

Plans for a Seasonal Forecast System (SFS)



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Avichal Mehra¹, Yan Xue², Phil Pegion³, Jessie Carman⁴ and William Komaromi²

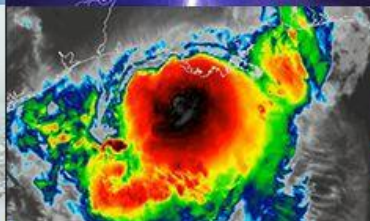
¹ NOAA NWS Environmental Modeling Center

² NOAA NWS Office of Science and Technology Integration

³ NOAA OAR Physical Science Laboratory

⁴ NOAA OAR Weather Program Office

9th NOAA Ensemble Users Workshop



NATIONAL WEATHER SERVICE

Building a Weather-Ready Nation // 1

Outline

Motivation

Based on UFS Infrastructure

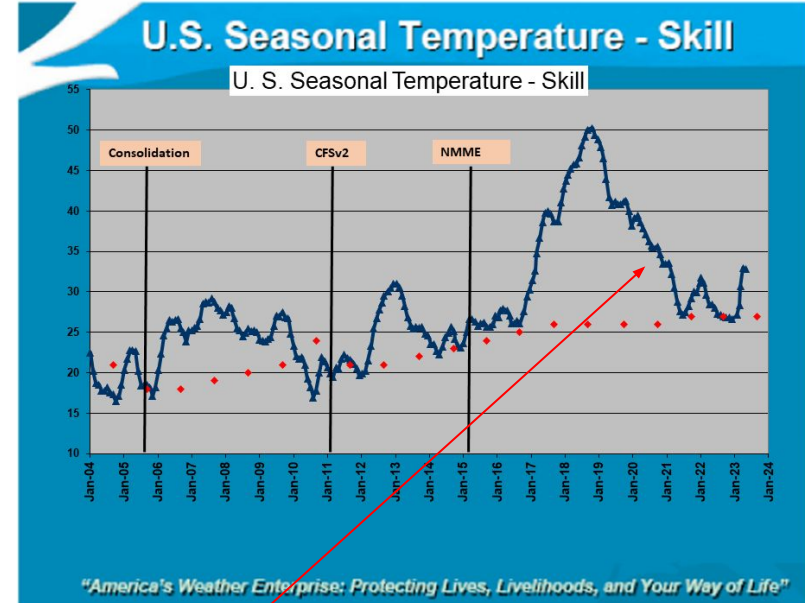
SFS Development Goals and Objectives

SFS Development Focus Areas

Year 1 Plans

SFS Development Plan: Motivation

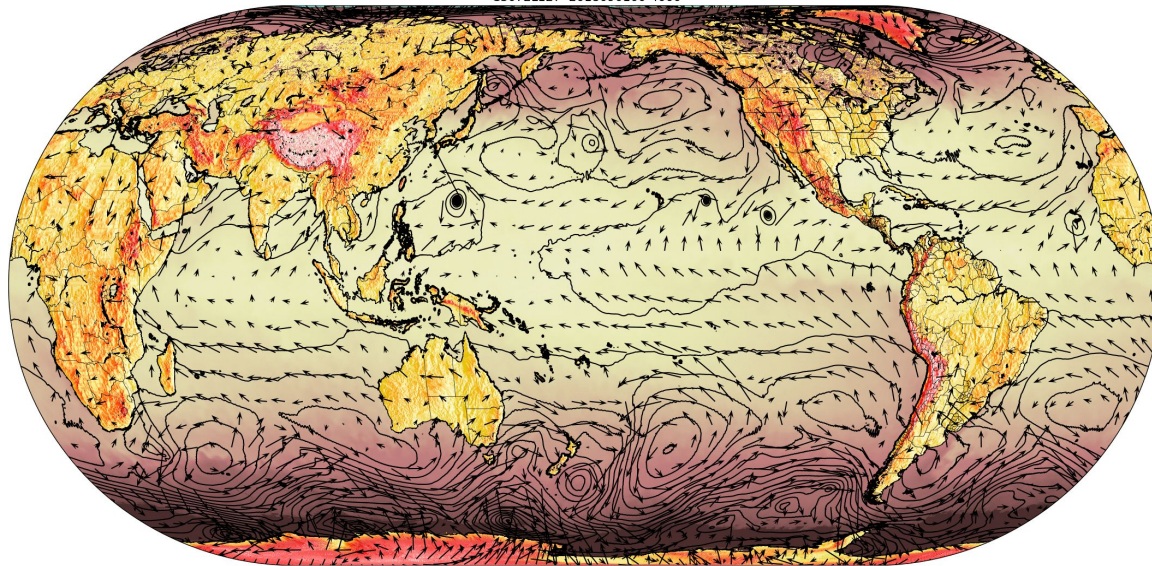
- Weather Act 2017 on Subseasonal and Seasonal (S2S) Prediction
 - Subseasonal (2 weeks - 3 months)
 - Seasonal (3 months - 2 years)
- NOAA's S2S Report to Congress (2020)
 - Improving the skill of S2S forecasts
 - Enhancing the value of S2S products for stakeholders
- Progress and challenges in improving U.S. seasonal temperature skill



