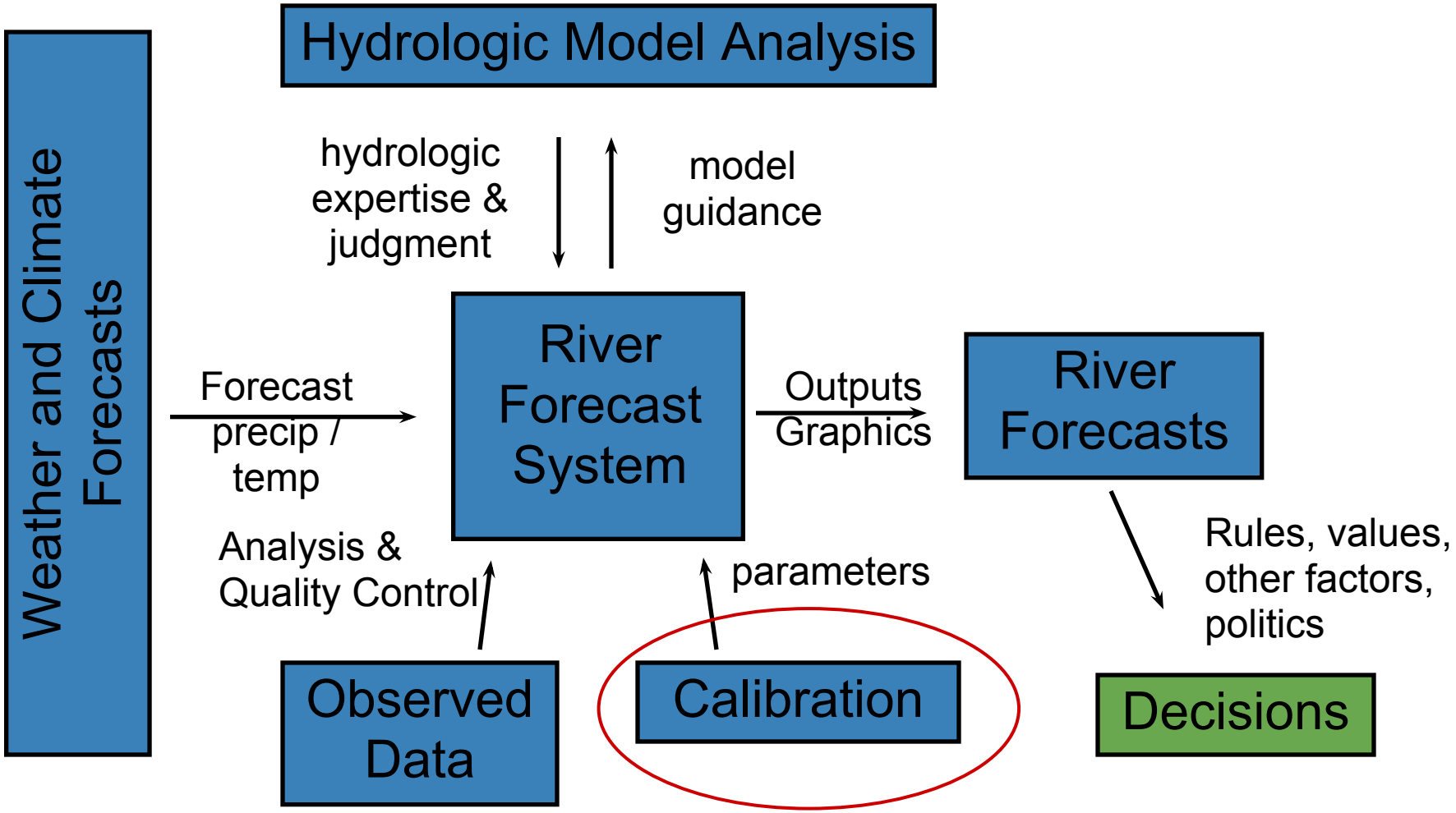
# CBRFC Operations

John Lhotak
Development and Operations Hydrologist
Colorado Basin River Forecast Center

# Presentation Outline

- Forecasting Process
  - Daily Operations
    - Models/Calibration
    - Data
    - Products
  - Water Supply Operations
    - Ensemble Streamflow Prediction (ESP)
    - Products
    - New daily guidance
    - Future
- McPhee - Current Forecast
- Website demo

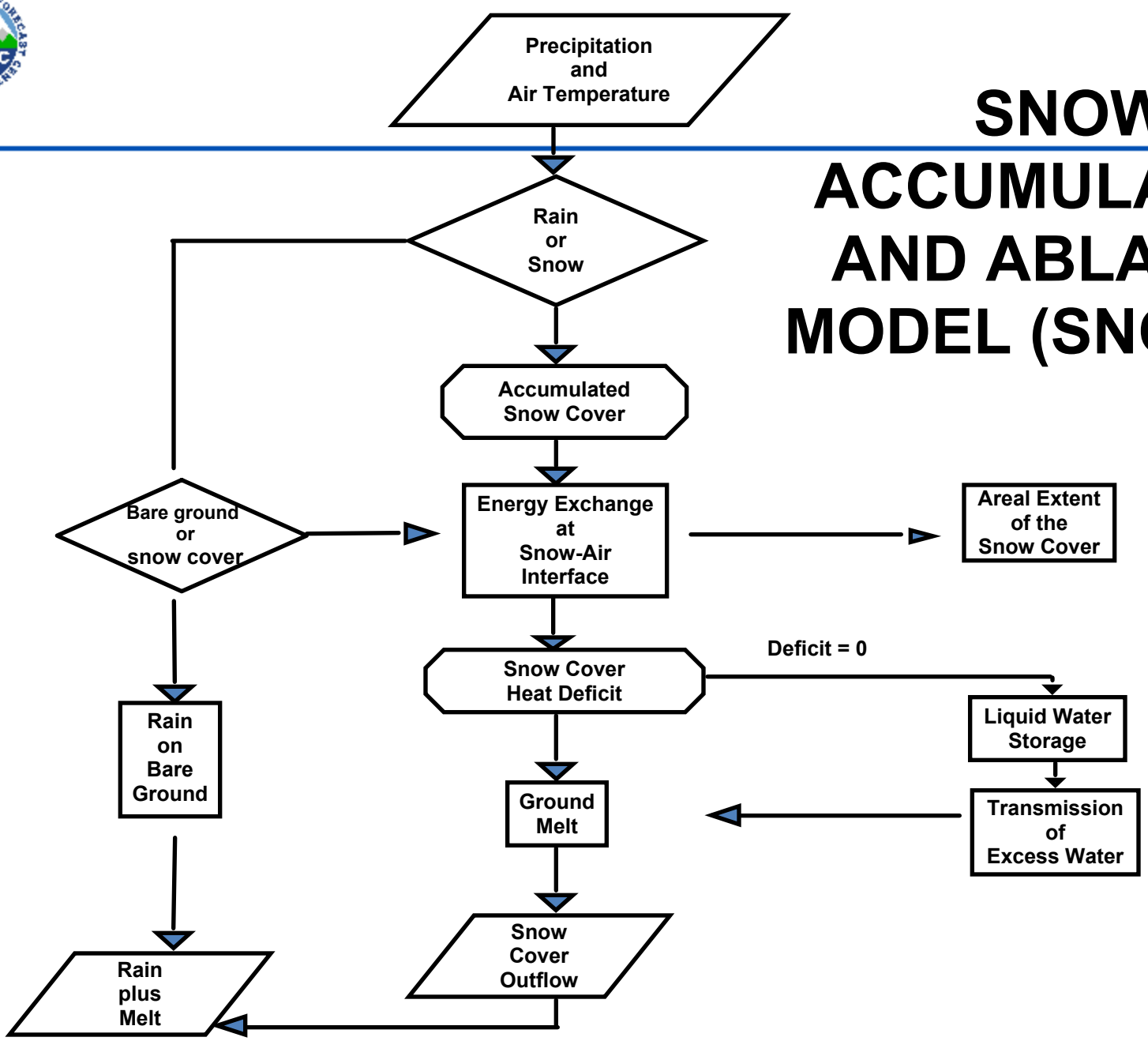
# Forecast Process



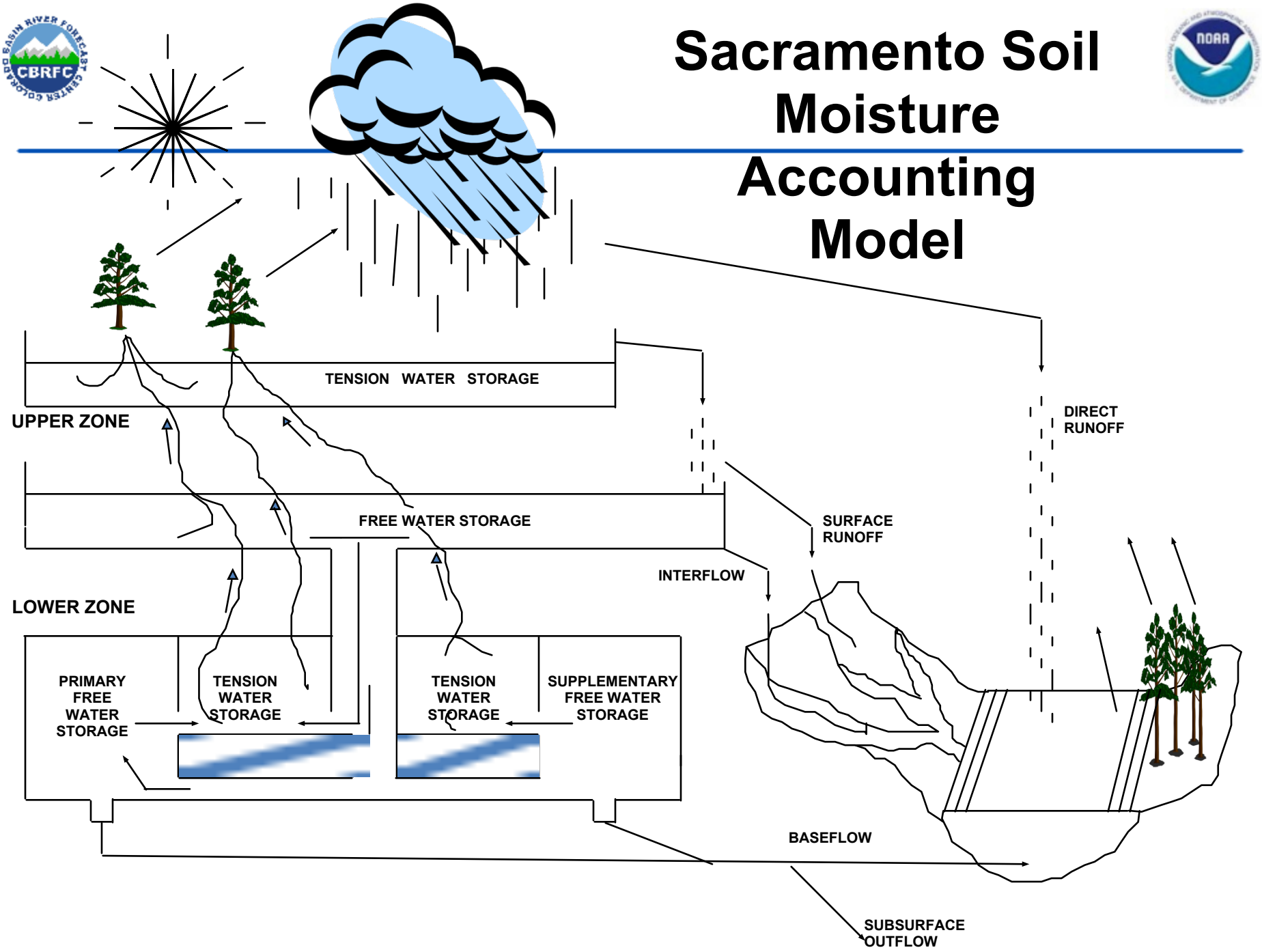
# Models

- A snow model is first run for each area in the basin accumulates/ablates snow
- A soil moisture model is then run for each area
  - Controls amount of water from the snow model retained in the soil
    - evaporates or
    - ends up in the stream

# SNOW ACCUMULATION AND ABLATION MODEL (SNOW-17)



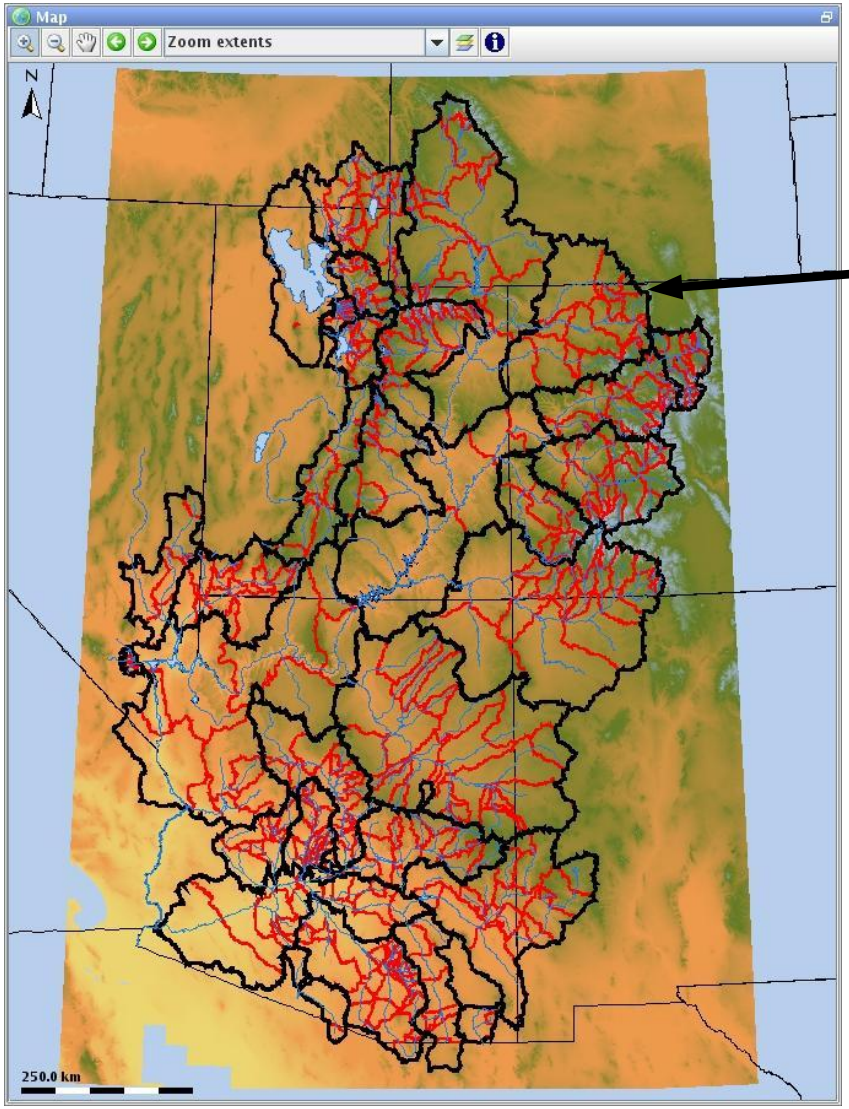
# Sacramento Soil Moisture Accounting Model



# Calibrations - Inputs

- Precipitation and temperature are calculated every six hours at each area within the basin
- 30 year historical record calculation
- Used to calibrate hydrologic models
- Operationally done in a similar way
- Ensures our forecasts will have similar quality/characteristics to calibration

# Calibration Example

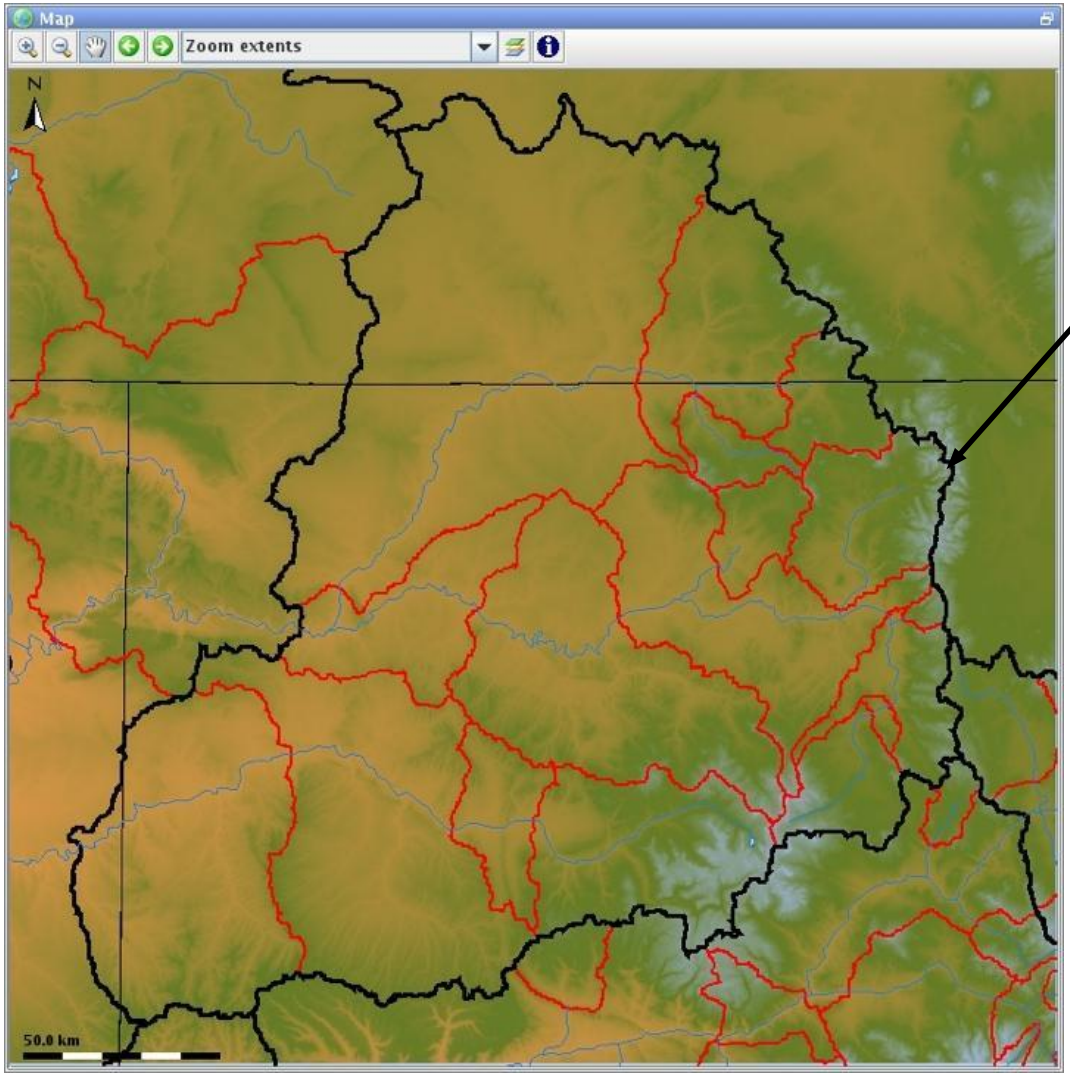



CBRFC area is broken into 30 forecast Groups

This example is from the White - Yampa Group

*

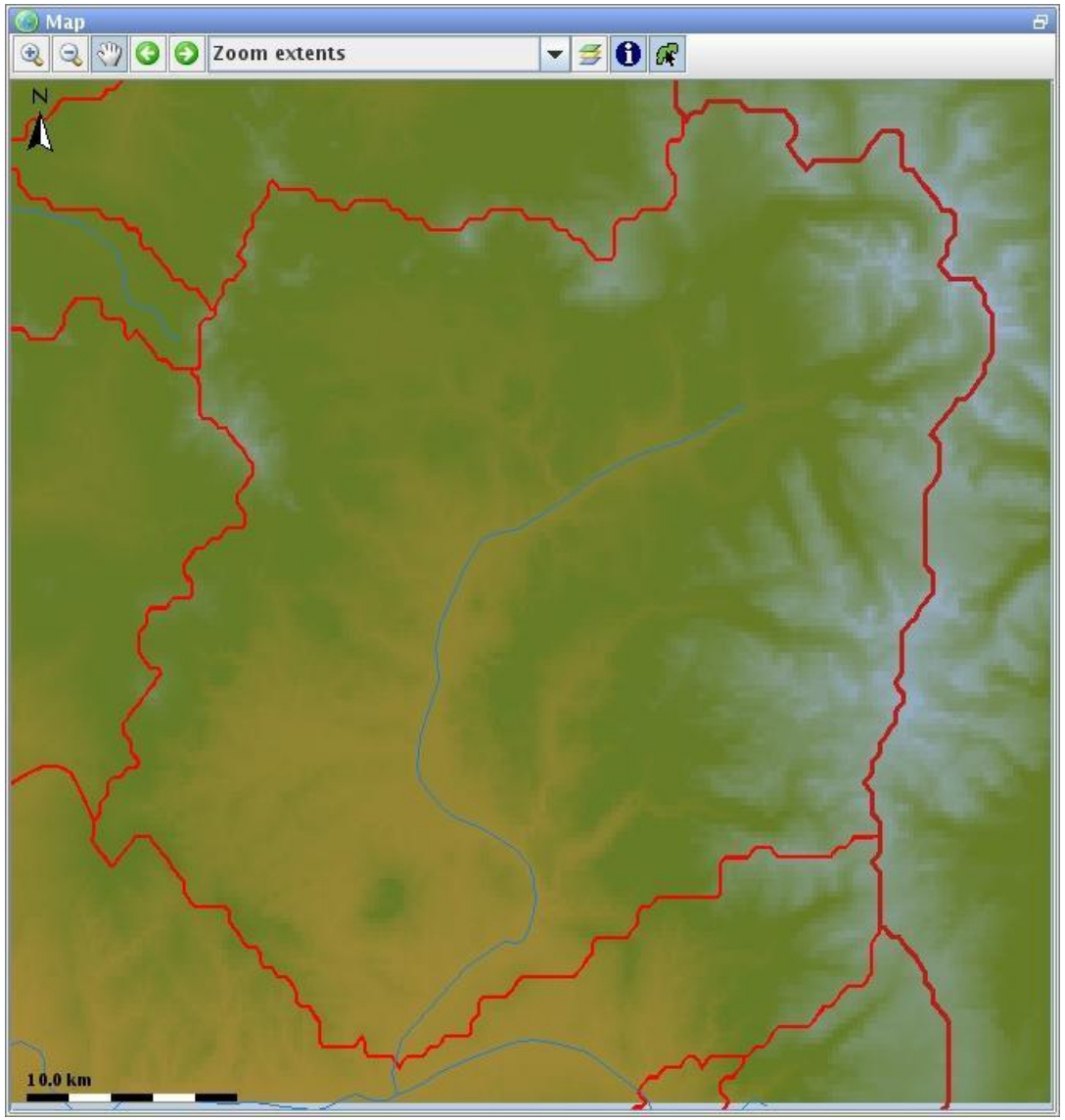
# White Yampa Basin



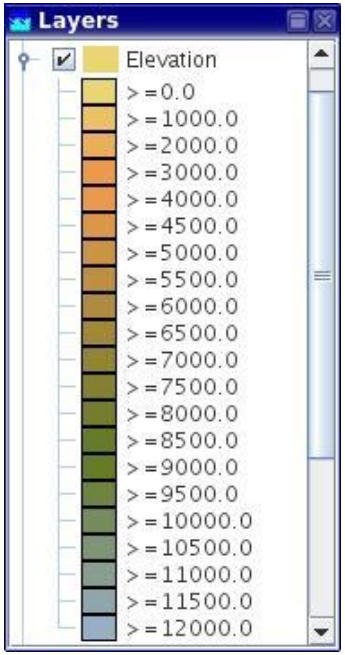

We will look at the
Elk River near Milner

ENMC2

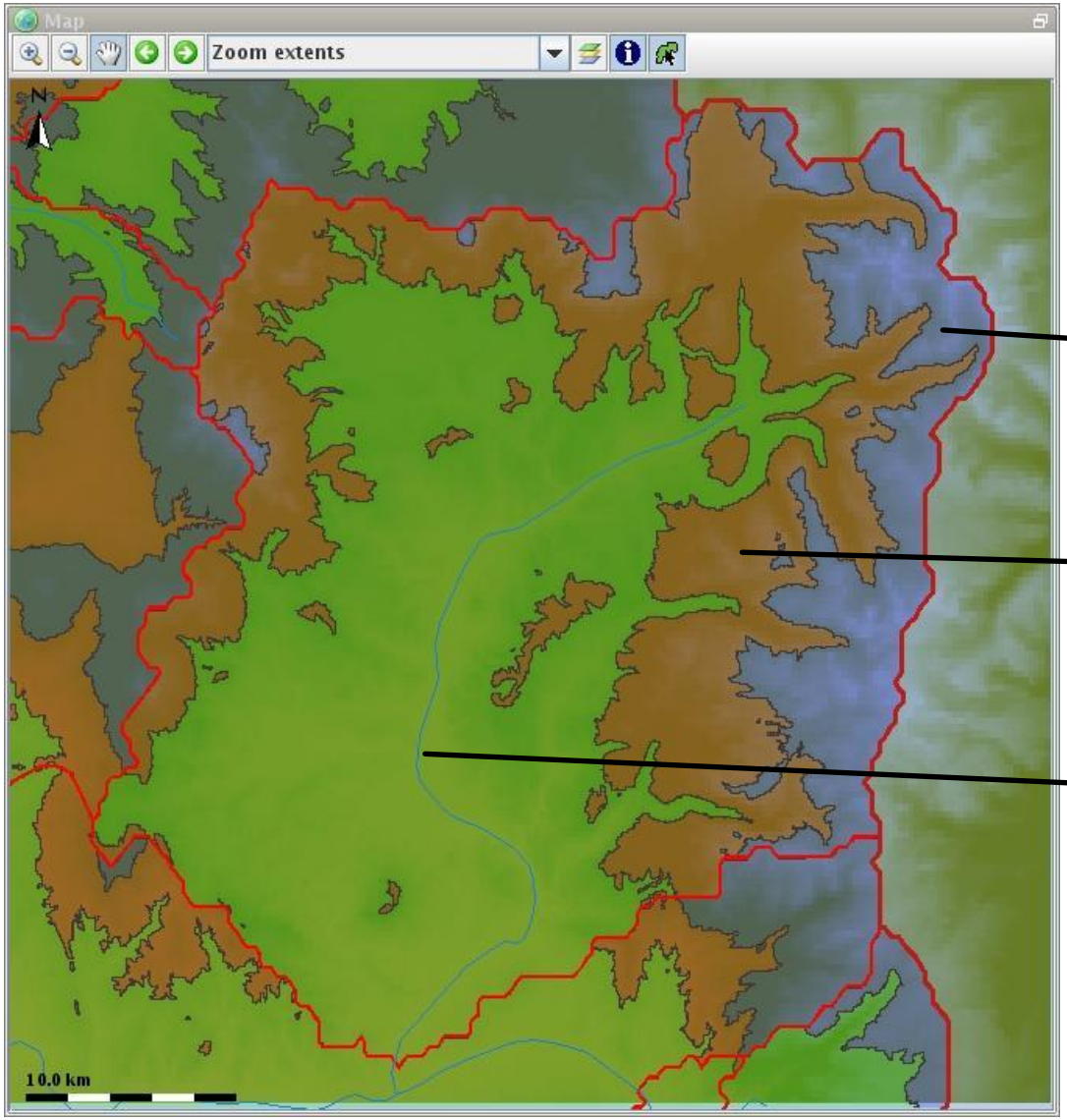
# Elk near Milner (ENMC2)




