Ensemble Forecast Systems and MOS

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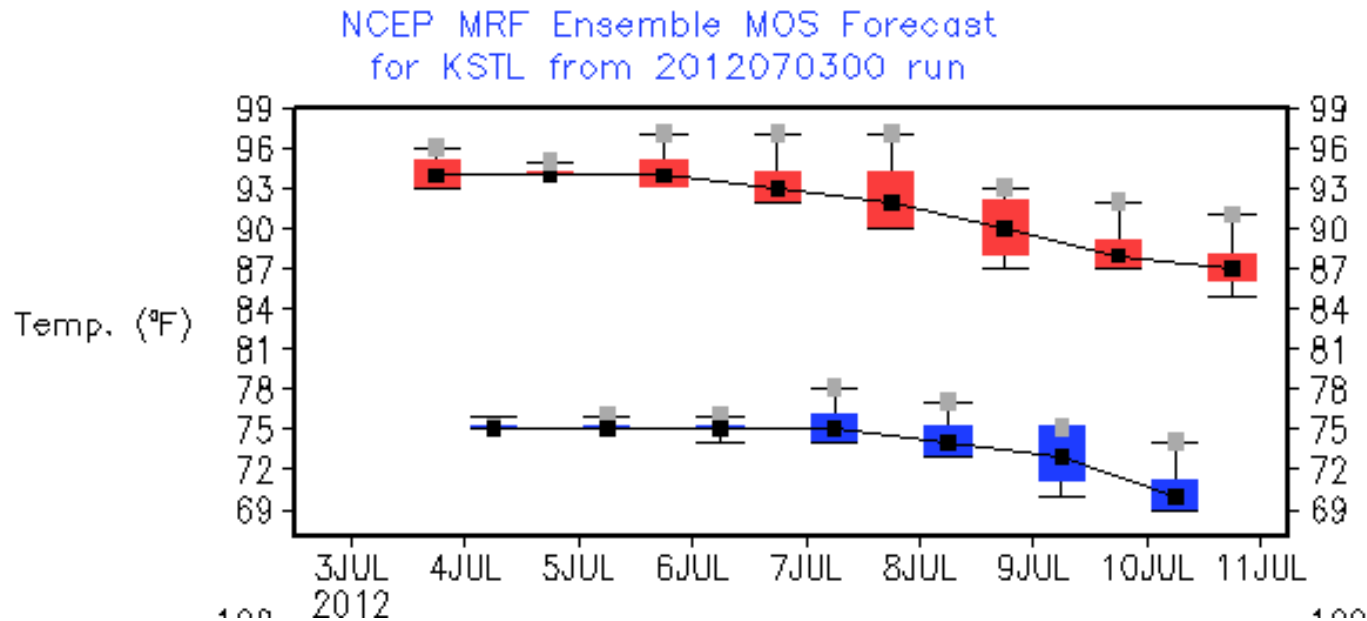
Harry R. Glahn Symposium

January 6, 2015

Background--Early 1990s

- MOS well accepted in the operational mainstream

- First Ensemble Forecast System (EFS) introduced at NWS National Meteorological Center (NMC)

- As MOS and EFS evolved, repeated calls for an "Ensemble MOS" product
  - Theoretically challenging
  - Computationally intensive
  - Data intensive

Earliest Efforts

- MOS forecast equations from deterministic model applied to raw ensemble output
- First moment improved, not second moment

NCEP MRF Ensemble MOS Forecast
for KSTL from 2012070300 run

Temp. (°F)

