

Attribution of Seasonal Climate Anomalies March-April-May 2021

(<https://www.cpc.ncep.noaa.gov/products/people/mchen/AttributionAnalysis/>)

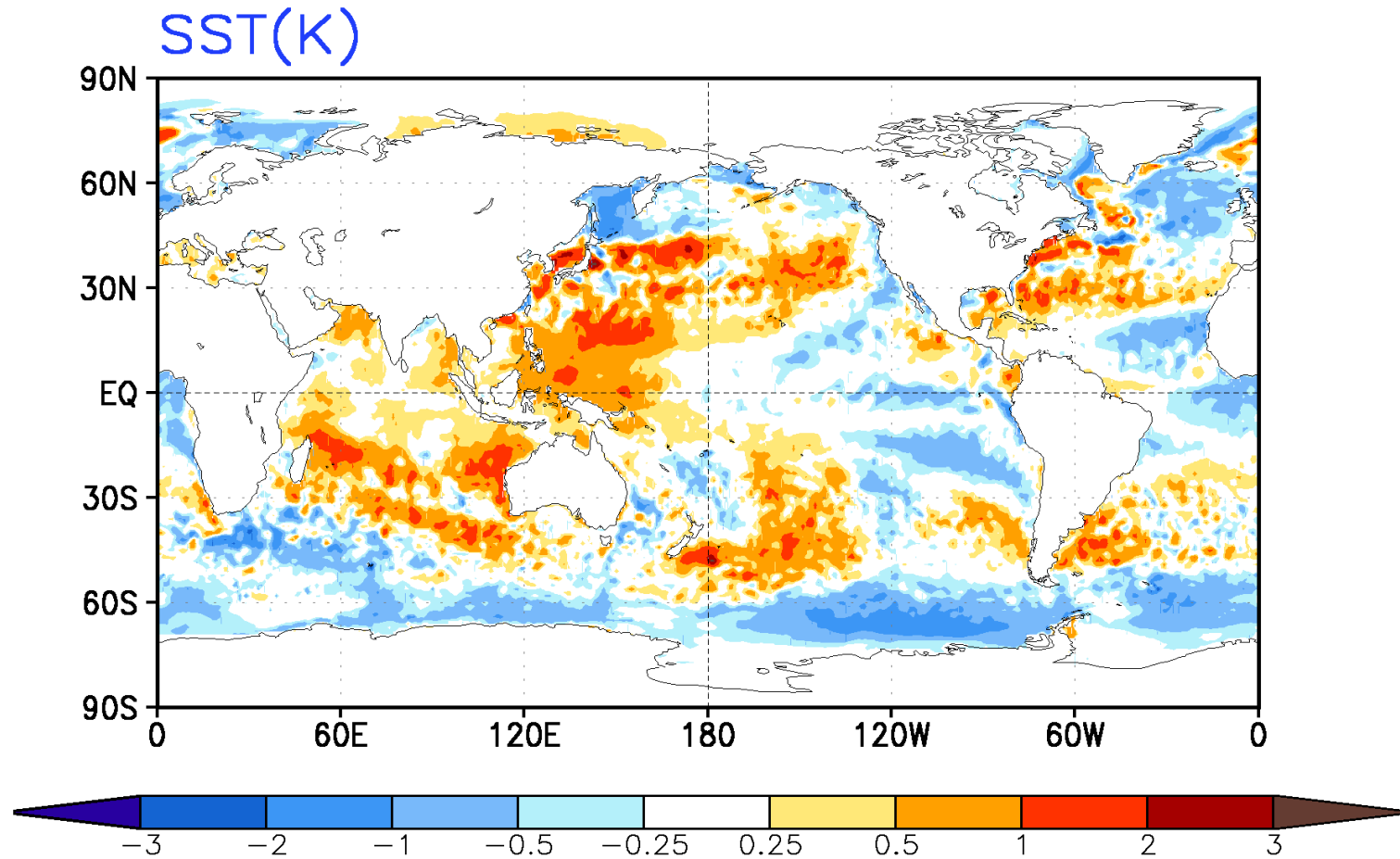
Summary of Observed Conditions and Outlooks

- SST cold anomalies weakened in the central/eastern Pacific; the tropical Indian Ocean and the western and NE Pacific Ocean remained on the warm side. Another feature to note is the prevalence of cold SST anomalies (blue) in global oceans (slide 4).
- In general, the large-scale distribution of negative and positive precipitation anomalies in the equatorial Pacific and over the Maritime Continent ([a reflection of La Niña conditions](#)) was predicted in CFSv2 and other MME forecast systems (slides 11, 33, 34, & 39).
- The average of MAM2021 height anomalies was in [positive phase of AO](#) pattern. The large scale z200 anomaly pattern of low (high) over the polar (30°N-60°N) areas were predicted in the initialized CFSv2, while the location of anomaly centers were shifted in the model prediction, for example absence of trough over the continental US, that led to errors in forecasting cold anomalies (slides 12, 15, 16).
- The ensemble means of CFSv2, and MME models did not capture most of observed anomalies in NA temperature and precipitation; even the best 4 members of CFSv2 did not have cold anomalies over the southern part of central US (slides 26, 28, 33, 34, 38-41).
- May2021 monthly forecasts from the shortest 3-day-leads initial conditions captured the observed precipitation positive anomalies over the gulf of Mexico, while missed observed temperature cold anomalies over the central to eastern US (slides 30, 31).

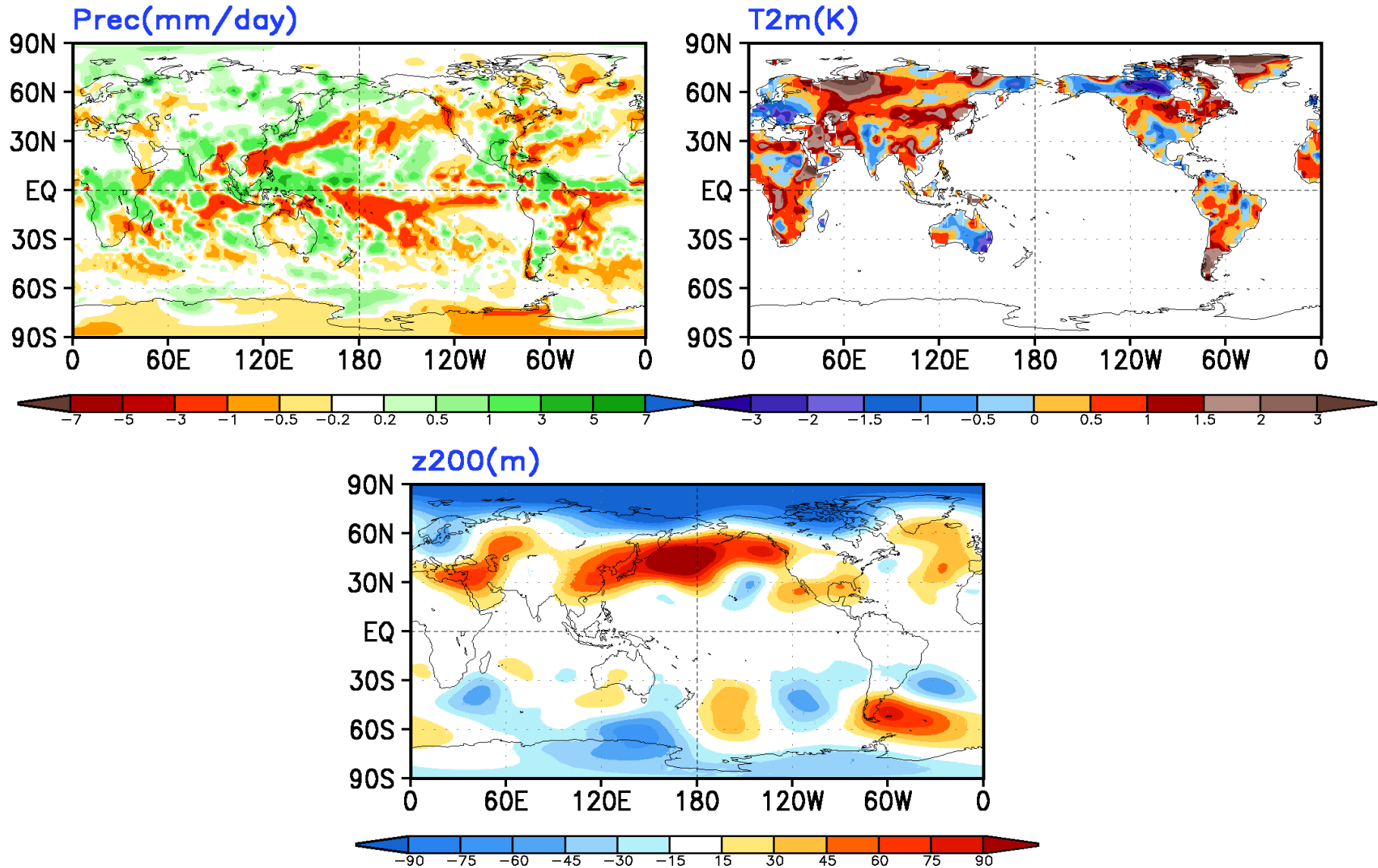
Observed Seasonal Anomalies

Global and North America

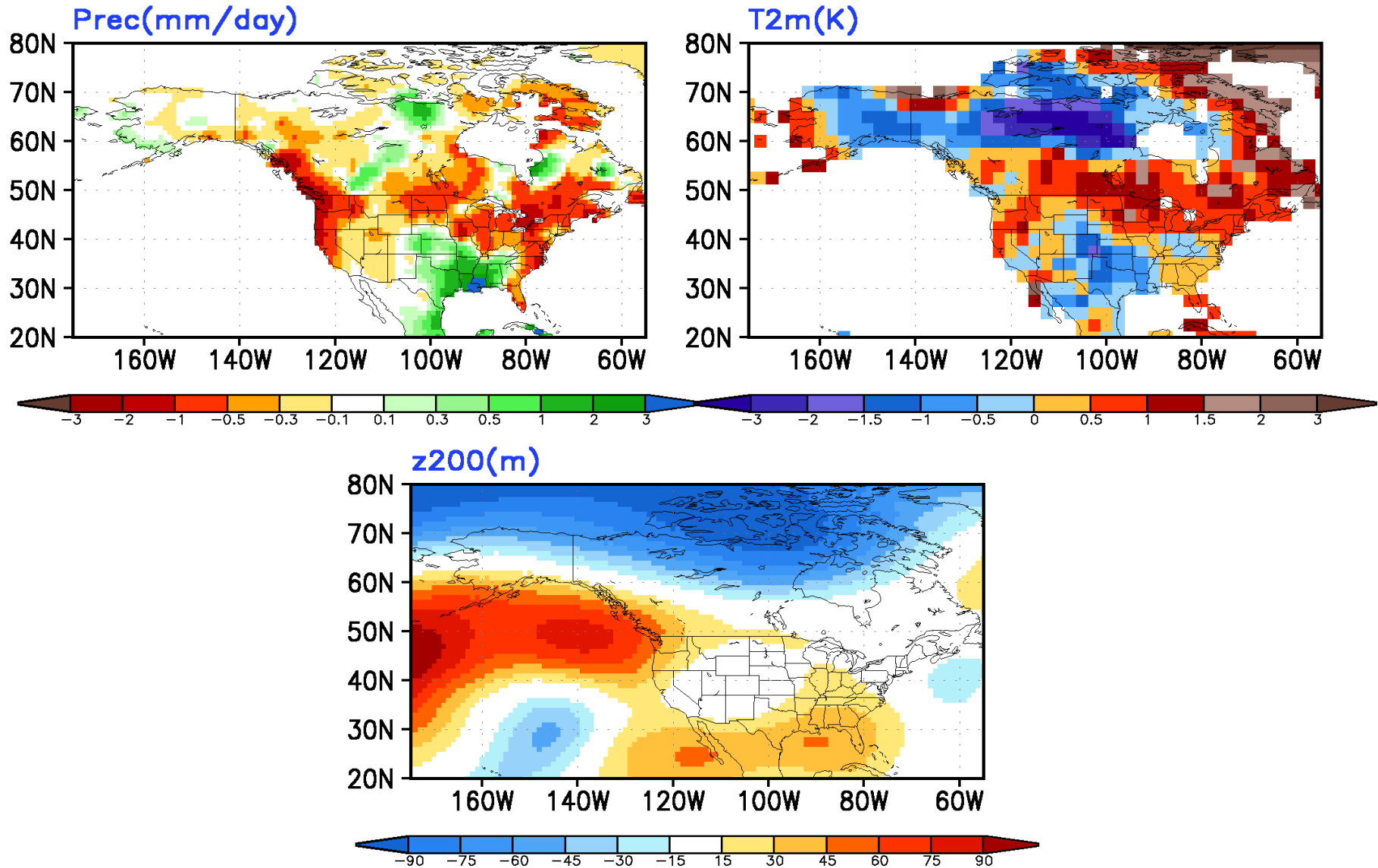
Observed Anomaly MAM2021



Observed Anomaly MAM2021



Observed Anomaly MAM2021



CPC Seasonal Outlooks and NMME Forecasts

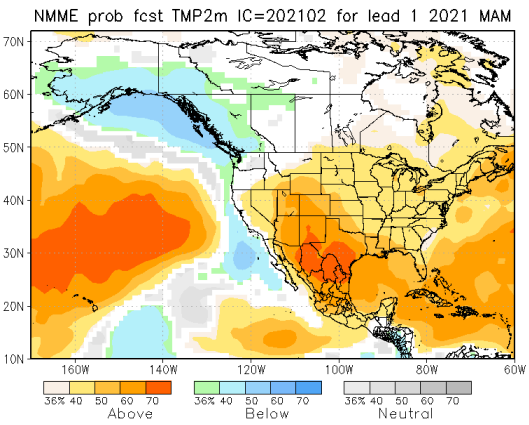
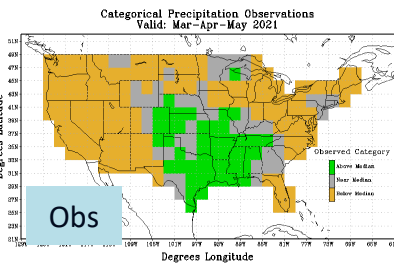
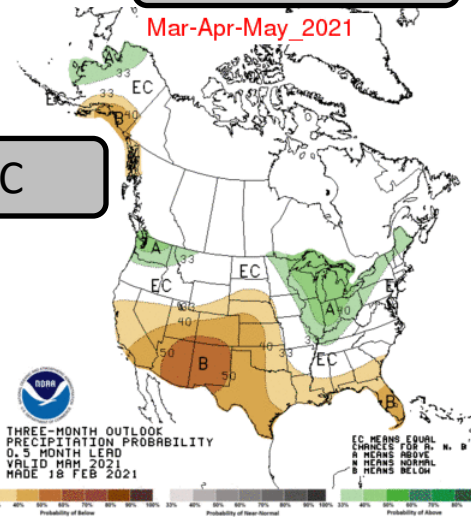
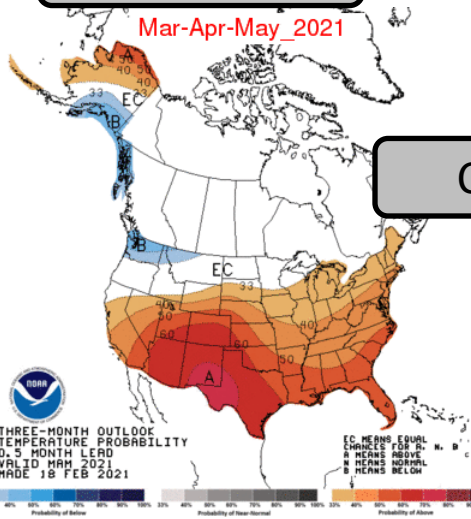
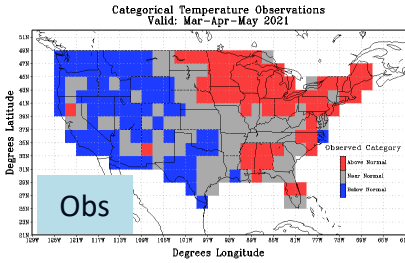
Temperature

