Model Post Processing for Sub-seasonal to Seasonal Timescales:
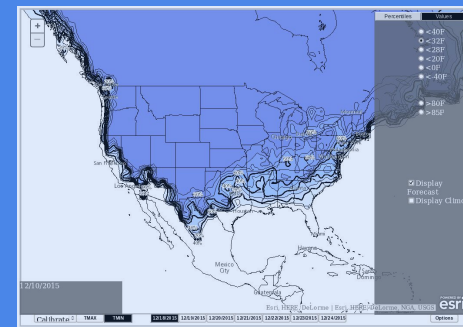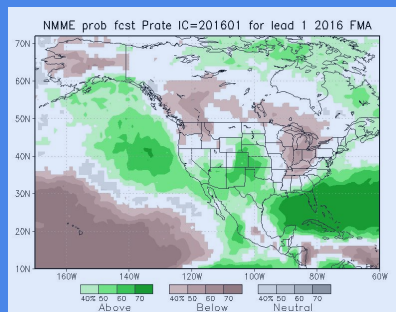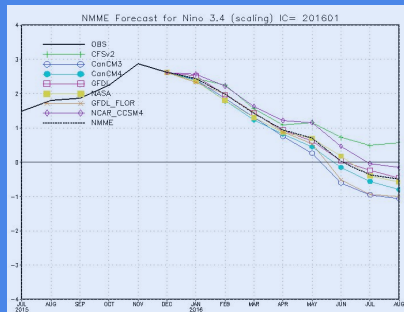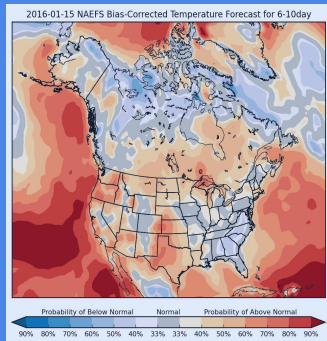# *CPC products and underlying data requirements*

Melissa Ou, Dan Collins, Mike Charles

Overview

- Post-processing for S2S climate forecasts
- CPC products created from model post-processing
- How we post-process
- CPC data requirements for post-processing
- Summary
- Topics for discussion

Why does CPC post-process?

- Forecasts at climate time scales need to be expressed in probabilities
- Model probabilities often increasingly over-confident at longer timescales
- Uncalibrated model output beyond week-1 show poor reliability
- Uncalibrated week-2 forecasts show negative RPSS
- Biases and uncertainty (errors) grow with lead time
- Support increasing user demand for forecasts with longer lead times (weeks 3-4)
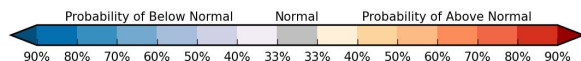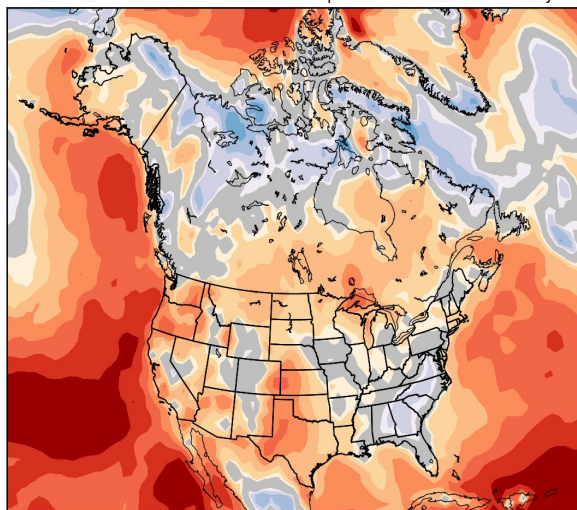
What we Produce Using MPP

