



Center for Western Weather
and Water Extremes

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AT UC SAN DIEGO

CW3E S2S Outlook: 13 Feb 2023

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UC San Diego



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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*

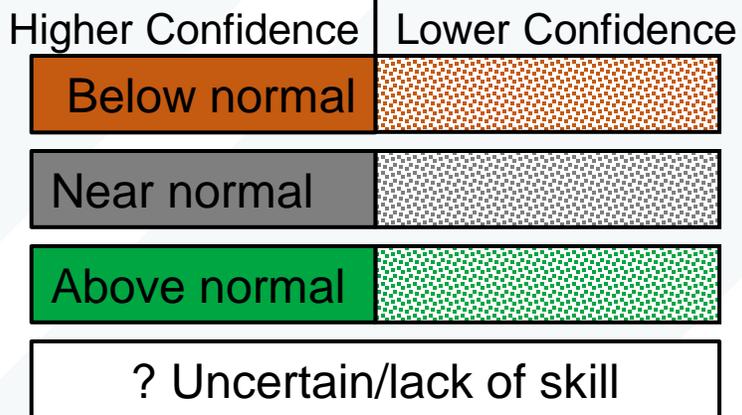
Summary: Subseasonal Precipitation Outlook by Product & Model

This slide shows the CW3E synthesis of subseasonal products by product and model. Click [here](#) for a detailed explanation.

Forecasts Initialized 9 Feb 2023

Region	Week 2 (17–23 Feb)						Week 3 (24 Feb – 2 Mar)						Week 4 (3–9 Mar)					
	NCEP ^{1,2,3}		ECCC ¹		ECMWF ^{1,2}		NCEP ^{1,2,3}		ECCC ¹		ECMWF ^{1,2}		NCEP ^{2,3}		ECMWF ²			
WA/OR	Below normal	?	Above normal	N/A	N/A	Below normal	?	N/A	Below normal	?	Above normal	N/A	N/A	Below normal	?	Above normal	N/A	N/A
Northern CA	Below normal	?	?	N/A	N/A	Below normal	?	N/A	Below normal	?	Above normal	N/A	N/A	?	?	?	N/A	N/A
Central CA	Below normal	?	?	N/A	N/A	Below normal	?	N/A	Below normal	?	Above normal	N/A	N/A	?	?	?	N/A	N/A
Southern CA	?	?	?	Below normal	N/A	N/A	Below normal	?	N/A	?	Above normal	N/A	N/A	?	?	?	N/A	N/A

Each box from left to right indicates each product that is available in that category. N/A indicates product is unavailable. Forecast confidence is assessed based on the level of ensemble agreement (high confidence: $\geq 75\%$ agreement; low confidence: $< 75\%$ agreement)



- Week 2 forecasts generally show low likelihood of AR activity over CA
- Week 3 forecasts show large model-to-model disagreement, with NCEP and ECMWF predicting below-normal AR activity in CA, and ECCC predicting above-normal AR activity in CA
- Low likelihood of persistent ridging activity near the US West Coast during the next several weeks, with moderate-to-high confidence in Pacific Ridge conditions through Week 3

Subseasonal products included in this Outlook:

¹CW3E/JPL Atmospheric River Activity Forecasts ([DeFlorio et al. 2019](#)); first column under each model

²CW3E/JPL Ridging Forecasts ([Gibson et al. 2020](#)); second column under each model

³IRI North American Weather Regime Forecasts ([Robertson et al. 2020](#)); third column under each model

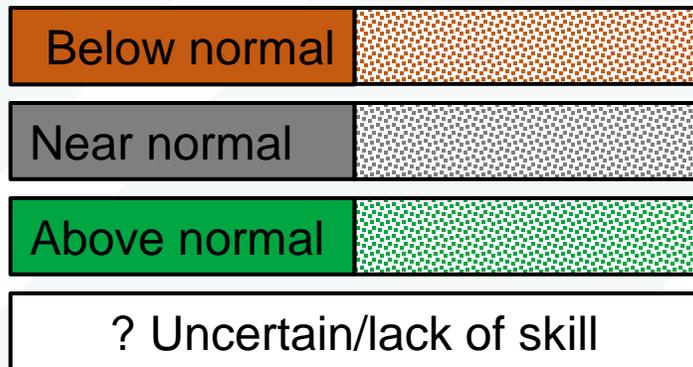
Summary: Subseasonal Precipitation Outlook by Model

This slide shows the CW3E synthesis of subseasonal products by model

Forecasts Initialized 9 Feb 2023

Region	Week 2 (17–23 Feb)			Week 3 (24 Feb – 2 Mar)			Week 4 (3–9 Mar)	
	NCEP ^{1,2,3}	ECCC ¹	ECMWF ^{1,2}	NCEP ^{1,2,3}	ECCC ¹	ECMWF ^{1,2}	NCEP ^{2,3}	ECMWF ²
WA/OR	Below normal	Above normal	Below normal	Below normal	Near normal	Below normal	Above normal	?
Northern CA	Below normal	Above normal	Below normal	Below normal	Above normal	Below normal	Near normal	?
Central CA	?	Above normal	Below normal	Below normal	Above normal	Below normal	Near normal	?
Southern CA	Near normal	Below normal	Below normal	Below normal	Above normal	Below normal	Near normal	?

Higher Confidence | Lower Confidence



- Week 2 forecasts generally show low likelihood of AR activity over CA, except for NCEP over Southern CA
- NCEP and ECMWF show high confidence in below-normal AR activity over CA during Week 3, but ECCC is predicting above-normal AR activity over CA
- Low likelihood of persistent ridging activity near the US West Coast during the next several weeks, but moderate-to-high confidence in Pacific Ridge conditions through 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](#))

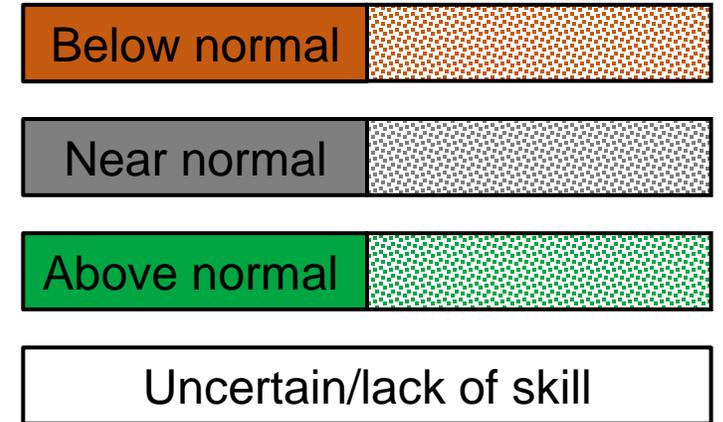
Summary: Week 2 Precipitation Outlook

This slide shows the CW3E synthesis of subseasonal products by model for Week 2

Forecasts Initialized 9 Feb 2023

Region	Week 2 (17–23 Feb)			
	NCEP ^{1,2,3}	ECMWF ¹	ECMWF ^{1,2}	Multi-Model Forecast
WA/OR	Below normal	Below normal	Below normal	Below normal
Northern CA	Below normal	Below normal	Below normal	Below normal
Central CA	Uncertain/lack of skill	Below normal	Below normal	Below normal
Southern CA	Near normal	Below normal	Below normal	Below normal

Higher Confidence | Lower Confidence



- Week 2 forecasts generally show low likelihood of AR activity over CA, except for NCEP in Southern CA
- Low likelihood of persistent ridging activity near the US West Coast during Week 2
- High confidence in Pacific Ridge conditions during Week 2

Subseasonal products included in this Outlook:

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

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

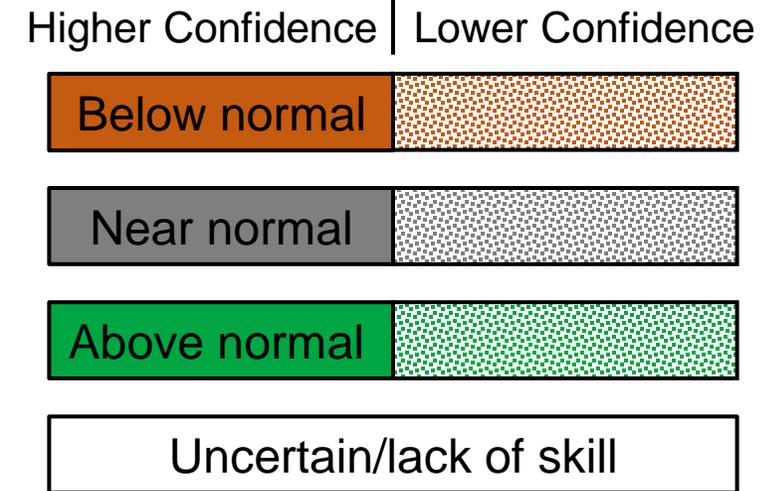
³IRI North American Weather Regime Forecasts ([Robertson et al. 2020](#))

