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

The Past: A Brief Recap

The Need for Change: Stakeholders, Science, and Verification

The Future: Perspectives and Direction

- Science and Stakeholders

The Past

SWS (Statistical Prediction)

ESP (Hydrologic Model Prediction)

VIPER (Statistical Prediction)

(River Forecast Centers)

(Water and Climate Center)

Forecast Coordinatio

Official Coordinated Forecast

Other Inputs

. . . .

Water Managers and Users

Decisions

Methods

➢ Statistical 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)

➢ Ensemble 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

Forecast 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

Past practice:

- Not conducive to more frequent (daily/weekly) updates
- Not conducive to ensemble based forecasts
- Coordination and manual combination does not systematically add skill (see verification)
- Forecast process not repeatable
- In spite of some success, integration of new science is difficult

New practice should:

- Leverage NOAA/NWS expertise with weather and climate prediction
- Leverage CBRFC daily forecast operations
- Leverage CBRFC forecaster expertise
- Provide short to long term forecast information including ensembles
- Ease ability to integrate new science, methodology, and technology

1983 Forecast Assessment

The statistical 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 data or changes in data sources require complete recomputation).

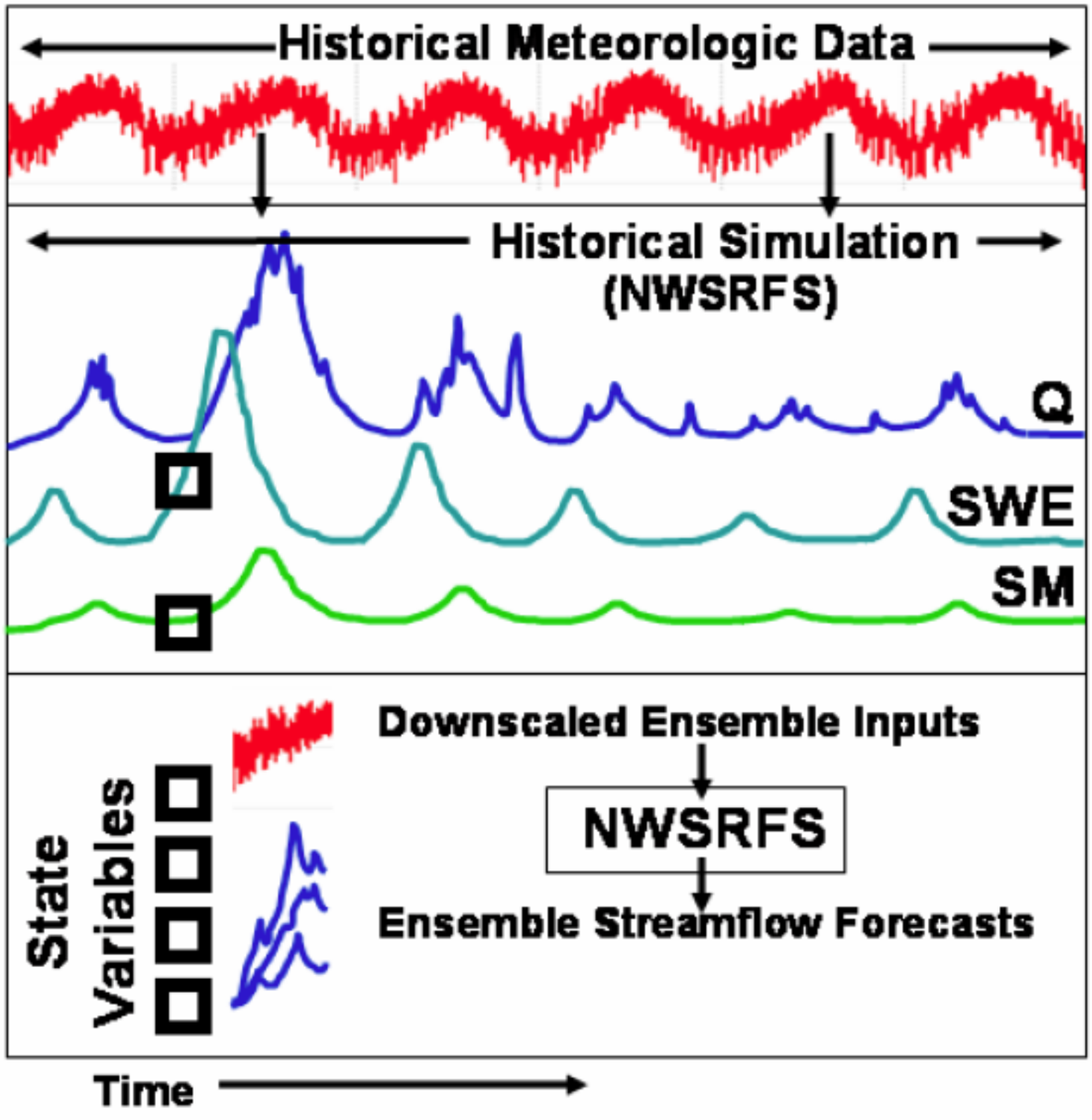
Forecast Verification

Key Questions:

- How accurate is each forecast tool?
- How reliable is each forecast tool?
- How do these answers change over time or space?

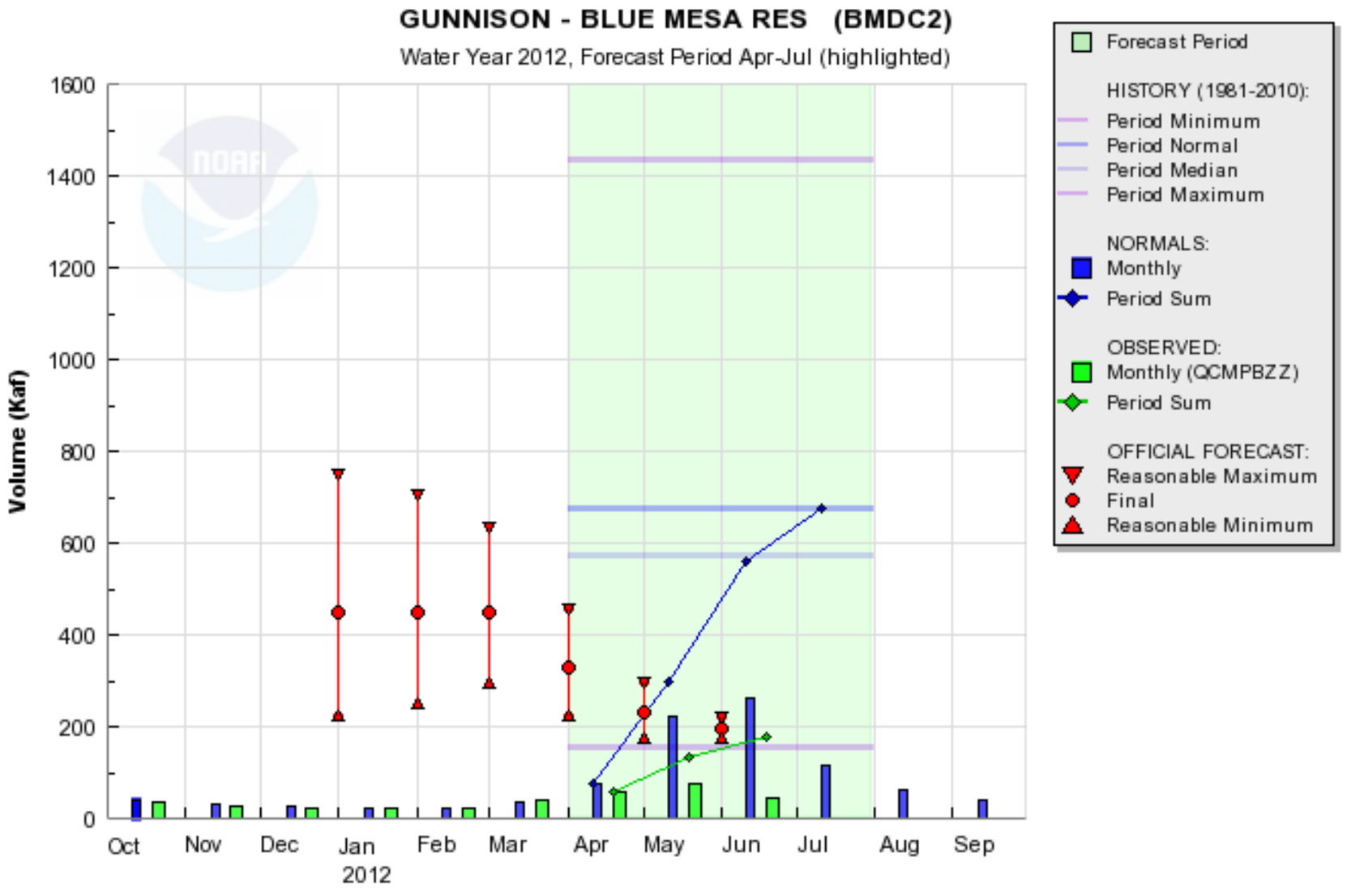
Verification Strategy

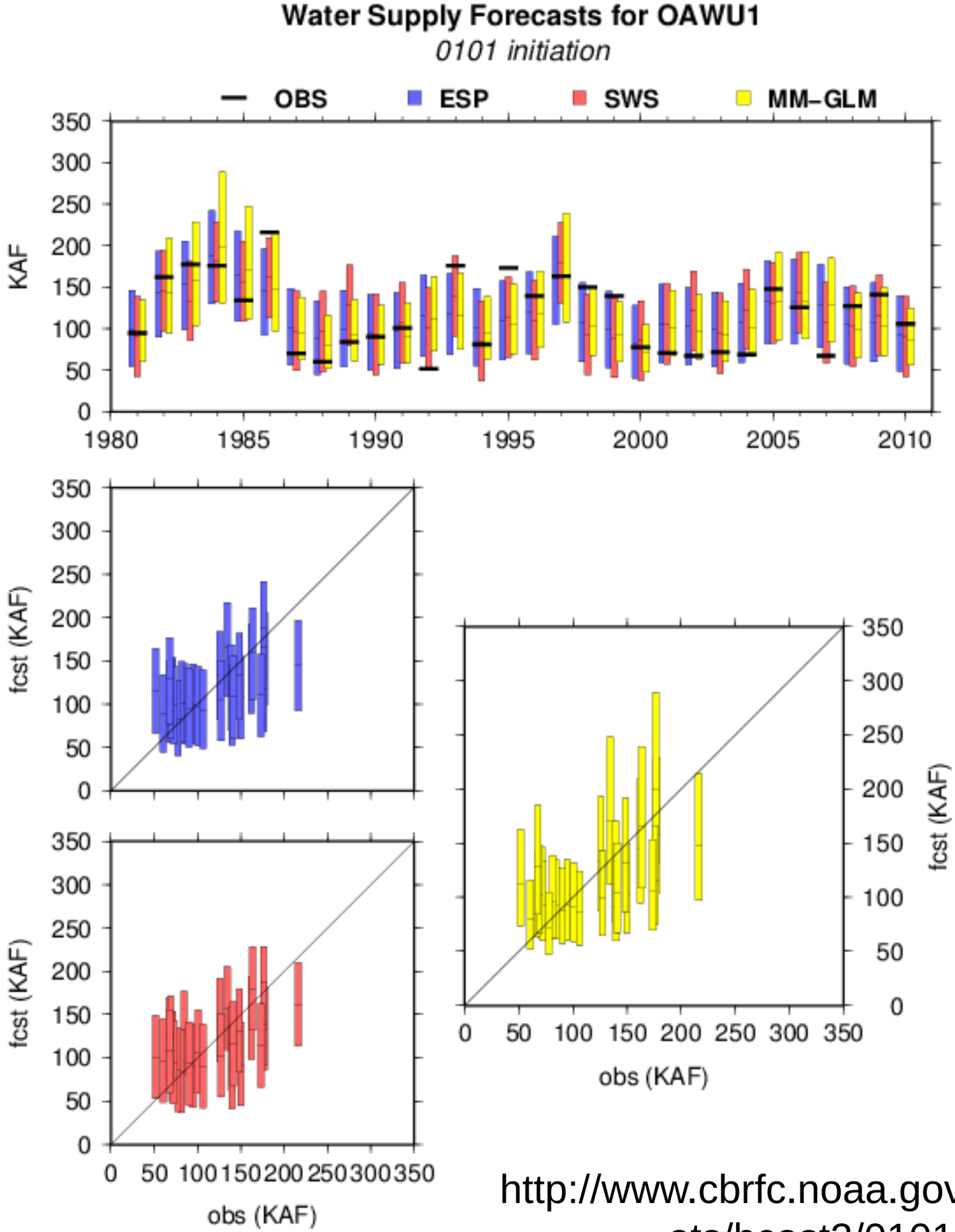
- Systemic answers require large number of forecasts
- Use reforecasts to have a large sample size
  - Reforecasts use current calibrations to simulate past forecasts
  - Do not (yet) incorporate weather forecasts (which would make it better)