3JUL 4JUL 5JUL 6JUL 7JUL 8JUL 9JUL 10JUL 11JUL
2012

Challenges

- Develop accurate and reliable probabilistic forecasts of NDFD weather elements

- Find practical ways to disseminate forecasts

- Verify forecasts

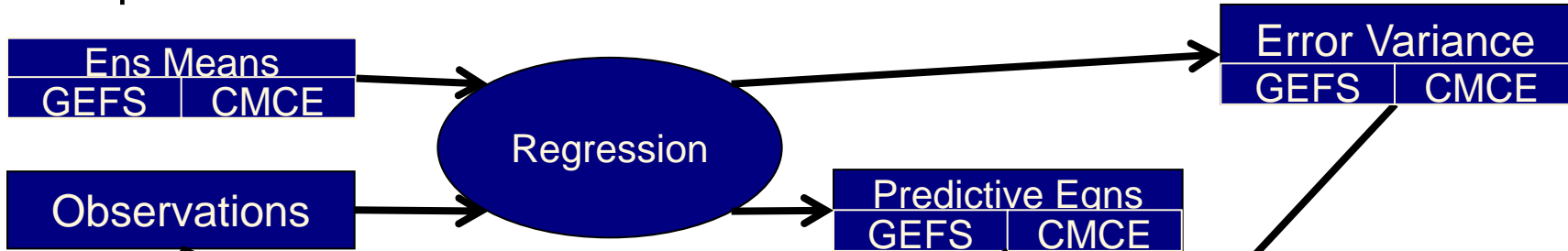# Ensemble Kernel Density MOS (EKDMOS; 2009, 2012, 2013)

1. Use forward screening multiple linear regression with ensemble means
2. Estimate error variance from regression
3. Perform second regression to obtain spread-skill relationship
4. Apply equations to individual ensemble members and combine results with Kernel Density fitting
   a. Gaussian kernel
   b. Standard deviation produced by the regression
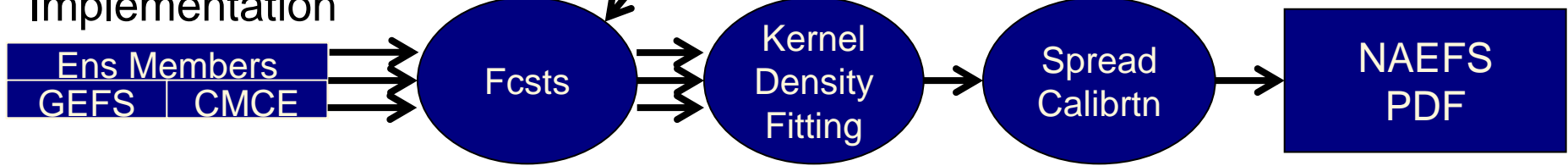5. Apply spread-skill relationship to calibrate spread

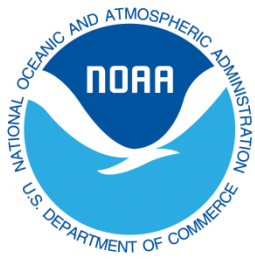# EKDMOS Method (graphic)

