NOAA's Colorado Basin River Forecast Center

Forecast Uncertainty and Verification Tools

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Service Coordination Hydrologist

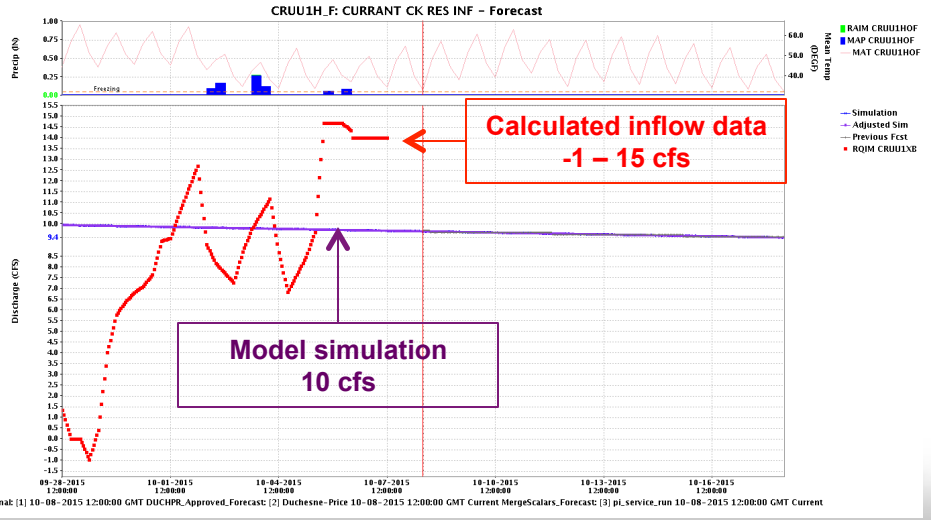
2016 Stakeholder Open House

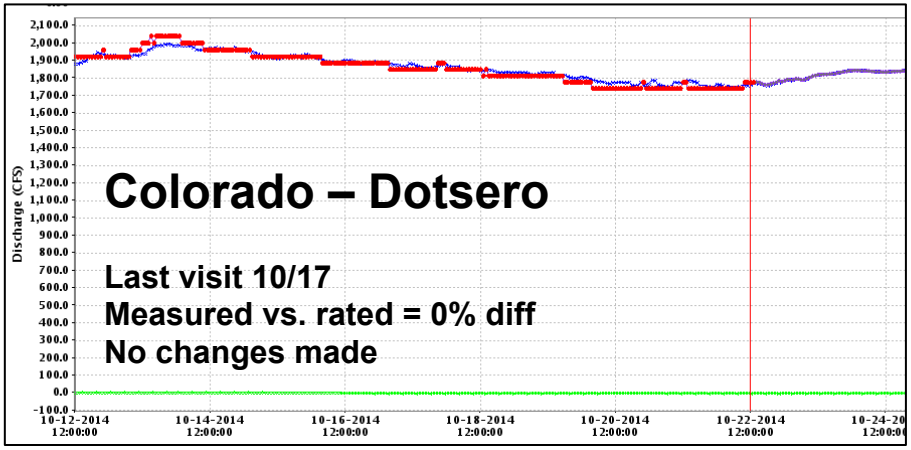
Understanding Sources of Error

- Data
  - Undetected errors in historical/current observations
  - Data density/Gage network distribution
  - Unmeasured Depletions
  - Forecasted Weather Conditions
- Hydrologic Model
  - The model itself
  - Initial Conditions
  - Calibration Error (bias)

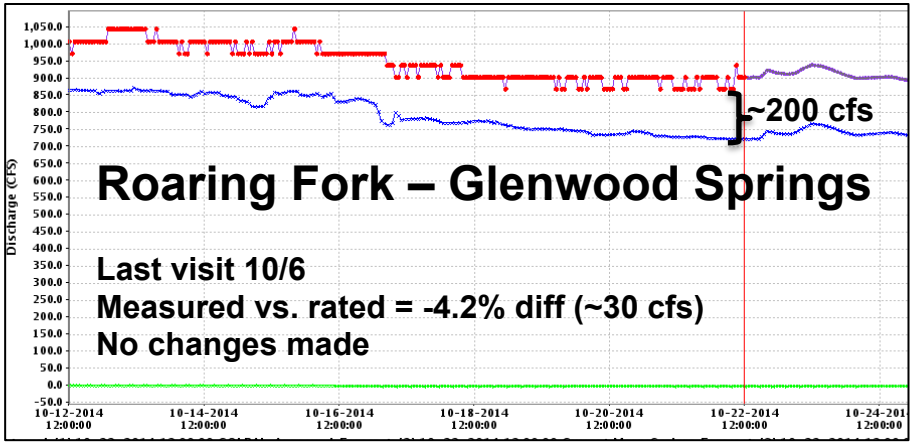
Data

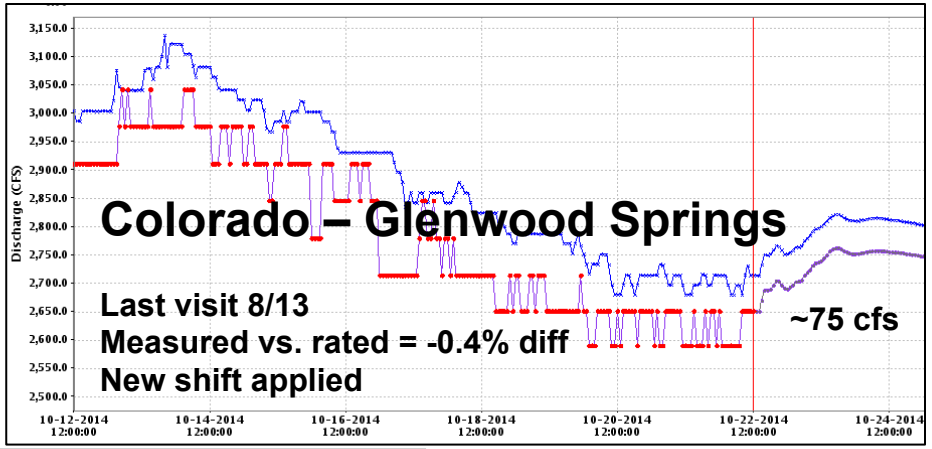
- Gage Issues
  - Freezing, aquatic growth
  - Malfunctions
  - Flooding issues (gage destroyed, channel changes, etc…)
  - Measurement accuracy
- Bad data
- Missing data

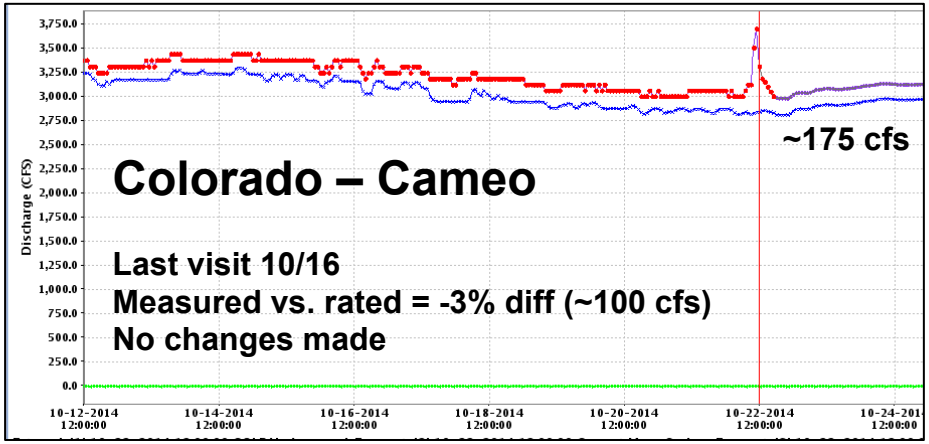




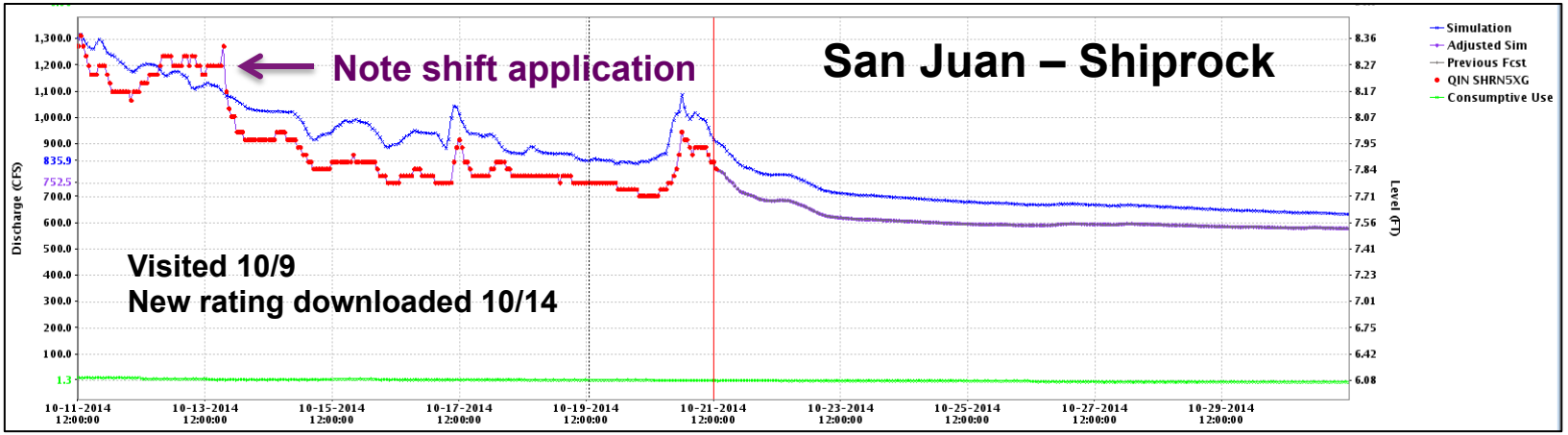
Red = observed
Blue = simulated

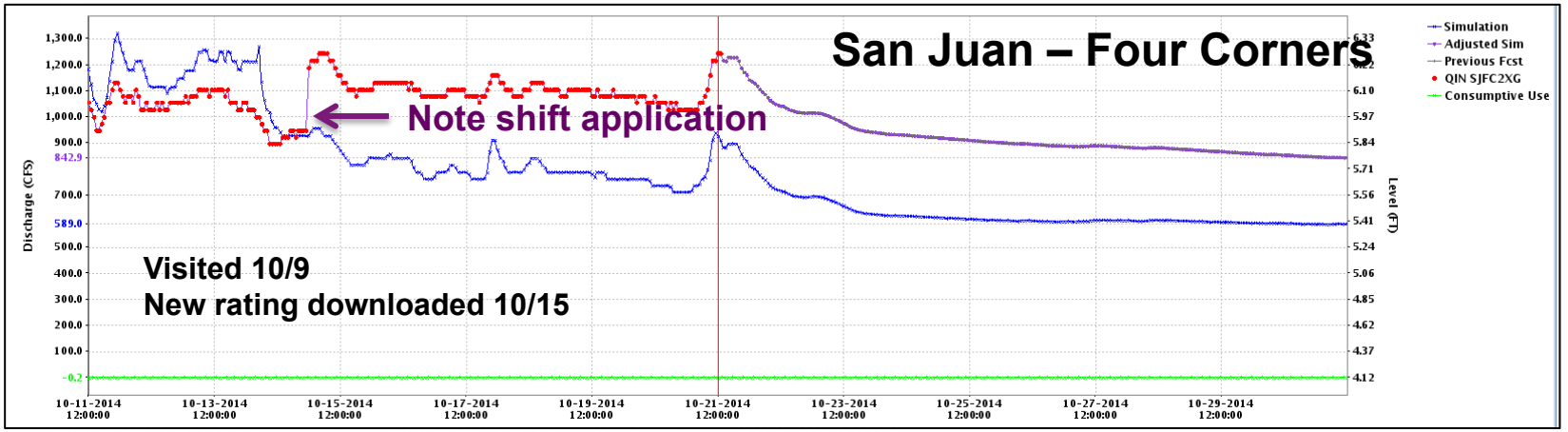


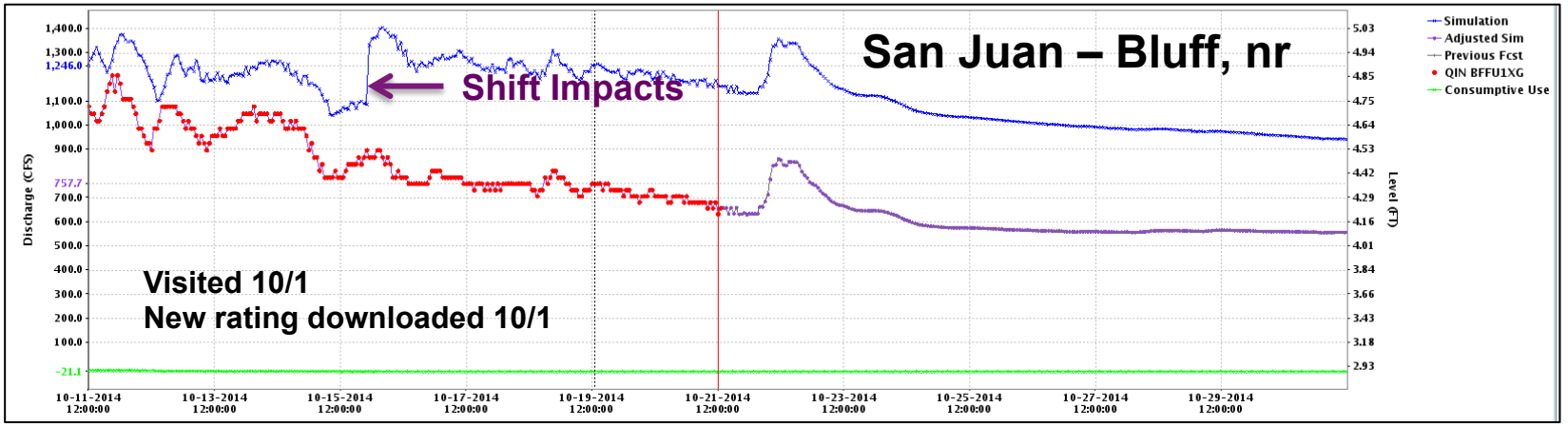




*These dates are from 2014. The USGS has visited all these sites multiple times since then!

