Water Supply Forecasting Tools and Processes

Colorado River Commission
Technical Workshop
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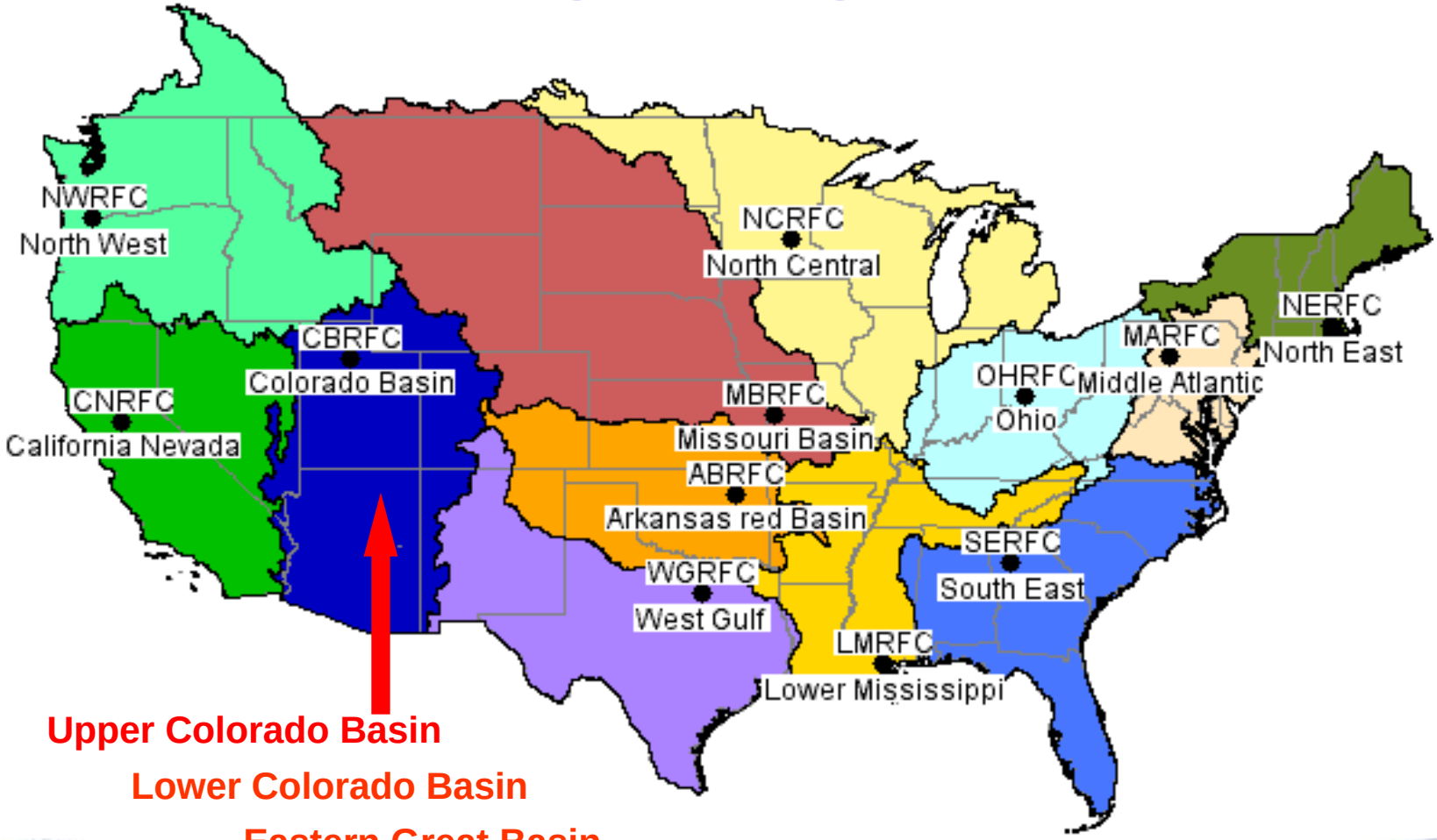
Water Supply Forecasting Tools and Processes

- CBRFC – who we are and what we do
- Statistical Water Supply (SWS)
- NWS River Forecast System - Ensemble Streamflow Prediction (ESP)
- Sources of Error
- Lake Powell and Lake Mead forecasts

