

Western Water Verification

www.nwrfc.noaa.gov/westernwater/beta

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Outline

- Verification capabilities
- Graphing capabilities
- Example

Motivations

- Improve understanding of uncertainty from forecast tools
 - How good are our forecasts?
 - How much value do human forecasters add?
 - Is one tool better than another?
 - How do the above questions depend on lead time?
Amount of runoff?
- Can we use what we learn to:
 - Improve forecasts?
 - Make forecast process more efficient?
 - Improve collaboration?
 - Convey uncertainty to our users?

Verification Capabilities

NOAA/NWS Water Resource Forecasts

water supply map water supply forecasts ensemble forecast verification climate scenarios data checkout about western water

Location: **Invalid Location** [change location](#) [clear location](#)

Search:

Browse:

Location must be selected before verification data can be displayed

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

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

Verification Capabilities

NOAA/NWS Water
Resource Forecasts

water supply
map

water supply
forecasts

ensemble
forecast

verification

climate
scenarios

data
checkout

about
western water

Location: Blue at Dillon Res, Colorado (DIRC2 - CBRFC)

change location

clear location

Seasonal Forecast Verification and Analysis

1 Select Period:

Select Period ▼

2 Select Years:

Select Period First ▼

3 Select Data Sources:

- Coordinated Forecast
- National Weather Service
- Natural Resource Conservation Service
- Statistical Water Supply
- California Department of Water Resources
- Ensemble Streamflow Prediction
- Ensemble Streamflow Prediction - Empirical
- Ensemble Streamflow Prediction - Normal
- Ensemble Streamflow Prediction - Lognormal
- Ensemble Streamflow Prediction - Wakeby
- Ensemble Streamflow Prediction - Logwiebull
- Ensemble Streamflow Prediction - Weibull
- Ensemble Streamflow Prediction - Loglogistic

Verification Capabilities

4 Select Plot Type:

- Historical
- Streamflow Histogram
- Scatterplot
- Mean Absolute Error (Lead Time)
- Mean Absolute Error (Years)
- Root Mean Squared Error (Lead Time)
- Root Mean Squared Error (Year)
- Skill Score (Lead Time)
- Skill Score (Years)
- Percent Difference
- Probability of Detection Above Threshold
- Probability of Detection Below Threshold
- False Alarm Rate Above Threshold
- False Alarm Rate Below Threshold
- Rank Histogram
- Rank Histogram (Lead Time)
- Climate Variability
- Contingency Table

Load Statistics

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

Verification Capabilities

NOAA/NWS Water
Resource Forecasts

water supply
map

water supply
forecasts

ensemble
forecast

verification

climate
scenarios

data
checkout

about
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Location: Blue at Dillon Res, Colorado (DIRC2 - CBRFC)

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clear location

Seasonal Forecast Verification and Analysis

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Select Period ▼

2 Select Years:

Select Period First ▼

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- California Department of Water Resources
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- Ensemble Streamflow Prediction - Weibull
- Ensemble Streamflow Prediction - Loglogistic

- Select Forecast Period
- Forecasts Available
- Climatology Available

Verification Capabilities

NOAA/NWS Water
Resource Forecasts

water supply
map

water supply
forecasts

ensemble
forecast

verification

climate
scenarios

data
checkout

about
western water

Location: Blue at Dillon Res, Colorado (DIRC2 - CBRFC)

change location

clear location

Seasonal Forecast Verification and Analysis

1 Select Period: Apr-Jul

2 Select Years:

3 Select Data Sources:

- Coordinated Forecast
- National Weather Service
- Natural Resource Conservation Service
- Statistical Water Supply
- California Department of Water Resources
- Ensemble Streamflow Prediction
- Ensemble Streamflow Prediction - Empirical
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- Ensemble Streamflow Prediction - Logwiebull
- Ensemble Streamflow Prediction - Weibull
- Ensemble Streamflow Prediction - Loglogistic

•Select Years

•Appear on Period Selection

•Select any set of years available

Verification Capabilities

NOAA/NWS Water
Resource Forecasts

water supply
map

water supply
forecasts

ensemble
forecast

verification

climate
scenarios

data
checkout

about
western water

Location: Blue at Dillon Res, Colorado (DIRC2 - CBRFC)

change location

clear location

Seasonal Forecast Verification and Analysis

1 Select Period:

Apr-Jul

2 Select Years:

2002
2003
2004
2005
2006
2007
2008

3 Select Data Sources:

- Coordinated Forecast
- National Weather Service
- Natural Resource Conservation Service
- Statistical Water Supply
- California Department of Water Resources
- Ensemble Streamflow Prediction
- Ensemble Streamflow Prediction - Empirical
- Ensemble Streamflow Prediction - Normal
- Ensemble Streamflow Prediction - Lognormal
- Ensemble Streamflow Prediction - Wakeby
- Ensemble Streamflow Prediction - Logwiebull
- Ensemble Streamflow Prediction - Weibull
- Ensemble Streamflow Prediction - Loglogistic

•Select Data Source

•Six Main Sources Selected by Default

•ESP option additional

Verification Capabilities

4 Select Plot Type:

- Select Plot Type
- Historical By Default

- Historical
- Streamflow Histogram
- Scatterplot
- Mean Absolute Error (Lead Time)
- Mean Absolute Error (Years)
- Root Mean Squared Error (Lead Time)
- Root Mean Squared Error (Year)
- Skill Score (Lead Time)
- Skill Score (Years)
- Percent Difference
- Probability of Detection Above Threshold
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Lead Statistics

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Site Options

Previous 5 Locations Viewed

[GBYC2](#)

Print Graph

Display Raw Data

Verification Capabilities

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•Load Statistics

Load Statistics

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[GBYC2](#)

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

Load Statistics

About Forecast Verification

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Site Options

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[GBYC2](#)

Print Graph

Display Raw Data

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

Load Statistics

About Forecast Verification

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Site Options

Previous 5 Locations Viewed

GBYC2

Print Graph

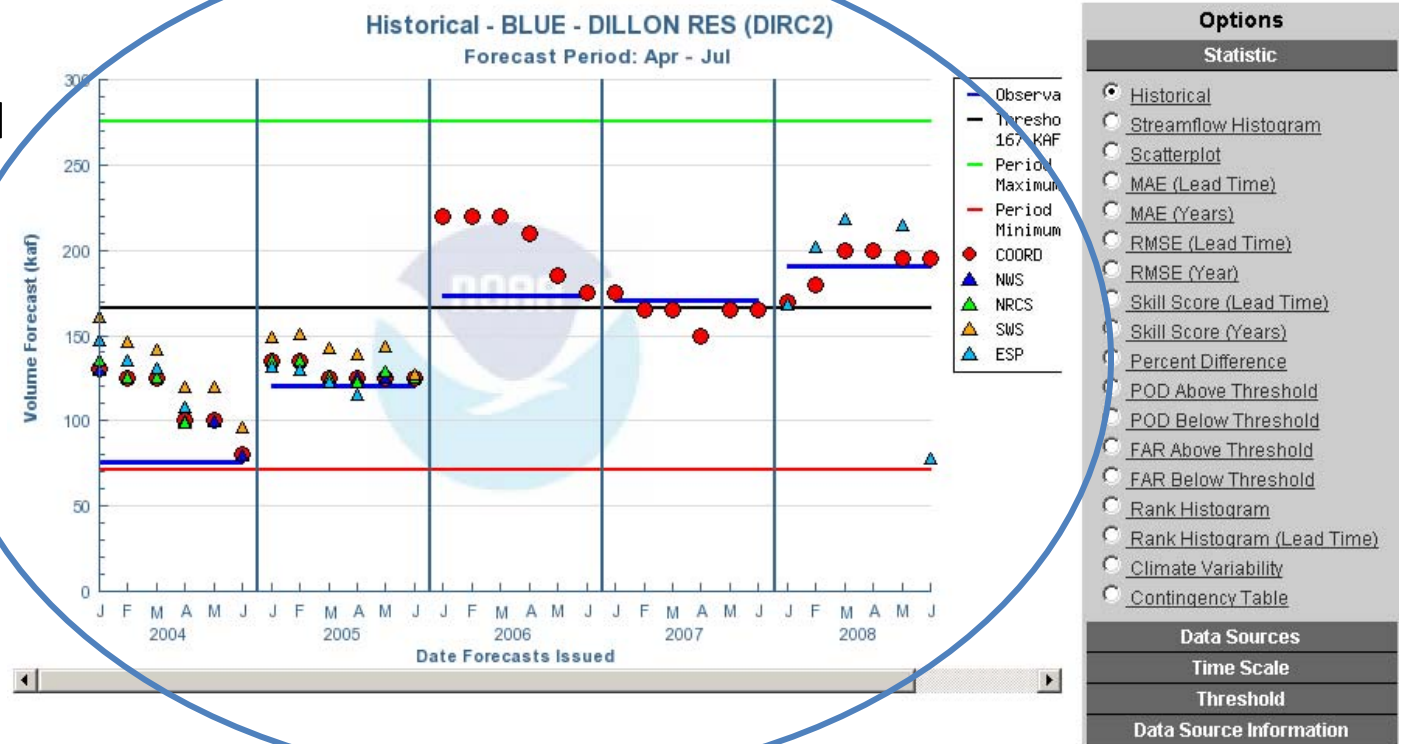
Display Raw Data

Verification Capabilities

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

Location: Blue at Dillon Res, Colorado (DIRC2 - CBRFC) change location clear location

Seasonal Forecast Verification and Analysis



About Historical

The historical plot displays the forecasted streamflow for the selected agencies by month and year for the forecast period. The forecast period is the month range that a forecast is valid for and the months that the observed streamflow is summed over. The observed streamflow period of record maximum and minimum streamflow is displayed as well as the threshold value (historical average is default).

Site Options

Previous 5 Locations Viewed

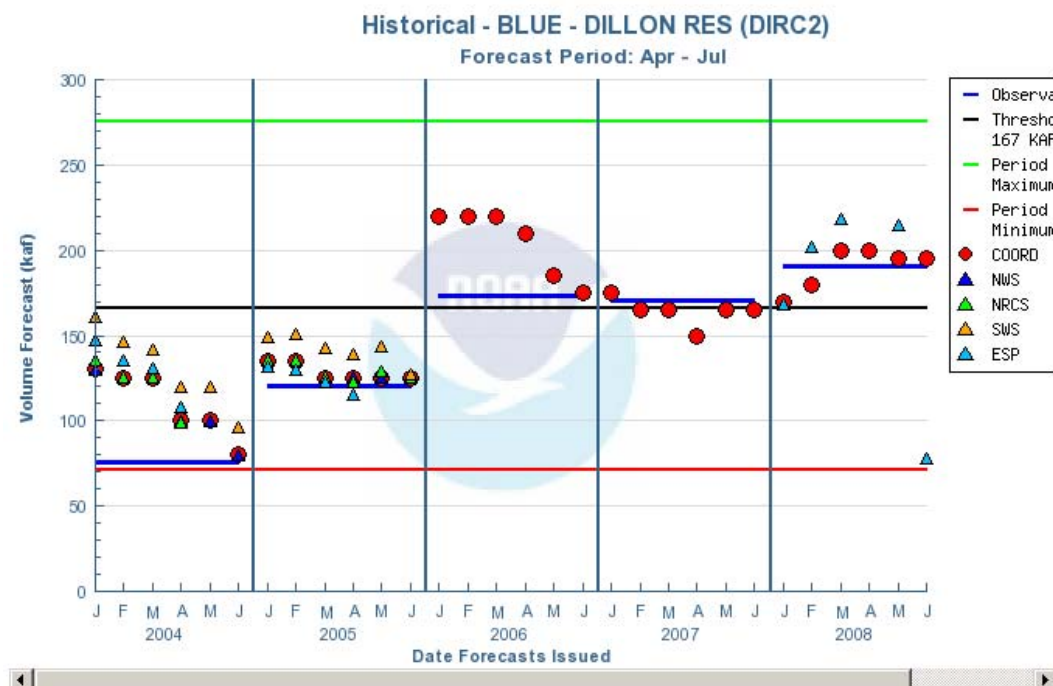
[DIRC2, GBYC2](#)

Print Graph Display Raw Data

Verification Capabilities

Seasonal Forecast Verification and Analysis

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



Options

Statistic

- Historical
- Streamflow Histogram
- Scatterplot
- MAE (Lead Time)
- MAE (Years)
- RMSE (Lead Time)
- RMSE (Year)
- Skill Score (Lead Time)
- Skill Score (Years)
- Percent Difference
- POD Above Threshold
- POD Below Threshold
- FAR Above Threshold
- FAR Below Threshold
- Rank Histogram
- Rank Histogram (Lead Time)
- Climate Variability
- Contingency Table

Data Sources

Time Scale

Threshold

Data Source Information

About Historical

The historical plot displays the forecasted streamflow for the selected agencies by month and year for the forecast period. The forecast period is the month range that a forecast is valid for and the months that the observed streamflow is summed over. The observed streamflow period of record maximum and minimum streamflow is displayed as well as the threshold value (historical average is default).

