Improving Sub-Seasonal to Seasonal Precipitation Forecasting for Water Management
Sub-Seasonal to Seasonal (S2S) Precipitation Forecasting

- Operational weather models – typically 2 weeks out (higher skill in first week)
- Sub-seasonal – 2 weeks to about 60 days
- Seasonal – up to 12 months
Variability of Western Precipitation

Slide courtesy of Mike Dettinger, USGS
The Problem – S2S Precip Forecasting Skill Inadequate for Water Management

Seasonal (Lead 0.5 Months) Precipitation Heidke Skill Score
DJF Manual Forecasts From 1995 to 2016

Average = 7.2

NWS CPC figure
There has been one serious problem in these forecasting techniques, and that is the lack of a proven system of long-range weather forecasting. The precipitation levels are never known until relatively late in each season, after the fact.

The procedure used by the NWS in these predictions is beyond the scope of this report, but is based upon predictions of airflow patterns in the atmosphere. The 30-day outlooks have been issued since 1947 but experience shows that success has been modest, with temperature forecasts enjoying more success than precipitation forecasts. Figure 28 is a com-

Although it would be desirable to develop additional skill in forecasting the weather a month hence, what is needed for operation and management of a complex water supply project is a long-term projection, at least a year in advance, with a high degree of reliability.
NOAA’s California Drought Service Assessment

- **Goals:**
  - Understand drought impacted decisions
  - Assess NOAA’s effectiveness in supporting those decisions

- **Methodology:**
  - 3 focus sectors (water resources, agriculture, fisheries)
  - 100+ interviews
  - 40+ reviewers
  - 400+ comments

- **Major Recommendations:**
  - Improve seasonal prediction for water resources
  - Develop full natural flow modeling and forecasting
  - Improve NOAA internal coordination
In the Beginning There Was HMT/EFREP...

NOAA Hydrometeorology Testbed/DWR Enhanced Flood Response & Emergency Preparedness programs, a state-federal research observations partnership
State of California Investments in Observing & Understanding Atmospheric River Storms

- NOAA HMT/DWR EFREP (state share) -- $15M
- DWR AQPI grant to Bay Area water agencies -- $19M
- Calwater I & II field observing campaigns -- $5M
- Other research with University of California system & NASA -- $3.5M
Weather Forecasts

- Forecast-Informed Reservoir Operations (FIRO)
- Advanced Quantitative Precipitation Information (AQPI)

**AR Occurrence Climatology**
- Chance of an AR occurring sometime during a week-long period in mid-January
- Climatology based on all week-3 ECMWF forecasts from 1996-2015 for mid-January

**AR Occurrence Forecast Relative to Climatology**
- Week 3 ECMWF forecast valid for Jan 16-22, 2018
- Values shown are forecast minus climatology (top)
- ECMWF ensemble forecast includes 51 members

Experimental Sub-seasonal forecasts
Example CDWR-Funded S2S Activities

Short-term (weather timescale) atmospheric river forecasting

Sub-seasonal experimental atmospheric river outlooks

CDWR contract with Scripps Institution of Oceanography

CDWR contract with NASA JPL
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<th>Event or System Condition</th>
<th>2019</th>
<th>2020</th>
<th>2024</th>
<th>2022</th>
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1 Reservoir initial conditions based on results from 35 simulations of December 31, 2018 conditions using the Mid-term Probabilistic Operations Model. MTOM uses the April 3, 2018 unregulated inflow forecast from the CBRFC.
2 Each of the 35 initial conditions were coupled with 110 hydrologic inflow sequences based on resampling of the observed natural flow record from 1906-2015 for a total of 3,850 traces analyzed.
3 Percentages shown may not sum to 100% due to rounding to the nearest percent.
4 Percentages shown may not be representative of the full range of future possibilities that could occur with different modeling assumptions.
5 The chance of a Lower Basin Shortage in calendar year 2019 is negligible.
NEXT GENERATION EARTH SYSTEM PREDICTION

STRATEGIES FOR SUBSEASONAL TO SEASONAL FORECASTS

Committee on Developing a U.S. Research Agenda to Advance Subseasonal to Seasonal Forecasting

Board on Atmospheric Sciences and Climate
Ocean Studies Board
Division on Earth and Life Studies

This prepublication version of Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts has been provided to the public to facilitate timely access to the report. Although the substance of the report is final, editorial changes may be made throughout the text and citations will be checked prior to publication. The final report will be available through the National Academies Press in spring 2016.

