CBRFC Water Supply Forecasting: What Does the Future Hold?

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NWS Colorado Basin River Forecast Center

CBRFC Stakeholder Forum
July 31, 2012

Outline

e Past: A Brief Recap

e Need for Change: Stakeholders,
Science, and Verification

e Future: Perspectives and Direction

Science and Stakeholders

The Past

SWS (Statistical Prediction)

ESP (Hydrologic Model Prediction)

VIPER (Statistical Prediction)

Offic
Coordi
Forec

Forecast Coordination

Water Managers and Users

Decisions

Methods

atistical Forecasting

- Statistical Regression Equations
- Primary NOAA/RFC forecast method from 1940's to mid 1990's.
- Primary NRCS/NWCC forecast method
- Historical Relationships between flow, snow, & precipitation (1971-2000+)
- Tied to a fixed runoff period (inflexible)

nsemble Simulation Model Forecasting

- A component of a continuous conceptual model (NWSRFS)
- Continuous *real time* inputs (temperature, precipitation, forecasts)
- Accounts for soil moisture states (SAC-SMA) - drives runoff efficiency
- Builds and melts snowpack (Snow-17) – output feeds SAC-SMA
- Flexible run date, forecast period, forecast parameters.
- Evolving toward ESP as primary forecast tool at NOAA/RFCs

Past Output

ecast attributes:

Target: seasonal volume (typically April-July)

Frequency: monthly or semi-monthly during winter
spring

Probabilities: 10,50,90% forecast exceedence

Format: email, publication, and web site

Other tools: online toolsets

Coordination with NRCS

The Need to Change

t practice:

- ot conducive to more frequent (daily/weekly) updates
- ot conducive to ensemble based forecasts
- oordination and manual combination does not systematically ad
  kill (see verification)
- orecast process not repeatable
- spite of some success, integration of new science is difficult

practice should:

- everage NOAA/NWS expertise with weather and climate predicti
- everage CBRFC daily forecast operations
- everage CBRFC forecaster expertise
- rovide short to long term forecast information including ensemble
- ase ability to integrate new science, methodology, and technolo

1983 Forecast Assessment

tatistical models are deficient in several aspects:

1. The forecasts are for monthly or seasonal volumes and do not provide day-to-day values or allow frequent updates.

2. The models do a poor job of predicting flows for extreme conditions that have not been observed historically.

3. The models do not account for large variations from normal in both temperature and precipitation that may occur subsequent to the date of the forecast.

4. These techniques are not amenable to easy changes (i.e., additional

Forecast Verification

y Questions:

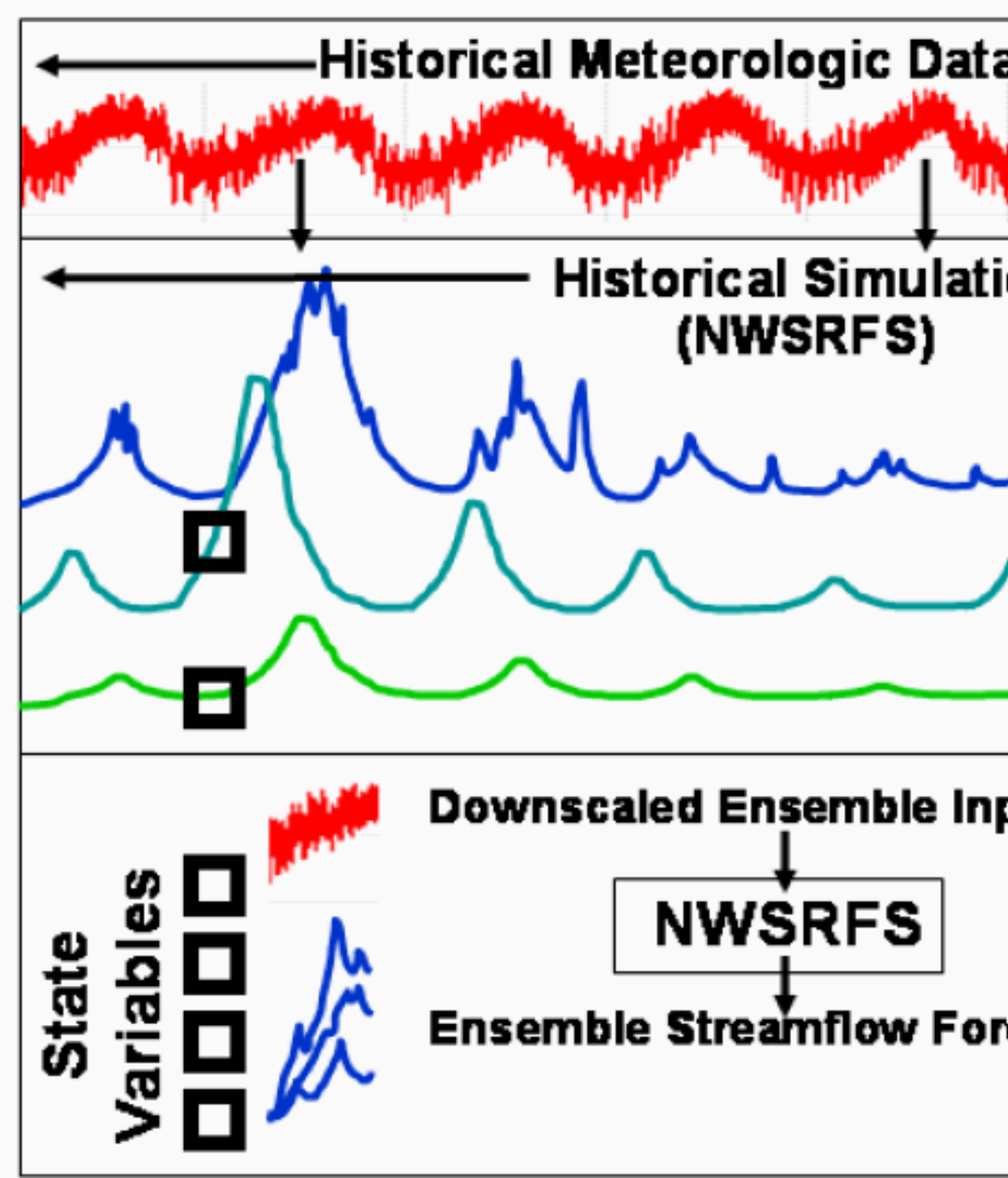
How accurate is each forecast tool?

How reliable is each forecast tool?

How do these answers change over tim
or space?

Verification Strategy

- Systemic answers require large number of forecasts
- Use reforecasts to have a large sample size
  - Reforecasts use current calibrations to simulate past forecasts
  - Do not (yet) incorporate weather



Metrics Explained

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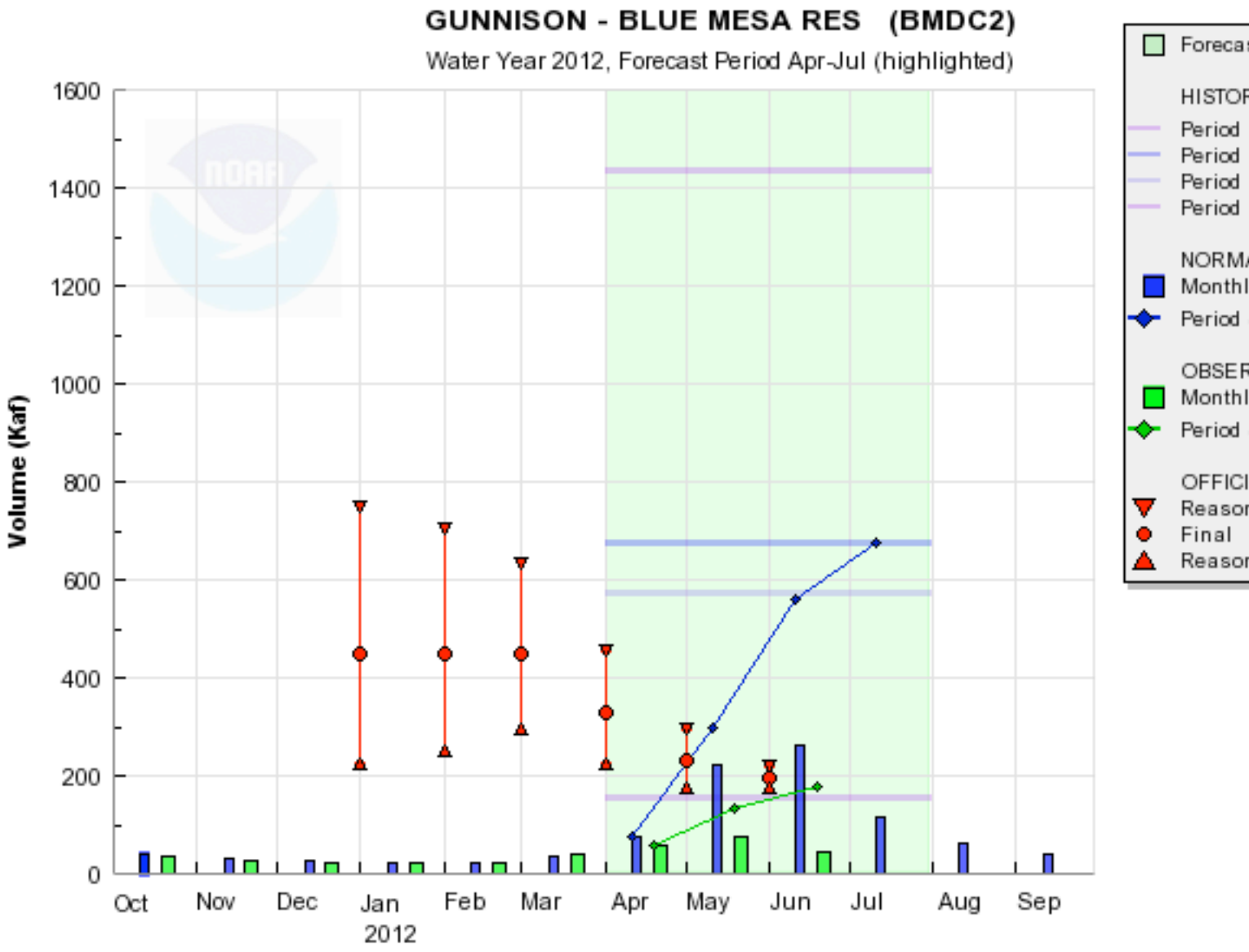
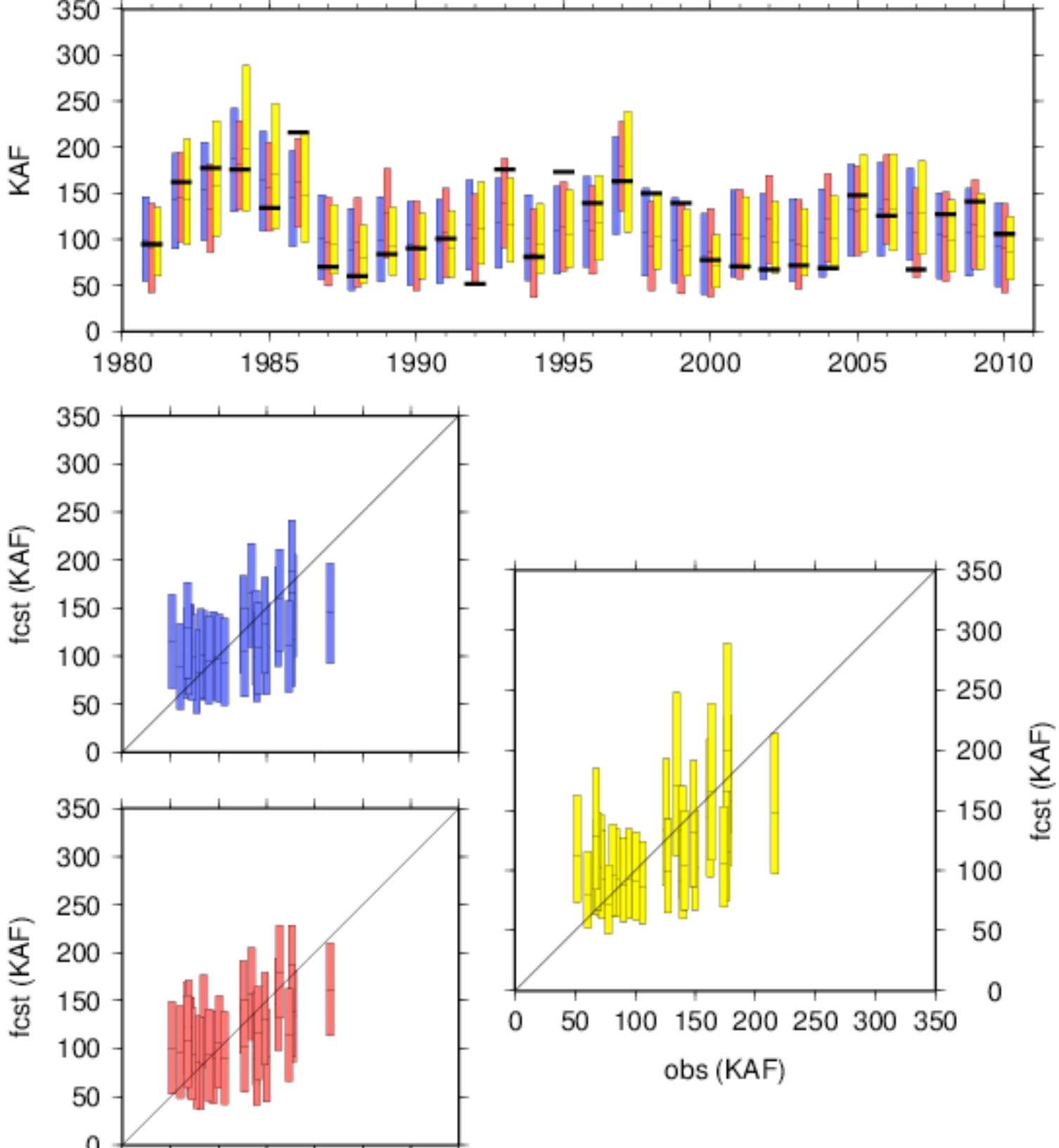


