The Review of GEFSv12 Reforecasts and Plan of GEFSv13

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Reforecast Configurations

	Forecast System	Frequency and Ensemble Size	IC	frequency and resolution of output data
31-year GEFSv12 reforecast (1989-2019) (Finished on March 2020)	FV3 GFSv15.1 and GEFSv12 C384 L64	Everyday except Wed., 5 members, out to 16 days Every Wed. 11 members, out to 35 days	Phase I (1989 – 1999): CFS analysis, BV-ETR perturbation, initiated at 00Z Phase II (2000 – 2019): Hybrid FV3 GFS/EnKF analysis with IAU and EnKF F06 perturbation, restarted at 03Z (ESRL/PSD)	Days 1-10: surface: 3 hourly at 0.25 deg. atmos: 3 hourly at 0.5 deg. Days 11-35: surface and atmos.: 6 hourly, at 0.5 deg.
30-year GEFSv13 reforecast (1994-2023) (planned to be finished by ~ March 2025)	Ensemble Prototype 4 (HR1) C384 (may add aerosol?)	Everyday except Mon. and Thur., 5 members, out to 16 days Every Mon. and Thur., 11 members, out to 35 days (48 days? CPC)	GEFSv13 replay reanalysis with IAU and ERA5 perturbations for atmos, lagged differences between four reanalyses for ocean (ESRL/PSD), restarted at 03Z.	Surface: same as GEFSv12 Atmos.: (>=100hpa): 6 hourly at 1 deg. (< 100hpa): daily at 1 deg. Ocean: daily at 1 deg. Ice: daily at original res. (0.25 deg.) Wave: 6 hourly.

GEFSv12 Reforecast for Public Access

Upper air variables: 176
Surface and other single-level variables: 43

Data access through AWS: (20 years:2000 - 2019)

https://noaa-gefs-retrospective.s3.amazonaws.com/index.html

Data access through NCEP ftp: (11 years:1989 - 1999 and 20 years:2000 - 2019)

ftp://ftp.emc.ncep.noaa.gov/GEFSv12/

Proposed GEFSv13 Reforecast for WCOSS Access

2D surface and other single-level variables: 39 (>22 for GEFSv12)

PRMSL	PWAT (entire atmosphere)	SOILW (0.0m-0.1m)
PRES (surface)	CAPE (180-0mb)	SOILW (0.1m-0.4m)
TMP (2m)	HLCY (3000-0m)	SOILW (0.4m-1.0m)
Tmax (2m)	CIN (180-0mb)	SOILW (1.0m-2.0m)
Tmin (2m)	TCDC (entire atmosphere)	TSOIL (0.0m-0.1m)
RH (2m)	WEASD (surface)	TSOIL (0.1m-0.4m)
UGRD (10m)	OLR (TOA)	Freezing Level
VGRD (10m)	DLWRF (surface)	Snowfall Accumulation
APCP (surface)	DSWRF (surface)	PEVPR (surface)
CRAIN (surface)	ULWRF (surface)	WATR (surface)
CFRZR (surface)	USWRF (surface)	FDNSSTMP (foundation T)
CICEP (surface)	LHTFL (surface)	TMP (surface)
CSNOW(surface)	SHTFL (surface)	Bucket snowfall accumulation

3D atmosphere variables: 79 (>55 for GEFSv12)

Levels	U	V	T	RH	HGT	VVEL	O3MR
1, 2, 3, 5, 7, 20, 30, 70 hPa	X	X	X				
10, 50, 100 hPa	X	X	X		X		X
200, 250, 500, 700, 925, 1000 hPa	X	X	X	X	X		
850 hPa	X	X	X	X	X	X	
0.995 (hybrid)	X	X	X	X			

33 Ocean variables: SST,SSH,SSS,MLD_003,Taux,Tauy, SSU, SSV, temp (25 levels)

10 Seaice variables: sea ice concentration, ice thickness, ice/snow surface temperature,u Ice velocity, v ice velocity, snow depth on ice, ice/snow albedo, top-melt, bottom-melt, freeze-melt

