Increasing Forecast Skill through Bridging of Climate Teleconnections:

A Hybrid Statistical- Dynamical Prediction System

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MAPP/NGGPS PI Meeting

Calibration, **B**ridging, and **M**erging (CBaM)

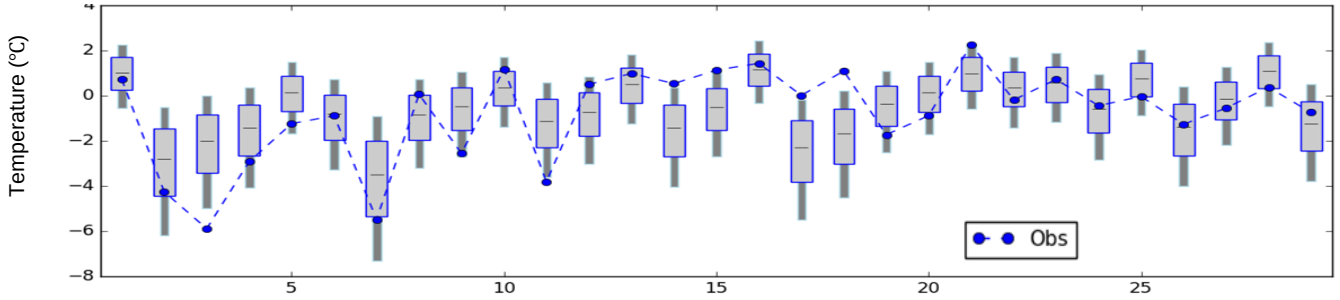
CBaM:

- Developed by CSIRO collaborators
- Application to NMME and North America

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

- Calibration and bridging model uses **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
  - Comparison to **Ensemble Regression (EReg) baseline** used at CPC (Unger et al. 2009)
- 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)



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

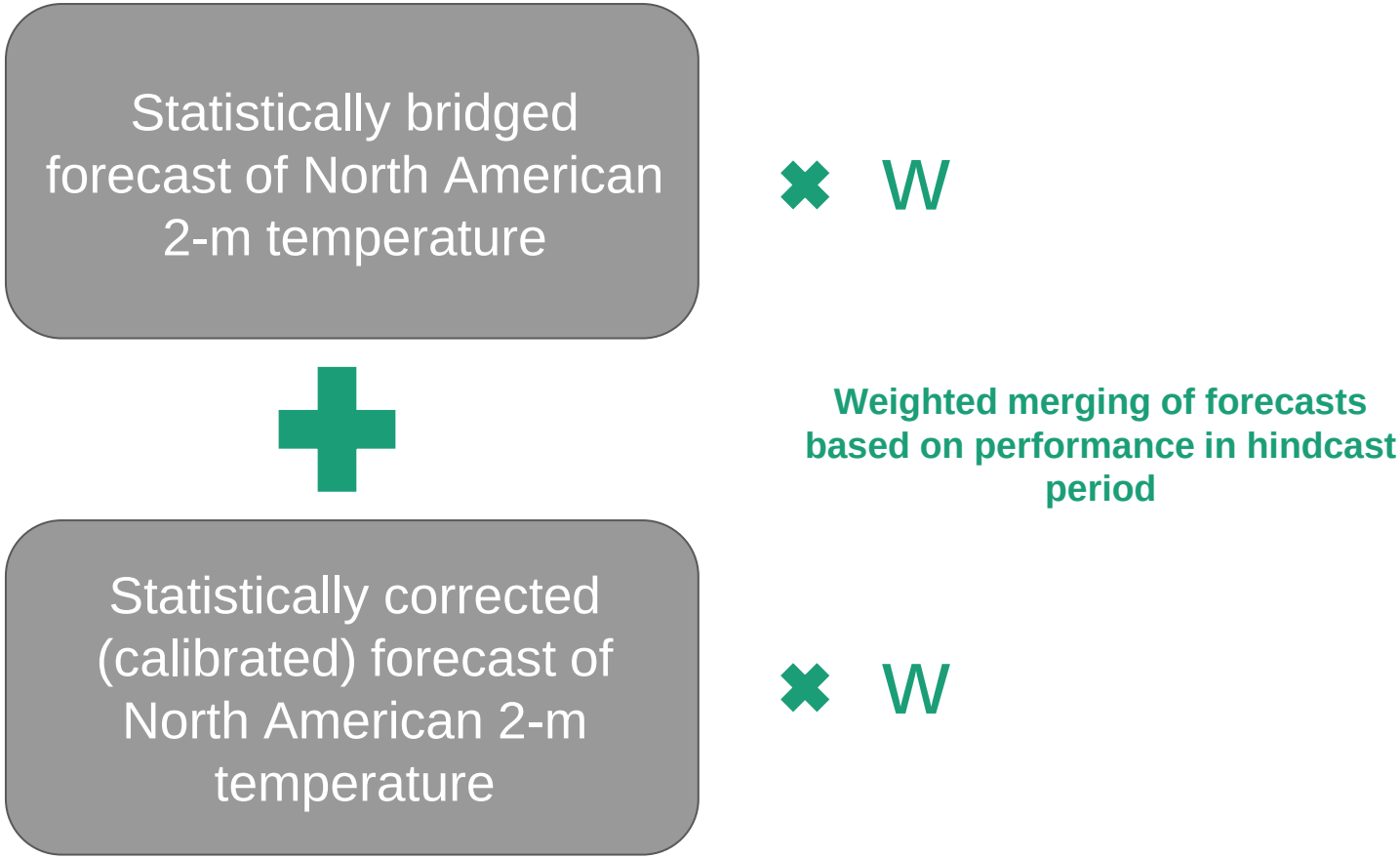
Calibration, **Bridging**, and Merging (CBaM)

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

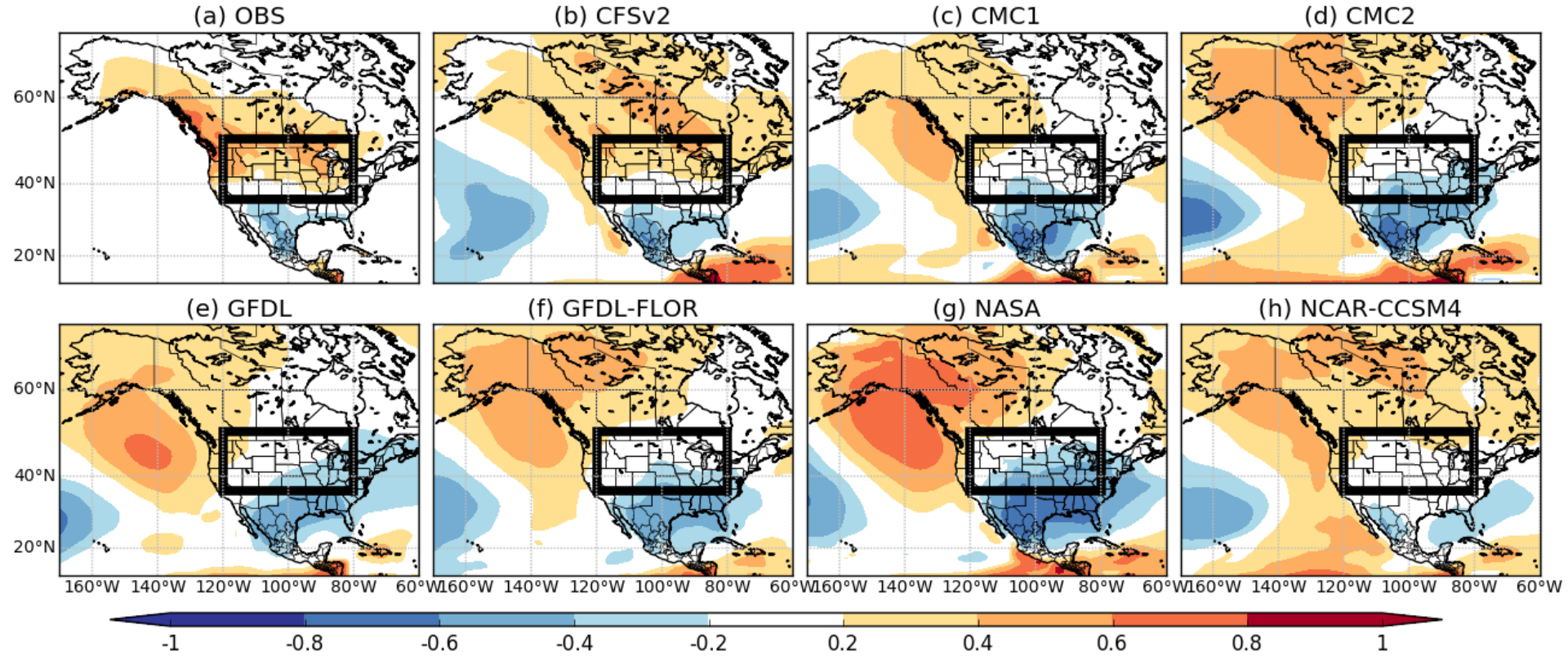
Statistical post-processing

Statistically bridged forecast of North American 2-m temperature

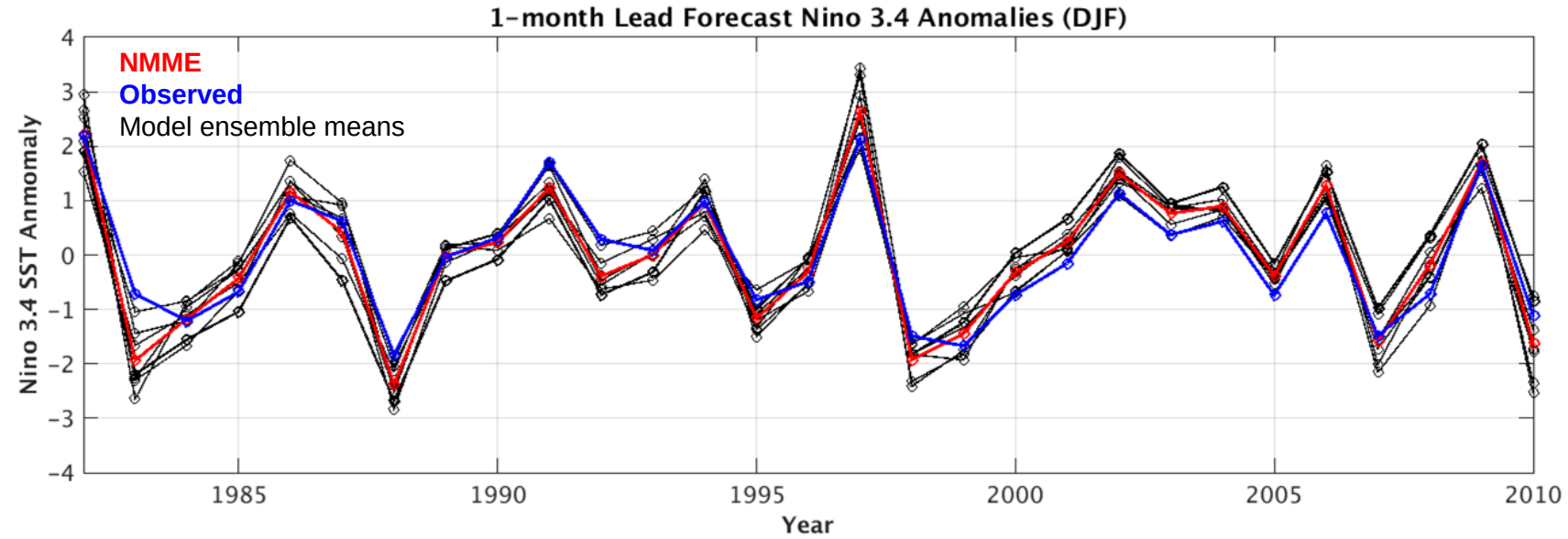
Calibration, Bridging, and **Merging** (CBaM)



