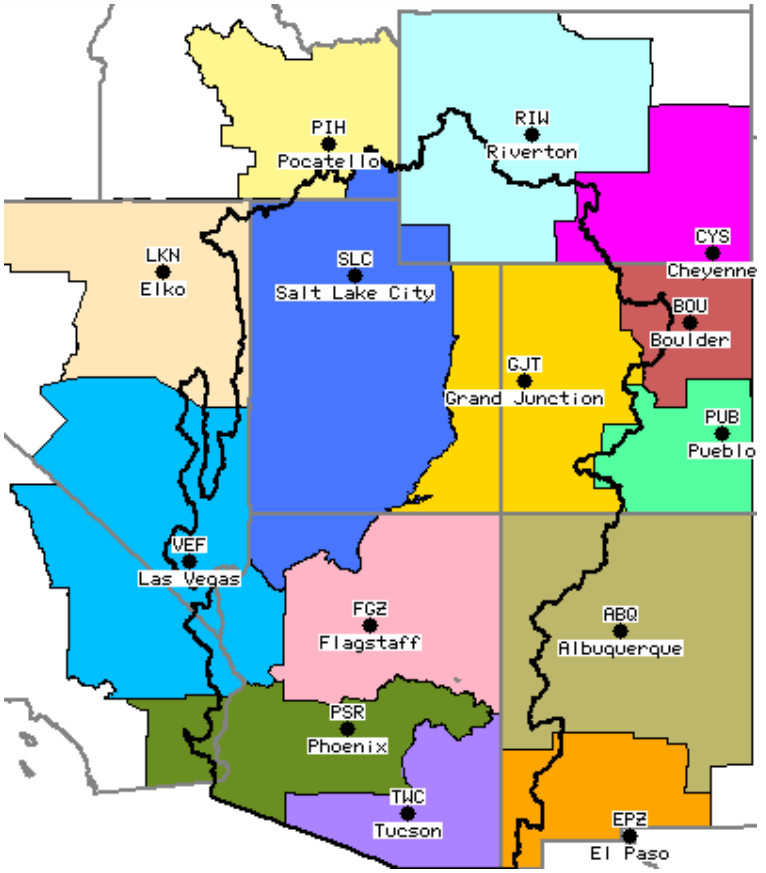
Colorado Basin River Forecast Center

Overview

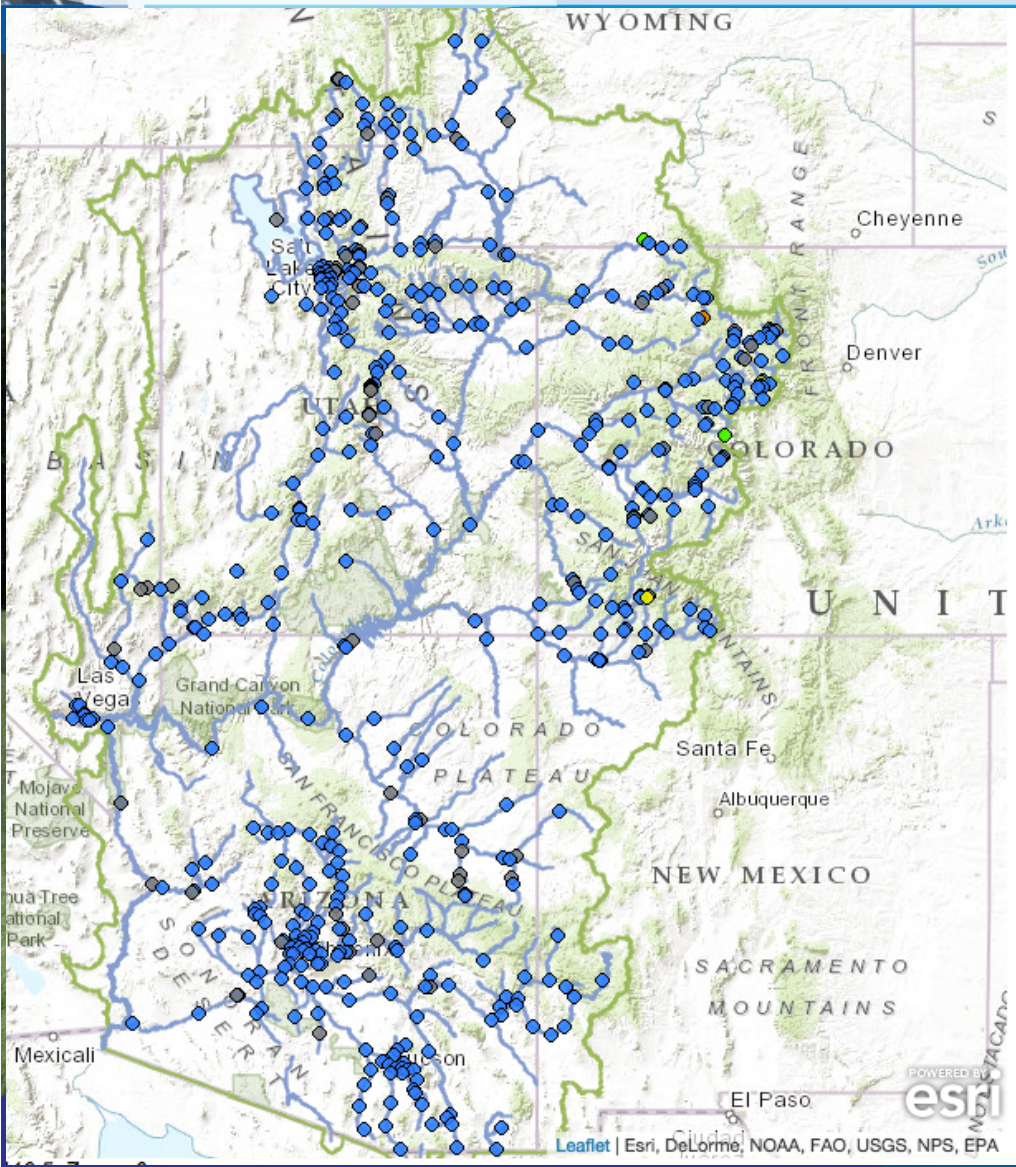
- CBRFC Staffing and Operations
- River Forecast Points in the Phoenix HSA
- Data Sources / Forecast Abilities & Limitations
- RFC – WFO Coordination
- RFC Products – Present & Future
- Phoenix Stakeholder Interactions

CBRFC

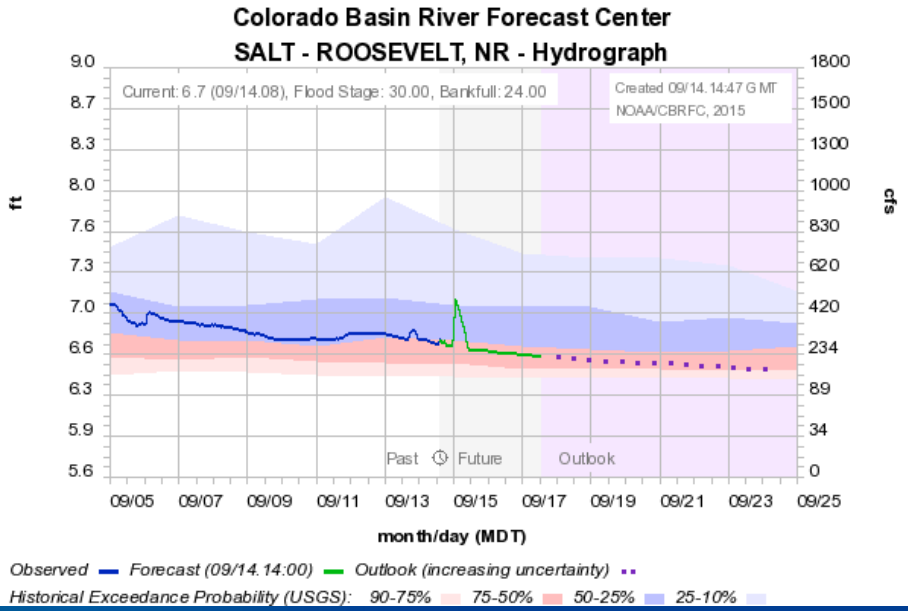
- One of 13 NWS River Forecast Centers
- Major programs include:
  - Flood and routine river forecasts
  - Water Supply Forecasts
  - Flash flood support
- 15 person staff includes meteorology, hydrology, and IT expertise – 2 vacancies (SCH, hydrologist)



Flood Forecasts / Routine Forecasts

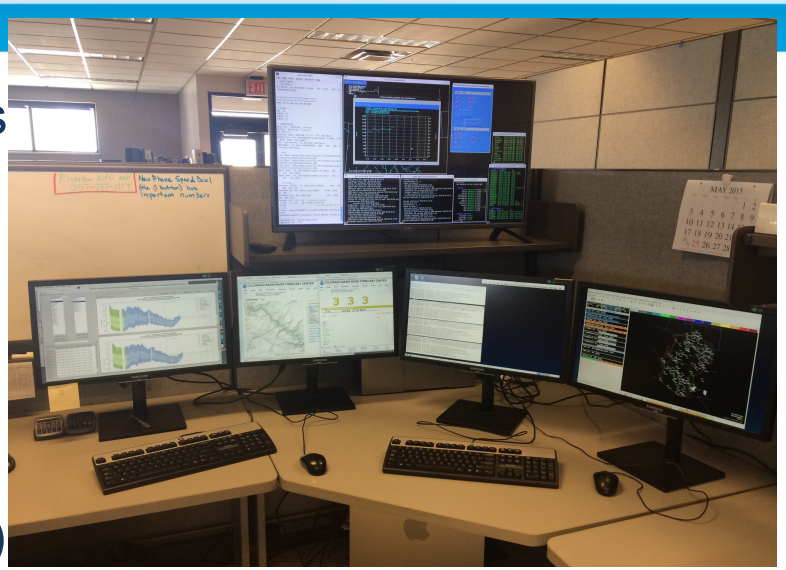


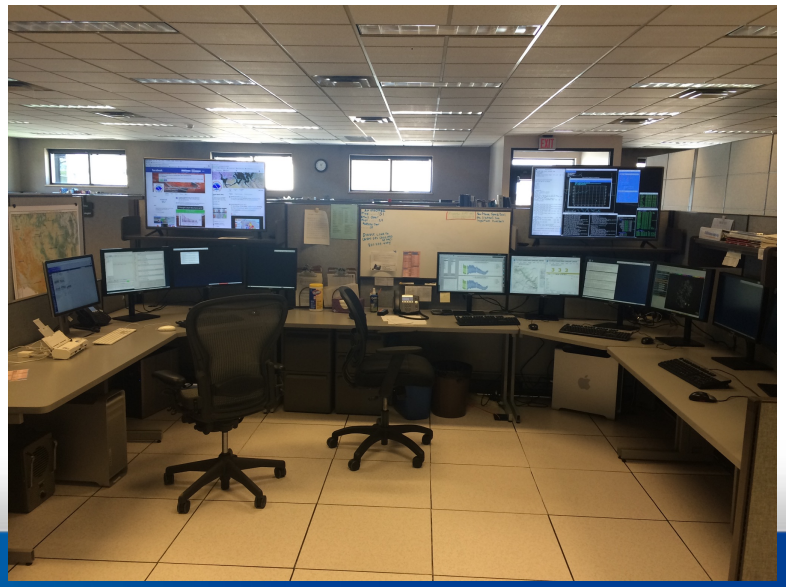
- Nominally provided at ~400 points every 6 hours (or 1 hour) out to 10 days.
- Flexible web interface to select and identify forecasts and data
- Requires large amounts of data (e.g. snow, precip, temps, streamflow)



