



**NOAA**  
**WEATHER**  
PROGRAM OFFICE

July 5, 2023

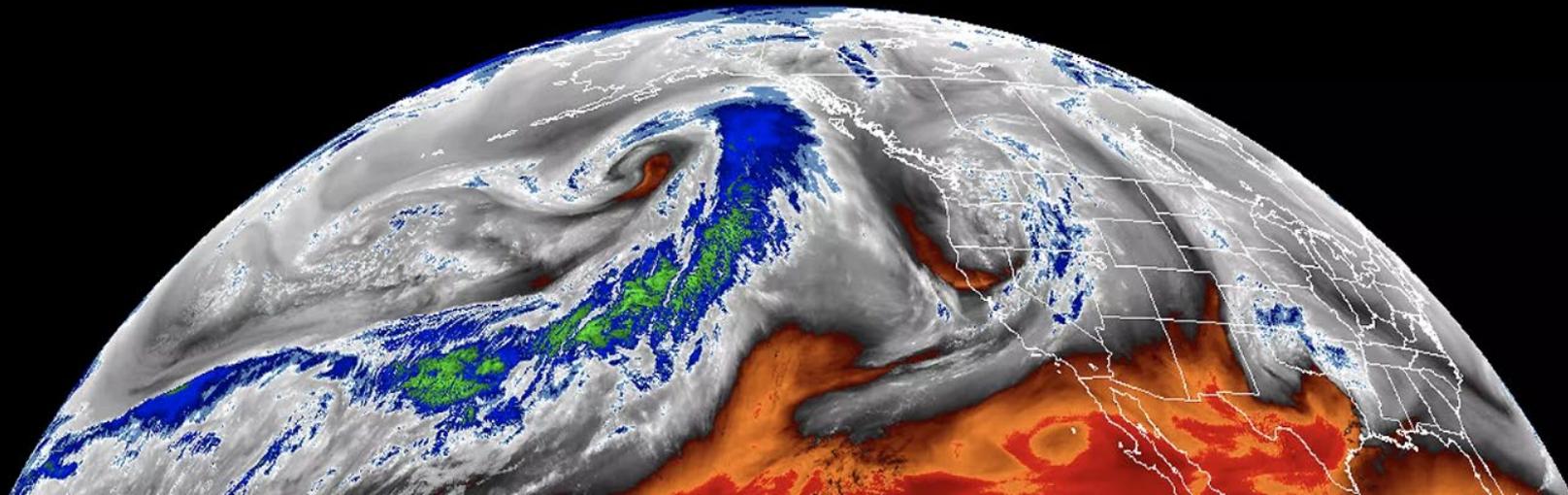
# NOAA's S2S Program Plan and Project Highlights

Dorothy Koch<sup>1</sup>, Mark Olsen<sup>1</sup>, **Jessie Carman<sup>1</sup>**, Kevin Garrett<sup>2</sup>,  
Yan Xue<sup>2</sup>, Vijay Tallapragada<sup>3</sup>

<sup>1</sup>NOAA OAR Weather Program Office

<sup>2</sup>NOAA NWS Office of Science and Technology Integration

<sup>3</sup>NOAA NWS Environmental Modeling Center



## FY23 Congressional Appropriations → Funding

Subseasonal to Seasonal (S2S) Weather Prediction - Total Congressional Appropriation of \$12.1M specifically for S2S

**\$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*

**\$19.2M**

Other synergistic activities

- *\$12.2M → Water in the West Initiative*
- *\$7M → OAR & NWS Fire Wx Forecasting*

NOAA is also encouraged to pursue a pilot project for S2S precipitation forecasts supporting water management in the western U.S.

# NOAA's S2S Goals: In Development

## Goals:

- Improve S2S forecast skill
- Enhance S2S products for stakeholders



Develop UFS  
Seasonal  
Forecast  
System (SFS) v1



Improve  
prediction &  
predictability;  
address model  
biases



Operational  
forecast goals



Post-processing



Improve  
communication  
of seasonal  
forecasts and  
uncertainty

# NOAA's S2S Goals: In Development

## Goals:

- Improve S2S forecast skill
- Enhance S2S products for stakeholders



Develop UFS  
Seasonal  
Forecast  
System (SFS) v1



Improve  
prediction &  
predictability;  
address model  
biases



Operational  
forecast goals



Post-processing



Improve  
communication  
of seasonal  
forecasts and  
uncertainty

- Improve data assimilation, especially coupled DA
- Conduct Reanalysis/reforecast for extended range
- Component developments, especially land, atmospheric chemistry, ocean, and ice

# NOAA's S2S Goals: In Development

## Goals:

- Improve S2S forecast skill
- Enhance S2S products for stakeholders



Develop UFS  
Seasonal  
Forecast  
System (SFS) v1



Improve  
prediction &  
predictability;  
address model  
biases



Operational  
forecast goals



Post-processing



Improve  
communication  
of seasonal  
forecasts and  
uncertainty

- Improved coupled modeling ability
- Improved (fully coupled) data assimilation

# NOAA's S2S Goals: In Development

## Goals:

- Improve S2S forecast skill
- Enhance S2S products for stakeholders



Develop UFS  
Seasonal  
Forecast  
System (SFS) v1



Improve  
prediction &  
predictability;  
address model  
biases



Operational  
forecast goals

- Temperature
- Precipitation
- Storm outlook



Post-processing



Improve  
communication  
of seasonal  
forecasts and  
uncertainty

# NOAA's S2S Goals: In Development

## Goals:

- Improve S2S forecast skill
- Enhance S2S products for stakeholders



Develop UFS  
Seasonal  
Forecast  
System (SFS) v1



Improve  
prediction &  
predictability;  
address model  
biases



Operational  
forecast goals



Post-processing



Improve  
communication  
of seasonal  
forecasts and  
uncertainty

- Diagnostic and verification tools
- Innovative statistical techniques
- Include AI/ML