Differences in model & observed Nino 3.4 correlation pattern



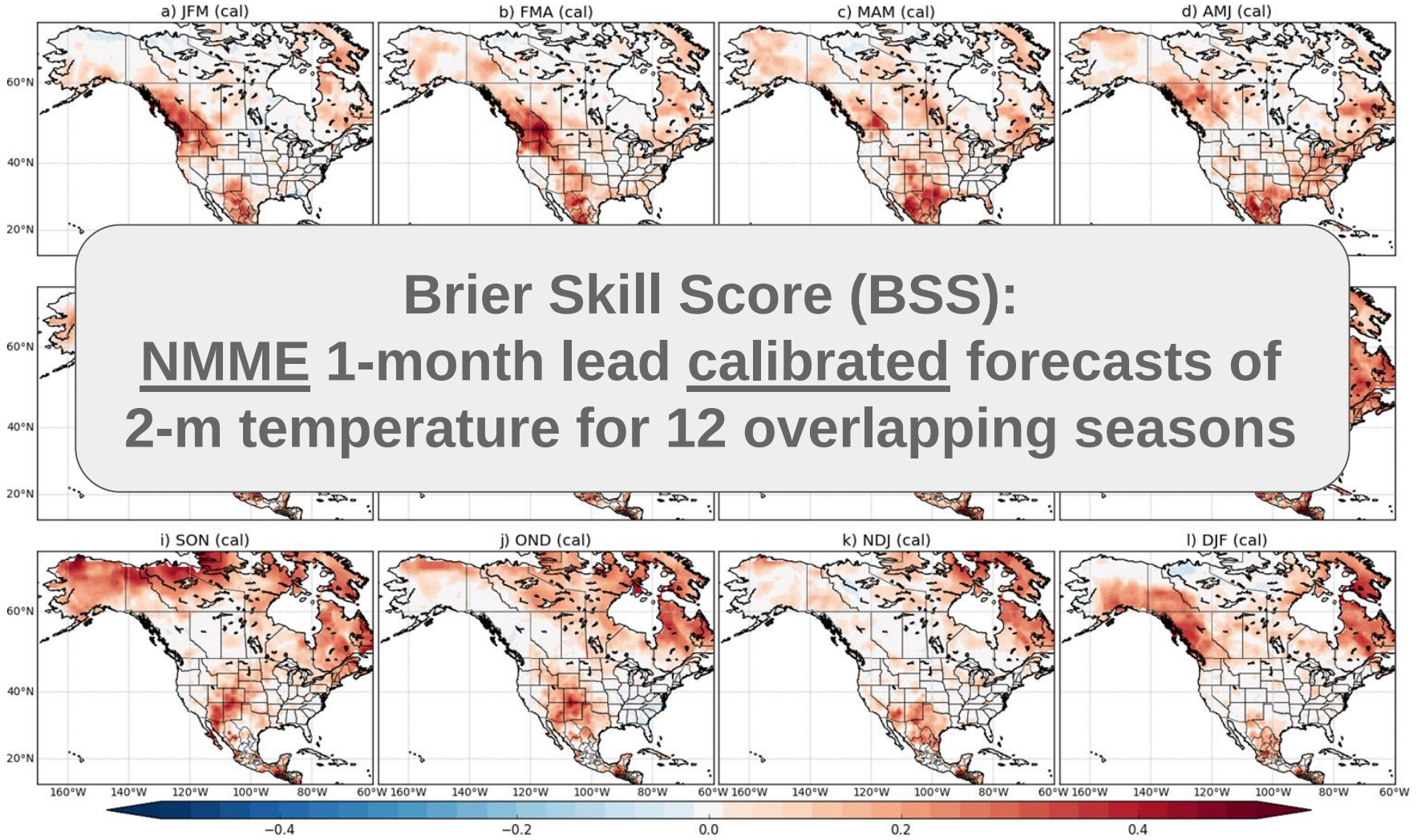
Skill in forecasts of large-scale climate indices



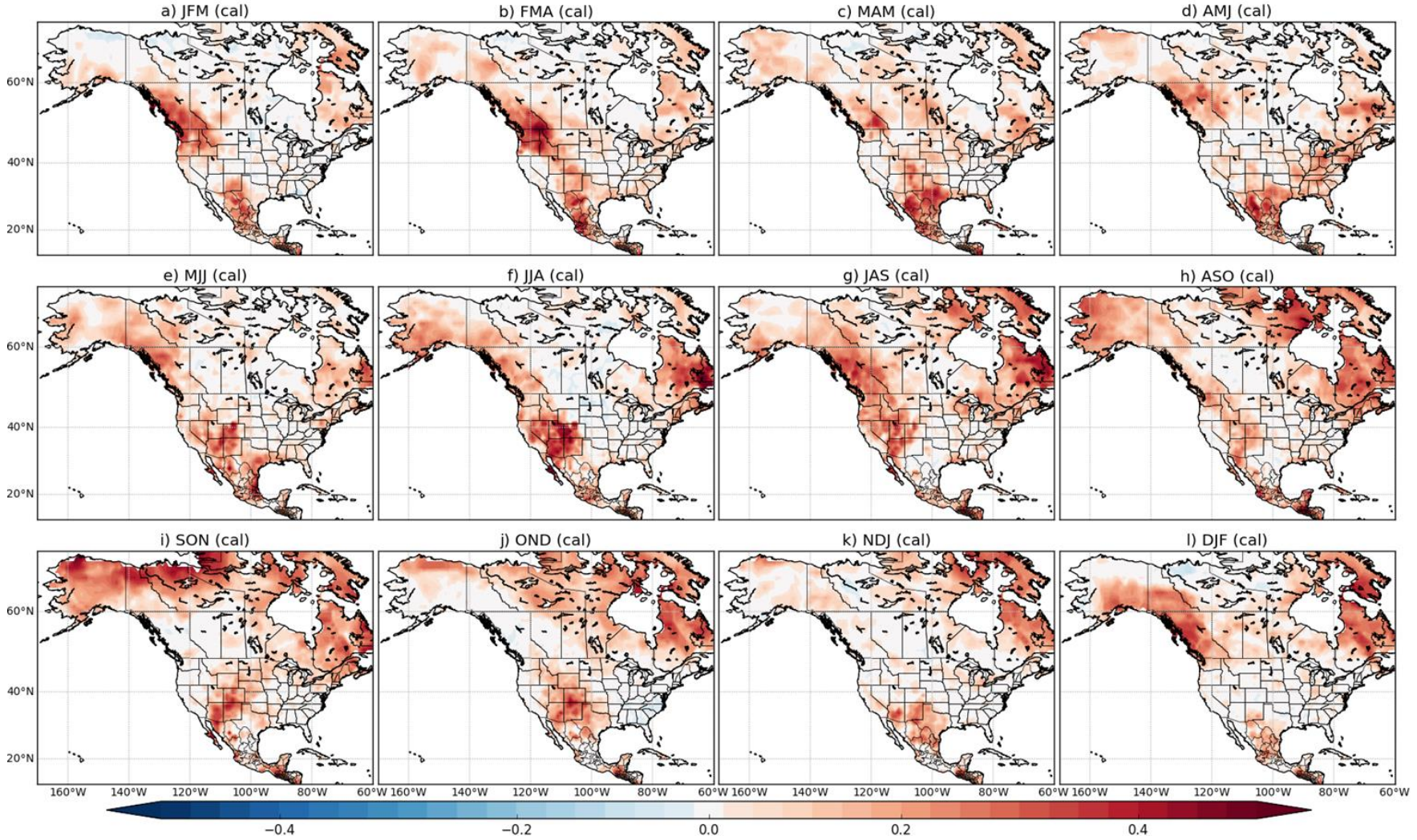
	CFSv2	CMC1	CMC2	GFDL	FLOR	NASA	CCSM4	NMME
Correlation w/obs	0.86	0.96	0.96	0.92	0.94	0.95	0.88	0.95

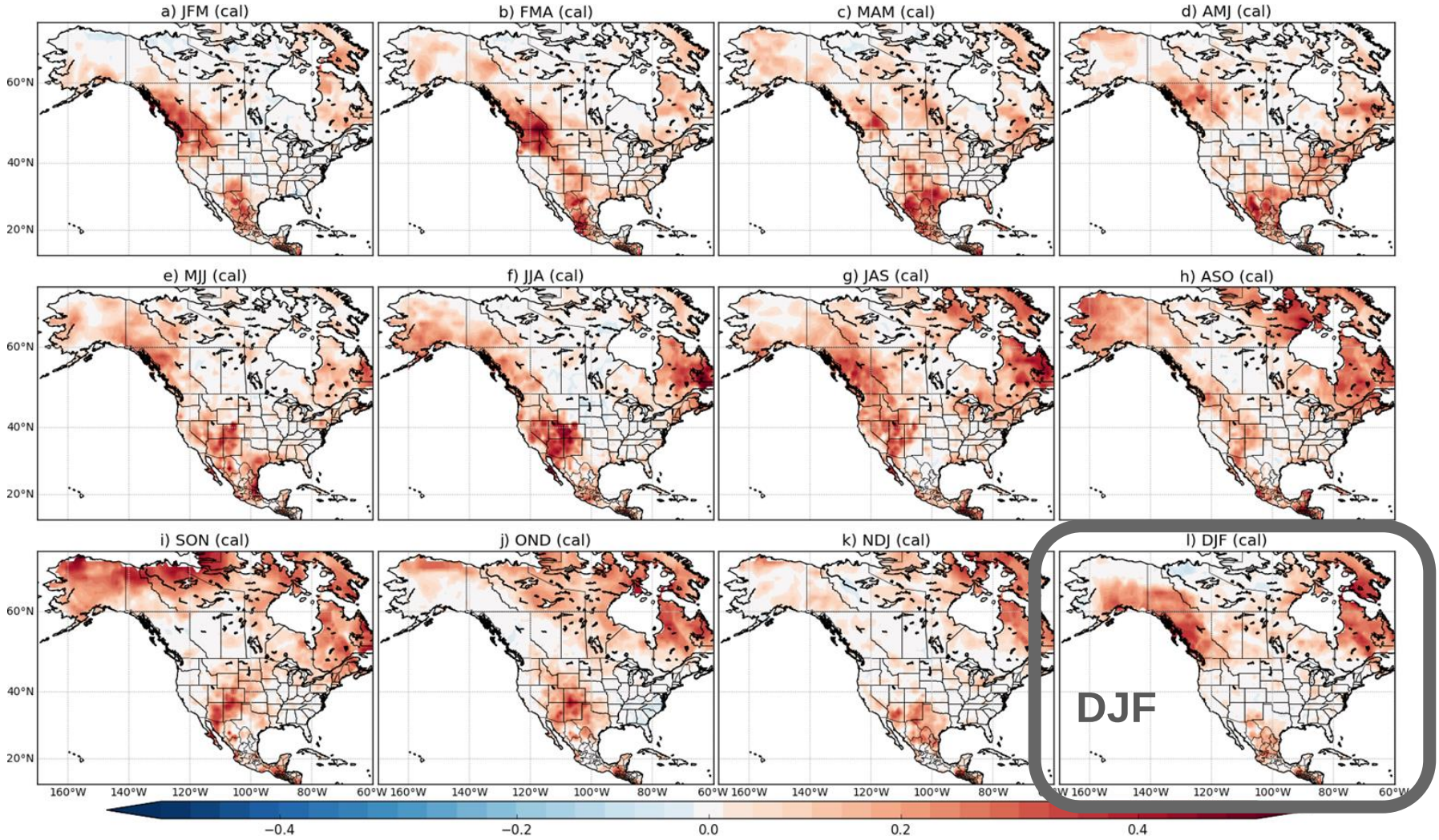
Objective

- **Question**: Does statistical **bridging** using climate indices improve forecast skill, beyond the skill of **calibrated** model forecasts of temperature and precipitation?