Typical Operational Day

- Driven by 1-2 staff members – others assist
- Quality Control (observations and forecast data)
- Other data input (reservoir release schedules) / Update ratings
- Hydrologic Model Interaction (CHPS)
- Forecast Output / Product Dissemination
- Initiate Ensemble Streamflow Prediction (long-term/seasonal)
- Provide model updates / WFO coordination as needed





Focus on Inputs

- The inputs are much more important than the quality of the hydrologic model
- Model simulations are governed by current soil moisture and future snowmelt and precipitation (QPF)
- Accurate observed precipitation, temperature and freezing levels are important to maintain correct soil moisture
- Accurate future precipitation, temperature and freezing levels (and soil moisture) are important for future hydrologic predictions

Inputs required for model

- Observed and Future
  - Precipitation
  - Temperature
  - Freezing level
- Observed flow and reservoir pool elevation

Observed Precipitation

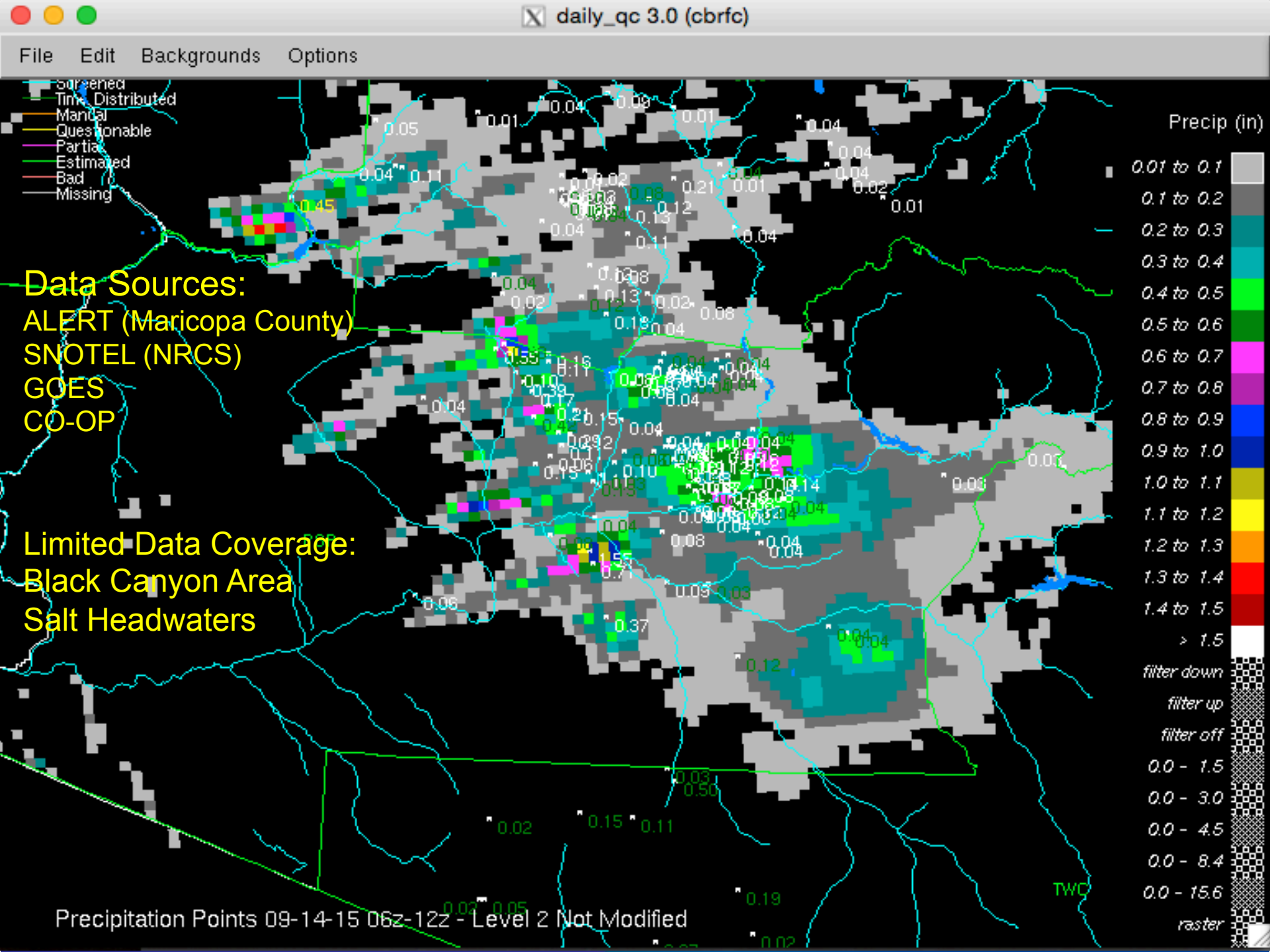
- Gages - sources
  - GOES (many agencies)
  - ALERT (several FCDs)
  - COOP
  - COCORAHS
  - SNOTEL
  - All data is databased
- Radar
  - Trim usable area by elevation/freezing level
  - Eliminate clutter areas
  - Calculate bias using gages
- Satellite
  - Use in areas of poor radar/gage coverage

Observed Precipitation - Gages

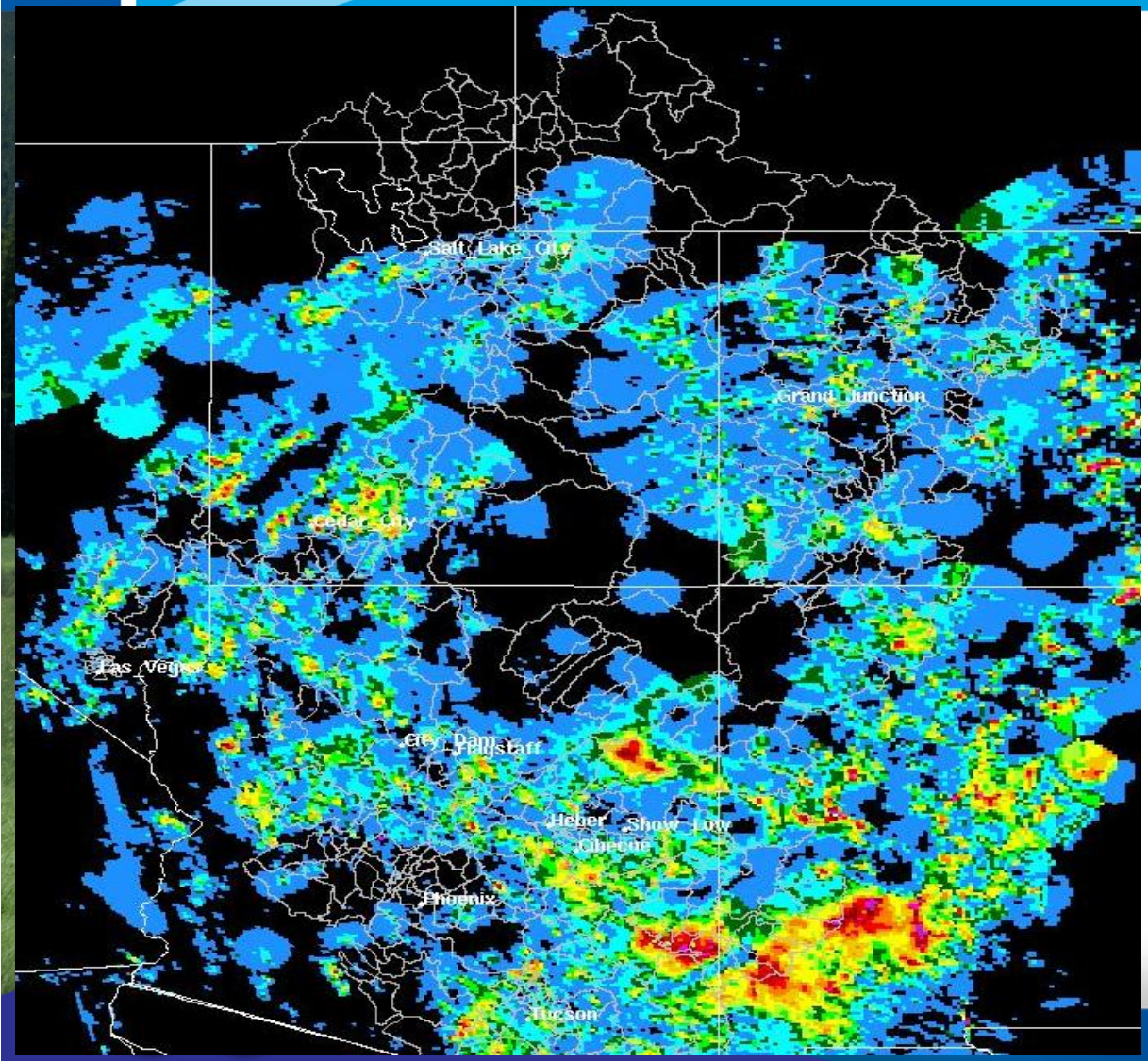
- GOES
  - Through HADS feed
  - Various agencies (USGS, NFS, NPS, BLM, etc.)
- COCORAHs
  - from website
- SNOTEL
  - through NRCS feed
- COOP
  - from WFO's
- ALERT
  - from base stations through WFOs
    - PSR (Maricopa County)
    - TWC (Pima County)
  - from jefuller
    - Remaining Counties
  - from Tohono O'odham thru internet
  - from Zuni thru internet