- 6-10/8-14 day tercile T&P
  - short-term calibration (from recent verification), long-term reforecast calibration
- 8-14 day probabilistic extremes (Tmin/Tmax, precipitation, etc.)
  - various percentiles and quantitative thresholds (e.g. 0 C; 1 inch liquid equiv/day)
- 3-4 week T&P forecasts
- 1 and 3 month T&P outlooks
  - CFS and NMME hindcasts processed for skill maps - guidance for adjusting probs
  - CFS and NMME hindcasts for bias correction
- CPC SST consolidation and ENSO probabilities
- Monthly El Nino 3.4 NMME SST Plume forecasts
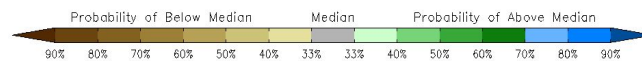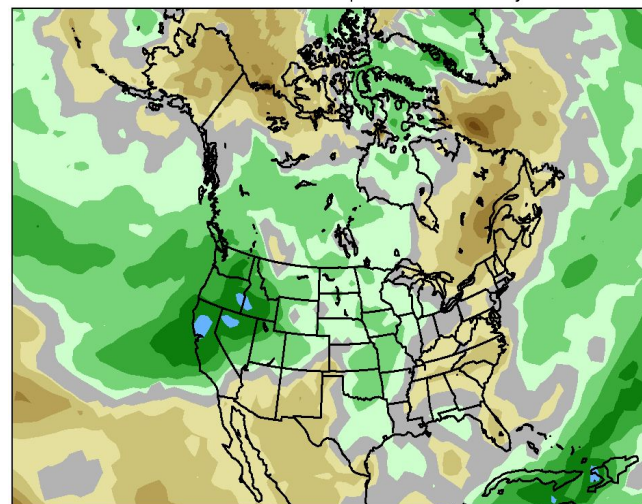
What we Produce Using MPP
6-10/8-14 day T&P Tools

2016-01-15 NAEFS Bias-Corrected Temperature Forecast for 6-10day

Probability of Below Normal · Normal · Probability of Above Normal

90% 80% 70% 60% 50% 40% 33% 33% 40% 50% 60% 70% 80% 90%

2016-01-15 GEFS Rfcst-Calib Precipitation Forecast for Days 6-10

Probability of Below Median · Median · Probability of Above Median

90% 80% 70% 60% 50% 40% 33% 33% 40% 50% 60% 70% 80% 90%

Sample NAEFS tool:
Using short-term correction

Sample reforecast tool (GEFS, ECWMF):
Using multi-year hindcast statistics

What we Produce Using MPP
8-14 day probabilistic T&P extremes
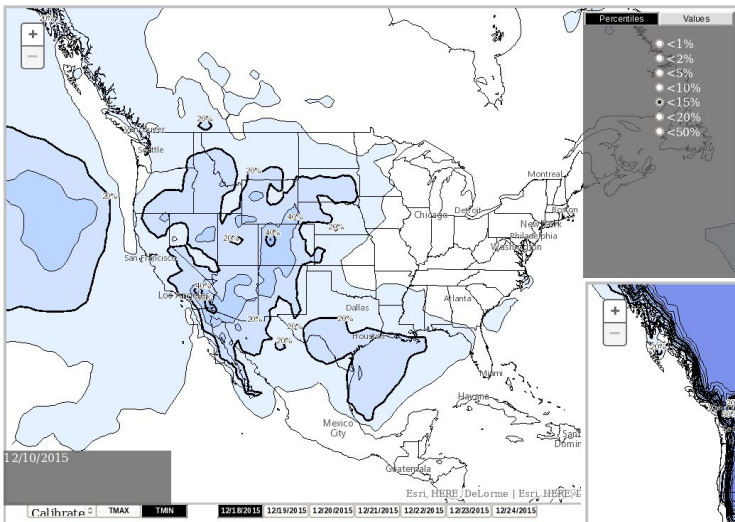
Probabilities of tmin < 32 Deg F

Probabilities of tmin < 15th percentile
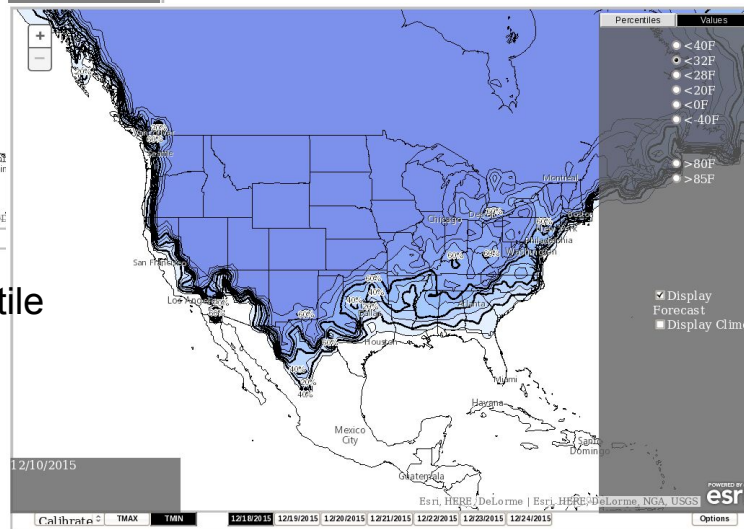
- GEFS Reforecast Tool
- Tmin/Tmax exceeding/lower than threshold percentiles and actual values
- Precipitation, other variables, tools to follow
- Tmax extremes warm biased
- Will support global tropical hazards forecast

