CBRFC
Water Supply Briefing

June 5, 2020

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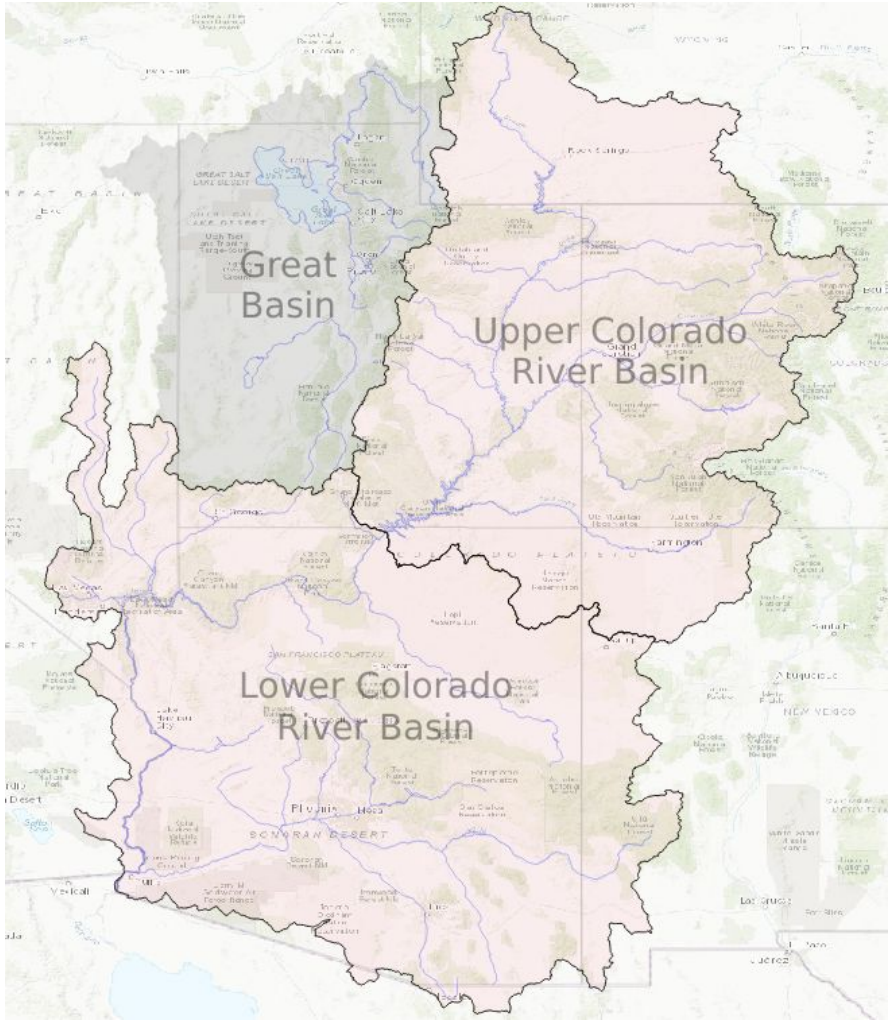

Today's Presentation

May & Water Year Precipitation Review

Early June SWE Conditions

June Water Supply Forecasts

Peak Flows

Historical Forecast Error

Upcoming Weather

Contacts & Questions

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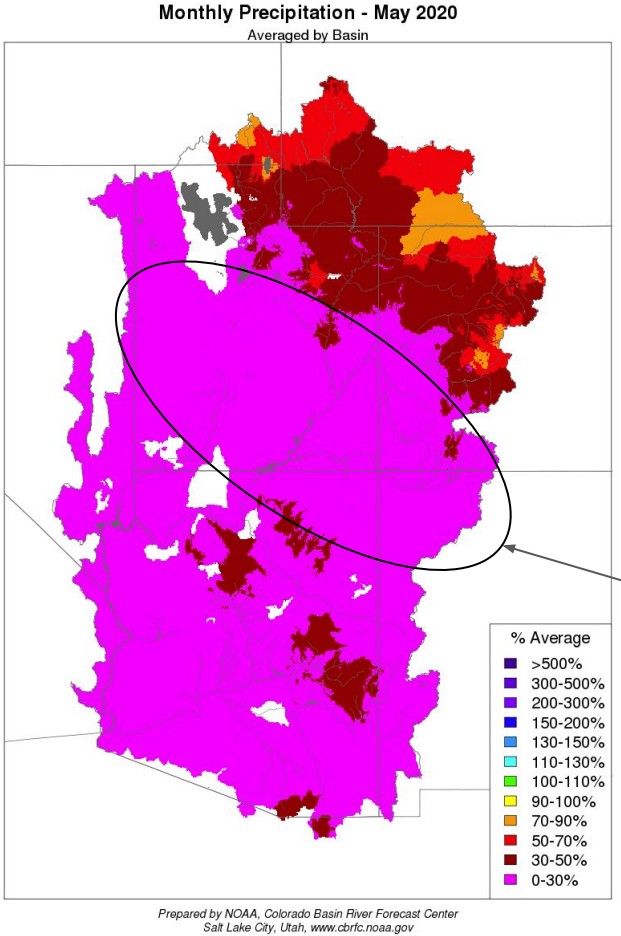
May Precipitation Summary



The May weather pattern featured general ridging, leading to quite dry conditions.

A few storm systems clipped the very northern portions of the basin. However, the Bear, Upper Green, Yampa and Colorado mainstem headwaters still had much below average May precipitation.

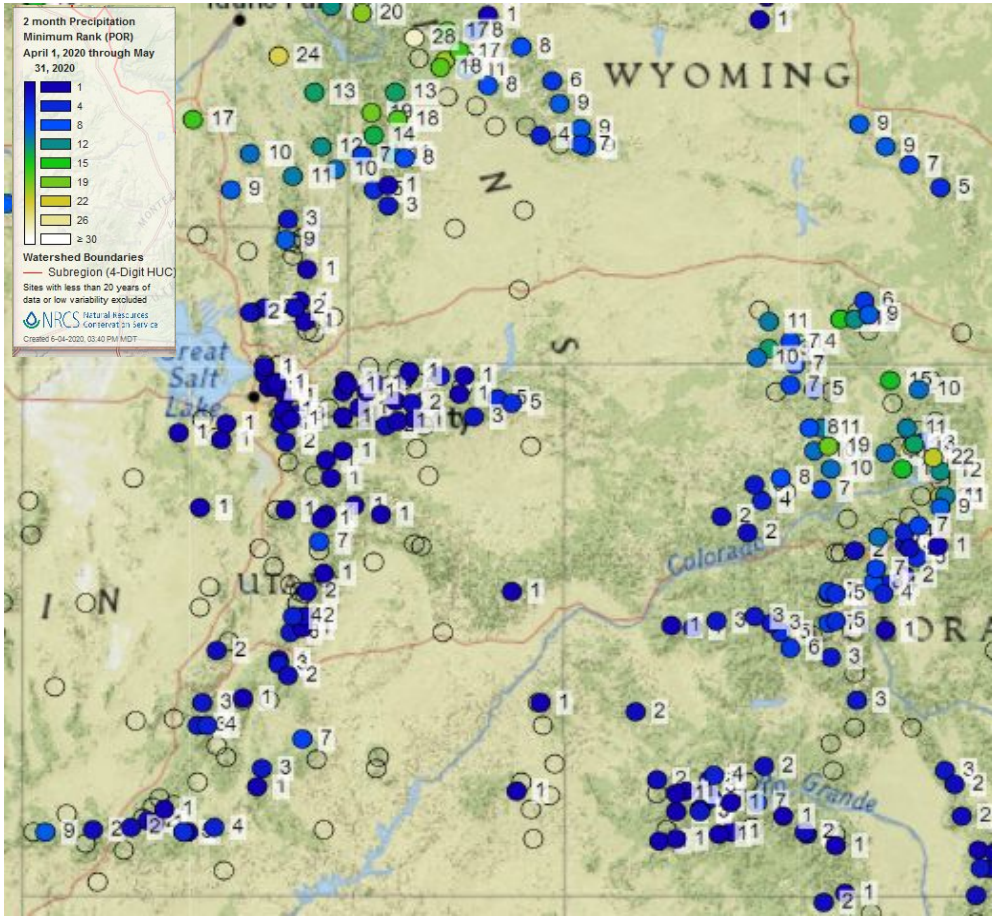
The rest of the Upper Colorado and Great Basin fared even worse. Several SNOTEL sites across Utah and Southwest Colorado had near record low precipitation amounts for the month.