CBRFC



Upper Colorado Basin

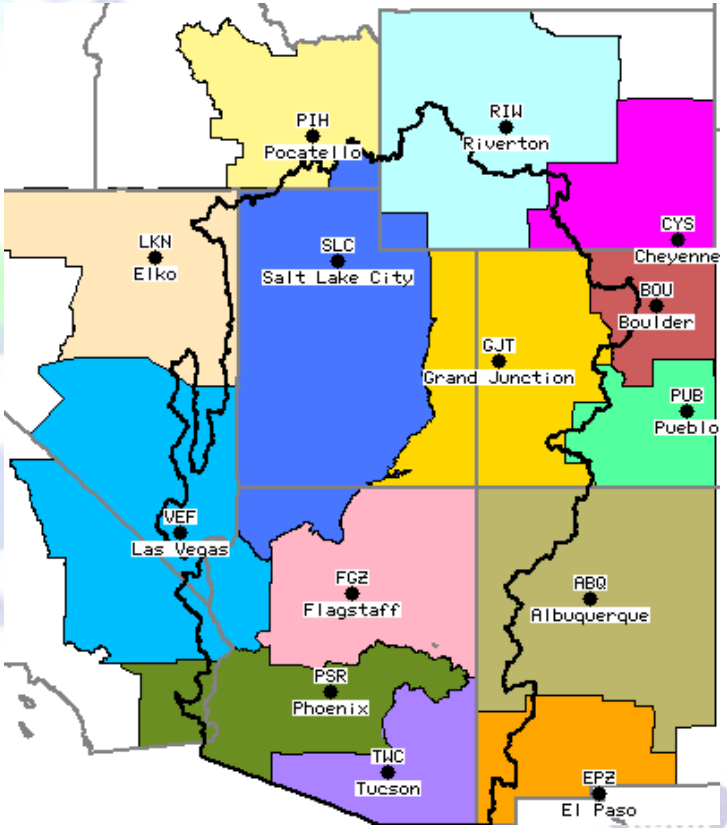
Lower Colorado Basin

Eastern Great Basin

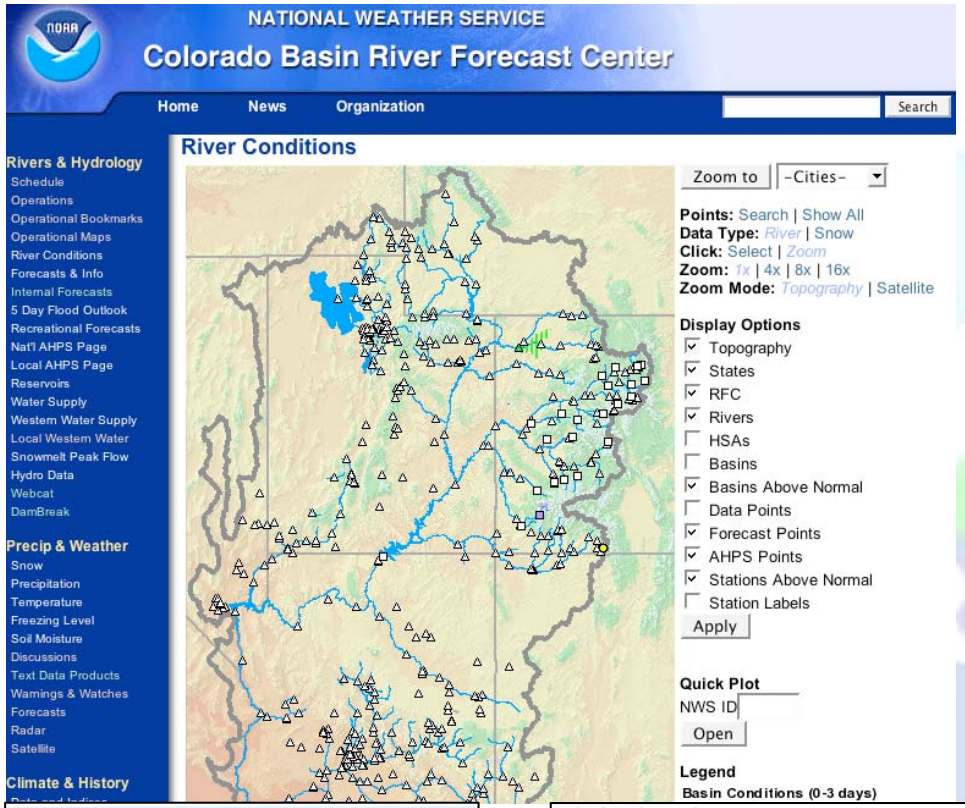
- One of 13 NWS River Forecast Centers
- Located in Salt Lake City, UT

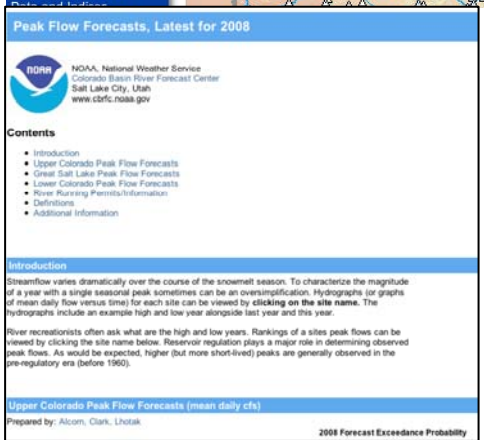
CBRFC

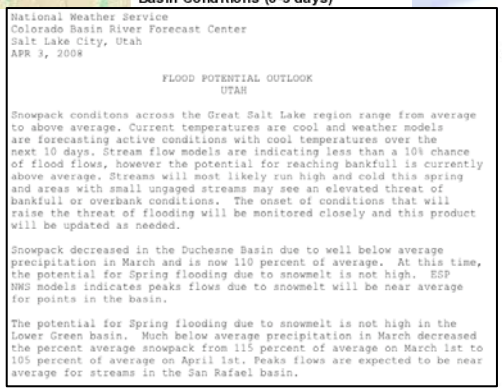
- Mission:
  - Protect lives and property
  - Enhance national economy
- Major programs include:
  - Flood and routine river forecasts
  - Flash flood support
  - Water Supply Forecasts