Precipitation

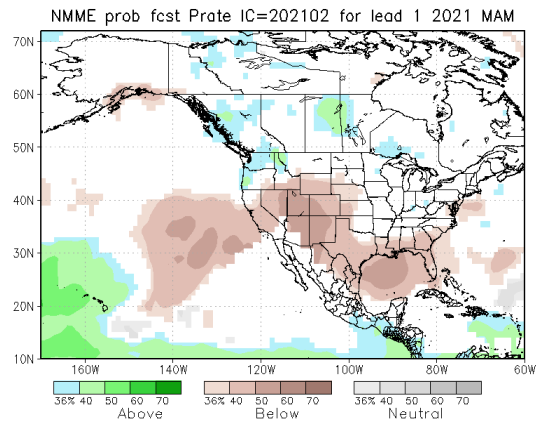
Temp nonEC
HSS=0

Prec nonEC
HSS=0

CPC



NMME



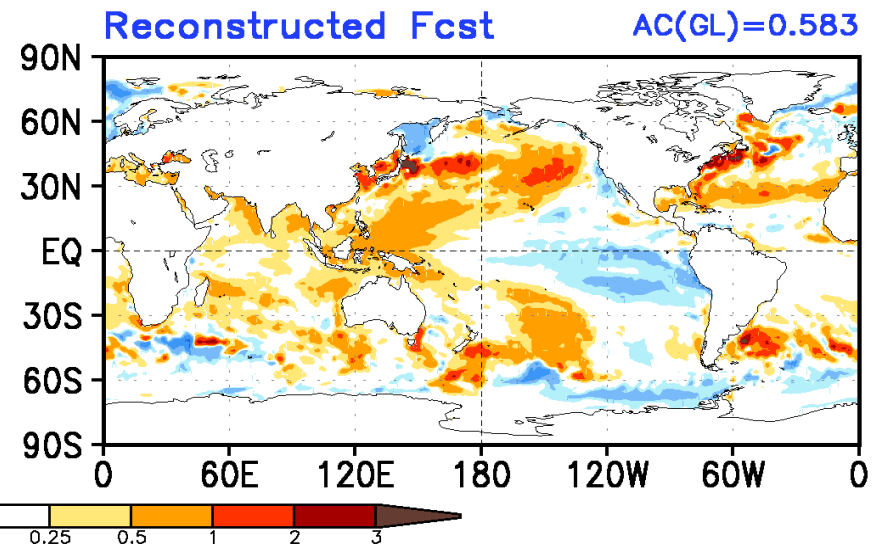
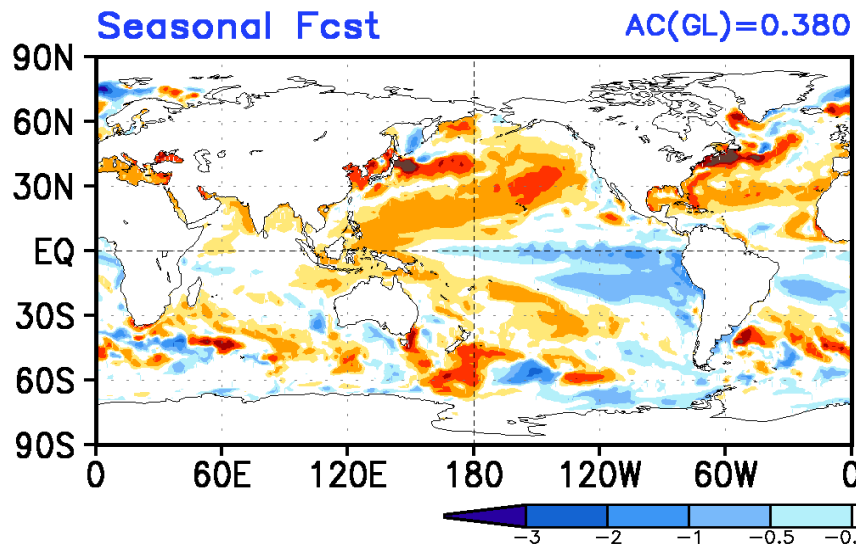
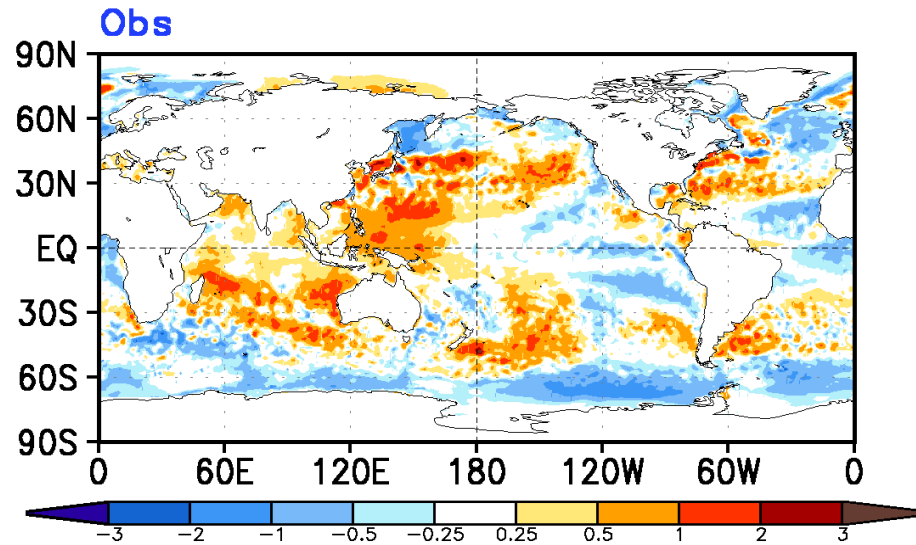
For the rationale behind CPC outlooks see: https://www.cpc.ncep.noaa.gov/products/archives/long_lead/PMD/2021/202102_PMD90D

Model Simulated/Forecast Ensemble Mean Anomalies

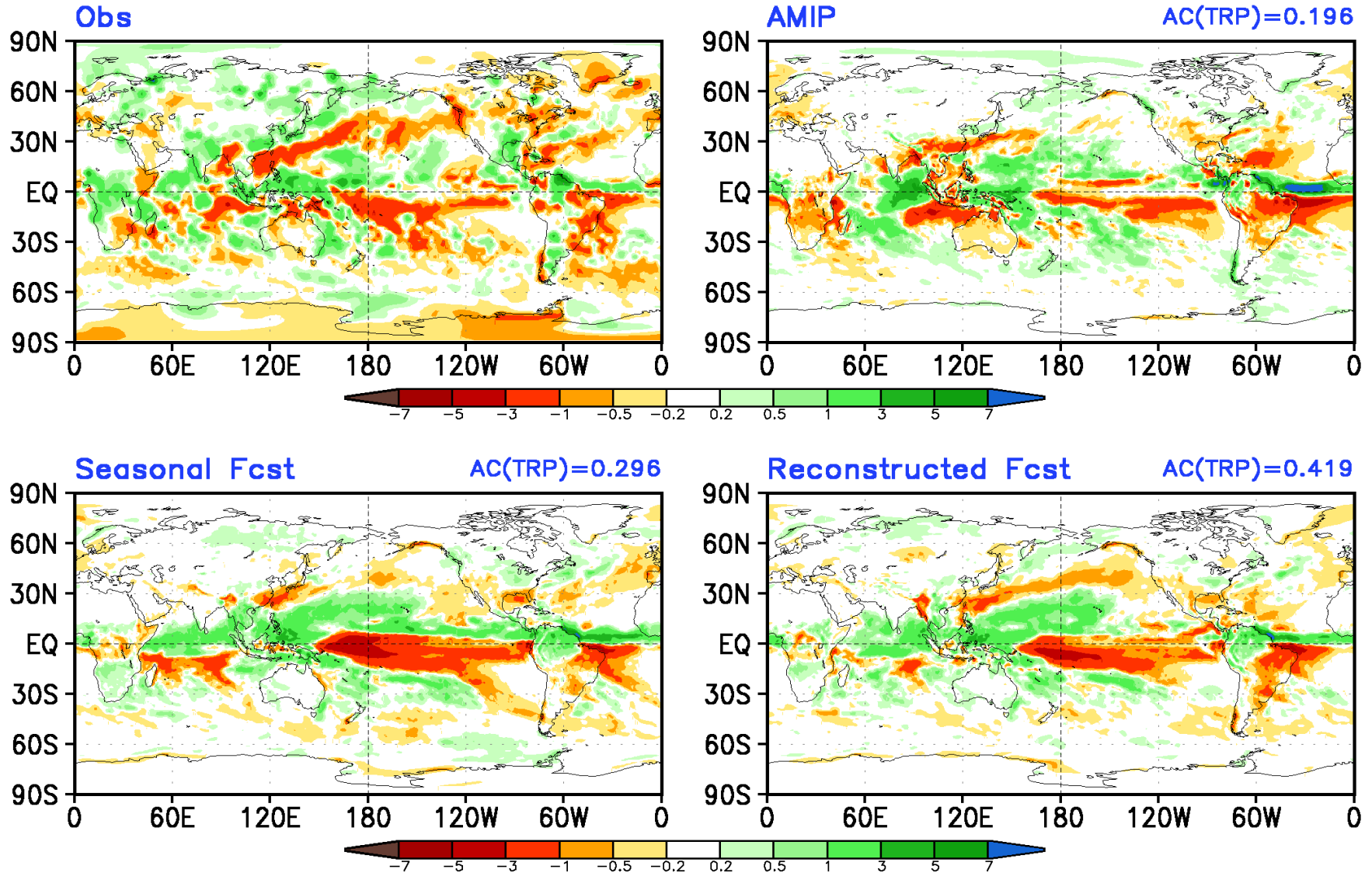
Model Simulated/Forecast Ensemble Average Anomalies

- CFS **AMIP simulations** forced with observed sea surface temperatures (18 members ensemble)
- CFSv2 real time operational forecasts
 - **Seasonal forecast**: the seasonal mean forecasts based on 40 members from the latest 10 days before the target season (0-month-lead). For example, 2016AMJ seasonal mean forecasts are 40 members from 22-31 March2016 initial conditions.
 - **Reconstructed forecast**: 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).

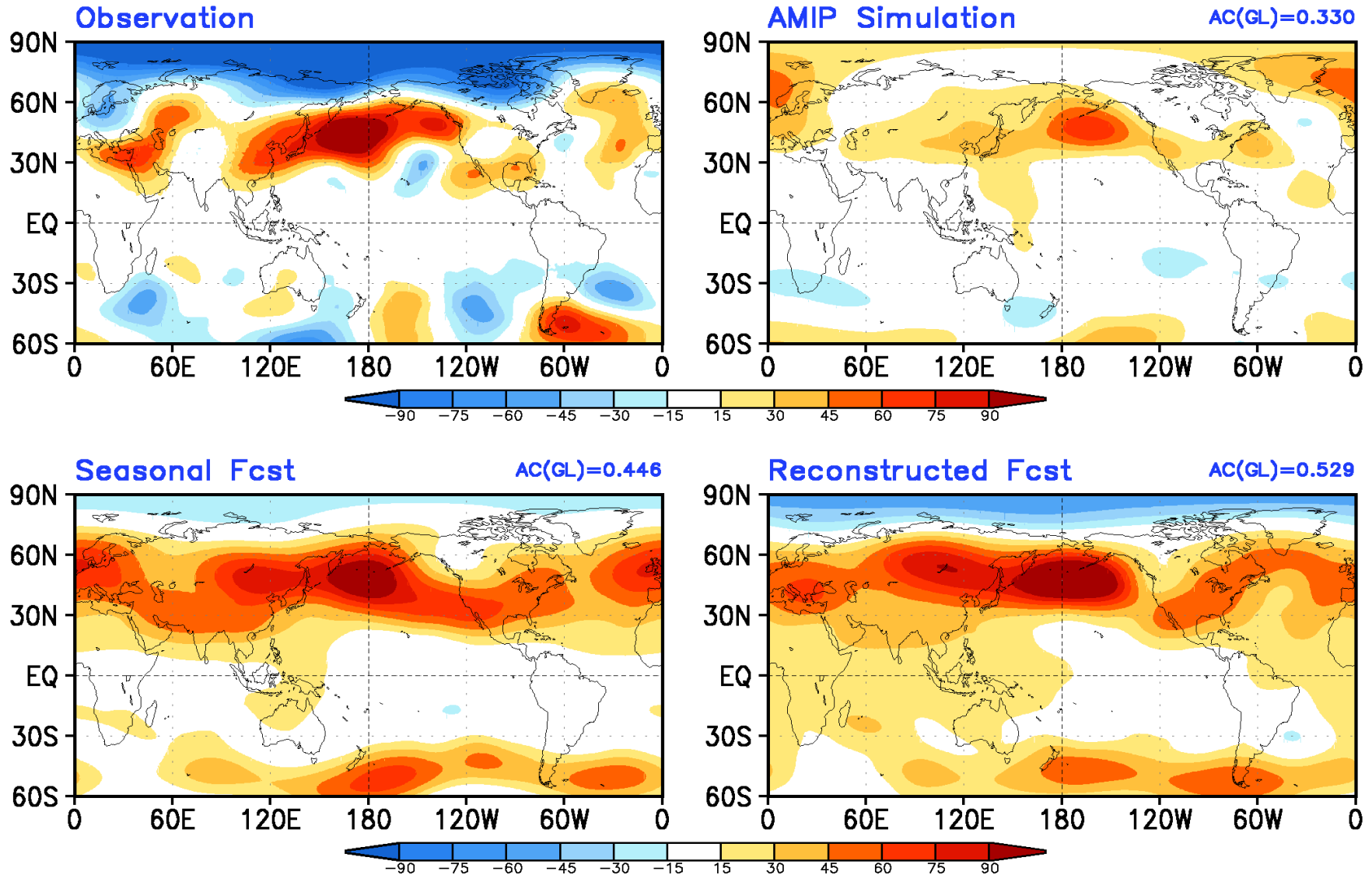
MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies SST(K)



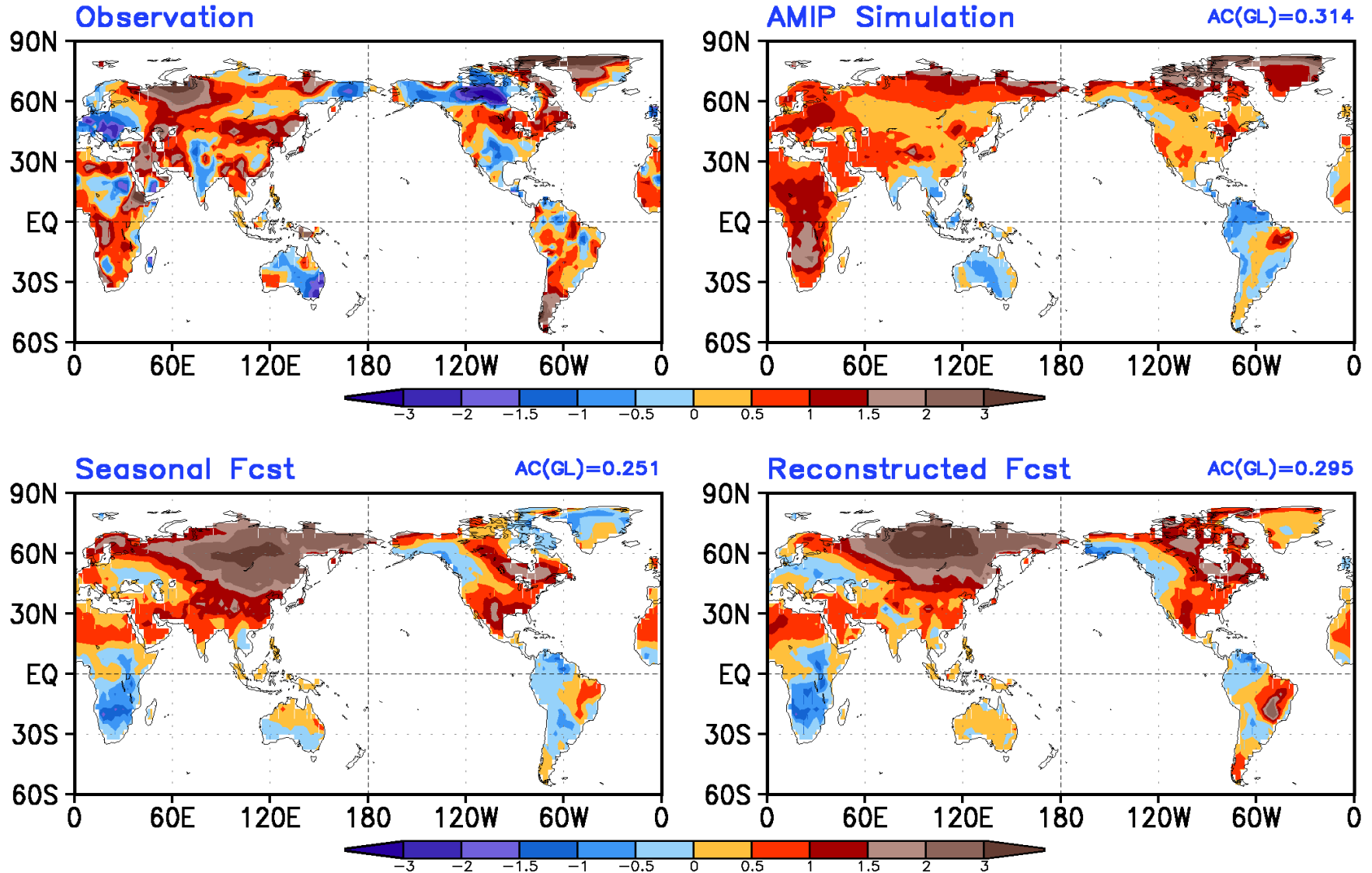
MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies Prec(mm/day)



