NOAA's Colorado Basin River Forecast Center

Water Year 2015 Hydrologic Conditions, Trends, and Forecasts So Far

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Basin States Technical Committee Meeting

April 28, 2015

Las Vegas, NV – McCarran International Airport

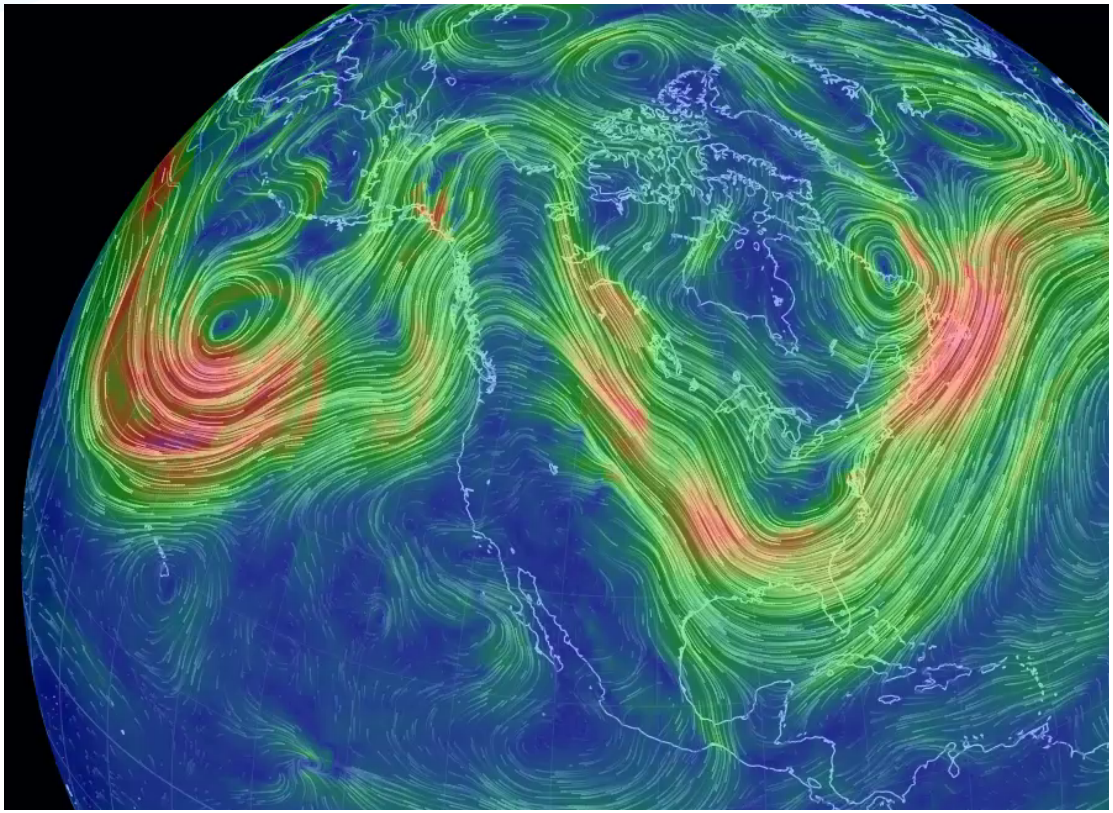
The Take Away

- WY 2015 water supply is projected to be well below average, due to a combination of dry conditions and warm temperatures throughout the basin. In some areas (e.g., San Juan, Great Basin), poor soil moisture conditions have exacerbated impacts
- Poor snowpack and early melt conditions have been prevalent
- Forecasted April – July unregulated inflow to Lake Powell is 3.4 MAF (47% of average)

Overview

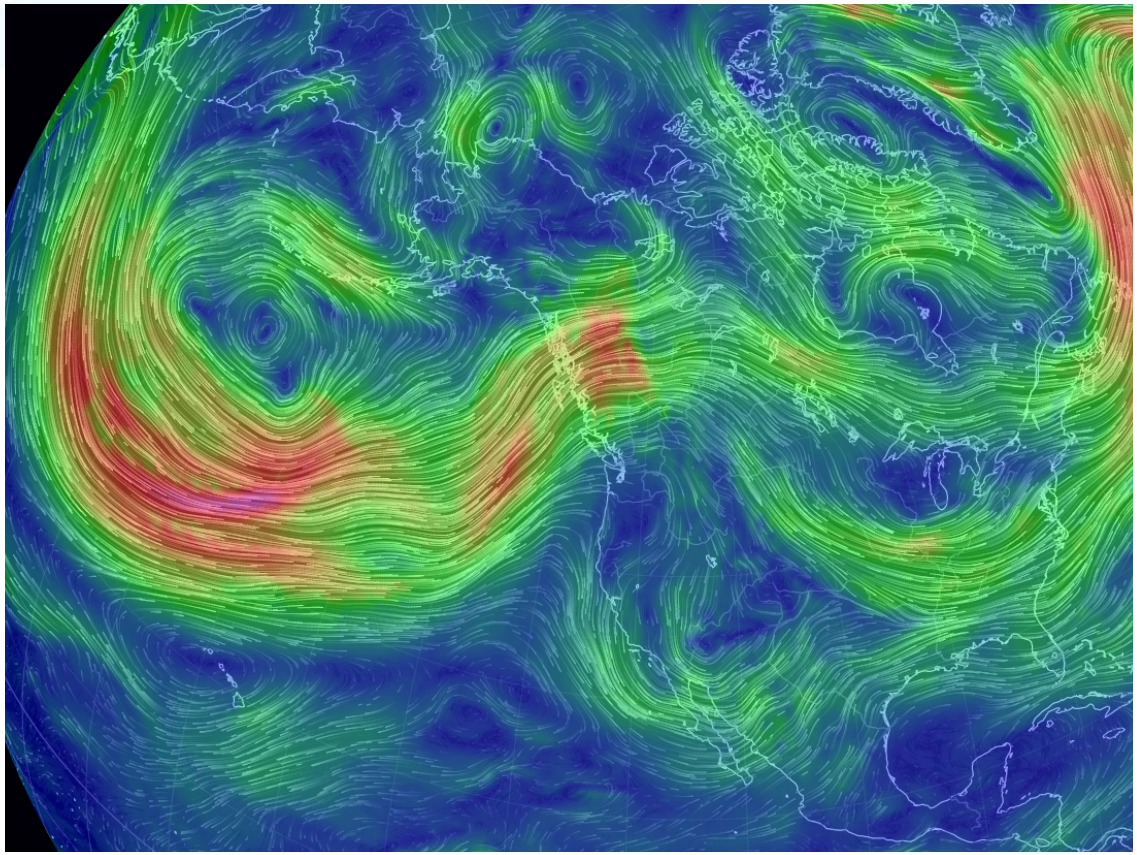
- This season's hydroclimatic conditions
  - Winter precipitation and high pressure ridge
  - Record setting winter temperatures
  - Early runoff and melt
  - Forecasted April through July streamflow
- Looking ahead
- Questions and comments

Winter Jet Stream Déjà Vu



This image is from January 21, 2014 and illustrates the dominant weather pattern we observed throughout much of WY 2014. Last year, winter temperatures in the Upper Colorado region were near to below normal.

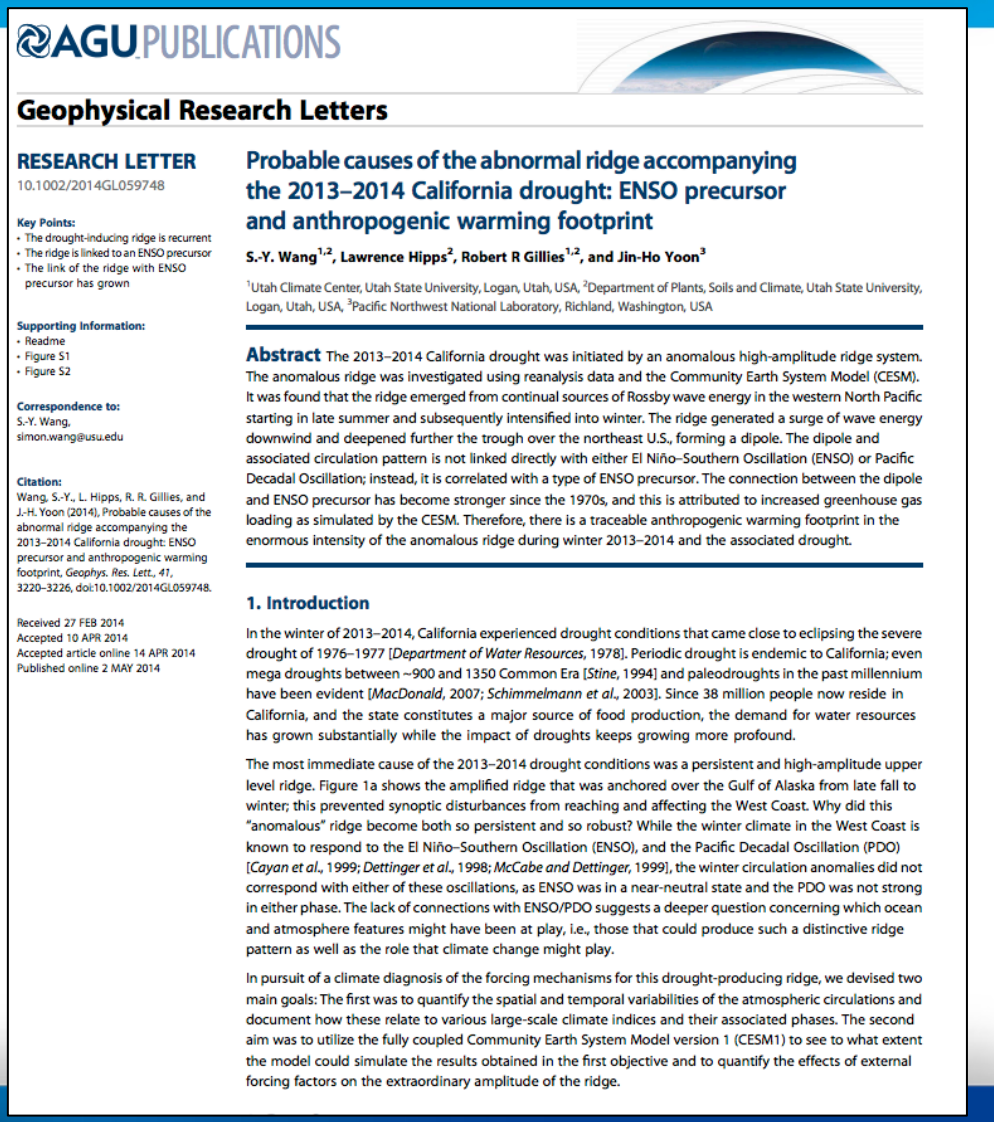
Winter Jet Stream Déjà Vu



This image is from January 21, 2015 and illustrates the dominant weather pattern we observed throughout much of WY 2015. Again, a high pressure ridge over the western U.S. is pushing moisture around the Colorado River Basin; however, this year, temperatures in the Upper Colorado region were much above normal.

Winter Jet Stream Déjà Vu

Recent research out of the Utah Climate Center and Utah State University suggests this ridge is associated with an ENSO precursor and increased greenhouse gas loading in the CESM. "…there is a traceable anthropogenic warming footprint … during winter 2013-2014 and the associated drought."



AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2014GL059748

Key Points:
- The drought-inducing ridge is recurrent
- The ridge is linked to an ENSO precursor
- The link of the ridge with ENSO precursor has grown

Supporting Information:
- Readme
- Figure S1
- Figure S2

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Probable causes of the abnormal ridge accompanying the 2013–2014 California drought: ENSO precursor and anthropogenic warming footprint

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Abstract The 2013–2014 California drought was initiated by an anomalous high-amplitude ridge system. The anomalous ridge was investigated using reanalysis data and the Community Earth System Model (CESM). It was found that the ridge emerged from continual sources of Rossby wave energy in the western North Pacific starting in late summer and subsequently intensified into winter. The ridge generated a surge of wave energy downwind and deepened further the trough over the northeast U.S., forming a dipole. The dipole and associated circulation pattern is not linked directly with either El Niño–Southern Oscillation (ENSO) or Pacific Decadal Oscillation; instead, it is correlated with a type of ENSO precursor. The connection between the dipole and ENSO precursor has become stronger since the 1970s, and this is attributed to increased greenhouse gas loading as simulated by the CESM. Therefore, there is a traceable anthropogenic warming footprint in the enormous intensity of the anomalous ridge during winter 2013–2014 and the associated drought.

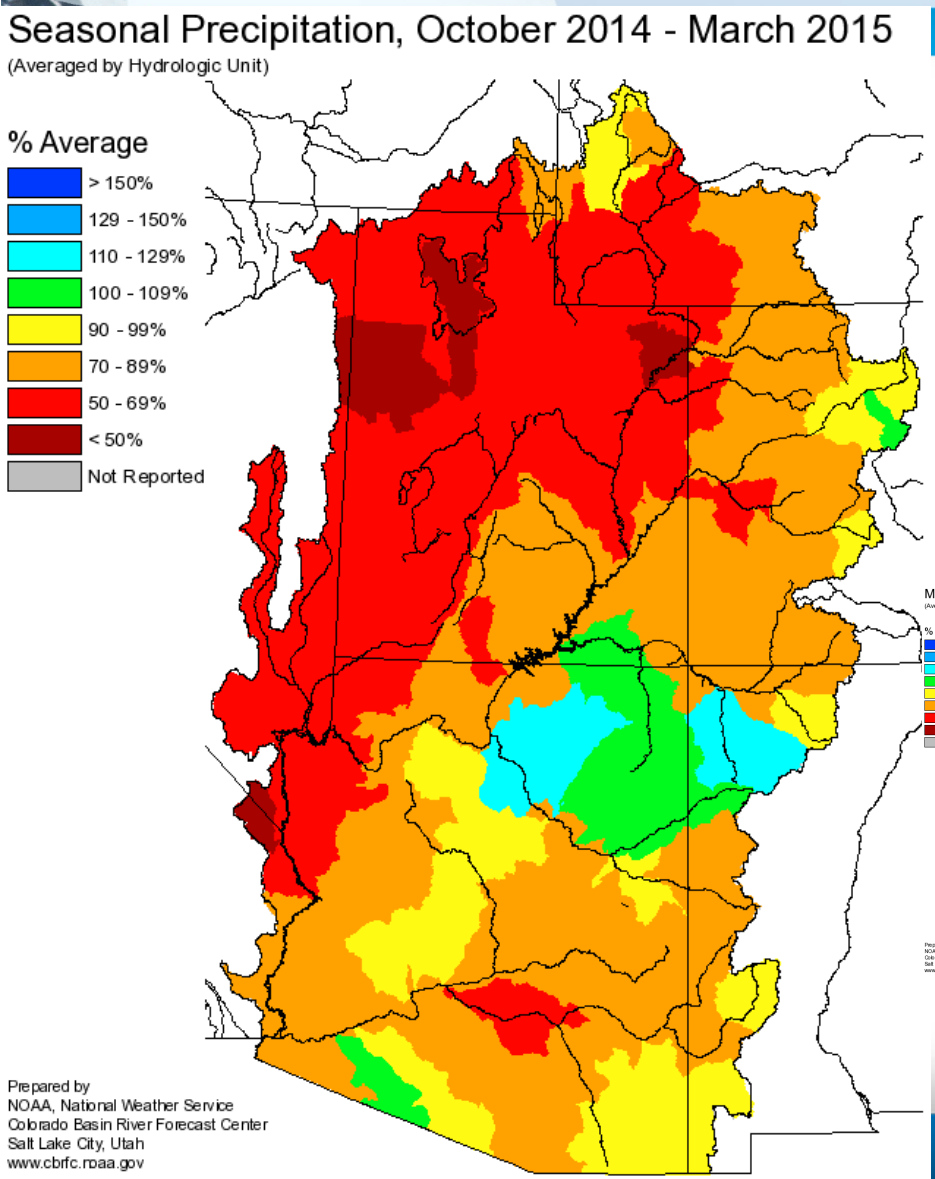
1. Introduction

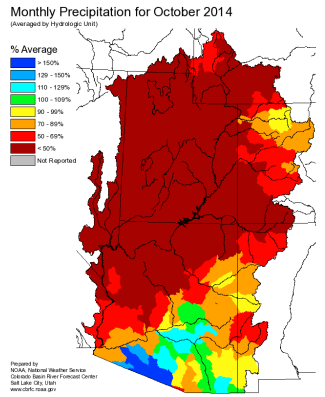
In the winter of 2013–2014, California experienced drought conditions that came close to eclipsing the severe drought of 1976–1977 [*Department of Water Resources*, 1978]. Periodic drought is endemic to California; even mega droughts between ~900 and 1350 Common Era [*Stine*, 1994] and paleodroughts in the past millennium have been evident [*MacDonald*, 2007; *Schimmelmann et al.*, 2003]. Since 38 million people now reside in California, and the state constitutes a major source of food production, the demand for water resources has grown substantially while the impact of droughts keeps growing more profound.

