



Multi-Model Ensembles in NWS Climate Prediction Center Subseasonal to Seasonal Forecasts: Metrics for Impact Events

Dan Collins, Climate Prediction Center

Sarah Strazzo, CSIRO partners Q.J. Wang and Andrew Schepen, Liwei Jia, Emily Becker, Emerson LaJoie, the SubX Team



Prediction of extremes in seasonal temperature from NMME

Acknowledgements: Sarah Strazzo, Q.J. Wang, Andrew Schepen, Liwei Jia, and Emily Becker

Subseasonal & Seasonal Forecasting of Extremes & MME

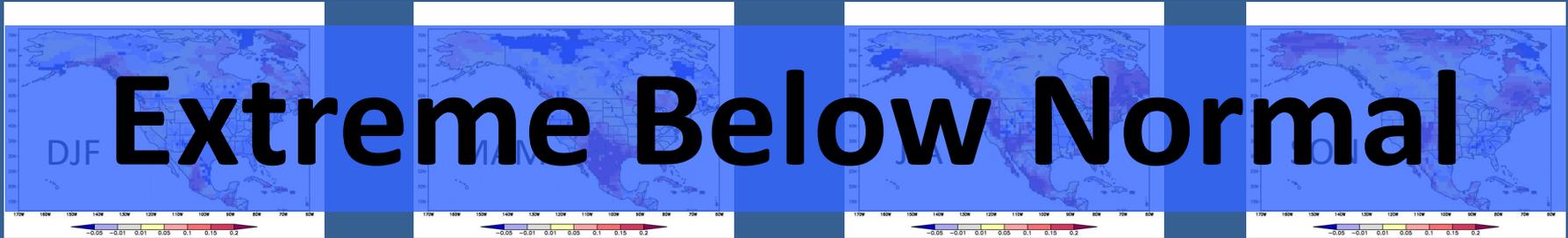
- Low predictability of extremes - as for all S2S forecasts - due to small signal/noise ratio
- Some individual models have fewer than 10 ensemble members -> Poor resolution of tails of distribution / extremes
- Probability of extremes should be consistent with 3-category tercile forecasts for Above and Below normal
- Multi-Model Ensemble reduces noise and cancels errors
- MME better resolve the probability distributions, including tails / extremes

Prediction of extremes in seasonal temperature from NMME

- **NMME: 1-month lead seasonal temperature forecast skill**
(e.g., November 1st initialization predictions of DJF Temperature)
 - 1982 to 2010 hindcasts
- Considering the skill of probability forecasts for negative and positive **extreme anomalies** (i.e. **10th and 90th percentile** forecasts)
 - ... and calibration of ensemble probabilities for above and below normal terciles simultaneously
- **Counts** of ensemble member “probabilities”
 - Model climatological mean removed and variance corrected
- **Calibrated Ensemble Regression (EReg)** probabilities (Unger et al 2009).
 - Calibrates probability based on hindcast correlation skill
 - Gaussian distribution for mean forecast error fit around ensemble members

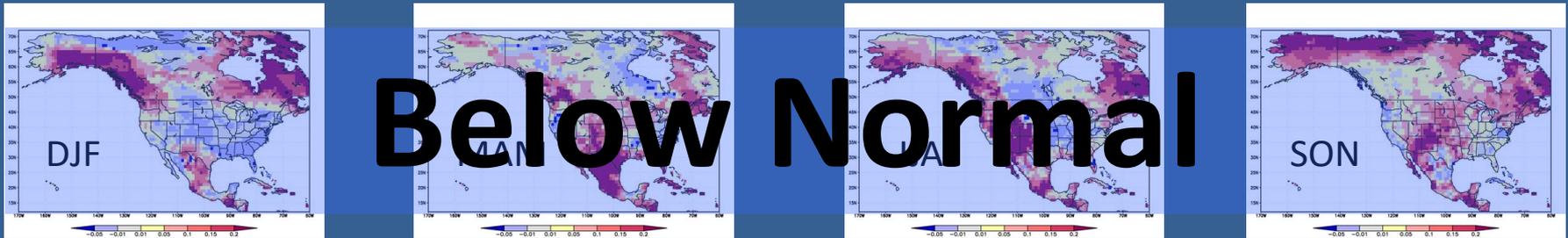
Brier Skill Scores: Extreme 10th percentile vs. Below Normal tercile (top) and Extreme 90th vs. Above Normal tercile (bottom) calibrated hindcast