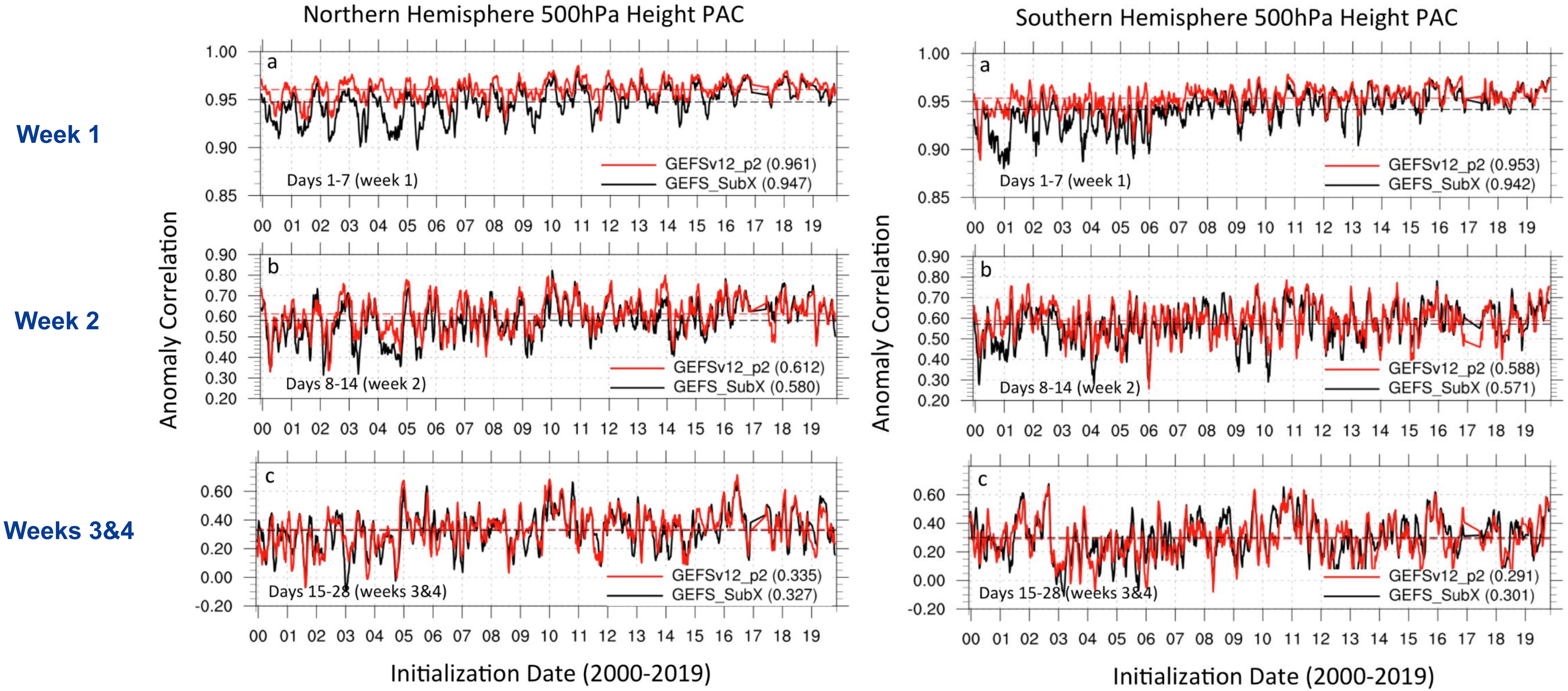
More detail can be found in the poster by Sinsky et al.: “The community support of the GEFS reforecasts (GEFSv12/GEFSv13)”

Evaluation and Application of GEFSv12 Reforecast

Reference:

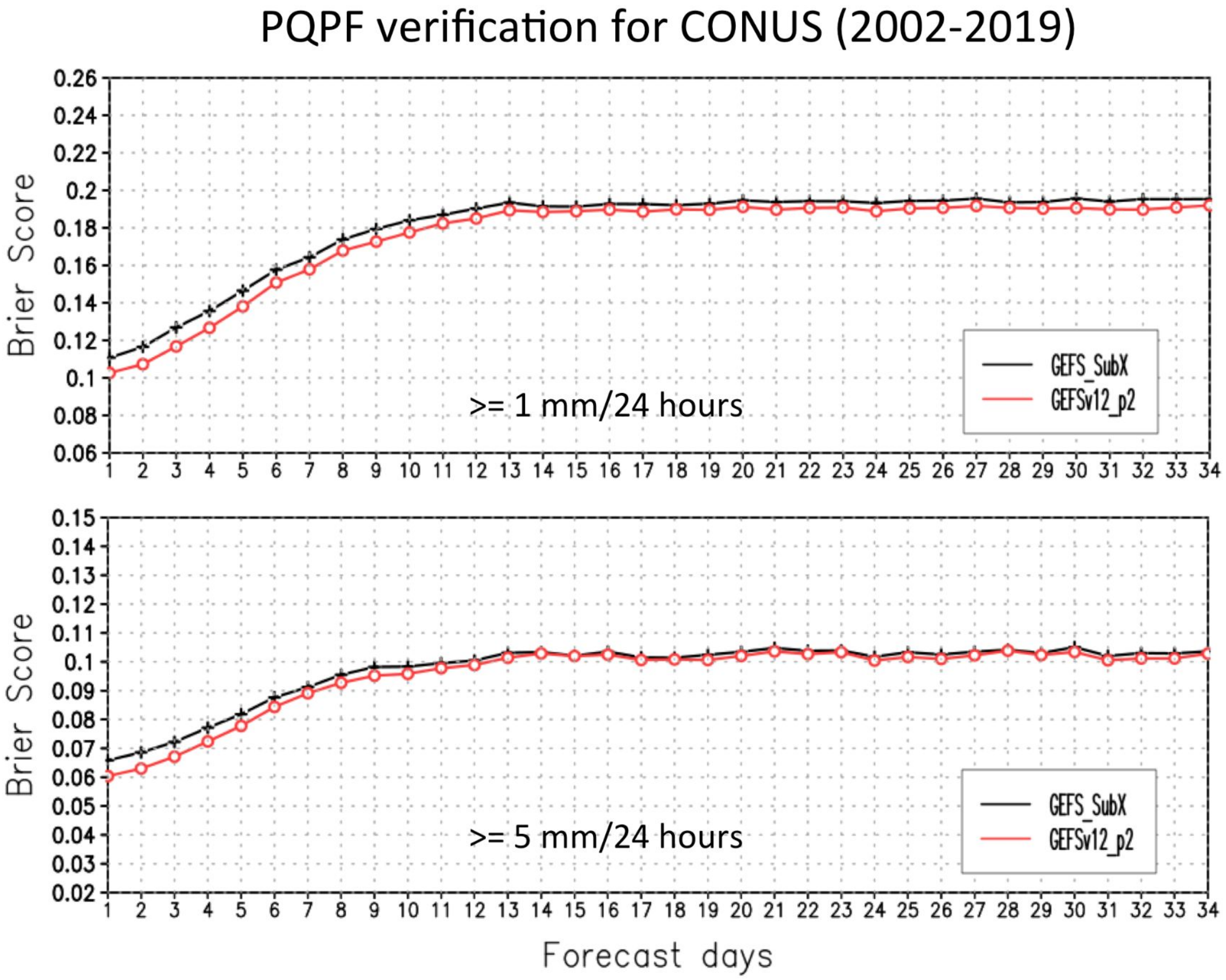
Hong Guan, Yuejian Zhu, Eric Sinsky, Bing Fu, Wei Li, Xiaqiong Zhou, Xianwu Xue, Dingchen Hou, Jiayi Peng, M. M. Nageswararao, Vijay Tallapragada, Thomas M. Hamill, Jeffrey S. Whitaker, Gary Bates, Philip Pegion, Sherrie Frederick, Matthew Rosencrans, and Arun Kumar, 2022: GEFSv12 reforecast dataset for supporting subseasonal and hydrometeorological applications. *Mon. Wea. Rev.*, **150**, 647–665, https://doi.org/10.1175/MWR-D-21-0245.1