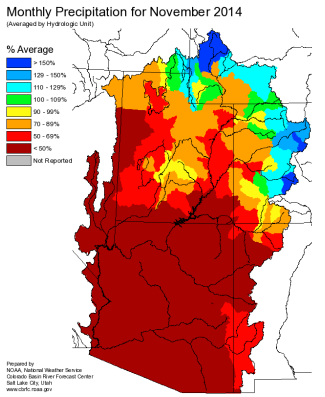
The most immediate cause of the 2013–2014 drought conditions was a persistent and high-amplitude upper level ridge. Figure 1a shows the amplified ridge that was anchored over the Gulf of Alaska from late fall to winter; this prevented synoptic disturbances from reaching and affecting the West Coast. Why did this "anomalous" ridge become both so persistent and so robust? While the winter climate in the West Coast is known to respond to the El Niño–Southern Oscillation (ENSO), and the Pacific Decadal Oscillation (PDO) [*Cayan et al.*, 1999; *Dettinger et al.*, 1998; *McCabe and Dettinger*, 1999], the winter circulation anomalies did not correspond with either of these oscillations, as ENSO was in a near-neutral state and the PDO was not strong in either phase. The lack of connections with ENSO/PDO suggests a deeper question concerning which ocean and atmosphere features might have been at play, i.e., those that could produce such a distinctive ridge pattern as well as the role that climate change might play.

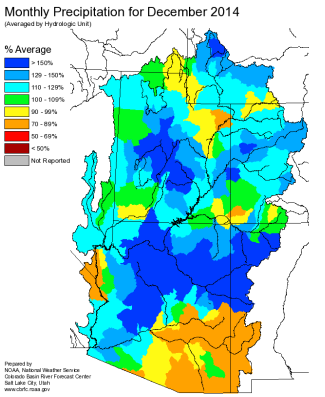
In pursuit of a climate diagnosis of the forcing mechanisms for this drought-producing ridge, we devised two main goals: The first was to quantify the spatial and temporal variabilities of the atmospheric circulations and document how these relate to various large-scale climate indices and their associated phases. The second aim was to utilize the fully coupled Community Earth System Model version 1 (CESM1) to see to what extent the model could simulate the results obtained in the first objective and to quantify the effects of external forcing factors on the extraordinary amplitude of the ridge.

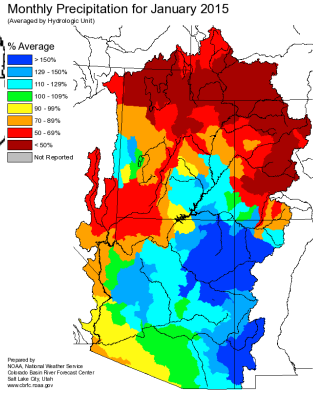
Precipitation

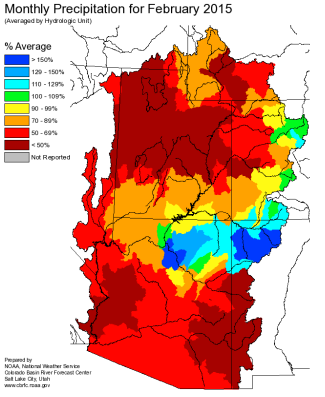


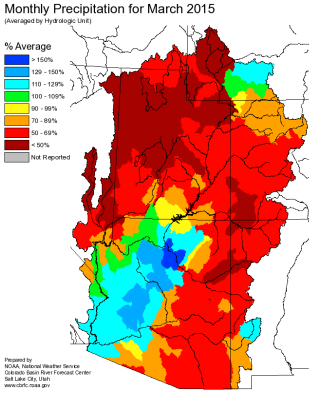




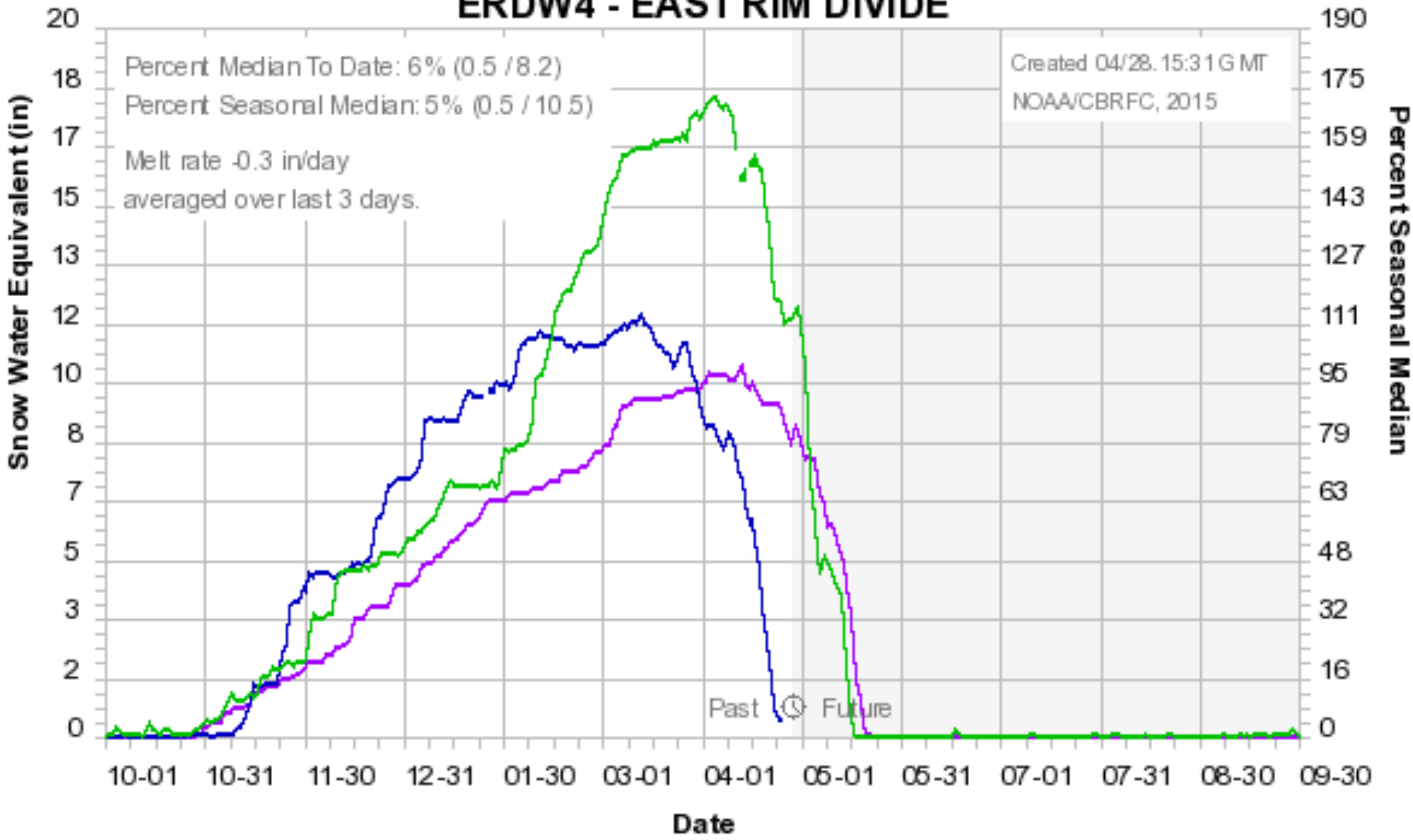






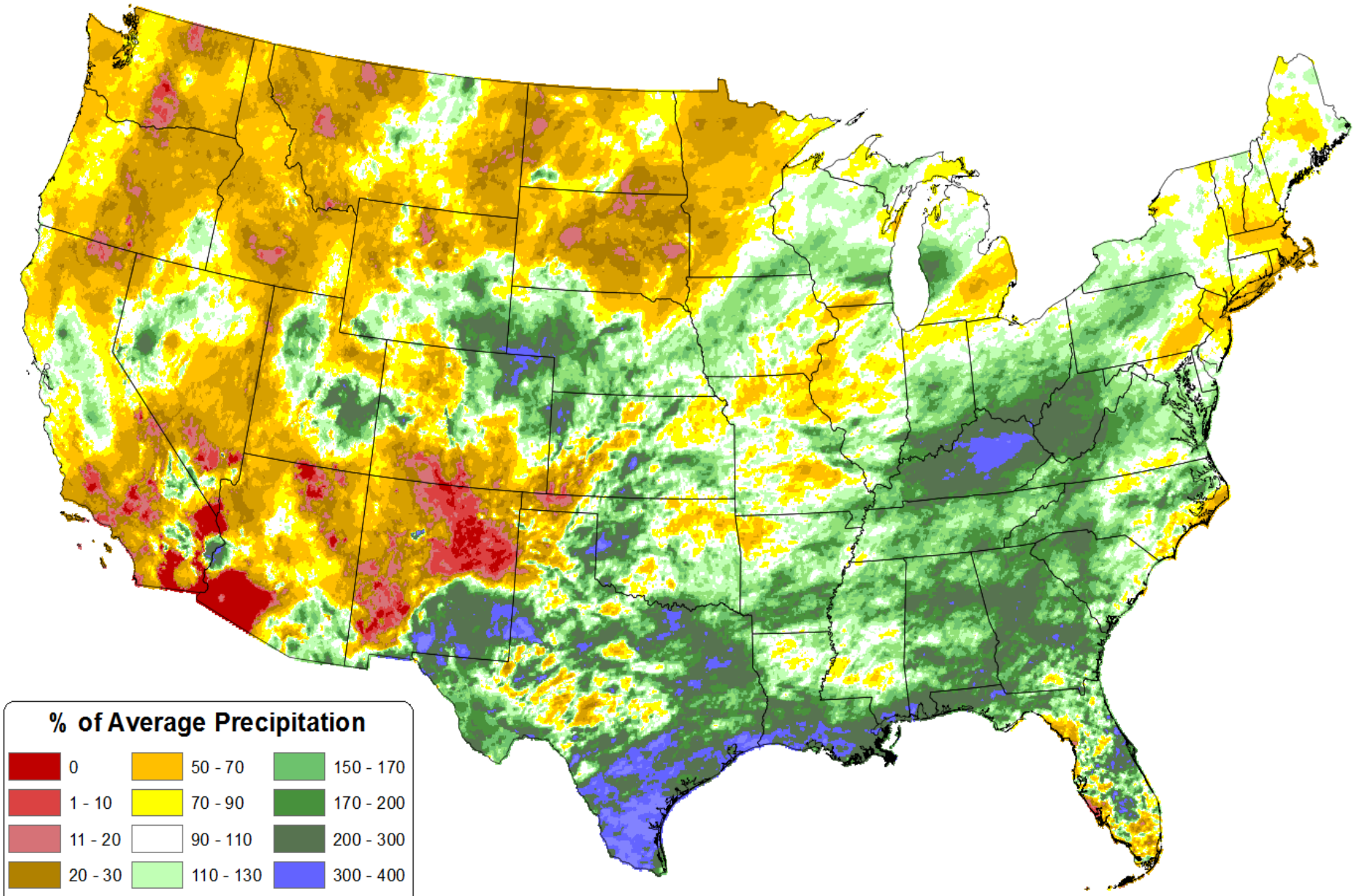


Colorado Basin River Forecast Center
ERDW4 - EAST RIM DIVIDE



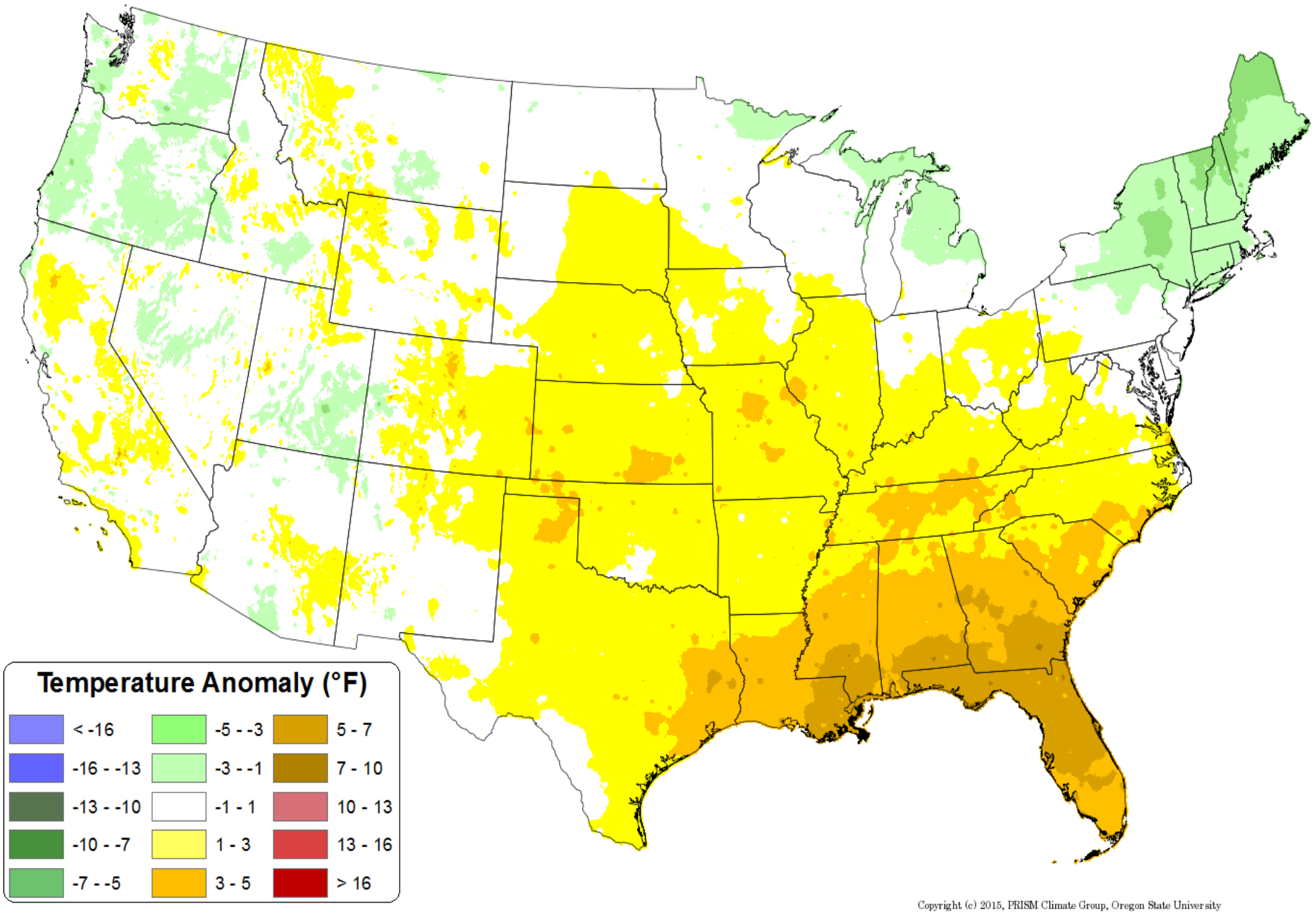
Total Precipitation Anomaly: 01 April 2015 - 26 April 2015

