Where We Are Now in California

- State emergency proclamations for drought issued in April, May, July, & Oct
- All 58 counties now covered by state proclamations
- All counties covered by USDA drought disaster designations
Persistent & Extreme Drought

- WY 2021 2nd driest for statewide precipitation, after 1924
- WYs 2020 + 2021 are California’s driest 2-year period for statewide precipitation, beating WYs 1976 + 1977
USGS Statewide Runoff

Annual California Runoff

- **Annual Runoff**
- **Lowess Smoothing Runoff**

*Graph showing annual runoff from 1905 to 2020, with two lines indicating different methods of smoothing the data.*
Bridging the Valley of Death

From multiple decades to days

Climate | Where the decisions happen | Weather
<table>
<thead>
<tr>
<th>Climate</th>
<th>Water Operations</th>
<th>Weather</th>
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<tbody>
<tr>
<td>Long-term planning</td>
<td>Annual water allocations, Water supply forecasts, Water rights administration, Water budgets, Water transfers, Water pricing, Delivery schedules, Water agency budgets, Reservoir operations, Recharge operations</td>
<td>Reservoir operations, Recharge operations, Flood forecasts</td>
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Key Need – Skillful S2S Precipitation Forecasts to Support Water Management

• Although it would be desirable to develop additional skill in forecasting the weather a month hence, what is needed for operation & management of a complex water supply project is a long-term projection, at least a year in advance, with a high degree of reliability. (CDWR, 1978, review of 1976-77 Drought)

• The Panel recommends that DWR identify & seek funding for research in the areas of long-range weather forecasting...Improved long-range weather forecasting would be invaluable in operating federal, State, and local water projects... (Governor’s Advisory Drought Planning Panel, 2000)

• Top findings include: Improve seasonal prediction. Numerous stakeholders commented on the need for a seasonal prediction capability focused on cool season mountain precipitation, both in California and in the Colorado River Basin. (NOAA, California Drought 2014 Service Assessment)

• Skillful sub-seasonal to seasonal (S2S) precipitation forecasting would be extremely useful in informing drought preparedness and response. CDWR, 2020, California’s Most Significant Droughts)
Lead Time for Drought Preparedness & Response (& Water Management Generally)

Seasonal Water Management Funnel

Beginning of Wet Season

- Taking shortage mitigation measures, e.g., negotiating temporary water transfers
- Making initial water supply allocations
- Revising initial allocations
- Making reservoir release pursuant to rule curves

End of Wet Season

Forecast Certainty

- Lead Time
- Days

Discretion for Decision Making

- More
- Less

More

Less

Months

Less
Decision Support Opportunities

• Improve seasonal precipitation forecasts to support costly resource allocation and policy decisions.
• Improve understanding of dynamics in the climate system during the (hopefully) wet season.
• Improve sub-seasonal precipitation forecasting to encourage greater use of FIRO and FloodMAR.
Sub-seasonal to Seasonal (S2S) Precipitation Forecasting

• S2S forecasts extend from 2 weeks to 1-2 years
• Long recognized as major need for improving drought response
• Skill of operational NOAA National Weather Service outlooks is minimal
• DWR is funding experimental forecasts to catalyze NOAA research, & urging needed federal investment in NOAA model improvements
Historical Skill of NOAA Seasonal Precipitation Outlooks

Seasonal (Lead 0.5 Months) Precipitation Heidke Skill Score
DJF Manual Forecasts From 1995 to 2019

Average = 7.9
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 115-23)
**Methods** | **Organization(s)** | **Nor Cal** | **So Cal** | **Upper Colo**
---|---|---|---|---
Machine Learning based Forecast for Nov-Jan (Gibson et al.) | Jet Propulsion Laboratory, California Institute of Technology | | | |
Univ. of Arizona Hybrid Seasonal Forecast for Nov-Jan (Zeng et al.) | Center for Western Weather and Water Extremes, University of Arizona | | | |
Evolution-centric Statistical Forecast for Dec-Feb (Sengupta et al.) | Jet Propulsion Laboratory, California Institute of Technology | | | |
NOAA ESRL Seasonal Forecast (Switanek et al.) | | | | |
NMME Seasonal Forecast for Dec-Feb | The North American Multi-Model Ensemble | U | | U |
NOAA CPC Seasonal Outlook for Nov-Jan | | U | | U |

- **Above Normal**
- **Below Normal**
- **Normal**
- **U** Uncertain/Equal Chances

* NOAA CPC Seasonal Outlook is the only Operational product
Winter Outlook Workshop Agenda

1:00 Opening Remarks
Improving Seasonal Precipitation Forecasting
Jeanine Jones, California Department Water Resources

1:20 Research Forecasts from NOAA’s North American Multi-Model Ensemble
Mike Anderson, California Department Water Resources

1:40 Experimental NOAA ESRL Forecast for DWR
Matt Switanek, NOAA Earth Systems Research Laboratory

2:10 Experimental NASA JPL Contract Forecasts for DWR
Duane Waliser, NASA Jet Propulsion Laboratory
  • Machine Learning Forecast
    o Mike DeFlorio, University of California, San Diego,
      Scripps Institution of Oceanography
  • Forecast with Precipitation, Temperature, and Snowpack
    o Xubin Zeng, University of Arizona
  • Evolution-Centric Statistical Forecast
    o Agniv Sengupta, NASA Jet Propulsion Laboratory

3:40 Ongoing Research with Climate Diagnostics
Gudrun Magnusdottir, University of California, Irvine

4:10 Runoff Efficiency with USGS Basin Characterization Model
Lorraine Flint, Earth Knowledge, Inc.

4:40 Q&A Discussion

5:00 Adjourn
Improving Sub-Seasonal to Seasonal Precipitation Forecasting for Water Management
### Experimental Seasonal Precipitation Forecast for Winter 2021-22

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- ☓ Above Normal
- ☒ Below Normal
- ☘ Normal
- ☉ Uncertain/Equal Chances

*NOAA CPC Seasonal Outlook is the only Operational product.

**Slide Credit:** A. Sengupta, M. DeFlorio, D. Waliser