Introduction to Verification

Lisa Holts

Hydrologist Intern

Colorado Basin River Forecast Center

Outline

- Verification background
- Error overview
- Forecasting patterns
- Data Issues
- Verification application
- Results

Different
perspectives on skill

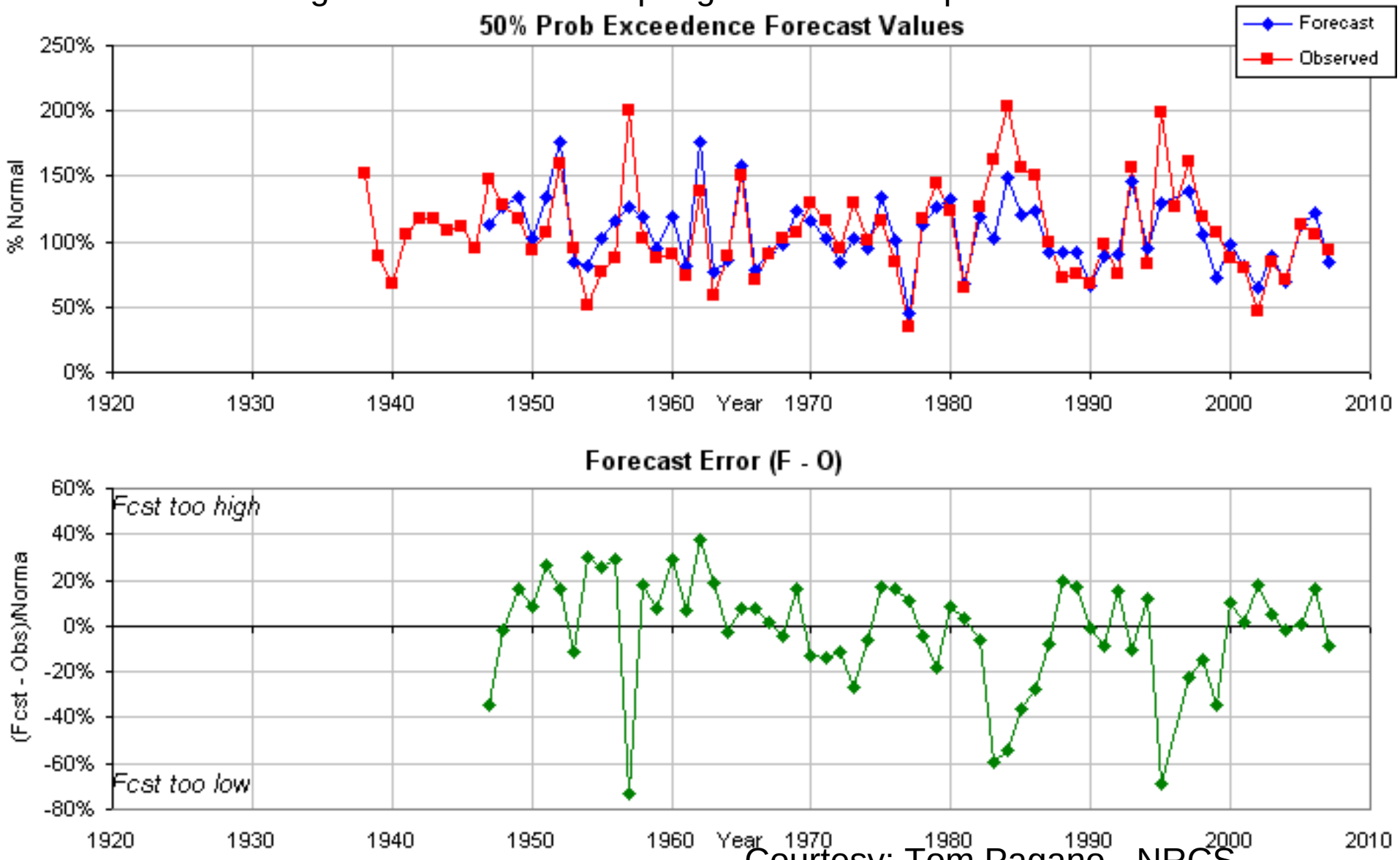
How good were
historical forecasts:
Where?
When?
Why?

How forecasts
communicate their own skill

Courtesy: Tom Pagano - NRCS

A water manager interested in a single river probably wants to know typical forecast error

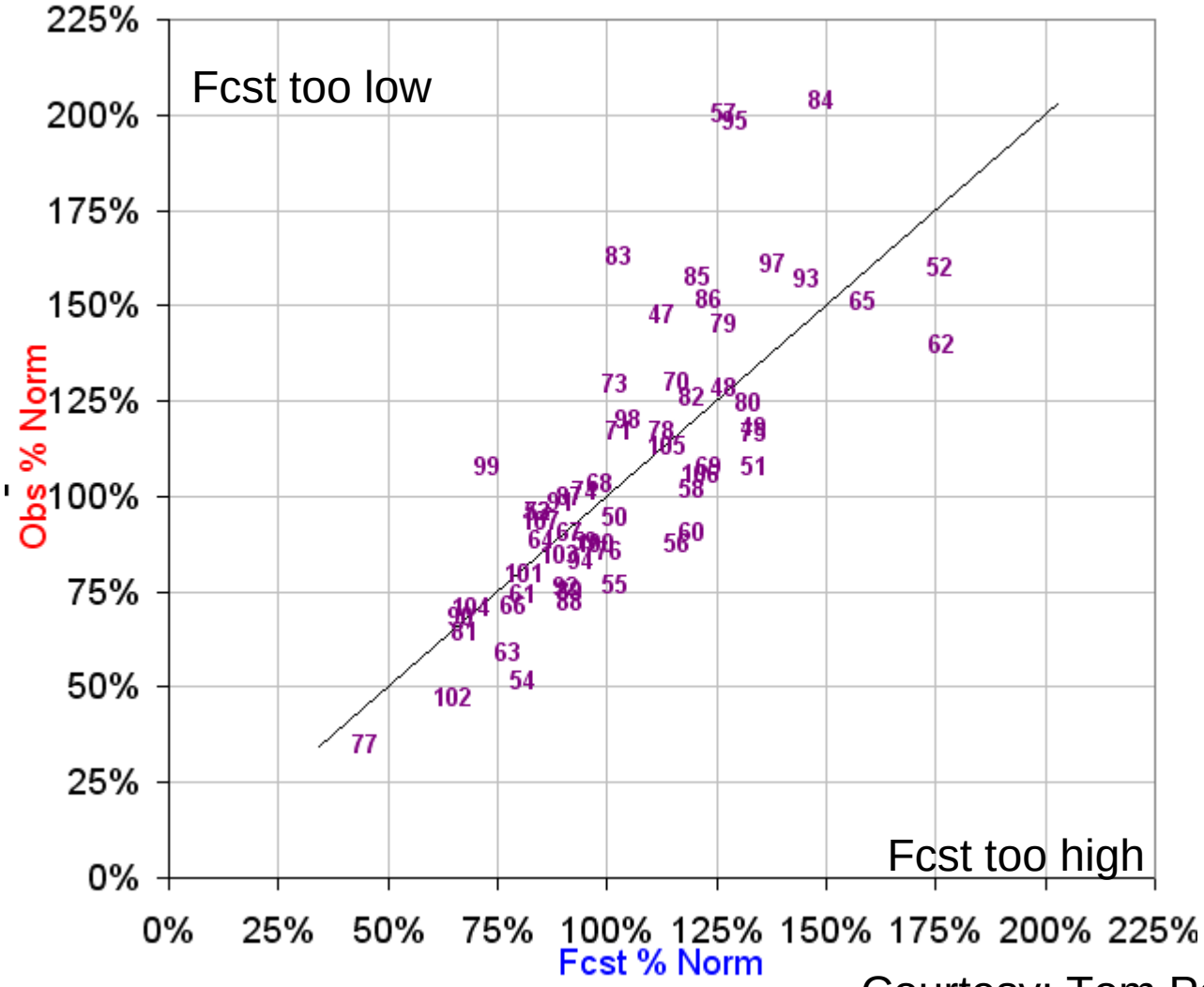
Roaring fork at Glenwood Springs 1947-2007 April 1 Forecasts



Courtesy: Tom Pagano - NRCS

A water manager interested in a single river probably wants to know typical forecast error

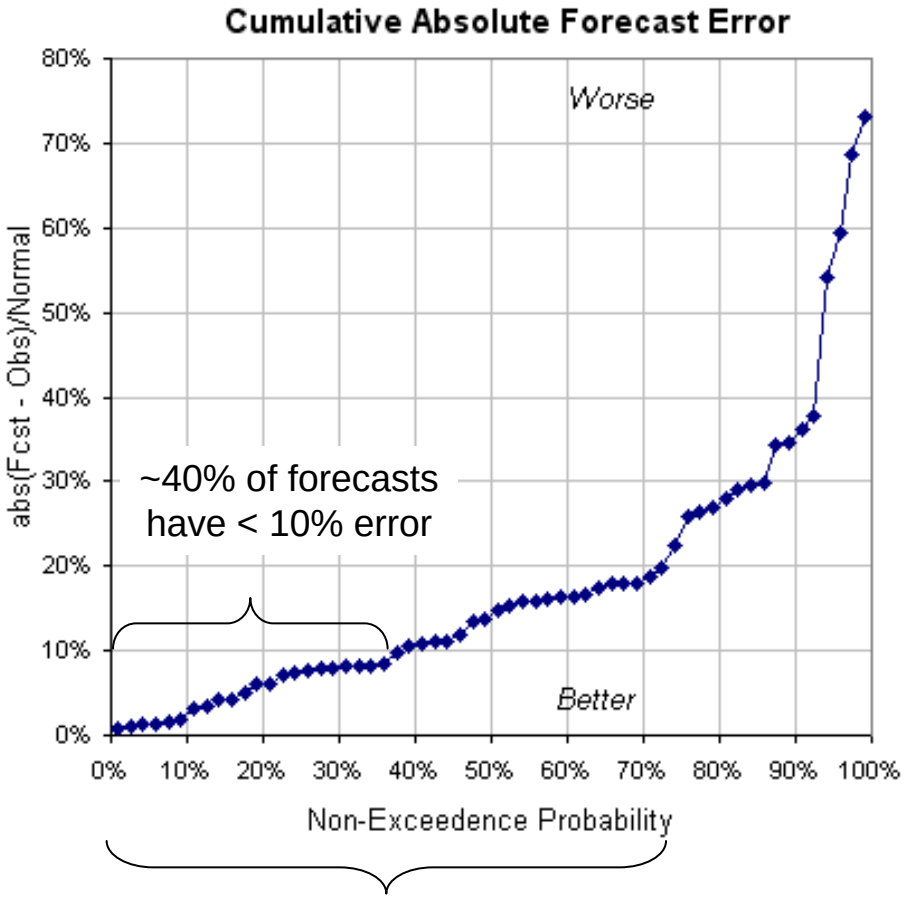
Roaring fork at Glenwood Springs 1947-2007 April 1 Forecasts



Correlation: 0.77
Bias: -2%
Average Error: 18%

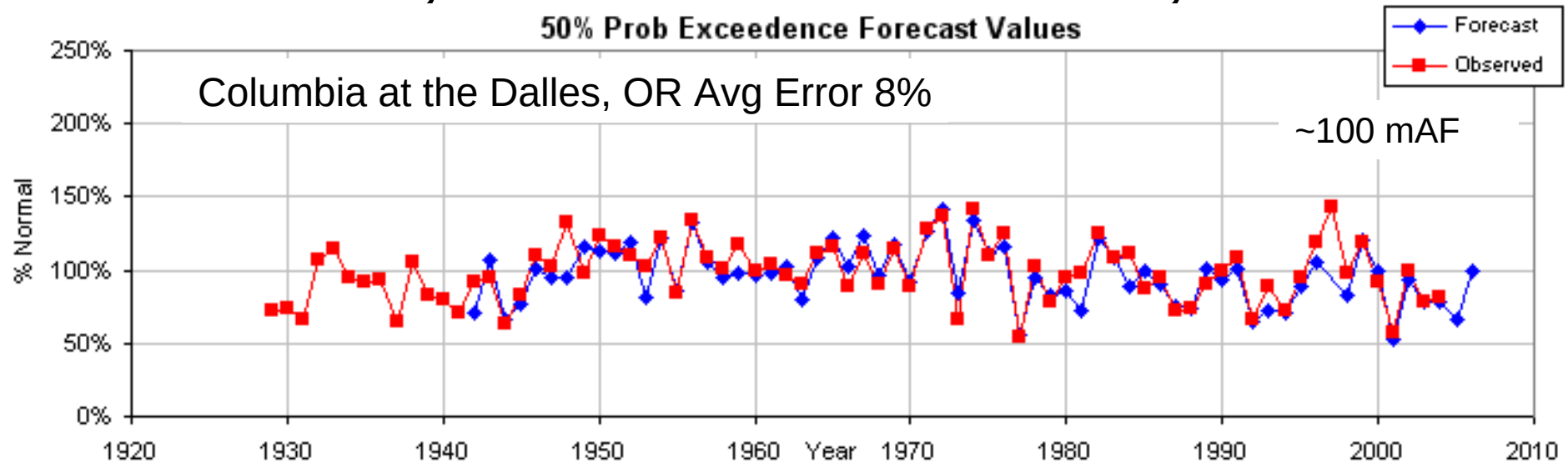
Courtesy: Tom Pagano - NRCS

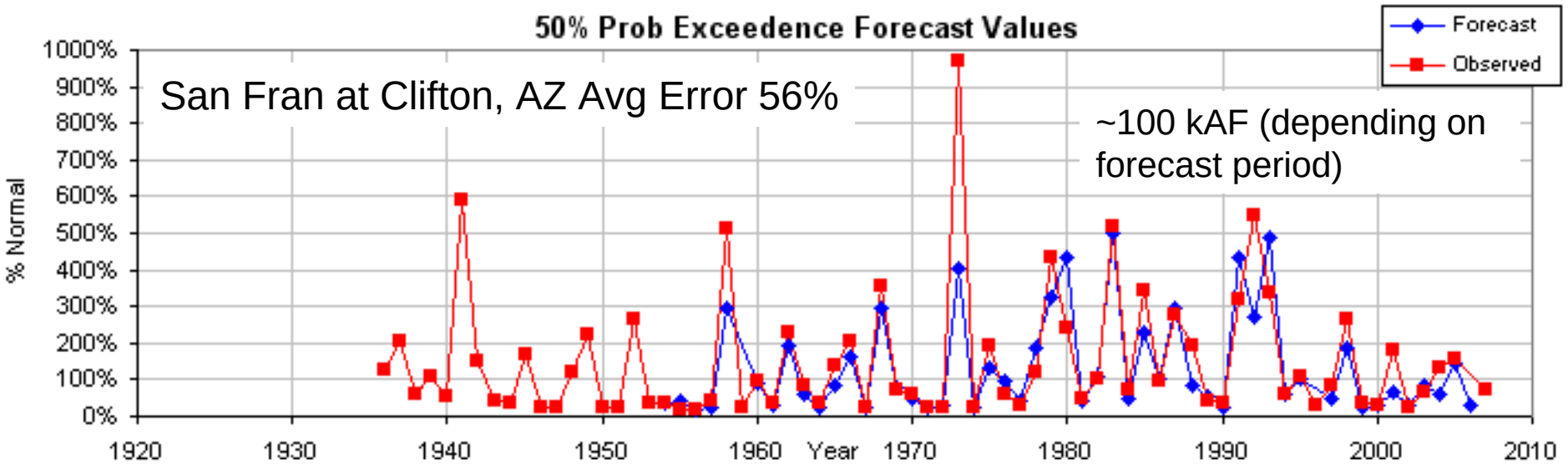
Roaring Fork at Glenwood Springs 1947-2007 April 1 Forecasts



Courtesy: Tom Pagano - NRCS

However, percent of normal error is mostly determined by observed streamflow variability.