Brier Skill Score (BSS):
NMME 1-month lead calibrated forecasts of 2-m temperature for 12 overlapping seasons


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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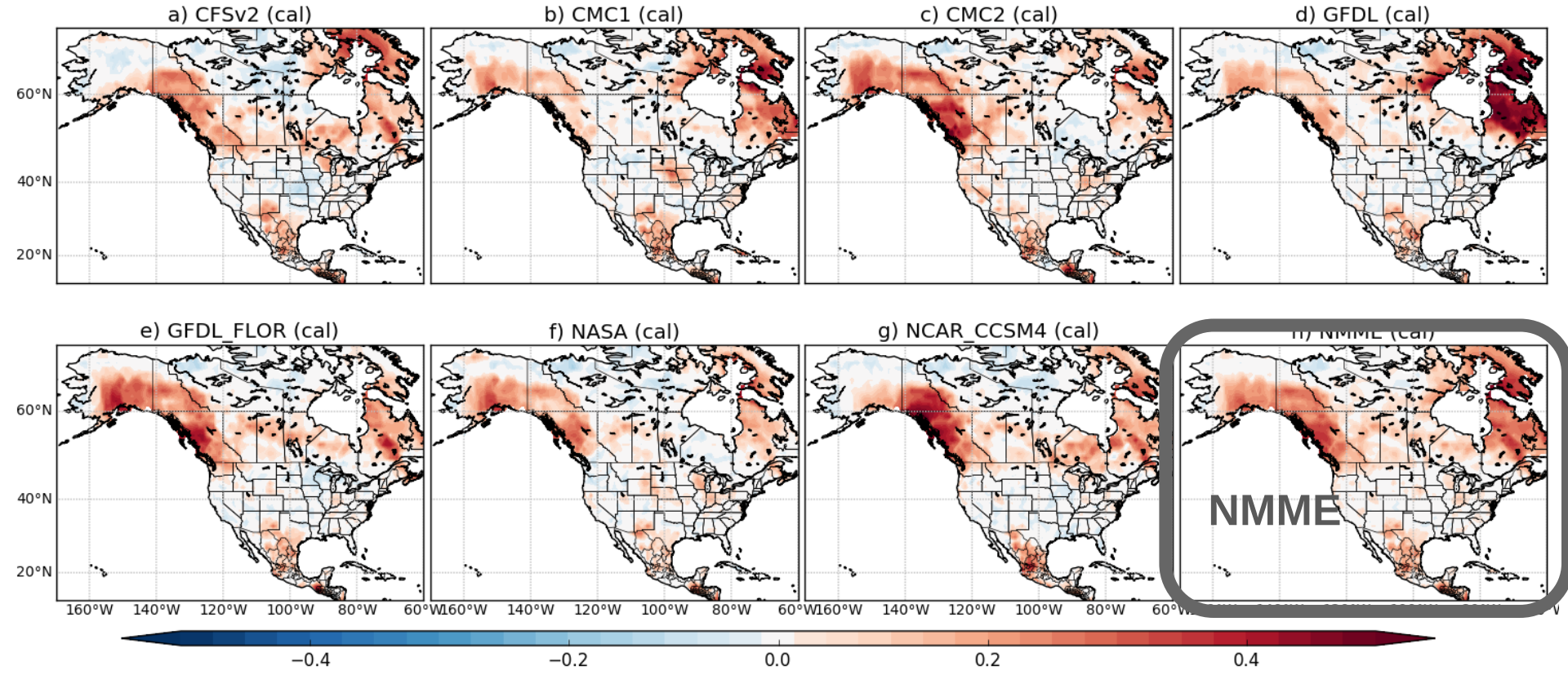
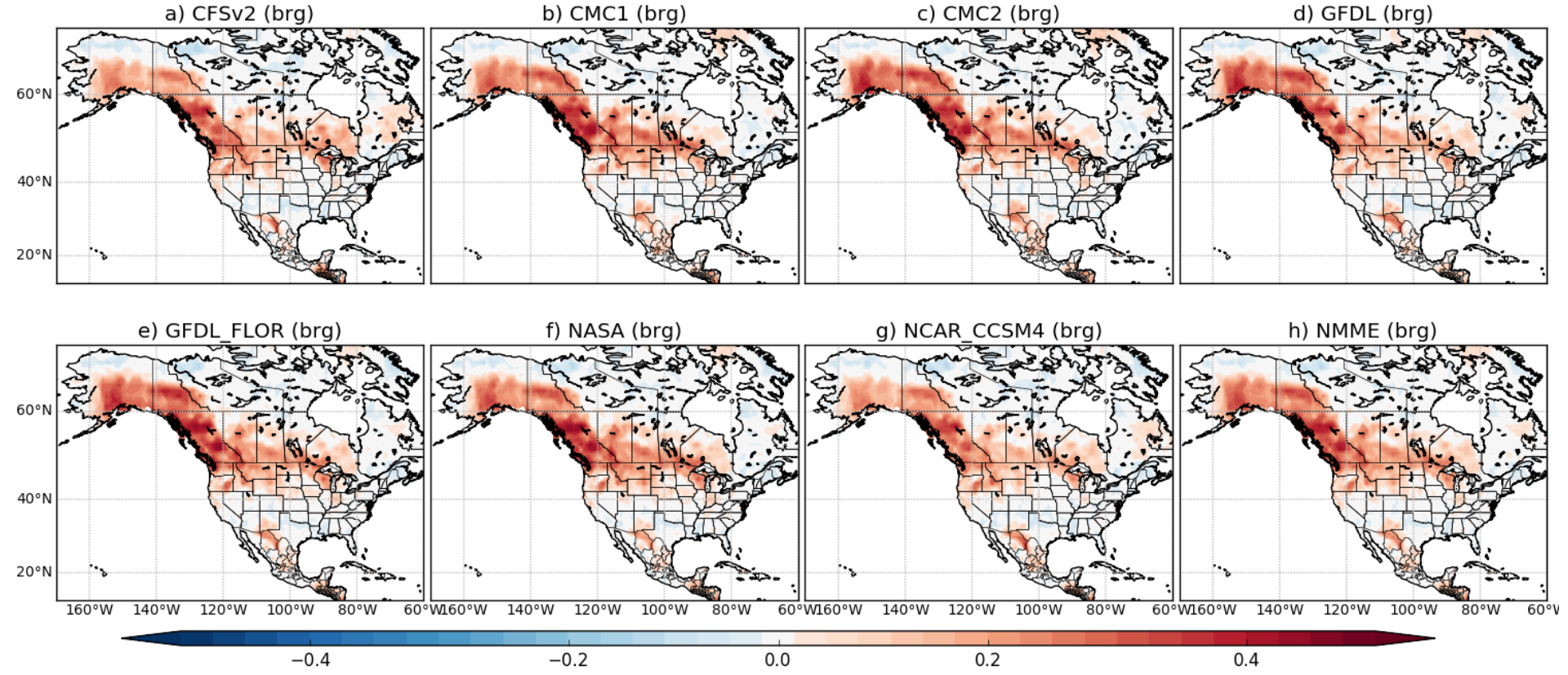
g) JAS (cal)
h) ASO (cal)
i) SON (cal)
j) OND (cal)
k) NDJ (cal)
l) DJF (cal)
DJF
60°N
40°N
20°N
160°W
140°W
120°W
100°W
80°W
60°W
−0.4
−0.2
0.0
0.2
0.4

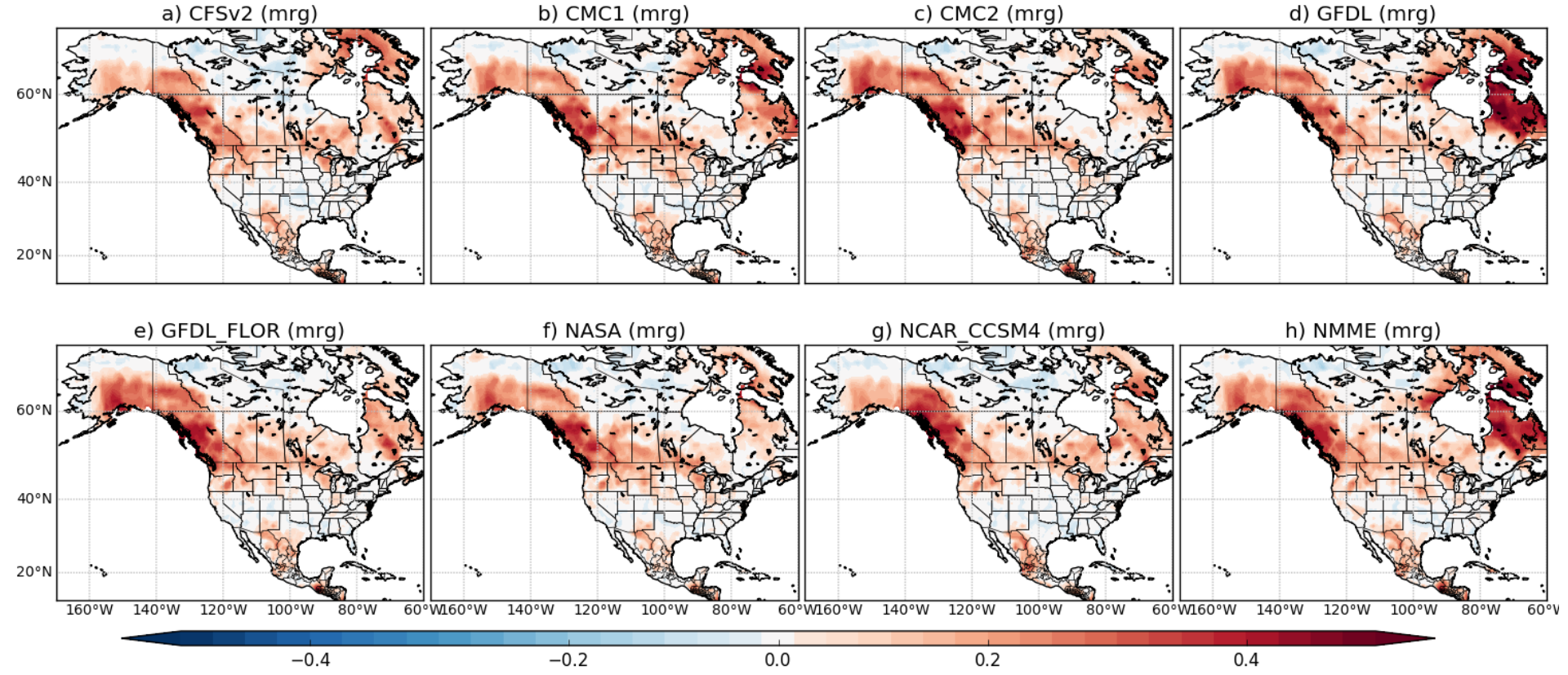
BSS: Model calibrated forecasts of DJF 2-m temperature



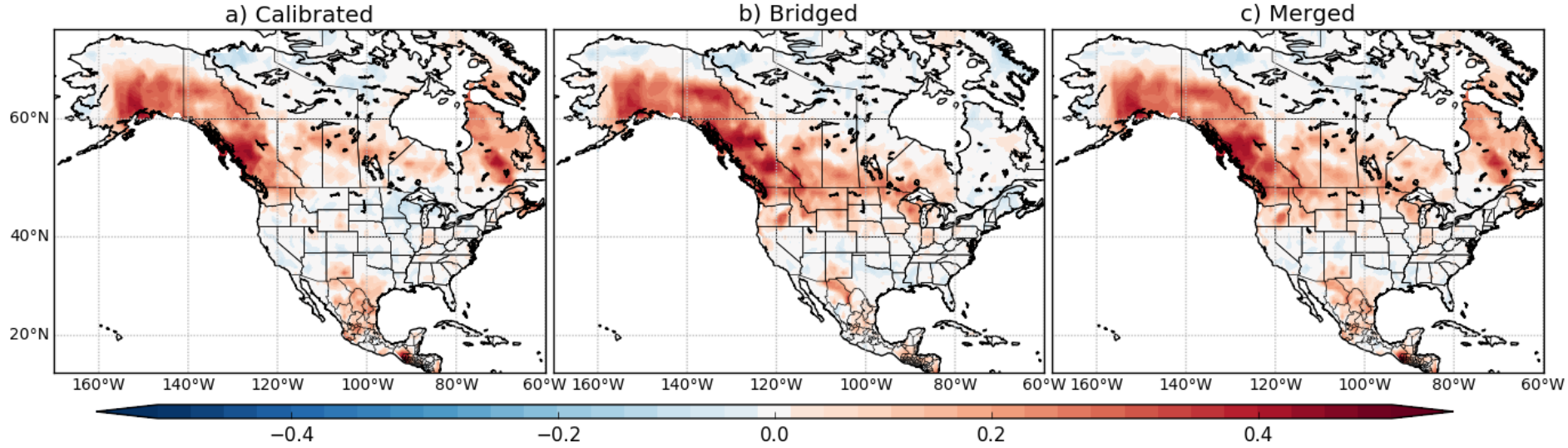
BSS: Lead 1 bridged forecasts of DJF 2-m temperature

