NAEFS v7.0: Proposed Implementation of the North American Ensemble Forecast System (NAEFS) v7.0.0

Presented by:

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Environmental Modeling Center

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NAEFS Briefing Outline

- Introduction, Project Motivation, and Project Status (Jason Levit)
- Science Discussion (Bo Cui and Hui-Ya Chuang)
- NAEFSv7 Verification and NWS Field Evaluation (Alicia Bentley and Geoff Manikin)
- Conclusions and Request for Approval (Jason Levit)

Acknowledgements

Project Manager: Jason Levit
Project Lead: Hui-Ya Chuang

Evaluation Lead: Geoff Manikin
Global Verification Project Lead: Alicia Bentley
Lynker Lead: Shelley Melchior

Code Manager/Developer: Bo Cui

EIB EE2 Review: Dan Iredell

Coordination: Rahul Mahajan, Raffaele Montuoro

NCO: Steven Earle, Justin Cooke, Anne Myckow, Margaret Curtis, Jesse Marks

National Weather Service: Regions and National Centers

NAEFS Status as of 7/13/23

NAEFS v7.0
Status as of July 13, 2023

G

Project Information & Highlights

Project Manager: Jason Levit; **Backup**: Hui-Ya Chuang

Leads: Jason Levit (EMC), Steven Earle (NCO)

Scope: Develop an updated version of the North American Ensemble Forecast System with additional GEFS members. Upgrade FNMOC related products from 1.0 degree to 0.5 degree to allow FNMOC and NCO to eliminate the 1.0 degree data. Upgrade GEFS calibration to 31 members.

Expected benefits: Upgrade NAEFS to use the full 31 members of the GEFS (NAEFS currently uses 21 members). Tune and calibrate all products based on new data.

Dependencies: GEFS

G **Schedule**

Milestones & Deliverables	Date	Status
Test and tune NAEFS jobs	Q2FY23	Completed
Internal EMC testing	Q3FY23	Completed
EMC/NCO kick off meeting	Q3FY23	Completed
Release candidate code frozen	Q4FY23	In Progress
Complete full retrospective/real time runs and evaluation	Q4FY23	In Progress
Conduct OD brief and deliver final system code to NCO	Q4FY23	Planned
Start 30-day evaluation and IT testing	Q1FY24	Planned
Operational implementation	Q1FY24	Planned

EMC | NCO | Blue text indicates changes from previous quarter

G **Issues/Risks**

Risk: Prioritizing this upgrade within the implementation stack; **Mitigation**: Engage NCEP OD on prioritization of model implementations.

G **Resources**

Staff: .4 Fed FTEs + .75 Contractor

Funding Source: STI

Compute: TBD

Archive: TBD

R **Management Attention Required** | Y **Potential Management Attention Needed** | G **On Target**

Project Motivation

Main Goal: Upgrade NAEFS to using 31 GEFS members from 21

Historical Context:

- GEFSv12 increased GEFS membership from 21 to 31 members
- NAEFS not upgraded with GEFSv12, considered a science change
- NAEFS was frozen due to focus on DSRA projects

Post 2022 Supercomputer Moratorium:

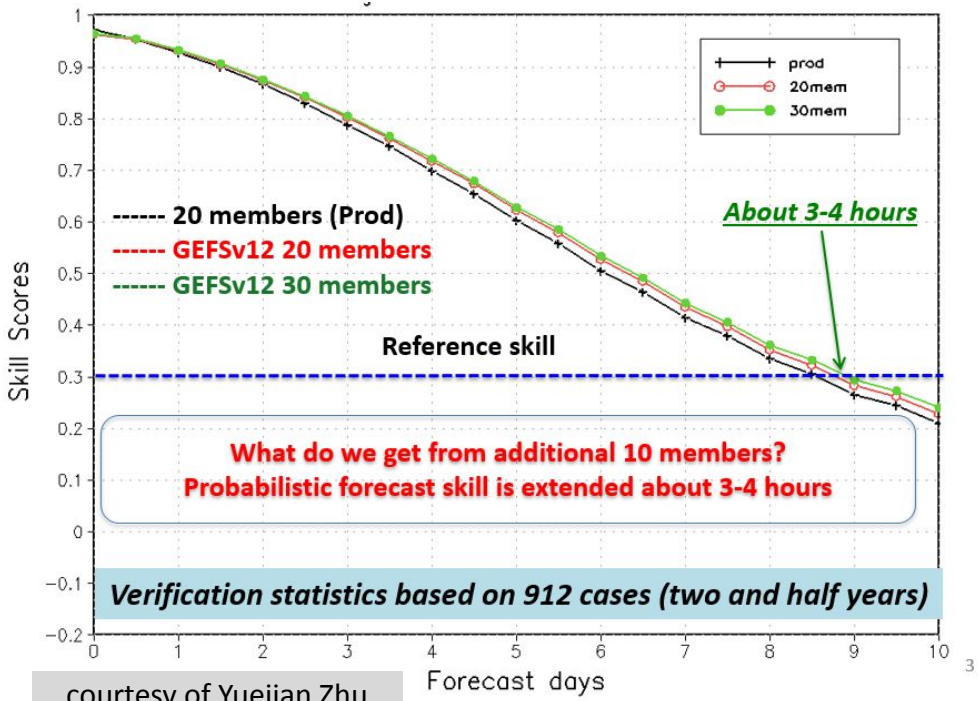
- Goal to align NAEFS with GEFS membership
- “Do no harm” expectation
- Ensure scientific consistency in EMC products

North American Ensemble Forecast System (NAEFS)

– *International project to produce operational multi-center ensemble products*
– *Bias corrects and combines global ensemble forecasts from Canada & USA*
– *Generates probability products for global and regional for weather forecasters, specialized users, and end users*
  – *global forecasts at 0.5 degree, up to 384 hours, 4 times per day*
  – *downscaled products, CONUS(2.5km) and Alaska(3km)*

- NAEFS Milestones
  – First NAEFS implementation – bias correction – IOC, May 30 2006 — Version 1
  – NAEFS follow up implementation – CONUS downscaling - December 4 2007 — Version 2
  – Alaska implementation – Alaska downscaling - December 7 2010 — Version 3
  – CONUS/Alaska new variables expansion – April 8 2014 — Version 4
  – CONUS/Alaska NDGD (2.5km/3km) and expansion – March 29th 2016 — Version 5
  – CMC/GEFS/NAEFS high resolution (0.5 deg) upgrade – July 18 2018 — Version 6
  – GEFS v12 Reforecast bias upgrade – September 23, 2020 — Version 6.1
  – GEFS/NAEFS utilize all 31 GEFS members instead of 21 – Q1 2024 — Version 7

Value Demonstration of GEFS members



courtesy of Yuejian Zhu

Cont. Ranked Prob. Skill Scores of NH 500hPa height

- *GEFSv11 vs. GEFSv12*
- *Raw ensemble forecasts without bias correction*
- *Extend about 3-4 hours skill*

NAEFS v6.1:

- *GEFS: 21 calibrated members*
- *NAEFS: 42 calibrated members(21 GEFS + 21 CMCE)*

NAEFS v7:

- *GEFS: 31 calibrated members*
- *NAEFS: 52 calibrated members (31 GEFS + 21 CMCE)*

- GEFS members increased from 21 to 31 during GEFSv12 upgrade in 2020
- Increasing ensemble size from 20 to 30 leads to significant improvements

Highlights of NAEFS v7 Products and Changes

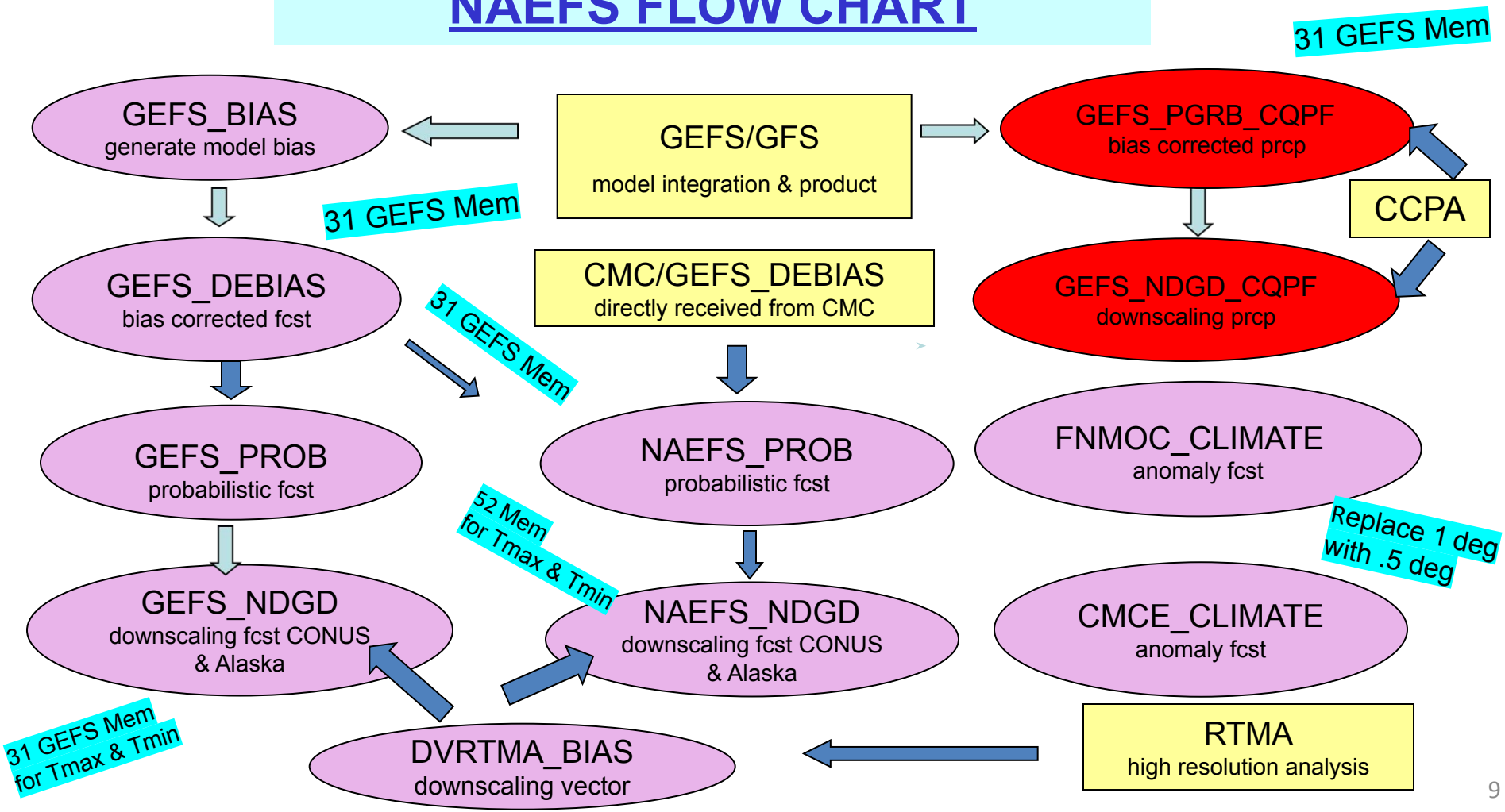
- NCEP GEFS: calibrate 53 variables globally, downscale 10 variables on ndgd
  - Bias correct all 31 GEFS members instead of 21
  - Create GEFS probabilistic forecasts and anomaly forecasts from 31 calibrated members
  - Downscale products (CONUS 2.5km & Alaska 3km) from GEFS probability forecasts

- NAEFS : calibrated 53 variables globally, downscale 10 variables on ndgd
  - Combine 31 GEFS + 21 CMCE calibrated ensembles forecasts
  - Create NAEFS probabilistic forecast and anomaly forecasts from 52 calibrated members
  - Downscaled products (CONUS 2.5km & Alaska 3km) from NAEFS probability forecasts

