Application of a hybrid statistical-dynamical prediction system to seasonal forecasts of North American temperature

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Calibration, Bridging, and Merging (CBaM)

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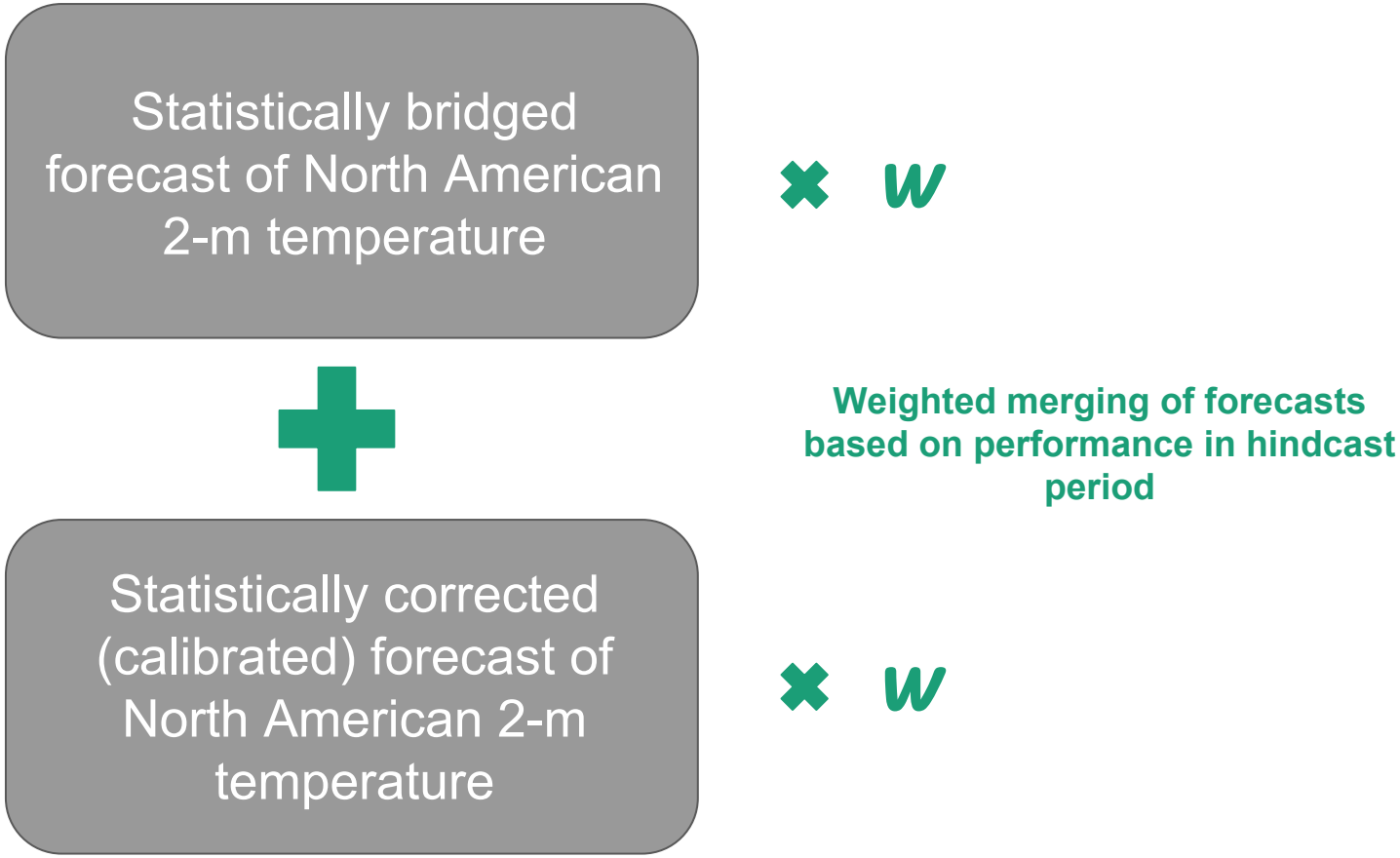
Calibration, **Bridging**, and Merging (CBaM)

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

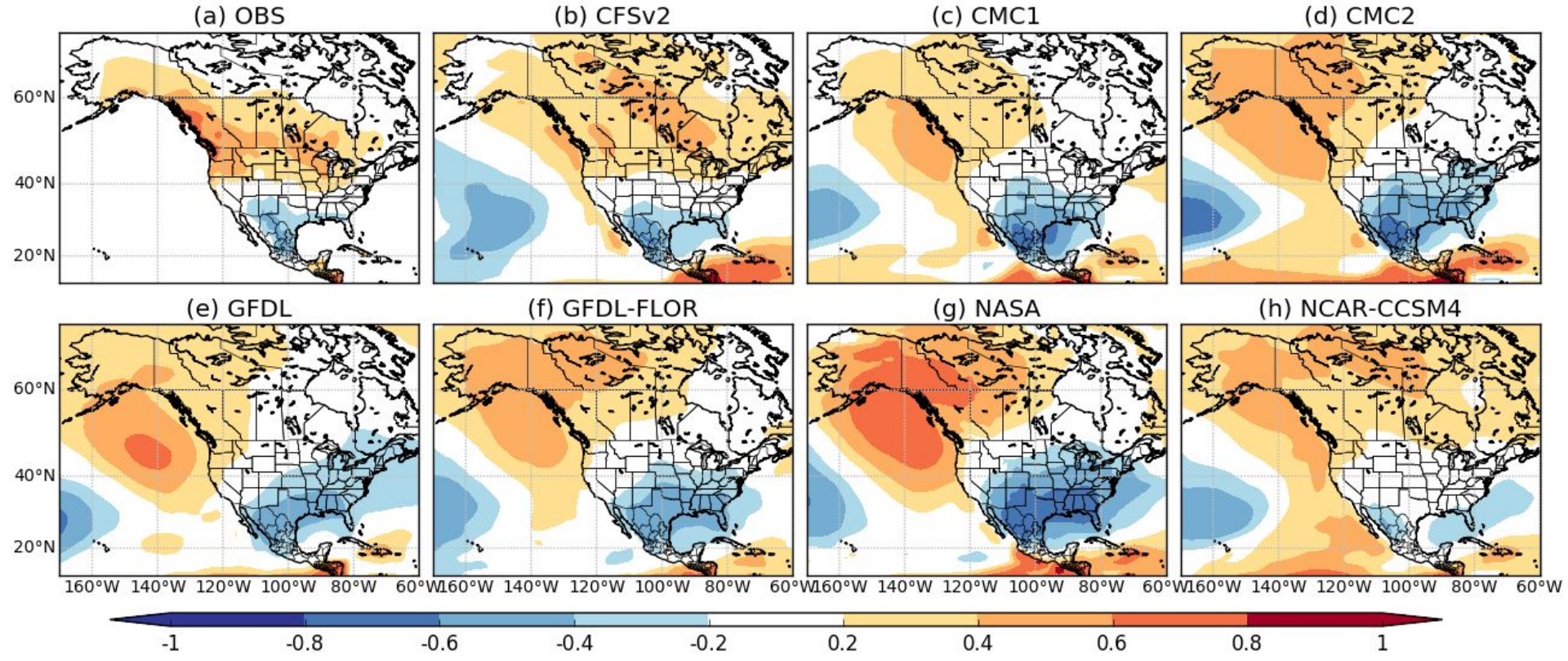
Statistical post-processing

Statistically bridged forecast of North American 2-m temperature

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



Why bridging?



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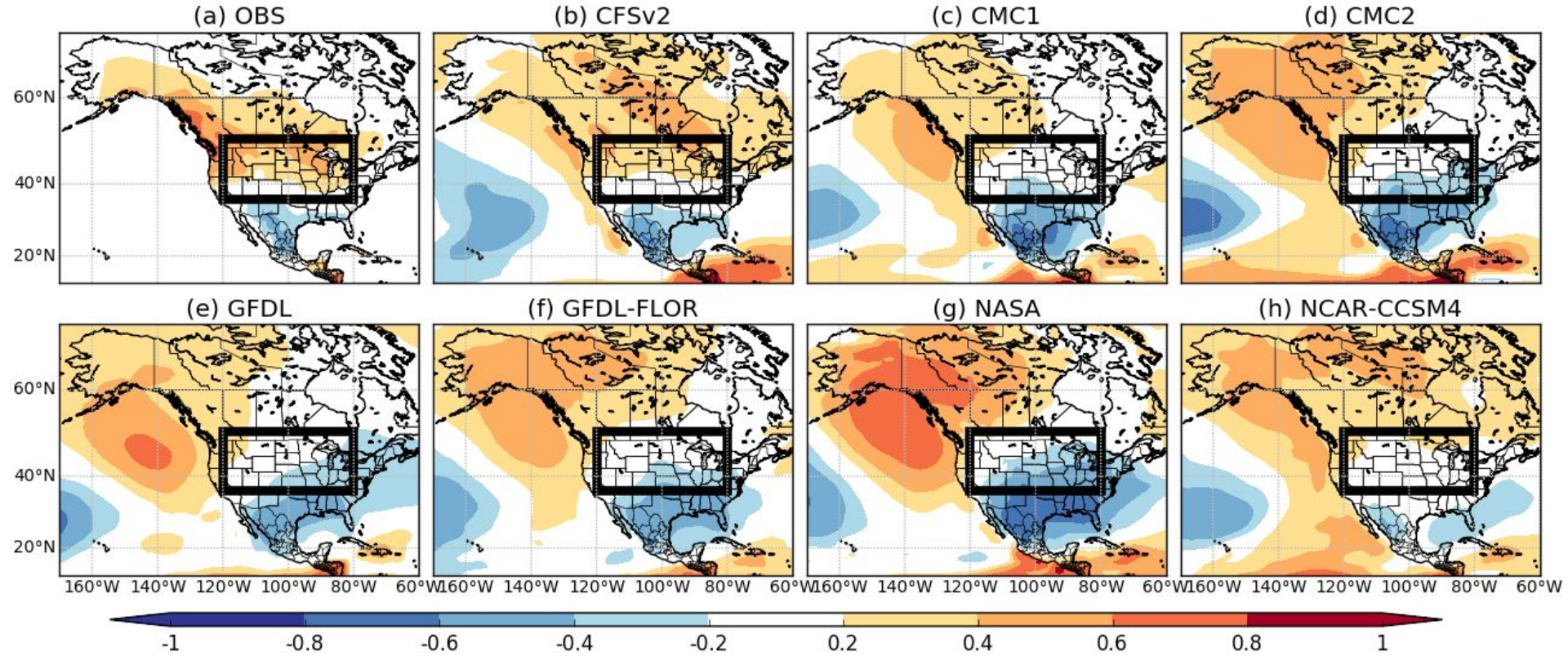
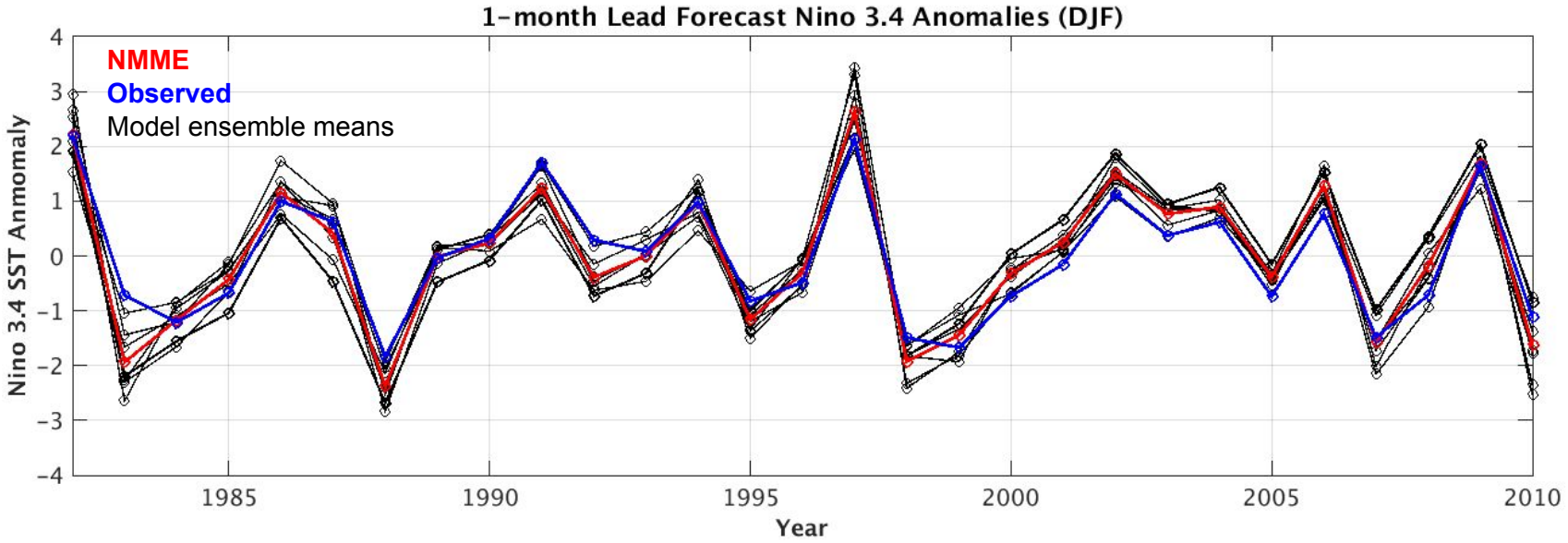


