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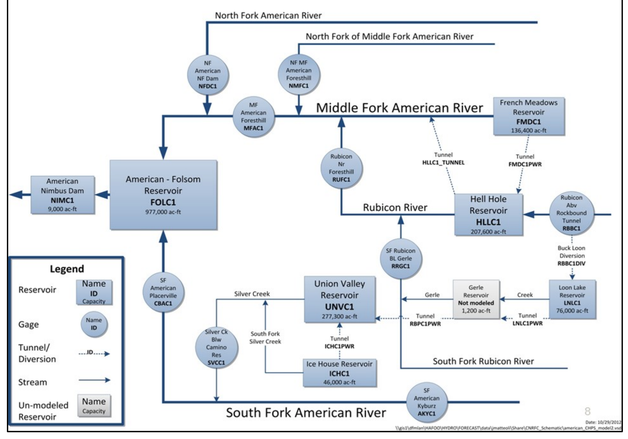
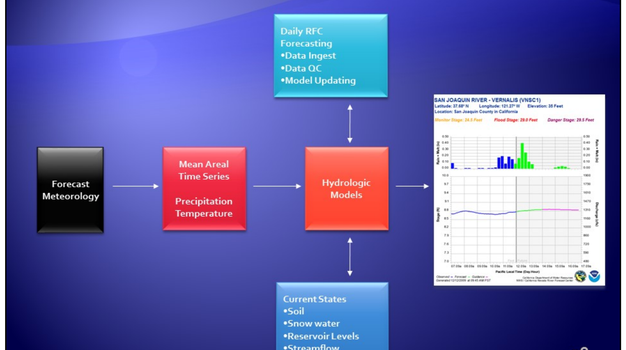
ENSEMBLE MODELING TO IMPROVE HYDROPOWER GENERATION AND FLOOD FORECASTS IN THE AMERICAN RIVER BASIN

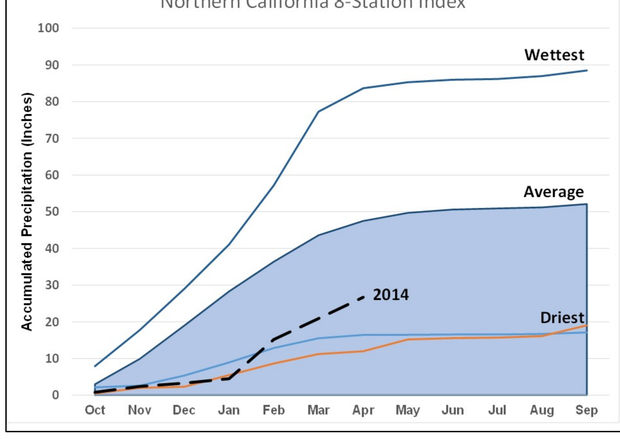
American River Basin CNRFC Model



Deterministic Forecasts



Northern California 8-Station Index



Background

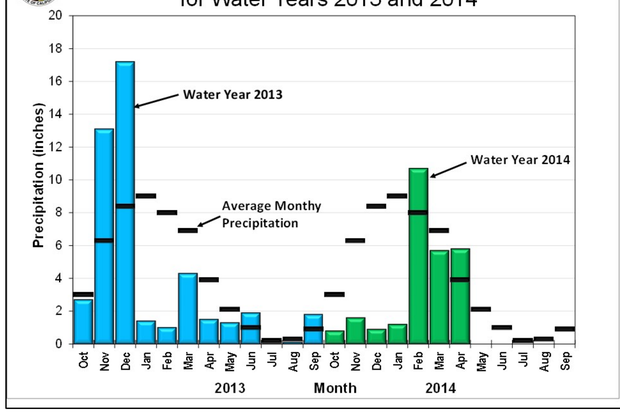
- Prior study
  - Reviewed SMUD's inflow forecasting
  - Recommended SMUD-NWS partnership
- Result
  - NWS added Upper American River forecast points
  - Ensemble forecasts

NWS Calibration

Deterministic vs. Ensemble

- Deterministic forecasts use the CURRENT model states and a single set of inputs to generate a single set of results
- Ensemble forecasts use the CURRENT model states and an ensemble of inputs to generate an ensemble of different results

Northern Sierra 8 Station Precipitation for Water Years 2013 and 2014



American River

Full Natural Flow

Definition: The natural flow of a stream without regulation, control, diversion or import.