# NOAA's S2S Goals: In Development

## Goals:

- Improve S2S forecast skill
- Enhance S2S products for stakeholders



Develop UFS  
Seasonal  
Forecast  
System (SFS) v1



Improve  
prediction &  
predictability;  
address model  
biases



Operational  
forecast goals



Post-processing



Improve  
communication  
of seasonal  
forecasts and  
uncertainty

- Temp/Precip
- Extremes,  
compound events
- Uncertainty

# 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

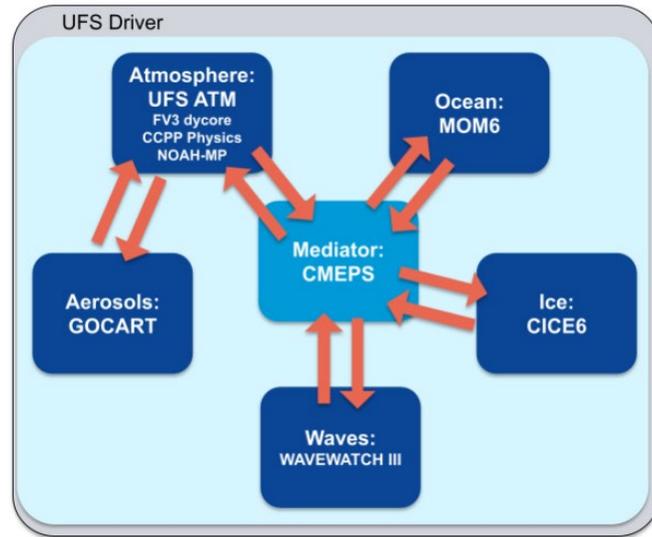
### Future UFS Systems

**GFS v17**

**GEFS v13**

**SFS v1**

### UFS System Configuration



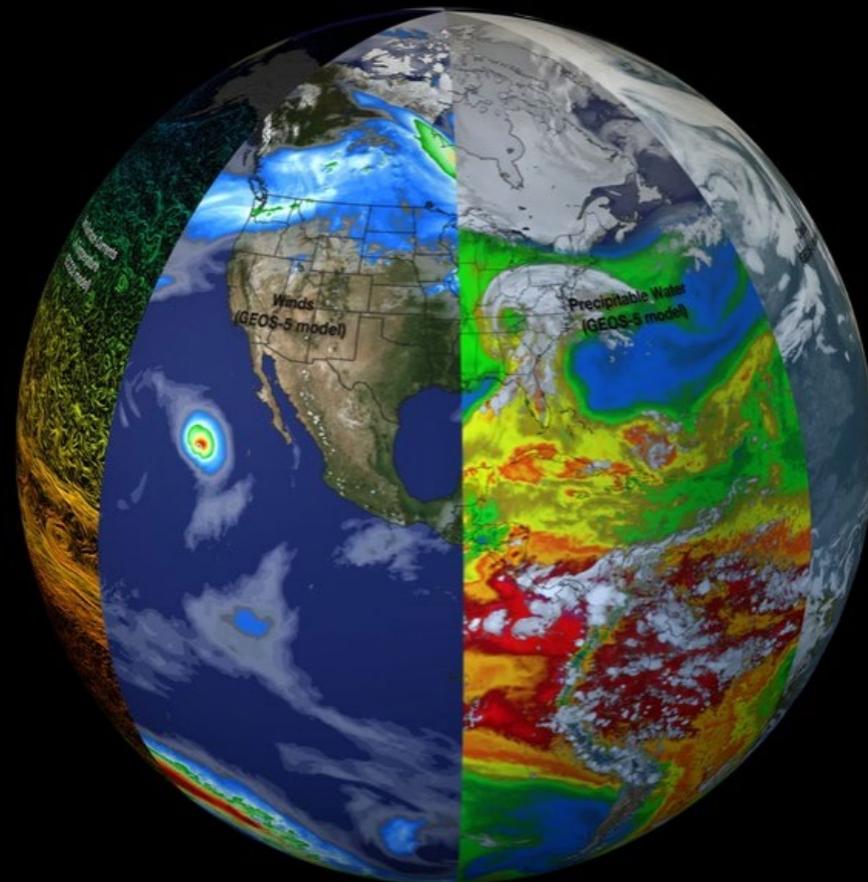
# NOAA SFS Development Plan

## GOALS:

- 1) Balanced **initializations** across interfaces
- 2) **Minimize systematic drift** from initial conditions
- 3) Best **estimation of uncertainties** in ensemble forecasts
- 4) **Reduce systematic biases** and improve forecast skill
- 5) **SFS infrastructure** should provide critical support

## SFS will be:

- Enabled to run in the cloud
- Incorporated into UFS repositories
- Provided to community through the Earth Prediction Innovation Center (EPIC)



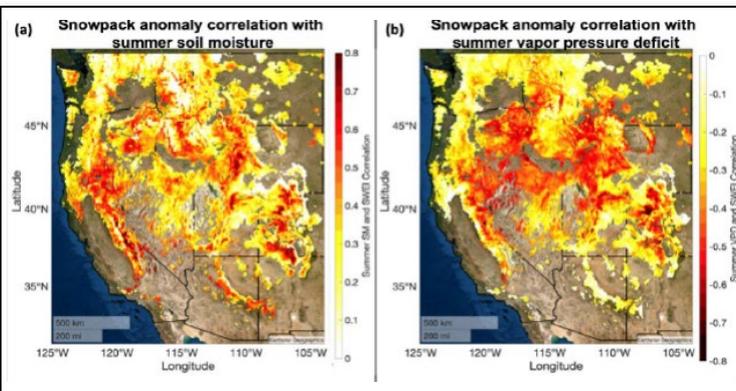
# HIGHLIGHTS: WPO External Projects (Research and Development)

S2S Program funded research developing the UFS S2S and the Global Ensemble Forecast System:



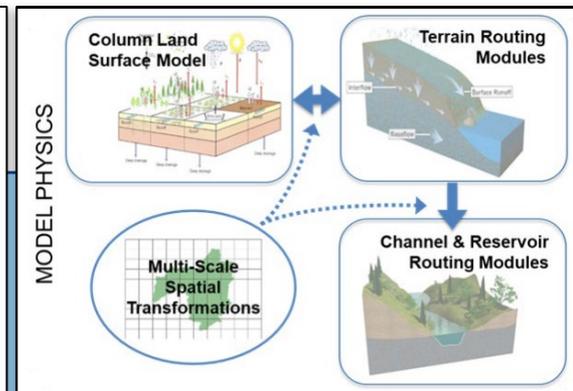
**Assessing the impact of dynamic vegetation on drought forecasts**  
(Otkin - U. Wisconsin)

**PRIMARY GOAL:** Compare UFS vegetation treatments, particularly flash drought



**Enhancing NOAA UFS subseasonal to seasonal predictions of precipitation and drought via improved representation of snowpack processes**  
(He - NCAR)

**PRIMARY GOAL:** Advance understanding/modeling of aerosols, vegetation, processes on snowpack in UFS—correlates with summer vapor pressure

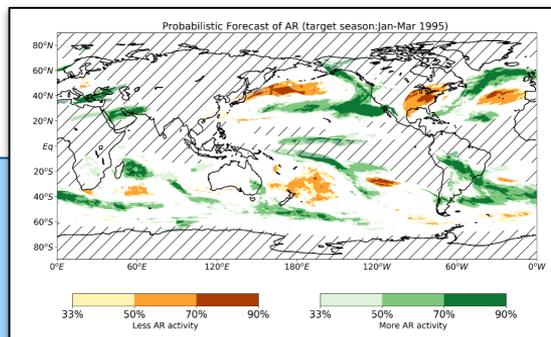


**Integrated surface physics for coupled hydrometeorology in the UFS for S2S prediction**  
(Gochis - NCAR)

**PRIMARY GOAL:** Extend Noah-MP+WRF-Hydro globally, update coupling, to connect NWP→S2S terrestrial hydrologic processes