The basin is first broken into elevation zones



# Elk near Milner (ENMC2)




Upper (10000-11970)

Middle (8500-10000)

Lower (7205-8500)

# Calibrations - Inputs

In reality the 3 areas (upper, middle and lower) are represented (simulated) by only 3 points (Lumped Model)

The inputs our model needs for calibrations and operations (at these 3 points) are:

- precipitation
- temperature
- freezing level

# Calibrations - Precipitation

Each area (upper, middle and lower) MAP is built using precipitation stations that (hopefully) have similar characteristics to that area

For the ENMC2

- Upper area – DRLC2 .46, ELKC2.46
- Middle area - DRLC2 .46, ELKC2.46
- Lower area - DRLC2 .46, ELKC2.46

These weights were chosen to guarantee water balance in each area. The water balance in each area was calculated using the PRISM sets

# ENMC2-Precipitation Gages

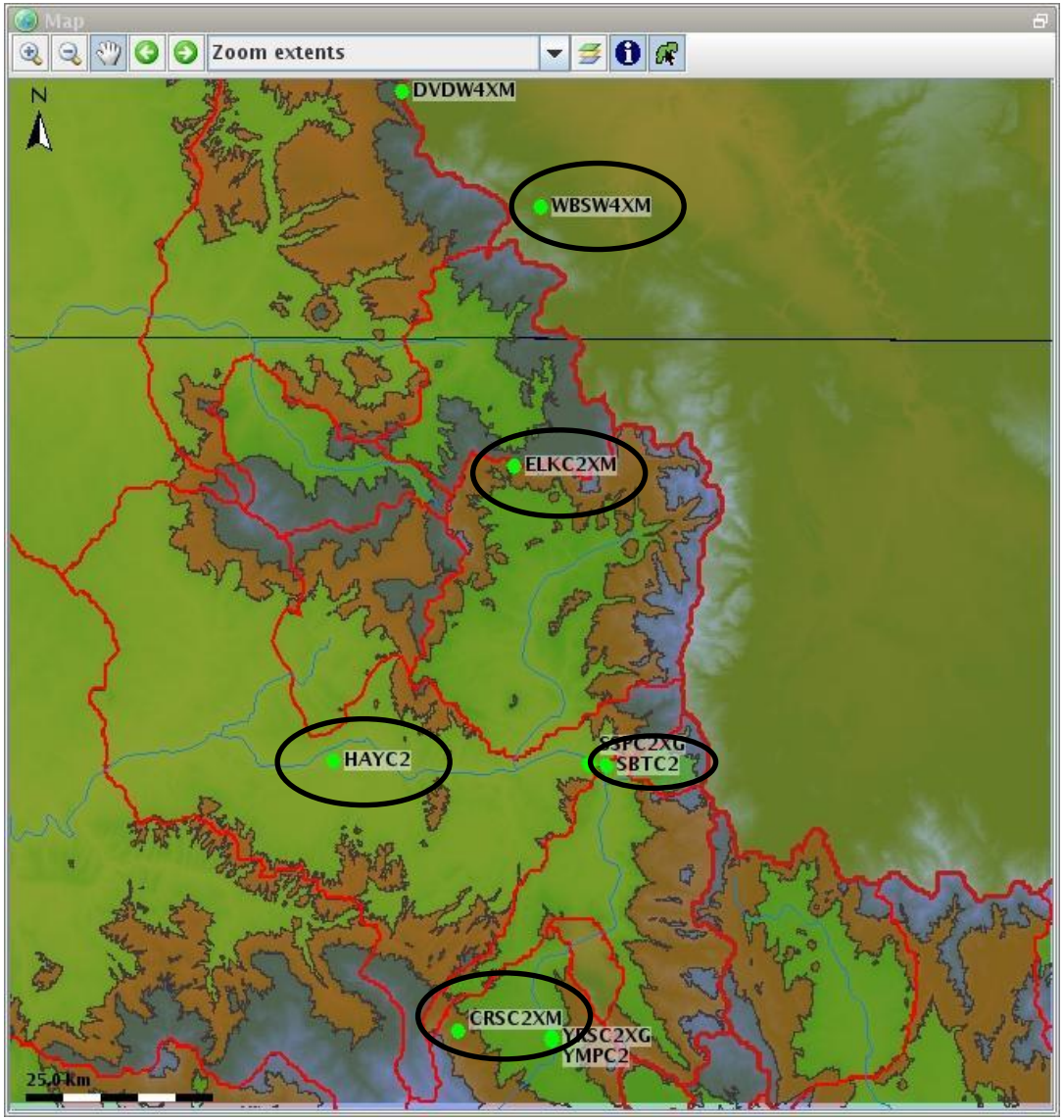
# Calibrations/Simulations - Temperature

Nearby stations (whose climatology is known) area used to calculate the temperature at the mid-point elevation of the area (whose climatologies are calculated using the climatology of the nearby stations)
Temperature is calculated by using the difference in station and area climatology

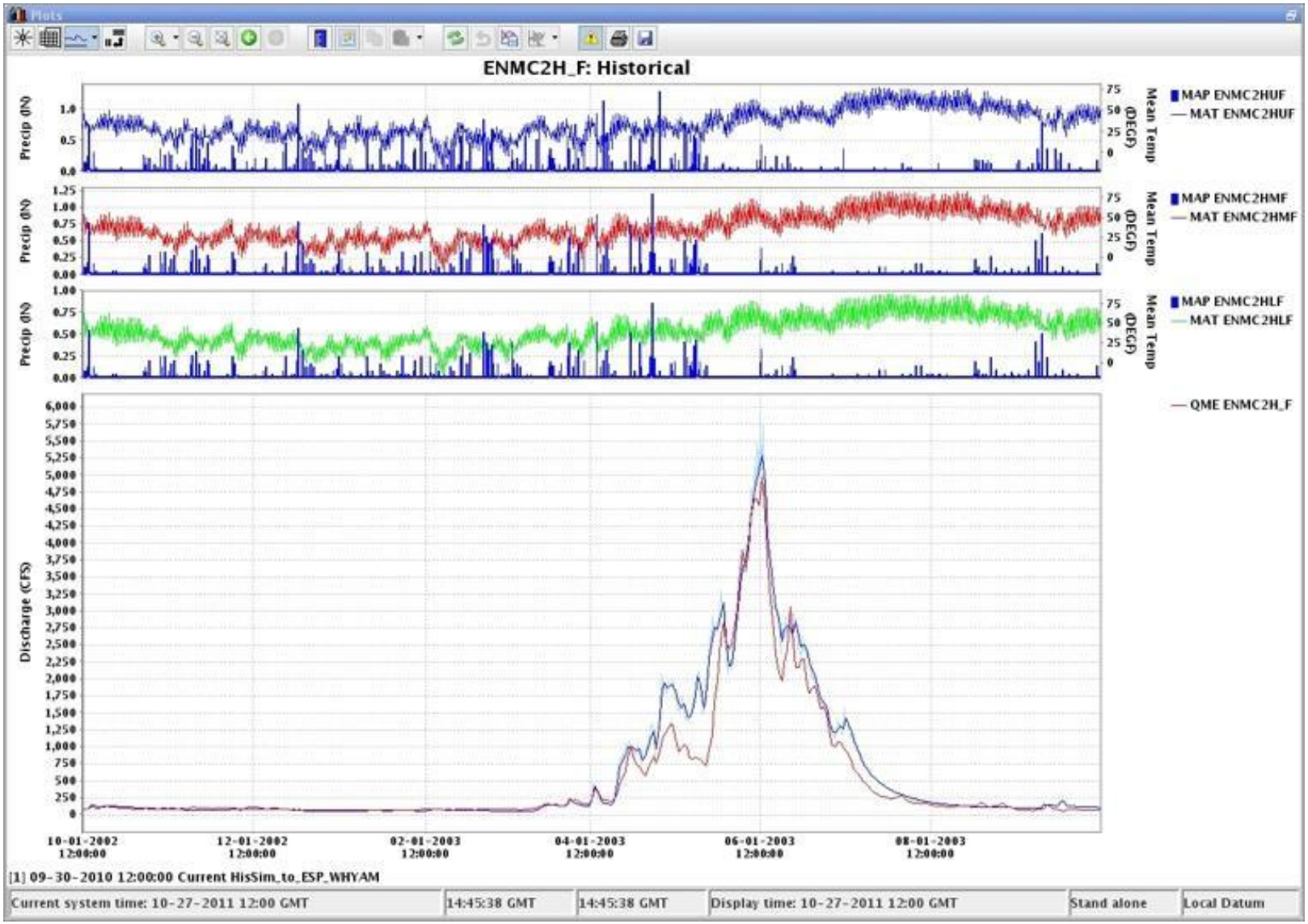
For the ENMC2

- Upper area – CRSC2 0.009, ELKC2 0.011
- Middle area - SBTC2 0.009, CRSC2 0.013, ELKC2 0.045
- Lower area - WBSW4 0.009, SBTC2 .02,HAYC2 0.013, ELKC2 0.019

# ENMC2- Temperature Gages



# Calibrations - Results



# Calibrations - Reservoirs

Reservoir modeling is difficult as they are not physically based. However, we calibrate the reservoir models assuming two different modes:

- Irrigation (use average releases)
- Spillway/passflow

Operationally we can do the following:

- Assume the current release
- Input a schedule
- Allow the spill/passflow rules

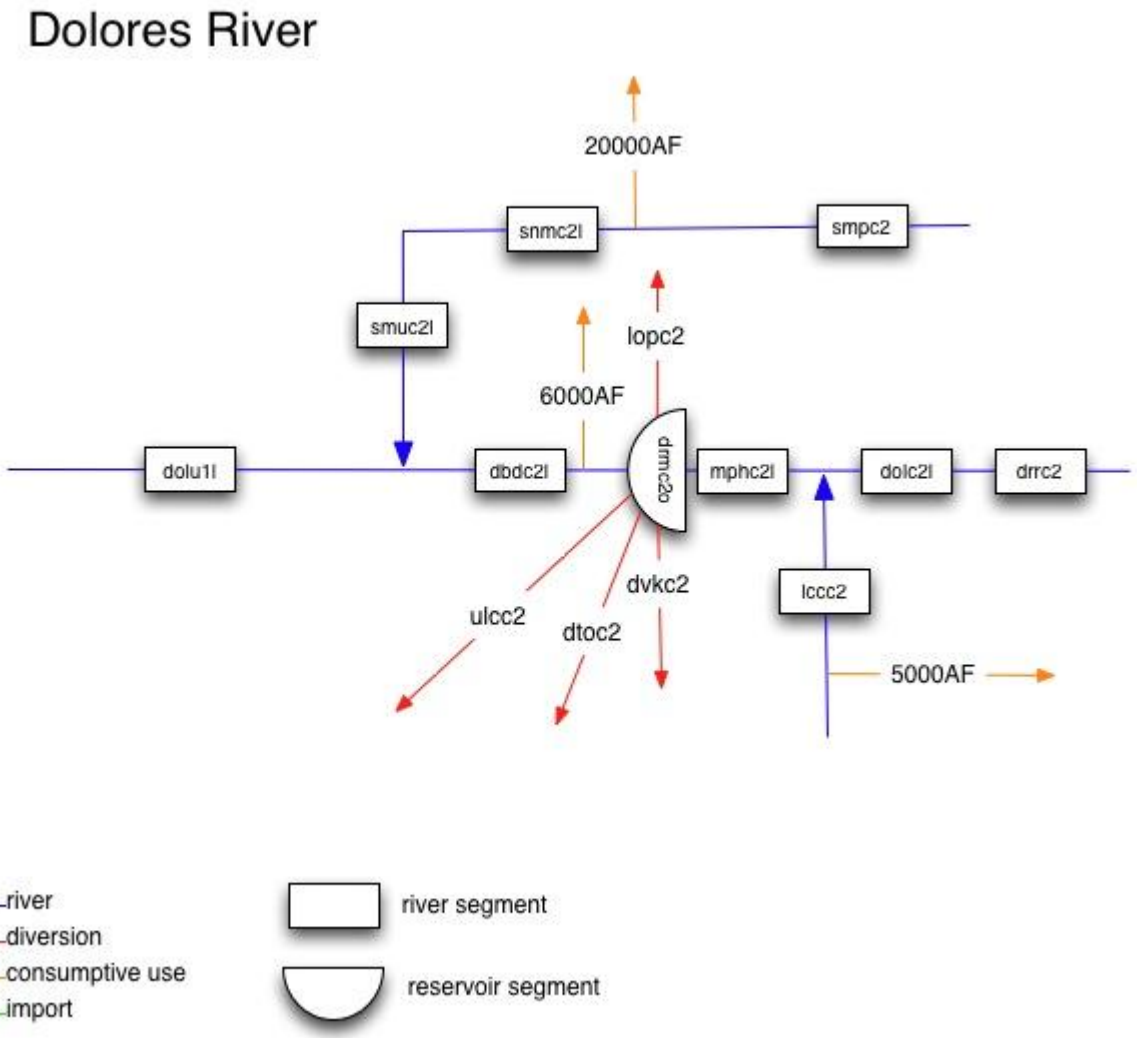
# Adjustments to Flow

- Unregulated flow = Observed flow + Diversions (measured) + Storage
- Natural flow = Unregulated flow + Consumptive Use
- Consumptive use (in basin irrigation) can only be estimated
  - In our simulations, we simulate natural flow but subtract out the consumptive use so the output is always unregulated flow

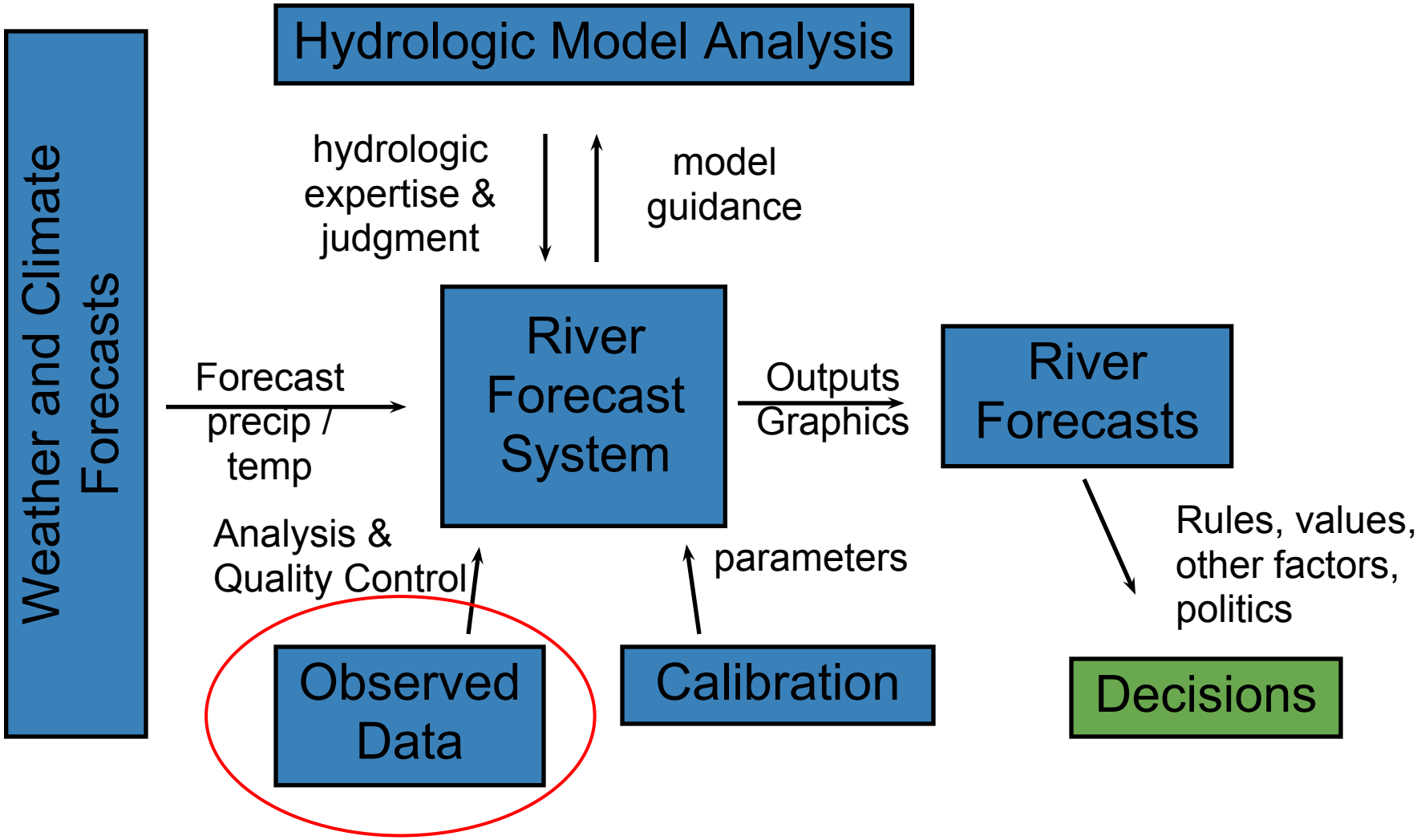
So:

- We simulate “natural flow”
- We remove the in-basin irrigation (consumptive use)
- This is the simulated unregulated flow. It simulates the actual flow plus the measured diversions (adjusted flow)
- Operational considerations
  - Observed flow = Unregulated flow - Diversions - Storage

# Dolores Adjustments to Flow



# Forecast Process



# Key Observing Systems

NRCS SNOTEL
USGS Stream Gauging
NWS COOP, Radar, etc

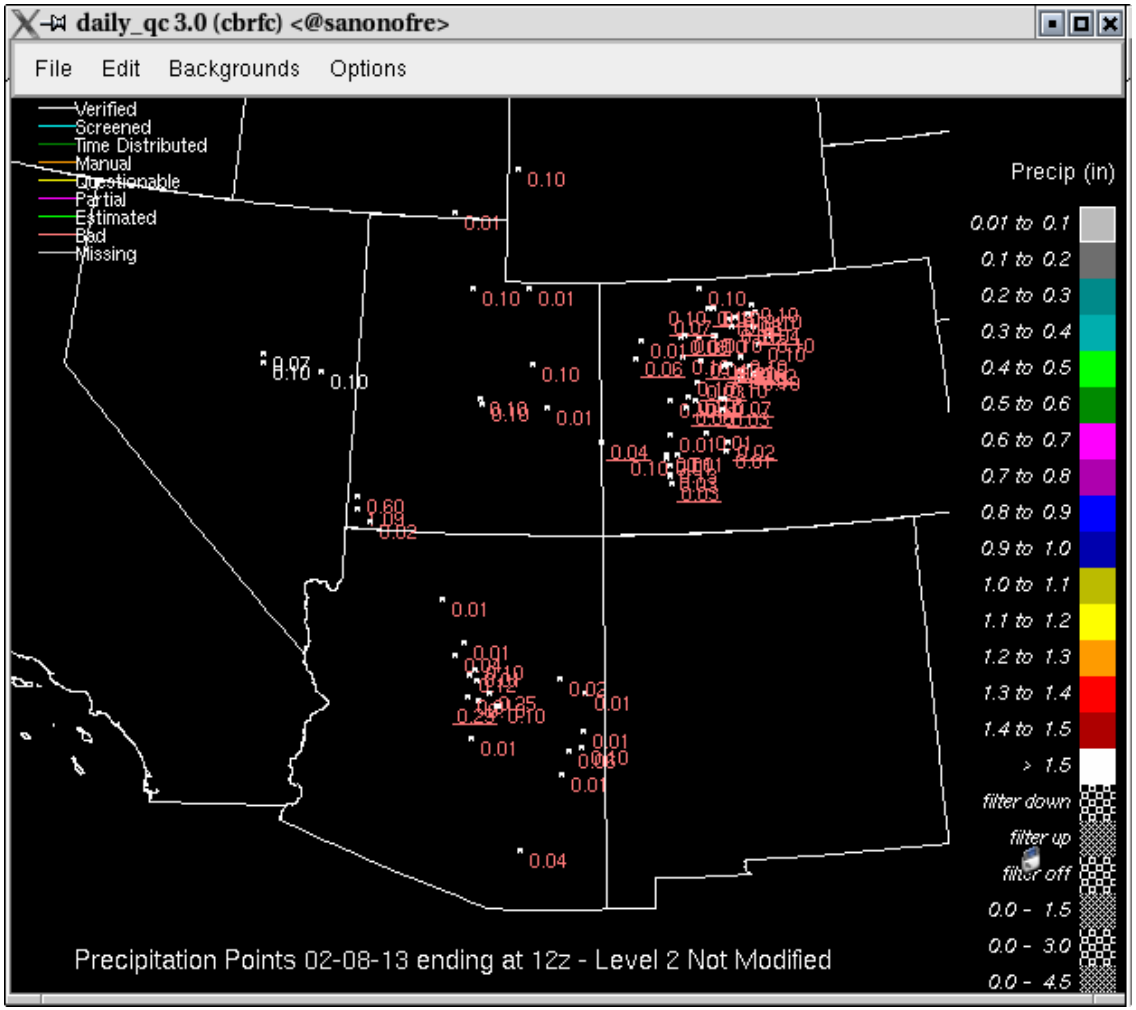
Data Used in CBRFC Daily Ops:

- ~260 precipitation
- ~330 temperature
- ~875 flows including river, reservoir, and diversion
- ~95 storage

# Data Quality Control

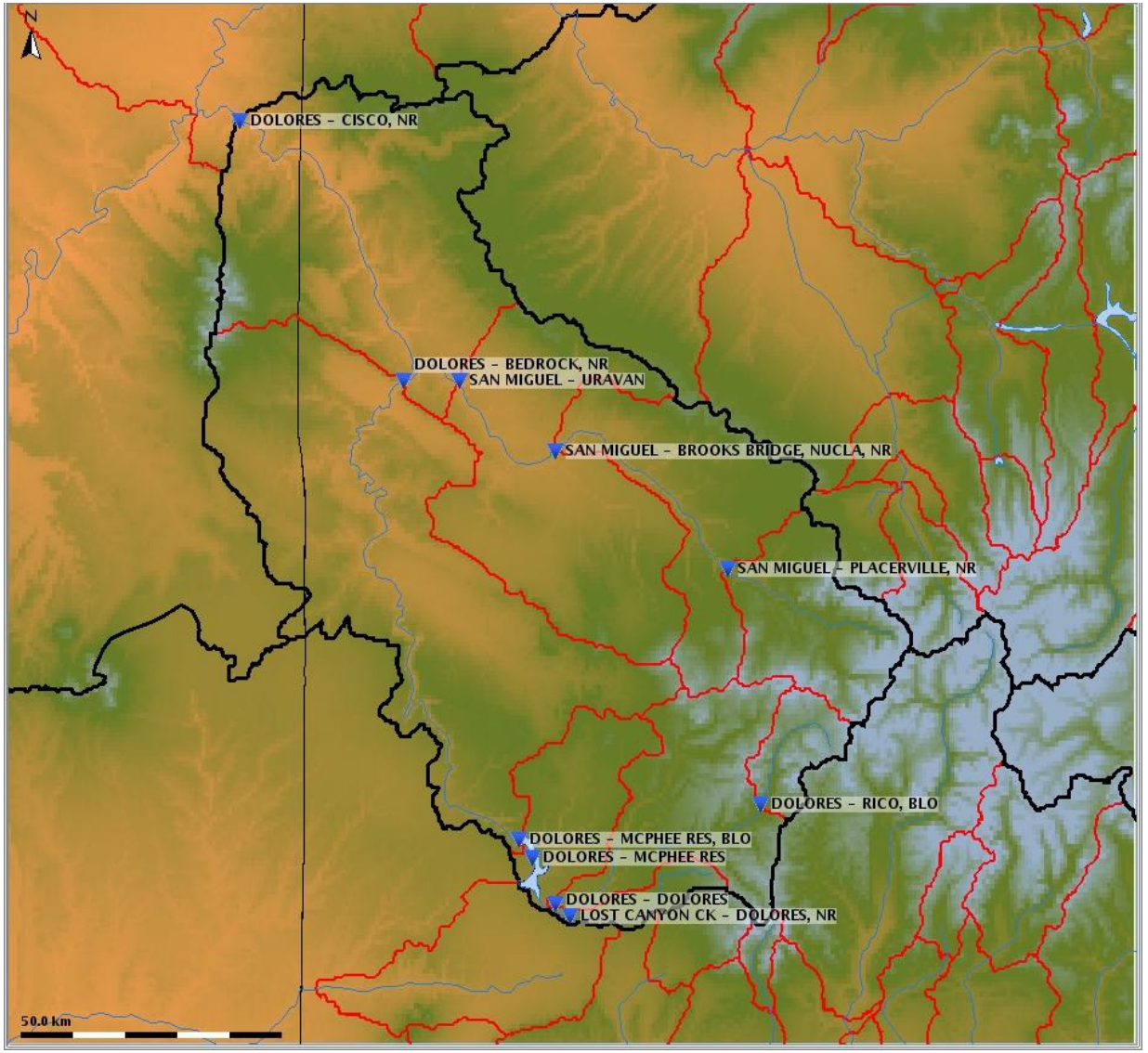
The goal is to feed the models with the best available data.