CBRFC/NWS/NOAA 07


KAF
0
50
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200
250
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1980
1985
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1995
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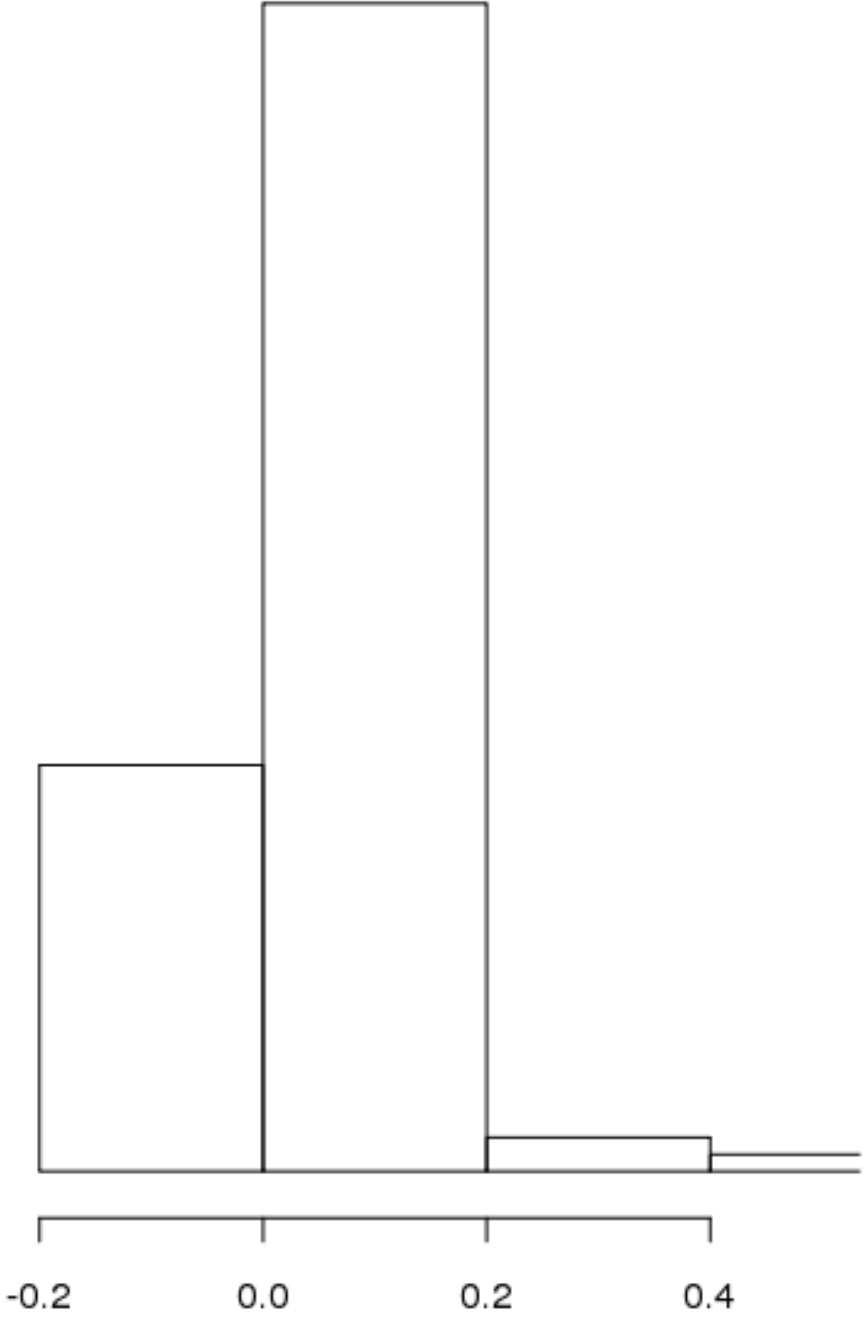
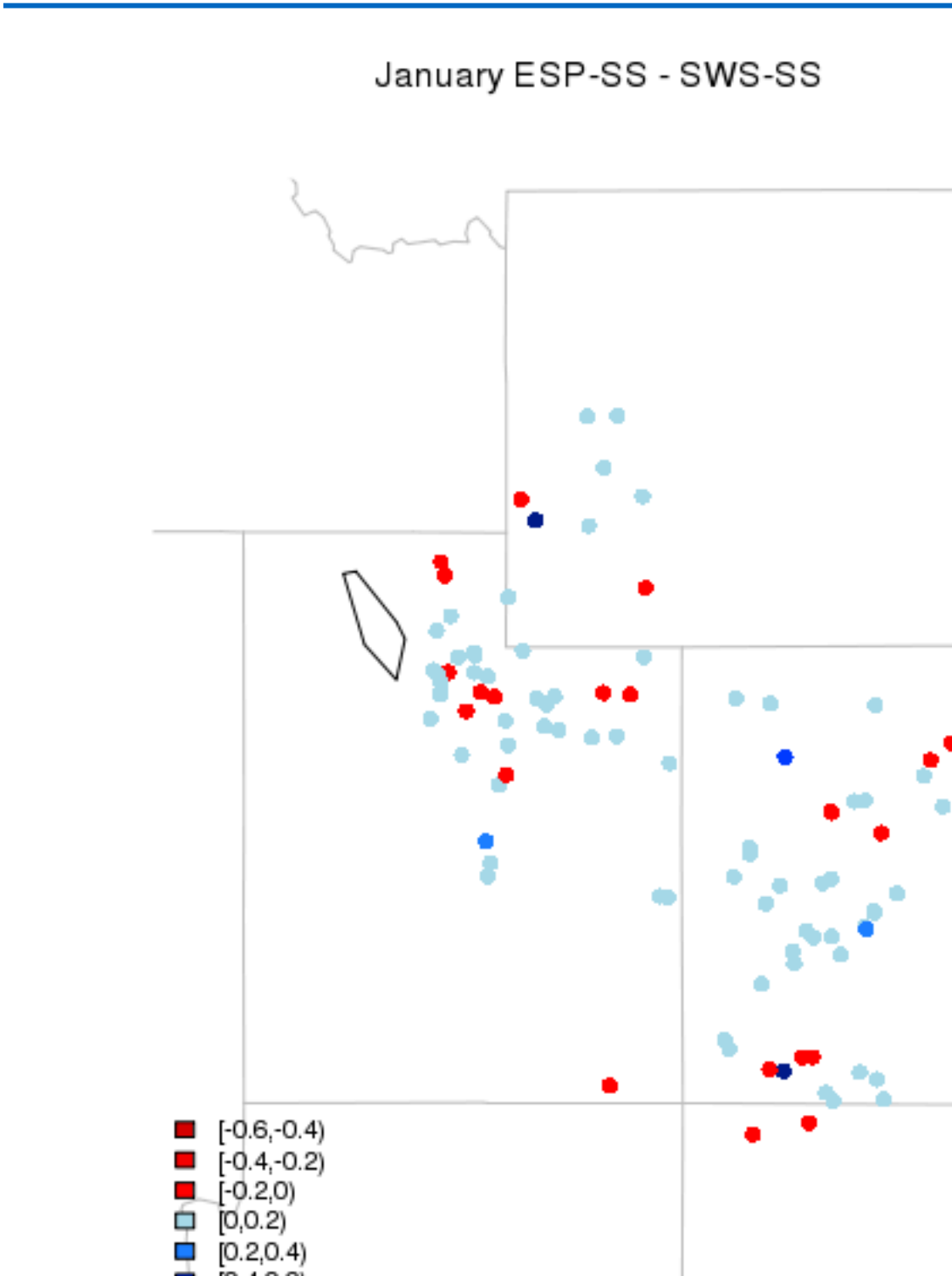
fcst (KAF)
fcst (KAF)
obs (KAF)
fcst (KAF)

