



Ensemble Pre-Processor

Limin Wu

**Acknowledgments: DJ Seo, John Schaake,
Julie Demargne, James Brown**

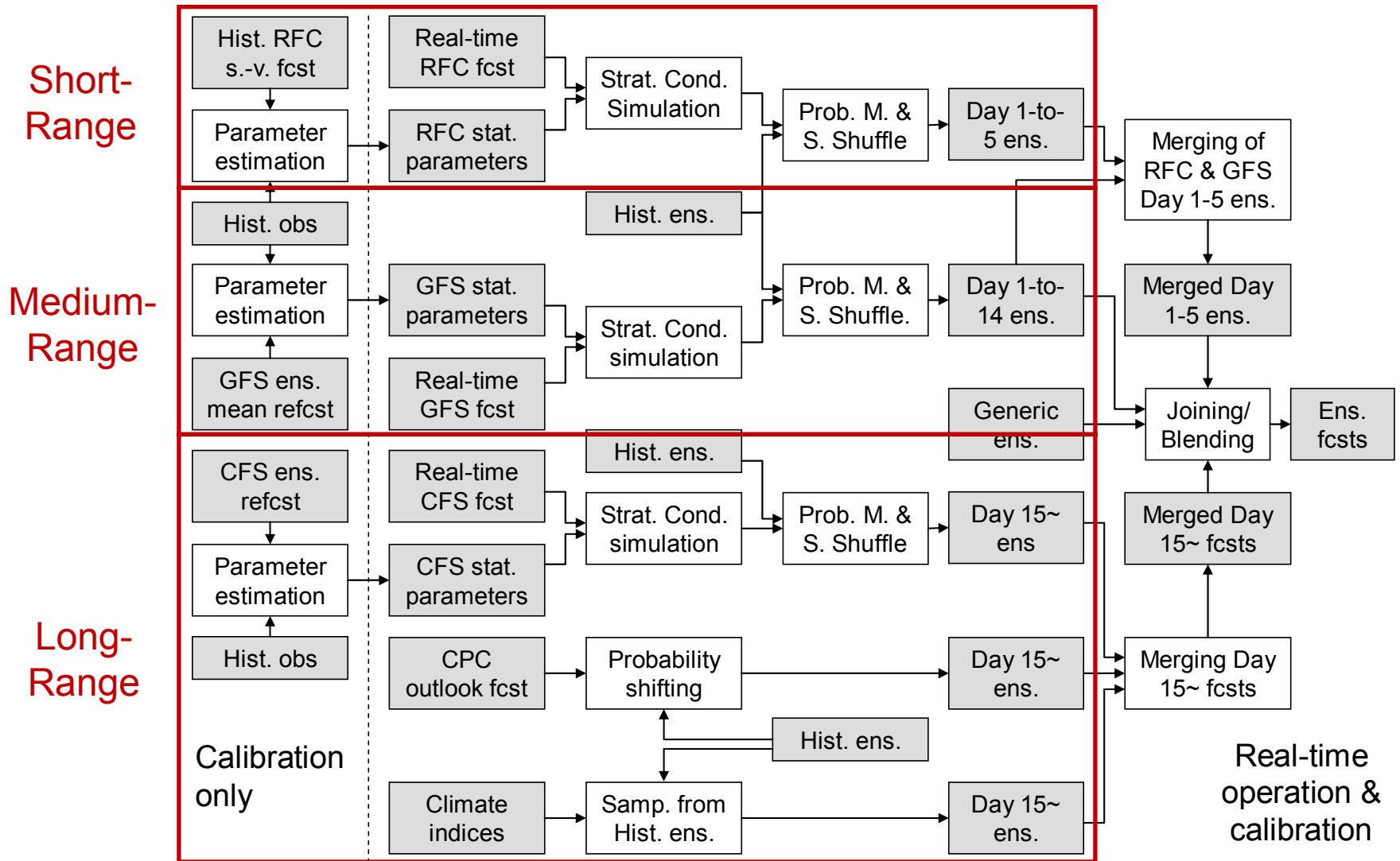
NOAA/NWS/Office of Hydrologic Development

In this presentation

2

- ❑ How EPP works
 - “Schaake Shuffle” explained! (well, hopefully)
- ❑ Improvements made to better-capture skill in the HPC/RFC single-value QPF
- ❑ Verification of precipitation ensembles from the RFC and GFS Subsystems

Ensemble Pre-Processor III (EPP3)

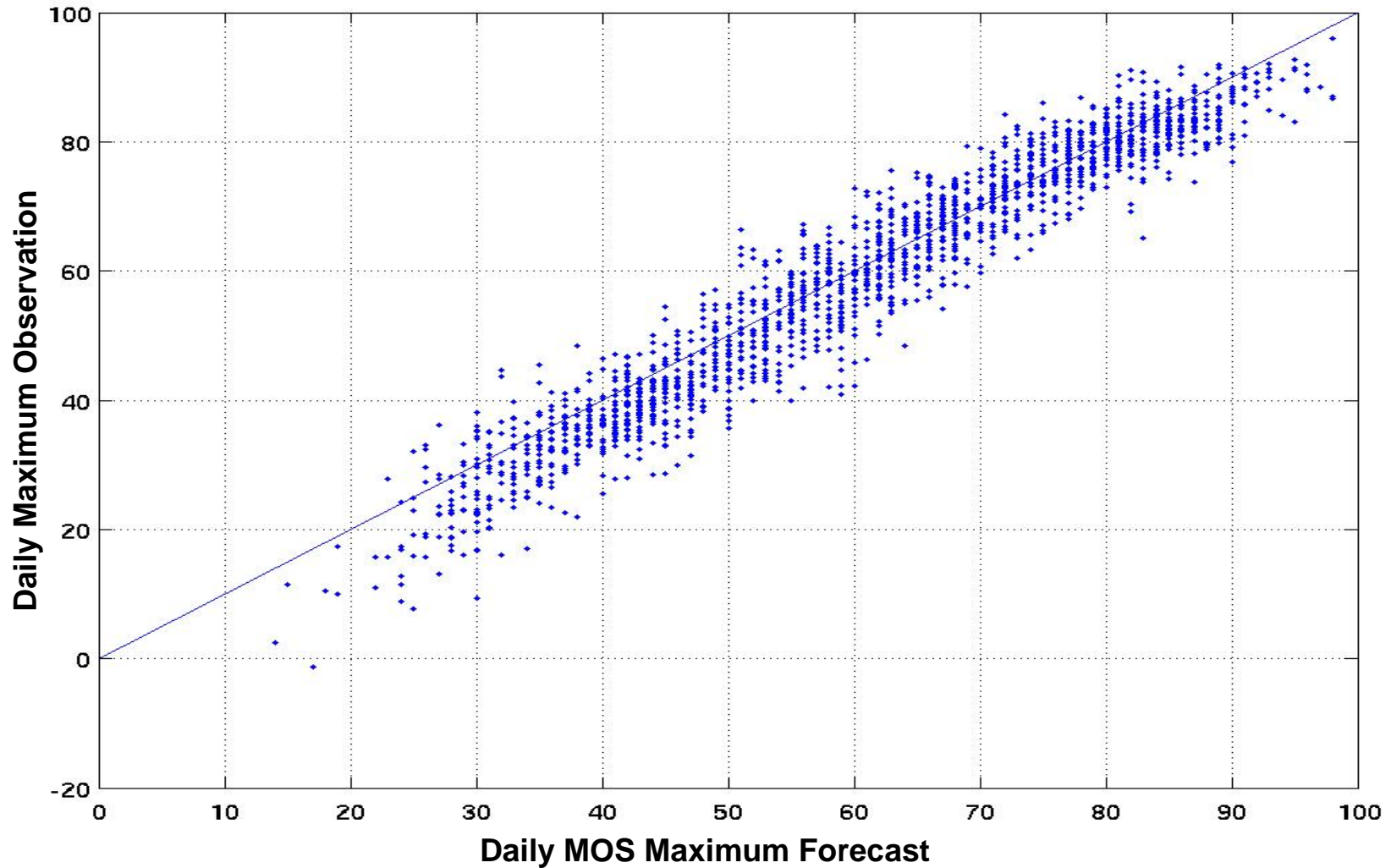


From XEFS Design & Gap Analysis Report (NWS 2007)

How EPP Works

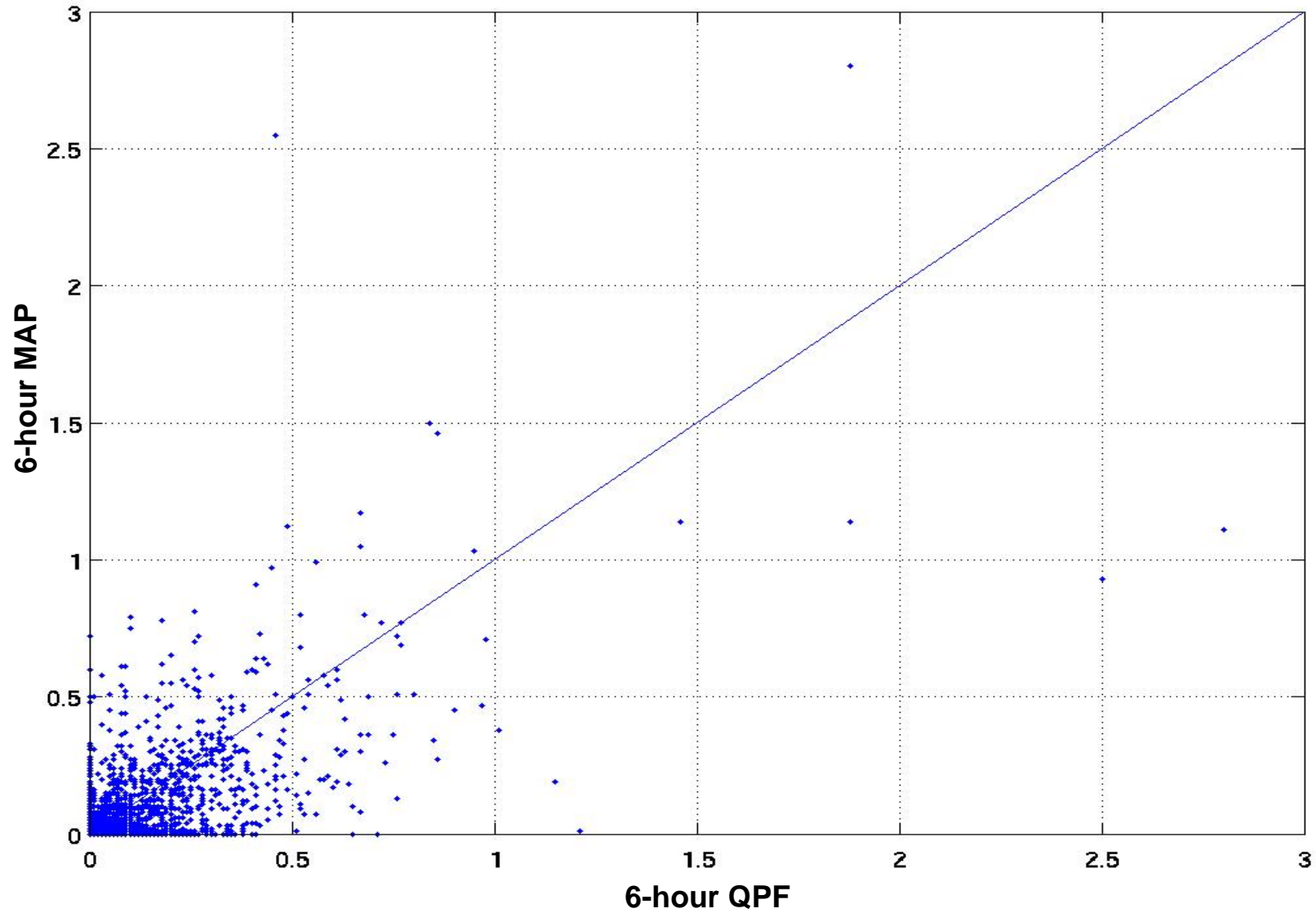
- ❑ Calibration – Models the joint probability distribution between the (historical) single-value forecast and the verifying observation
 - Captures skill in the single-value forecasts
 - Quantifies uncertainty in the single-value forecasts
- ❑ Ensemble Generation - Samples ensembles from the above probability distribution conditional on the (real-time) single-value forecast
- ❑ “Schaake Shuffle” - Replicates (in the rank correlation sense) in the above ensembles the space-time variability and co-variability in the historical ensembles

Joint relationship between fcst and obs T_{max} Huntingdon in Juniata River Basin

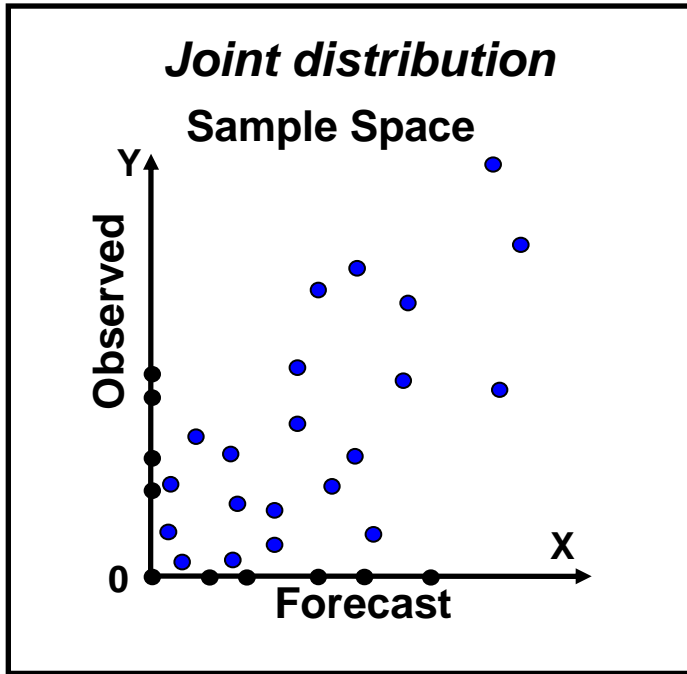


Joint relationship between fcst and obs precipitation

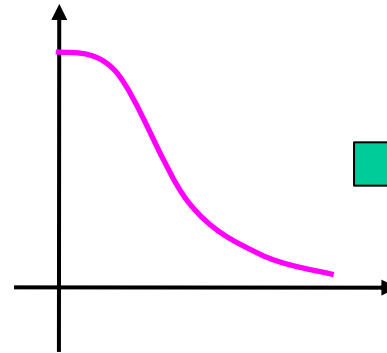
Huntingdon in Juniata River Basin



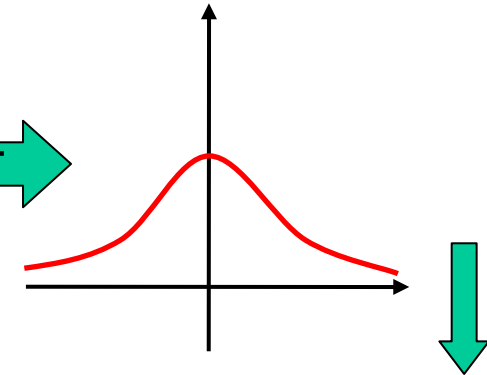
Step 1: Calibration



PDF of Observed



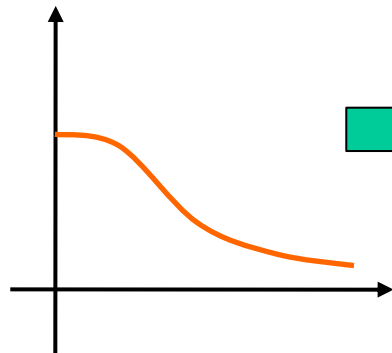
PDF of STD Normal



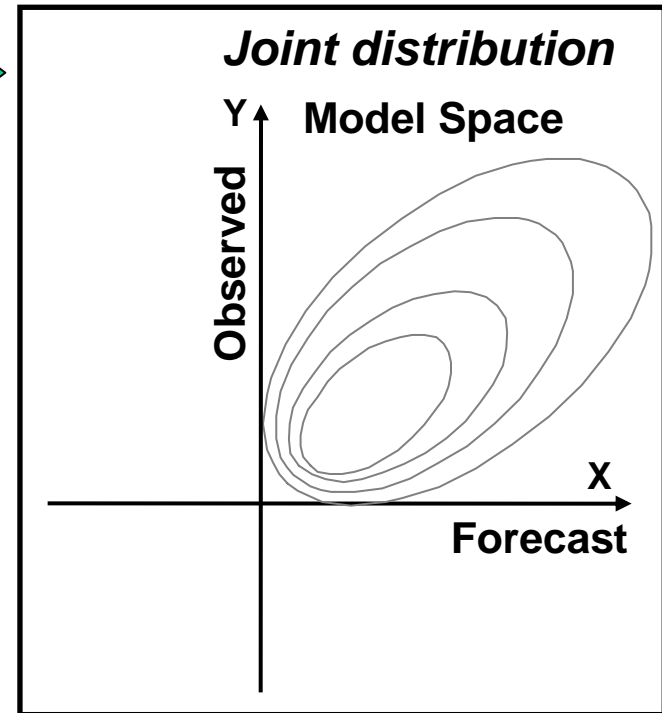
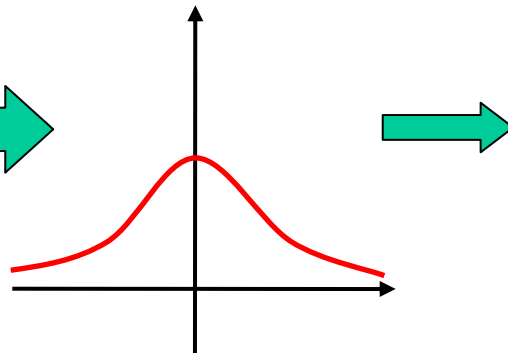
NQT

Correlation(X,Y)