Extreme 10th



Extreme Below Normal

Below Normal



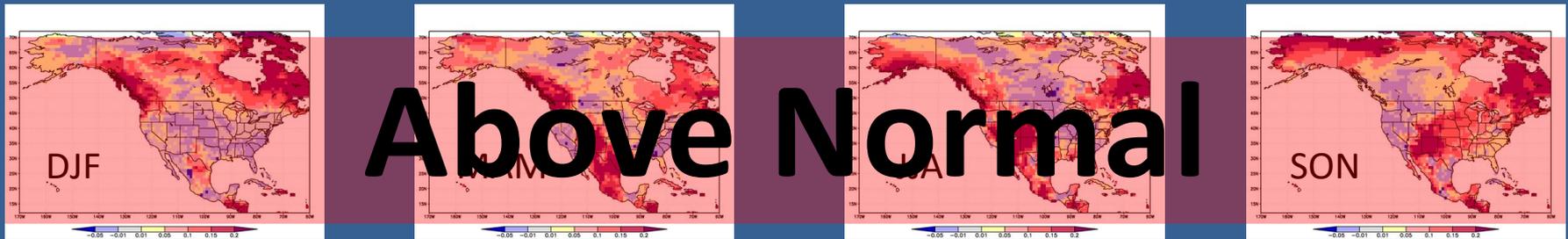
Below Normal

Extreme 90th



Extreme Above Normal

Above Normal

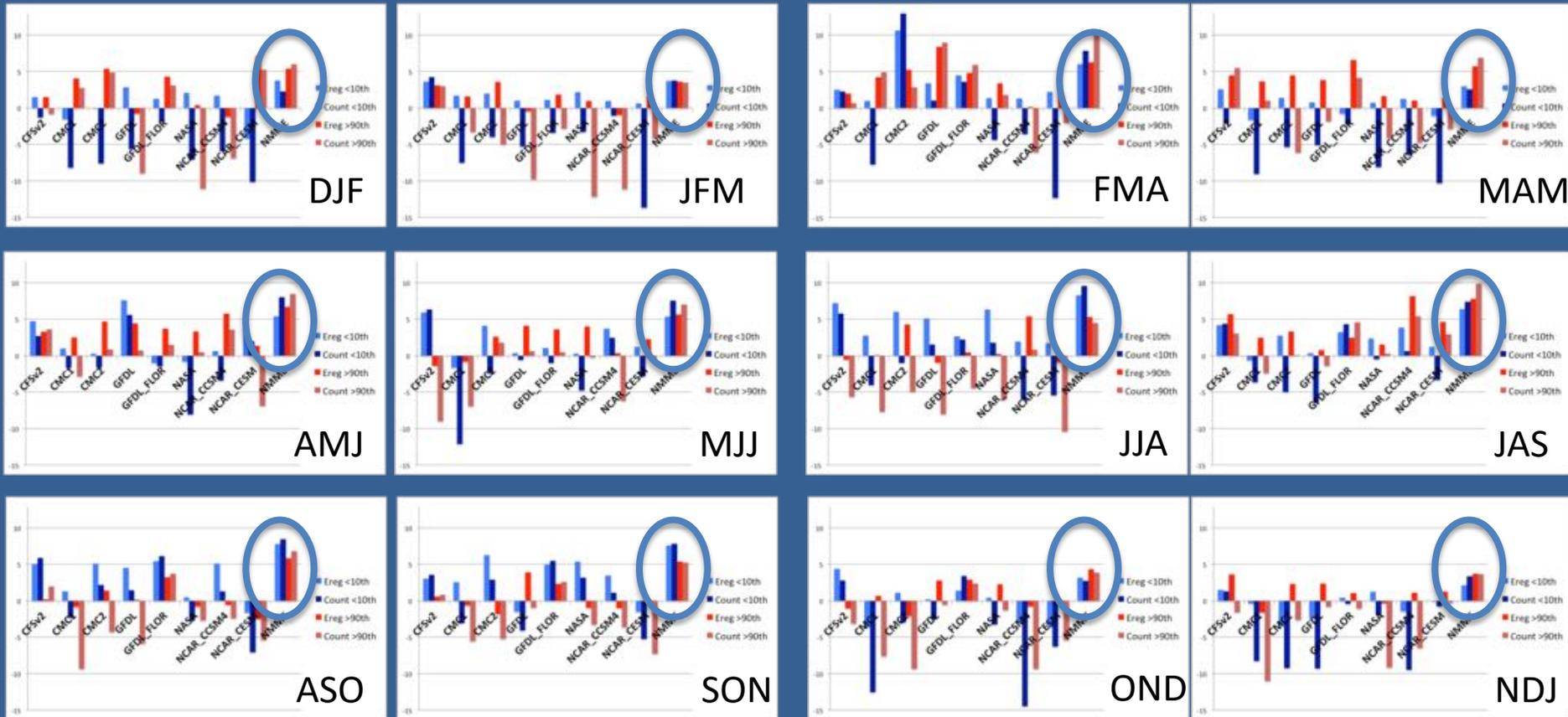


Above Normal

North America average Brier Skill Scores 10th and 90th percentiles

Raw count probabilities & calibrated probabilities

*Combined NMME (far right)



- Combined NMME has positive skill in all seasons.
- MME mean not always the greatest skill, but always near the top



Application of a hybrid statistical-dynamical prediction system: Calibration, Bridging and Merging (CBaM)

Acknowledgements:

Sarah Strazzo, Q.J. Wang, Andrew Schepen (CSIRO),
Liwei Jia, and Emily Becker

Calibration, Bridging, and Merging (CBaM)

