



Center for Western Weather  
and Water Extremes

SCRIPPS INSTITUTION OF OCEANOGRAPHY  
AT UC SAN DIEGO

# CW3E Subseasonal Outlook: 20 December 2024

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UC San Diego



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OCEANOGRAPHY

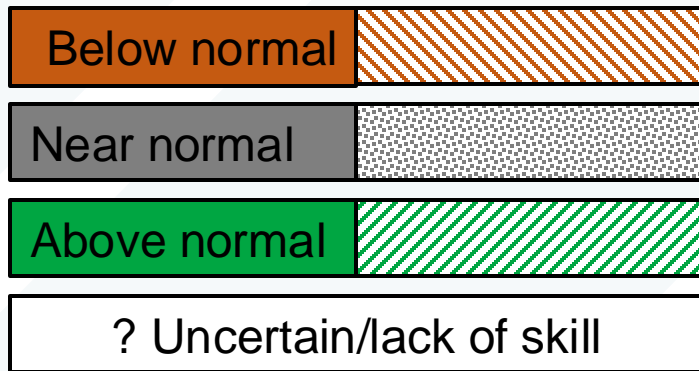
# Summary: Subseasonal Precipitation Outlook by Model

This slide shows the CW3E synthesis of subseasonal products by model

## Forecasts Initialized 19 Dec 2024

Region	Week 2 (26 Dec–1 Jan)				Week 3 (2–8 Jan)				Week 4 (9–15 Jan)			
	NCEP <sup>1,2,3</sup>	ECMWF <sup>1,2</sup>	ECMWF <sup>1,2</sup>	Multi-Model Forecast	NCEP <sup>1,2,3</sup>	ECMWF <sup>1,2</sup>	ECMWF <sup>1,2</sup>	Multi-Model Forecast	NCEP <sup>1,2,3</sup>	ECMWF <sup>1,2</sup>	ECMWF <sup>1,2</sup>	Multi-Model Forecast
WA/OR		Higher Confidence				Lower Confidence	Higher Confidence		Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence
Northern CA		Higher Confidence			Higher Confidence	Lower Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence
Central CA		Higher Confidence			Higher Confidence	Lower Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence
Southern CA		Lower Confidence	Higher Confidence		Higher Confidence	Lower Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence	Higher Confidence

Higher Confidence | Lower Confidence



- High degree of uncertainty in precipitation over all of CA during Week 2
- Models lean towards below-normal precipitation over all of CA (with low confidence) during Weeks 3–4

### Subseasonal products included in this Outlook:

<sup>1</sup>CW3E/JPL Atmospheric River Activity Forecasts ([DeFlorio et al. 2019](#), [Zhang et al. 2023](#))

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

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

# Summary

## MJO/QBO Conditions

- MJO convection is currently located over the Western Pacific (Phase 6); QBO is in the westerly phase
  - The above MJO and QBO combinations favor a moderate likelihood (40% probability) of above-normal precipitation in Southern CA during Weeks 2–3 (27 Dec – 9 Jan)
  - Without considering QBO/ENSO conditions, MJO in the Western Pacific during OND is associated with increases in wet extremes in CA at lag times of 2–4 weeks, particularly in Northern and Central CA
- Models forecast MJO to remain over the Western Pacific during Weeks 1–2 (20 Dec – 2 Jan)

## Week 2 forecasts (26 Dec – 1 Jan):

- Models agree on above-normal AR activity over Northern and Central CA but disagree on AR activity over Southern CA
  - In Southern CA, ECCO and ECMWF agree on near-normal AR activity, and NCEP is forecasting above-normal AR activity
- Ridging outlooks show high likelihood of above-normal North-ridge (dry conditions over all of CA) and moderate-to-high likelihood of South-ridge (dry conditions in Southern CA) activity during Weeks 1–2
- The discrepancy between the AR activity and ridging outlooks in NCEP may be due to the weak ridging over the western US downstream of the persistent trough over the North Pacific being picked up by the model. The weak ridge and its longitudinal fluctuation still allow AR activity to reach the US West Coast
- IRI weather regime tool shows high likelihood of regime shifts from Pacific Trough (above-normal precipitation in CA) to Greenland High (slightly below-normal precipitation in CA) during Week 2

# Summary

## Week 3 Forecasts (2–8 Jan):

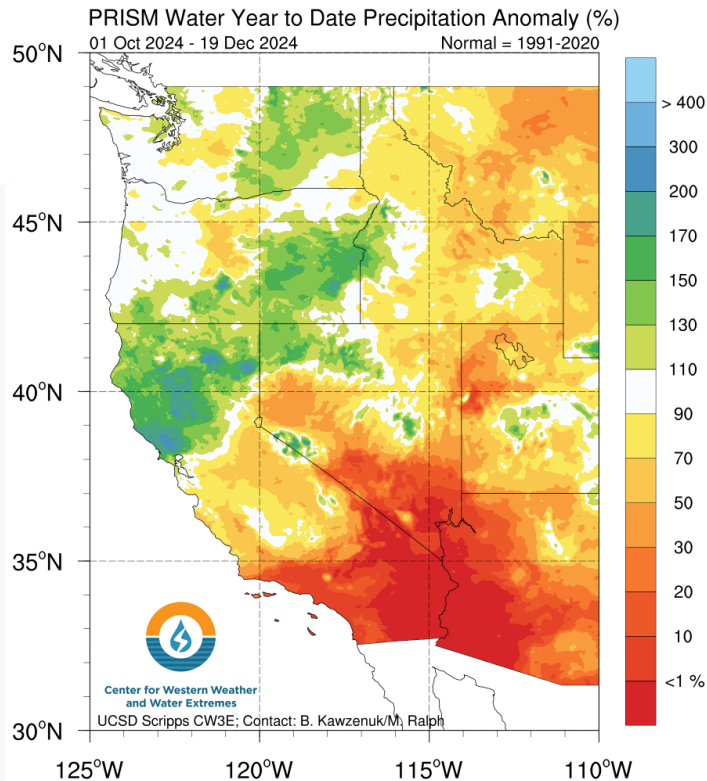
- Models disagree somewhat on AR activity in CA during Week 3
  - ECCC and ECMWF agree on near-normal AR activity over all of CA
  - NCEP is forecasting above-normal AR activity over Northern and Central CA, and slightly below-normal AR activity over Southern CA
- Ridging outlooks show moderate-to-high likelihood of above-normal North-ridge activity (dry conditions over all of CA) during Weeks 3–4
- IRI weather regime tool shows moderate likelihood of regime shifts from Greenland High (slightly below-normal precipitation in CA) to West Coast Ridge (below-normal precipitation in CA) during Week 3

## Week 4 Forecasts (9–15 Jan):

- Models disagree somewhat on AR activity in CA during Week 4
  - NCEP and ECCC agree on above-normal AR activity over Northern and Central CA; ECMWF is forecasting near-normal AR activity over these regions
  - ECCC is also forecasting above-normal AR activity over Southern CA; NCEP is forecasting slightly above-normal AR activity and ECMWF is forecasting near-normal AR activity

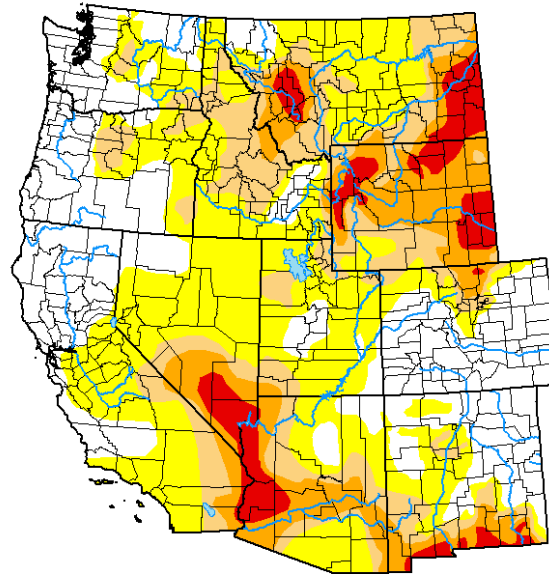
# Hydrologic Summary

## Precipitation



## Drought Conditions

### U.S. Drought Monitor West



December 17, 2024

(Released Thursday, Dec. 19, 2024)

Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	30.42	69.58	34.63	18.13	6.26	0.00
Last Week 12-10-2024	30.41	69.59	34.76	18.15	6.58	0.00
3 Months Ago 08-17-2024	19.08	80.92	38.66	9.52	2.08	0.11
Start of Calendar Year 01-02-2024	51.19	48.81	25.08	13.17	4.67	0.66
Start of Water Year 10-01-2024	20.06	79.94	37.38	9.85	2.47	0.11
One Year Ago 12-19-2023	55.06	44.94	23.85	13.69	5.07	0.66

#### 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>

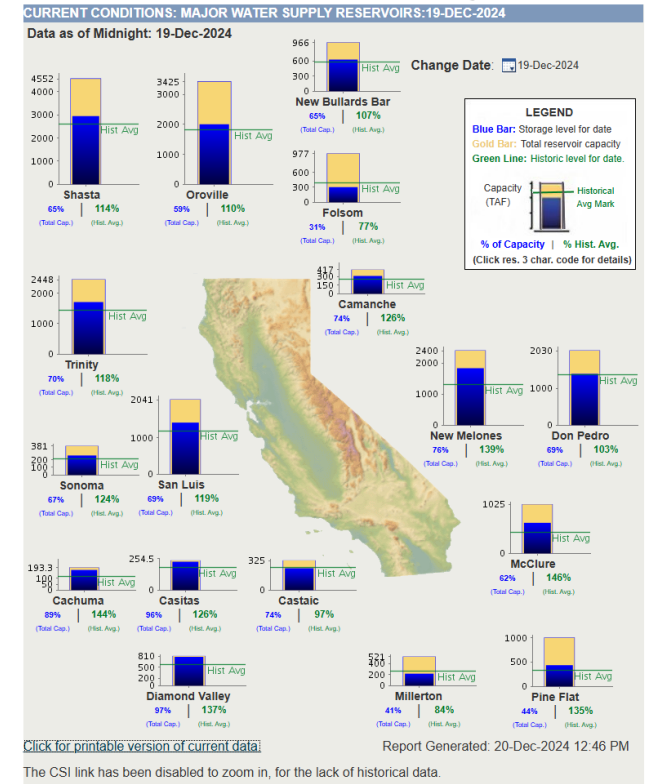
#### Author

Brian Fuchs  
National Drought Mitigation Center



[droughtmonitor.unl.edu](https://droughtmonitor.unl.edu)