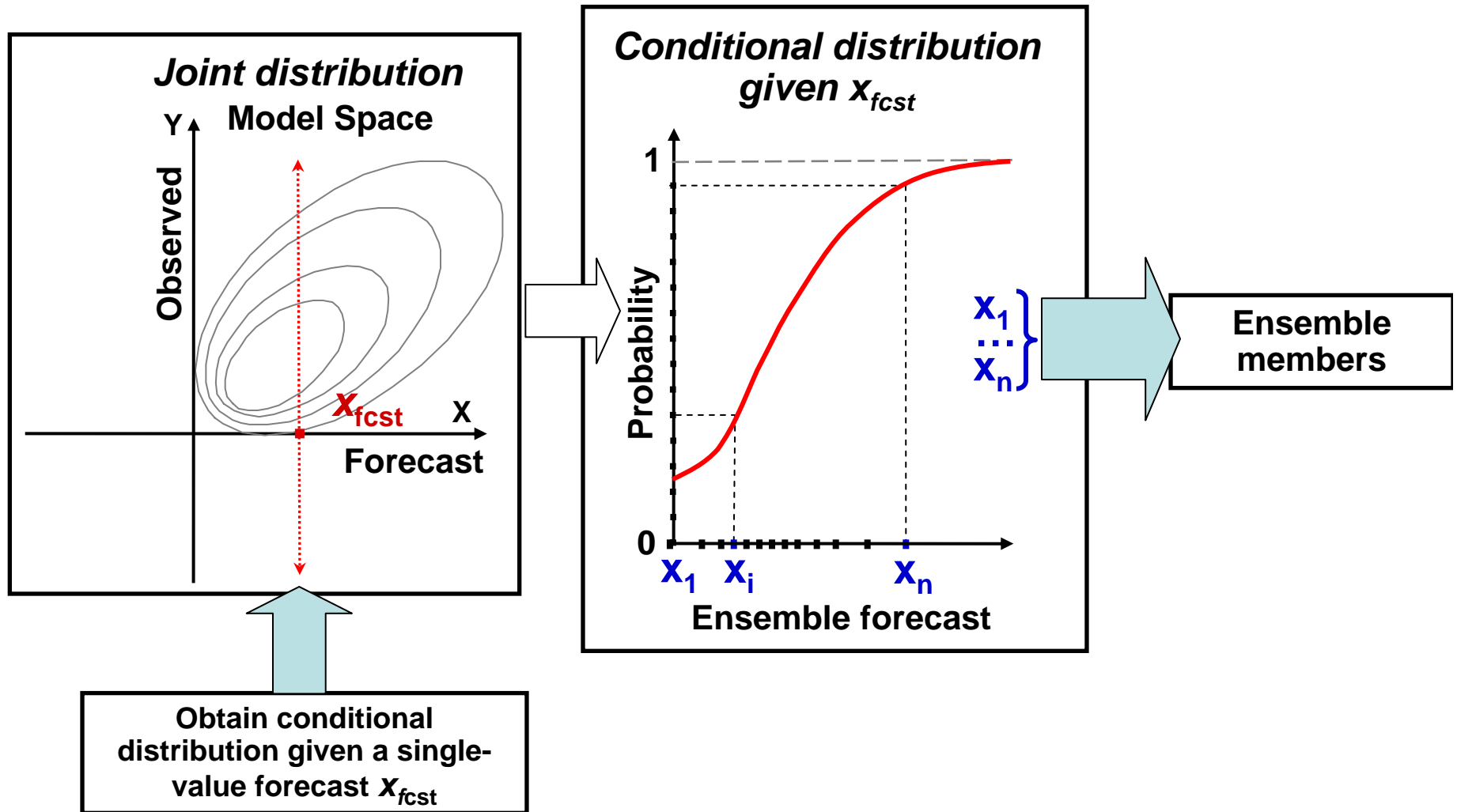
PDF of Forecast



PDF of STD Normal

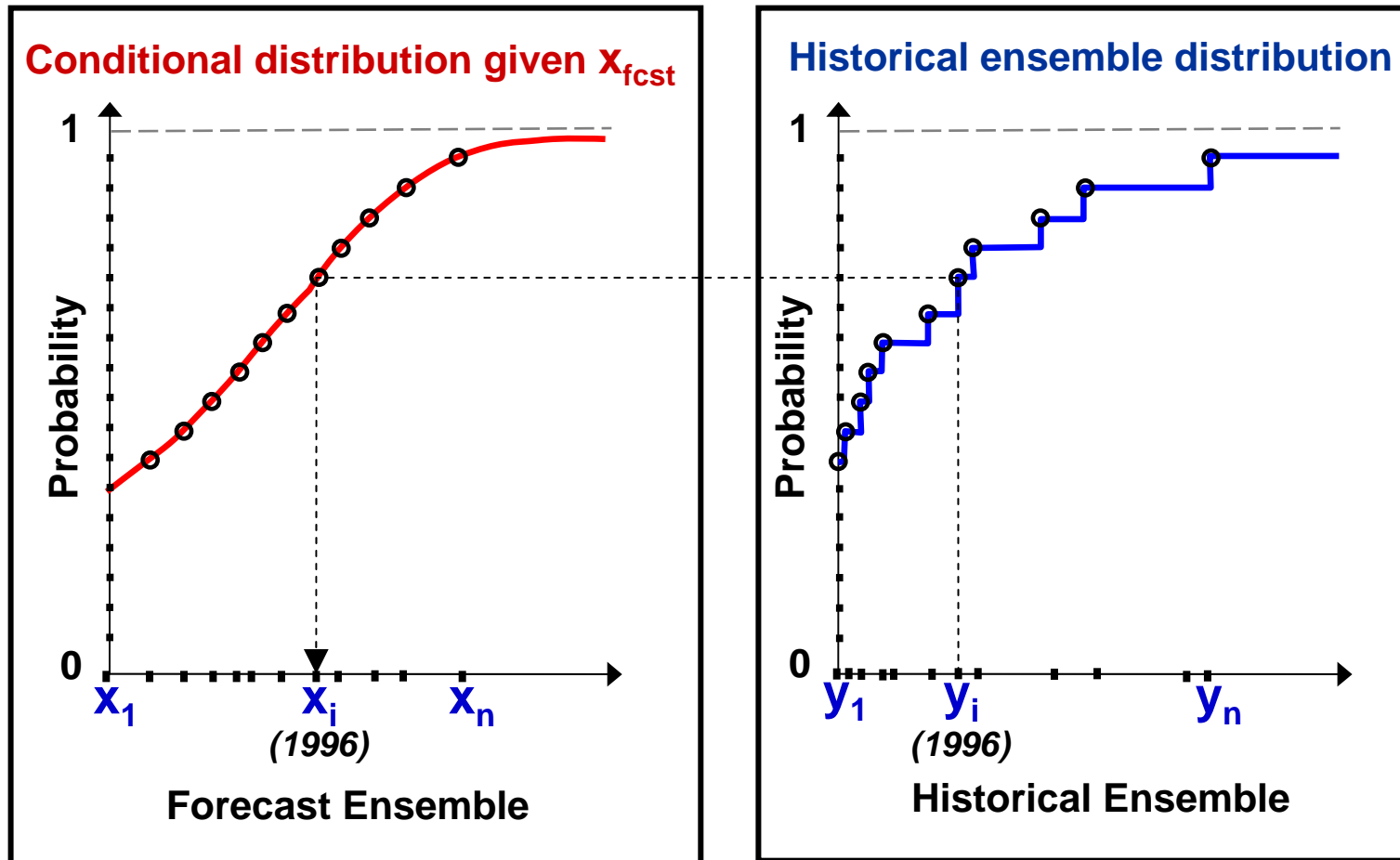


Step 2: Ensemble Generation



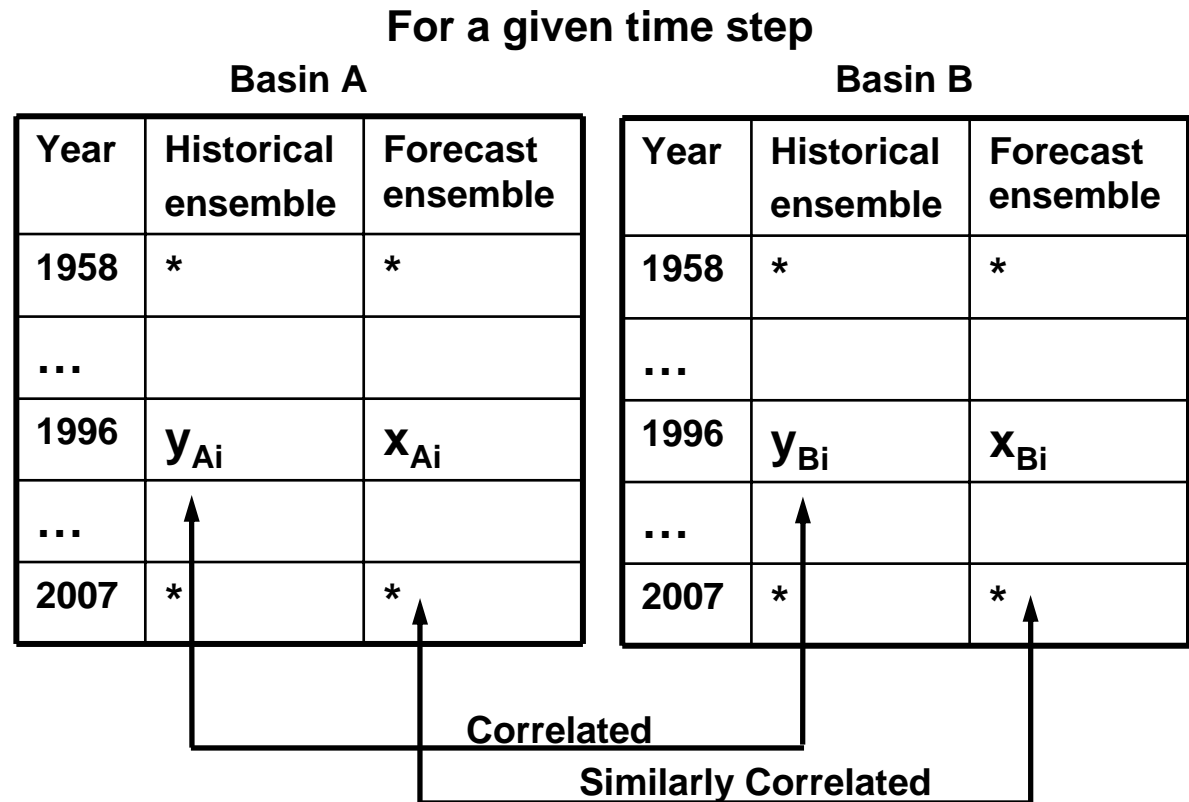
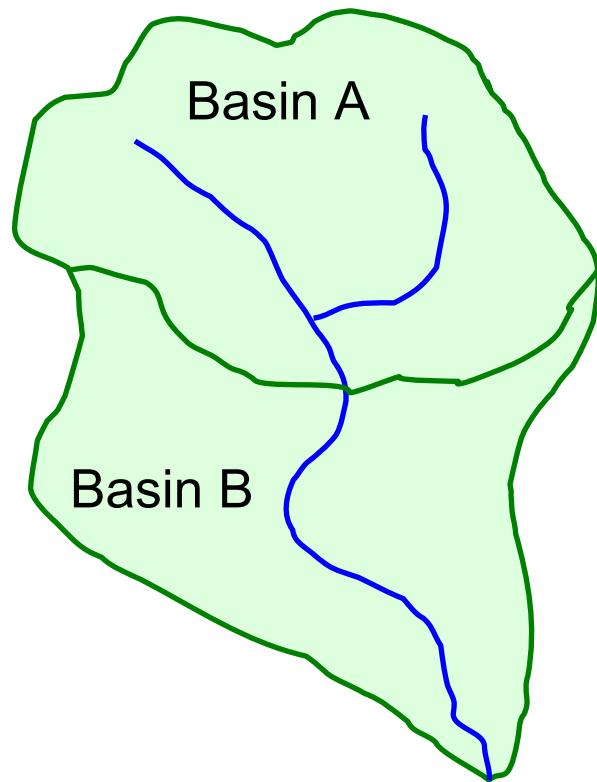
Step 3: Schaake Shuffle

- For each segment at each time step, associate forecast ensemble members (left panel) with historical ensemble members (right panel) by rank (and hence year)



Step 3: Schaake Shuffle (cont.)

- ❑ The spatial variability between two neighboring MAP basins is preserved (in terms of rank correlation) in the forecast ensembles



- ❑ Similarly, temporal variability, as well as co-variability with temperature, is preserved (in terms of rank correlation) in the forecast ensembles

Improvements Made to Better-Capture Skill ¹¹ in the HPC/RFC Single-Value QPF

- Additional options in distribution modeling
 - Includes nonparametric
- Parameter optimization of the linear regression model
- Explicit modeling of precipitation intermittency

Wu et al. (in preparation)

Verification

- Dependent verification carried out for AB-, CN- and MARFC test basins
- Independent verification carried out for HUNP1 in MARFC, in progress for all other test basins
- Hydrologic verification under way
 - Via the Hydrologic Ensemble Hindcaster

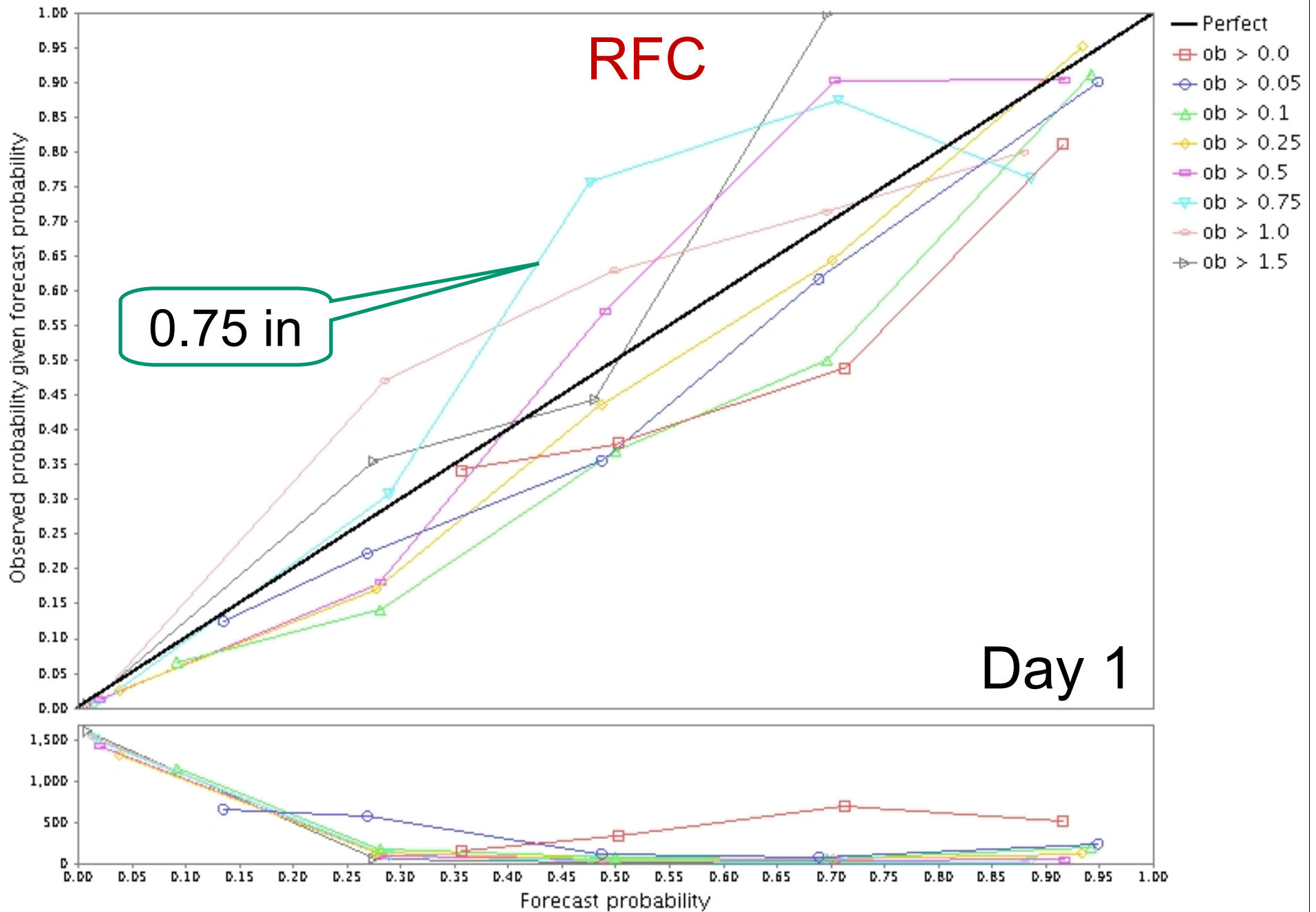
Examples of precipitation ensemble verification

Component	Forecasts Used	Option	ID
RFC subsystem	Days 1, 2: RFC single-value QPF	w/o parameter optimization	RFC
	Days 3 to 14: Resampled climatology	w/ parameter optimization	RFC-OPT
GFS subsystem	Days 1 to 14: GFS ensemble-mean QPF	w/o temporal aggregation	GFS
		w/ temporal aggregation	GFS-TA
	Days 1, 2: RFC single-value QPF Days 3 to 14: GFS ensemble-mean QPF	w/o temporal aggregation	GFS-RFC