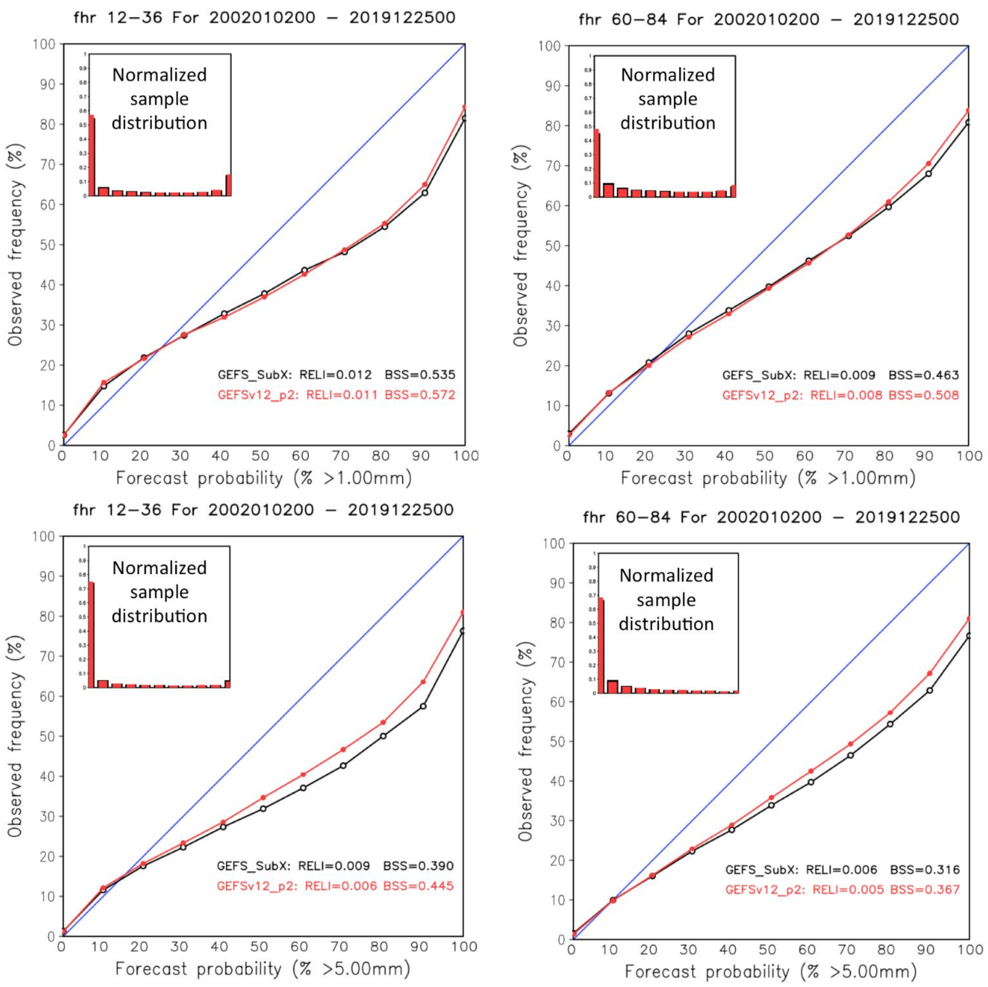
Ensemble Mean Skills of 500hPa Geopotential Height (GEFSv12 vs SubX)



- The GEFSv12_p2 outperforms GEFS_SubX except for SH WKs 3 and 4 forecasts. The significant tests indicate that values are not significantly different between the two experiments for WKs 3 and 4 for SH.

CONUS PQPF Skills (2000-2019)

