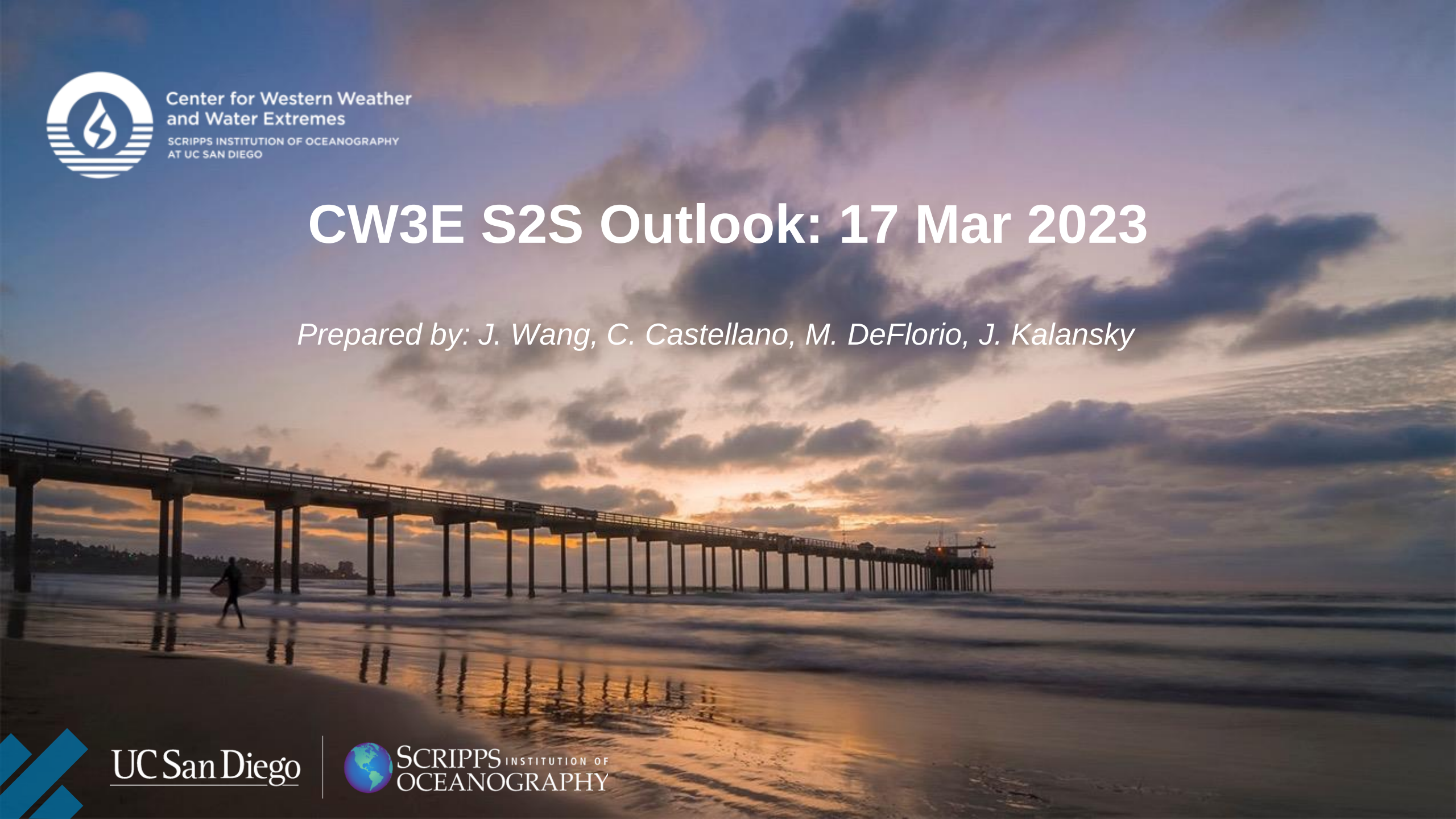


CW3E S2S Outlook: 17 Mar 2023

Prepared by: J. Wang, C. Castellano, M. DeFlorio, J. Kalansky

CW3E S2S Forecasts: Glossary & Context

- **The outlooks are based on CW3E subseasonal to seasonal forecast products that can be found here: https://cw3e.ucsd.edu/s2s_forecasts/**

- **CW3E subseasonal (2–6 weeks lead time) atmospheric river, ridging, and circulation regime products use three different global ensemble prediction systems to create these products:**
  - NCEP GFS (US Model): Weeks 2–3
  - NCEP CFSv2 (US Model): Weeks 2–6
  - ECCC (Canadian Model): Weeks 2–3
  - ECMWF (European model): Weeks 2–6

- **CW3E seasonal precipitation products are produced using statistical and machine learning models. The suite of models includes:**
  - CCA (canonical correlation analysis) based statistical model
  - Machine learning model, which also includes comparison to NMME (North American Multi-Model Ensemble)

- ***On the following slides, the term confidence refers to the forecasters' interpretation of the magnitude of the anomalies, the level of ensemble agreement, and the skill of the products used to generate the forecasts. All the tools used are shown in the outlook presentation.***

- ***The thresholds for below-normal, near-normal, and above-normal conditions are determined by forecast product and noted on each forecast product slide***

Summary: Subseasonal Precipitation Outlook by Model

This slide shows the CW3E synthesis of subseasonal products by model

Forecasts Initialized 16 Mar 2023

Region	Week 2 (24–30 Mar)				Week 3 (31 Mar–6 Apr)				Week 4 (7–13 Apr)		
	NCEP[1,2,3]	ECCC[1]	ECMWF[1,2]	Multi-Model Forecast	NCEP[1,2,3]	ECCC[1]	ECMWF[1,2]	Multi-Model Forecast	NCEP[2,3]	ECMWF[2]	Multi-Model Forecast
WA/OR											
Northern CA											
Central CA											
Southern CA											

Higher Confidence | Lower Confidence

- Below normal
- Near normal
- Above normal
- Uncertain/lack of skill

- Models agree on the near-normal precipitation over Central and Southern CA during Week 2
- Models agree on the below-normal precipitation over Southern CA and near-normal precipitation over Northern CA during Week 3
- Week 4 forecasts are uncertain

Subseasonal products included in this Outlook:

[1]CW3E/JPL Atmospheric River Activity Forecasts (DeFlorio et al. 2019)
[2]CW3E/JPL Ridging Forecasts (Gibson et al. 2020)
[3]IRI North American Weather Regime Forecasts (Robertson et al. 2020)

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

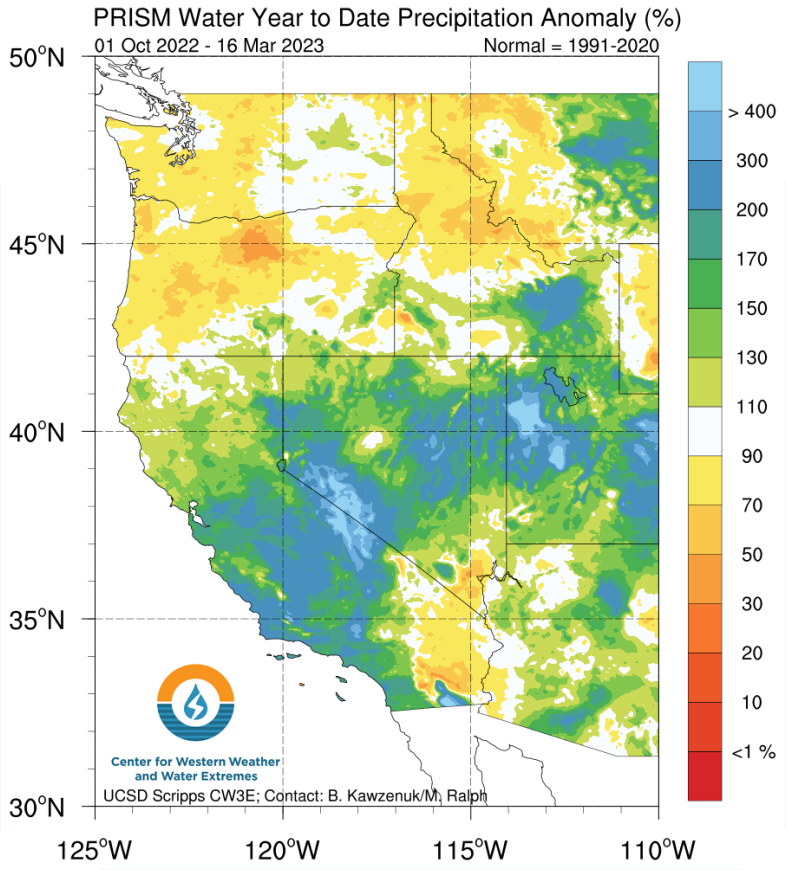
Summary

- **Week 2 forecasts (24–30 Mar):** Models agree on low likelihood (<30%) of AR activity over CA
- NCEP and ECMWF are forecasting strong MJO activity over the Indian Ocean during Week 1, which is climatologically associated with decreased AR activity over the Northeast Pacific and Western US in Week 2
- Both NCEP and ECMWF are showing low likelihood of persistent ridging activity near the US West Coast during Weeks 1–2
- Anomalously cold conditions and near-normal precipitation are predicted over CA during most of week 2 with moderate-to-high confidence
- **Week 3 forecasts (31 Mar–6 Apr):** Models agree on below-normal AR activity over Southern CA and near-normal AR activity over Northern CA
- Both NCEP and ECMWF are showing potential for persistent ridging activity near the US West Coast during Weeks 3-4 but the ensemble members disagree on the center of ridging activity
- **Mar-May seasonal forecasts:** Statistical model based on Feb SST is predicting above-normal precipitation over portions of WA, OR, and Northern CA, and below-normal precipitation over Southern CA with low confidence

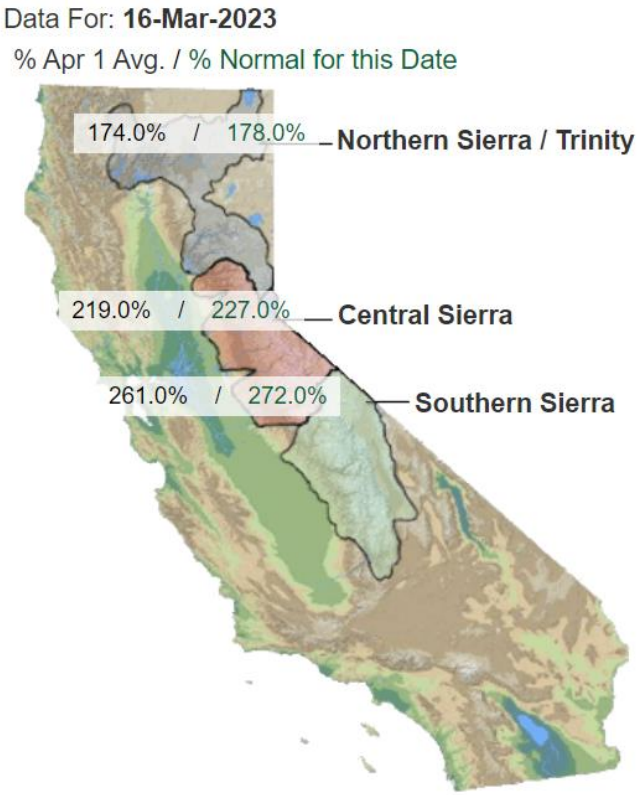
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Water Year Hydrologic Summary