Small, variable streams have relatively more error than large ones

Courtesy: Tom Pagano - NRCS

Basic patterns:

Snowmelt-dominated areas do best

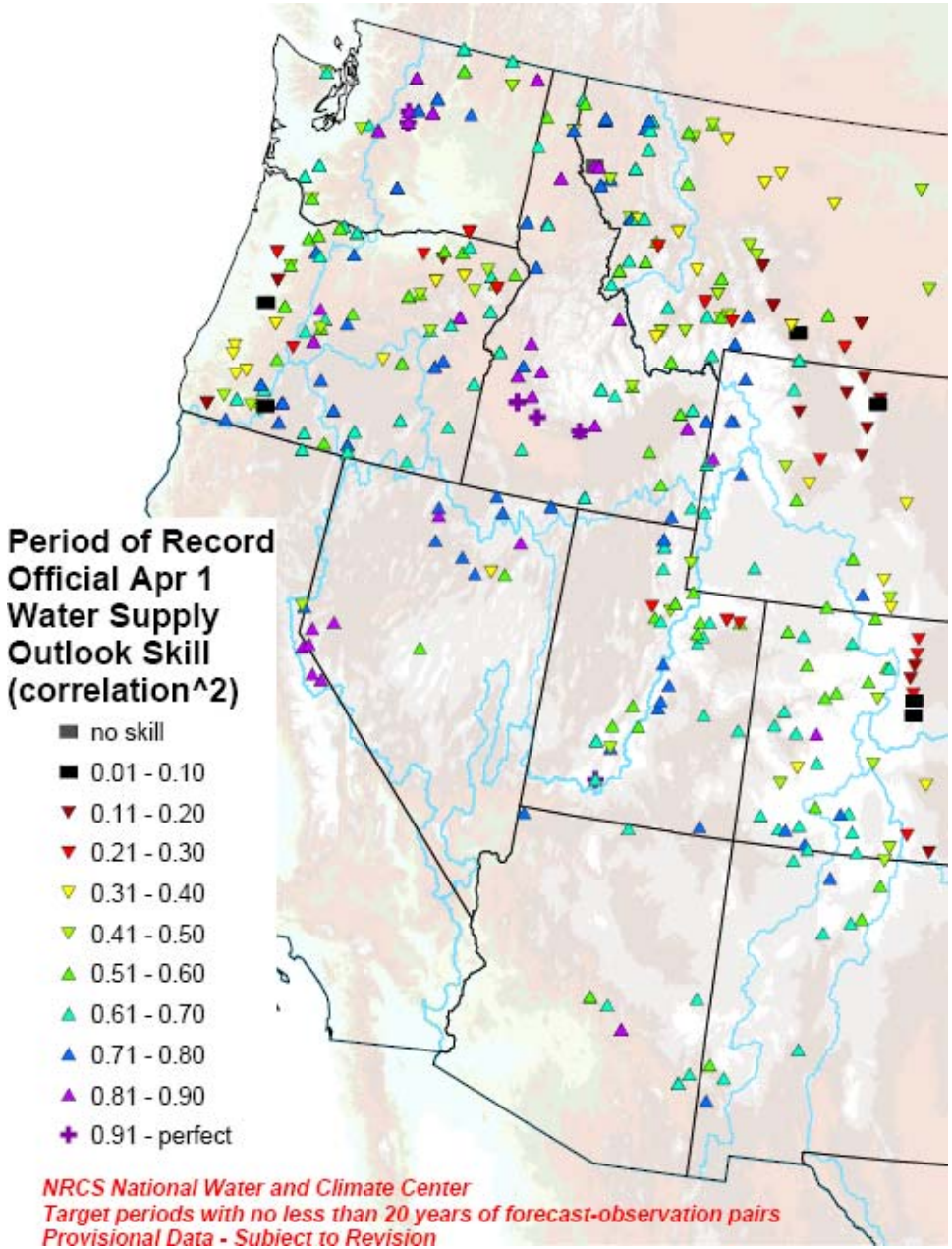
Forecasts improve with leadtime

Spring rainfall areas do poorly

Complex geology an issue

Unaccounted diversions a pain

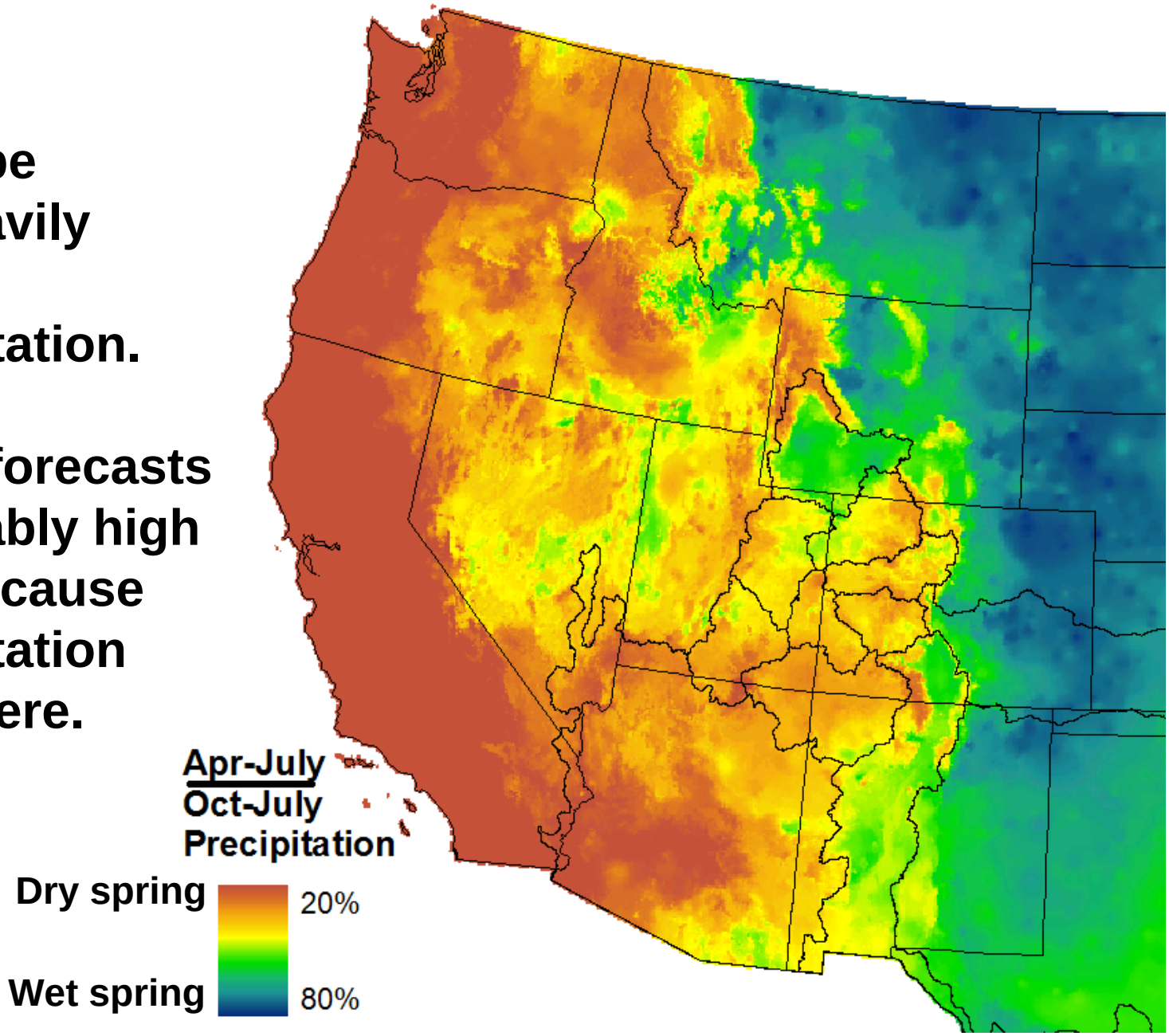
Some places just a data mess



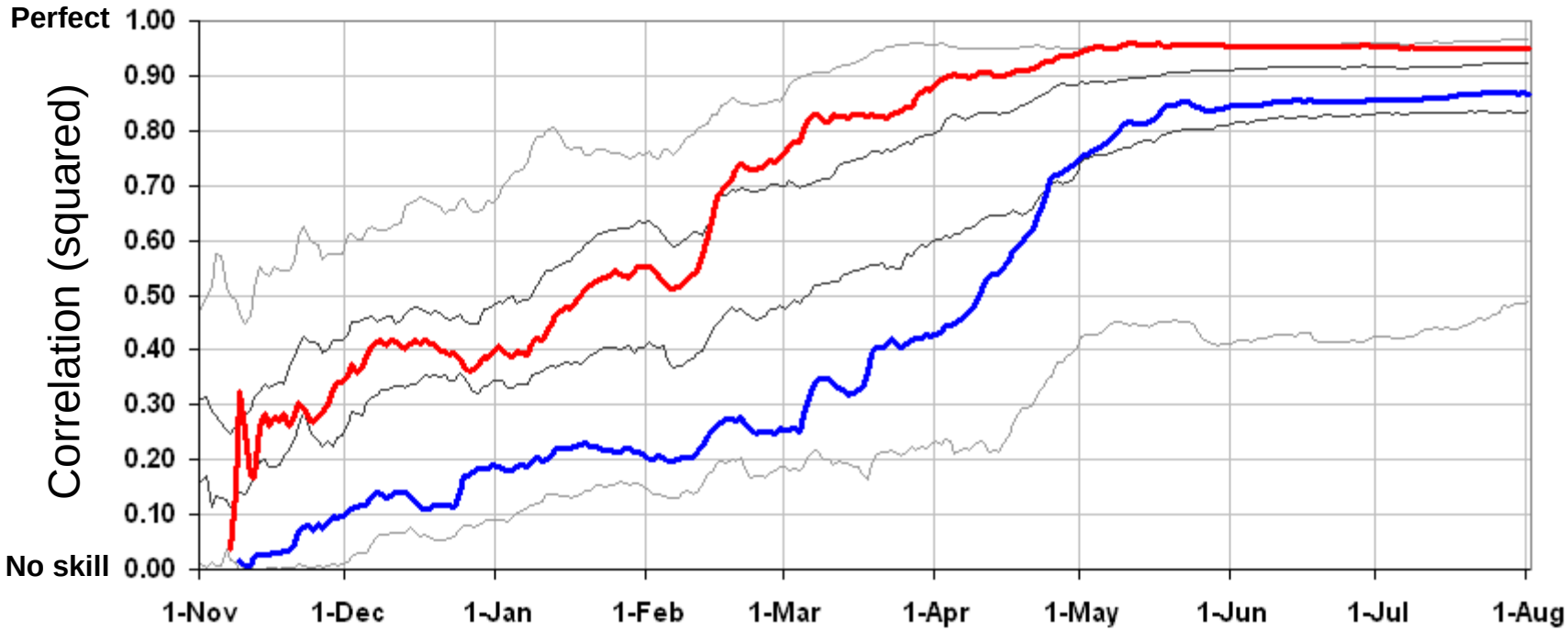
Courtesy: Tom Pagano - NRCS

Most east-slope basins are heavily influenced by spring precipitation.

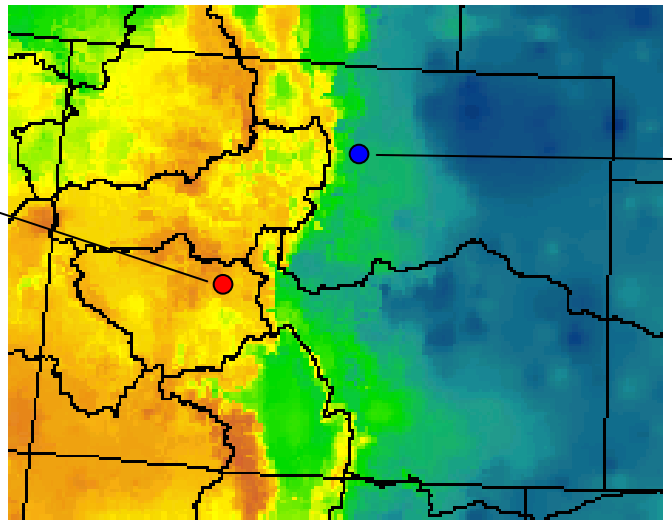
Water supply forecasts have unavoidably high uncertainty because spring precipitation is unknown there.



Courtesy: Tom Pagano - NRCS



East River at Almont
Winter precipitation dominated…
High skill by April 1



Boulder Ck nr Orodell
Spring precipitation dominated…
Low skill by April 1

Courtesy: Tom Pagano - NRCS

Incomplete historical records

Getting the right “observed”

Changes in forecast system

Getting the right balance between usefulness and understandability

Courtesy: Tom Pagano - NRCS

<u>Incomplete historical records:</u>
To get a stable set of data,
you often need decades of old forecasts,
which often aren't available.

Lake Powell Inflow Example:

1947: April 1 forecasts start (Apr-Sep target)
1947-1963: Gage moves 4 times (or is just the name changed?)
~1960: February and March 1 forecasts start
1960: Apr-July target now available
1980: January 1 forecasts start
1980's: NRCS-NWS coordination starts

NRCS digital records missing: 1981, 1985-1989, 1996

Courtesy: Tom Pagano - NRCS

Getting the right observed:

But this is just comparing "today's" version of the observed.
The old forecasters could've been shooting at a different target.

Types of streamflow:

Observed
Actual
Modified
Unregulated/Regulated
Adjusted/Unadjusted
Natural
"Lewis and Clark" flow

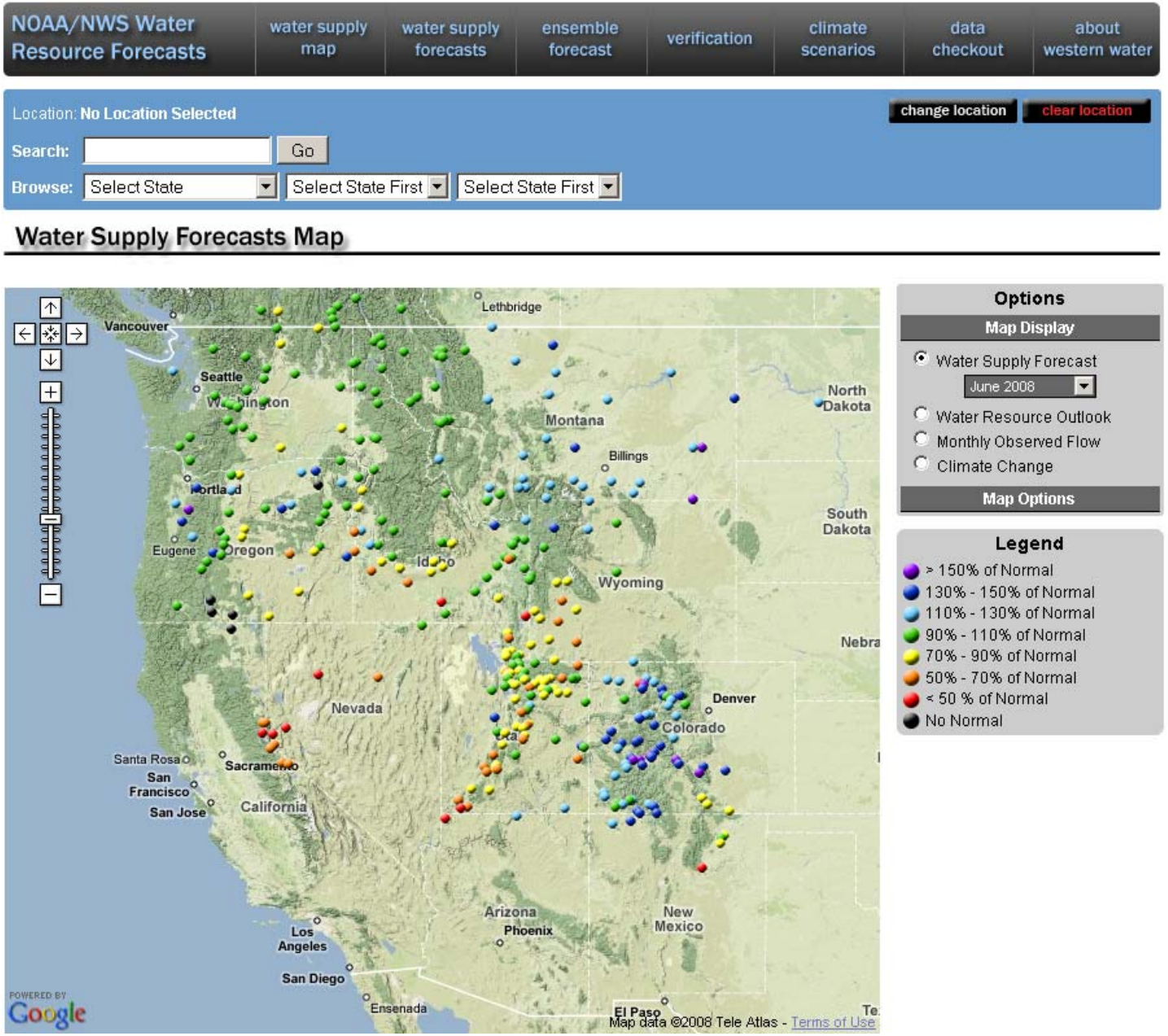
Types of adjustments:

Reservoir storage
Diversions
Consumptive use
Transpiration
Changing demand
Land use change
Evaporation from reservoirs
Bank storage
Surface/Groundwater interactions

Do users even know the target of the current forecasts?

