NOAA/NWS MRW & S2S

Status and Plan in Developing and Implementing Medium-Range Weather, Subseasonal to Seasonal (S2S) Forecast Systems Based on the Unified Forecast System at NOAA

AGU 2023 - Town Hall

Time: **13:00 - 14:00 PST, Friday, December 15, 2023**
Location: **2018 - West (Level 2, West, Moscone Center)**

Unified Forecast System

The Unified Forecast System (UFS) is a community-based coupled Earth modeling system, designed to support the Weather Enterprise and also be the source system for NOAA's operations.

UFS Research-to-Operations (UFS R2O) Project

The UFS-R2O Project is a subset of the larger UFS community. It is a major ongoing undertaking at the National Oceanic and Atmospheric Administration (NOAA)'s Office of Science and Technology Integration Modeling Program (OSTI-Modeling) in the National Weather Service (NWS), in collaboration with the Weather Program Office in the Office of Oceanic and Atmospheric Research (OAR), to build partnerships across the research and operational environmental modeling communities with a focus on transitioning UFS-based applications into the NWS - National Centers for Environmental Prediction (NCEP)'s operational modeling suite. The Medium-Range and Subseasonal-to-Seasonal (MRW/S2S) component of the UFS-R2O project, or the MRW/S2S Application Team (AT), is responsible for the development and transition to operations of GFSv17 and GEFSv13.

Goals:

- Improve predictions through various updates and upgrades to atmospheric physics, component models, and representation of interactions across model components
- Enhance forecast skill through improved initialization with a weakly coupled data assimilation
- Improve MJO propagation and intensity.
- Reduce low bias in convective available potential energy (CAPE).
- Improve low-level inversions and reduce 10m wind speed bias.
- Improve mixed-phase clouds and supercooled liquid clouds.

Global Forecast System v17 (GFSv17)

GFSv17 configuration in comparison to GFSv16

	GFSv16: Implementation Mar 2021	GFSv17: Target Implementation Mar 2026
Model	FV3/Noah WW3 (one-way coupling)	FV3/Noah_MP MOM6/CICE6/WW3 (two-way coupling)
Resolution	C786L127 (13km, 80km top)	C786L127 or C1152L127 (13km or 9km, 80km top)
Physics	GFDL MP, sa-TKE-EDMF, non-orographic GWDs	Thompson MP; UGWD; Updated convection, surface and PBL physics schemes; MERRA-2 aerosol climatology
Deterministic Forecast	GSI, GLDAS 16 days from 00Z, 06Z, 12Z and 18Z	GSI, JEDI Ocean/Sea Ice, JEDI Snow 16 days from 00Z, 06Z, 12Z and 18Z

Challenges:

We seek community inputs and collaboration in the following areas:

- Develop scale-aware physics parameterizations for UFS applications across different temporal and spatial scales.
- Characterize and reduce GFS systematic biases in both coupled and uncoupled modes.
- Improve GFS large-scale flow pattern through optimizing dycore options and physics parameterizations.
- Improve GFS hurricane track and intensity forecast.
- Improve forecasting of surface weather sensible elements such as air temperature, wind direction, humidity, wind speed, clouds, precipitation, visibility, and surface pressure.

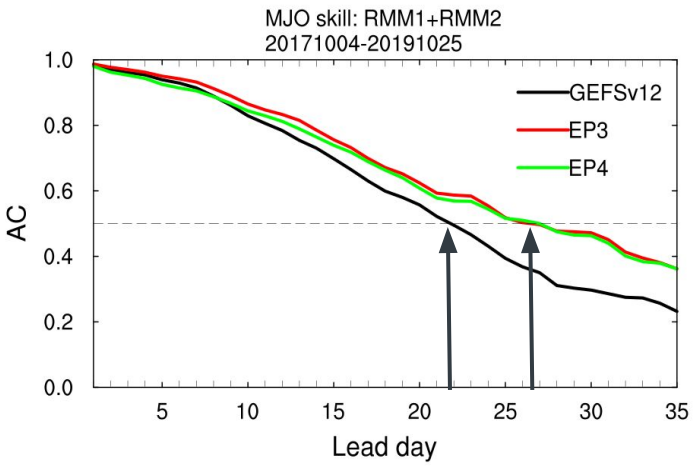
Global Ensemble Forecast System v13

GEFSv13 configuration in comparison to GEFSv12:

	GEFSv12: Implementation Sep 2020	GEFSv13: Target Implementation Mar 2026
Model	FV3/Noah WW3/GOCART (one-way coupling)	FV3/Noah_MP MOM6/CICE6/WW3/GOCART (two-way coupling)
Resolution	C384L64 (~25km, 55km top)	C384L127 (~25km, 80km top)
Physics	GFDL MP, Stochastic physics (SPPT, SKEB)	GFSv17 physics + Stochastic physics (SPPT, SKEB, ocean)
Ensemble Forecast - Realtime	GSI, GLDAS 16 days (06Z, 12Z and 18Z), 31 members 35 days (00Z), 31 members	GSI, JEDI Ocean/Sea Ice, JEDI Snow 16 days (06Z, 12Z and 18Z), 31 members 48 days (00Z), 31 members
Ensemble Forecast - 31-years Reforecast	GEFSv12 reanalysis (CFSR) in 2000-2019 (1989-1999) 16 days, every day, 5 members 35 days, every Wednesday, 11 members	Replay to ERA5 Atmos, ORAS5 Ocean/Sea Ice, Noah_MP spin up, snow DA in 1994-2024 16 days, every day, 6 members 48 days, every Monday, Thursday, 11 members

Goals:

- Improve MJO propagation and intensity, extend useful skill by 5-10 days
- Improve CRPS skill of Z500, T2m, tropical cyclone and sea ice extended; improve brier skill scores of CONUS PQRF
- Improve west coast and Arctic air mass forecast
- Improve hurricane track and intensity forecast
- Improve Sudden Stratospheric Warming forecast



Four GEFSv13 Ensemble Prototypes (EP1 - EP4): EP3 and EP4 both have higher MJO skill (RMM1+RMM2) than GEFSv12 for longer lead times (extend skill for 4-5 days).

Challenges:

We seek community inputs and collaboration in the following areas:

- Sophisticated evaluation tools for diagnosis of model uncertainties across model components
- Ensemble evaluation for the individual component of the coupled model system
- AI/ML based ensemble post-processing techniques
- SPP based stochastic physics schemes development

Seasonal Forecast System Development Plan

SFS Development Project:

The NWS Office of Science and Technology Integration (OSTI) Modeling Program and the OAR Weather Program Office (WPO) Subseasonal-to-Seasonal Program are jointly supporting the SFS development project, referred to as SFS Application Team under UFS R2O. A SFS development plan has been drafted with a goal to build SFS v1 as a replacement of the more than one decade-old Climate Forecast System version 2 (CFSv2). The SFSv1 will build upon and extend the capabilities of the NOAA Global Ensemble Forecast System (GEFS), building upon GEFSv13 which is currently in development and testing, for extended range forecasting.

Outcomes:

- Produce a global coupled model using systematic testing and evaluation strategy
- Improve physics parameterizations, dycore options and land physics
- Improve ocean and sea ice processes that minimizes long-term model drift
- Develop an ensemble framework that realistically represents forecast uncertainties
- Complete reanalysis and reforecast for the 1979-present
- Develop SFS model infrastructure that enables development on both on-premise and cloud HPC
- Develop an integrated METplus-based verification package for SFS

Challenges:

We seek community inputs and collaboration in the following areas:

- Reduce model drift (bias) in any medium (e.g., ocean, land surface, etc.) and teleconnections that often overwhelm predictive signal
- Create initial conditions representing the true state while also not producing a shock to the coupled system at initialization time
- Initialize the Earth system components that are not well observed (e.g., deep ocean, sea ice characteristic, land subsurface, etc.) to maximize prediction skill.