What we Produce Using MPP
Weeks 3-4 T&P Tools: Reforecast bias removal

Anomaly and probability of above and below median
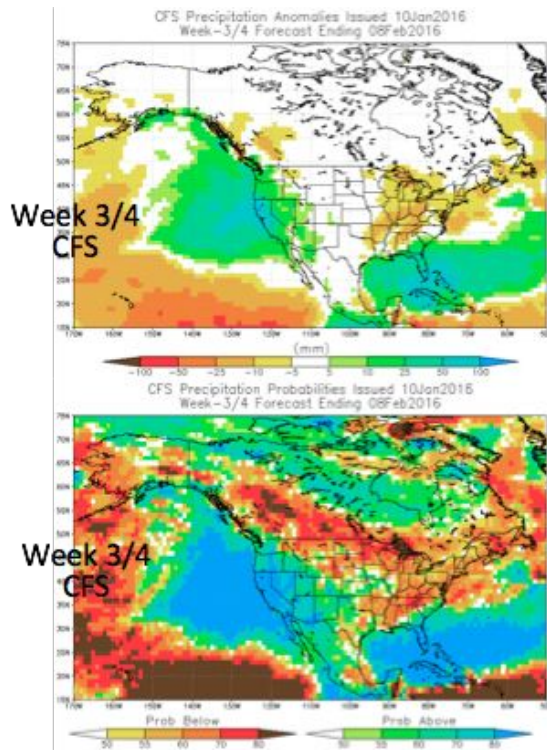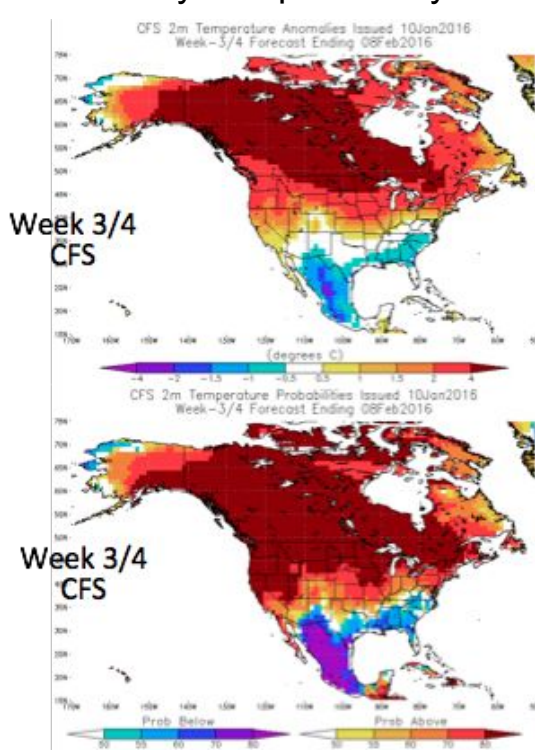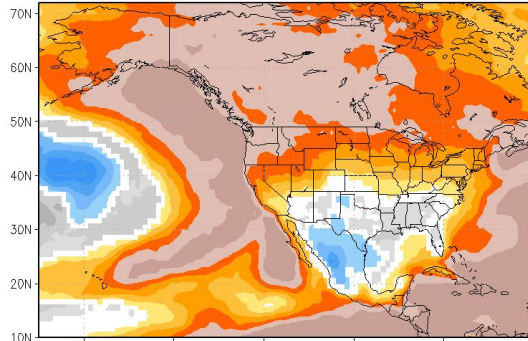

- **CFS, JMA, and ECMWF reforecast bias-corrected**

Future:
- Environment Canada EPS
- Calibrated gaussian ECMWF
- GEFS reforecast calibration
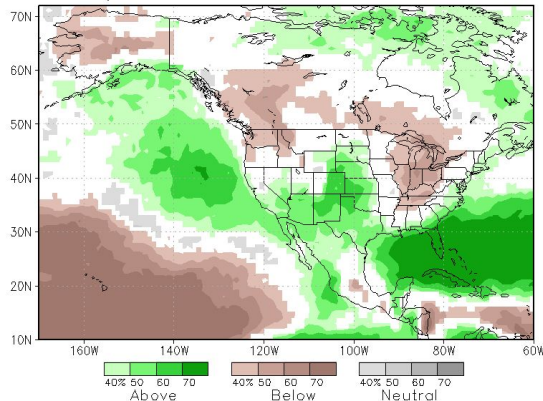- Subseasonal NMME models, once generated in real-time

