Attribution of Seasonal Climate Anomalies
April-May-June 2017

Attribution of Seasonal Climate Anomalies

- Goal
  - In the context of seasonal climate variability and its prediction, utilize seasonal climate forecasts and atmospheric general circulation model (AGCM) simulations to attribute causes for the observed seasonal climate anomalies.
  - The analysis can also be considered as an analysis of predictability of the observed seasonal climate anomalies.

Outline

- Methodology
- Data description
- Observed seasonal anomalies
- Ensemble average seasonal mean anomalies from AGCM simulations and initialized forecasts
- Seasonal mean anomalies from the individual AGCM simulations and initialized forecasts
- Summary
- References

Methodology - 1

- Compare observed seasonal mean anomalies with those from model simulations and forecasts.
- Ensemble averaged of model simulated/predicted seasonal mean anomalies are an indication of the predictable (or attributable) component of the corresponding observed anomalies.
- For seasonal mean atmospheric anomalies, predictability could be due to
  - Anomalous boundary forcings [e.g., sea surface temperature (SSTs); soil moisture etc.];
  - Atmospheric initial conditions.
- The influence of anomalous boundary forcings (particularly due to SSTs, can be inferred from the ensemble mean of AGCM simulations forced by observed SSTs, the so called AMIP simulations). This component of predictability (or attributability) is more relevant for longer lead seasonal forecasts.

Methodology - 2

- The influence of the atmospheric initial state can be inferred from initialized predictions. This component is more relevant for short lead seasonal forecasts.
- The influence of unpredictable component in the atmospheric variability can be assessed from the analysis of individual model simulations, and the extent anomalies in individual runs deviate from the ensemble average anomalies.
- The relative magnitude of ensemble averaged seasonal mean anomalies to the deviations of seasonal mean anomalies in the individual model runs is a measure of seasonal predictability (or the extent observed anomalies are attributable).
- Observed anomalies are equivalent to a realization of a single model run, and therefore, analysis of individual model runs also gives an appreciation of how much observed anomalies can deviate from the component that are attributable (Kumar et al. 2013).

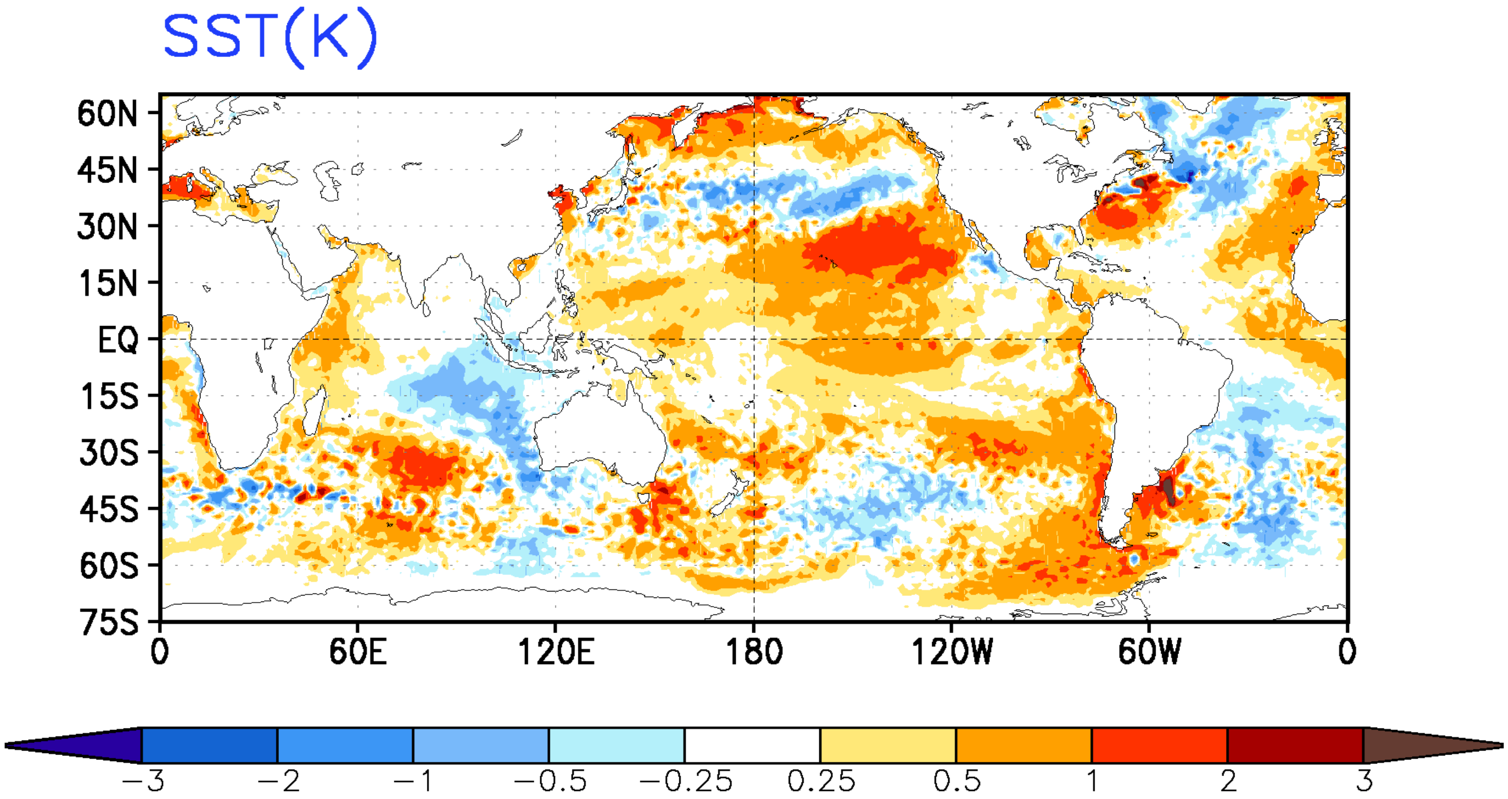
Data

- Observations
  - SST: NCDC daily OI analysis (Reynolds et al., 2007)
  - Prec: CMAP monthly analysis (Xie and Arkin, 1997)
  - T2m: GHCN-CAMS land surface temperature monthly analysis (Fan and van den Dool, 2008)
  - 200mb height (z200): CFSR (Saha et al., 2010)
- 0-month-lead seasonal mean forecasts from CFSv2 (Saha et al. 2014)
  - 0-month-lead: the seasonal mean forecasts based on 40 members from the latest 10 days before the target season;
  - 0-month-lead-monthly: the seasonal mean forecasts constructed from 3 individual monthly forecasts with the latest 10 days initial conditions for each individual monthly forecasts. This approach for constructing seasonal mean anomalies has more influence from the initial conditions (Kumar et al. 2013)
- Seasonal mean AMIP simulation from CFSv2 (provided by Dr. Bhaskar Jha)
  - 18 members
- All above seasonal mean anomalies are based on 1999-2010 climatology.
- z200 responses to tropical heating in linear model (provided by Dr. Peitao Peng)
- Seasonal mean anomalies of z200, T2m, and Prec forecasted from the Constructed Analog Model (provided by Dr. Peitao Peng)

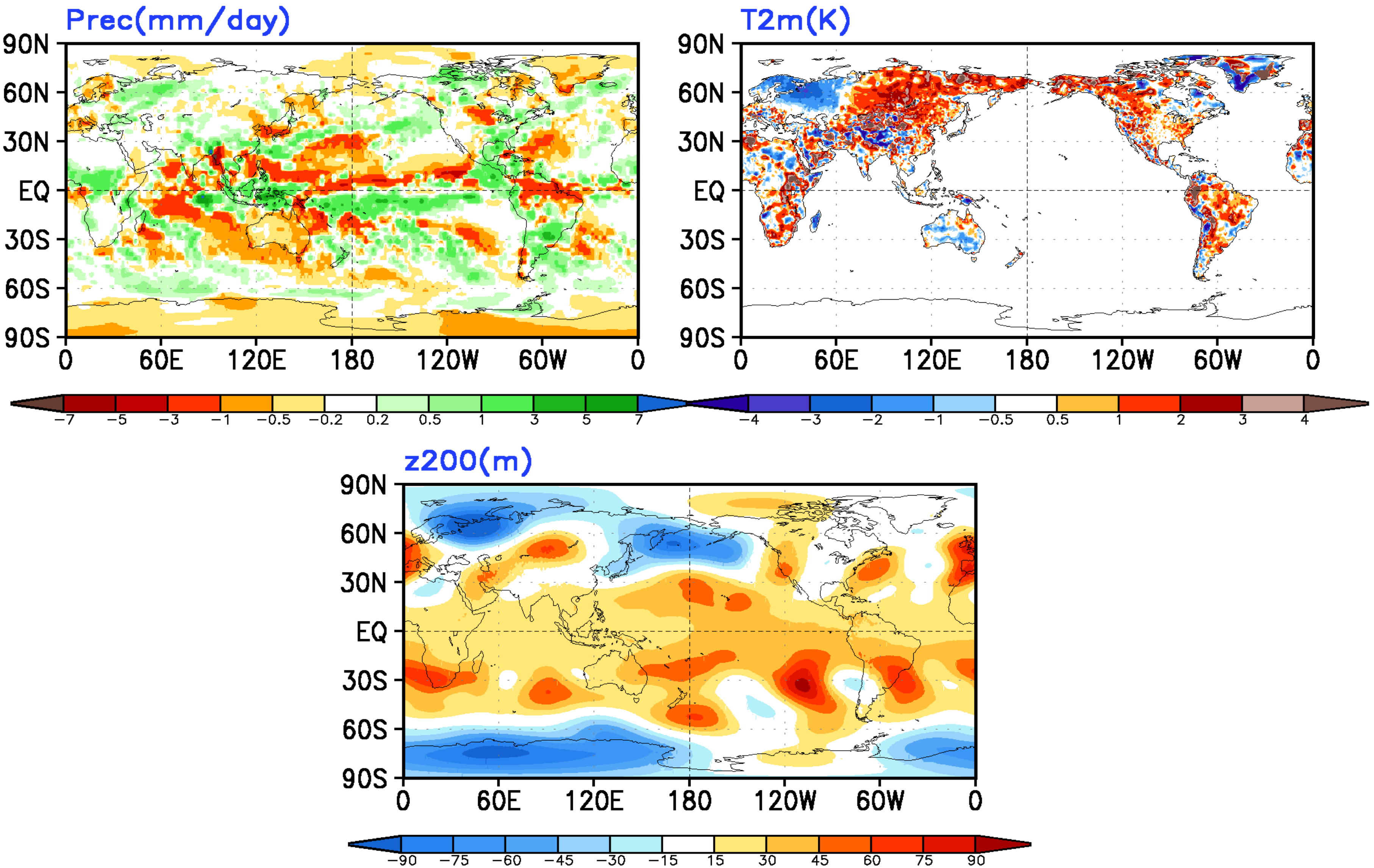
Observed Seasonal Anomalies

Global and North America

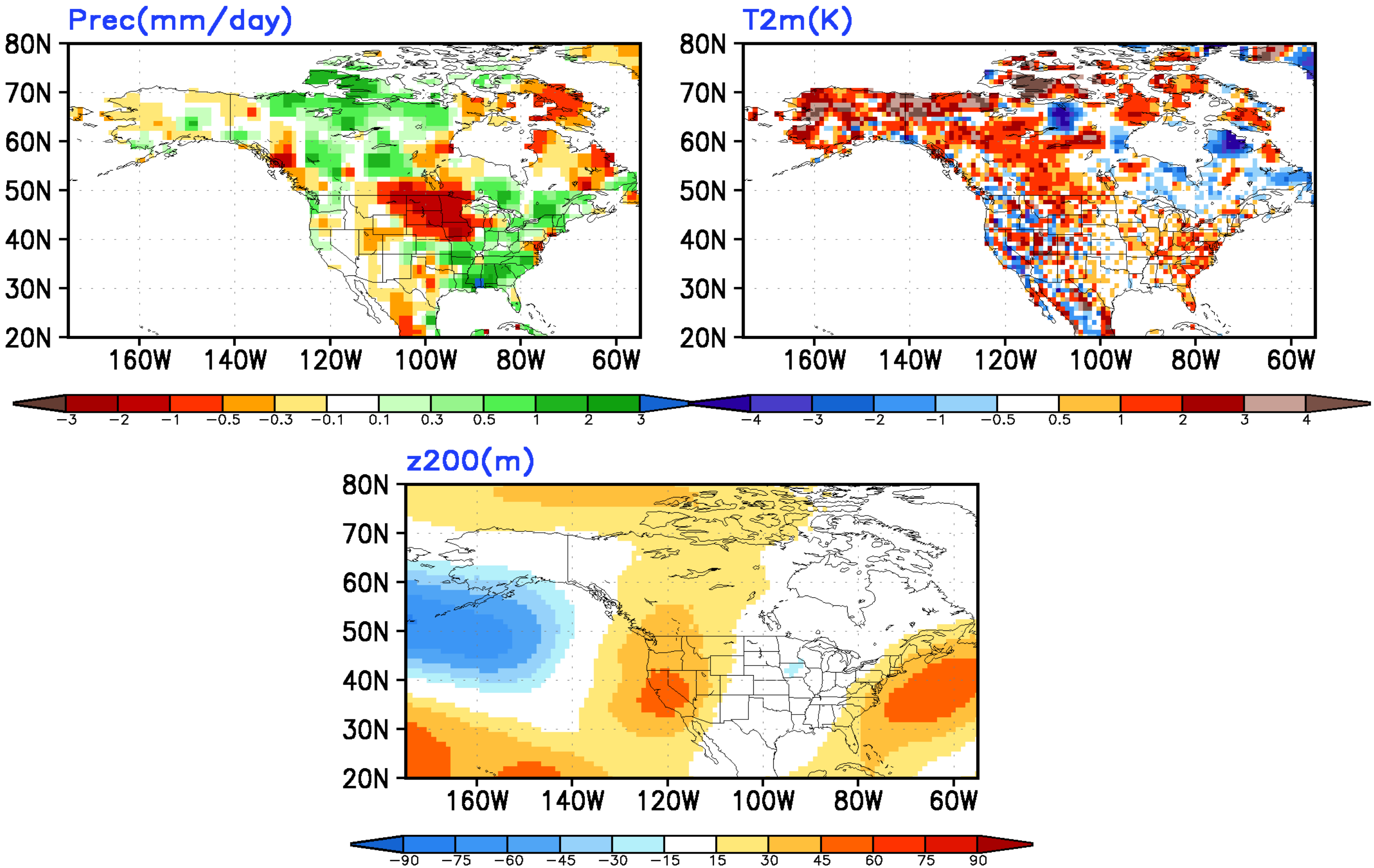
Observed Anomaly AMJ2017



Observed Anomaly AMJ2017



Observed Anomaly AMJ2017



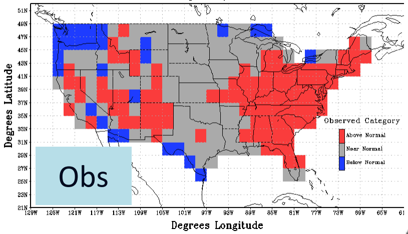
AMJ2017 CPC Seasonal Outlooks and NMME Forecasts

