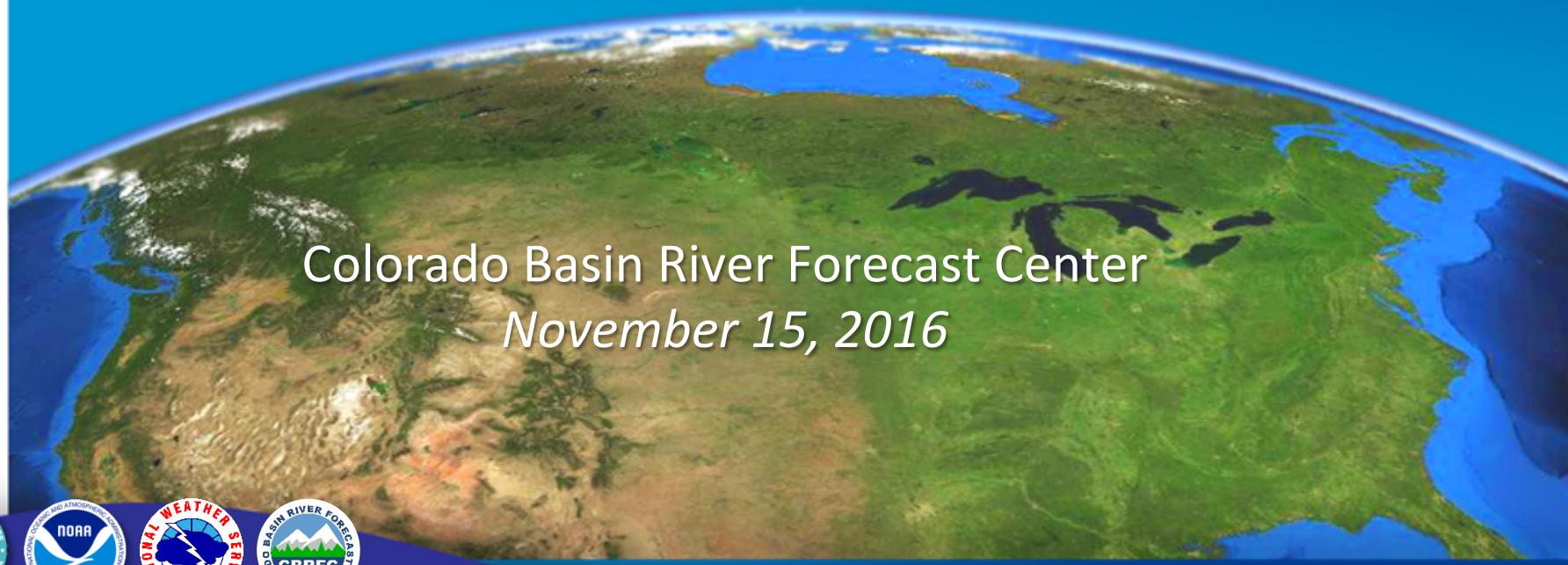
NOAA's Colorado Basin River Forecast Center

2016 Water Supply Verification Briefing



Colorado Basin River Forecast Center

November 15, 2016

Focal Points

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Overview

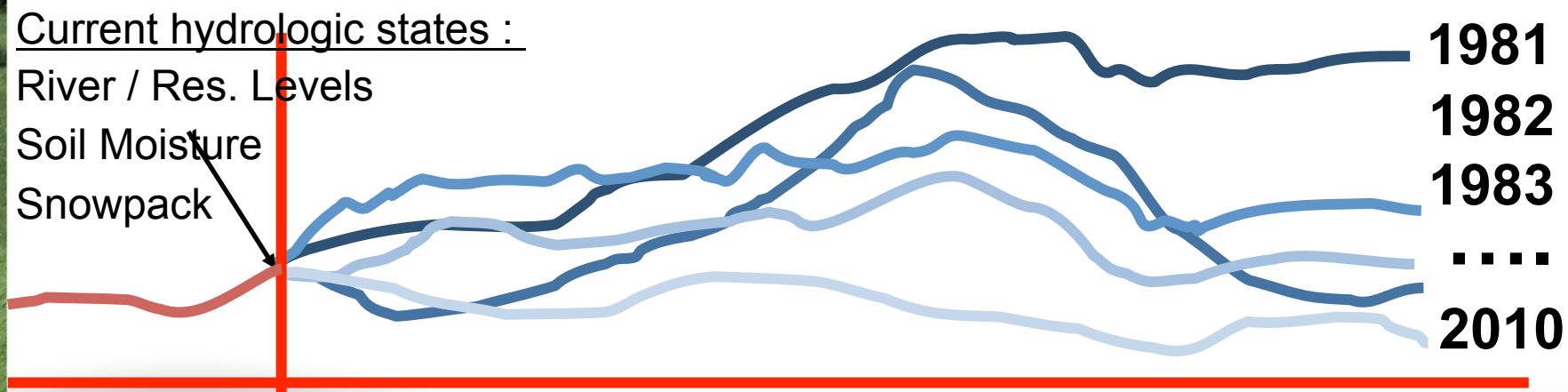
- Take Away Points
- Background
- 2016 Observed Volumes vs. Forecasts
  - Upper Colorado River Basin
  - Great Basin
  - Lower Colorado River Basin
- Forecast Drivers
- Accuracy and Performance
- Summary

The Take Away

- Overall, CBRFC forecasts performed well throughout much of the basin this season
  - Dry and warm February and March conditions, coupled with dry soil moisture conditions, impeded runoff
  - An unusually wet May negatively impacted forecast performance in the Green River Basin
- Great Basin forecasts were impacted by early runoff in March, but some areas in the north did benefit from May precipitation
- Lower Colorado River Basin did not realize forecasted wet El Niño conditions

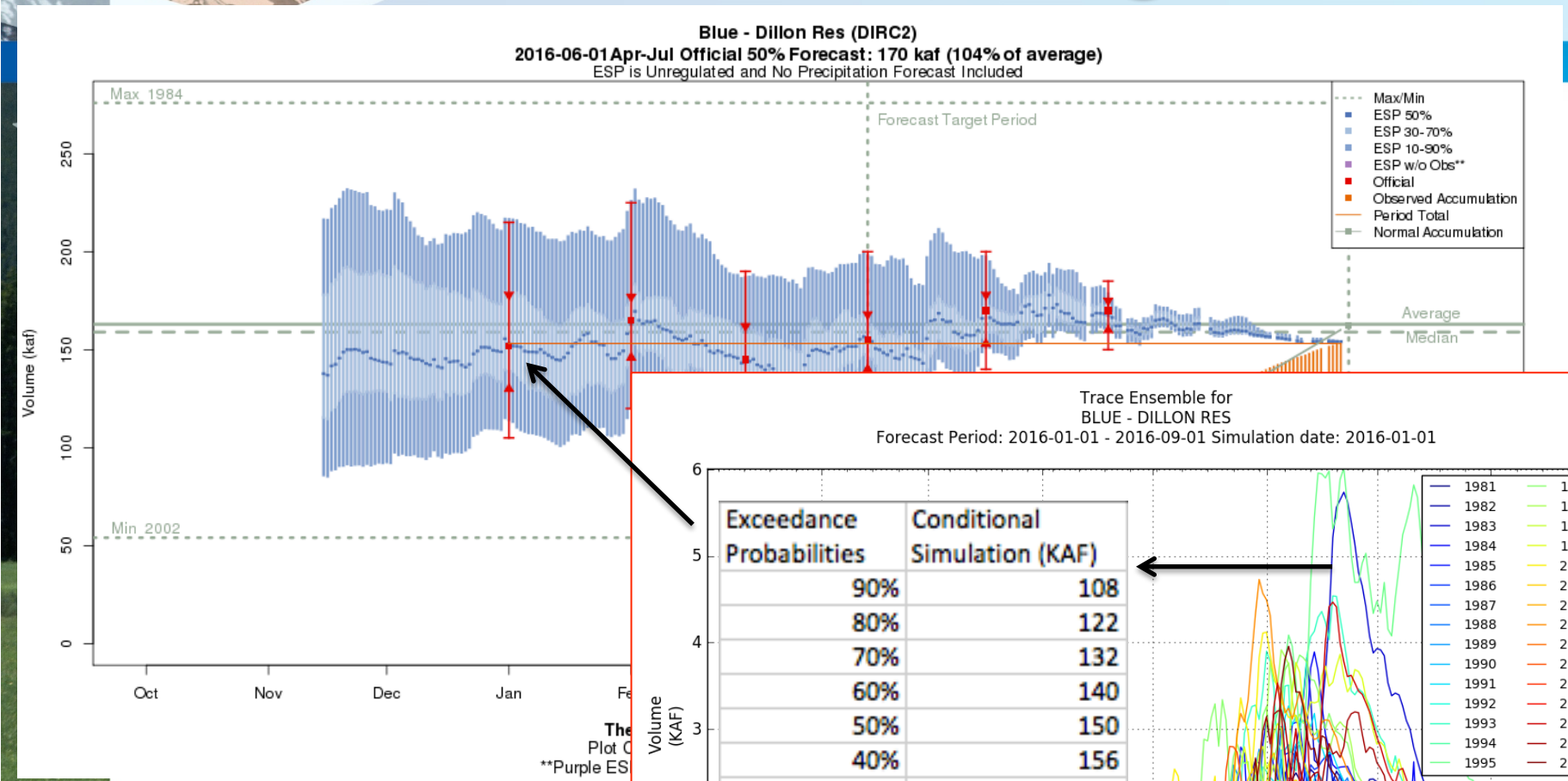
ESP Probabilistic Forecasts

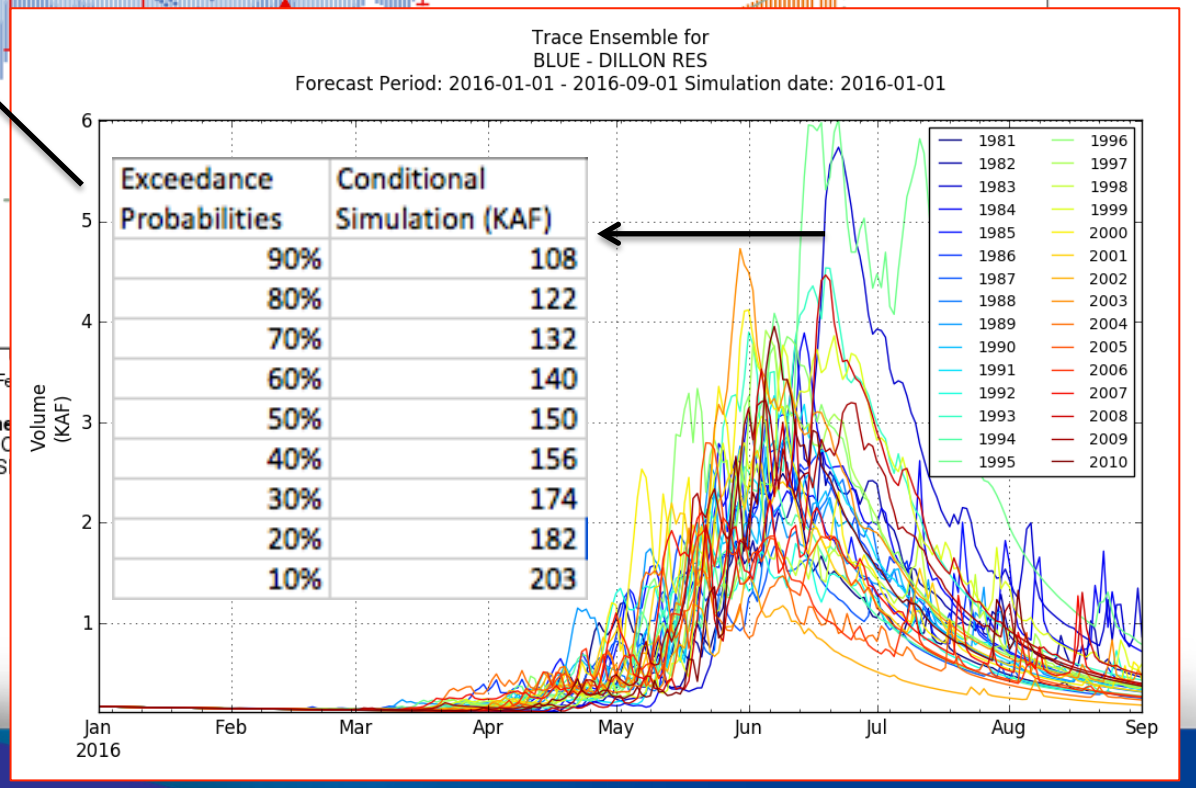
- Start with current conditions (from the daily model run)
- Apply precipitation and temperature from each historical year (1981-2010)
- A forecast is generated for each of the years (1981-2010*) *as if, going forward,* that year will happen
- This creates 30 possible future streamflow patterns. Each year is given a 1/30 chance of occurring



*We are updating this to 1981-2015

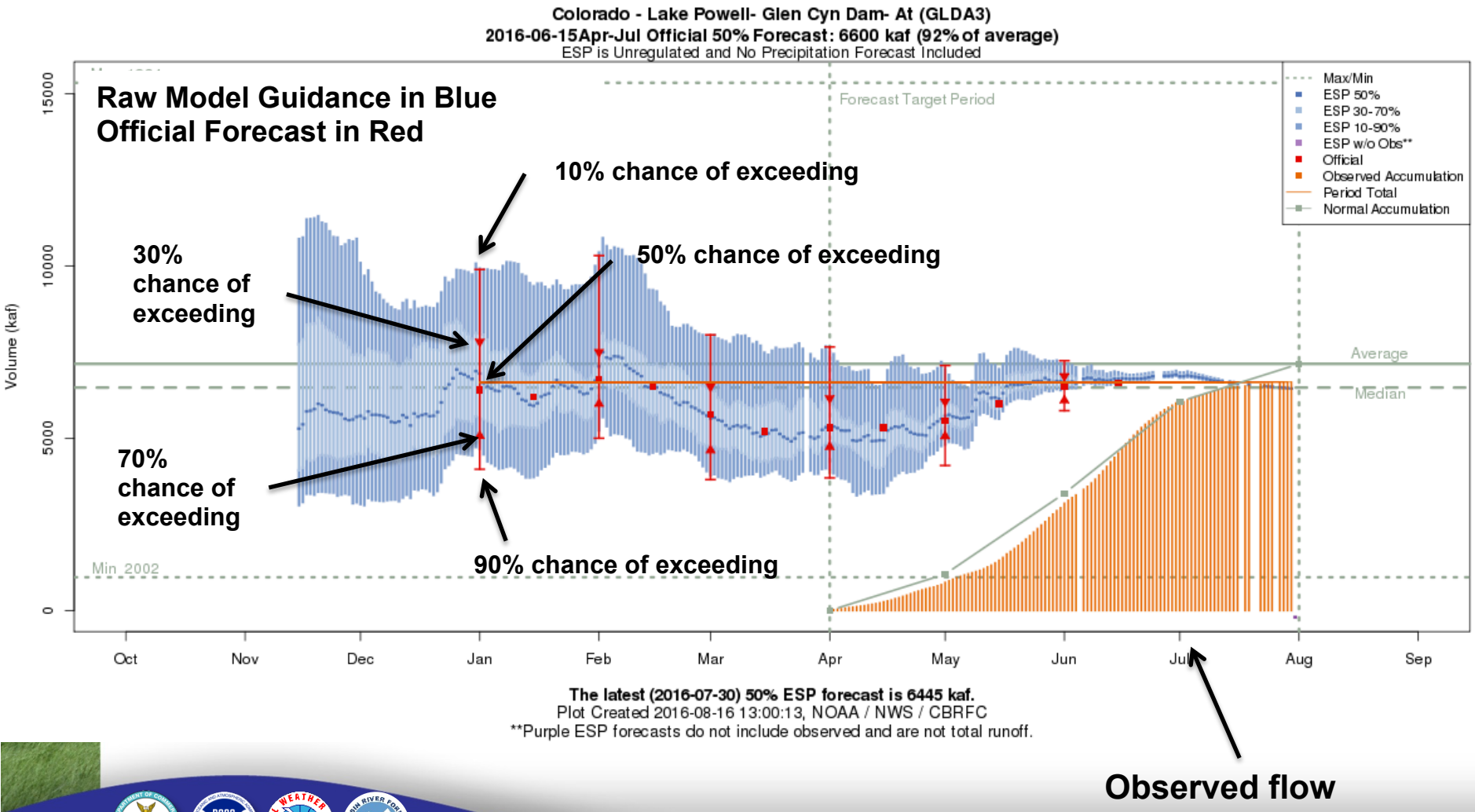
Communicating Forecasts





Exceedance Probabilities	Conditional Simulation (KAF)
90%	108
80%	122
70%	132
60%	140
50%	150
40%	156
30%	174
20%	182
10%	203

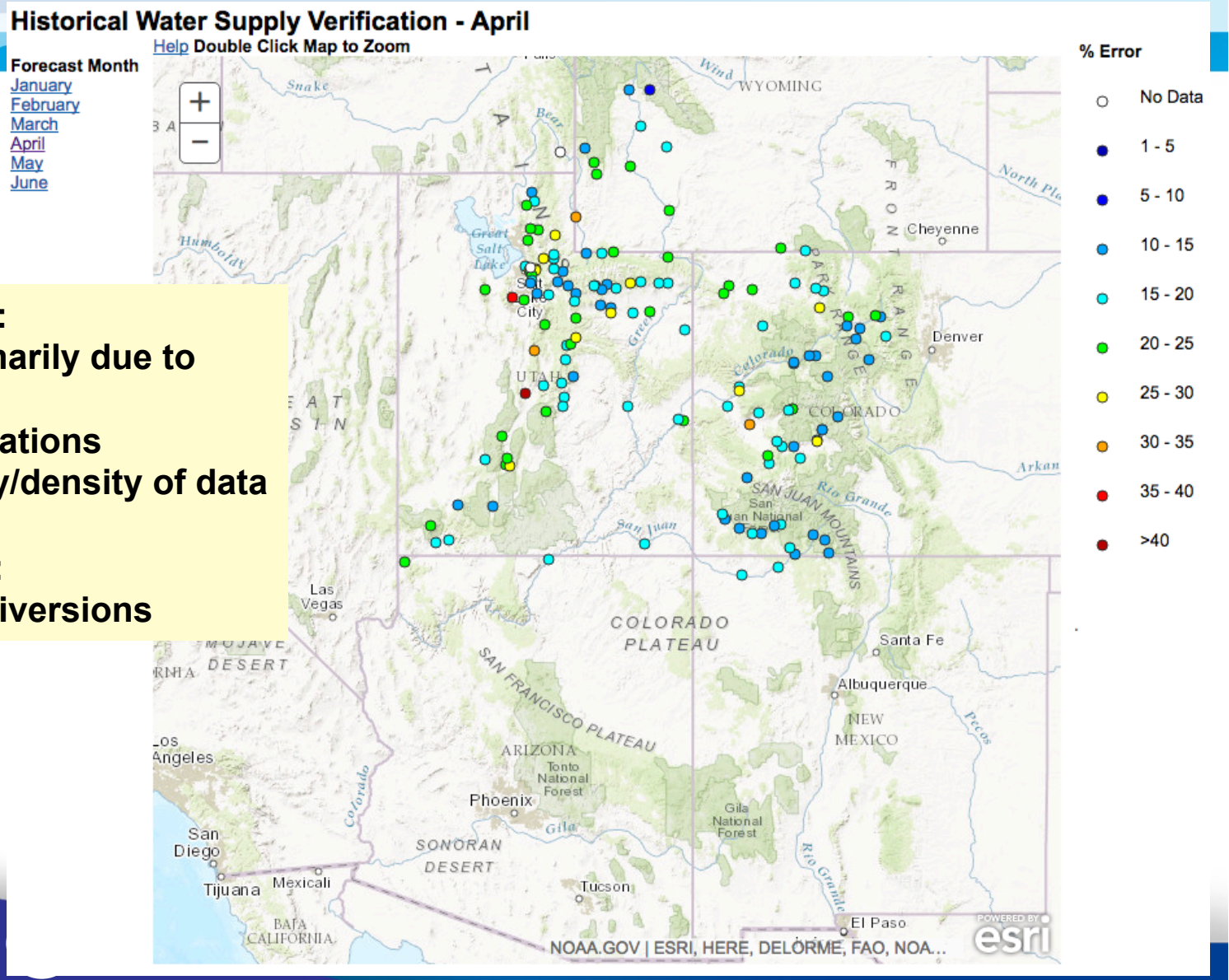
2016 Forecast Progression: Lake Powell



Historical Verification

More Success:
- **Runoff primarily due to snowmelt**
- **Higher elevations**
- **High quality/density of data**