Courtesy: Tom Pagano - NRCS

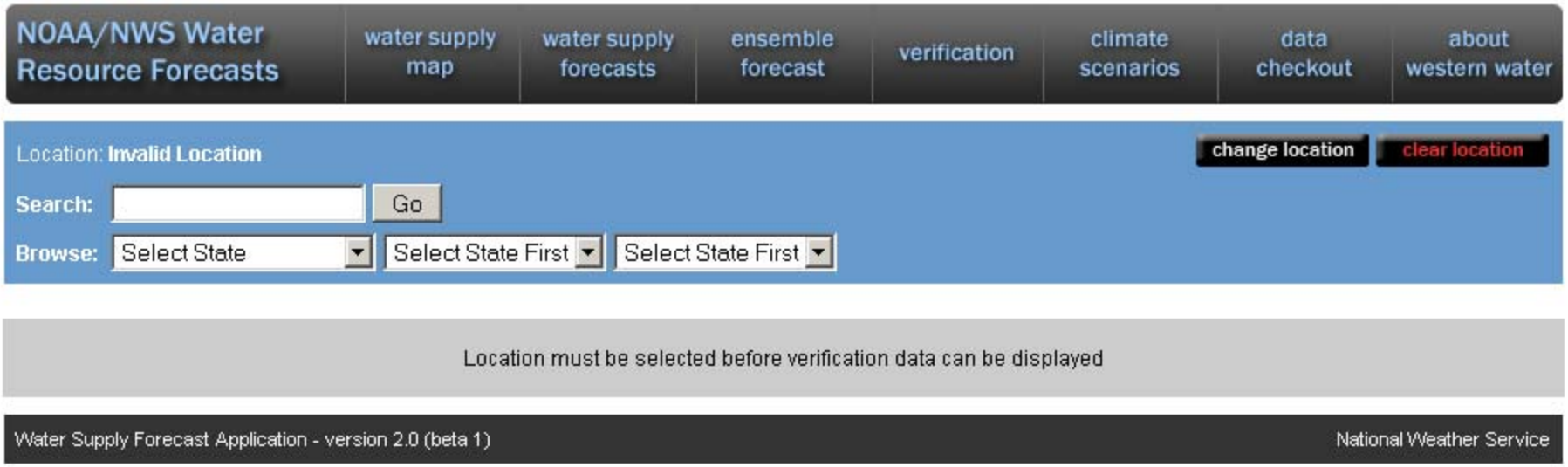
www.nwrfc.noaa.gov/westernwater/beta



Application

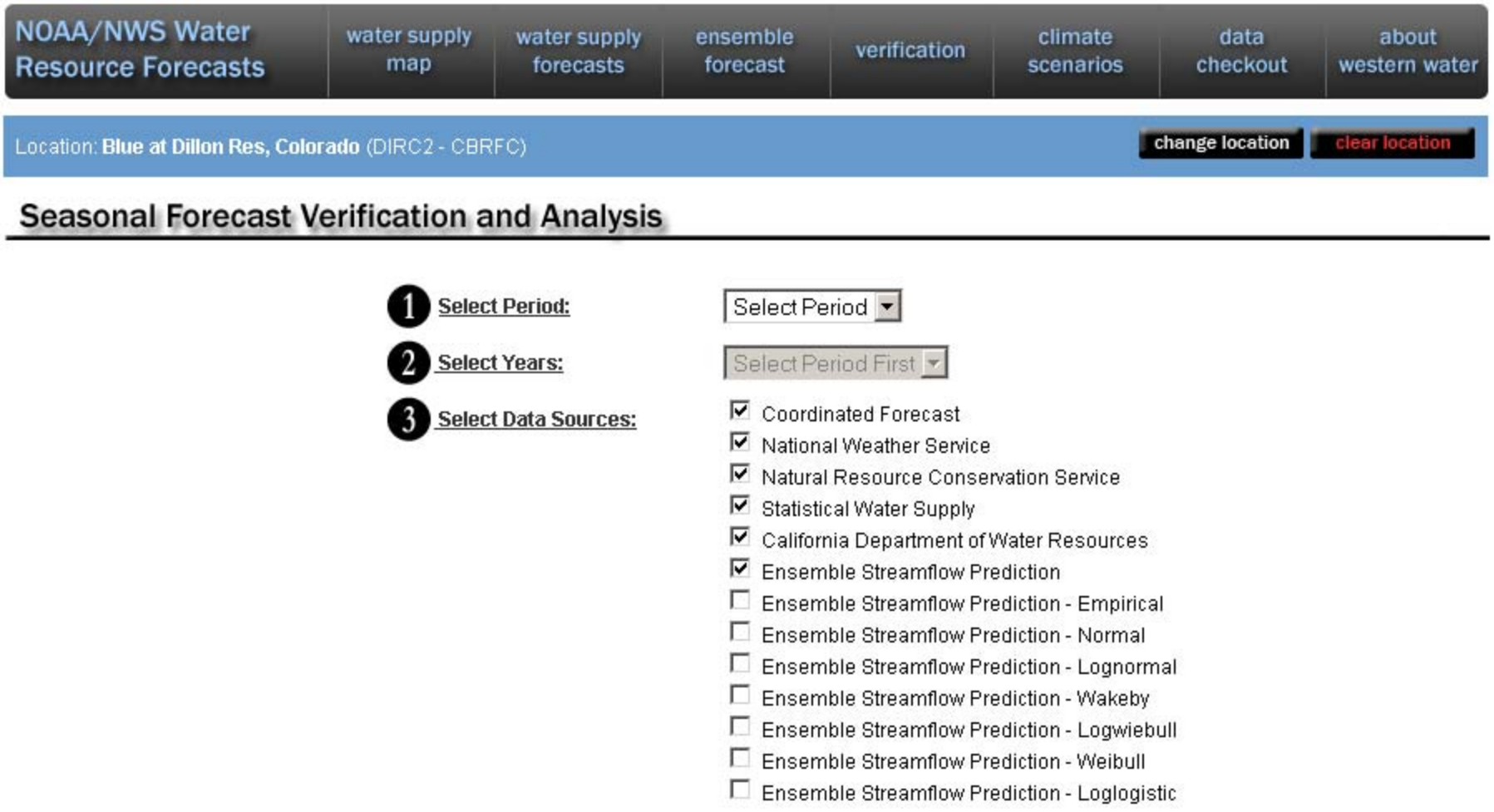
- Map
- Water Supply Forecasts
- Verification
- Data Checkout

Verification Capabilities

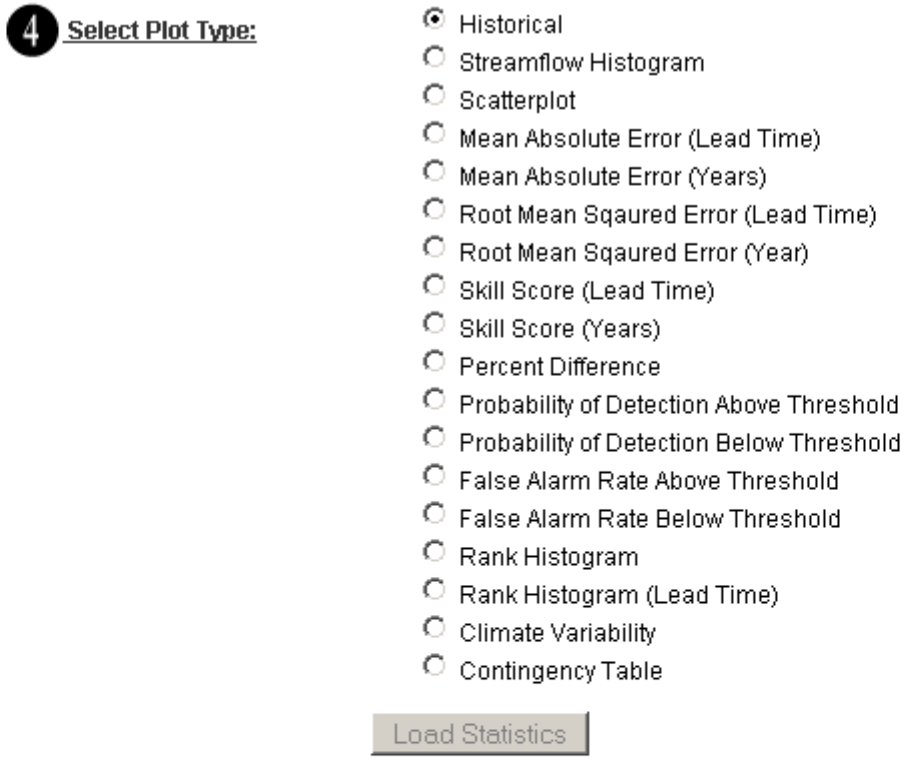


- Search By
  - Station ID
  - State, River, Location
- Location
  - Change
  - Clear
  - Return to main menu

Verification Capabilities



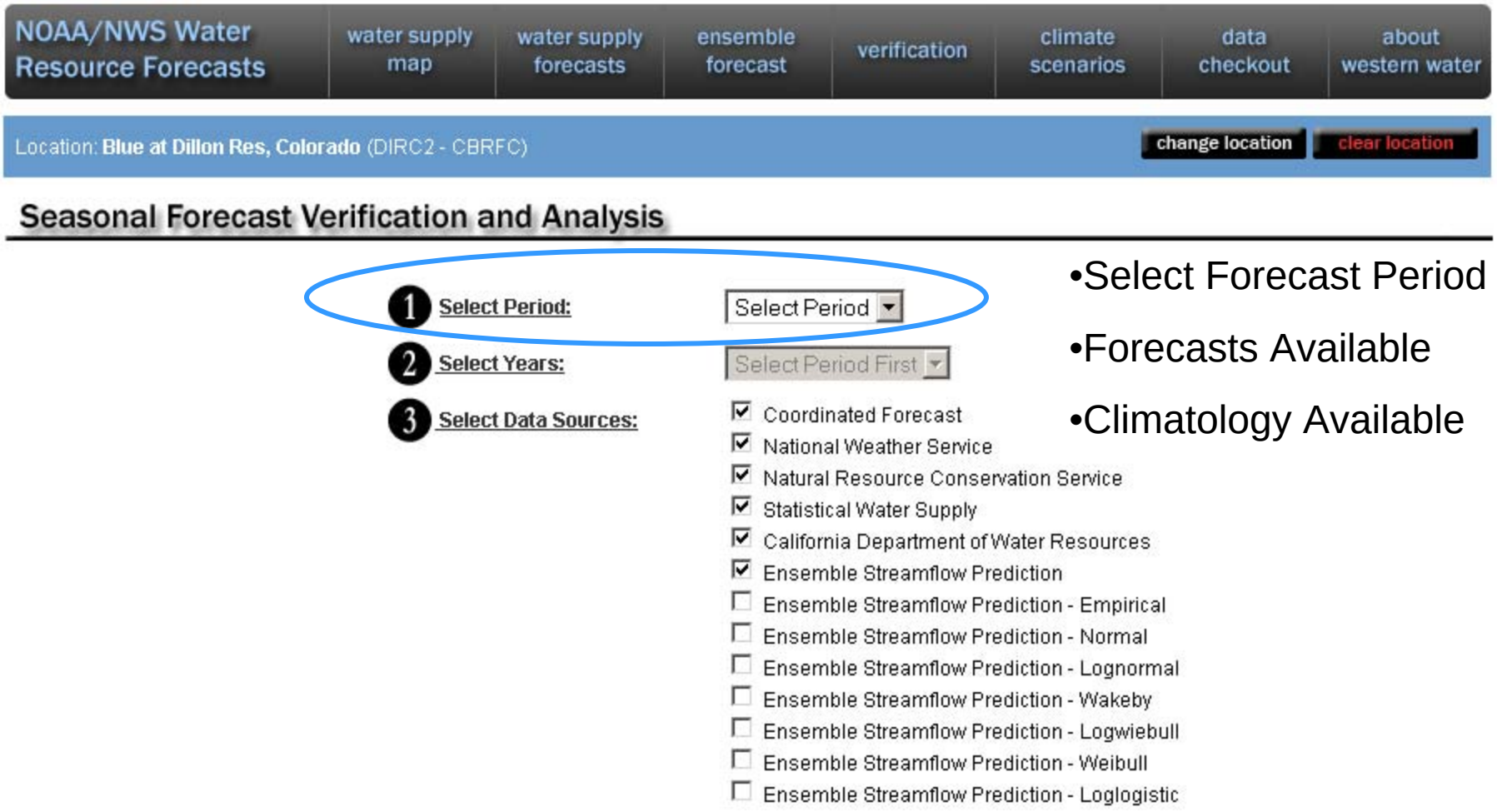
Verification Capabilities



About Forecast Verification

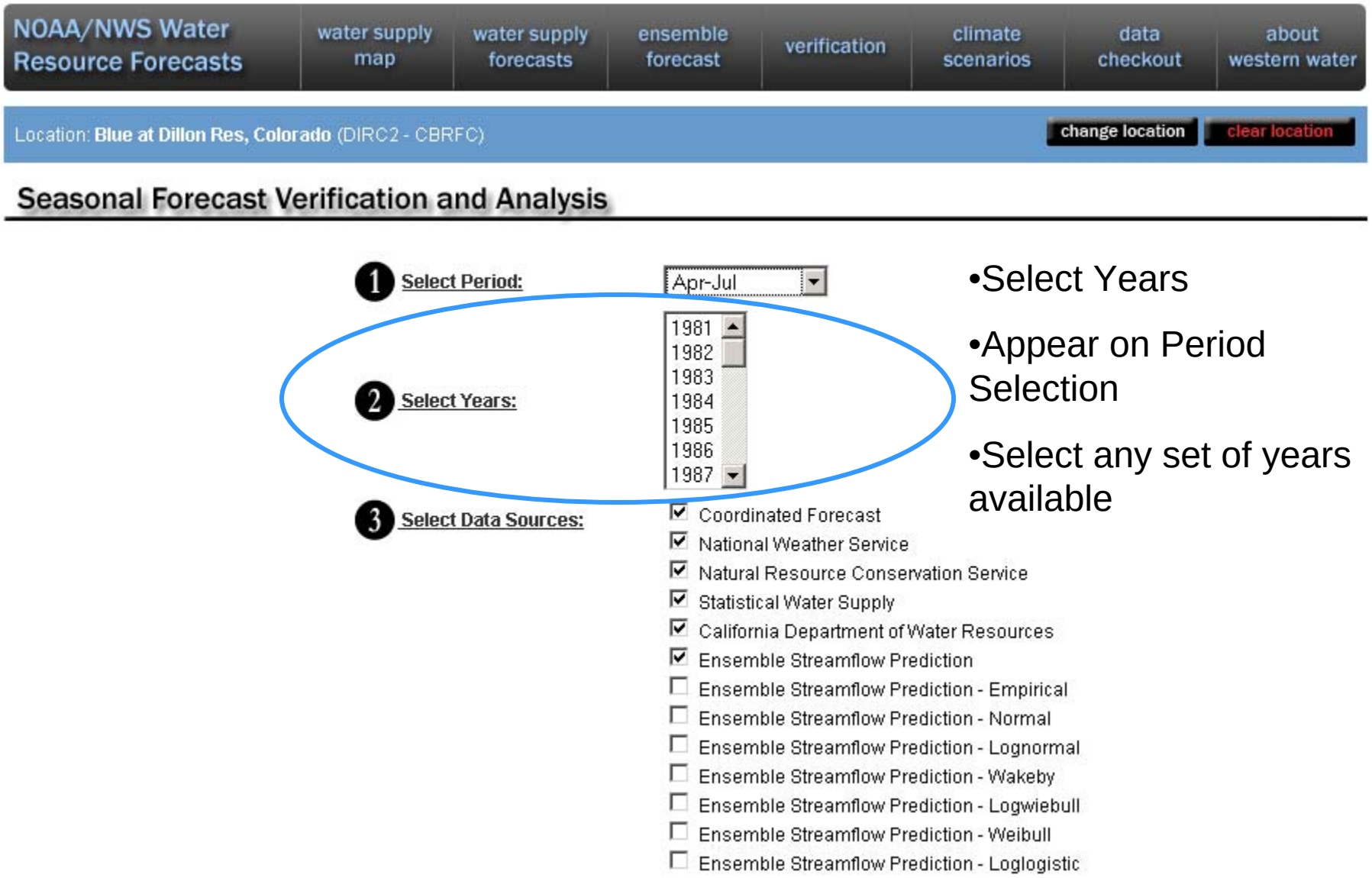
Forecast verification provides meaningful information about the quality of forecasts. Verification is an important for assessing past forecast performance and providing information about current forecast confidence. The seasonal forecast verification application allows users to obtain relatively simple plots and statistics explaining past performance. The application allows the user to choose (1) a forecast period (season), (2) the forecast years, (3) forecast types, and (4) verification metric. All data supporting the plots are archived in a database and may be accessed separately through the data checkout application as well.

Verification Capabilities



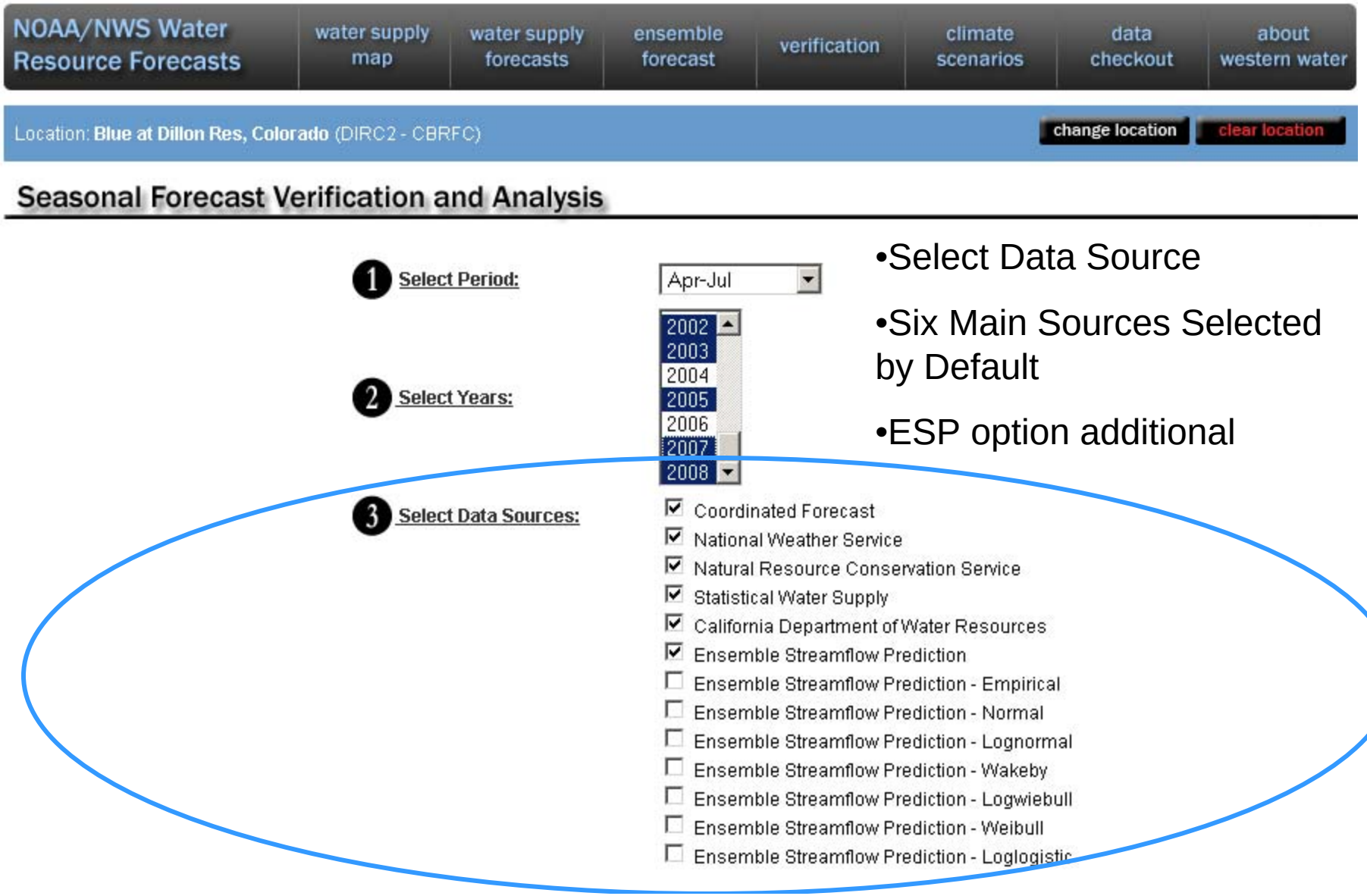
- Select Forecast Period
- Forecasts Available
- Climatology Available