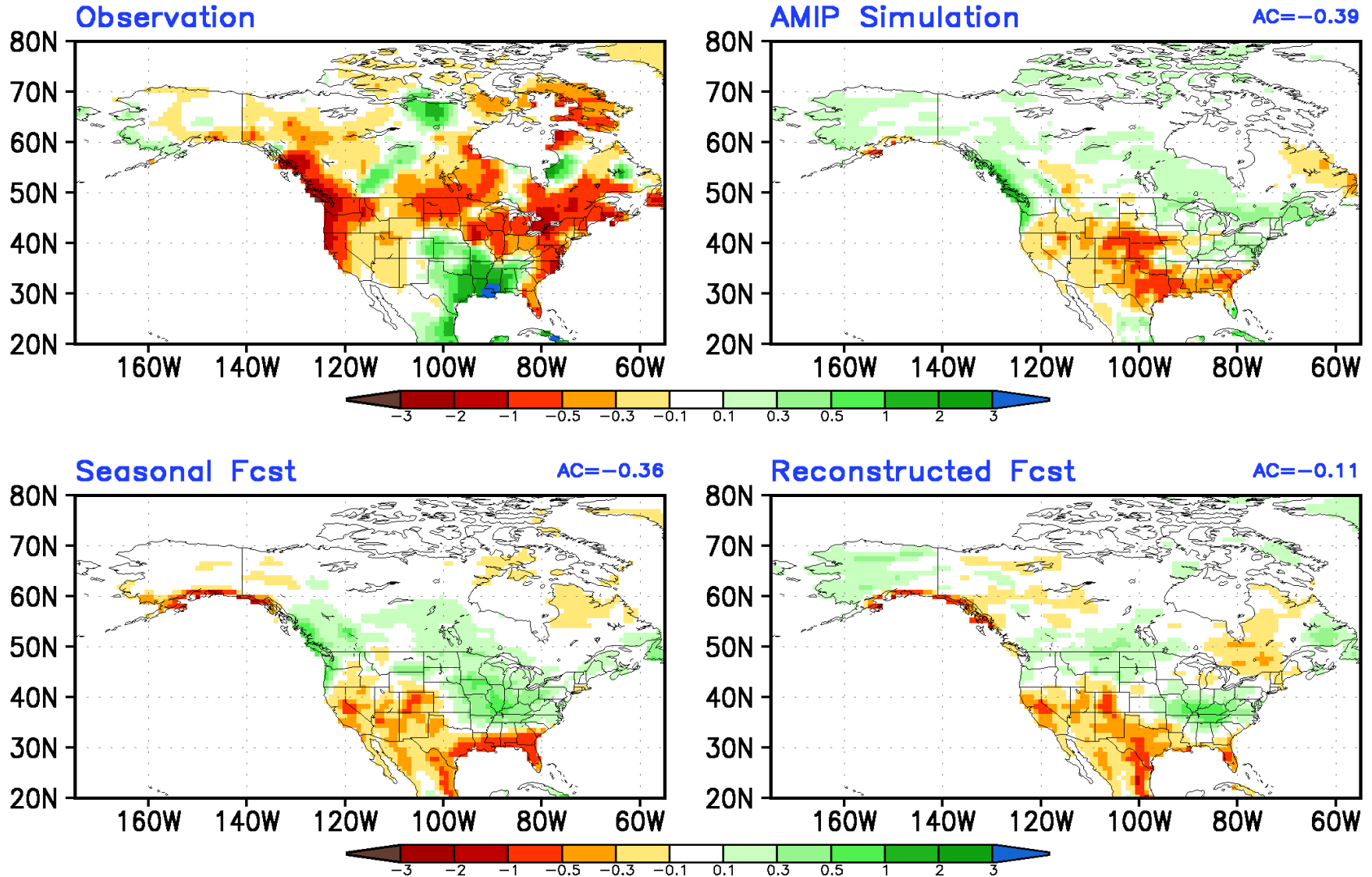
MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies z200(m)



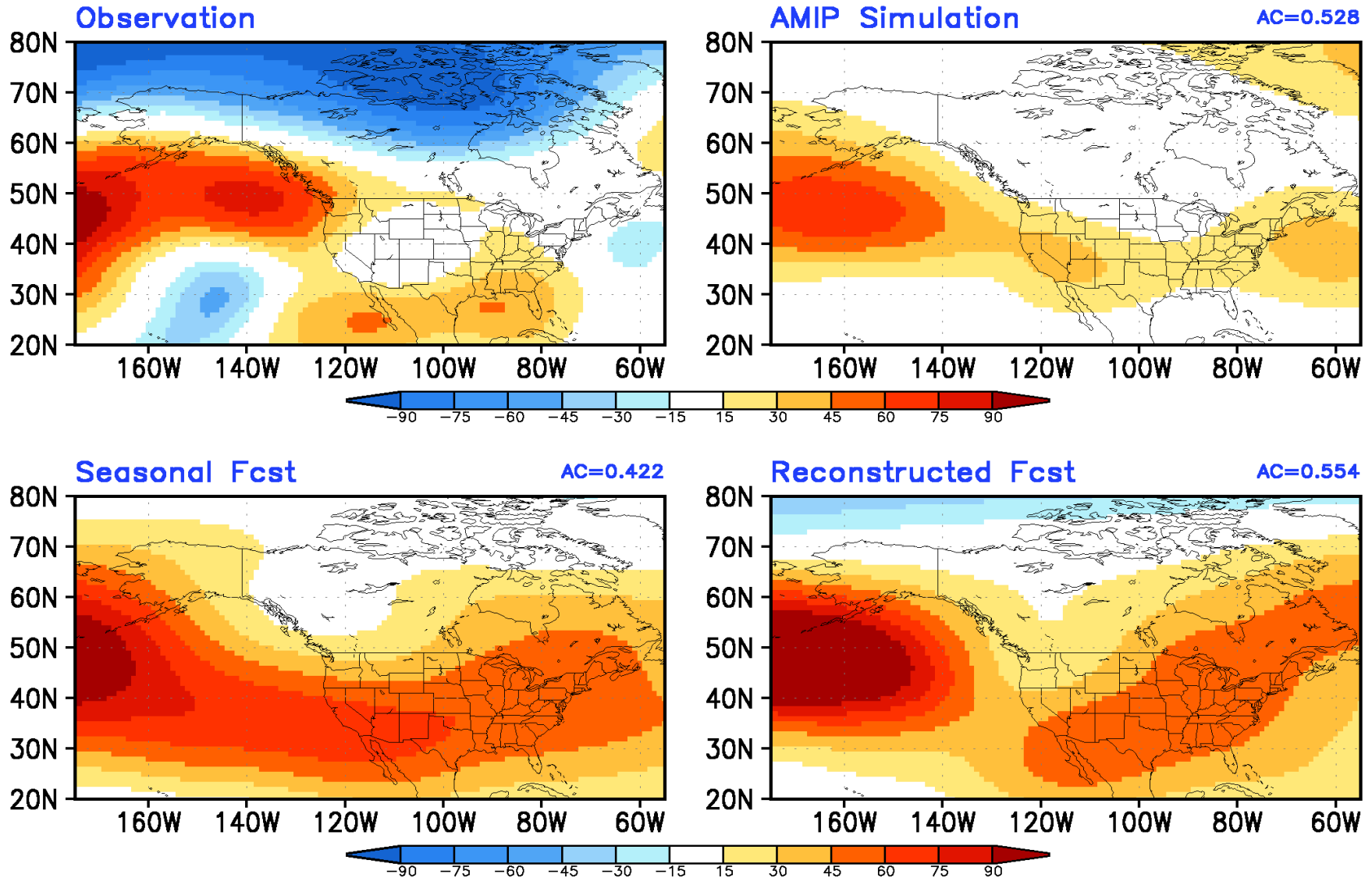
MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies T2m(K)



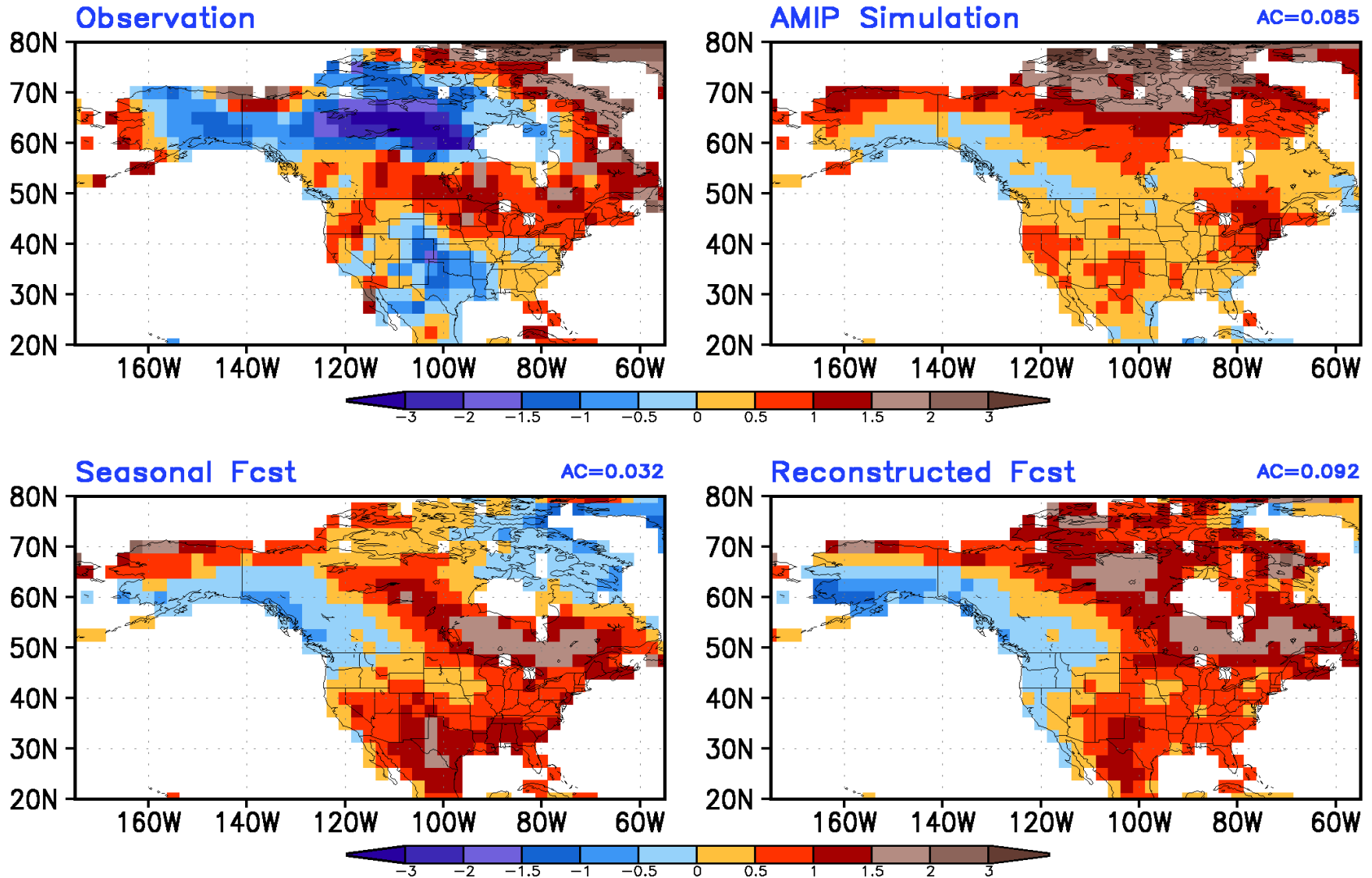
MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies Prec(mm/day)



MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies z200(m)



MAM2021 Observed & Model Simulated/Forecast Ensemble Average Anomalies T2m(K)

