

Western US Testbed Activities and Outlook

Andy Wood, *Civil and Environmental Engineering, U. of Washington*

Frank Weber, *BC Hydro*

Kevin Werner, *NOAA NWS Western Region Scientific Services Division*

Tom Pagano, *USDA/NRCS National Water and Climate Center*

**3rd Hydrologic Ensemble
Prediction
Experiment Workshop**

**Stresa, Italy
Jun 27-29, 2007**

Outline

❑ Review of Testbed Definition

❑ Testbed Related Activities

- BC Hydro
- NWS – National Weather Service
- NRCS – National Resources Conservation Service
- UW – University of Washington

❑ Considerations for the Future

Testbed Objectives & Approach

To facilitate the comparison and evaluation of practical ensemble forecast related methods *that are **viable** in an operational setting*, and to **address current operational forecast difficulties**. Focus areas:

- ❑ strategies for snow data assimilation
 - the implications of snow assimilation for estimating **initial conditions** errors
- ❑ hydrologic model error reduction and parameter estimation **model application** calibration
- ❑ opportunities from climate forecast research **future forcings**

APPROACH: make available datasets and models related to those methods, and request that others in the community contribute alternative approaches (data, models, methods) for a parallel evaluation (retrospective, and if possible, in real-time).

Testbed Datasets -- Accessibility

6 basins: The **Mica Basin, BC** (power production, flood control), **Feather River, CA** (reservoir-based water management); **Yakima River, WA** (irrigation and fisheries); **Salmon River, ID** (unimpaired, snow-driven); **Upper Klamath Lake, OR** (irrigation, fisheries, water quality); **Gunnison River, CO** (energy, fisheries)

flow observations (real-time / past)	hindcast datasets	hydrology models
observed forcing datasets (real-time / past)	ensemble forecast forcings	model state outputs (real-time / past)
snow observations (real-time / past)	skill / accuracy assessments	methods / model documentation

for most

for half

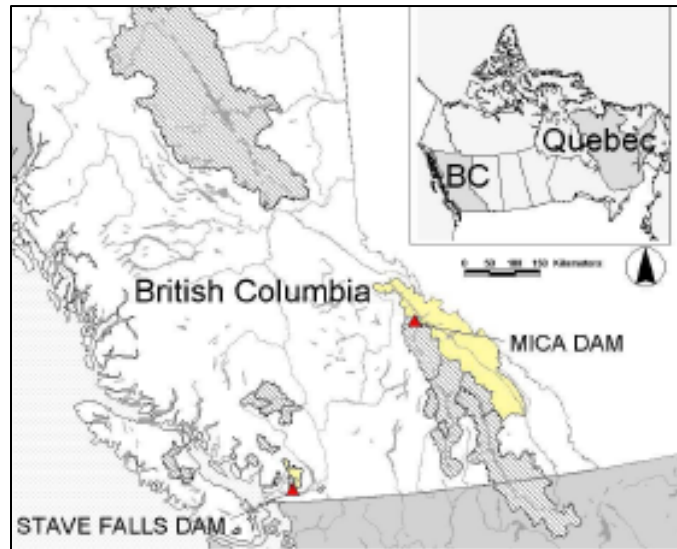
for few

BC Hydro Forecasting

BC Hydro Forecasting

BC Hydro Forecasting

- Mica Basin, BC, Canada



- Data available:
 - operational long-term seasonal fcsts
 - (1980-2005, 21-39 ESP members)

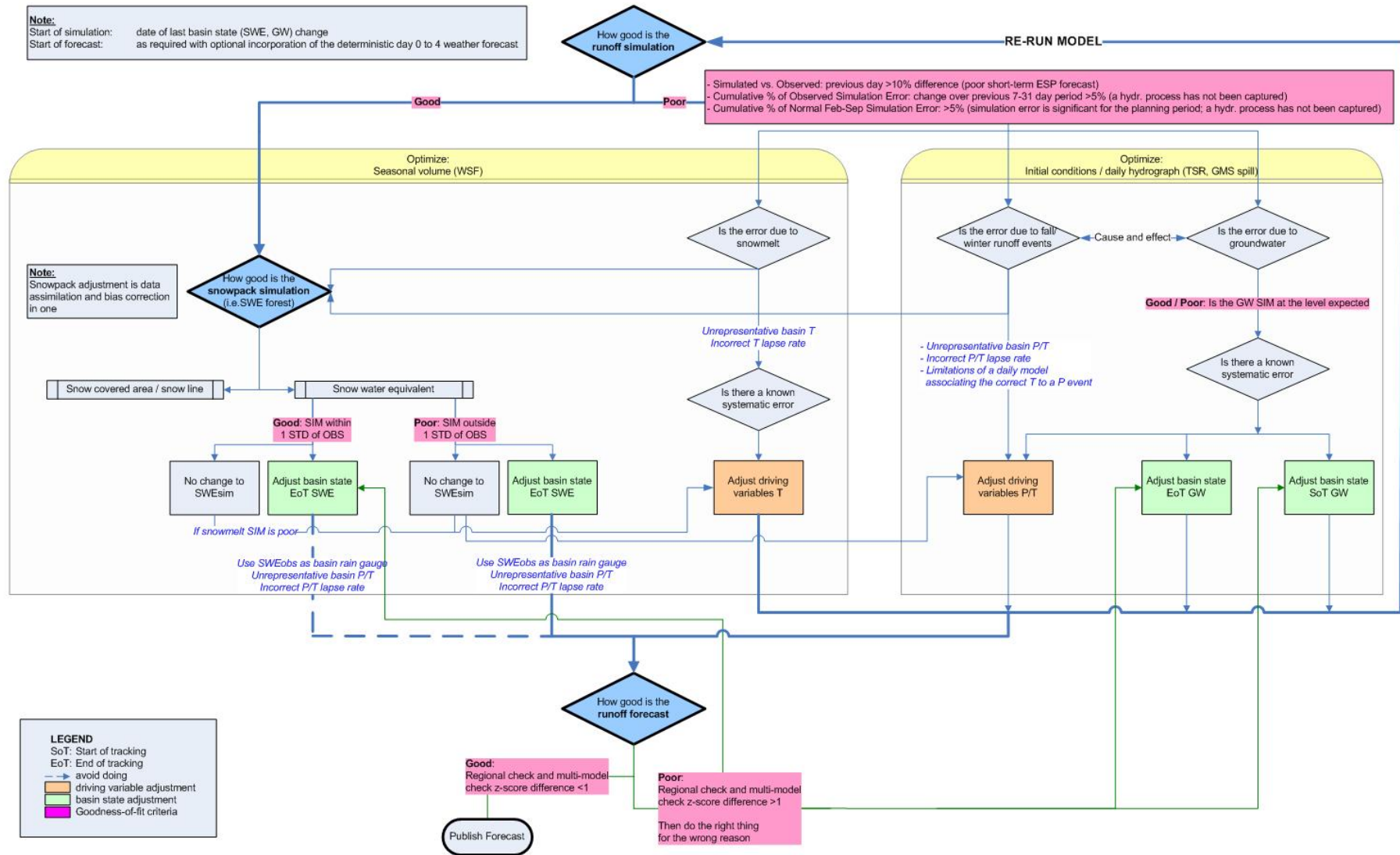
BC Hydro Forecasting

- forecast verification
 - deterministic (ens. mean)
 - residual Feb-Sep fcsts
 - relative bias
 - MAE skill score relative to climatology
 - coefficient of determination
 - monthly fcsts
 - relative bias (simulation bias!)
 - probabilistic
 - residual Feb-Sep fcsts
 - CRPS skill score relative to climatology
 - monthly fcsts
 - CRPS skill score relative to climatology

BC Hydro Forecasting

Ensemble Streamflow Prediction Decision Support Diagram v.3

Wednesday, 2007, April 25



NWS Western Water Supply Activities

Kevin Werner, WR/SSD

Jay Breidenbach, WFO Boise

Cass Goodman, Steve Shumate, CBRFC

Alan Takamoto, Scott Staggs, CNRFC

Don Laurine, NWRFC

Chad Kahler, WFO Tuscon

Goals: **Project in a Nutshell**

A “one stop shop” for NWS water information at the seasonal timescale
Consistent presentation of products between RFCs
Harness collective innovation from multiple offices
Build RFC redundancy in both technology and human resources

Users:

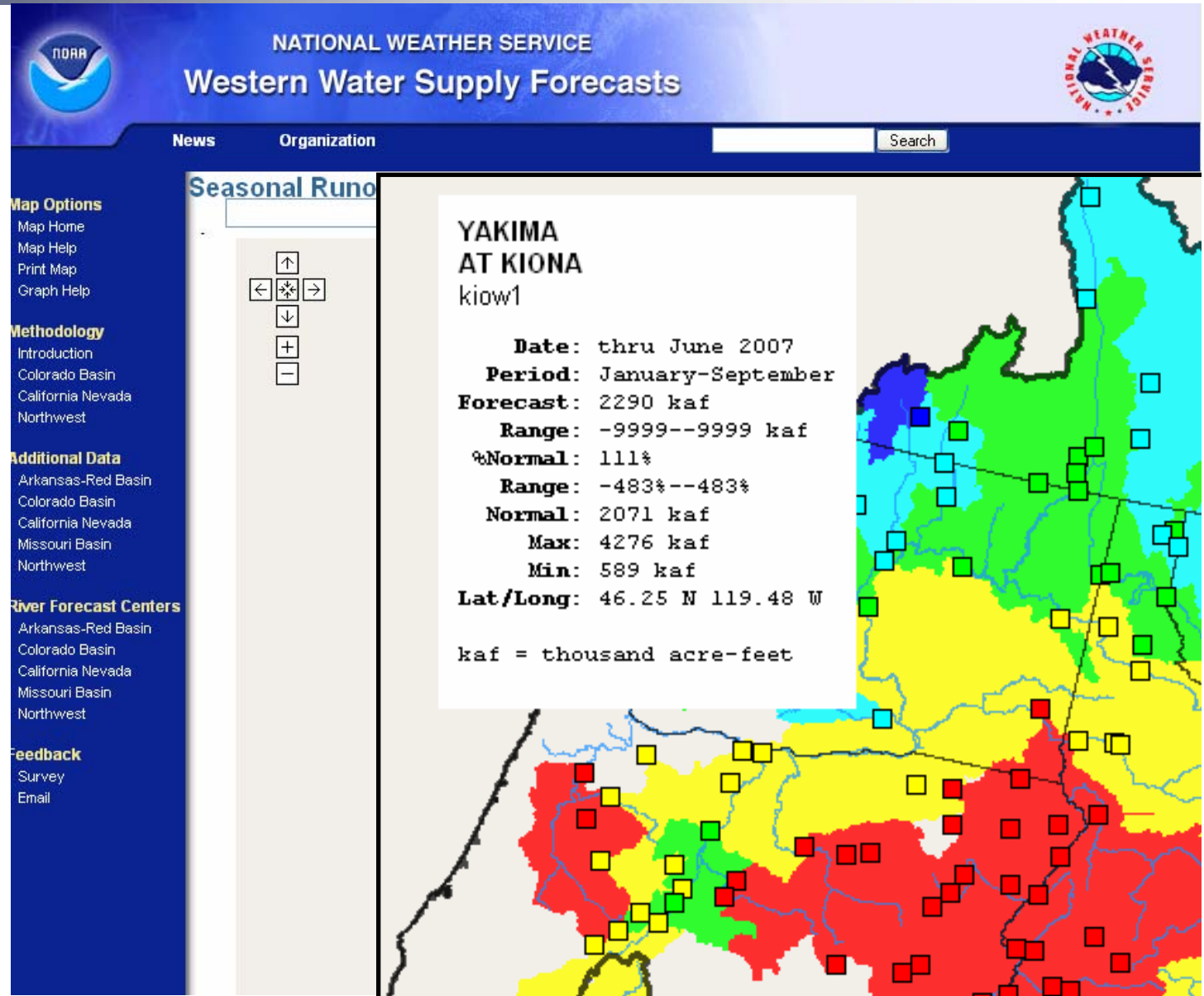
Existing Water Supply forecast users – e.g., USBR
Groups with cross basin interests (e.g. media, power companies)
NWS internal uses

History:

April 2005:	Working group formed, planning meeting held
January 2006:	Initial website launched
September 2006:	Included AB, WG, and MB RFCs in development
March 2007:	Launched outreach effort and included SHs
June 2007:	Launched verification capabilities

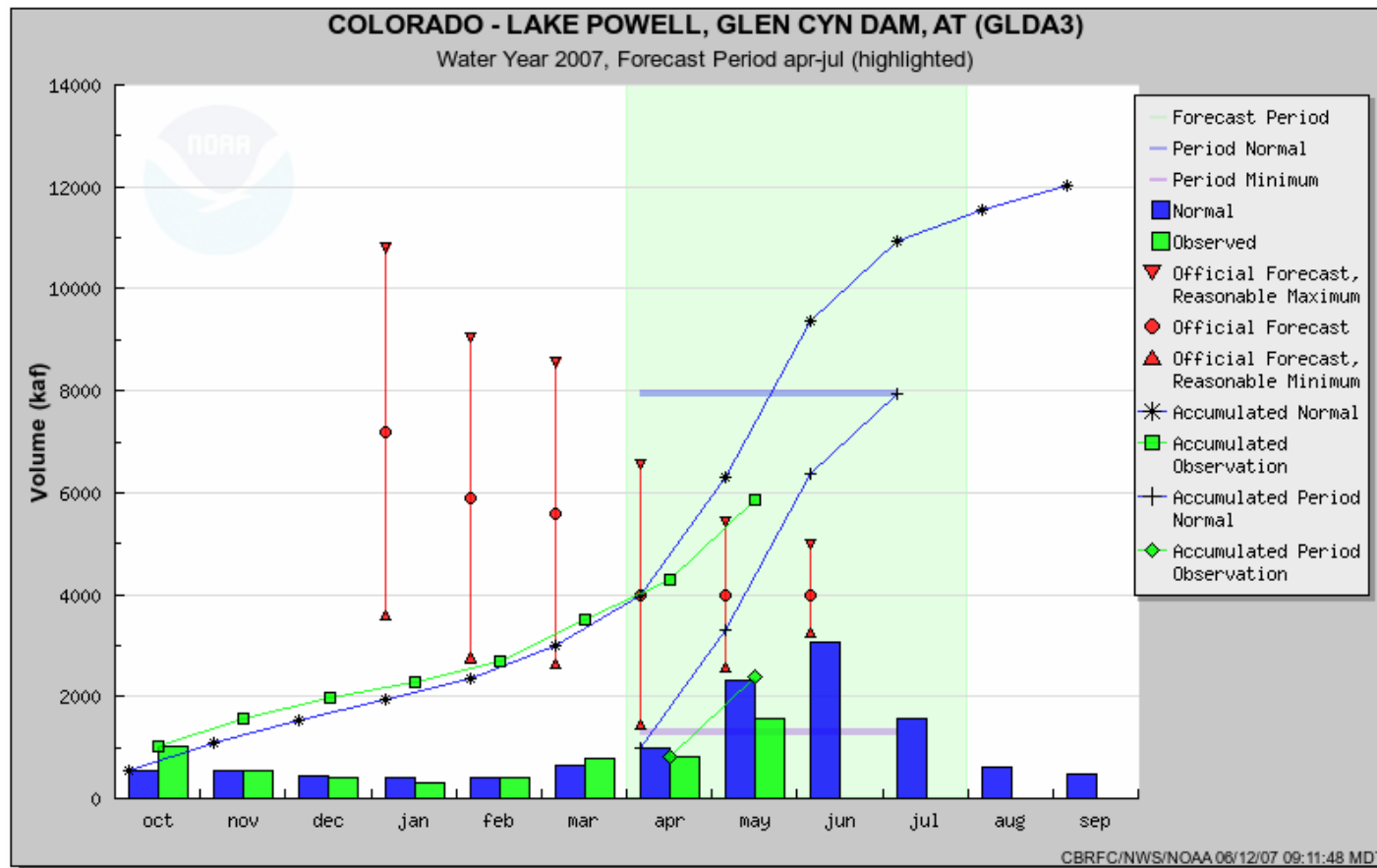
NWS Western Water Supply Map

- “One Stop Shop” for NWS water supply forecasts
- Flexible and consistent map presence across western USA
- Zoomable to basin scale
- Mouse over capability for forecast values



www.cbrfc.noaa.gov/westernwater

NWS Western Water Supply Web



Forecast Evolution Plot

- Originally developed at NWRFC
- Evolution of current year forecasted and observed streamflow

