Water Supply Forecasting Tools and Processes

Forecast Verification Workshop

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Brenda Alcorn
Senior Hydrologist
Colorado Basin River Forecast Center

Water Supply Forecasting Tools and Processes

- Statistical Water Supply (SWS)
- NWS River Forecast System - Ensemble Streamflow Prediction (ESP)
- Coordination with the Natural Resources Conservation Service (NRCS)
- Sources of Error
- When and What

Statistical Water Supply (SWS)

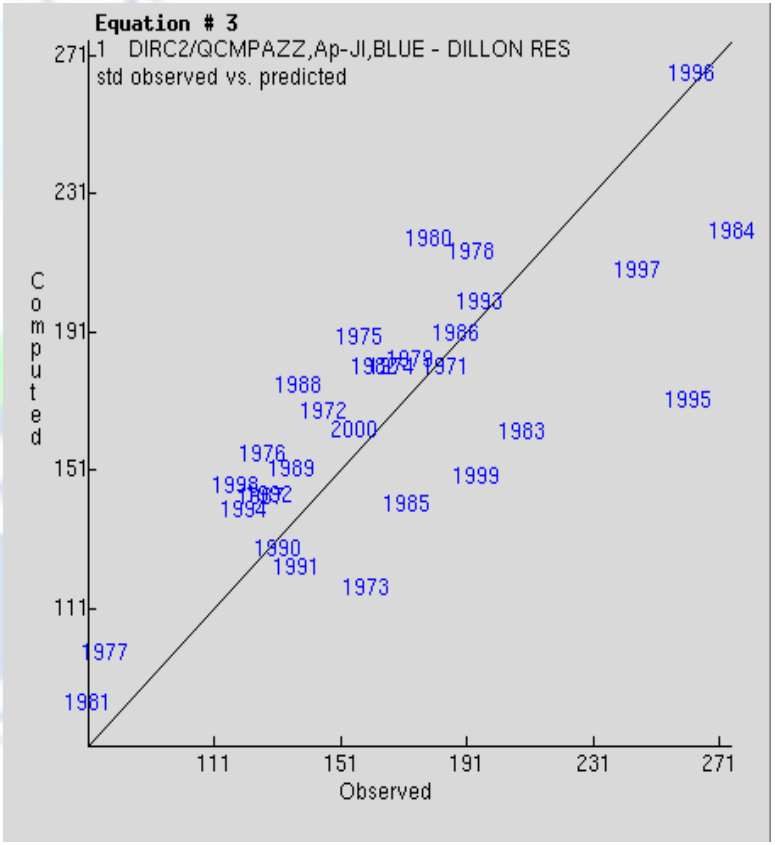
- Regression equations that relate observed data to future seasonal streamflow volume.
- Inputs are monthly values.
  - Total precipitation (can be multiple months)
  - First of month snow water equivalent
  - Monthly flow volume
  - Climate indices (SOI)
- Output is a seasonal volume (i.e. April-July).
  - 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)