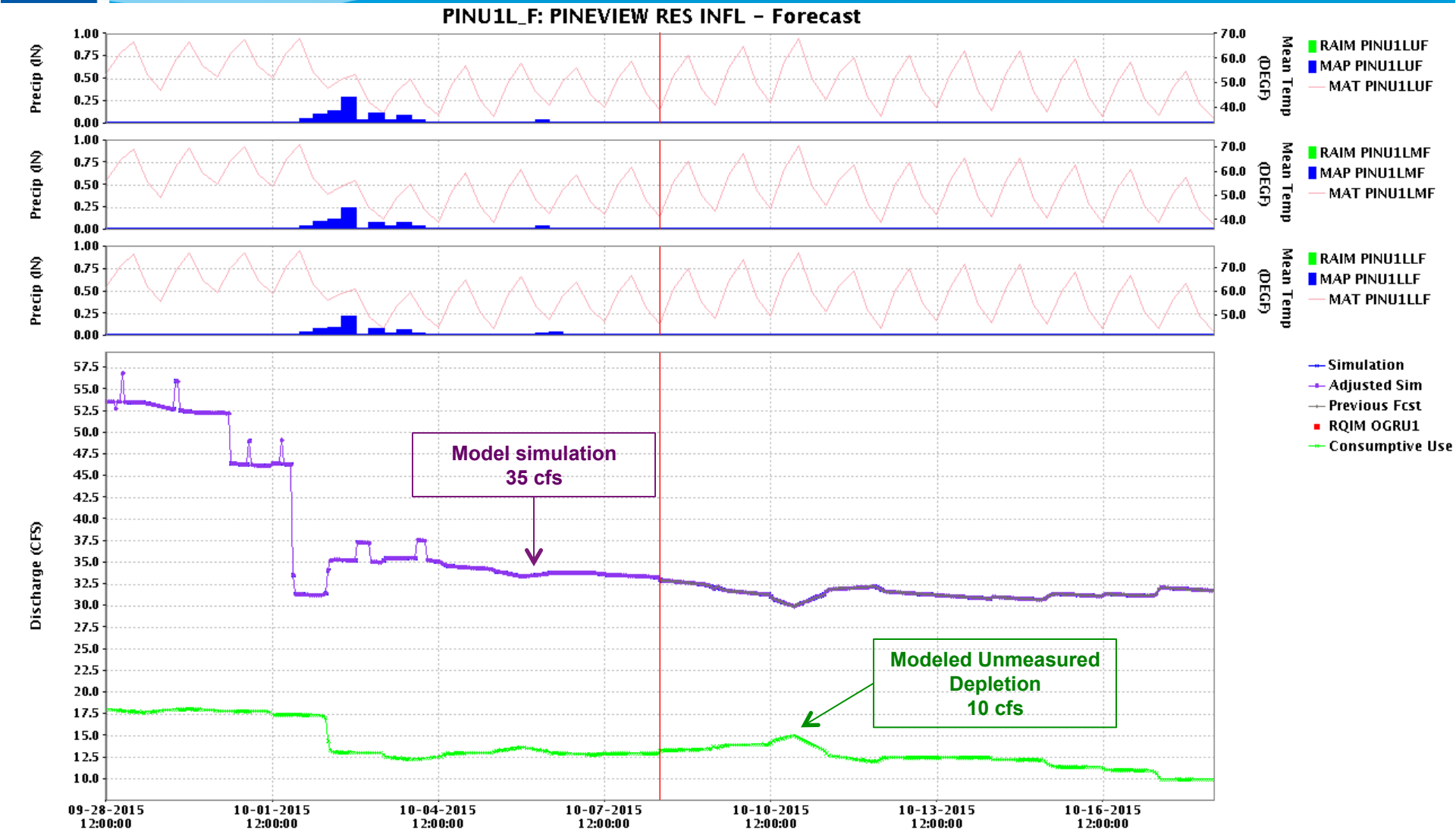




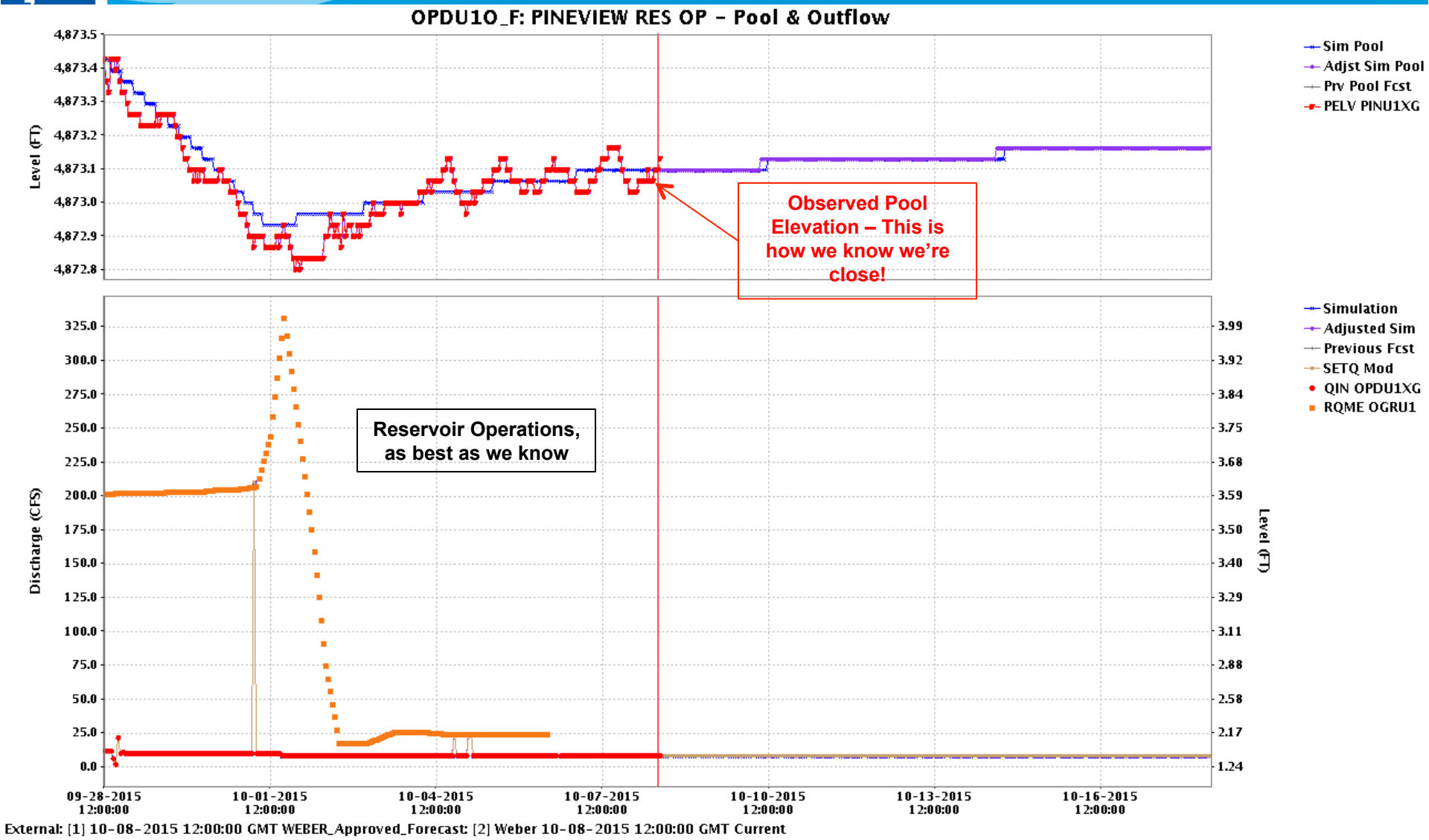


*Again, these dates are from 2014. The USGS has visited all these sites multiple times since then!

Missing Data

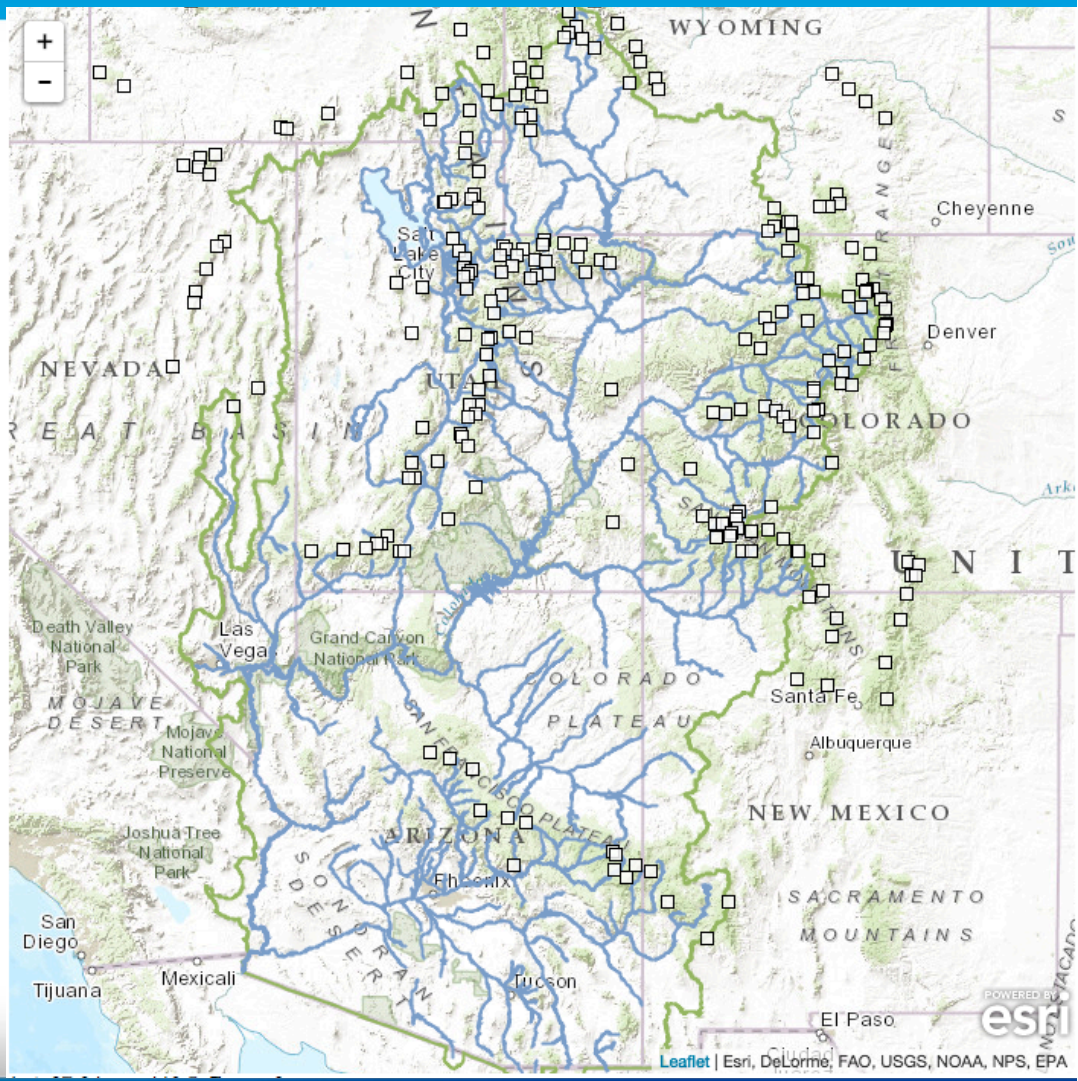


Missing Data



Gage Density

- SNOTEL Network
  - Since it became available, has improved accuracy of forecasts
  - In some areas the gage density is better
- All gages ➔



Gage Density

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  - Since it became available, has improved accuracy of forecasts
  - In some areas the gage density is better
- All gages ≥ 7,000 ft.

