NOAA's Seasonal Forecast System (SFS) Development Plan and SFS Application Team

Yan Xue[1], Kevin Garrett[1], Jessie Carman[2], Avichal Mehra[3], Philip Pegion[4]

[1] NOAA NWS Office of Science and Technology Integration
[2] NOAA OAR Weather Program Office
[3] NOAA NWS Environmental Modeling Center
[4] NOAA OAR Physical Science Laboratory

NATIONAL WEATHER SERVICE

UIFCW, Jul 24-28, 2023, Boulder, CO

FY23 Congressional Appropriations → Funding

$5.0M
National Weather Service (NWS)

- ***Development of Seasonal Forecast System (SFS)***

$7.1M
Oceanic & Atmospheric Research (OAR)

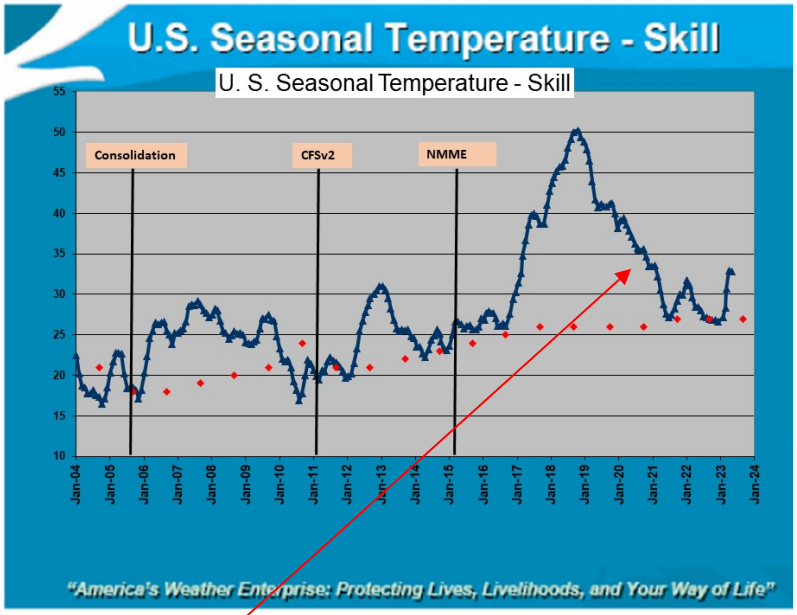
- ***Weather Program Office's S2S Research Program***

"S2S Weather Prediction: The agreement provides $12,100,000 across NOAA line offices for its efforts to ***improve S2S Weather Prediction***. This includes $5,000,000 in NWS Science and Technology Integration for the development of the ***Seasonal Forecast System*** and $7,100,000 for the S2S research program in the OAR U.S. Weather Research Program"

SFS Development Plan: 1. Introduction

- 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

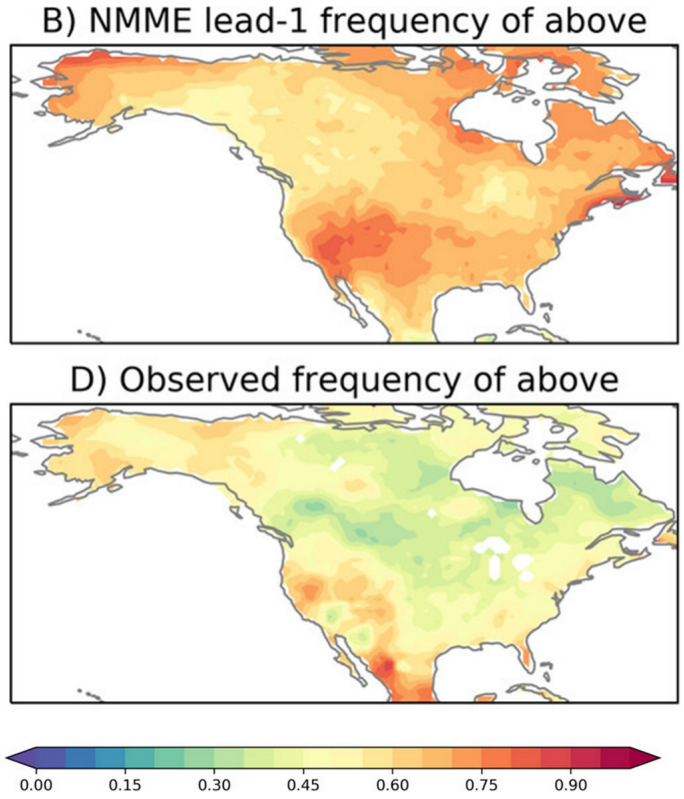
- Progress and challenges in improving U.S. seasonal temperature skill