We check data inputs each morning before feeding to the model



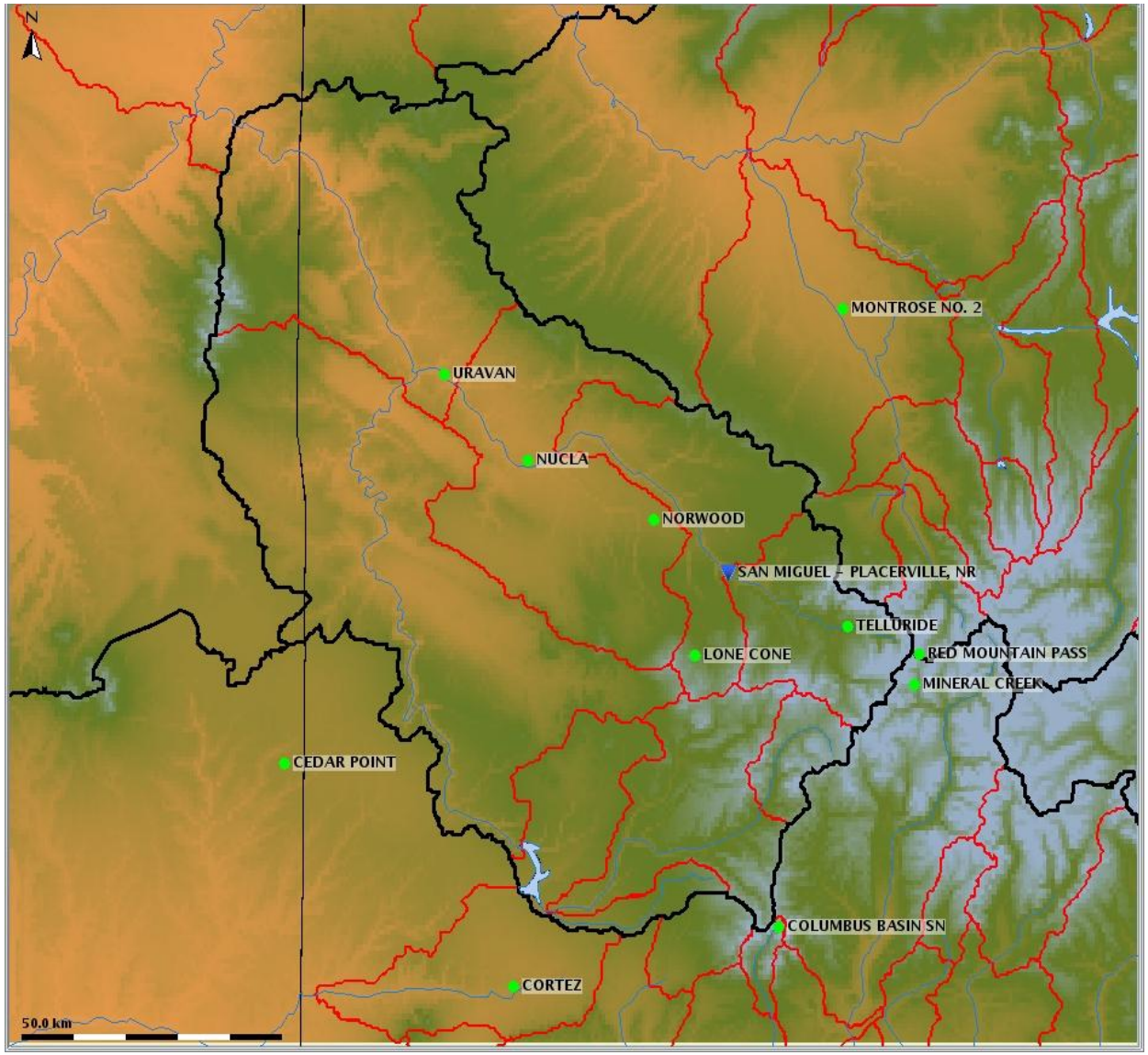
# Dolores Forecast Locations

10 Forecast Locations in the Dolores, 4 above McPhee



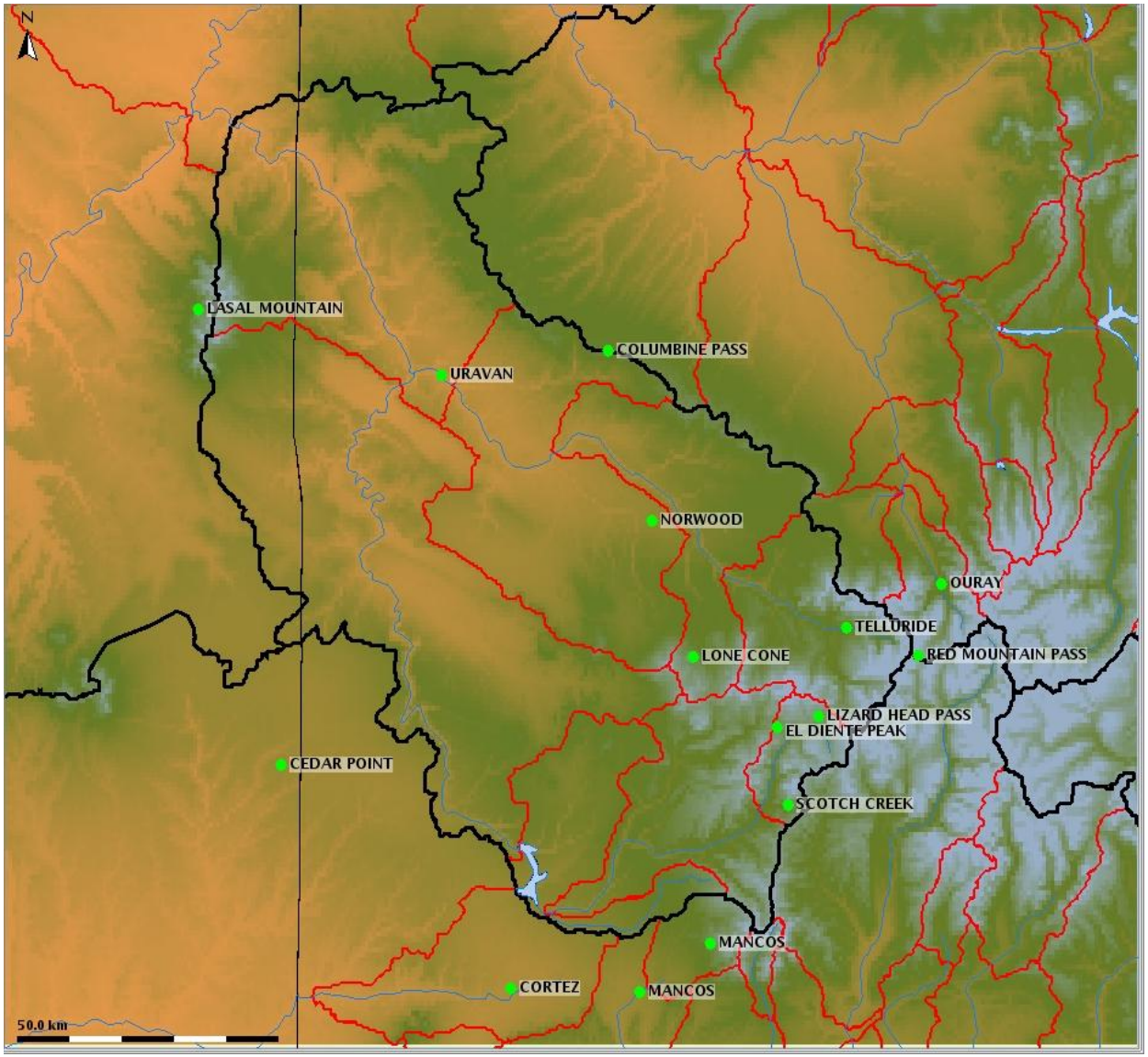
# Dolores Temperature Stations

3 GOES
4 SNOTEL
5 COOP

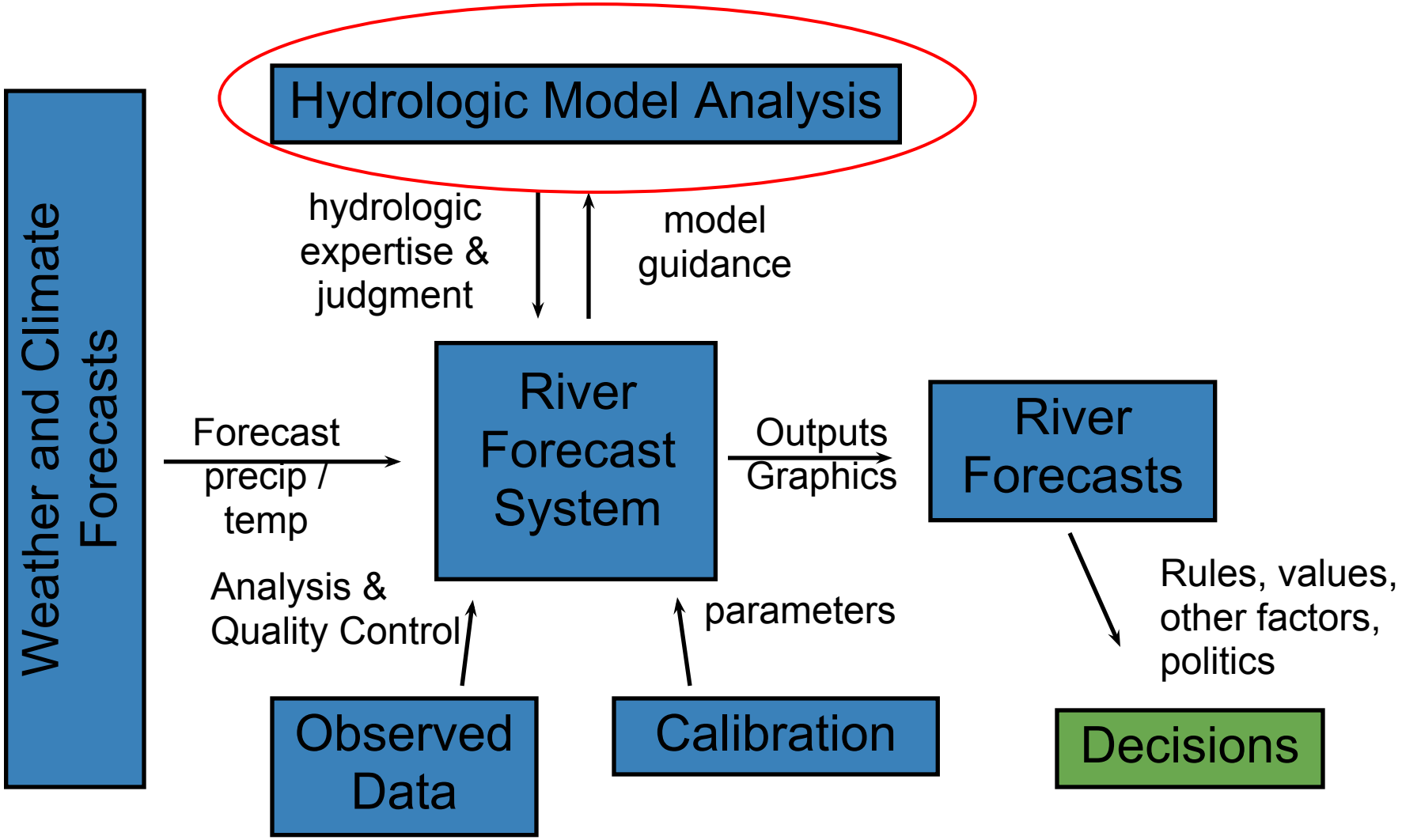


# Dolores Precipitation Stations

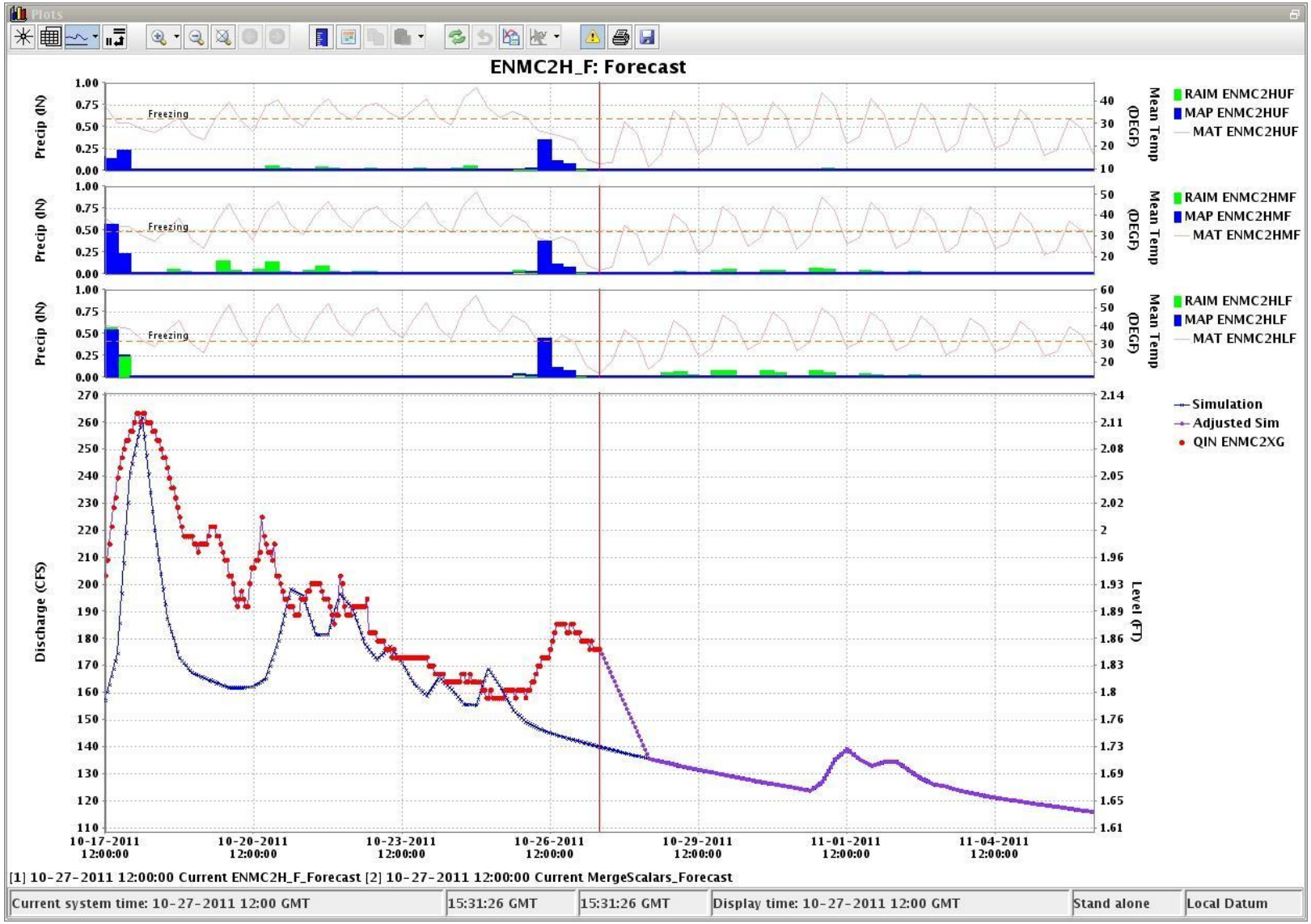
8 SNOTEL
7 COOP



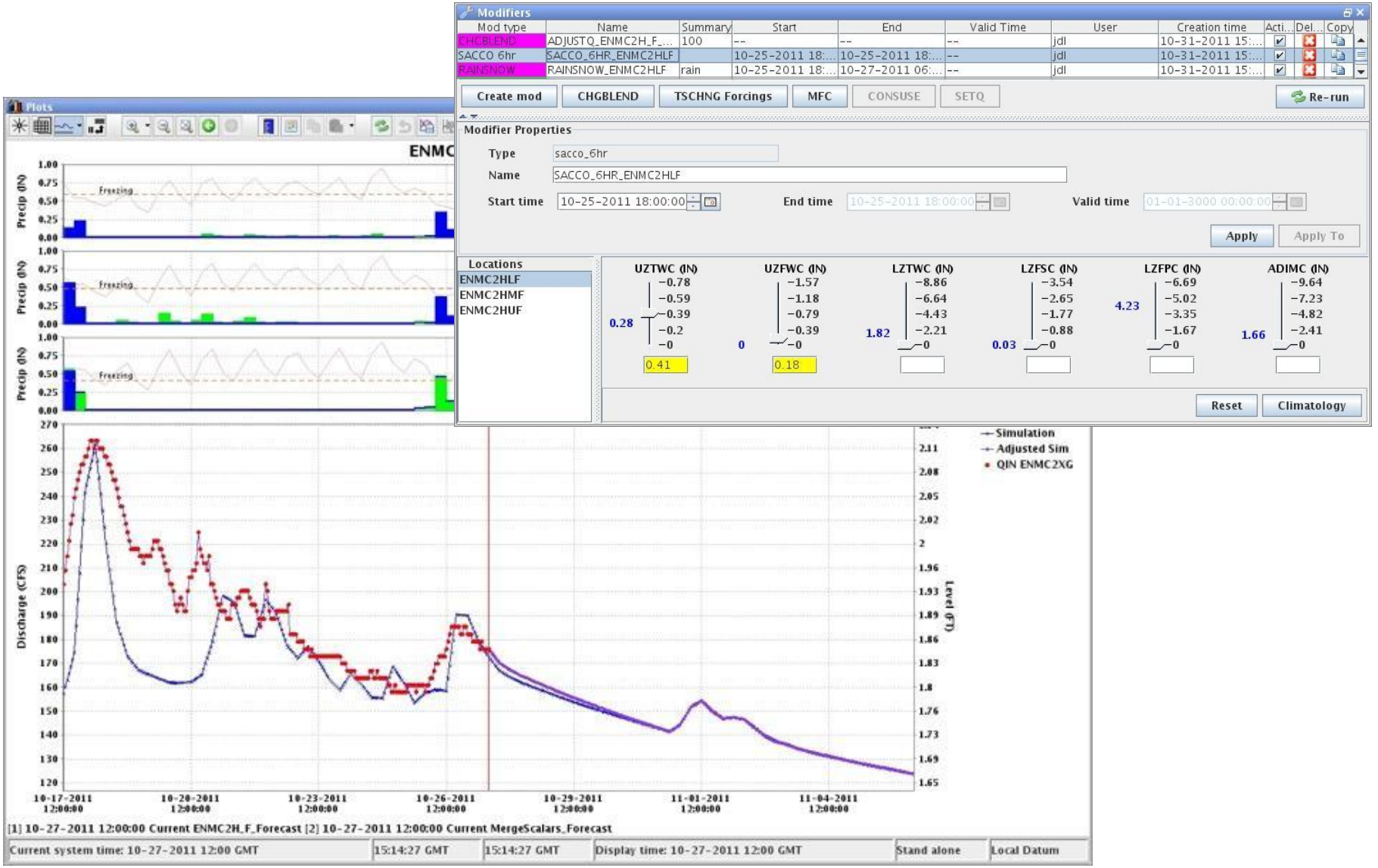
# Forecast Process



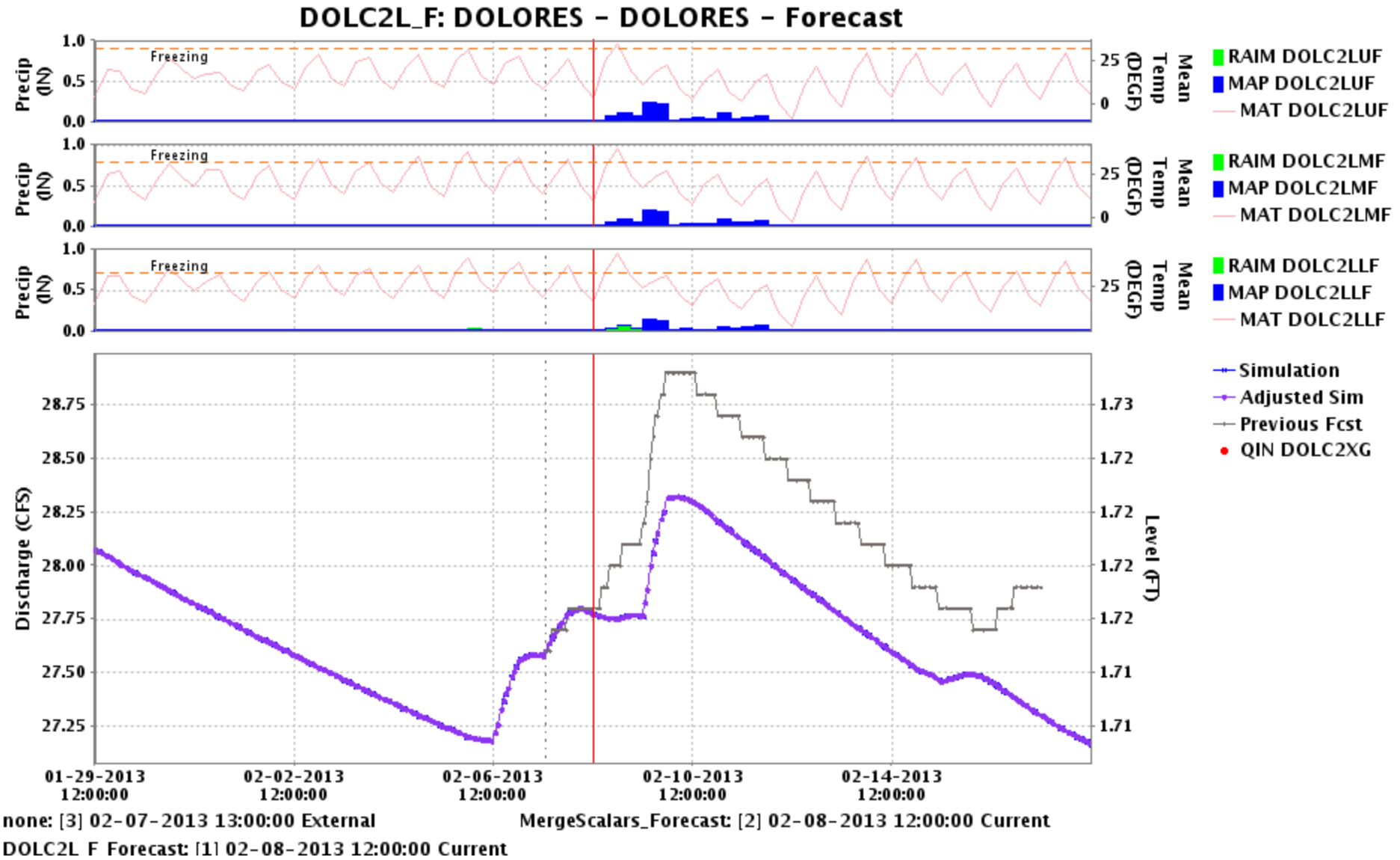
# Simulations - Real Time (no mods)