➔

Gage Density

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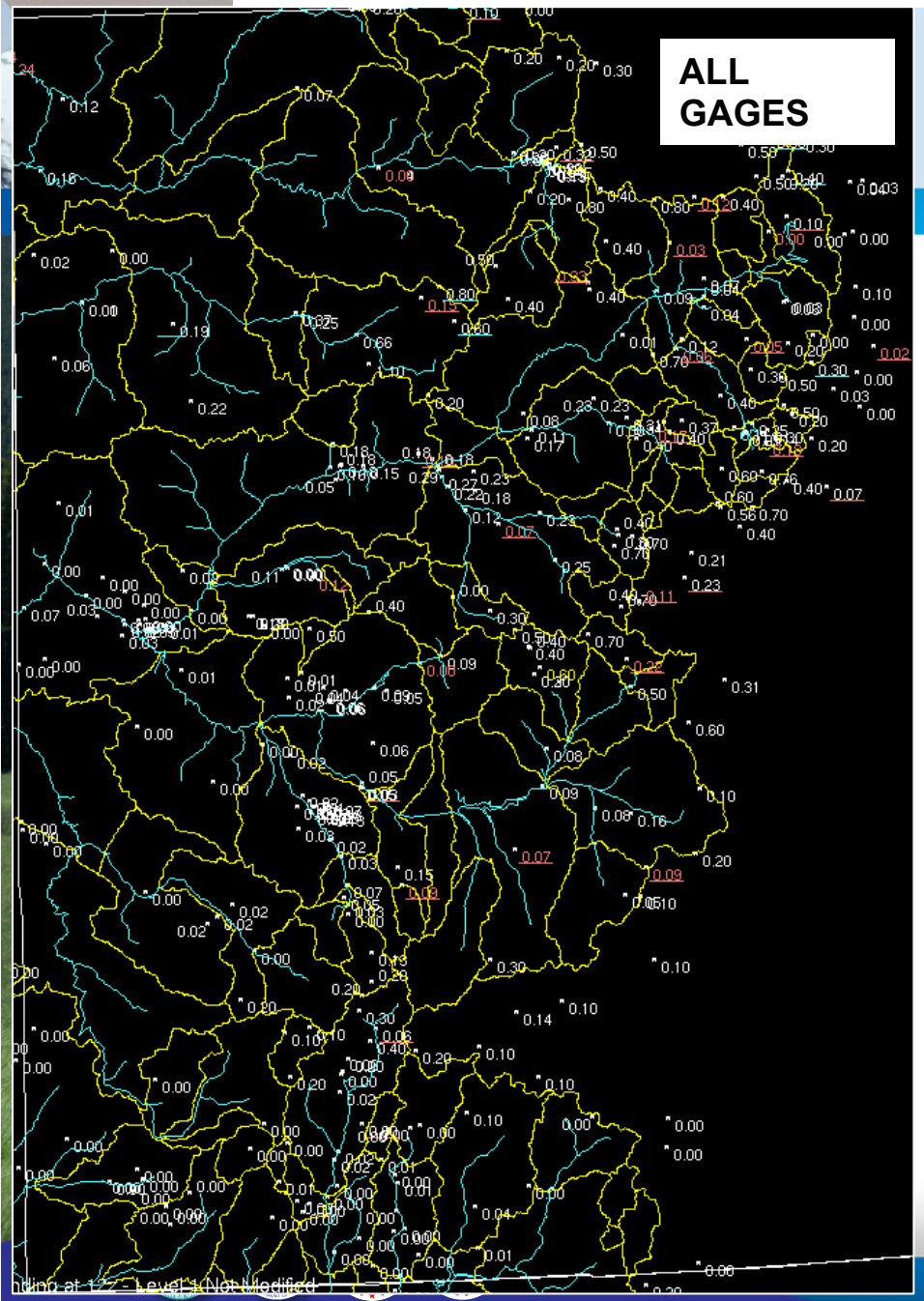
  - Since it became available, has improved accuracy of forecasts
  - In some areas the gage density is better
- All gages ≥ 9,000 ft.

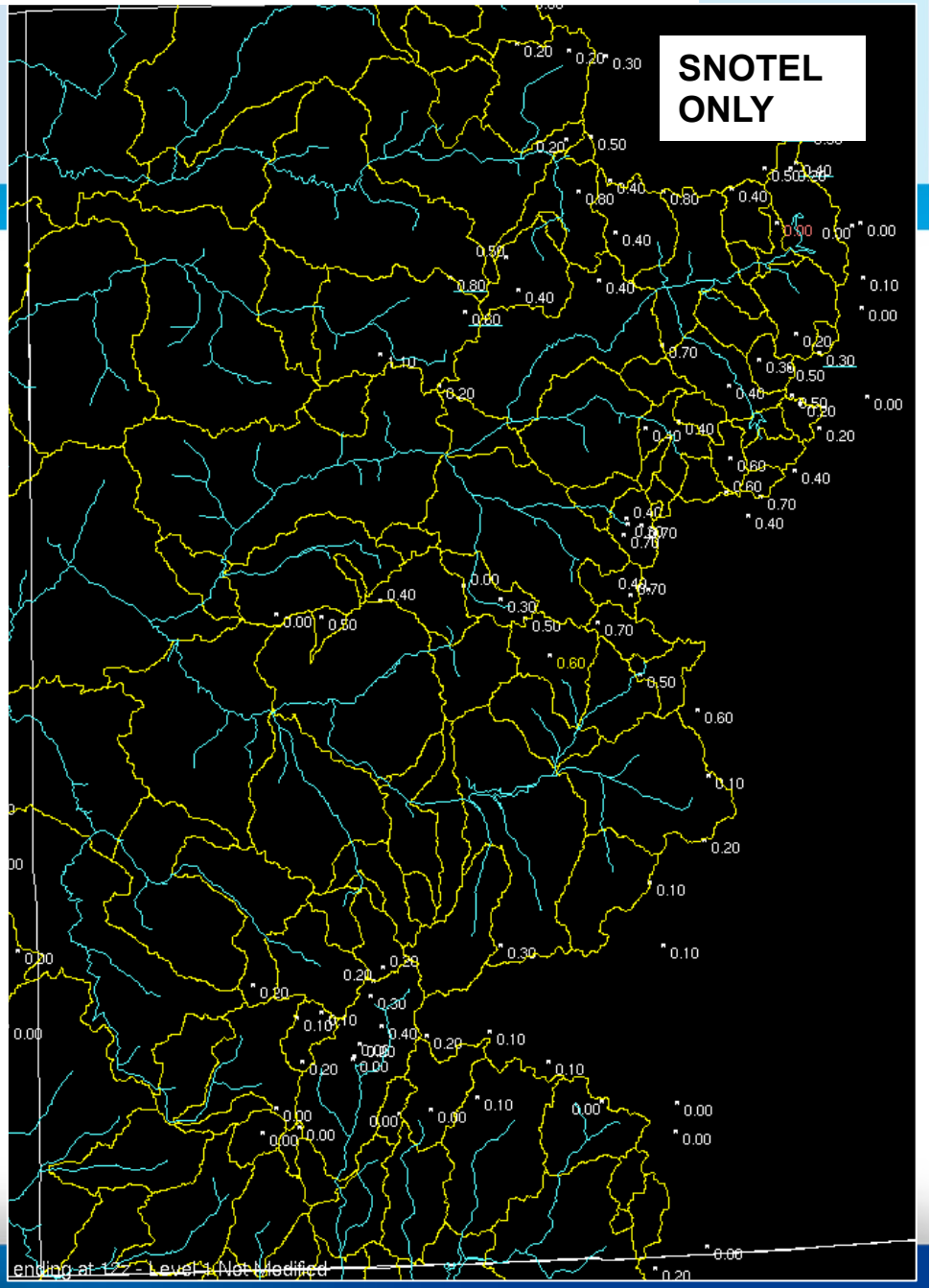
➔

Gage Density

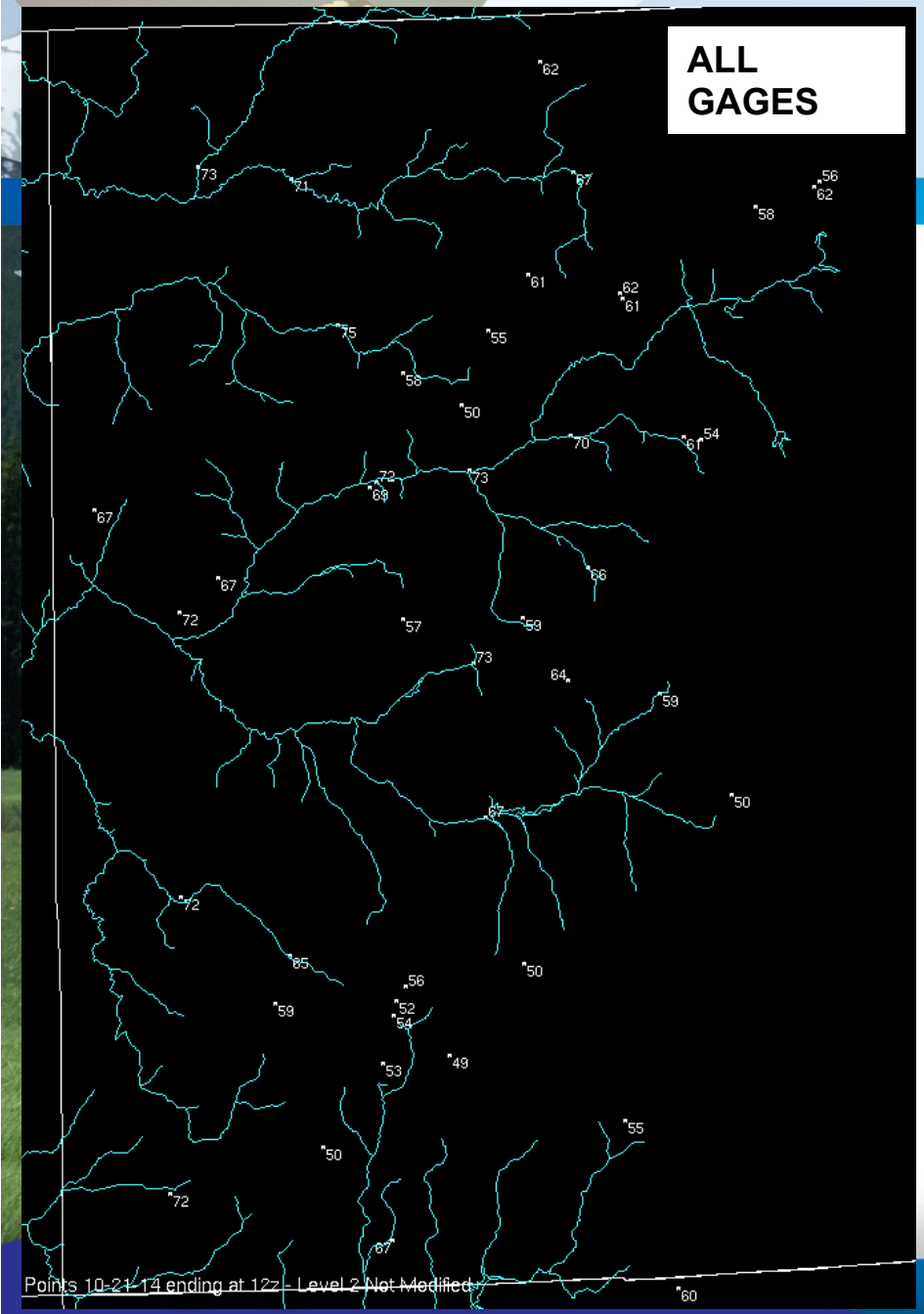
- SNOTEL Network
  - Since it became available, has improved accuracy of forecasts
  - In some areas the gage density is better
- All gages ≥ 10,000 ft. ➔