Summary: Week 3 Precipitation Outlook

This slide shows the CW3E synthesis of subseasonal products by model for Week 3

Forecasts Initialized 9 Feb 2023

Region	Week 3 (24 Feb – 2 Mar)			
	NCEP ^{1,2,3}	ECCC ¹	ECMWF ^{1,2}	Multi-Model Forecast
WA/OR				
Northern CA				
Central CA				
Southern CA				



- NCEP and ECMWF show high confidence in below-normal AR activity over CA during Week 3, but ECCC is predicting above-normal AR activity over CA
- Low likelihood of persistent ridging activity near the US West Coast during Week 3
- Moderate-to-high confidence in Pacific Ridge conditions during Week 3

Subseasonal products included in this Outlook:

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

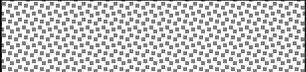
²CW3E/JPL Ridging Forecasts ([Gibson et al. 2020](#))

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

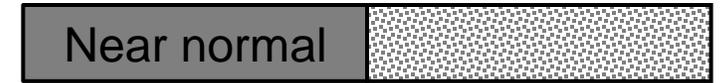
Summary: Week 4 Precipitation Outlook

This slide shows the CW3E synthesis of subseasonal products by model for Week 4

Forecasts Initialized 9 Feb 2023

Region	Week 4 (3–9 Mar)		
	NCEP ^{2,3}	ECMWF ²	Multi-Model Forecast
WA/OR			
Northern CA			
Central CA			
Southern CA			

Higher Confidence | Lower Confidence



- Low likelihood of persistent ridging activity near the US West Coast during Week 4
- Low-to-moderate confidence in Pacific Ridge conditions during Week 4

Subseasonal products included in this Outlook:

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

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

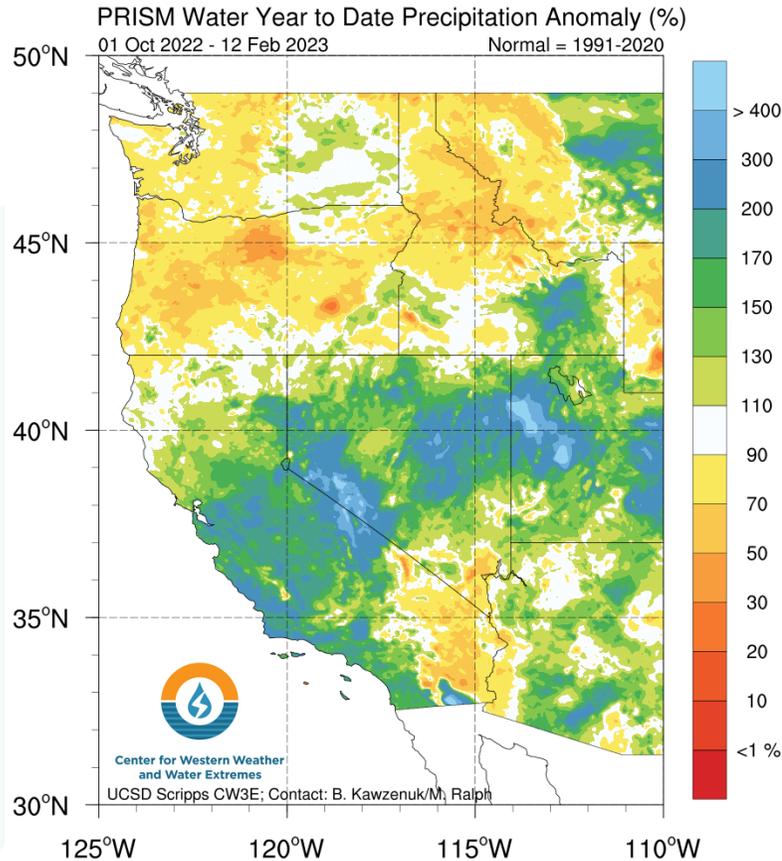
³IRI North American Weather Regime Forecasts ([Robertson et al. 2020](#))

Summary

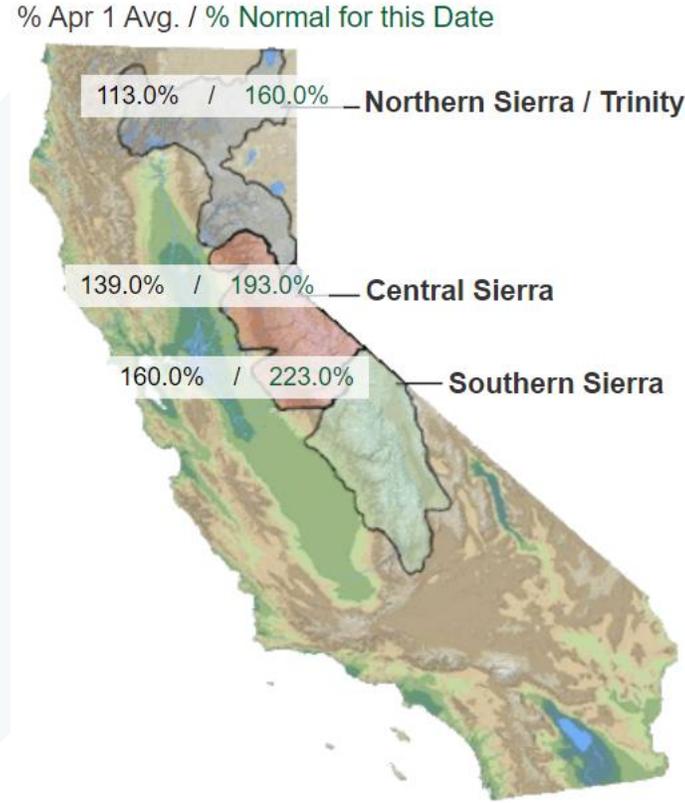
- **Week 2 forecasts (17–23 Feb):** Models generally agree on low likelihood (< 30% probability) of AR activity over Northern CA, Oregon, and Washington
 - NCEP is showing higher probabilities (40–70%) of AR activity over Southern CA on 19 Feb
- NCEP and ECMWF are forecasting strong MJO activity over the Western Pacific during Week 1, which is climatologically favorable for AR activity in the Northeast Pacific Ocean during Weeks 1–2
- Both NCEP and ECMWF are showing low likelihood of persistent ridging activity near the US West Coast during Weeks 1–2
- **Week 3 forecasts (24 Feb – 2 Mar):** Model disagreement in predicted AR activity over CA
 - ECMWF and NCEP are predicting below-normal AR activity with high confidence
 - ECCO is predicting above-normal activity over CA, especially Southern CA
- Both NCEP and ECMWF are showing low likelihood of persistent ridging activity near the US West Coast during Weeks 3–4
 - ECMWF is predicting near-normal ridging activity, but the ensemble members disagree on the center of ridging activity