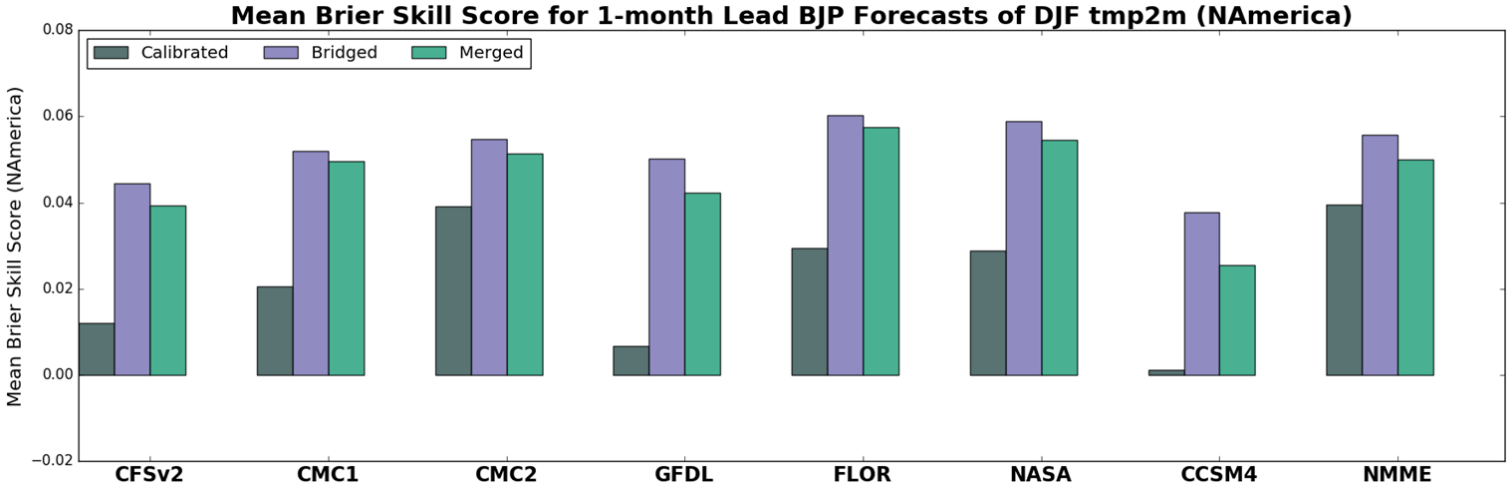


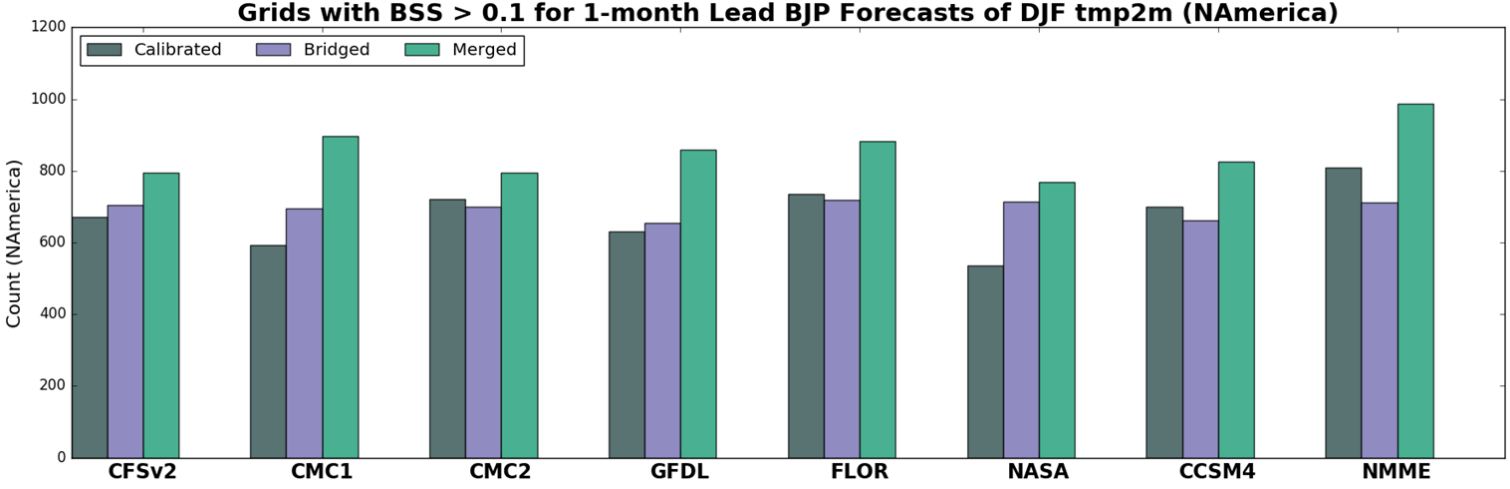
BSS: Lead 1 merged forecasts of DJF 2-m temperature

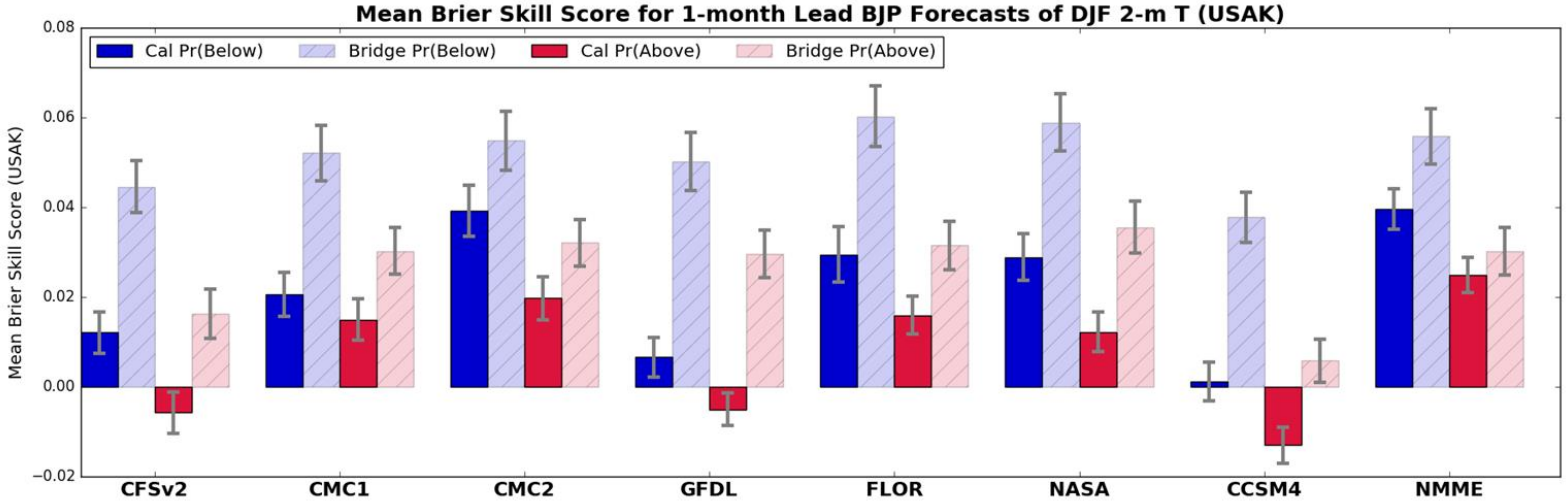


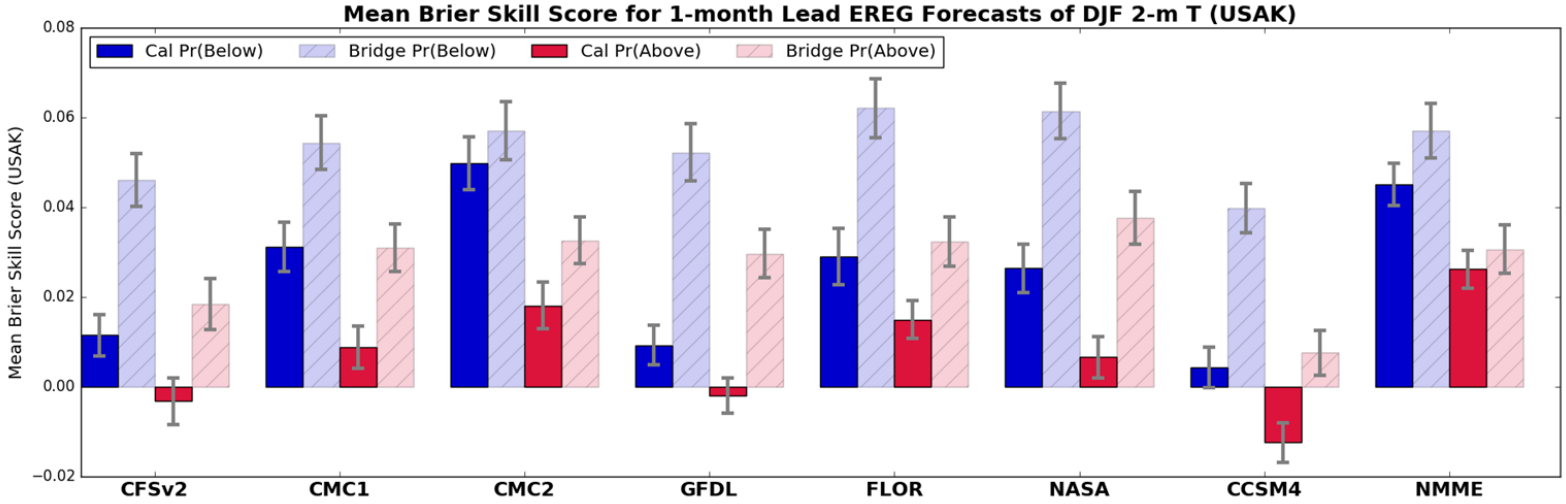
BSS: NMME calibrated, bridged, & merged forecasts