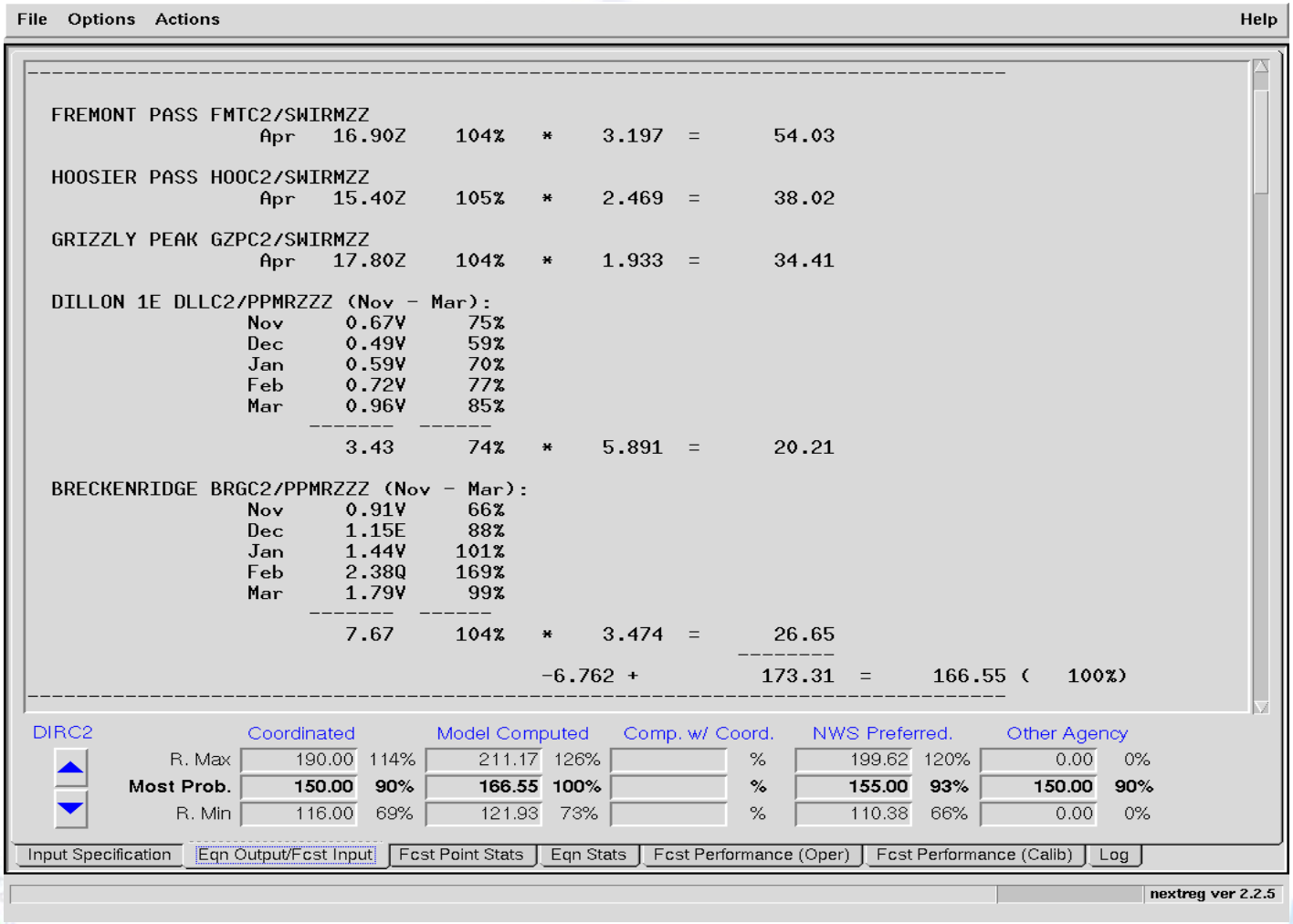
Sample Equation for April 1:

Apr-Jul volume for Dillon Reservoir
- Apr 1 swe Fremont Pass Snotel
- Apr 1 swe Hoosier Pass Snotel
- Apr 1 swe Grizzly Peak Snotel
- Nov-Mar precip Dillon
- Nov-Mar precip Breckenridge

R^2 = .60
Standard Error = 32.02
Number of observations = 30 (1971-2000)
Number of principal components used = 1