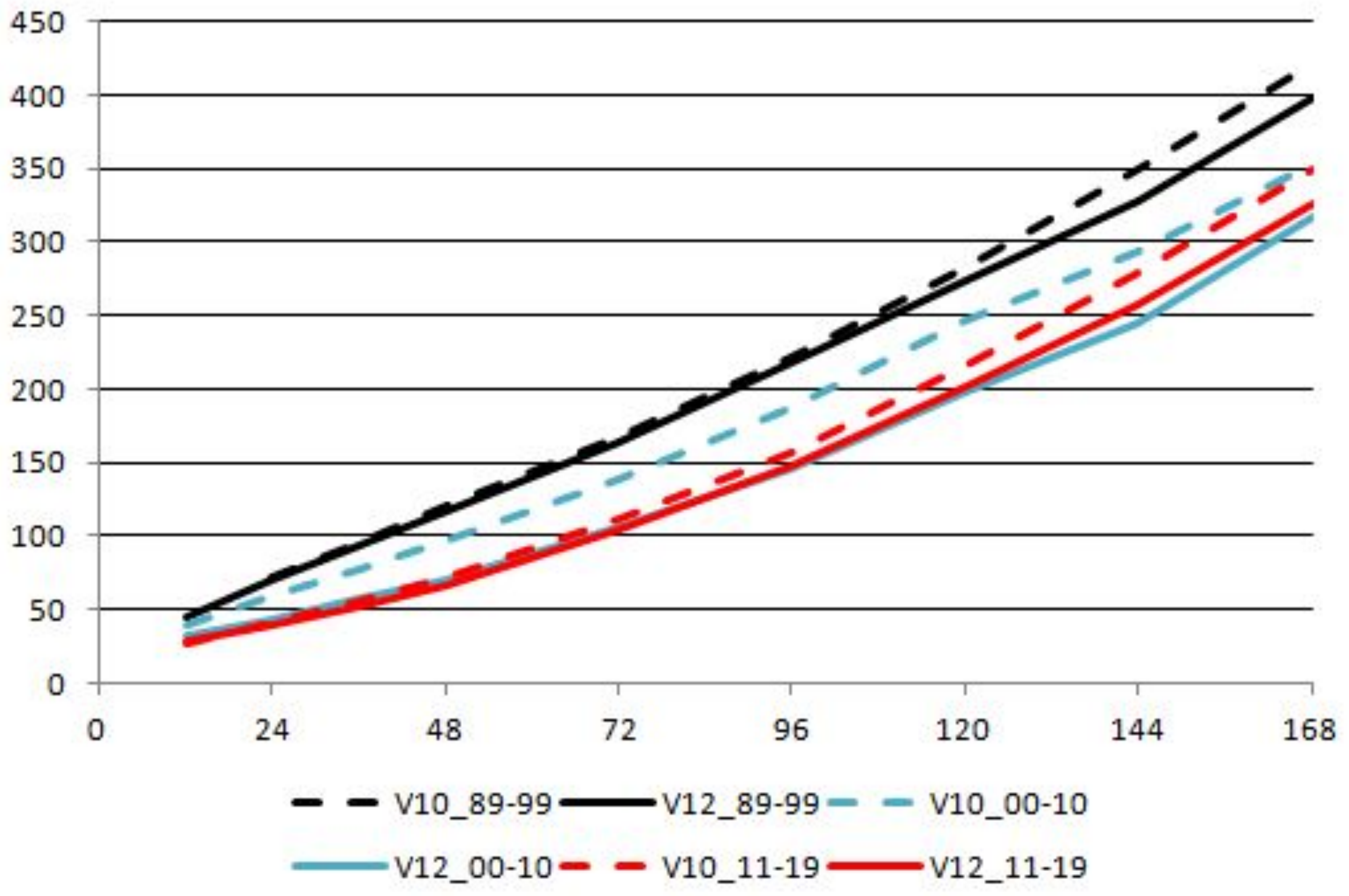




- The **GEFSv12** consistently displays the better Brier scores compared to the **GEFS_SubX**, with a more obvious improvement at lead times <10 days. Forecast skill reaches saturated values at ~ day 13 for all situations.
- Based on reliability diagram, the two experiments show very similar performance for the precipitation >1.00 mm.
- For the heavier precipitation category (>5 mm), the GEFSv12 slightly outperforms the GEFS_SubX.

Comparison of TS Track Errors (GEFSv10 .vs GEFSv12)

The TS track errors averaged over the Atlantic, East Pacific and West Pacific basins



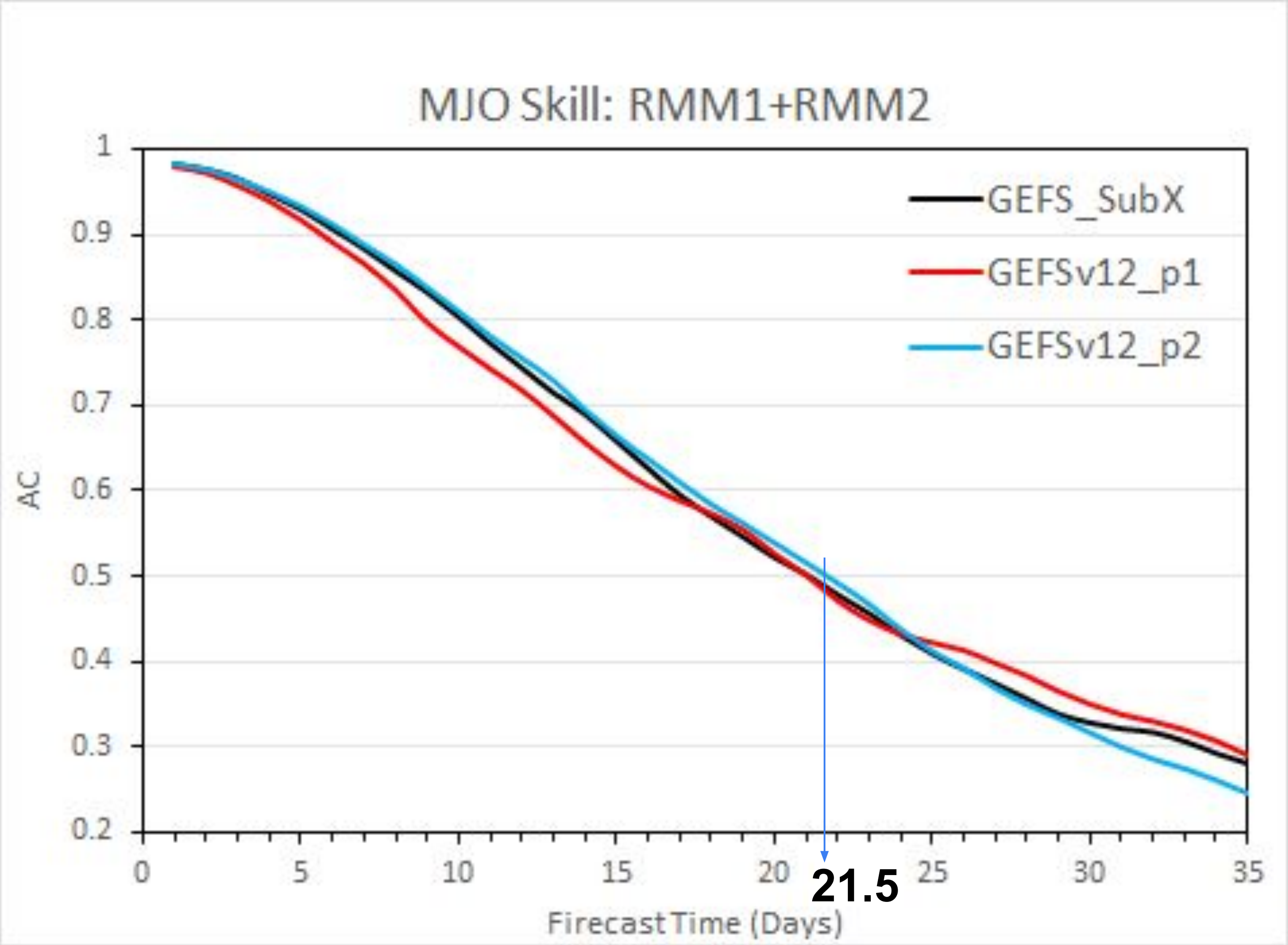
- Why do we compare to GEFSv10?
  - *Because we have similar reforecast configuration to cover the same period.*