Less Success:
- **Unknown diversions**



2016 Verification

2016 Water Supply Verification - April

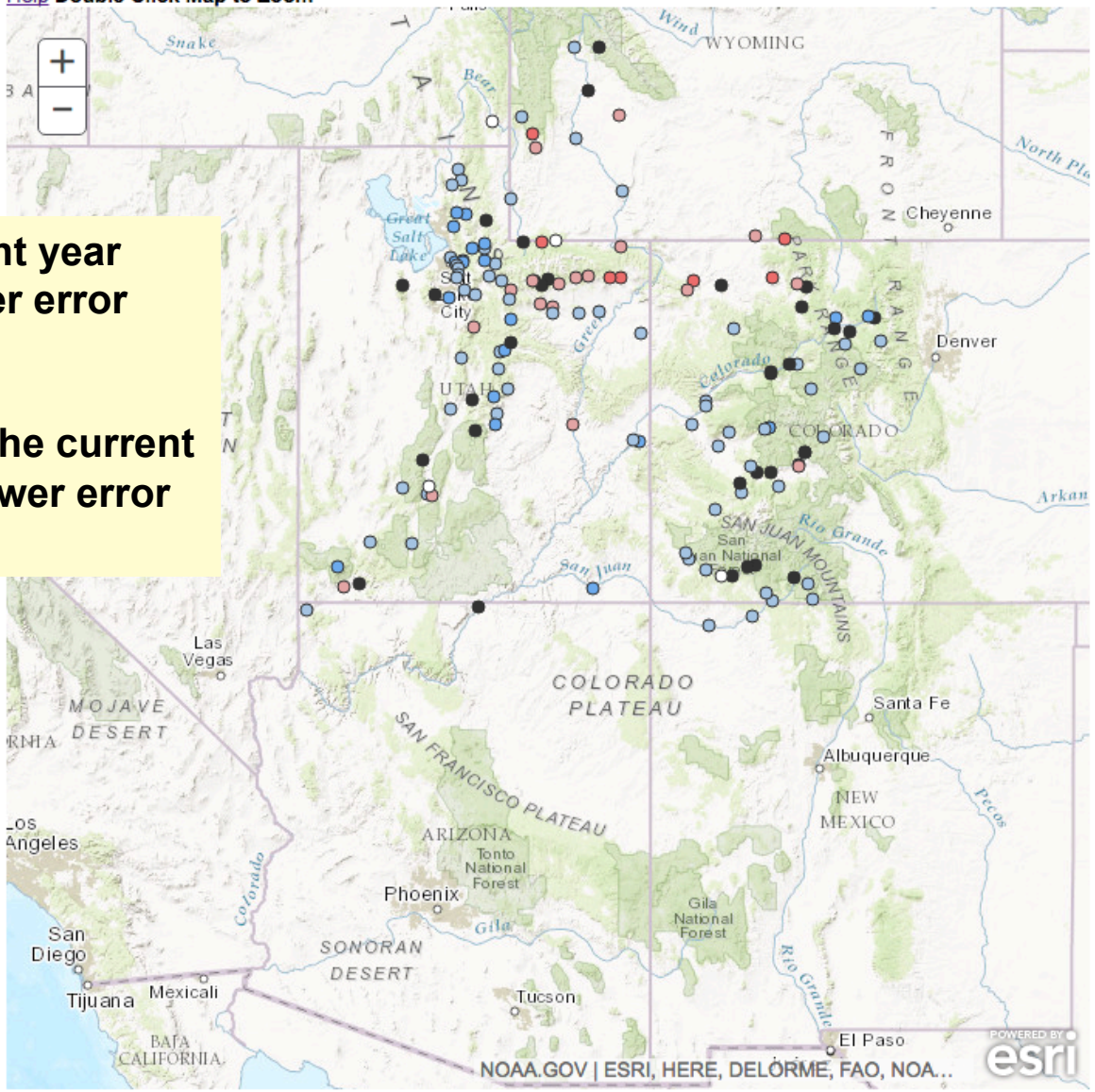
Help Double Click Map to Zoom

Forecast Month

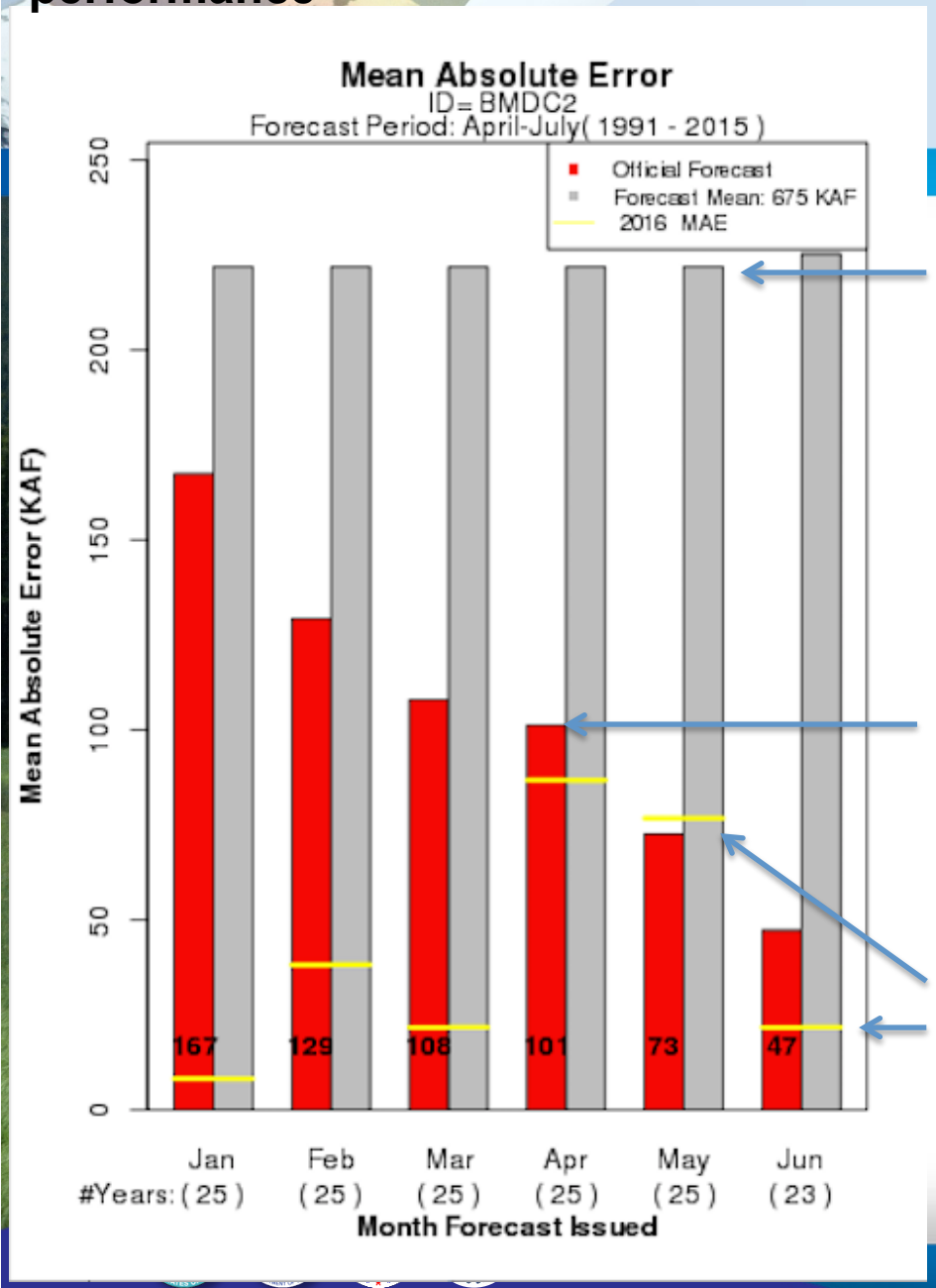
January
February
March
April
May
June

Red indicates current year forecast had a higher error than the ESP model

Blue indicates that the current year forecast had lower error than the ESP model



Verification: 2016 Monthly Apr-July Forecasts compared to historical performance

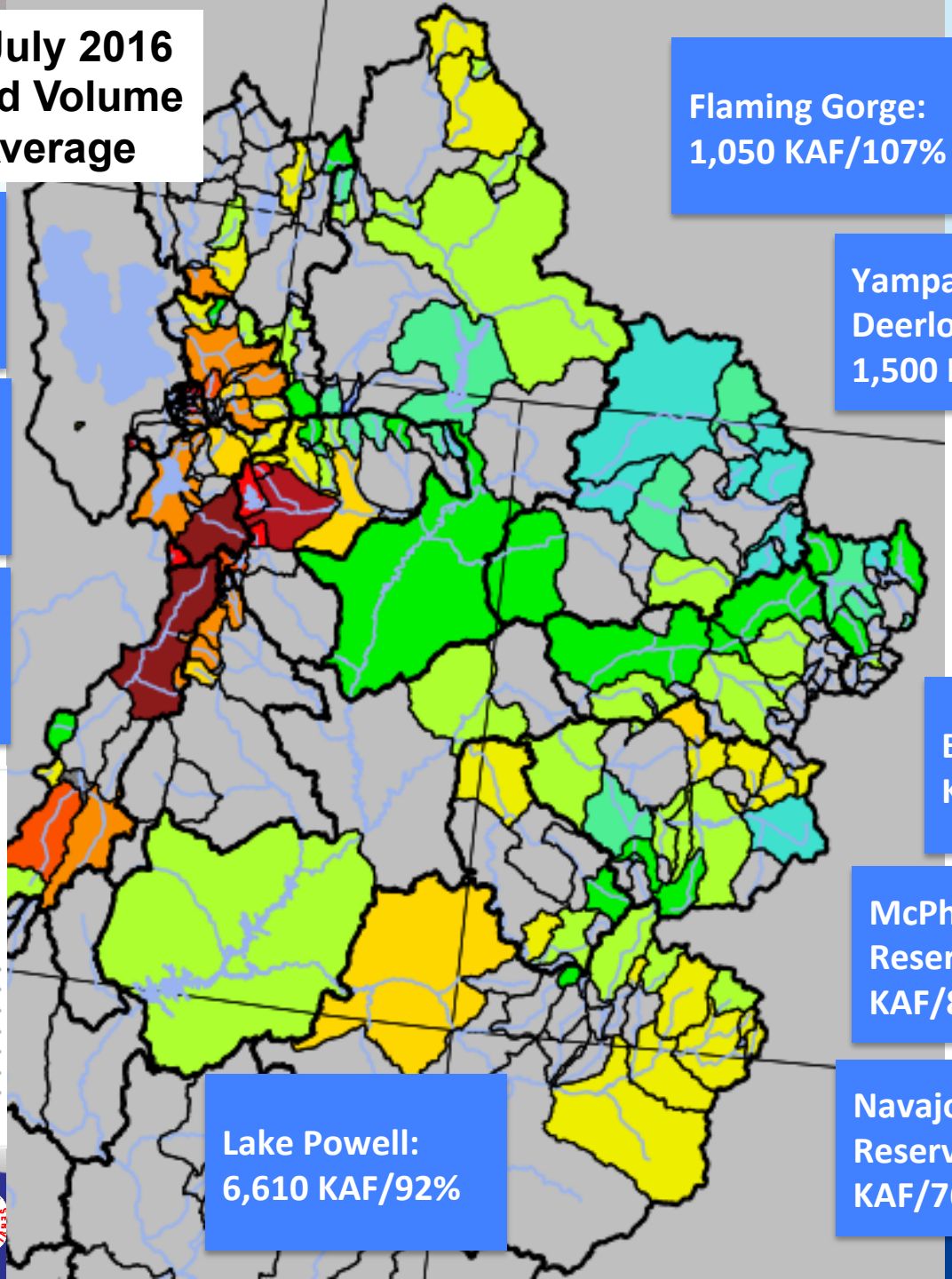


If we were to simply forecast average every time

Our mean forecast error is better than forecasting average

2016 Error (yellow lines)

April – July 2016 Observed Volume % of Average



Bear – UT/WY Stateline: 114 KAF/102%

Weber - Oakley: 98 KAF/83%

Provo - Woodland: 77 KAF/77%

Flaming Gorge: 1,050 KAF/107%

Yampa - Deerlodge: 1,500 KAF/120%

Colorado - Cameo: 2,280 KAF/97%

Blue Mesa: 600 KAF/89%

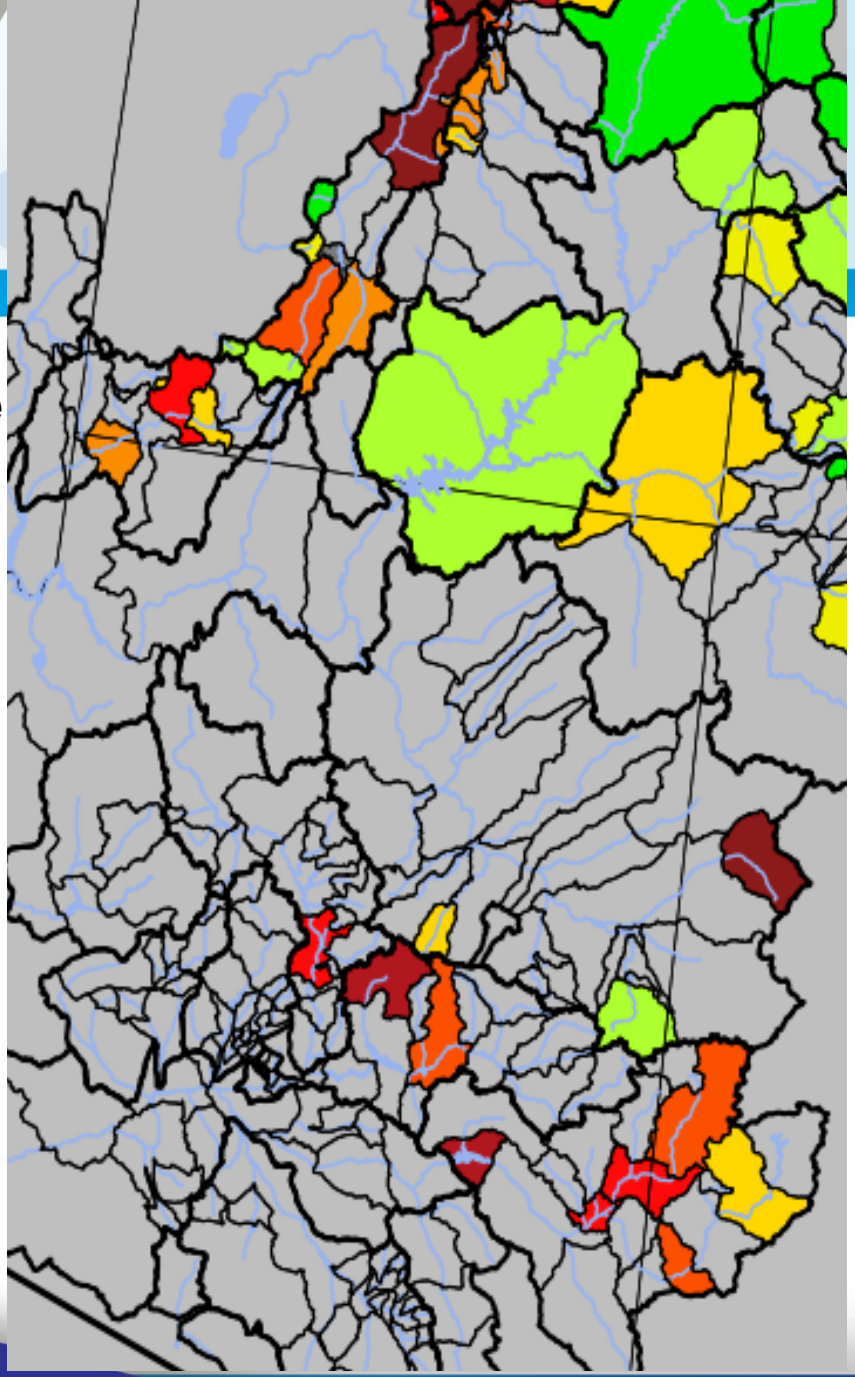
McPhee Reservoir: 240 KAF/81%

Navajo Reservoir: 560 KAF/76%

Lake Powell: 6,610 KAF/92%

April – July Observed Volume % of Average

Virgin - Virgin: 42 KAF/55%



January – May Observed Volume % of Median

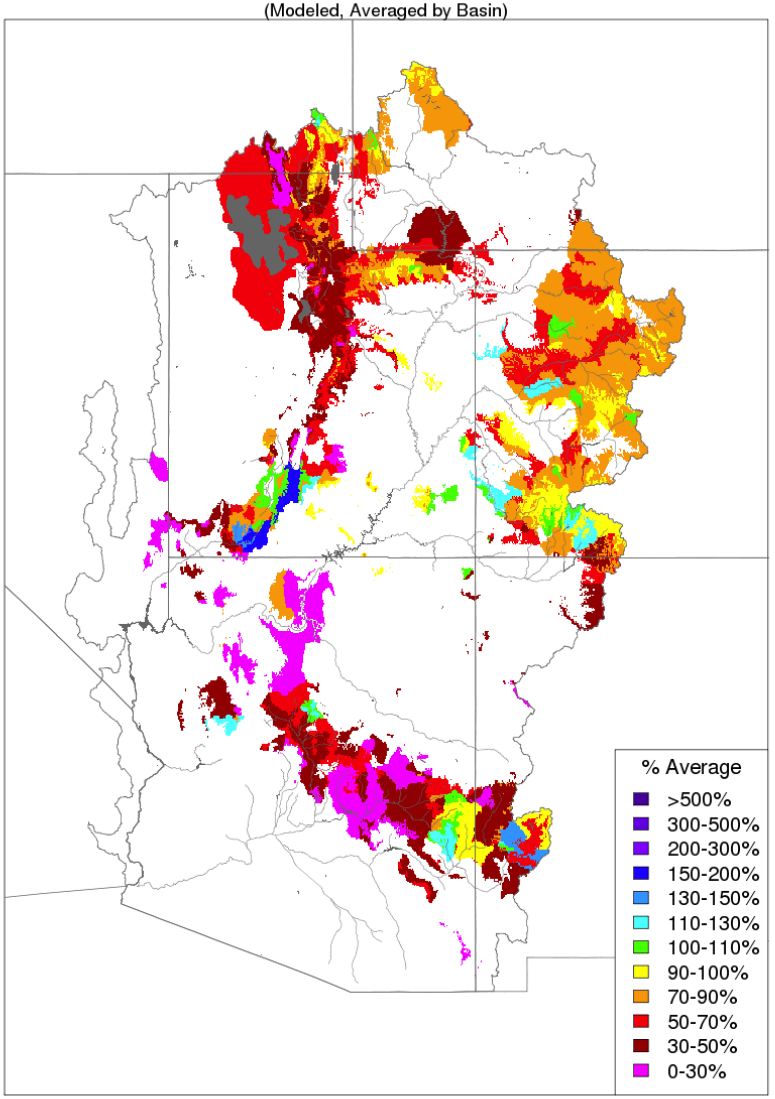
Verde - Horseshoe: 98 KAF/62%

Salt - Roosevelt: 210 KAF/68%

Gila - Gila: 49 KAF/88%

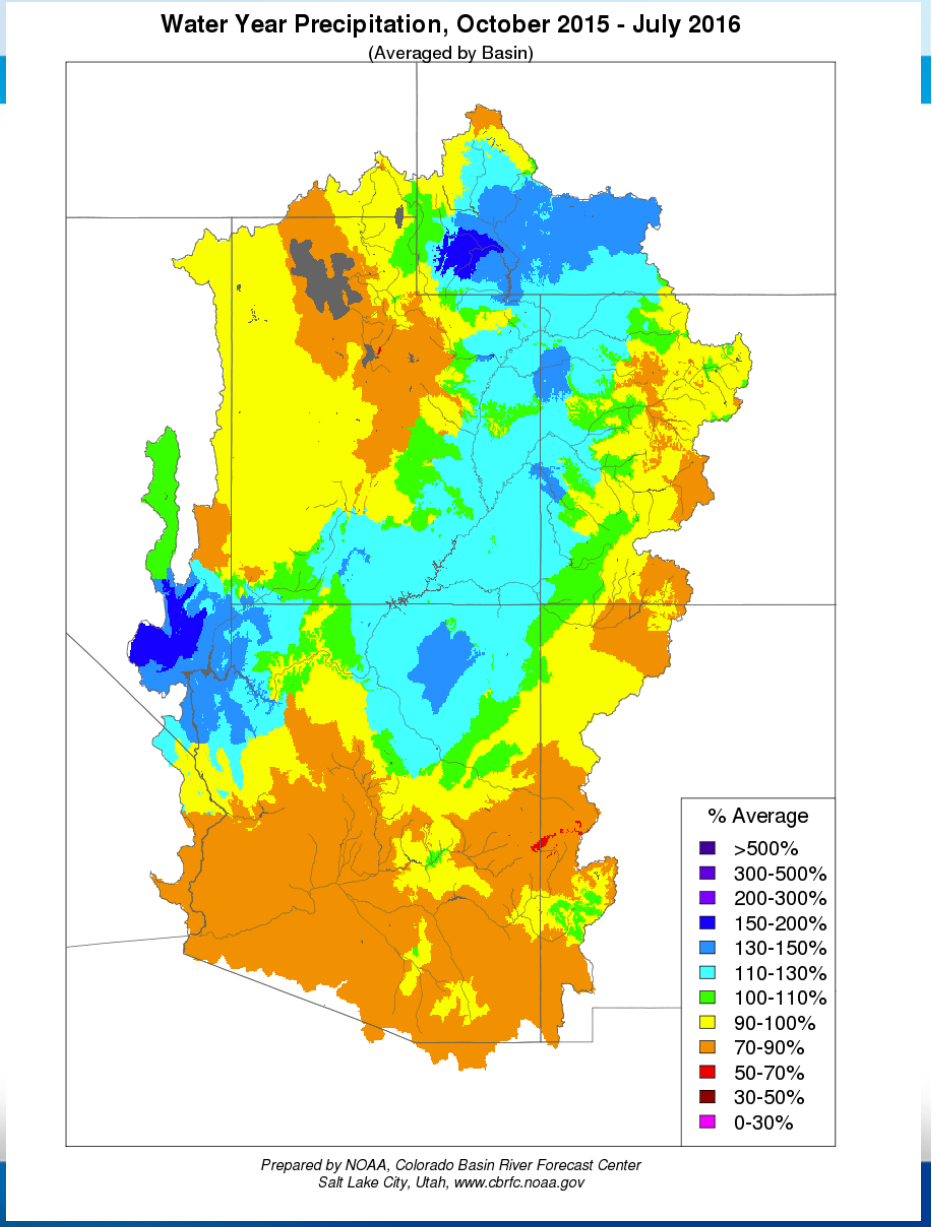
2016 Water Year Climate

Dry soil moisture conditions in Fall 2015 leading into the snowpack accumulation season

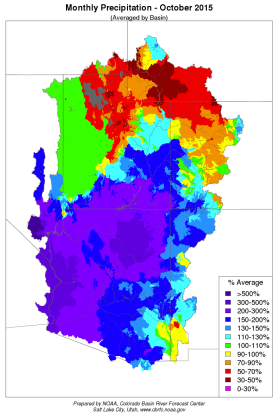


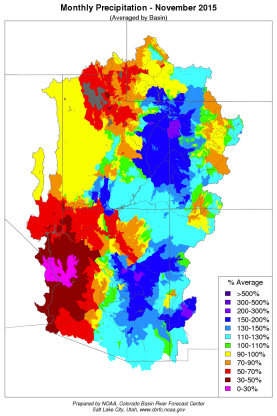
2016 Water Year Climate

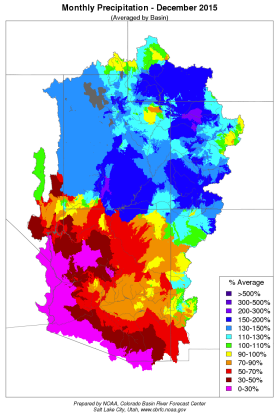