A recent degradation in forecast skill results from the inability of North American Multi-Model Ensemble (NMME) to accurately forecast cold anomalies (Becker et al. 2022).

Coupled-Unified Forecast System (UFS): A six-way fully coupled global forecast system

Warm shade: Surface Temp, Contour: MSLP, Cool shade: Convective Cloud Cover, Arrows: 10m Wind
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UFS Earth System Model Components:

- FV3 (Atmosphere)
- MOM6 (Ocean)
- CICE6 (Sea Ice)
- WW3 (Waves)
- NOAH-MP (Land)
- GOCART (Aerosols)

A fully coupled UFS serves as a foundation for future operational global forecast systems at NOAA/NWS/NCEP ranging from weather to subseasonal to seasonal scales.

NWS Weather, Subseasonal, Seasonal Forecast Systems: Transition to Global Coupled UFS-based Systems

Current Operational Systems

GFS v16 (since March 2021)
Weather (0-16 days),
deterministic, **no coupling with
ocean/ice**. FV3

GEFS v12 (since September 2020)
Subseasonal (0-35 days),
ensemble, **no coupling with
ocean/ice**. FV3

CFS v2 (since March 2011)
Seasonal (0-9 months), ensemble,
coupled with ocean/ice. Spectral
Atm/MOM4 Ocean/SIS1 Sea ice

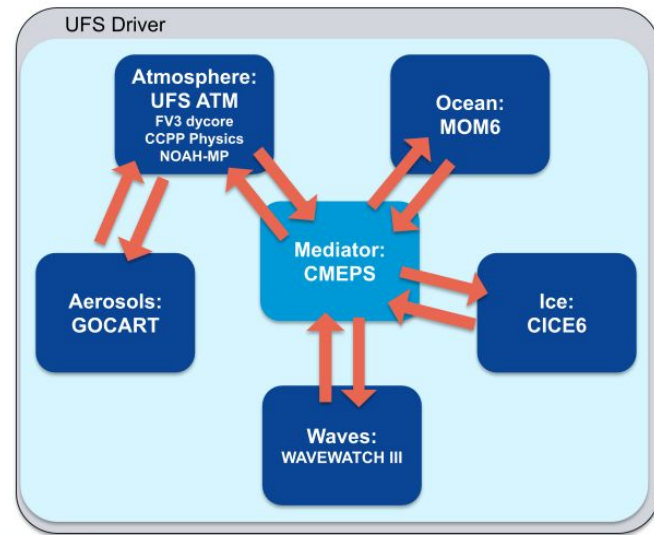
Future UFS Systems

GFS v17
(T20 Phase)

