



Center for Western Weather
and Water Extremes

SCRIPPS INSTITUTION OF OCEANOGRAPHY
AT UC SAN DIEGO

CW3E Subseasonal Outlook: 22 March 2024

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UC San Diego



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CW3E Subseasonal Outlooks: Glossary & Context

- The outlooks are based on CW3E subseasonal 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 CFSv2 (US Model): Weeks 2–6
 - ECCO (Canadian Model): Weeks 2–3
 - ECMWF (European model): Weeks 2–6
- *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*

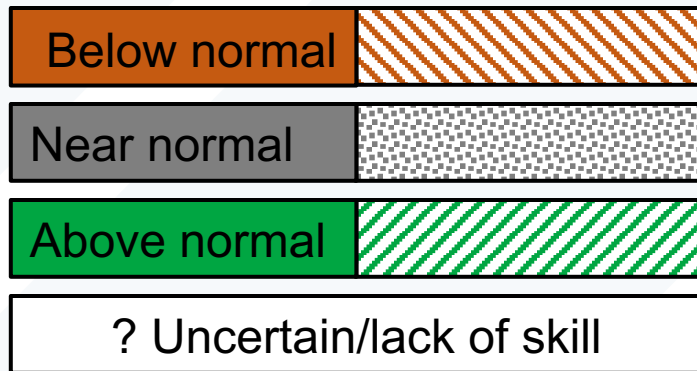
Summary: Subseasonal Precipitation Outlook by Model

This slide shows the CW3E synthesis of subseasonal products by model

Forecasts Initialized 21 Mar 2024

Region	Week 2 (29 Mar – 4 Apr)		Week 3 (5–11 Apr)		Week 4 (12–18 Apr)
	ECCC ¹	ECMWF ^{1,2}	ECCC ¹	ECMWF ^{1,2}	ECMWF ²
WA/OR	Higher Confidence	Lower Confidence	Below normal	Below normal	Below normal
Northern CA	Above normal	Higher Confidence	Below normal	Below normal	Below normal
Central CA	Above normal	Below normal	Below normal	Below normal	Below normal
Southern CA	Higher Confidence	Below normal	Below normal	Below normal	Below normal

Higher Confidence | Lower Confidence



- Week 2 forecasts are uncertain due to potential shift in large-scale pattern from wet to dry conditions early in Week 2
- ECCC and ECMWF generally agree on below-normal precipitation in CA during Week 3

Subseasonal products included in this Outlook:

¹CW3E/JPL Atmospheric River Activity Forecasts ([DeFlorio et al. 2019](#))

²CW3E/JPL Ridging Forecasts ([Gibson et al. 2020](#))

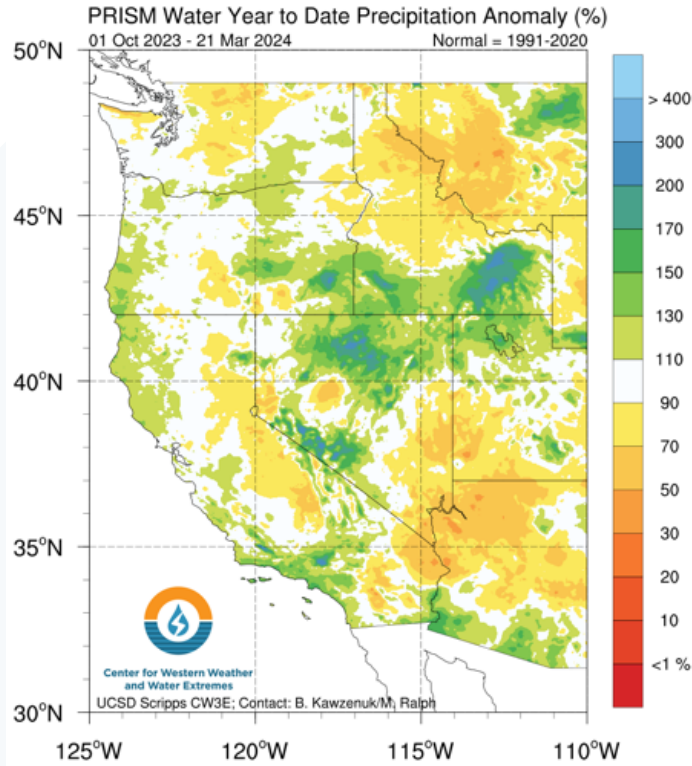
³IRI North American Weather Regime Forecasts ([Robertson et al. 2020](#))

Summary

- **Week 2 forecasts (29 Mar – 4 Apr):** Models show potential for AR activity over CA during early part of Week 2 and very low likelihood (< 20% probability) of AR activity over CA during second half of Week 2
 - ECCO is more confident in AR activity (40–70 % probability) over Northern and Central CA on 30 Mar compared to ECMWF (30–50% probability)
- MJO convection currently over the Western Pacific is forecast to propagate eastward into the Western Hemisphere and Africa during Week 1, then weaken toward the end of Week 1
 - MJO activity over the Western Pacific during JFM is associated with a decreased likelihood of wet extremes in Central and Southern CA at lag times of 3–4 weeks
- ECMWF is showing high likelihood of above-normal West-ridge activity during Weeks 1–2
 - The West-ridge type is typically associated with wet conditions over the Pacific Northwest and dry conditions over Central and Southern CA
- **Week 3 forecasts (5–11 Apr):** Models are forecasting below-normal AR activity over CA with high confidence
- ECMWF is showing low likelihood of persistent ridging activity near the US West Coast during Weeks 3–4
- IRI weather regime tool shows possible transition from Pacific Ridge (cool conditions in CA) to West Coast Ridge (dry and warm conditions in CA) at the end of March, but forecast uncertainty remains high, and this product only goes out to 31 Mar
- CW3E's statistical forecasts based on current MJO and QBO conditions are showing a high likelihood (> 50% probability) of below-normal AR occurrence in Northern CA during Weeks 2–3 and below-normal precipitation in Northern CA during Weeks 2–5