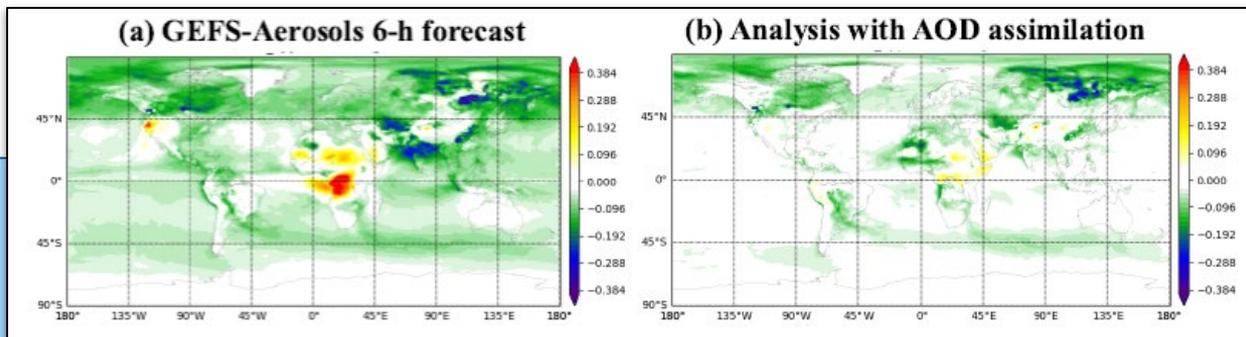
# HIGHLIGHTS: Climate Test Bed (Development and Demonstration)

In partnership with the Climate Prediction Center (CPC) and the Environmental Modeling Center (EMC), S2S Program research advancing NOAA's operational S2S prediction capabilities:



**Development of a Global Aerosol Reanalysis at NOAA in Support of Climate Monitoring and Prediction**  
Huang (CU Boulder)

**PRIMARY GOAL:** Add an Aerosol Optical Depth (AOD) to JEDI-based data assimilation, which is crucial for one of UFS components



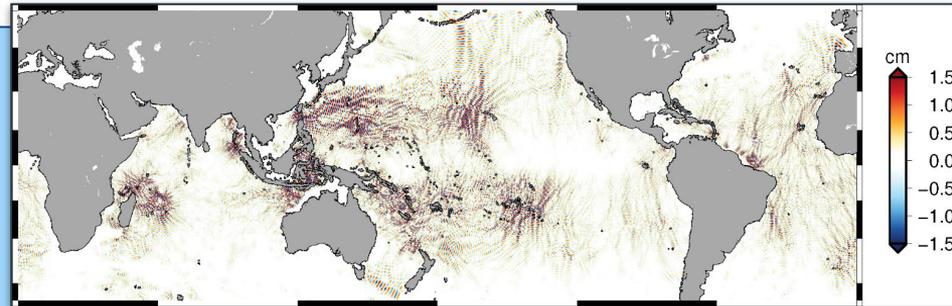
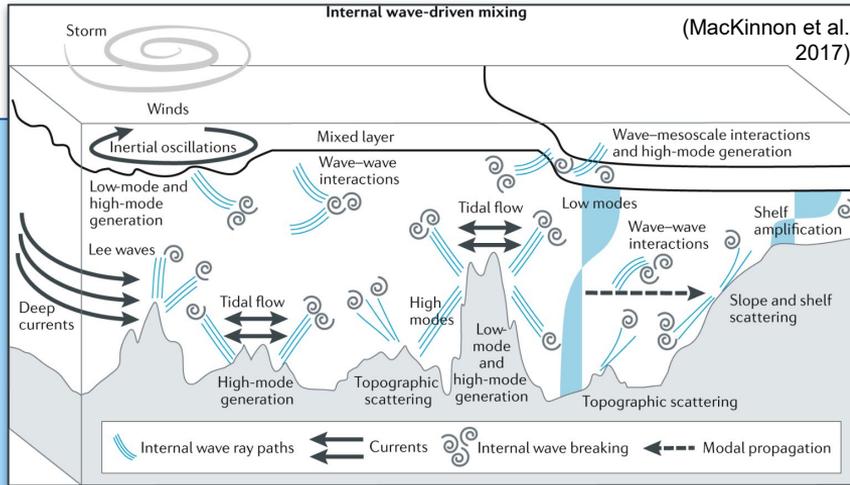
**Transitioning NMME-based seasonal predictions of atmospheric river activity into an operational forecast product**  
Xiang (UCAR/GFDL)

**PRIMARY GOAL:** Create a seasonal AR forecast tool



# HIGHLIGHTS: NOPP

WPO participated in FY22's Office of Naval Research's Oceanographic Partnership Program (NOPP), which is a funding opportunity requiring cross-agency collaboration.



**PRIMARY GOAL:** Simulate tides with MOM6, ocean mixing caused by internal tides, and climate scale ocean-cryosphere interactions

## WPO's interest:

- High-resolution MOM6 projects
- Leverage NOAA/NOPP matching
- Partnership with other agencies

**High Resolution Ocean Models for Coupled Earth System Prediction Across Space and Time Scales**  
Zaron (Oregon State University)

