# How NOAA Proposes to Improve Sub-seasonal to Seasonal (S2S) Forecasts.

Tom Hamill

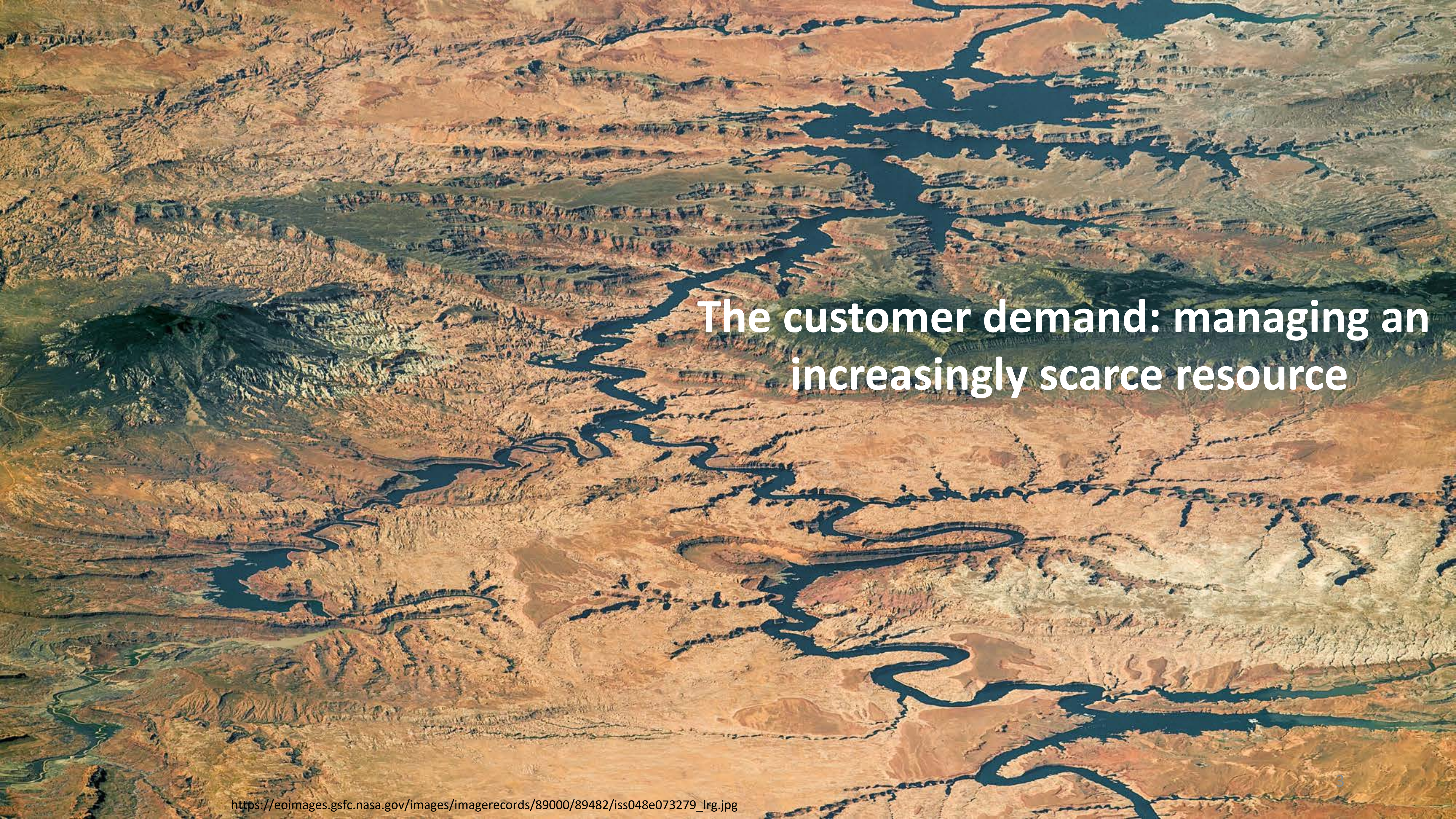
*NOAA Earth System Research Lab, Physical Sciences Division, Boulder, Colorado*

(303) 497-3060 ; tom.hamill@noaa.gov

# Topics today

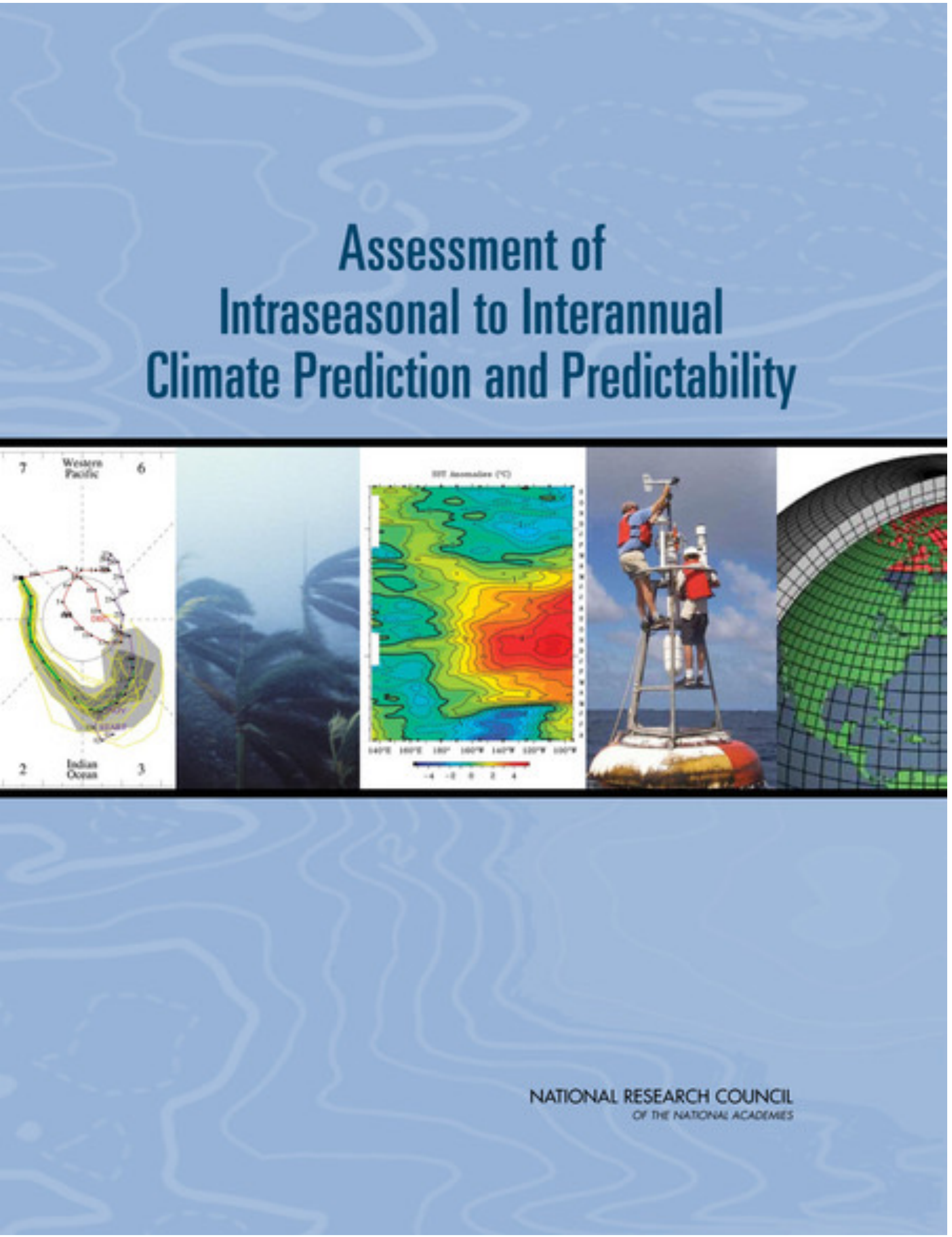
- Why is NOAA increasingly interested in S2S forecasts?
- NOAA's current NGGPS and nascent S2S projects.
- S2S predictability: potential sources of skill for S2S forecasts, and research challenges/needs to model them correctly.
- A roadmap for improving NOAA's S2S predictions.
  - Demonstration project for seasonal western US precipitation.
- Conclusions.