Site Options

Previous 5 Locations Viewed

DIRC2, GBYC2

Print Graph | Display Raw Data

Verification Capabilities

Options

Statistic

Historical

MAE (Lead Time)

MAE (Years)

RMSE (Lead Time)

RMSE (Year)

Skill Score (Lead Time)

Skill Score (Years)

Percent Difference

POD Above Threshold

POD Below Threshold

FAR Above Threshold

FAR Below Threshold

Rank Histogram

Rank Histogram (Lead Time)

Climate Variability

Contingency Table

Data Sources

Time Scale

Threshold

Data Source Information

The Historical displays forecast streamflows for the selected period from all agencies and observed streamflows from past years while referencing the historical maximum, minimum, and average.

- **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

| Options |
|---|
| Statistic |
| Data Sources |
| <input checked="" type="checkbox"/> <u>Coordinated Forecast</u> |
| <input checked="" type="checkbox"/> <u>National Weather Service</u> |
| <input checked="" type="checkbox"/> <u>Natural Resource Conservation Service</u> |
| <input checked="" type="checkbox"/> <u>Statistical Water Supply</u> |
| <input checked="" type="checkbox"/> <u>California Department of Water Resources</u> |
| <input checked="" type="checkbox"/> <u>Ensemble Streamflow Prediction</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Empirical</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Normal</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Lognormal</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Wakeby</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Logwiebull</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Weibull</u> |
| <input type="checkbox"/> <u>Ensemble Streamflow Prediction - Loglogistic</u> |
| Time Scale |
| Threshold |
| Data Source Information |

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

Verification Capabilities

| Options | |
|-------------------------|--|
| Statistic | |
| Data Sources | |
| Time Scale | |
| Period: | Apr-Jul ▾ |
| Years: | 1996 ▲ 1997 1998 1999 2000 2001 2002 ▾ |
| Month: | Jan ▾ |
| Threshold | |
| Graph Options | |
| Data Source Information | |

- **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

| Options | |
|-------------------------|---|
| Statistic | |
| Data Sources | |
| Time Scale | |
| Threshold | |
| Threshold Value: | <input type="text" value="mean"/> (KAF) |
| Data Source Information | |

- **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

| Options | |
|-------------------------|-------|
| Statistic | |
| Data Sources | |
| Time Scale | |
| Threshold | |
| Data Source Information | |
| COORD | 100% |
| NWS | 60% |
| NRCS | 60% |
| SWS | 60% |
| CADWR | 0% |
| ESP | 56.7% |

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

Example

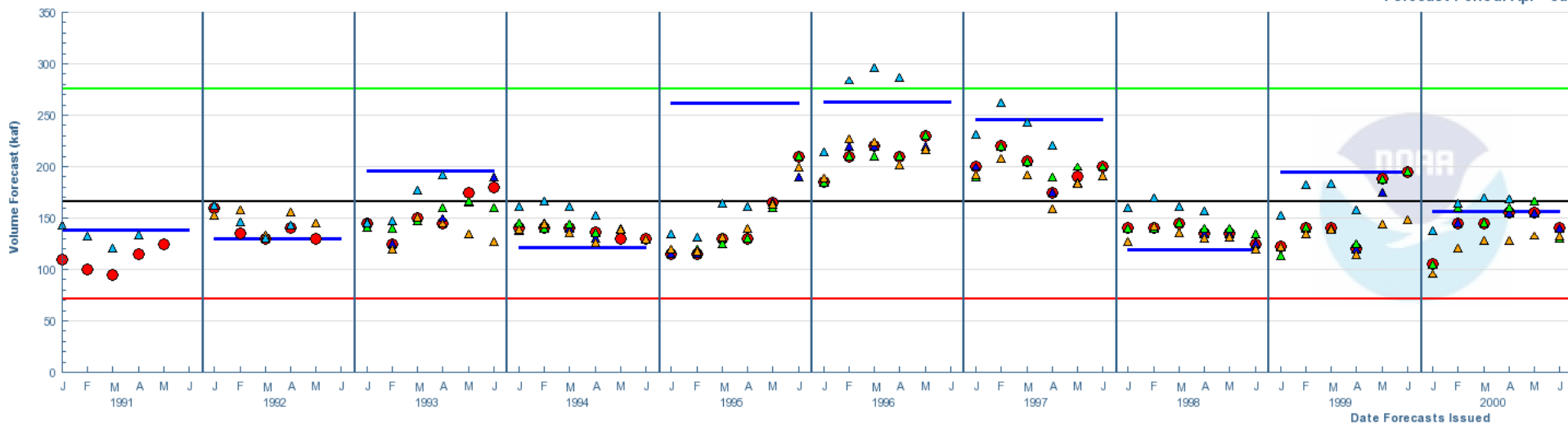
DIRC2

1991 – 2008 Forecast Available

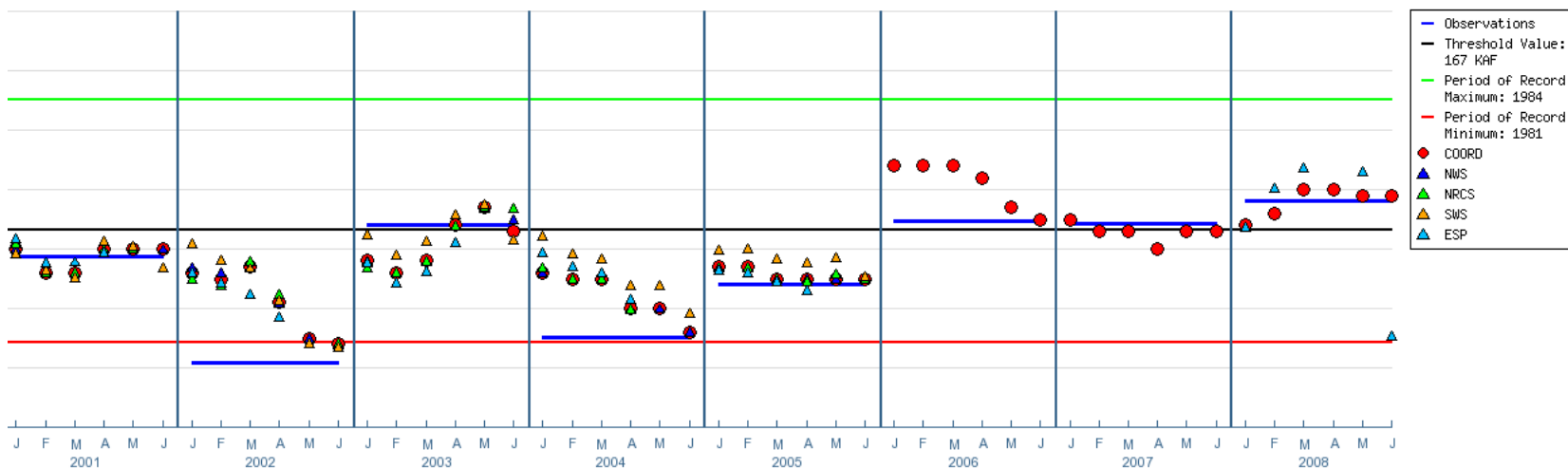
Historical

Historical - BLUE - DILLON RES

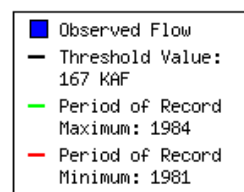
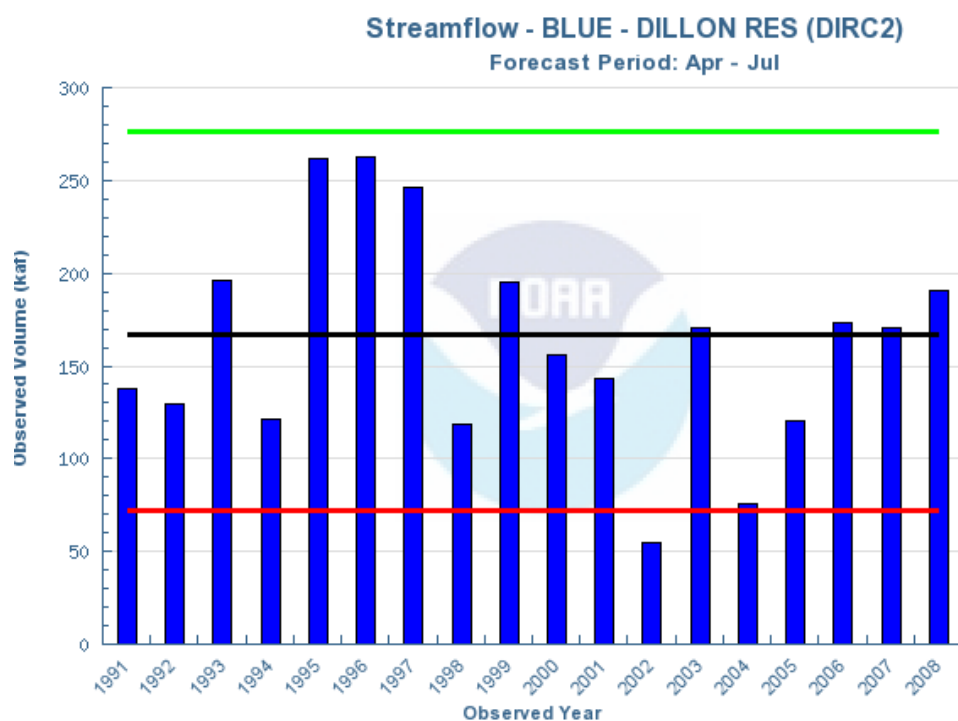
Forecast Period: Apr - Jul



(DIRC2)



Streamflow Histogram

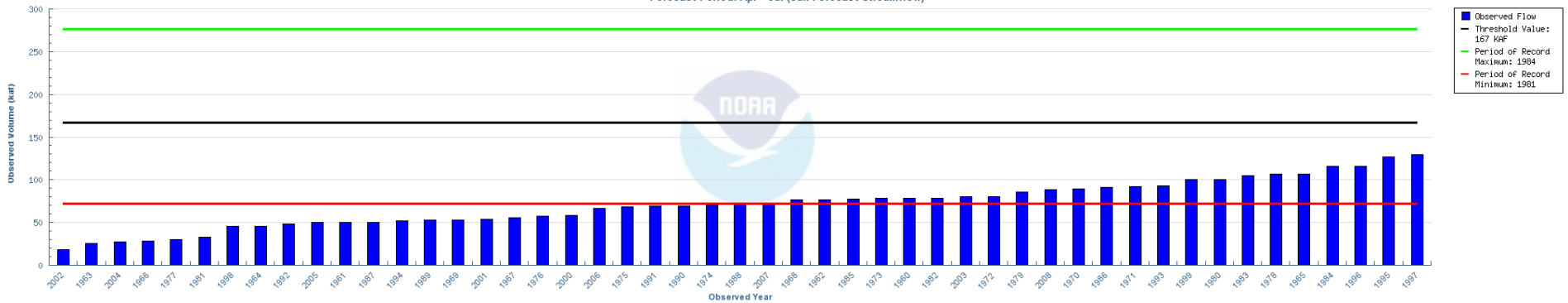


| Options | |
|-------------------------|----------|
| Statistic | |
| Data Sources | |
| Time Scale | |
| Threshold | |
| Graph Options | |
| Sortable: | Unsort |
| Years: | Selected |
| Months: | Sum |
| Data Source Information | |