Raw dynamical model
forecast of North American
2-m temperature

Statistical post-
processing



Statistically corrected
(calibrated) forecast of
North American 2-m
temperature

Calibration, **Bridging**, and Merging (CBaM)

Dynamical model forecast
of a relevant climate index
(e.g., Niño 3.4)

**Statistical post-
processing**



Statistically bridged
forecast of North American
2-m temperature

Calibration, Bridging, and **Merging** (CBaM)

Statistically bridged
forecast of North American
2-m temperature

x **W**



**Weighted merging of forecasts
based on performance in hindcast
period**

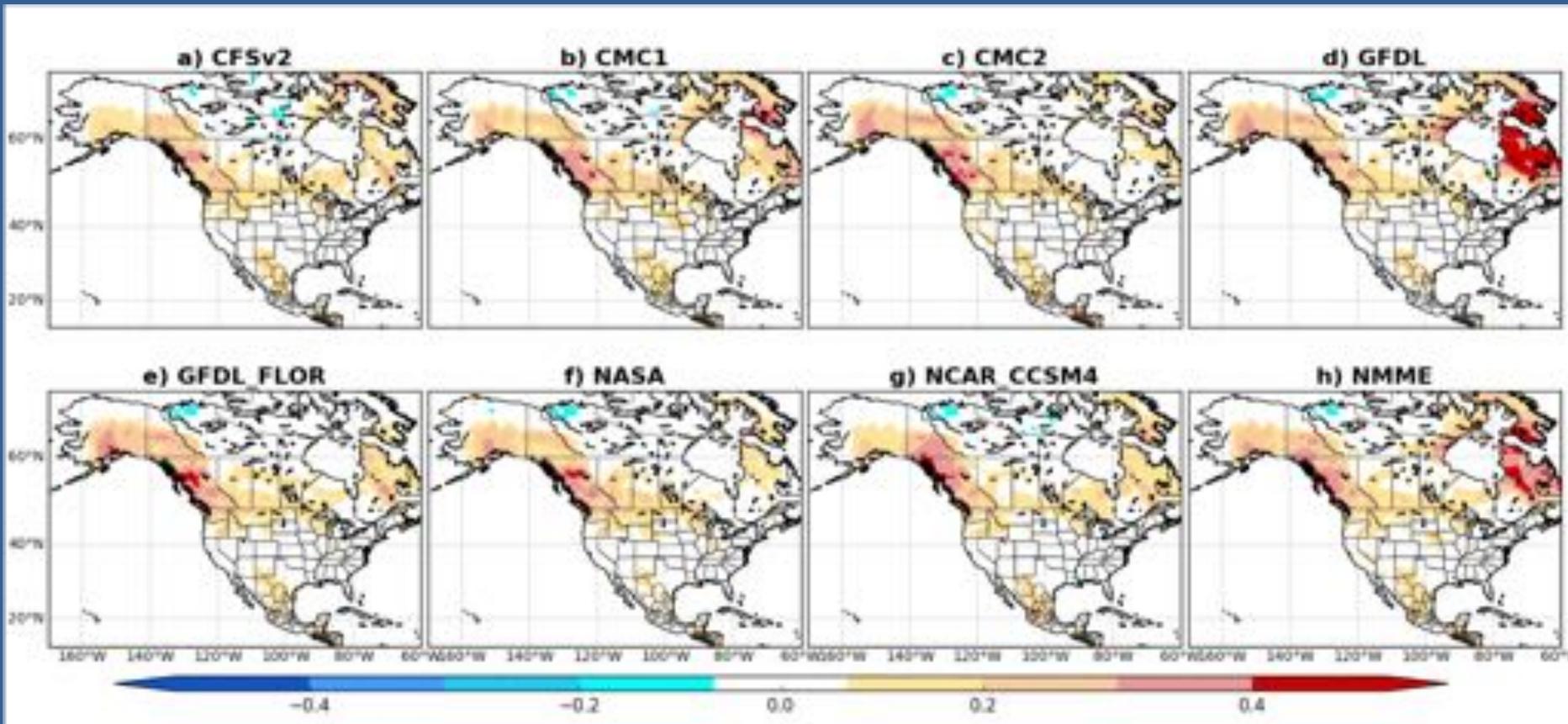
Statistically corrected
(calibrated) forecast of
North American 2-m
temperature