Hydrologic Summary

Precipitation

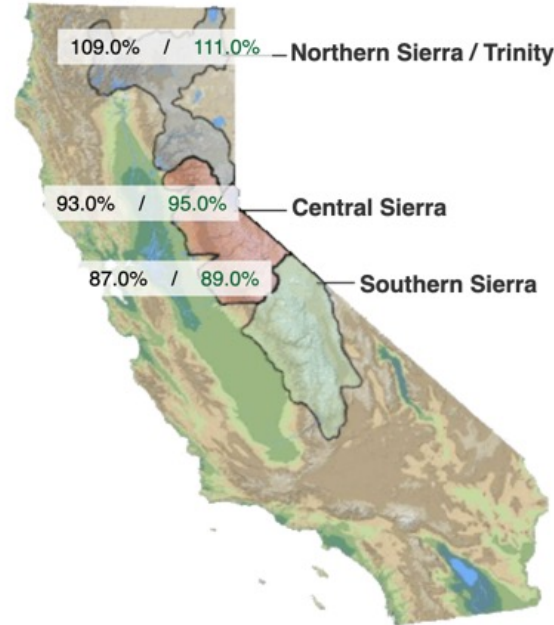


Snowpack Conditions

Provided by the California Cooperative Snow Surveys

Data For: 22-Mar-2024

% Apr 1 Avg. / % Normal for this Date

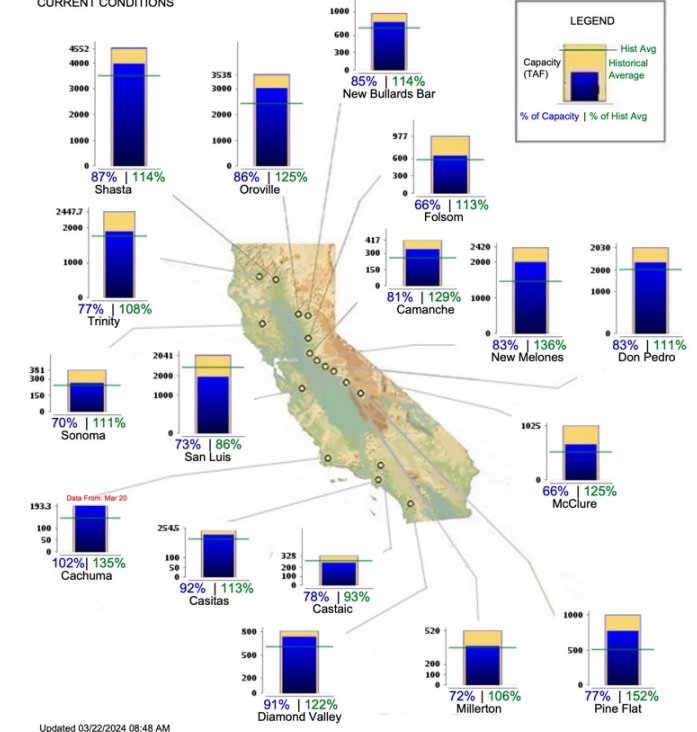


Source: California DWR

Reservoir Storage

CALIFORNIA MAJOR WATER SUPPLY RESERVOIRS
CURRENT CONDITIONS

Midnight - March 21, 2024



Source: California DWR

- As of 21 Mar, water-year-to-date precipitation is above-normal in coastal Southern CA, slightly above normal in coastal Northern and Central CA, and slightly below-normal over the Sierra Nevada
- Current snowpack is slightly above-normal in the Northern Sierra Nevada, near-normal in the Central Sierra Nevada, and slightly below-normal in the Southern Sierra Nevada
- Statewide snowpack is 98% of normal for this time of year
- Most large reservoirs in CA are operating at $\geq 70\%$ storage capacity and above-normal storage for this time of year

Looking Back: Week 3 AR Activity Forecasts

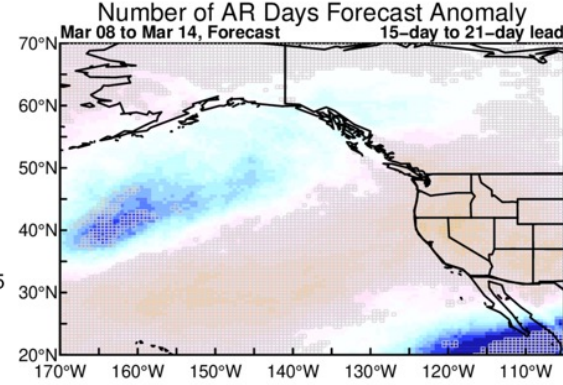
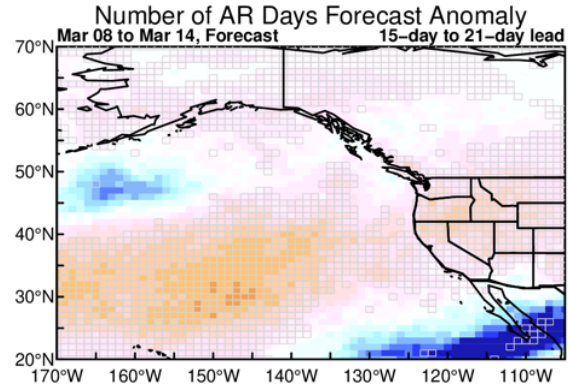
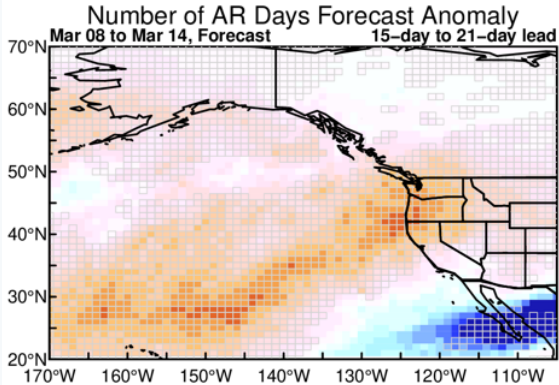
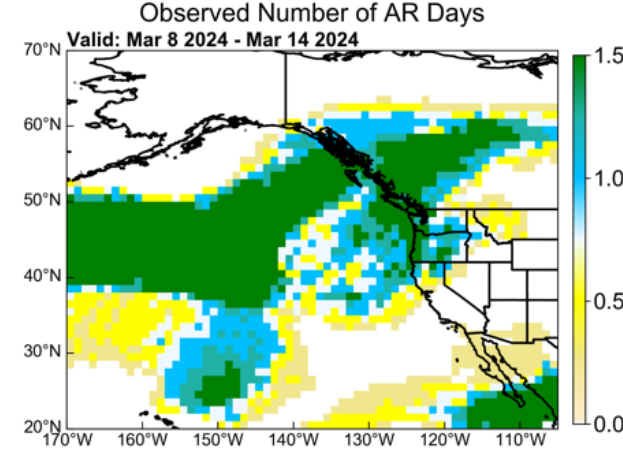
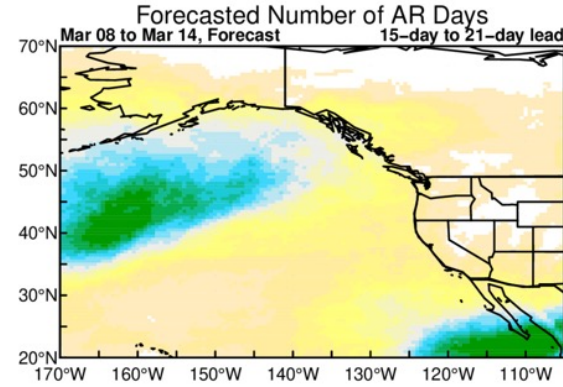
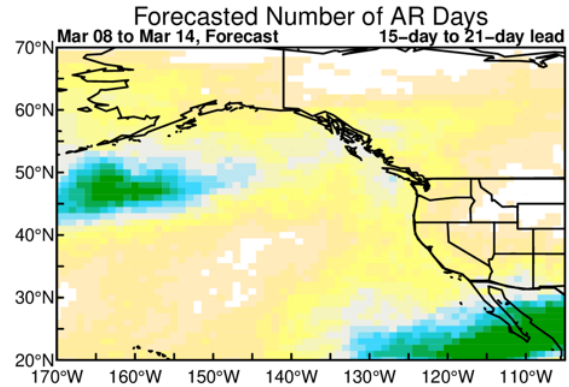
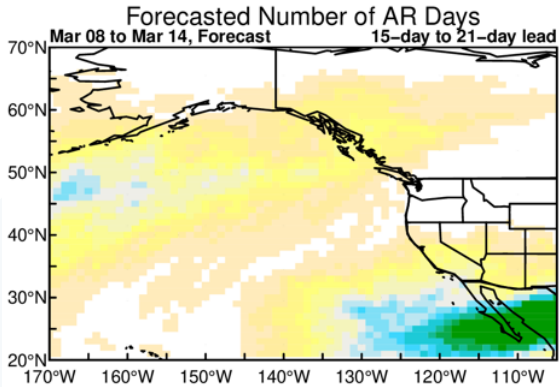
Forecasts Initialized 22 Feb 2024; Valid: 8–14 Mar 2024

NCEP

ECCC

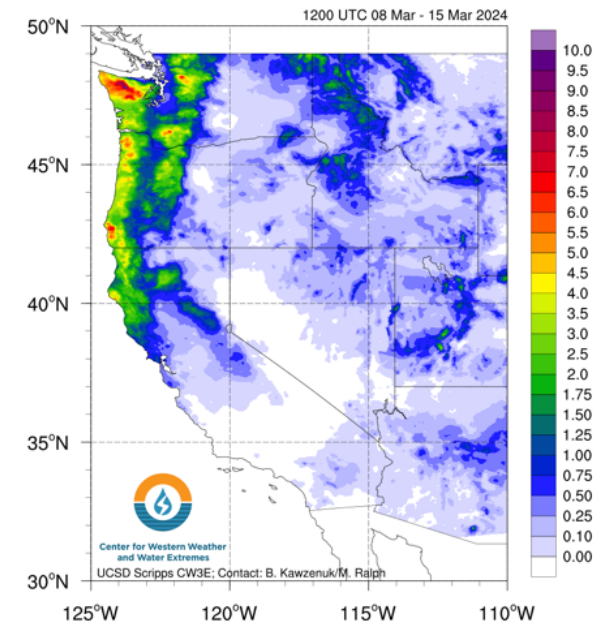
ECMWF

Observed (GFS Analysis)