May 2020 Precip Summary

Basin	Precip (% Avg)
Upper Green	50%
Duchesne	30%
Price/San Rafael	15%
Yampa/White	60%
Upper CO Mainstem	50%
Gunnison	40%
Dolores	20%
San Juan	20%
Lake Powell	40%
Virgin	7%
Salt/Verde	20%
Little Colorado	25%
Upper Gila	15%
Bear	45%
Weber	30%
Six Creeks	30%
Provo	25%

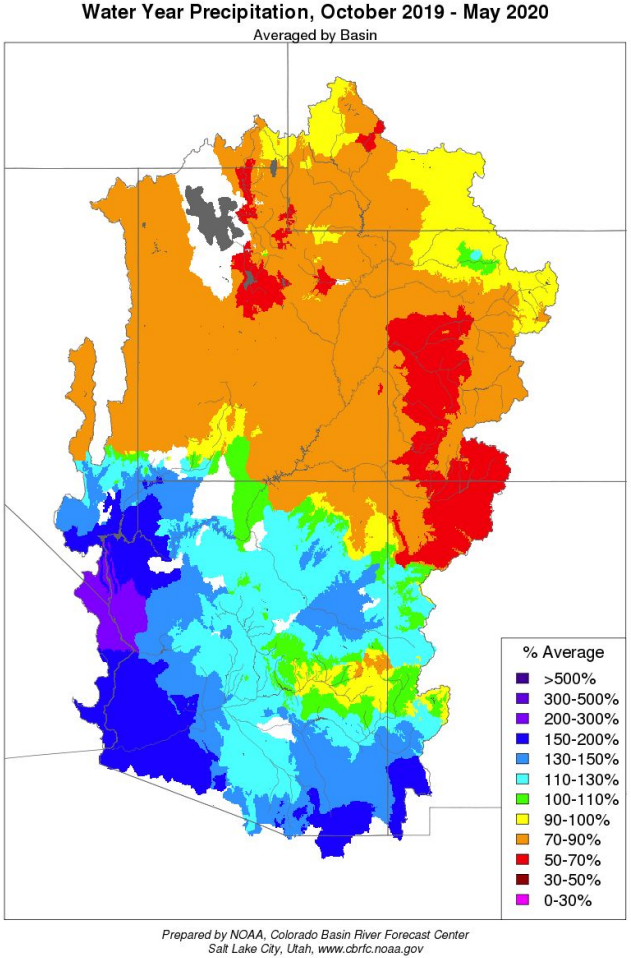
One of the Driest April-May Periods

April-May SNOTEL *Minimum* Precip Rankings



The April-May period was near record dry over much of Utah and southwest Colorado, where most SNOTEL sites are in the top 3 driest, with many being the driest on record out of 34-40 years.

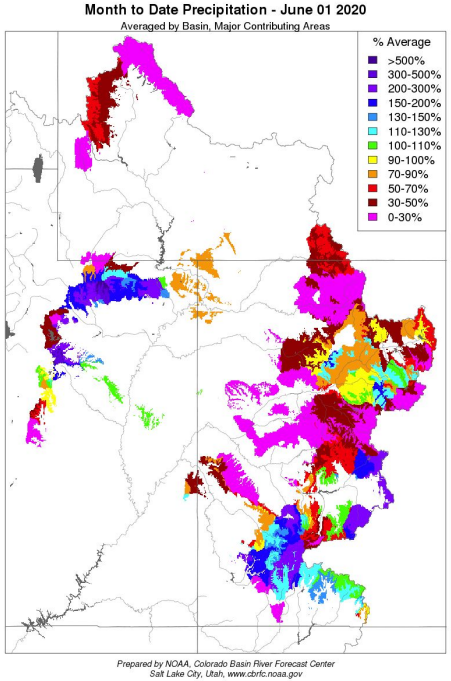
Water Year Precipitation Summary



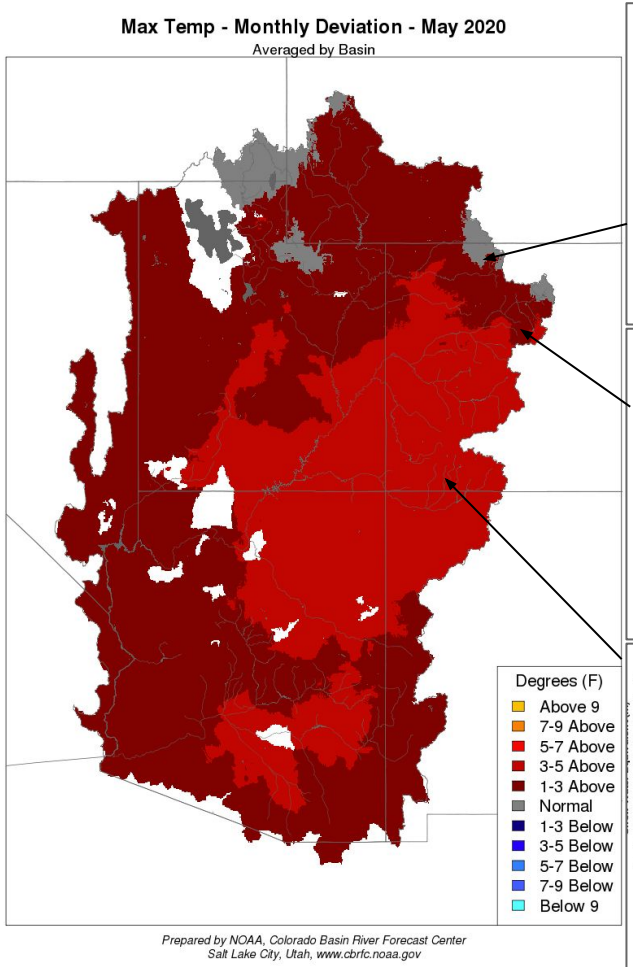
Water Year 2020
Oct-May Precip Summary

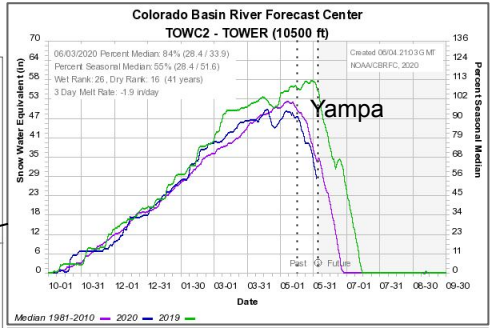
Basin	Precip (% Avg)
Upper Green	85%
Duchesne	80%
Price/San Rafael	80%
Yampa/White	95%
Upper CO Mainstem	85%
Gunnison	75%
Dolores	70%
San Juan	65%
Lake Powell	80%
Virgin	100%
Salt/Verde	105%
Little Colorado	110%
Upper Gila	110%
Bear	85%
Weber	80%
Six Creeks	80%
Provo	75%

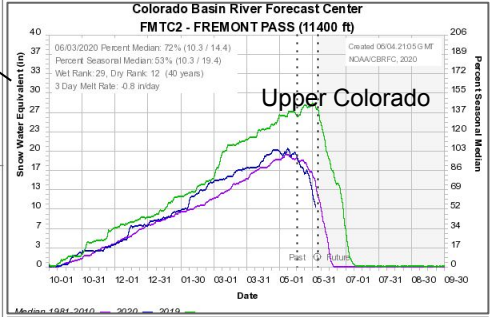
Duchesne, San Juan, and Colorado Headwater basins have received some precipitation the first few days of the month.