Period ending 7 AM EST 26 Apr 2015
Base period: 1981-2010
(Map created 27 Apr 2015)



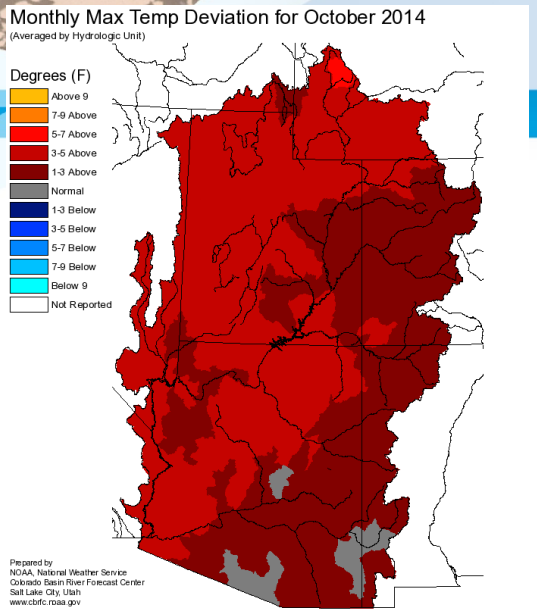
Daily Mean Temperature Anomaly: 01 April 2015 - 26 April 2015

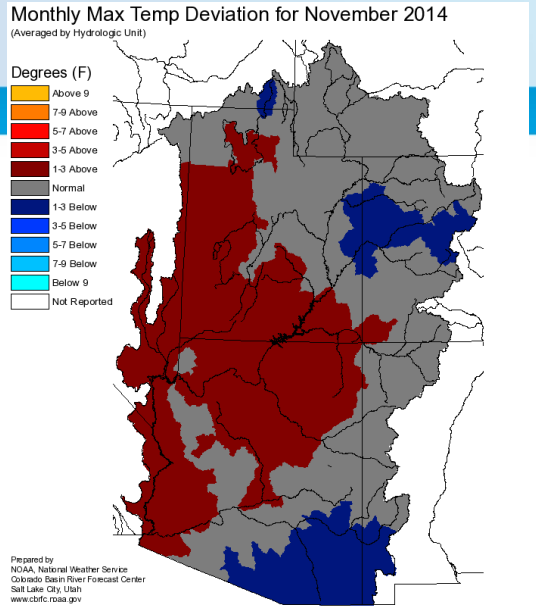
Period ending 7 AM EST 26 Apr 2015
Base period: 1981-2010
(Map created 27 Apr 2015)