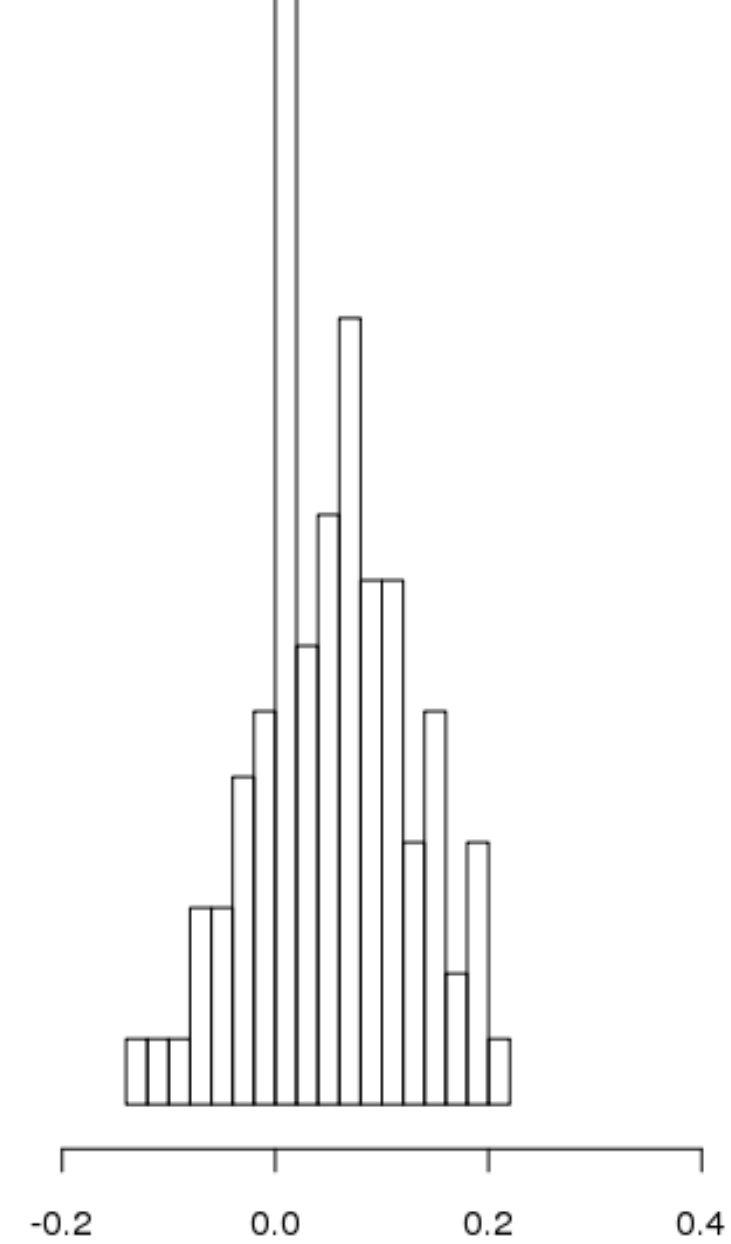
50% Forecast Accuracy



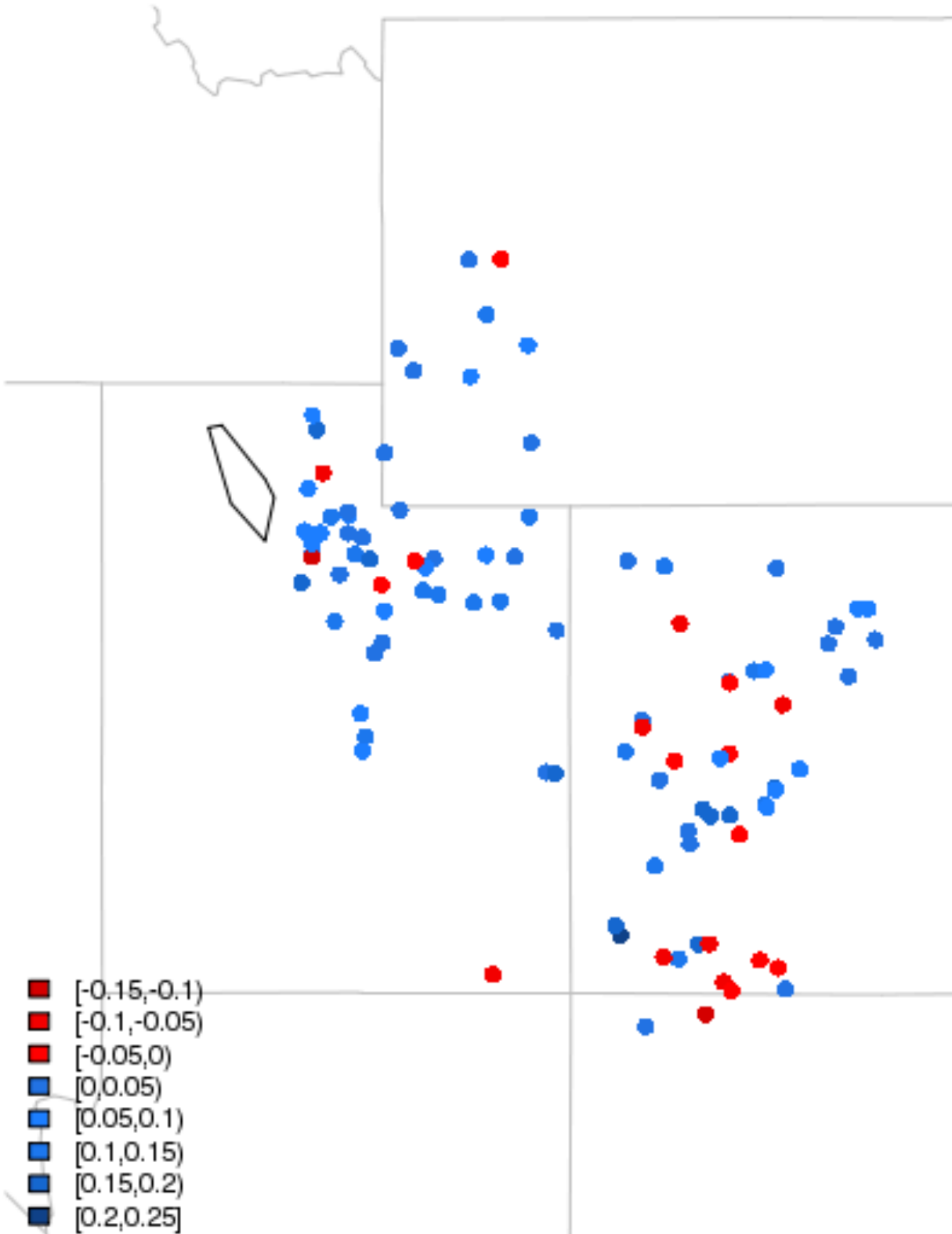
more accurate in 74 of 98 cases



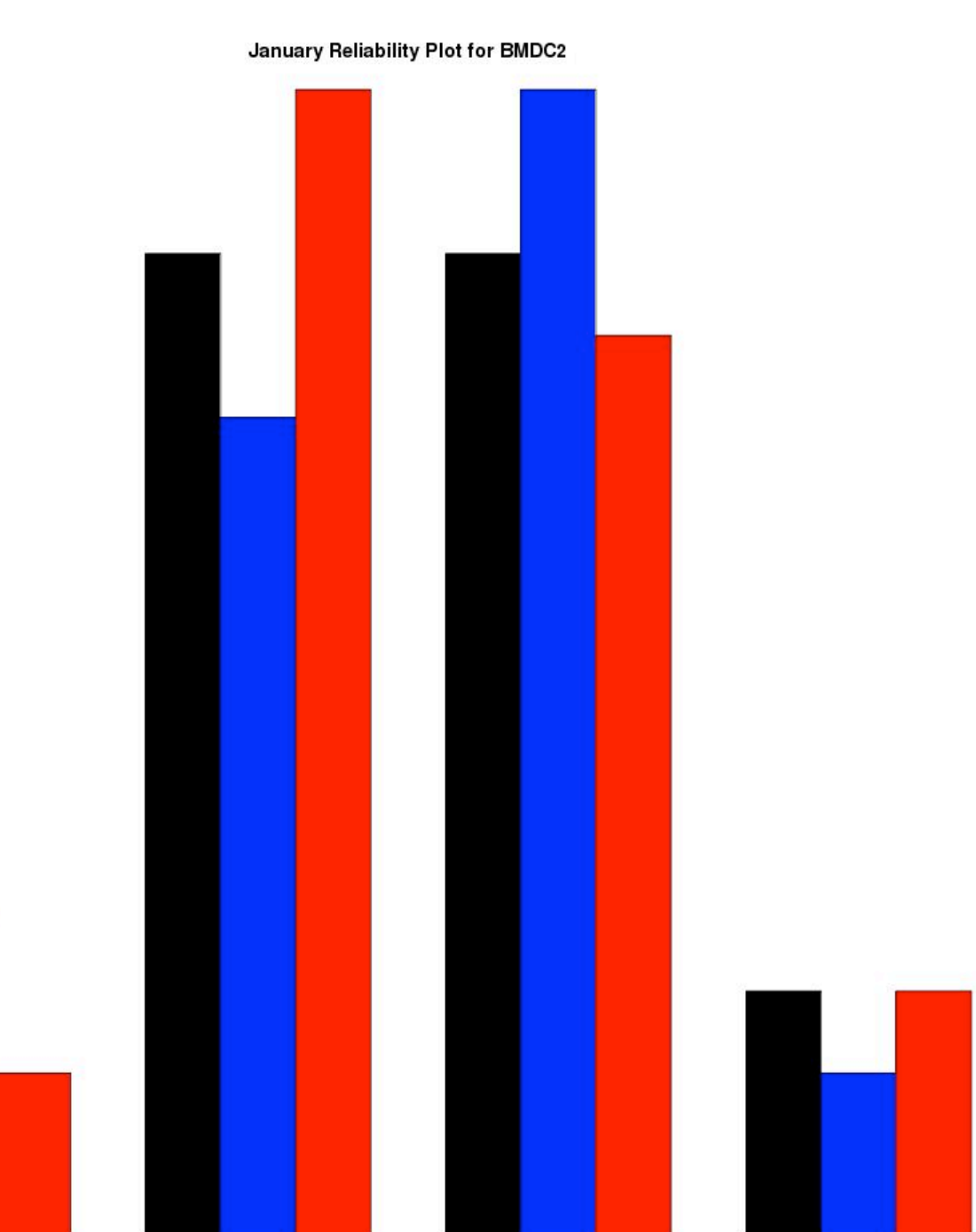
50% Forecast Accuracy

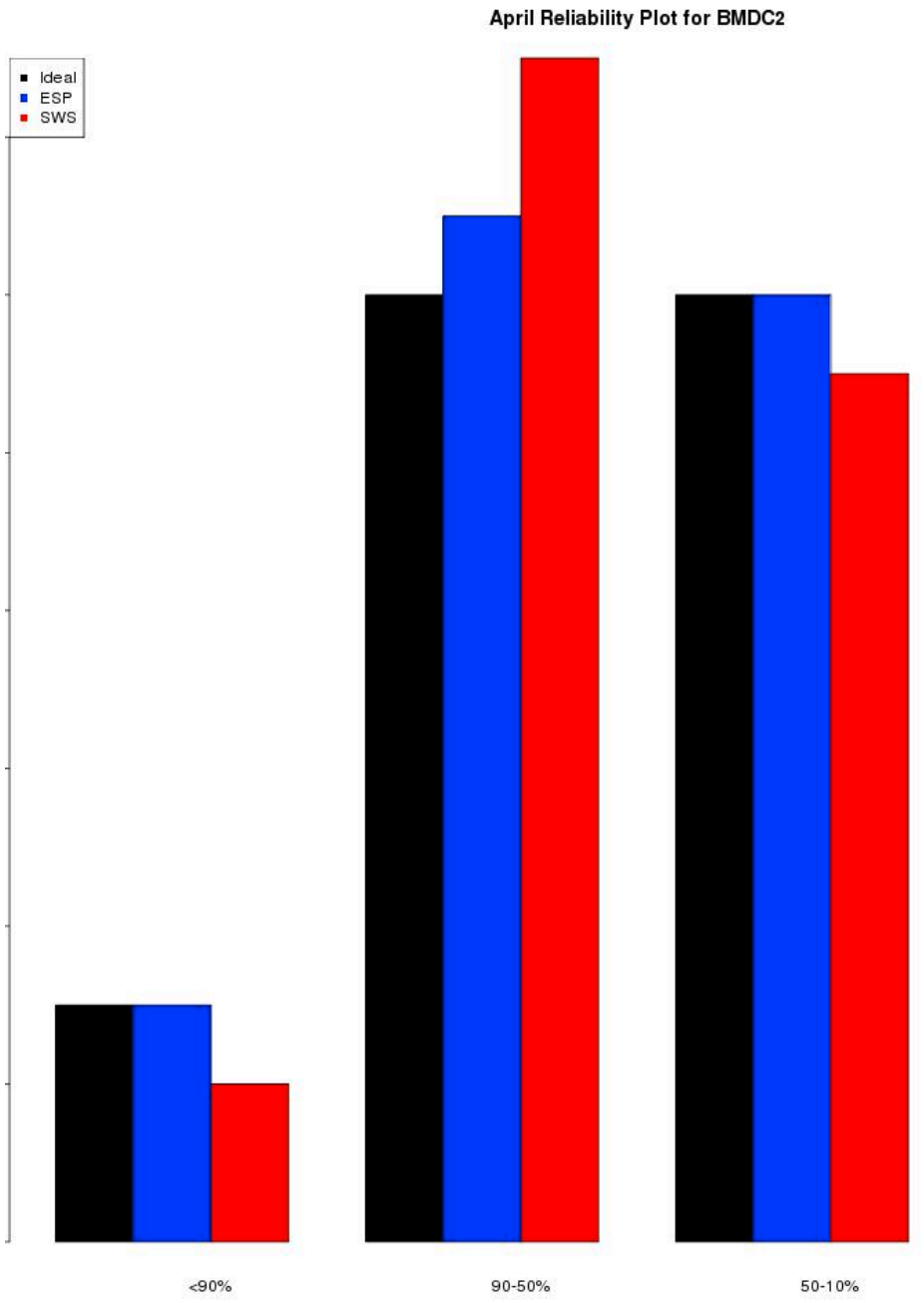