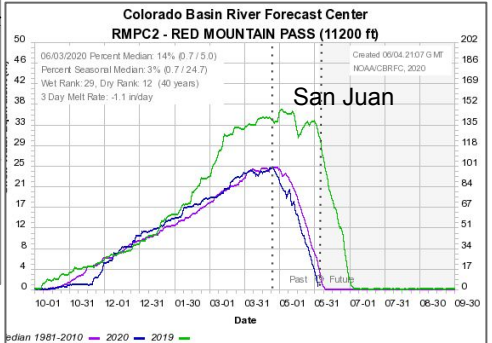


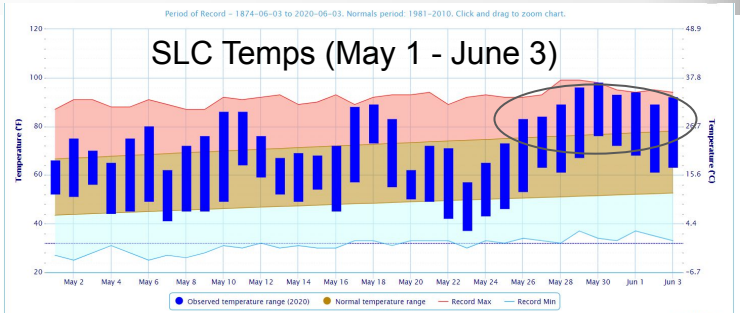
May Temperature Summary



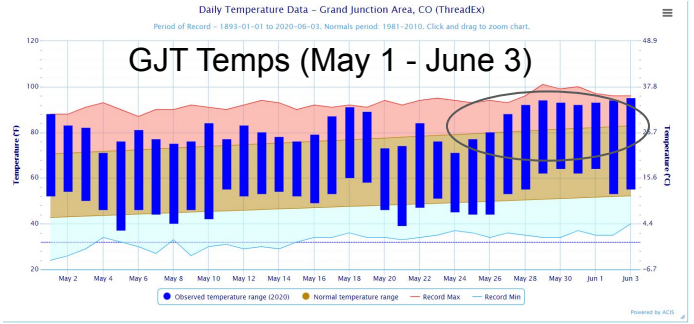








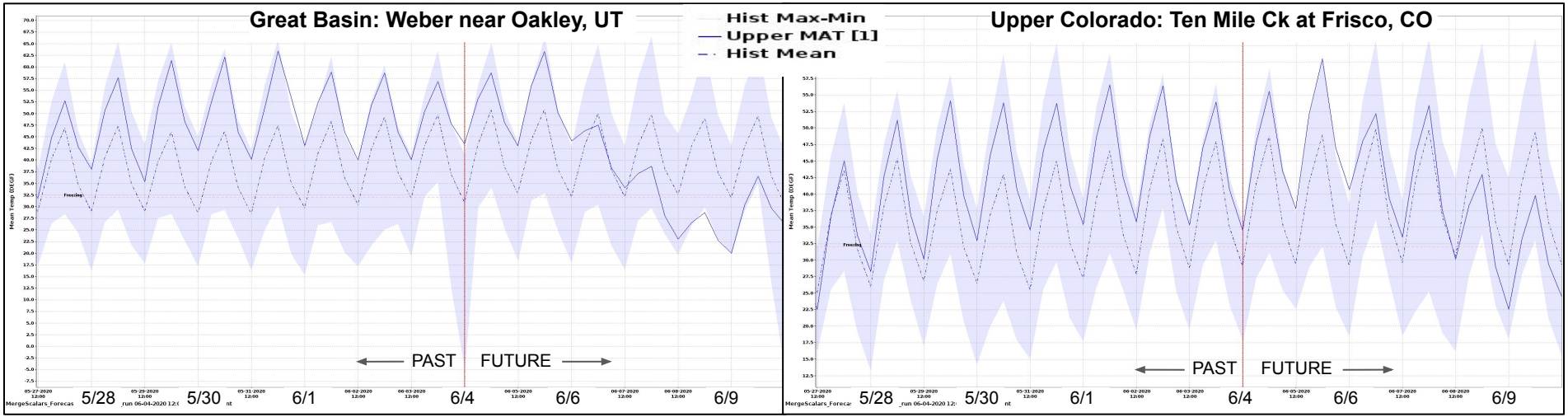
Avg Temp (last 10 days): 76.1F
*This is **second** warmest over this period in over 140 years!



Avg Temp (last 10 days): 72.7F
*This is **seventh** warmest over this period in over 130 years!

May 28 - June 6 Temperatures

Much above average (~10+ deg) to near record maximum temperatures across the Upper Colorado and Eastern Great Basin for 8-9 days in a row. While every individual day was not a record, this period taken as a whole may be a record in the last ~40 years (our model calibration period is 1981-2015).

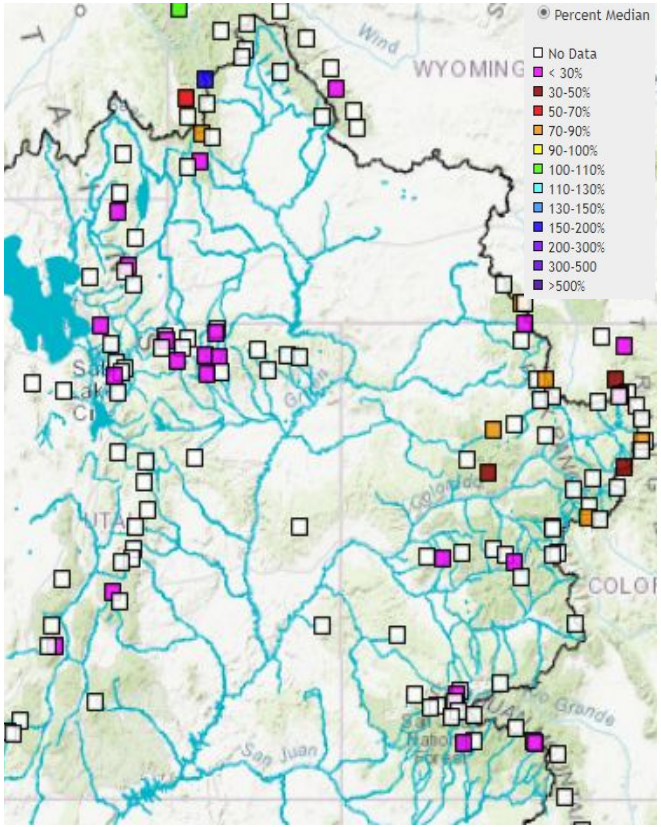


Model Mean Areal Temperature (MAT) plots show the recent extended period of much above normal temperatures.
Shading is the 1981-2015 maximum and minimum MAT's for each day, dotted line is the mean.
Solid line is the observed and forecast MAT values.

Note the big turn around in temperatures being forecast in the next few days.

Early June Snow Conditions

NRCS SNOTEL (Observed): June 4th

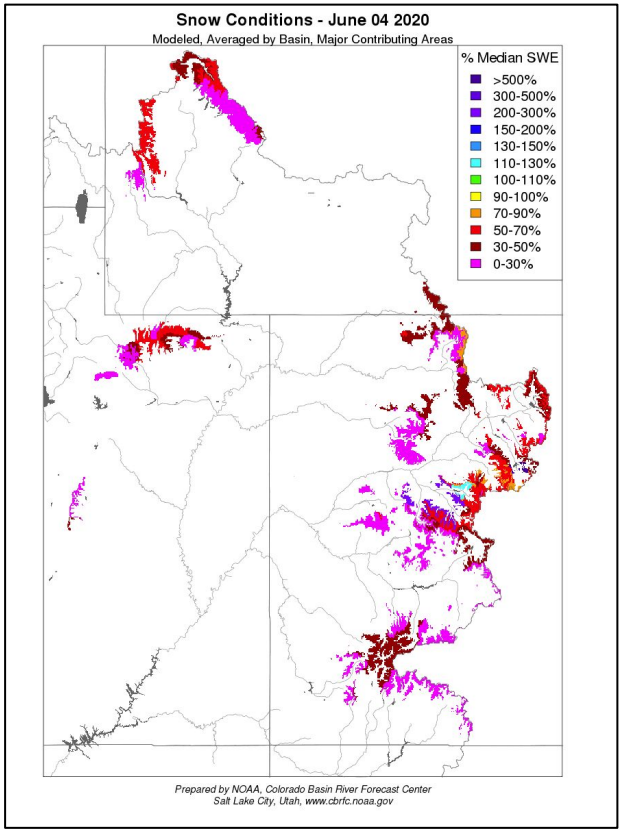


This time of year it is normal for many of the SNOTEL sites to be melted out, but that doesn't mean there isn't any snow left.

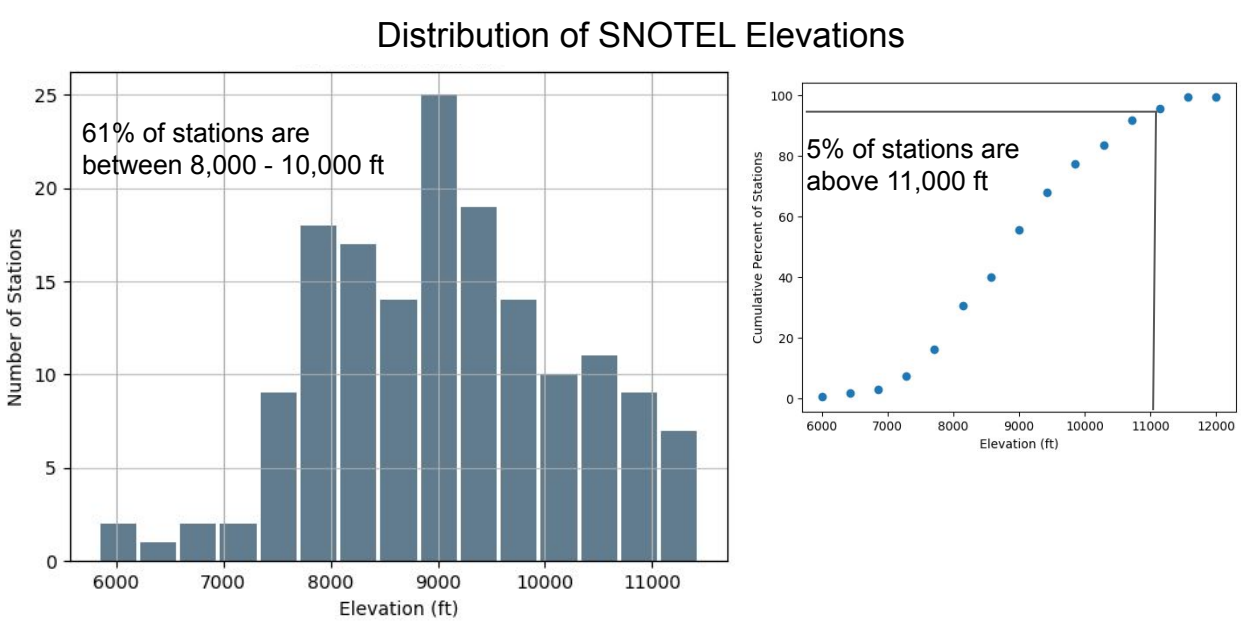
The map of CBRFC model snow indicates the areas where snow still exists.

Percent median values can be misleading this time of year as the median values are generally small and so a few tenths difference in observed swe can make a big difference in the percent median value.