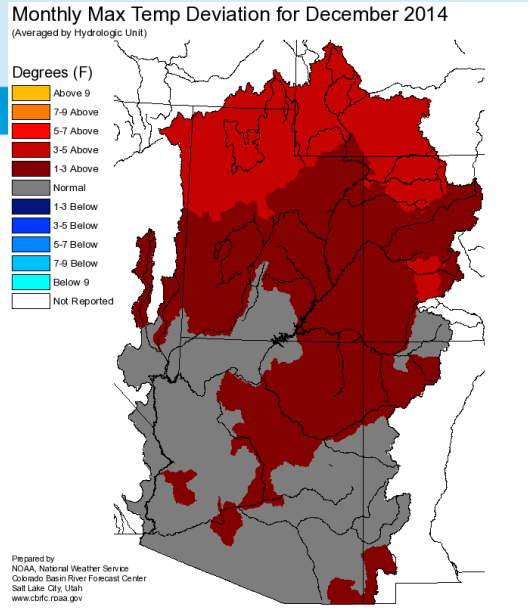


Oct – Dec Temperatures

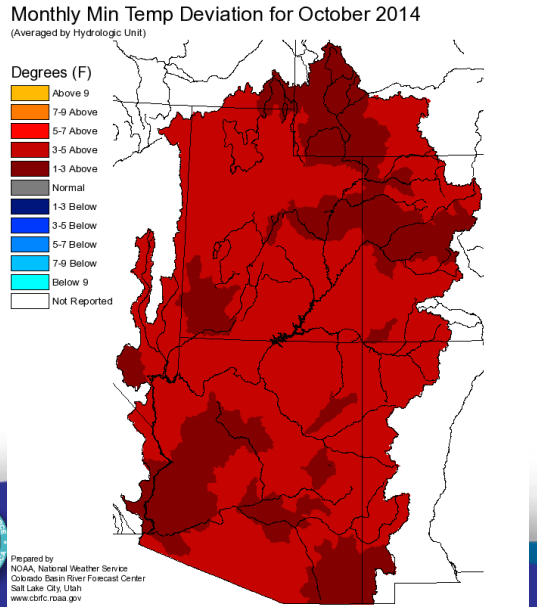
Max Temps

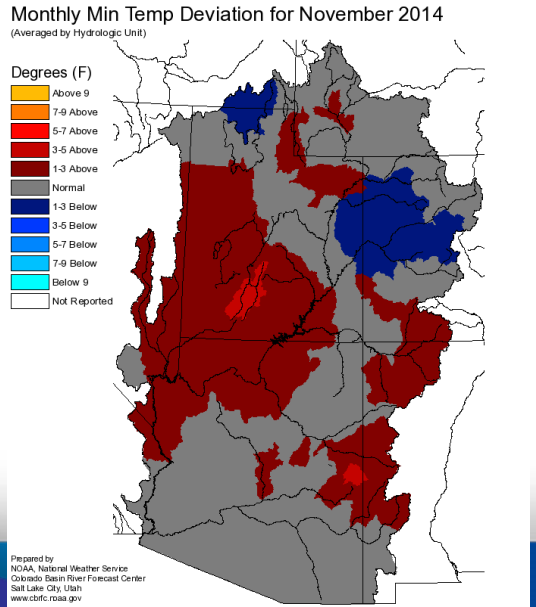


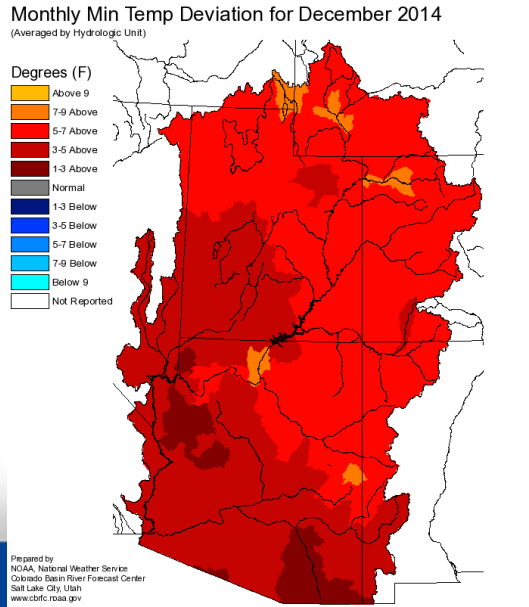




Min Temps

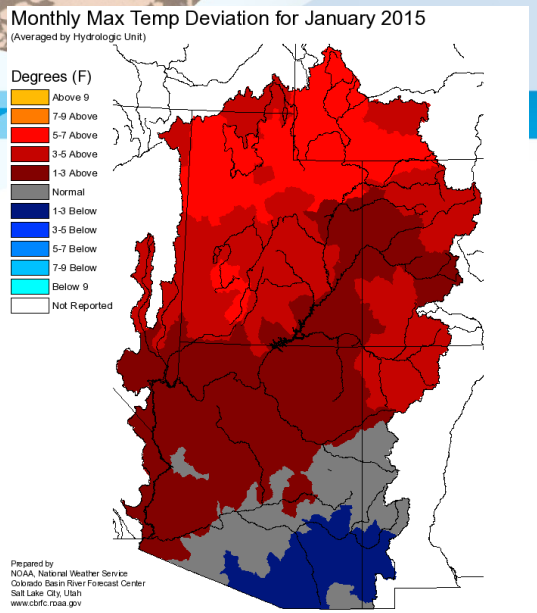


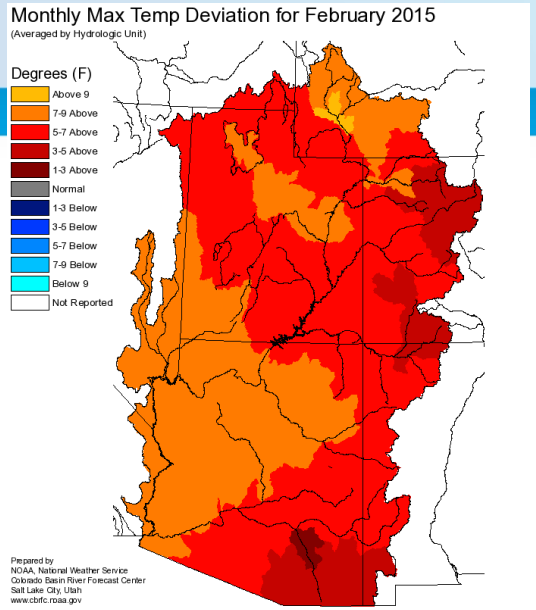


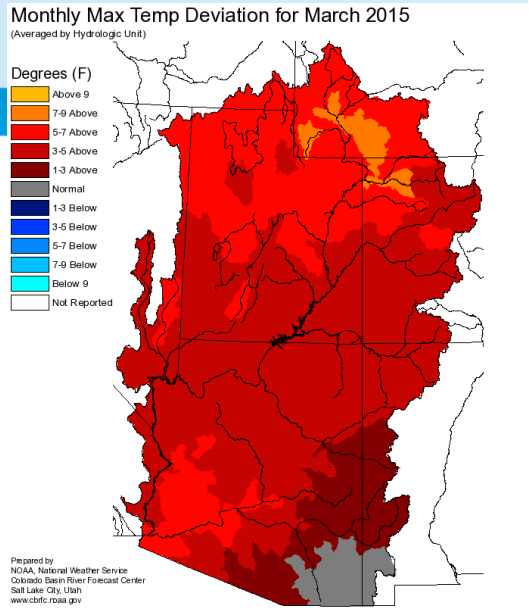


Jan – Mar Temperatures

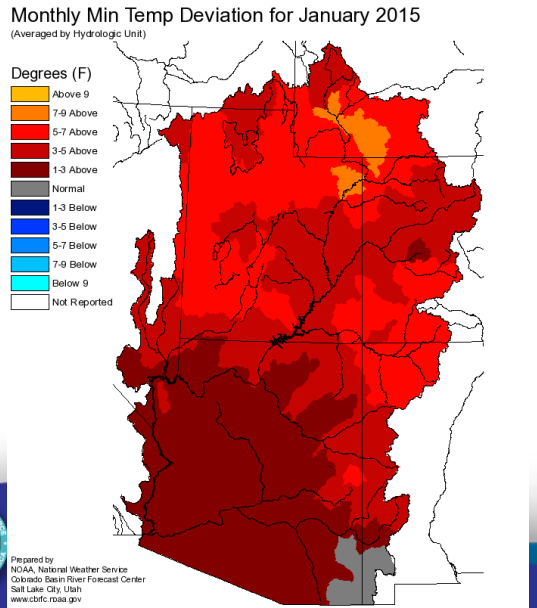
Max Temps

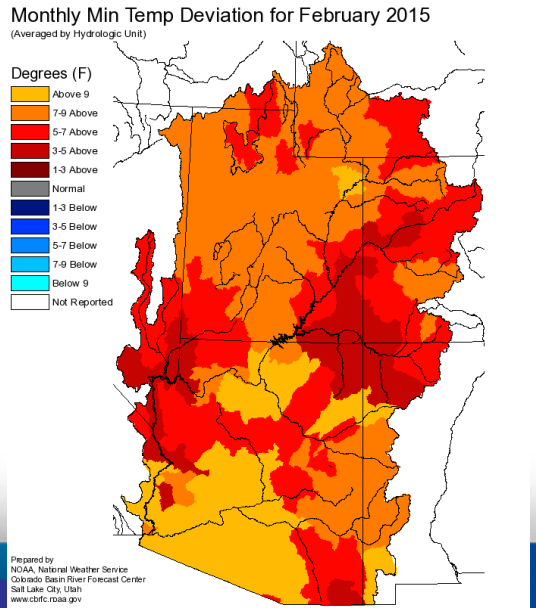


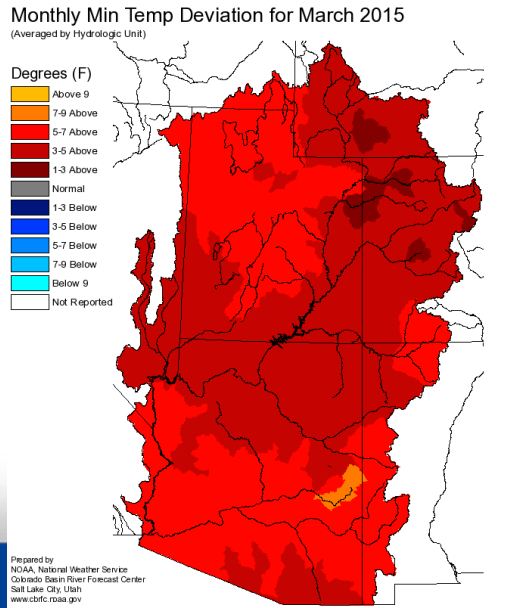




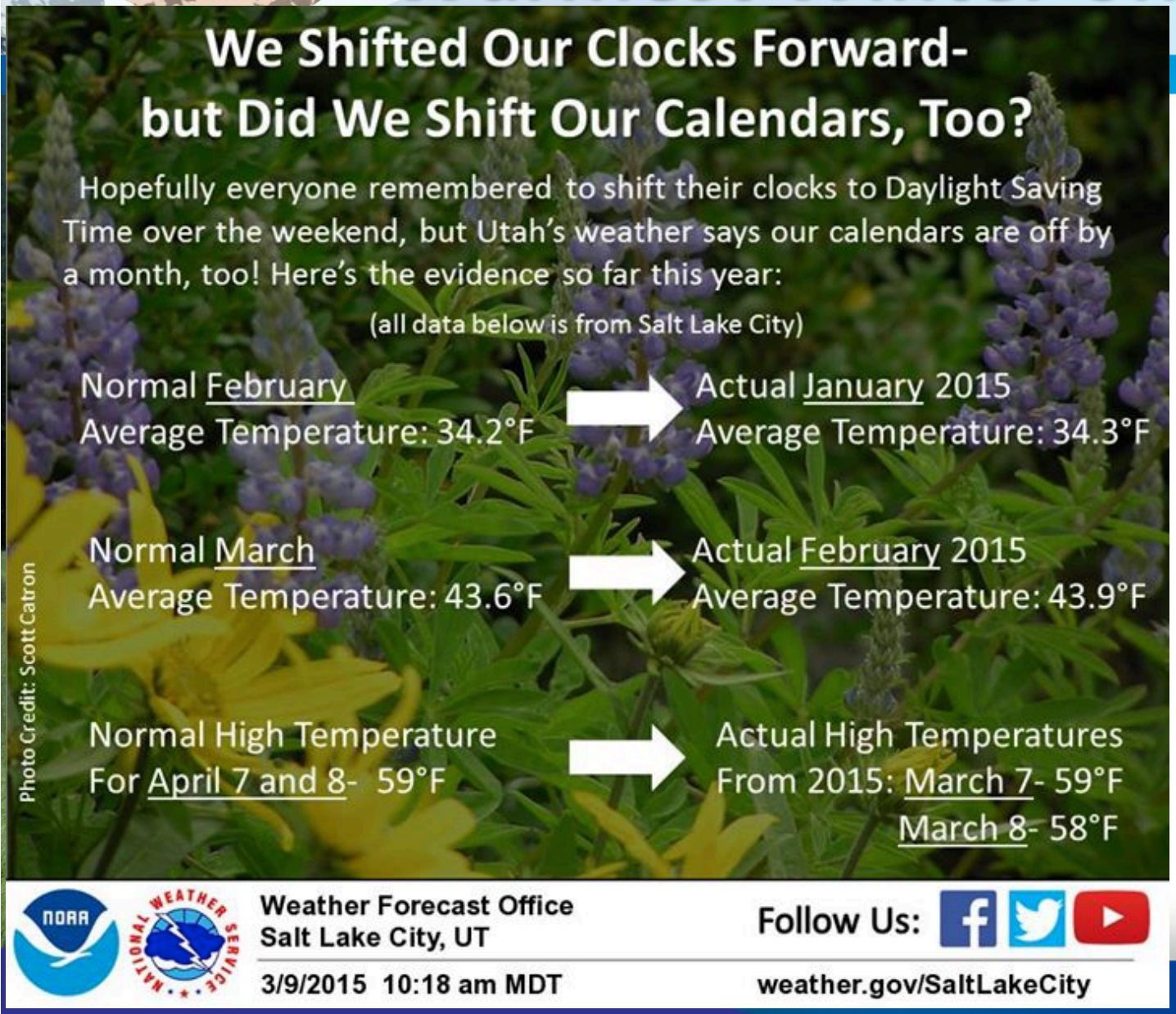
Min Temps







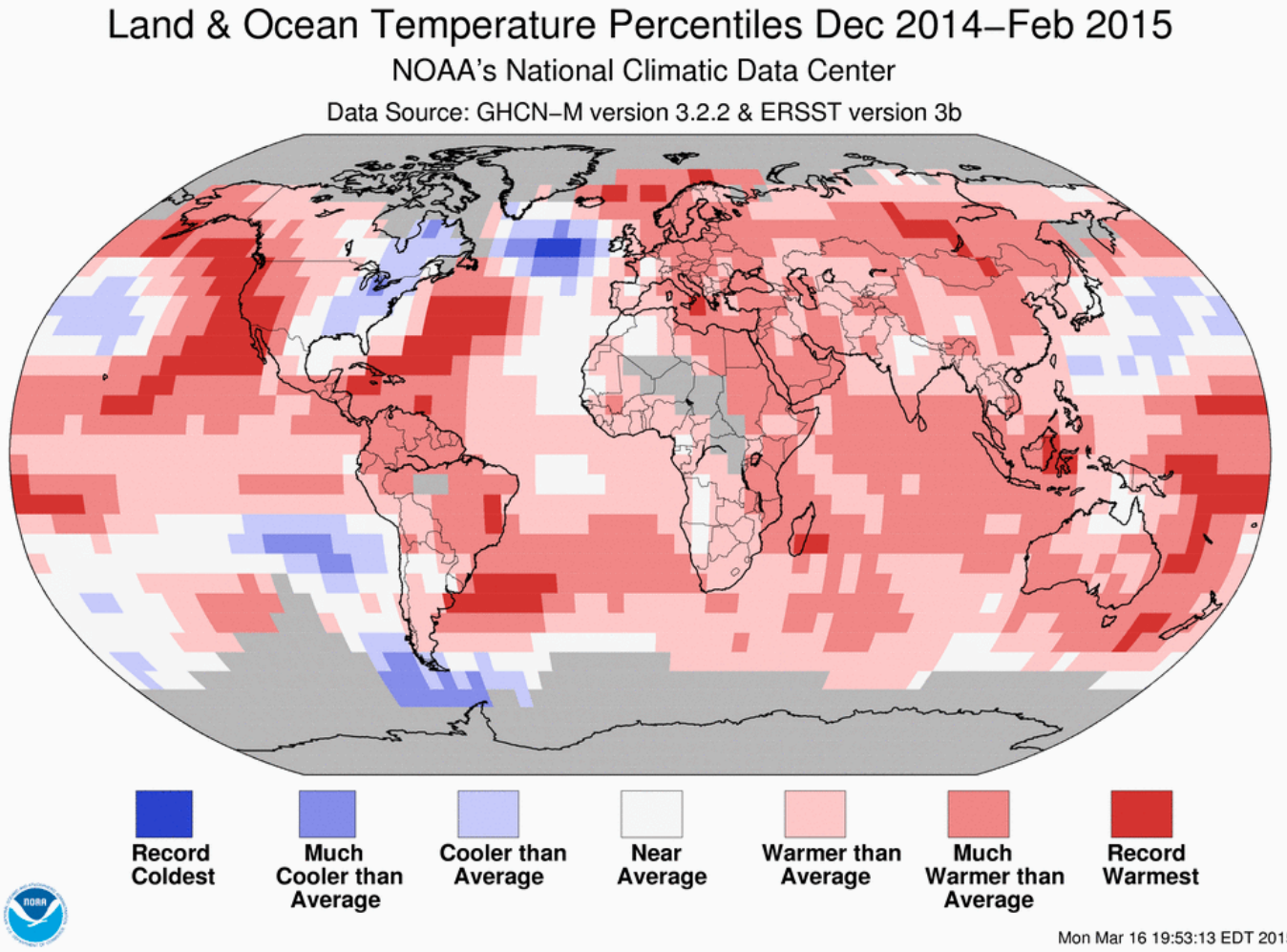
Warmest Winter on Record



This graphic, courtesy of Brian McInerney over at the SLC WFO, shows an interesting correlation between average temperatures this year compared to average.

Warmest Winter on Record

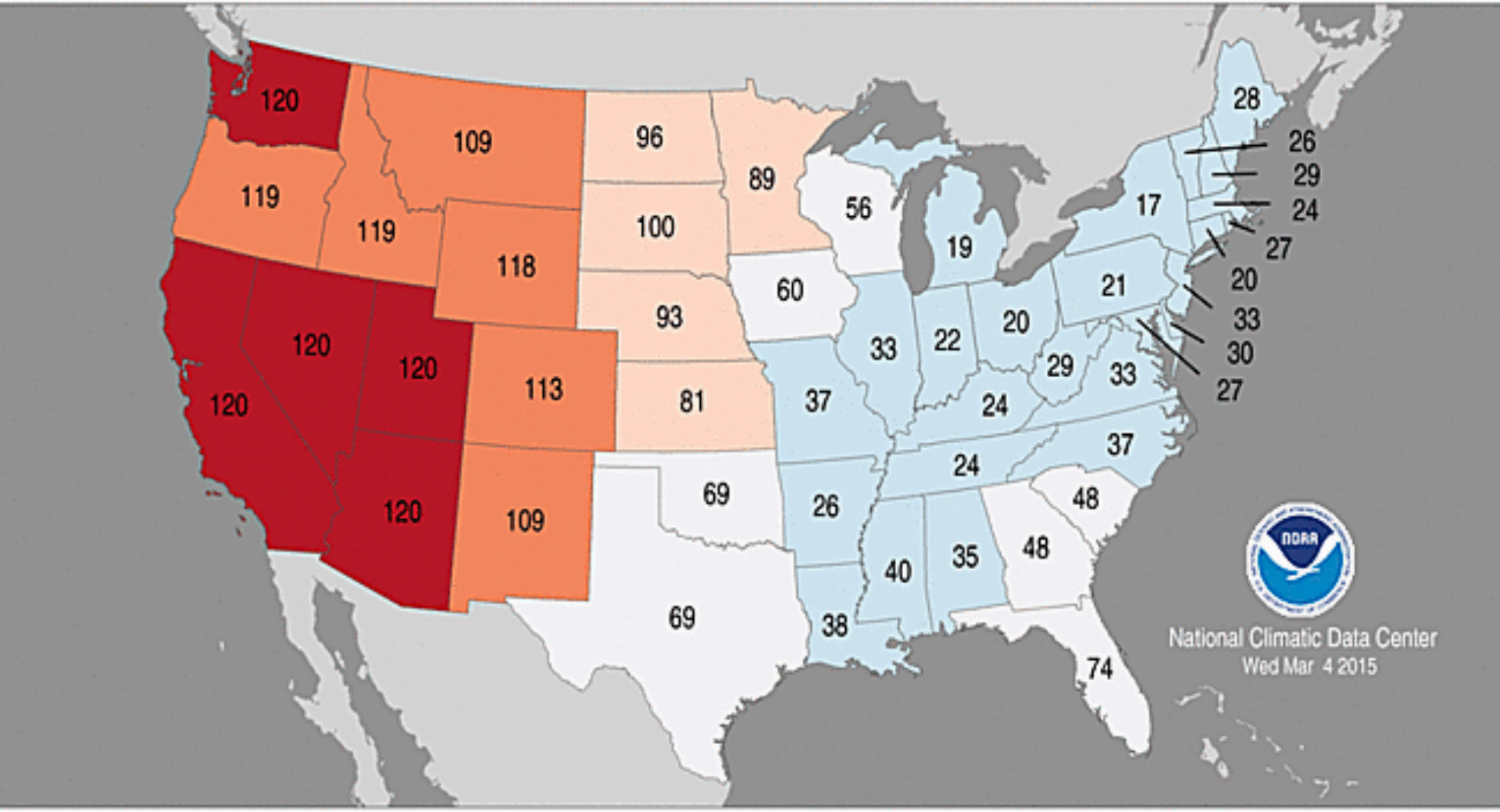
Average global temperatures was 1.42°F above the 20th century average, and highest Dec – Feb in the 1880 – 2015 record, beating the previous high set in 2007.



Statewide Average Temperature Ranks

December 2014–February 2015

Period: 1895–2015



Record Coldest (1)

Much Below Average

Below Average

Near Average

Above Average

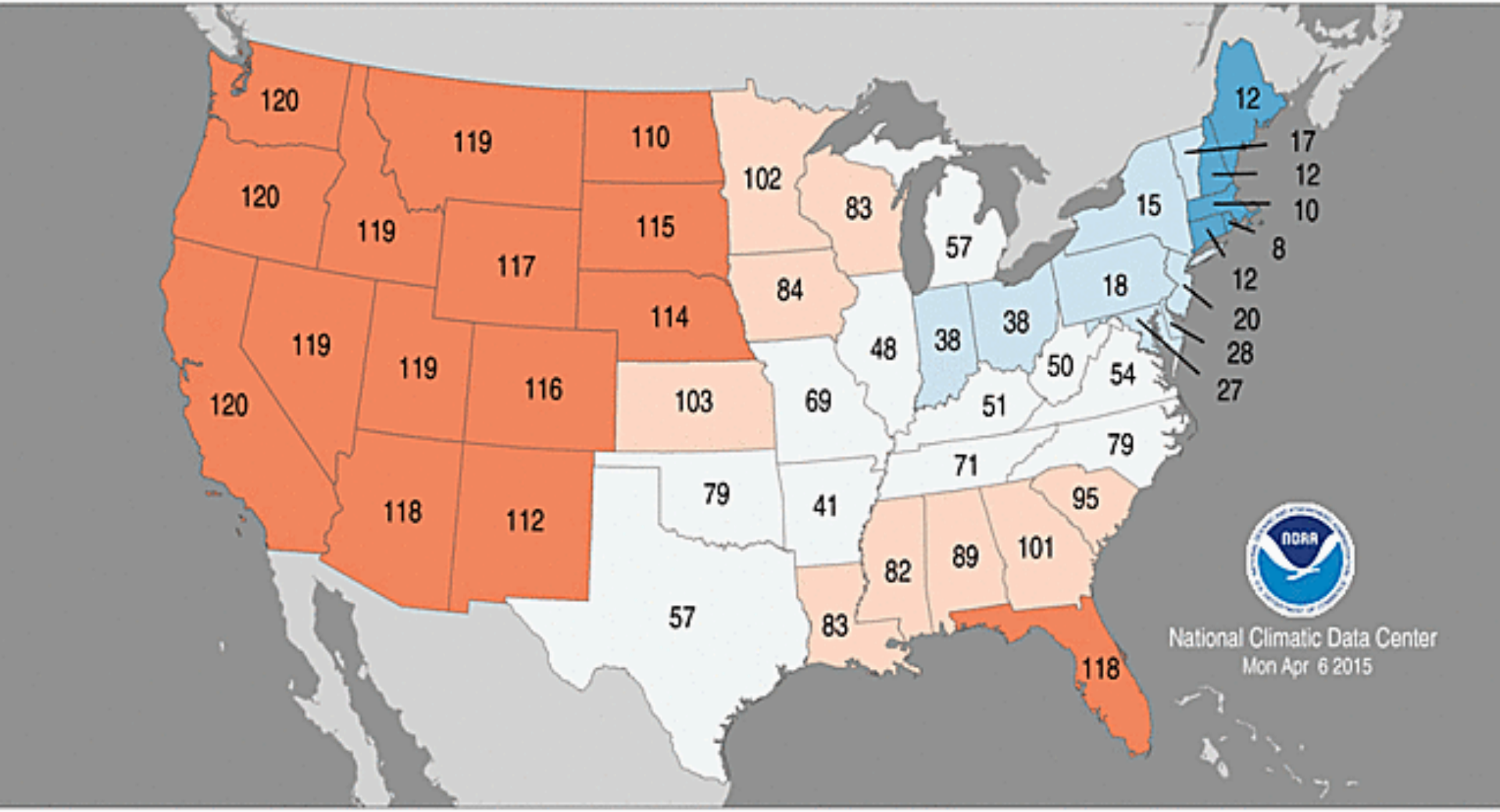
Much Above Average

Record Warmest (120)

Statewide Average Temperature Ranks

March 2015

Period: 1895–2015



Record Coldest (1)

Much Below Average

Below Average

Near Average

Above Average

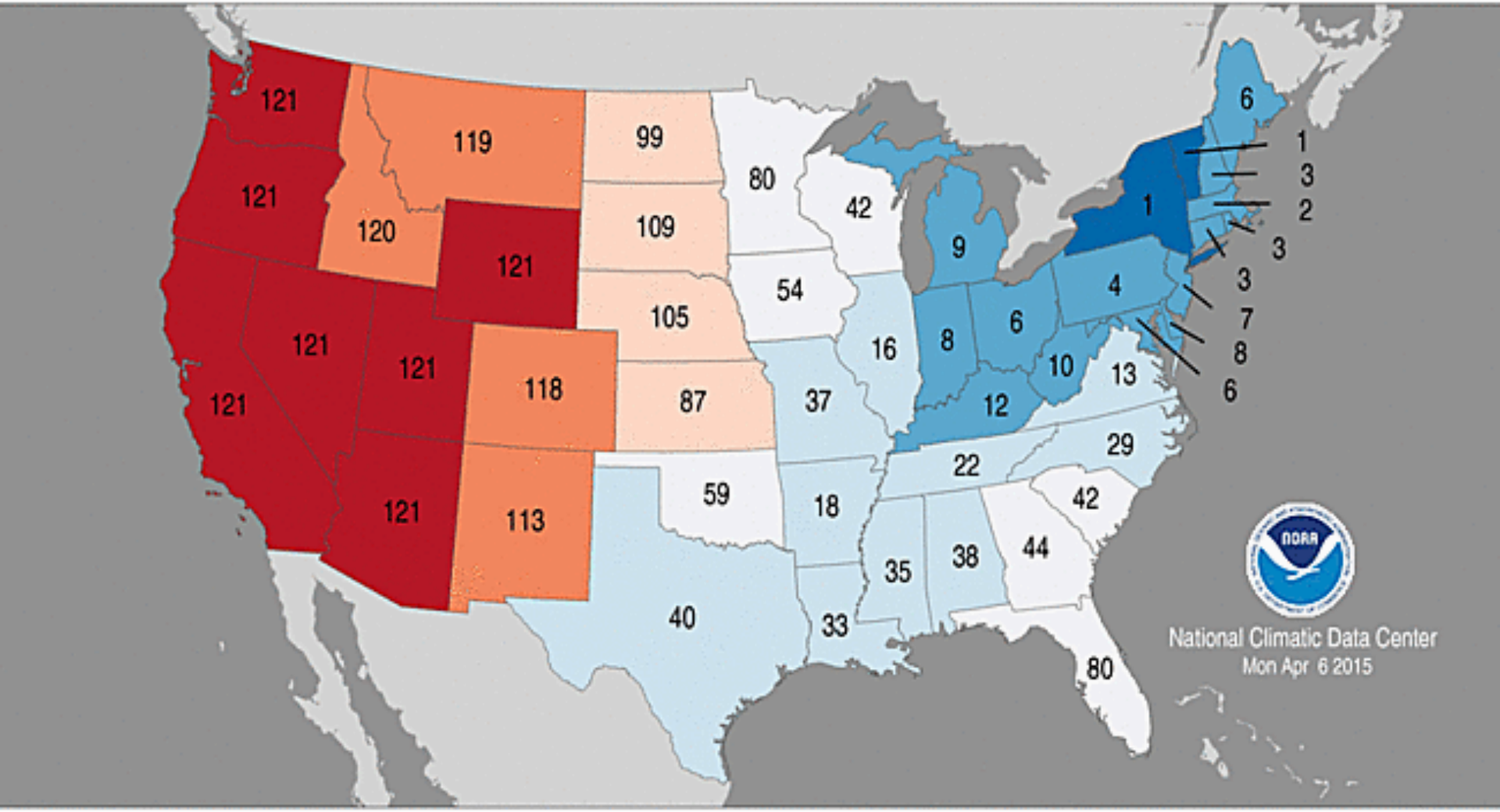
Much Above Average

Record Warmest (121)