- NCEP GEFS Precipitation: calibrated and downscaled products
  - Bias correct all 31 GEFS members, 6hr & 24hr accumulated QPFs/PQPFs for CONUS
  - Downscale 31 GEFS bias corrected members, 6hr and 24hr accumulated QPFs/PQPFs for CONUS

- NAVY FNMOC – Fleet Numerical Meteorology and Oceanography Center ensemble
  - Upgrade FNMOC ensemble products from 1 deg to 0.5 deg

NAEFS FLOW CHART



NAEFS Statistical Post-Processing Techniques

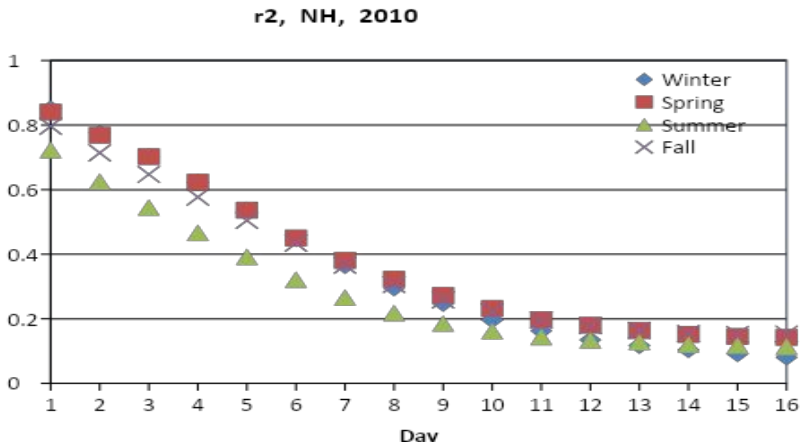
- Bias Correction : remove lead-time dependent bias from GEFS at 0.5 degree grid
  - 51 normal distributed variables: decaying average bias and reforecast bias for each lead time, at each grid point, and each parameter
  - Precipitation: bias from frequency matching and decaying average methods

- Ensemble Combination
  - Adjust CMCE 21 bias corrected ensemble by removing analysis differences
  - Combine NCEP GEFS and CMCE calibrated members

- Downscaling: downscale bias-corrected forecast to finer grid
  - Use RTMA/CCPA as reference
  - 10 surface variables: downscaling vector from accumulated differences between interpolated GDAS and RTMA
  - Precipitation: use CCPA climatology to derive downscaling ratio
  - NDGD resolution, CONUS 2.5km & Alaska 3km
  - No dependence on lead time

NAEFSv7 upgrade from 21 to 31 GEFS members. No science and technique changes.

NAEFS Bias Correction: Reforecast Bias



r could be estimated by linear regression from joint samples, the joint sample mean could be generated from decaying average (*Kalman Filter* average) for easy forward.

Bias corrected forecast: The new (or bias corrected) forecast (***F***) will be generated by applying decaying average bias (***B***) and reforecast bias (***b***) to current raw forecast (***f***) for each lead time, at each grid point, and each parameter.

$$F_{i,j}^{m} = f_{i,j}^{m} + (r_{i,j}^{2} - 1) \cdot b_{i,j} - r_{i,j}^{2} B_{i,j}$$

bias corrected forecast

raw forecast

reforecast bias

decaying average bias

NAEFS Bias Correction: Decaying Average

1). Bias Estimation:

$$b_{i,j}(t) = f_{i,j}(t) - a_{i,j}(t_0)$$

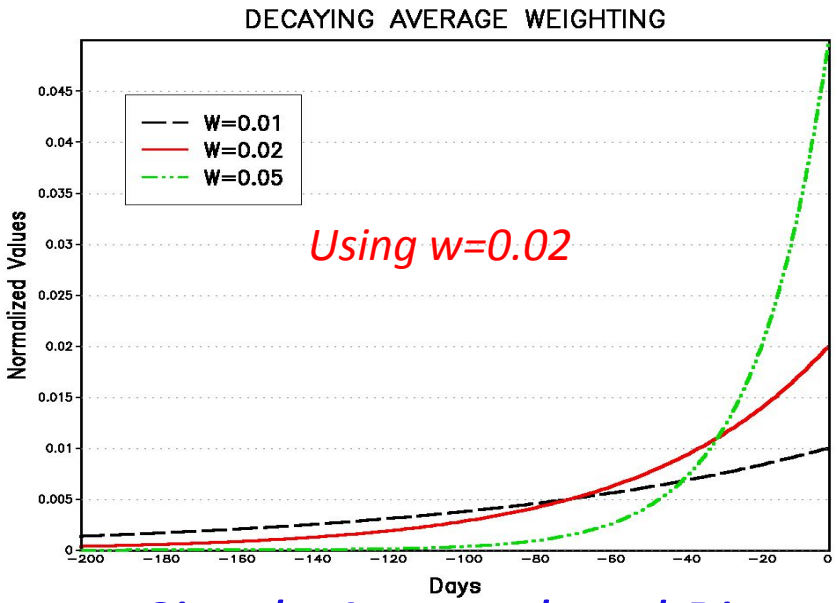
2). Decaying Average (Kalman Filter method)

$$B_{i,j}(t) = (1-w)\cdot B_{i,j}(t-1) + w\cdot b_{i,j}(t)$$

3). Decaying Weight: w =0.02 in GEFS bias correction (~ past 50-60 days information)

4). Bias corrected forecast:

$$F_{i,j}(t) = f_{i,j}(t) - B_{i,j}(t)$$



Simple Accumulated Bias

Assumption: Forecast and analysis (or observation) is fully correlated

NAEFS Bias Corrected Fields & Probability Forecasts

Variables	Level	Total 51
GHT	10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	10
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
PRES	Surface	1
PRMSL	Pressure Reduced to MSL	1
VVEL	850 hPa	1
Td	2m	1
RH	2m	1
WIND	10 m wind speed	1

GEFS & NAEFS probability forecasts are based on bias corrected ensemble. Products include ensemble mean, spread, mode, 10, 50 and 90 percentage probability forecasts.

NAEFS Downscaling Parameters and Products

Variables	Domains	Resolutions	Total 10/10
Surface Pressure	CONUS/Alaska	2.5km/3km	1/1
2-m temperature	CONUS/Alaska	2.5km/3km	1/1
10-m U component	CONUS/Alaska	2.5km/3km	1/1
10-m V component	CONUS/Alaska	2.5km/3km	1/1
2-m maximum T	CONUS/Alaska	2.5km/3km	1/1
2-m minimum T	CONUS/Alaska	2.5km/3km	1/1
10-m wind speed	CONUS/Alaska	2.5km/3km	1/1
10-m wind direction	CONUS/Alaska	2.5km/3km	1/1
2-m dew-point T	CONUS/Alaska	2.5km/3km	1/1
2-m relative humidity	CONUS/Alaska	2.5km/3km	1/1

GEFS/NAEFS downscaled products

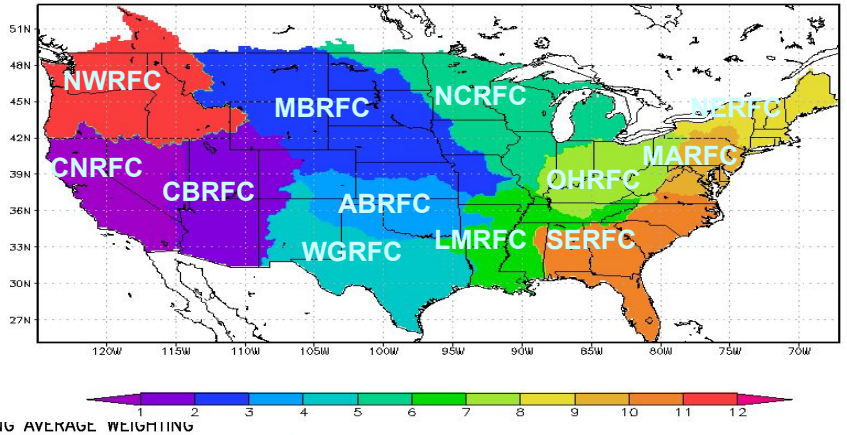
- Created from 0.5 degree GEFS and NAEFS probabilistic forecasts
- Products include ensemble mean, spread, mode, 10, 50, 90 percentage probability forecasts

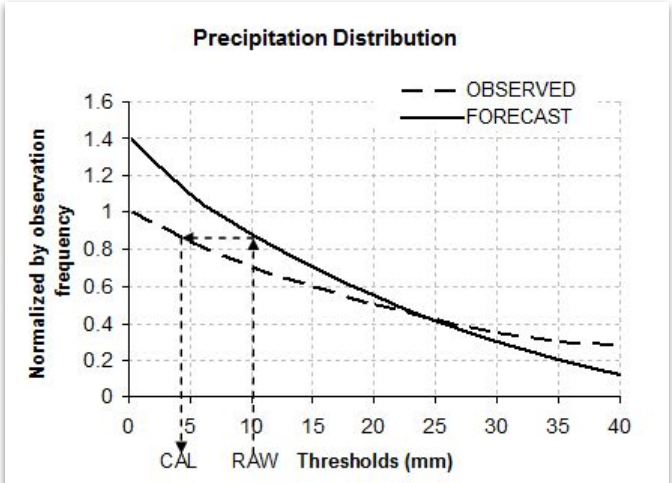
GEFS Precipitation Calibration: Frequency Matching Method

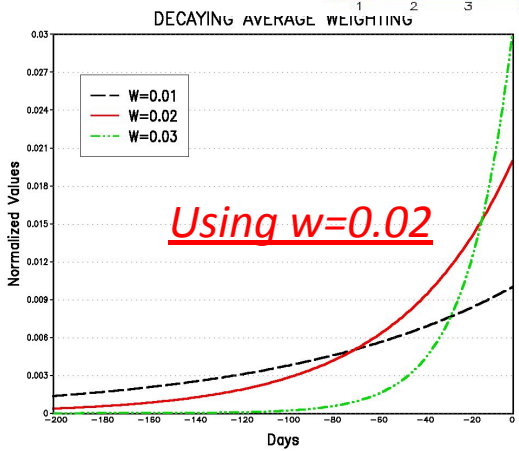
Calculate for Obs and Fcst respectively

$$\overline{CDF}_j = (1-W) * \overline{CDF}_{j-1} + W * CDF_j$$

CDF is cumulative distribution function over a given domain with value exceed a threshold. W weight to accumulate CDF



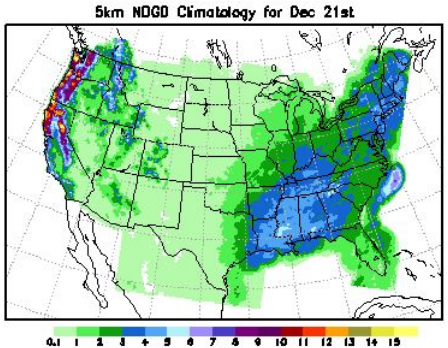




Frequency matching and decaying average method

GEFS Precipitation Downscaling Methodology

QPE_H



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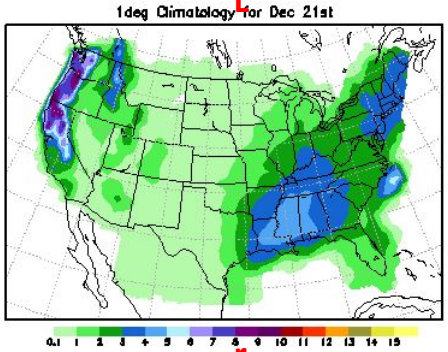
QPE_L



