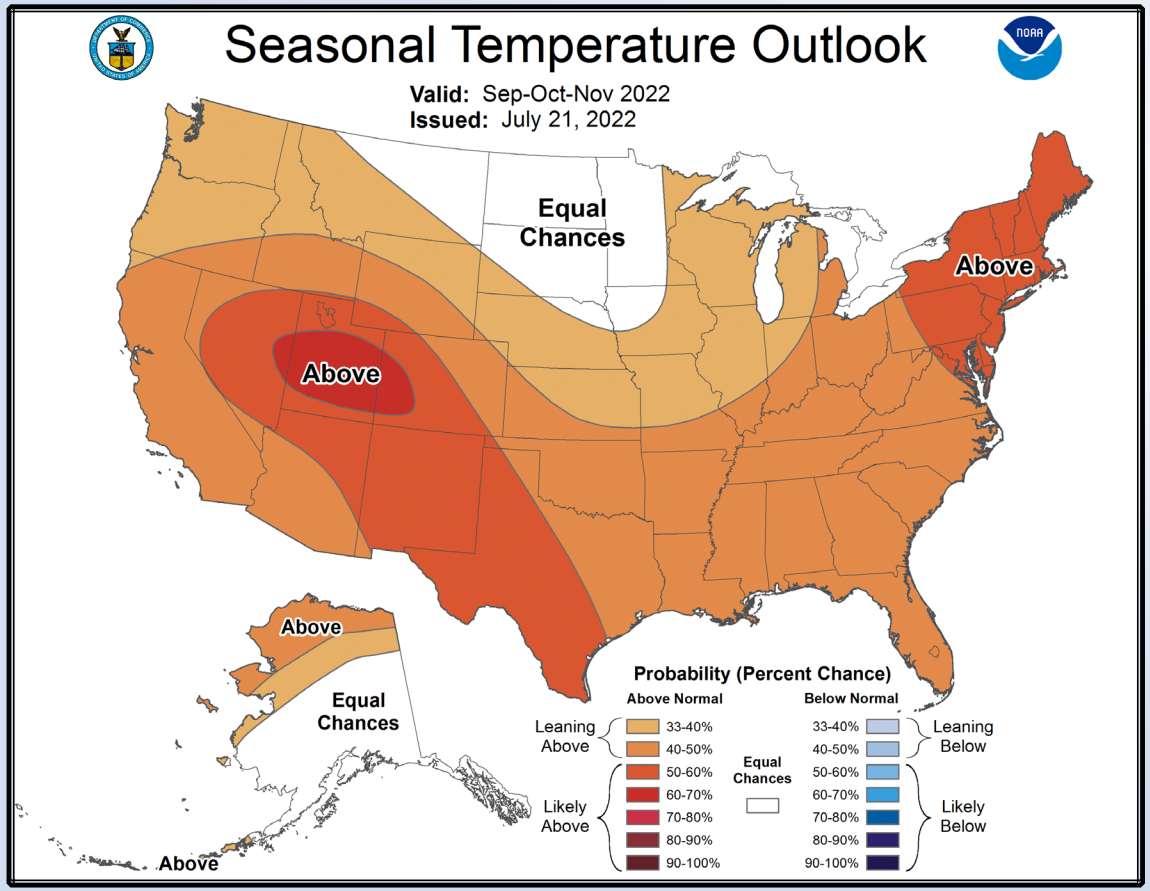
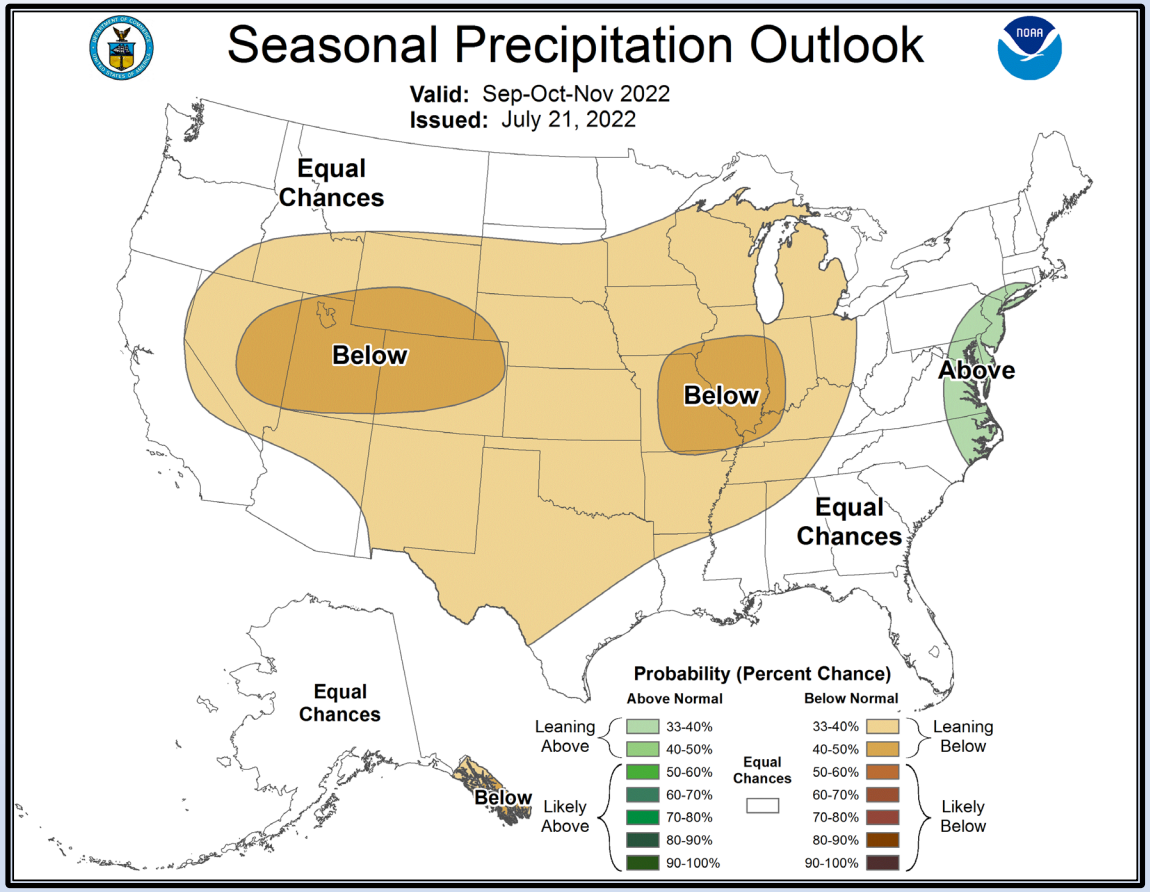
SAB EISWG Review

Subseasonal and Seasonal (S2S) Forecast Innovation Report

30 Aug 2022





Overview

- Background
- Executive Summary
- Additional Findings and Recommendations

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S2S Review Team

- **Jon White**, RADM, USN (Ret.), Oceanographer/Meteorologist
- **Ilse Gayl**, VP, Corporate Development Advanced Environmental Monitoring
- **Michael Anderson**, PhD, State Climatologist, CA Dept. of Water Resources (SAB CWG member)
- **Cecilia Bitz**, PhD, Professor and Chair, Department of Atmospheric Sciences, University of Washington (SAB CWG member)
- **Rong Fu**, PhD, Professor, Department of Atmospheric and Oceanic Sciences, Director, the Joint Institute for Regional Earth Science and Engineering, University of California – Los Angeles (SAB CWG member)

Weather Act: Title II. Subseasonal *and* Seasonal Forecasting Innovation:

Definitions: Subseasonal = 2 weeks to 3 months; Seasonal = 3 months to 2 years

Functions:

- Make forecasts
- Improve forecasts
- Determine & Communicate impacts
- Internet clearinghouse for all forecasts

Report (to Senate and House Committees):

- How information is utilized in public planning and preparedness
- Specific plans and goals for the continued development of forecasts and related products
- Research, monitoring, observing, and forecasting requirements to meet the goals

A Tale of Two Reports …

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)

37 Pages

SUPPLEMENT FOR REPORT TO CONGRESS

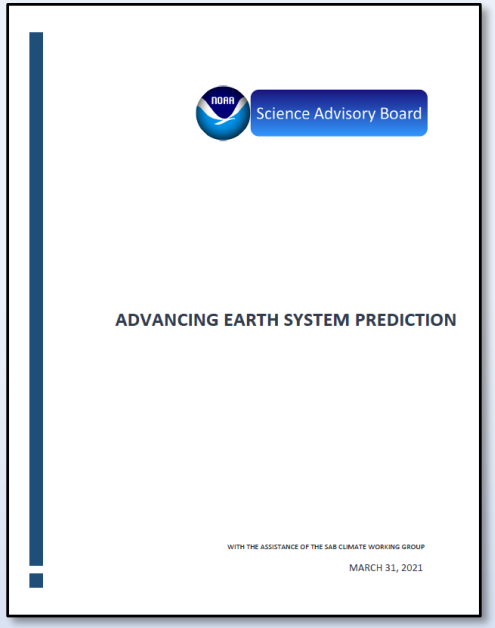
SUBSEASONAL AND SEASONAL FORECASTING INNOVATION: PLANS FOR THE TWENTY-FIRST CENTURY

