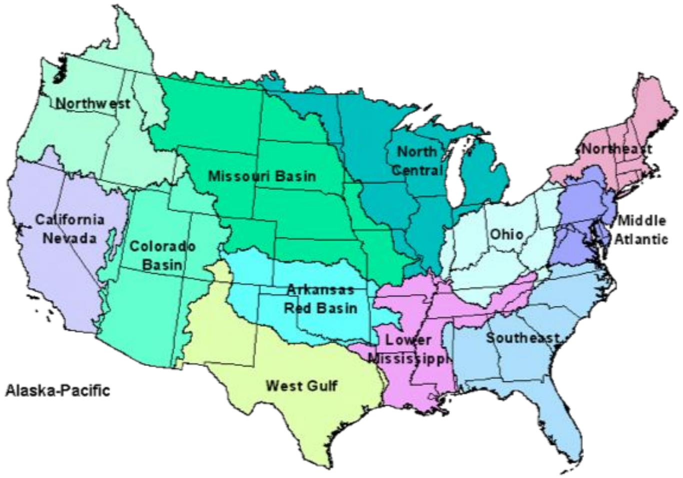
CBRFC 101

NOAA

Overview of NWS Hydrology Program

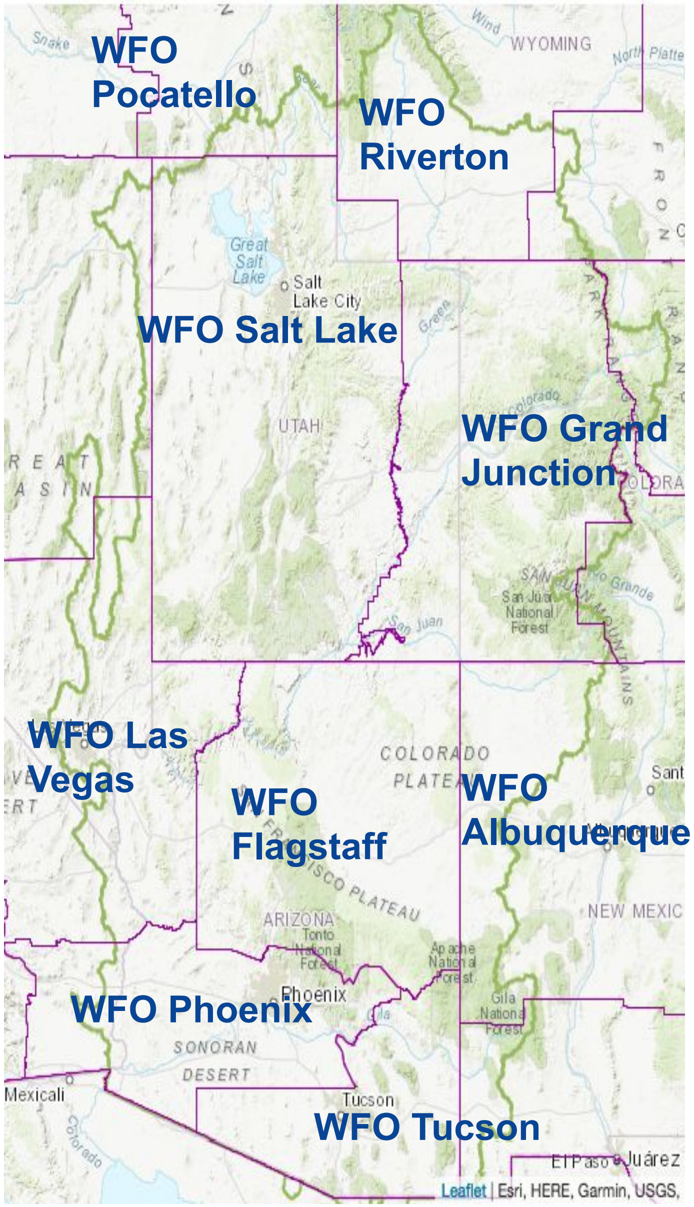
- Who, What, and Where are River Forecast Centers
  - Work with area Weather Forecast Offices
  - Notifying the public
- Summary of key operations, products, and services
- Flood operations at a RFC
- Coordination with Reclamation

RFCs and WFOs



- 13 RFCs nationwide
  - Work with 122 Weather Forecast Offices (WFOs)
  - Support NOAA's hydrologic services and products
- Focused on decision support
- Western RFCs have the additional role of providing water supply services

Working with the WFOs



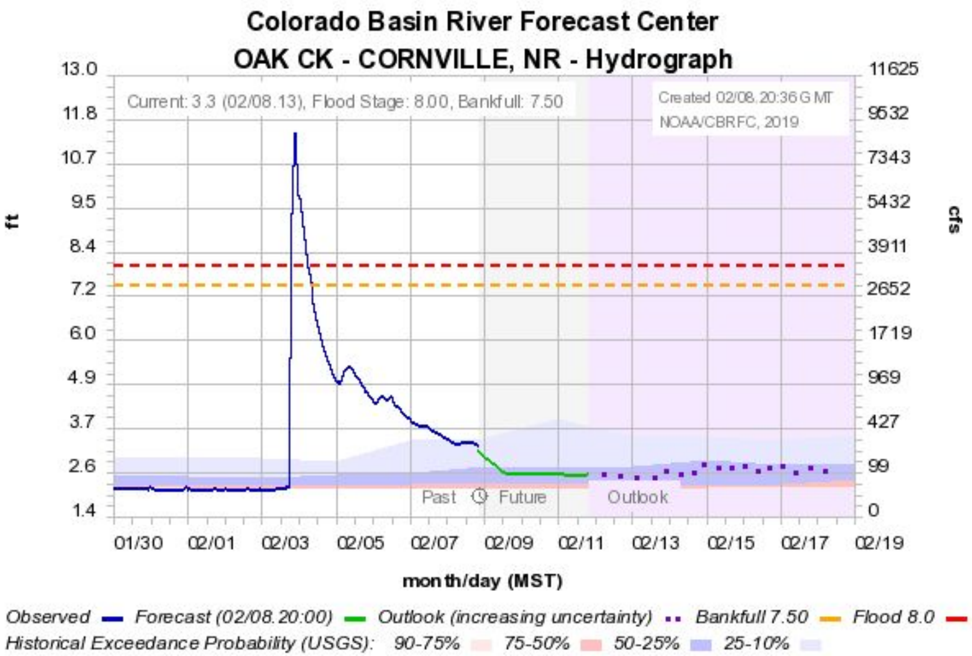
- RFCs provide streamflow and water supply forecasts
- Weather Forecast Offices
  - Flood Watches and Warnings
  - Determine flood stages
  - "Eyes on the ground" – document impacts, notify communities
  - Work closely with Emergency Manager

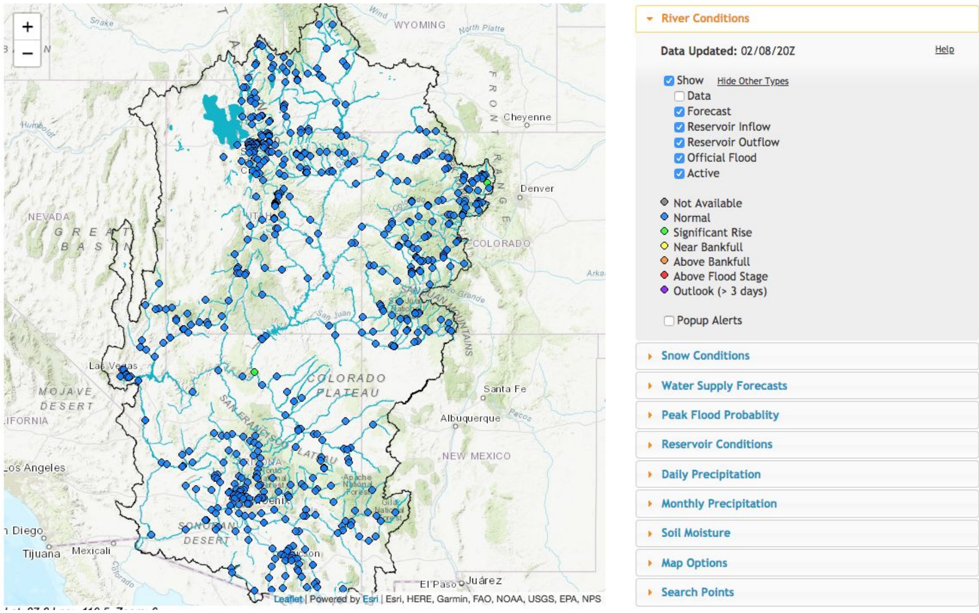
Colorado Basin River Forecast Center

- Works with a broad and diverse set of stakeholders
    - Federal agencies (e.g., Reclamation, Army Corps)
    - Municipal and Agricultural Water Users
    - State, academic, NGOs
- Data consumers - we rely on information provided by many of our stakeholders
- Really strives to be transparent and accessible