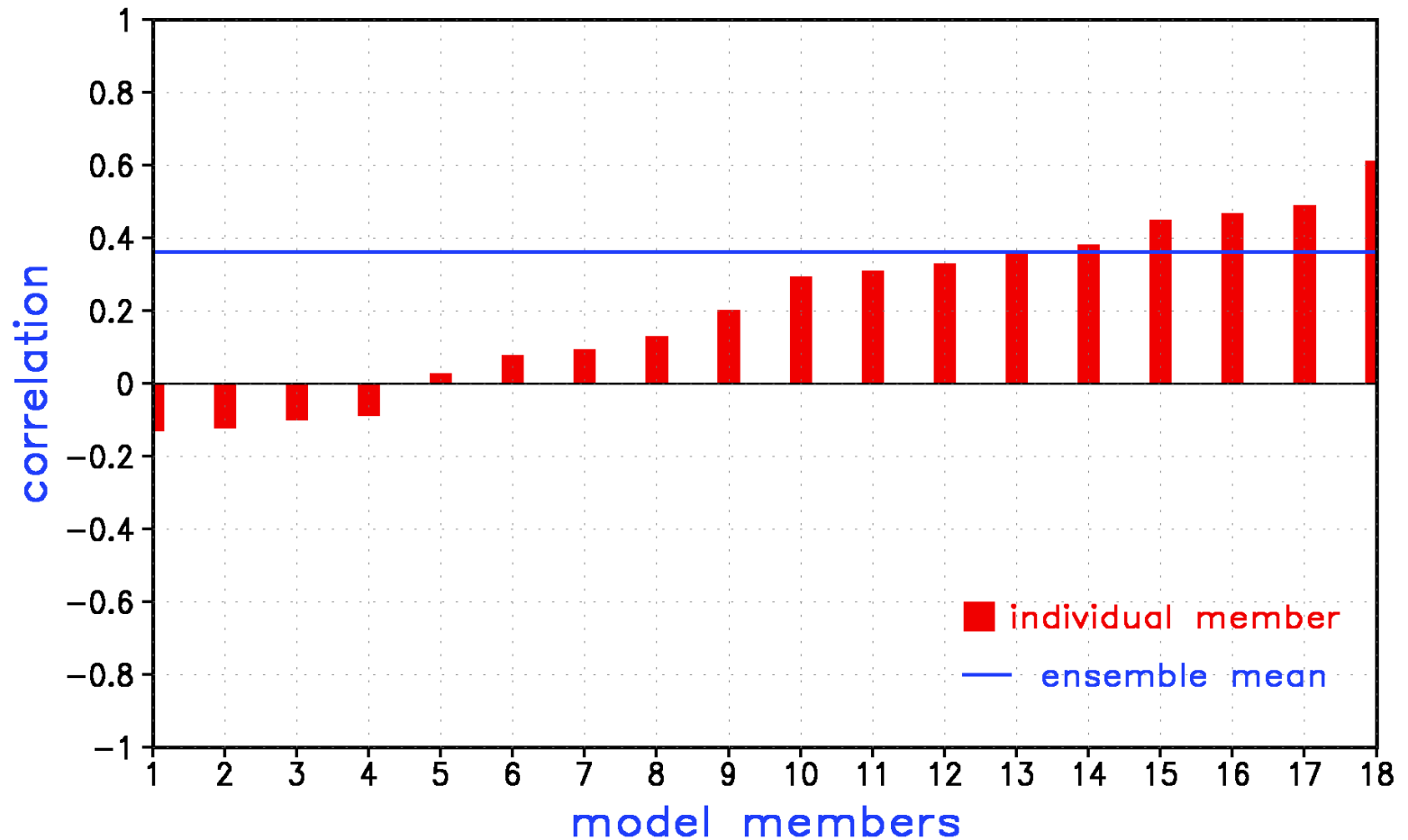


Model Simulated/Forecast Anomalies: Individual Runs

Model Simulated/Forecast Anomalies: Individual Runs

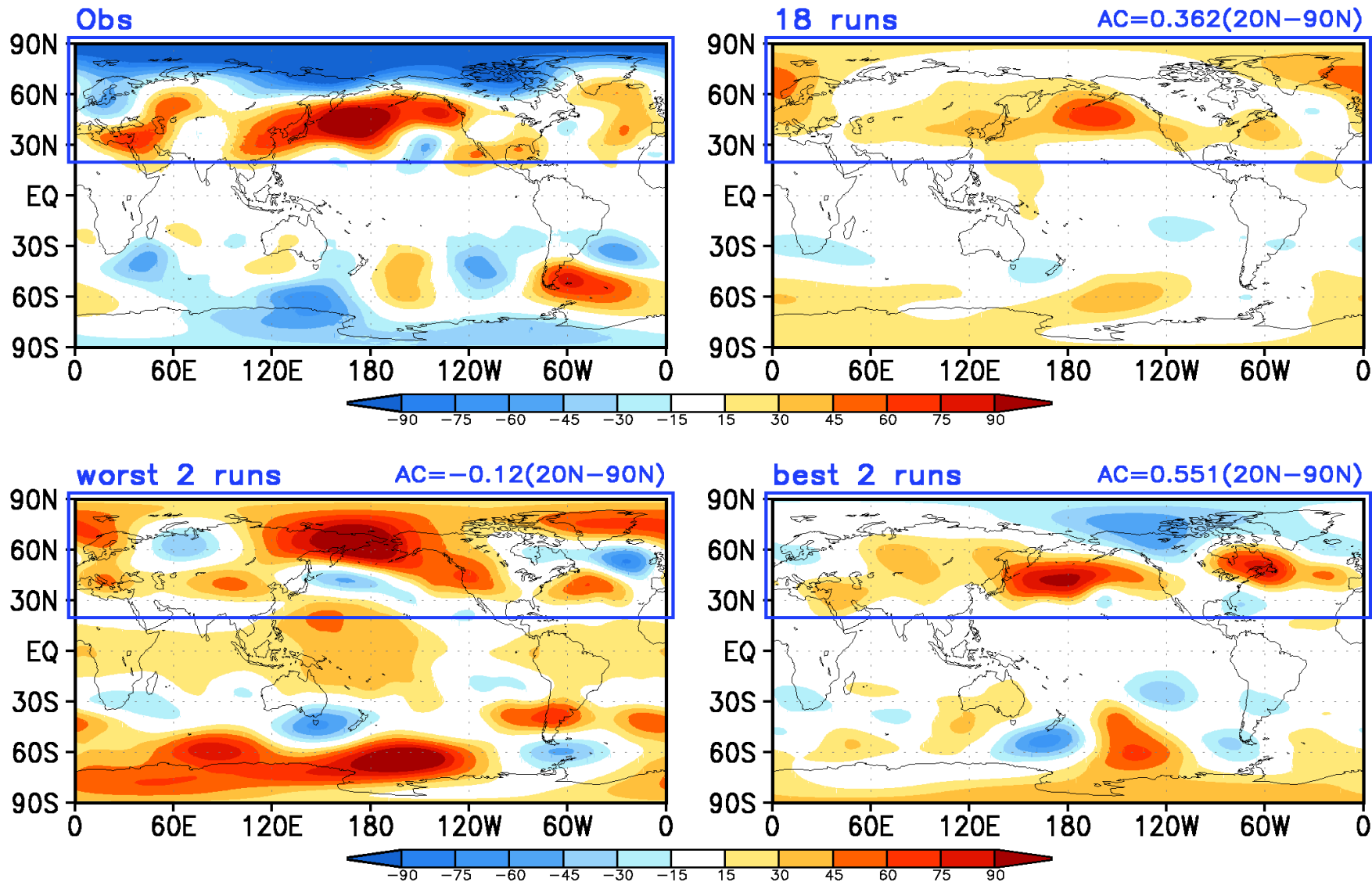
- In this analysis, anomalies from individual model runs are compared against the observed seasonal mean anomalies. The spatial resemblance between them is quantified based on anomaly correlation (AC).
- The distribution of AC across all model simulations is indicative of probability of observed anomalies 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 seasonal mean outcomes.
- For further details see: 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](https://doi.org/10.1002/grl.50657).

MAM2021 Anomaly Correlation for Individual AMIP Simulation with Observation — z200(20N–90N)

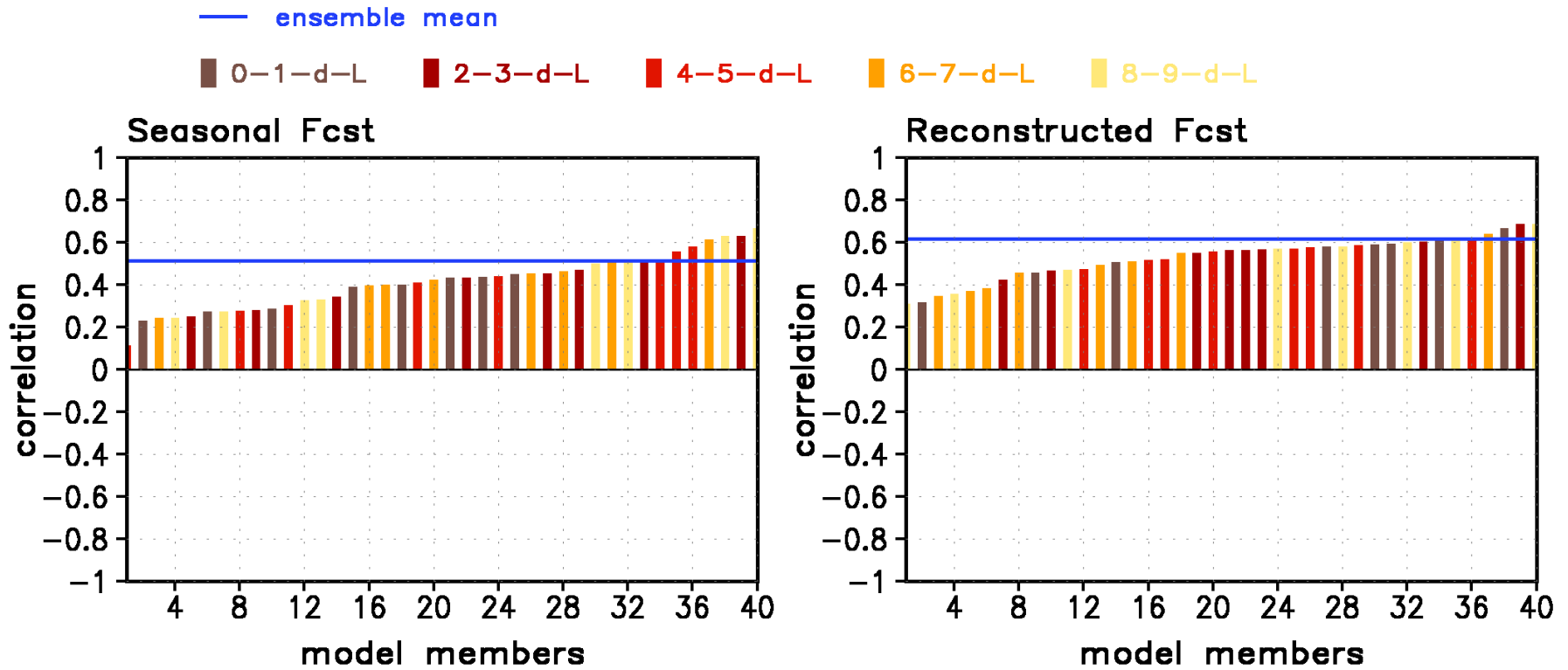


Observed & AMIP Ensemble Average Anomalies

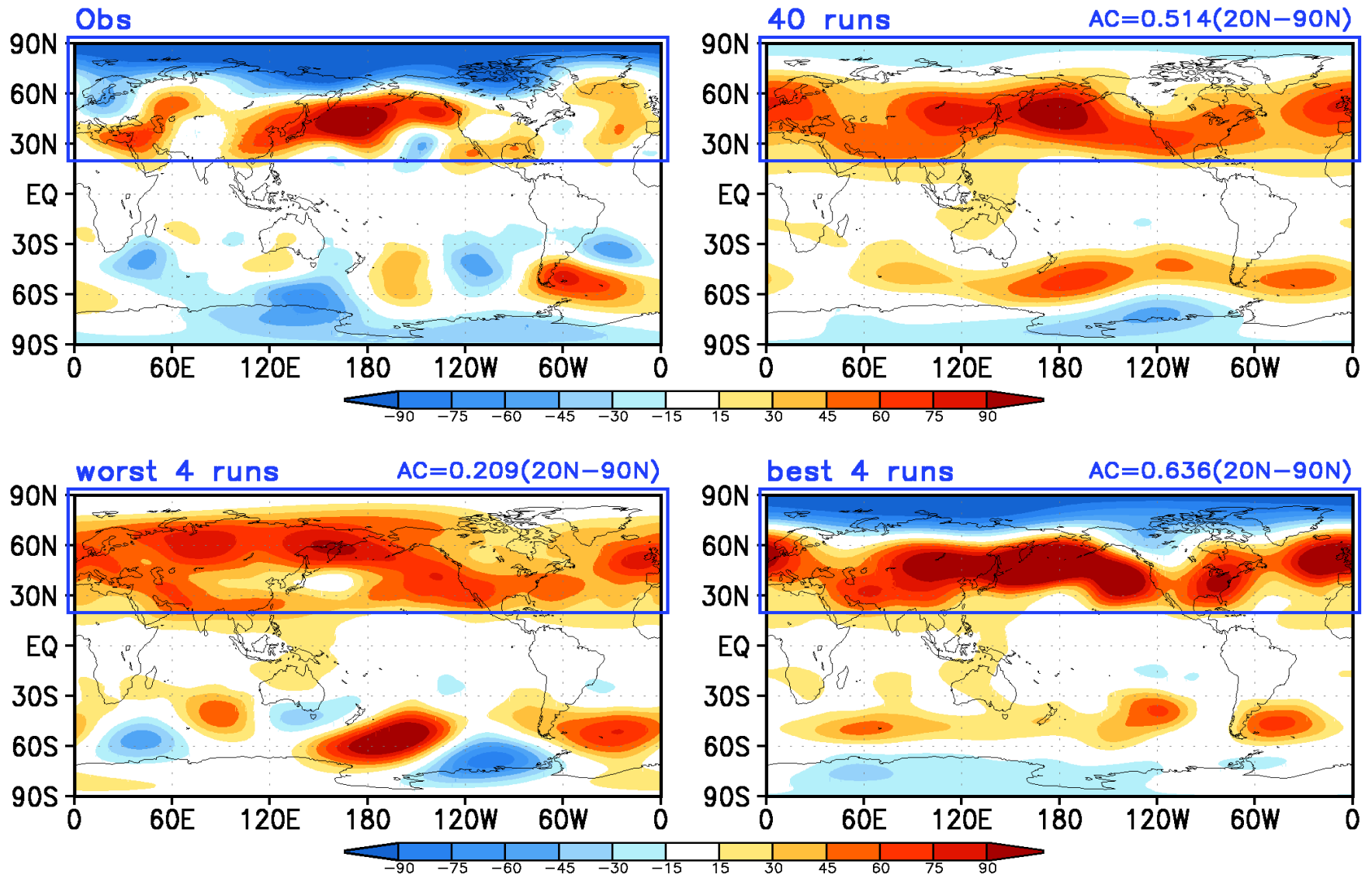
MAM2021 z200(m) 18 runs/worst 2 runs/best 2 runs



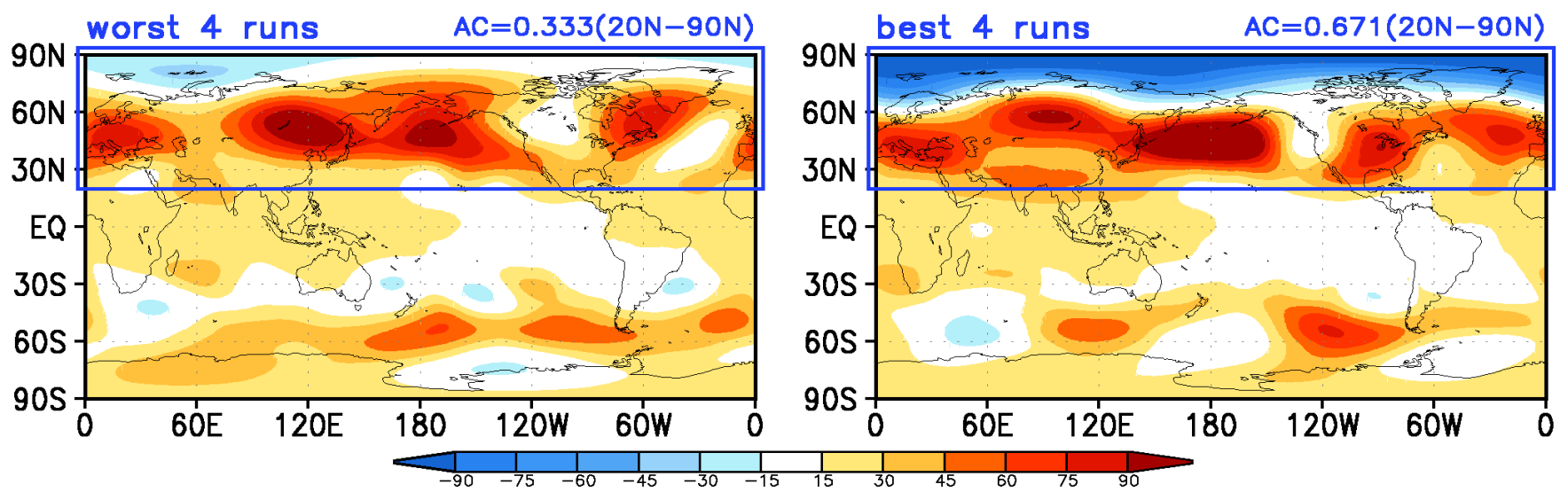
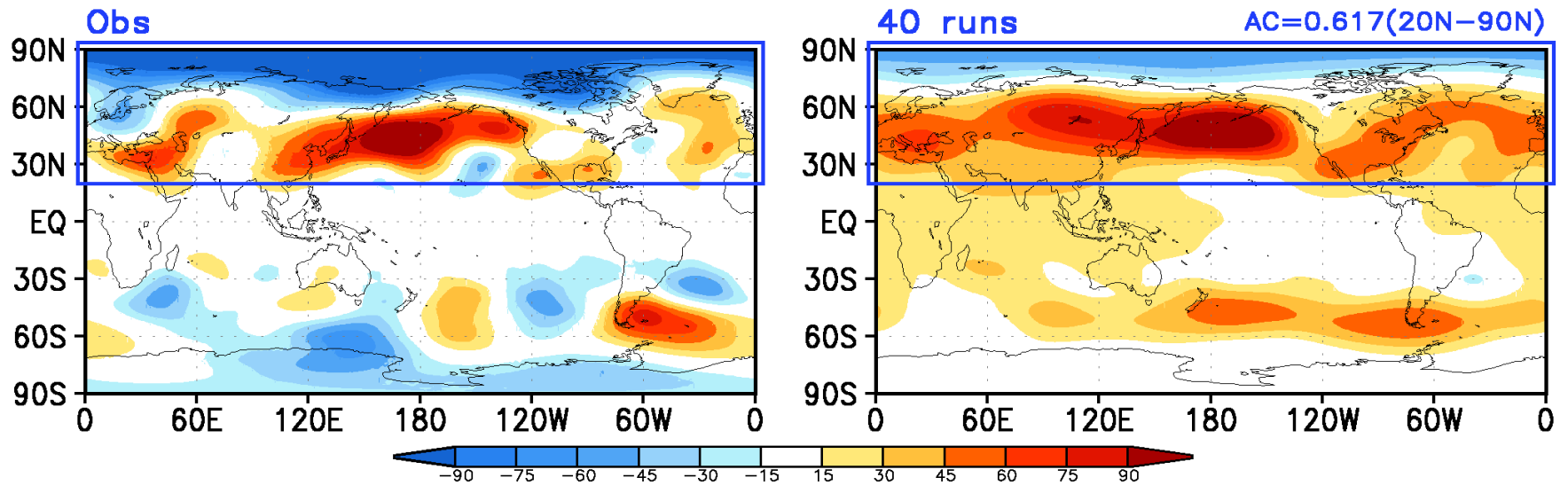
MAM2021 Anomaly Correlation for Individual CFSv2 Forecast with Observation -- z200 (20N-90N)



Observed & CFSv2 Forecast Ensemble Average Anomalies MAM2021 z200(m) 40 runs/worst 4 runs/best 4 runs Seasonal Forecast



