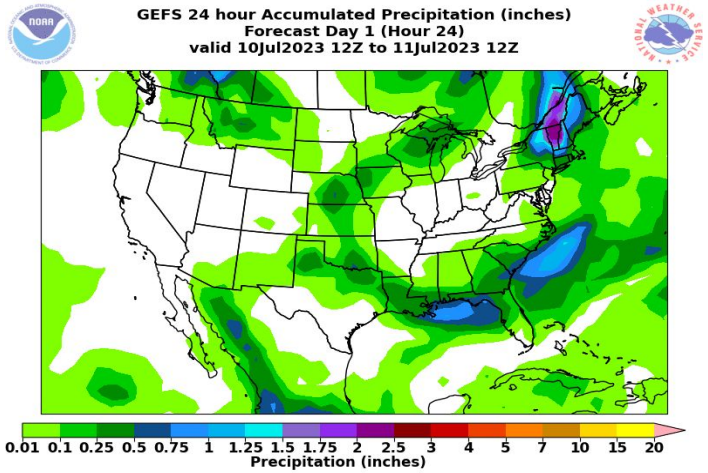
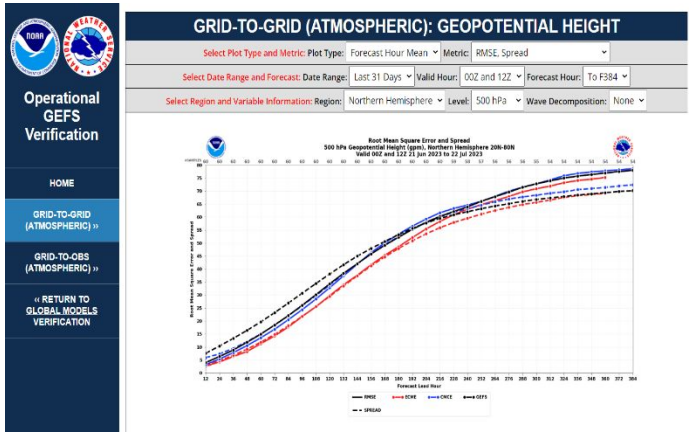
Novel Ensemble Verification and Validation Efforts at EMC





Binbin Zhou, Geoff Manikin, Alicia Bentley, Logan Dawson,
Jason Levit, Perry Shafran, Shelley Melchior, Steven Simon

NOAA/NWS/NCEP/Environmental Modeling Center, College Park, MD

9th NOAA Ensemble User Workshop
August 22 - 24, 2023, College Park, Maryland

EVS Motivation and Benefits

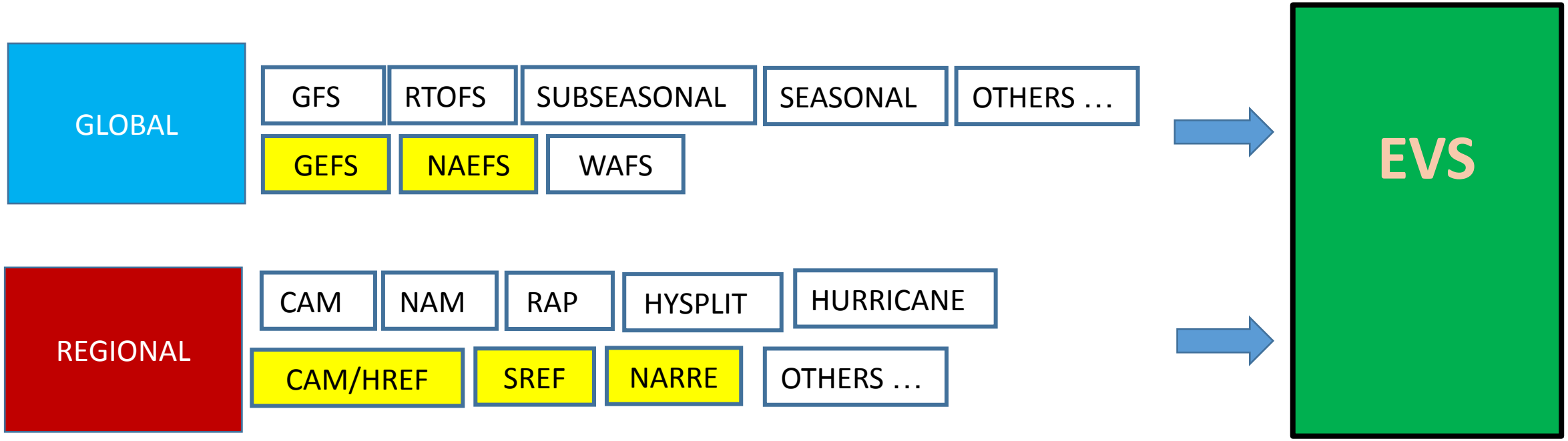
- The new EMC Verification System (EVS) is a unified software based on the Model Evaluation Tools (METplus) developed by the Developmental Testbed Center (DTC)
- Will be used to monitor operational models at real-time and evaluate model updates at NCEP
- Replaces legacy software currently maintained by EMC staff but significantly expands current verification work
- Invokes the results of the 2021 DTC UFS Evaluation Metrics Workshop
- Will feature graphics that follow a standardized format; graphics will be displayed on a centralized verification web site

2021 DTC UFS Evaluation Metrics Workshop

- Invoked the knowledge of the broad user community to provide comprehensive verification details and metric prioritization for each UFS component. A snippet from the list for the Short-Range Weather (SRW) application:

PARAMETER	LEVEL	DETERM. METRICS	ENSEMBLE METRICS	PROB. METRICS	TEMPORAL ATTRIBUTES	THRESHOLDS	REGIONS	VERIF. TYPE	VALIDATION SOURCES
Precipitation	Surface	Total Interest (MODE), FSS, and Contingency Table Counts	FSS + CTC + Rank Histogram	Reliability Diagram	Hourly to f24 and then 3-hourly, also 24-hourly	3h: 0.25", 0.5", 1" (include 0.1" in winter) and 24h: 1" and 2" (include 0.5" in winter)	CONUS divided into fourths + Alaska	Grid-to-grid, grid-to-obs	CCPA (CONUS), Stage IV (Alaska)
Temperature	Sfc/2-m	BCRMSE + Bias	RMSE of Ens. Mean + Ensemble Spread + Ranked	ROC + Reliability + BSS	Hourly to f24 and then 3-hrly	0°C, 60°F (when paired with high Td)?	CONUS divided into fourths + Alaska	Grid-to-obs	METARS + some mesonet + marine obs
Wind	Sfc/10-m	BCRMSE + Mean Error Bias	RMSE of Ens. Mean + Ensemble Spread + Ranked Histogram	ROC + Reliability + BSS	Hourly to f24 and then 3-hrly		CONUS divided into fourths + Alaska	Grid-to-obs	METARS + some mesonet + marine obs
Dew Point	Sfc/2-m	BCRMSE + Threshold Bias (do not compute stats for low values)	RMSE of Ens. Mean + Ensemble Spread	ROC + Reliability + BSS	Hourly to f24 and then 3-hrly	50, 60, 70°F (possibly 40 and 50 in the west?); need lower threshold for fire wx	CONUS divided into fourths + Alaska	Grid-to-obs	METARS + some mesonet + marine obs
Updraft Helicity	2-5 km	FSS, CTC	RMSE of Ens. Mean + Ensemble Spread	BSS + Reliability + ROC	24-hrly	99th percentile	SPC Convective Outlook areas of "Marginal" or greater	Grid-to-grid	SPC storm reports