- Water Year precipitation shows above average precipitation in parts of the Green River Basin through the runoff periods
  - A relatively wet start through January
  - Followed by a dry, warm period in February
  - March continued to be dry and warm in the San Juan River Basin
  - Series of storms in April and May in the Green and Colorado Headwater regions greatly impacted total runoff

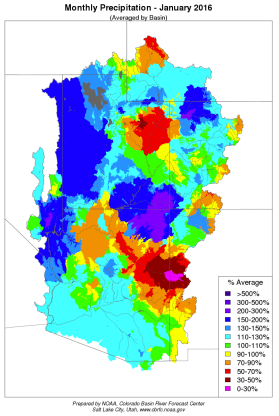


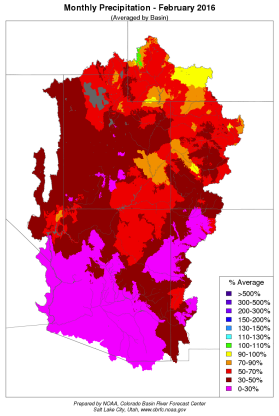
2016 Water Year Climate

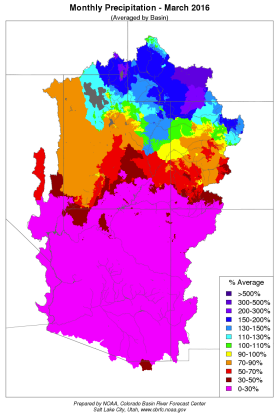




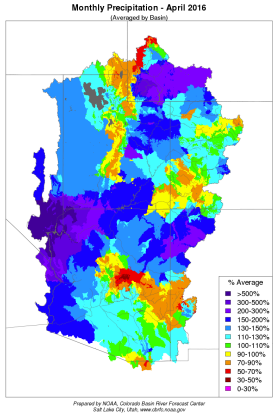


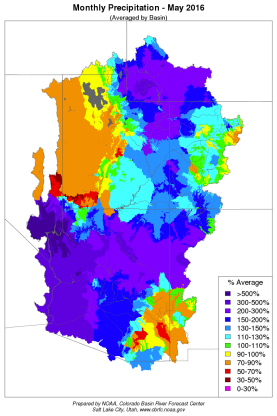


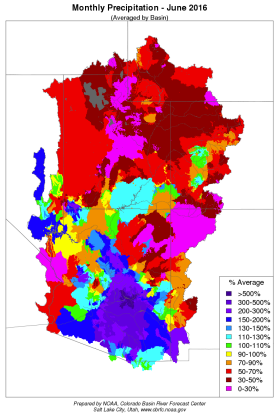


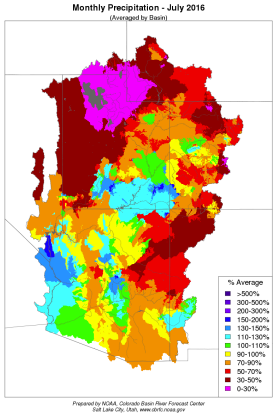


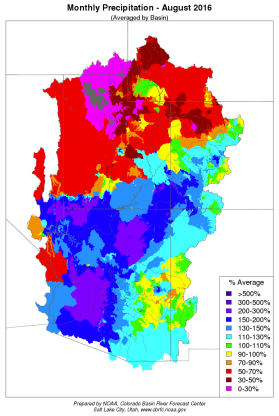
Dry February, Mixed March

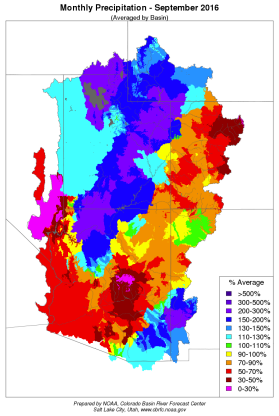






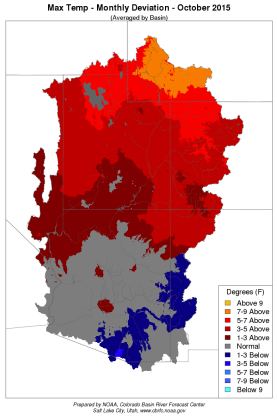


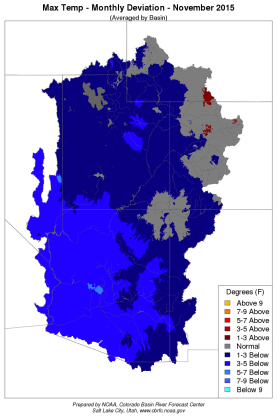


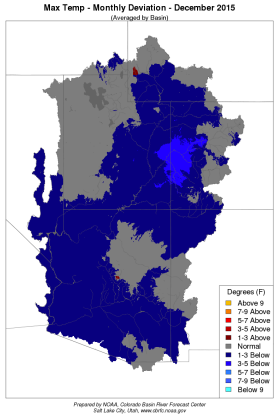


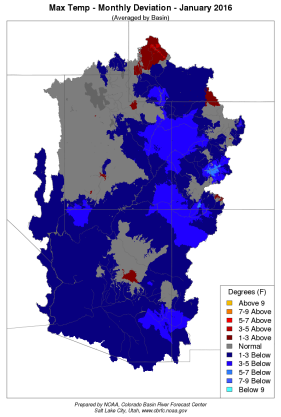
Wet April and May (especially)

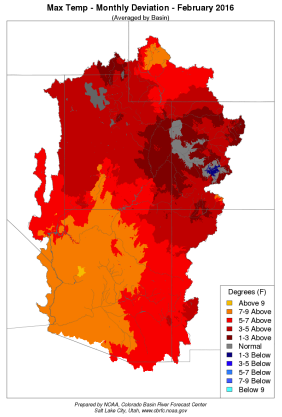
2016 Water Year Climate

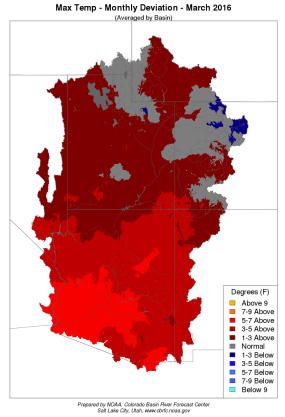






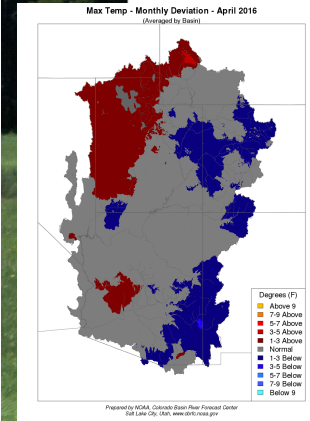


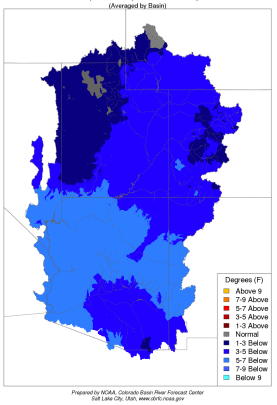


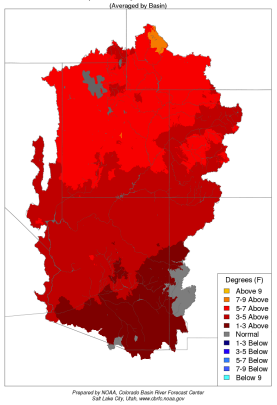


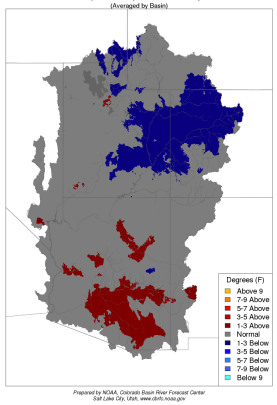
Relatively cool start to the year

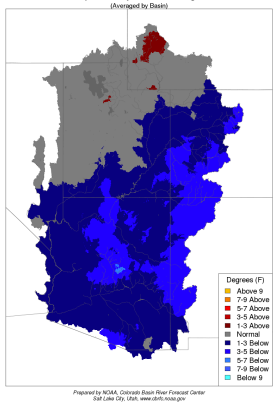
Warm February and March

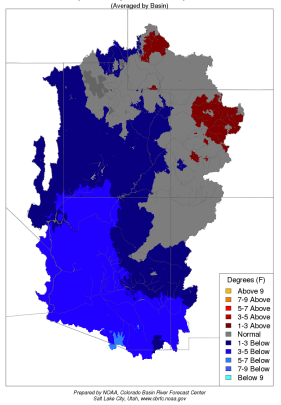












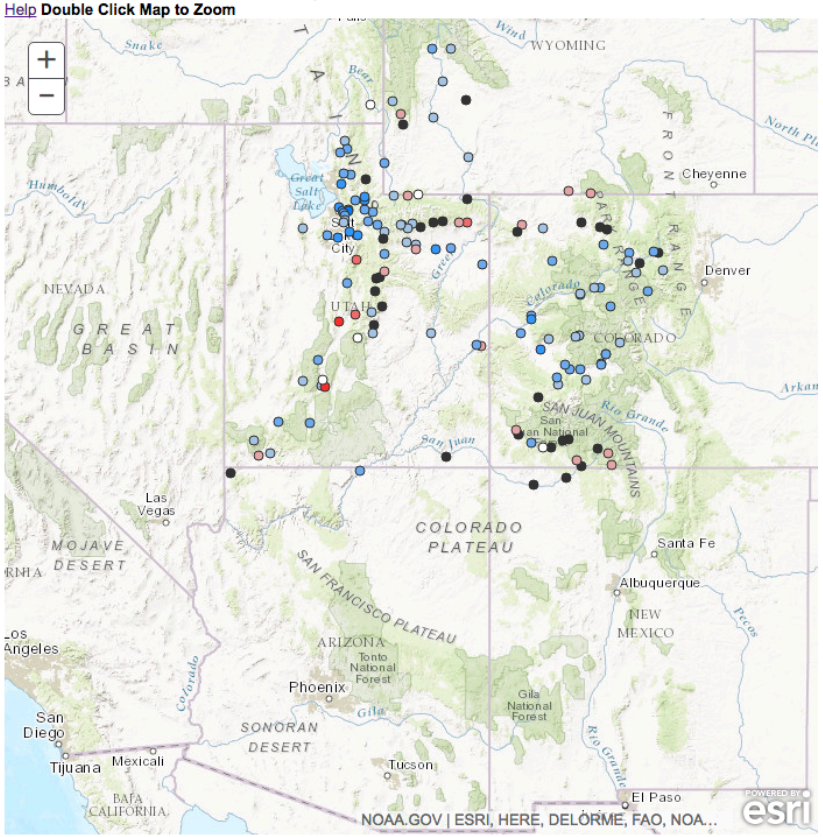
Cool May

2016 Climate Impacts to Verification

2016 Water Supply Verification - January

Help Double Click Map to Zoom

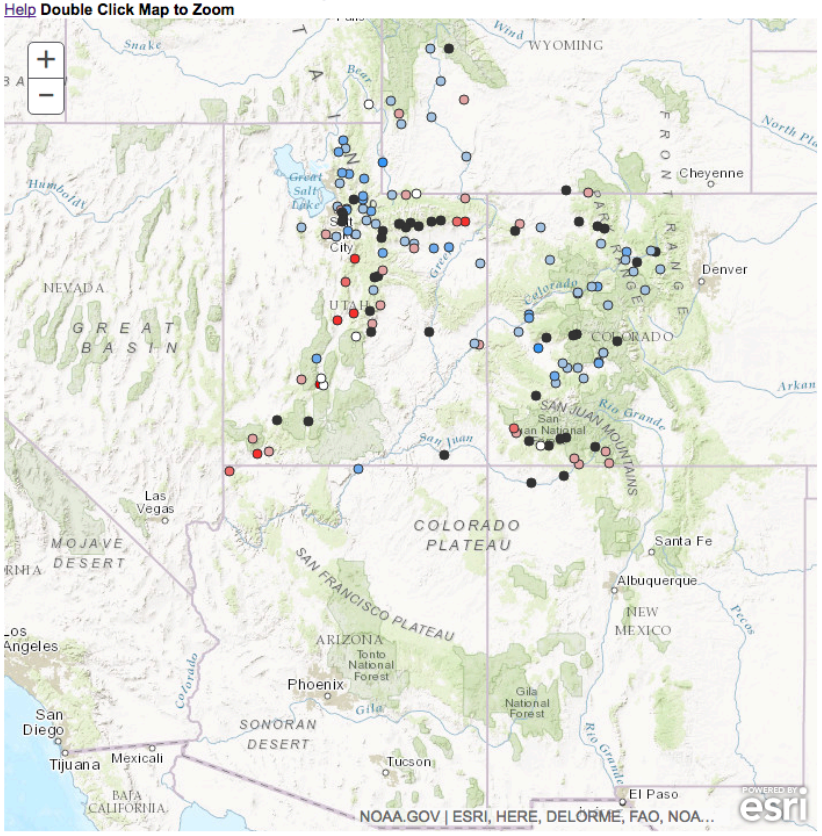
Forecast Month
January
February
March
April
May
June



