A New GFSv15 based Climate Model Dataset and Its Application to Understanding Climate Variability, and Predictability

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Summary

- NOAA Climate Prediction Center (CPC) has generated a large 100-member ensemble of AMIP simulations from 1979-present using the GFSv15 with FV3 dynamical core.

- These simulations are forced with the observed evolution of sea surface temperatures (SSTs) and are in support of CPC's efforts to attribute observed seasonal climate anomalies to external forcings.

- The goal of this analysis is to document the performance of these simulations in replicating observed climate variability and trends, together with an assessment of climate predictability.

Outline

1) Simulation of observed trends

2) Simulation of US climate response to three strong El Niño events

3) Assessment of US climate predictability

4) Simulation of extreme events—2022 summer South Asia flooding

Data and method

- **Model data**

1) 100-member FV3_GFS AMIP simulations.
2) 30-member GFSv2 (the atmospheric component of CFSv2) AMIP simulations (the previous version of CPC AMIP simulations).

- **Observational data**

NCEP Z200, GHCN_CAMS T2m and GPCC and CMAP precipitation.

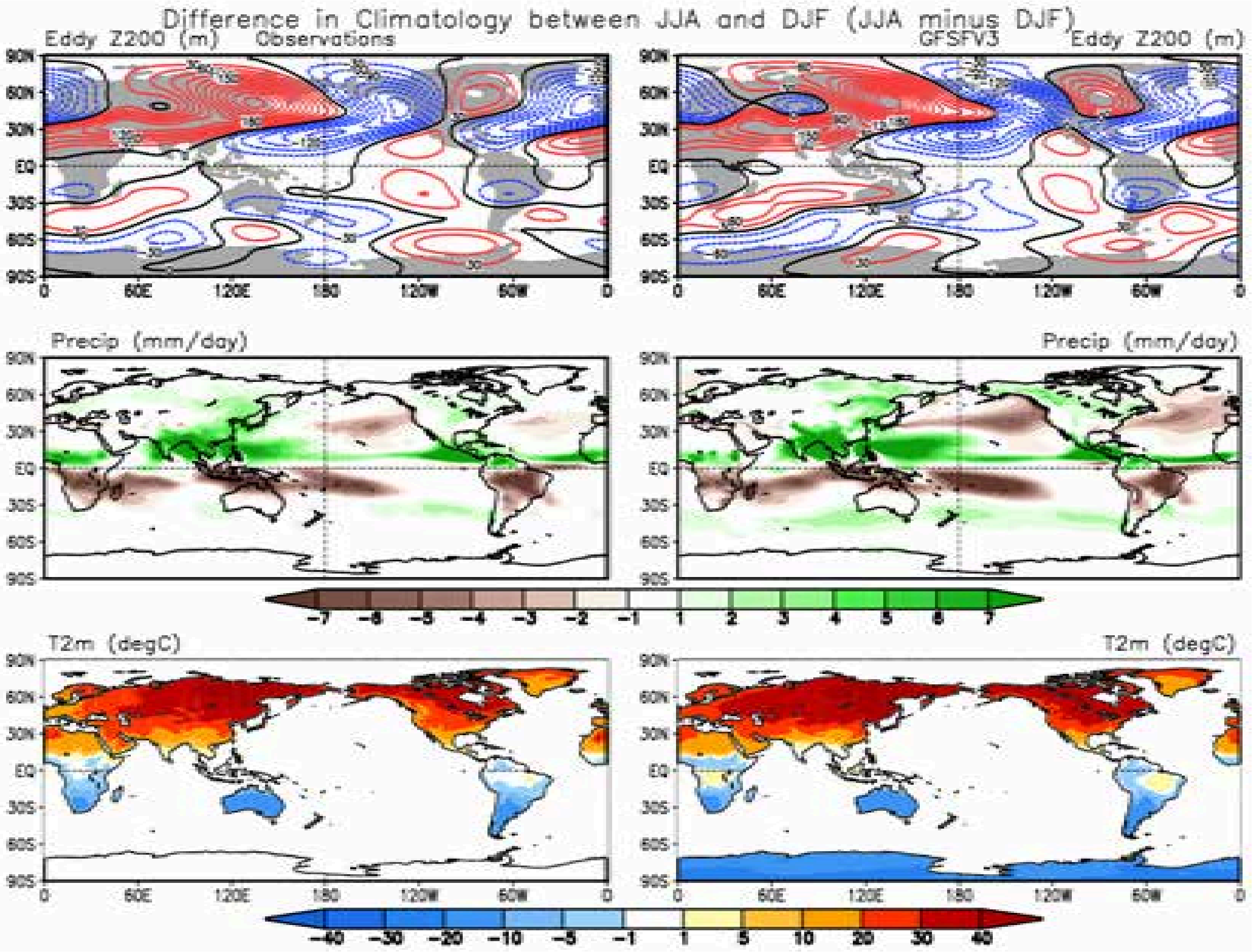
- **Method**

All anomalies are computed relative to 1991-2020 base period.

1) Simulation of observed trends

Difference in climatology between JJA and DJF (JJA-DJF)

