CPC Ensemble-based Extended Range Products

David Unger

NOAA/NWS/NCEP

Climate Prediction Center

Recent Developments

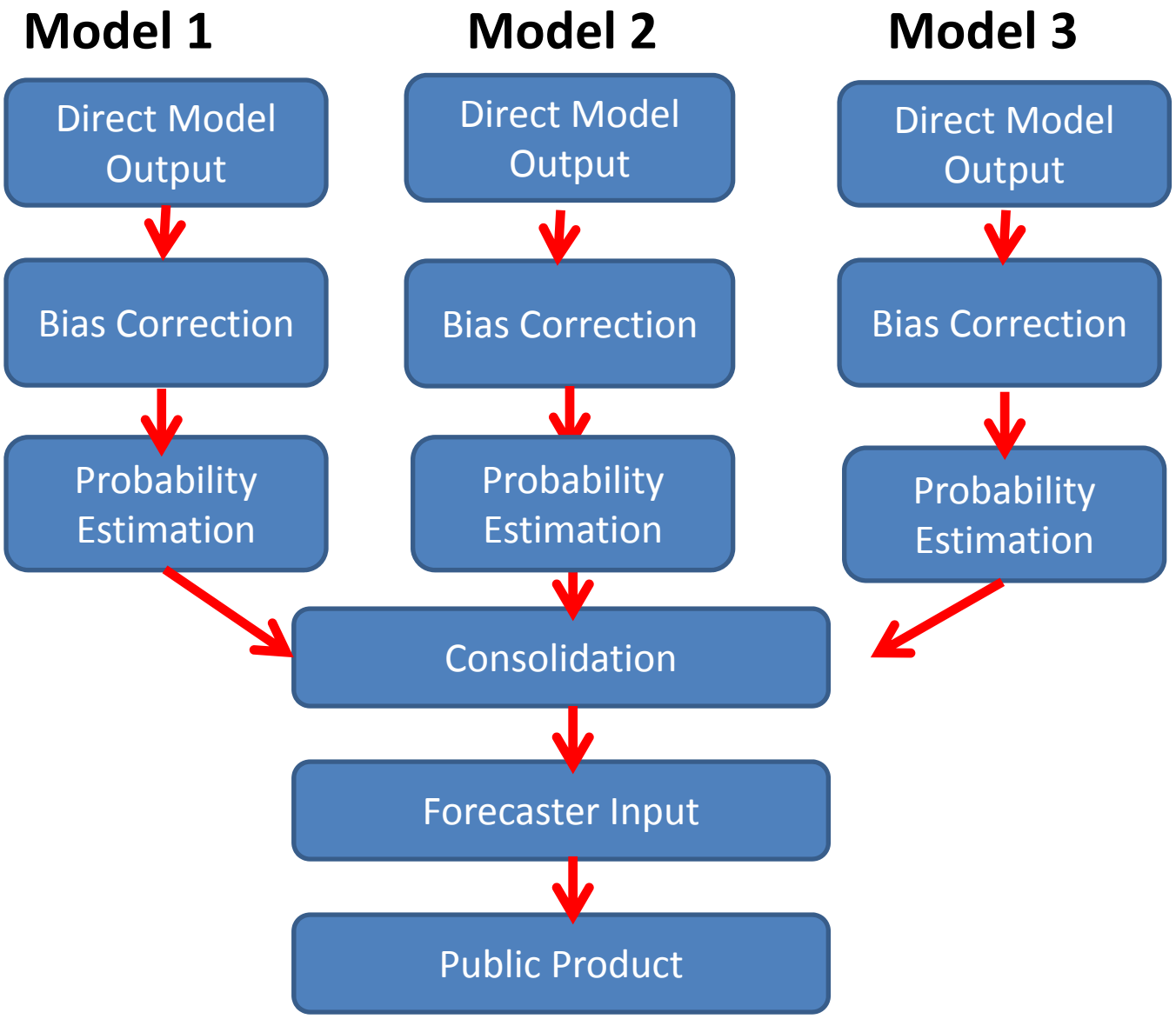
- CPC 6-10 day and Week 2 guidance tool based on GEFS reforecasts
- Probability of daily extreme temperatures, days 8-14.
- Automated “first guess” based on multi-model ensembles.

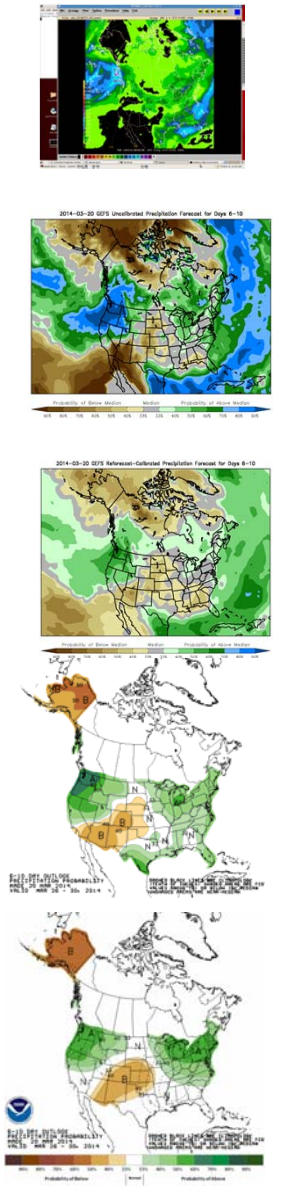
Overview of Ensemble Models

Time Range (Lead)	Models	Elements (primary focus)
Seasonal (1-13 mo)	CFSv2 NMME IMME	Temperature, Precipitation Soil Moisture, Z200 SST
Intra-seasonal Weeks 3 and 4 *	CFSv2 GEFS-Extended NAEFS	Temperature, Precipitation MJO SST
Week-2 6-10 Days	GEFS GFS-Deterministic NAEFS ECMWF	Temperature, Precipitation MJO Teleconnection Indices Wind Chill/Heat Index Temperature extremes Precipitation extremes* Wind Speed Extremes* Global Tropical Hazards

Red=Restricted access
* = Future product

CPC Ensemble Post Processing





Bias Correction Methods

- Direct model forecasts (No bias correction)
- Bias correction relative to full hindcast data
- Adaptive bias correction

