NOAA's National Weather Service

The Colorado River Basin Drought

Michelle Stokes

Hydrologist In Charge

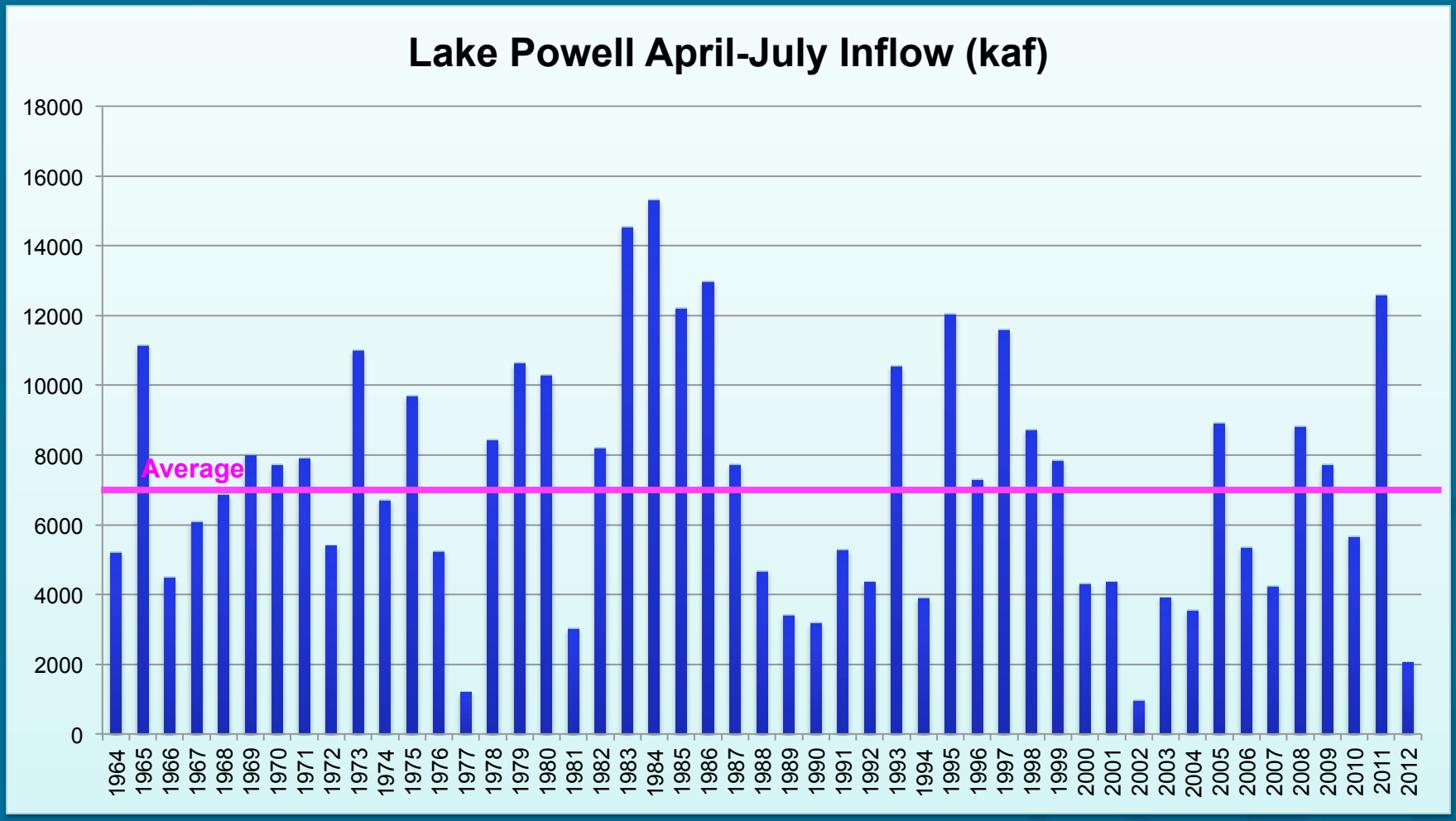
Colorado Basin River Forecast Center

April 29, 2013

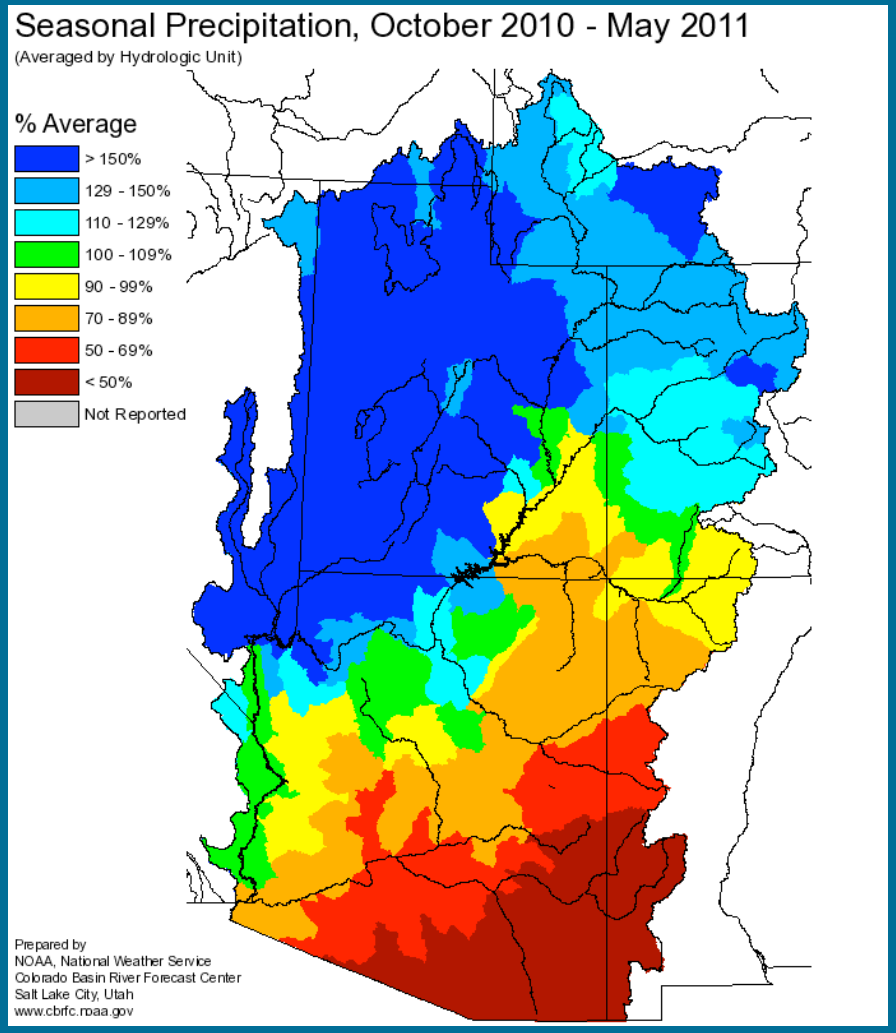
Overview

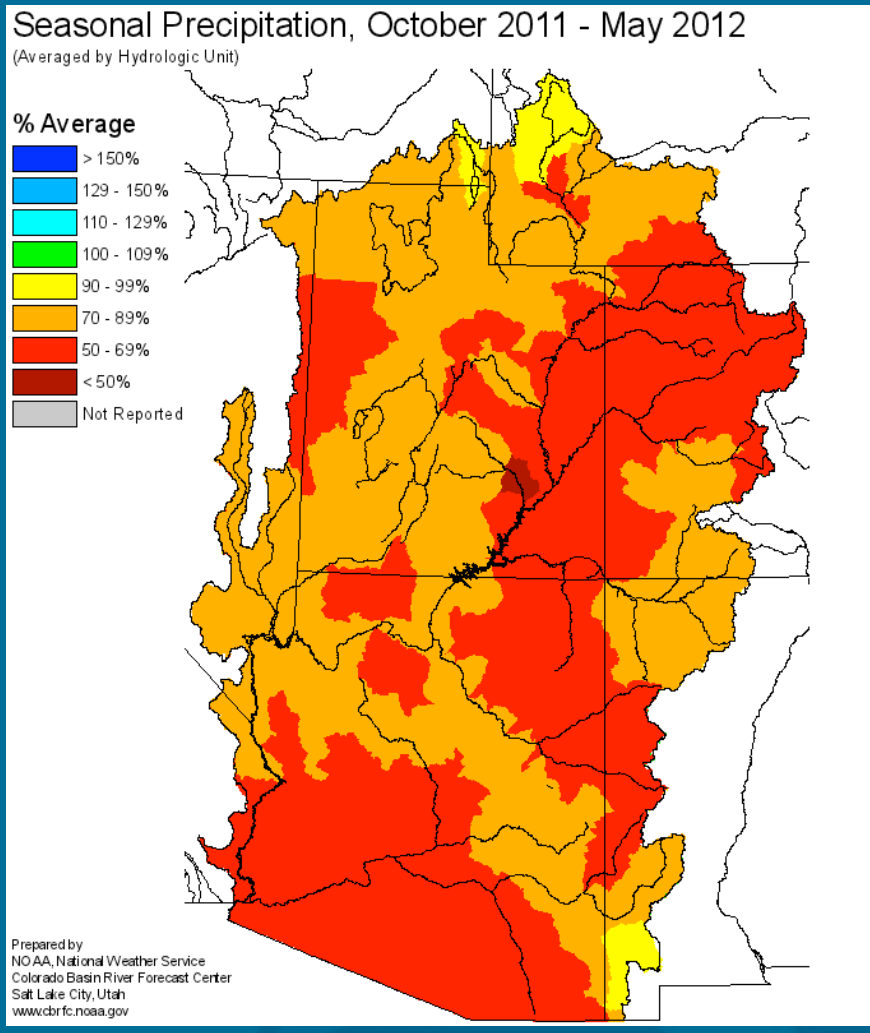
- *Recent History*
- *Water Supply Forecasts for 2013- 2014*
- *Beyond 2014…*
- *Incorporating climate information into water supply forecasts*

Lake Powell Inflows



Very wet to very dry year…





Current Drought

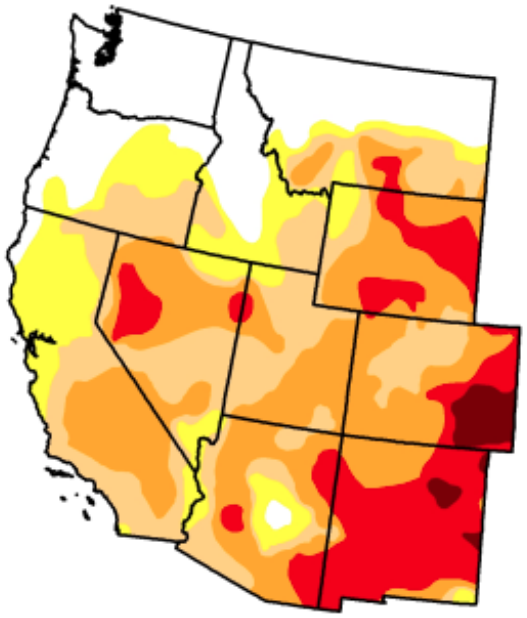
U.S. Drought Monitor

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 (04/16/2013 map)	19.84	80.16	63.67	41.05	14.73	1.64
3 Months Ago (01/22/2013 map)	22.60	77.40	68.24	44.51	17.27	2.15
Start of Calendar Year (01/01/2013 map)	24.39	75.61	69.31	45.04	18.01	2.15
Start of Water Year (09/25/2012 map)	15.12	84.88	77.15	43.65	16.85	1.77
One Year Ago (04/17/2012 map)	32.80	67.20	46.92	24.14	3.77	0.91



Intensity:

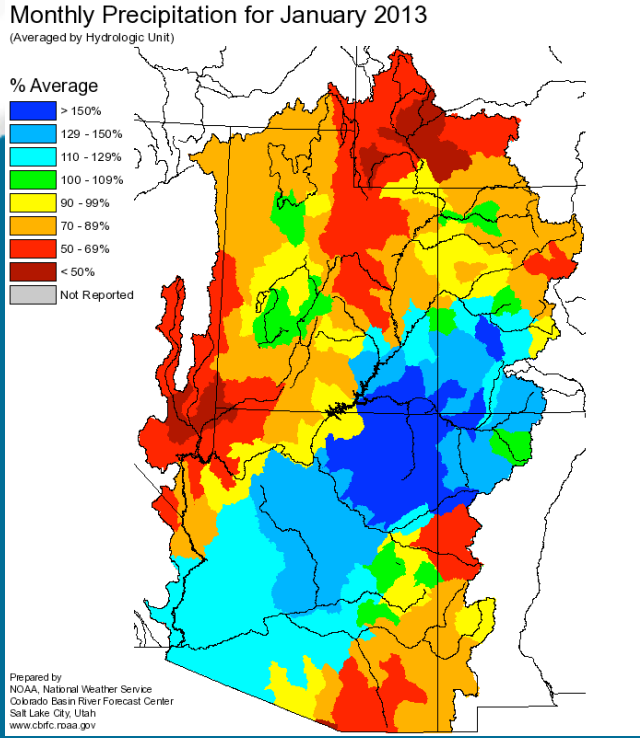
- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

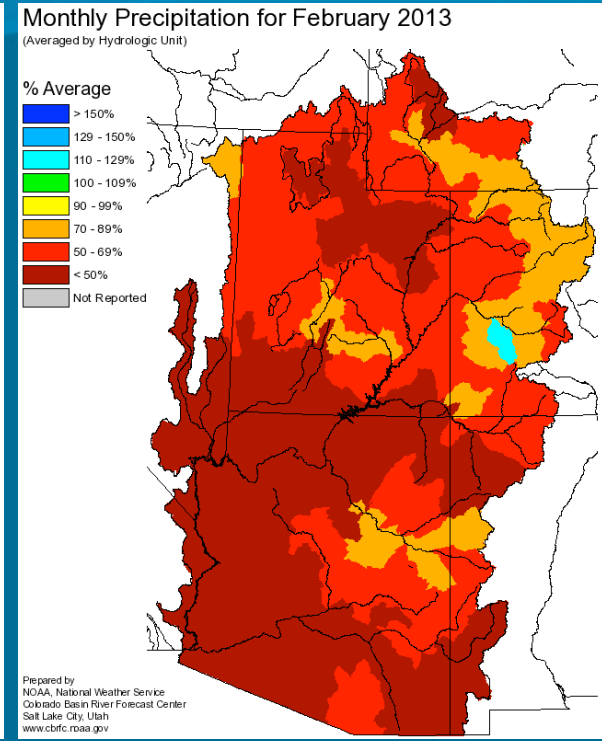
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

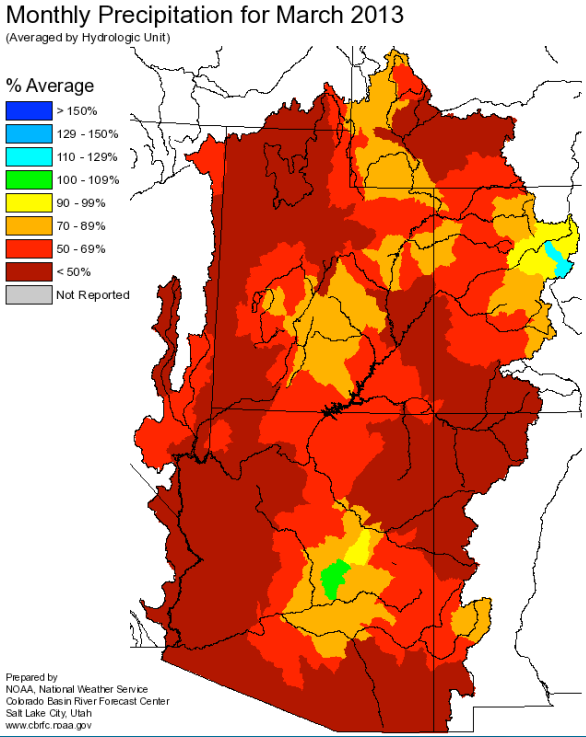
http://droughtmonitor.unl.edu

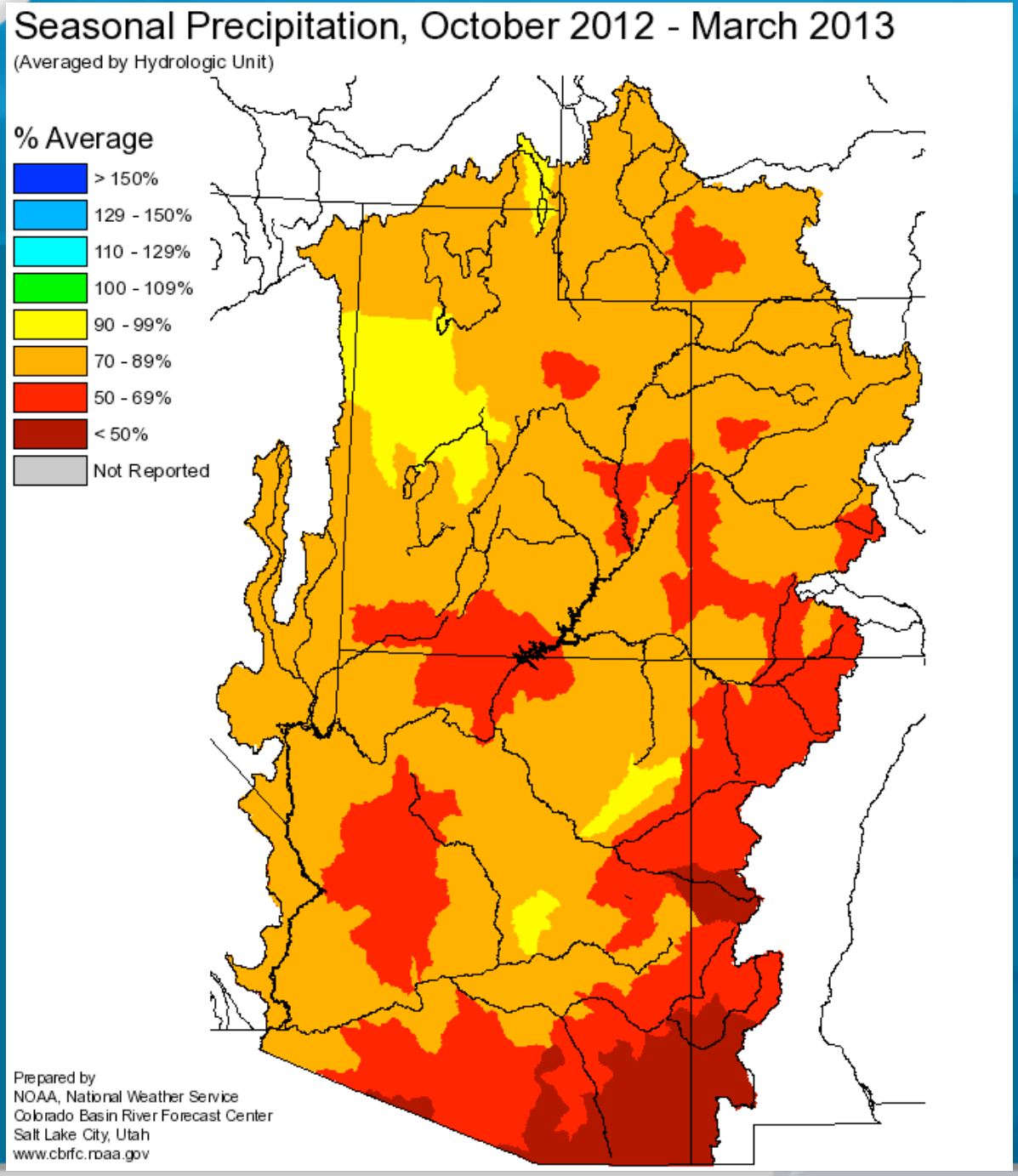
Released Thursday, April 25, 2013
Eric Luebehusen, U.S. Department of Agriculture

2013 Precipitation

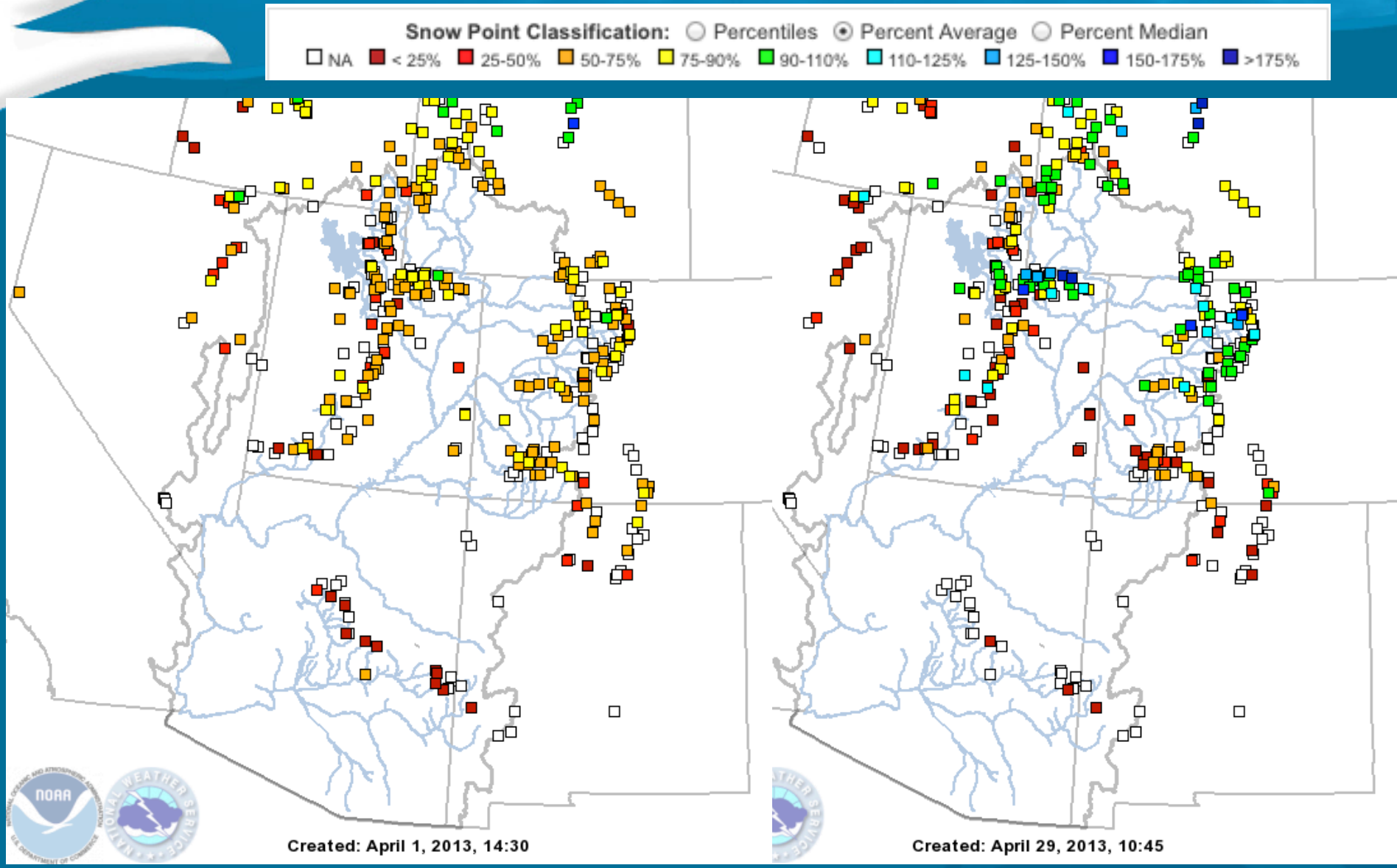







Seasonal Precipitation, October 2012 - March 2013
(Averaged by Hydrologic Unit)
% Average
> 150%
129 - 150%
110 - 129%
100 - 109%
90 - 99%
70 - 89%
50 - 69%
< 50%
Not Reported
Prepared by
NOAA, National Weather Service
Colorado Basin River Forecast Center
Salt Lake City, Utah
www.cbrfc.noaa.gov

