

# Water Resource Status and Forecast Methods Of the Western Region RFC's

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- How does the RFC make water supply forecasts?
- What is our current status and projection?
- Where can I find this water resource information?

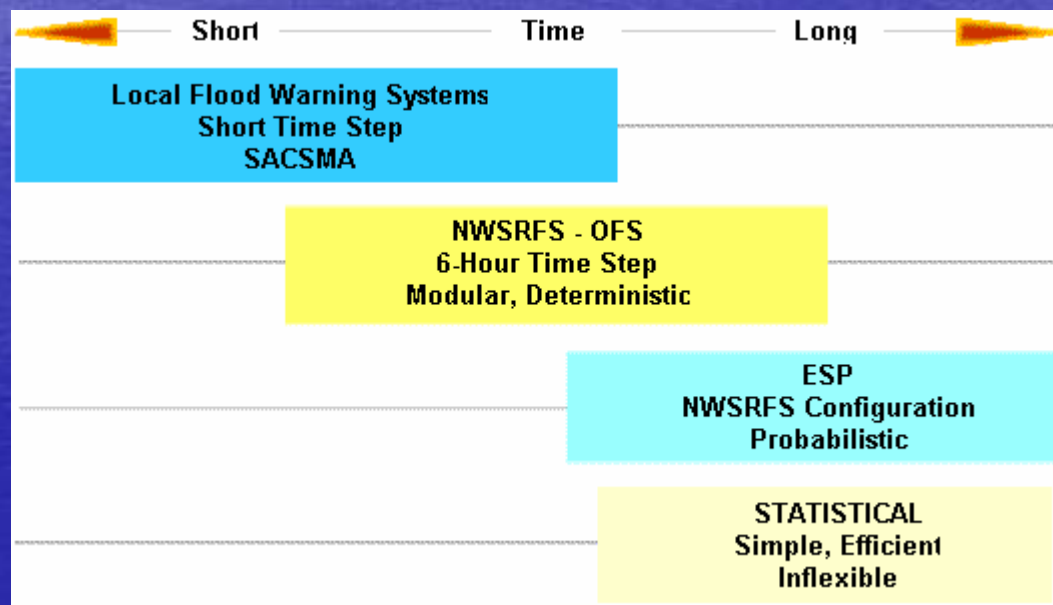
# The Process of Making Water Supply Forecasts

## Two fundamental methods

- statistical regression – equations to relate observed data to a future seasonal streamflow volume
- ESP – using the current states of our continuous conceptual daily river model as the initial conditions then applying various schemes of future weather

# Current RFC Forecast Tools

- Sacramento Soil Moisture Accounting (SAC SMA) commonly used at RFCs
- 6 hour time step for routine flood forecasting operations
- Ensemble Streamflow Prediction used for longer time scales
- Statistical regression equations used for seasonal streamflow prediction



# Statistical Regression

- Multivariate regression equations created using principal component analysis (PCA)
  - Data sites used in snowmelt regression equations tend to be highly inter-correlated. PCA gets beyond this and allows us to calculate optimal coefficients
- Can be non-linear which helps with the extremes

Equation # 4

Y 1 LPHC2/QCMRZZZ,Ap-J1,LA PLATA - HESPERUS

= 3.711  
 + -0.918 X1 SOI--/CIIRZZZ,Ja,  
 + 1.966 X3 HSPC2/PPMRZZZ,Ja,FORT LEWIS  
 + 0.859 X5 MNCC2/SWIRMZZ,Fe,MANCOS  
 + 0.600 X6 LPLC2/SWIRZZZ,Fe,LA PLATA SNOWCOURSE

Number of observations used = 26

Number of principal components used = 1

CORRELATION COEFFICIENT (R) = 0.862  
 STANDARD ERROR = 6.351 (rank = 10)  
 JACKKNIFE CORRELATION COEFFICIENT = 0.838  
 JACKKNIFE STANDARD ERROR = 6.851  
 JACKKNIFE BIAS: above average flow = -2.994 (12 obs.)  
 below average flow = 2.991 (14 obs.)