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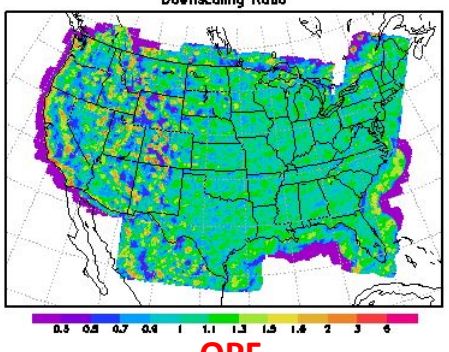
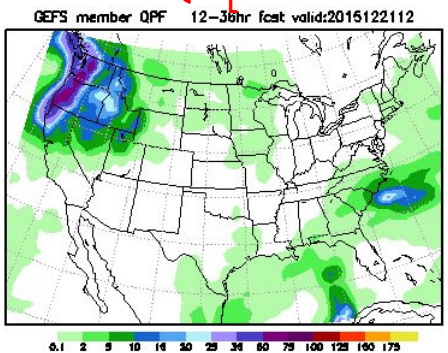
$r=QPE_H/QPE_L$



QPF_L



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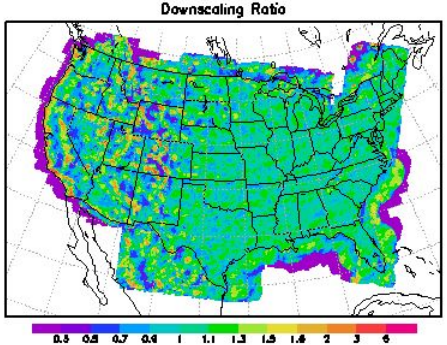

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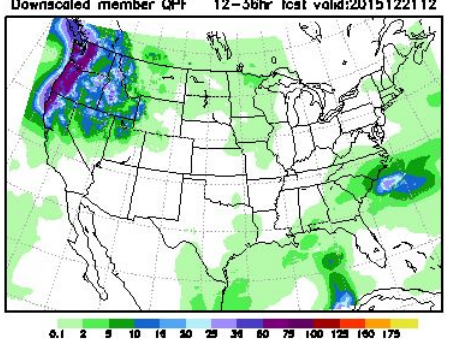
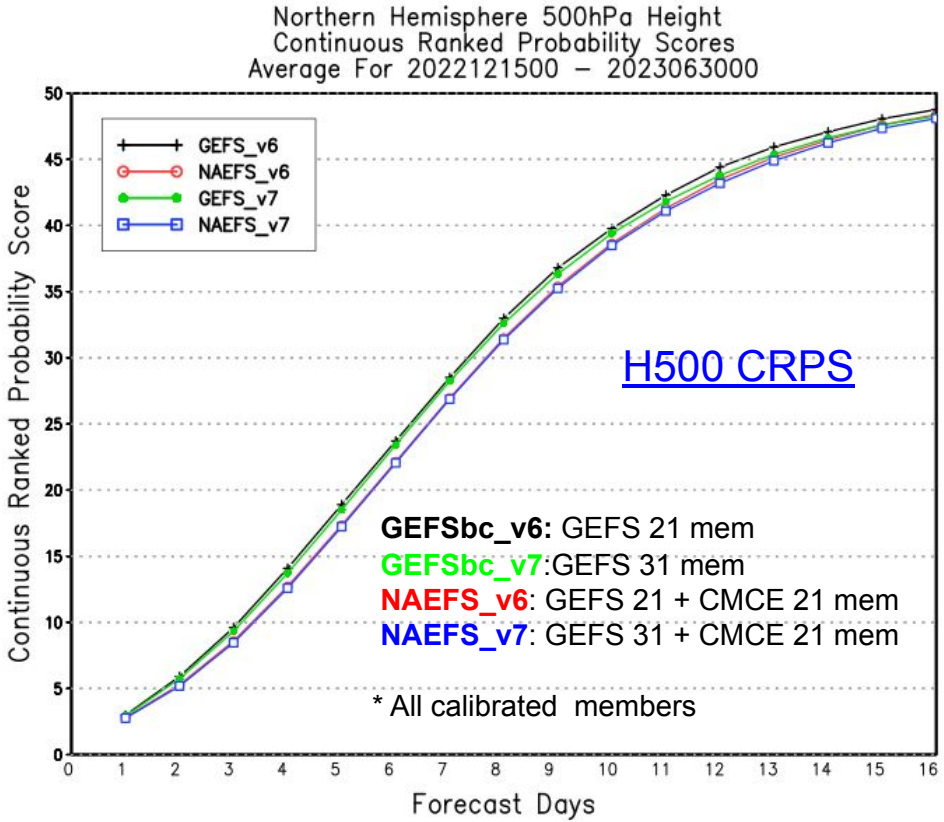
QPF_H



To avoid CONUS border issue (purple in r map), there is no downscaling outside of CONUS.

To avoid extreme outliers, r is bounded: $0.3 < r < 5$ (cold seasons); $0.9 < r < 5$ (warm seasons).

Value Demonstration of 31 GEFS Calibrated Members



Bias Corrected Forecast

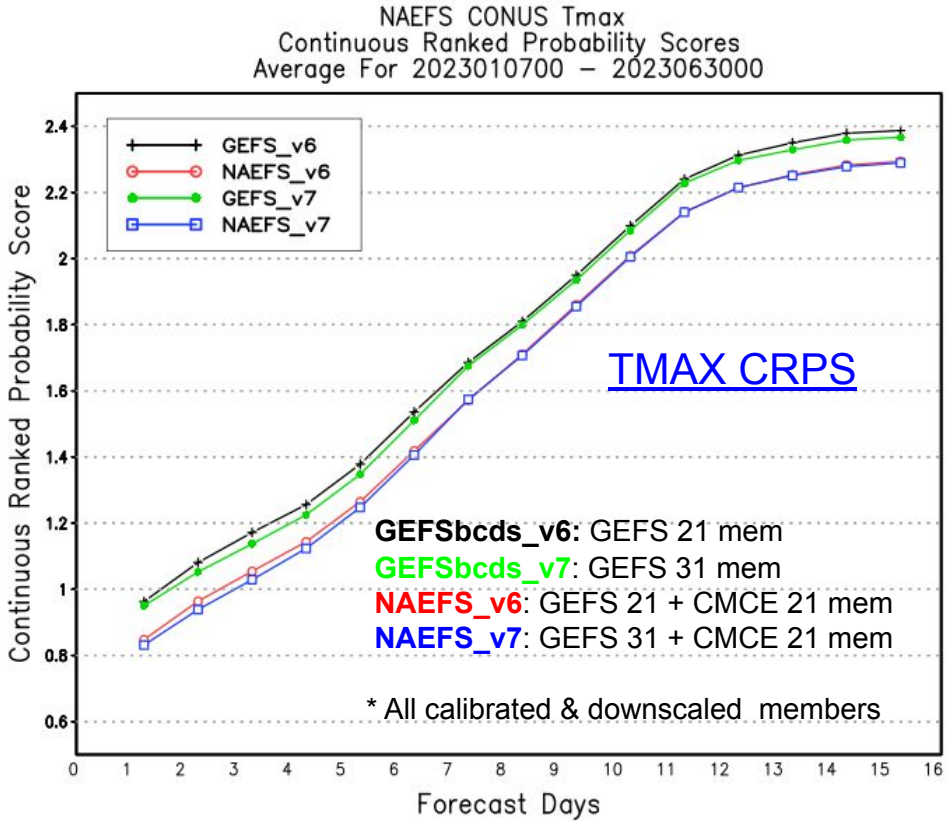
Continuous Ranked Probability Score

CRPS measures the reliability and resolution (the lower the CRPS, the better)

- GEFSbc with 31 members performed better than 21 members from Days 1-16
- NAEFSv6 and NAEFSv7 are better than individual GEFS ensemble
- NAEFSv7 and NAEFSv6 were very similar at Days 1–11; NAEFSv7 are slightly better at Days 12-16

Verification statistics based on 198 cases

Value Demonstration of 31 GEFS Calibrated Members



Bias Corrected and Downscaled Forecast

- Tmax: pick up the maximum value from bias corrected & downscaled forecasts

Continuous Ranked Probability Score

- GEFS with 31 members performed notably better than 21 members for all lead time
- NAEFSv7 performed better at Days 1-7. NAEFSv7 and NAEFSv6 were very similar at Days 8–16

Verification statistics based on 175 cases

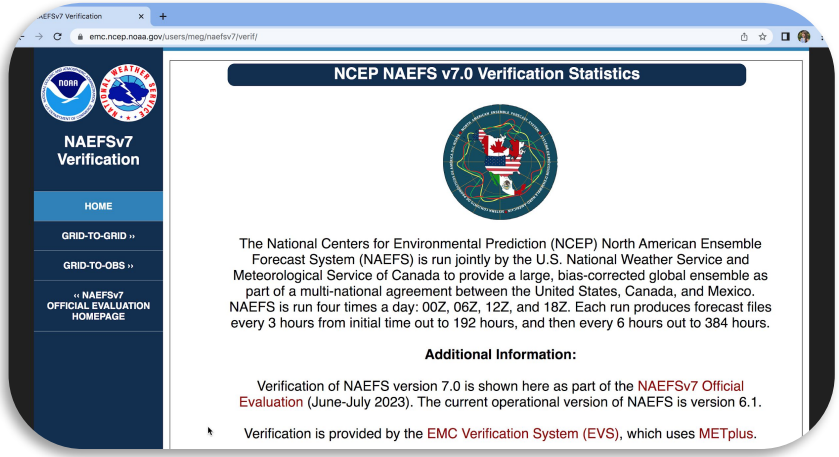
NAEFSv7 Field Evaluation

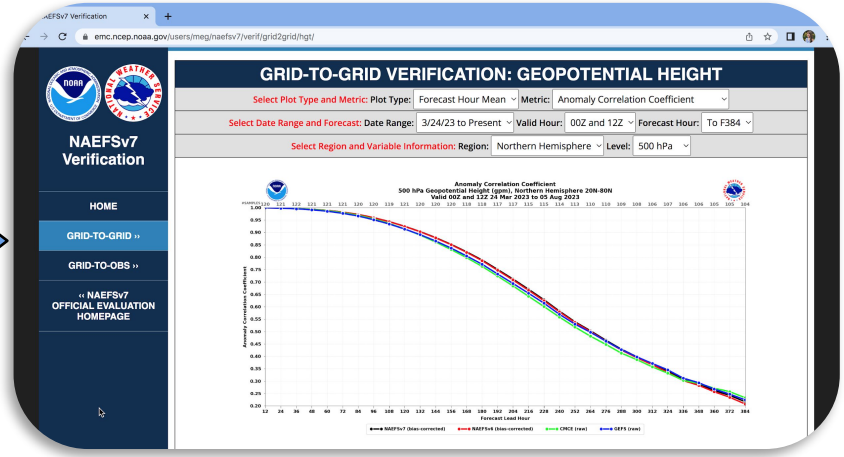
- Assess the statistical performance of the NAEFSv7 parallel
- Provide a few examples of bias-corrected precipitation forecasts
- Review the comments and recommendations from NWS Centers/Regions

NAEFSv7 Official Evaluation Webpage
https://www.emc.ncep.noaa.gov/users/meg/naefsv7