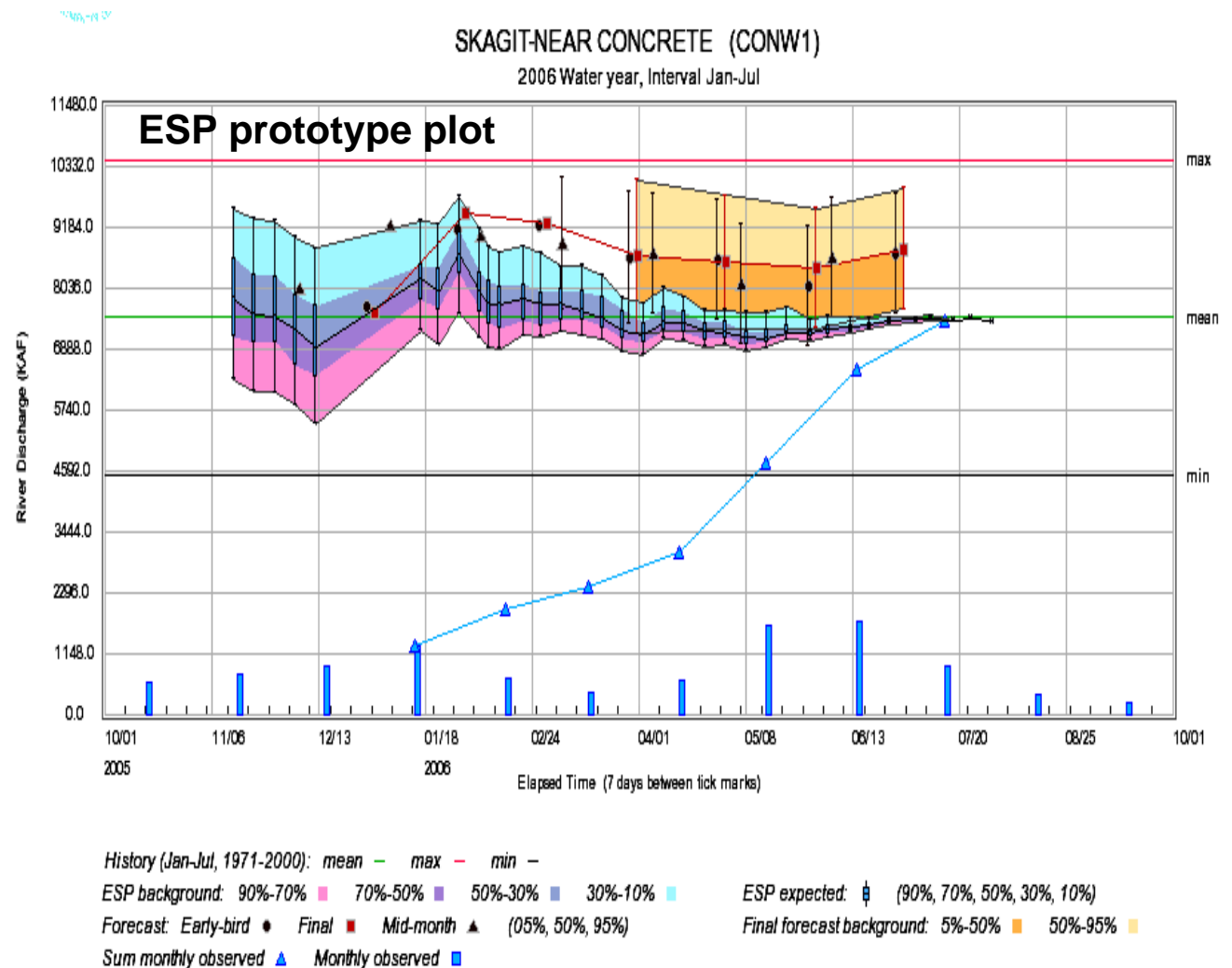
Options to include:

- Normal streamflow volume
- Forecast window
- Forecast accumulation
- ...and more!

NWS Western Water Supply Web – FY07

Developments

- Incorporate water supply points east of the Continental Divide (MB, AB, 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
- Develop training and outreach materials



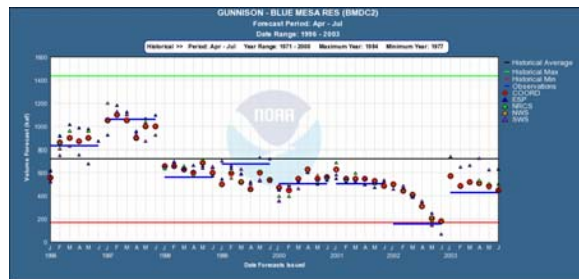
Created: 2006Nov03 22:14 GMT

NWS Western Water Supply Web

Forecast Verification

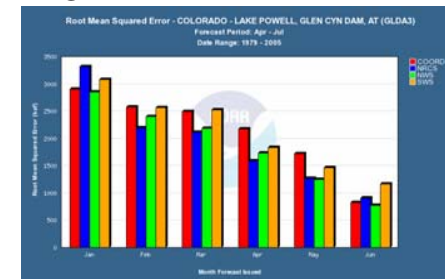
- **Goal:** Provide users of all types with forecast verification information
 - Easy to understand
 - Meaningful
 - Accessible from forecasts
 - Dynamically generated plots from database

Data Visualization



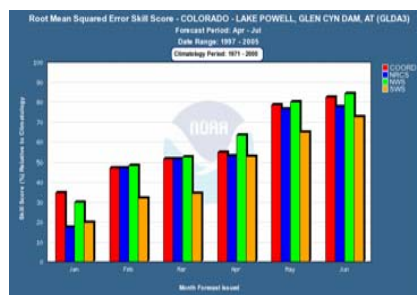
Error

- MAE, RMSE, etc
- Conditional on Lead time, year



Skill

- Skill relative to Climatology
- Conditional



Categorical

- Traditional (NWS) verification including FAR and POD
- Category definitions tied to climatology values (e.g. mean flow, terciles, etc.) or user definable