x **W**

Calibration, Bridging and Merging (CBaM)

Brier Skill Scores: DJF below normal temperature

*Bayesian Model Averaging (BMA) weighted NMME (lower right)



Brier Skill Scores: Calibration, Bridging and Merging (CBaM)

12 overlapping 3-month seasons for below normal temperature

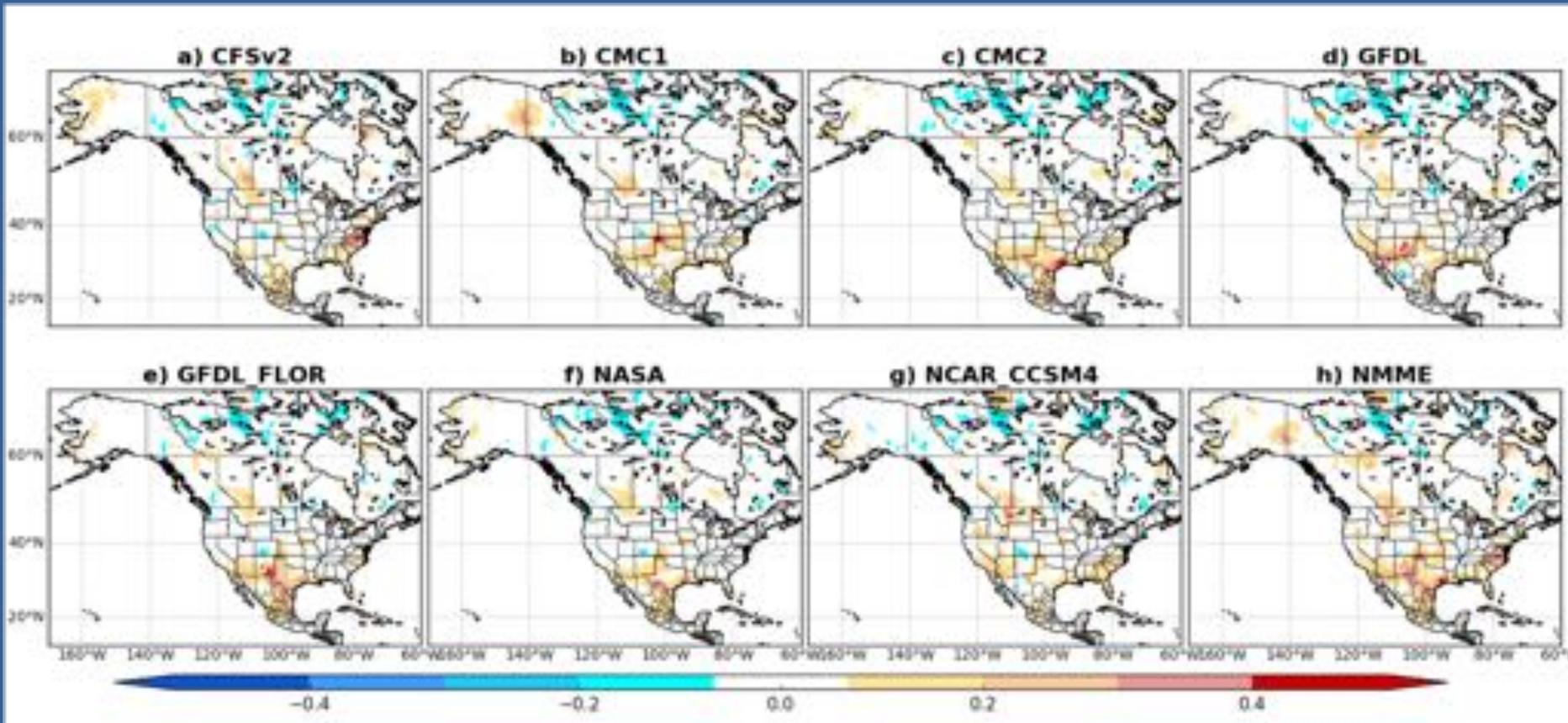
*Bayesian Model Average weighted NMME (far right)