YEAR	OBSERVED	COMPUTED	ERROR	JACKKNIFE COMPUTED	JACKKNIFE ERROR
76	15.85	11.20	-4.65	11.85	-4.00
77	3.68	11.81	8.13	12.74	9.06
78	26.99	27.84	0.85	27.88	0.89
79	44.28	44.10	-0.18	44.29	0.01

# ESP

- Ensemble Streamflow Prediction (ESP)
  - Uses current model states of soil moisture, modeled snowpack and current flow
  - Various methods of data assimilation are in use at the RFC's to update the seasonal snowpack with observed data

# Making an Ensemble Forecast Using ESP

Past

Stages

Soil/Snow

States

Blend QPF/QTF

Flow Traces

1971

1972

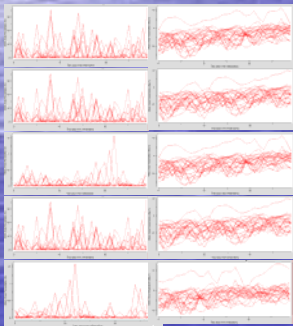
1973

1974

1975

Past <- -> Future Time

71  
72  
73  
74  
75



Historical Precip/Temps for Past Years  
Creates a Flow for Each Year

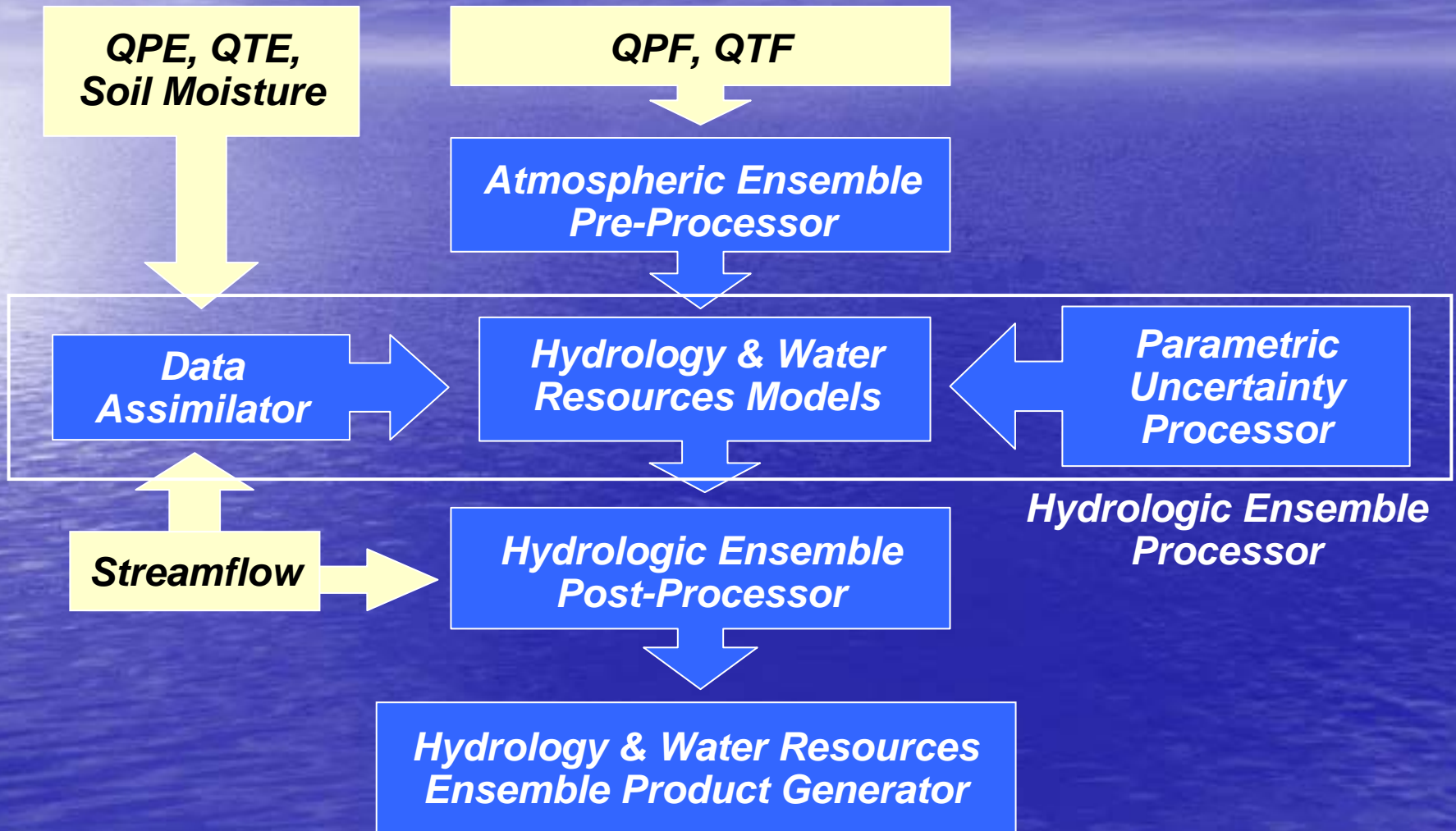




# Current ESP Capabilities

- OHD's Ensemble Pre-Processor (EPP):
  - Testing and development at 4 RFCs: CN, CB, AB, MA
  - Currently leverages:
    - Historical HAS QPFs
    - CDC's frozen GFS
    - Basin climatologies
- Local efforts at other RFCs:
  - NC using HPC confidence intervals
  - OH using geospatial statistics
- CPC Pre-adjustment technique