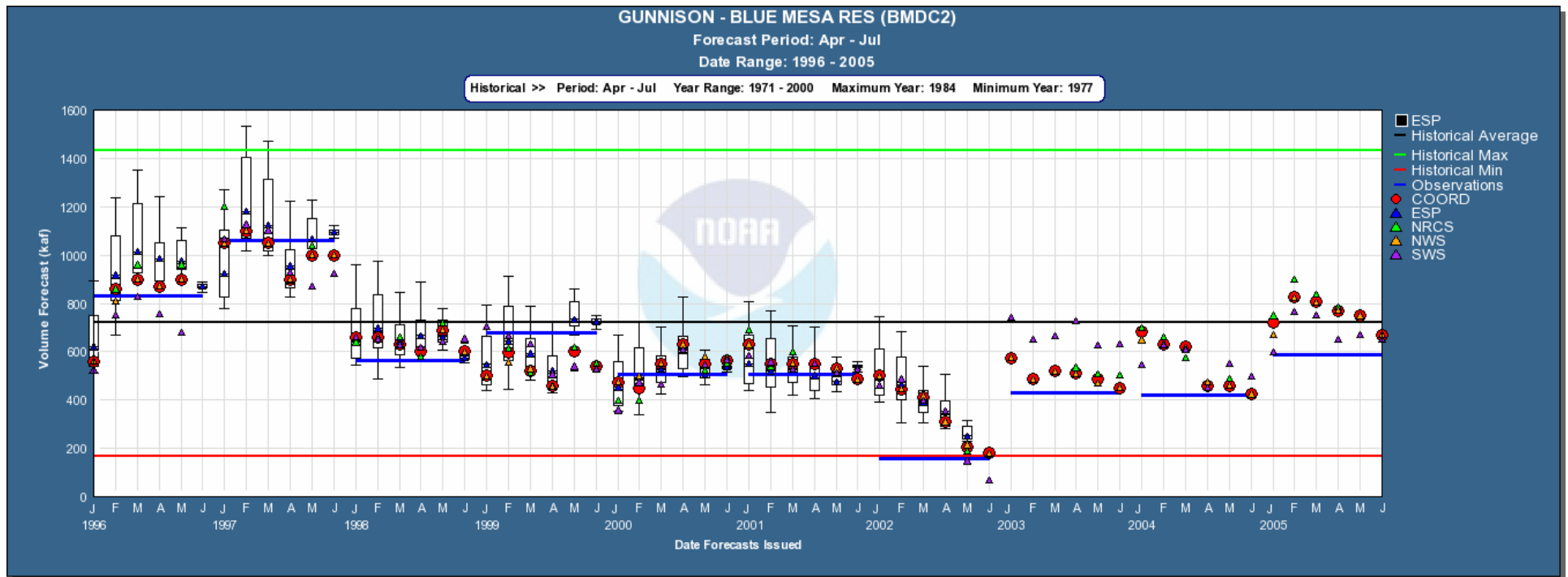
Plot credit: Chad Kahler

NWS Western Water Supply Web

Verification -- Archive visualization

Historical forecast and reforecast examination

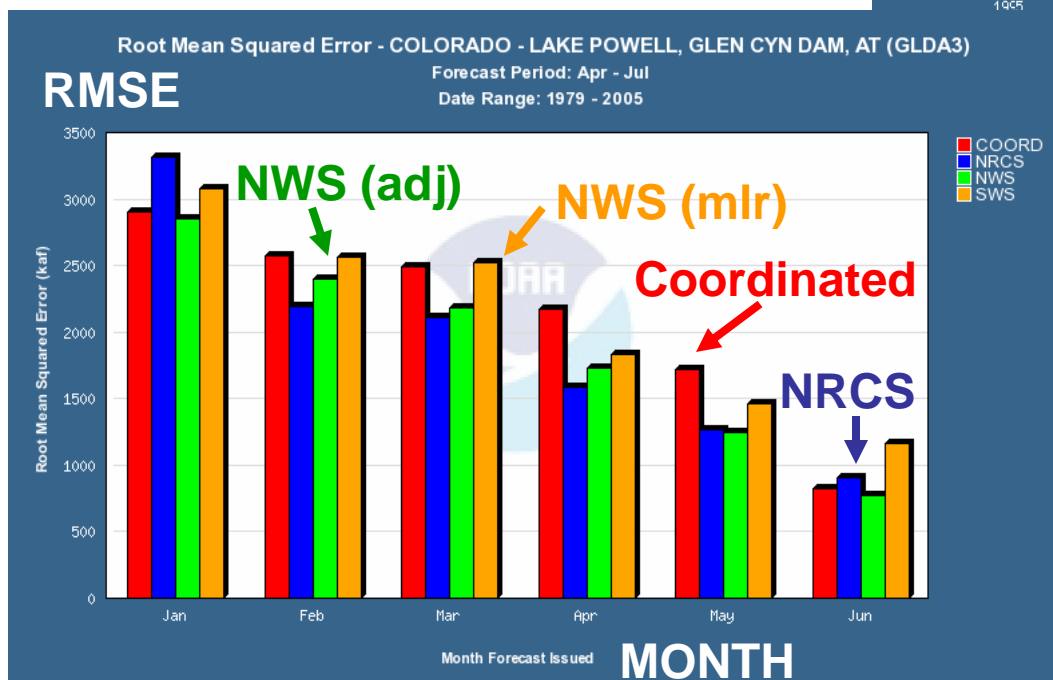
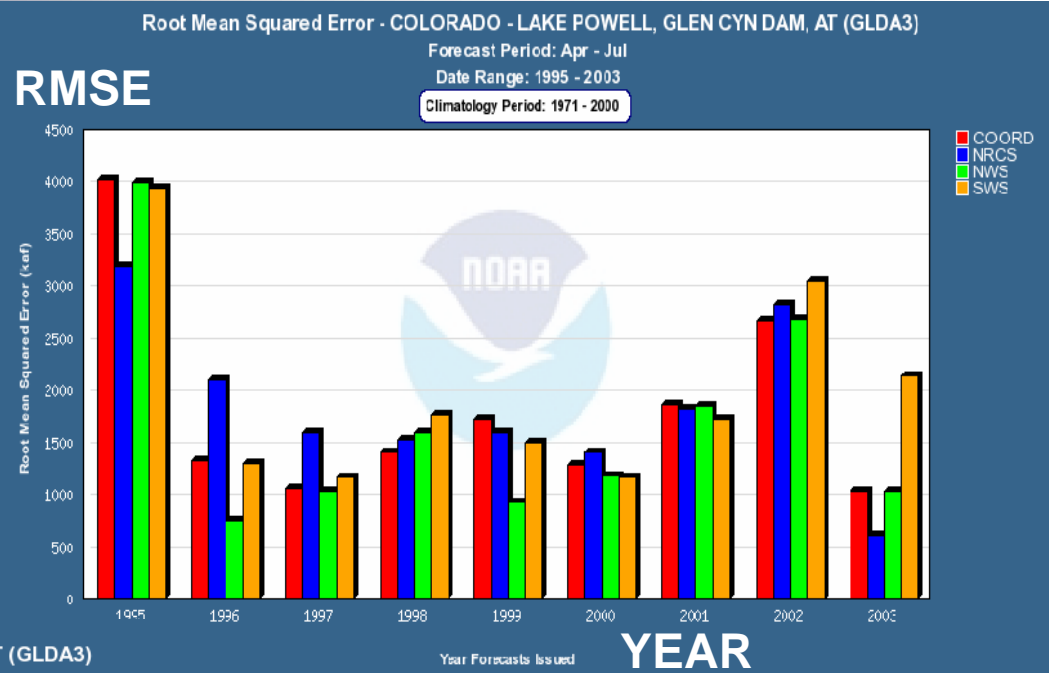
- Visually compare archived forecasts and reforecasts to observed volumes



- for now, just graphics, but raw data on the way

NWS Western Water Supply Web

WS Verification -- Error statistics



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

NRCS Forecasting

Statistical Forecasting based on MLR, using

- snow water equivalent
- current streamflow
- cumulative precip
- ENSO indices

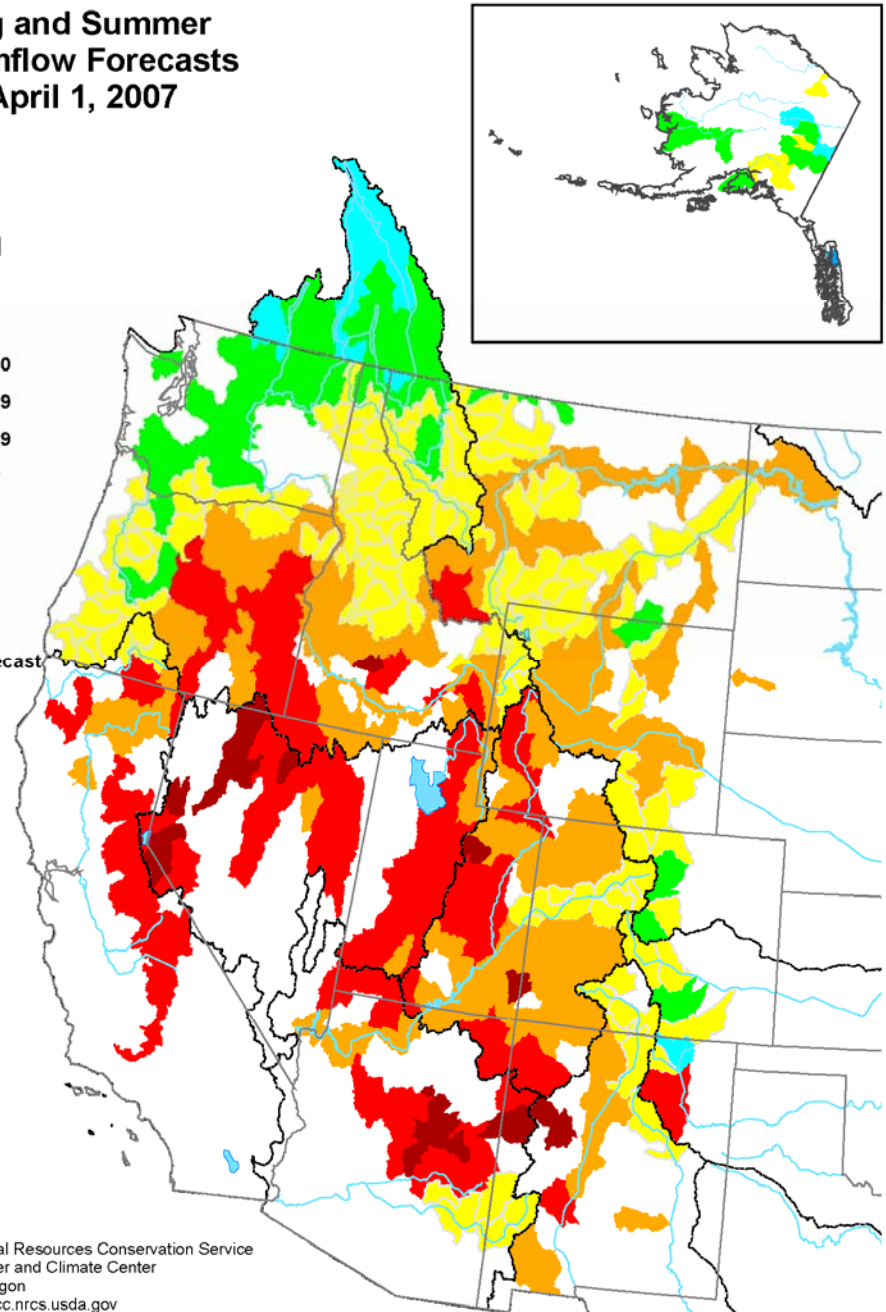
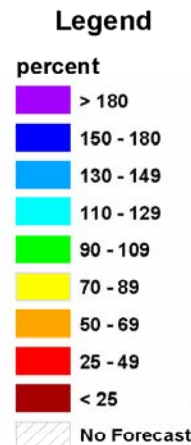
Hundreds of Forecast Points

**Predict cumulative summer flows
(volume forecast)**

**Moving from monthly forecast
updates to more frequent – up to
daily**

Also: Trying ESP

**Spring and Summer
Streamflow Forecasts
as of April 1, 2007**



Prepared by
USDA, Natural Resources Conservation Service
National Water and Climate Center
Portland, Oregon
<http://www.wcc.nrcs.usda.gov>

