



Advanced Hydrologic Prediction Services: Ensemble Streamflow Prediction

**California-Nevada River Forecast Center
National Weather Service**



AHPS – Defined

Advanced Hydrologic Prediction Services

- The umbrella under which the NWS will improve the quality, relevance, and delivery of hydrologic information and forecasts to customers and partners.
- Bottom line: All beneficial changes in the hydrologic services program can be classified as AHPS.



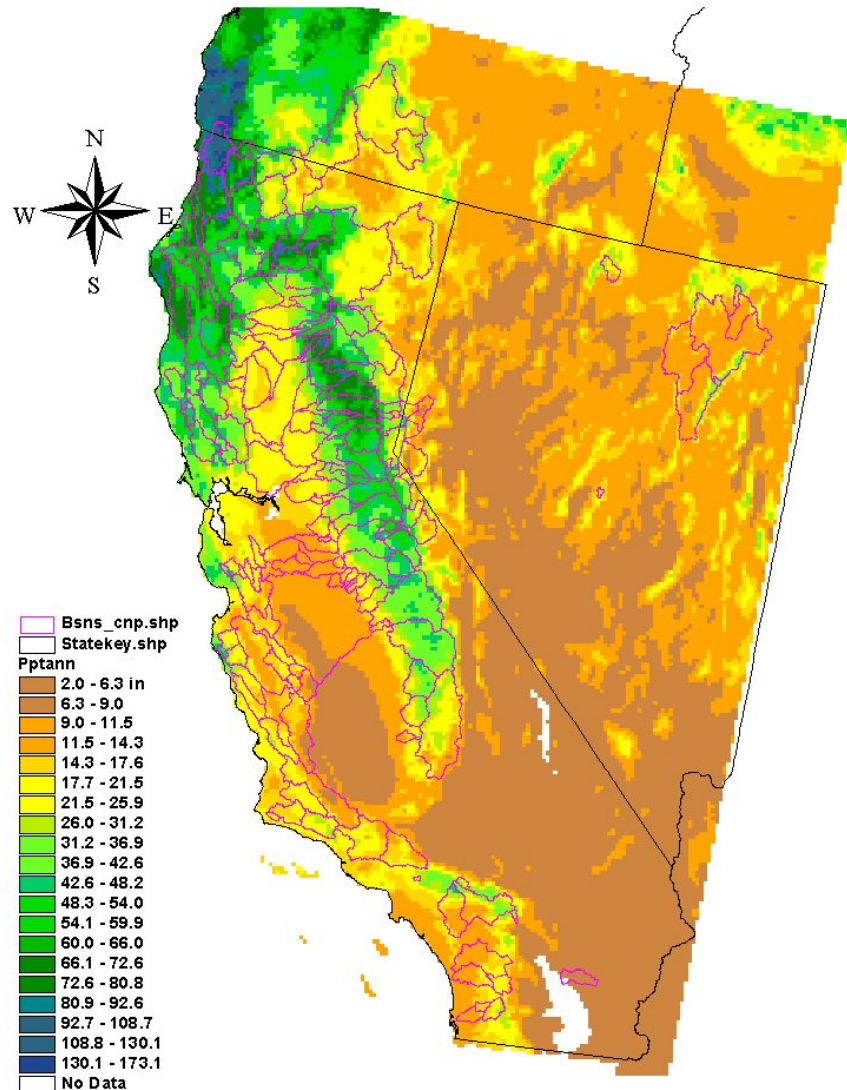
ESP-Defined

Ensemble Streamflow Prediction

- **Ensemble Hydrologic Forecasting Definition:**
“A process whereby a continuous hydrologic model is successively executed several times for the same forecast period by use of varied data input scenarios...”

CNRFC Operations

- 200+ Basins modeled
- 87 Flood Forecast Points
 - Partners: Calif. DWR
 - Season: Oct. 15 – Apr. 15
- 50 Reservoir Inflow Points
 - COE, BUREC, Res Mangrs
 - Season: year-round
- 50 Water Supply Points
 - Season: Jan.1 – Jul. 1