Metrics Explained

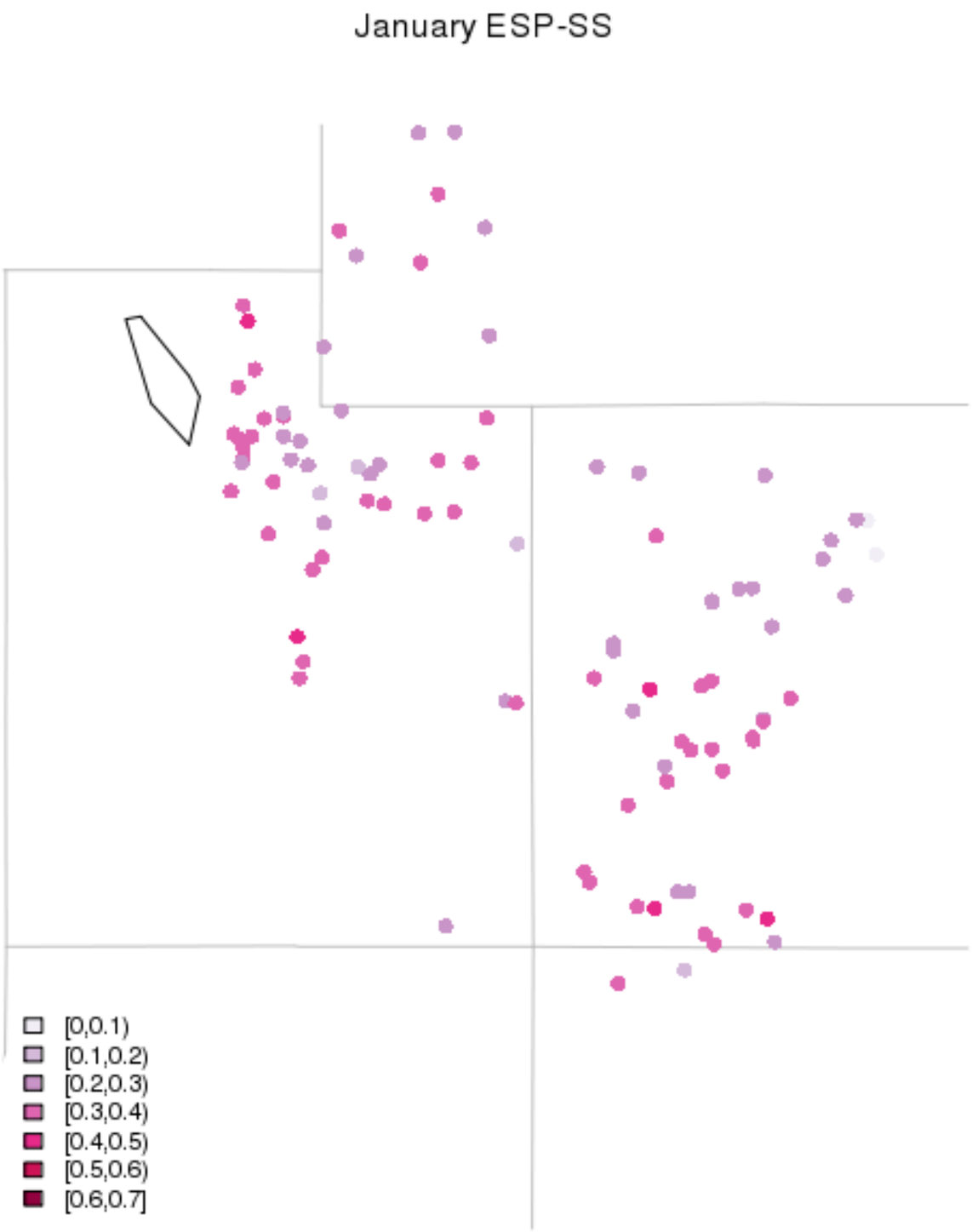
- Accuracy: Forecast-Observed
- Reliability: Relationship of observed to forecasts