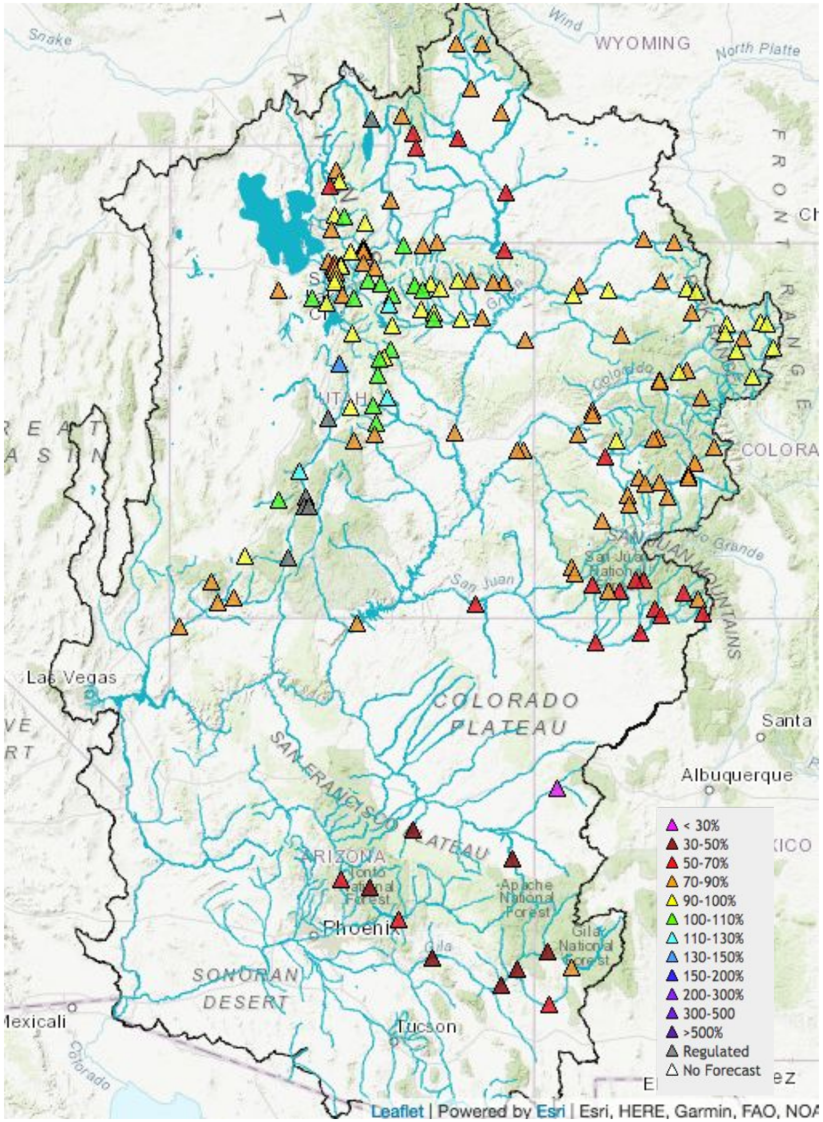
Flood Forecasts

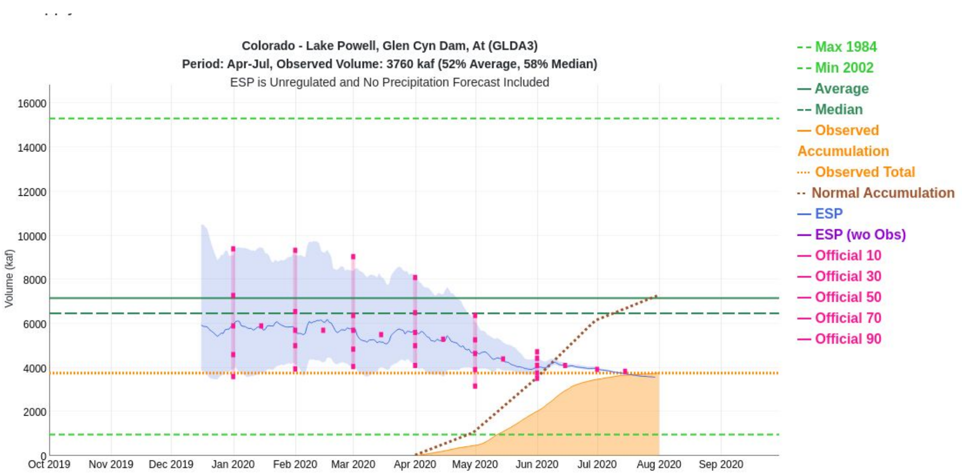
- 10 day deterministic hydrographs issued daily
- WFOs are the key stakeholders
  - WFOs issue Flood Watches and Warnings based on RFC guidance
  - Flexible support abilities
  - Provide actionable, risk-based, information





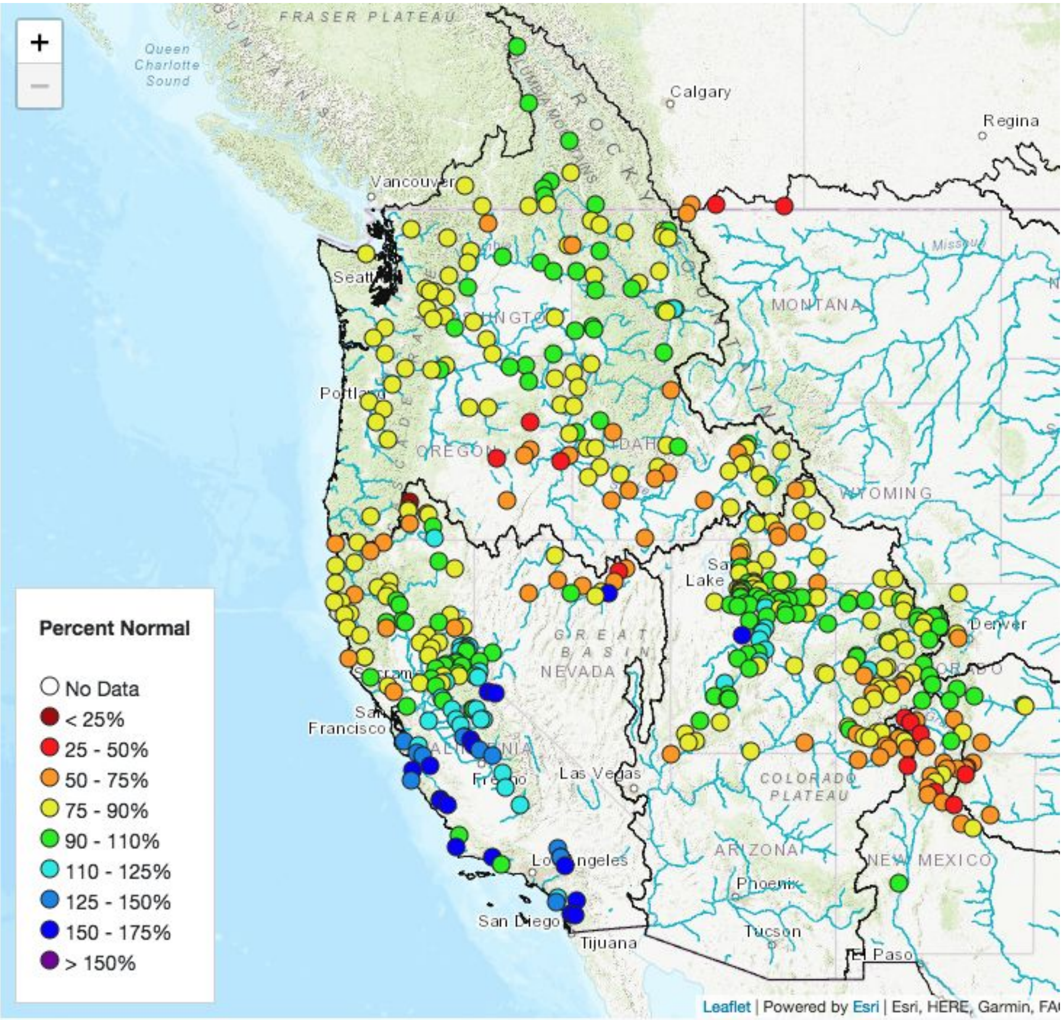
Water Supply Forecasts





- Probabilistic volumetric forecasts
- Updated daily from January through July, with monthly “official” forecasts
- Monthly and seasonal timesteps
- 1 - 5 year forecasts
- Used by Reclamation in reservoir operations models, and other water managers