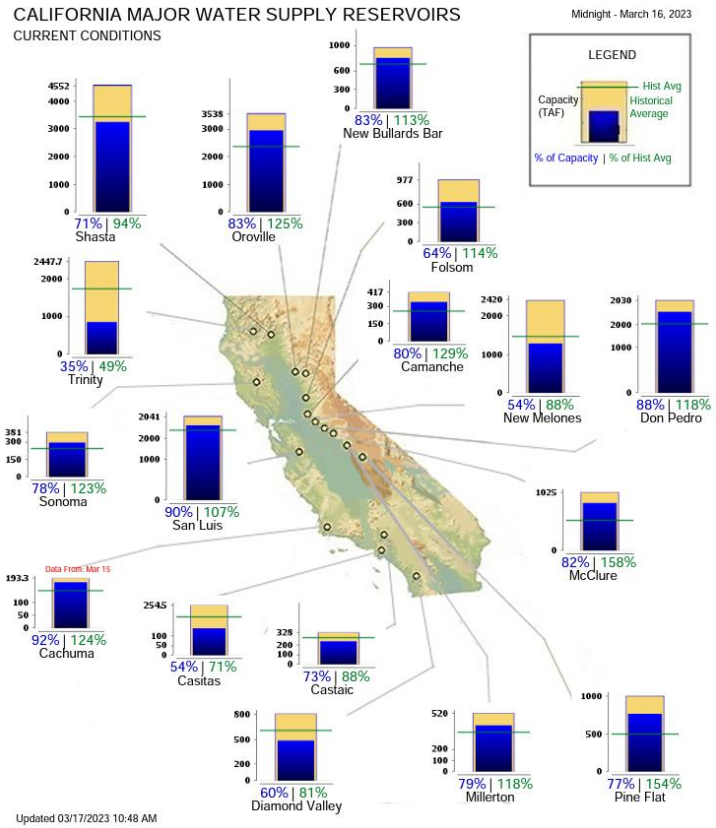
Precipitation



Snowpack Conditions



Reservoir Storage



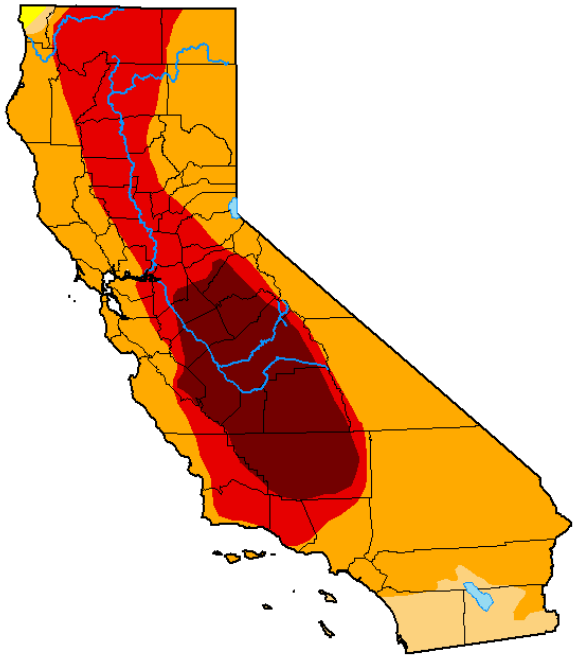
Source: California Department of Water Resources

- As of 16 Mar, water-year-to-date precipitation is above normal across much of the state
- Portions of Central CA have received > 200% of normal precipitation since 1 Oct
- Statewide snowpack is still well-above normal, especially in Central and Southern Sierra Nevada, where current snowpack is 227% and 272%, respectively, of normal for this date
- Very wet conditions during Dec–Feb led to a significant increase in water storage throughout the state
- Nearly all reservoirs in California are currently operating at greater than 50% storage capacity

Drought Conditions

U.S. Drought Monitor

California



September 27, 2022

(Released Thursday, Sep. 29, 2022)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	99.76	94.01	40.91	16.57
Last Week 09-20-2022	0.00	100.00	99.76	94.06	40.91	16.57
3 Months Ago 06-28-2022	0.00	100.00	99.79	97.48	59.81	11.59
Start of Calendar Year 01-04-2022	0.00	100.00	99.30	67.62	16.60	0.84
Start of Water Year 09-28-2021	0.00	100.00	100.00	93.93	87.88	45.66
One Year Ago 09-28-2021	0.00	100.00	100.00	93.93	87.88	45.66

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:

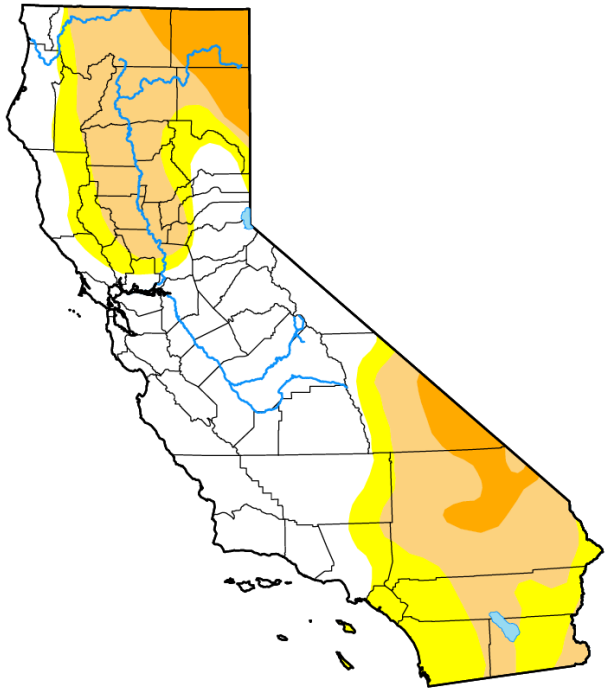
Richard Heim

NCEI/NOAA

droughtmonitor.unl.edu

U.S. Drought Monitor

California



March 14, 2023

(Released Thursday, Mar. 16, 2023)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	44.66	55.34	36.42	8.49	0.00	0.00
Last Week 03-07-2023	26.84	73.16	43.06	19.00	0.00	0.00
3 Months Ago 12-13-2022	0.00	100.00	97.94	80.56	35.50	7.16
Start of Calendar Year 01-03-2023	0.00	100.00	97.93	71.14	27.10	0.00
Start of Water Year 09-27-2022	0.00	100.00	99.76	94.01	40.91	16.57
One Year Ago 03-15-2022	0.00	100.00	100.00	93.23	35.22	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:

Brad Rippey

U.S. Department of Agriculture

droughtmonitor.unl.edu

- A very wet Dec–Feb period brought substantial drought relief to much of California
- At the start of the water year, 94% of the state was experiencing severe or worse drought conditions, and 41% of the state was experiencing extreme or exceptional drought
- As of 14 Mar, only 8% of the state was experiencing severe drought conditions, and no areas are experiencing extreme or exceptional drought
- The greatest improvement in drought conditions has occurred over Central California

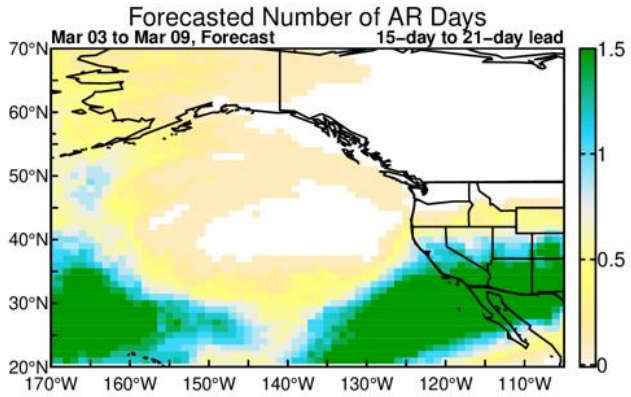
Center for Western Weather and Water Extremes

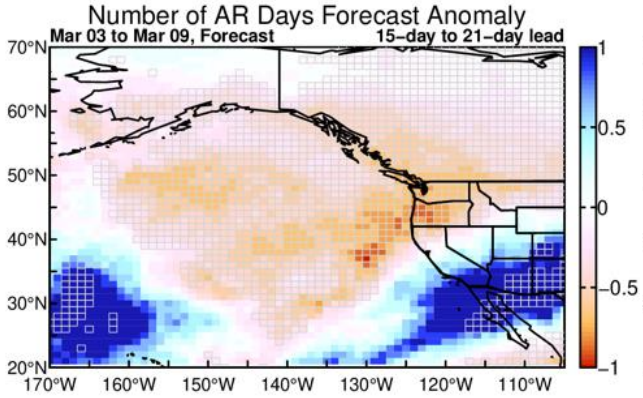
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Looking Back: Week 3 AR Activity Forecasts

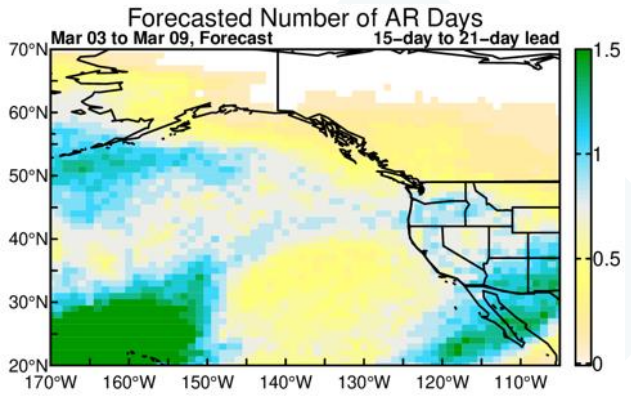
Forecasts Initialized 16 Feb 2023; Valid: 3–9 Mar 2023

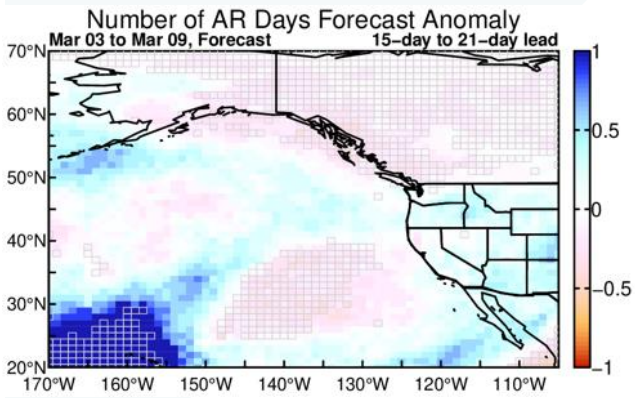
NCEP



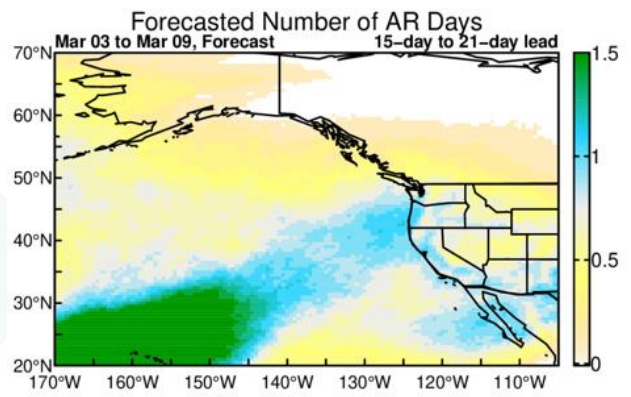


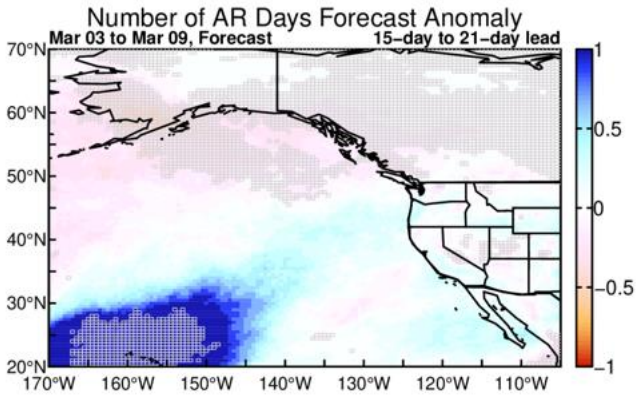
ECCC





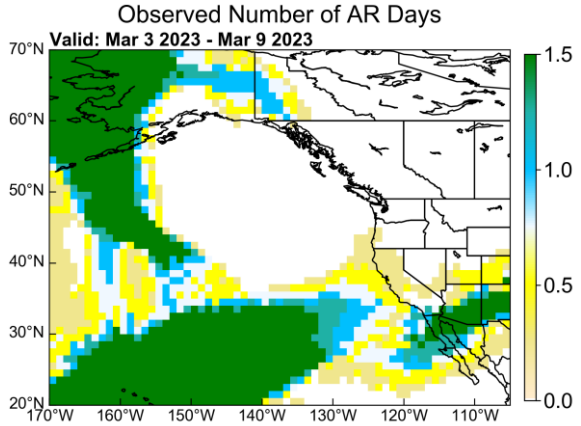
ECMWF



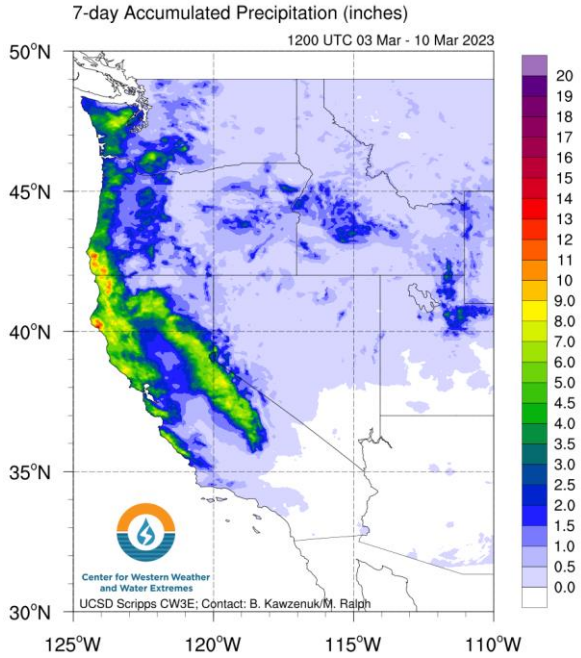


Shading: Fractional # of AR days over a 7-day period (top) and forecast minus model climatology (bottom)
Grey cells: >75% of ensemble members agree on sign of anomaly