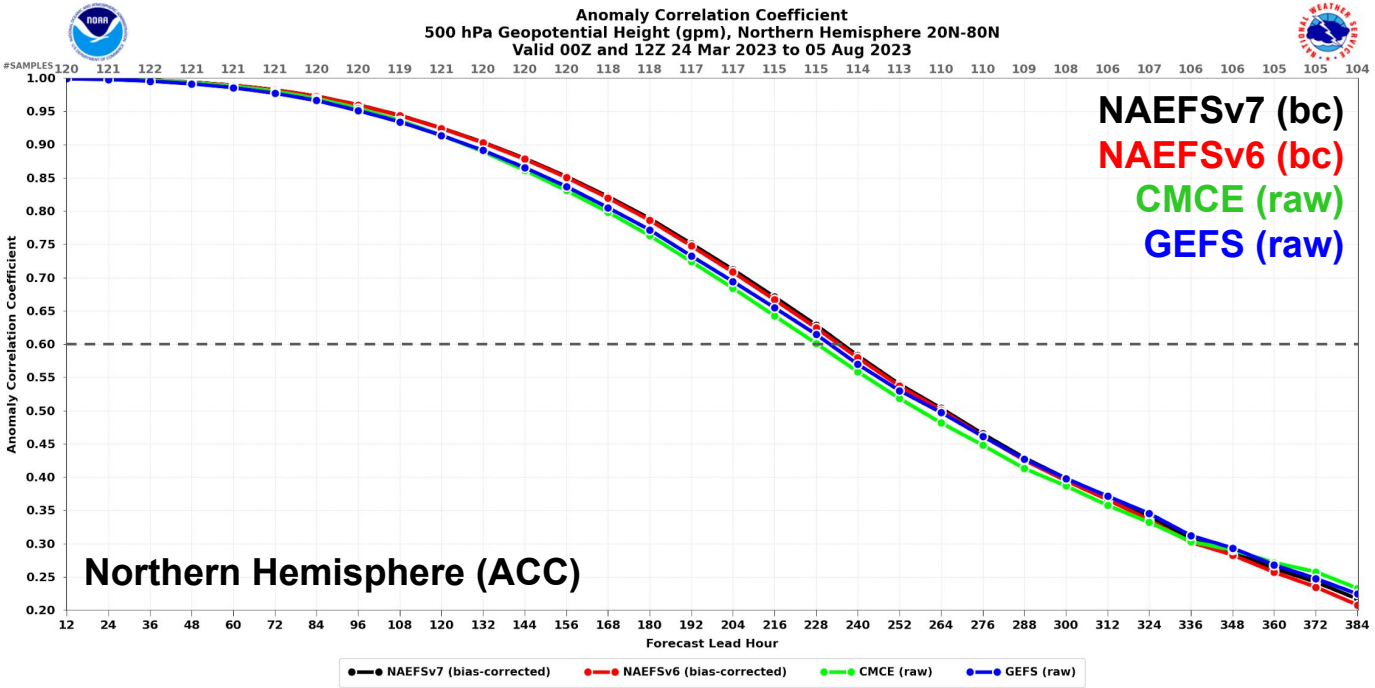
Statistical Performance of NAEFSv7 Parallel

- Statistics and verification graphics for the NAEFSv7 Official Evaluation were produced using the METplus-based EMC Verification System (EVS)
- Verification graphics showing the NAEFSv7 parallel, NAEFSv6, GEFS, and CMCE during 3/24/23–8/5/23 can be found on the [NAEFSv7 verification webpage]



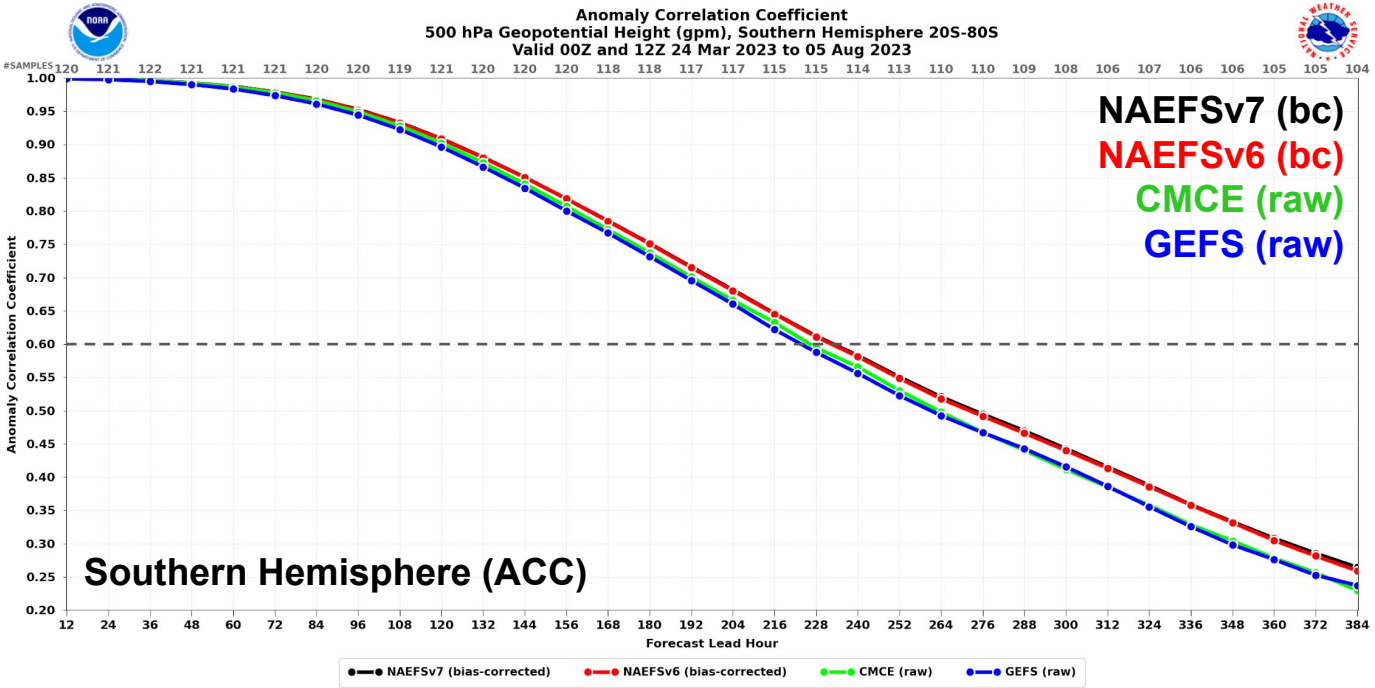


NAEFSv7: 500-hPa Geopotential Height



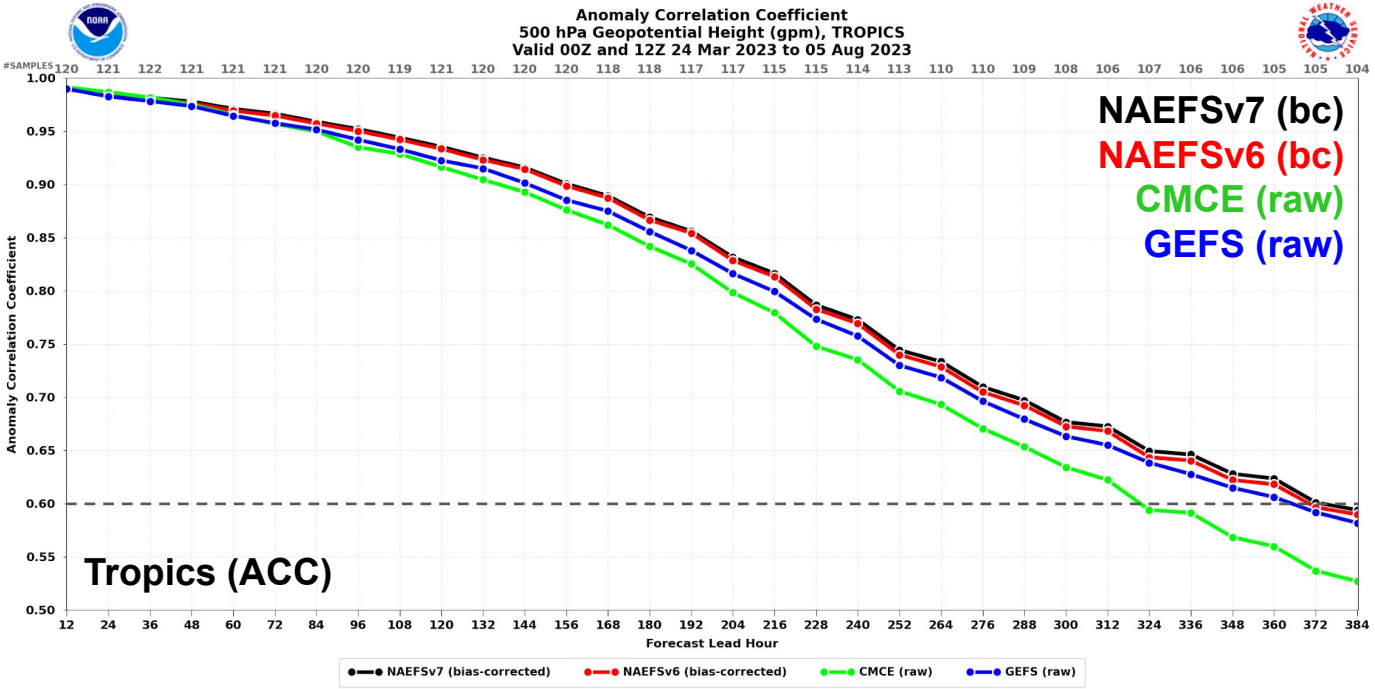
- **NAEFSv7** and **NAEFSv6** were very similar at Days 1–6; **NAEFSv7** had slightly higher ACC at Days 7–11
- Bias-corrected **NAEFSv7** performed better than its raw **GEFS** and **CMCE** inputs (benefit of bias-correction)
- **NAEFSv7** had “useful skill” (i.e., ACC score ≥ 0.6) for the longest of the models compared (out to ~9.83 days)

NAEFSv7: 500-hPa Geopotential Height



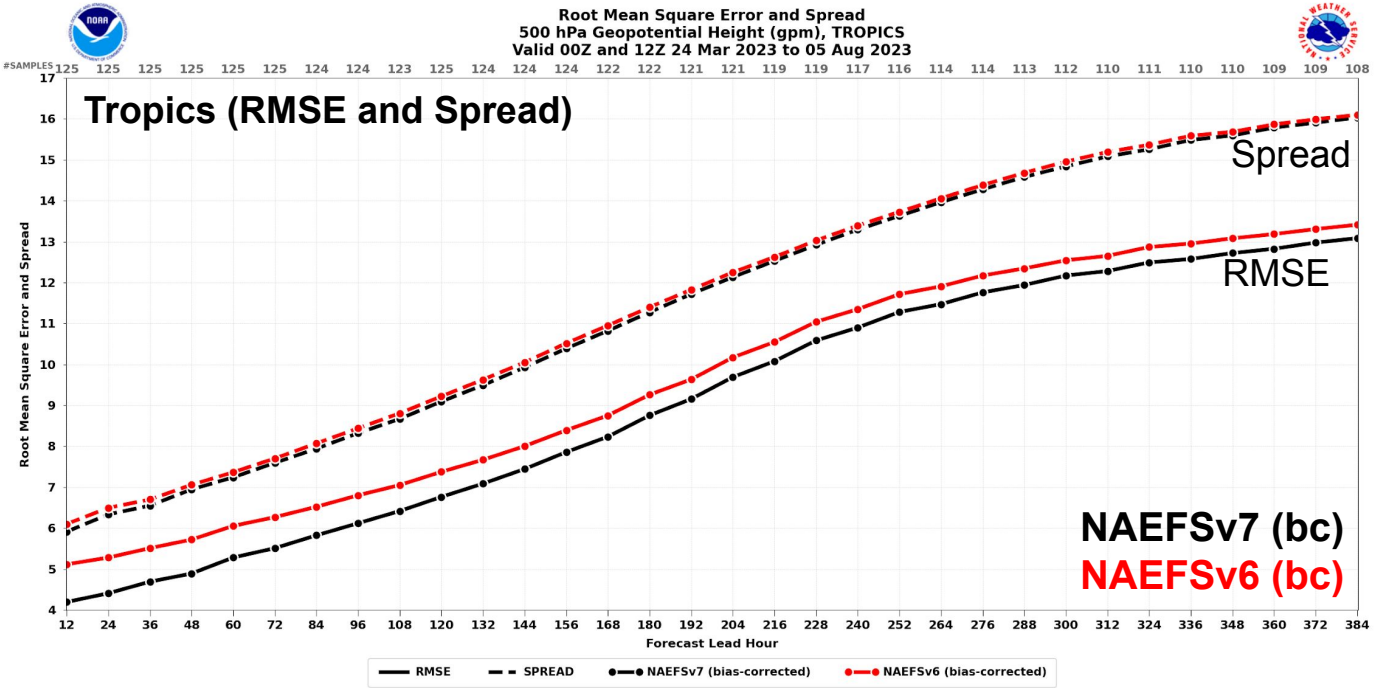
- **NAEFSv7** and **NAEFSv6** were very similar at Days 1–10; **NAEFSv7** had slightly higher ACC at Days 11–13
- Bias-corrected **NAEFSv7** performed better than its raw **GEFS** and **CMCE** inputs (benefit of bias-correction)
- **NAEFSv7** had “useful skill” (i.e., ACC score ≥ 0.6) for slightly longer than **NAEFSv6** (out to ~9.75 days)