Observed Precipitation

7-day Accumulated Precipitation (inches)



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

- All models failed to capture AR activity over the Pacific Northwest and British Columbia
- ECCC and ECMWF captured some AR activity over the North Pacific south of Alaska
- A series of ARs produced at least 2–6 inches of total precipitation over western WA, western OR, and coastal Northern CA during 8–12 Mar

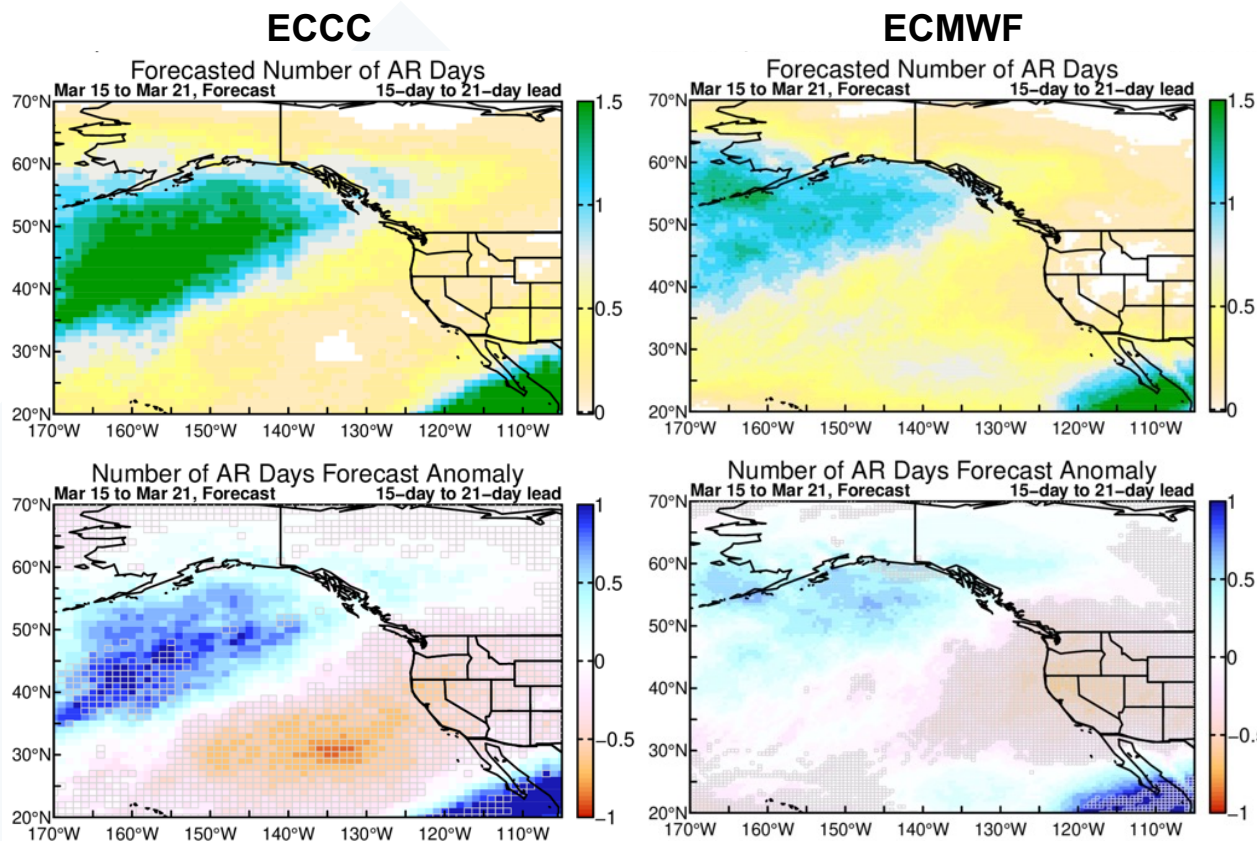


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UCSD Scripps CW3E; Contact: B. Kawzenuk/M. Ralph

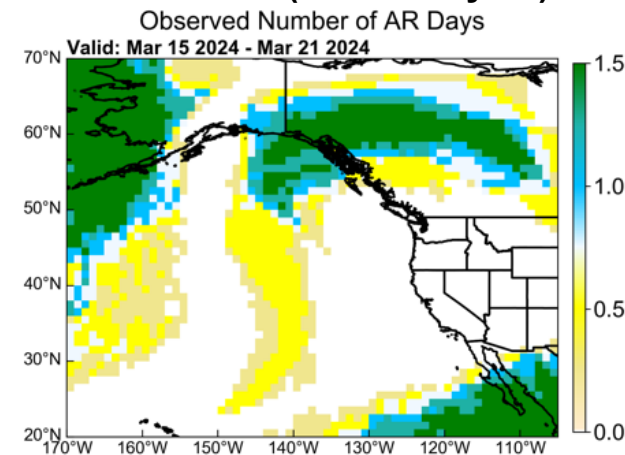
Looking Back: Week 3 AR Activity Forecasts

Forecasts Initialized 29 Feb 2024; Valid: 15–21 Mar 2024

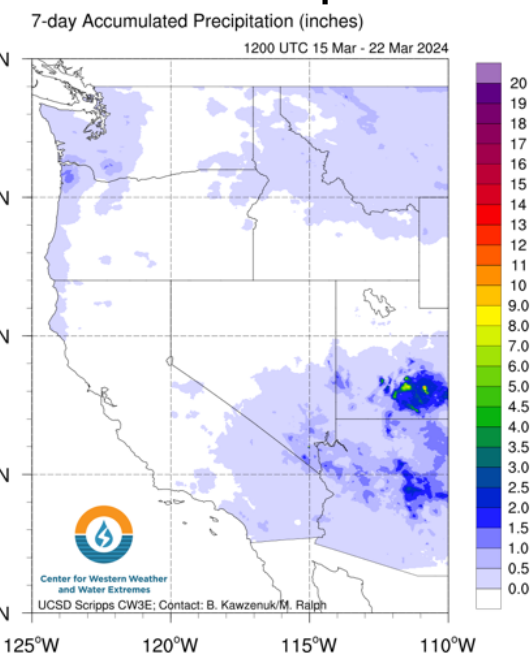
NCEP Forecast
Unavailable



Observed (GFS Analysis)



Observed Precipitation

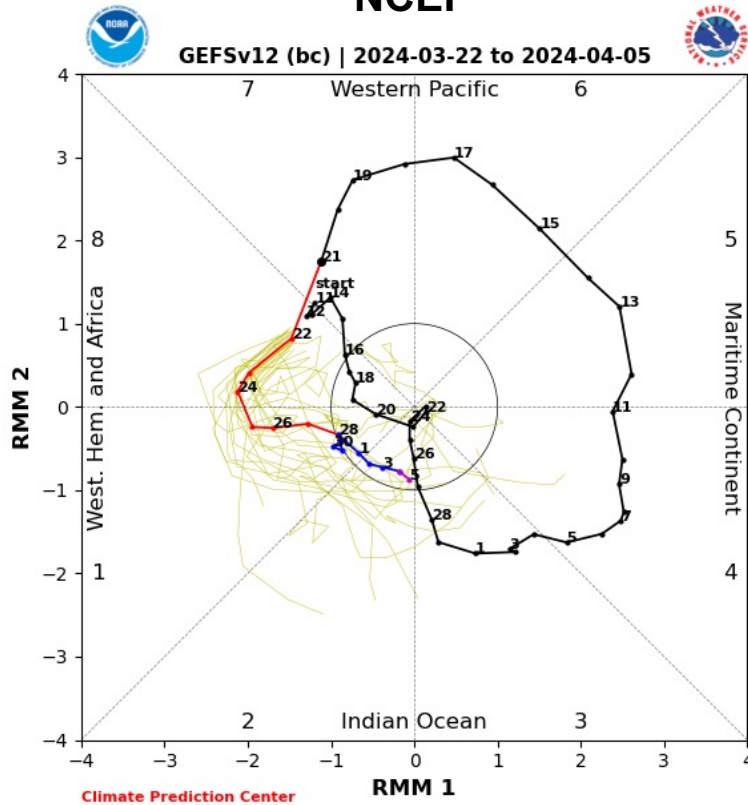


Shading: Fractional # of AR days over a 7-day period (top) and forecast minus model climatology (bottom)
Grey cells: >75% of ensemble members agree on sign of anomaly