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


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



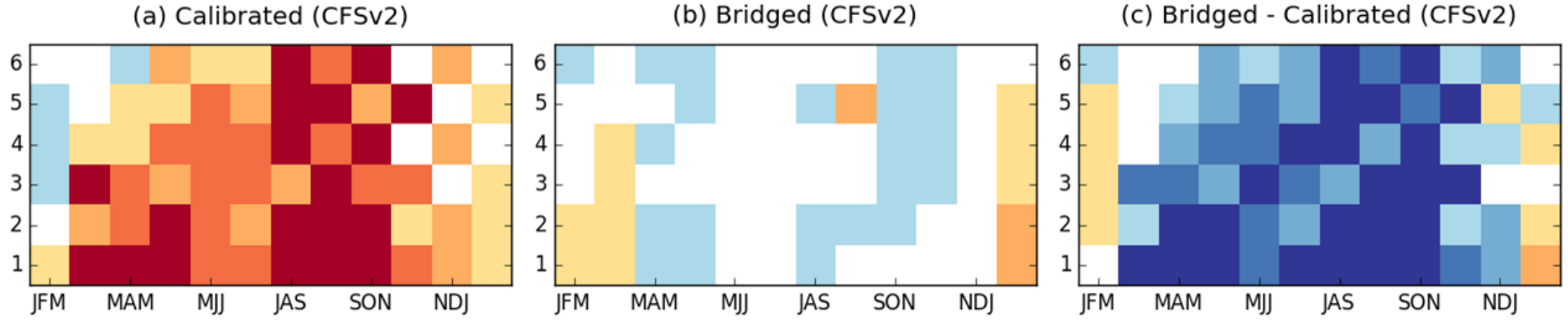


Bayesian Joint Probability

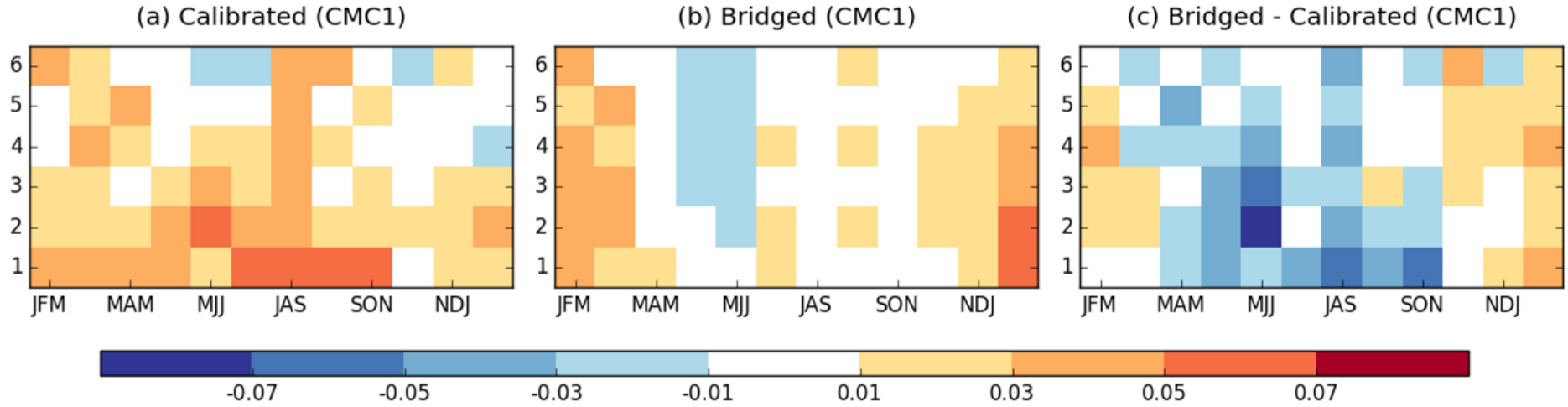
2-m Temperature

Ensemble Regression

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

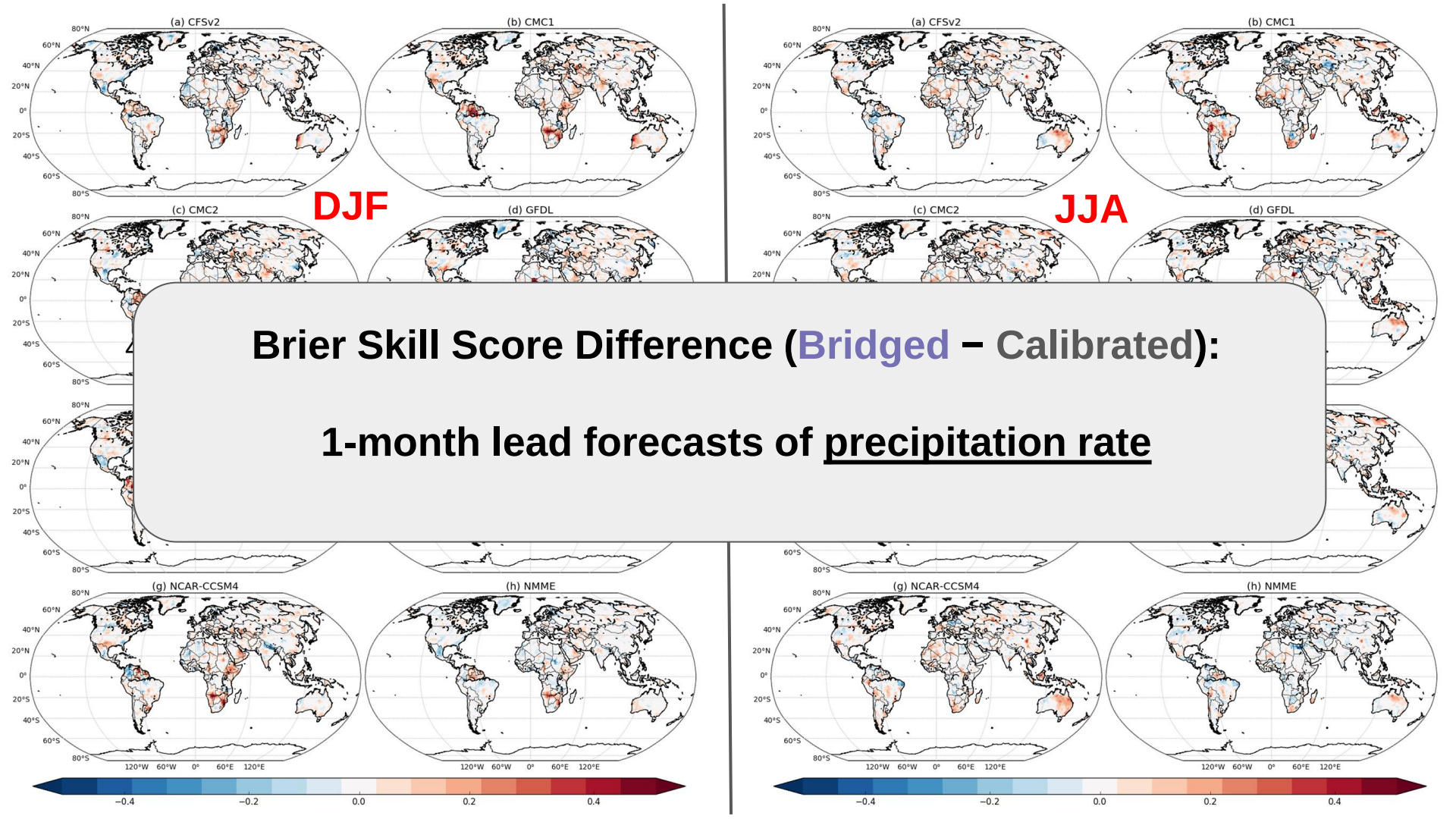


Brier Skill Score: Probabilistic forecasts of below normal US + AK 2-m Temperature (CMC1)



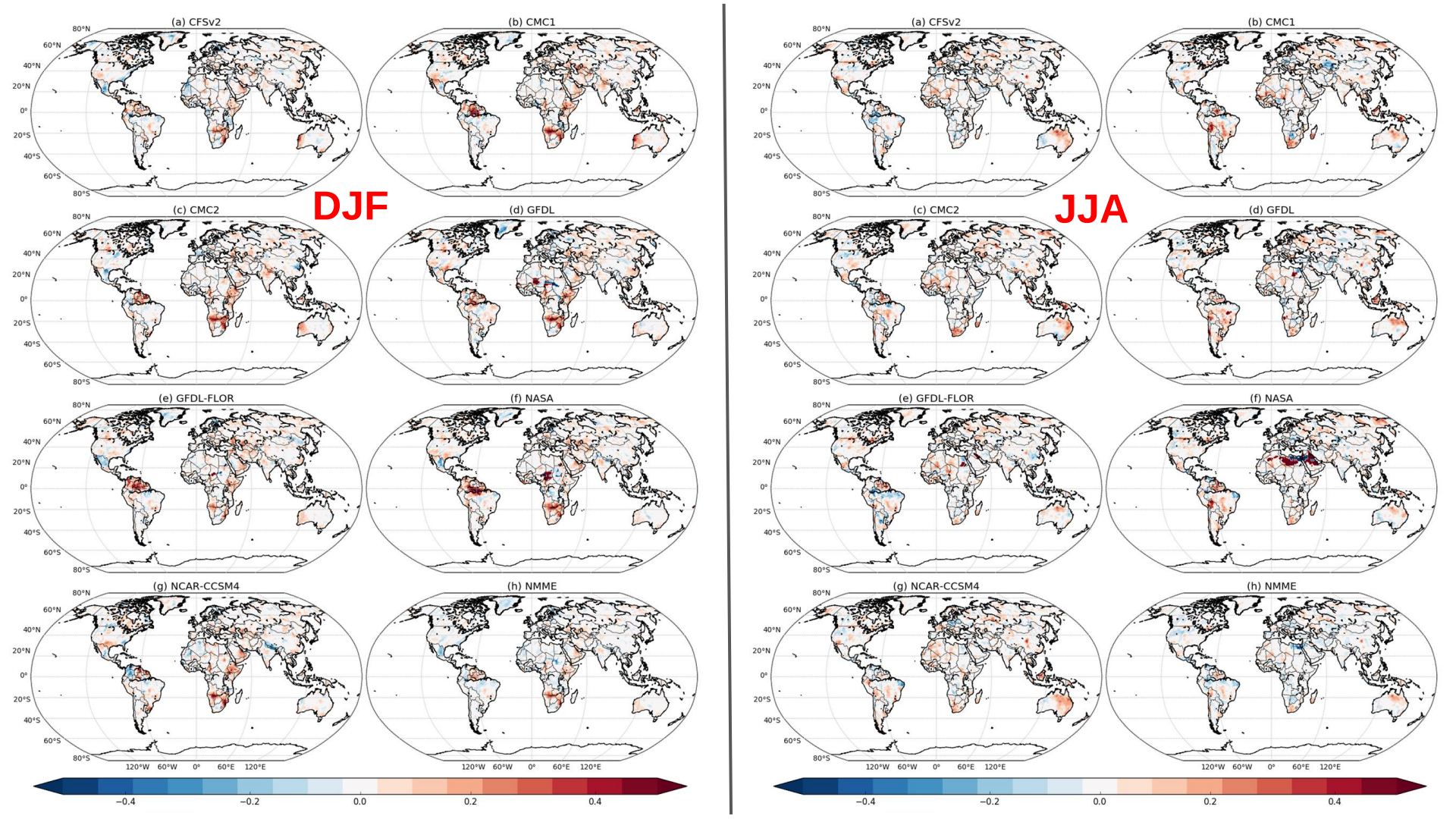
Precipitation bridging

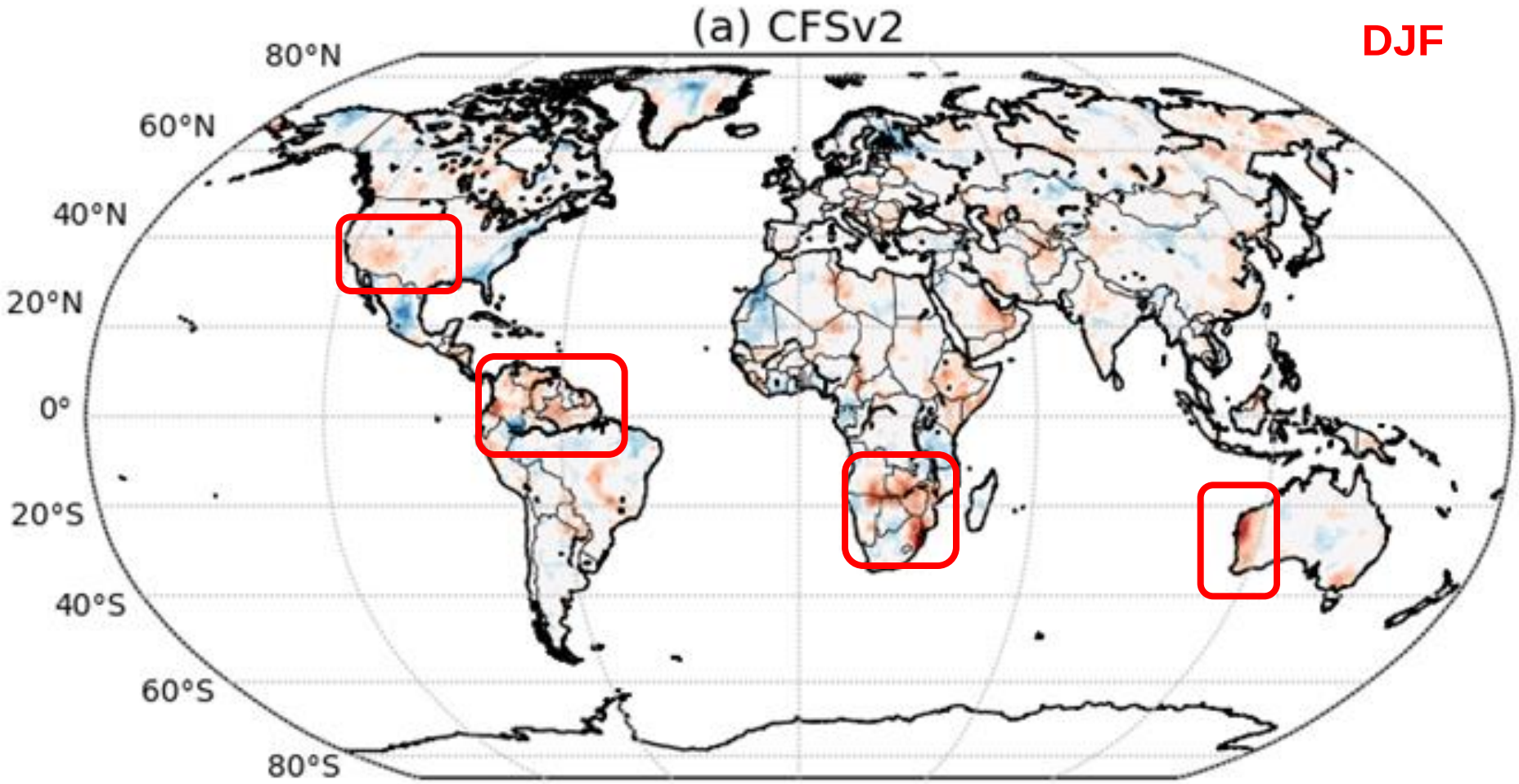
- Can lower skill of precipitation forecasts be enhanced by bridging?