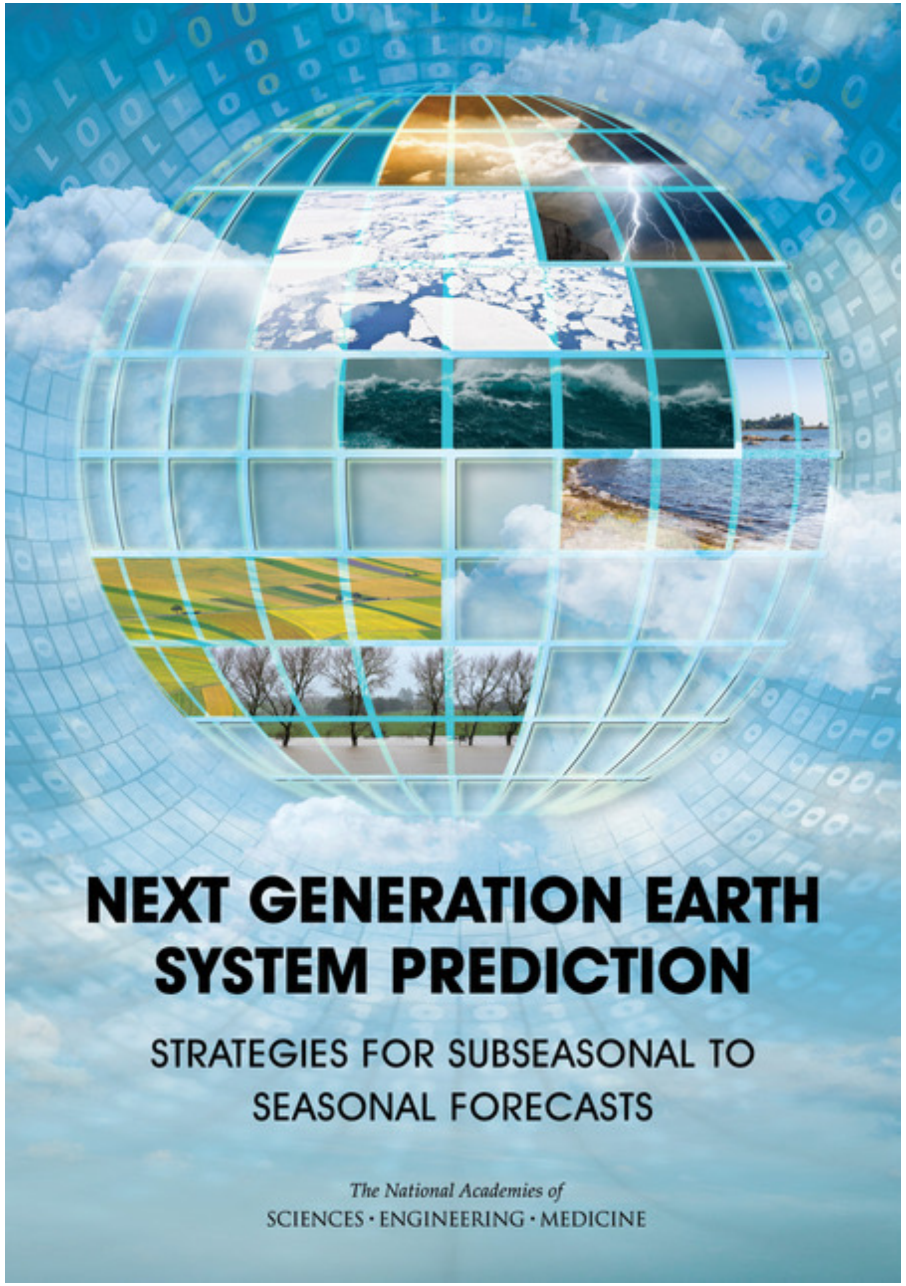
# The customer demand: managing an increasingly scarce resource



https://eoimages.gsfc.nasa.gov/images/imagerecords/89000/89482/iss048e073279_lrg.jpg

# The potential: The US National Academy of Sciences endorsed S2S prediction in 2010, 2016.




National Research Council. 2010. *Assessment of Intraseasonal to Interannual Climate Prediction and Predictability*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12878.

National Academies of Sciences, Engineering, and Medicine. 2016. *Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts*. Washington, DC: The National Academies Press. https://doi.org/10.17226/21873.

# The World Meteorological Organization is behind S2S. International project objectives:

1. To improve forecast skill and understanding on the sub-seasonal to seasonal timescale, with special emphasis on high-impact weather events.
2. To promote the initiative's uptake by operational centers and exploitation by the applications community.
3. To capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services.

S2S project is jointly sponsored by WMO World Weather Research Program and World Climate Research Program.

Public Law 115–25
115th Congress

An Act

To improve the National Oceanic and Atmospheric Administration's weather research through a focused program of investment on affordable and attainable advances in observational, computing, and modeling capabilities to support substantial improvement in weather forecasting and prediction of high impact weather events, to expand commercial opportunities for the provision of weather data, and for other purposes.

Apr. 18, 2017
[H.R. 353]

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

Weather Research and Forecasting Innovation Act of 2017. 15 USC 8501 note.

**SECTION 1. SHORT TITLE; TABLE OF CONTENTS.**

(a) SHORT TITLE.—This Act may be cited as the "Weather Research and Forecasting Innovation Act of 2017".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:



# Weather Research and Forecast Innovation Act of 2017

Authorization to spend money in legislation like this.

However, appropriations bills to fund this are separate from authorization. S2S *appropriations* in part depend on stakeholder advocacy.