# Elements of a Hydrologic Ensemble Prediction System

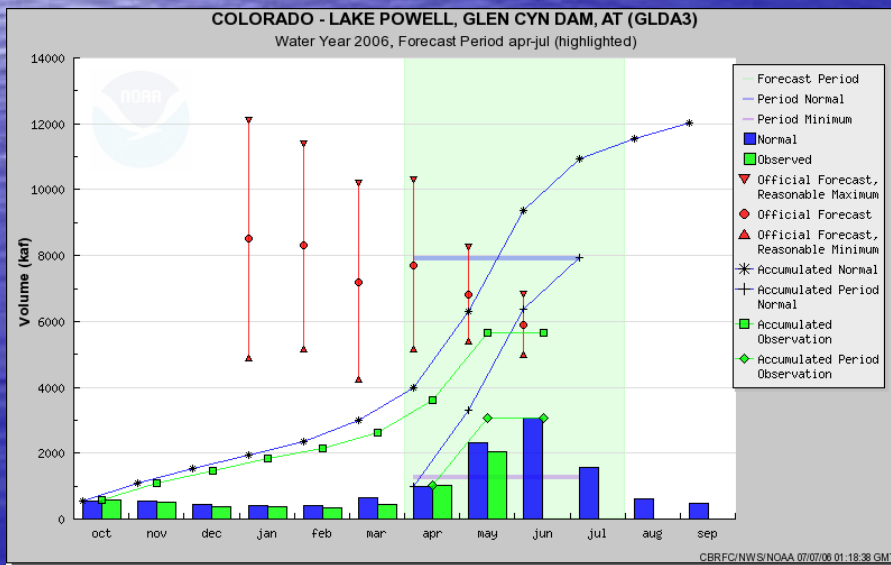
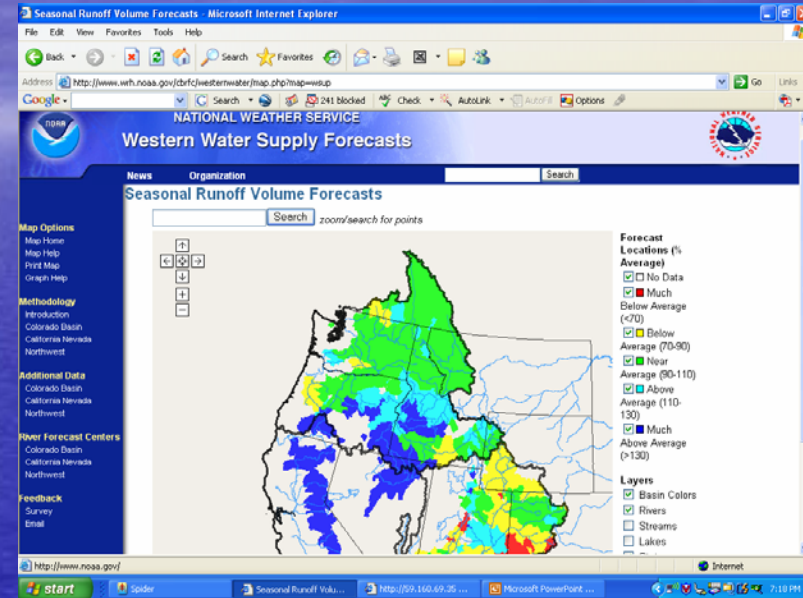


# Advancements in forecast dissemination

- Western Water Supply
- NWRFC's ESP graph

# Western Water Supply

- Color coded water supply map for all NWS water supply forecasts
- Forecast point specific plots depict current year forecast evolution and month by month climatologies