ESP more
curate than
VS in 78 of

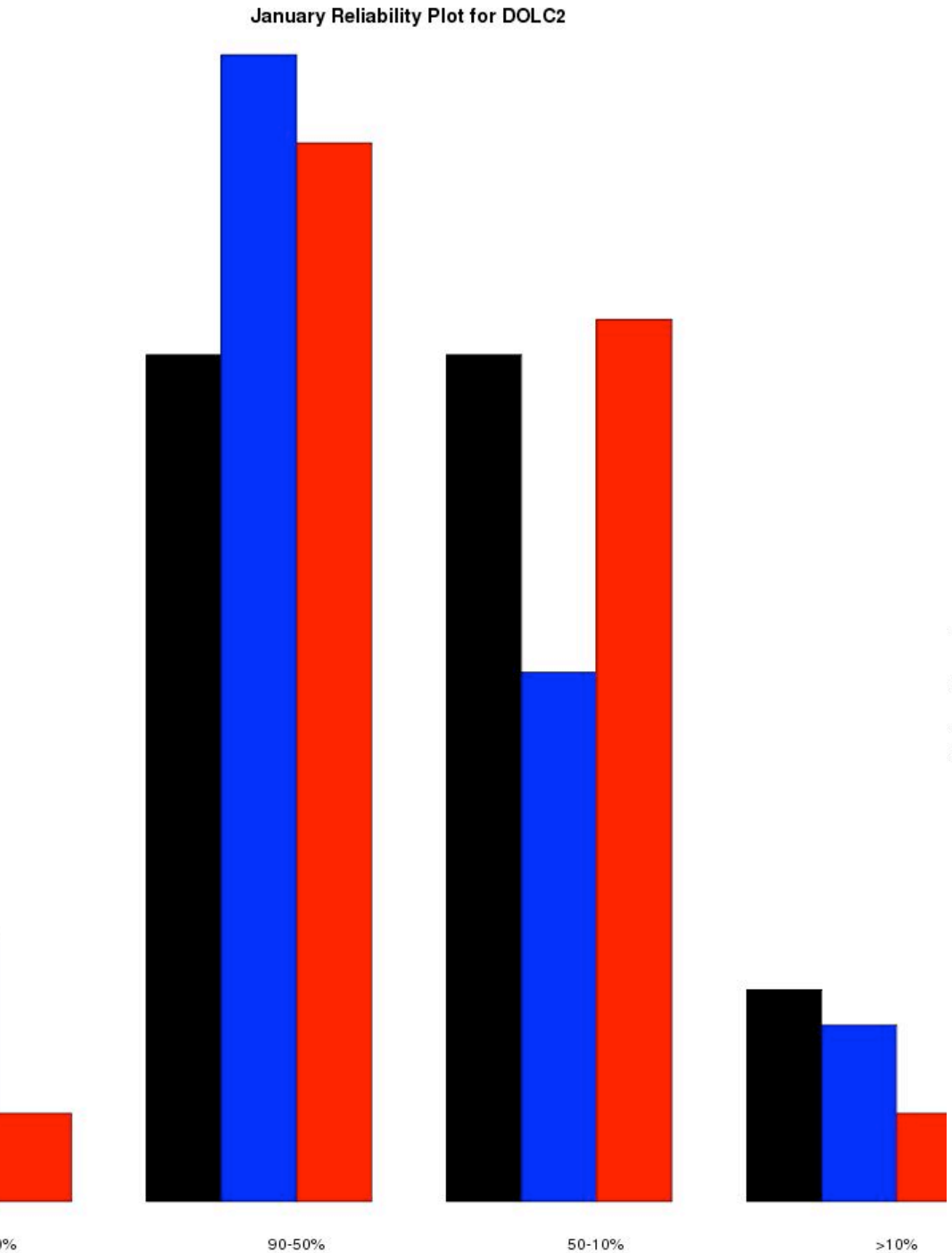


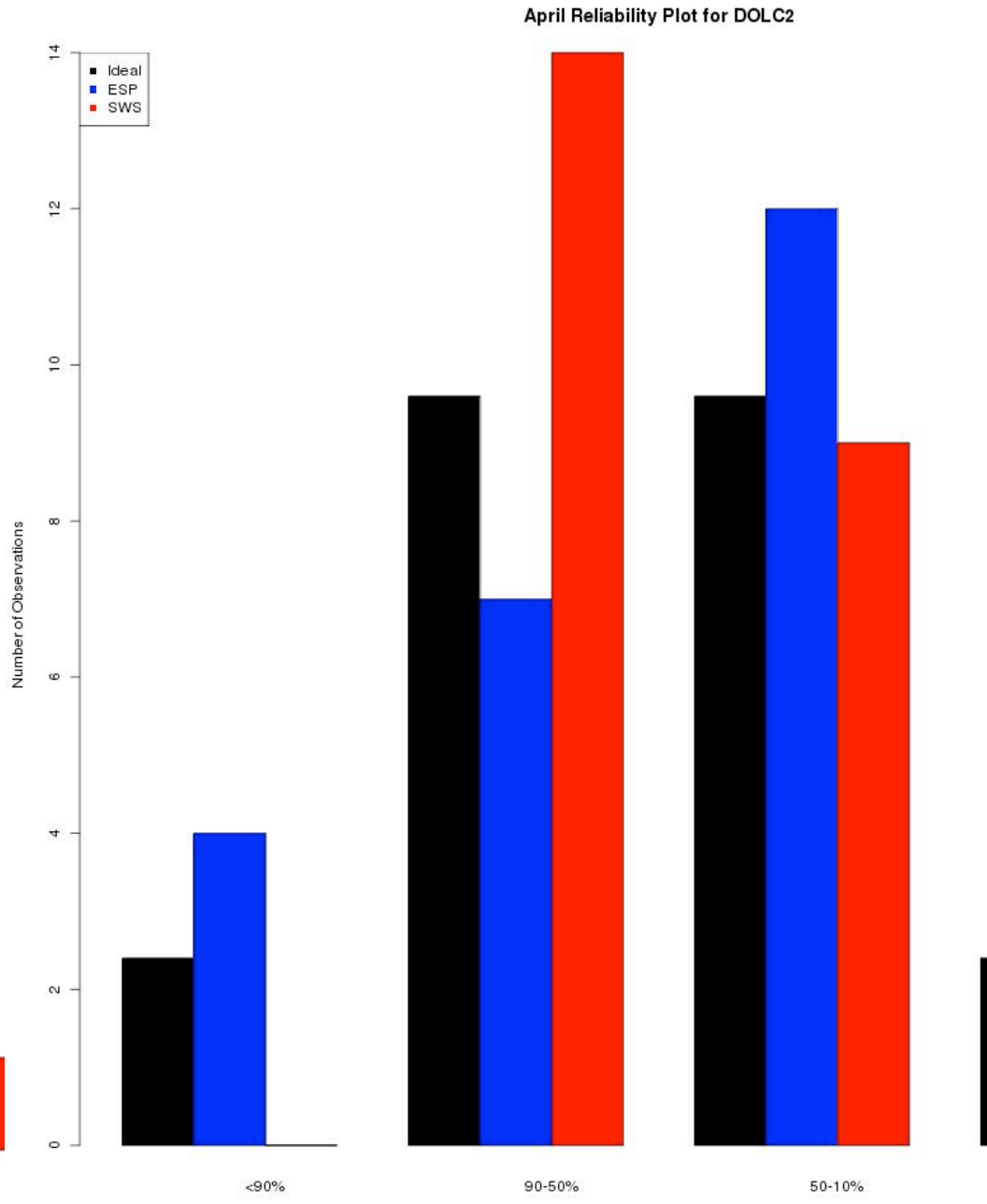
Forecast Reliability



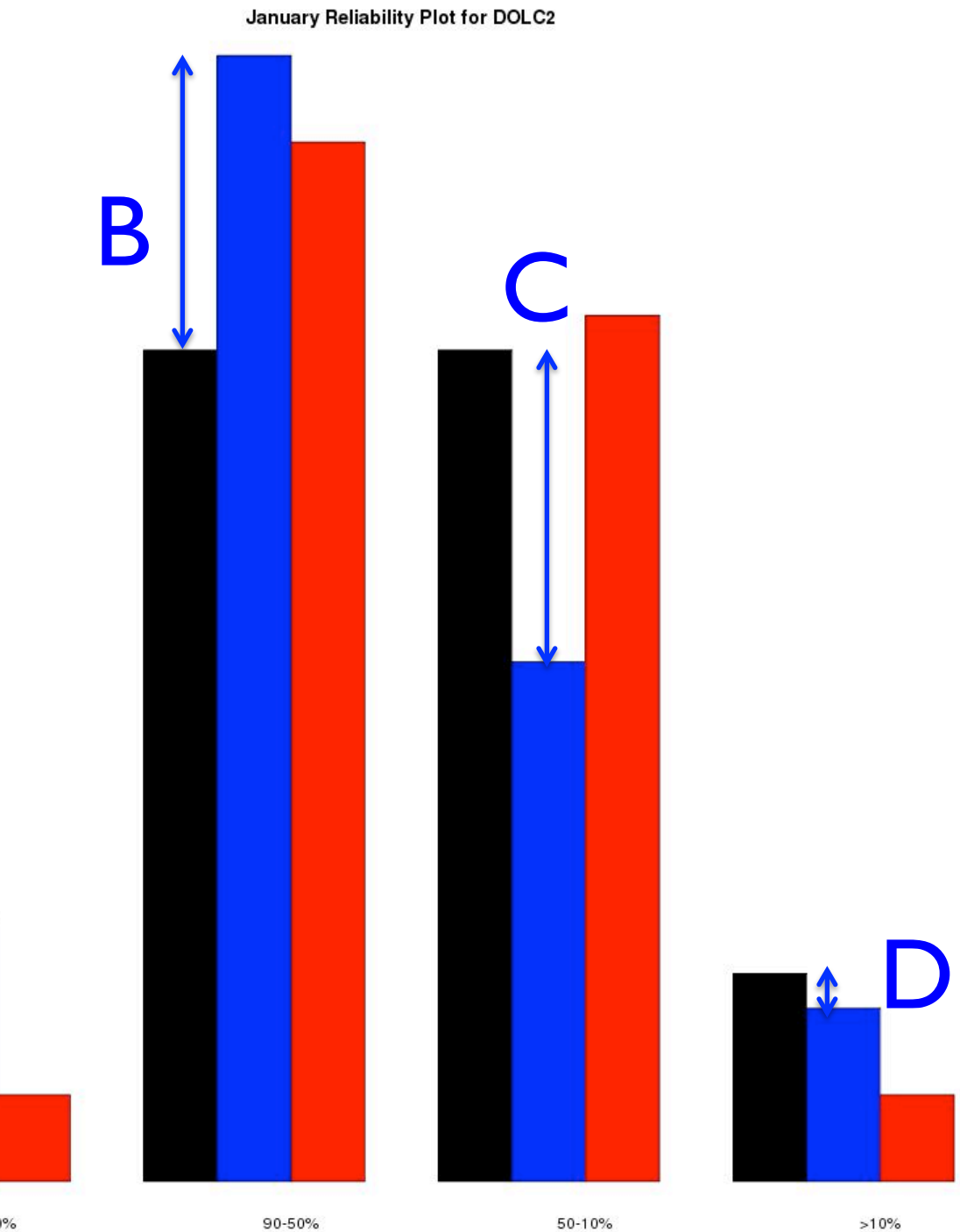


Forecast Reliability



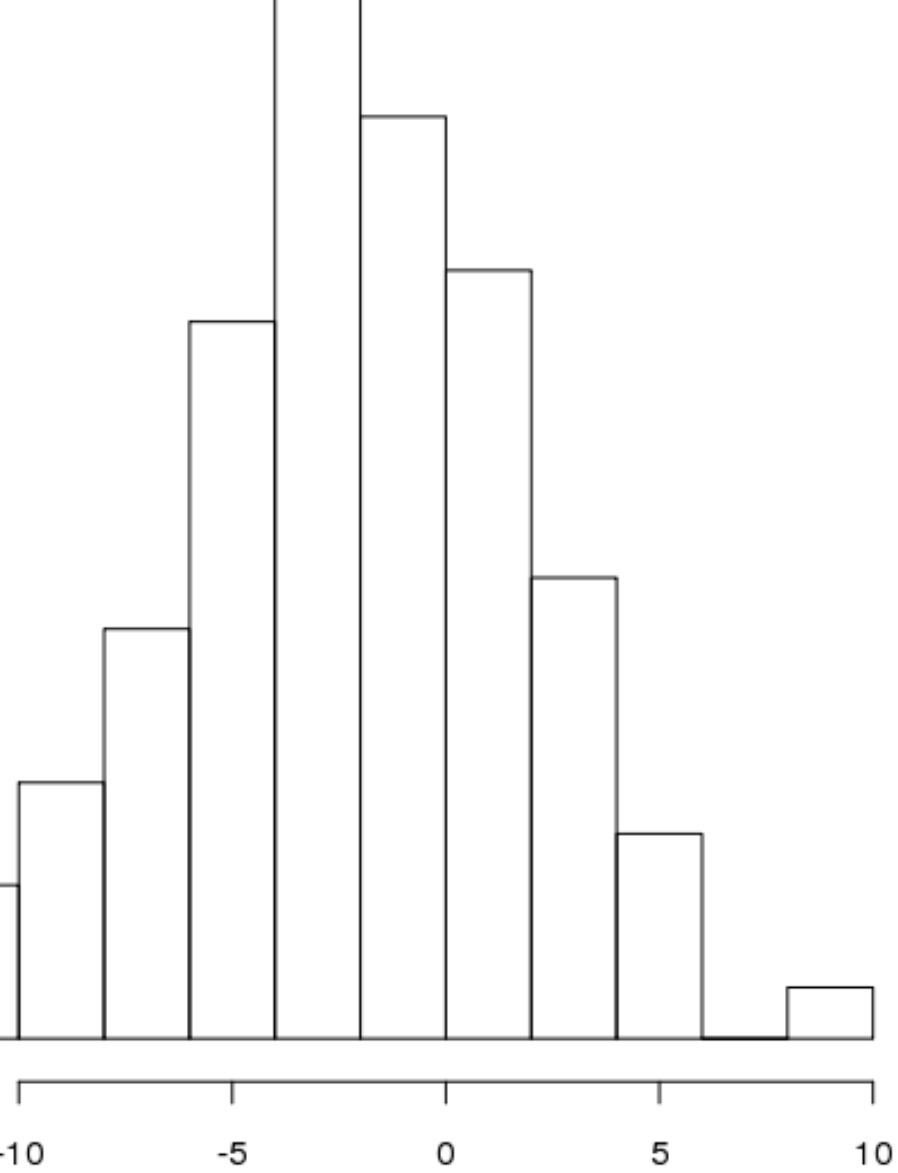