Verification Capabilities



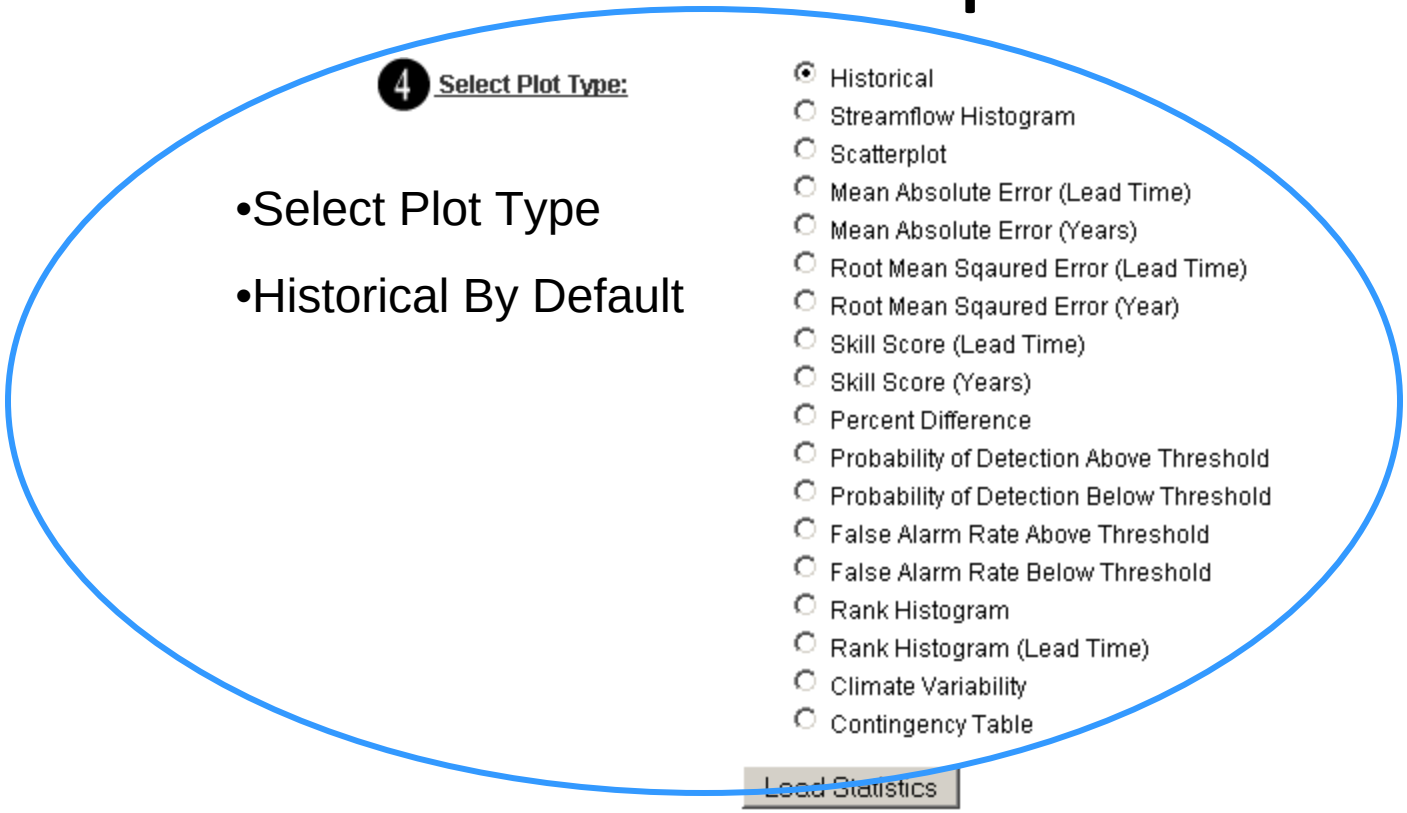
- Select Years
- Appear on Period Selection
- Select any set of years available

Verification Capabilities



- Select Data Source
- Six Main Sources Selected by Default
- ESP option additional

Verification Capabilities



About Forecast Verification

Forecast verification provides meaningful information about the quality of forecasts. Verification is an important for assessing past forecast performance and providing information about current forecast confidence. The seasonal forecast verification application allows users to obtain relatively simple plots and statistics explaining past performance. The application allows the user to choose (1) a forecast period (season), (2) the forecast years, (3) forecast types, and (4) verification metric. All data supporting the plots are archived in a database and may be accessed separately through the data checkout application as well.

Site Options

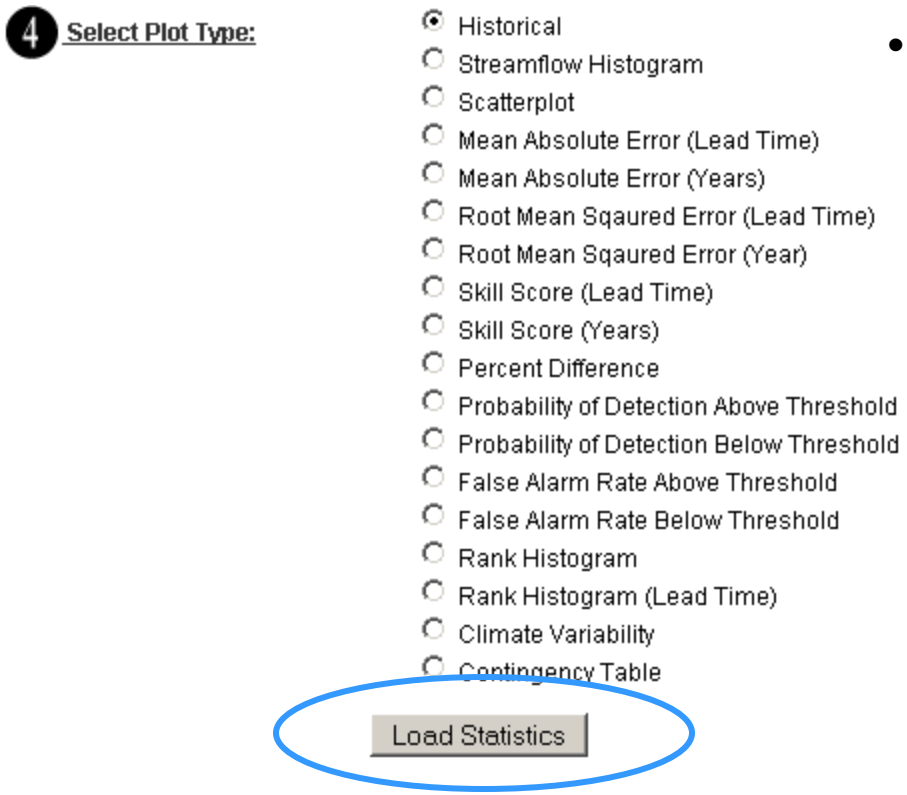
Previous 5 Locations Viewed

GBYC2

Print Graph | Display Raw Data

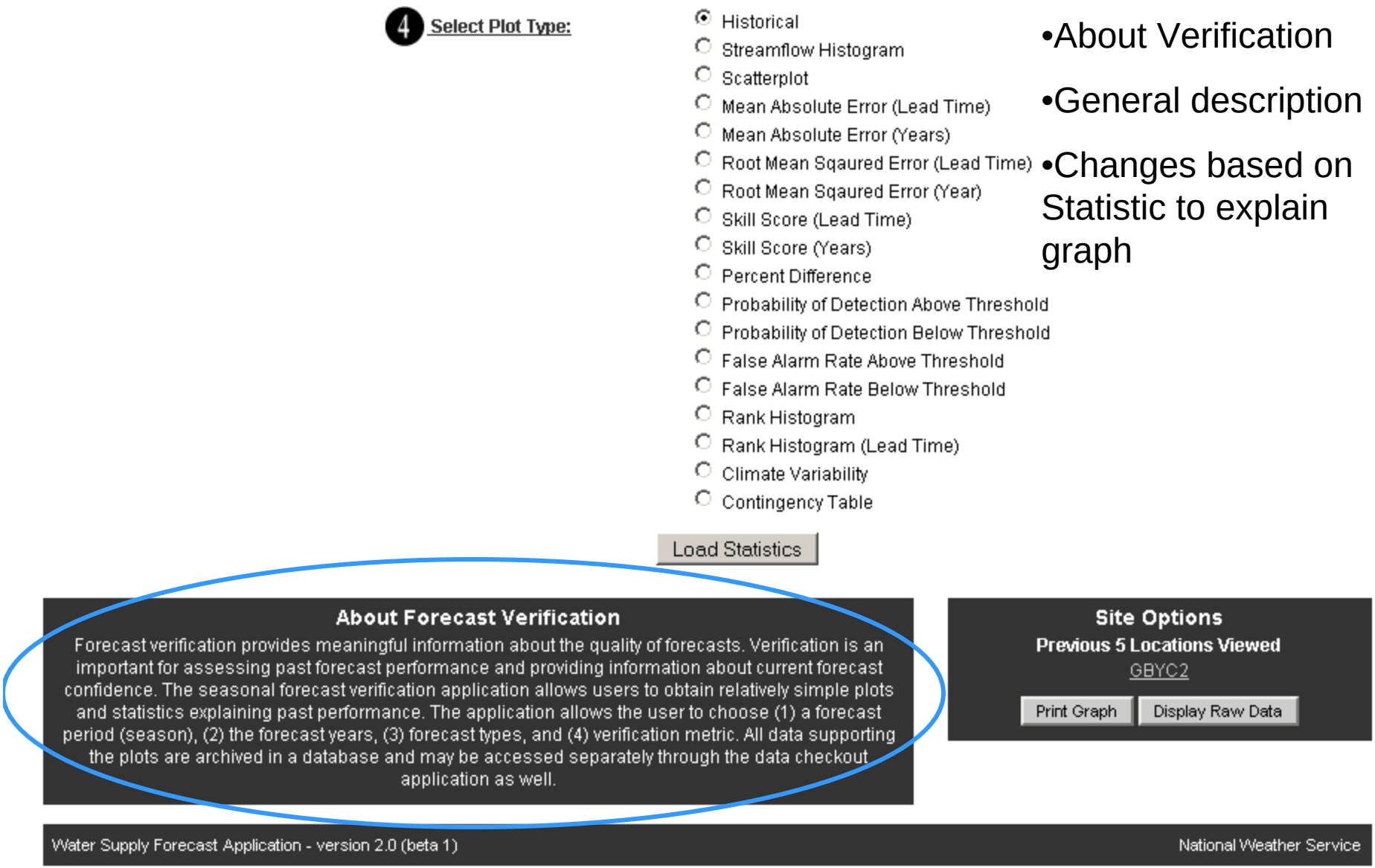
Water Supply Forecast Application - version 2.0 (beta 1) National Weather Service

Verification Capabilities



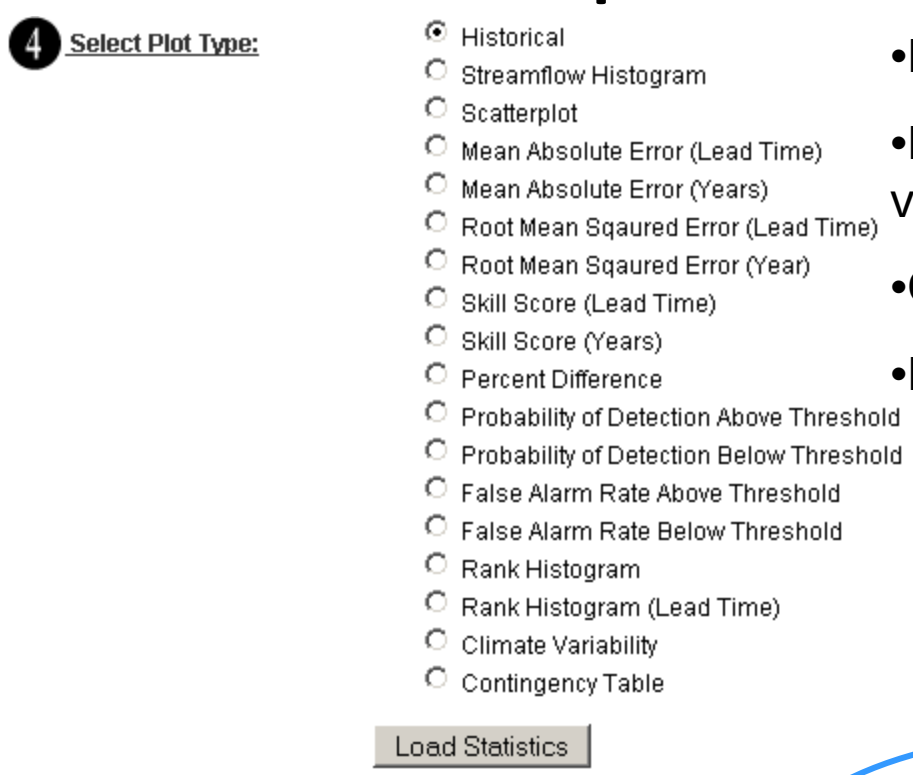
- Load Statistics

Verification Capabilities

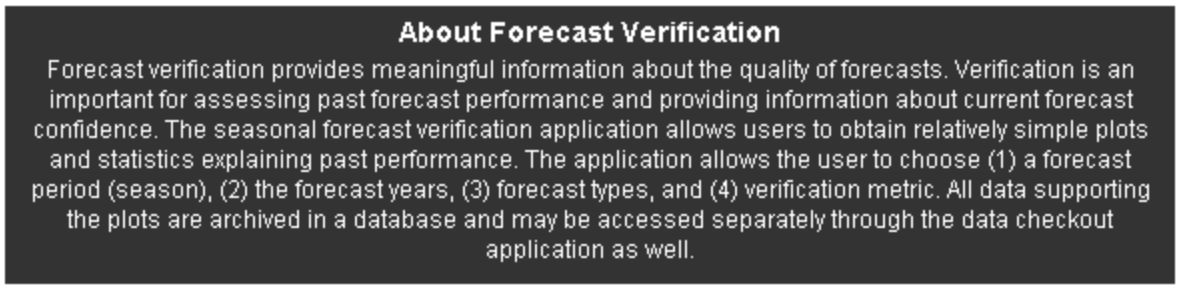


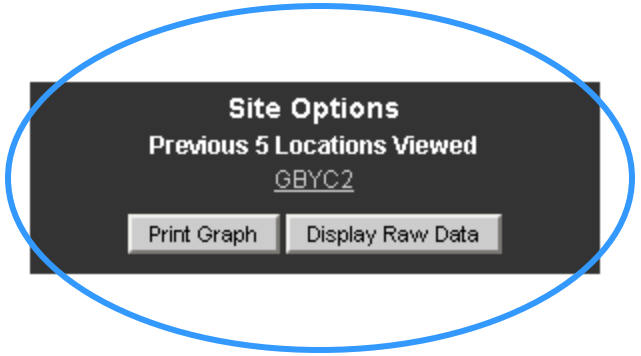
- About Verification
- General description
- Changes based on Statistic to explain graph

