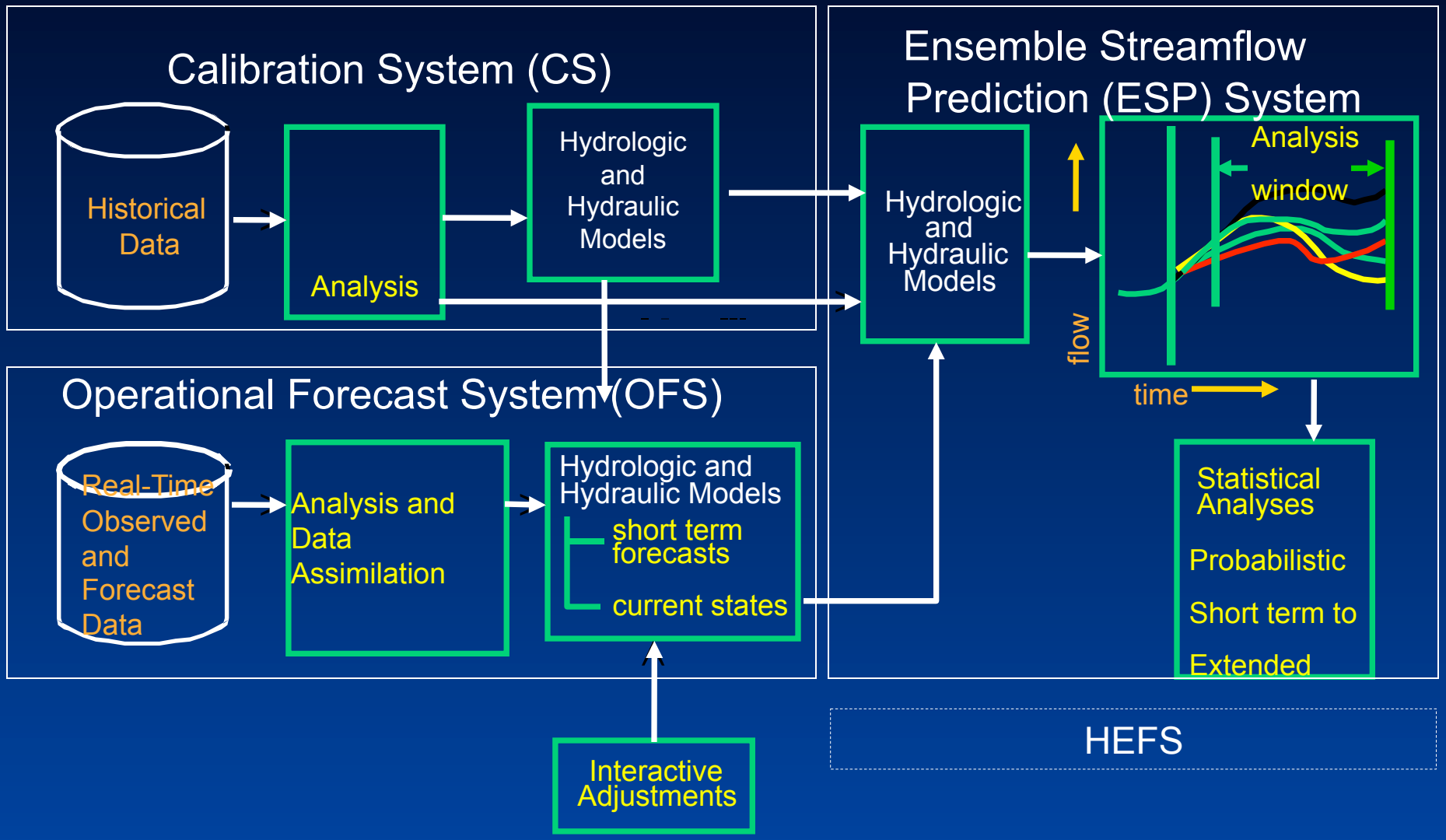
Water Supply Forecast using the Ensemble Streamflow Prediction Model

Kevin Berghoff, Senior Hydrologist
Northwest River Forecast Center
Portland, OR

Overview

- Community Hydrologic Prediction System (CHPS)
  - 3 Components to model
    - Calibration
    - Operational Forecast System
    - Ensemble Streamflow Prediction - ESP

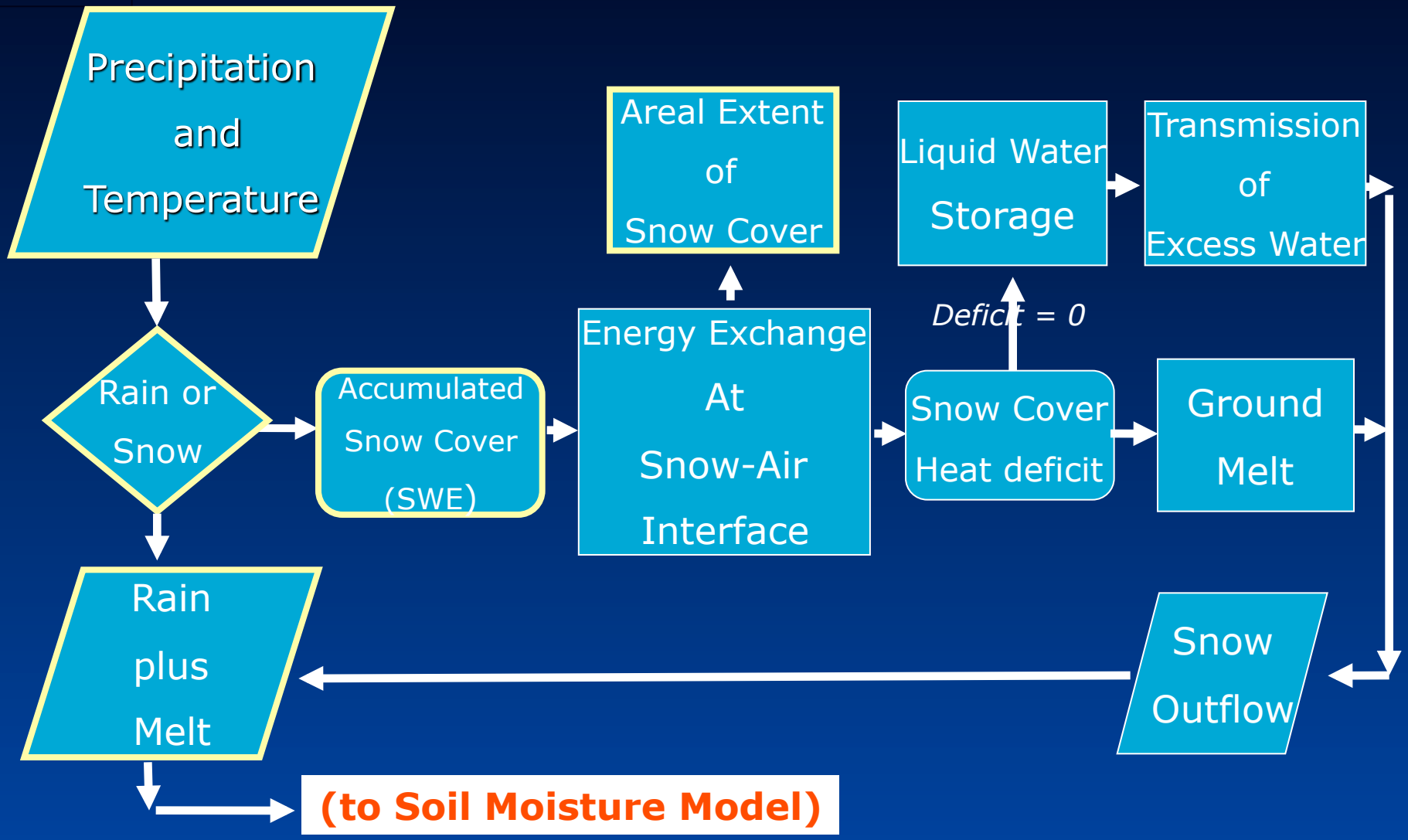
Community Hydrologic Prediction System - CHPS



CHPS Model Calibration

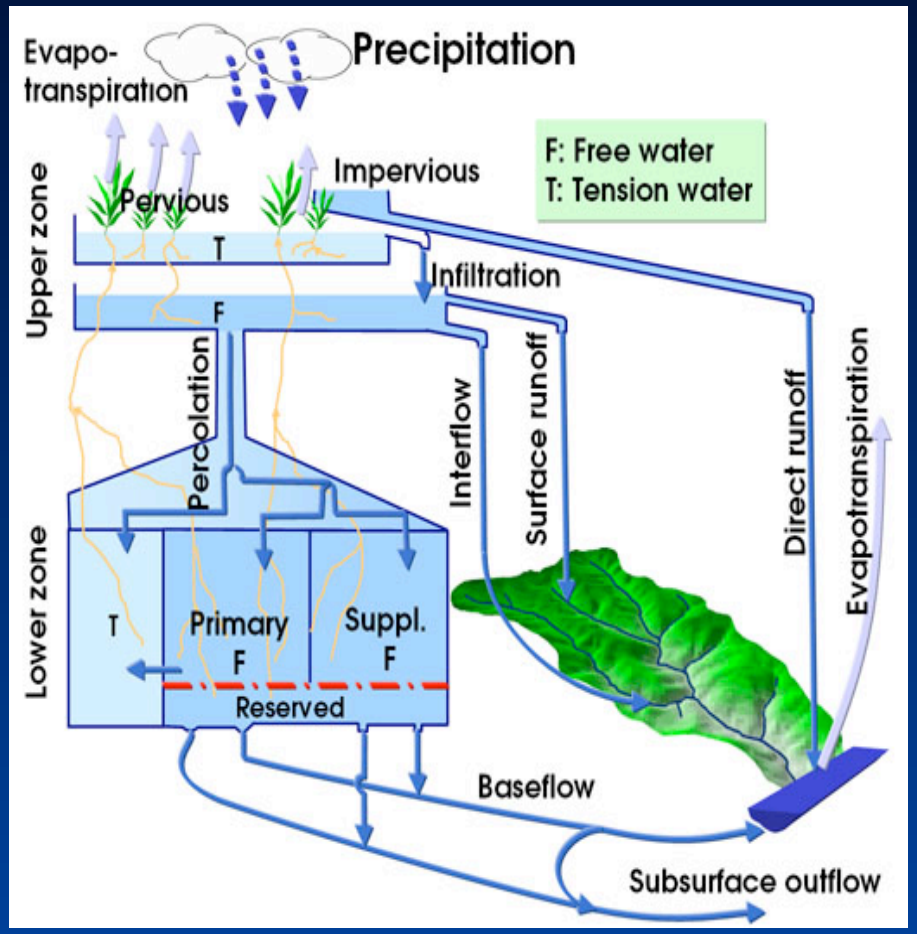
- Historical precipitation and temperature used to generate Mean Areal Precipitation (MAP) and Mean Areal Temperature (MAT) for each basin
- SAC-SMA and SNOW-17 model parameters are adjusted to match the simulated river flow to the observed flow data over the entire calibration period of record
- Timing and attenuation of routed flows from upstream points

Snow-17 Model

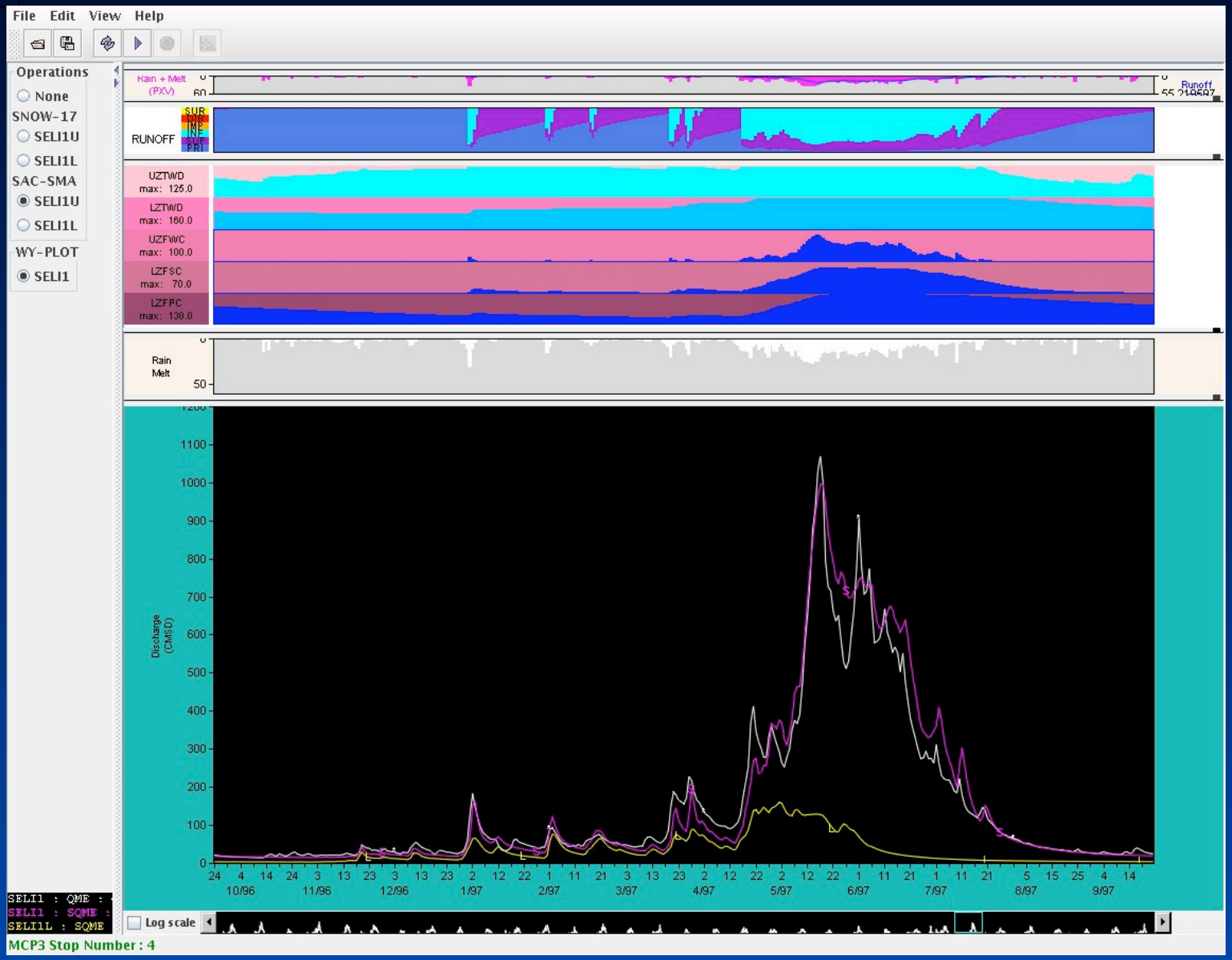


Sacramento Soil Moisture Accounting (SAC-SMA) Model

- Snow Model
- Soil Moisture/Runoff
- Consumptive Use
- River Routing
- Reservoir Regulation
- Flow and Stage
- Forecasts