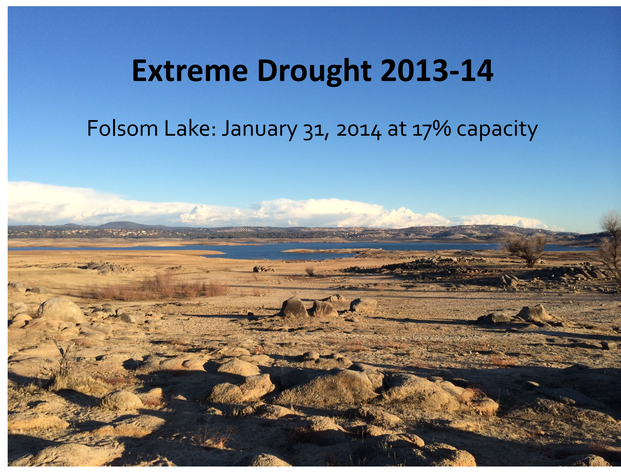
Examples:

- Accretion flow (downstream gage – upstream gage)
- Water balance
- Rainfall runoff
- Correlation

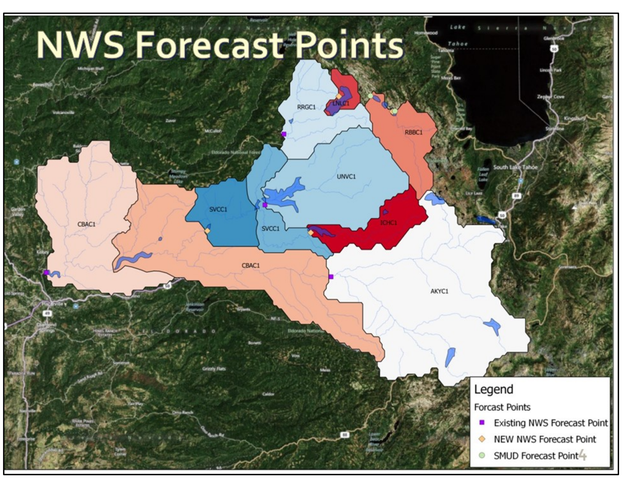
Ensemble Forecasting

Extreme Drought 2013-14

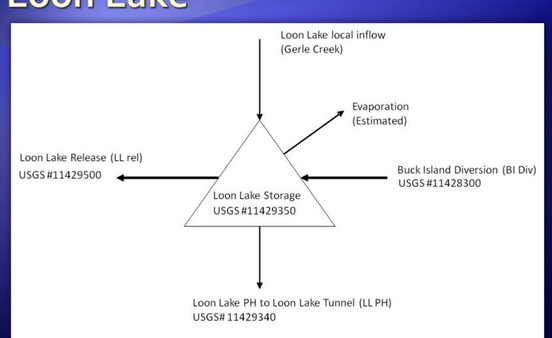
Folsom Lake: January 31, 2014 at 17% capacity



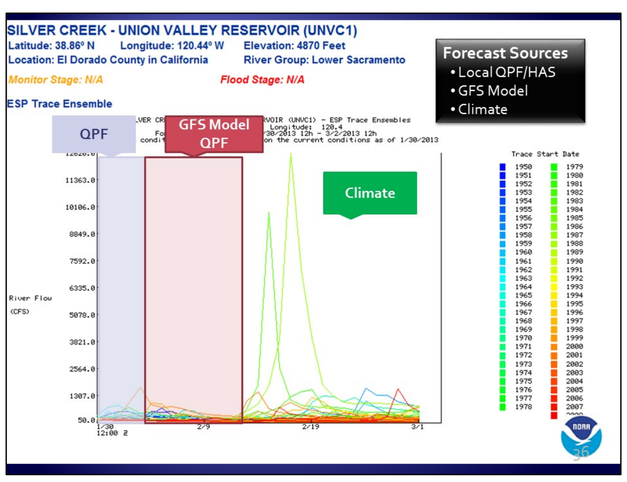
NWS Forecast Points

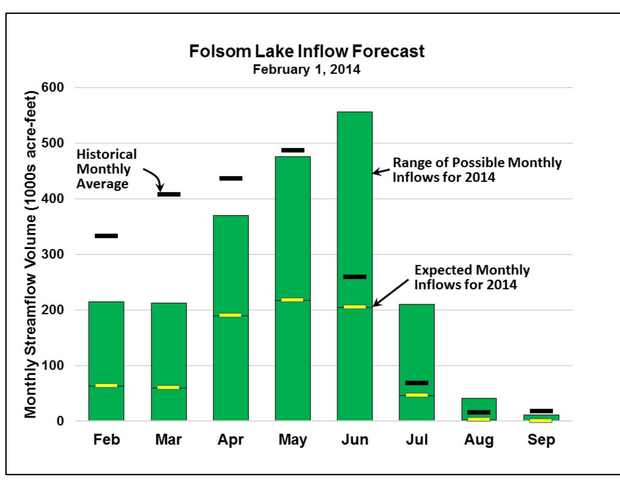


Un-impairing Gerle Creek at Loon Lake



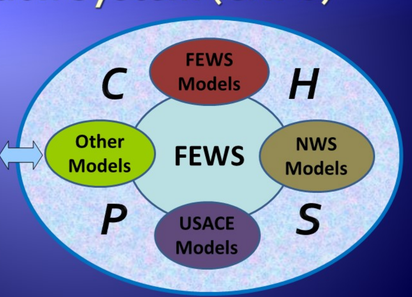
Local Unimpaired Inflow = S2 – S1 + Evap + LL rel + LL PH – BI div.