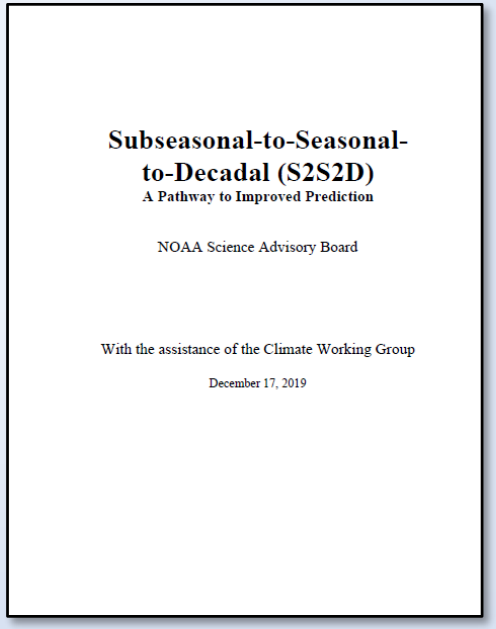
Developed pursuant to: House Report 353 accompanying
Section 201 of the Weather Research and Forecasting Act of 2017, Public Law 115-25

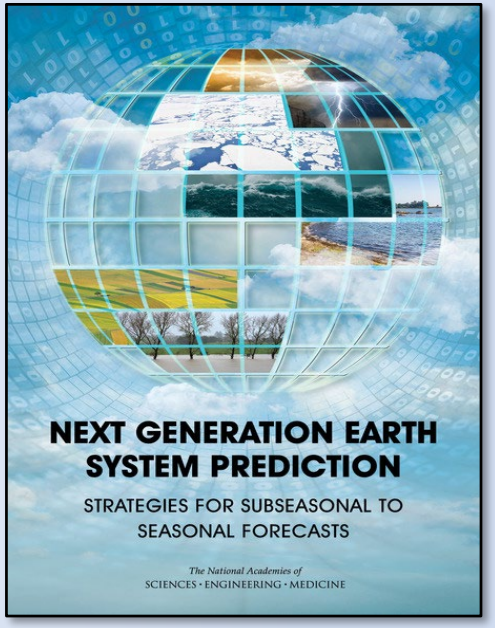
156 Pages

"NOAA S2S Report" = official report + supplement

Key References used in this review *and* to help guide continuing S2S requirements, plans, priorities, investments, etc.







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Executive Summary - BLUF (Bottom Line Up Front)

Our review concludes that the *official report*, in tandem with its *supplement*, <u>is responsive to the congressional tasking and sufficiently addresses the specific information requested</u>.

… and NOAA continues to progress and innovate in concert with plans identified in the report.

… and Congress has responded with some budgetary initiatives and acknowledgements.

Urgency

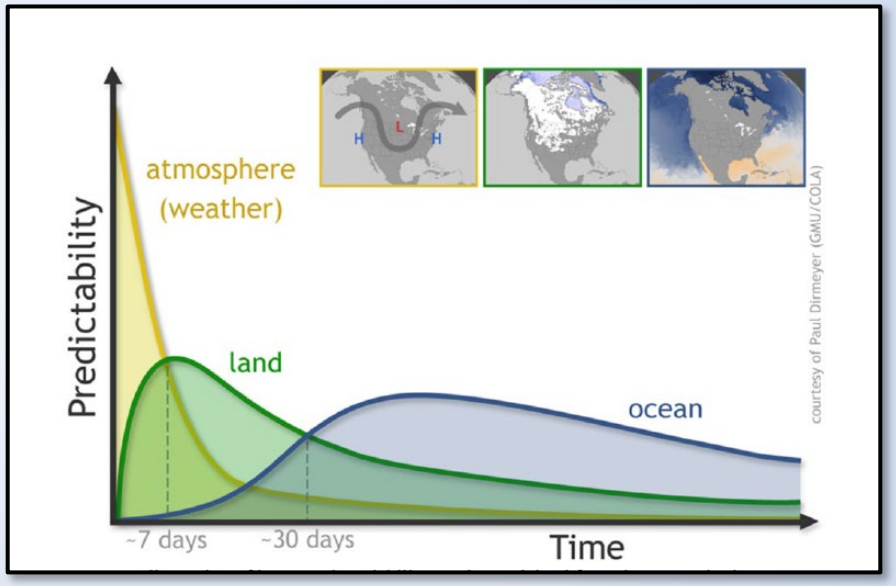
- The importance of S2S forecasts and decision-making by leaders at every level of government as well as the private sector is growing.
- Recent subseasonal and seasonal extremes of temperature and precipitation have had catastrophic impacts on safety, security (including water and food), and economic prosperity across the nation and around the globe.
- As stated in the NOAA S2S Report, this has led to steadily increasing demand for S2S information, as well as the need for greater skill and effectiveness of S2S products.
- The various programs and plans described in the NOAA S2S Report provide an excellent framework to continue advancing S2S forecast products and decision-support services, and to influence larger federal policies and fiscal appropriations to meet these growing needs.

We concur with the NOAA Report Summary Statement:

"Our society continues to change and become more vulnerable to impacts from extreme S2S influenced weather events, including tornadoes, hurricanes, snow, blizzards, heat, cold, drought, fire, and floods. Improved subseasonal to seasonal prediction is a critical component to enable decision makers to make informed decisions to address extreme events ranging from drought to flooding and heat to cold. As our S2S predictive capability improves, decision makers at all levels will have better information to make informed decisions to save lives and property."

Summary Findings/Recommendations:

- Availability of NOAA S2S Report *Supplement*
- "S2S" Definitions
- Strategic Goal(s)
- Advancing Earth System Prediction
  - EPIC



- Interagency and International Collaboration
  - NOAA leadership role on the Interagency Council for Advancing Meteorological Services (ICAMS)

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Additional Findings/Recommendations:

A. How S2S Information is used in public planning and preparedness

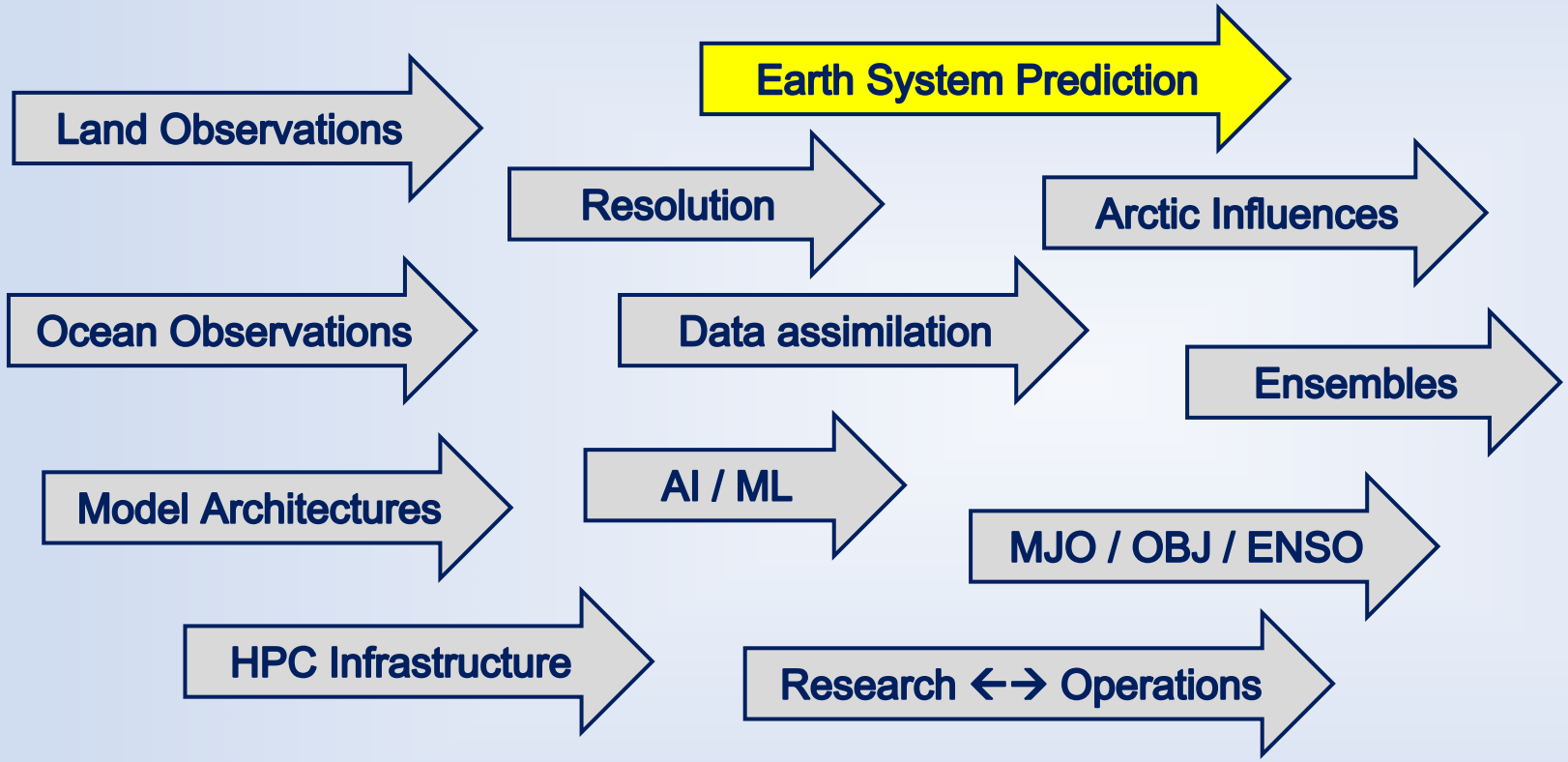
[NOAA Report Section II. Current S2S Products and Services.]