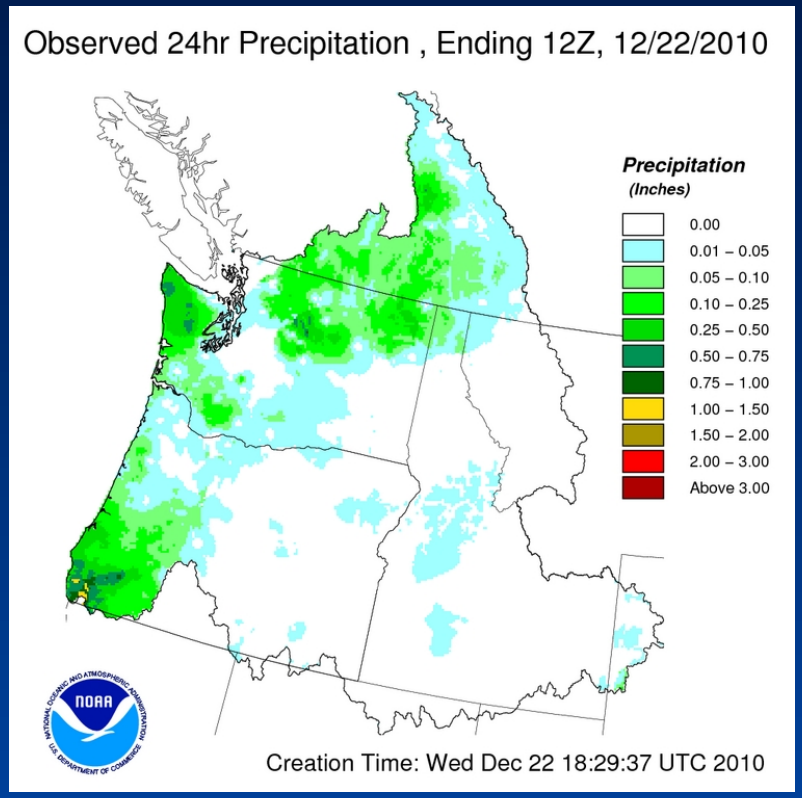


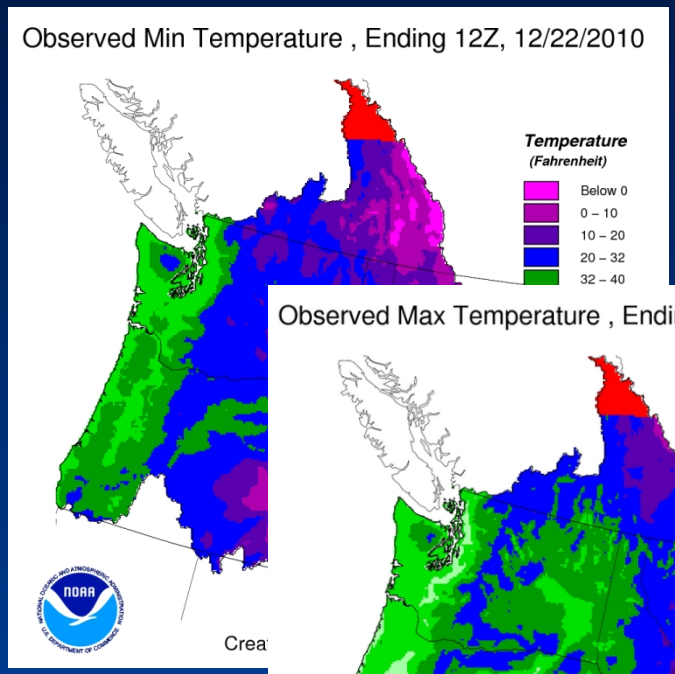
CHPS Model Calibration

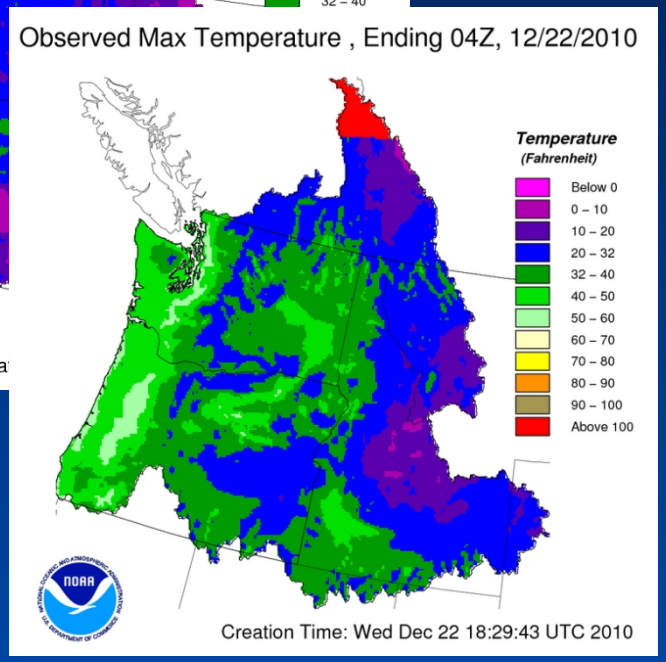


Operational Forecast System

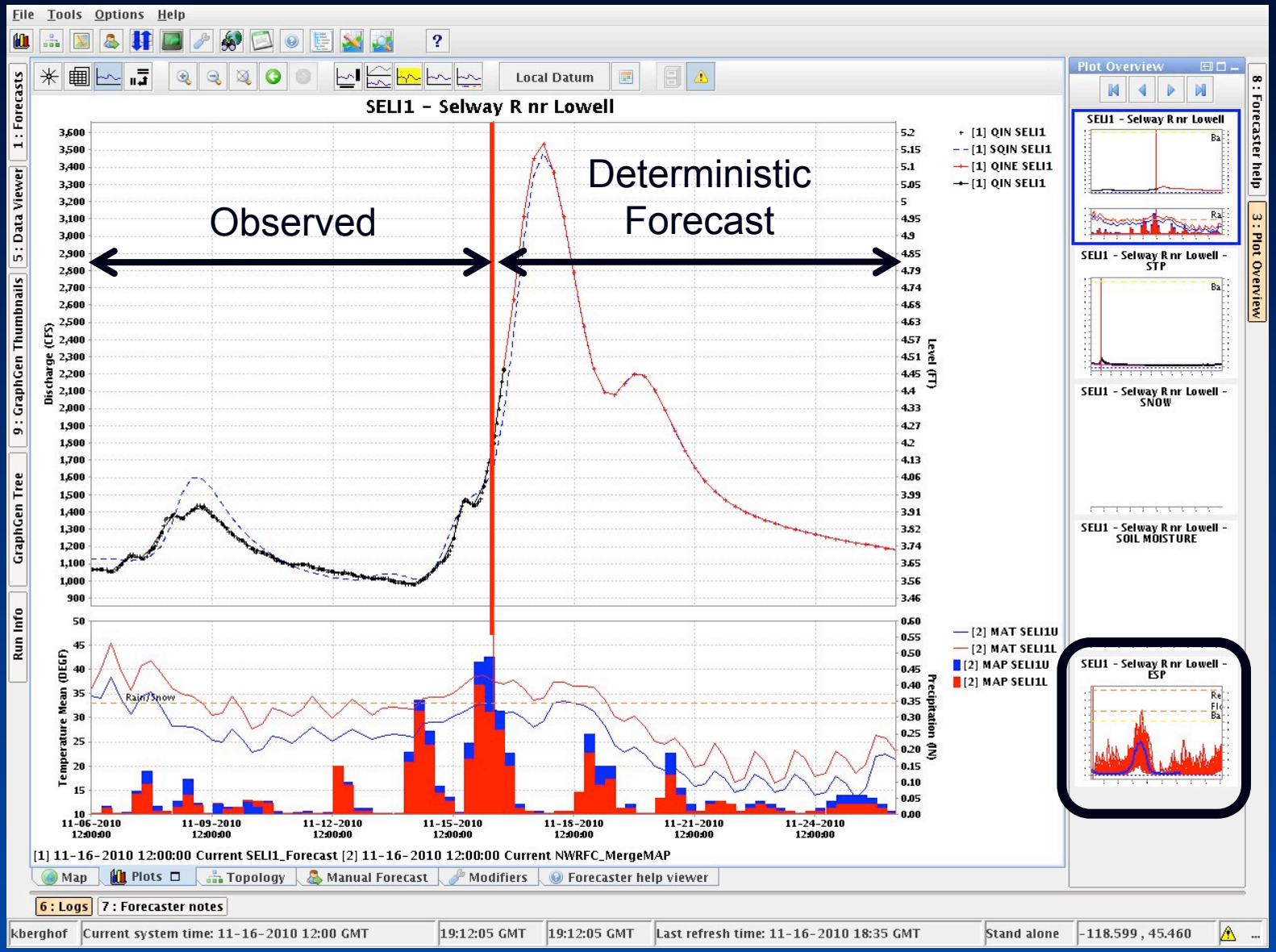
- Observed and 10 Day Forecast Inputs
  - Precip, Temperature



