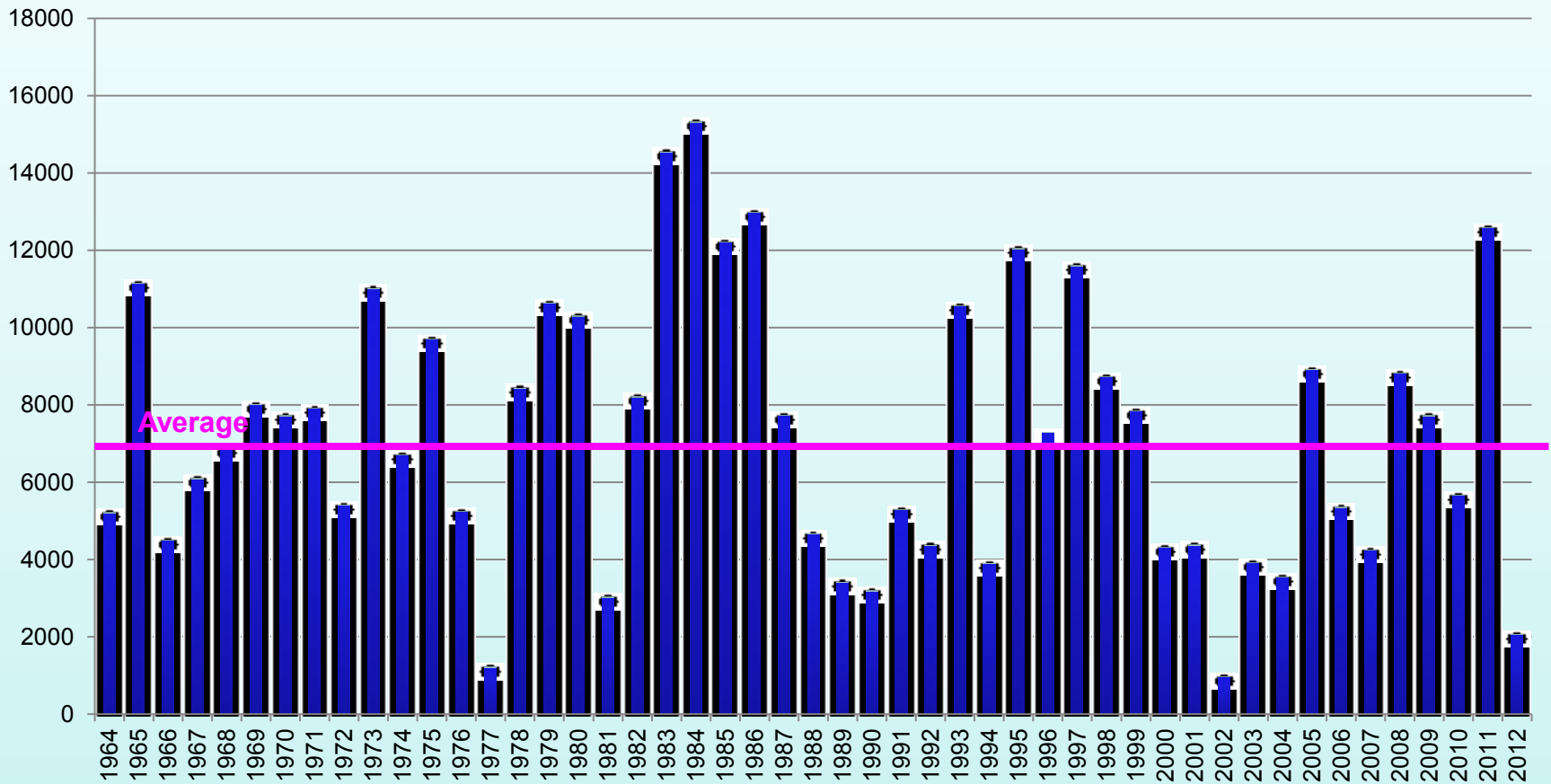
*April 29, 2013*

# Overview

- *Recent History*
- *Water Supply Forecasts for 2013- 2014*
- *Beyond 2014...*
- *Incorporating climate information into water supply forecasts*

# Lake Powell Inflows

Lake Powell April-July Inflow (kaf)

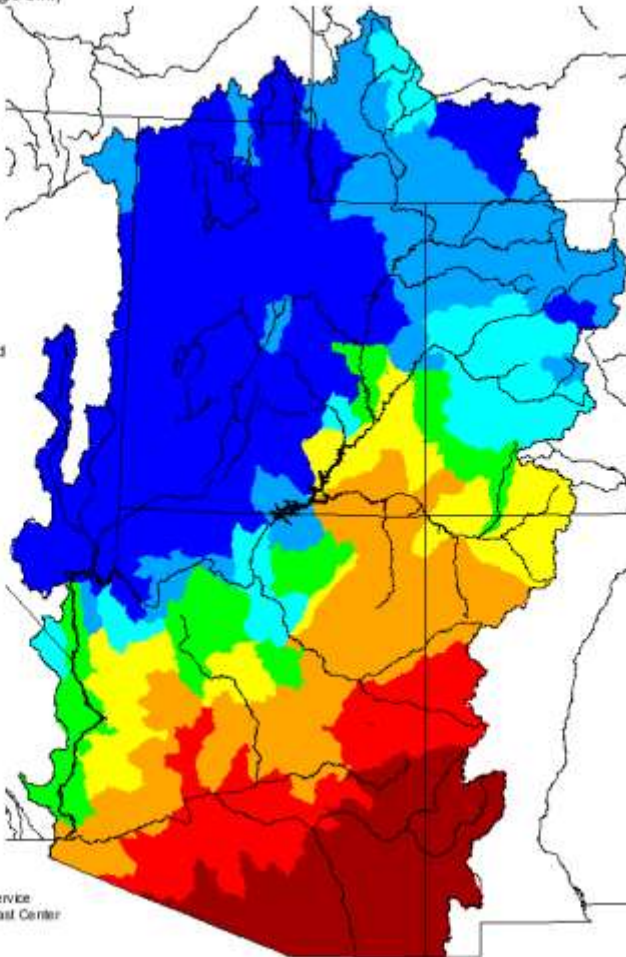
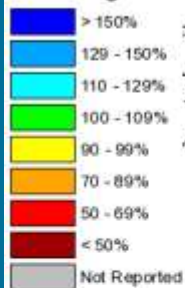


# Very wet to very dry year...

Seasonal Precipitation, October 2010 - May 2011

(Averaged by Hydrologic Unit)

% Average

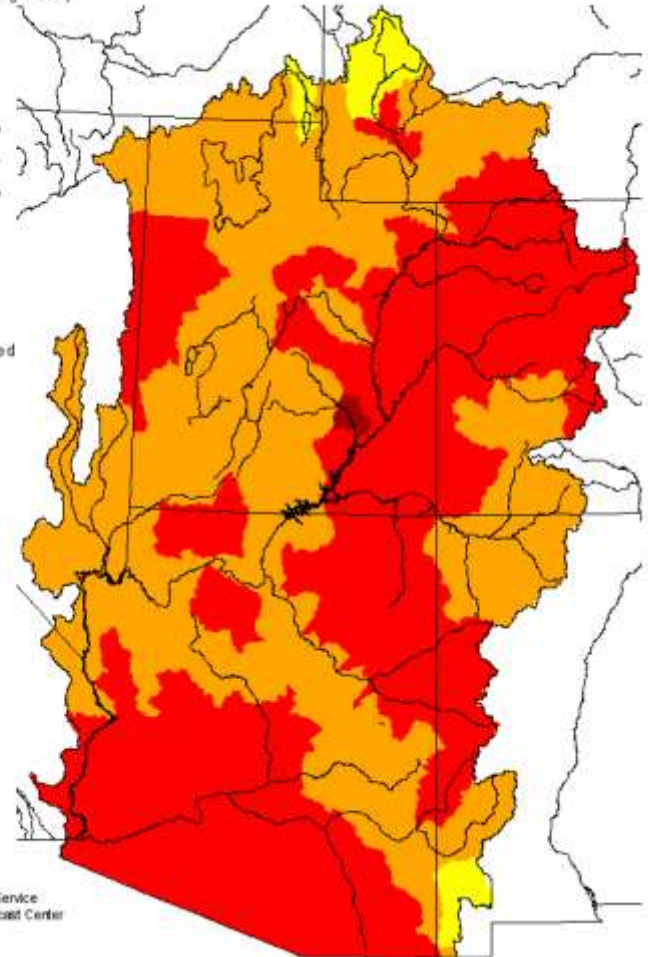
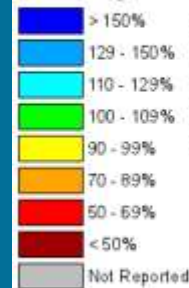


Prepared by  
NOAA, National Weather Service  
Colorado Basin River Forecast Center  
Salt Lake City, Utah  
[www.cbrfc.noaa.gov](http://www.cbrfc.noaa.gov)

Seasonal Precipitation, October 2011 - May 2012

(Averaged by Hydrologic Unit)

% Average



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# Current Drought

## U.S. Drought Monitor West

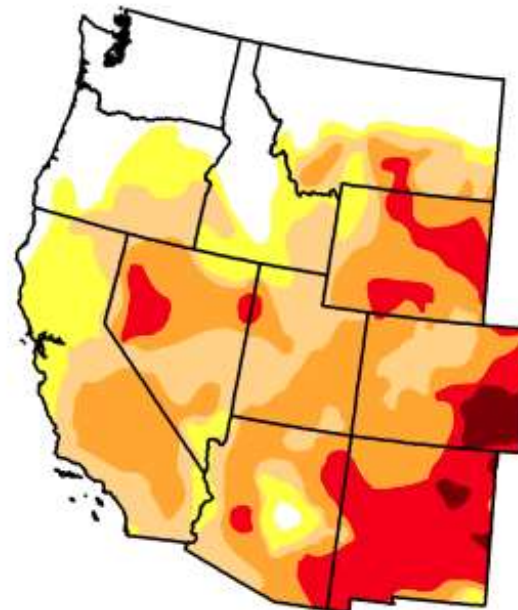
April 23, 2013

Valid 7 a.m. EST

|                                               | Drought Conditions (Percent Area) |       |       |       |       |      |
|-----------------------------------------------|-----------------------------------|-------|-------|-------|-------|------|
|                                               | None                              | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4   |
| Current                                       | 20.28                             | 79.72 | 66.00 | 43.41 | 16.10 | 1.87 |
| Last Week<br>(04/16/2013 map)                 | 19.84                             | 80.16 | 63.67 | 41.05 | 14.73 | 1.64 |
| 3 Months Ago<br>(01/22/2013 map)              | 22.60                             | 77.40 | 68.24 | 44.51 | 17.27 | 2.15 |
| Start of<br>Calendar Year<br>(01/01/2013 map) | 24.39                             | 75.61 | 69.31 | 45.04 | 18.01 | 2.15 |
| Start of<br>Water Year<br>(09/25/2012 map)    | 15.12                             | 84.88 | 77.15 | 43.65 | 16.85 | 1.77 |
| One Year Ago<br>(04/17/2012 map)              | 32.80                             | 67.20 | 46.92 | 24.14 | 3.77  | 0.91 |

### Intensity:

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



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

<http://droughtmonitor.unl.edu>



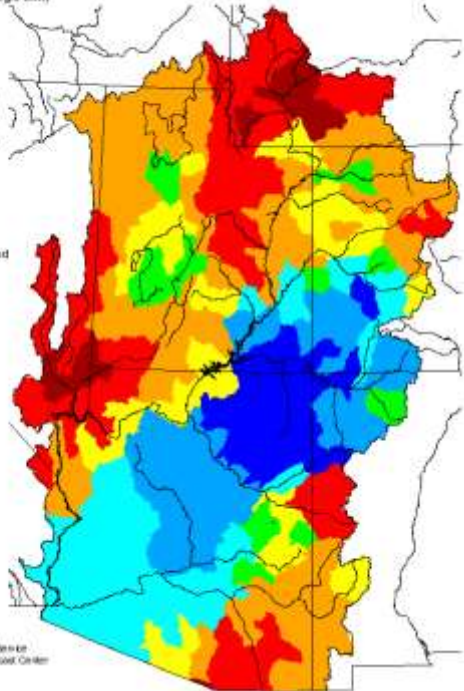
Released Thursday, April 25, 2013  
Eric Luebehusen, U.S. Department of Agriculture