## Reservoir Storage



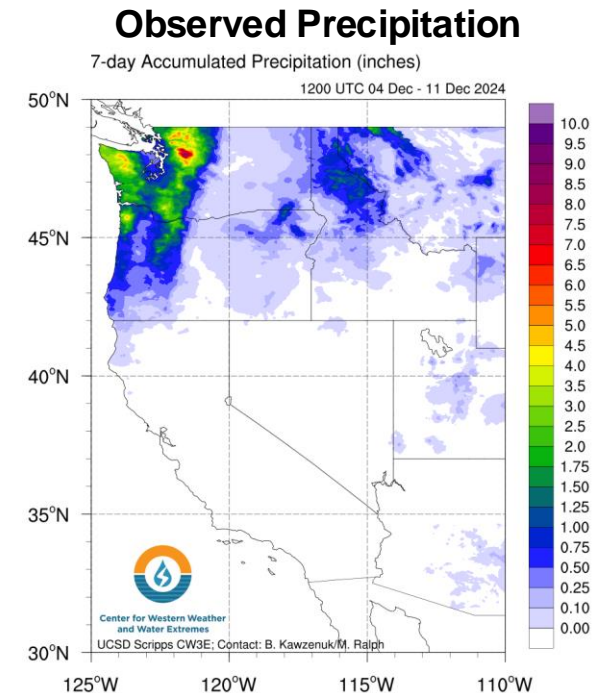
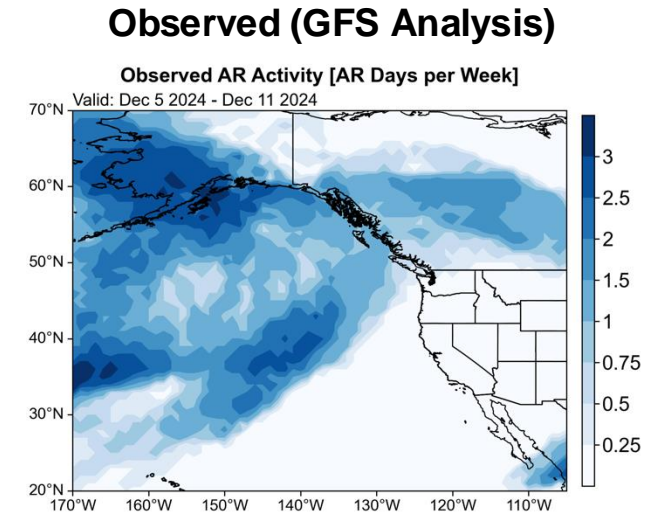
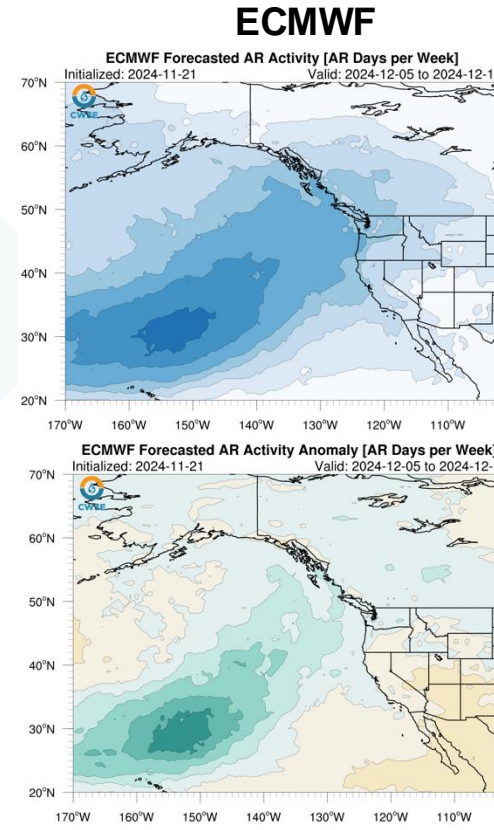
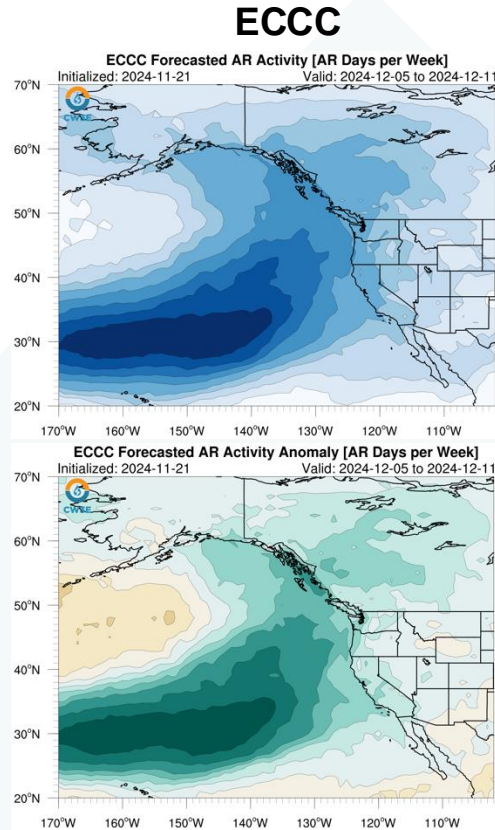
Source: California DWR

- As of 19 Dec, water-year-to-date precipitation is **above normal (> 130% of normal)** in Northern CA, **slightly below-normal (50–90% of normal)** in Central CA, and **well-below normal (< 20% of normal)** in Southern CA
- The most recent drought monitor update is showing **abnormally dry conditions (D0)** over the San Joaquin Basin and coastal Southern CA and **moderate drought-to-severe drought (D1–D2)** in the desert regions of southeastern CA
- Most large reservoirs in CA are still operating at **near or above-normal storage** for this time of year

# Looking Back: Week 3 AR Activity Forecasts

Forecasts Initialized 21 Nov 2024; Valid: 5–11 Dec 2024

NCEP  
Unavailable

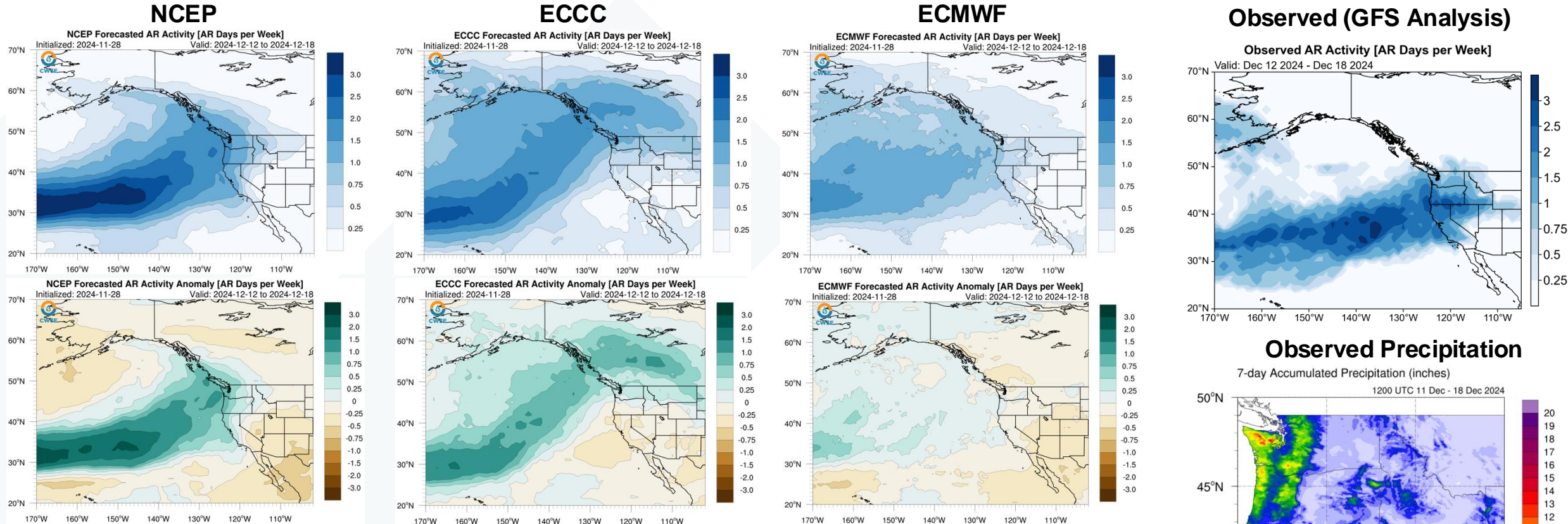


Shading: Fractional # of AR days forecast over a 7-day period (top) and forecast minus model climatology (bottom; green/blue = higher than climatology; brown = lower than climatology)

- All models overestimated AR activity over the US West Coast
- Observed AR activity was much farther north (over British Columbia) due to ridging
- The more zonal axis of AR activity in the forecasts suggests that the models struggled to predict the location and amplitude of the ridging in this forecast at a 3-week lead time
- An AR and a low-pressure system produced at least 3–6 inches of precipitation over the Olympic Mountains and Washington Cascades during 6–8 Dec

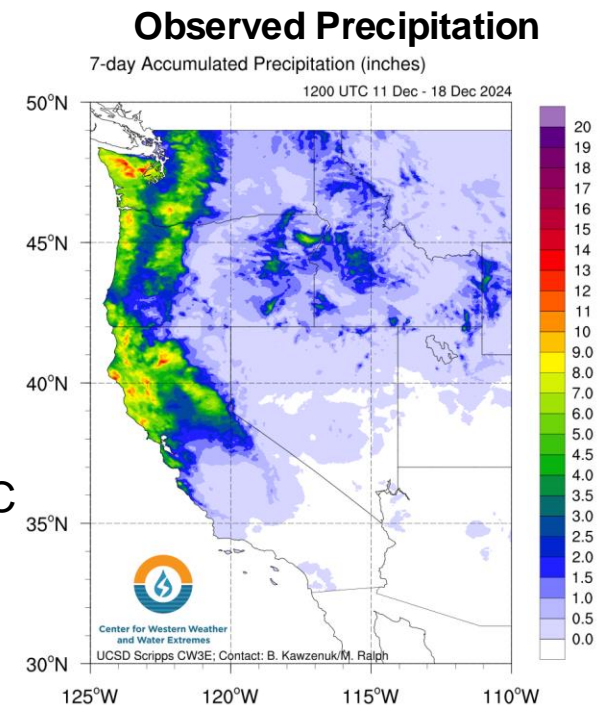
# Looking Back: Week 3 AR Activity Forecasts