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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# Federal action plan focused on improving water prediction for Western U.S.

Weather | water

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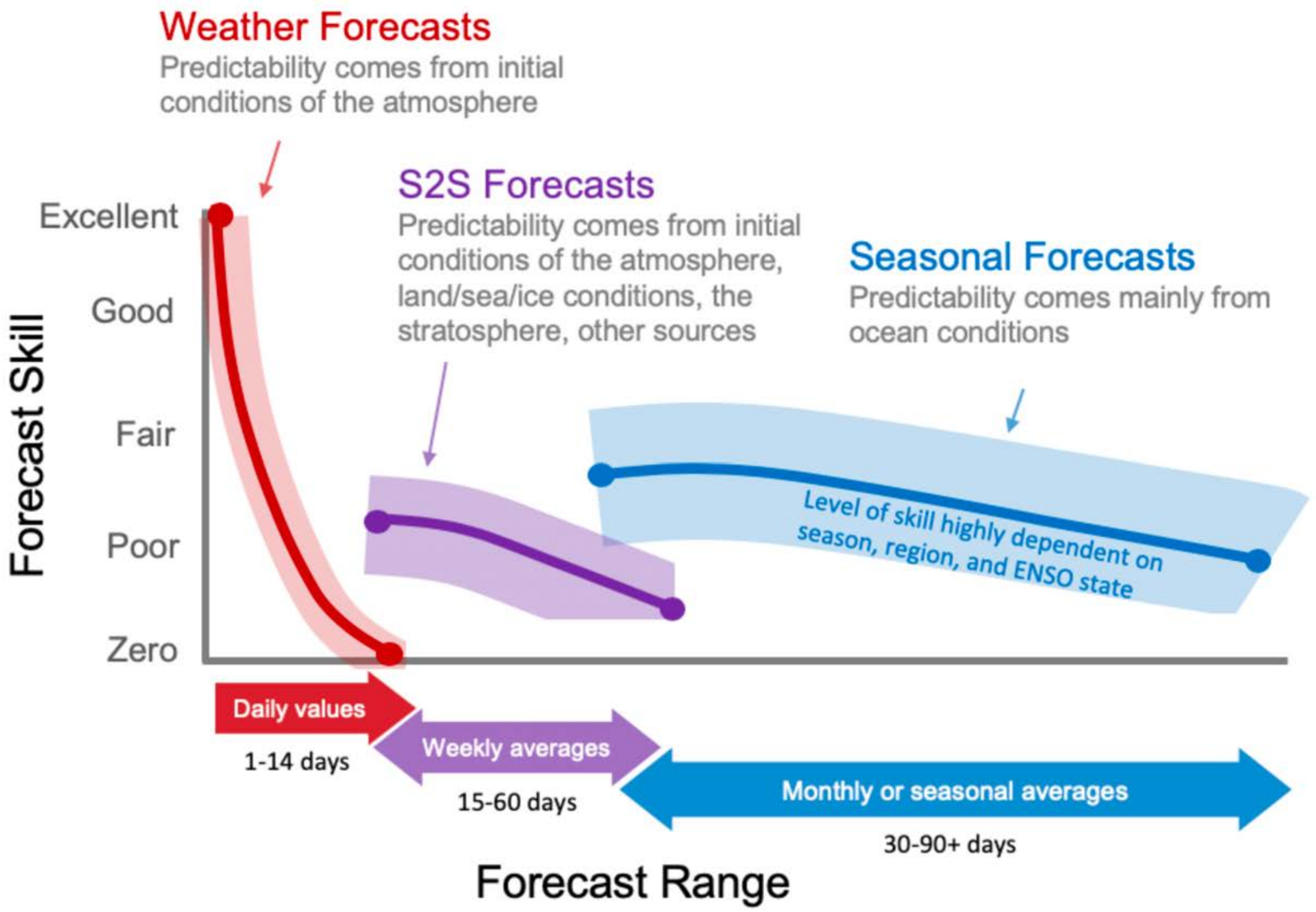
October 18, 2019 —

To promote reliable access to water, last year President Trump issued a Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West. In that memo, the President directed the U.S. Department of Commerce (DOC) and the U.S. Department of the Interior (DOI) to develop an action plan, in coordination with water experts and resource managers, to improve forecasts of water availability. In response to the President's directive, today, the DOC and the DOI are releasing the *Federal Action Plan for Improving Forecasts of Water Availability* (Action Plan).

The Action Plan identifies four areas for improvement: enhance weather forecasts to improve water prediction; improve and expand the use of water forecast information to benefit water management outcomes; improve science and technology for water prediction; and implement integrated water availability assessments at national and local basin scales.

https://www.noaa.gov/media-release/federal-action-plan-focused-on-improving-water-prediction-for-western-us

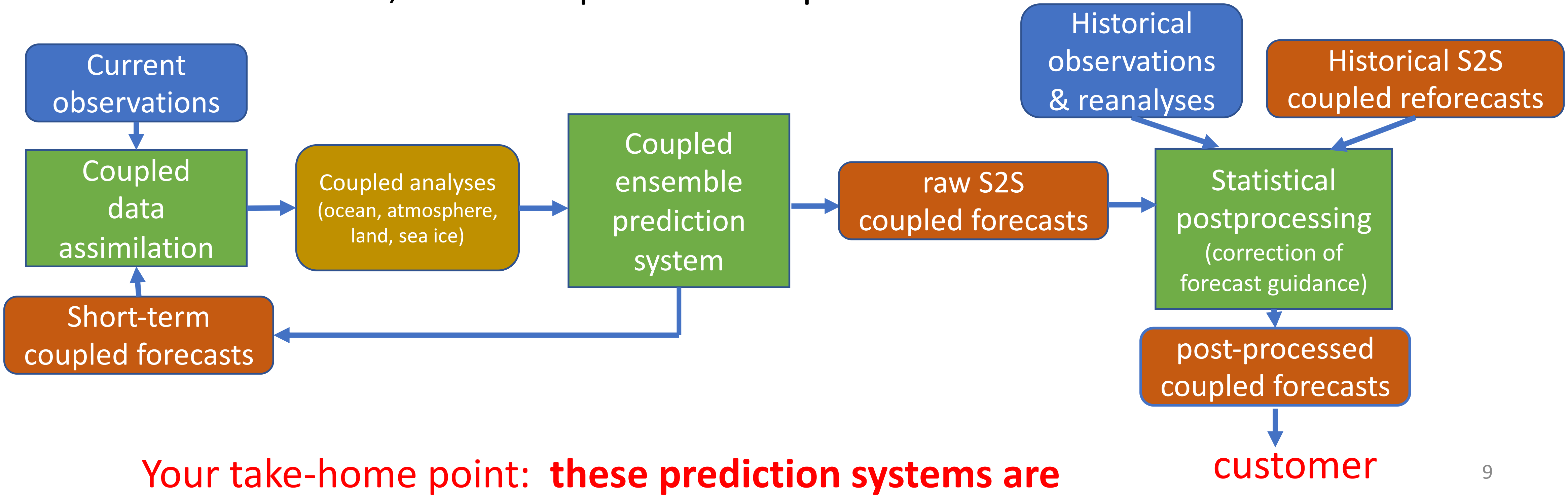
# Understanding what is and is not possible: weather, sub-seasonal, and seasonal predictability.




adapted from figure by Elisabeth Gawthrop and Tony Barnston, IRI.