# 2013 Precipitation

Monthly Precipitation for January 2013

(Averaged by Hydrologic Unit)

% Average

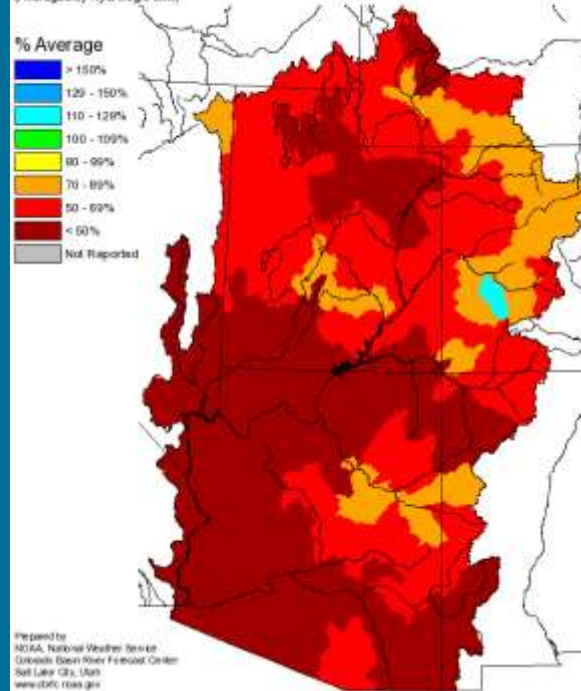


Prepared by:  
NOAA, National Weather Service  
Colorado Basin River Forecast Center  
Salt Lake City, Utah  
www.cbrfc.noaa.gov

Monthly Precipitation for February 2013

(Averaged by Hydrologic Unit)

% Average

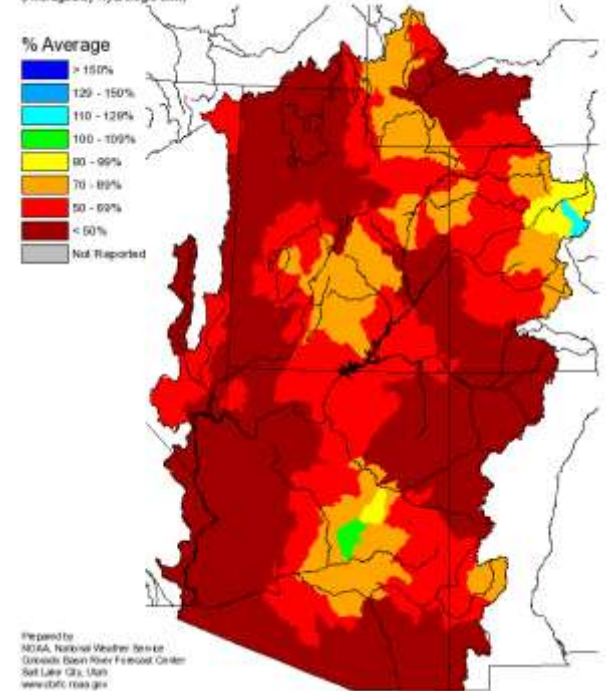


Prepared by:  
NOAA, National Weather Service  
Colorado Basin River Forecast Center  
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www.cbrfc.noaa.gov

Monthly Precipitation for March 2013

(Averaged by Hydrologic Unit)

% Average

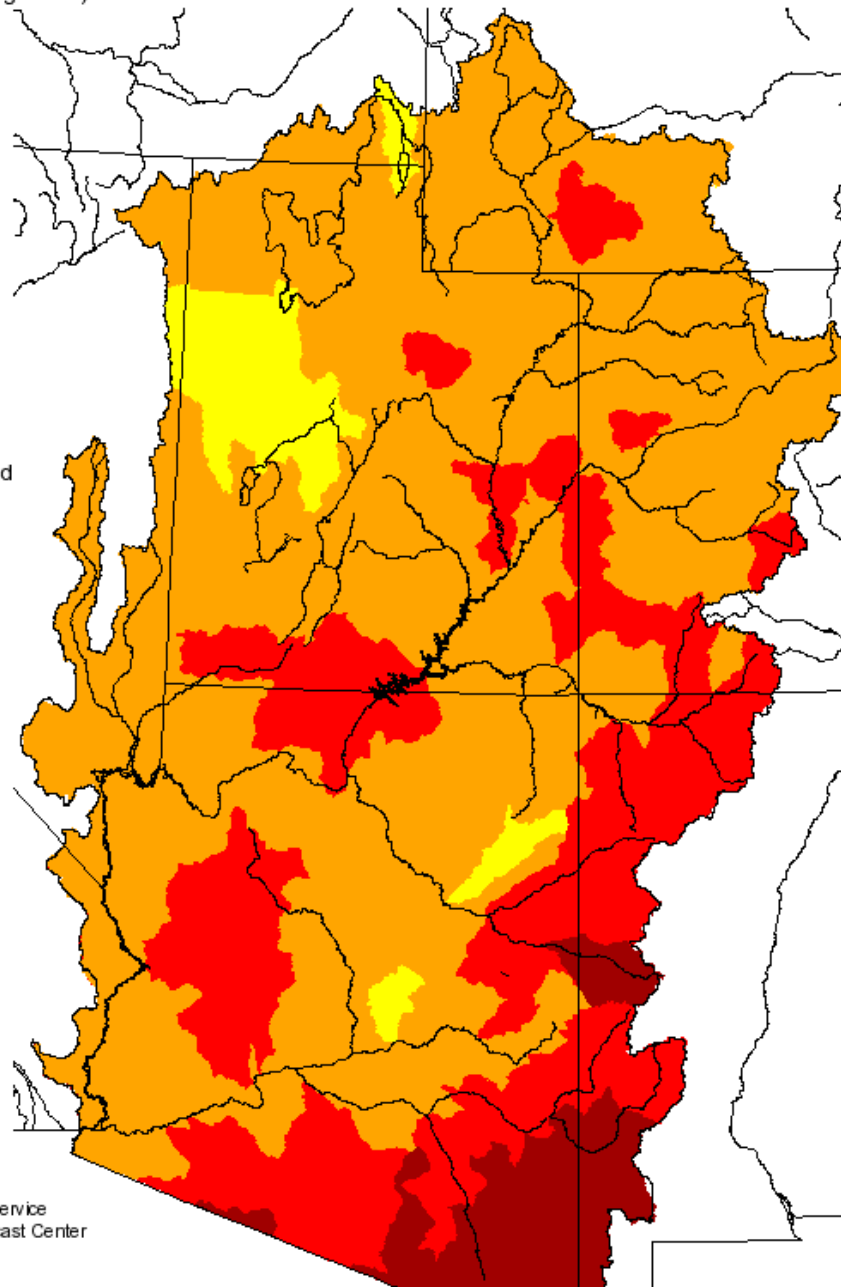
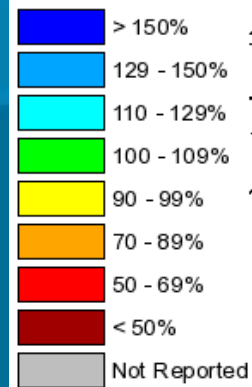


Prepared by:  
NOAA, National Weather Service  
Colorado Basin River Forecast Center  
Salt Lake City, Utah  
www.cbrfc.noaa.gov

# Seasonal Precipitation, October 2012 - March 2013

(Averaged by Hydrologic Unit)

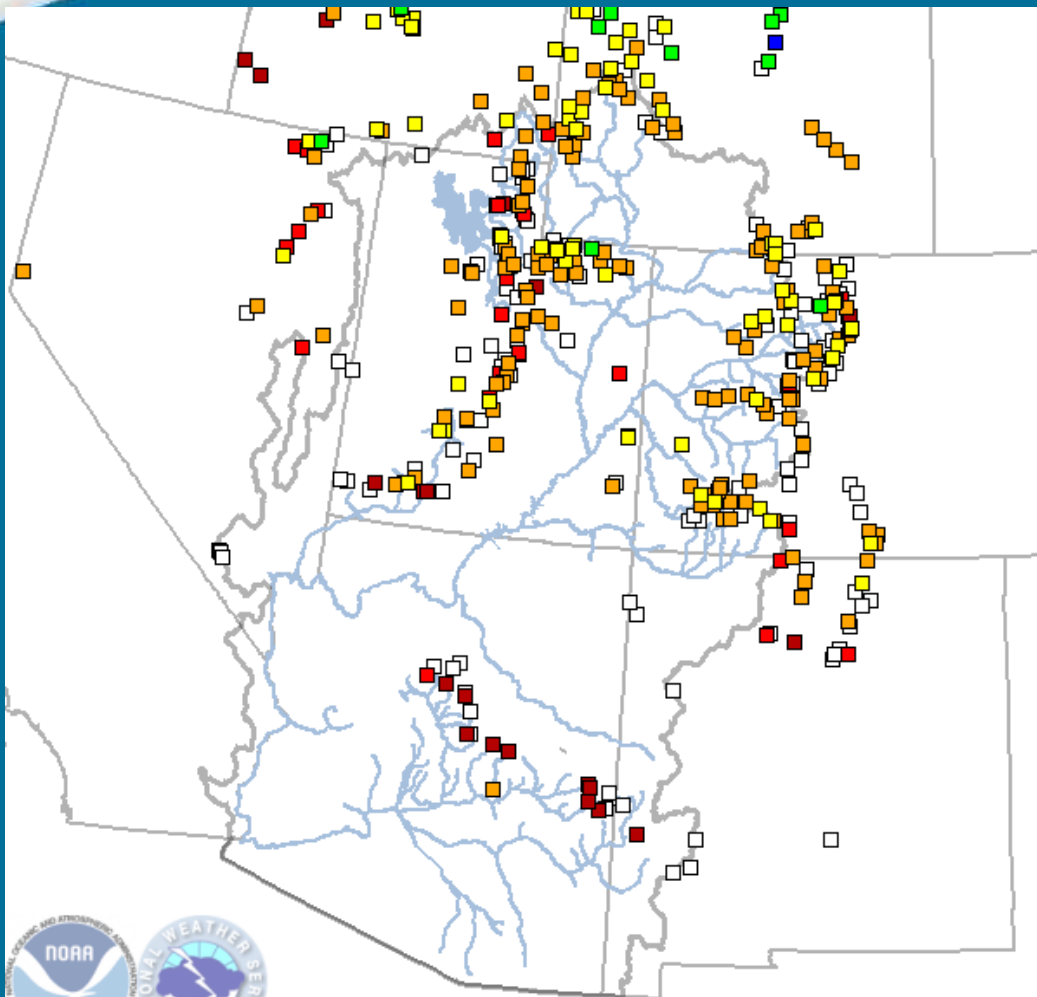
## % Average



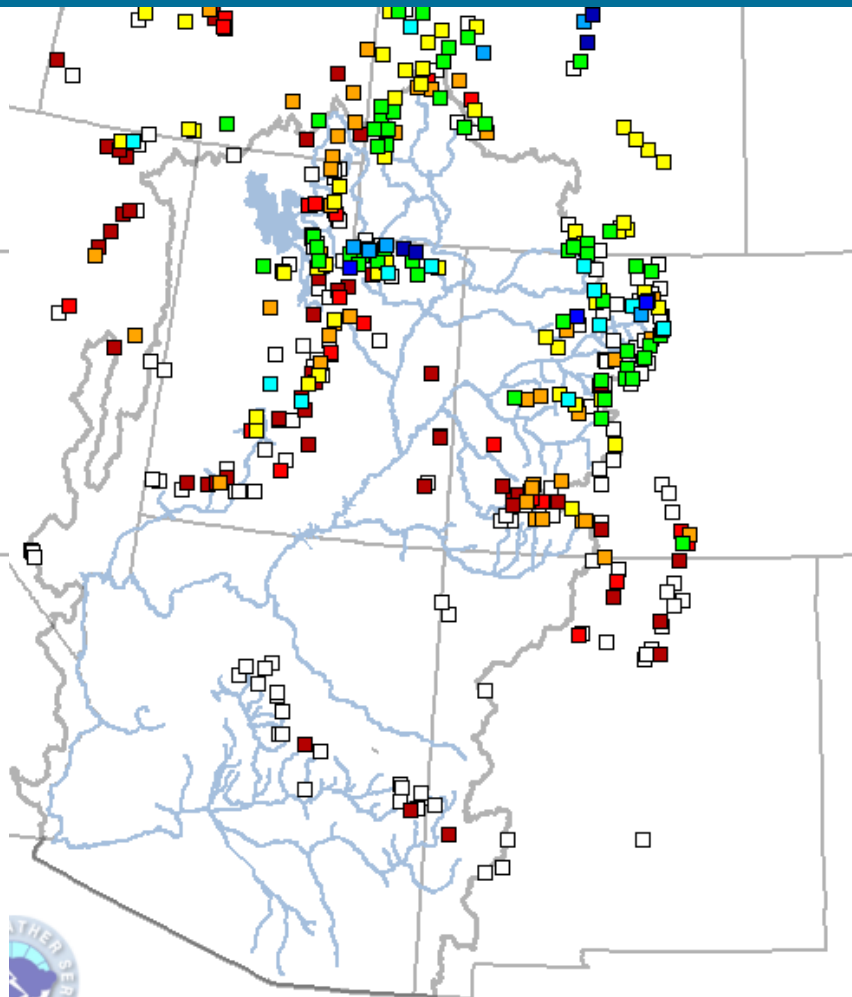
Prepared by  
NOAA, National Weather Service  
Colorado Basin River Forecast Center  
Salt Lake City, Utah  
[www.cbfc.noaa.gov](http://www.cbfc.noaa.gov)