- S2S Product "Internet Clearing House" – national and regional (Congressional tasking)
- Additional product verification and use metrics
- Publicize/maintain "Potential Future Products List" (App. C)
- Catalogue product use *best practices*.

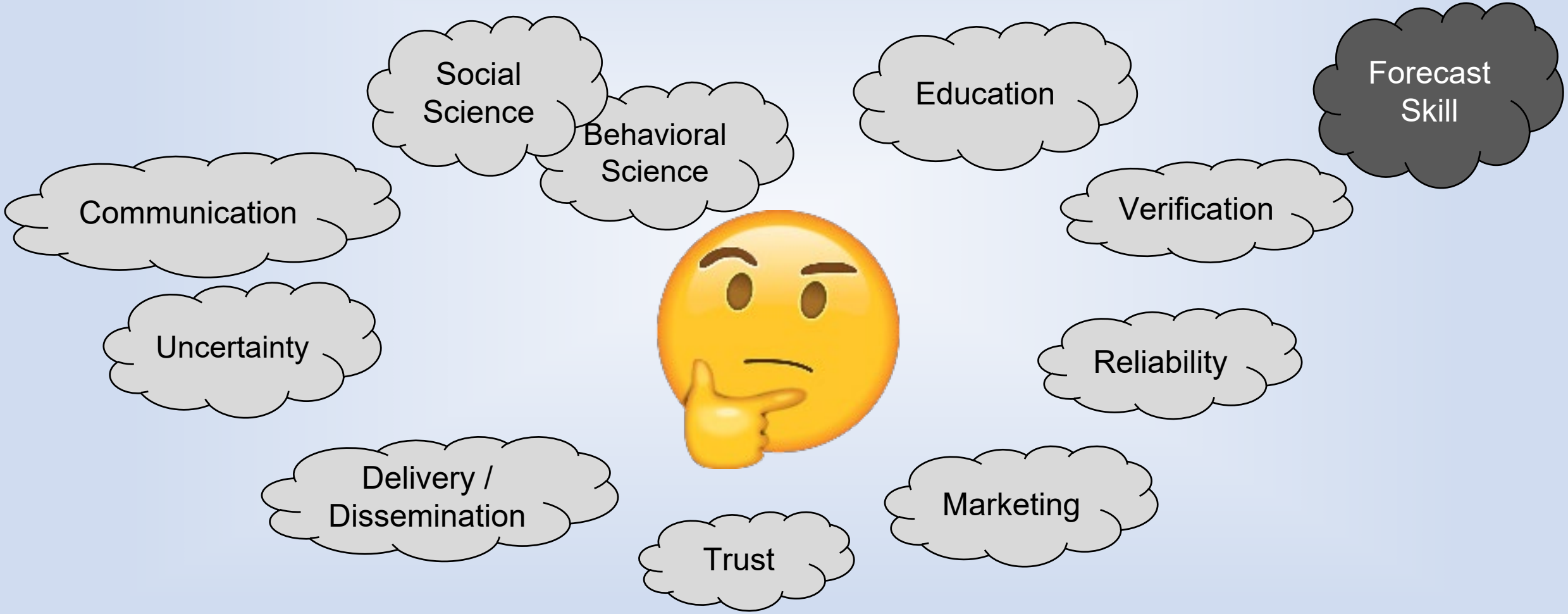
Additional Findings/Recommendations:

B. Specific plans and goals for the continued development of S2S forecasts and related products [NOAA Report Section III. Current Plans for Improving S2S Products and Services.]

Goal #1: Improving Forecast Skill



Goal #2: Enhancing Product Value to Stakeholders



Additional Findings/Recommendations:

B. Specific plans and goals for the continued development of S2S forecasts and related products [NOAA Report Section III. Current Plans for Improving S2S Products and Services.]

- Additional specificity of goals and plans
  - Roadmaps
- Stakeholder value
  - Categorical use cases
  - Means to assess/measure “value”
  - Interagency collaboration around social and behavioral science application
    - Intelligence community
    - DHS/FEMA

Additional Findings/Recommendations:

C. Identification of research, monitoring, and observing requirements to meet the specific goals [NOAA Section IV. Requirements for Improving S2S Products and Services - "*Longer term research requirements, no specific plans or goals*"]

- Prioritization process – R2O determination
  - PWR Report
- Predictability
- Seamless S2S(2D) alignment in OAR (WPO … CPO)
  - Diagram on next slide
- IOOS regional engagement
- Pilot projects

S2S Requires All RLs Engaged

CPO: Observations & Research

- Climate research and process studies across scale - can be helpful for S2S scales as well
- Collaboration on Earth System modeling (e.g., ocean, atmosphere and land processes; Climate Process Teams)

WPO: Research and R2O

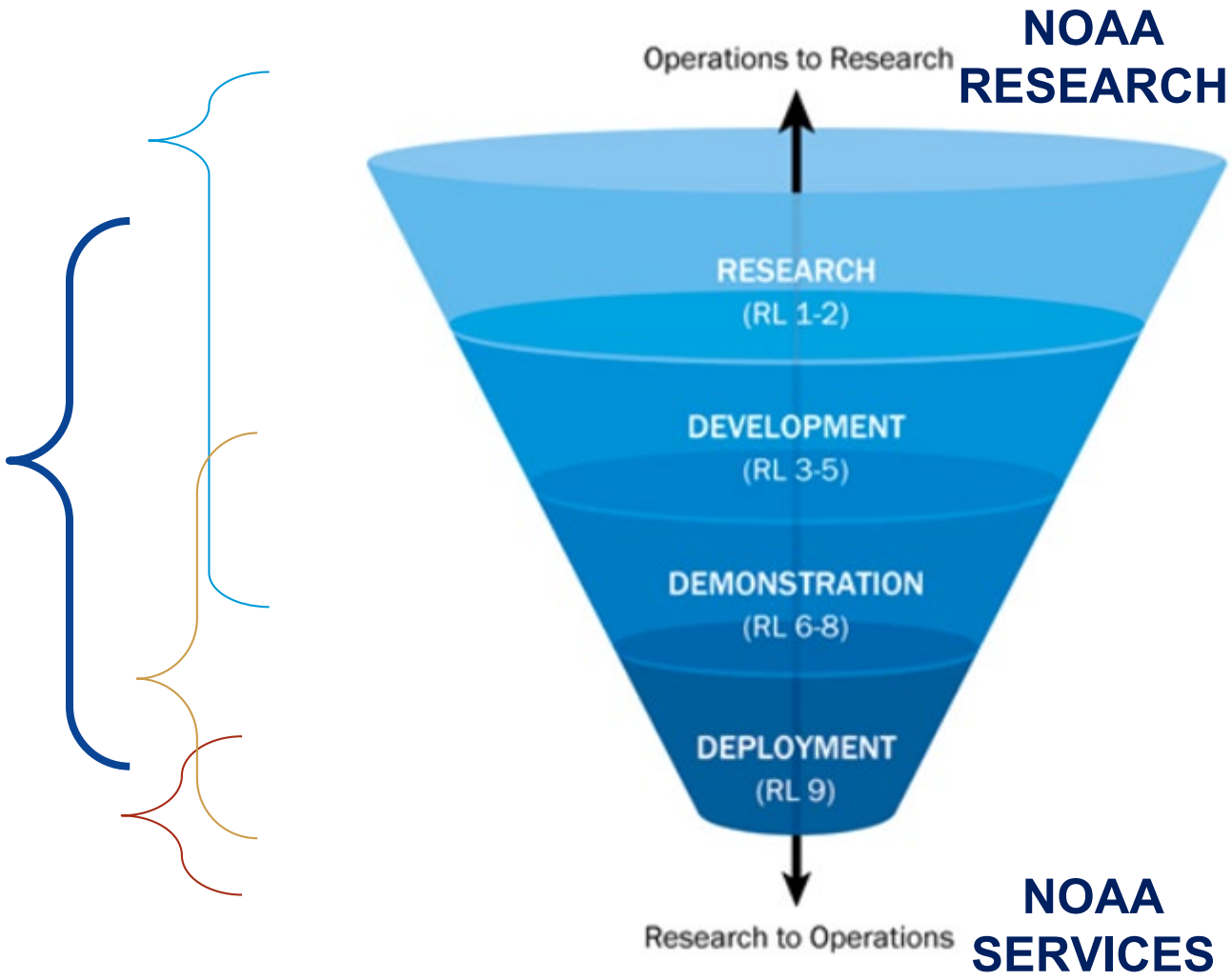
- S2S prediction, including data assimilation
- Weather research and process studies across scales
- Climate Test Bed