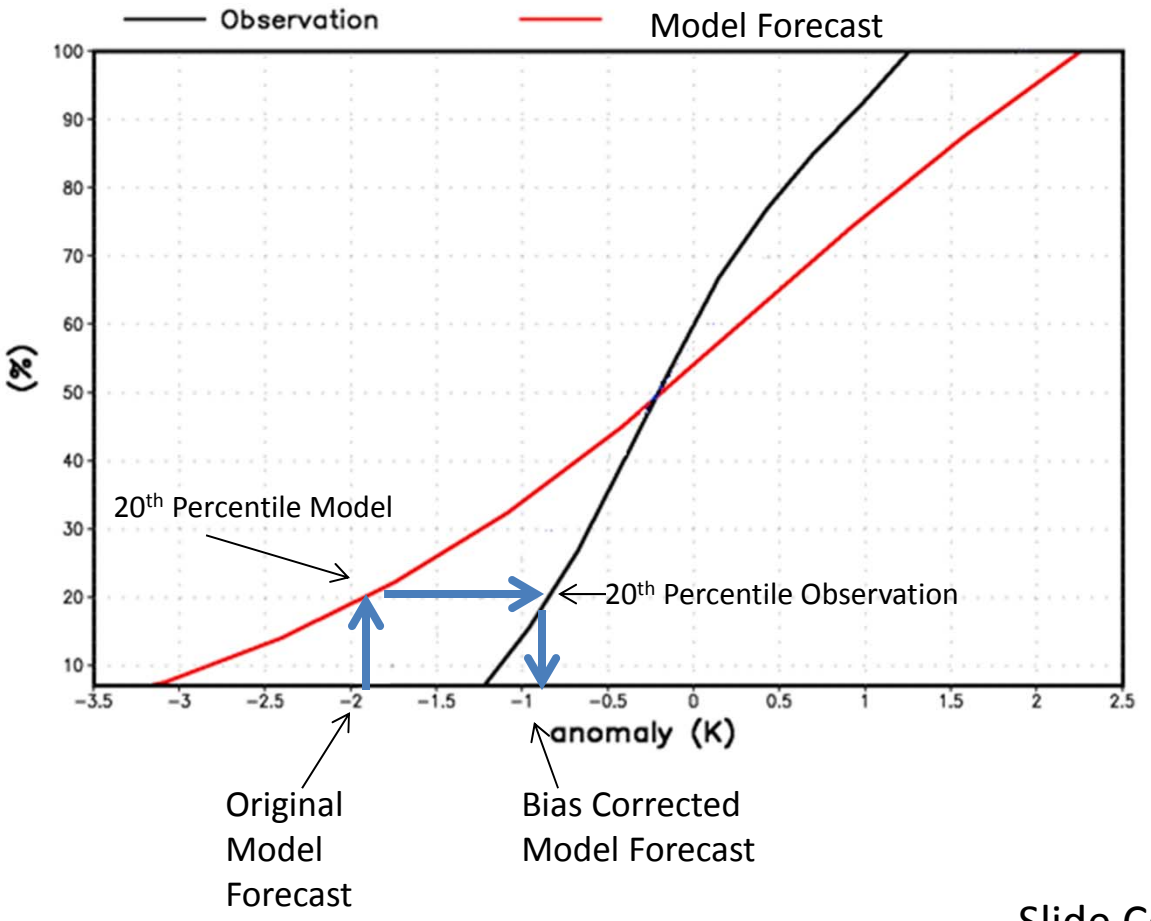
  N-Day trailing running mean

  Exponentially Weighted Moving Average (EWMA)
- PDF Mapping (Hindcast or Adaptive)
- Ensemble Regression

Bias Correction Method
PDF Mapping

PDF mapping (PDFc)

$$f_{PDFc} = o(Pc(f))$$

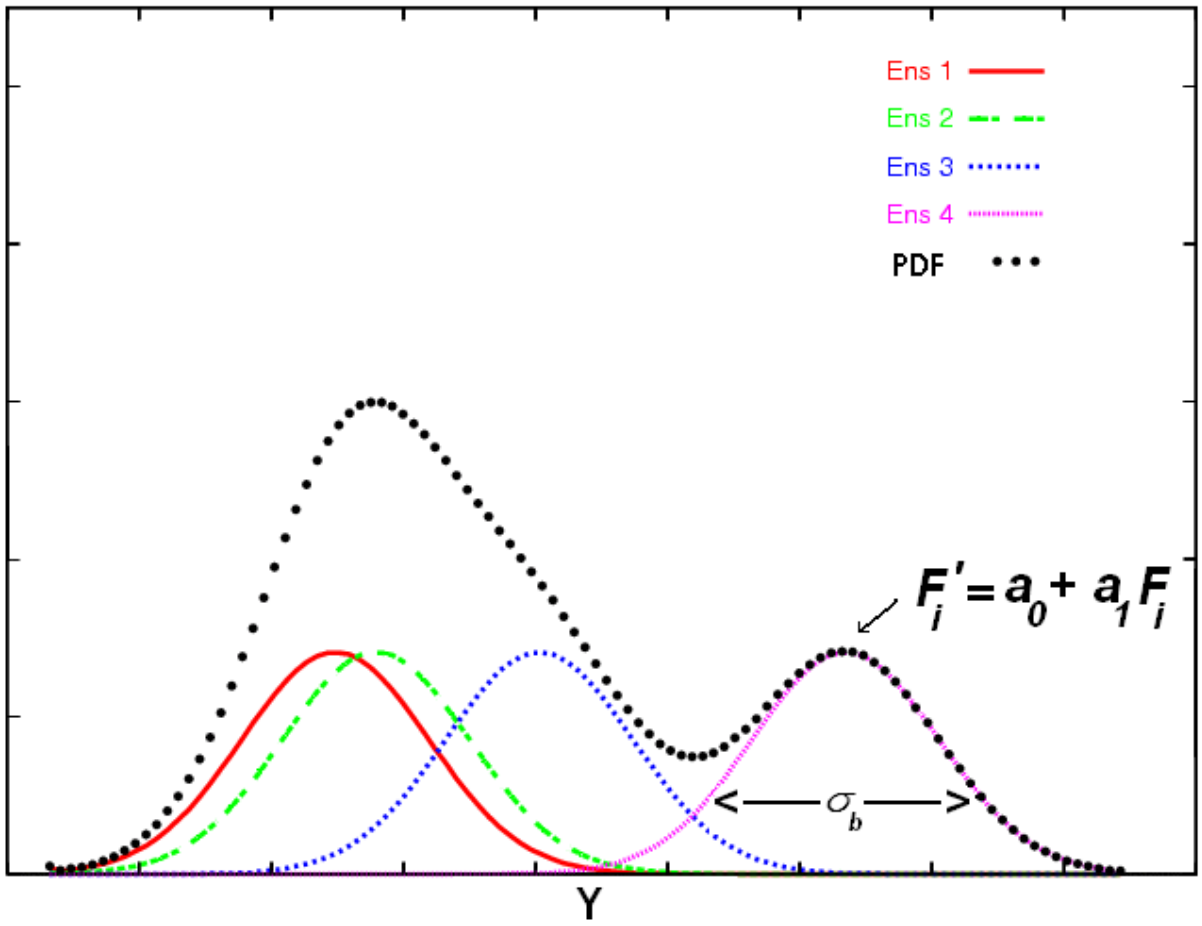


Slide Courtesy of Wanqiu Wang

Estimation of Probabilities

- Direct Member counts (No Bias Correction)
- Bias Corrected Member Counts
- Kernel-smoothing on regression-corrected forecasts (Ensemble Regression)