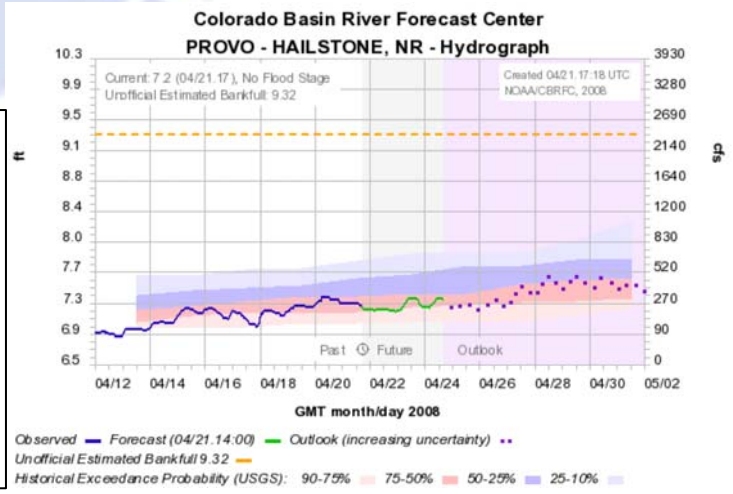
Flood Forecasts / Routine Forecasts





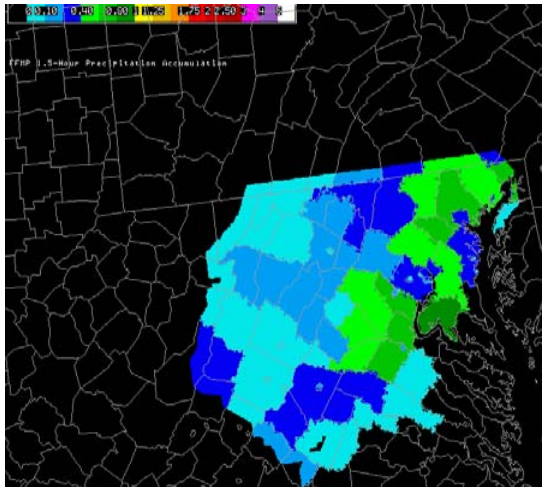


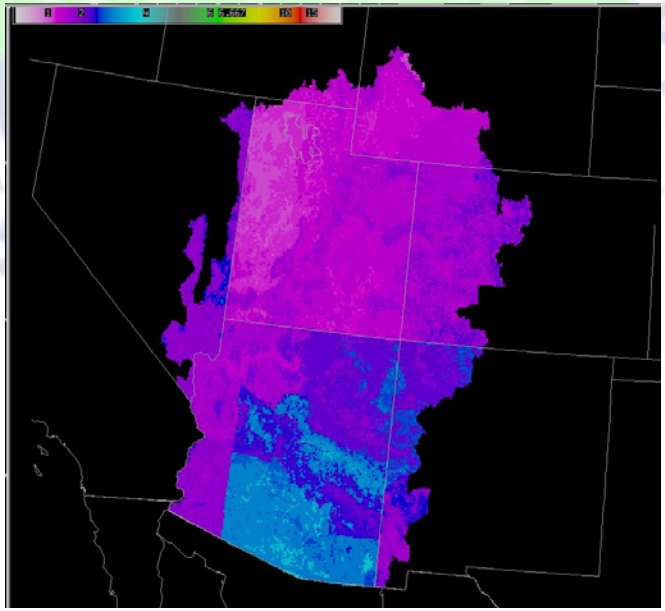
- Nominally provided at ~400 points every 6 hours out to 10 days.
- Flexible web interface to forecasts and data
- Requires large amounts of data (e.g. snow, precip, streamflow)

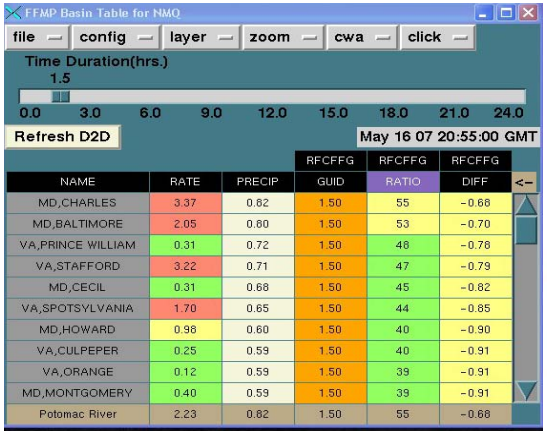


Flash Flood

- Support NWS flash flood program at WFOs through innovative flash flood guidance and (eventually) distributed model







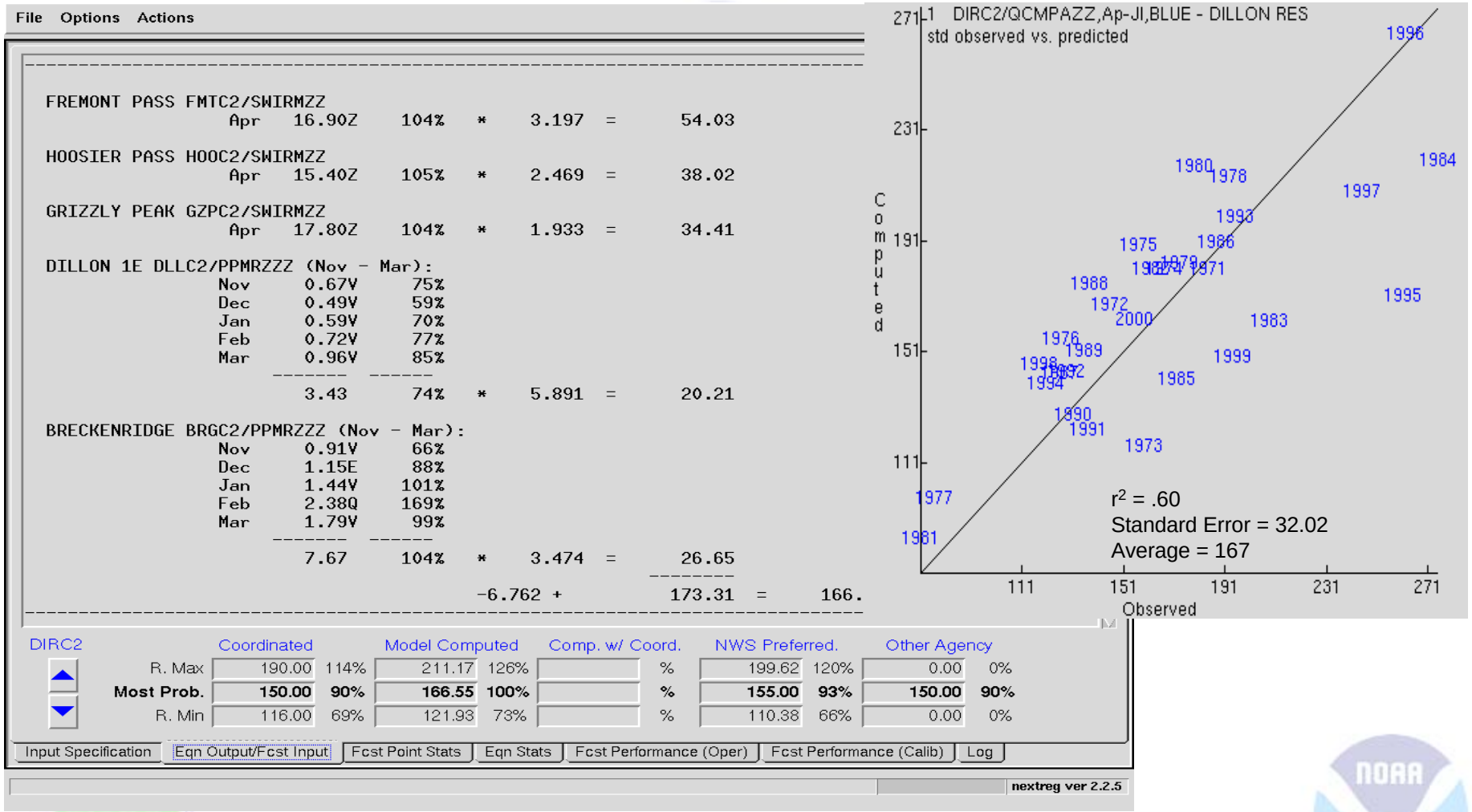
Water Supply

- WHEN:
  - At the beginning of each month January-May.
  - Mid-month updates for some points.
- WHAT:
  - Seasonal volume (April-July most common).
  - "Natural" flow.
    - Flow that would be expected given no water management activities.
    - We attempt to account for all known and measured diversions and reservoir regulation upstream for which data is available.
      - Many unknown/unmeasured diversions.
      - Sometimes hard to get all adjustment data in real-time.
    - Adjustments we account for available at: http://www.cbrfc.noaa.gov/wsup/guide/
- WHERE to find it:
  - http://www.cbrfc.noaa.gov/wsup/wsup.cgi

Statistical Water Supply (SWS)

- Regression equations that relate observed data to future seasonal streamflow volume.
- Inputs are monthly values.
  - Total precipitation (can be multiple months)
  - First of month snow water equivalent
  - Monthly flow volume
  - Climate indices (SOI)
- Output is a seasonal volume (i.e. April-July).
  - It is really a conditional probability distribution, not a single value; the equation result is the 50% exceedance.
  - Other exceedance levels (10%, 90%, etc.) can be calculated by using the standard error.