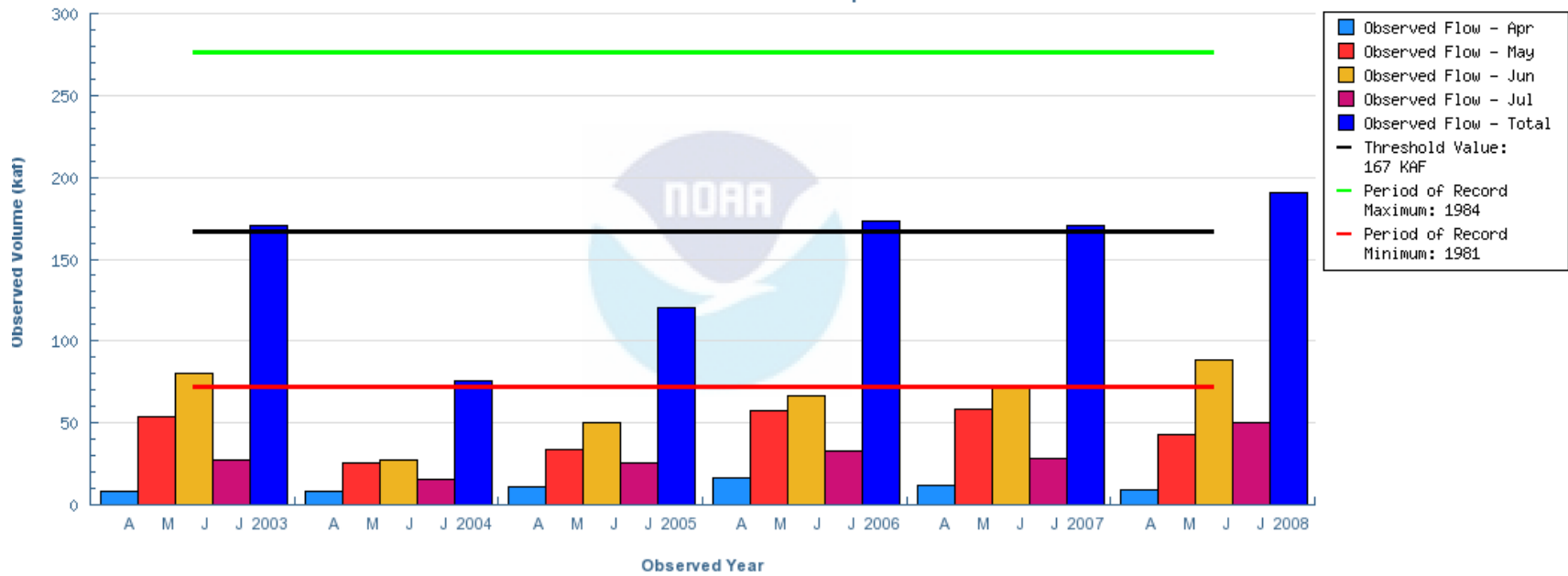
- **Graph Options**
 - Any Combination of Options
 - Sort/Unsort Years
 - Display selected Years or All Observed Years
 - Display Summed Months
 - Individual Months
 - Each Month and Summed

Streamflow Histogram

Streamflow - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul (Jun Forecast Streamflow)

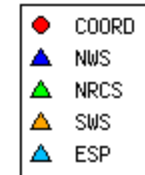
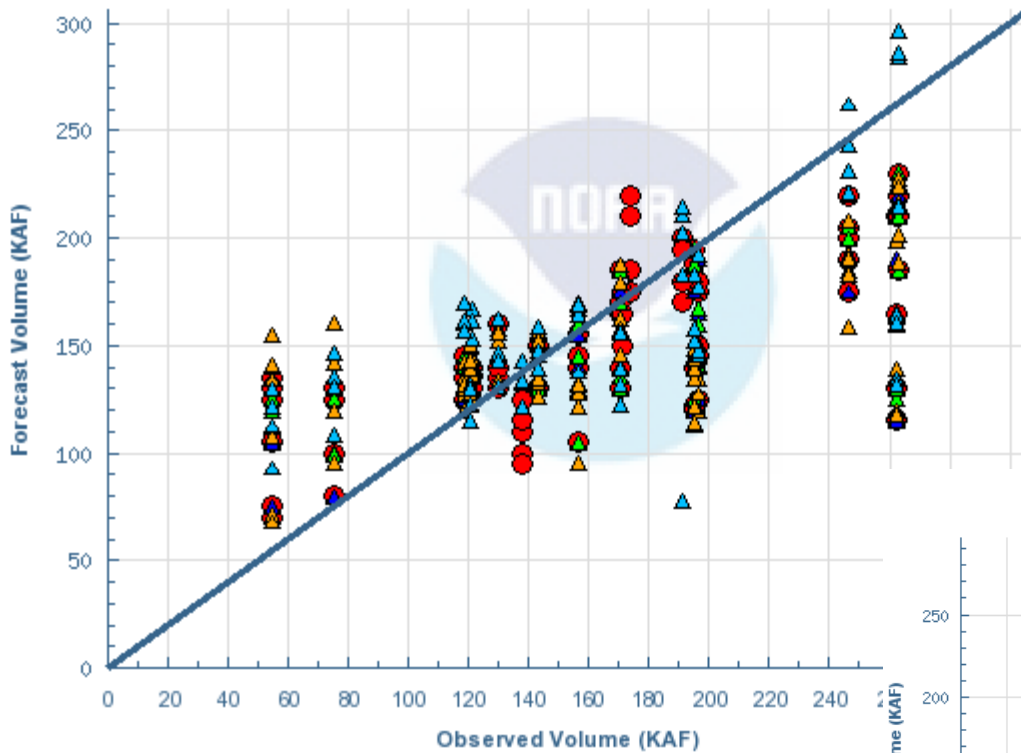


Streamflow - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



Scatterplot

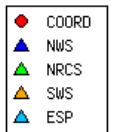
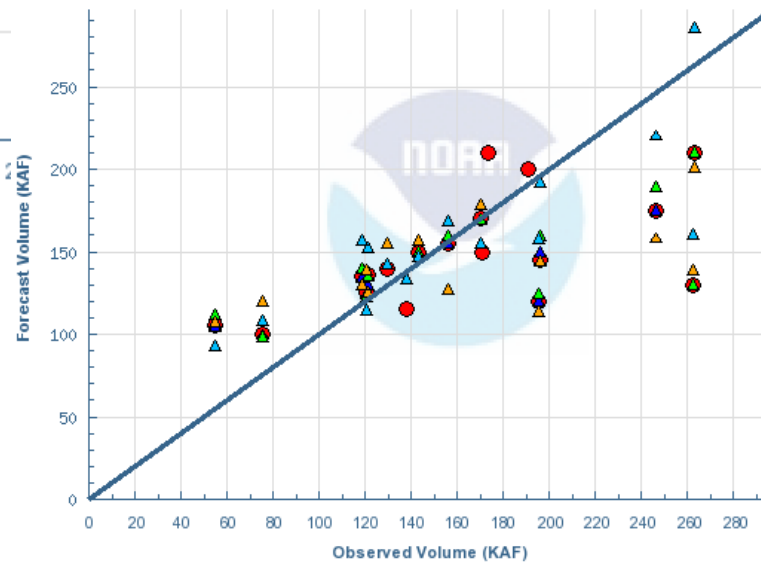
Streamflow - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



| Options | |
|-------------------------|-----|
| Statistic | |
| Data Sources | |
| Time Scale | |
| Threshold | |
| Graph Options | |
| Months: | All |
| Data Source Information | |

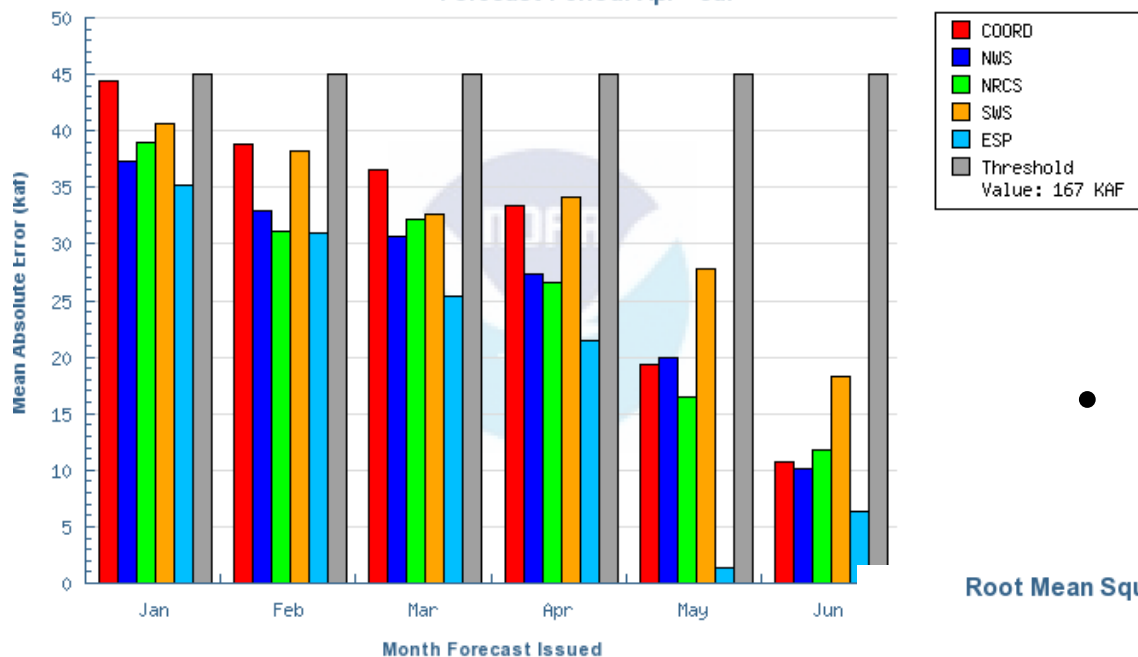
- **Graph Options**
 - Display All Months or Specific forecast Month

Streamflow - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul (Apr Forecast Streamflow)



Error and Skill By Lead Time

Mean Absolute Error - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



Options

Statistic

Data Sources

Time Scale

Threshold

Graph Options

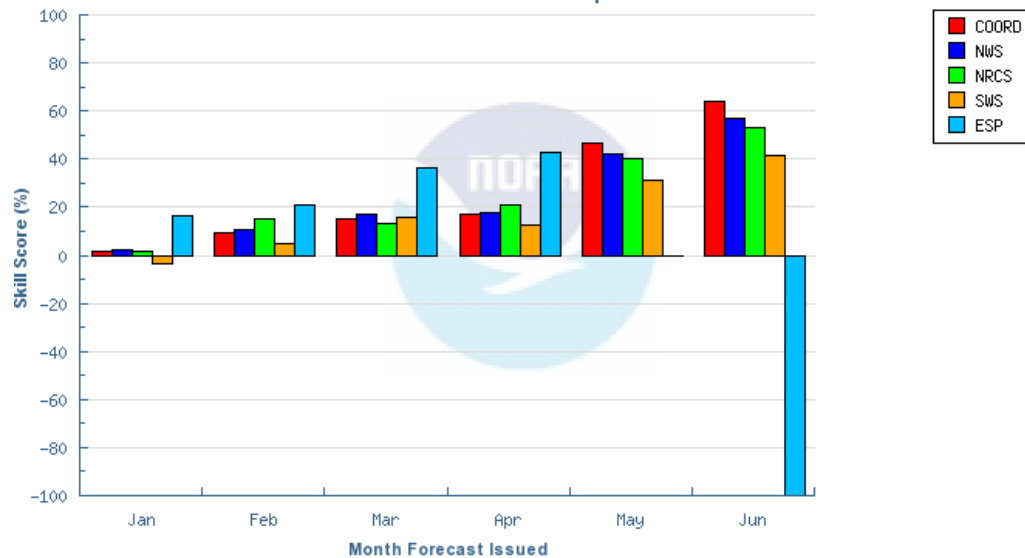
Years:

Data Source Information

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

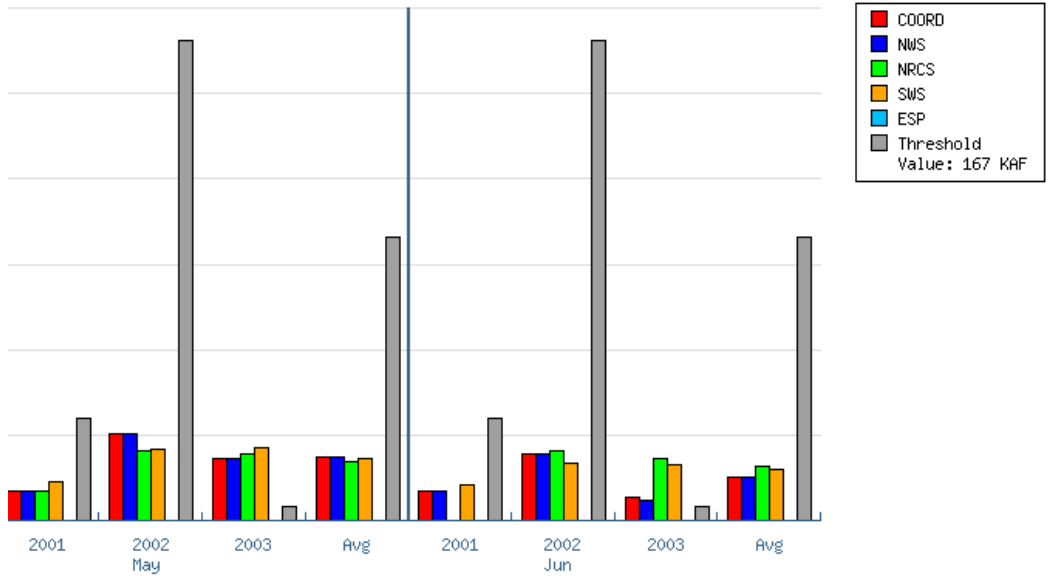
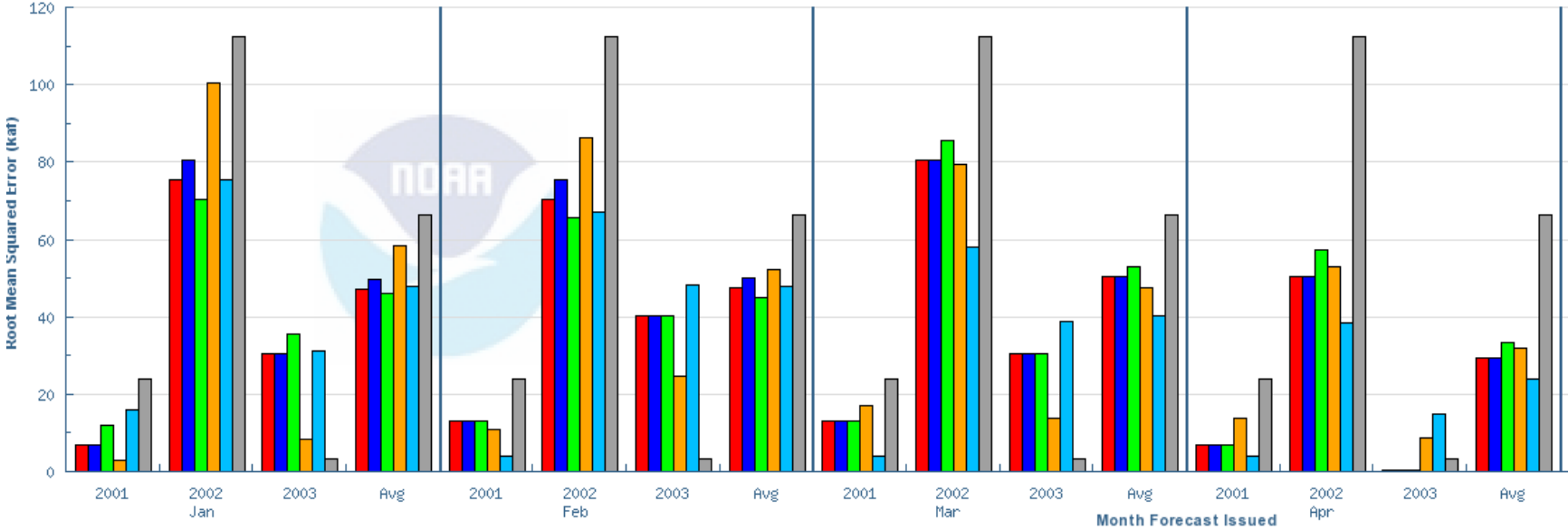
- Comparison of forecast error to “average” error useful diagnostic tool

Root Mean Squared Error Skill Score Relative to Threshold - 167 KAF
BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



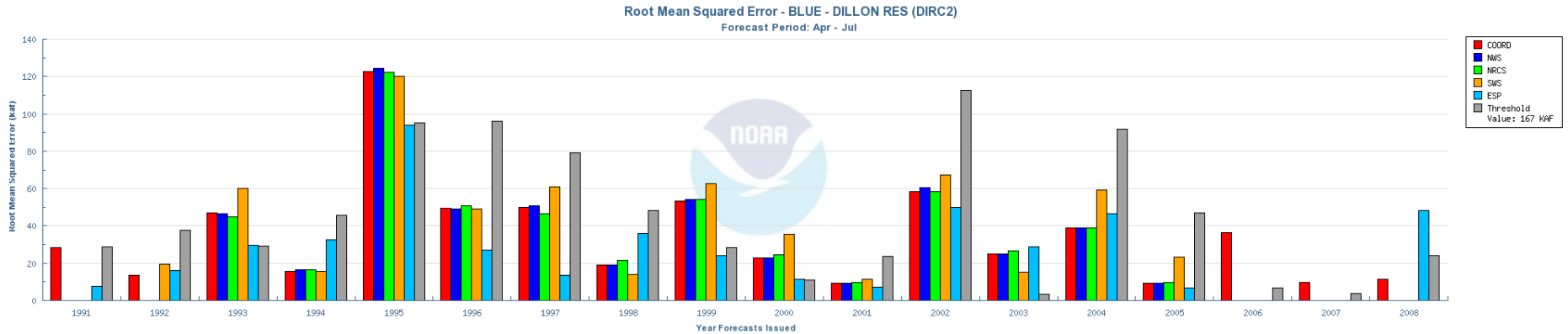
Error and Skill By Lead Time

Root Mean Squared Error - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



■ COORD
■ NWS
■ NRCS
■ SWS
■ ESP
■ Threshold
 Value: 167 KAF

Error and Skill By Year



Options

- Statistic
- Data Sources
- Time Scale
- Threshold
- Graph Options

Months:

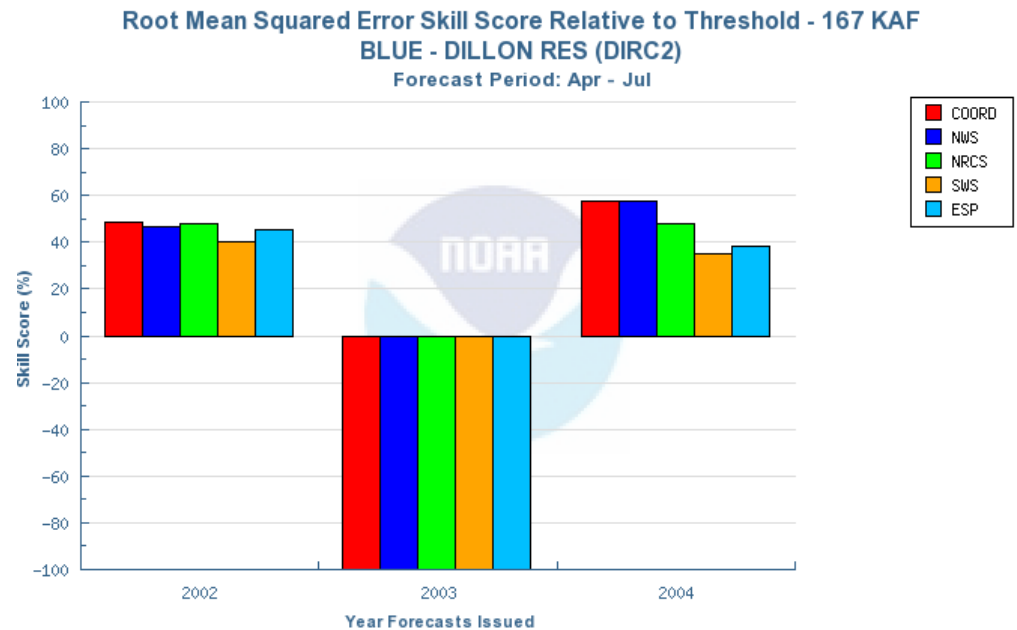
Data Source Information

- **Graph Options**

- Display All Months or Specific forecast Month

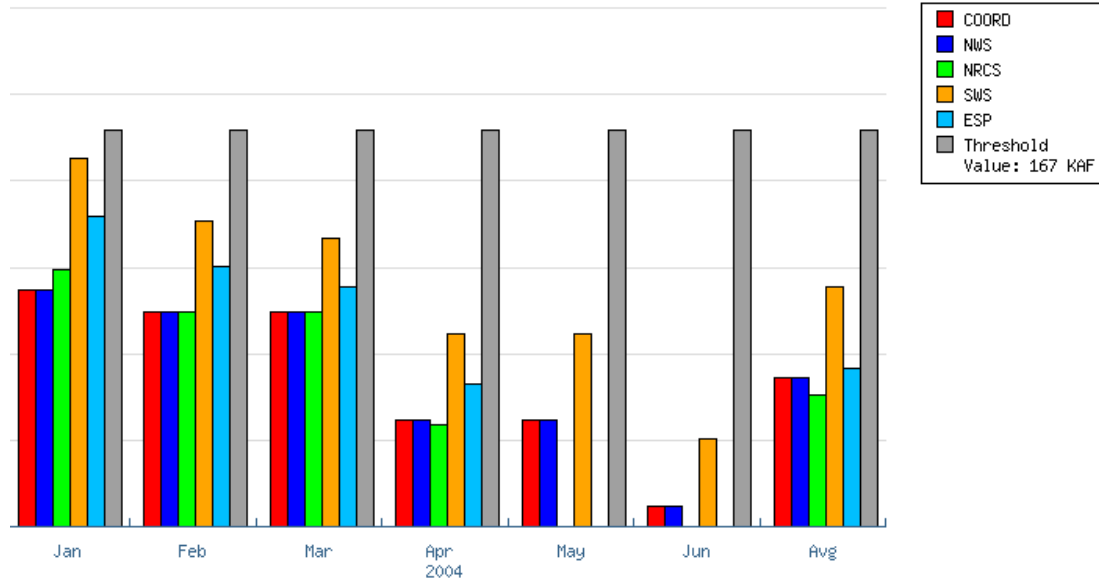
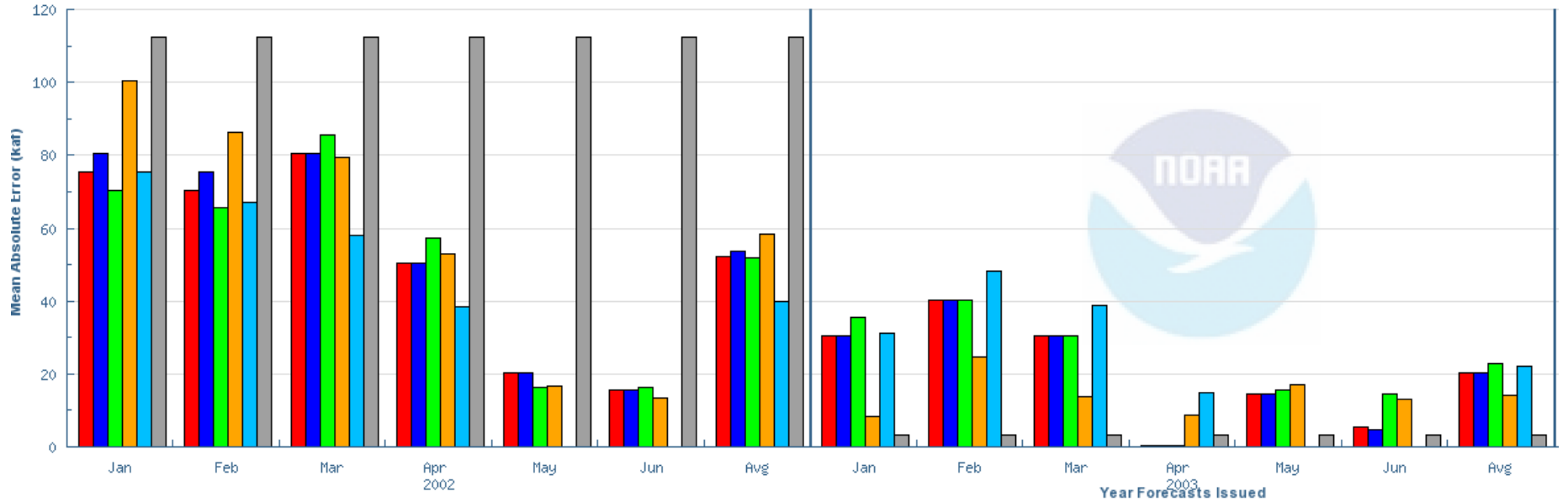
- **Warning**