Calibration, Bridging and Merging (CBaM)

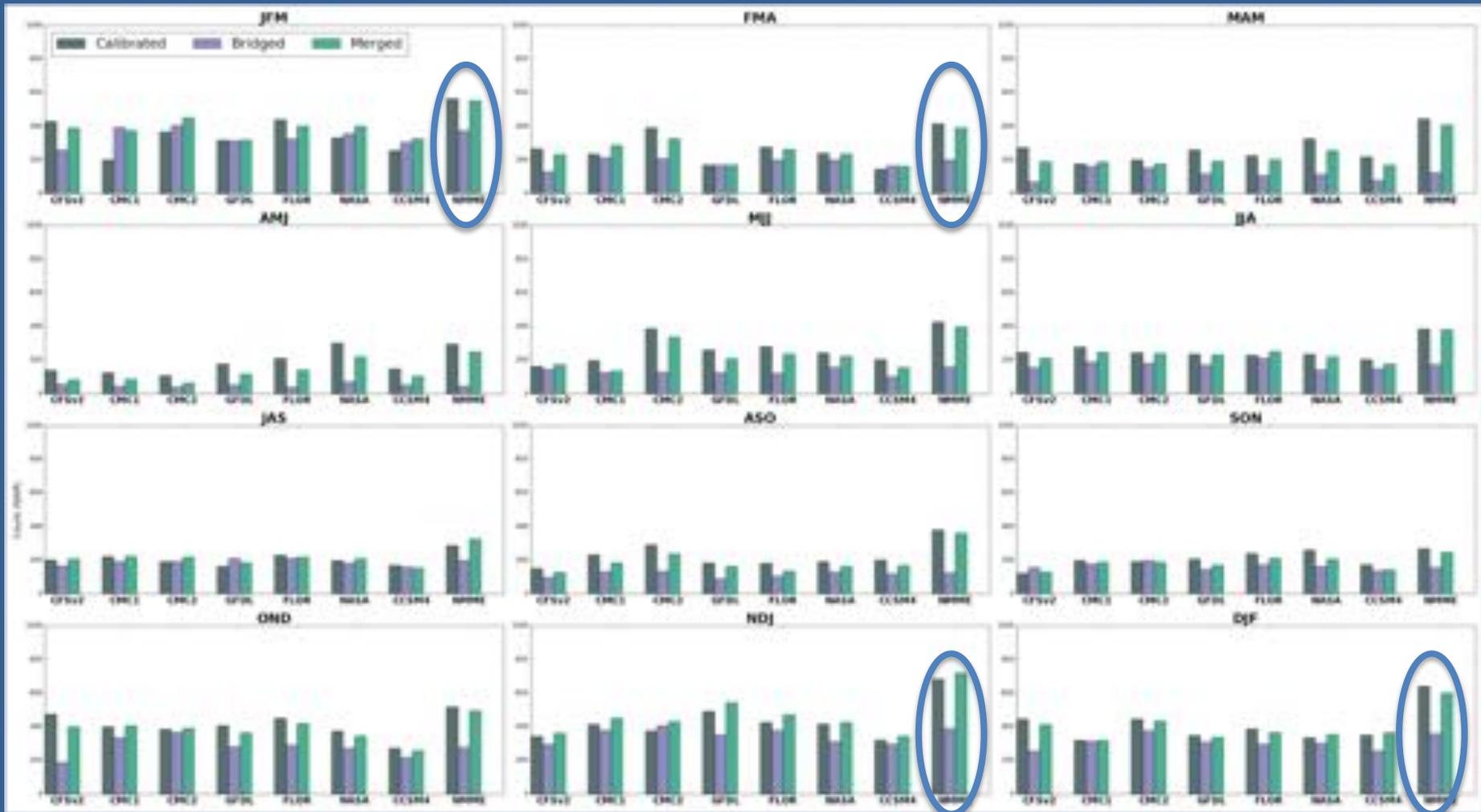
Brier Skill Scores: DJF above normal precipitation