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).

SFS Development Plan: 2. Goals and Objectives

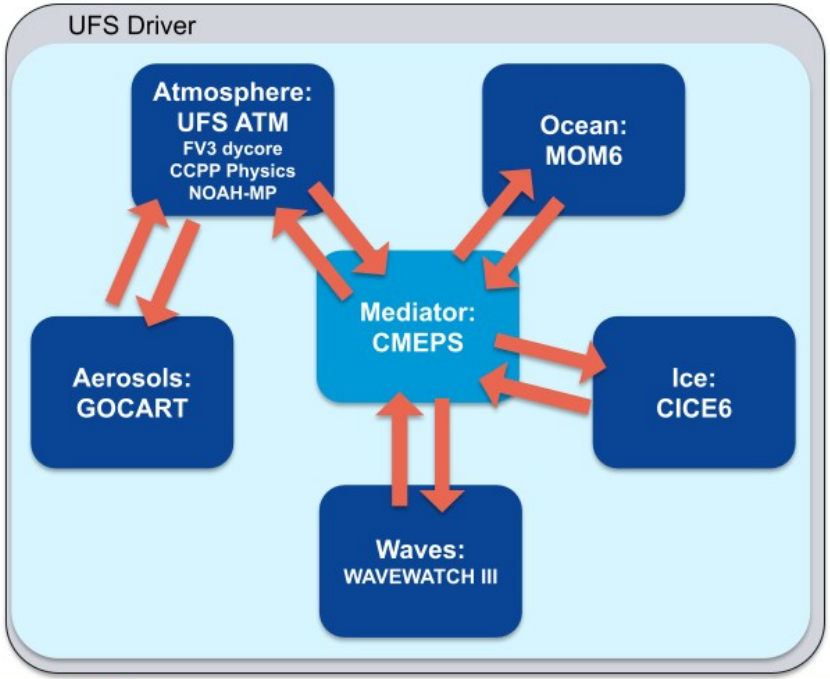
- Develop SFSv1 as a replacement of Climate Forecast System version 2 (CFSv2), a decade-old system
- Address common errors in CFSv2 and NMME
  - MJO propagation across Maritime Continent
  - False ENSO alarms
  - Positive SST trend errors in tropical Pacific
  - **Too frequent above-normal temperature forecast**
  - **Too infrequent below-normal temperature forecast**
- Release the coupled SFS system to the public
- Release reanalysis-reforecast data sets to the community