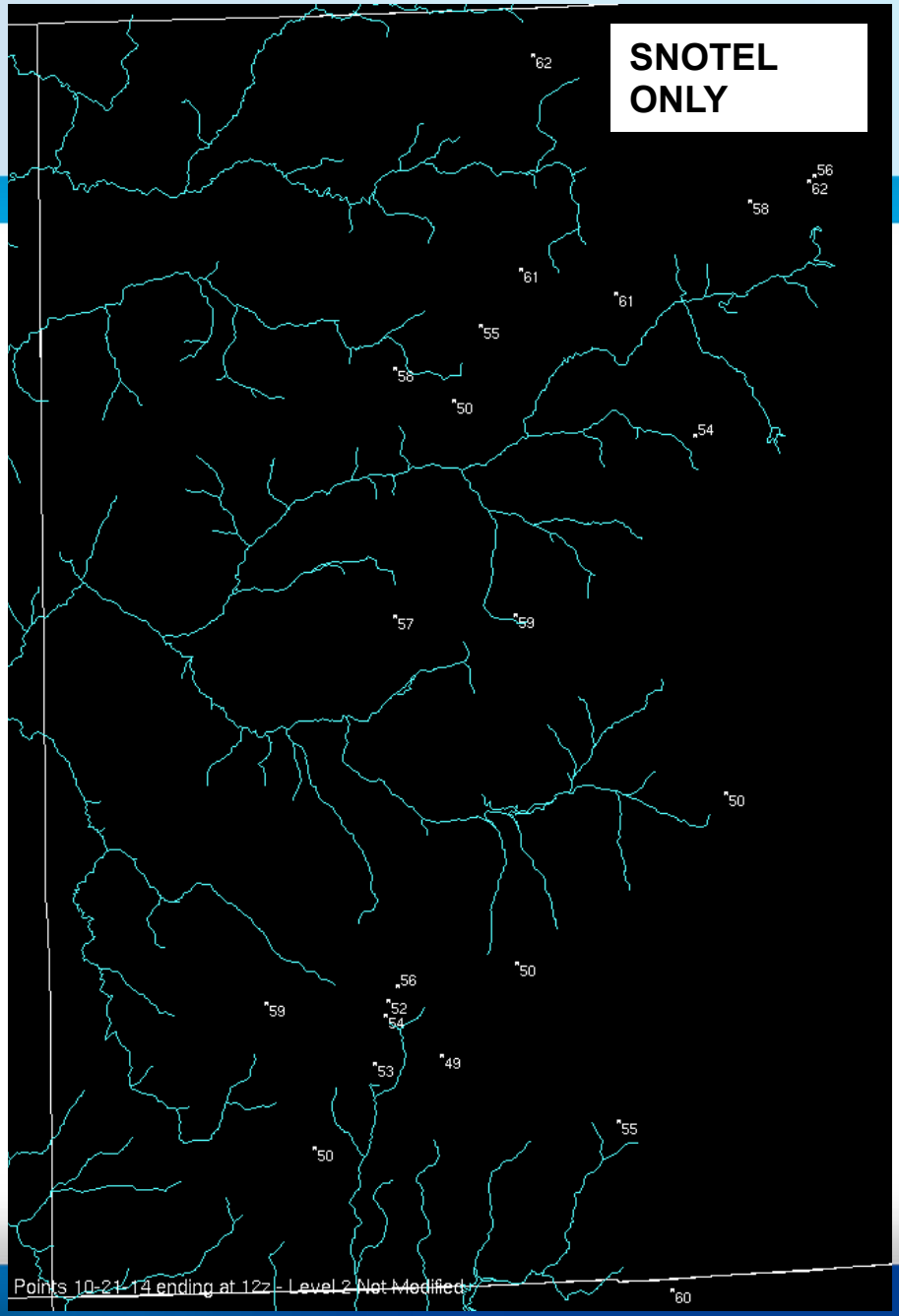
DAILY_QC 24 HOUR PRECIPITATION ENDING 10/13/2014 12Z





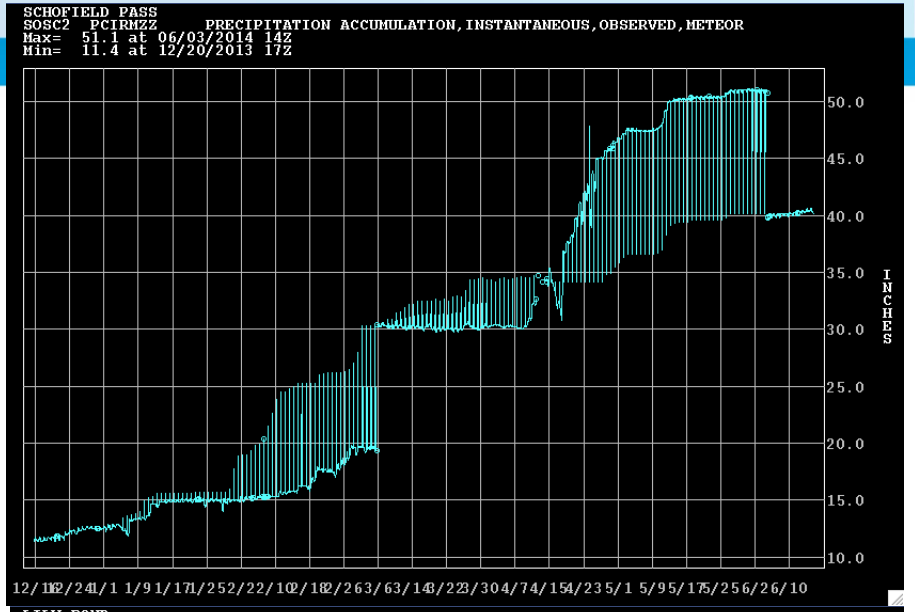
DAILY_QC TEMPERATURE STATIONS

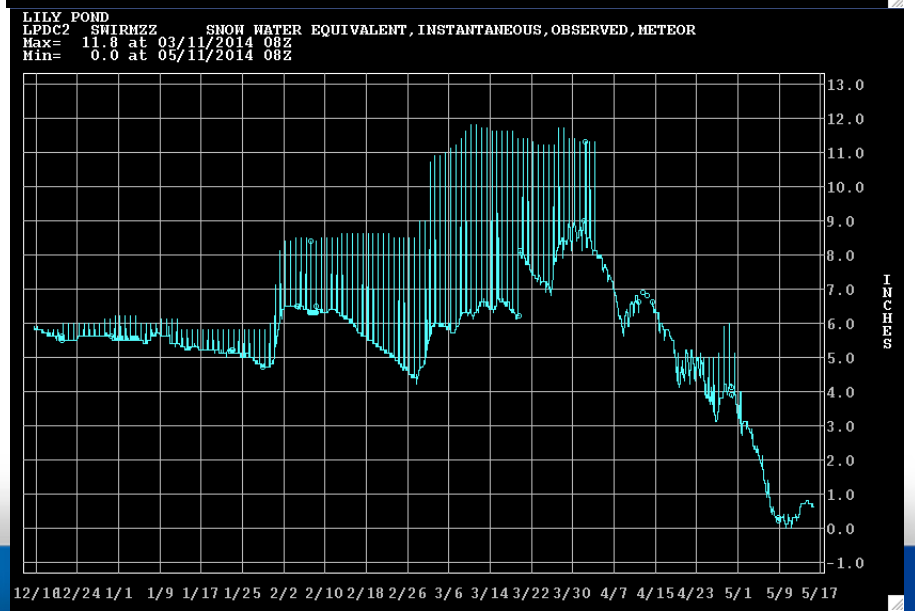


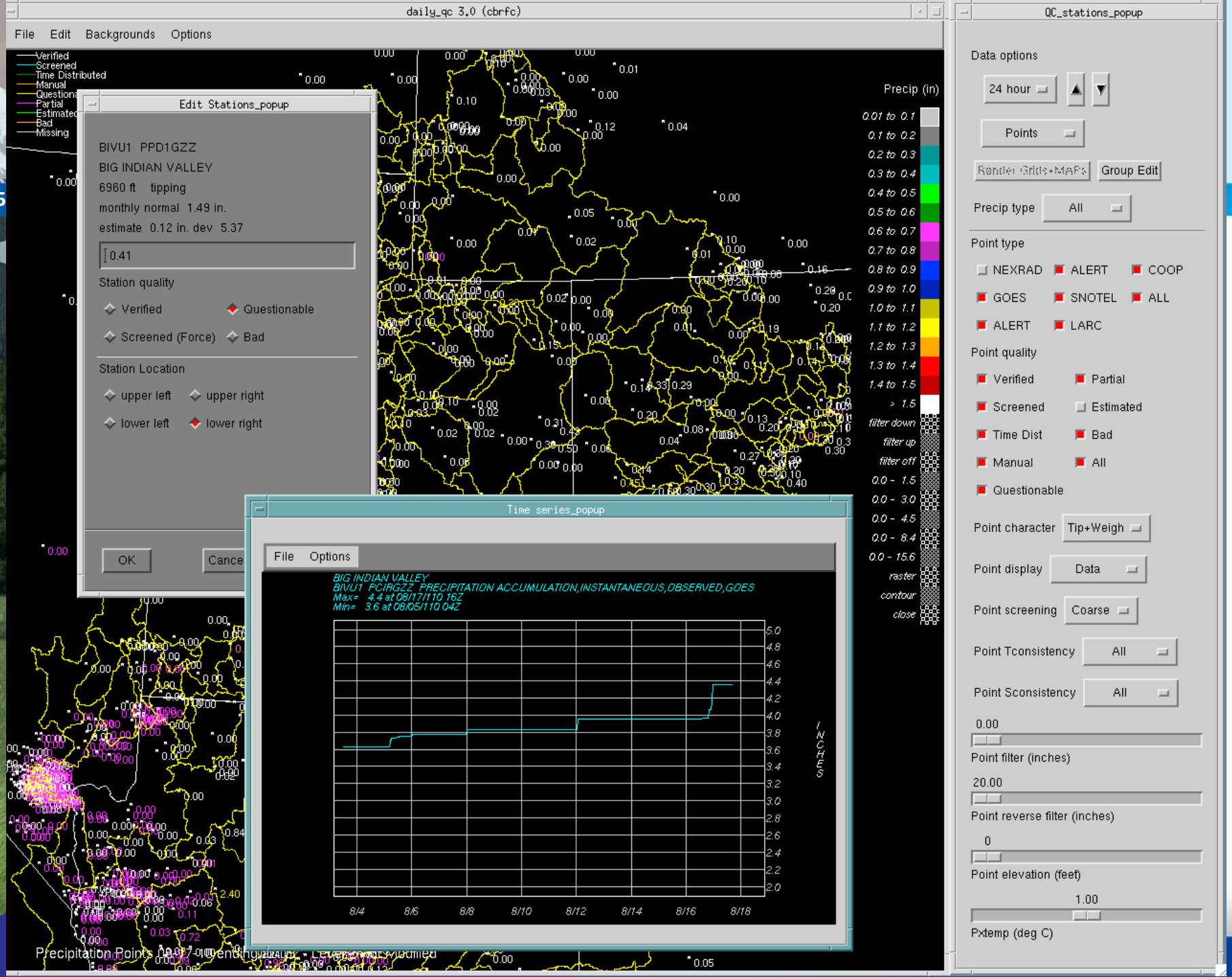


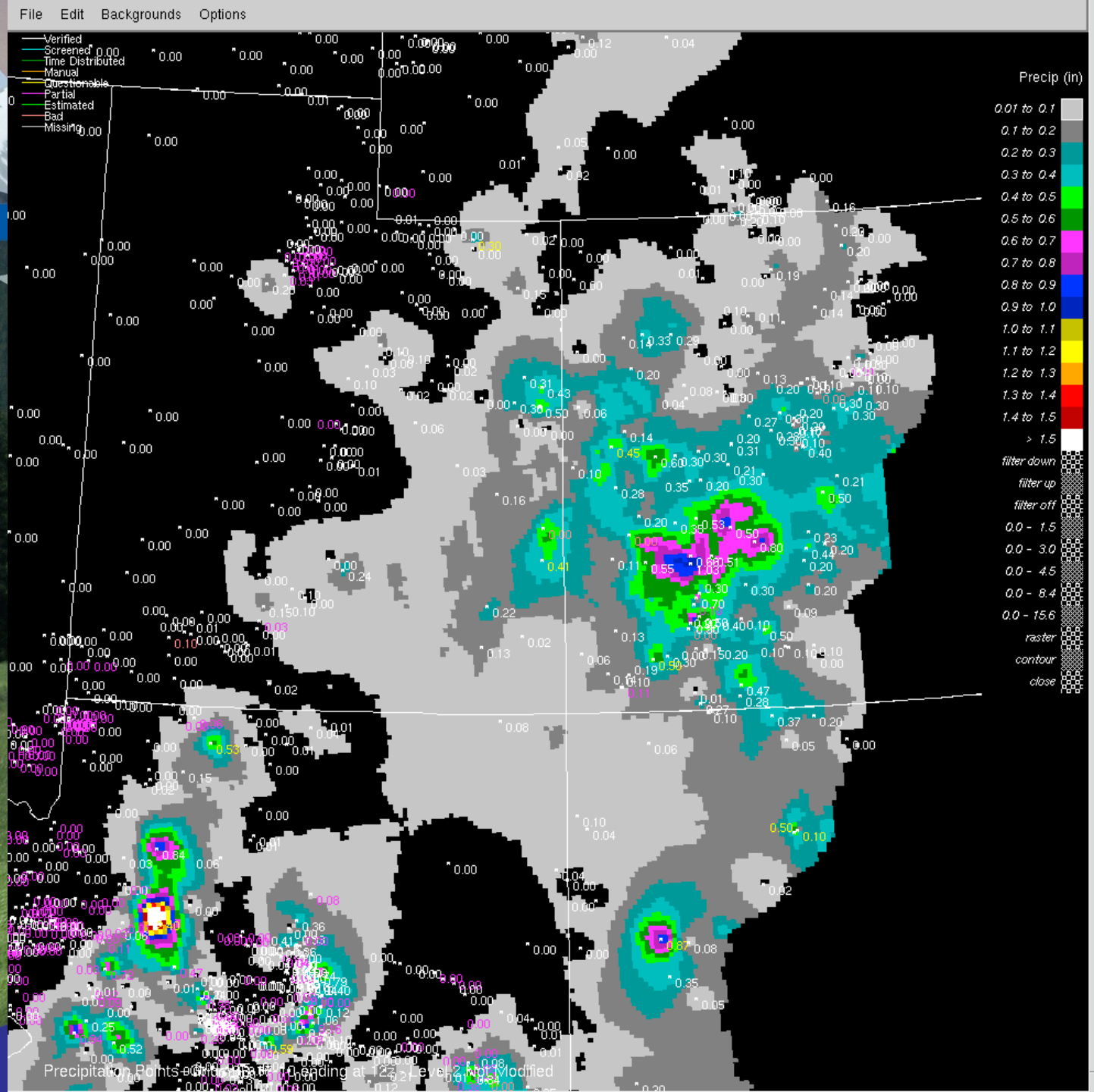
SNOTEL Issues

- Bad precipitation readings (2014)
  - Columbine
  - Lake Irene
  - Tower
  - Schofield Pass
- Bad pillow readings (2014)
  - Lily Pond
- Changing conditions at the sites
  - Vail Mountain
  - Upper San Juan
  - Red Mountain