NAEFSv7: 500-hPa Geopotential Height



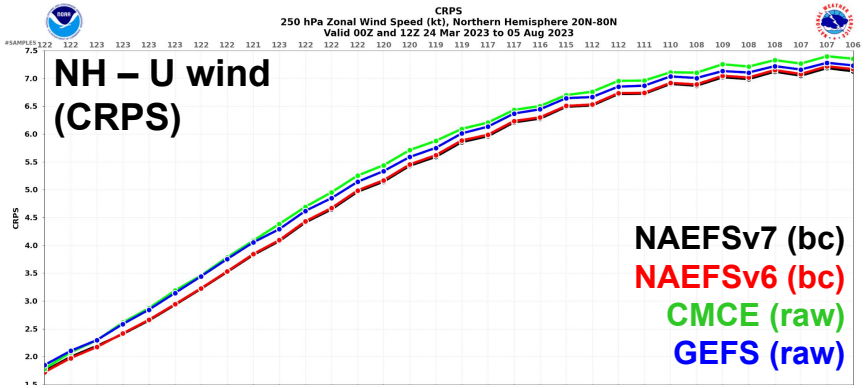
- **NAEFSv7** had slightly higher ACC than **NAEFSv6** in the tropics at almost all forecast lead times (Days 1–16)
- Bias-corrected **NAEFSv7** performed better than its raw **GEFS** and **CMCE** inputs (benefit of bias-correction)

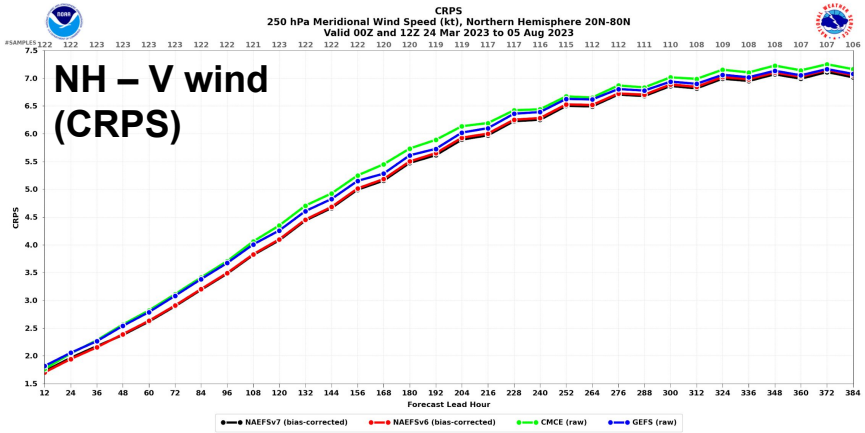
NAEFSv7: 500-hPa Geopotential Height



- **NAEFSv7** had slightly higher ACC than **NAEFSv6** in the tropics at almost all forecast lead times (Days 1–16)
- Bias-corrected **NAEFSv7** performed better than its raw **GEFS** and **CMCE** inputs (benefit of bias-correction)
- **NAEFSv7** had lower RMSE than **NAEFSv6** and very similar ensemble spread at all forecast lead times

NAEFSv7: 250-hPa U and V Winds

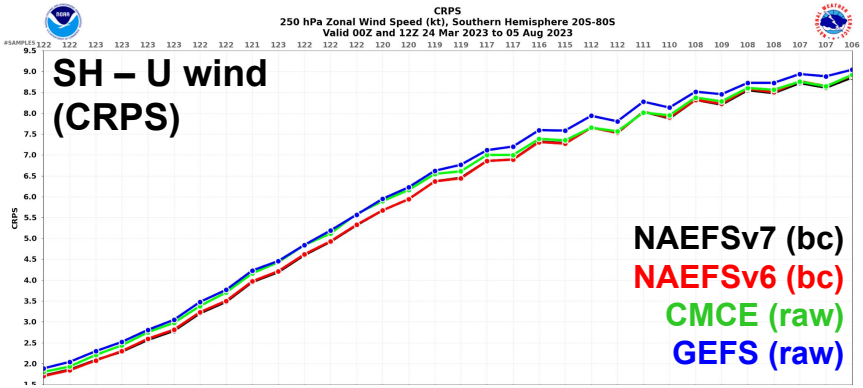


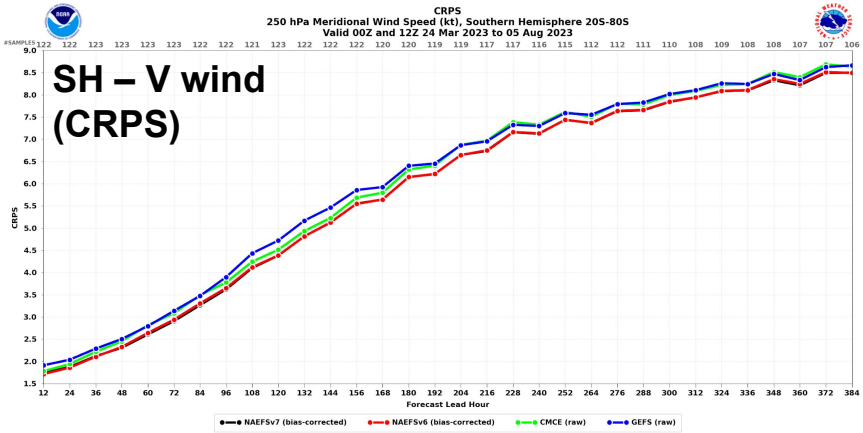


- *Continuous Ranked Probability Score (CRPS) measures the accuracy of a set of probabilistic forecasts (the lower the CRPS, the better)*

- **NAEFSv7** had slightly lower CRPS than **NAEFSv6** in the Northern Hemisphere (NH), and both have lower CRPS than raw inputs (**GEFS**/**CMCE**)

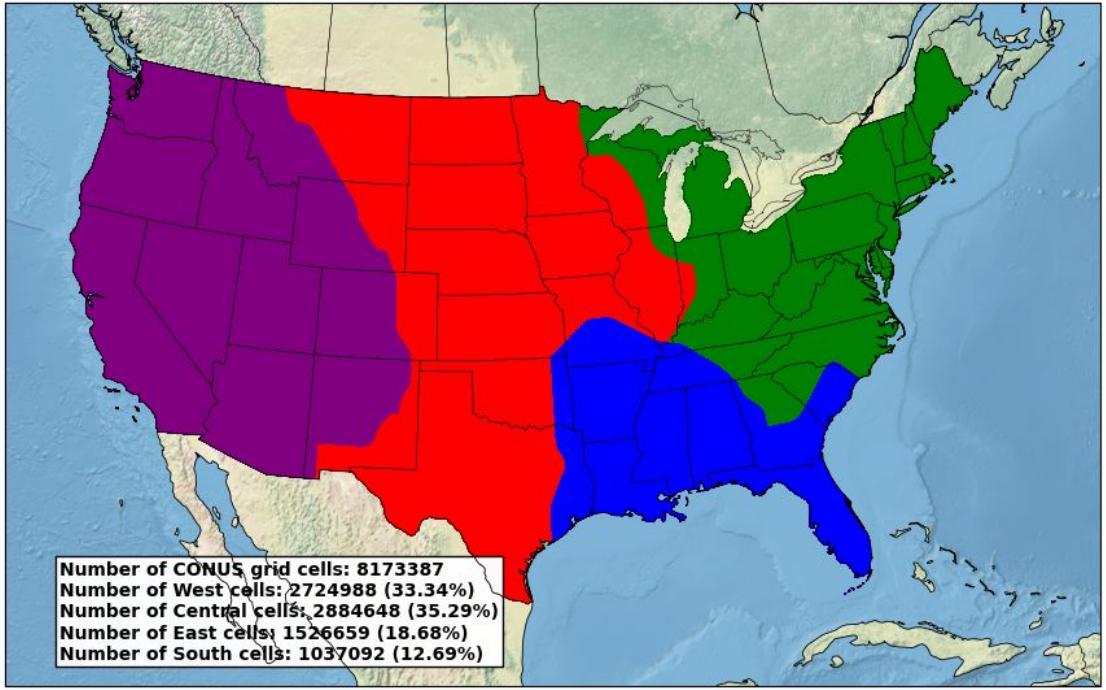
NAEFSv7: 250-hPa U and V Winds





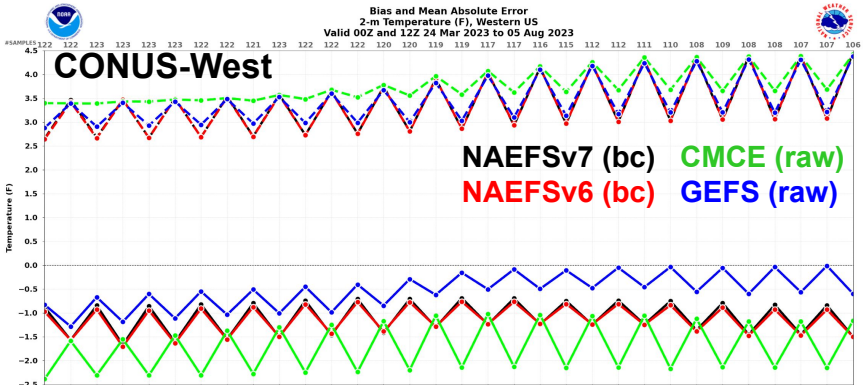
- *Continuous Ranked Probability Score (CRPS) measures the accuracy of a set of probabilistic forecasts (the lower the CRPS, the better)*
- **NAEFSv7** had slightly lower CRPS than **NAEFSv6** in the Northern Hemisphere (NH), and both have lower CRPS than raw inputs (**GEFS**/**CMCE**)
- **NAEFSv7** and **NAEFSv6** had very similar CRPS in the Southern Hemisphere (SH)
- **NAEFSv7** and **NAEFSv6** had very similar CRPS in the Tropics as well (not shown)

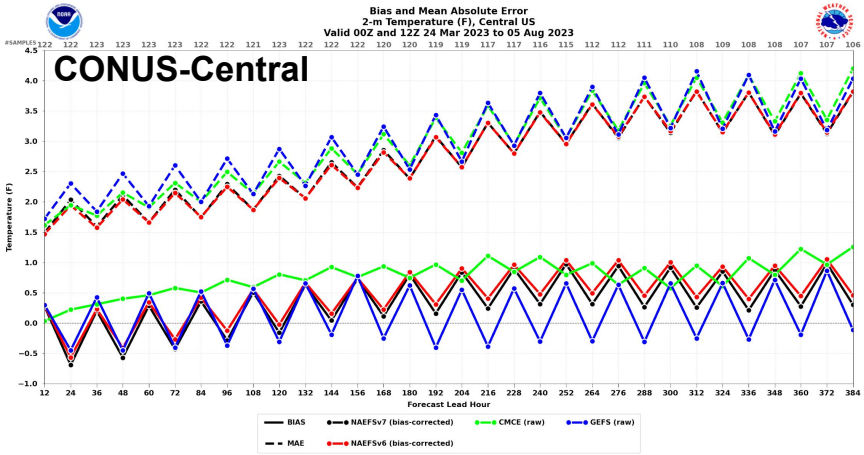
NAEFSv7: 2-m Temp. and 10-m U/V Winds



- A meaningful examination of near-surface parameters (e.g., 2-m temperature, 10-m wind) requires that the CONUS be separated into four sub-regions (West, Central, East, and South) and that Alaska is its own region
- The plot above shows the four CONUS sub-regions, created by combining similar Bukovsky Regions (see link)

