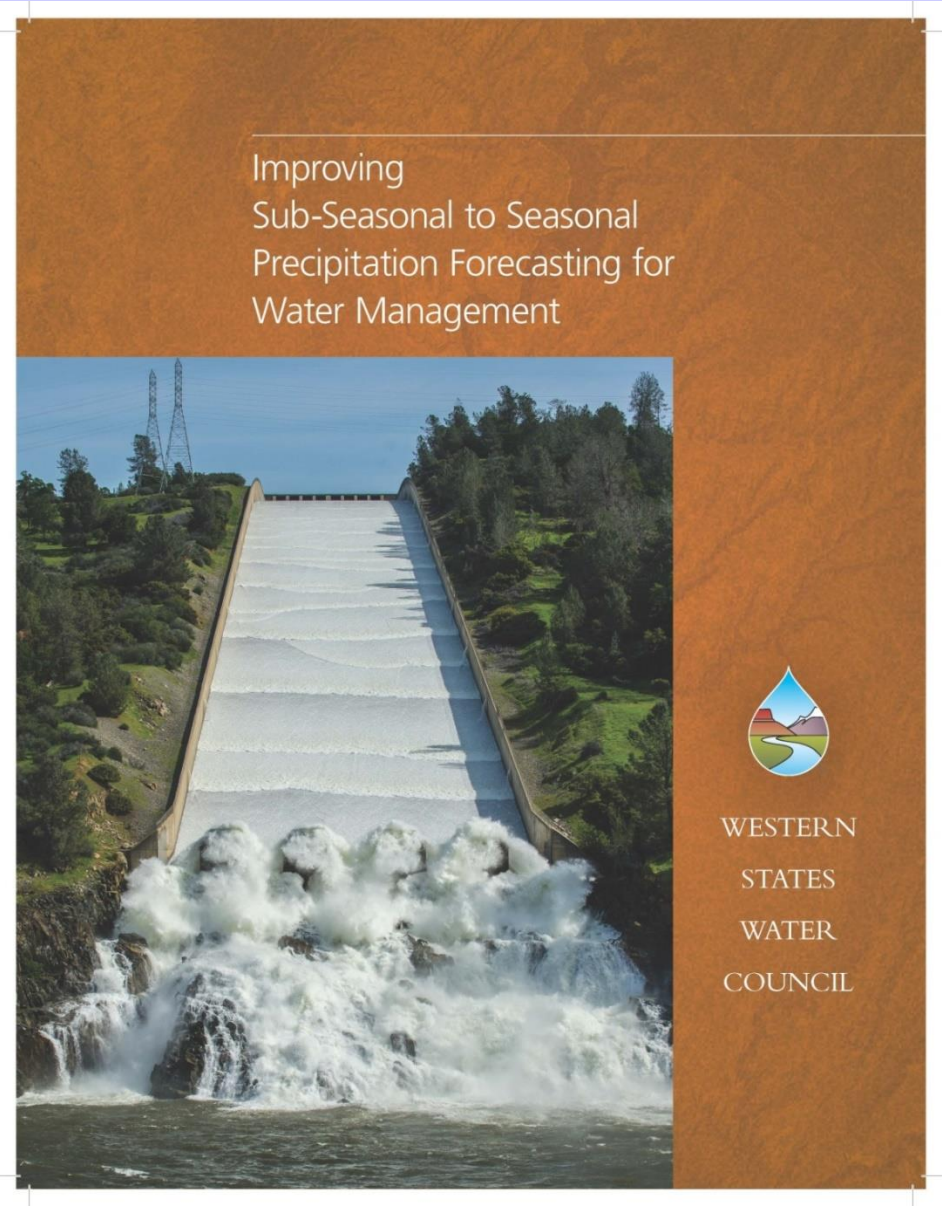


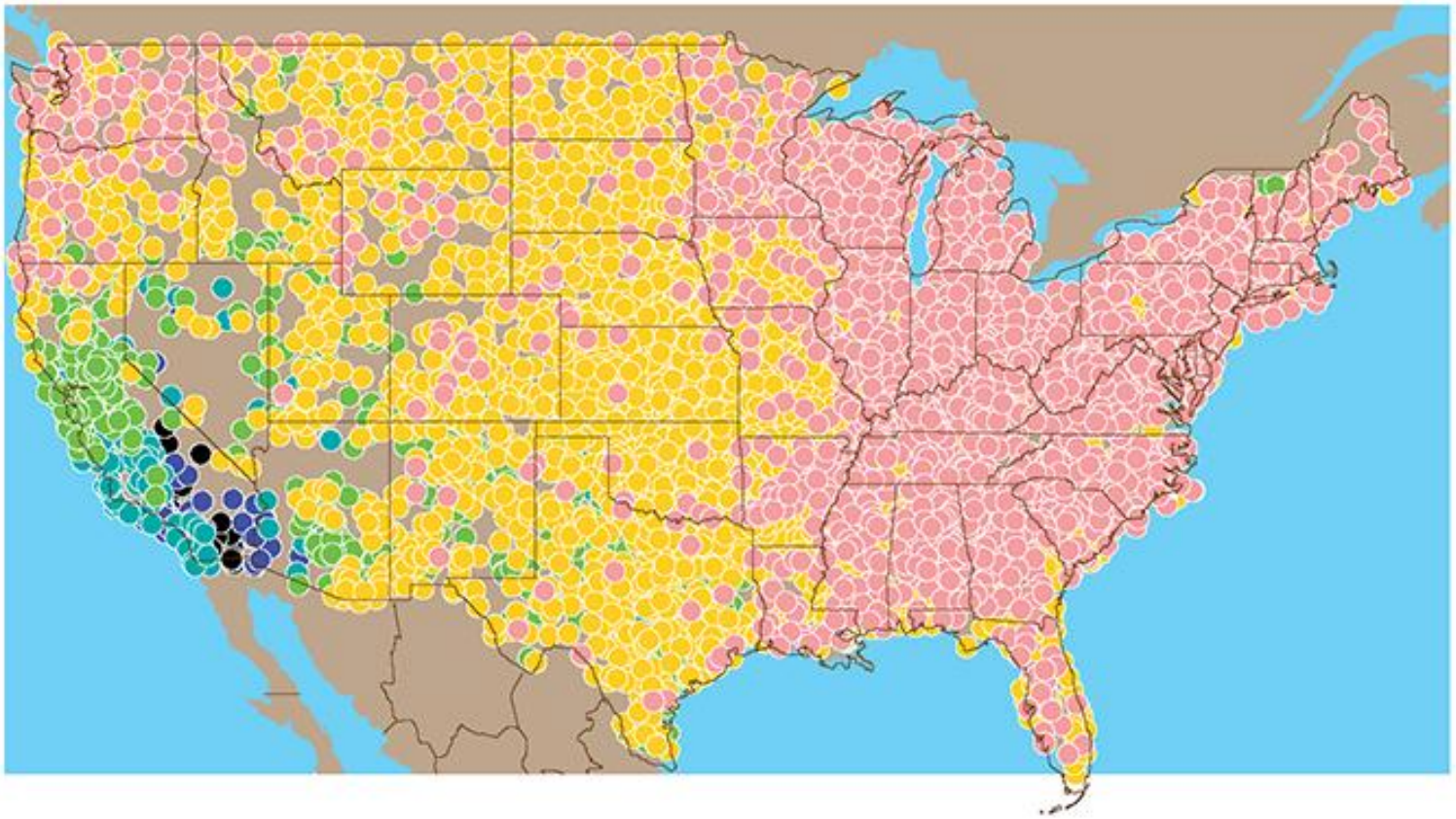
Atmospheric Rivers – Potential Tool for Improving Sub-Seasonal to Seasonal Precipitation Forecasting?

Jeanine Jones, California Department of Water Resources

Importance of Improving S2S Forecasting

- Skillful sub-seasonal to seasonal precipitation forecasting very important for water management, as well as for other sectors such as agriculture and transportation
- Present scientific skill for S2S forecasting is not adequate to support water management decision-making
- Lack of resources being directed to S2S forecasting, especially for the Western U.S.

California Precipitation is Uniquely Variable



Variation of Total Precipitation, Water Years 1951-2008

$$\frac{\text{Std Dev of Annual Precipitation}}{\text{Mean Annual Precipitation}}$$

10% 20% 30% 40% 50% 60% 70%

Dettinger et al, 2011

CALIFORNIA DROUGHT

2014 SERVICE ASSESSMENT

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.*

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

THE NATIONAL ACADEMIES PRESS
Washington, DC
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Lead Time Very Important for Water Management

- Public health & safety decisions
- Balancing risk/cost trade-offs
- Increasing water management efficiency
- Operating within legal & regulatory frameworks
- Reducing impacts of extreme events
- Responding to increased competition for resources