And then came April…



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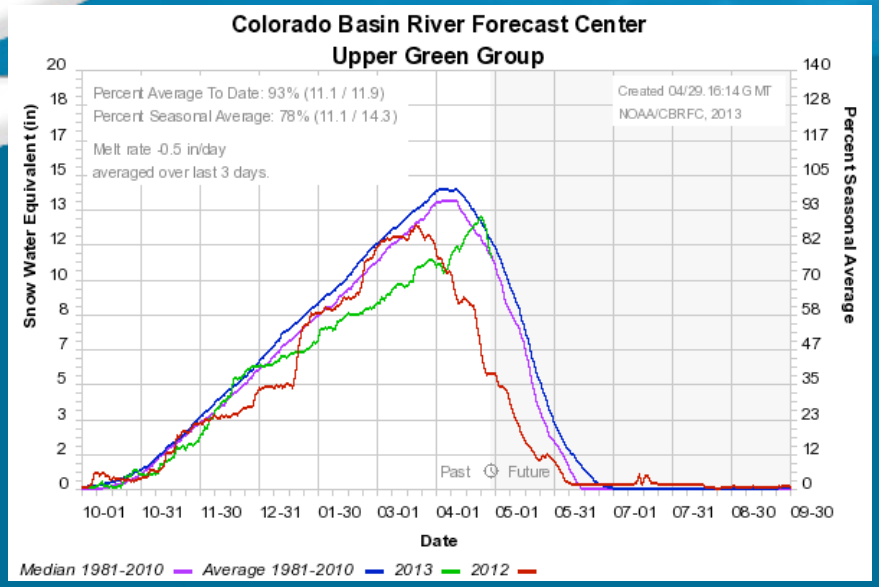
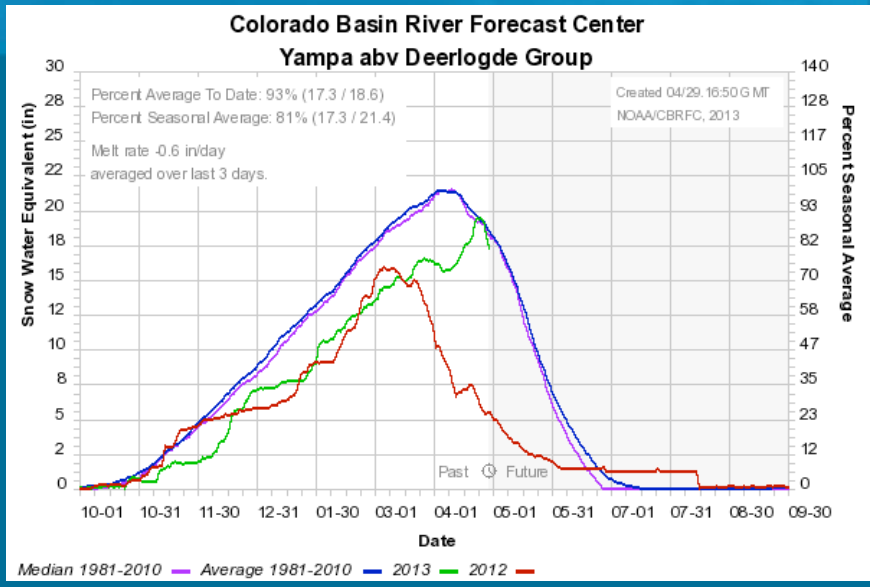
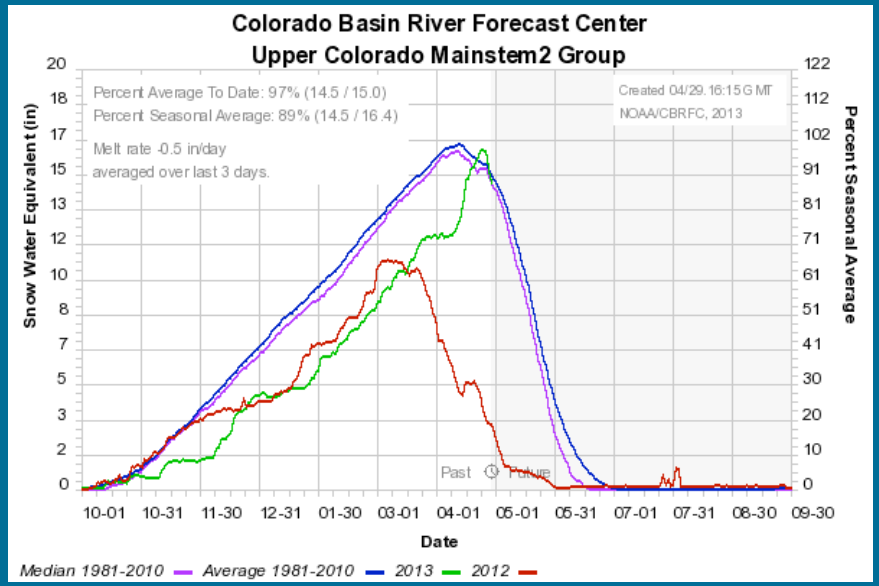
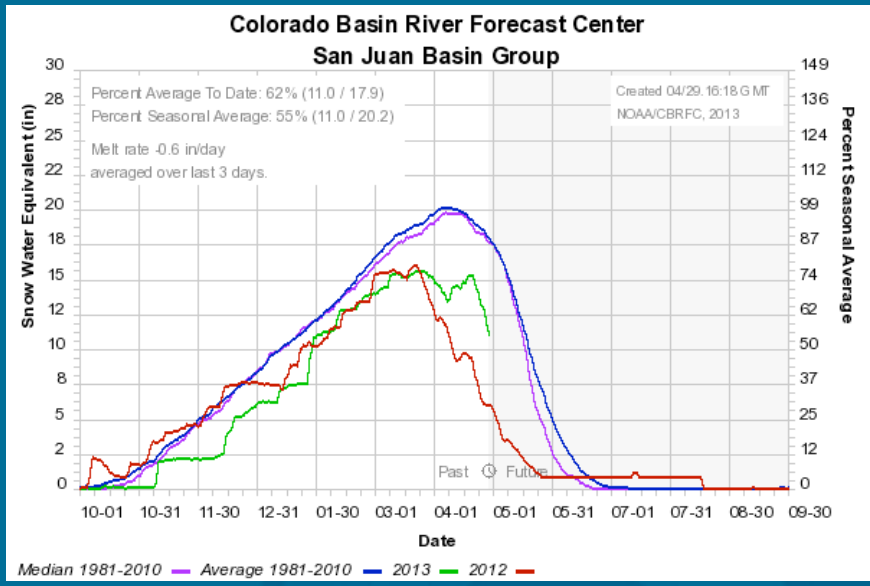
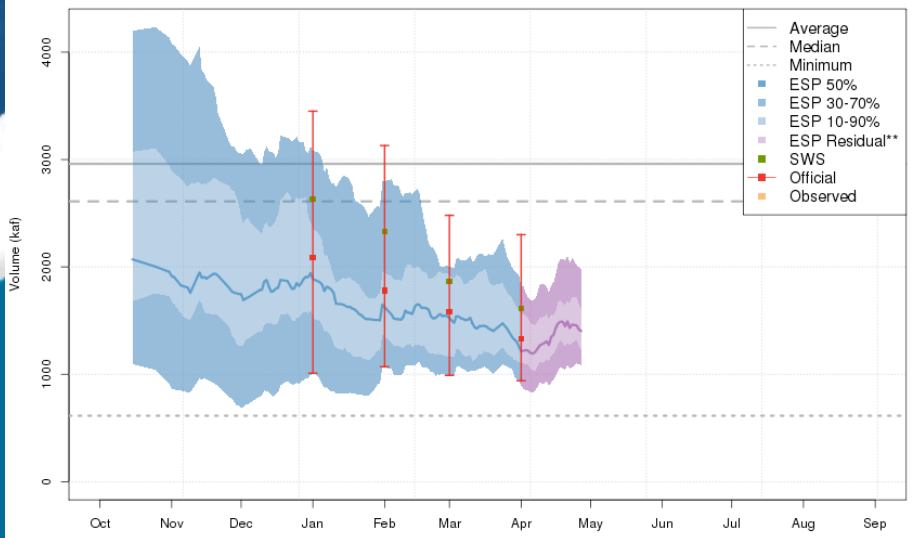

Colorado Basin River Forecast Center
Upper Green Group
Percent Average To Date: 93% (11.1 / 11.9)
Percent Seasonal Average: 78% (11.1 / 14.3)
Melt rate -0.5 in/day
averaged over last 3 days.
Created 04/29.16:14 G MT
NOAA/CBRFC, 2013
Snow Water Equivalent (in)
Percent Seasonal Average
Past
Future
10-01 10-31 11-30 12-31 01-30 03-01 04-01 05-01 05-31 07-01 07-31 08-30 09-30
Date
Median 1981-2010
Average 1981-2010
2013
2012


Colorado Basin River Forecast Center
Yampa abv Deerlogde Group
Percent Average To Date: 93% (17.3 / 18.6)
Percent Seasonal Average: 81% (17.3 / 21.4)
Melt rate -0.6 in/day
averaged over last 3 days.
Created 04/29.16:50 G MT
NOAA/CBRFC, 2013
Snow Water Equivalent (in)
Percent Seasonal Average
Past
Future
10-01 10-31 11-30 12-31 01-30 03-01 04-01 05-01 05-31 07-01 07-31 08-30 09-30
Date
Median 1981-2010
Average 1981-2010
2013
2012


Colorado Basin River Forecast Center
Upper Colorado Mainstem2 Group
Percent Average To Date: 97% (14.5 / 15.0)
Percent Seasonal Average: 89% (14.5 / 16.4)
Melt rate -0.5 in/day
averaged over last 3 days.
Created 04/29.16:15 G MT
NOAA/CBRFC, 2013
Snow Water Equivalent (in)
Percent Seasonal Average
Past
Future
10-01 10-31 11-30 12-31 01-30 03-01 04-01 05-01 05-31 07-01 07-31 08-30 09-30
Date
Median 1981-2010
Average 1981-2010
2013
2012

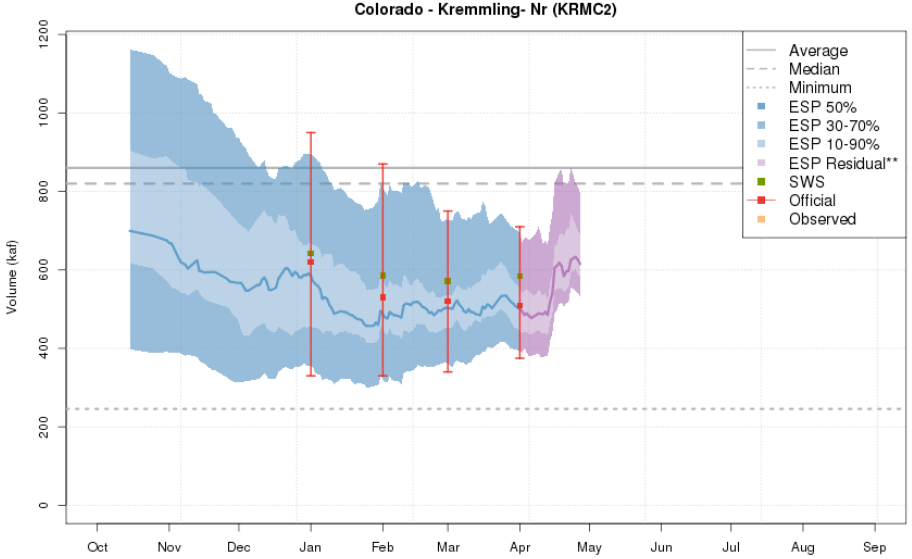

Colorado Basin River Forecast Center
San Juan Basin Group
Percent Average To Date: 62% (11.0 / 17.9)
Percent Seasonal Average: 55% (11.0 / 20.2)
Melt rate -0.6 in/day
averaged over last 3 days.
Created 04/29.16:18 G MT
NOAA/CBRFC, 2013
Snow Water Equivalent (in)
Percent Seasonal Average
Past
Future
10-01 10-31 11-30 12-31 01-30 03-01 04-01 05-01 05-31 07-01 07-31 08-30 09-30
Date
Median 1981-2010
Average 1981-2010
2013
2012