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



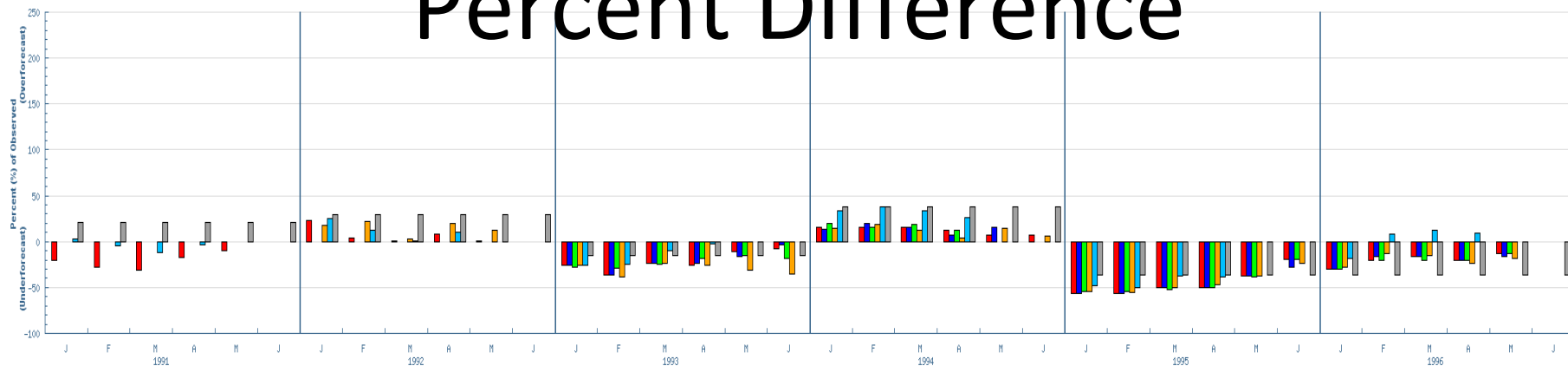
Error and Skill By Year

Mean Absolute Error - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul

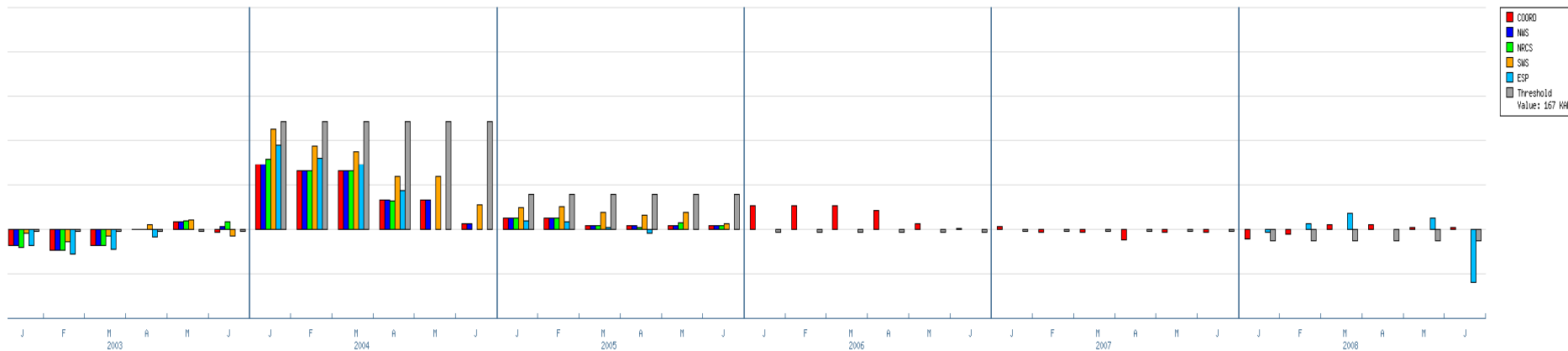
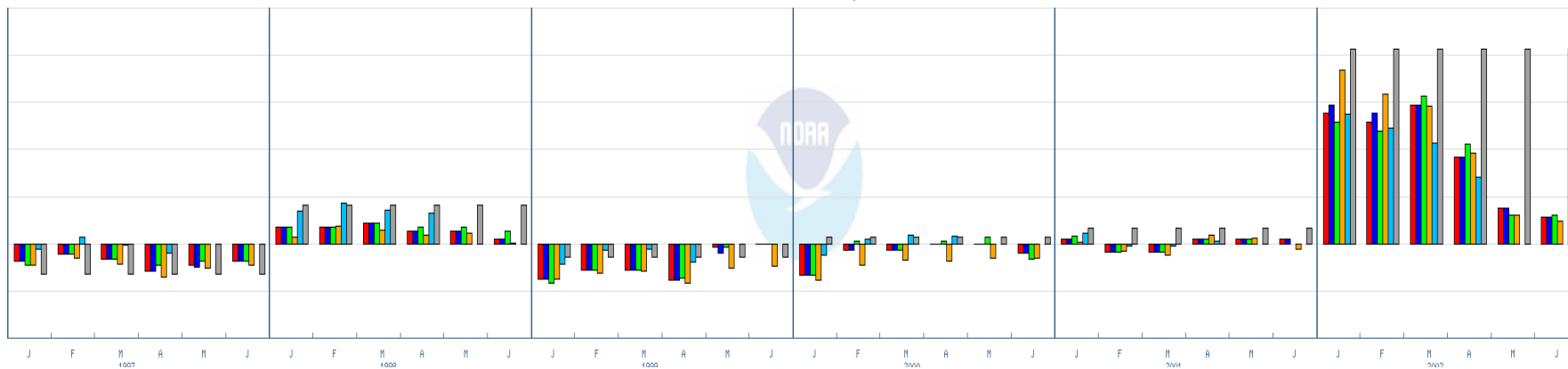


- COORD
- NWS
- NRCS
- SWS
- ESP
- Threshold Value: 167 KAF

Percent Difference



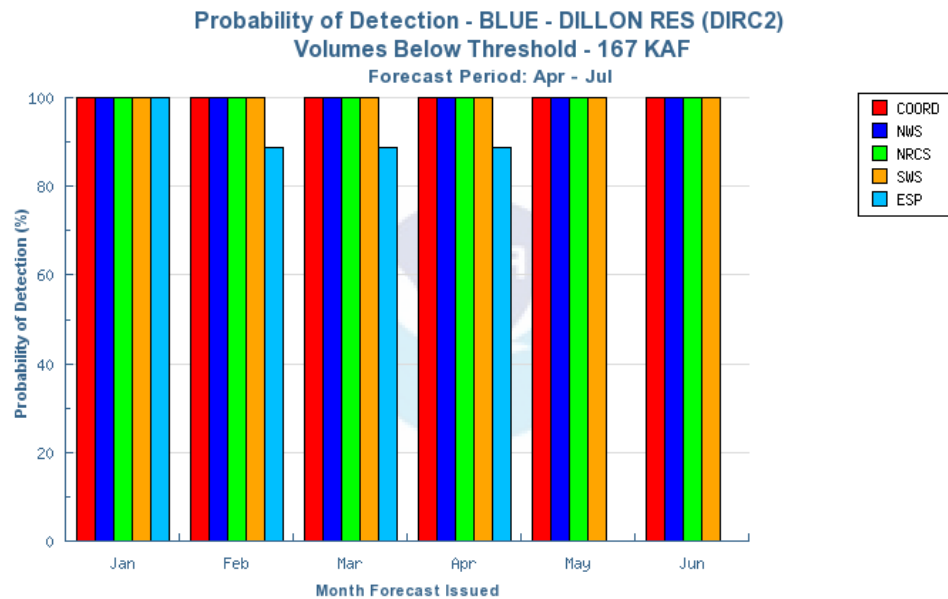
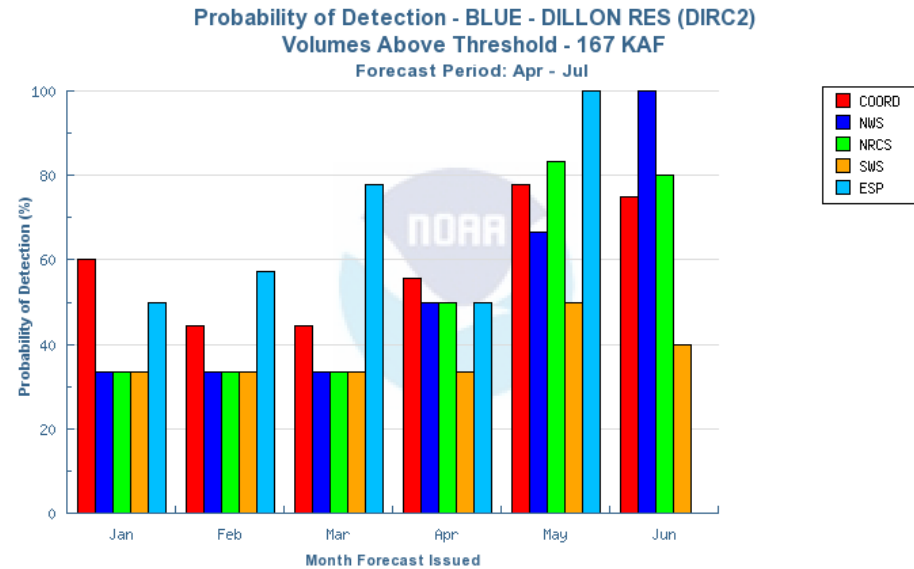
BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



- COORD
 - NWS
 - NCS
 - SWS
 - ESP
 - Threshold
- Value: 167 KWF

Probability of Detection

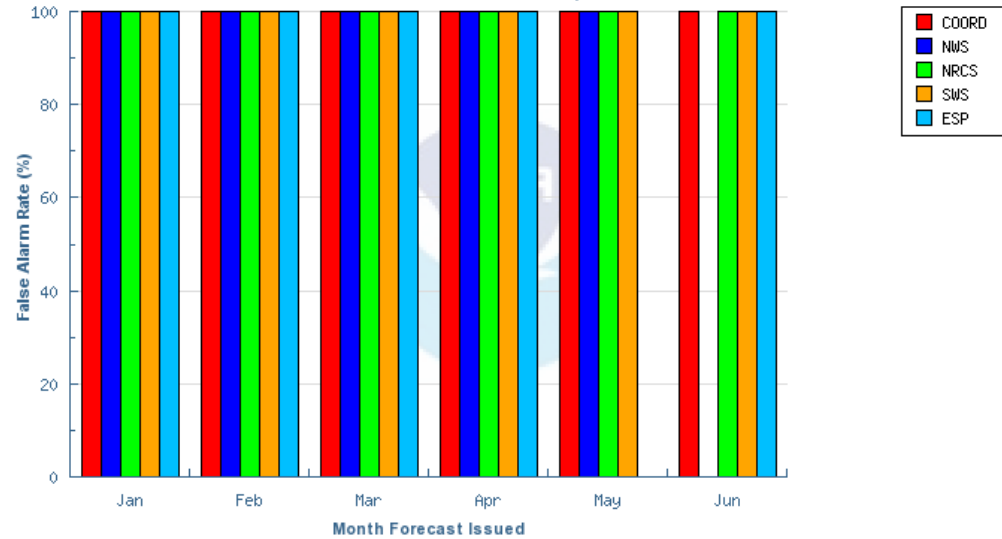
- High years much for difficult to detect in the early season
- All forecasts during low years have been for low volumes