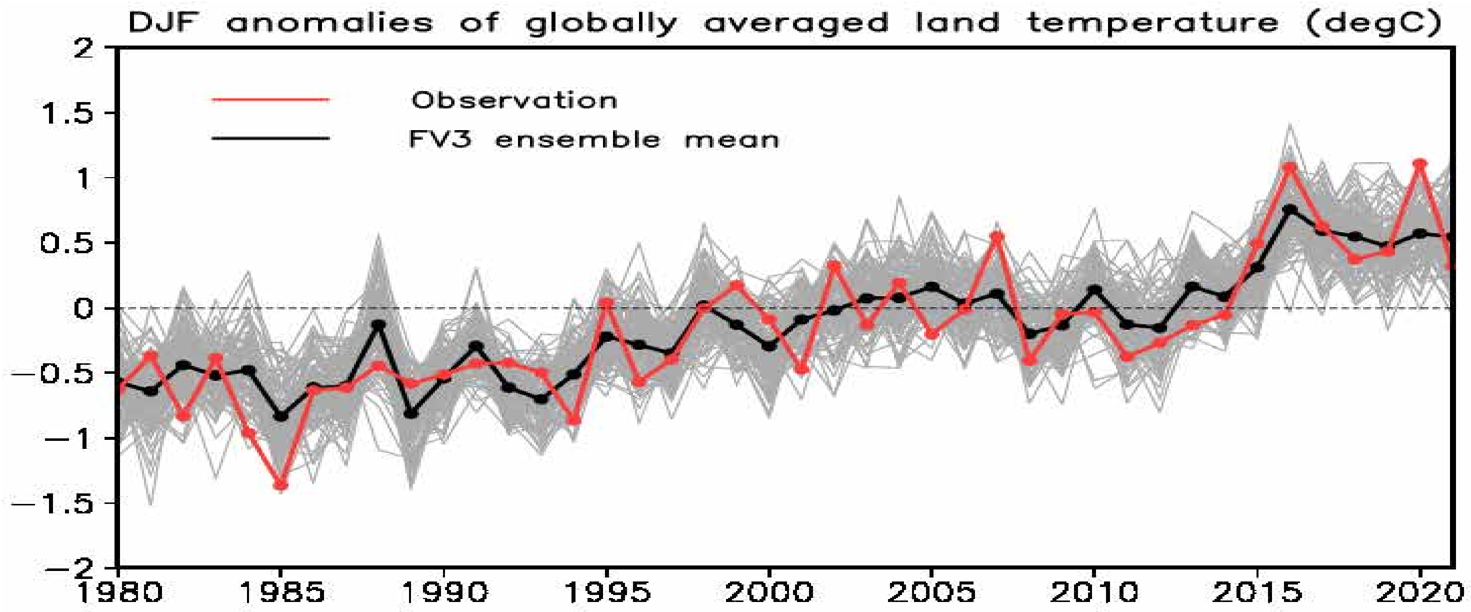
Observation | FV3_GFS



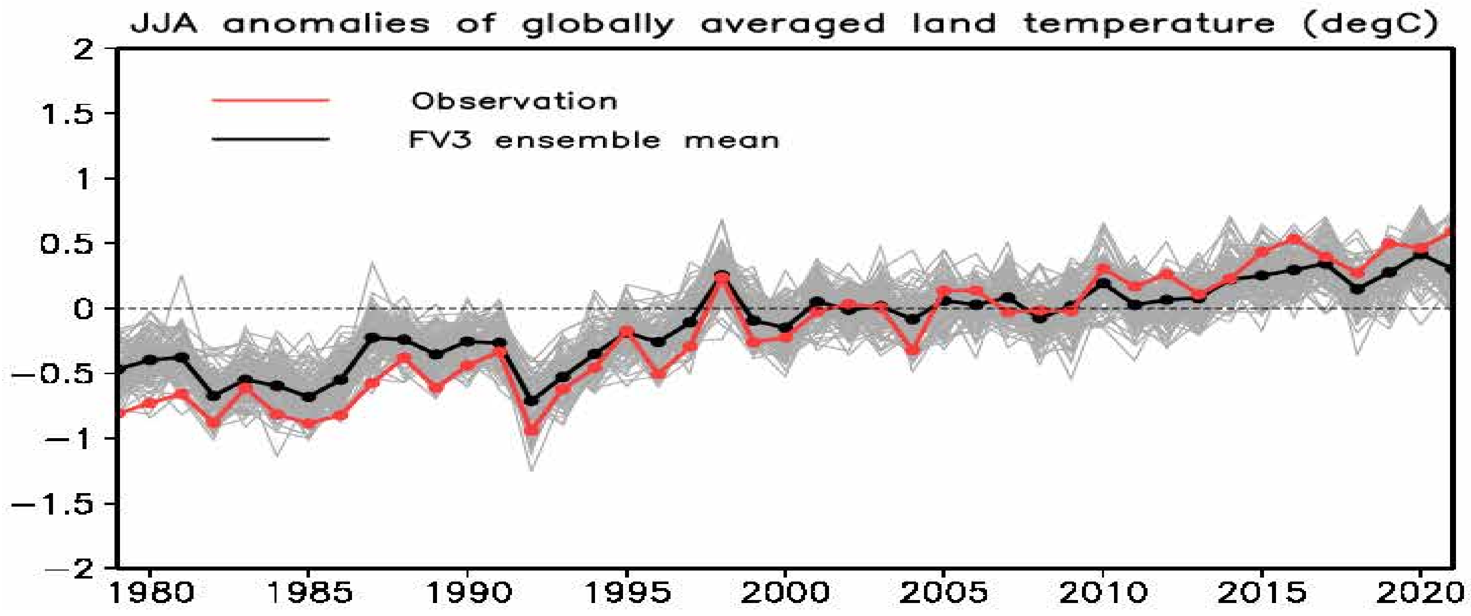
	Global mean	Pattern Correlation
Eddy Z200	OBS: 0.17 Model: 0.056	0.94
Precip.	OBS: 0.076 Model: 0.17	0.82
T2m	OBS: 12.95 Model: 12.09	0.98

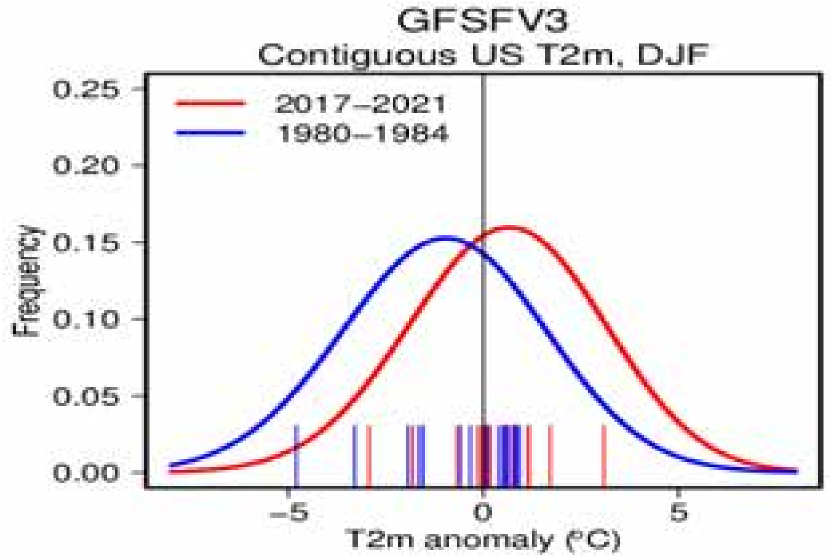
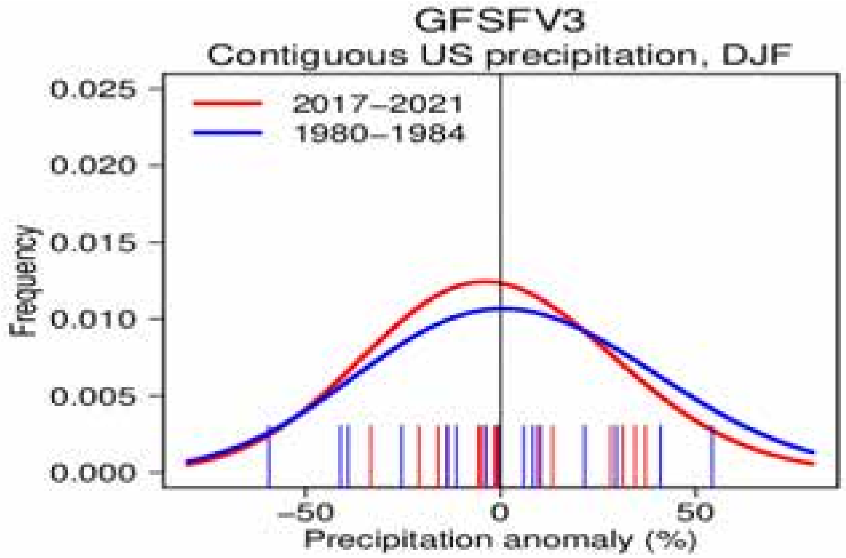
Time series of T2m over global land