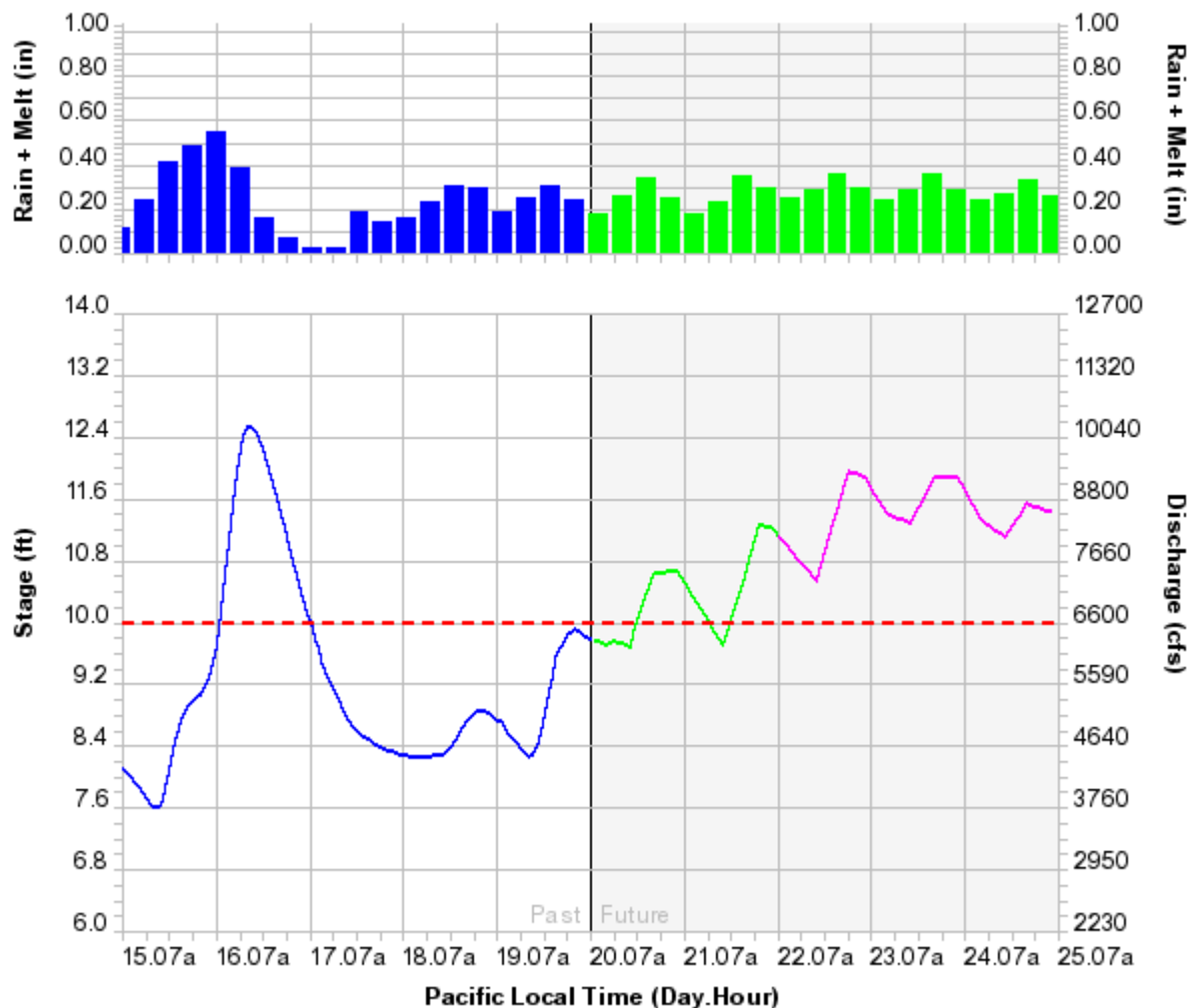




Deterministic Forecasts

Forecast Issuance: 5/20/05 7:31 AM PDT

Next Forecast Issuance: 5/21/05 9:00 AM PDT

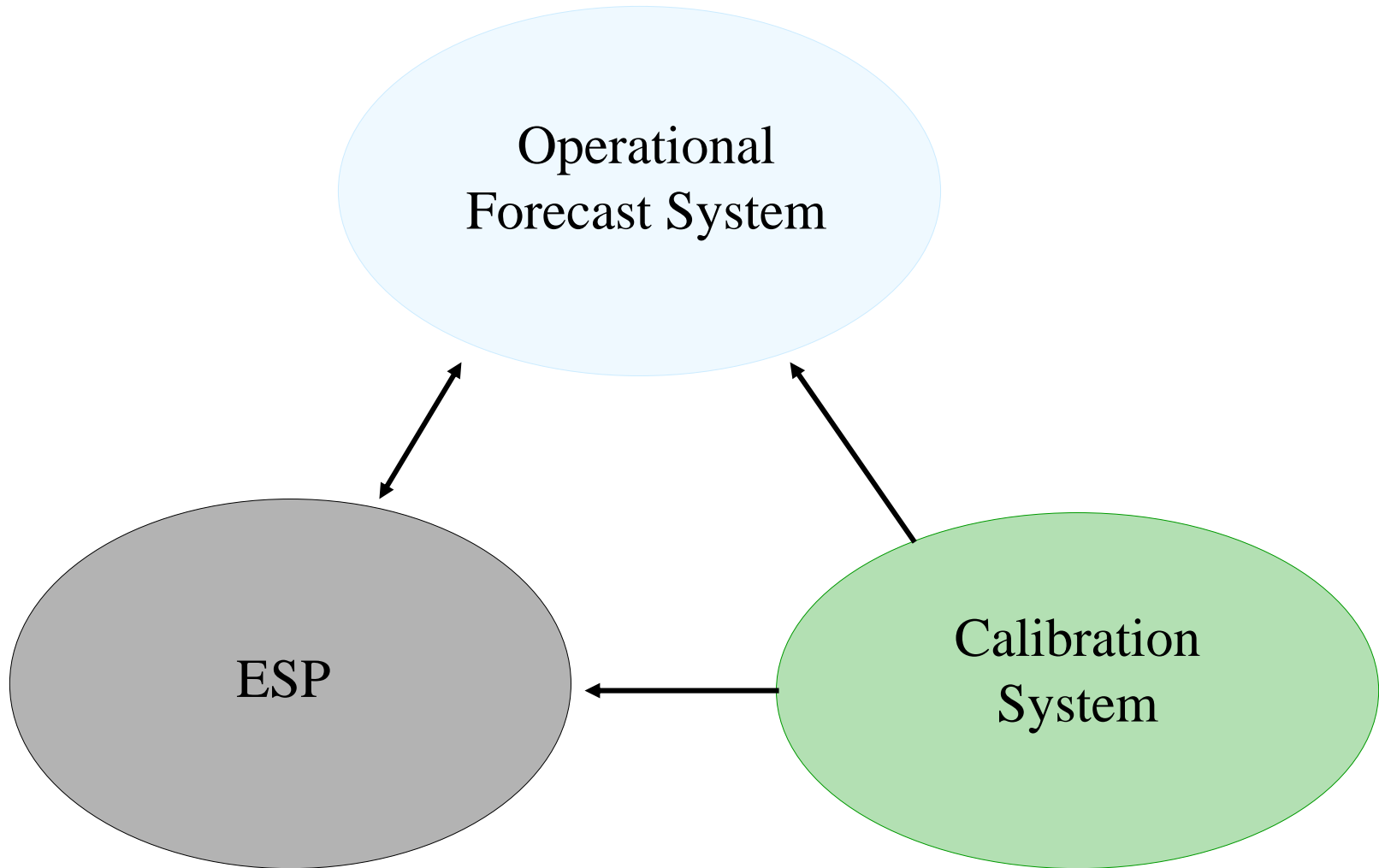


Observed - Forecast - Guidance - Flood 10.0 -
 Graphic Generated 05/20/2005 at 07:32 AM PDT

California Department of Water Resources
 California Nevada River Forecast Center (CNRFC) , NWS / NOAA



Modeling Fundamentals





Ensemble Streamflow Prediction (ESP)

- NWSRFS models and current states.
- Historical MAPs and MATs from calibration.
- Flexible analysis window.
- Many forecast variables.
- Better performance under extreme conditions.
- Use of weather and climate forecasts.



Hydrologic Ensemble Uses (Risk Management)

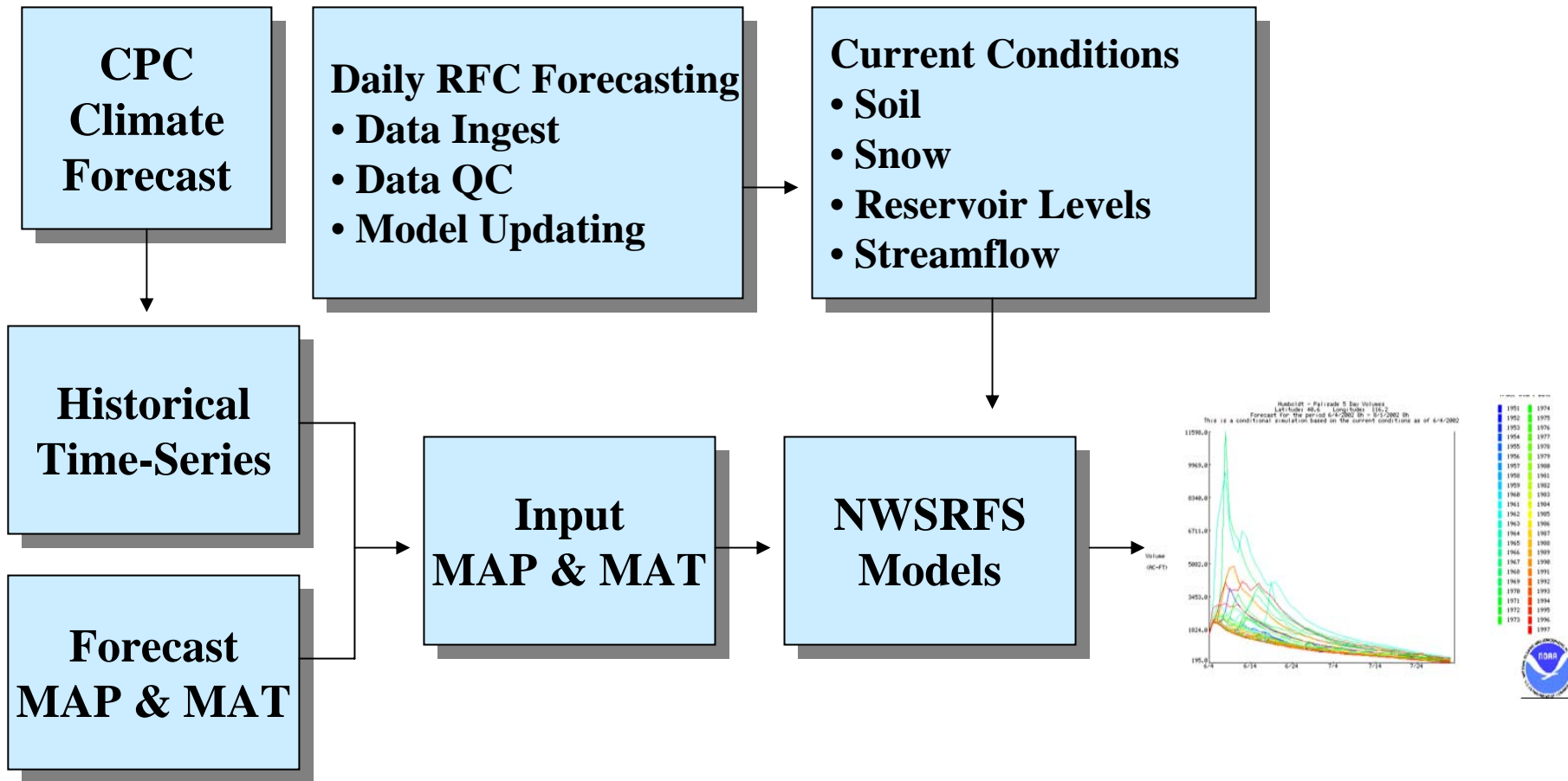
- Short-range (hours to days)
 - Watch and warning program
 - Local emergency management activities
 - Reservoir and flood control system management
 - Navigation
 - Power

- Medium-range (days to weeks)
 - Reservoir management
 - Local emergency management preparedness
 - Navigation
 - Snowmelt runoff management
 - Power

- Long-range (weeks to months)
 - Water supply planning
 - Reservoir management
 - Power