2016 Water Supply Verification - February

Help Double Click Map to Zoom

Forecast Month
January
February
March
April
May
June

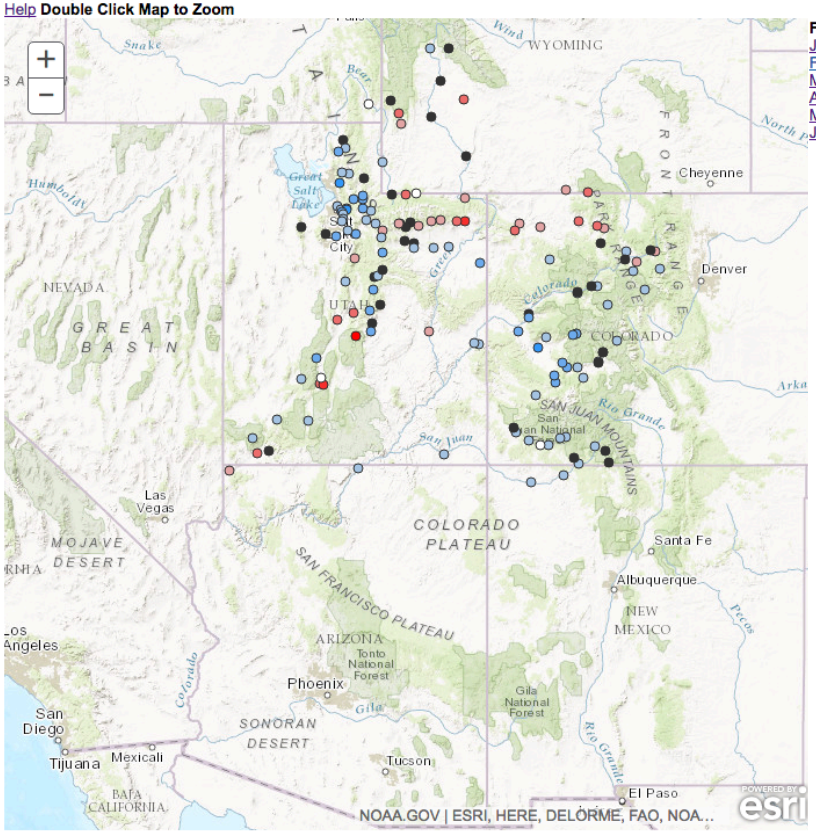


2016 Climate Impacts to Verification

2016 Water Supply Verification - March

Help Double Click Map to Zoom

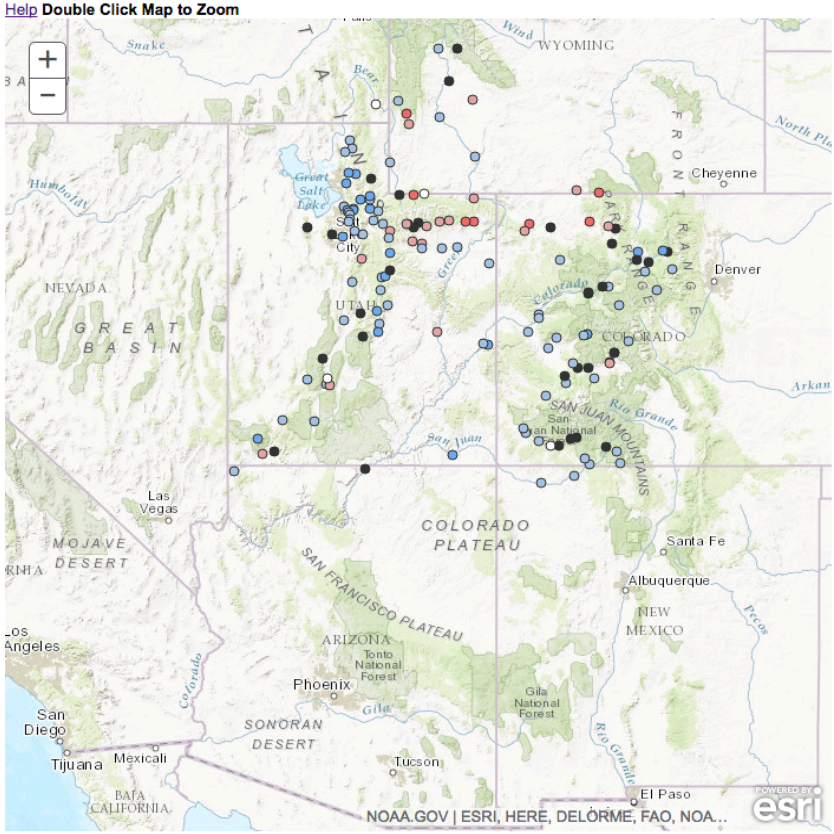
Forecast Month
January
February
March
April
May
June



2016 Water Supply Verification - April

Help Double Click Map to Zoom

Forecast Month
January
February
March
April
May
June

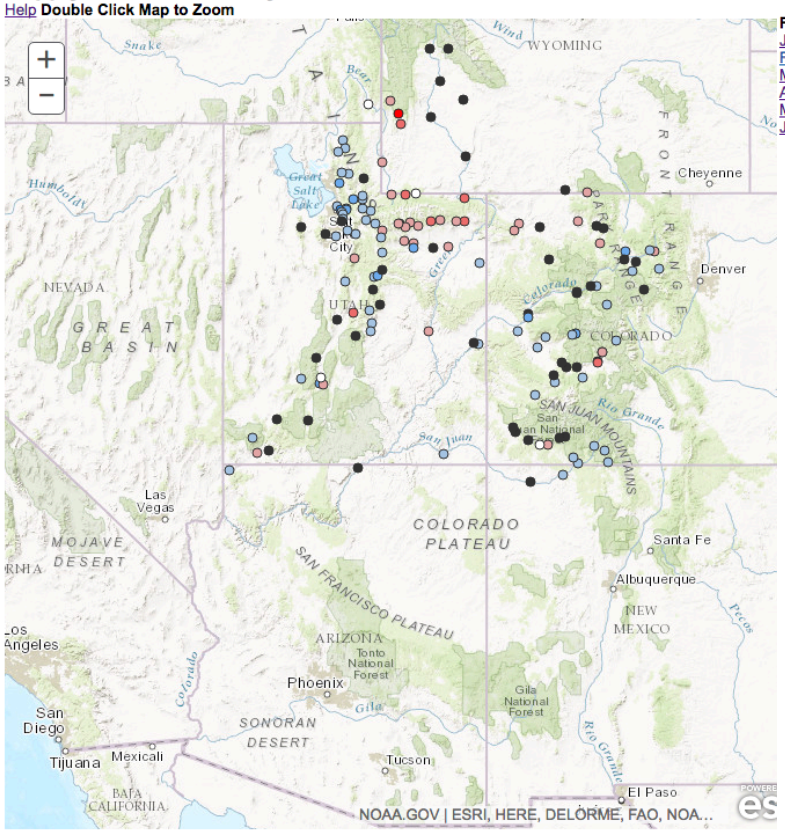


2016 Climate Impacts to Verification

2016 Water Supply Verification - May

Help Double Click Map to Zoom

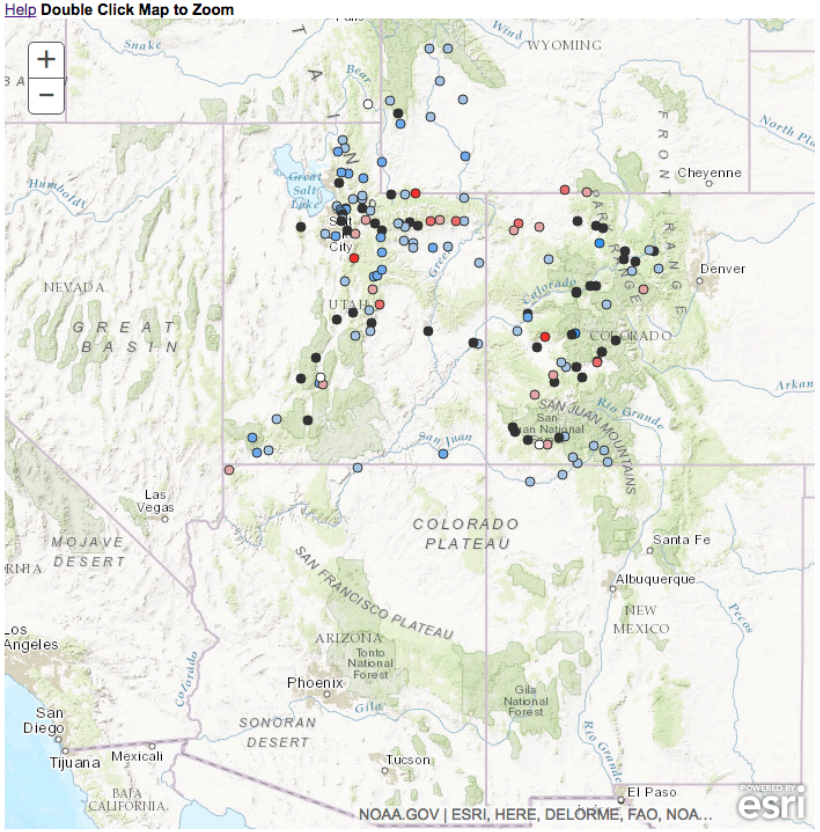
Forecast Month
January
February
March
April
May
June



2016 Water Supply Verification - June

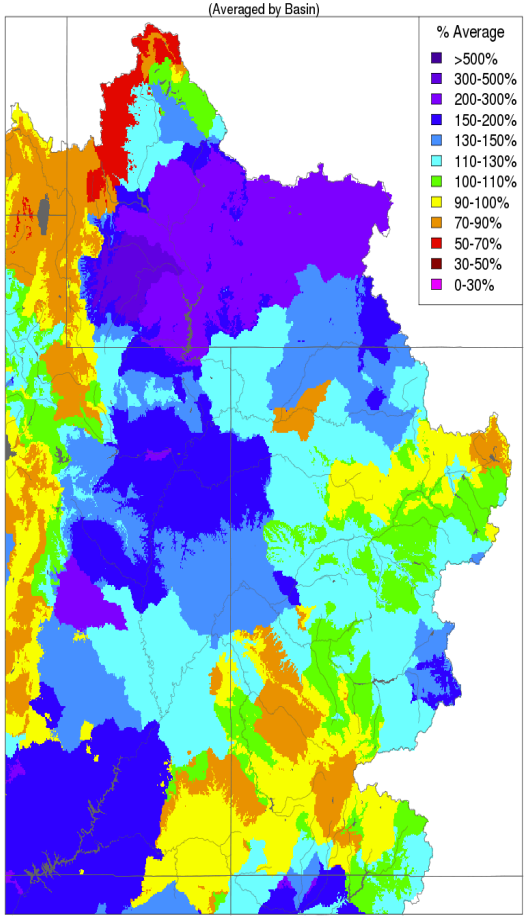
Help Double Click Map to Zoom

Forecast Month
January
February
March
April
May
June



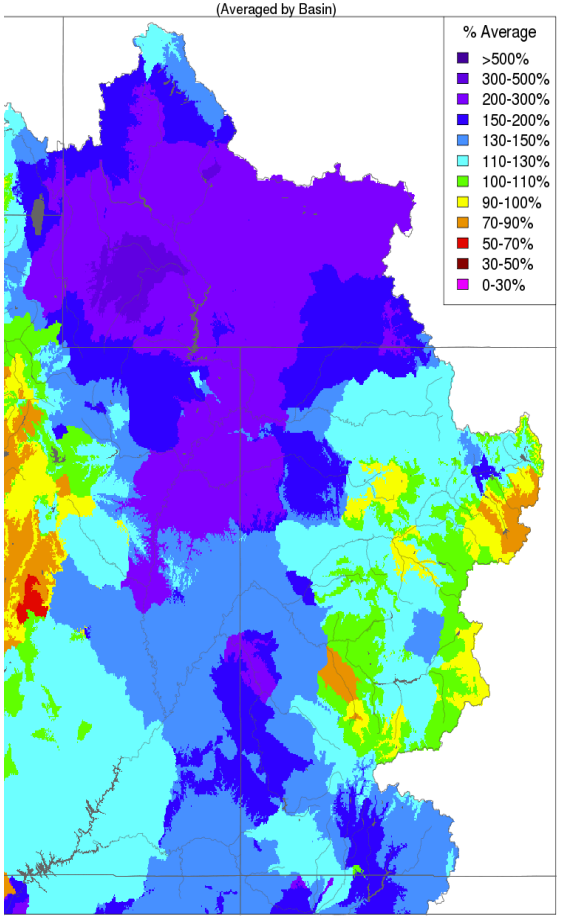
Green River Basin

Monthly Precipitation - April 2016
(Averaged by Basin)



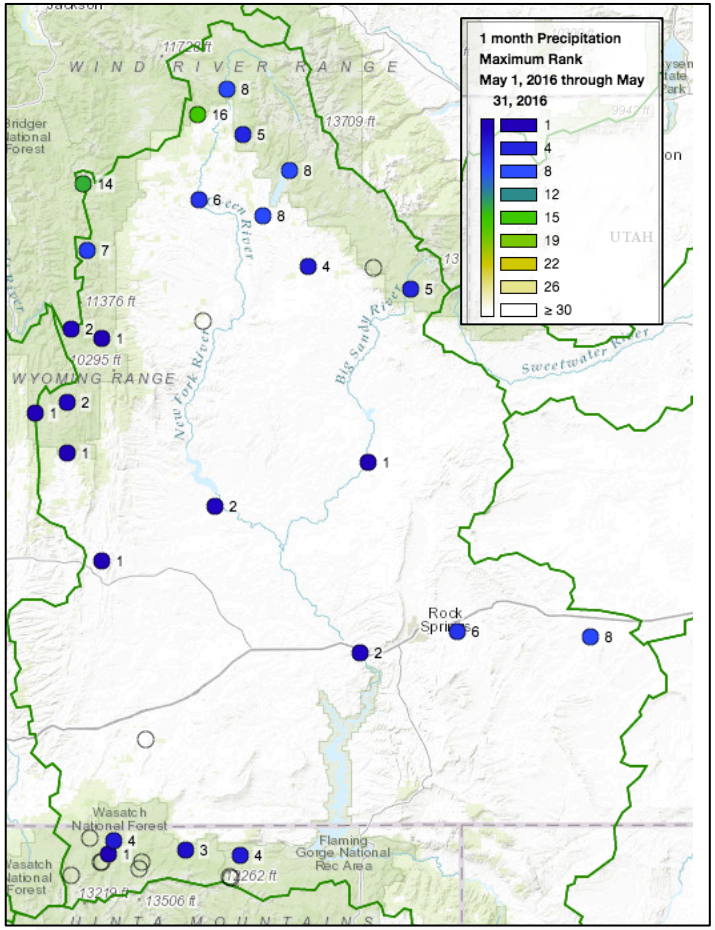
Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

Monthly Precipitation - May 2016
(Averaged by Basin)



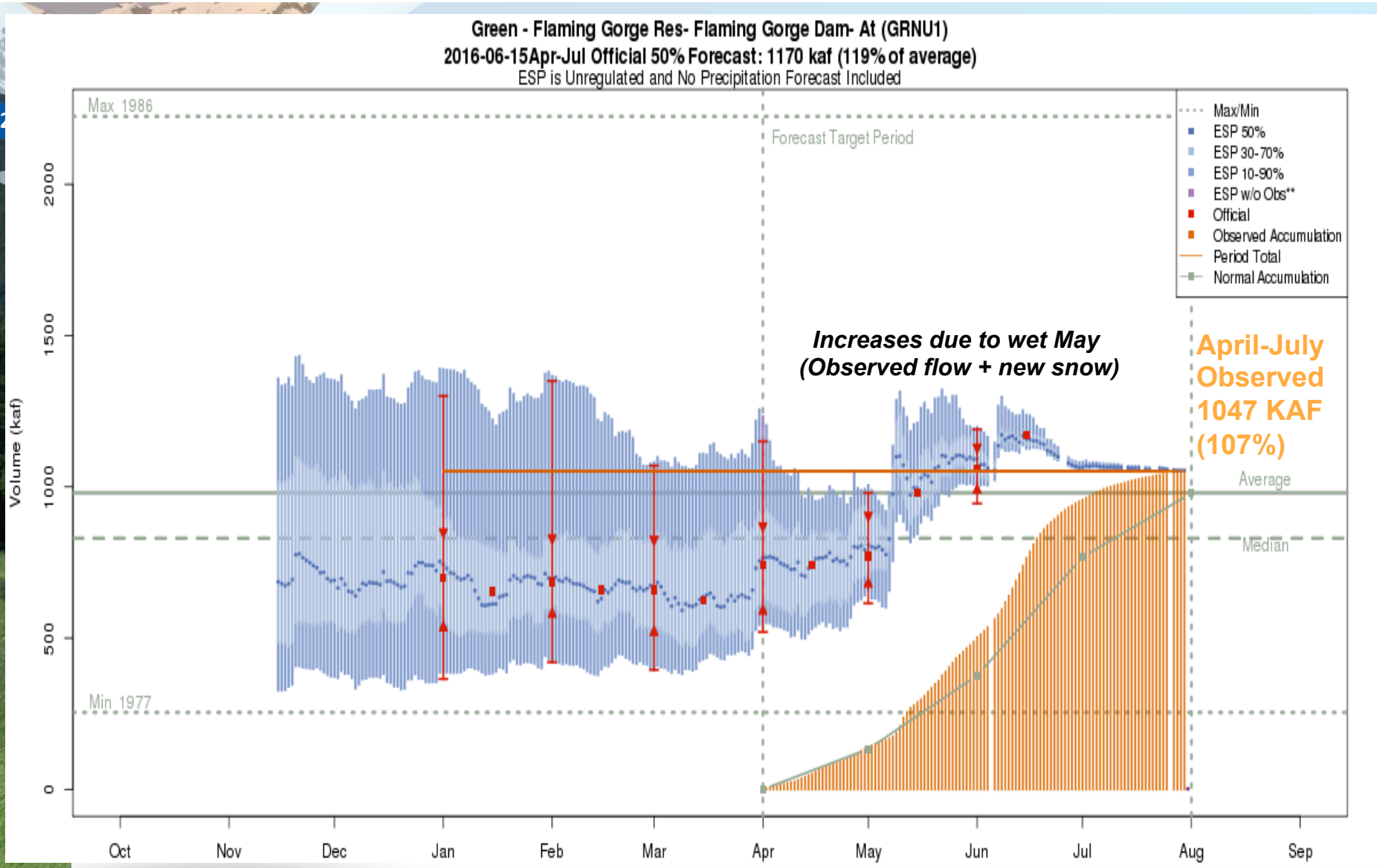
Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

May Precipitation Ranking



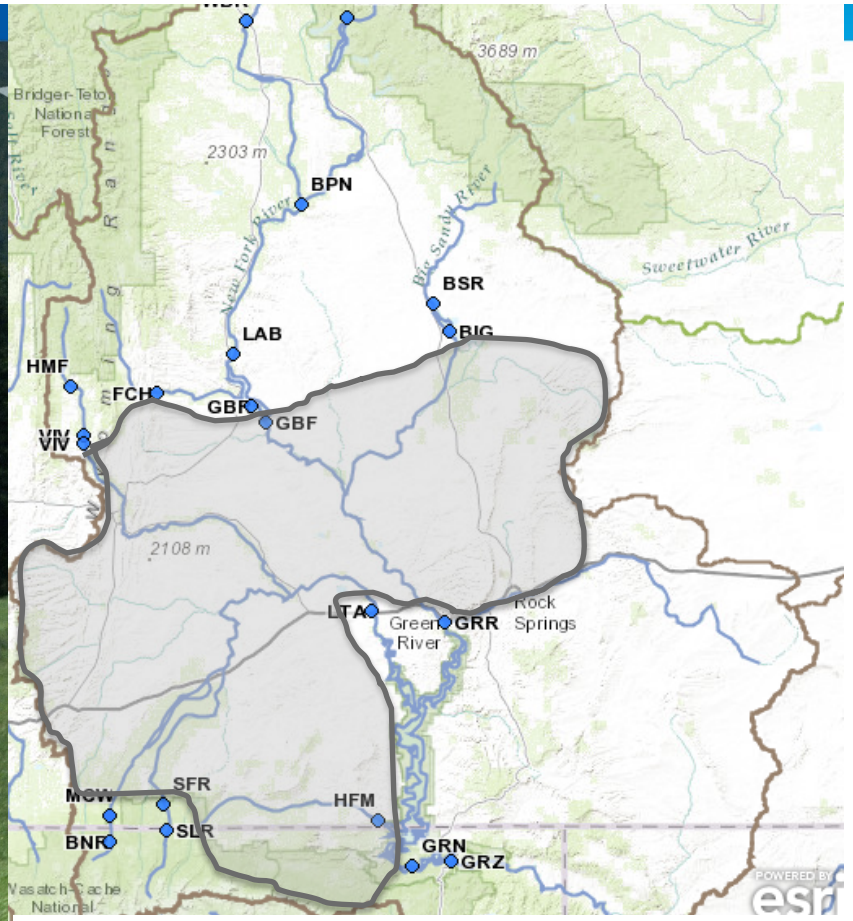
Most sites in top 5 of historical record