Forecasts Initialized 28 Nov 2024; Valid: 12–18 Dec 2024

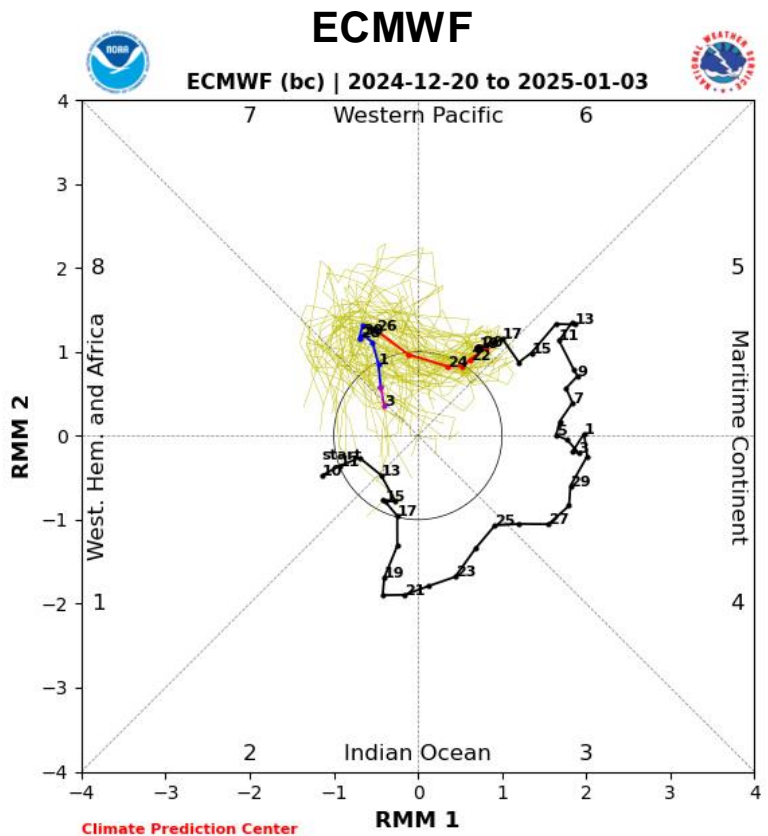
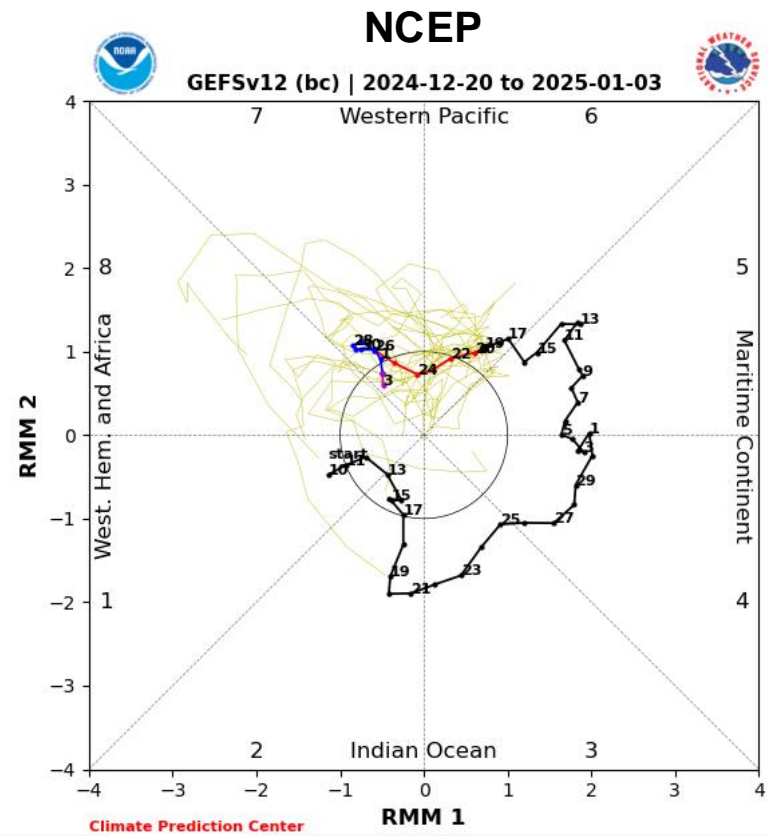


Shading: Fractional # of AR days forecast over a 7-day period (top) and forecast minus model climatology (bottom; green/blue = higher than climatology; brown = lower than climatology)

- NCEP captured the overall AR structure and activity over California and the Pacific Northwest
- AR activity over California was underestimated in ECCC and ECMWF. The underestimate in ECCC was due to too meridional AR orientation and ECMWF predicted overall too weak AR activity
- An AR produced over >5 inches of precipitation over much of Northern California and Western Oregon and Washington; This AR also produced some precipitation over Central California

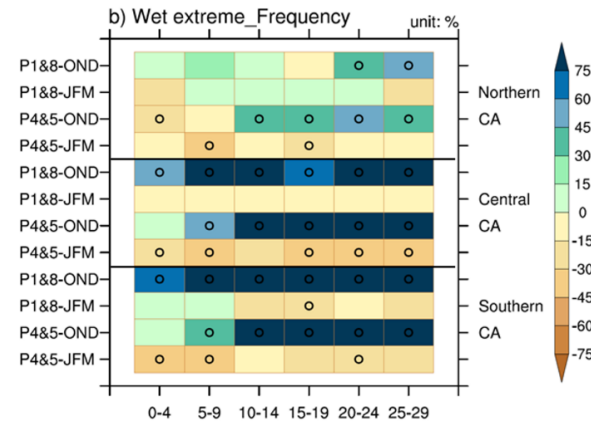
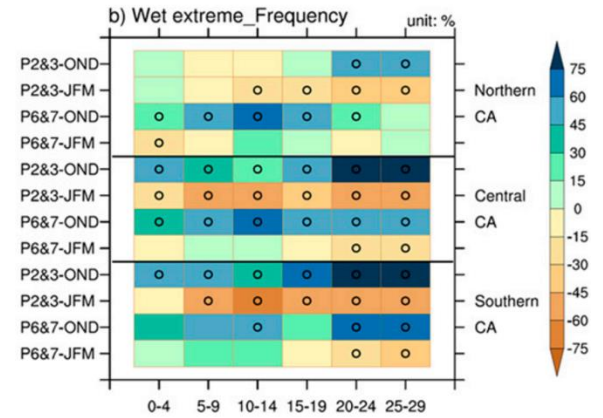


# Dynamical Model MJO Forecasts (NCEP vs. ECMWF)



Black: Last 40 days of observations (10 Nov – 19 Dec); Red: Week 1 (20–26 Dec) ensemble mean; Blue: Week 2 (27 Dec–2 Jan) ensemble mean; Yellow: Ensemble members

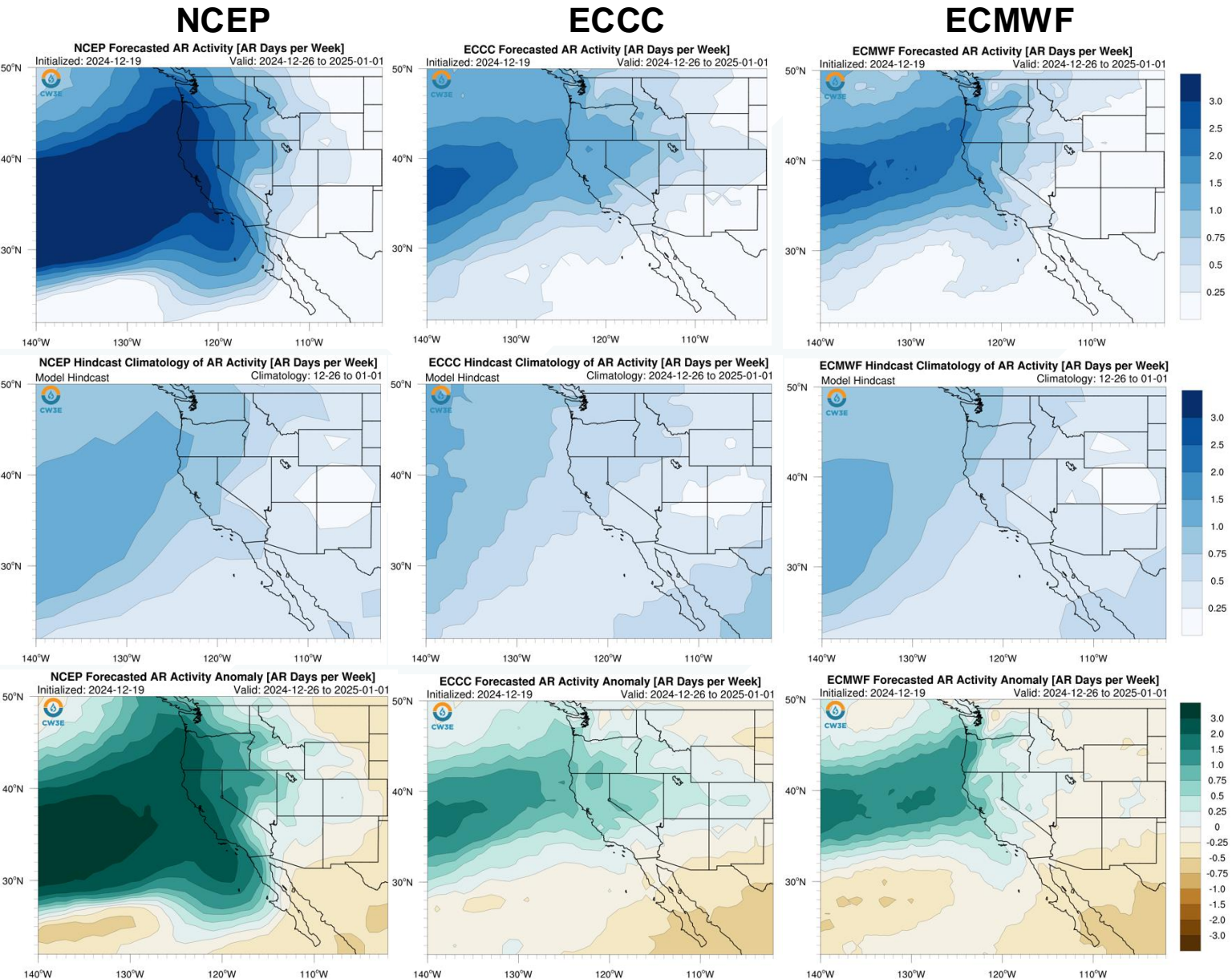
- As of 19 Dec, strong MJO convection is located over the Western Pacific (Phase 6) and is forecasted to remain in the Western Pacific in Weeks 1-2 (20 Dec – 2 Jan)
- Both models are forecasting MJO convection to weaken and re-intensify in Week 1 (20-26 Dec) and weaken again at the end of Week 2 around 1 Jan
- Without considering QBO/ENSO conditions, MJO activity over the Western Pacific during OND is associated with statistically significant increases in wet extremes in CA at lag times of 2–4 weeks, particularly in Northern and Central CA