DJF



JJA

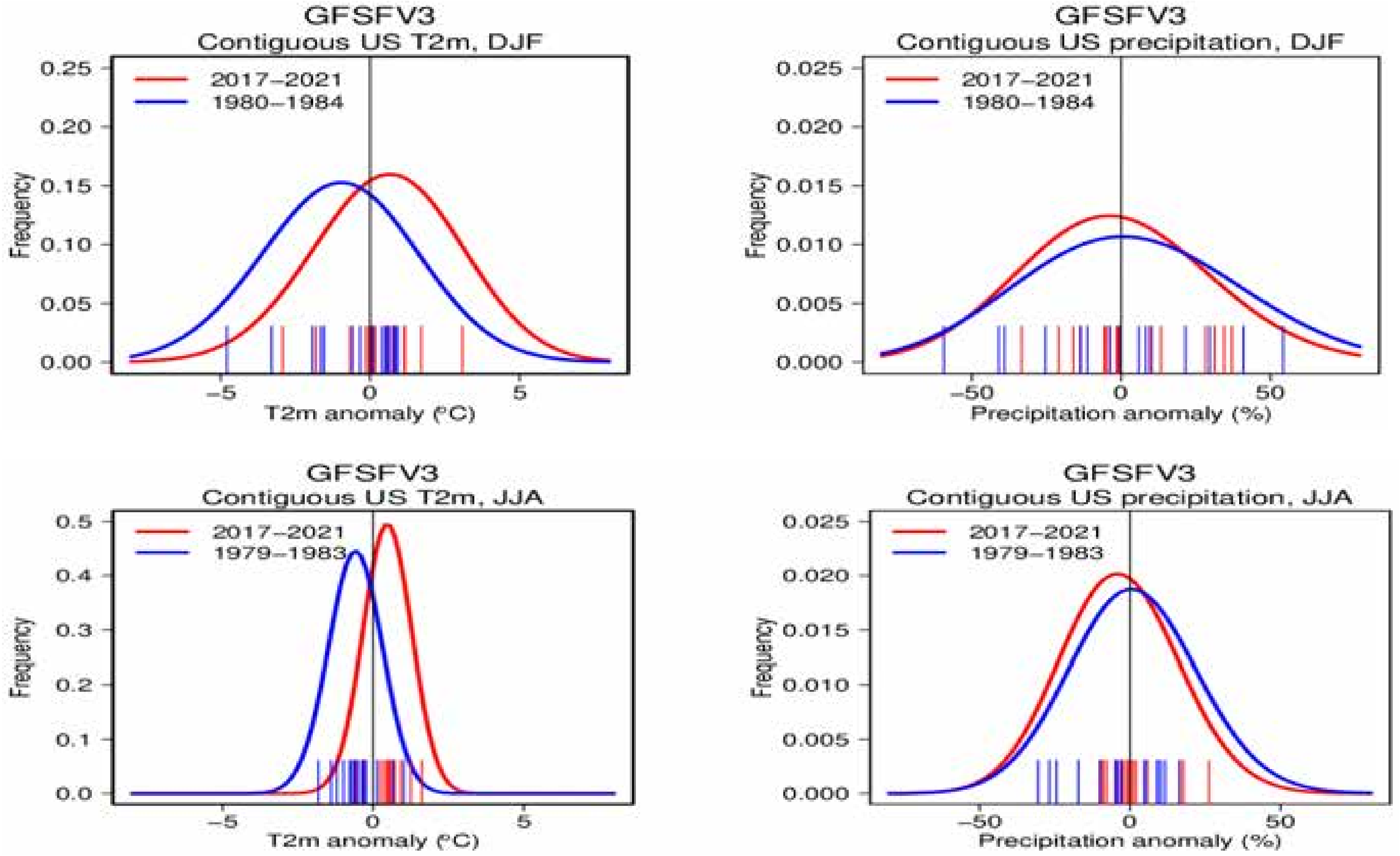


	Contiguous US T2m	Contiguous US precipitation
DJF		

Contiguous US T2m **Contiguous US precipitation**

DJF

JJA



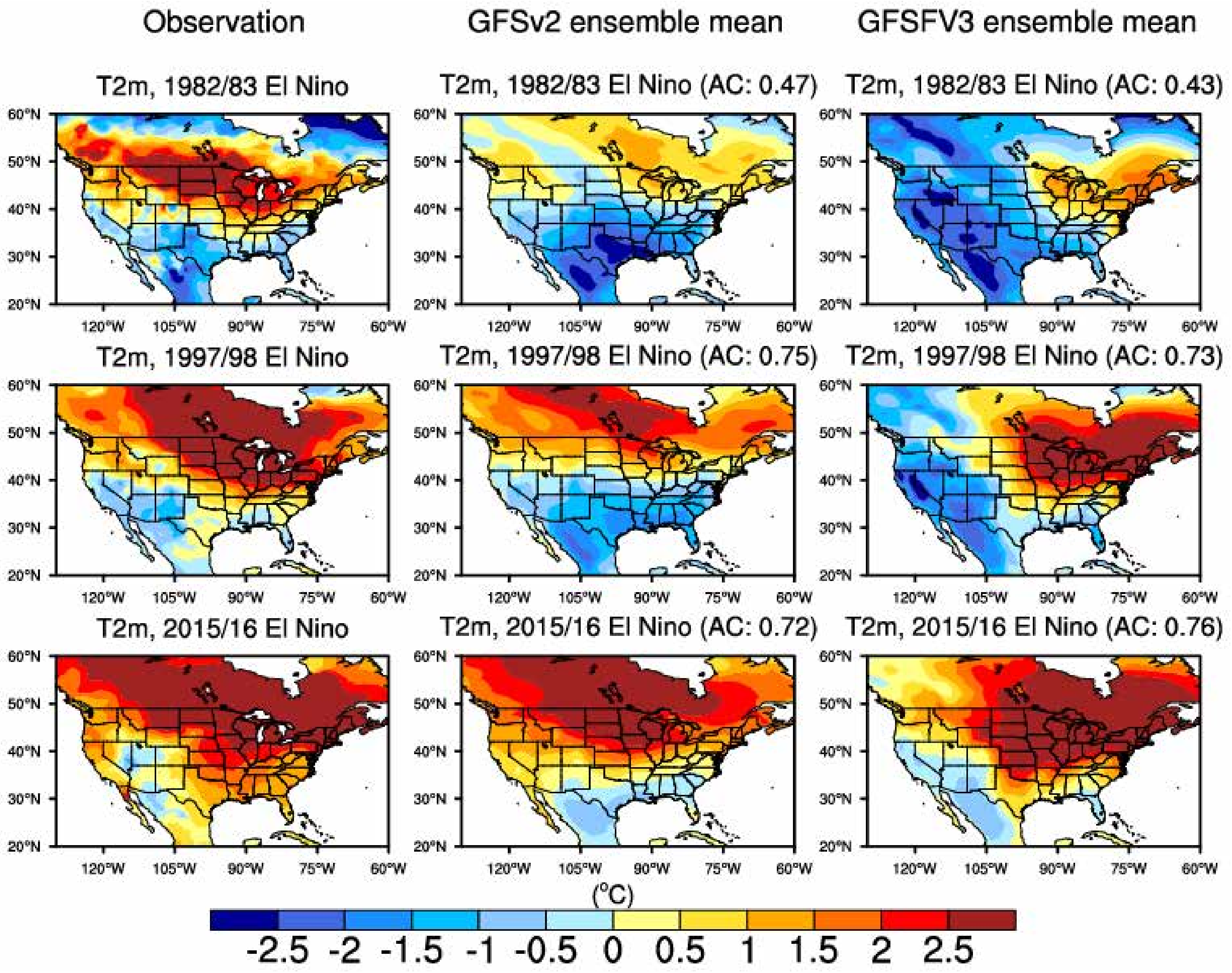
2) Simulation of US climate response to three strong El Niño events