STI: Research and R2O

- Weather research and model development
- Transitions, implementation

CPC: Operational Climate Products

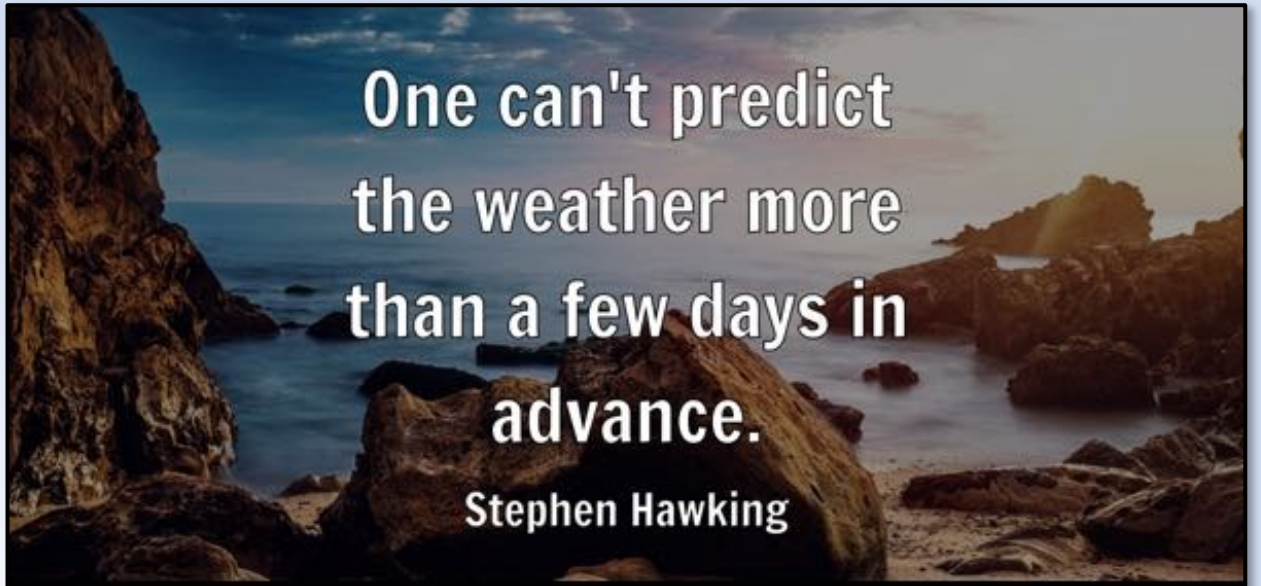
- One month, three months, and seasonal temperature and precipitation outlooks

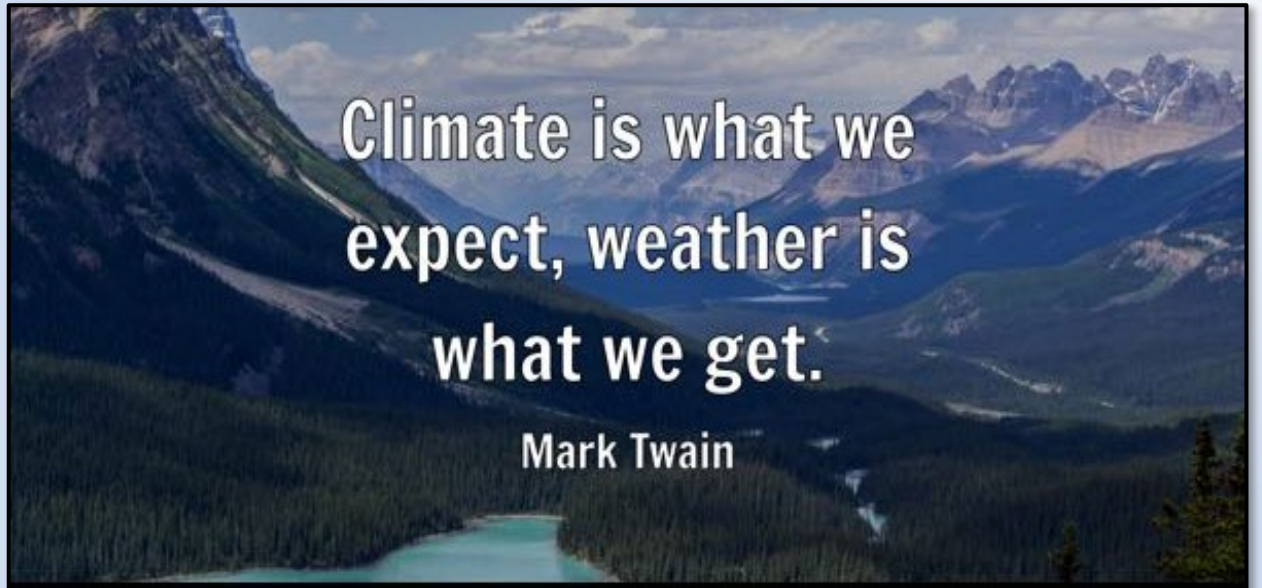


I'm not an economist and we all know economists were created to make weather forecasters look good.

— Rupert Murdoch —

AZ QUOTES





Additional Info

Weather Act: Title II. Subseasonal *and* Seasonal Forecasting Innovation:

Definitions: Subseasonal = 2 weeks to 3 months; Seasonal = 3 months to 2 years

(c) Functions:

(1) Collect and utilize information in order to make usable, reliable, and timely foundational forecasts of subseasonal and seasonal temperature and precipitation;

(2) Leverage existing research and models from the weather enterprise to improve the forecasts under paragraph (1);

(3) Determine and provide information on how the forecasted conditions under paragraph (1) may impact—

(A) The number and severity of droughts, fires, tornadoes, hurricanes, floods, heat waves, coastal inundation, winter storms, high impact weather, or other relevant natural disasters; (B) Snowpack; and (C) Sea ice conditions; and

(4) develop an Internet clearinghouse to provide the forecasts under paragraph (1) and the information under paragraphs (1) and (3) on both national and regional levels."

Weather Act: S2S Report Requirements

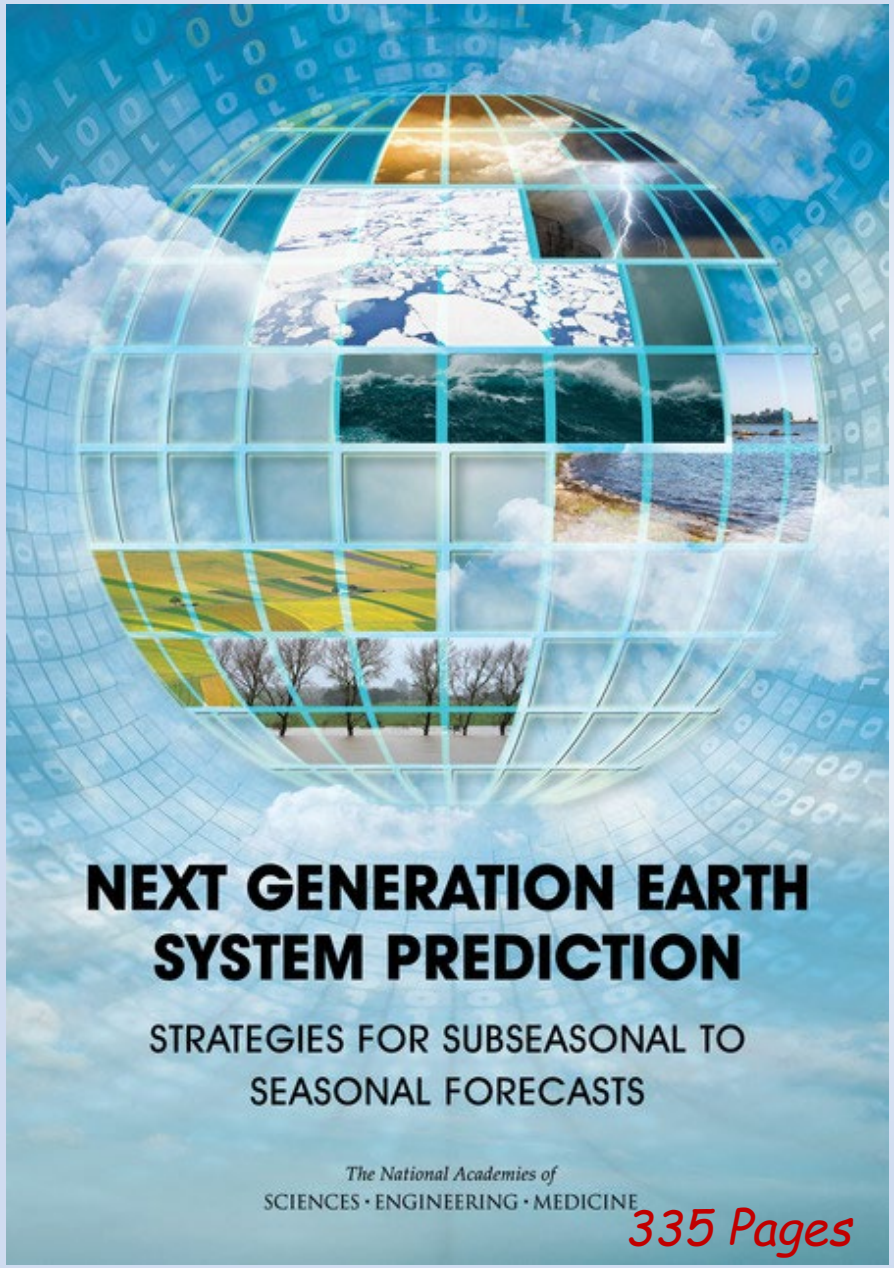
(1) IN GENERAL.—Not later than 18 months after the date of the enactment of the Weather Research and Forecasting Innovation Act of 2017, **the Under Secretary shall submit** to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives **a report**, including—