Western Water Supply Forecast Webpage

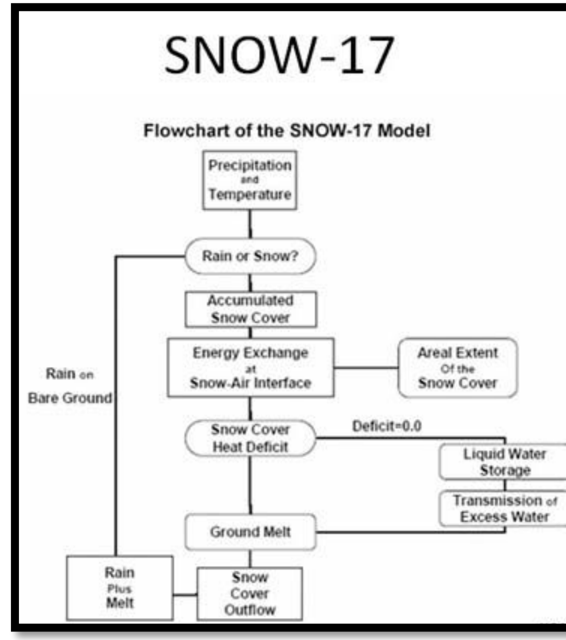


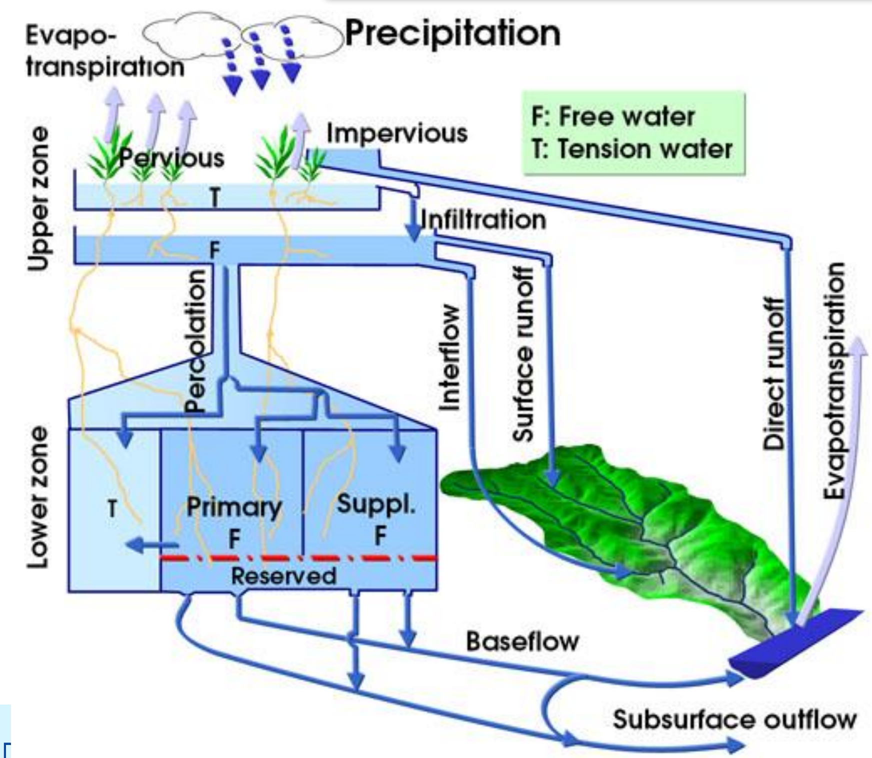
- Centralized interface for water supply forecast information from 6 RFCs in the West
- Links to individual RFC forecasts
- Evolving to increased functionality

https://www.cbrfc.noaa.gov/wsup/graph/west/map/esp_map.html

CBRFC Model Description

- Continuous
- Conceptual
- Lumped
- Main components are:
  - Sac-SMA (soil moisture)
  - SNOW-17
- Quality of the precipitation data (historical and real time) is the most important part of the model





CBRFC Model Setup

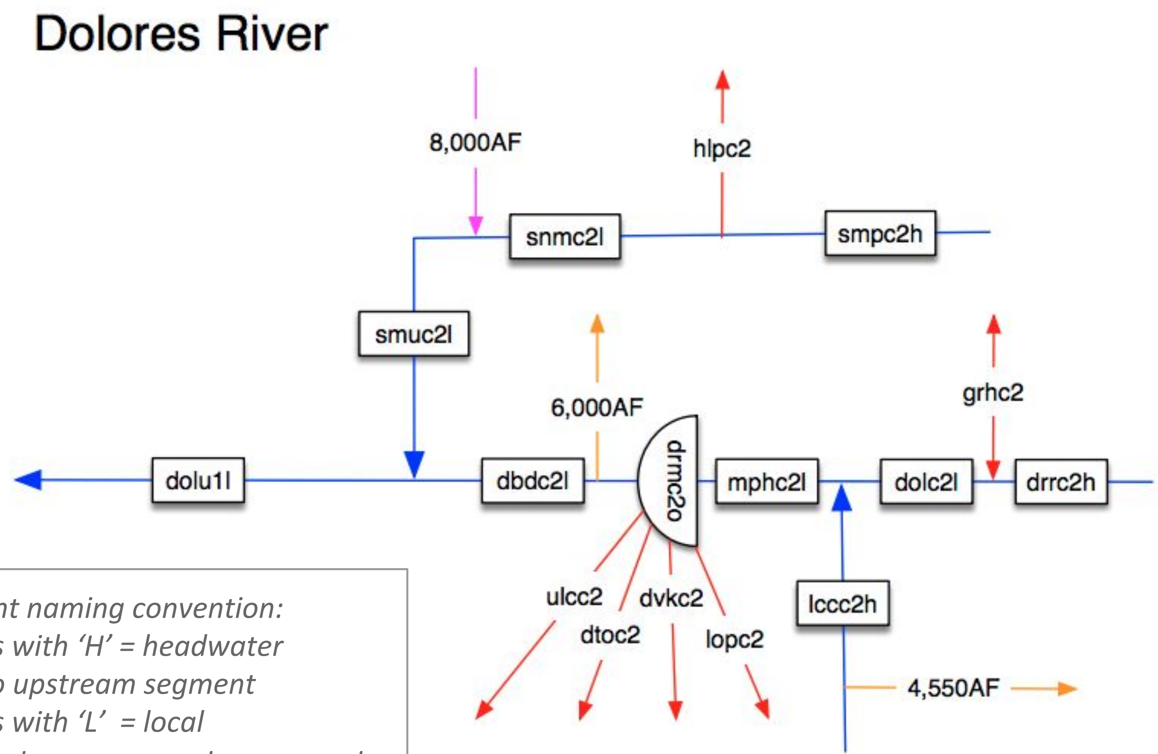
Each river point in the model is called a segment.

There are 478 river points/segments and 97 reservoirs in the CBRFC model.

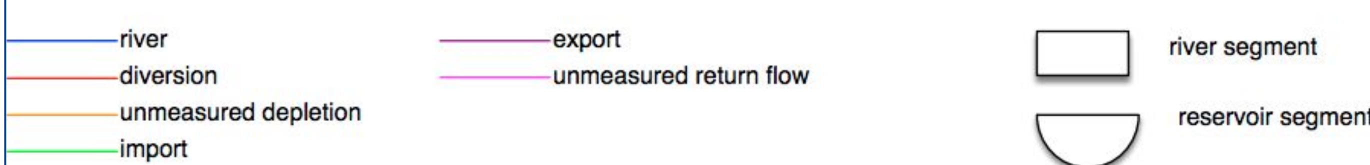
Stick Diagrams for each basin are available on our webpage.

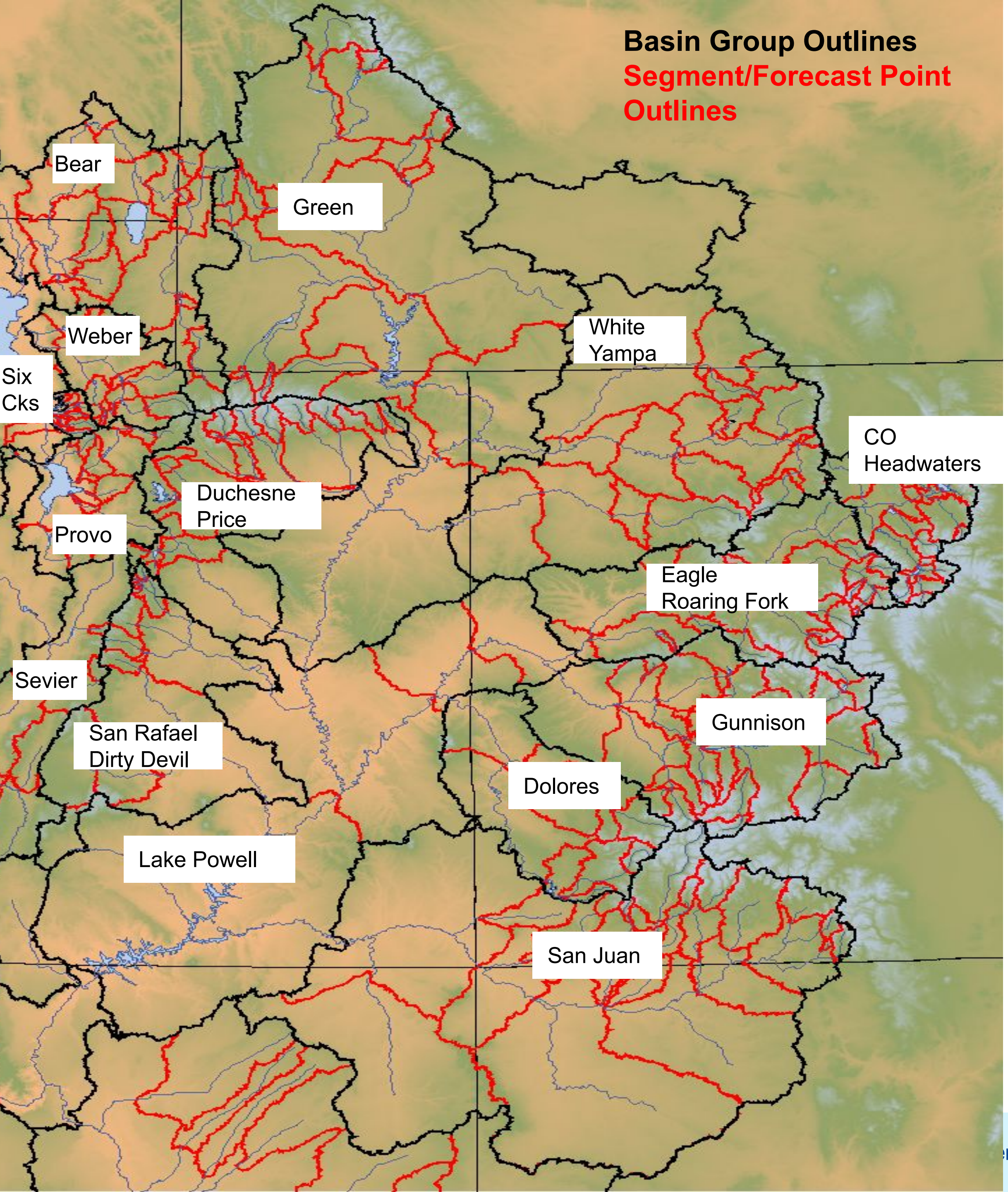
These show segment connections as well as measured and unmeasured loss/gains that are included in our model.