# The components of improved S2S prediction. We seek:

- Optimal estimation of the initial (coupled) state, including joint state estimation of rapidly changing (atmosphere) and more slowly changing (ocean, land, ice) variables.
- Dramatic reduction of systematic errors in the coupled predictions.
- The most accurate, unbiased probabilistic predictions.




Your take-home point: **these prediction systems are complicated and require substantial R&D and computer resources to improve forecasts.**

# NGGPS and S2S programs

2014 2018 2022

## Next-Generation Global Prediction System

Improving global **weather** predictions focused around a single, dramatically improved modeling system, the Unified Forecast System or “UFS”

- Follow international best practice and concentrate resources to develop one great system that developers across the US (including academics, business) can help improve.

## Anticipated S2S project

UFS Prediction system improvements specifically related to the S2S time scale.

# An S2S program could include demonstration projects, such as understanding and predicting western US snowfall.

- 1. Numerical experiments and statistical benchmarks to define the upper end of predictive skill.
  - Also, understand the sources of predictive skill. How much from El Nino, how much from land-state anomalies, etc.
- 2. Build an improved next-generation seasonal prediction system.
- 3. Determine how well precipitation, snow, and runoff predictions were made over the last several decades using improved prediction system.
- 4. Start producing experimental guidance in demo projects, share with customers for advanced look and your evaluation and feedback.
- 5. Migrate the improved system into day-to-day operations in the NWS.
- 6. Produce regular seasonal snow and runoff forecasts operationally across the western US.

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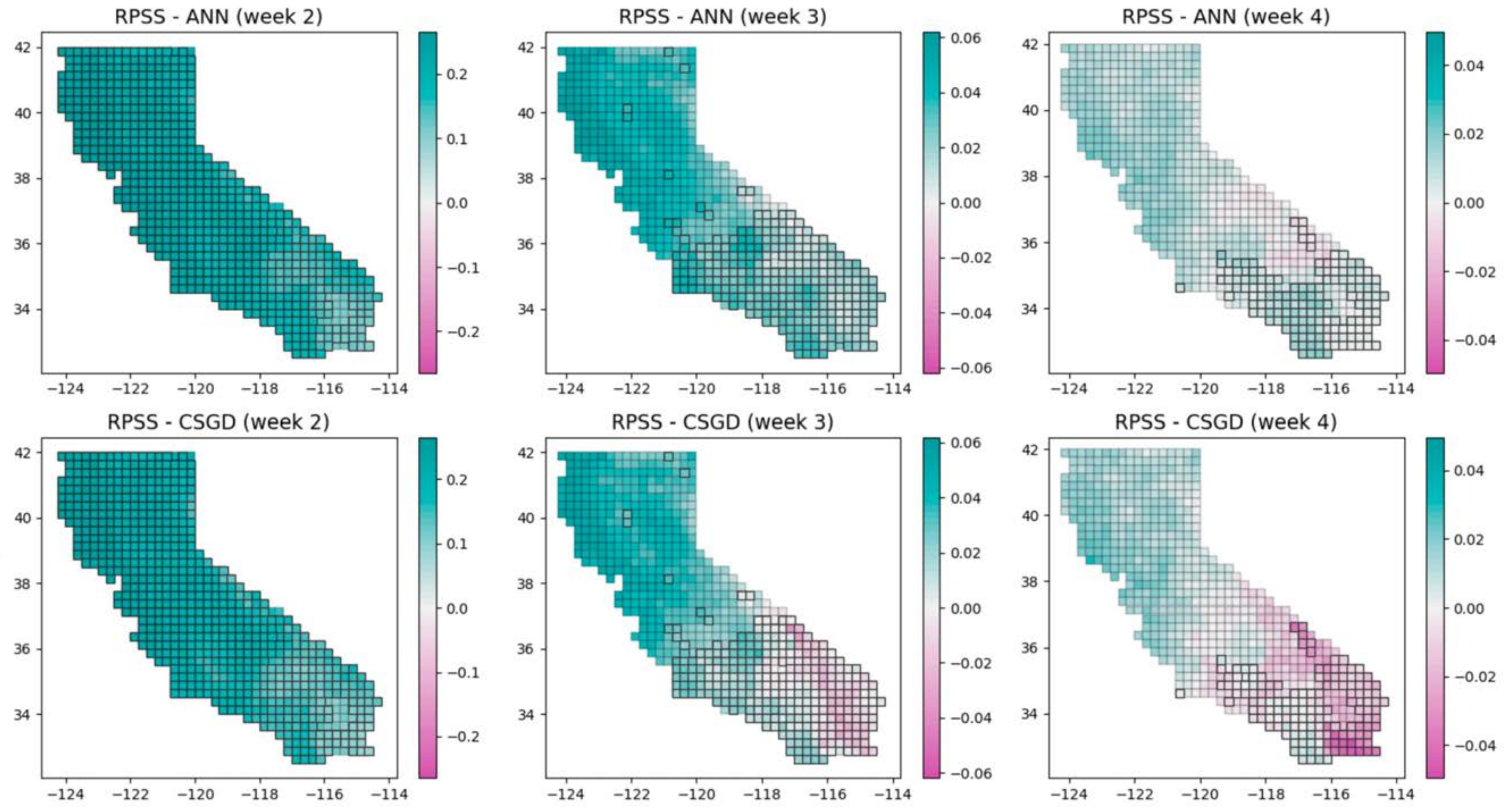
# Statistical corrections to the raw (ECMWF) weather prediction guidance, weeks 2 to 4. What's the current state of the art?

new, with artificial neural net

current standard (Scheuerer and Hamill, 2015 here)




Skill of weekly average precipitation drops off from weeks 2 to week 4.