- Why do we consider three different periods?
  - 1989-1999: Both v10 and v12 are using the same initial conditions, but different models
  - 2000-2010: GEFSv10 used CFS reanalysis initial analysis.
  - 2010-2019: GEFSv10 moved to use real-time GDAS (different from CFS reanalysis) around Spring 2011).

- The GEFSv12 reduces the track errors with the maximum reduction during the 2000–2010 period.

- More discussion - please refer to the manuscript led by Guan et al., 2022.

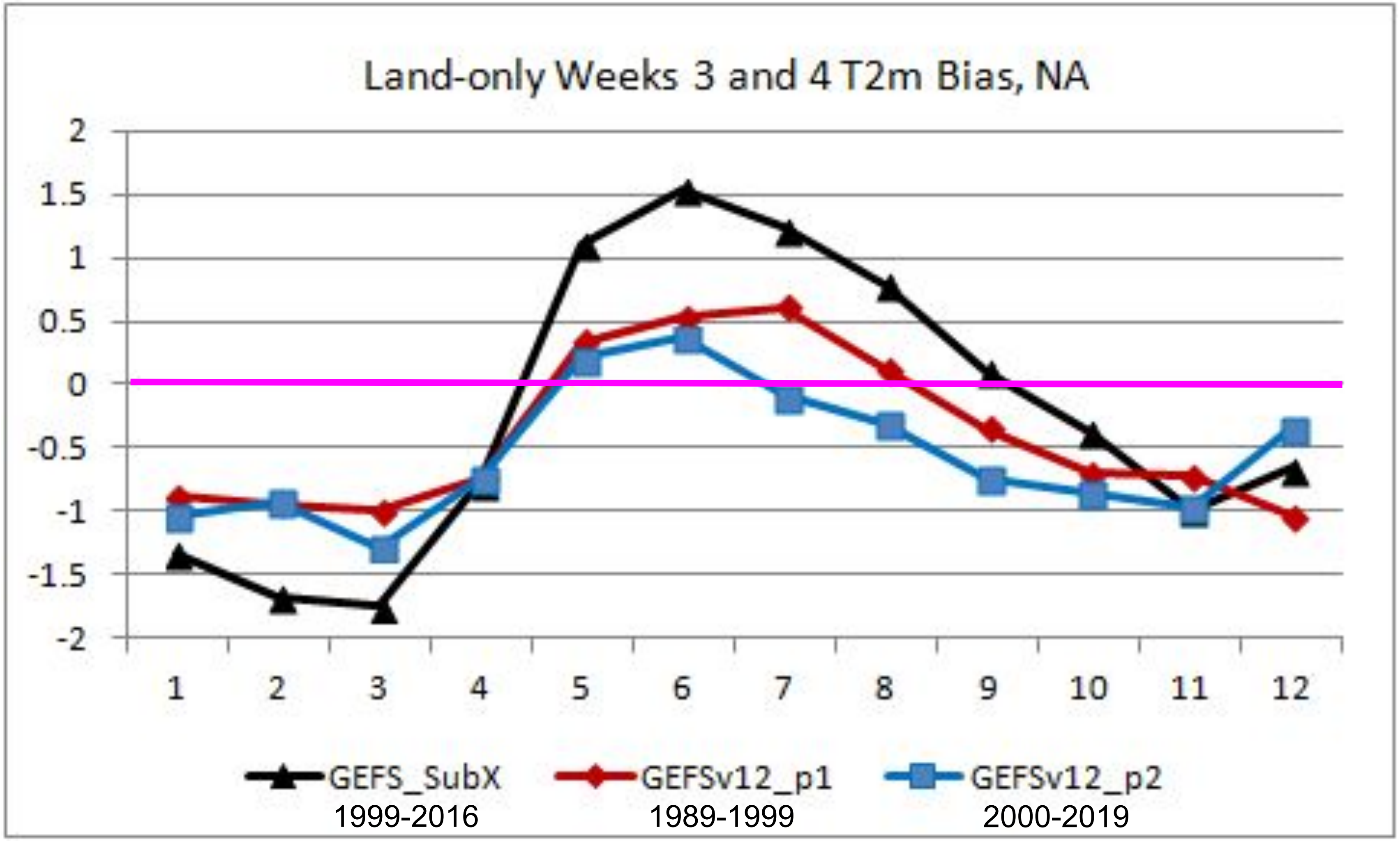
Comparison of MJO Skill Scores (RMM1+RMM2)