Observed Precipitation - Radar

- Compiled once per hour
- 4km resolution
- Hybrid Scan is know for each radar
- Mask is calculated for each radar using the hybrid scan. No cells where:
  - beam center is above freezing level
  - occultation is >= 3
  - beam center is 7000 feet AGL (?)
  - beam center is above 17000 feet MSL summer and 12000 feet MSL winter
- Bias adjustments
  - Compared with gage
    - importance of metadata
    - point vs grid issues
    - hourly adjustment (some history)
    - 24 hour bias is calculated
- Radar data is combined with gage only field
  - Gage influence is smaller summer
  - Gage influence is larger in winter


daily_qc 3.0 (cbrfc)
File
Edit
Backgrounds
Options
Screened
Time Distributed
Manual
Questionable
Partial
Estimated
Bad
Missing
Data Sources:
ALERT (Maricopa County)
SNOTEL (NRCS)
GOES
CO-OP
Limited Data Coverage:
Black Canyon Area
Salt Headwaters
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
Precipitation Points 09-14-15 06z-12z - Level 2 Not Modified

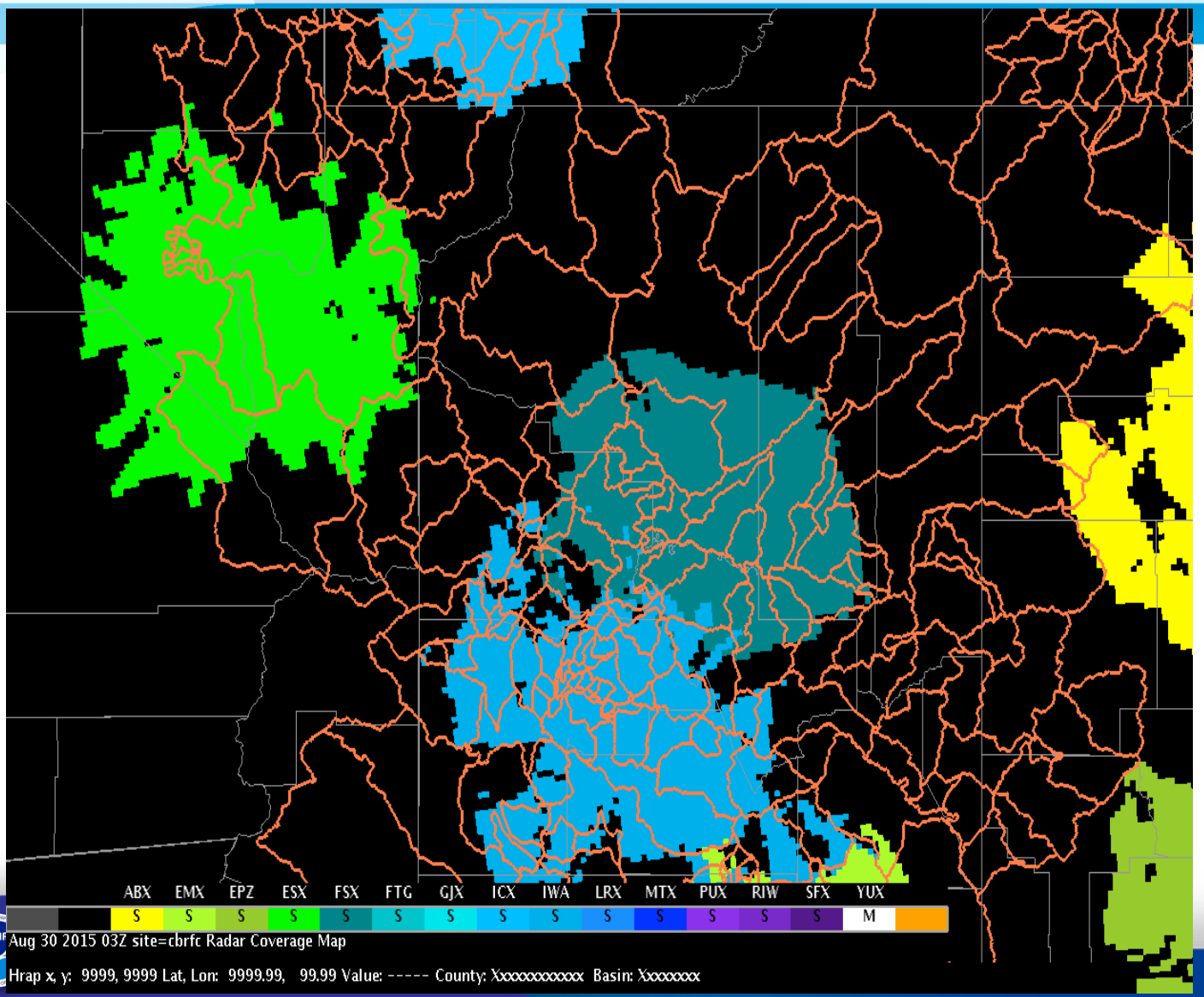
Model Inputs: Multi-sensor Precipitation Estimator (MPE) – NEXRAD



- Utilize radar and gage information
- Develop best estimate of precipitation over the CBRFC region

Typical Summer radar mask

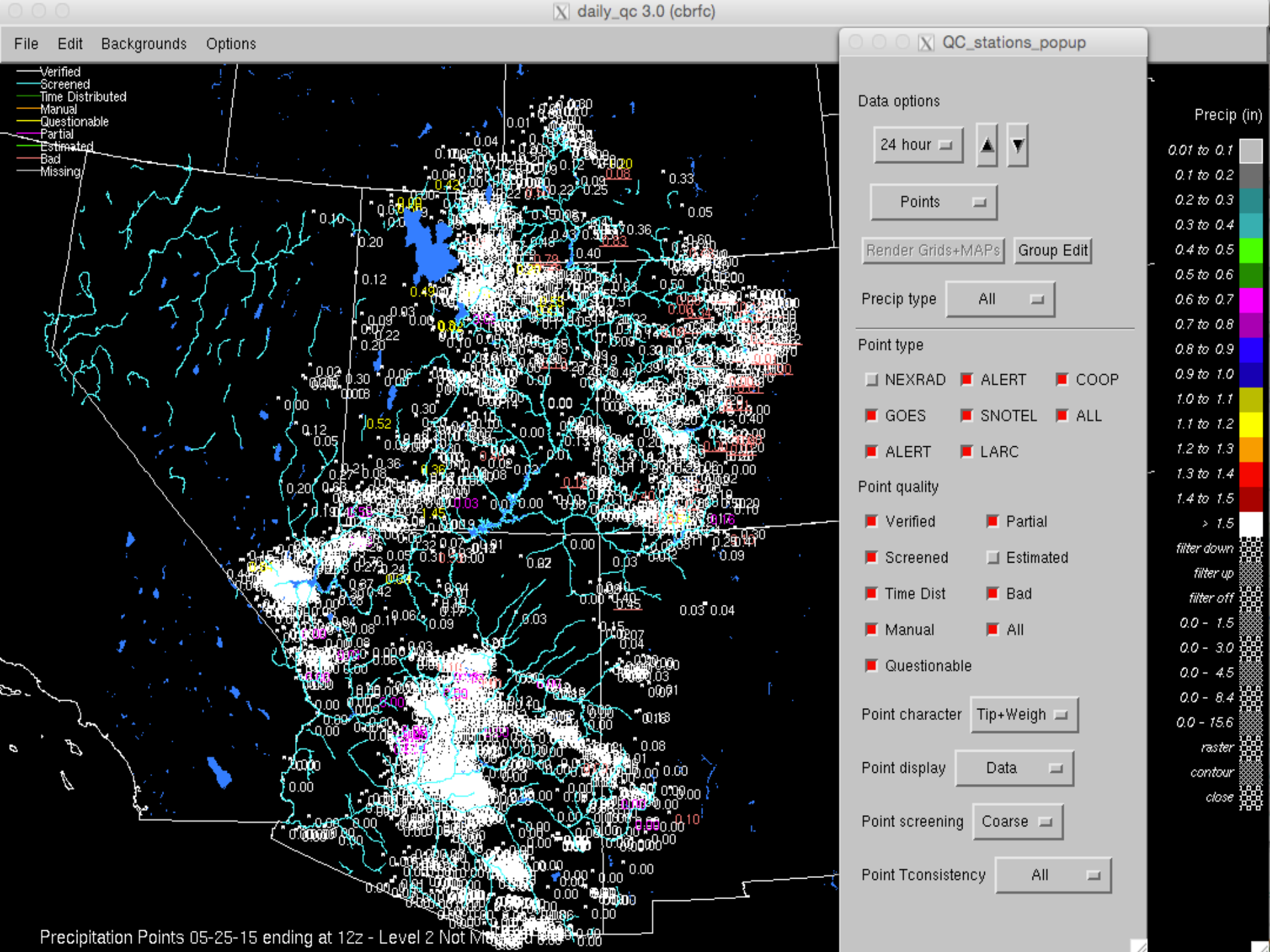
Typical Summer Radar Mask



Data Quality Control

- Arizona, New Mexico, Nevada, Southern Utah
  - Multi-sensor Precipitation Estimator MPE (Radar)
  - "Front ended" by Daily_QC Procedure (6 & 24 hr data)
  - 1 hour time-step
  - Mixture of gage and radar*
  - Satellite estimates can be used in data void areas (infrequent)
  - QC temperatures and freezing levels as well
  - Outputs include points, grids, and areal values

*Note: RFCs are currently not using dual-pol radar info.


daily_qc 3.0 (cbrfc)
File
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Verified
Screened
Time Distributed
Manual
Questionable
Partial
Estimated
Bad
Missing
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
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
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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
Precipitation Points 05-25-15 ending at 12z - Level 2 Not M