*Bayesian Model Averaging (BMA) weighted NMME (lower right)



Brier Skill Scores: Calibration, Bridging and Merging (CBaM)

12 overlapping 3-month seasons for below normal precipitation
*Bayesian Model Average weighted NMME (far right)





NWS Climate Prediction Center Subseasonal Experiment (SubX) products

Acknowledgements:

Emerson LaJoie and the SubX team

Current NWS Week 3/4 Operational Guidance from a combination of dynamical and statistical models

Tools Available for Forecast Date: 2016/09/16

Choose Another Date: 2016/09/16

Please select the tools you wish to see:

500mb Height - Dynamical Models

Anom Mean + Anom Standardized Anom Spread Rel to Reforecasts

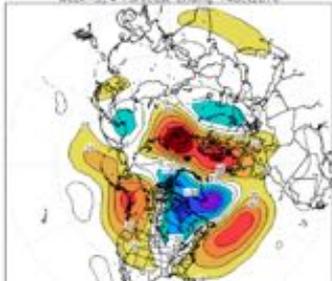
Week-3/4 Week-3 Week-4

CFS

Updates daily by 1340 UTC

[Product Description](#)

CFS 500hPa Height Anomalies Issued 15Sep2016
Week-3/4 Forecast Ending 14Oct2016

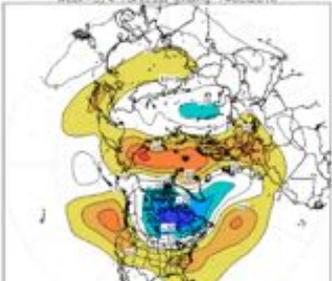


ECMWF

Updates Tuesdays and Fridays only by 1340 UTC

[Product Description](#)

ECMWF 500hPa Height Anomalies Issued 15Sep2016
Week-3/4 Forecast Ending 14Oct2016

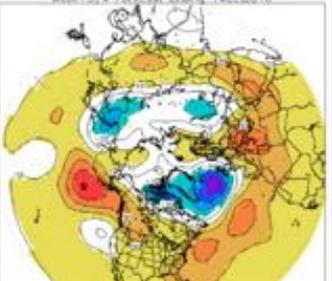


JMA

Updates Thursdays only by 1340 UTC

[Product Description](#)

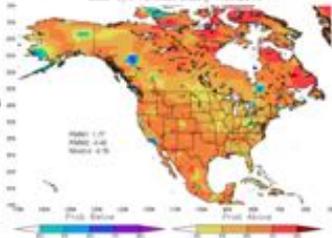
JMA 500hPa Height Anomalies Issued 14Sep2016
Week-3/4 Forecast Ending 14Oct2016



Forecast - Combined

Anom Prob

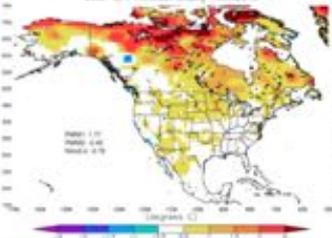
MLR-Combined Temperature Probabilities Issued 16Sep2016
Week-3/4 Forecast Ending 14Oct2016