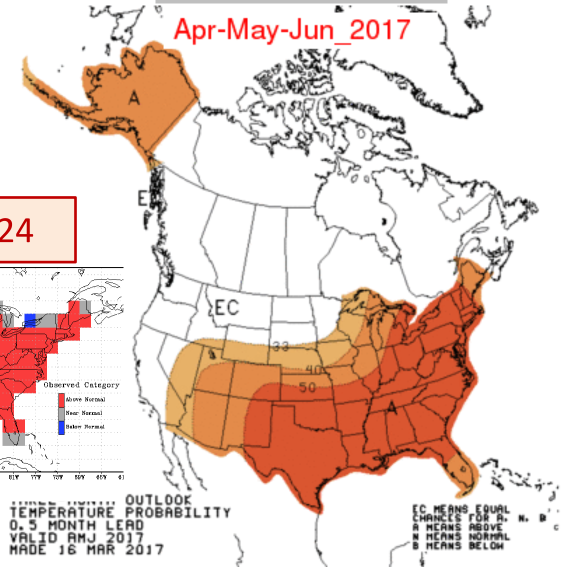
Temperature

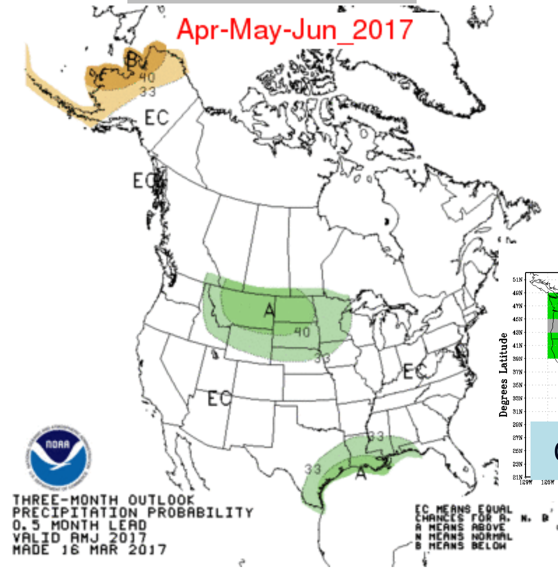
Precipitation

CPC

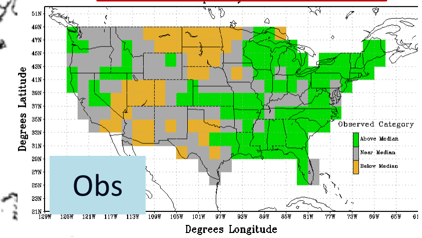
Temp HSS=24

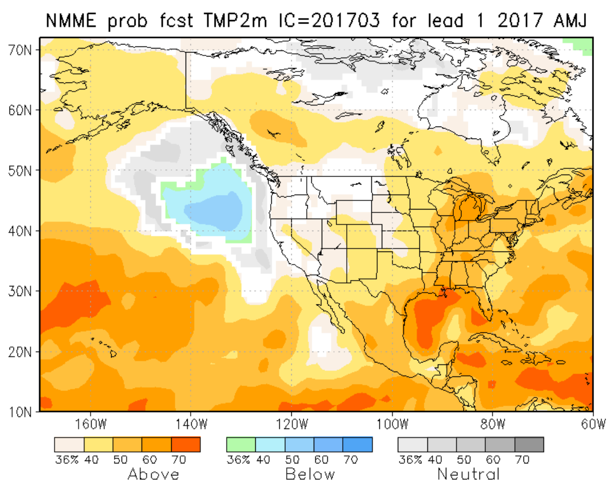


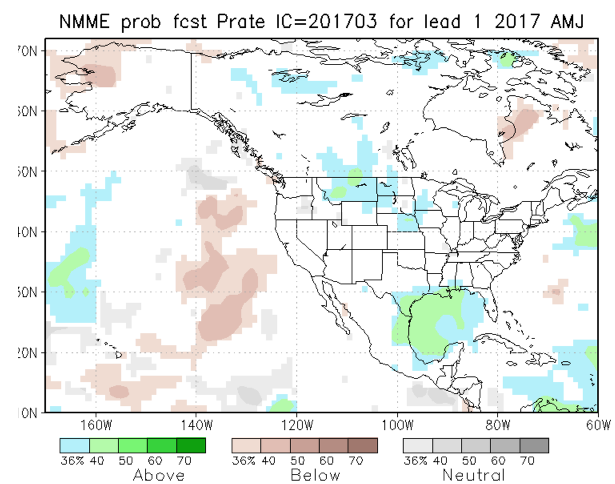




Prec HSS=-17







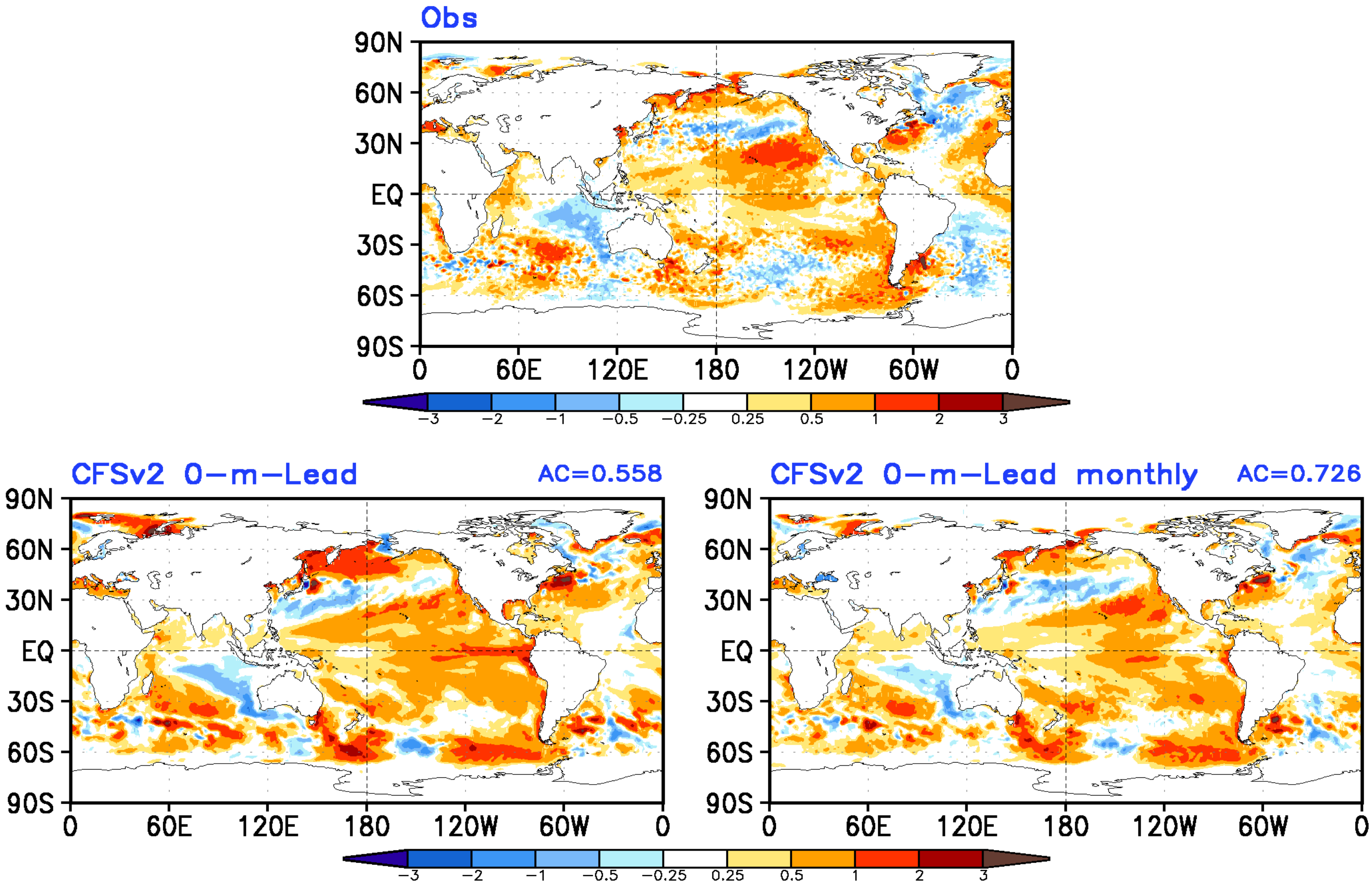
NMME

Model Simulated/Forecast Ensemble Average Anomalies

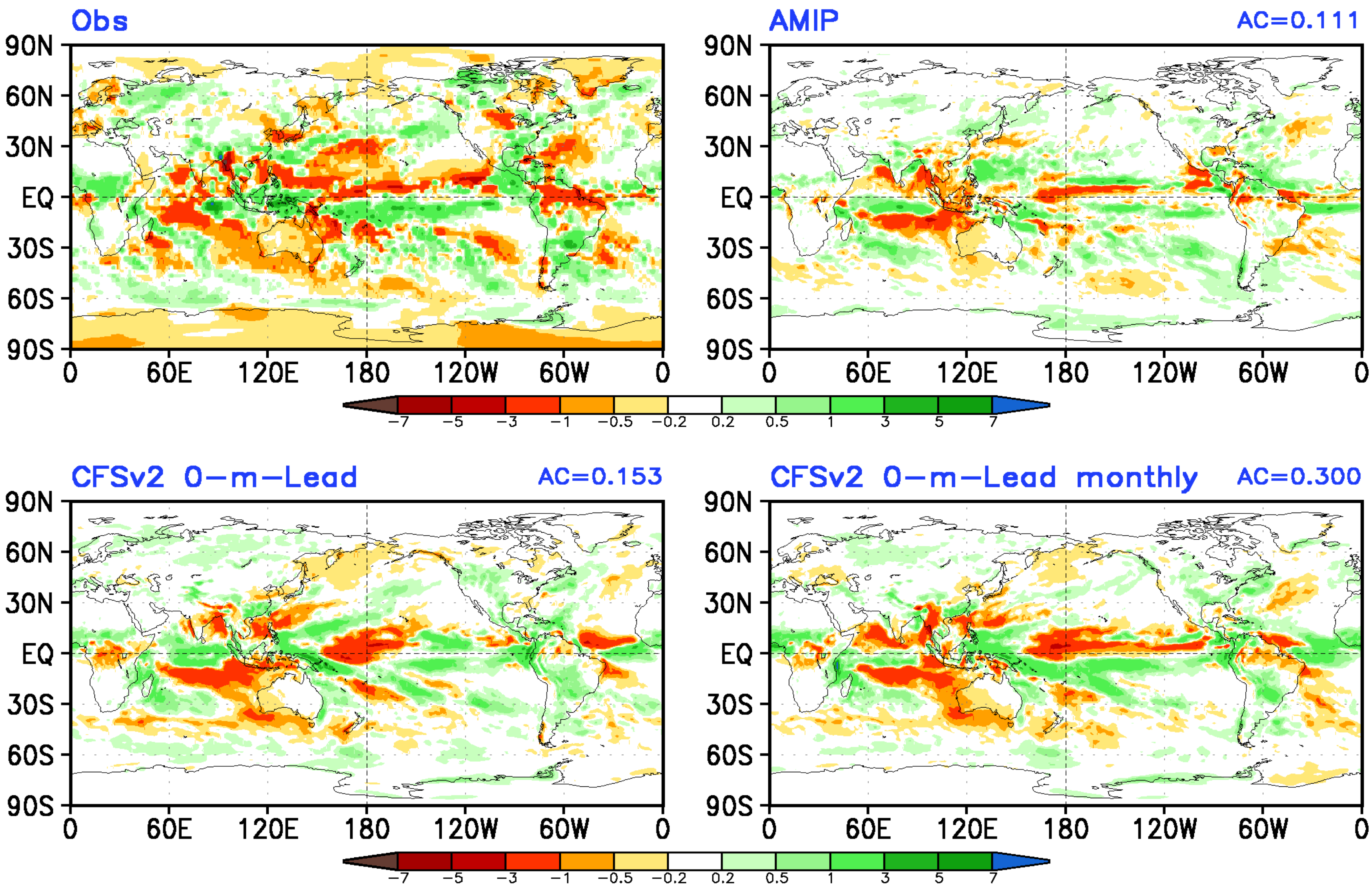
Model Simulated/Forecast Ensemble Average Anomalies

- CFS AMIP simulations forced with observed sea surface temperatures (18 members ensemble)
- CFSv2 real time operational forecasts
  - 0-month-lead: the seasonal mean forecasts based on 40 members from the latest 10 days before the target season. For example, 2016AMJ seasonal mean forecasts are 40 members from 22-31 March2016 initial conditions.
  - 0-month-lead-monthly: the seasonal mean forecasts constructed from 3 individual monthly forecasts with the latest 10 days initial conditions for each individual monthly forecasts. This approach for constructing seasonal mean anomalies has more influence from the initial conditions (Kumar et al. 2013). For example, the constructed 2016AMJ seasonal mean forecasts are the average of April2016 forecasts from 22-31 March2016 initial conditions, May2016 forecasts from 21-30 April2016 initial conditions, and June2016 forecasts from 22-31 May2016 initial conditions.
- Numbers at the panels indicate the spatial anomaly correlation (AC).

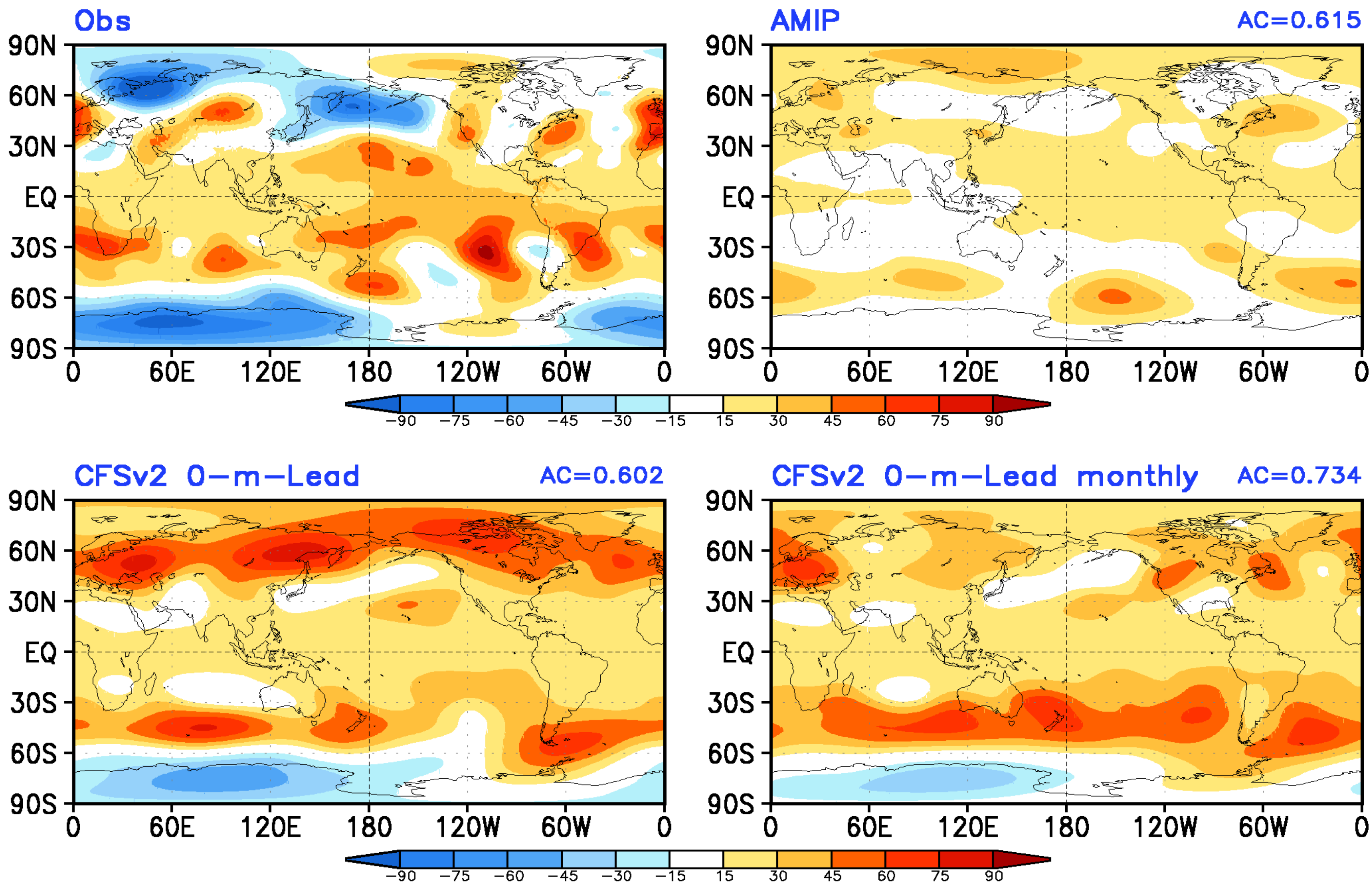
AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies SST(K)