Regression With Error Estimates Applied



Consolidation

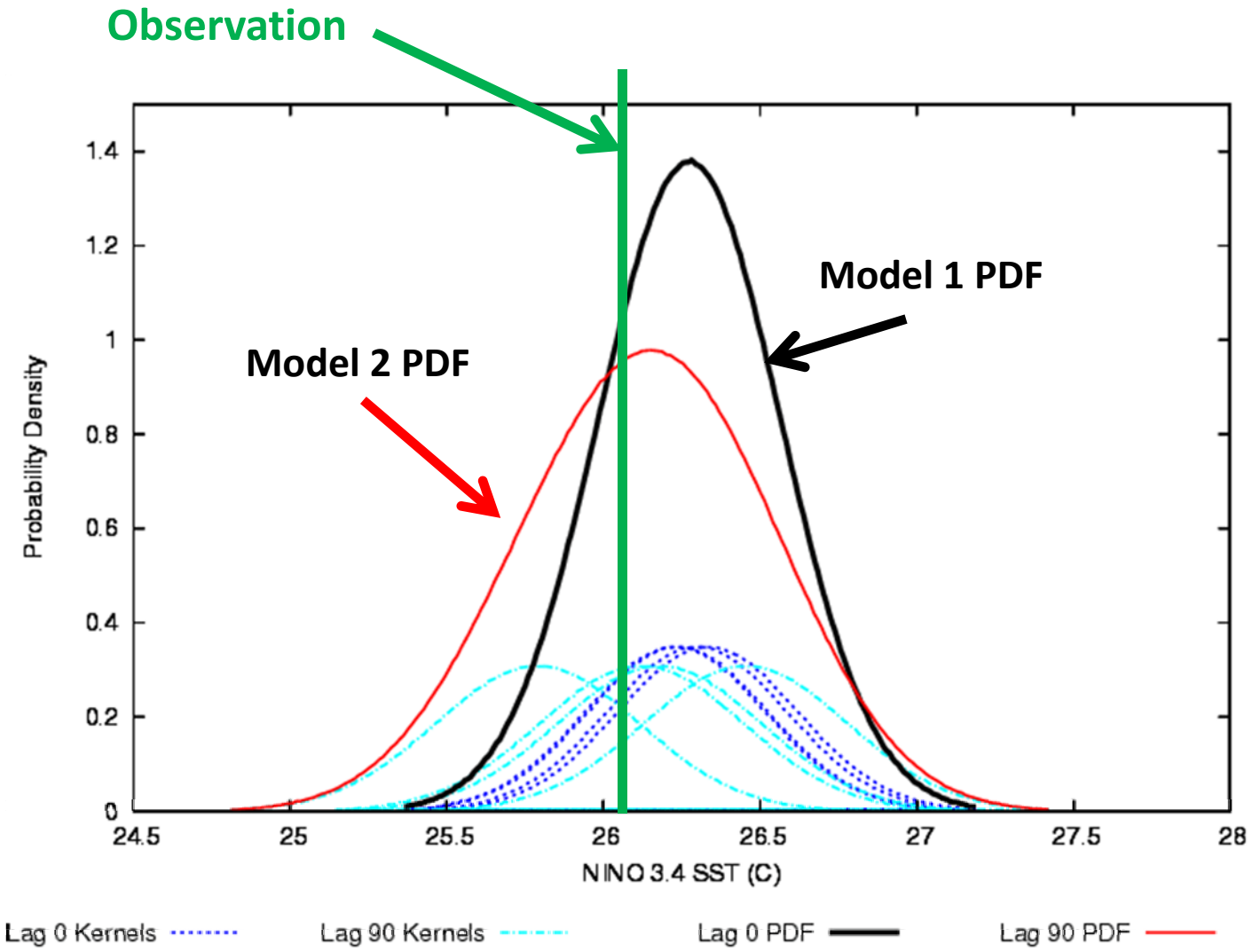
- **Combine ensembles of different models**
- **Combine forecast based on dynamic ensembles with statistical forecast estimates.**

Methods

- **Subjective weighting (Blend)**
- **Objective weights**

  Based on the probability of the closest match

Best Member Determination



Estimated from statistically generated PDF

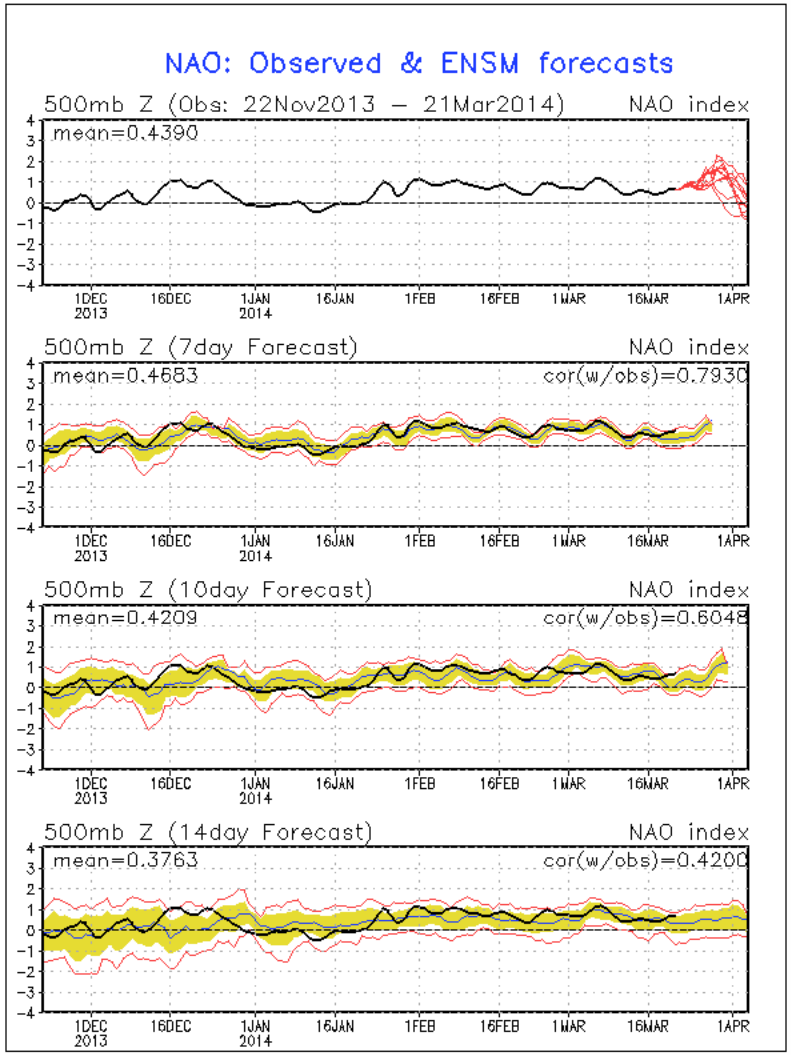
Accounts for model spread, variable member count