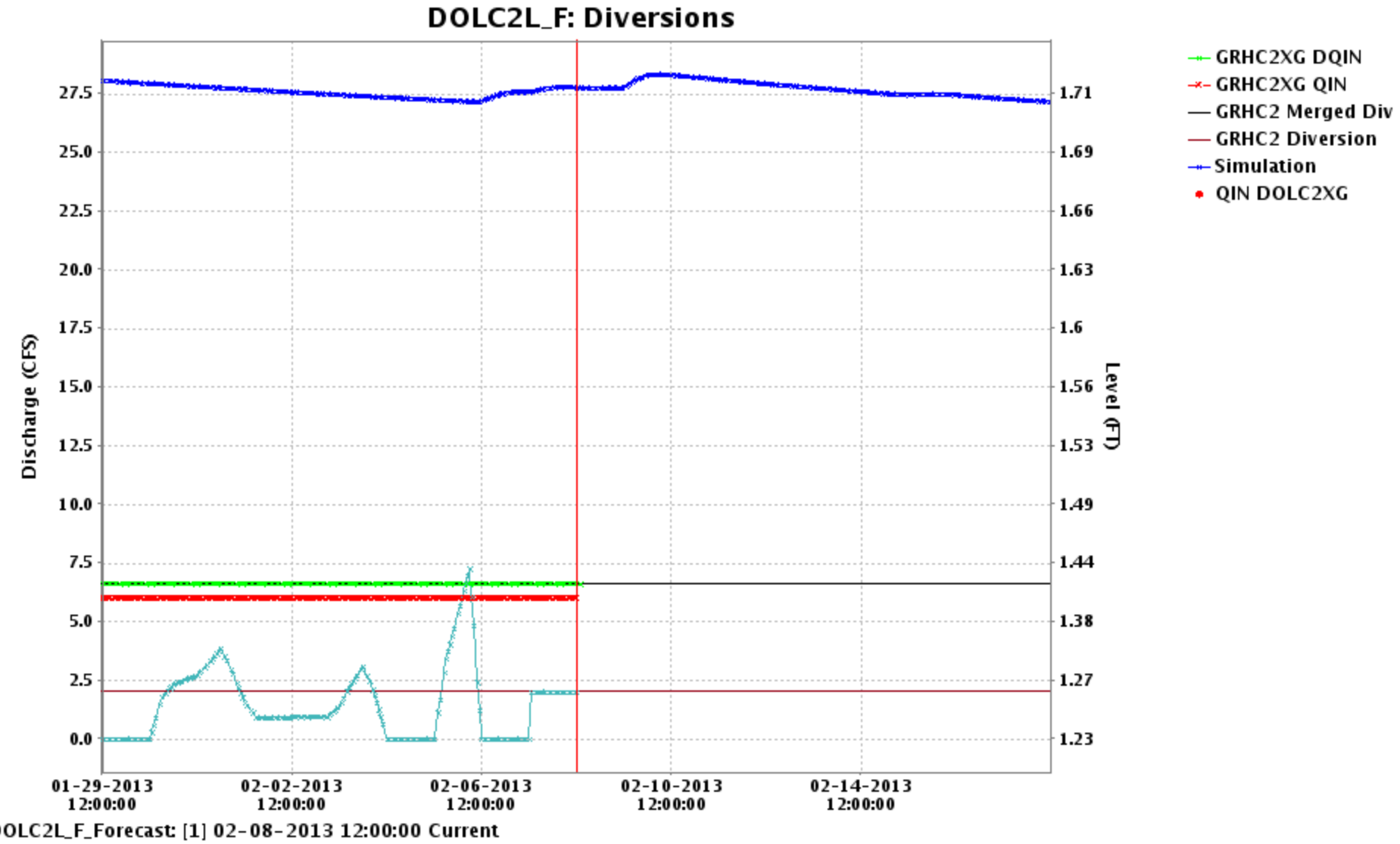
# Simulations - Results (with mods)



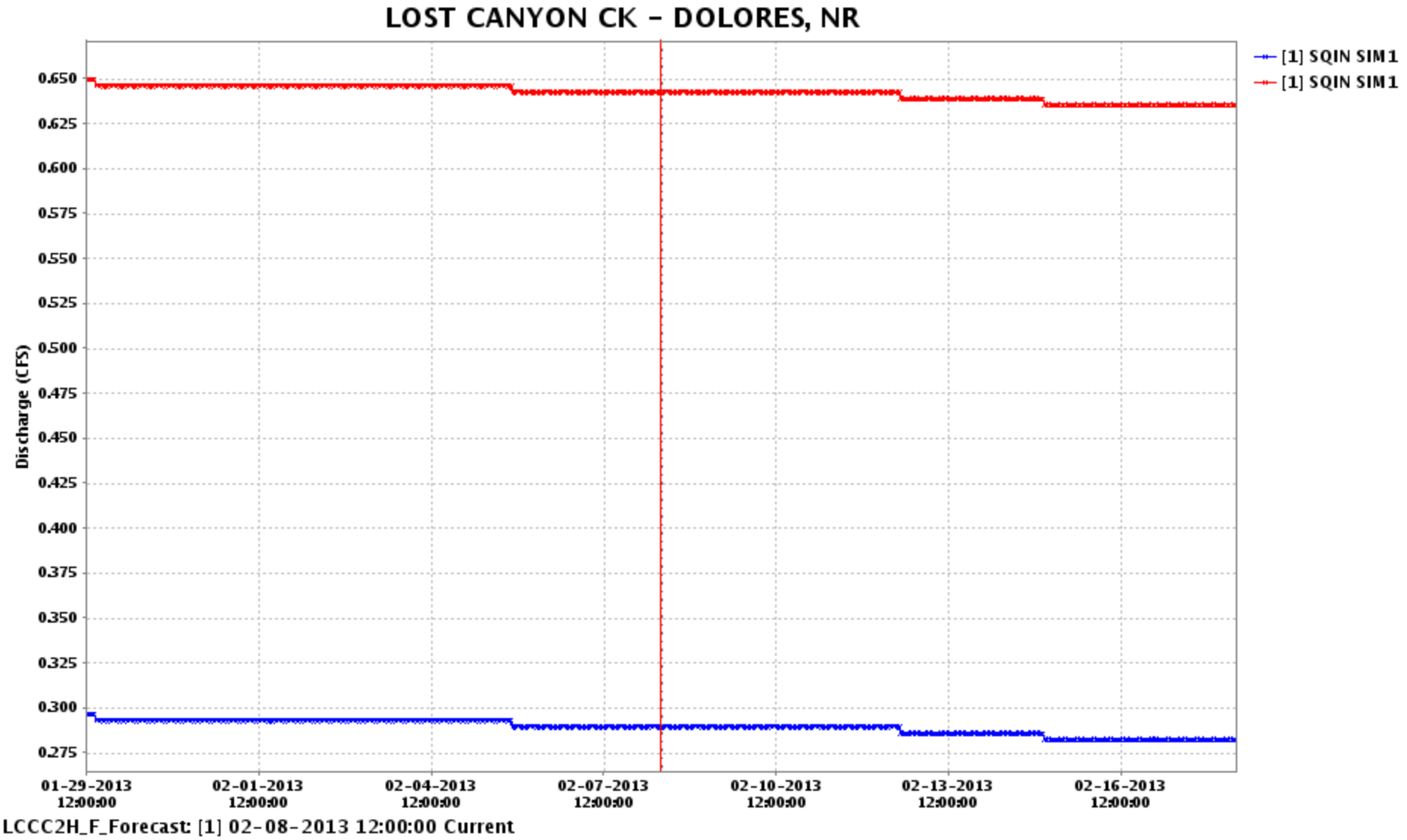
# Dolores - Dolores Forecast



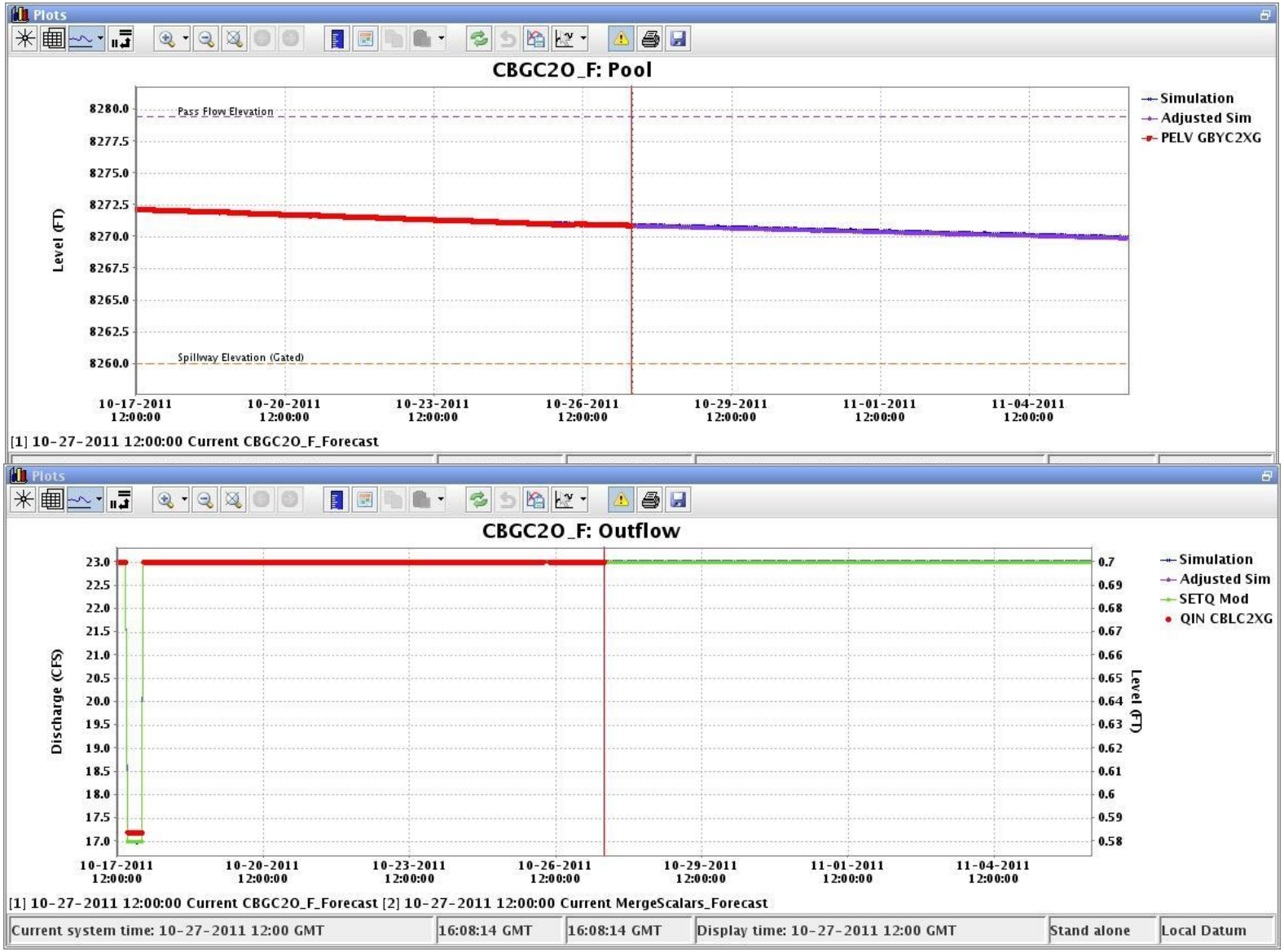
# Dolores - Groundhog



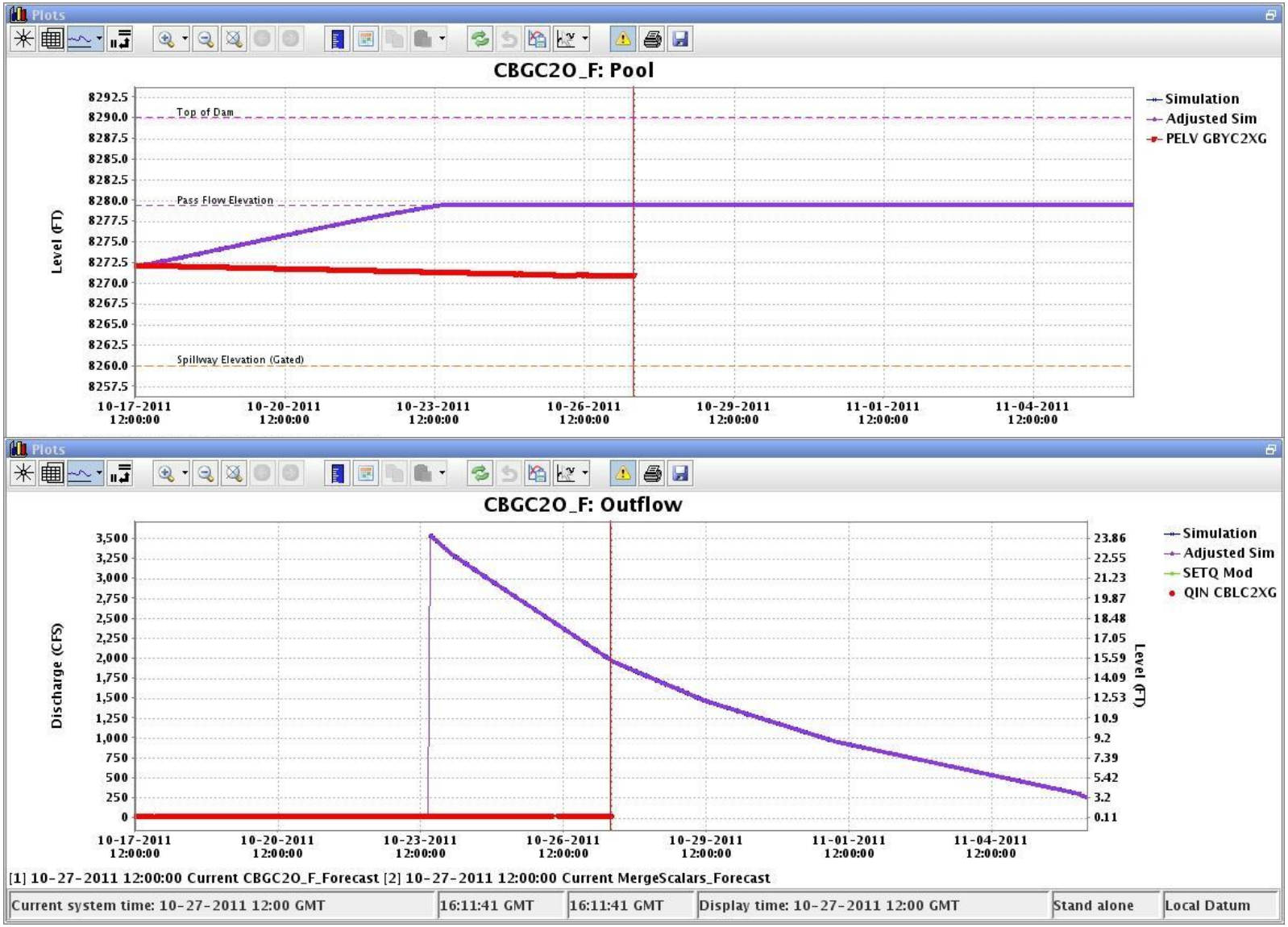
# Lost Canyon - Summit Reservoir



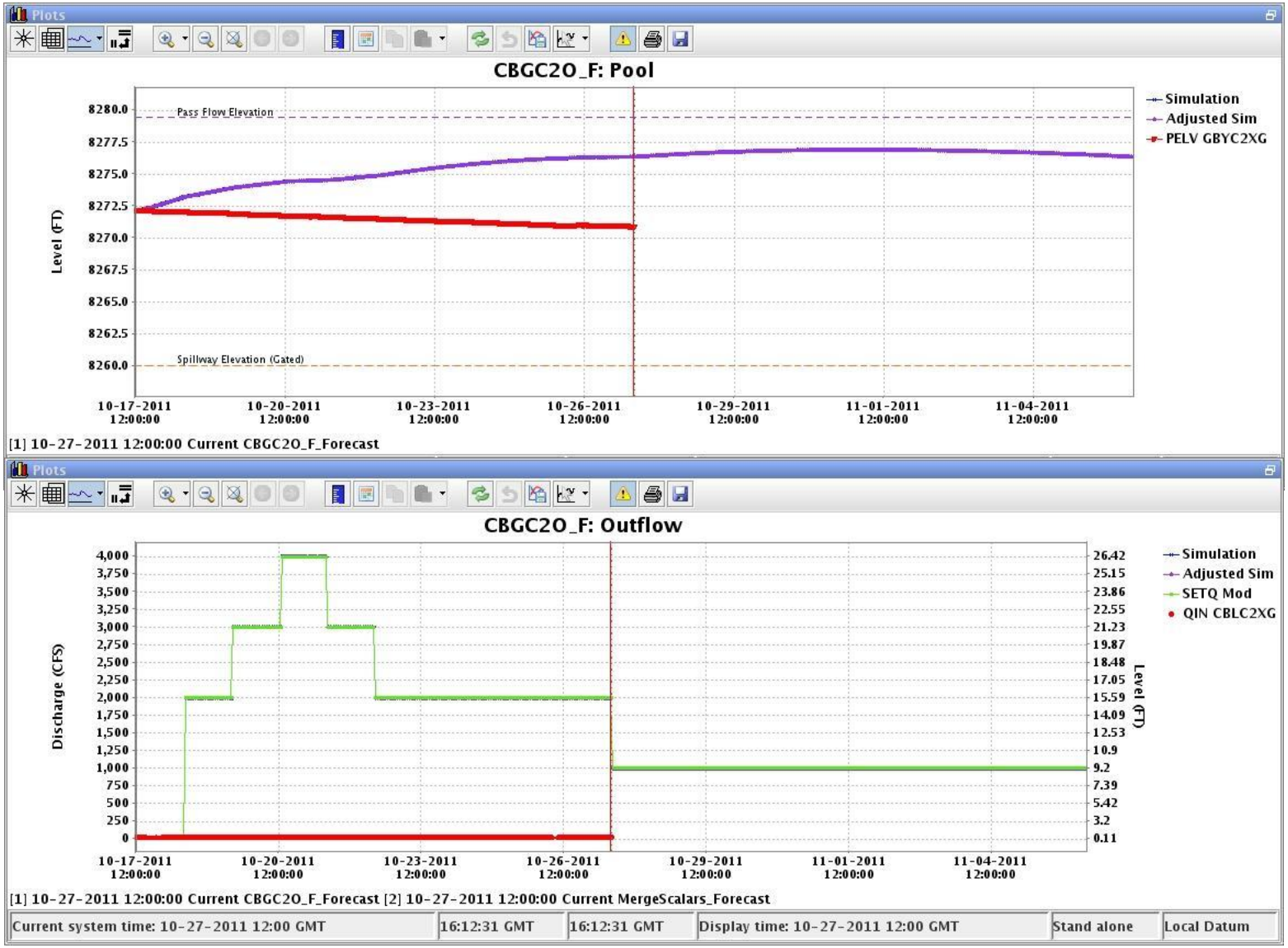
# Reservoir Simulations – Assume Constant Outflow



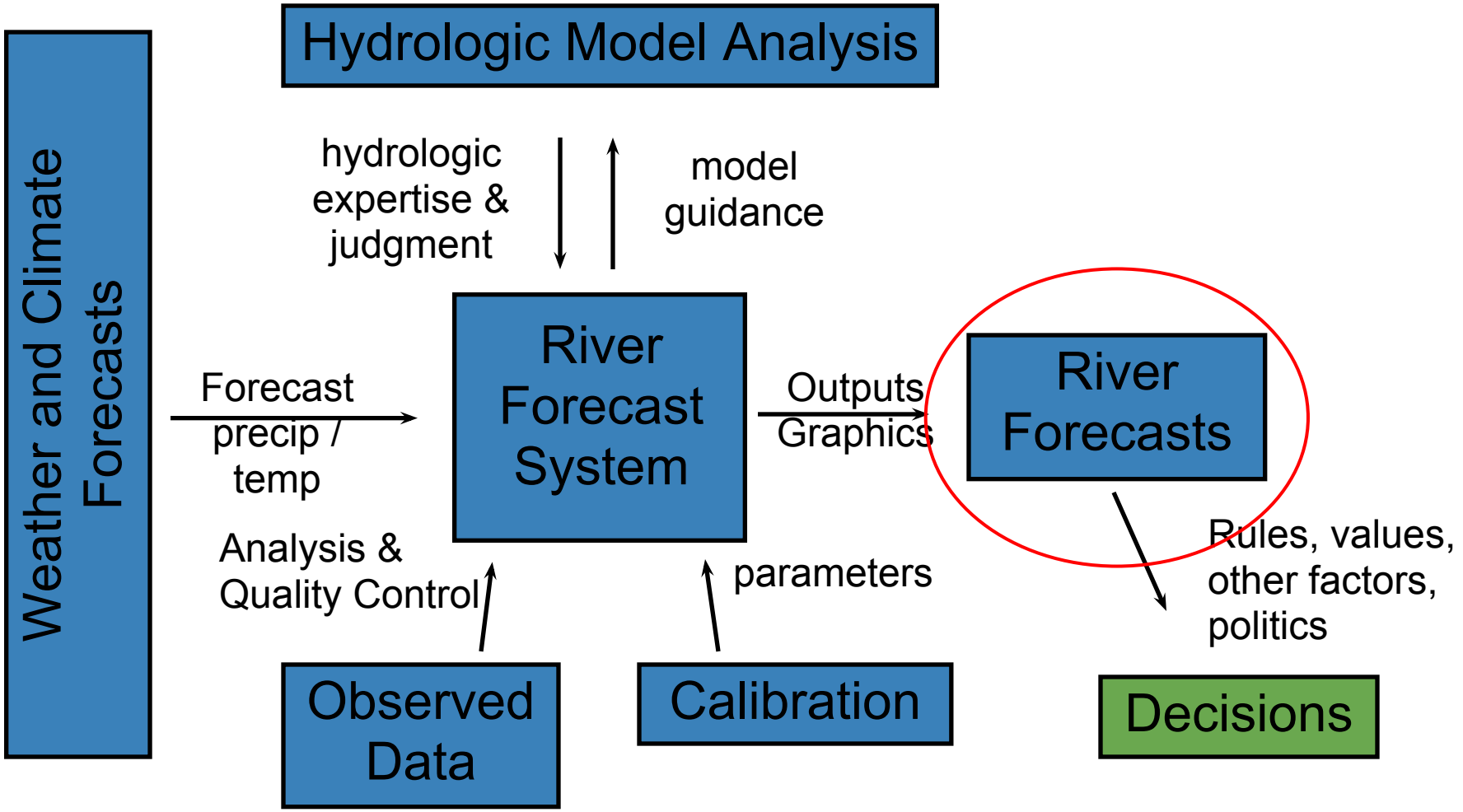
# Reservoir Simulations – Use Rules



# Reservoir Simulations – Release Schedule



# Forecast Process



# Products

Web Graphics
Text Products
Recreation Report

Finished forecasting by 10am

- Update throughout day as needed

# Water Supply Operations

Start January 1st

End June 1st

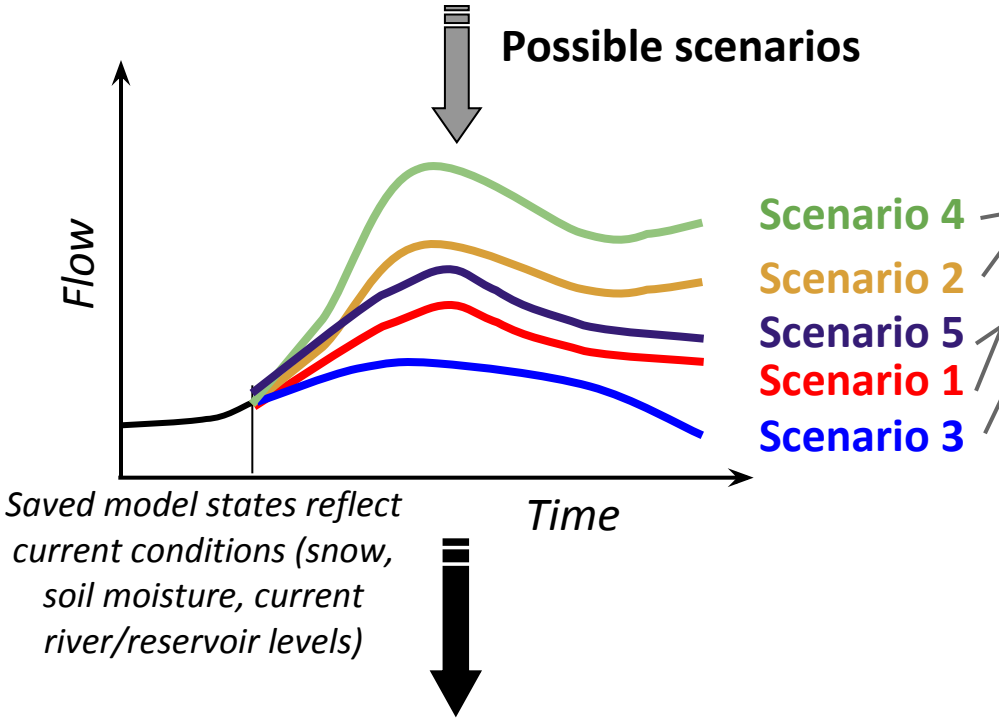
Forecasts at the beginning and middle of each month