Why bridging?



	CFSv2	CMC1	CMC2	GFDL	FLOR	NASA	CCSM4	NMME
Correlation w/obs	0.86	0.96	0.96	0.92	0.94	0.95	0.88	0.95

Objectives, data, methods

- **Question**: Does statistical **bridging** using the forecast Niño 3.4 index improve forecast skill beyond what skill is achieved through **calibration**?

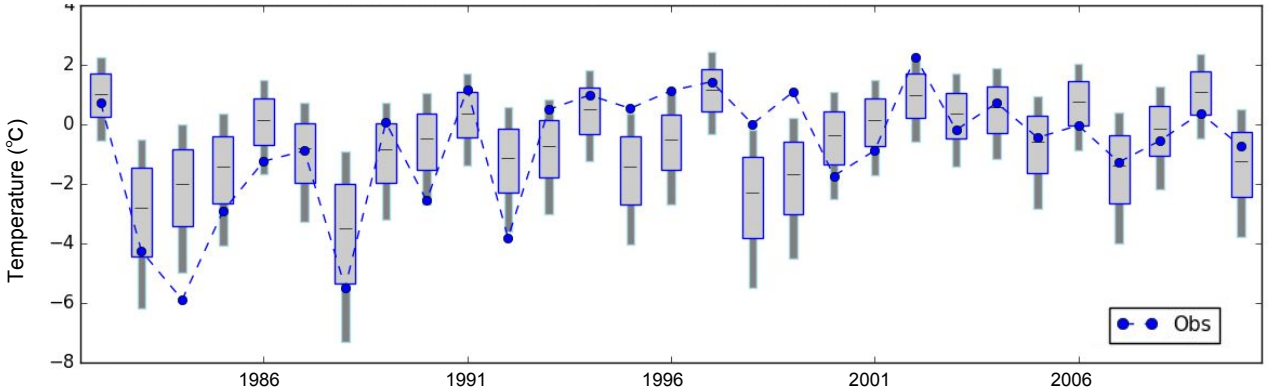
- **Data**: 29-year North American Multi-Model Ensemble hindcast
  - 1982 -- 2010

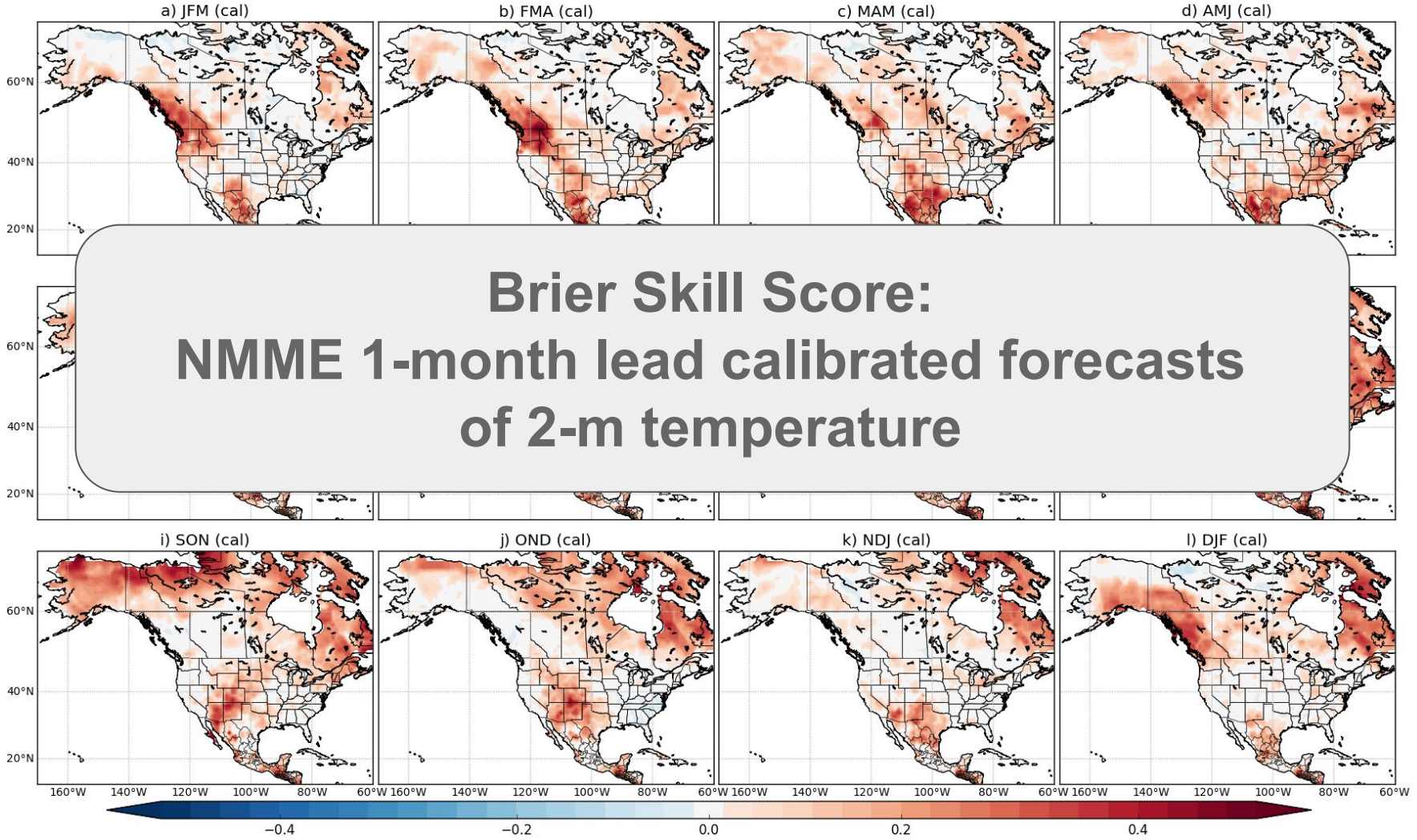
- **Method**: Calibration, bridging, and merging (CBaM) using Bayesian Joint Probability (BJP) modeling and Bayesian Model Averaging (BMA)