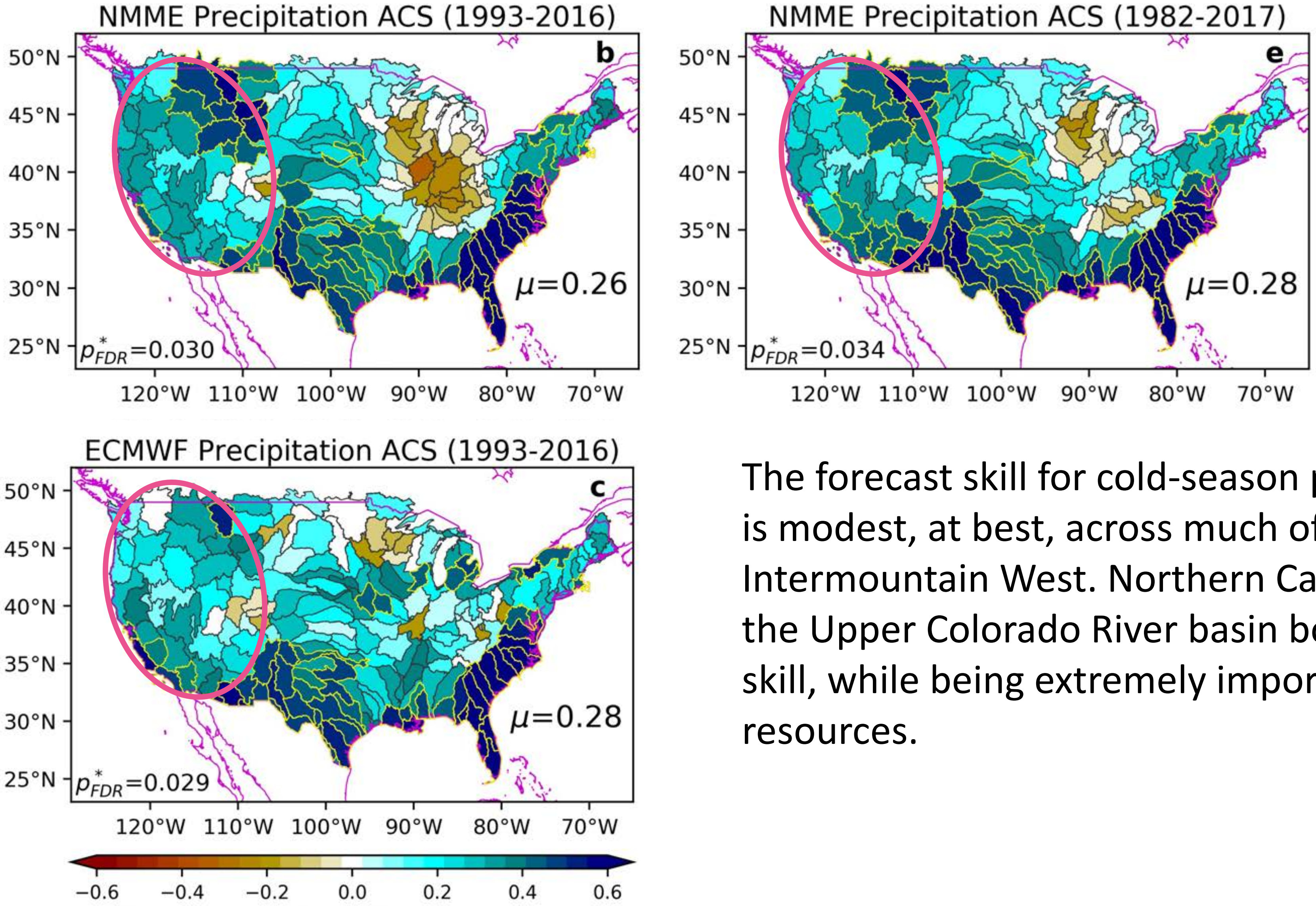
Advanced statistical postprocessing techniques can exploit underlying skill in the forecast that is hidden because of systematic errors.

c/o Michael Scheuerer, PSD and U. Colorado



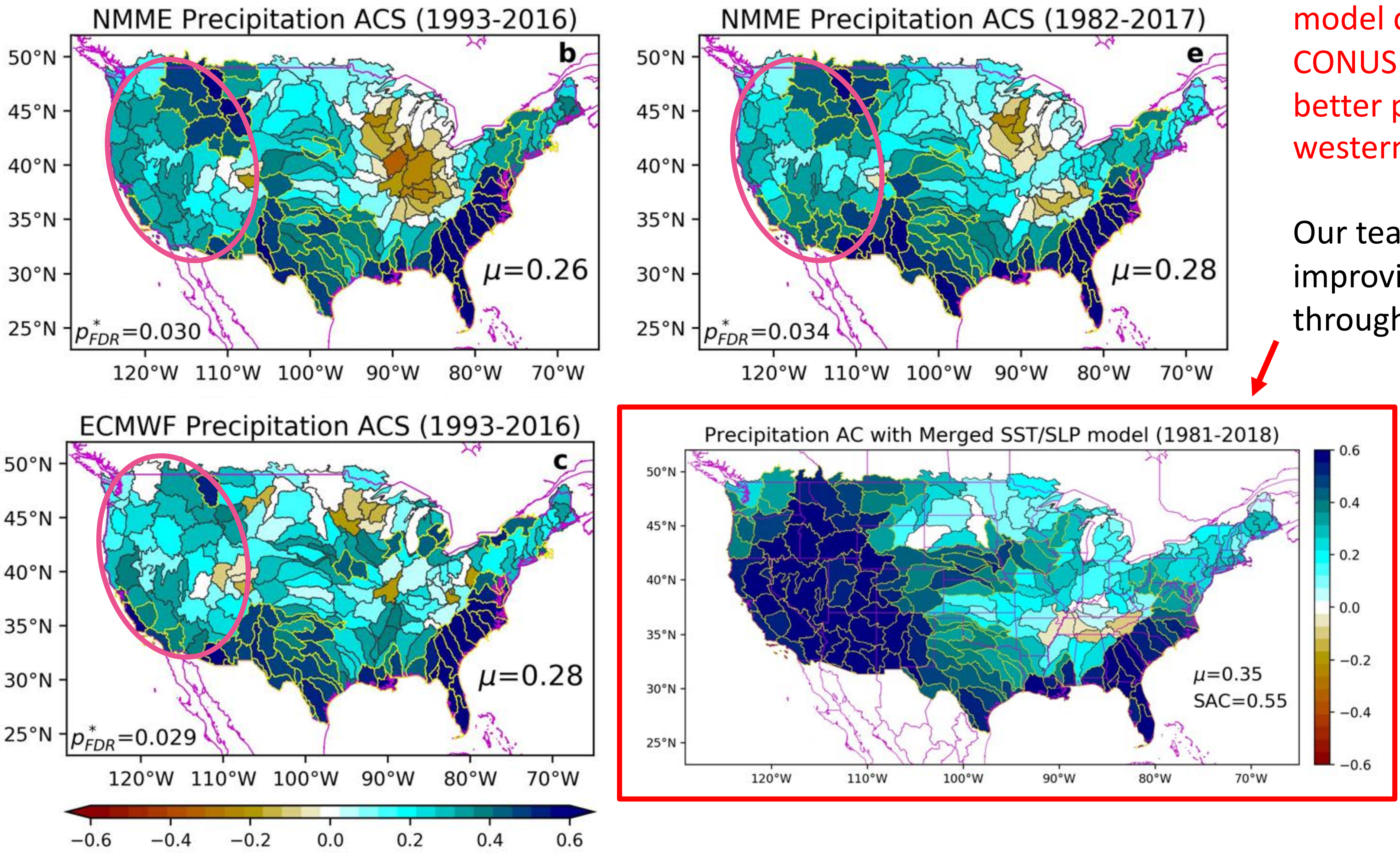
with funding from California DWR (thanks)

# Current skill of dynamical models' precipitation forecasts for the winter season (November-March)




The forecast skill for cold-season precipitation is modest, at best, across much of the Intermountain West. Northern California and the Upper Colorado River basin both have low skill, while being extremely important for water resources.