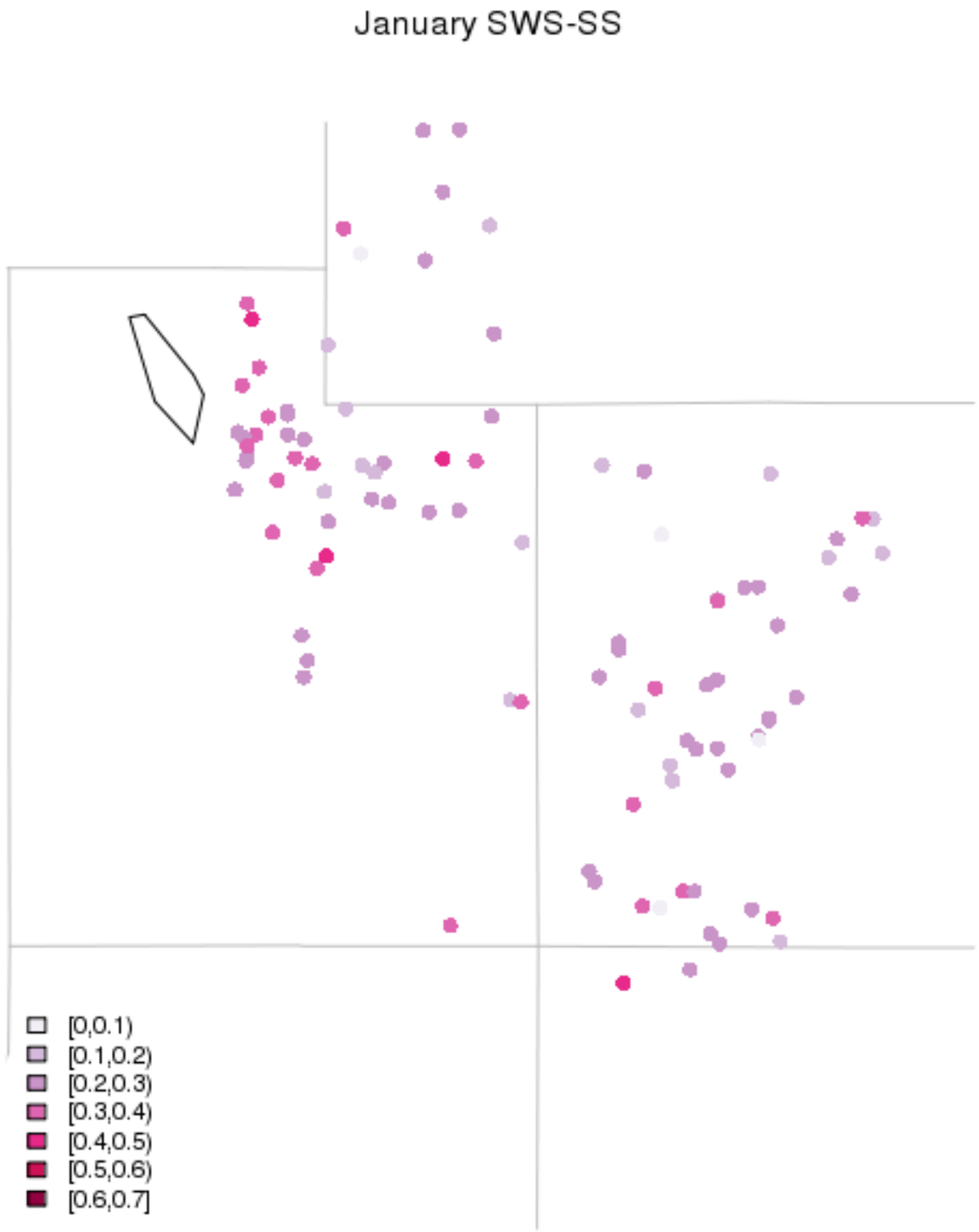


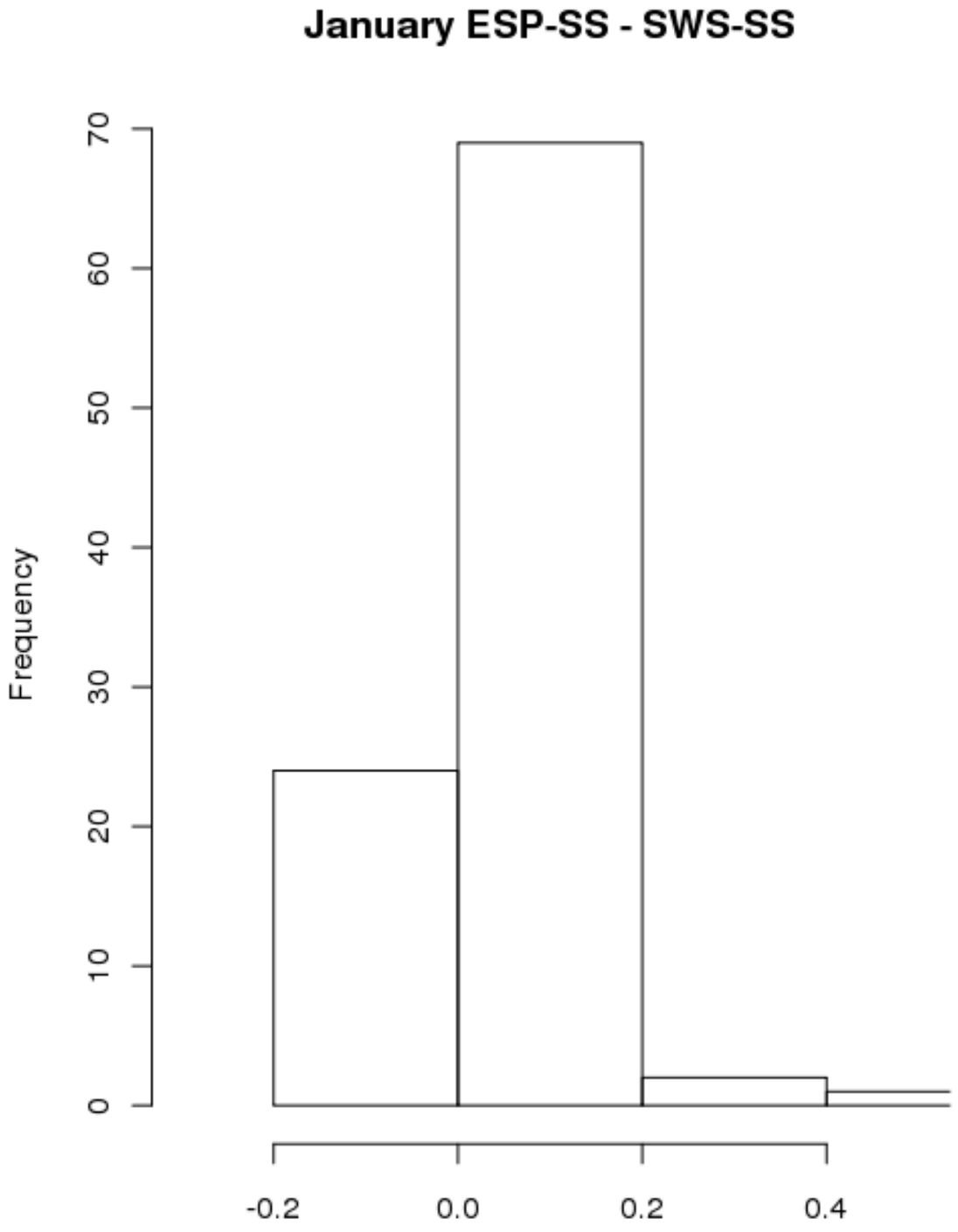


http://www.cbrfc.noaa.gov/wsup/verification/plots/hcast2/0101/index.html

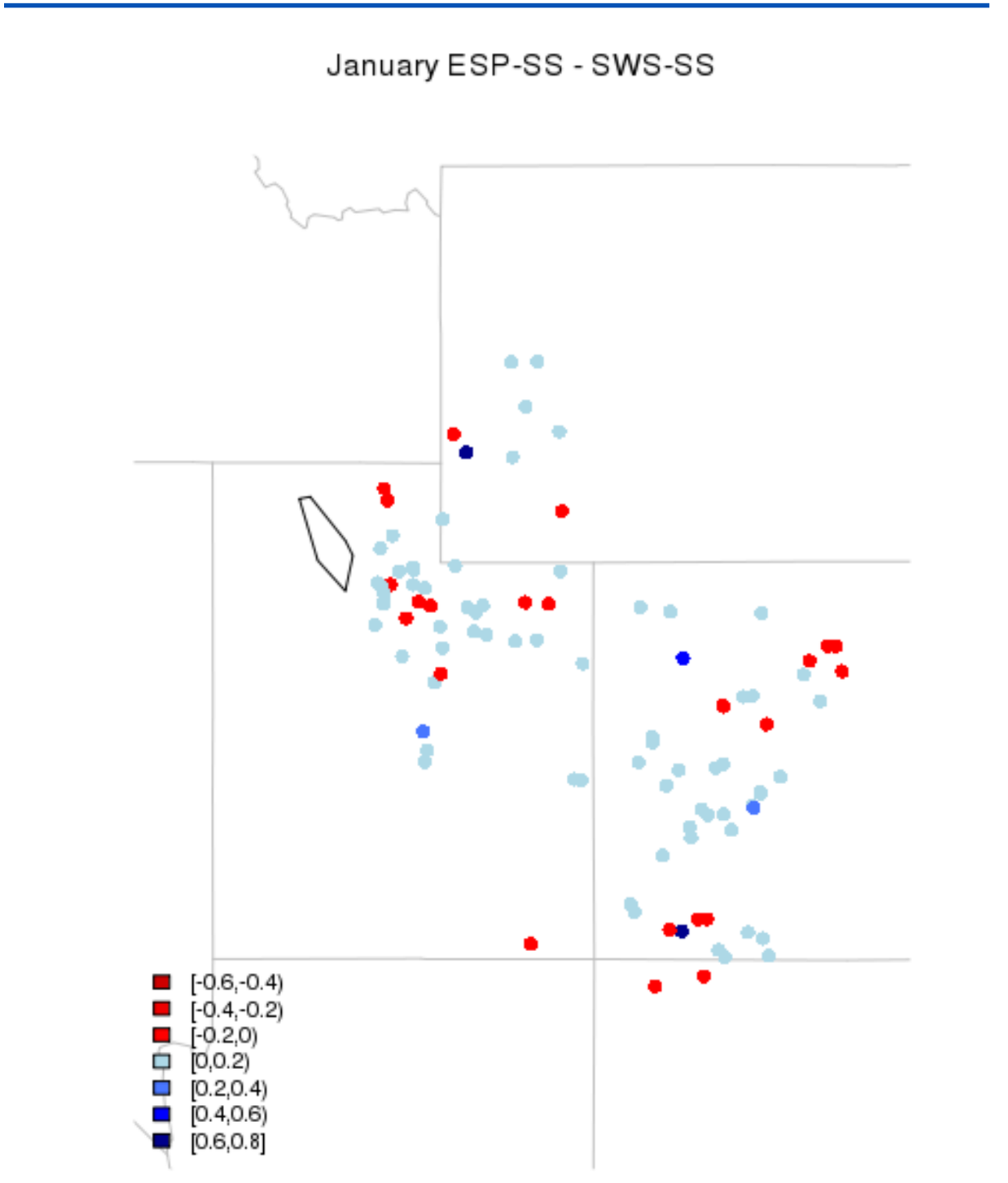
January 1
50% Forecast Accuracy





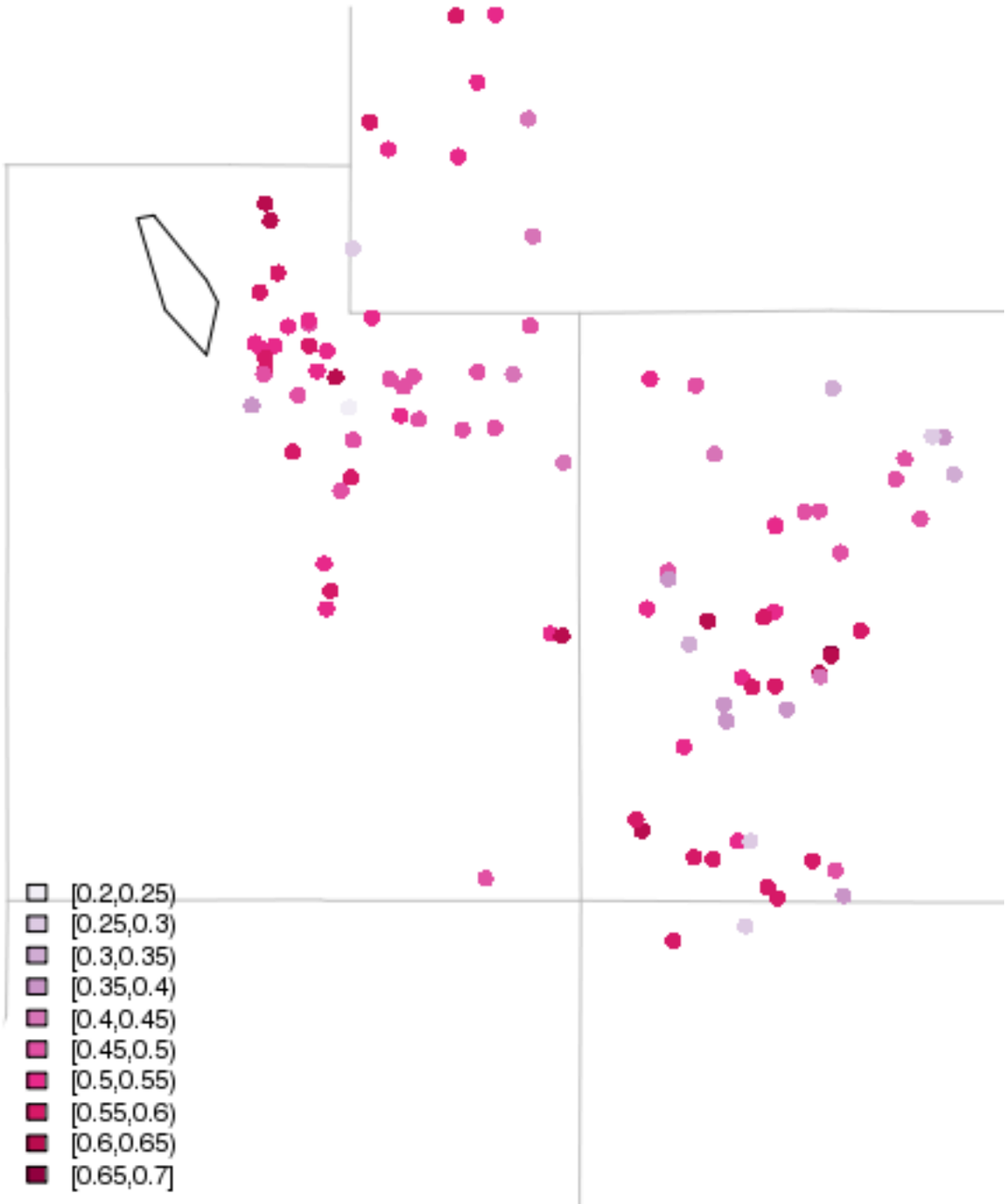


ESP more accurate in 74 of 98 cases

