Colorado Basin River Forecast Center

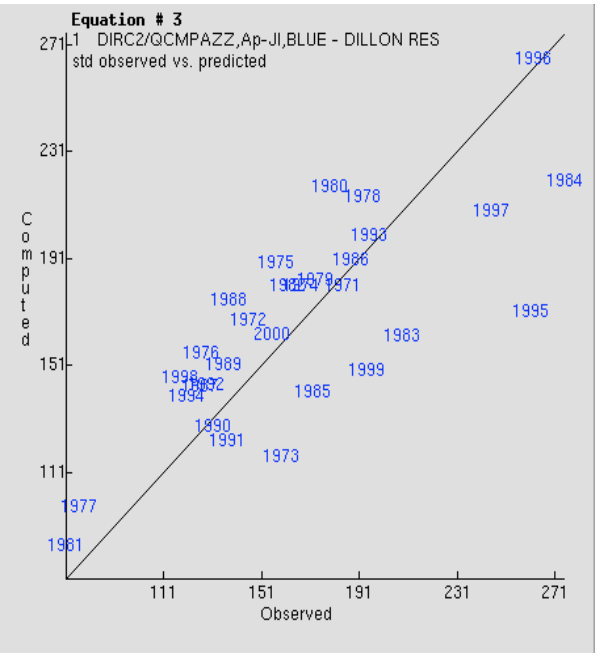
Water Supply Forecasting Tools

The Colorado Basin River Forecast Center (CBRFC) uses two separate tools for water supply forecasting: Statistical Water Supply (SWS) and the National Weather Service (NWS) River Forecasting System Ensemble Streamflow Prediction (ESP). These tools are described in this document, as well as the process followed by the hydrologists at the CBRFC to formulate a water supply forecast.

Statistical Water Supply (SWS)

SWS is a software package to develop and run regression equations that relate observed data to future seasonal streamflow volume. The inputs to these equations are monthly values, and can include one or more of the following: total precipitation (monthly or multi-months), snow water equivalent at different locations (as of the first of the month), monthly flow volume, and climate indices such as SOI. The output from these equations is a seasonal volume, such as a volume for the months of April through July. This output is a conditional probability distribution, not a single value. The standard output provides the 10%, 50%, and 90% exceedance values.