# And then came April...

**Snow Point Classification:** ○ Percentiles ⊙ Percent Average ○ Percent Median  
□ NA ■ < 25% ■ 25-50% ■ 50-75% ■ 75-90% ■ 90-110% ■ 110-125% ■ 125-150% ■ 150-175% ■ >175%



Created: April 1, 2013, 14:30

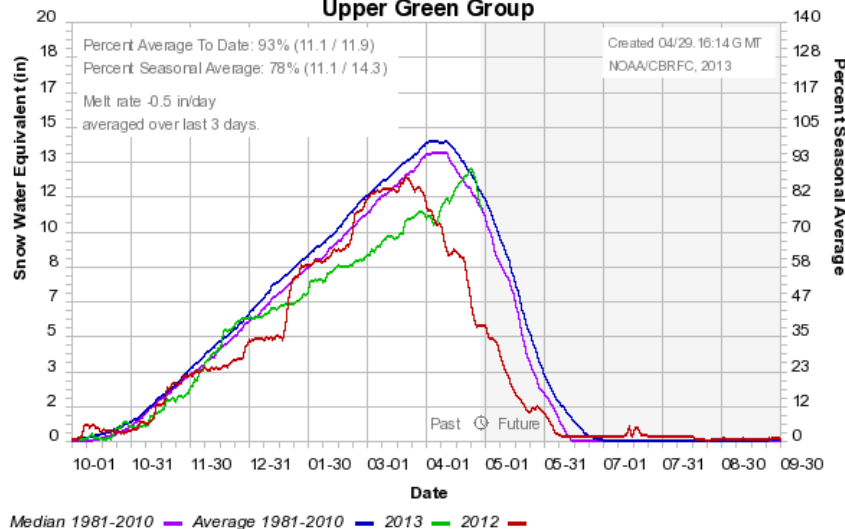


Created: April 29, 2013, 10:45

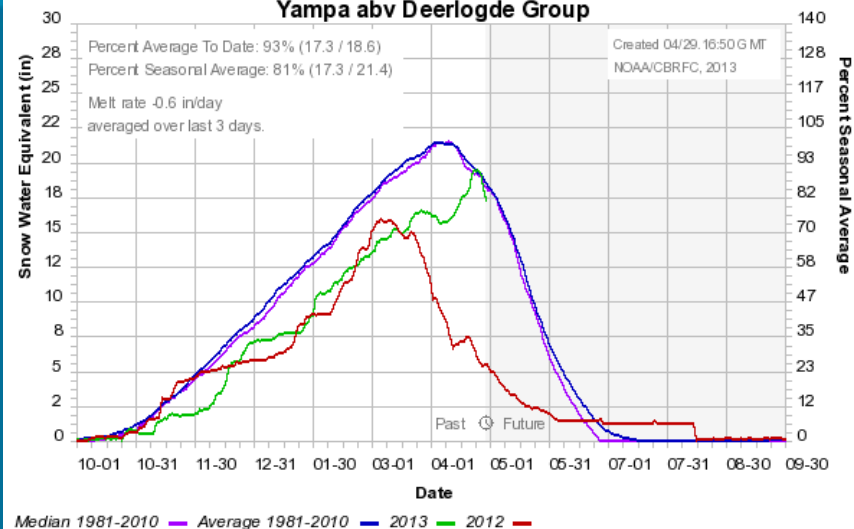


# SNOTEL

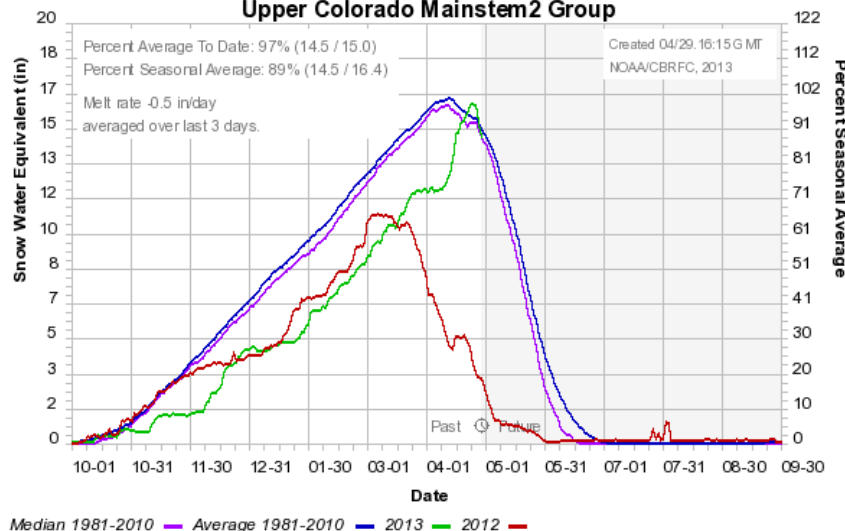
Colorado Basin River Forecast Center  
Upper Green Group



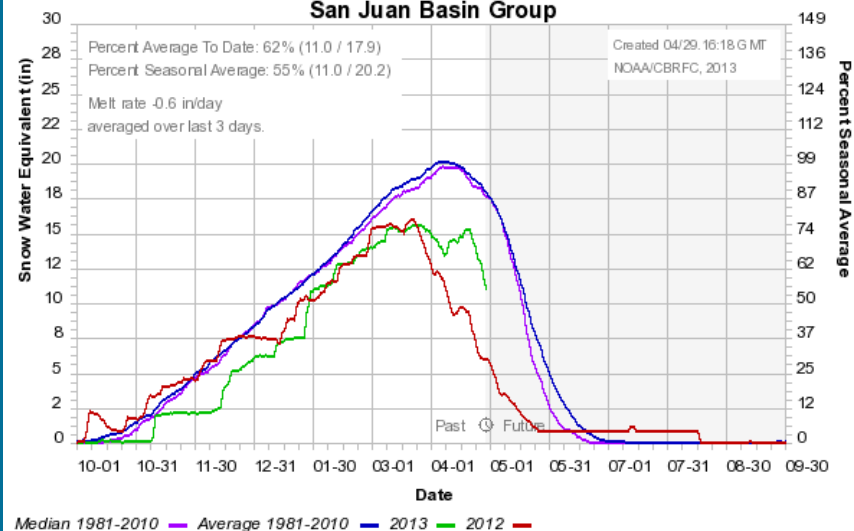
Colorado Basin River Forecast Center  
Yampa abv Deerlogde Group



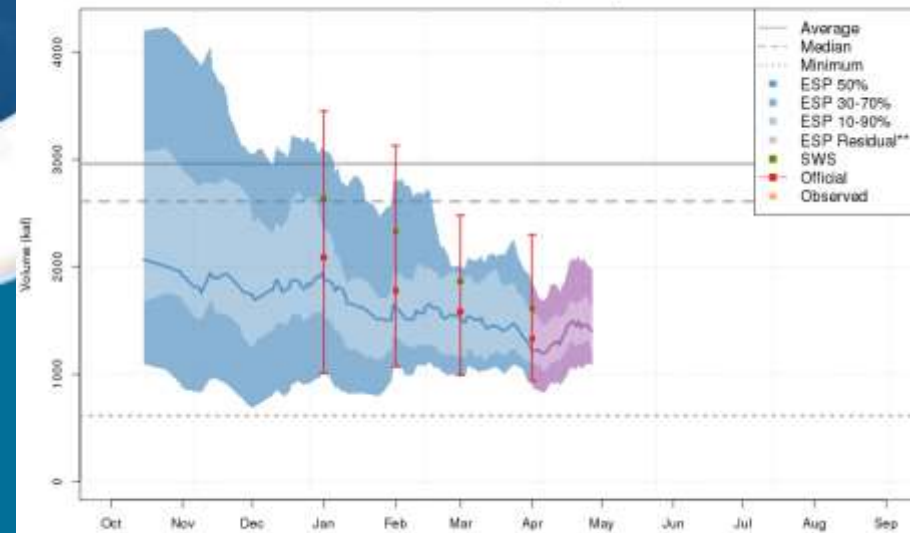
Colorado Basin River Forecast Center  
Upper Colorado Mainstem2 Group



Colorado Basin River Forecast Center  
San Juan Basin Group

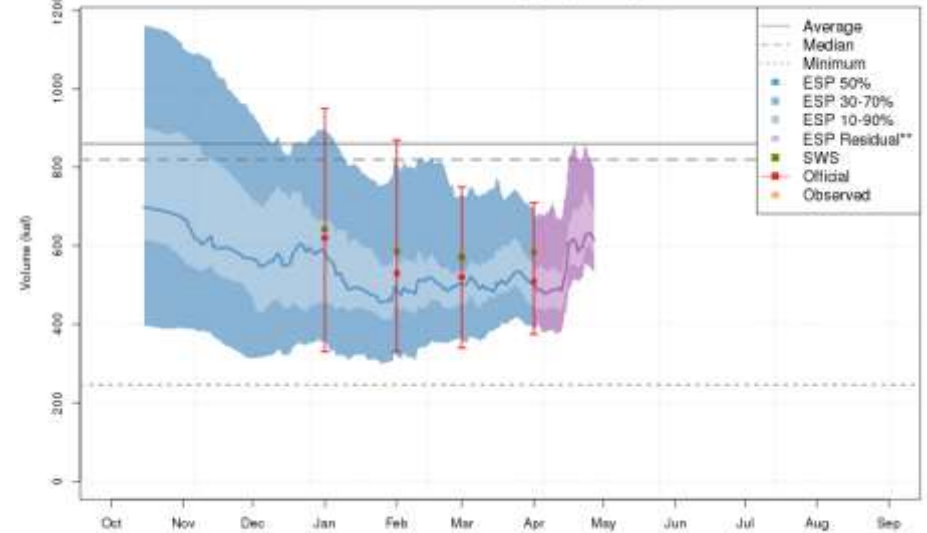


**2013 Runoff Forecast Apr-Jul**  
Green - Green River- Ut (GRVU1)



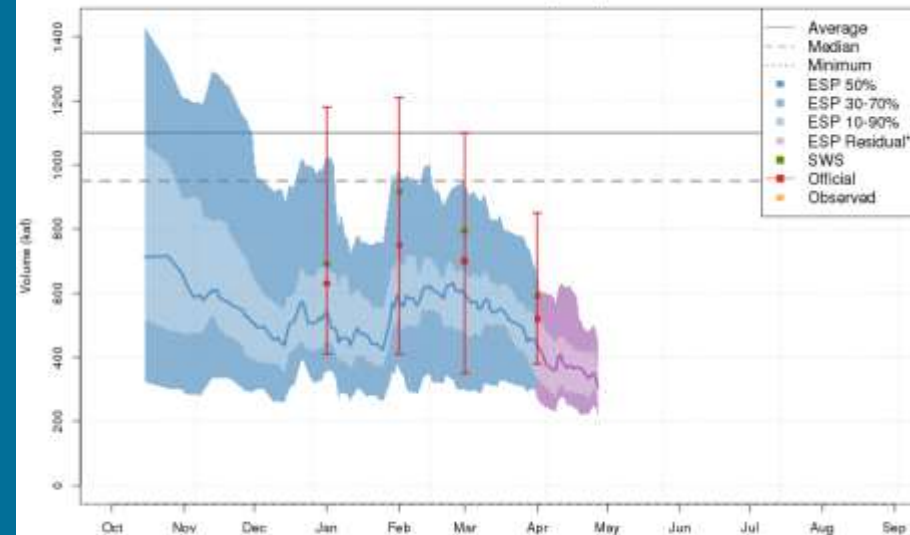
Plot Created 2013-04-28 15:44:45, Latest ESP Run from 2013-04-01, CBRFC / NWS / NOAA  
Maximum of 8798.8 in 1917, Minimum of 613.7 in 1934, Average/Median for 1981-2010:  
\*\*No residual observations available, ESP Residual is not total runoff.