CBRFC (Model)



SNOTEL Network

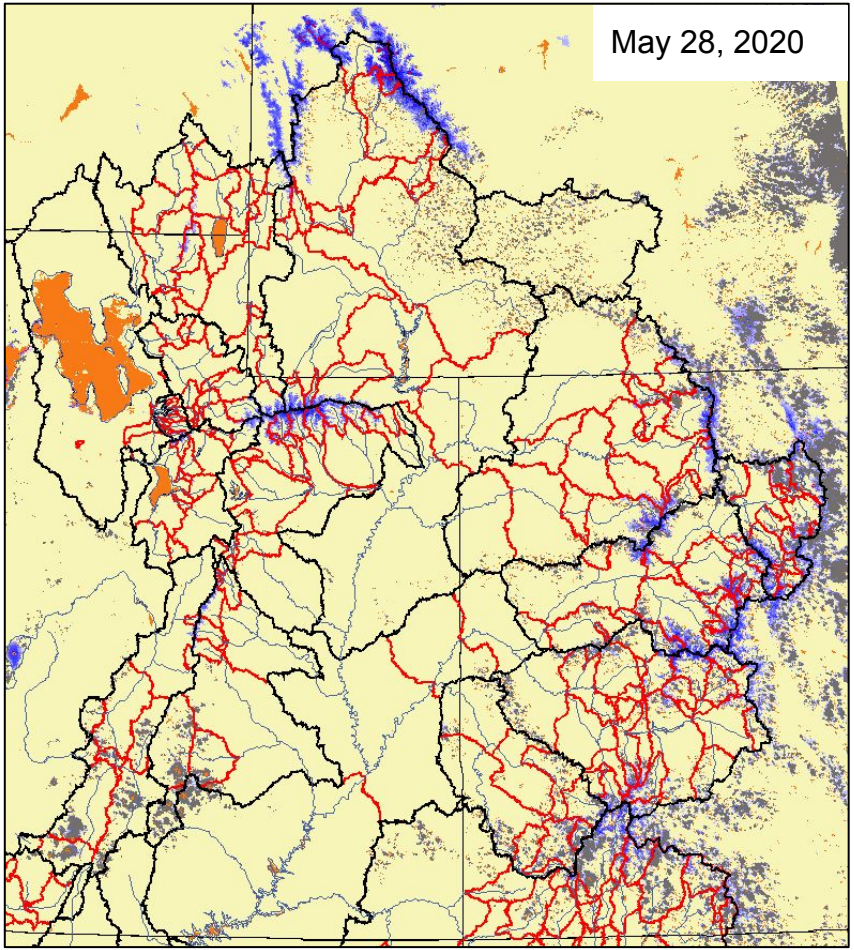


The SNOTEL network is invaluable to our model. However, it does have limitations.

Just 5% of the stations are above 11,000 ft., while a significant amount of runoff comes from those highest elevations and where most of the snow still exists this time of year.

SNOTEL snow information is most useful to the CBRFC model during the accumulation period. We need to use other tools during the melt to make sure the model is tracking snow correctly.

Satellite Snow



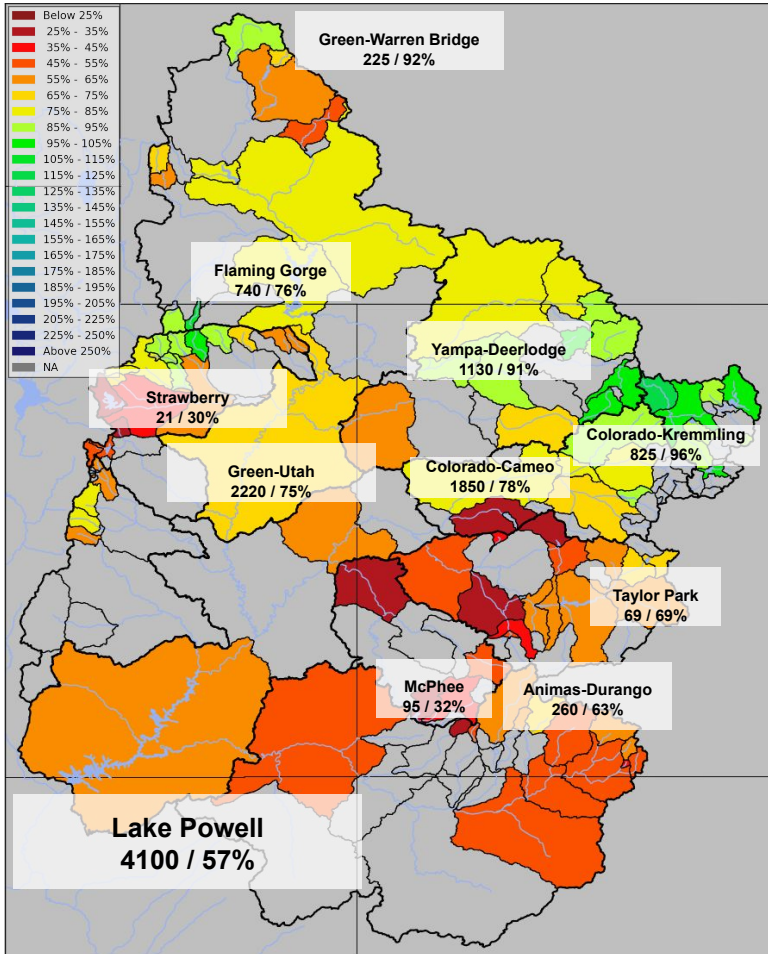
One of the tools we use is a satellite snow product produced by NASA's Jet Propulsion Laboratory (JPL).

We currently use this to compare where snow is actually being observed and where our model thinks snow still exists as a way to update the areal extent of snow in the model, but not necessarily the amount of snow.

We are in the process of developing procedures that would help us use this product to objectively update the amount of snow as well.

The main drawback to this product is that it needs clear skies, ideally for a couple of days in a row. This image is the last clear picture we have. Gray areas indicate clouds and the blue areas indicate snow.

June 1st Water Supply Forecasts: Upper Colorado



Forecast water supply volumes in the Upper Colorado River Basin generally decreased 5-20% from those issued in May.

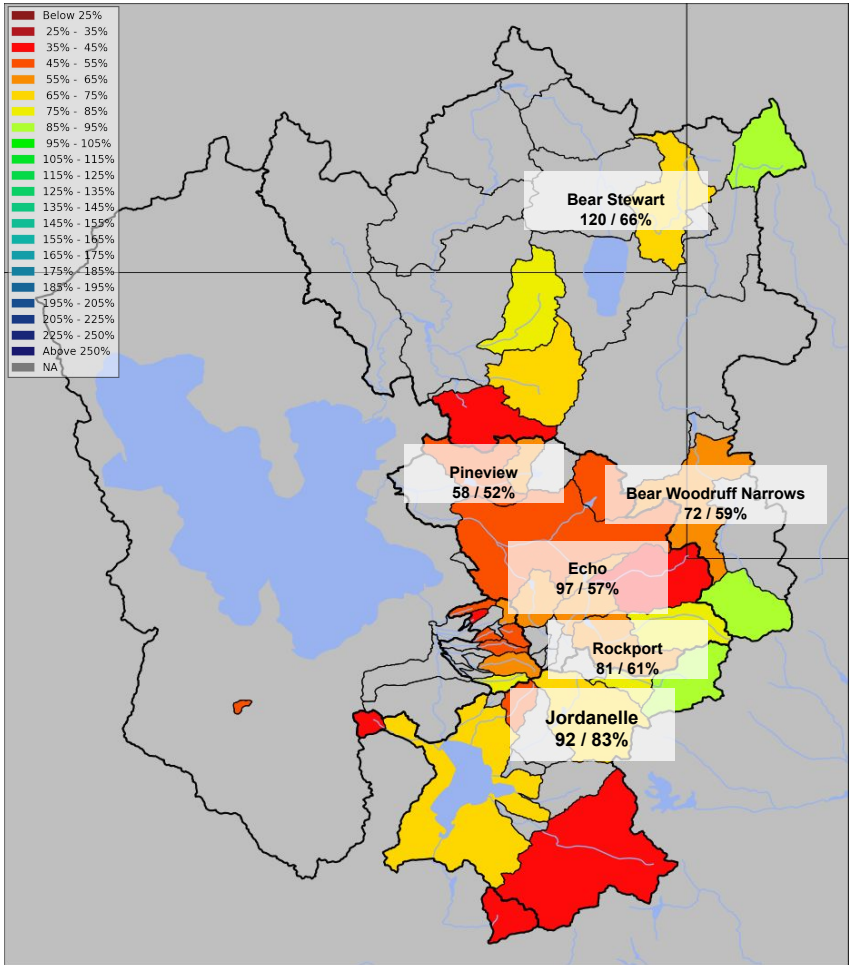
Highest forecast volumes with respect to average are in the Yampa, Upper Colorado mainstem above Kremmling and parts of the Upper Green and Duchesne basins with forecasts 90-100% of average.

Outside of these areas forecasts are below to much below average.

Change in Forecasts May - June 2020

Green-Warren Bridge:	-10 KAF	(-4%)
Flaming Gorge:	-140 KAF	(-16%)
Strawberry:	- 9 KAF	(-30%)
Yampa-Deerlodge:	-90 KAF	(-7%)
Colorado-Kremmling	-35 KAF	(-4%)
Colorado-Cameo:	-150 KAF	(-7%)
Taylor Park:	-4 KAF	(-6%)
Green River-Utah:	-320 KAF	(-13%)
Animas Durango:	-- no change --	
McPhee:	-35 KAF	(-17%)
Lake Powell:	-550 KAF	(-12%)

June 1st Water Supply Forecasts: Eastern Great Basin



Forecast water supply volumes in the Eastern Great Basin generally decreased 5-30% from those issued in May.

