

# Calibration, Bridging, and Merging (CBaM) of North American Multi-Model Ensemble (NMME) Seasonal Forecasts Given Updated Climate Normals

**CDPW 2021**

Johnna Infanti (NOAA/CPC)\*, Dan Collins (NOAA/CPC), Andrew Schepen (CSIRO), Sarah Strazzo (Embry-Riddle Aeronautical University), QJ Wang (University of Melbourne), Ginger Zhang (NOAA/CPC)



Climate normals (climatology) mandated to be updated every 10 years across NOAA

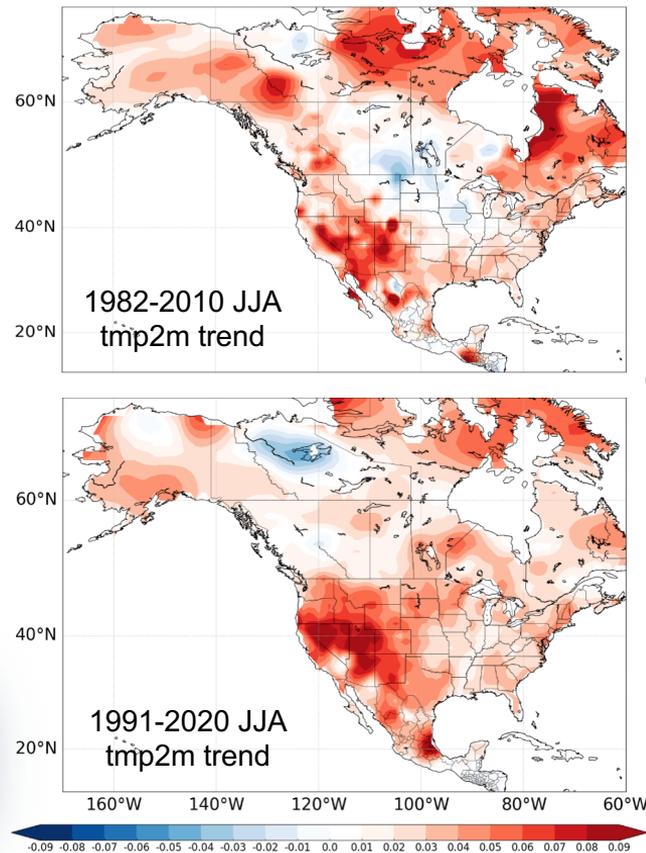
- Prior to the beginning of 2021, climatology was defined using 1981(1982)-2010
- CPC tools have shifted to 1991-2020

What does this mean??

- Forecasts are made respective to a more recent (and generally warmer!) period
- ... More work!!

How does this shift impact calibrated (CBaM) seasonal hindcasts and forecasts?

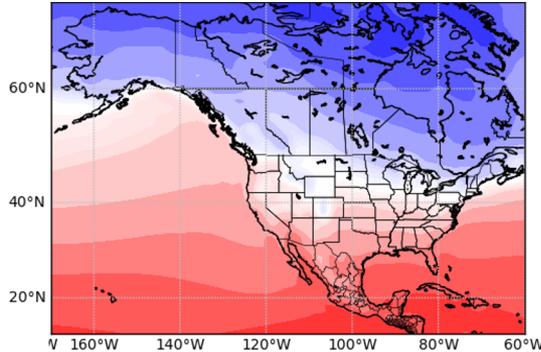
**Example:** Observed JJA decadal tmp2m trend in 1982-2010 and 1991-2020



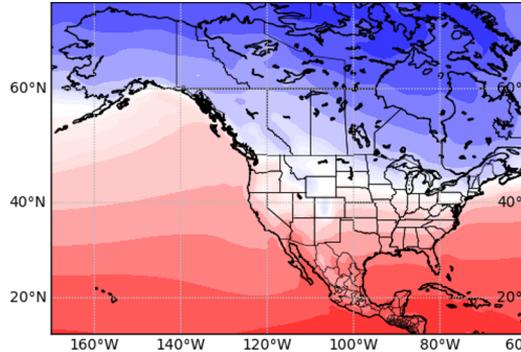
# Climate Normals: Difference in Models (CFSv2 Example)

Feb-Apr (FMA)