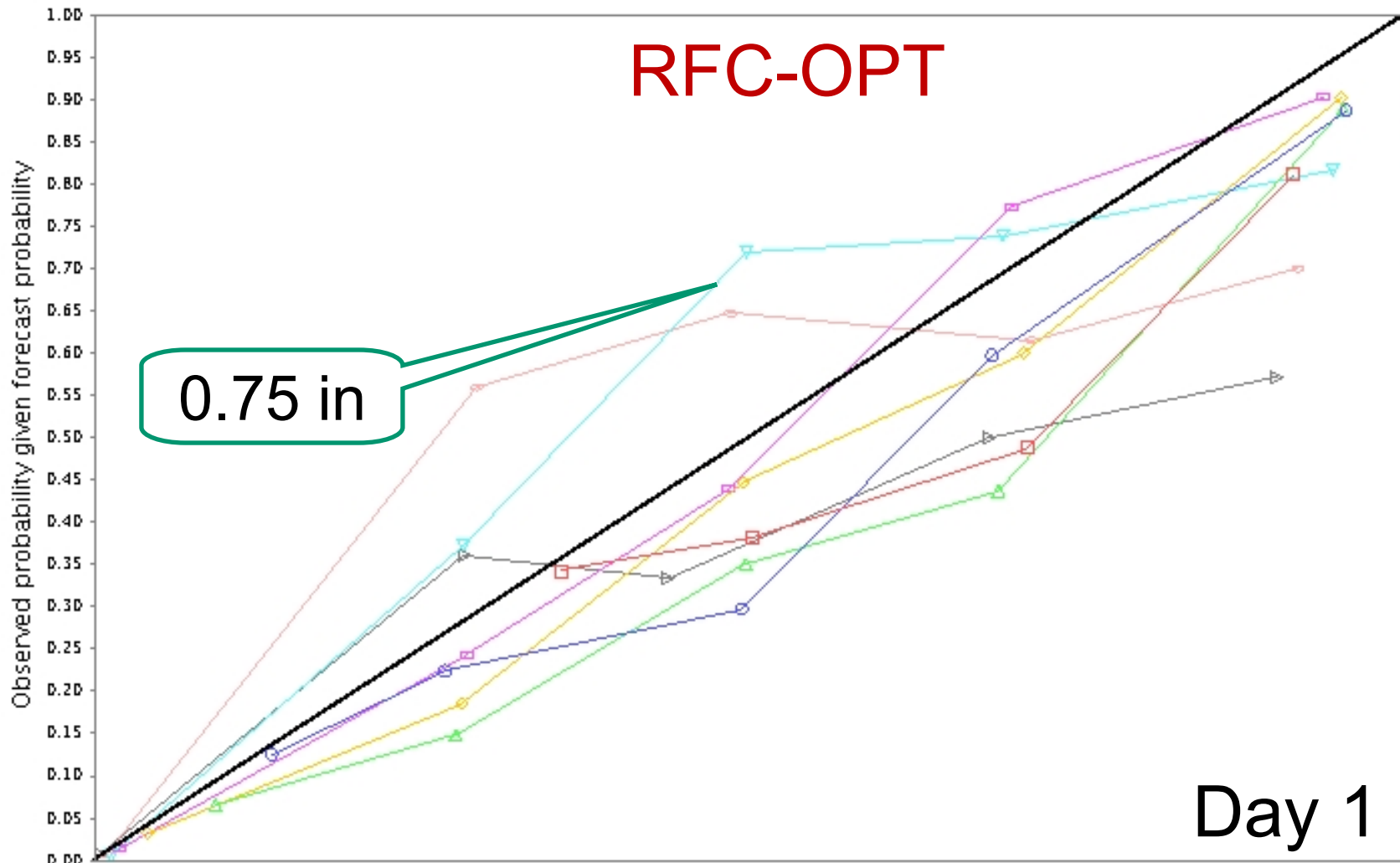
In the following slides

14

- Verification of 24-hr
precipitations ensembles at
 - CNRFC
 - MARFC
 - ABRFC



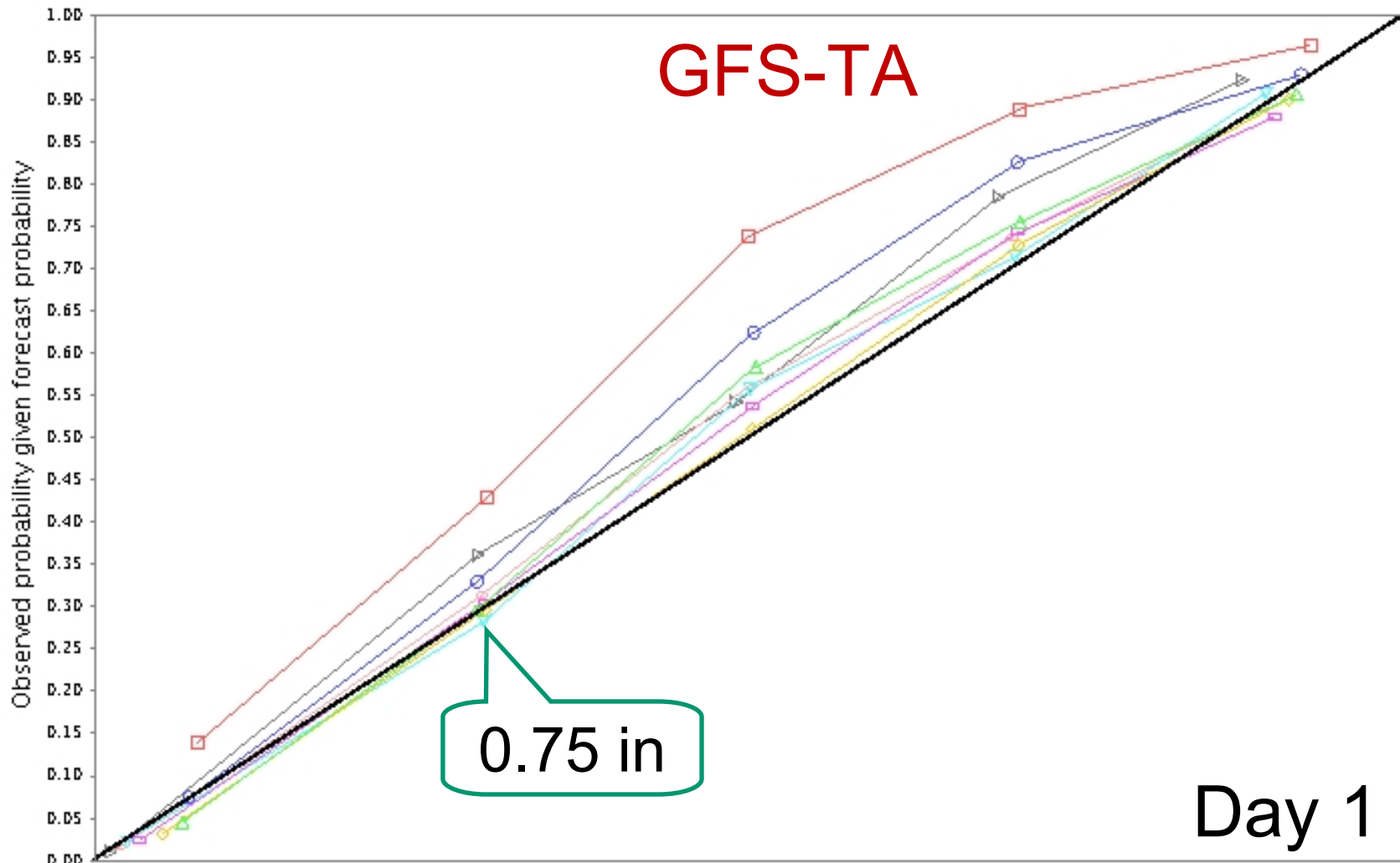
RFC-OPT



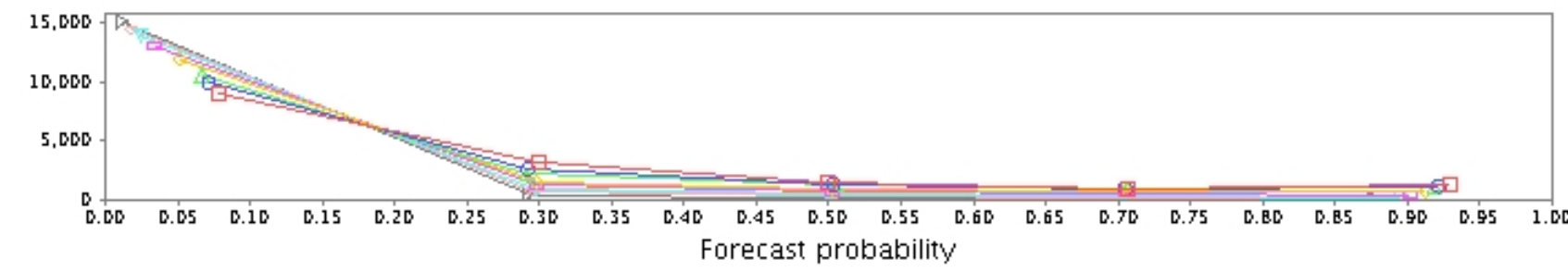
- Perfect
- ob > 0.0
- ob > 0.05
- △ ob > 0.1
- ◇ ob > 0.25
- ob > 0.5
- ▽ ob > 0.75
- ◊ ob > 1.0
- ◀ ob > 1.5

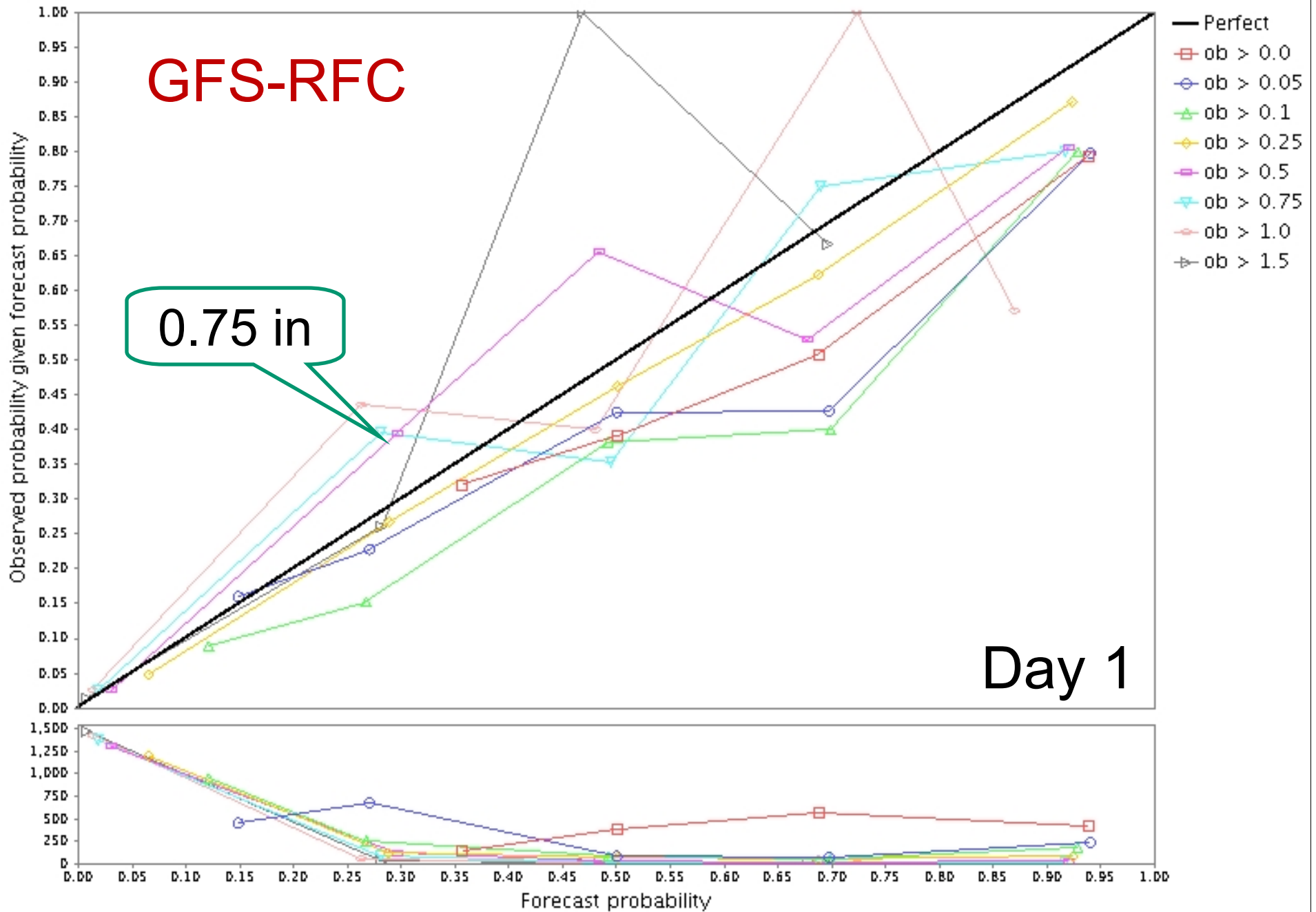
0.75 in

GFS-TA



- Perfect
- ob > 0.0
- ob > 0.05
- △ ob > 0.1
- ◇ ob > 0.25
- ob > 0.5
- △ ob > 0.75
- ◇ ob > 1.0
- △ ob > 1.5

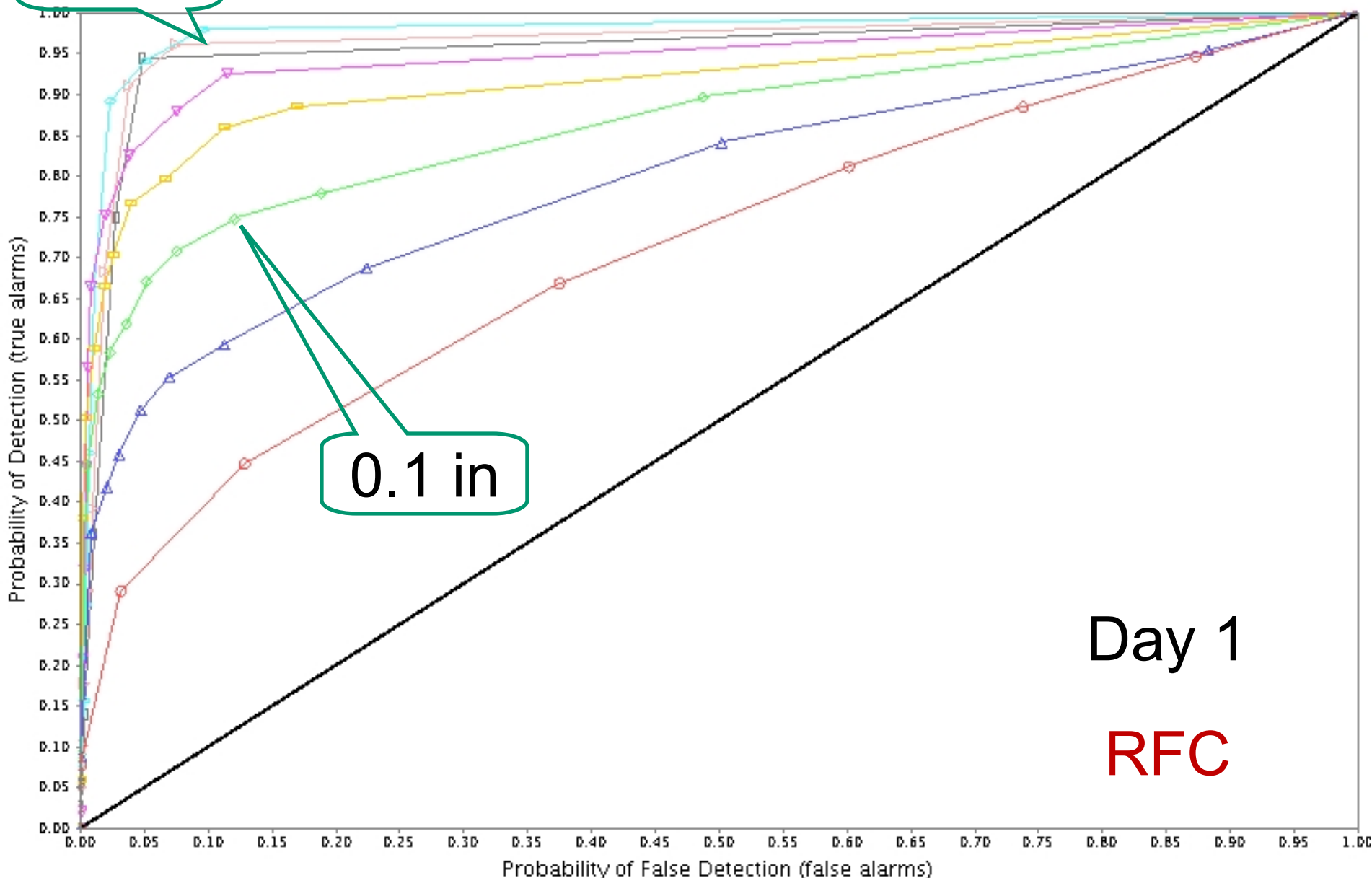




1.0 in

Relative Operating Characteristic for different event (probability) thresholds.
agg_3optBW_24h at lead hour 15

NFDC1 20



0.1 in

Day 1

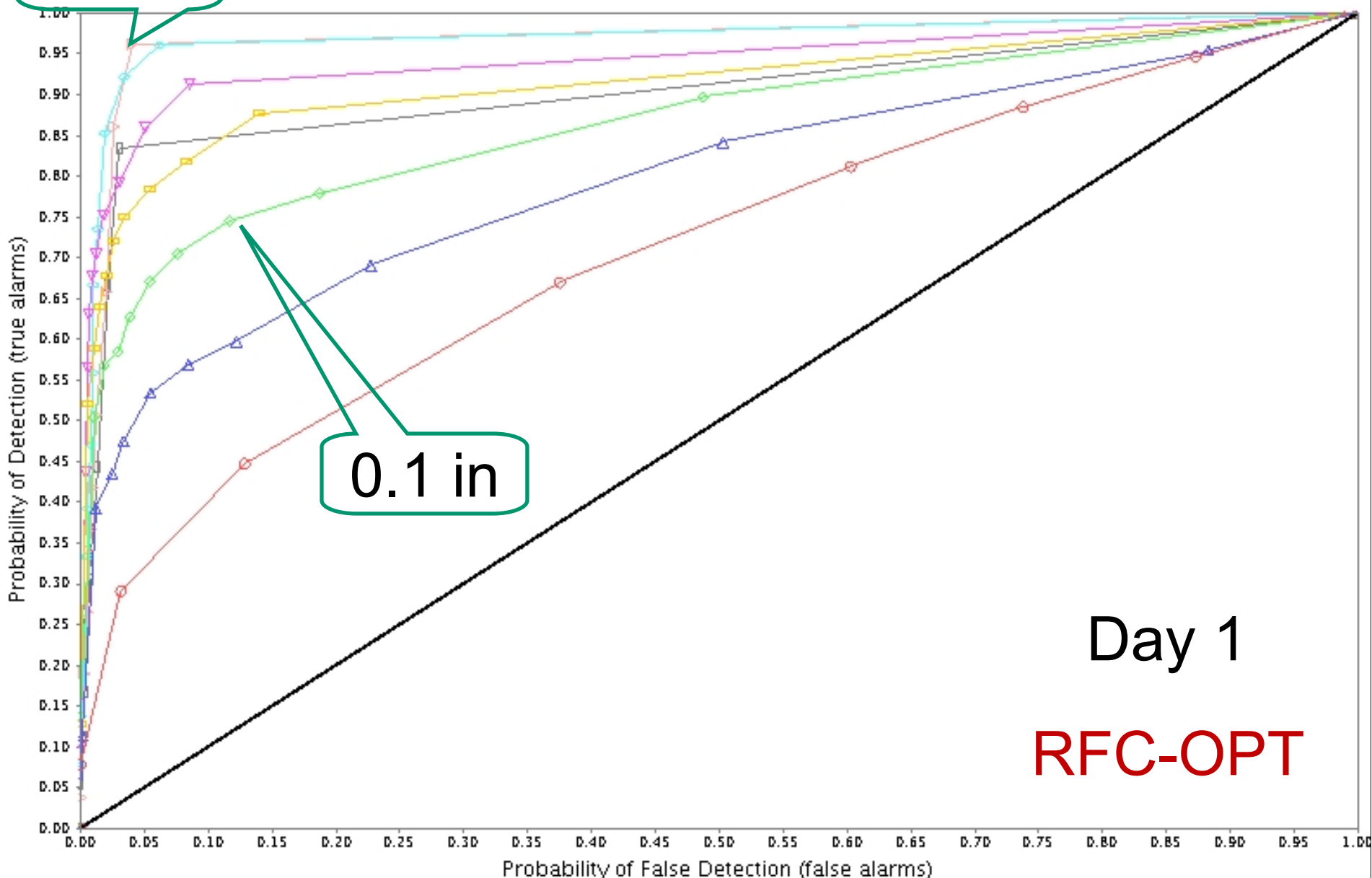
RFC

- Random guess (no skill)
- ob > 0.0
- △ ob > 0.05
- ◇ ob > 0.1
- ob > 0.25
- ▽ ob > 0.5
- ◀ ob > 0.75
- ▶ ob > 1.0
- ⊕ ob > 1.5

1.0 in

Relative Operating Characteristic for different event (probability) thresholds.
agg_60th_3optBW_24h at lead hour 15