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



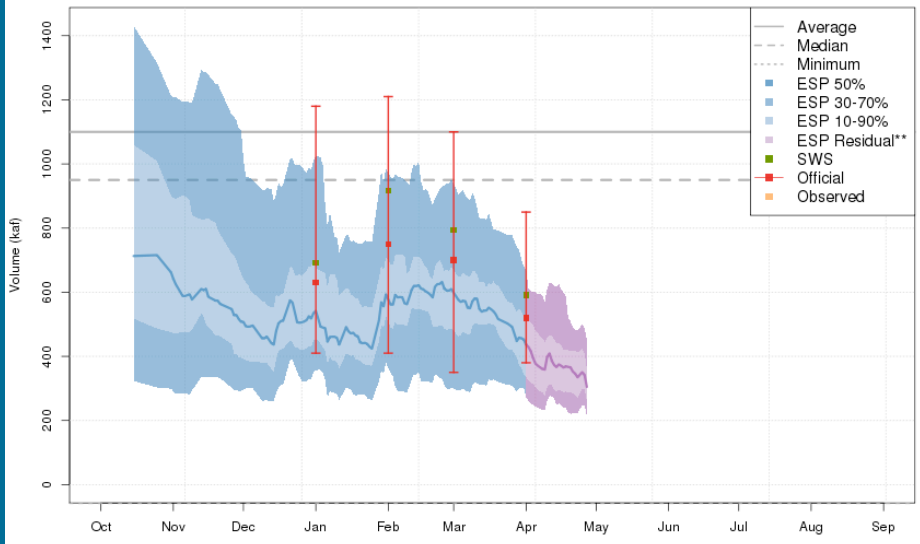
Plot Created 2013-04-28 15:44:45, Lastest ESP Run from 2013-04-01, CBRFC / NWS / NOAA
Maximum of 6798.8 in 1917, Minimum of 613.7 in 1934, Average/Median for 1981-2010.
**No residual observations available, ESP Residual is not total runoff.

2013 Runoff Forecast Apr-Jul
Colorado - Kremmling- Nr (KRMC2)



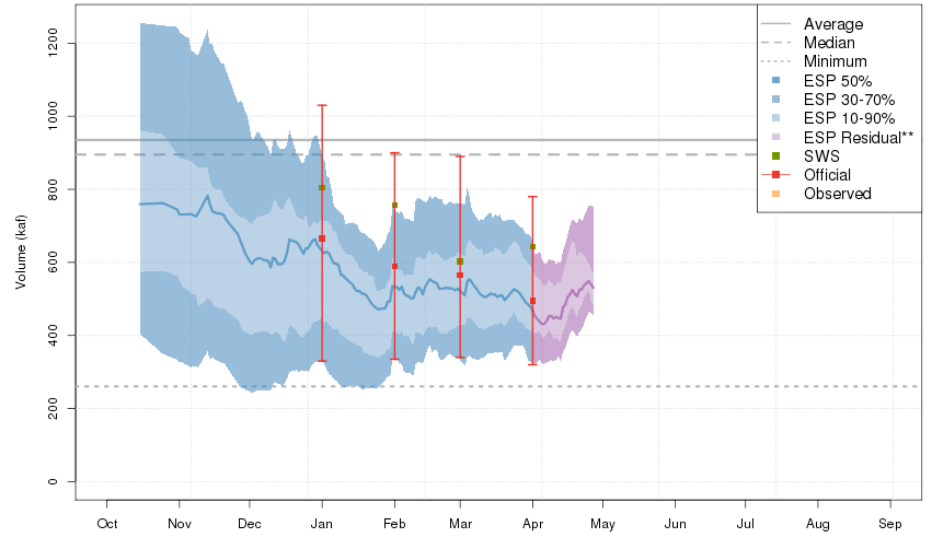
Plot Created 2013-04-28 15:45:13, Lastest ESP Run from 2013-04-01, CBRFC / NWS / NOAA
Maximum of 1766.9 in 2011, Minimum of 245.7 in 2002, Average/Median for 1981-2010.
**No residual observations available, ESP Residual is not total runoff.

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



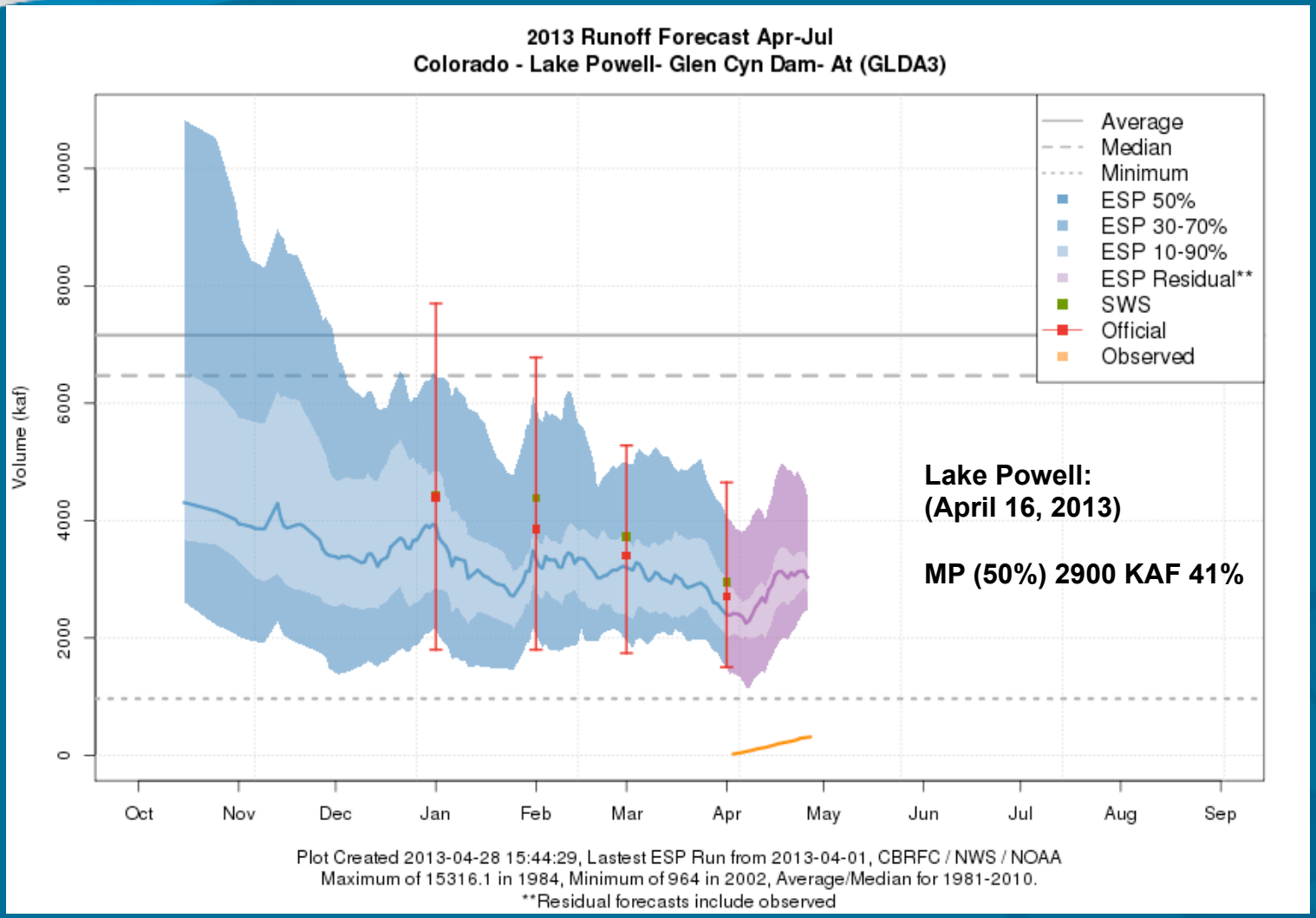
Plot Created 2013-04-28 15:42:26, Lastest ESP Run from 2013-04-01, CBRFC / NWS / NOAA
Maximum of 3175.2 in 1941, Minimum of -61.2 in 2002, Average/Median for 1981-2010.
**No residual observations available, ESP Residual is not total runoff.

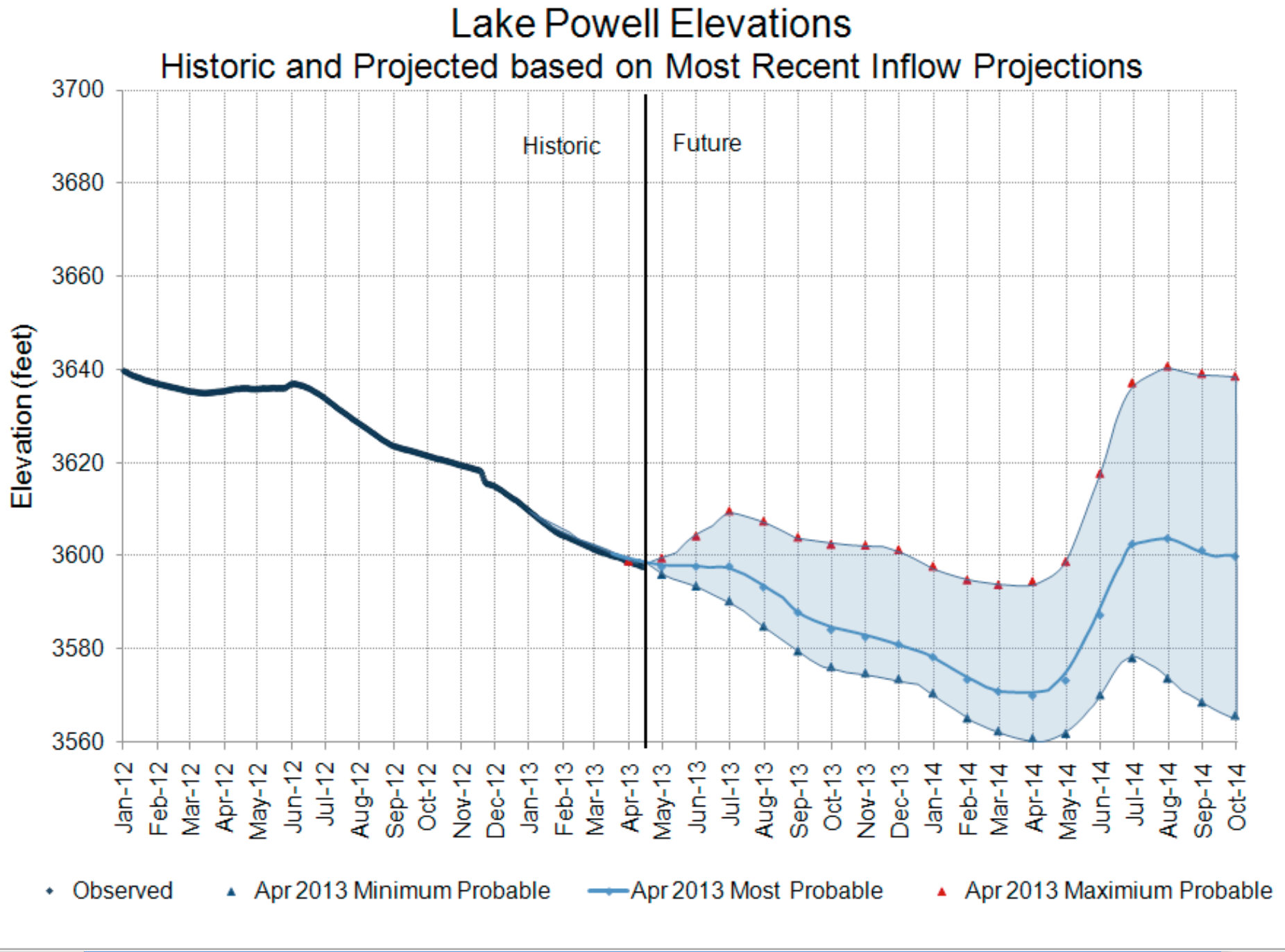
2013 Runoff Forecast Apr-Jul
Yampa - Maybell- Nr (MBLC2)