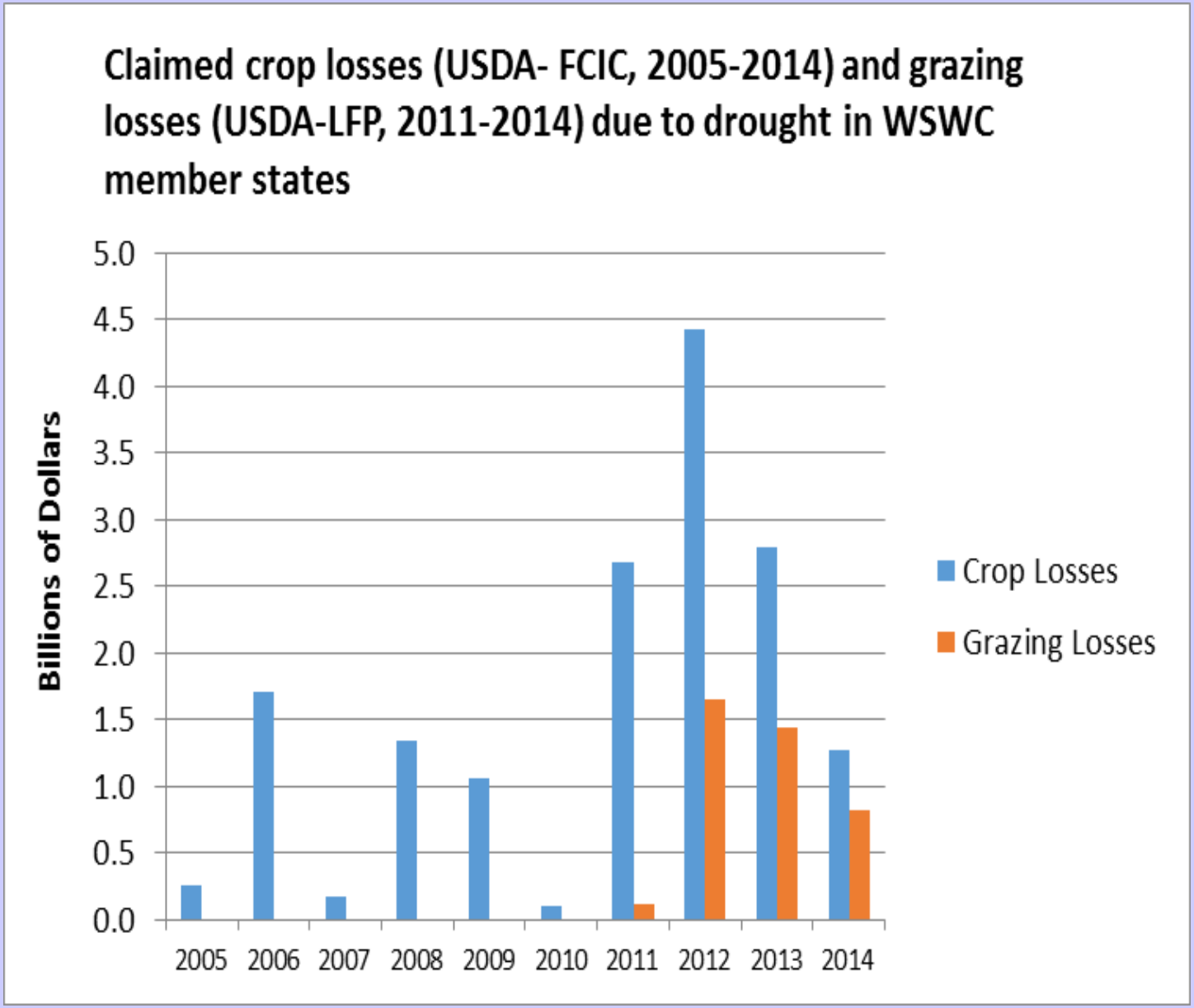
Will the Rest of This Winter be Wet or Dry? Example Sub-Seasonal Decisions

- How much water will we be able to provide to our water users? When can we make the announcement?
- Will we hit hydrologic shortage triggers that require extraordinary conservation measures, or the need to negotiate contracts or adopt regulations?
- Is an elevated flood risk likely this spring? Should we pre-position resources?
- If the rest of this winter looks dry, can we use reservoir flood control space to store water for allocation to users (e.g., forecast-informed reservoir operations)?
- Will we have to curtail diversions on intensively used rivers? How early in the season?

Will This Winter be Wet or Dry? Example Seasonal Decisions

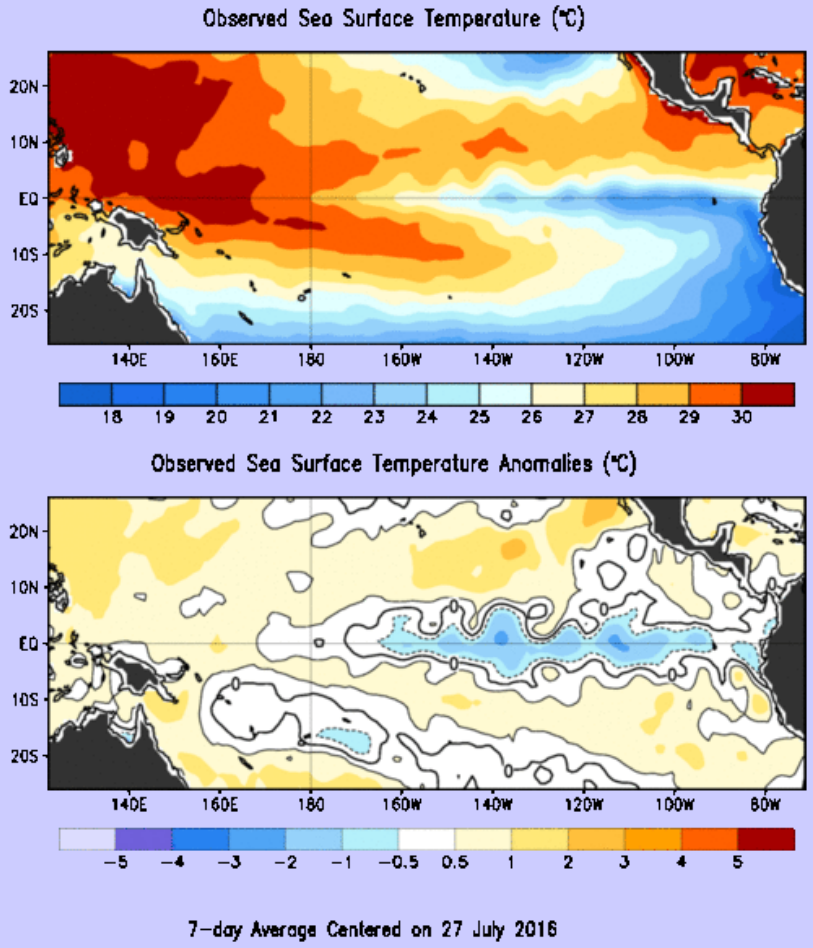
- Should we begin negotiating contracts for one-time sale of surplus wet-weather water? Can we set up a temporary groundwater banking program to take advantage of wet conditions?
- Do we need to seek additional drought response funding or raise water rates? Do we need to budget for enhanced water conservation activities?
- Should we make plans and adopt regulations for adopting a drought water bank?
- Should we intensify flood preparedness activities in vulnerable areas?