Observed (GFS Analysis)



Observed Precipitation

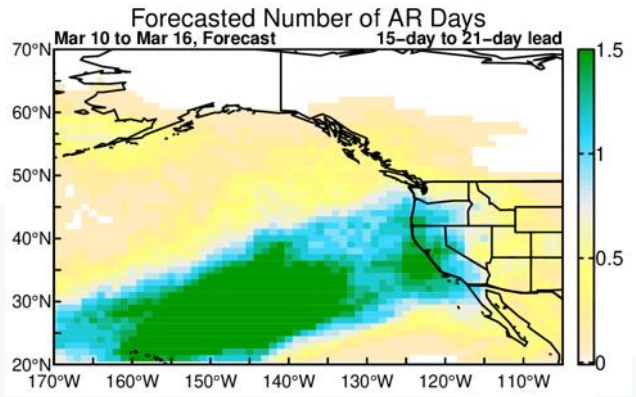


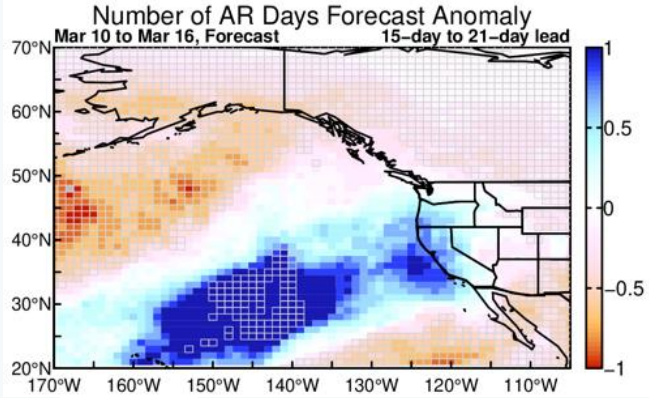
- NCEP correctly predicted low AR activity over WA and OR
- All models overpredicted AR activity over CA, especially in the NCEP model
- A winter storm brought heavy snow to Northern California Coast Ranges and Sierra Nevada during 4–6 Mar
- An AR made landfall in Northern and Central CA on 9–10 Mar

Looking Back: Week 3 AR Activity Forecasts

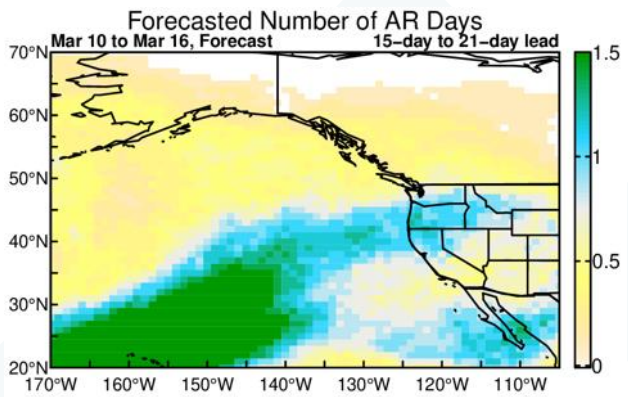
Forecasts Initialized 23 Feb 2023; Valid: 10–16 Mar 2023

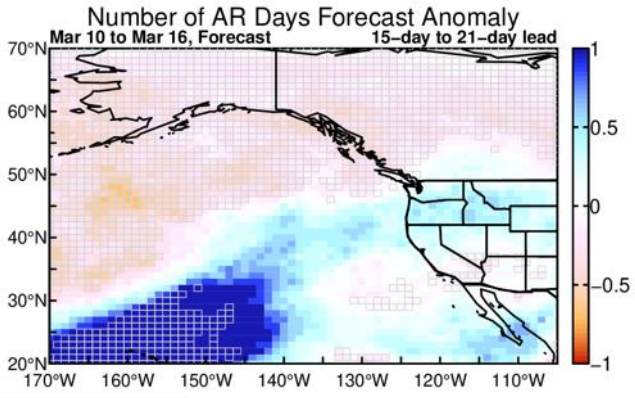
NCEP





ECCC

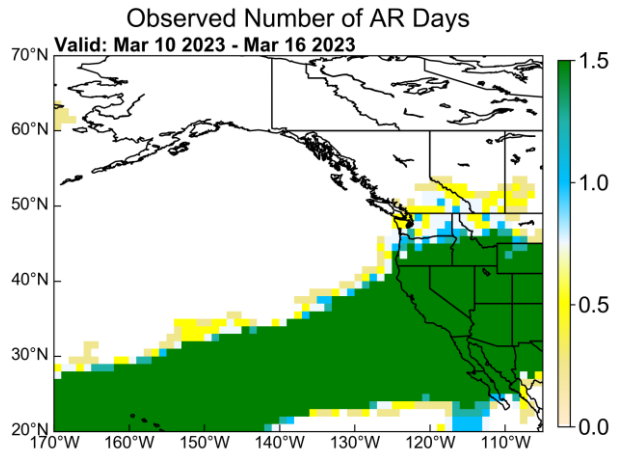




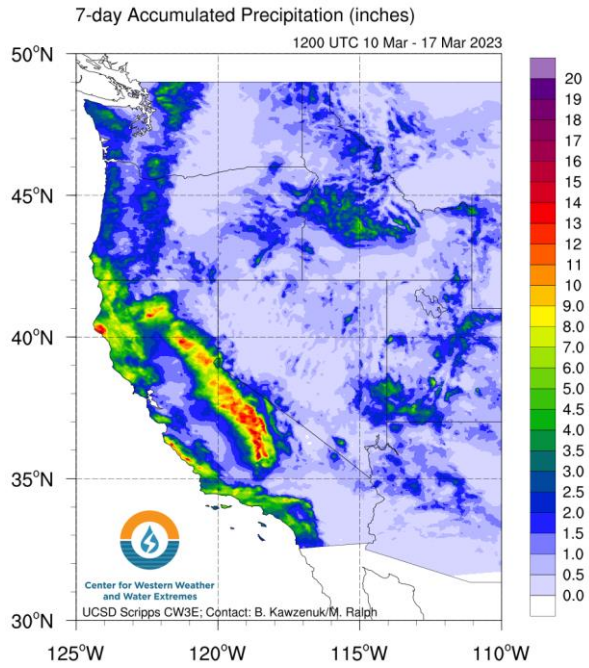
ECMWF

Unavailable

Observed (GFS Analysis)



Observed Precipitation

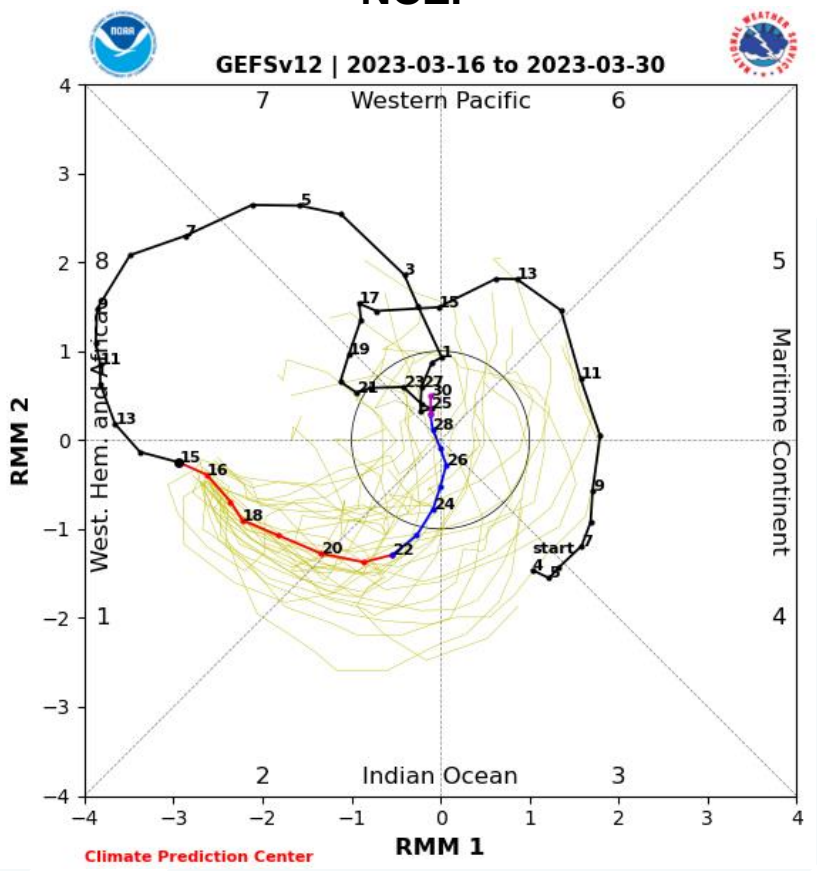


Shading: Fractional # of AR days over a 7-day period (top) and forecast minus model climatology (bottom)
Grey cells: >75% of ensemble members agree on sign of anomaly

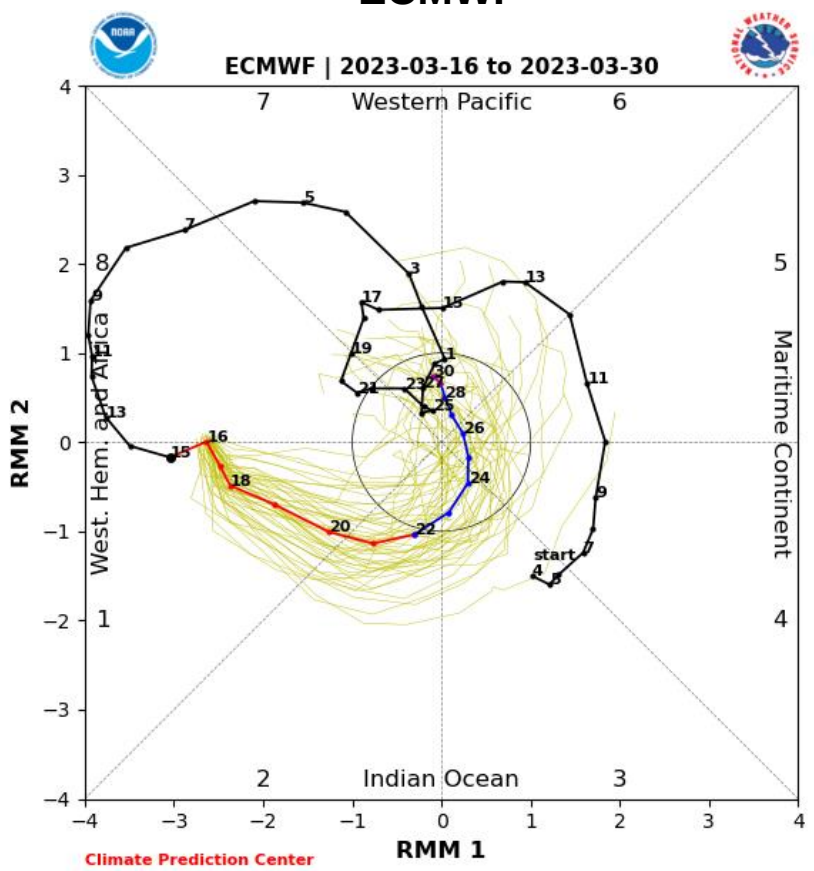
- Both NCEP and ECCC verified over OR and Northern CA but missed the AR activity over Southern CA
- NCEP also correctly predicted above-normal AR activity over Central CA
- Multiple ARs brought heavy rain over Northern CA, the Sierra Nevada, Central California Coast Ranges, and Transverse Ranges, and moderate precipitation over coastal Southern CA