- Development began in 2005
- Includes participation from each RFC

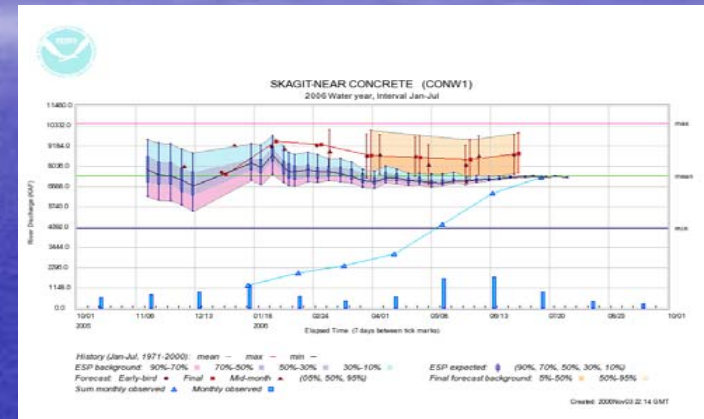
# Goals and Motivation

## (for Western Water Supply page)

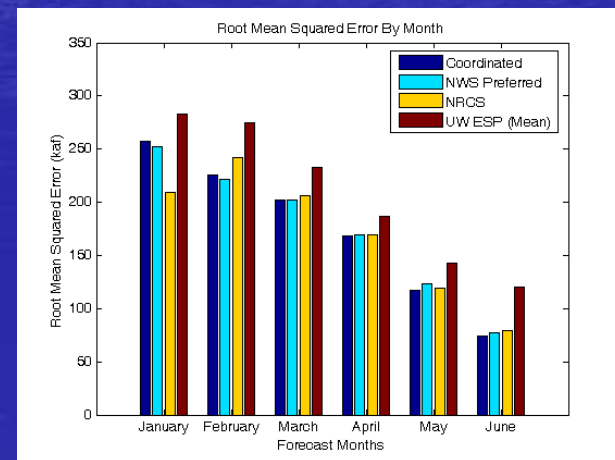
- A “one stop shop” for NWS water information at the seasonal timescale
- Consistent presentation of products between RFCs
- Harness collective innovation from multiple offices

# Western Water Supply Web: FY07 Developments

- Incorporate water supply points east of the Continental Divide (MB, AB, and WG RFCs)
- Add ESP forecasts to forecast plot – prototype developed at NWRFC
- Add forecast verification information – prototype developed at WRH/SSD
- Develop database capabilities for website




ESP prototype plot



Verification prototype plot

# ESP Services

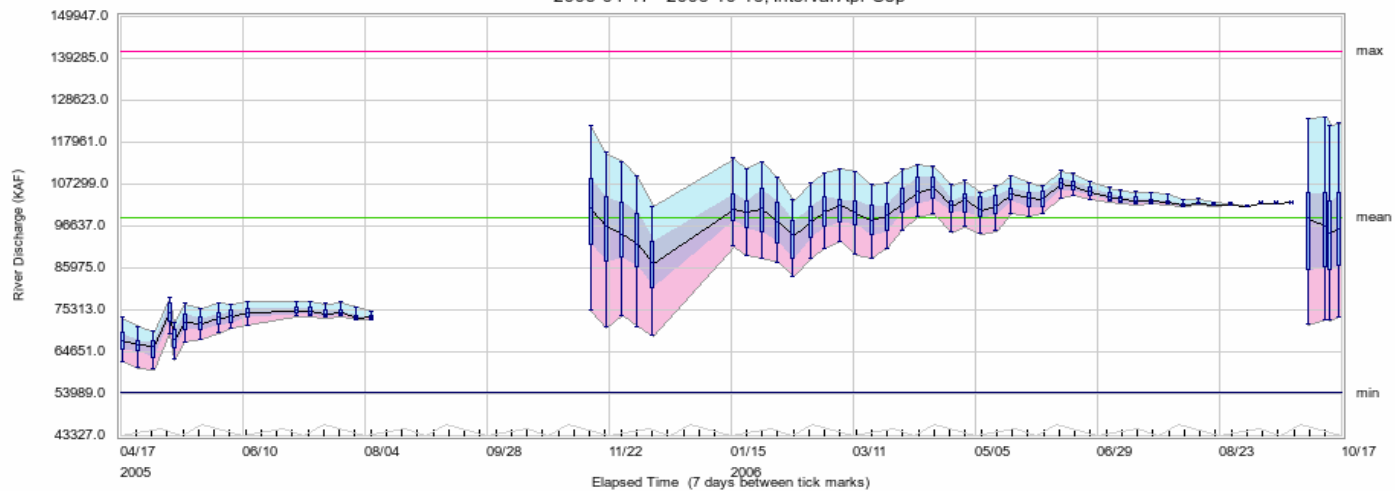
- Prototype multi-year ensemble based plot developed at NWRFC
- Dynamically generated plots based on selectable
  - Start and end year
  - Forecast window
  - Background layers