# A new statistical reference for dynamical weather predictions




A new statistical forecast model developed for the CONUS provides much better predictions across the western US.

Our team's activity toward improving S2S was jumpstarted through California DWR $.

c/o Matt Switanek
ESRL/PSD and U. Colorado

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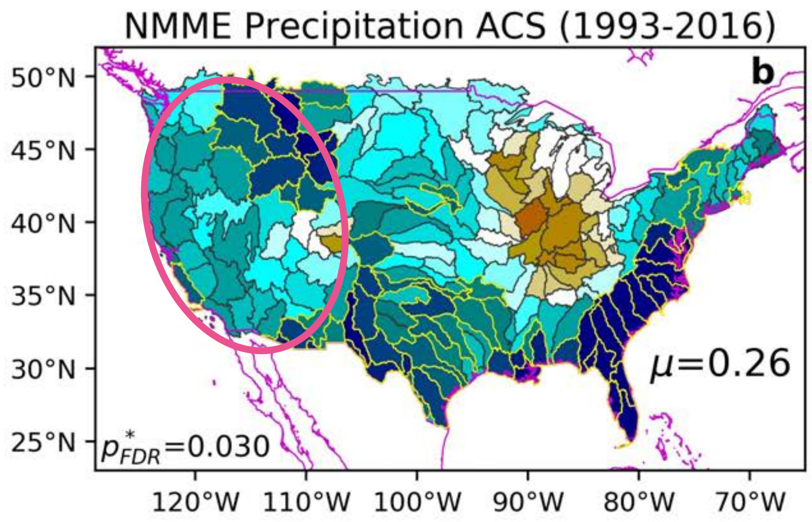
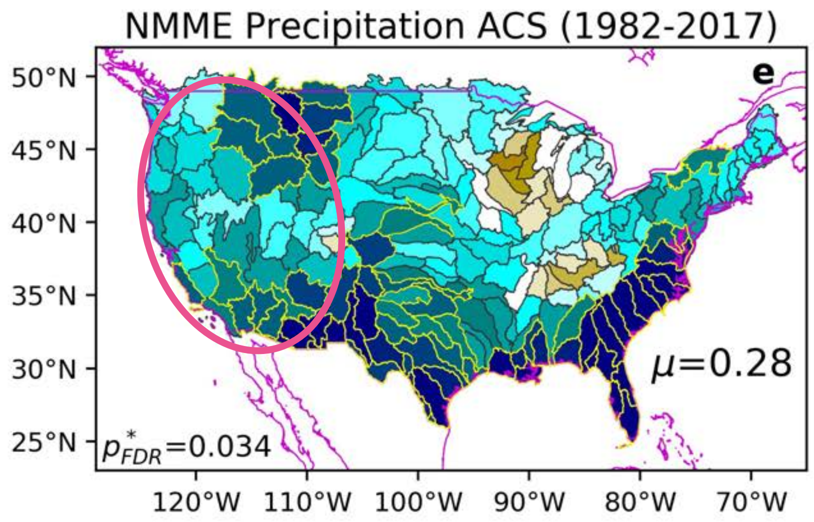
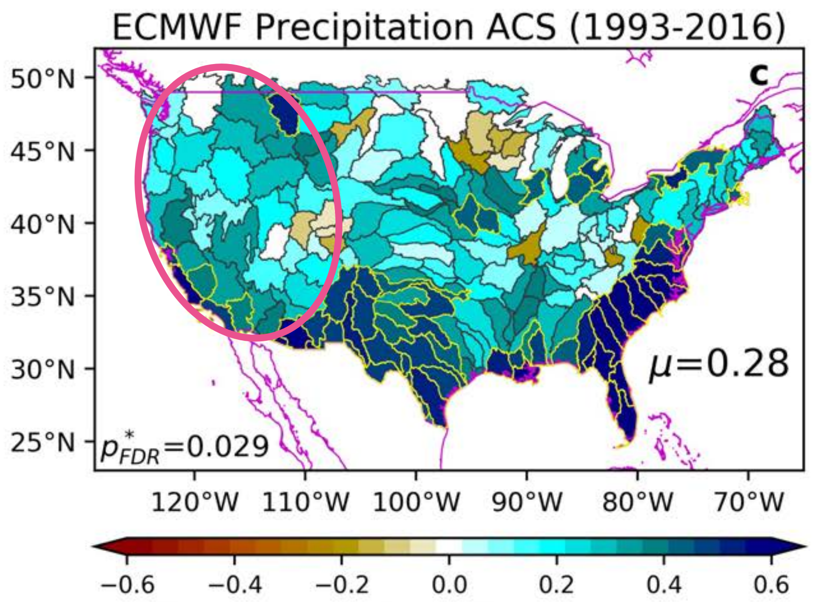
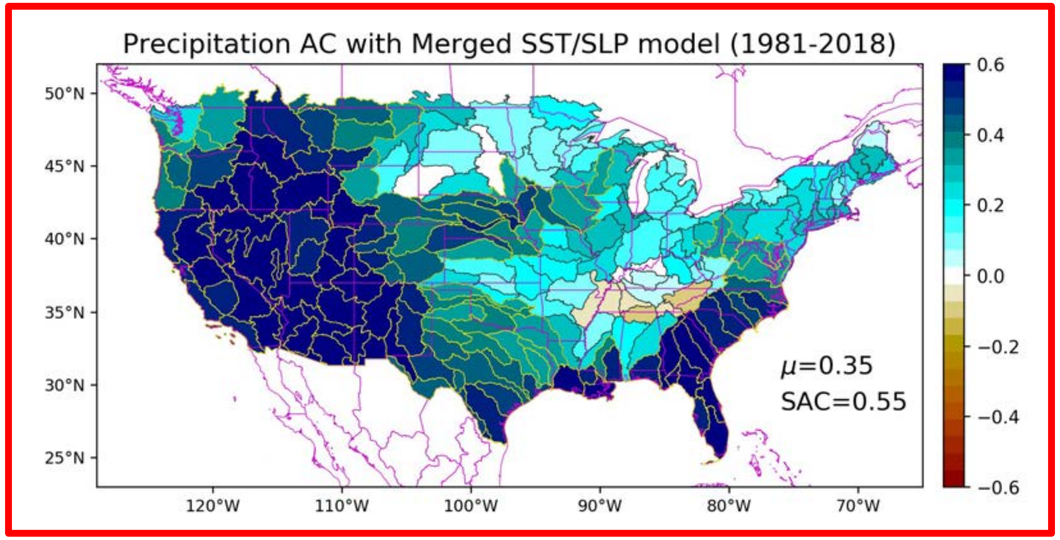