NFDC1 21



0.1 in

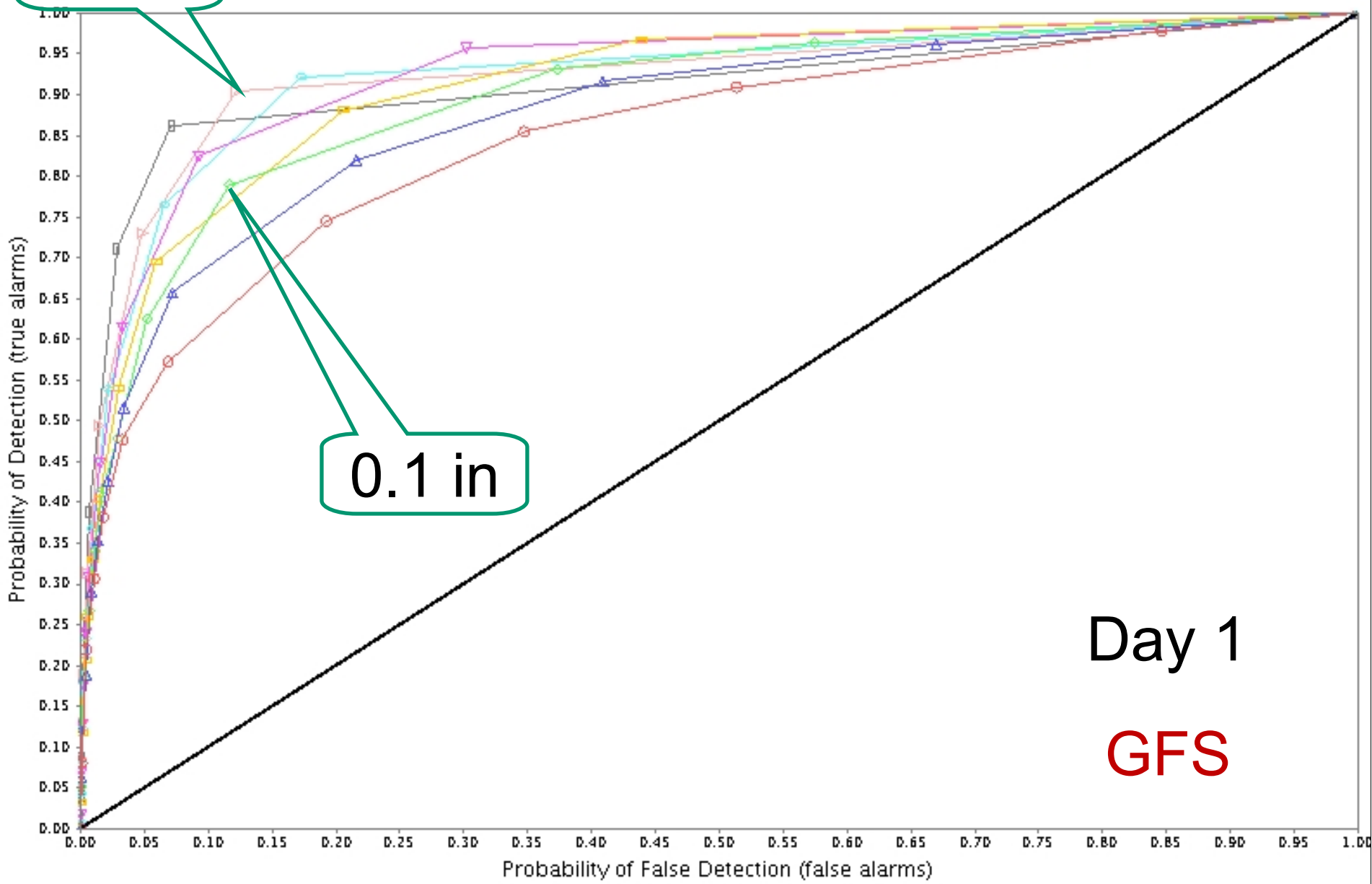
Day 1

RFC-OPT

- Random guess (no skill)
- ob > 0.0
- △ ob > 0.05
- ◇ ob > 0.1
- ob > 0.25
- ▽ ob > 0.5
- ◀ ob > 0.75
- ▶ ob > 1.0
- ⊕ ob > 1.5

Relative Operating Characteristic for different event (probability) thresholds.
agg_101_01_24h at lead hour 15

NFDC1 22



1.0 in

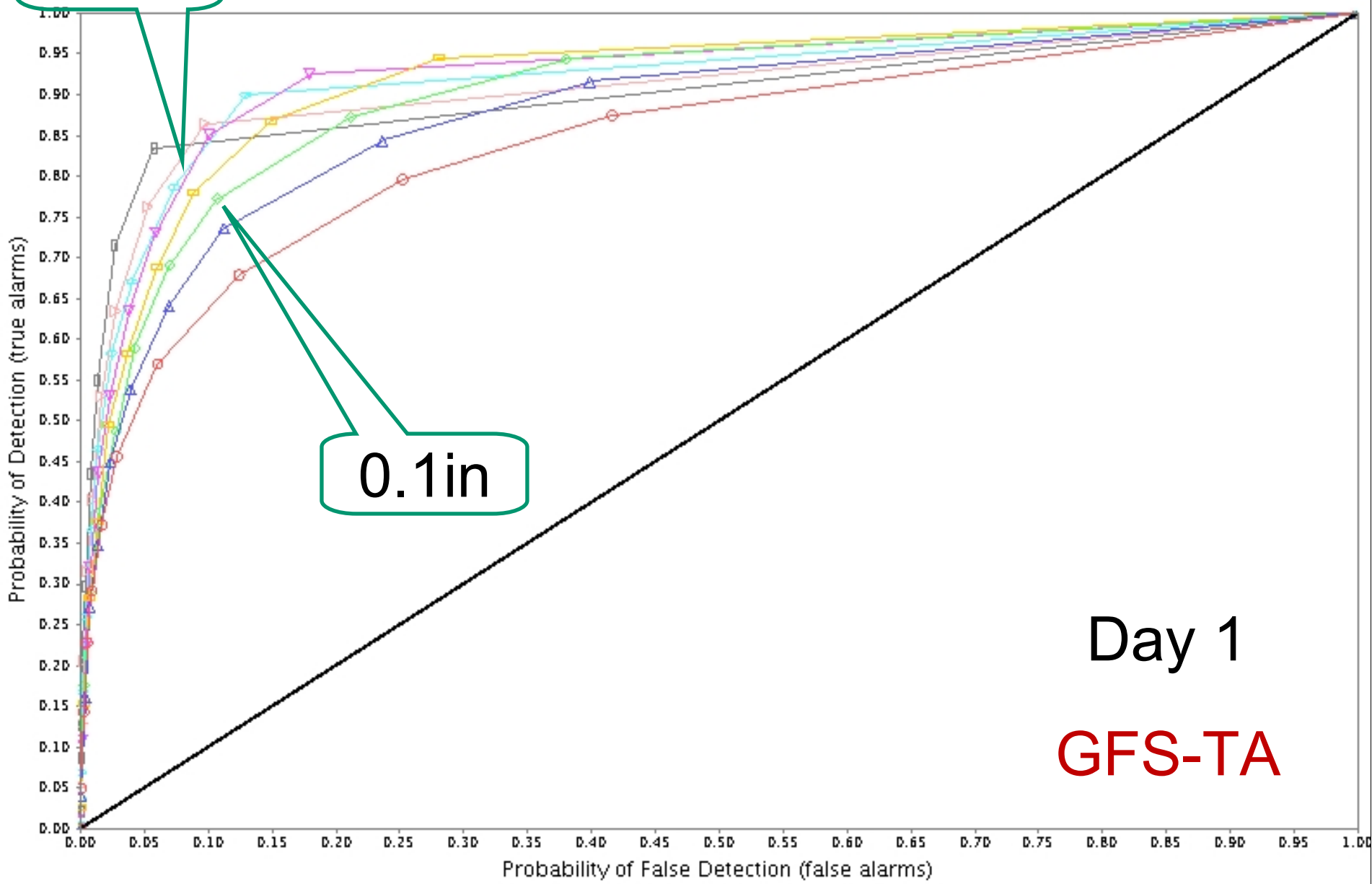
0.1 in

Day 1
GFS

- Random guess (no skill)
- ob > 0.0
- △ ob > 0.05
- ◇ ob > 0.1
- ob > 0.25
- ▽ ob > 0.5
- ◀ ob > 0.75
- ▶ ob > 1.0
- ⊕ ob > 1.5

Relative Operating Characteristic for different event (probability) thresholds.
agg_102_01_24h at lead hour 15

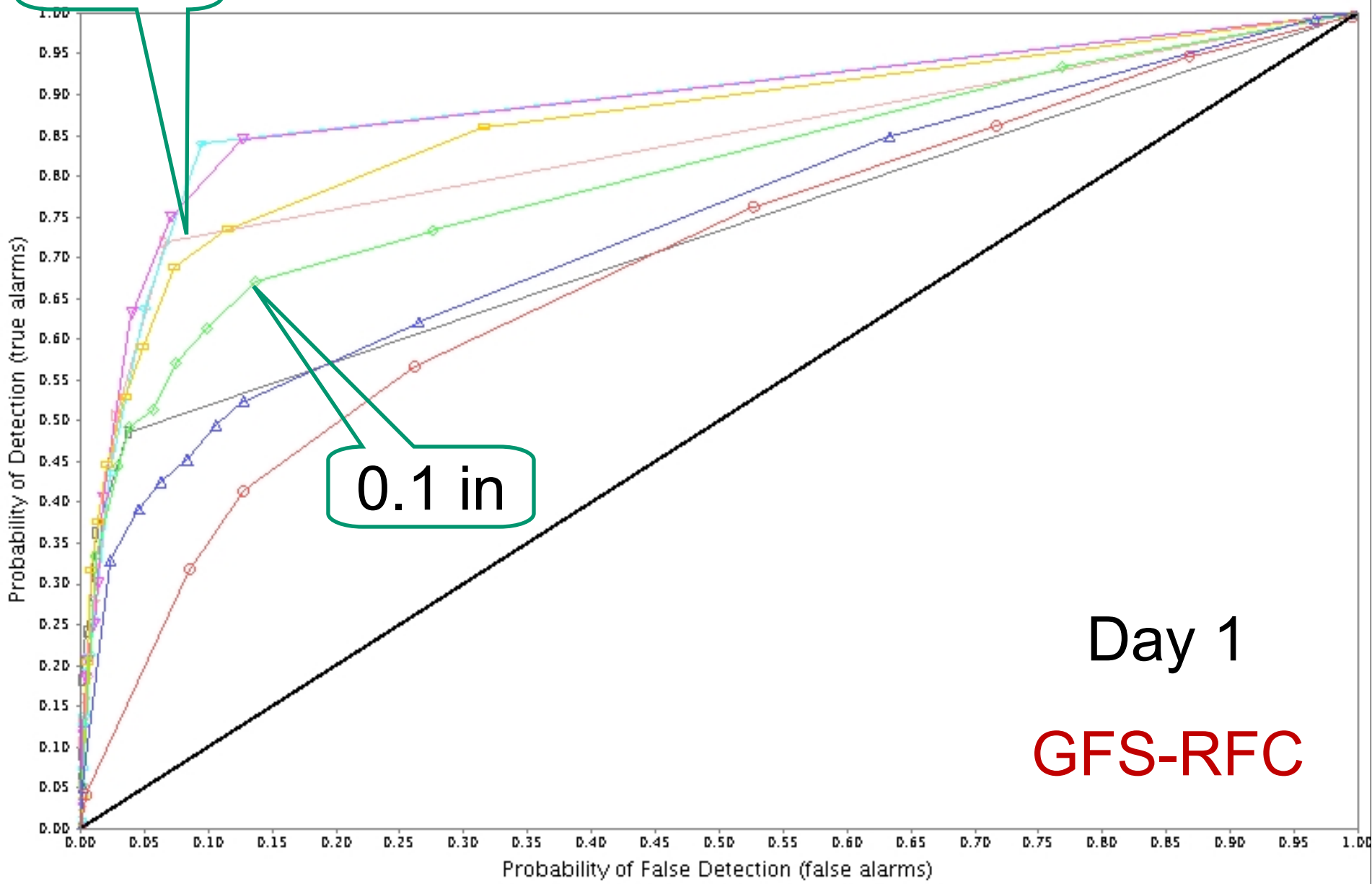
NFDC1 23



— Random guess (no skill) ○ ob > 0.0 ▲ ob > 0.05 ◆ ob > 0.1 □ ob > 0.25 ▼ ob > 0.5 ▷ ob > 0.75 ◂ ob > 1.0
◻ ob > 1.5

Relative Operating Characteristic for different event (probability) thresholds.
agg_201_01_24h at lead hour 15