GEFS v13
(T20 Phase)

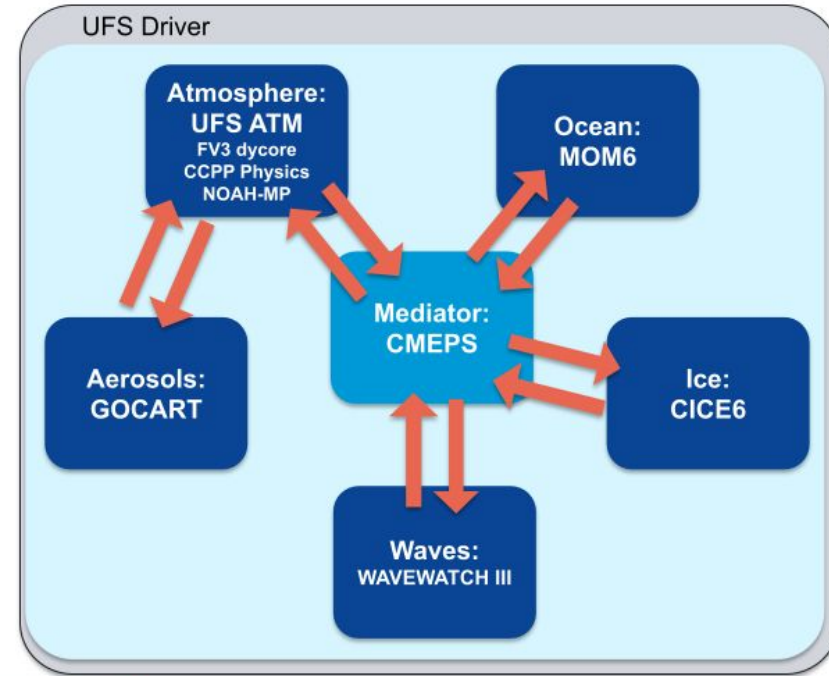
SFS v1
(Planning Phase)

UFS System Configuration



SFS Development Plan: Based on UFS Framework

- 1) Finite Volume Cubed Sphere (FV3) dynamical core
- 2) Common Community Physics Package (CCPP)
- 3) Noah-Multi Parameterization Land Surface Model (Noah-MP LSM)
- 4) Modular Ocean Model (MOM),
- 5) Los Alamos Sea ice model (CICE)
- 6) WAVEWATCH III wave model (WW3)
- 7) Goddard Chemistry Aerosol Radiation and Transport (GOCART)
- 8) Community Mediator for Earth Prediction System (CMEPS)
- 9) Joint Effort for Data Assimilation Integration (JEDI)
- 10) Enhanced Model Evaluation Tools (METplus)

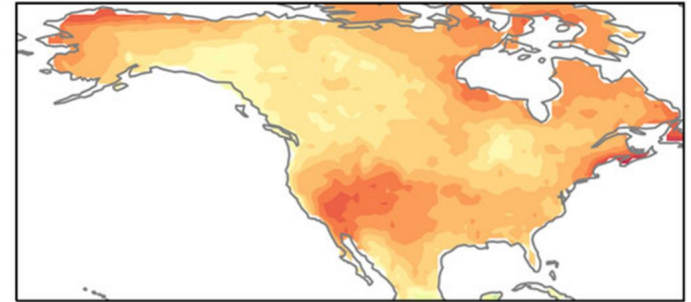


**MRW/S2S Applications:
GFS v17, GEFS v13, SFS v1**

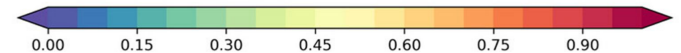
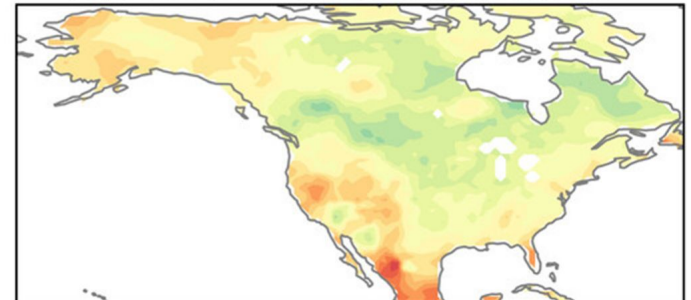
SFS Development Plan: Objectives