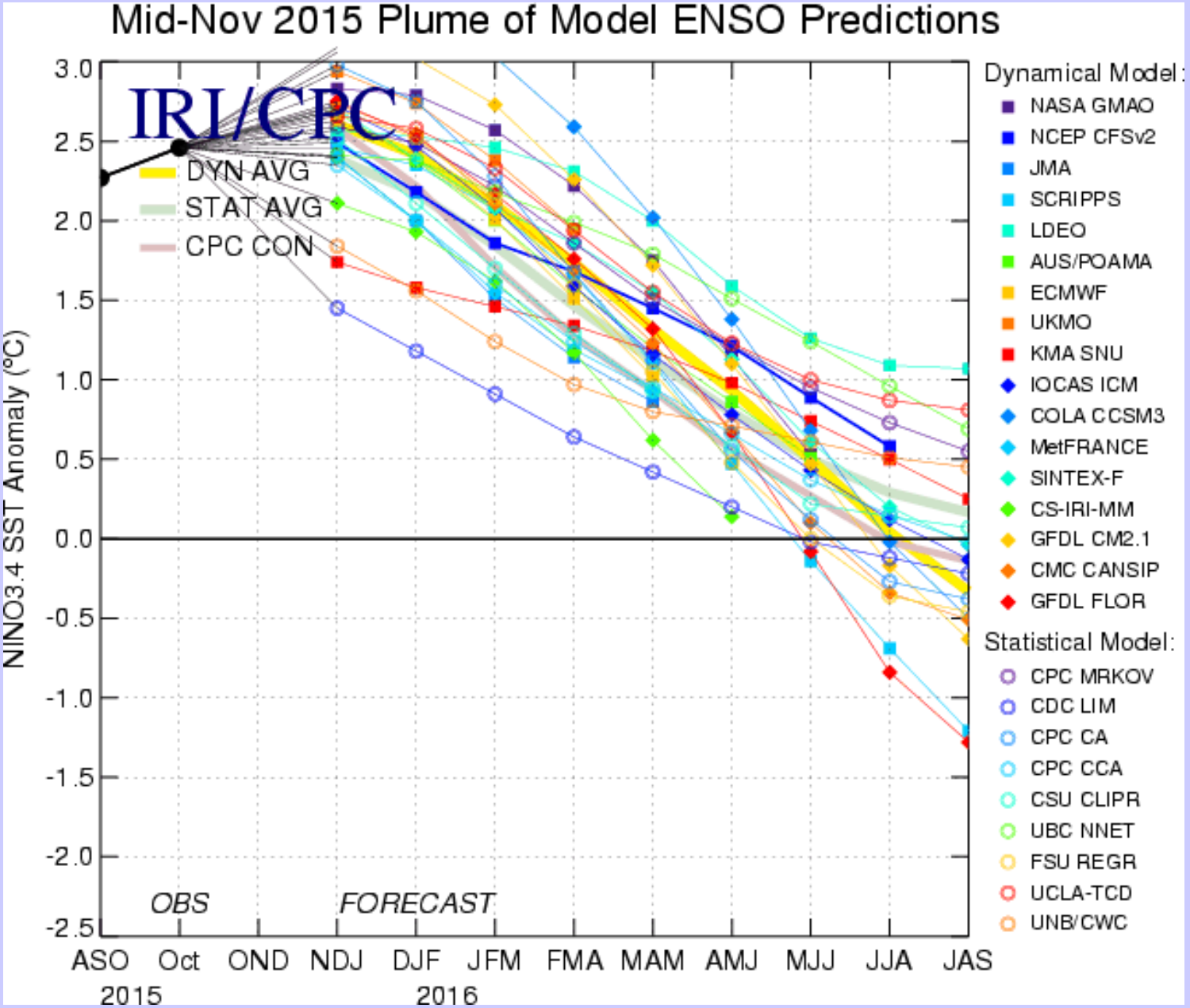
Large Potential Economic Benefits

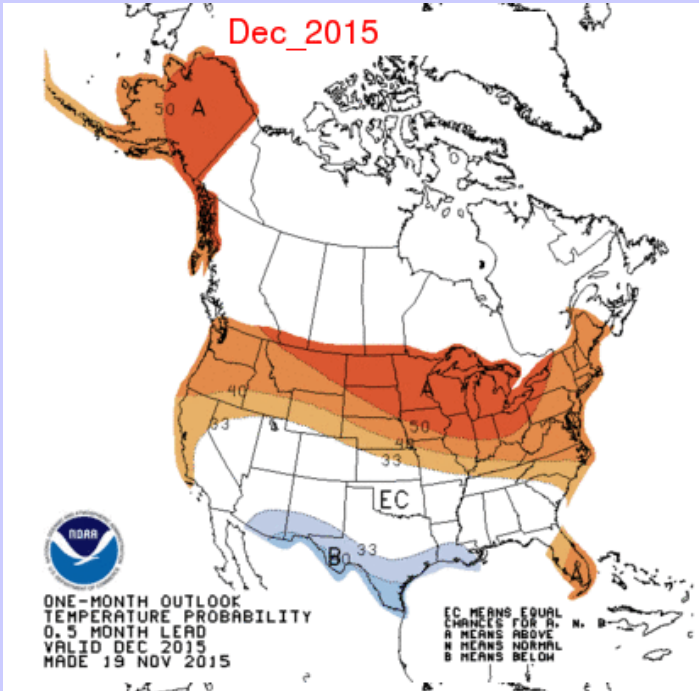


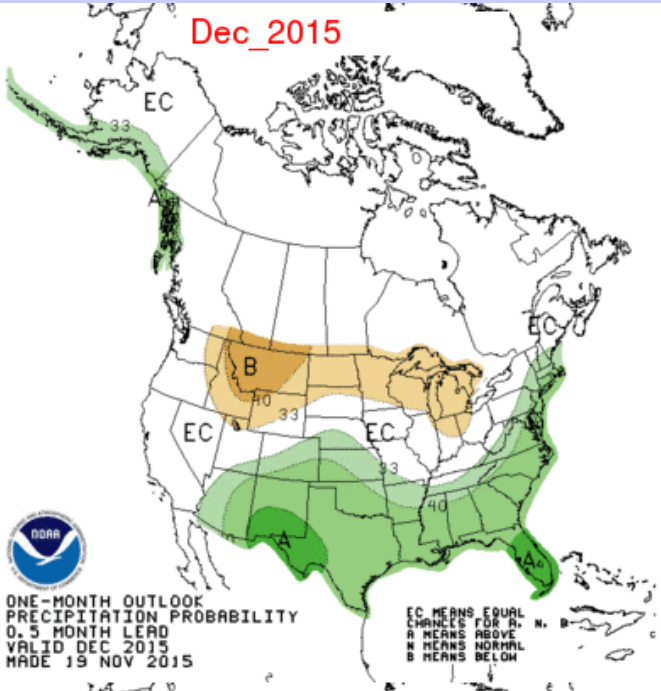
Sources of NOAA (and IRI) Forecast Skill

- 1. ENSO
- 2. Trends (difference between 10yr temp mean or 15yr precip mean & 30yr climatology)
- 3. MJO
- 4. NAO
- 5. PDO
- 6. Soil moisture/snow cover
- 7. Statistical forecast tools
- 8. Dynamical forecast models
- 9. Consolidation of trends & forecasts




Mid-Nov 2015 Plume of Model ENSO Predictions
IRI/CPC
DYN AVG
STAT AVG
CPC CON
NINO3.4 SST Anomaly (°C)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
OBS
FORECAST
ASO
Oct
OND
NDJ
DJF
JFM
FMA
MAM
AMJ
MJJ
JJA
JAS
2015
2016
Dynamical Model:
NASA GMAO
NCEP CFSv2
JMA
SCRIPPS
LDEO
AUS/POAMA
ECMWF
UKMO
KMA SNU
IOCAS ICM
COLA CCSM3
MetFRANCE
SINTEX-F
CS-IRI-MM
GFDL CM2.1
CMC CANSIP
GFDL FLOR
Statistical Model:
CPC MRKOV
CDC LIM
CPC CA
CPC CCA
CSU CLIPR
UBC NNET
FSU REGR
UCLA-TCD
UNB/CWC


Dec_2015
ONE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
0.5 MONTH LEAD
VALID DEC 2015
MADE 19 NOV 2015
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW


Dec_2015
ONE-MONTH OUTLOOK
PRECIPITATION PROBABILITY
0.5 MONTH LEAD
VALID DEC 2015
MADE 19 NOV 2015
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
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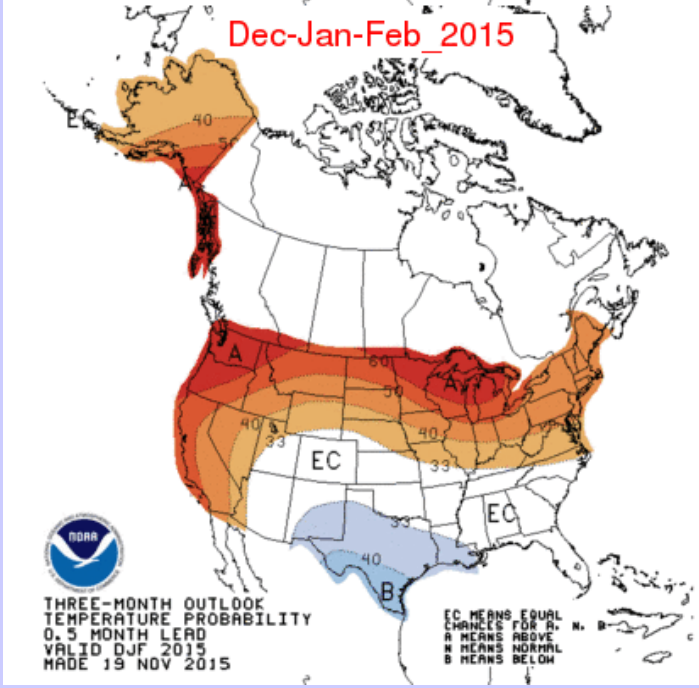
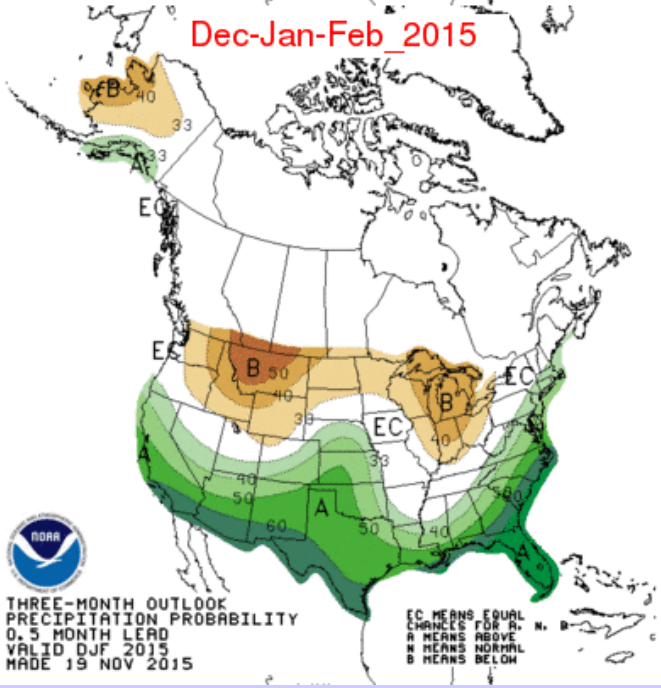
B MEANS BELOW


Dec-Jan-Feb_2015
THREE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
0.5 MONTH LEAD
VALID DJF 2015
MADE 19 NOV 2015
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW


Dec-Jan-Feb_2015
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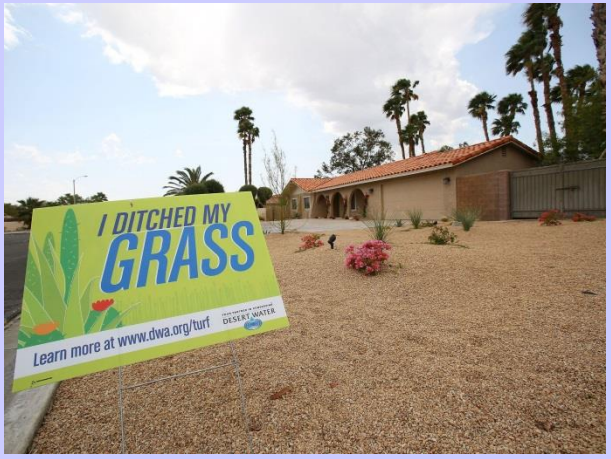
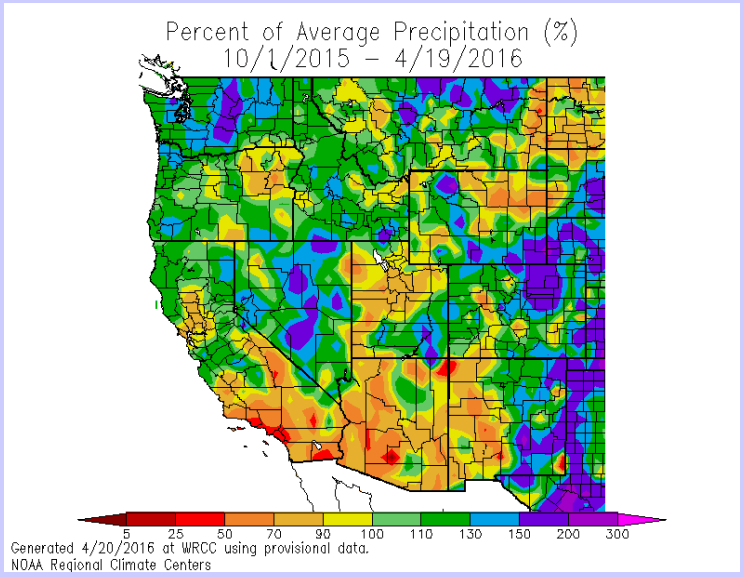
PRECIPITATION PROBABILITY
0.5 MONTH LEAD
VALID DJF 2015
MADE 19 NOV 2015
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW

Water Year 2016 – What Actually Happened

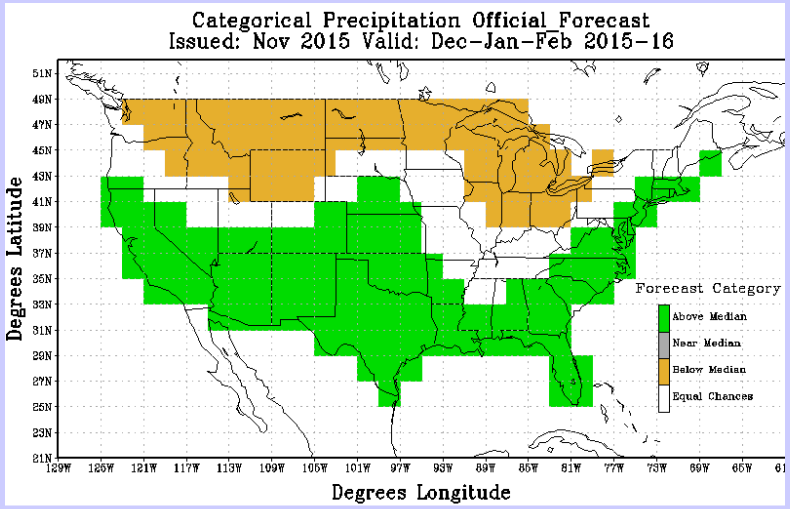
Snoqualmie, WA in November 2015

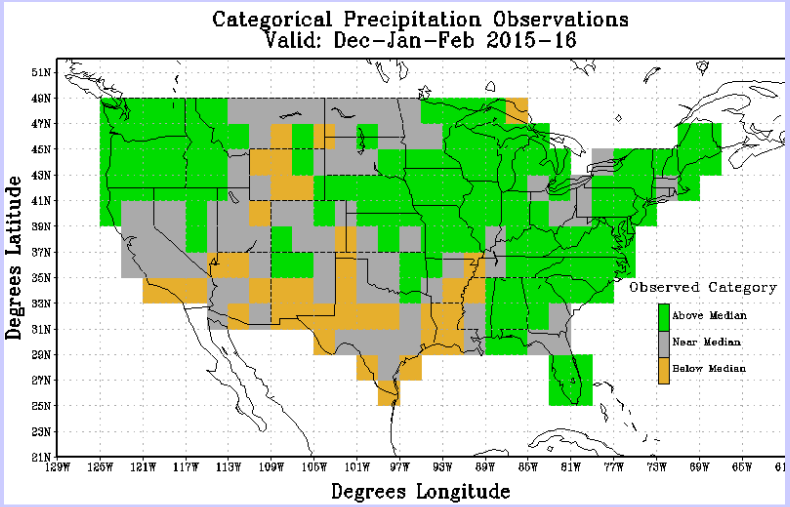
Meanwhile in Southern California





Present Forecasting Skill Not Usable for Water Management





Precipitation Forecast Heidke Skill Scores :

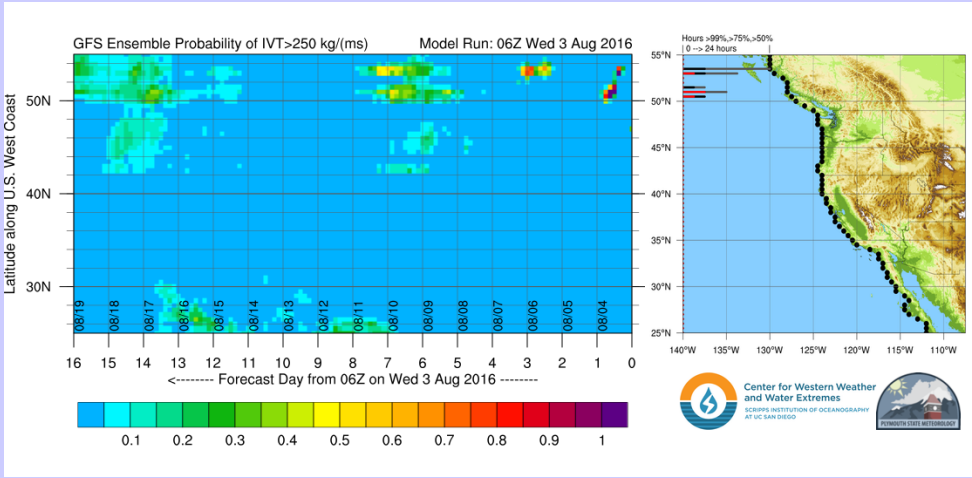
Non-Equal Chance(non EC) forecasts: -7.87