Forecast Reliability

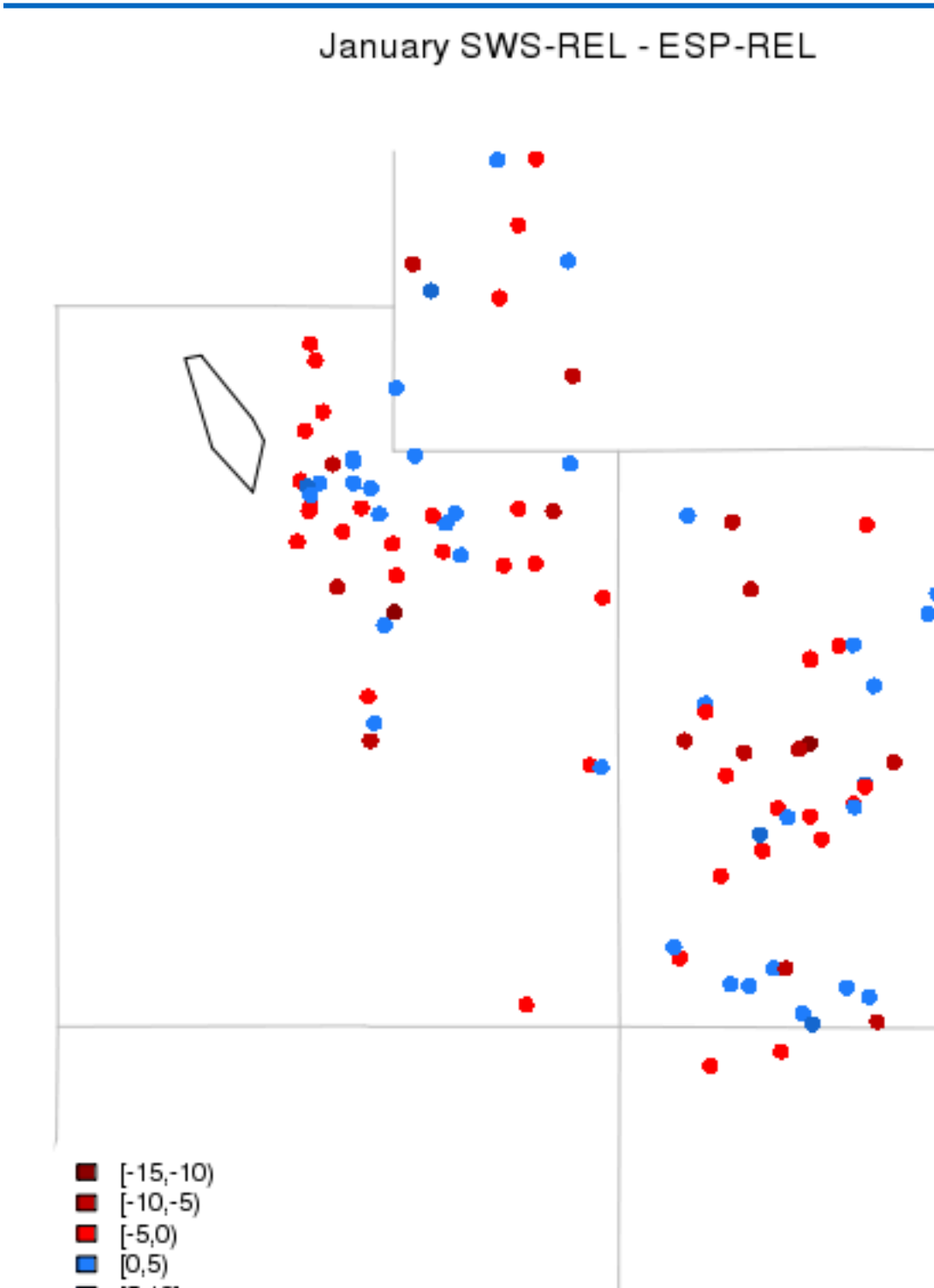


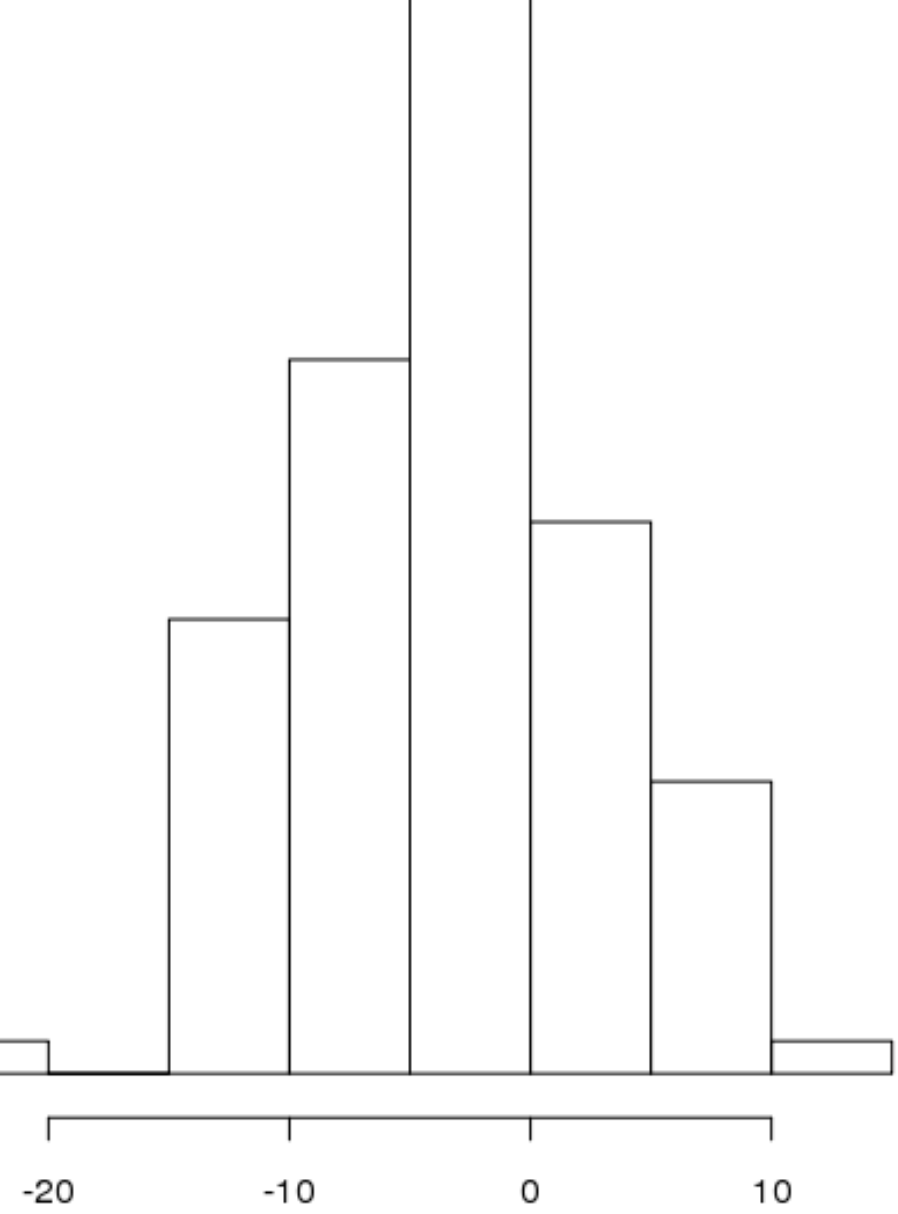
Ok; But how do
reliability of fore
system vary ove
points?

|A| + |B| + |C| +
Gives a measure
total reliability.