Upper Green: Flaming Gorge Reservoir



Upper Green: Flaming Gorge Local

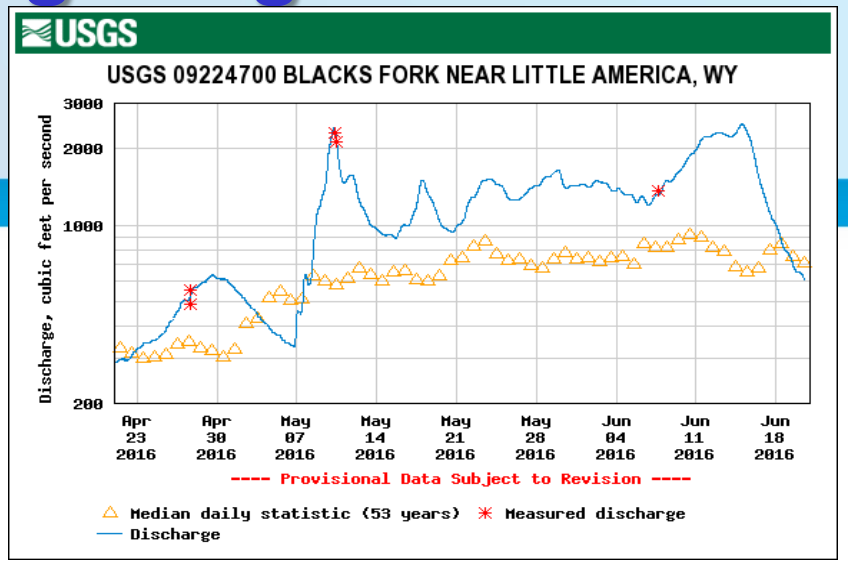
Regulated Flow from Viva Naughton, Meeks Cabin, Stateline, and Big Sandy Reservoirs and Henry's Fork

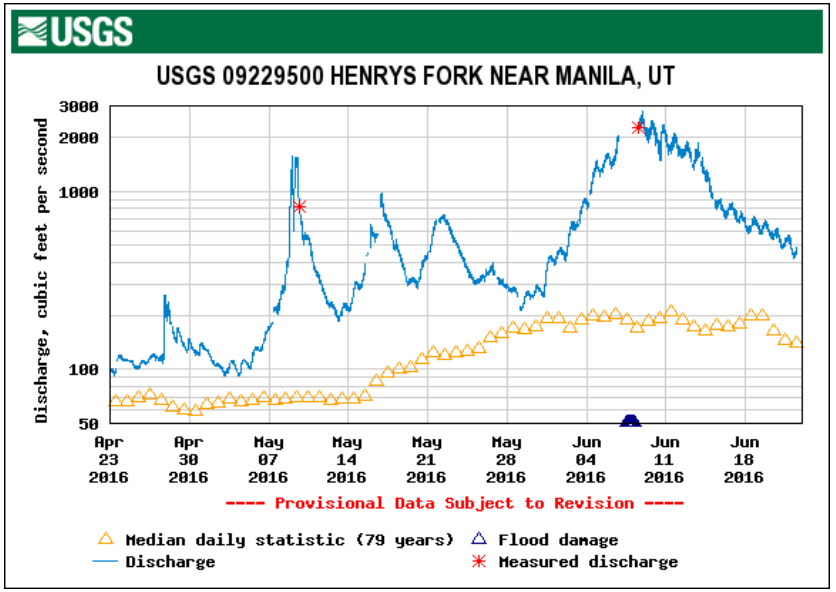


Typically this area does not contribute significant flows to Flaming Gorge inflow

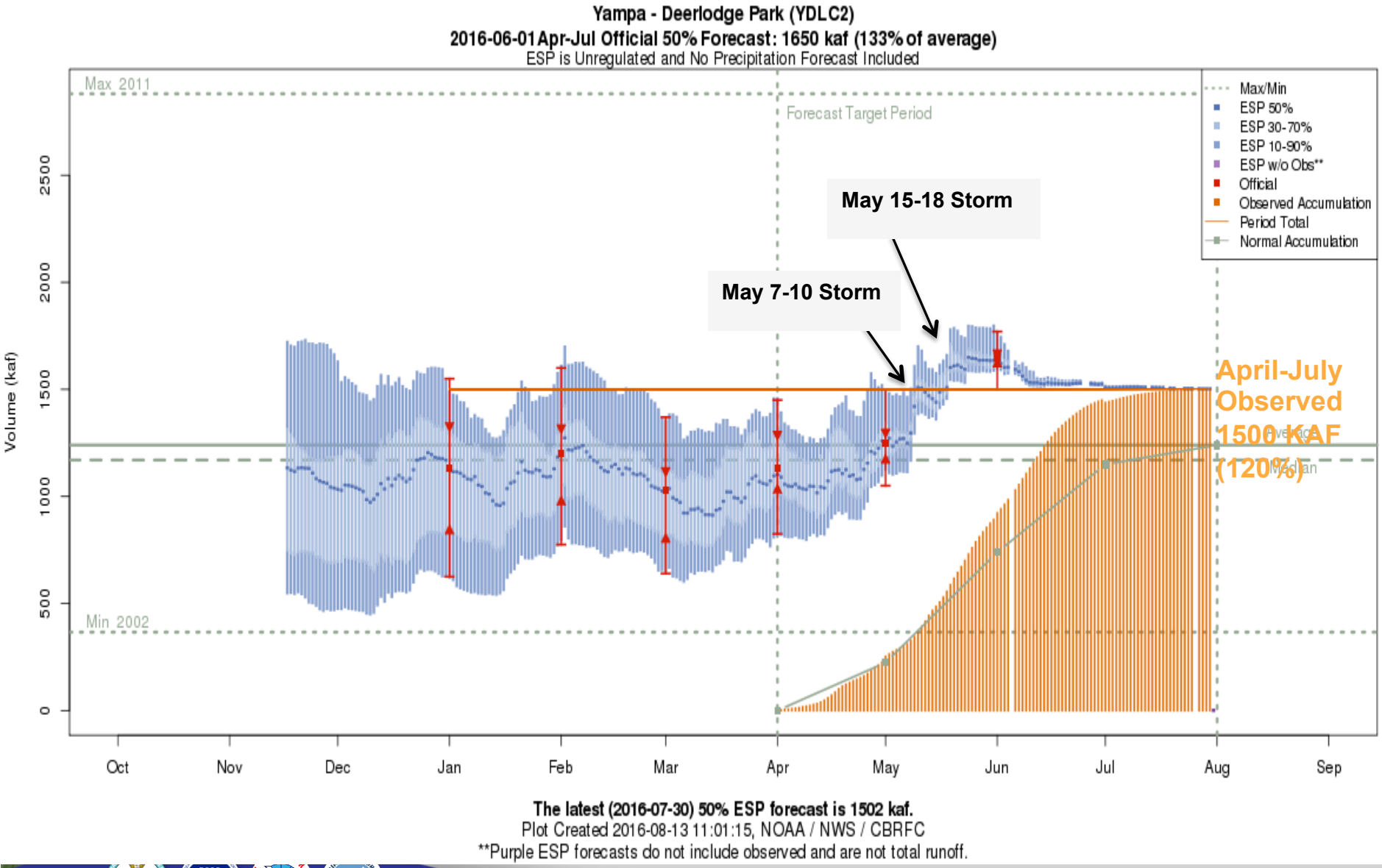
Average % Contribution = ~25%

2016 % Contribution=~ 40%

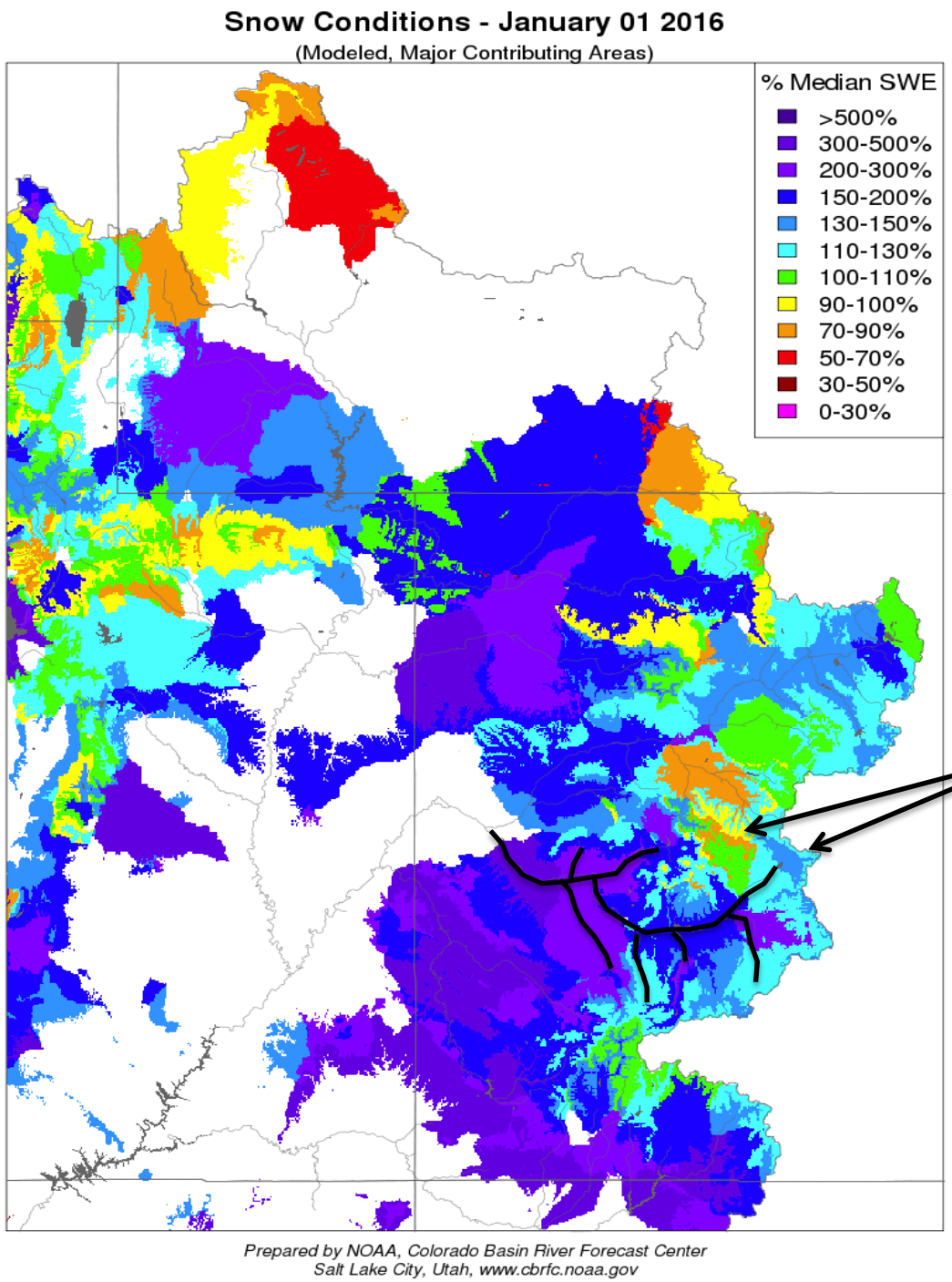




Yampa River: Yampa nr Deerlodge



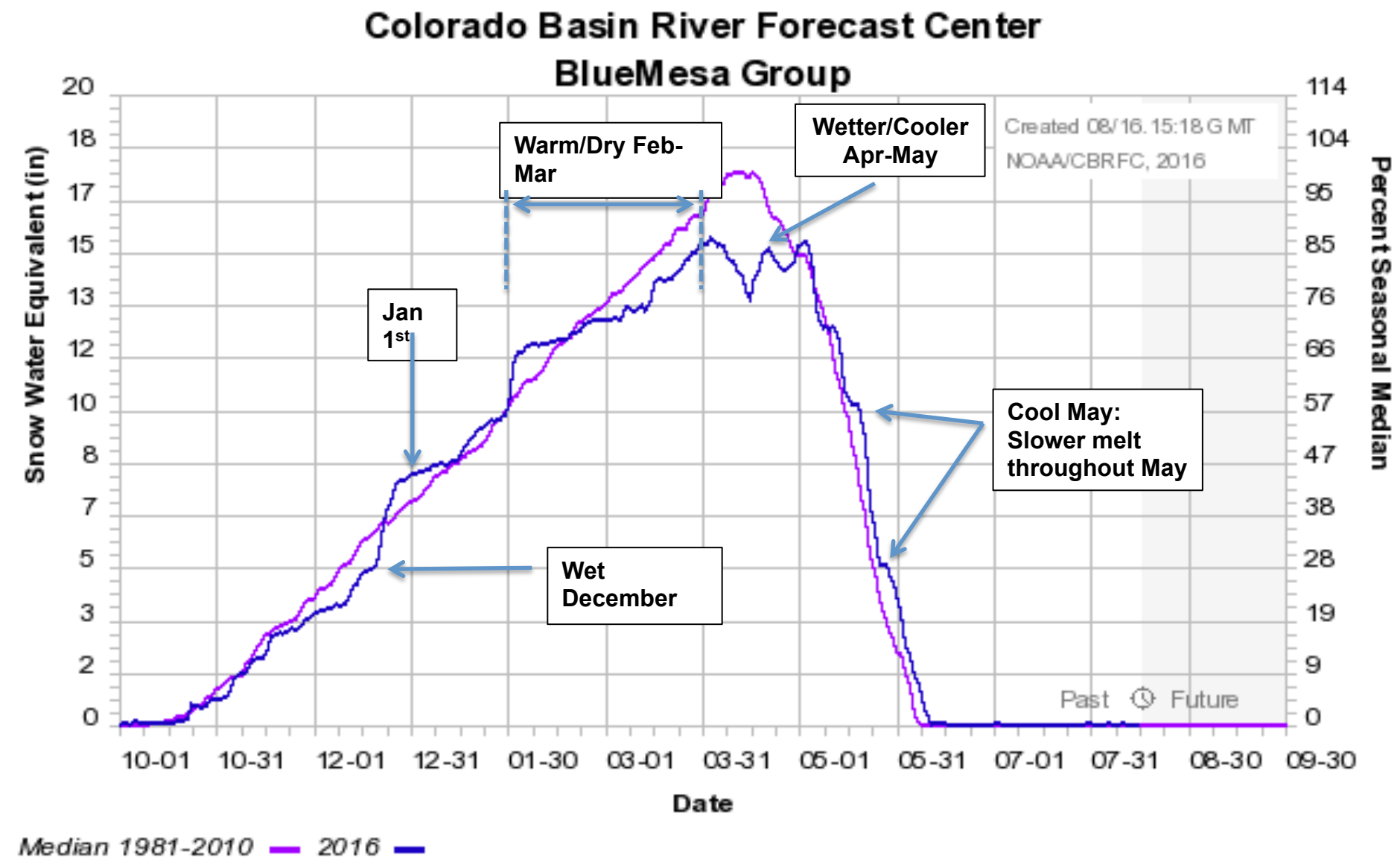
Gunnison River Basin Forecasts



A late start to snowpack accumulation at highest elevations

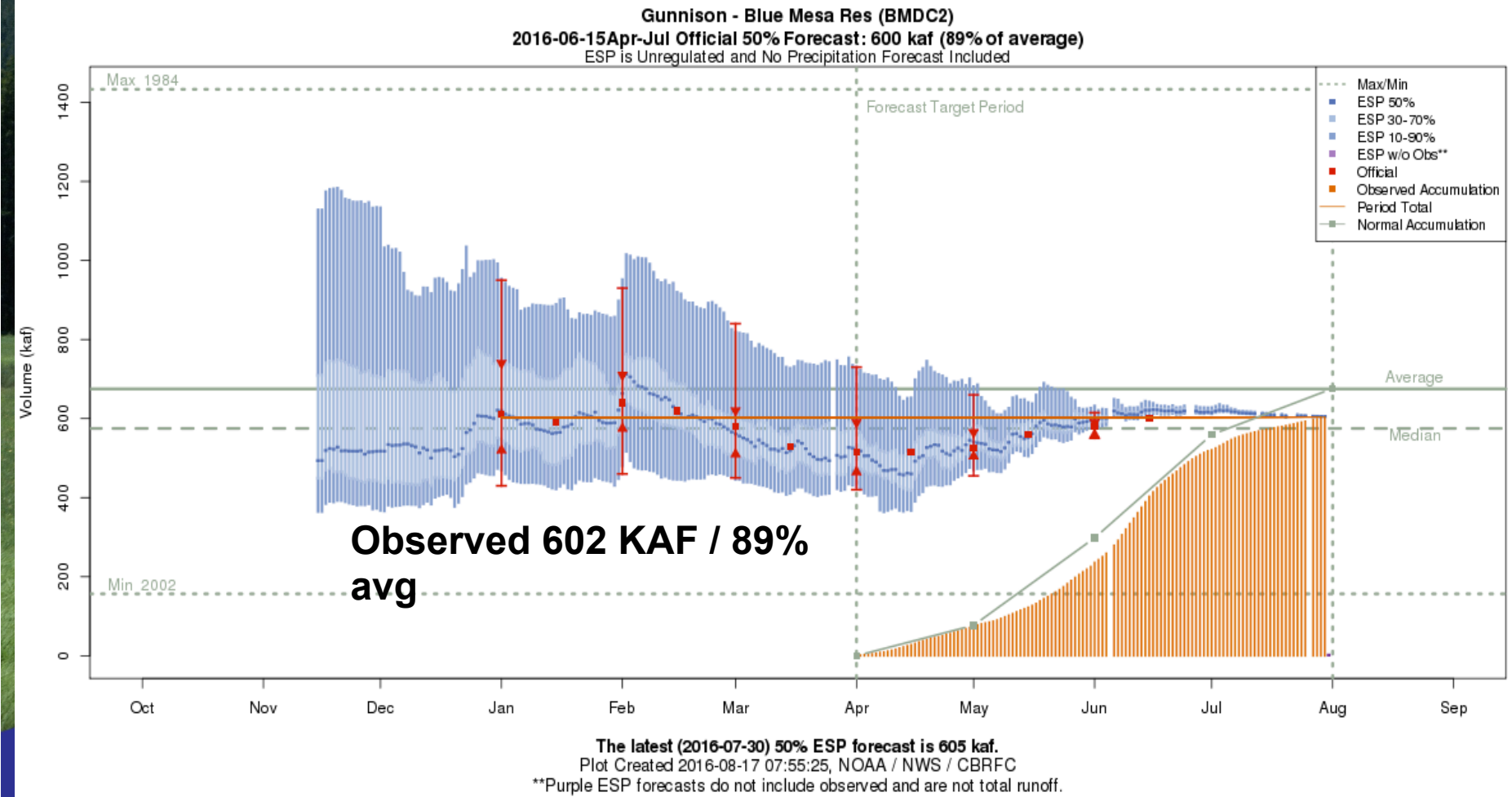
<u>Higher elevation areas (~11,000+ Ft)</u> Lower snow (as a percent of normal) compared to lower elevation areas.