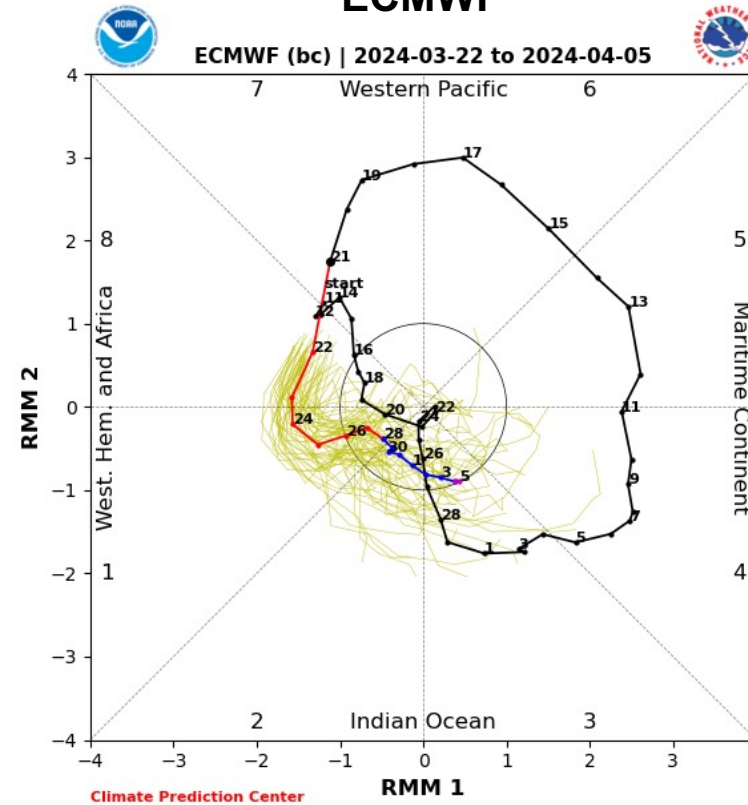
- ECCC and ECMWF both captured the lack of AR activity over CA and the entire western US due to ridging near the US West Coast
- Ridging activity led to mostly dry conditions during this period over the US West Coast
- A cutoff low produced heavy snowfall over portions of the Upper Colorado River Basin during 15–16 Mar

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)

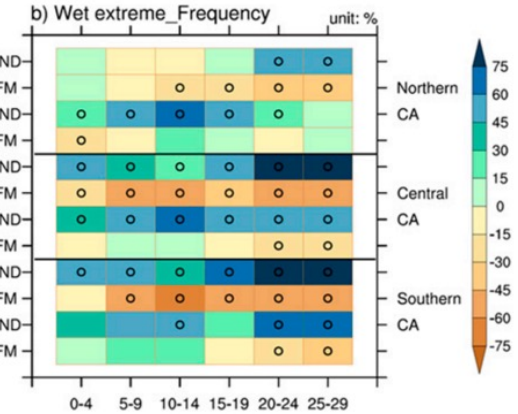


Figure 8 from Wang et al. (2023)

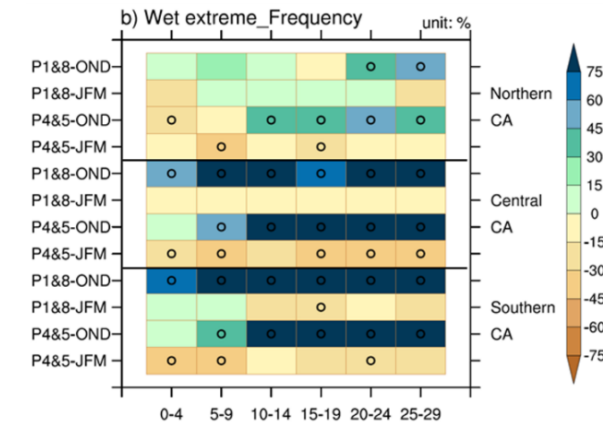


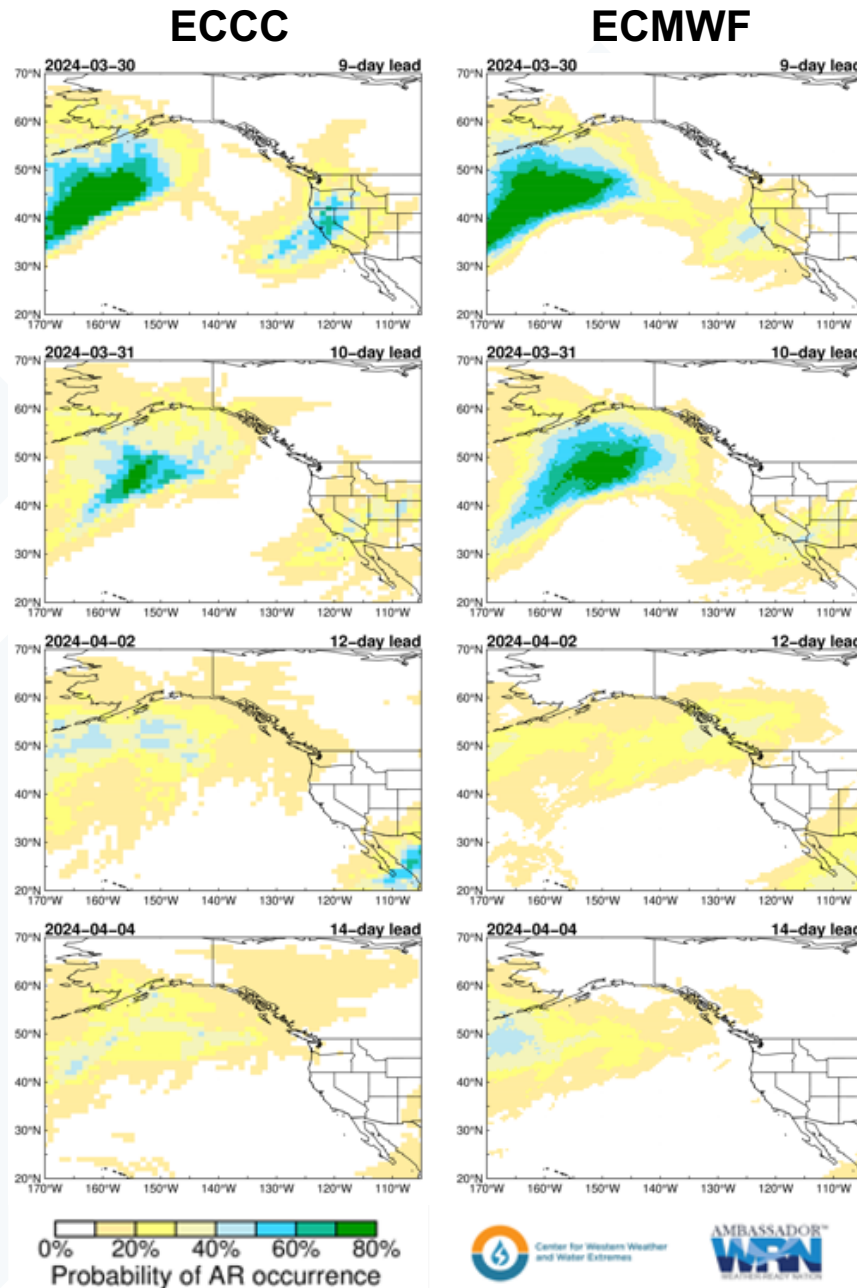
Figure S6 from Wang et al. (2023)

- MJO convection is currently located over the Western Pacific
- NCEP and ECMWF are both forecasting MJO convection to propagate eastward into the Western Hemisphere and Africa (Phases 8 and 1) during Week 1, then weaken at the end of Week 1
- MJO activity over the Western Pacific during JFM is associated with a statistically significant decrease in wet extremes in Central and Southern CA at lag times of 3–4 weeks
- MJO activity over the Western Hemisphere and Africa during JFM is associated with a statistically significant decrease in wet extremes in Southern CA at lag times of 2–3 weeks

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

Forecasts Initialized 21 Mar 2024

NCEP Forecasts
Unavailable

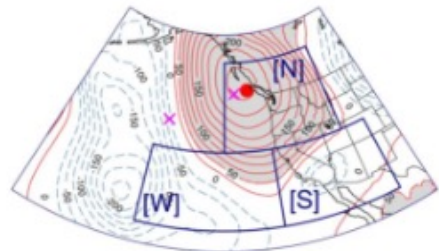


- ECCC is forecasting moderate likelihood (40–70% probability) of AR activity in Northern and Central CA on 30 Mar
- ECMWF is forecasting slightly lower likelihood (30–50% probability) of AR activity in Northern and Central CA on 30 Mar
- Both models are forecasting low-to-moderate likelihood (30–50% probability) of AR activity over Southern CA on 31 Mar and very low likelihood (< 20% probability) of AR activity over all of CA during the rest of Week 2 (1–4 April)

Models show potential for AR activity over CA during early part of Week 2, but ECCC is more confident in AR activity over Northern/Central CA. Models agree on low likelihood of AR activity in CA during second half of Week 2.