Development

| Ens Means	
GEFS	CMCE

Observations

Regression

Predictive Eqns	
GEFS	CMCE

Error Variance	
GEFS	CMCE

Spread Calibration

Ens Members	
GEFS	CMCE

Spread Calibrtn

Spread/Skill Relationship

Implementation

Ens Members	
GEFS	CMCE

Fcsts

Kernel Density Fitting

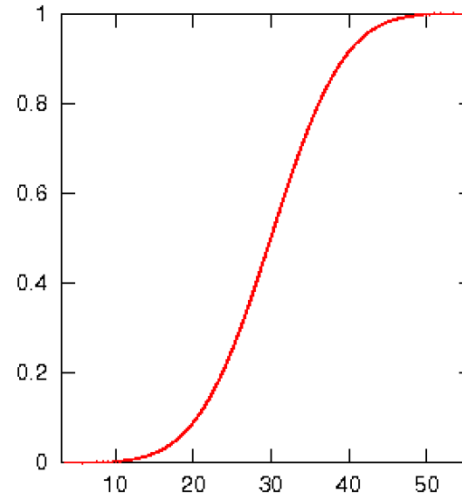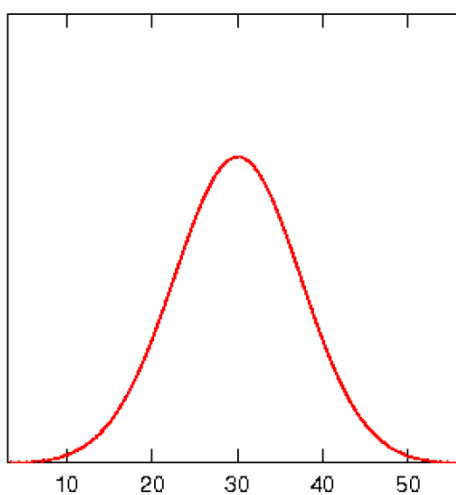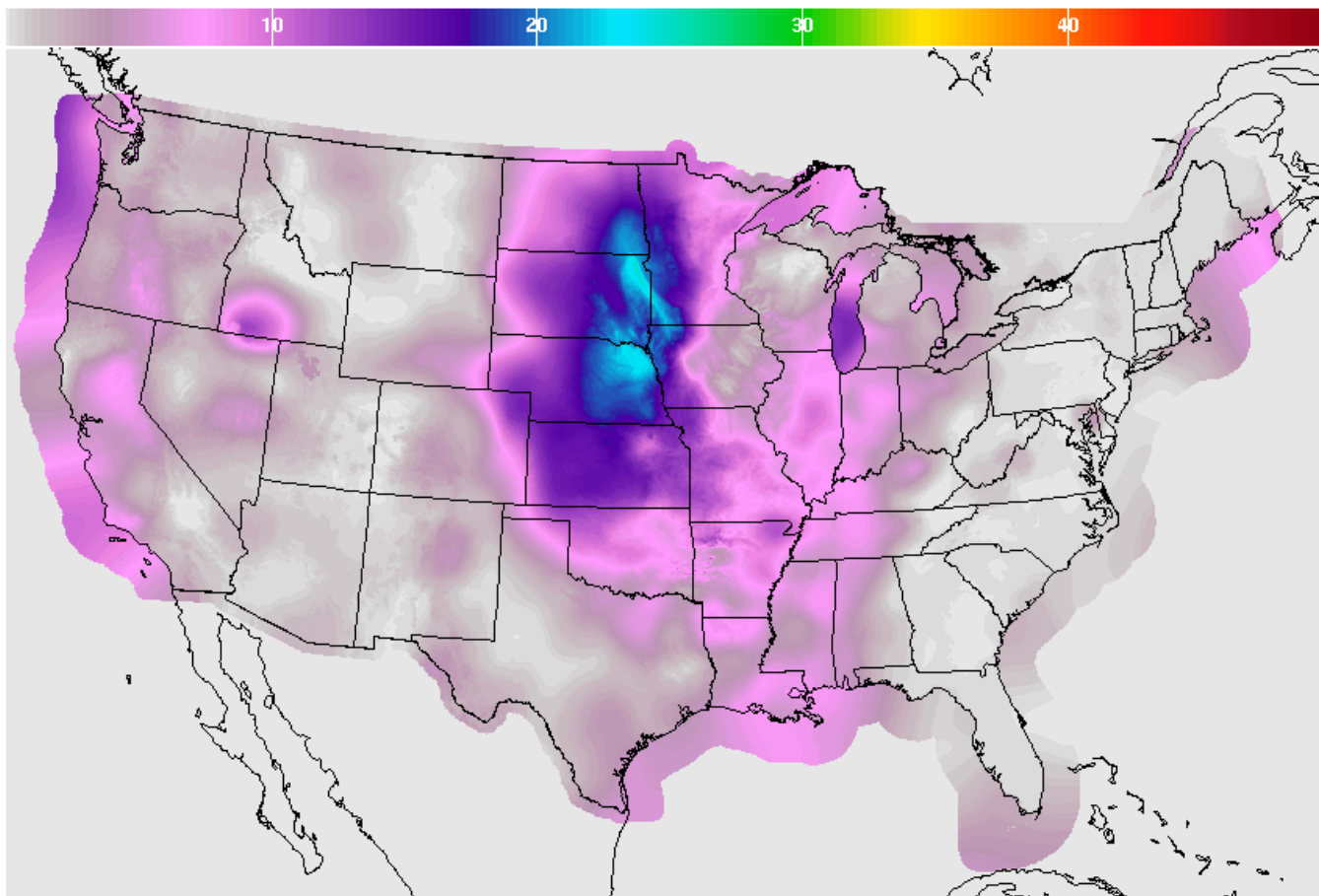Spread Calibrtn