Statistical Water Supply (SWS)

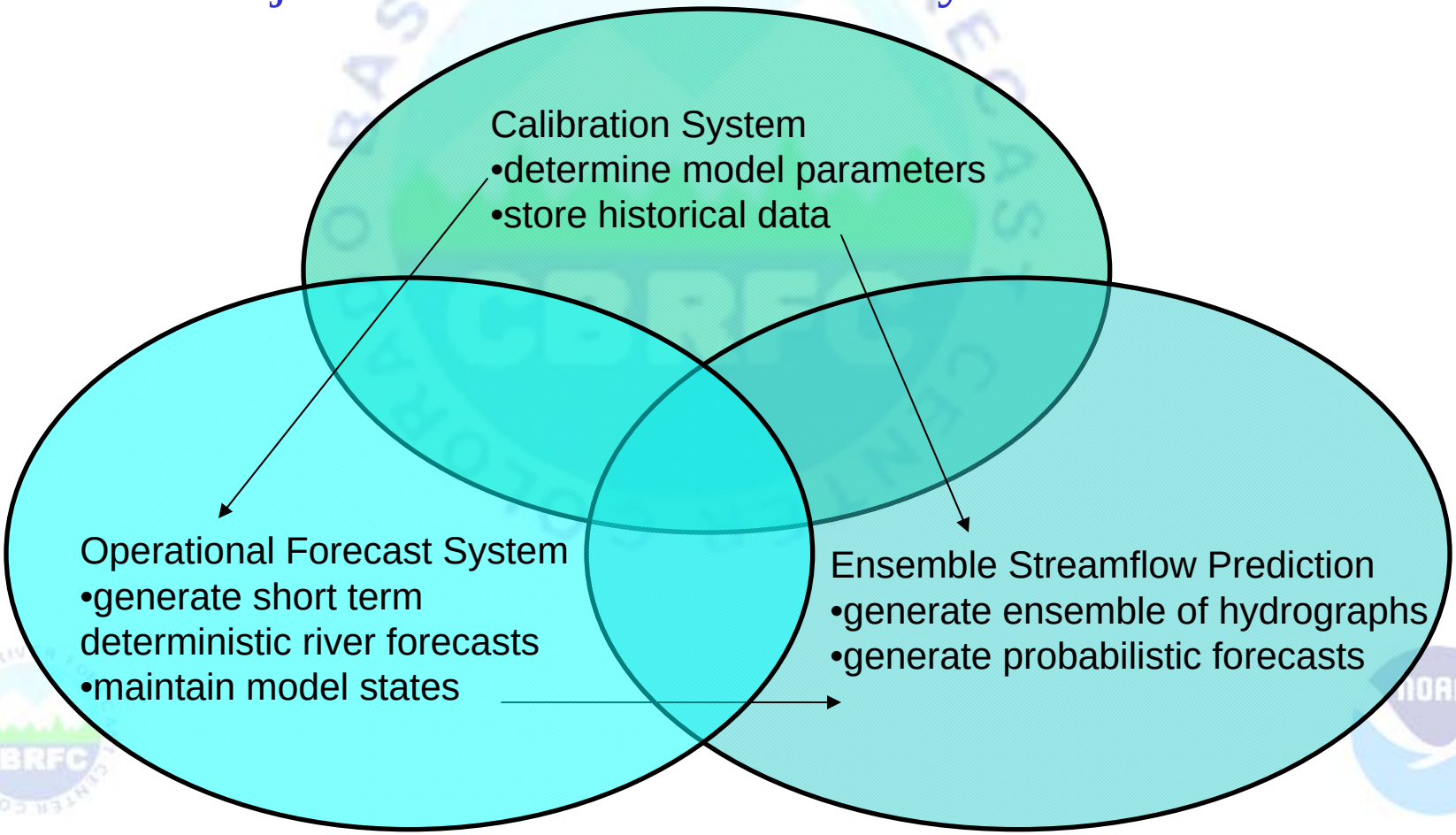


Statistical Water Supply (SWS)

- Headwater vs. local/routed forecast point
  - For downstream points the regression equation 'routes' the upstream volume forecast; it's input is the upstream forecast volume(s).
  - If there is significant 'local' contribution between the points, an equation can be created for the local volume and is then included in the routed equation.
- Example: Lake Powell inflow
  - Too big an area to be handled by a headwater equation.
  - Good correlation with upstream volumes:
    - Green at Green River + Colorado nr Cisco + San Juan nr Bluff
    - r^2 = .994 for observed data

NWS River Forecast System

- Continuous, conceptual hydrologic model composed of three major interrelated functional systems.



Calibration System (CS)

- Choose from a variety of models and processes that can:
  - Simulate snow accumulation and ablation.
  - Compute runoff using a soil moisture model.
  - Time the distribution of runoff from the basin to the outlet.
  - Perform channel routing.
  - Model reservoir operations.
- Determine the optimal set of parameters for each model to best simulate flow.
- Store historical precipitation, temperature and flow time series for the basin.