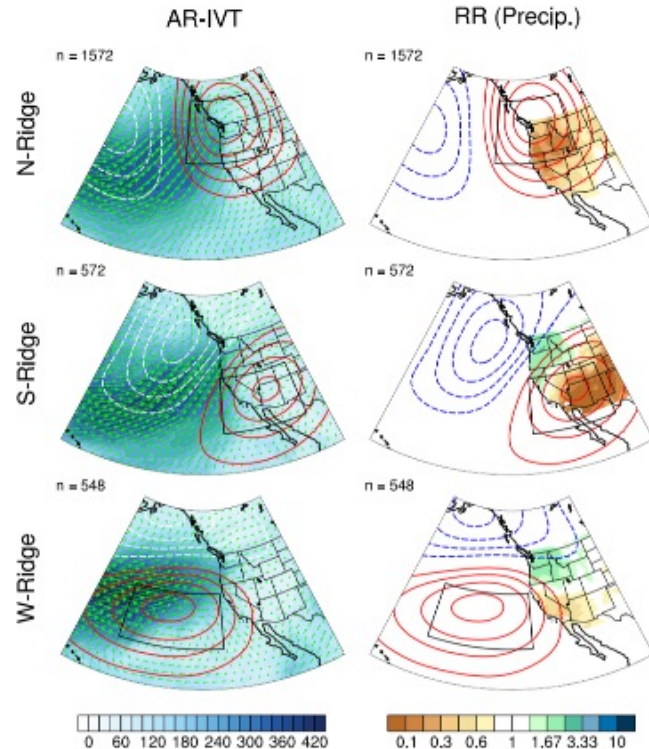
**Note that the probabilities of AR occurrence in the Week 2 AR activity plots may differ from the probabilities of AR conditions in the AR landfall tool. These discrepancies exist due to the use of different models (e.g., GEFS vs. CFSv2), model configurations (S2S models are coupled between ocean, land, and atmosphere), and methods for AR detection.*

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



- 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 CA 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 CA and wet conditions over the Pacific Northwest

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



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California Institute of Technology



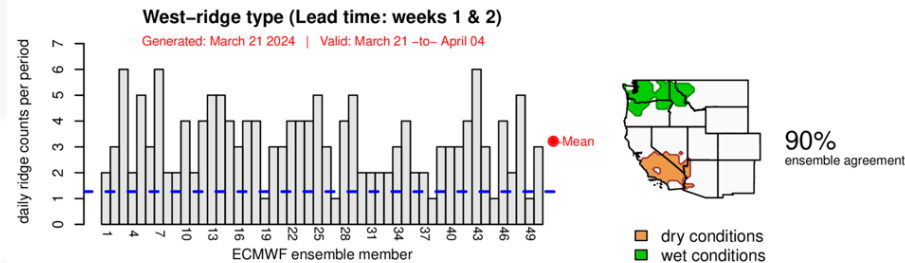
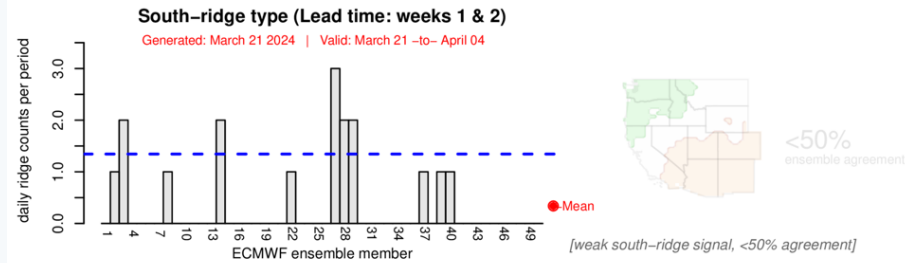
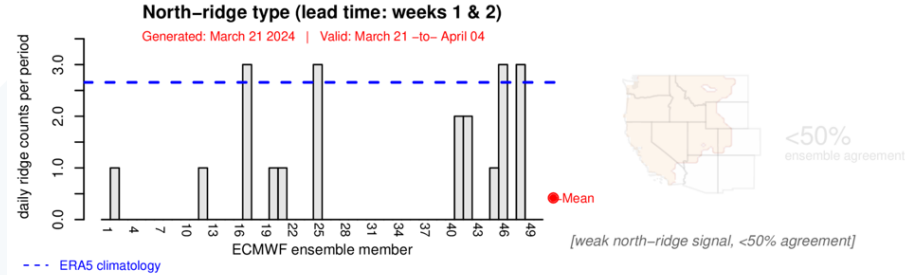
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Contact: pgibson@ucsd.edu
Reference: Gibson et al. (2020)
Journal of Climate

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

ECMWF

CW3E Subseasonal Ridging Forecast (Uses ECMWF model)



NCEP Forecasts Unavailable

Forecasts Initialized 21 Mar 2024

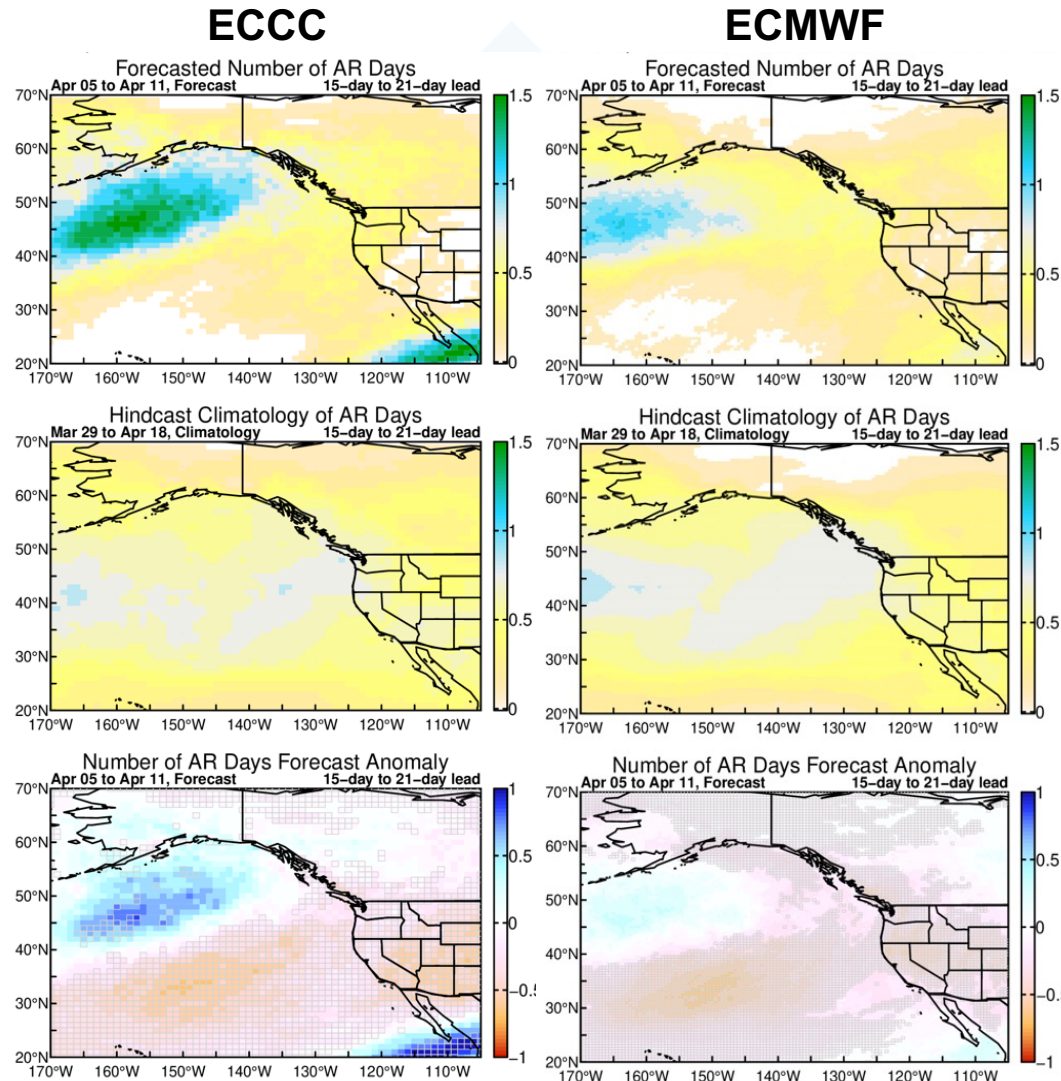
- ECMWF is showing high confidence (90% ensemble agreement) in above-normal West-ridge activity during Weeks 1–2 (21 Mar – 4 Apr)
- ECMWF is also forecasting very low North-ridge and South-ridge activity