Observation GFSv2 ensemble mean GFSFV3 ensemble mean

1982/83
DJF

1997/98
DJF

2015/16
DJF

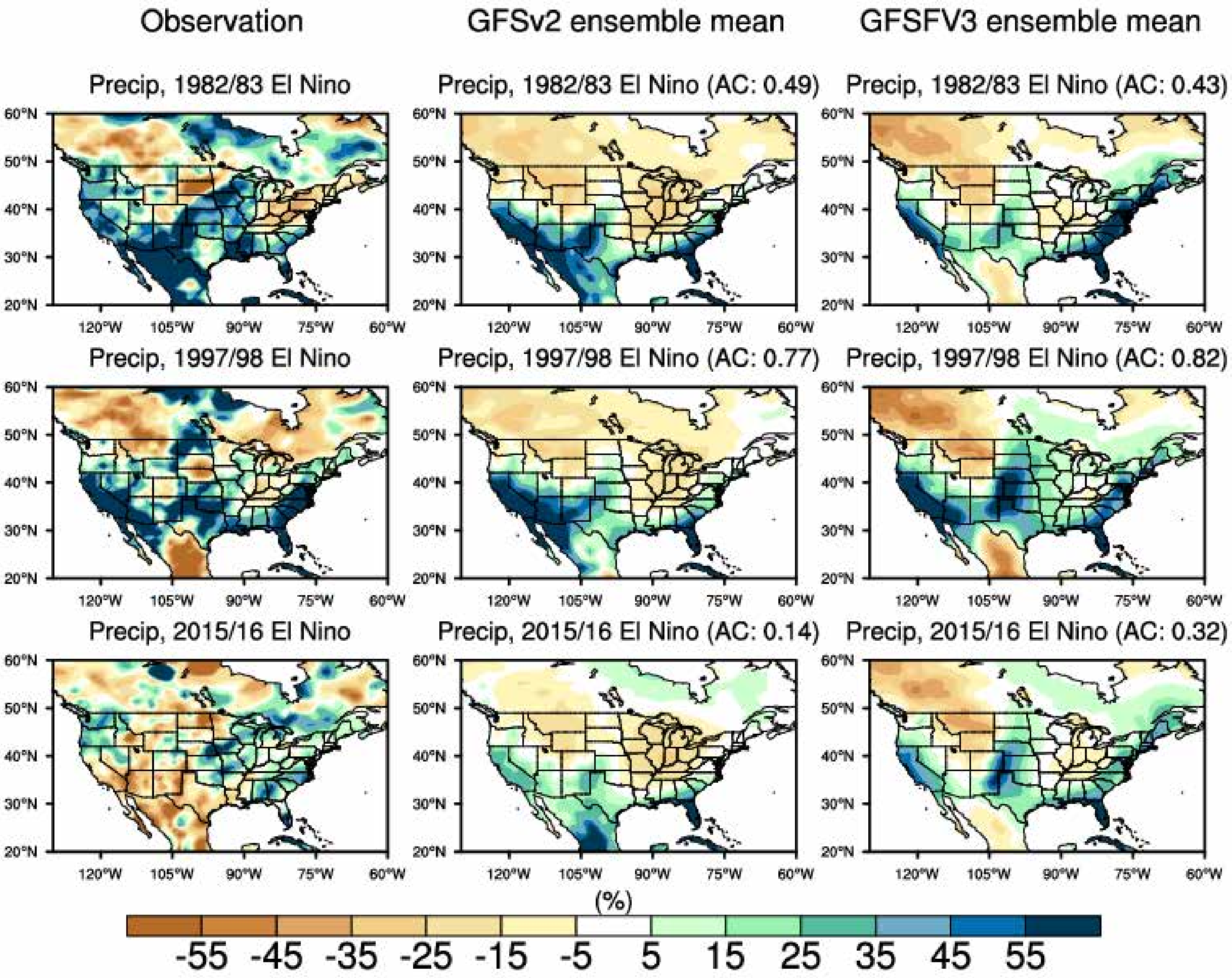


Observation GFSv2 ensemble mean GFSFV3 ensemble mean

1982/83 DJF

1997/98 DJF

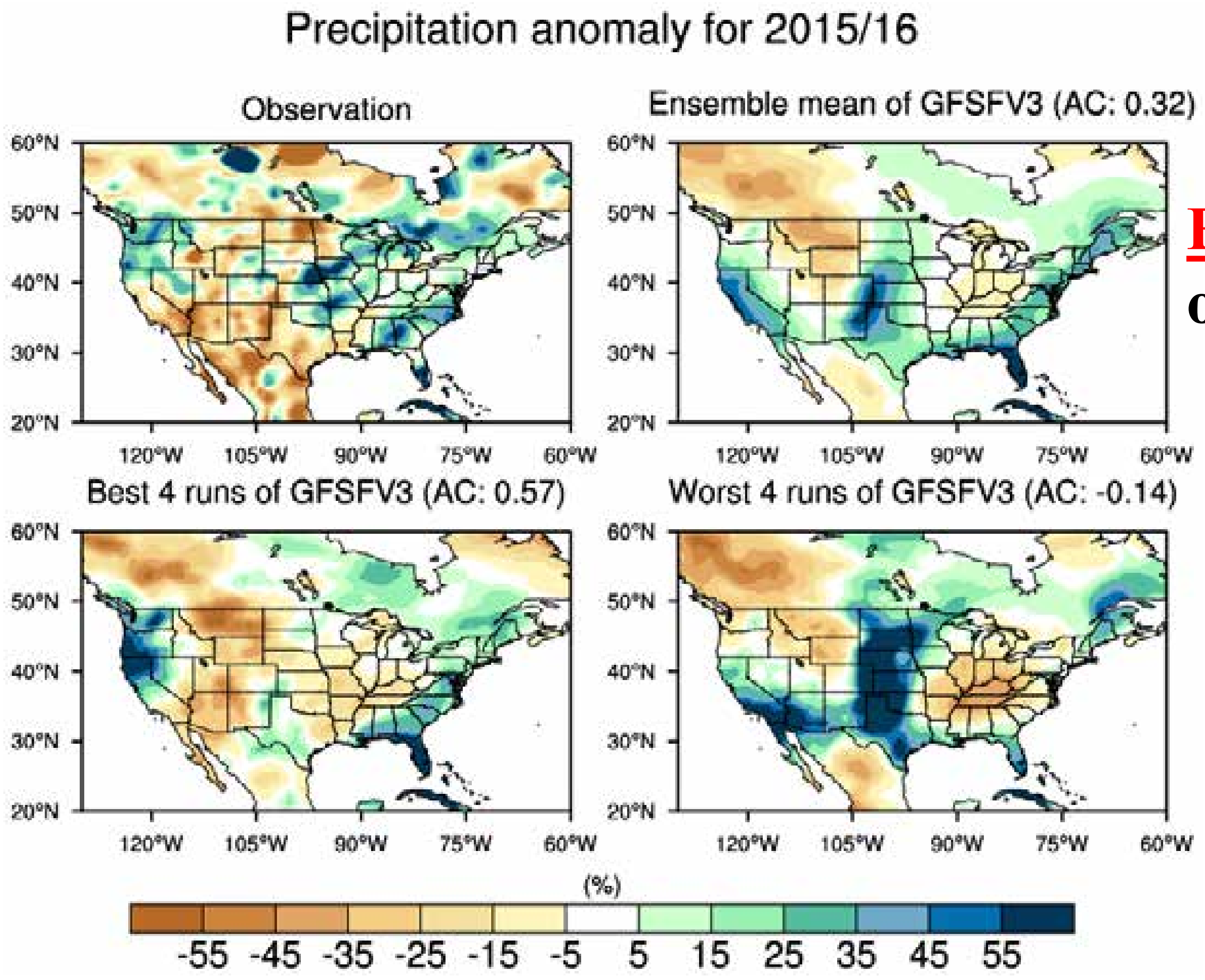
2015/16 DJF



Precipitation anomaly for 2015/16 DJF

Observation

Composite of best 4 runs of GFSFV3



Ensemble mean of GFSFV3

Composite of worst 4 runs of GFSFV3

3) Assessment of US climate predictability

- Climate predictability is assessed by quantifying the signal-to-noise ratio (SNR) which is the ratio of predictable and unpredictable components.