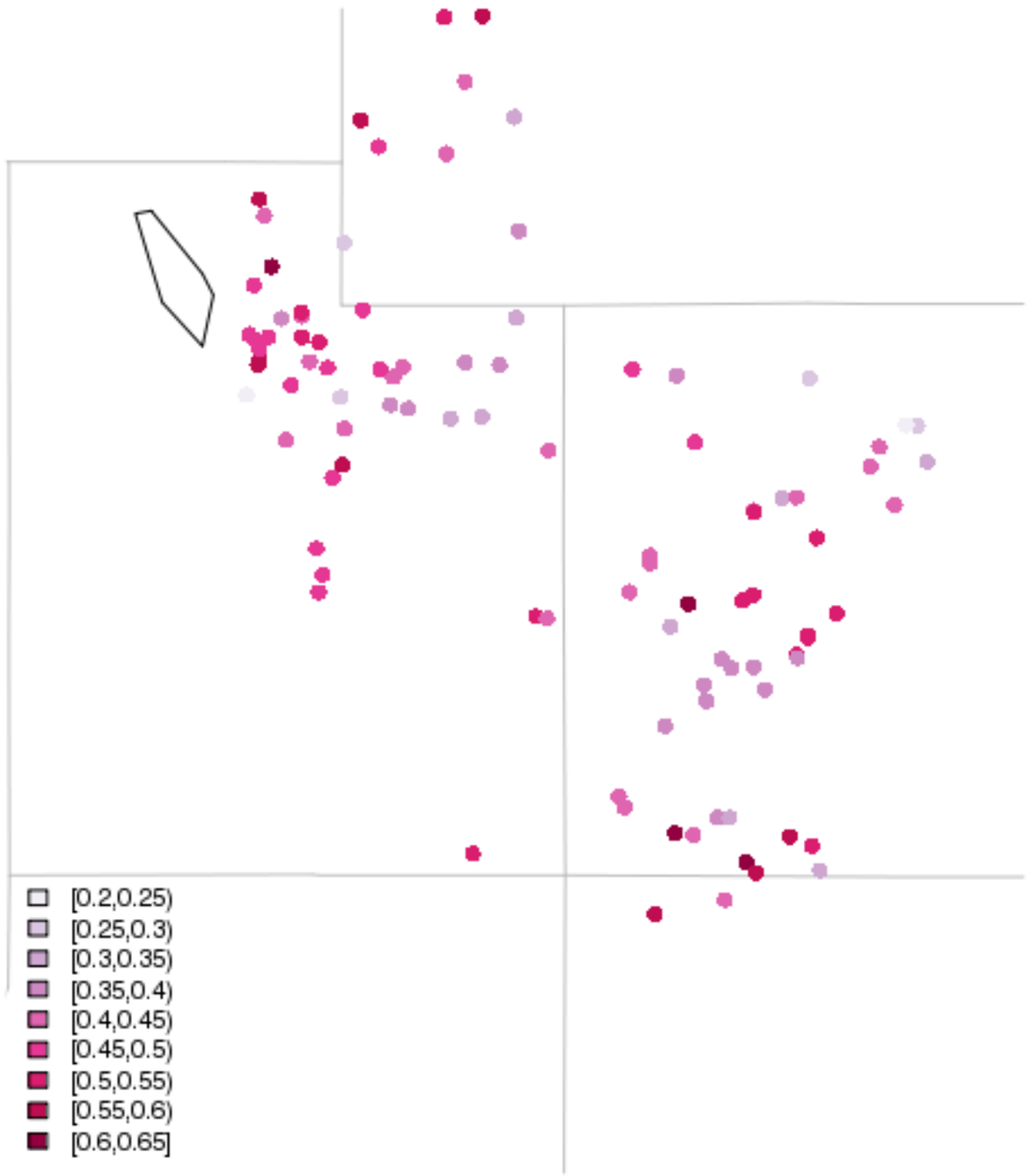


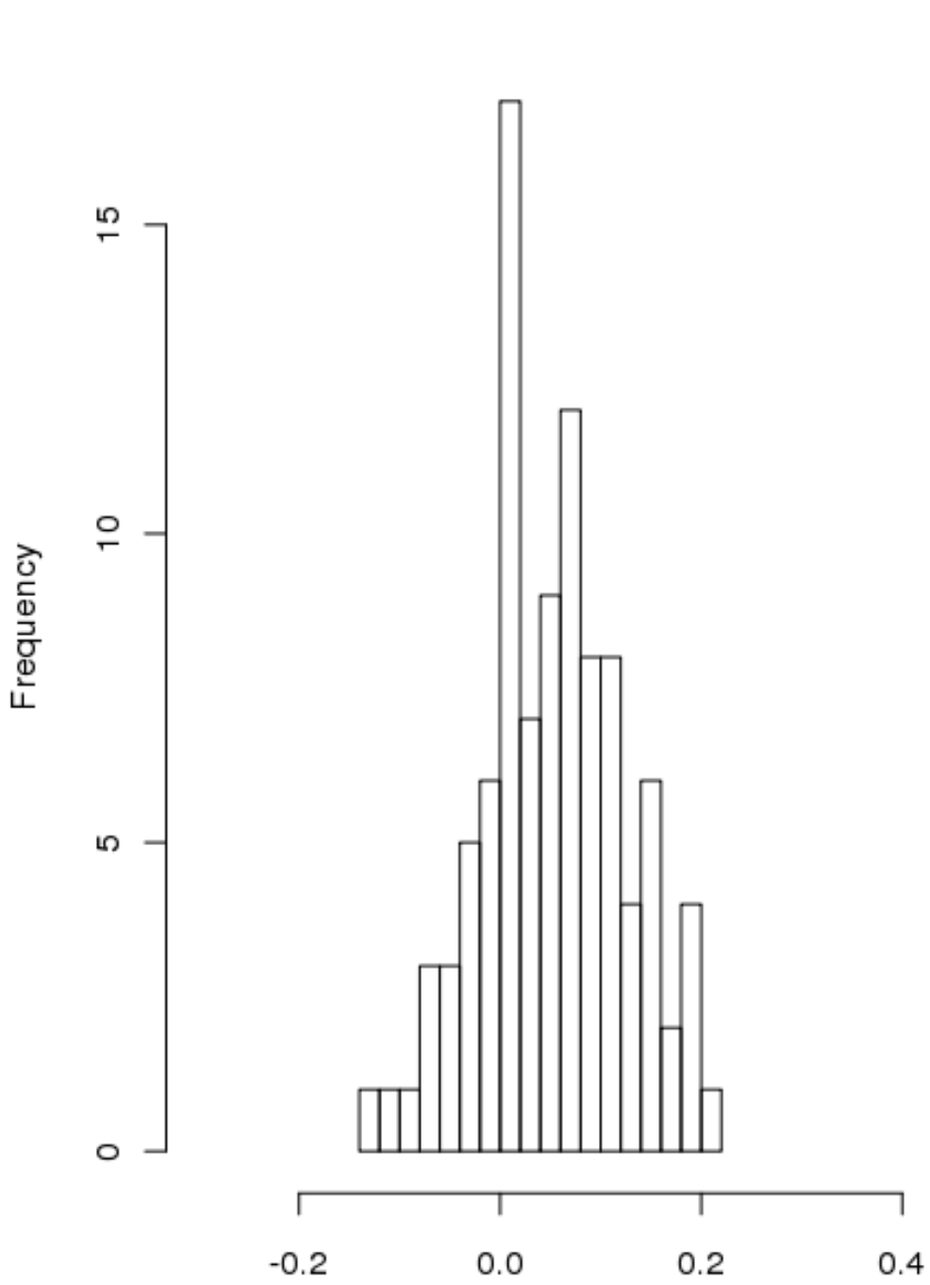
April 1
50% Forecast Accuracy

April 1 ESP-SS

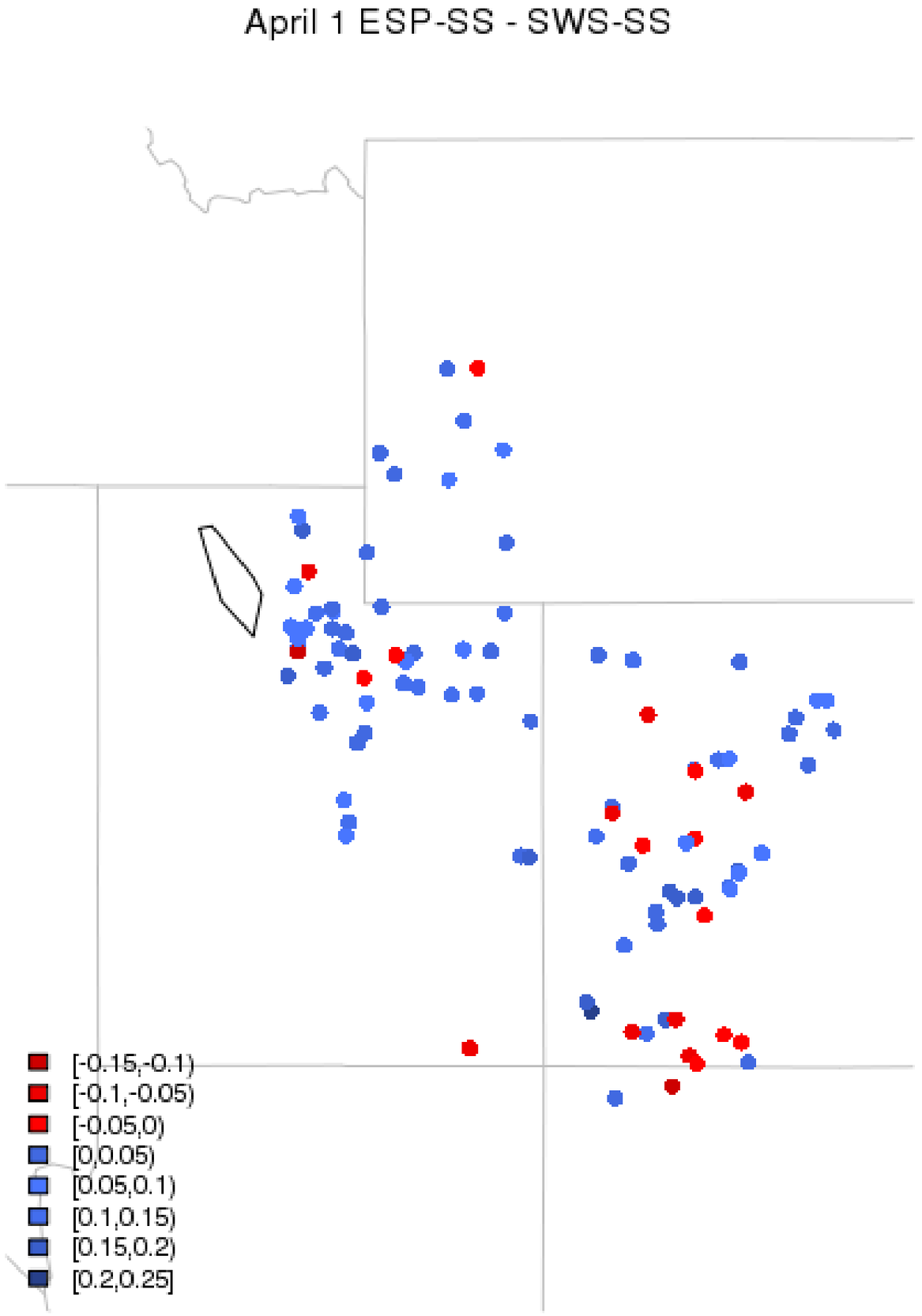


April 1 SWS-SS

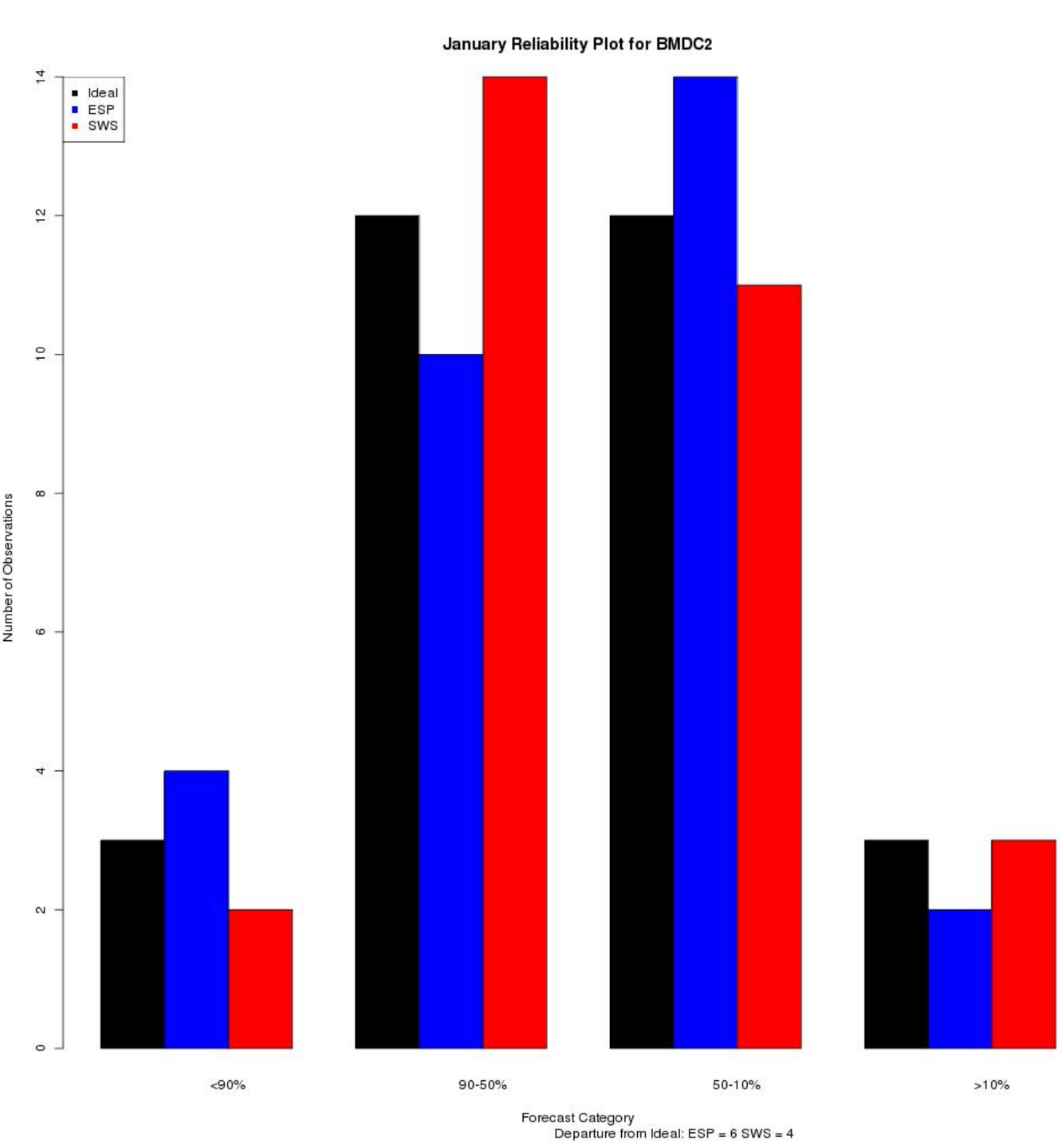


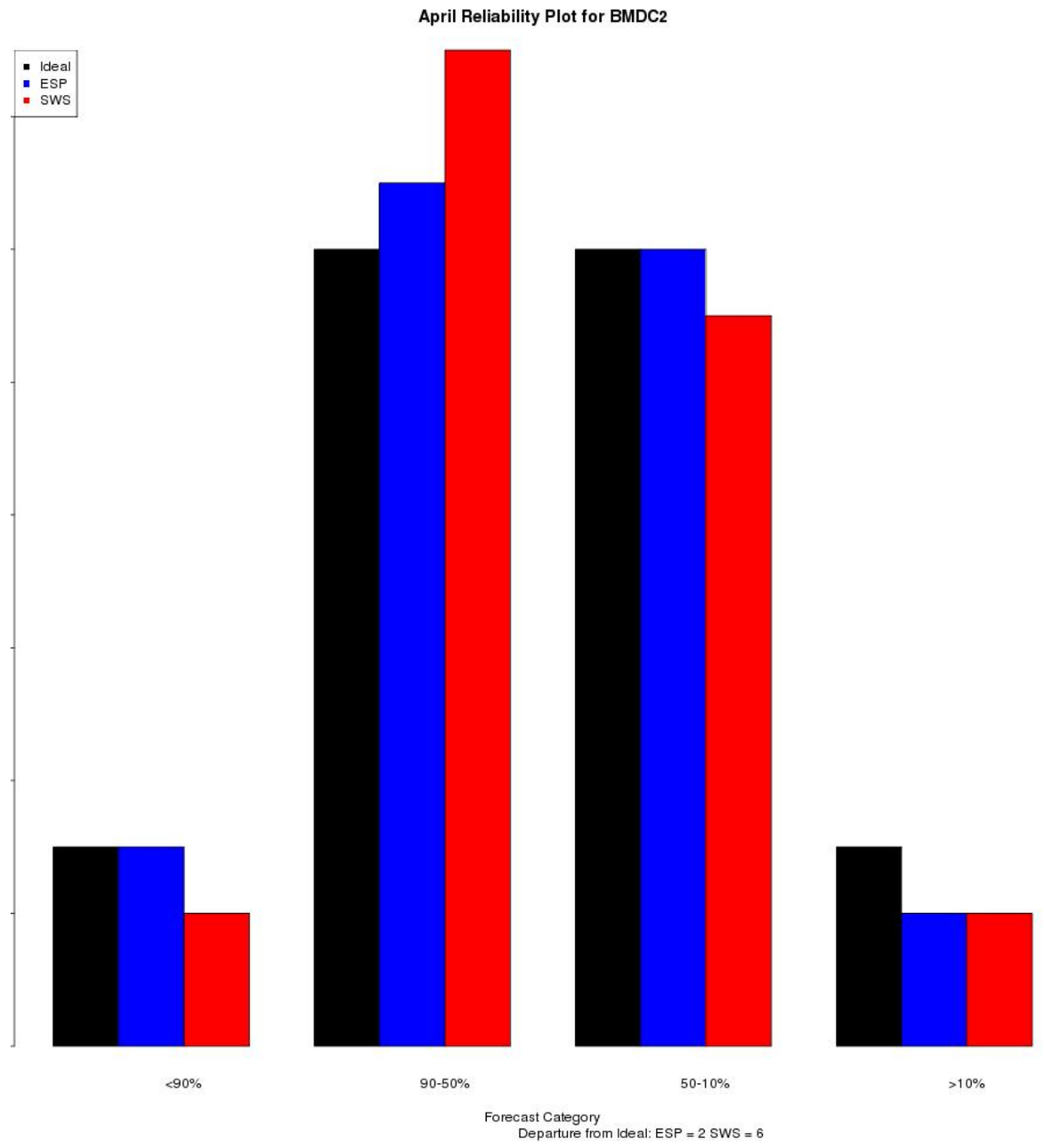