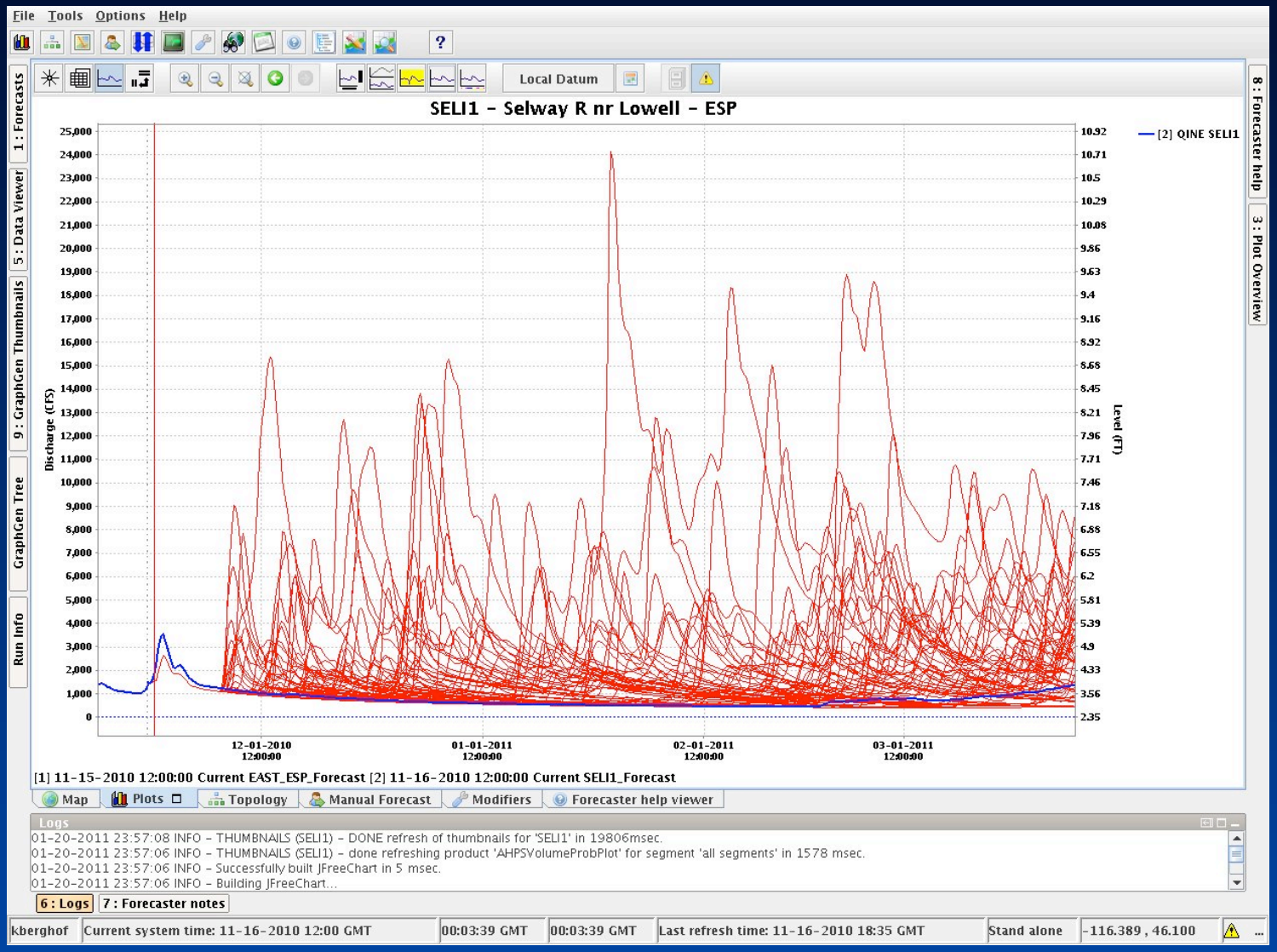




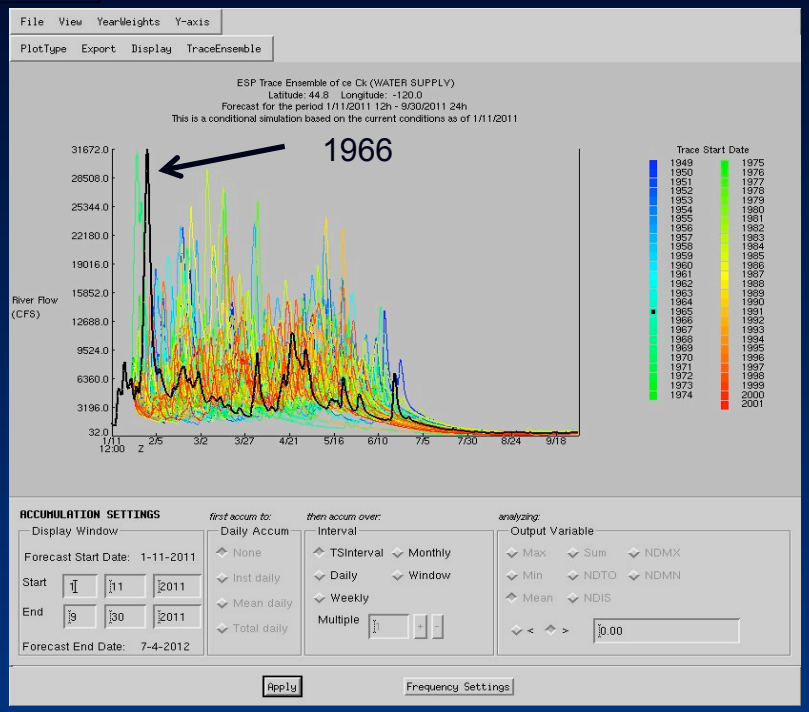
Operational Forecast System

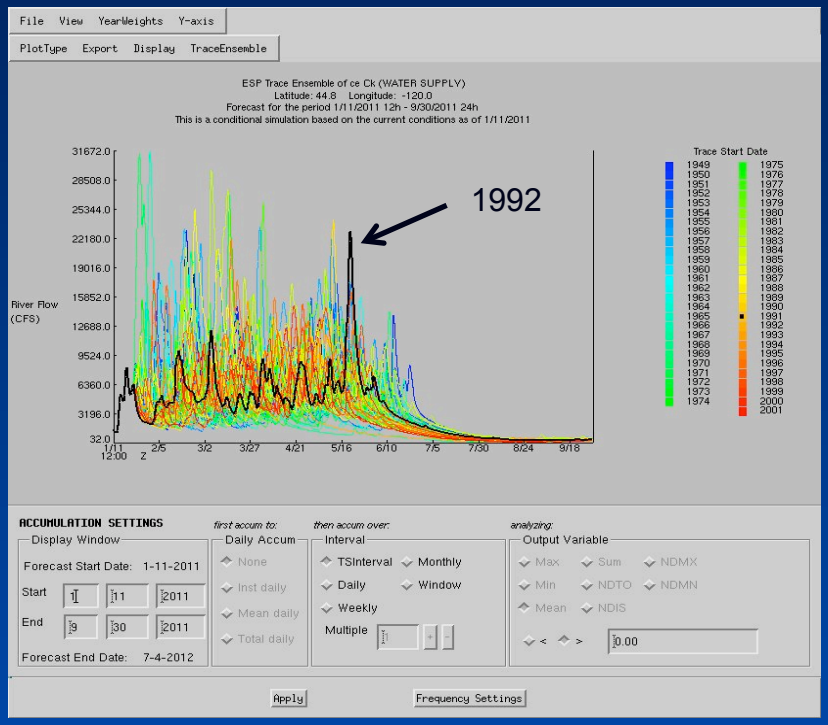


Ensemble Streamflow Prediction



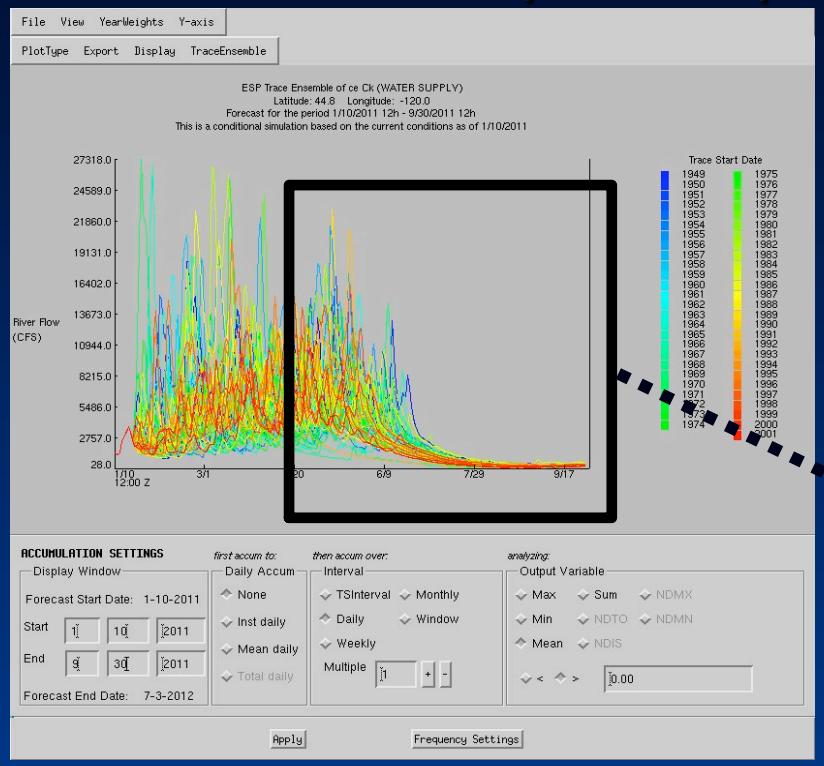
ESP Trace Ensemble Plot

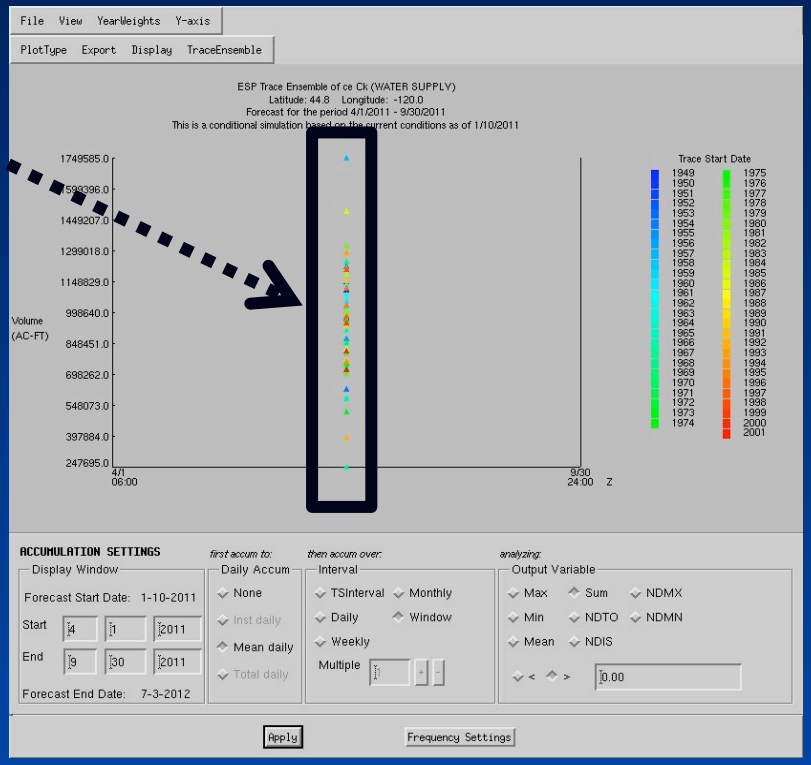




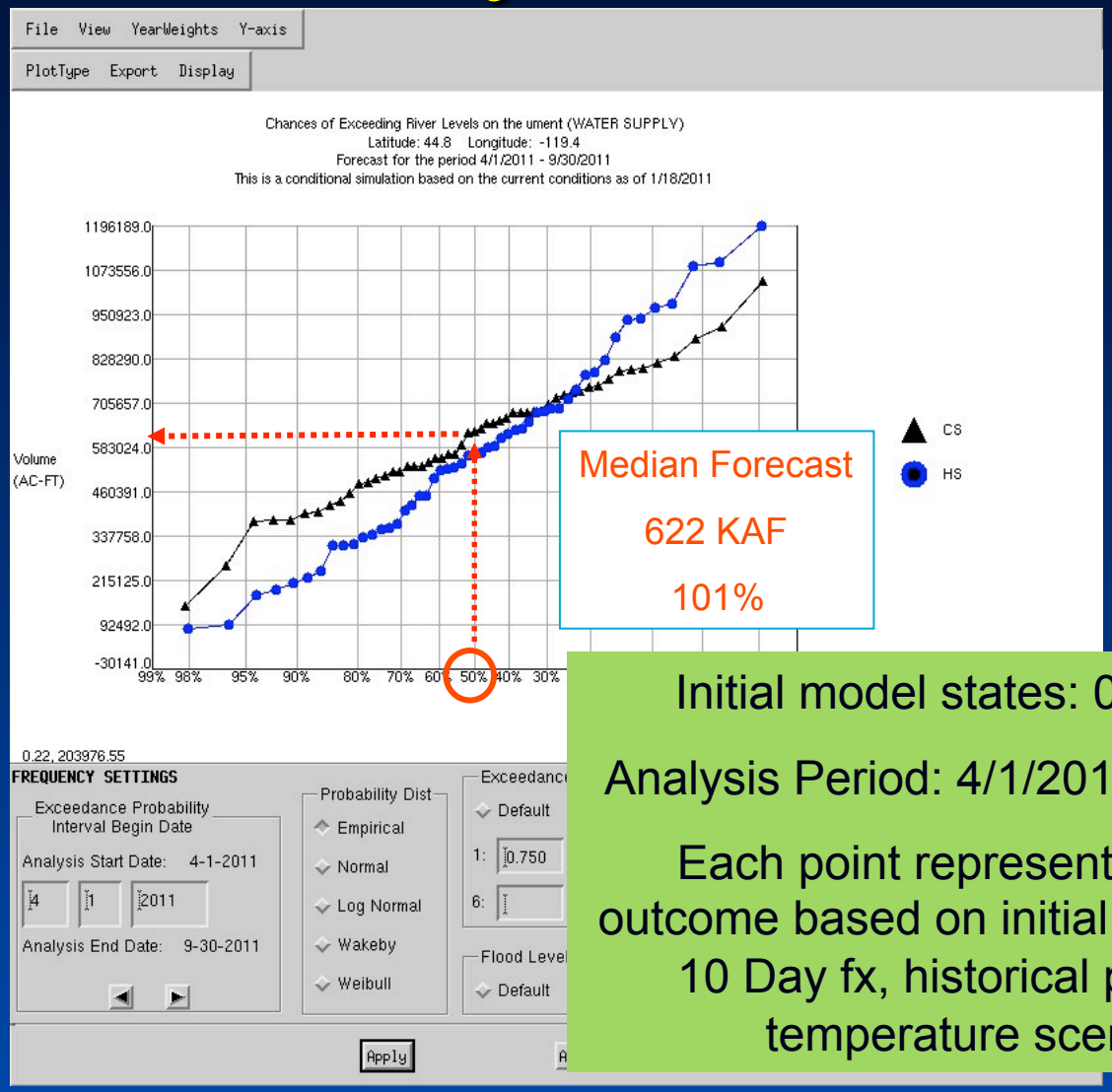
ESP Accumulated Flow Volume

April – Sept Forecast Period





ESP Example:
NF John Day at Monument



Median Forecast

622 KAF

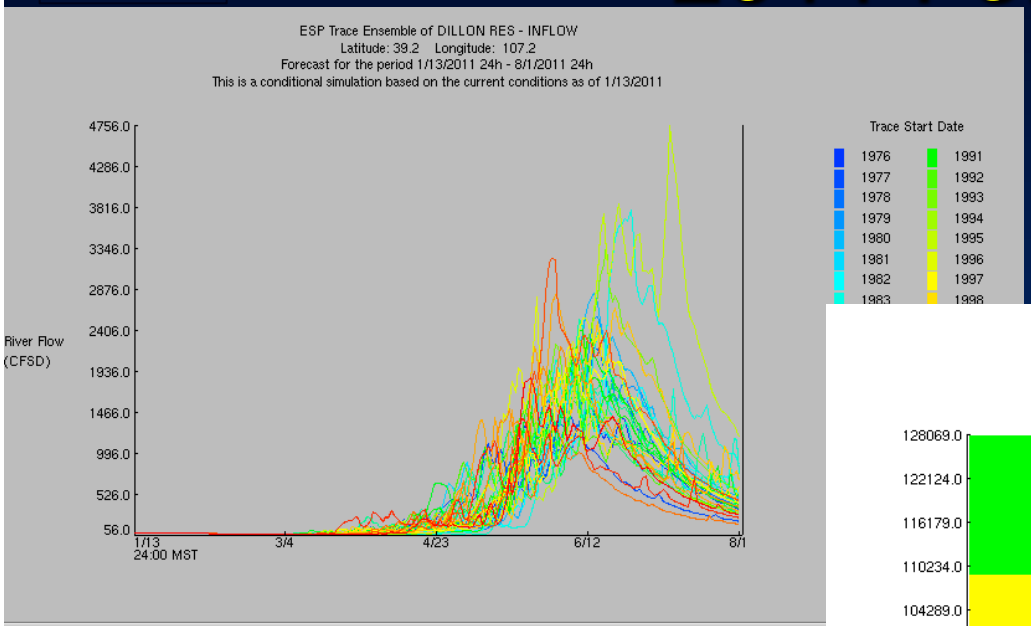
101%

Initial model states: 01/18/2011

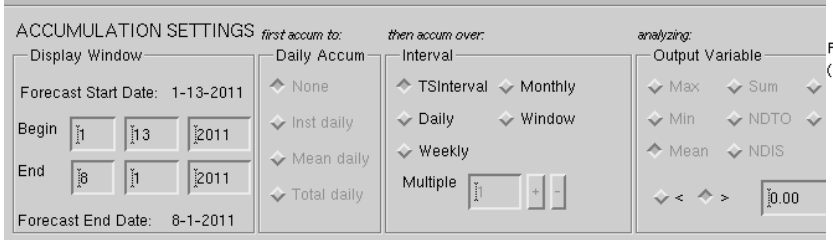
Analysis Period: 4/1/2011 – 9/30/2011

Each point represents possible outcome based on initial model states, 10 Day fx, historical precip and temperature scenarios

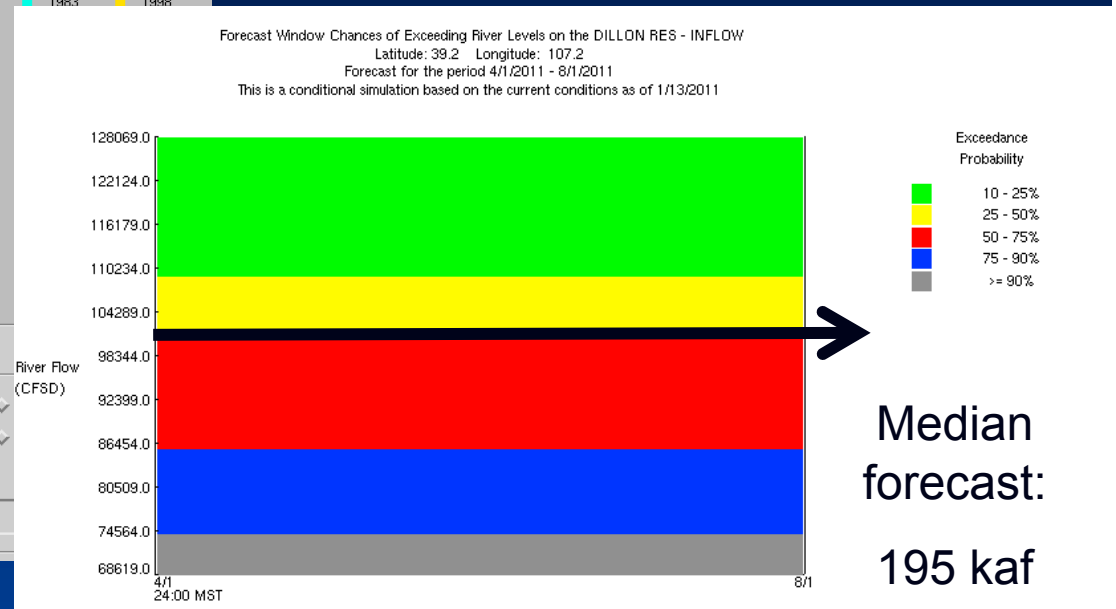
Example: Dillon Reservoir 2011 Forecast



April – July forecast

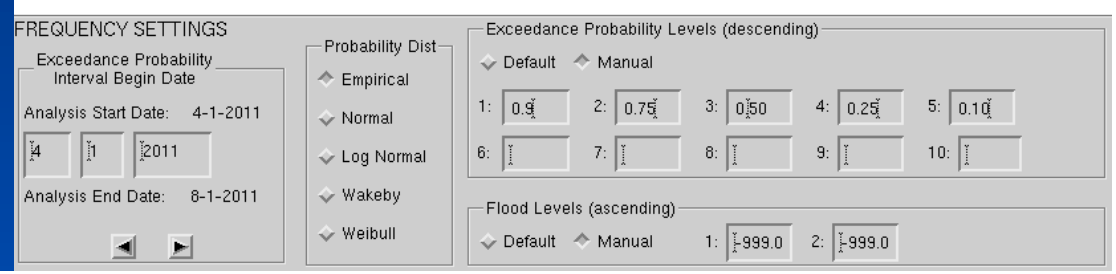


Spaghetti Forecast



Median forecast:

195 kaf



Sources of Uncertainty

Real-time data

(variability and uncertainty)

Calibration

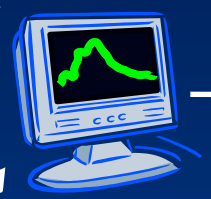
(parameter uncertainty)

Computer model

(model structure uncertainty)

User/forecaster

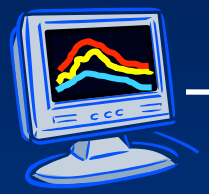
(level of experience, personal bias)

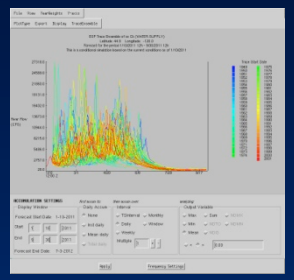


Current model states

Meteorological Input

(precip and temp variability)