Water Year Hydrologic Summary

Precipitation

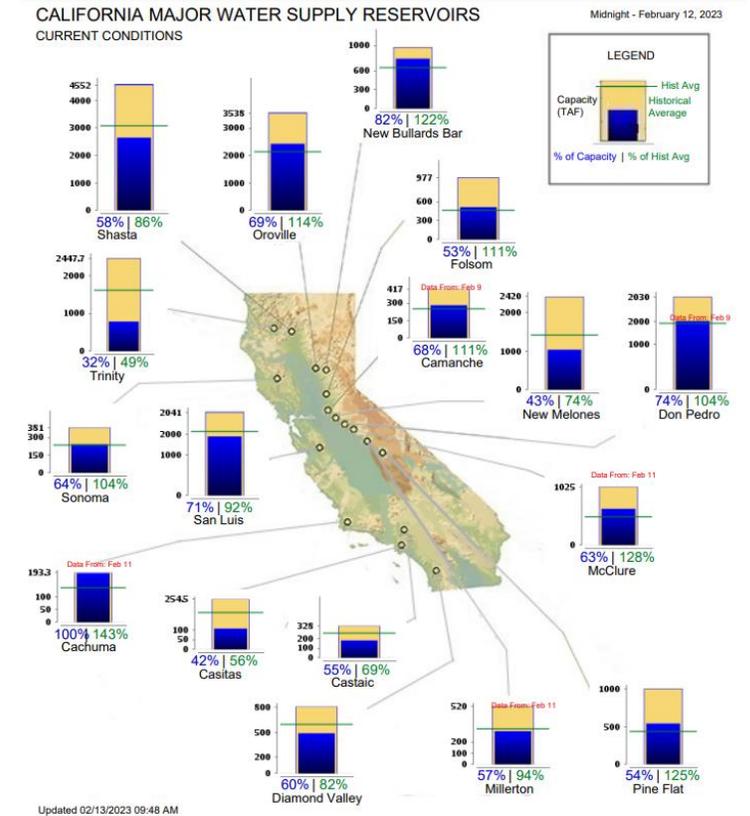


Snowpack Conditions



Source: California Department of Water Resources

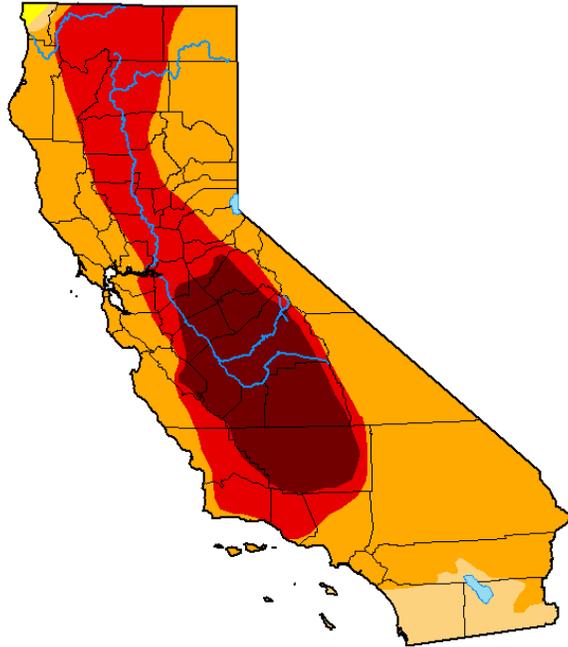
Reservoir Storage



- As of 12 Jan, 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 Southern Sierra Nevada, where current snowpack is 223% of normal for this date and 160% of normal for 1 Apr
- Very wet conditions during Dec–Jan led to a significant increase in water storage throughout the state
- Most large 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:



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>

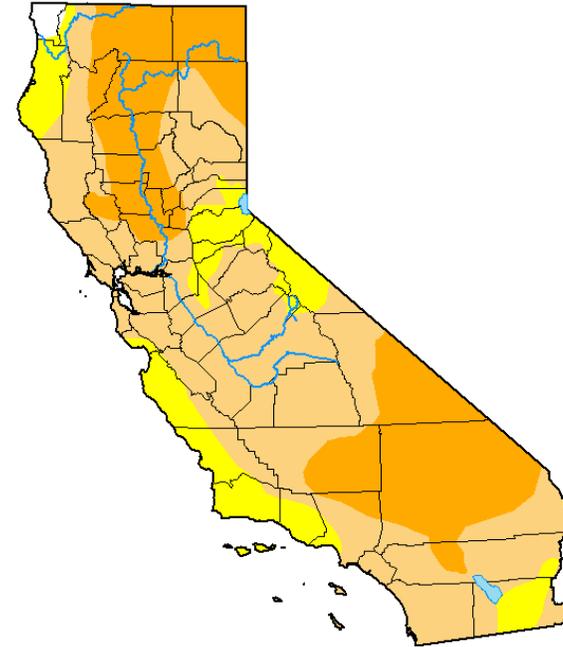
Author:

Richard Heim
NCEI/NOAA



droughtmonitor.unl.edu

U.S. Drought Monitor California



February 7, 2023
(Released Thursday, Feb. 9, 2023)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.64	99.36	84.60	32.62	0.00	0.00
Last Week 01-31-2023	0.64	99.36	89.56	32.57	0.00	0.00
3 Months Ago 11-08-2022	0.00	100.00	99.51	88.09	41.39	16.57
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 02-08-2022	0.00	100.00	99.25	66.42	1.39	0.00

Intensity:



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

- A very wet Dec–Jan 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 7 Feb, only 33% 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

Looking Back: Week 3 AR Activity Forecasts

Forecasts Initialized 12 Jan 2023; Valid: 27 Jan – 2 Feb 2023

NCEP

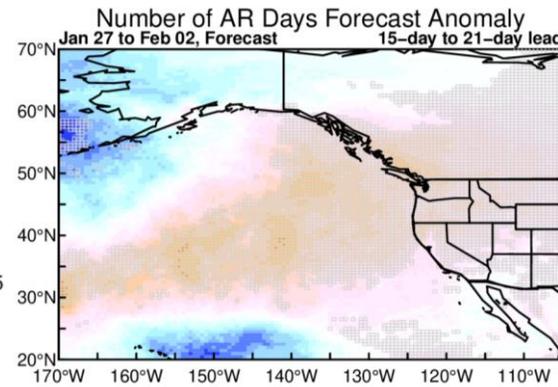
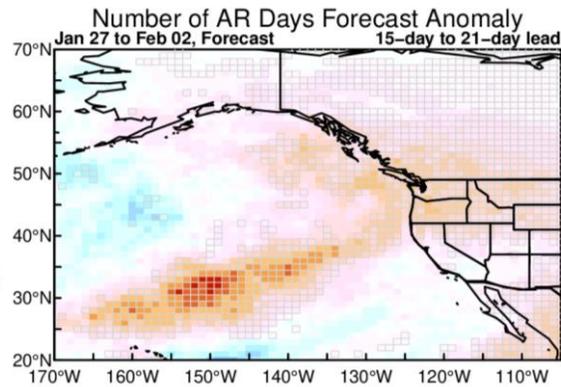
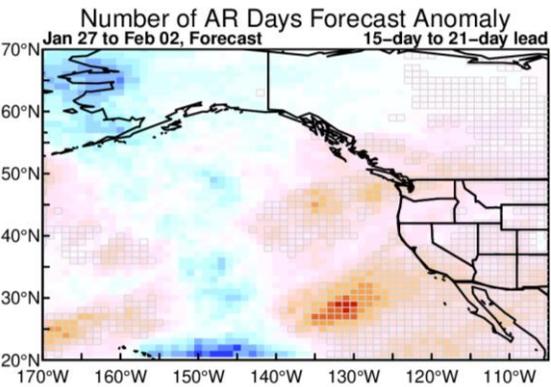
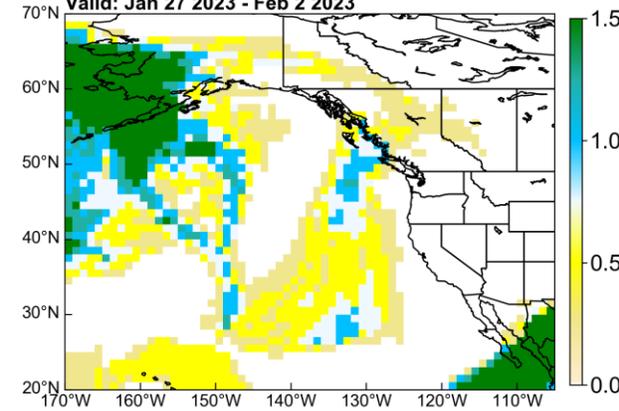
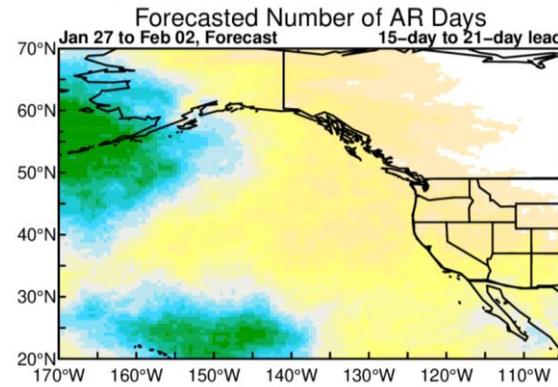
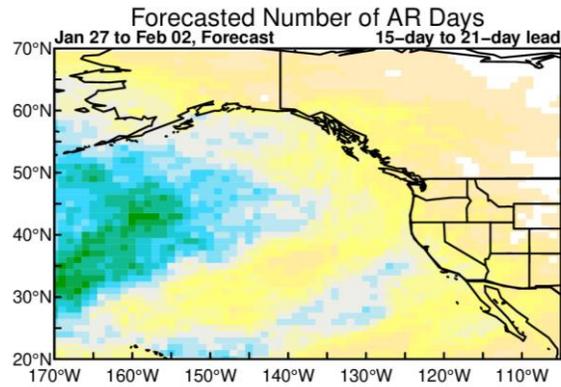
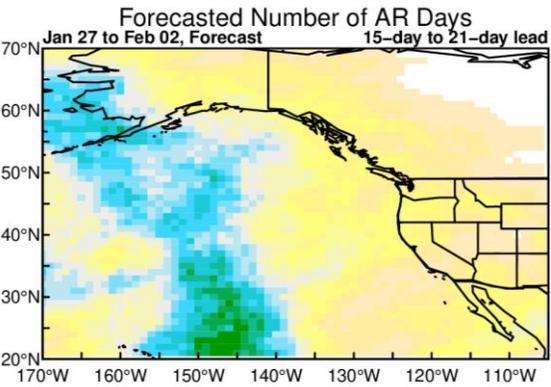
ECCE

ECMWF

Observed (GFS Analysis)