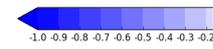
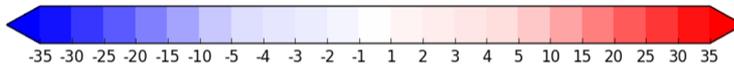
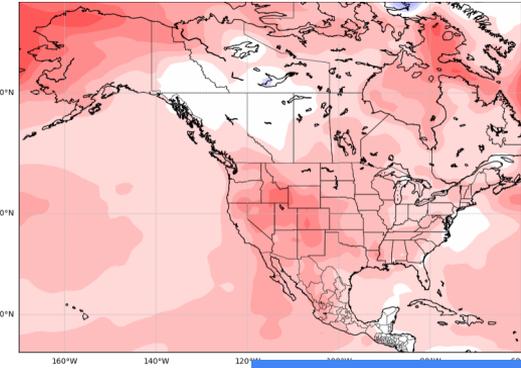
1991-2020



1982-2010



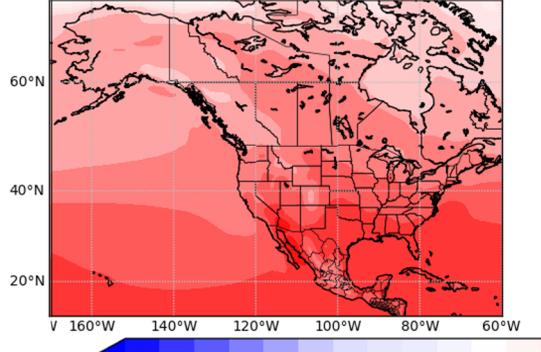
1991-2020 minus 1982-2010



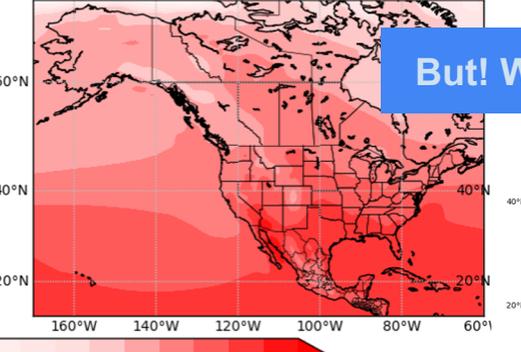
Model climo  $\neq$  observed climo

Jun-Aug (JJA)

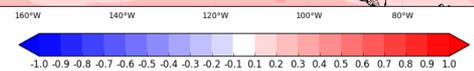
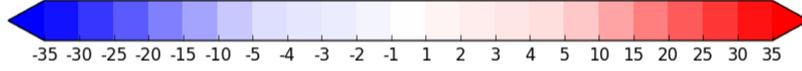
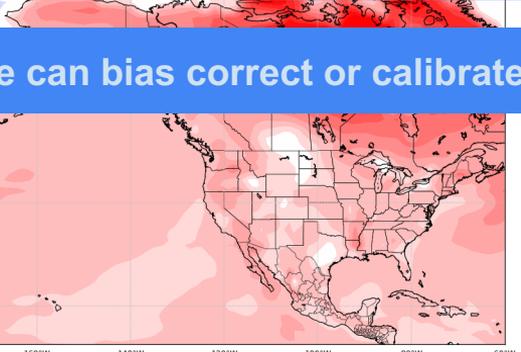
1991-2020



1982-2010



1991-2020 minus 1982-2010



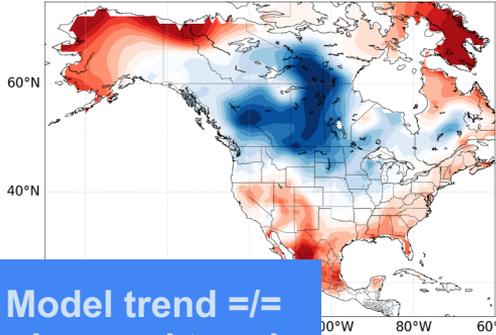
But! We can bias correct or calibrate!