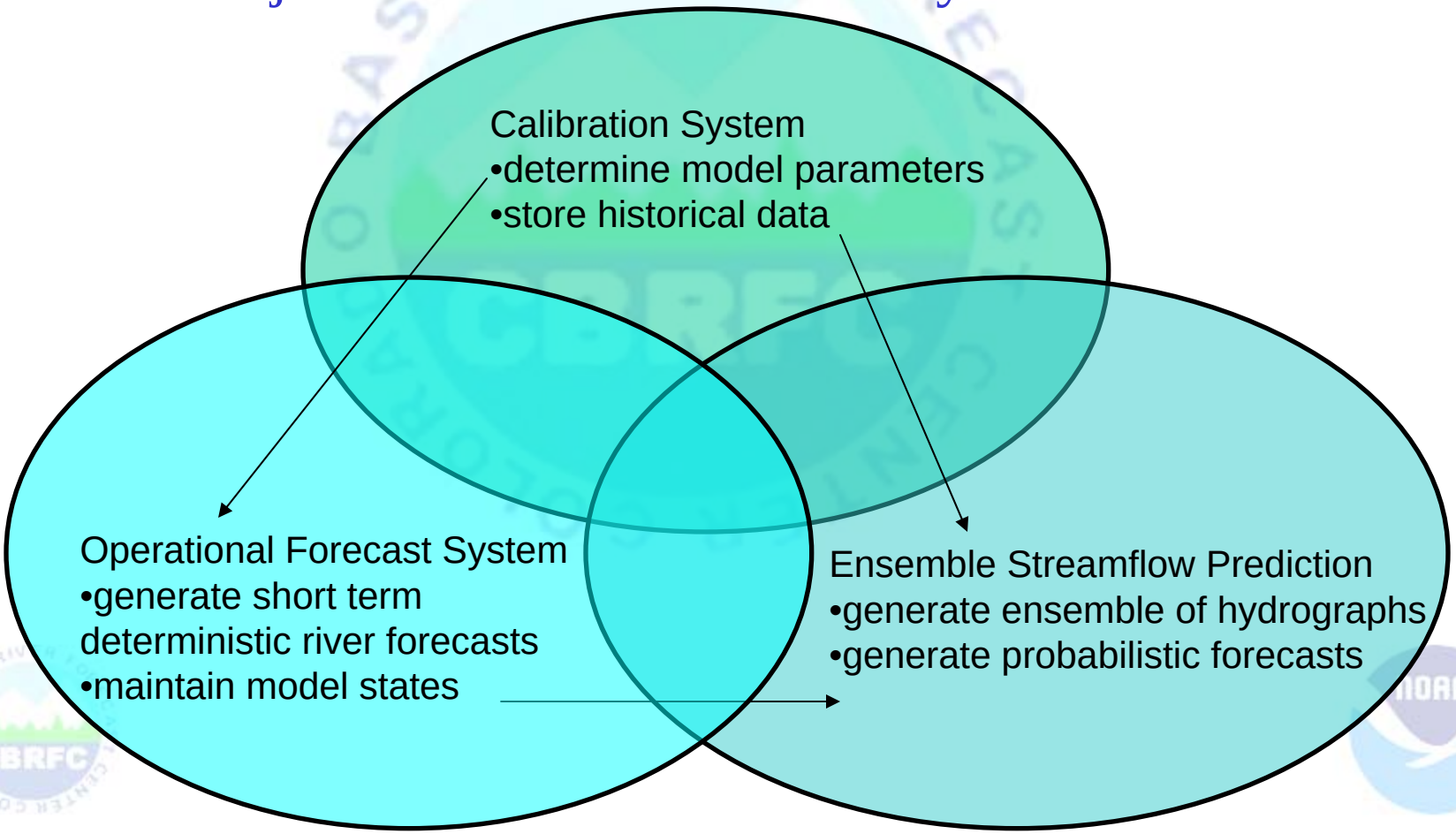


Statistical Water Supply (SWS)



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.

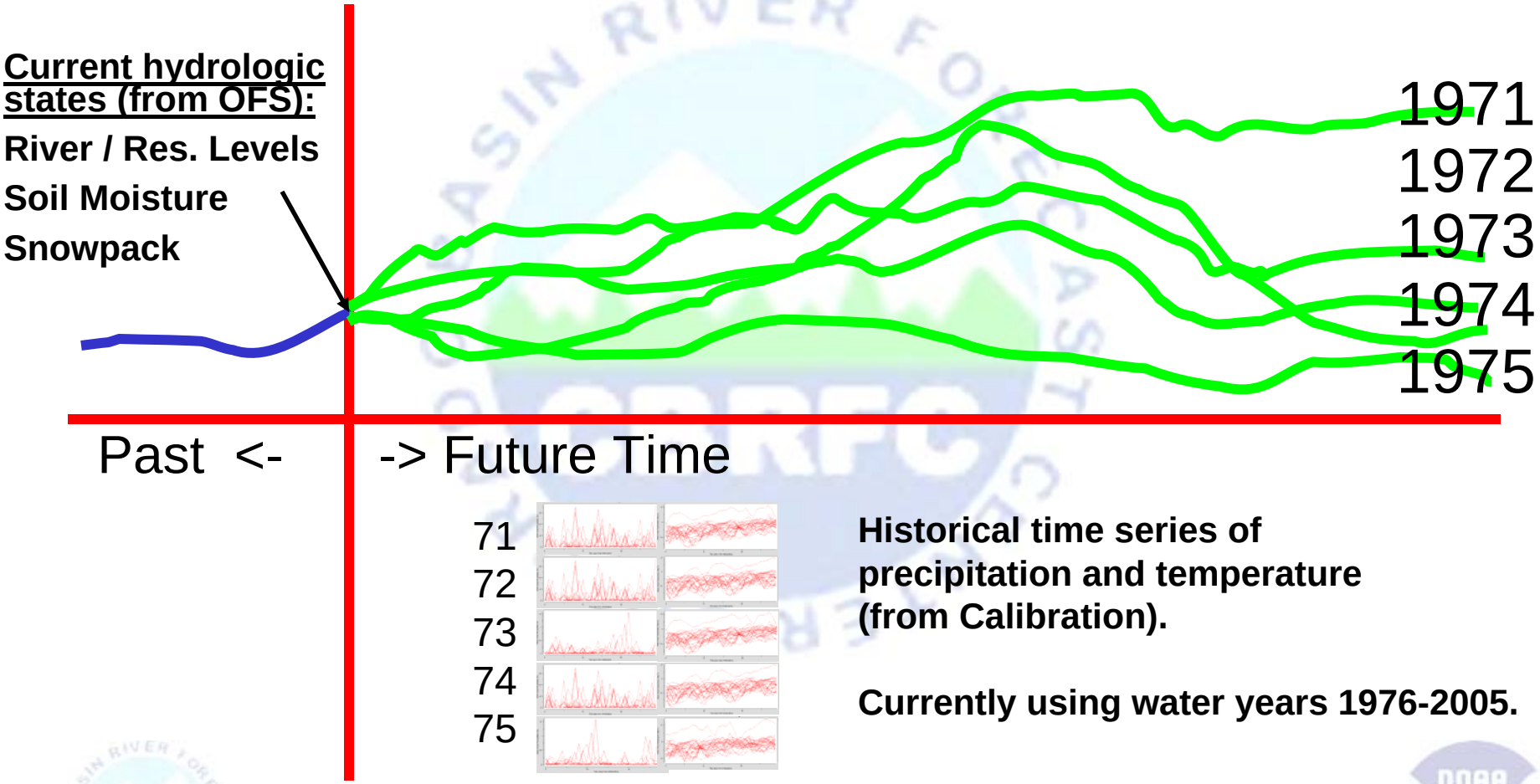
Operational Forecast System (OFS)