Observed Number of AR Days

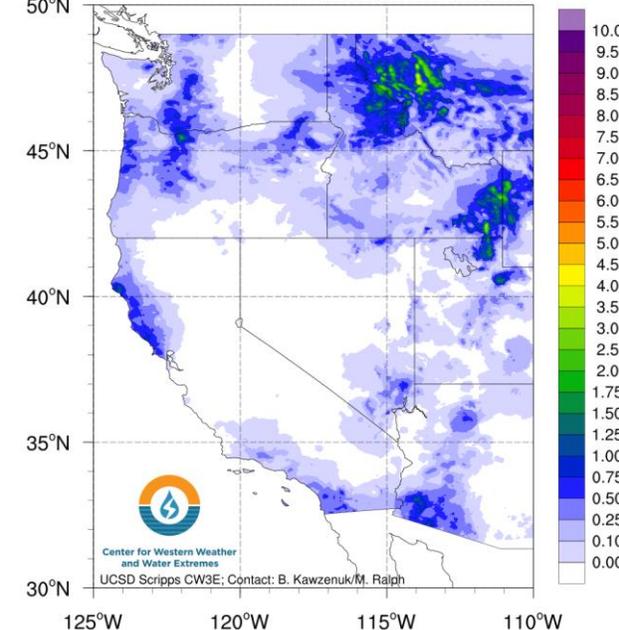
Valid: Jan 27 2023 - Feb 2 2023



Observed Precipitation

7-day Accumulated Precipitation (inches)

1200 UTC 27 Jan - 03 Feb 2023



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 correctly predicted low AR activity over the US West Coast

ECCE picked up on AR activity offshore, but incorrectly predicted AR activity extending eastward into CA instead of northward into British Columbia

- Little precipitation (generally < 1 inch) was observed over the US West Coast during this period

Looking Back: Week 3 AR Activity Forecasts

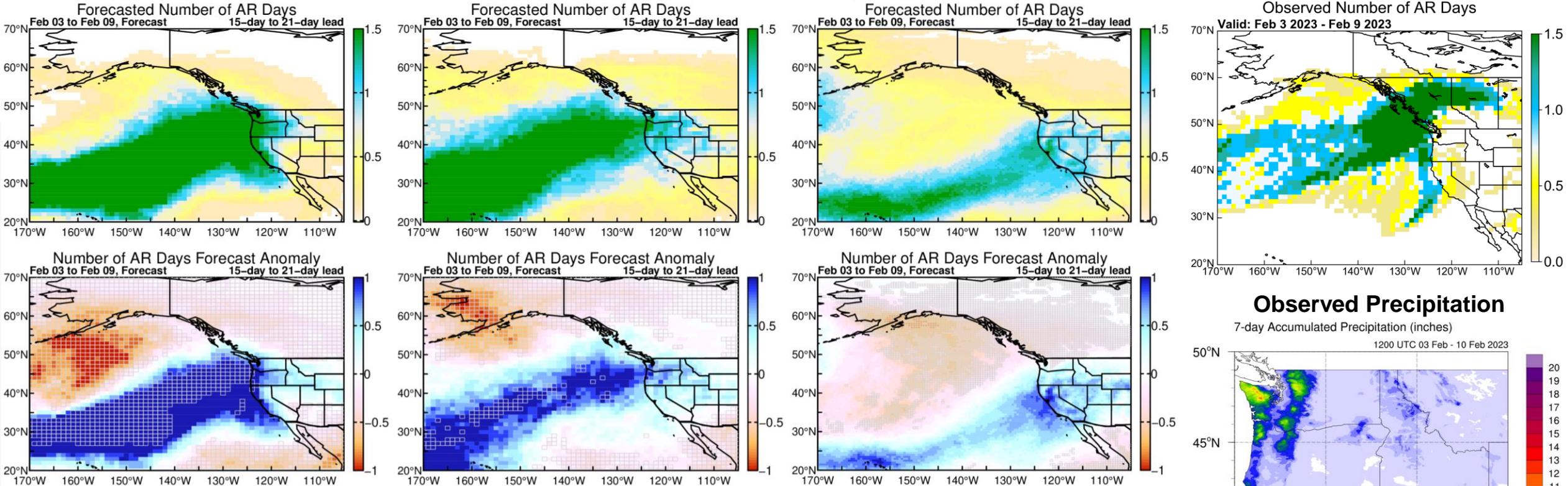
Forecasts Initialized 19 Jan 2023; Valid: 3–9 Feb 2023

NCEP

ECCE

ECMWF

Observed (GFS Analysis)



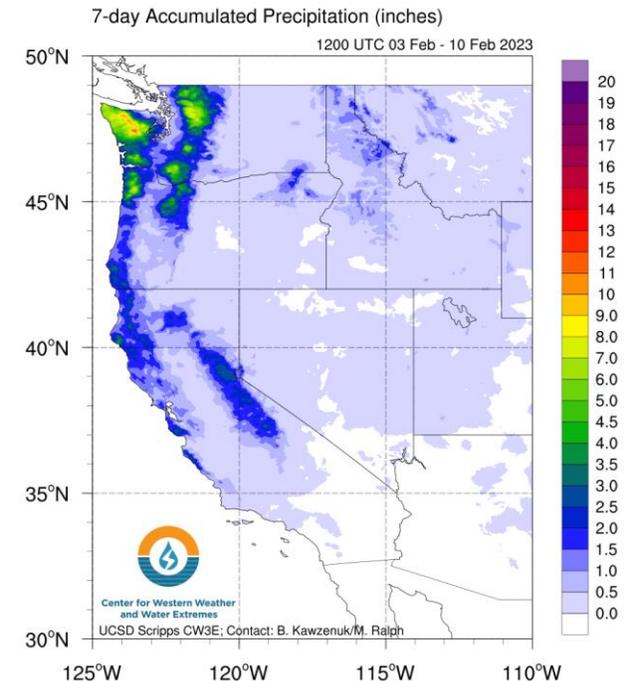
Shading: Fractional # of AR days over a 7-day period (top) and forecast minus model climatology (bottom)
Grey cells: >75% of ensemble members agree on sign of anomaly

ECCE verified over CA; NCEP and ECMWF predicted too much AR activity over CA

All models correctly predicted AR activity over the Northeast Pacific, but ECMWF predicted center of AR activity too far south compared to observed AR activity

- Multiple weak ARs brought more than 5 inches of precipitation to the Olympic Peninsula, WA Cascades, and northern OR Coast Ranges, as well as 1–3 inches of precipitation to the Northern CA Coast Ranges and Sierra Nevada

Observed Precipitation



Dynamical Model MJO Forecasts (NCEP vs. ECMWF)