Plot Created 2013-04-28 15:45:37, Lastest ESP Run from 2013-04-01, CBRFC / NWS / NOAA
Maximum of 1987.9 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




Lake Powell Elevations
Historic and Projected based on Most Recent Inflow Projections
Historic
Future
Elevation (feet)
3700
3680
3660
3640
3620
3600
3580
3560
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Observed
Apr 2013 Minimum Probable
Apr 2013 Most Probable
Apr 2013 Maximium Probable

Lake Powell & Lake Mead
Operational Diagrams for 2010

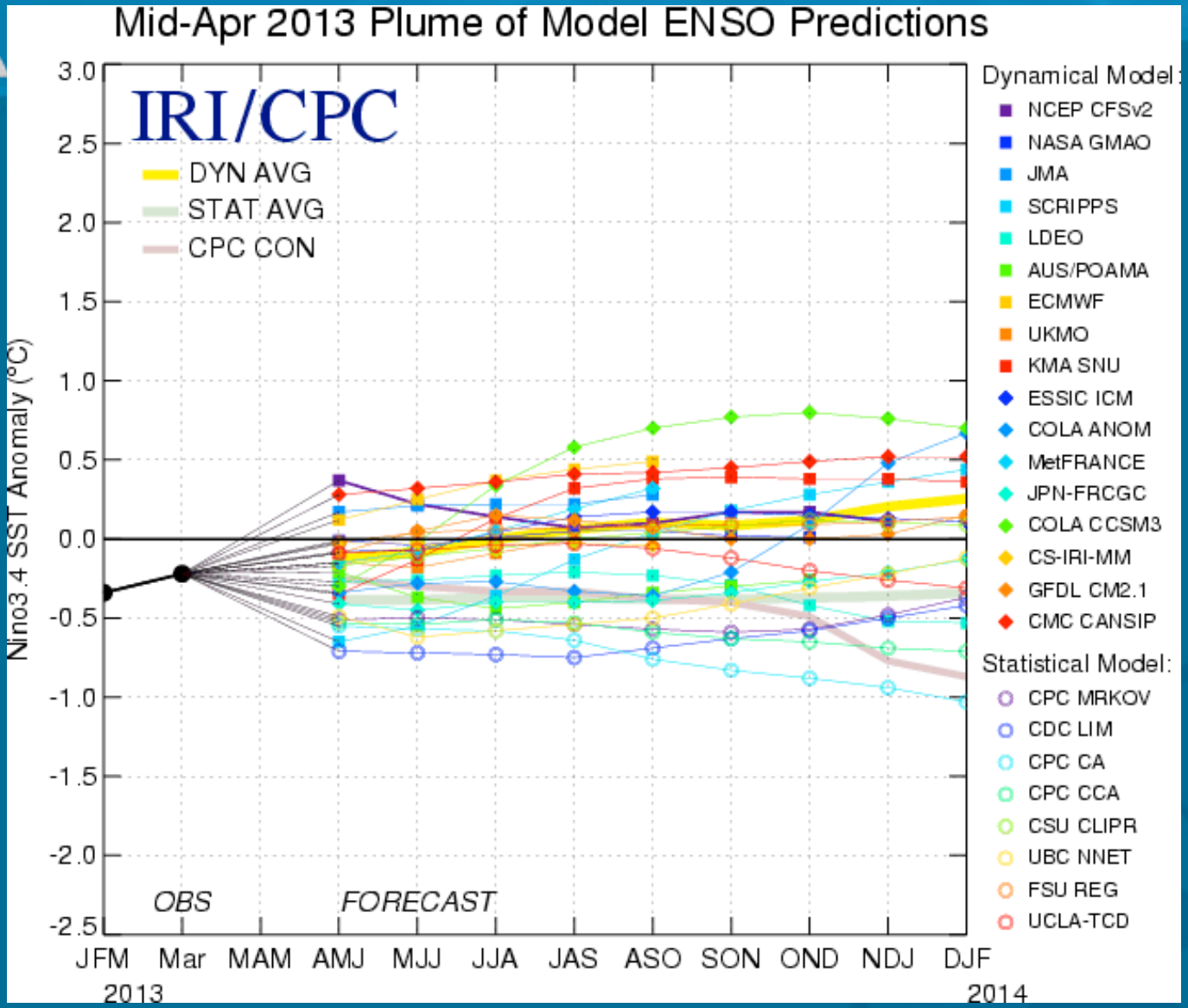
Upper Colorado Reservoir Management

Major releases depend on CBRFC April 1 Forecasts

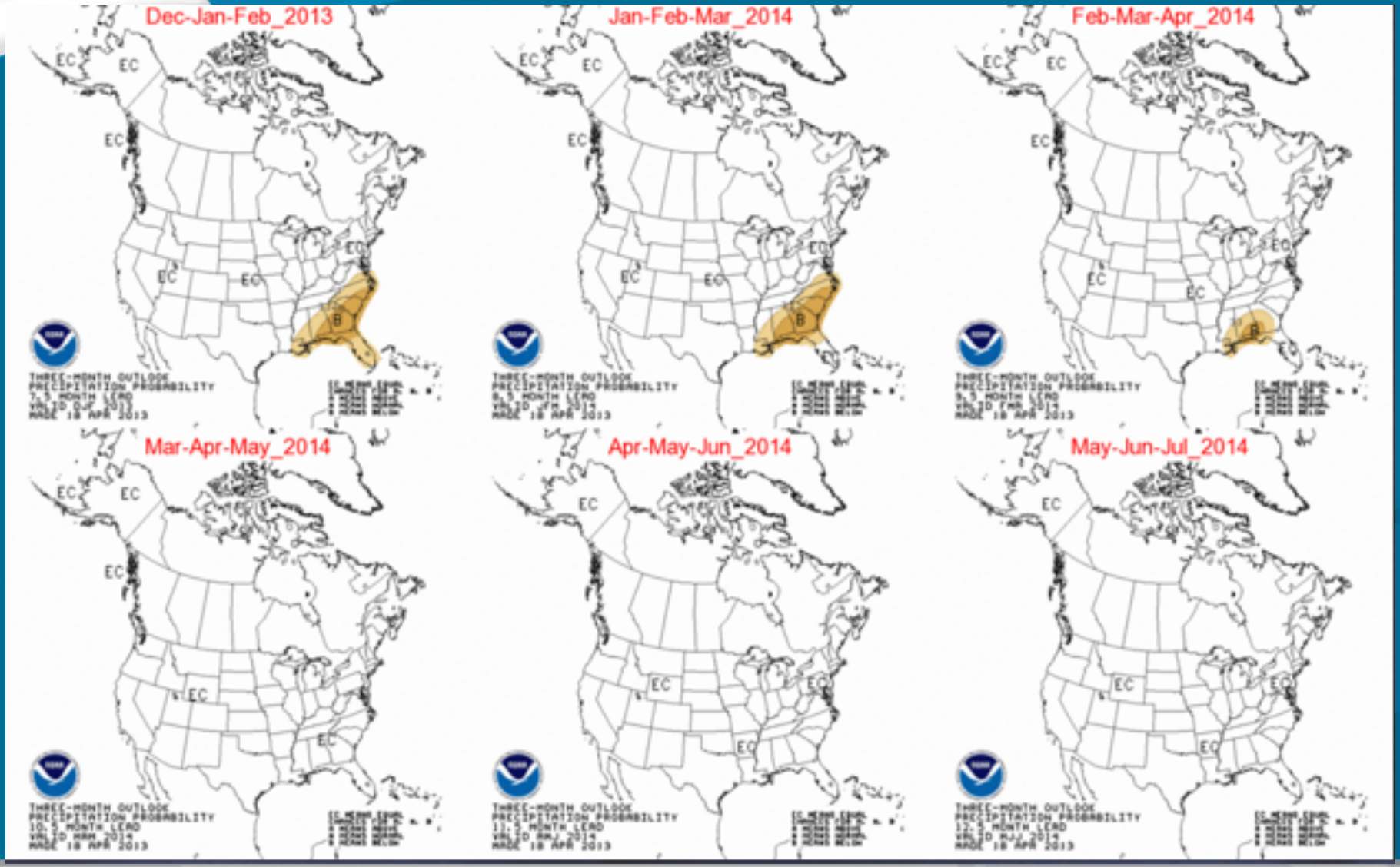
Lake Powell		
Elevation (feet)	**Opertaions According to Interim Guidelines**	**Live Storage (MAF)**
3,700	**Equalization Tier** Equalize, Avoid Spills or Release 8.23 MAF	**24.3**
3,636 - 3,666 (2008-2026)		**15.5 - 19.3** (2008-2026)
	Upper Elevation Balancing Tier[1] Release 8.23 MAF; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 MAF	
3,575		**9.5**
	Mid-Elevation Release Tier Release 7.48 MAF; if Lake Mead < 1,025 feet, Release 8.23 MAF;	
3,525		**5.9**
	Lower Elevation Balancing Tier Balance contents with a min/max release of 7.0 and 9.5 MAF	
3,490		**4.0**
3,370		**0**

Lake Mead		
Elevation (feet)	**Opertaions According to Interim Guidelines**	**Live Storage (MAF)**
1,220	**Flood Control, 70R or ICS Surplus**	**25.9**
1,200		**22.9**
	Domestic or ICS Surplus	
1,145		**15.9**
1,105	**Normal Operations or ICS Surplus**	**11.9**
1,075		**9.4**
	Shortage 333 KAF[2]	
1,050		**7.5**
	Shortage 417 KAF[2]	
1,025		**5.8**
	Shortage 500 KAF[2] and Consultation[3]	
1,000		**4.3**
895		**0**

ENSO Neutral



CPC Precipitation Outlook



2014 Outlook

- *Dry antecedent conditions*
- *Model trends back to normal*

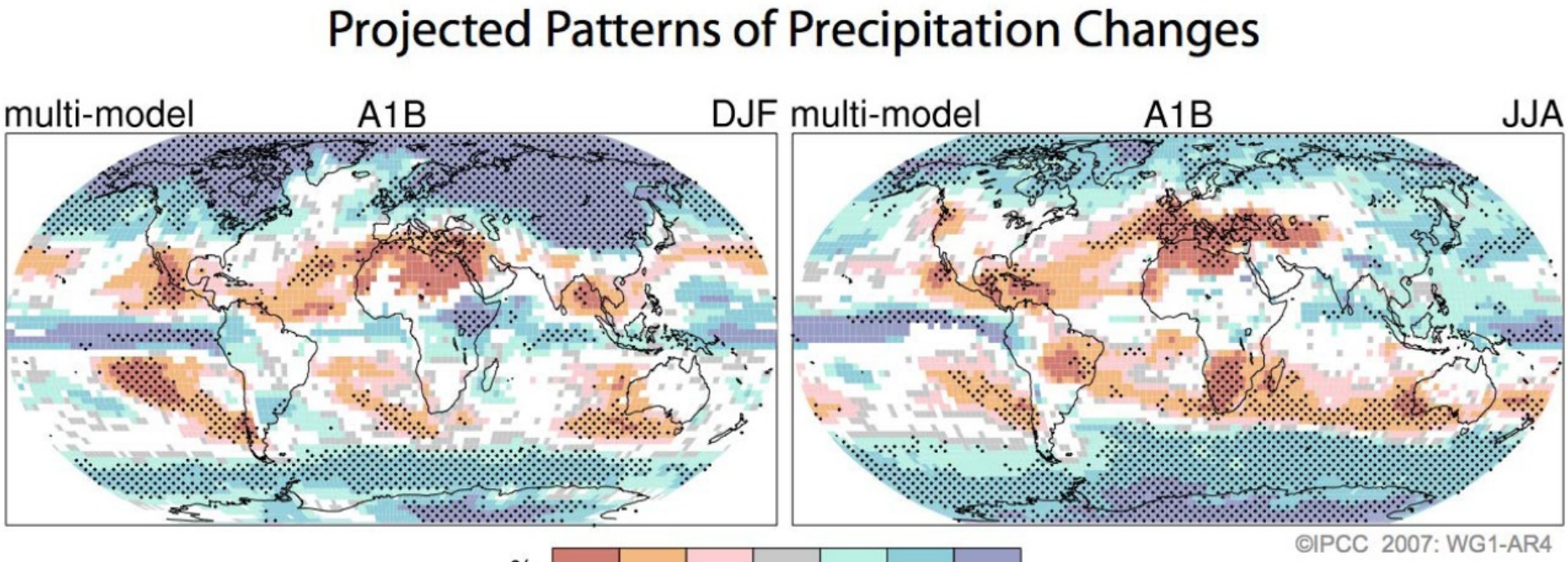
- *Water supply forecasts for Lake Powell 2014: 85-90% of average.*