- 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)

5 days forecast precipitation

10 days forecast temperature

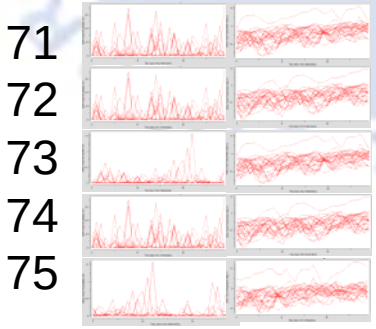
Current hydrologic states (from OFS):

River / Res. Levels

Soil Moisture

Snowpack

Past <- -> Future Time



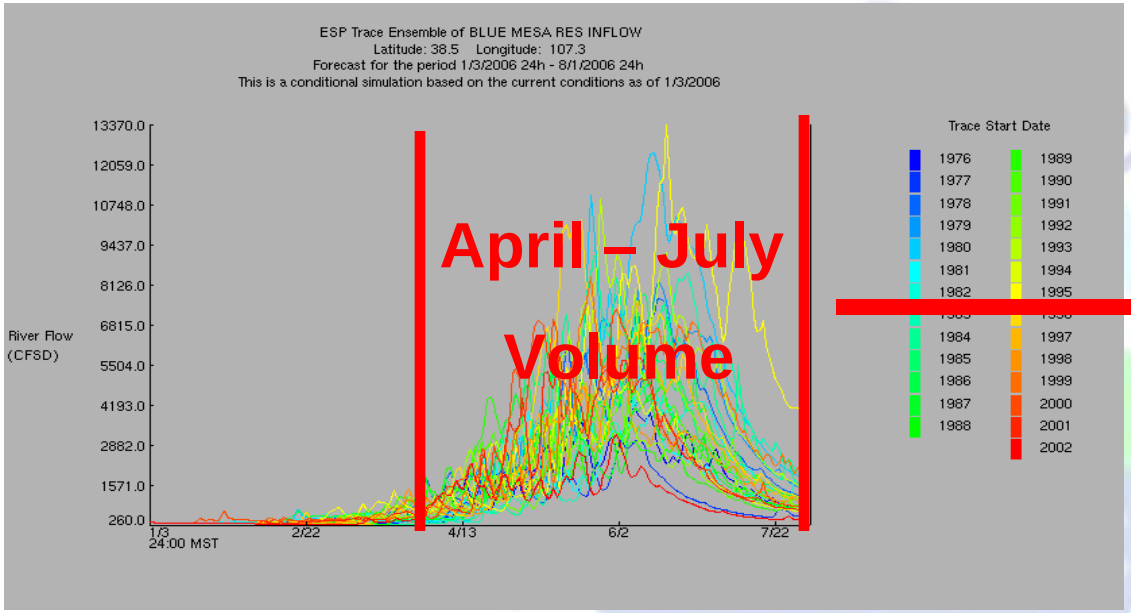
Historical time series of precipitation and temperature (from Calibration).