https://www.cbrfc.noaa.gov/wsup/guide/sticks.php



Segment naming convention:
- *ends with 'H' = headwater*
    - *no upstream segment*
- *ends with 'L' = local*
    - *upstream segment passes water*
- *ends with 'O' = reservoir operation*





Model Setup

<u>Number of Segments:</u>

White/Yampa River Basin
- 17 River, 2 Reservoirs

Duchesne/Price River Basin
- 24 River, 7 Reservoirs

Green River Basin
- 16 River, 6 Reservoirs

San Rafael/Dirty Devil River Basin
- 14 River, 7 Reservoir

Colorado Headwaters River Basin
- 17 River, 6 Reservoirs

Eagle/Roaring Fork River Basin
- 22 River, 4 Reservoirs

Gunnison River Basin
- 29 River, 8 Reservoir

Dolores River Basin
- 9 River, 1 Reservoirs

San Juan River Basin
- 25 River, 3 Reservoirs

Lake Powell
- 2 River, 1 Reservoir

Upper Colorado Total
- *175 River, 44 Reservoirs*

Great Basin Total
- *83 River, 22 Reservoirs*

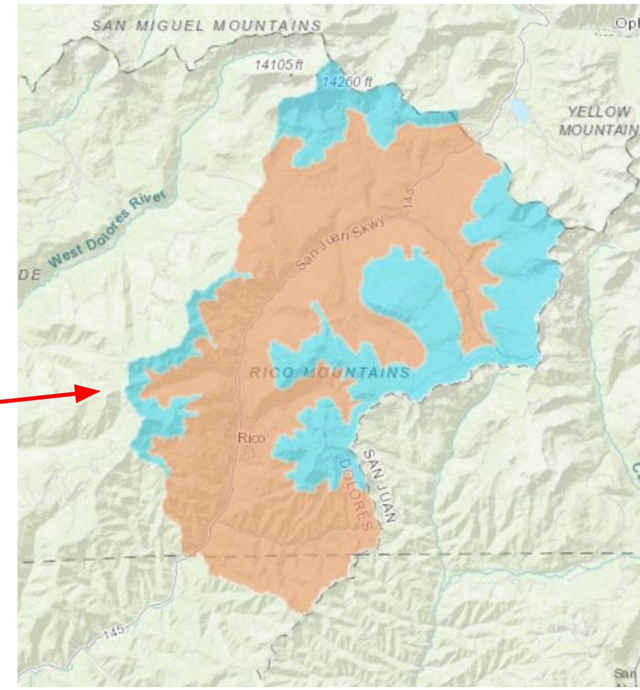
Lower Colorado Total
- *220 River, 31 Reservoirs*

CBRFC Model Setup

Each segment is broken into 2-3 elevation zones based on similar characteristics.

Each zone is represented by a single, mean areal point for precipitation and temperature.

Dolores River below Rico, CO (DRRC2)



Lower Zone: 8,320 ft - 11,000 ft (69 mi^2)

Upper Zone: 11,000 ft - 14,172 ft (36 mi^2)

Model Point Selection → Calibration

- Include river points where long term historical and real-time data (and a need) exists
  - Data: river, diversions, reservoirs, precip, temp
  - Needs: flood forecast, reservoir inflow, improved model
- Calibration is the crux of the forecast process
  - Calibrations are done offline
  - When running in forecast mode we make sure they are run the same as in calibration mode (same inputs)
- The forecasts are objective
- The process is evolutionary
  - We are always seeking ways to improve the calibrations
- More specifics about calibrations coming tomorrow

Calibration Steps

- Store historical precipitation, temperature and flow time series for each segment over the calibration period
- Choose from a variety of sub-models and processes
  - Snow model
  - Soil moisture model
  - Unit Hydrograph
  - Channel routing
  - Reservoir operations
- Determine the optimal set of parameters for each model, for each elevation zone to best simulate *unregulated* flow at each model point
  - ~450 total zones in the Upper Colorado

CBRFC Unregulated Flow

- Segments are calibrated to the *Unregulated Flow*
  - *Measured* diversions, imports, exports, and reservoir regulation are added to observed flow to approximate natural flow
    - Observations are available historically and in real time
  - *Unmeasured* depletions and return flows are not added back in and why this is not the same as true ‘Natural Flow’
    - Usually known, unmeasured irrigation
    - Derived by CBRFC during calibration using a model that is a function of irrigated acres and temperature so model can simulate observed flows correctly

$$Q_u = Q_o + D + E - I + \Delta S$$

- Q_u = unregulated flow
- Q_o = observed/measured flow
- D = measured diversion
- E = measured transbasin export
- I = measured import
- ΔS = change in reservoir storage

Note that this may be different from other agencies’ definition of unregulated flow

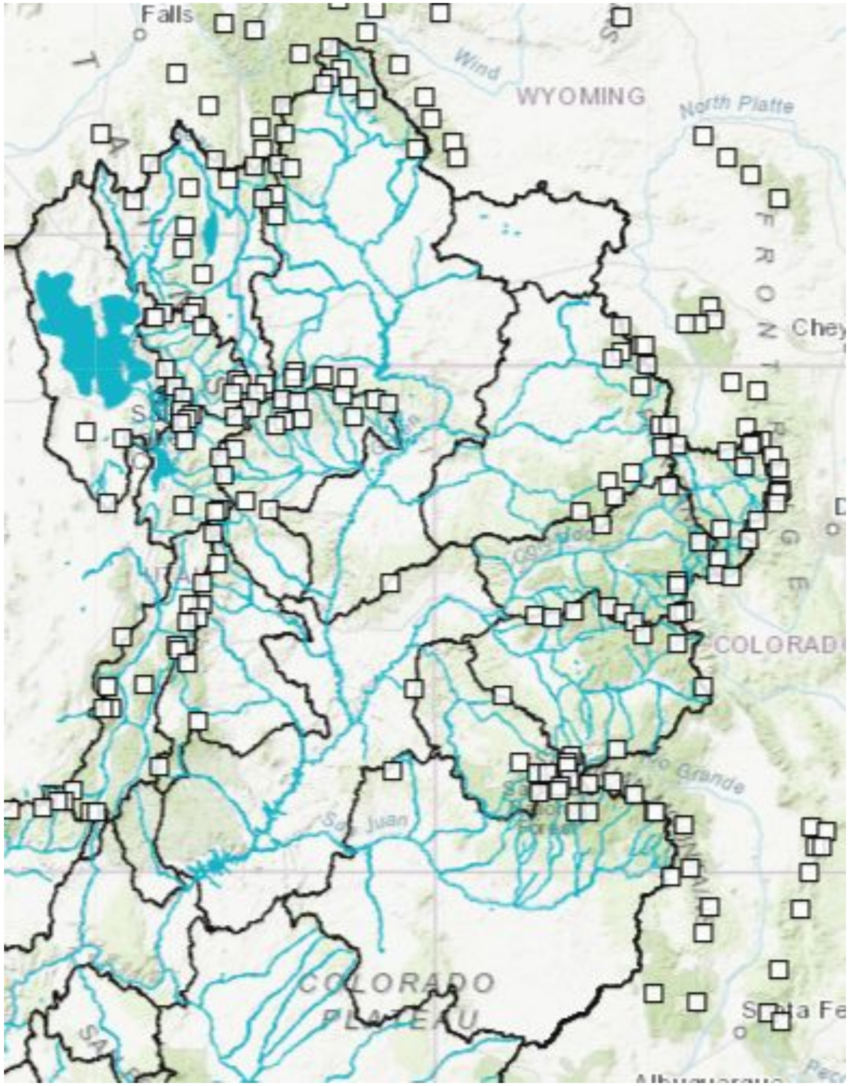
Calibration Basics

- Water balance is calculated using the PRISM climate data set
- Evaporation determined through water balance and regionalized
- Forced by 6 hourly precipitation and temperature spanning the calibration period (currently 1981-2015)
  - Mean Areal Precipitation (MAP) for each subarea (elevation zone) is calculated using pre-determined station weights
    - Use precipitation stations that (ideally) have similar characteristics to that area
    - Weights are chosen to guarantee water balance in each area
  - Mean Areal Temperature (MAT) for each subarea (elevation zone) represents the mid-point elevation
    - Nearby stations are used to calculate the temperature of the MAT
  - Use the same stations to calculate MAP's and MAT's in the operational environment to ensure our forecasts will have similar quality and characteristics to the calibration
    - Mostly use SNOTELS (desire high elevation sites when available)
- *Extensive analysis & quality control of historical data is performed*