- The signal component in the SNR is the variance of ensemble mean but the noise component is the variance of departure in the individual members from the ensemble mean (Kumar and Hoerling 1995).

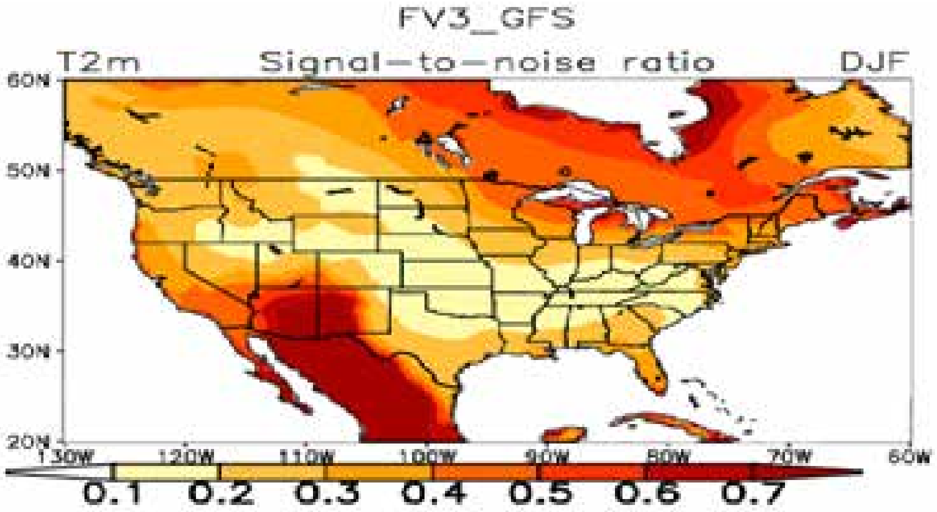
- Higher SNR value indicates larger predictability.

- The anomaly correlation is defined as the correlation of anomalies between AMIP ensemble means and the observation.

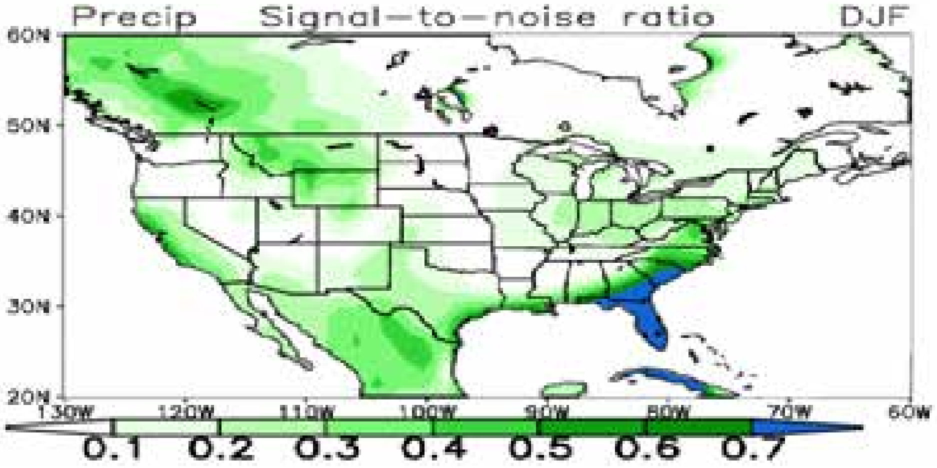
FV3_GFS, DJF

Signal-to-noise ratio

T2m



Precip



Higher signal-to noise value indicates larger predictability.

FV3_GFS, DJF

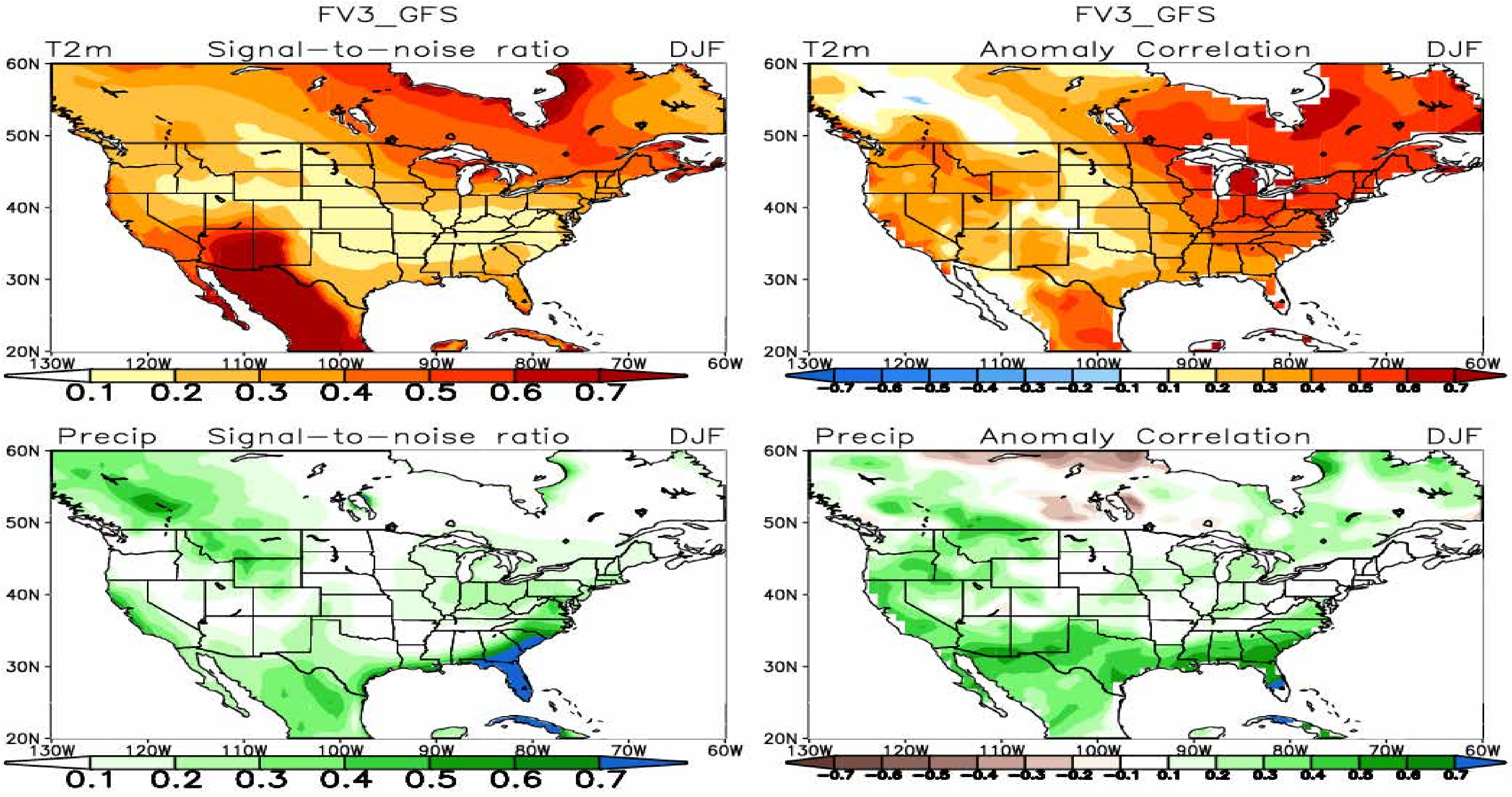
Signal-to-noise ratio

FV3_GFS, DJF

Anomaly correlation with OBS

T2m

Precip



Higher signal-to noise value indicates larger predictability.