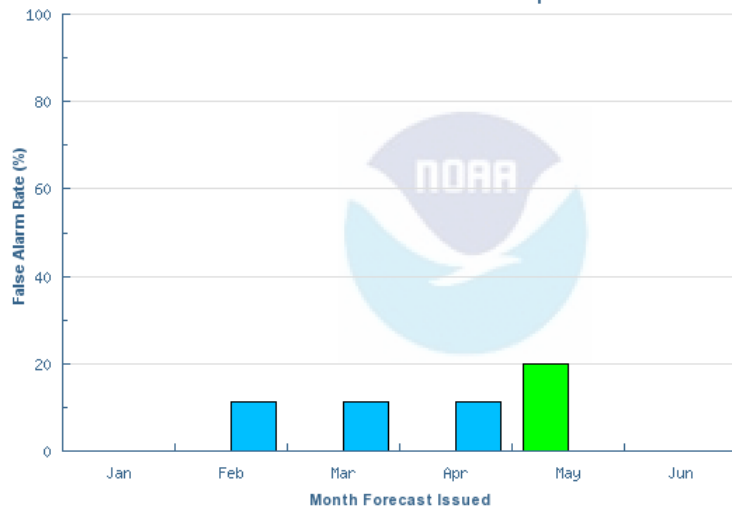
False Alarm Rate

- Similar story here as with POD

False Alarm Rate - BLUE - DILLON RES (DIRC2)
Forecasts Above Threshold - 167 KAF
Forecast Period: Apr - Jul

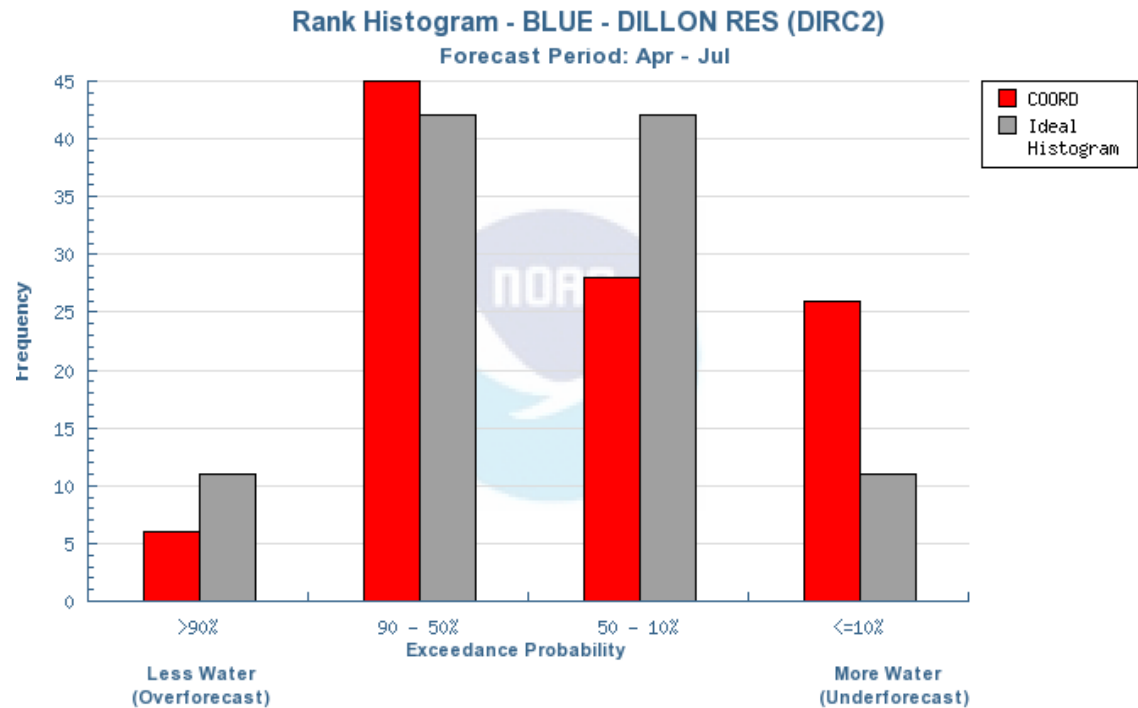


False Alarm Rate - BLUE - DILLON RES (DIRC2)
Forecasts Below Threshold - 167 KAF
Forecast Period: Apr - Jul



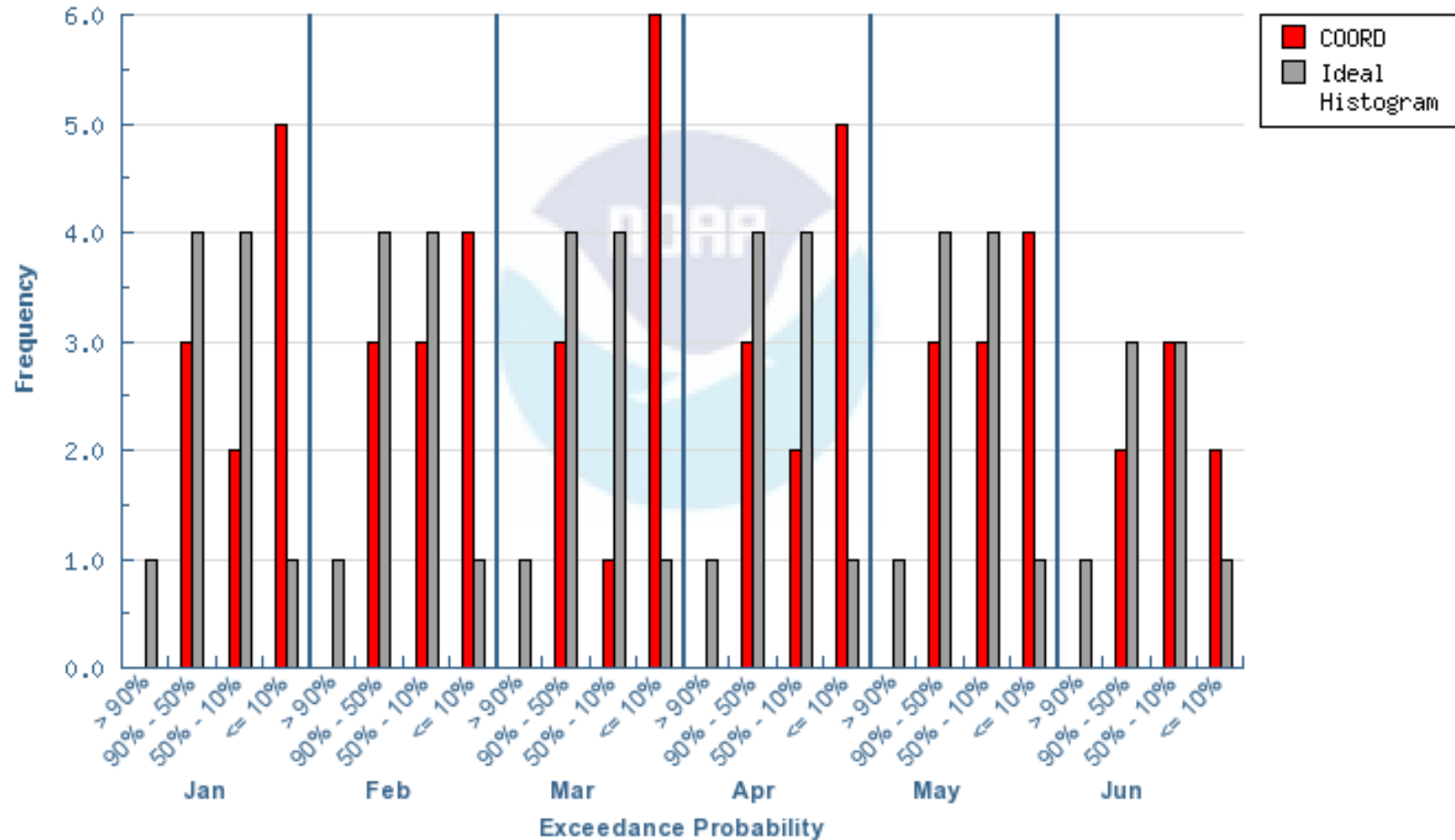
Forecast Distribution

- 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



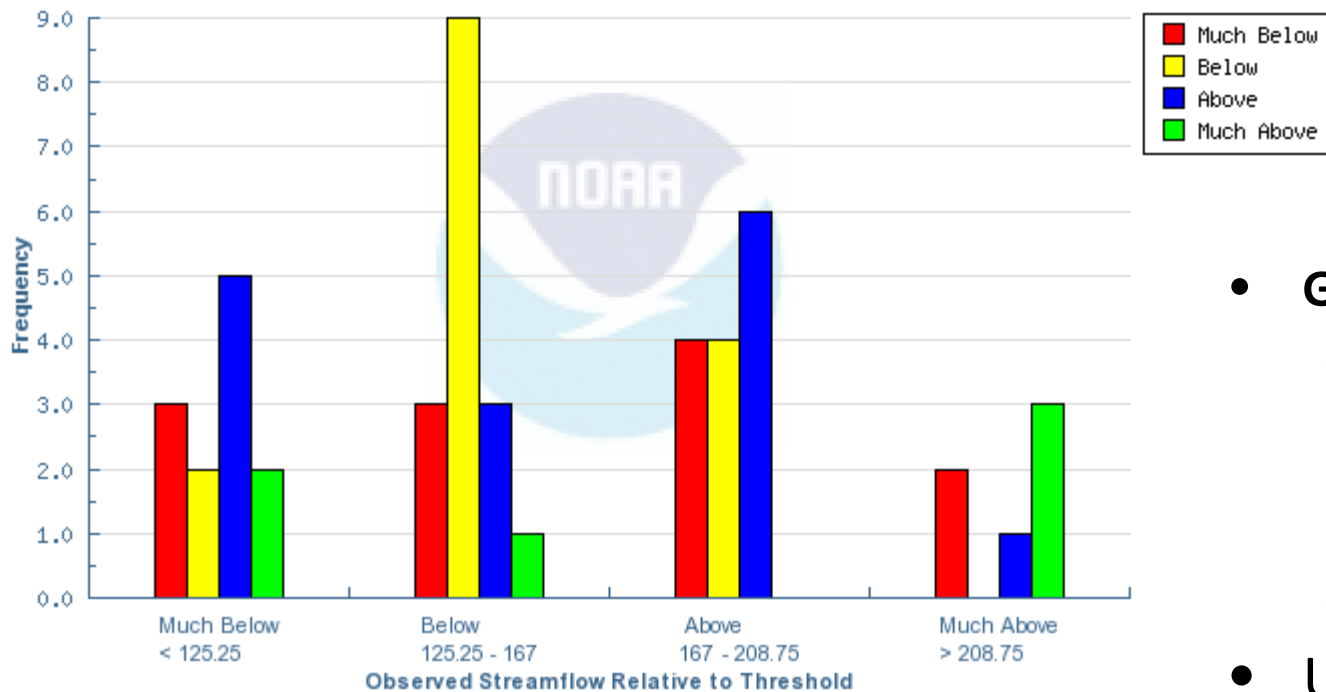
Forecast Uncertainty by month

Rank Histogram by Lead Time - BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul



Observed Lag-1 Analysis Climate Variability

Climate Variability with Threshold - 167 KAF
BLUE - DILLON RES (DIRC2)
Forecast Period: Apr - Jul
Date Range: 1960 - 2008



| Options | |
|-------------------------|----|
| Statistic | |
| Data Sources | |
| Time Scale | |
| Threshold | |
| Graph Options | |
| Percent: | 25 |
| Data Source Information | |