Bayesian **J**oint **P**robability (BJP) Model

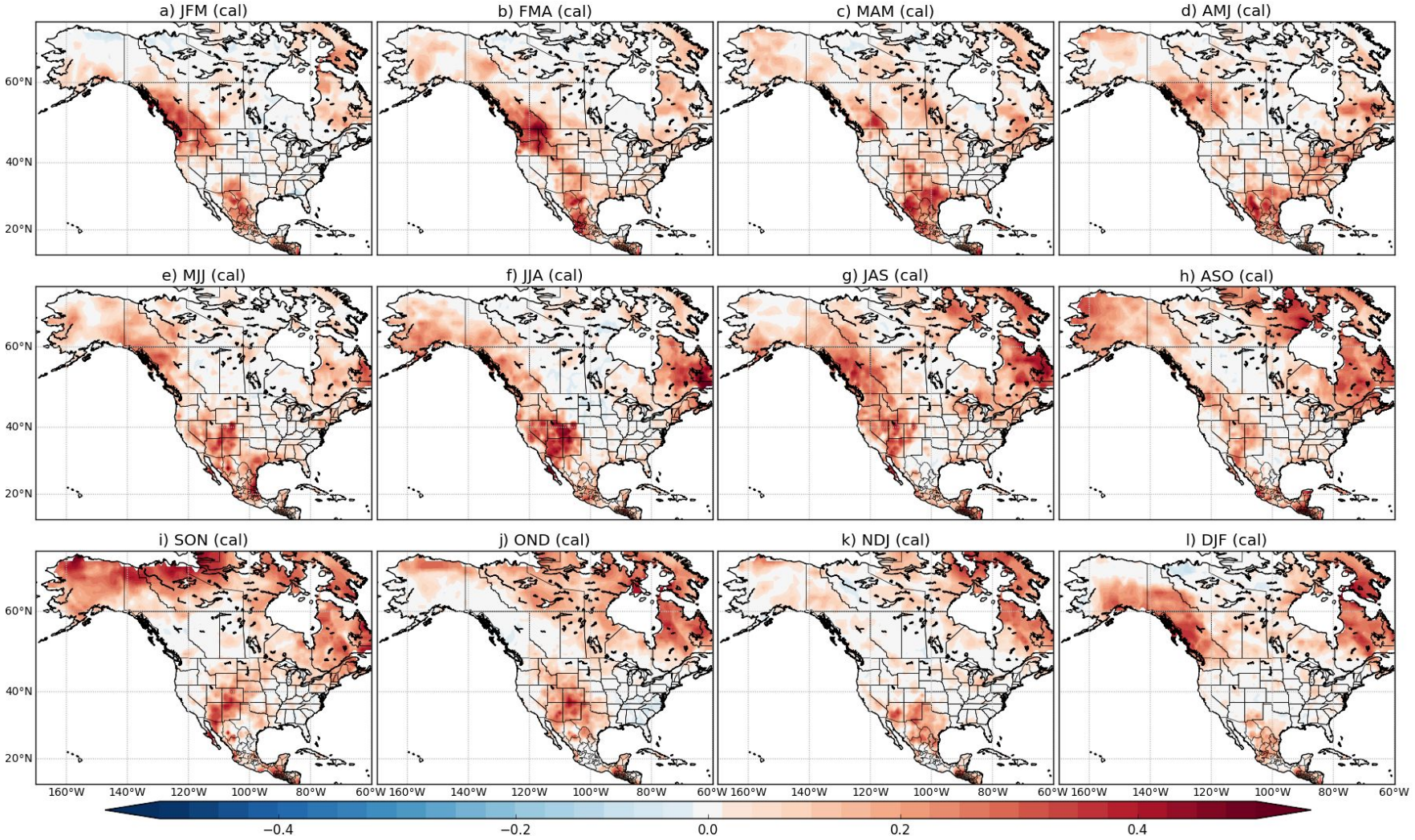
- We develop calibration and bridging models using **Bayesian Joint Probability (BJP)** modeling (Wang et al. 2009)
  - Predictor (e.g., Niño 3.4) and predictand (e.g., 2-m T) modeled using a bivariate normal distribution, where the distribution parameters are not assumed to be fixed
  - Individual **calibration** and **bridging** BJP models are developed for each NMME member mean, grid point, lead, and season
- BJP generates a statistical ensemble by sampling from the posterior distribution of the bivariate normal parameters (n = 1000)

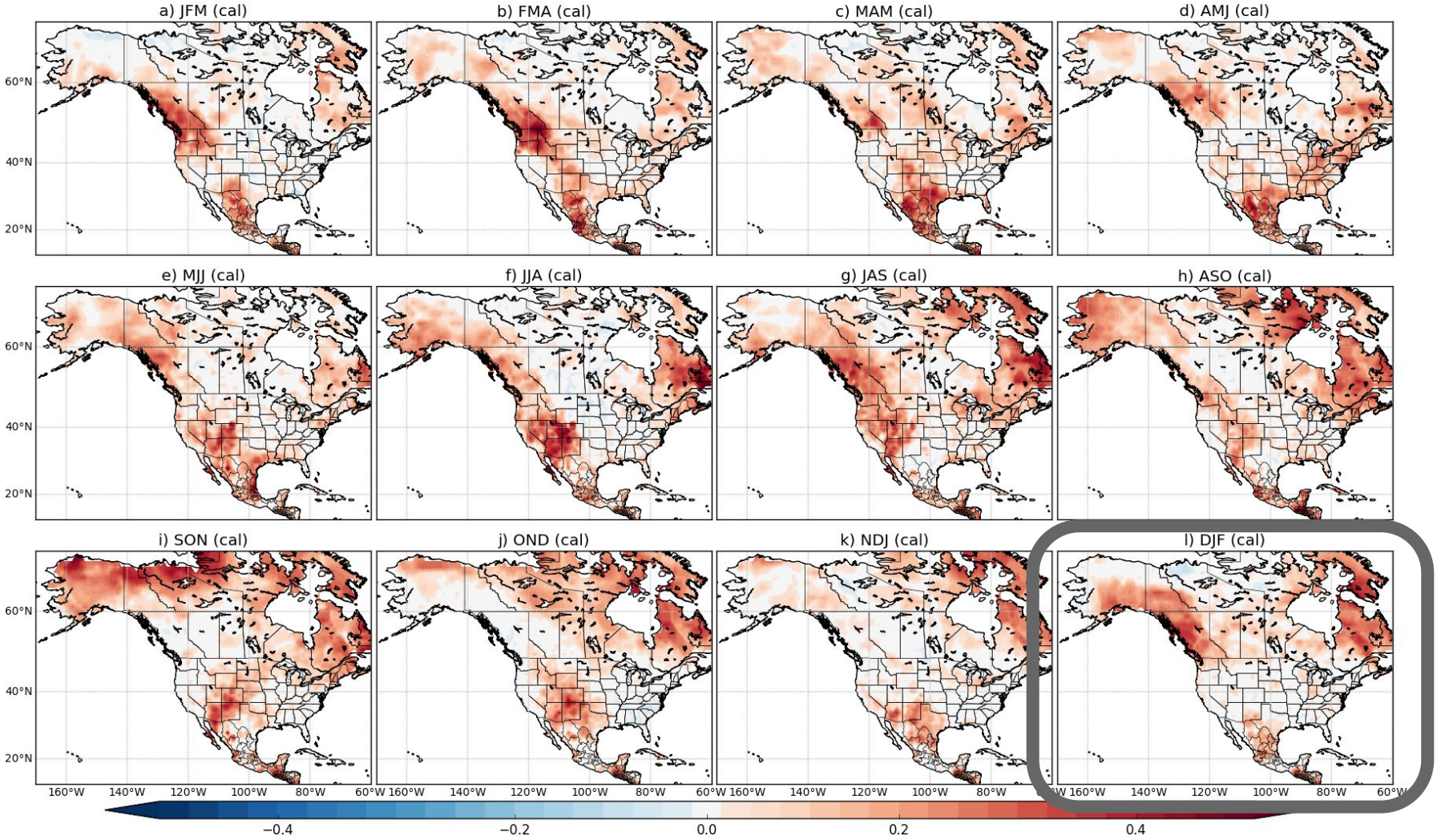
BJP Niño 3.4 bridged forecast of DJF 2-m temperature for a single grid point (1-month lead)





Brier Skill Score: NMME 1-month lead calibrated forecasts of 2-m temperature


a) JFM (cal)
b) FMA (cal)
c) MAM (cal)
d) AMJ (cal)
e) MJJ (cal)
f) JJA (cal)
g) JAS (cal)
h) ASO (cal)
i) SON (cal)
j) OND (cal)
k) NDJ (cal)
l) DJF (cal)
60°N
40°N
20°N
160°W
140°W
120°W
100°W
80°W
60°W
−0.4
−0.2
0.0
0.2
0.4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160°W
140°W
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−0.4
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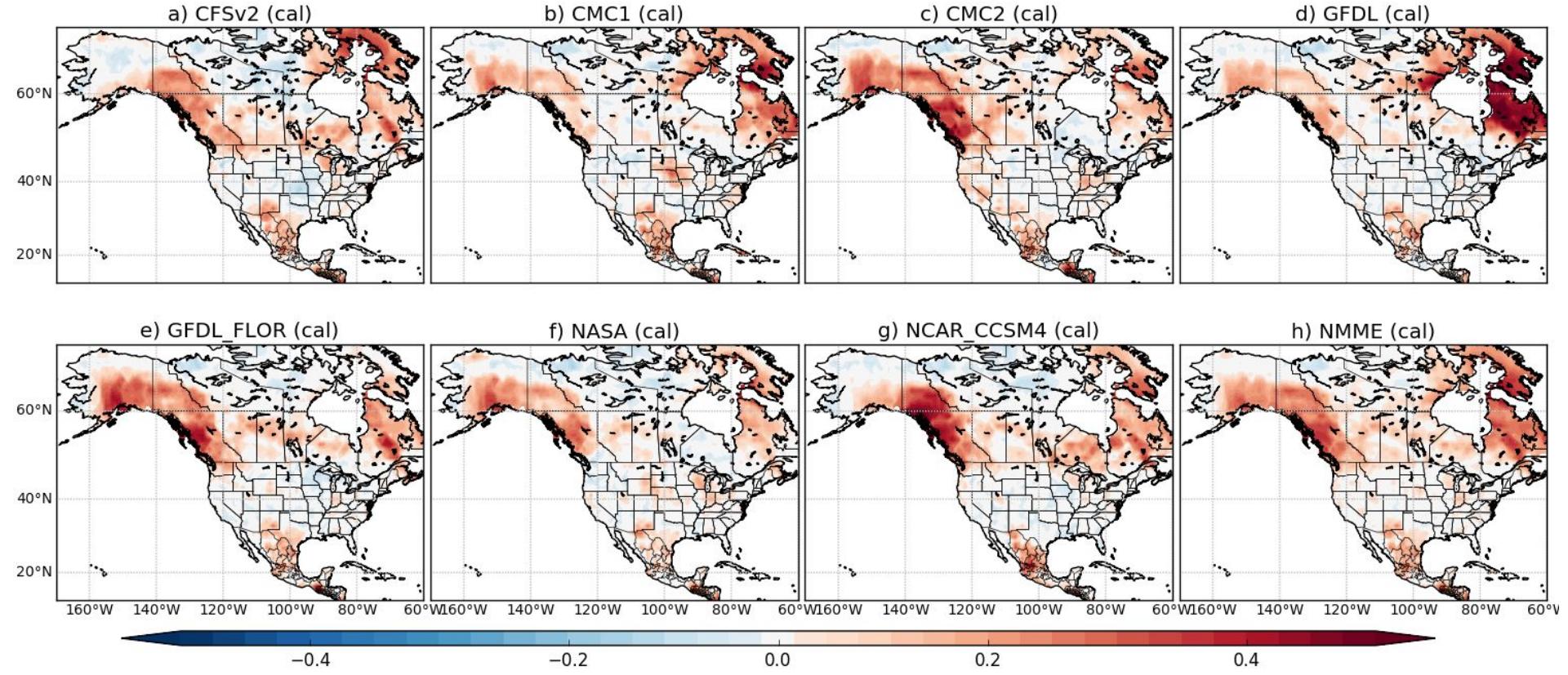
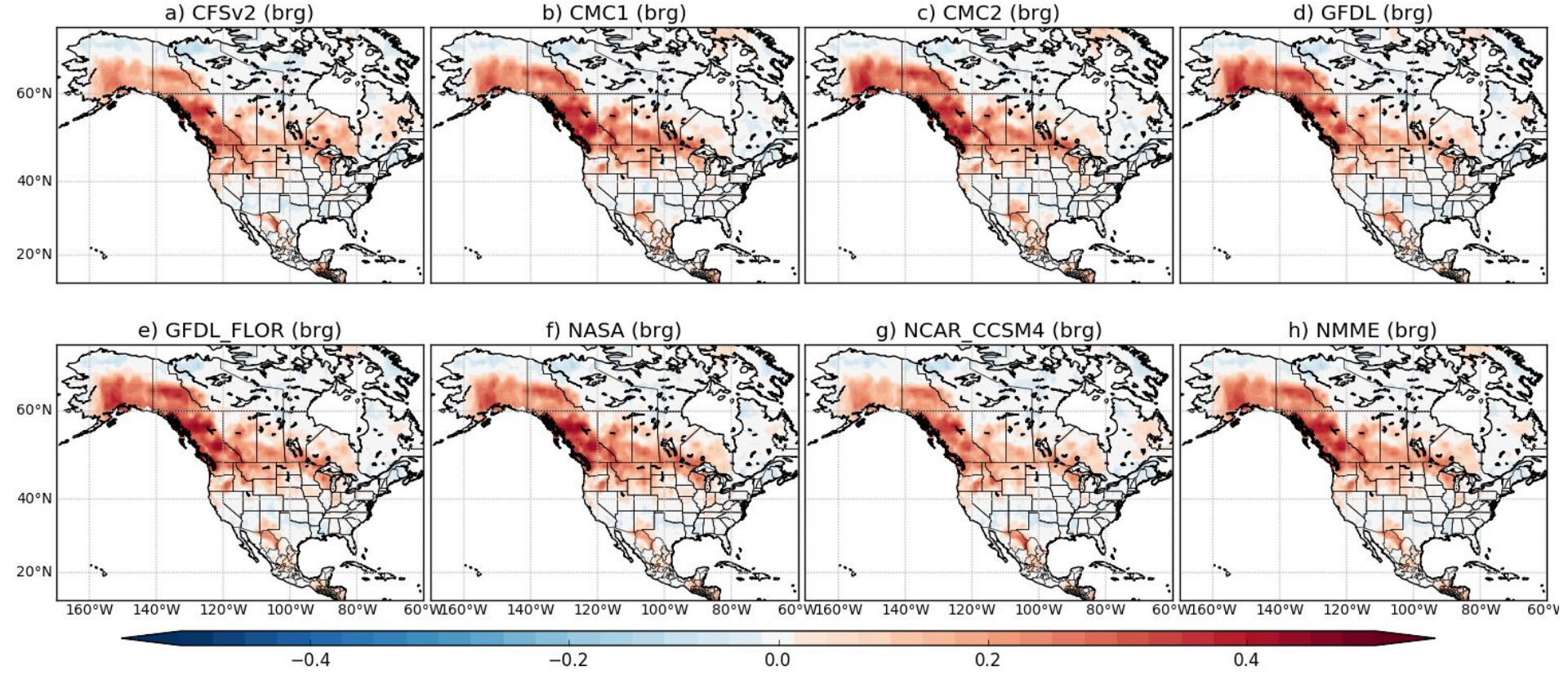
0.0
0.2
0.4