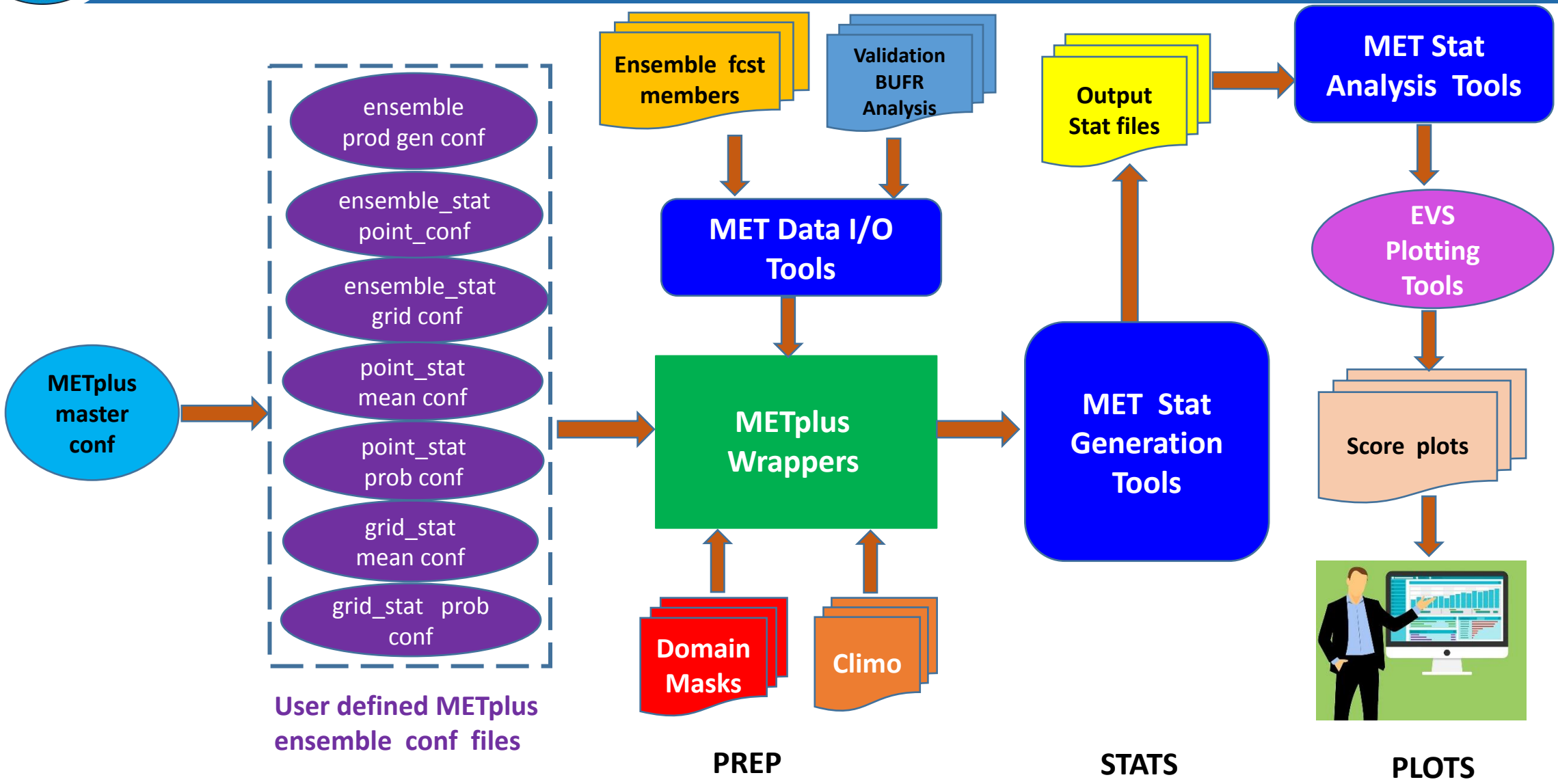
EVS Model components



Ensemble Forecast System

GEFS Global Ensemble Forecast System
NAEFS N. American Ensemble Forecast System
HREF Hi-Resolution Ensemble Forecast
SREF Short Range Ensemble Forecast
NARRE N. American Rapid Refresh Ensemble

EVS/Ensemble METplus Flowchart



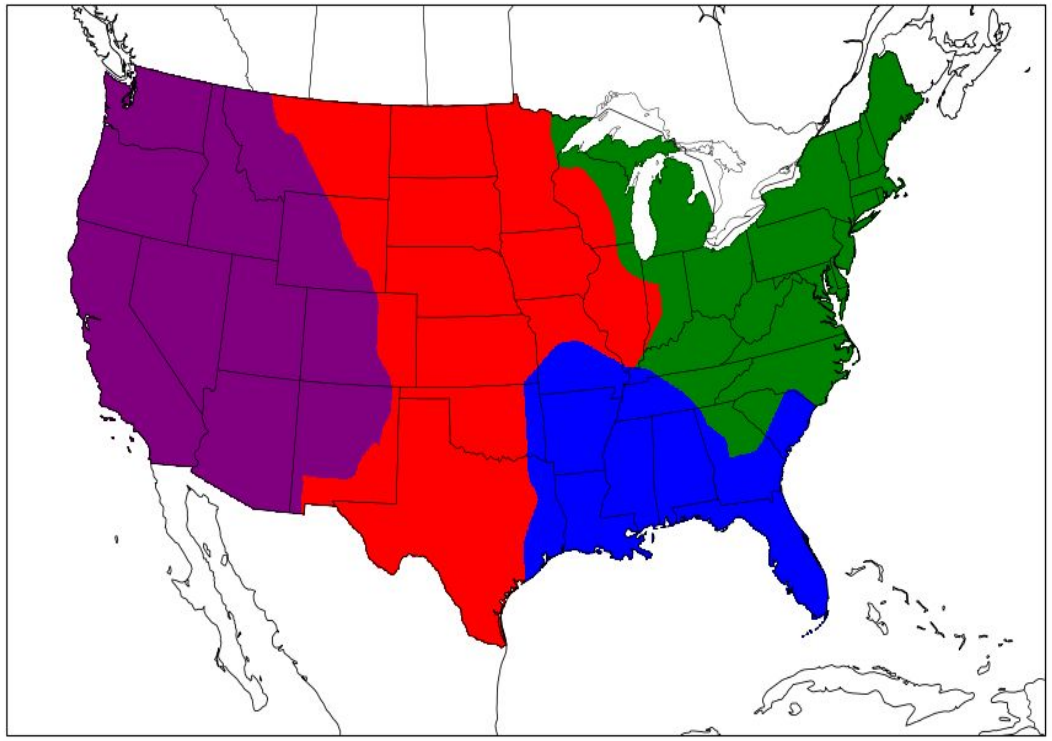
Domains

- Global domains (same as current ensemble verification)

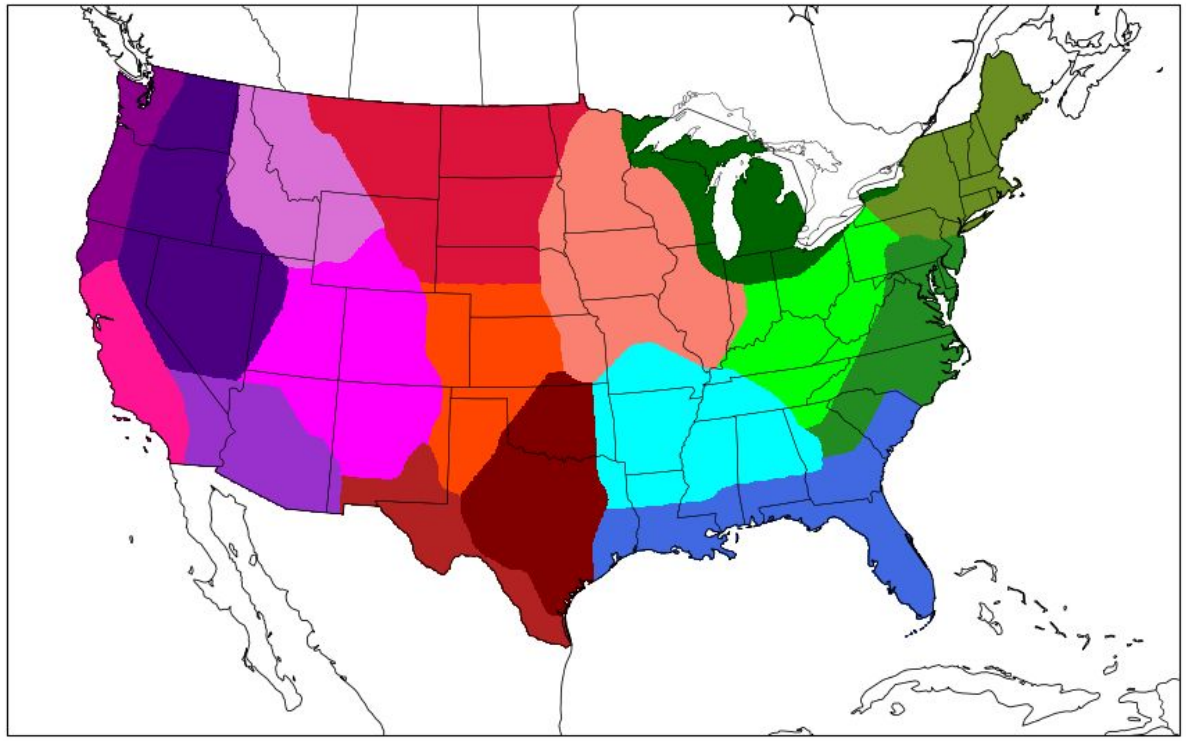
  N/S/Hemisphere and Tropical (20N/S ~ 80N/S, 20S ~ 20N), CONUS/E/W/S/C