ESP more accurate than SWS in 78 of 98

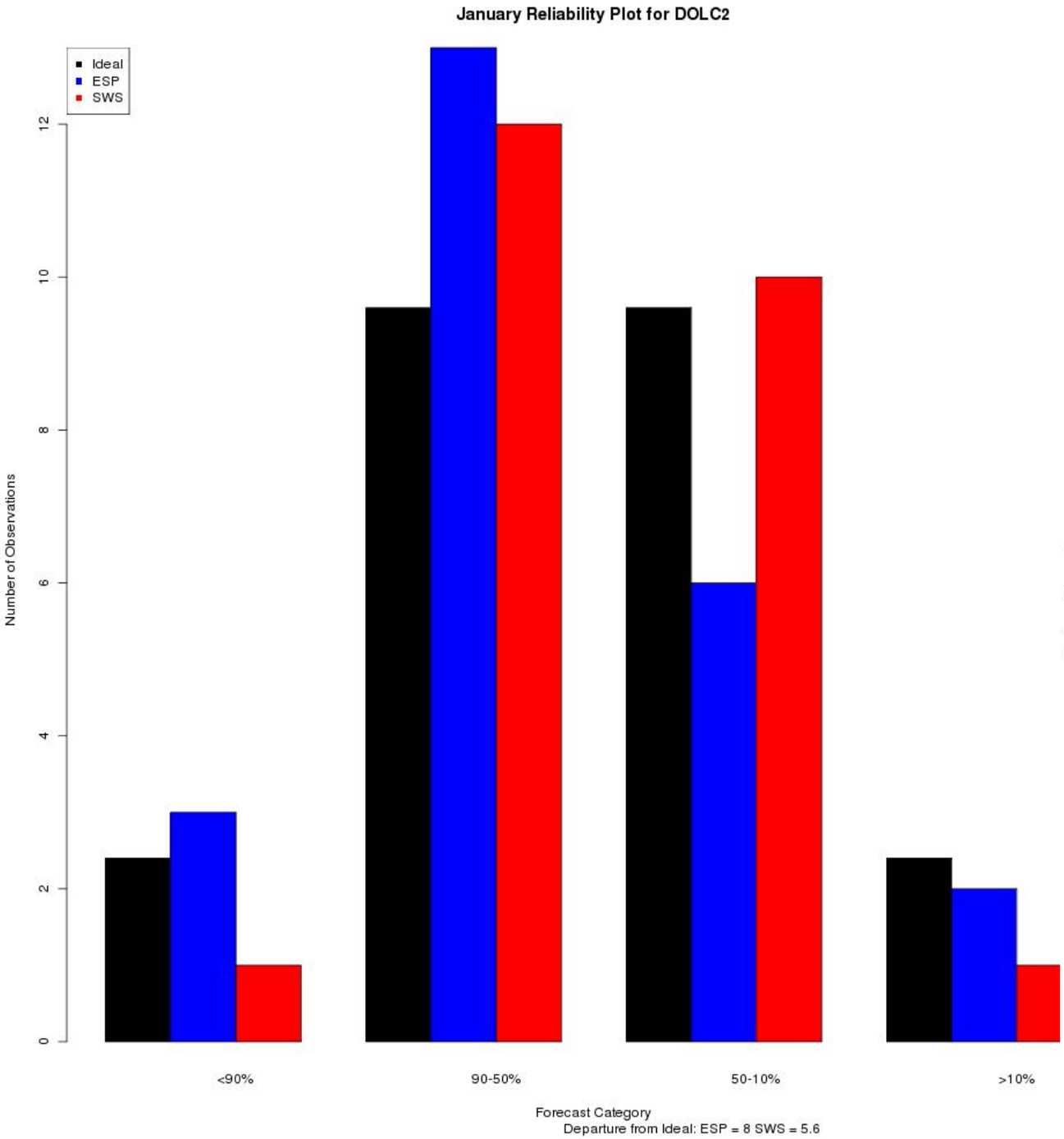


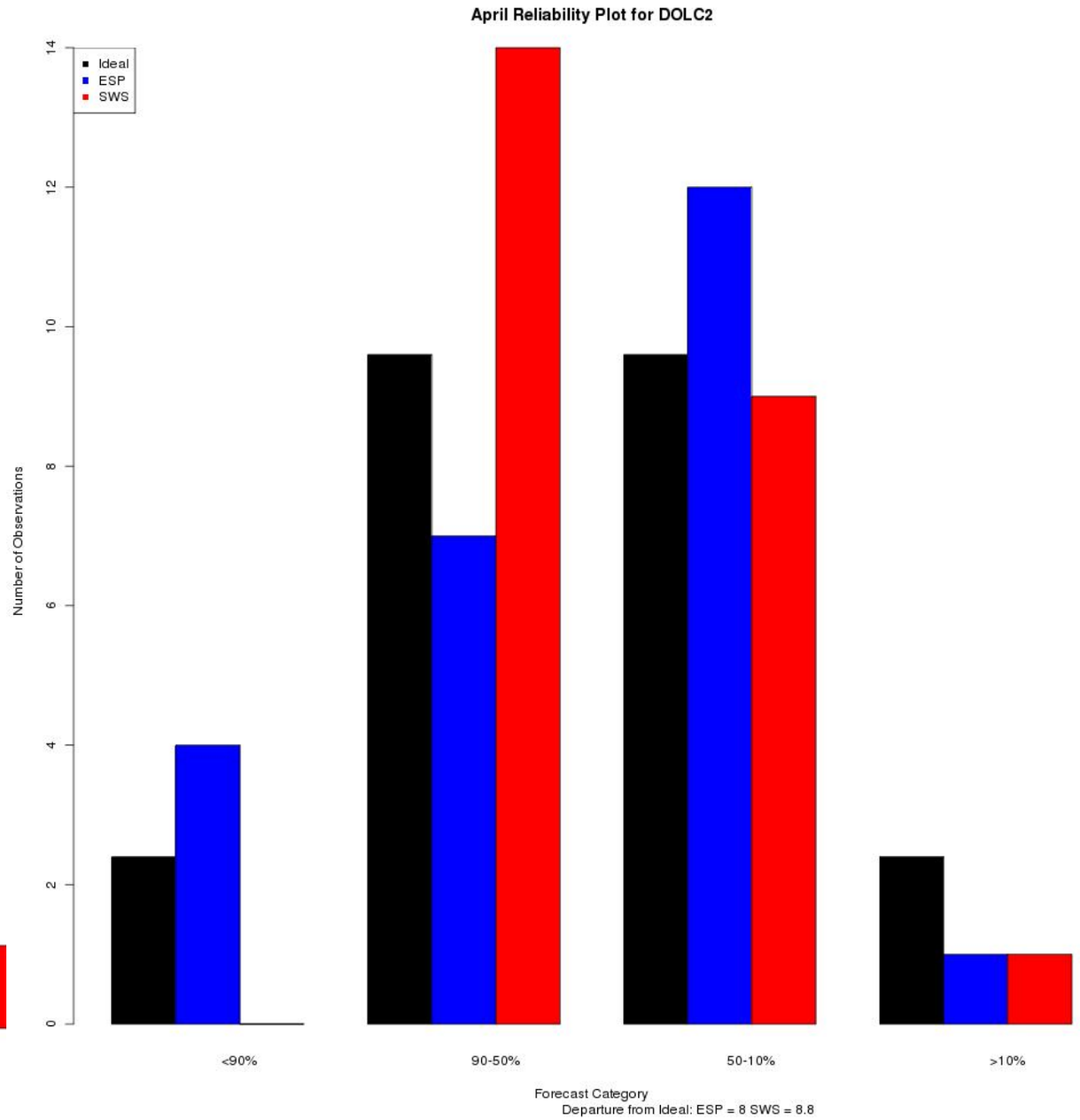
Forecast Reliability



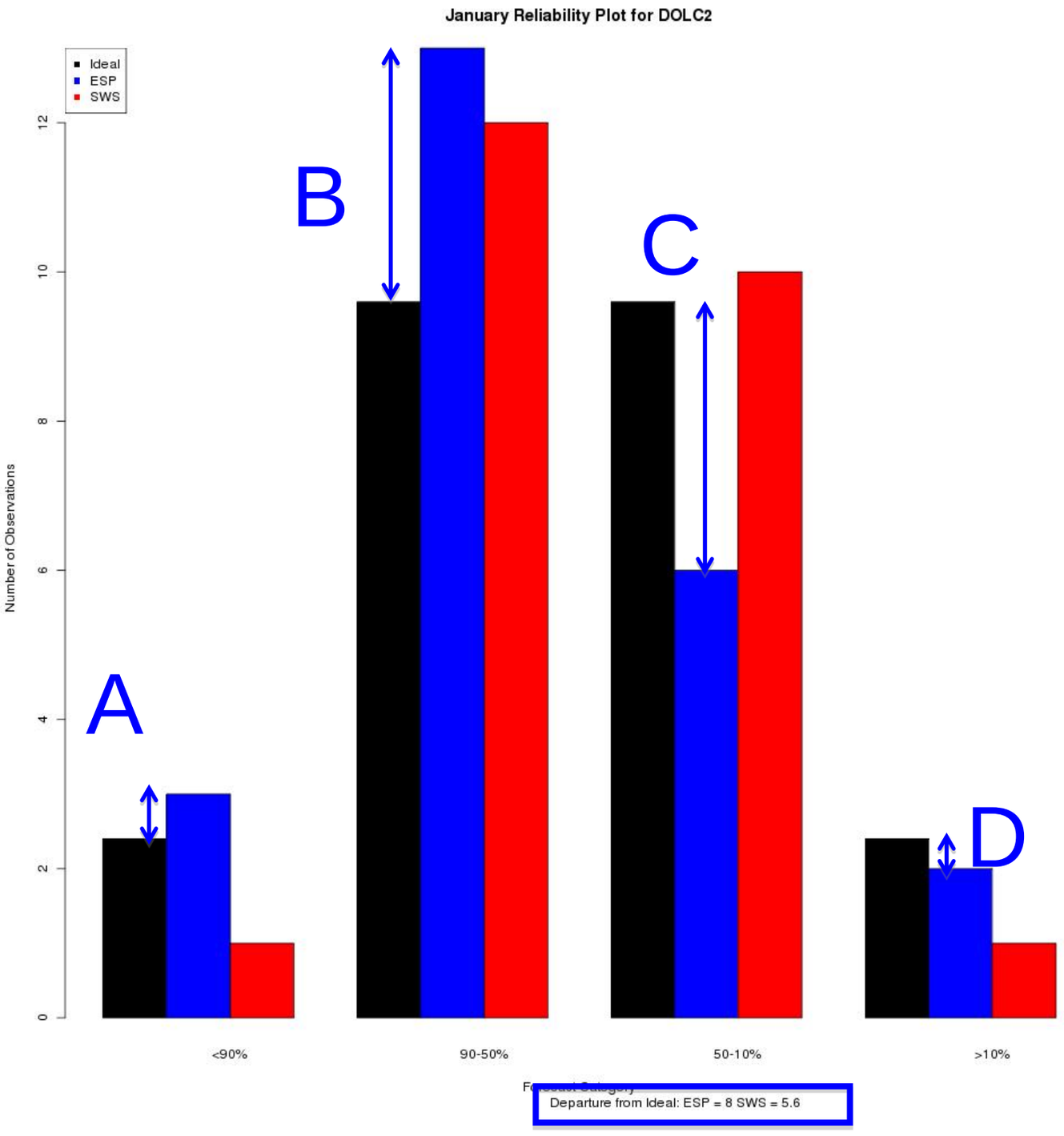


Forecast Reliability



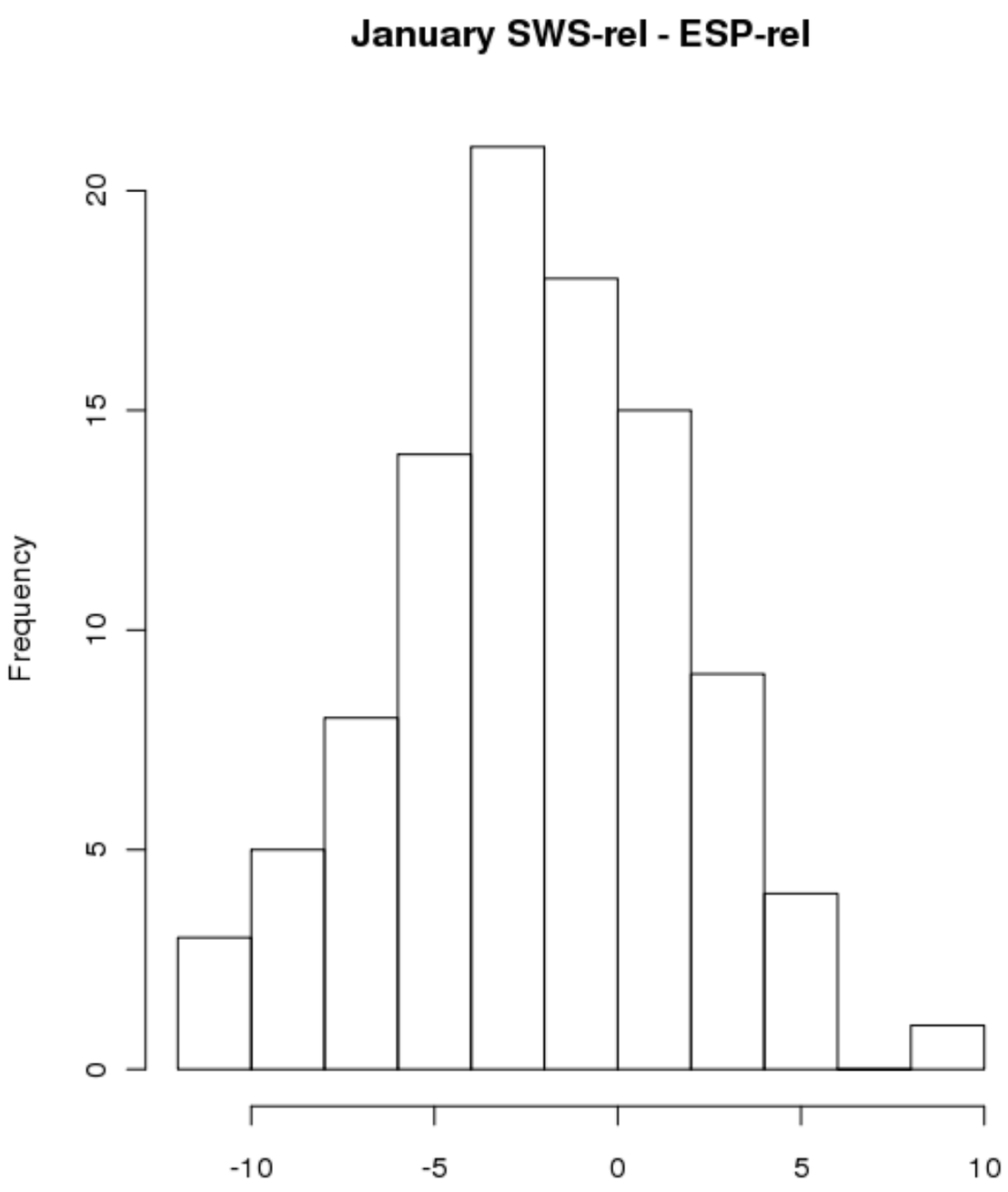


Forecast Reliability

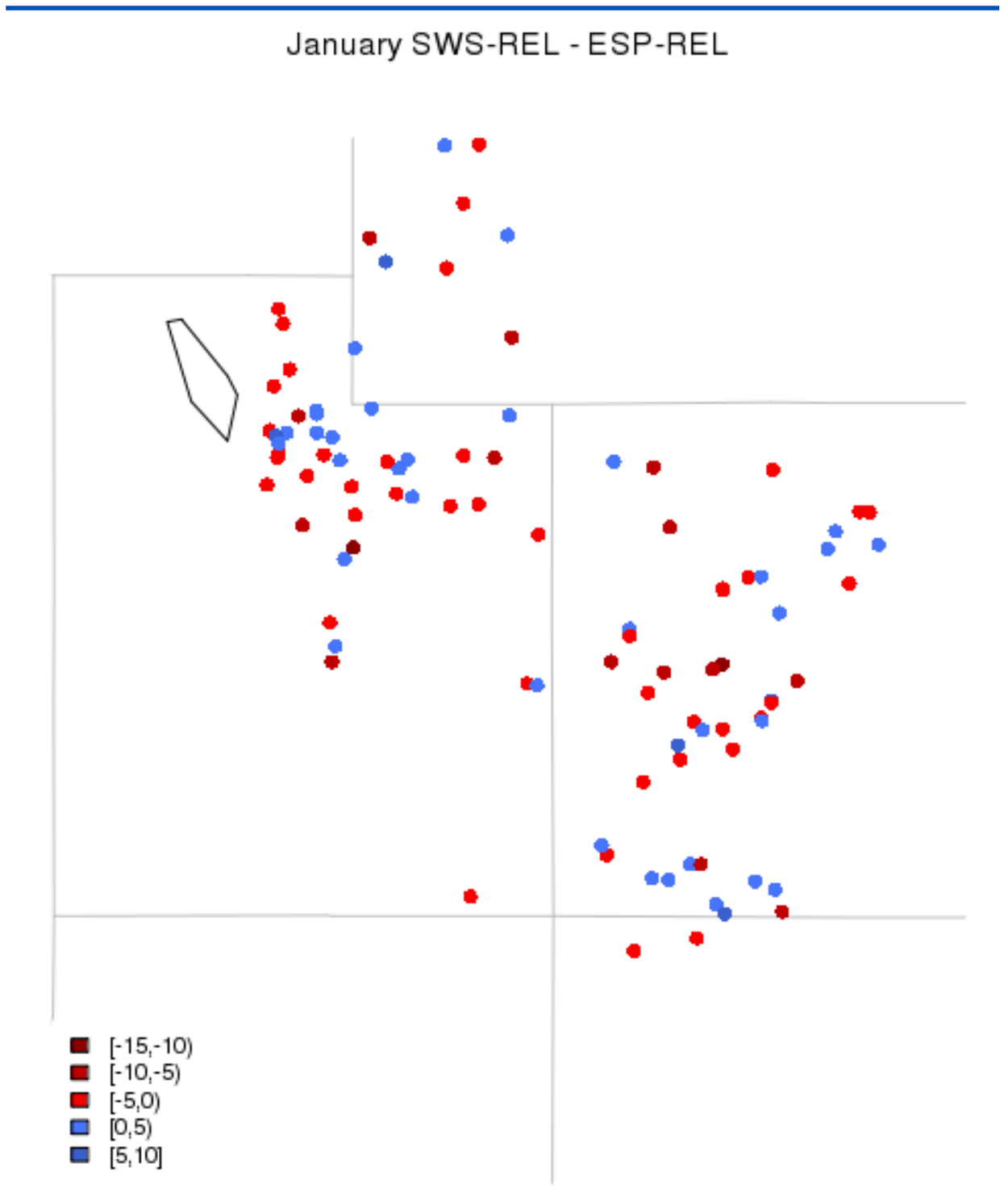


