Water Supply - Ensemble Streamflow Prediction

Ensemble Streamflow Prediction (ESP) is a modeling component of the National Weather Service Community Hydrologic Forecasting System (CHPS). The CBRFC uses ESP to produce probabilistic forecasts of streamflow with a lead time of up to 5 years. ESP utilizes a conceptually based modeling system and historical forcings to simulate soil moisture, snow pack, and streamflow. The CBRFC's modeling and forecasting paradigm contains a calibration component and an operational component.

The **calibration component** is where the parameters of the model are determined and where the model stores historical precipitation, temperature and streamflow data. The different models and processes that make up the calibration component 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

An optimal set of parameters for each model is developed to best simulate past flows.

The **operational component** generates the short-term deterministic (10 to 15 days) 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 have gone through a quality control process by CBRFC hydrologists and meteorologists)
- Forecast precipitation (7 days) and temperatures and freezing levels (10 days)
- It is important to note that snow and snow water equivalent (SWE) are not direct inputs to the model. The snow model within each segment (or basin) builds and melts its own snowpack based on precipitation, freezing level, and temperature inputs.
- Soil moisture is also an important, modeled component that does not utilize observed soil moisture measurements.

The states in each segment (or basin) can be adjusted by forecasters in real time. The operational component is run at least daily so there is continual quality control, updating and adjusting.

ESP relies on current hydrologic model states and historical precipitation and temperature time series from each year of the calibration period (currently 1991-2020 for most areas). Short term (7-day) precipitation and temperature forecasts can also be incorporated. The CBRFC runs two variations of ESP for each basin:

- ESP with 7 days of forecast precipitation (QPF) and temperature (QTF). Temperature forecasts blend back to the historical time series for days 8 through 12, while precipitation goes directly to the historical time series on day 8
- ESP NoQPF uses just the historical precipitation and temperature time series

The historical precipitation and temperature time series are used with current hydrologic conditions to generate equally likely sequences of future hydrologic conditions, or an ensemble of forecast flows. Based on statistical distributions applied to these ensembles, ESP derives probabilistic hydrologic forecasts. The system allows the display of any exceedance levels requested. ESP output can be post-adjusted based on climate scenarios such as El Niño and La Niña, and adjusted for model (calibration) bias. The figures below depict the ESP technique, and output:

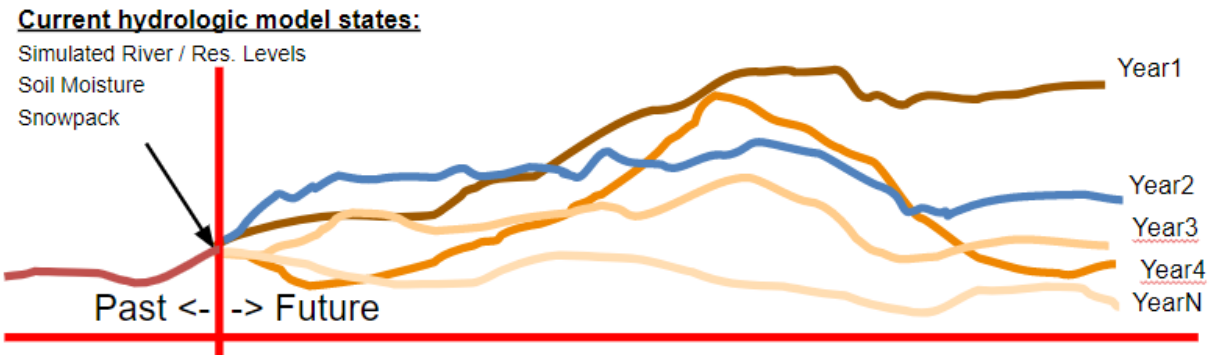

Fig 1. Schematic illustrating the general ESP methodology

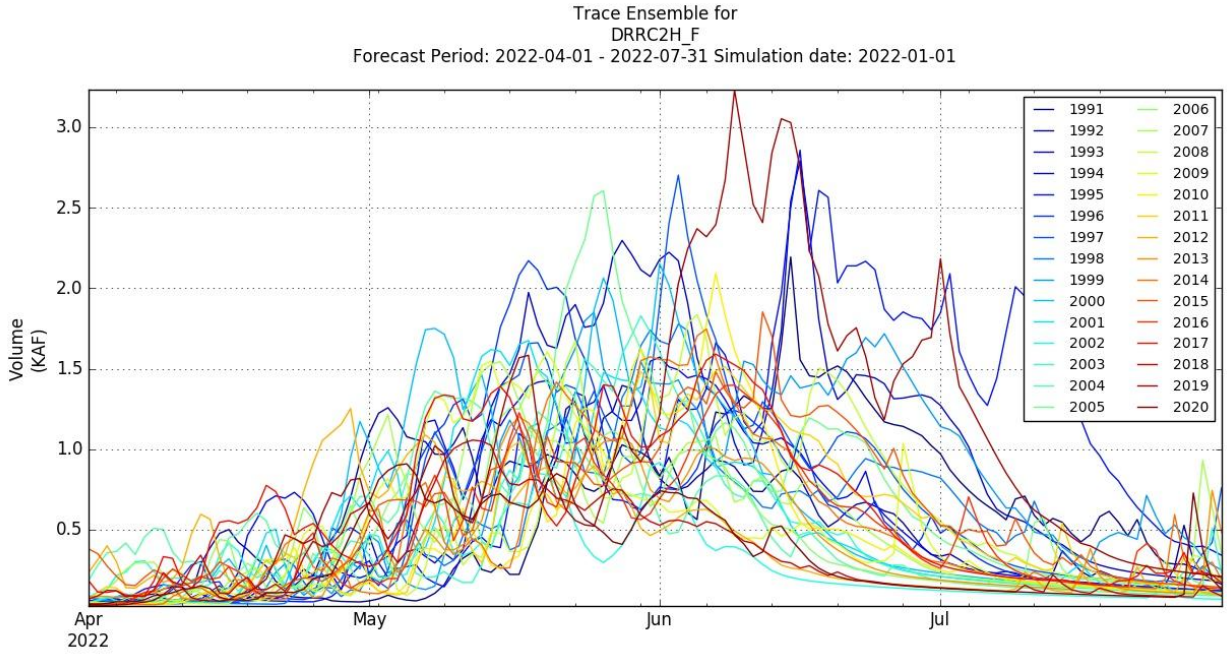

Fig 2. An ensemble of hydrologic traces spanning the calibration period (1991 - 2020) over the seasonal forecast period (April - July for this segment)

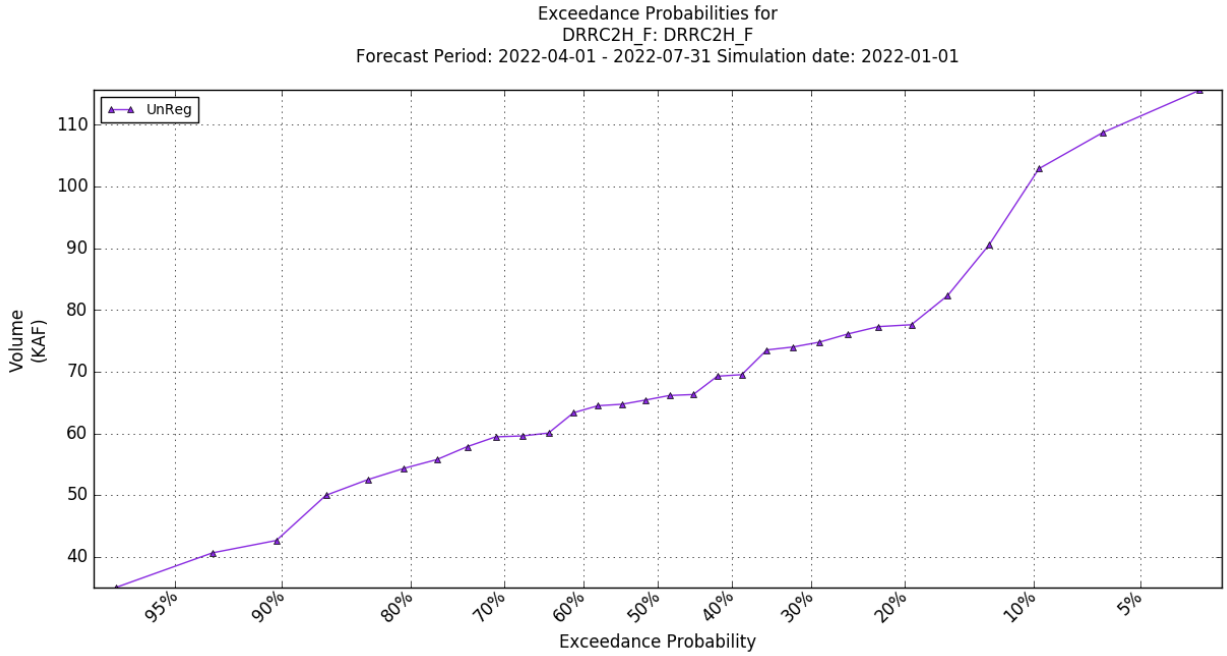

Fig 3. Exceedance probabilities developed from the ESP traces in Figure 2.

Fig 4. ESP generated exceedance probabilities including observations and historical simulation