- Regional: CONUS/E/W/S/C CONUS subregions, Alaska, Hawaii and Puerto Rico

CONUS, CONUS/E/W/C/S



CONUS Bukovsky Sub-regions



Global ensemble verification components (EVS v1)

Models	Types	Variables	Validation	Climatology	Metrics	Domains	Time
All in 1x1 degree **GEFS** **NAEFS** **CMCE** **ECME** Specific for WMO in 1.5x1.5 degree	Grid2grid	Upper level fields (H, T, U, V)	Model own analysis	WMO/ERA-5	ACC, Bias, Abs Error, RMSE/Spread, ETS, CSI, Fbias, FSS Performance diagram, CPRS, CRPSS, BS, Reliability, etc Spatial map	Global, N. Hemisphere S. Hemisphere Tropical CONUS CONUS-East CONUS-West CONUS-Central CONUS-South Alaska Antarctic Arctic	384 forecast hours
		Surface fields (U10, V10, PMSL)					
		Precip	CCPA	CPC precip data			
		Snowfall (depth)	NOHRSC	N/A			
		Sea ice (concentration)	OSI_SAF	N/A			
		SST	GHRSST	N/A			
	Grid2obs	Profiles (H, T, RH, U, V)	PrepBufr/RAOB	WMO/ERA-5			
		Surface fields (T, Td, RH, U, V, PMSL, Vis, Ceiling, CAPE, Cloud, etc)	PrepBufr/METAR				
	Grid2obs	Wave height Peak wave period 10-m wind speed	Buoys, C-man, prepBufr(ships), etc	WMO/ERA-5	RMSE, Bias, PCC, Std Dev, Sc Index, Mean, 95th Percentile, etc	Global, Individual buoys, U.S. Coastal Water Regions	
	Grid2obs	Tropical Cyclone (track, intensity, genesis)	Best track	N/A	RMS, Bias	N. Atlantic, East Pacific, West Pacific	

New efforts, never done before at EMC

Regional ensemble verification components (EVS v1)

Models	Types	Variables	Validation	Metrics	Domains	Fcst hours
HREF (2.5 km, 4 km) **SREF** (32km) **NARRE** (13km)	Grid2grid	Precip products (mean, pmmn, plmn, pavrg, prob), Precip ensemble	CCPA (CONUS) MRMS (Alaska)	Bias, Fbias ETS, CSI, FSS, Performance diagram, RMSE, Spread BS, BSS, ROC, Reliability, Rank histogram etc Spatial map (24h precip)	CONUS CONUS-East CONUS-West CONUS-Central CONUS-South COUNS 32 sub-regions Alaska Hawaii Puerto Rico SPC Severe Weather Risk Outlook Areas: 6 Risk Levels for Day 1, 2, and 3	HREF-48 fhr SREF-87 fhr NARRE-12fhr
		Snowfall ensemble	NOHRCS			
		Simulated radar reflectivity	MRMS			
		Echo top height	MRMS			
		Updraft Helicity	SPC Storm Reports			
	Grid2obs	High level fields (T850mb, Wind speed 700, 850mb) Profiles (H, T, RH, U, V)	PrepBufr/ROAB			
		Surface fields (T, Td, RH, U, V) PMSL, Vis, Ceiling, Cloud, CAPE-sfc, CAPE-midlevel, PBL height, Wind-Gust, Wind-speed, etc)	PrepBufr/METAR			