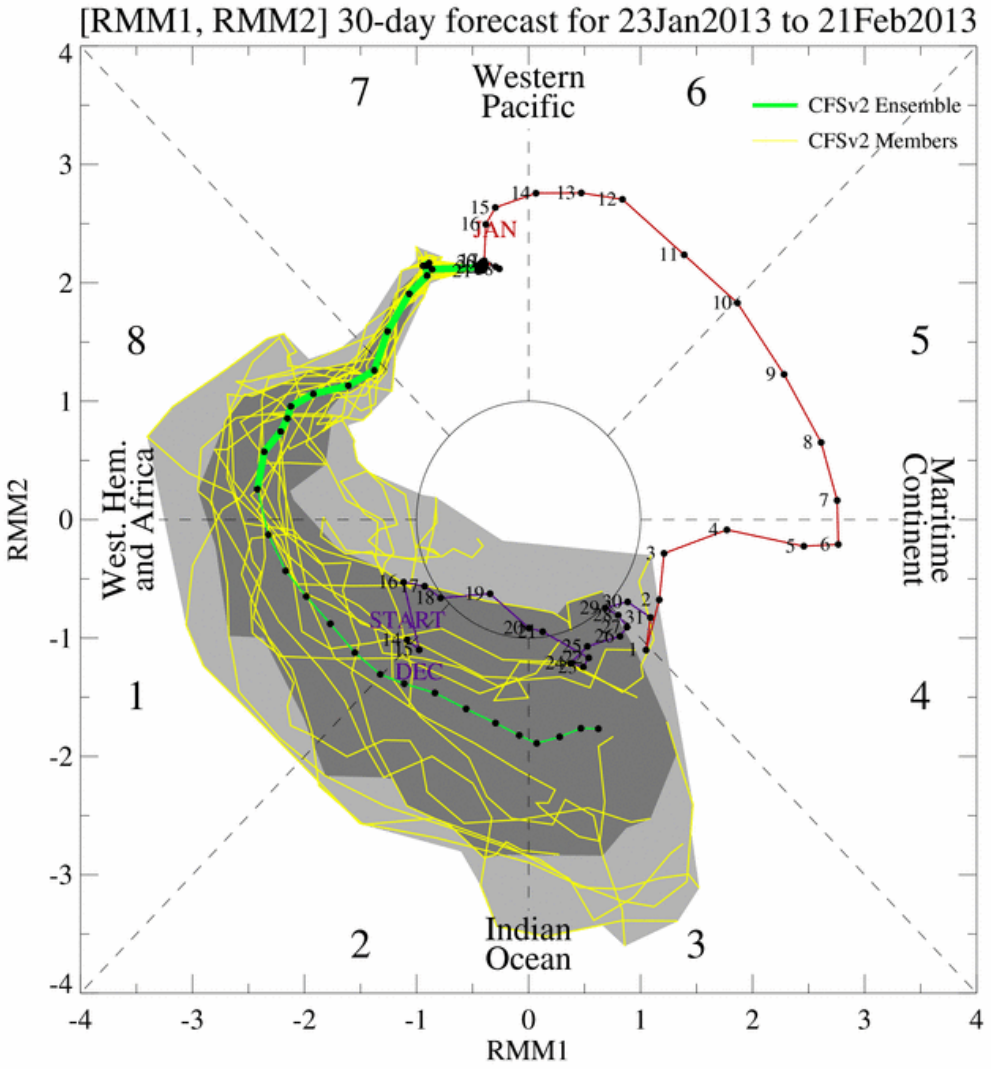
Accounts for redundancy

PRODUCTS

MJO and Teleconnection Indices

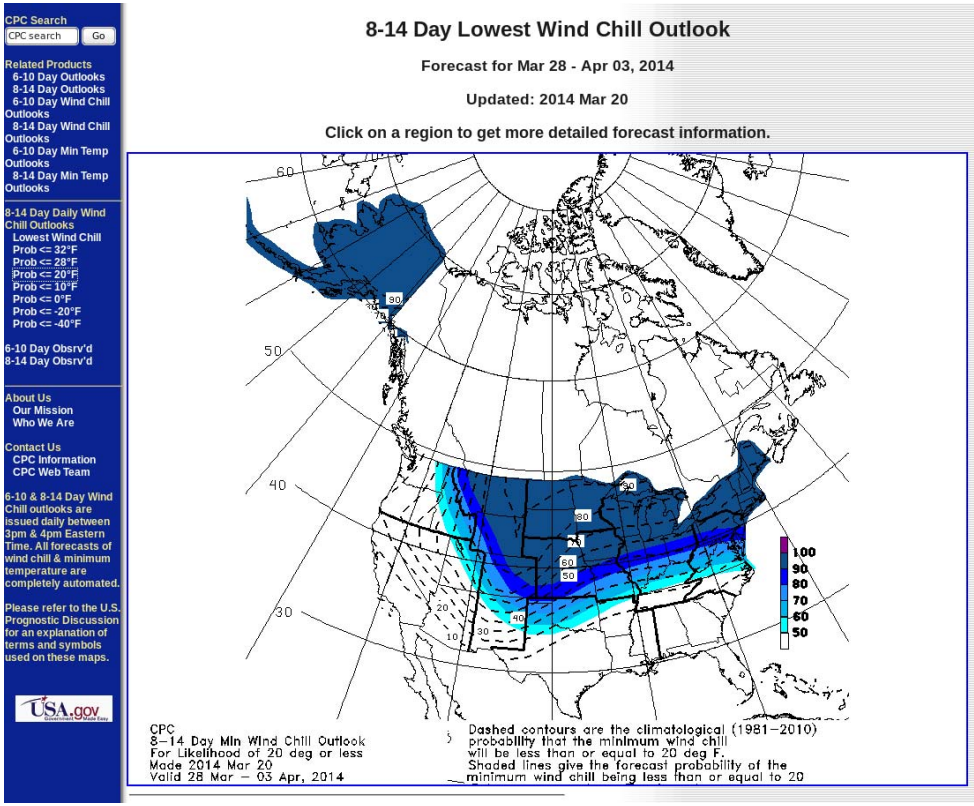
GEFS, Direct Model Counts

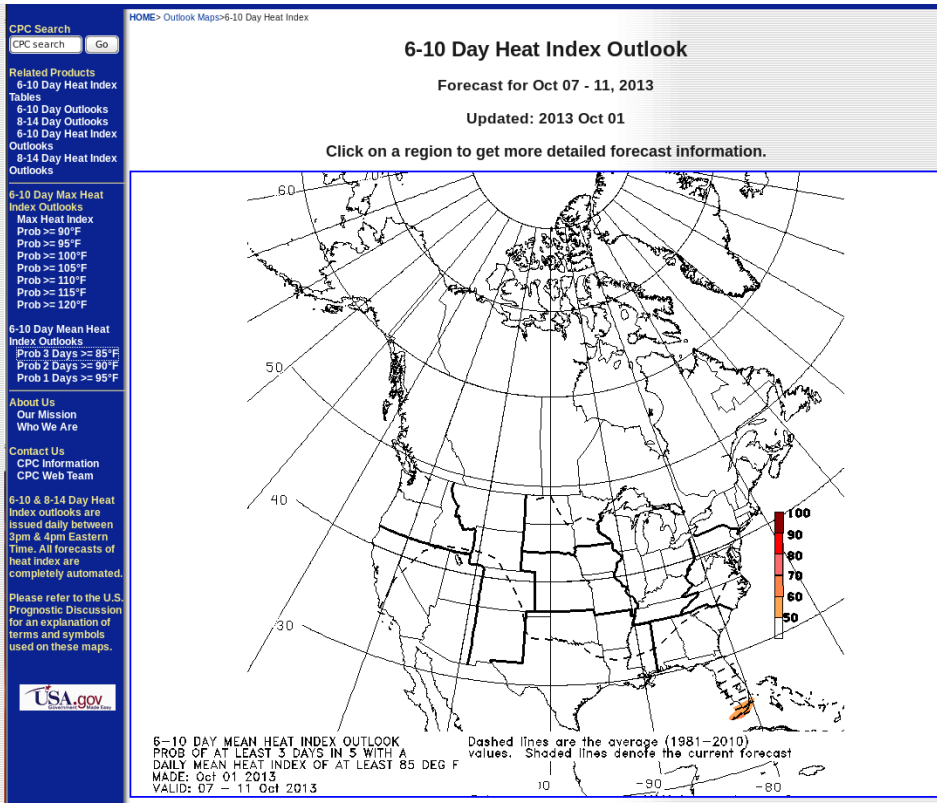




Wind Chill and Heat Index