**2013 Runoff Forecast Apr-Jul**  
Colorado - Kremmling- Nr (KRM2)



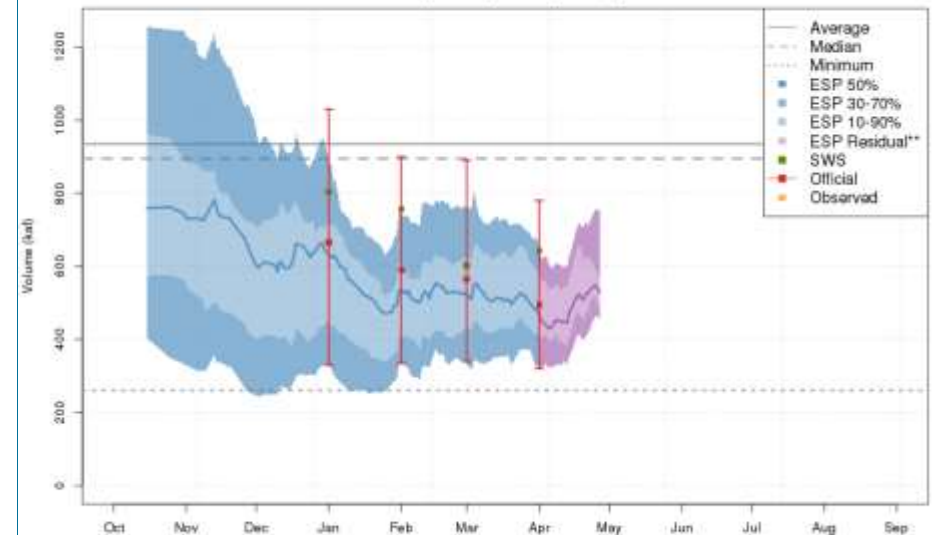
Plot Created 2013-04-28 15:45:13, Latest ESP Run from 2013-04-01, CBRFC / NWS / NOAA  
Maximum of 1766.9 in 2011, Minimum of 245.7 in 2002, Average/Median for 1981-2010:  
\*\*No residual observations available, ESP Residual is not total runoff.

**2013 Runoff Forecast Apr-Jul**  
San Juan - Bluff- Nr (BFFU1)



Plot Created 2013-04-28 15:42:26, Latest ESP Run from 2013-04-01, CBRFC / NWS / NOAA  
Maximum of 3175.2 in 1941, Minimum of -61.2 in 2002, Average/Median for 1981-2010:  
\*\*No residual observations available, ESP Residual is not total runoff.

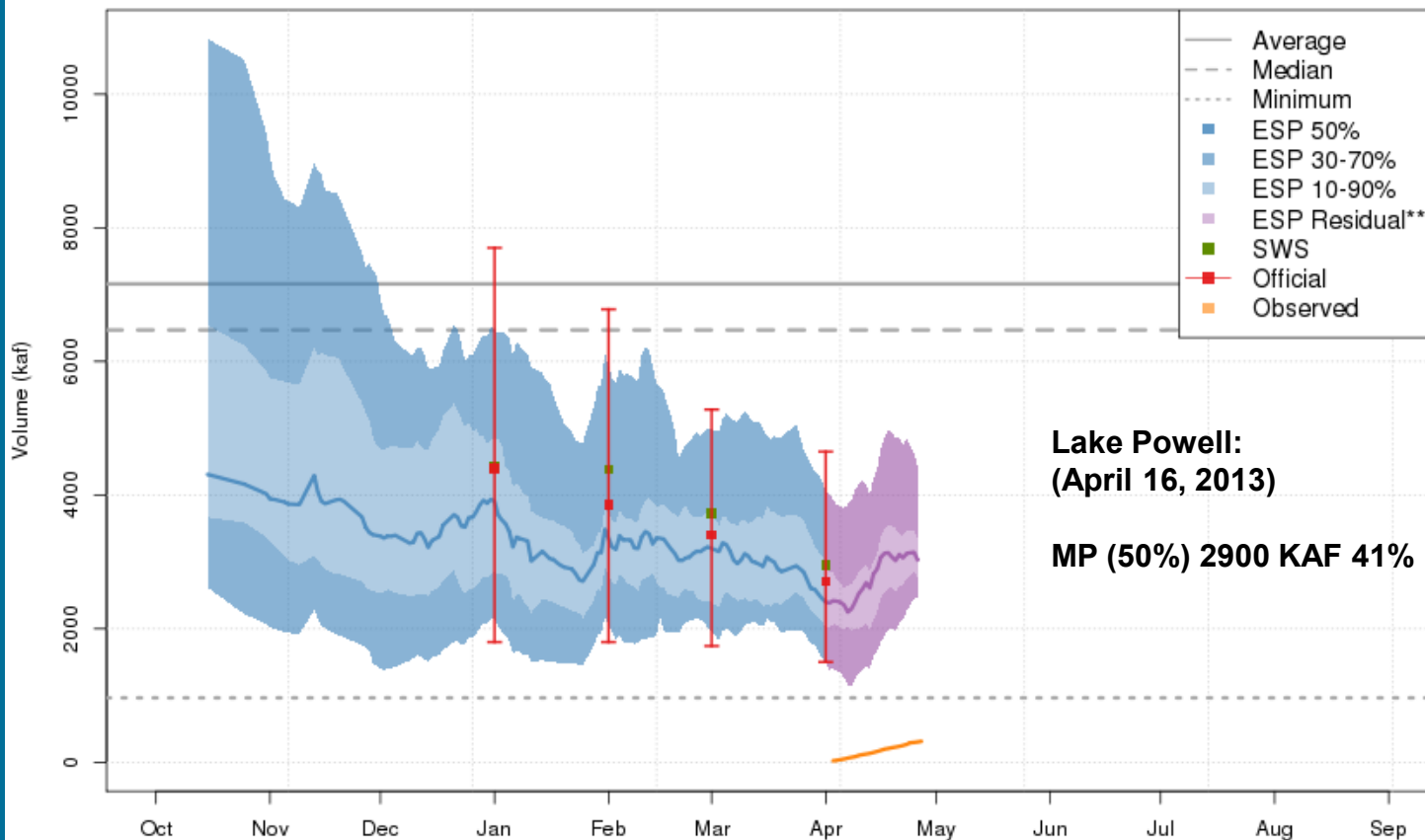
**2013 Runoff Forecast Apr-Jul**  
Yampa - Maybell- Nr (MBLC2)



Plot Created 2013-04-28 15:45:37, Latest ESP Run from 2013-04-01, CBRFC / NWS / NOAA  
Maximum of 1667.9 in 2011, Minimum of 260.6 in 1977, Average/Median for 1981-2010:  
\*\*No residual observations available, ESP Residual is not total runoff.

# Lake Powell Forecast - 2013

2013 Runoff Forecast Apr-Jul  
Colorado - Lake Powell- Glen Cyn Dam- At (GLDA3)



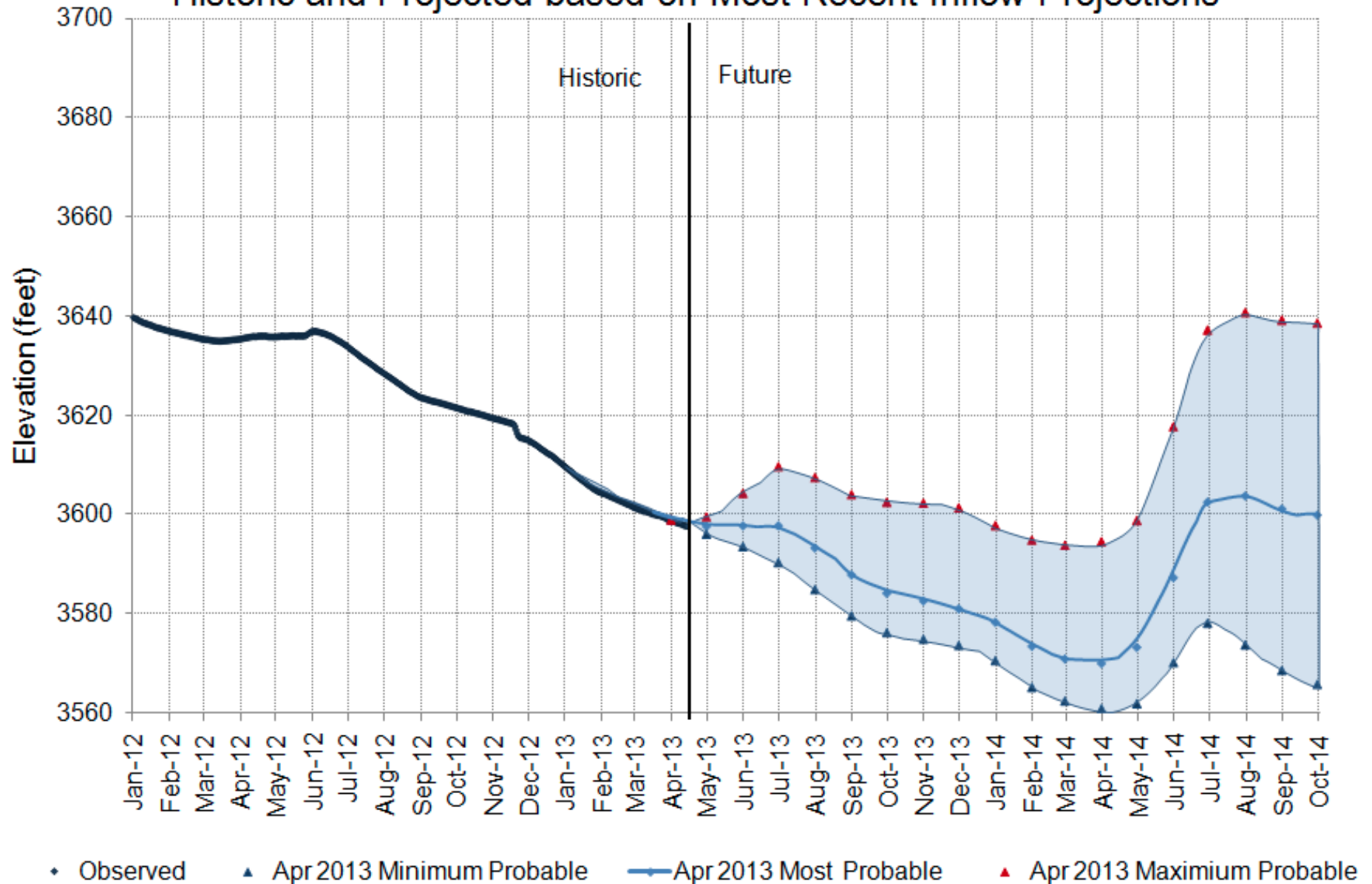
**Lake Powell:**  
**(April 16, 2013)**

**MP (50%) 2900 KAF 41%**

Plot Created 2013-04-28 15:44:29, Lastest ESP Run from 2013-04-01, CBRFC / NWS / NOAA  
Maximum of 15316.1 in 1984, Minimum of 964 in 2002, Average/Median for 1981-2010.  
\*\*Residual forecasts include observed