NFDC1 24

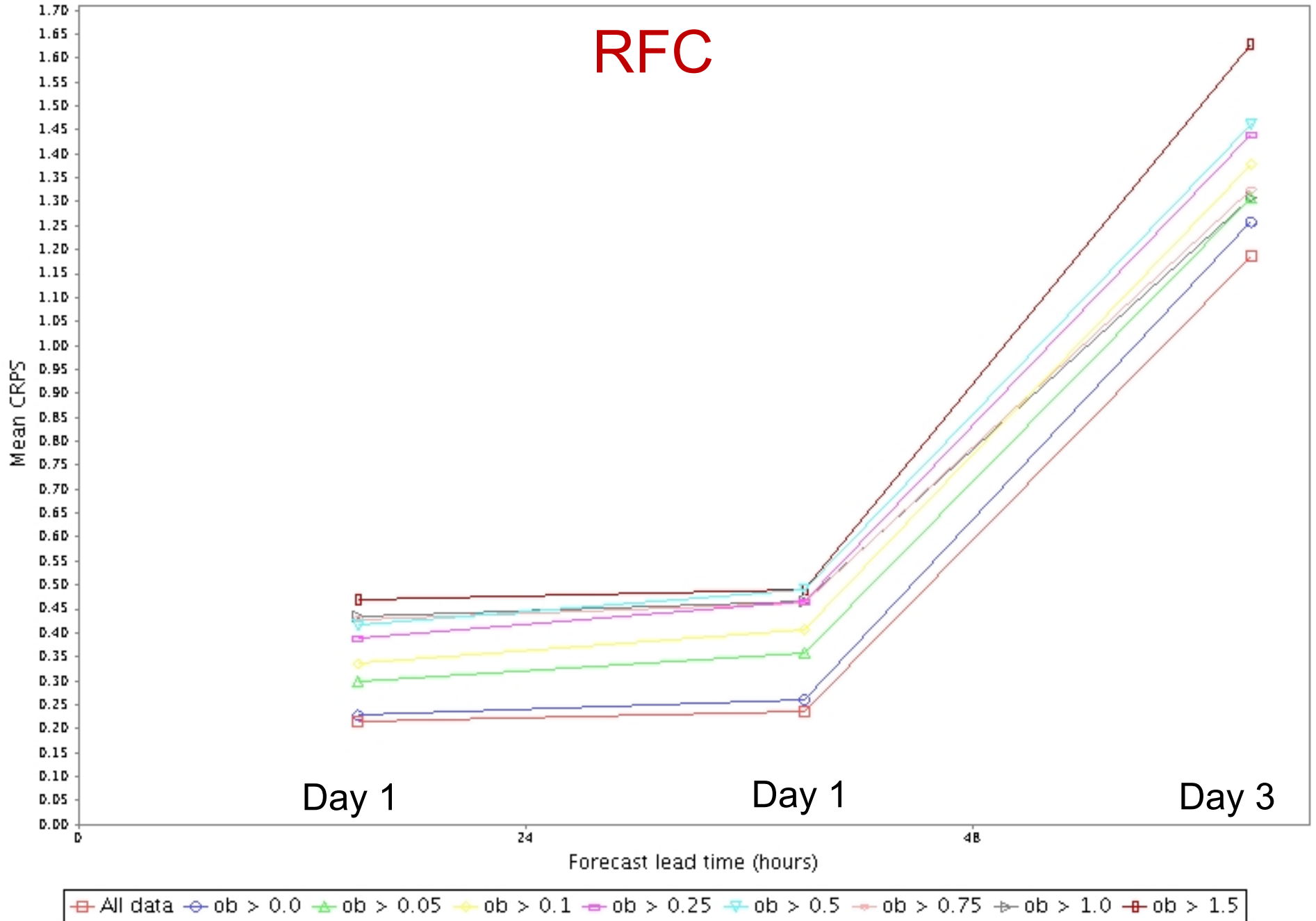


Day 1

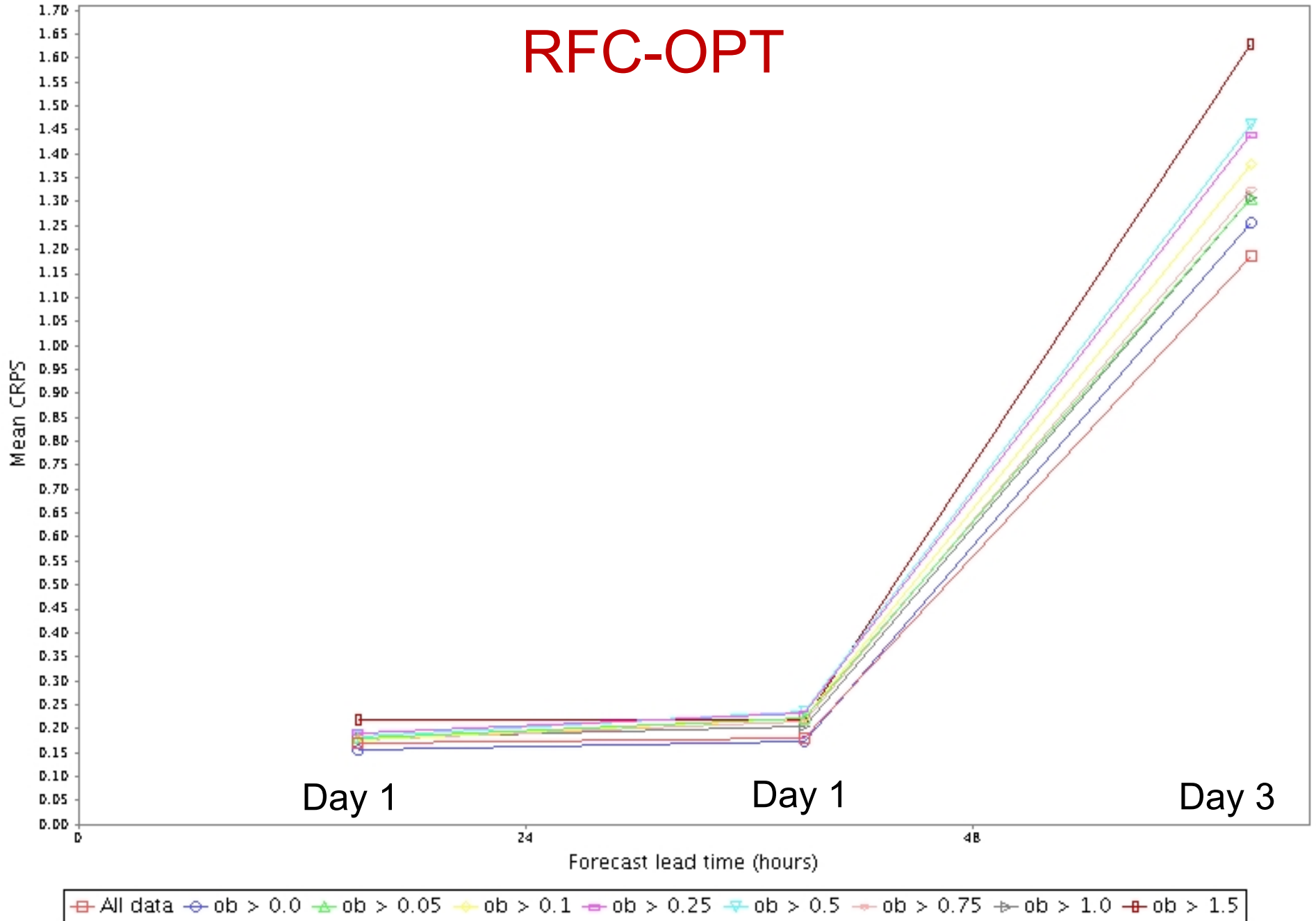
GFS-RFC

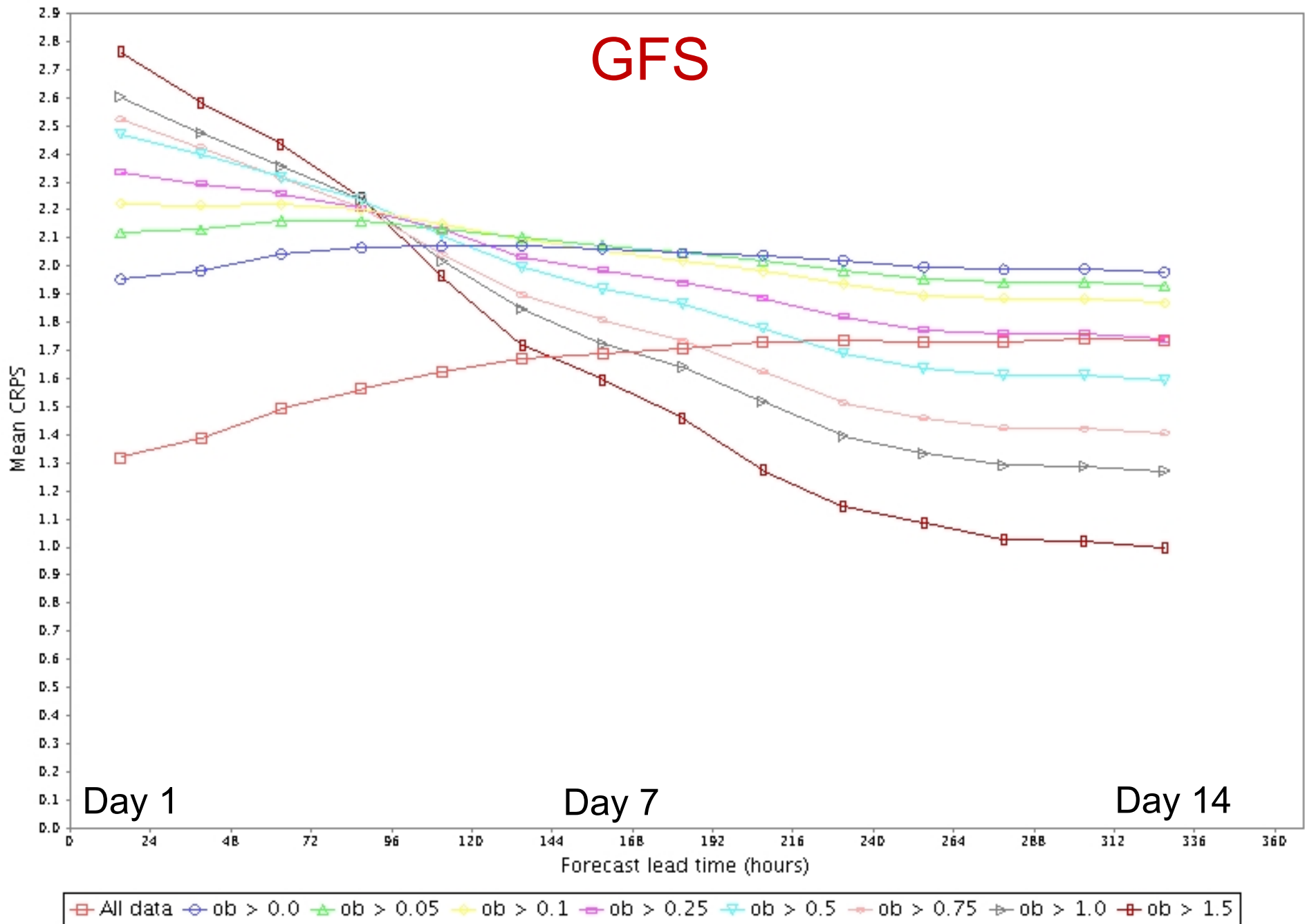
- Random guess (no skill)
- ob > 0.0
- △ ob > 0.05
- ◇ ob > 0.1
- ob > 0.25
- ▽ ob > 0.5
- ◀ ob > 0.75
- ▶ ob > 1.0
- ⊕ ob > 1.5

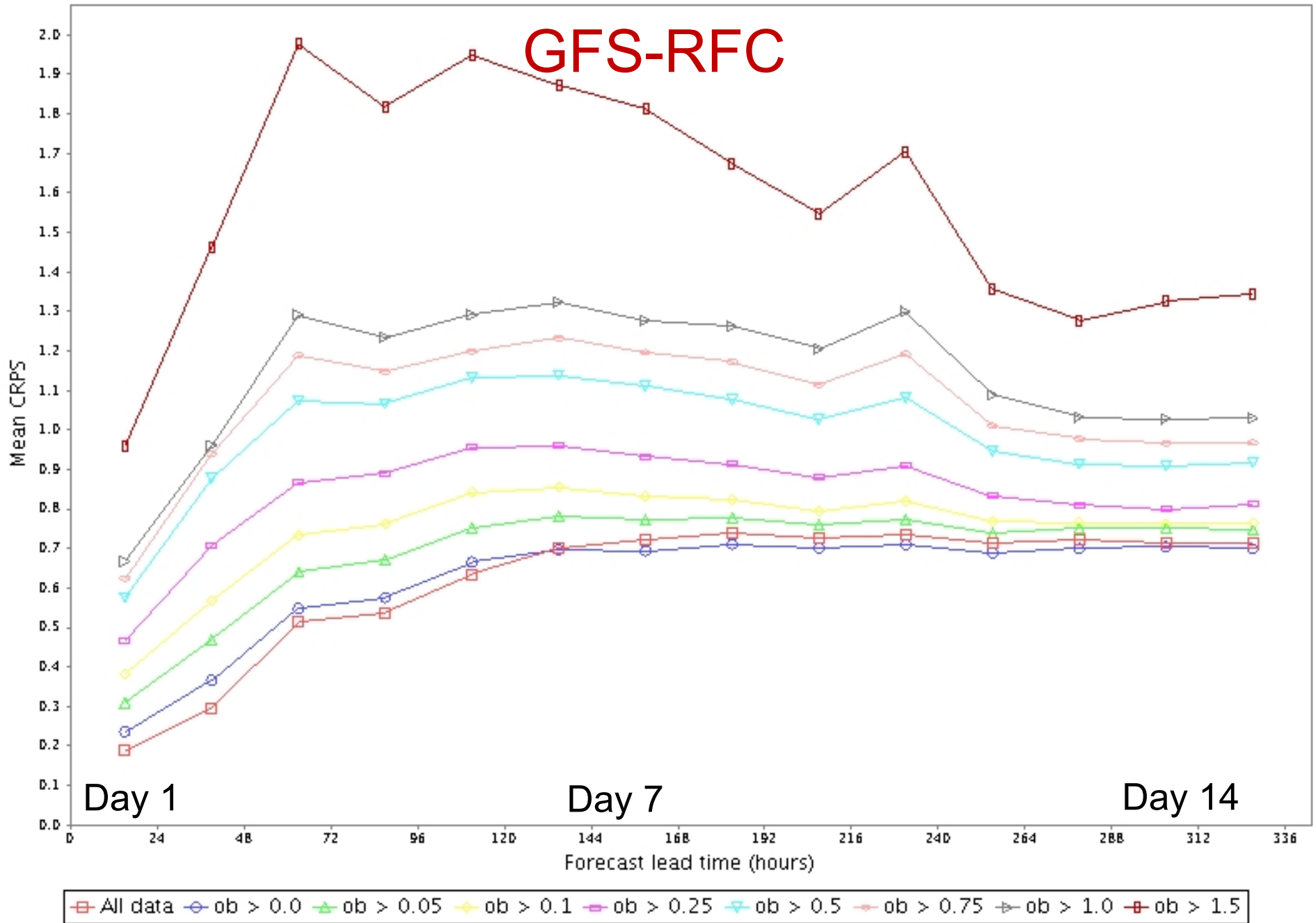
RFC



RFC-OPT





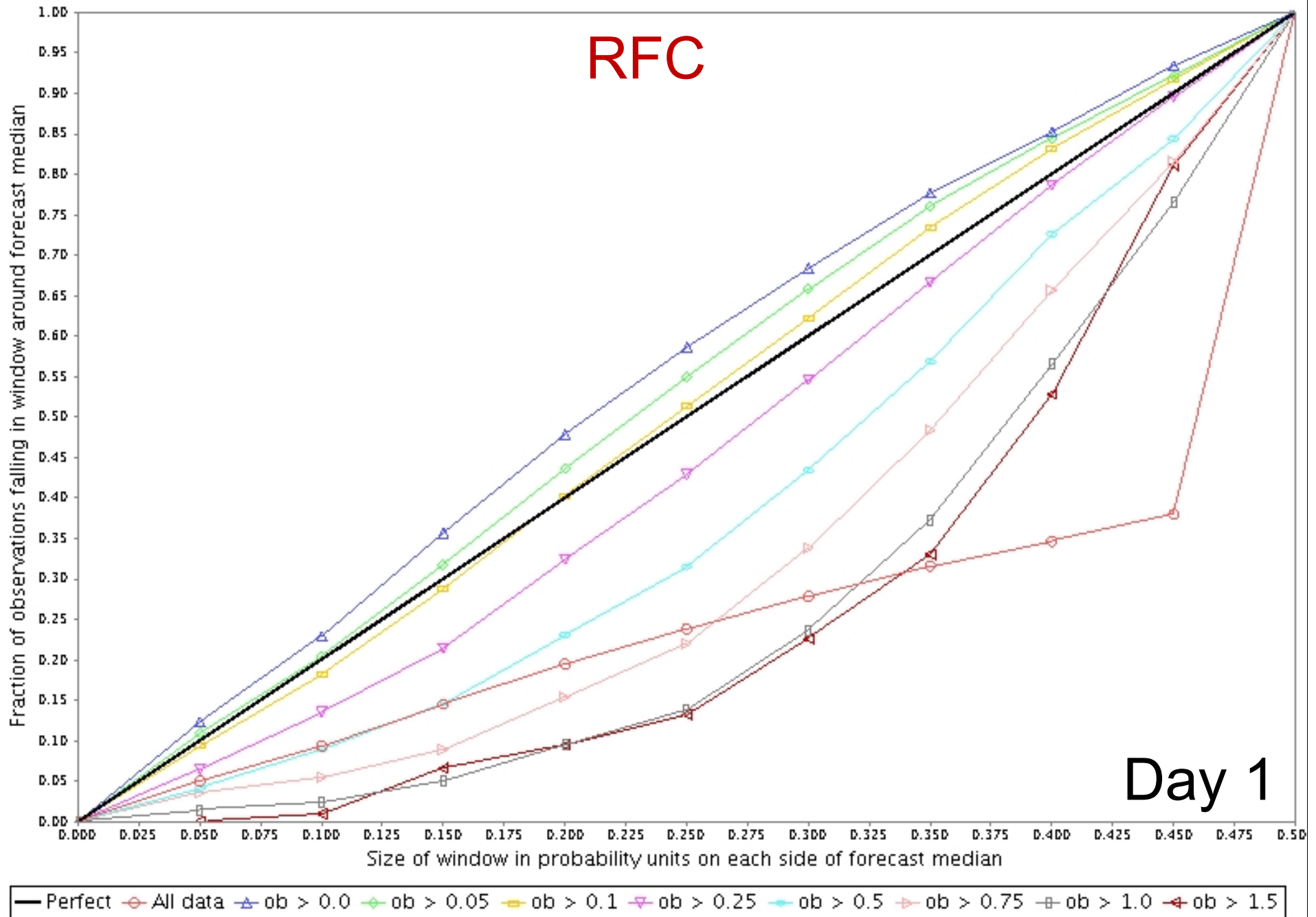


10 Juniata Basins

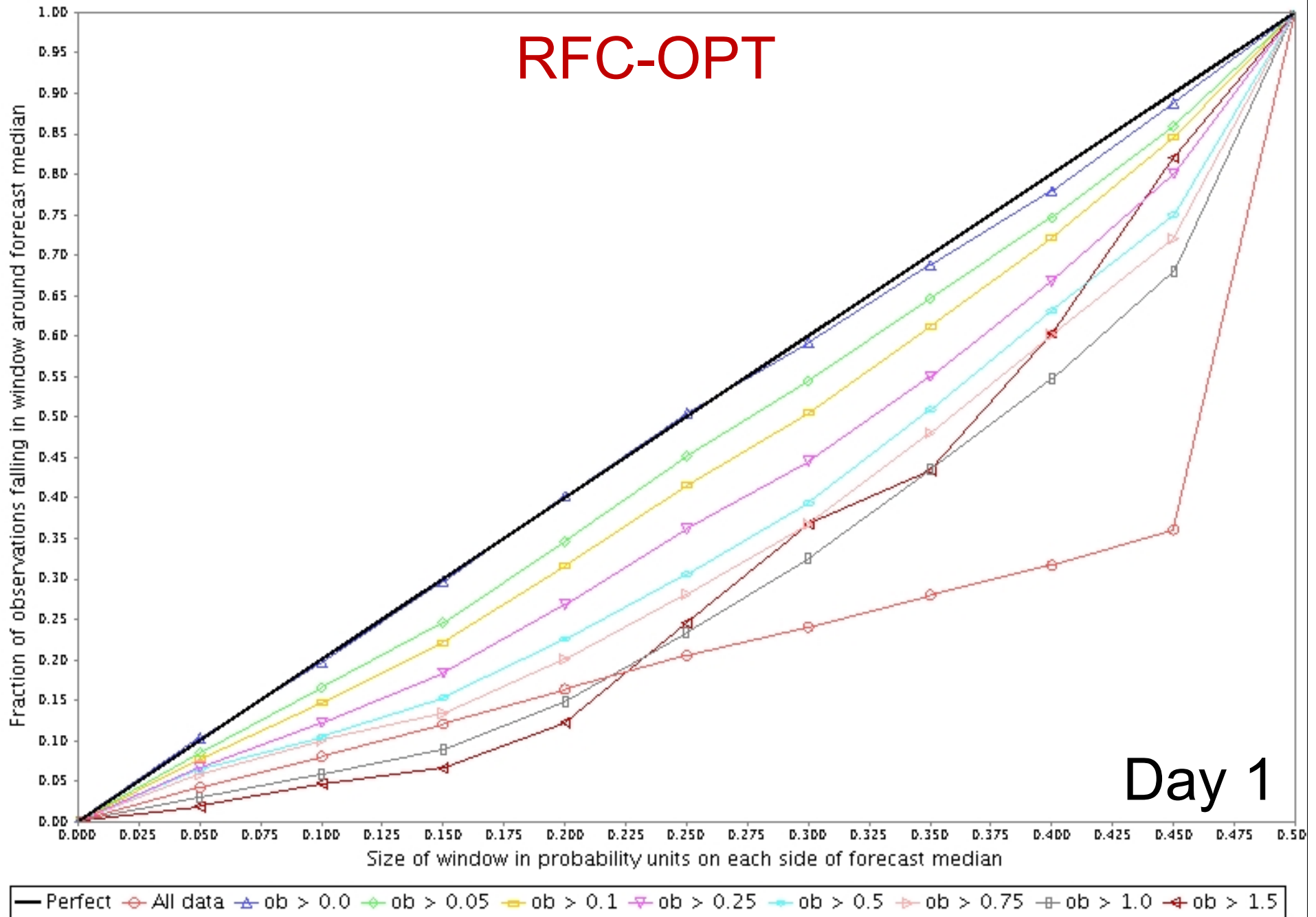
Cumulative Talagrand plot,
agg_3optBW_24h at lead hour 15