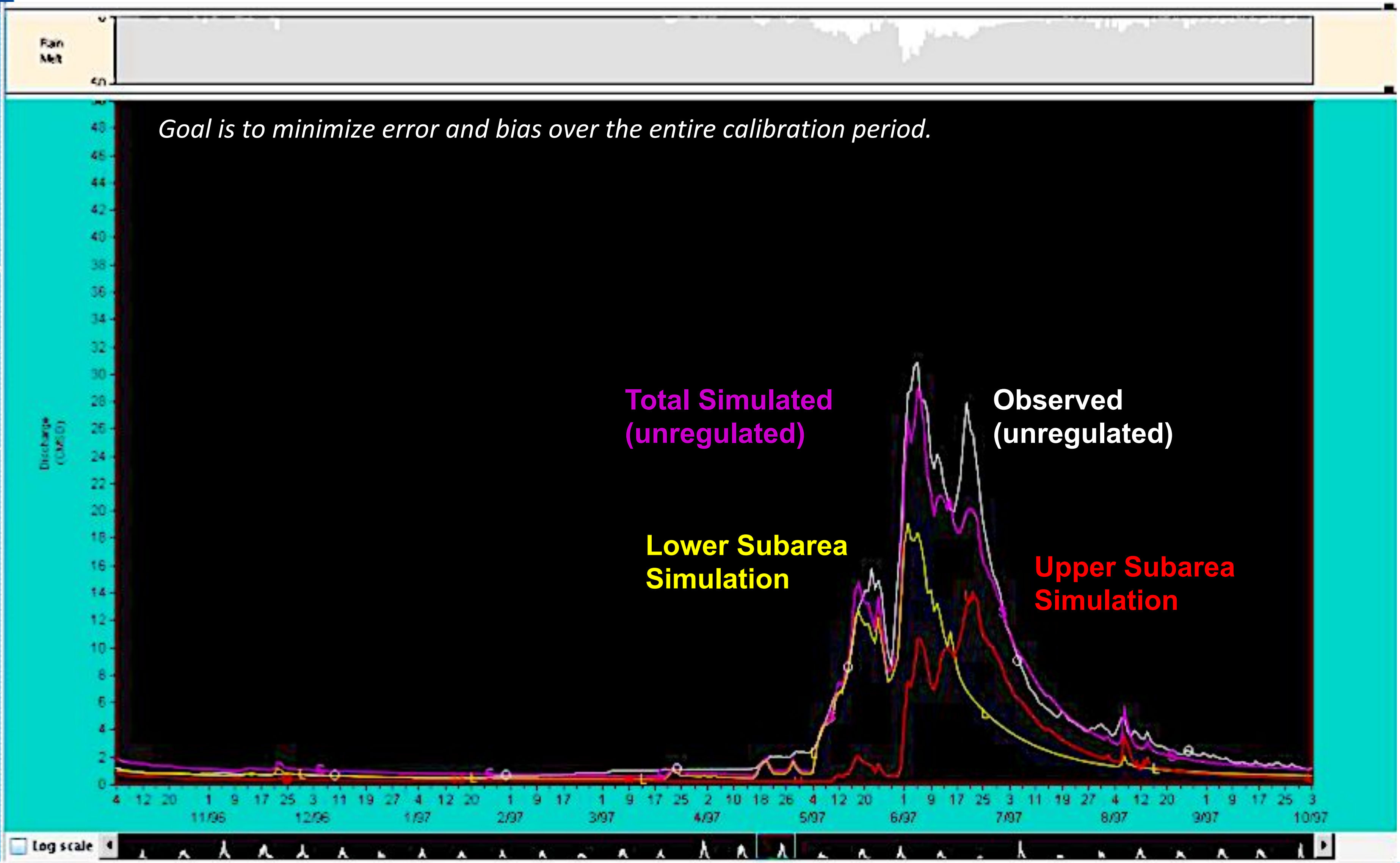
SNOTEL Stations

Upper Basin (UC and GB) precipitation and temperature forcings:

- Use SNOTEL stations with long, uniform records
  - 10 to 15 years of data minimum
- High elevation precip stations
  - Best correlated with runoff
- SNOTEL temperature stations
  - Do not have the biases low elevation urban stations have
  - Snow ablation uses a temperature index model
  - Temperature well correlated with snowmelt physical processes



Calibration Results



Calibration Errors

Data

Errors in data used in model calibration

Density and availability of data over an area

Model

Model is conceptual so many hard-to-measure parameters are estimated

Basin scale model may not capture characteristics at smaller spatial scales

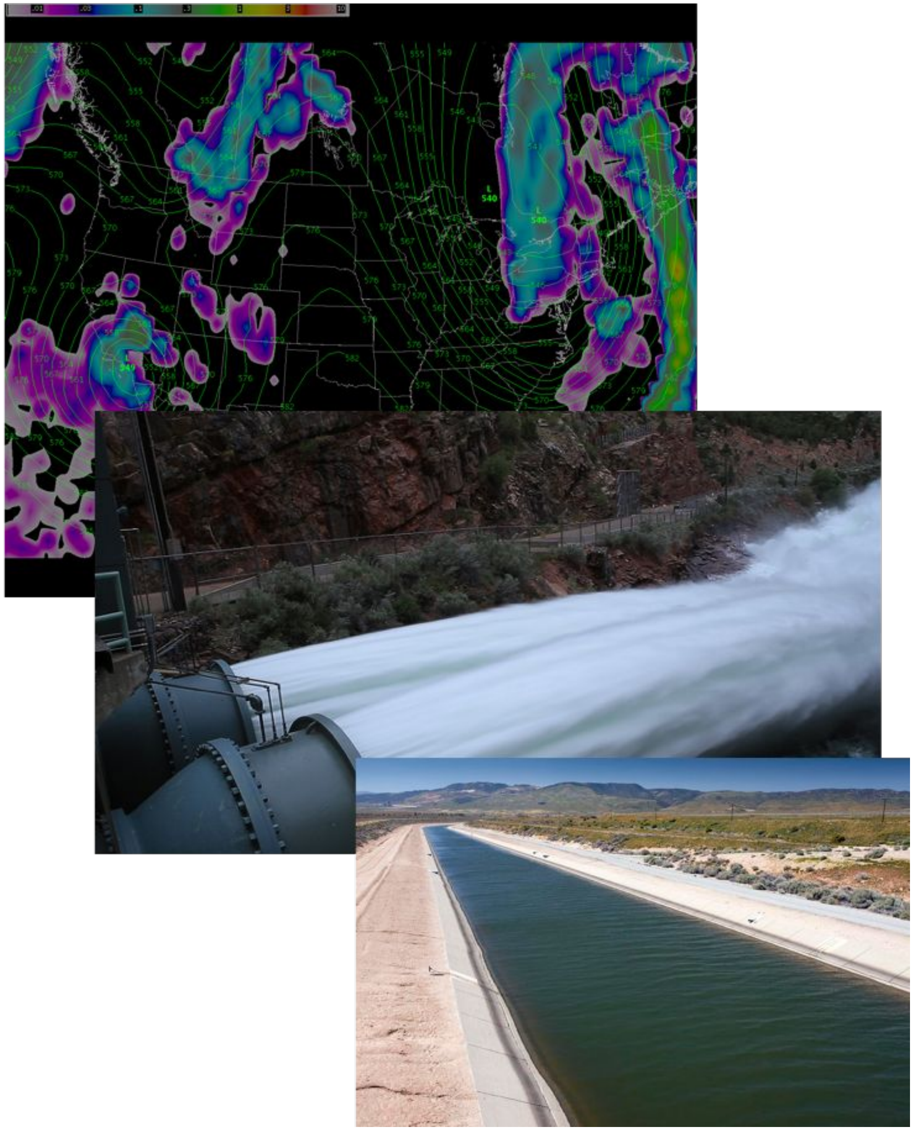
Gage Data is Vital

Gage data is really at the heart of what we do. Quality data allows us to make accurate forecasts; without it, our forecasts have significantly more uncertainty