Dynamical Model MJO Forecasts (NCEP vs. ECMWF)

NCEP



ECMWF



Black line: Last 40 days of observations; Yellow lines: Ensemble members
Forecast: (red: week 1, blue: week 2, purple: > week 2)

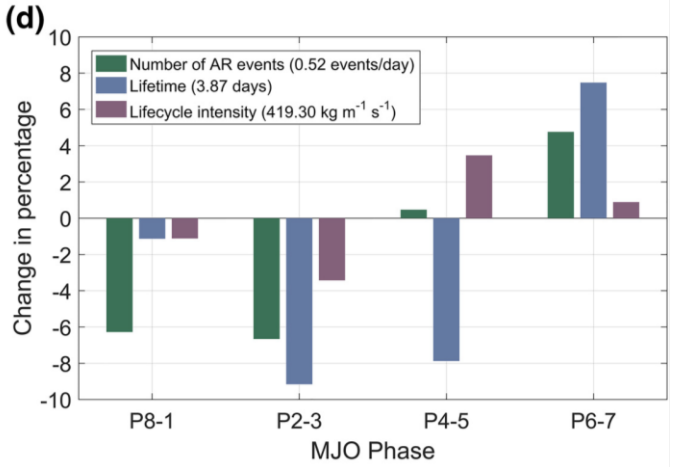


Figure 2d from Zhou et al. (2021)

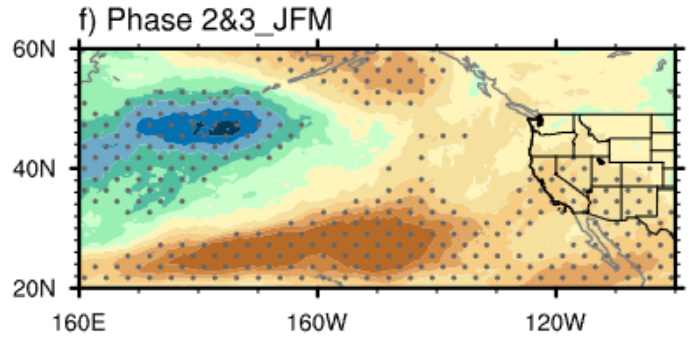


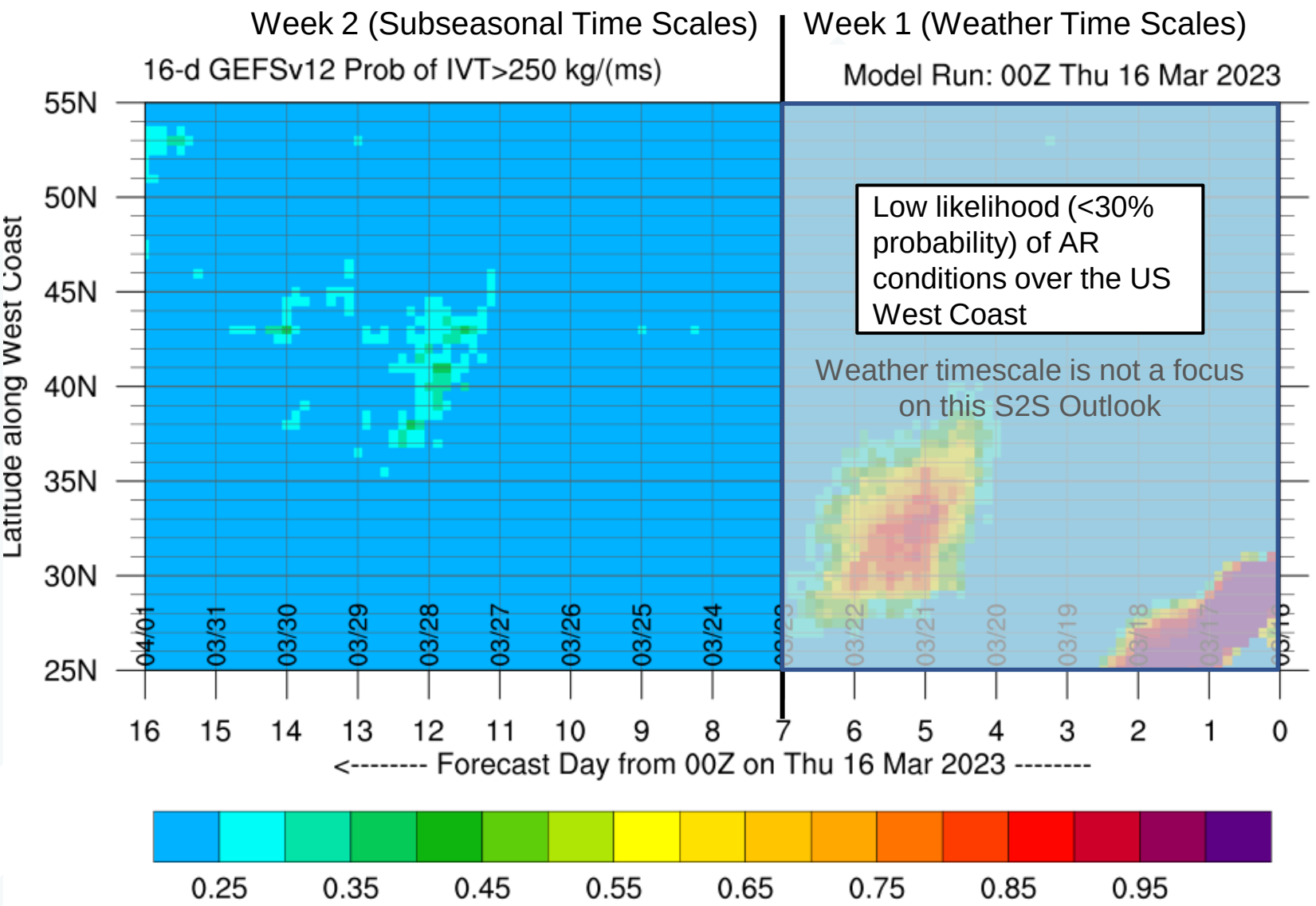
Figure 10f from Wang et al. (2023)

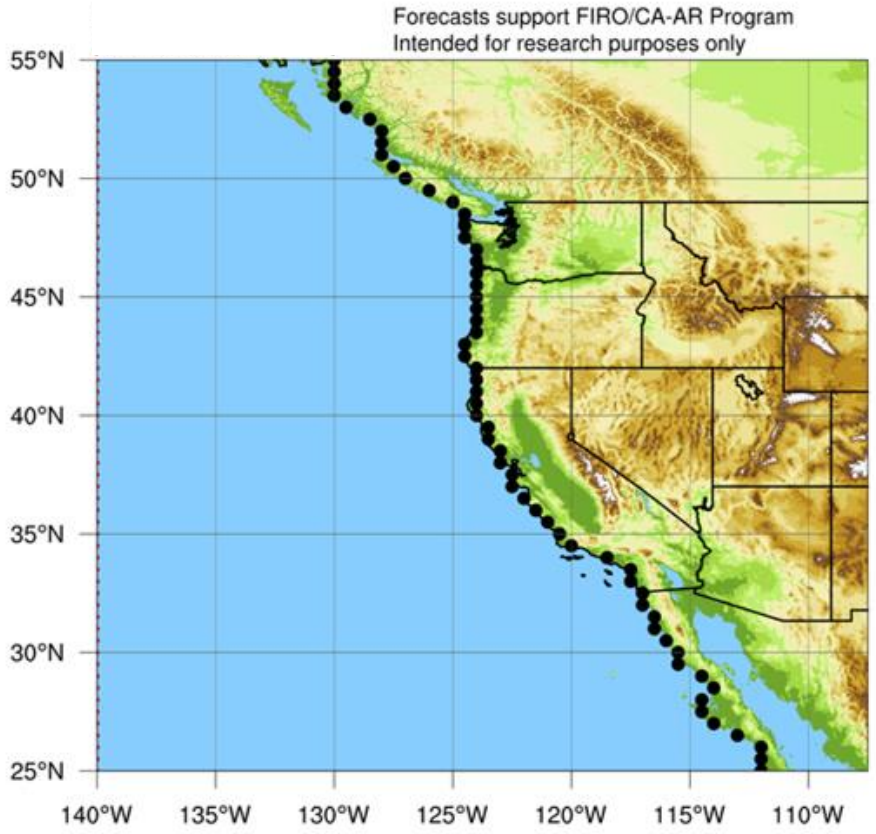
- Both NCEP and ECMWF are forecasting strong MJO activity over the Indian Ocean during Week 1 which weakens during Week 2
- MJO activity over the Indian Ocean is generally associated with significant decreases in AR activity over the subtropical Northeast Pacific and California

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

NCEP GEFS AR Landfall Tool: Valid 00Z 16 Mar – 00Z 1 Apr

Forecasts Initialized 16 Mar 2023





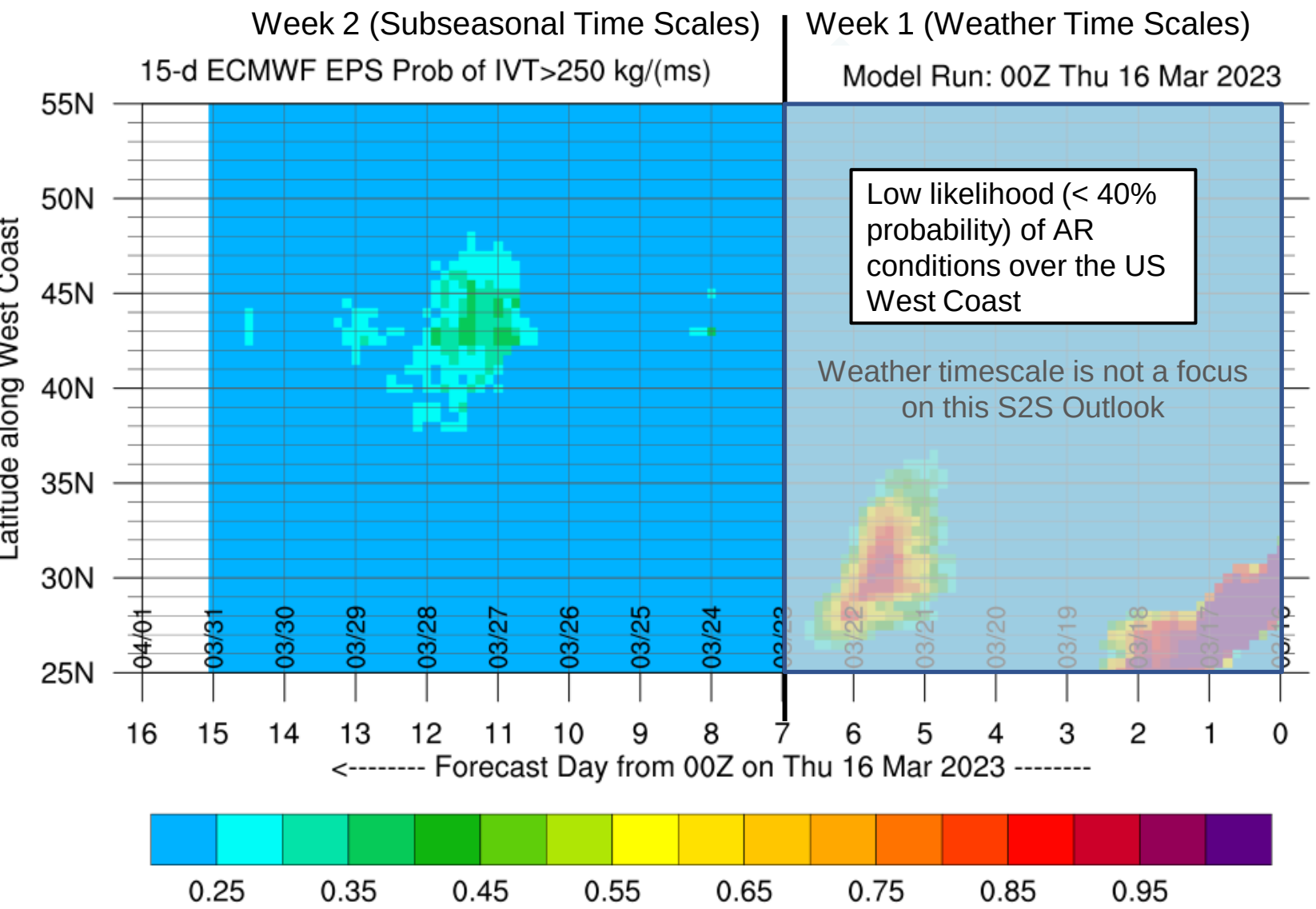
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