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)



From IPCC 4th Assessment Report

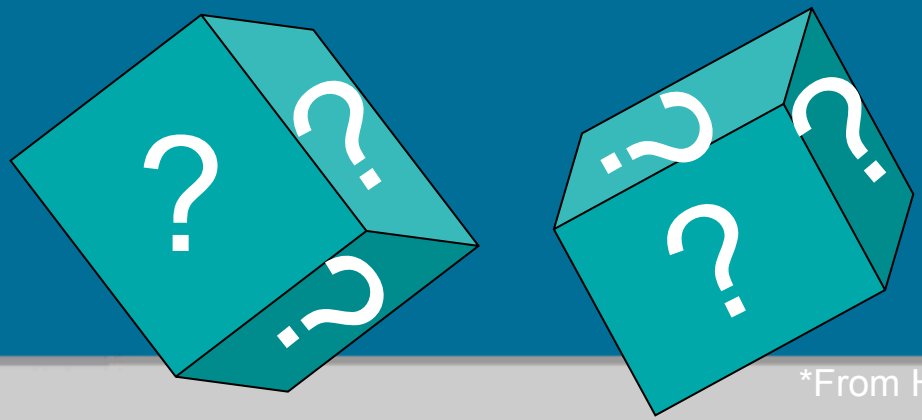
Adapted from Western Water Assessment

Loading the climate dice*

Assume the period from 1951 – 1980 as a "base period"

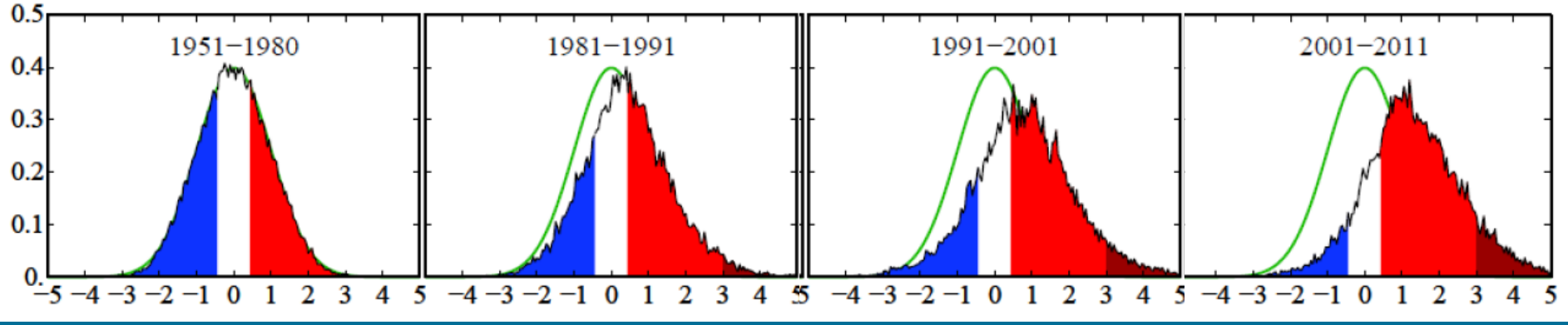
- **Relatively stable global temperature**
- **Within the Holocene range, which is a period of time that the natural world and civilization adapted to**

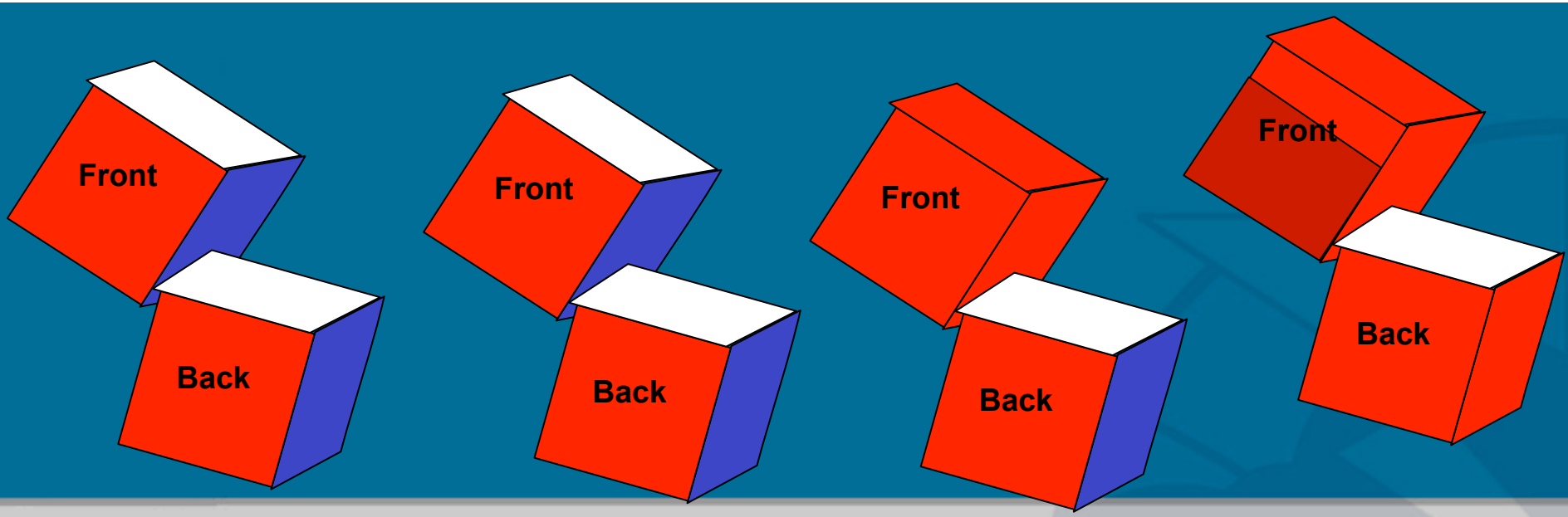
Fit the information to a standard bell curve