Becker et al. 2022

SFS Development Plan: 3. Transition to UFS Framework

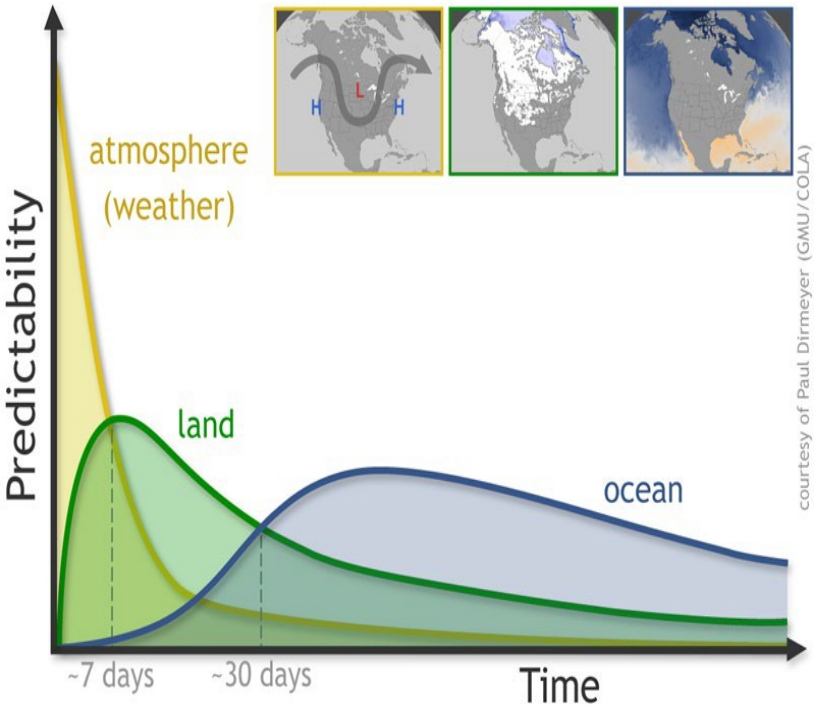
1) Finite Volume Cubed Sphere (FV3) dynamical core
2) Common Community Physics Package (CCPP)
3) Noah-Multi Parameterization Land Surface Model (Noah-MP LSM)
4) Modular Ocean Model (MOM),
5) Los Alamos Sea ice model (CICE)
6) WAVEWATCH III wave model (WW3)
7) Goddard Chemistry Aerosol Radiation and Transport (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:
GFSv17, GEFSv13, SFSv1

SFS Development Plan: 4. 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



* **Key goals of project**

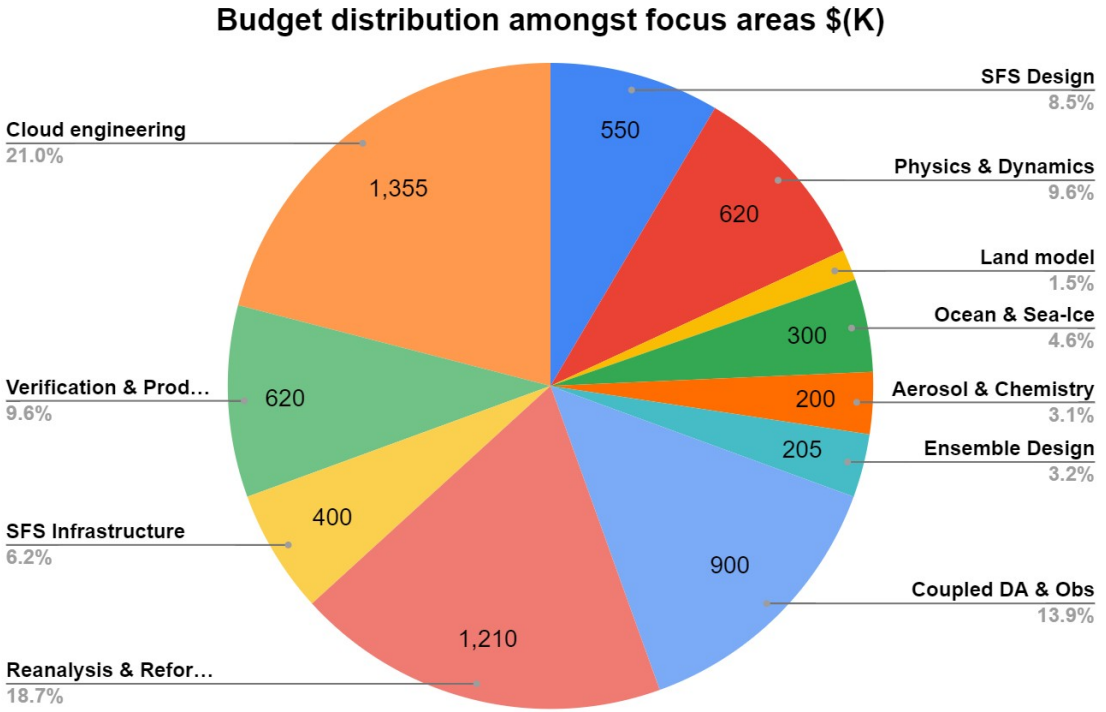
SFS Development Goals

- 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. overconfident 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***