Station	Water Year	Interval	Layers	
 ARA11 - ANDERSON RANCH DAM TB12 HWR11 - BIG LOST-AT HOW L RNCH NR CHILLY MACH - BIG LOST-AT MACKAY HAL11 - BIG WOOD-AT HAILEY MAG11 - BIG WOOD-MAGIC DAM OUTFLOW DARM8 - BITTERROOT-NR DARBY BITM8 - BITTERROOT-NR MISSOULA BONM8 - BLACKFOOT-NR BONNER LUC11 - BOISE-BOISE LUCKY PEAK DAM PAR11 - BOISE-NR PARMA BOXW1 - BOXLEY-NEAR EDGEWICK HOT11 - BRUNEAU-NR HOT SPRINGS	First 2005 2006 2007 Last 2007 2006 2005	<input type="radio"/> Jan-Jul <input type="radio"/> Jan-Aug <input type="radio"/> Jan-Sep <input type="radio"/> Feb-Sep <input type="radio"/> Mar-Jul <input type="radio"/> Mar-Aug <input type="radio"/> Mar-Sep <input type="radio"/> Apr-Jun <input type="radio"/> Apr-Jul <input type="radio"/> Apr-Aug <input type="radio"/> Apr-Sep <input type="radio"/> May-Jul <input type="radio"/> May-Sep	<input checked="" type="checkbox"/> ESP background <input checked="" type="checkbox"/> ESP expected <input checked="" type="checkbox"/> Sum monthly observed <input checked="" type="checkbox"/> Forecast background <input checked="" type="checkbox"/> Water supply forecast <input checked="" type="checkbox"/> Grid	
	<input type="button" value="Generate Graph"/>			
	<ul style="list-style-type: none"><li>• Choose graph characteristics (or accept defaults), then click on "Generate Graph" button to plot data.</li><li>• Click on station description in listbox. The program will read the data for the selected station and then (re)enable additional controls. Note: letting the mouse cursor rest on a selection for a while will cause the station ID to appear temporarily.</li></ul>			

# ESP Service (con't)



COLUMBIA-THE DALLES DAM (TDAO3)  
2005-04-17 - 2006-10-16, Interval Apr-Sep



History (Apr-Sep, 1971-2000): mean — max — min —  
ESP background: 90%-70% ■ 70%-50% ■ 50%-30% ■ 30%-10% ■ ESP expected: ◆ (90%, 70%, 50%, 30%, 10%)

Created: 2007Feb01 22:41 GMT



# ESP Service (con't)

- Ensemble analysis software prototype
  - Developed at CBRFC and improved by CN and NW
  - Allow web user access to NWS ensemble software (ESPADP)
  - Manipulation of raw ensemble

The screenshot displays the ESPADP web interface. On the left is a navigation menu with categories like River Information Data, WEATHER, CLIMATE, and STORM SUMMARIES. The main content area is titled '1 Select a Location:' and has a dropdown menu set to 'AMERICAN RIVER - FOLSOM LAKE (FOLC1)'. Below this are sections for '2 Select an Accumulation Type:' (Mean, Minimum, Maximum, Summation), '3 Select an Interval:' (Day, Week, Month, Entire Period), '4 Select a Starting Date:' (Month: Jul, Day: 06, Year: 2006), and '5 Select an Ending Date:' (Month: Oct, Day: 06, Year: 2006). There are also options for '6 Select a Plot Option and Generate:' (Traces, Probability, Expected Value, Exceedance) and '7 Select a Table Option and Generate:' (Forecast Info, Quantiles, Flood Quantiles). A 'Generate a Plot' button and a 'Generate a Table' button are visible. At the bottom, there is a 'Help' section titled 'Making Selections and Interpreting Results' and a footer with contact information for the National Weather Service.