The pattern of anomaly correlation with OBS, generally, follows that of SNR.

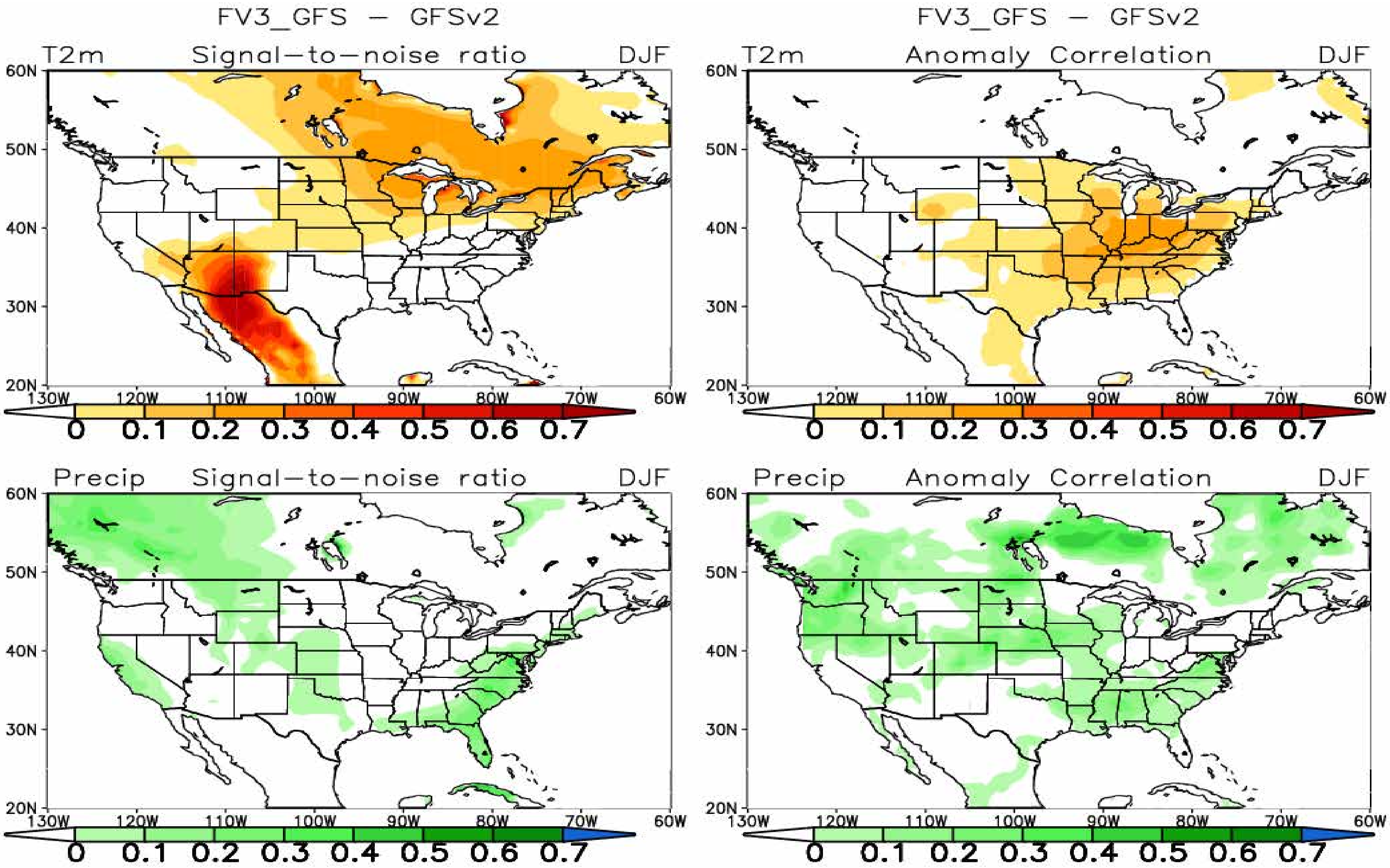
FV3_GFS minus GFSv2, DJF

Signal-to-noise ratio

Anomaly correlation with OBS

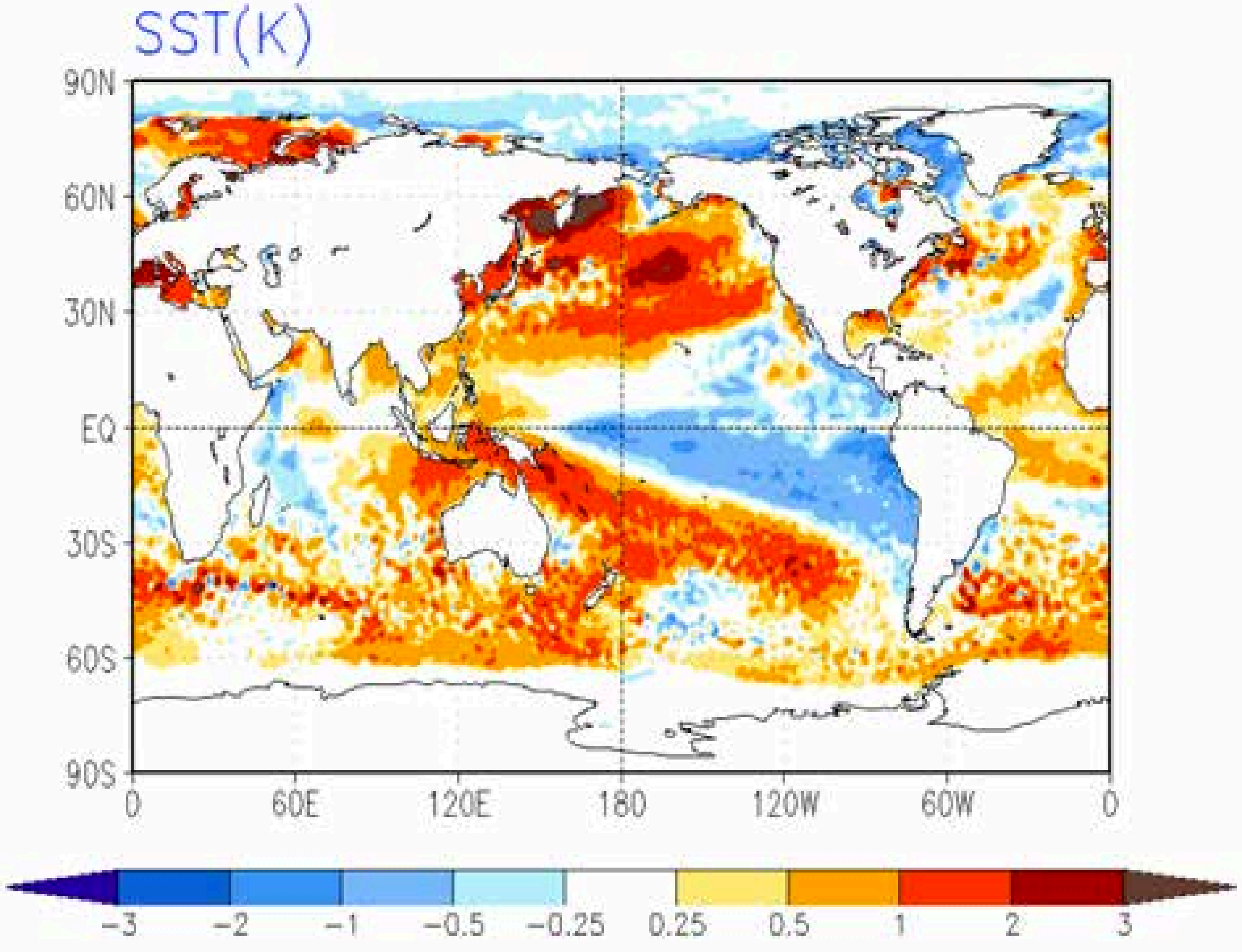
T2m

Precip

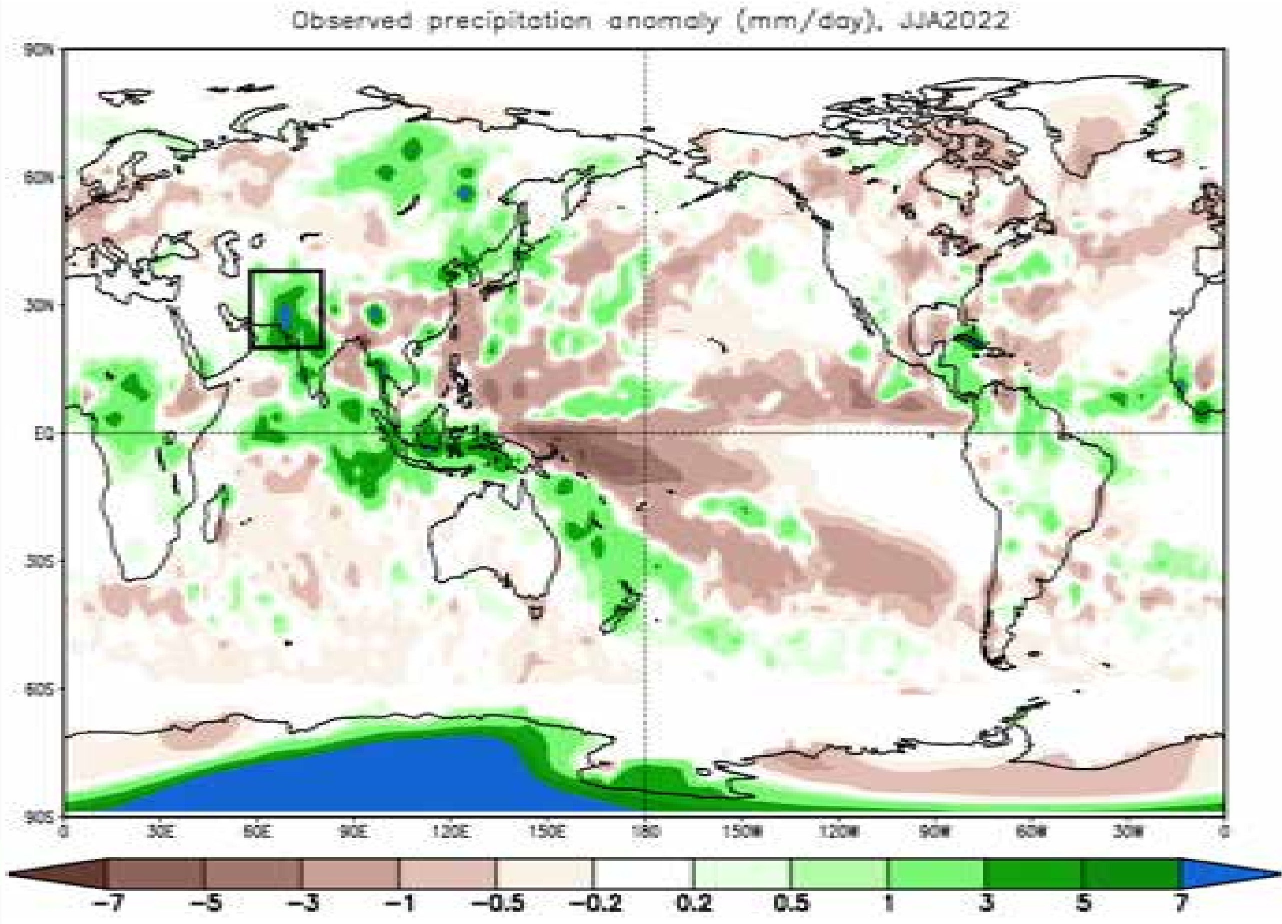