- Phase 1: 1989-1999 (red)
- Phase 2: 2000-2019 (blue)
- GEFS SubX: (black)
  A updated version of GEFSv11 which was running in near real-time since October 2017 to support NOAA SubX project.
- Climatology:
  - CFS reanalysis climatology
  - GEFSv12 reanalysis climatology
  - GEFS_SubX reforecast climatology
  - GEFSv12 reforecast climatology

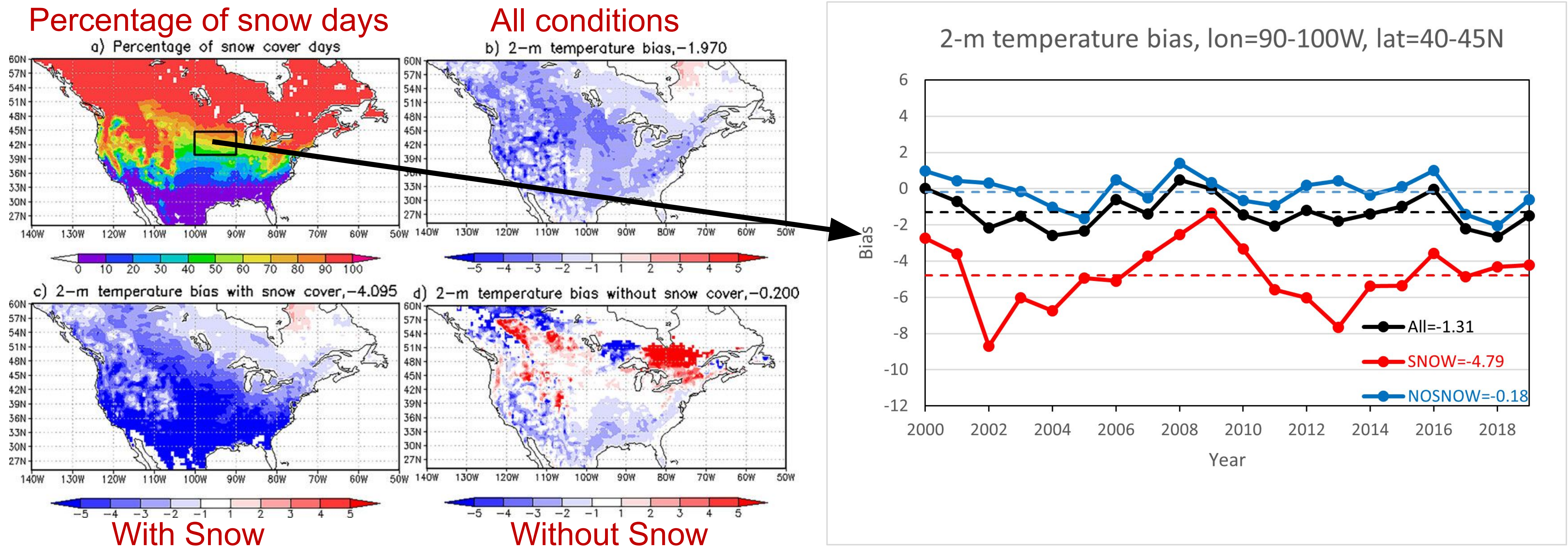
- Overall, the MJO forecast skill for the GEFSv12_p2 (~21.5 days) is similar to the GEFS_SubX and GEFSv12_p1 (21 days) when using AC=0.5 as the threshold of the useful skill.

Monthly Difference of NA Land 2-m Temperature Bias



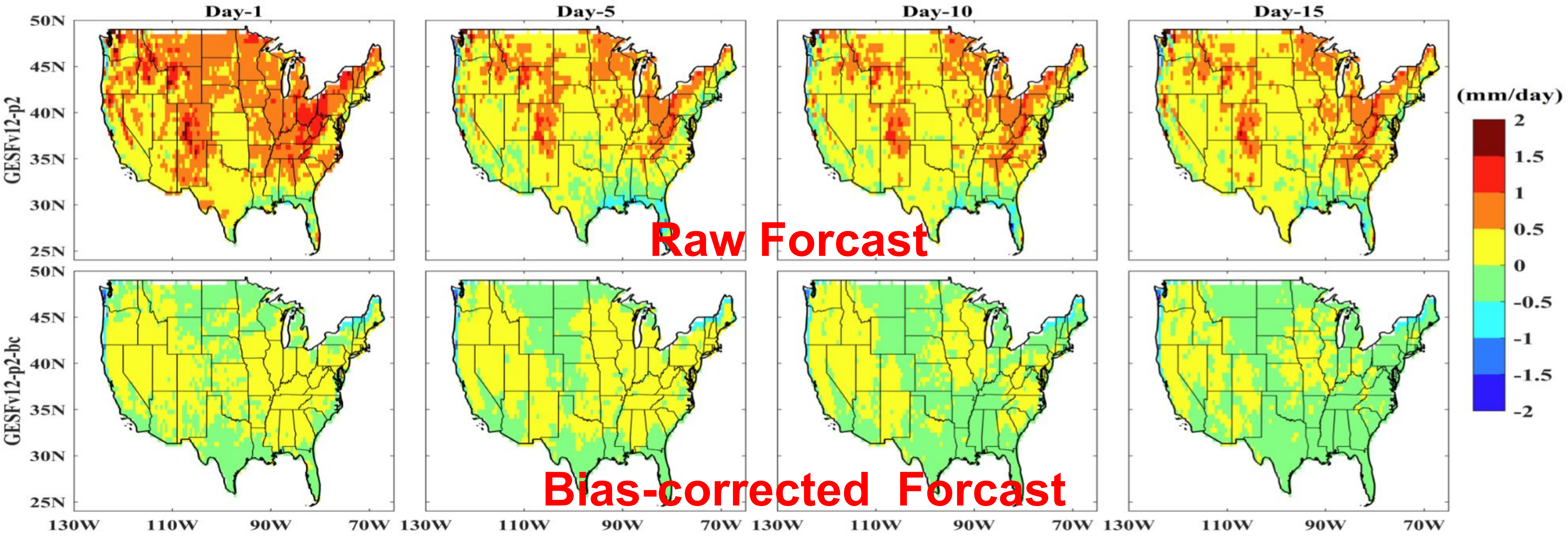
- Day 15-28 average (weeks 3&4)
- All three sets of reforecasts display a cold bias during the October–April and warm bias during the May–June period
- For most of months, GEFSv12 demonstrates less (or improved) bias than GEFS SubX forecast.
- There is a systematic difference between the phase 1 and phase 2 for July, August, and Sept.