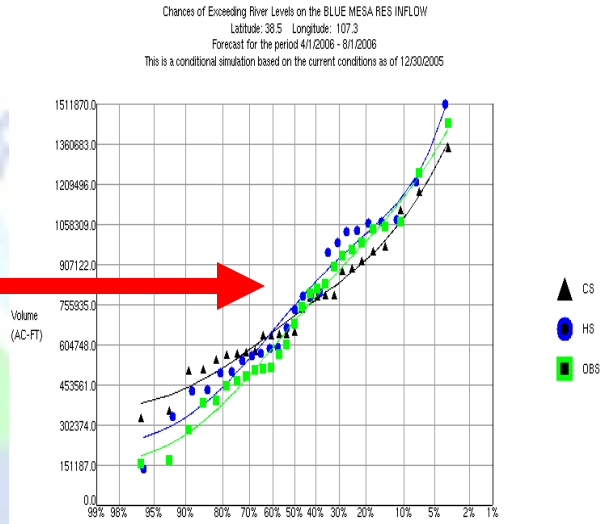
Climate Model Forecasts:

1) **Pre-adjust: input time series are shifted based on the CPC forecast probability anomalies.**

2) **Post-adjust: output traces are weighted by year; alters the likelihood (probability) of a value occurring, not the individual ensemble 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. Correct for model bias

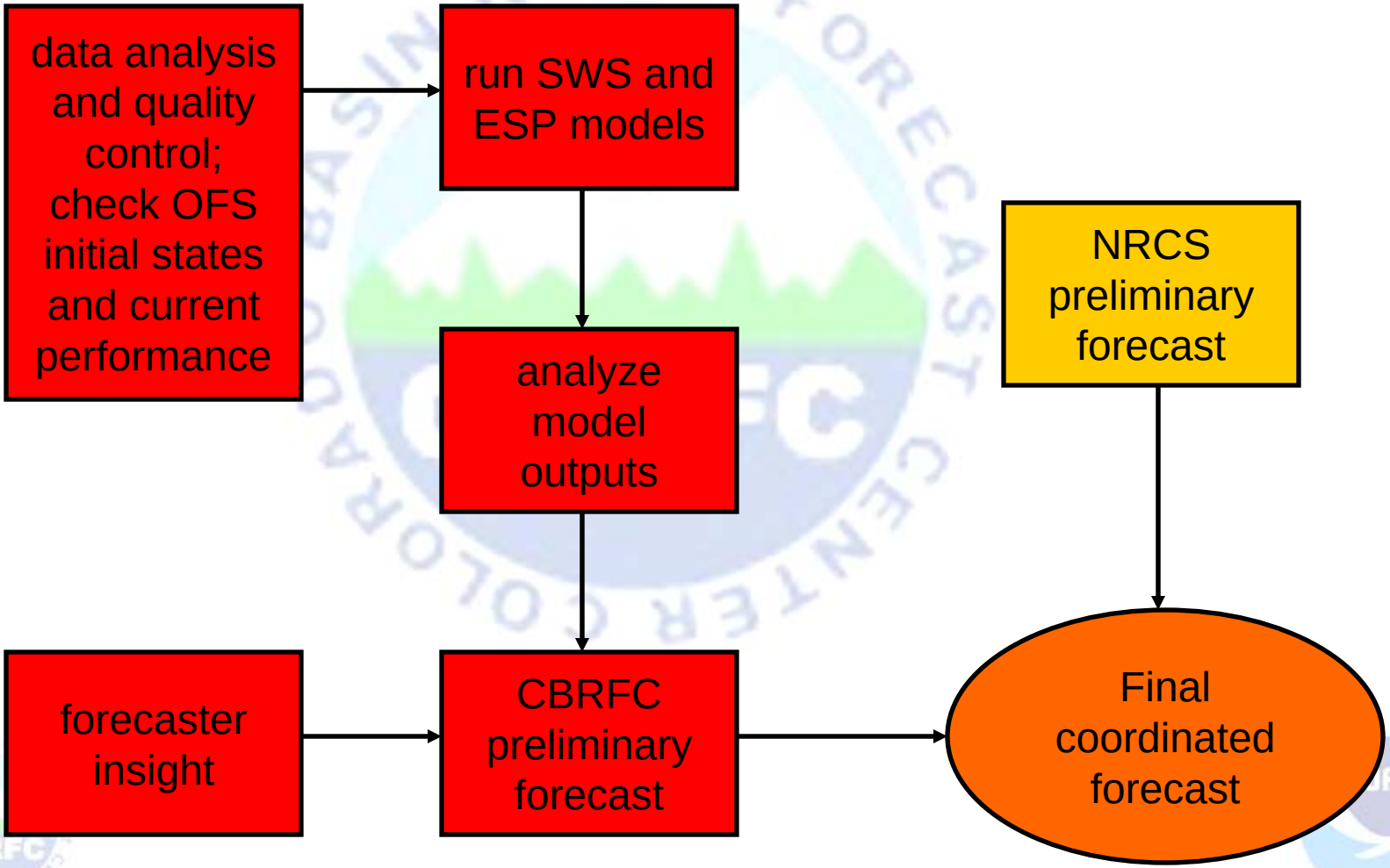
# Exceedance Probabilities	Conditional Simulation	Historical Simulation	Historical Observed
0.900	438320.500	328520.656	262730.375
0.750	552369.562	499977.531	435810.375
0.500	711742.375	751782.938	691946.625
0.250	877104.812	973699.188	935549.938
0.100	1080490.375	1170393.125	1157333.250