# Climate Normals: Difference in Trend (Obs vs. NMME, Example for 1991-2020)



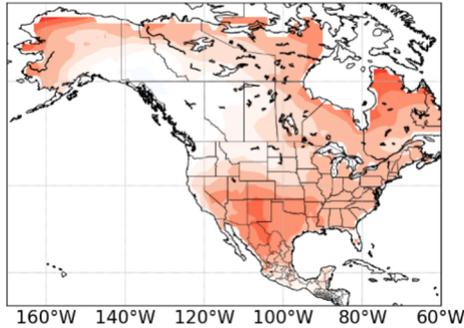
### FMA Observed Trend

Obs Init:01 Obs



### Lead 1 FMA NMME Trend

1-month lead Init:01 NMME Raw



Model trend  $\neq$  observed trend

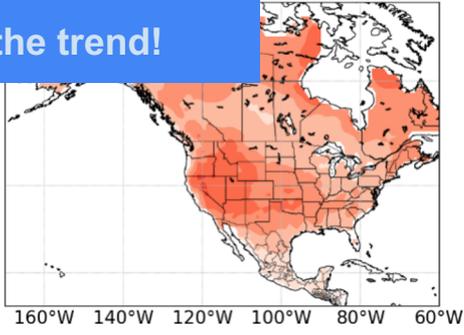
### Trend

### Lead 1 JJA NMME Trend

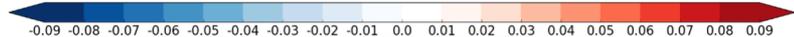
Obs Init:05 Obs



1-month lead Init:05 NMME Raw



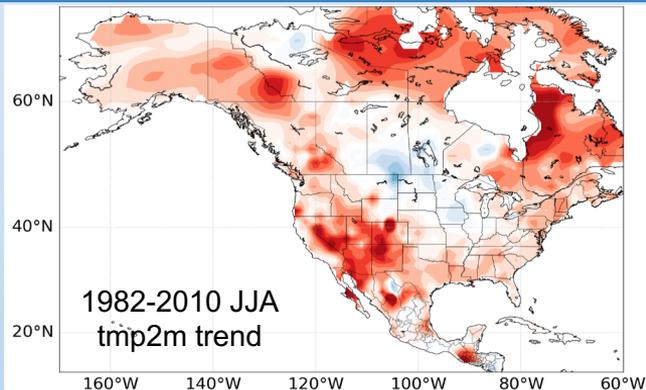
But! We can correct the trend!



- Models tend to have ubiquitously warm trend, and thus, climate shift(s) are also toward warm. However, there can be some spatial and temporal differences that are not correctly captured by the models.
- Both trend and climatology are important when updating climate normals - Given that forecasts are made with respect to a given climatology and trend is a key player in forecasts, we can see more accuracy (skill, reliability) when forecasts are calibrated, or calibrated in addition to correcting trend.
- We use Bayesian Joint Probability (BJP) and Bayesian Model Averaging (BMA) to calibrate, correct teleconnections, and form weights for averaging

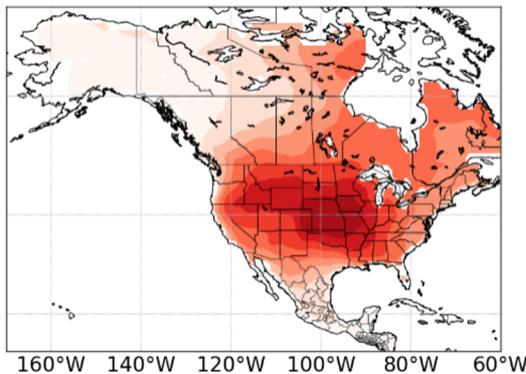
# Why add the trend? JJA 1982-2010 Example...

Observed  
Trend

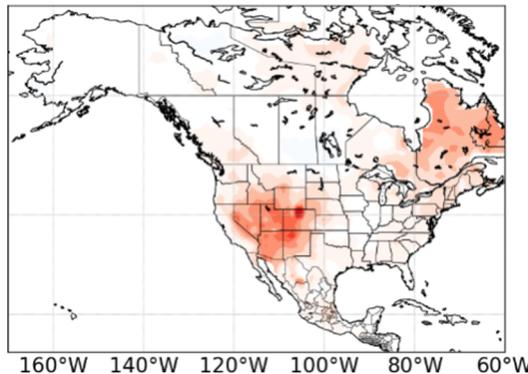


\*Overarching results will be similar for 1991-2020, though trends will differ

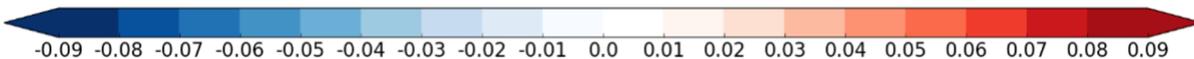
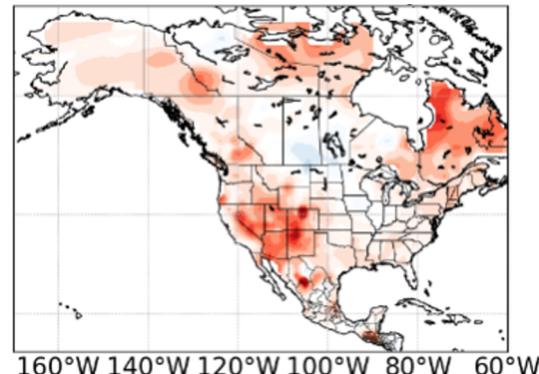
Raw NMME JJA Trend



BJP NMME JJA Trend



BJP+T NMME JJA Trend



Trend plays a large role in forecasts, especially when drivers such as ENSO are inactive

# The Full CBaM System

As noted earlier, we can calibrate to correct these things...  
so what is the calibration method used?