2-m Temperature Bias Impacted by Snow Cover (408-hr forecast for Jan. Feb., and March)



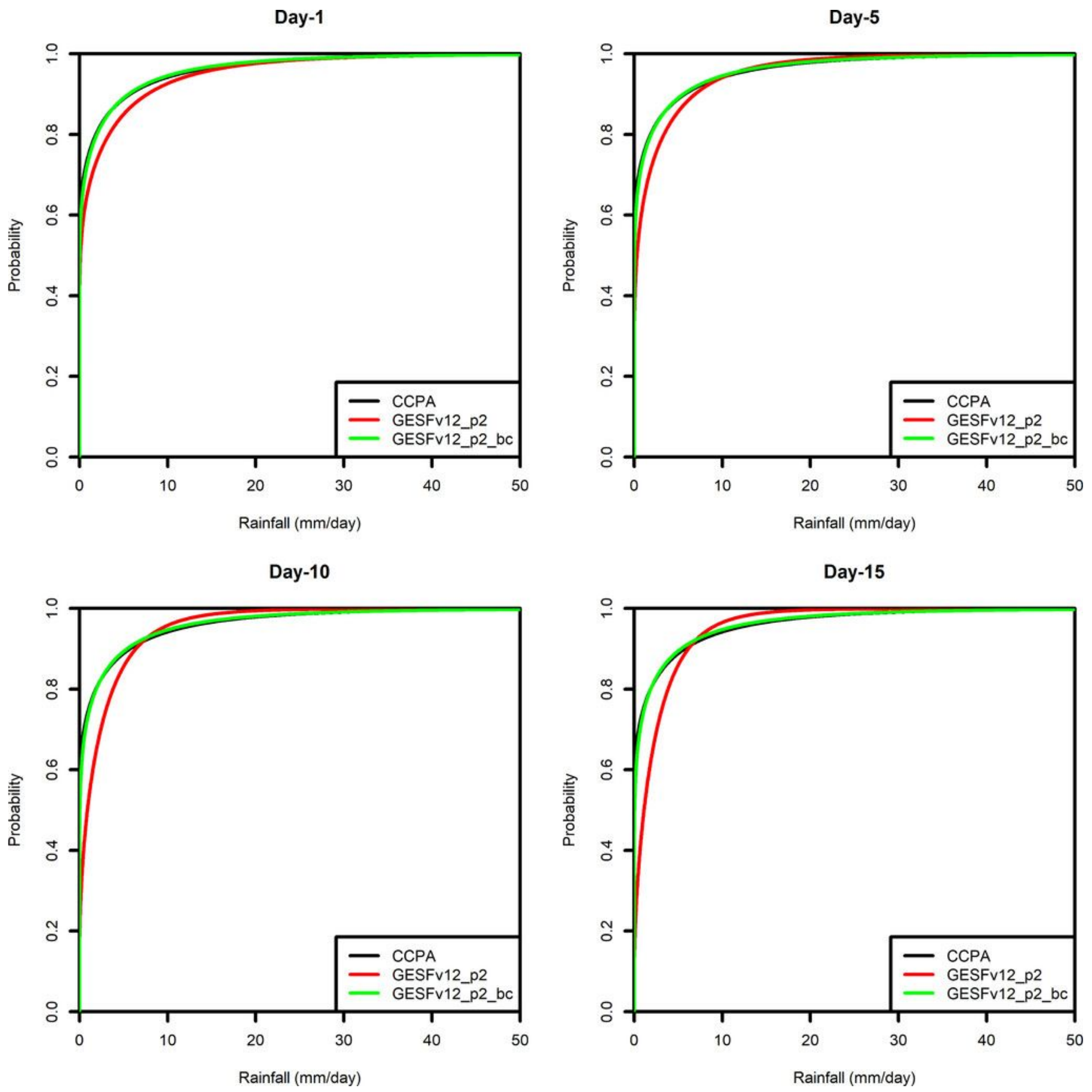
- A larger cold bias is dominant under the existence of snow cover with a domain-averaged value of −4.79°C during the GEFSv12_p2 period.
- Bias is much smaller under snow-free conditions where the average value is about −0.18°C.
- There is considerable room for improving the 2-m temperature forecast under snow-covered conditions.