Verification Capabilities



- Previous Sites
- Remembers last 5 visited
- Go to Data Checkout
- Print Graph





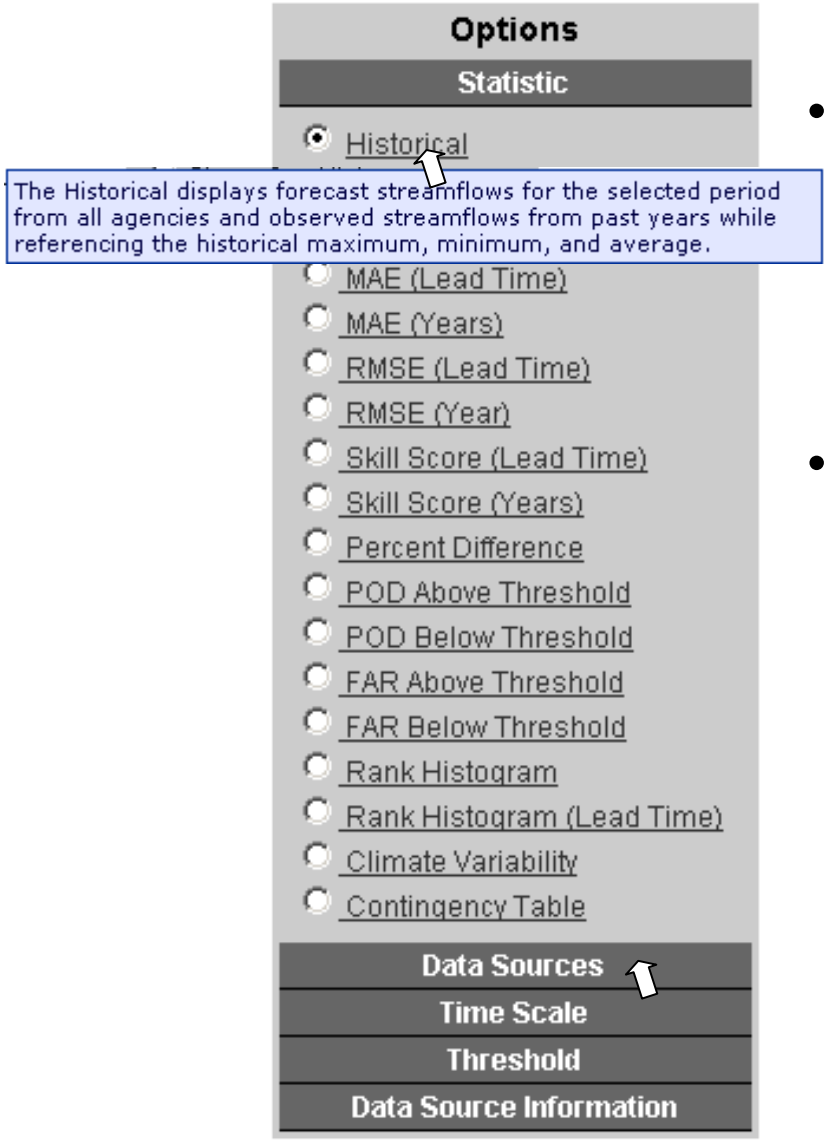
Verification Capabilities

- **Plot Area**
  - Auto scroll when needed
  - Clearly labeled with legend

Verification Capabilities

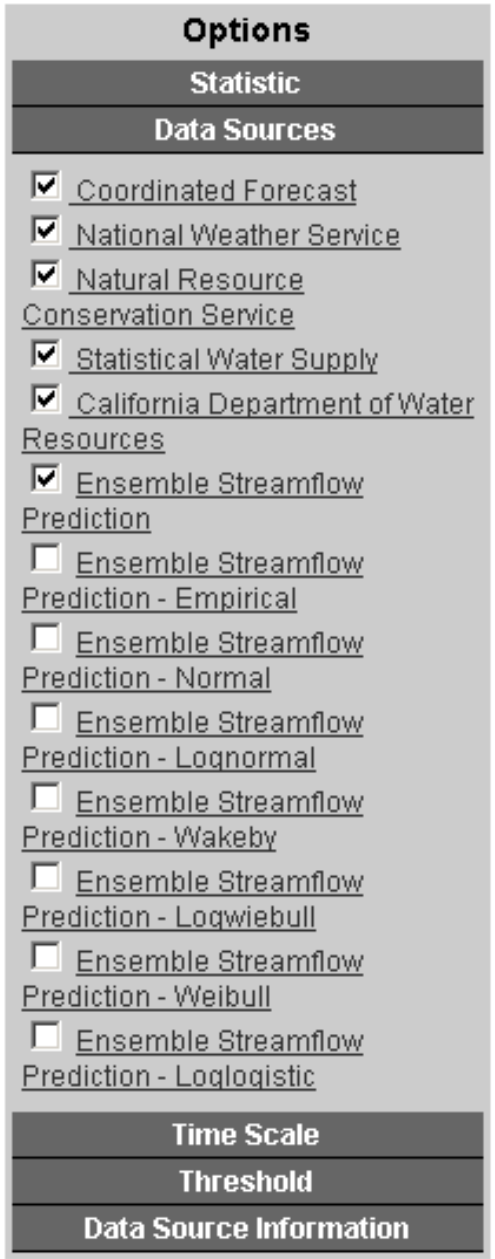
- **Side Options**
  - Statistic
  - Forecast Type/Data Source
  - Time Scale
  - Threshold
  - Data Source Information
  - Graph Options

Verification Capabilities



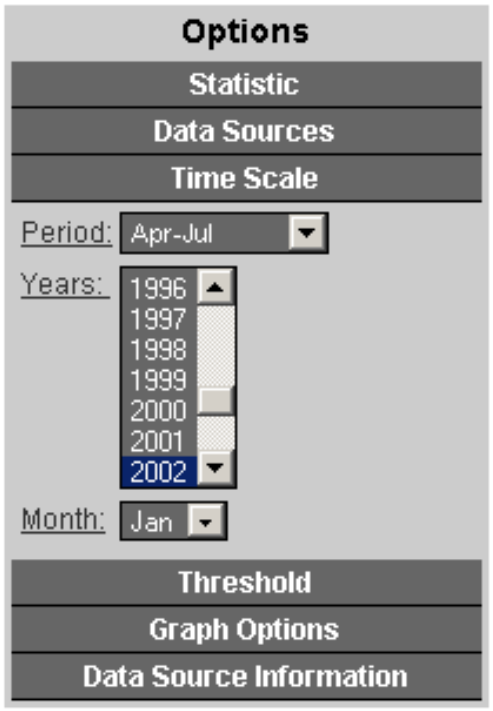
- **Statistic**
  - 18 Statistic choices
  - Graph change on click
  - Mouse-over displays info about graph
- **Group Titles**
  - Mouse and click to display other options

Verification Capabilities



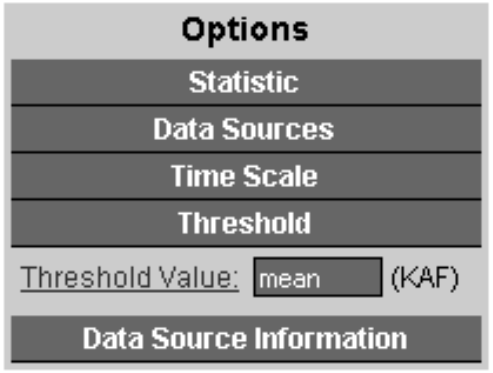
- **Forecast Type**
  - Change Data Sources to be displayed
  - Graph change on click

Verification Capabilities



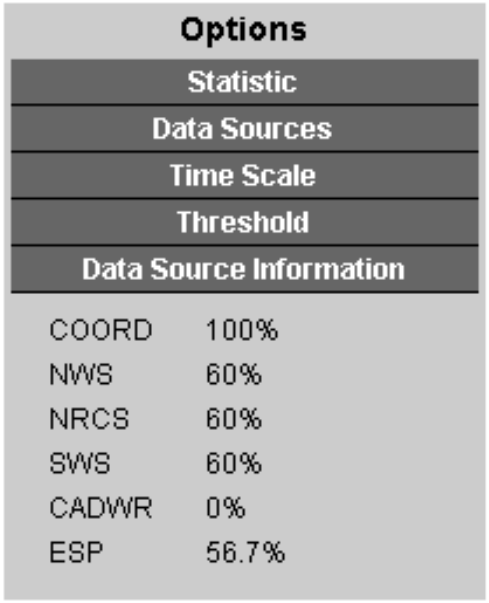
- **Time Scale**
  - Change Period
  - Modify Years
  - Graph change on click
  - Month
    - Only displayed when Contingency Table Statistic is chosen
    - Change the month the table displays

Verification Capabilities



- **Threshold**
  - Default is Climatology / Historical Average
  - Enter value in KAF and press enter
  - Type ‘mean’ to return to default
  - Valid option for all but Rank Histogram statistic options.
  - Graph change on ‘Enter’

Verification Capabilities

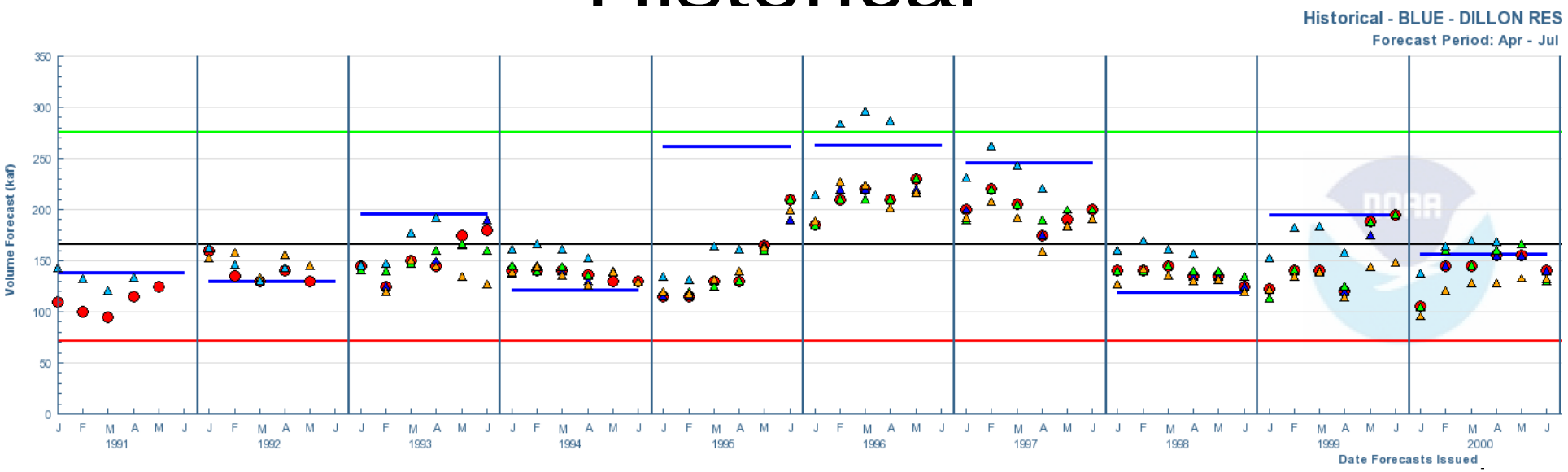


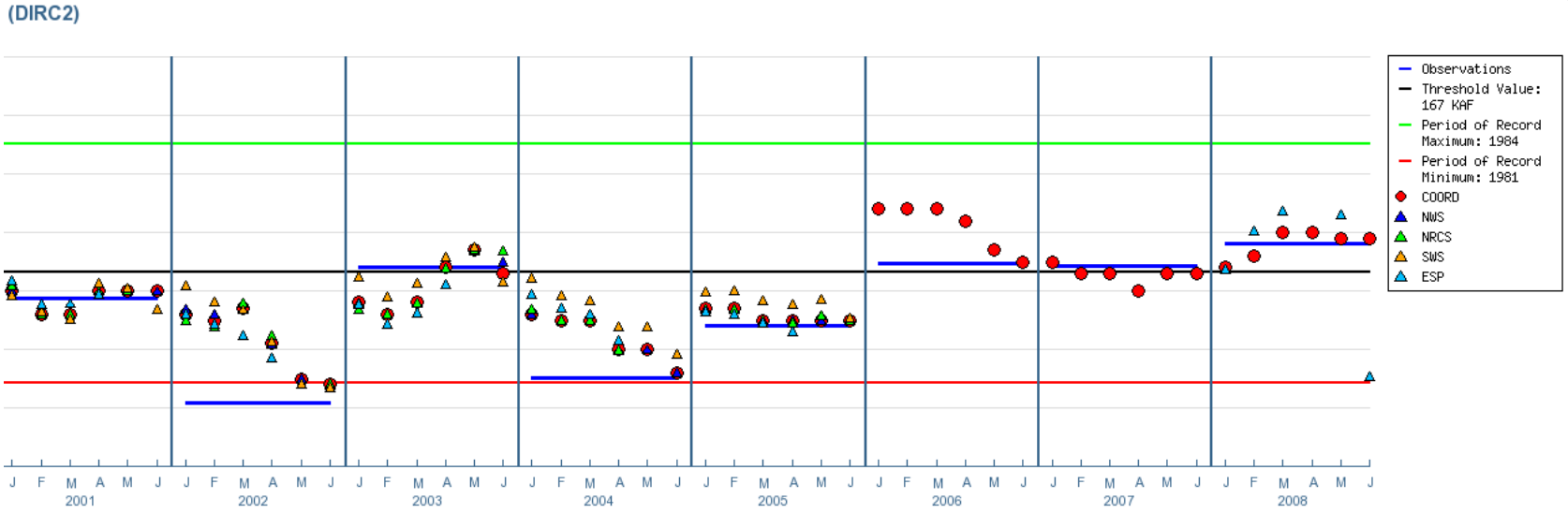
- **Data Source Information**
  - Calculated the percent of forecasts available
  - Keep in mind; can skew thoughts about statistics

Example

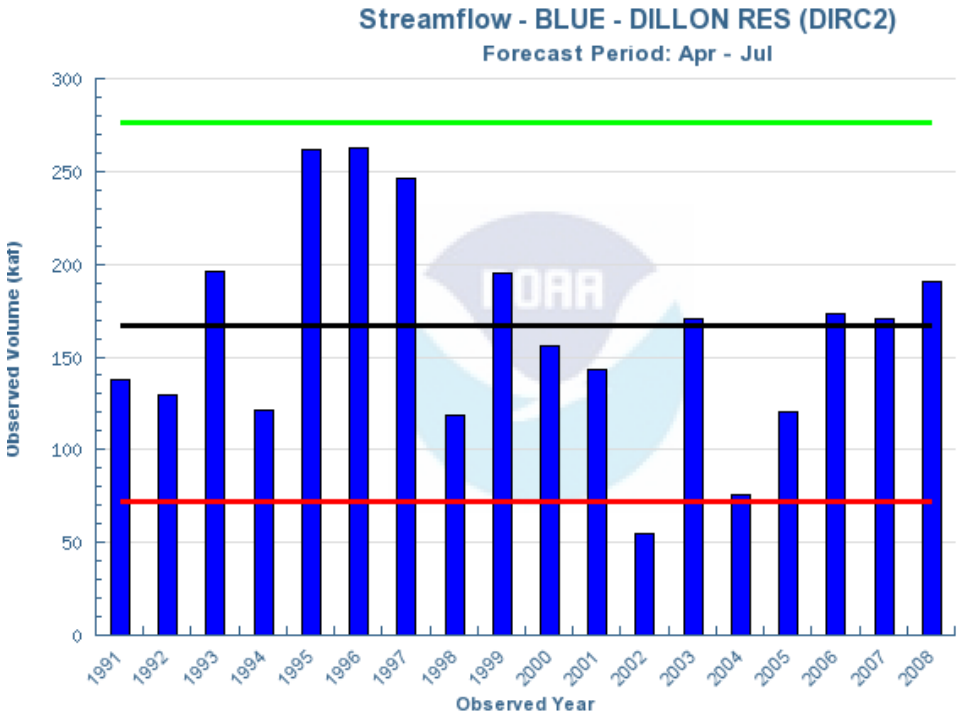
DIRC2
1991 – 2008 Forecast Available

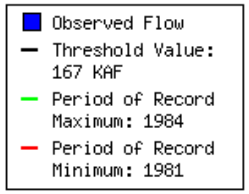
Historical

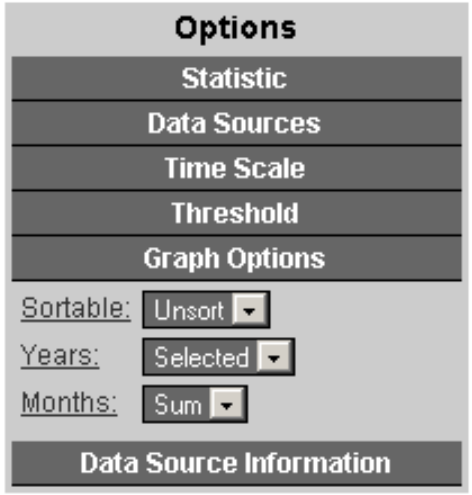

Historical - BLUE - DILLON RES
Forecast Period: Apr - Jul
Volume Forecast (kaf)
350
300
250
200
150
100
50
0
J F M A M J
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Date Forecasts Issued


(DIRC2)
J F M A M J
2001
2002
2003
2004
2005
2006
2007
2008
Observations
Threshold Value: 167 KAF
Period of Record Maximum: 1984
Period of Record Minimum: 1981
COORD
NWS
NRCS
SWS
ESP