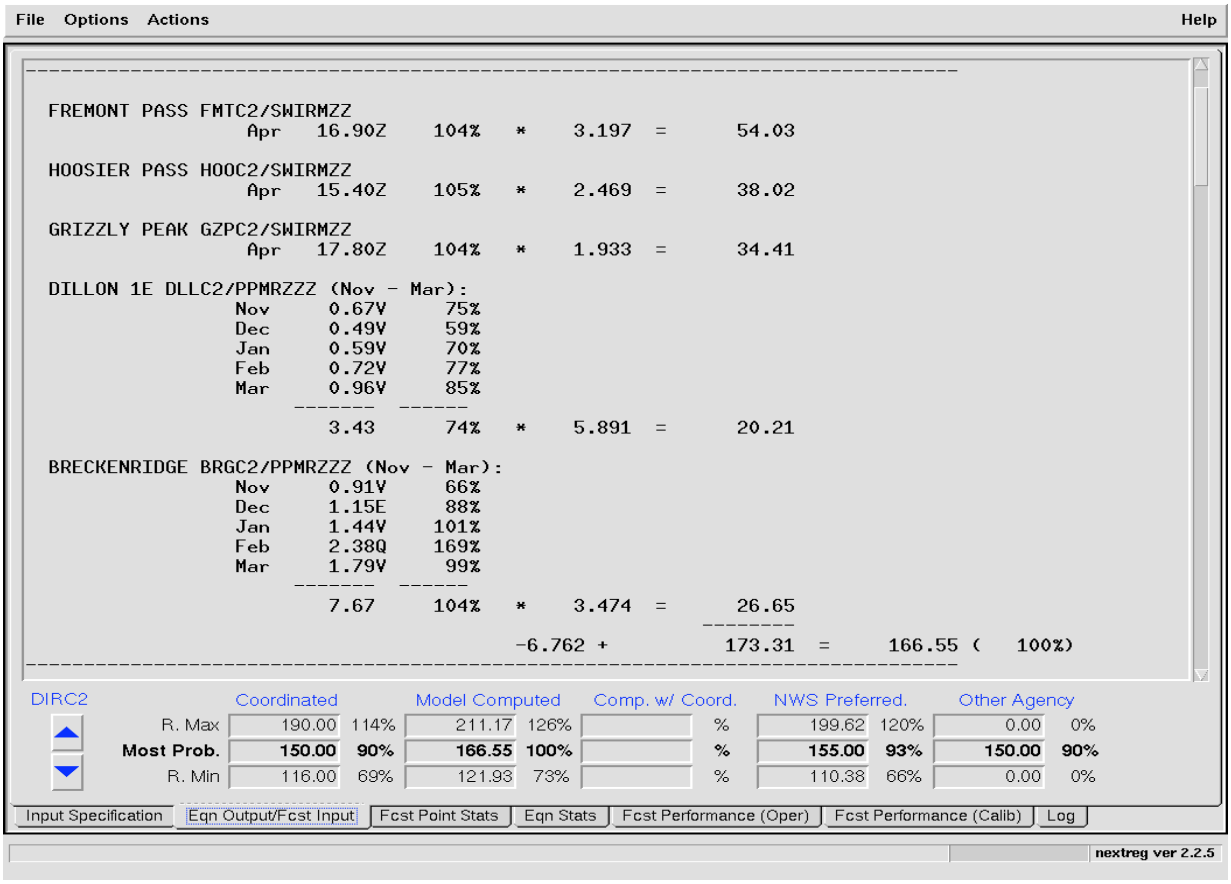
Here is an example of screen shots from the SWS interface which show the April 1st equation for Dillon Reservoir.



Sample equation for April 1:

Apr-Jul volume for Dillon Reservoir
Apr 1 SWE for Fremont Pass SNOTEL
Apr 1 SWE for Hoosier Pass SNOTEL
Apr 1 SWE for Grizzly Peak SNOTEL
Nov-Mar precipitation at Dillon
Nov-Mar precipitation at Breckenridge

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



NWS River Forecast System – NWSRFS

NWSRFS is a continuous, conceptual hydrologic model. It is composed of three major interrelated functional systems: the Calibration System, the Operational Forecast System, and the Ensemble Streamflow Prediction.

The Calibration System, or CS, is where the parameters of the model are determined. It is also where the model stores historical precipitation, temperature and streamflow data. In this system the hydrologist chooses from a variety of models and processes to model various river segments. The different models and processes will:

- simulate the 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.

The hydrologist determines the optimal set of parameters for each model to best simulate past flows.

The Operational Forecast System, or OFS, generates the short-term deterministic river forecasts. This is where the model tracks and maintains the current model states, including soil moisture and snowpack.

Inputs are:

- Observed precipitation, temperature, freezing levels, and streamflow (which have been previously quality controlled by hydrologist and meteorologists).
- Forecast precipitation (5 days) and temperatures and freezing levels (10 days).
- **Note: snow and snow water equivalent (swe) are not a direct input to the model. The snow model within each segment builds and melts its own snowpack based on precipitation and temperature inputs.

The states in each segment can be adjusted by the 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) in a program referred to as SEUES-lite.

OFS is run multiple times per day so there is continual quality control, updating and adjusting.

The Ensemble Streamflow Prediction (ESP) function is where future ensemble hydrographs and probabilistic forecasts are generated. This is the function used in water supply forecasting.

ESP uses model states from OFS as a starting point and can also use the precipitation forecast (out 5 days) and temperature forecast (out 10 days) as inputs. It then uses the historical precipitation and temperature time series from CS as potential future weather scenarios to generate an ensemble of forecast flows. Based on statistical distributions applied to these ensembles, ESP derives probabilistic hydrologic forecasts, such as volume, peak, minimum number of days to given flow, etc. The hydrologist can choose different probability distributions such as empirical, log, wakeby, etc. The system allows the display of any exceedance levels requested. The ESP output can be pre- or post- adjusted with climate forecasts, and adjusted for model (calibration) bias. See Figures 1 and 2 for additional information.