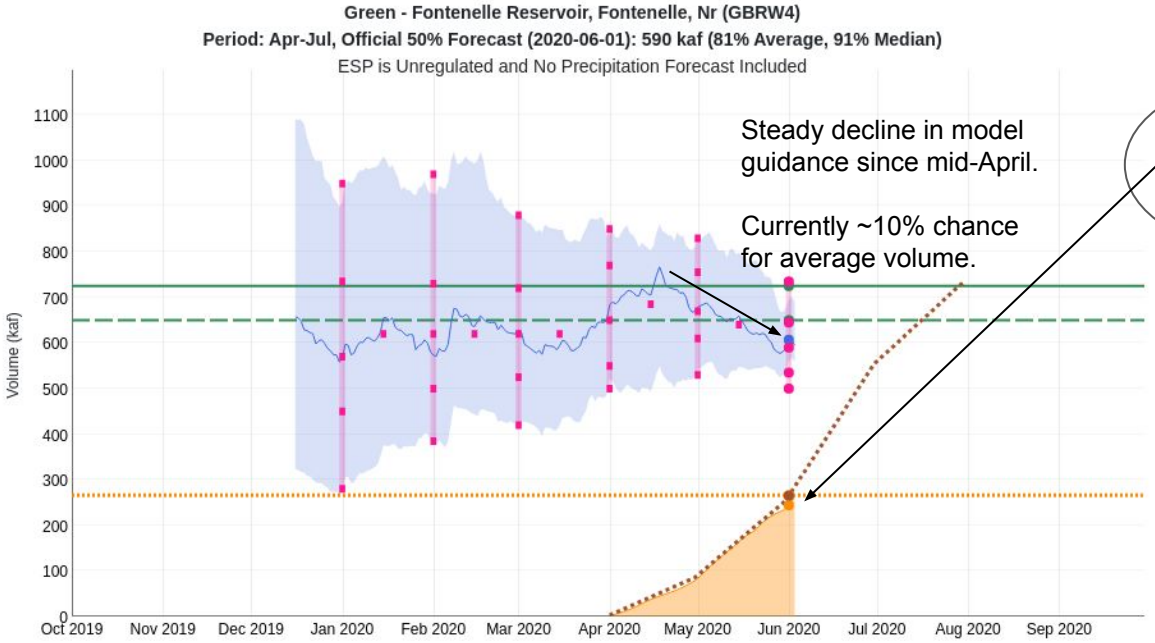
Highest forecast volumes with respect to average are in the Bear River Basin and headwaters of the Provo with volumes between 85-90% of average.

Outside of these areas forecasts are below to much below average.

Change in Forecasts May - June 2020

Rockport:	-11 KAF	(-13%)
Echo:	-12 KAF	(-11%)
Pineview:	-25 KAF	(-25%)
Bear Woodruff Narrows:	-17 KAF	(-19%)
Bear Stewart Dam:	-45 KAF	(-27%)
Jordanelle:	-3 KAF	(-3%)

Upper Green River Basin: Fontenelle Reservoir



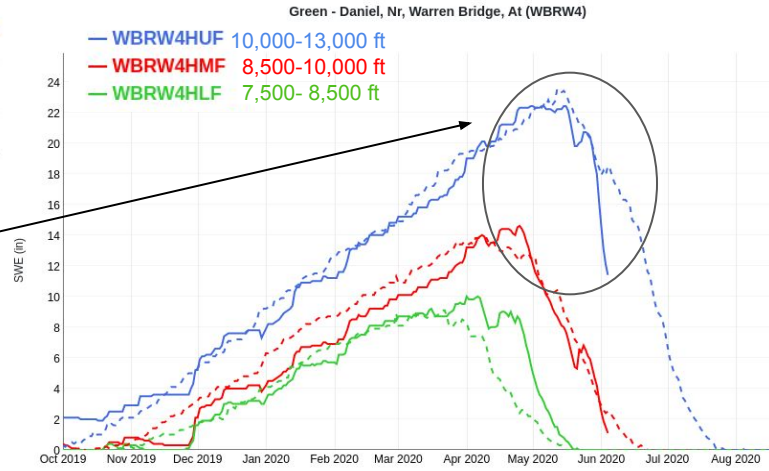
Steady decline in model guidance since mid-April.

Currently ~10% chance for average volume.

2020/06/01:
Average: 725
Median: 650
Observed
Accumulation: 244
Observed Total: 266
Normal
Accumulation: 265
ESP: 607
Official 10: 735
Official 30: 645
Official 50: 590
Official 70: 535
Official 90: 500

Observed data is now part of the April-July forecast total.

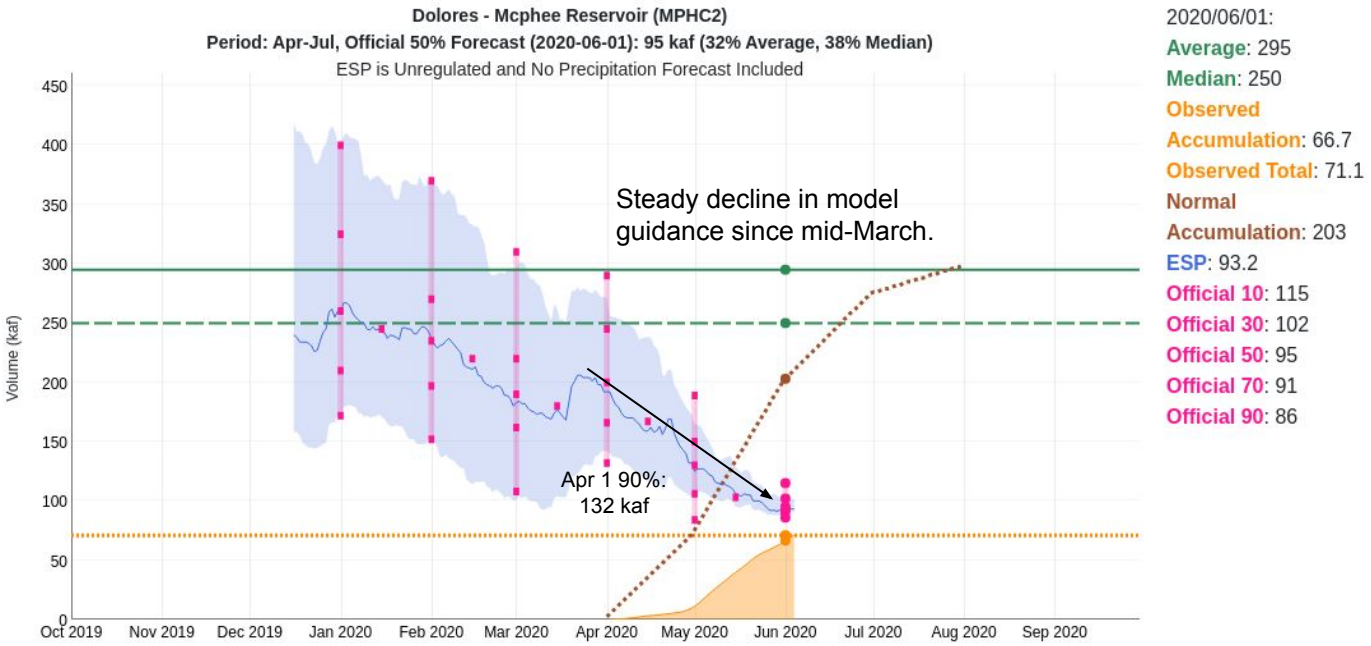
If not available daily model guidance will be plotted in purple.



Model snow plot indicates little to no snow accumulation from the last week of April to mid-May, when on average it should accumulate ~3 inches of swe in the highest elevations. A rapid period of melt began mid-May, interrupted briefly by a storm system, and continues to the current time. Normal time for snowmelt, but accelerated.

A near normal snowpack has quickly become below normal due to lack of precipitation and much above normal temperatures.

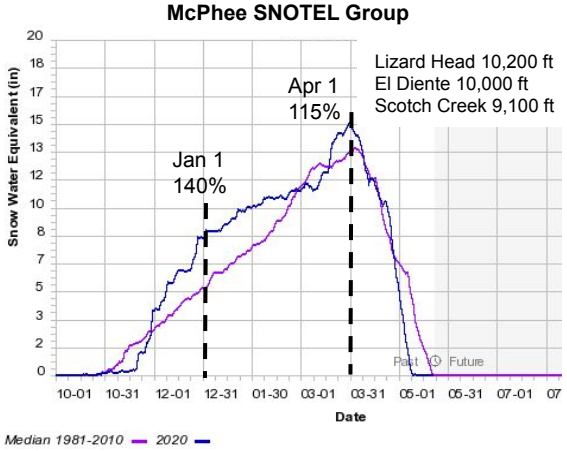
Dolores River Basin: McPhee Reservoir

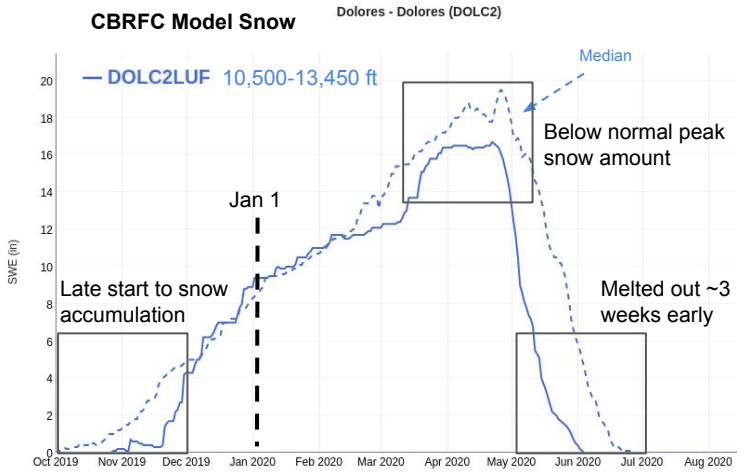


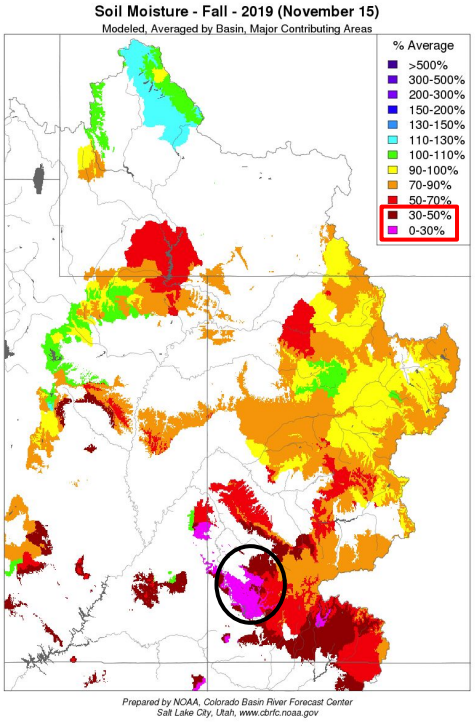
Current 50% forecast is below 90% forecasts from as recent as April 1.