Streamflow Histogram

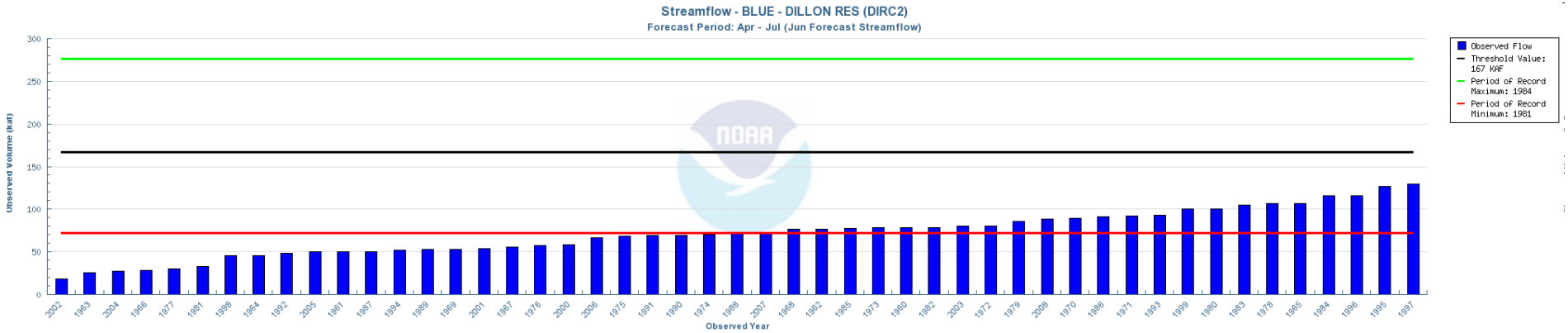


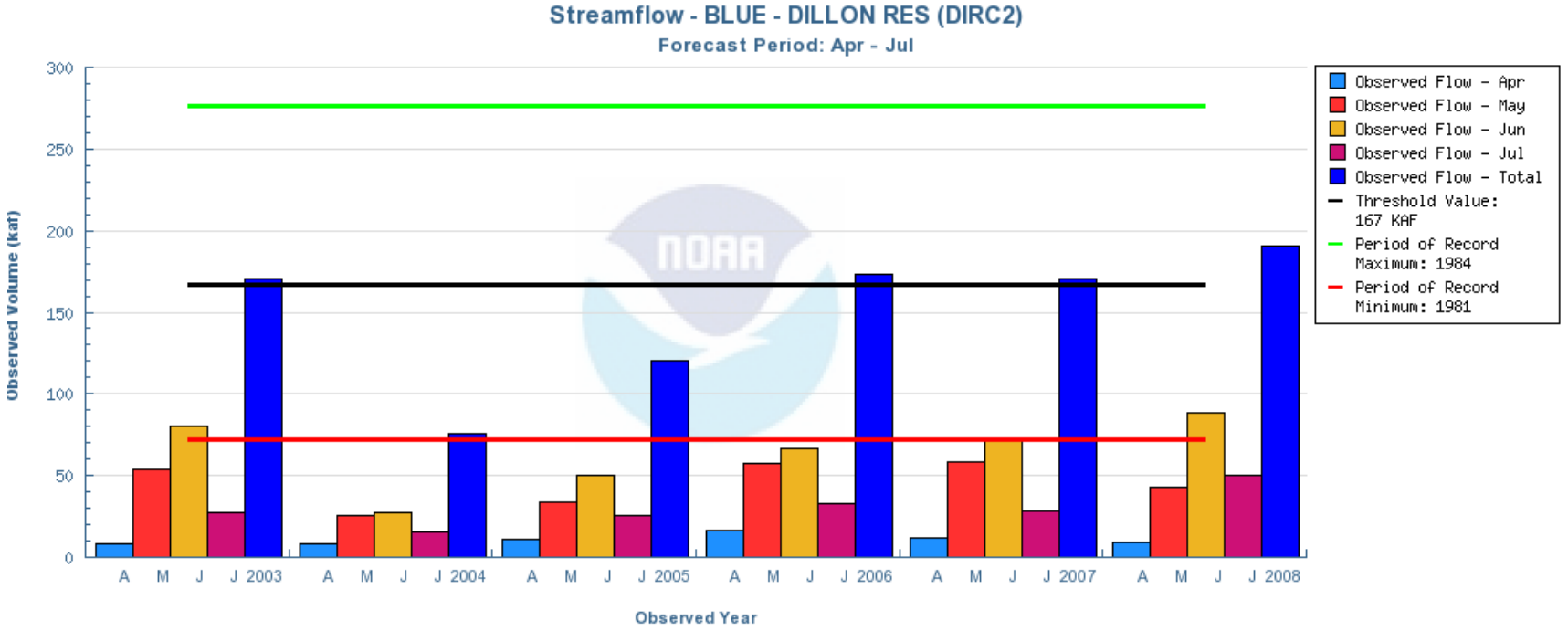




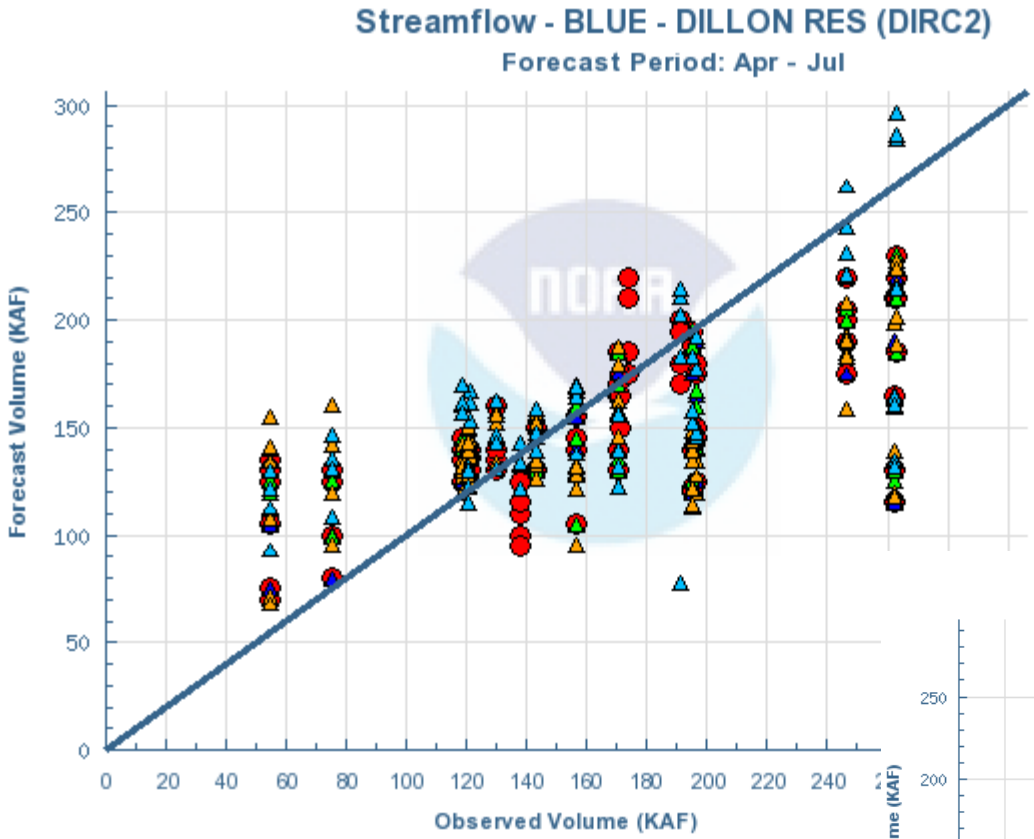
- **Graph Options**
  - Any Combination of Options
  - Sort/Unsort Years
  - Display selected Years or All Observed Years
  - Display Summed Months
  - Individual Months
  - Each Month and Summed

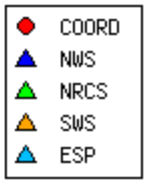
Streamflow Histogram

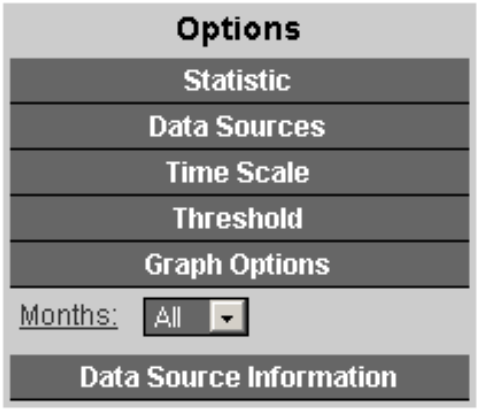




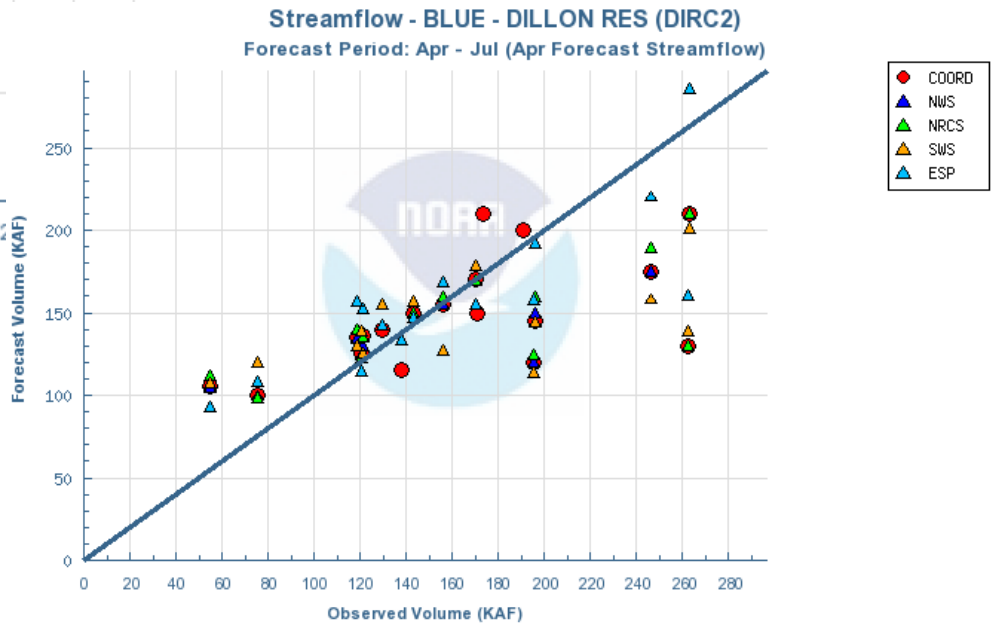
Scatterplot



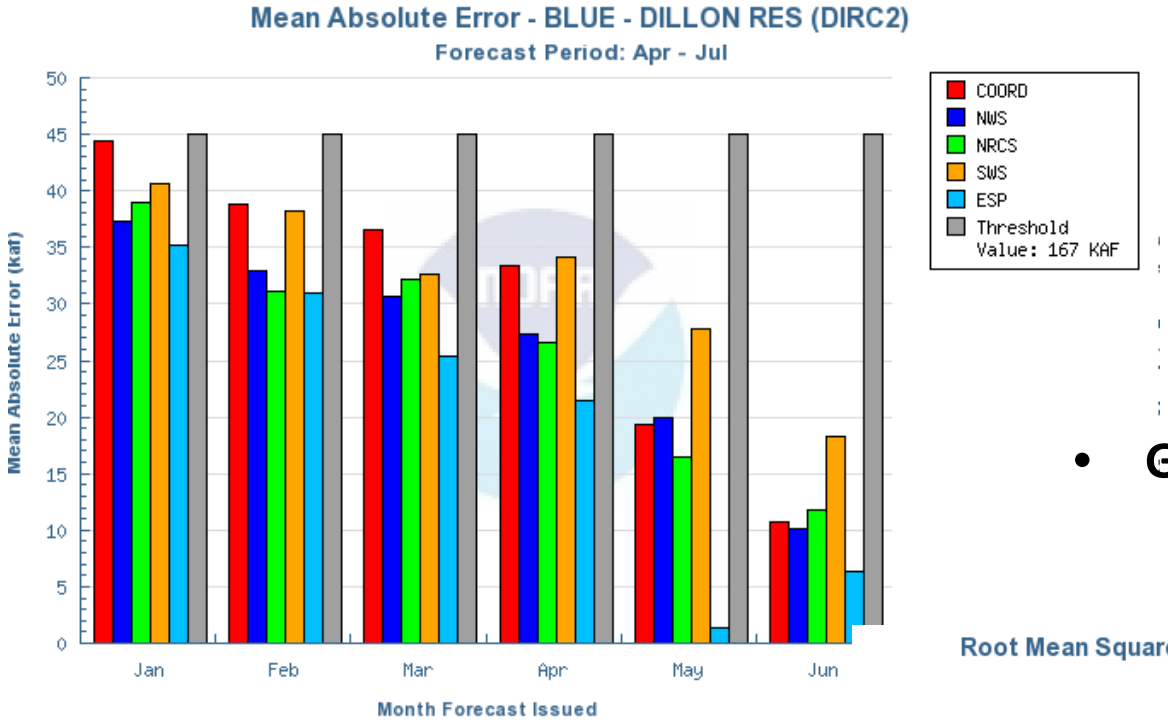


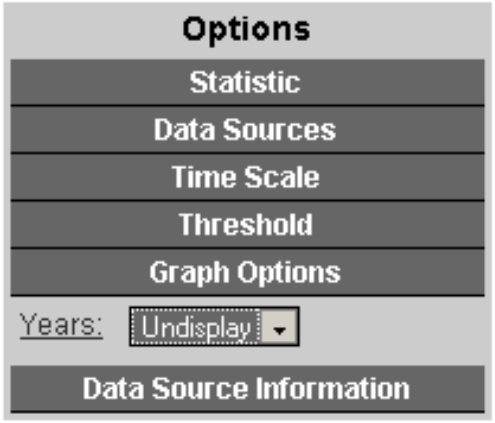


- **Graph Options**
  - Display All Months or Specific forecast Month



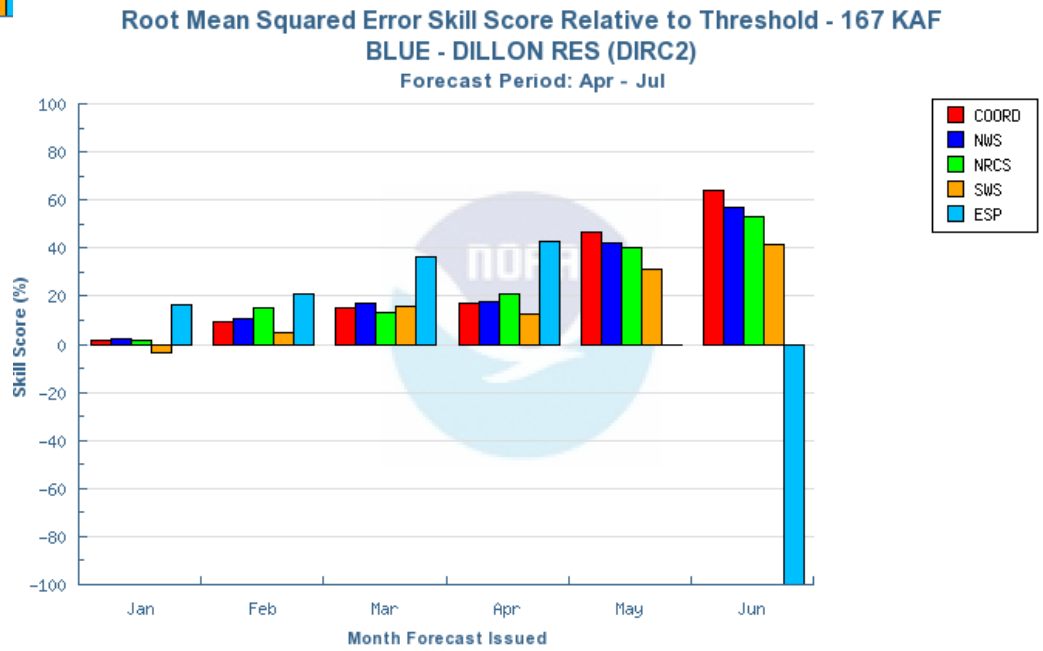
Error and Skill By Lead Time



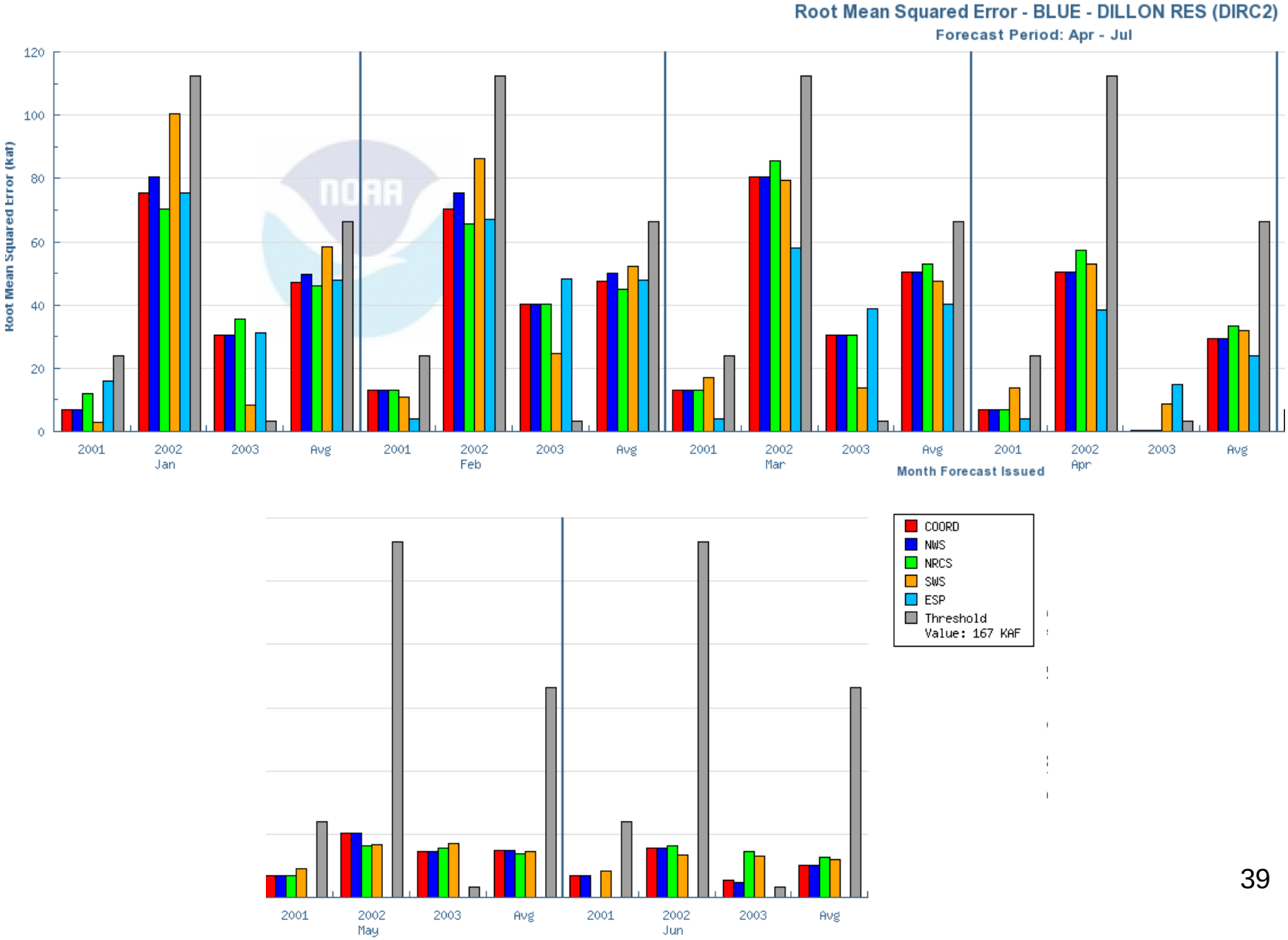


- **Graph Options**
  - Display/Undisplay years within the months

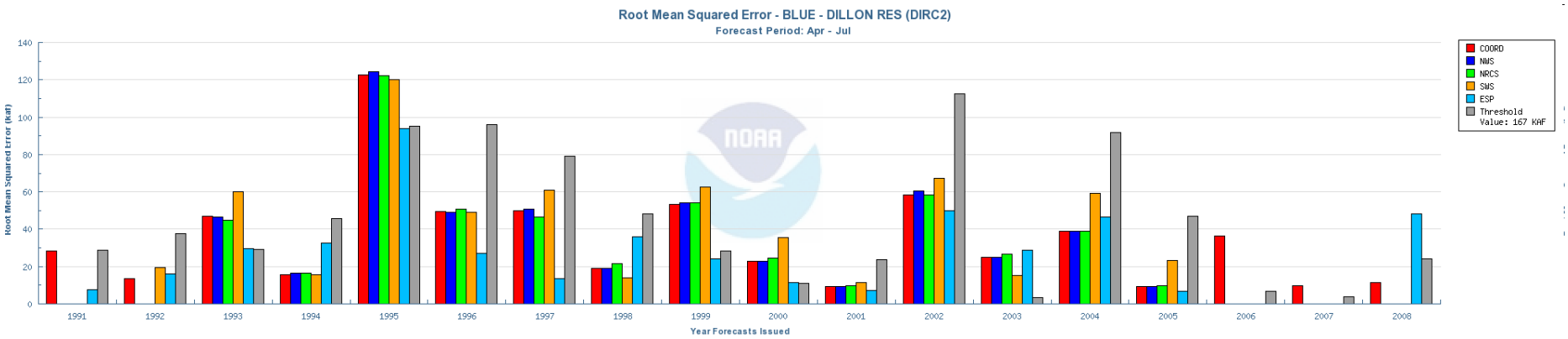
- Comparison of forecast error to "average" error useful diagnostic tool