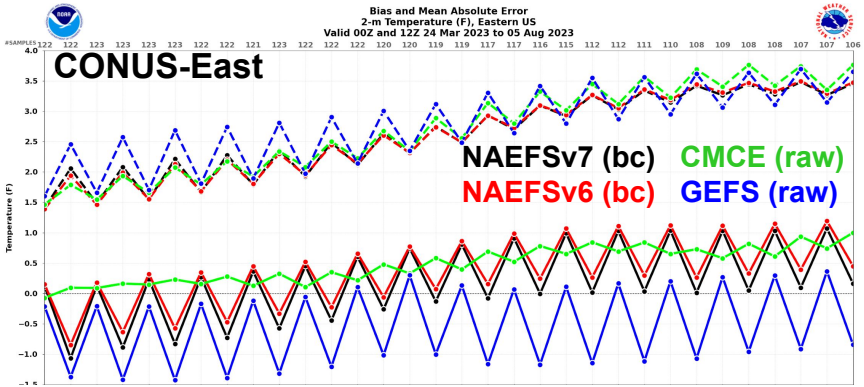
NAEFSv7: 2-m Temperature

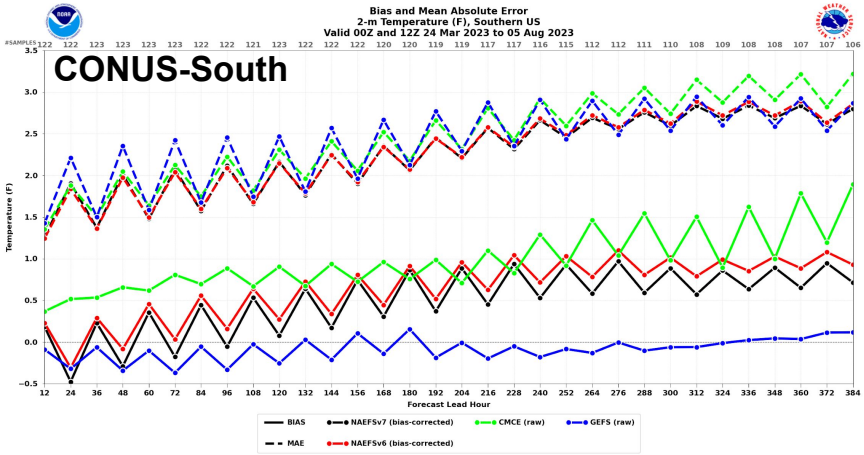




- **NAEFSv7** had a comparable cold bias to **NAEFSv6** over CONUS-West at all lead times
- **NAEFSv7** had slightly less of a warm bias than **NAEFSv6** over CONUS-Central at Days 5–16

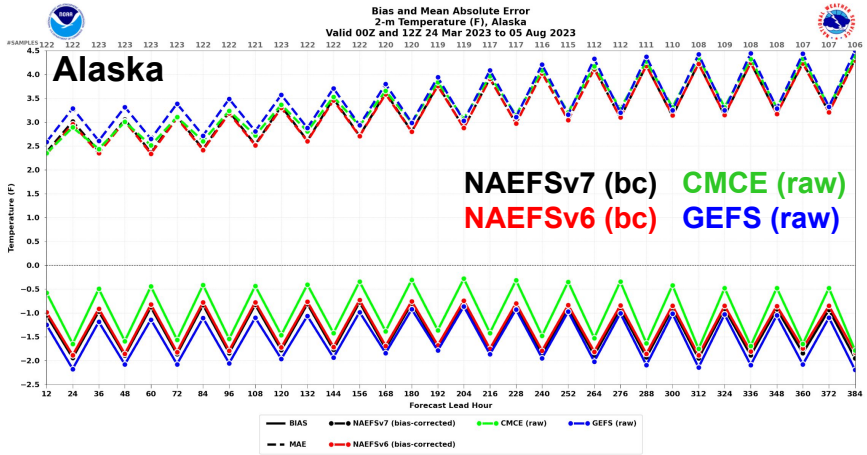
NAEFSv7: 2-m Temperature





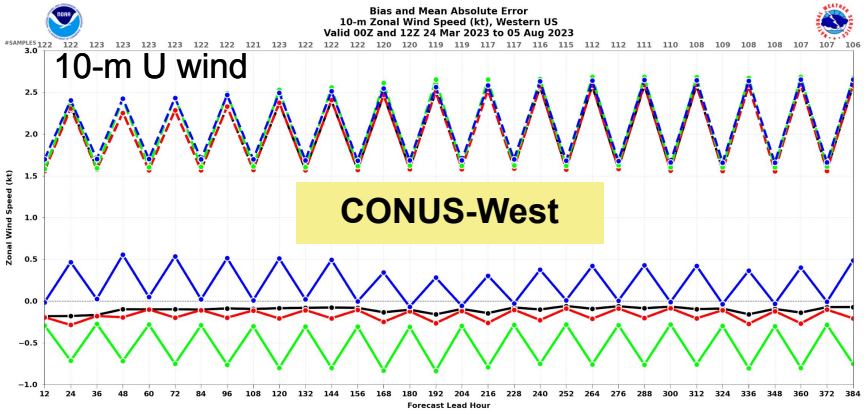
- **NAEFSv7** had a comparable cold bias to **NAEFSv6** over CONUS-West at all lead times
- **NAEFSv7** had slightly less of a warm bias than **NAEFSv6** over CONUS-Central at Days 5–16
- **NAEFSv7** had slightly more of a cold bias than **NAEFSv6** over CONUS-East at Days 1–4 and slightly less of a warm bias at Days 8–16
- **NAEFSv7** had slightly less of a warm bias than **NAEFSv6** over CONUS-South at Days 4–16

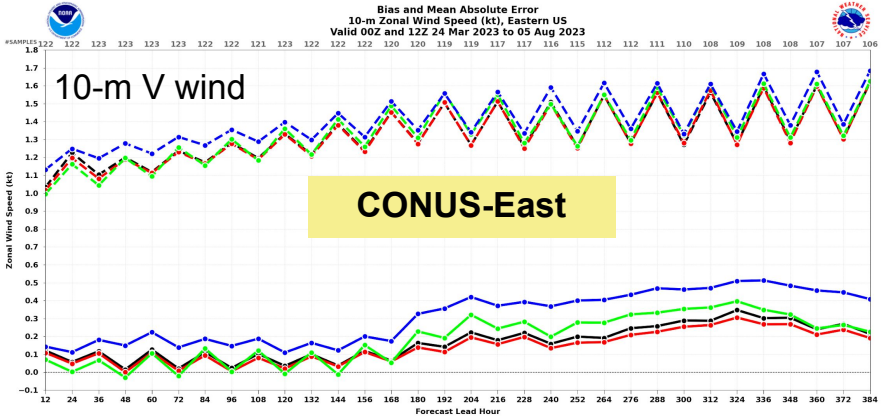
NAEFSv7: 2-m Temperature



- **NAEFSv7** had a comparable cold bias to **NAEFSv6** over CONUS-West at all lead times
- **NAEFSv7** had slightly less of a warm bias than **NAEFSv6** over CONUS-Central at Days 5–16
- **NAEFSv7** had slightly more of a cold bias than **NAEFSv6** over CONUS-East at Days 1–4 and slightly less of a warm bias at Days 8–16
- **NAEFSv7** had slightly less of a warm bias than **NAEFSv6** over CONUS-South at Days 4–16
- **NAEFSv7** had a comparable cold bias to **NAEFSv6** over Alaska at all lead times

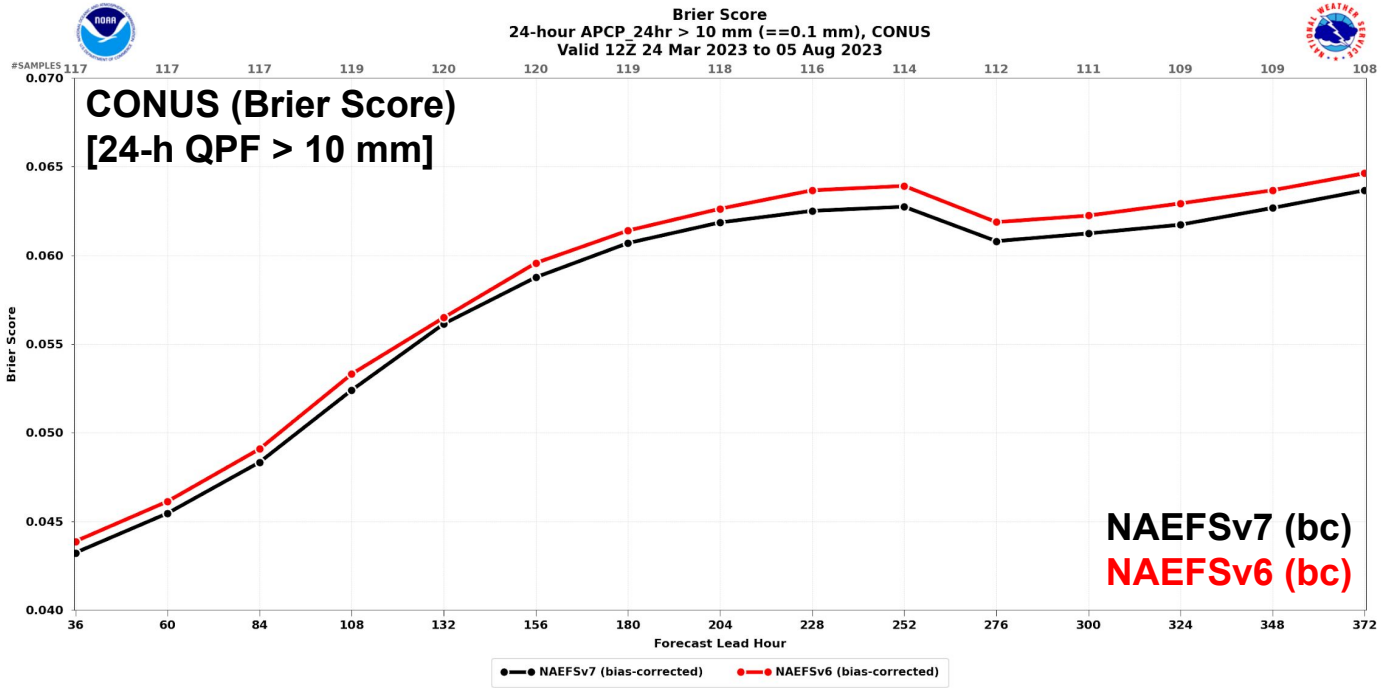
NAEFSv7: 10-m U and V Winds





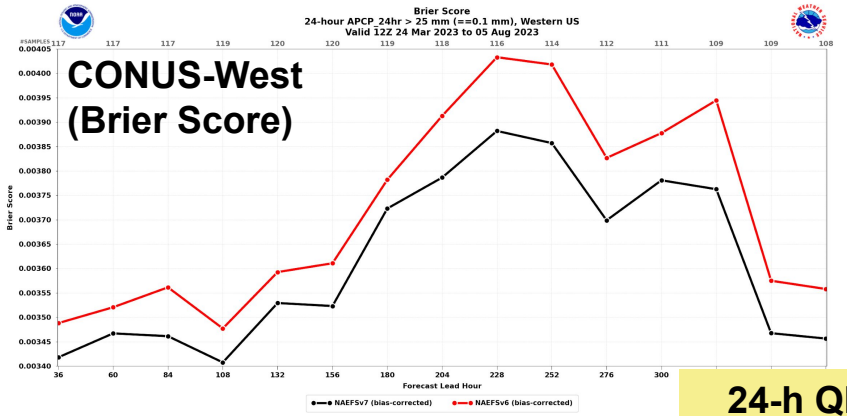
- **NAEFSv7** had slightly less of a low 10-m U wind-speed bias than **NAEFSv6** and a comparable high 10-m V wind-speed bias over CONUS-West at all lead times
- **NAEFSv7** had comparable 10-m U and V wind-speed biases to **NAEFSv6** over CONUS-Central at all lead times (no 10-m U wind-speed bias and high V wind-speed bias)
- **NAEFSv7** had slightly more of a high 10-m U wind-speed bias than **NAEFSv6** at Days 7–16 and a comparable high 10-m V wind-speed bias over CONUS-East at Days 1–16
- **NAEFSv7** had comparable high 10-m U and V wind-speed biases to **NAEFSv6** over CONUS-South at all lead times
- **NAEFSv7** had comparable 10-m U and V wind-speed biases to **NAEFSv6** over Alaska at all lead times