(A) An analysis of the **how information** from the National Oceanic and Atmospheric Administration on subseasonal and seasonal forecasts **is utilized in public planning and preparedness**;

(B) **Specific plans and goals** for the continued development of the subseasonal and seasonal forecasts and related products

(C) Identification of **research, monitoring, observing, and forecasting requirements** to meet the goals described in subparagraph (B).

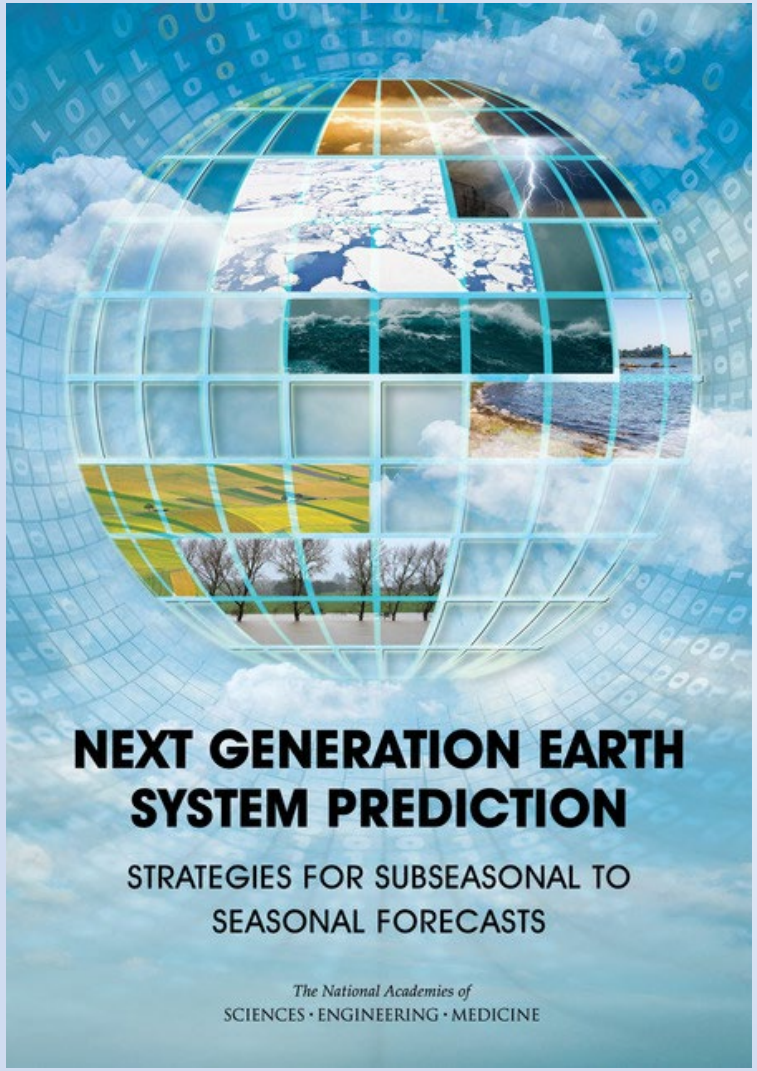
(2) CONSULTATION.—In developing the report under paragraph (1), the Under Secretary shall consult with relevant Federal, regional, State, tribal, and local government agencies, research institutions, and the private sector.

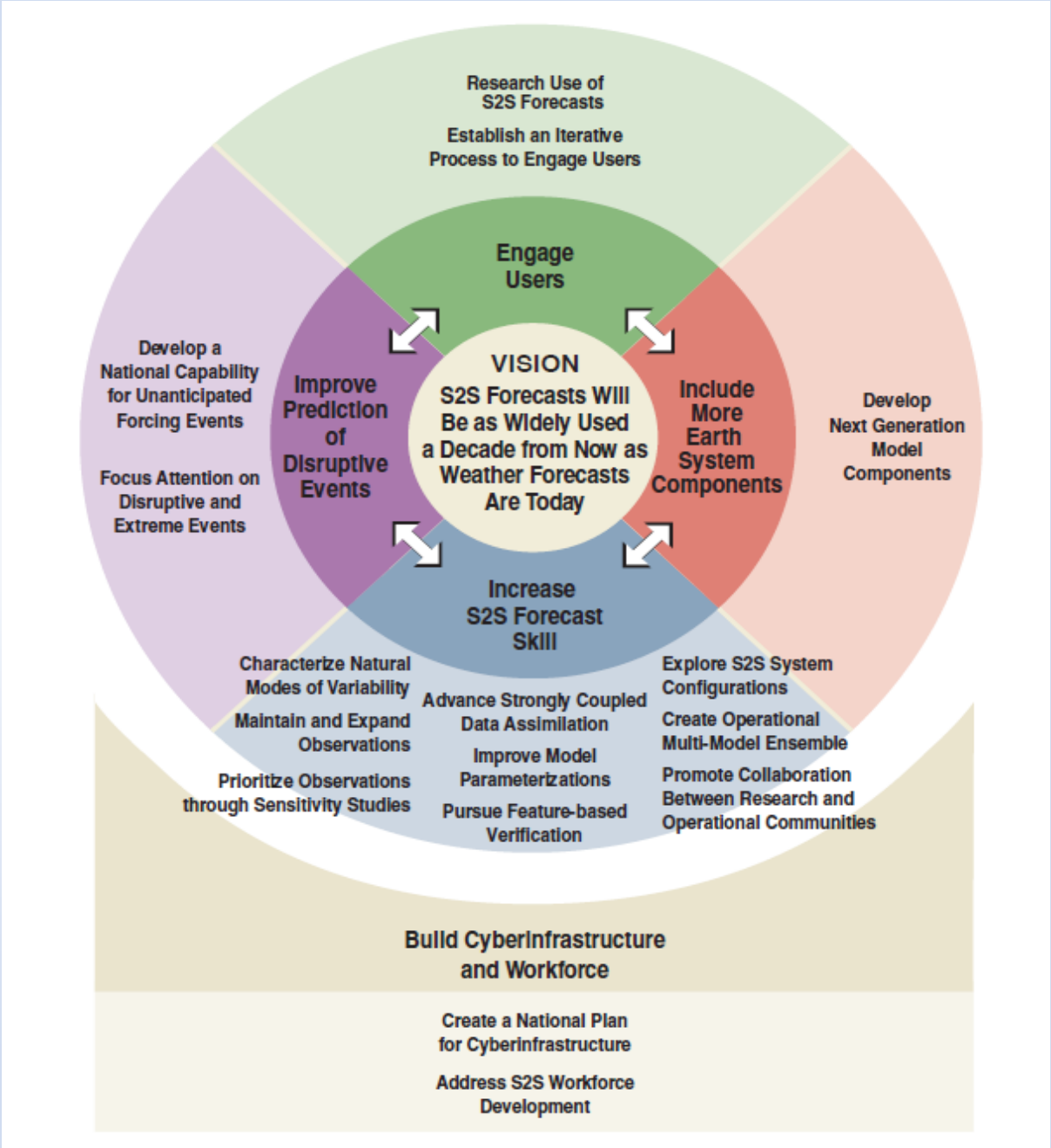


NAS Report - 2016

- **Vision:** Subseasonal to seasonal forecasts (S2S) (i.e., forecasts of environmental conditions made approximately 2 weeks to 12 months in advance) will be as widely used a decade from now as weather forecasts are today.
- This report presents a research agenda that provides the framework for the physical and social sciences communities to collaboratively advance the skill, breadth, and value of S2S predictions.