- **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 |
| F o r e c a s t S t r e a m f l o w | 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 |

Options

Statistic

Data Sources

Time Scale

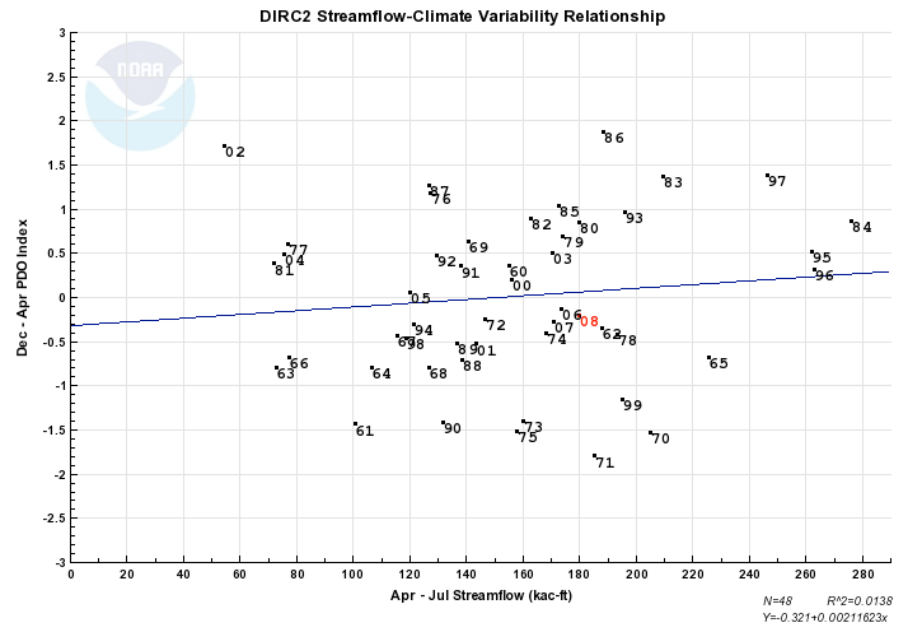
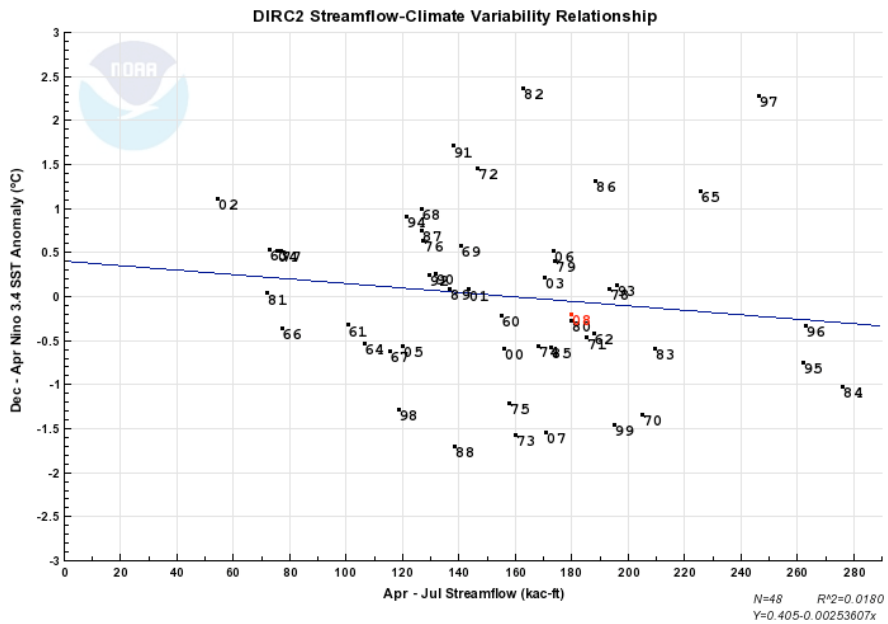
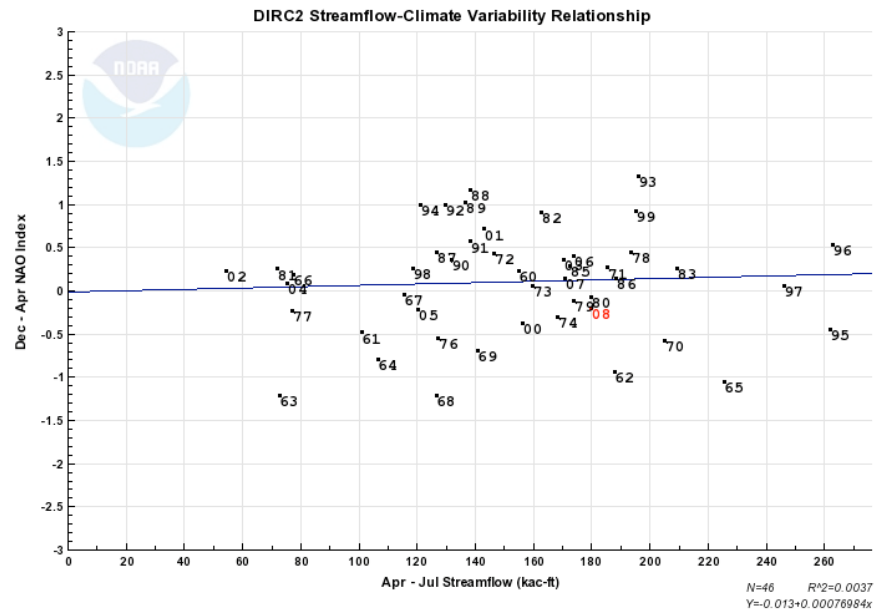
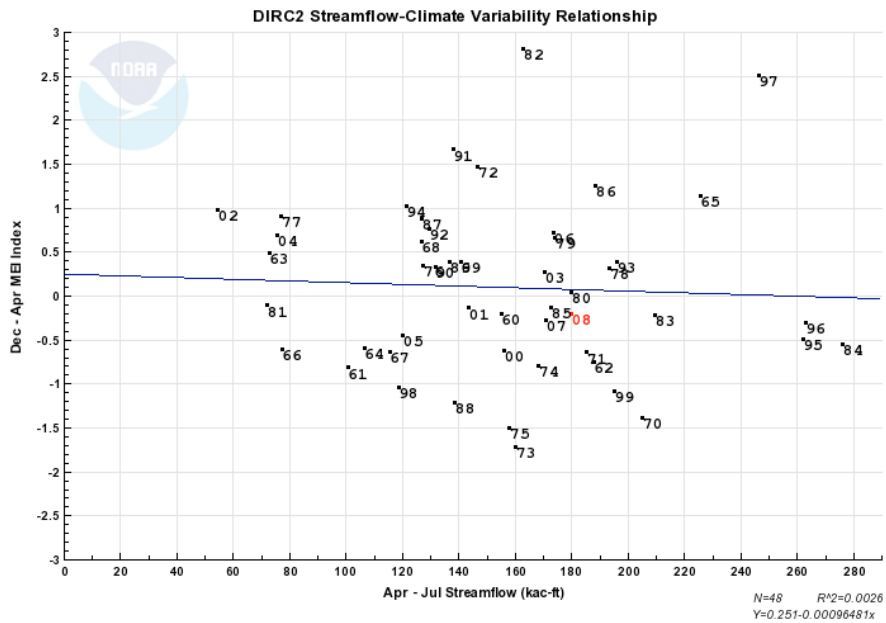
Threshold

Graph Options

Percent: ▾

Data Source Information

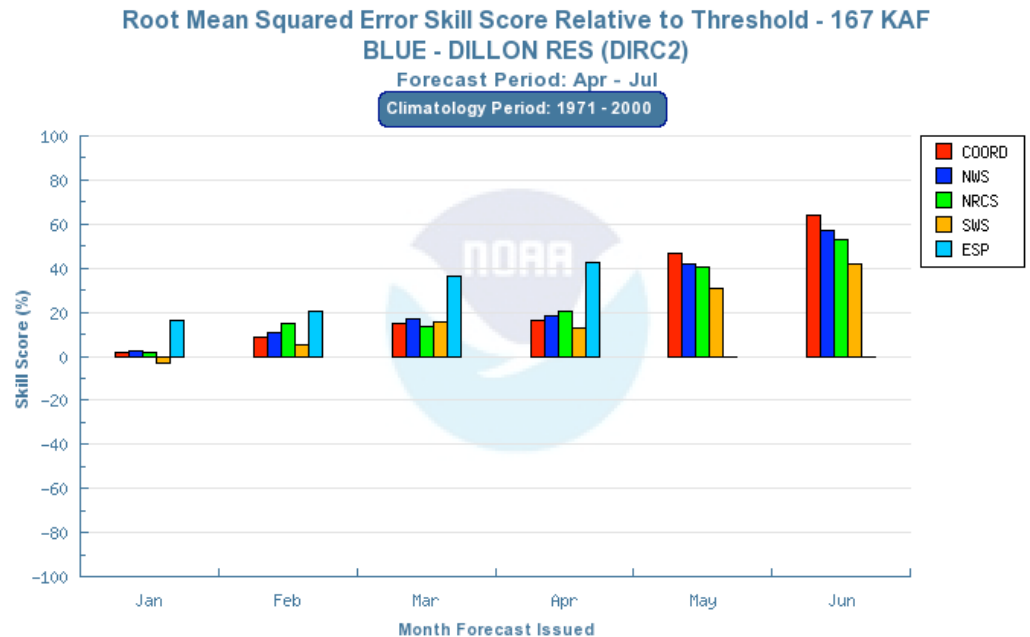
- **Graph Options**
 - Select the percentage to adjust the categories
 - 25% Default
 - Month Displayed January by default



Results that might be presented ...

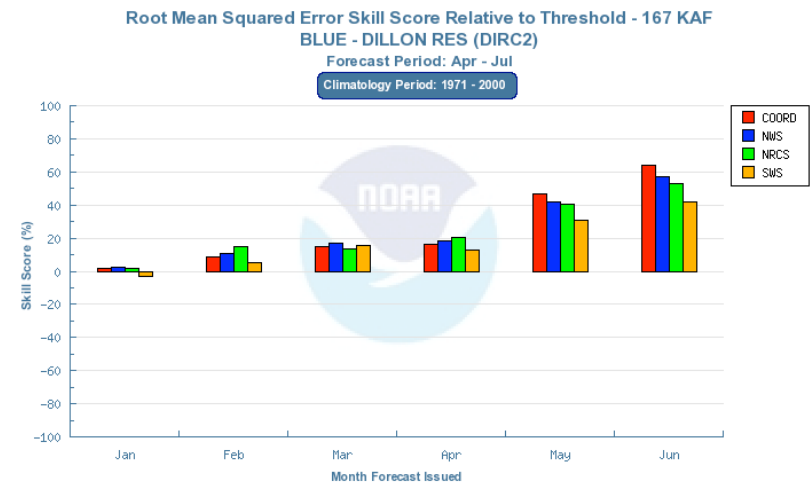
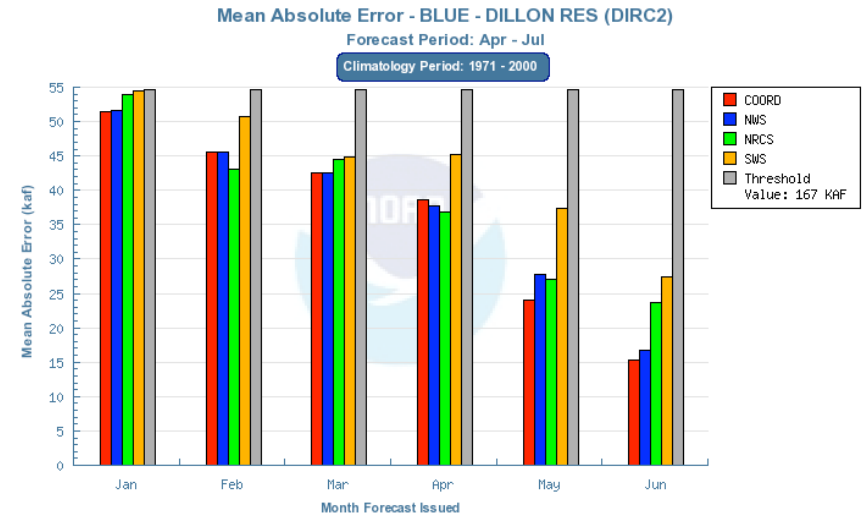
ESP is really, really good