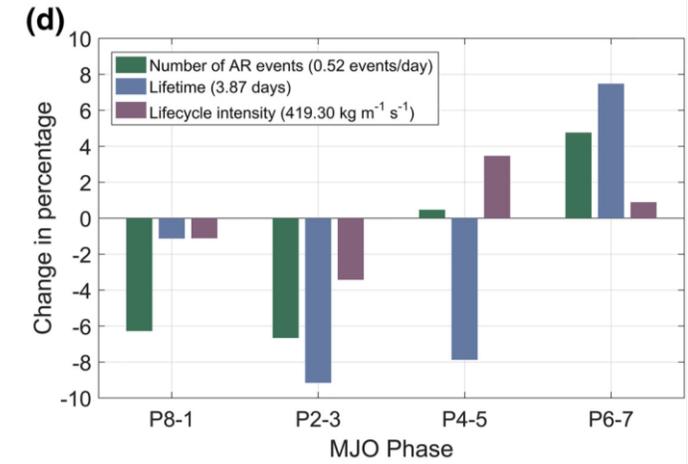
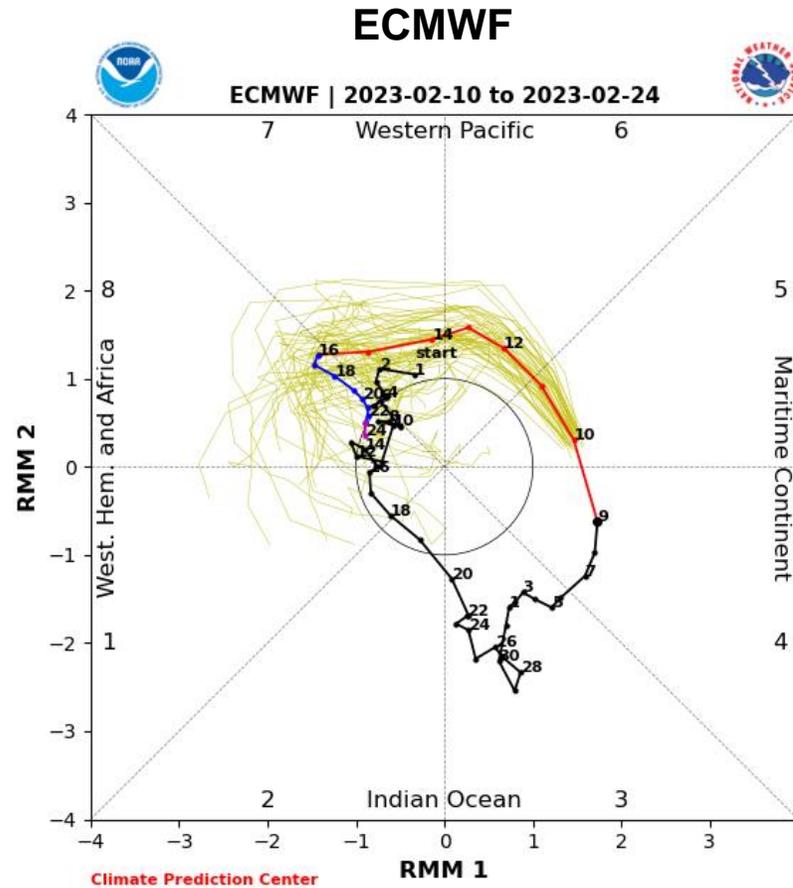
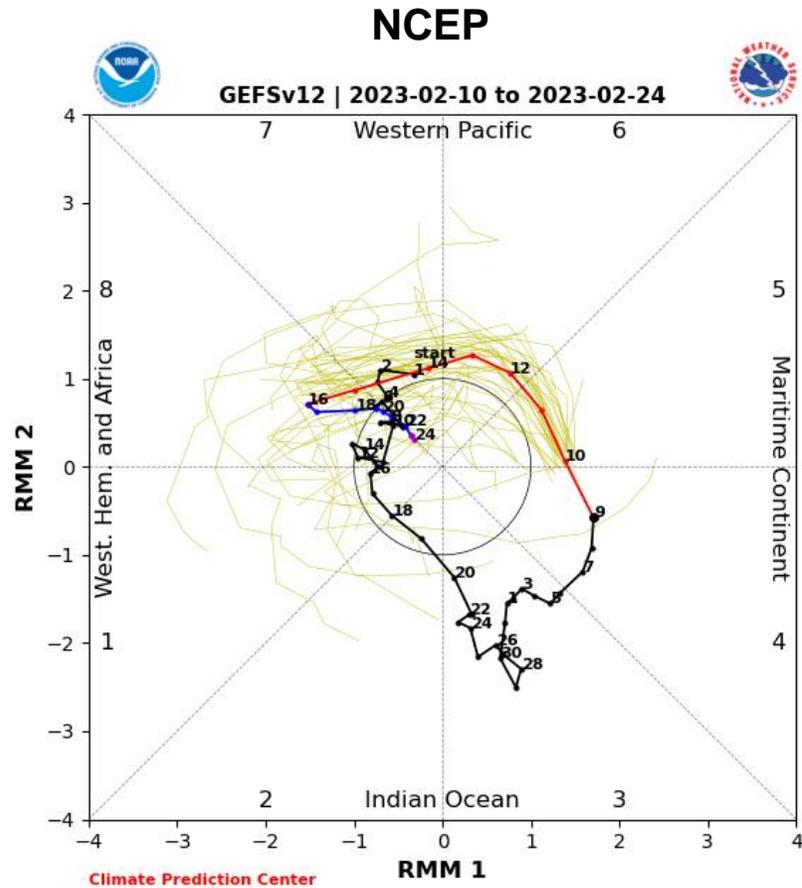
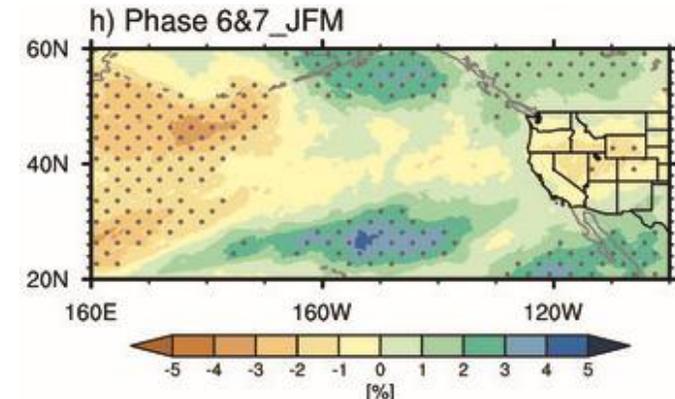
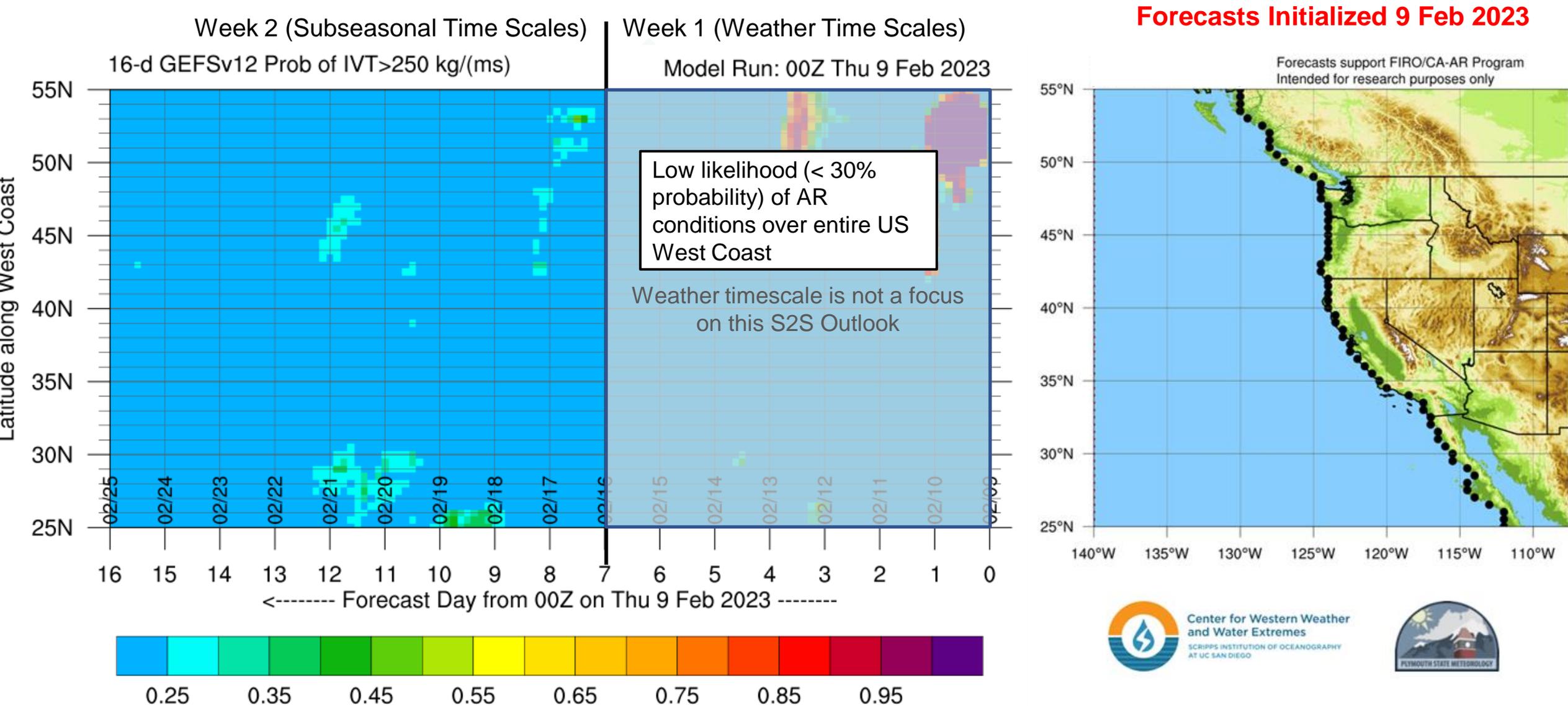


Figure 2d from Zhou et al. (2021)