ECMWF is showing a high likelihood of above-normal ridging activity west of CA during Weeks 1–2

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

Forecasts Initialized 21 Mar 2024

NCEP Forecasts
Unavailable



- ECCC and ECMWF are both forecasting below-normal AR activity over CA and the entire western US with high confidence (> 75% ensemble agreement) during Week 3 (5–11 Apr)

Models agree on below-normal AR activity in CA during Week 3

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

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

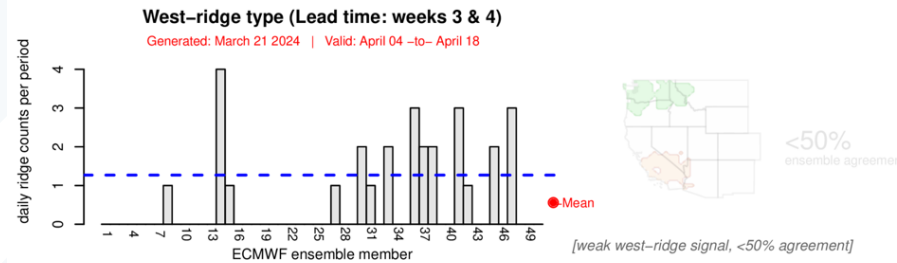
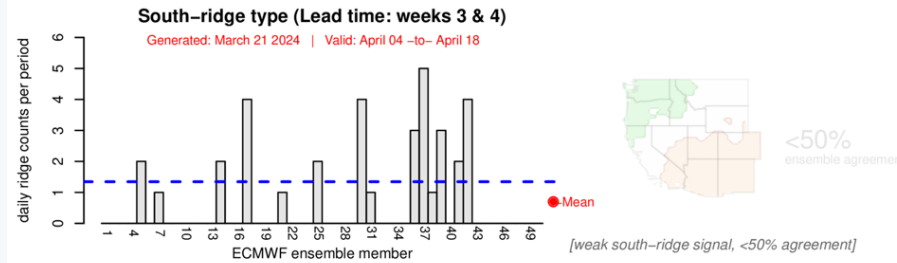
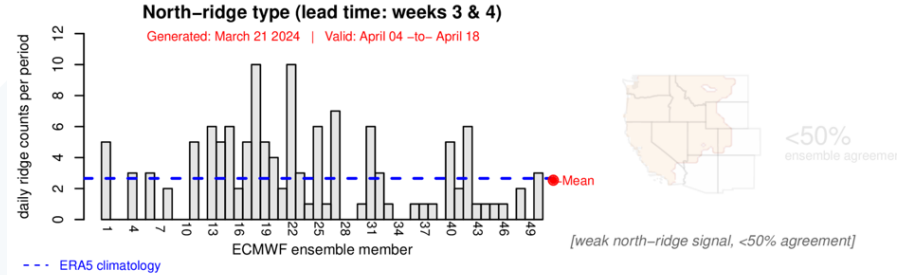
ECMWF

CW3E Subseasonal Ridging Forecast (Uses ECMWF model)

Forecasts Initialized 21 Mar 2024

- ECMWF is forecasting near-normal North-ridge activity and below-normal South-ridge and West-ridge activity during Weeks 3–4 (4–18 Apr)

NCEP Forecasts Unavailable

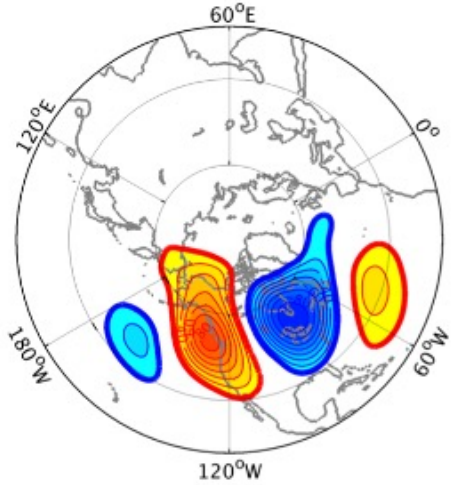


ECMWF is showing low likelihood of persistent ridging activity near the US West Coast during Weeks 3–4

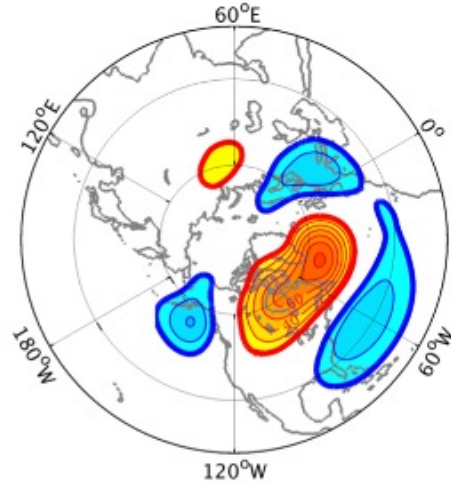


Background Info: IRI Subseasonal Weather Regime Forecasts

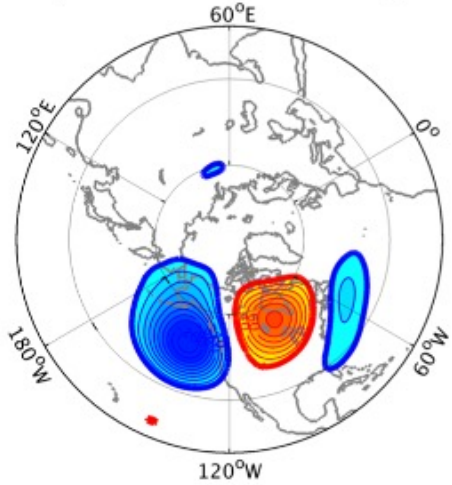
a) WR 1: West Coast Ridge



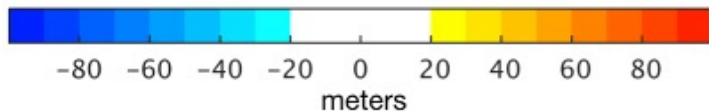
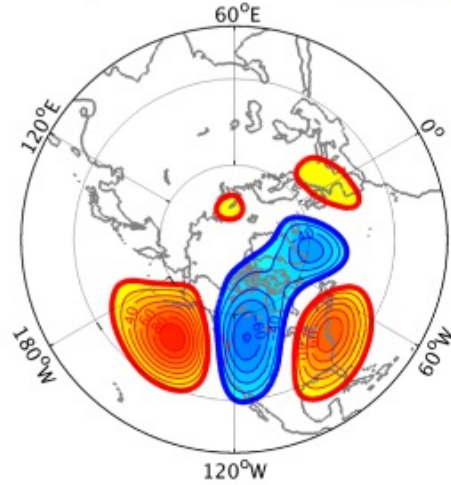
b) WR 2: Greenland High



c) WR 3: Pacific Trough



d) WR 4: Pacific Ridge



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)