We spend a significant amount of time on data quality control

Forecast Data is Vital

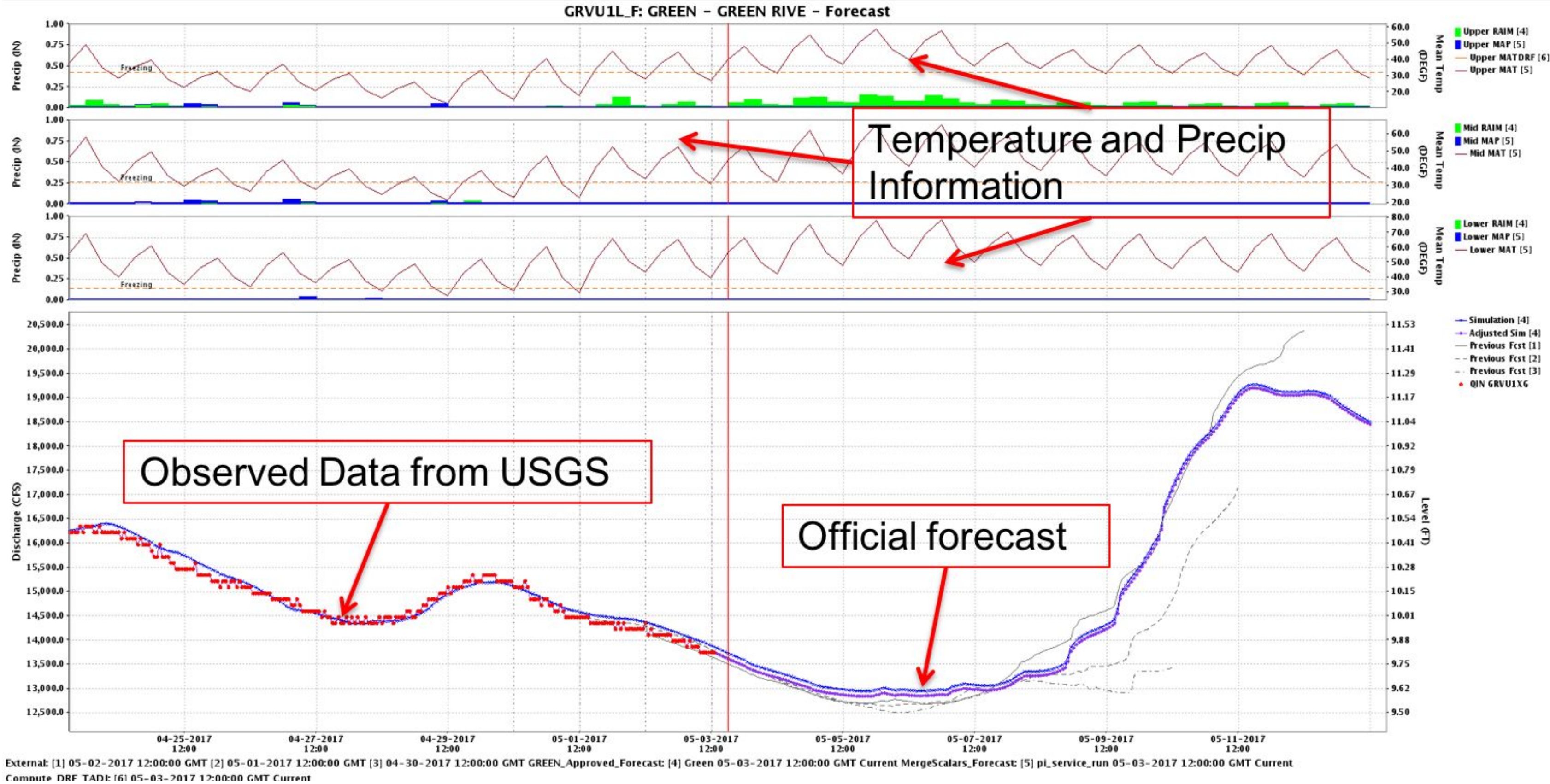
- Short term skill limitations
  - Dependent on skill in weather forecast
  - Knowledge of planned operations (e.g., reservoir operations and use)



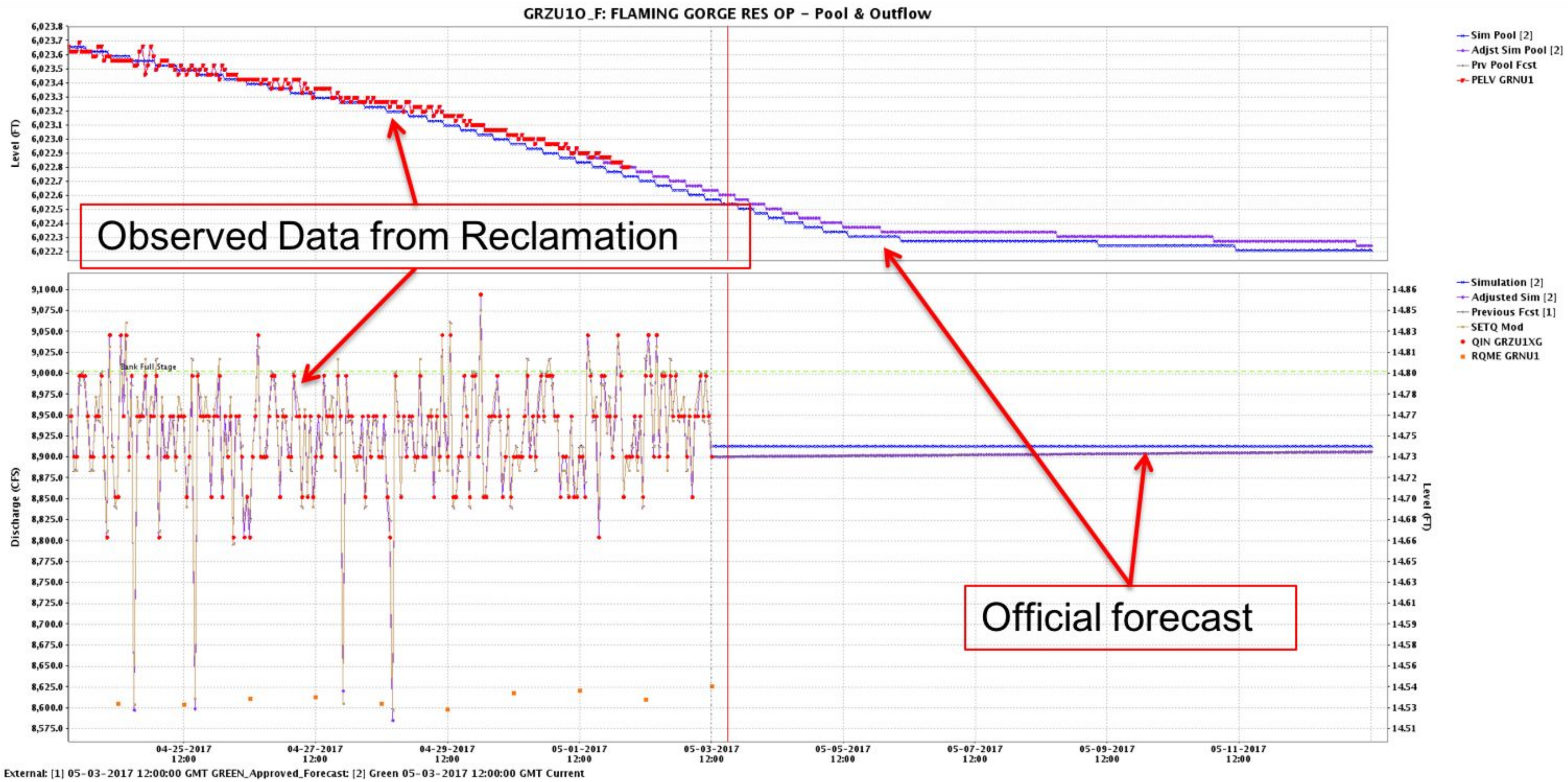
Developing a Forecast

- Forecasters analyze observed and future precipitation and temperature information
- Utilize streamflow observations to assess model performance
- Make adjustments (snow, diversions, etc…). We refer to these as “modifications” or “mods”
  - Strive to make sure this is done with a physical basis and reasoning
  - Stakeholders may contribute information not in the model
- This is done at least once per day