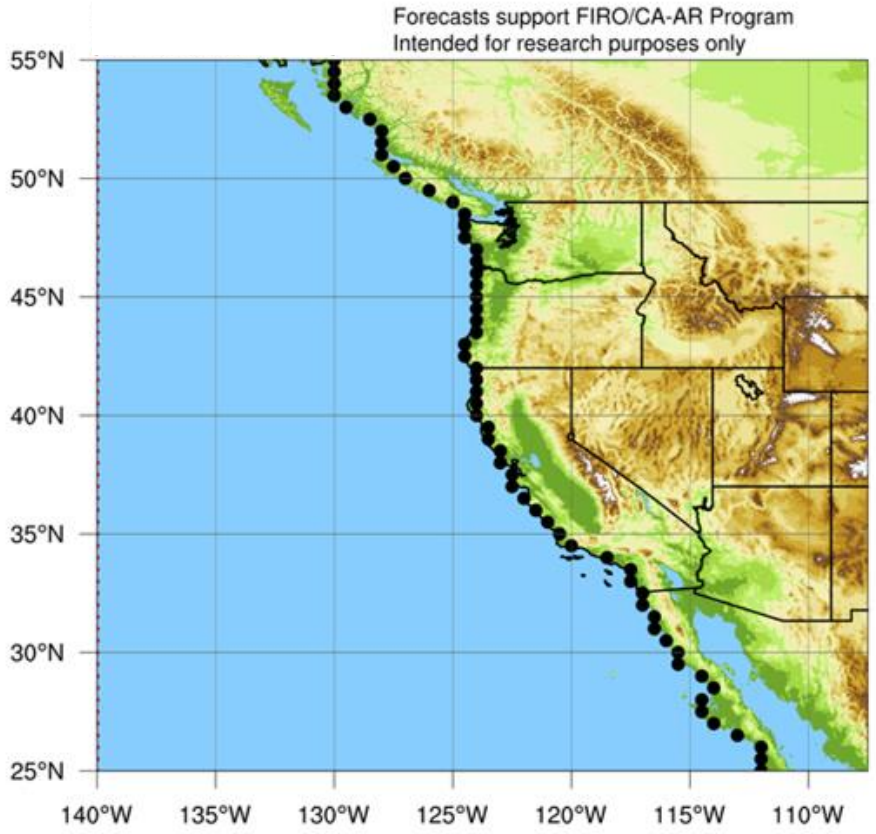
PLYMOUTH STATE METEOROLOGY

- NCEP is forecasting low likelihood of AR conditions over California in Week 2, with strong MJO activity over the Indian Ocean during Week 1

ECMWF EPS AR Landfall Tool: Valid 00Z 16 Mar – 00Z 31 Mar

Forecasts Initialized 16 Mar 2023





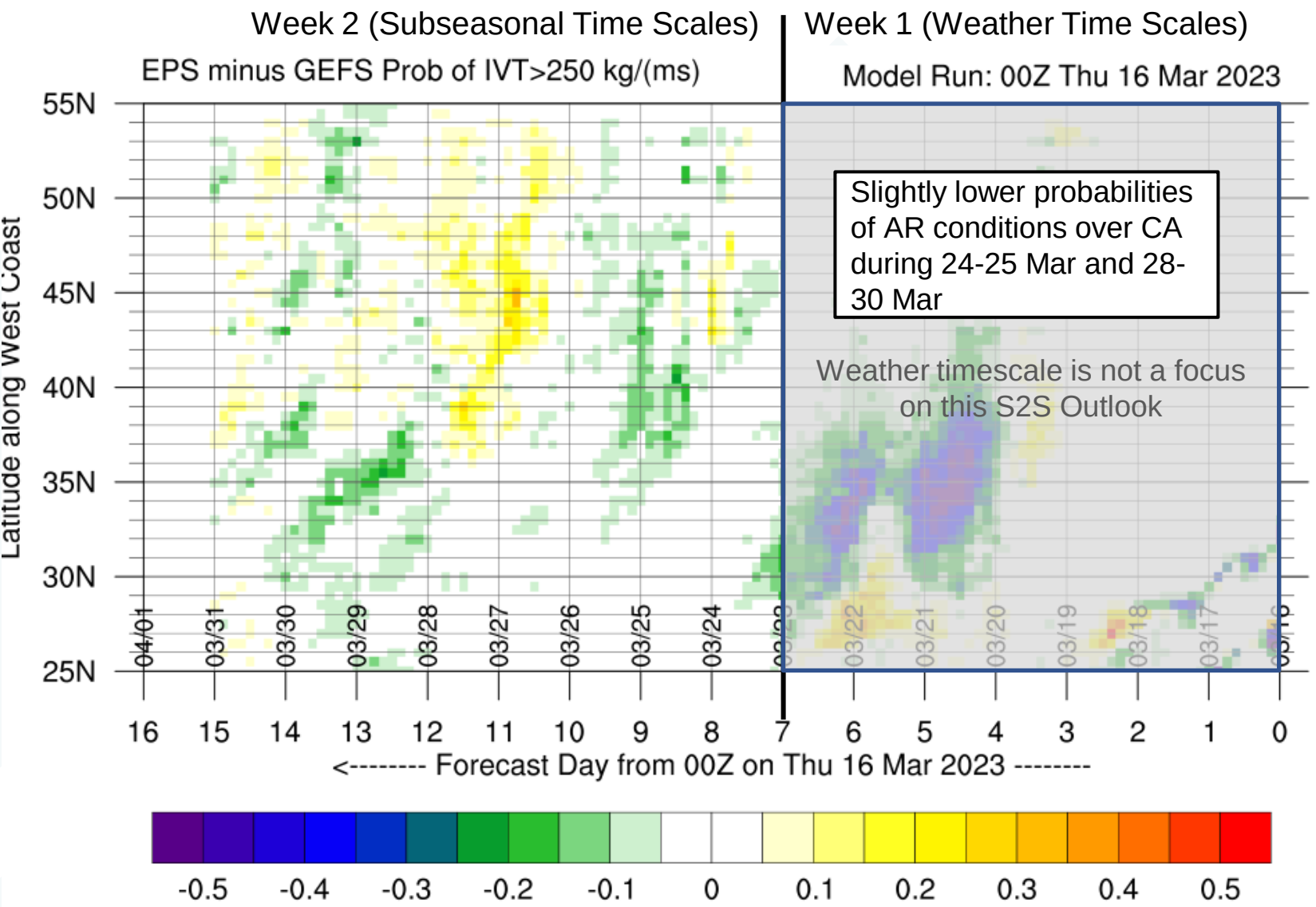
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

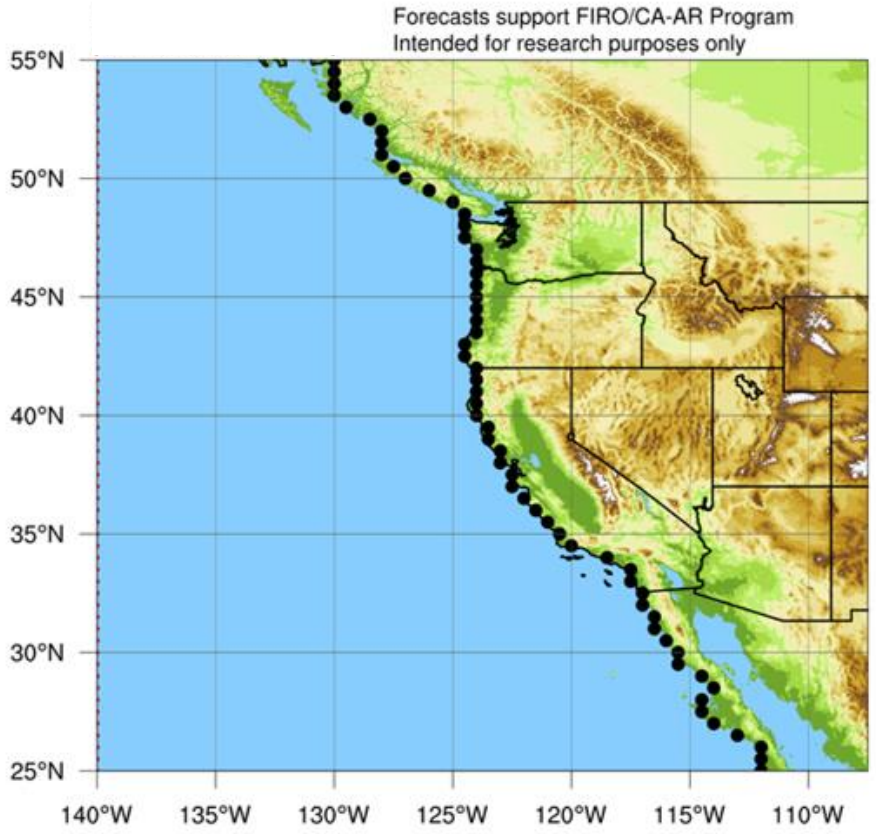
PLYMOUTH STATE METEOROLOGY

- ECMWF is forecasting low likelihood of AR conditions over California during Week 2, with strong MJO activity over the Indian Ocean during Week 1

EPS Minus GEFS AR Landfall Tool: Valid 00Z 16 Mar – 00Z 31 Mar

Forecasts Initialized 16 Mar 2023





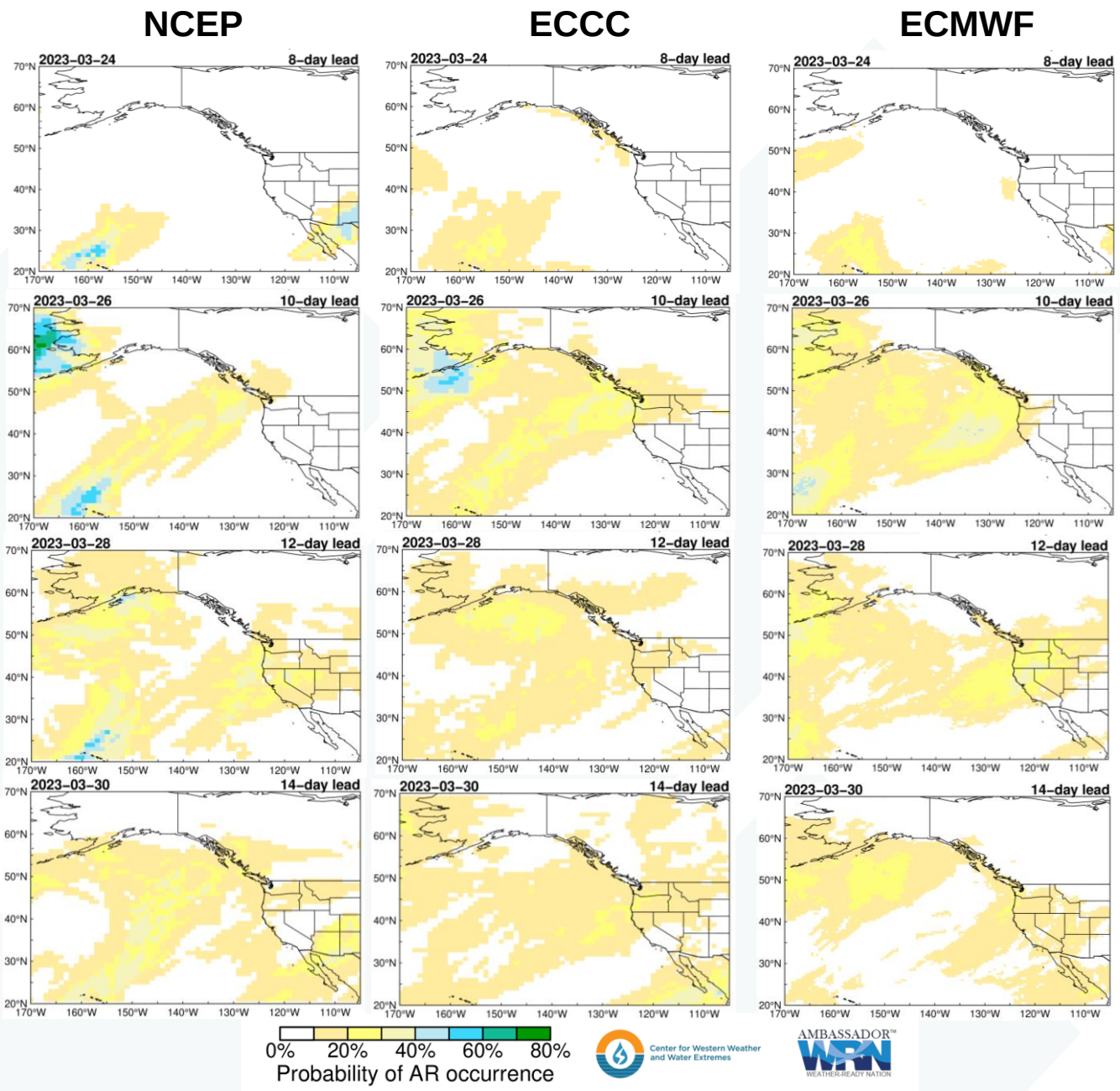
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