Based on Ensemble Streamflow Prediction (ESP) and Statistical Water Supply equations

New for the year is Daily ESP Guidance

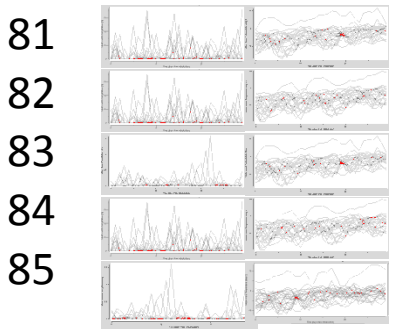
# ESP Technique

Multiple streamflow scenarios with historic meteorological or forecast weather/climatic data




*Saved model states reflect current conditions (snow, soil moisture, current river/reservoir levels)*

Historical time series of precipitation and temperature




*CBRFC: Currently using water years 1981-2010*

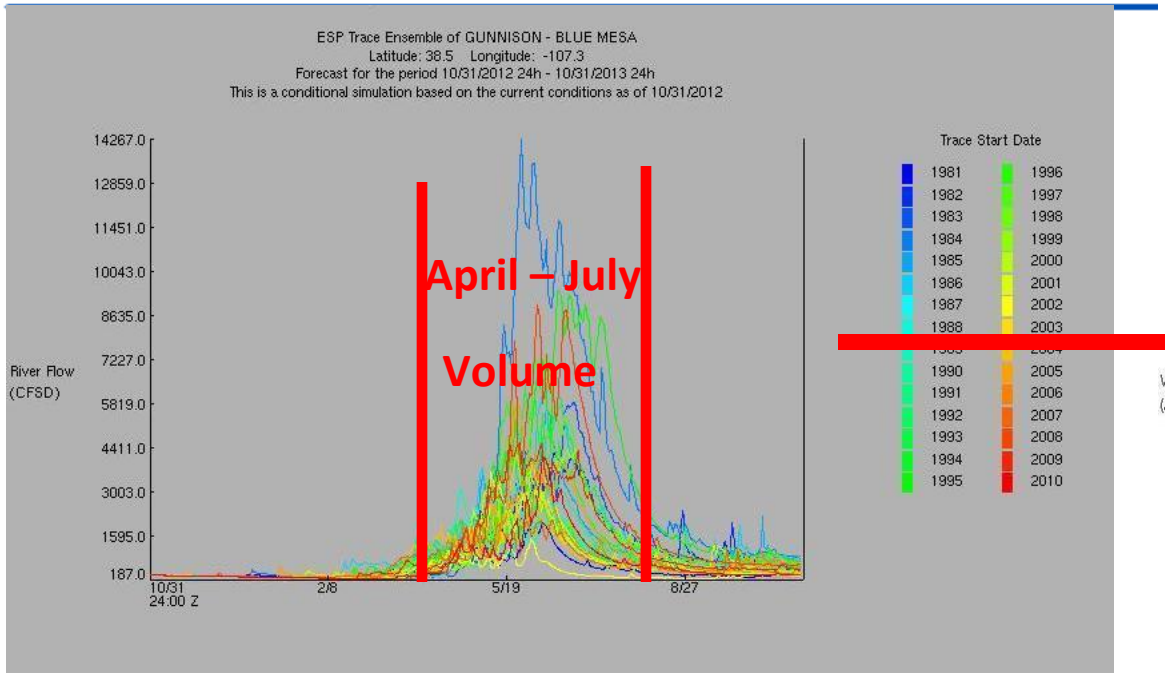
Can also include forecast precipitation and temperature.

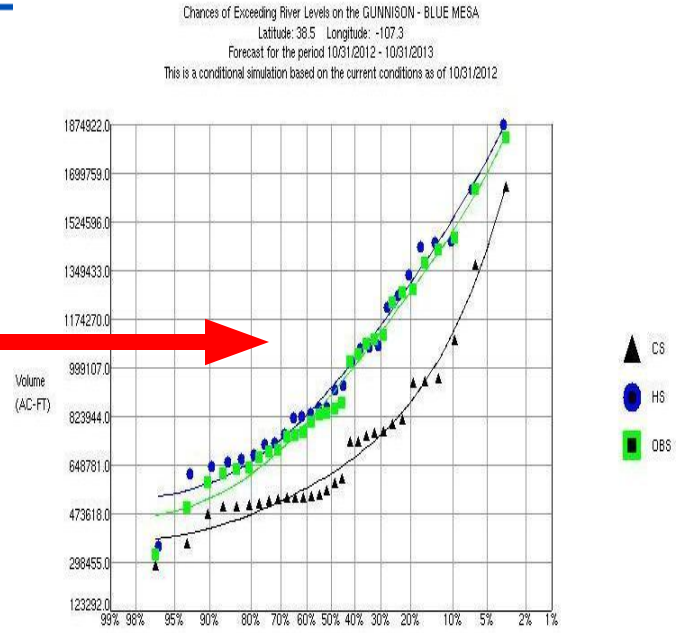
*CBRFC:*

- *Use 10 days of forecast max/min temperatures.*
- *Two runs –*
  - *5 days of forecast precipitation*
  - *0 days of forecast precipitation*

Results used in statistical analysis to produce forecasts with probabilistic values

# Ensemble Streamflow Prediction (ESP)




1. Select a forecast window
2. Select a forecast variable
3. Model derives a distribution function
4. 50% exceedance value = most probable forecast
5. Also use 10%/90% levels

| # Exceedance # Probabilities | Conditional Simulation | Historical Simulation | Historical Observed |
|---|---|---|---|
| 0.900 | 417330.156 | 581462.500 | 525460.000 |
| 0.750 | 493856.750 | 699928.938 | 659224.812 |
| 0.700 | 517683.500 | 741569.312 | 705094.750 |
| 0.600 | 565268.875 | 829048.438 | 799524.375 |
| 0.500 | 616216.625 | 923809.188 | 898919.562 |
| 0.400 | 676330.375 | 1029094.688 | 1006031.062 |
| 0.300 | 755745.938 | 1151067.250 | 1126296.500 |
| 0.250 | 808794.500 | 1222083.250 | 1194804.500 |
| 0.100 | 1123002.375 | 1534576.375 | 1490881.125 |

# ESP 'Modes'

## UNREGULATED

**(Water Supply Volume Forecasts)**

- Not what will be observed in the rivers.
- No diversions (for places we have historical/real time measurements).
  - Trans-basin diversions.
- No water held by reservoirs (passes through).
- Consumptive Use operation still in effect.

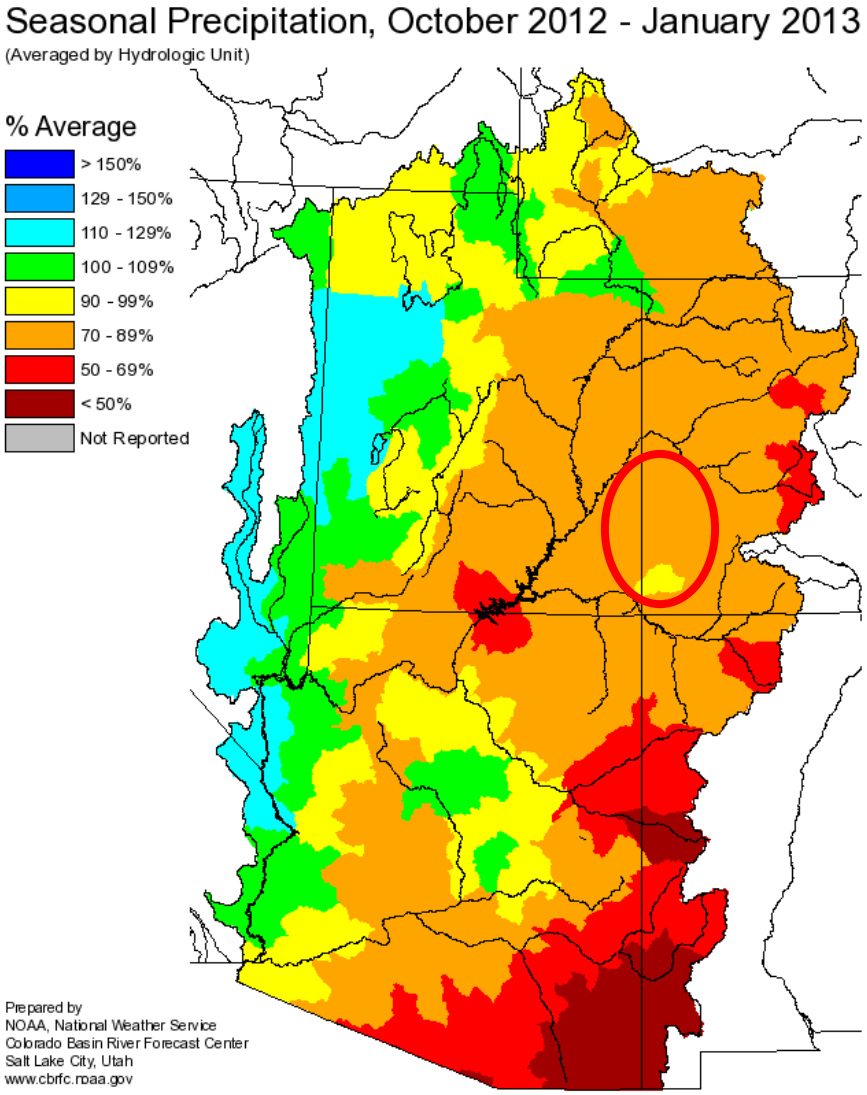
## REGULATED

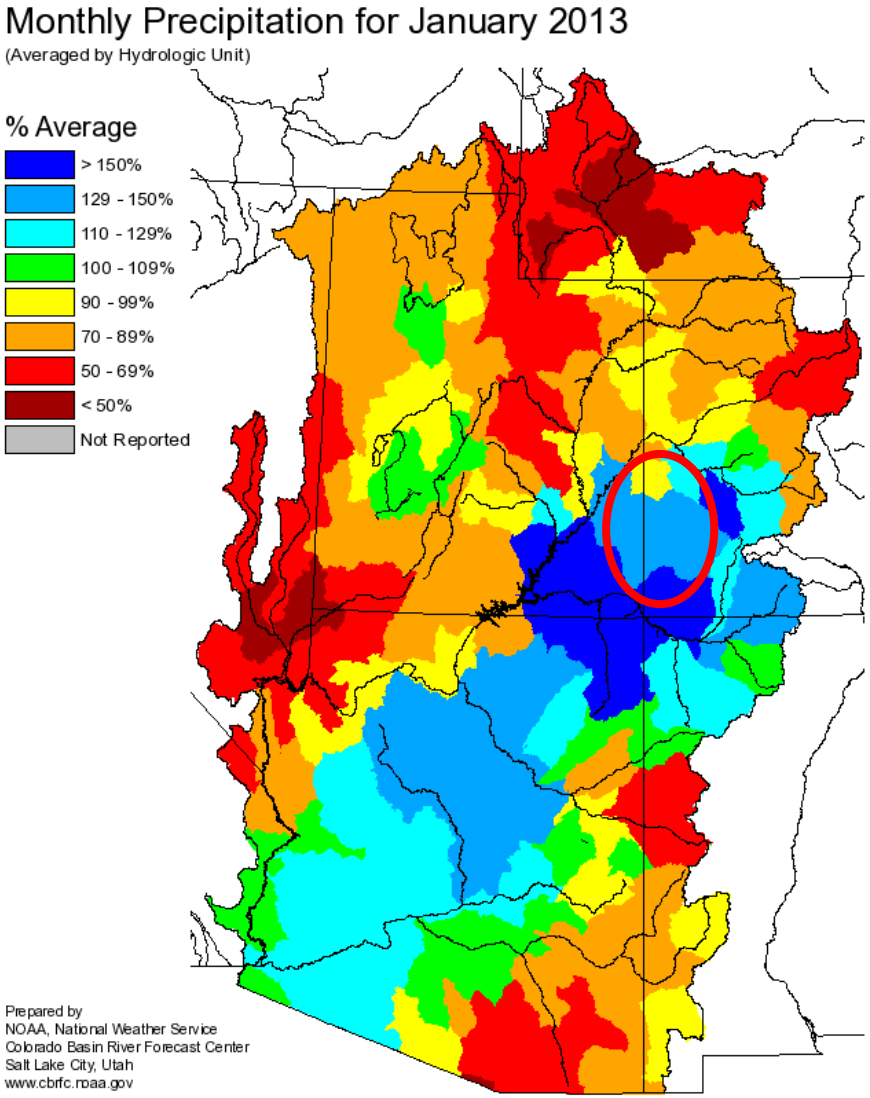
**(Peak Flow Forecasts)**

- Observed mean daily peak.
- Historical diversion data used in calculation of each year's hydrograph.
- Reservoirs operated based on a set of 'rules'.
  - Time of year or elevation.
- Similar to daily forecast methodology.

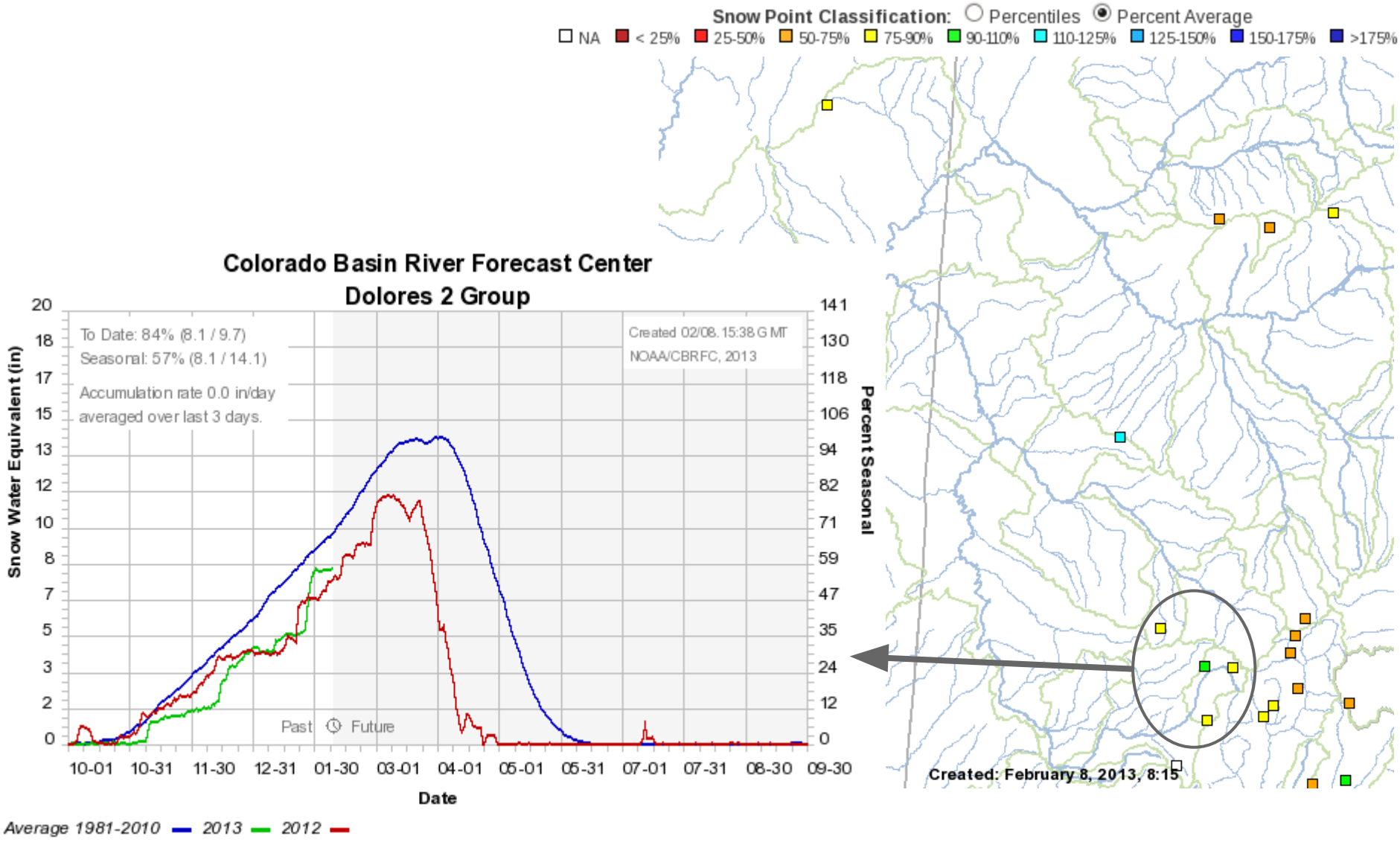
# Current McPhee April - July Volume Forecast

# Precipitation



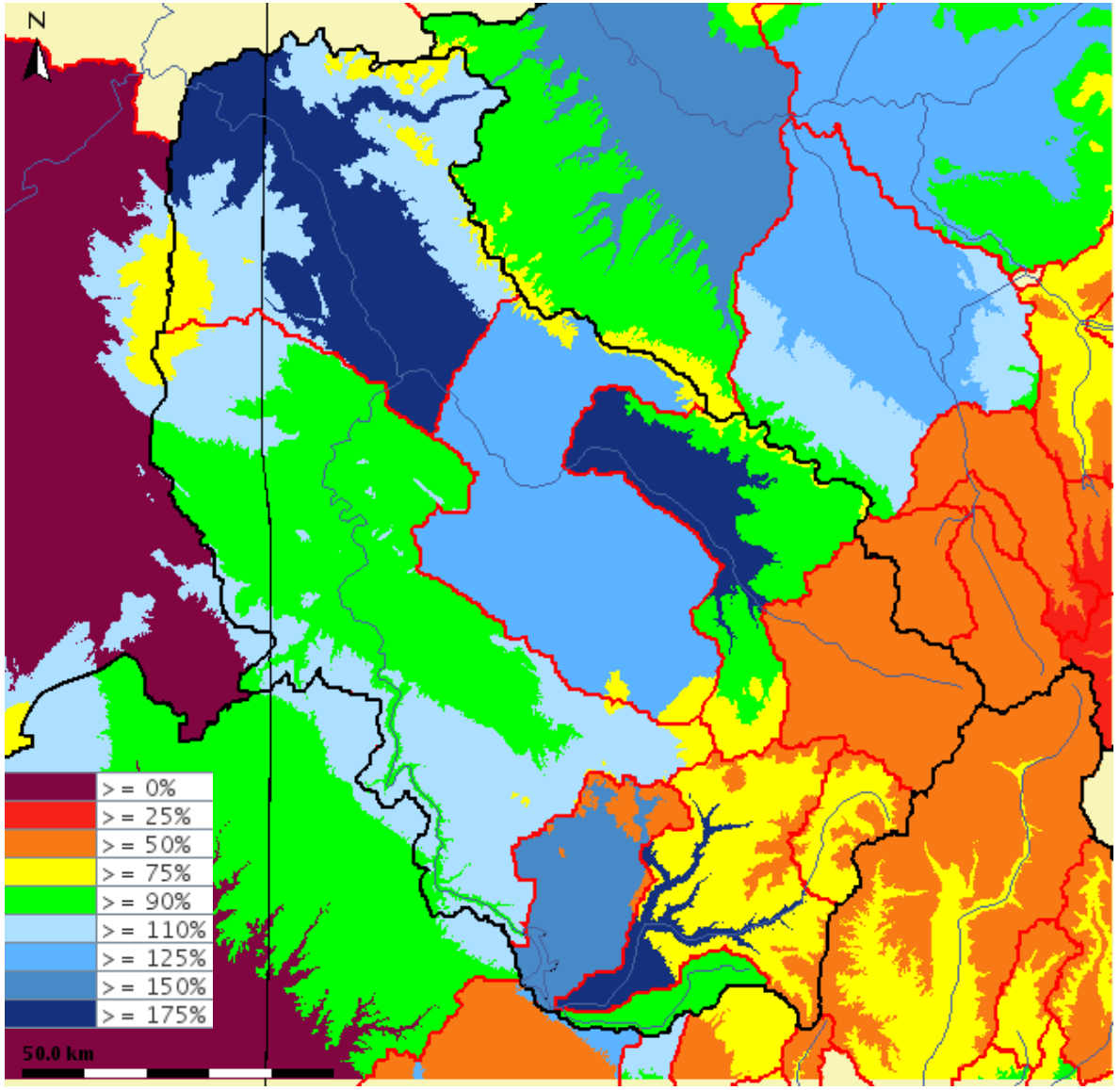



# Current Snow Conditions



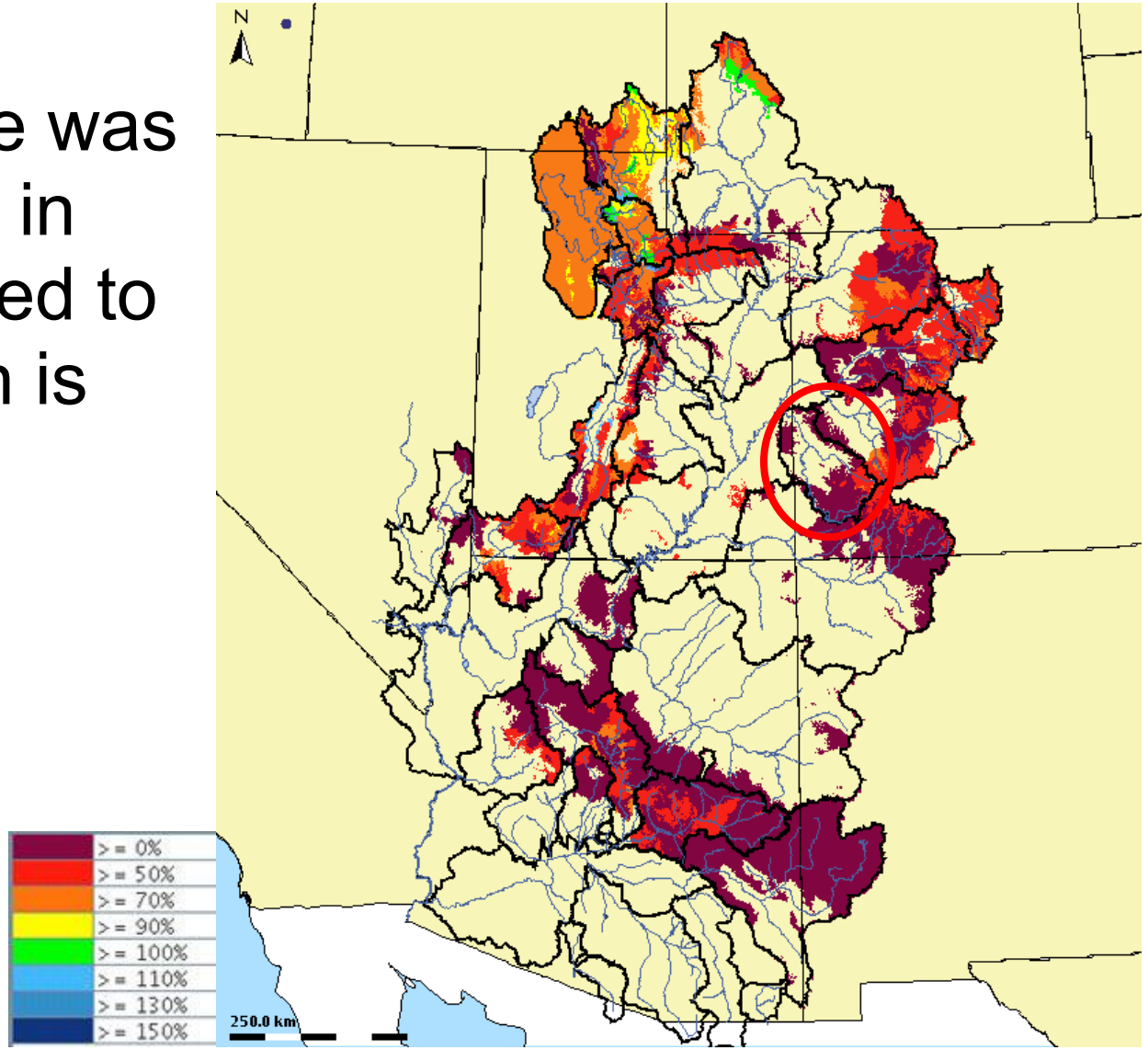
# Feb 8th Model Snow % of Avg

Cooler lower elevation temperatures causing higher % averages in lower zones.