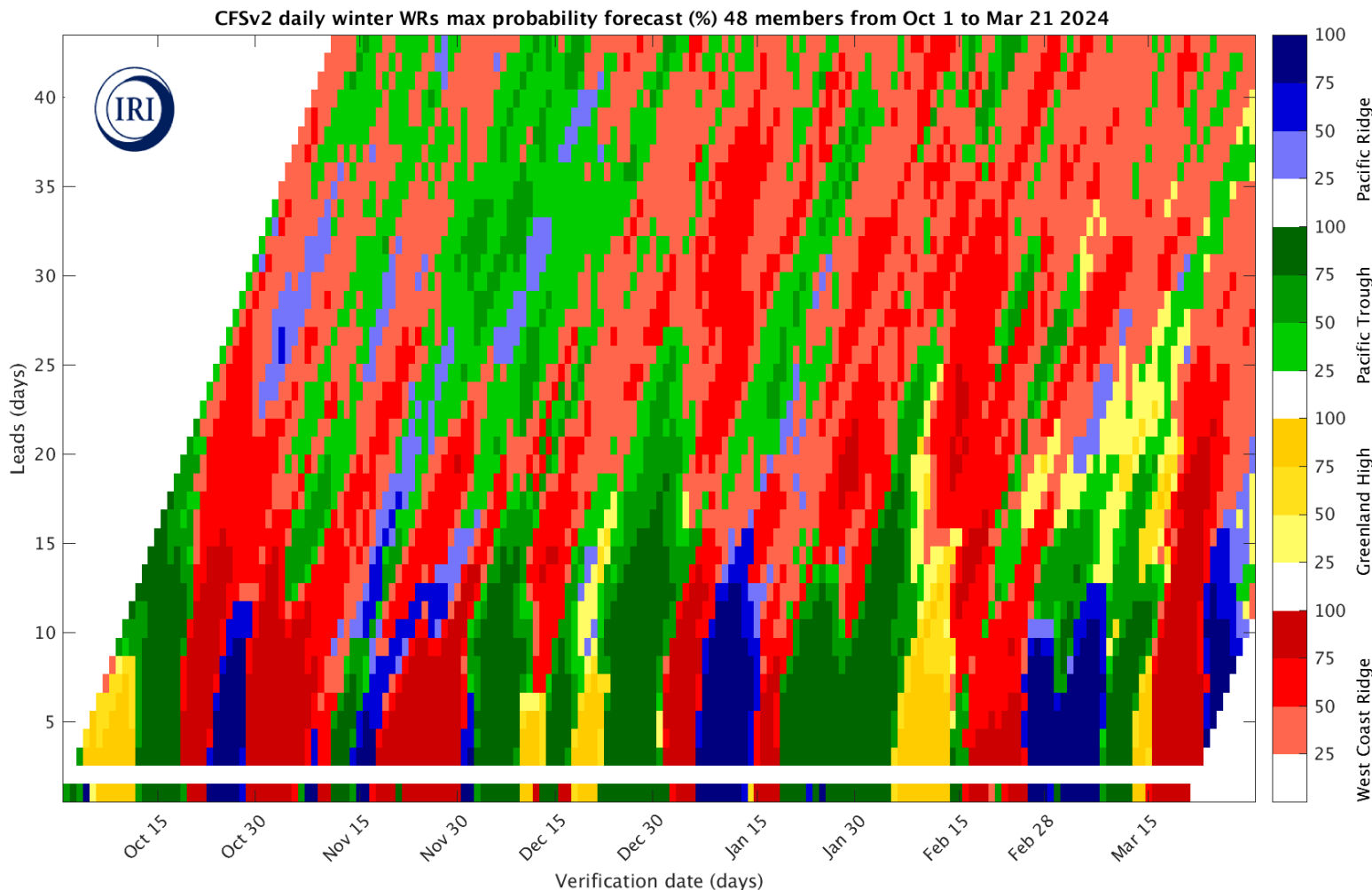
Reference: [Robertson et al. \(2020\)](#)

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

Forecast Initialized 21 Mar 2024



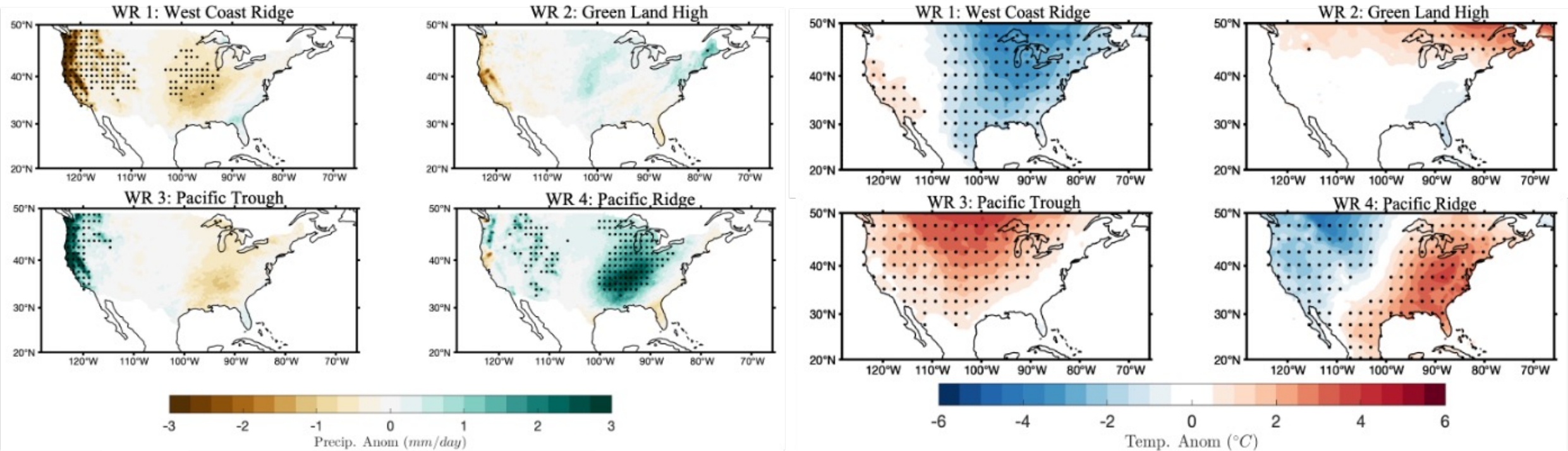
- Daily forecast out to 45-day lead time based on NCEP CFSv2 ensemble
- High likelihood (> 75% ensemble agreement) of Pacific Ridge during much of Week 1 (22–28 Mar)
- Possible transition from Pacific Ridge to West Coast Ridge during Week 2 (29 Mar – 4 Apr), but ensemble agreement is low
- Note that forecasts do not extend beyond 31 Mar in this product

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. See the next slide for temperature/precipitation implications.