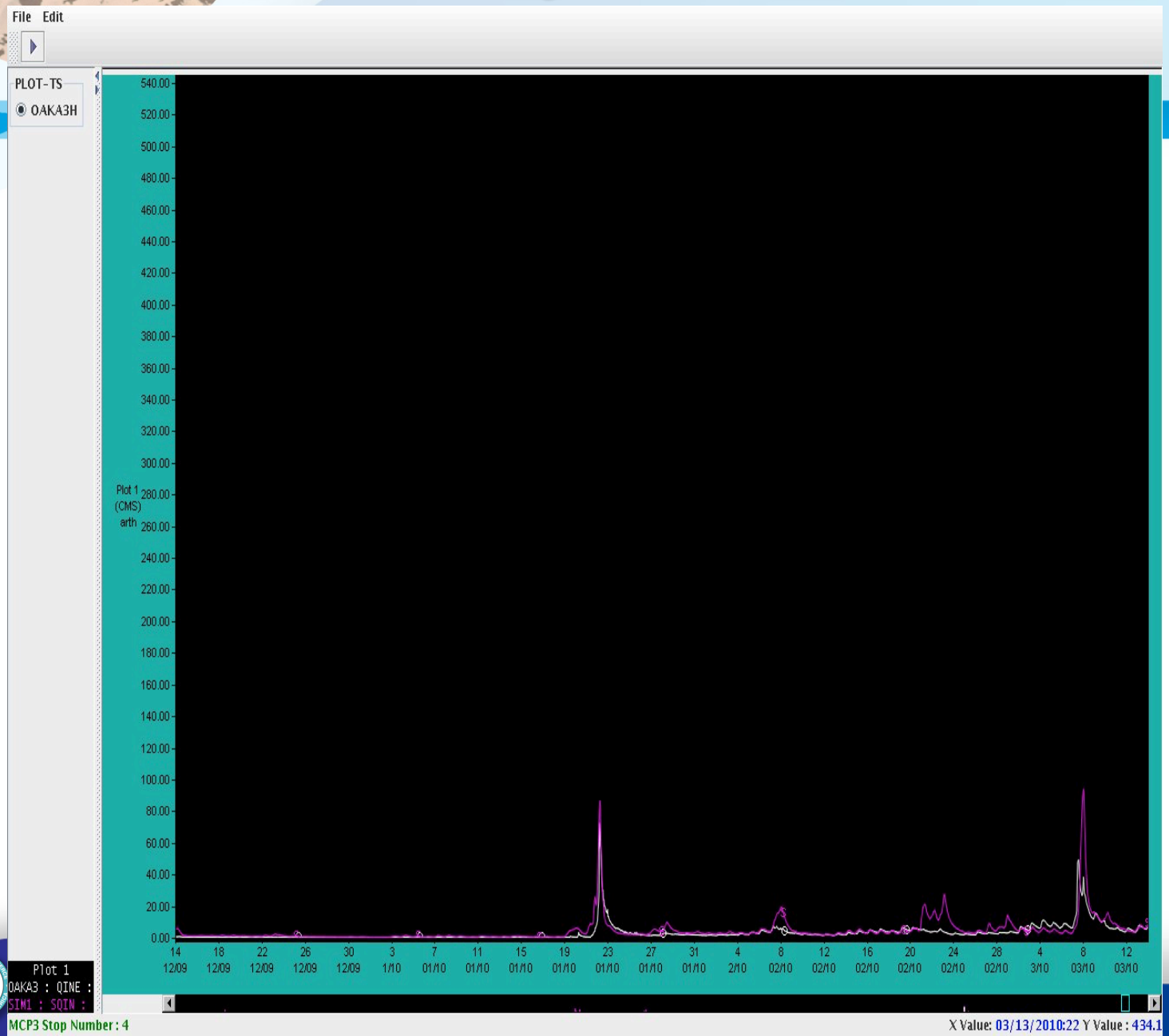
Observed Temperature

- Gages - sources
  - GOES (many agencies)
  - COOP
  - SNOTEL
- Used for snowmelt only
- Maximum/minimum and 3 hourly instantaneous
- Spatial density of gages not as important

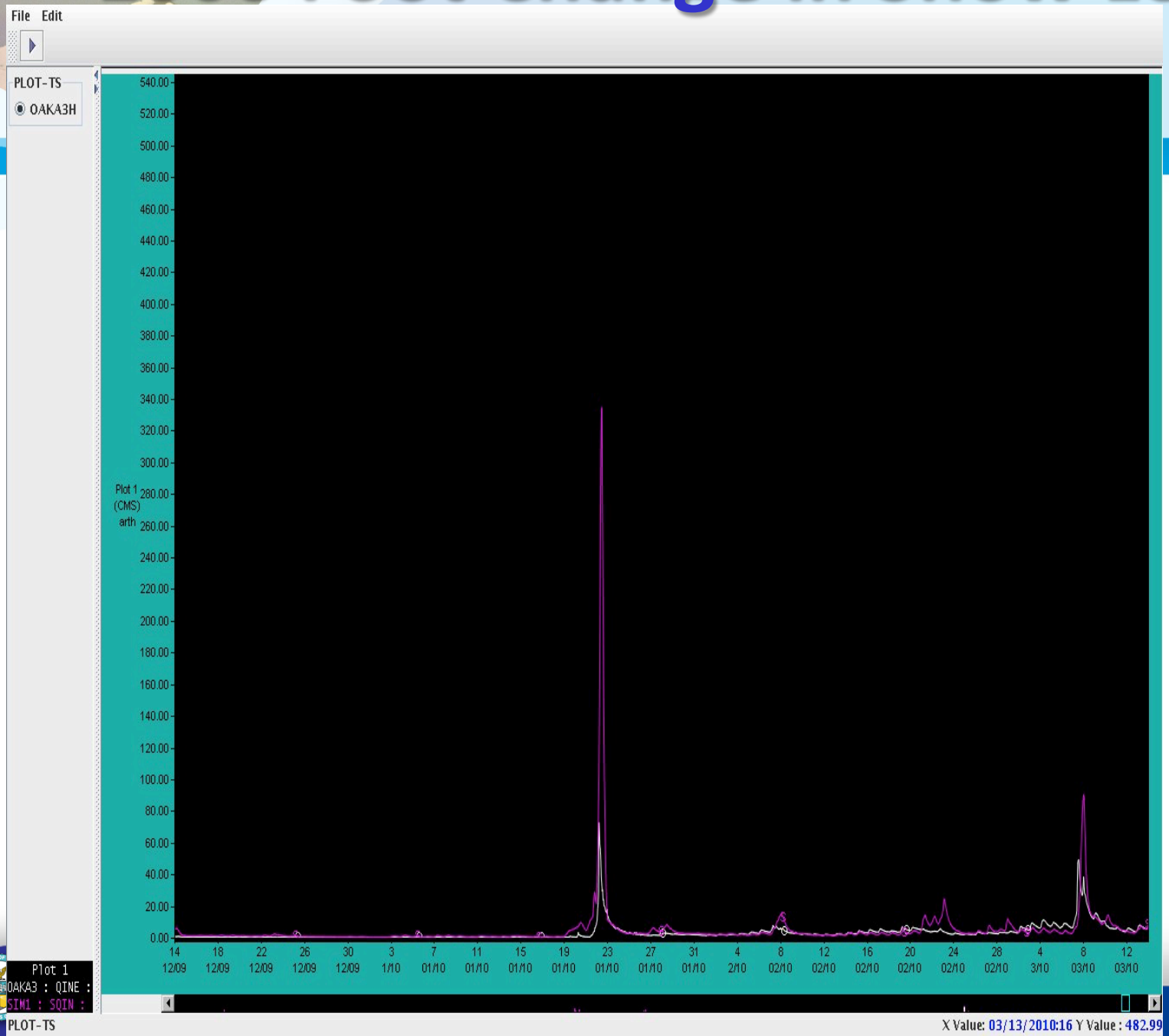
Observed Freezing Level

- From the RAP13 initial analysis?
- Used to type precipitation (rain/snow)
- About 1x1 degree resolution
- Freezing level is very important in Arizona (perhaps as important as the precipitation)
- Snotel site BRMA3 at 6380 feet
  - Follow temperature and SWE during flooding events

January 2010 event OAKA3



1000 Foot Change in Snow Level



Future Precipitation

- We examine output from various sources
  - Raw model
  - WFO
  - GFS as starting point
- We are forecasting large scale events

- Technique
  - grids to points
  - modify using percent of monthly normal
  - points to grids using PRISM
    - importance of proper scaling
  - 6 hourly through day 5
    - time distributed to 1 hourly
  - Investigate using higher resolution (space and time) models for hourly QPF (e.g., HRRR)
    - Project to verify timing/ location/volume of HRRR QPF

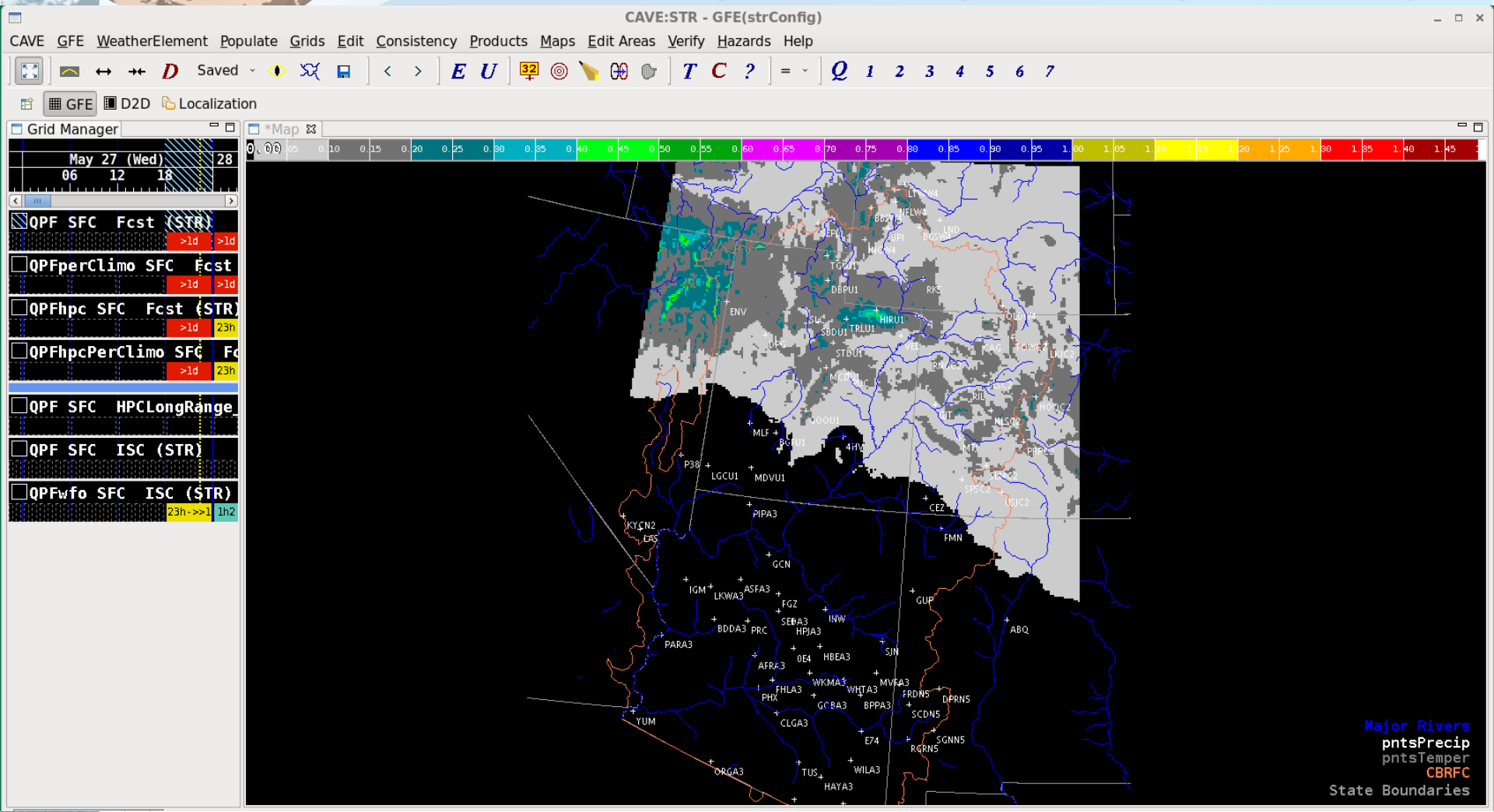
Future Temperature

- Currently use MOS max/min generated at MDL through 10 days
- Same sites used in calibration
- Transitioning to WFO produced through 7 days
  - testing at SLC
  - Additional WFOs through this fall
  - days 8-10 will continue to be produced by MDL
- The departure from normal grid is produced and the forecaster then smooths the grid