Statewide Average Temperature Ranks

January–March 2015

Period: 1895–2015



Record Coldest (1)

Much Below Average

Below Average

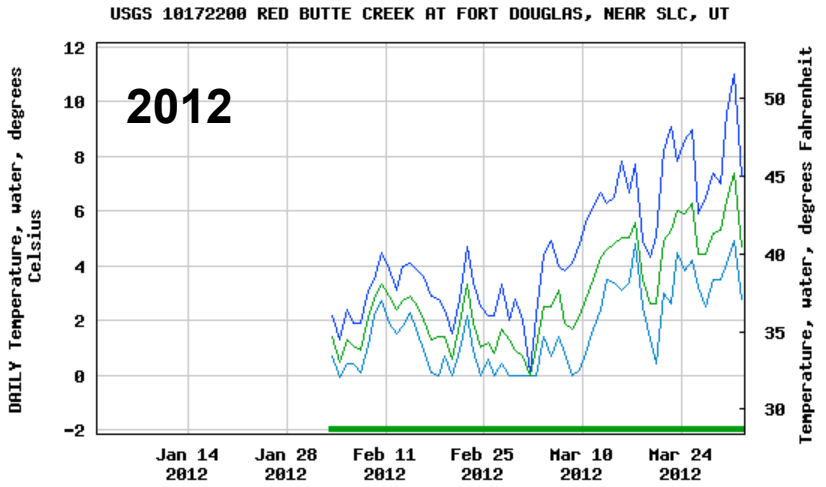
Near Average

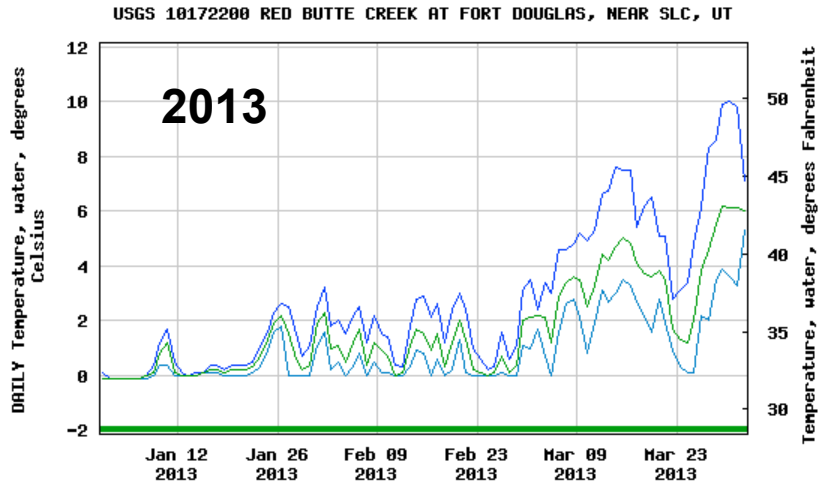
Above Average

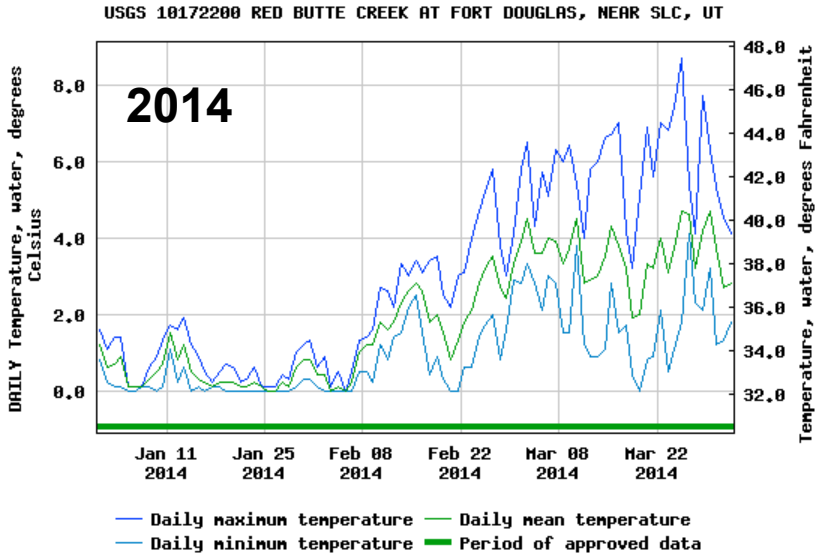
Much Above Average

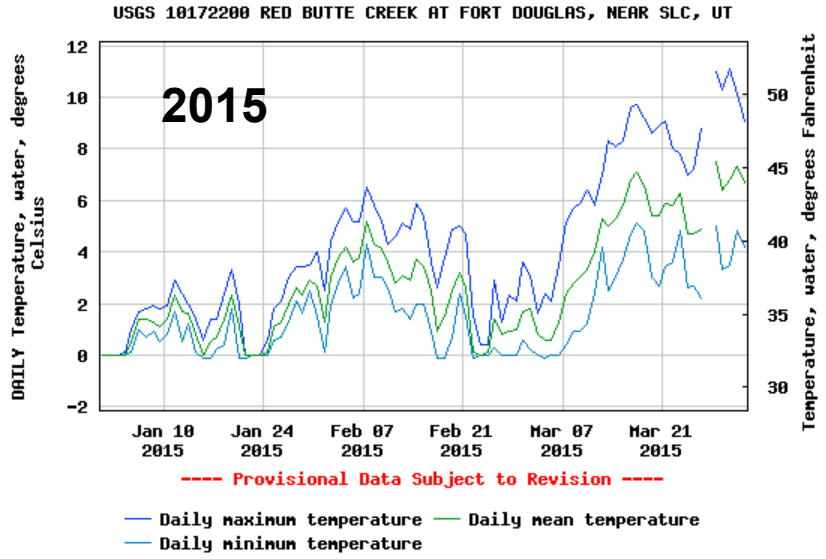
Record Warmest (121)

Water Temperatures







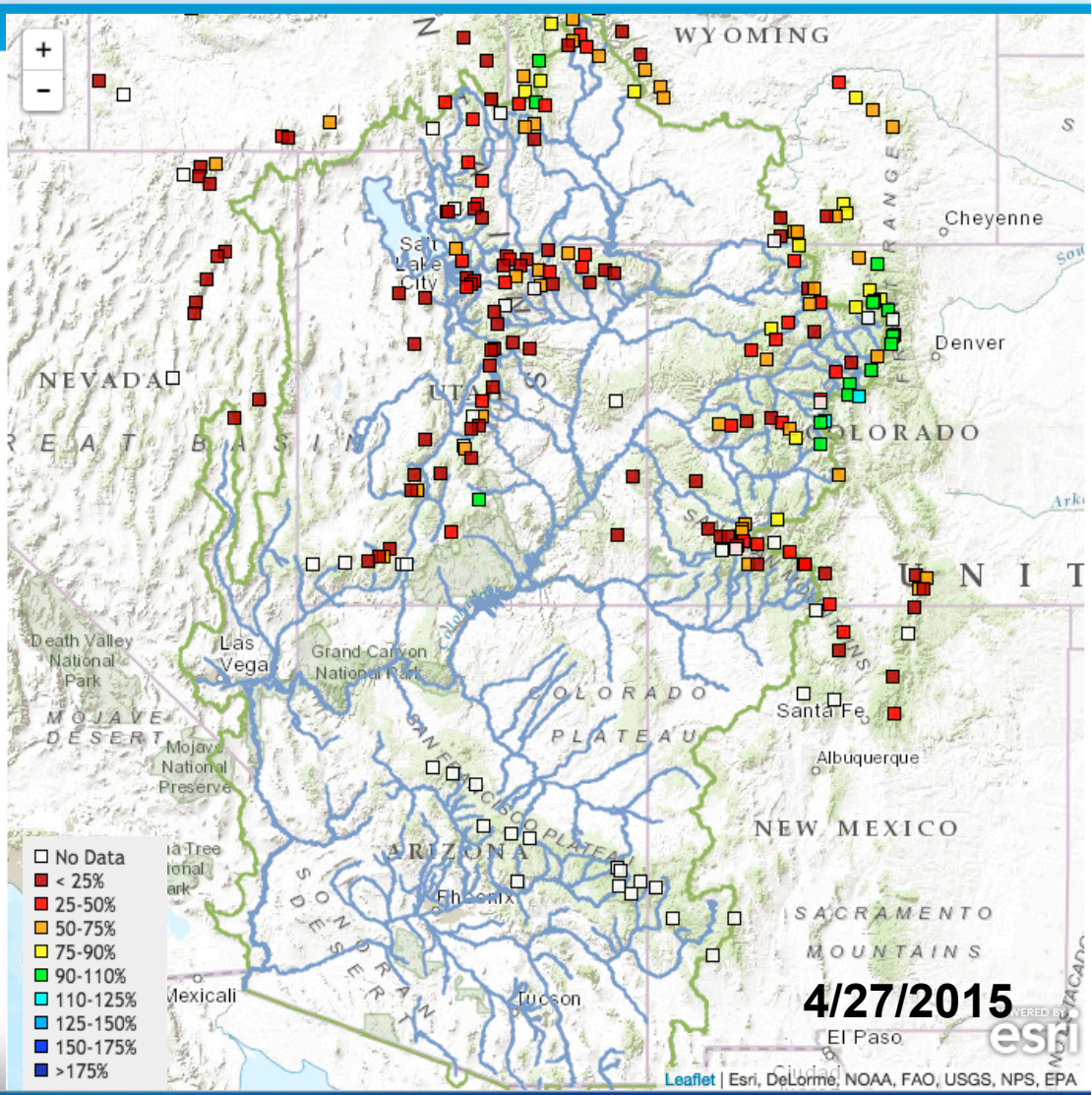


What does all this mean?

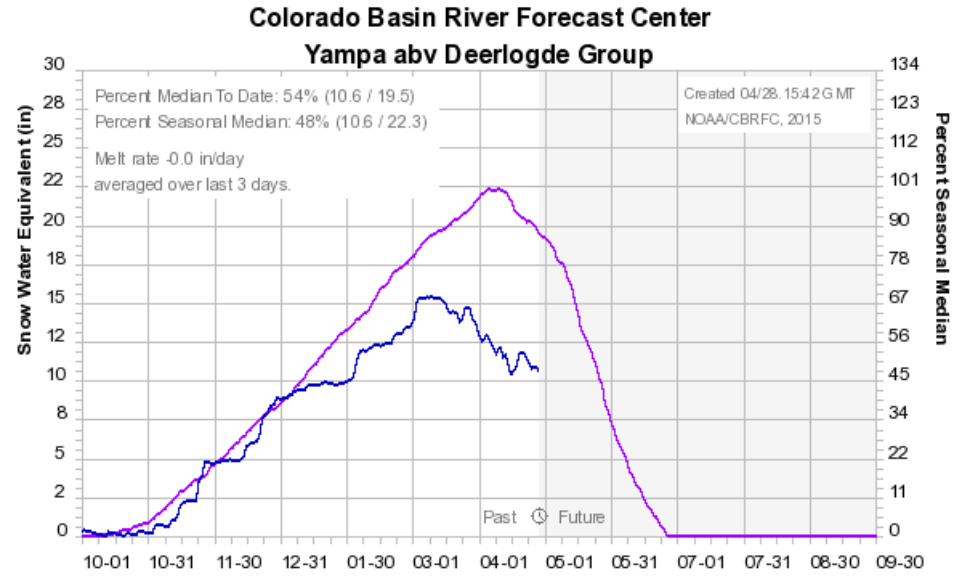
- Poor snowpack due to lack of precip and record temps, have led to early melt/runoff!
- Streamflow gages
  - Many gages are running well above average currently, despite poor snowpack conditions
  - Diurnal flow conditions seen as early as late January at low elevation sites in Utah
  - Gages that are usually ice-affected in March were not ice-affected in March this year

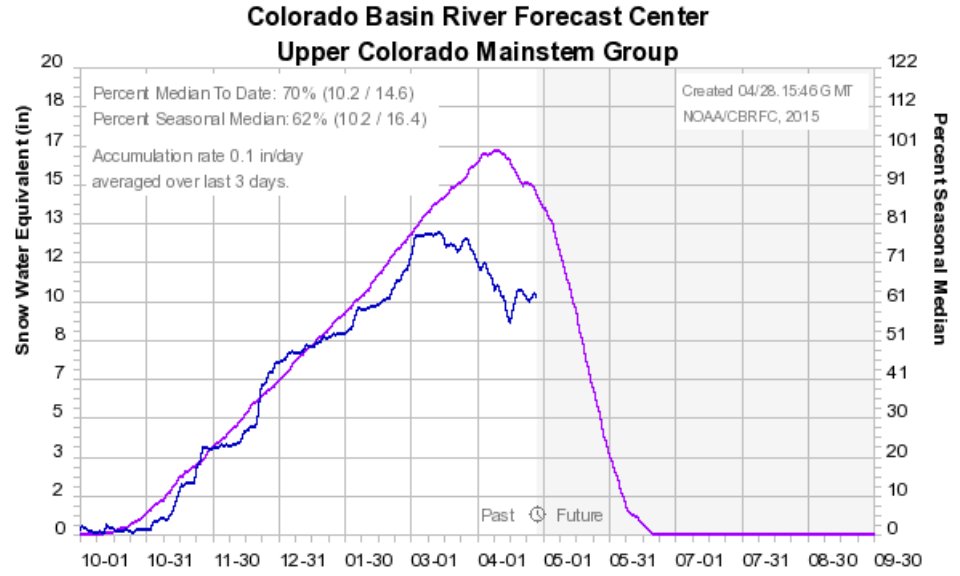
Current Snowpack Conditions

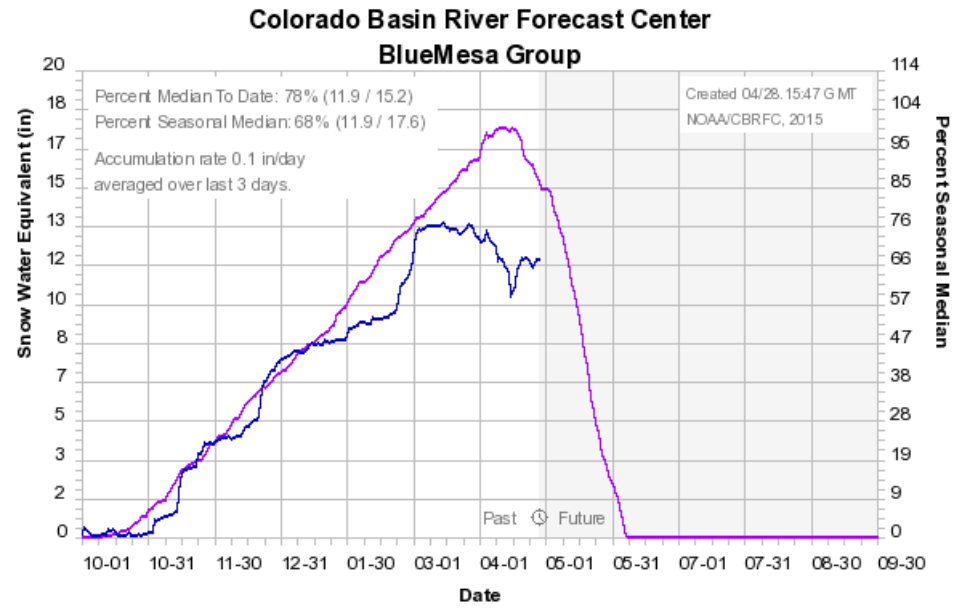
- Poor snowpack conditions throughout the CBRFC region
  - Great Basin, Duchesne, and San Juan regions seeing record dry conditions
  - Early melt evident at many stations