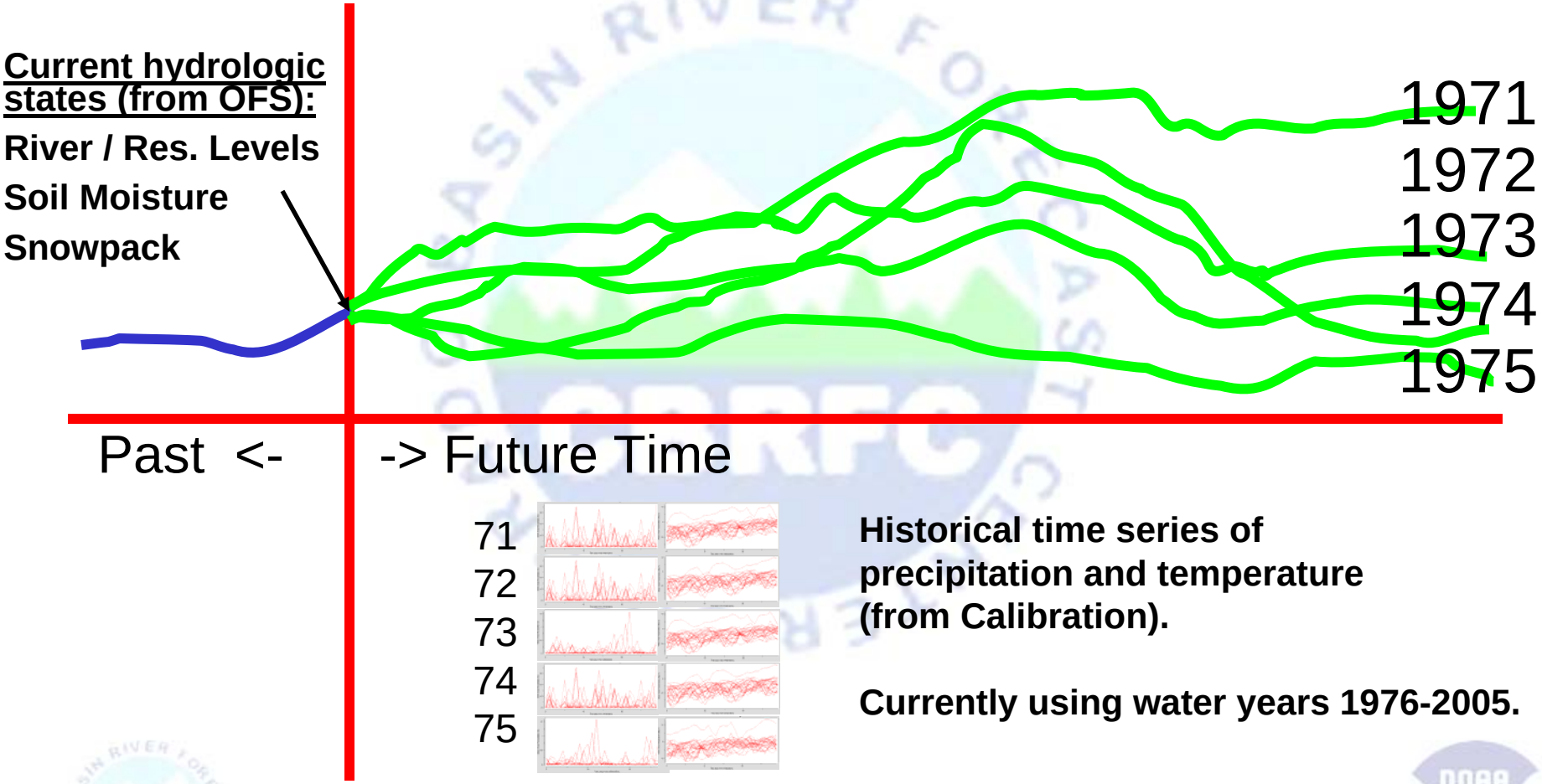
Operational Forecast System (OFS)

- Keeps track of model states, including soil moisture and snowpack.
- Inputs are:
  - Observed precipitation, temperature, and streamflow (which have been quality controlled before input).
  - Forecast precipitation (5 days) and temperature (10 days).
  - **Note: snow/swe is not a direct input, the snow model within each segment builds and melts its own snowpack based on precipitation and temperature inputs.
- Segments/states can be adjusted by forecasters in real time.
  - Snow states are updated at the beginning of each winter month by comparing model simulated snowpack to SNOTEL site data (not a one to one relationship).
- Run multiple times per day so there is continual quality control, updating and adjusting.

Ensemble Streamflow Prediction (ESP)

- Uses model states from OFS as starting point and can also use the QPF (5 days) and QTF (10 days) inputs.
- Uses historical precipitation and temperature time series from CS and statistical distributions to derive probabilistic flow forecasts.
  - Can choose different probability distributions (e.g. empirical, log, wakeby).
  - Can display any exceedance levels wanted.
- Can be pre- or post- adjusted with climate forecasts.
- Can adjust output for model (calibration) bias.

Ensemble Streamflow Prediction (ESP)