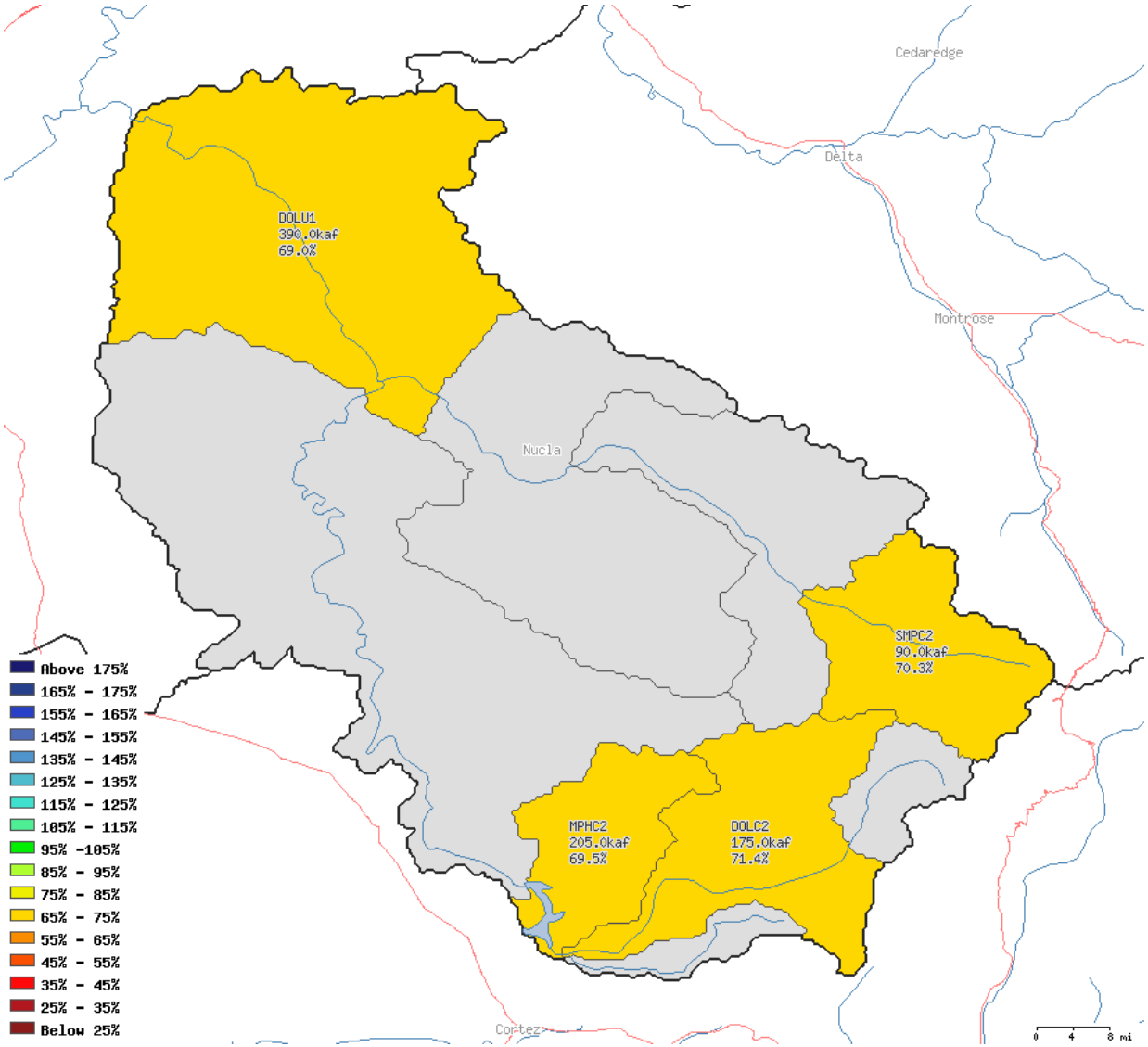
# 2012 December Soil Moisture

Above McPhee was about average in 2011, Compared to this year which is well below.

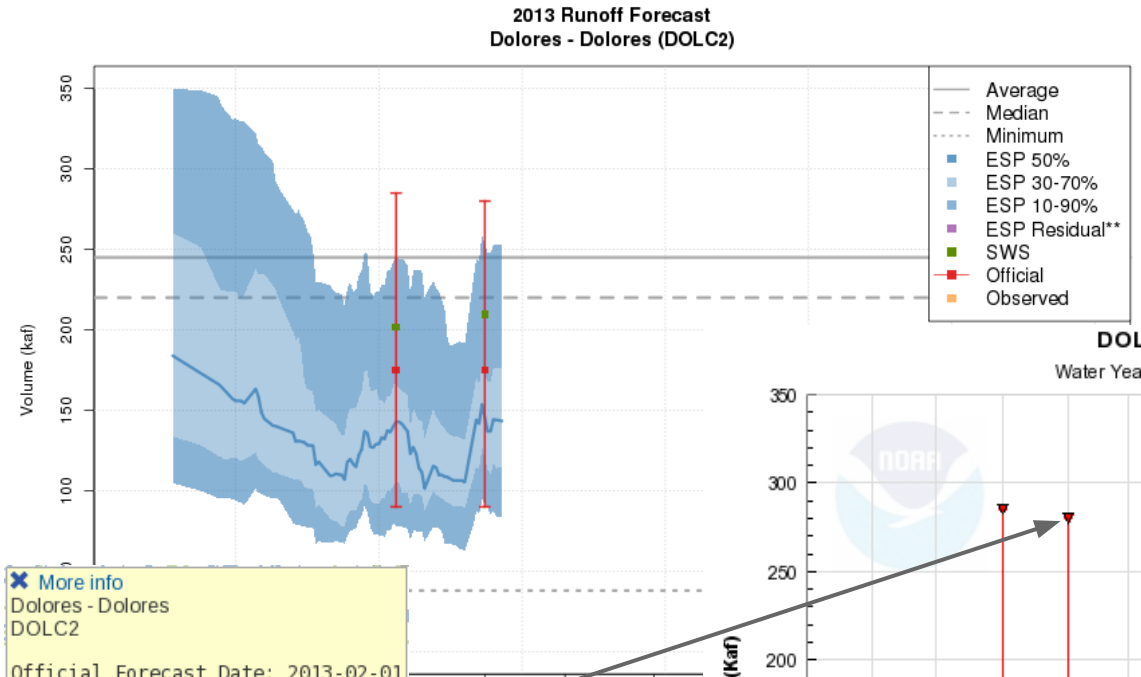


# April - July Volume Forecast

Dolores -
175 kaf
71.4%
McPhee -
205 kaf
69.5%



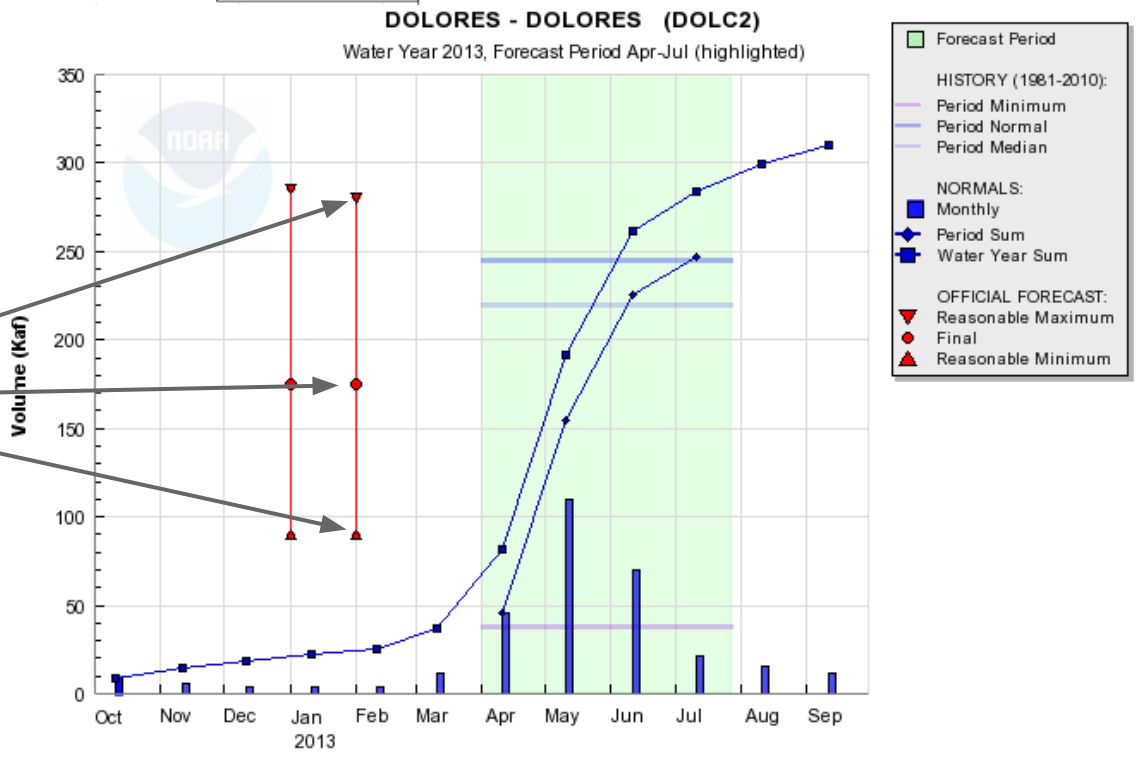
# Dolores April-July Evolution Plot




More info
Dolores - Dolores
DOLC2

| | |
|---|---|
| Official Forecast Date: | 2013-02-01 |
| Official Min (90%): | 90 kaf |
| Official MP (50%): | **175 kaf** |
| Official Max (10%): | 280 kaf |
| Official Percent Avg: | **71%** |
| Official Percent Med: | **80%** |
| Average: | *245 kaf* |
| Median: | *220 kaf* |
| ESP Min (90%): | 83 kaf |
| ESP Min (70%): | 114 kaf |
| ESP MP (50%): | **143 kaf** |
| ESP Min (30%): | 176 kaf |
| ESP Max (10%): | 253 kaf |
| ESP Percent Average: | **58%** |
| ESP Percent Median: | **65%** |
| ESP Date: | 2013-02-07 |

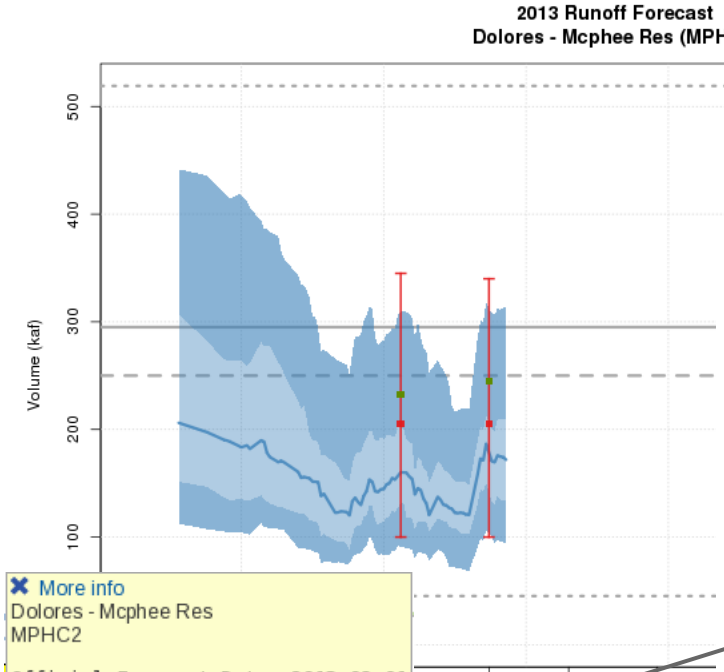
02-07 13:35:58, Lastest ESP Run from 2
72.5 in 1926, Minimum of 38 in 1977 Av




No data before 2012-10-01

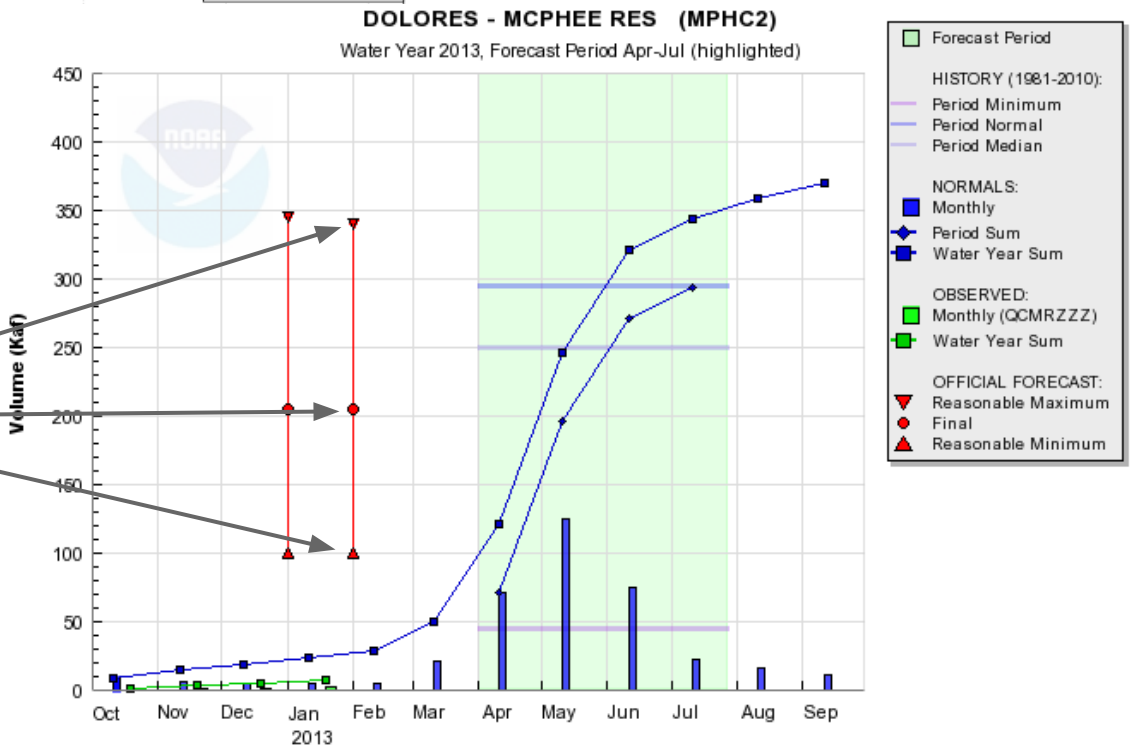
CBRFC/NWS/NOAA 02/08/13 16:16:14 UTC

# McPhee April-July Evolution Plot

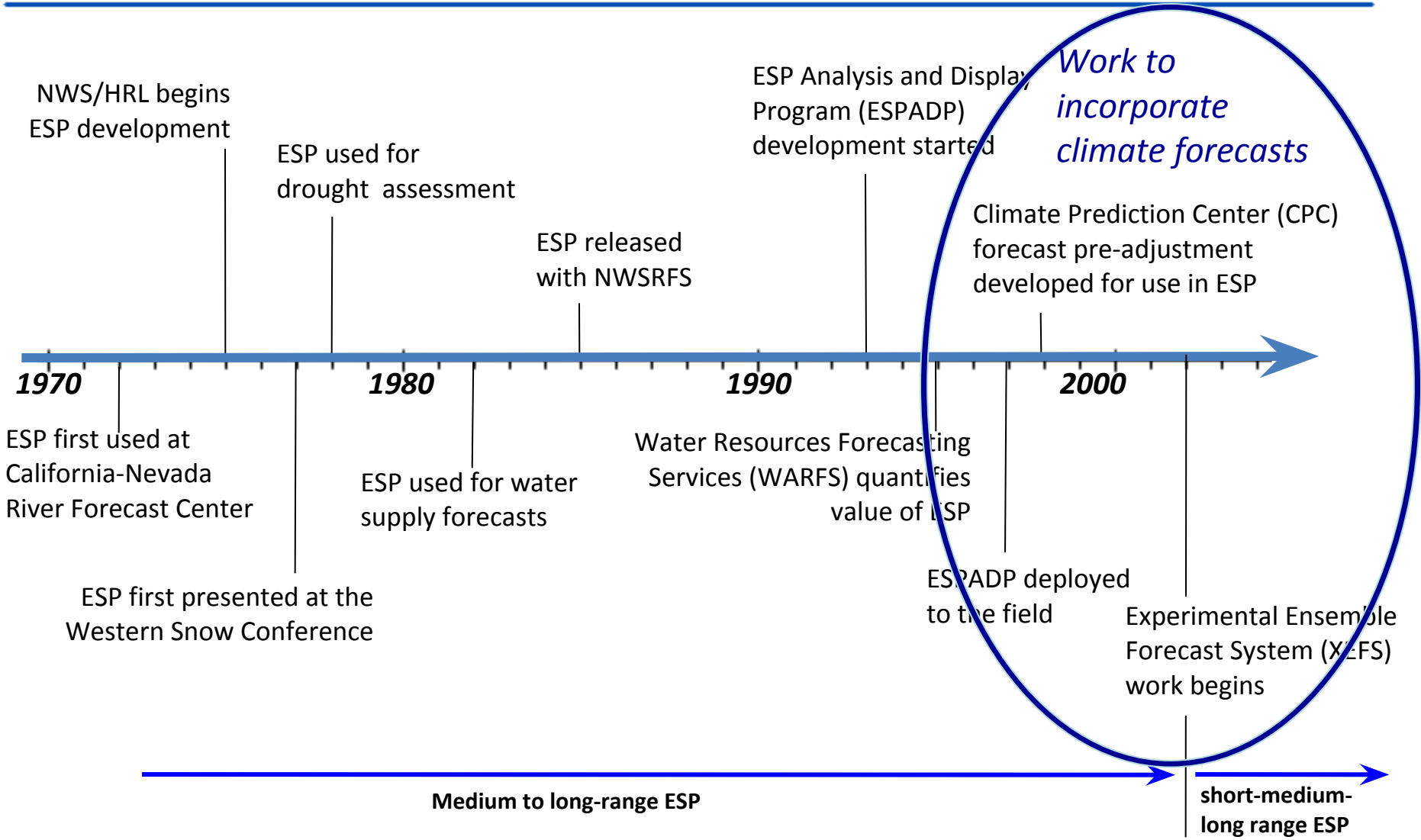



More info
Dolores - Mcphee Res
MPHC2

| | |
|---|---|
| Official Forecast Date: | 2013-02-01 |
| Official Min (90%): | 100 kaf |
| Official MP (50%): | **205 kaf** |
| Official Max (10%): | 340 kaf |
| Official Percent Avg: | **69%** |
| Official Percent Med: | **82%** |
| Average: | *295 kaf* |
| Median: | *250 kaf* |
| ESP Min (90%): | 95 kaf |
| ESP Min (70%): | 134 kaf |
| ESP MP (50%): | **172 kaf** |
| ESP Min (30%): | 209 kaf |
| ESP Max (10%): | 314 kaf |
| ESP Percent Average: | **58%** |
| ESP Percent Median: | **69%** |
| ESP Date: | 2013-02-07 |



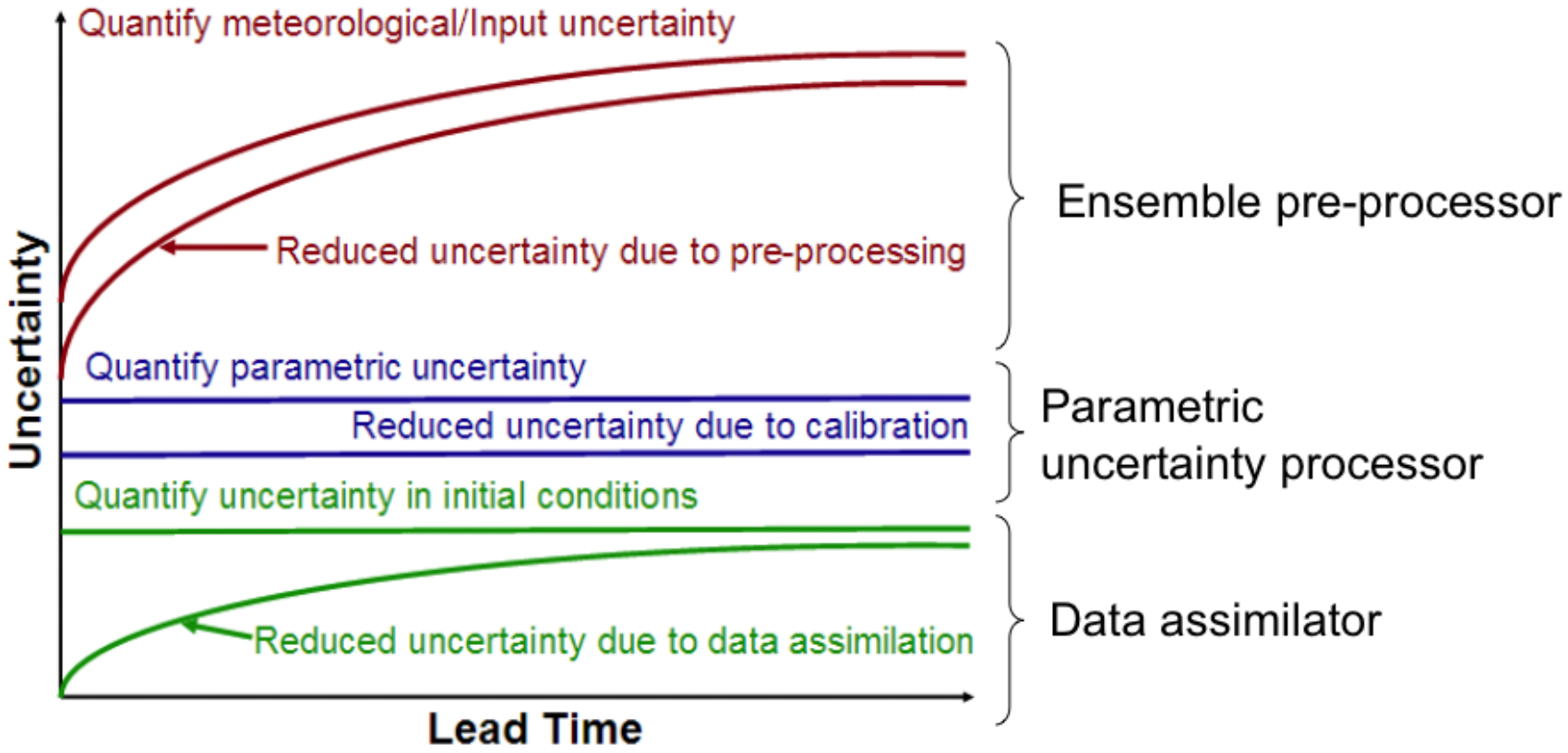
# Historic development of ESP



# Hydrologic Ensemble Forecast System (HEFS)

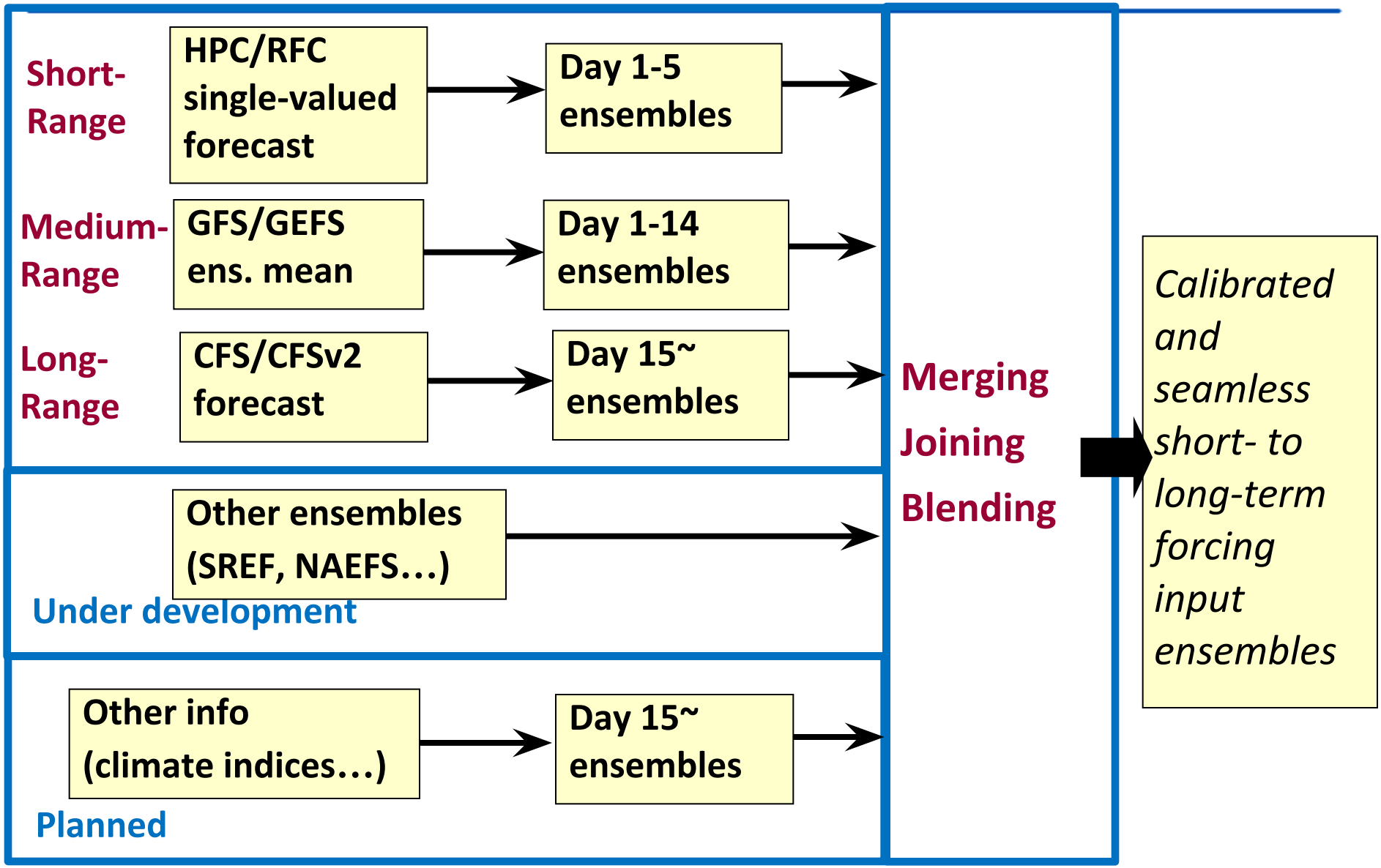
- Motivations:
  - Quantify and reduce uncertainties in ESP due to:
    - Future weather and climate
    - Calibration
    - Initial conditions
  - Provide unbiased and skillful forecast ensembles to stakeholders and NWS hydrologic forecast products
  - Generate reforecast dataset consistent with real time forecasts