# Lake Powell Elevations

Historic and Projected based on Most Recent Inflow Projections



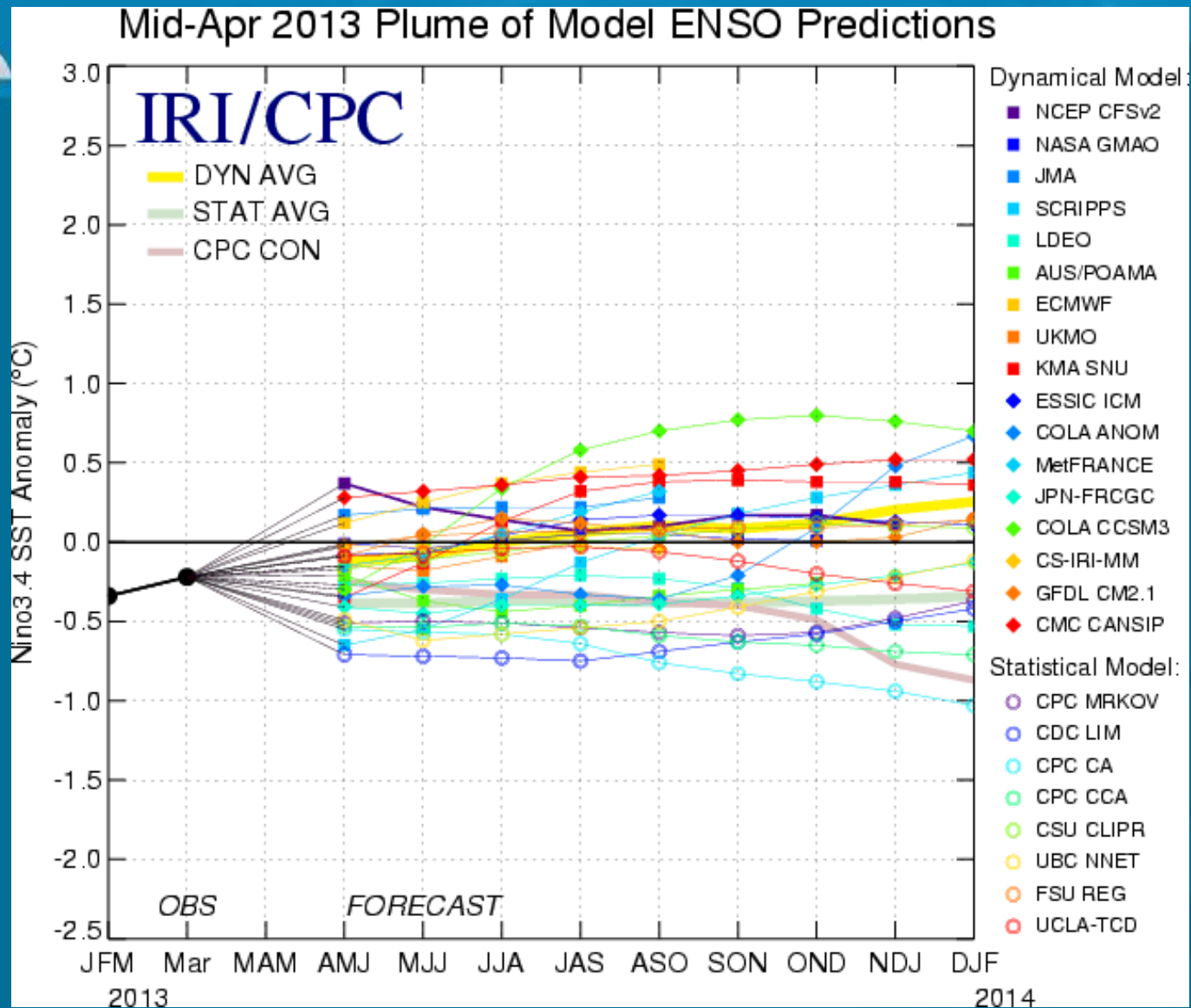
# Lake Powell & Lake Mead Operational Diagrams for 2010

Upper Colorado Reservoir Management

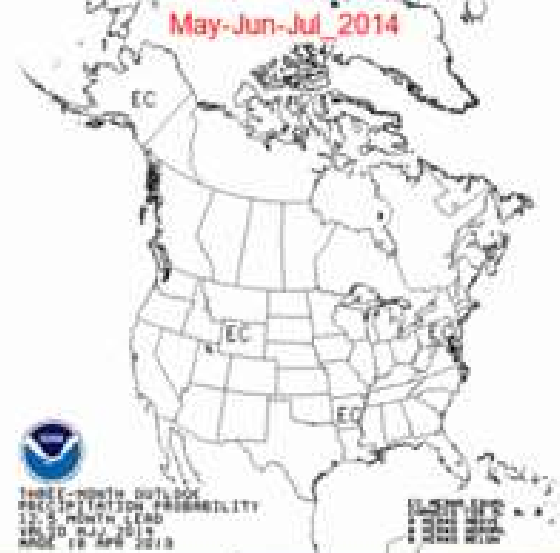
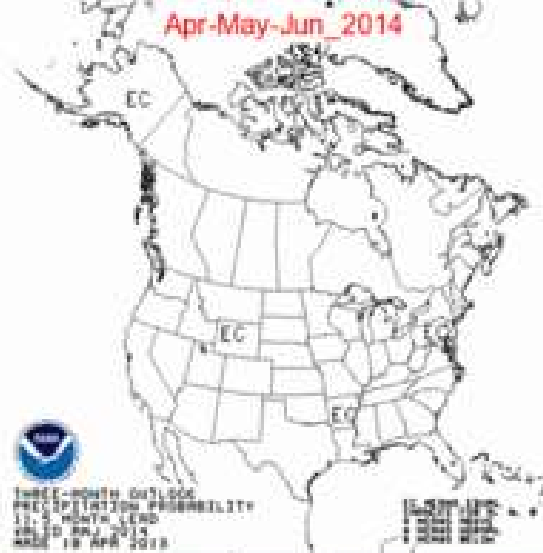
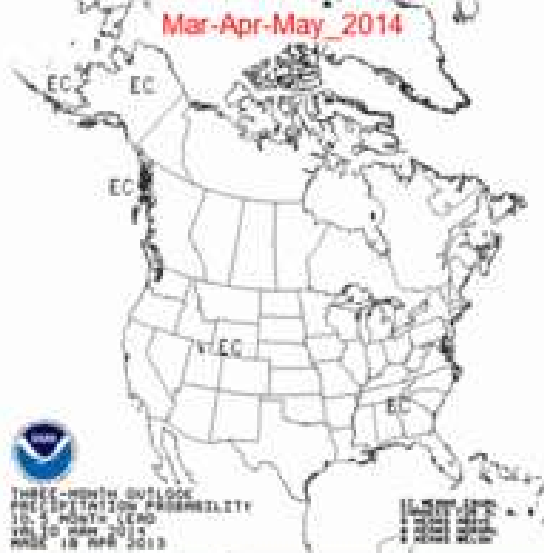
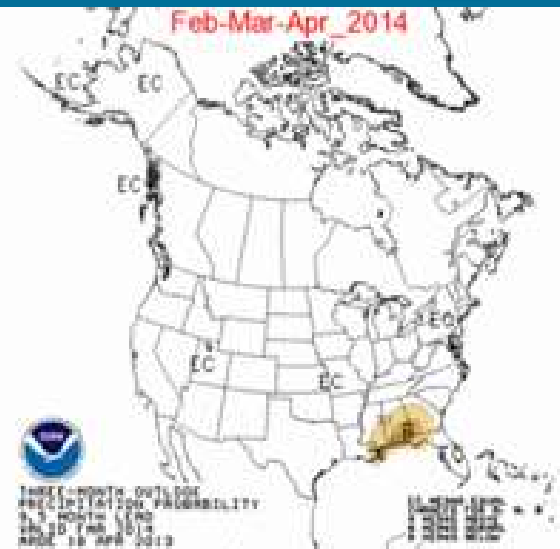
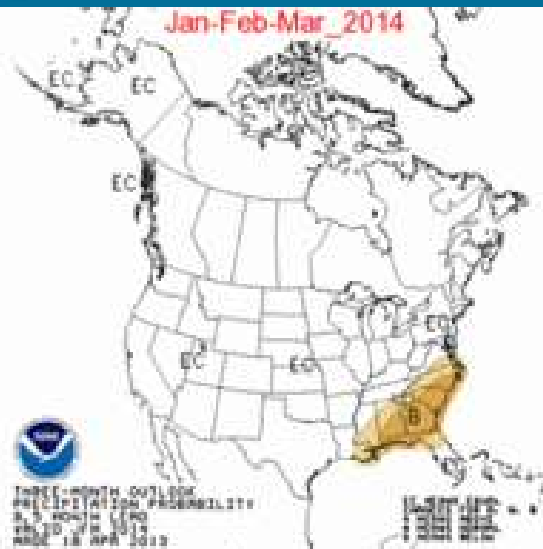
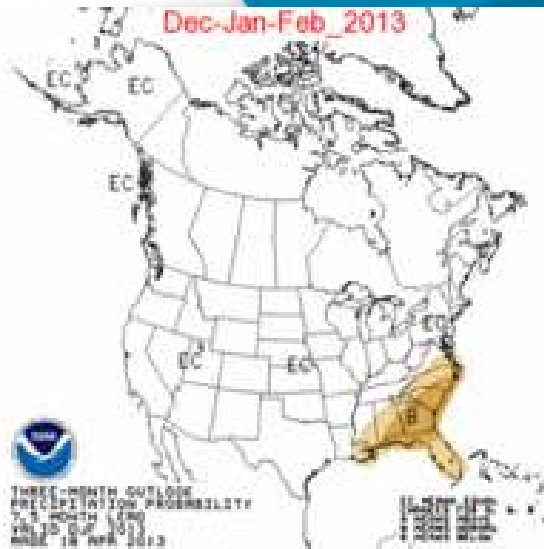
*Major releases depend on CBRFC April 1 Forecasts*

| Lake Powell                  |                                                                                                                                                                       |                            | Lake Mead        |                                                                         |                    |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------|-------------------------------------------------------------------------|--------------------|
| Elevation (feet)             | Operations According to Interim Guidelines                                                                                                                            | Live Storage (MAF)         | Elevation (feet) | Operations According to Interim Guidelines                              | Live Storage (MAF) |
| 3,700                        | Equalization Tier<br>Equalize, Avoid Spills<br>or Release 8.23 MAF                                                                                                    | 24.3                       | 1,220            | Flood Control, 70R or ICS<br>Surplus                                    | 25.9               |
| 3,636 - 3,666<br>(2008-2026) | Upper Elevation<br>Balancing Tier <sup>1</sup><br>Release 8.23 MAF;<br>if Lake Mead < 1,075 feet,<br>balance contents with<br>a min/max release of<br>7.0 and 9.0 MAF | 15.5 - 19.3<br>(2008-2026) | 1,200            | -----<br>Domestic or ICS Surplus                                        | 22.9               |
|                              |                                                                                                                                                                       |                            | 1,145            | -----<br>15.9                                                           |                    |
| 3,575                        | ▼-----                                                                                                                                                                | 9.5                        | 1,105            | Normal Operations ▼<br>or ICS Surplus                                   | 11.9               |
| 3,525                        | Mid-Elevation<br>Release Tier<br>Release 7.48 MAF;<br>if Lake Mead < 1,025 feet,<br>Release 8.23 MAF;                                                                 | 5.9                        | 1,075            | -----<br>9.4                                                            |                    |
|                              |                                                                                                                                                                       |                            | 1,050            | -----<br>Shortage 333 KAF <sup>2</sup>                                  | 7.5                |
| 3,490                        | Lower Elevation<br>Balancing Tier<br>Balance contents with<br>a min/max release of<br>7.0 and 9.5 MAF                                                                 | 4.0                        | 1,025            | -----<br>Shortage 417 KAF <sup>2</sup>                                  | 5.8                |
| 3,370                        |                                                                                                                                                                       |                            | 1,000            | -----<br>Shortage 500 KAF <sup>2</sup><br>and Consultation <sup>3</sup> | 4.3                |
|                              |                                                                                                                                                                       | 0                          | 895              |                                                                         | 0                  |

# ENSO Neutral



# CPC Precipitation Outlook



# 2014 Outlook

- *Dry antecedent conditions*
- *Model trends back to normal*
- *Water supply forecasts for Lake Powell 2014:  
85-90% of average.*

# Climate is changing...

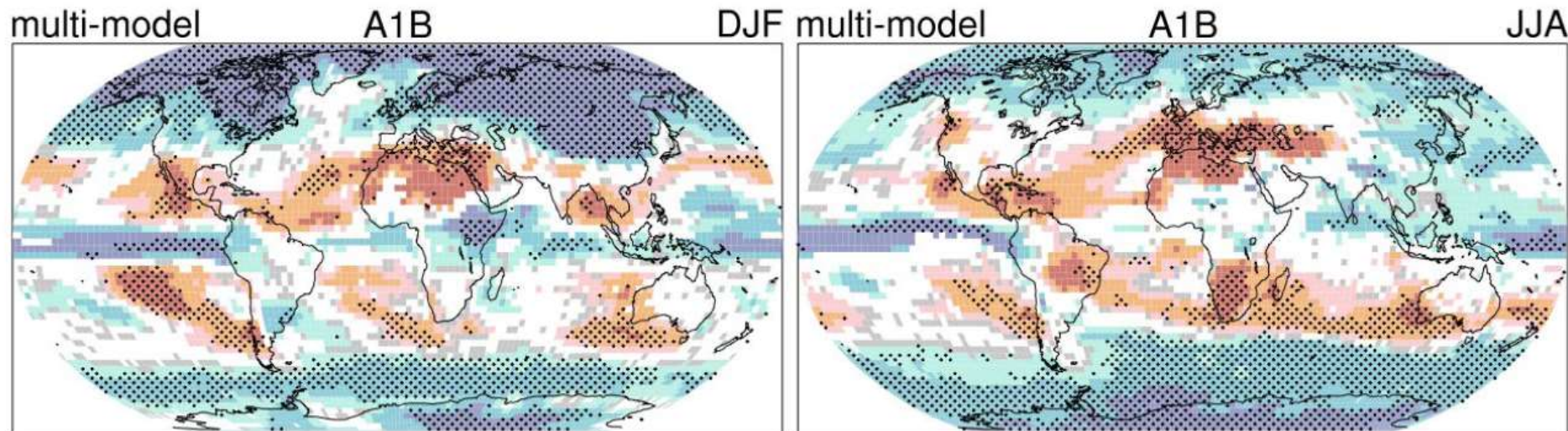
## What can we expect?