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).

- Requires extensive calibration and maintenance.
- Can compute many hydrologic variables over any period.
- Can be run at any time.
- 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
  - Temperature and precipitation

When and What

- 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/

Adjustment Example

EAGLE - GYPSUM, BLO adjusted flow =

+ EAGLE - GYPSUM, BLO observed flow
+ HOMESTAKE TUNNEL observed flow
+ EWING DITCH observed flow
+ COLUMBINE DITCH observed flow
+ WURTZ DITCH observed flow
+ HOMESTAKE RESERVOIR change in storage

Adjustment Example

COLORADO - CAMEO, NR CAMC2 QCMPAZZ
+ COLORADO - CAMEO, NR CAMC2 QCMRZZZ
+ TWIN LAKES TUN - TWIN LAKES, NR, EAST PORTAL, AT TWTC2 QCMRZZZ
+ CHARLES H. BOUSTED TUN CBTC2 QCMRZZZ
+ FRYING PAN - RUEDI RES, BASALT, NR RURC2 LSMRZZZ
+ HAROLD D. ROBERTS TUN - DILLON RES DIV, GRANT, NR RBTC2 QCMRZZZ
+ MOFFAT TUN - EAST PORTAL MOFC2 QCMRZZZ
+ ALVA B ADAMS TUN - ESTES PARK, NR, EAST PORTAL, AT ABTC2 QCMRZZZ
+ HOMESTAKE TUN - GOLD PARK, NR HSTC2 QCMRZZZ
+ GRAND RIVER DITCH - LA POUDRE PASS GRDC2 QCMRZZZ
+ COLORADO - SHADOW MTN RES, GRAND LK, NR SMRC2 LSMRZZZ
+ COLORADO - LAKE GRANBY, GRANBY, NR GBYC2 LSMRZZZ
+ WILLIAMS FORK - WILLIAMS FORK RES, PARSHALL, NR WFDC2 LSMRZZZ
+ BLUE - GREEN MTN RES GMRC2 LSMRZZZ
+ BLUE - DILLON RES DIRC2 LSMRZZZ
+ WILLOW CK - WILLOW CK RES, GRANBY, NR WCRC2 LSMRZZZ
+ HOMESTAKE CK - HOMESTAKE RES HMAC2 LSMRZZZ
+ HOOSIER PASS TUN - HOOSER PASS, NR HPTC2 QCMRZZZ
+ WOLFORD MOUNTAIN RESERVOIR WORC2 LSMRZZZ AVG
+ COLUMBINE DITCH CLMC2 QCMRZZZ
+ EWING DITCH - LEADVILLE, NR EWDC2 QCMRZZZ
+ WURTZ DITCH WZDC2 QCMRZZZ
+ BUSK-IVANHOE TUN BITC2 QCMRZZZ
+ BOREAS PASS DITCH BORC2 QCMRZZZ

Thank You!

www.cbrfc.noaa.gov

(801) 524-5130

brenda.alcorn@noaa.gov