NRCS Forecasting

Streamflow Forecasts as of April 1, 2007

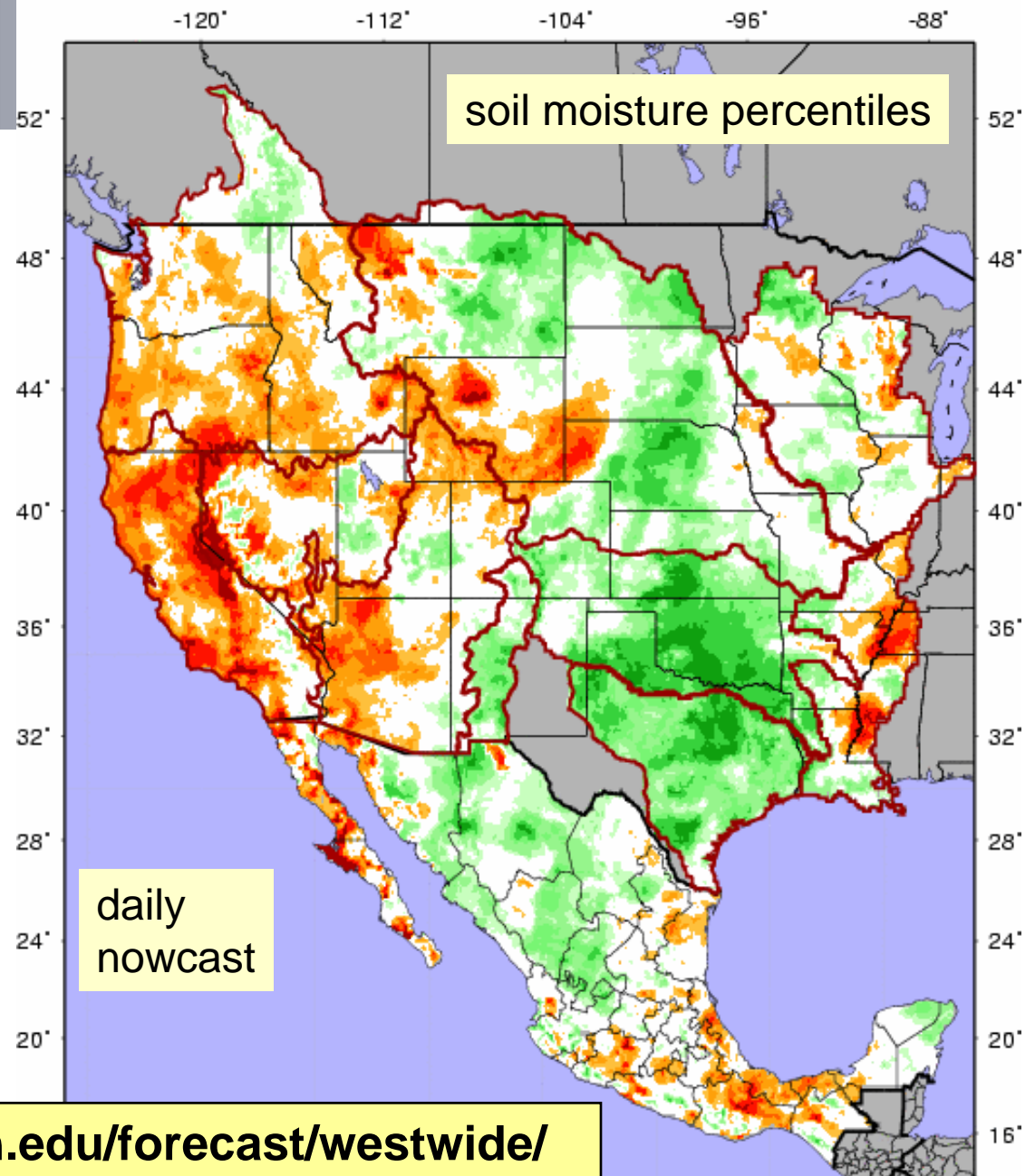
Stream and Station	Forecast Period	Forecasts This Year				30 Year
		Most Probable		Reasonable		'71-'00
		kaf	%avg	Max %avg	Min %avg	Average Runoff kaf
Alaska						
Gulkana River Sourdough, AK	Apr-Jul	410	86	118	62	475
Kenai River Cooper Landing, AK	Apr-Jul	965	104	122	88	925

NRCS is now making available historical records of its forecasts -- the data inputs, outputs, and observations.

fcst_yr,fcst_id,fcst_name,pub_per,fcst_per,fcst_avg,fcst_jan,fcst_feb,fcst_mar,fcst_apr,fcst_may,fcst_jun
1977,06049450,SUM OF E + W FKS HYALITE CK NR BOZEMAN MT,47,APRIL JULY,24.4,,,16,18.9,,
1977,06049450,SUM OF E + W FKS HYALITE CK NR BOZEMAN MT,49,APRIL SEPT,28.2,,,18.9,22,,
1977,06049450,SUM OF E + W FKS HYALITE CK NR BOZEMAN MT,57,MAY JULY,22.7,,,,,14.7,
1977,06049450,SUM OF E + W FKS HYALITE CK NR BOZEMAN MT,59,MAY SEPT,26.5,,,,,17.5,
1978,06049450,SUM OF E + W FKS HYALITE CK NR BOZEMAN MT,47,APRIL JULY,24.4,,26.8,28,24.2,,

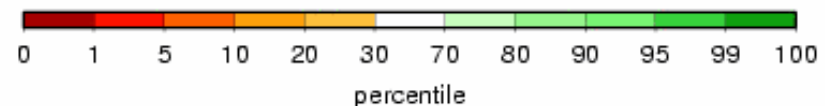
Fewer fancy graphics here, but the RAW data is now easily accessed.

UW Forecasting



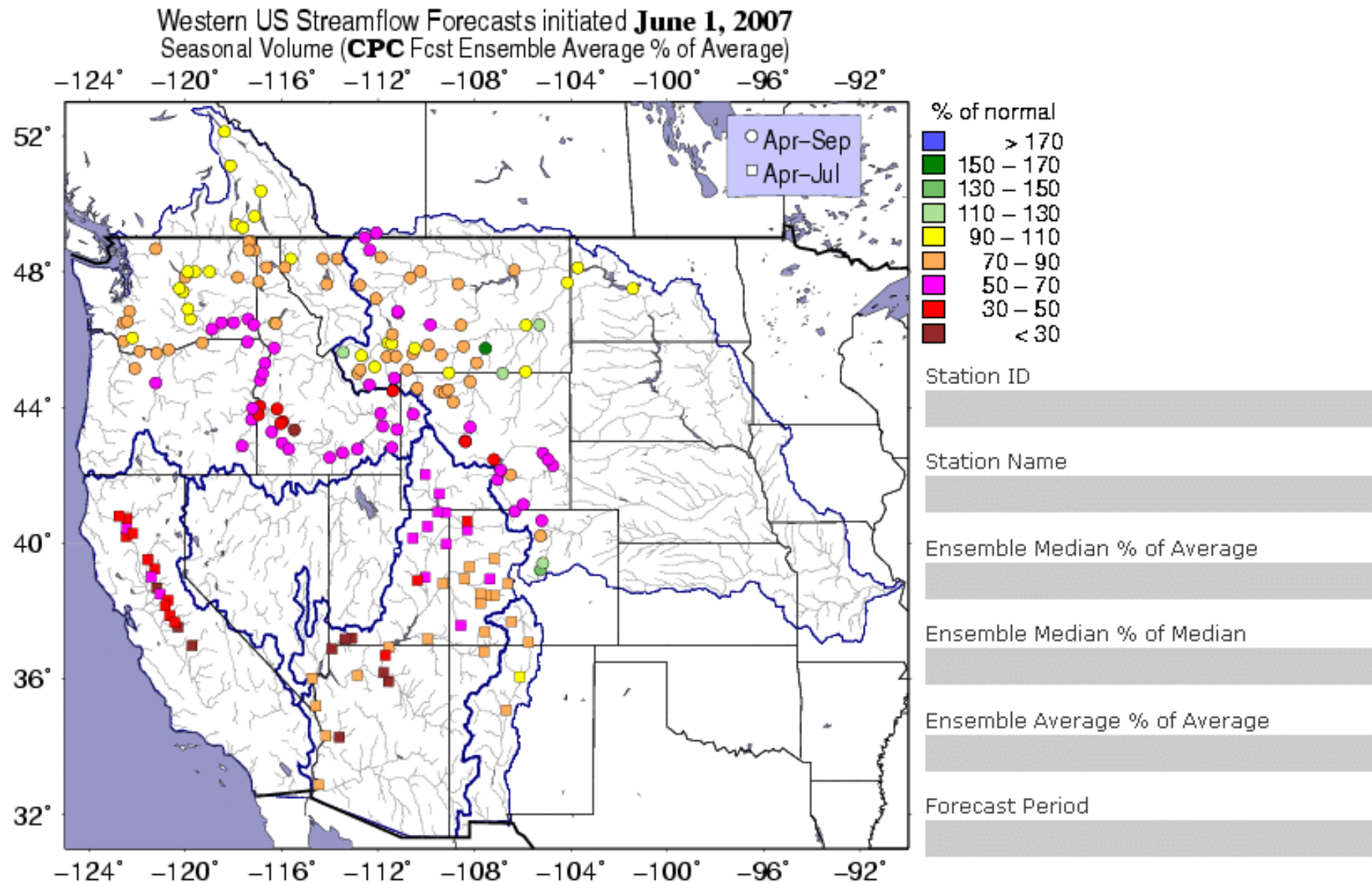
<http://www.hydro.washington.edu/forecast/westwide/>

funded by NOAA, NASA



UW Forecasting: Summer Volume Forecasts

Type of Forecast: [ESP](#) [CPC](#)