30

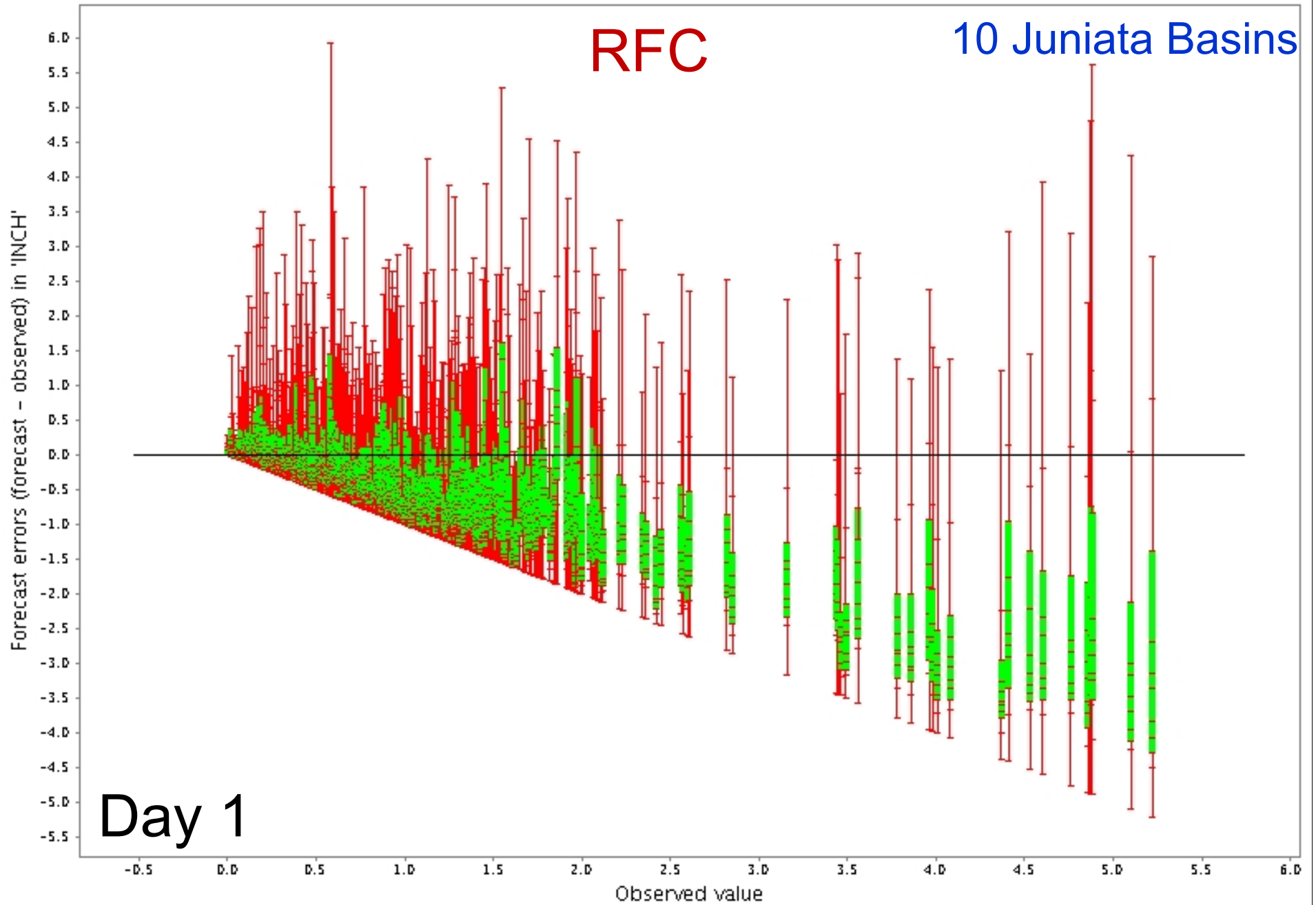
RFC



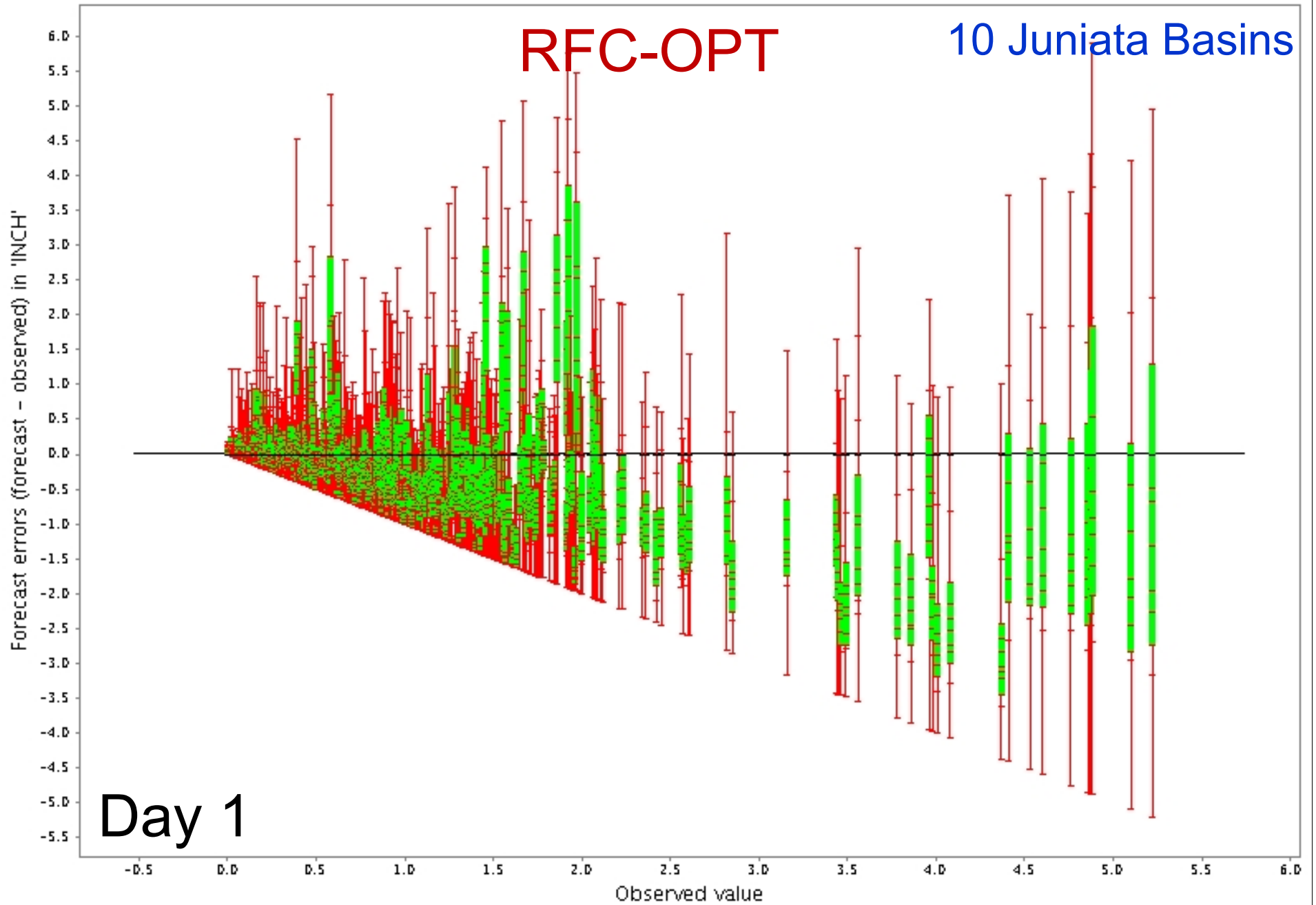
RFC-OPT



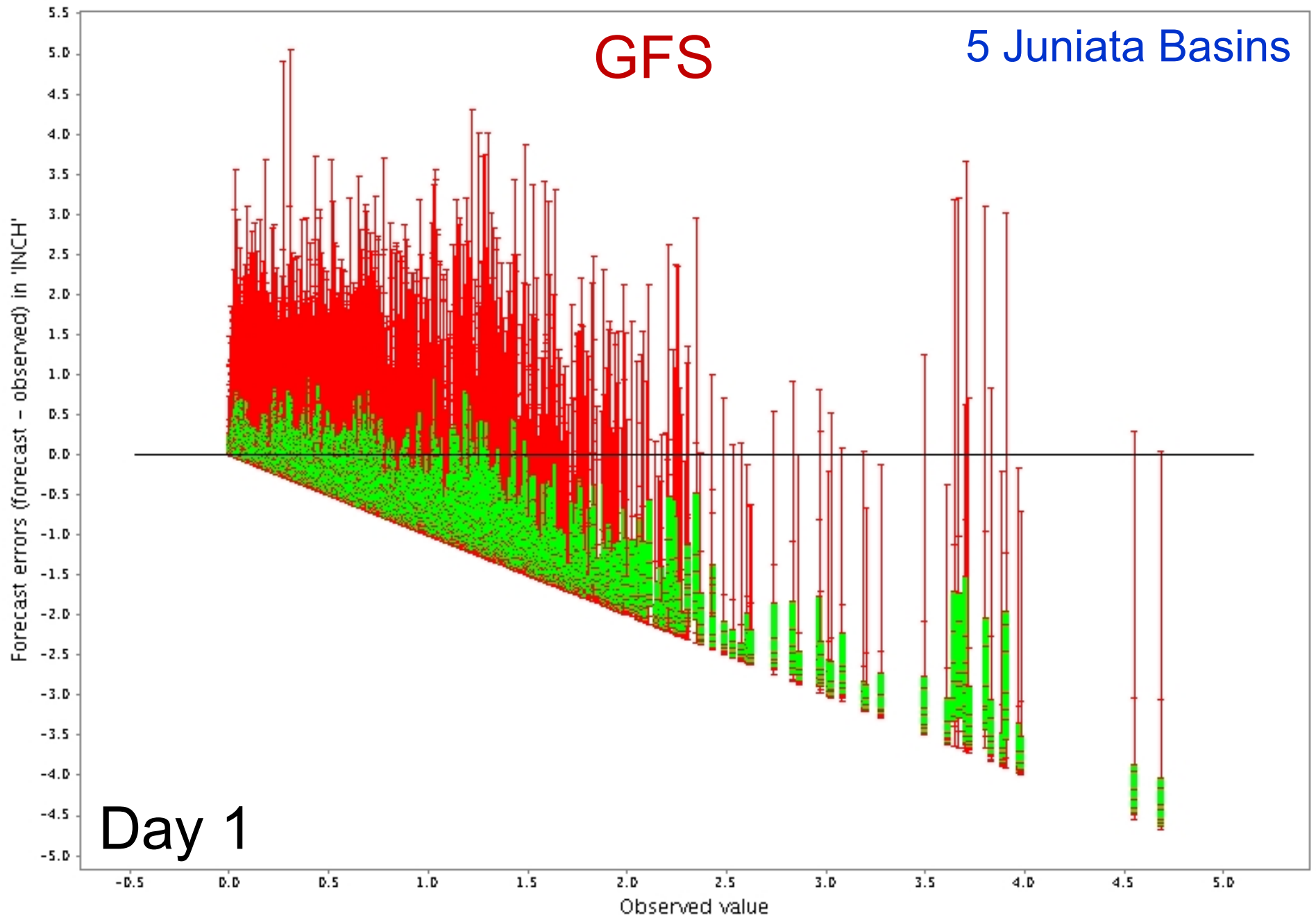
Modified box plot of ensemble forecast errors against observed value.
agg_3optBW_24h at lead hour 15



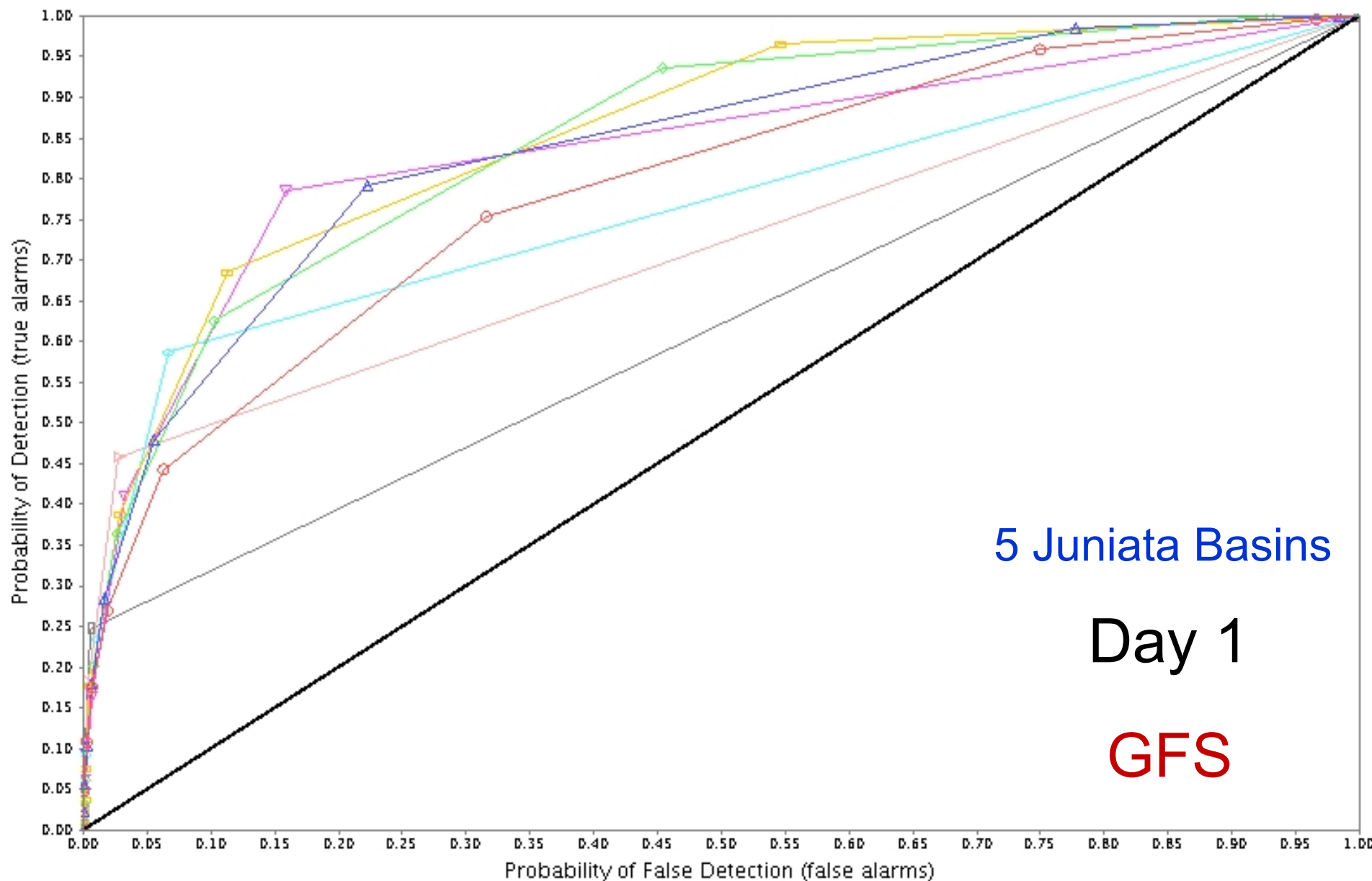
Modified box plot of ensemble forecast errors against observed value.
agg_60th_3optBW_24h at lead hour 15



Modified box plot of ensemble forecast errors against observed value.
5basin_agg_101_01_24h at lead hour 15

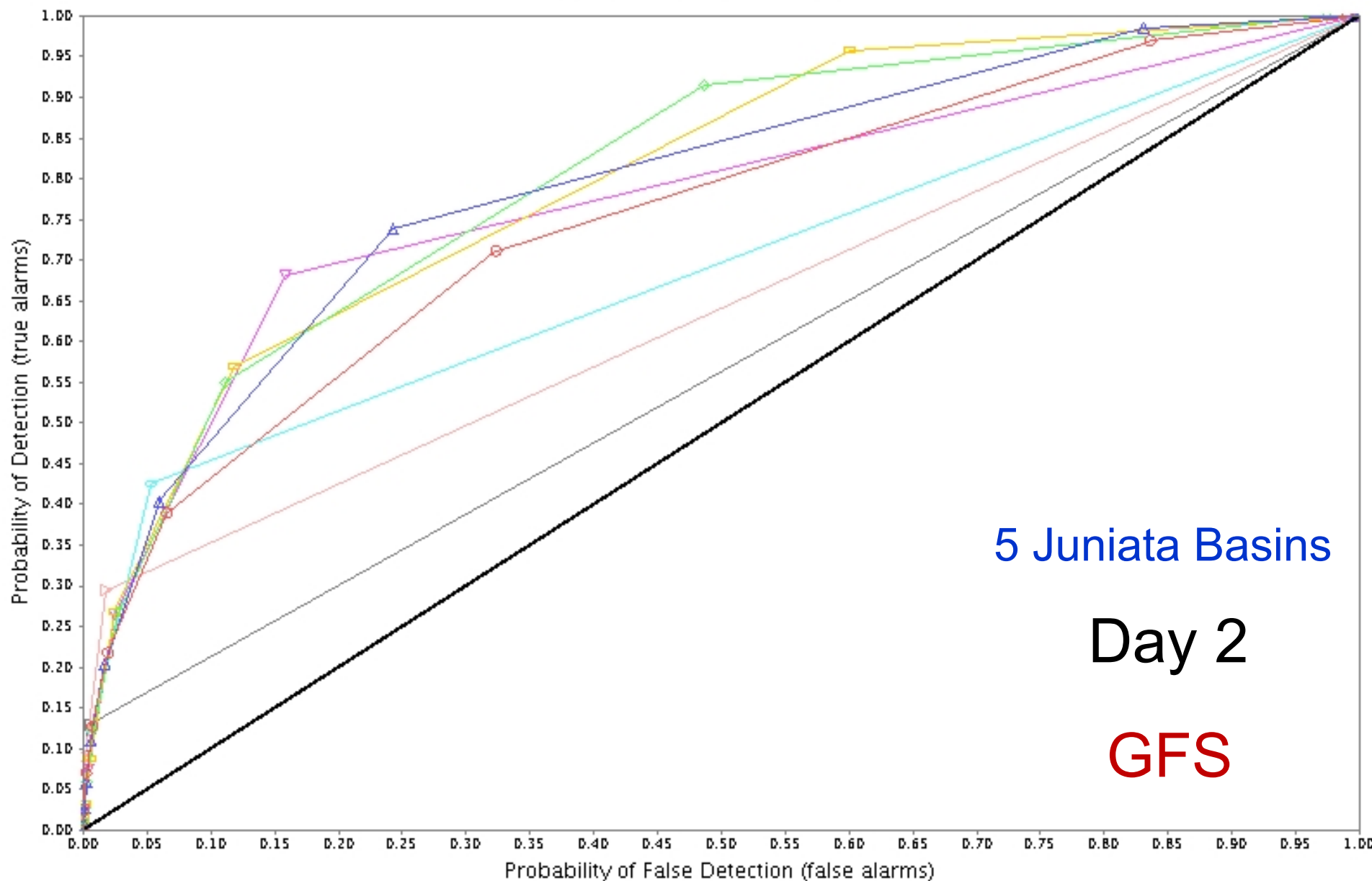


Relative Operating Characteristic for different event (probability) thresholds.
5basin_agg_101_01_24h at lead hour 15



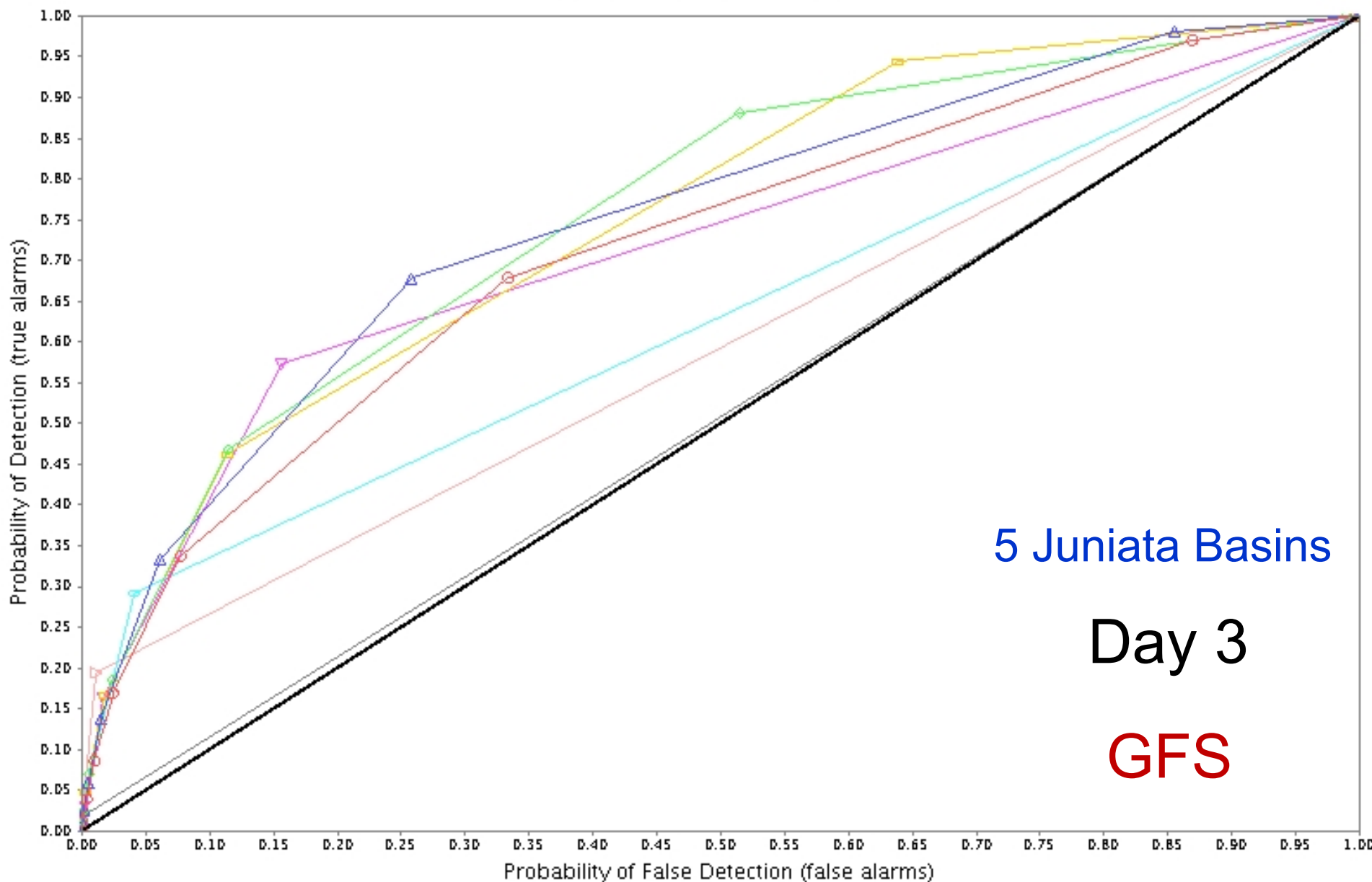
— Random guess (no skill) ○ ob > 0.0 ▲ ob > 0.05 ◆ ob > 0.1 ■ ob > 0.25 ▼ ob > 0.5 ▷ ob > 0.75 ◁ ob > 1.0
⊕ ob > 1.5