FY23 Budget for SFS Development:

$5.0M (NWS)

$1.46M (OAR)



OFFICE OF SCIENCE & TECHNOLOGY INTEGRATION

WEATHER PROGRAM OFFICE

EMC

CPC

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, Wanqui Wang, Neil Barton)
5) Aerosol and Atmospheric Composition Improvements (Lead: Ivanka Stajner)
6) Coupled Ensemble Strategies, Design and Development (Leads: Philip Pegion, Yuejian Zhu, Neil Barton)
7) Coupled Data Assimilation Developments and Observation (Leads: Daryl Kleist, Sergey Frolov)
8) SFS Reanalysis & Reforecast (Leads: Sergey Frolov, Daryl Kleist, Phil Pegion, Yuejian Zhu)
9) SFS Infrastructure and Cloud Strategy (Leads: Arun Chawla, Rahul Mahajan, Jun Wang, Denise Worthen, Phil Pegion)
10) Product Developments & Verification (Leads: Wanqiu Wang, Jason Levit, Tara Jensen, Juliana Dias)

SFS Year 1 Plan (Oct 1, 23 - Sep 30, 24)

- SFS design & testing and analysis
  - Phase I reforecast configuration: 1-degree, GEFSv13 based, 3-month lead time, 30-years of Jan. and Jun. starts; Initialized with GEFSv13 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 physics
  - 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 (Oct 1, 23 - Sep 30, 24)

- 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
- Verification and product development
  - Verification and diagnostics package, science evaluation to meet stakeholder needs

We welcome feedback and seek collaboration!

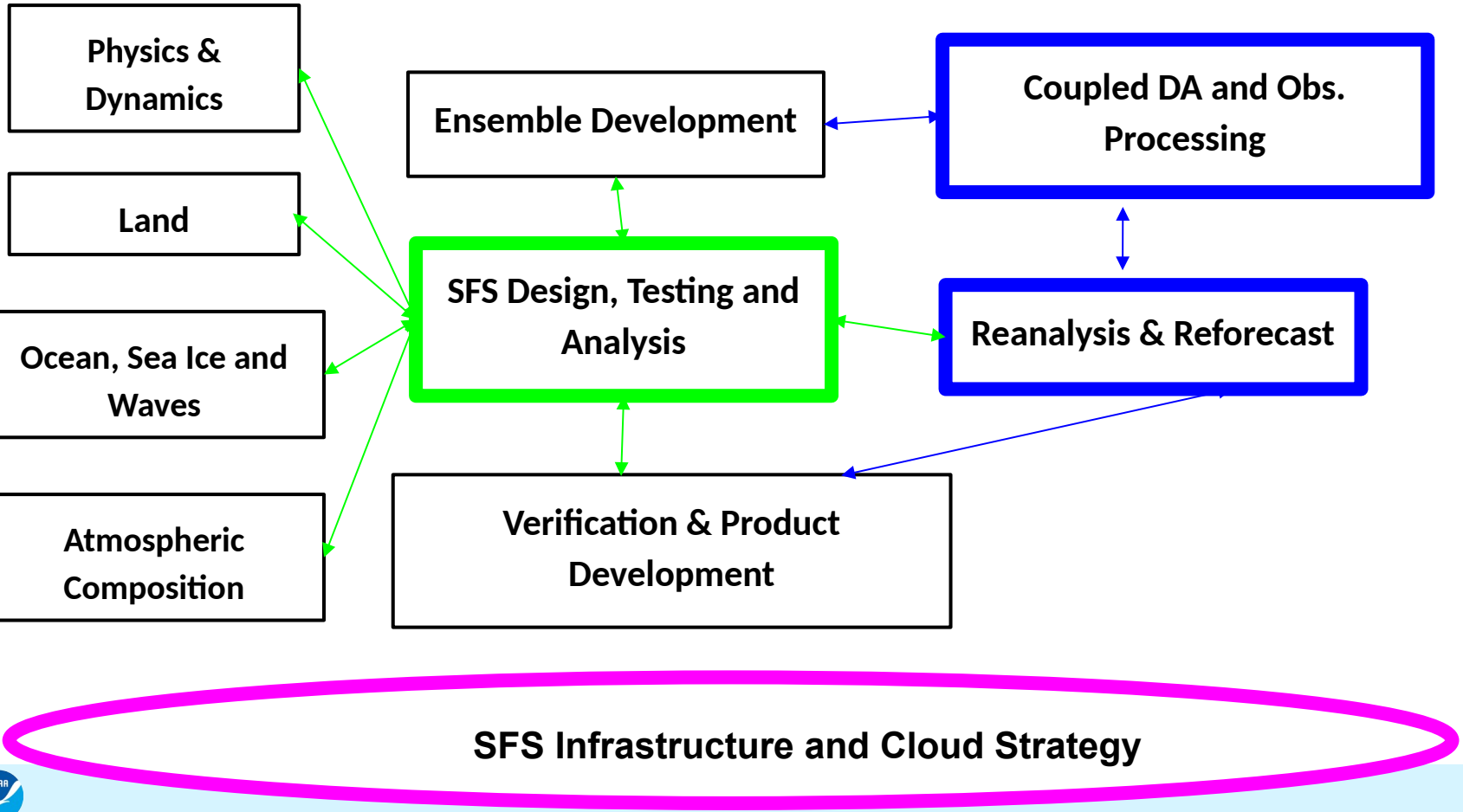
Yan Xue: NWS/OSTI-Modeling, S2S Lead, Yan.Xue@noaa.gov