ESP Trace Ensembles

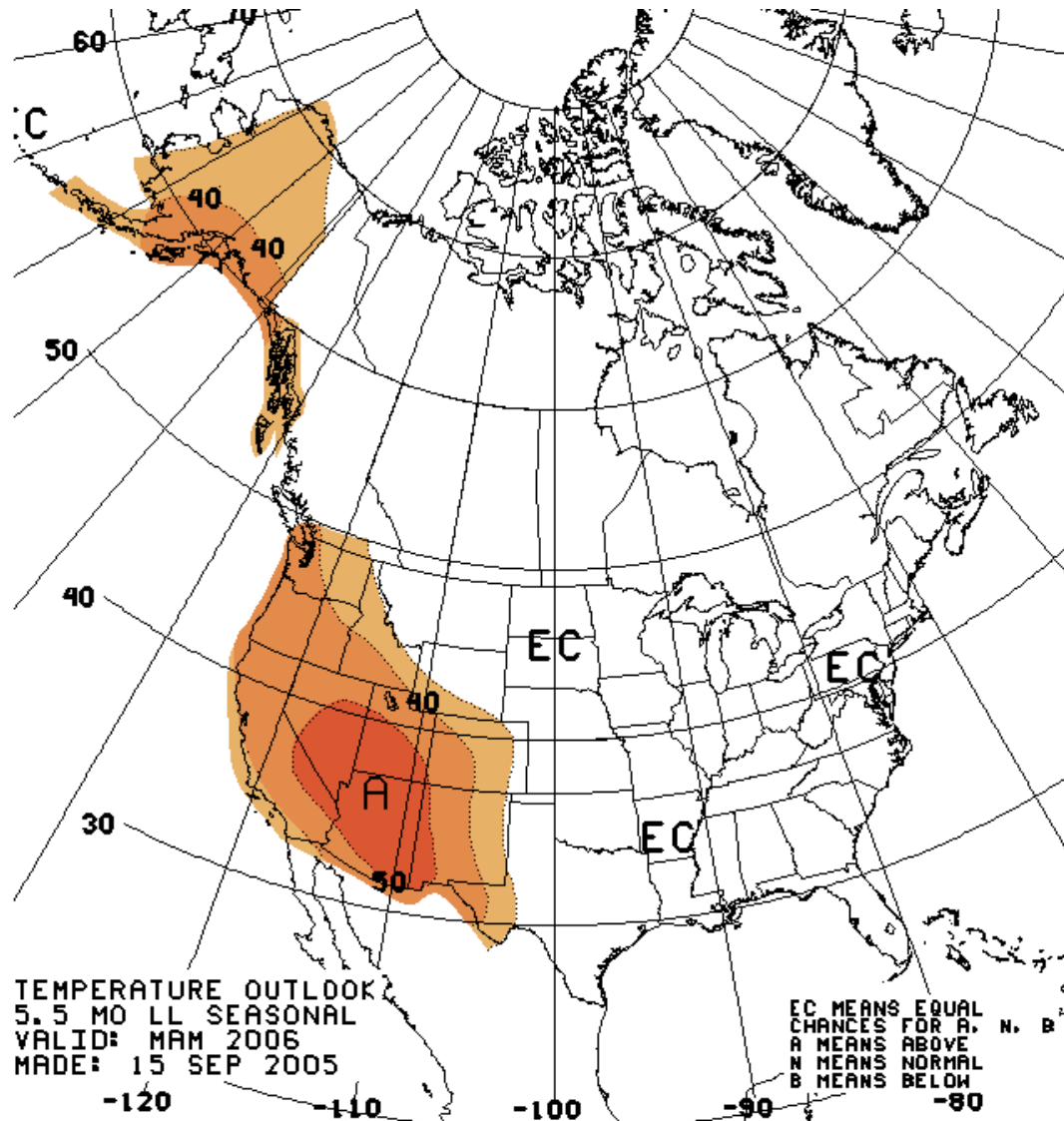
Overview





Climate Adjustments

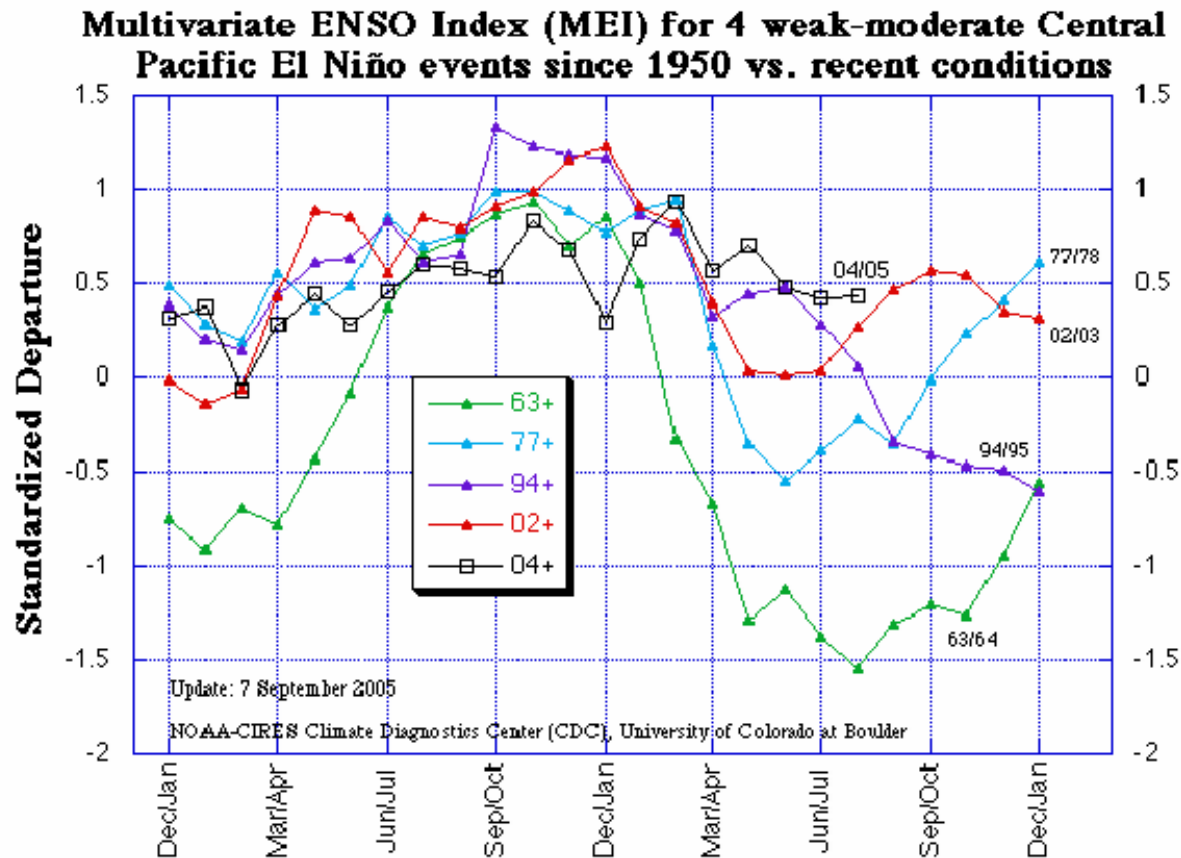
Seasonal Forecasts



Climate Adjustments

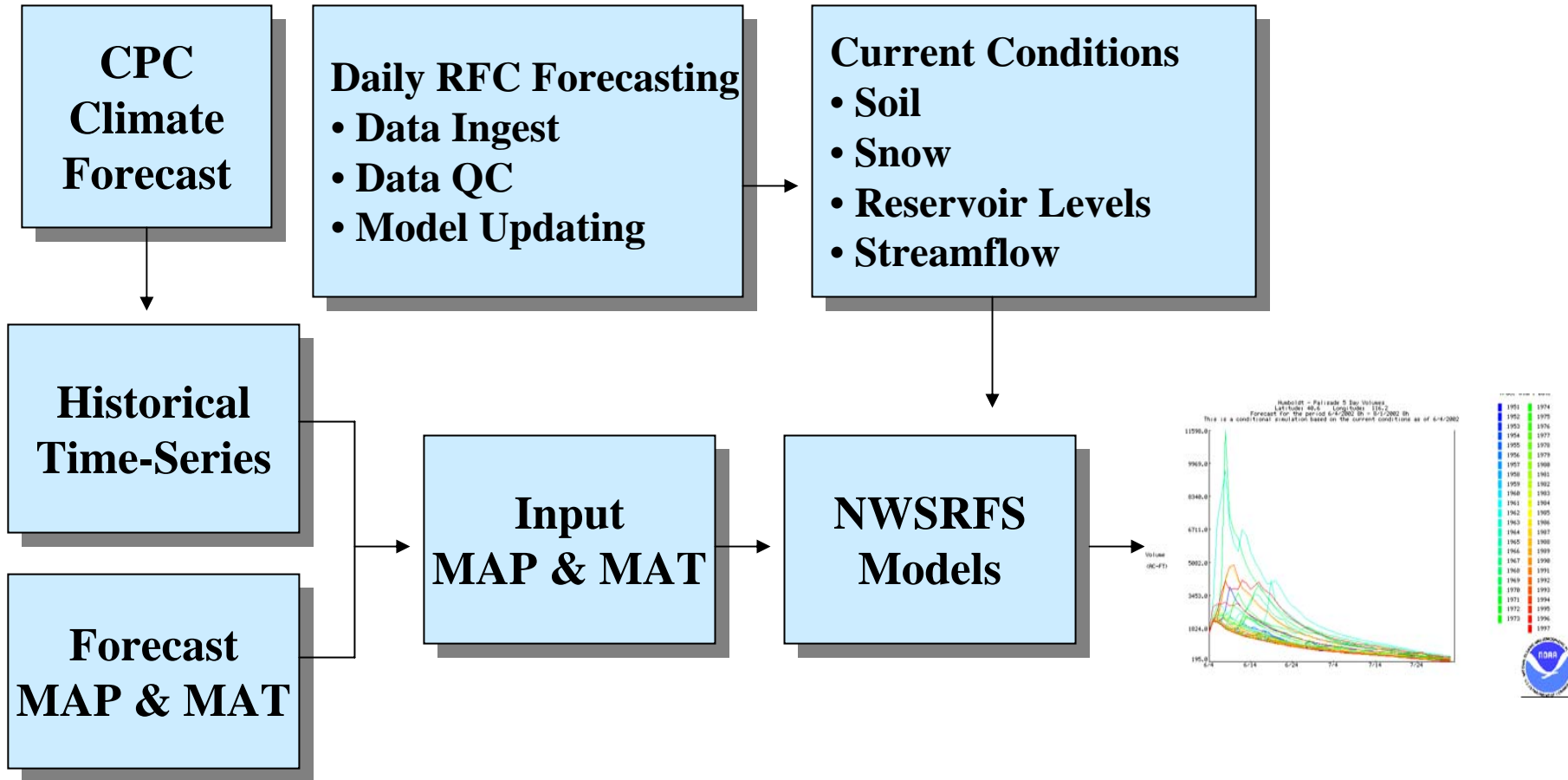
Year Weights

- Ability to weight years with similar climate
- Most valuable when climate has a strong signal