New efforts, never done before at EMC

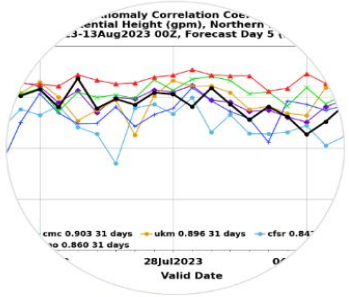
New EVS Webpage Interface

EMC Verification

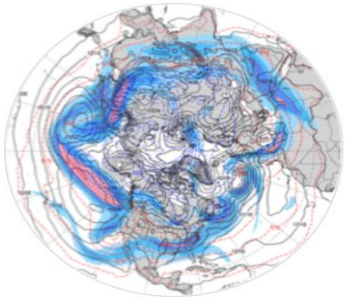
NOAA

EMC VERIFICATION | ABOUT US | MODEL EVALUATION GROUP

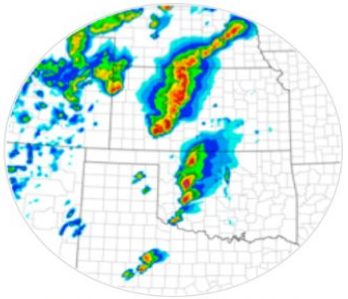
EMC Home / EMC Verification



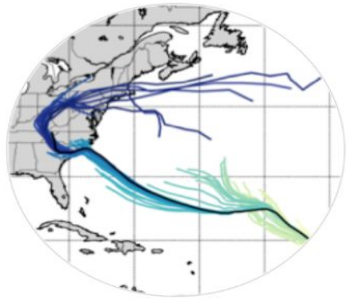
Headline Scores



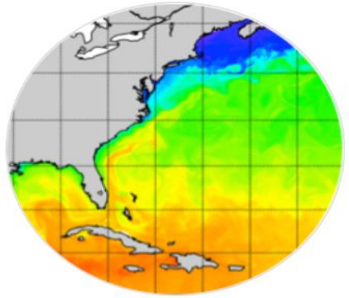
Global Models



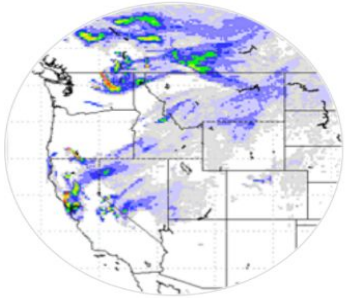
Regional/Hi-Res Models



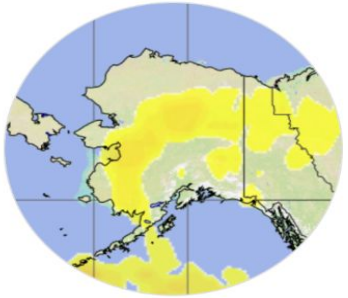
Hurricane Models



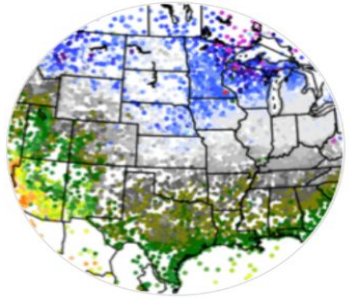
Ocean/Lake Models



Air Quality Models



Aviation Products



Real-time Analyses

New EVS Webpage Interface

Operational GEFS Verification

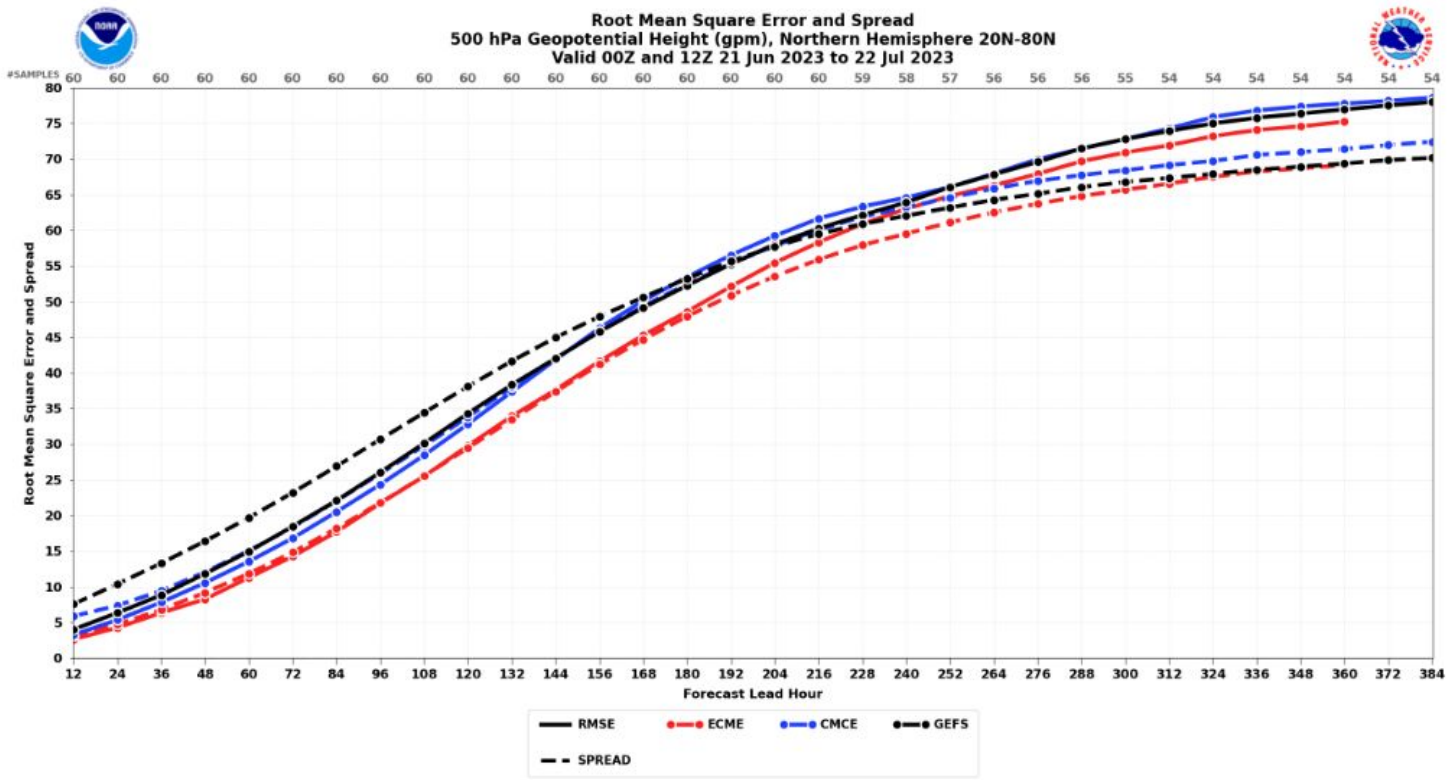
- HOME
- GRID-TO-GRID (ATMOSPHERIC) ››
- GRID-TO-OBS (ATMOSPHERIC) ››
- ‹‹ RETURN TO GLOBAL MODELS VERIFICATION