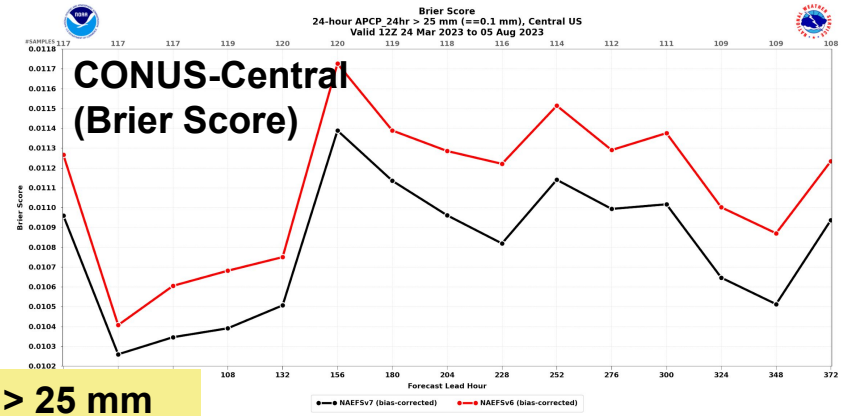
NAEFSv7: Precipitation



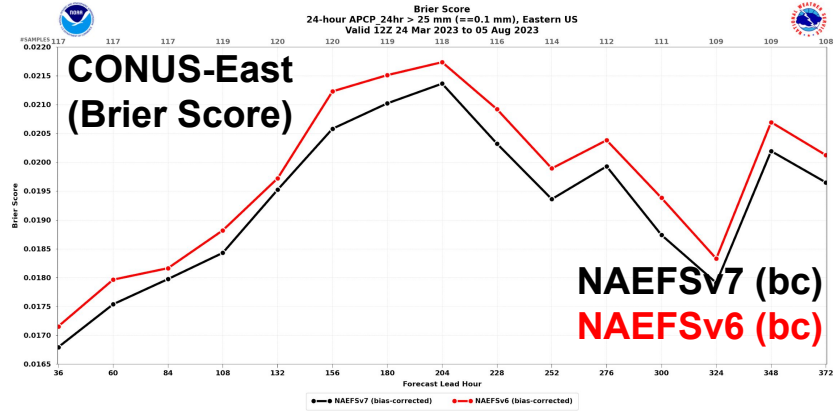
- Of the parameters evaluated, bias-corrected 24-h precipitation showed the most improvement in **NAEFSv7**
- Brier Scores for various 24-h QPF thresholds (>1, 5, 10, 25, 50 mm) were notably better in **NAEFSv7**
- Brier Scores were also notably better in **NAEFSv7** in all four CONUS sub-regions (West, Central, East, South)

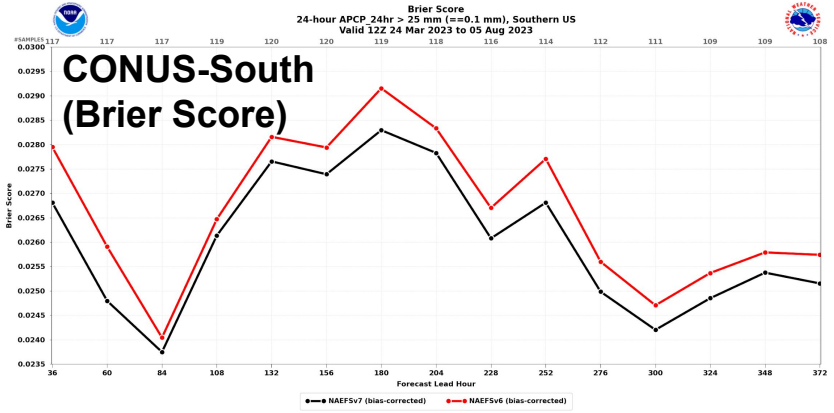
NAEFSv7: Precipitation



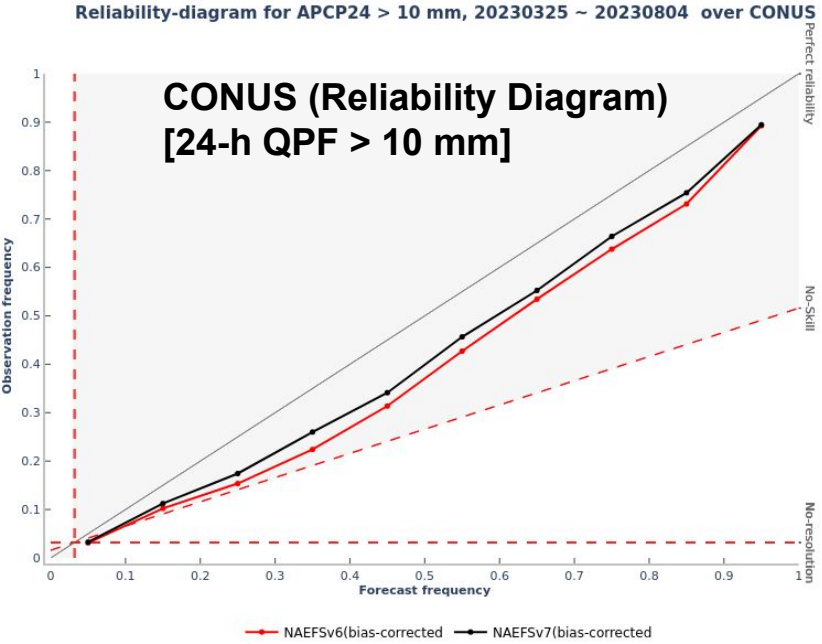


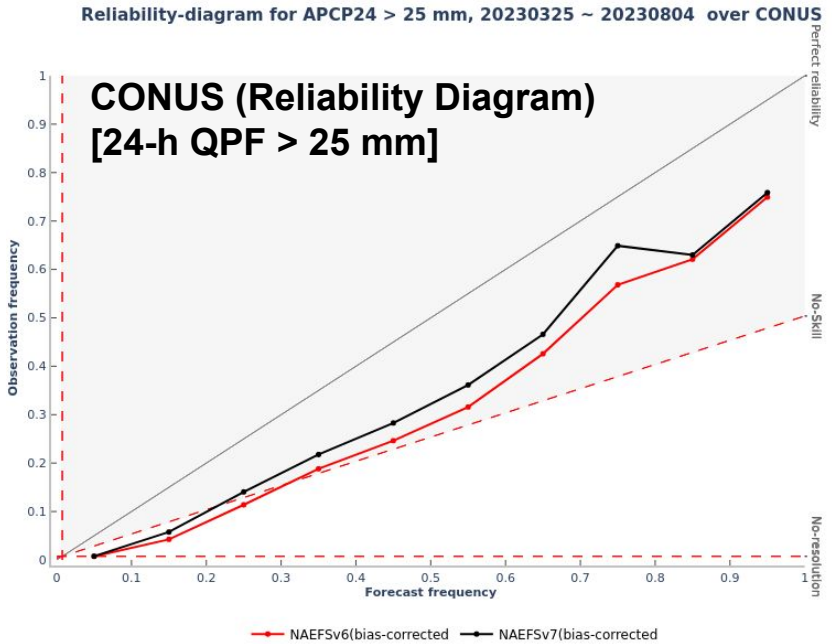
24-h QPF > 25 mm





NAEFSv7: Precipitation

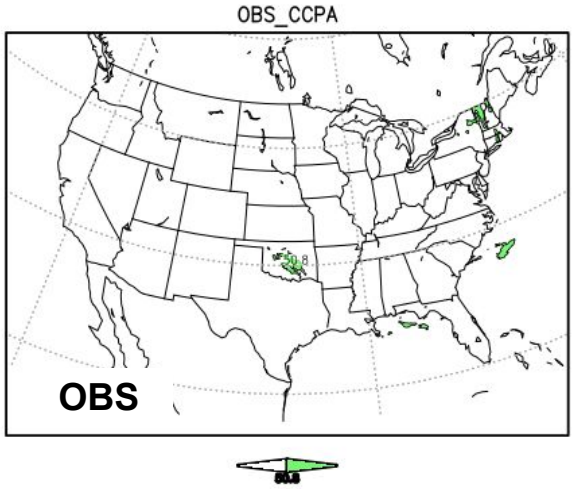


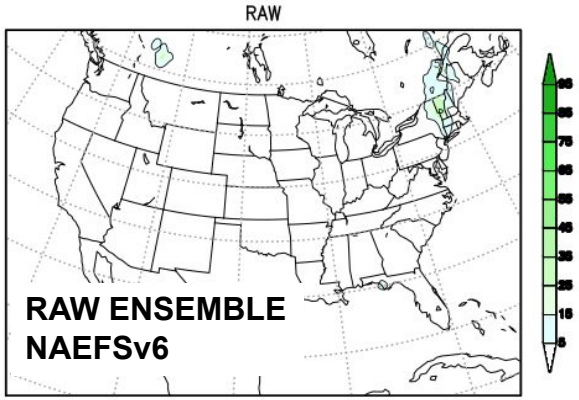


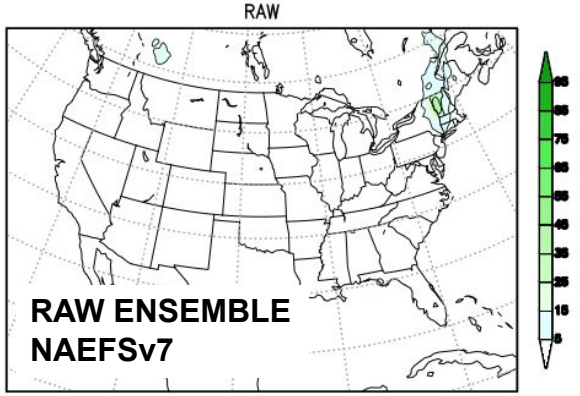
- Reliability Diagrams of 24-h QPF at different thresholds (>1, >5, >10, >25, >50 mm) all showed improvement in **NAEFSv7**, where improvement is indicated by a line being closer to the diagonal “perfect reliability line”
- **NAEFSv7** bias-corrected 24-h QPF even had some skill at >50 mm, whereas **NAEFSv6** did not (not shown)