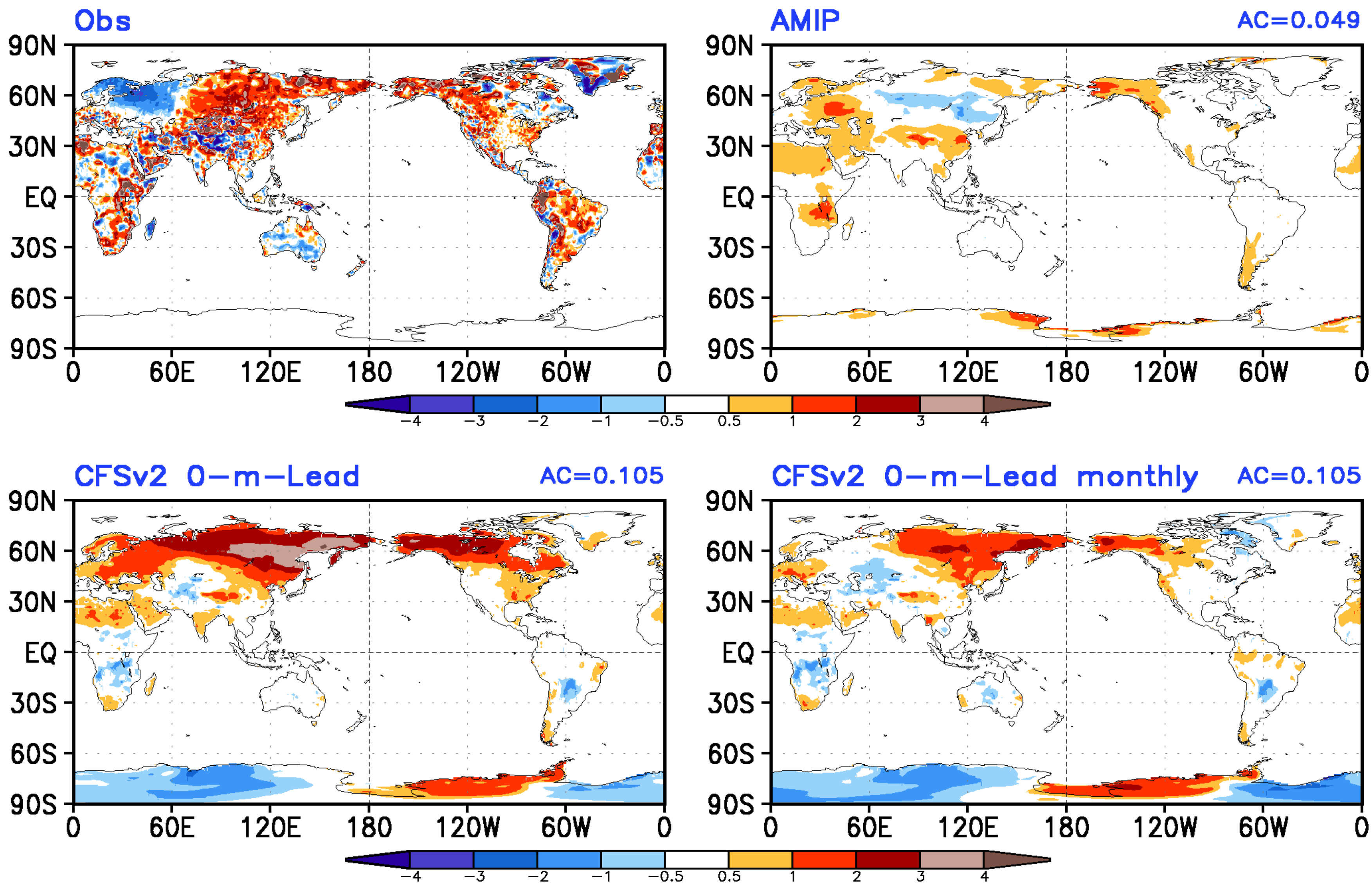
AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies Prec(mm/day)



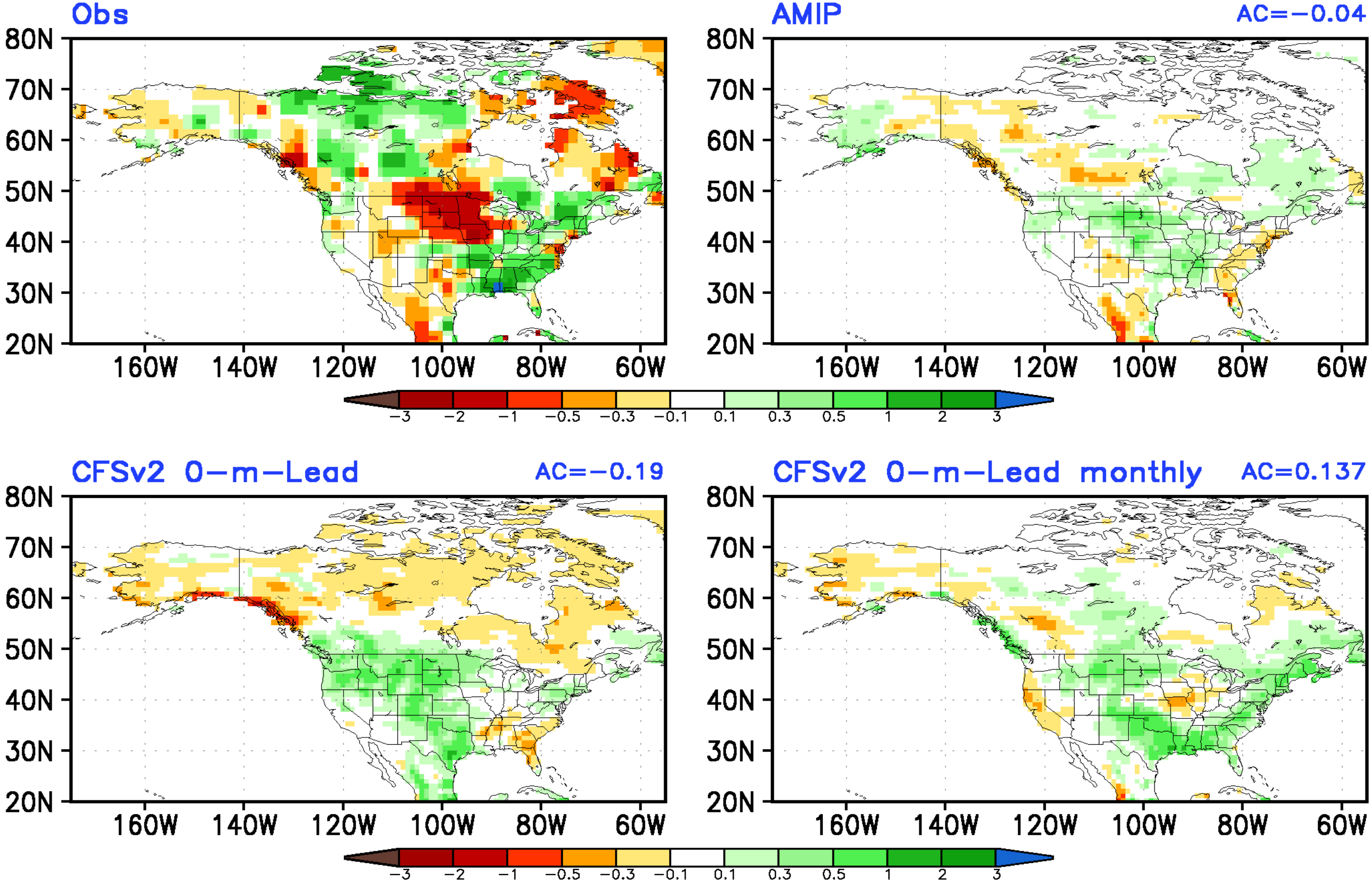
AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies z200(m)



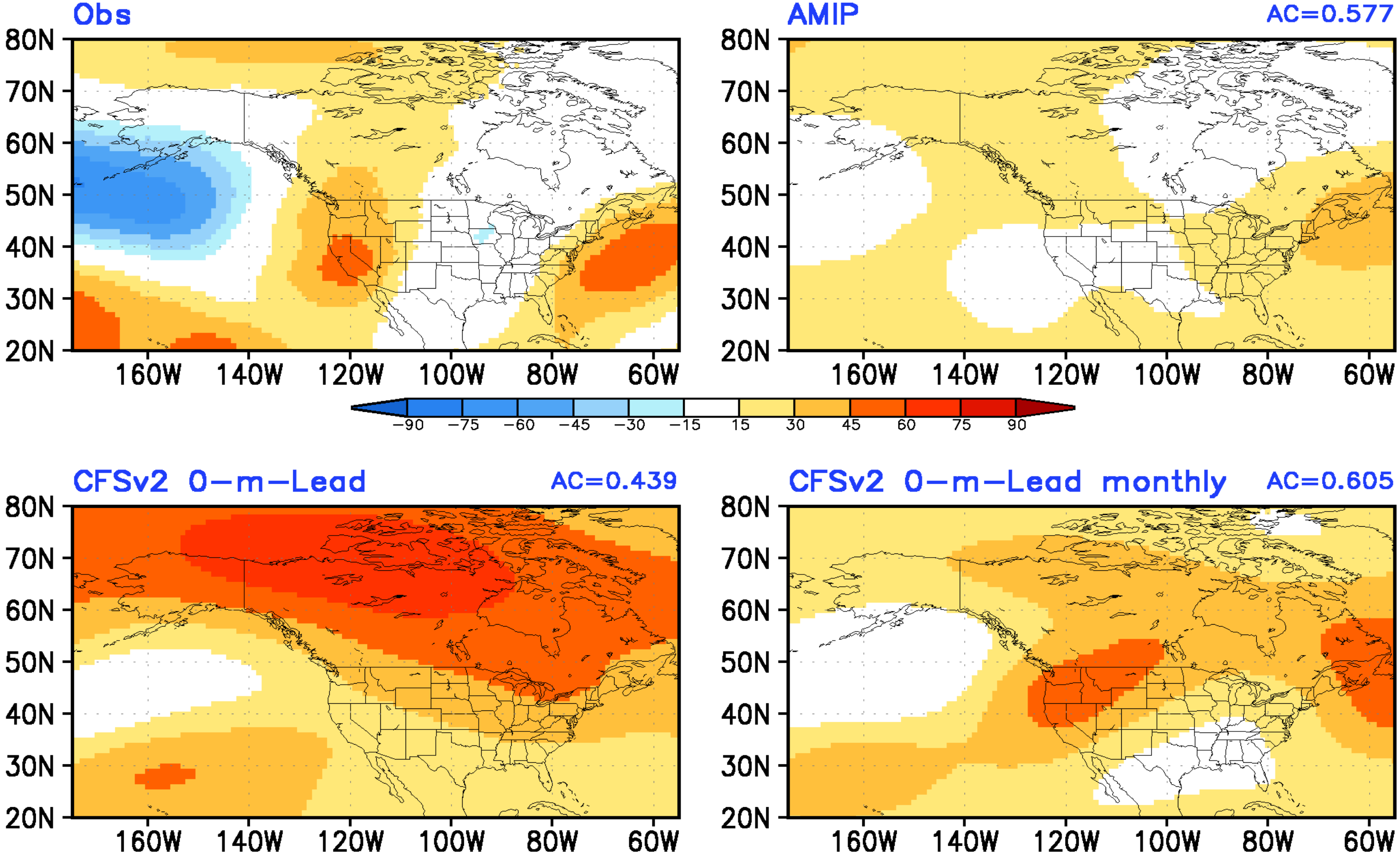
AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies T2m(K)



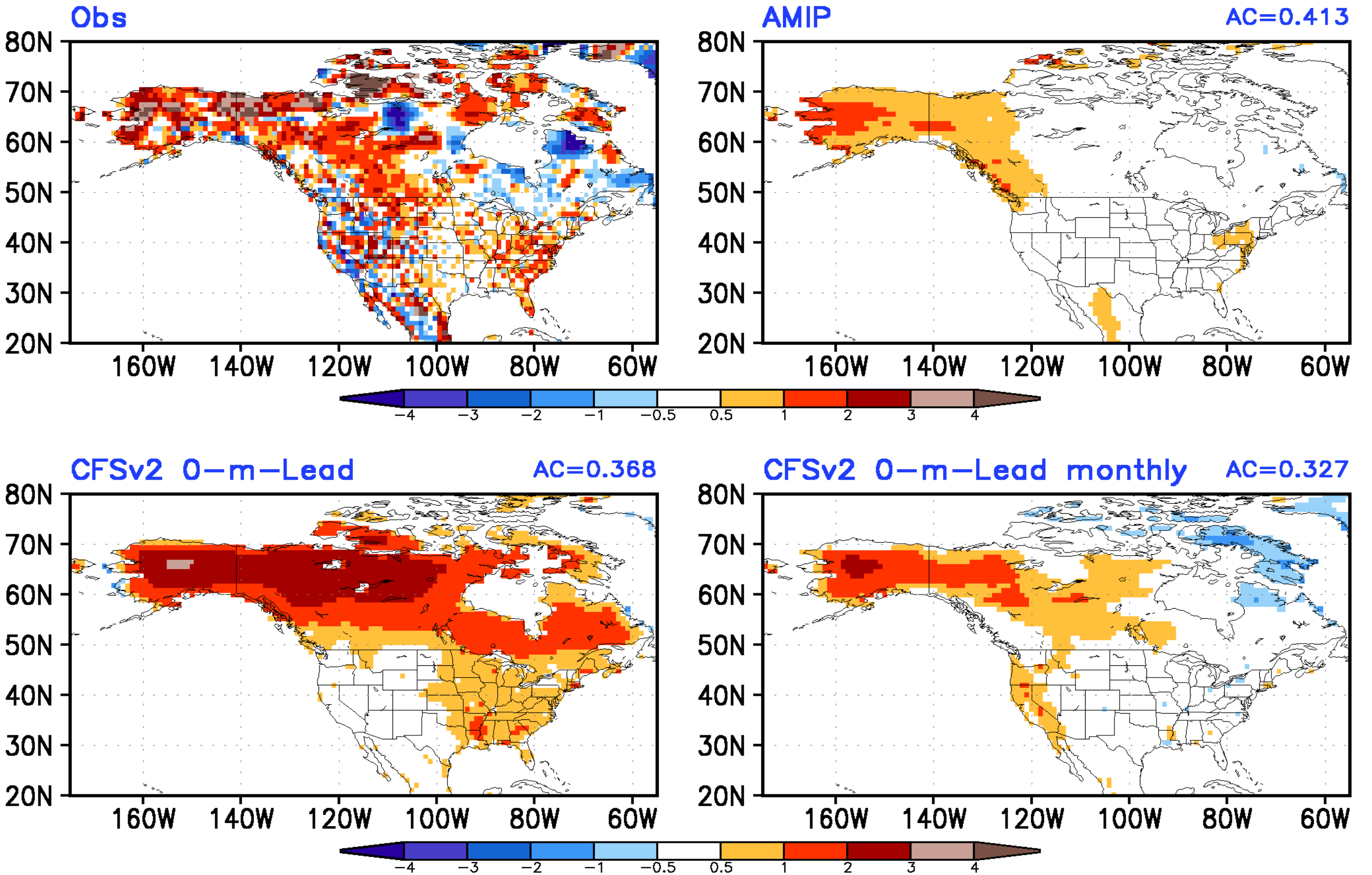
AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies Prec(mm/day)



AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies z200(m)



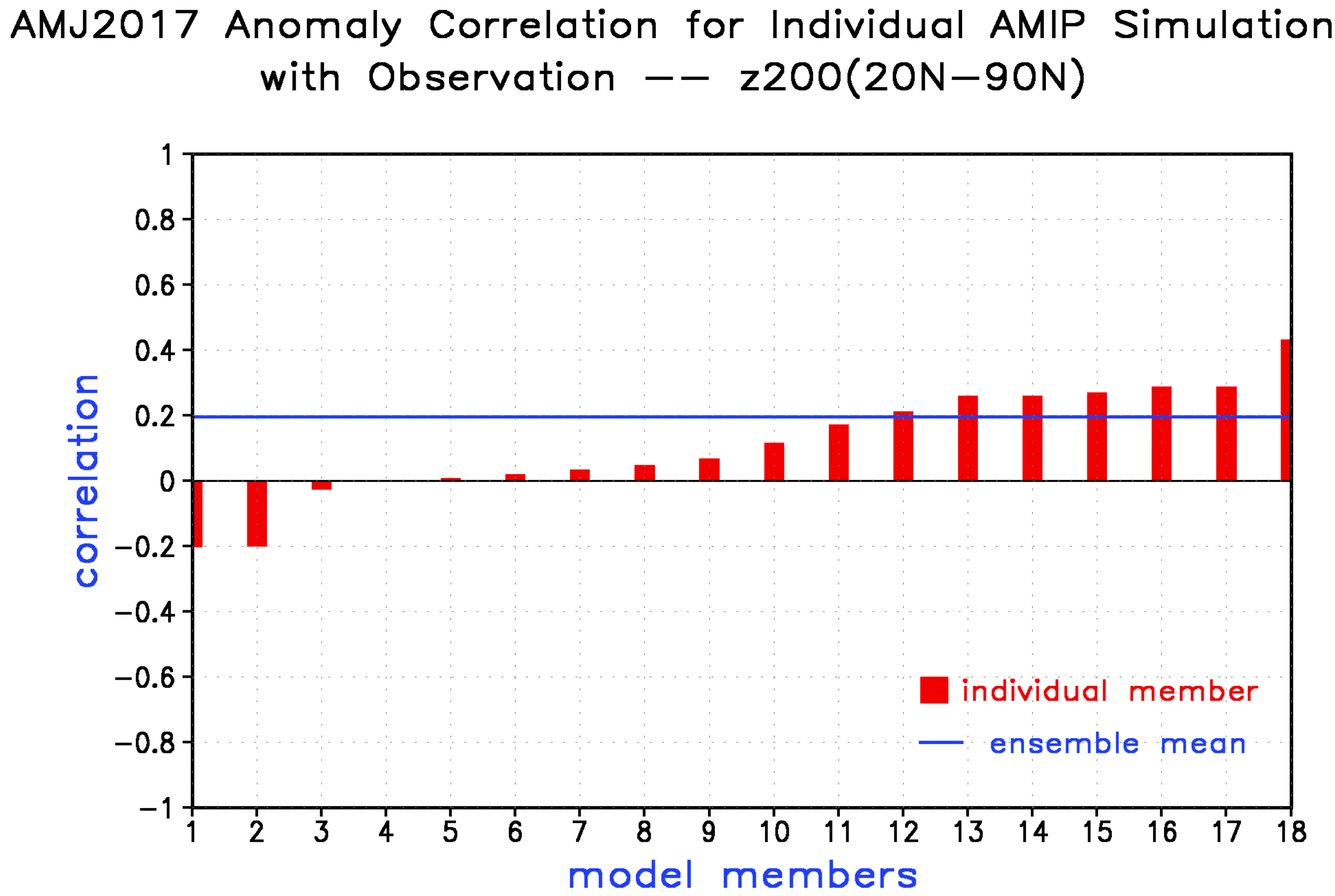
AMJ2017 Observed & Model Simulated/Forecast Ensemble Average Anomalies T2m(K)



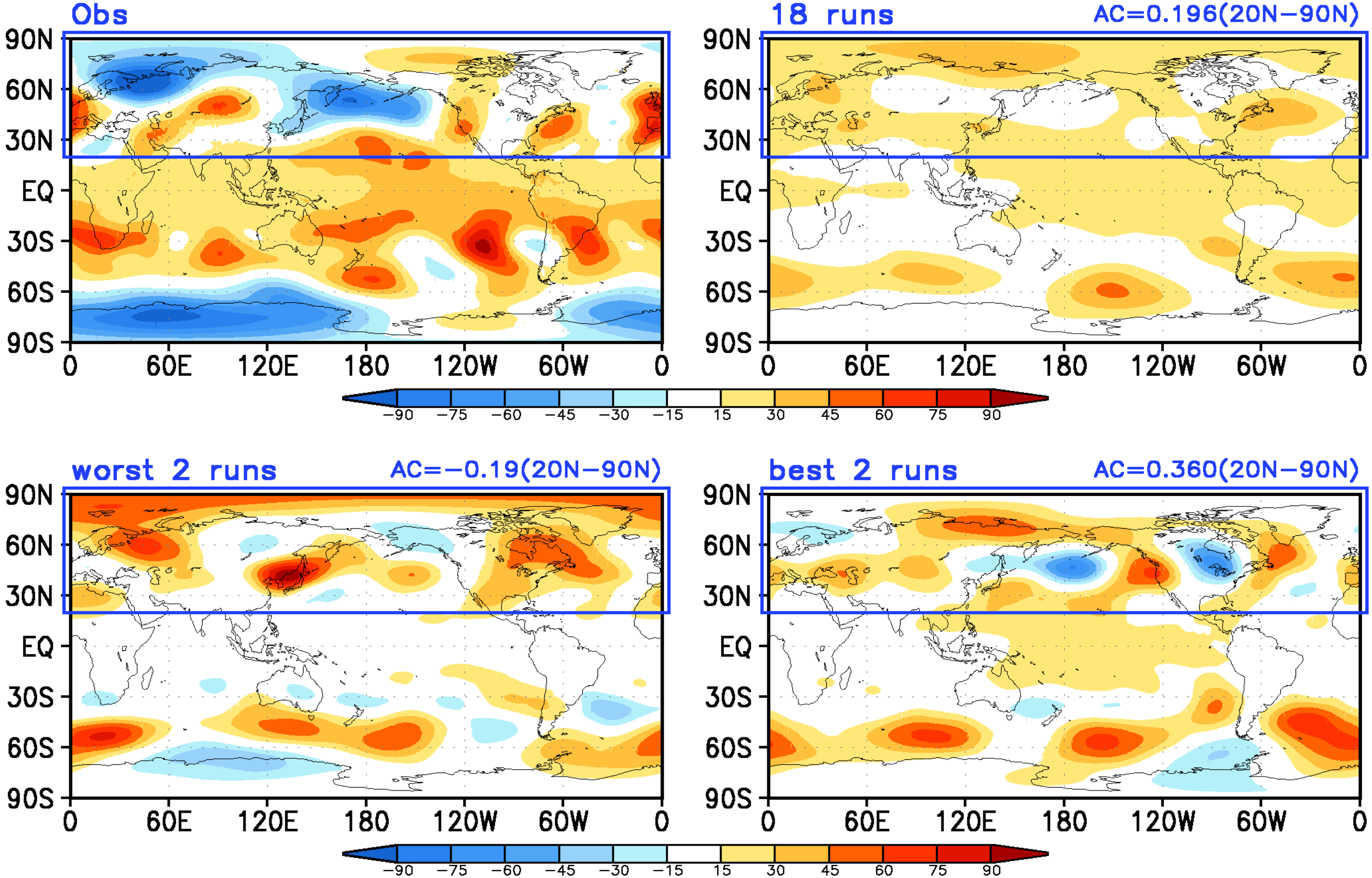
Model Simulated/Forecast Anomalies: Individual Runs

Model Simulated/Forecast Anomalies: Individual Runs

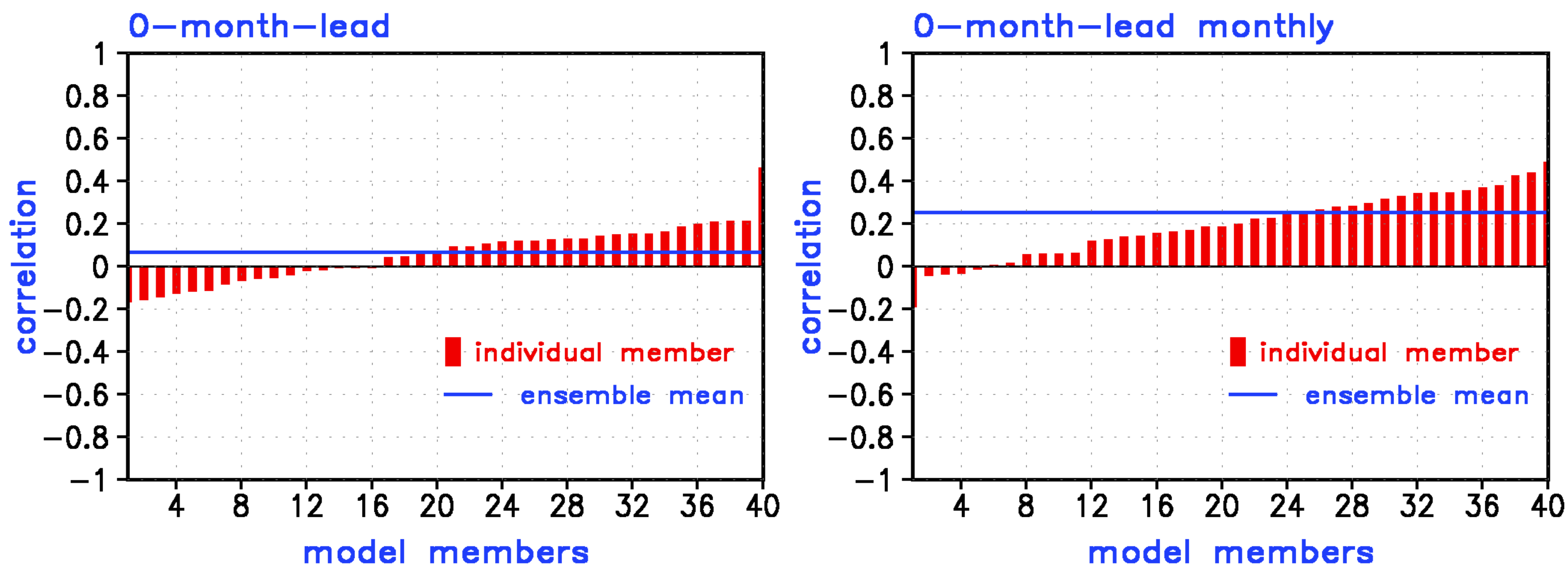
- In this analysis, anomalies from individual model runs are compared against the observed seasonal mean anomalies. The spatial resemblance between them is quantified based on anomaly correlation (AC).
- The distribution of AC across all model simulations is indicative of probability of observed anomalies to have a predictable (or attributable) component.
- One can also look at best and worst match between model simulated/forecast anomalies to assess the range of possible outcomes.


AMJ2017 Anomaly Correlation for Individual AMIP Simulation
with Observation -- z200(20N-90N)
correlation
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
model members
individual member
ensemble mean

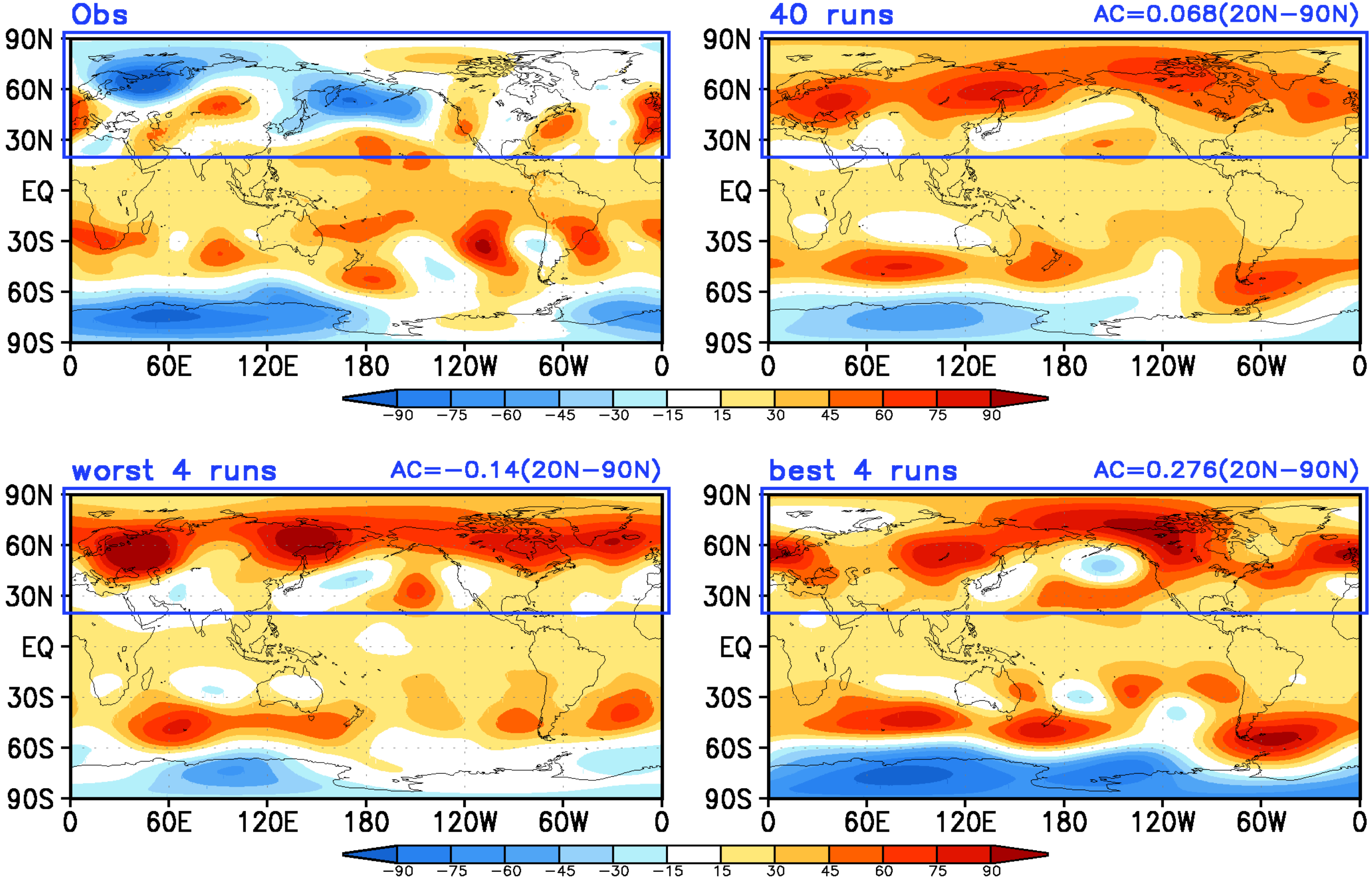
Observed & AMIP Ensemble Average Anomalies
AMJ2017 z200(m) 18 runs/worst 2 runs/best 2 runs