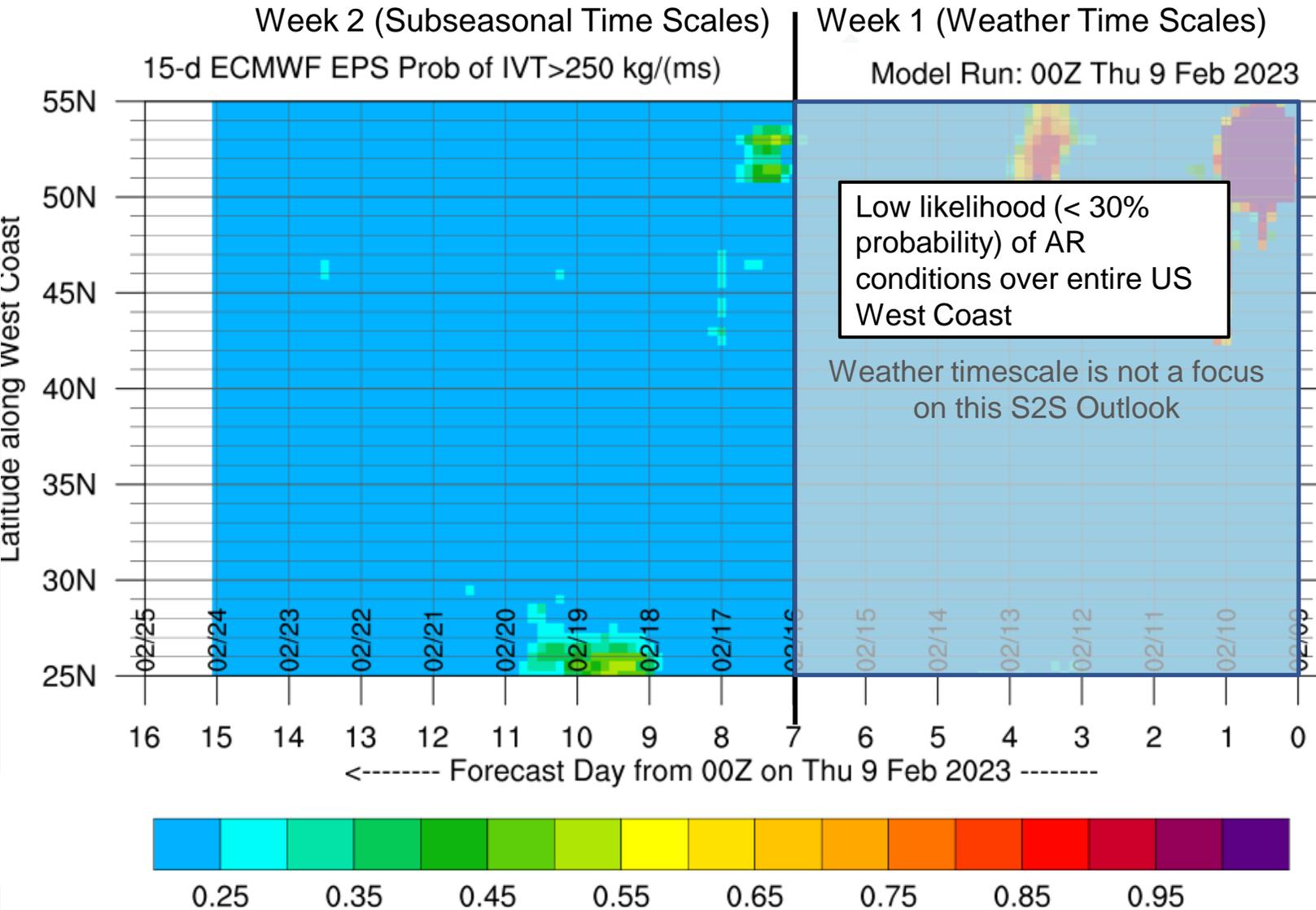
- Both NCEP and ECMWF are forecasting strong MJO activity over the Maritime Continent to rapidly propagate eastward into the Western Pacific during Week 1
- Large uncertainty during Week 2, with some ensemble members forecasting strong MJO activity in the Western Hemisphere, and others forecasting MJO activity to weaken
- MJO activity over the Western Pacific is generally associated with increases in AR activity over the subtropical Northeast Pacific and near-normal AR activity over CA

NCEP GEFS AR Landfall Tool: Valid 00Z 9 Feb – 00Z 25 Feb

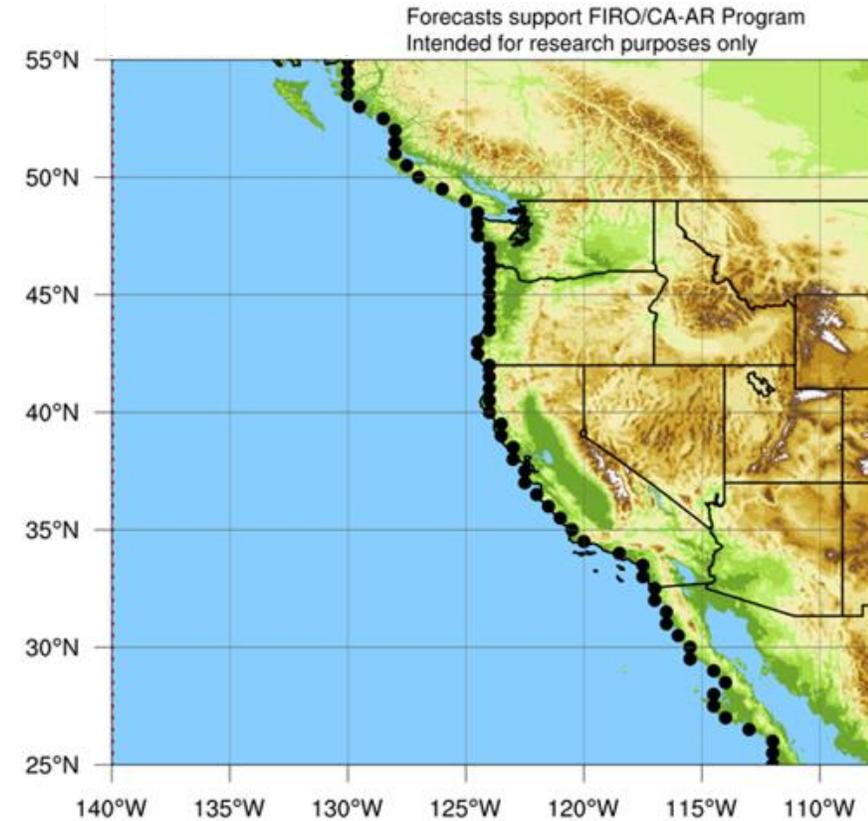


- NCEP is forecasting low likelihood of AR conditions over California in Week 2, with strong MJO activity over the Western Pacific during Week 1