Was the model ‘wrong’ or is this ‘expected’ given the extreme dryness of the past few months?

Dolores River Basin: McPhee Reservoir







What the model had right (initial states):

- *Snow*: Model shows the very late start to the upper elevation snow accumulation and how it was running behind the lower elevations percentage-wise all season.
- *Soil Moisture*: Model soils were very dry due to the near-record dry 2019 monsoon season.

→ Jan 1 forecast was below average (88%) even though SNOTEL sites indicated much above median (140%) snow in the basin.

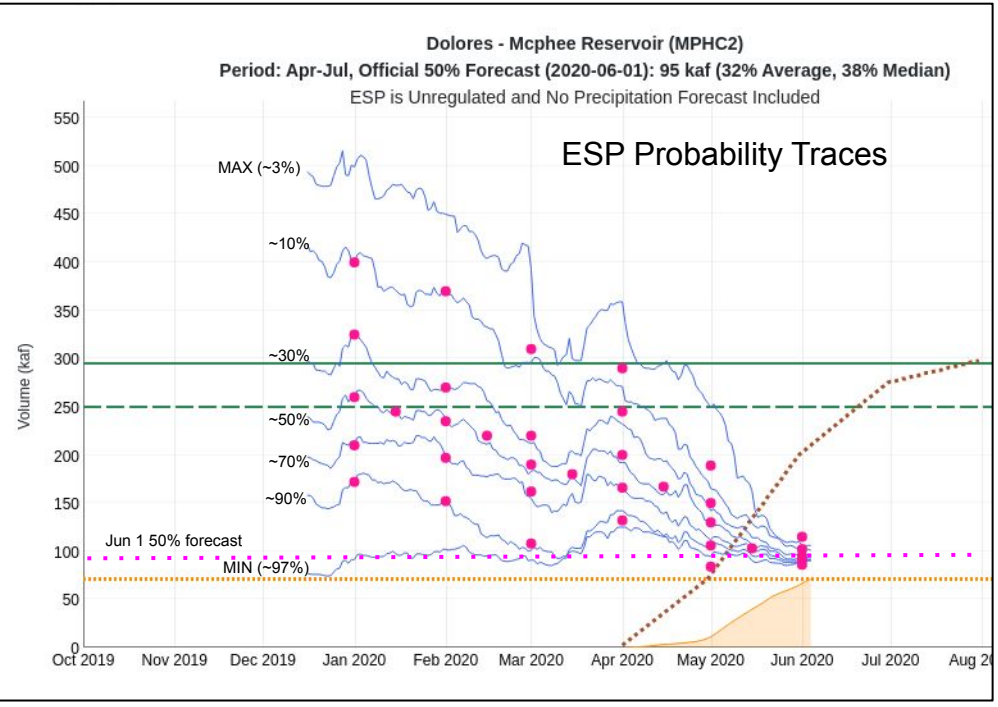
Dolores River Basin: McPhee Reservoir

The minimum ESP trace has ~3% chance of being too high (1/35).

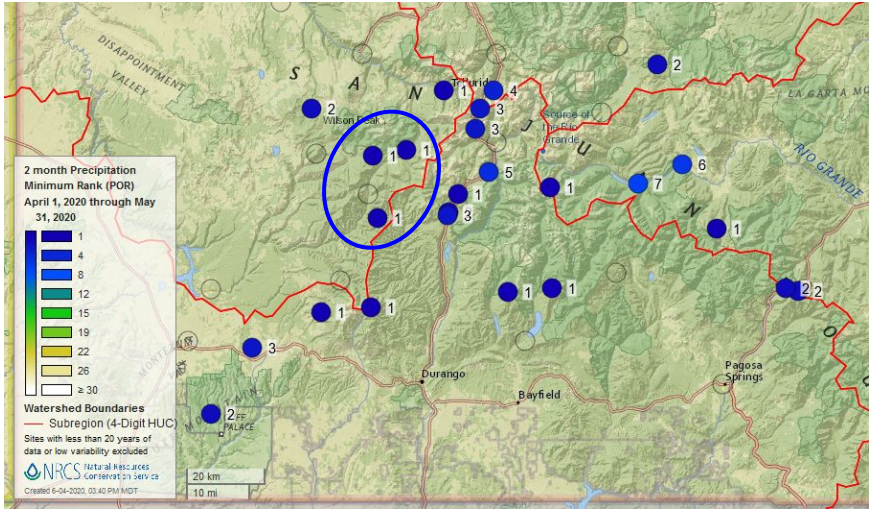
- Minimum trace values: April 1 - 125 kaf; May 1 - 94 kaf
- June 1 50% - 95 kaf

Given that the April-May period was the driest on record at SNOTEL sites in the area (with 34-40 years of data) this is an expected result.

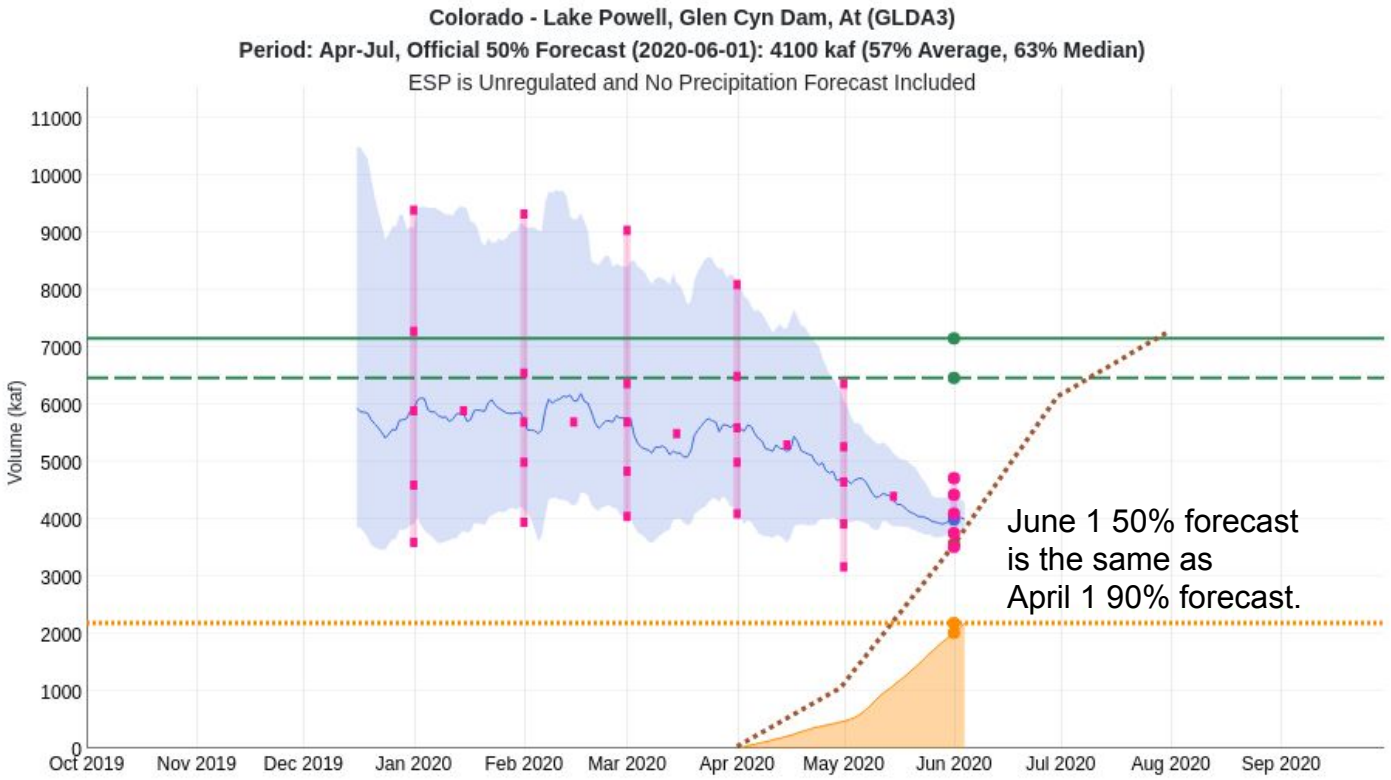
- No indication this was coming on April 1: "The weather pattern becomes more uncertain in the 8-14 day period (April 10-16); however, a weak mean trough across the Intermountain West suggests slightly increased odds for below normal temperatures and above normal precipitation." -*CBRFC April Discussion*