- ESP is much better than any other forecast method particularly in high years
- With “real” ESP as opposed to ESP reforecasts, results should be even better



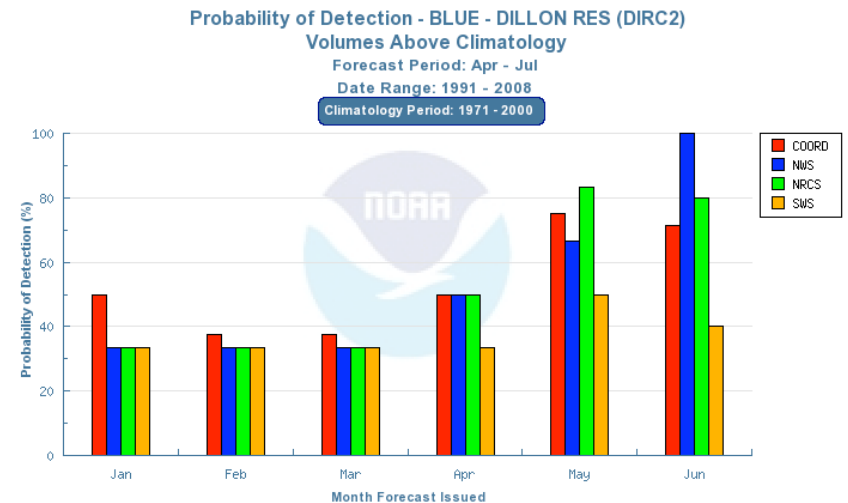
Forecast Quality

- January forecasts are essentially as good as climatology
- Coordination process appears to add (marginal) value except in April.
- Forecast tweaks much less than the error should not be entertained unless some overriding rationale exists to support those tweaks.



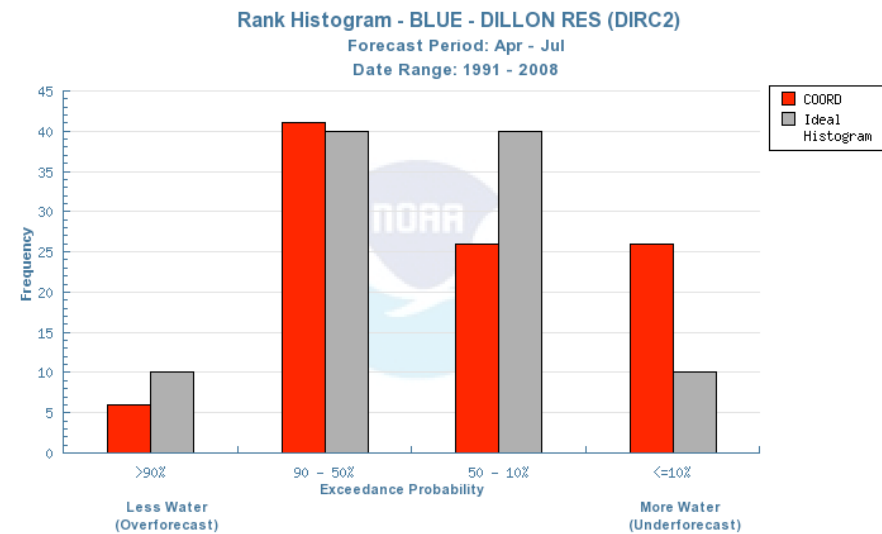
High flows hard Low flows no so hard

- Forecast system is perfect (POD = 100% in all cases) for detecting below average flows.
- Forecasts struggle with detecting high flows even through May.



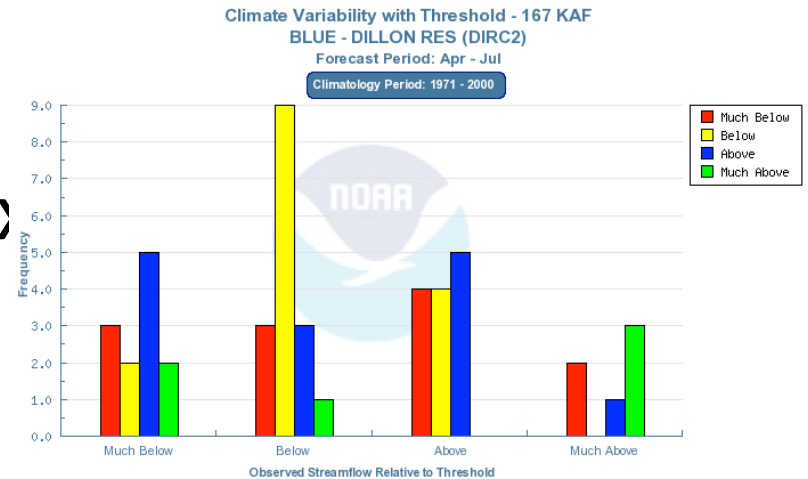
Reasonable max not so reasonable

- Observed streamflow greater than the reasonable max nearly 30% of the time.



Climate variability not much help

- Very low predictability based on prior year hydrology or climate index
- Weak tendency for low years to follow low years



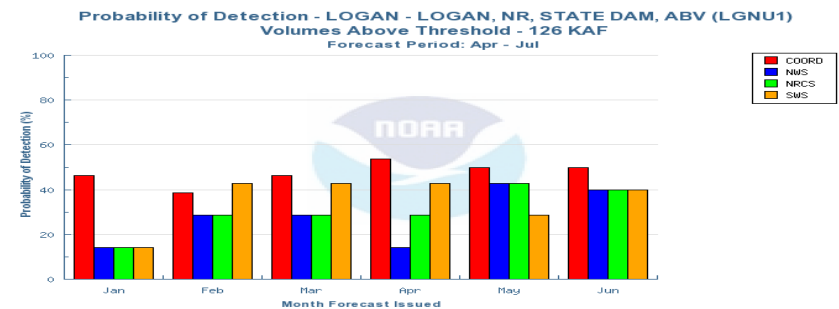
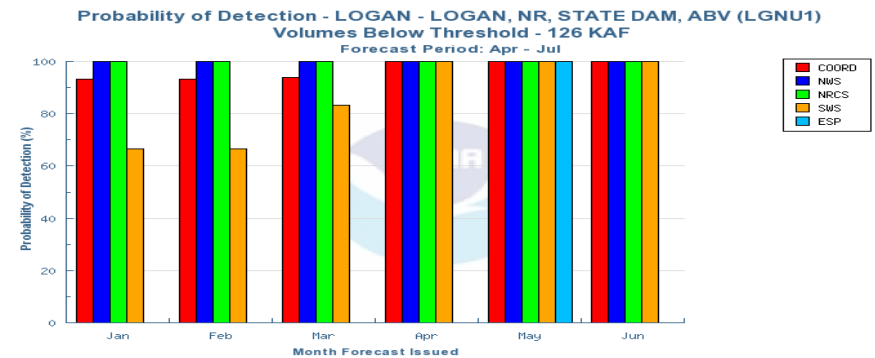
Possible Application (Discussion)

- April DIRC2 forecast is 150kAc-ft. Average error for April is 35kAc-ft. How could you use this information to:
 - Improve your forecast?
 - Improve your forecast process?
 - Improve forecast application?

Great Basin Case Study

credit: Brent Bernard

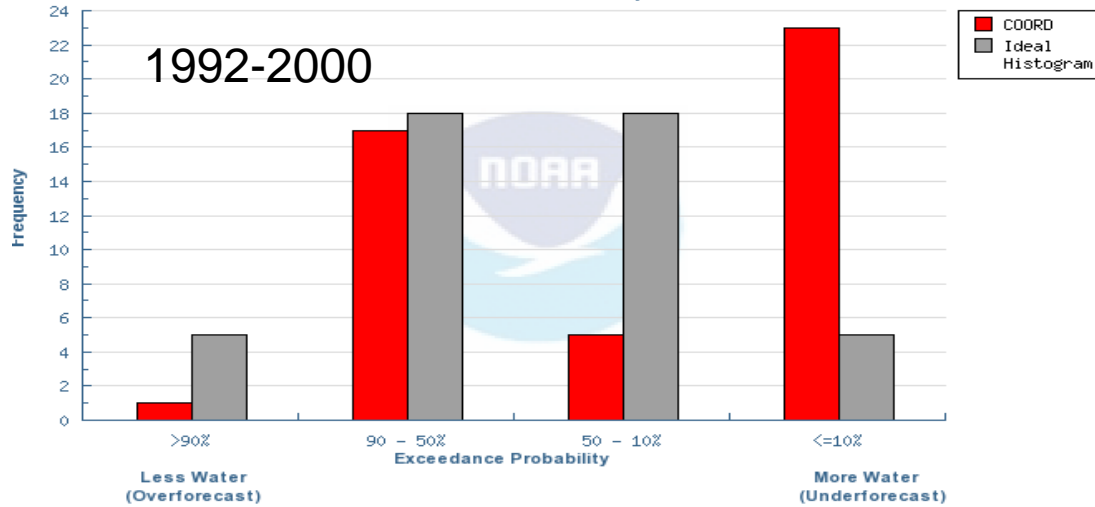
- Findings indicate we detect low flows better than high flows with current and often over forecast the 10% exceedance values.



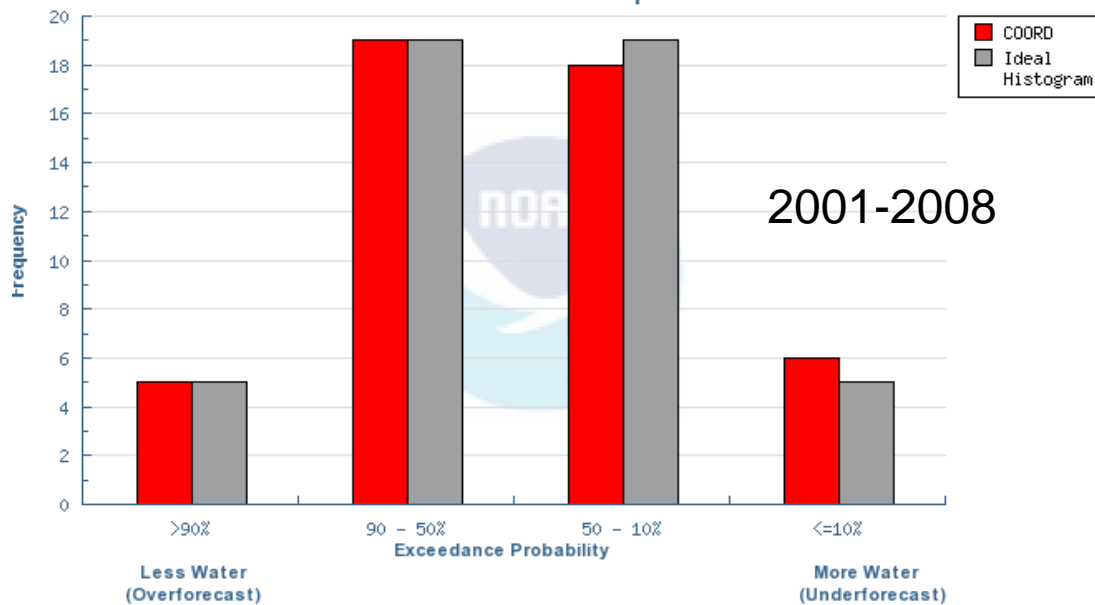


Bear River – Near Utah, Wyoming State Line Rank Histogram

Rank Histogram - BEAR - UTAH-WYOMING STATE LINE, NR (BERU1)
Forecast Period: Apr - Jul



Rank Histogram - BEAR - UTAH-WYOMING STATE LINE, NR (BERU1)
Forecast Period: Apr - Jul



- That many of the data sets from 1991-2008 have a binary split indicating that more extremes have occurred in observed flow during the last 20 years.