Using reforecast data (2002-2019) to calibrate Precipitation
(Quantile Mapping Method)



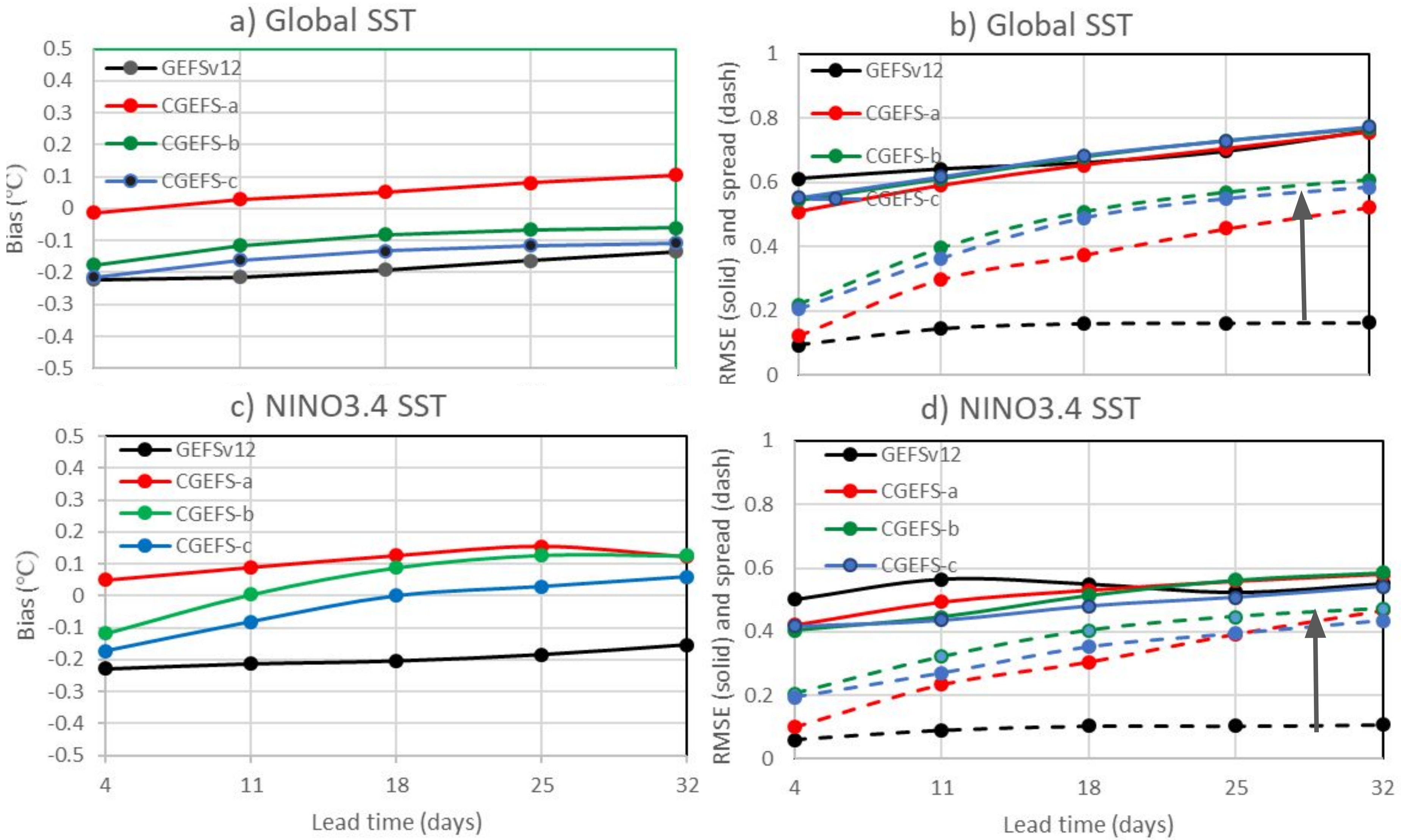
- Quantile mapping method is desired to make the ensemble mean probability distribution more consistent with the CCPA precipitation distribution.
- An independent cross-training method is applied during a CCPA and reforecast coexisting period (2002–2019).
- The calibration using the reforecast data dramatically reduce forecast bias for all lead days.

CONUS Precipitation Probabilistic Distribution (2002-2019)



- For day 10 and day 15, the raw forecast tends to underestimate the probability of precipitation less than ~7.5 mm day−1 and overestimate the corresponding value more than ~7.5 mm day−1.
- After the calibration, the model curves overlap the observed curves for all lead days.

Reforecast as a benchmark to develop GEFSv13 (SST)



Ref. OSTIA

GEFSv12: reforecast

CGEFS-a: EP1 (P5)

CGEFS-b: EP3 (P8)

CGSES-c: EP4 (HR1+)

- Overall, three coupling experiments show a better or similar performance than the uncoupling experiment (GEFSv12).
- Coupling system and ocean perturbation (green dashed lines) dramatically improve the SST spread (black dash lines).
- The differences in SST rmse for all experiments are relatively small.

Summary:

- The GEFSv12 reforecast dataset is being used to support the stakeholders and public users. It is easy to be download.
- The evaluation shows that GEFSv12 perform equal or better than GEFS SubX or GEFSv10.
- For CONUS high latitude winter season, 2-m temperature error is impacted by snow cover.
- For CONUS precipitation application, the calibration using the reforecast data could remove forecast bias and improve probabilistic distribution.
- GEFSv12 reforecast has been used as a benchmark to develop GEFSv13. Coupling-based GEFSv13 improves SST forecast skill and uncertainty.
- GEFSv13 reforecast will be run from Jan. 2024, finished on ~ March, 2025.