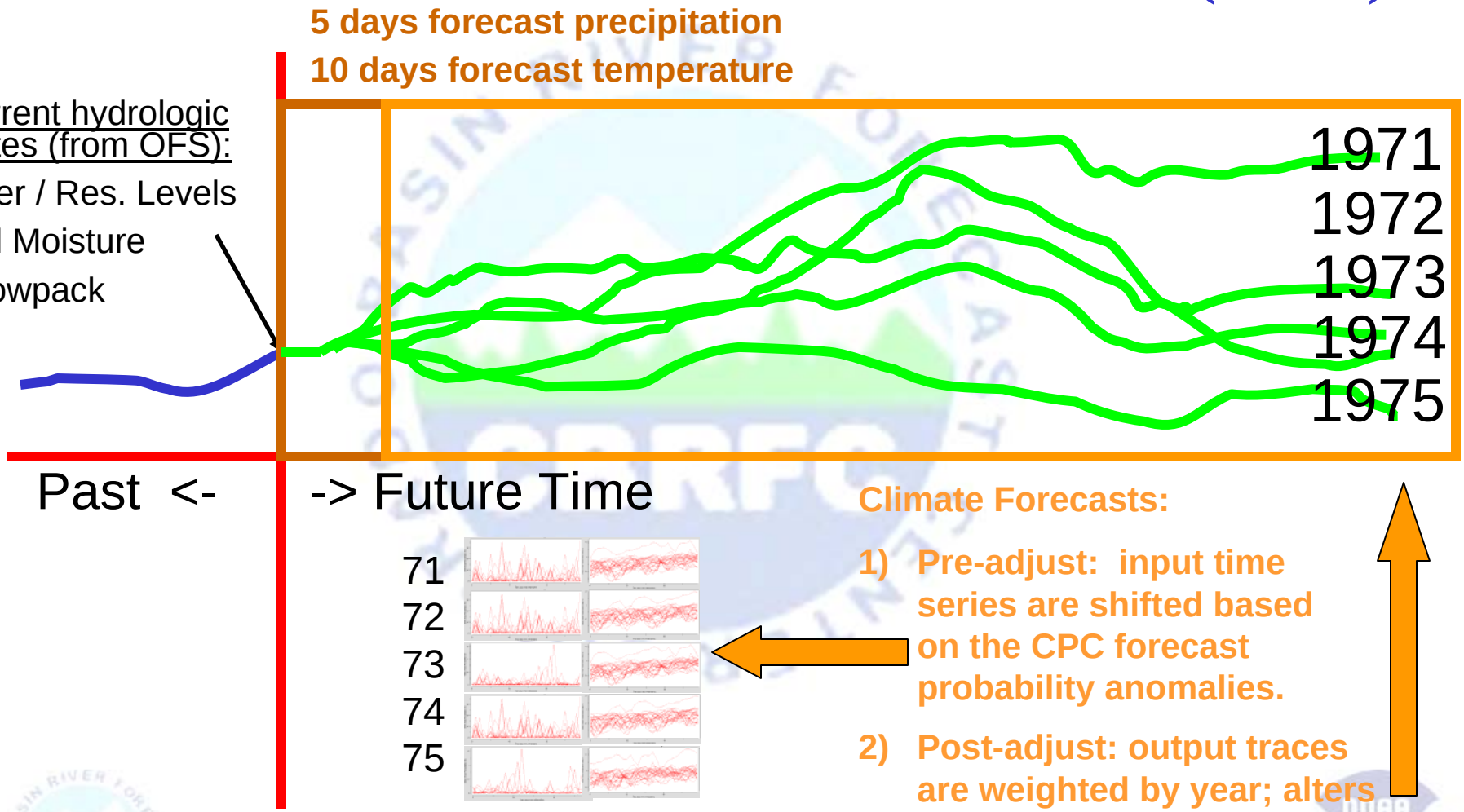


Historical time series of precipitation and temperature (from Calibration).

Currently using water years 1976-2005.

Start with current conditions – Apply each year of historical climate – Create several possible future streamflow patterns

Ensemble Streamflow Prediction (ESP)



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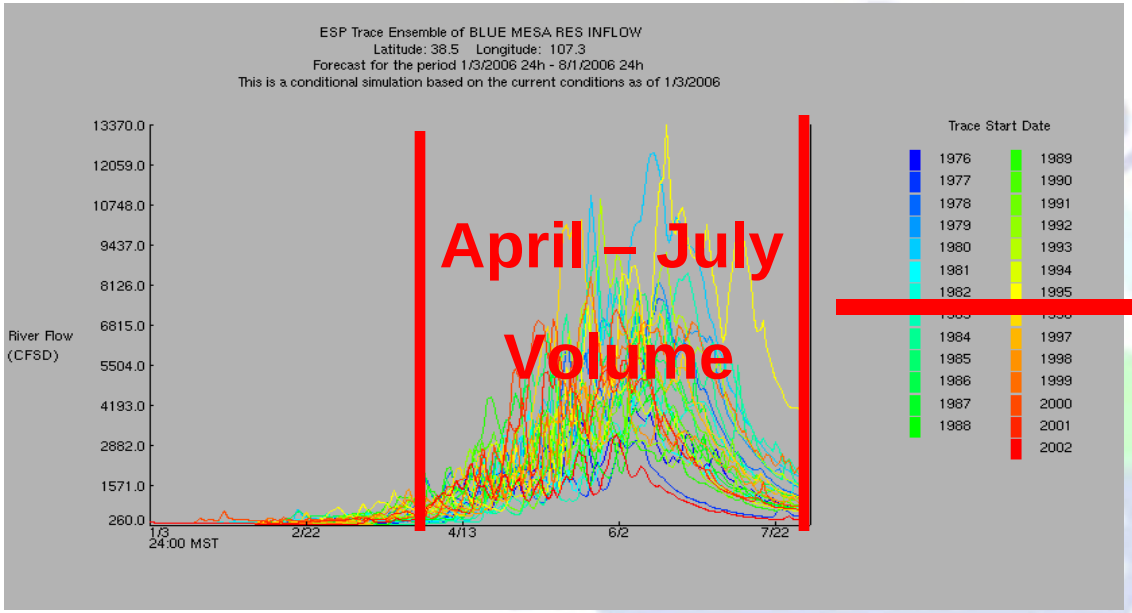
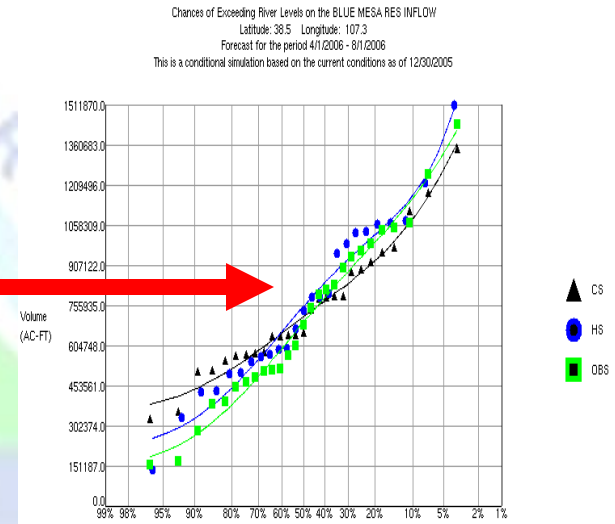
Ensemble Streamflow Prediction (ESP)





1. Select a forecast window
2. Select a forecast variable
3. Model derives a distribution function
4. 50% exceedance value = most probable forecast
5. Correct for model bias