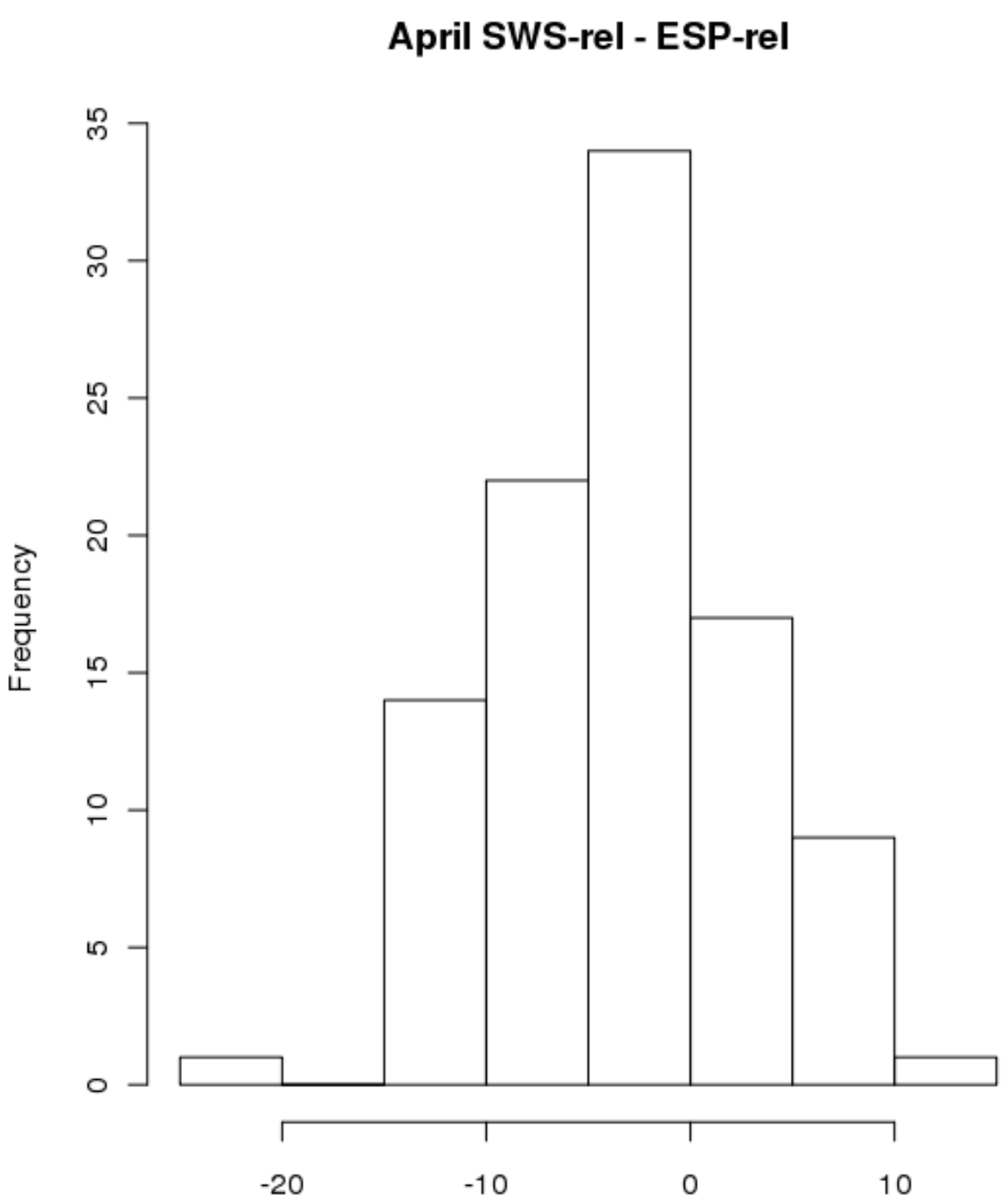
Ok; But how does reliability of forecast system vary over all points?

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

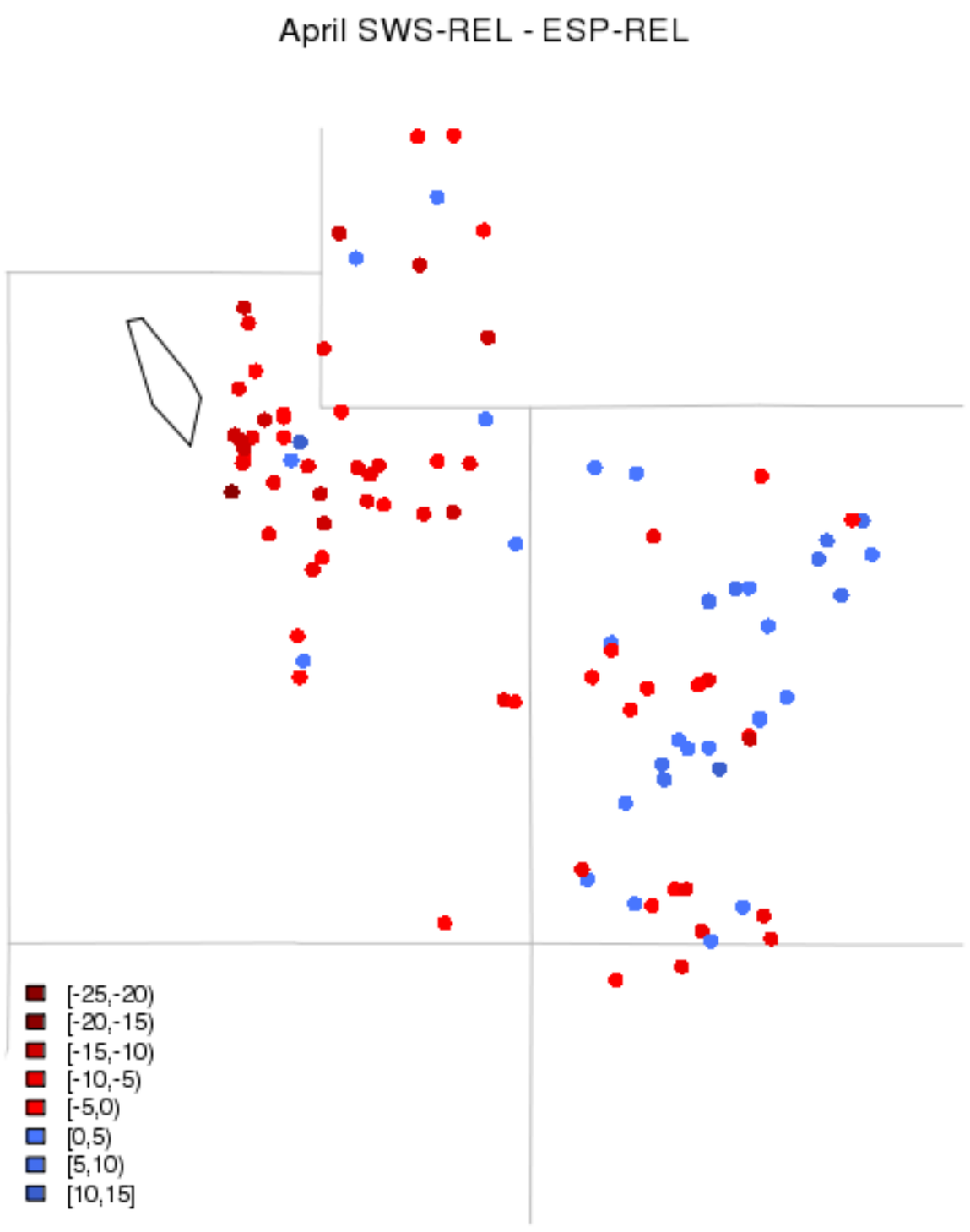


ESP more reliable at 29 of 98 points. ESP and SWS equally reliable at 10 points.