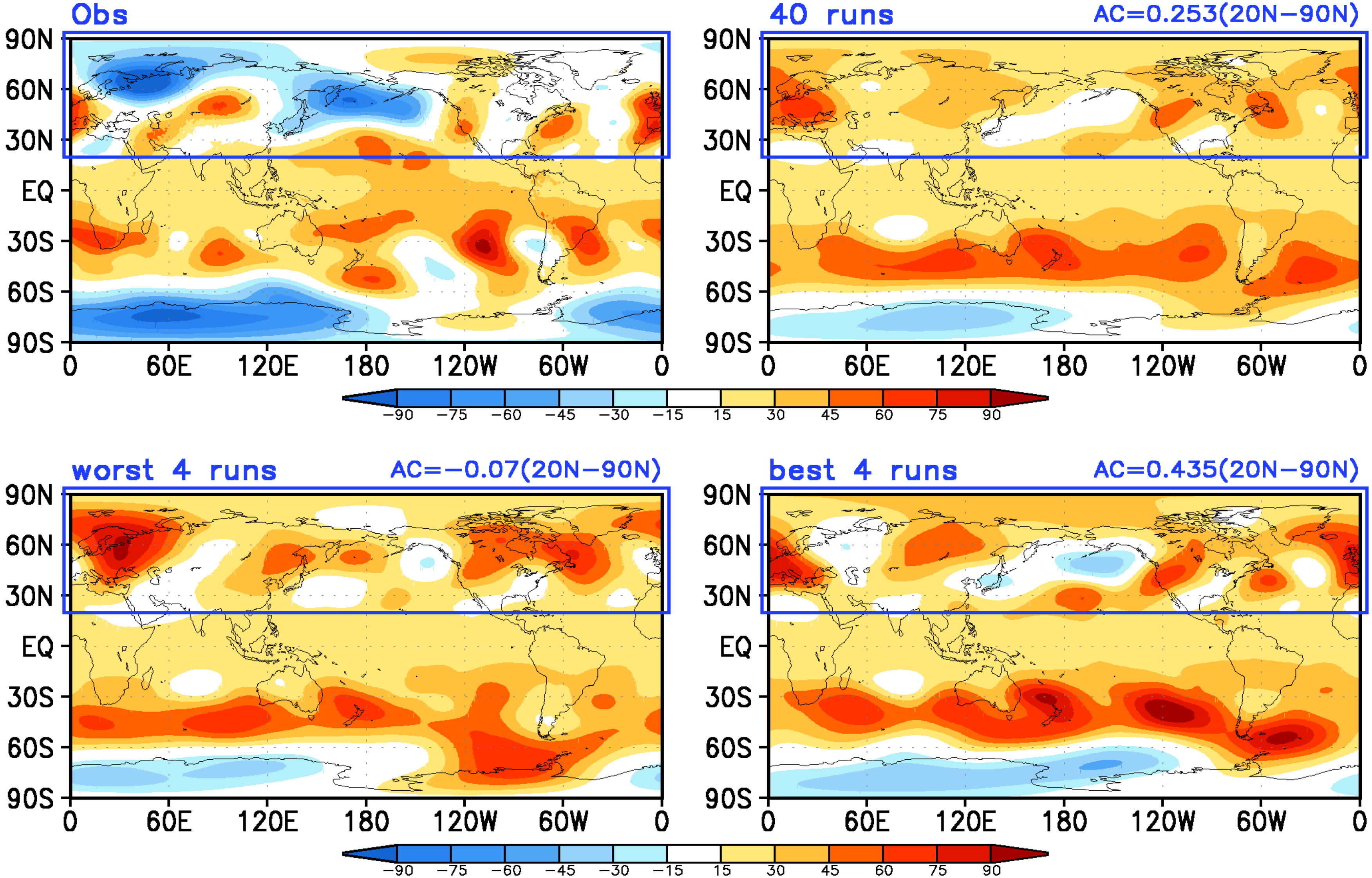
AMJ2017 Anomaly Correlation for Individual CFSv2 Forecast with Observation -- z200 (20N-90N)



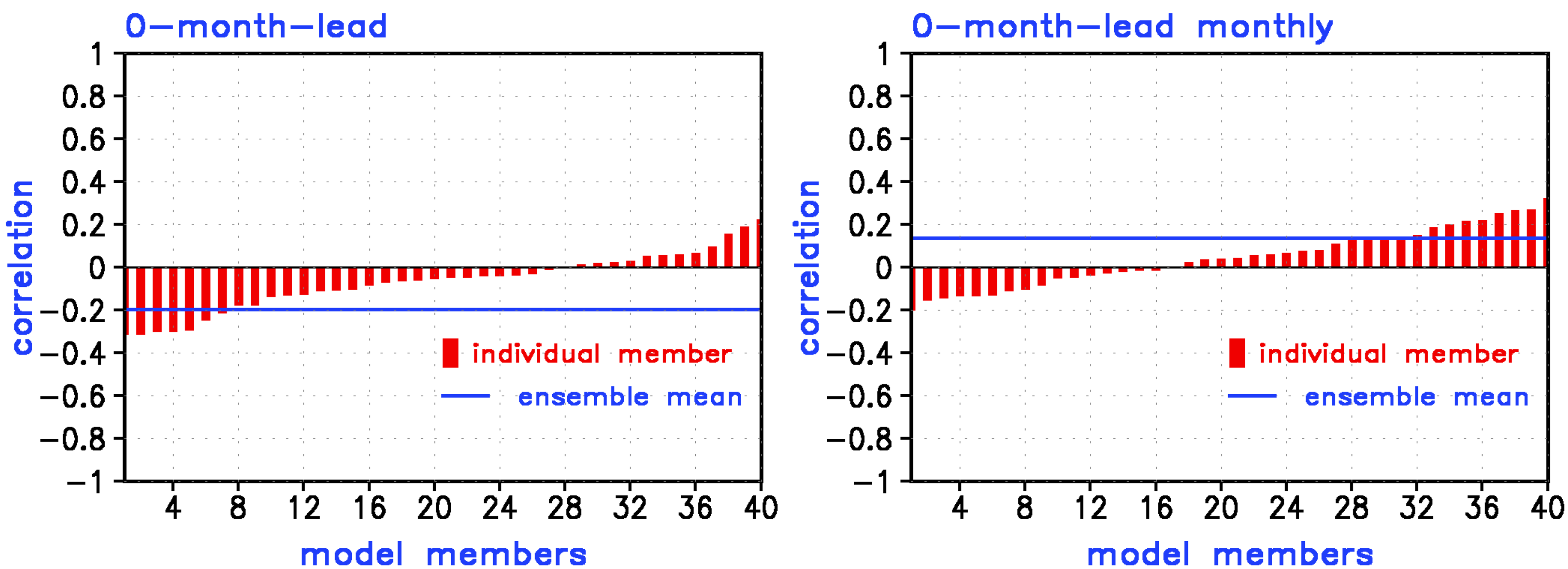
Observed & CFSv2 Forecast Ensemble Average Anomalies
AMJ2017 z200(m) 40 runs/worst 4 runs/best 4 runs
0-month-lead



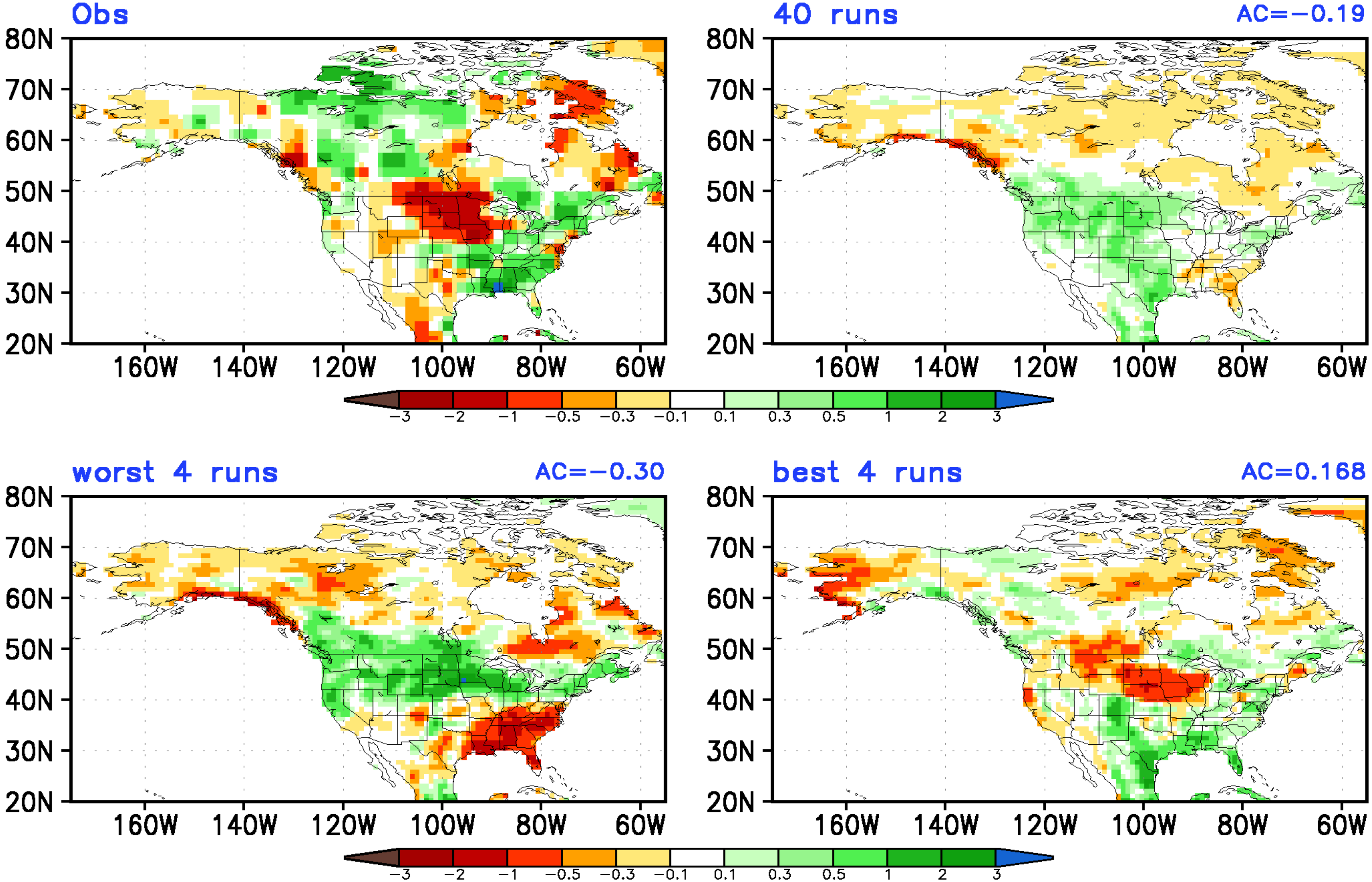
Observed & CFSv2 Forecast Ensemble Average Anomalies
AMJ2017 z200(m) 40 runs/worst 4 runs/best 4 runs
0-month-lead monthly



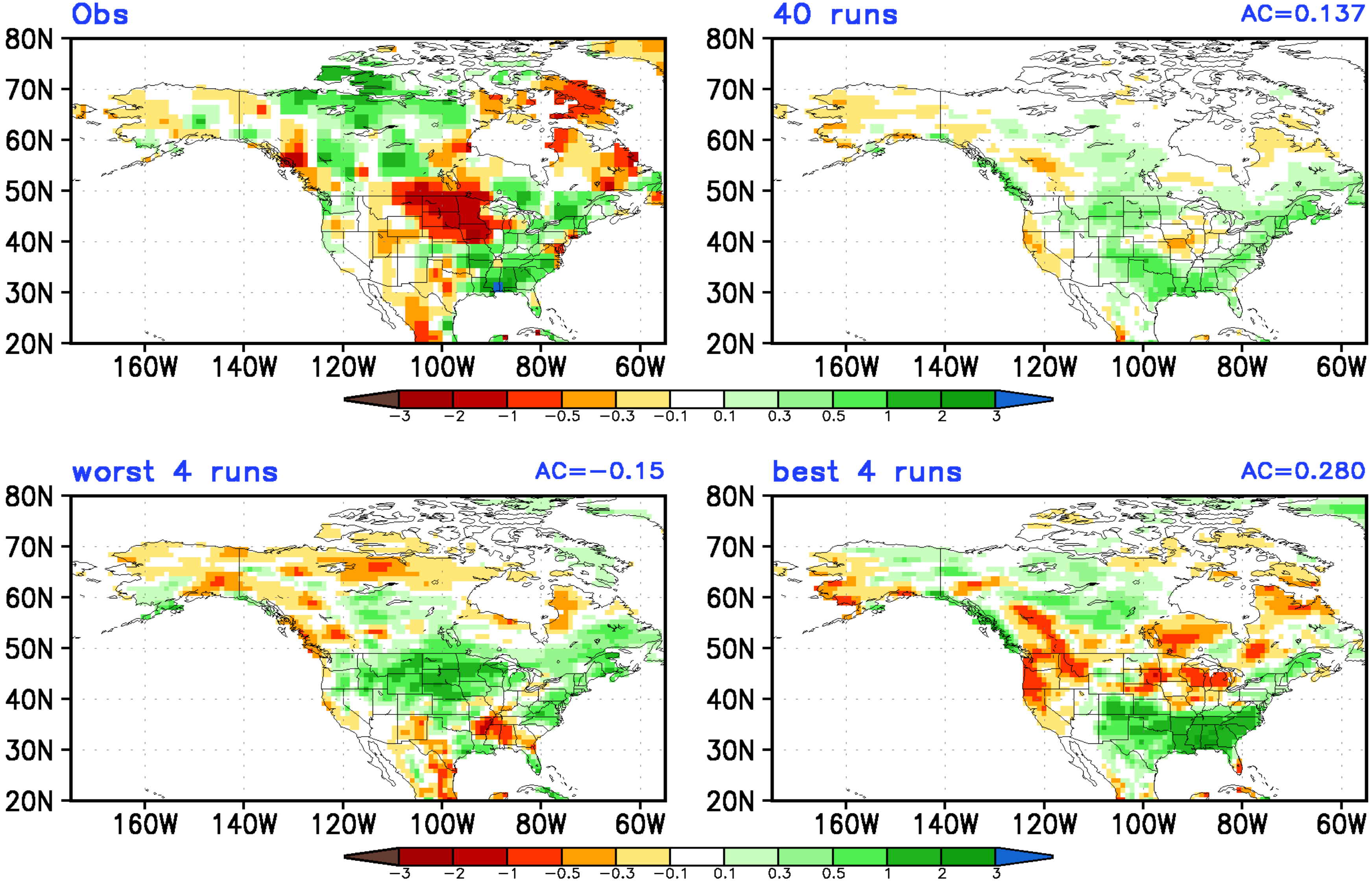
AMJ2017 Anomaly Correlation for Individual CFSv2 Forecast with Observation -- Prec (NA)