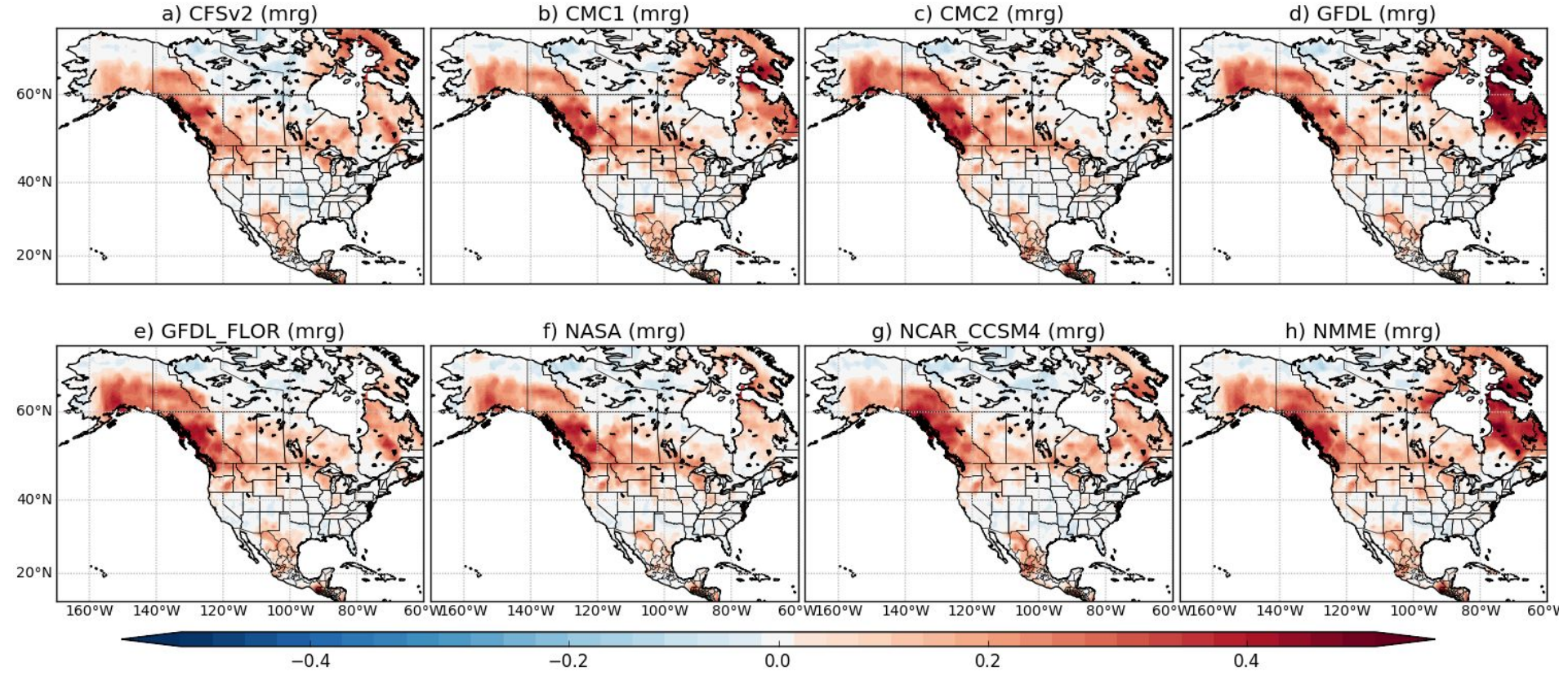
BSS: Lead 1 calibrated forecasts of DJF 2-m temperature



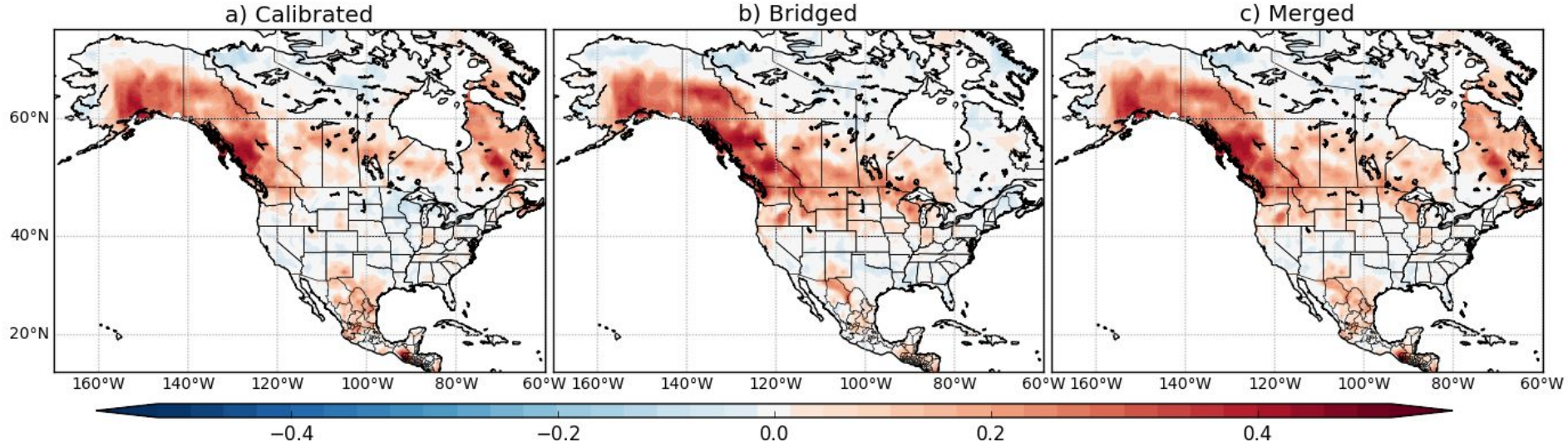
BSS: Lead 1 bridged forecasts of DJF 2-m temperature