PLYMOUTH STATE METEOROLOGY

- ECMWF is forecasting slightly lower likelihood of AR conditions over CA during 24-25 Mar and 28-30 Mar compared to NCEP

Subseasonal Outlooks: Week 2 AR Activity (NCEP vs. ECCC vs. ECMWF)

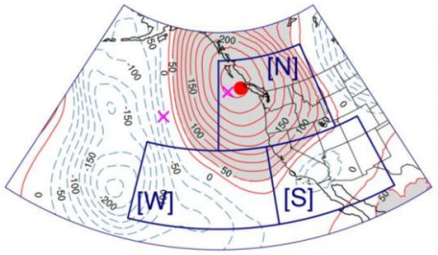
Forecasts Initialized 16 Mar 2023



- All models are showing low probabilities (<30%) of AR activity over CA during Week 2 (24-30 Mar)

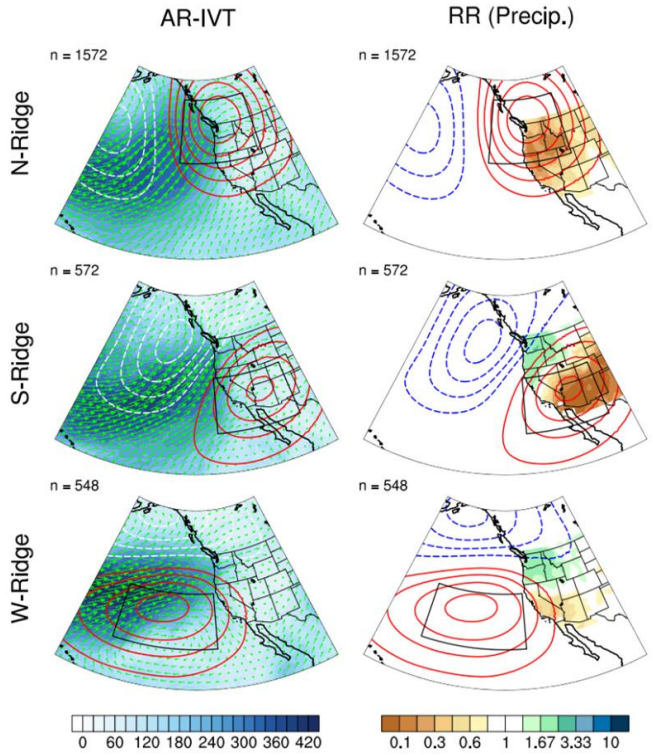
Models agree on low likelihood of AR activity over CA during Week 2 (24–30 Mar)

Background Info: Subseasonal Ridging Outlooks



N = North Ridge
S = South Ridge
W = West Ridge

This slide contains background information about the three different ridge types in CW3E's subseasonal ridging outlook tool



How each ridge type typically influences precipitation
Left: Maps showing the average influence of each ridge type (red contours) on integrated vapor transport (IVT, blue shading indicates greater moisture transport, arrows indicate direction) during atmospheric river events
Right: Maps showing the 'Relative Risk' (RR) of precipitation under each ridge type. Brown shading indicates a reduced chance of precipitation when ridging occurs. For example, a RR value of 0.2 indicates a 5-fold reduction in the likelihood of precipitation

- The North-Ridge type is typically associated with widespread dry conditions across the entire western US
- The South-Ridge type is typically associated with dry conditions in Southern California and the Colorado River Basin and wet conditions in the Pacific Northwest
- The West-Ridge type is typically associated with dry conditions over Central and Southern California and wet conditions over the Pacific Northwest

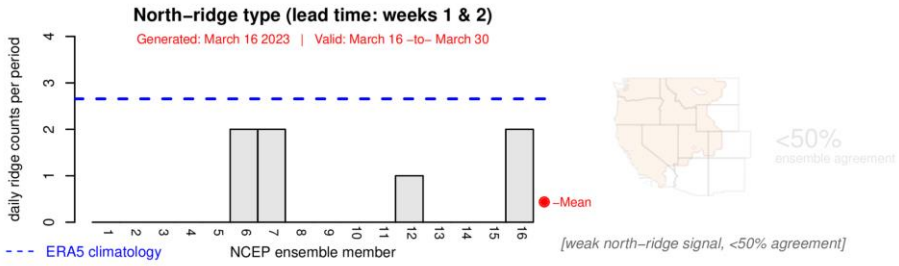
Jet Propulsion Laboratory
California Institute of Technology
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO
Contact: pgibson@ucsd.edu
Reference: Gibson et al. (2020) Journal of Climate

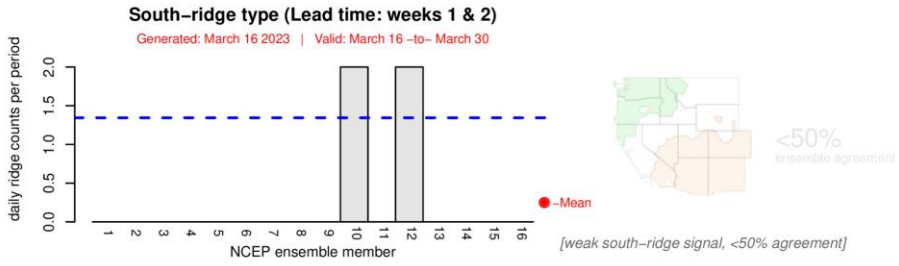
Subseasonal Outlooks: Weeks 1–2 Ridging Forecasts (NCEP vs. ECMWF)

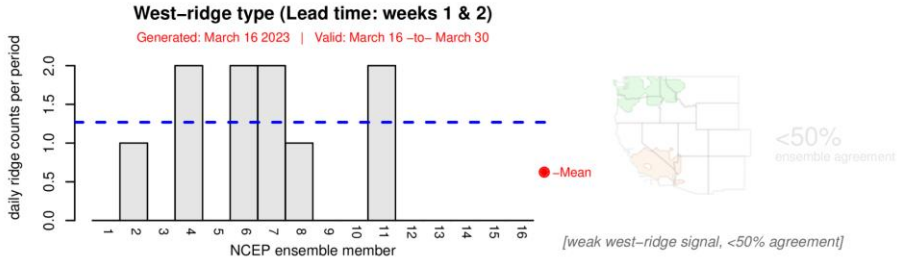
Forecasts Initialized 16 Mar 2023

NCEP

CW3E Subseasonal Ridging Forecast
(Uses NCEP CFSv2 model)





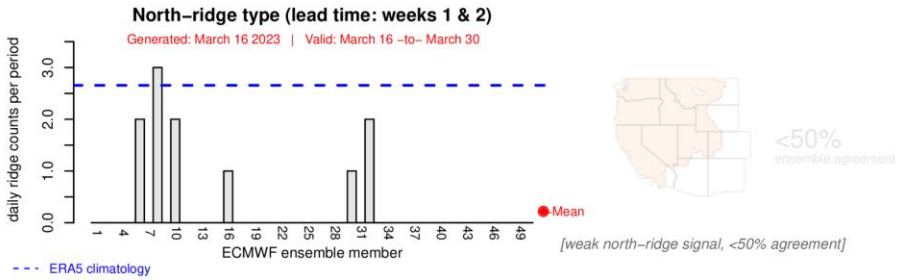


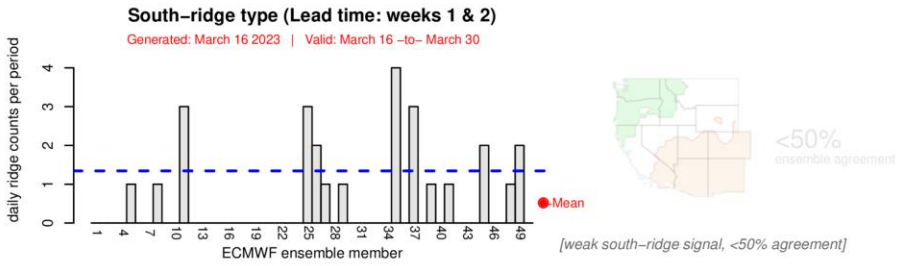
Center for Western Weather and Water Extremes

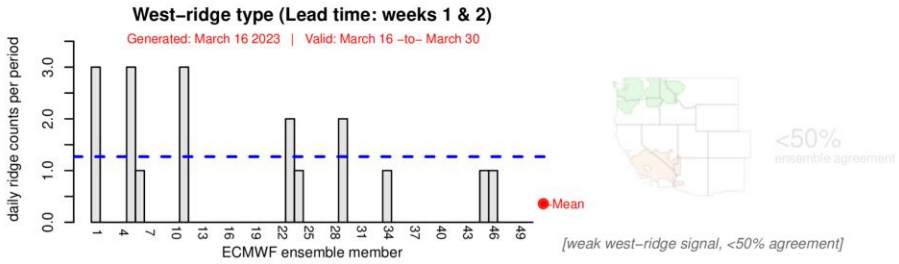
AMBASSADOR™ WRN WEATHER-READY NATION

ECMWF

CW3E Subseasonal Ridging Forecast
(Uses ECMWF model)







Center for Western Weather and Water Extremes

AMBASSADOR™ WRN WEATHER-READY NATION

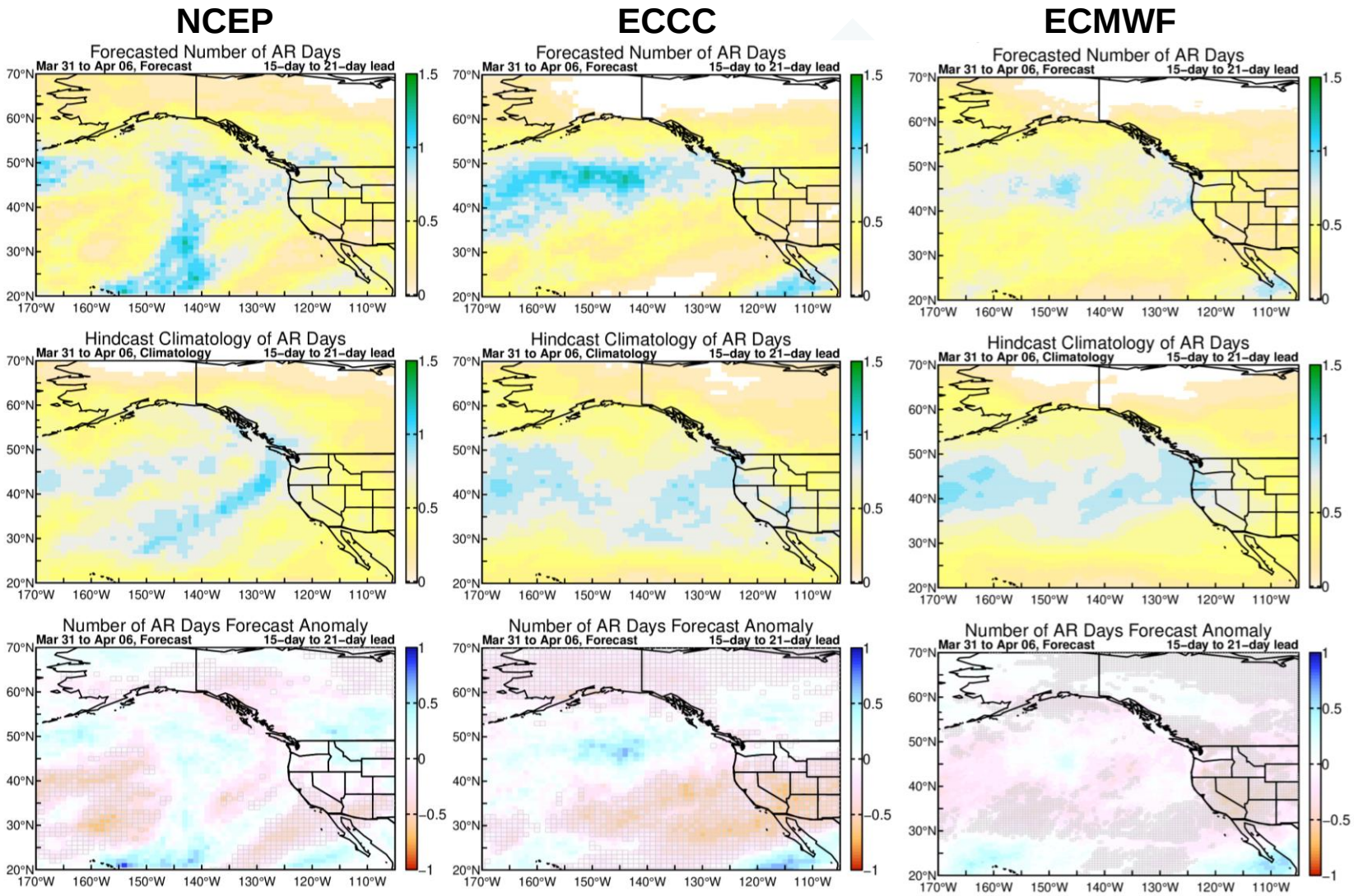
- Both models are showing low confidence (< 50% ensemble agreement) in any one particular ridge type during Weeks 1–2 (16–30 Mar)