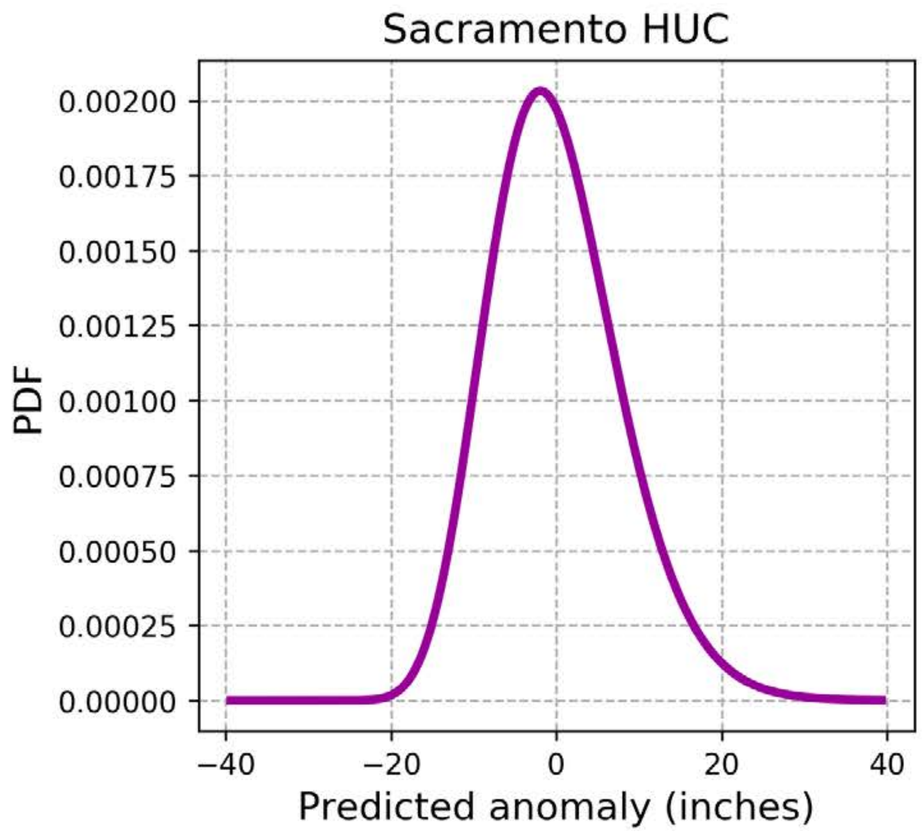



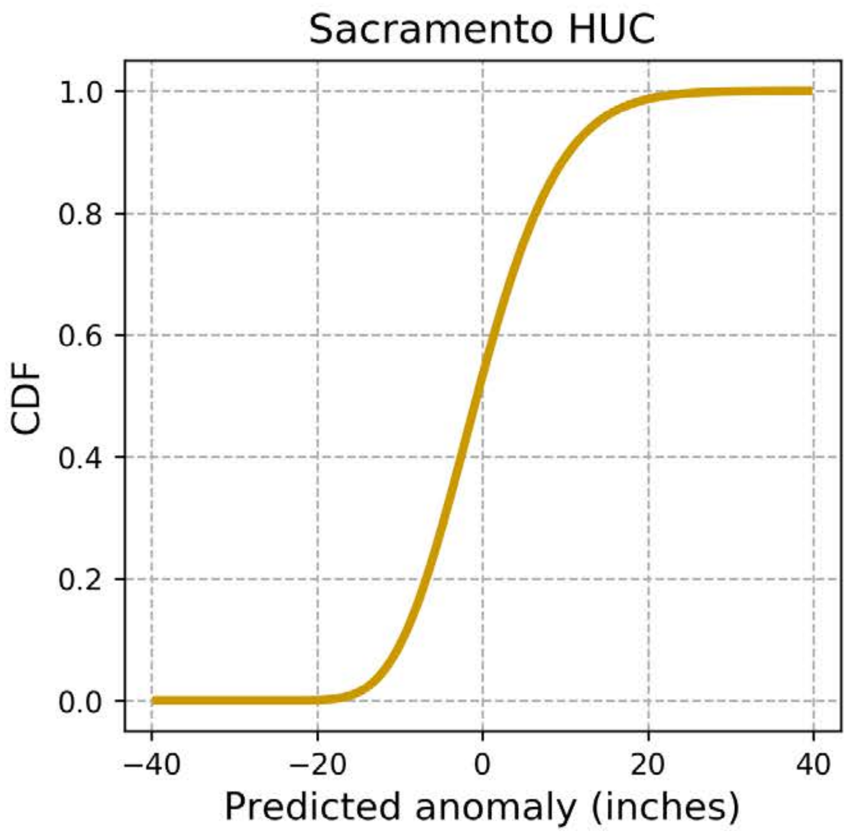

With time and effort we should be able to build numerical S2S prediction systems that beat this.