*Wet get wetter and dry get drier...and the Southwest likely to get drier; variability likely to increase*

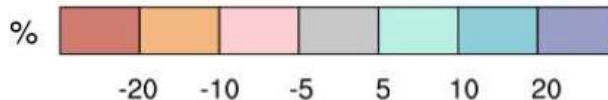
*Wide range of projected declines in Colorado River average inflow (0 to 40%)*

*Lot's of research on-going (and needed)*

### Projected Patterns of Precipitation Changes



From IPCC 4<sup>th</sup> Assessment Report



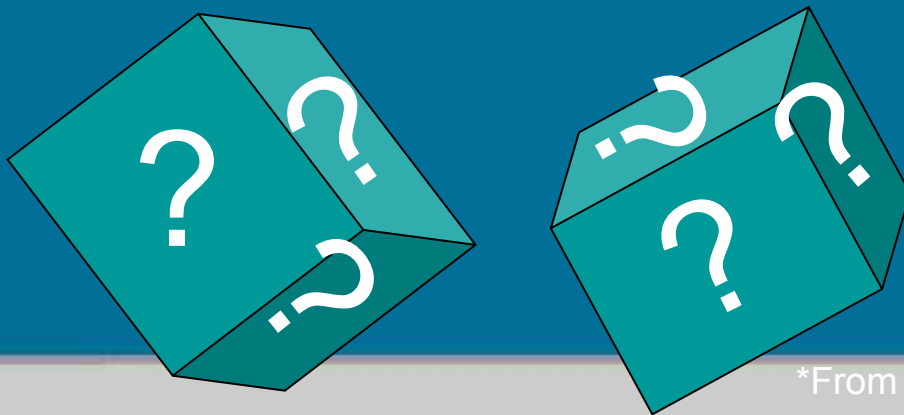
Adapted from Western Water Assessment

# Loading the climate dice\*

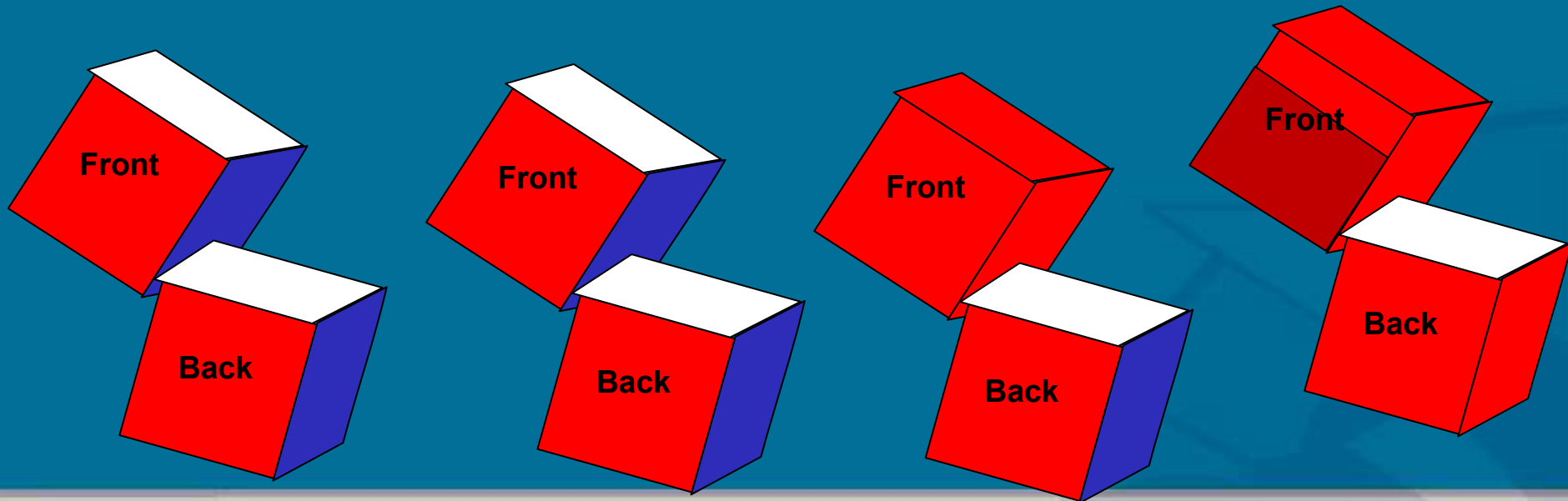
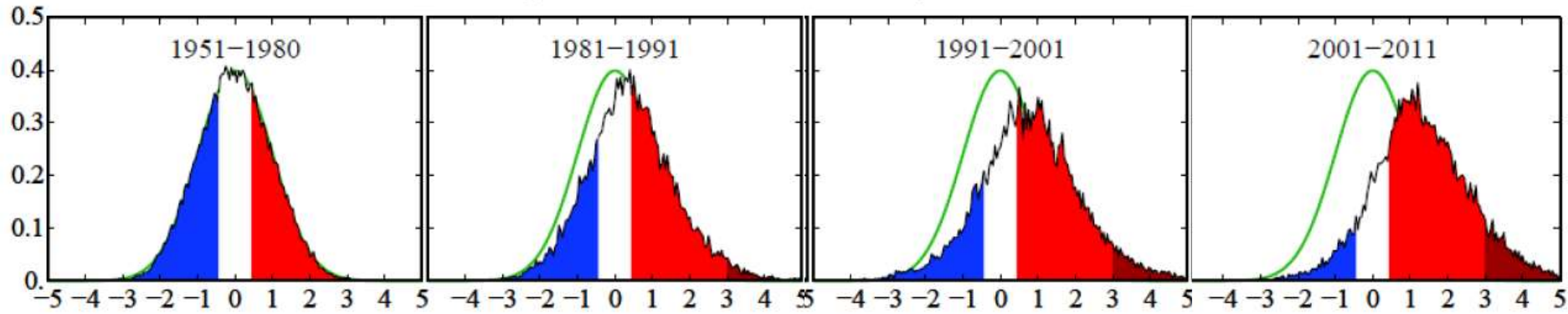
*Assume the period from 1951 – 1980 as a “base period”*

- Relatively stable global temperature
- Within the Holocene range, which is a period of time that the natural world and civilization adapted to

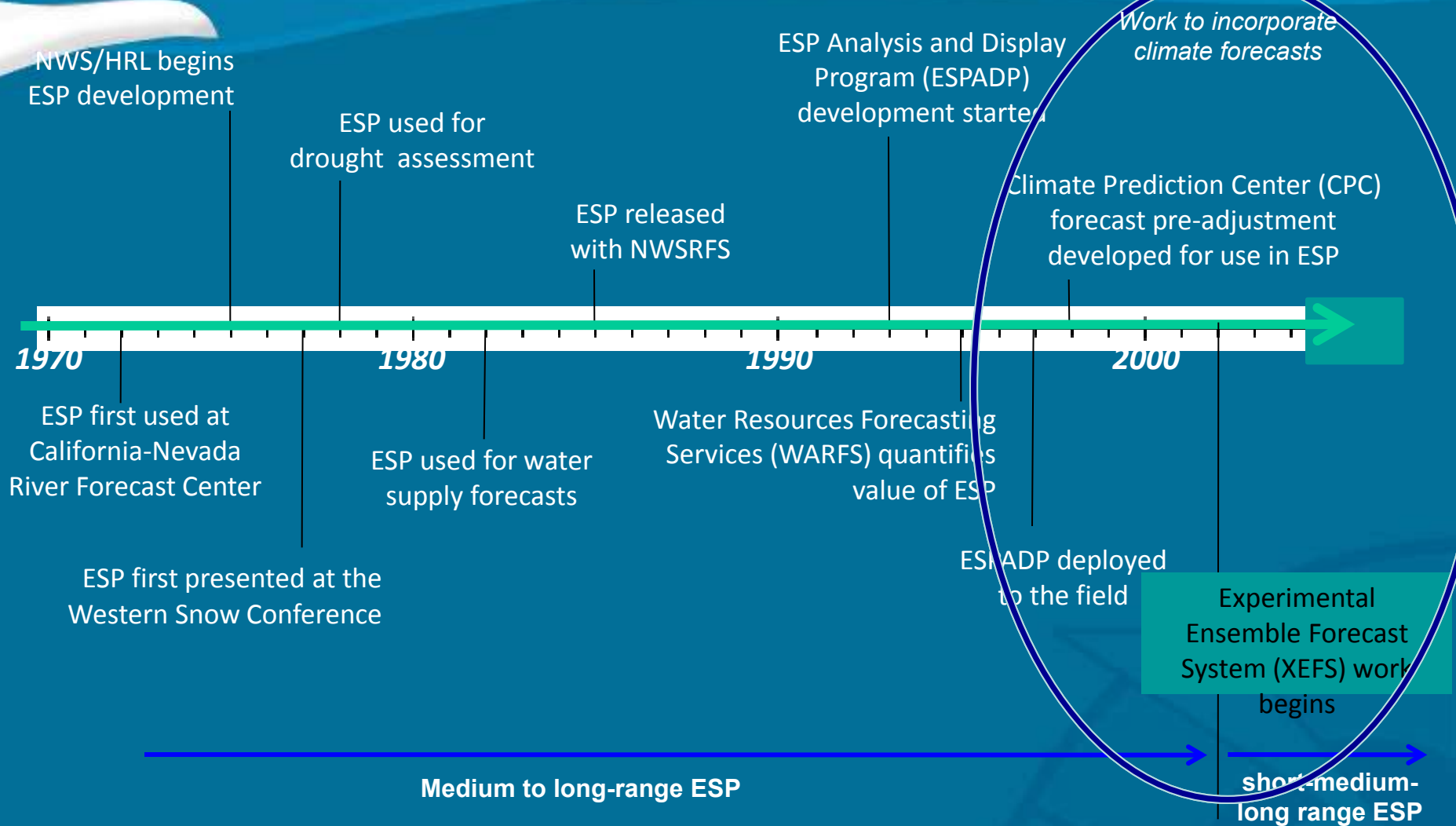
*Fit the information to a standard bell curve*