NAEFS PDF

Dissemination

- Operational: 2.5-km grids of T, Td, MaxT, MinT
- Experimental: 2.5-km grids of apparent temperature, wind speed, and prob. QPF
- Select points on the quantile function
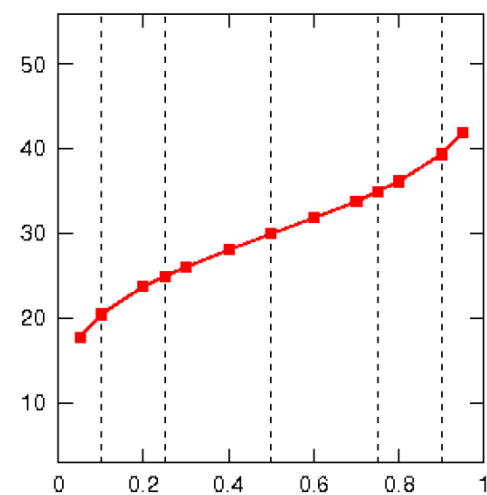
Example Grid (10-50-90)

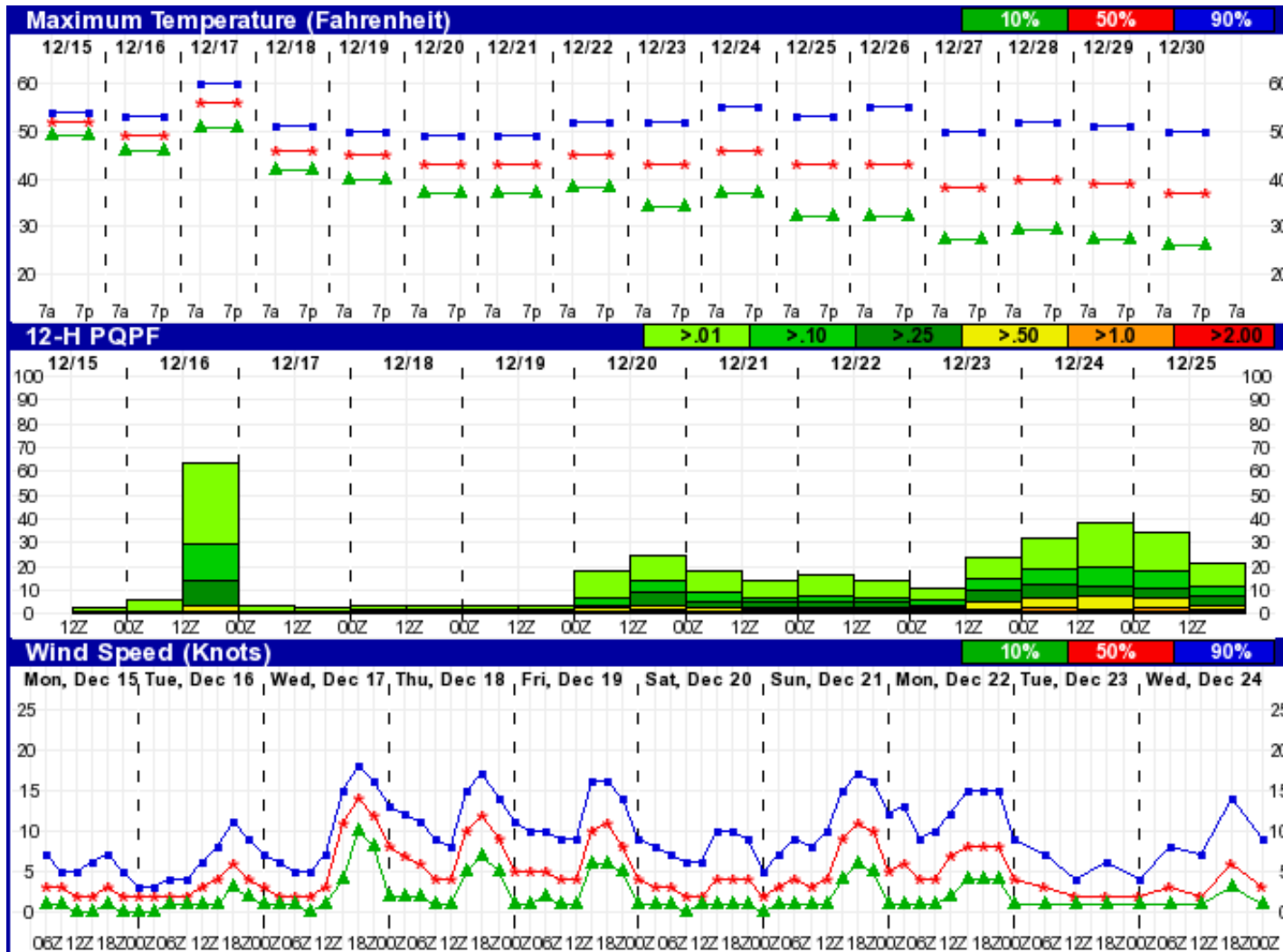WindSpd(Kts) 10% Mon Dec 15 2014 7PM EST
(Tue Dec 16 2014 00Z)
NDGD Prototype EKDMOS
Graphic created–Dec 15 3:54AM EST