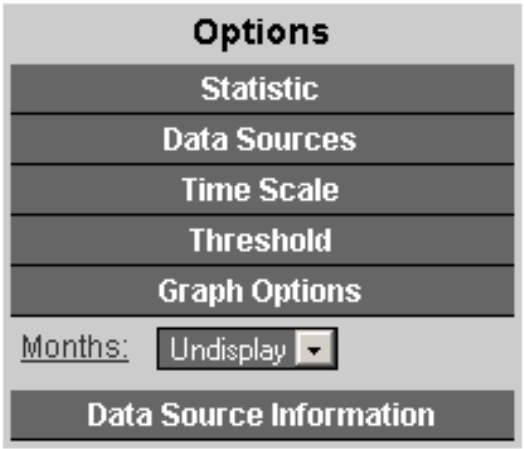


Error and Skill By Lead Time

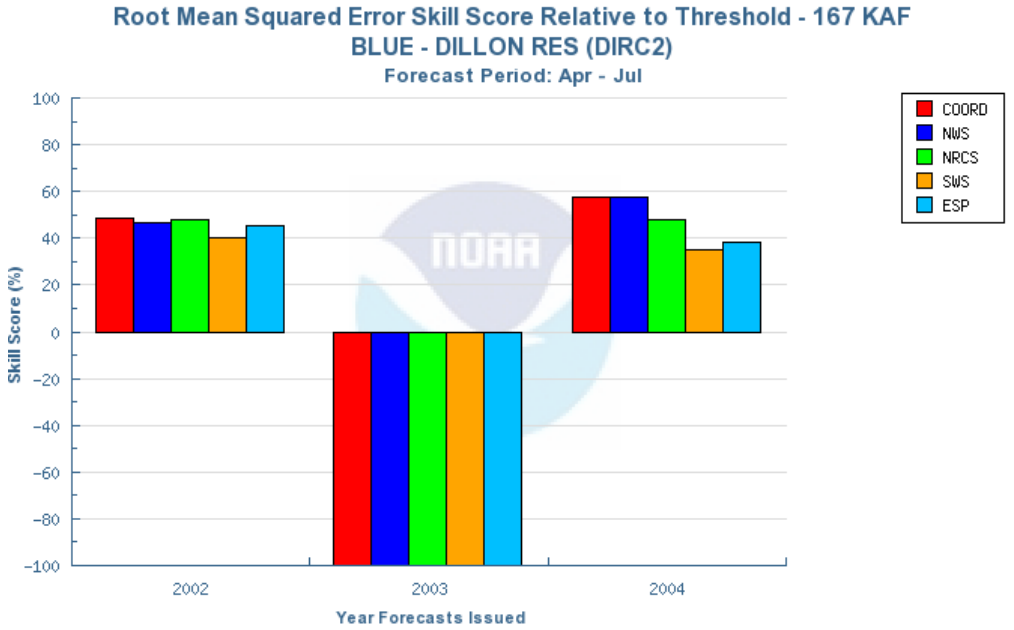


Error and Skill By Year



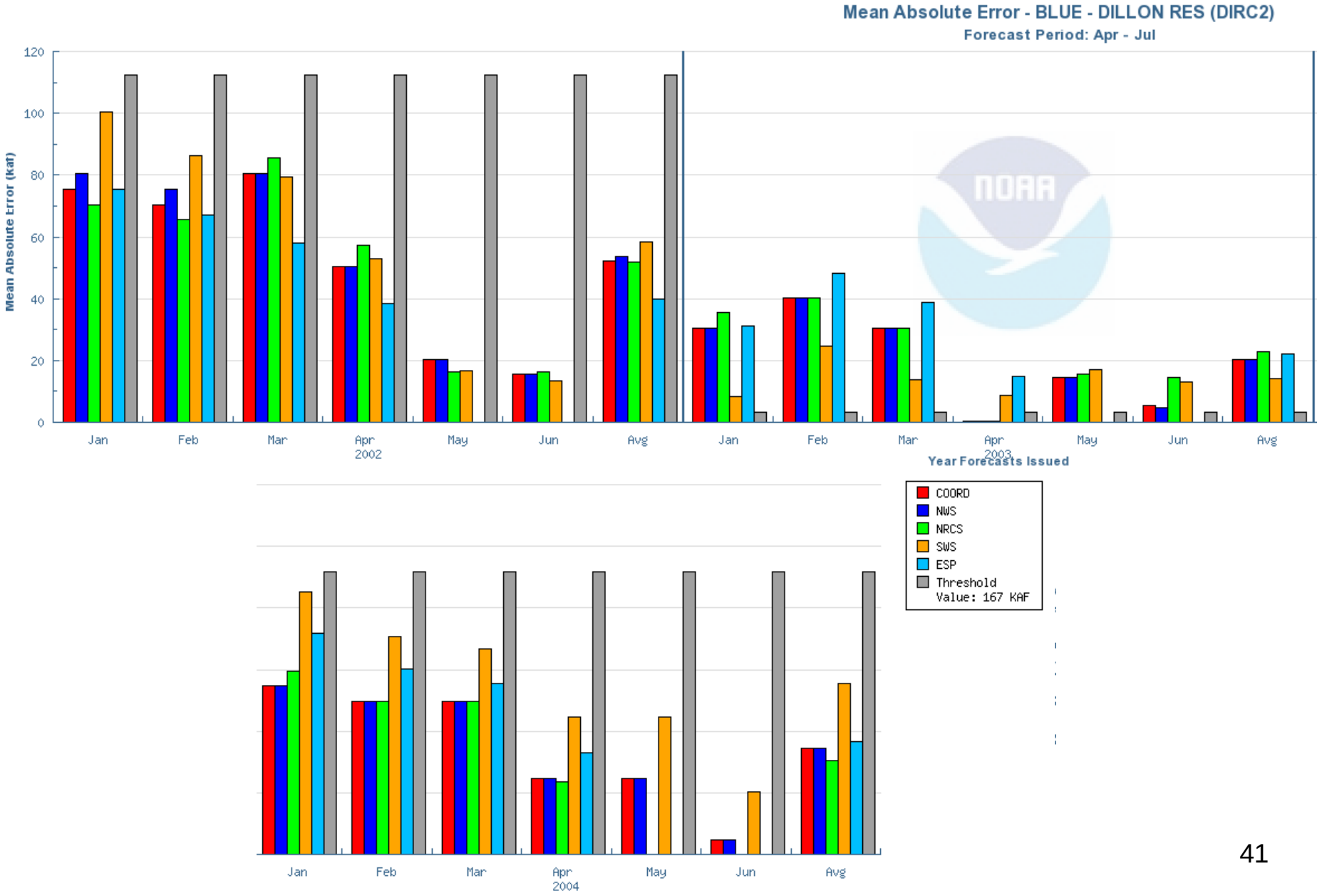


- **Graph Options**
  - Display All Months or Specific forecast Month

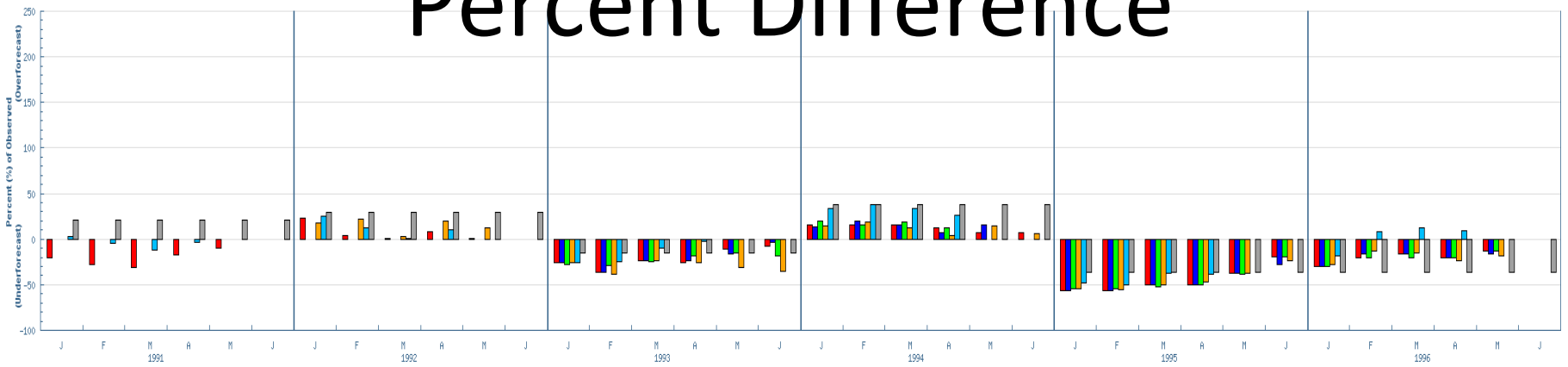


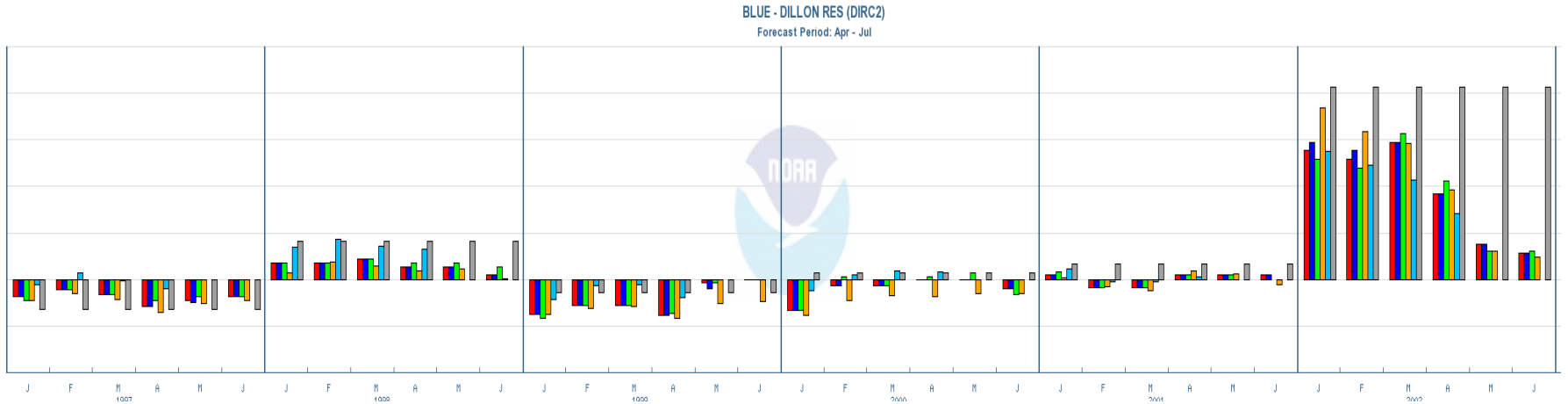
- **Warning**
  - SS can be miss leading when observed close to threshold (2003)