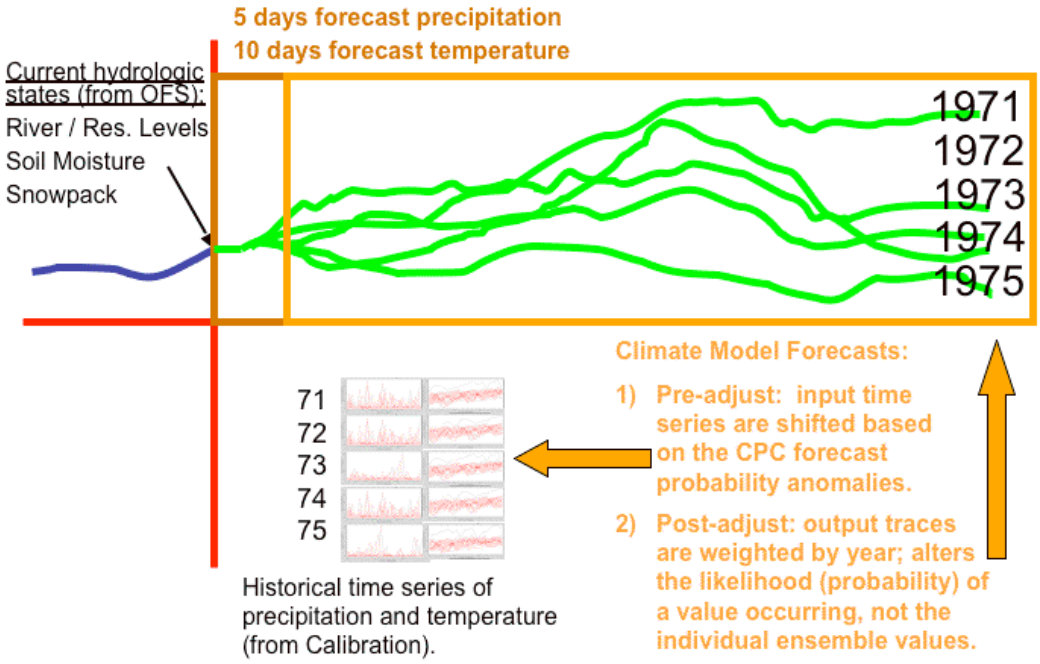


Fig 1 - Depiction of ESP methodology

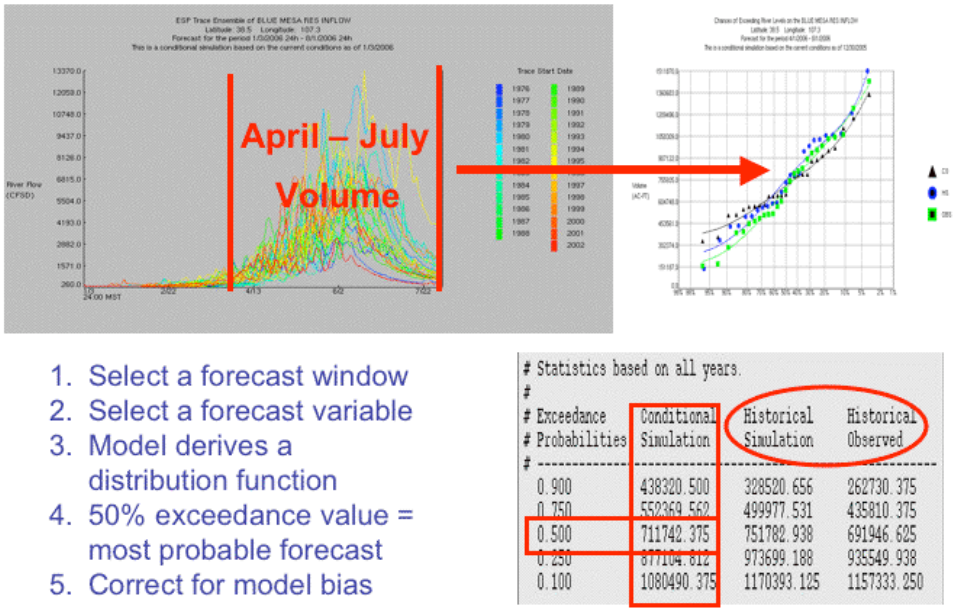


Fig 2 – Explanation of ESP interface

Comparing SWS and ESP – Each model has its strengths and weaknesses. SWS is a very easy model to calibrate, maintain and run. However it only works for pre-set seasonal volumes, and the equations can only be run at a specific time, for example on the first of the month. ESP on the other hand requires extensive calibration and maintenance. However, it is flexible in that it can compute many hydrologic variables over any period. It can also be run at anytime, and keeps track of soil moisture states.