Kevin Garrett: NWS/OSTI-Modeling, Director, Kevin.Garrett@noaa.gov

Jessie Carman: OAR/WPO, S2S Program Manager, Jessie.Carman@noaa.gov

Avichal Mehra: NWS/NCEP/EMC, Co-Lead SFS AT, Avichal.Mehra@noaa.gov

Ten Research & Development Focus Areas



NWS Weather, Subseasonal, Seasonal Forecast Systems:

Transition to Global Coupled UFS-based Systems

Current Systems

GFS v16 (since March 2021) Weather (0-14 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

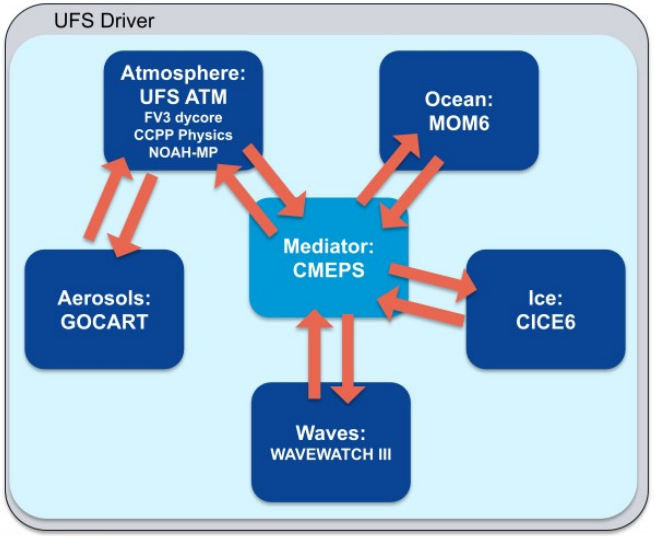
Future UFS Systems

GFS v17 (T2O Phase)

GEFS v13 (T2O Phase)

SFS v1 (Planning Phase)

UFS System Configuration



NWS Subseasonal-to-Seasonal Forecast

- **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