**Bayesian Joint Probability (BJP)** used in **Calibration, Bridging, and Merging (CBaM)** forecast system (Schepen et al. 2016; Strazzo et al. 2019) which provides NMME forecasts of temperature and precip over North America <https://www.cpc.ncep.noaa.gov/products/people/sstrazzo/cbam/index.php>

## Calibration

Raw dynamical model forecast of North American tmp2m or prate

Statistical post-processing (BJP) with respect to observed quantities

Statistically corrected (**calibrated**) forecast of North American tmp2m or prate

## Bridging

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

Statistical post-processing (BJP) with respect to bridging index

Statistically **bridged** forecast of North American tmp2m or prate

Statistically bridged forecast of North American 2-m temperature



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

× *W*

Weighted **merging** (BMA) of forecasts based on performance in hindcast period

× *W*

\*Slide and information courtesy Sarah Strazzo

## Merging

# Datasets/Methods Considered

\*Raw NMME

\*With respect to 1982-2010 Climatology  
 \*With respect to 1991-2020 Climatology

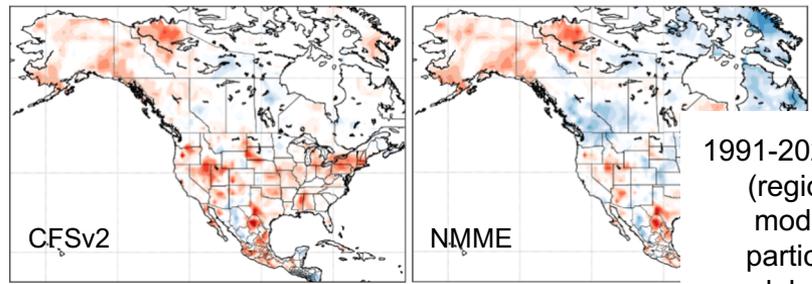
BJP Calibrated NMME	Calibrated with respect to 1982-2010 Climatology Calibrated with respect to 1991-2020 Climatology
BJP+T Calibrated NMME	Calibrated and “perfectly predicted” trend added with respect to 1982-2010 Calibrated and “perfectly predicted” trend added with respect to 1991-2020
CBaM NMME	Calibrated, Bridged, and Merged with respect to 1982-2010 Climatology Calibrated, Bridged, and Merged with respect to 1991-2020 Climatology
C(T)BaM NMME	Calibrated with trend, Bridged, and Merged with respect to 1982-2010 Calibrated with trend, Bridged, and Merged with respect to 1991-2020

\*For raw NMME differences, Qin Zhang had a poster “Updating Climate Normals Impact on NMME Forecast” on Wednesday October 27

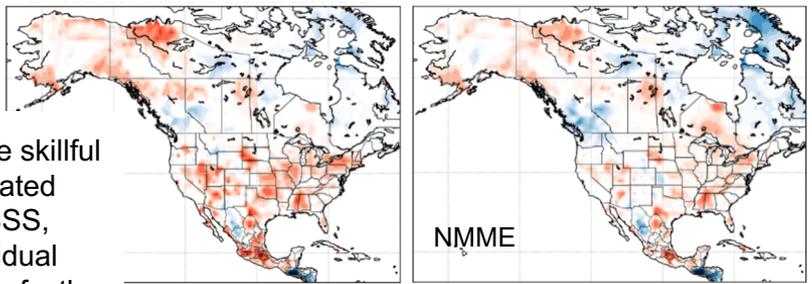
# How does CBaM hindcast skill change from 1982-2010 to 1991-2020?

For raw NMME differences, Qin Zhang had a poster “Updating Climate Normals Impact on NMME Forecast” on Wednesday October 27. Focus here is on **BJP** and **BJP+T** differences

Difference in upper tercile BSS (1991-2020 minus 1982-2010) for **BJP** Calibrated Lead 1 FMA Hindcasts

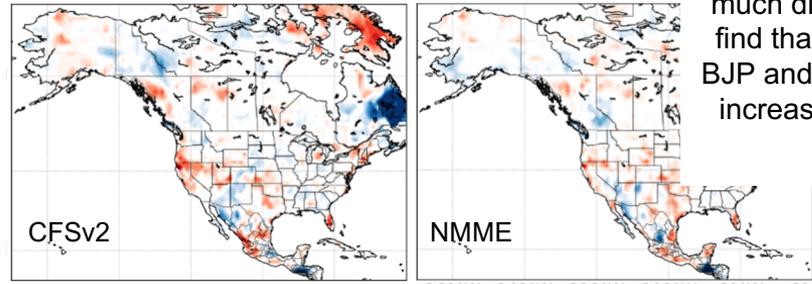


Difference in upper tercile BSS (1991-2020 minus 1982-2010) for **BJP+T** Calibrated Lead 1 FMA Hindcasts