Developing a Forecast



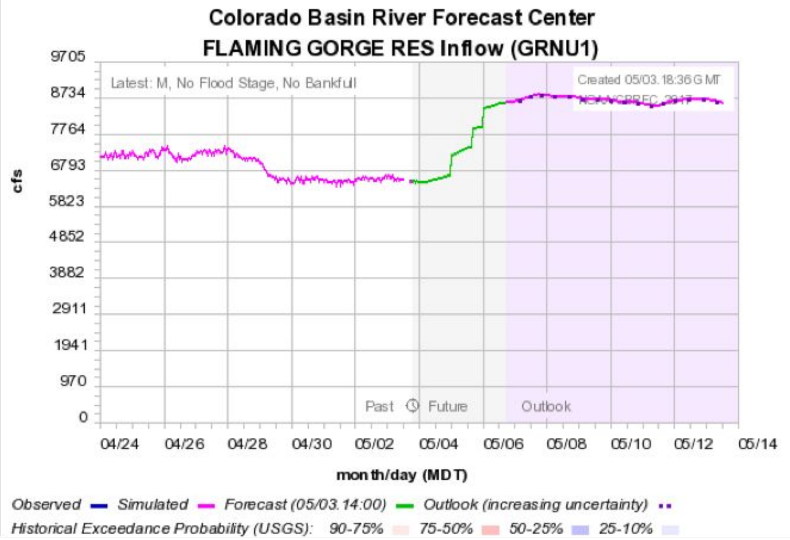
Developing a Forecast

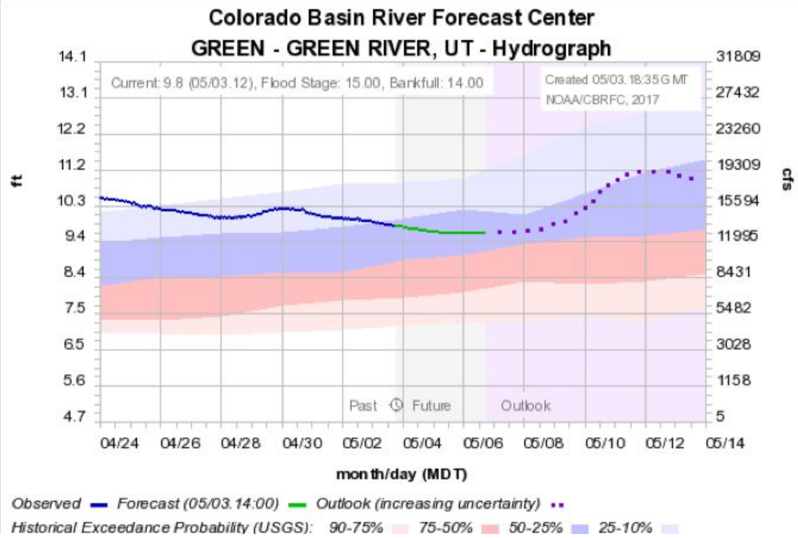


Developing a Forecast

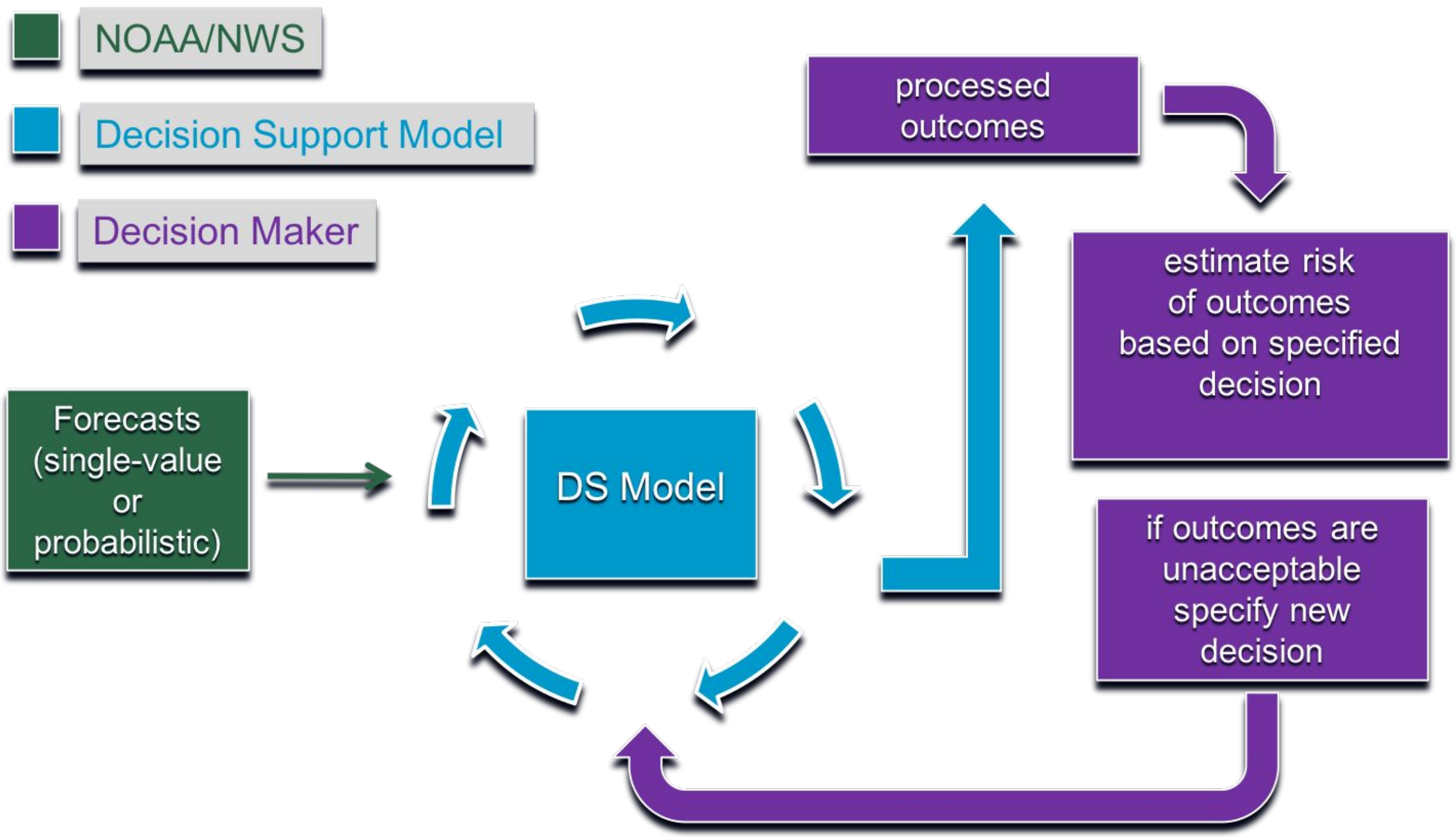
- Products are published to our websites and communicated to stakeholders in a variety of ways

- Many of these graphics have been improved and updated based on stakeholder input -- new hydrograph is accessible under ‘Beta Hydrograph’