## Multi-Model Ensembles (MMEs)

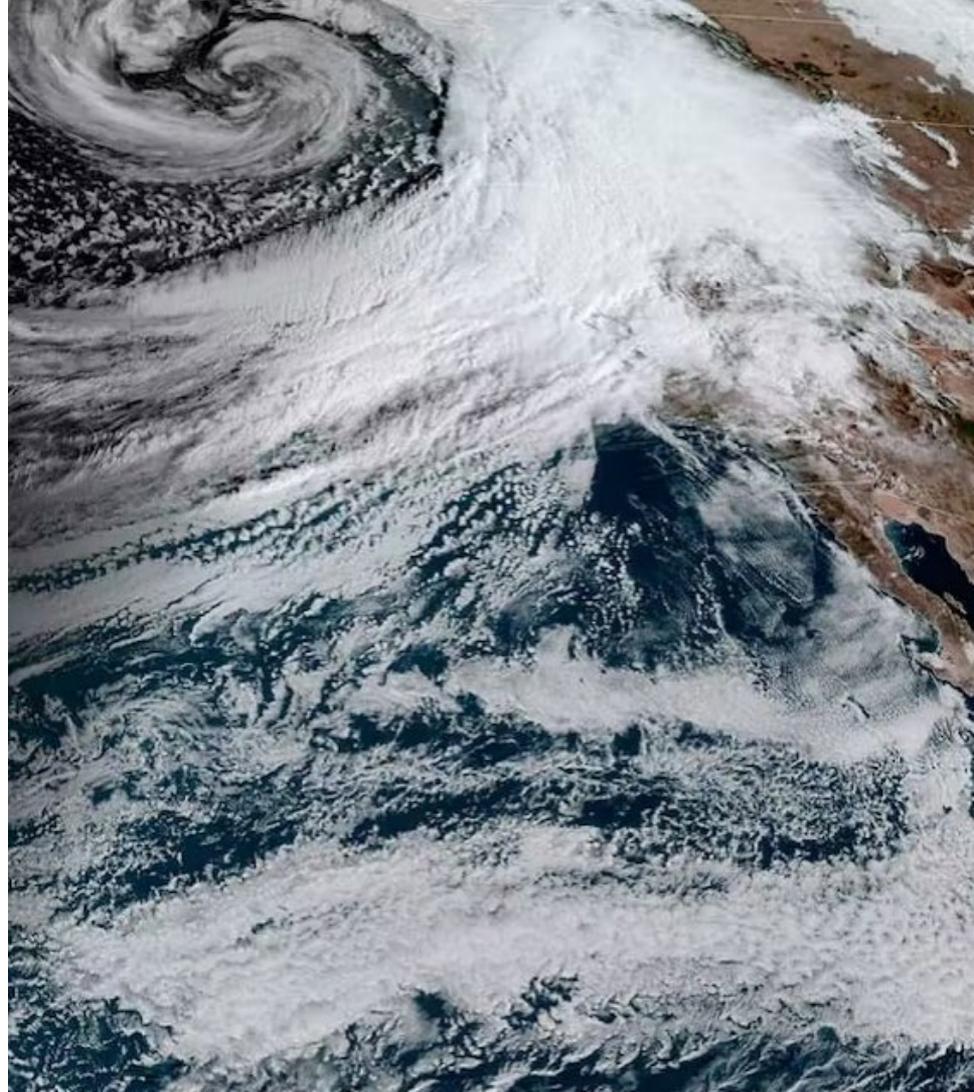
Real-time, updating, multi-model ensembles over the S2S timescale pull greater unified benefit from multiple investments.

### **Subseasonal Experiment (SubX)**

- Discontinued in FY23 due to limited funds and congressional guidance for S2S Program

### **North American Multi-model Ensemble (NMME)**

- NMME: Meeting Future Needs workshop held two weeks ago and explored:
  - Potential data and product needs for research and decision support
  - Required infrastructure and cost to support data and product needs





# Bridging the Gap to Decisions

## Western U.S. Hydrology

- Congressional appropriations provided first directed funding in FY22
- FY23 appropriations specified an increased focus

## Western U.S. Hydroclimatological Study

- Congressional directive to conduct a study of hydroclimatological changes in major river basins of the western U.S. over the next 30 years

## MME efforts

- Partnerships with other agencies
- Provide multiple research and operational benefits over these timescales



# Pathway to Seamless Weather-to-Climate Prediction

Support UFS SFS development

External competitions/community support

Internal competitions/NOAA support

Infrastructure support furthering community  
use/access, including EPIC and cloud

External agency and international partnerships

**Workshop planned for  
further planning with S2S  
community (*tentatively  
this winter*)**

**We invite and welcome any  
collaboration/coordination!**

**Contact:**

Dr. Mark Olsen (OAR): [mark.olsen@noaa.gov](mailto:mark.olsen@noaa.gov)

Dr. Yan Xue (NWS): [yan.xue@noaa.gov](mailto:yan.xue@noaa.gov)

# Pathway to Seamless Weather-to-Climate Prediction

Support UFS SFS development

External competitions/community support

Internal competitions/NOAA support

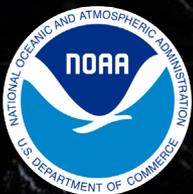
Infrastructure support furthering community  
use/access, including EPIC and cloud

External agency and international partnerships

## American Meteorological Society 2024 Annual Meeting

Baltimore, Maryland

1. Subseasonal-to-seasonal (S2S) Part 1: Stakeholder needs and priorities
2. Subseasonal-to-seasonal (S2S) Part 2: Predictions and predictability
3. Subseasonal-to-seasonal (S2S) Part 3: S2S Model developments and innovations



**NOAA**  
**WEATHER**  
PROGRAM OFFICE

# THANK YOU



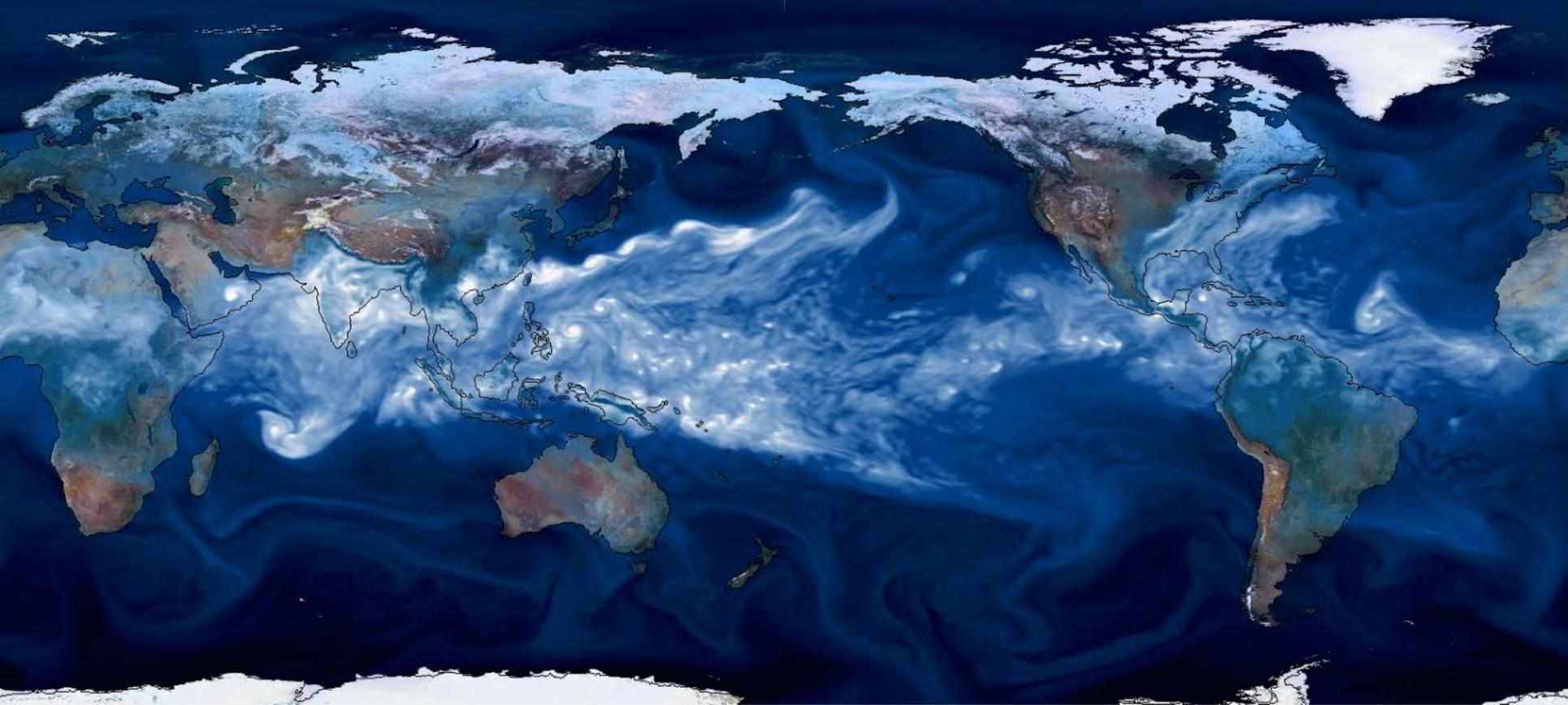
[wpo.noaa.gov](http://wpo.noaa.gov)