Relative Operating Characteristic for different event (probability) thresholds.
5basin_agg_101_01_24h at lead hour 39



— Random guess (no skill) ○ ob > 0.0 △ ob > 0.05 ◇ ob > 0.1 □ ob > 0.25 ▽ ob > 0.5 ◆ ob > 0.75 ⬠ ob > 1.0
⊕ ob > 1.5

Relative Operating Characteristic for different event (probability) thresholds.
5basin_agg_101_01_24h at lead hour 63



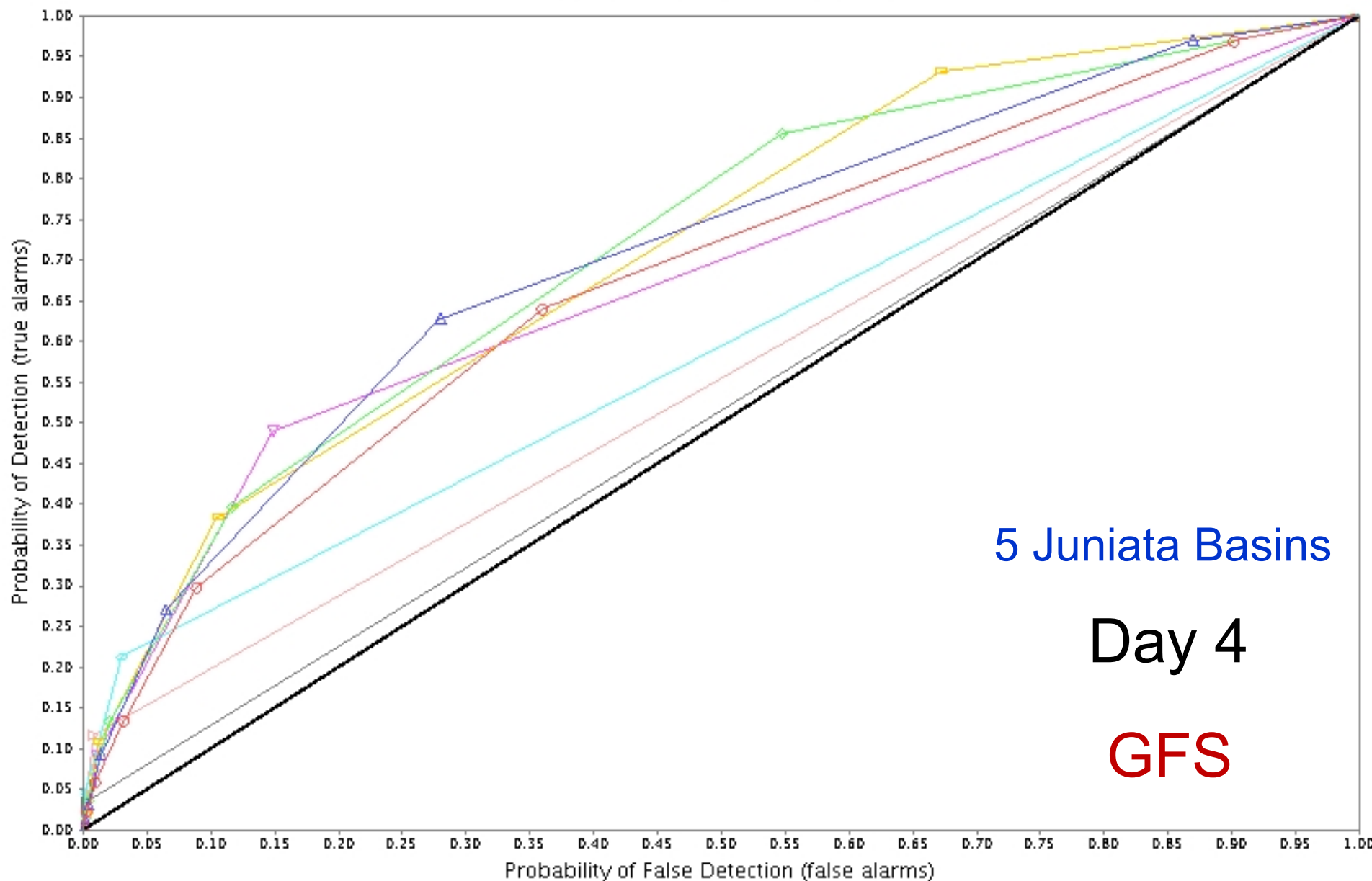
5 Juniata Basins

Day 3

GFS

— Random guess (no skill) ○ ob > 0.0 ▲ ob > 0.05 ◆ ob > 0.1 ● ob > 0.25 ▼ ob > 0.5 ◆ ob > 0.75 ▲ ob > 1.0
⊕ ob > 1.5

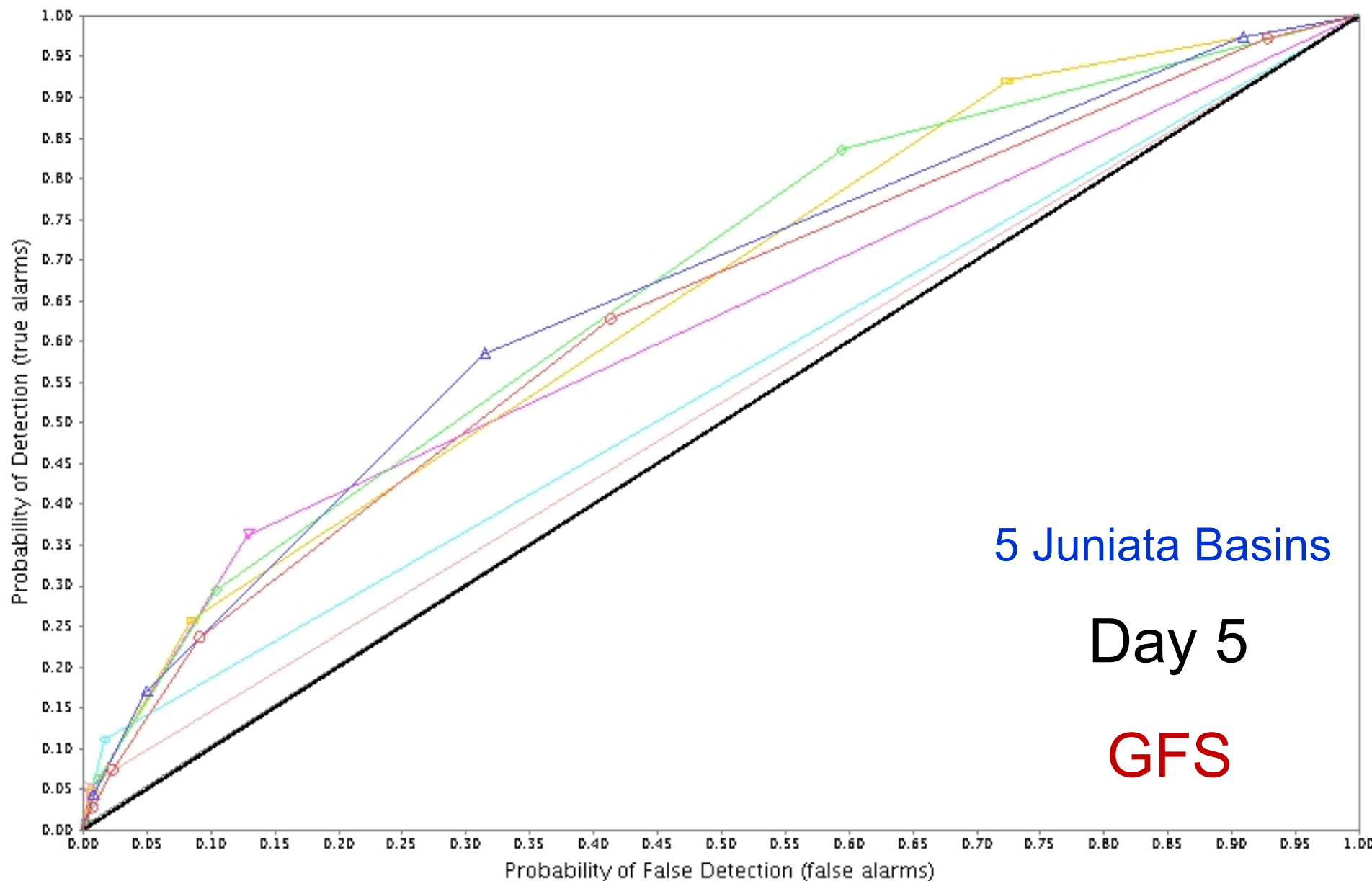
Relative Operating Characteristic for different event (probability) thresholds.
5basin_agg_101_01_24h at lead hour 87



— Random guess (no skill) ○ ob > 0.0 ▲ ob > 0.05 ◆ ob > 0.1 ■ ob > 0.25 ▼ ob > 0.5 ◆ ob > 0.75 ▲ ob > 1.0
⊕ ob > 1.5

Relative Operating Characteristic for different event (probability) thresholds.
5basin_agg_101_01_24h at lead hour 111

40

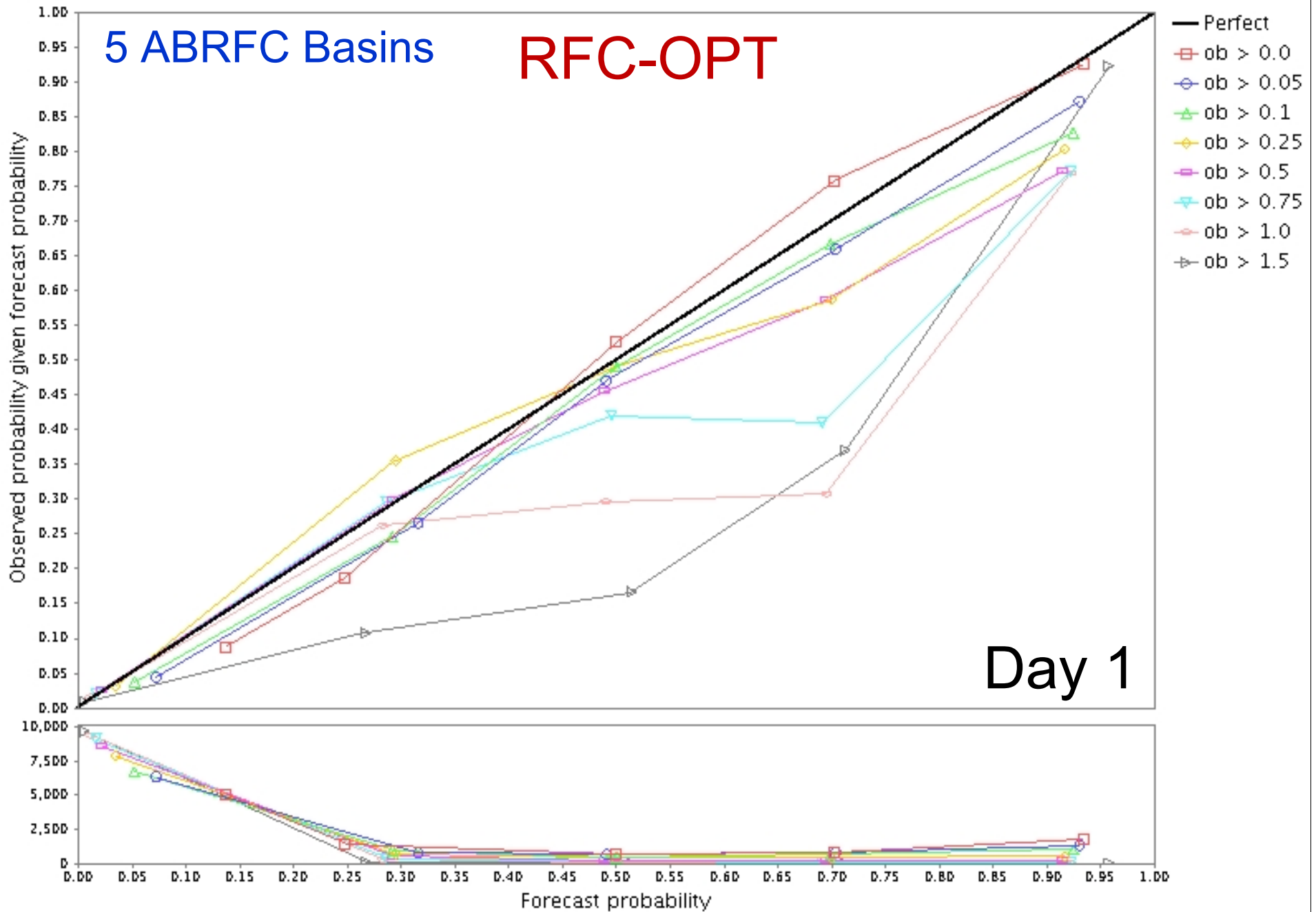


— Random guess (no skill) —○— ob > 0.0 —△— ob > 0.05 —◇— ob > 0.1 —□— ob > 0.25 —▽— ob > 0.5 —◇— ob > 0.75 —△— ob > 1.0 —□— ob > 1.5

Reliability diagram for various event thresholds (upper) and sample counts (lower).
abrfc_agg_60th_3optBW_24h at lead hour 15

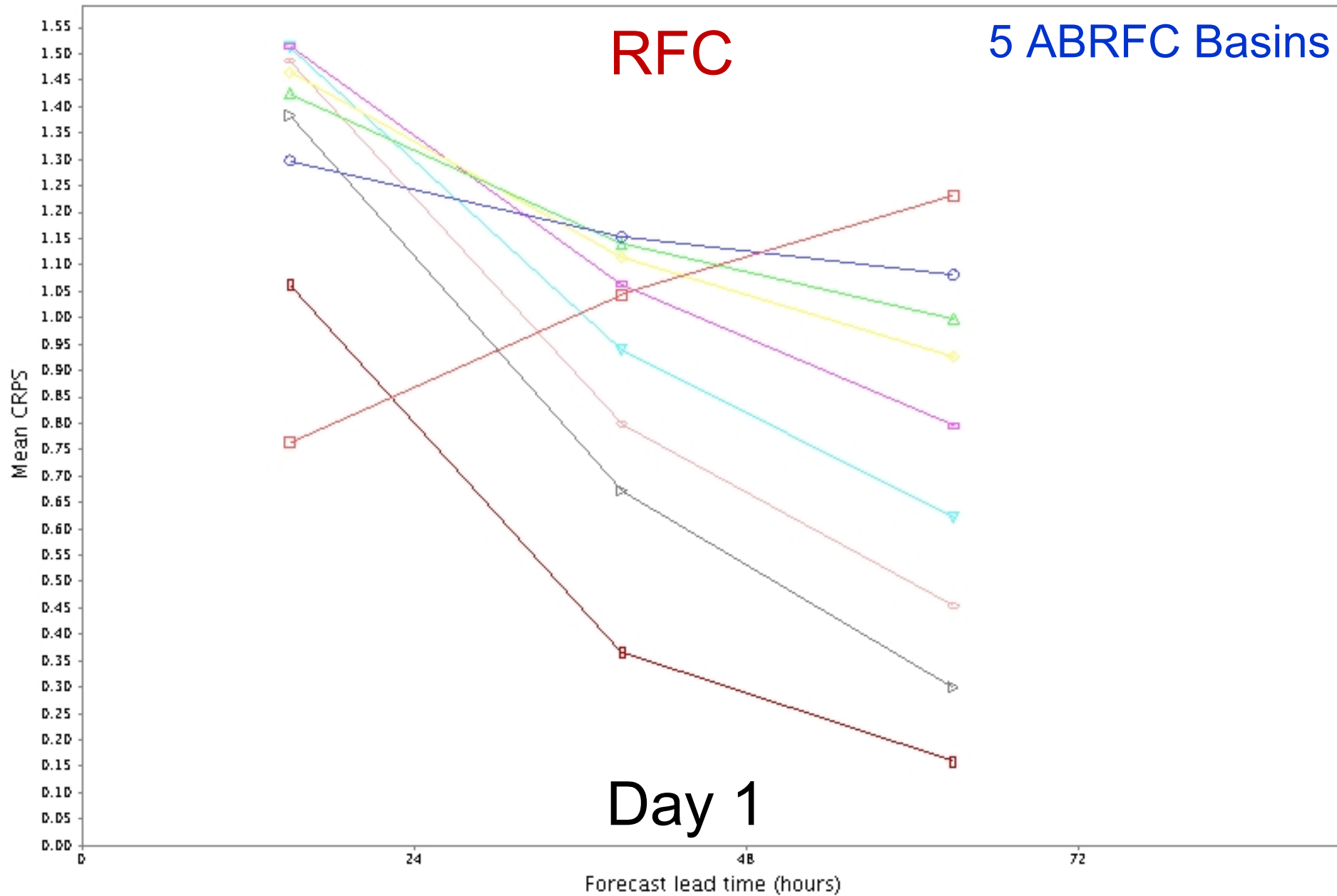
5 ABRFC Basins

RFC-OPT

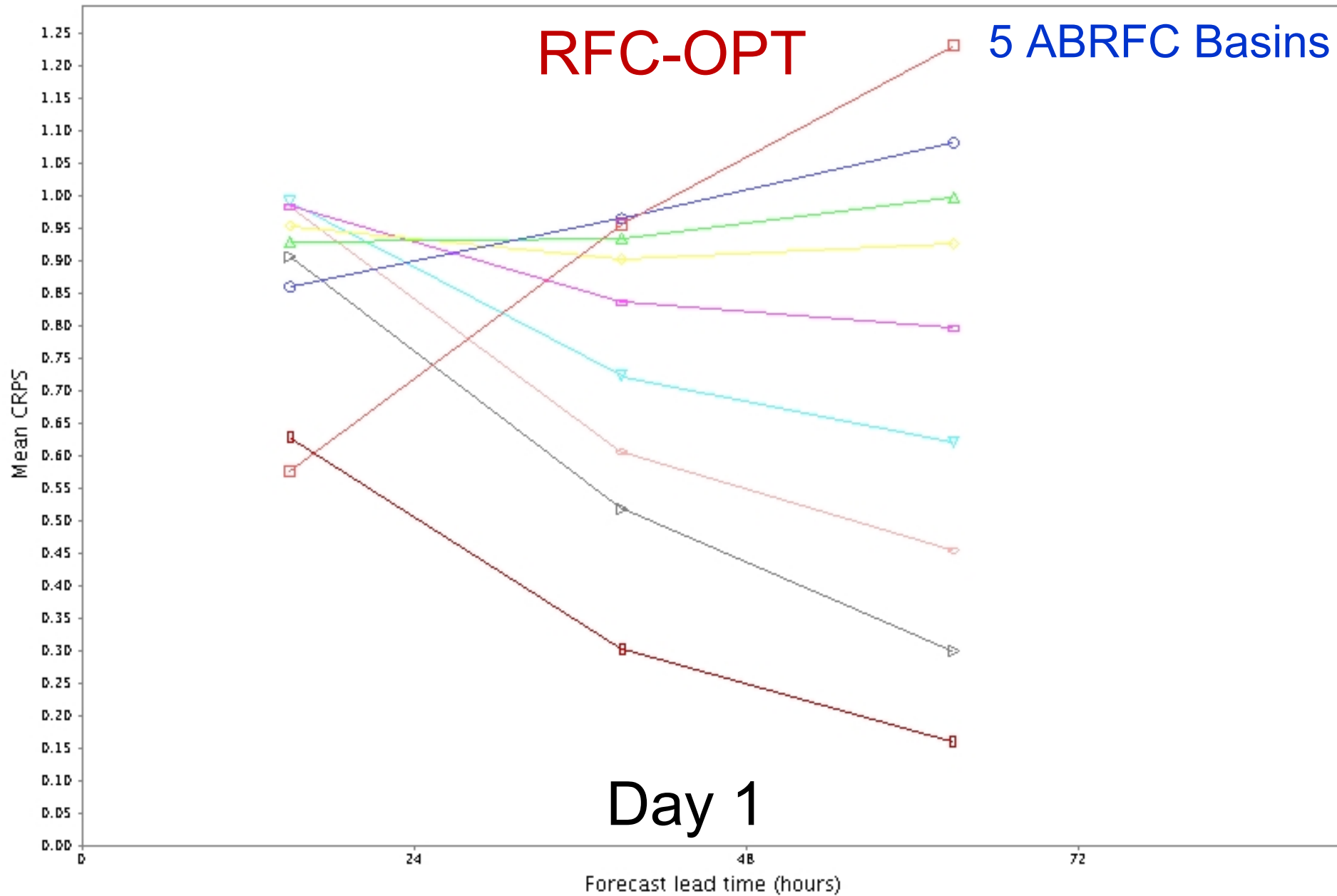


RFC

5 ABRFC Basins



Legend: All data (red square), ob > 0.0 (blue circle), ob > 0.05 (green triangle), ob > 0.1 (yellow diamond), ob > 0.25 (purple square), ob > 0.5 (cyan triangle), ob > 0.75 (pink circle), ob > 1.0 (grey triangle), ob > 1.5 (brown square)