Forecast - Separate

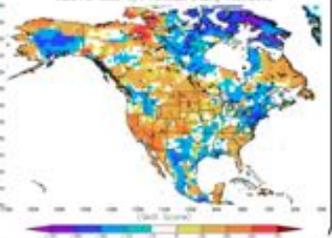
Contributions From: MJO ENSO Trend

MLR-Trend Temperature Anomalies Issued 16Sep2016
Week-3/4 Forecast Ending 14Oct2016



Historical Skill

MLR-Combined Historical Model Skill Scores
Valid For Week-3/4 Forecast Ending 14Oct2016



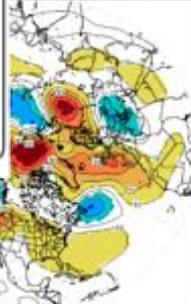
Constructed Analog

Updates Fridays only by 1330 UTC

[Product Description](#)

Anomaly Forecast

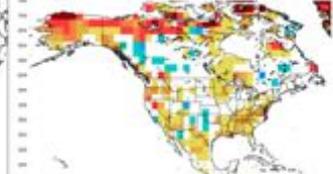
Anomalies Issued 16Sep2016
Forecast Ending 14Oct2016



Forecast

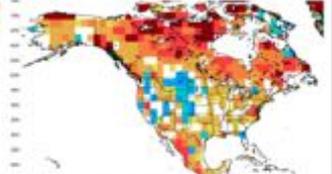
Anom Prob

Constructed-Analog Temperature Anomalies Issued 16Sep2016
Week-3/4 Forecast Ending 14Oct2016



Historical Skill

Constructed-Analog Historical Model Skill Scores
Valid For Week-3/4 Forecast Ending 14Oct2016



- Operational model guidance from 3 models: NCEP CFSv2, ECMWF & JMA
- Statistical Multivariate Linear Regression of MJO & ENSO impacts
- Constructed Analog of 200-hPa stream function



Experimental Week 3/4 Guidance from SubX dynamical models

cpc.ncep.noaa.gov

SubX Week 3/4 forecasts

[IRI Data Library](#)

[Week 3/4 Operational Model Forecasts](#)

North America	Global
500-hPa height	500-hPa height
2-m Temperature	2-m Temperature
Precipitation	Precipitation

cpc.ncep.noaa.gov

SubX Week3/4 tas forecast

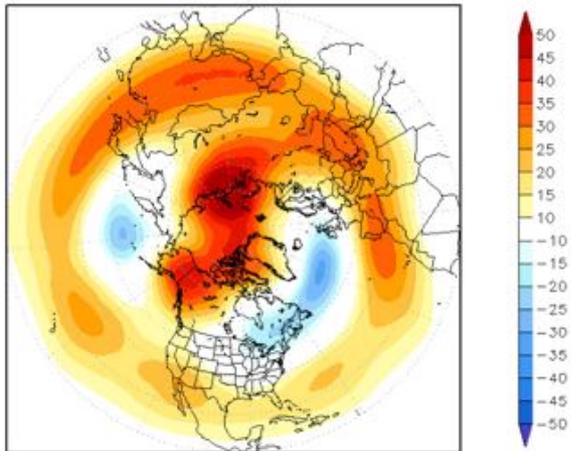
MME

MME 2m anomaly 01 Dec 2017 valid Dec16-Dec29

RSMAS_CCSM4 **ECCC** **FIM** **CFSv2**

GEFS **NESM** **GEOS**

MME 500mb anom 01 Dec 2017 Valid Dec16-Dec29



MME 500mb anomaly 01 Dec 2017 valid Dec16-Dec29

RSMAS_CCSM4 **ECCC** **FIM** **CFSv2**

GEFS **NESM** **GEOS**





Subseasonal Experiment (SubX)



- Testing large MME in hindcasts and in real-time guidance for operational week 3-4 outlook
 - Week 3-4 temperature skill; Limited precipitation skill
 - Individual ensemble models have varying skill
 - MME improves skill overall
- Continued work on:
 - Model bias corrections,
 - Hybrid statistical-dynamical systems, and
 - Methods of model combinations