NAS Report (2016)





Innovation

To Address Key Areas Requiring Improvement from the S2S Report

- **Understanding/Estimating Limits of Predictability**
- **Drought Prediction Tools**
- **Unified Modeling Framework**
- **Madden-Julian Oscillation and Associated Teleconnections**
- **Coupled Data Assimilation**
- **Earth System Model Development**
- **Robust Community Participation: Earth Prediction Innovation Center (EPIC)**

Modeling Innovation

To Address Key Areas Requiring Improvement from the S2S Report

- **Simplifying the NCEP Production Suite**
- **Improved MJO Prediction Skill**
- **Coupled Data Assimilation Development**
- **GEFSV12 Implementation**

The Earth Prediction Innovation Center – EPIC

Partnering with the Community for the Benefit of the Nation

Vision

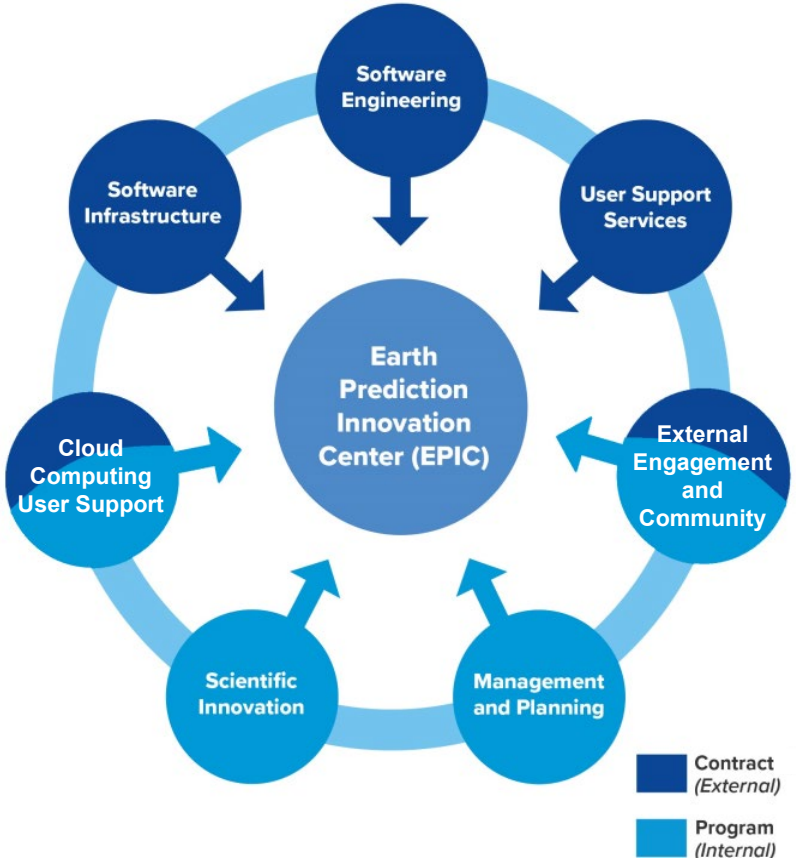
Enable the most accurate and reliable operational numerical forecast model in the world.

Mission

To be the catalyst for community research and modeling system advances that continually inform and accelerate advances in our nation's operational forecast modeling systems.

Strategy

- Modernize modeling infrastructure
- Provide Community Support
- Accelerate Community Innovations



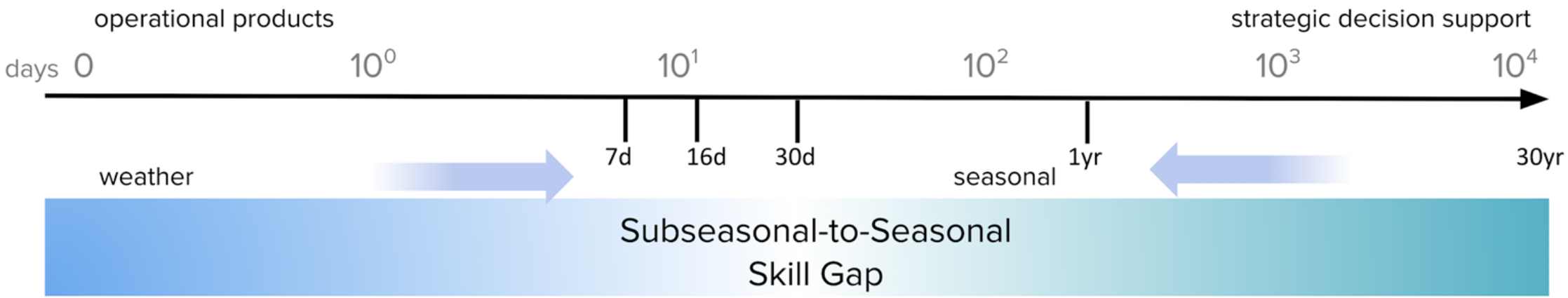
FY21 Activities Include

- EPIC Community Center website
- 3rd Annual Cloud Workshop
- 2nd EPIC Community Workshop
- Community Modeling Symposium at AMS 102
- Documentation and release of cloud-based UFS code and Applications

S2S Modeling

- EPIC will provide infrastructure needed for UFS
  - Seasonal forecast system (SFS) and
  - Earth system components

Identified S2S Skill Gap



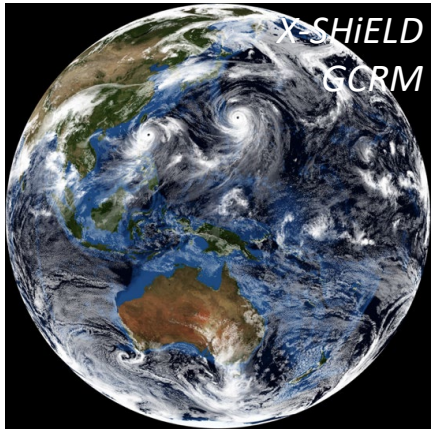
Needs Across Time Scales:

- Improved use of Cloud-based High-performance Computing
- Common model architectures
- Uncertainty depiction, especially common metrics
- Product creation

To Bridge the Skill Gap between Weather & Climate Prediction:

- Fully-couple air-ocean-land-ice modeling systems
- Improve data assimilation
- Improve process representation and higher resolution
- Advance reanalysis and reforecasts
- Build multi-model ensembles

Seamless Weather to Climate

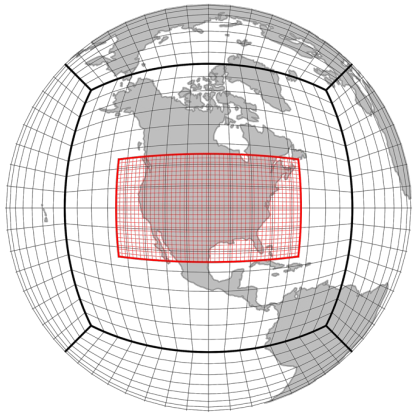


Scientific and technical (modeling) elements support shift to a seamless, holistic weather-climate, regional-global modeling approach.

- Weather (UFS) and Climate (GFDL) systems overlap at subseasonal to seasonal timescales

Common challenges:

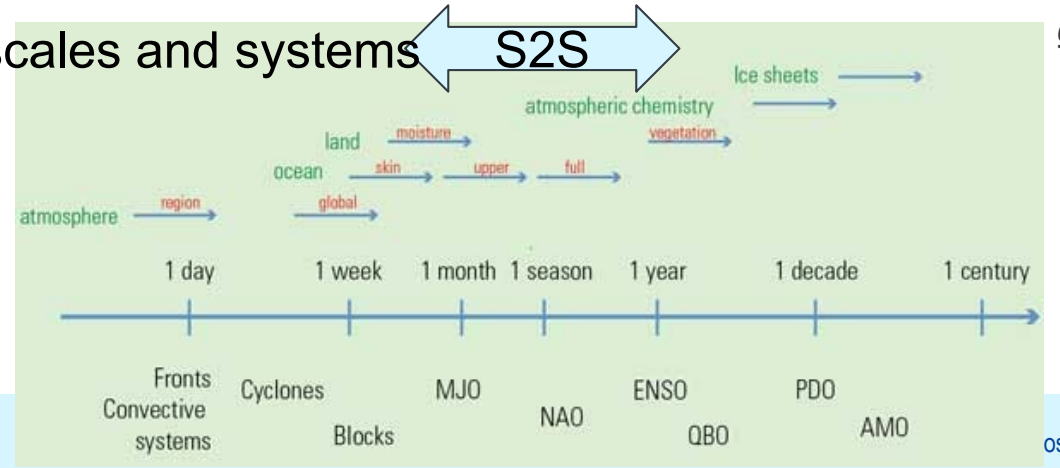
- Phenomena: Prediction of extreme events, tropical cyclones, tornadic thunderstorms, hydroclimate extremes, winter storms and cold waves, smoke-dust-fire
- Physics: Improvements to Boundary Layer, clouds and precipitation, coupling
- Technical: Increased resolution (convective-scale modeling)