4) Simulation of extreme events—2022 summer South Asia flooding

Observed Anomaly JJA2022



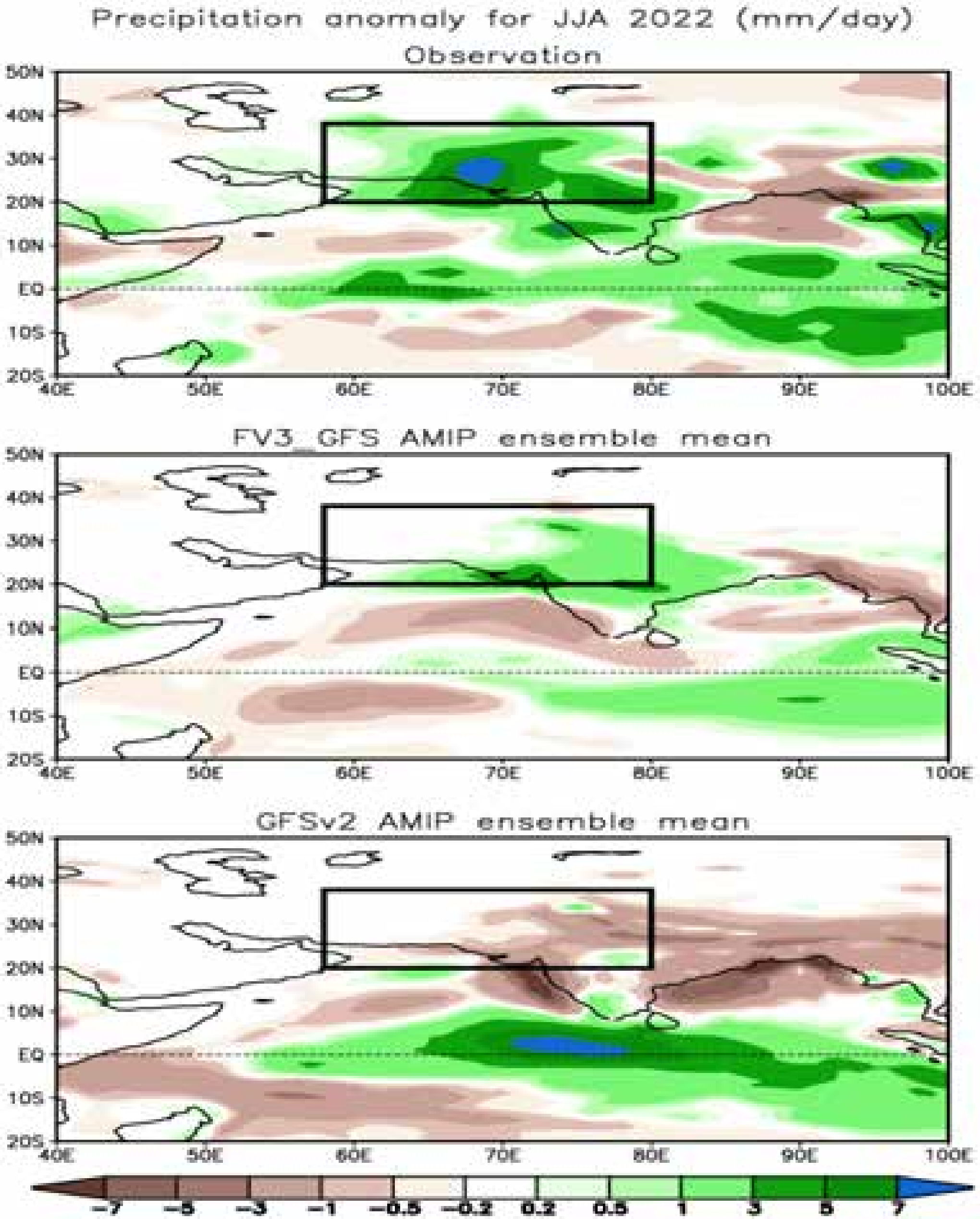
Observed Precip. anomaly JJA2022



SST plot is from https://www.cpc.ncep.noaa.gov/products/people/mchen/AttributionAnalysis/images/Attribution202208.pdf