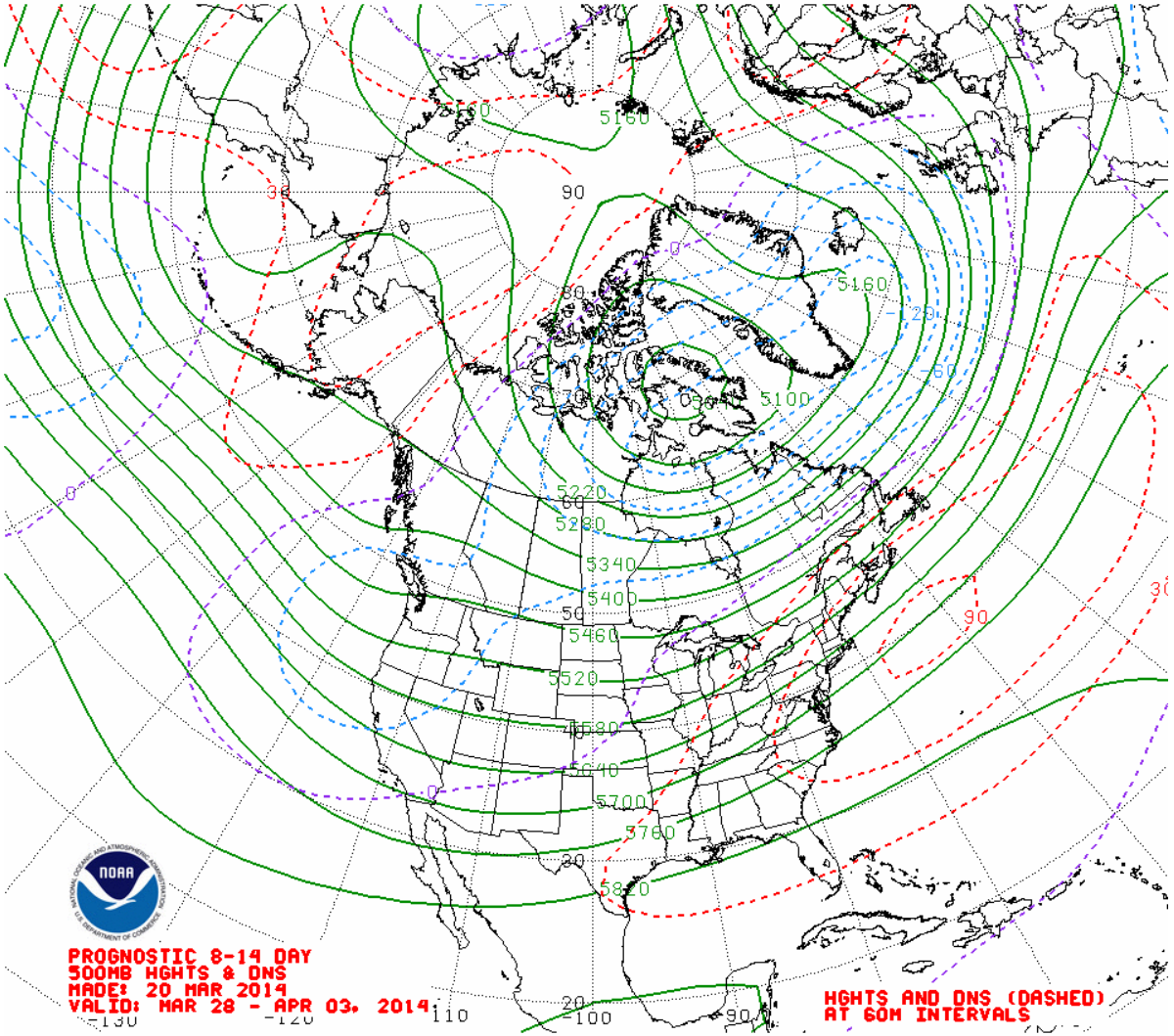
GEFS , Bias corrected model counts





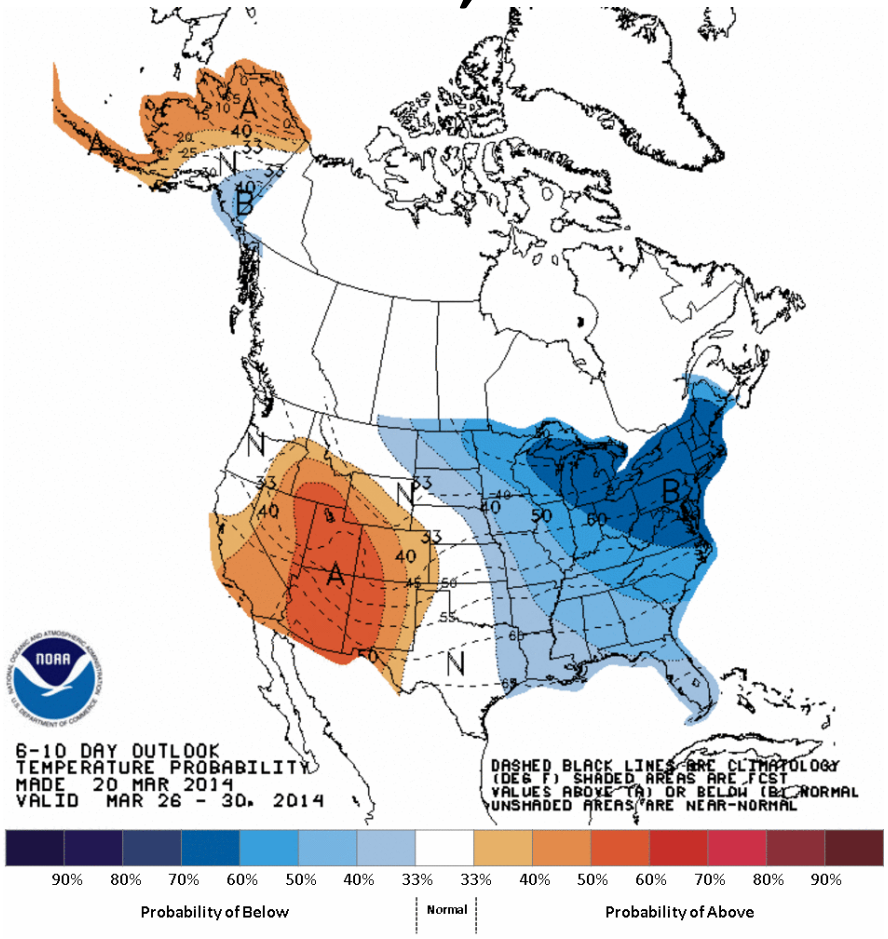
500-hpa Heights

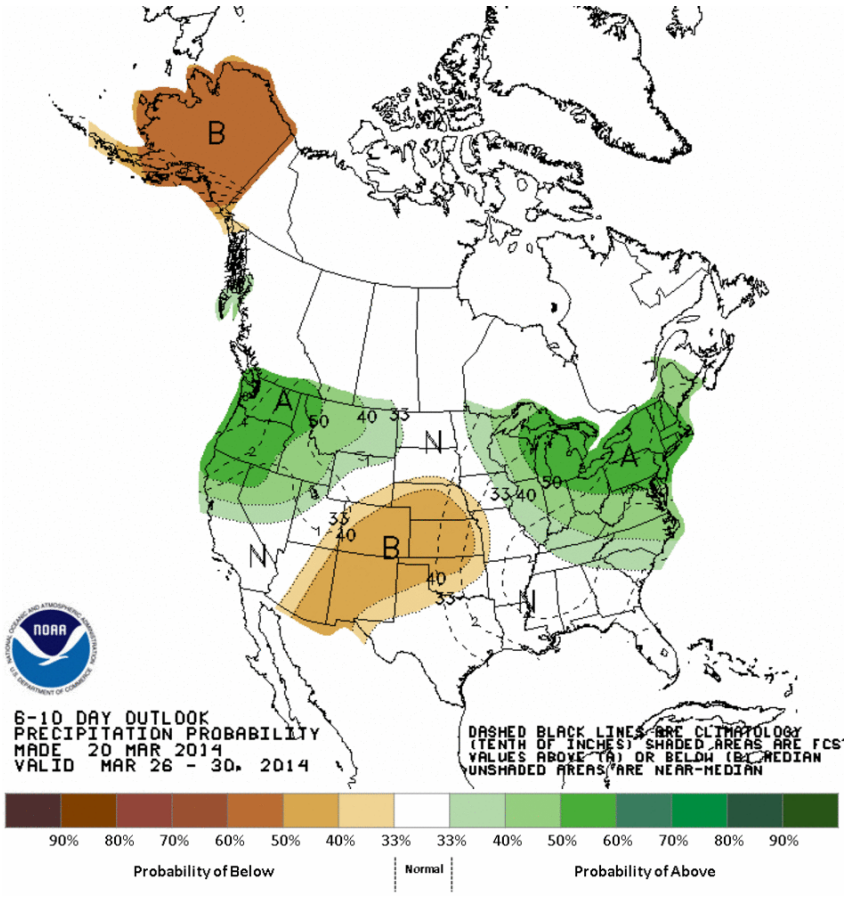
Consolidation, Direct model forecasts, Manual blend