Subseasonal Outlooks: IRI North American Weather Regime Forecasts

Precipitation

Temperature



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

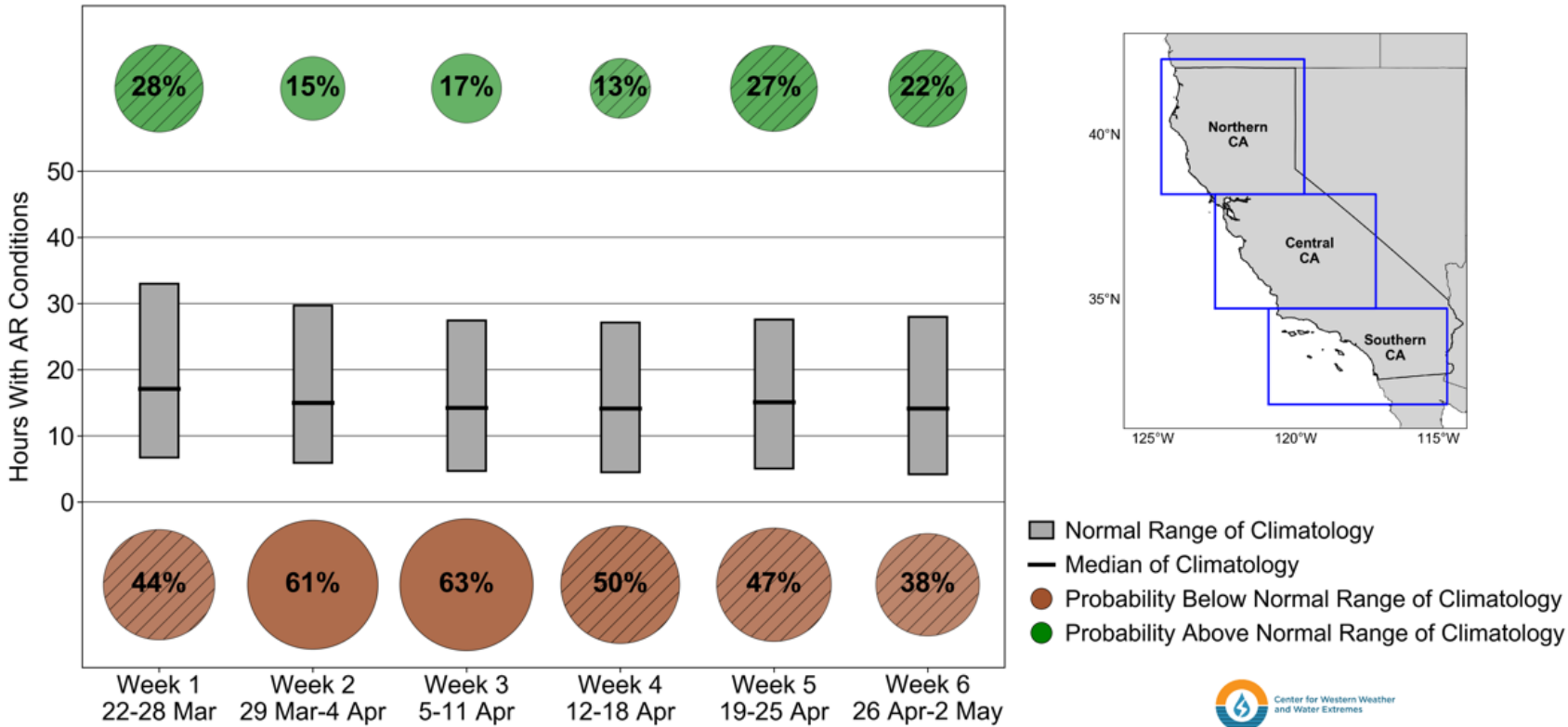
- Cooler-than-normal conditions predicted over CA during the fourth week of March with high confidence
- Possible transition from cool conditions to warm and dry conditions at the end of March, but there is a high degree of forecast uncertainty

Subseasonal Outlooks: AR Activity and Precipitation Based on MJO and QBO

Forecasts Initialized 21 Mar 2024

AR Occurrence: Northern CA

Northern CA Subseasonal AR Occurrence Outlook
Issued: 21 Mar 2024 MJO Phase 7 EQBO



- CW3E's statistical forecast tool based on current MJO and QBO conditions is showing a high likelihood (> 50%) of below-normal AR occurrence during Weeks 2–3 in Northern CA
- The same product is showing a high likelihood of below-normal AR occurrence in Central CA during Weeks 2–5 and in Southern CA during Weeks 4–5



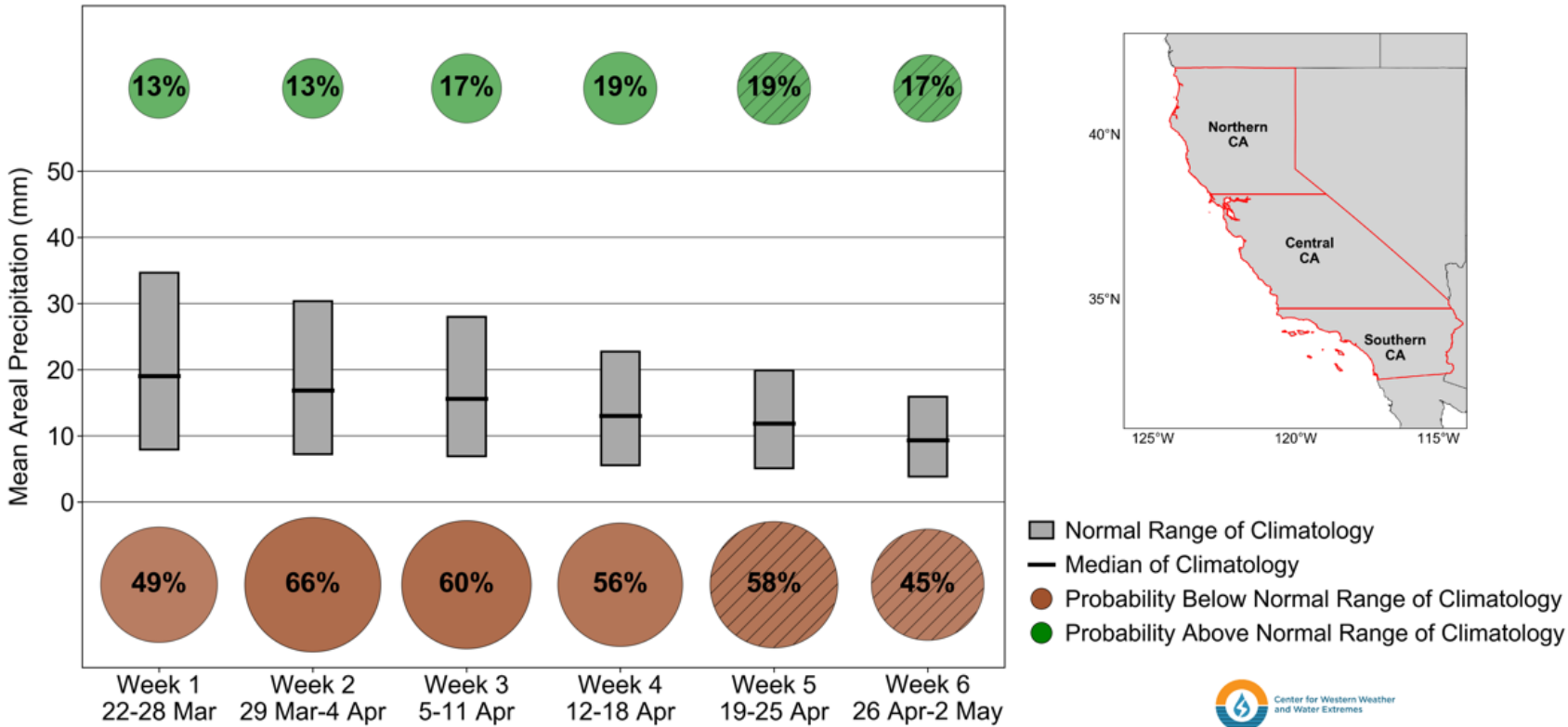
This product shows weekly probabilities of above-normal and below-normal AR occurrence in California. These probabilities are calculated for lead times of 1–6 weeks based on the current season (i.e., OND or JFM) and phases of the Madden-Julian Oscillation (MJO) and Quasi-biennial Oscillation (QBO). If MJO convection is weak or the QBO is in a neutral phase, no probabilities will be displayed. Circles without hatching denote periods with higher predictability based on the hindcast skill assessment in [Castellano et al. \(2023\)](#)

Subseasonal Outlooks: AR Activity and Precipitation Based on MJO and QBO

Forecasts Initialized 21 Mar 2024

Precipitation: Northern CA

Northern CA Subseasonal Precipitation Outlook
Issued: 21 Mar 2024 MJO Phase 7 EQBO



- CW3E's statistical forecast tool based on current MJO and QBO conditions is showing a high likelihood (> 50%) of below-normal precipitation during Week Weeks 2–5 in Northern CA
- The same product is showing a high likelihood of below-normal precipitation in Central CA during Week 2 and Week 5



This product shows weekly probabilities of above-normal and below-normal precipitation in California. These probabilities are calculated for lead times of 1–6 weeks based on the current season (i.e., OND or JFM) and phases of the Madden-Julian Oscillation (MJO) and Quasi-biennial Oscillation (QBO). If MJO convection is weak or the QBO is in a neutral phase, no probabilities will be displayed. Circles without hatching denote periods with higher predictability based on the hindcast skill assessment in [Castellano et al. \(2023\)](#)