SNOTEL Group Above Blue Mesa Reservoir

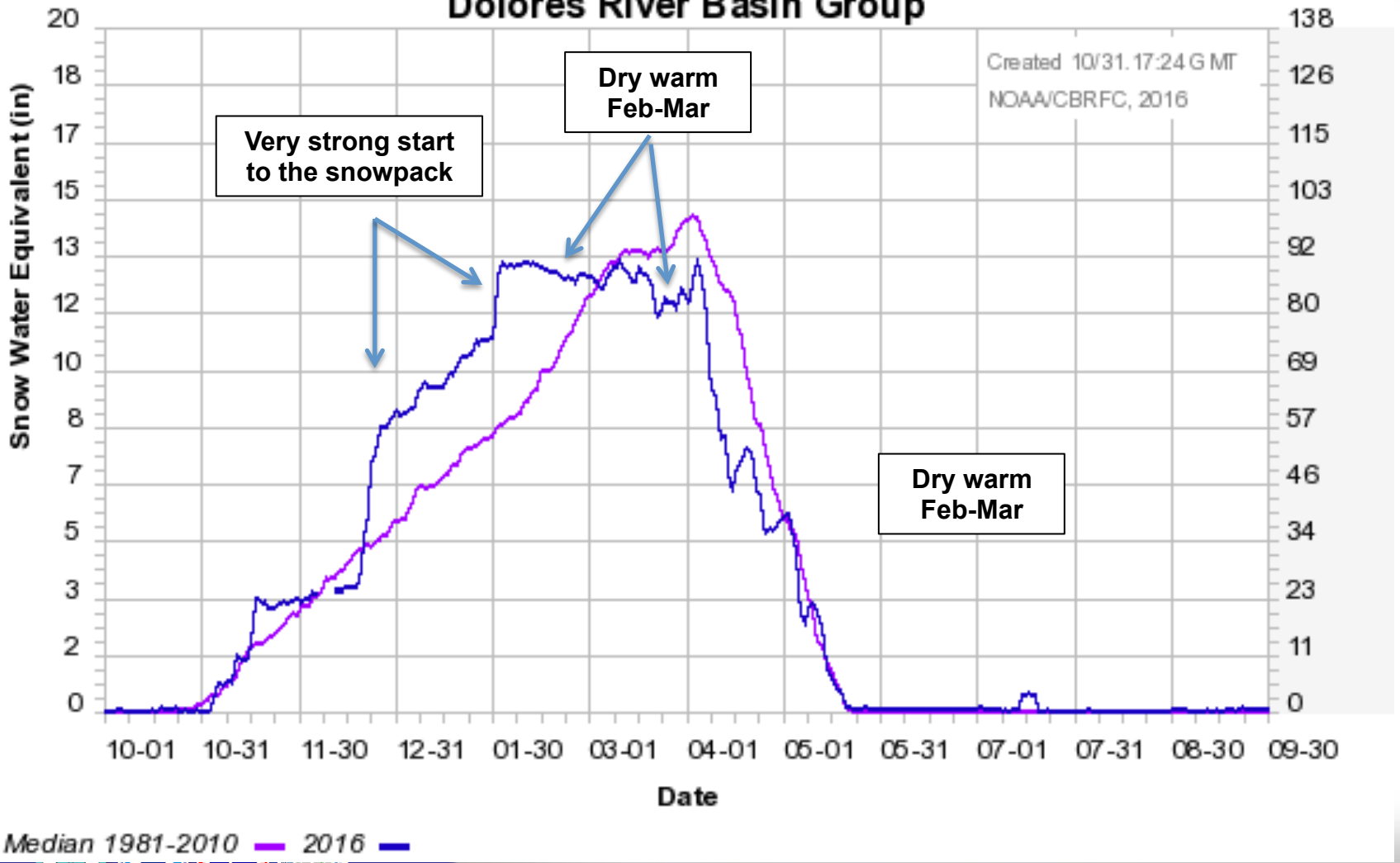


Gunnison River – Blue Mesa Reservoir Inflow

Model performed fairly well with forecast errors below historical mean error levels. Possibly too little high elevation snow in the model late in the season due to the cool May.

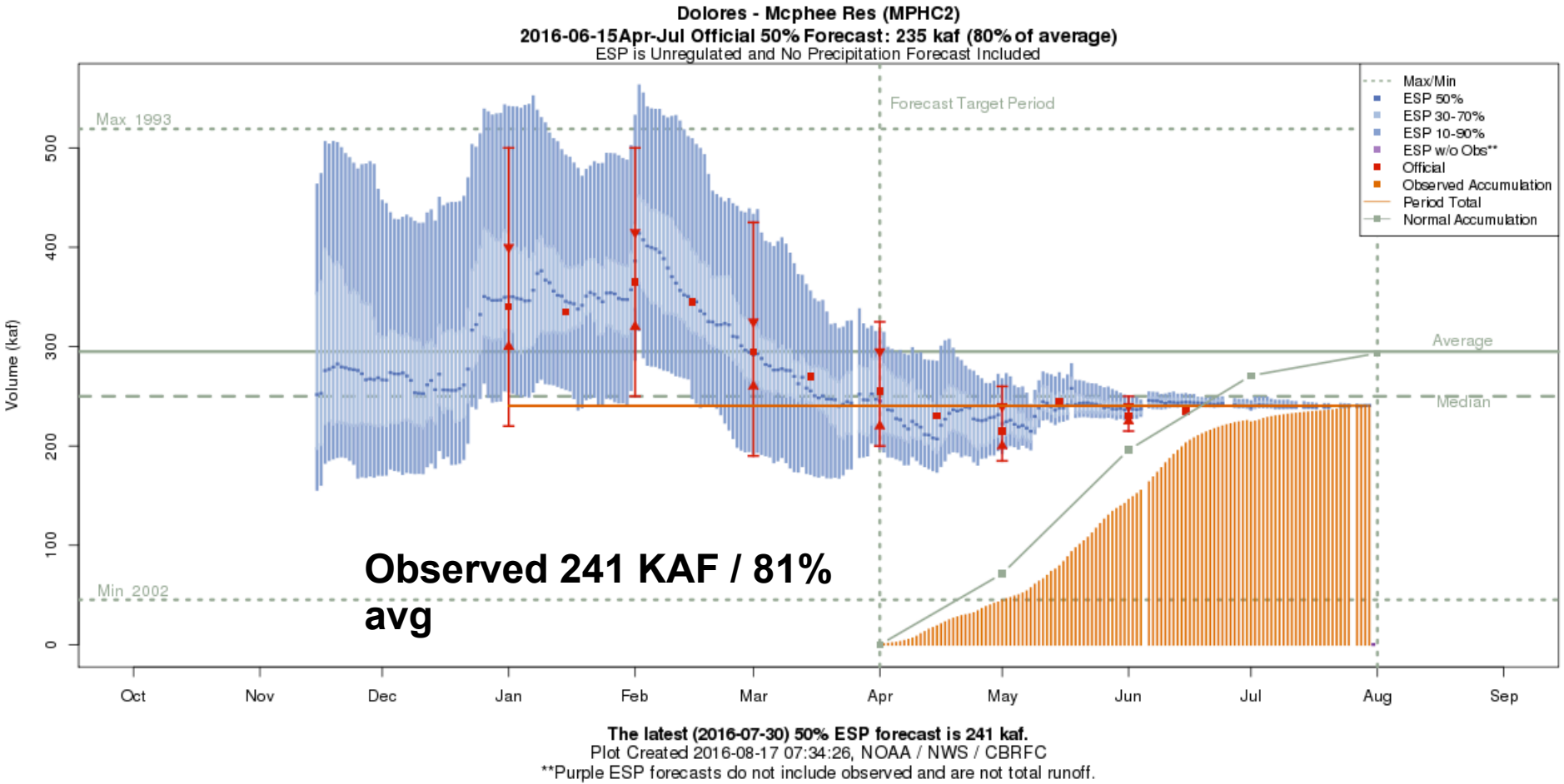


Dolores Basin SNOTEL Group

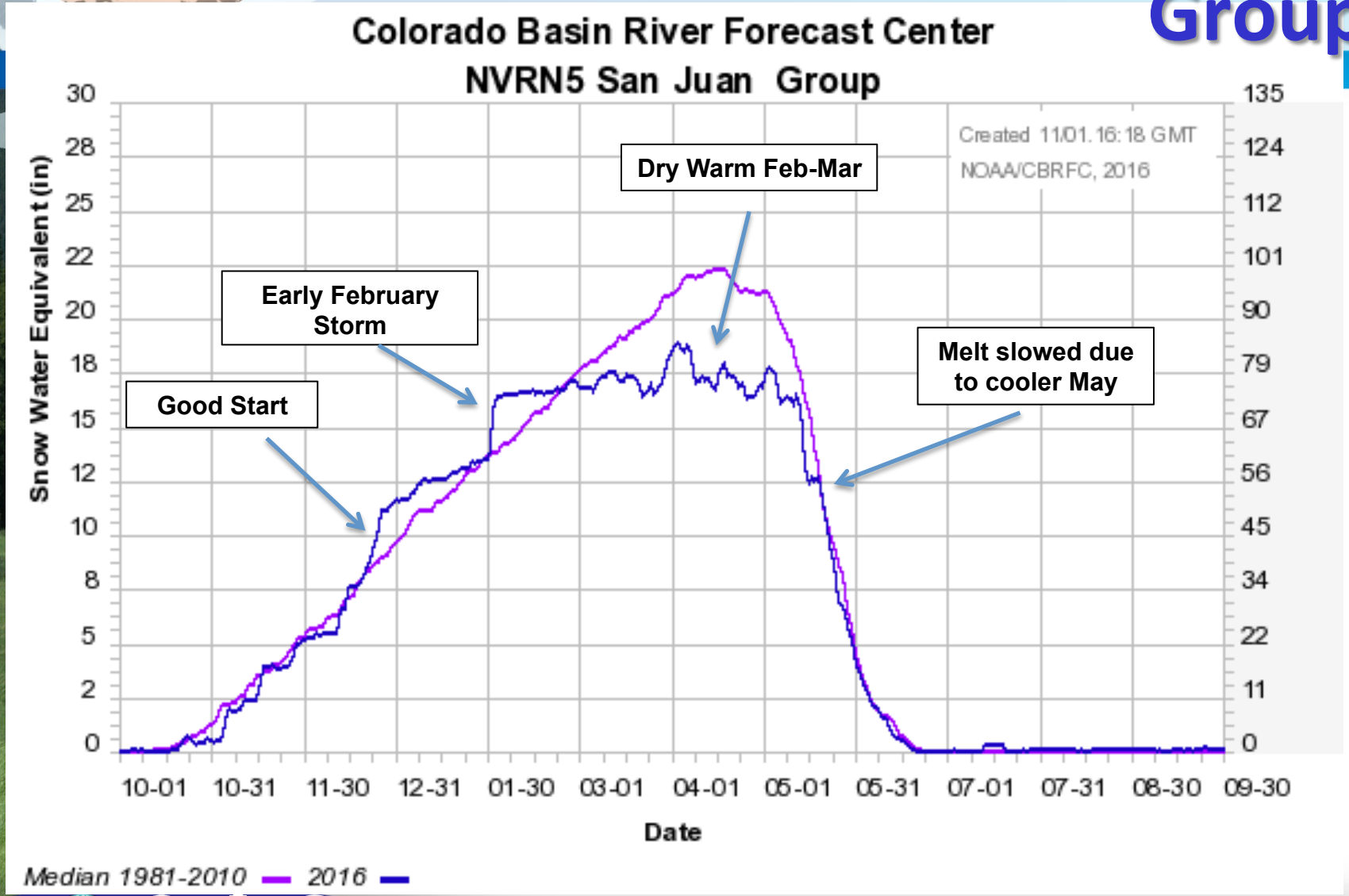


Dolores River - McPhee Reservoir Inflow

Model performed as expected and initial states adequate, the dry Feb-Mar period had the greatest impact and was caught by the model. Peak runoff timing an issue.

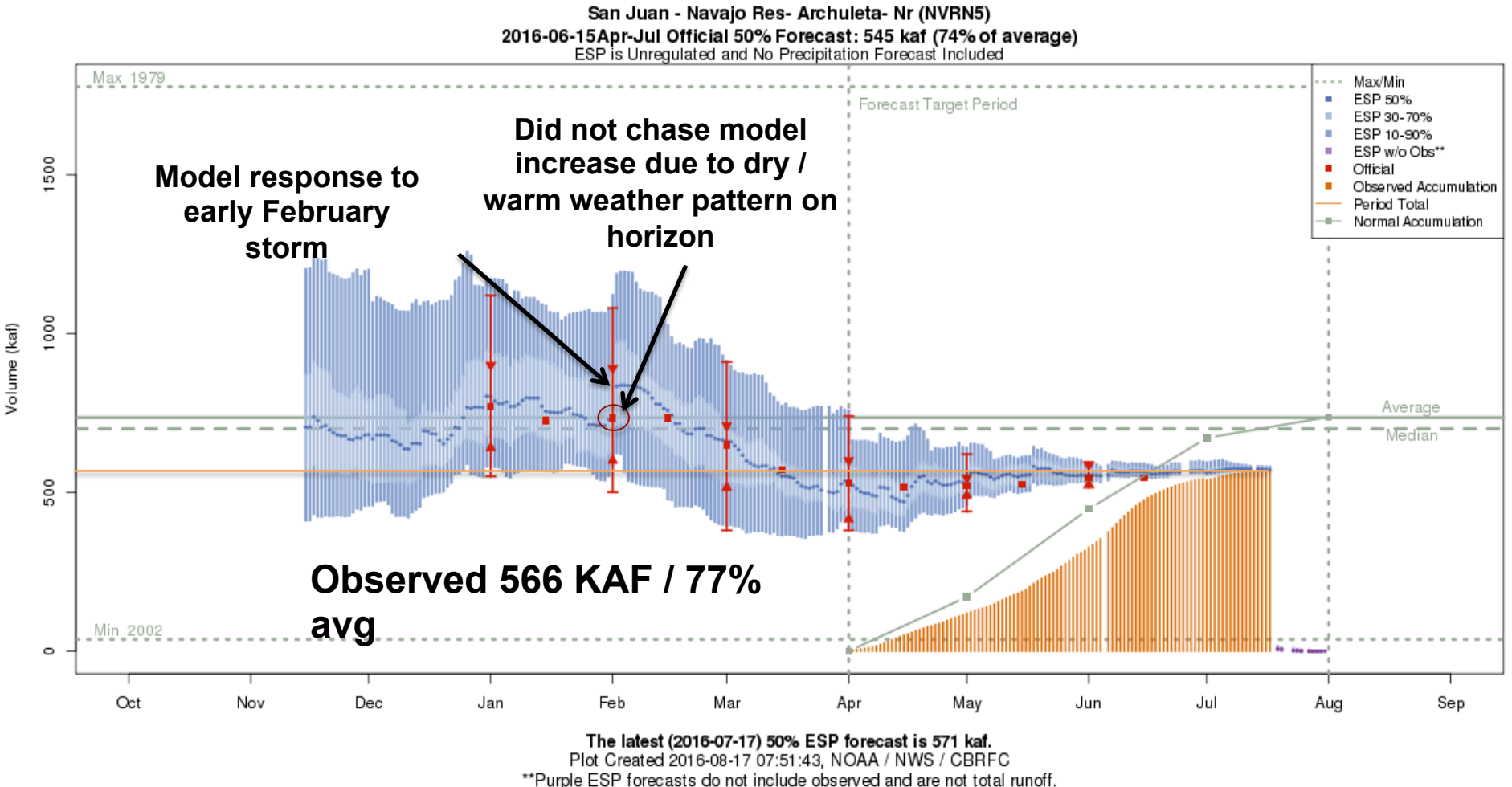


San Juan above Navajo Res SNOTEL Group

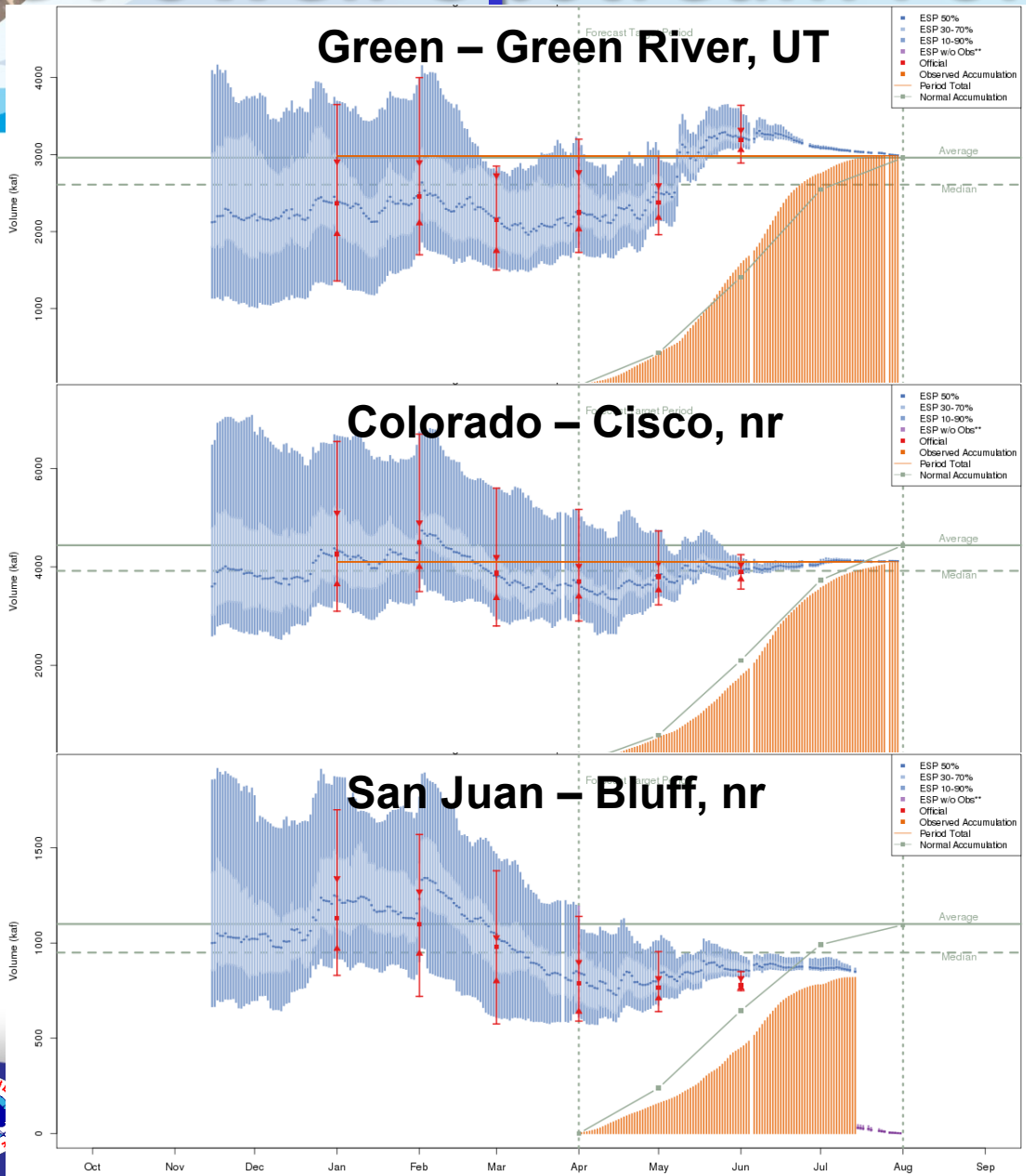


San Juan River - Navajo Reservoir Inflow

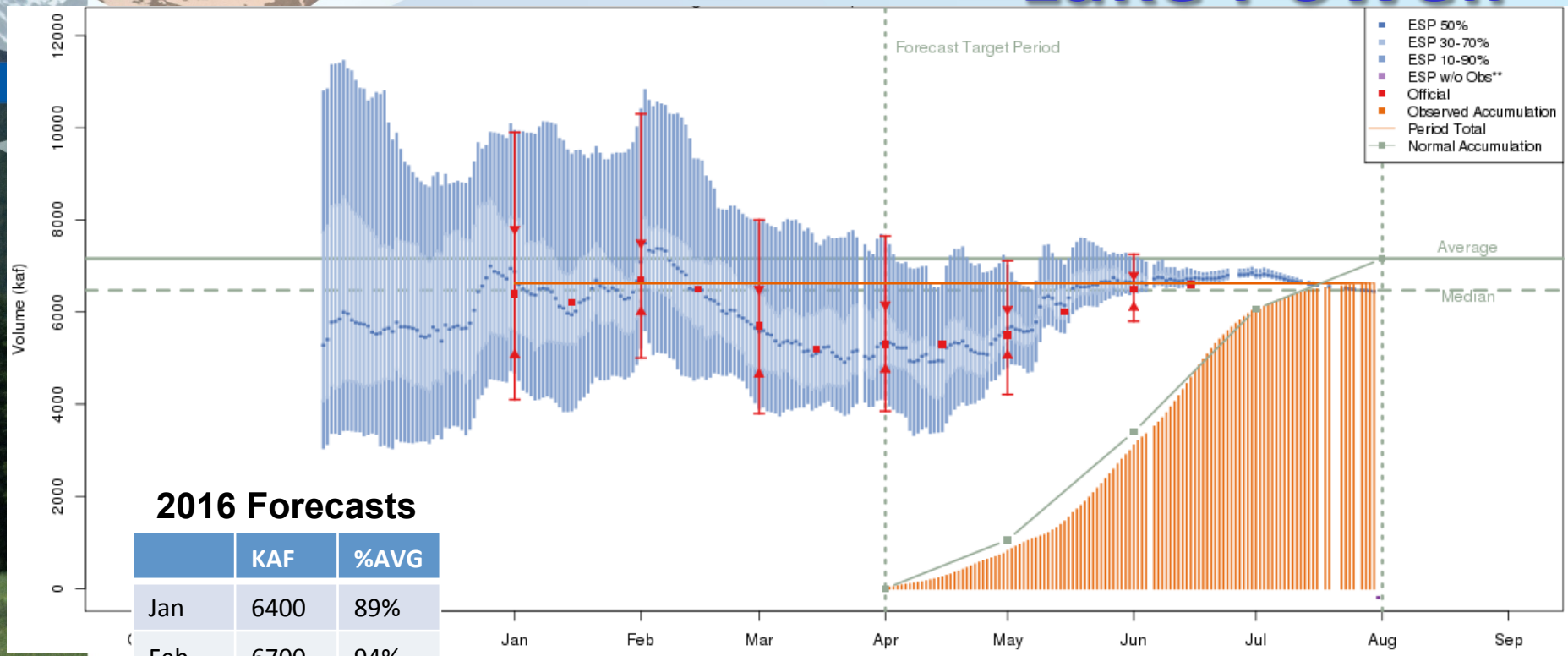
Model performed as expected and initial states were adequate, the dry Feb-Mar period had the greatest impact and was caught by the model.