- Develop SFS v1 as a replacement of Climate Forecast System version 2 (CFSv2), a legacy system
- Address common errors in CFSv2 and NMME
 - MJO propagation across Maritime Continent
 - False ENSO alarms
 - Positive SST trend errors in tropical Pacific
 - Too frequent above-normal temperature forecast
 - Too infrequent below-normal temperature forecast
- Develop SFS as a community modeling system
- Release reanalysis-forecast data sets to the community

B) NMME lead-1 frequency of above



D) Observed frequency of above

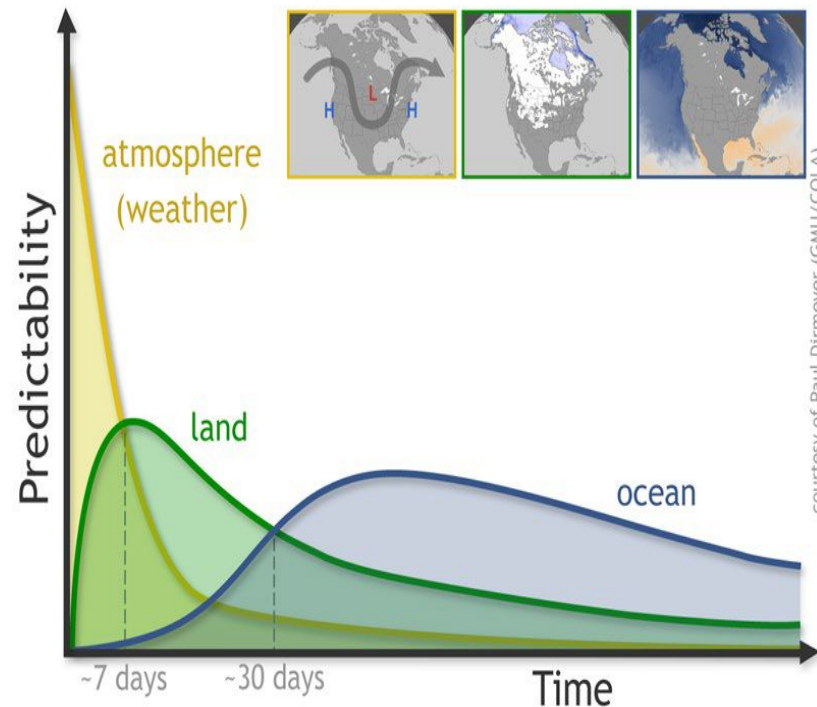


SFS Development Goals

- Coupled reanalysis should provide ***balanced initializations*** across interfaces between coupled model components that ***maximize source of long-term predictability***, e.g. from ***ocean, sea ice and land***
- Coupled model should minimize systematic drift from initial conditions and ***minimize false alarms for extreme events***, e.g. overconfidence in El Nino forecast
- Ensemble forecasts should provide ***best estimation of uncertainties***
- Improvements in physics/dynamics and model components should ***reduce systematic biases and improve forecast skill***
- ***SFS infrastructure*** should provide critical support to model coupling, testing, evaluation and eventual transition to operations
- SFS developments should be incorporated into ***UFS repositories***

SFS Development Plan: Research and Development Focus Areas

- 1) SFS Design, Testing and Analysis
- 2) Physics and Dynamics Improvements
- 3) Land Model Improvement
- 4) Ocean, Waves and Sea-Ice Model Improvements
- 5) Aerosol and Atmospheric Composition Improvements
- 6) Coupled Ensemble Strategies, Design and Development
- 7) Coupled Data Assimilation Developments and Observation
- 8) SFS Reanalysis & Reforecast
- 9) SFS Infrastructure and Cloud Strategy
- 10) Product Developments & Verification