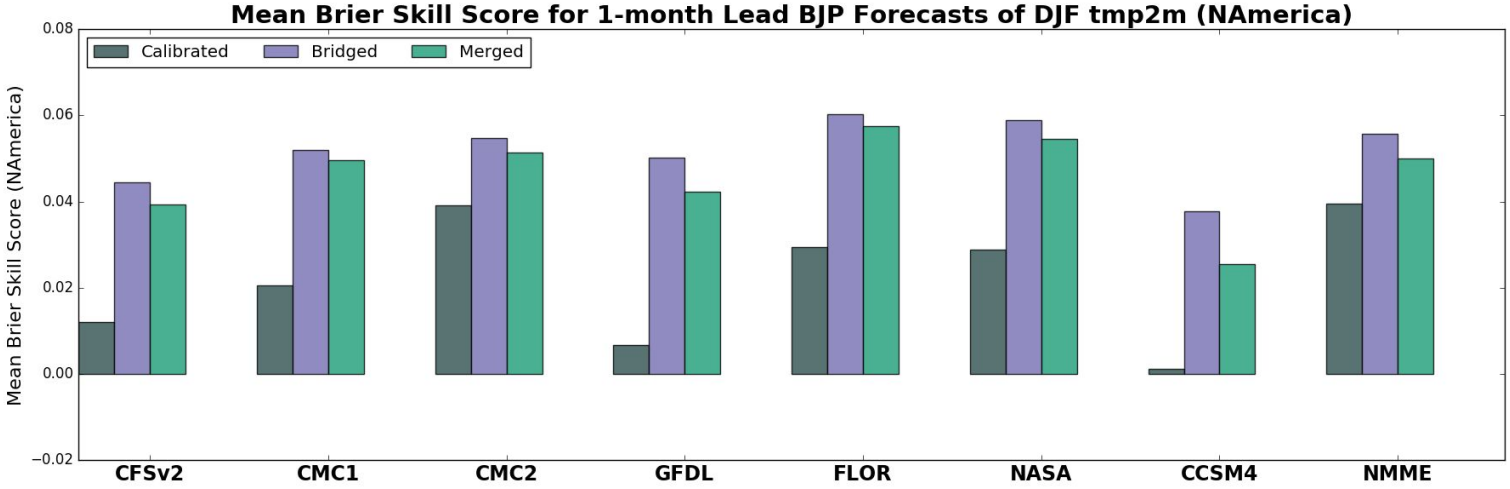


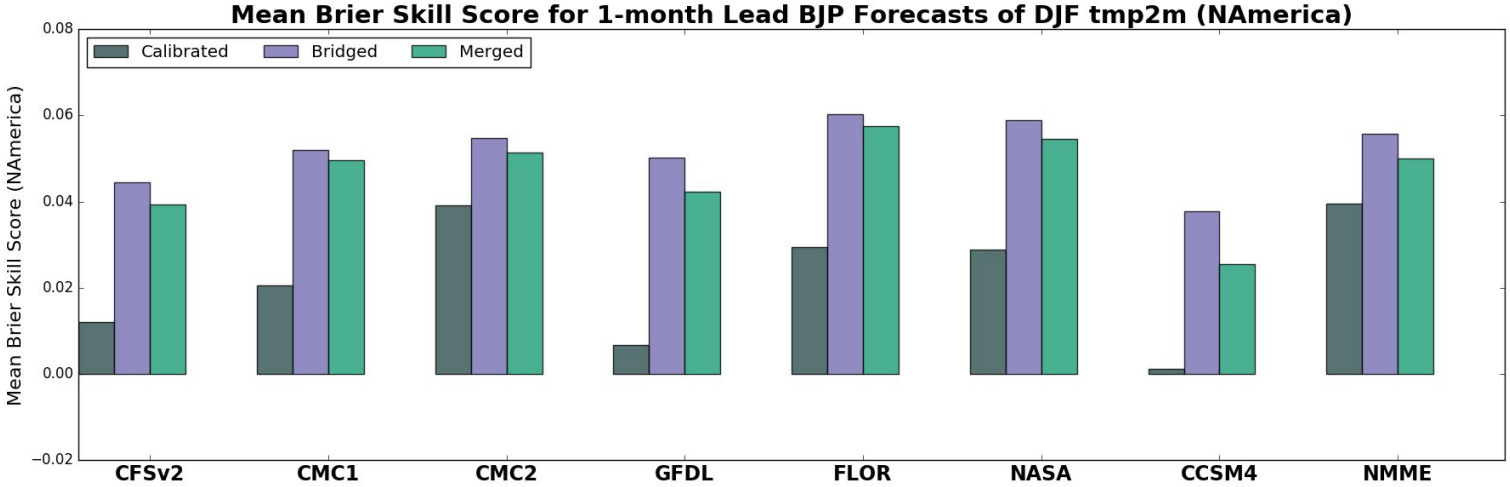
BSS: Lead 1 merged forecasts of DJF 2-m temperature



BSS: Lead 1 calibrated, bridged, and merged forecasts




Mean Brier Skill Score for 1-month Lead BJP Forecasts of DJF tmp2m (NAmerica)
Calibrated
Bridged
Merged
Mean Brier Skill Score (NAmerica)
0.08
0.06
0.04
0.02
0.00
−0.02
CFSv2
CMC1
CMC2
GFDL
FLOR
NASA
CCSM4
NMME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Mean Brier Skill Score (NAmerica)
0.08
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CFSv2
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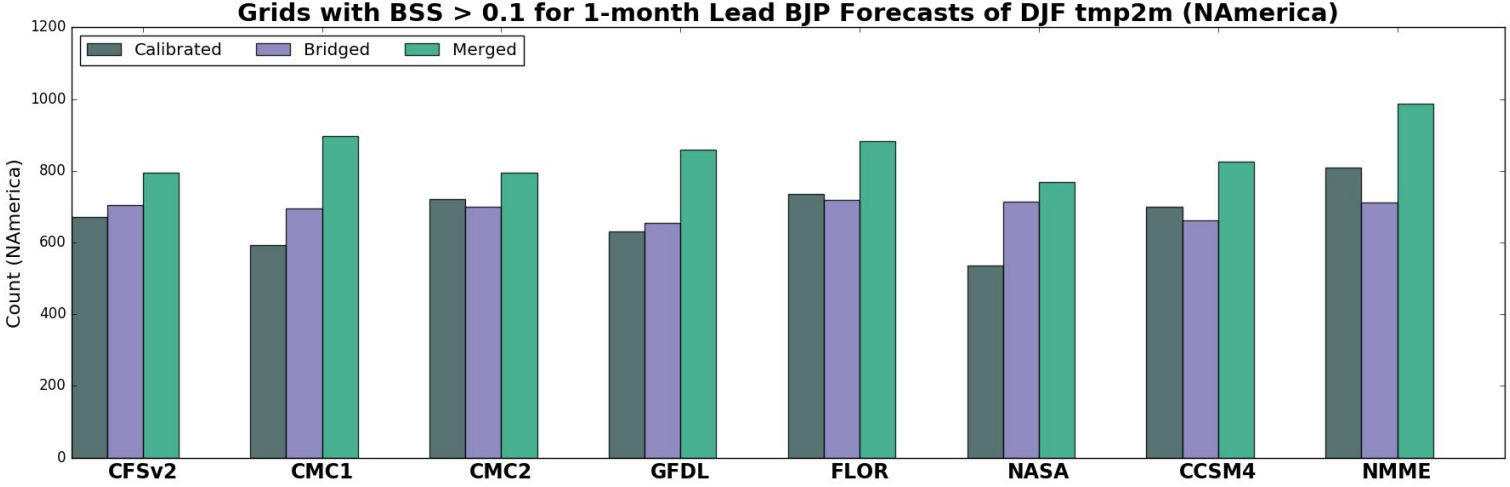
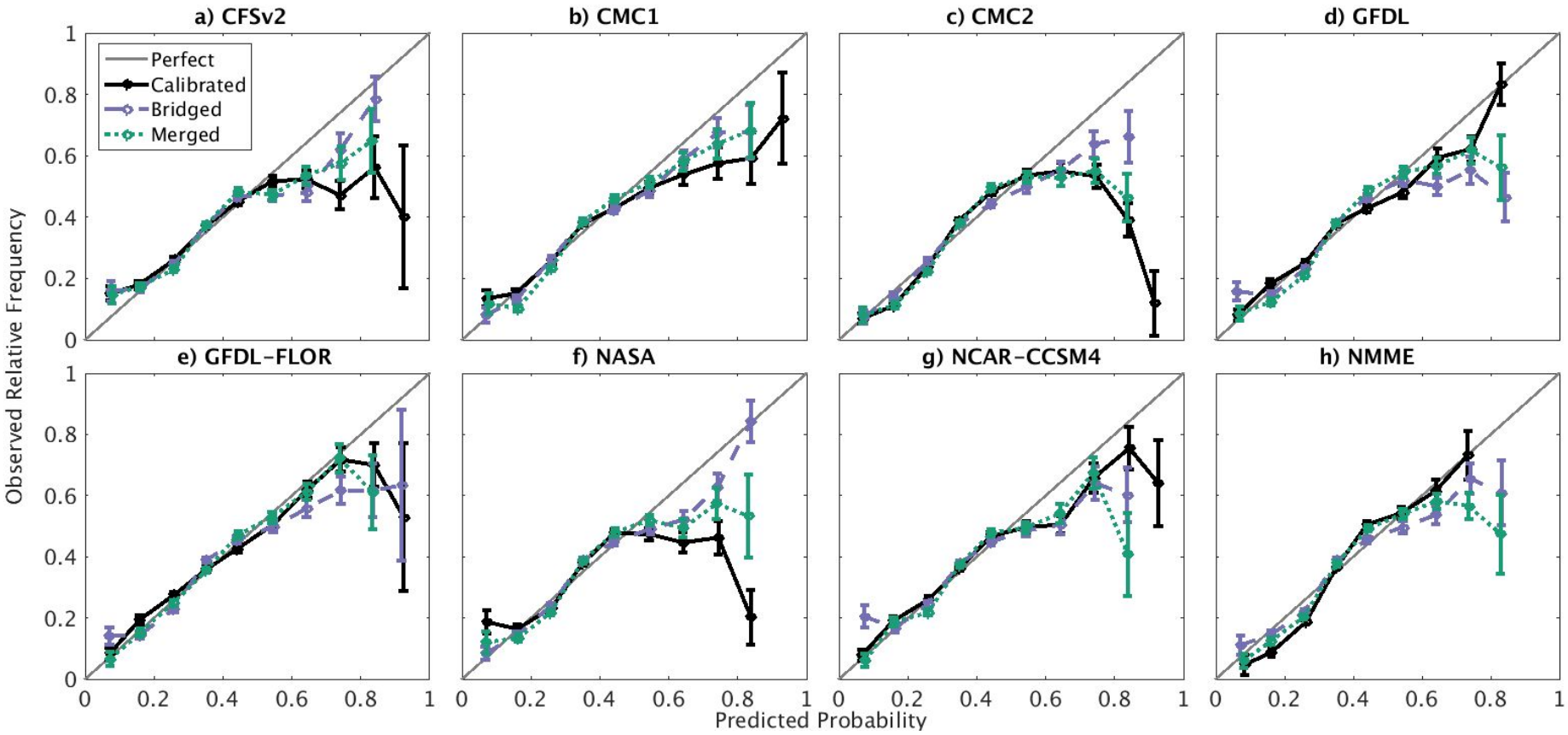
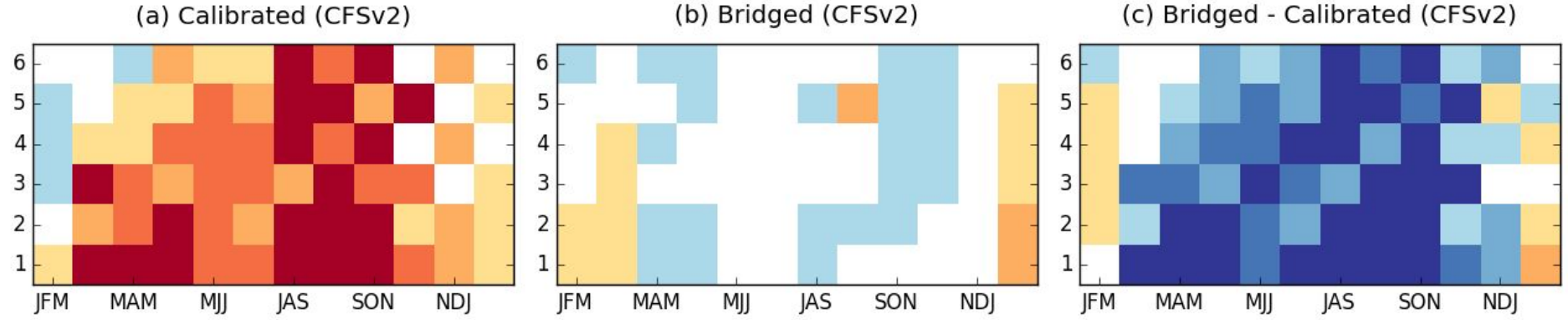