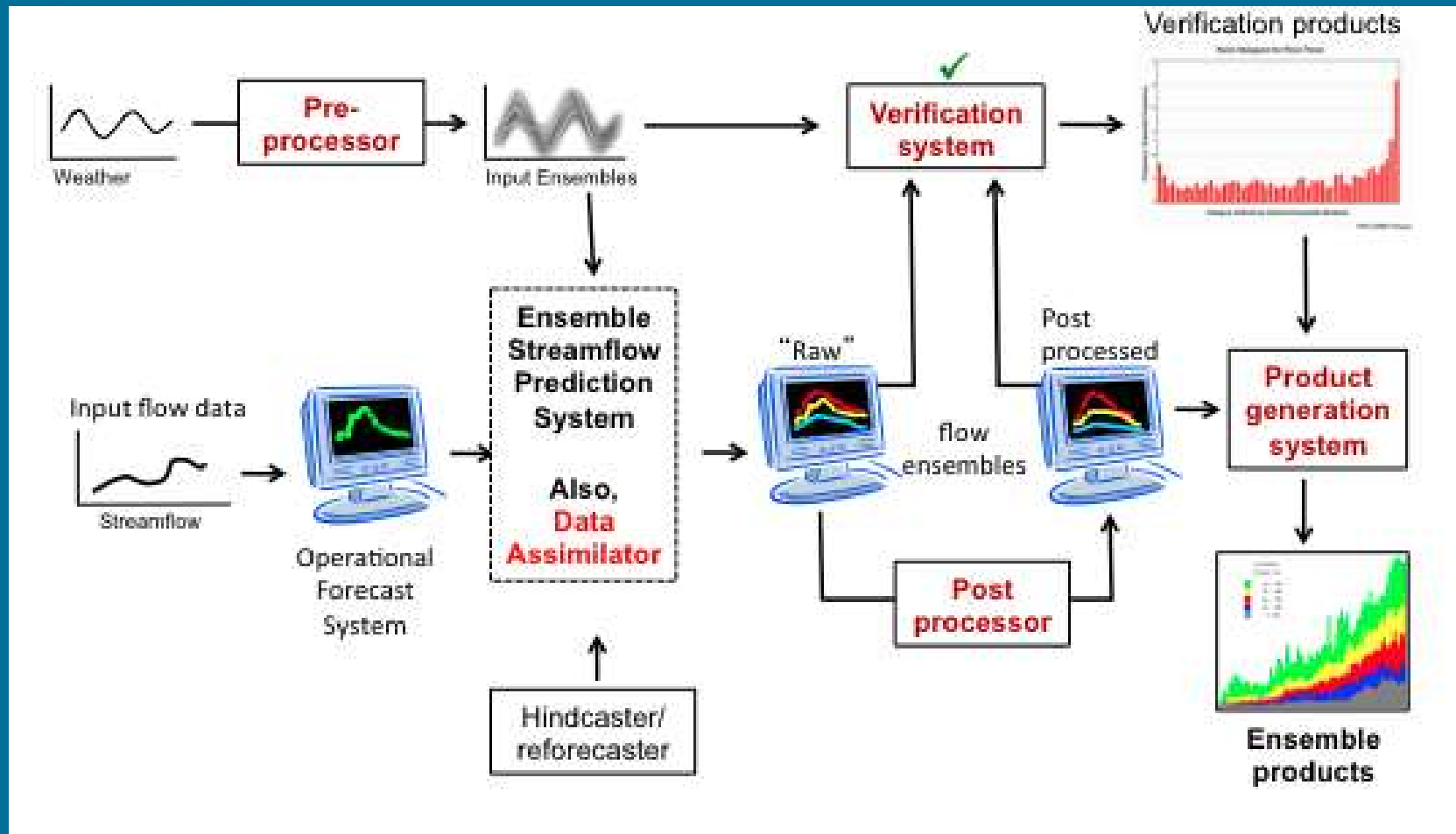
# Loading the climate dice



# Historic development of ESP (Ensemble Streamflow Prediction)



# Hydrologic Ensemble Forecast System - HEFS

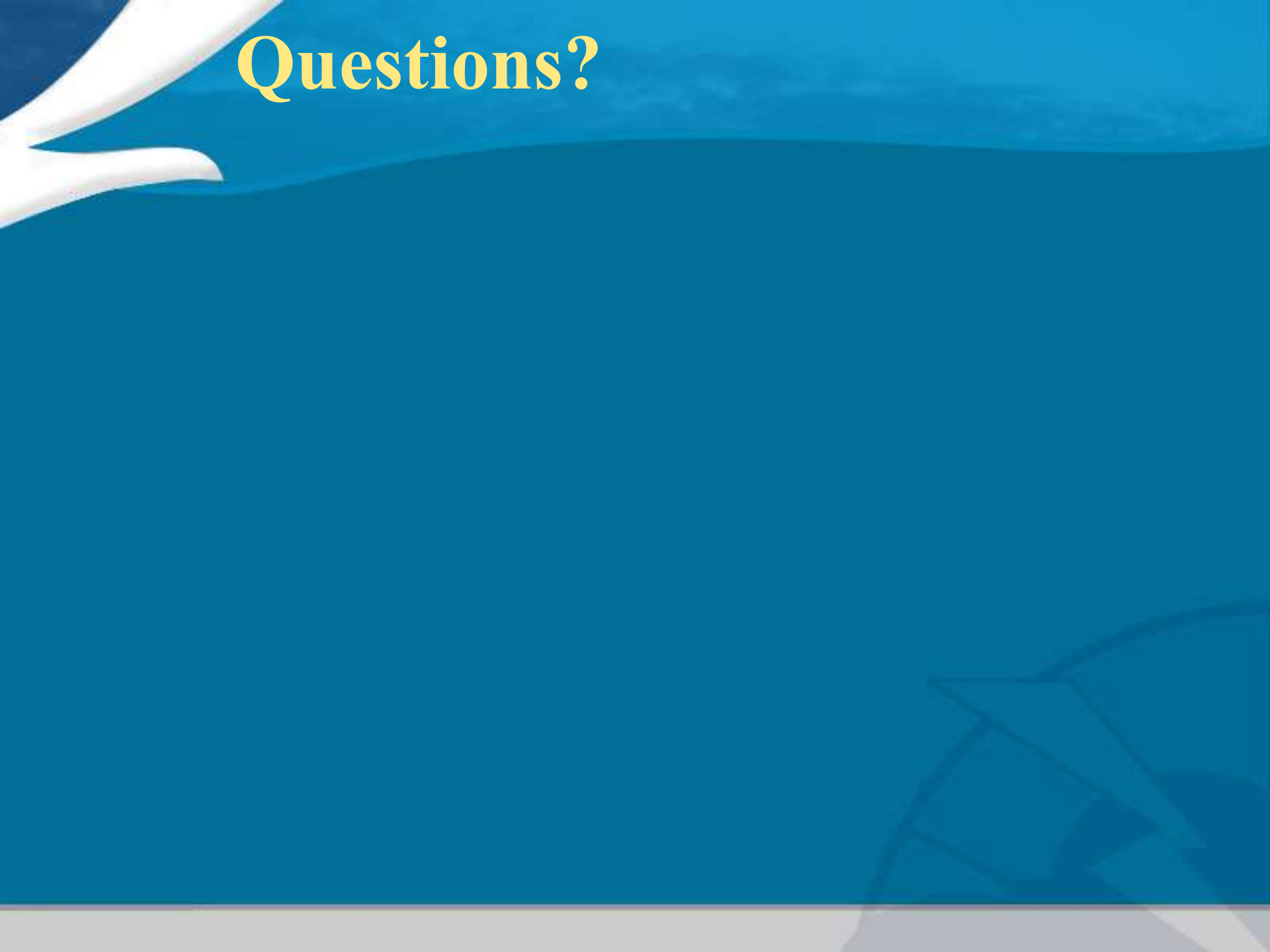


# How the CBRFC is helping stakeholders adapt

- *Ensemble streamflow traces*
- *Snow monitoring*
- *Model enhancement/improvements:*
  - ESP analysis
  - Verification
  - Daily updates
  - Recalibrate

# When will the drought end?

- *When we figure out how to adapt to it!*
  - Build upon current cooperative and collaborative relationships to provide stakeholders with the tools they need to make informed and beneficial decisions.
  - Reach out to those that are unaware of the tools and resources available to them at the CBRFC.
- *Strengthen data availability and analytical techniques through active participation and communication*
  - Regional stakeholder groups
  - National initiatives to inform the public about climate change



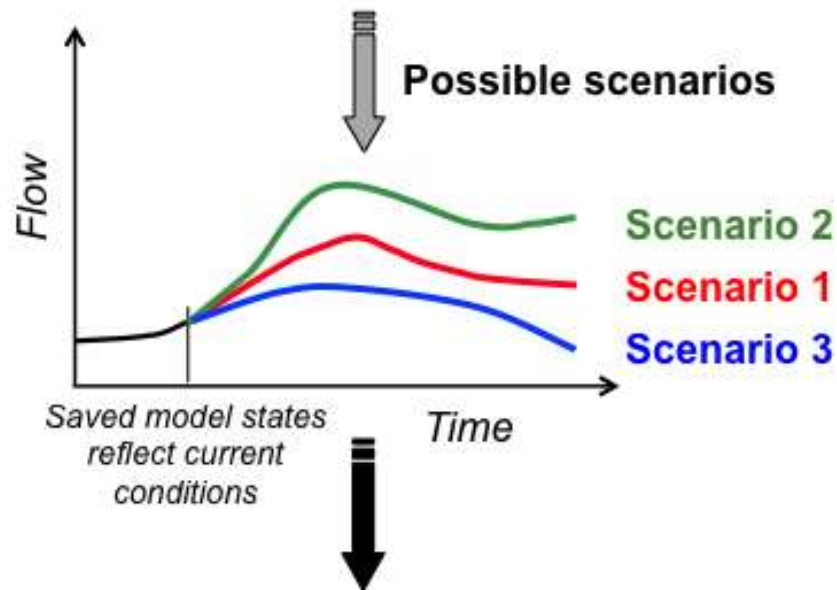
# Questions?



***Backup slides***

# Forecast Method: Ensemble Streamflow Prediction Technique

Multiple streamflow scenarios with historic meteorological or forecast weather/climatic data

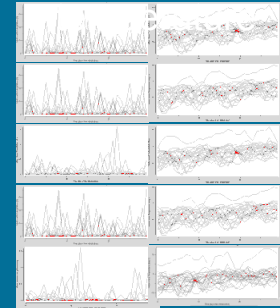


Results used in statistical analysis to produce forecasts with probabilistic values

The COMET Program

Historical time series of precipitation and

81  
82  
83  
84  
85



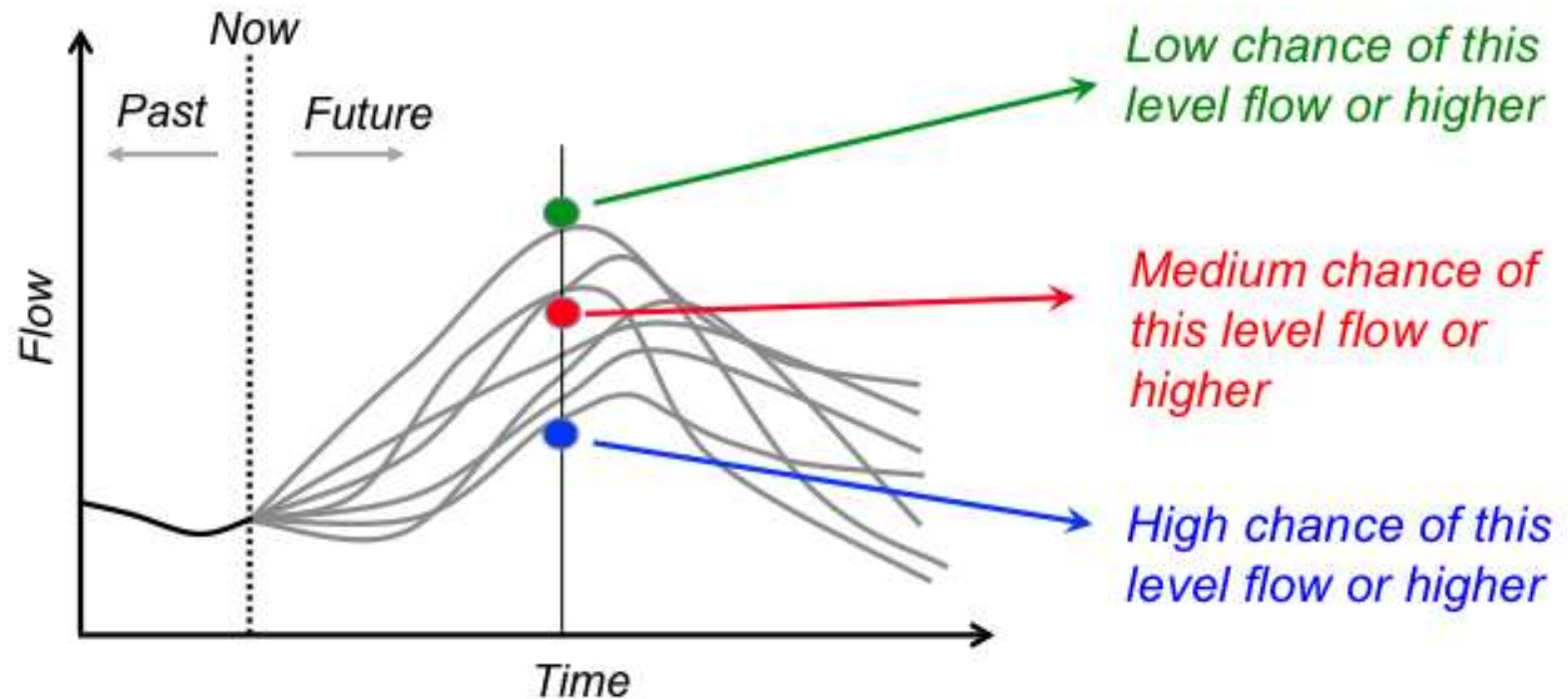
*CBRFC: Currently using water years 1981-2010*

Can also include forecast precipitation and temperature.