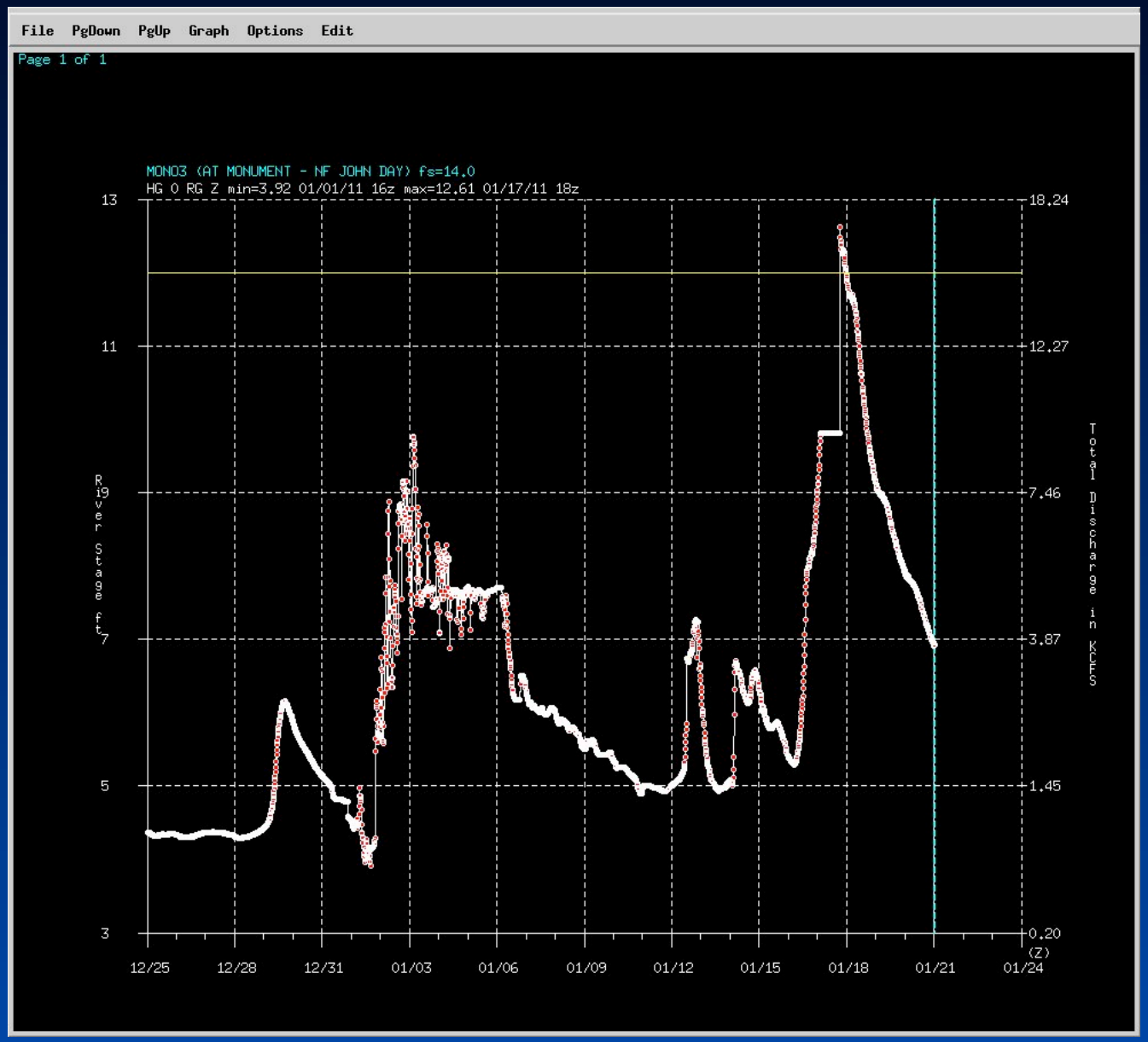




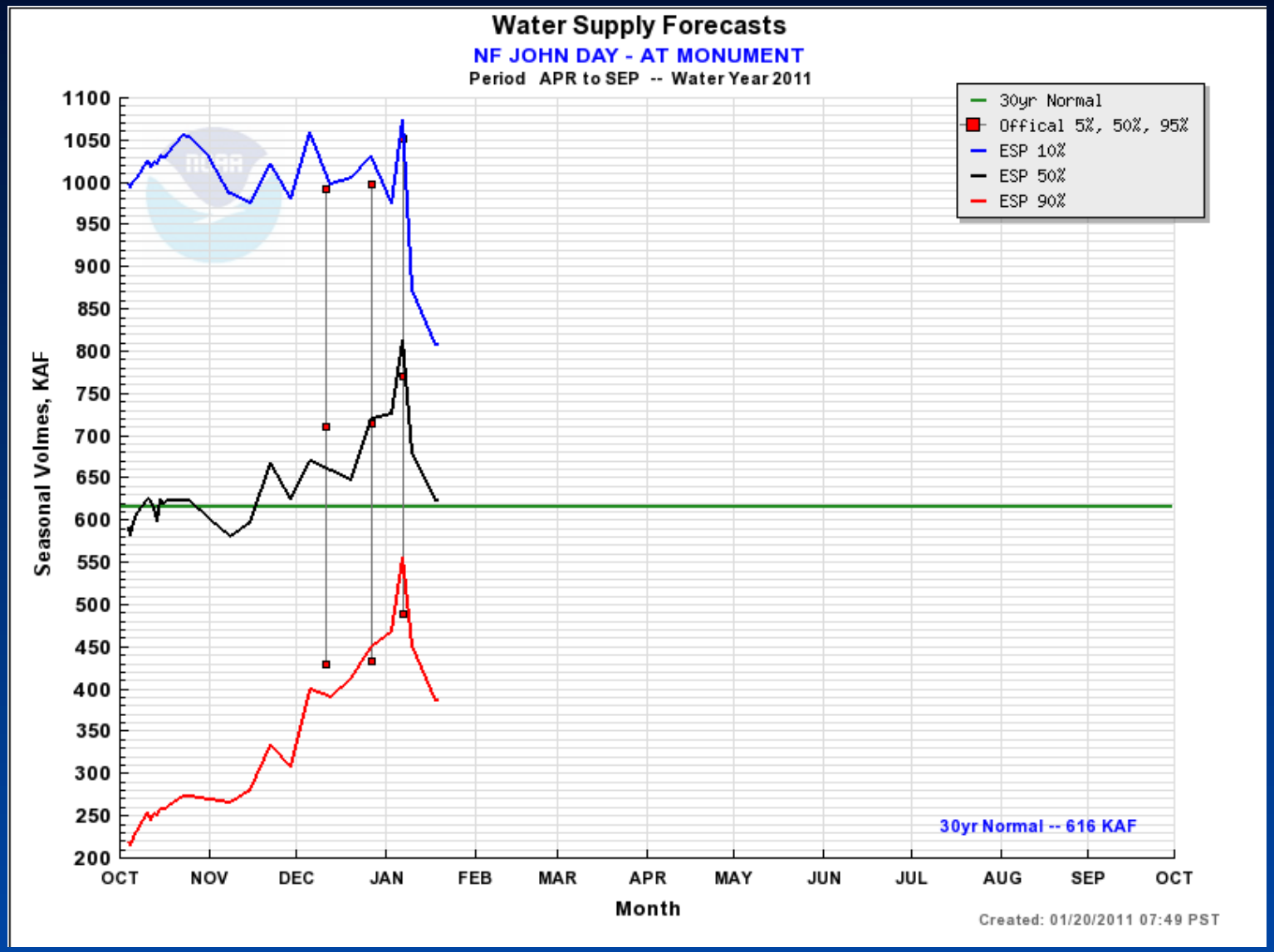
Output of streamflow ensembles (cumulative uncertainty)

©The COMET Program

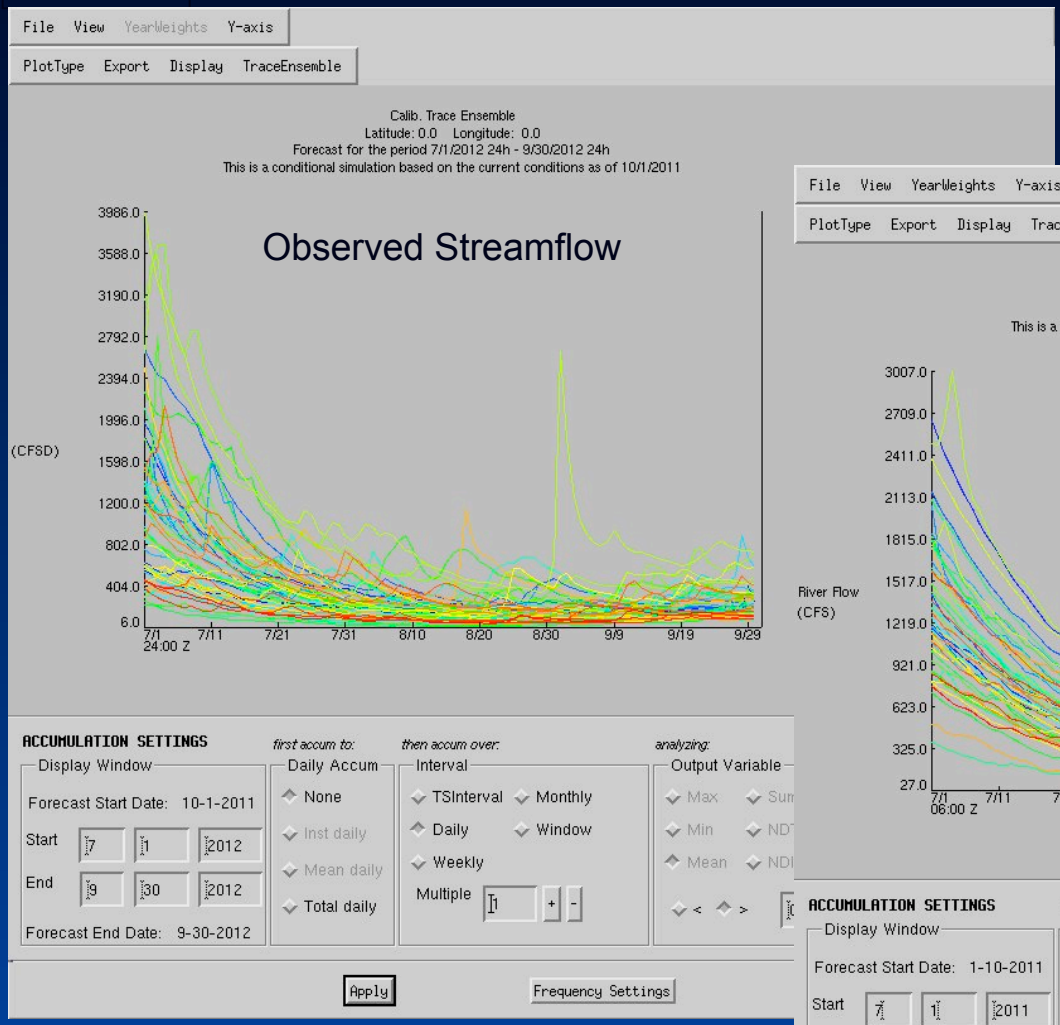
Data Issues

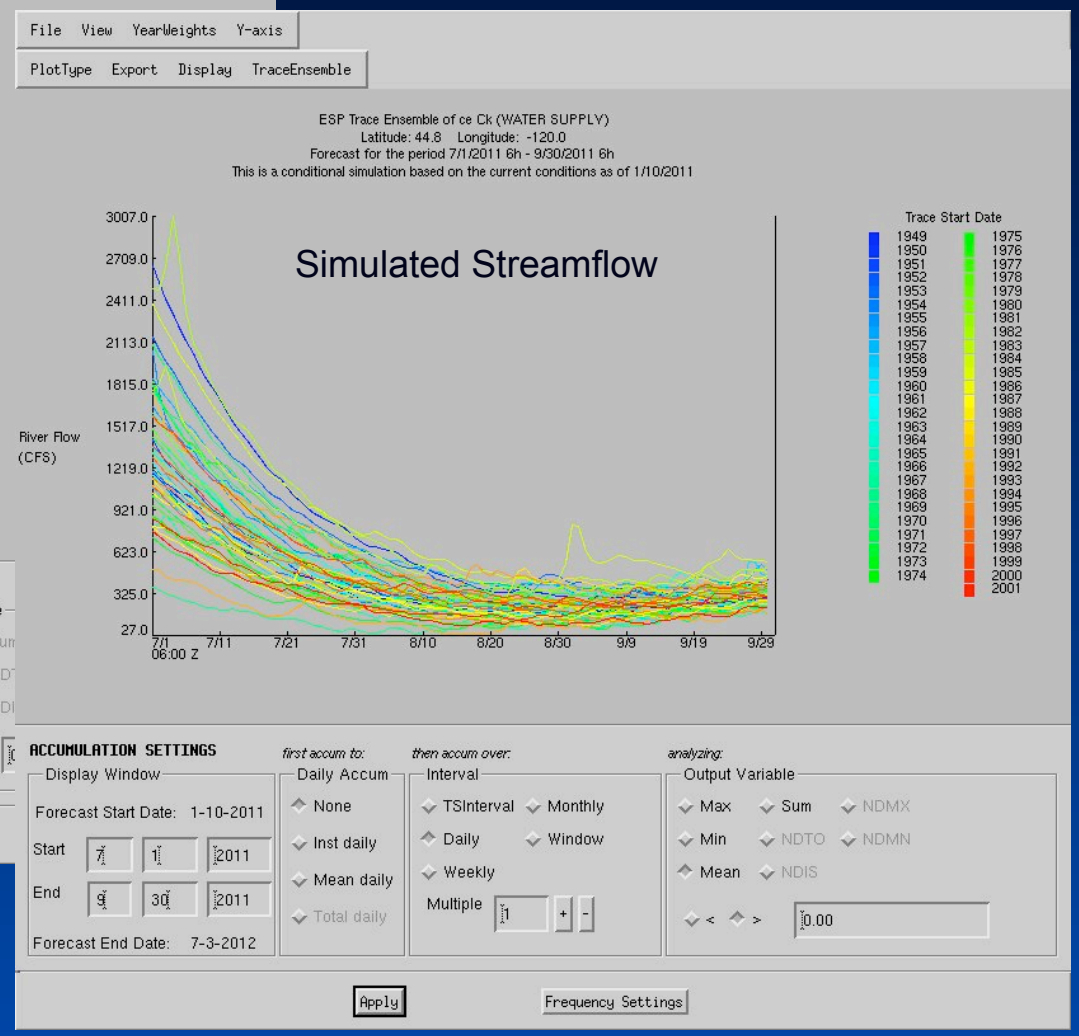

File PgDown PgUp Graph Options Edit
Page 1 of 1
MONO3 (AT MONUMENT - NF JOHN DAY) fs=14.0
HG 0 RG Z min=3.92 01/01/11 16z max=12.61 01/17/11 18z
River Stage ft
13
11
9
7
5
3
18.24
12.27
7.46
3.87
1.45
0.20
Total Discharge in KCFS
12/25
12/28
12/31
01/03
01/06
01/09
01/12
01/15
01/18
01/21
01/24
(Z)

ESP Uncertainty



ESP Uncertainty





Summary

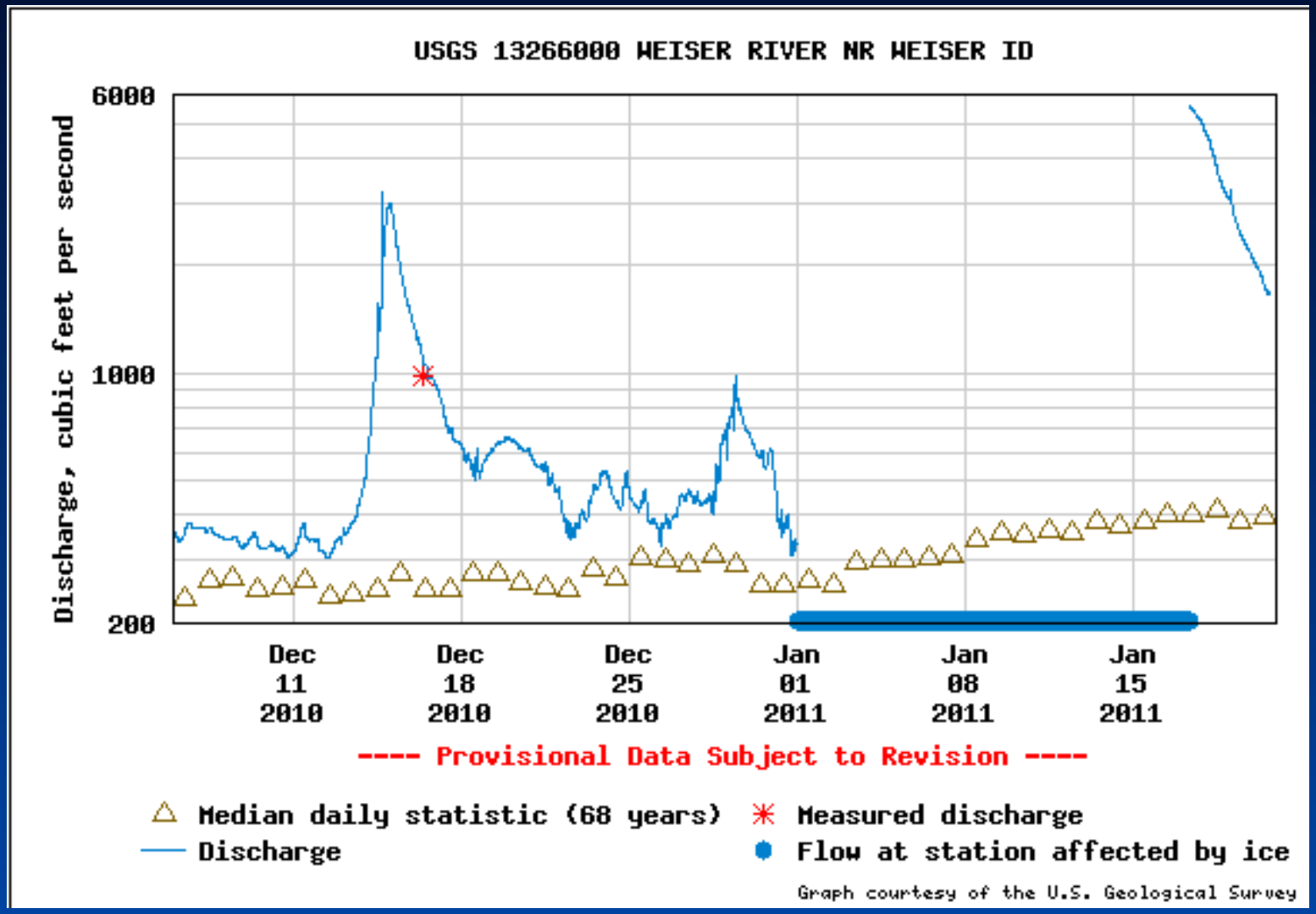
- ESP Assumption: Past meteorological data is a reasonable representation of future scenarios
- Ensemble of forecasts generated using past precip and temperature data, current model states (soil moisture, snowpack)
- Flexibility – allows user to specify desired forecast period and statistical analysis
- Allows users to incorporate probabilistic information into operational decisions
- ESP forecasts useful when strong climatological signal present