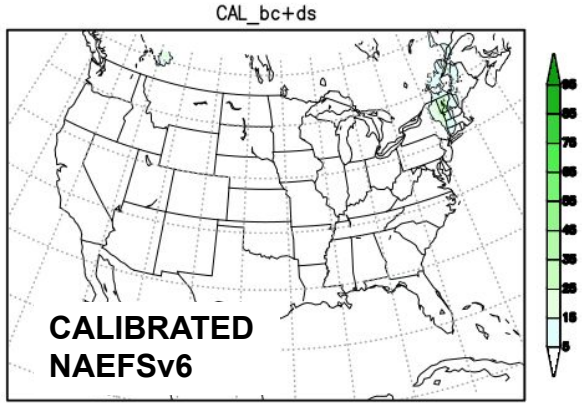
QPF Case Example: VT Flooding

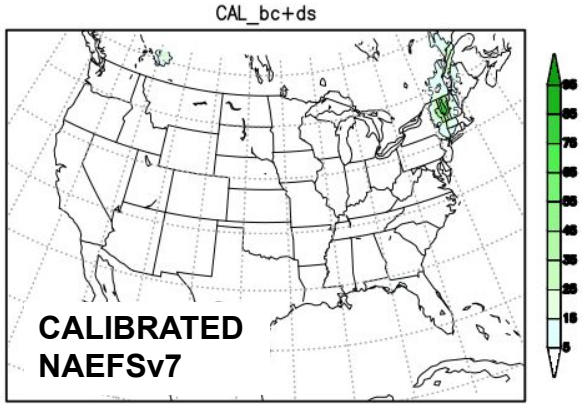
DAY 2–3 PROB of 24h QPF > 2”





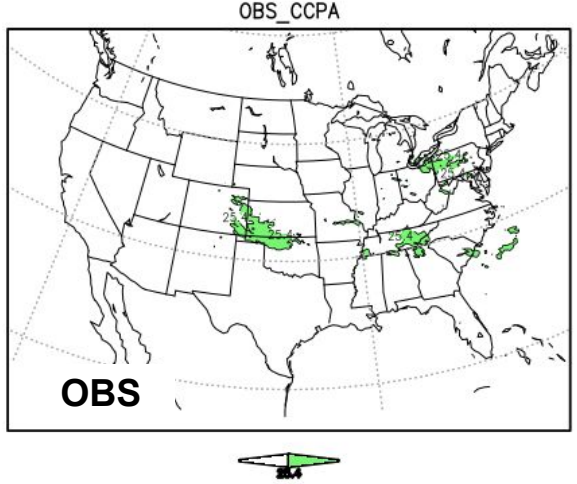


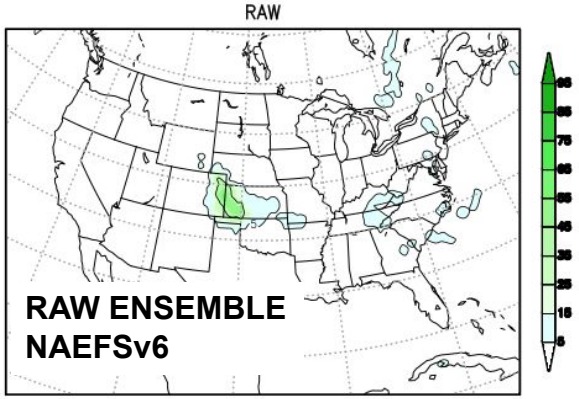


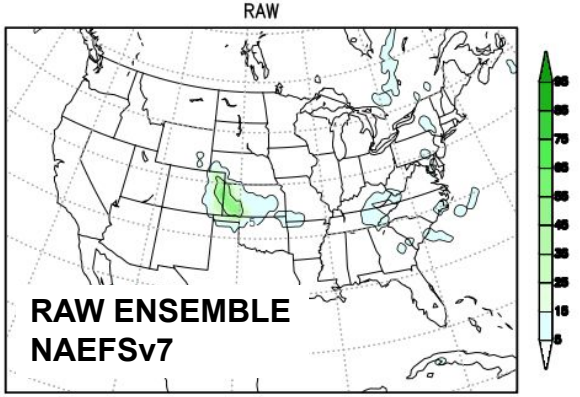


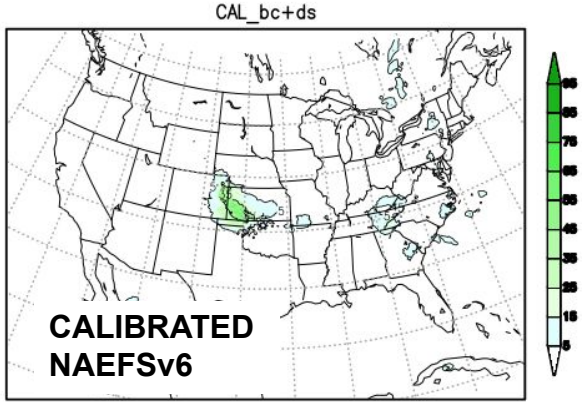
QPF Case Example: High Plains MCS

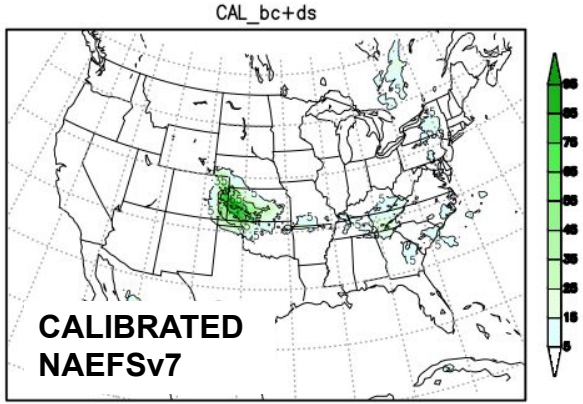
DAY 3–4 PROB of 24h QPF > 1”











NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Summary of NAEFSv7 Verification Statistics

Parameter	Remarks (Improvement / Neutral / Degradation)
500-hPa Geo. Height	Comparable in the NH and SH; slight improvement in the tropics at all forecast lead times
1000-hPa Geo. Height	Slight improvement in the NH in the short range; comparable in the SH; slight improvement in the tropics at all forecast lead times
250-hPa U/V Winds	Slight improvement in the NH at all lead times; comparable in the SH and tropics
850-hPa U/V Winds	Slight improvement in the NH at all lead times; comparable in the SH; slight improvement in U wind in the tropics with comparable V wind
850-hPa Temperature	Slight improvement in the NH warm bias at all lead times; slightly larger cold bias in the SH; comparable in the tropics
2-m Temperature	Comparable over CONUS-West and Alaska; slight decrease in the warm bias over CONUS-Central/East/South at longer lead times; slight increase in the cold bias over CONUS-East at shorter lead times
10-m U/V Winds	Comparable over CONUS-Central, CONUS-South, and Alaska; slight improvement in U wind low bias over CONUS-West; slight increase U wind high bias over CONUS-East
24-h Precipitation	**Improvement over all CONUS sub-regions and thresholds,** modest skill at >50 mm; comparable frequency bias for most CONUS sub-regions

NAEFSv7 Field Evaluation

- Assess the statistical performance of the NAEFSv7 parallel
- Provide a few examples of bias-corrected precipitation forecasts
- Review the comments and recommendations from NWS Centers/Regions

NAEFSv7 Official Evaluation Webpage
https://www.emc.ncep.noaa.gov/users/meg/naefsv7

NAEFSv7 Field Evaluation

Information that users were asked to provide:

- What are your overall impressions of NAEFSv7 relative to NAEFSv6?
- What is your recommendation?

The questions were kept simple due to the limited scope of the proposed upgrade.

Evaluations were requested from each NWS Region, as well as WPC and CPC. Eastern Region and CPC were unable to participate due to resource limitations.

NWS Southern Region

- Reliability for very light QPF is slightly worse in the CONUS-South in NAEFSv7
- Overall, though, it seemed like the QPF was slightly improved in NAEFSv7
- Bigger diurnal swings in 2m temperature ACC in the South compared to some other regions, but this is similar to NAEFSv6
- Would have liked to have seen forecast images
- **Supports implementation of NAEFSv7**

NCEP Weather Prediction Center (WPC)

- Differences in the stats between NAEFSv6 and NAEFSv7 were overall minor
  - Biggest differences were in QPF
- Noted some improvement in 500-hPa ACC over the Tropics, as well as lower RMSE
- Better reliability and Brier Score in NAEFSv7 for 24-h QPF for 5, 10, 25 mm thresholds
- Some improvement in the warm bias in NAEFSv7 over the Central/Southern/Eastern CONUS in the medium-to-long range, but the cool bias is slightly worse
- Overall, NAEFSv7 offers limited improvement but certainly doesn't degrade the forecast
- **Supports implementation of NAEFSv7**

NWS Western Region

- Some small improvements and some small areas of degradation
- Mostly very similar performance due to small scope of changes
- Would like to have seen forecast images, especially from a real-time parallel
- **Supports implementation of NAEFSv7**

NWS Alaska Region

- Based on the limited amount of data available, NAEFSv7 performs very similarly to NAEFSv6

- **Supports implementation of NAEFSv7**

NWS Central Region

- Based on the verification statistics, it was difficult to find any characteristics of NAEFSv7 that reflected vast improvement over the current operational NAEFS

- Some improvement in NAEFSv7, relative to v6, at Day 8 and beyond
  - The two systems were overall indistinguishable on Days 1–7

- Slight edge for NAEFSv6 on precip bias scores

- It is a challenge to assess an upgrade with only verification statistics
  - Would have much preferred to have at least a short period of forecast graphics available for v6/v7 comparisons

- **Neutral regarding proposed implementation of NAEFSv7**

NWS Pacific Region

- Based on the provided verification statistics, it appears NAEFSv7 performs similarly to NAEFSv6

- **Supports implementation of NAEFSv7**

Overall Impressions of NAEFSv7

Center/Region	Recommendation	Key Remarks
Southern Region	**Implement**	Few overall differences, but NAEFSv7 slightly better. Slightly worse for small precip thresholds, but perhaps slightly better overall for precip.
Weather Prediction Center (WPC)	**Implement**	Differences in objective verification overall pretty minor. Some improvement in 500-hPa heights over Tropics. Better QPF Brier Scores and reliability for 5, 10, 25 mm thresholds. Some improvement in longer-range warm bias for East, South, and Central. Cool bias slightly worse at shorter forecast ranges.
Alaska Region	**Implement**	Performance is overall very similar between NAEFSv6 and v7.

Improvement Neutral Degradation

Overall Impressions of NAEFSv7

Center/Region	Recommendation	Key Remarks
Western Region	**Implement**	Some small improvements, some slight degradation. Very similar overall performance, as expected due to the small scope of the changes.
Central Region	**Neutral**	Tough to find any vast improvement with NAEFSv7. Some slight improvement at Day 8 and beyond. Slight edge for NAEFSv6 with precip bias.
Pacific Region	**Implement**	NAEFSv7 performs very similarly to NAEFSv6.

Improvement Neutral Degradation

Overall Impressions (MEG and Evaluators)

- Some slight improvement in NAEFSv7 relative to NAEFSv6, especially for the majority of precipitation stats
- Overall, NAEFSv7 performed very similarly to NAEFSv6
- The similar performance of NAEFSv7 is not surprising given the limited scope of the changes – the primary purpose of this upgrade is the utilize all 31 GEFS members in NAEFS (which were added in GEFSv12, but not included yet)
- Evaluators support the proposed NAEFSv7 upgrade

Request for Approval to Proceed with Implementation

- **Summary:**
  - This upgrade allows all GEFS members to be used by the NAEFS
  - Both GEFS bias-corrected and downscaled guidance are improved for most metrics computed for most parameters due to the increased number of calibrated GEFS members

- **Project Status:**
  - All software developed and checked for September 1 code delivery
  - NAEFSv7 stats are overall either as good or slightly better than NAEFSv6
  - All field evaluators either approve of the proposed implementation or are neutral

- **Request approval from EMC Director to proceed with implementation**