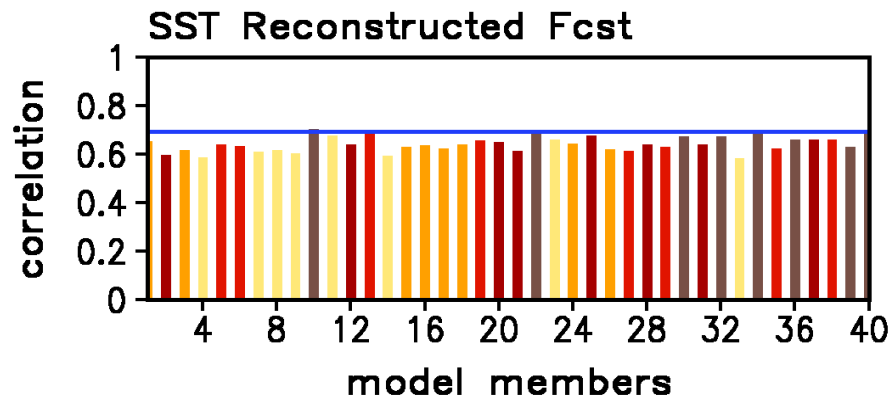
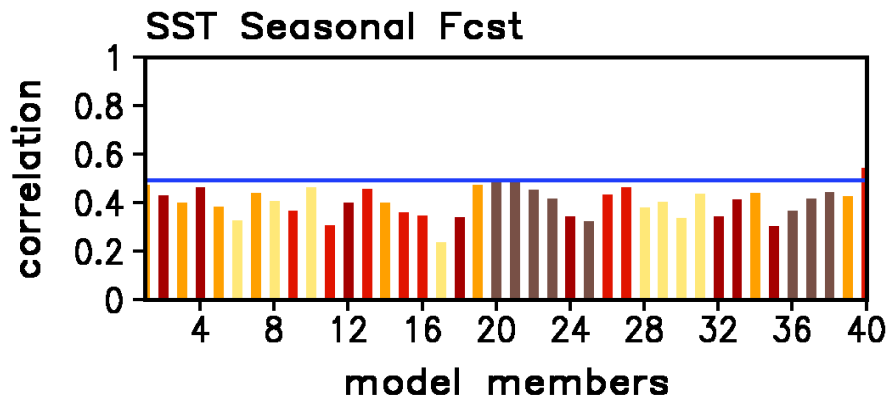
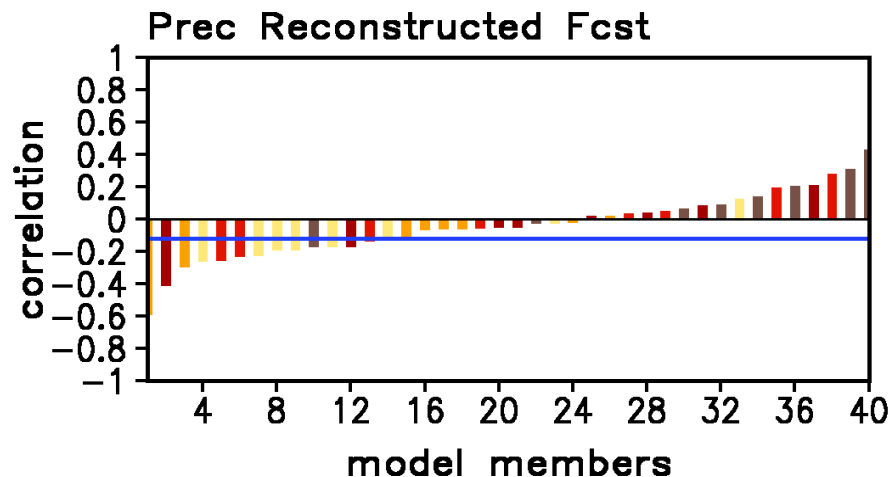
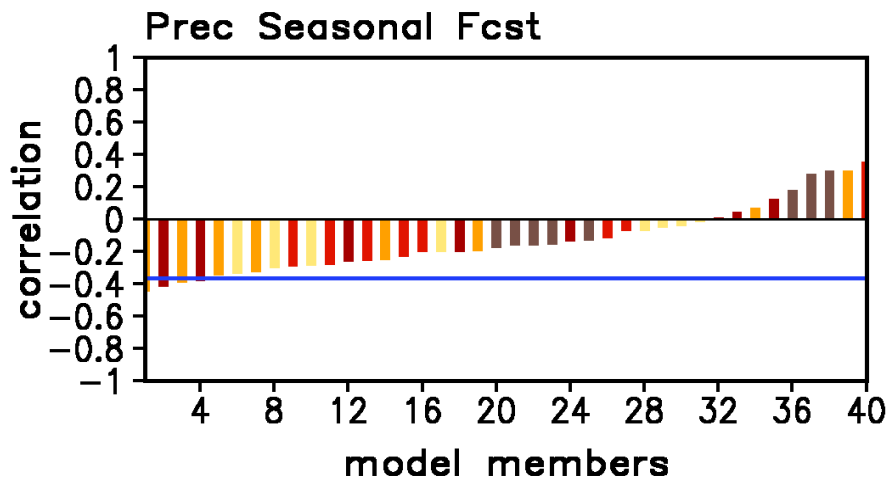
Observed & CFSv2 Forecast Ensemble Average Anomalies MAM2021 z200(m) 40 runs/worst 4 runs/best 4 runs Reconstructed Forecast



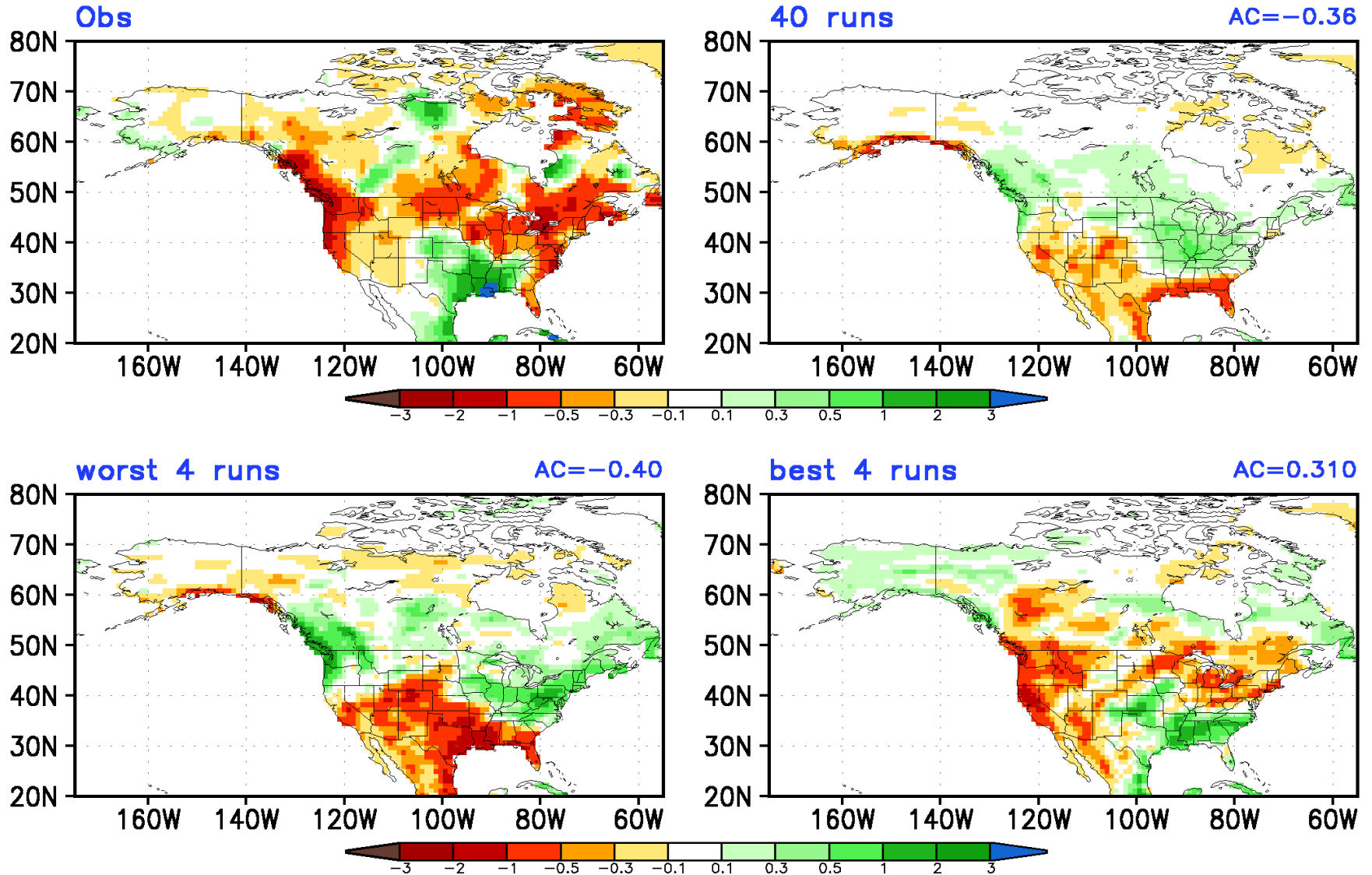
MAM2021 Anomaly Correlation for Individual CFSv2 Forecast with Observation -- Prec(NA)/SST(30S-30N)

— ensemble mean

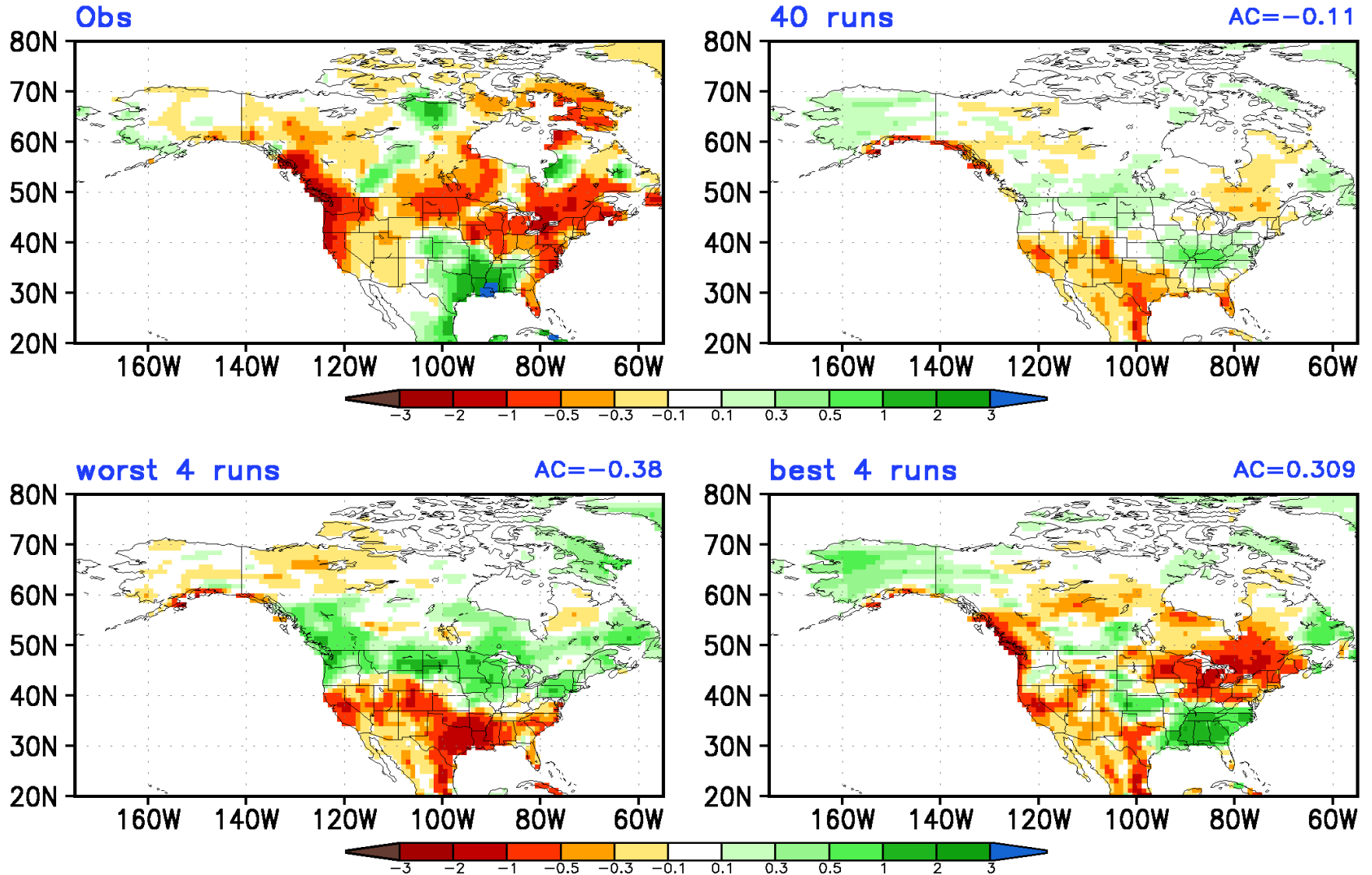
0-1-d-L 2-3-d-L 4-5-d-L 6-7-d-L 8-9-d-L



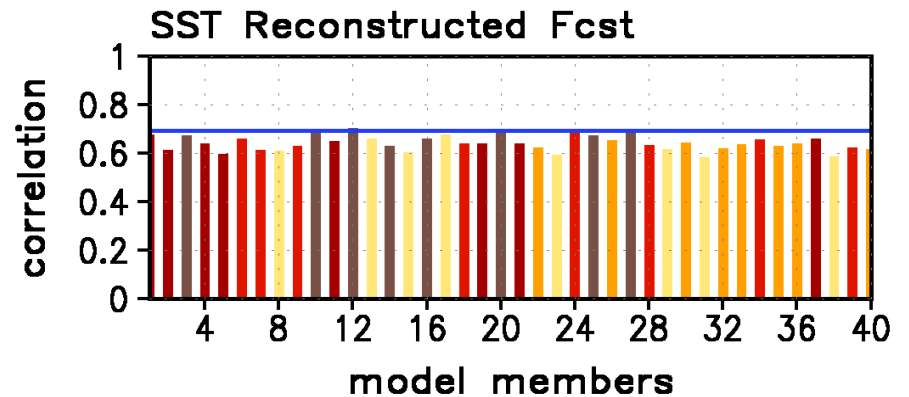
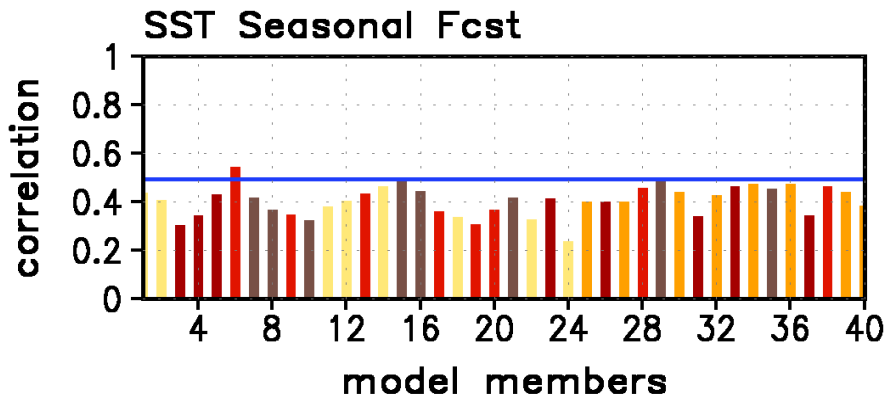
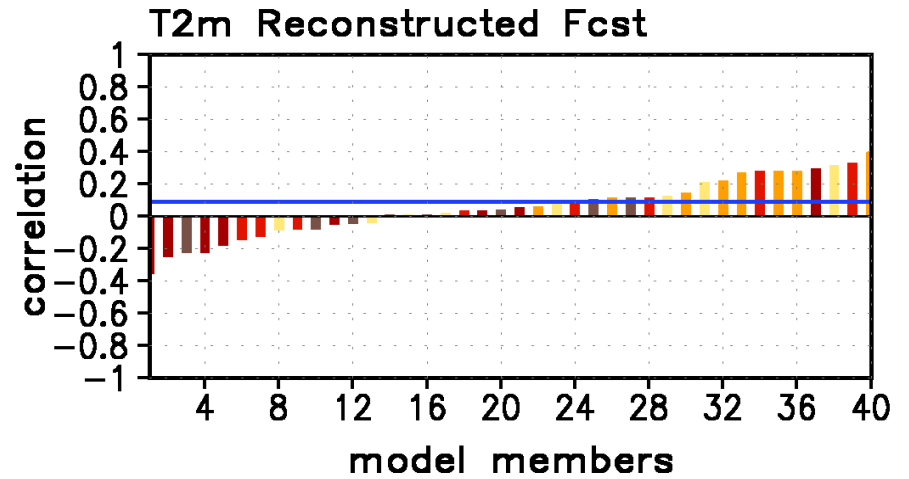
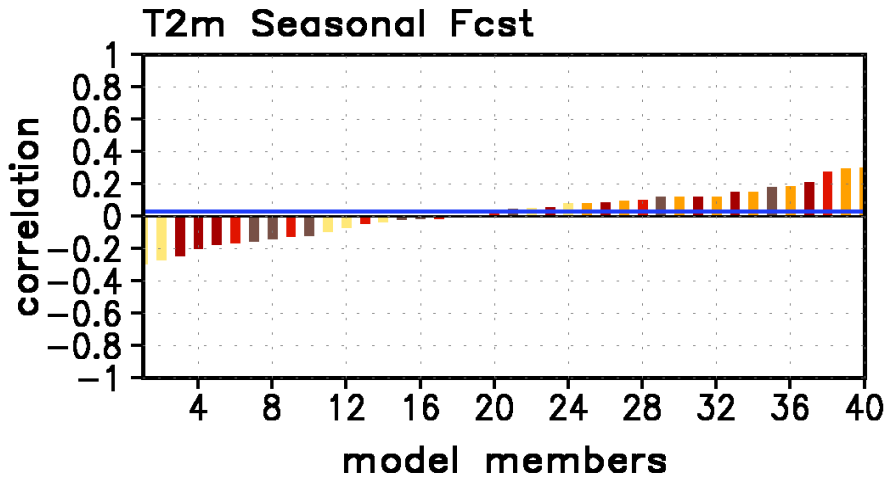
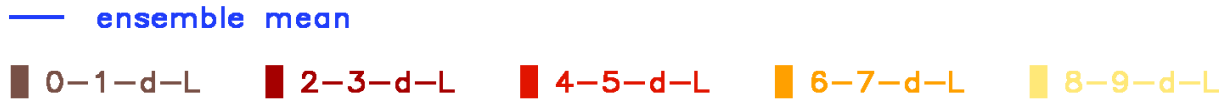
Observed & CFSv2 Forecast Ensemble Average Anomalies MAM2021 Prec(mm/day) 40 runs/worst 4 runs/best 4 runs Seasonal Forecast