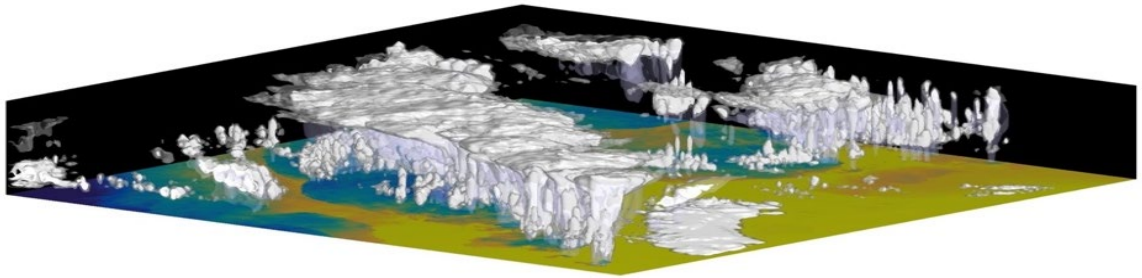


Nested grid in a global model

Precipitation Prediction

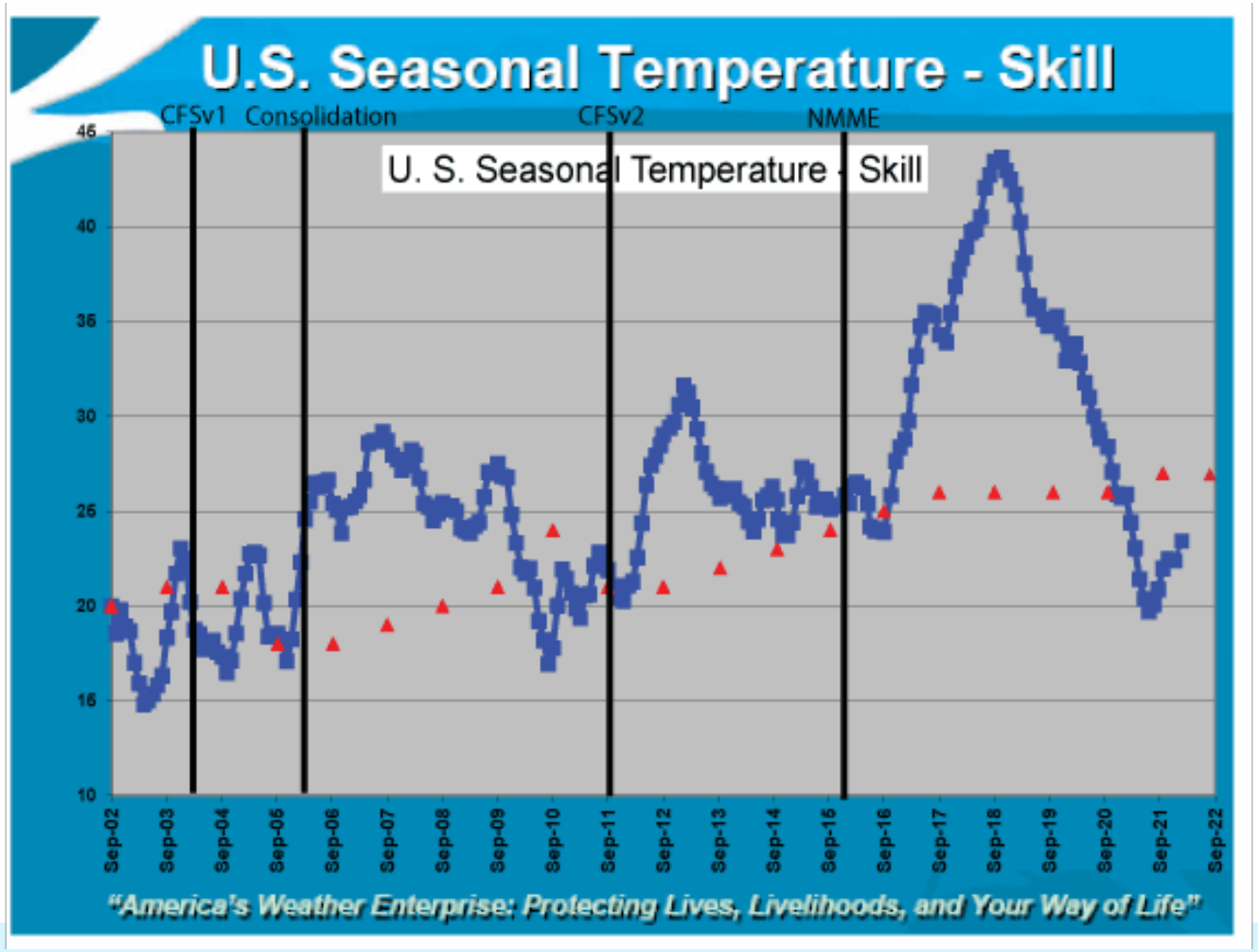
- Challenges must be addressed across scales and systems



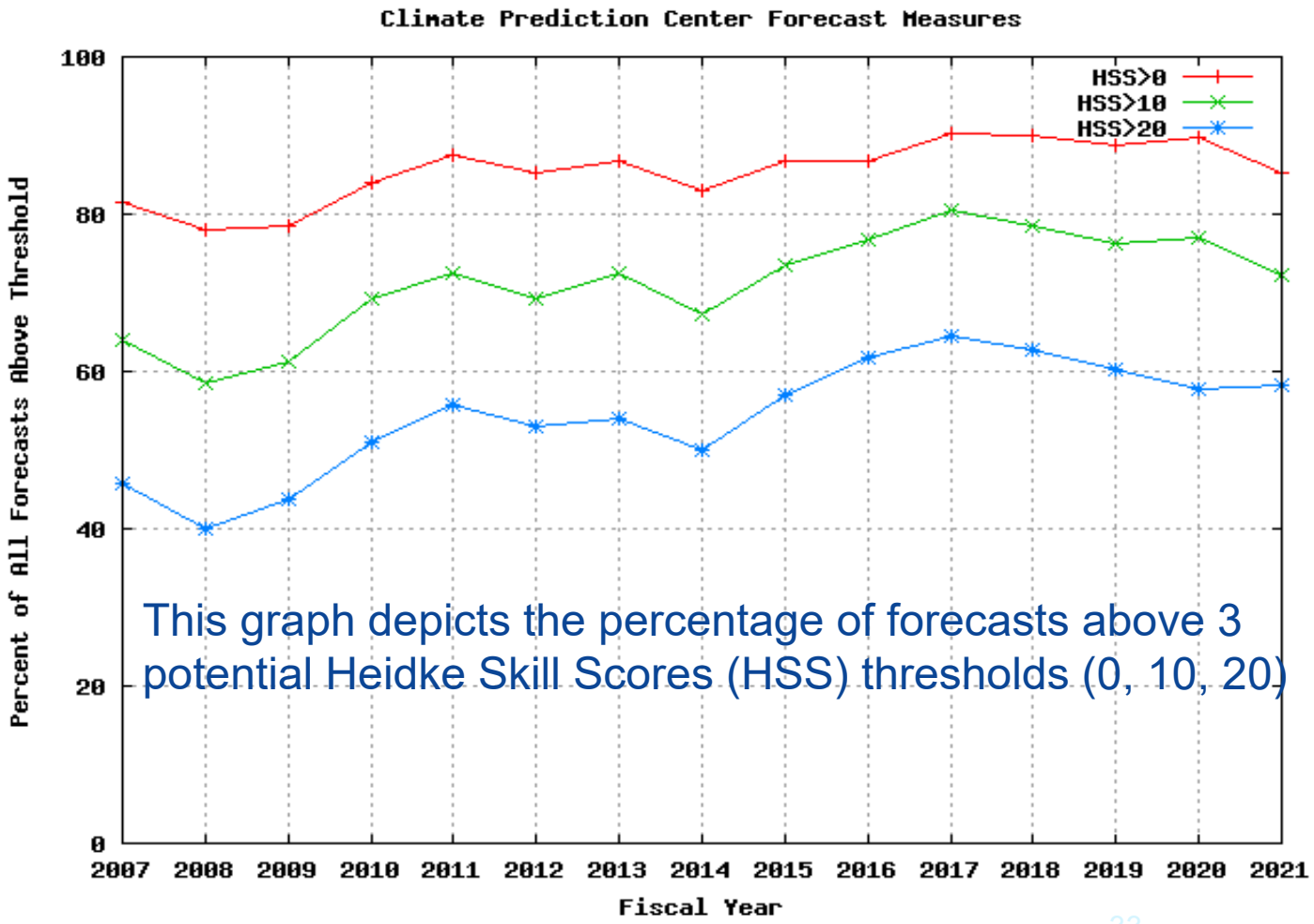


High-resolution squall-line forecast

CPC Official GPRA Metric
48 Month Running Mean of First Season Lead Surface Temperature



CPC Performance trends:
forecast Skill thresholds



This graph depicts the percentage of forecasts above 3 potential Heidke Skill Scores (HSS) thresholds (0, 10, 20)