April-May SNOTEL *Minimum* Precip Rankings



Lake Powell



2020/06/01:
Average: 7160
Median: 6470
Observed
Accumulation: 2020
Observed Total: 2190
Normal
Accumulation: 3570
ESP: 4000
Official 10: 4720
Official 30: 4430
Official 50: 4100
Official 70: 3760
Official 90: 3520

Historical (1981-2010) ESP Reforecast Verification

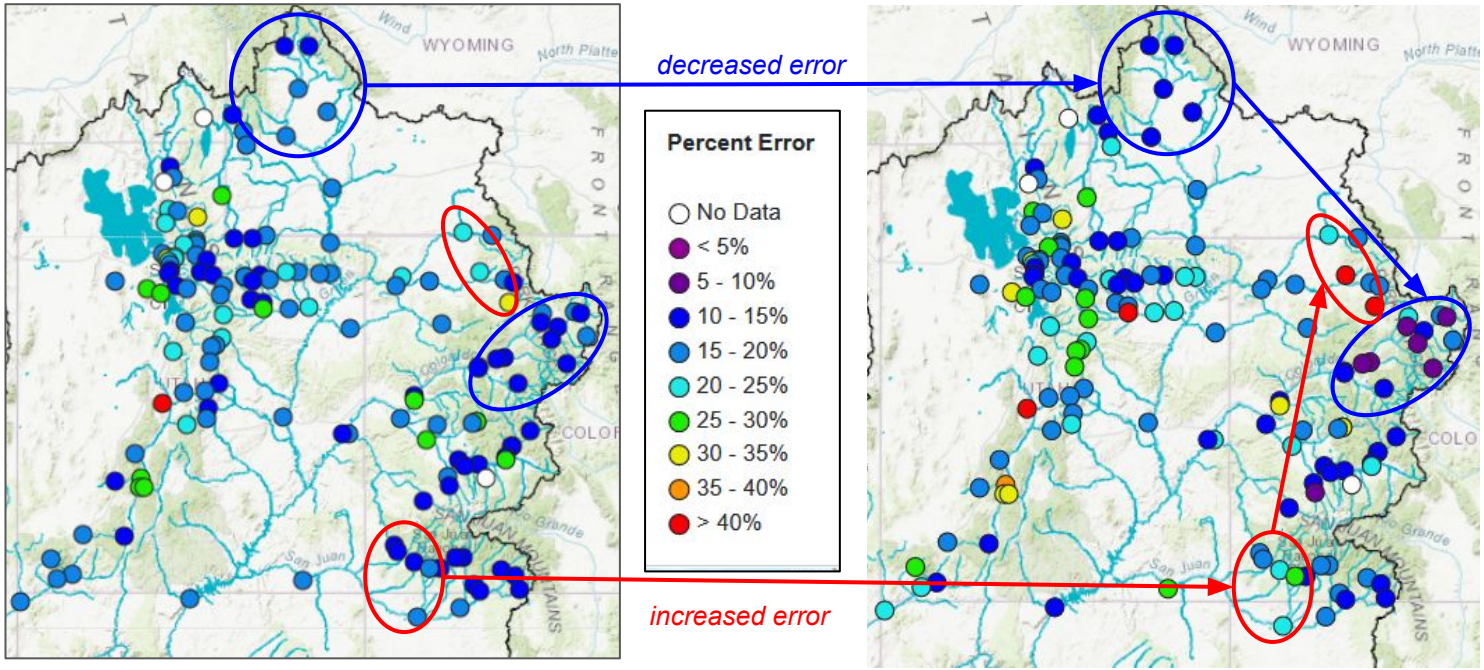
Forecasts are better than just going with average.
Error tends to decrease each month into the spring.

Where Forecasts are Better:
-Headwaters
-Primarily snow melt basins
-Known diversions / demands

Where Forecasts are Worse:
-Lower elevations (rain/early melt)
-Downstream of unmeasured diversions / irrigation

May Forecast Error: April-July Volume

June Forecast Error: April-July Volume



- Higher elevation sites where streamflow is still mostly driven by snowmelt into June and July generally have decreased error between May and June.
- Average model error tends to increase between May and June at lower elevation sites that melt out earlier and are more likely to be affected by late spring/early summer rain.

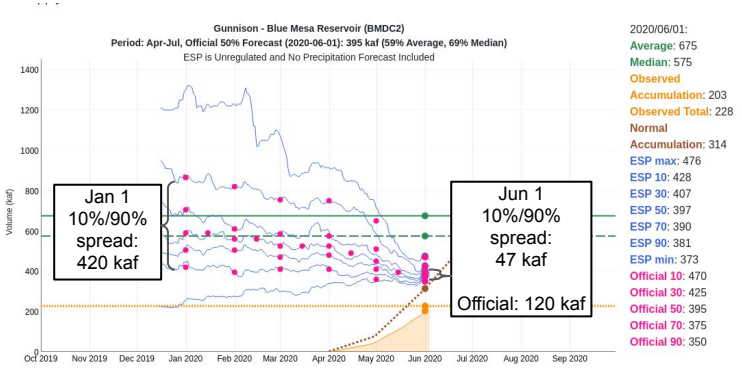
June 1 Uncertainties vs. Model (Over)confidence

June 1 Uncertainties:

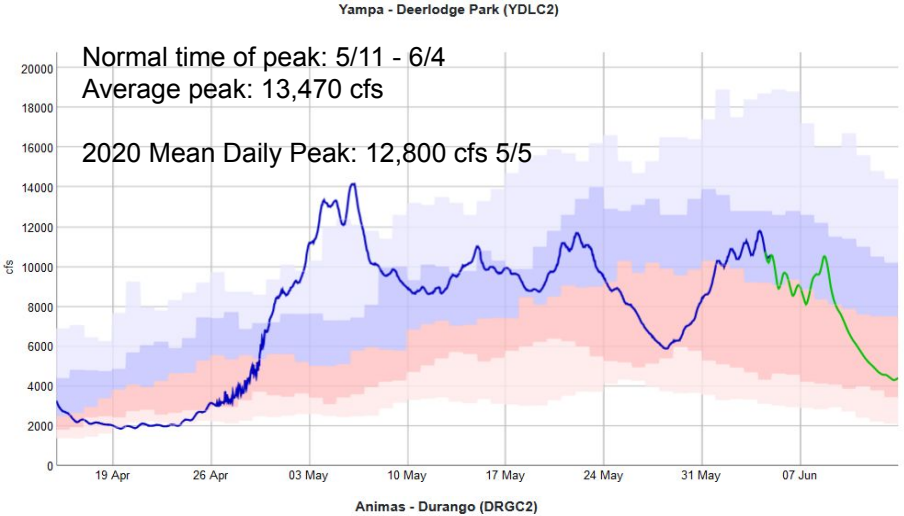
- How much snow is left and where:
  - Always an uncertainty in the model but becomes harder to verify this time of year.
- Unmeasured diversions:
  - Irrigation demands ramp up in the spring.
  - Model has assumptions for average amount of these unmeasured depletions based on calibration.
    - In a dry, warm spring irrigation water is often taken sooner and at larger volumes than normal (and vice versa).
    - In low years, these depletions are a larger percentage of the whole.
- Observed flow to date (April-May):
  - This is part of the forecast in two ways:
    - Model is adjusted during the runoff as needed to match observed flows.
      - Run-time modifications can directly and/or indirectly affect model soil moisture.
    - Added to June-July forecast to get full April-July period volume.
  - Channels can change significantly during runoff .
    - USGS visits sites as often as they can but sometimes large changes occur between visits and previous flows are adjusted.
- Future weather:
  - Always an uncertainty.
  - Precipitation events can have a larger effect percentage-wise during low years.

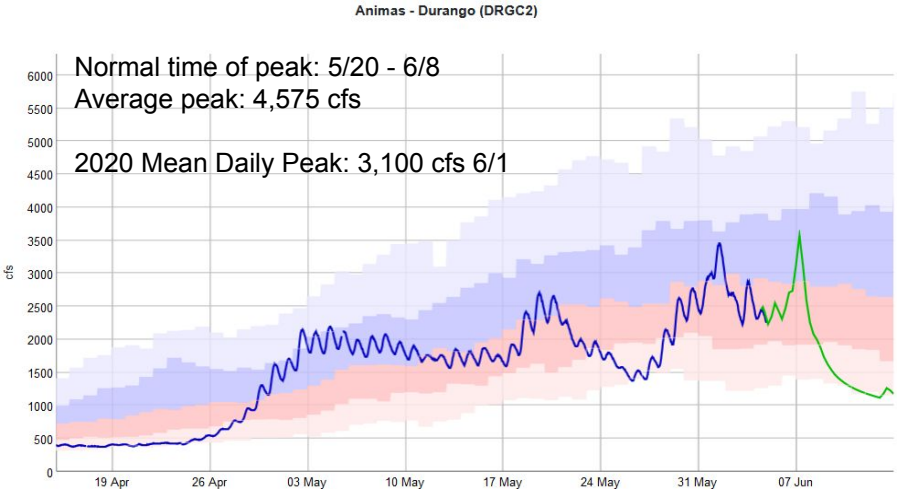
ESP Model Uncertainty:

- Out of all of the uncertainties listed to the left, the only uncertainty accounted for in ESP is future weather.
  - This is what produces the 10%, 90%, etc. exceedance levels.
  - Early in the season this is huge, but narrows as the season progresses.
  - By May/June (depending on the area), the amount of additional precipitation we can expect is greatly reduced.
- The model assumes its current snow and soil moisture states are perfect.
  - At this time there is no way to account for uncertainty in the initial conditions.
- All of this leads to the model's late season overconfidence (10/90 spread too narrow) as seen in the evolution plots.