daily_qc 3.0 (cbrfc)
File Edit Backgrounds Options
Verified
Screened
Time Distributed
Manual
Questionable
Partial
Estimated
Bad
Missing
Edit Stations_popup
BIVU1 PPD1GZZ
BIG INDIAN VALLEY
6960 ft tipping
monthly normal 1.49 in.
estimate 0.12 in. dev 5.37
0.41
Station quality
Verified
Questionable
Screened (Force)
Bad
Station Location
upper left
upper right
lower left
lower right
OK
Cance
Precip (in)
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
0.7 to 0.8
0.8 to 0.9
0.9 to 1.0
1.0 to 1.1
1.1 to 1.2
1.2 to 1.3
1.3 to 1.4
1.4 to 1.5
> 1.5
filter down
filter up
filter off
0.0 - 1.5
0.0 - 3.0
0.0 - 4.5
0.0 - 8.4
0.0 - 15.6
raster
contour
close
Time series_popup
File Options
BIG INDIAN VALLEY
BIVU1 PCIRGZZ PRECIPITATION ACCUMULATION,INSTANTANEOUS,OBSERVED,GOES
Max= 4.4 at 08/17/110 16Z
Min= 3.6 at 08/05/110 04Z
8/4 8/6 8/8 8/10 8/12 8/14 8/16 8/18
INCHES
QC_stations_popup
Data options
24 hour
Points
Render Grids+MAPs
Group Edit
Precip type
All
Point type
NEXRAD
ALERT
COOP
GOES
SNOTEL
ALL
ALERT
LARC
Point quality
Verified
Partial
Screened
Estimated
Time Dist
Bad
Manual
All
Questionable
Point character
Tip+Weigh
Point display
Data
Point screening
Coarse
Point Tconsistency
All
Point Sconsistency
All
0.00
Point filter (inches)
20.00
Point reverse filter (inches)
0
Point elevation (feet)
1.00
Pxtemp (deg C)
Precipitation Points



Data options

24 hour

Points+Grids

Render Grids+MAPS | Group Edit

Precip type: All

Point type

- NEXRAD
- ALERT
- COOP
- GOES
- SNOTEL
- ALL
- ALERT
- LARC

Point quality

- Verified
- Partial
- Screened
- Estimated
- Time Dist
- Bad
- Manual
- All
- Questionable

Point character: Tip+Weigh

Point display: Data

Point screening: Coarse

Point Tconsistency: All

Point Sconsistency: All

0.00

Point filter (inches)

20.00

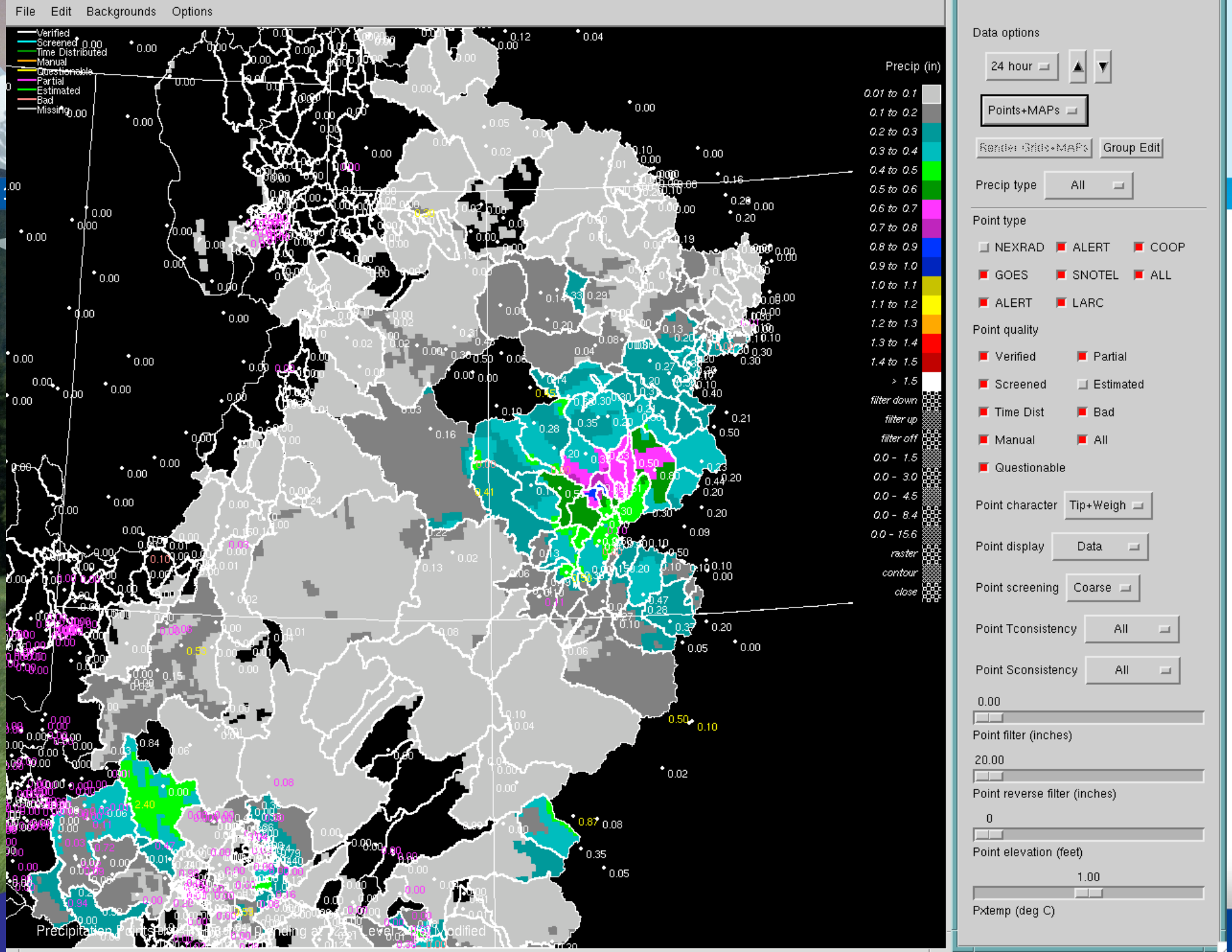
Point reverse filter (inches)

0

Point elevation (feet)

1.00

Pxtemp (deg C)


File
Edit
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Options
Verified
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Time Distributed
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Partial
Estimated
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Precip (in)
0.01 to 0.1
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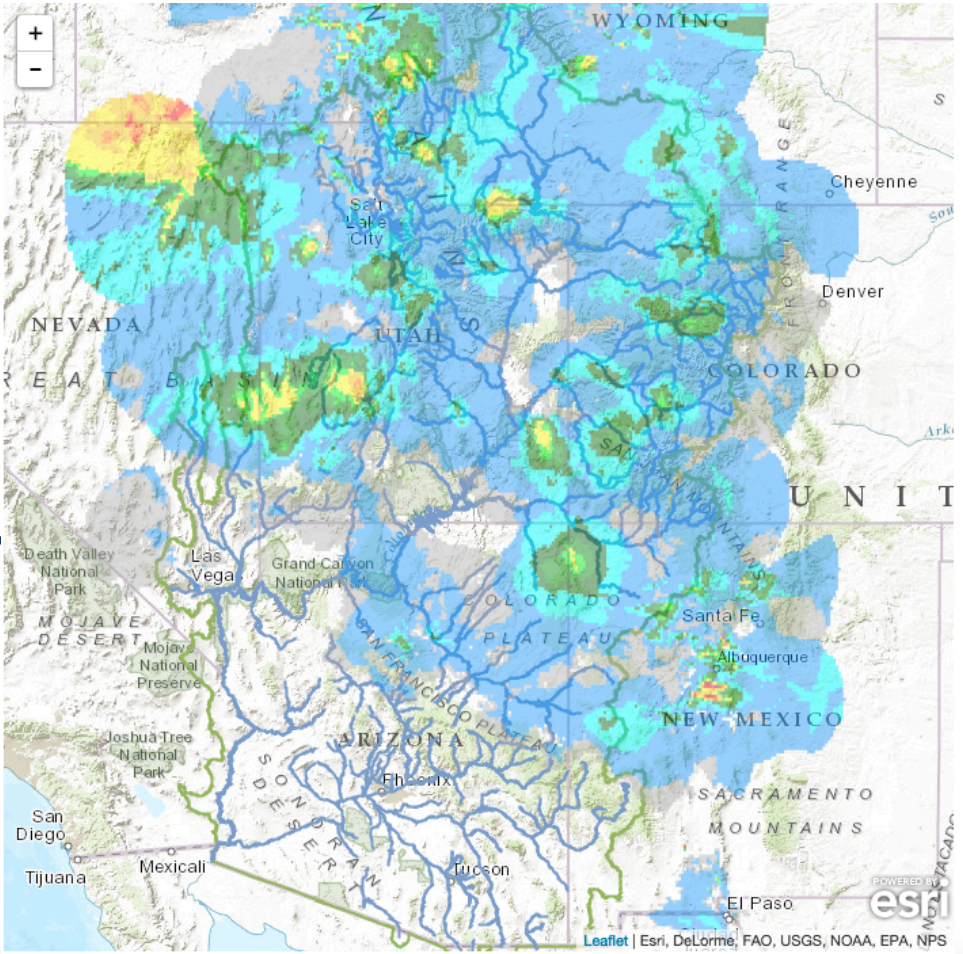
Point Sconsistency
All
0.00
Point filter (inches)
20.00
Point reverse filter (inches)
0
Point elevation (feet)
1.00
Pxtemp (deg C)

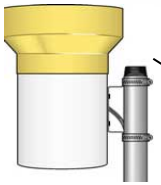
Quantitative Precipitation Estimate (QPE)

- Combination of gage, radar, and satellite information
- Coverage can vary based on season
- Despite QA/QC process, incorrect data can slip through

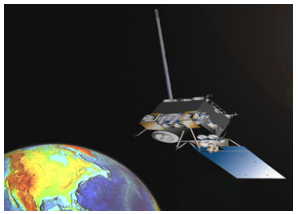


Quantitative Precipitation Estimates (QPE)