[@NOAA\\_WPO](https://twitter.com/NOAA_WPO)



# Supplementary Slides



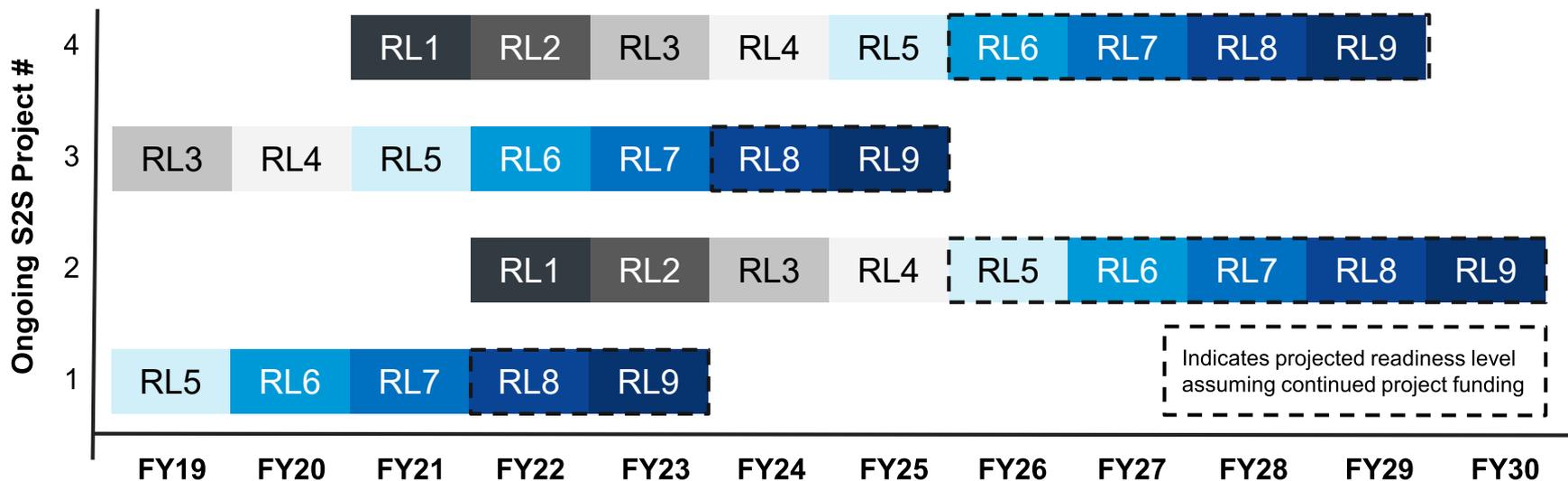
# Next Generation S2S: SFS v2

## Lab Efforts

- WPO is coordinating with NOAA labs to develop a high-level assessment of S2S work
- **GOAL:** Identify research/development gaps and needs

## WPO Efforts

- Fund projects at varying levels of development, or readiness levels (RLs, RL9 is operation-ready) to address gaps and needs

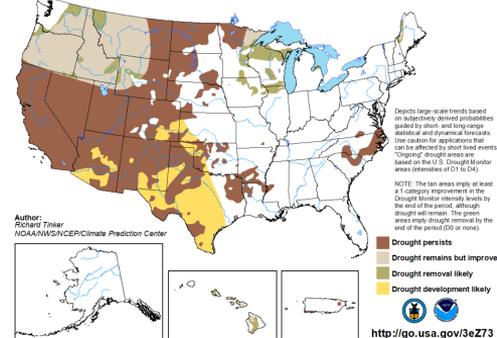




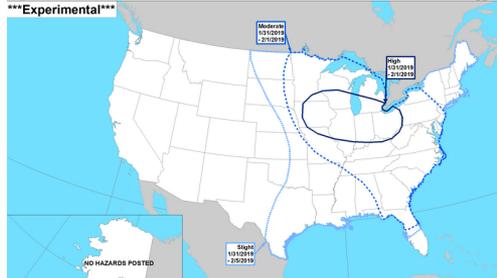
# NWS Subseasonal-to-Seasonal Forecasts

- **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

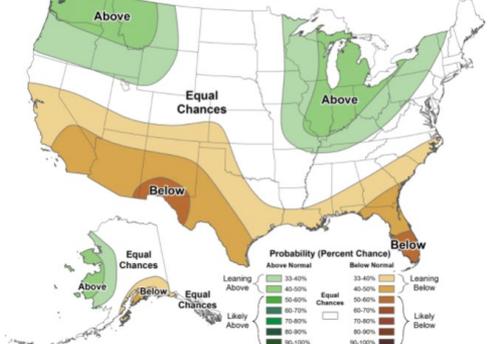
U.S. Seasonal Drought Outlook Valid for November 18, 2021 - February 28, 2022  
Drought Tendency During the Valid Period Released November 18, 2021



Risk of Hazardous Temperatures Valid: 01/31/2019-02/06/2019



Seasonal Precipitation Outlook Valid: Dec-Jan-Feb 2021-22 Issued: November 18, 2021