Grids with BSS > 0.1 for 1-month Lead BJP Forecasts of DJF tmp2m (NAmerica)
Calibrated
Bridged
Merged
Count (NAmerica)
1200
1000
800
600
400
200
0
CFSv2
CMC1
CMC2
GFDL
FLOR
NASA
CCSM4
NMME

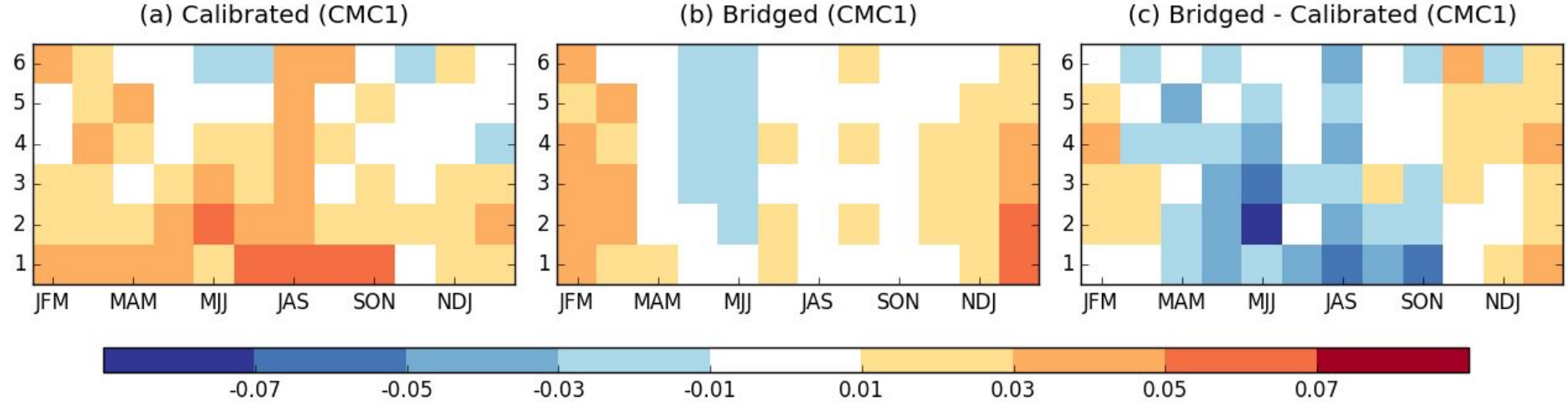
Reliability: Lead 1 forecasts of DJF 2-m temperature



Brier Skill Score: Probabilistic forecasts of below normal US + AK 2-m Temperature (CFSv2)



Brier Skill Score: Probabilistic forecasts of below normal US + AK 2-m Temperature (CMC1)



Summary

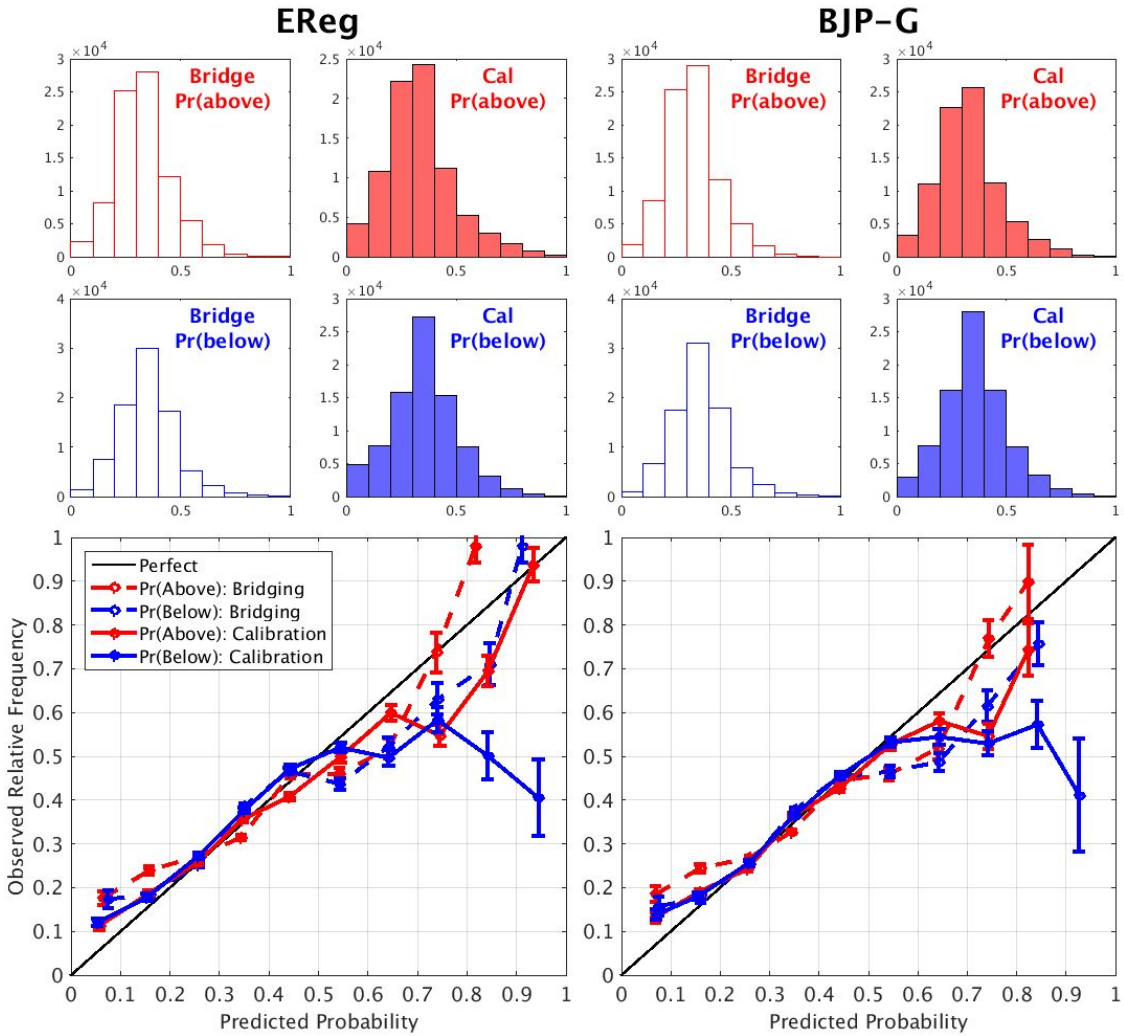
- We compared calibrated, bridged and merged NMME forecasts of North American 2-m temperature
  - We generated individual calibration and bridging models for each NMME member (ensemble mean), season, lead, and grid point
  - Bayesian joint probability modeling was used to establish bridging and calibration models using
    - Either **NMME reforecast 2-m temperature (calibration)** or the **NMME reforecast Niño 3.4 index (bridging)** as the predictor
    - Observed 2-m temperature as the predictand
  - **Multi-model merging** was implemented via Bayesian model averaging
- Overall, **calibration** yielded higher-skill forecasts relative to **bridging**
  - Exception: DJF, particularly over the northern United States
  - Difference between calibration and bridging skill varies by model
- **Merged** forecasts result in the best *coverage* of skill over North America, but not necessarily the highest skill at individual grid points

Ongoing and future work

- Application to precipitation forecasts
- Testing using real-time forecasts (2012 -- present)
- Exploring additional bridging predictors (e.g., AO/NAO)
- Incorporating all ensemble members
- Application to subseasonal forecasts

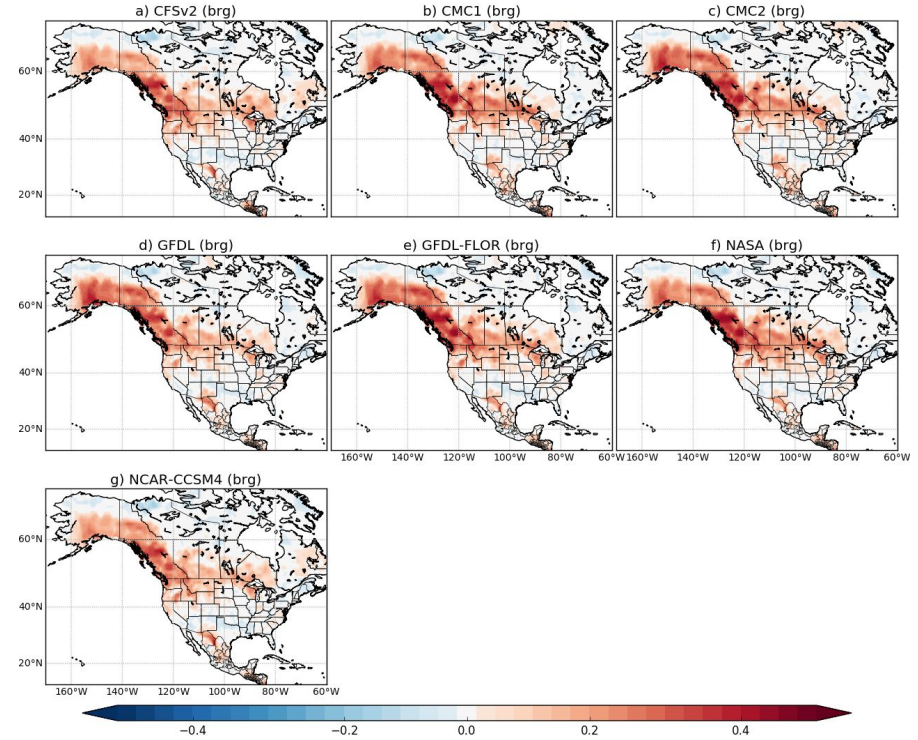
Thank you!