# Current Status

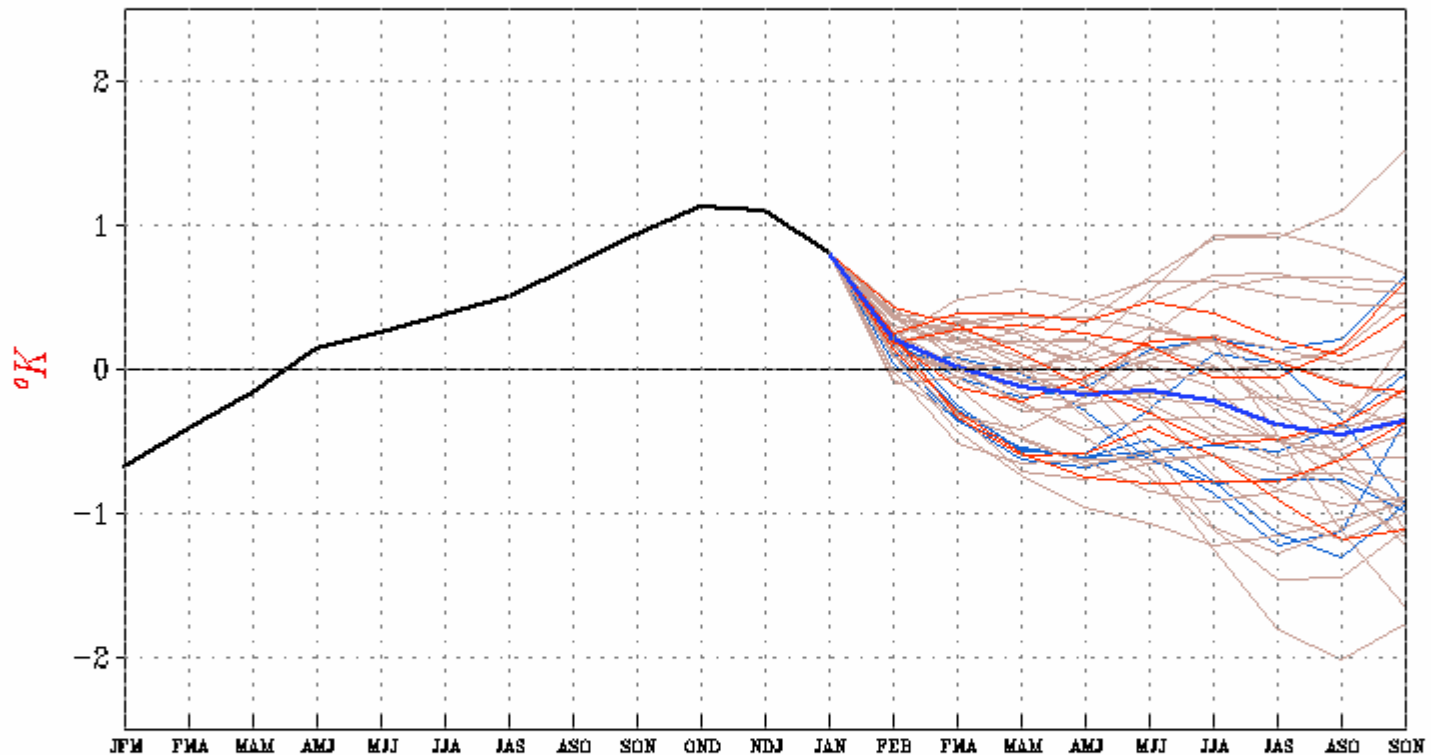
- [CBRFC's snow data page](#)
- [National Operational Hydrologic Remote Sensing Center](#)
- [Nationwide precip analysis interface](#)
- [Western Water Supply](#)
- [Drought Monitor](#)

# Water Supply Forecast Release Schedule For 2006-2007 Water Year

Type of fcst	Month							
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Official Forecast		8	7	7	6	7	7	9
Peak Flow Forecast		9	8	8	9	8	8	10
Mid-month update	21	19	15	15	19	17	21	



### Forecast *Nino3.4* SST anomalies from CFS



- Latest 6 forecast members
- Earliest 6 forecast members
- Other forecast members
- Forecast ensemble mean
- OIv2 observation

Forecast initial conditions: 8Jan2007 to 27Jan2007.

Base period for climatology is 1971–2000. Base period for bias correction is 1982–2003.

# Verification

“Hydrologic forecast verification must be conducted in the terms by which the forecasts were created. This requires that researchers become knowledgeable of operational forecasting procedures.”