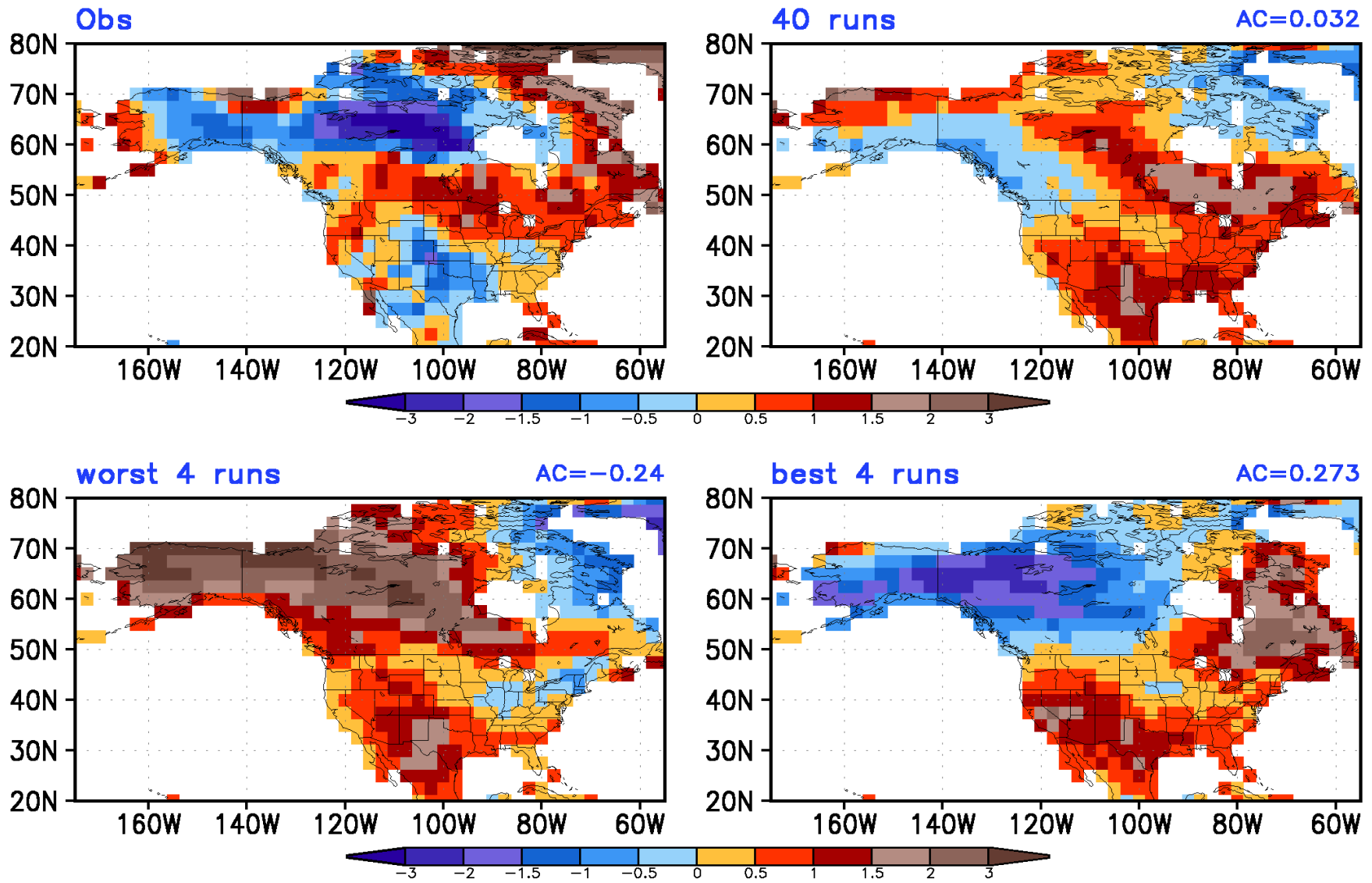
Observed & CFSv2 Forecast Ensemble Average Anomalies MAM2021 Prec(mm/day) 40 runs/worst 4 runs/best 4 runs Reconstructed Forecast



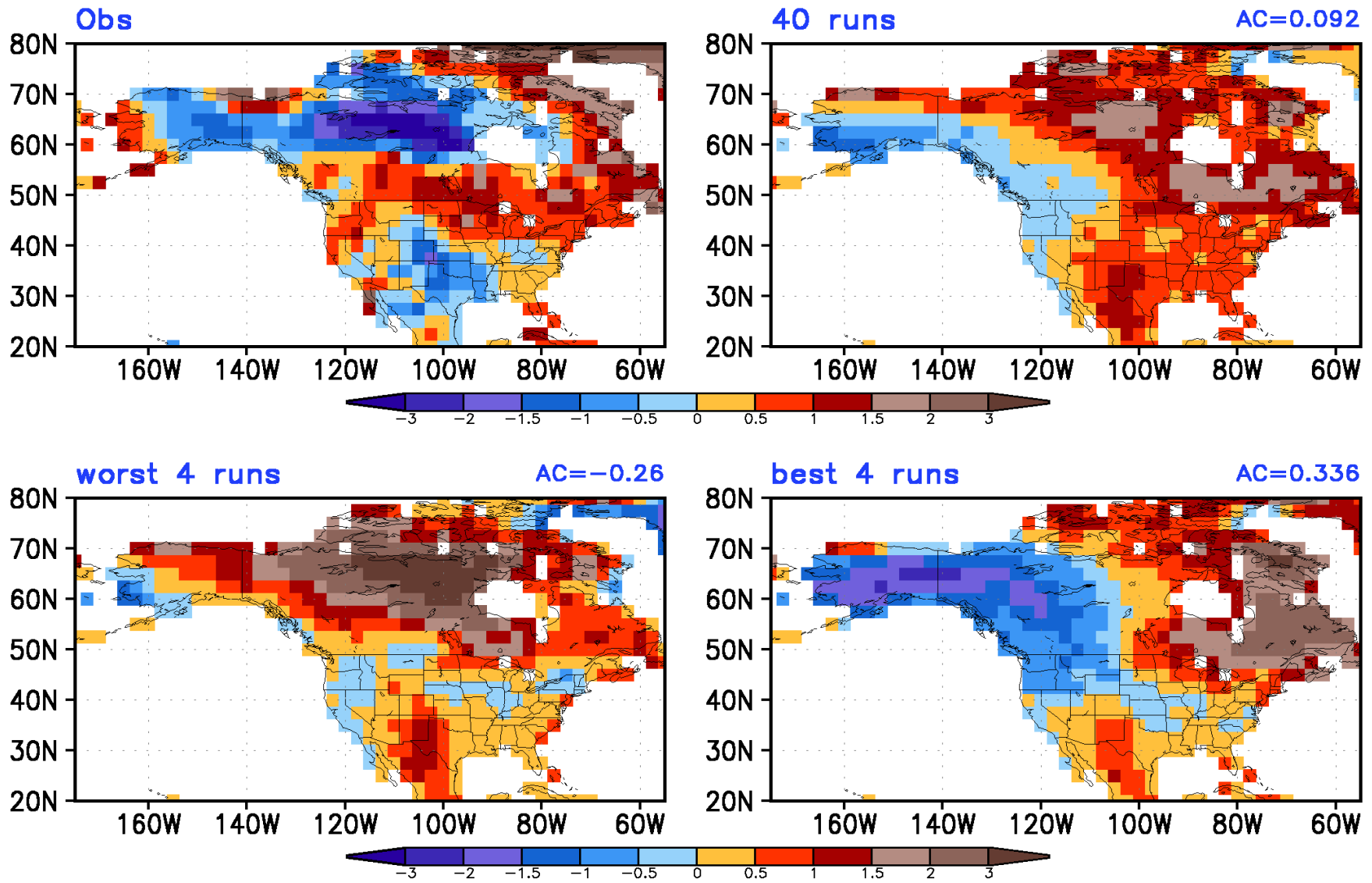
MAM2021 Anomaly Correlation for Individual CFSv2 Forecast with Observation -- T2m(NA)/SST(30S-30N)



Observed & CFSv2 Forecast Ensemble Average Anomalies MAM2021 T2m(K) 40 runs/worst 4 runs/best 4 runs Seasonal Forecast

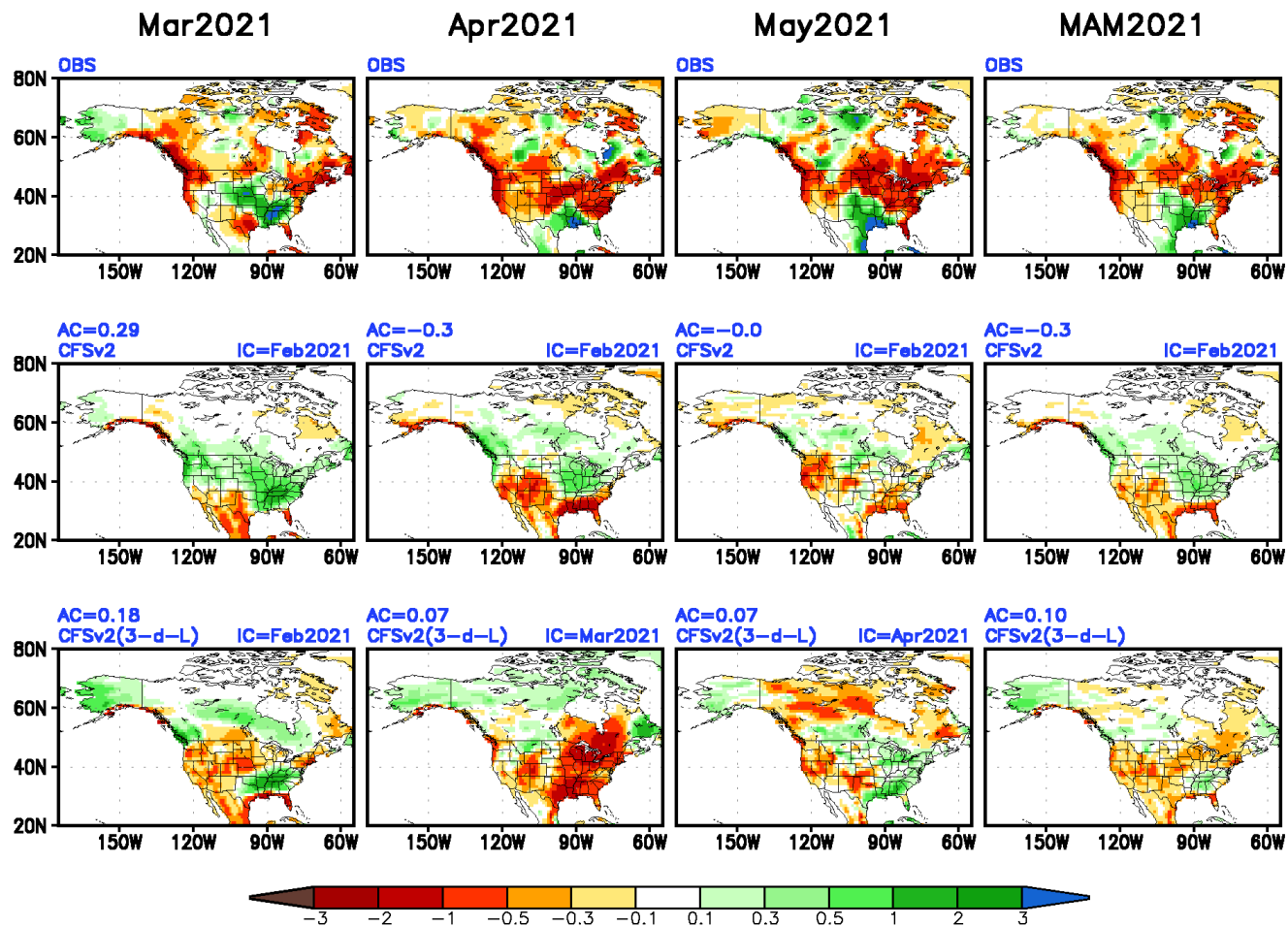


Observed & CFSv2 Forecast Ensemble Average Anomalies MAM2021 T2m(K) 40 runs/worst 4 runs/best 4 runs Reconstructed Forecast



Monthly Means Prec(mm/day) Observed & Forecasts

Monthly MAM2021 Prec(mm/day) Observed & Forecasts



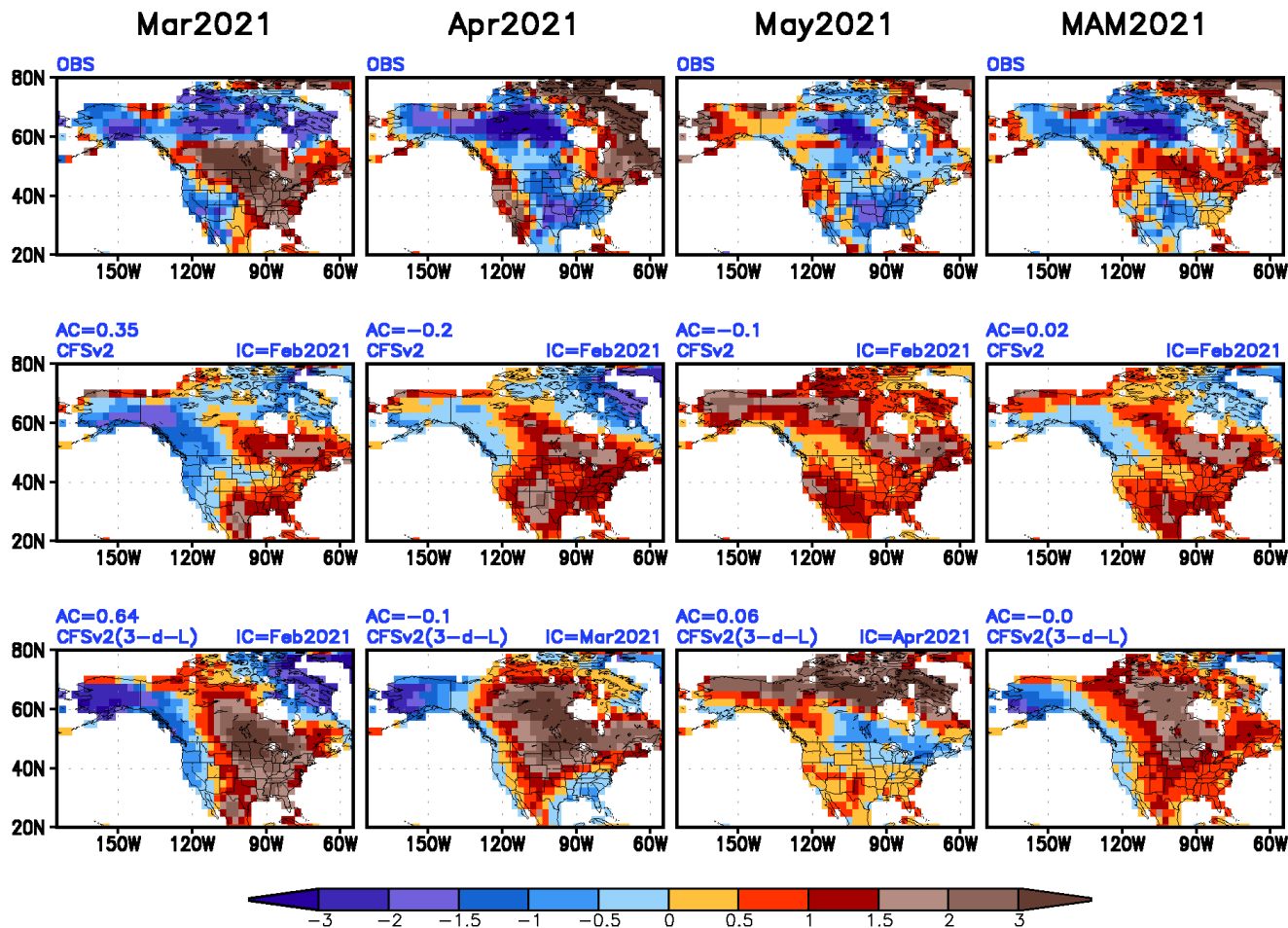
Top row: Observed anomaly

Middle row: CFSv2 seasonal forecasts from the initial conditions from the month prior to the target season.

Bottom row: CFSv2 monthly forecasts from the last three days of the month prior to the target month.