ECMWF EPS AR Landfall Tool: Valid 00Z 9 Feb – 00Z 24 Feb



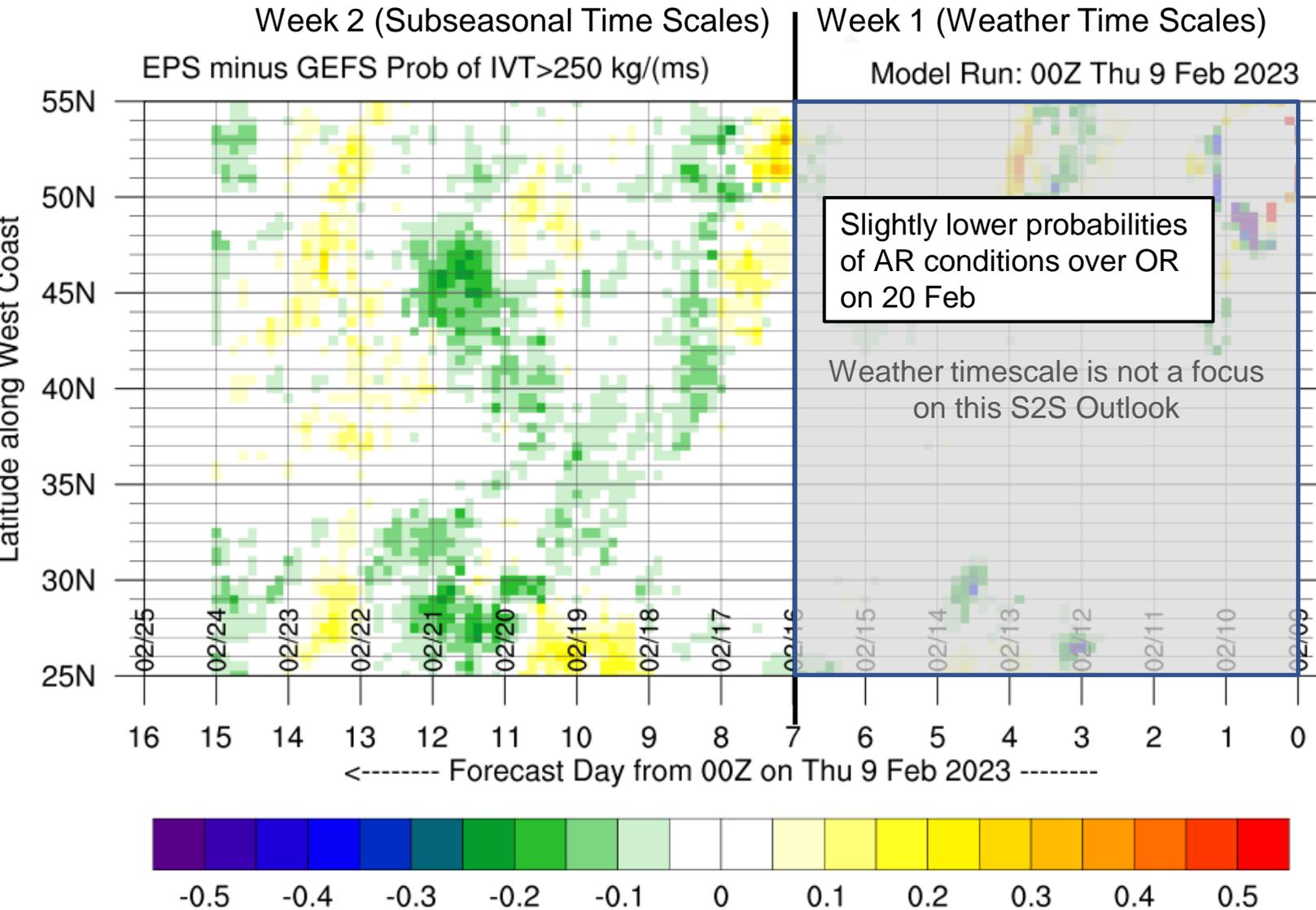
Forecasts Initialized 9 Feb 2023



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

EPS Minus GEFS AR Landfall Tool: Valid 00Z 9 Feb – 00Z 24 Feb

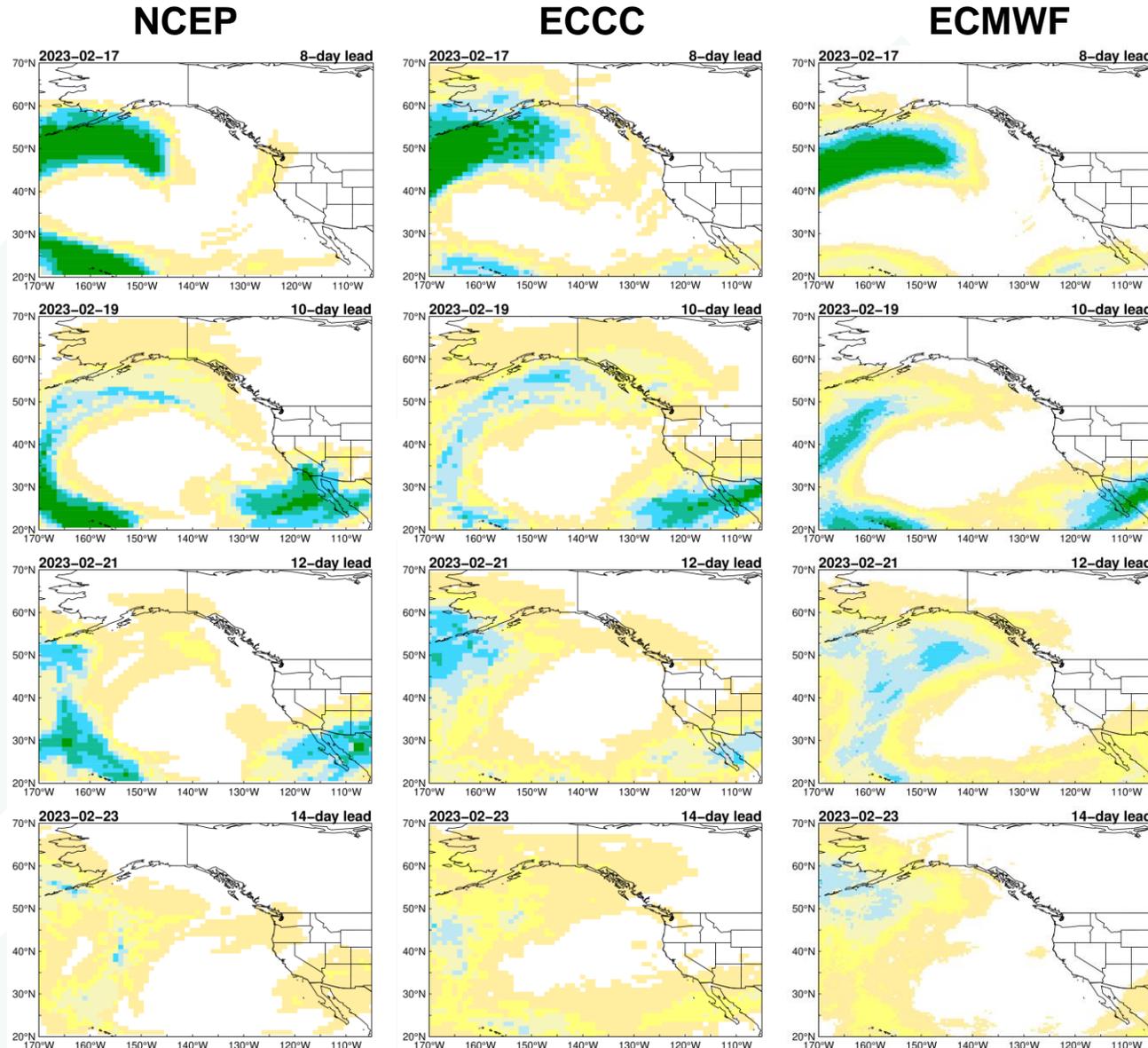
Forecasts Initialized 9 Feb 2023



- ECMWF is forecasting slightly lower likelihood of AR conditions over Oregon on 20 Feb compared to NCEP

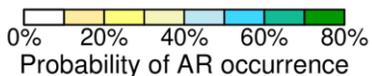
Subseasonal Outlooks: Week 2 AR Activity (NCEP vs. ECCC vs. ECMWF)

Forecasts Initialized 9 Feb 2023

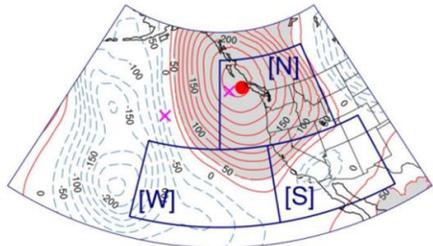


- All models are showing low probabilities (< 30%) of AR activity over Northern CA, OR, and WA during Week 2 (17–23 Feb)
- NCEP is showing moderate likelihood (40–70% probability) of AR activity over Southern CA on 19 Feb
- ECCC and ECMWF are showing lower probabilities of AR activity over Central and Southern CA, especially ECMWF

Models agree on low likelihood of AR activity over Northern CA during Week 2 (17–23 Feb), but disagree on likelihood of AR activity over Central and Southern CA

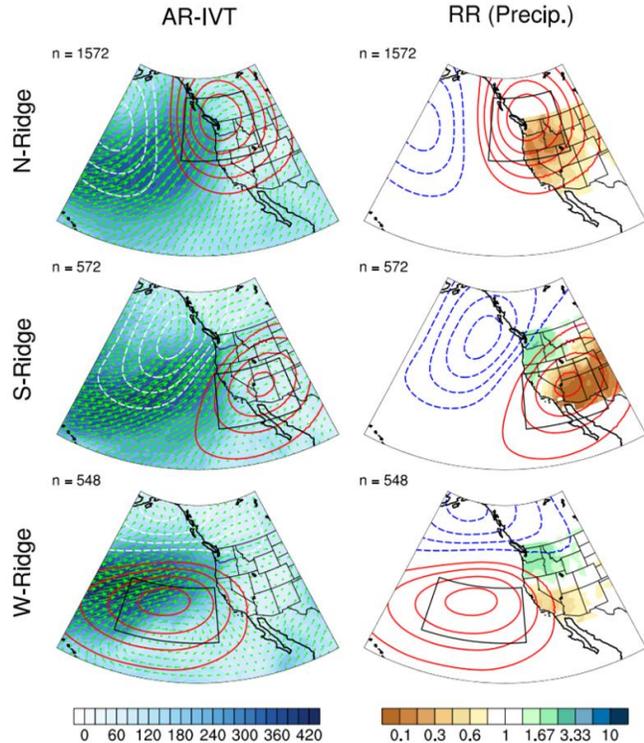


Background Info: Subseasonal Ridging Outlooks



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 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