Rain Gage Measurement

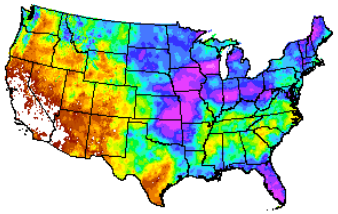


GOES Satellite Estimate



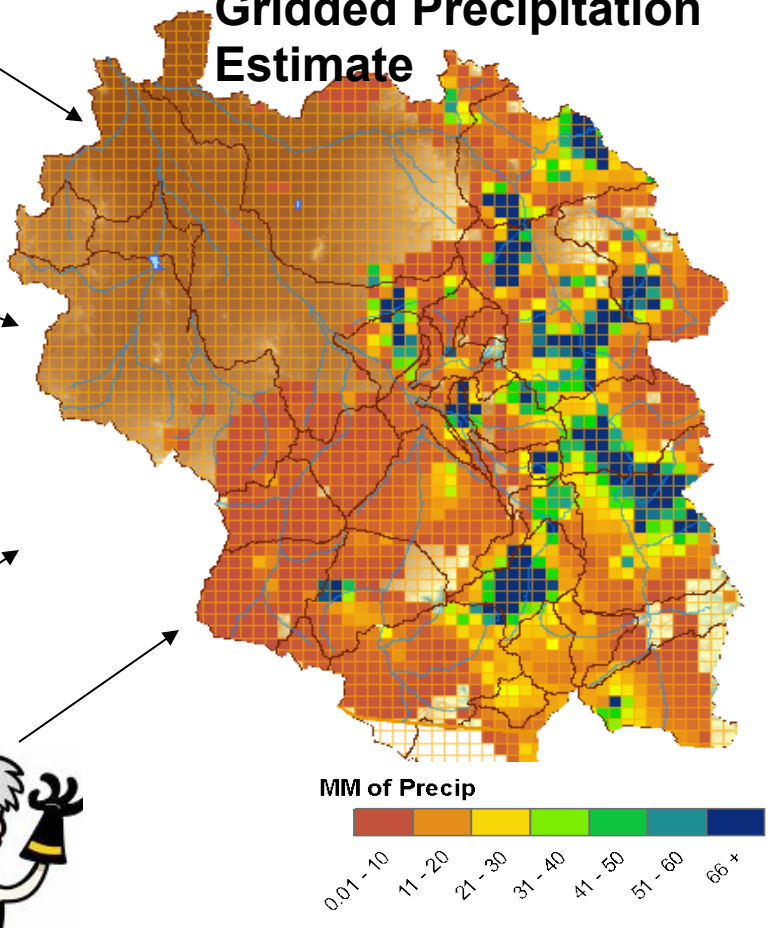
Radar Estimate

Climate patterns



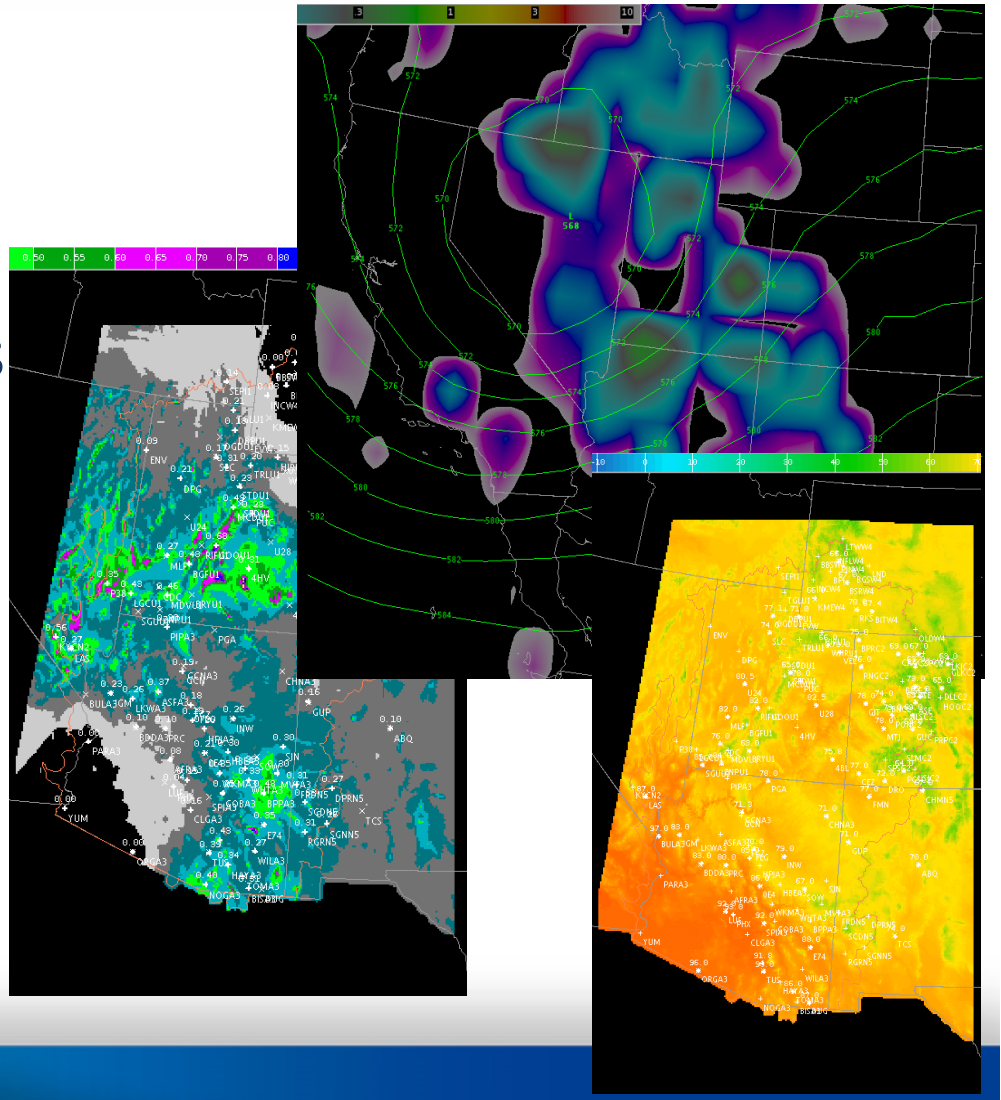
Forecaster Analysis

Gridded Precipitation Estimate



Quantitative Precipitation/ Temperature Forecast (QPF/QTF)

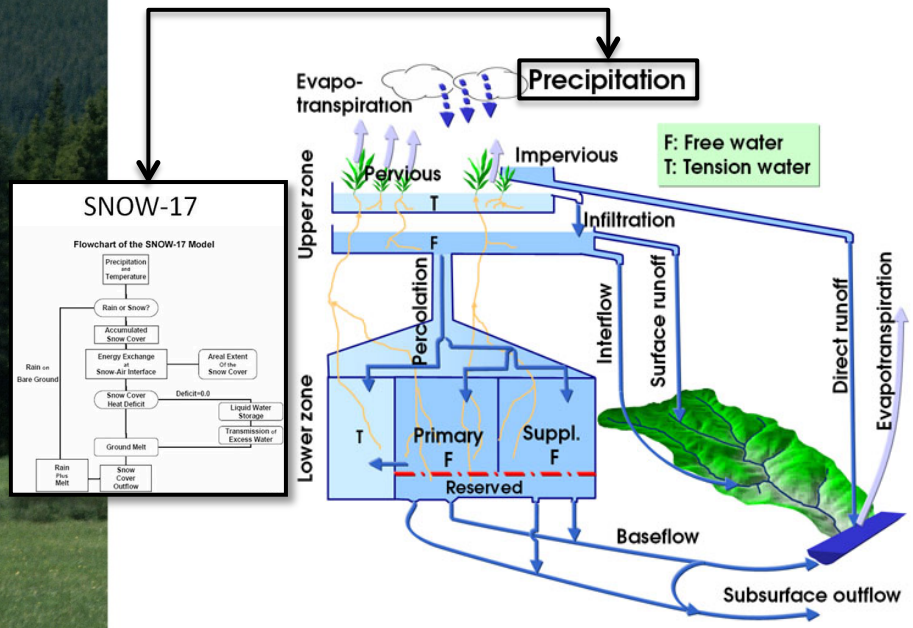
- We use precipitation forecast out to 5 days
- We use temperature forecast out to 10 days
- Convective storms are difficult for models to forecast



Unmeasured Depletions

- Representative of water taken from the basin, but not gaged and/or reported
- Function of temperature and irrigated acreage
- An calculated value, not based on actual use that may be occurring

Hydrologic Model



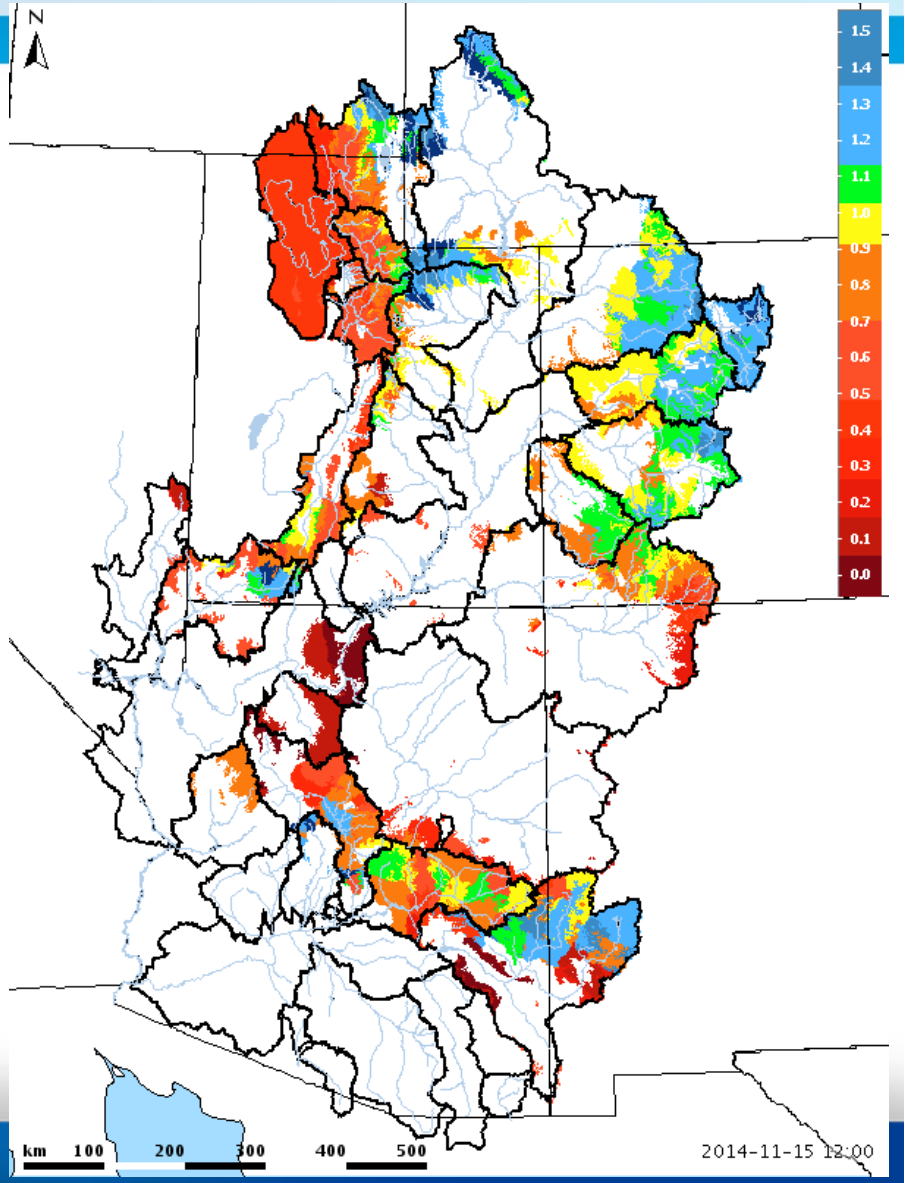
- Current model is basically a temperature index model
  - Could we do better with a more physically based model?
  - A distributed model?
  - Could a different model utilize more and new data in a timely way?

CBRFC Soil Moisture

- Seasonal volumes are controlled by SWE and soil moisture
- Do we have SWE right?
  - Mischaracterizing rain vs. snow events
  - Missed precipitation event
- Do we have the soil moisture right?
  - Have we captured baseflow conditions accurately?
  - Has a storm event impacted soil state conditions?

Hydrologic Model

- Initial Conditions can be a source of error
  - Data errors caused by gage malfunction or inaccuracy
  - Missing Data
  - Incorrect model states
- Common errors
  - SWE too high/low, snow or rain?
  - Bad streamflow information
  - Inaccurate precip/temp
  - Reservoir conditions
  - Diversions



So are our forecasts any good?

- They are!
  - Consistently beat climatology
  - Forecast tends to improve as more information is collected (e.g., more snow observed…)
  - Forecasts can be less accurate outside of the runoff period due to convective, localized events
- Tools available on website to assess skill

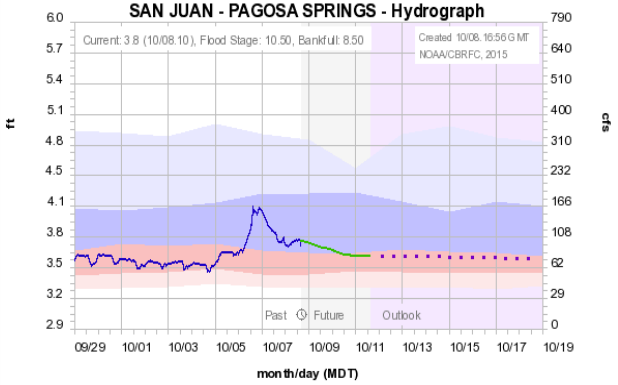
Daily Forecast Verification

COLORADO BASIN RIVER FORECAST CENTER
NATIONAL WEATHER SERVICE / NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

SAN JUAN - PAGOSA SPRINGS (PSPC2)

Info: Station | Rating type | Critical Stages | Yearly Peaks | Daily Stats | Recent Verification | Seasonal Verification | USGS data

Colorado Basin River Forecast Center
SAN JUAN - PAGOSA SPRINGS - Hydrograph



Observed — *Forecast (10/08.14:00)* — *Outlook (increasing uncertainty)* ••

Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10%

Observed=QRIRGZZ, Simulated=QRI2ZZZ, Forecast=QRIFEZZ F (2015-10-08 14:00)
resoutid=

Hydrograph Options

- [ ] Critical Stages
- [ ] Simulated
- [ ] Raw Data
- [ ] Linear Flow
- [ ] Mean Daily Values
- [ ] Forecast Peak
- [ ] Historical Peak
- [ ] Yearly Peaks
- [ ] Daily Maxima
- [x] Statistics
- [ ] Contingency
- [ ] Adjust
- [ ] Requery
- [ ] Forecasts

Years: 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1944

Date: 10-08-15
Past Days: 10
Future Days: 10
ESP: Off
Analog Years: Off
Analog Years Period: Off

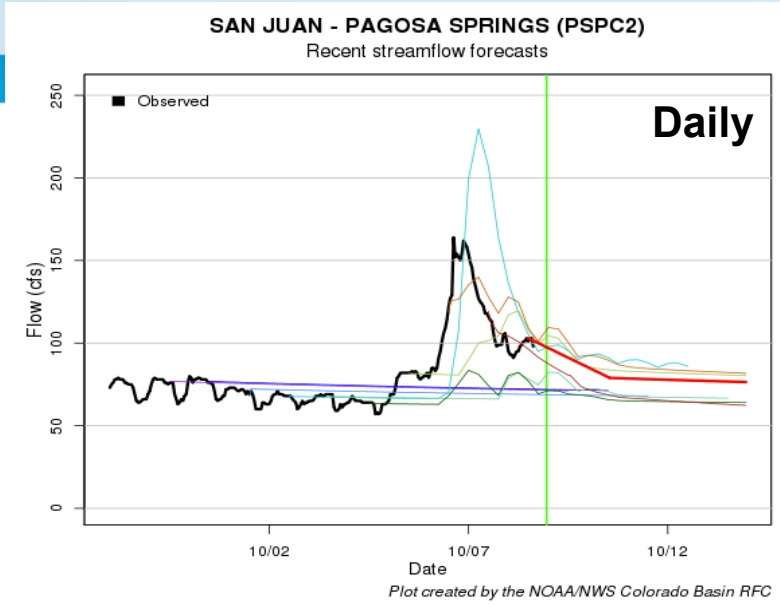
Graphs

- [ ] Precipitation
- [ ] Temperature
- [ ] Freezing Level
- [ ] Snow
- [ ] Soil Moisture
- [x] Hydrograph