Exhibit 13

Department of Commerce
National Oceanic and Atmospheric Administration
Operations, Research, and Facilities
PROGRAM INCREASE FOR 2022
(Dollar amounts in thousands)

		2022 Base		2022 Estimate		Increase from 2022 Base	
		Personnel	Amount	Personnel	Amount	Personnel	Amount
Science Technology Integration	Pos./BA	427	158,309	435	161,809	8	3,500
	FTE/OBL	421	158,309	427	161,809	6	3,500

Co-Development of Sub-Seasonal to Seasonal (S2S) Decision Support Services to Mitigate the Impacts of Extreme Events and Enable a Resilient Society (+$3,500, 6 FTE/ 8 Positions) – This increase includes research and development, product/service development, operational transition, and user training and outreach in support of sub-seasonal to seasonal decision support services (DSS). For example, extended periods of significantly below normal temperatures can adversely impact crop planting and harvesting schedules. NWS proposes to provide improved delivery of new publicly available products and services which will better provide information to vulnerable and underserved communities. NOAA requests a total $5.3 million to develop S2S (week two to three months) DSS for long lead time extreme events that occur on a timeframe from weeks to months. This initiative also includes $0.9 million for high performance computing for Central Processing [NWS-43], $0.5 million for user engagement surveys and workshops in the Analyze, Forecast, and Support [NWS-76], and $0.4 million for improved delivery of new products and services for Dissemination [NWS-122].

FY22 Congressional Budget Initiative – Pilot Project (Unfunded)

Subseasonal to Seasonal Weather Prediction. —Within funding for the U.S. Weather Research Program, the Committee provides $5,000,000 above the fiscal year 2021 enacted level for a subseasonal to seasonal research program to seed innovative research testbeds. Such efforts shall include a pilot project for subseasonal to seasonal precipitation forecasts for water management in the western United States recommended in NOAA's report to Congress pursuant to section 201 of the Weather Research and Forecasting Innovation Act of 2017 (Public Law 115–25). The pilot project should be carried out in coordination with the National Weather Service and should be focused on achieving measurable objectives for operational forecast improvement, including forecasts of seasonal mountain snowpack accumulation and total seasonal precipitation.

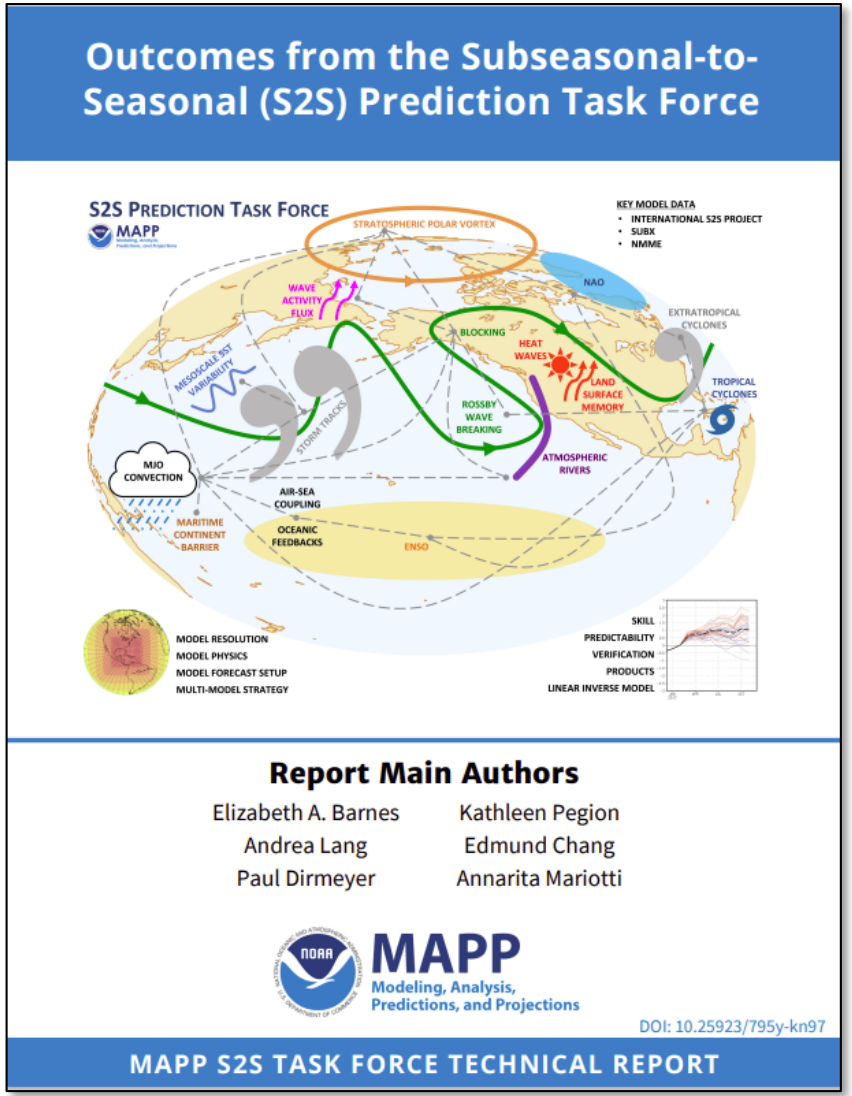
FY22 Congressional Budget Initiative – Funded ($2M)

As part of NOAA's focus on expanding climate services to inform climate adaptation efforts, NOAA, in collaboration with the interagency Integrated Water Cycle Group (IWCG of the U.S. Global Change Resources Program (USGCRP), including NASA, the Department of the Interior, the U.S. Army Corps of Engineers, the Council on Environmental Quality, and other Federal agencies, as appropriate, shall conduct a study of hydroclimatological changes in the major river basins of the Western United States over the next 30 years. …

…

To support this work on western water across timescales, as well as to advance the work on Sub-seasonal to Seasonal (S2S) weather prediction, the agreement provides an increase of $2,000,000 above the fiscal year 2021 enacted level to Climate Competitive Research.

Ongoing NOAA S2S Activities:
Report from S2S Prediction Task Force (June 2021)



- S2S Task Force active 2016 – 2020
- Run under OAR-CPO-MAPP
- 100+ pages
  - Includes deeper analysis of S2S product usefulness to decision-makers
- Efforts spanned a wide range of topics that all fit under the umbrella of S2S:
  - Atmospheric phenomena and processes
  - Interactions at the ocean-atmosphere and land-atmosphere interfaces
  - Organization and testing of dynamical subseasonal prediction models and systems
  - Exploring alternative ways to advance prediction using post-processing techniques.

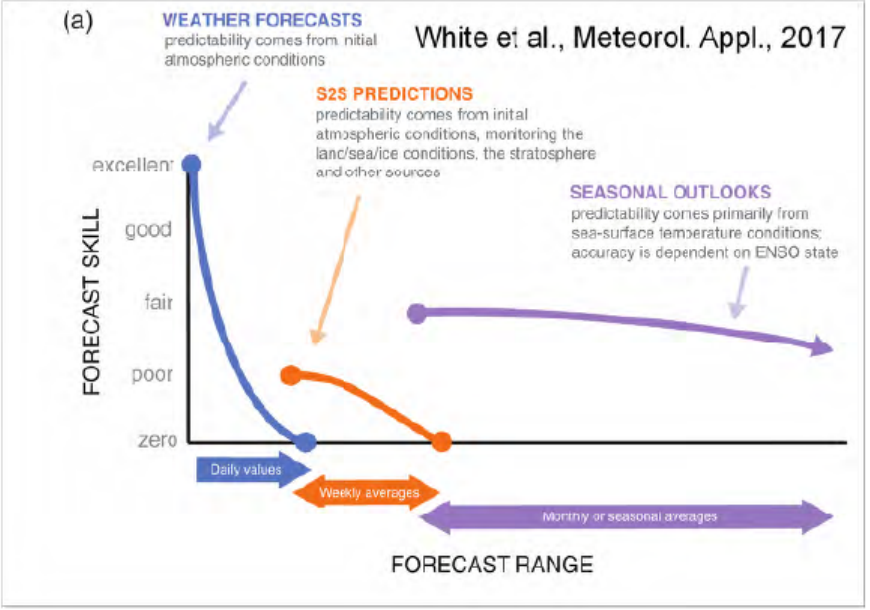
Subseasonal to Seasonal (S2S) Prediction

Presented by
Baoqiang Xiang

Geophysical Fluid Dynamics Laboratory Review
October 29-31, 2019

S2S prediction is a frontier but remains challenging

S2S: 10 days to one season



Multiagency and international efforts:

1) WWRP/WCRP S2S project

2) SubX (Participation in the NOAA/MAPP S2S Task Force)

➢ Falling into the time range of '**the Weather Act**' in 2017 (hours~2 years)

IBM

- Subseasonal forecasts are generated at weekly intervals up to 5 weeks out.
- Seasonal forecasts predict weather anomalies at monthly intervals up to 7 months out.