The CBRFC forecasters use both ESP and SWS along with hydrologic expertise to determine a NWS preferred forecast. This forecast is then coordinated with the NRCS preferred forecast which also uses techniques similar to SWS.

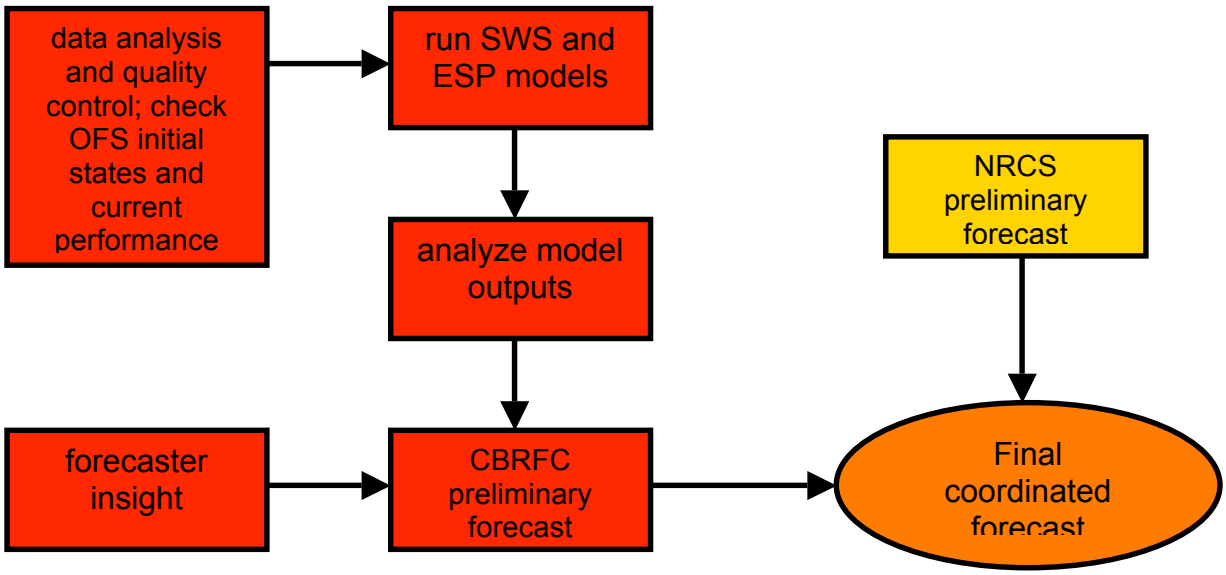


Fig 3 - Forecast Process

The official water supply forecasts are issued at the beginning of each month, from January through May. Some points are updated mid-month.

For most points, the forecast is the expected volume for April through July. It represents as close to natural flow s can be calculated by measured imports, exports, and reservoir storage. It does not include unmeasured quantities such as consumptive use, evaporation, etc. The adjustments we do account for can be found at http://www.cbrfc.noaa.gov/wsup/guide/.