Diagnostics and Analysis

The development of the Medium Range Weather (MRW) and Subseasonal to Seasonal (S2S) applications proceeded through the creation of a series of prototypes, each encompassing both infrastructure and scientific enhancements. So far, the impact of scientific upgrades has been assessed with respect to the following areas: tropical variability with a focus on the MJO, MJO-teleconnections, and Indian monsoon; surface weather over the CONUS including extreme events and land-atmosphere interactions; troposphere-stratosphere coupling; the impact of tropical SST biases on the forecast skill over the North America and ENSO. Additionally, for each model component, an overall assessment was conducted, consisting of metrics such as mean bias and anomaly correlation.

Challenges:
We seek community inputs and collaboration in the following areas:

- Evaluation of ocean variability forecasted by the S2S application
- Evaluation of sea-ice variability forecasted by the S2S application
- Evaluation of the aerosol impact on the S2S forecast skill
- Evaluation of initialization on the forecast skill in all model components
- Diagnosing and understanding sources of model errors with sensitivity experiments
- Increasing confidence in skill evaluation with longer experiments and larger ensemble size

S2S Metrics and Forecast Products

Development of UFS S2S Applications (GEFS, SFS) requires proficient tools to evaluate various prototype experiments, retrospective forecasts and real time forecasts, as well as the initial conditions. Improvements in UFS S2S forecast products depend on a number of factors, including (1) initial conditions for individual model components (atmosphere, ocean, ice, and land), especially for the temporal consistency throughout the retrospective and forecast periods, (2) representation of processes that affect S2S variability, especially for those associated with the S2S climate modes such as ENSO and MJO and teleconnection, and (3) comparison with the existing forecast systems including GEFSv12, the Climate Forecast System version 2 (CFSv2) and the North American Multi-Model Ensemble (NMME). The UFS R2O Project will develop a METplus-based verification and diagnostics capability for UFS S2S verification and validation, and will add new products via the Unified Post Processor (UPP) as well as ocean, ice, and ensemble-based products The evaluation will be done for mean states and anomalies that affect operational forecast products, including soil moisture, atmospheric teleconnections, tropical oceanic surface and subsurface variability, tropical intraseasonal oscillation, and Arctic sea ice. Both deterministic and probabilistic metrics will be used, including Heidke Skill Score (HSS) and Ranked Probability Skill Score (RPSS).

Challenges:
We seek community inputs and collaboration in the following areas:

- Develop METplus-based verification and diagnostics package for UFS S2S Applications
- Diagnose deficiencies in the new reanalyses that are used to initialize GEFS and SFS forecasts
- Diagnose sources of deficiencies in model's representation of physical processes that influence the prediction of S2S anomalies
- Diagnose errors and understand forecast skill of retrospective and real-time forecasts
- Develop decision support products using GEFS and SFS forecast data
- Add new ensemble products such as mean, spread, exceedance probabilities for new variables required by stakeholders
- Investigate the use of artificial intelligence and machine learning algorithms for developing post-processed products

How to Engage with the UFS?

NOAA Grants in Support of UFS S2S Applications
WPO grants emphasize use of UFS for S2S and its applications.

Proposals for the FY24 NOFO (CTB, Fire Wx) were due 16 Nov. Proposals presently under review, and notifications will be made later in the fiscal year. WPO expects a larger set of competitions in FY25 due to grant cycles; interested investigators should keep eyes open for WPO's FY25 call.

WPO is also conducting a BIL-funded competition for a Data Assimilation Consortium, to work with EPIC and hence UFS. Proposals were due 13 Oct and are in review.

Webinars
UFS webinar
Weeks 3-4/S2S webinar
UFS S2S All-hands Meeting

Feedbacks and suggestions:

https://vlab.noaa.gov/web/osti-modeling/workshops/agu2023_mrw-s2s_townhall

Please let us know where you see barriers in collaborating with UFS (lack of information, funding, HPC etc.)

Please contact us at:
nws_modeling_pmo@noaa.gov