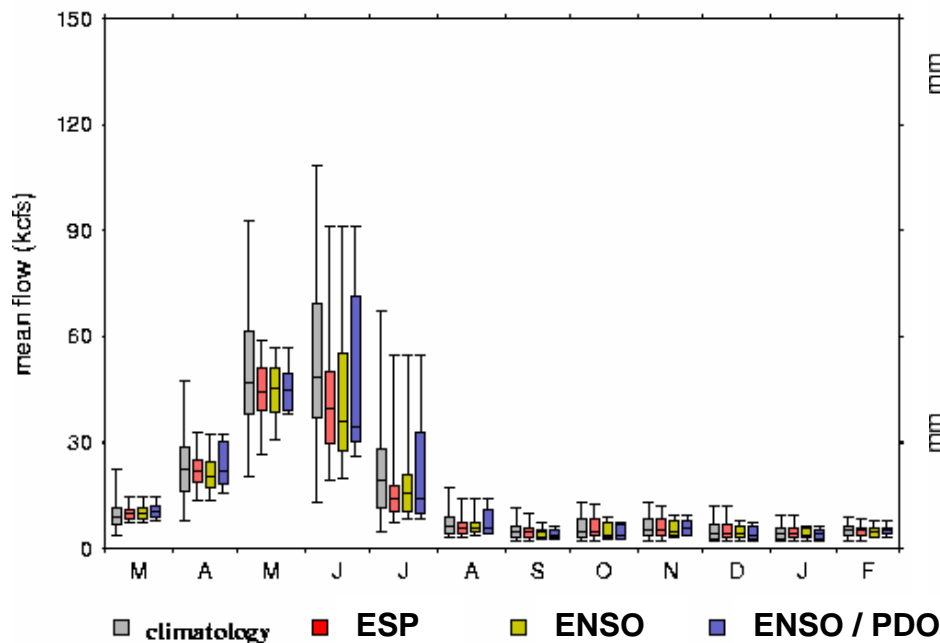


Streamflow Forecast Details

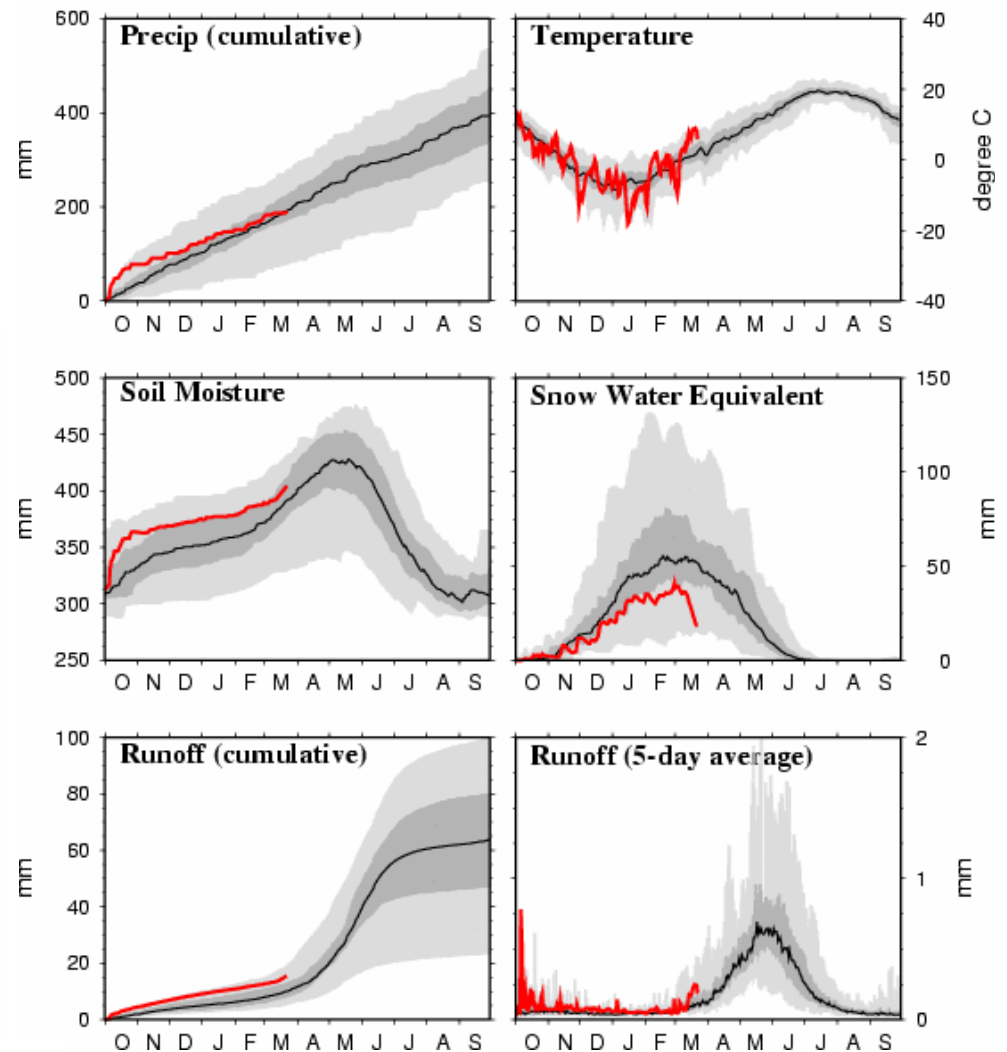
Streamflow Forecast vs. Climatology (1960-99)

FORECAST DATE: March 01, 2007

Colorado R at Lees Ferry, AZ 09380000



"Colorado River at Lees Ferry, AZ"
Water Year 2007 (2006/10/1 to 2007/03/22)
(CURRENT shown against 1971-2000 min, max and quartiles)



UW-NWS-NRCS Forecast Assessment Effort

Domain & Forecast Period

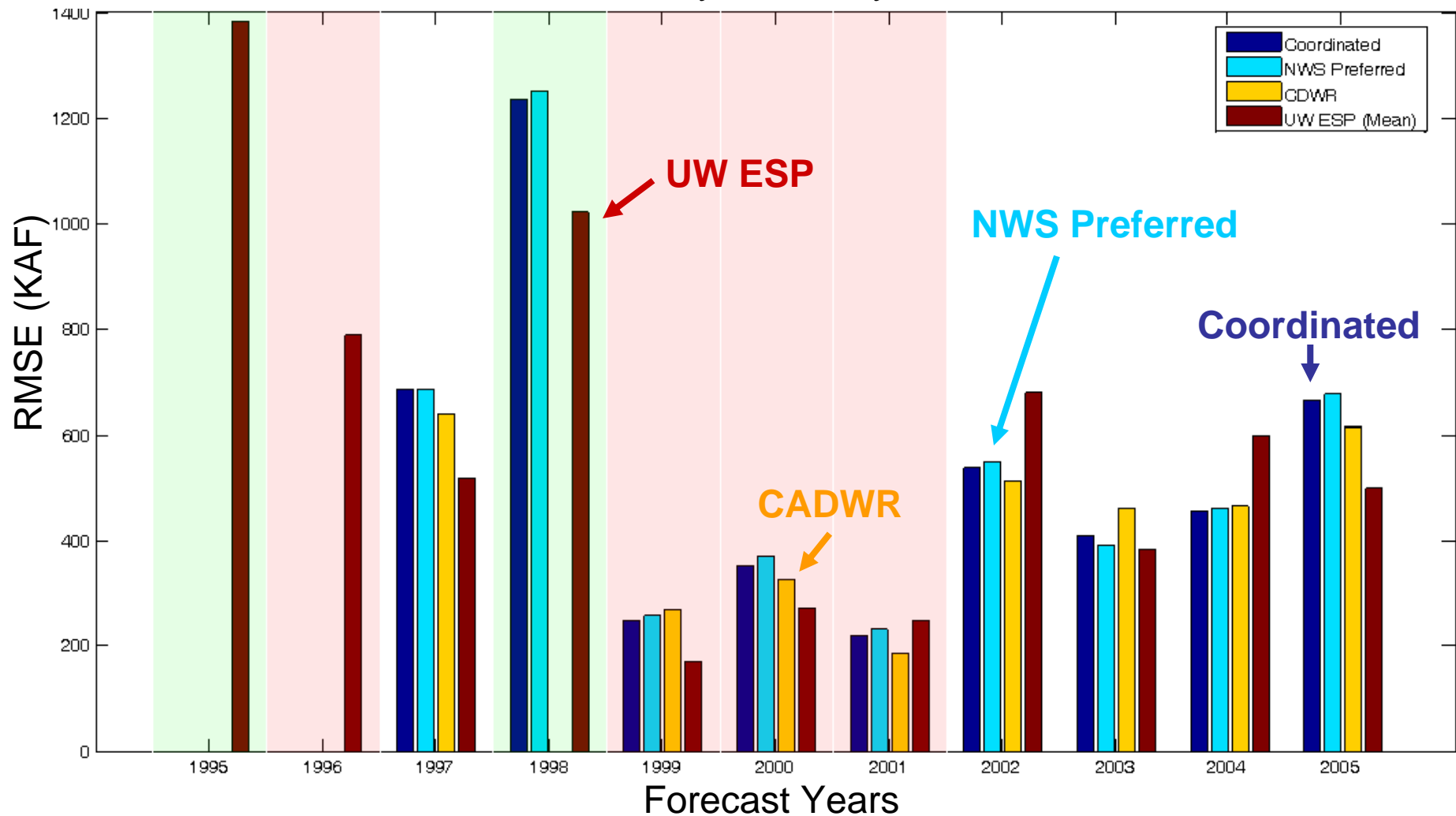
River	Stations	ID	Forecast Period
+++++			
Feather River	Inflow to Lake Oroville	OROC1	April - July
Yakima River	Yakima near Parker	PARW1	April - September
Salmon	Salmon at Whitebird	WHBI1	April - July
Klamath	Inflow to Klamath Lake	KLAO3	March - September
Gunnison	Blue Mesa / Grand	BMDC2 / GJNC2	April - July
Snake River	Jackson Lake T	JLKW4	April - September
Owyhee River	Owyhee Reservoir (OR)	OWYO3	March - July
Blackfoot River	near Bonner (ID)	BONM8	April - September
Salt River	near Roosevelt (AZ)		April - July
American River	Inflow to Folsom Reservoir		April - July
Weber River	near Oakley (UT)		April - July
Green River	Inflow to Fontanelle Res. (WY)		April - July