Future Freezing Level

- Sampled from GFS40 freezing level grid
- Typically we do not modify
  - we will make small adjustments in hydrologic model

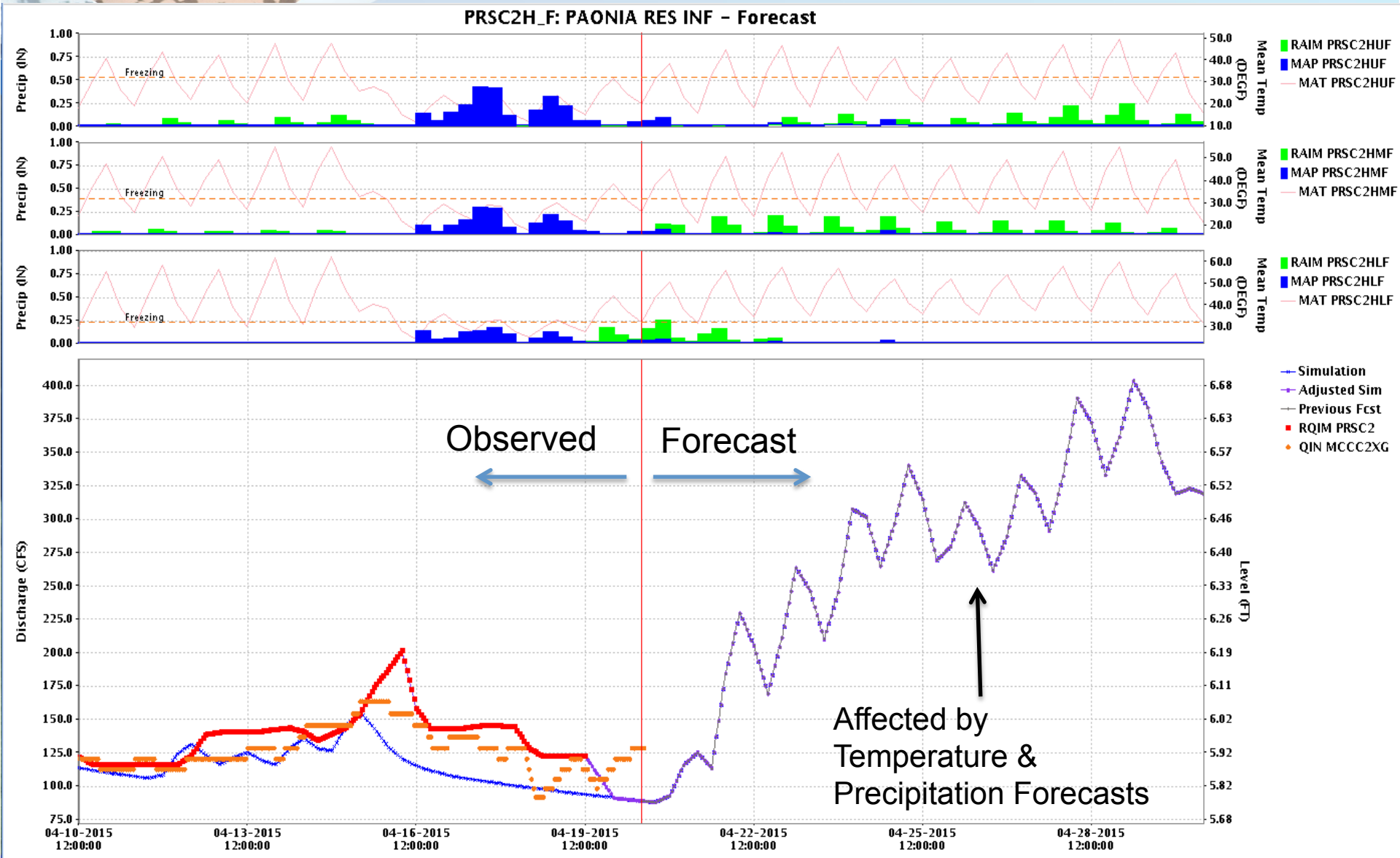
Model Inputs: GFE is Utilized to input QPF and QTF
5 days of Precip / 10 days of Temp



CHPS

- Community Hydrologic Prediction System
- Interface for interacting with our hydrologic model
  - Coupled Sac-SMA and SNOW-17
  - Lumped model (Precipitation represented as an areal mean)
  - 6 hour time step (QPF evenly distributed into hourly values)
  - Minimal to no skill in short-duration flash flood situations
  - Skill exists in routing upstream events
  - Model parameters can be modified (MODS)
  - “What If” scenarios are possible

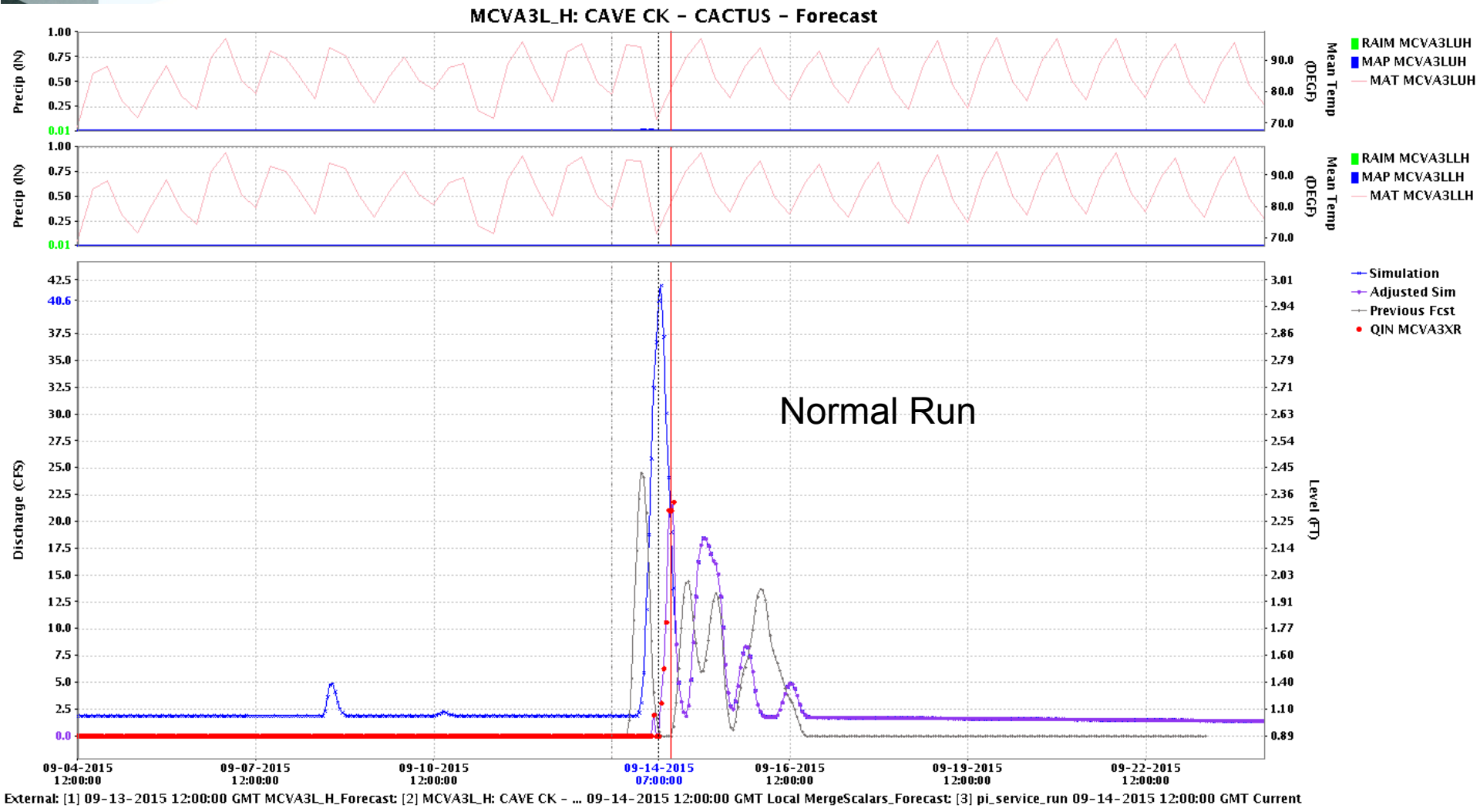
CHPS


PRSC2H_F: PAONIA RES INF - Forecast
Precip (IN)
Freezing
Mean Temp (DEGF)
RAIM PRSC2HUF
MAP PRSC2HUF
MAT PRSC2HUF
RAIM PRSC2HMF
MAP PRSC2HMF
MAT PRSC2HMF
RAIM PRSC2HLF
MAP PRSC2HLF
MAT PRSC2HLF
Simulation
Adjusted Sim
Previous Fcst
RQIM PRSC2
QIN MCCC2XG
Discharge (CFS)
Level (FT)
Observed
Forecast
Affected by Temperature & Precipitation Forecasts
04-10-2015 12:00:00
04-13-2015 12:00:00
04-16-2015 12:00:00
04-19-2015 12:00:00
04-22-2015 12:00:00
04-25-2015 12:00:00
04-28-2015 12:00:00