ESP Cautions

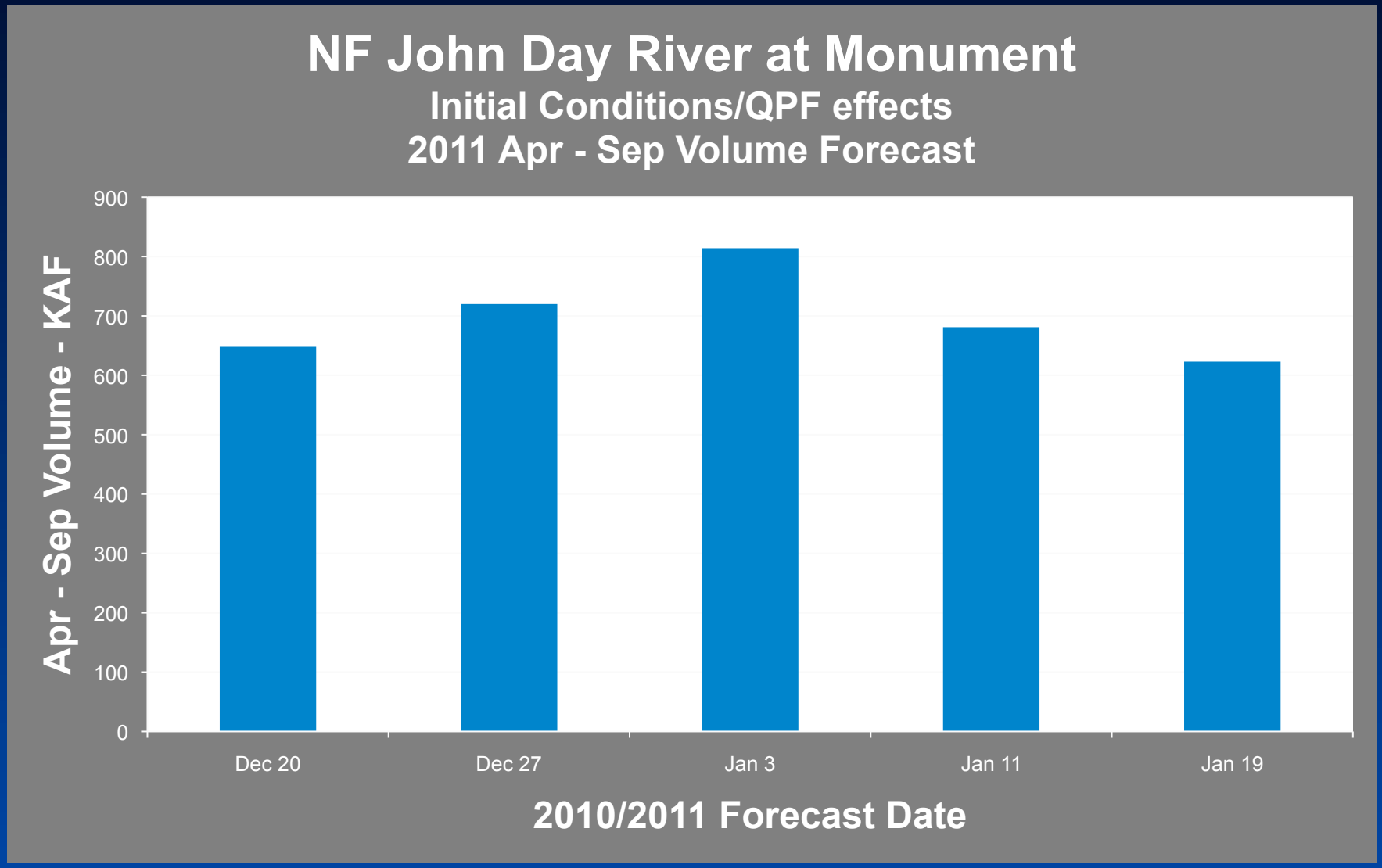
- Less than 30 day lead time (NWRFC specific)
- Unaccounted for sources of uncertainty
- Tend to under forecast high years, over forecast low years

Questions?

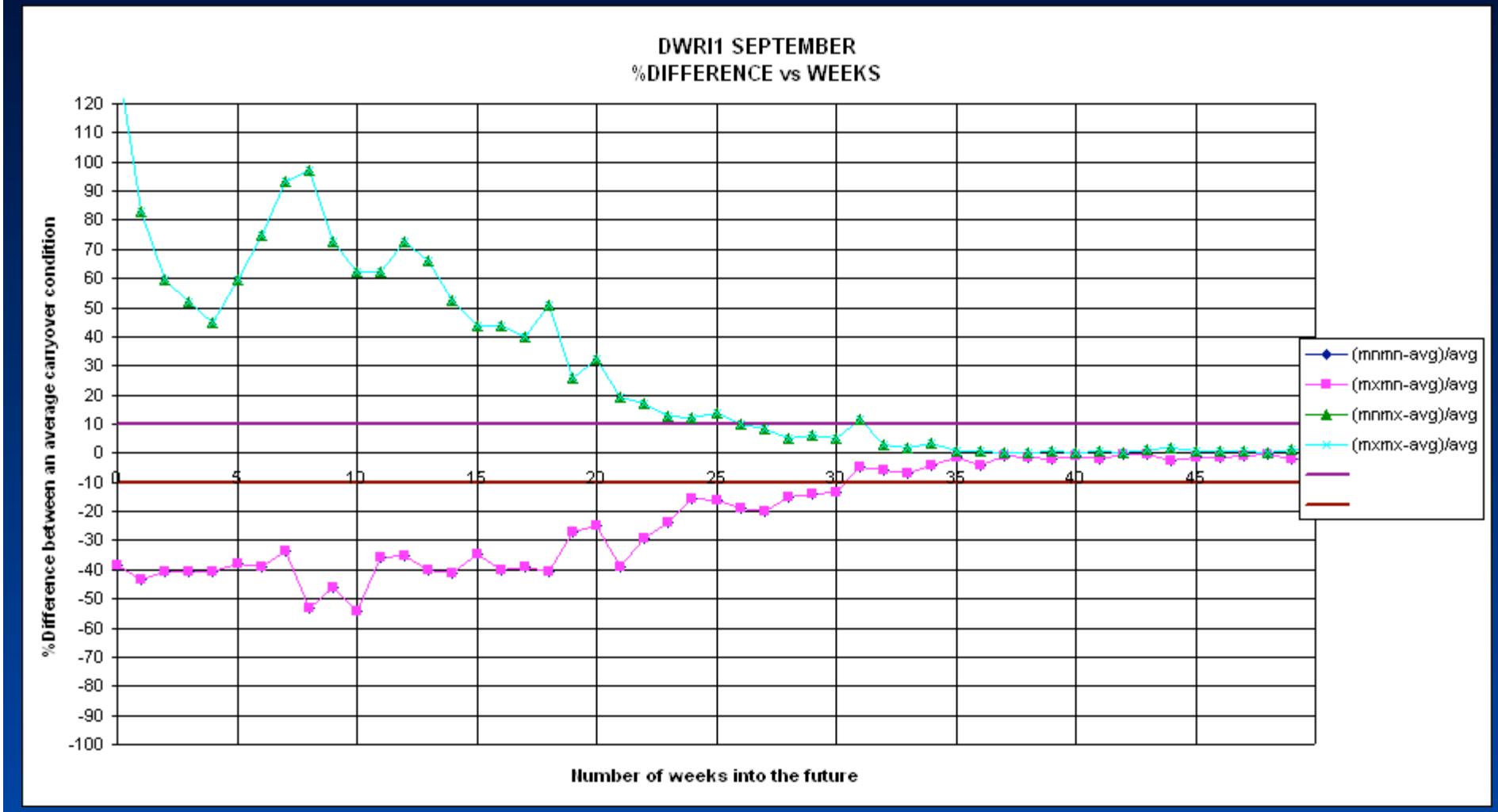
Data Issues


USGS 13266000 WEISER RIVER NR WEISER ID
Discharge, cubic feet per second
6000
1000
200
Dec 11 2010
Dec 18 2010
Dec 25 2010
Jan 01 2011
Jan 08 2011
Jan 15 2011
---- Provisional Data Subject to Revision ----
Median daily statistic (68 years)
Measured discharge
Discharge
Flow at station affected by ice
Graph courtesy of the U.S. Geological Survey

ESP Uncertainty



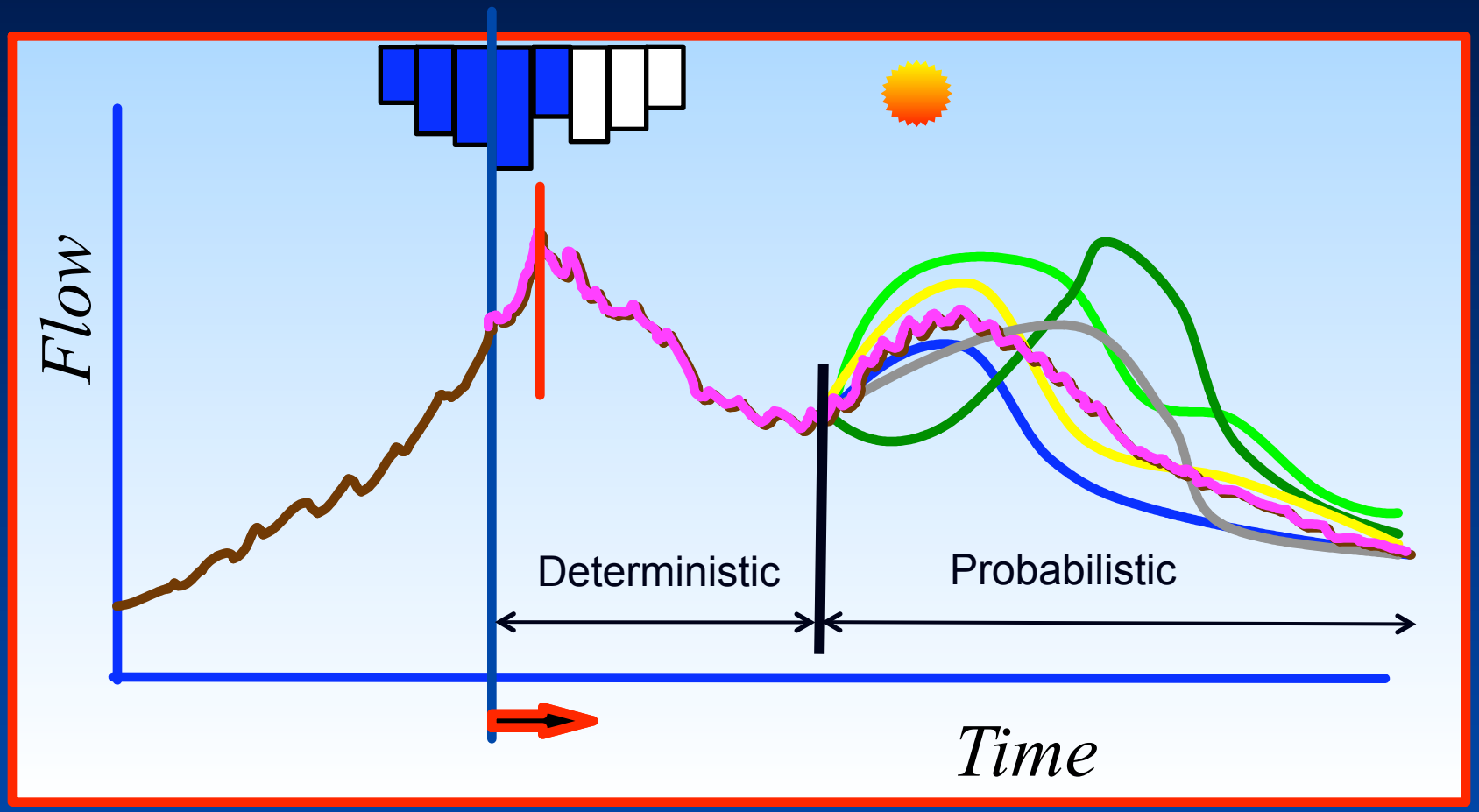
ESP Sensitivity Study: Summer/Fall Soil Moisture