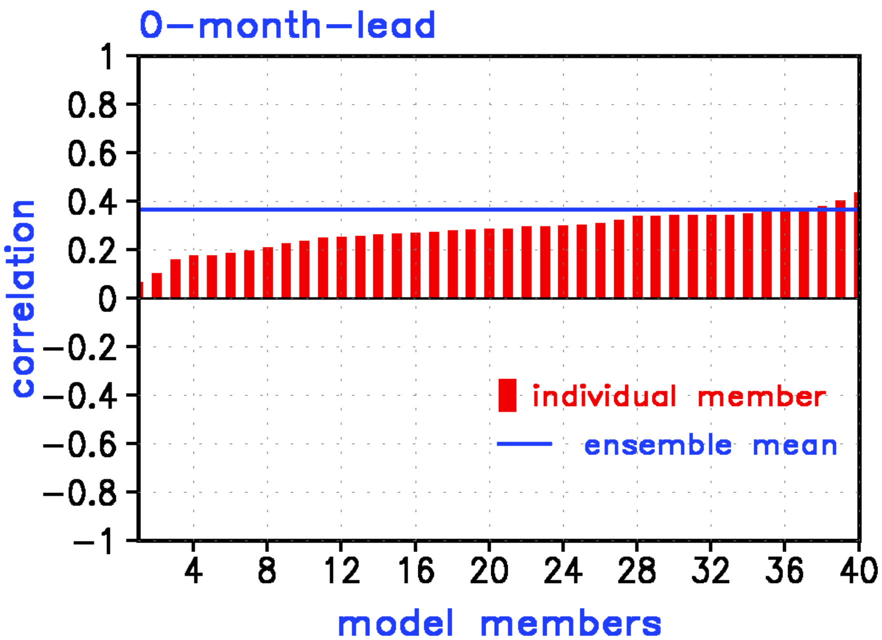
Observed & CFSv2 Forecast Ensemble Average Anomalies
AMJ2017 Prec(mm/day) 40 runs/worst 4 runs/best 4 runs
0-month-lead

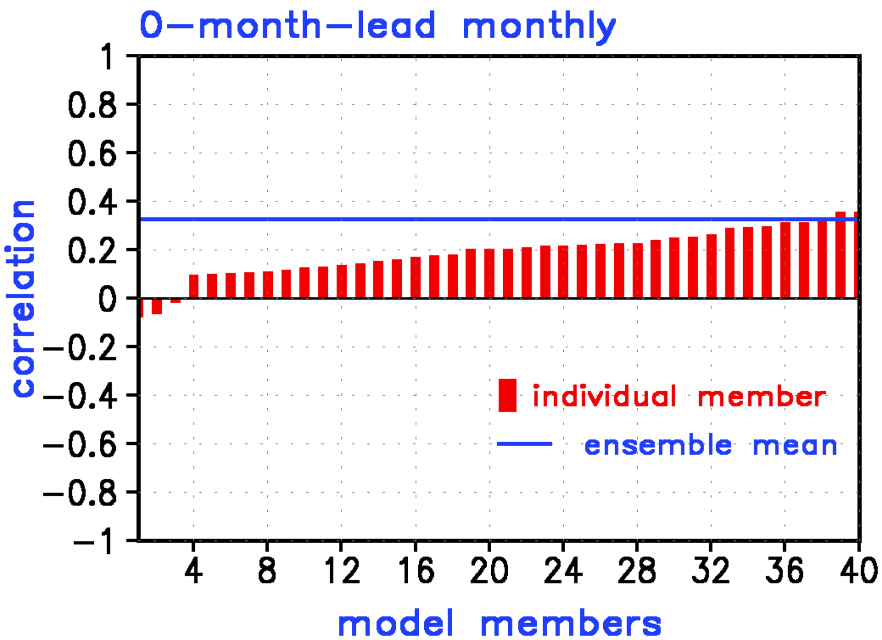


Observed & CFSv2 Forecast Ensemble Average Anomalies
AMJ2017 Prec(mm/day) 40 runs/worst 4 runs/best 4 runs
0-month-lead monthly

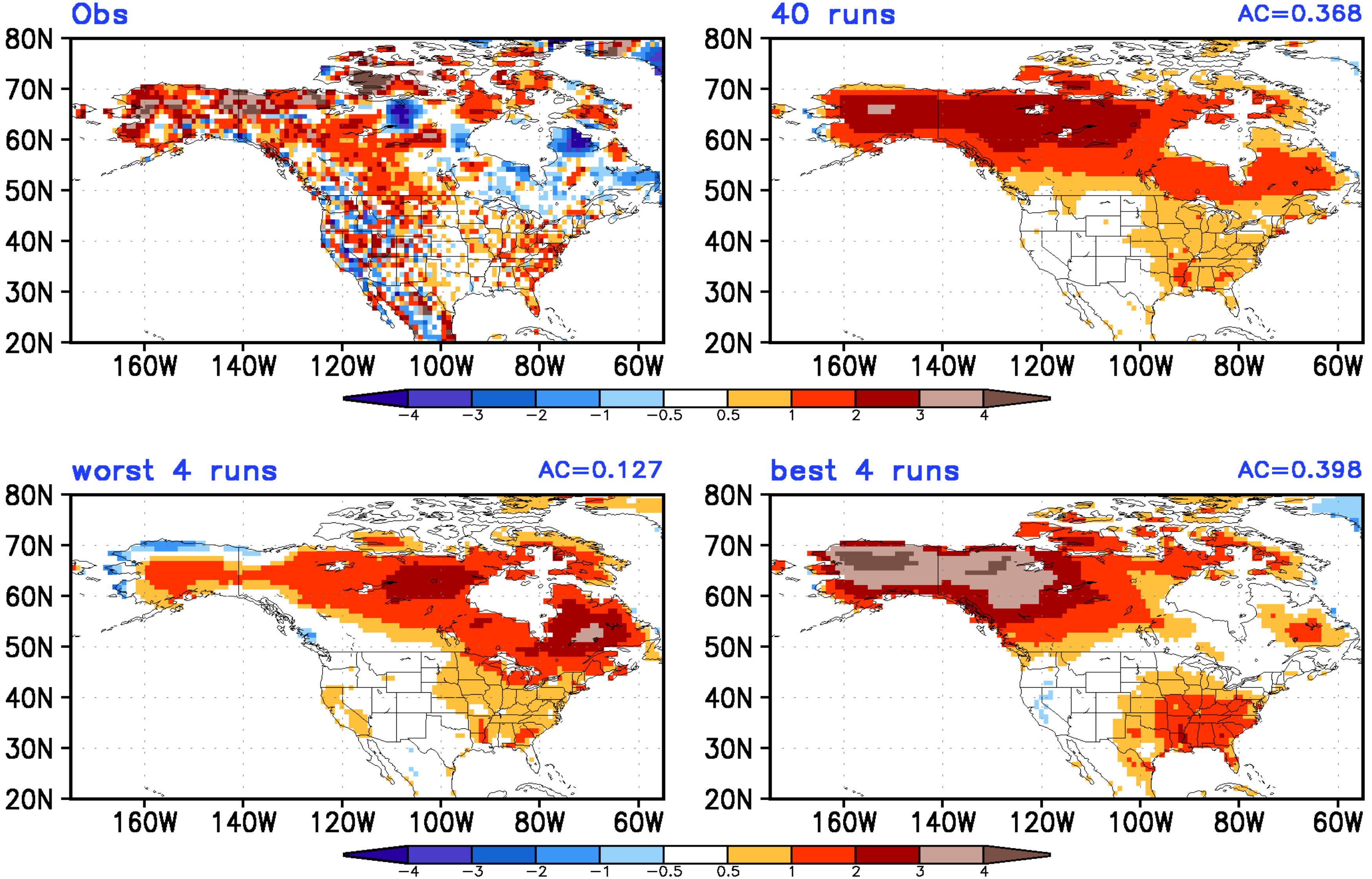


AMJ2017 Anomaly Correlation for Individual CFSv2 Forecast with Observation -- T2m (NA)

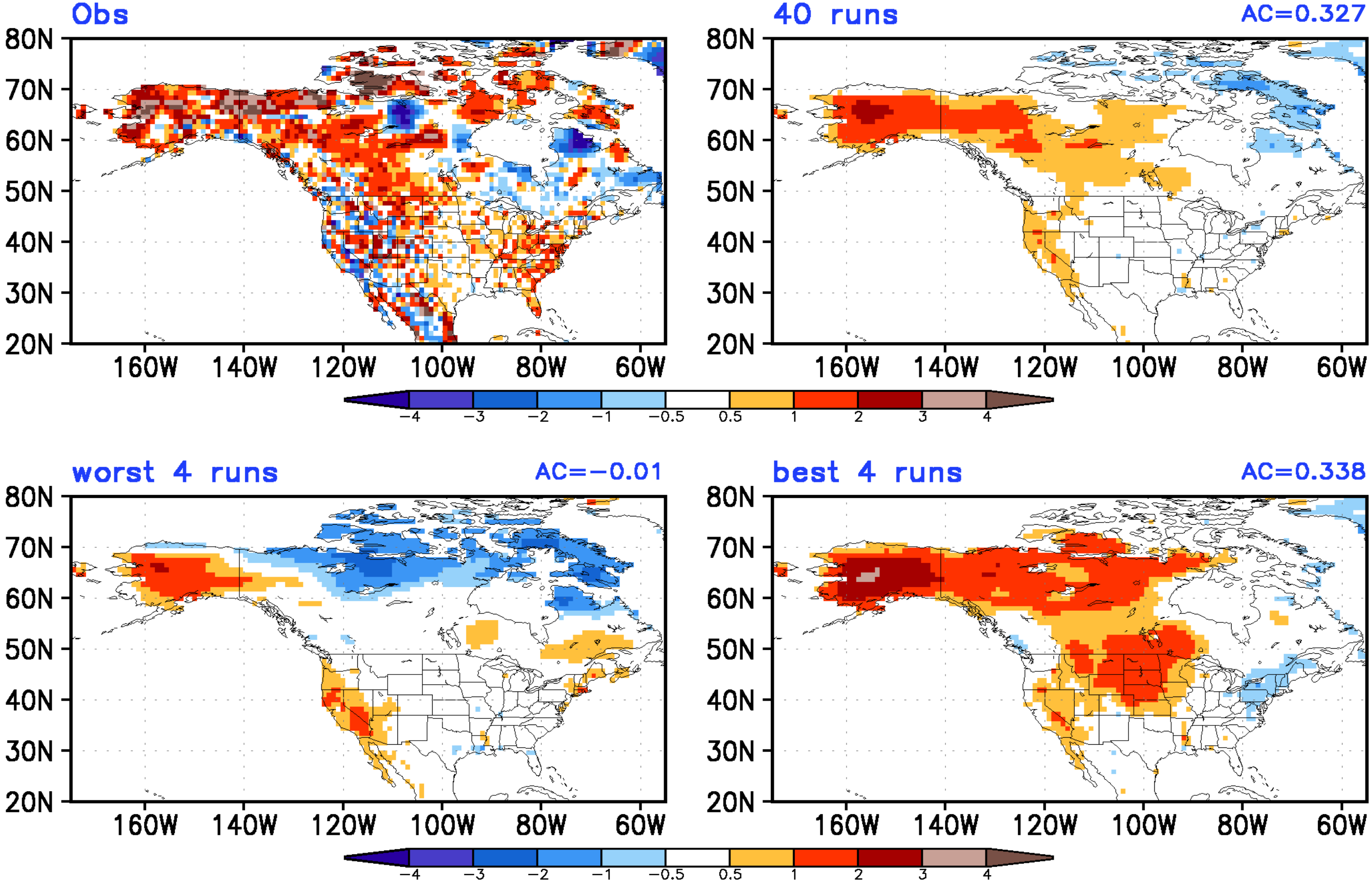




Observed & CFSv2 Forecast Ensemble Average Anomalies AMJ2017 T2m(K) 40 runs/worst 4 runs/best 4 runs 0-month-lead

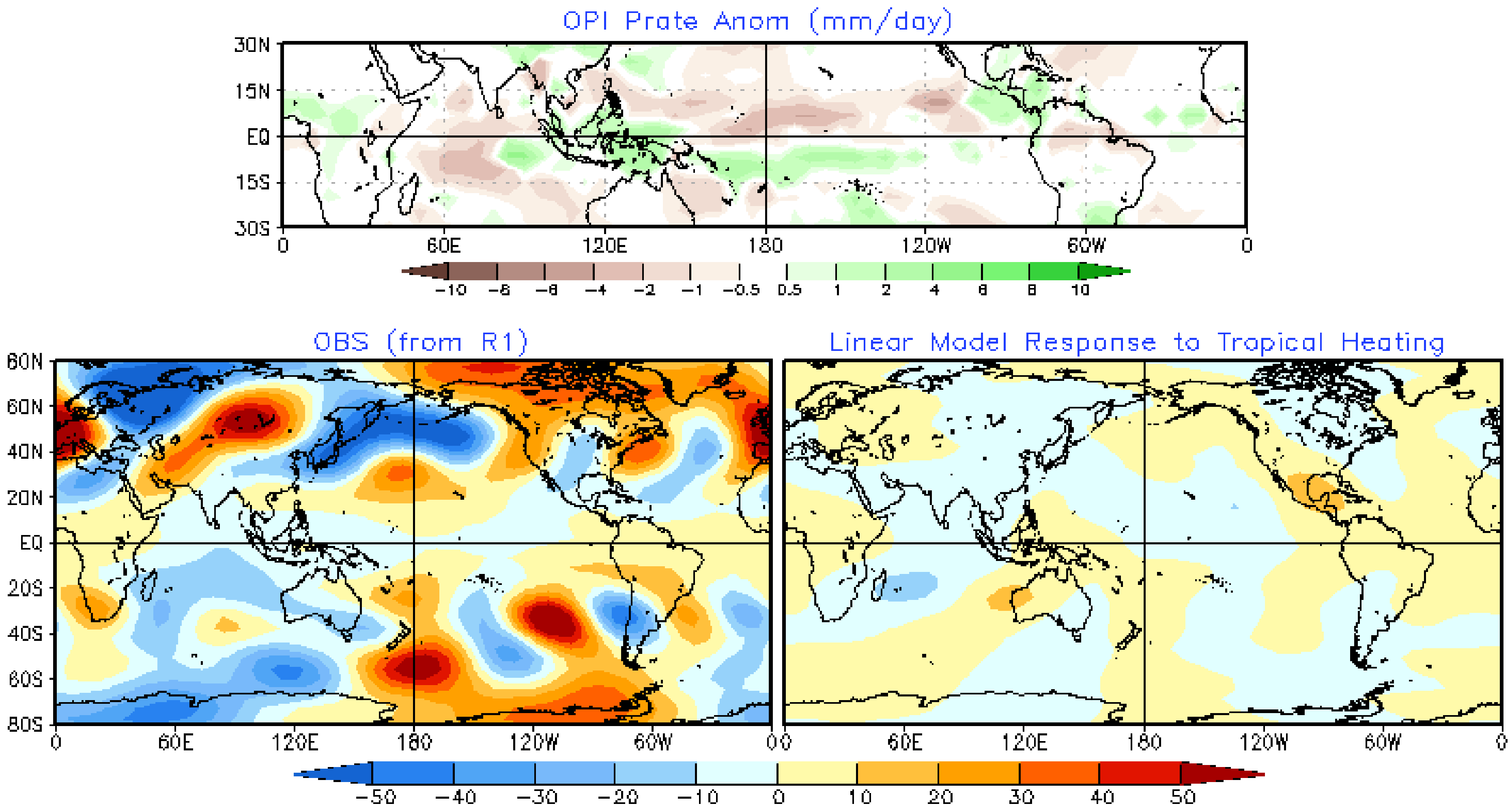


Observed & CFSv2 Forecast Ensemble Average Anomalies
AMJ2017 T2m(K) 40 runs/worst 4 runs/best 4 runs
0-month-lead monthly