# AR Activity Forecasts: Week 2 (NCEP vs. ECCC vs. ECMWF)

Forecasts Initialized 19 Dec 2024



- All models agree on above-normal AR activity over Northern CA during Week 2 (26 Dec – 1 Jan)
- In Central CA, NCEP and ECCC agree on above-normal AR activity, and ECMWF is forecasting slightly above-normal AR activity
- In Southern CA, ECCC and ECMWF agree on near-normal AR activity, and NCEP is forecasting above-normal AR activity
- NCEP is forecasting much more AR activity in general over CA compared to ECCC and ECMWF

Models agree on above-normal AR activity over Northern and Central CA during Week 2 (26 Dec – 1 Jan)

Shading: Fractional # of AR days forecast over a 7-day period (top), model climatology (middle), and forecast minus model climatology (bottom; green/blue = higher than climatology; brown = lower than climatology)

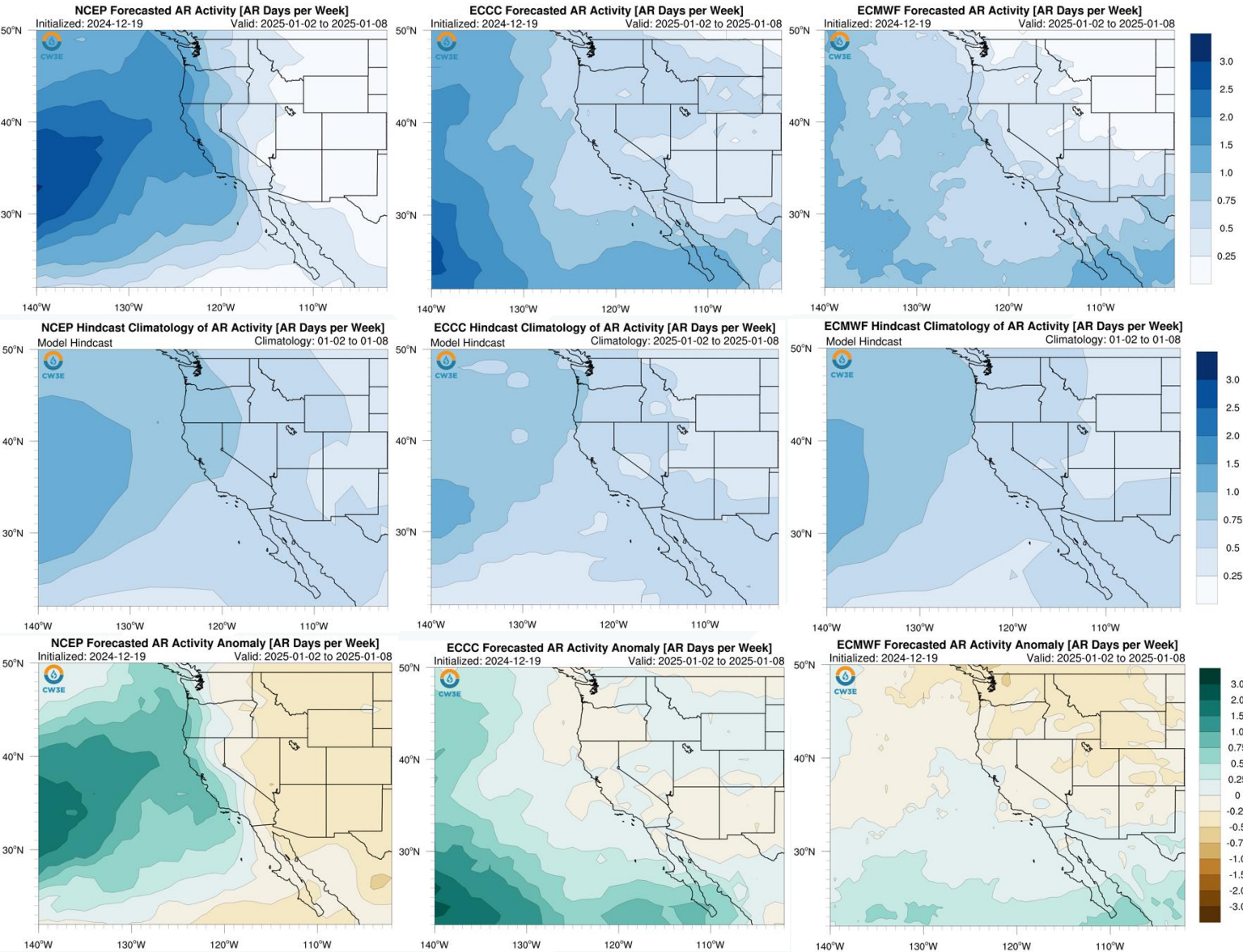
# AR Activity Forecasts: Week 3 (NCEP vs. ECCC vs. ECMWF)

Forecasts Initialized 19 Dec 2024

## NCEP

## ECCC

## ECMWF



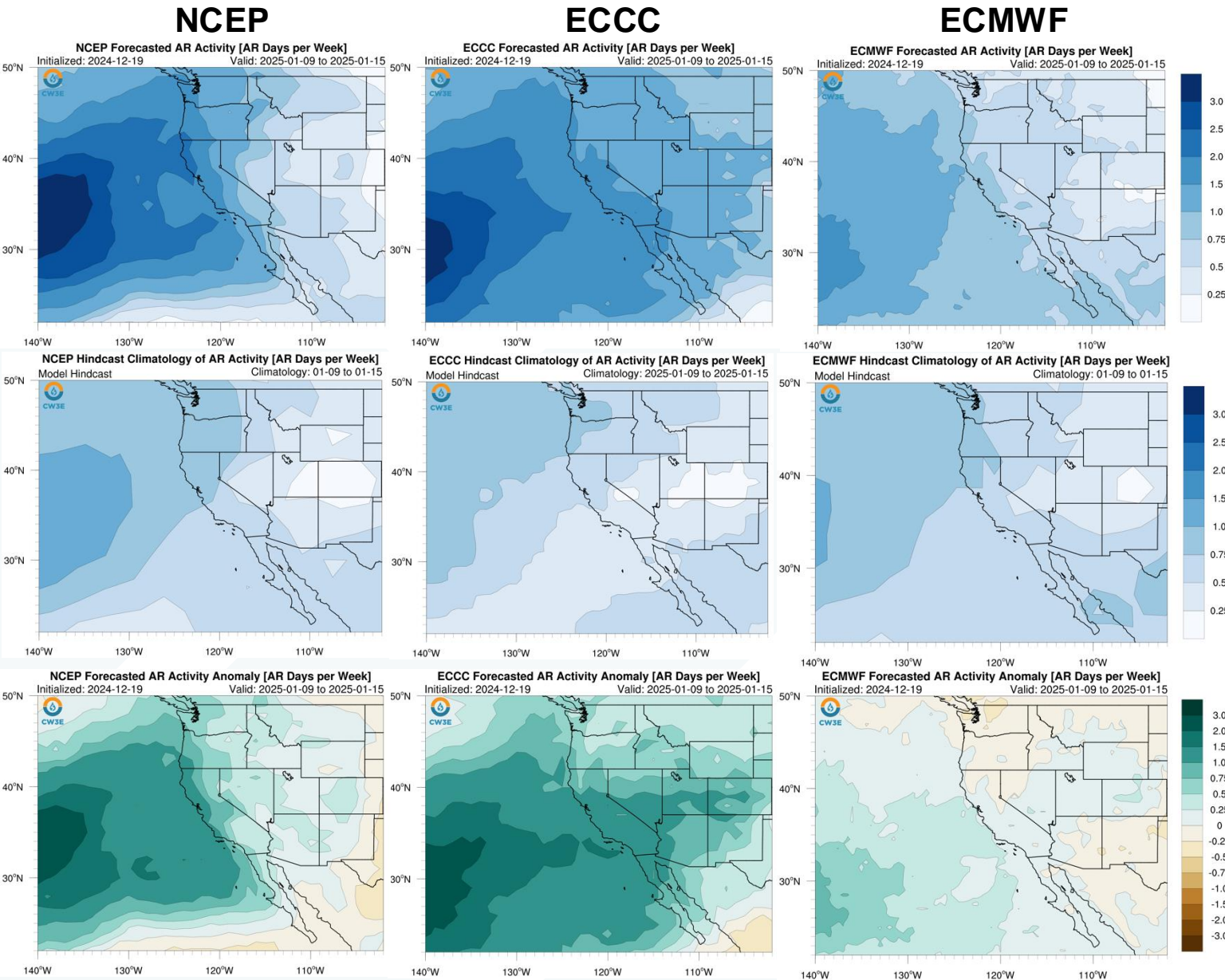
- ECCC and ECMWF agree on near-normal AR activity over all of CA during Week 3 (2–8 Jan)
- NCEP is forecasting above-normal AR activity over Northern and Central CA, and slightly below-normal AR activity over Southern CA