Tabular Data

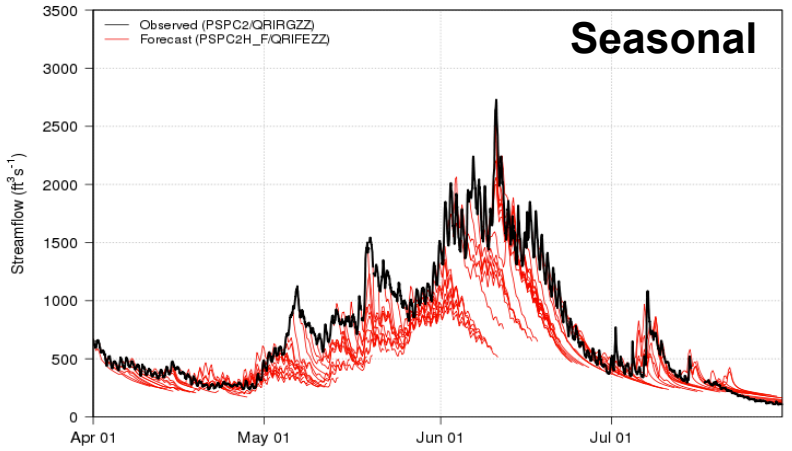
- [ ] Precipitation
- [ ] Temperature
- [ ] Freezing Level
- [ ] Snow
- [ ] Soil Moisture
- [ ] Flows

Apply and Redisplay



Plot created by the NOAA/NWS Colorado Basin RFC

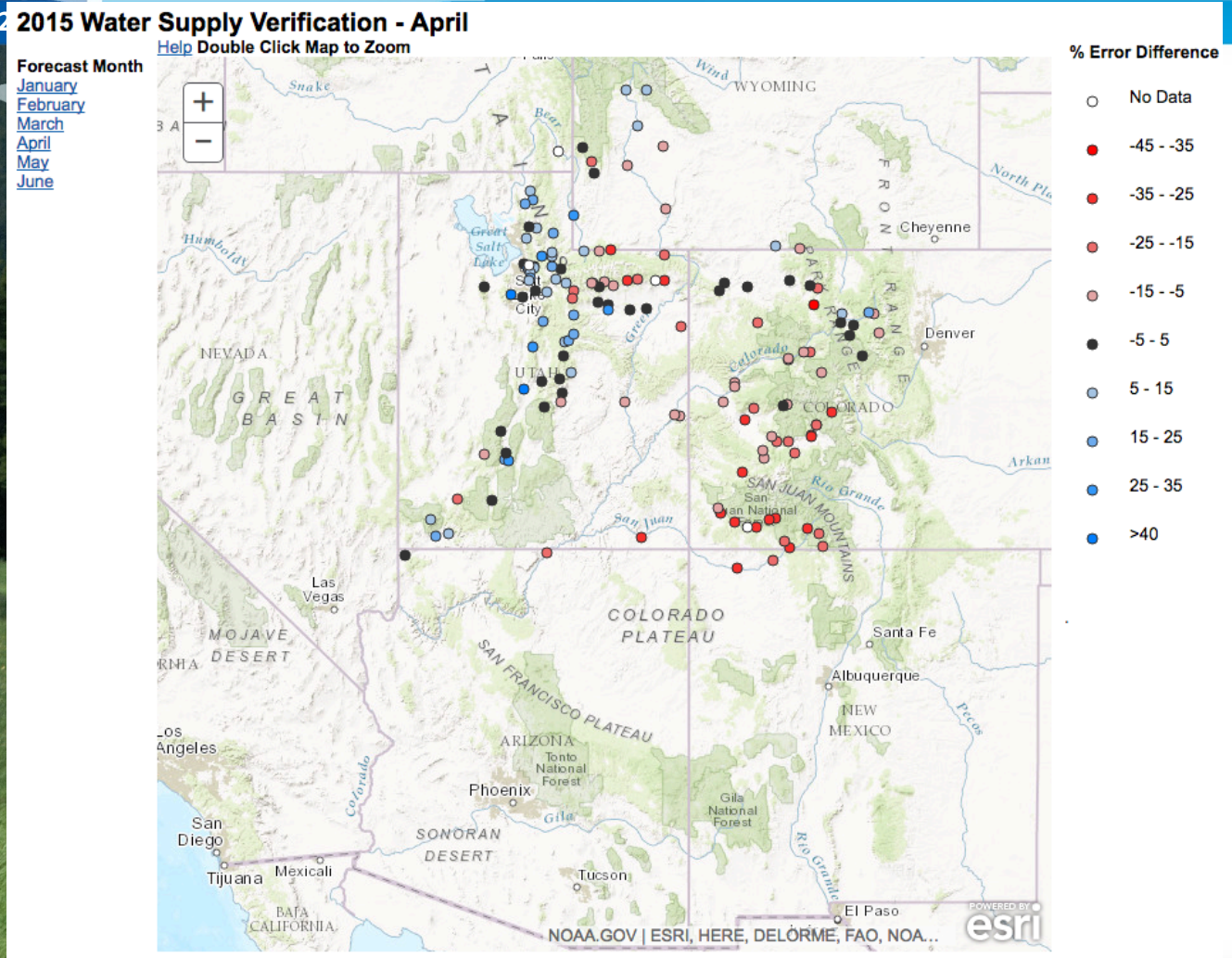
CBRFC Deterministic Forecasts for SAN JUAN - PAGOSA SPRINGS (PSPC2)
(includes forecasts issued 20150401 to 20150731)



Error Summary:

Lead Time (days):	1	2	3	4	5	Overall
Mean Error:	-68.2	-104.4	-131.2	-171.2	-206.1	-136.2
Mean Abs. Error:	111.7	145.0	168.1	196.7	227.7	169.9
Relative Abs. Error (%):	12.4	17.3	19.9	22.1	25.1	19.3

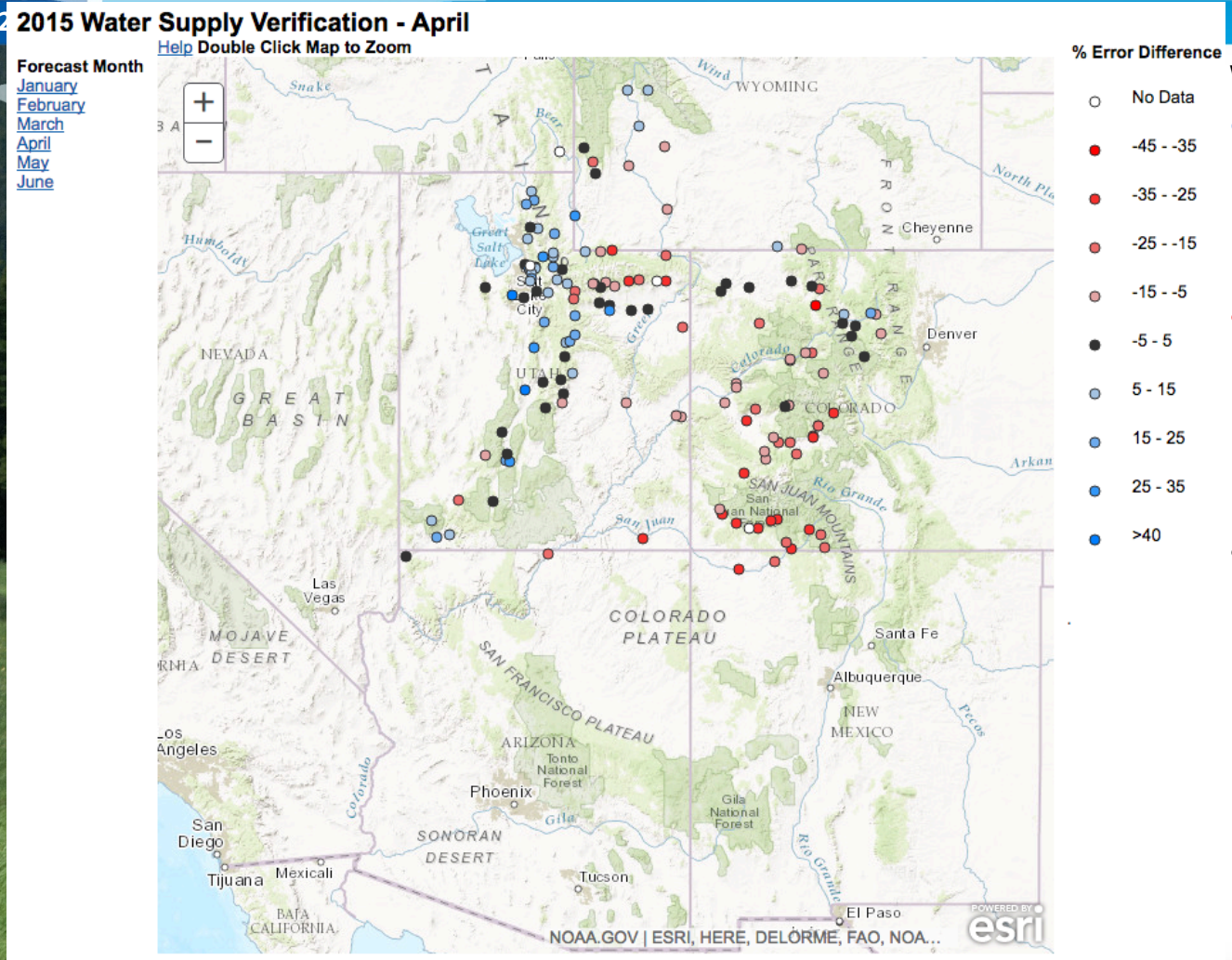
Water Supply Forecast Verification



What is on the map?

- Mean Absolute Percent Error
- Based on 30 years of (1981-2010) reforecasts
- Indicator of quality of model calibration
- Only analyzes 50% exceedance forecast
- April-June forecast lead times
- “Help” Option

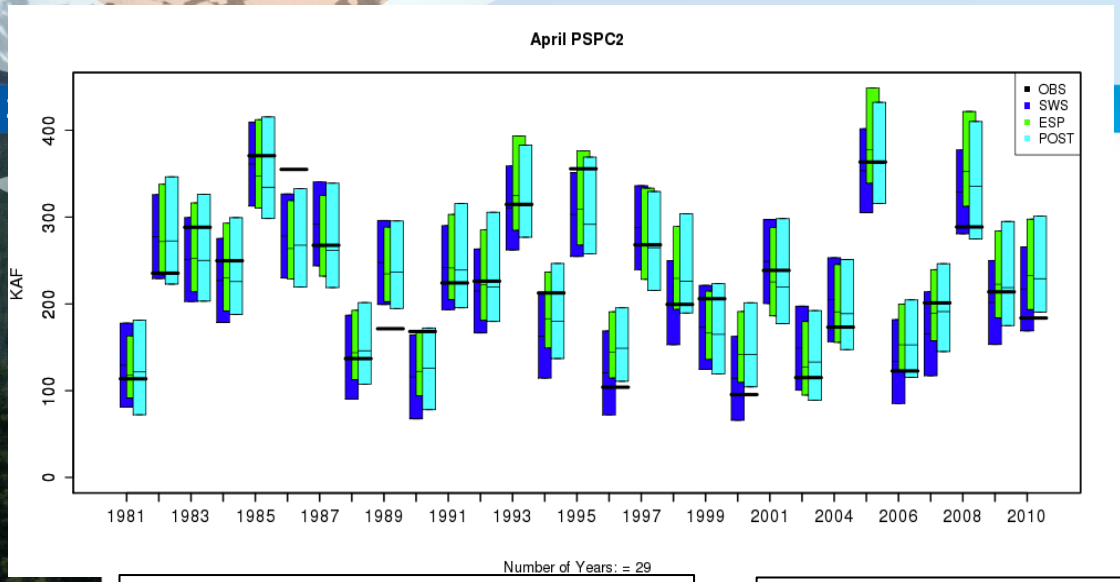
Water Supply Forecast Verification



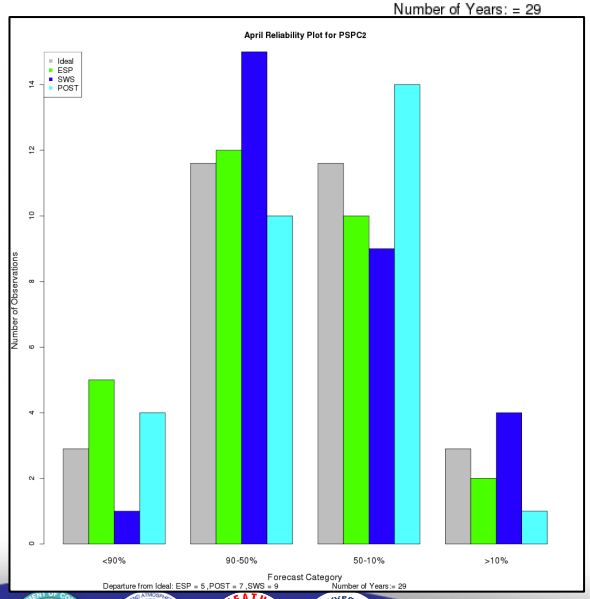
What does the map mean?