What we Produce Using MPP
Monthly and Seasonal T&P, Monthly SST:
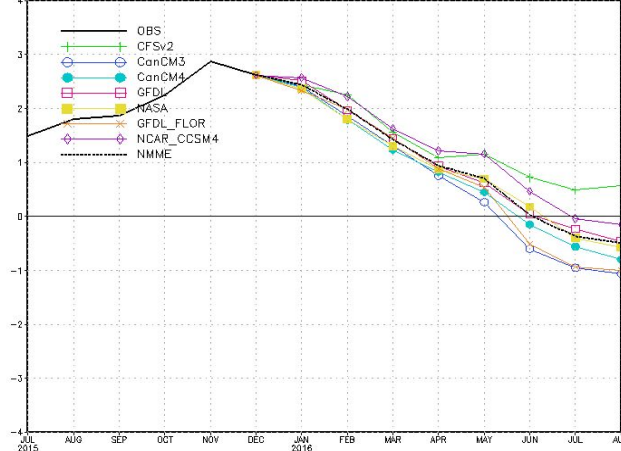## Hindcast mean & variance bias removal

NMME prob fcst TMP2m IC=201601 for lead 1 2016 FMA

NMME prob fcst Prate IC=201601 for lead 1 2016 FMA

NMME Forecast for Nino 3.4 (scaling) IC= 201601

- OBS
- CFSv2
- CanCM3
- CanCM4
- GFDL
- NASA
- GFDL_FLOR
- NCAR_CCSM4
- NMME

- Bias adjusted and variance correction

Sample NMME Nino 3.4 SST tool:
Using variance correction

How we Post-Process

- Calibration and bias correction using long-term reforecast dataset
  - Reforecast tools using ensemble regression technique
  - Remove long-term model bias using reforecast dataset
  - Significantly improves reliability and RPSS of probabilistic forecasts
- Bias correction
  - Recent (45-day) bias correction tools
- Uncertainty / spread improvement
  - CPC's version of NAEFS - Adds kernels around each ensemble member, increasing spread (now done for precip in addition to temp)

How we Post-Process (cont'd)

- Multi-model combination
  - ERF Consolidation tool - Spatial weights based on past model skill
  - Monthly/Seasonal - Combined MME used to make count-based probabilities
- Variance correction
  - NMME and individual models (T&P, Nino 3.4 SST forecast) - Scale the variance using model hindcast SD/Obs SD

In development:
- Calibrated probabilities to optimize Brier Skill Score

Data Requirements for Post-Processing

- Model data must be produced in a timely manner for operational schedule
- Good communication regarding model changes impacting downstream post-processing
- Advanced access (~ 2-3 months) to retrospective forecasts for new proposed model versions and reforecasts
- Clearly organized reforecast data with good file naming schema
- Sufficient length of hindcasts

Reforecast Requirements for Post-Processing

- Need large enough sample of reforecasts:
  - Especially for longer-term forecasts (climate scale)
  - Need to capture climate events, requiring more years of data
  - Need to capture extreme events which occur infrequently in record
- Updated reforecasts with new model version
  - Need identical model, initialization, and reanalysis for calibration statistics

Recent CPC results studying skill sensitivity to smaller reforecast: (week-2 tercile T&P forecasts):

- Need minimum of 20 years of reforecasts, preferably 30 years
- 5 - 6 members (control + 4-5 members), produced once or twice weekly
- Dropping to 10 years and 3 members led to large skill loss

Summary

- MPP especially important for long time scale forecasts (subseasonal to seasonal)
- CPC forecasters rely on post-processed guidance for entire suite of forecasts
- MPP needed for public model products
- CPC post-processes via long and short term calibration, bias-correction, uncertainty improvement, multi-model combination, and variance correction
- Long-term reforecasts updated with model versions essential
- Need for timely data access for real-time operational processing maintaining timeliness

Collaborative Work on MPP

- CPC operations does R&D
- We have R2O standards that make it very easy to go to ops
- Basic good software practice needed
- CPC is currently developing a few centralized Python packages to help with MPP
  - data-utils – data-related utilities like reading grib1/2 files, interpolation, plotting, etc.
  - mpp – model post-processing techniques (bias-correction, calibration, etc.)
- They will be on GitHub soon
- Email mike.charles@noaa.gov if you're from NOAA and interested in using GitHub