# Uncertainties in Hydrologic Forecast

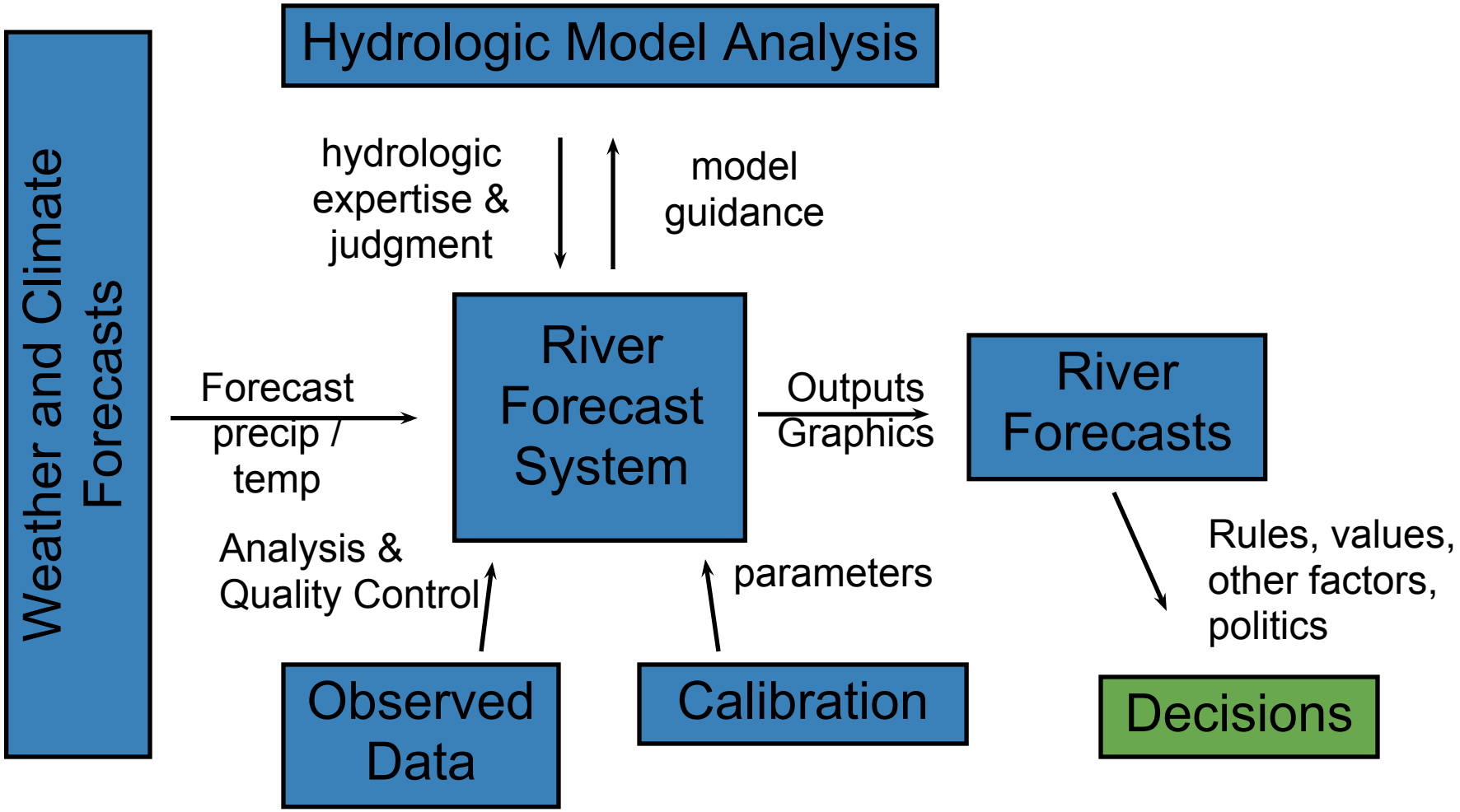



Flow regulations: A large challenge

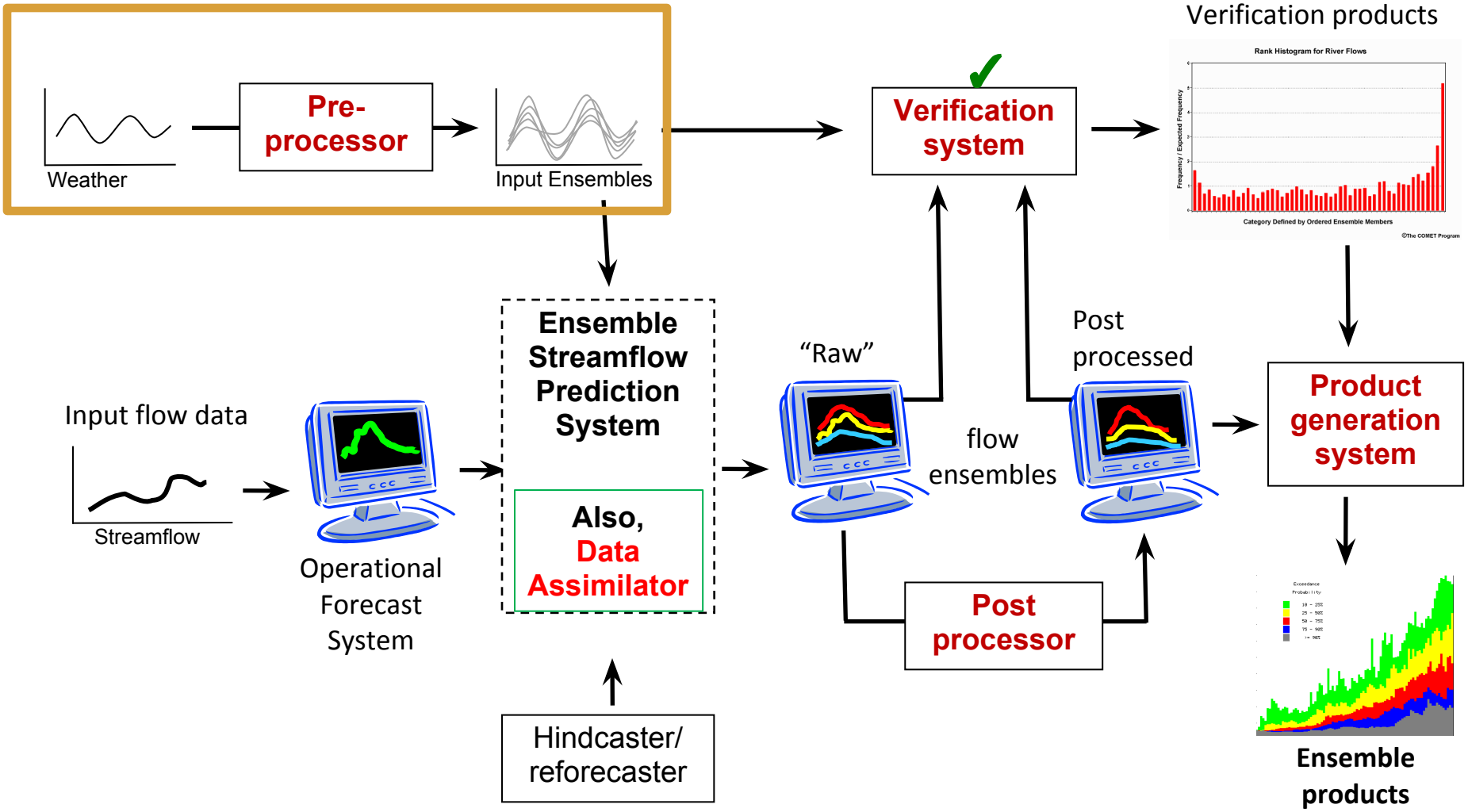
# Atmospheric Ensemble Processor: current & new forecast sources



# Forecast Process



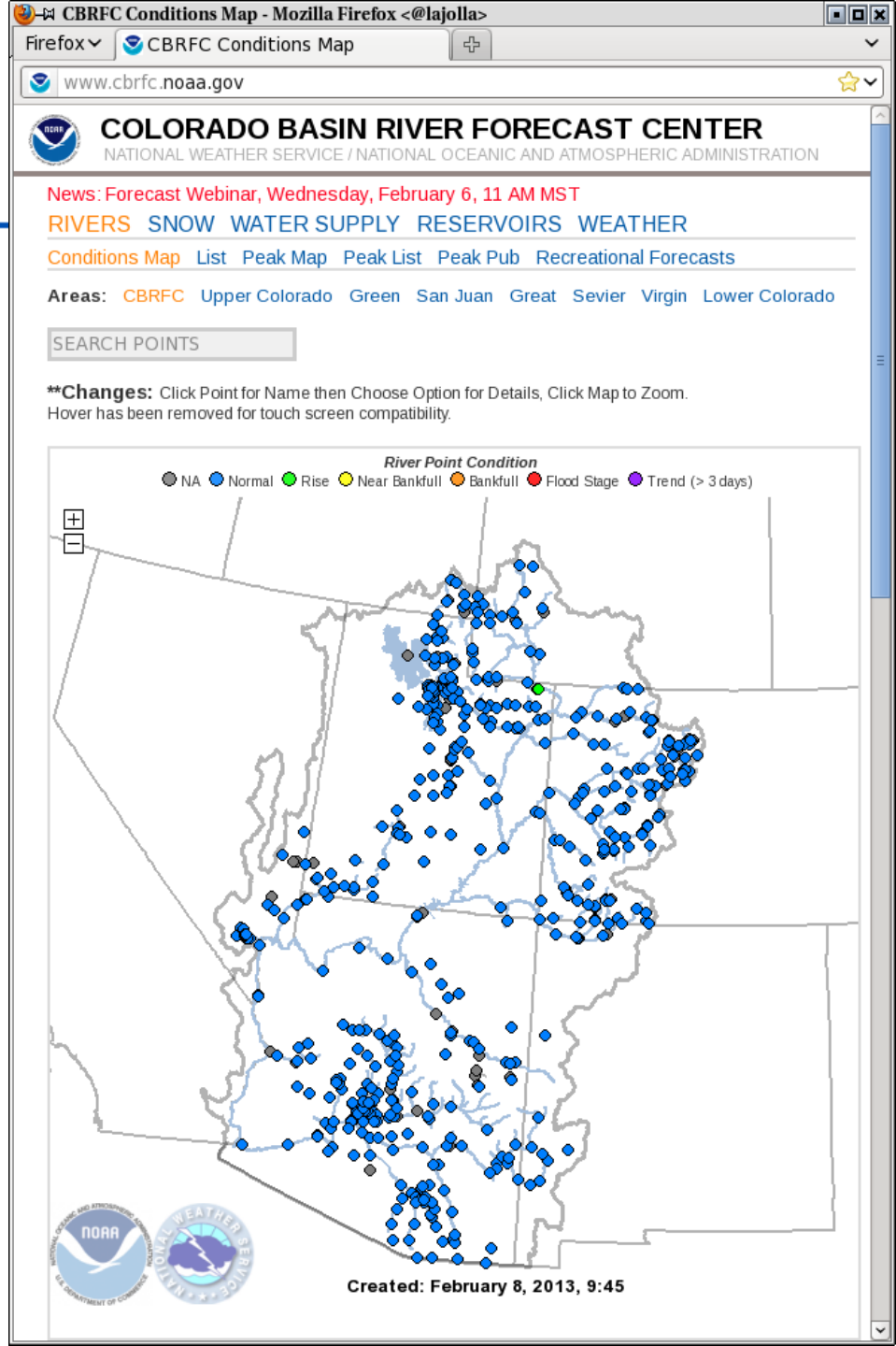
# Upgrade Forecast - ESP Process



# Web Site Overview

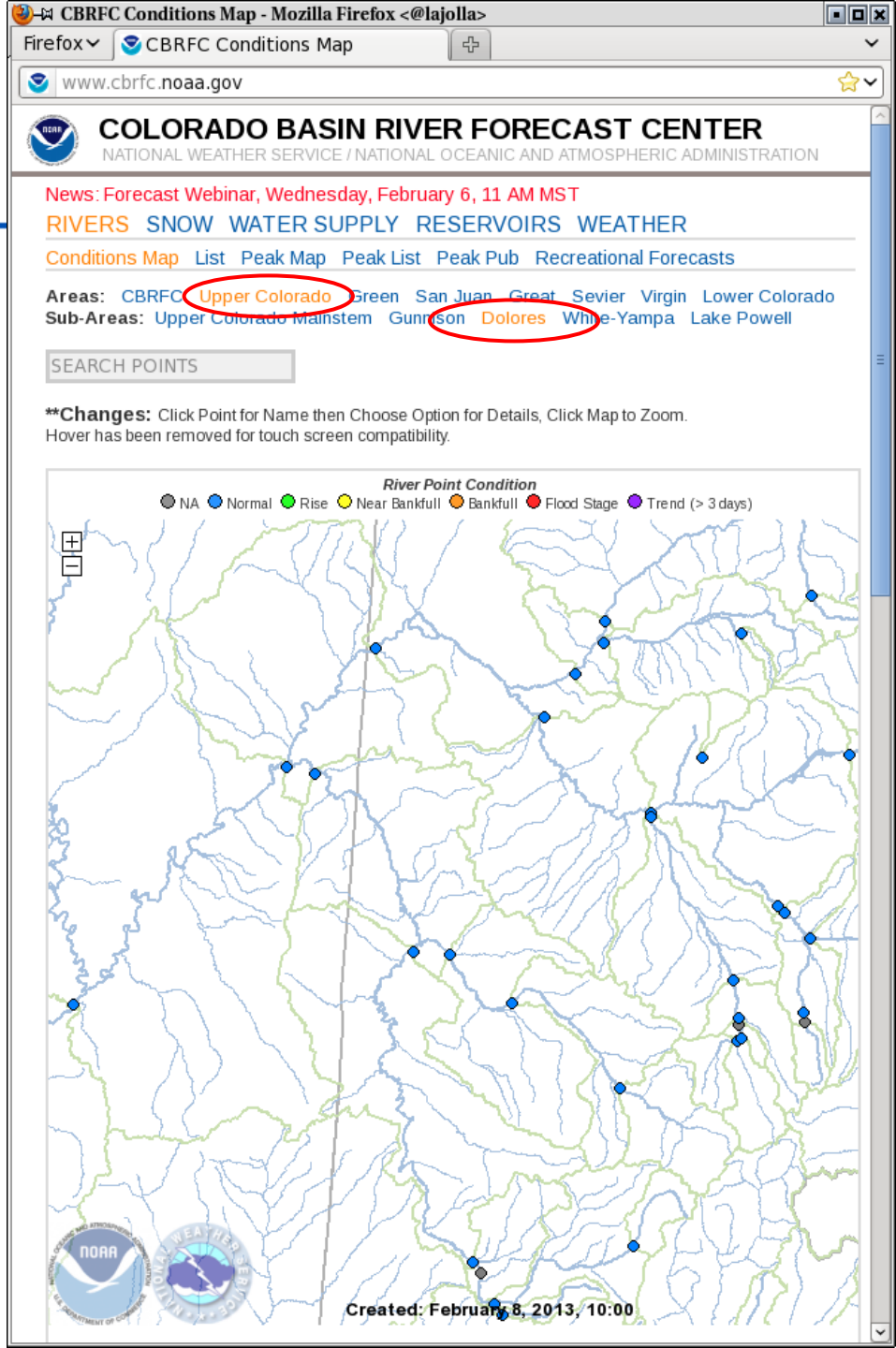
## CBRFC Home Page

http://www.cbrfc.noaa.gov/



# Web Site Overview

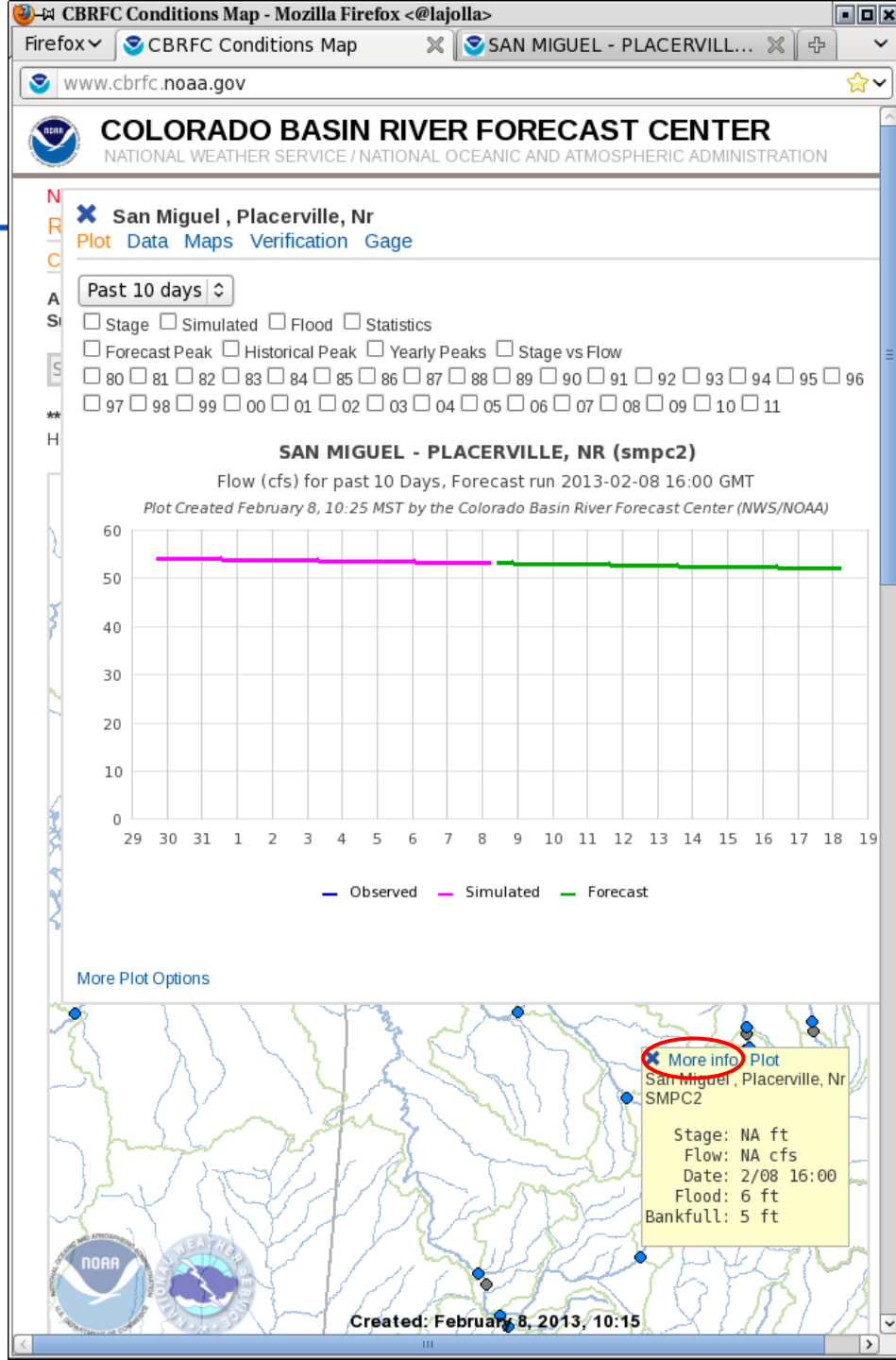
Choosing the Area and Sub-Area will drill the map to the selection



# Web Site Overview

Clicking a River Icon will pop up an information box with the current stage and flow if available.

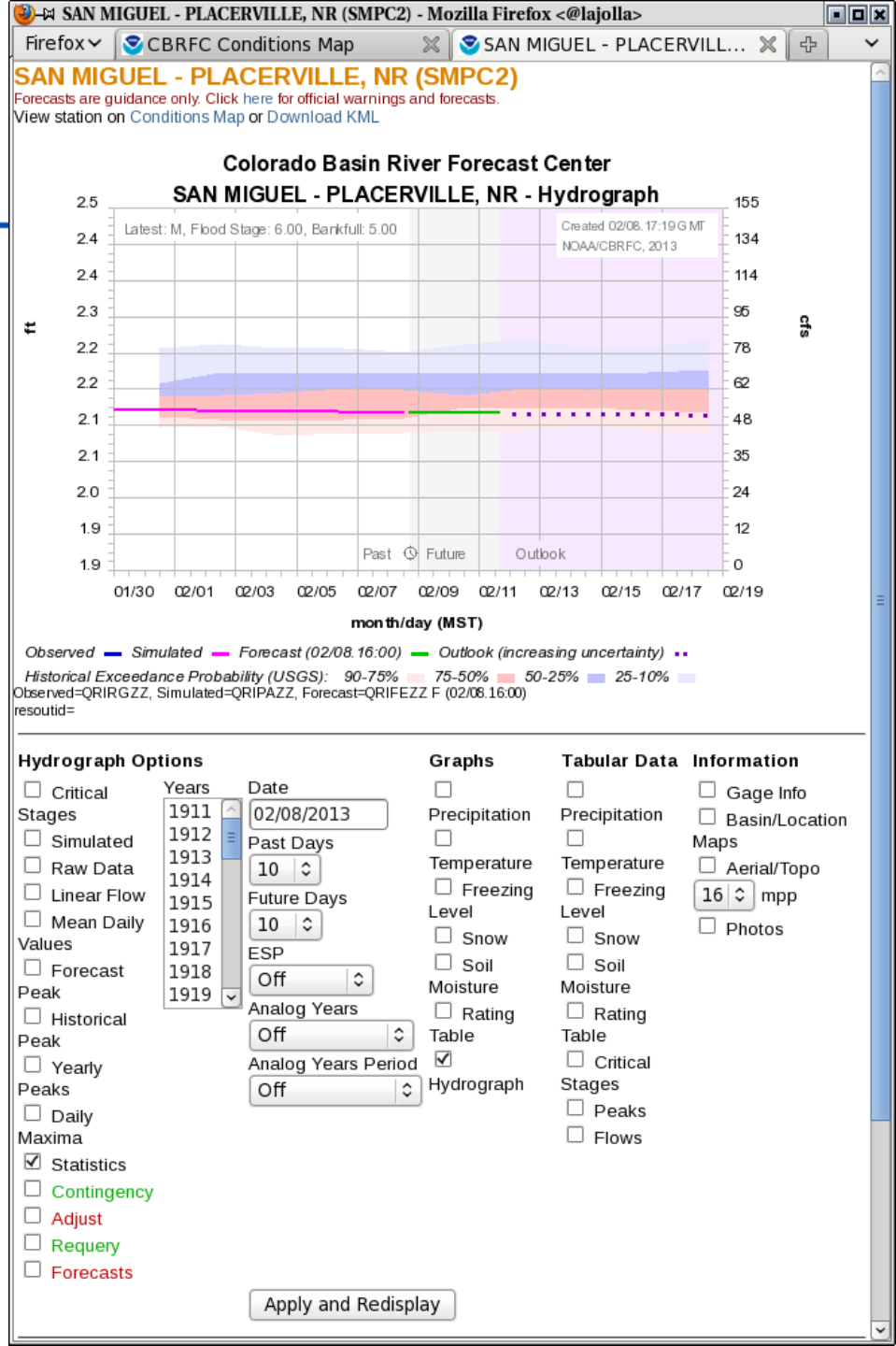
Clicking *More info* will pop up a plot on the page while Clicking *Plot* will open a new tab with the station plot



# Web Site Overview

River Plot page.