Official Forecast

Consolidation, Manual Forecaster adjustments

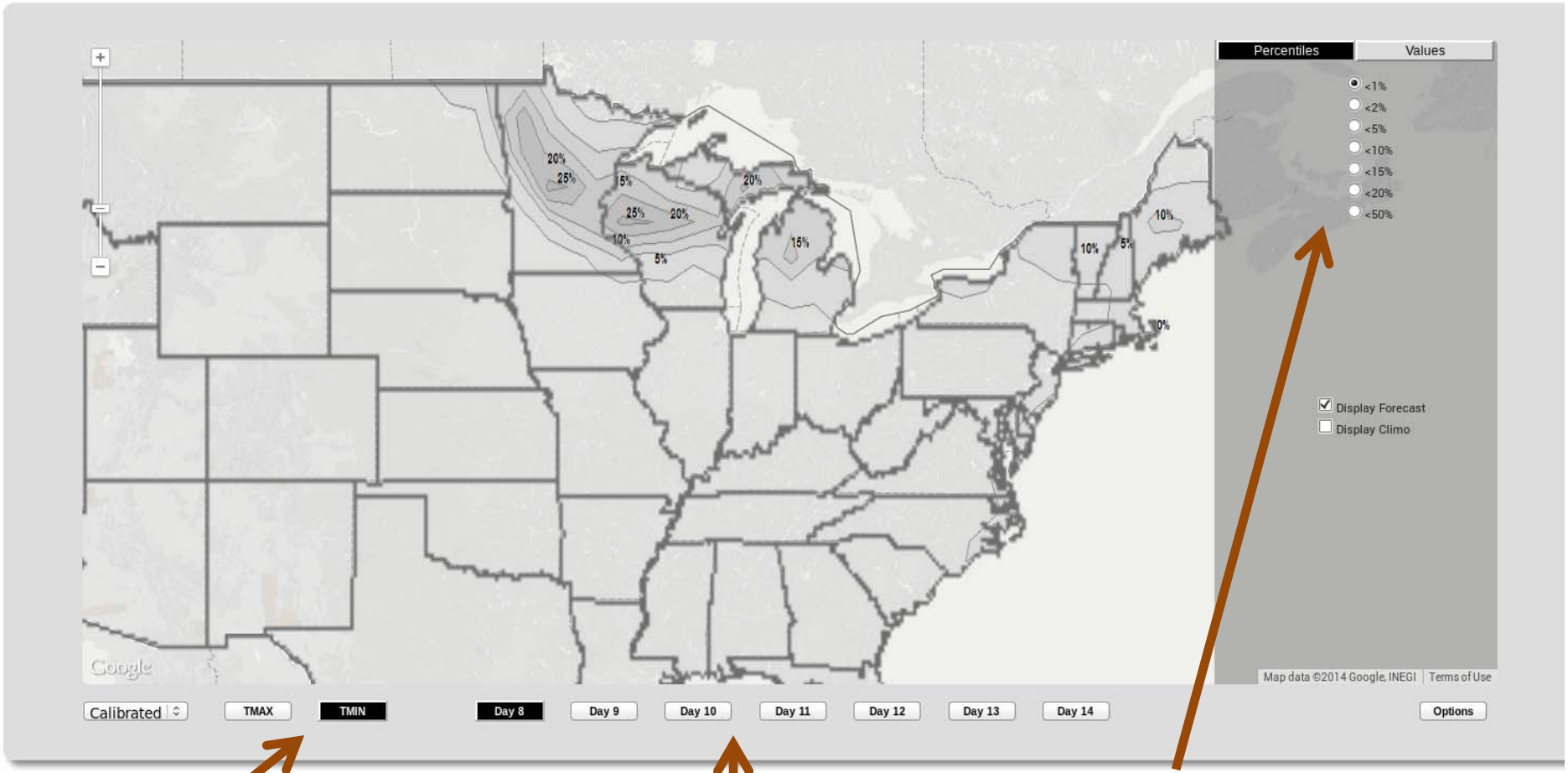




NEW PRODUCTS

Probabilistic Extremes Product

GEFS Ensemble Regression Kernel PDF



Maximum or Minimum Daily Temperature

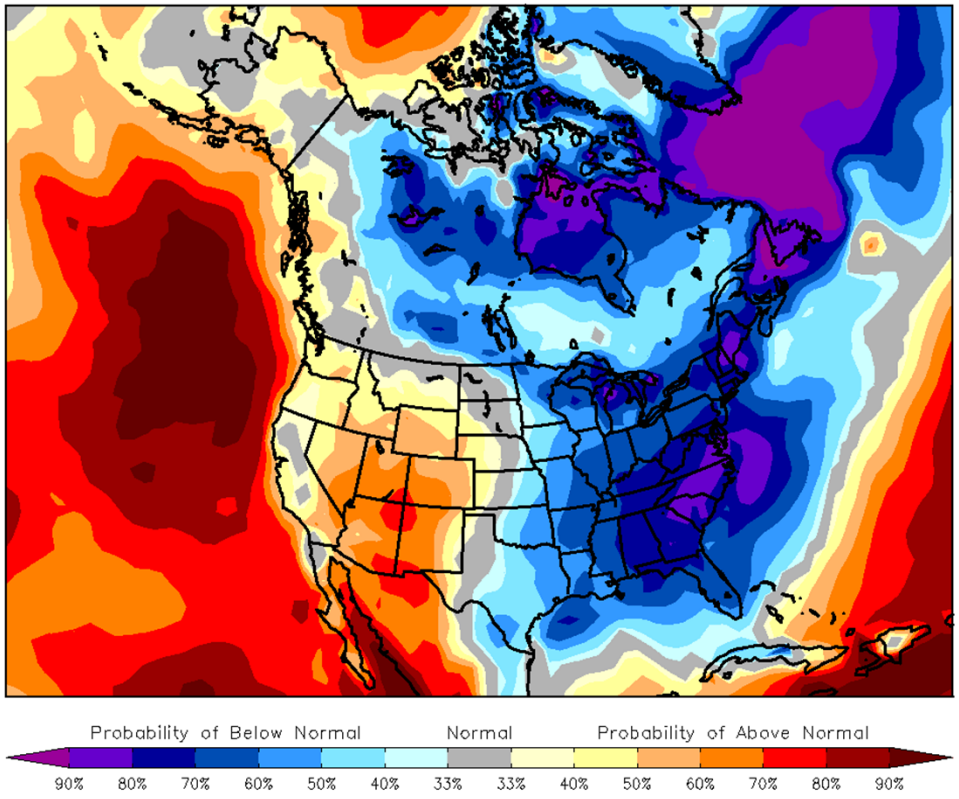
Daily Resolution

Selectable percentiles Relative to Climatology