# Demo-ing products for water managers: merged forecast for this winter, Nov-Mar 2019/2020




SAC Mean 1981-2018 = 28.3 inches

10% = 17.7 inches
50% = 26.8 inches
90% = 37.9 inches

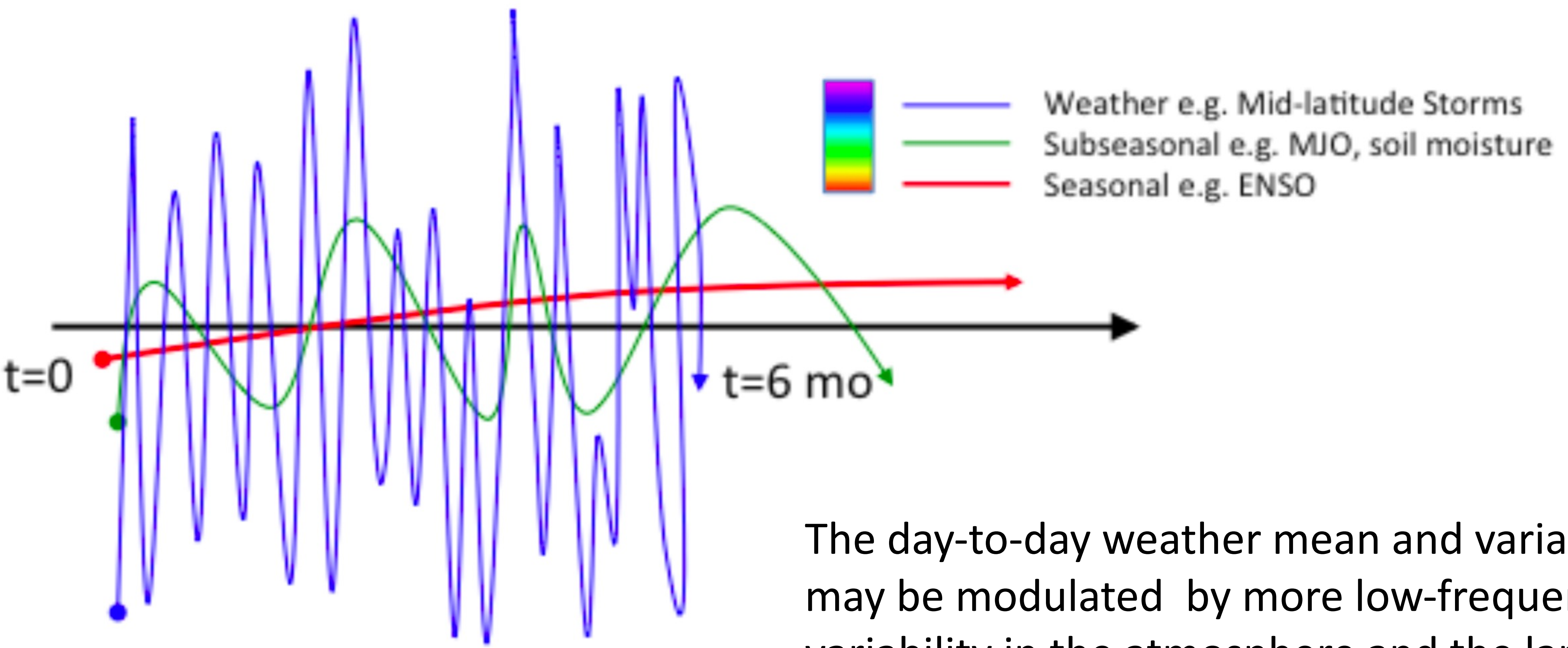
38% chance of below normal
32% chance of normal
30% chance of above normal

c/o Matt Switanek

# Conclusions

- NOAA may soon have an S2S program, thanks to Congressional legislation and a Federal Action Plan.  Authorized, but not yet appropriated.
- Western US seasonal precipitation forecasting likely could be improved with the sustained effort of a funded S2S program.  We have encouraging new results with statistical models.
- Congress listens closely to constituents such as you.
  - How much resources should Congress allocate to NOAA for this?
  - Should there be demonstration projects including western water issues?
  - Relative priorities, weather vs. sub-seasonal vs. seasonal.

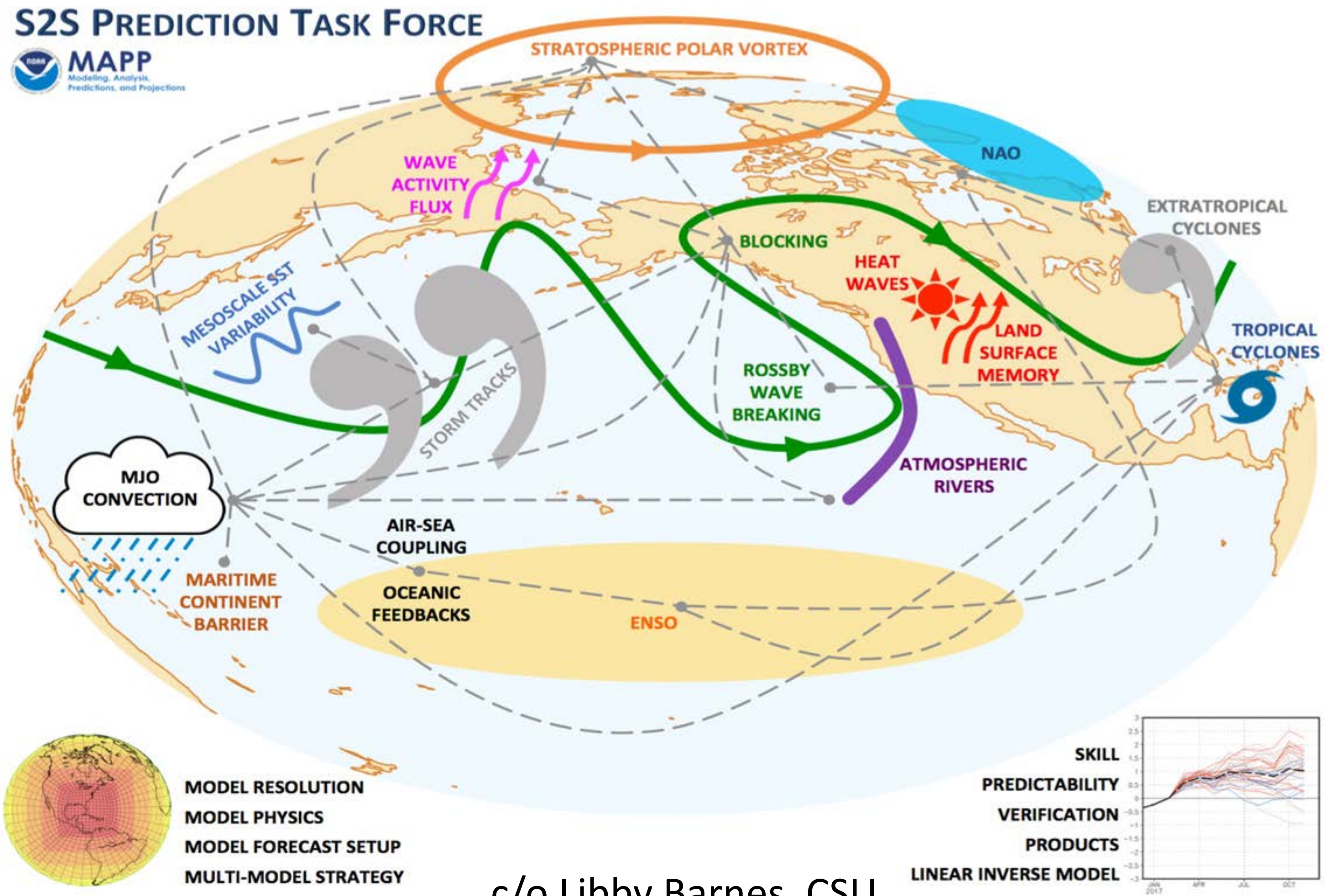
# Weather, sub-seasonal, and seasonal variations.




The day-to-day weather mean and variability may be modulated by more low-frequency variability in the atmosphere and the land and ocean state, e.g., El Nino.

from 2016 NAS report on S2S improvement, [here.](#)

# *Inter-connected* sources of skill for S2S forecasts, and research challenges in modeling them correctly.




c/o Libby Barnes, CSU

- Madden-Julian Oscillation, slowly moving clusters of tropical thunderstorms.
- Polar stratospheric anomalies, “sudden stratospheric warming” that modulates persistent deviations of the jet stream.
- Sea-surface temperature anomalies, especially El Nino/La Nina.
- Land-surface state anomalies. Wet springs → cooler summers.
- Snow anomalies.
- Sea-ice anomalies.
- and more.