There is low confidence in any one particular ridge type over the US West Coast during Weeks 1–2 (16–30 Mar)

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Subseasonal Outlooks: Week 3 AR Activity (NCEP vs. ECCC vs. ECMWF)

Forecasts Initialized 16 Mar 2023



Shading: Fractional # of AR days forecast over a 7-day period (top), model climatology (middle), and forecast minus model climatology (bottom)
Grey cells: >75% of ensemble members agree on sign of anomaly

- All models are predicting below-normal AR activity over Southern CA and near-normal AR activity over Northern CA during Week 3 (31 Mar – 6 Apr) with high confidence (> 75% ensemble agreement)
- All models are predicting near-normal AR activity over OR and WA with moderate-to-high confidence

All models are predicting near-to-below-normal AR activity over CA in Week 3 (31 Mar – 6 Apr) with high confidence

Center for Western Weather and Water Extremes

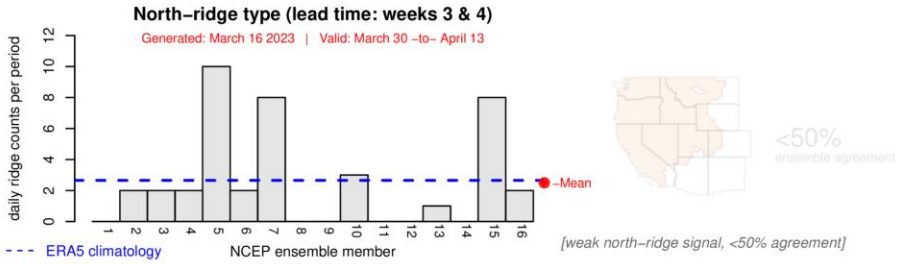
AMBASSADOR™ WRN WEATHER-READY NATION

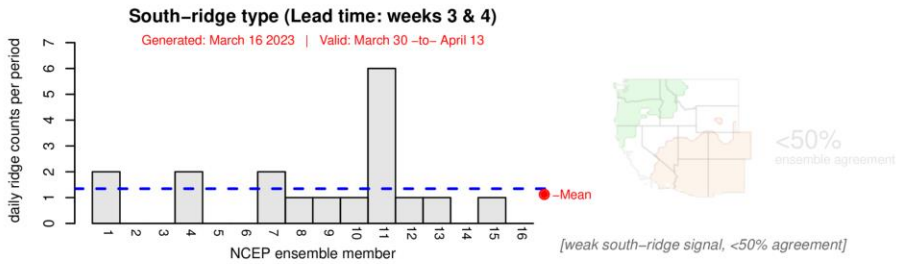
Subseasonal Outlooks: Weeks 3–4 Ridging Forecasts (NCEP vs. ECMWF)

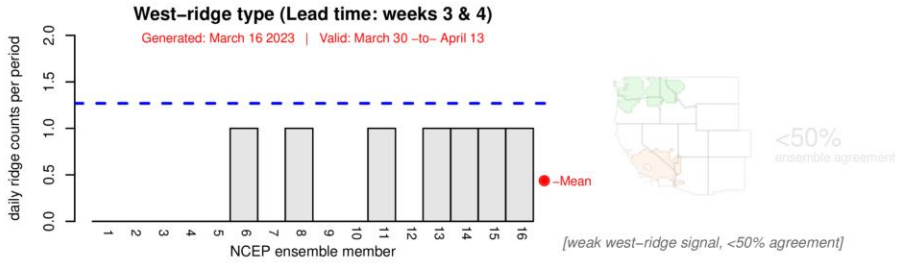
Forecasts Initialized 16 Mar 2023

NCEP

CW3E Subseasonal Ridging Forecast
(Uses NCEP CFSv2 model)

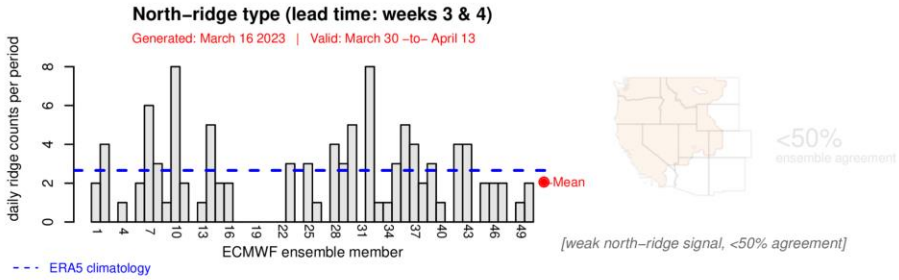


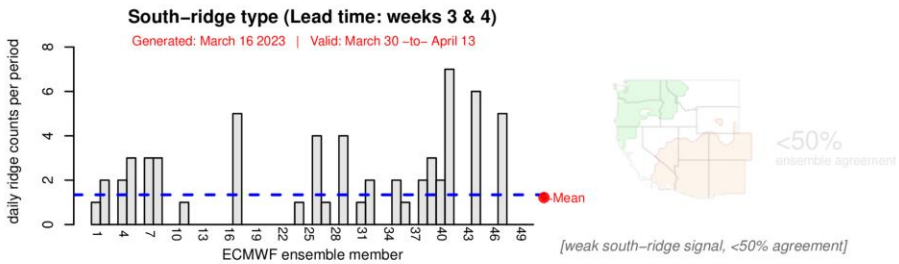


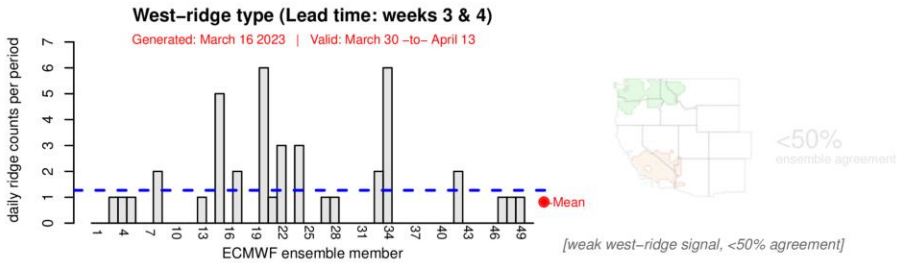


ECMWF

CW3E Subseasonal Ridging Forecast
(Uses ECMWF model)





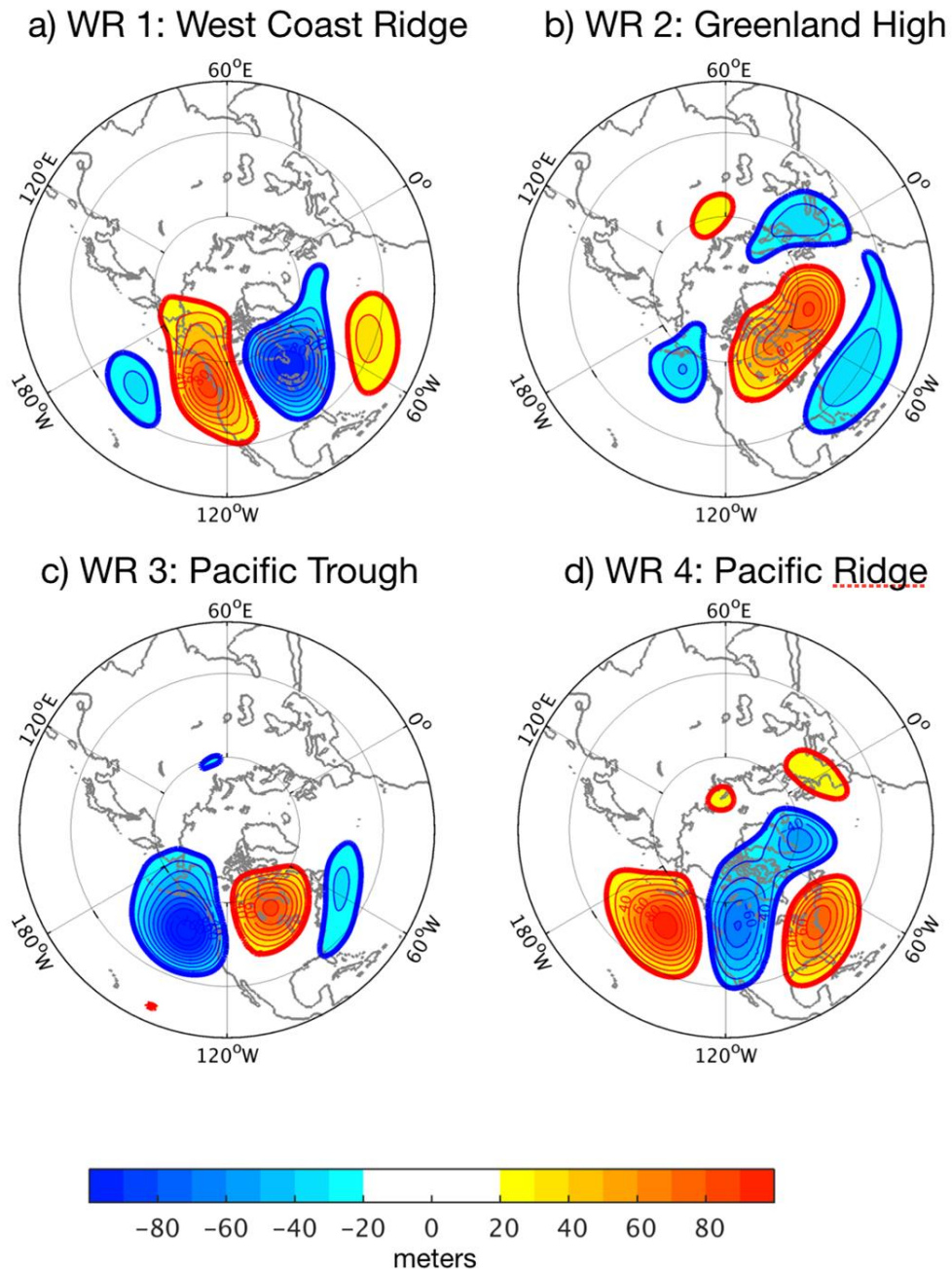


- Both models are showing low confidence (< 50% ensemble agreement) in any one particular ridge type during Weeks 3–4 (30 Mar – 13 Apr)
- Both models are predicting near-normal ridging activity north or south of CA during Weeks 3–4
- ECMWF is also predicting near-normal ridging activity west of CA

Both models are showing potential for persistent ridging activity near the US West Coast during Weeks 3–4 (30 Mar – 13 Apr)

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Background Info: IRI Subseasonal Weather Regime Forecasts