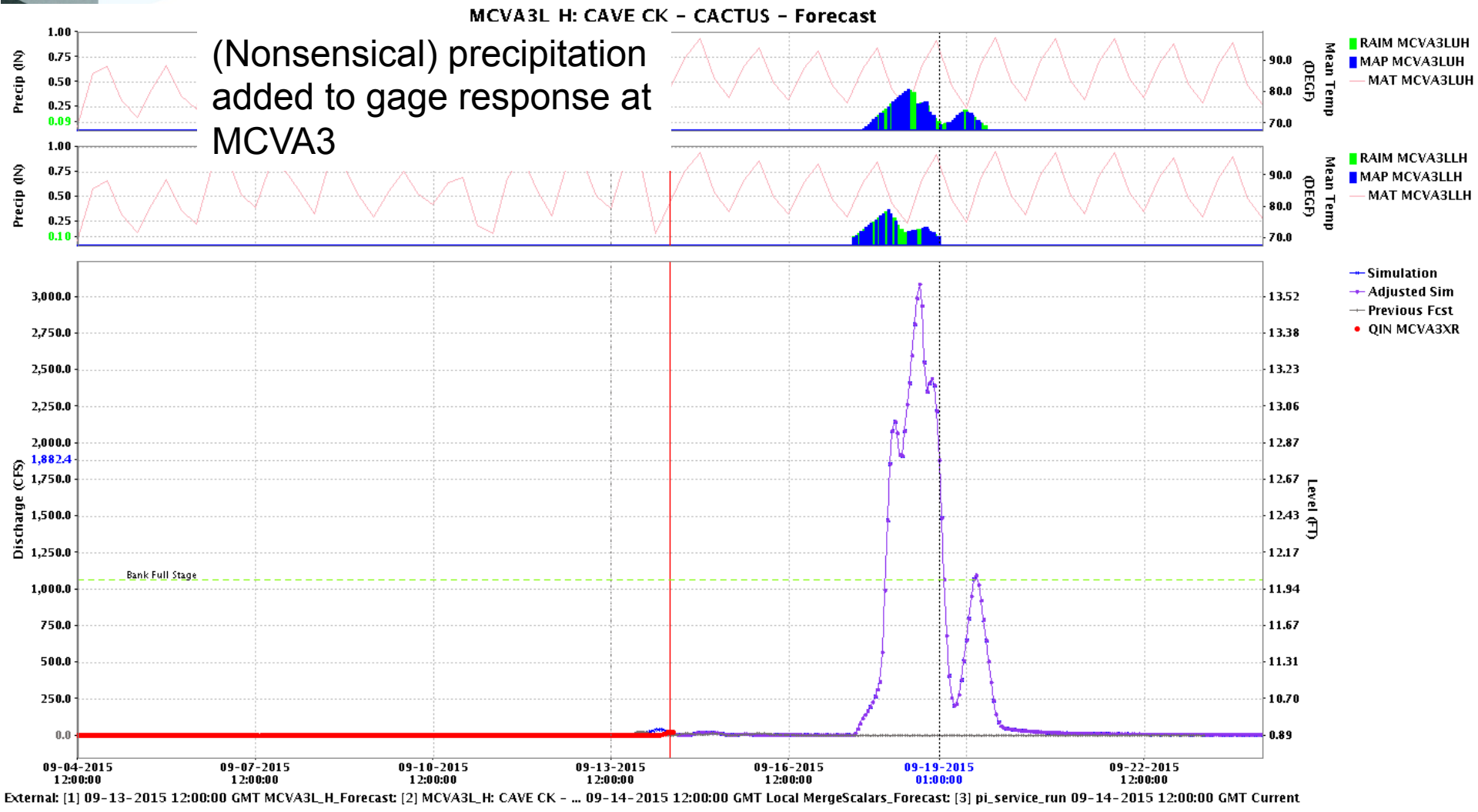
CHPS

- Contingency Runs
  - We have the ability to input variable precipitation amounts into our model to answer "What if…?" types of questions
  - Only available to WFOs, which can then view the results through our webpage

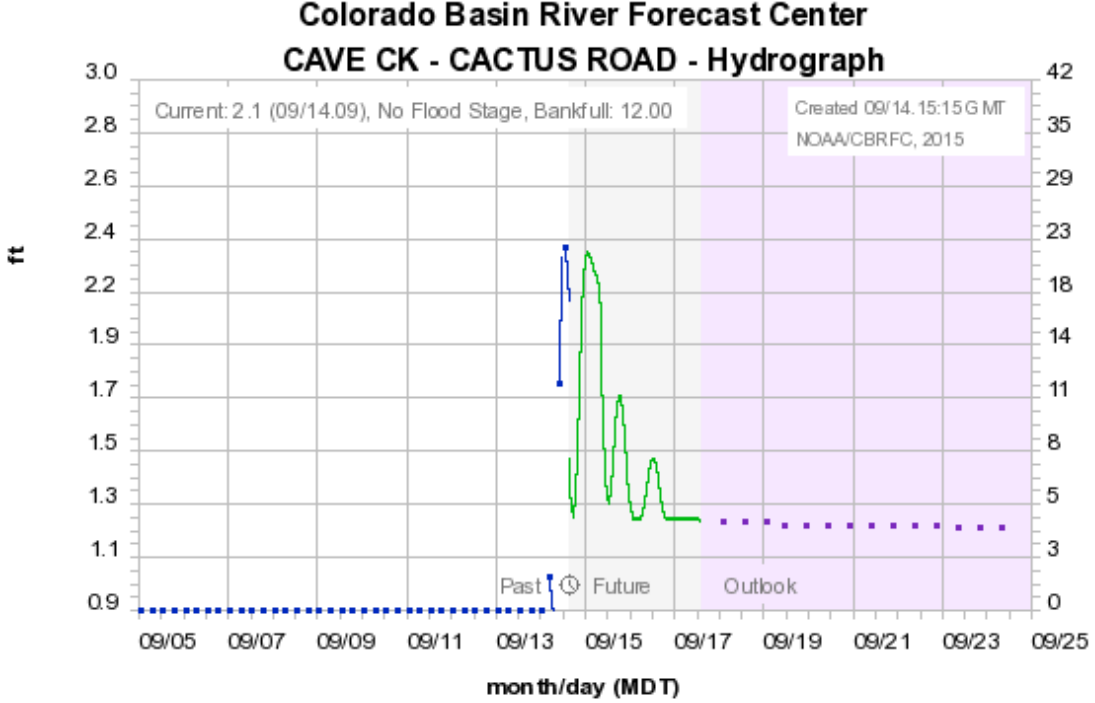
Contingency Runs



Contingency Runs



(Nonsensical) precipitation added to gage response at MCVA3



Hydrograph Options

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

Date: 09-14-15
Past Days: 10
Future Days: 10
ESP: Off

Graphs

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

Tabular Data

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

WFOs can check the "Contingency" box to see the resulting forecasts

Phoenix Area Forecast Points

Phoenix Metro Area

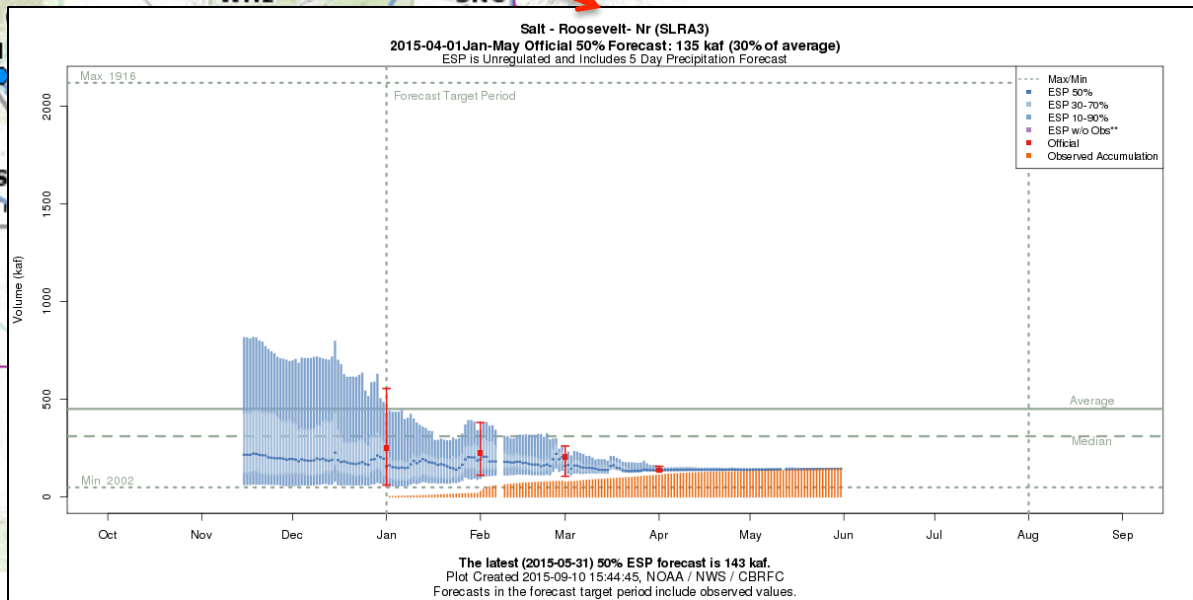
- Calibrated using USGS gage information
- Attempt at local flood issues (very limited forecast ability for short duration events)
- Forecast scenarios are possible (develop thresholds)

Phoenix Area Forecast Points

Phoenix Metro Area

- Better skill in winter type synoptic situations & snowmelt runoff
- Minimal to no skill in short duration flash flood

Just a few water supply points in the PSR HSA, but important to stakeholders in the area.



Phoenix Area Forecast Points

- Forecast Abilities
  - Wintertime synoptic long duration precipitation events
  - Routing of observed upstream flows
  - Flash Floods
- Primary Challenges
  - QPF & Freezing level accuracy; tropical moisture source; lack of observations
  - Rating table accuracy, changing river channels (impacts critical levels)
  - Many (consider scenarios & rule-of thumb thresholds)

Hydrology Issues

- Verde River
  - Good gage data
  - Importance of Bartlett and Horseshoe dams
    - Limited storage (370K Acre-feet)
- Agua Fria
  - Fair gage data
  - Importance of Lake Pleasant
- Little Colorado Drainage
  - Fair gage data western
  - Poor gage data eastern