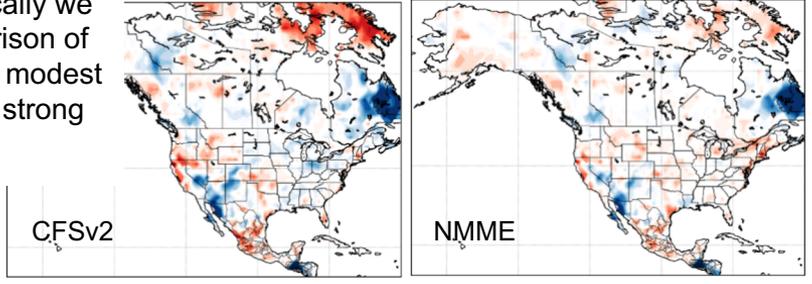


1991-2020 slightly more skillful (regionally) in calibrated models based on BSS, particularly for individual models. Addition of perfectly predicted trend doesn't make much difference - typically we find that direct comparison of BJP and BJP+T shows modest increase in regions of strong bias in trend.

**BJP** Calibrated Lead 1 JJA Hindcasts



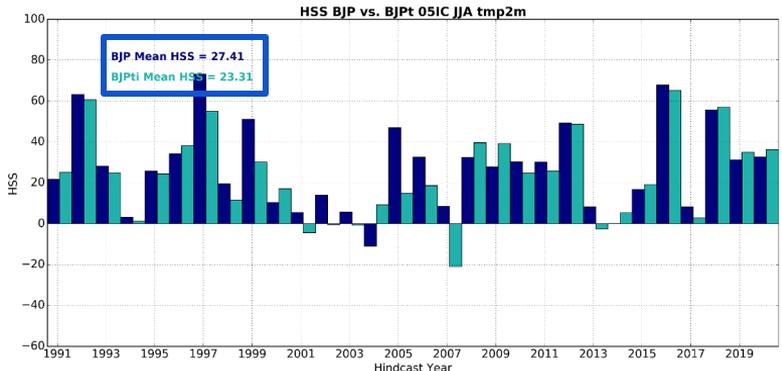
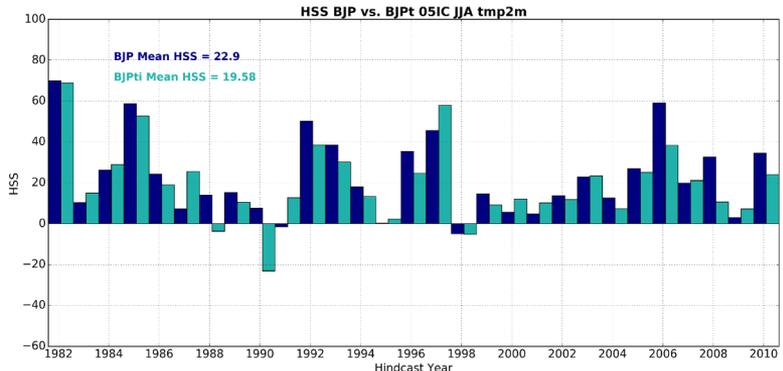
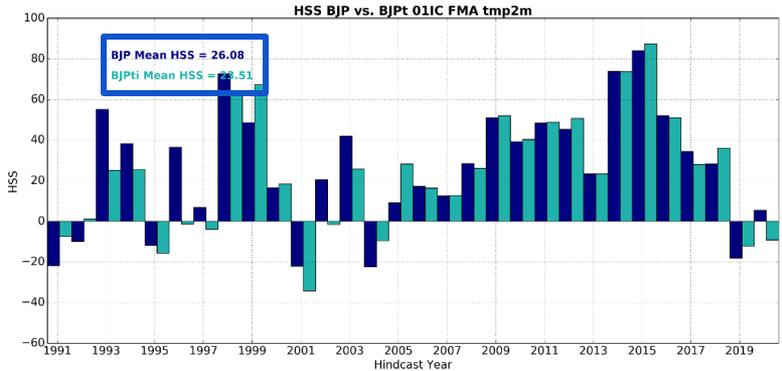
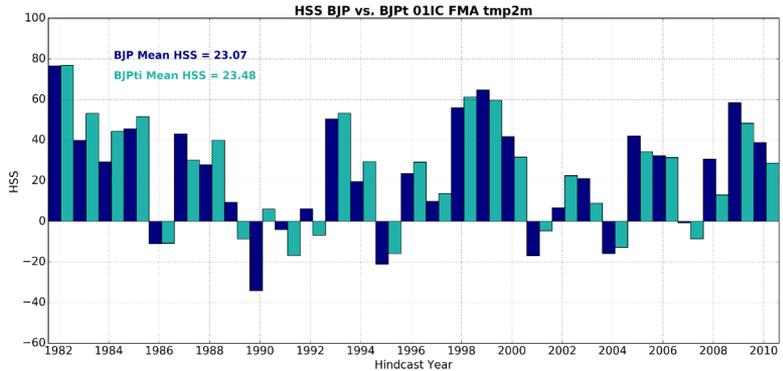
**BJP+T** Calibrated Lead 1 JJA Hindcasts