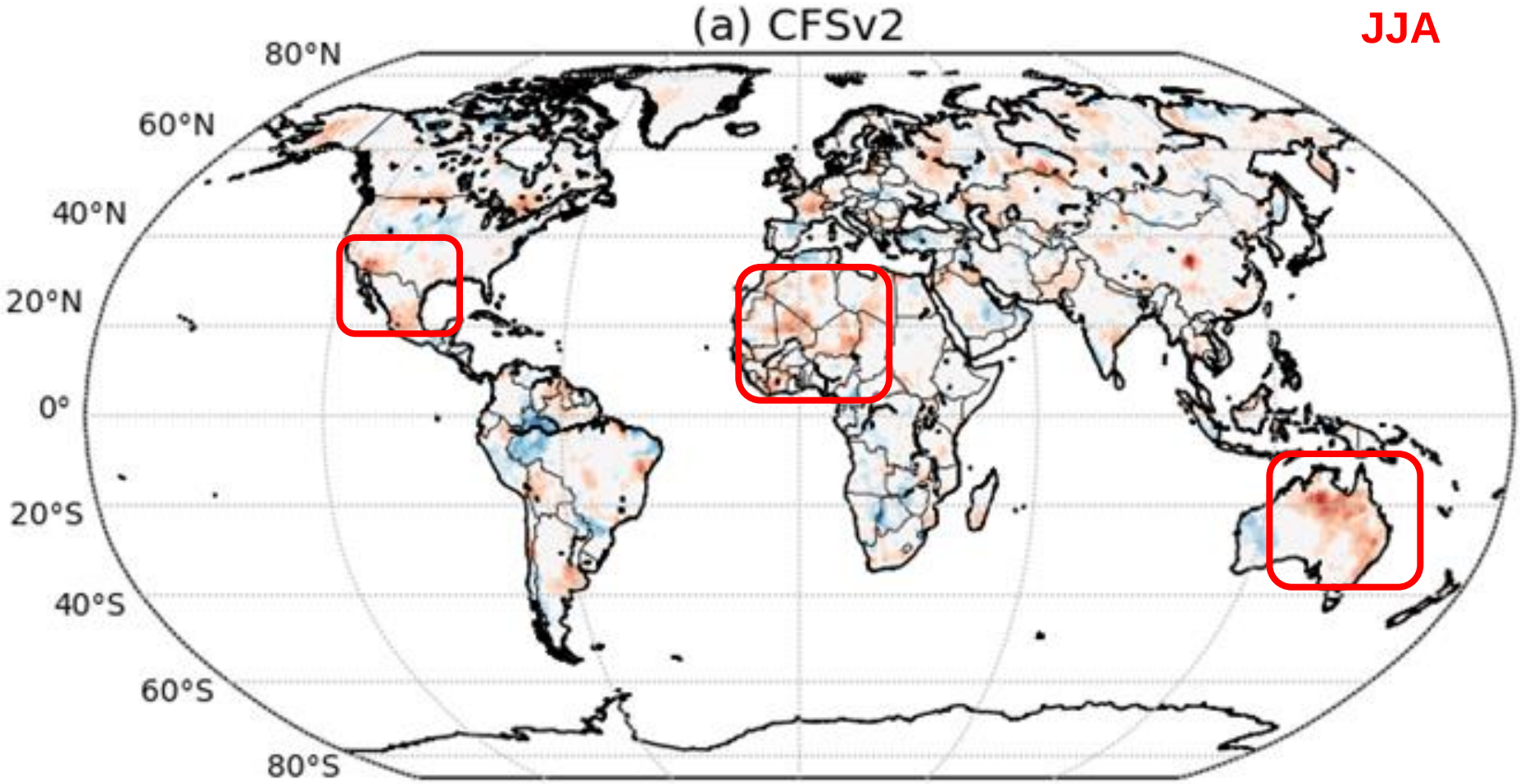


Brier Skill Score Difference (Bridged − Calibrated):

1-month lead forecasts of precipitation rate


DJF
JJA
(a) CFSv2
(b) CMC1
(c) CMC2
(d) GFDL
(e) GFDL-FLOR
(f) NASA
(g) NCAR-CCSM4
(h) NMME
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S
120°W 60°W 0° 60°E 120°E
−0.4 −0.2 0.0 0.2 0.4


(a) CFSv2
DJF
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S


(a) CFSv2
JJA
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S

Conclusions

- On average, **calibrated forecasts** are greater skill relative to Nino 3.4 **bridging**
- **Bridging** models provide greater skill *in particular seasons and regions*
  - Example: Winter temperatures, over the northern United States
- **Bridging** skill and enhancement of **calibrated forecasts** varies by model
- **Merged** forecasts result in ***the most coverage of positive skill***.

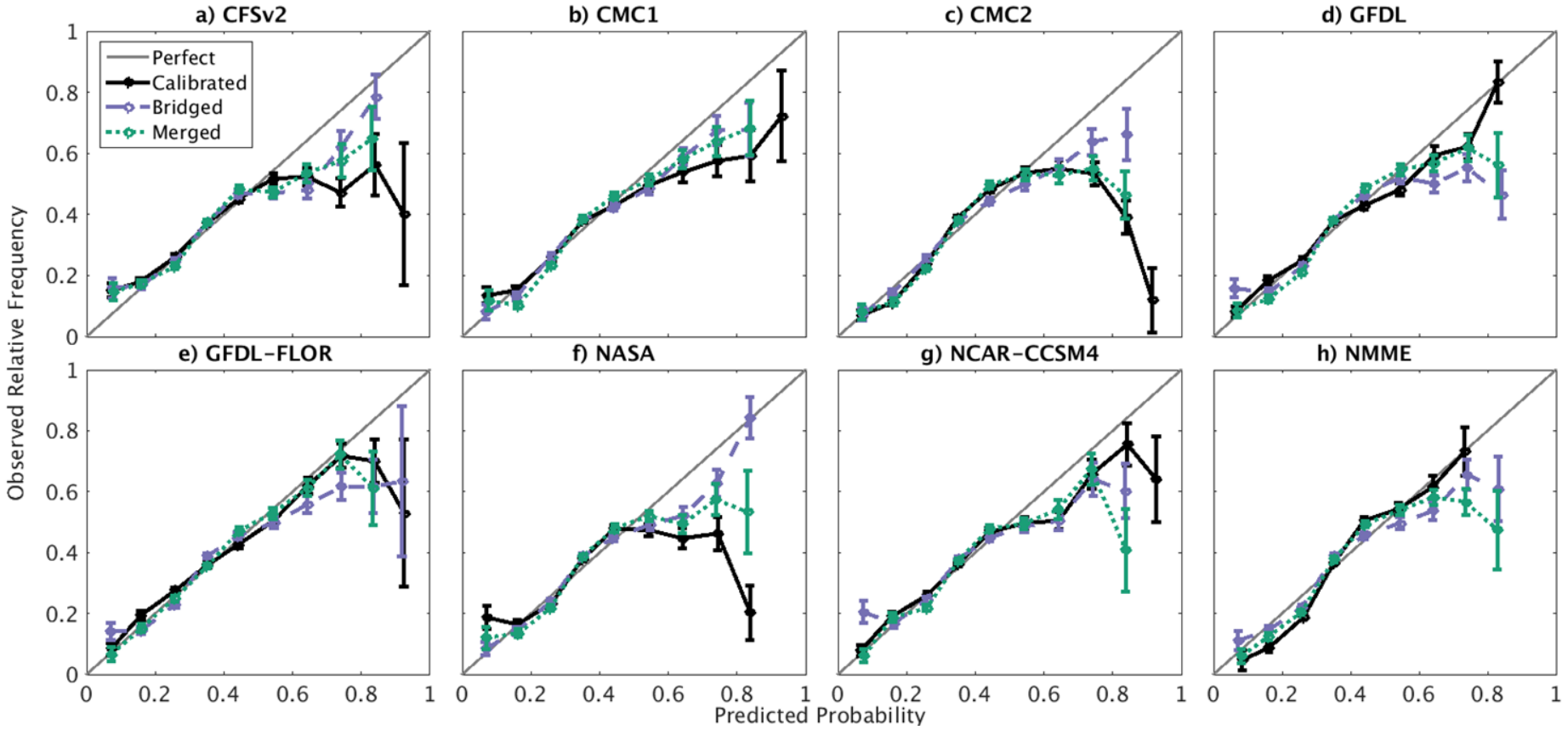
Ongoing and future work

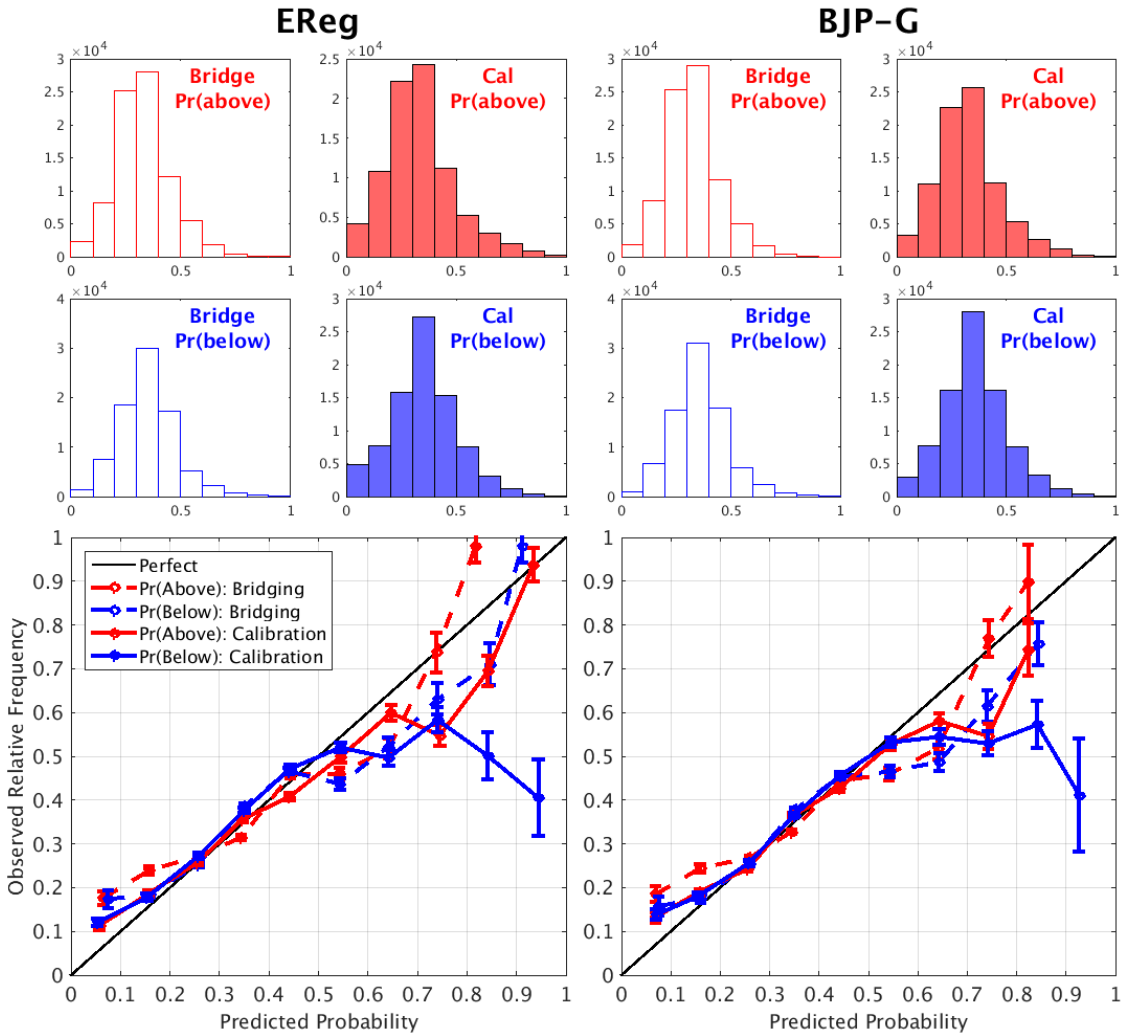
- ➢Exploring **additional climate indices** for bridging (e.g., AO/NAO)
- ➢Incorporating all **ensemble members**
- ➢Application to **subseasonal** forecasts

Thank you!