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One Hundred Fifteenth Congress of the United States of America

AT THE FIRST SESSION

Began and held at the City of Washington on Tuesday, the third day of January, two thousand and seventeen

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.

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

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:

Sec. 1. Short title; table of contents.
Sec. 2. Definitions.

TITLE I—UNITED STATES WEATHER RESEARCH AND FORECASTING IMPROVEMENT

Sec. 101. Public safety priority.
Sec. 102. Weather research and forecasting innovation.
Sec. 103. Storms warning improvement and extension program.
Sec. 104. Hurricane forecast improvement program.
Sec. 105. Weather research and development planning.
Sec. 106. Observing system planning.
Sec. 107. Observing system simulation experiments.
Sec. 108. Annual report on computing resource prioritization.
Sec. 109. United States Weather Research program.
Sec. 110. Authorization of appropriations.

TITLE II—SUBSEASONAL AND SEASONAL FORECASTING INNOVATION

Sec. 201. Improving subseasonal and seasonal forecasts.

TITLE III—WEATHER SATELLITE AND DATA INNOVATION

Sec. 301. National Oceanic and Atmospheric Administration satellite and data management.
Sec. 302. Commercial weather data.
Sec. 303. Unnecessary duplication.

TITLE IV—FEDERAL WEATHER COORDINATION

Sec. 401. Environmental Information Services Working Group.
Sec. 402. Interagency weather research and forecast innovation coordination.
Sec. 403. Office of Oceanic and Atmospheric Research and National Weather Service exchange program.
Sec. 404. Visiting fellows at National Weather Service.
Sec. 405. Warning coordination meteorologists at weather forecast offices of National Weather Service.
Sec. 406. Improving National Oceanic and Atmospheric Administration communication of hazardous weather and water events.
Sec. 407. National Oceanic and Atmospheric Administration Weather Ready All Hazards Award Program.
NOAA NWS Operational Products
Next Steps

• Increase visibility/awareness of need for improved forecast skill
• Emphasize priority for sustained S2S effort in NOAA budget, for National Weather Service and Office of Atmospheric Research
• Implement Weather Research & Forecasting Innovation Act of 2017
• Support forecast improvement pilot projects
Subseasonal-to-Seasonal (S2S) Precipitation Coalition

The Subseasonal-to-Seasonal (S2S) Precipitation Coalition is a broad-based, multi-state coalition of entities committed to advancing federal support for enhanced precipitation prediction in the Western United States.

After enduring several years of drought, Western states have experienced historic precipitation in recent months. In both extremes, improved forecasting will allow communities throughout the West to better prepare for wet and dry seasons alike.

Effective water management in the West is enhanced by sound, scientifically-based decisions made weeks to months ahead of time. While some of these key decisions hinge on expectations or predictions of precipitation, snow pack and general watershed conditions, precipitation forecasting beyond 5-7 days is highly uncertain.

The science community has identified a strategy for pursuing improvements to national precipitation forecasts from two weeks to several months in advance. The S2S Precipitation Coalition is informing policymakers of the importance of these water decisions and the need for forecast research and related science.

**Founding Members**
Association of Metropolitan Water Agencies
Association of California Water Agencies
California Department of Water Resources
Colorado River District
Orange County Water District
Salt River Project
Sonoma County Water Agency
Scripps Institution of Oceanography, UC San Diego
Western States Water Council

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September 2017