RFC – WFO Coordination

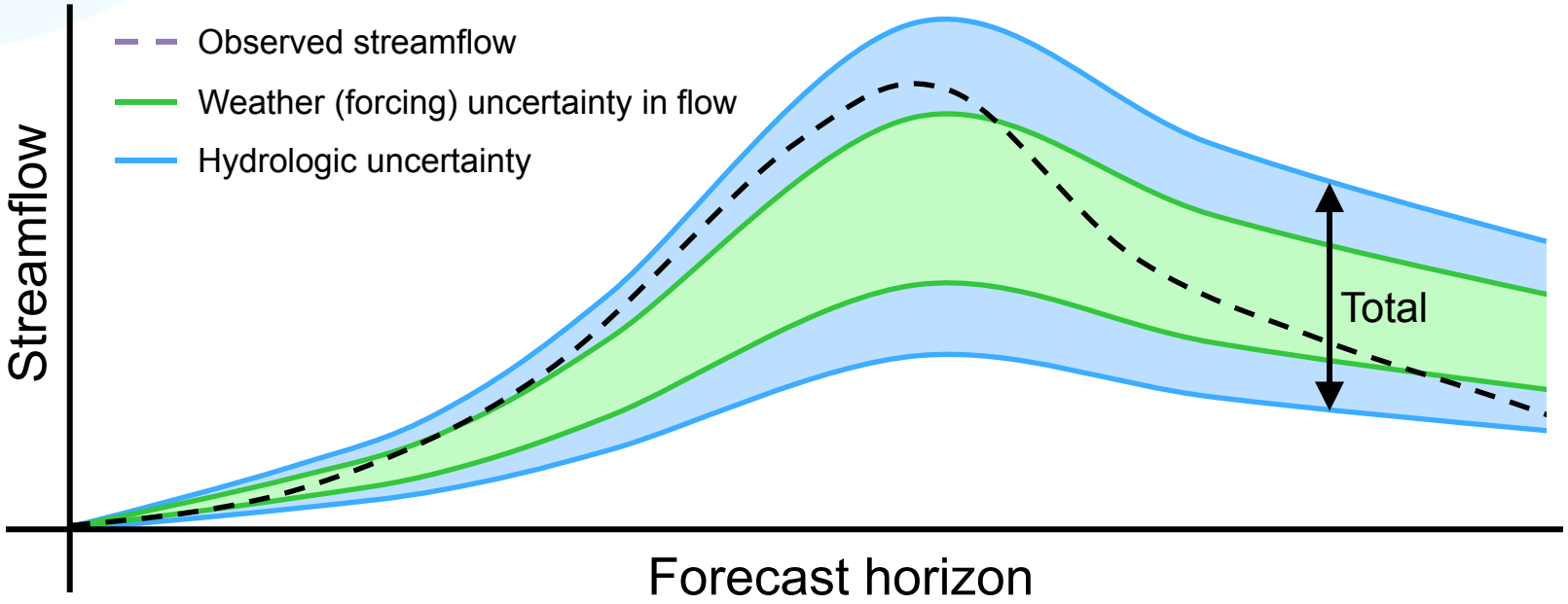
- Routine
  - E-19 and Critical Level updates
  - Rating table issues
  - New data sources
- Prior to potential flood event
  - Coordinate precipitation potential/QPF (plans to switch radar Z-R, etc.)
  - RFC will call WFO if any forecasts reach critical levels
  - RFC will extend hours to support WFO operations
  - Coordinate any other areas of concern

RFC – WFO Coordination

- During flood events
  - Office should take the initiative to contact the other if QPF is changing or forecast river levels are changing.
  - Pass along any changes to critical levels (follow up with updated E-19 following event)
  - The RFC willing to participate in any WFO-Stakeholder coordination calls that occur.

Hydrologic Ensemble Forecast System (HEFS)

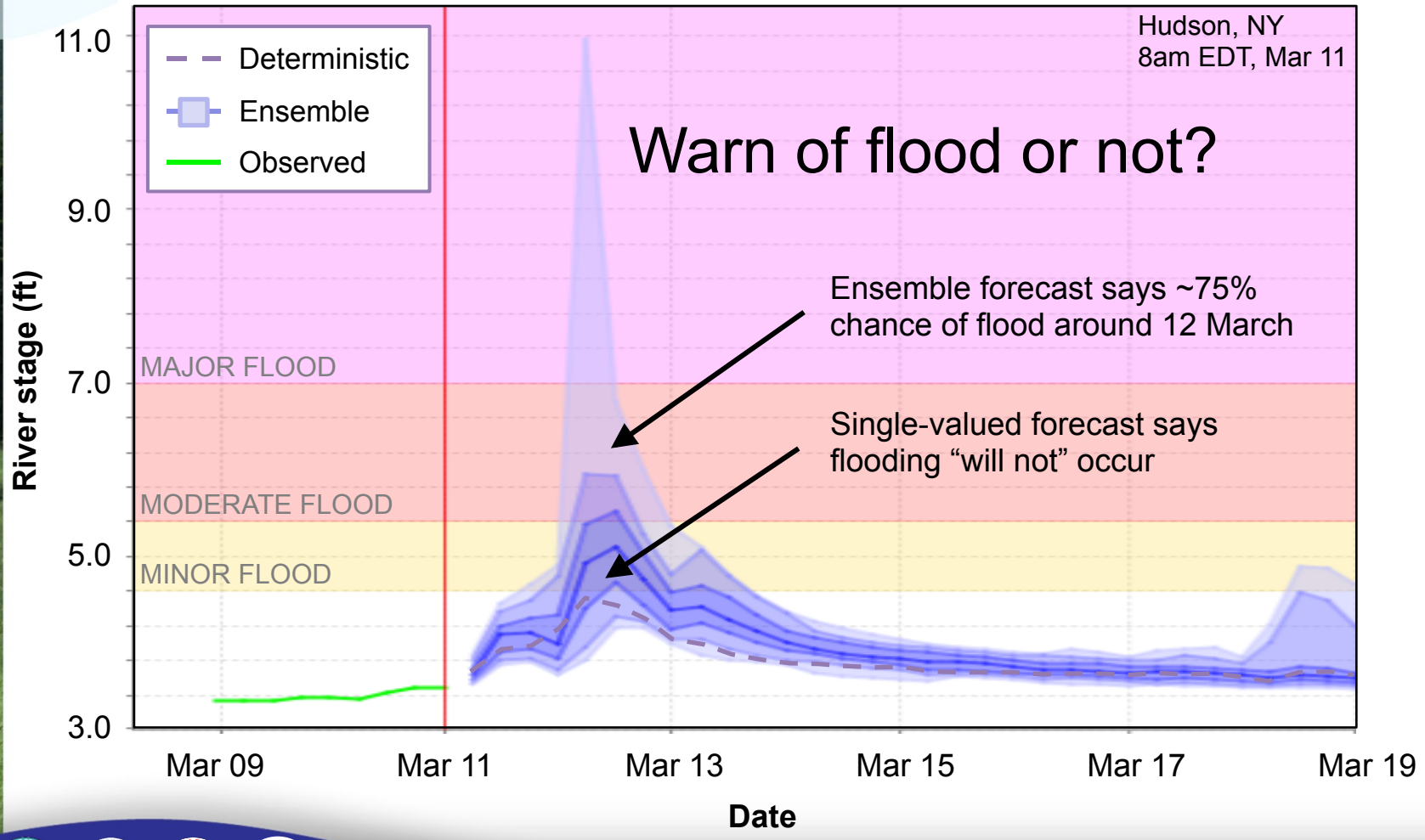
Goal: quantify total uncertainty in flow



- HEFS aims to “capture” observed flow consistently
- So, must account for total uncertainty & remove bias
- Total = forcing uncertainty + hydrologic uncertainty

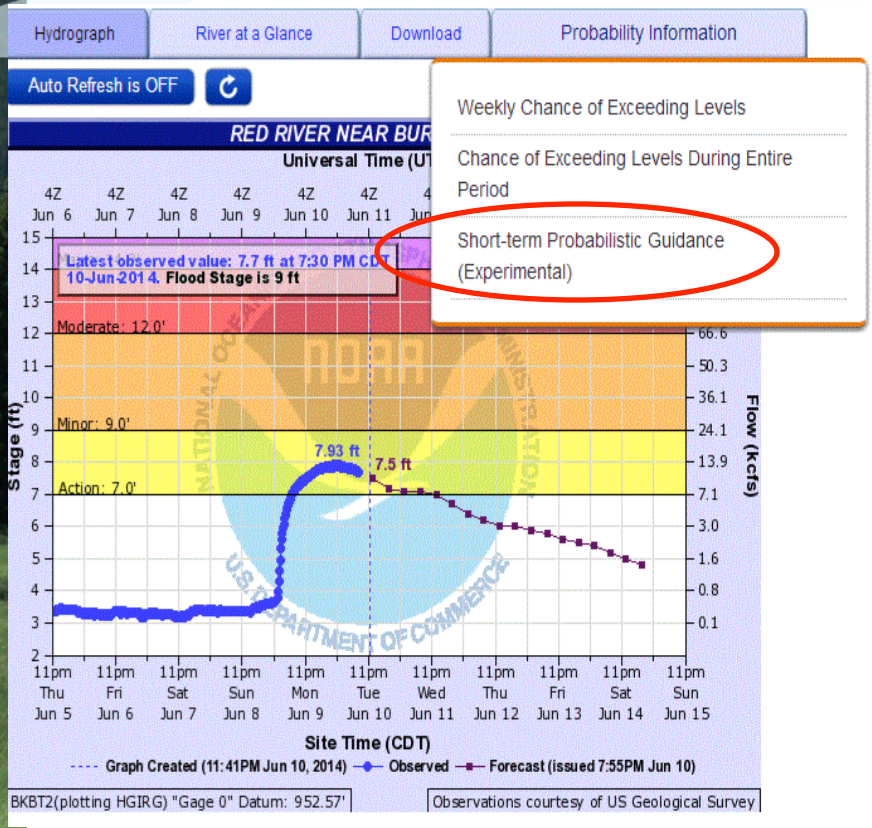
Why use hydrologic ensemble forecasts?

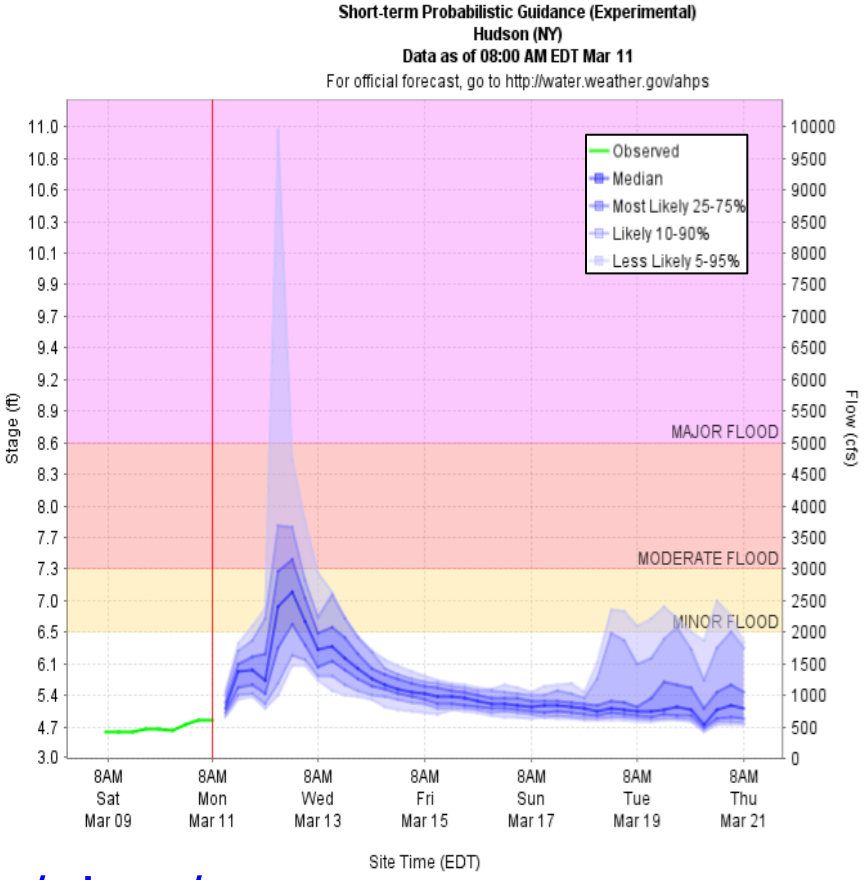
Goal: better-informed water decisions



Example of national HEFS product

AHPS short-range probabilistic product





See: http://water.weather.gov/ahps/

Going Forward with HEFS

Ensemble forecasts are the future

- Forecasts incomplete unless uncertainty captured
- Ensemble forecasts are becoming standard practice
- HEFS implementation, products, and validation is ongoing and expanding
- Initial validation results are promising