12 basins

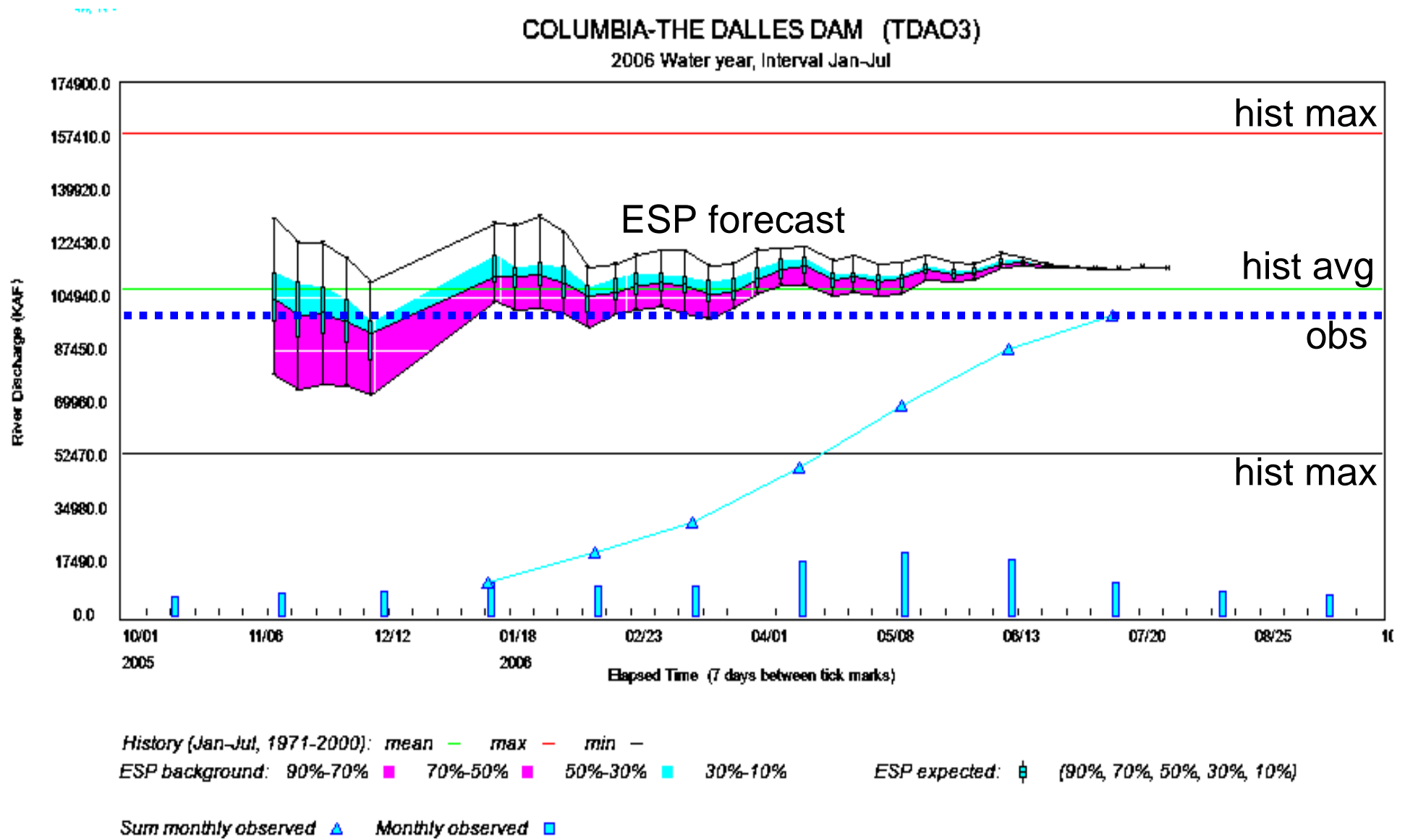
A Simple Plan: Compare retrospective forecasts (ESPs, statistical)
using common verification measures

UW-NWS-NRCS Forecast Assessment Effort

Feather R., California at Oroville Dam
RMSE by forecast year

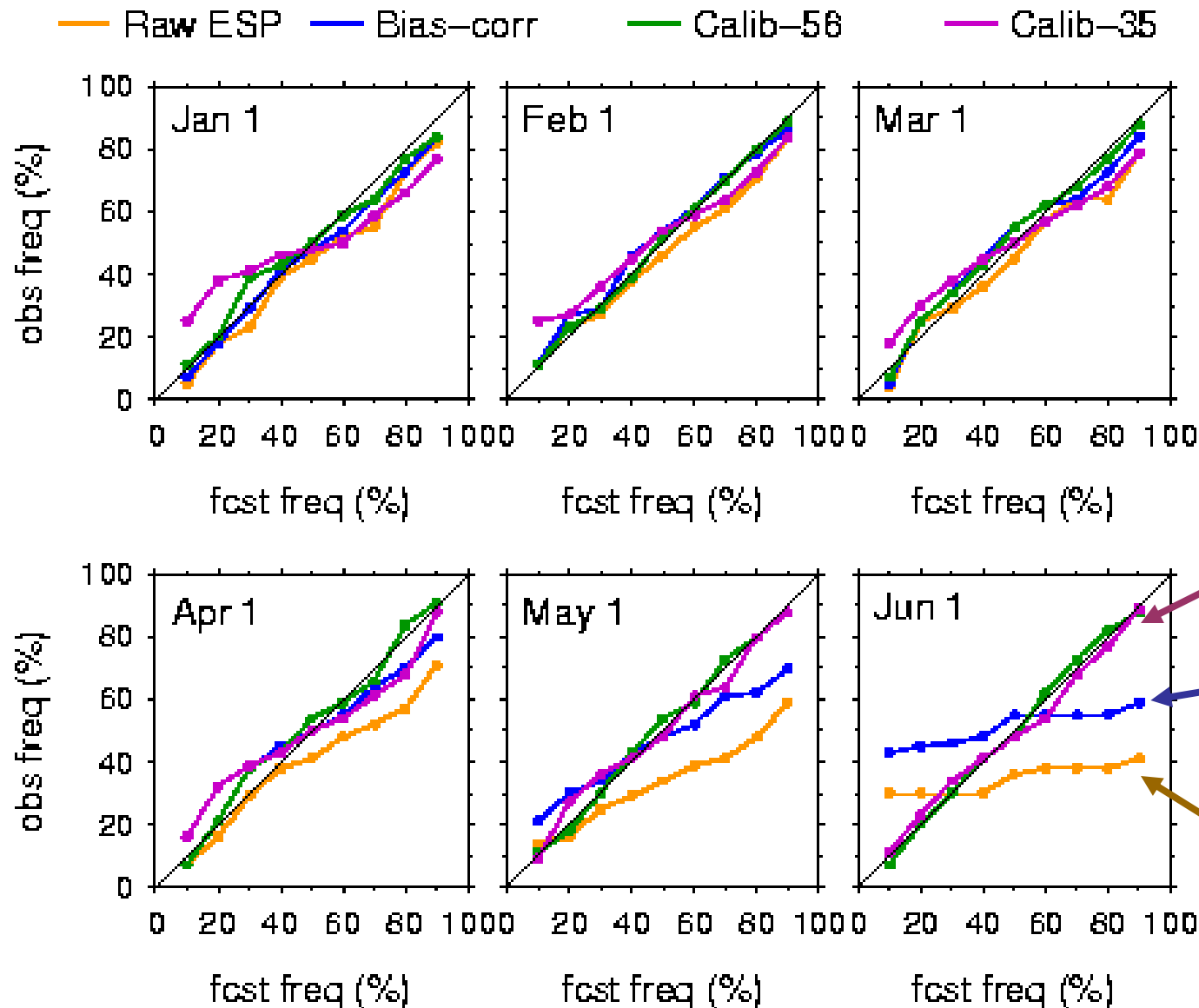


Forecast Calibration: Overconfidence example



Forecast Calibration: Reliability can be improved

Feather R. Inflow to Oroville Reservoir, CA



...but not with
bias-correction
alone

Tested an algorithm
from NWS EPP

Calibrated
ESP

Quantile-Quantile
bias correction
(Panofsky & Brier, '68)

Raw ESP

Considerations for the Future

Testbed focus

- ☐ add 3 topic areas:
 - ☐ calibrating predictions from one or more models (merging)
 - ☐ merging forecasts at medium & seasonal lead times
 - ☐ user-focused forecast verification