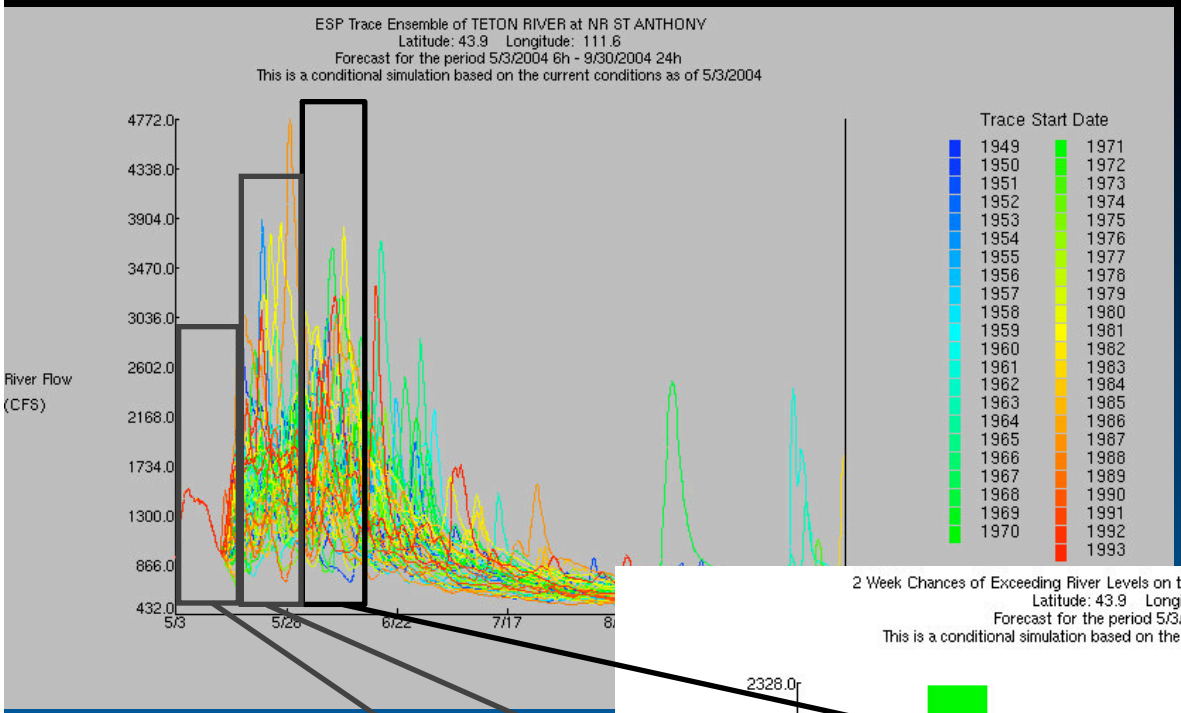


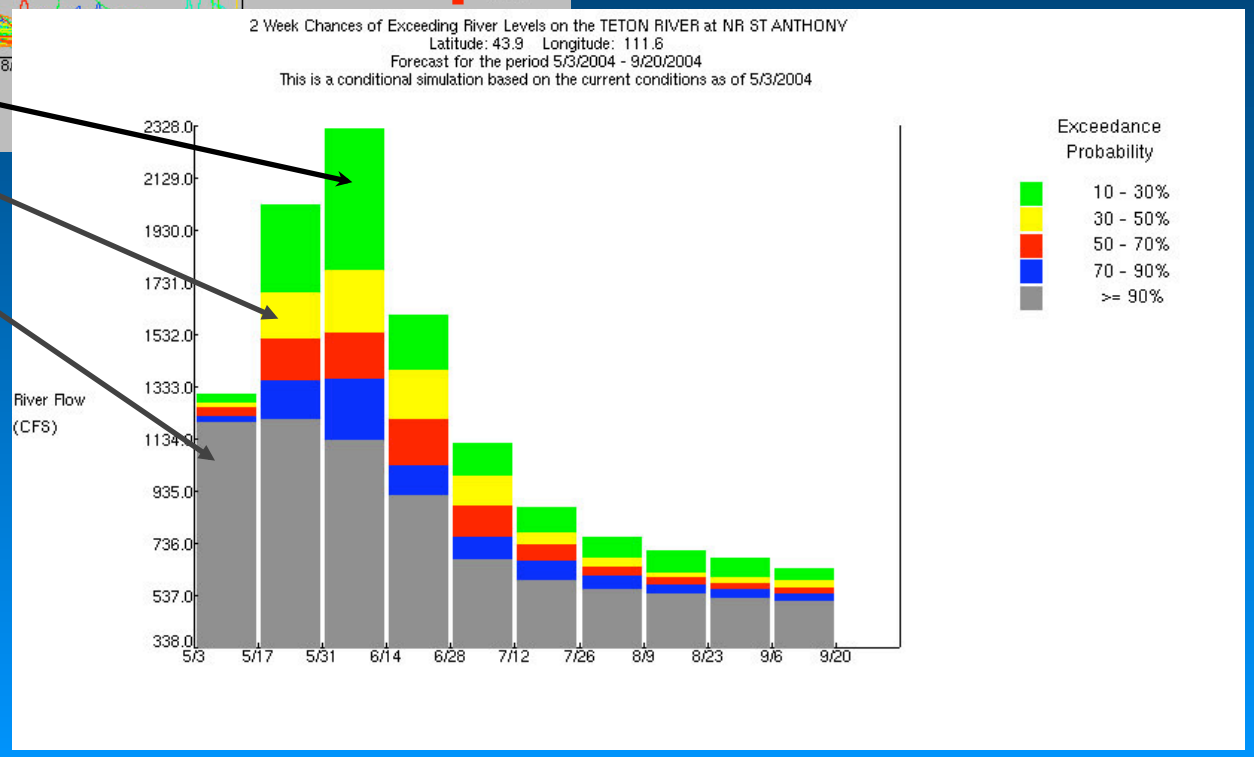
Advances in Time Scales

NWRFC Forecast Products

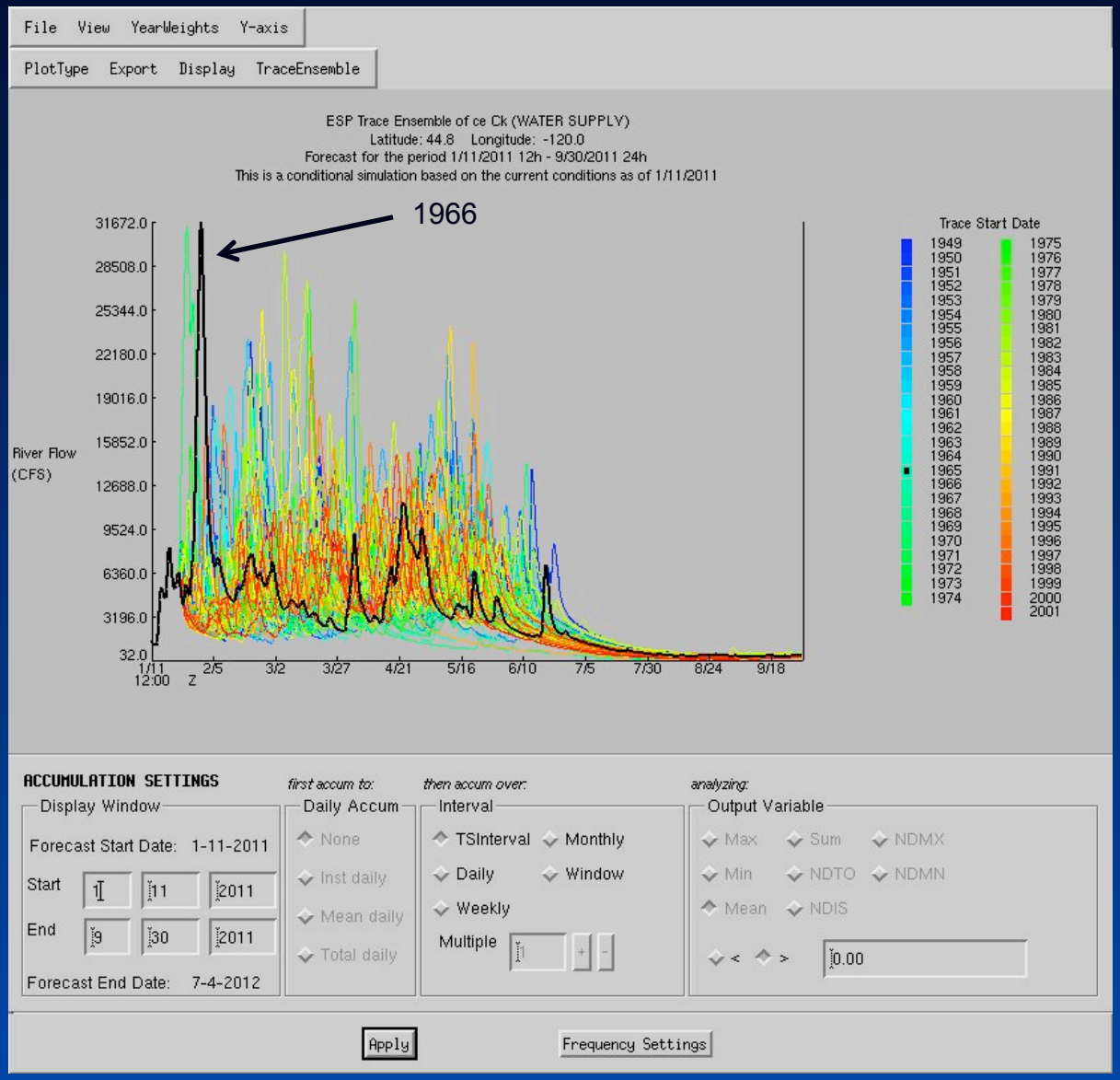
ESP Concept




ESP Trace Ensemble of TETON RIVER at NR ST ANTHONY
Latitude: 43.9 Longitude: 111.6
Forecast for the period 5/3/2004 6h - 9/30/2004 24h
This is a conditional simulation based on the current conditions as of 5/3/2004
River Flow
(CFS)
4772.0
4338.0
3904.0
3470.0
3036.0
2602.0
2168.0
1734.0
1300.0
866.0
432.0
5/3
5/26
6/22
7/17
Trace Start Date
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993

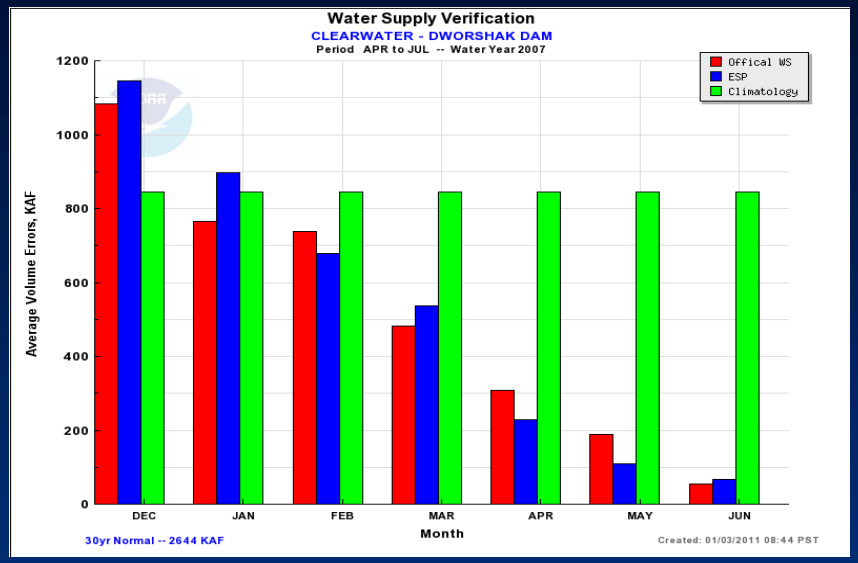

2 Week Chances of Exceeding River Levels on the TETON RIVER at NR ST ANTHONY
Latitude: 43.9 Longitude: 111.6
Forecast for the period 5/3/2004 - 9/20/2004
This is a conditional simulation based on the current conditions as of 5/3/2004
River Flow
(CFS)
2328.0
2129.0
1930.0
1731.0
1532.0
1333.0
1134.0
935.0
736.0
537.0
338.0
5/3
5/17
5/31
6/14
6/28
7/12
7/26
8/9
8/23
9/6
9/20
Exceedance
Probability
10 - 30%
30 - 50%
50 - 70%
70 - 90%
>= 90%