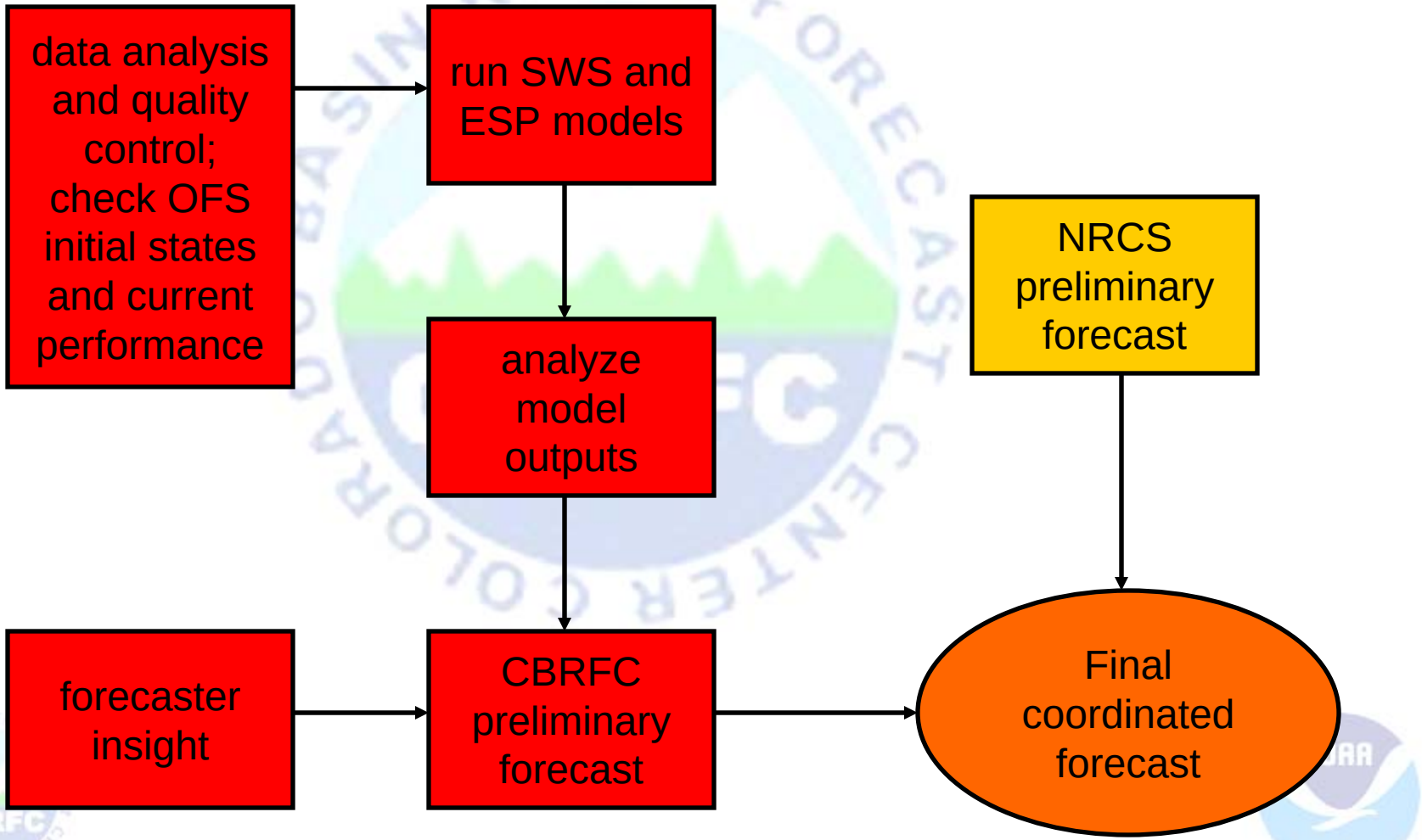
```
# Statistics based on all years.
#
# Exceedance    Conditional    Historical     Historical
# Probabilities Simulation     Simulation     Observed
# ------------------------------------------------------
  0.900         438320.500     328520.656     262730.375
  0.750         552369.562     499977.531     435810.375
  0.500         711742.375     751782.938     691946.625
  0.250         877104.812     973699.188     935549.938
  0.100         1080490.375    1170393.125    1157333.250
```

SWS vs. ESP

- Easy to calibrate, maintain and run.
- Works only for seasonal volumes.
- Equations are made to be run only at specific times (i.e. first of month) for a specific period.

- Requires extensive calibration and maintenance.
- Can compute many hydrologic variables over any period.
- Can be run at any time for any period.
- Keeps track of soil moisture.