HEFS will evolve and improve

- Science and software will improve through feedback
- Guidance will improve through experience
- Continue to educate stakeholders on its benefits

Radar Bias Adjustment Product

- Measures the difference between gage and radar precipitation readings
- Develops a bias value to indicate how well gage and radar are in agreement
  - Bias < 1 indicates gage is lower than radar
  - Bias > 1 indicates gage is higher than radar
  - Mean bias should ideally be between 0.8 and 1.2

Radar Bias Adjustment Product

- Summary available through SLCHCMSTR text product
- Updated daily with more detail at:

http://www.cbrfc.noaa.gov/weather/nexrad/archive/

```
IWA 2015 9 14
QUAL HB5    DIST  HRS GAGE  RADAR BIAS
X    SRRA3 33.24 24  0.86  1.19  0.72
G    MRSA3 27.66 24  0.40  0.56  0.72
G    MCDA3 31.83 24  0.63  0.91  0.69
G    ZPHA3 31.83 24  0.87  1.13  0.77
X    CHLA3 30.15 24  1.46  2.08  0.70
X    YMCA3 34.21 24  0.47  1.13  0.42

bias spectrum <0.6 0.6-0.8 0.8-1.2 1.2-1.4 >1.4
# of GAUGES     1     23        9        2       1
mean bias is 0.790987
```

Where could we help more?

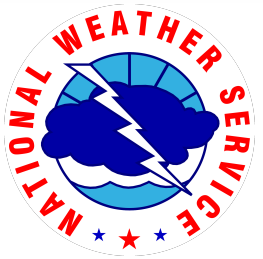
- Events
  - Would contingency runs be helpful?
  - Help determine thresholds for short-duration / FF
  - QPF options, short-duration potential (but early in day)
  - Timely and accessible information?
  - Rating table updates (coordinate with USGS?)
- Data
  - The more data the better – stage and precipitation
  - SRP reservoir operations
  - East Clear Creek? White River?

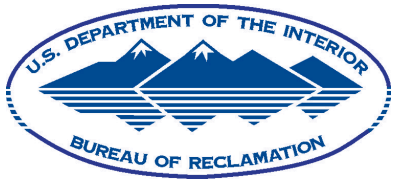
Where could we help more?

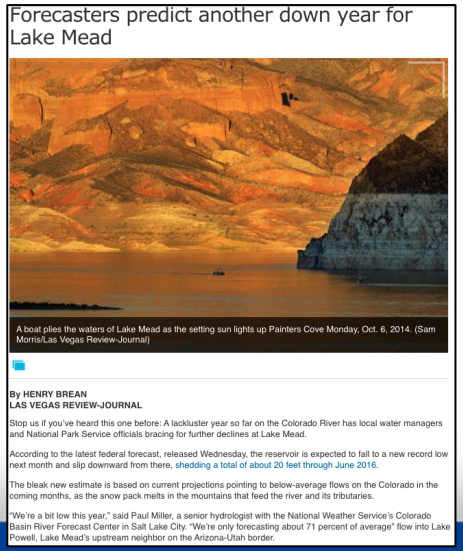
- Improved Coordination
  - Would like to visit at least once a year!
  - Open invitation to visit RFC
- Actions
  - Soil Moisture Grids
  - Precipitation Grids
  - Resolve E-19 (and E-19a) Issues
  - HRRR project
  - Others?

CBRFC Stakeholders in the PSR area

- WFO Support
  - Flood Forecast
  - Warning Support
- Water Supply
  - Bureau of Reclamation
  - Central Arizona Project
- Recreation
- General Public







Forecasters predict another down year for Lake Mead

A boat plies the waters of Lake Mead as the setting sun lights up Painters Cove Monday, Oct. 6, 2014. (Sam Morris/Las Vegas Review-Journal)

By HENRY BREAN
LAS VEGAS REVIEW-JOURNAL

Stop us if you've heard this one before: A lackluster year so far on the Colorado River has local water managers and National Park Service officials bracing for further declines at Lake Mead.

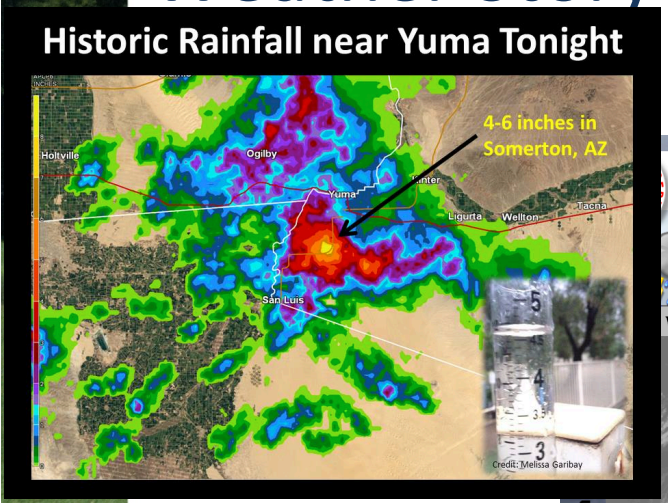
According to the latest federal forecast, released Wednesday, the reservoir is expected to fall to a new record low next month and slip downward from there, shedding a total of about 20 feet through June 2016.

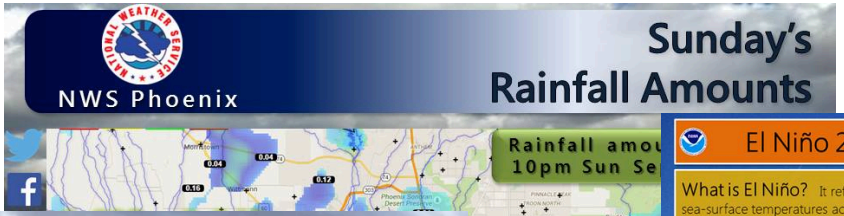
The bleak new estimate is based on current projections pointing to below-average flows on the Colorado in the coming months, as the snow pack melts in the mountains that feed the river and its tributaries.

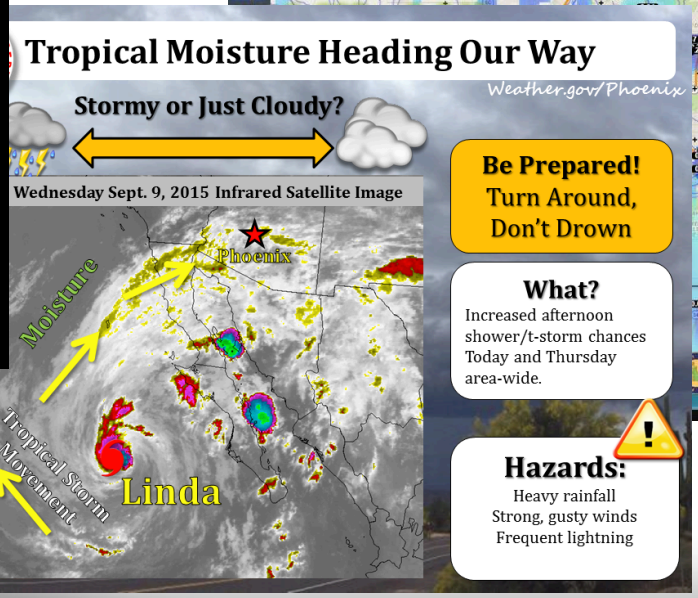
"We're a bit low this year," said Paul Miller, a senior hydrologist with the National Weather Service's Colorado Basin River Forecast Center in Salt Lake City. "We're only forecasting about 71 percent of average" flow into Lake Powell, Lake Mead's upstream neighbor on the Arizona-Utah border.

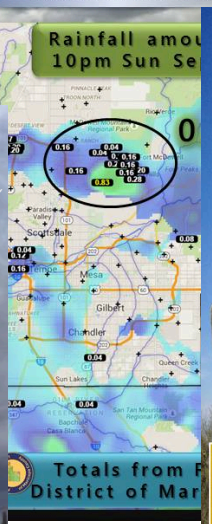
CBRFC Stakeholders in the PSR area

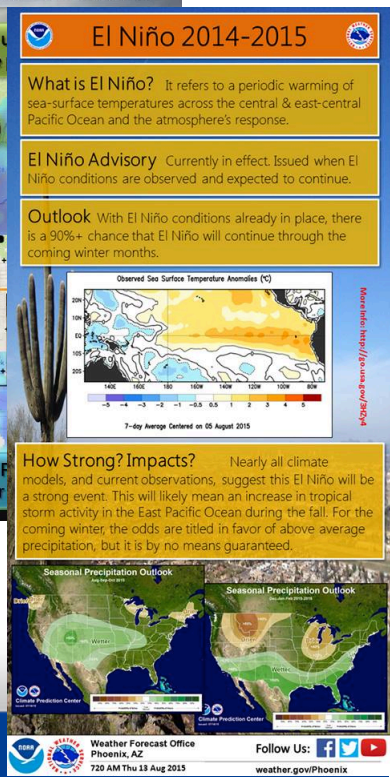
Our stakeholders love hydro-related information you put out on Facebook, Twitter, and the Weather Story











National Water Center

The first-ever U.S. center for water forecast operations, research, and collaboration across federal agencies

60,000 sq ft “green” building

University of Alabama Campus, Tuscaloosa, AL

Opened May 2015, initial staffing underway

National Water Center

Mission

The National Water Center collaboratively researches, develops and delivers state-of-the science National hydrologic analyses, forecast information, data, decision-support services and guidance to support and inform essential emergency services and water management decisions.

- A foundation for developing a national "common operating picture" to enable critical decisions effecting the Nation's most valuable resource
- Fully integrated water resources program directed towards consistent products for impact-based decision support services
- Catalyst for accelerating research to operations
- Nerve center for optimization of data-flow among RFCs and IWRSS partners

A Catalyst for Modernizing the NWS Hydrology Program

Contact us!

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