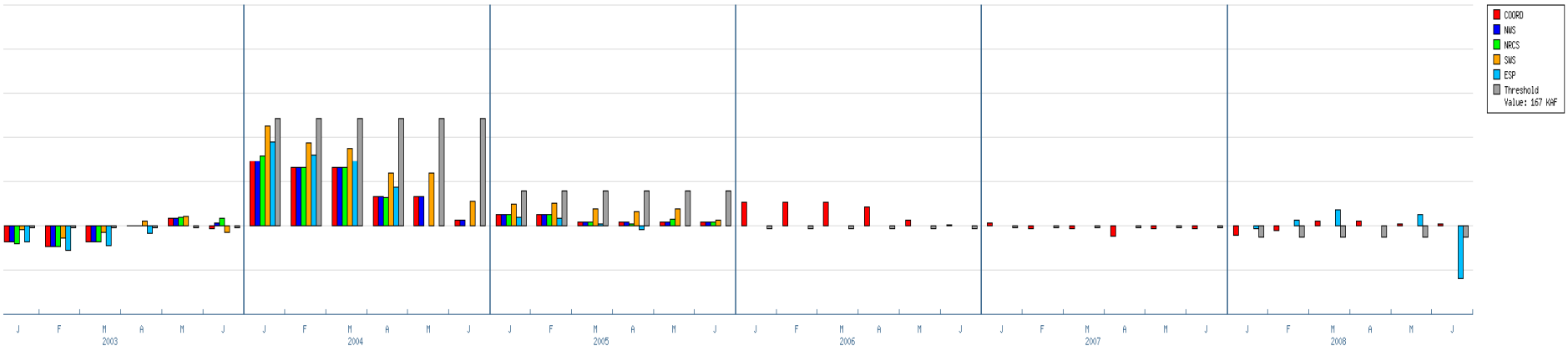
Error and Skill By Year



Percent Difference

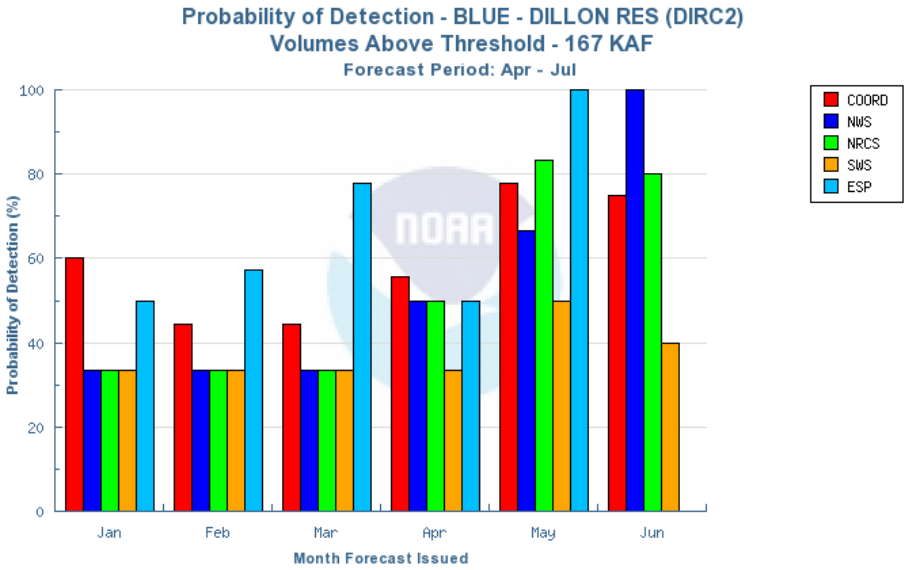


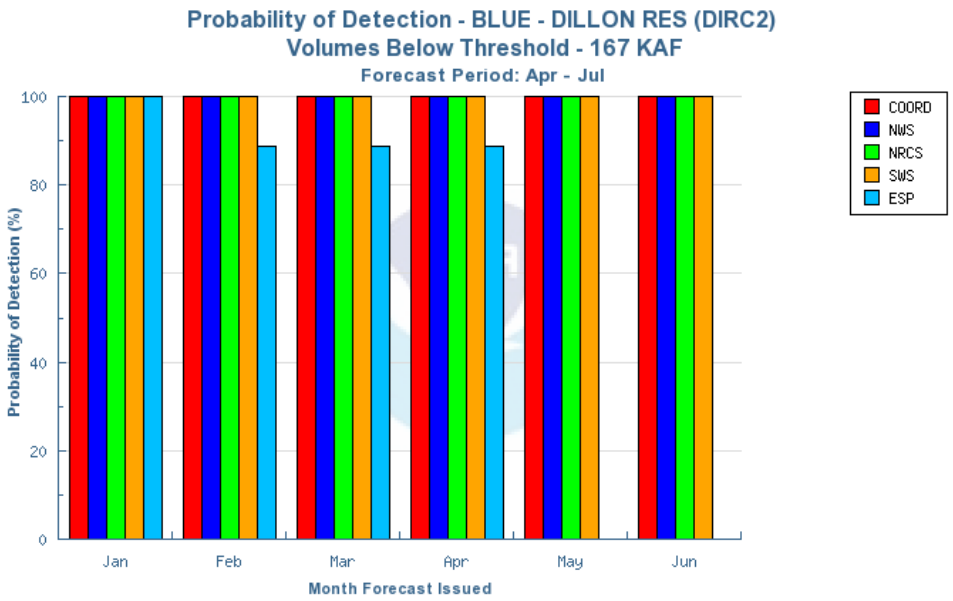




Probability of Detection

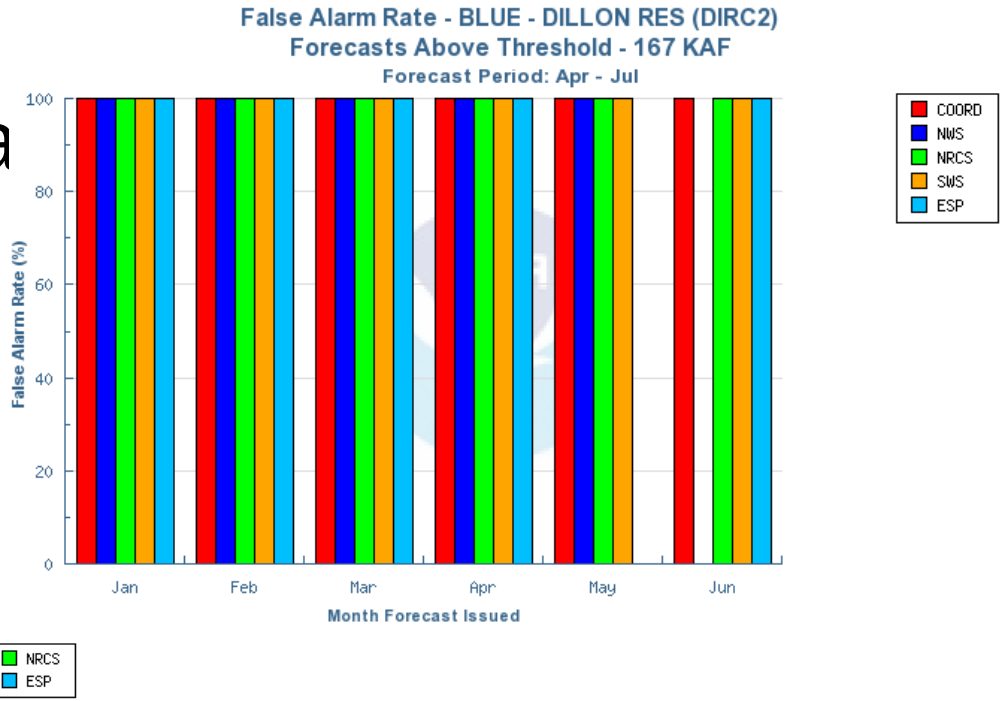
- High years much for difficult to detect in the early season
- All forecasts during low years have been for low volumes

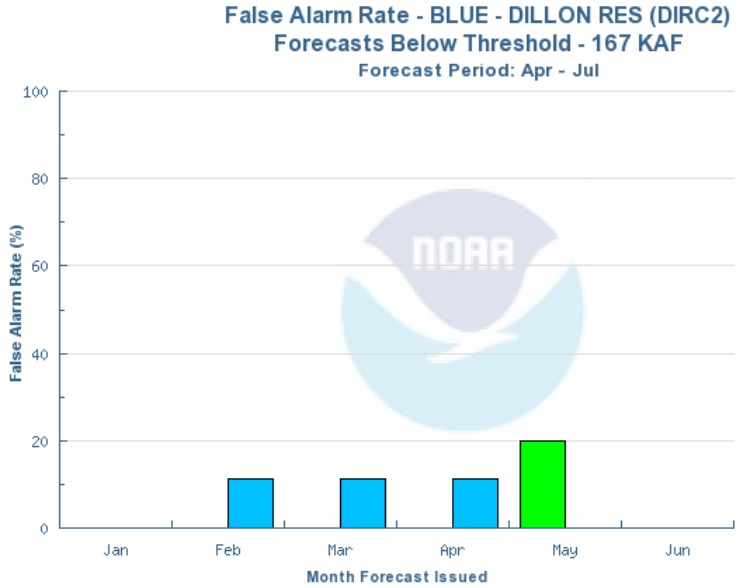




False Alarm Rate

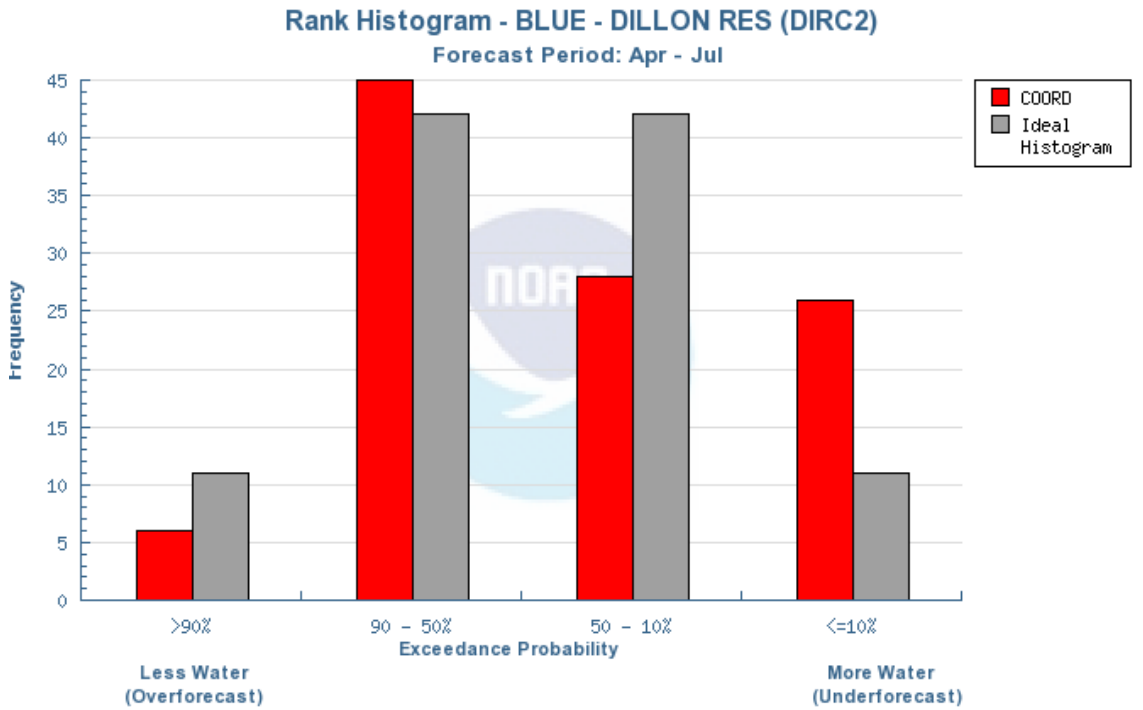
- Similar story here a
  with POD



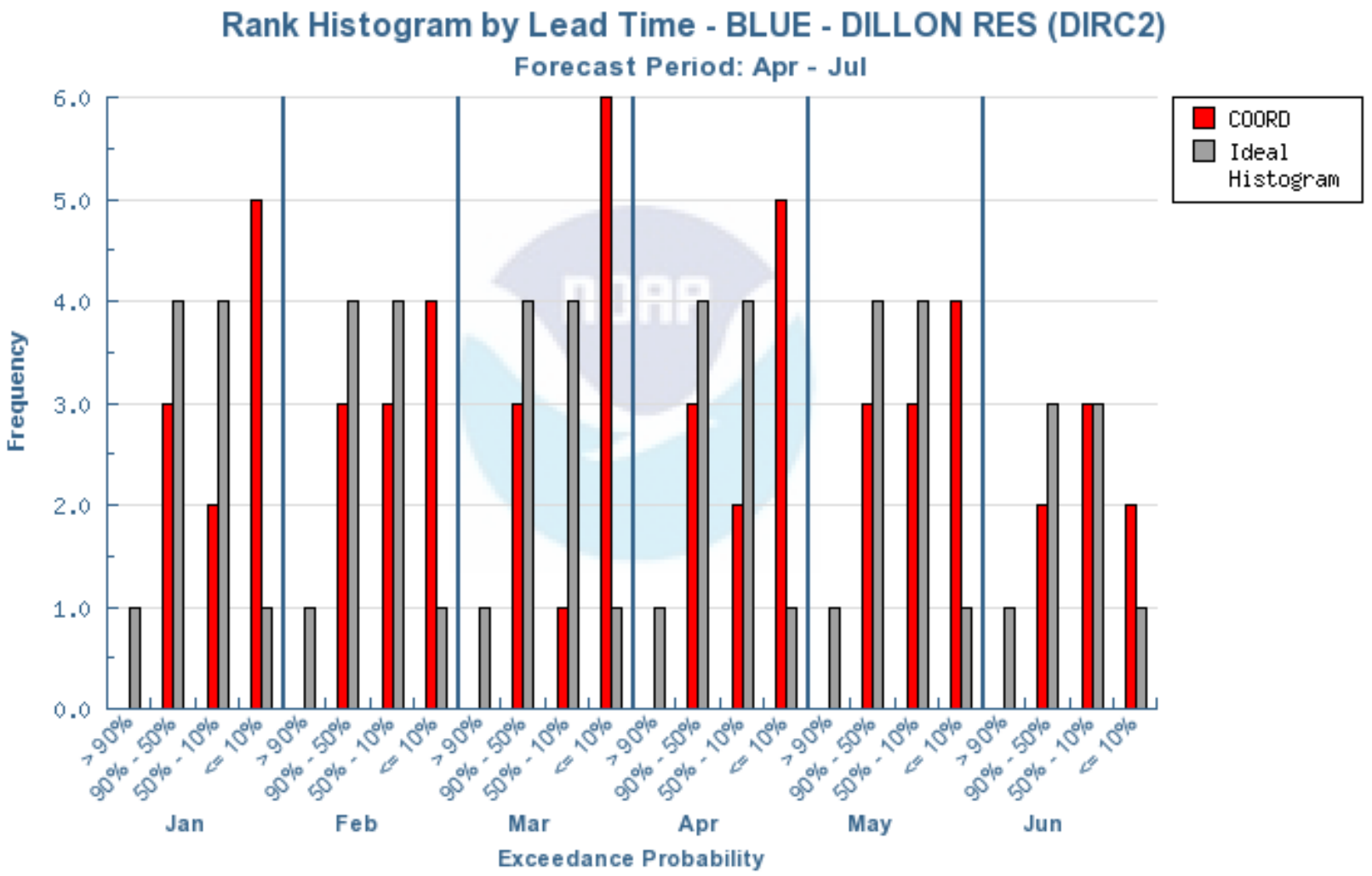


Forecast Distribution

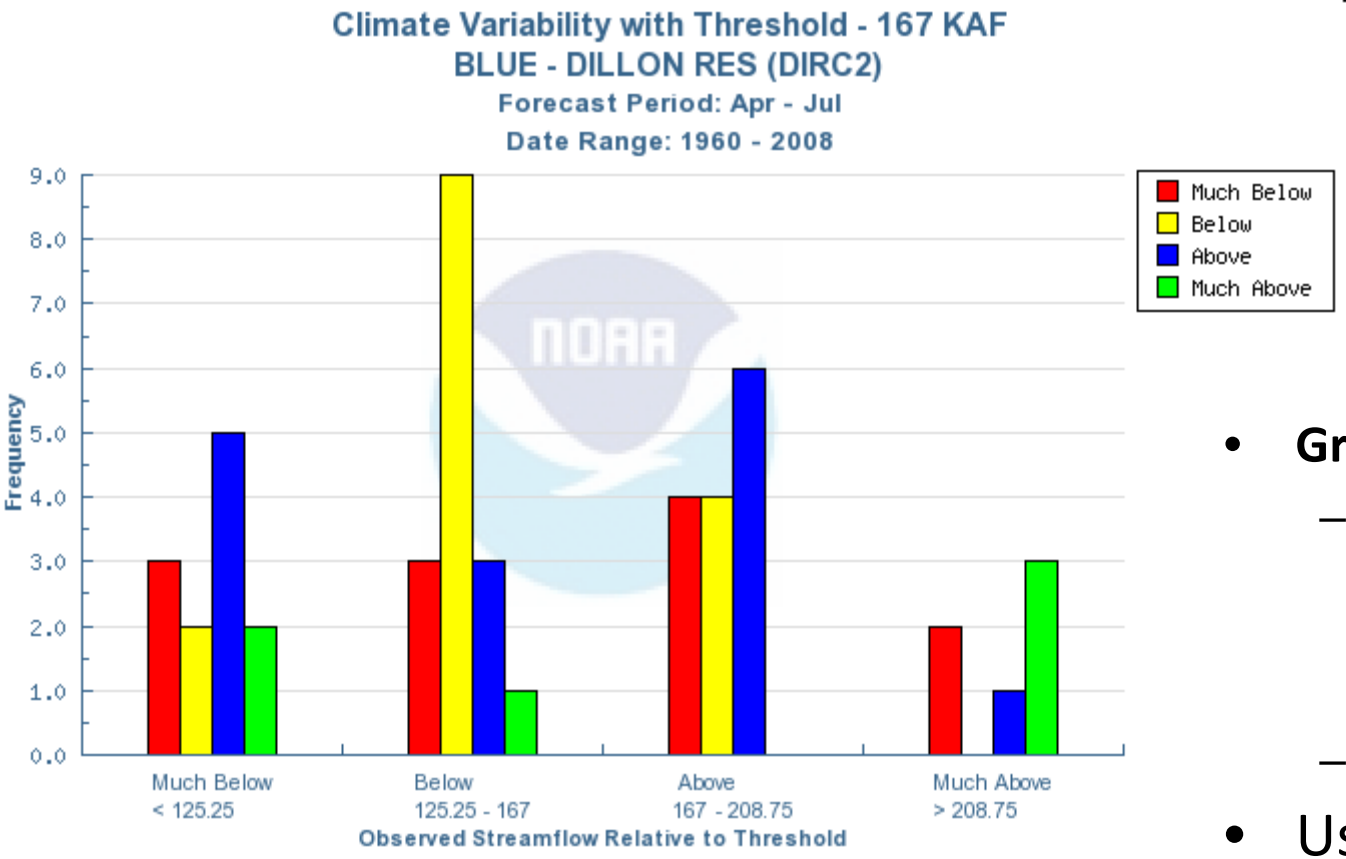
- Some tendency to underforecast
- 26% of observed streamflow falls above the 10% exceedance forecast value
- Reasonable max not so reasonable
- Results very dependent on years selected

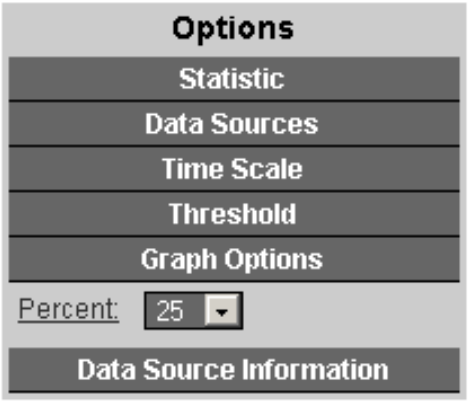


Forecast Uncertainty by month



Observed Lag-1 Analysis Climate Variability



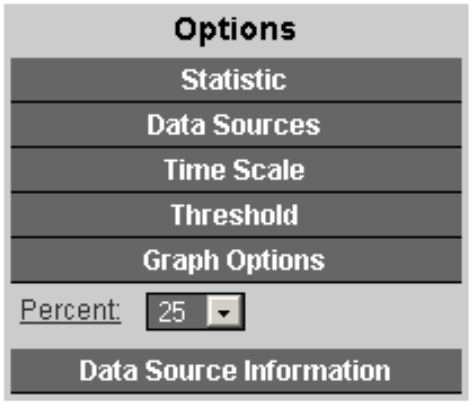


- **Graph Options**
  - Select the percentage to adjust the categories
  - 25% Default
- Uses all observed years in database

Contingency Table

Contingency Table for Jan with Threshold - 167 KAF
BLUE - DILLON RES (DIRC2)

COORD NWS NRCS SWS ESP		Observed Streamflow			
		Much Below < 125.25 KAF	Below 125.25 - 167 KAF	Above 167 - 208.75 KAF	Much Above > 208.75 KAF
Forecast Streamflow	Much Below < 125.25 KAF	2002	1991 2000 2000 2000 2000	1999 1999 1999 1999	1995 1995 1995 1995
	Below 125.25 - 167 KAF	1994 1998 2002 2004 2005 1994 1998 2002 2004 2005 1994 1998 2004 2005 1994 1998 2002 2004 2005 1994 1998 2002 2004 2005	1992 2001 2001 2001 1992 2001 1991 1992 2000 2001	1993 2003 1993 2003 1993 2003 1993 2003 1993 1999 2003	1995
	Above 167 - 208.75 KAF			2007 2008 2008	1996 1997 1996 1997 1996 1997 1996 1997
	Much Above > 208.75 KAF			2006	1996 1997



- **Graph Options**
  - Select the percentage to adjust the categories
  - 25% Default
  - Month Displayed January by default