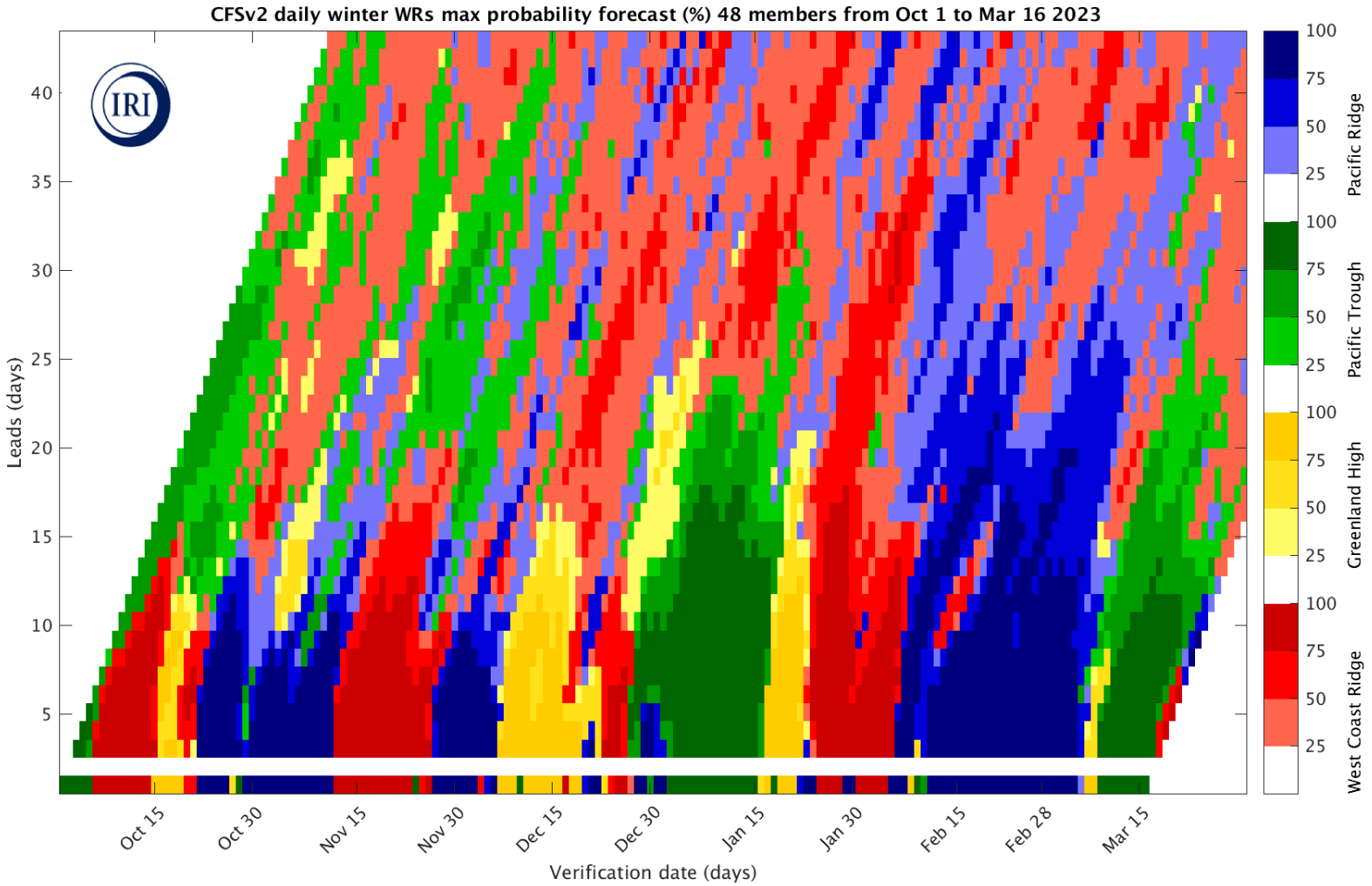
This slide contains background information about IRI's North American weather regime forecast product

- Four dominant weather regimes identified using cluster analysis on daily 500-hPa geopotential height anomalies from MERRA data (1981–2015)

More info: https://wiki.iri.columbia.edu/index.php?n=Climate.S2S-WRs

Subseasonal Outlooks: IRI North American Weather Regime Forecasts

Forecast Initialized 16 Mar 2023

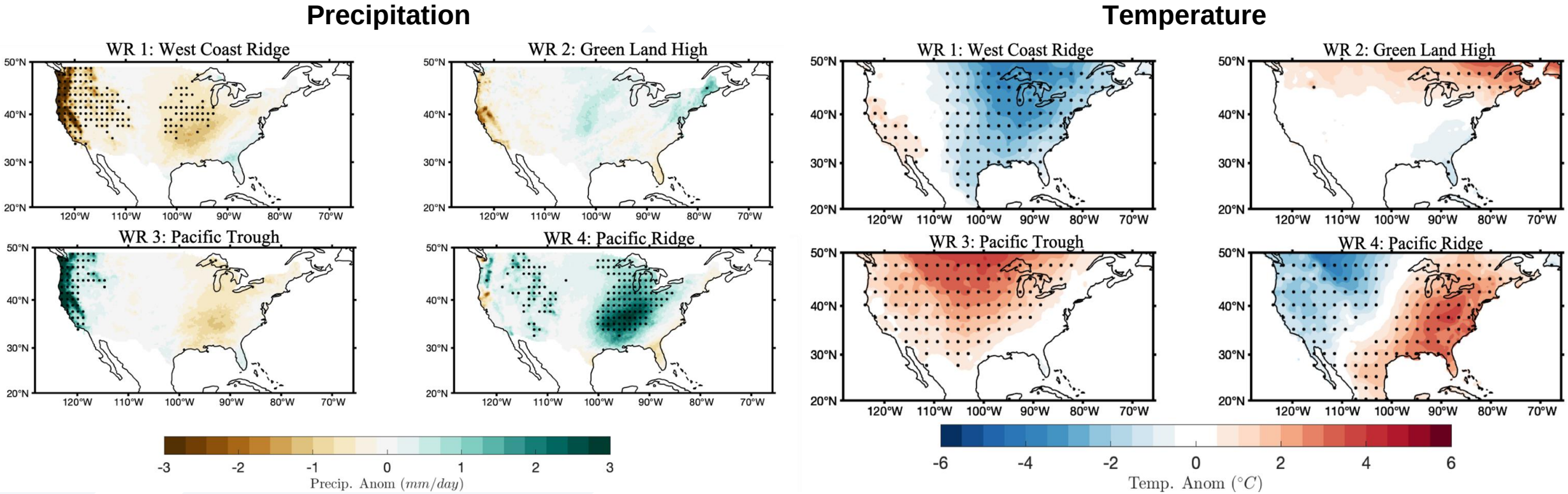


This graphic shows the which of the four North American weather regimes (different colors) is most likely to occur over the next 45 days. Darker (lighter) shading denotes higher (lower) probability of a particular regime.

- Daily forecast out to 45-day lead time based on NCEP CFSv2 ensemble
- High likelihood (> 75%) of West Coast Ridge during most of Week 1
- Moderate-to-high likelihood (> 50%) of Pacific Ridge during most of Week 2
- West Coast Ridge forecast in early Week 3, but with low confidence (< 50% ensemble agreement)

For more information about the forecast product: https://wiki.iri.columbia.edu/index.php?n=Climate.S2S-WRs

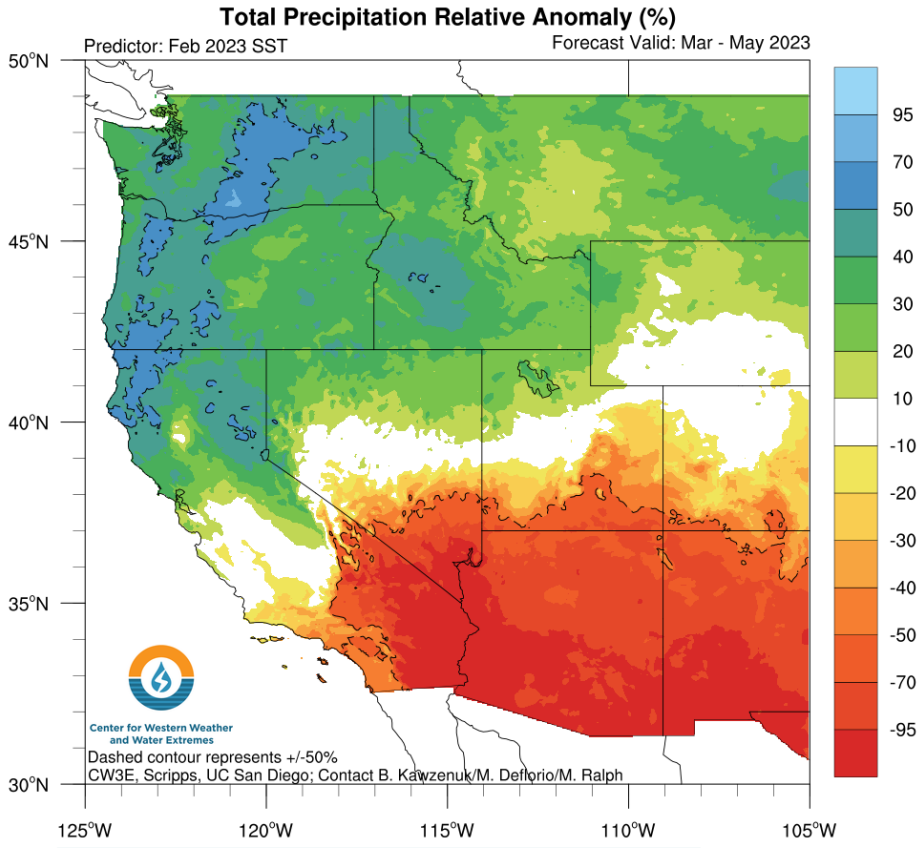
Subseasonal Outlooks: IRI North American Weather Regime Forecasts



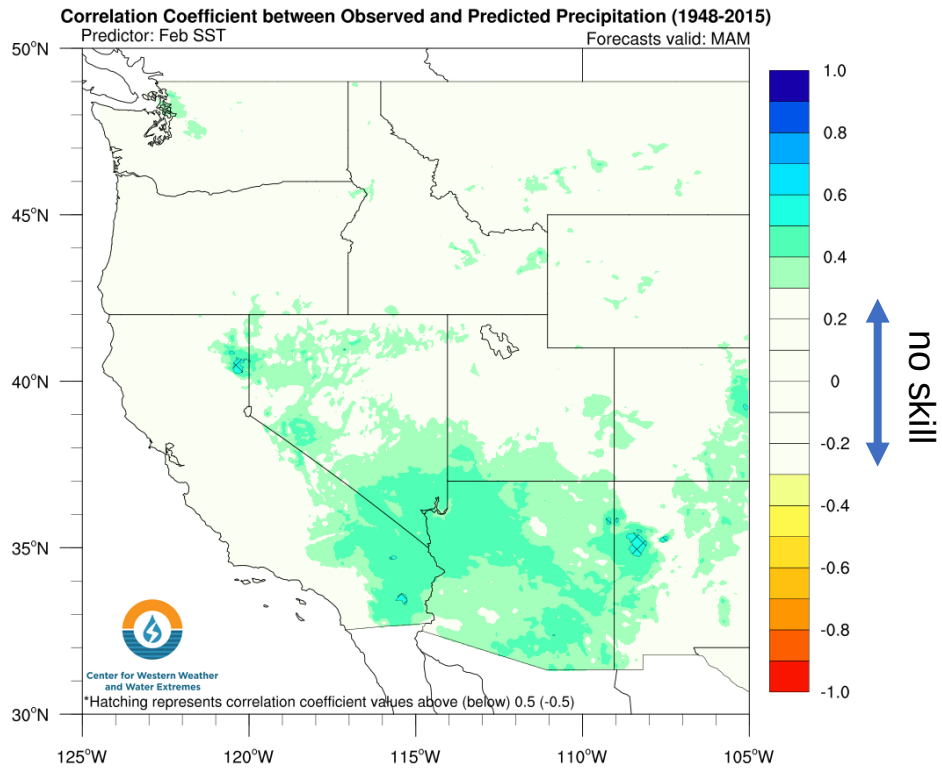
Historical precipitation (left) and temperature (right) composites associated with each regime

- Anomalously warm conditions and below-normal precipitation are predicted over California during most of week 1 with high confidence
- Anomalously cold conditions and near-normal precipitation are predicted over California during most of week 2 with moderate-to-high confidence

Seasonal CCA Outlooks: Mar–May 2023 Precipitation



Skill Assessment



- CW3E statistical model based on Feb SST is predicting above-normal Mar–May 2023 precipitation over portions of WA, OR, and Northern CA, and below-normal Mar–May 2023 precipitation over Southern CA
- Forecast confidence is low given the limited correlation skill (< 0.5) in these regions

CCA: Canonical correlation analysis relating seasonal precipitation anomalies to observed monthly Pacific SST anomalies (click here for more background information)
Above-normal: >30%; Below-normal: <-30%