ESP Trace Ensembles

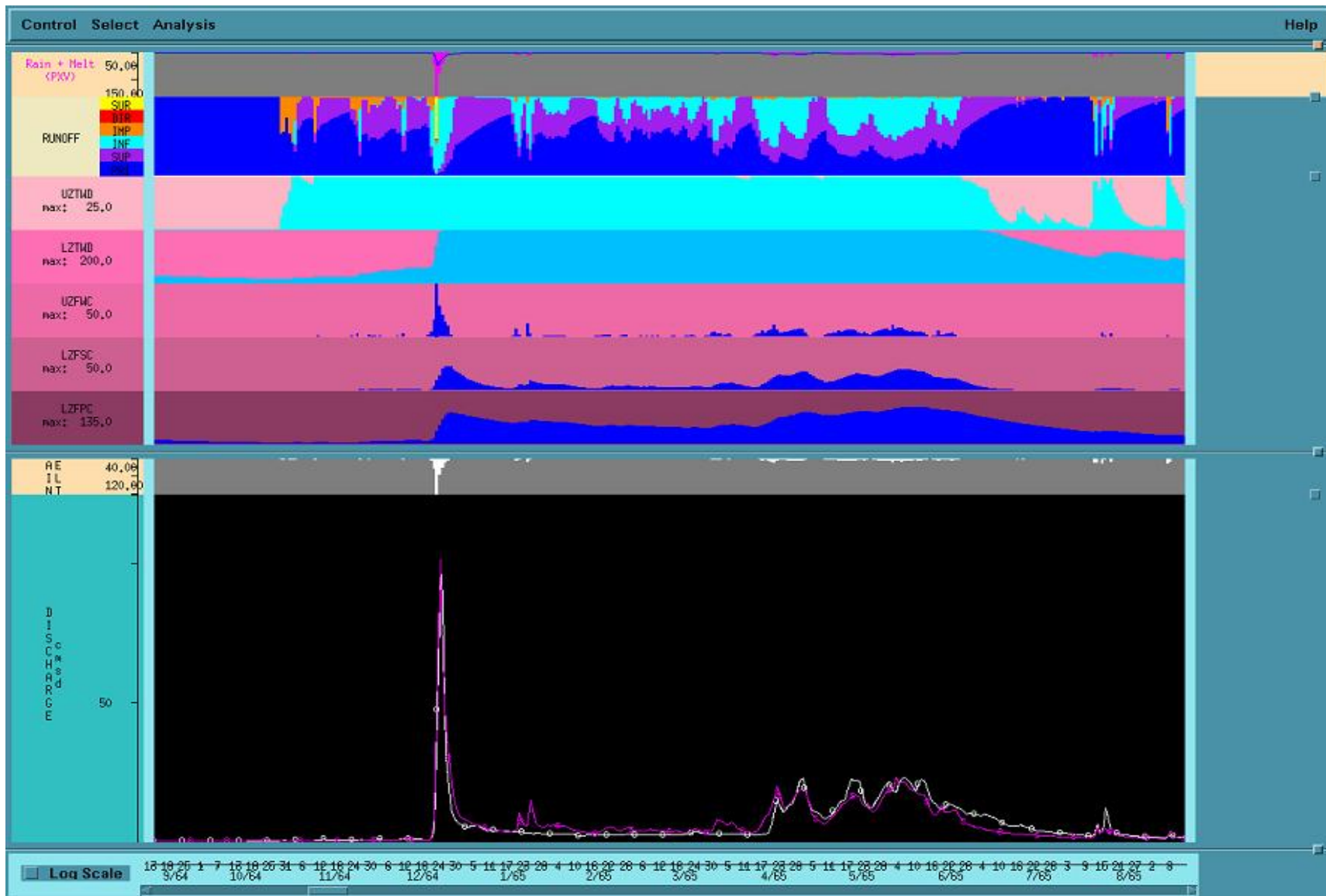
Overview





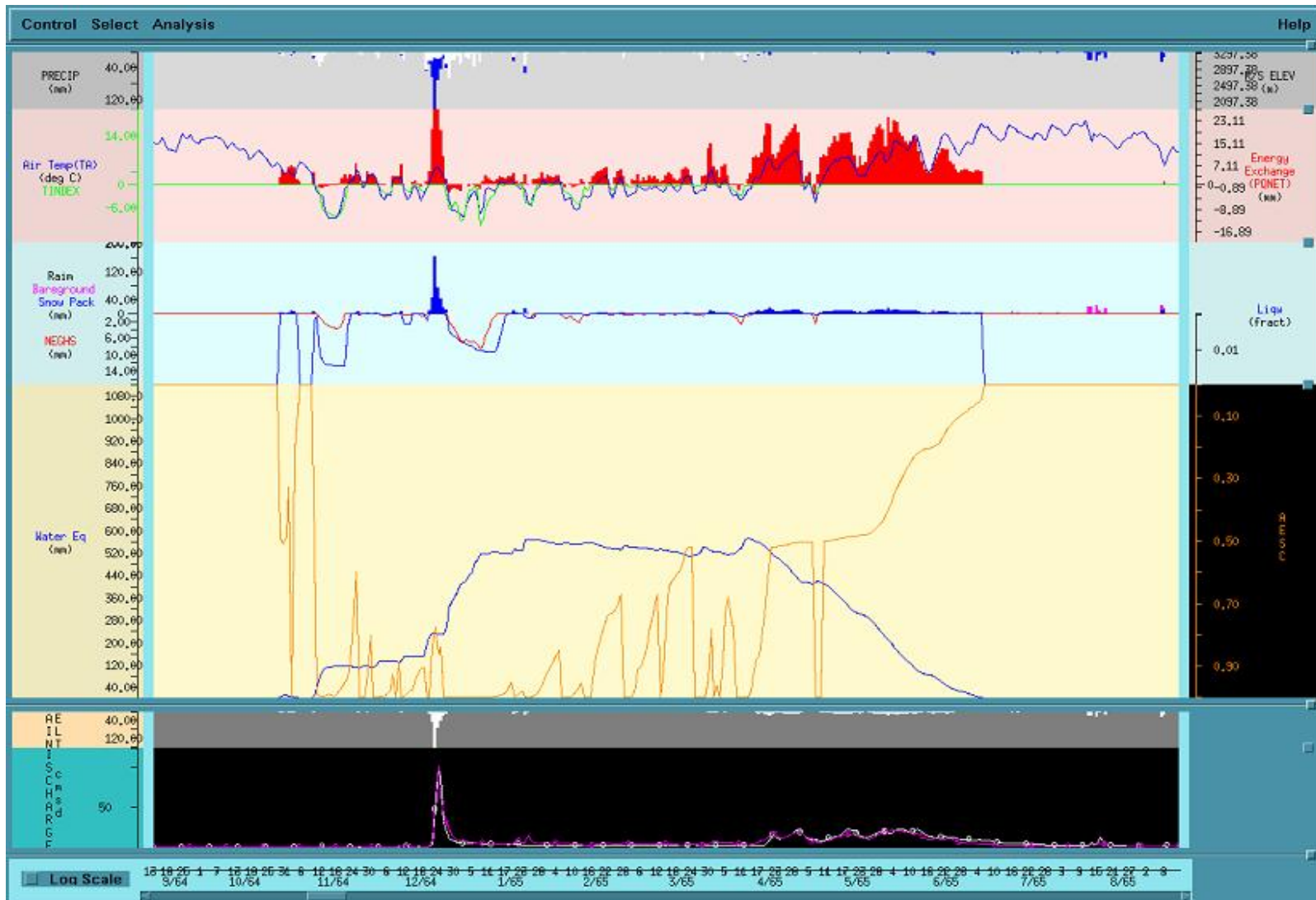
Current Conditions

SAC-SMA Model



Current Conditions

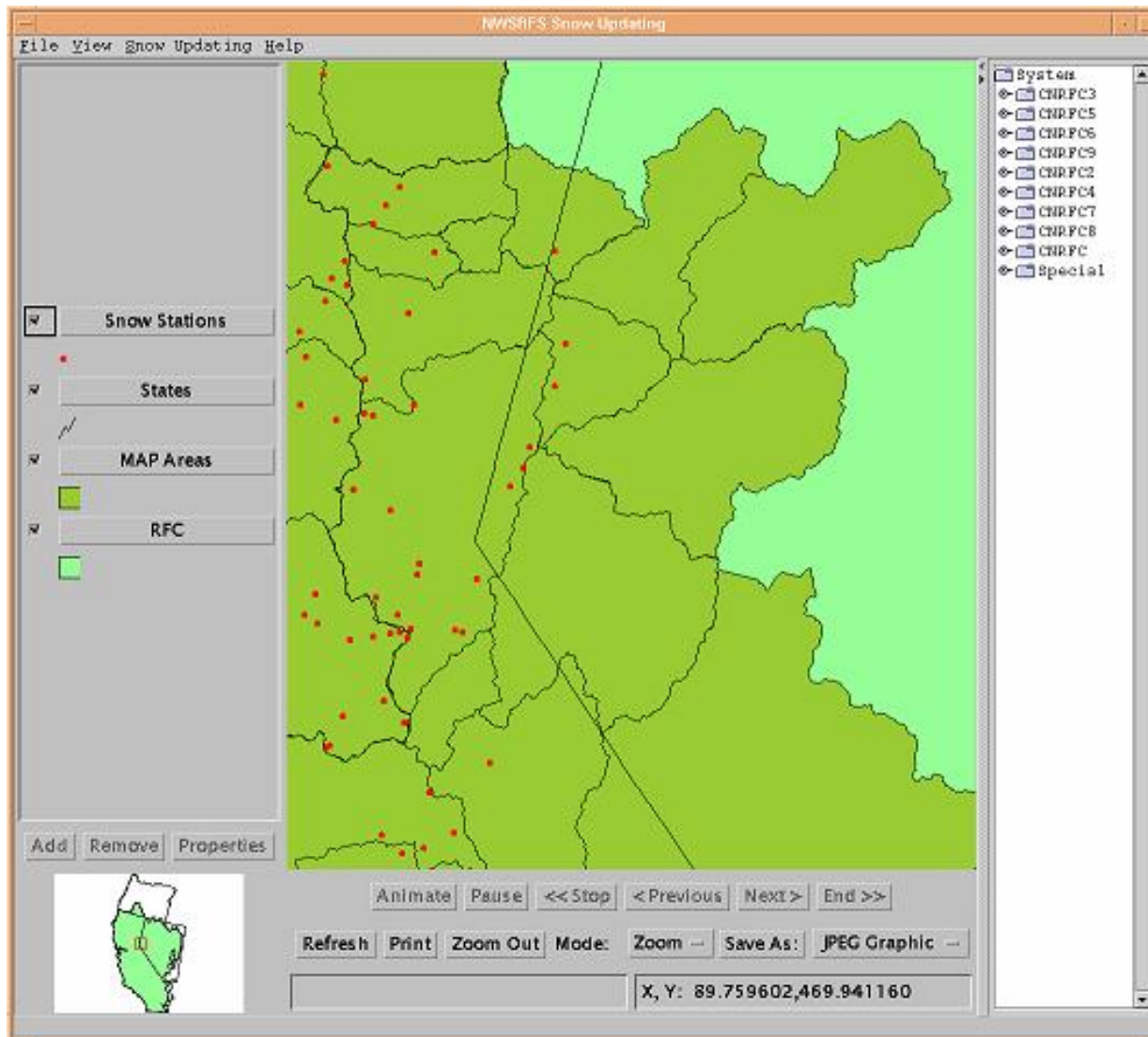
SNOW-17 Model





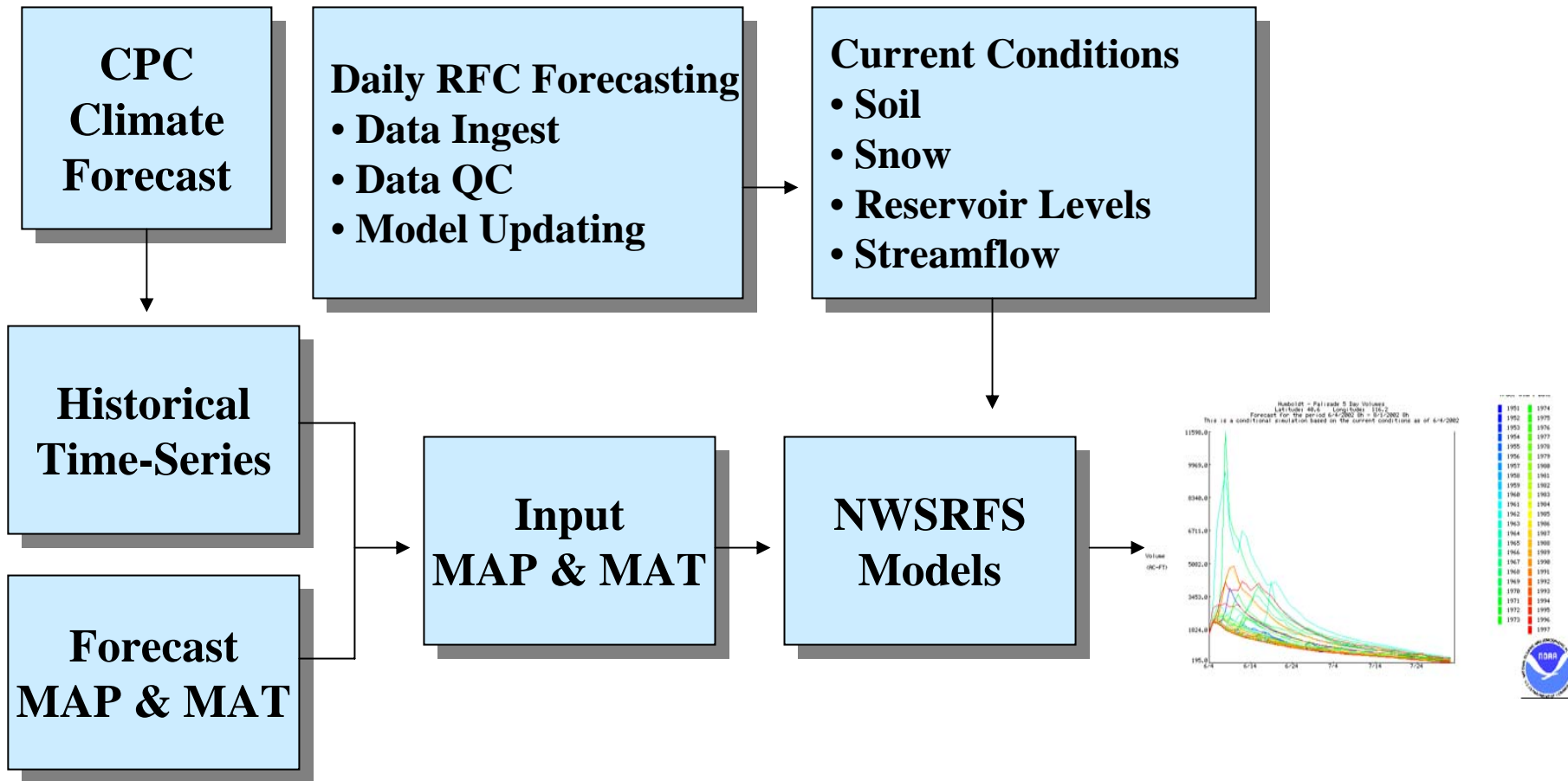
Current Conditions

Snow Model Updating



ESP Trace Ensembles

Overview





ESP Trace Ensembles

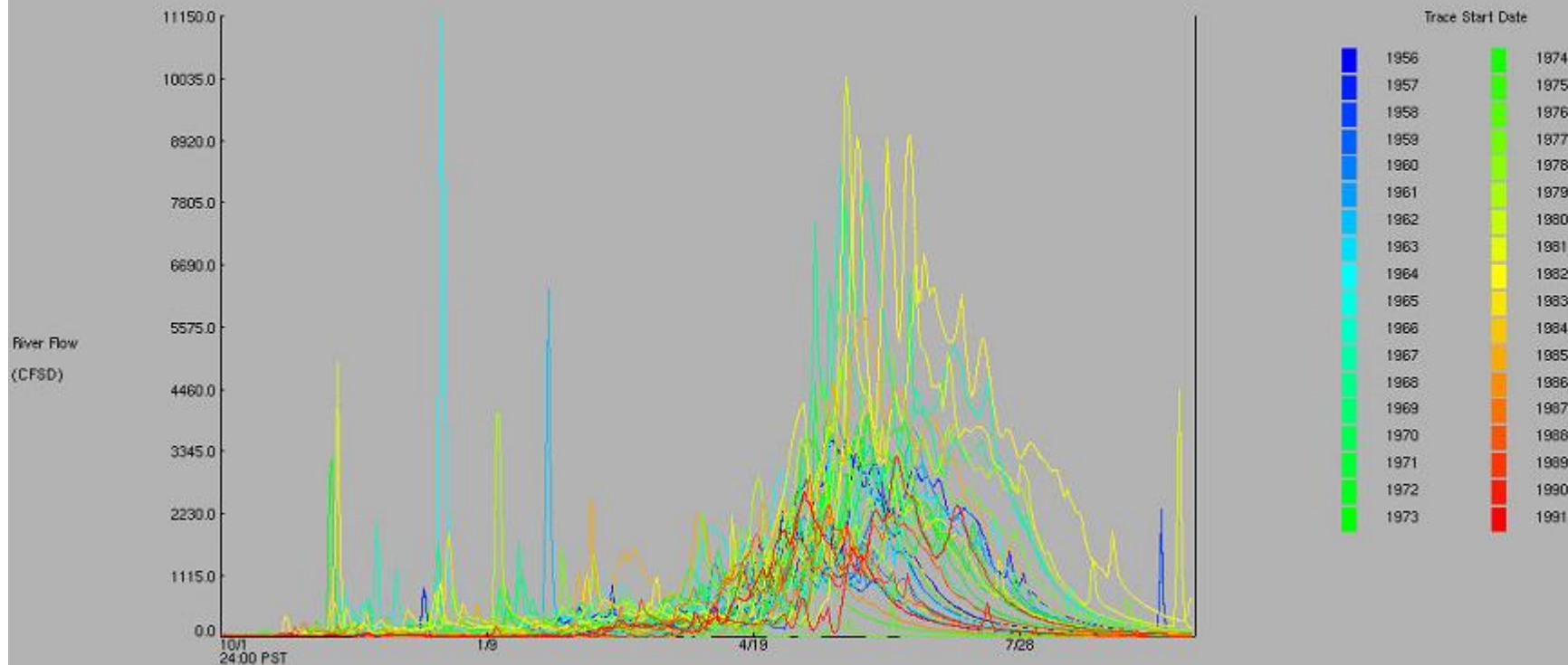


ESP Trace Ensemble of MERCED - POHONO BR

Latitude: 37.7 Longitude: 118.7

Forecast for the period 10/1/2005 24h - 10/1/2006 24h