Monthly Means T2m(K) Observed & Forecasts

Monthly MAM2021 T2m(K) Observed & Forecasts



Top row: Observed anomaly

Middle row: CFSv2 seasonal forecasts from the initial conditions from the month prior to the target season.

Bottom row: CFSv2 monthly forecasts from the last three days of the month prior to the target month.

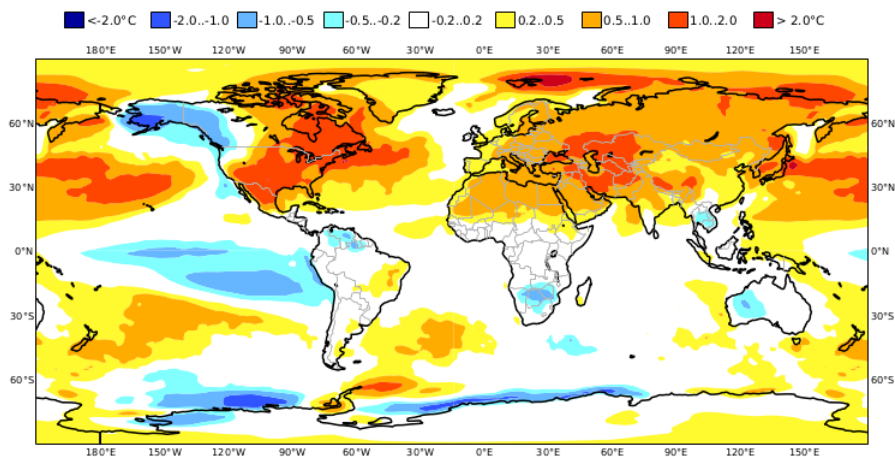
Seasonal Forecasts from other multi-model systems and linear models

C3S Seasonal Forecast

(https://climate.copernicus.eu/charts/c3s_seasonal/)

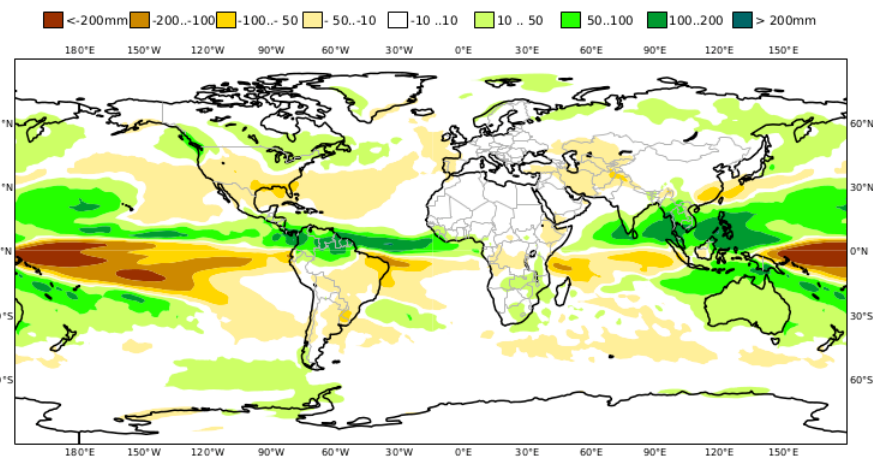
C3S multi-system seasonal forecast
Mean 2m temperature anomaly
Nominal forecast start: 01/02/21
Variance-standardized mean

ECMWF/Met Office/Météo-France/CMCC/DWD/NCEP/JMA
MAM 2021



C3S multi-system seasonal forecast
Mean precipitation anomaly
Nominal forecast start: 01/02/21
Variance-standardized mean

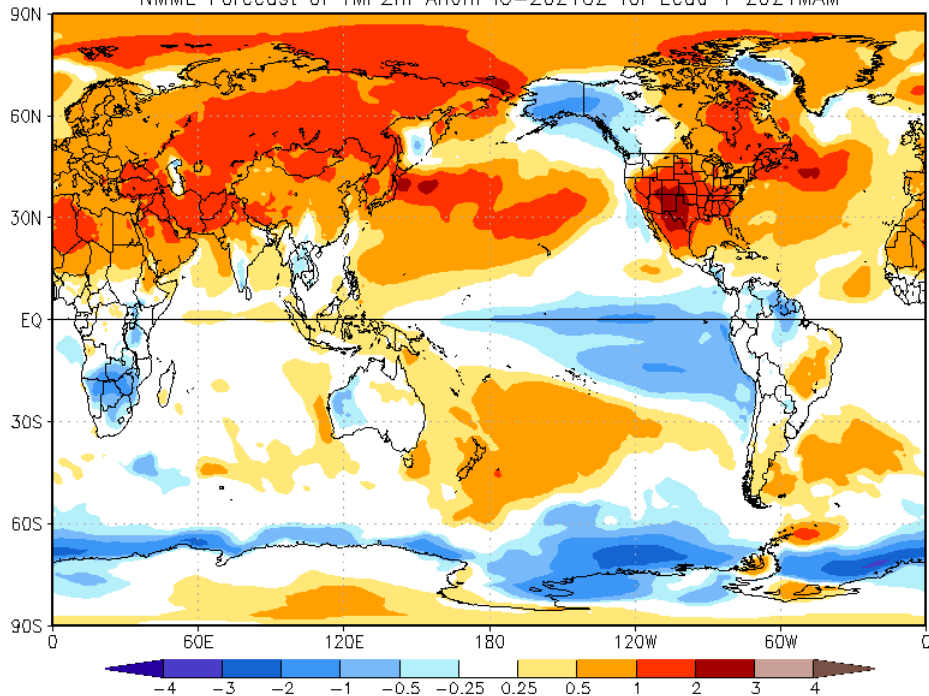
ECMWF/Met Office/Météo-France/CMCC/DWD/NCEP/JMA
MAM 2021



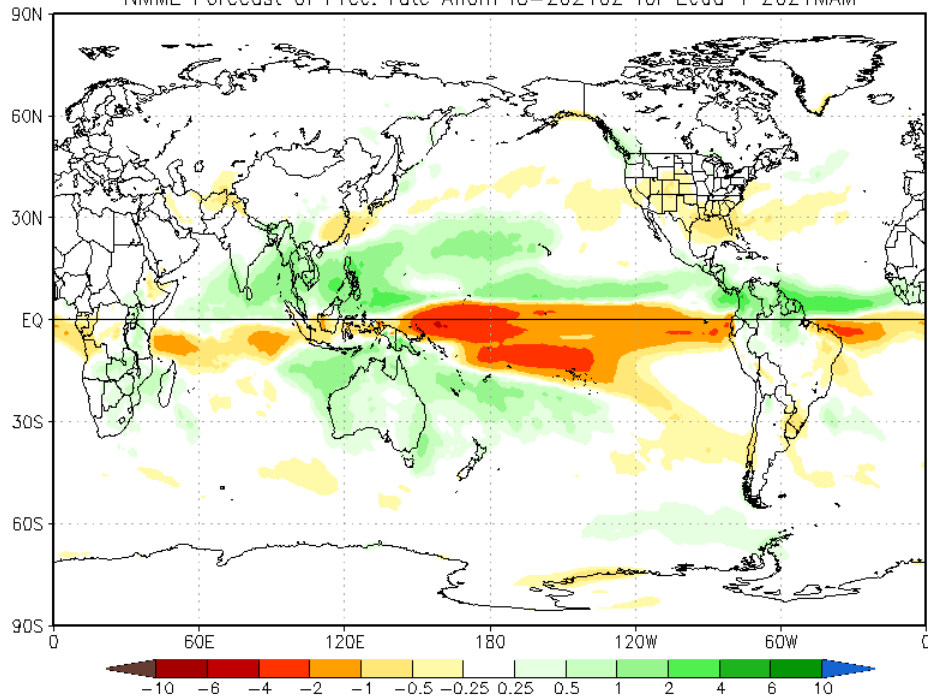
North American Multi-Model Ensemble Seasonal Forecast

(<https://www.cpc.ncep.noaa.gov/products/NMME/>)

NMME Forecast of TMP2m Anom IC=202102 for Lead 1 2021MAM

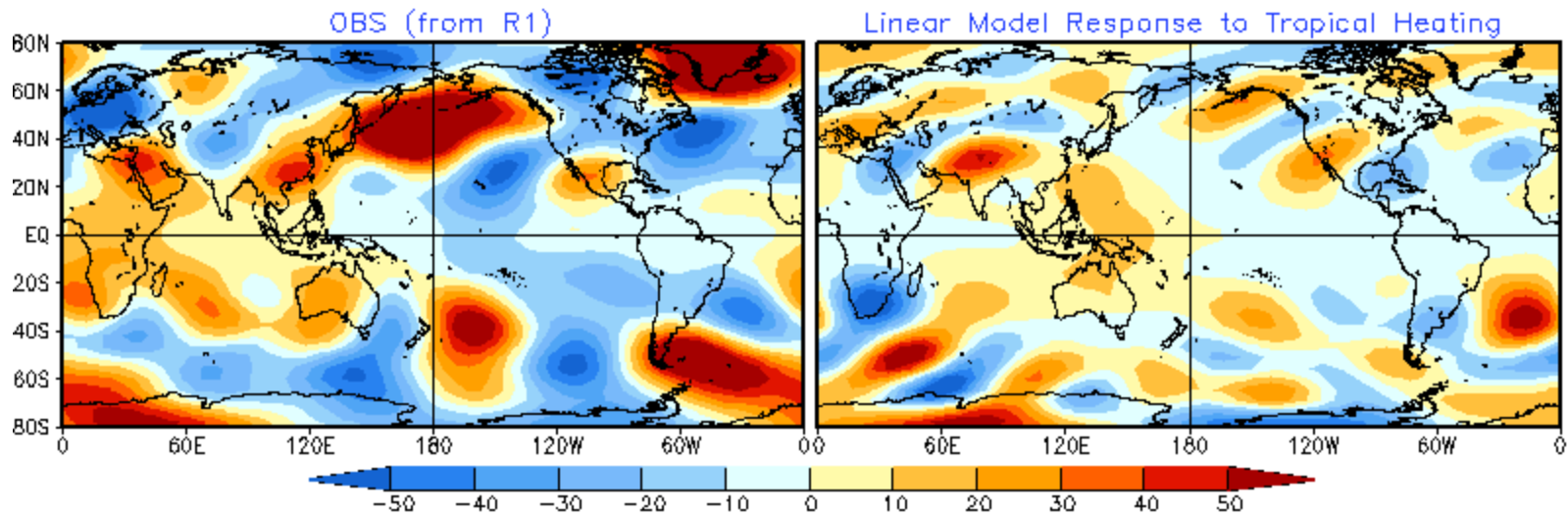
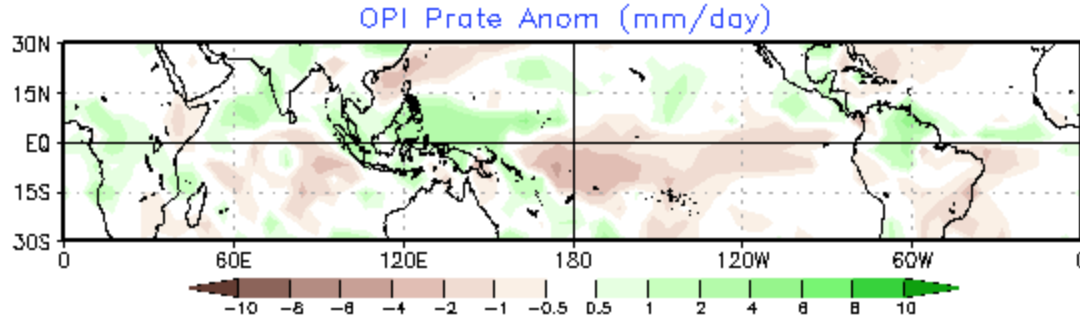


NMME Forecast of Prec. rate Anom IC=202102 for Lead 1 2021MAM



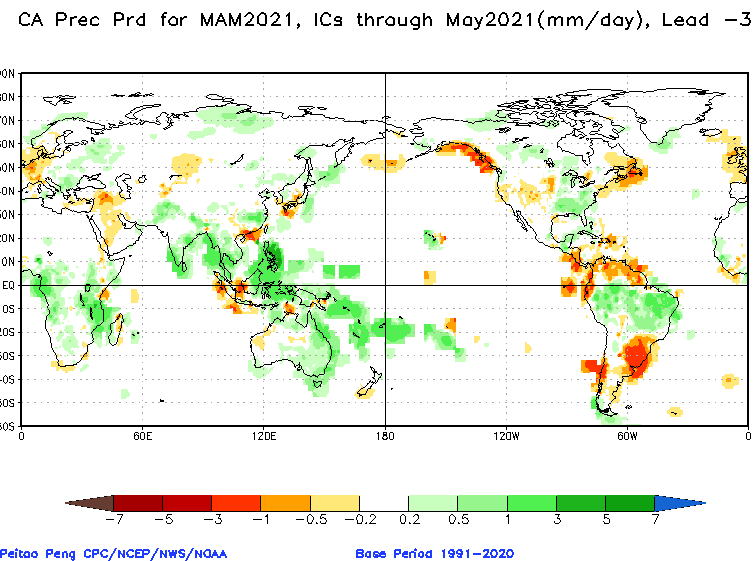
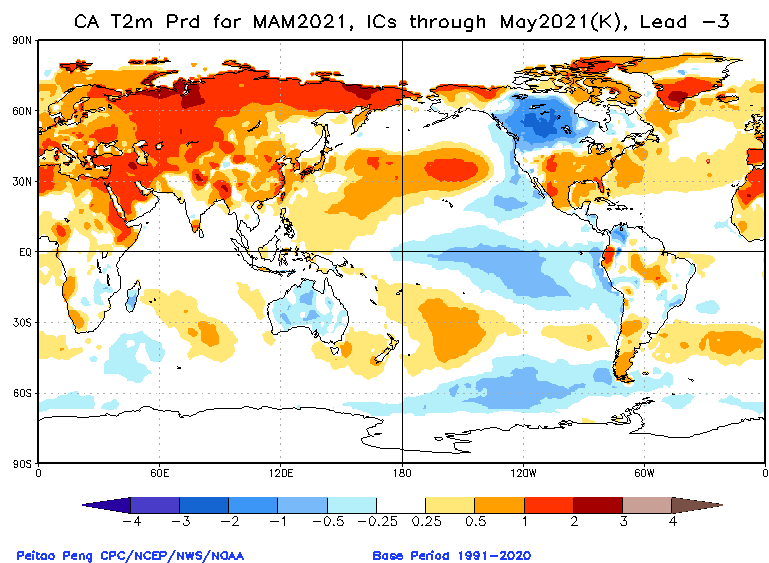
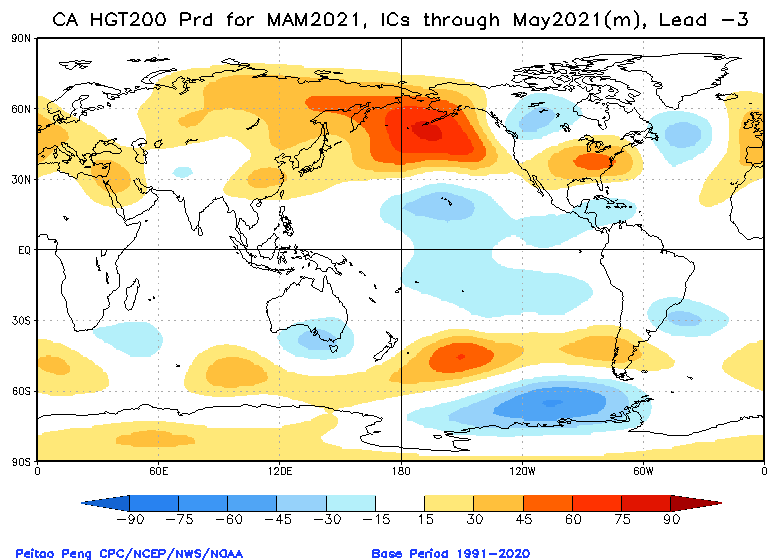
200mb Height from Linear Model

MAM2021 200mb Eddy HGT(m)
OBS vs. Linear Model Response to Tropical Heating
Heating is converted from Prate in 15S-15N



Pattern COR: global=0.00, tropics(30S-30N)=0.02

Seasonal Forecasts from the Constructed Analog Model



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 42-45 are from the Lead Center.
- For latest seasonal outlook guidance see <http://www.wmo.int/pages/prog/wcp/wcasp/LC-LRFMME/index.php>
- *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.*