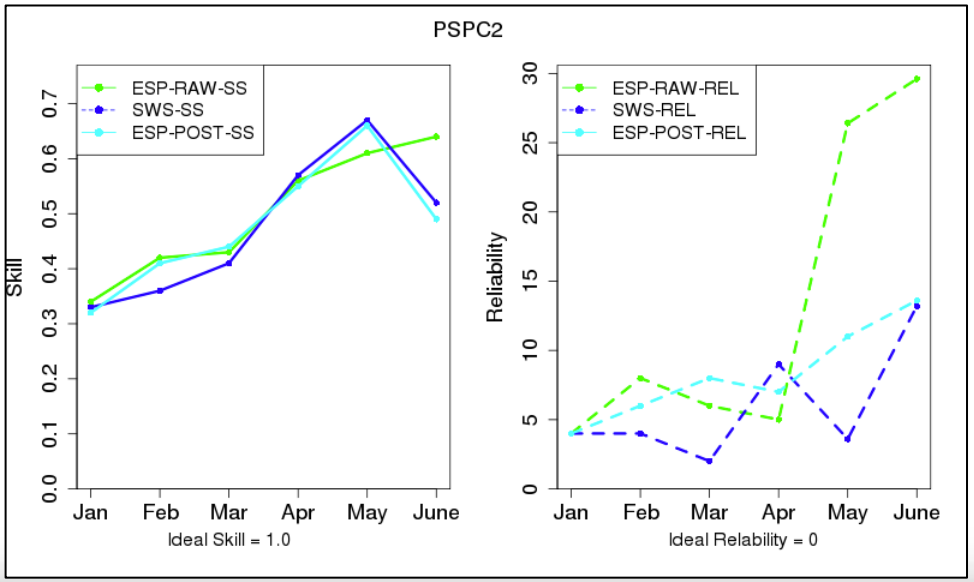
- Positive = 2015 Forecast performed BETTER than raw ESP model
- Negative = 2015 Forecast performed WORSE than raw ESP model
- -5 to 5 = 2015 Forecast normal performance

Water Supply Forecast Verification

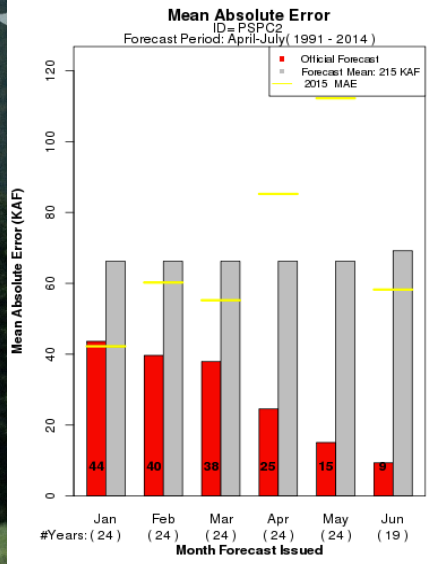


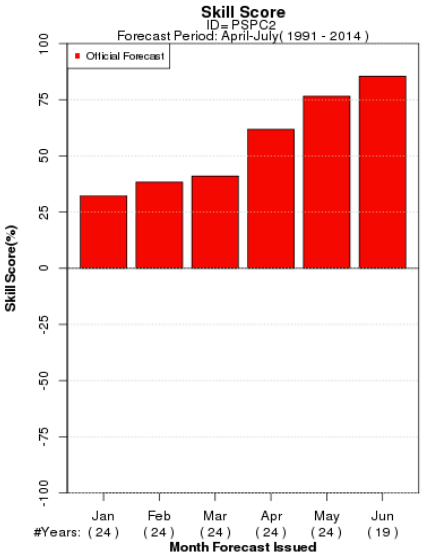
- Based on 30 years of reforecasts
- Skill and spread of ensembles and statistical regressions

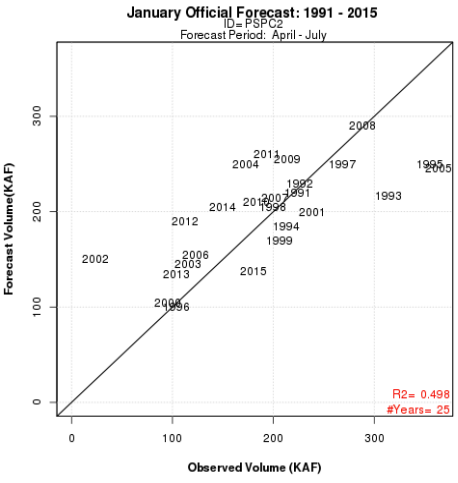


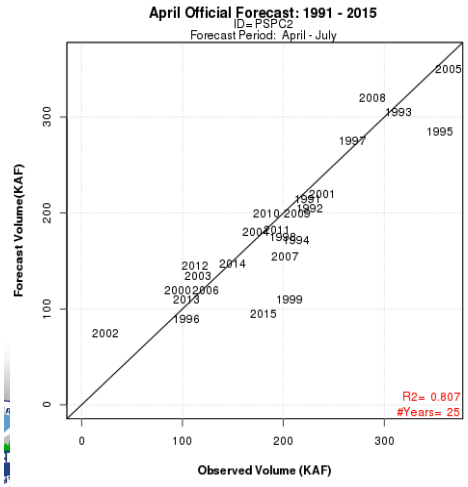


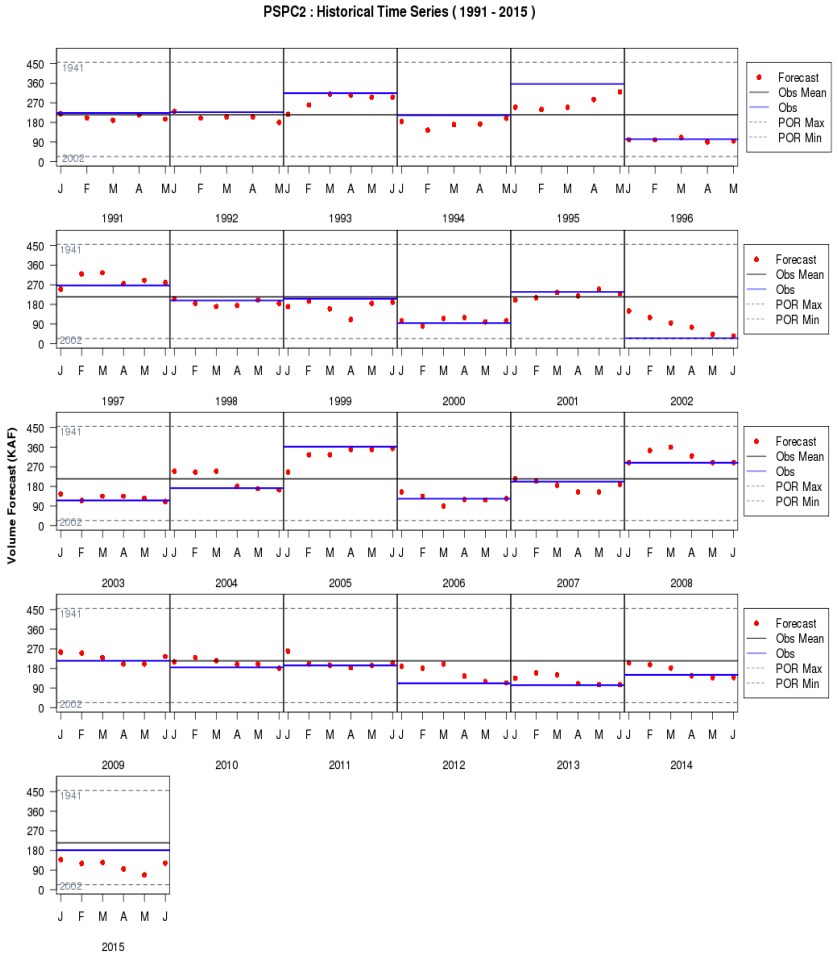
Water Supply Forecast Verfication



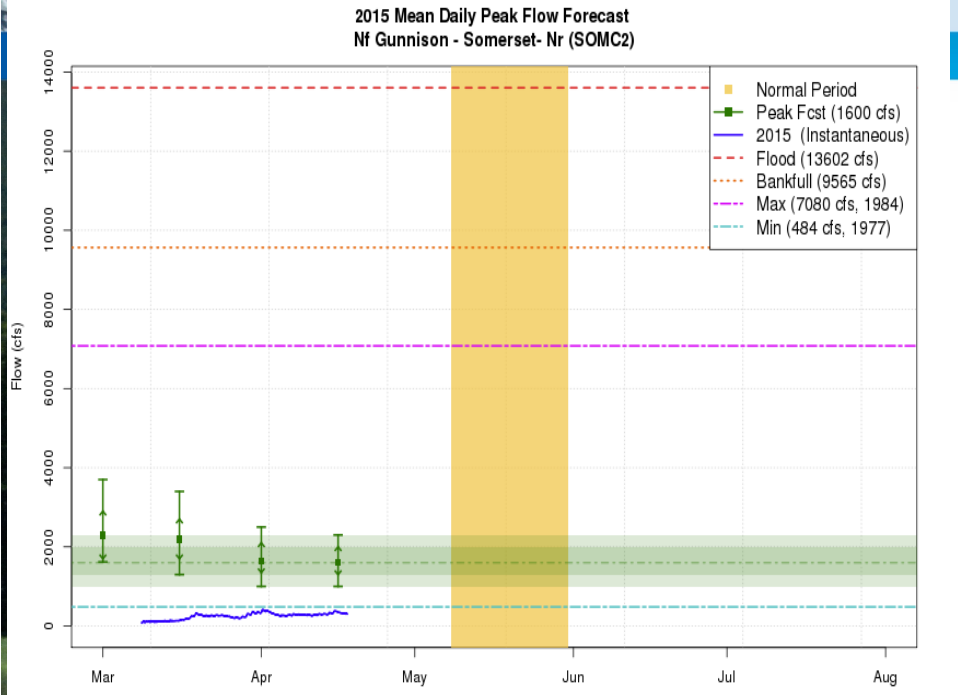








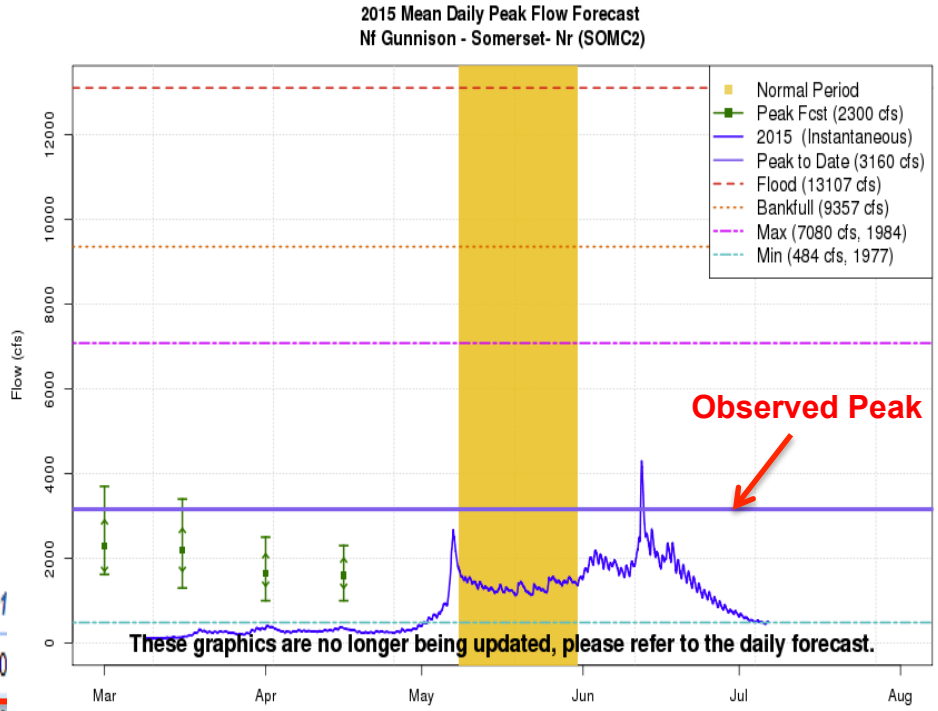
Peak Flow Verification



These graphics are updated approximately every two weeks between 3/1 and 5/1
Plot Created 2015-04-17 14:40:31
CBRFC / NWS / NOAA

River	Location	Flood Flow	Issue Date	Mean Daily 90	Mean Daily 75	Mean Daily 50	Mean Daily 25	Mean Daily 1
East	Almont	3170	2015-04-16	750	900	1000	1300	150
Nf Gunnison	Somerset	13870	2015-04-16	1000	1300	1600	2000	230
Surface Ck	Cedaredge	1410	2015-04-16	45	65	90	115	16
Gunnison	Grand Junction	19520	2015-04-16	6000	6600	6600	7000	7500

April-July Season



Plot Created 2015-07-06 10:05:50
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Questions?