# How does CBaM hindcast skill change from 1982-2010 to 1991-2020?

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Heidke Skill Score (upper and lower terciles)

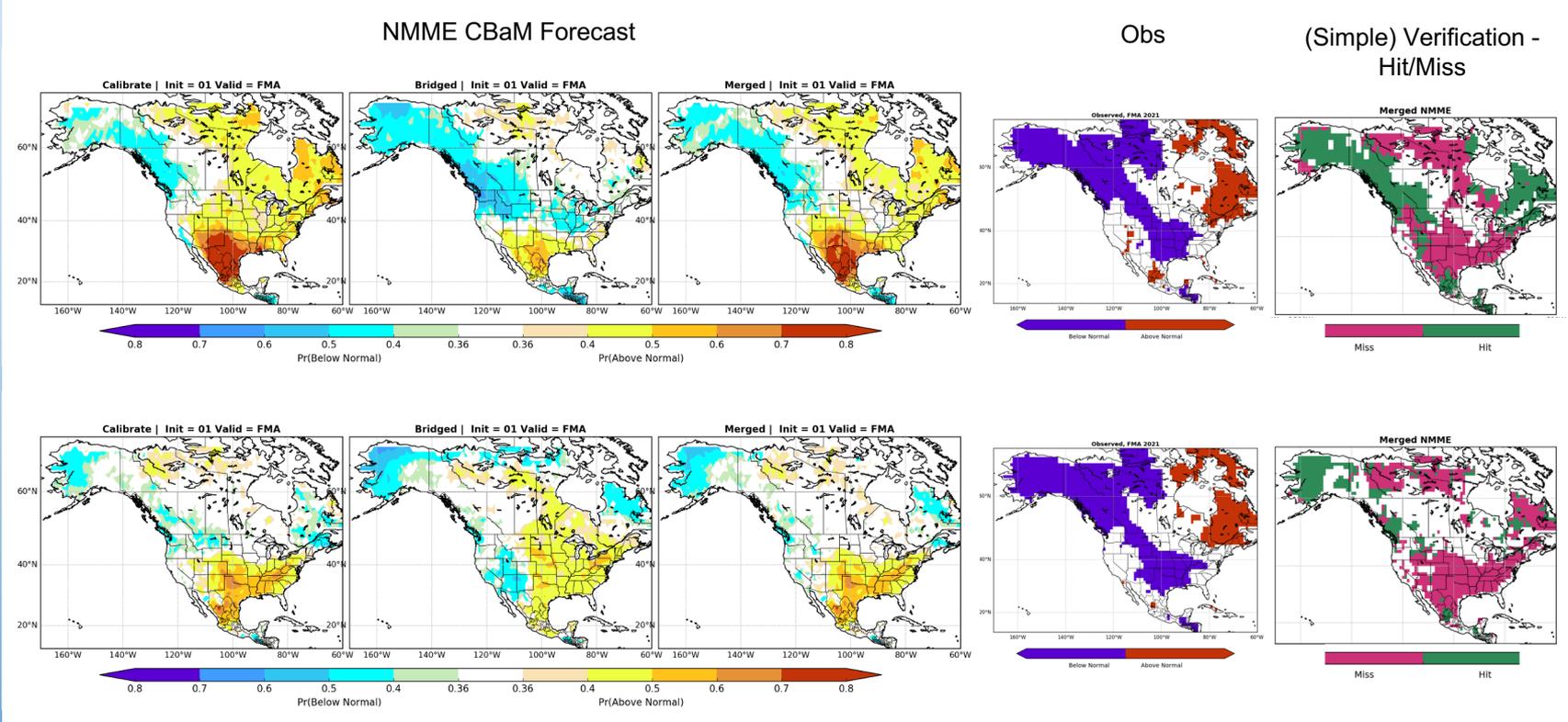


# Realtime Differences: CBaM - FMA2021

Raw NMME, **CBaM**, CTBaM with 1991-2020 climatologies have been running in realtime since approximately January 2021. 2 example forecasts will be shown, **January 2021 lead 1 (FMA)** and May2021 lead 1 (JJA) tmp2m