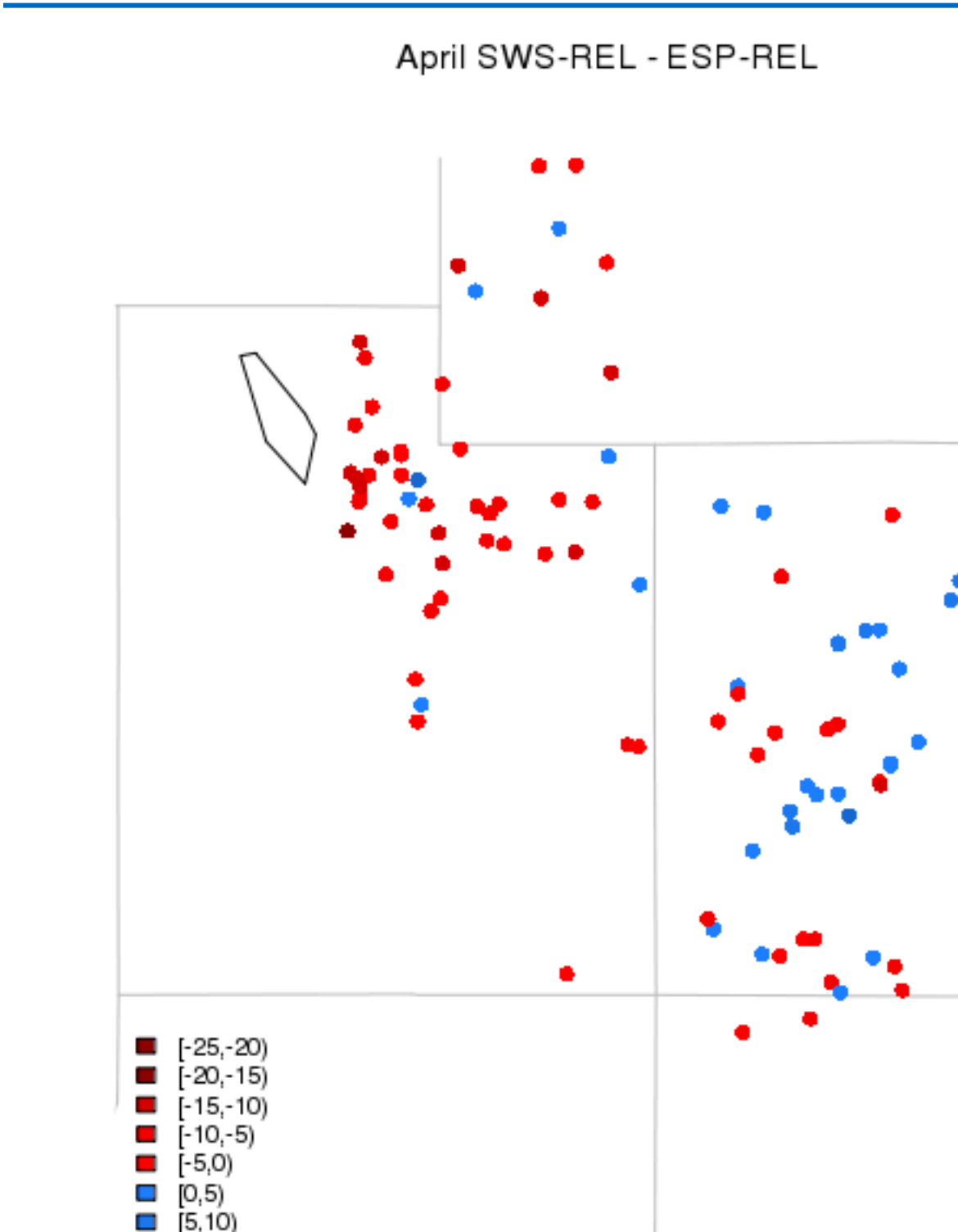


reliable at 29 of 98 points. ESP and
lly reliable at 10 points.