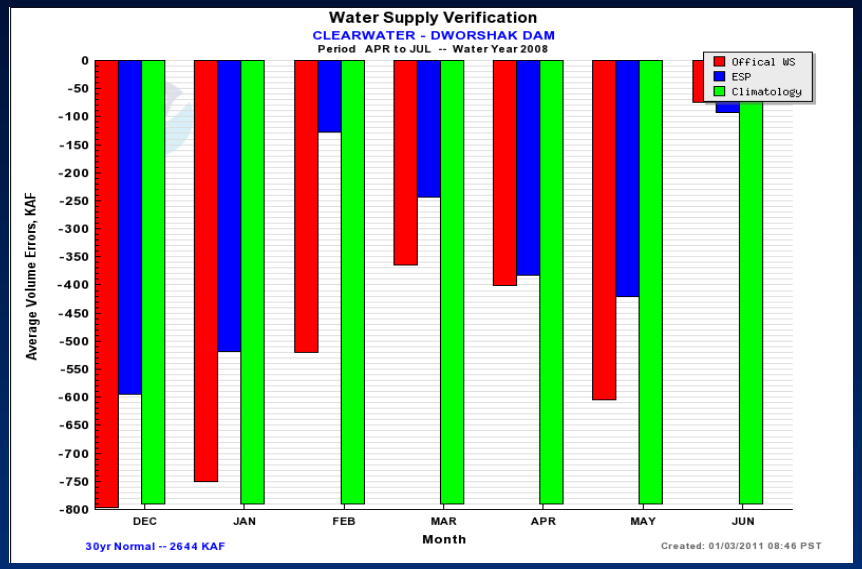
ESP Trace Ensemble Plot

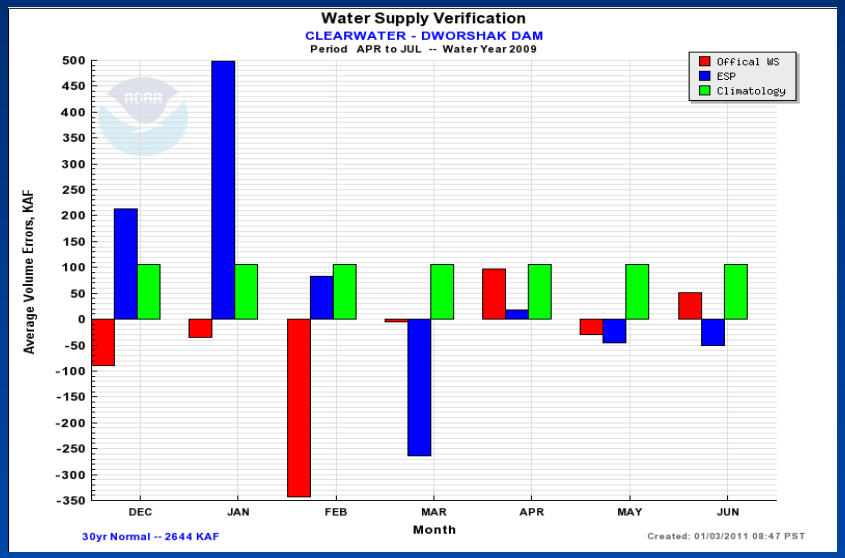


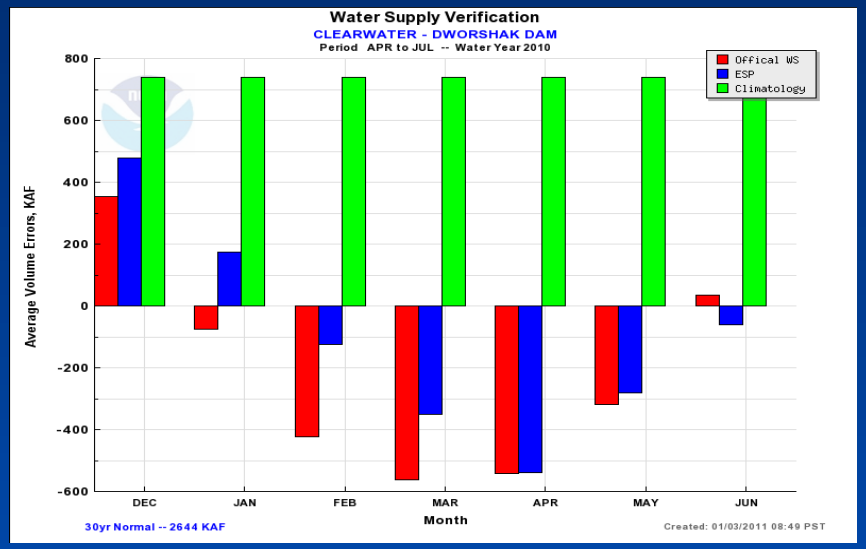
ESP Verification

Dworschak Dam



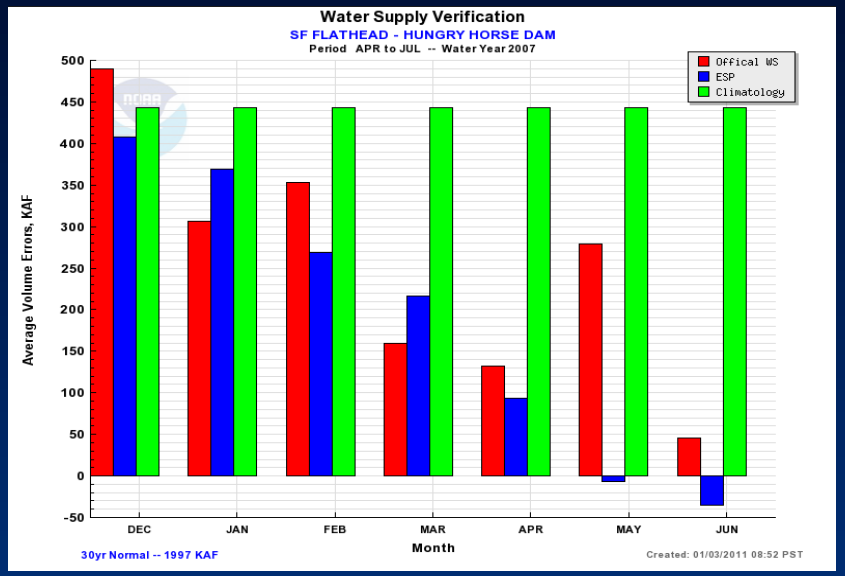


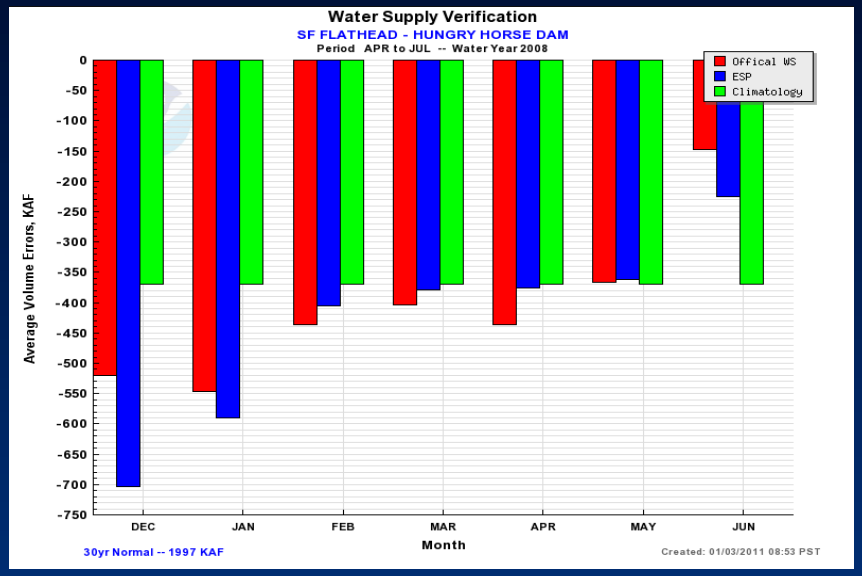


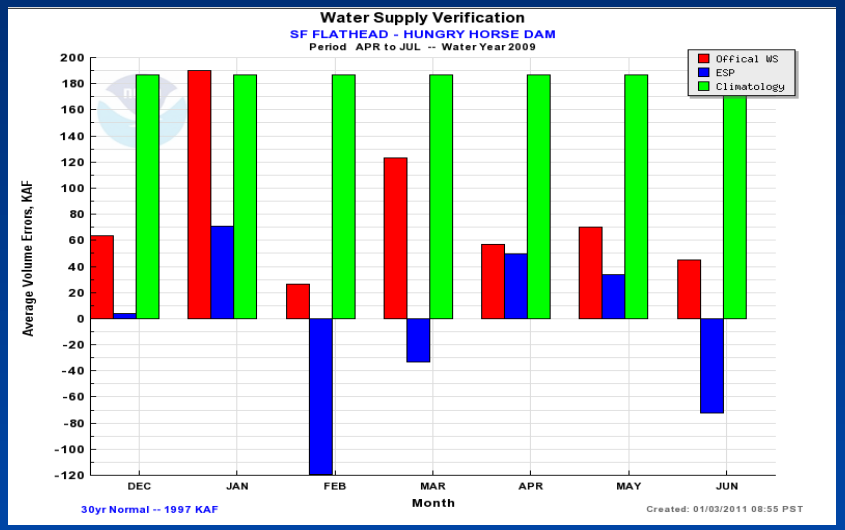


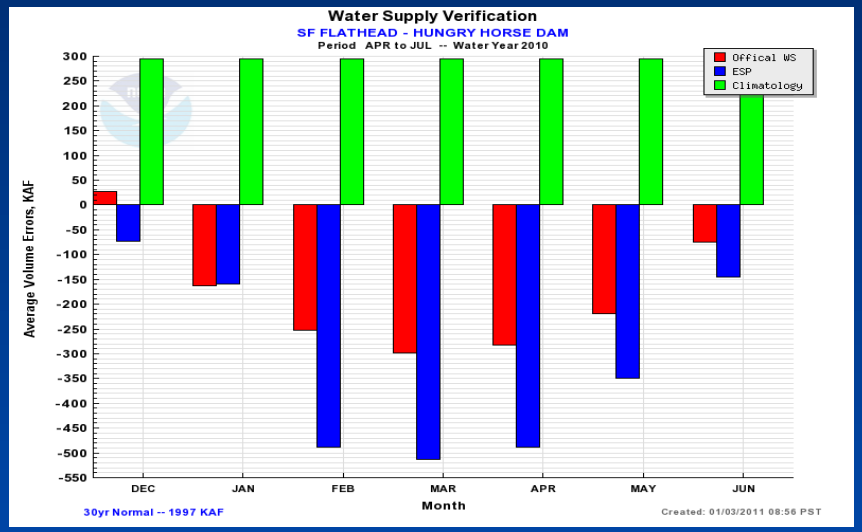
ESP Verification

Hungry Horse Dam

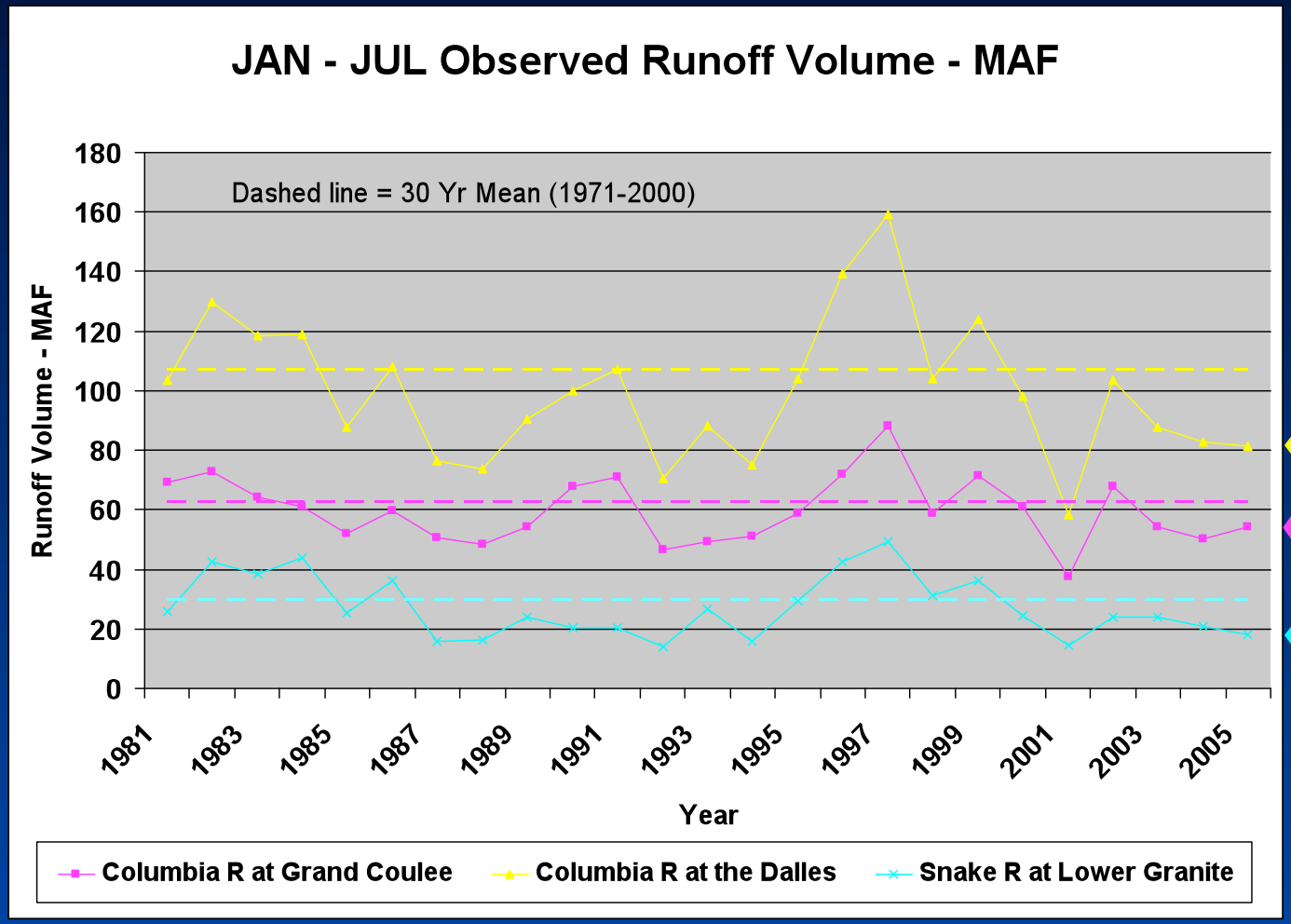








Recent Historical Perspective

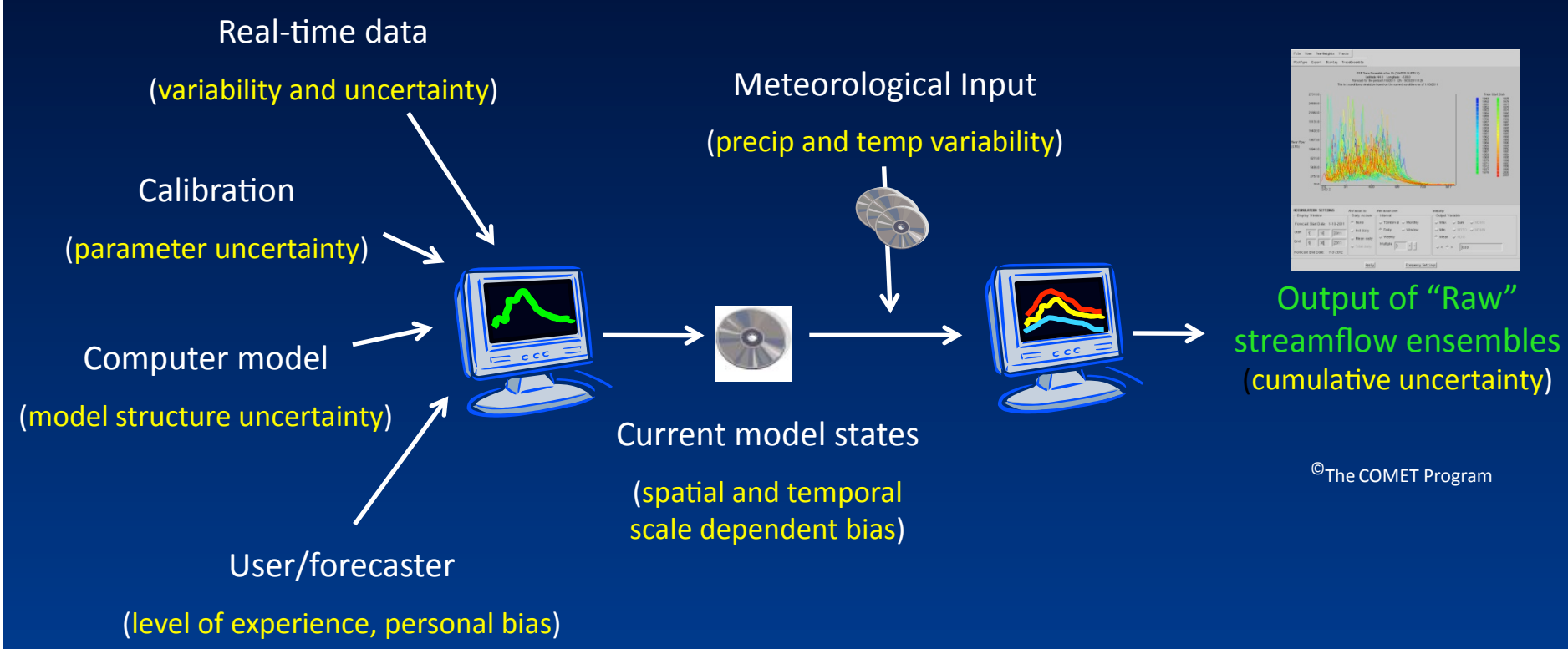


96.6 – 90%

63.6 - 101%

25.5 – 85%

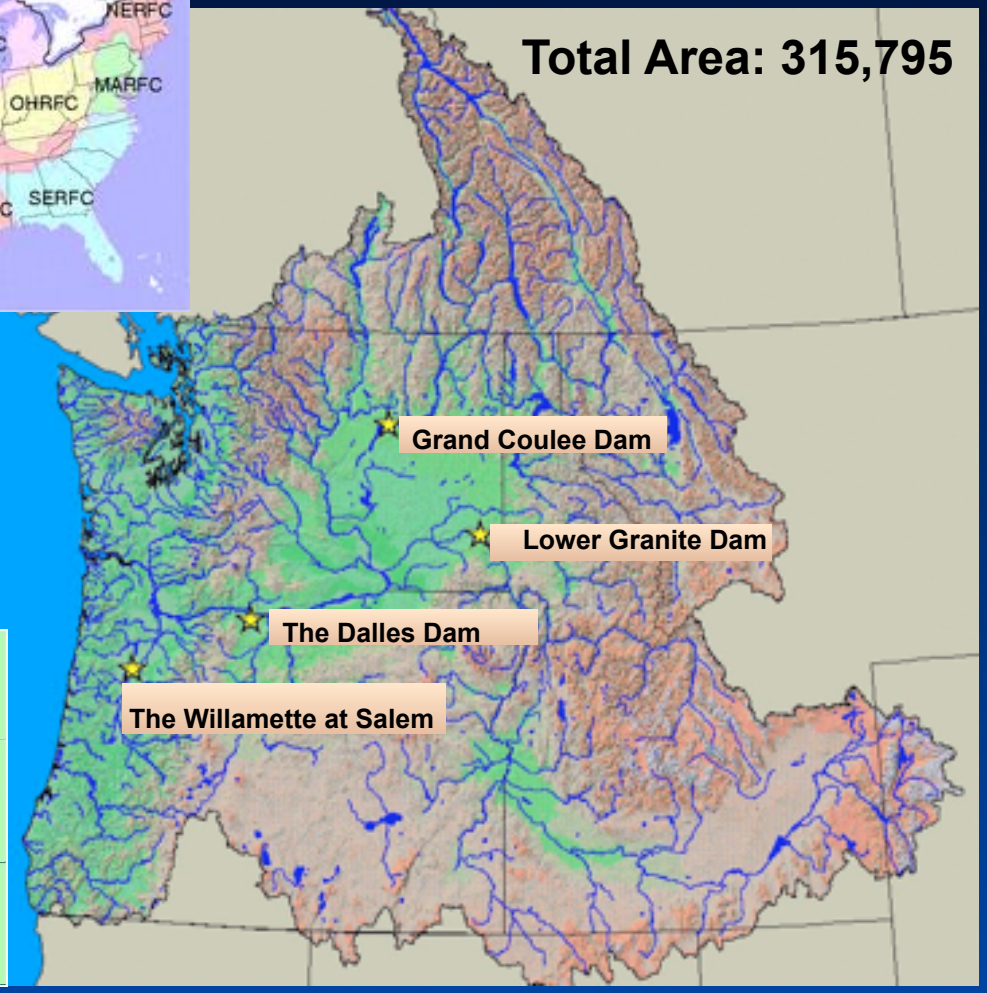
ESP uncertainty

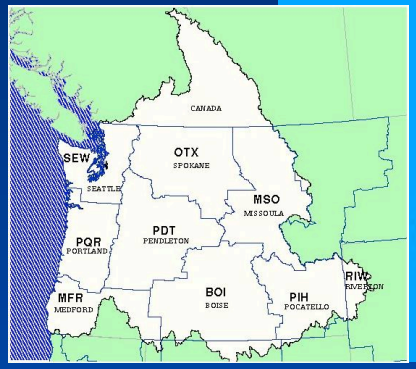


©The COMET Program

This slide from Kevin Werner

Northwest River Forecast Center





Columbia and Snake River Basins

Coastal Drainages of Oregon and Washington

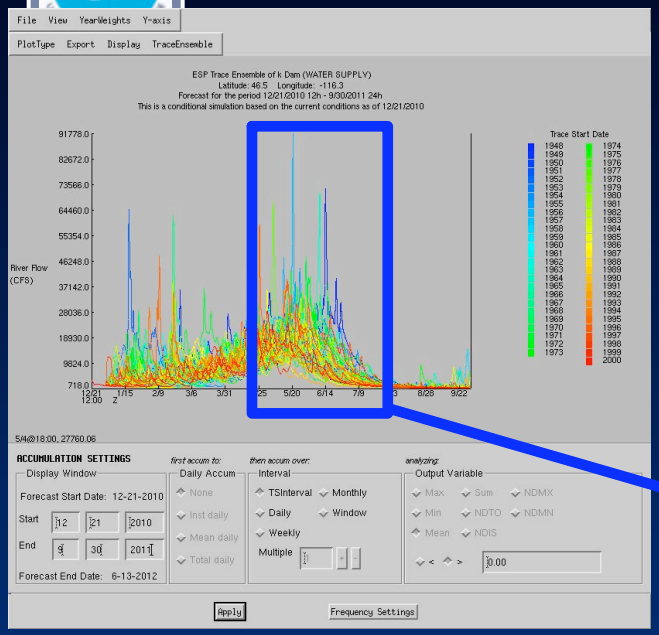
6 States & CANADA

Support for 9 NWS Field Offices (WFOs)