Models disagree somewhat on AR activity in CA during Week 3 (2–8 Jan)

Shading: Fractional # of AR days forecast over a 7-day period (top), model climatology (middle), and forecast minus model climatology (bottom; green/blue = higher than climatology; brown = lower than climatology)

# AR Activity Forecasts: Week 4 (NCEP vs. ECCC vs. ECMWF)

Forecasts Initialized 19 Dec 2024

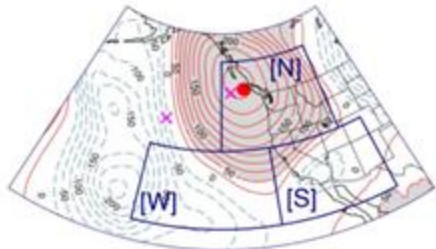


- NCEP and ECCC agree on above-normal AR activity over Northern and Central CA during Week 4 (9–15 Jan); ECMWF is forecasting near-normal AR activity over these regions
- ECCC is also forecasting above-normal AR activity over Southern CA; NCEP is forecasting slightly above-normal AR activity and ECMWF is forecasting near-normal AR activity

Models disagree somewhat on AR activity in CA during Week 4 (9–15 Jan)

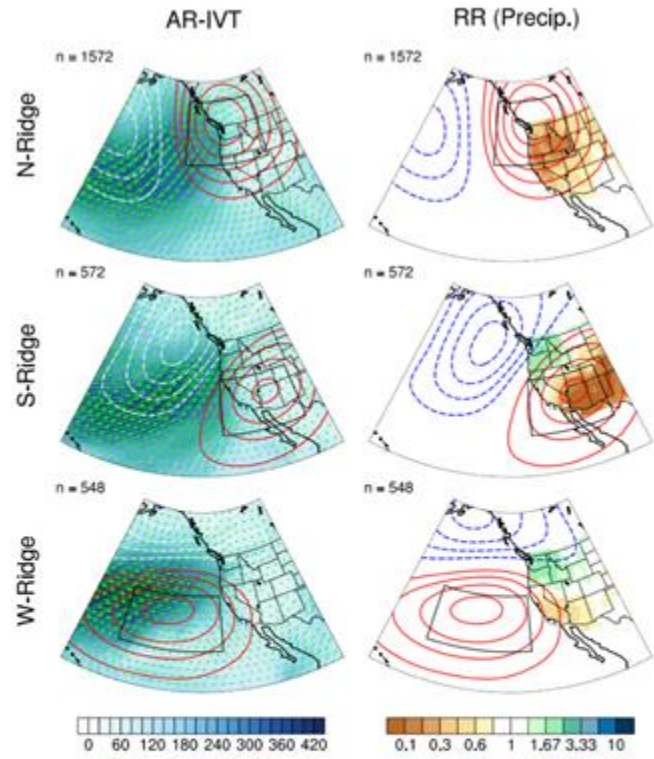
Shading: Fractional # of AR days forecast over a 7-day period (top), model climatology (middle), and forecast minus model climatology (bottom; green/blue = higher than climatology; brown = lower than climatology)

# 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



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

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

Forecasts Initialized 19 Dec 2024

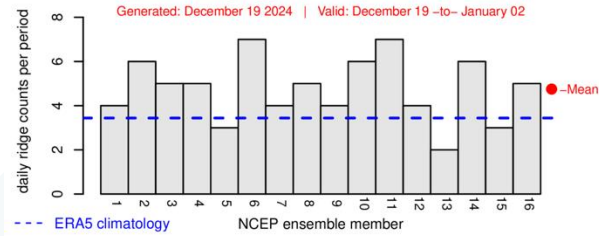
## NCEP

### CW3E Subseasonal Ridging Forecast

(Uses NCEP CFSv2 model)

#### North-ridge type (lead time: weeks 1 & 2)

Generated: December 19 2024 | Valid: December 19 –to– January 02

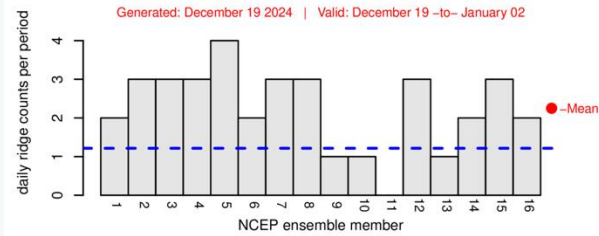


81% ensemble agreement

dry conditions  
wet conditions

#### South-ridge type (Lead time: weeks 1 & 2)

Generated: December 19 2024 | Valid: December 19 –to– January 02

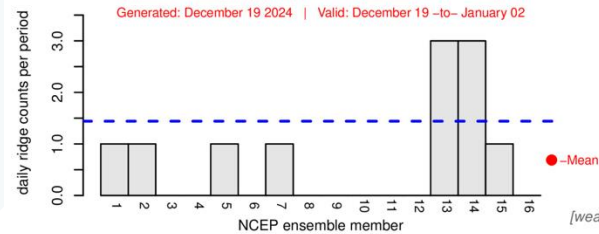


75% ensemble agreement

dry conditions  
wet conditions

#### West-ridge type (Lead time: weeks 1 & 2)

Generated: December 19 2024 | Valid: December 19 –to– January 02



<50% ensemble agreement

[weak west-ridge signal, <50% agreement]



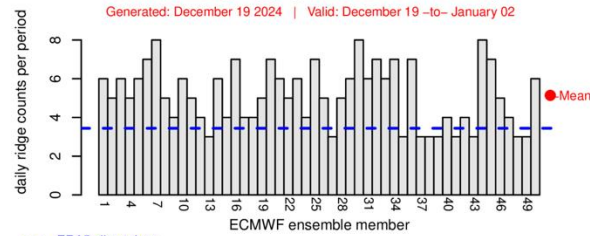
## ECMWF

### CW3E Subseasonal Ridging Forecast

(Uses ECMWF model)

#### North-ridge type (lead time: weeks 1 & 2)

Generated: December 19 2024 | Valid: December 19 –to– January 02

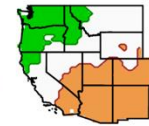
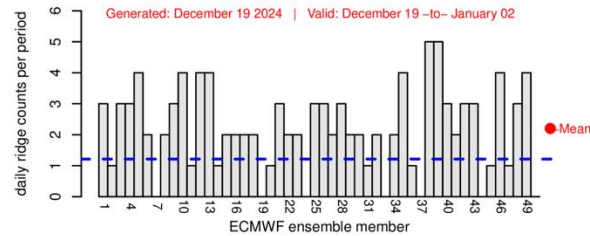


80% ensemble agreement

dry conditions  
wet conditions

#### South-ridge type (Lead time: weeks 1 & 2)

Generated: December 19 2024 | Valid: December 19 –to– January 02

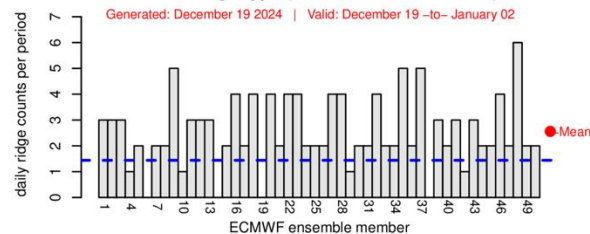


70% ensemble agreement

dry conditions  
wet conditions

#### West-ridge type (Lead time: weeks 1 & 2)

Generated: December 19 2024 | Valid: December 19 –to– January 02



84% ensemble agreement

dry conditions  
wet conditions



- NCEP and ECMWF are forecasting a high likelihood ( $\geq 75\%$  ensemble agreement) of above-normal North-ridge activity during Weeks 1–2 (19 Dec – 2 Jan)

- NCEP is also forecasting a high likelihood (75% ensemble agreement) of above-normal South-ridge activity during Weeks 1–2

- ECMWF is also forecasting a high likelihood of above-normal West-ridge activity and a moderate likelihood (70% ensemble agreement) of above-normal South-ridge activity

Models agree on high likelihood of above-normal ridging activity over the Pacific Northwest and moderate-to-high likelihood of above-normal ridging activity over the southwestern US during Weeks 1–2 (19 Dec – 2 Jan)

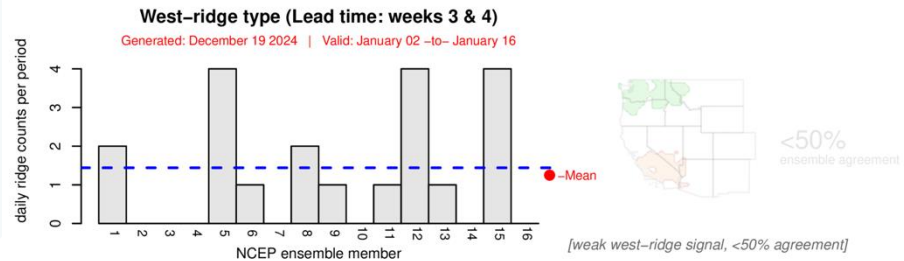
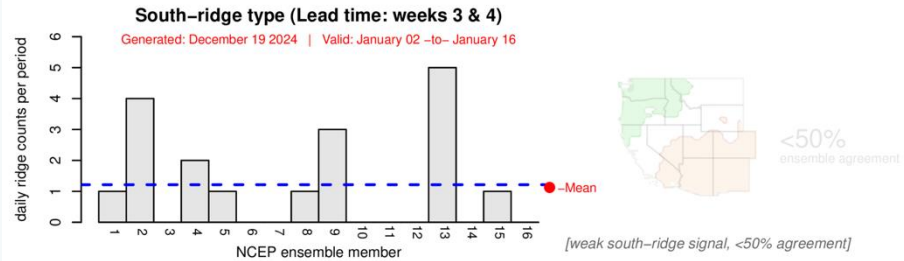
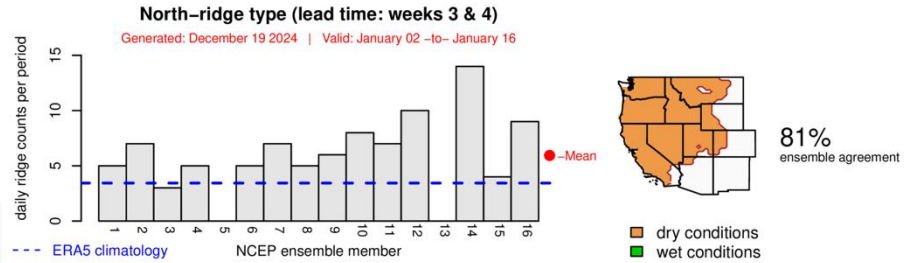