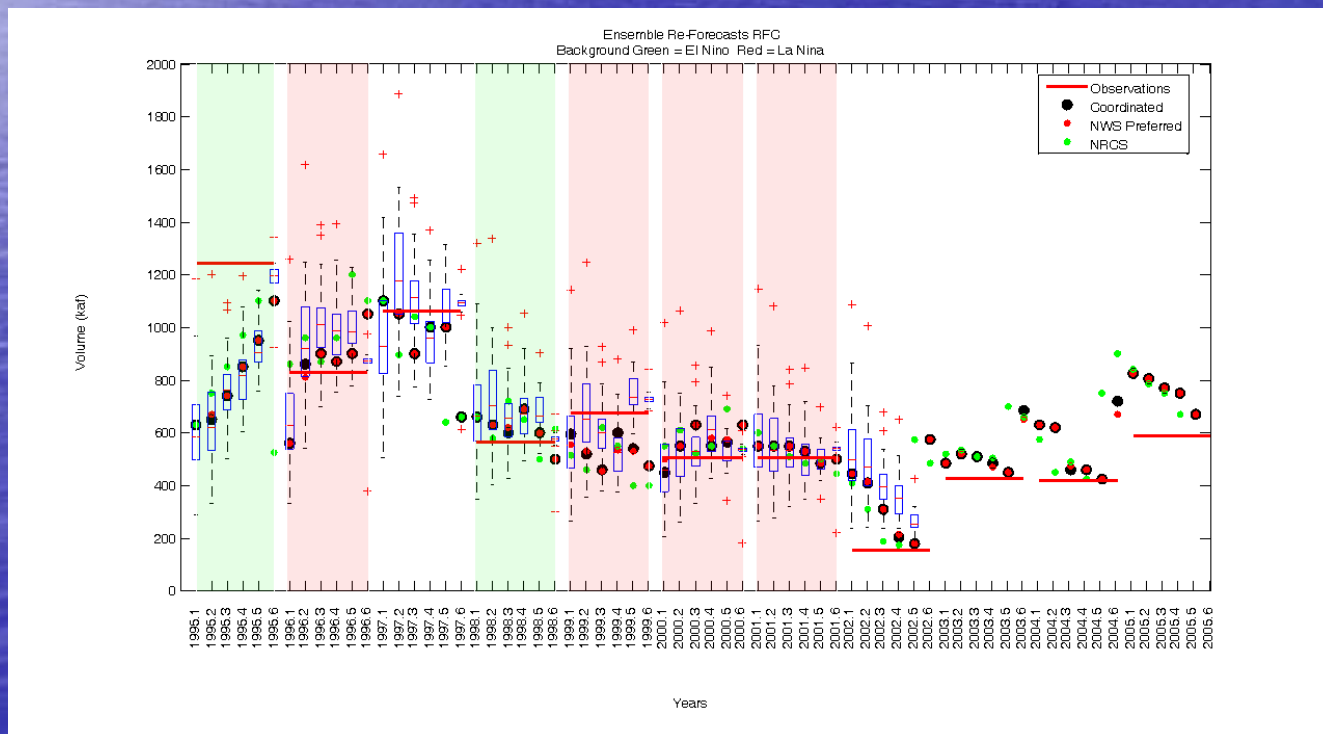
– Bisher Imam and Holly Hartmann, AHPS verification report 2006