Probabilities calculated with respect to 1982-2010 climo

Probabilities calculated with respect to 1991-2020 climo

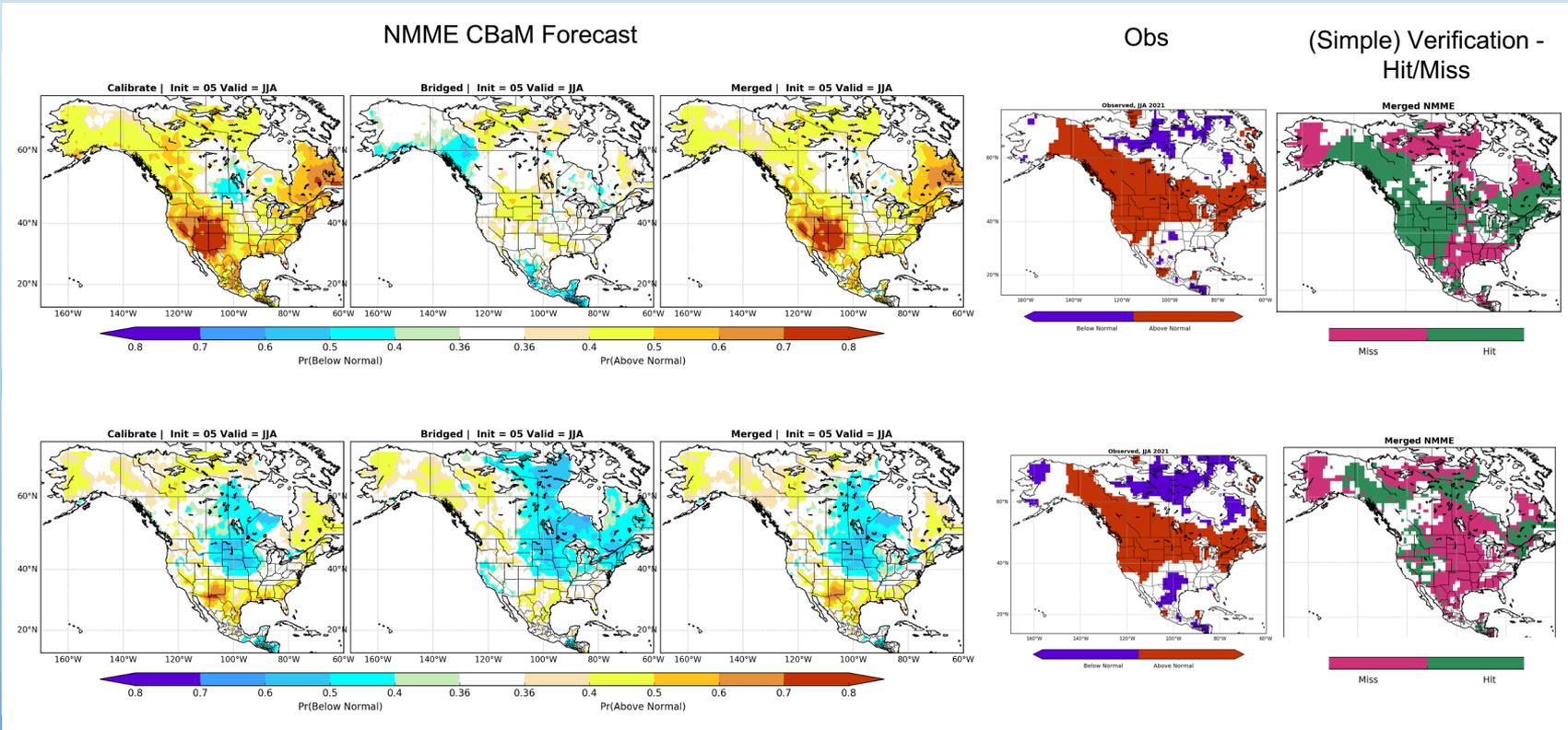


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Raw NMME, **CBaM**, CTBaM with 1991-2020 climatologies have been running in realtime since approximately January 2021. 2 example forecasts will be shown, January 2021 lead 1 (FMA) and **May2021 lead 1 (JJA) tmp2m**