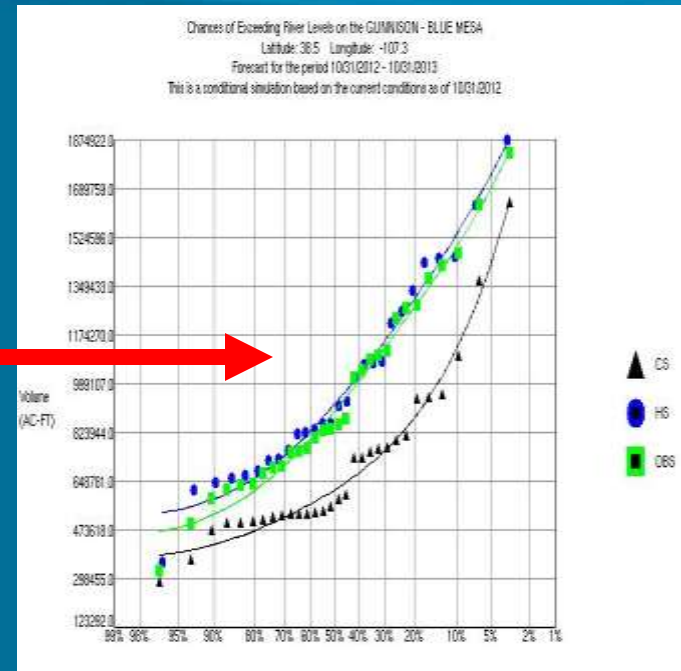
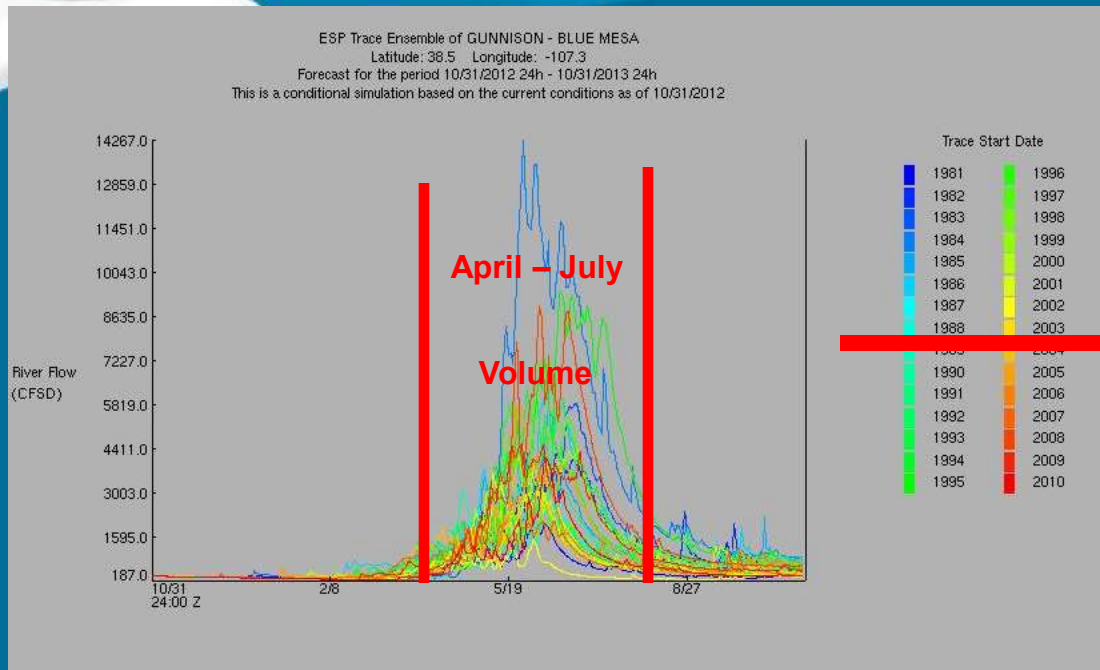
*CBRFC:*

- 10 days of forecast max/min temperatures.
- 5 days of forecast precipitation and 0 days of forecast precipitation

# ESP Technique (cont.)



# ESP - cont

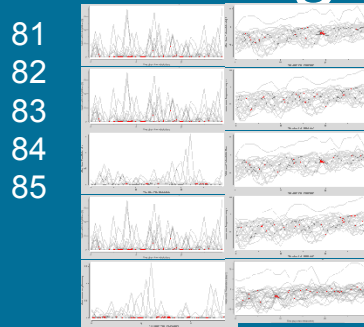


1. Select a forecast window
2. Select a forecast variable
3. Model derives a distribution function
4. 50% exceedance value = most probable forecast
5. Also use 10%/90% levels

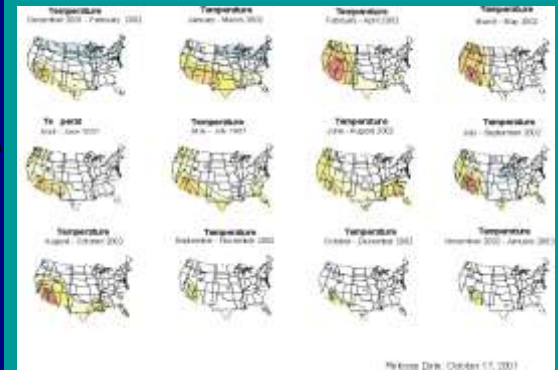
| # Exceedance    | Conditional | Historical  | Historical  |
|-----------------|-------------|-------------|-------------|
| # Probabilities | Simulation  | Simulation  | Observed    |
| 0.900           | 417330.156  | 581462.500  | 525460.000  |
| 0.750           | 493856.750  | 699928.938  | 659224.812  |
| 0.700           | 517683.500  | 741569.312  | 705094.750  |
| 0.600           | 565268.875  | 829048.438  | 799524.375  |
| 0.500           | 616216.625  | 923809.188  | 898919.562  |
| 0.400           | 676330.375  | 1029094.688 | 1006031.062 |
| 0.300           | 755745.938  | 1151067.250 | 1126296.500 |
| 0.250           | 808794.500  | 1222083.250 | 1194804.500 |
| 0.100           | 1123002.375 | 1534576.375 | 1490881.125 |

# Incorporating Climate Forecasts in ESP

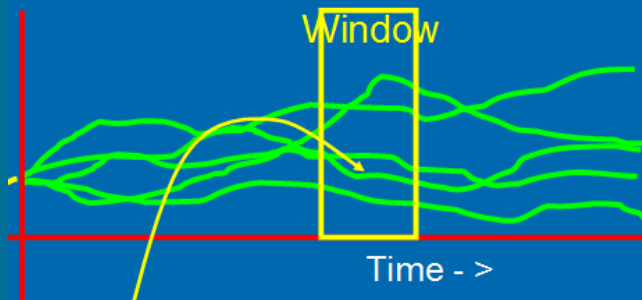
Pre-Adjustment Technique  
Weight/Modify Inputs



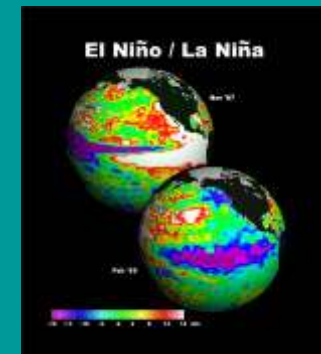
Climate Forecasts



Post-Adjustment Technique  
Weight Outputs



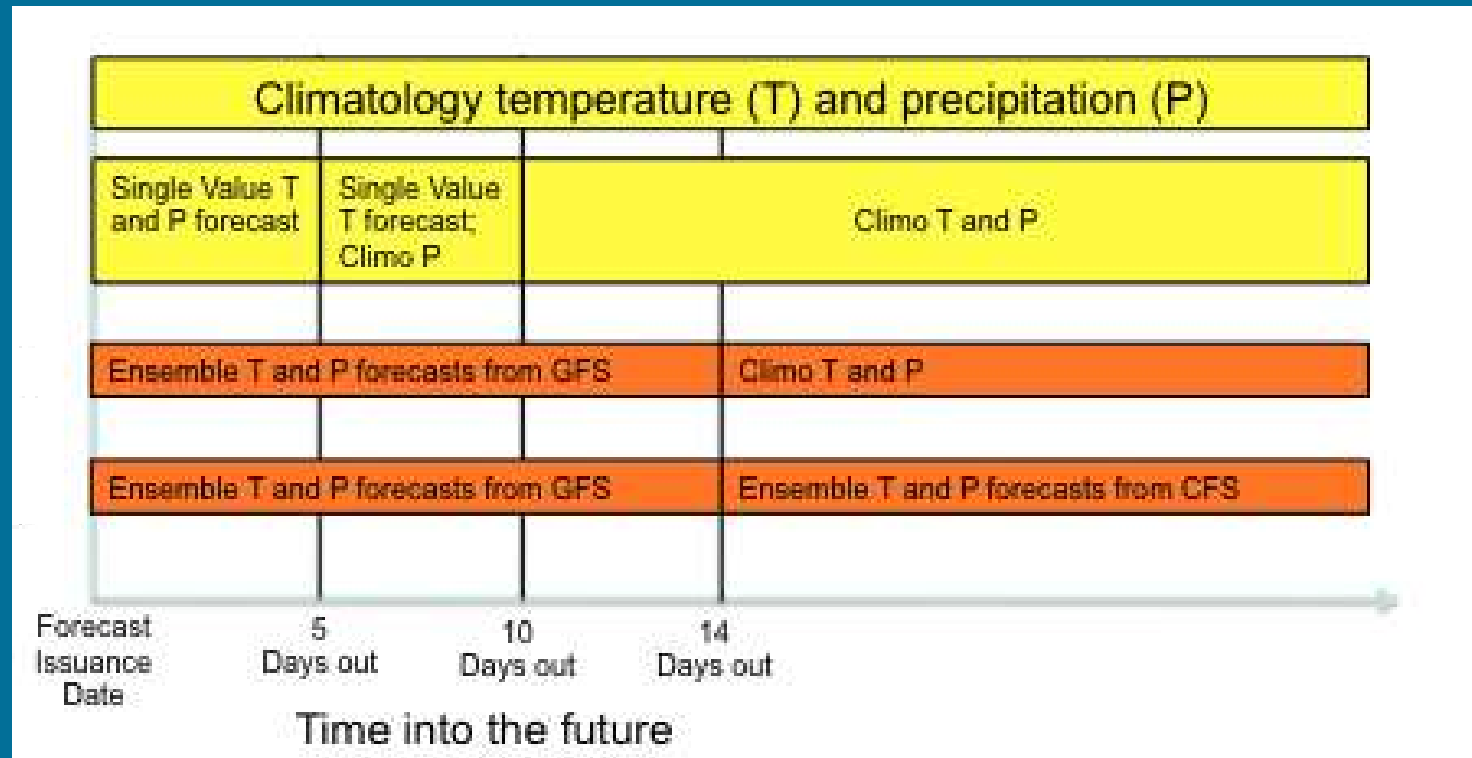
Current and historical  
ENSO states



# HEFS - cont

ESP

HEFS



# Experimental ensembles (with short to long range climate inputs)

**GFS (14 days) and CFS based ensembles:** experimental products updated daily at Colorado RFC (CBRFC) & California-Nevada RFC (CNRFC)