GRID-TO-GRID (ATMOSPHERIC): GEOPOTENTIAL HEIGHT

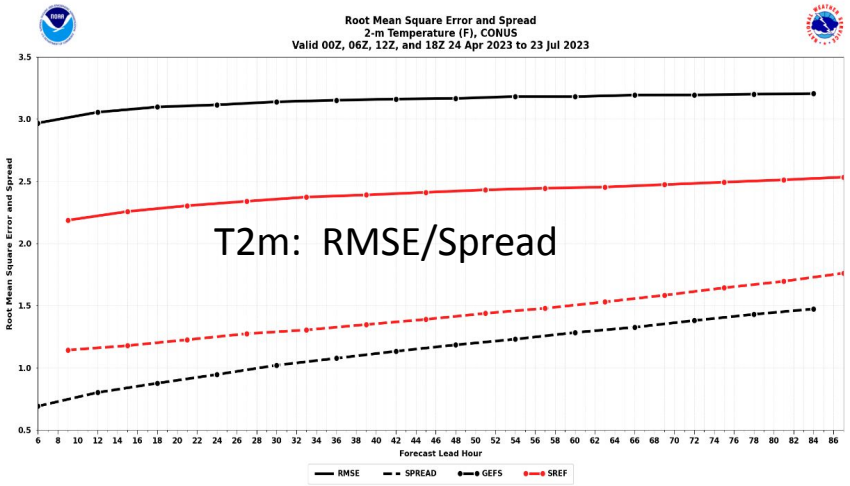
Select Plot Type and Metric: **Plot Type:** Forecast Hour Mean **Metric:** RMSE, Spread

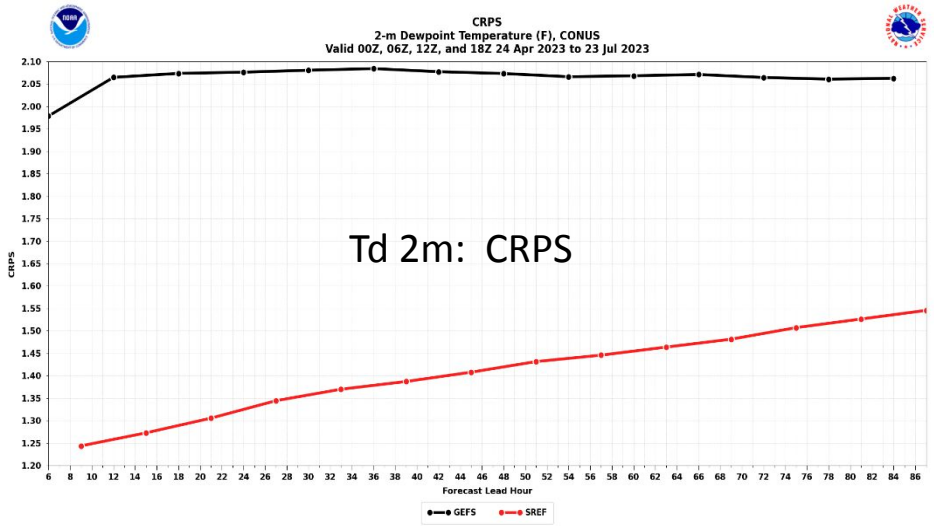
Select Date Range and Forecast: **Date Range:** Last 31 Days **Valid Hour:** 00Z and 12Z **Forecast Hour:** To F384

Select Region and Variable Information: **Region:** Northern Hemisphere **Level:** 500 hPa **Wave Decomposition:** None