Lake Powell Upstream Forecasts



Lake Powell



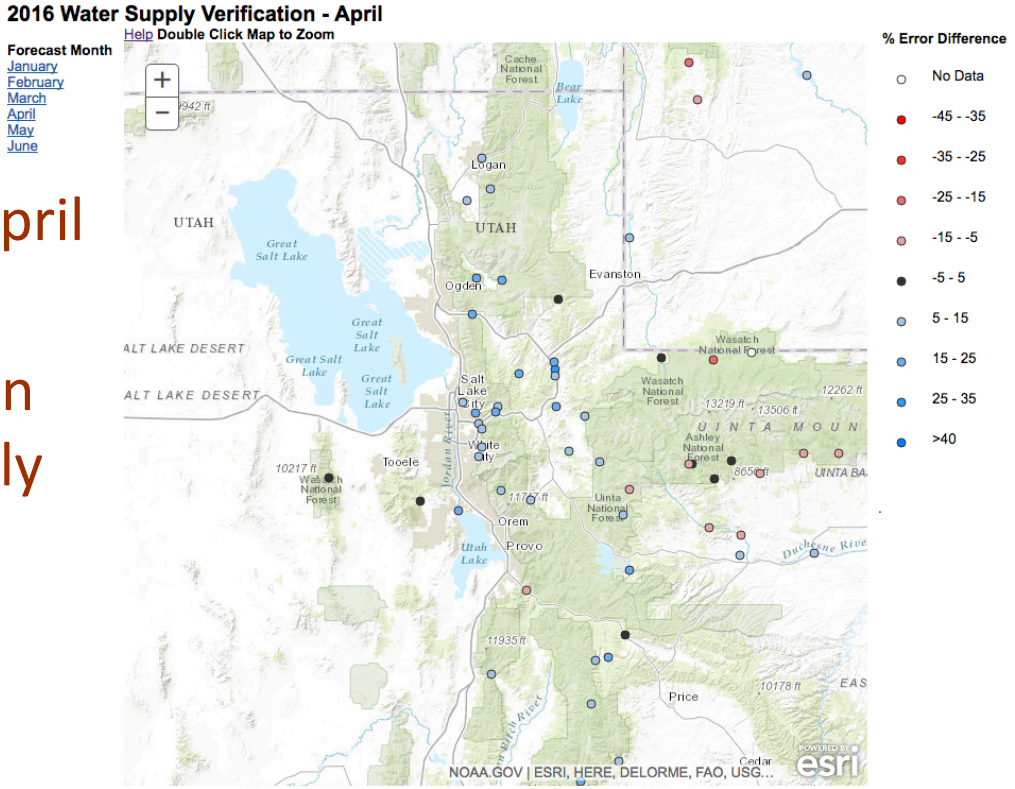
2016 Forecasts

	KAF	%AVG
Jan	6400	89%
Feb	6700	94%
Mar	5700	80%
Apr	5300	74%
May	5500	77%
Jun	6500	91%
Obs	**6610**	**92%**

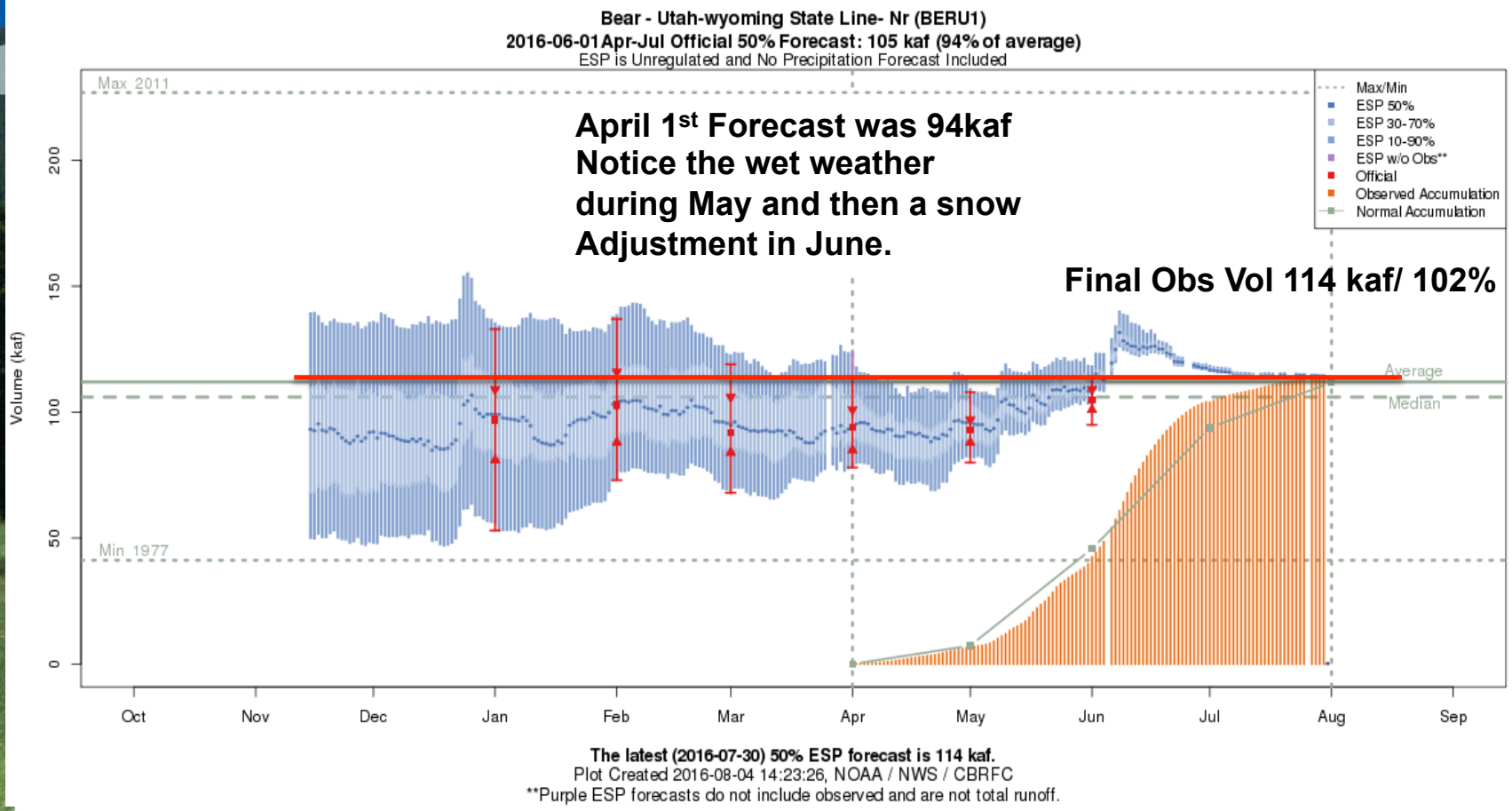
4th largest May-Jun forecast change (2015, 1995, 2011)

Great Basin Verification

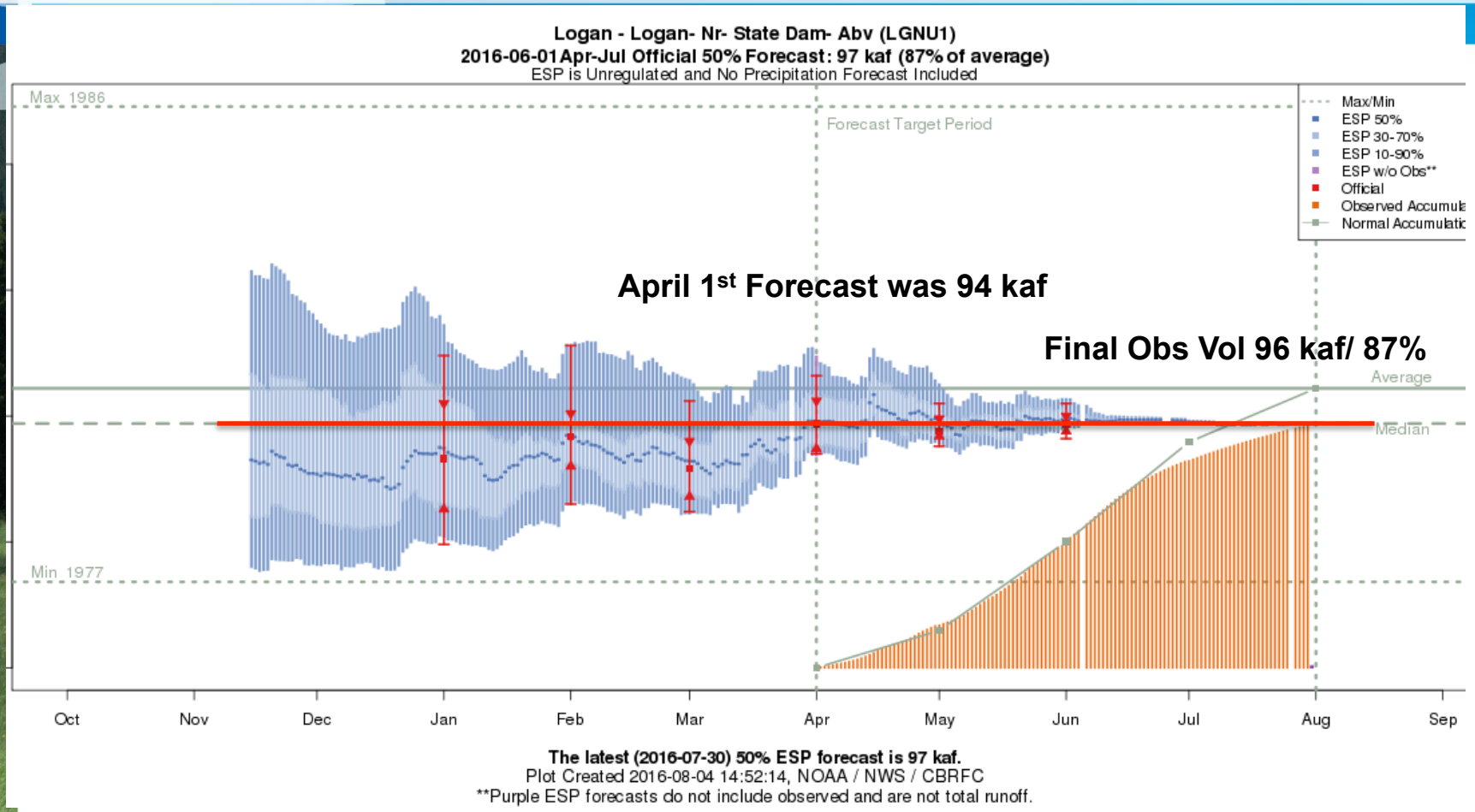
- Great Basin forecasts performed well
  - Early runoff in March was not captured in April through July totals
  - Low elevation basins in particular showed early runoff
- Late spring precip benefitted northern areas



Bear at Utah/Wyoming Stateline

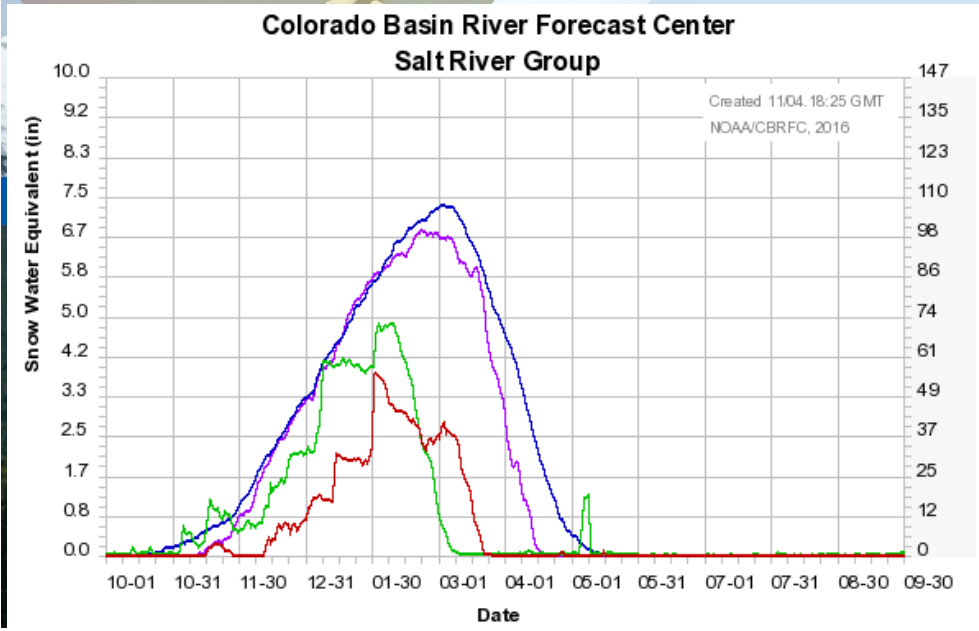


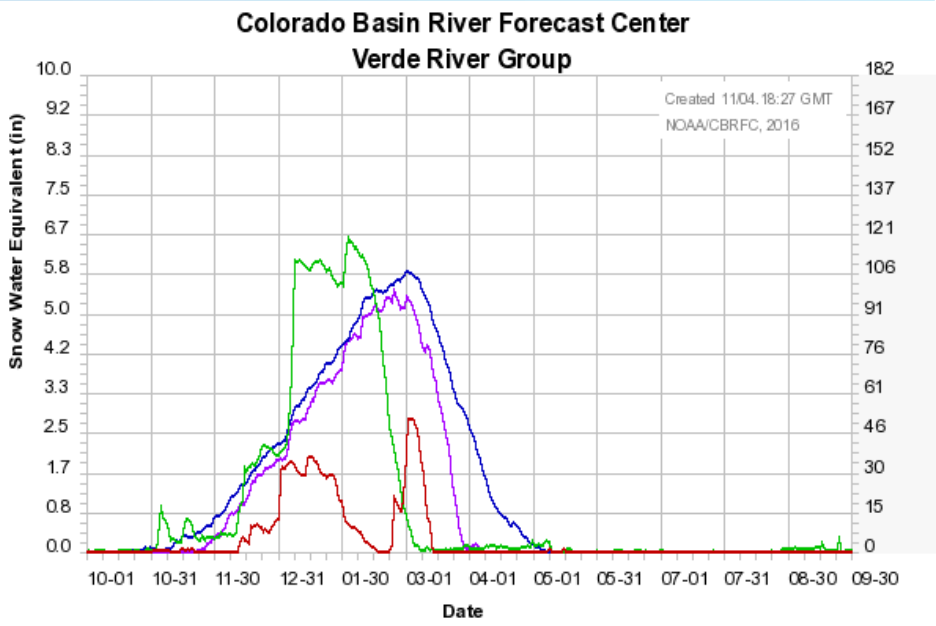
Logan at Logan

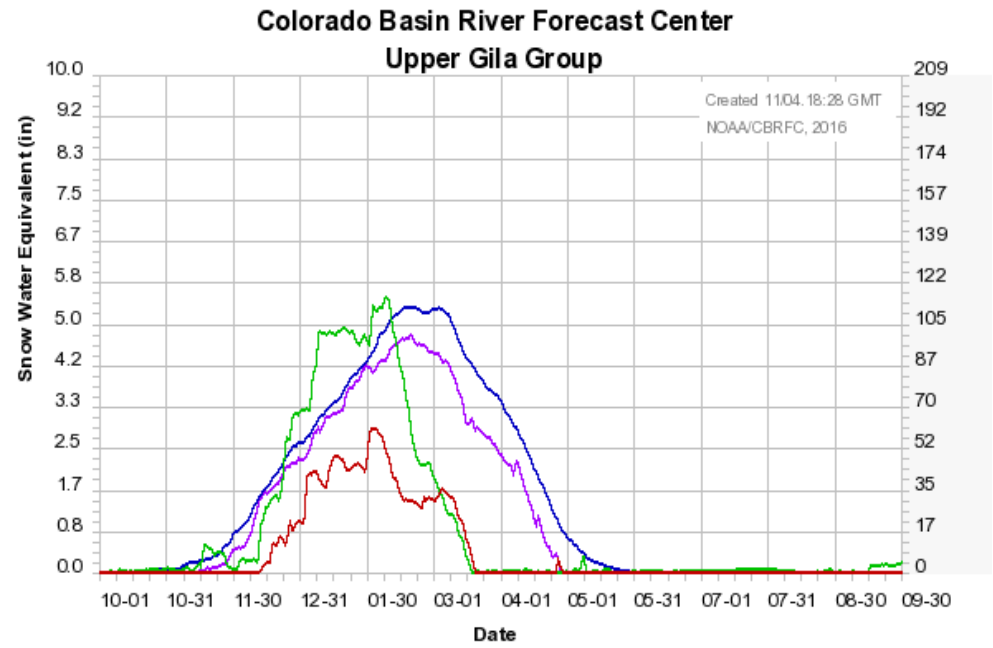


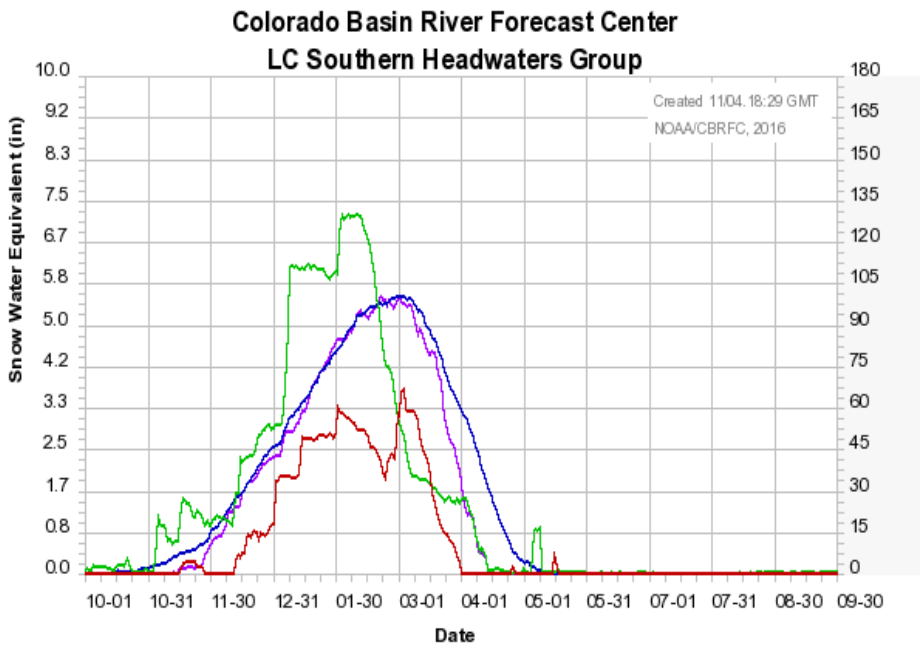
Lower Colorado River Basin

- Strong El Niño Event occurred
  - Correlation with higher flows in the Lower Colorado River Basin
  - Past El Niño events are weighted in our Lower Basin Forecasts
- Precipitation expected during an El Niño event did not occur