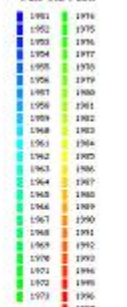
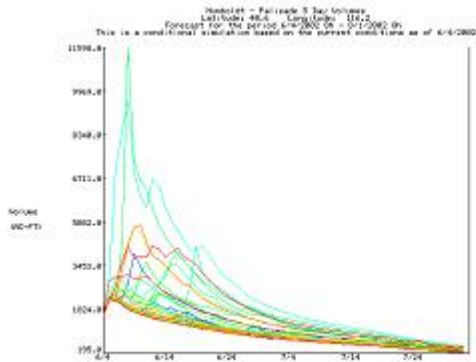
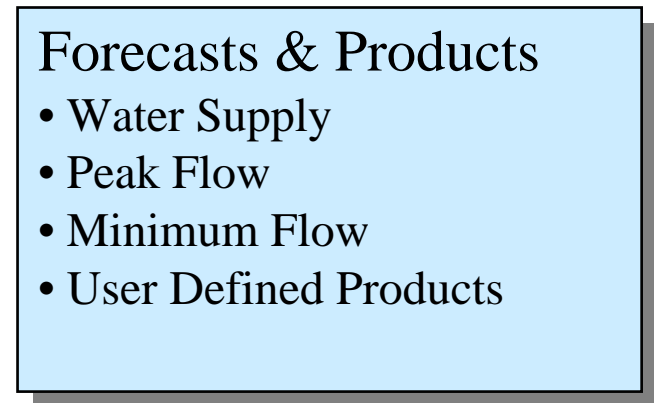
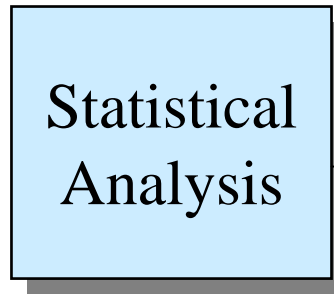
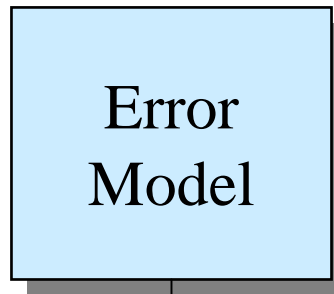
This is a conditional simulation based on the current conditions as of 10/1/2005





ESP Products

Statistical Processing





ESP Products

Forecast Tabular Display

File						
# ESP Forecast Information						
#						
# Analysis Period: 1/1/2005 24 - 5/31/2005 24 (PST)						
# Forecast Parameters: Volume (Sum) - (AC-FT)						
#						
# Forecast Interval: 1 Month						
# Forecast Point: UPPER KLAMATH LAKE						
#						
# UPPER KLAMATH LAKE	0.90	0.70	0.50	0.30	0.10	Units
#	-----					
01/01/2005 - 01/31/2005	51133.13	78957.99	106631.70	144004.64	222366.95	(AC-FT)
02/01/2005 - 02/28/2005	54461.19	85510.02	116818.41	159589.97	250573.69	(AC-FT)
03/01/2005 - 03/31/2005	73703.77	117685.84	162655.95	224810.05	358963.41	(AC-FT)
04/01/2005 - 04/30/2005	62175.82	106205.07	153796.28	222713.44	380425.97	(AC-FT)
05/01/2005 - 05/31/2005	61066.31	100473.91	141775.42	200054.62	329154.78	(AC-FT)