# Example Meteogram (MaxT, QPF, wind speed)

Verification

- Focus on first & second moments of the forecast distributions

- First moment verification straightforward (MAE, Bias)

- Second moment verification techniques presented here

Verfying Second Moment

- Cumulative Reliability Diagram (CRD, top) and Probability Integral Transform (PIT, bottom) histogram

- CRD evaluated similar to reliability diagram

- PIT is the value of the CDF at the value observed. Histogram formed from a number of cases.

(i) 168-h Dep EKDMOS
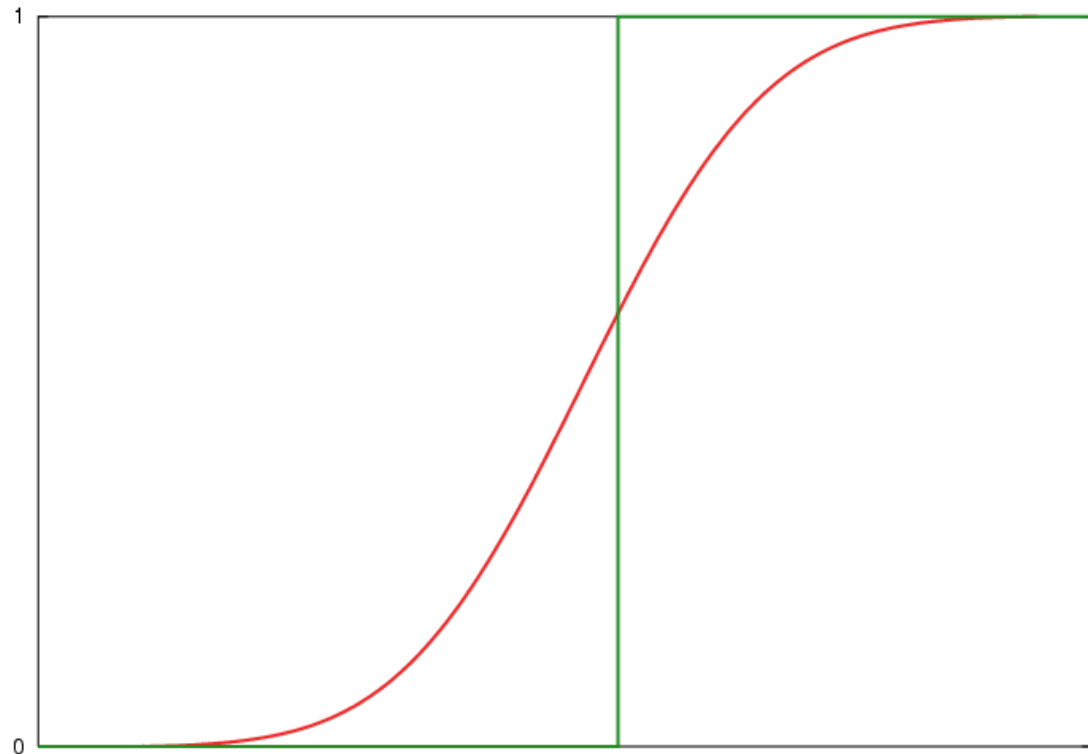

(c) 168-h Dep EKDMOS
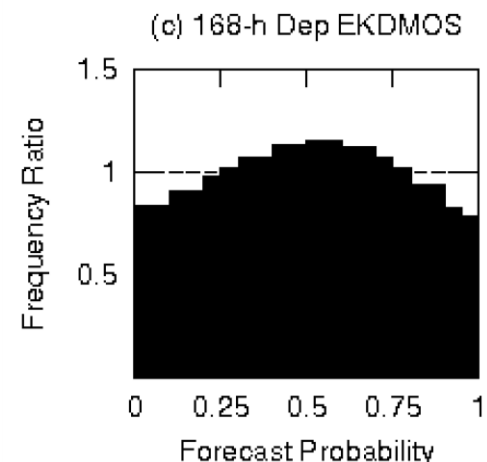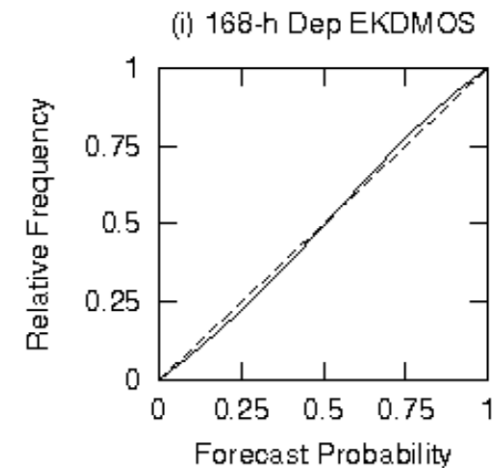