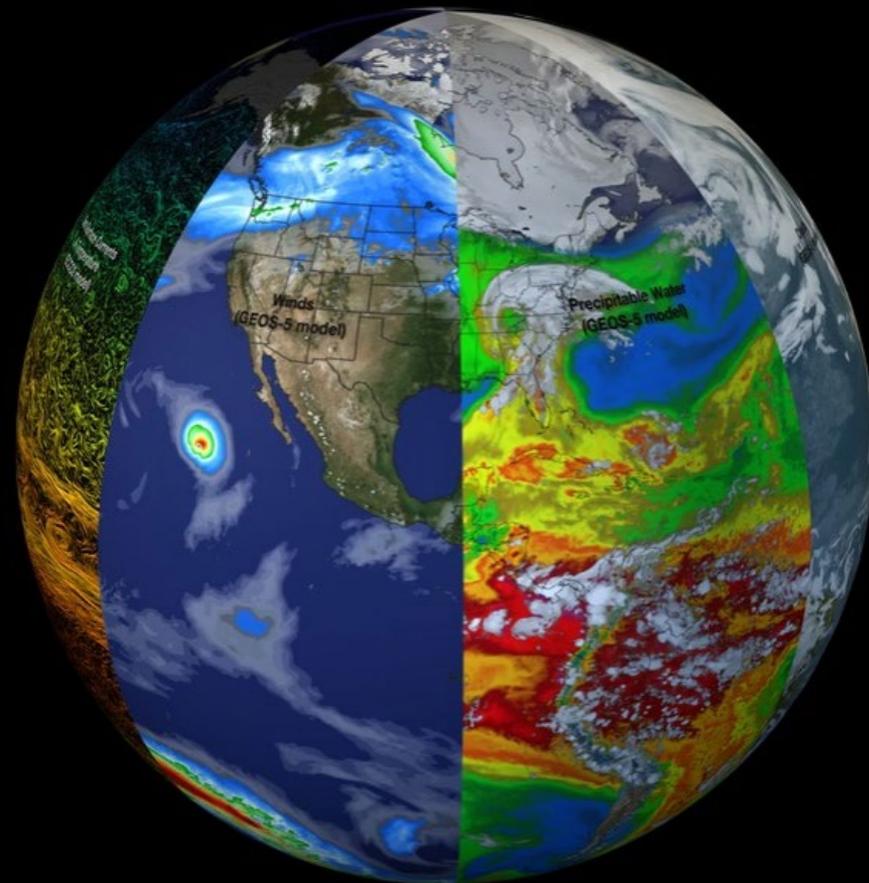
# NOAA SFS Development Plan

A team of NOAA scientists are drafting an SFS Development Plan that will provide requirements for development and implementation of SFS v1.

The SFS will replace the current operational Climate Forecast System (v2).

## Year 1 (Oct 23-Sept 24): Preliminary Capability

- Includes initial configuration of coupled model and baseline skill evaluation
- Coupled reanalysis scout runs
- SFS global workflow
- Initial verification and diagnostics package



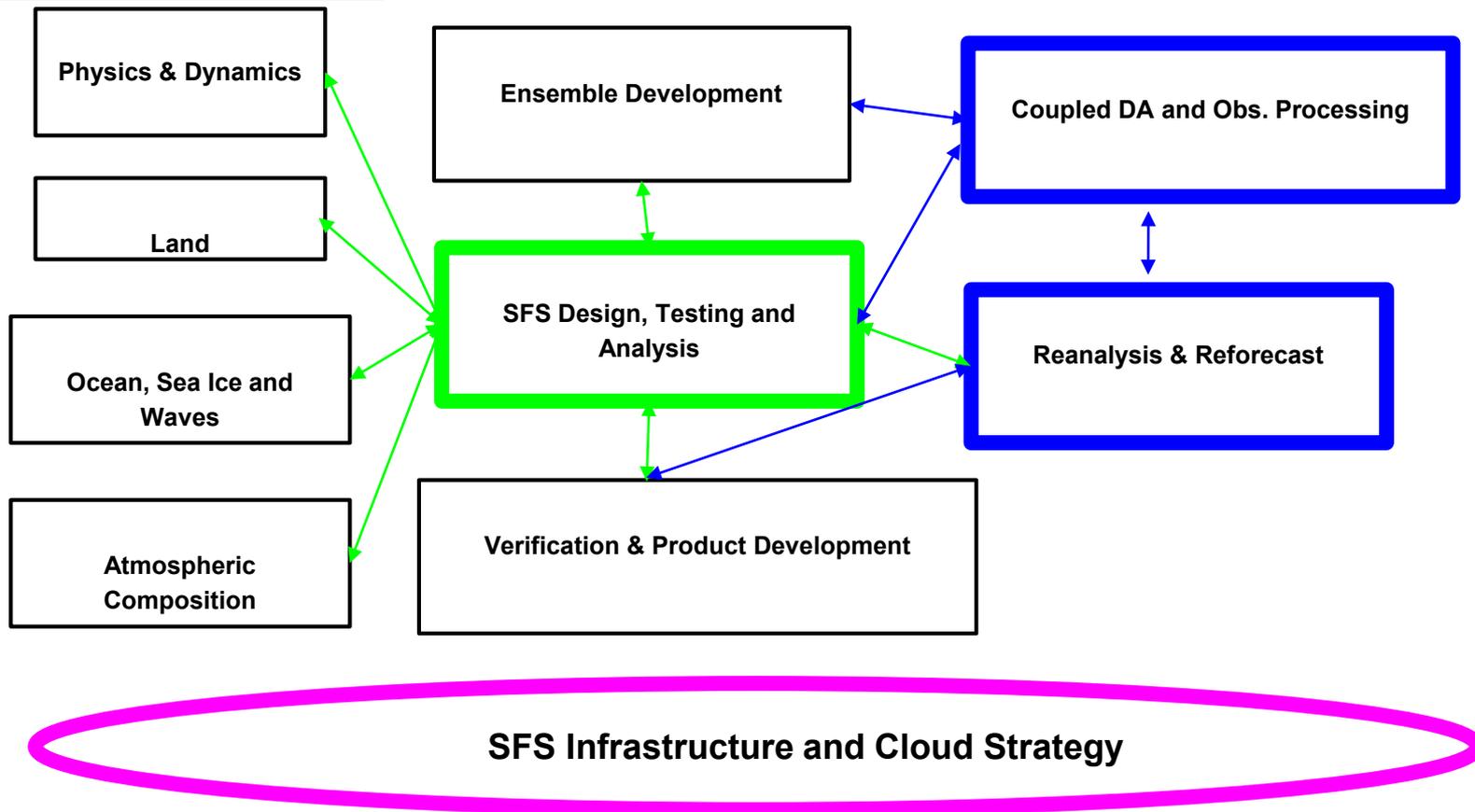
# SFS Development Plan Writing Team

Name	OAR	Focus Areas
Ligia Bernardet	GSL	Physics, prototype
Shan Sun	GSL	Prototype, ocean, sea ice
<b>Philip Pegion</b>	<b>PSL</b>	Ensemble, prototype, reforecast, infrastructure/cloud
Juliana Dias	PSL	Verification and diagnostics
Sergey Frolov	PSL	Reanalysis, coupled DA, infrastructure/cloud
Clara Draper	PSL	Land
Greg Frost	CSL	Atmospheric composition

Name	NWS	Focus Areas
David DeWitt	NWS/CPC	Product & verification
<b>Wanqiu Wang</b>	<b>NWS/CPC</b>	Product & verification Prototype, ocean, sea ice, reforecast