ESP Products

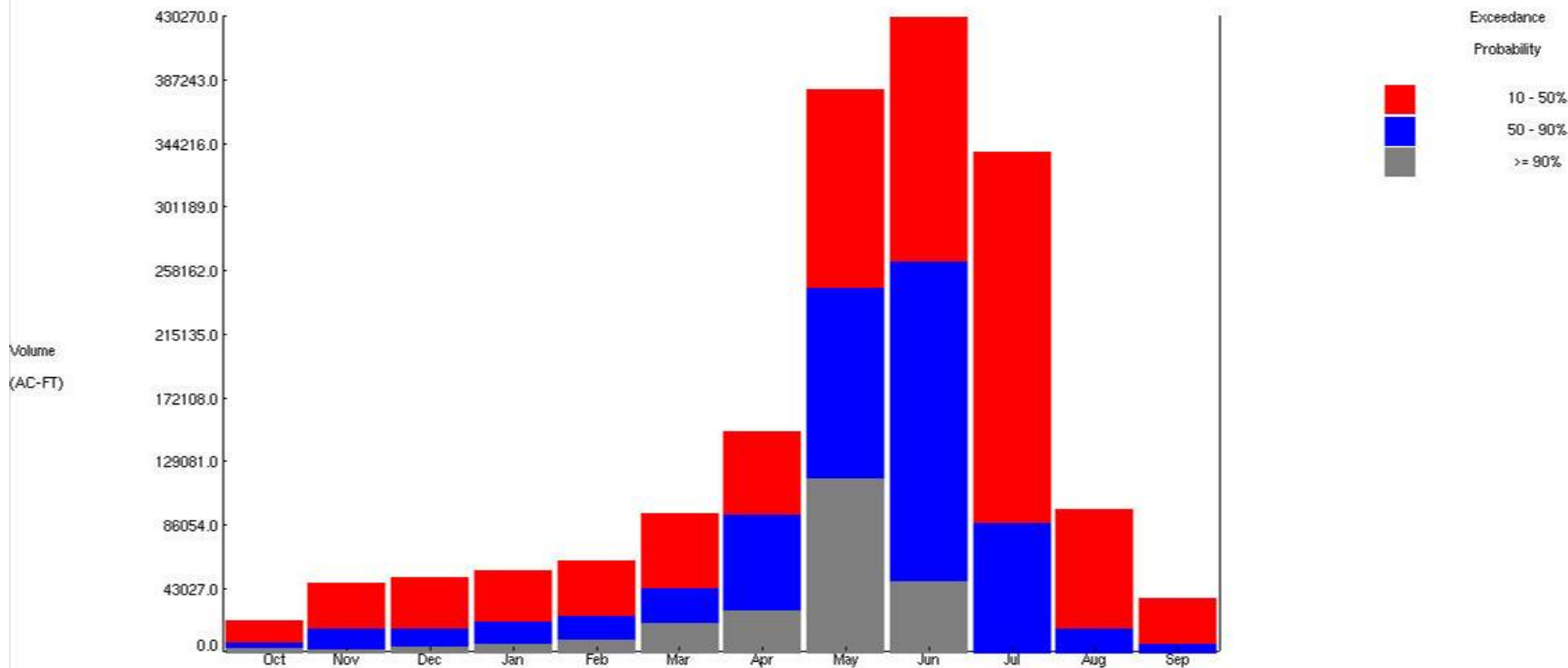
Probability Histograms

1 Month Chances of Exceeding River Levels on the TUOLUMNE - H_HETCHY

Latitude: 38.0 Longitude: 119.8

Forecast for the period 10/1/2005 - 9/1/2006

This is a conditional simulation based on the current conditions as of 10/1/2005





ESP Products

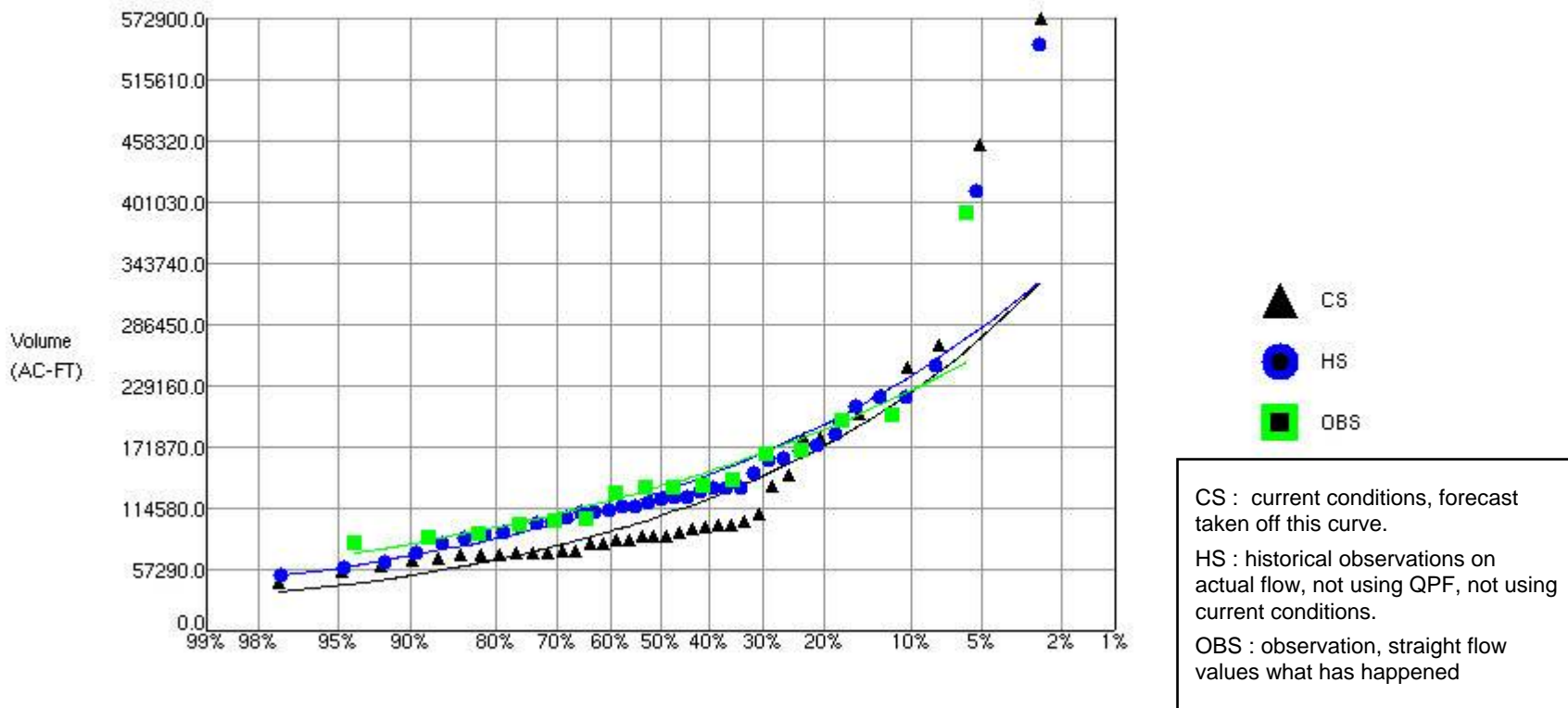
Exceedance Probability Plots

Chances of Exceeding River Levels on the UPPER KLAMATH LAKE

Latitude: 42.2 Longitude: 121.8

Forecast for the period 1/1/2005 - 2/1/2005

This is a conditional simulation based on the current conditions as of 10/15/2004





Forecast of Runoff Volumes for the Snowmelt Season

Issued Wednesday, June 5, 2002

Produced by the NWS California Nevada River Forecast Center and the California Dept. of Water Resources



Remarks: The 5-day period begins with temperatures well above normal. Into the weekend, a weak trough will move into the intermountain west and lower temperatures closer to normal. High pressure will rebuild early next week and once again warm temperatures to above normal. No precipitation is expected.

Please note: Snowmelt peak flows have occurred or are occurring at all forecast points. This will be the final snowmelt forecast for this season. Any agency requiring additional snowmelt forecast guidance is requested to contact the CNRFC.

Forecasts reflect predicted short-term precipitation and temperature as well as the predicted shift from normal climatology provided by NOAA's Climate Prediction Center.

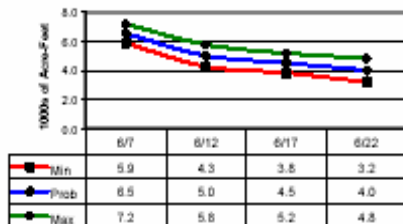
Min: Reasonable minimum (90 percent chance of being exceeded)
 Prob: Most probable volume (50 percent chance of being exceeded)
 Max: Reasonable maximum (10 percent chance of being exceeded)
 Pk Vol/Date: Most probable peak 1-day volume of runoff (in thousands of acre-feet) and the date of occurrence

Indicated values are unimpaired flow volumes in thousands of acre-feet in 5-day intervals for the next 20 days. The date indicated above each column is the mid-point of the 5-day interval.

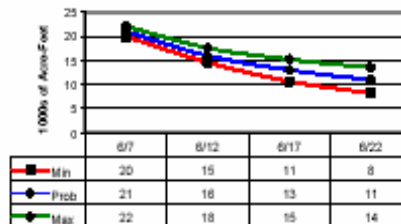
ESP Products

Spring Snowmelt Forecast

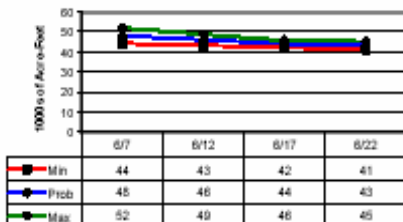
Willamson River at Chiloquin



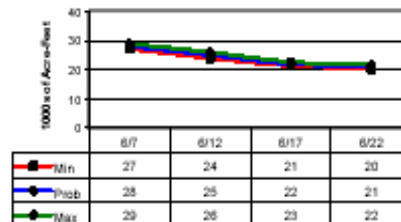
Trinity River at Lewiston



Shasta Reservoir Inflow



Feather River at Oroville

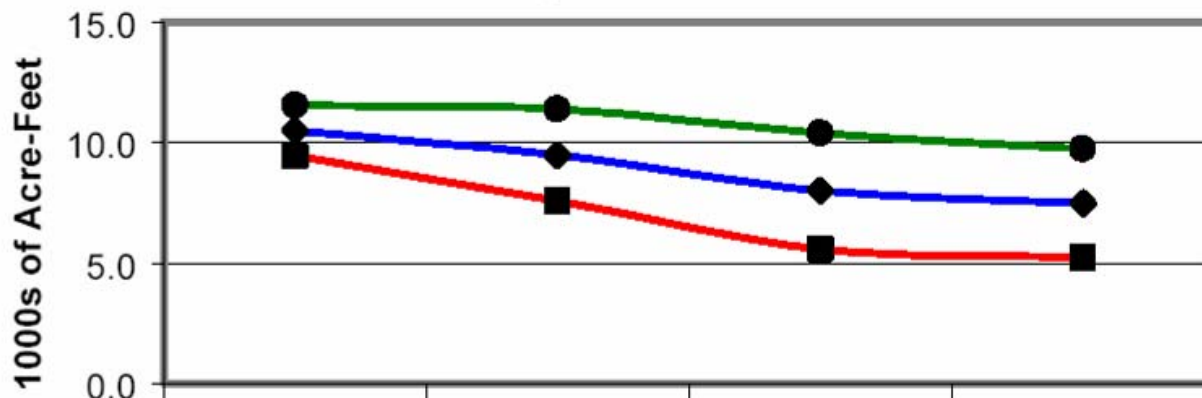




Sample Snowmelt Forecast

Humboldt River at Palisade

Peak 1-Day Vol. 2.3 Date: 6/6



	6/7	6/12	6/17	6/22
■ Min	9.5	7.6	5.6	5.3
◆ Prob	10.5	9.5	8.0	7.5
● Max	11.6	11.4	10.4	9.8



ESP Products



“Build your own product”

at

www.cnrfc.noaa.gov

AHPS / ESP Trace Analysis

1 Select a Location:

MERCED RIVER - YOSEMITE AT POHONO BRIDGE (POHC1)