Initial model states: 12/21/2010

Analysis Period: 4/1/2011 – 8/1/2011

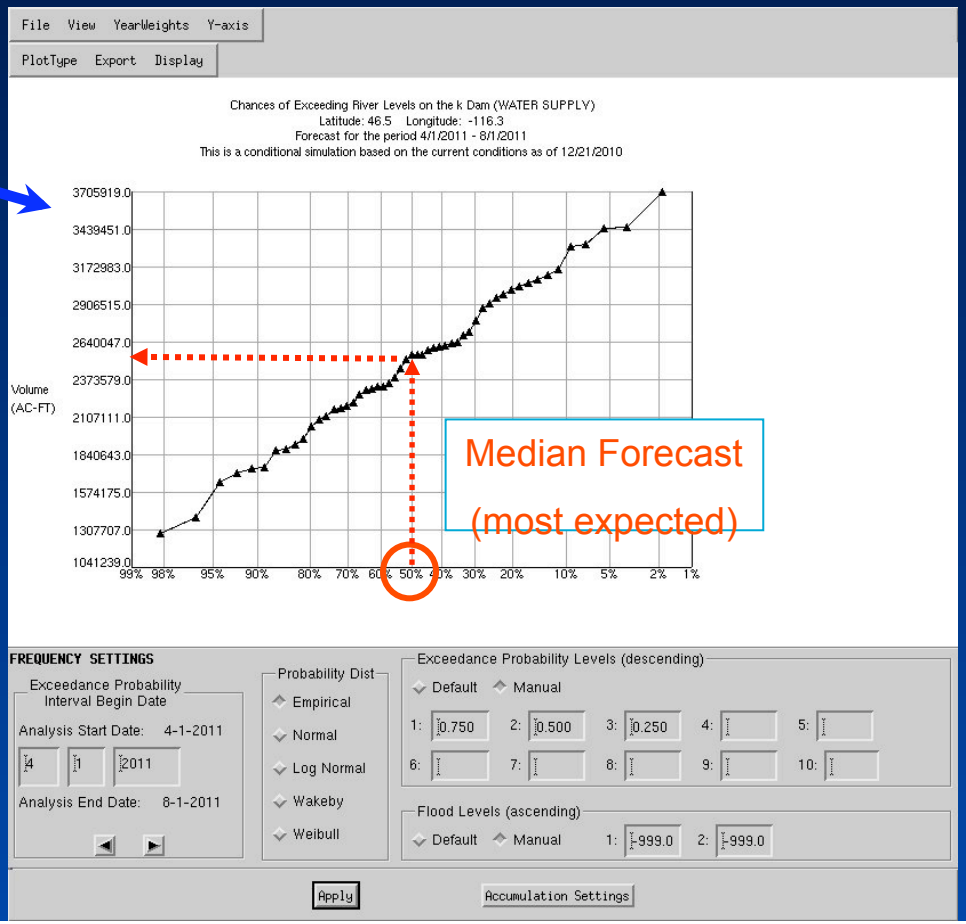
Each trace represents possible outcome based on initial model states, QPF, historical MAP, MAT



Exceedance Probability Plot:

Ranked flow volumes (each point represents area under individual ensemble traces) for Jan-Jul period.

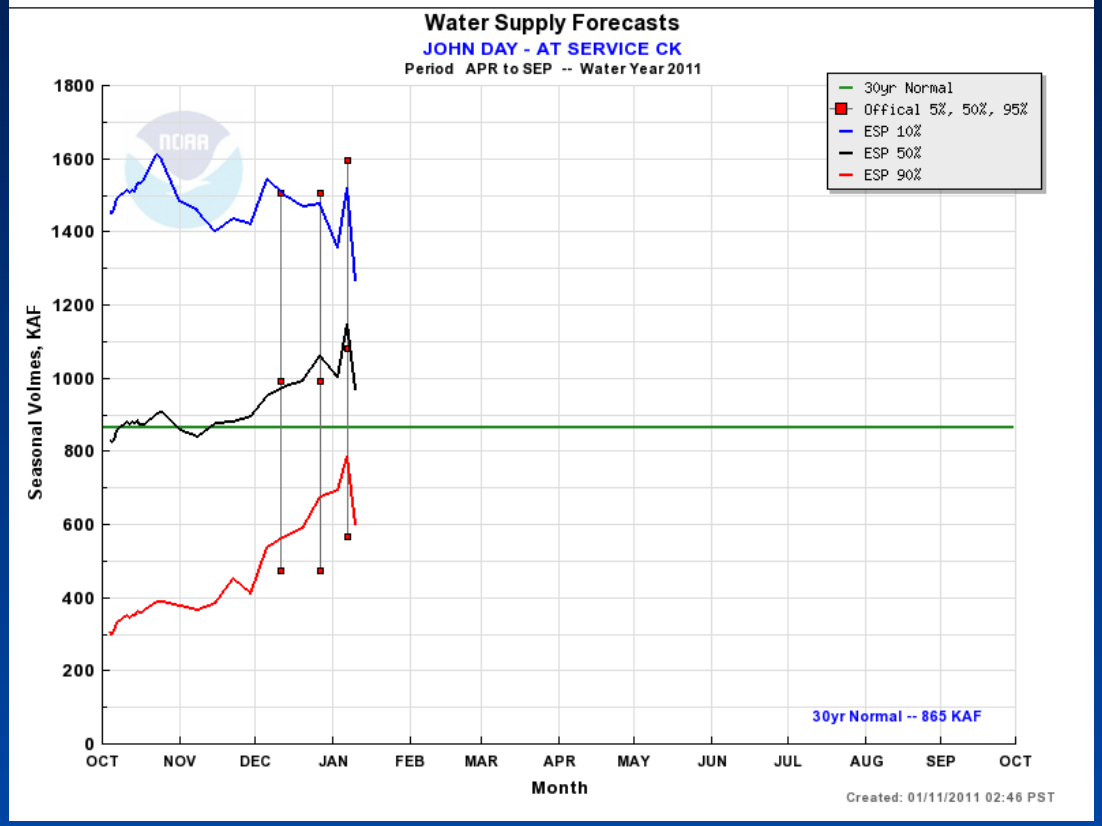
50% Value is comparable



ESP Water Supply Forecast

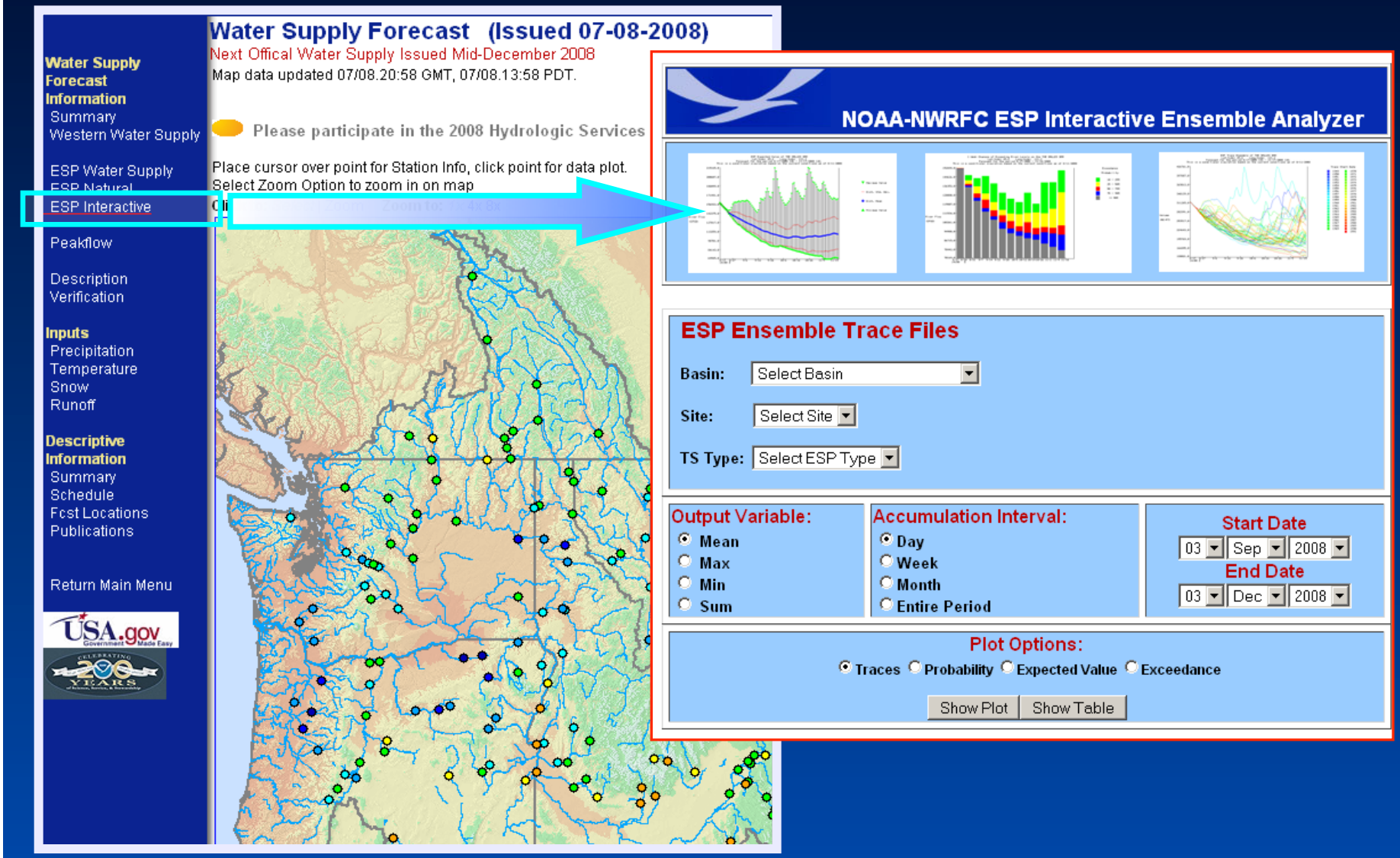
JOHN DAY - AT SERVICE CK (SERO3)
Forecasts for Water Year 2011

Offical Water Supply Forecast *Issued: 2011-01-07*					ESP Water Supply Forecast *Issued: 2011-01-10*				
	Forecasts Are in KAF				Forecasts Are in KAF				
Forecast Period	95 %	50 %	% Normal	05 %	90 %	50 %	% Normal	10 %	30 Year Normal
APR-SEP	565	1080	125	1595	599	968	112	1268	865
APR-JUL	535	1050	125	1565	576	939	112	1222	838

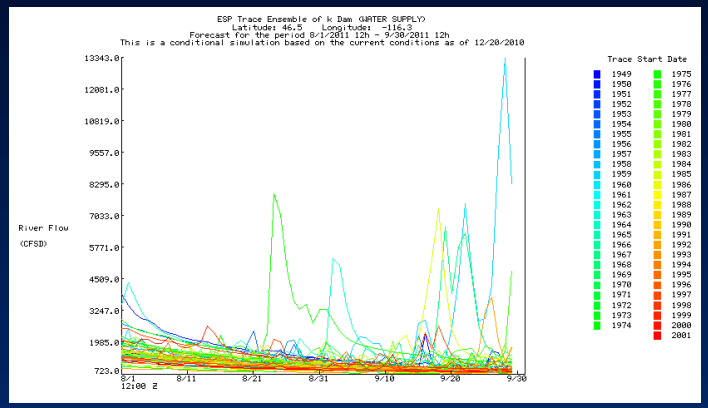


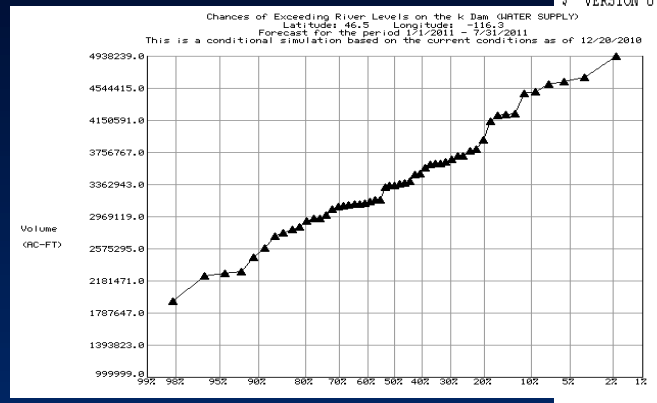
ESP Interactive Ensemble Analyzer

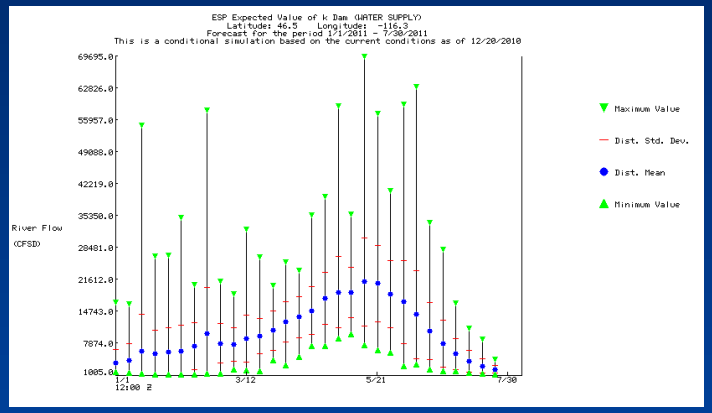
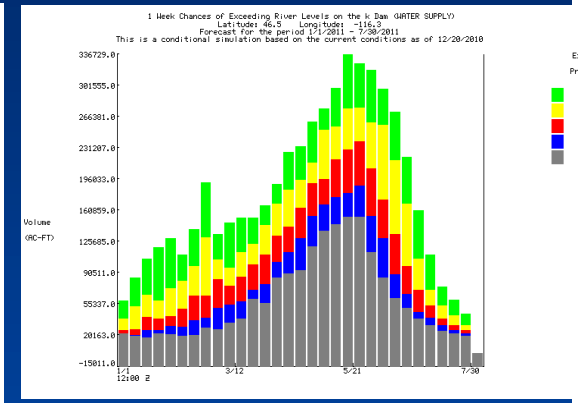
http://www.nwrfc.noaa.gov/espadp/espadp.cgi



ESP Interactive Web Site






```
$ OUTPUT FROM THE ESPADP TRACEFILE EXPORT COMMAND
$  VERSION 0.00
    TSID=DWRI1I    DTYPE=QINE  IDT=24  UNITS=CFS
CONDITIONAL SIMULATION)
E=12/21/2010 04:03:07.00
UN PERIOD=12/20/2010 12 -  6/12/2012 12
ACES=53
RACE=0
RACE DATA FOLLOWS
----------------

WRI1I   DESCRIPTION=ESP TRACE YEAR 1948
CORD = 12/1948 THRU  6/1950
ISSING DATA = -999.00, SYMBOL FOR ACCUMULATED DATA = -998.00
NITS=CFS  DIMENSIONS=  DATA TIME INTERVAL=24 HOURS
T=(A12,2I2,I4, 1F9.0)

 INE      CFS  24   DWRI1I      ESP TRACE YEAR 1948
12  1948 6  1950   1F9.0
DWRI1I      1248   1     -999
DWRI1I      1248   2     -999
DWRI1I      1248   3     -999
DWRI1I      1248   4     -999
DWRI1I      1248   5     -999
DWRI1I      1248   6     -999
DWRI1I      1248   7     -999
            248   8     -999
            248   9     -999
            248  10     -999
            248  11     -999
            248  12     -999
            248  13     -999
            248  14     -999
            248  15     -999
            248  16     -999
            248  17     -999
            248  18     -999
            248  19     -999
            248  20     2682
            248  21     2296
            248  22     2146
            248  23     2028
DWRI1I      1248  24     1970
DWRI1I      1248  25     1982
DWRI1I      1248  26     2531
DWRI1I      1248  27     2920
DWRI1I      1248  28     2482
DWRI1I      1248  29     2084
DWRI1I      1248  30     1859
```