Name	NWS	Focus Areas
Vijay Tallapragada	NWS/EMC	
<b>Avichal Mehra</b>	<b>NWS/EMC</b>	Prototype, CONOPS
Arun Chawla	NWS/EMC	Infrastructure/cloud, CONOPS
Daryl Kleist	NWS/EMC	Coupled DA, reanalysis
Fanglin Yang	NWS/EMC	Physics, prototype
Ivanka Stajner	NWS/EMC	Atmospheric composition
Mike Barlage	NWS/EMC	Land
Yuejian Zhu	NWS/EMC	Ensemble, reforecast
Neil Barton	NWS/EMC	Ocean, sea ice, ensemble
Jun Wang	NWS/EMC	Infrastructure/Cloud
Rahul Mahajan	NWS/EMC	Infrastructure/Cloud

# SFS Development Plan: 10 Focus Areas



# SEASONAL TO SUBSEASONAL FORECASTS

Subseasonal to Seasonal (S2S) program seeks to advance two goals identified by NOAA and in the Weather Act:

- Improving the skill of S2S forecasts
- Enhancing the value of S2S products for stakeholders

***Subseasonal*** forecasts address weather between ***two weeks and three months***.

***Seasonal*** forecasts address weather between ***three months and two years***.



## REPORT TO CONGRESS

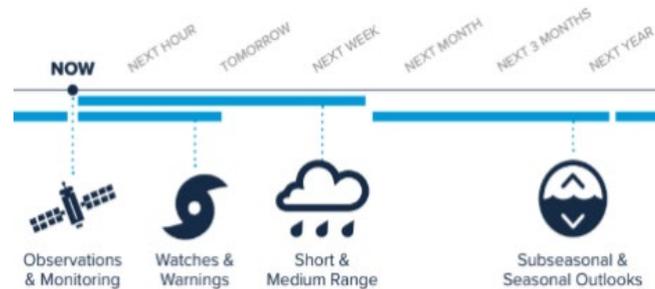
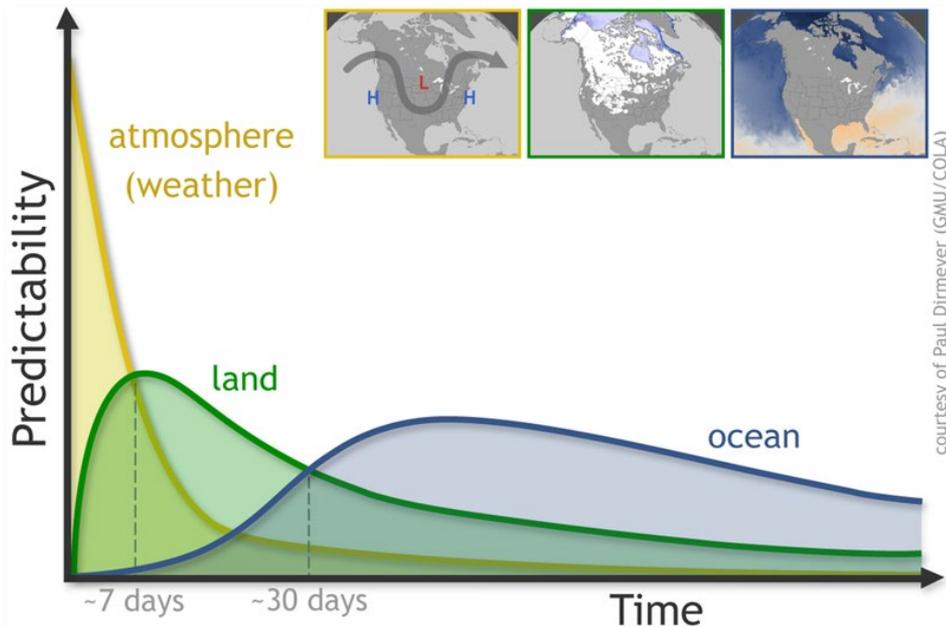
SUBSEASONAL AND SEASONAL FORECASTING  
INNOVATION: PLANS FOR THE TWENTY-FIRST  
CENTURY

Developed pursuant to  
Section 201 of the Weather Research and Forecasting Innovation Act of 2017.  
(Public Law 115-25)



# S2S FOCUS AREAS

NOAA provides a suite of weather and climate products from near-term forecasts to long-term projections.



1

Improving S2S model skill by emphasizing global coupled modeling in the UFS, postprocessing and product support tools

2

Stakeholder-driven product development that creates jobs, boosts economies and builds resilience to extreme events

# SUBSEASONAL TO SEASONAL (S2S) PROGRAM

## Our Drive

Address the increasing need for actionable S2S predictions and decision support as climate changes and population increases in hazardous areas (coasts, deserts).

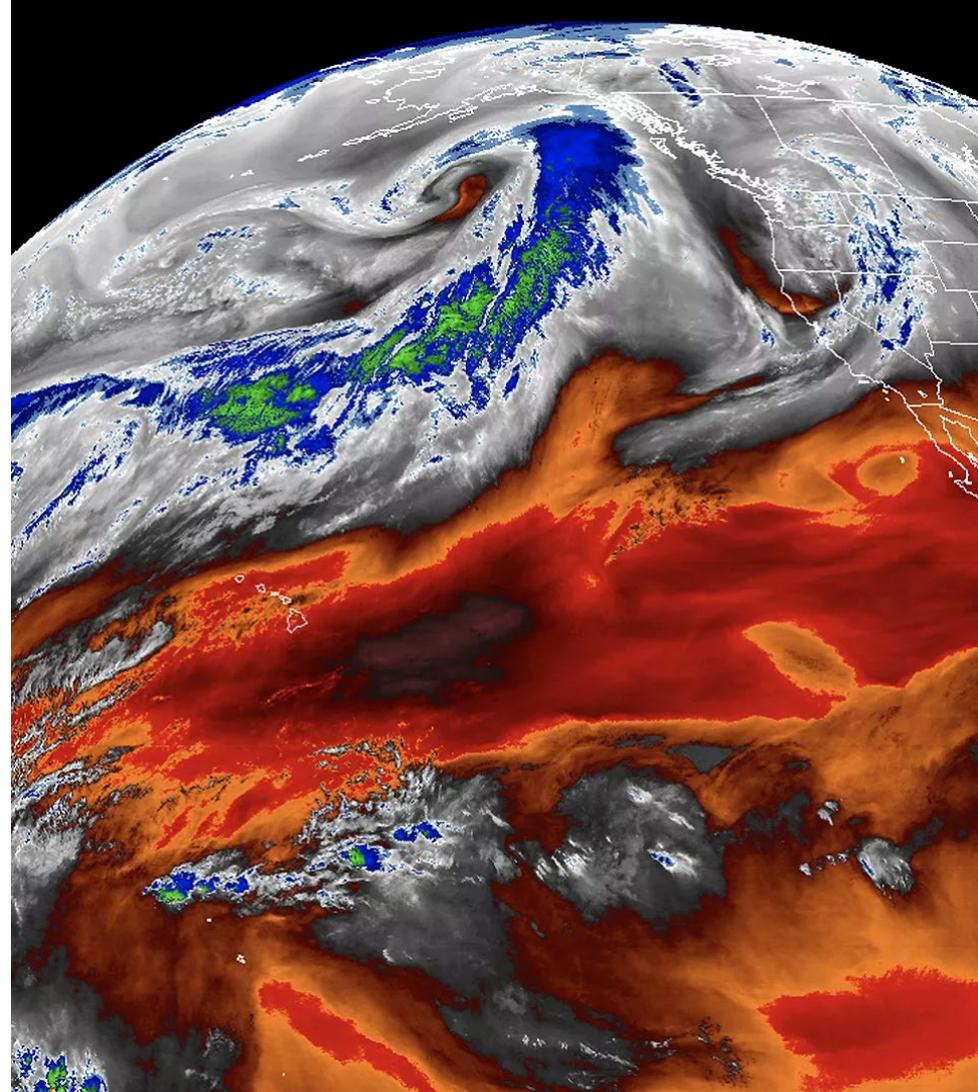
Support for UFS model component development