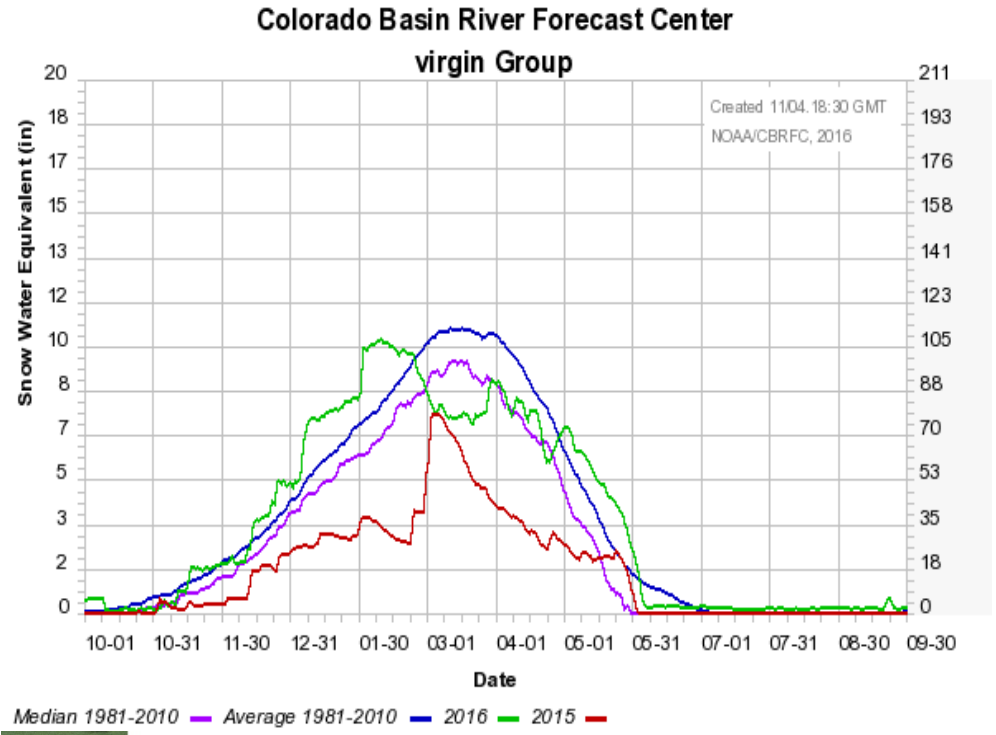


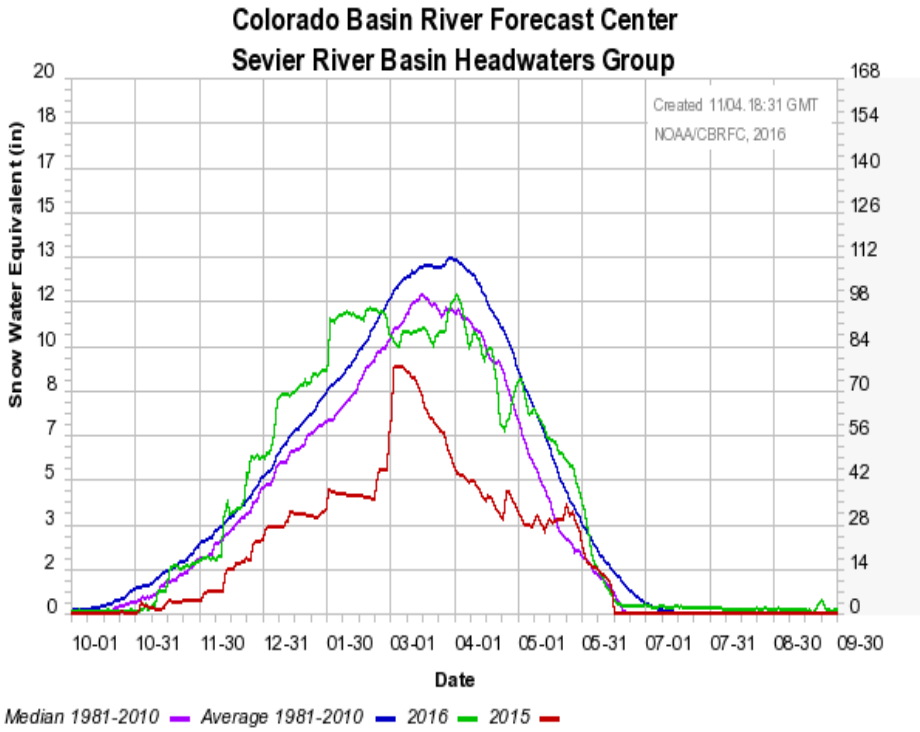


Median 1981-2010 — *Average 1981-2010* — *2016* — *2015* —

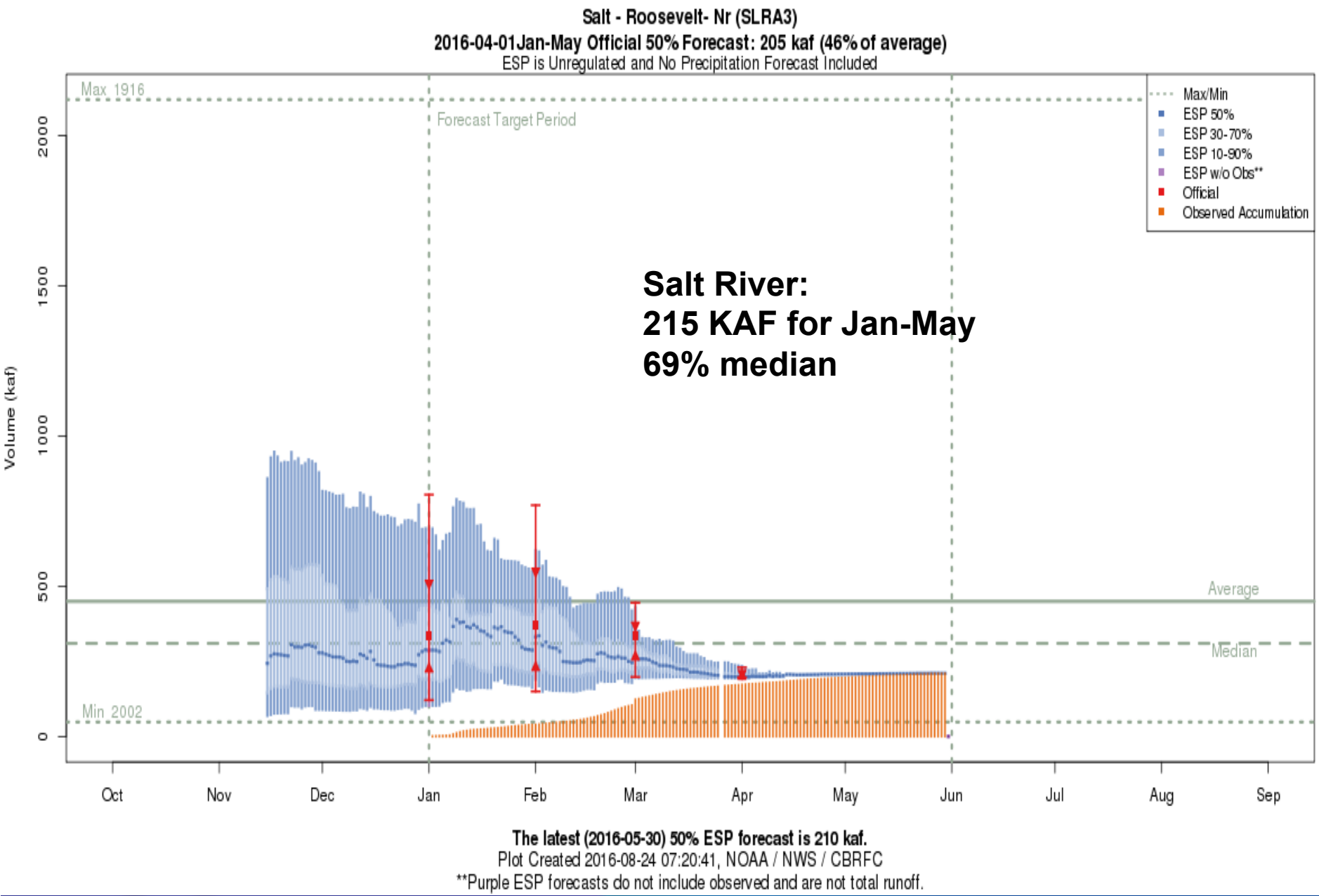
Median 1981-2010 — *Average 1981-2010* — *2016* — *2015* —

2016 Snowpack – Southern Utah

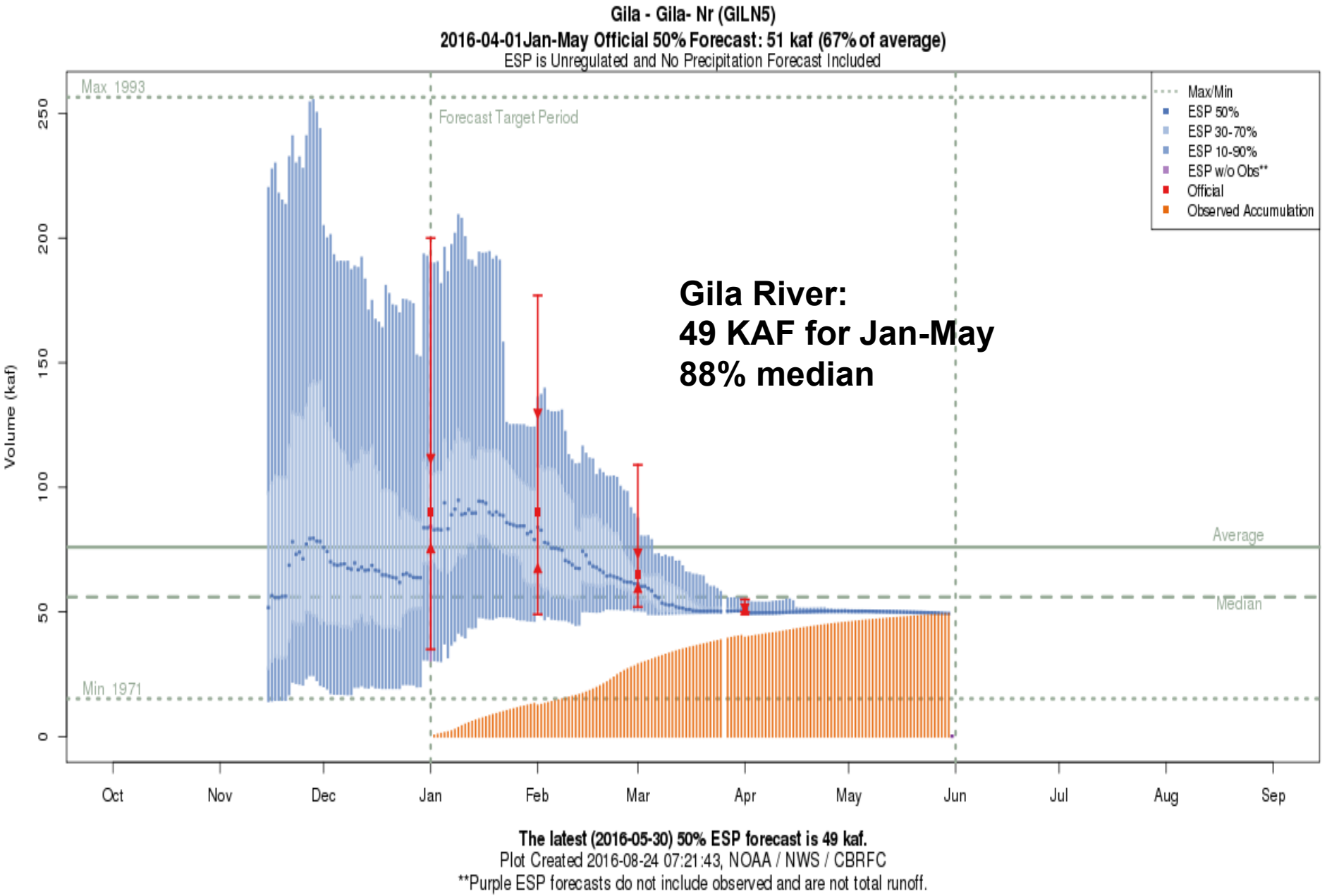




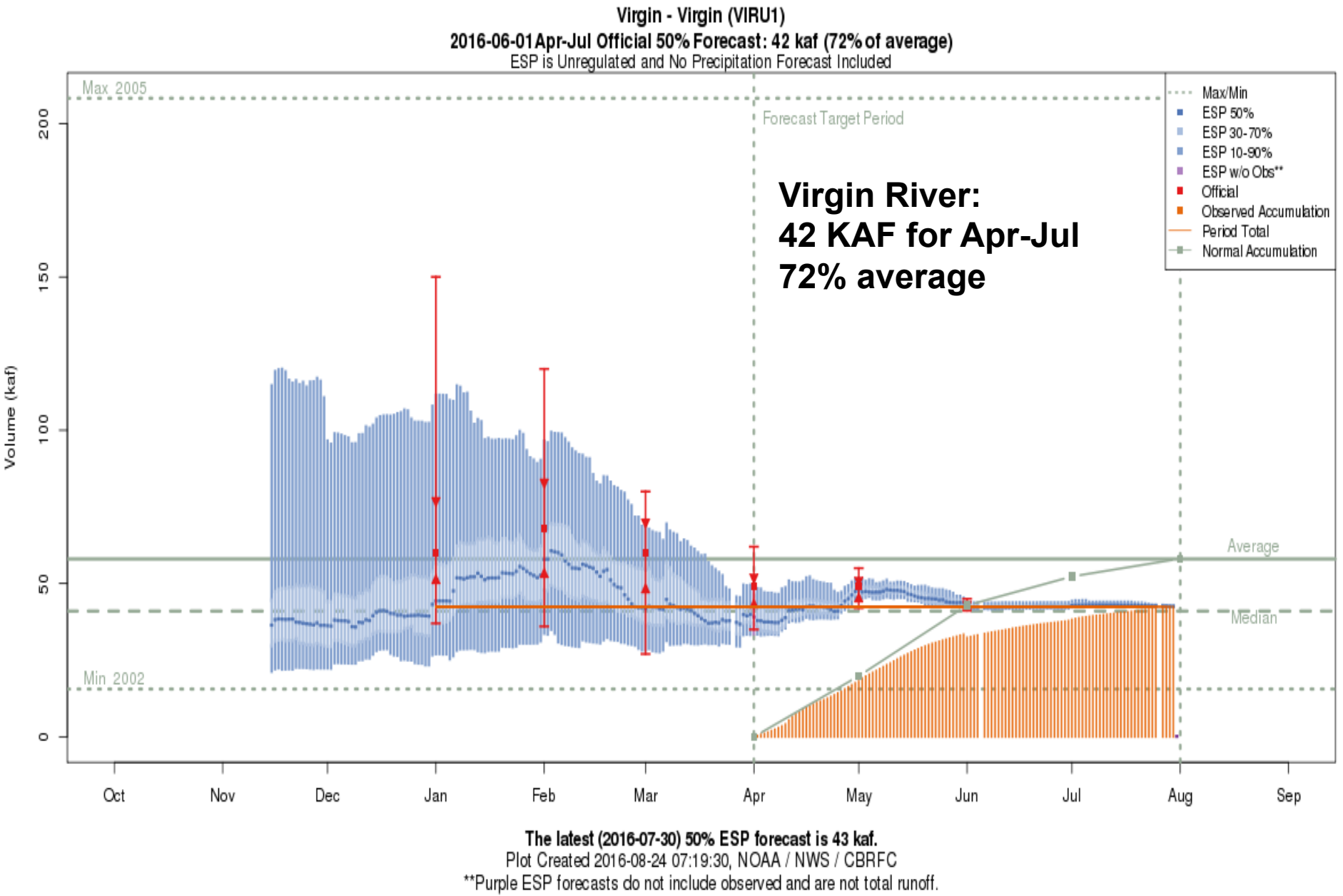
Salt


Salt - Roosevelt- Nr (SLRA3)
2016-04-01Jan-May Official 50% Forecast: 205 kaf (46% of average)
ESP is Unregulated and No Precipitation Forecast Included
Max 1916
Forecast Target Period
Max/Min
ESP 50%
ESP 30-70%
ESP 10-90%
ESP w/o Obs**
Official
Observed Accumulation
Salt River:
215 KAF for Jan-May
69% median
Average
Median
Min 2002
Volume (kaf)
0
500
1000
1500
2000
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
The latest (2016-05-30) 50% ESP forecast is 210 kaf.
Plot Created 2016-08-24 07:20:41, NOAA / NWS / CBRFC
**Purple ESP forecasts do not include observed and are not total runoff.

Upper Gila


Gila - Gila- Nr (GILN5)
2016-04-01Jan-May Official 50% Forecast: 51 kaf (67% of average)
ESP is Unregulated and No Precipitation Forecast Included
Max. 1993
Forecast Target Period
Max/Min
ESP 50%
ESP 30-70%
ESP 10-90%
ESP w/o Obs**
Official
Observed Accumulation
Gila River:
49 KAF for Jan-May
88% median
Average
Median
Min. 1971
Volume (kaf)
0
50
100
150
200
250
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
The latest (2016-05-30) 50% ESP forecast is 49 kaf.
Plot Created 2016-08-24 07:21:43, NOAA / NWS / CBRFC
**Purple ESP forecasts do not include observed and are not total runoff.

Virgin


Virgin - Virgin (VIRU1)
2016-06-01 Apr-Jul Official 50% Forecast: 42 kaf (72% of average)
ESP is Unregulated and No Precipitation Forecast Included
Max 2005
Min 2002
Forecast Target Period
Average
Median
Max/Min
ESP 50%
ESP 30-70%
ESP 10-90%
ESP w/o Obs**
Official
Observed Accumulation
Period Total
Normal Accumulation
Volume (kaf)
0
50
100
150
200
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Virgin River:
42 KAF for Apr-Jul
72% average
The latest (2016-07-30) 50% ESP forecast is 43 kaf.
Plot Created 2016-08-24 07:19:30, NOAA / NWS / CBRFC
**Purple ESP forecasts do not include observed and are not total runoff.

Summary

- Overall, Hydrologic Model performed well
  - Model states entering the winter were good!
  - Dry and Warm February and March significantly impacted runoff
  - Late season storms brought increased water supply, but impacted forecast performance
- El Niño did not pan out in the Lower Colorado River Basin