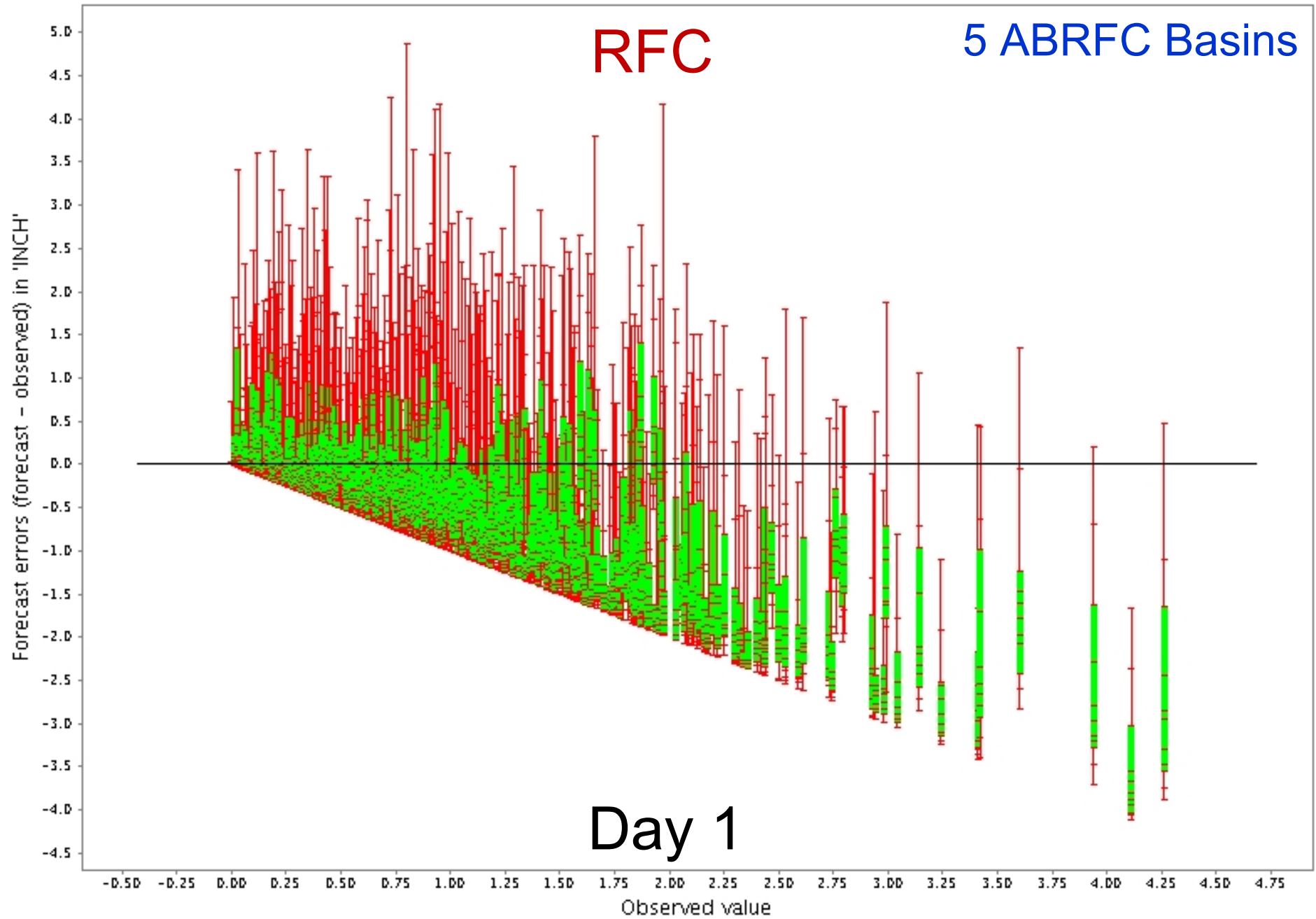


Legend:
- All data (red square)
- ob > 0.0 (blue circle)
- ob > 0.05 (green triangle)
- ob > 0.1 (yellow diamond)
- ob > 0.25 (purple square)
- ob > 0.5 (cyan triangle)
- ob > 0.75 (brown triangle)
- ob > 1.0 (grey triangle)
- ob > 1.5 (dark red square)

Modified box plot of ensemble forecast errors against observed value.
abrfc_agg_3optBW_24h at lead hour 15

RFC

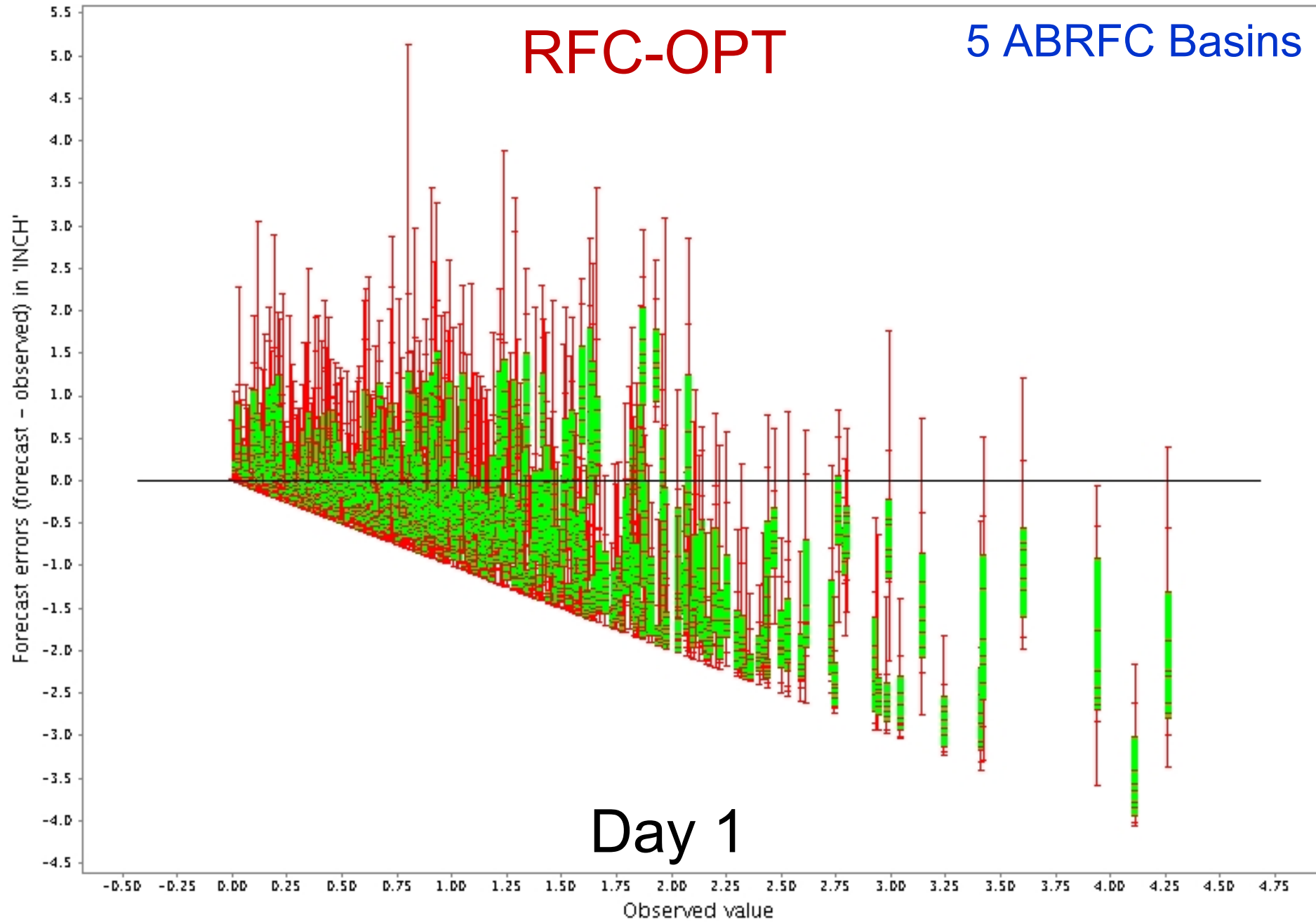
5 ABRFC Basins



Modified box plot of ensemble forecast errors against observed value.
abrfc_agg_60th_3optBW_24h at lead hour 15

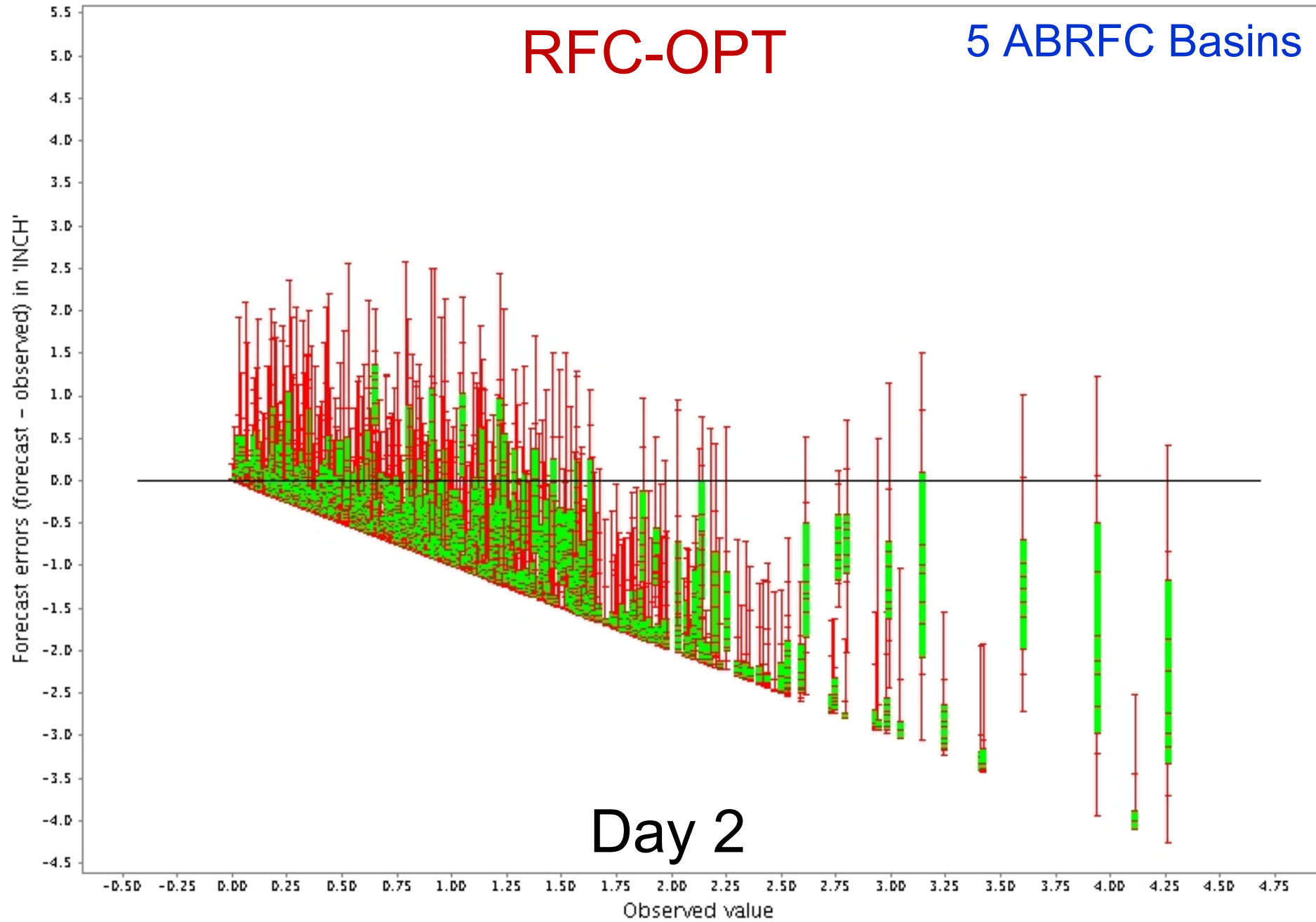
RFC-OPT

5 ABRFC Basins



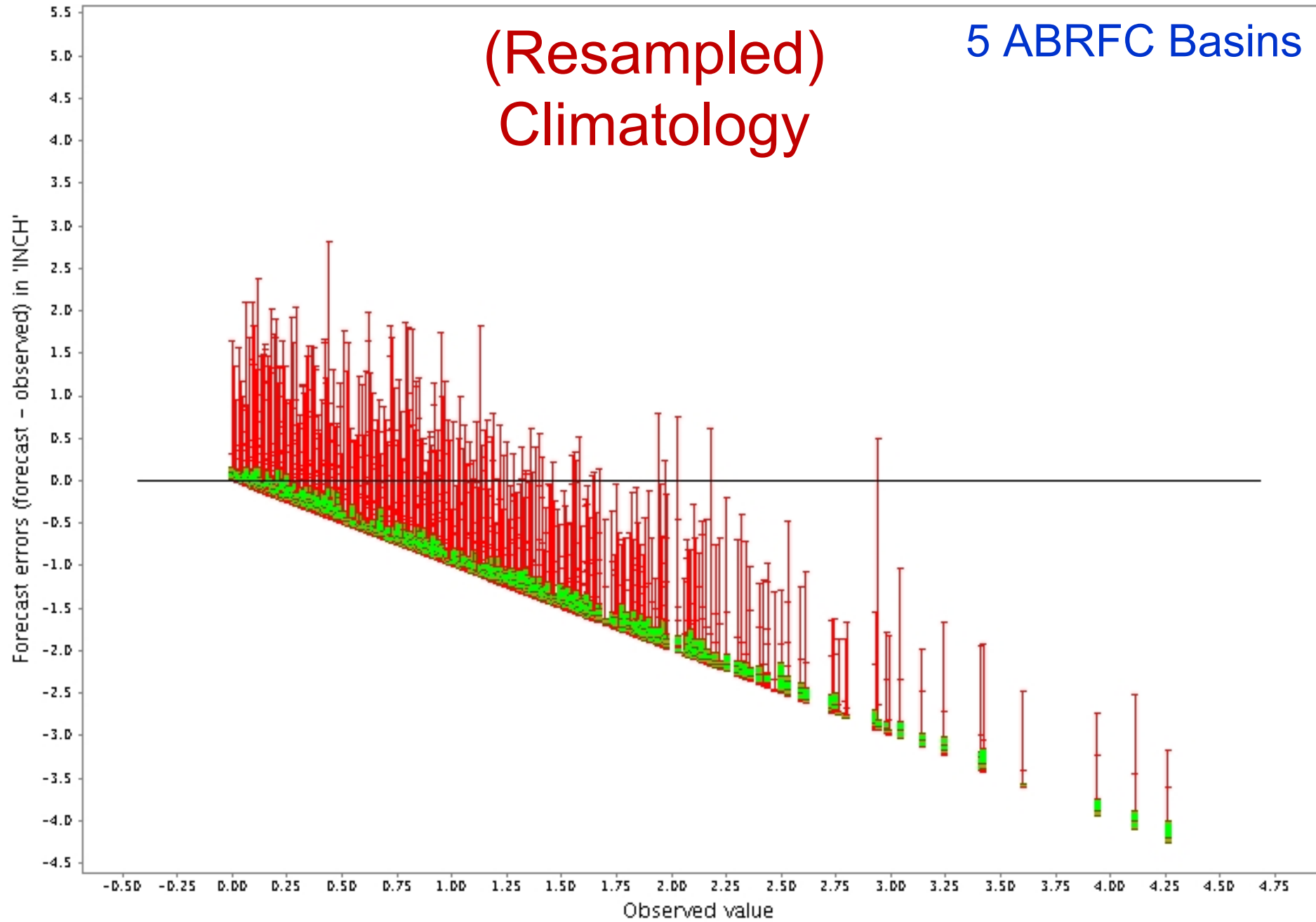
RFC-OPT

5 ABRFC Basins



(Resampled)
Climatology

5 ABRFC Basins



Summary of Precipitation Verification Results

- ❑ EPP ensembles from HPC/RFC single-value and GFS ensemble-mean forecasts are generally reliable
- ❑ EPP ensembles capture skill in HPC/RFC single-value forecast very well
- ❑ EPP ensembles capture skill in GFS ensemble-mean forecast for longer lead times
- ❑ EPP ensembles from RFC single-value forecast are more skillful than those from GFS ensemble mean for 24-hr amounts > 0.25 in
 - The opposite is observed for < 0.25 in



Thank You

Q/A, Discussion