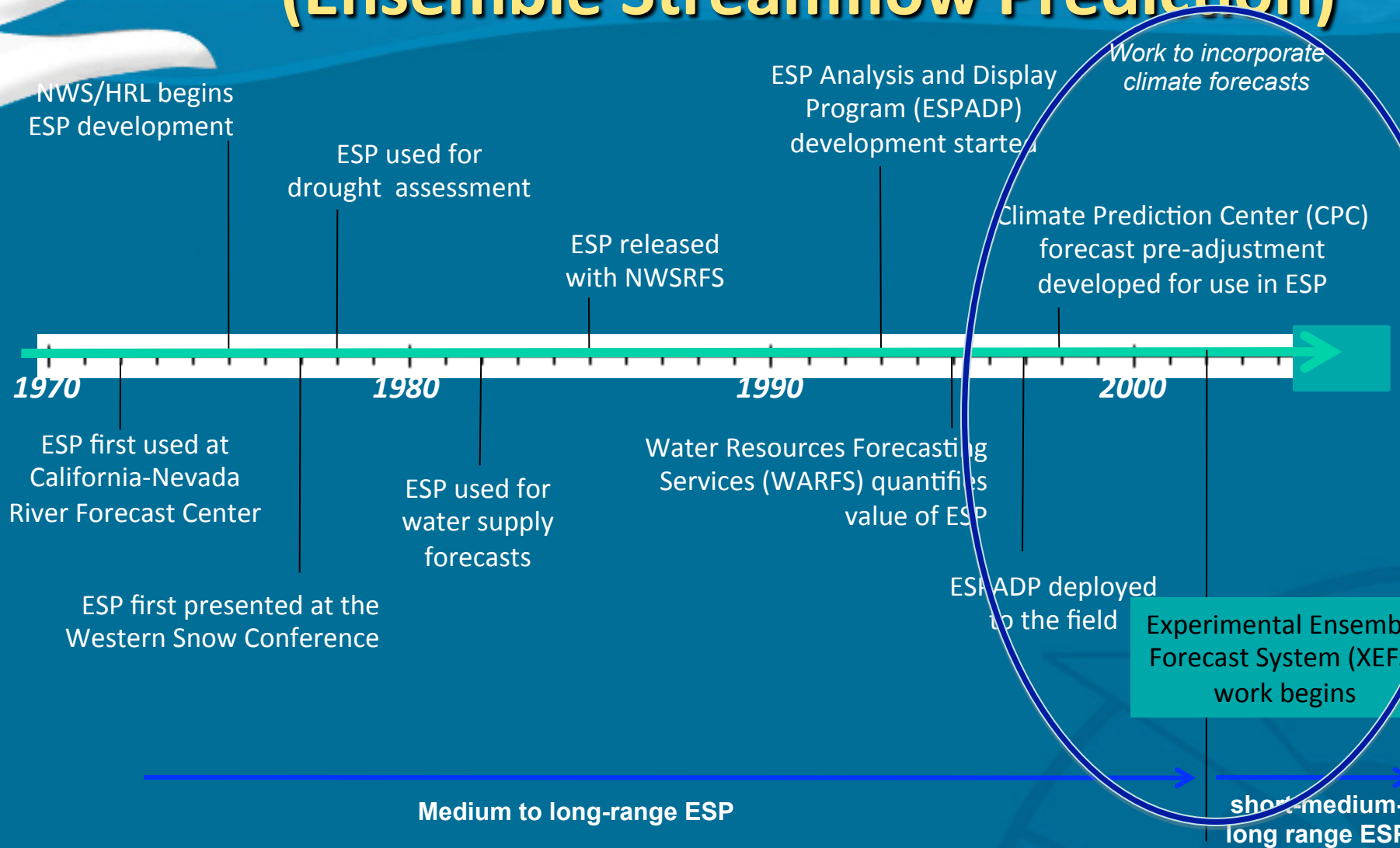
*From Hansen et al. 2012

Loading the climate dice





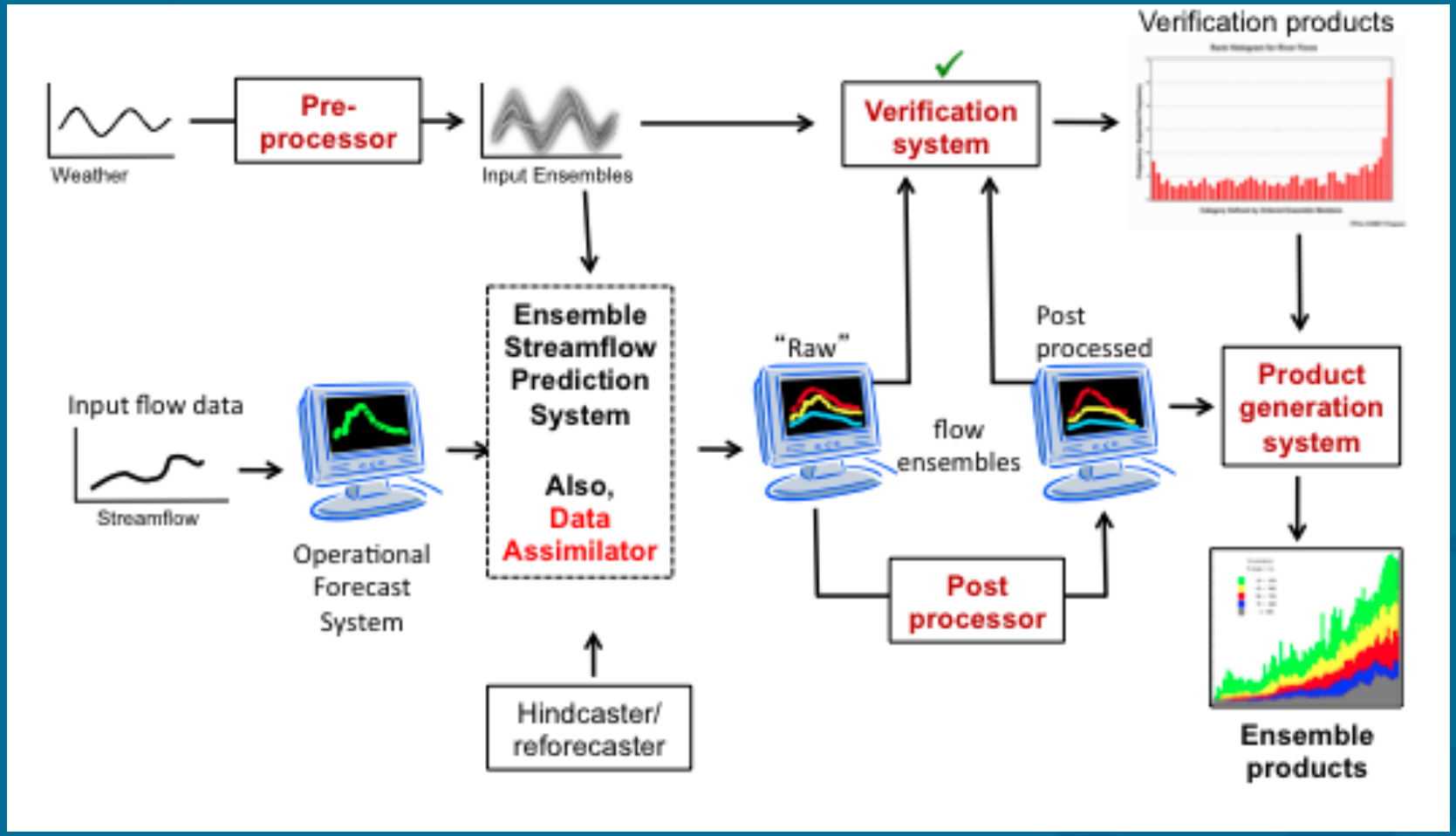
Historic development of ESP (Ensemble Streamflow Prediction)



Info

Western Snow Conference paper, 1977

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?

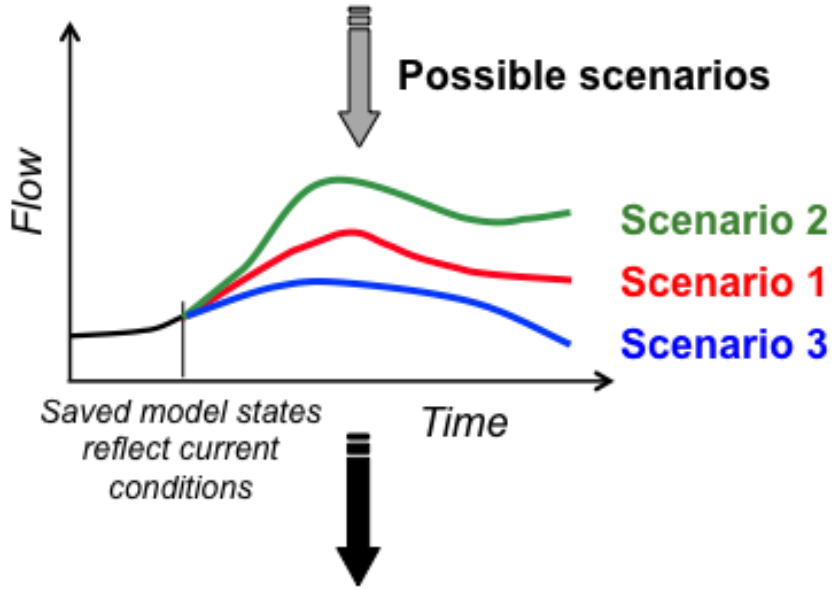
- ***When we figure out how to adapt to it!***
  - **Build upon current cooperative and collaborative relationships to provide stakeholders with the tools they need to make informed and beneficial decisions.**
  - **Reach out to those that are unaware of the tools and resources available to them at the 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

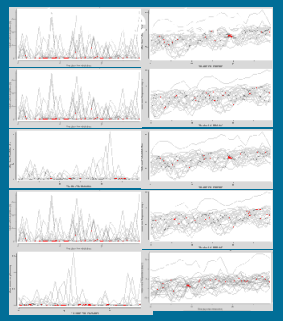
Multiple streamflow scenarios with historic meteorological or forecast weather/climatic data



Results used in statistical analysis to produce forecasts with probabilistic values

Historical time series of precipitation and

81
82
83
84
85



CBRFC: Currently using water years 1981-2010

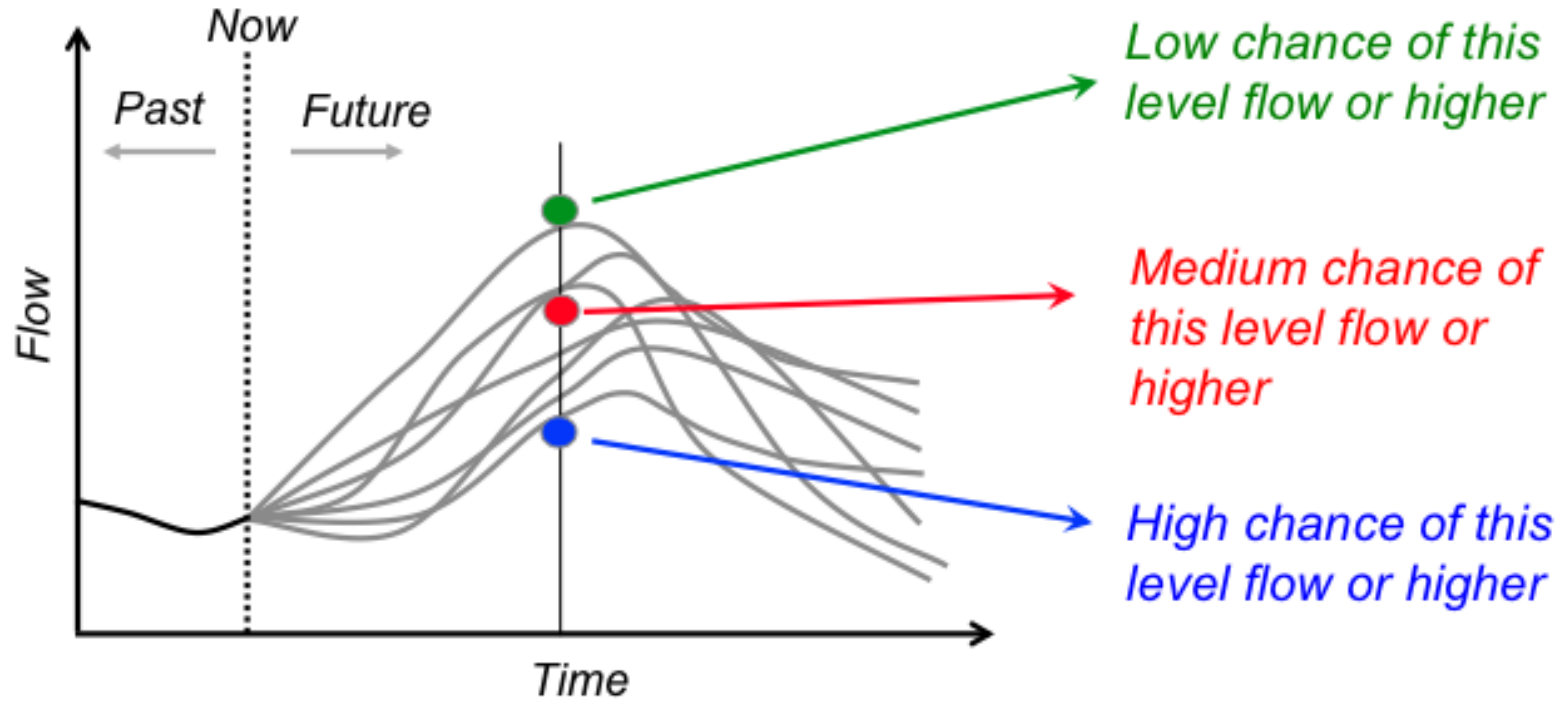
Can also include forecast precipitation and temperature.

CBRFC:

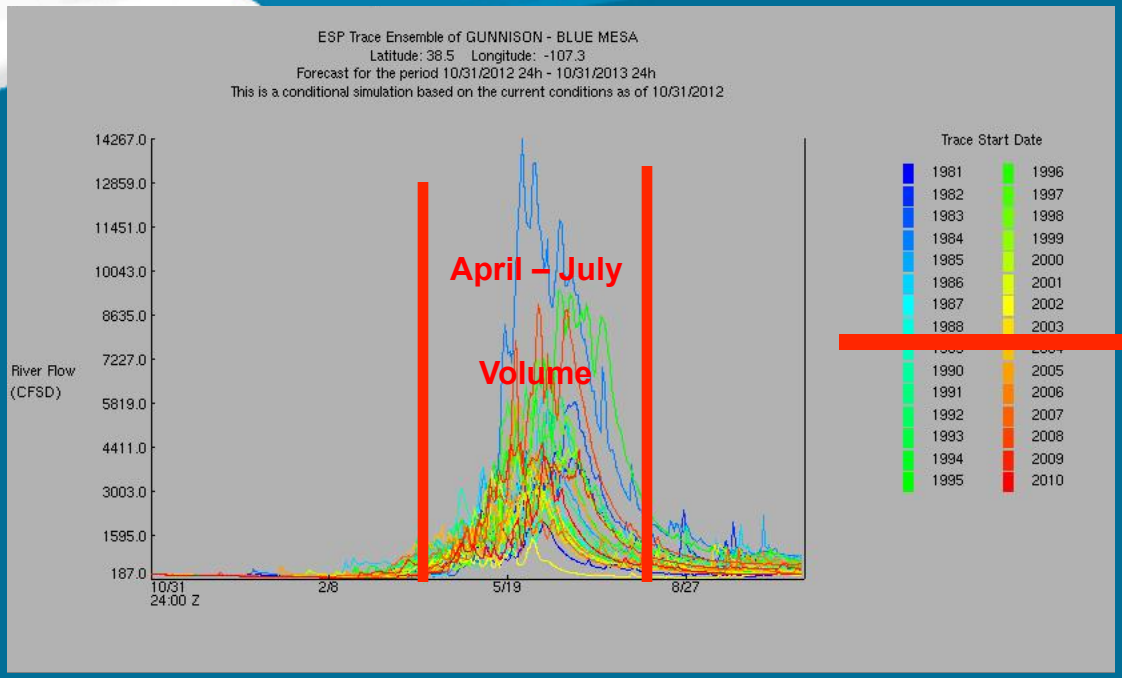
- *10 days of forecast max/min temperatures.*
- *5 days of forecast precipitation and 0 days of forecast precipitation*

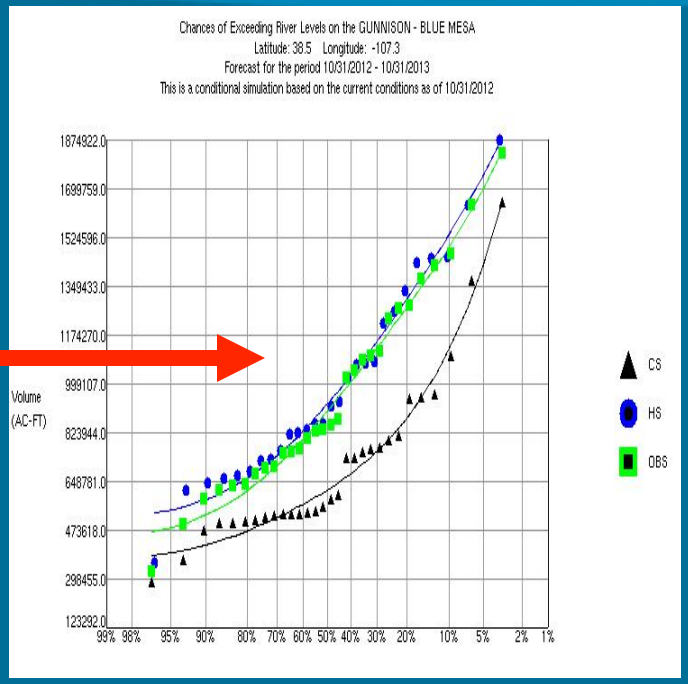
More information available from COMET: www.meted.ucar.edu/hydro/ESP/Intro/

ESP Technique (cont.)