All forecasts: -6.03

% coverage not Equal Chance forecasts : 76.72

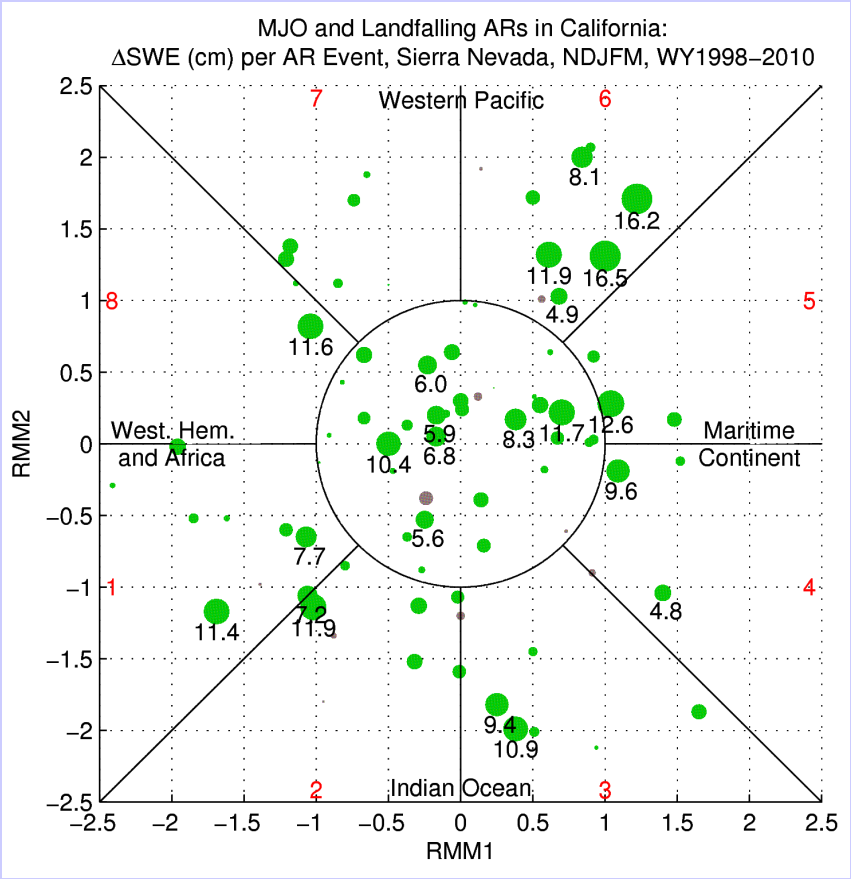
Improving Forecasting, Next Steps

- NRC 2016 describes 10-year research strategy
- Interested in improvements at regional spatial scale (orographic precip important in West)
- Low-hanging fruit?
- Forecasts of opportunity
- New science



Does the MJO Influence Atmospheric Rivers Timing or Frequency?

AR events during WY 1998-2010 are plotted in relation to the phase and amplitude of the MJO. The amplitude of the AR is shown in terms of ΔSWE as size of green circles. AR dots/events inside the unit circle occur during weak/no MJO. AR dots/events outside unit circle occur during strong MJO events in the given phase of the MJO life-cycle.



More high-impact ARs are observed during MJO phase 6 – convection in the W. Pacific Ocean, including the top two events during WY1998-2010

Guan, B., D. E. Waliser, N. Molotch, E. Fetzer, P. Neiman, 2012: Does the Madden-Julian Oscillation Influence Wintertime Atmospheric Rivers and Snowpack in the Sierra Nevada?, Mon. Wea. Rev., 140, 325–342,

State of California Investments in Observing & Researching AR Storms

- NOAA HMT project (state share) -- $15M
- Advanced precip monitoring & forecasting grant to Bay Area local agencies -- $19M
- Calwater I & II field observing campaigns -- $5M
- Research with UCSD/Scripps -- $3.5M

Summary

- AR forecasting clearly useful for flood risk management within weather timeframe
- Potential for seasonal water supply forecasting is intriguing (in California, e.g., < 10 storms make up annual water budget.)
- Can we predict (lack of) wet conditions to predict dry?
- Recent National Academy of Sciences report, new regional-scale observations of extreme precipitation/ARs and related research show pathway forward
- California is making big investment in ARs, looks like potential pathway for improving S2S forecasting in the West