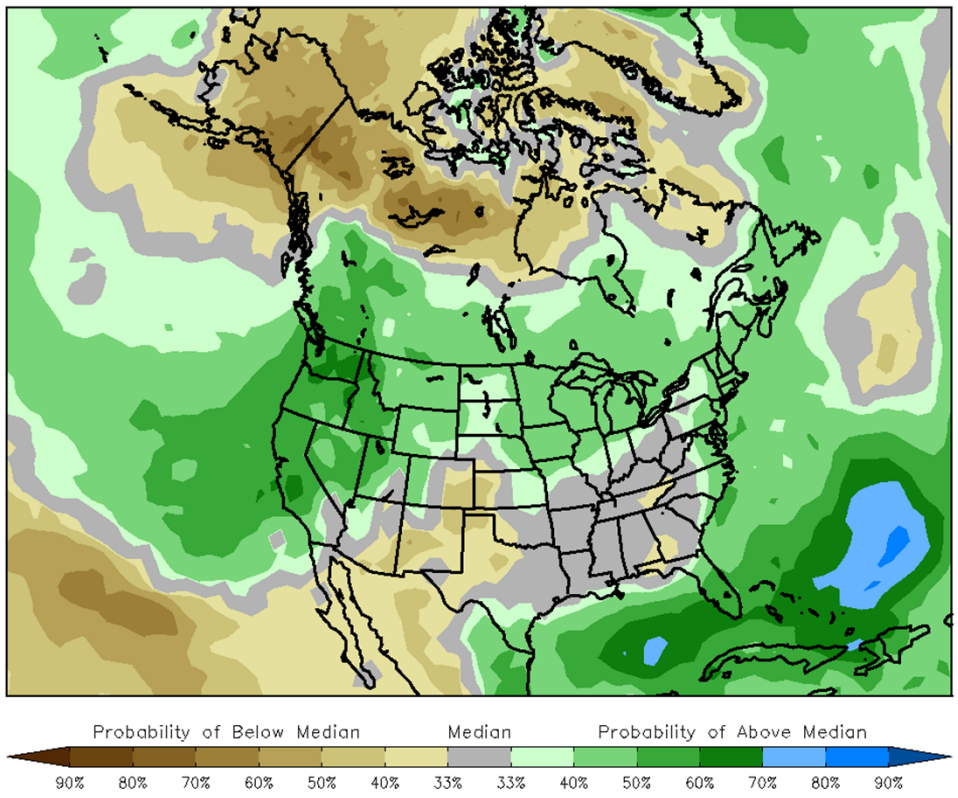
GEFS Reforecast

GEFS, Ensemble Regression, Kernel PDF

2014–03–20 GEFS Reforecast–Calibrated Temperature Forecast for Days 6–10

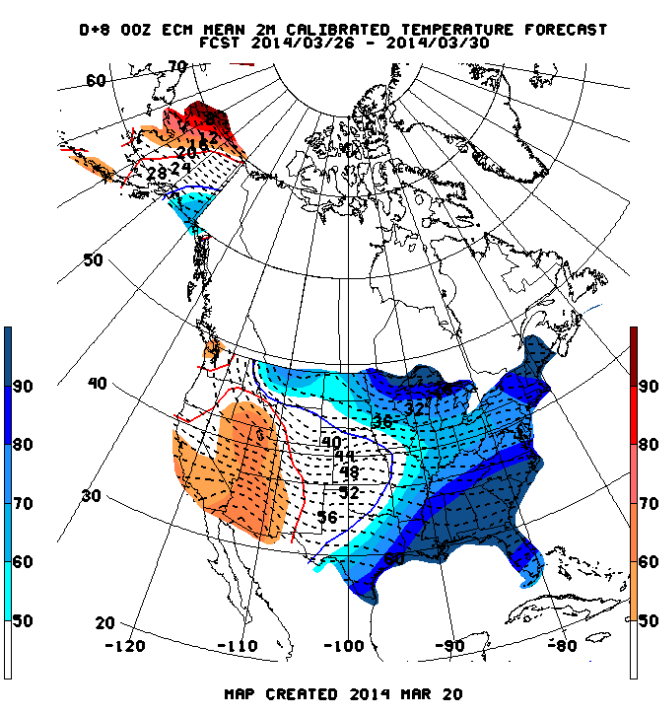


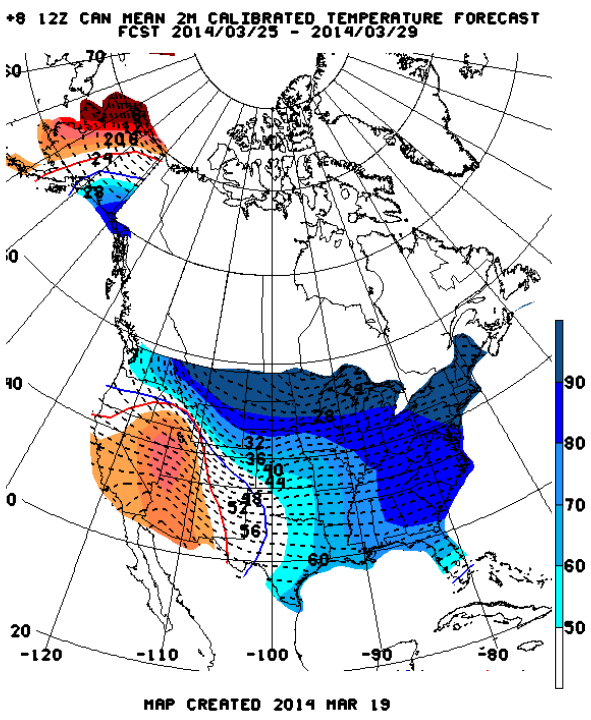
2014–03–21 GEFS Reforecast–Calibrated Precipitation Forecast for Days 6–10