Peak Flows





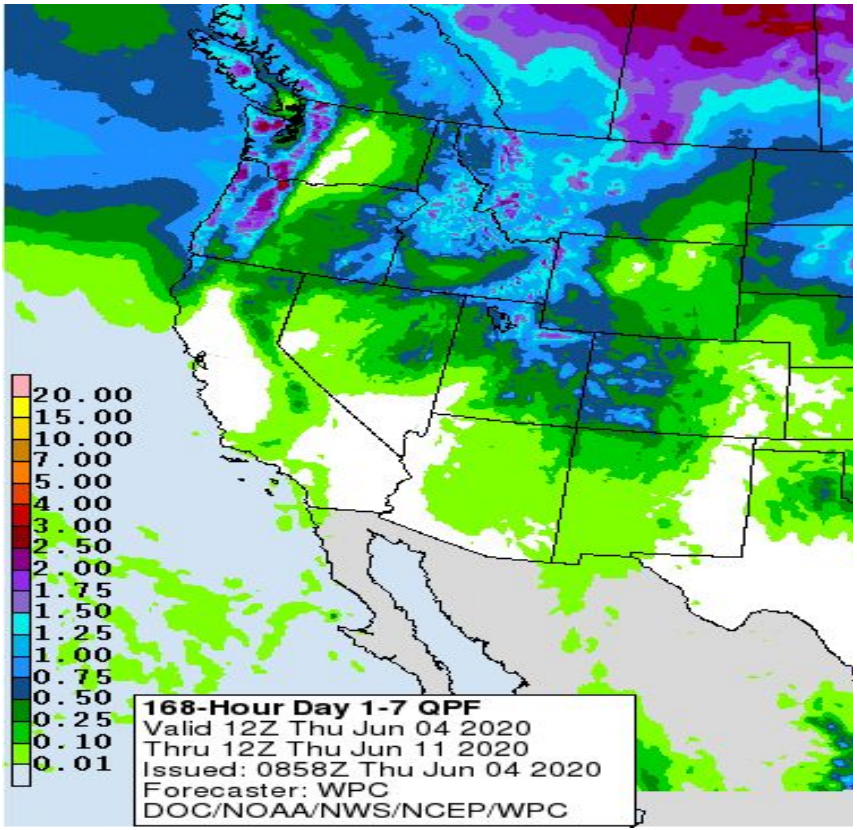
This was a year with multiple similar-magnitude peaks, rather than a single well-defined peak, on quite a few rivers.

Multiple periods of much above average temperatures from the end of April to current, combined with dry conditions led to generally low and early snowmelt peaks.

If not for this last week of extreme heat, many basins' official peaks for the year likely would have been from the warm-up just after mid-May. Very efficient runoff during this recent period likely helped runoff volumes, especially in the driest areas.

Most basins have seen their snowmelt peaks for the year during the last few days. However, precipitation forecast for this weekend could possibly push some rivers higher.

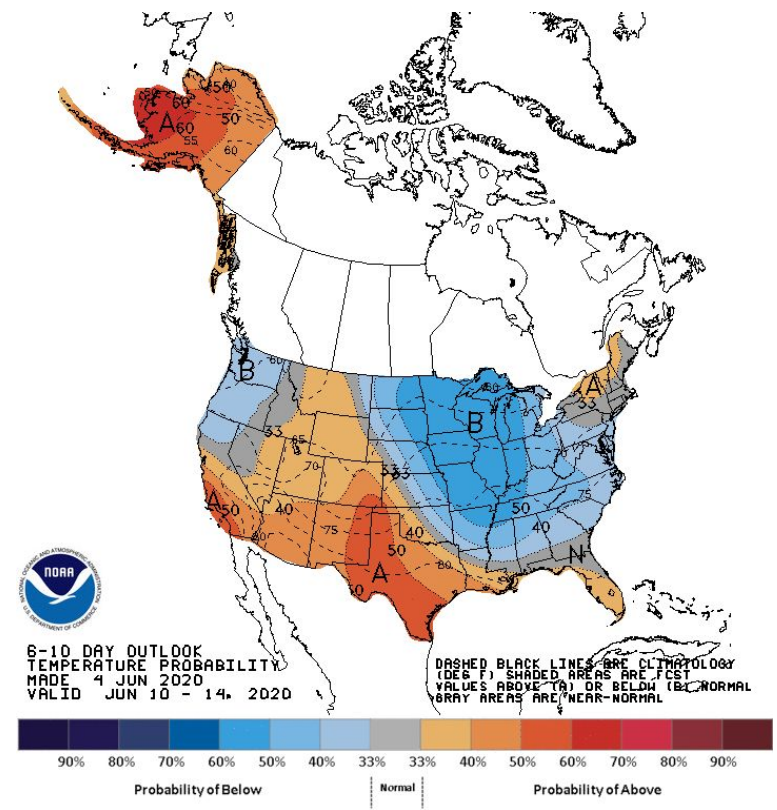
Upcoming Weather: Much Needed Precip on the Way

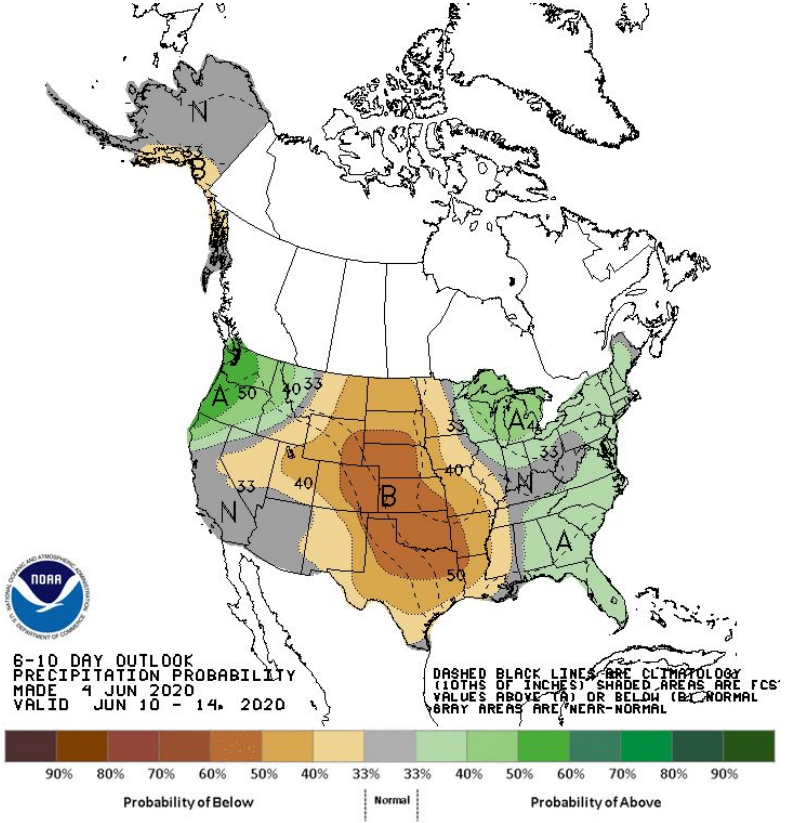


- Currently experiencing very warm temperatures (10-20 degrees above normal) through Friday.
- A trough will move into the Western US through the weekend, resulting in widespread precipitation. Forecasted amounts are generally 0.5-1.5 inches
- Temperatures will cool to **10-20 degrees below normal** late this weekend through early next week.

Upcoming Weather: 6 to 10 day Outlook (June 10-14)

After the upcoming wet/cool period through early next week, the models are in rather good agreement at showing increasing ridging and warming temperatures by Wednesday-Saturday of next week (June 10-13). The last half of June is climatologically quite dry across the region and significant precipitation events become less likely.





Summary

- May was another extremely dry month across the Colorado River Basin and Eastern Great Basin:
  - Near record low precipitation amounts across Utah and southwest Colorado.
  - Generally much below average elsewhere.

- Early June snow conditions:
  - Below normal across the basin due to dry conditions and recent heat.

- Much above normal temperatures over the last week:
  - Accelerated snowmelt and very efficient runoff.

- In general June April-July water supply volume forecasts are below to much below normal and dropped 5%-30% from May 1 forecasts.

- Peak flows due to snowmelt have occurred in many basins over the last few days:
  - Lower than normal, but higher than what might otherwise have been expected given the poor snowpack in some areas.

- Expecting a drastic change in the weather this weekend and into the middle of next week:
  - Temperatures will swing to much below average.
  - Increased chances for precipitation across the area.
  - Ridging and warm, dry weather will likely return for the second half of next week - this is normal for this time of year.

CBRFC Contacts

Basin Focal Points (Forecasters)

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CBRFC Water Supply Presentations
https://www.cbrfc.noaa.gov/present/present.php

Questions?