NWS Community Hydrologic Prediction System (CHPS)

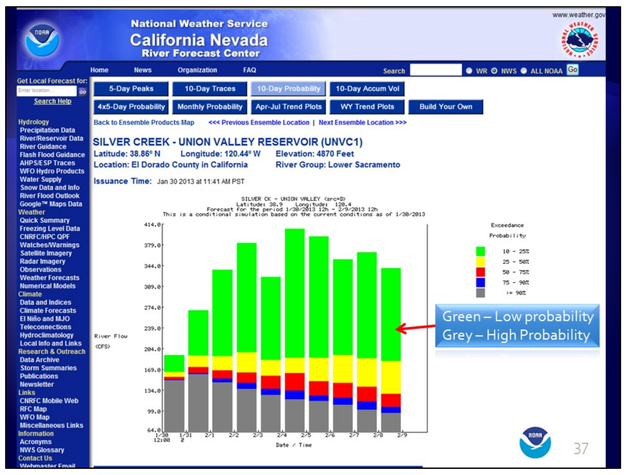
Models from federal, state, local, university and international researchers

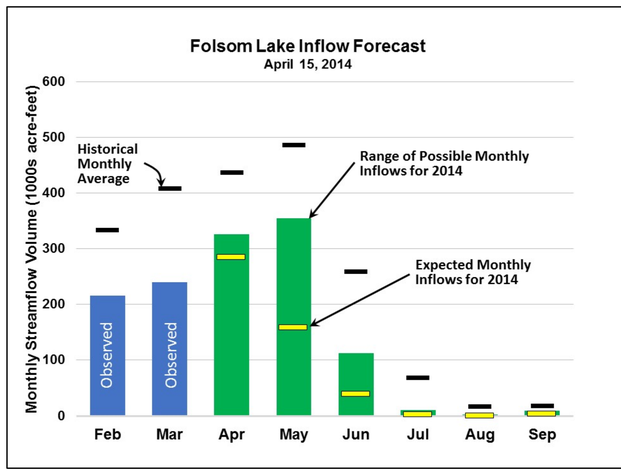


CNRFC Forecast Disaggregation

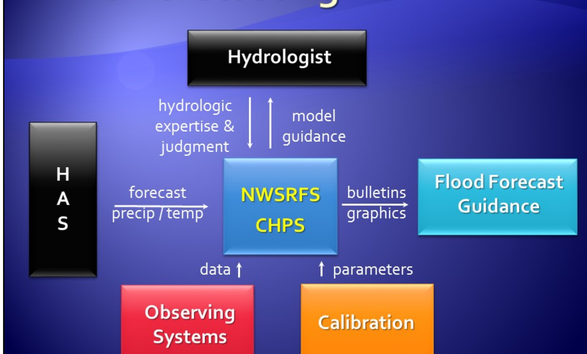
Needed to estimate flows from smaller contributing watersheds

- Used daily unimpaired flow developed for UARP FERC Relicensing (1975-2001)
- Calculated accretions for specific forecast areas
- Separated accretions by month
- Developed average daily runoff ratios to be applied to CNRFC Unimpaired forecasts

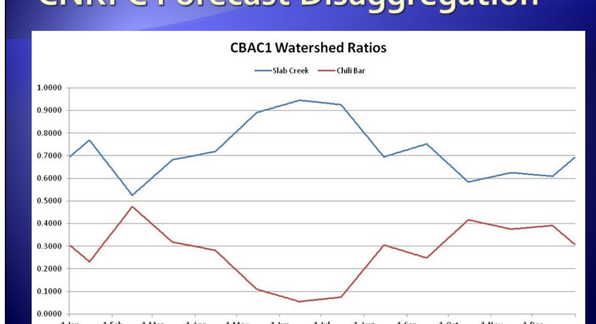




NWS Forecasting



CNRFC Forecast Disaggregation



Ensemble Assumptions

- Historical input (meteorology) scenarios are equally likely
  - Each has the same probability of occurrence
- Generated streamflow ensembles also equally likely
- Ensembles are reliable
  - Zero bias
    - The ensemble mean is a good indicator of the outcome with a 50% chance of being exceeded
  - Appropriate spread
    - Estimates away from the mean are representative of the true likelihood

Summary

- Ensemble streamflow predictions are just scenarios of equally likely outcomes from a deterministic prediction system.
- Ensemble streamflow predictions meet increasing requirements for risk and uncertainty information
- Continuous improvement by CNRFC to produce operational ensemble forecasts for the short, medium, and long-range time domains.
- Ensembles available in compatible formats for user applications

The ensemble forecasts are proving highly valuable in guiding SMUD's hydropower operations under severe drought. Previously, decision-makers relied on statistical regressions which break down under extreme conditions.