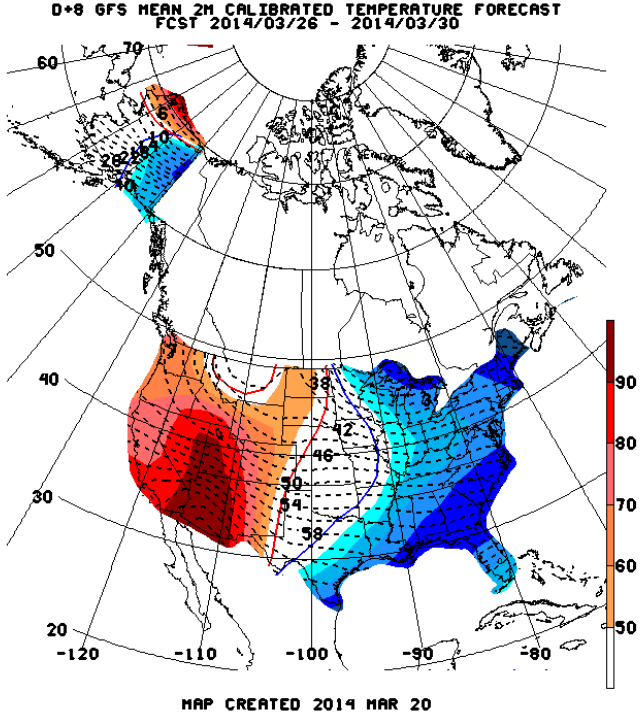


Bias Corrected Models

ECM, Canadian, GFS, Bias Corrected Counts
45-day running means of bias

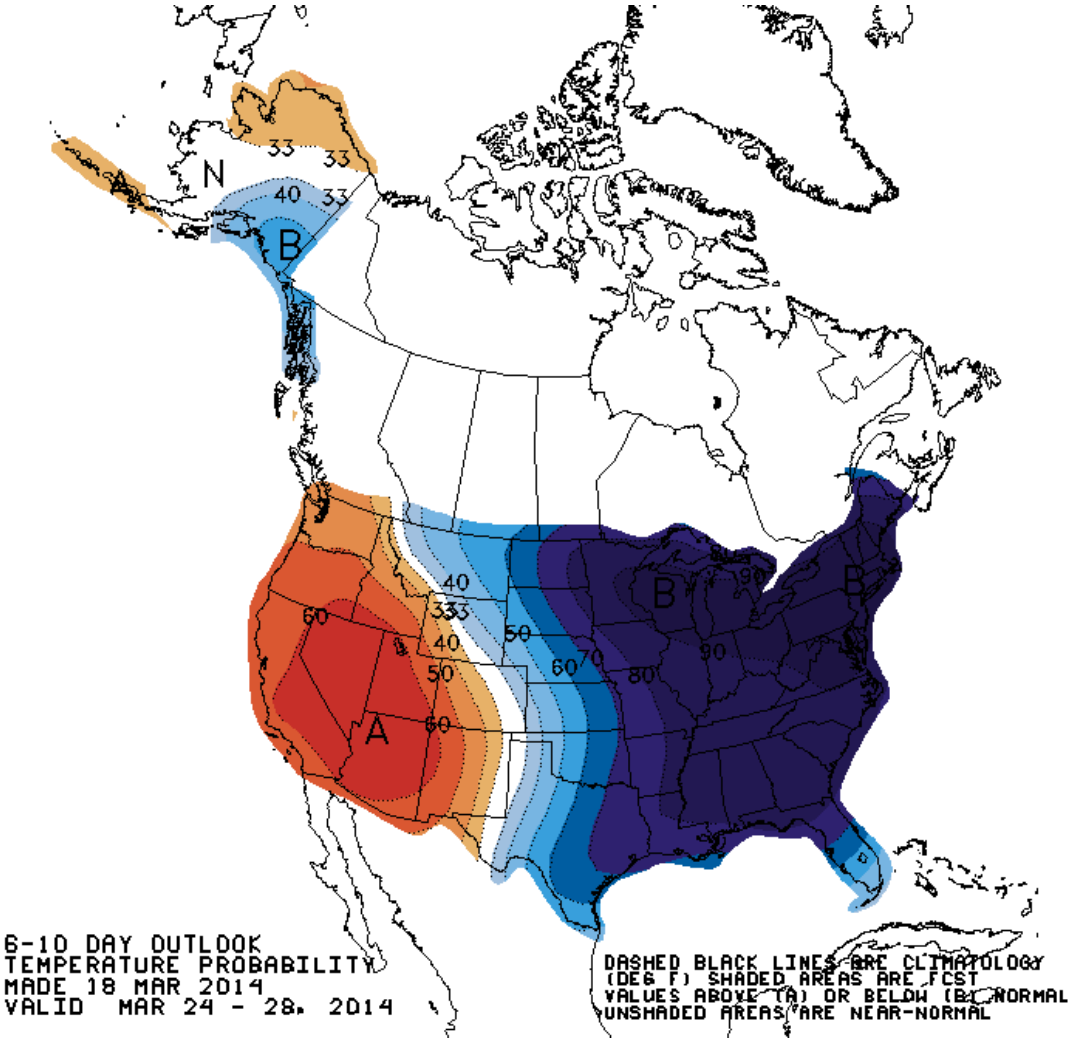




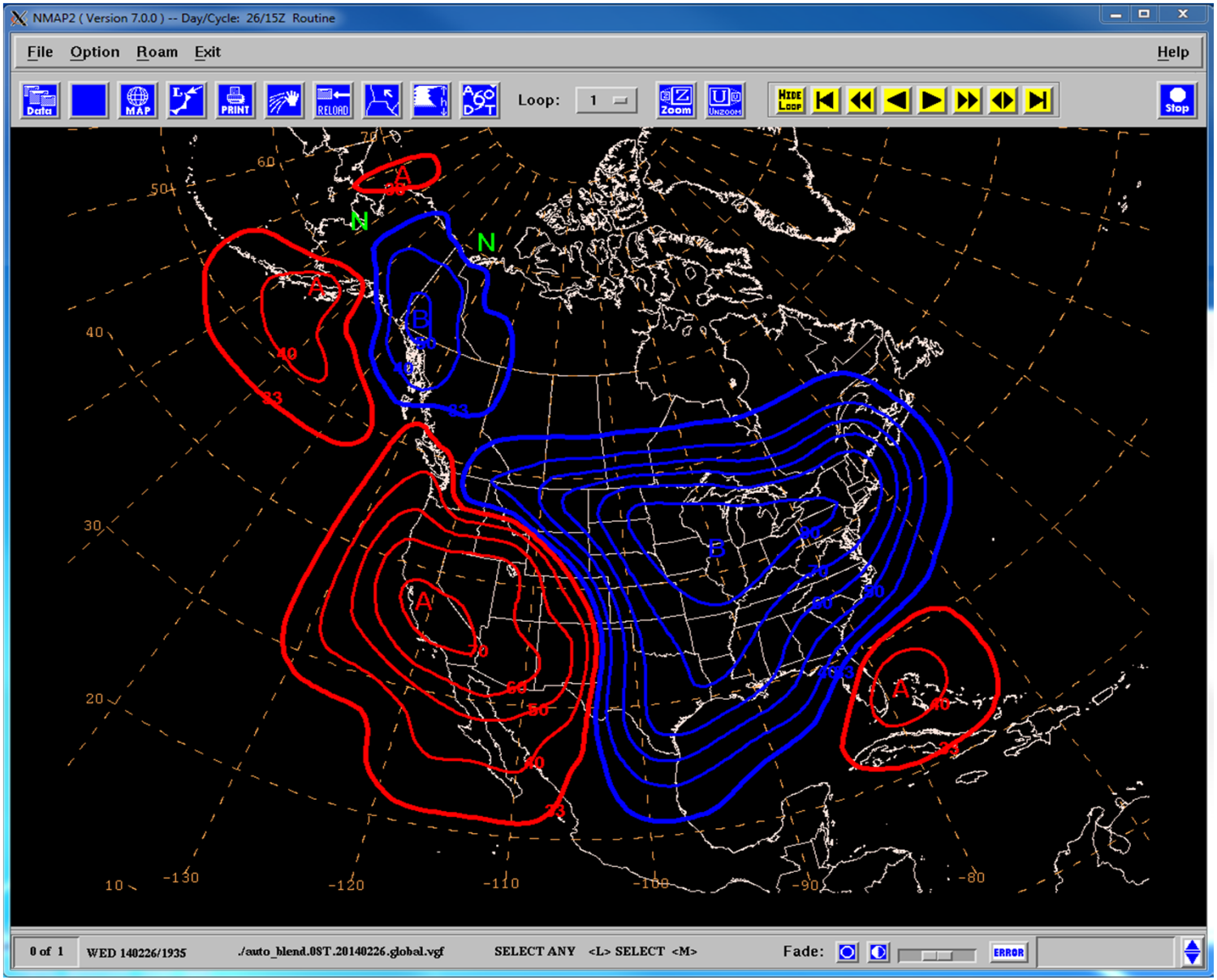


Auto-blend

Consolidation, Fixed weights, Subjective blend



Experimental Auto Output: Closed-Contoured VGF



Skill Comparison (Heidke Skill Score)

Temperature (D+8)

	Oct '13	Nov '13	Dec '13	Jan'14	Last 30 Days
Manual	32.7	10.4	48.5	44.0	**57.8**
Auto (Exp)	**39.8**	**19.6**	**49.1**	**51.3**	57.1
Best Tool	39.5 (Bias Corr ECMWF)	21.0 (Bias Corr ECMWF)	46.1 (Bias Corr ECMWF)	48.1 (GEFS Reforecast)	56.5 (GEFS Reforecast)

Temperature (D+11)

	Oct '13	Nov '13	Dec '13	Jan'14	Last 30 Days
Manual	19.3	9.2	37.6	36.3	45.1
Auto (Exp)	**27.3**	**10.9**	**41.0**	**37.9**	48.3
Best Tool	22.8 (Bias Corr ECMWF)	13.7 (Raw GFS Sup)	35.4 (Bias Corr ECMWF)	37.0 (Bias Corr ECMWF)	**51.3** (GEFS Reforecast)

Slide Courtesy of Scott Handel

Skill Comparison (Heidke Skill Score)

Precipitation (D+8)

	Oct '13	Nov '13	Dec '13	Jan'14	Last 30 Days
Manual	15.1	**17.1**	**21.6**	25.5	33.3
Auto (Exp)	**21.6**	15.3	21.3	**32.6**	**36.3**
Best Tool	20.4 (GEFS Reforecast)	13.4 (NAEFS)	21.7 (NAEFS)	31.6 (NAEFS)	35.9 (NAEFS)

Precipitation (D+11)

	Oct '13	Nov '13	Dec '13	Jan'14	Last 30 Days
Manual	4.5	4.0	16.0	23.2	29.9
Auto (Exp)	4.5	4.3	18.9	**34.8**	**37.4**
Best Tool	**8.4** (GEFS Reforecast)	**7.8** (Analogs (00z GFS)	**20.5** (NAEFS)	29.9 (GEFS Reforecast)	33.0 (NAEFS)

Slide Courtesy of Scott Handel

Influence on Forecast Operations

- ***Well calibrated*** **ensemble based guidance is required for credibility.**

  Badly calibrated reduces forecaster confidence.

- **Forecasters have (mostly) accepted new guidance. Scores have likely improved.**
- **Consolidation is a major focus.**

  (No clear path forward when models disagree)