Probabilities calculated with respect to 1982-2010 climo

Probabilities calculated with respect to 1991-2020 climo



- Model climatologies and trends are biased with respect to observations, so calibration (or bias correction) and calibration with corrected trend is desired
- Given the incorrect trend, there also tends to be some bias in models when shifting climatologies (climos/trends are overall warm in models, compared to observations)
- We employ Bayesian methodologies to correct the climatology with respect to observations, increase reliability, and correct trend (BJP and BJP+T)
- Hindcasts:
  - Using BJP calibration, we compared the BSS and HSS for 1982-2010 vs. 1991-2020 FMA and JJA hindcasts - there is increased skill in 1991-2020, particularly when considering HSS
  - However, the addition of corrected trend did not make much difference to skill (somewhat expected given prior results with direct comparison of BJP and BJP+T for an overlapping temporal period)
- Forecasts:
  - 2 example forecasts shown, FMA2021 and JJA2021
  - Probabilities/anomalies are weaker after shift to 1991-2020 due to warmer period
  - Individual forecast examples have differing results from hindcasts and the forecasts made with respect to 1991-2020 are less skillful given a *very* simple metric of hit/miss (but, keep in mind this is only 2 examples!)
  - Future: Add additional realtime skill metrics beyond hit/miss including HSS

# Questions?

Schepen A, Wang QJ, Robertson DE (2014) Seasonal Forecasts of Australian Rainfall through Calibration and Bridging of Coupled GCM Outputs. *Mon Wea Rev* 142:1758–1770. <https://doi.org/10.1175/MWR-D-13-00248.1>

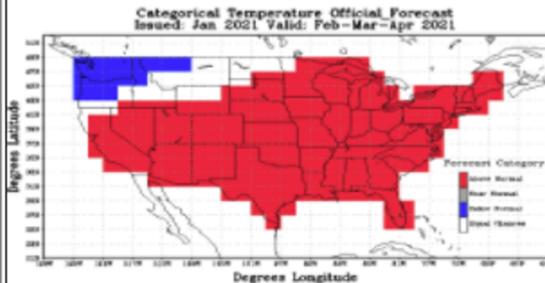
Strazzo S, Collins DC, Schepen A, et al (2019) Application of a Hybrid Statistical–Dynamical System to Seasonal Prediction of North American Temperature and Precipitation. *Mon Wea Rev* 147:607–625. <https://doi.org/10.1175/MWR-D-18-0156.1>

Wang QJ, Schepen A, Robertson DE (2012) Merging Seasonal Rainfall Forecasts from Multiple Statistical Models through Bayesian Model Averaging. *J Climate* 25:5524–5537. <https://doi.org/10.1175/JCLI-D-11-00386.1>

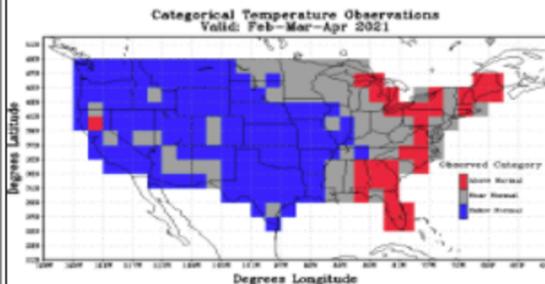
FMA2021

**Temperature Forecast Heidke Skill Scores :**  
Non-Equal Chance(non EC) forecasts: -14.49  
All forecasts: -12.93  
% coverage not Equal Chance forecasts : 89.22

**Temperature (Forecast)**  
**Download Forecast Data Archive**  
[\(CAT, PROB ABOVE PROB BELOW\)](#)  
[How To Read Temperature Forecasts](#)



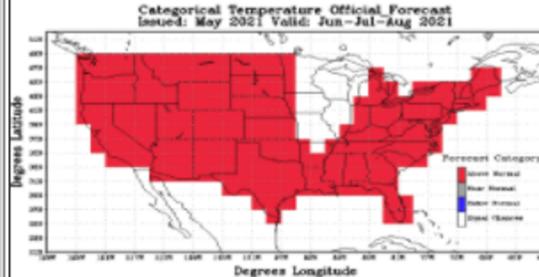
**Temperature (Observations)**  
**Download Observational Data Archive**  
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[How To Read Observations](#)



JJA2021

**Temperature Forecast Heidke Skill Scores :**  
Non-Equal Chance(non EC) forecasts: 37.80  
All forecasts: 33.41  
% coverage not Equal Chance forecasts : 88.36

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