Precipitation anomaly for JJA 2022

Observation



FV3_GFS

AMIP

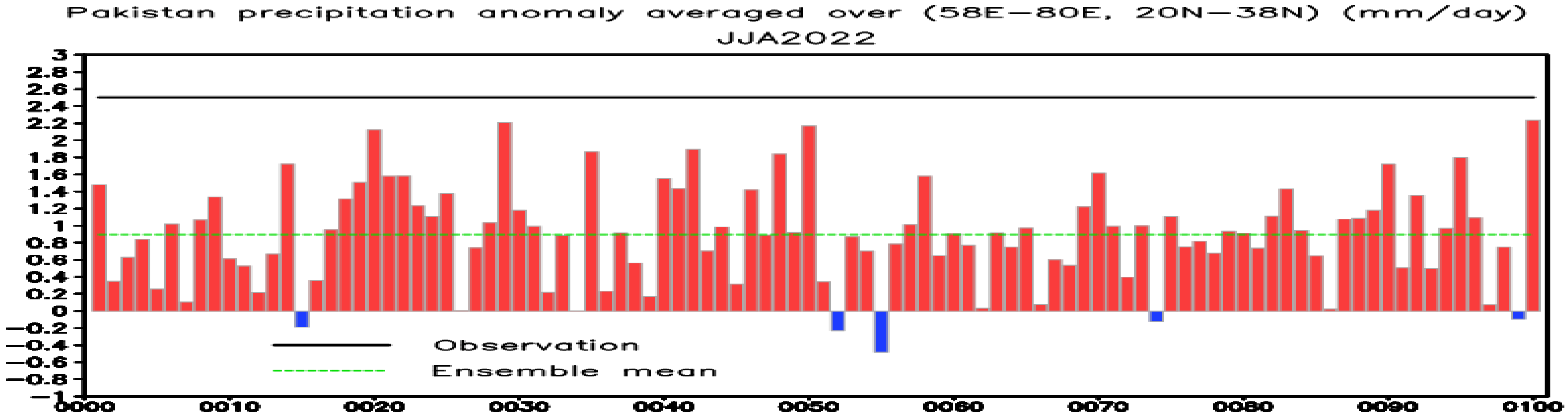
<u>ensemble mean</u>

GFSv2

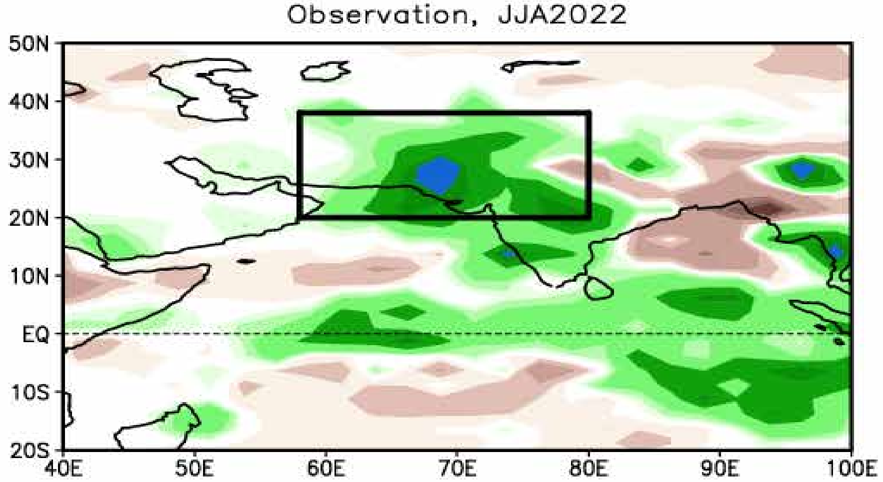
AMIP

<u>ensemble mean</u>

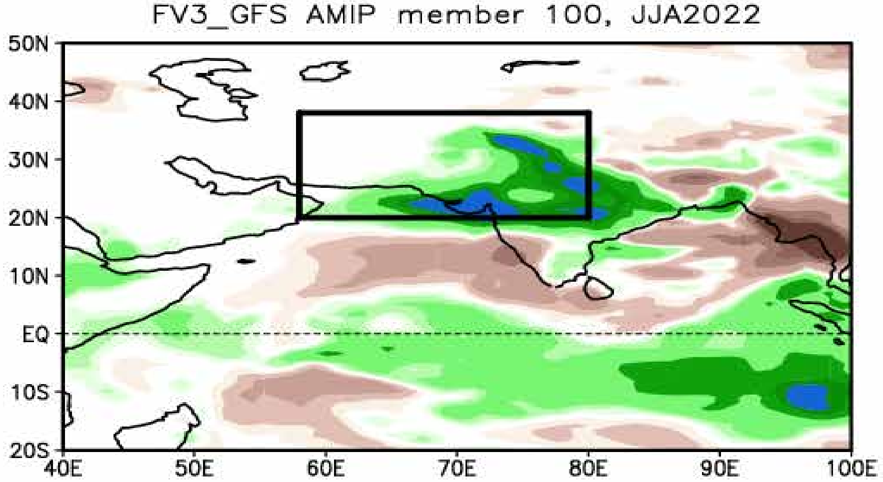
Precipitation anomaly over box region from FV3 individual members

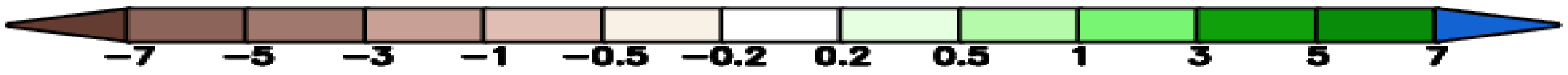


Observation



FV3 Member 100





Summary

- FV3_GFS model can realistically reproduce the observed climate variability and trends. Compared to old version GFSv2 model, FV3 model has a better simulation of extreme events, such as 2022 summer South Asia flooding.
- Associated with the warming trend over the global land, there is a US warming and drying climate trend.
- Both observations and simulations show a gradual southward shift of stronger warm anomalies from early strong El Nino (1982/83) to recent strong El Nino (2015/16).
- The ensemble AMIP experiments suggest that internal atmospheric noise, rather than a boundary-forced signal, was principally responsible for the failed SCAL rains in 2016.
- The strongest US winter surface temperature predictability is in the northeast while the strongest US winter precipitation predictability is in the southeast.
- The majority of FV3 individual runs produces a wet condition over the South Asia, indicating that the 2022 summer devastating flood over that region could be driven by the SST forcing.