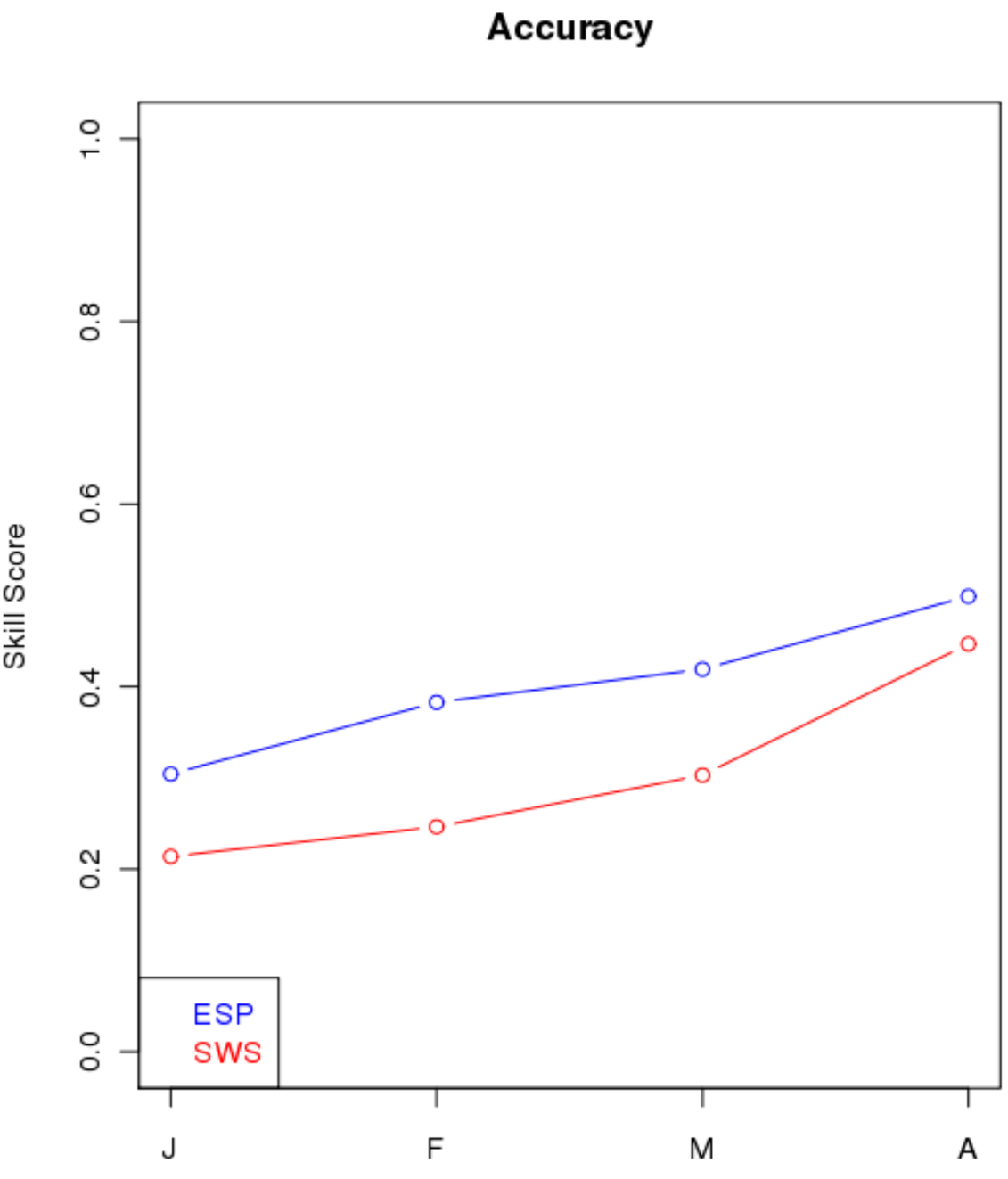


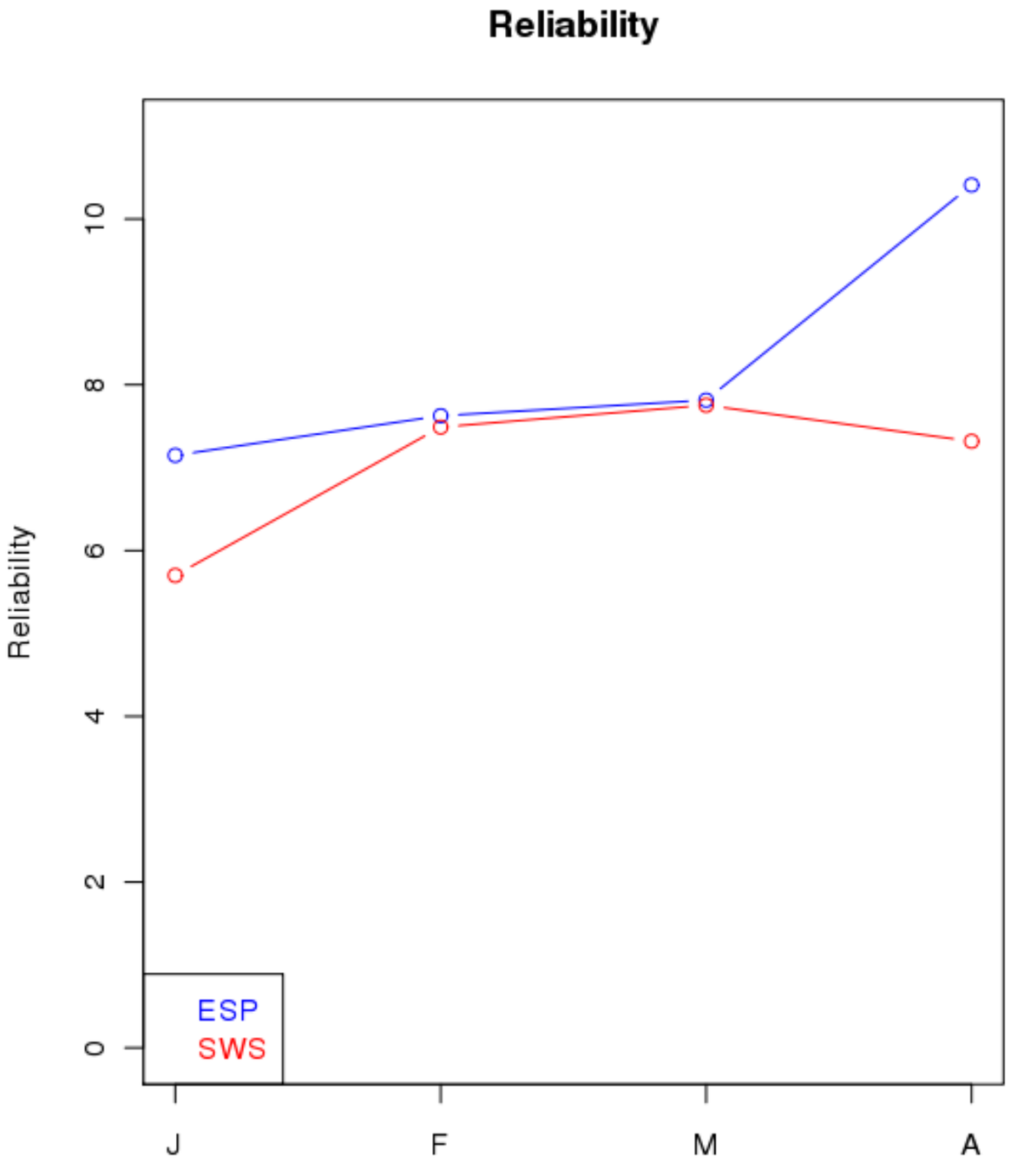


For April 1, ESP more reliable than SWS in 48 of 98 points



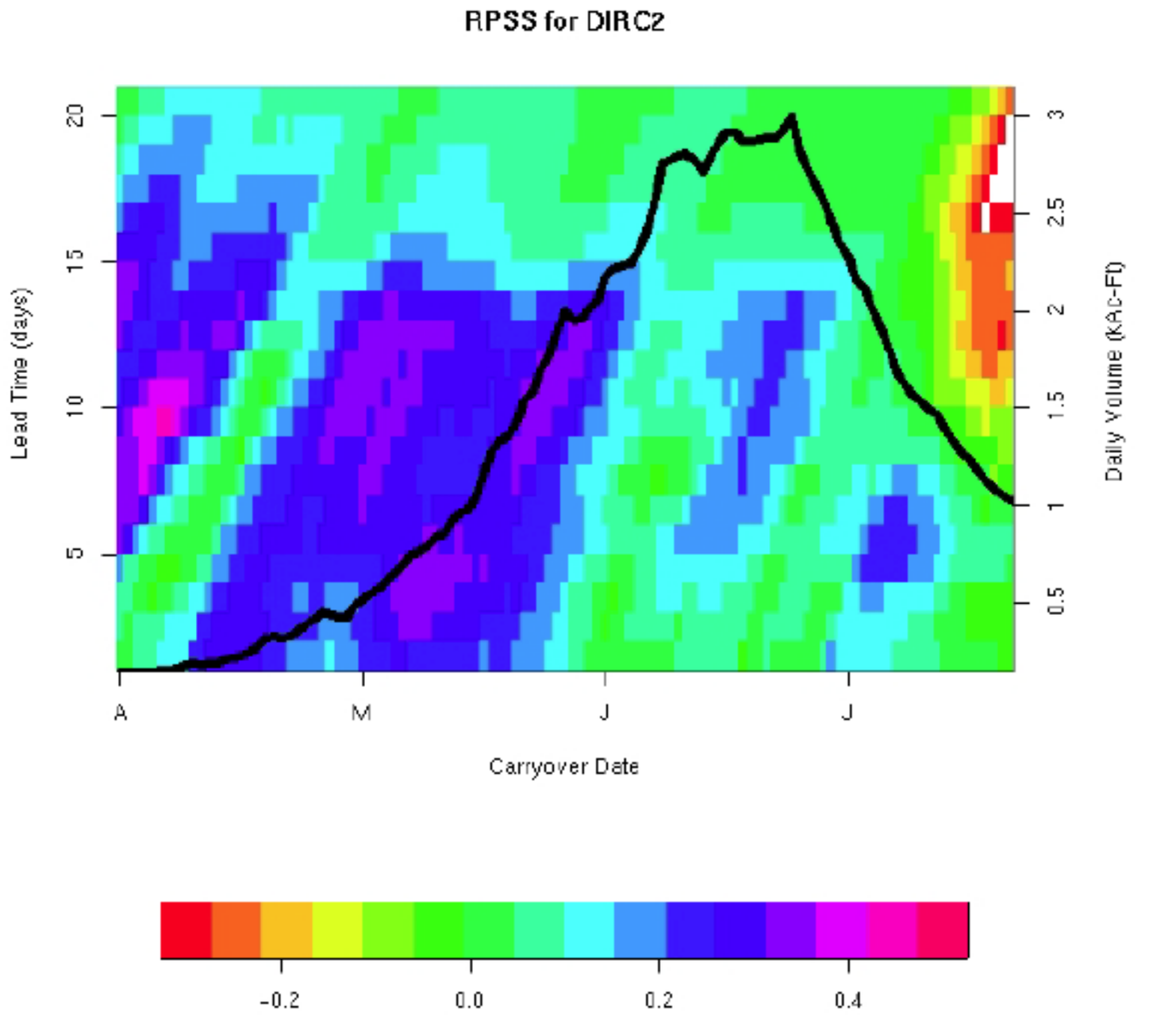
Across Lead Times





Weather Forecasts Will Help Even More…

Werner et al, 2004 compared ESP forecasts with 14 days of probabilistic weather inputs with ESP based on pure climatology. Showed that ESP with weather outperformed ESP without weather



Werner et al, 2004 – available at www.cbrfc.noaa.gov

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.

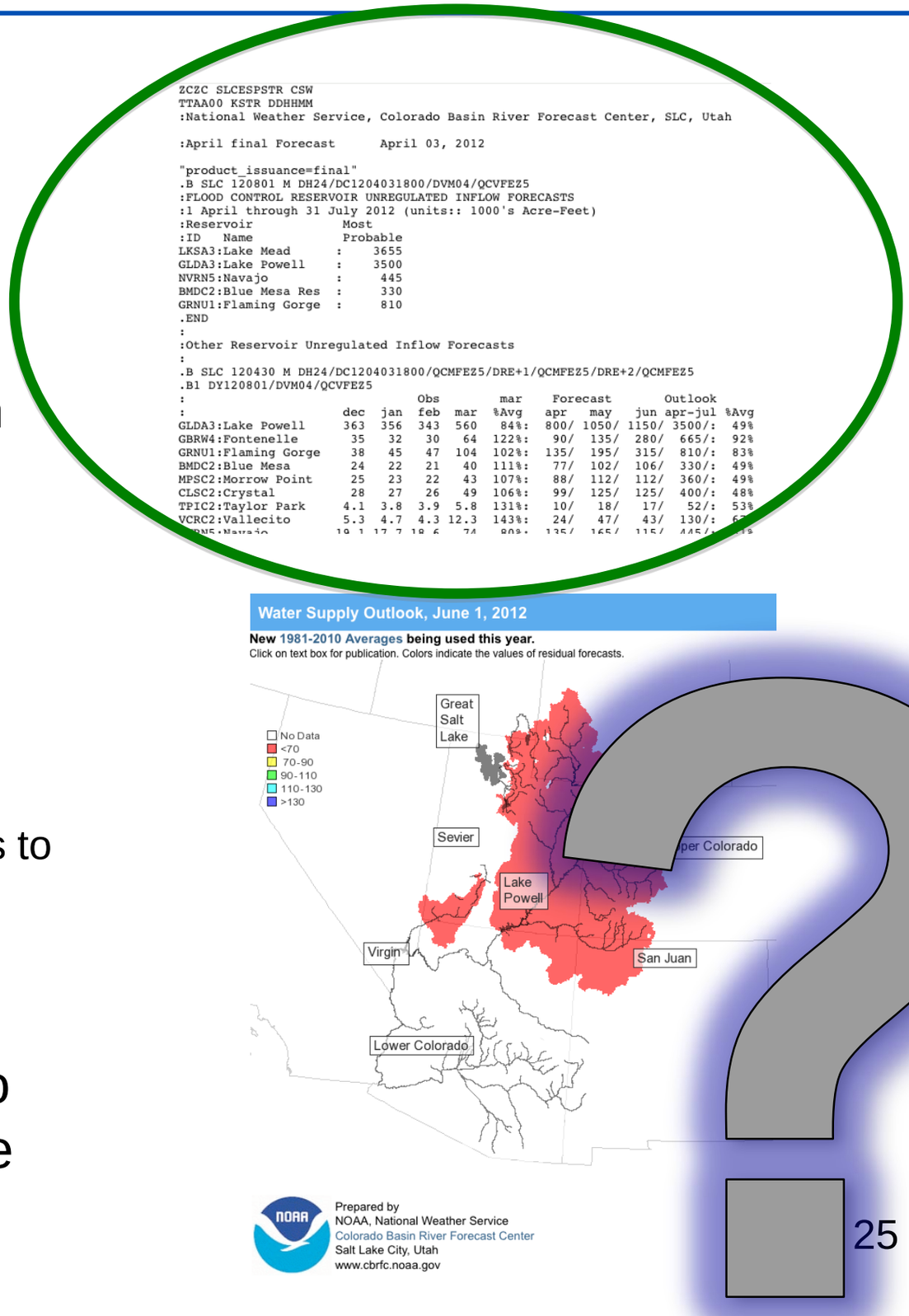
New Direction (NOAA/NWS)