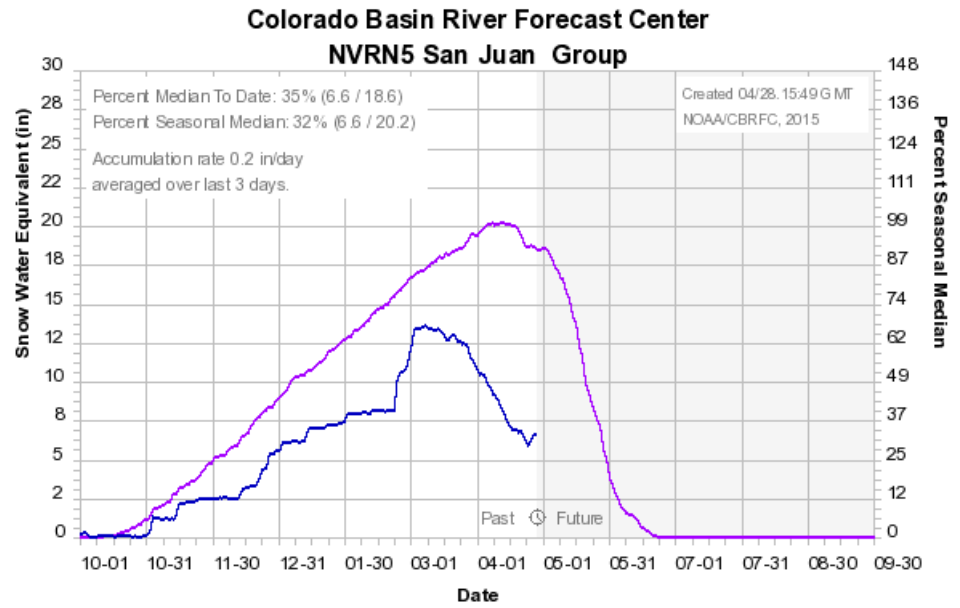


Snow Groups





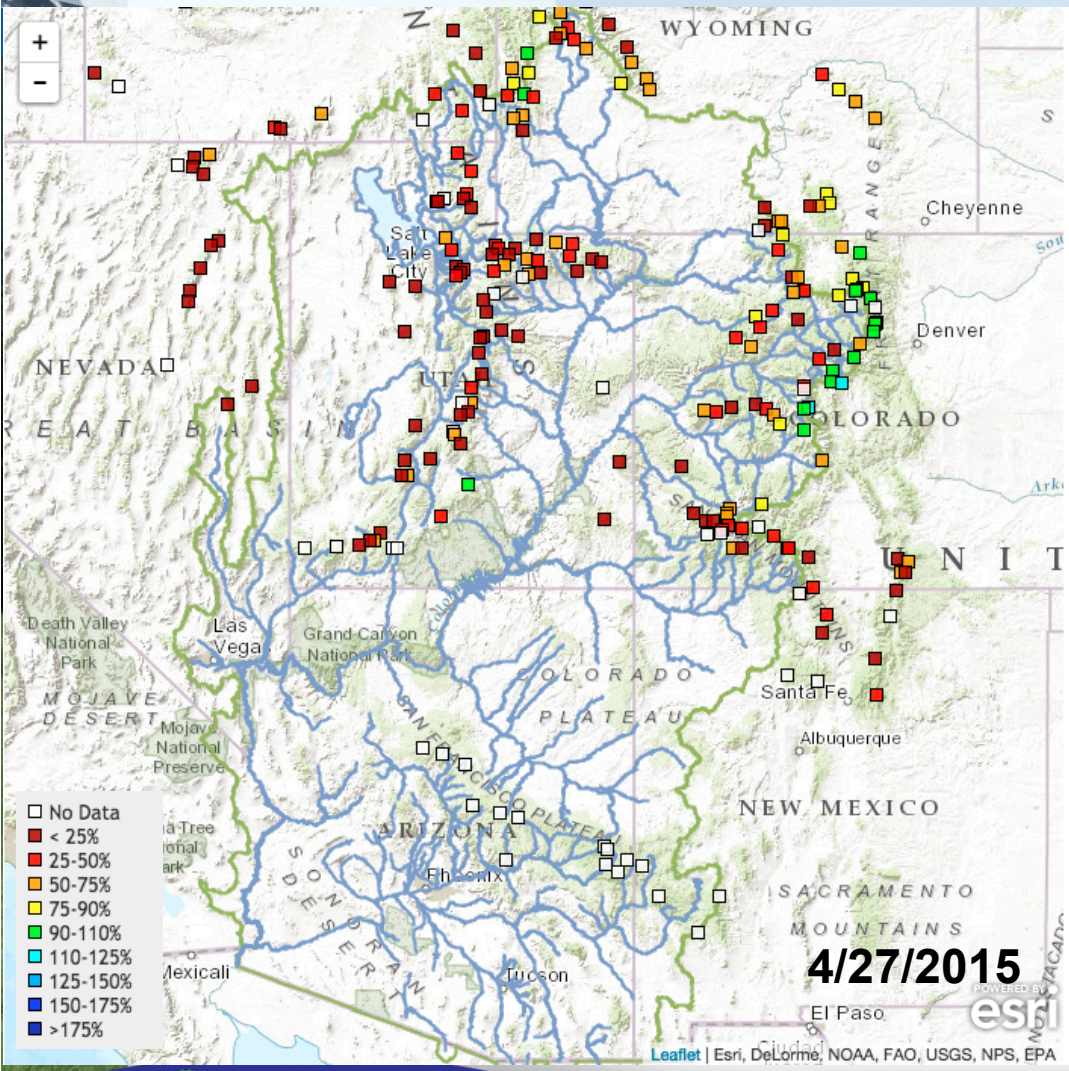




Median 1981-2010 — *2015* —

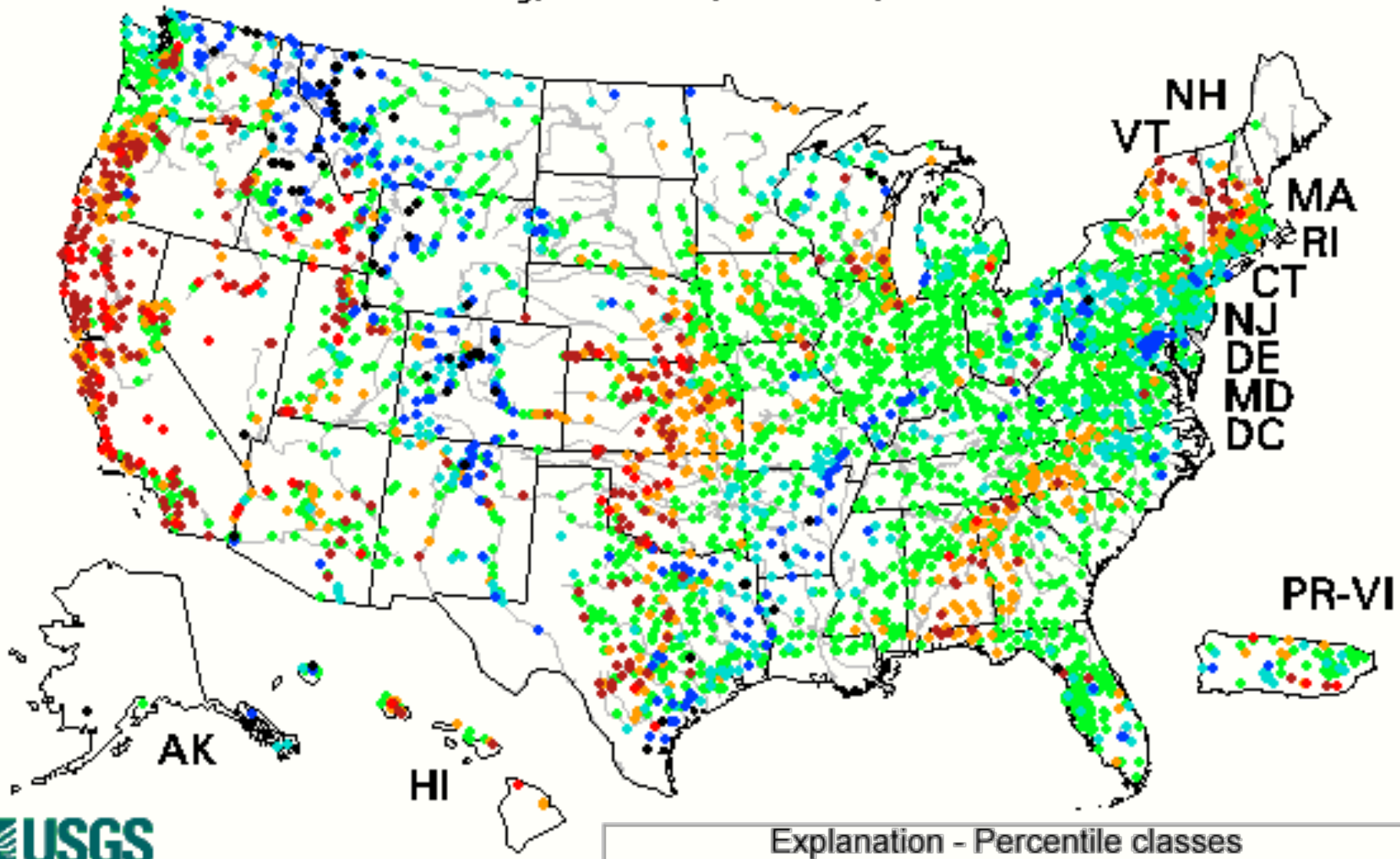
Median 1981-2010 — *2015* —

Preliminary SNOTEL Trends



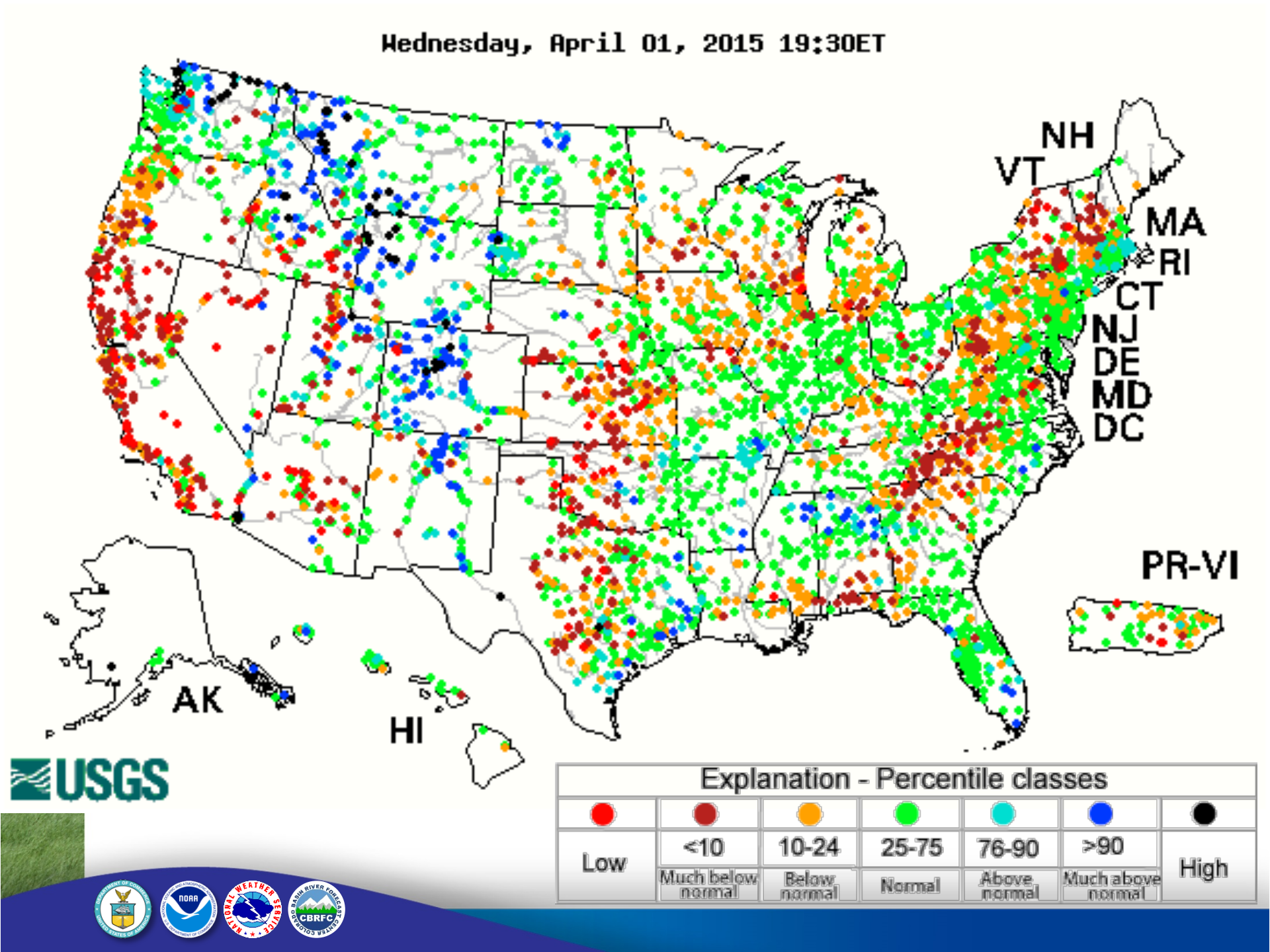
- 16 SNOTEL stations indicate the earliest date of 0 SWE on record
- 19 others show melt date in the top 5 on record (11 in top 3)
- At least 21 sites show a statistically significant (95% CI) trend towards earlier melt (about 0.5 to 1 day/year)