# Ridging Forecasts: Weeks 3–4 (NCEP vs. ECMWF)

Forecasts Initialized 19 Dec 2024

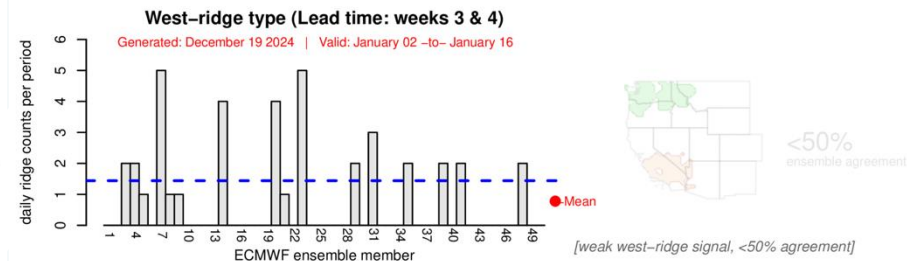
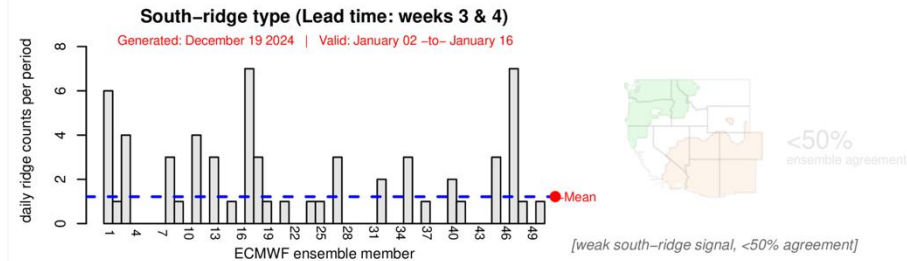
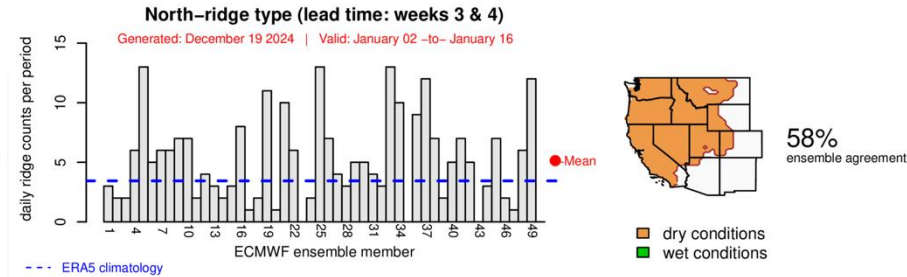
## NCEP

### CW3E Subseasonal Ridging Forecast (Uses NCEP CFSv2 model)



## ECMWF

### CW3E Subseasonal Ridging Forecast (Uses ECMWF model)



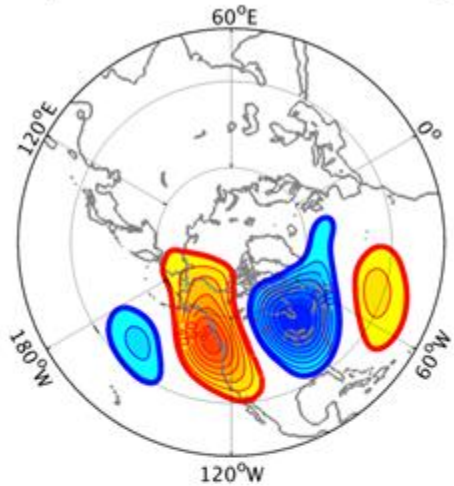
- NCEP is forecasting a high likelihood (81% ensemble agreement) of above-normal North-ridge activity during Weeks 3–4 (2–16 Jan)
- ECMWF is also forecasting above-normal North-ridge activity with moderate likelihood (58% ensemble agreement)
- Both models are forecasting near-normal South-ridge activity

Models agree on moderate-to-high likelihood of above-normal ridging activity over the Pacific Northwest during Weeks 3–4 (2–16 Jan)

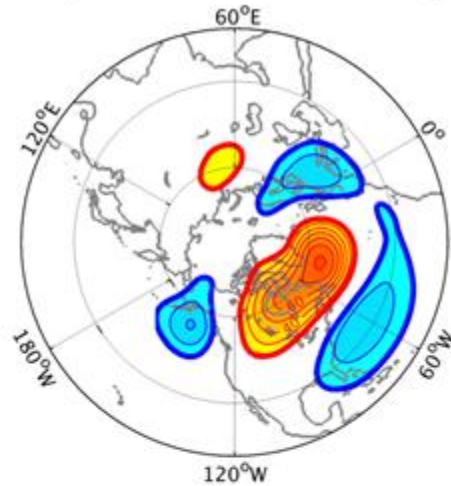


# Background Info: IRI Subseasonal Weather Regime Forecasts

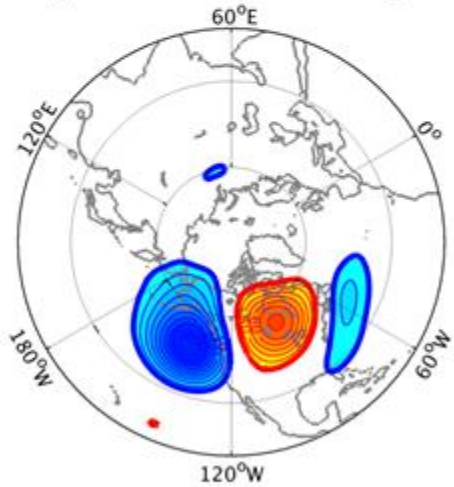
a) WR 1: West Coast Ridge



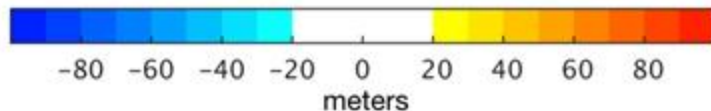
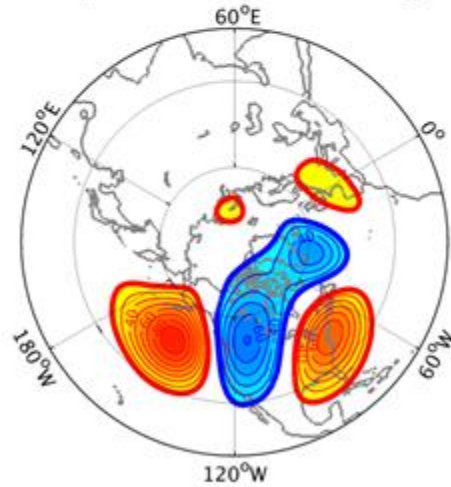
b) WR 2: Greenland High



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. \(2020\)](#)

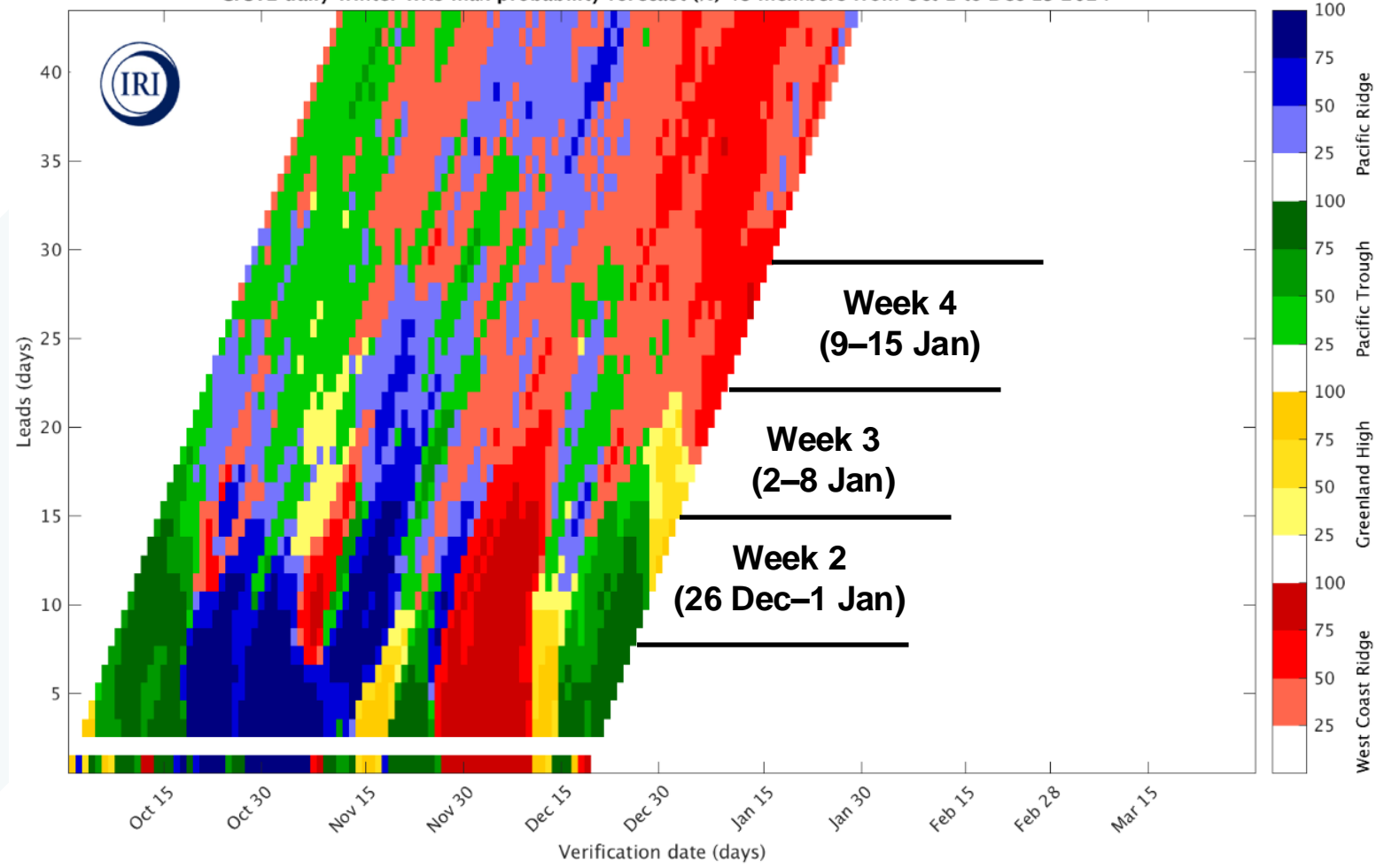
For more information about the forecast product:

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

# IRI North American Weather Regime Forecasts

**Forecast Initialized 19 Dec 2024**

CFSv2 daily winter WRs max probability forecast (%) 48 members from Oct 1 to Dec 19 2024



- Daily forecast out to 45-day lead time based on NCEP CFSv2 ensemble
- High likelihood (> 75% ensemble agreement) of regime transition from Pacific Trough to Greenland High during Week 2 (26 Dec – 1 Jan)
- Moderate likelihood (50–75% ensemble agreement) of regime transition from Greenland High to West Coast Ridge during Week 3 (2–8 Jan)
- Moderate likelihood (50–75% ensemble agreement) of West Coast Ridge persisting to Week 4 (9–15 Jan)

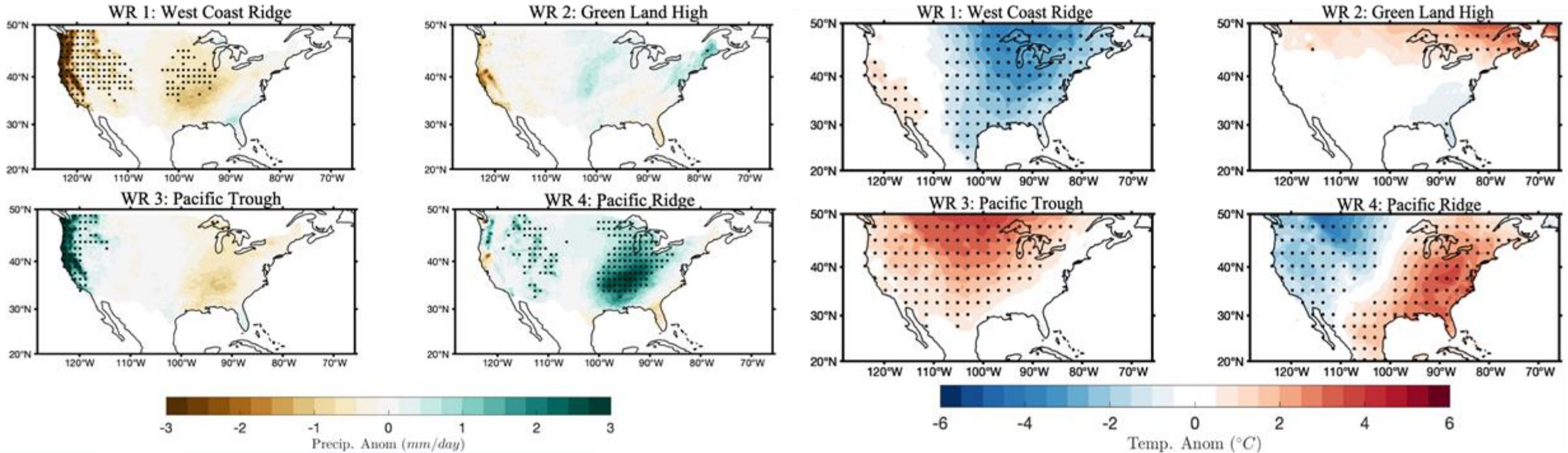
This graphic shows the which of the four North American weather regimes (different colors) is most likely to occur over the next 45 days. Darker (lighter) shading denotes higher (lower) probability of a particular regime. See the next slide for temperature/precipitation implications.



# IRI North American Weather Regime Forecasts

## Precipitation

## Temperature

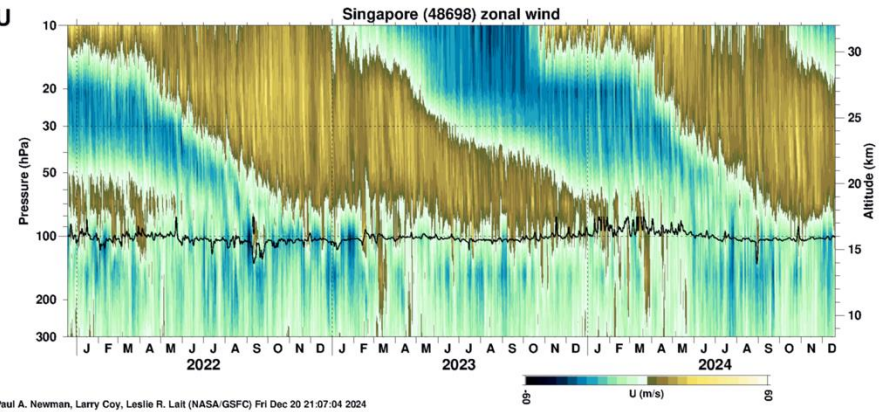


This graphic shows composite mean precipitation (left) and temperature (right) anomalies associated with each weather regime. Stippling (black dots) indicate statistically significant anomalies.

- Transition from above-normal precipitation and temperature to slightly below-normal precipitation and near-normal temperature predicted over CA during Week 2 (26 Dec – 1 Jan) with high confidence
- Transition from slightly below-normal precipitation and near-normal temperature to below-normal precipitation and above-normal temperature predicted over CA during Week 3 (2–8 Jan) with moderate confidence
- Below-normal precipitation and above-normal temperature predicted to persist over CA in Week 4 (9–15 Jan) with moderate confidence

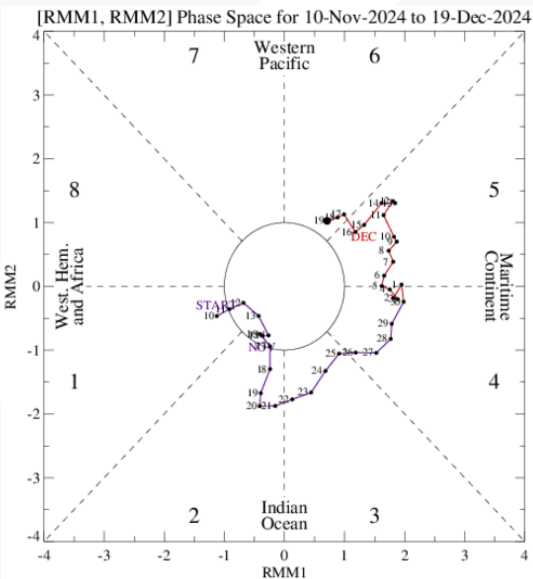
# Background Info: AR Activity and Precipitation Based on MJO and QBO

## QBO Conditions



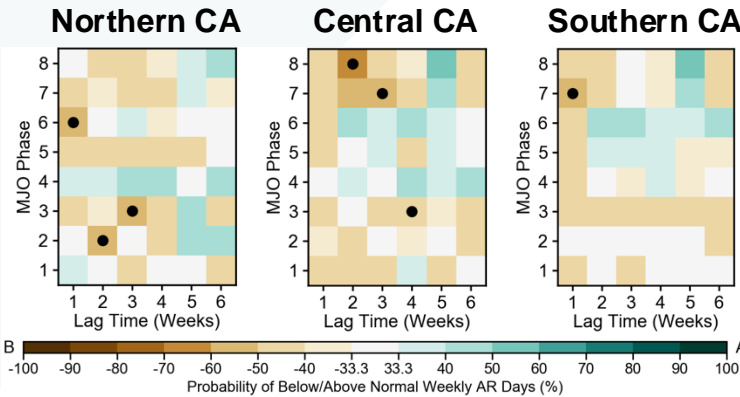
**QBO is in the westerly phase at 50-hPa**