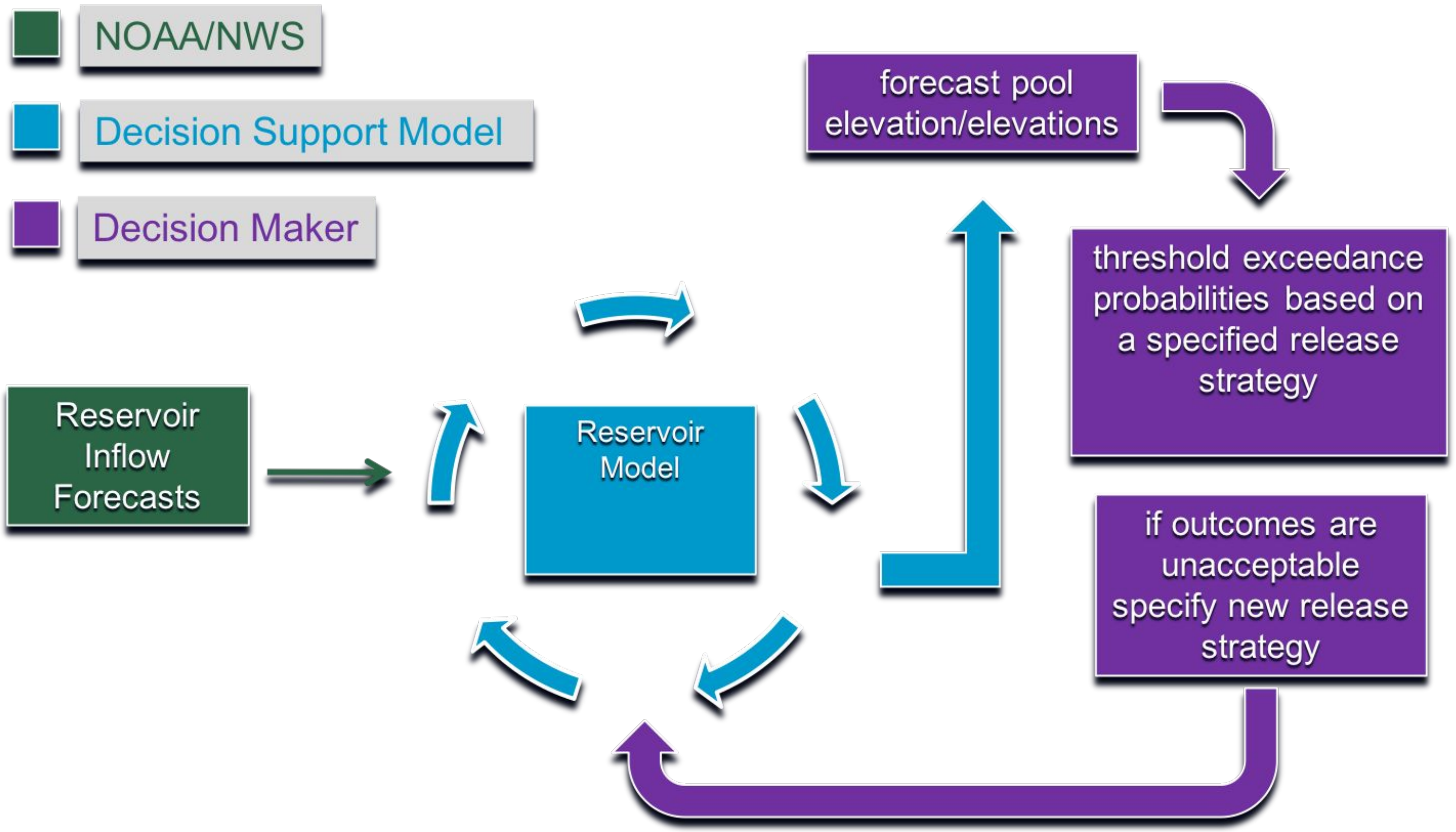




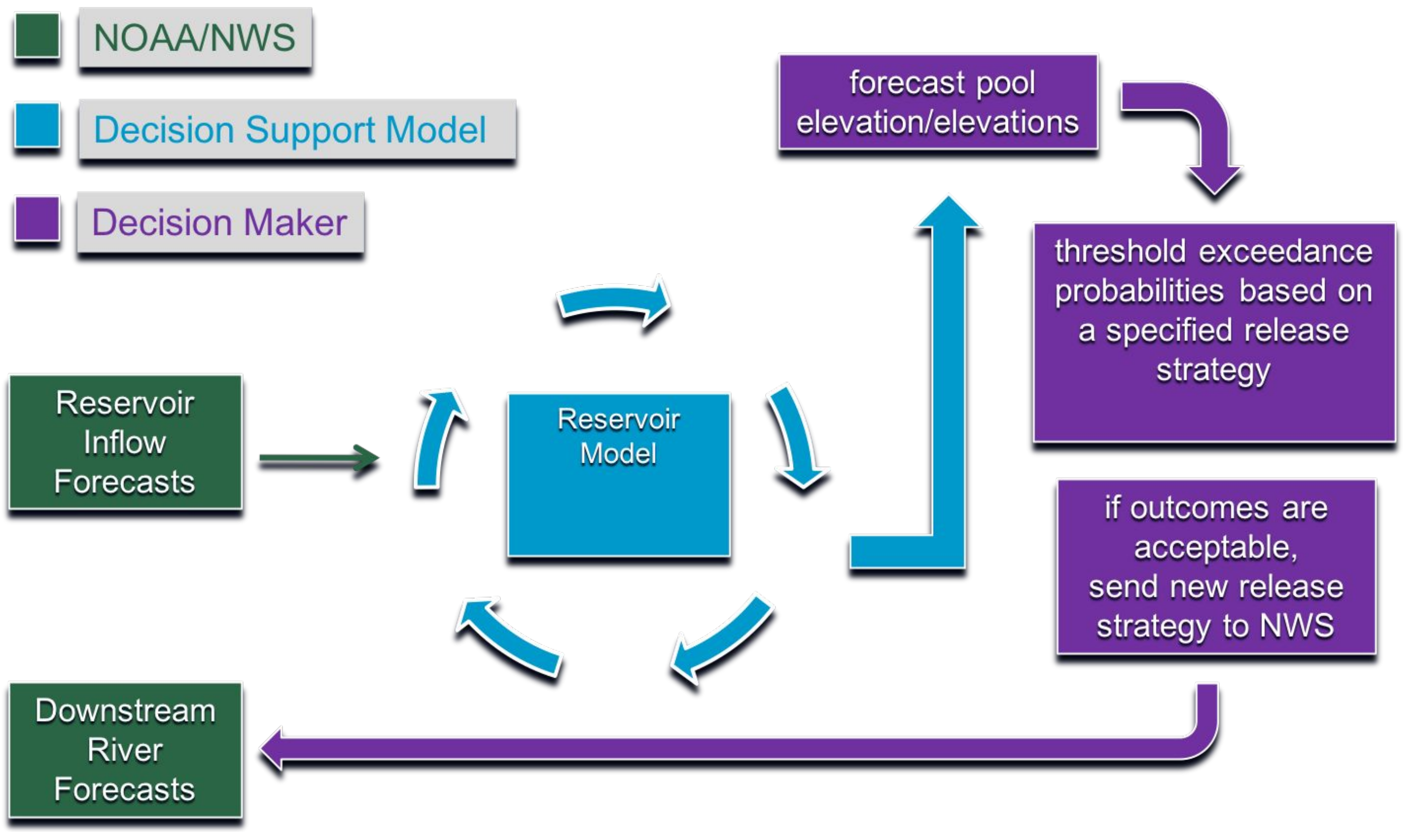
Roles of Forecasts in Decision Support



Role of Forecasts in Decision Support Typical Reservoir Operations



Role of Forecasts in Decision Support for Reservoir Operations



RFC Operations During Flood Events

Flash Flooding*

- Typically, RFCs offer limited support due to model limitations
- WFOs will take the lead and coordinate with stakeholders and EMs

*Localized flooding caused by short-term, convective, precip events.

Non-Flash Flooding**

- RFCs will coordinate with affected WFOs
- WFOs will coordinate with EMs, stakeholders
- RFCs available to provide continuous support to WFOs, including contingency runs

*Large scale, sometimes long-term flooding driven by synoptic scale events and snowmelt-driven runoff

National Water Center

Weather-Ready Nation
National Oceanic and Atmospheric Administration

National Water Model

Improving NOAA's Water Prediction Services

In August 2016, NOAA took a giant leap forward in its ability to forecast the flow of rivers and streams throughout the entire continental United States with the launch of the new high resolution National Water Model (NWM).

The NWM will enhance and expand NOAA's water flow forecasts, which to date have been available for approximately 4,000 river locations with stream gages operated by the U.S. Geological Survey. This new model will expand forecasts to 2.7 million stream locations nationwide. Leveraging the full network of nearly 8,000 U.S. Geological Service stream gauges and NOAA's investment in atmospheric modeling, the NWM will provide high-resolution forecasts of soil moisture, surface runoff, snow water equivalent, and other parameters.

We all recognize that water is an essential component of sustainable and resilient communities. But its also a stressed natural resource and potential threat to life, property, and livelihoods during extreme weather events.

Improved Water Information Services

The new NWM improves the National Weather Service's ability to deliver impact-based decision support services nationwide by providing "street level" water information and guidance, as well as serve as the foundation for additional private sector water services. At a minimum, the NWM will immediately provide predictive water information for many locations where none previously existed.

Initially, this new NWM-based information will be particularly useful in headwater areas in support of NOAA's flash flood mission.

How it Works

The NWM simulates the water cycle with mathematical representations of the different processes and how they fit together. This complex representation of physical processes such as snowmelt and infiltration and water movement through the soil layers varies significantly with changing elevations, soils, vegetation types and a host of other variables.

Additionally, extreme variability in precipitation over short distances and times can cause the response on rivers and streams to change very quickly. Overall, the processes are so complex that to simulate it with a mathematical model means that it needs a "supercomputer" in order to run in the time frame needed to support decision makers when flooding is threatening.

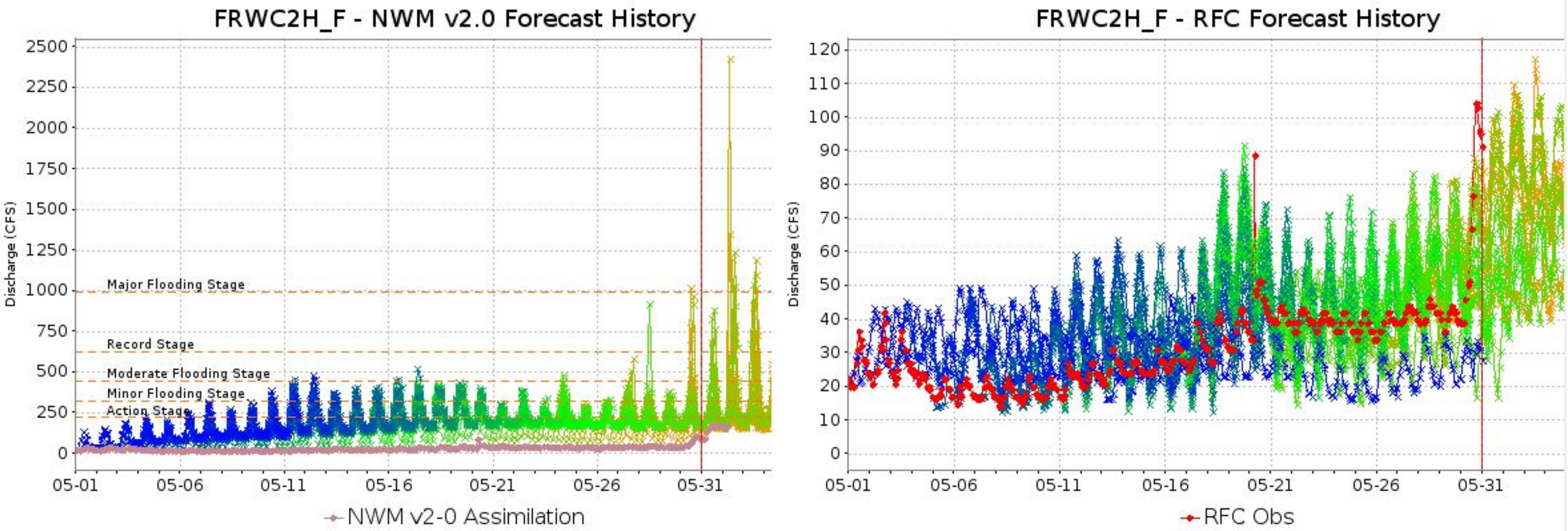
National Water Model is a new forecasting tool that will help forecasters predict when and where flooding can be expected.

www.water.noaa.gov

National Water Model

FRASER - WINTER PARK

Observations and Forecasts - T0: May 31 2020



NWM v2.0 Forecasts (-30 day to 10 day) Thresholds Report						
default	Bank	Action	Minor	Moderate	Major	Record
-	-	121	116	40	9	22

RFC Forecasts (-30 day to 10 day) Thresholds Report						
default	Bank	Action	Minor	Moderate	Major	Record
31	-	-	-	-	-	-

National Water Model

- Working with the National Water Center to help improve forecasts in our area
  - Provide information and feedback
  - Web-based comparison tool and calculated performance metrics
- Operational forecasts will continue to be made by the Colorado Basin River Forecast Center for the foreseeable future