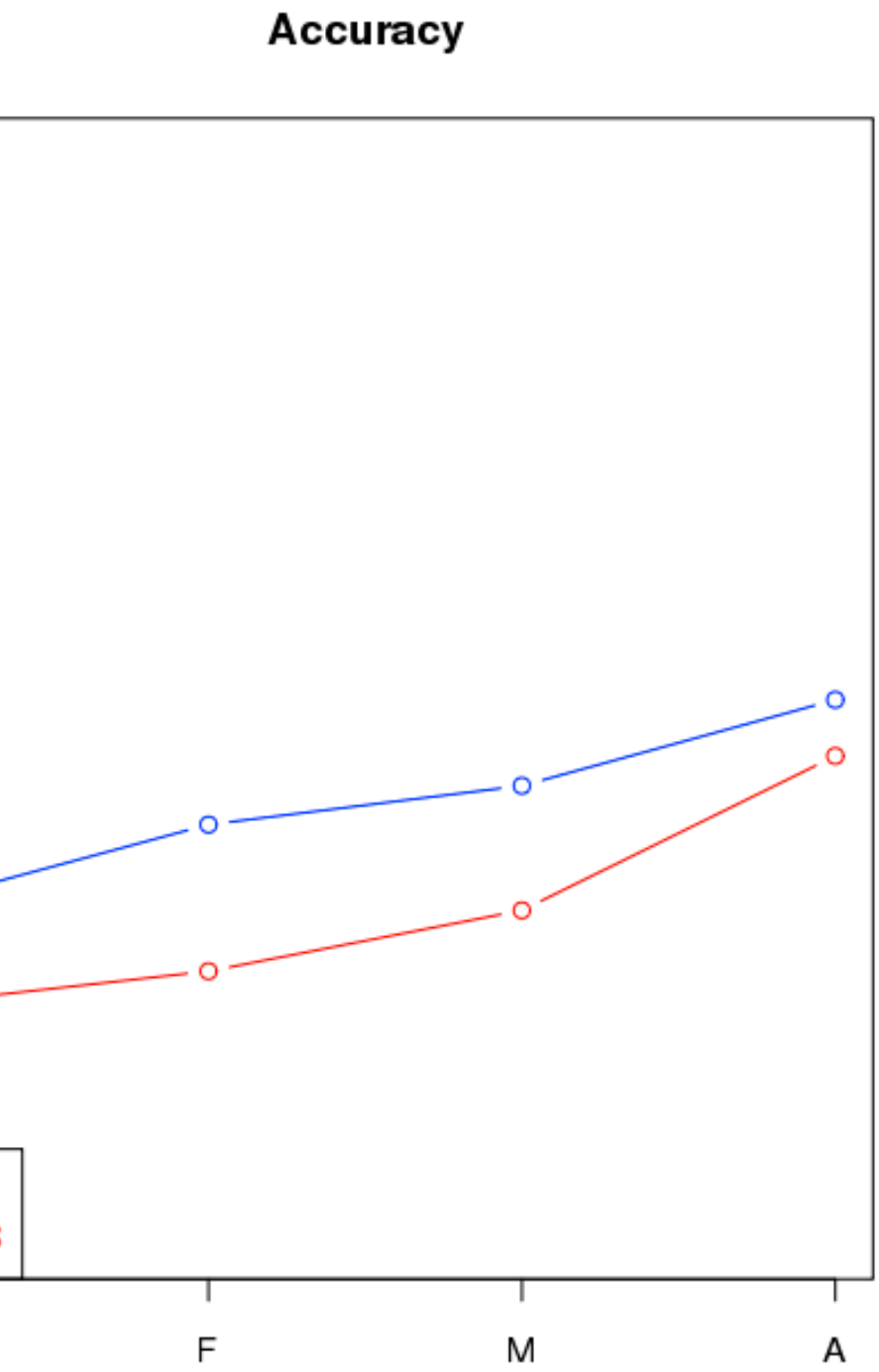


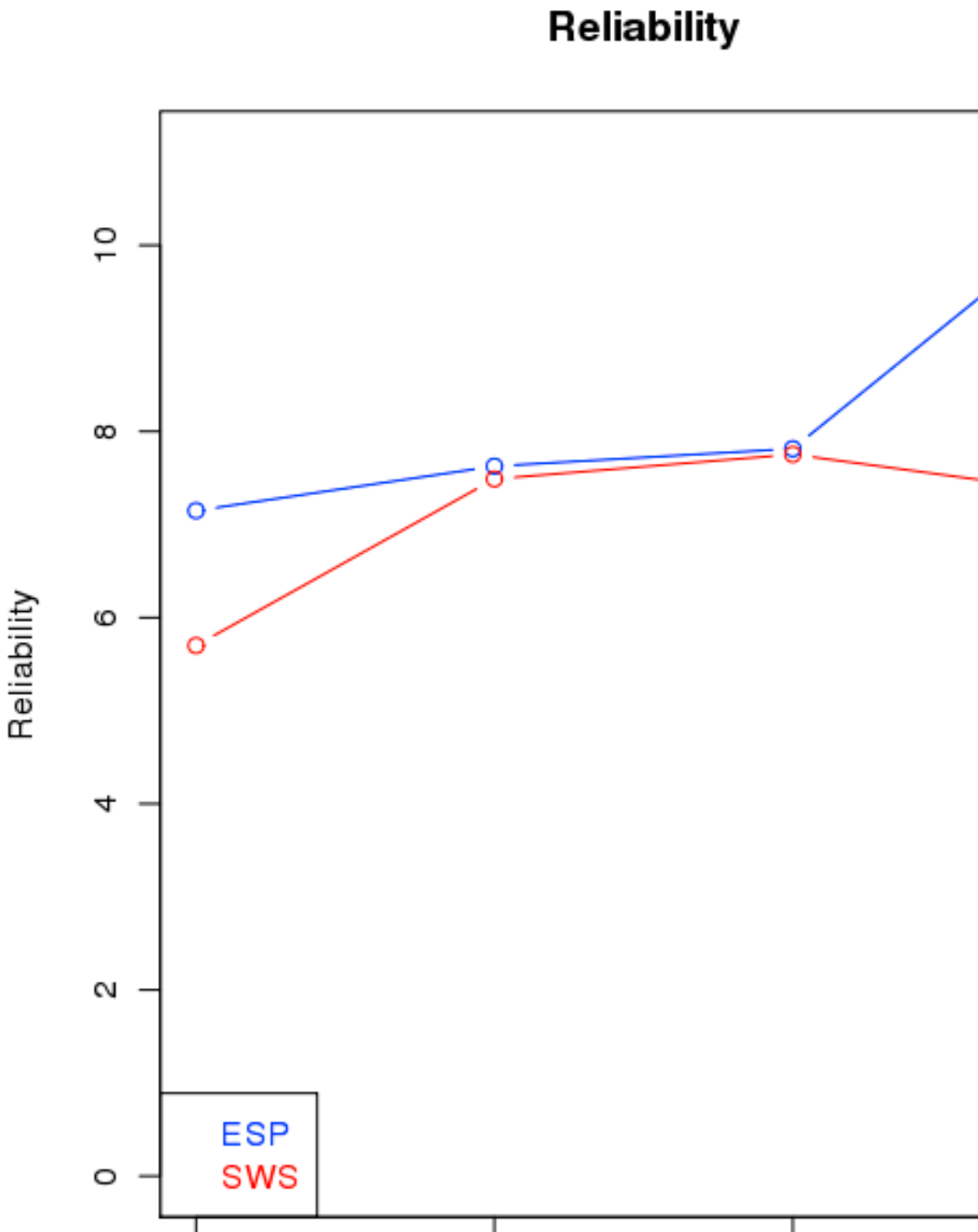


For April 1, ESP more reliable than SWS in 48 of 98



Across Lead Times





Weather Forecasts Will Help Even More…

ner et al, 2004
pared ESP
asts with 14
of probabilistic
ner inputs with
based on pure
tology. Showed
ESP with
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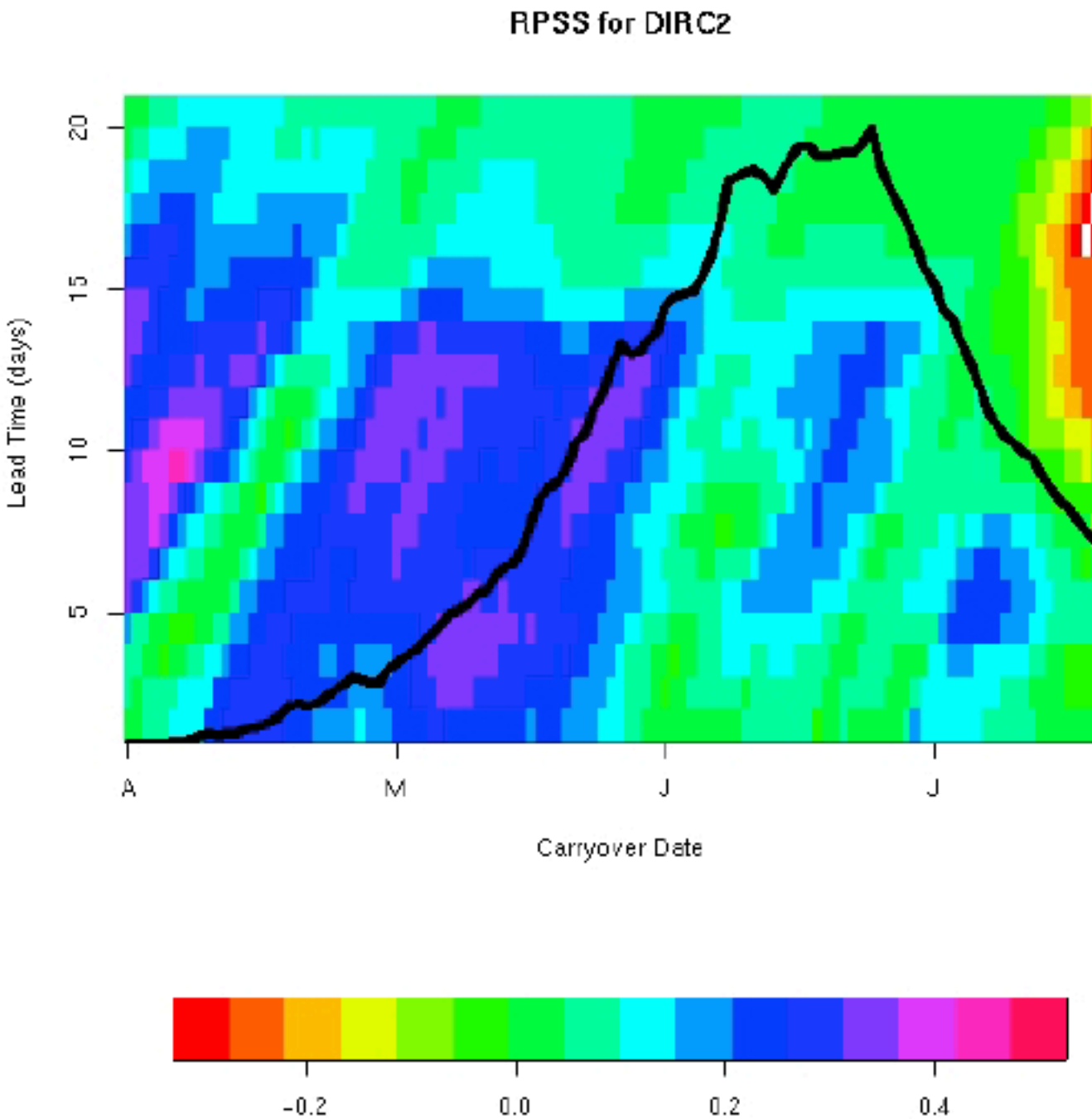


Verification Summary

Across all points for January 1:

- ESP significantly more accurate than SWS
- SWS slightly more reliable than ESP

Across all points for April 1:

- ESP generally more accurate than SWS
- SWS slightly more reliable than ESP

Inclusion of weather probabilistic weather forecast improves ESP accuracy by 10-40% during melt season.

New Direction (NOAA/NWS)

NWS RFCs are no longer coordinating forecast numbers with NRCS (informal coordination is important and will continue). For CBRFC stakeholders in WY13, there will be two different forecasts available.

NWS RFCs are moving toward:

- Daily updating ESP forecasts
- Routine integration of weather and climate forecasts
- Full season and residual forecasts
- Short to long lead ensemble forecasts
- Verification and reforecasts to quantitatively assess forecast
- Backward compatibility for key forecast products (e.g. emaile

New Direction (CBRFC)

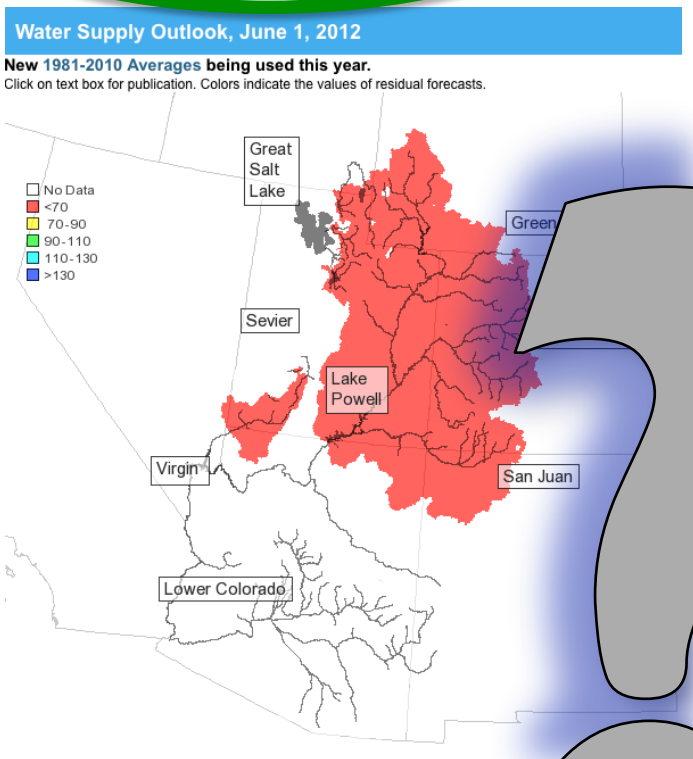
t does this mean for CBRFC?

- Continuation of text forecast products to support water management
- Discontinuation of water supply forecast publication
- Redeployment of forecast expertise from concentrated effort during first week of month toward more continual monitoring and adjustment of forecast skill.
- Key benefits:
  - Daily updating forecasts
  - Quick turn-around on monthly forecasts
  - Documentation of forecaster modifications to ESP
  - Access to ESP traces
  - Overhaul of Peak Flow Forecasts
- Note: We don't expect forecast skill to increase based on this direction alone

```
ZCZC SLCESPSTR CSW
TTAA00 KSTR DDHHMM
:National Weather Service, Colorado Basin River Forecast Center, SLC, Utah

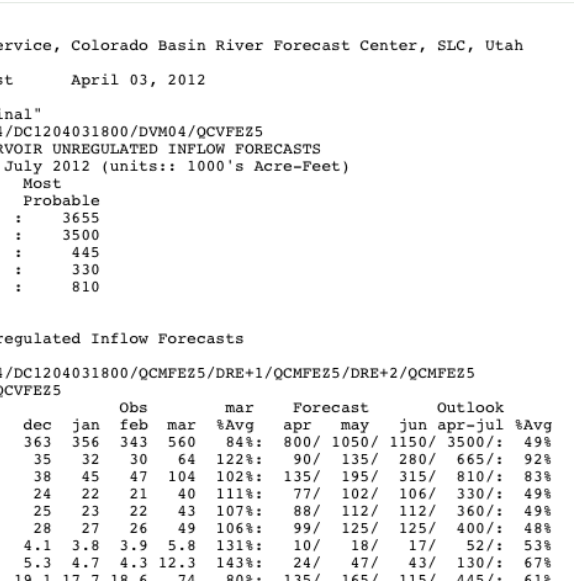
:April final Forecast      April 03, 2012

"product_issuance=final"
.B SLC 120801 M DH24/DC1204031800/DVM04/QCVFEZ5
:FLOOD CONTROL RESERVOIR UNREGULATED INFLOW FORECASTS
:1 April through 31 July 2012 (units:: 1000's Acre-Feet)
:Reservoir            Most
:ID   Name            Probable
LKSA3:Lake Mead      :    3655
GLDA3:Lake Powell    :    3500
NVRN5:Navajo         :     445
BMDC2:Blue Mesa Res  :     330
GRNU1:Flaming Gorge  :     810
.END
:
:Other Reservoir Unregulated Inflow Forecasts
:
.B SLC 120430 M DH24/DC1204031800/QCMFEZ5/DRE+1/QCMFEZ5/DRE+2/QCMFEZ5
.B1 DY120801/DVM04/QCVFEZ5
:                              Obs          mar     Forecast        Outlook
:                        dec  jan  feb  mar  %Avg   apr   may   jun apr-jul %Avg
GLDA3:Lake Powell        363  356  343  560   84%:  800/ 1050/ 1150/ 3500/:  49%
GBRW4:Fontenelle          35   32   30   64  122%:   90/  135/  280/  665/:  92%
GRNU1:Flaming Gorge       38   45   47  104  102%:  135/  195/  315/  810/:  83%
BMDC2:Blue Mesa           24   22   21   40  111%:   77/  102/  106/  330/:  49%
MPSC2:Morrow Point        25   23   22   43  107%:   88/  112/  112/  360/:  49%
CLSC2:Crystal             28   27   26   49  106%:   99/  125/  125/  400/:  48%
TPIC2:Taylor Park        4.1  3.8  3.9  5.8  131%:   10/   18/   17/   52/:  53%
VCRC2:Vallecito          5.3  4.7  4.3 12.3  143%:   24/   47/   43/  130/:  63%
```



Question

do you currently access CBRFC water supply forecasts?