Topics for Discussion

- **Suggestions to CPC for new methods of post processing?**
  - Applicability of various new statistical methods to S2S time scales that we may not be aware of
  - CPC experimenting with new CDF correction methods for precip but has not improved skill yet
  - Other methods – e.g. Quantile mapping
- **Research to operations (R2O):**
  - Techniques and products developed in the community need to be able to be efficiently transitioned/adjusted for climate forecast operations
  - CTB transition plan and early involvement between operations and researchers
  - Codes need to be written to be flexible
- **Operations to research (O2R):**
  - What is the best way for operations to communicate needs to the research community for improving and expanding MPP techniques?
  - Need for policies allowing publicly shared code repositories

Thank You

Email: melissa.ou@noaa.gov

Calculating PDF at obs
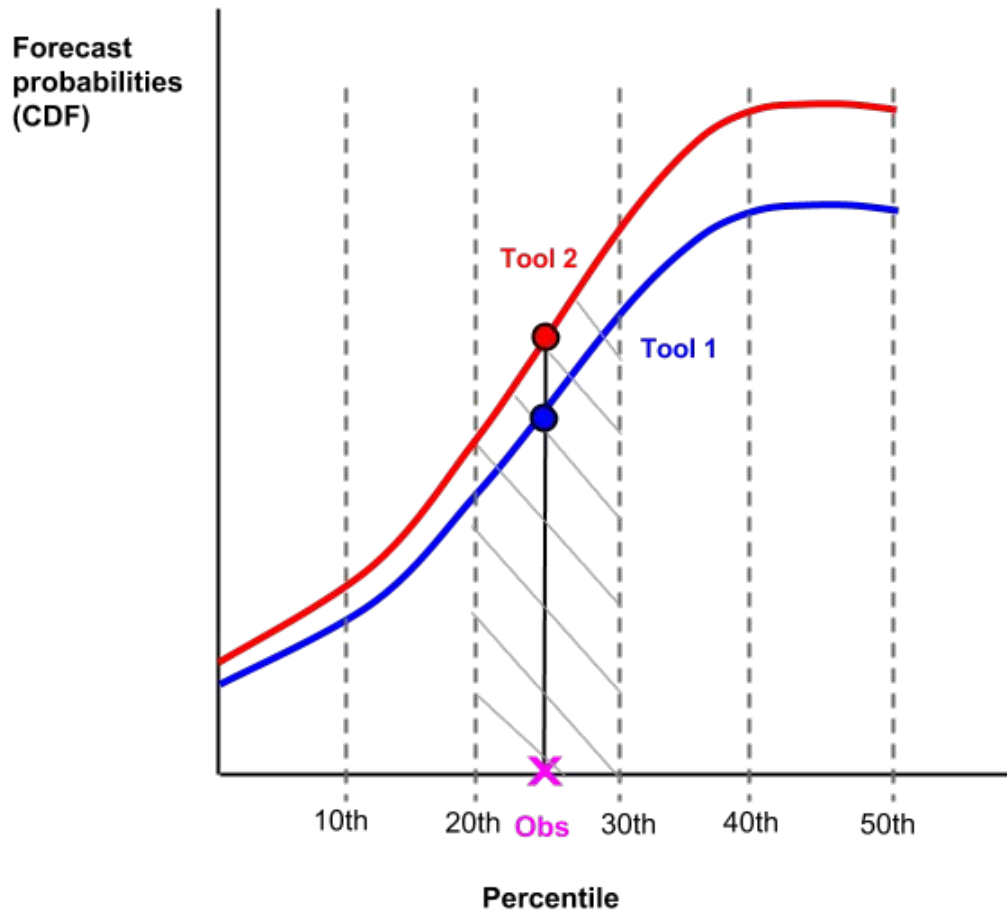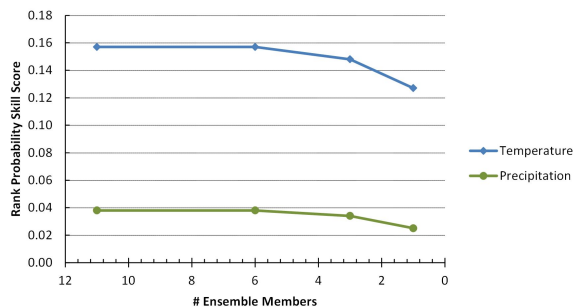
Skill sensitivity results - Week-2 T&P Forecasts