Extras

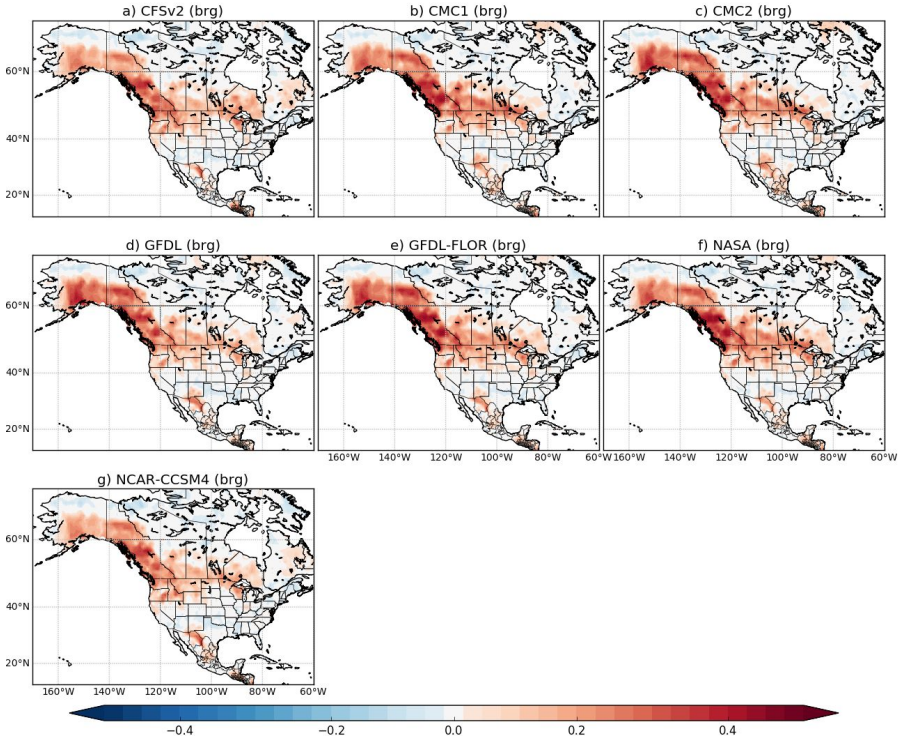


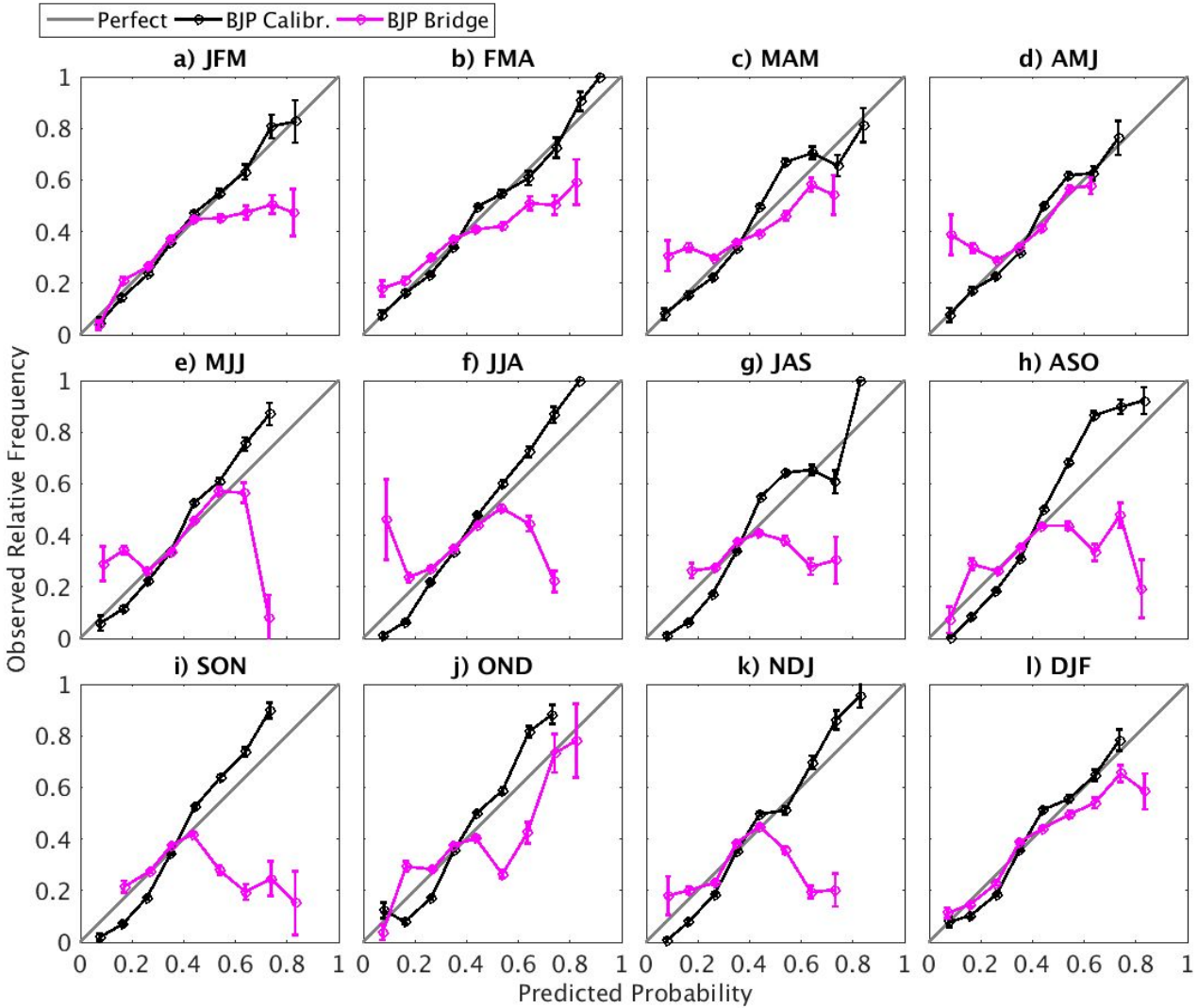
Reliability plots:
1-month lead calibrated and bridged CFSv2 forecasts of DJF 2-m temperature

1-Month Lead DJF Pr(Below normal 2-m T)
EReg Niño 3.4 Bridging

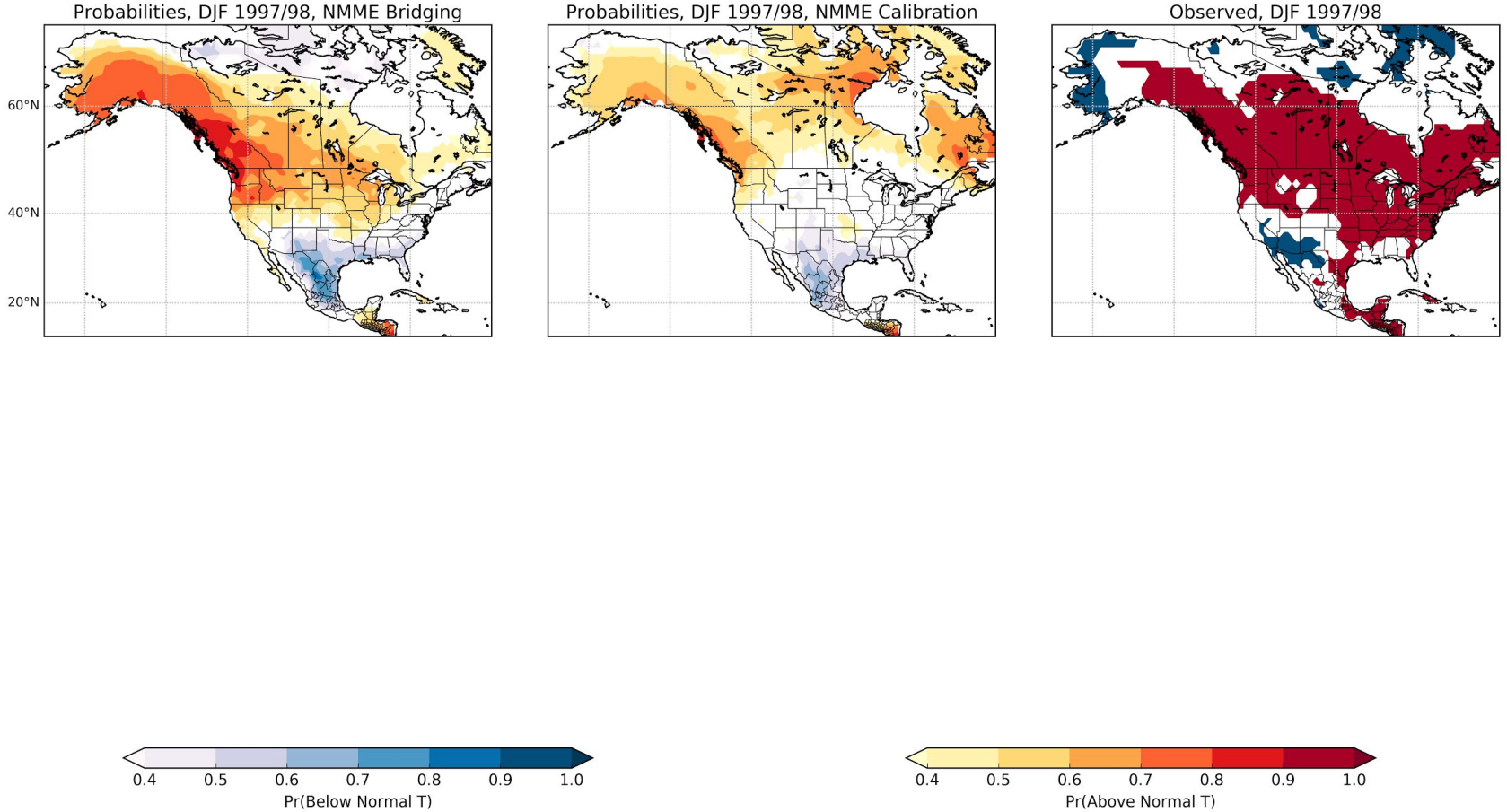


1-Month Lead DJF Pr(Below normal 2-m T)
BJP Niño 3.4 Bridging




Perfect
BJP Calibr.
BJP Bridge
a) JFM
b) FMA
c) MAM
d) AMJ
e) MJJ
f) JJA
g) JAS
h) ASO
i) SON
j) OND
k) NDJ
l) DJF
Observed Relative Frequency
Predicted Probability
0
0.2
0.4
0.6
0.8
1