Extras

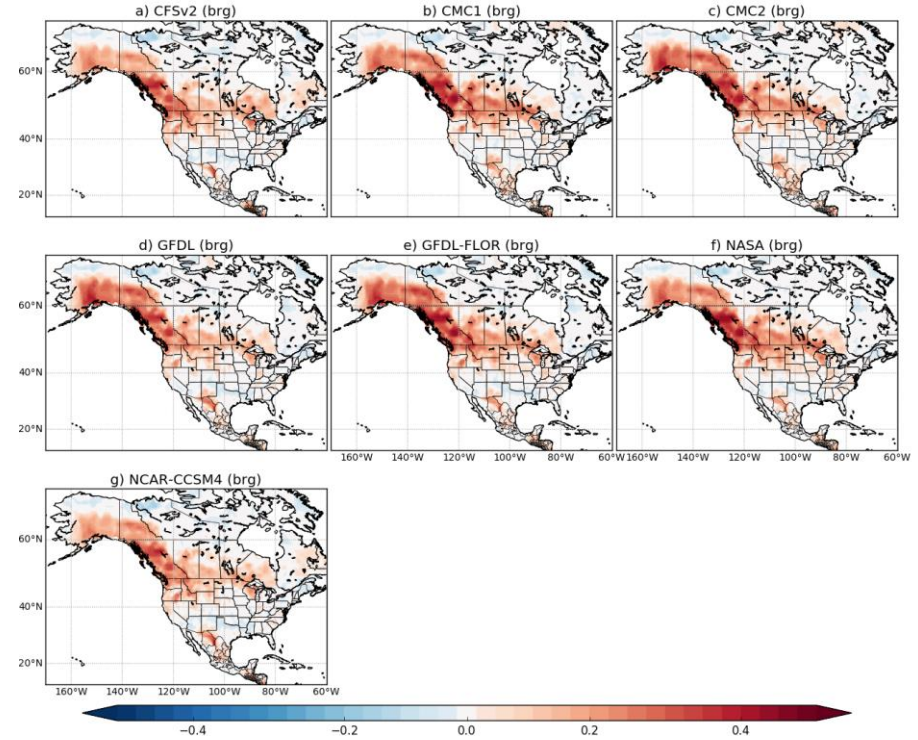
Reliability: Lead 1 forecasts of DJF 2-m temperature



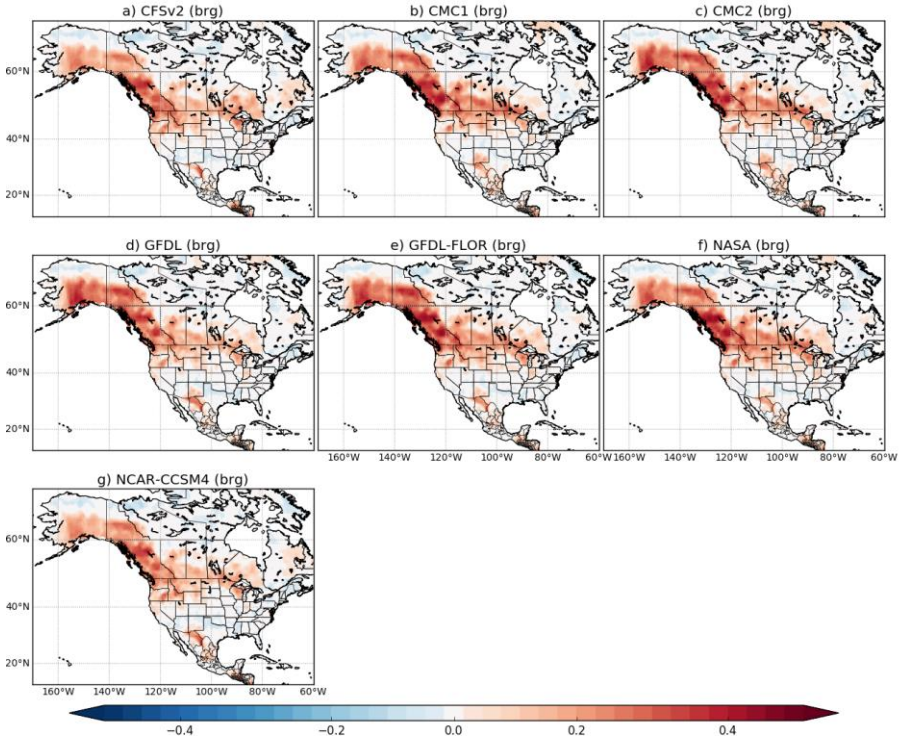


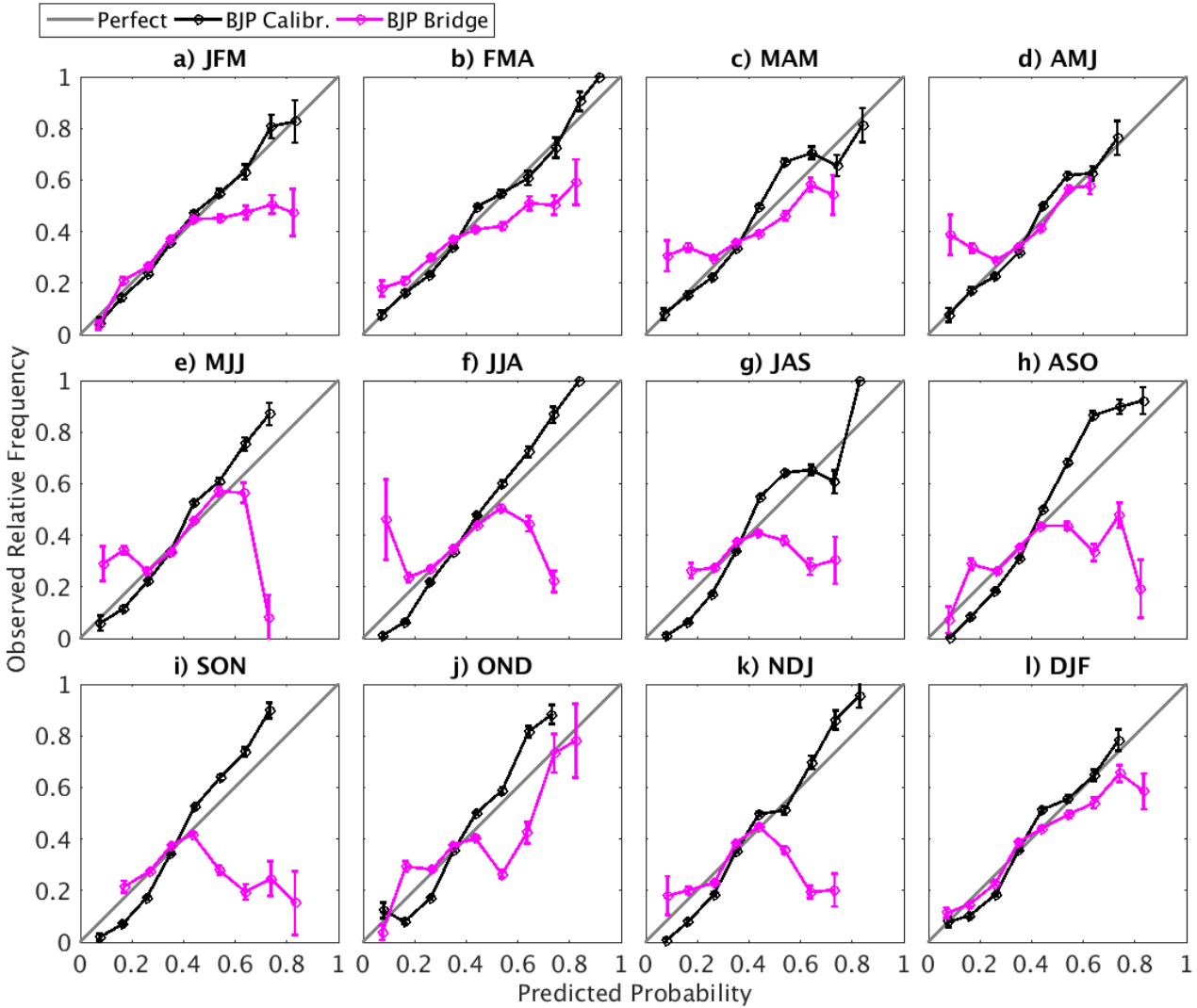
Reliability plots:
1-month lead calibrated and bridged CFSv2 forecasts of DJF 2-m temperature