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ervice, Colorado Basin River Forecast Center, SLC, Utah

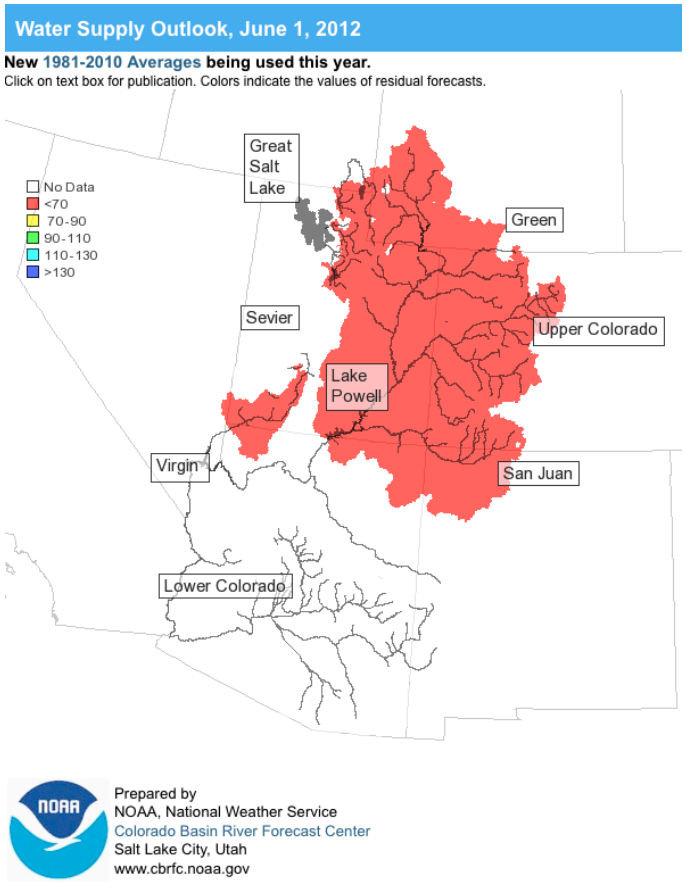
st      April 03, 2012

inal"
1/DC1204031800/DVM04/QCVFEZ5
RVOIR UNREGULATED INFLOW FORECASTS
 July 2012 (units:: 1000's Acre-Feet)
   Most
   Probable
 :    3655
 :    3500
 :     445
 :     330
 :     810

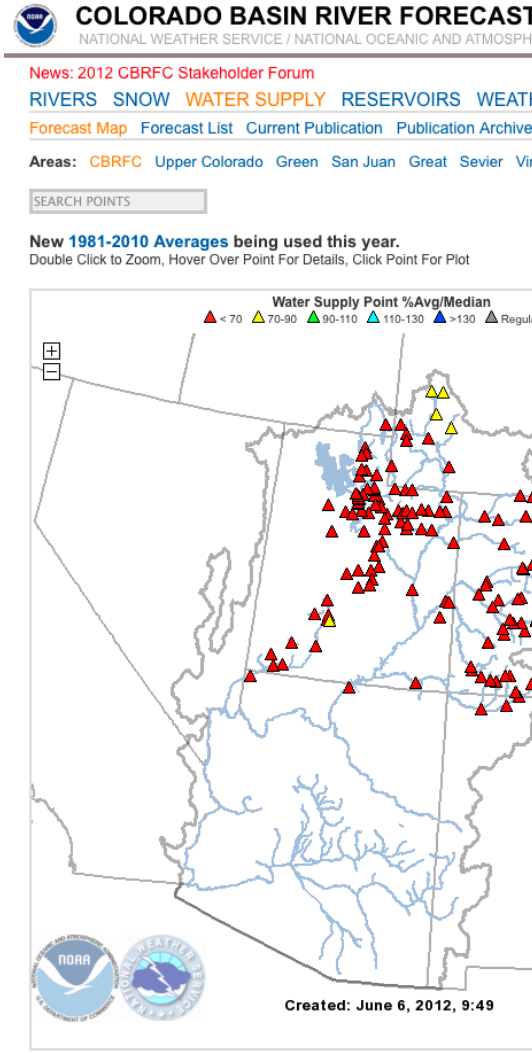

egulated Inflow Forecasts

1/DC1204031800/QCMFEZ5/DRE+1/QCMFEZ5/DRE+2/QCMFEZ5
QCVFEZ5
                Obs          mar     Forecast        Outlook
   dec  jan  feb  mar  %Avg   apr   may   jun apr-jul %Avg
   363  356  343  560   84%:  800/ 1050/ 1150/ 3500/:  49%
    35   32   30   64  122%:   90/  135/  280/  665/:  92%
    38   45   47  104  102%:  135/  195/  315/  810/:  83%
    24   22   21   40  111%:   77/  102/  106/  330/:  49%
    25   23   22   43  107%:   88/  112/  112/  360/:  49%
    28   27   26   49  106%:   99/  125/  125/  400/:  48%
   4.1  3.8  3.9  5.8  131%:   10/   18/   17/   52/:  53%
   5.3  4.7  4.3 12.3  143%:   24/   47/   43/  130/:  67%
```

ail / Text Product



Publication



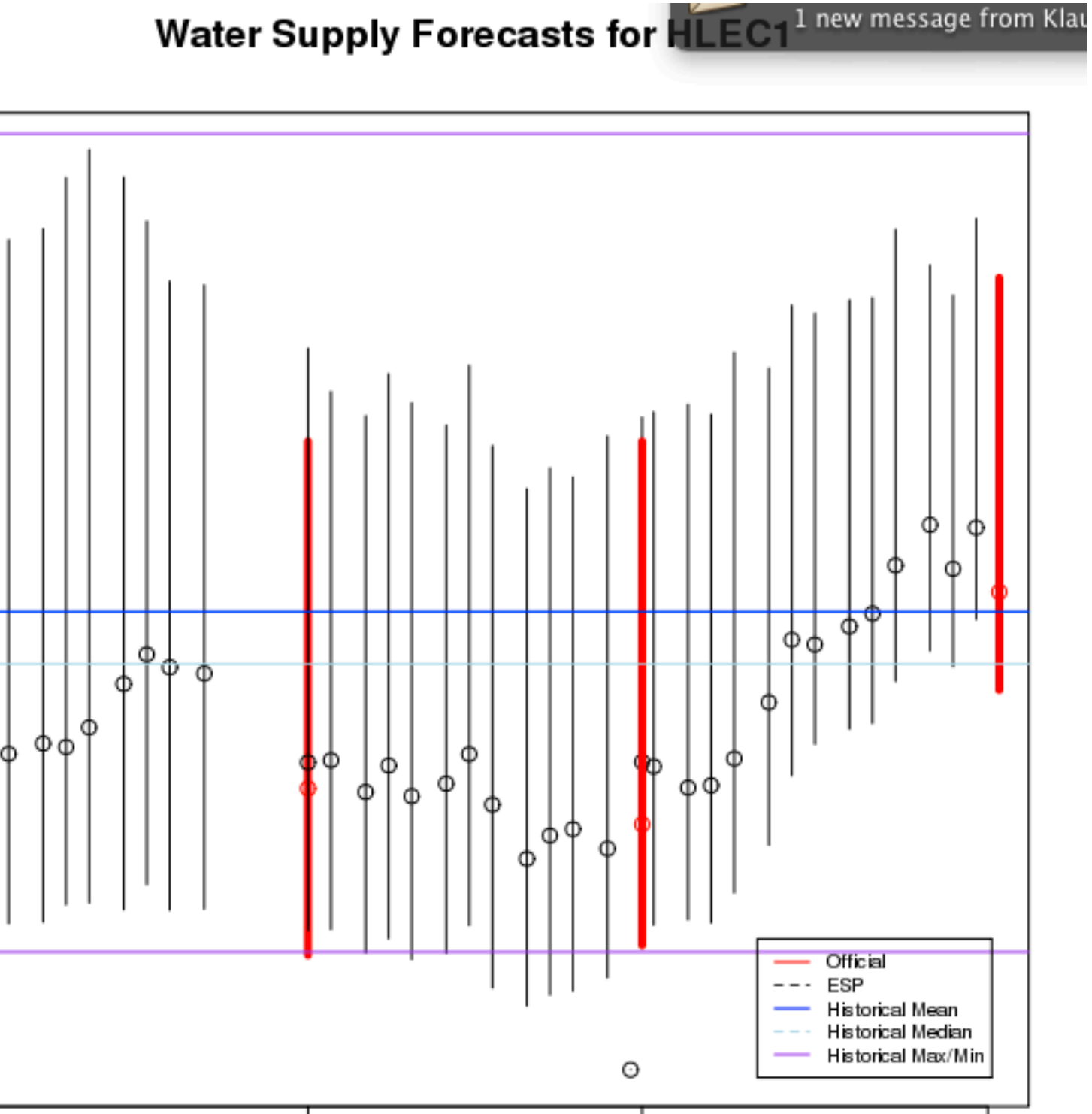
Website

July 24-Month Study
Date: July 10, 2012

rces Group, Salt Lake City
River Annual Operating Plan (AOP) Recipients

low ated) et)	Percent of Average (%)	July 9 Midnight Elevation (feet)	Reservoir Storage (acre-feet)
0	63	6502.32	317,000
0	48	6023.53	3,106,000
0	17	7474.48	467,000
0	9	6050.04	1,226,000

Examples



Example Log:
1/25 – Forecast problem
2/1 – SWS forecast is 60
3/1 – ESP biased high acc
bias statistics; official fore
lower.
3/2 – Snow update (forec
increase)
3/10 – Major QPF event

Download forecasts, trac

Examples

COLORADO - LAKE GRANBY, GRANBY, NR (GBYC2) Back

ase contact CBRFC with questions or for clarification.

Number of Forecasts: 25 OK

ESP RAW MODEL GUIDANCE (Exceedence kaf)

Forecast Period	90%	70%	50%	30%	10%
Jul-Jul 2012	9.8	9.9	**10.2**	11.0	12.8
Jun26-Jul 2012	12.2	12.3	**12.6**	13.2	14.8
Jun19-Jul 2012	16.5	16.6	**17.0**	18.1	19.4
Jun13-Jul 2012	23	23	**24**	25	27
Jun6-Jul 2012	33	34	**35**	37	43
Jun-Jul 2012	42	43	**45**	49	59
May22-Jul 2012	60	63	**66**	75	88
May15-Jul 2012	64	68	**71**	81	97
May8-Jul 2012	72	79	**87**	92	109
May-Jul 2012	80	90	**100**	106	127
Apr24-Jul 2012	105	115	**123**	134	155
Apr15-Jul 2012	110	119	**130**	148	183
Apr10-Jul 2012	102	120	**131**	145	177
Apr4-Jul 2012	111	130	**142**	161	193
Apr-Jul 2012	119	144	**153**	170	205
Apr-Jul 2012	122	145	**157**	173	210
Apr-Jul 2012	132	152	**172**	182	215
Apr-Jul 2012	134	157	**180**	193	230
Apr-Jul 2012	134	161	**184**	195	245
Apr-Jul 2012	132	162	**188**	205	245
Apr-Jul 2012	129	154	**173**	198	235
Apr-Jul 2012	130	156	**176**	195	265
Apr-Jul 2012	121	148	**171**	198	265
Apr-Jul 2012	136	158	**182**	210	280
Apr-Jul 2012	132	162	**181**	205	280

OFFICIAL COORDINATED FORECAST (Exceedence kaf)

Date Issued	Forecast Period	90%	50%
6/1/2012	Jun-Jul 2012	31	**45**
6/1/2012	Jun-Jul 2012	31	**45**
4/1/2012	Apr-Jul 2012	102	**150**
4/1/2012	Apr-Jul 2012	102	**150**
3/1/2012	Apr-Jul 2012	123	**180**
2/1/2012	Apr-Jul 2012	120	**180**

More examples: Cass?

Discussion

our input is key!

- Does paradigm described meet your needs? Why or why not?
- QPF vs no QPF?
- Forecast horizon?
- Seasonality of issuance?