Assertion

- ☐ HEPEX *has* increased collaboration / communication among HEPEX participants in our testbed

Questions

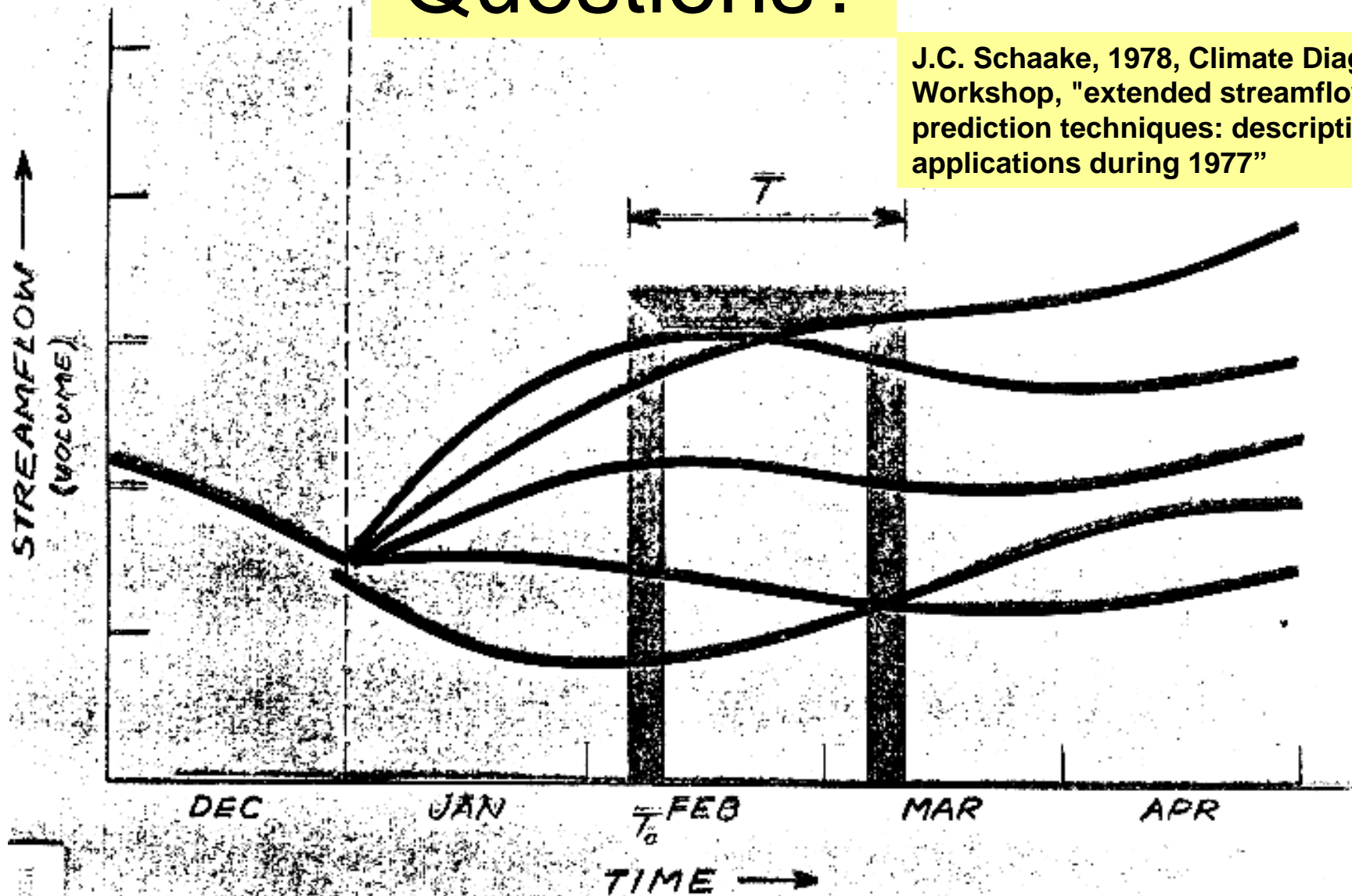
- ☐ Has testbed been a success to date?
 - ☐ have not developed greater collaboration with non-HEPEX folk to do HEPEX work
- ☐ To what extent should this be a goal?
- ☐ How might such collaborations be developed?

Recommendation

- ☐ READ: Kumar, Arun, 2007, *On the Verification and Skill of Seasonal Climate Forecasts*, *Mon. Weather Review* ... (not exact title!)

Questions?

J.C. Schaake, 1978, Climate Diagnostics Workshop, "extended streamflow prediction techniques: description and applications during 1977"



REGASTED FLOW AND ESP PREDICTED FLOWS (HISTORICAL INPUT)

Not Used

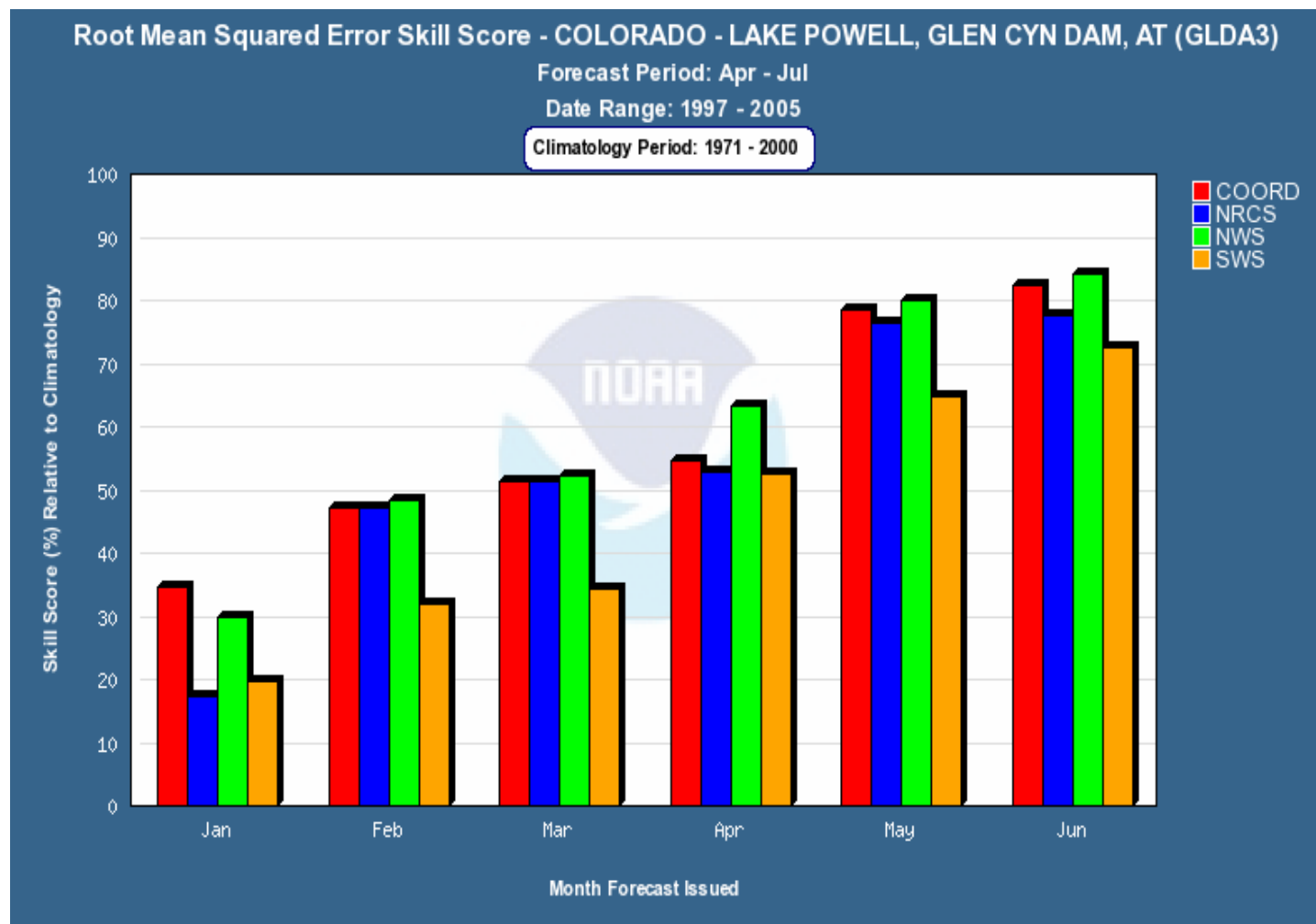
NWS Western Water Supply Web

WS Verification: Skill Scores

RMSE-SS for
deterministic

RPSS for
probabilistic

- Reference
forecast =
climatology
- Conditional
statistics
based on
lead time
and year
- Dynamically
generated



Forecast Calibration: Adjust Mean & Spread

Tested simple algorithm for calibrating ESP forecasts to solve spread/bias problem.

Based on algorithm
from NWS EPP.

(see poster for details)

Spread-Confidence Plots for 1996 April Forecast

April—July Feather R. Inflow to Oroville Reservoir, CA