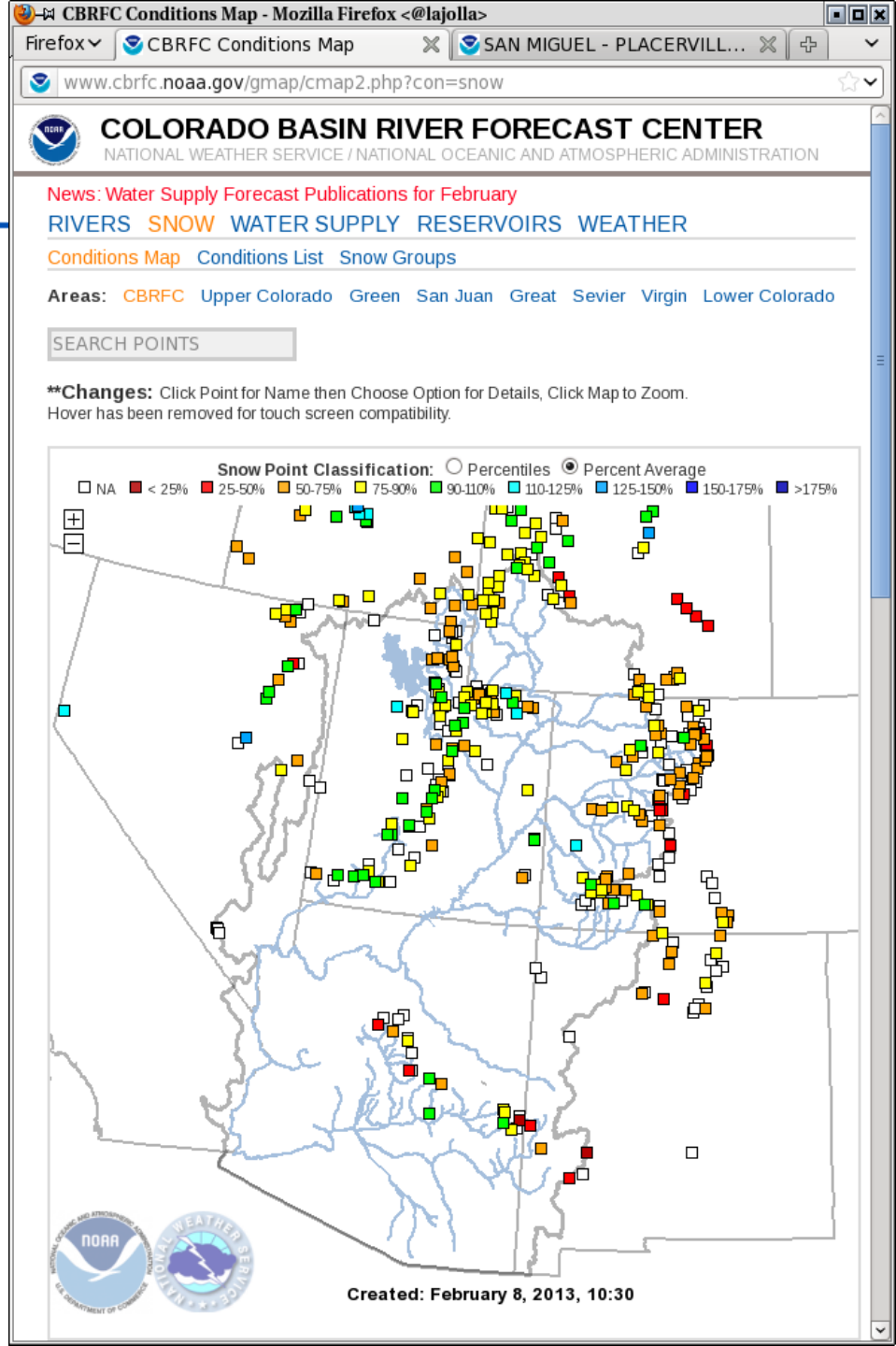
Many options to display different data



# Web Site Overview

Snow, Water Supply and Reservoir Map work the same way.

http://www.cbrfc.noaa.gov/gmap/cmap2.php?con=snow

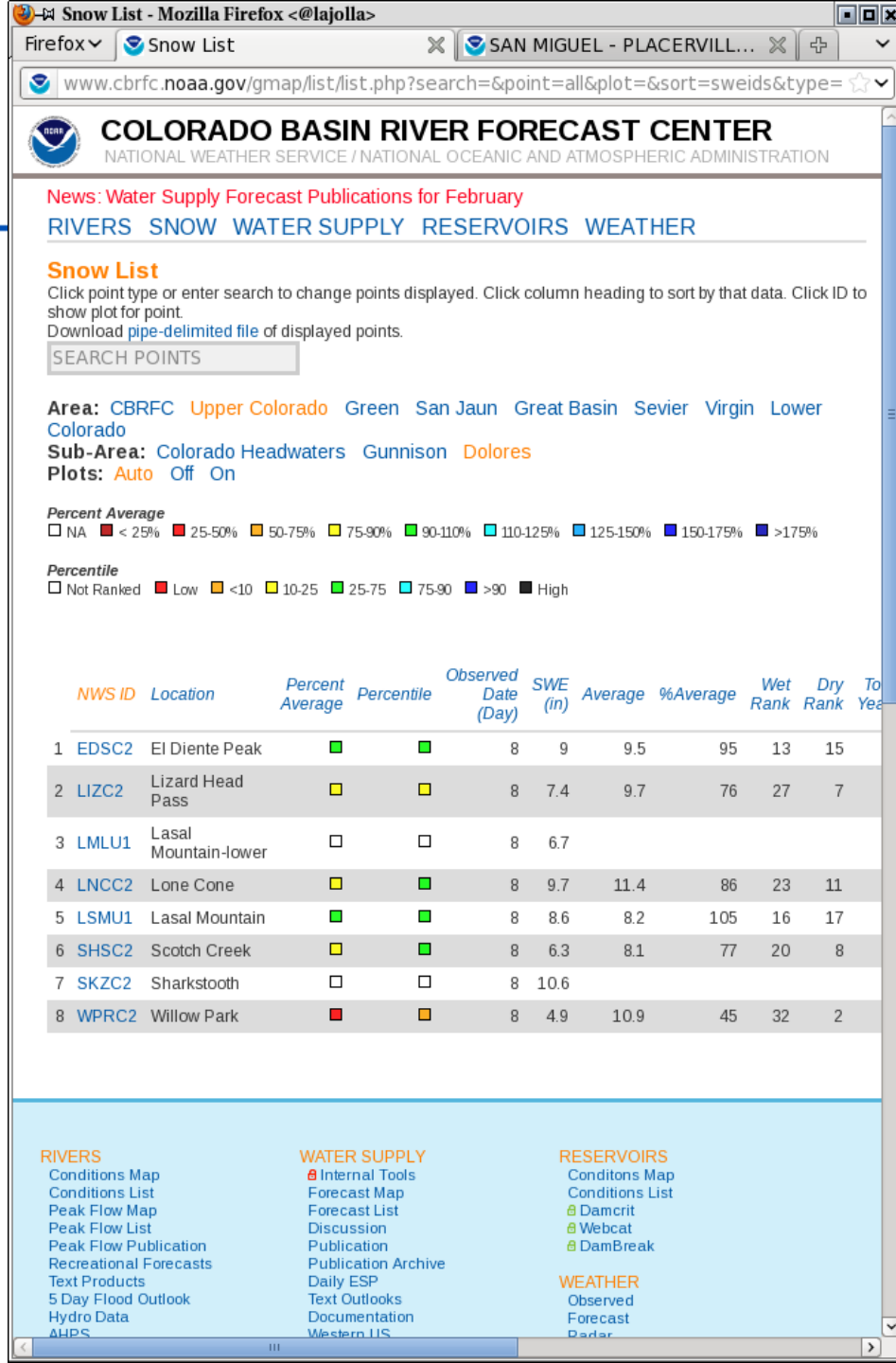


# Web Site Overview

River, Snow, Water Supply and Reservoirs can also be displayed as a list.

Example here is a Dolores Snow List

http://www.cbrfc.noaa.gov/gmap/list/list.php?search=&point=all&plot=&sort=sweids&type=snow&basin=1&subbasin=2&espqpf=0&espdist=empirical

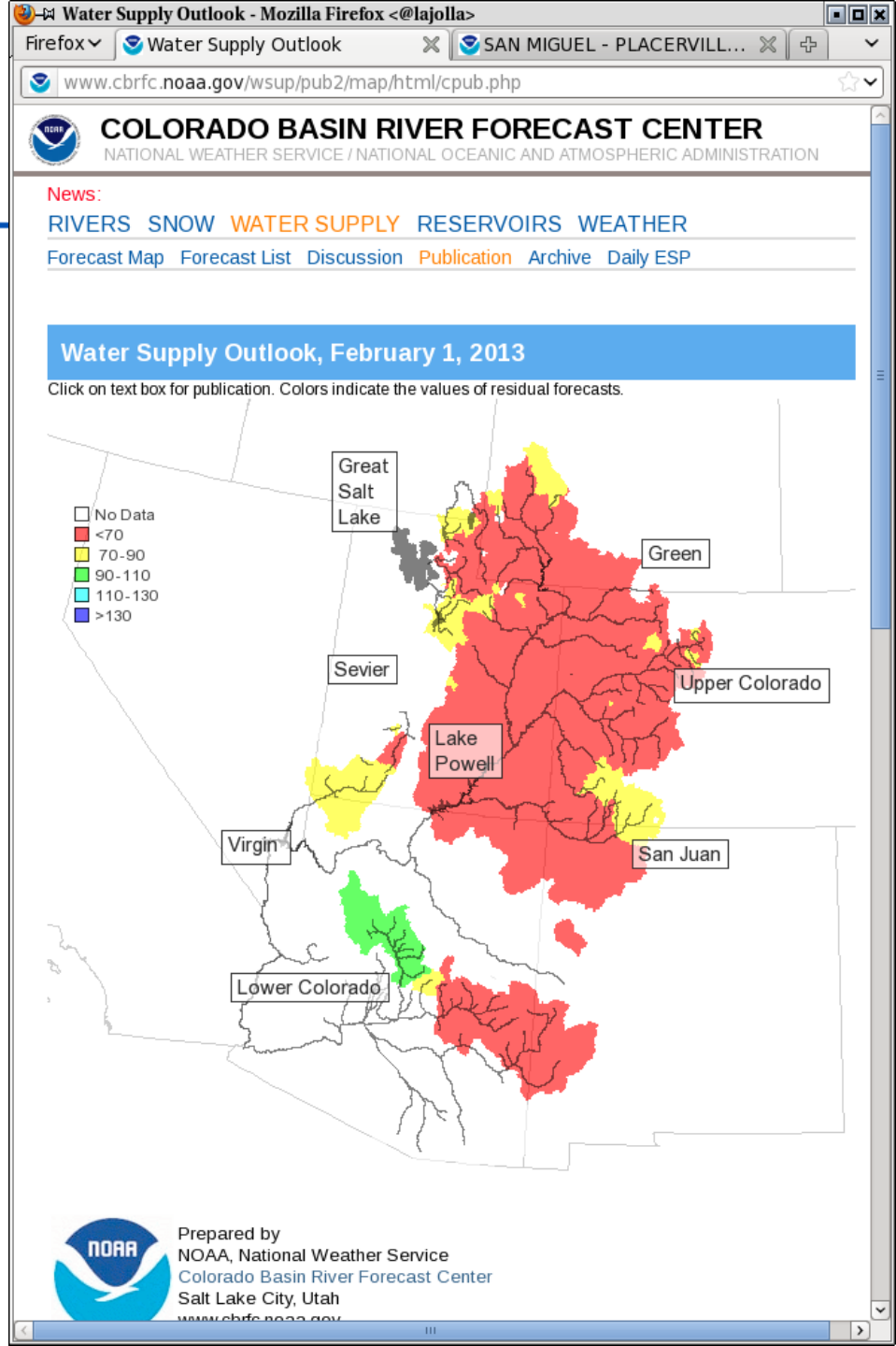


# Web Site Overview

Water Supply Publication provides an overview of the current outlook.

The Dolores in part of the Upper Colorado

http://www.cbrfc.noaa.gov/wsup/pub2/map/html/cpub.php

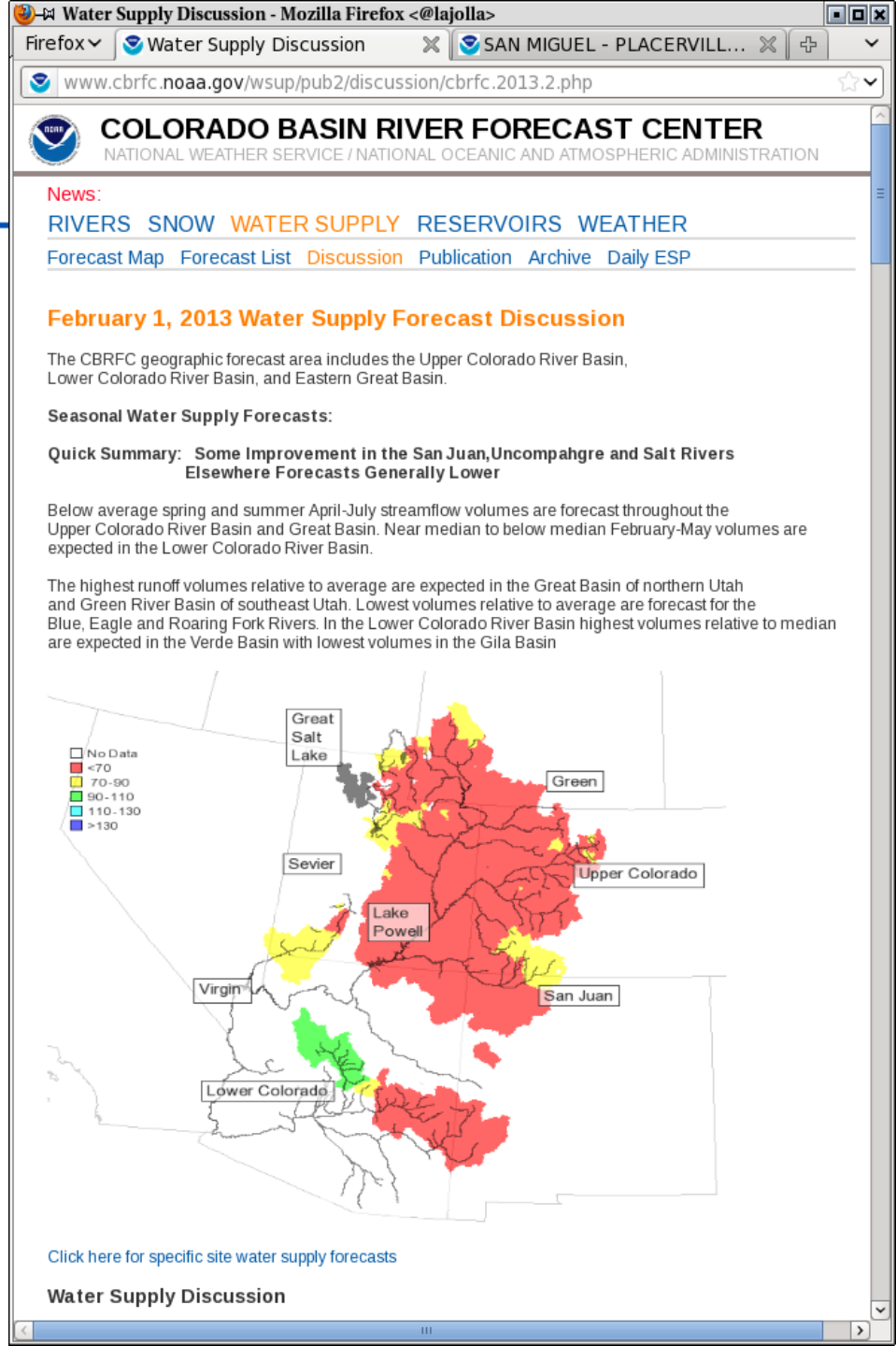


# Web Site Overview

New for this year is the Water Supply Forecast Discussion.

Gives a synopsis of the conditions used to make the current Water Supply Forecast.

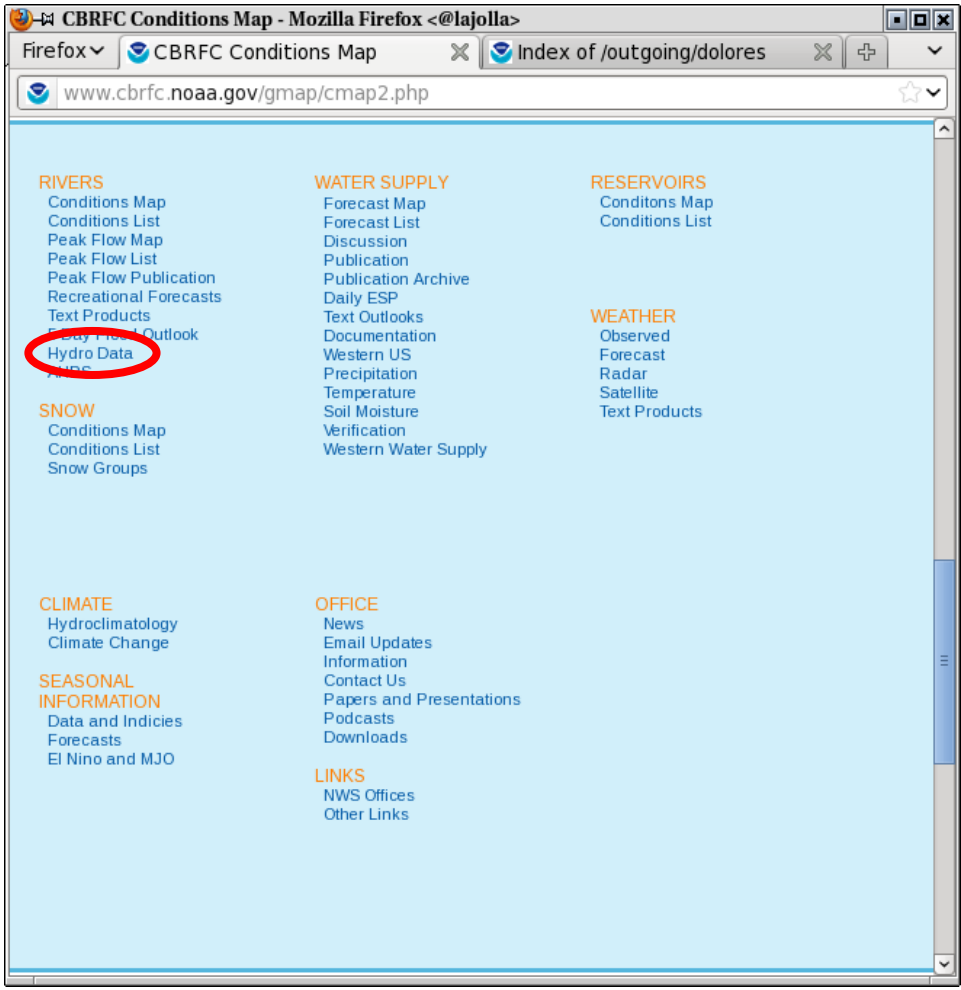
http://www.cbrfc.noaa.gov/wsup/pub2/discussion/cbrfc.2013.2.php



# Web Site Overview

Getting to Dolores ESP Traces

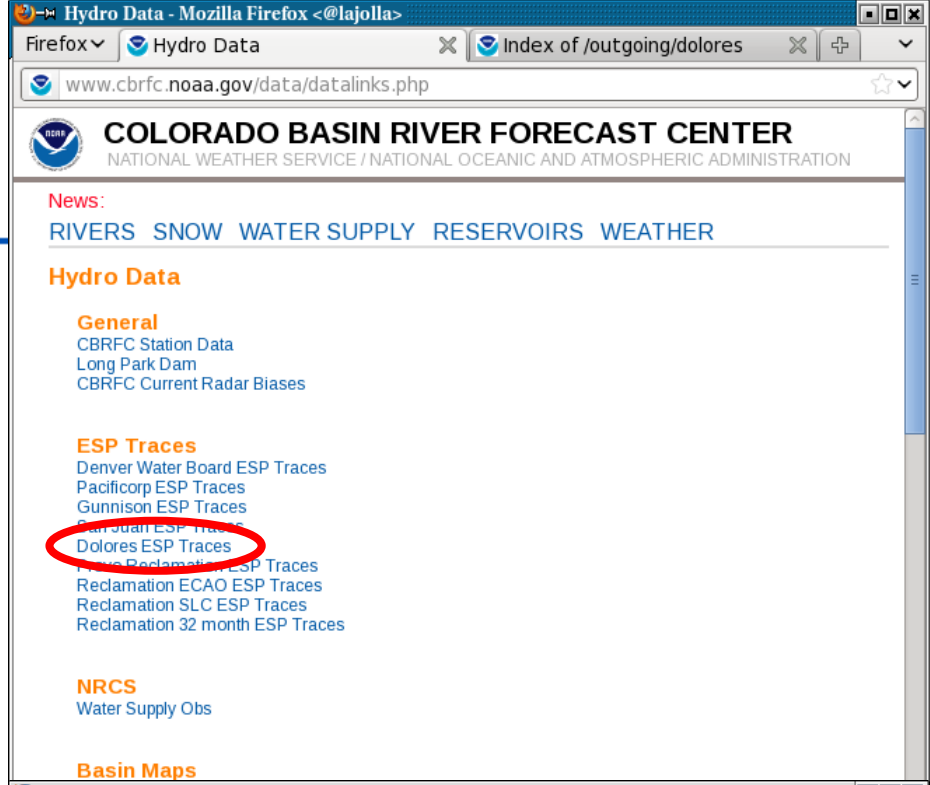
At the bottom of the main home page click *Hydro Data*

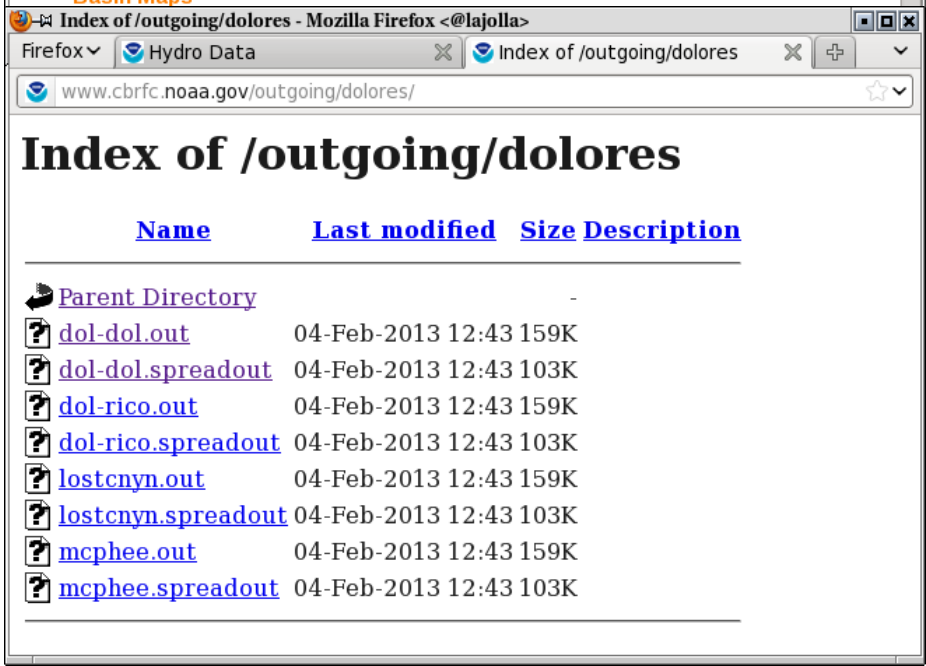


# Web Site Overview

Getting to Dolores ESP Traces continued

Under ESP Traces select *Dolores ESP Traces* and the page to download the files will open in a new tab



# Questions?