200mb Height from Linear Model

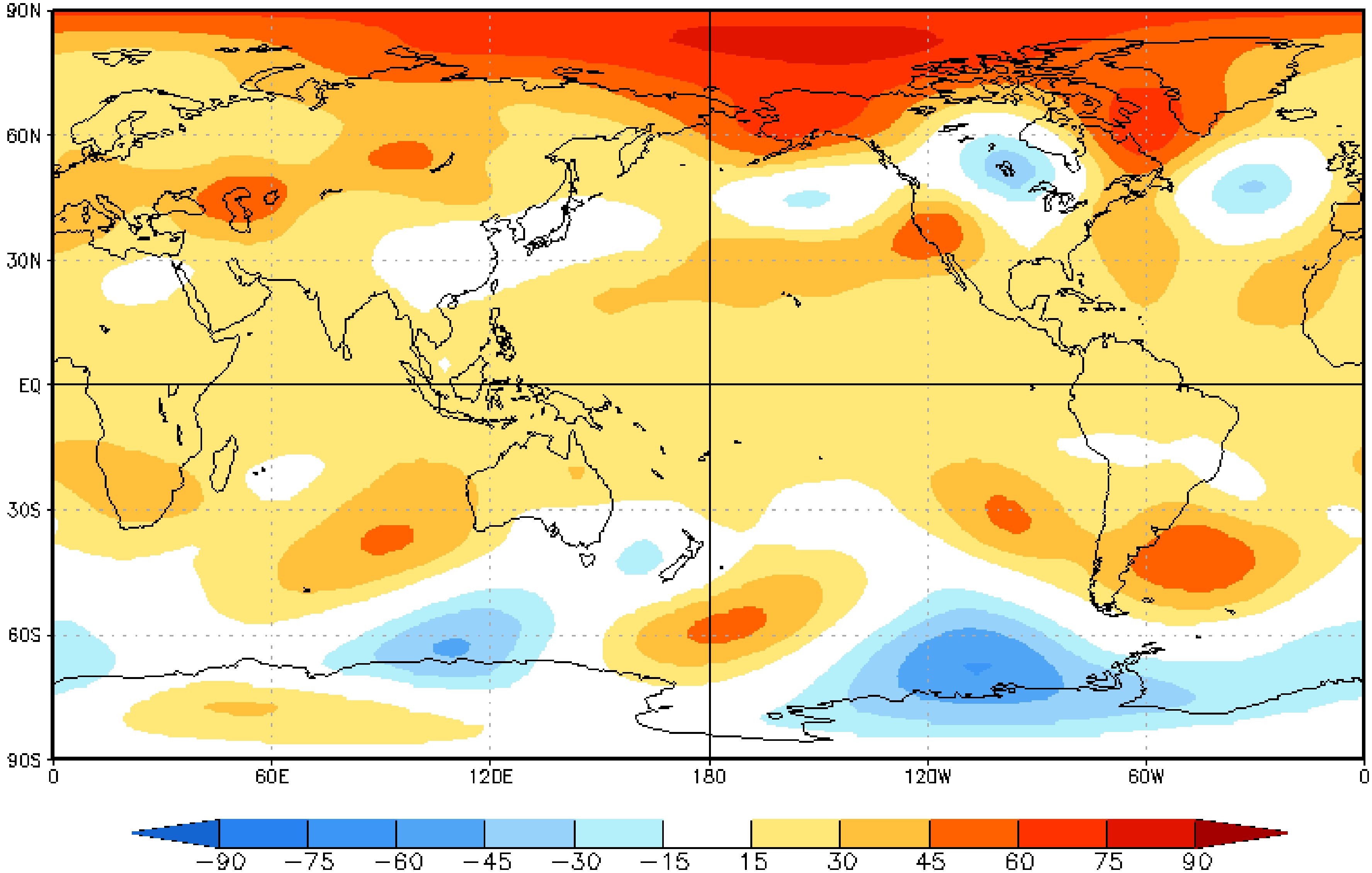
AMJ2017 200mb Eddy HGT(m)
OBS vs. Linear Model Response to Tropical Heating
Heating is converted from Prate in 15S–15N



Pattern COR: global=0.01, tropics(30S–30N)=0.10

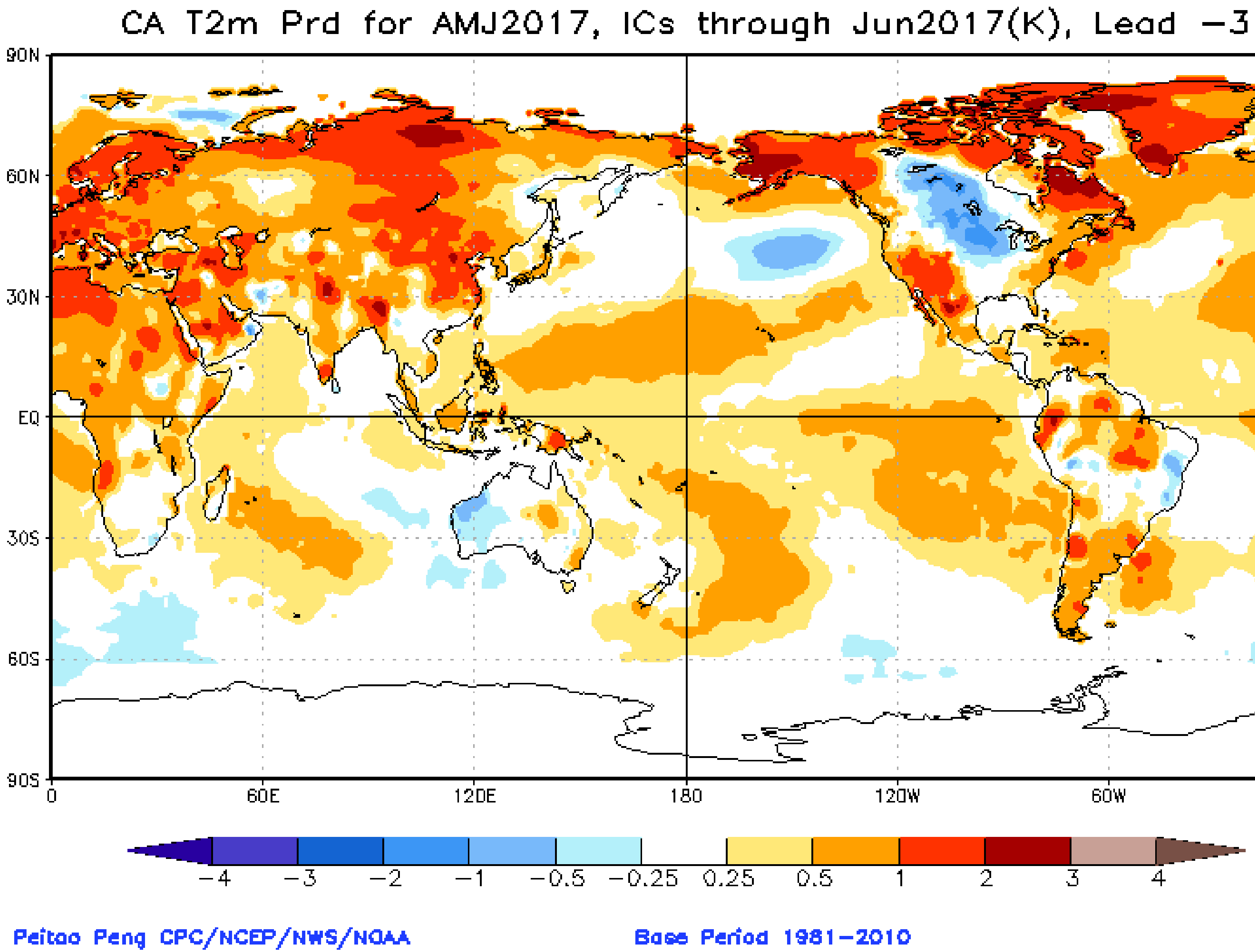
Seasonal Forecasts from the Constructed Analog Model

CA HGT200 Prd for AMJ2017, ICs through Jun2017(m), Lead -3



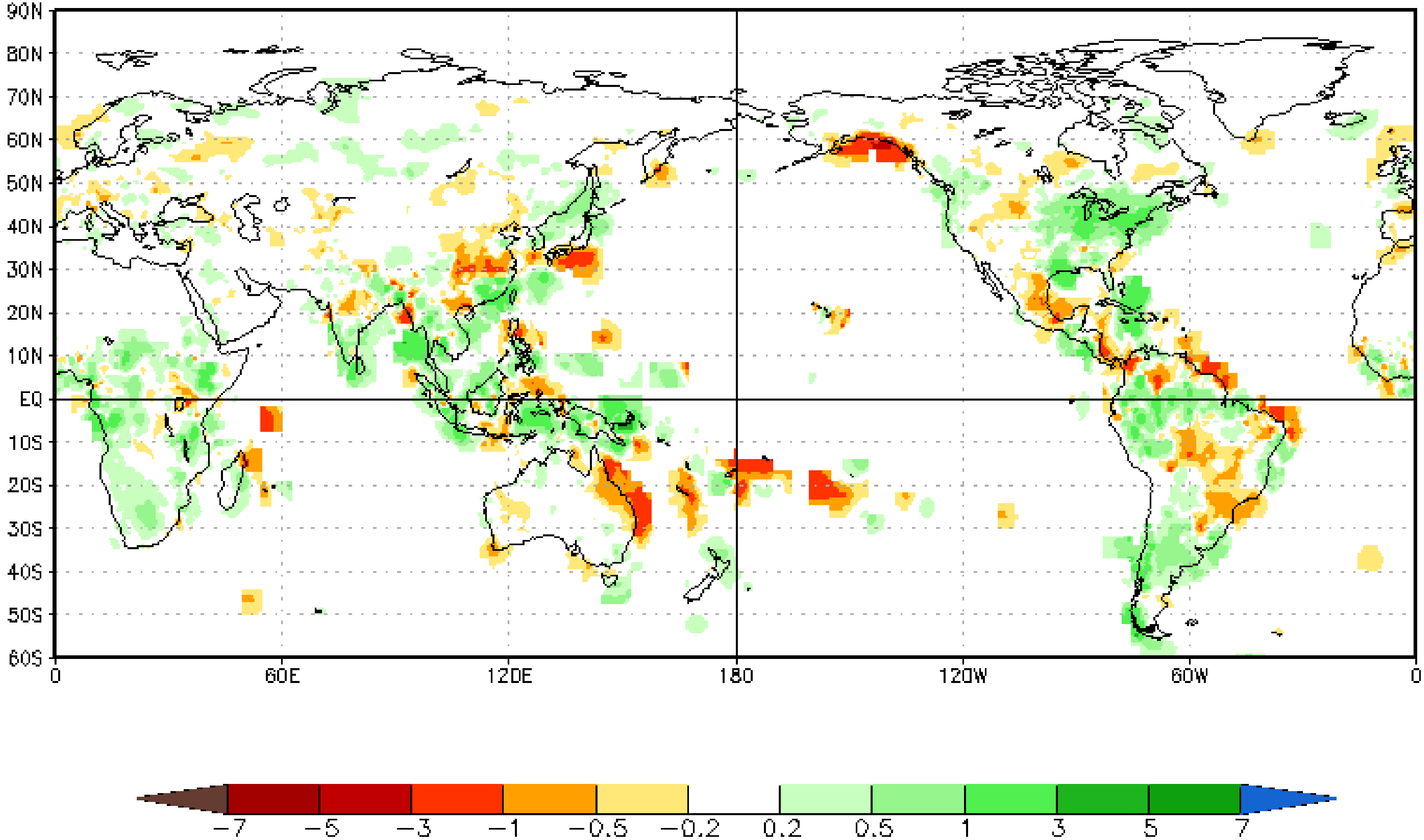
Peitao Peng CPC/NCEP/NWS/NOAA

Base Period 1981-2010



CA T2m Prd for AMJ2017, ICs through Jun2017(K), Lead -3
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
-4
-3
-2
-1
-0.5
-0.25
0.25
0.5
1
2
3
4
Peitao Peng CPC/NCEP/NWS/NOAA
Base Period 1981-2010