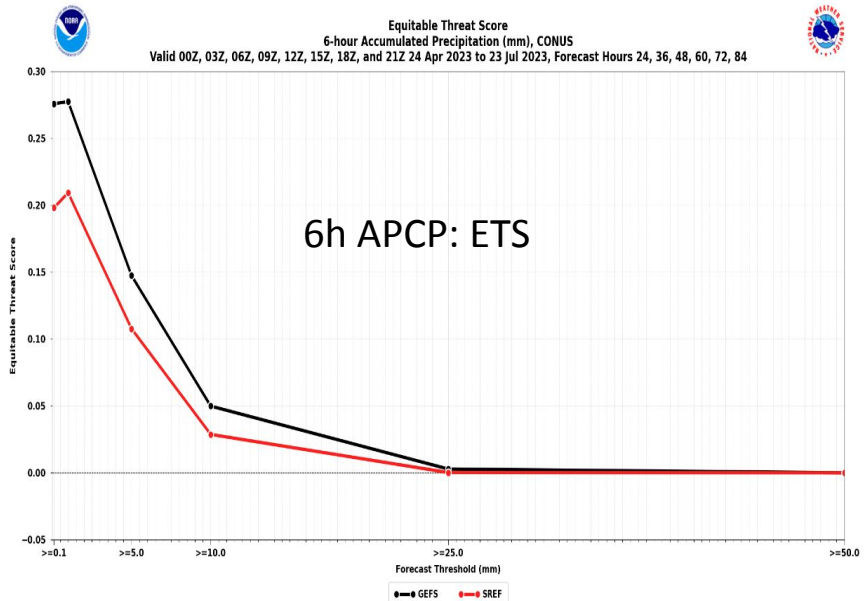
Example: GEFS vs SREF: 90 days Evaluation