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

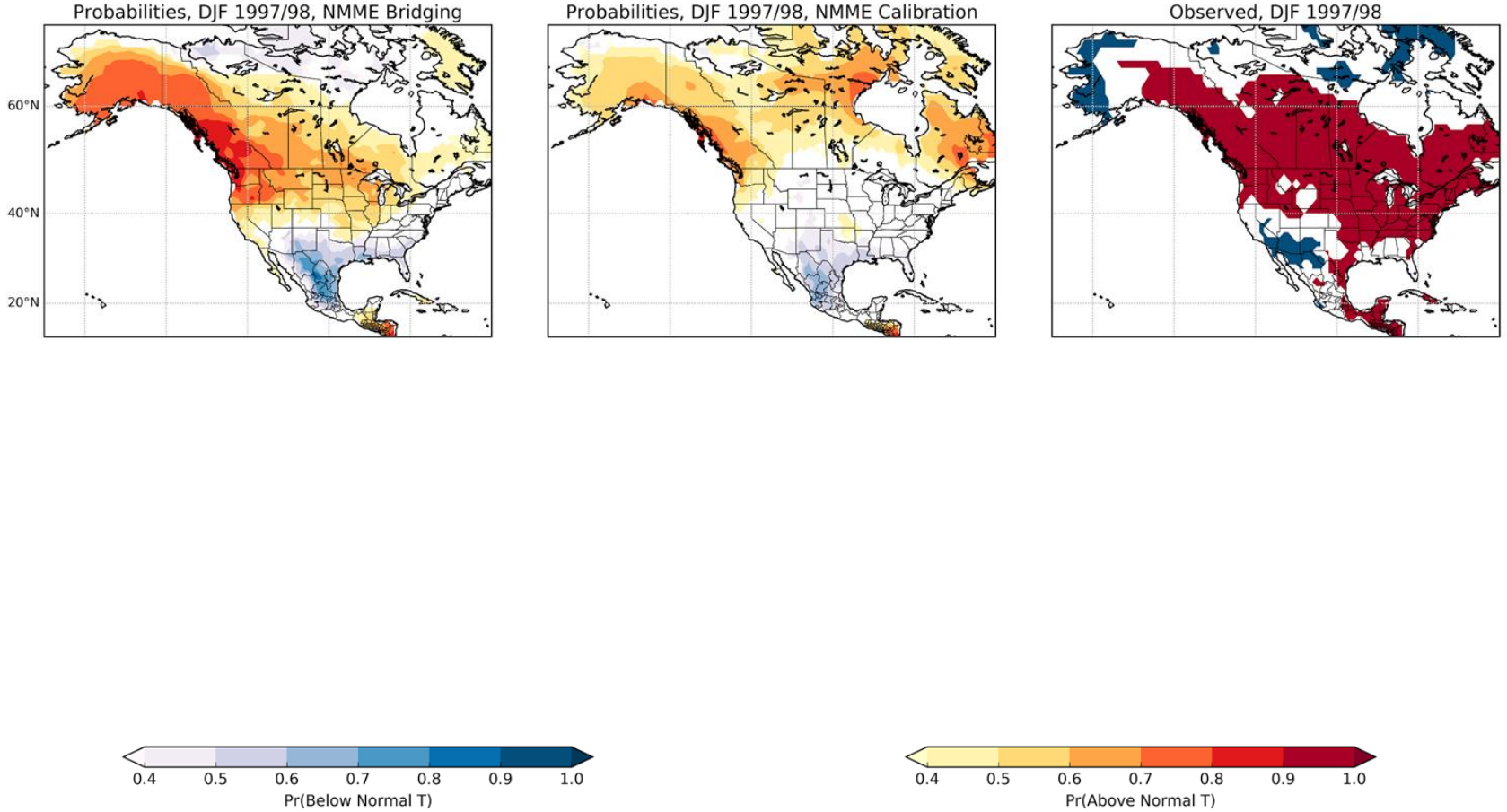


1-Month Lead DJF Pr(Below normal 2-m T)
BJP Niño 3.4 Bridging

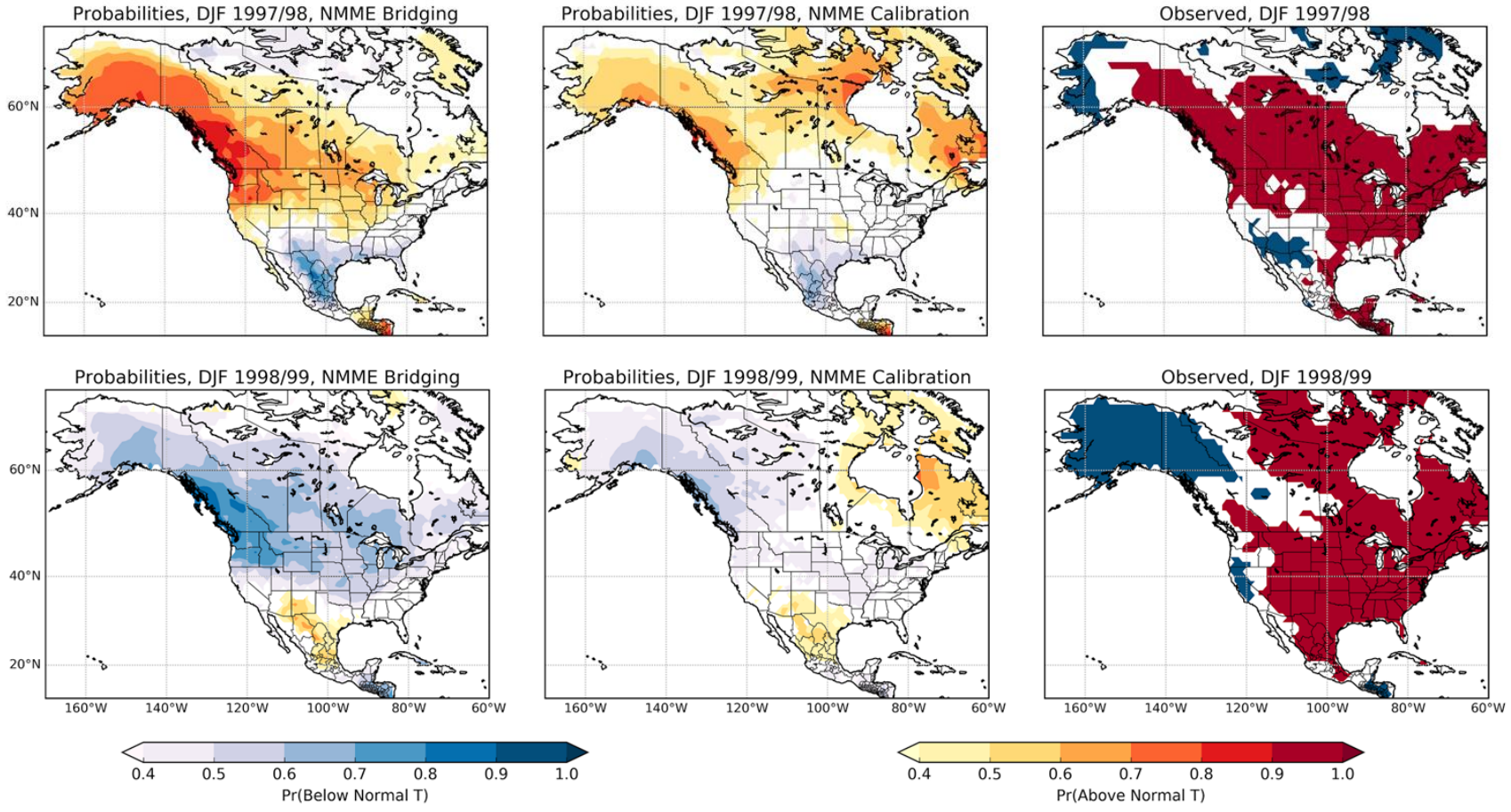


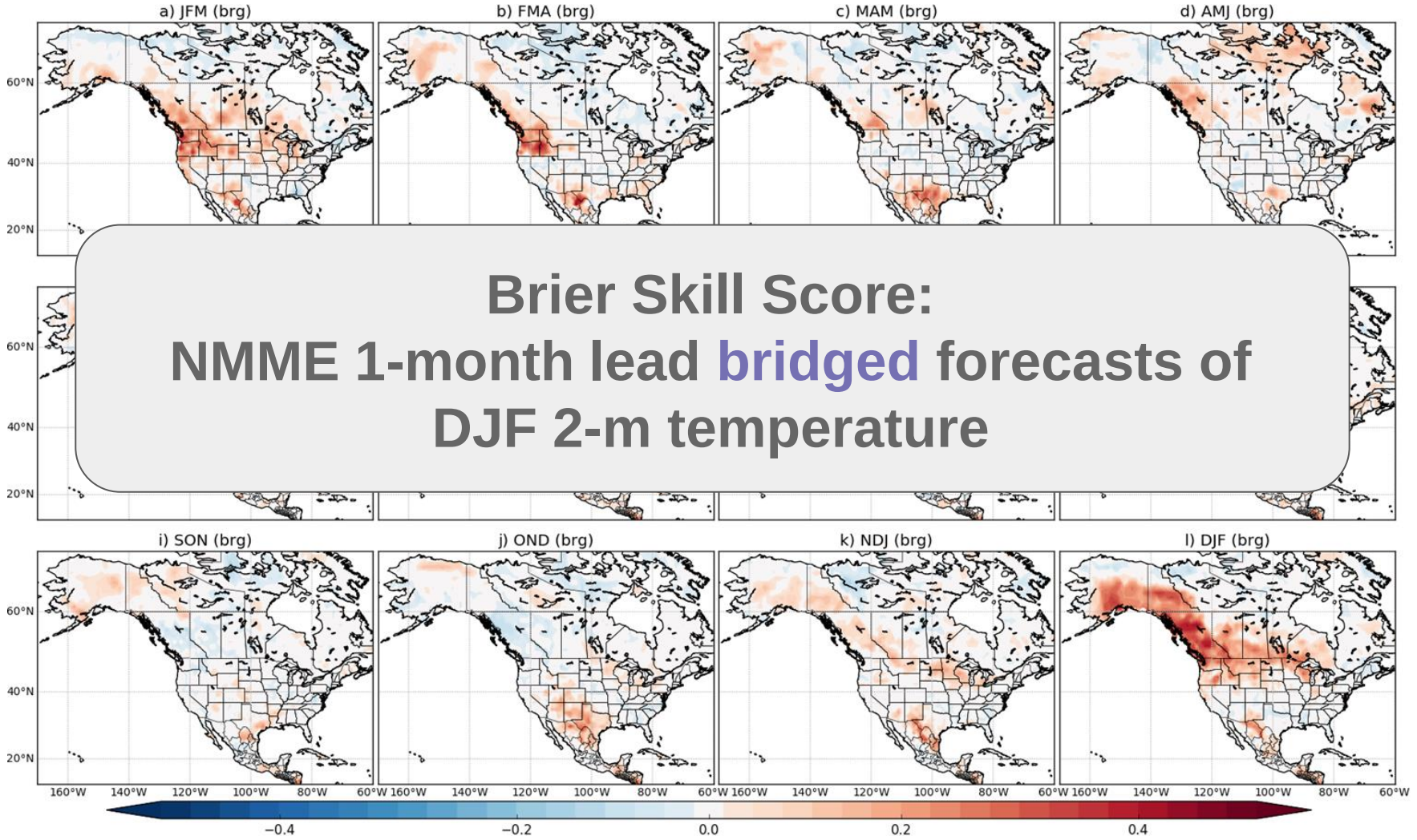

Perfect
BJP Calibr.
BJP Bridge
a) JFM
b) FMA
c) MAM
d) AMJ
e) MJJ
f) JJA
g) JAS
h) ASO
i) SON
j) OND
k) NDJ
l) DJF
Observed Relative Frequency
Predicted Probability
0
0.2
0.4
0.6
0.8
1

BJP probabilities of above/below normal temperature

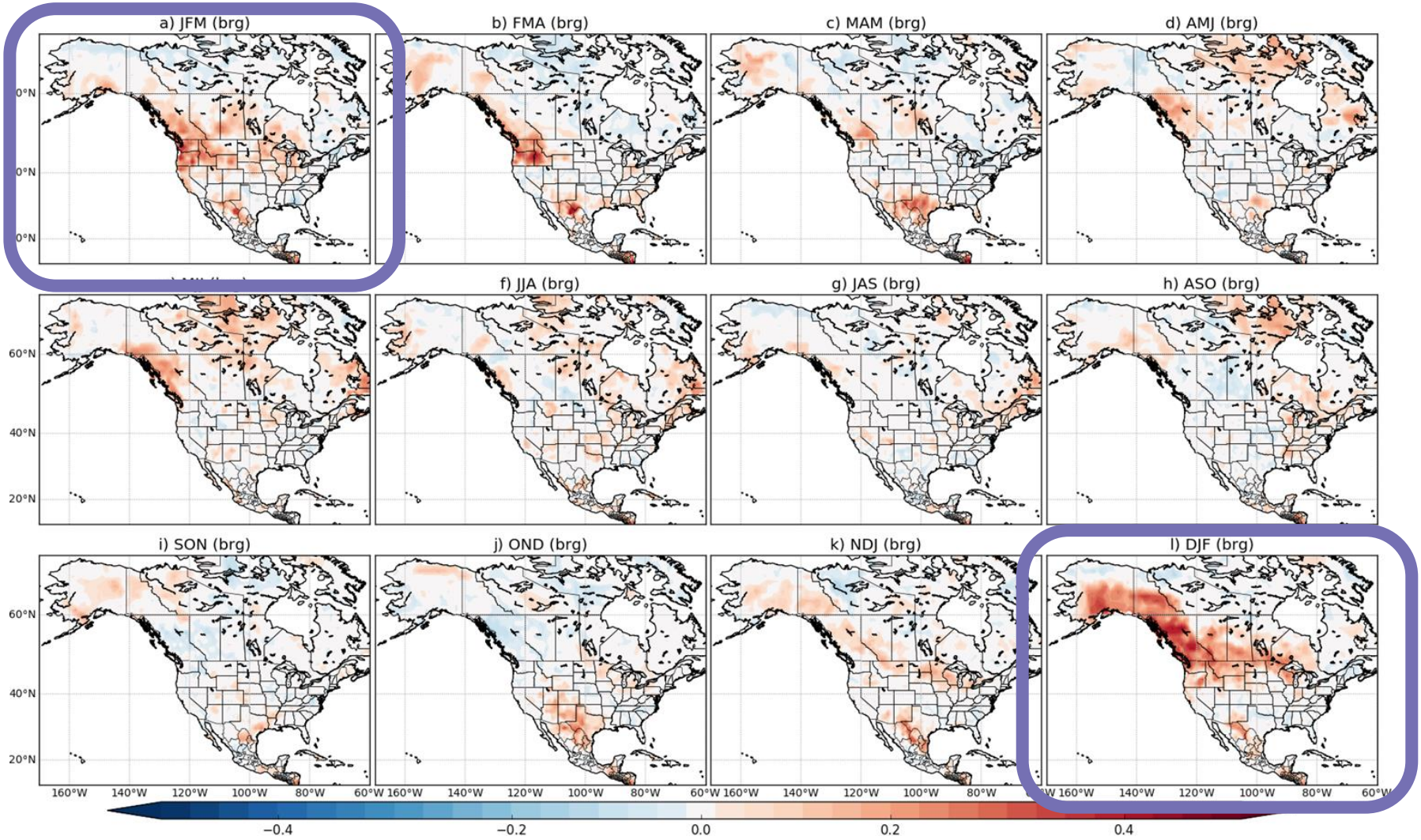


BJP probabilities of above/below normal temperature





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


a) JFM (brg)
b) FMA (brg)
c) MAM (brg)
d) AMJ (brg)
f) JJA (brg)
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h) ASO (brg)
i) SON (brg)
j) OND (brg)
k) NDJ (brg)
l) DJF (brg)
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