Summary of Water Supply Forecast Process



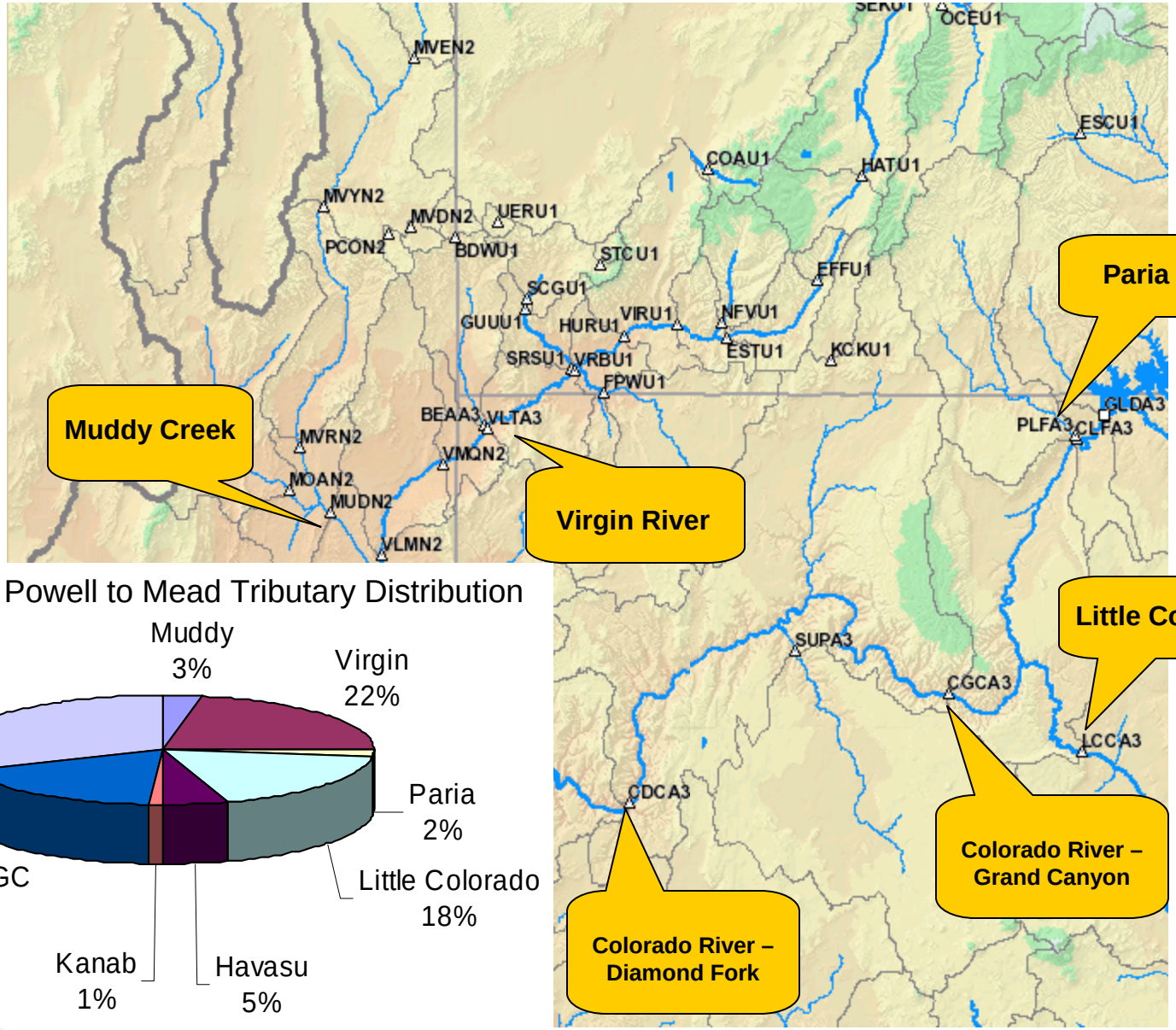
Sources of Error

- Data
  - Undetected errors in historical as well as current observations
    - Errors in streamflow measurements due to poor channel ratings/controls
  - Lack of data in some areas
  - Ungaged/unknown diversions (especially in low years)
  - Consumptive use
  - Distribution of snow vs. point measurements
- Model
  - Initial conditions (see data errors)
  - Calibration error (bias)
- Future weather
  - QPF (accuracy, distribution in space & time)
  - Spring temperatures affect melt/runoff pattern
  - Climate outlooks

Lake Powell and Lake Mead

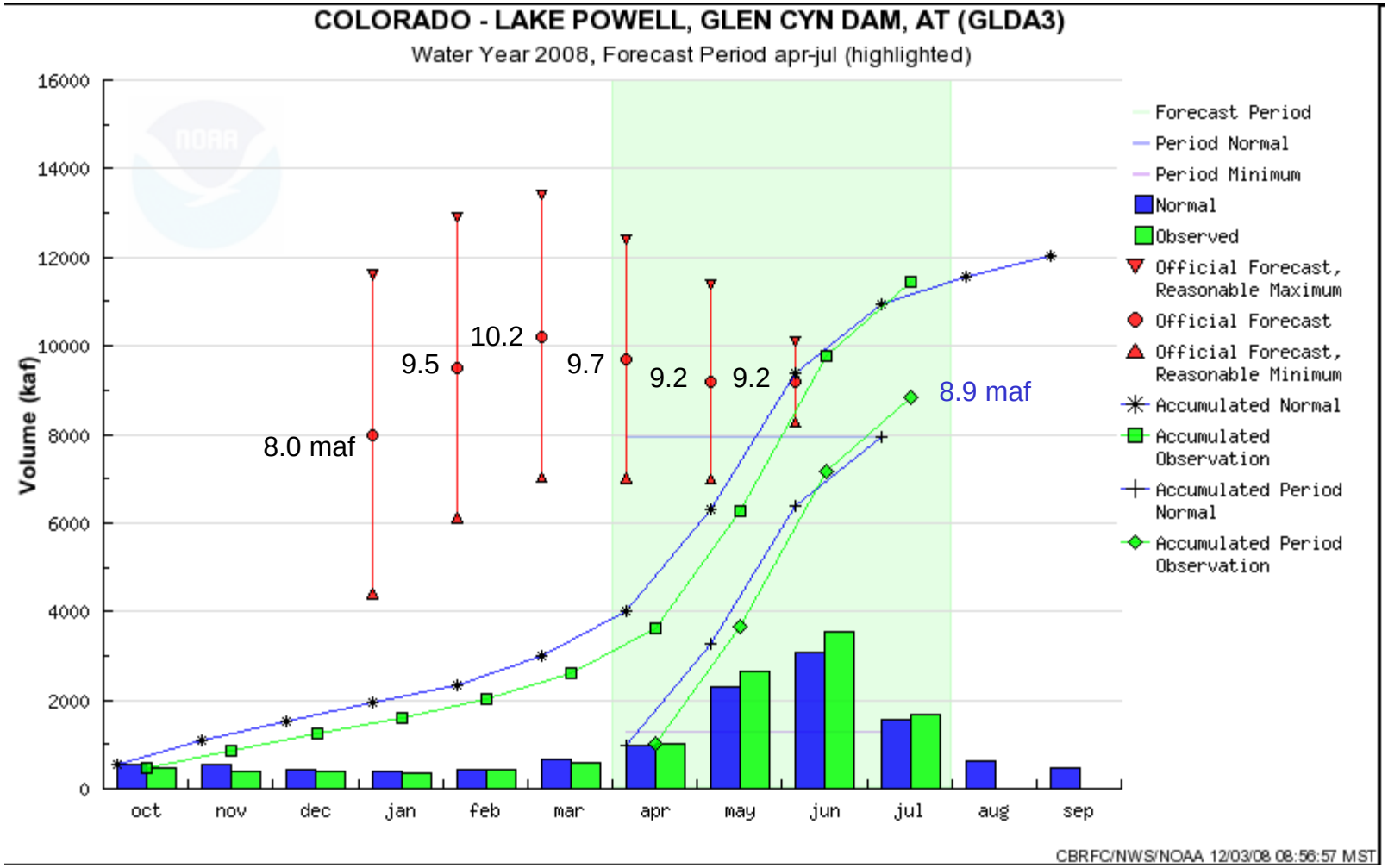
- Issued twice each month year-round.
  - First of month.
  - Mid-month.
- Monthly volumes for next three months.
  - Lake Powell values are the total ‘unregulated’ inflow.
  - Lake Mead values are the observed intervening (‘local’) flow between Lake Powell and Lake Mead.
- Based entirely on ESP (no SWS)
  - For months that are within the seasonal water supply window, it does take into account the official seasonal forecast volumes.

Lake Mead 'local' inflow forecasts



Annual Inflow Powell to Mead Tributary Distribution

Contact: Greg Smith (greg.smith@noaa.gov)



Apr-Jul 2008 8.9 maf /112%

Thank You!

www.cbrfc.noaa.gov

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