Continuous Ranked Probability Score (CRPS)

- Verifies predicted probability distribution
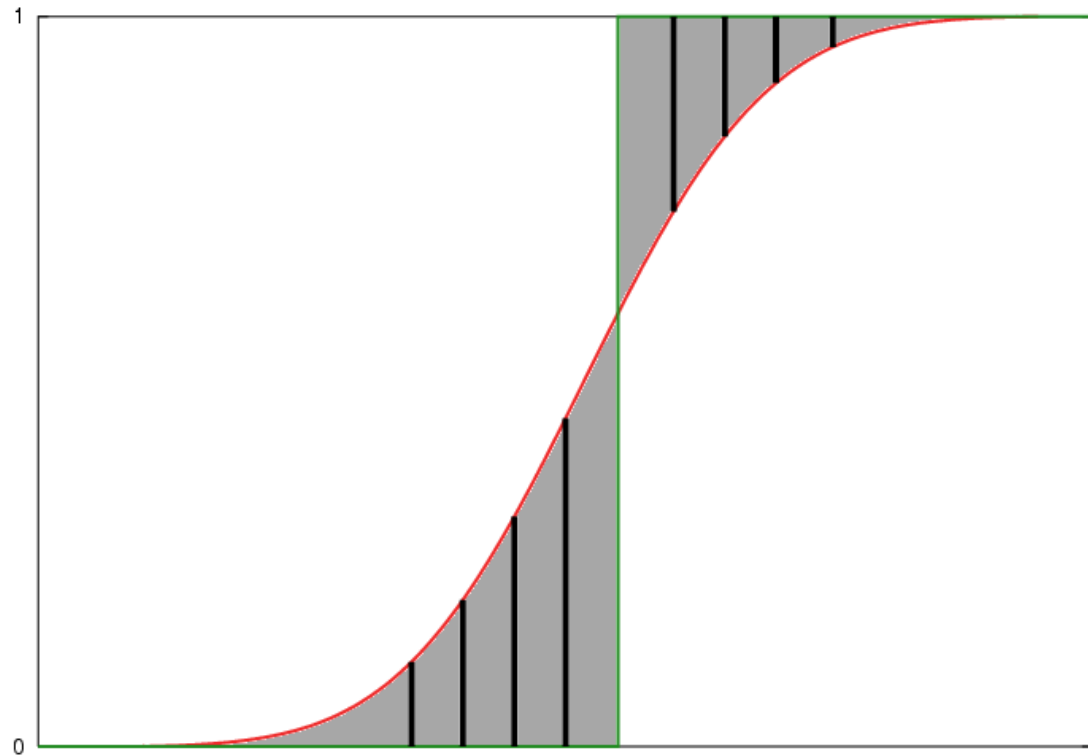- Sensitive to both accuracy and reliability

Red: Forecast CDF
Green: Unit Step Function of verifying ob.

Continuous Ranked Probability Score (CRPS)

- Squared measure of difference between CDF and verifying ob.

Red: Forecast CDF

Green: Unit Step Function of verifying ob.

Future

- EKDMOS techniques contribute to infrastructure for National Blend of Models
  - Adaptation for EFS with varying skill
  - Adaptation to compute forecasts directly on grids
- Develop ways to increase situational dependence of forecasts
- Develop ways to skew forecasts near climatological extremes