- 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 skill
  - Backward compatibility for key forecast products (e.g. emailed products)

New Direction (CBRFC)

What 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

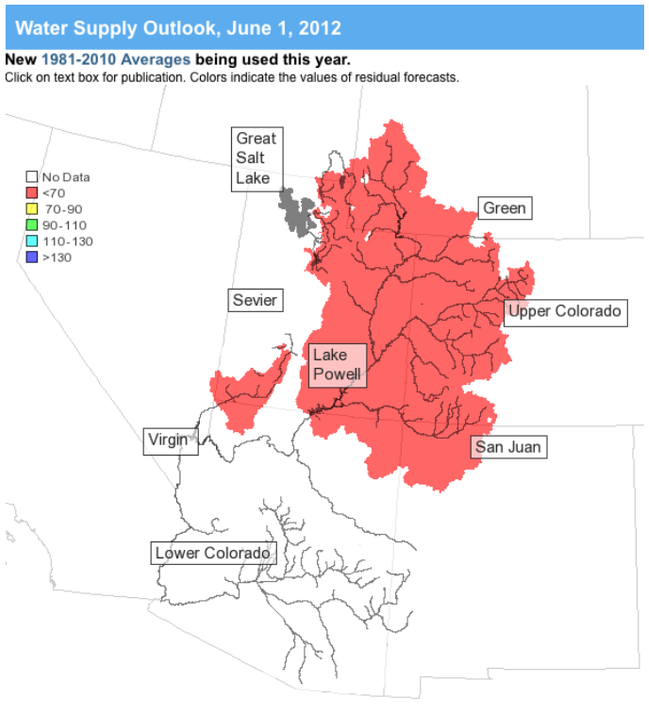


Question

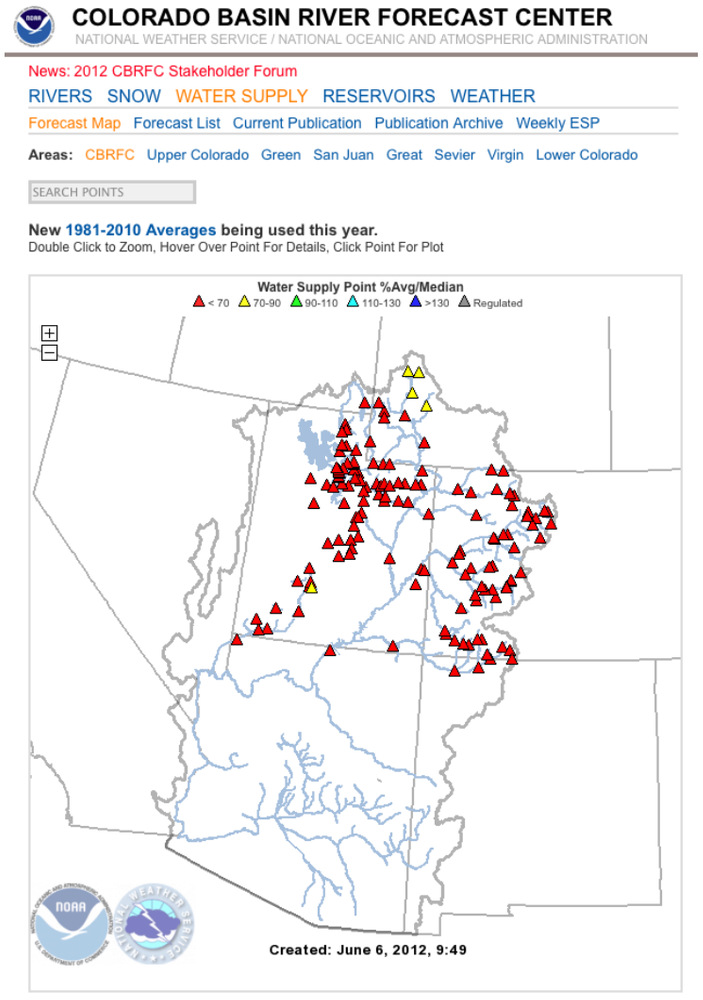
How do you currently access CBRFC water supply forecasts?

```
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/:  67%
NVRN5:Navajo       19.1  17.7 18.6   74  80%:  135/  165/  115/  445/:  61%
```

Email / Text Product



Publication



Website

July 24-Month Study
Date: July 10, 2012

From: Water Resources Group, Salt Lake City
To: All Colorado River Annual Operating Plan (AOP) Recipients

Current Reservoir Status

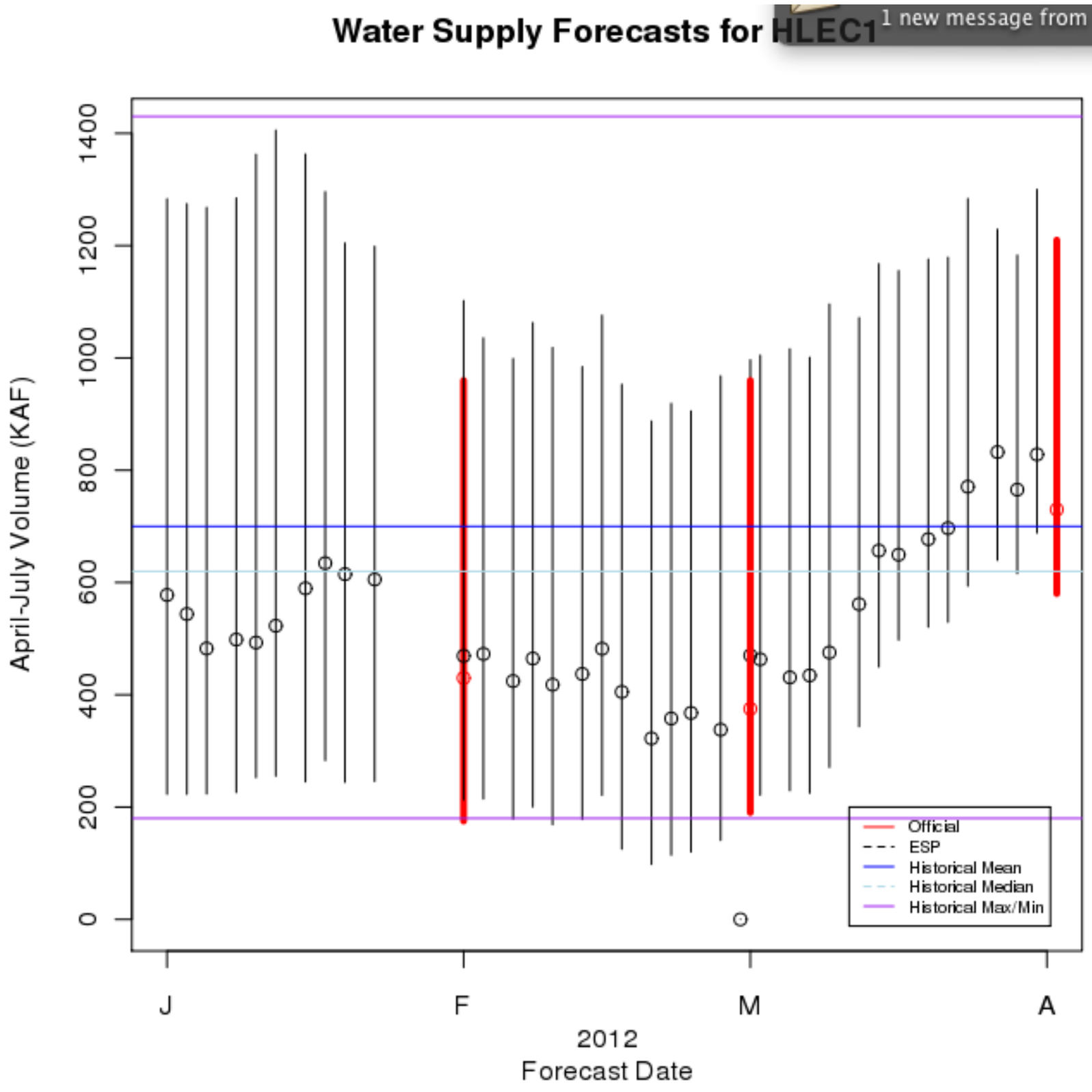
Reservoir	June Inflow (unregulated) (acre-feet)	Percent of Average (%)	July 9 Midnight Elevation (feet)	Reservoir Storage (acre-feet)
Fontenelle	189,000	63	6502.32	317,000
Flaming Gorge	188,000	48	6023.53	3,106,000
Blue Mesa	45,000	17	7474.48	467,000
Navajo	20,000	9	6050.04	1,226,000
Powell	354,000	13	3632.19	15,100,000

http://www.usbr.gov/lc/region/programs/strategies/RecordofDecision.pdf

USBR 24 month study

Other?

Examples



Example Log:
1/25 – Forecast problem
2/1 – SWS forecast is 600 KAF
3/1 – ESP biased high according to bias statistics; official forecast 10% lower.
3/2 – Snow update (forecast increase)
3/10 – Major QPF event on day 5

Download forecasts, traces, etc.

Examples

Weekly ESP for COLORADO - LAKE GRANBY, GRANBY, NR (GBYC2) Back

Data are provisional. Please contact CBRFC with questions or for clarification.

Input Options:
NWS ID: gbyc2 Number of Forecasts: 25 OK

ESP RAW MODEL GUIDANCE (Exceedence kaf)							OFFICIAL COORDINATED FORECAST (Exceedence kaf)				
Date Issued	Forecast Period	90%	70%	50%	30%	10%	Date Issued	Forecast Period	90%	50%	10%
7/1/2012	Jul-Jul 2012	9.8	9.9	**10.2**	11.0	12.8					
6/26/2012	Jun26-Jul 2012	12.2	12.3	**12.6**	13.2	14.8					
6/19/2012	Jun19-Jul 2012	16.5	16.6	**17.0**	18.1	19.4					
6/13/2012	Jun13-Jul 2012	23	23	**24**	25	27					
6/6/2012	Jun6-Jul 2012	33	34	**35**	37	43	6/1/2012	Jun-Jul 2012	31	**45**	62
5/31/2012	Jun-Jul 2012	42	43	**45**	49	59	6/1/2012	Jun-Jul 2012	31	**45**	62
5/22/2012	May22-Jul 2012	60	63	**66**	75	88					
5/15/2012	May15-Jul 2012	64	68	**71**	81	97					
5/8/2012	May8-Jul 2012	72	79	**87**	92	109					
4/30/2012	May-Jul 2012	80	90	**100**	106	127					
4/24/2012	Apr24-Jul 2012	105	115	**123**	134	155					
4/15/2012	Apr15-Jul 2012	110	119	**130**	148	183					
4/10/2012	Apr10-Jul 2012	102	120	**131**	145	177					
4/4/2012	Apr4-Jul 2012	111	130	**142**	161	193	4/1/2012	Apr-Jul 2012	102	**150**	205
3/30/2012	Apr-Jul 2012	119	144	**153**	170	205	4/1/2012	Apr-Jul 2012	102	**150**	205
3/26/2012	Apr-Jul 2012	122	145	**157**	173	210					
3/19/2012	Apr-Jul 2012	132	152	**172**	182	215					
3/13/2012	Apr-Jul 2012	134	157	**180**	193	230					
3/7/2012	Apr-Jul 2012	134	161	**184**	195	245					
2/29/2012	Apr-Jul 2012	132	162	**188**	205	245	3/1/2012	Apr-Jul 2012	123	**180**	245
2/22/2012	Apr-Jul 2012	129	154	**173**	198	235					
2/16/2012	Apr-Jul 2012	130	156	**176**	195	265					
2/7/2012	Apr-Jul 2012	121	148	**171**	198	265					
1/31/2012	Apr-Jul 2012	136	158	**182**	210	280	2/1/2012	Apr-Jul 2012	120	**180**	250
1/24/2012	Apr-Jul 2012	132	162	**181**	205	280					

Discussion

Your input is key!

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

- Feedback requested by August 15