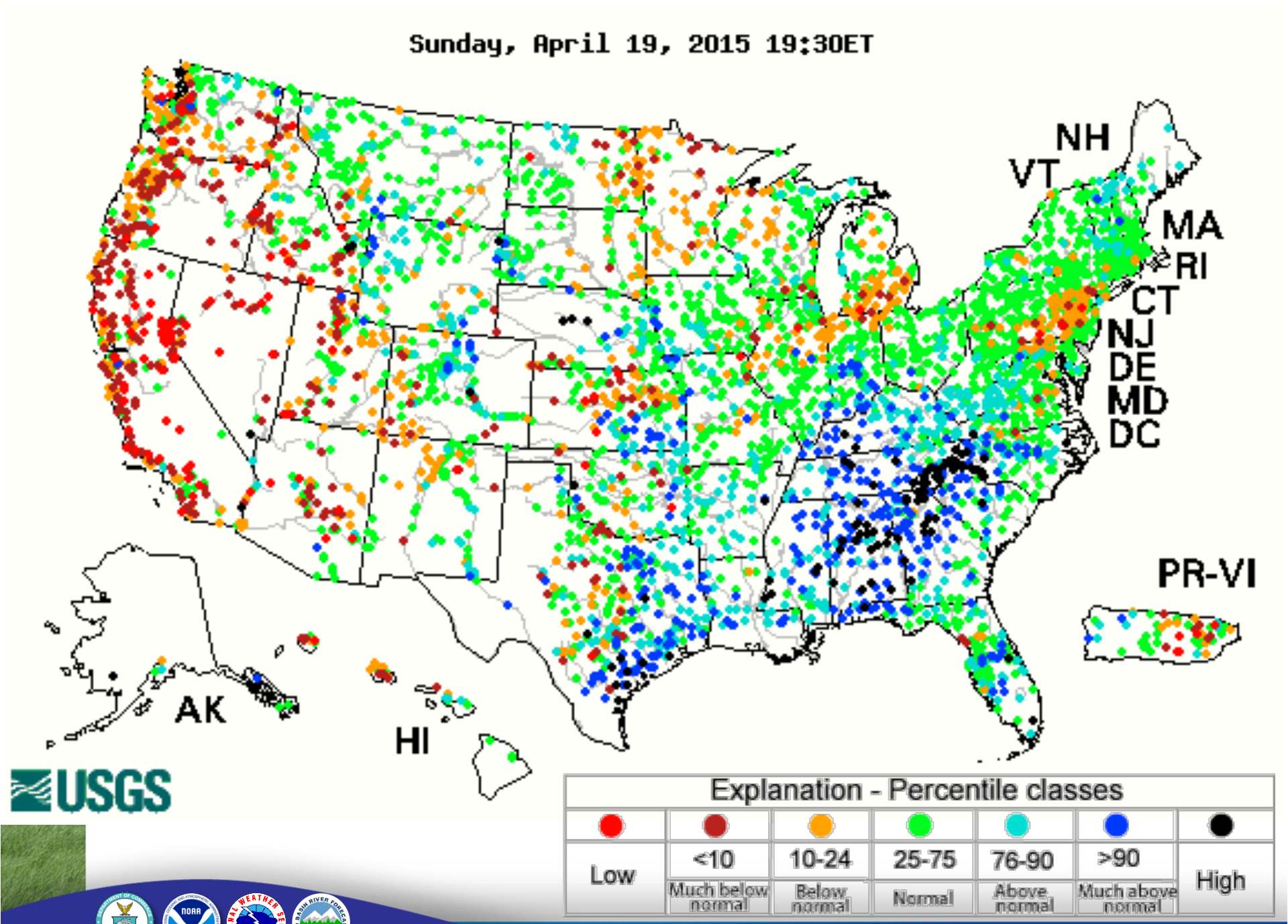
Friday, March 20, 2015 19:30ET



USGS

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


Wednesday, April 01, 2015 19:30ET
NH
VT
MA
RI
CT
NJ
DE
MD
DC
PR-VI
AK
HI
USGS
Explanation - Percentile classes
Low
<10
Much below normal
10-24
Below normal
25-75
Normal
76-90
Above normal
>90
Much above normal
High
NOAA
NATIONAL WEATHER SERVICE
CBRFC


Sunday, April 19, 2015 19:30ET
NH
VT
MA
RI
CT
NJ
DE
MD
DC
PR-VI
AK
HI
USGS
Explanation - Percentile classes
Low
<10
Much below normal
10-24
Below normal
25-75
Normal
76-90
Above normal
>90
Much above normal
High
NOAA
NATIONAL WEATHER SERVICE
CBRFC

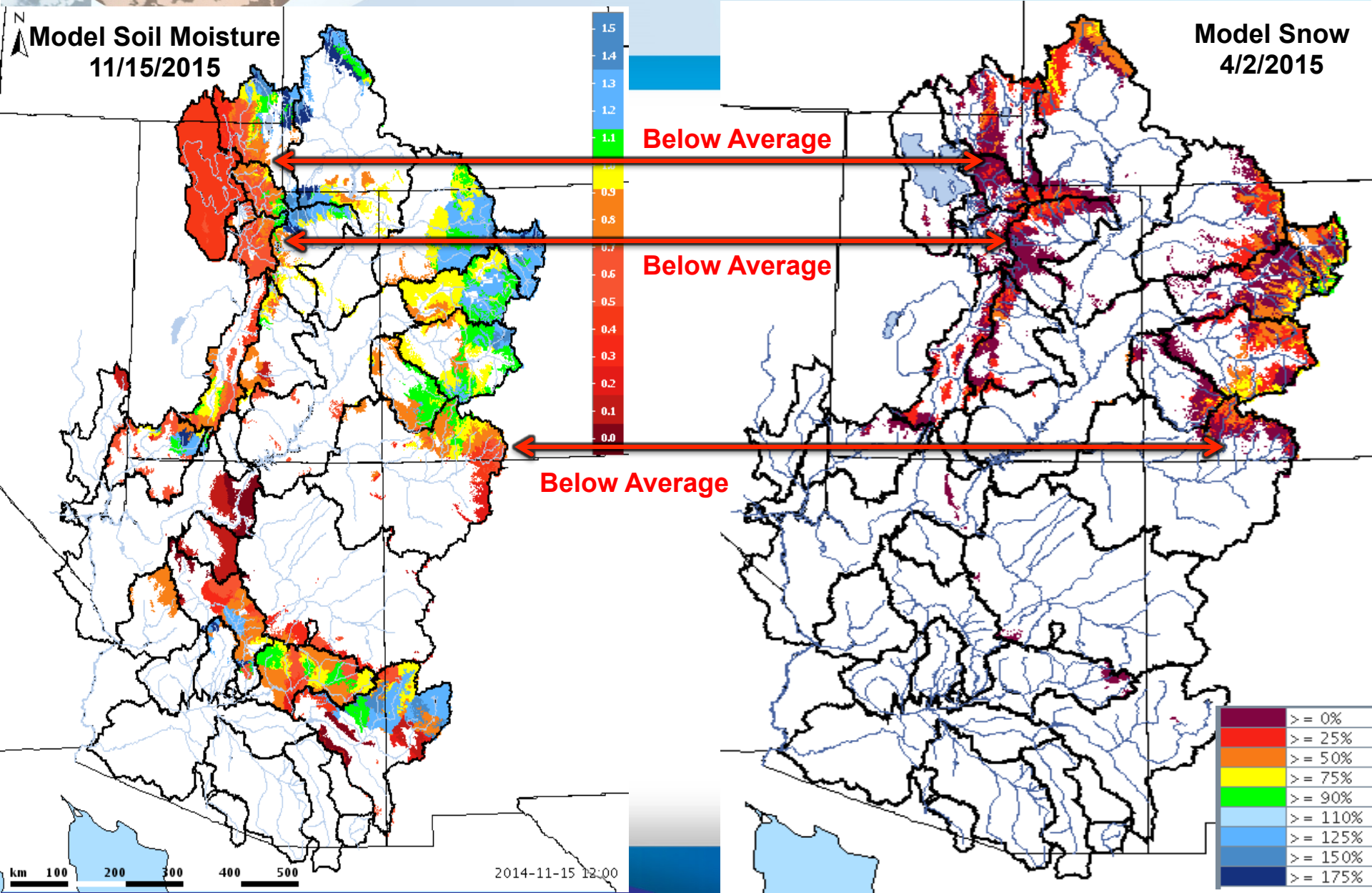
Record Breaking Conditions

- Early Runoff, record March unregulated flow volumes
  - Bear River at UT-WY Stateline
  - Hams Fork near Frontier
  - South Fork Rock Creek below Docs Diversion
- Almost record breakers (2nd highest volumes)
  - Provo near Woodland
  - Bear near Border
  - Hams Fork at Viva Naughton
  - Elkhead Creek near Hayden
  - Rock Creek at Upper Stillwater Reservoir

Record Breaking Conditions

- Upper Colorado Flows
  - Unregulated flows have been running above to much above average all winter, particularly above Kremmling
  - In March, 5 of 8 water supply points above Kremmling set new records for the month
  - Record high inflow at Ruedi Reservoir in the Roaring Fork
  - 11 of 14 water supply points above Cameo were in the top 3 monthly volumes in their period of record, most of which are 50 years or longer

Model Soil Moisture and Snow Signals

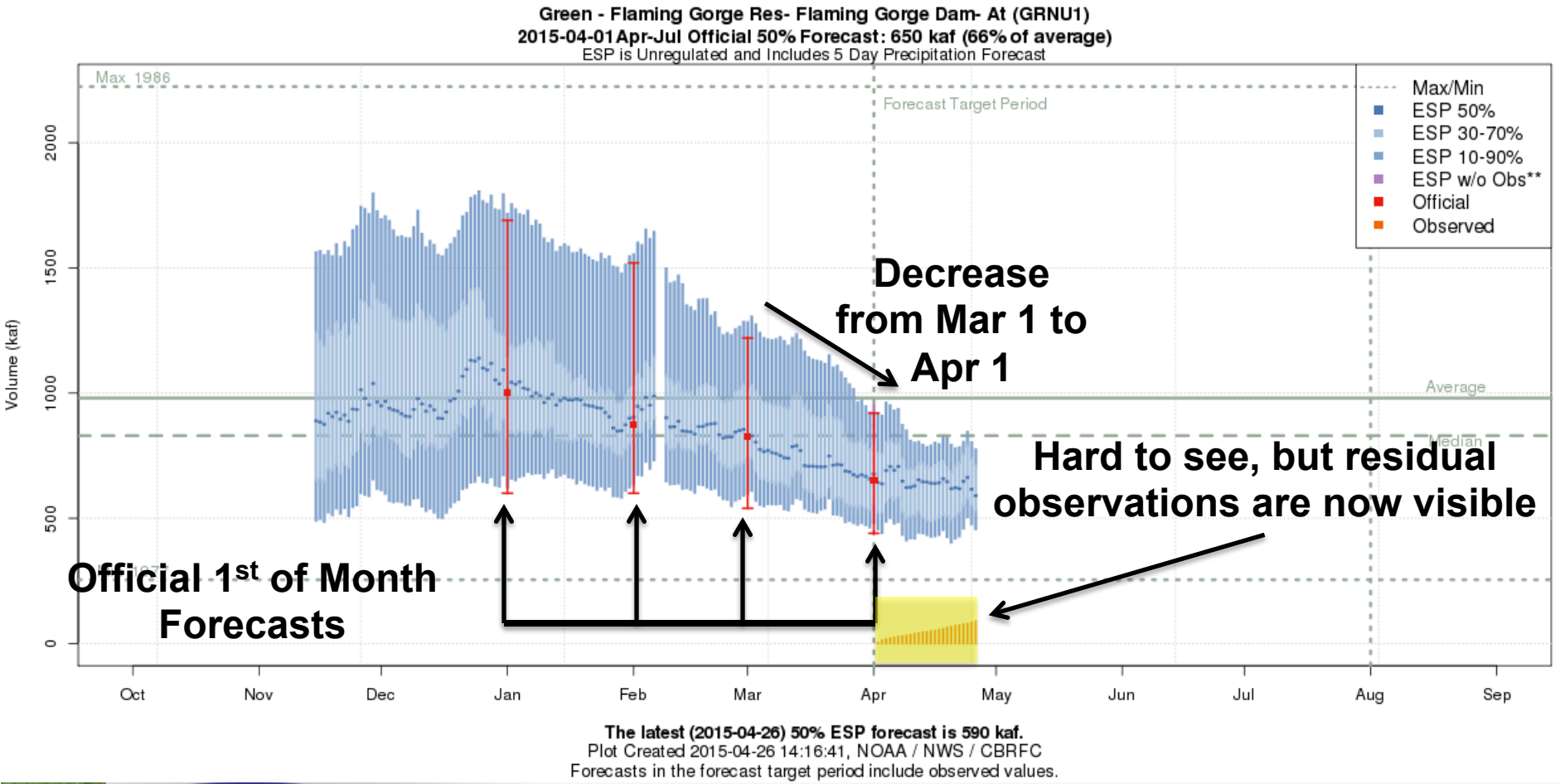


Forecasted April – July Runoff*

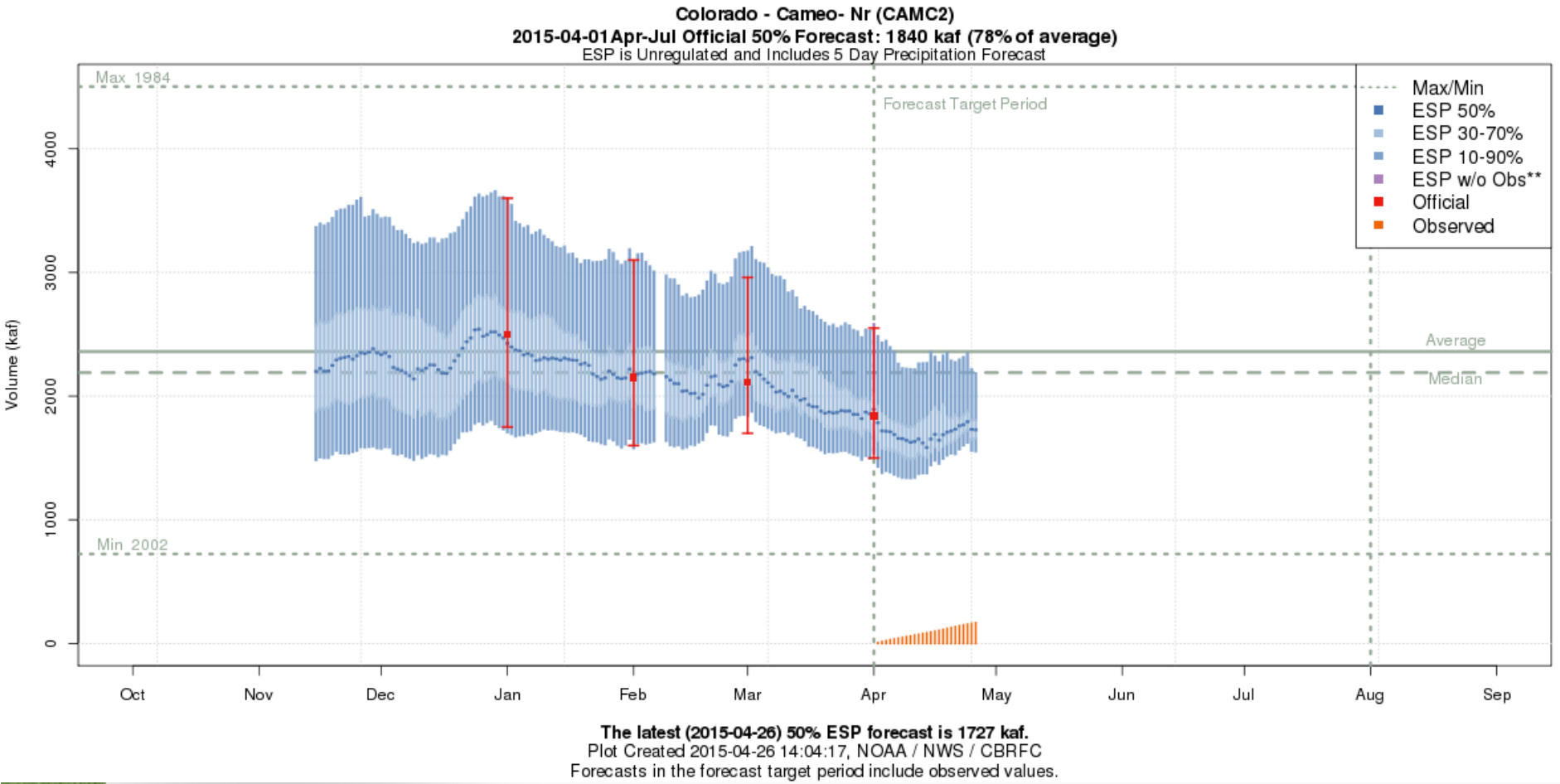
- Powell – 47% of average, 3.4 MAF
- Flaming Gorge – 64%, 625 KAF
- Blue Mesa – 67%, 450 KAF
- Navajo – 38%, 280 KAF