2 Select an Accumulation Type:

Mean Minimum Maximum Summation

3 Select an Interval:

Day Week Month Entire Period

4 Select a Starting Date: Month: Day: Year:

5 Select an Ending Date: Month: Day: Year:

6 Select a Plot Option and Generate:

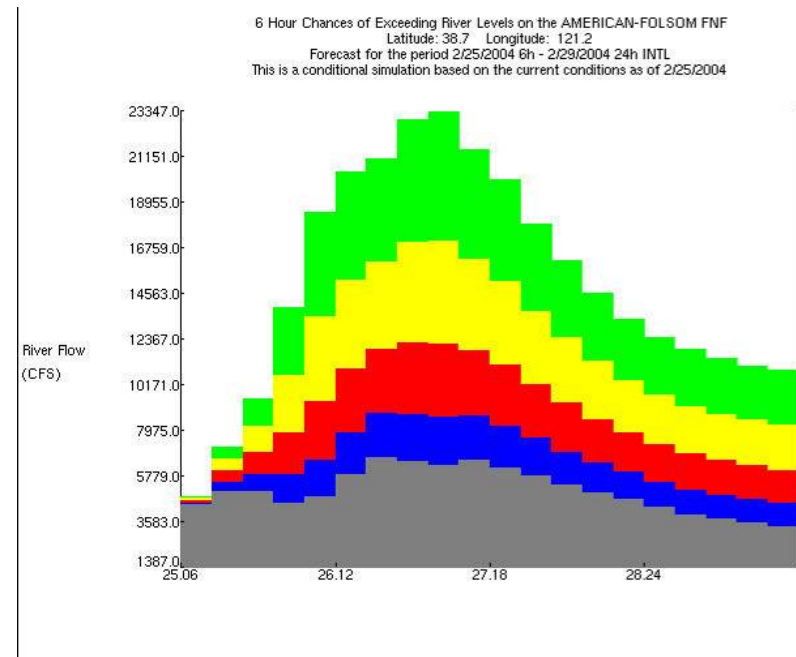
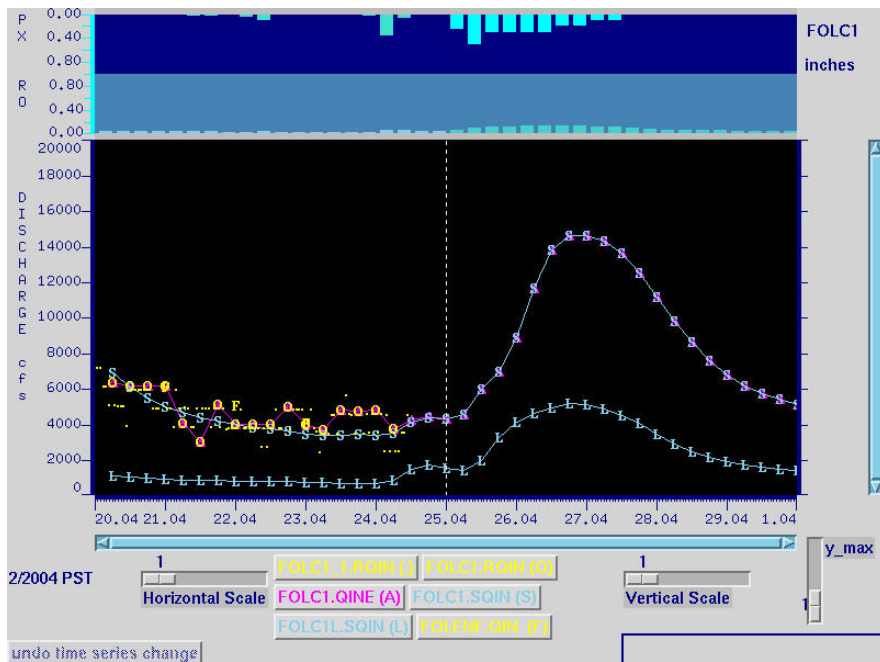
Traces Probability Expected Value Exceedance

or Select a Table Option and Generate:

Forecast Info Quantiles Flood Quantiles

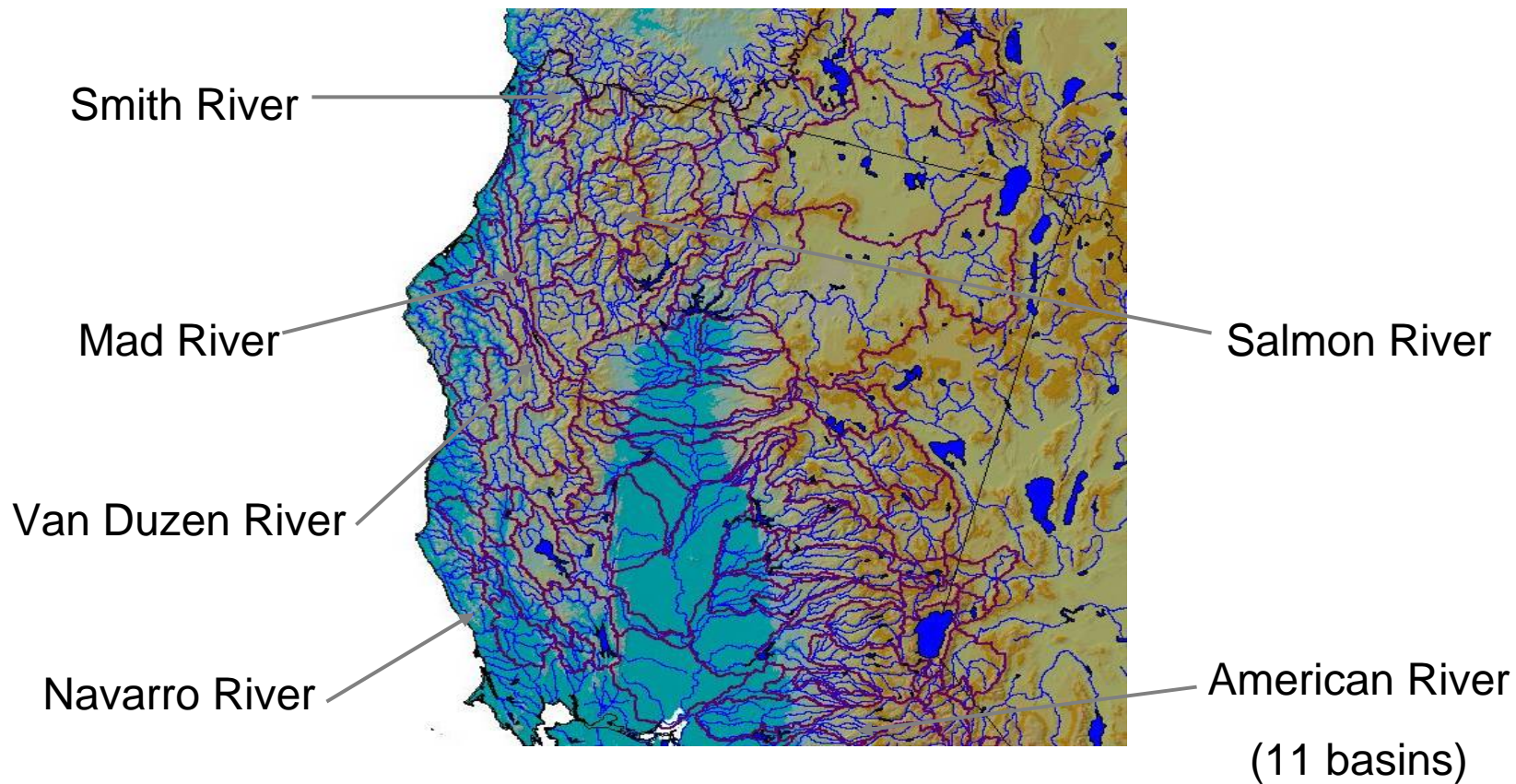
Ensemble Challenges

- Maintain coherence between deterministic and ensemble forecasts





Short-term Ensemble Prototype





Short-term Ensemble Prototype

- 5 day precipitation and temperature ensembles
- Based on operational deterministic precipitation and temperature forecasts
- Uses forecast (skill) and watershed climatology



Short-term Ensemble Prototype

- Appropriately integrate the uncertainty introduced from model, data, and human sources.

OBSERVATIONS

precipitation
air temperature
streamflow

MODEL STATES

snow
soil moisture
basin routing

MODELLING SYSTEM

simplifications
temporal issues
scale issues

???

MODEL PARMS

snow
soil moisture
basin routing

HUMAN INPUT

education
training
experience
mental state

FORECASTS

precipitation
air temperature
regulation



AHPS/ESP

Summary

- Hydrologic ensembles use variations of precip and temperature, based on historical time-series
- Historical MAPs and MATs are blended with short-term forecasts
- Climate forecasts used to adjust MAPs/MATs
- Initial conditions come from operational files
- Ensembles of traces are made by running the model from the current initial conditions
- Statistics are derived from the ensemble of traces