NOAA and external competitions

Innovations for Community Modeling

Interagency coordination and partnership

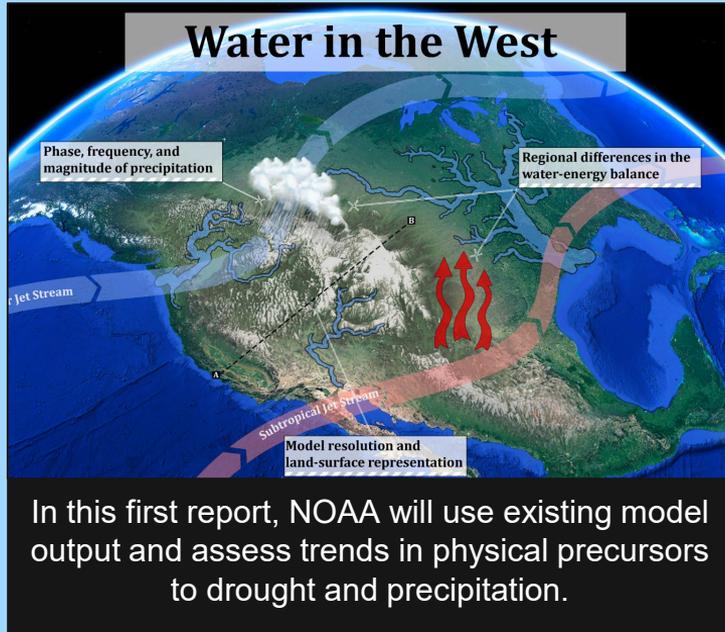
Looking forward: Western States Hydrology



# WESTERN STATES HYDROLOGY

## FY22 Congressional Directive

“NOAA [in collaboration with USGCRP and other partners] shall **conduct a study of hydroclimatological changes in the major river basins of the Western United States over the next 30 years.**”



**CPO** led drafting, review, and submission of the **interagency plan**. **WPO** received a \$2M increase for coordinating the **study**. This funding will support assessments of:

Geophysical Fluid Dynamics Laboratory

Larger-scale changes in precip., snow, heat, and extreme events within seasonal and decadal changes

Physical Science Laboratory

Baroclinic waves, atmospheric blocking, relationships to teleconnections (e.g., MJO, ENSO, etc.) within larger circulation patterns

S2S Program (WPO)

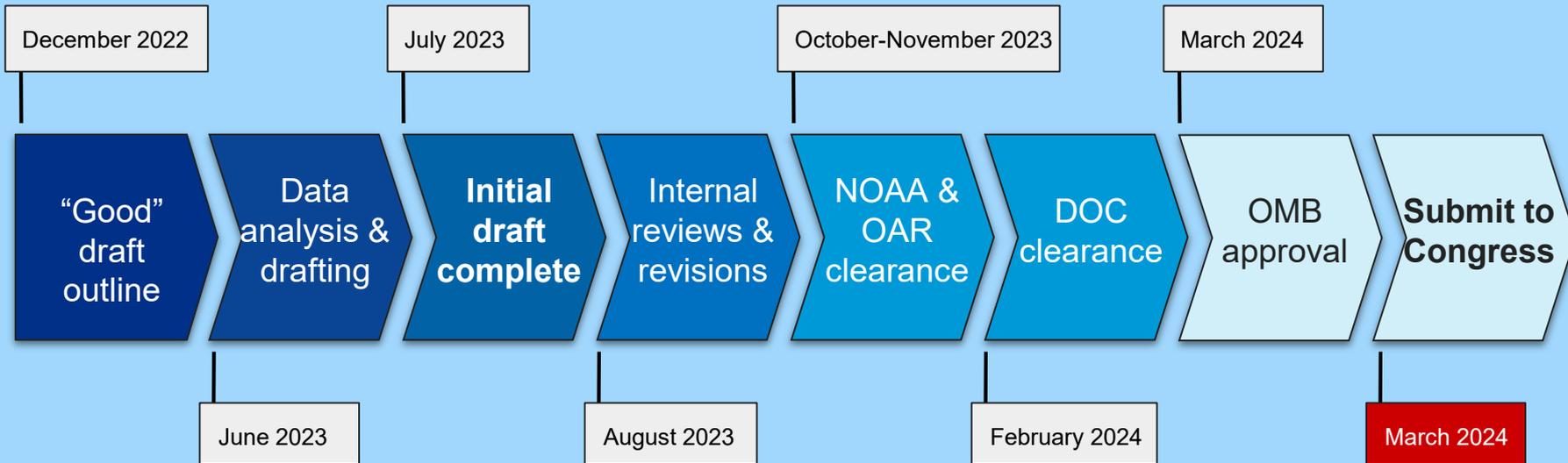
UFS prediction of Western States hydrological factors and land modeling (FY22)

# WESTERN STATES HYDROLOGY

## FY22 Congressional Directive

**Strategy:** Use existing output from NOAA and other-agency models for initial assessments.

- Provide preliminary assessments
- Highlight the need for more in-depth work
- Show what's possible with long-term effort



# WESTERN STATES HYDROLOGY

## FY22 Congressional Directive

### NOAA Geophysical Fluid Dynamics Laboratory

- Validate km-scale simulations, potential changes in warmed-climate simulations, for decision-support of precip events e.g. ARs/MCCs.
- Assess SPEAR output for changing WS hydroclimate on seasonal to decadal timescales, e.g. snow cover, river flow, drought/heat waves

### NOAA Physical Sciences Laboratory

- Study changes in baroclinic waves delivering precip, changes in S2S precip and temp extremes via CESM ensemble
- Identify changes in large-scale flow regimes, e.g. blocking, QBO, ENSO, MJO.