BJP probabilities of above/below normal temperature



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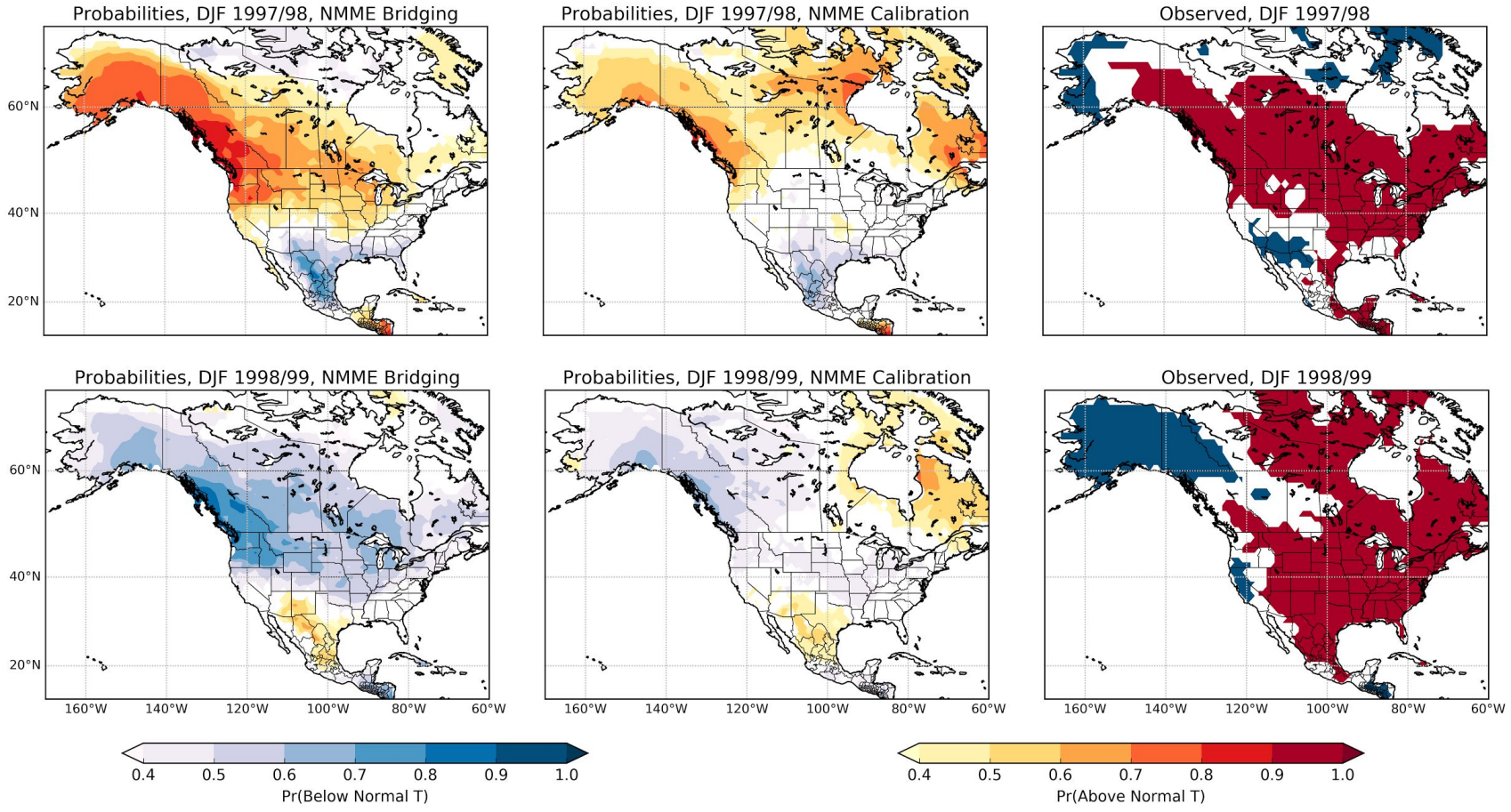

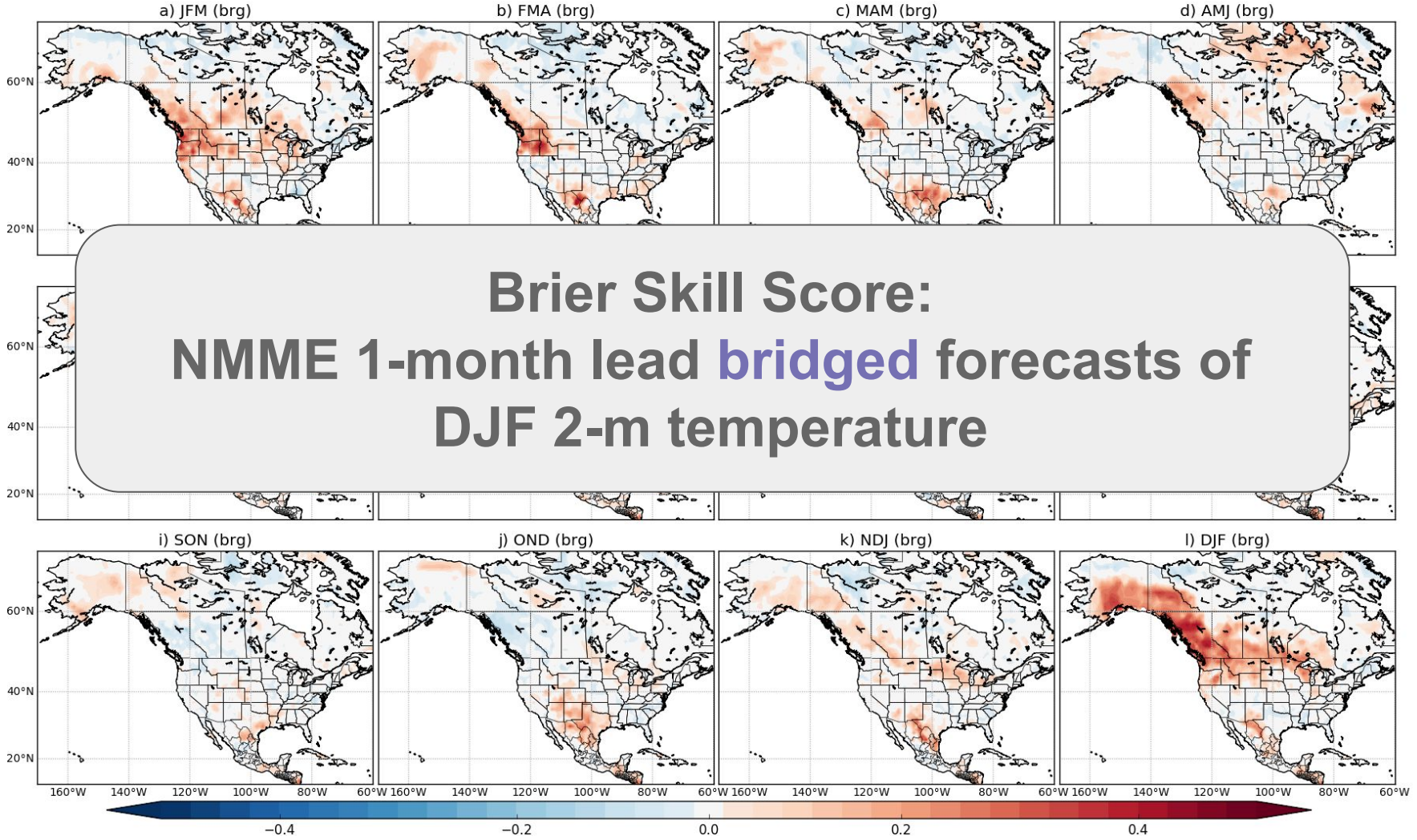

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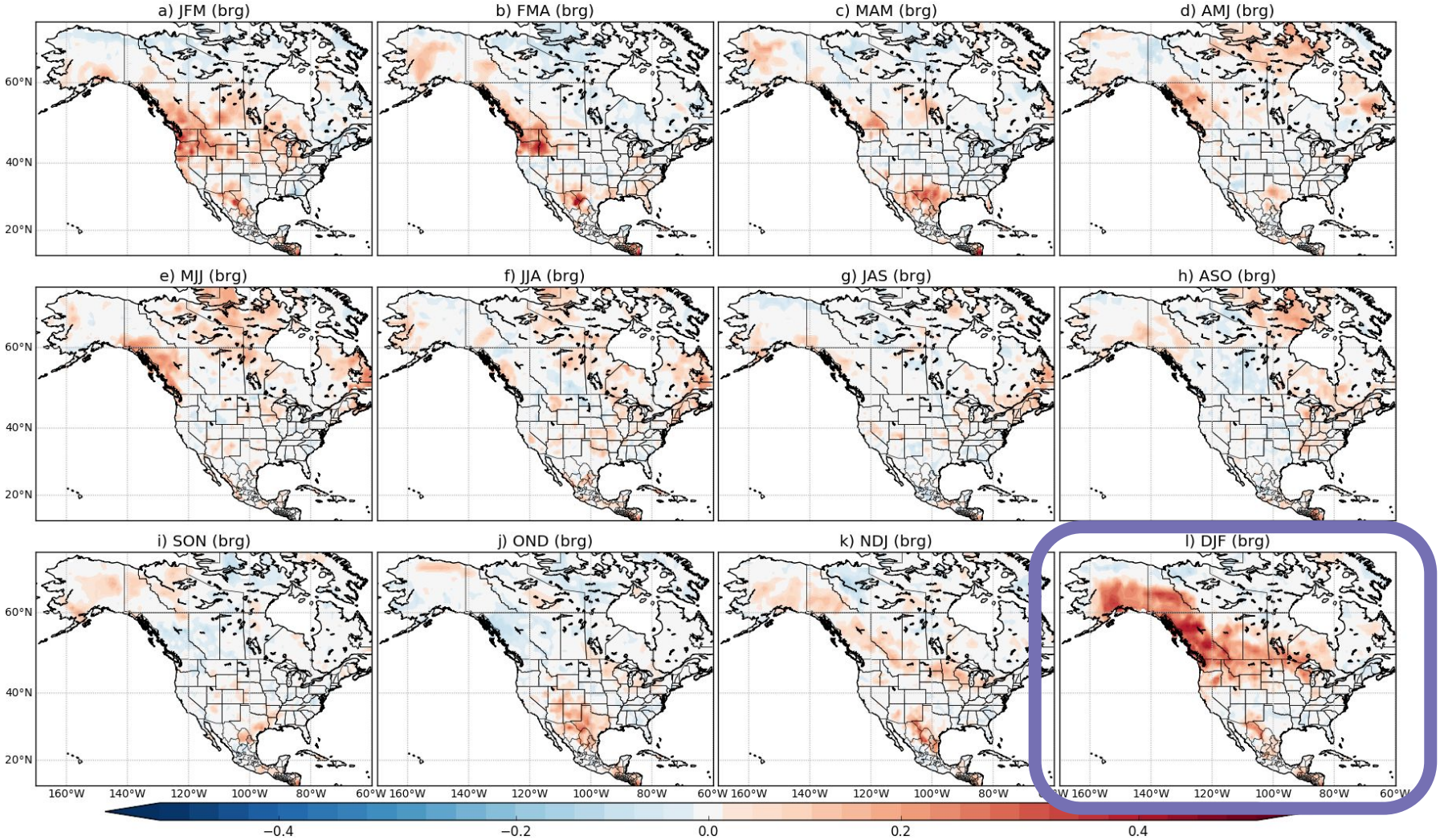
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