CA Prec Prd for AMJ2017, ICs through Jun2017(mm/day), Lead −3



Peitao Peng CPC/NCEP/NWS/NOAA

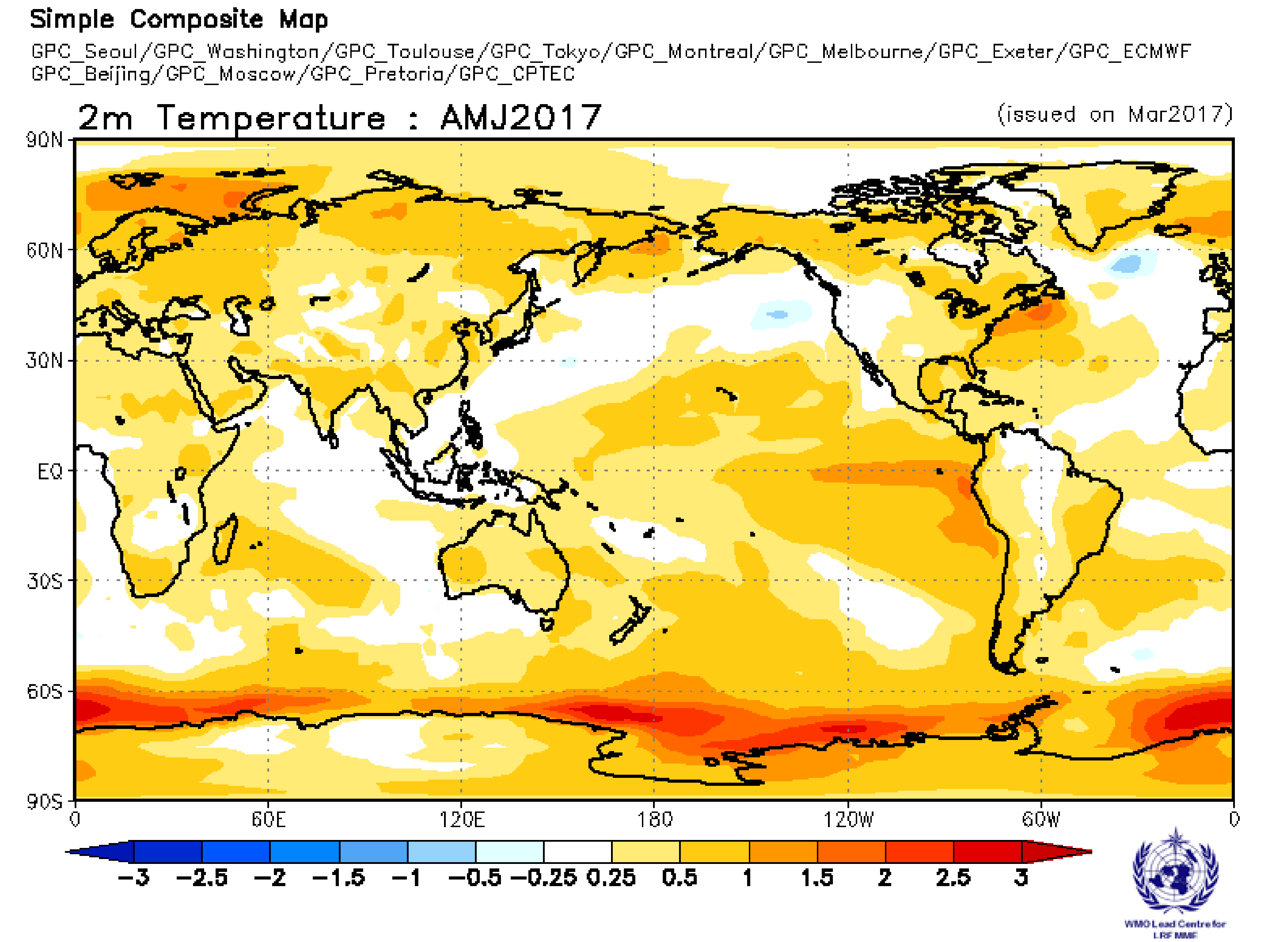
Base Period 1981−2010

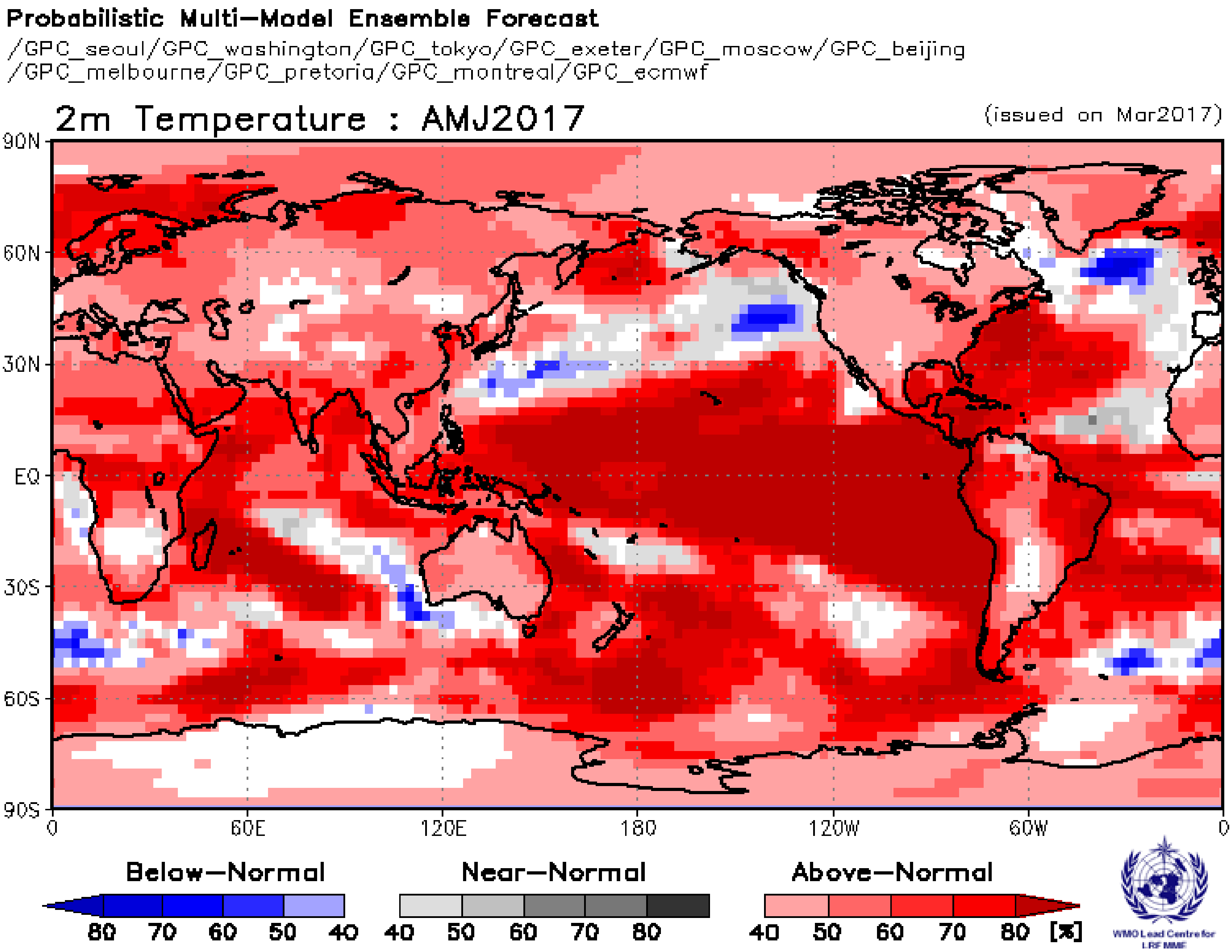
Seasonal Forecasts from WMO Lead Center for Long-Range Forecast Multi-Model Ensemble (LC-LRFMME)

https://www.wmolc.org/

- LC-LRFMME seasonal forecast are based on forecasts provided by WMO recognized Global Producing Centers (GPCs) for Long-Range Forecasts to the LC-LRFMME. Contribution of all GPCs is acknowledged.
- Seasonal forecasts from GPCs are merged into a multi-model ensemble forecast.
- LC-LRFMME forecasts are based on GPC seasonal forecast systems run during the first week of the month for the next season. For example, forecasts runs in first week of January for the seasonal mean of February-March-April.
- Forecasts in slides 41-44 are from the Lead Center.

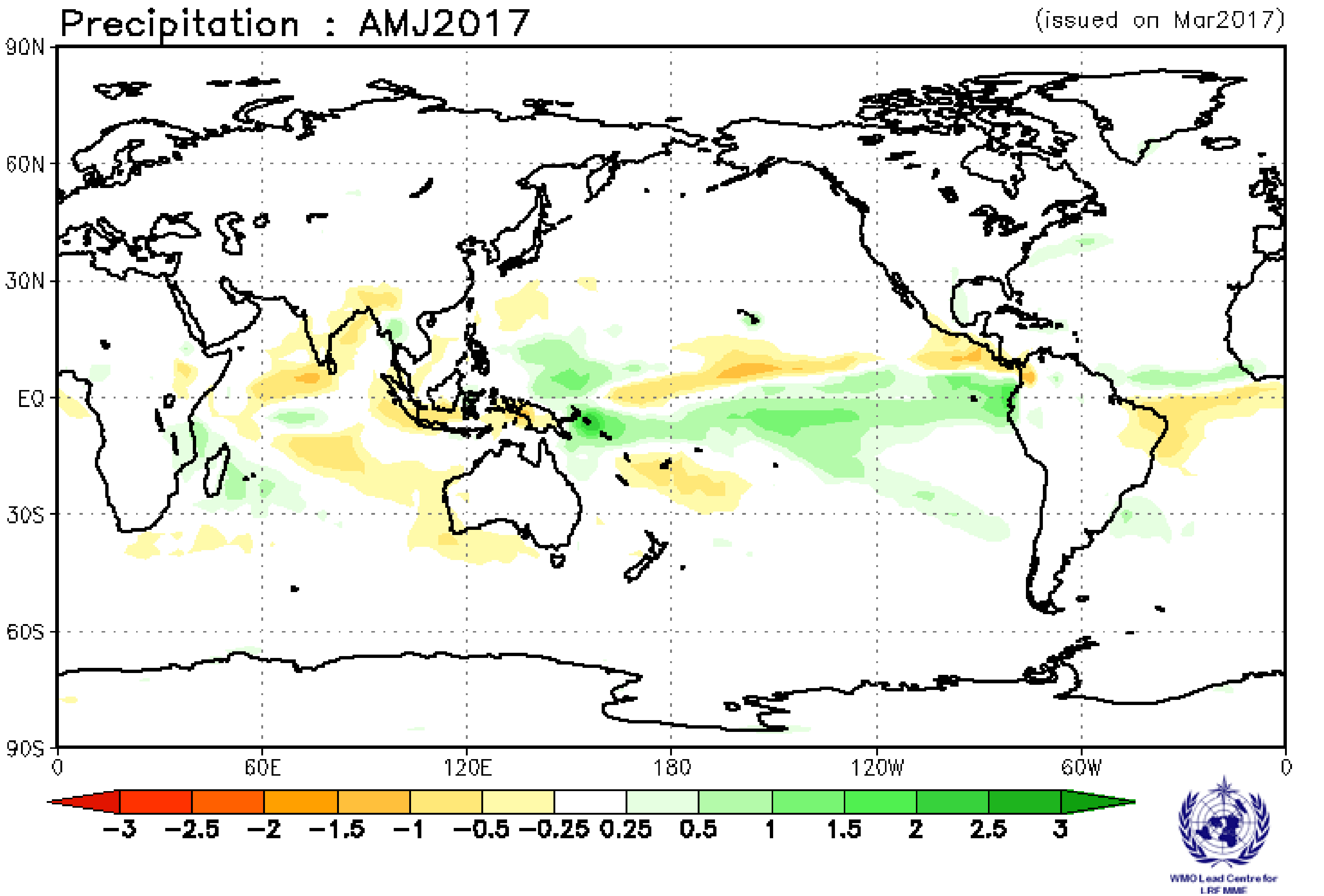
- *For more information see visit Lead Center website; also see Graham, R., and Co-authors, 2011: New perspectives for GPCs, their role in the GFCS and a proposed contribution to a 'World Climate Watch'. Climate Research, **47**, 47-55.*

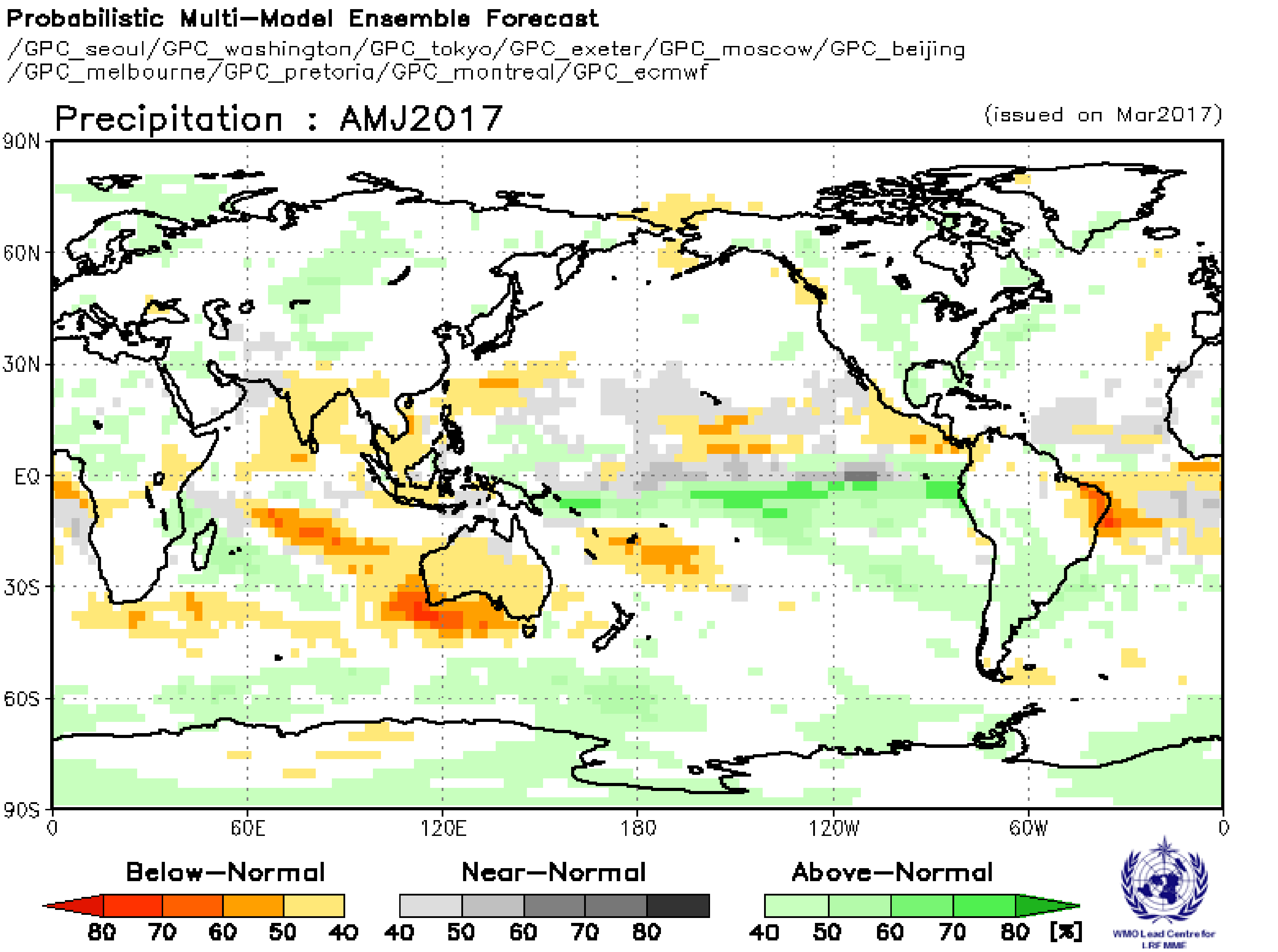

Simple Composite Map
GPC_Seoul/GPC_Washington/GPC_Toulouse/GPC_Tokyo/GPC_Montreal/GPC_Melbourne/GPC_Exeter/GPC_ECMWF
GPC_Beijing/GPC_Moscow/GPC_Pretoria/GPC_CPTEC
2m Temperature : AMJ2017
(issued on Mar2017)
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
−3 −2.5 −2 −1.5 −1 −0.5 −0.25 0.25 0.5 1 1.5 2 2.5 3
WMO Lead Centre for LRF MME


Probabilistic Multi-Model Ensemble Forecast
/GPC_seoul/GPC_washington/GPC_tokyo/GPC_exeter/GPC_moscow/GPC_beijing
/GPC_melbourne/GPC_pretoria/GPC_montreal/GPC_ecmwf
2m Temperature : AMJ2017
(issued on Mar2017)
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
Below-Normal
80 70 60 50 40
Near-Normal
40 50 60 70 80
Above-Normal
40 50 60 70 80 [%]
WMO Lead Centre for LRF MME

Simple Composite Map

GPC_Seoul/GPC_Washington/GPC_Toulouse/GPC_Tokyo/GPC_Montreal/GPC_Melbourne/GPC_Exeter/GPC_ECMWF
GPC_Beijing/GPC_Moscow/GPC_Pretoria/GPC_CPTEC





Probabilistic Multi-Model Ensemble Forecast
/GPC_seoul/GPC_washington/GPC_tokyo/GPC_exeter/GPC_moscow/GPC_beijing
/GPC_melbourne/GPC_pretoria/GPC_montreal/GPC_ecmwf
Precipitation : AMJ2017
(issued on Mar2017)
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
Below-Normal
80 70 60 50 40
Near-Normal
40 50 60 70 80
Above-Normal
40 50 60 70 80 [%]
WMO Lead Centre for LRF MME

References

Fan, Y., and Dool H. van den Dool (2008), A global monthly land surface air temperature analysis for 1948-present. J. Geophys. Res., 113, D01103. doi:10.1029/2007JD008470.

Kumar, A., M. Chen, M. Hoerling, and J. Eischeid (2013), Do extreme climate events require extreme forcings? Geophys. Res. Lett., 40, 3440-3445. doi:10.1002/grl.50657.

Reynolds, R. W. et al (2007), Daily high resolution-blended analyses for sea surface temperature. J. Clim., 20, 5473-5496. doi:10.1175/2007JCLI1824.1.

Saha, S. et al (2010), The NCEP climate forecast system reanalysis. Bull. Amer. Meteor. Soc., 91, 1015-1057. doi:10.1175/2010BAMS3001.1.

Saha, S. et al (2014), The NCEP climate forecast system version 2. J. Clim., 27, 2185-2208. doi:10.1175/JCLI-D-12-00823.1.

Xie, P, and P. A. Arkin (1997), Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. Bull. Amer. Meteor. Soc., 78, 2539-2558. doi: http://dx.doi.org/10.1175/1520-0477(1997)078%3C2539:GPAYMA%3E2.0.CO;2