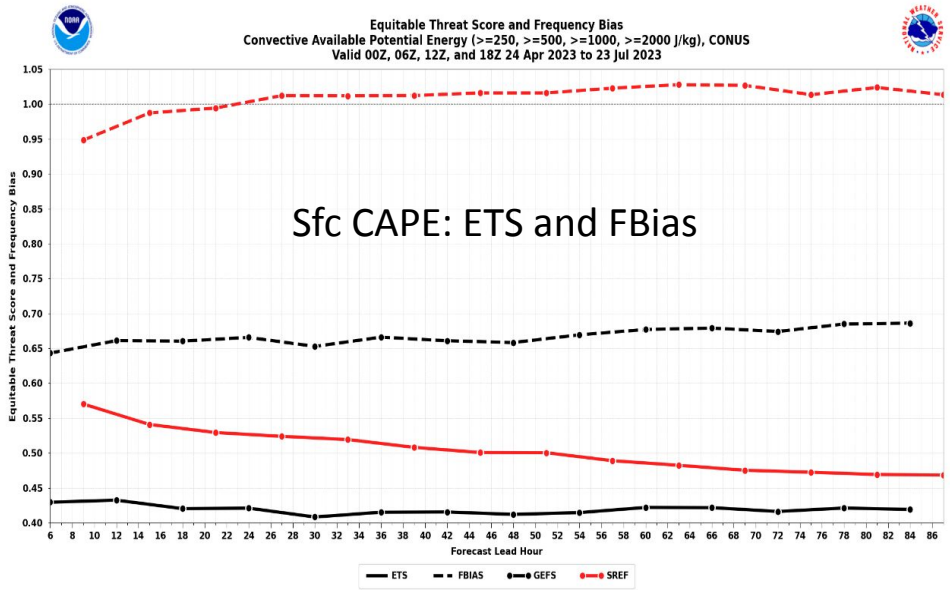




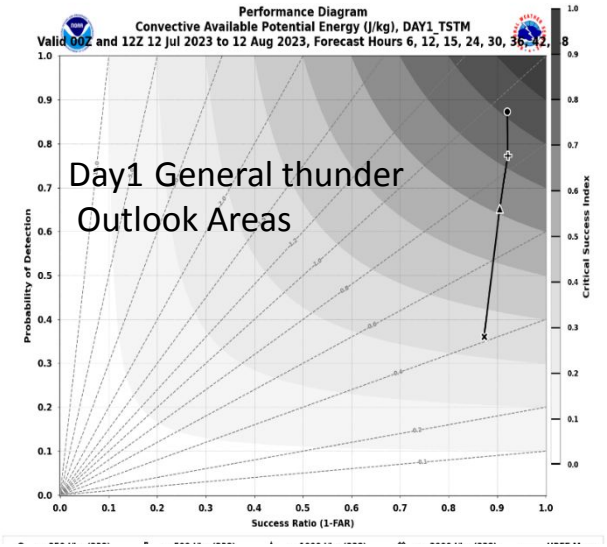
GEFS

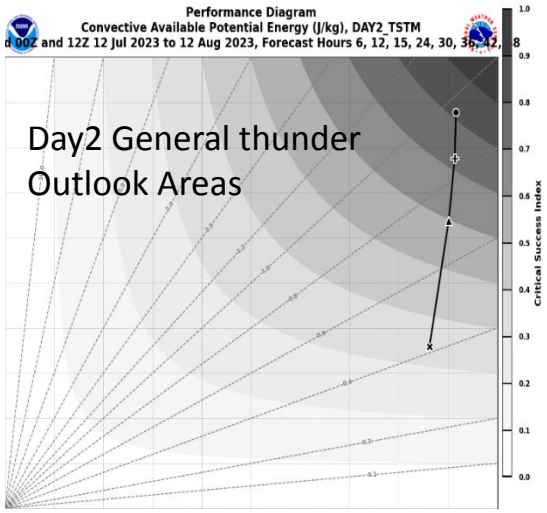
SREF

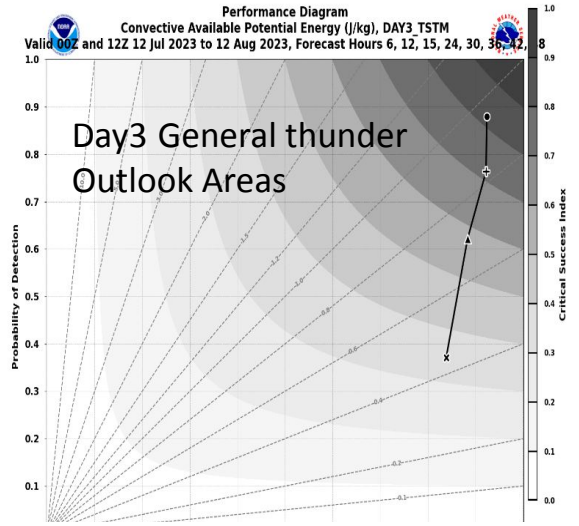


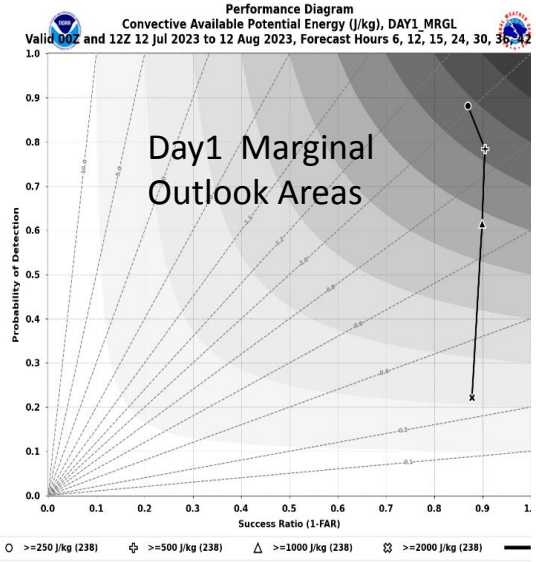


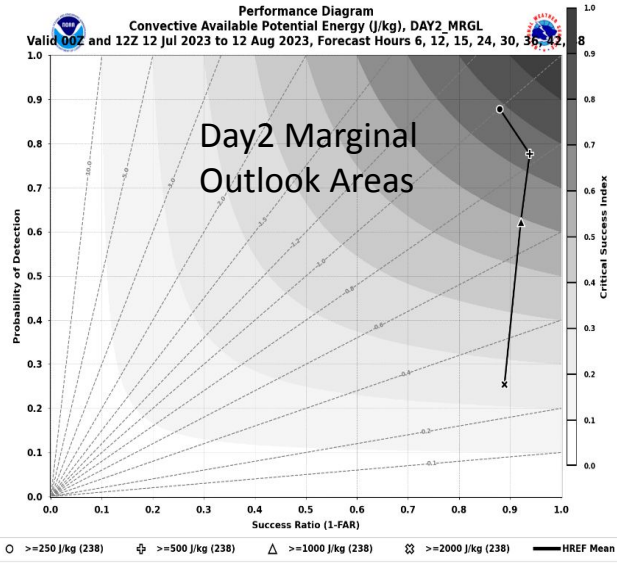
Example HREF: 31 days CAPE Performance over SPC Outlook Areas

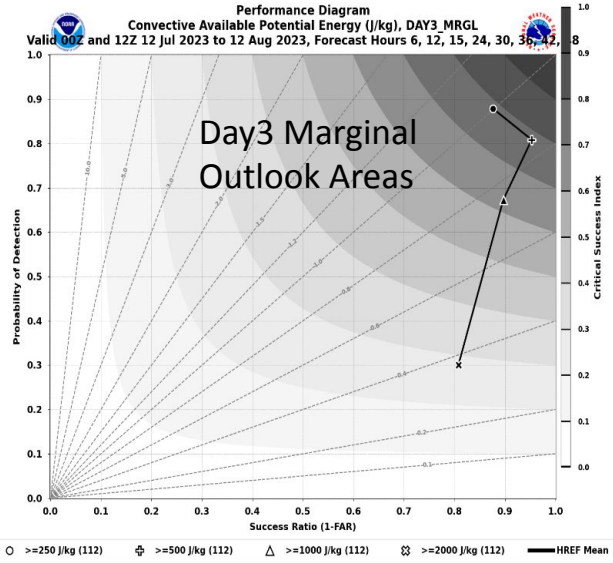












EVS v1.0 Transition to Operations Timeline

Fall 2020
Pre-Workshop
Community Surveys

Feb 2021
DTC UFS Evaluation
Metrics Workshop

Spring-Summer 2021
Harvesting Workshop
Community
Recommendations

Fall 2021 / Winter 2022
Final EVS Planning

Spring 2022 - Summer 2023
Develop Stats and Graphics

Winter / Spring 2023
Beta Testing

Summer 2023
Build Web Pages
Ecflow Work

September 2023
Code Handoff

December 2023
Implementation

Future Plans for EVS

- Create new components that resources prevented including in current software package
- Move components in development mode to operations where possible
- Add metrics and graphics as new METplus capabilities and validation data sources allow
- Adapt EVS components for use in development parallels of new systems
- Move graphic hosting from EMC web server to new cloud-based web server
- Add new phenomena-based metrics
- Target for EVS v2.0: Q1FY26

Summary

- EVS is a new effort at EMC and collaborated with DTC to build unified METplus-based verification system
- Replaces/expands the current verification system
- EVS has both deterministic model and ensemble forecast verifications
- Many new fields and features have been added in both global and regional ensemble components in EVS
- EVS v1 code has been completed and currently is in testing stage
- EVS v1 will be implemented at end of 2023
- EVS is still moving forward to add more features/capabilities