## MJO Conditions

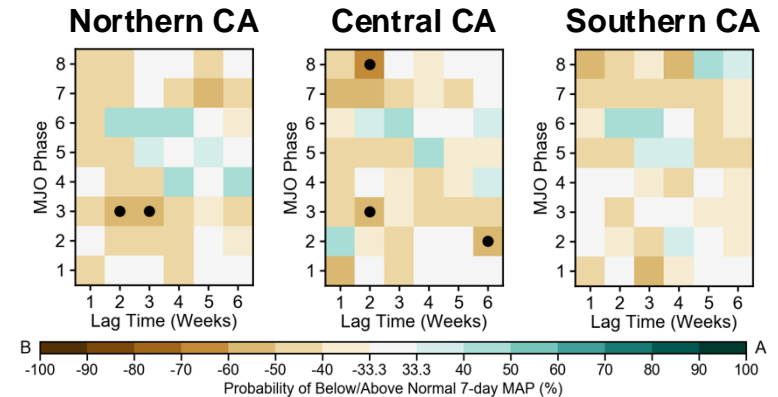


**MJO convection is currently located over the Western Pacific (Phase 6)**

## Probability of Above/Below-Normal AR Occurrence (WQBO in OND)



## Probability of Above/Below-Normal Precipitation (WQBO in OND)

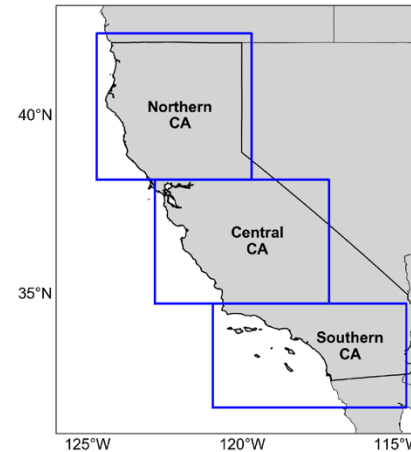
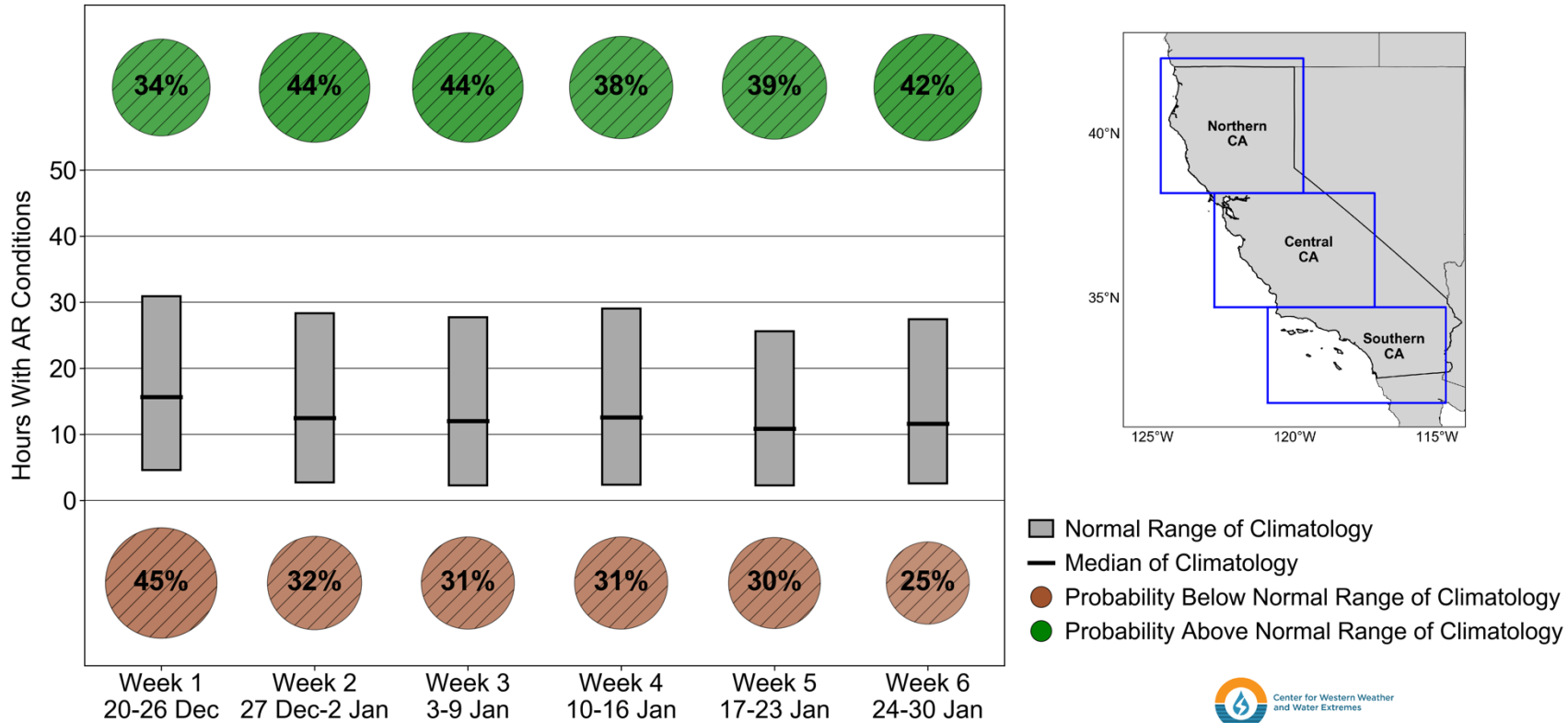


Probability matrices illustrating the weeks 1–6 lagged probability of below-normal (brown shading) or above-normal (green shading) AR occurrence and precipitation for all MJO phases when the QBO is in the westerly phase during OND in Northern CA (left), Central CA (middle), and Southern CA (right). White squares indicate that the near-normal category has the highest probability. The black dots denote statistically significant probabilities of below- or above-normal conditions based on a bootstrapping analysis. Historical observations less (more) than the lower (upper) tercile of climatology (1981–2019 period) are considered below (above) normal.

# AR Activity and Precipitation Based on MJO and QBO

## AR Occurrence: Southern CA

Southern CA Subseasonal AR Occurrence Outlook  
Issued: 19 Dec 2024 MJO Phase 6 WQBO



Normal Range of Climatology  
 Median of Climatology  
 Probability Below Normal Range of Climatology  
 Probability Above Normal Range of Climatology



Forecasts Initialized 19 Dec 2024

- CW3E's probabilistic AR occurrence forecast based on current MJO and QBO conditions (see forecast for all regions [here](#))
- **Moderate likelihood (> 40% probability) of above-normal AR occurrence in Southern CA during Weeks 2–3 (27 Dec – 9 Jan) and Week 6 (24–30 Jan)**
- Moderate likelihood of normal-normal AR occurrence in Central CA during Week 2 (27 Dec – 2 Jan)

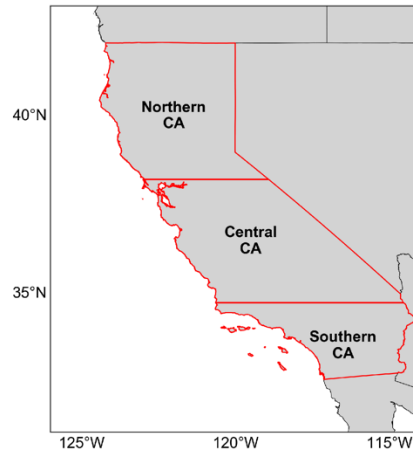
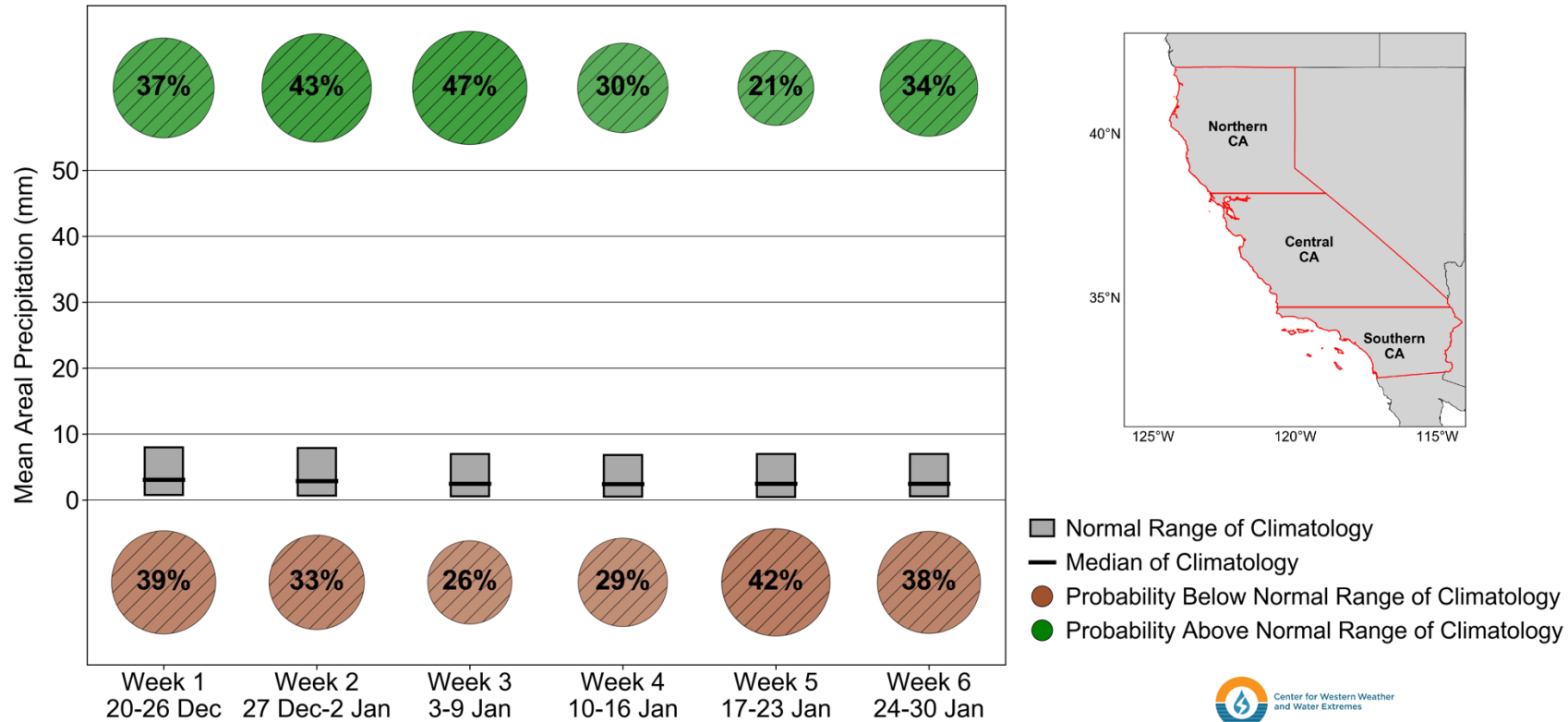
This product shows weekly probabilities of above-normal and below-normal AR occurrence in California. These probabilities are calculated for lead times of 1–6 weeks based on the current season (i.e., OND or JFM) and phases of the Madden-Julian Oscillation (MJO) and Quasi-biennial Oscillation (QBO). If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



# AR Activity and Precipitation Based on MJO and QBO

## Precipitation: Southern CA

Southern CA Subseasonal Precipitation Outlook  
Issued: 19 Dec 2024 MJO Phase 6 WQBO



Forecasts Initialized 19 Dec 2024

- CW3E's probabilistic precipitation forecast based on current MJO and QBO conditions (see forecast for all regions [here](#))
- **Moderate likelihood of above-normal precipitation in Southern CA during Weeks 2–3 (27 Dec – 9 Jan)**
- Moderate likelihood of above-normal precipitation in Northern CA during Weeks 2-4 (27 Dec – 16 Jan) and Central CA during Week 3 (3–9 Jan)



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 high confidence based on the hindcast skill assessment in [Castellano et al. \(2023\)](#)

# CW3E Subseasonal Outlooks: Glossary & Context

- The outlooks are based on CW3E subseasonal forecast products that can be found here: [https://cw3e.ucsd.edu/s\\_and\\_s\\_forecasts/](https://cw3e.ucsd.edu/s_and_s_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*