ESP - cont



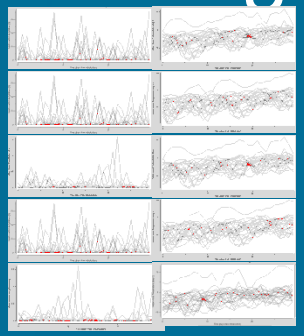


1. Select a forecast window
2. Select a forecast variable
3. Model derives a distribution function
4. 50% exceedance value = most probable forecast
5. Also use 10%/90% levels

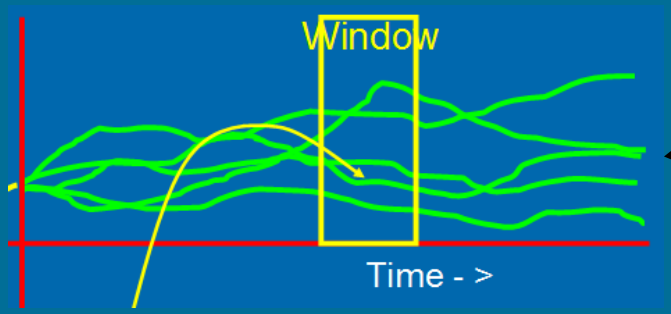
# Exceedance Probabilities	Conditional Simulation	Historical Simulation	Historical Observed
0.900	417330.156	581462.500	525460.000
0.750	493856.750	699928.938	659224.812
0.700	517683.500	741569.312	705094.750
0.600	565268.875	829048.438	799524.375
0.500	616216.625	923809.188	898919.562
0.400	676330.375	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

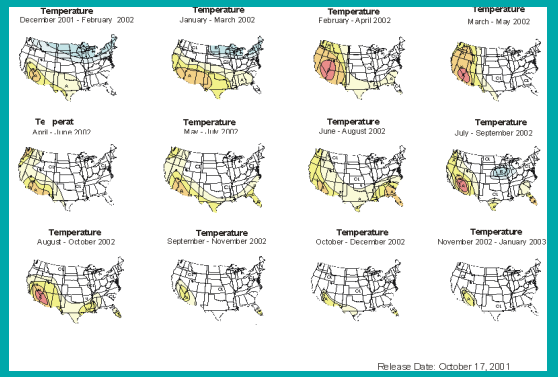
Pre-Adjustment Technique
Weight/Modify Inputs



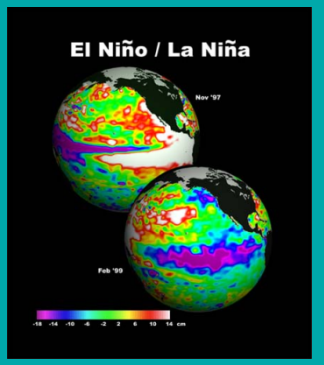
Post-Adjustment Technique
Weight Outputs



Climate Forecasts



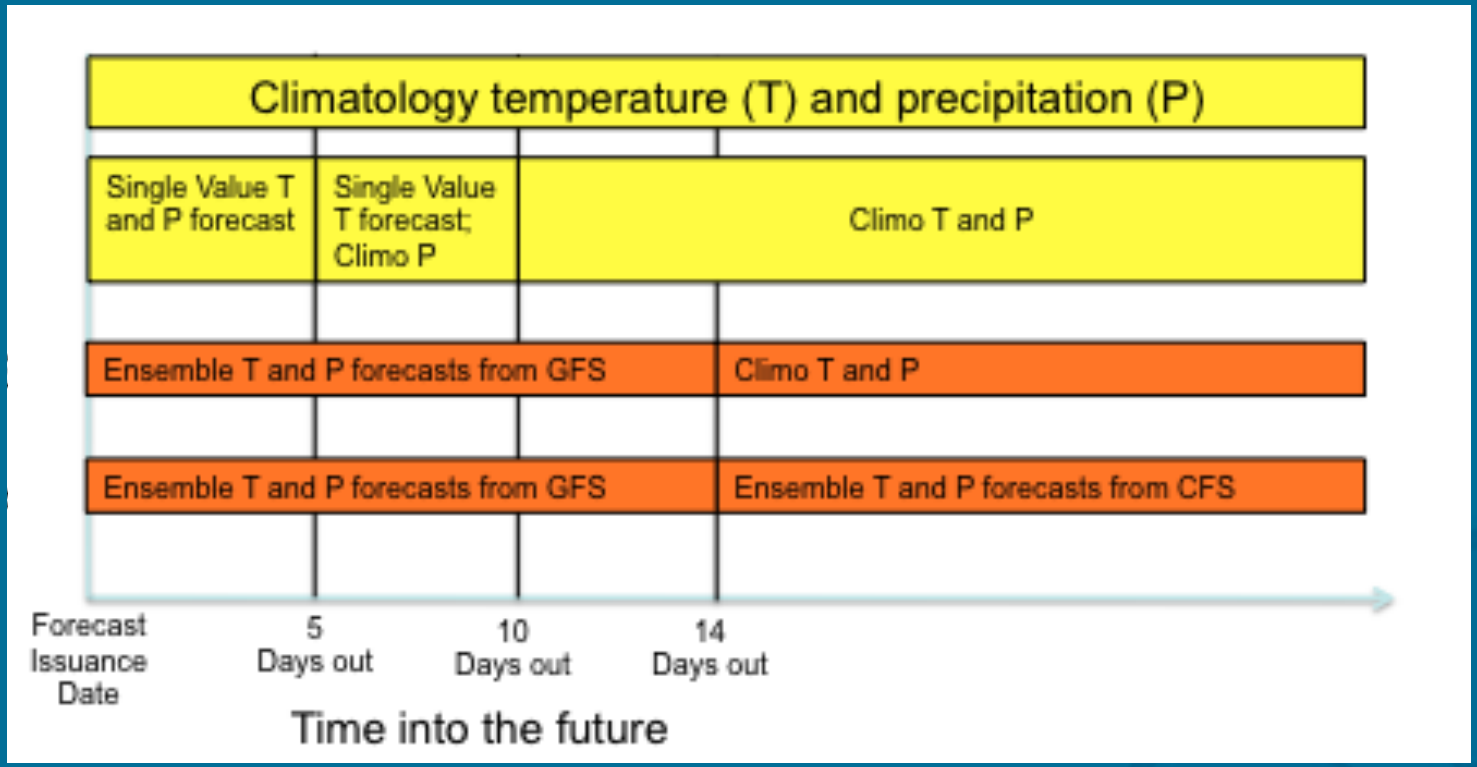
Current and historical ENSO states



HEFS - cont

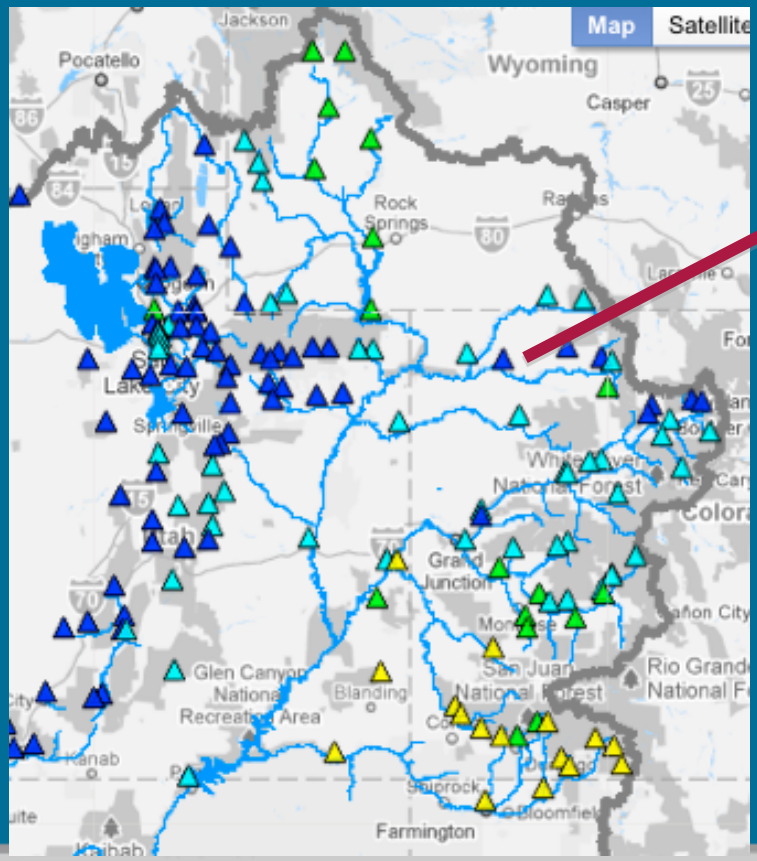
ESP

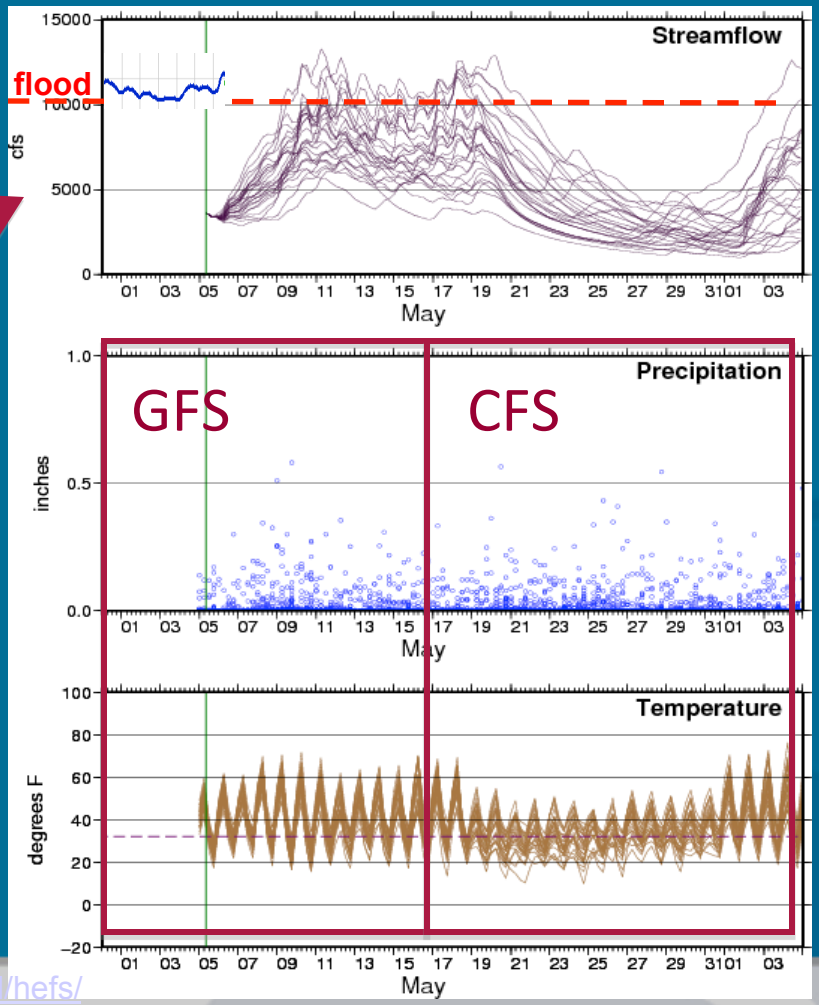
HEFS



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)





www.cbrfc.noaa.gov/devel/hefs/