## Water supply verification overview

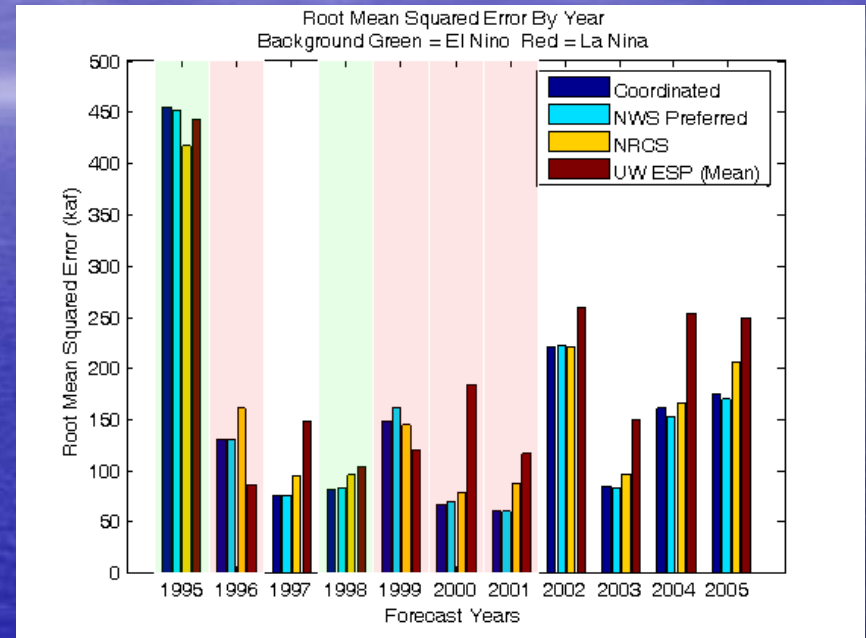
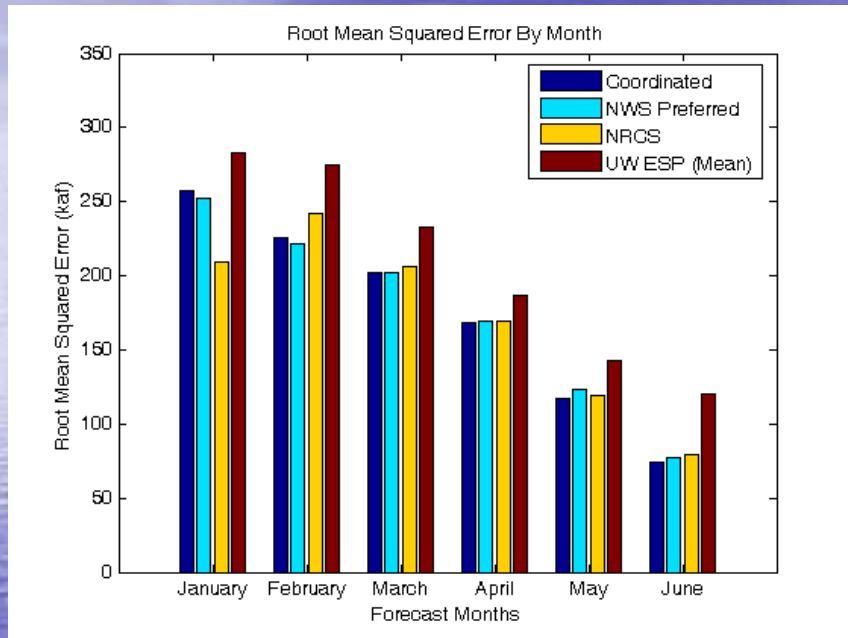
- Verification should allow comparisons between current and new forecast methodologies
- Error, skill, and categorical statistics
- Conditional statistics based on lead time, year, etc
- Side-by-side comparison of multiple forecast sources
- Dynamic, user specifiable plots created from database
- Deterministic (e.g. single value) and probabilistic (e.g. ensemble) forecast verification

# Verification: Archive visualization

- Historical forecast and reforecast examination
  - Visually compare archived forecasts and reforecasts to observed volumes



# Verification: Error statistics

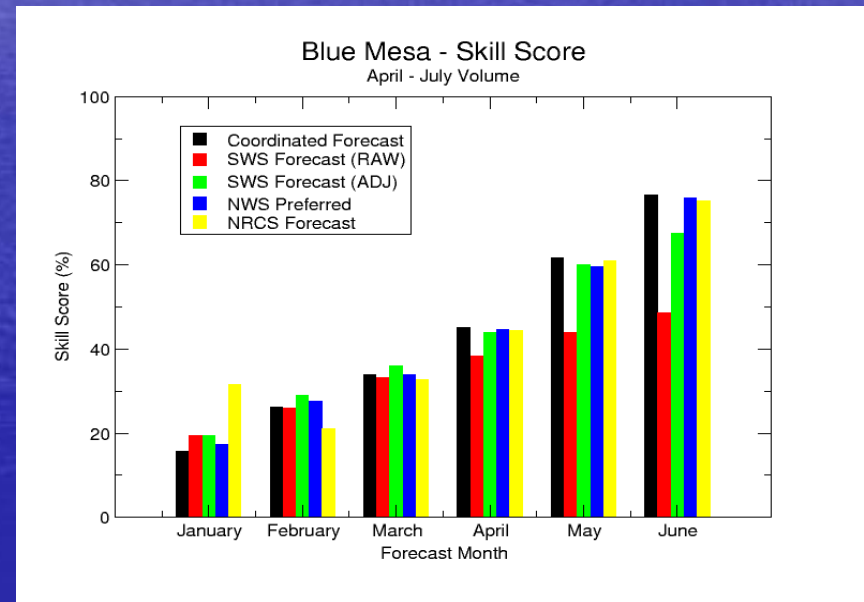


## Error Statistics

- RMSE, MAE, ME for deterministic, RPS for ensemble
- Conditional on lead-time (left) and year (right)
- Dynamically generated

# Verification: Skill

- Skill Scores
  - RMSE-SS for deterministic; RPSS for probabilistic
  - Reference forecast = climatology
  - Conditional statistics based on lead time and year
  - Dynamically generated





# Verification: Categorical

- Traditional (NWS) verification including:
  - False Alarm Ratio (FAR)
  - Probability of Detection (POD)
- Category definitions tied to climatology values (e.g. mean flow, terciles, etc.) or user definable