SFS Year 1 Plan (for FY24)

- SFS design & testing and analysis
 - Phase I reforecast configuration: 1-degree, GEFS v13 based, 3-month lead time, 30-years of 2 starts per year; initialized with GEFS v13 replay to ERA5 atmosphere, ORAS5 ocean/sea ice; 10-ensemble members, stochastic physics
 - Physics & dynamics upgrades focusing on improving ENSO, MJO, QBO, tropical convection
 - Land upgrades focusing on improving vegetation, soil moisture, snow
 - Ocean and sea ice upgrades focusing on improving sea ice, air-sea fluxes, reducing SST bias and long-term drift
 - Aerosol upgrades focusing on impacts on meteorology

SFS Year 1 Plan (for FY24)

- **Coupled data assimilation & reanalysis**
 - Retrieve, reformat, and stage reprocessed datasets for 1980-present on Cloud
 - Test weakly coupled data assimilation system through specific periods of interest
 - Generate a scout run at 1-degree for 40-years
- **SFS infrastructure and cloud strategy**
 - Improve model component testing, energy conservation, develop global workflow supported on both RDHPCS and cloud
 - Deploy all available CSP's (AWS, Azure, GCP) via NOAA RDHPCS allocations
- **Verification and product development**
 - Verification and diagnostics package, science evaluation to meet stakeholder needs

Questions?

For additional information, please contact the co-authors:

Avichal Mehra (Avichal.Mehra@noaa.gov)

Yan Xue (Yan.Xue@noaa.gov)

Phil Pegion (Philip.Pegion@noaa.com)

Jessie Carman (Jessie.Carman@noaa.gov)

William Komaromi (William.Komaromi@noaa.gov)