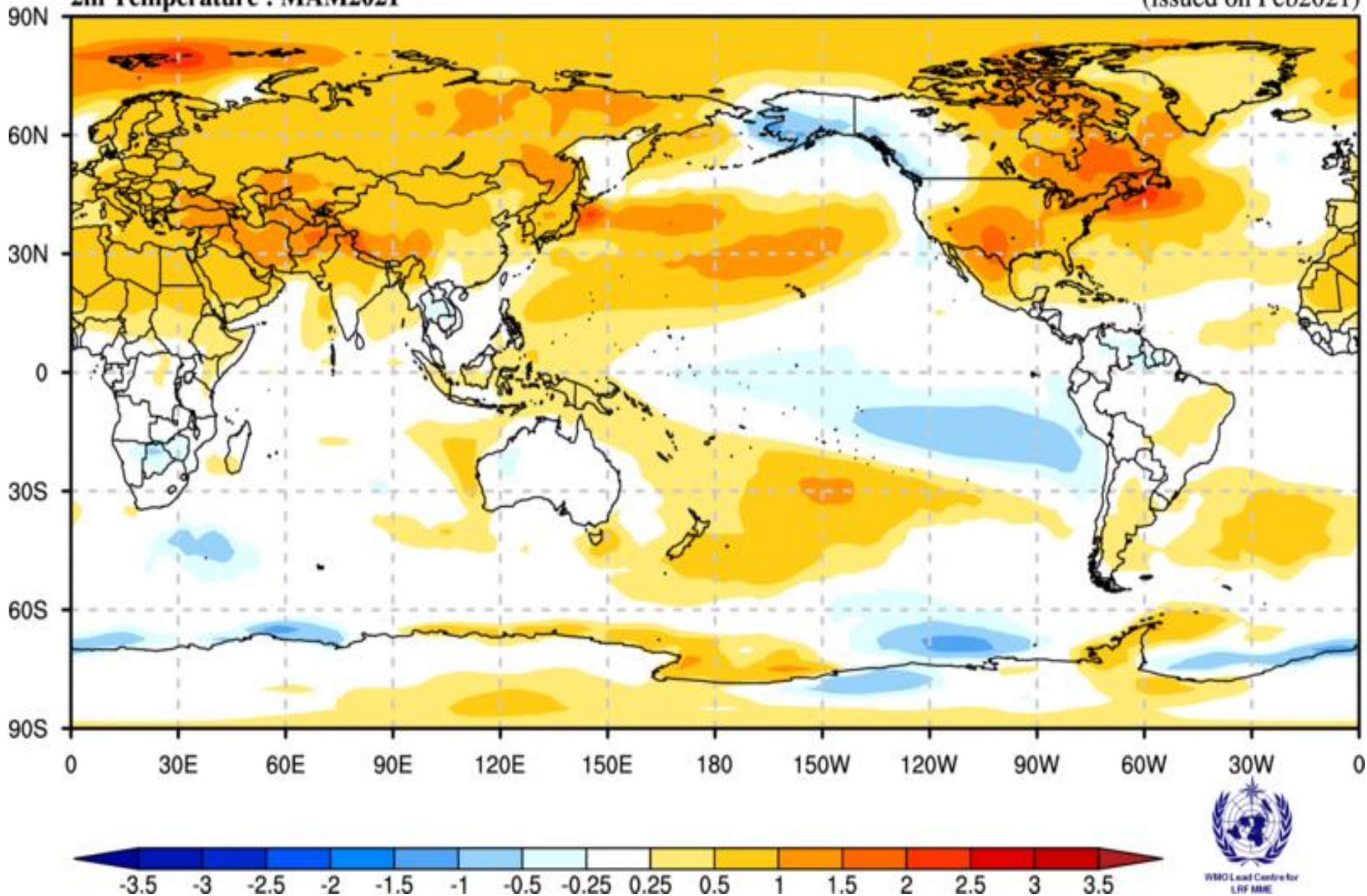
Simple Composite Map

Beijing, CPTEC, ECMWF, Exeter, Melbourne, Montreal, Moscow, Offenbach, Seoul, Tokyo, Toulouse, Washington

[Unit : K]

2m Temperature : MAM2021

(issued on Feb2021)



WMO Lead Centre for LRF MME

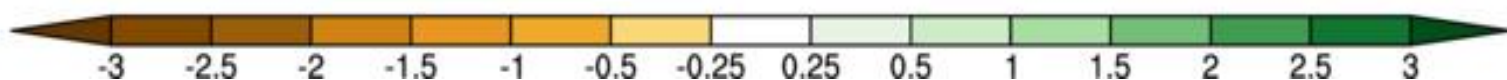
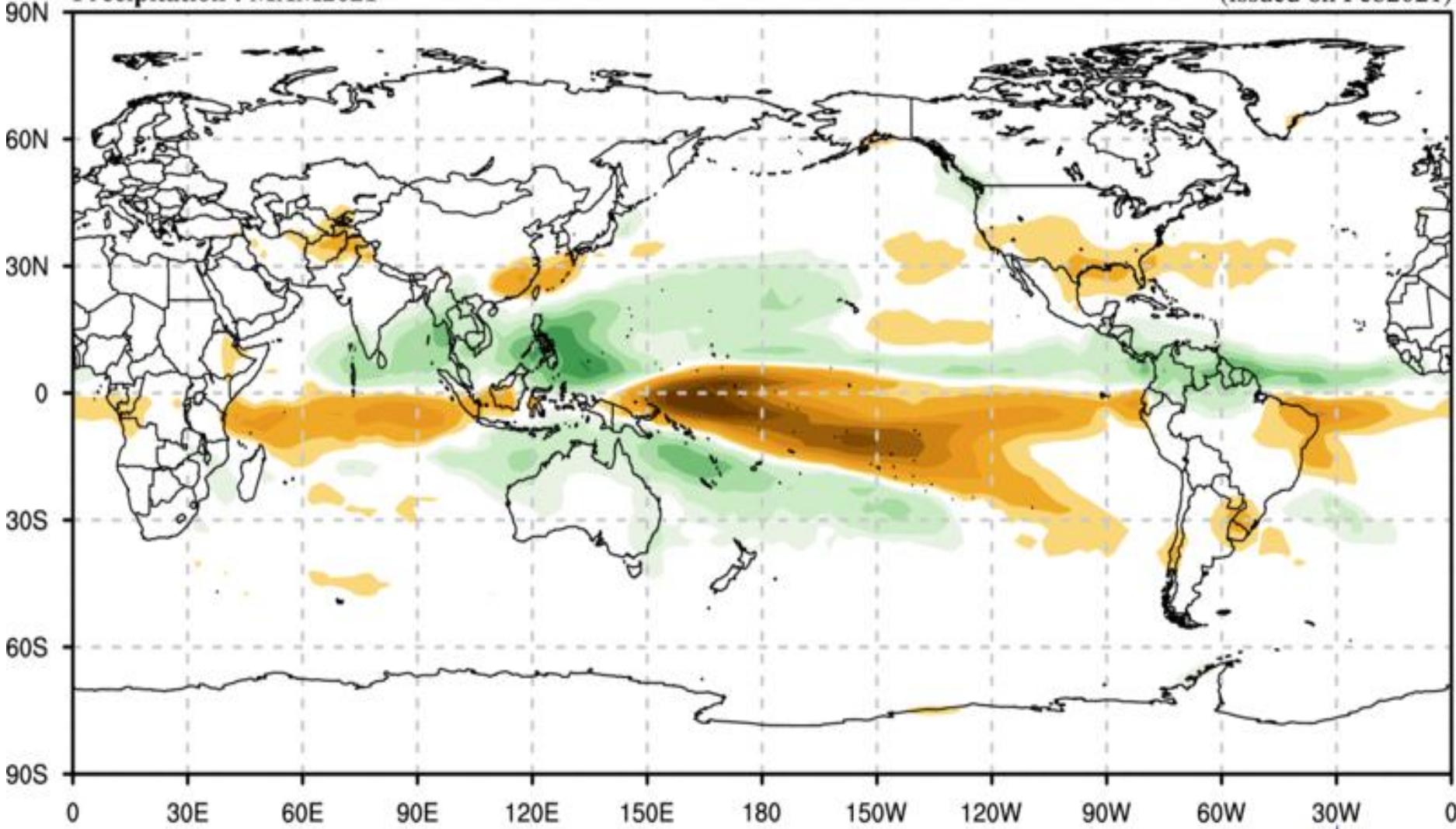
Simple Composite Map

Beijing, CPTEC, ECMWF, Exeter, Melbourne, Montreal, Moscow, Offenbach, Seoul, Tokyo, Toulouse, Washington

[Unit : mm]

(issued on Feb2021)

Precipitation : MAM2021

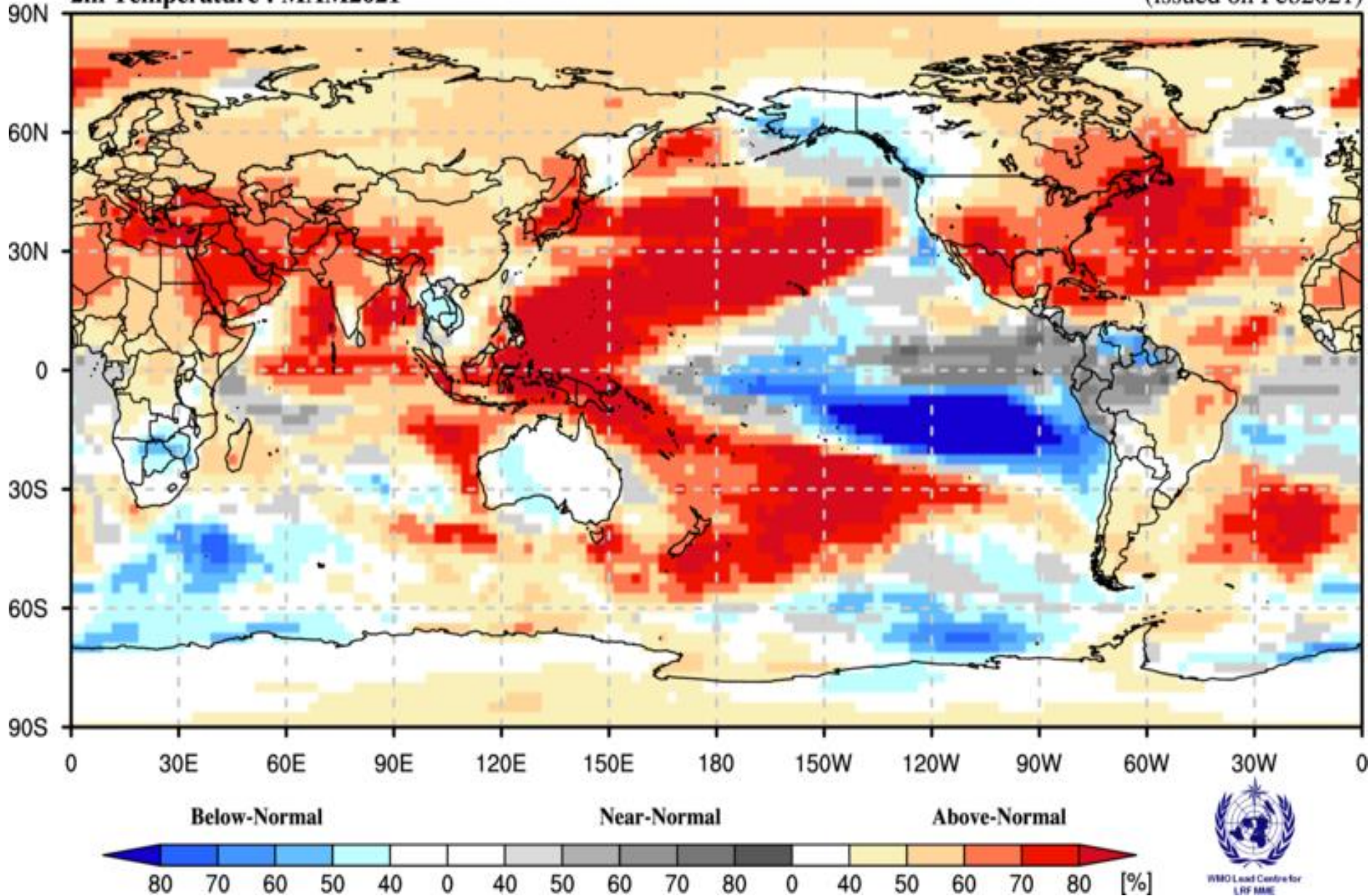


Probabilistic Multi-Model Ensemble Forecast

Beijing, CPTEC, ECMWF, Exeter, Melbourne, Montreal, Moscow, Offenbach, Seoul, Tokyo, Toulouse, Washington

2m Temperature : MAM2021

(issued on Feb2021)

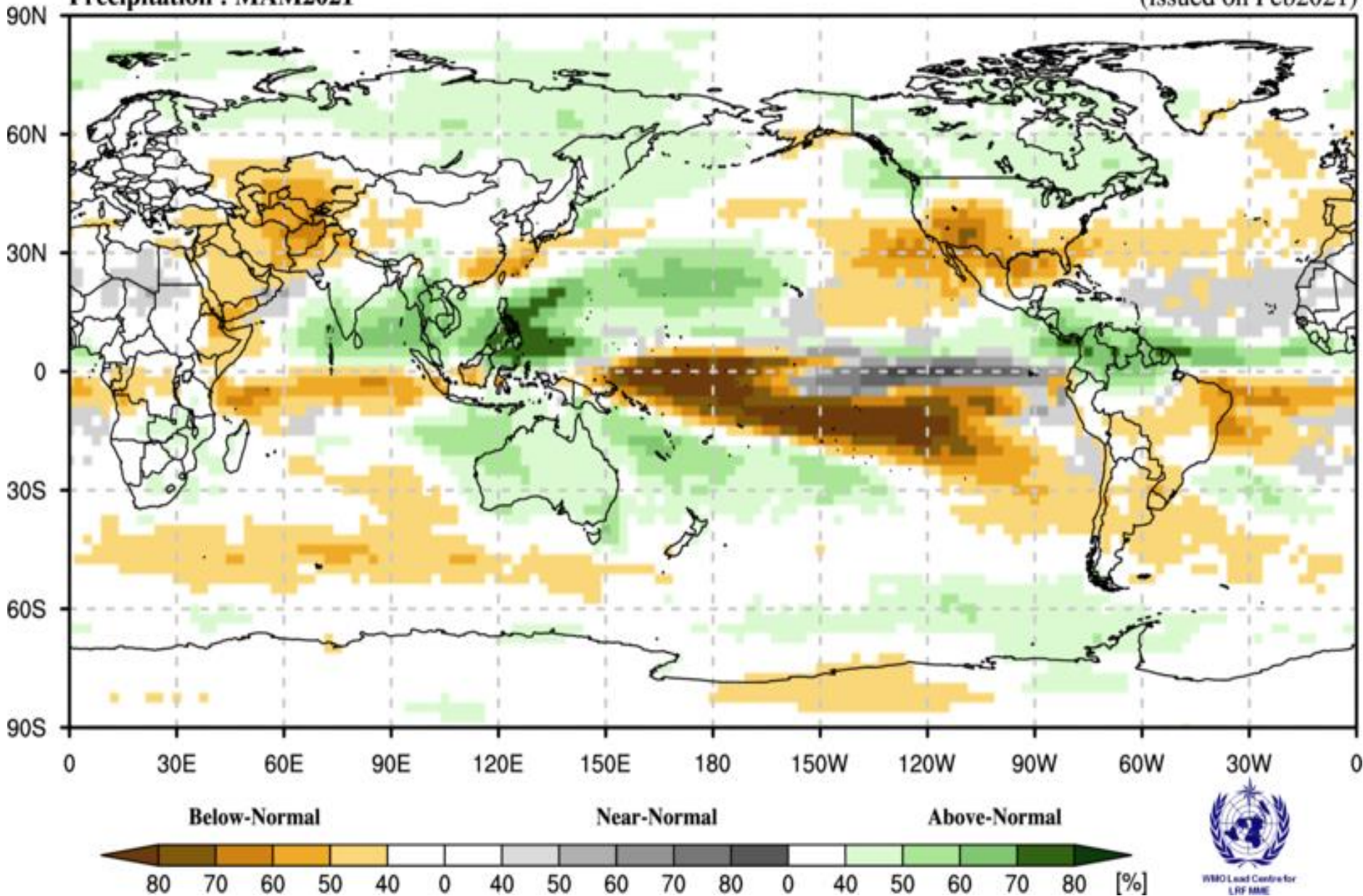


Probabilistic Multi-Model Ensemble Forecast

Beijing, CPTEC, ECMWF, Exeter, Melbourne, Montreal, Moscow, Offenbach, Seoul, Tokyo, Toulouse, Washington

Precipitation : MAM2021

(issued on Feb2021)



Background & Methodology

Attribution of Seasonal Climate Anomalies

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

Methodology - 1

- Compare observed seasonal mean anomalies with those from model simulations and forecasts.
- Ensemble averaged 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 mean anomalies.
- The relative amplitude of ensemble averaged seasonal mean anomalies to the deviations of seasonal mean anomalies in the individual model runs from the ensemble average 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 is 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)
 - Seasonal forecast: the seasonal mean forecasts based on 40 members from the latest 10 days before the target season (0-month-lead);
 - Reconstructed forecast: 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/CPC)
 - 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/CPC)
- Seasonal mean anomalies of z200, T2m, and Prec forecasted from the Constructed Analog Model (provided by Dr. Peitao Peng/CPC)