*April 2015 Mid-Month Forecast

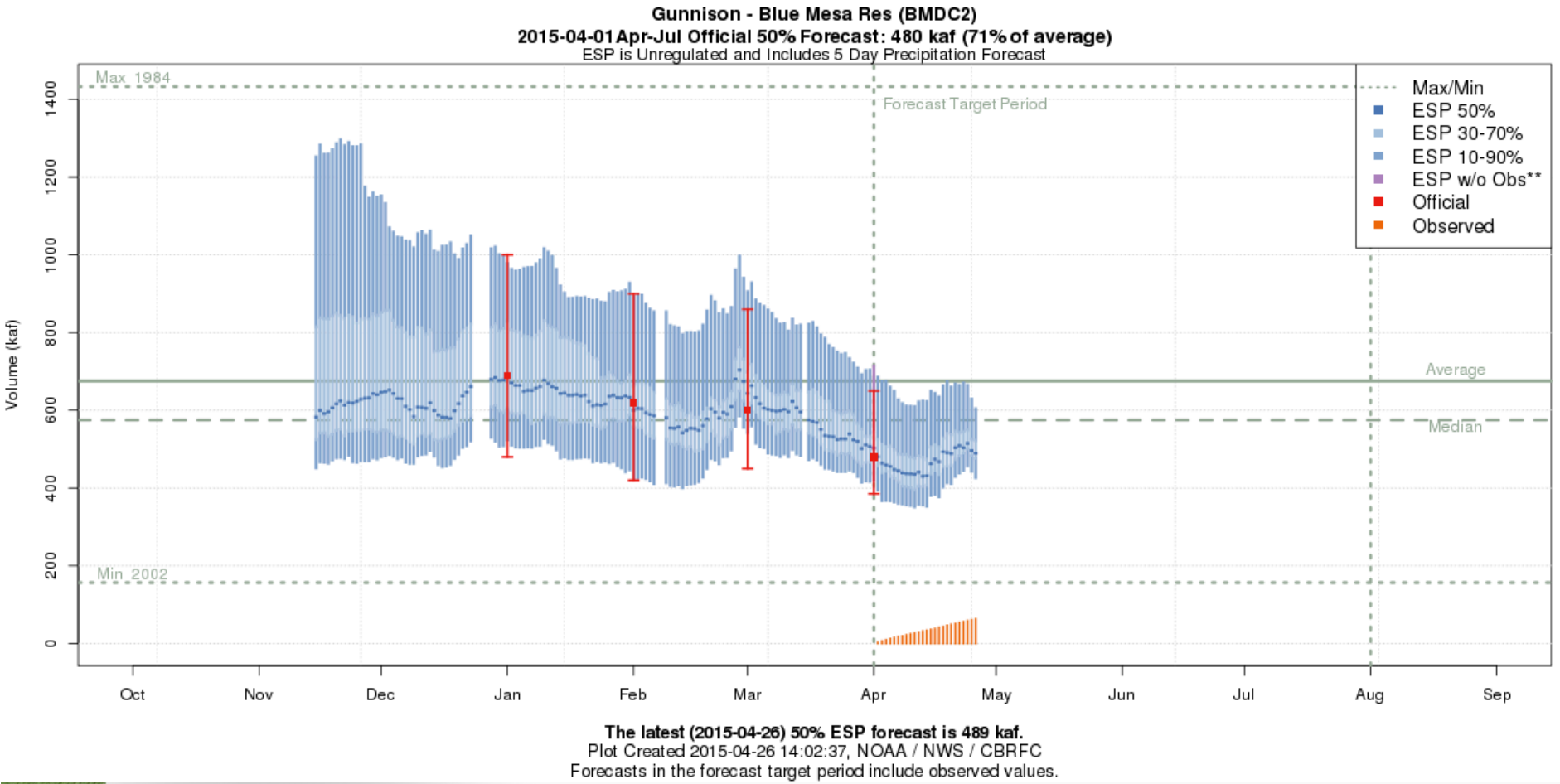
Green River at Flaming Gorge



Colorado near Cameo

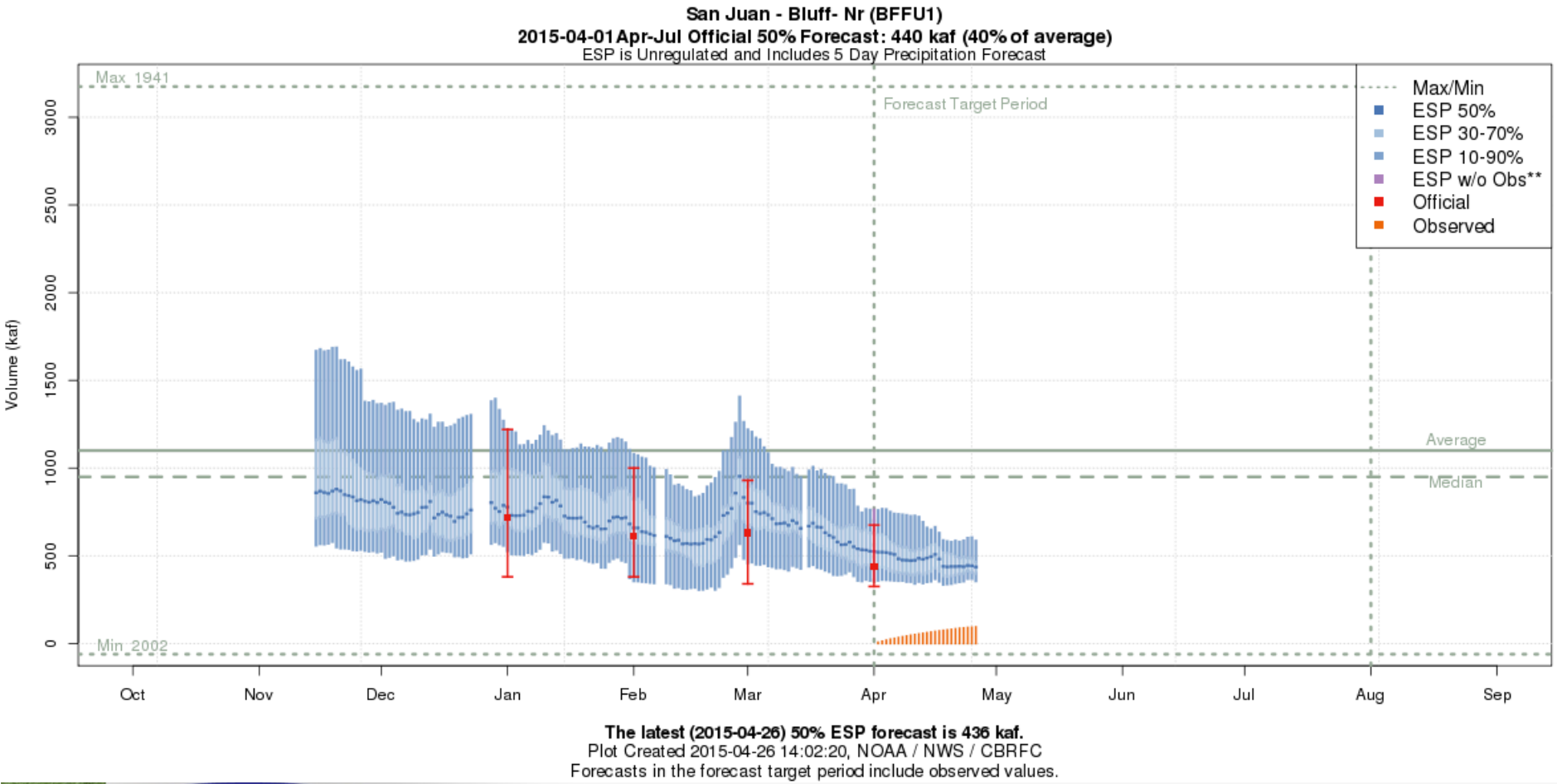


Gunnison near Blue Mesa



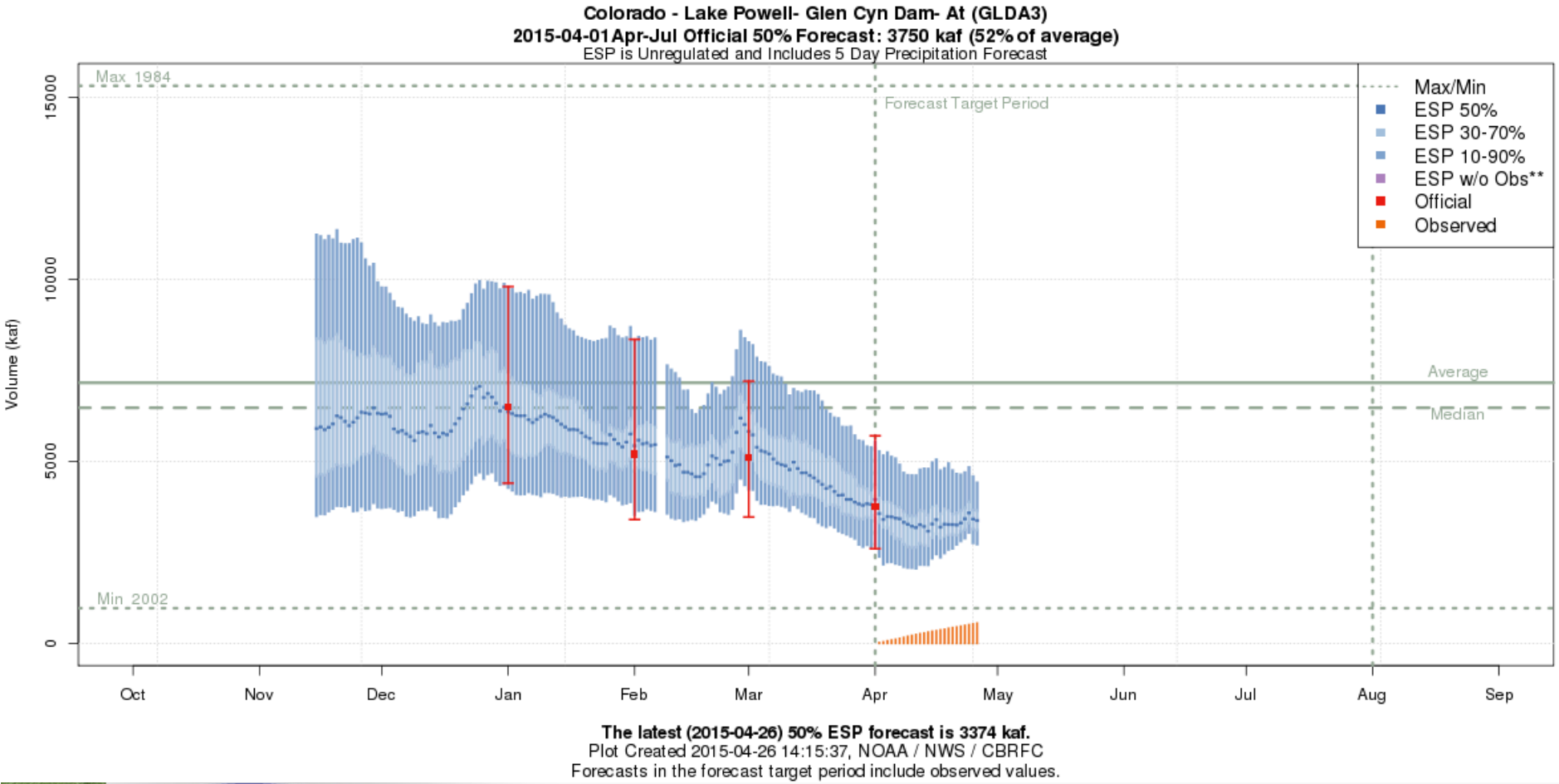
The latest (2015-04-26) 50% ESP forecast is 489 kaf.
Plot Created 2015-04-26 14:02:37, NOAA / NWS / CBRFC
Forecasts in the forecast target period include observed values.

San Juan Near Bluff

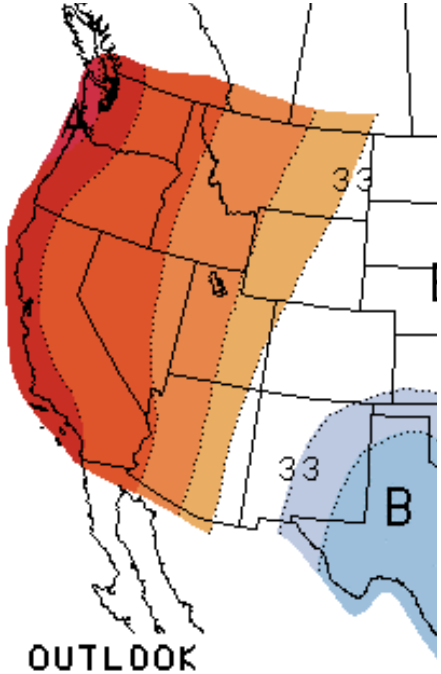


The latest (2015-04-26) 50% ESP forecast is 436 kaf.
Plot Created 2015-04-26 14:02:20, NOAA / NWS / CBRFC
Forecasts in the forecast target period include observed values.

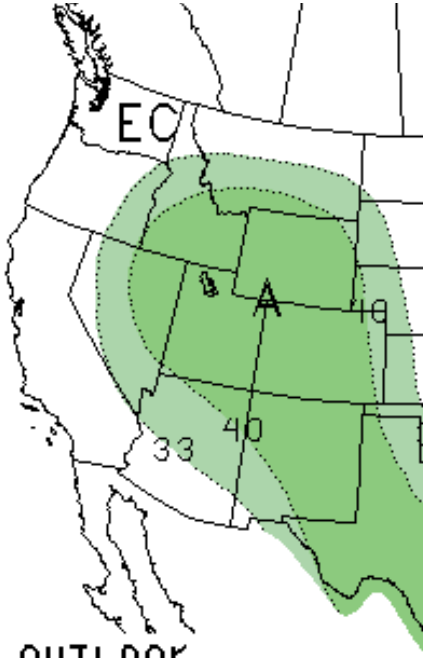
Lake Powell at Glen Canyon Dam



Looking ahead…



THREE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
0.5 MONTH LEAD
VALID MJJ 2015
MADE 16 APR 2015



THREE-MONTH OUTLOOK
PRECIPITATION PROBABILITY
0.5 MONTH LEAD
VALID MJJ 2015
MADE 16 APR 2015

News at the CBRFC

- Ashley Nielson filled vacant Senior Hydrologist position
- Chris Anderson, student at WSU, hired through UCAR to work on developing a water supply webpage for the West
- Website Improvements
  - New ESRI map and interface
  - Verification map and statistics available

Other NOAA News

- National Centers for Environmental Information (NCEI)
  - Merger between the National Climatic Data Center (NCDC), National Geophysical Data Center, National Oceanographic Data Center, and National Coastal Data Development Center
  - Provides access to environmental data and archives
  - Top priority to maintain products and services currently delivered

Update on FROMUS* Activities

- Back in February 2014, NIDIS held a drought workshop at the CBRFC
- Major recommendation proposes for Reclamation and the CBRFC to examine hydroclimatic drivers and assumptions in the 24-Month Study process
- Team formed with goal to identify sources of uncertainty and identify possible paths forward

*Forecasting and Reservoir Operation Modeling Uncertainty Scoping Team

Update on FROMUS Activities

- Currently working on completing draft uncertainty profiles for a number of parameters
- Hoping to have a product available by the end of the year

Contact us!

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Questions?