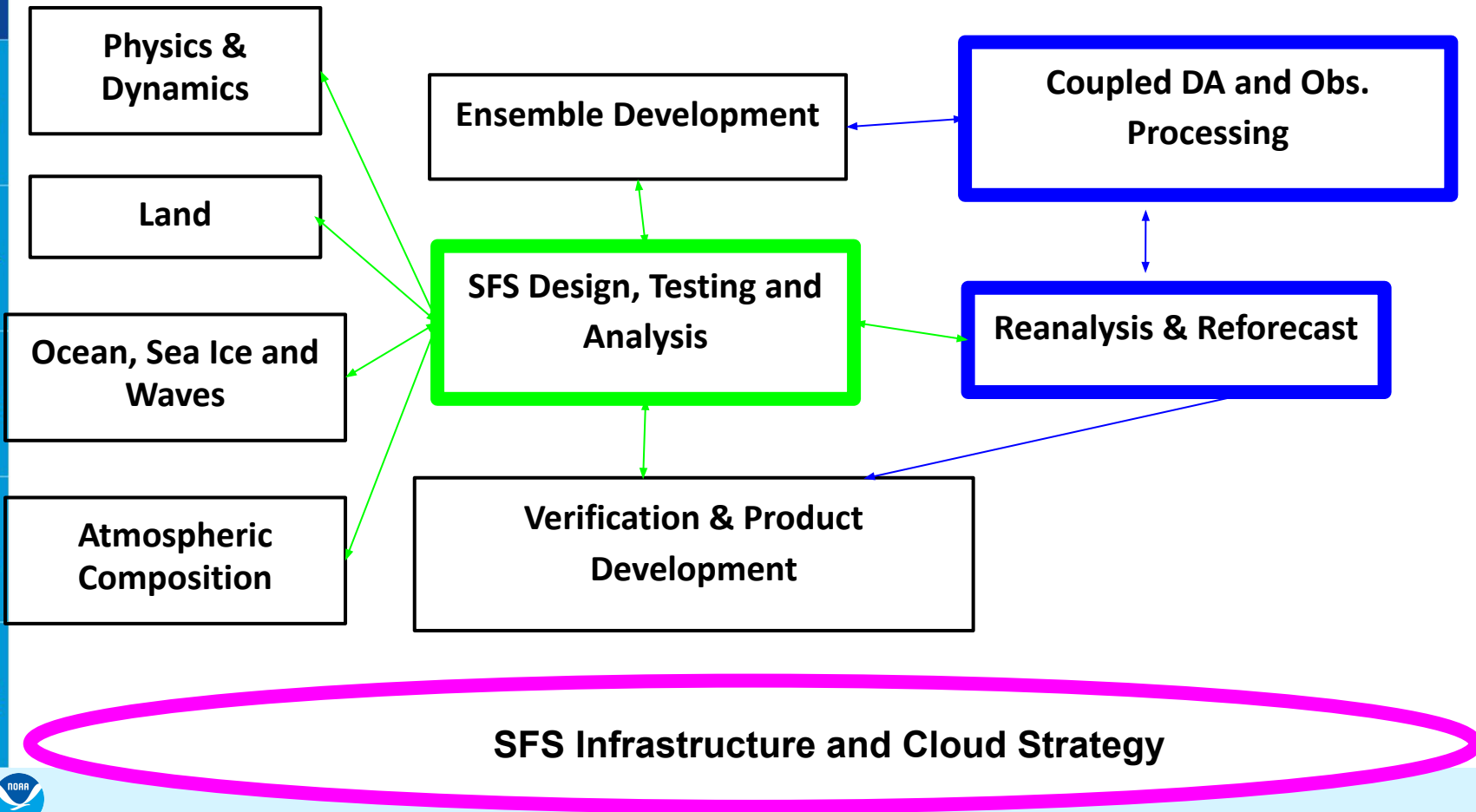
Backup Slides



SFS Application Team (Co-Leads: Avichal Mehra, Phil Pegion)

- 1) SFS Design, Testing and Analysis (Leads: Avichal Mehra, Shan Sun, Wanqiu Wang)
- 2) Physics and Dynamics Improvements (Leads: Fanglin Yang, Ligia Bernardet, Lisa Bengtsson)
- 3) Land Model Improvement (Leads: Mike Barlage, Clara Draper)
- 4) Ocean, Waves and Sea-Ice Model Improvements (Leads: Shan Sun, Neil Barton)
- 5) Aerosol and Atmospheric Composition Improvements (Lead: Ivanka Stajner)
- 6) Coupled Ensemble Strategies, Design and Development (Leads: Philip Pegion, Neil Barton)
- 7) Coupled Data Assimilation Developments and Observation (Leads: Daryl Kleist, Sergey Frolov)
- 8) SFS Reanalysis & Reforecast (Leads: Sergey Frolov, Daryl Kleist)
- 9) SFS Infrastructure and Cloud Strategy (Leads: Arun Chawla, Rahul Mahajan)
- 10) Product Developments & Verification (Leads: Wanqiu Wang, Jason Levit, Tara Jensen, Juliana Dias)

Ten Research & Development Focus Areas



Sample NWS S2S Forecast Products

- **Temperature and Precipitation Outlooks (CONUS, AK, HI)**
 - Week 2, Week 3-4, Monthly, and Seasonal
- **Monthly and Seasonal Drought Outlooks (CONUS, AK, HI)**
- **US Hazards Outlook**
 - Week 2 extremes of temperature, precipitation, and wind
- **Global Tropics Hazard Outlook**
 - Weeks 2-3 extremes of temperature and precipitation, and potential of tropical cyclones
- **Seasonal Hurricane Outlook**
- **ENSO Prediction**
- **Arctic Sea Ice Prediction**
 - Weeks 1-6, Monthly, and Seasonal