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



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

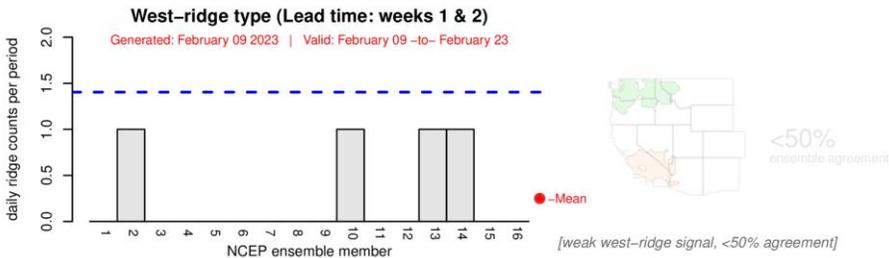
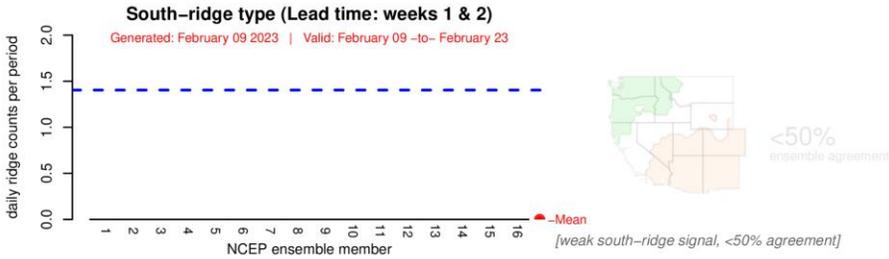
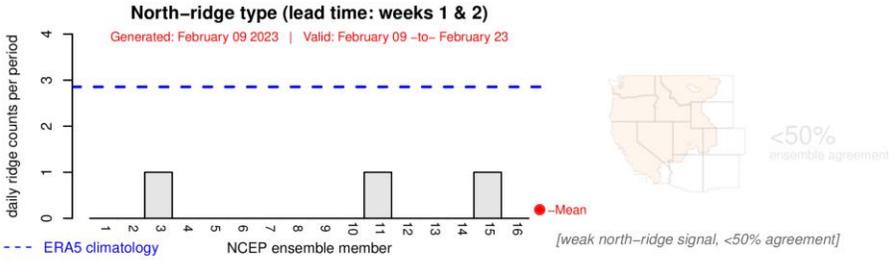
Subseasonal Outlooks: Weeks 1–2 Ridging Forecasts (NCEP vs. ECMWF)

Forecasts Initialized 9 Feb 2023

NCEP

CW3E Subseasonal Ridging Forecast

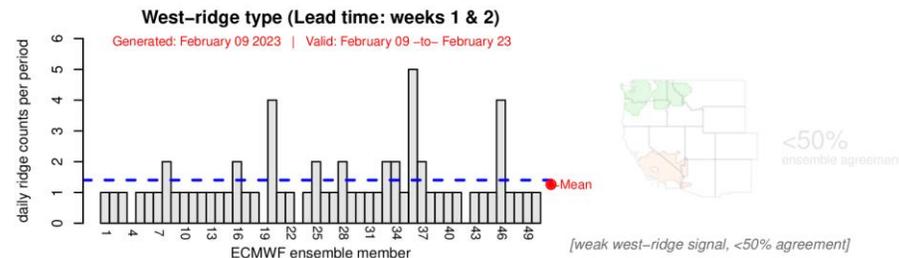
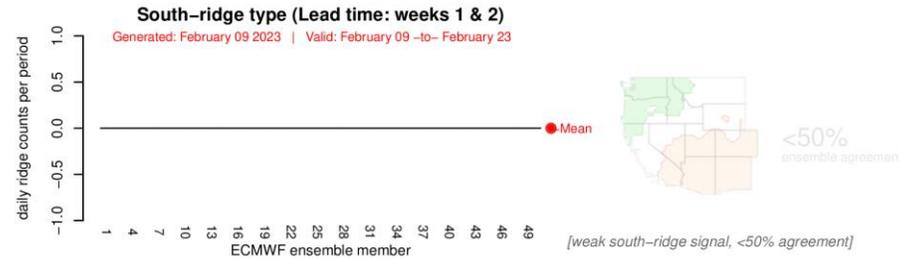
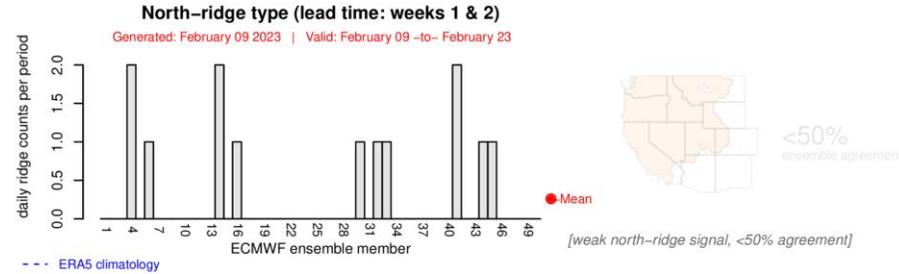
(Uses NCEP CFSv2 model)



ECMWF

CW3E Subseasonal Ridging Forecast

(Uses ECMWF model)



- Both NCEP and ECMWF are predicting very low occurrence of the North- and South-ridge types during Weeks 1–2 (9–23 Feb)
- NCEP is also predicting very low likelihood of ridging activity west of California
- ECMWF is predicting near-normal ridging activity west of California

Low likelihood of persistent ridging activity near the US West Coast during Weeks 1–2

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

Forecasts Initialized 9 Feb 2023

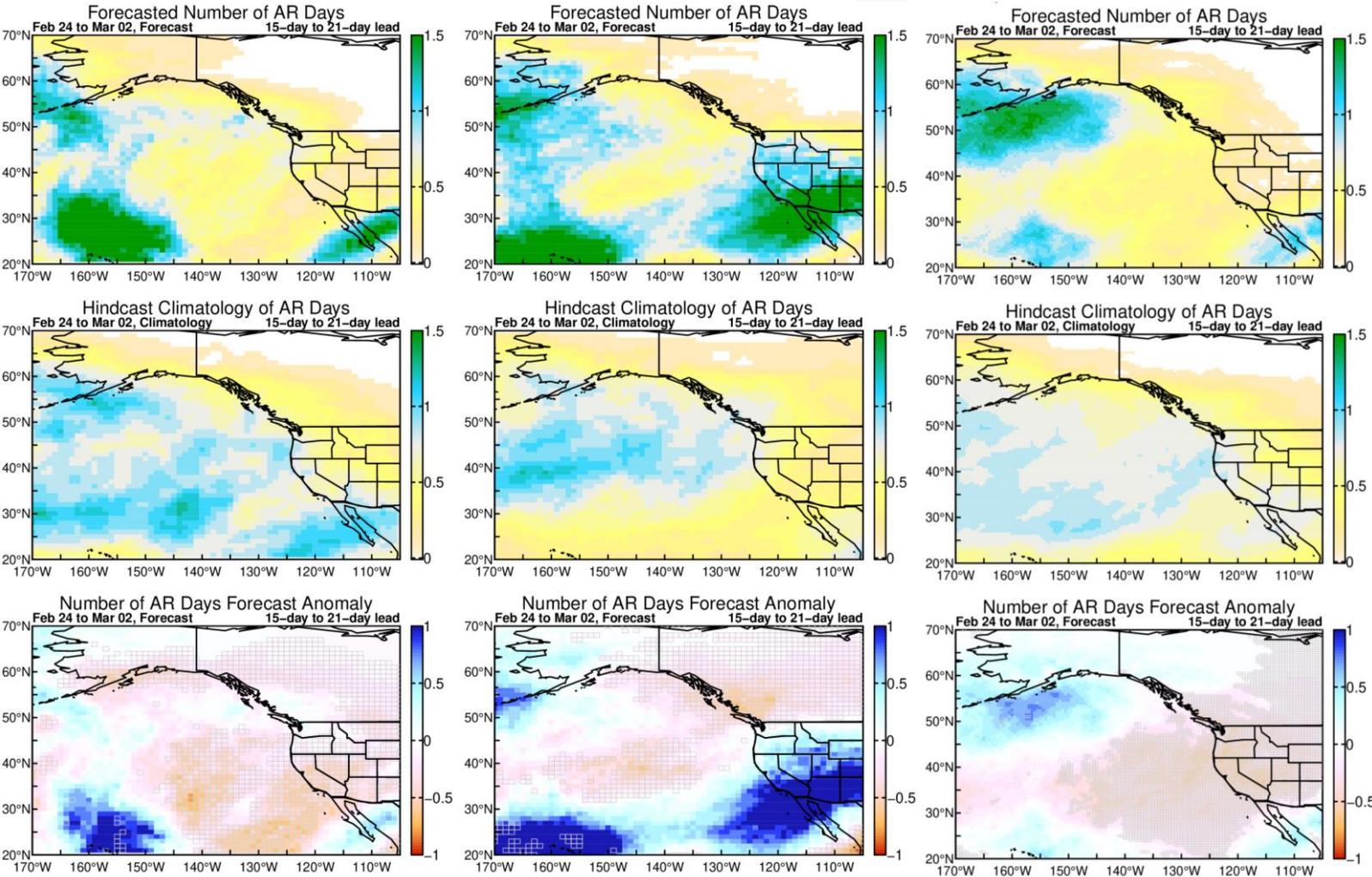
NCEP

ECCC

ECMWF

- NCEP and ECMWF are both predicting below-normal AR activity over CA during Week 3 (24 Feb – 2 Mar) with high confidence (> 75% ensemble agreement)
- ECCC is predicting above-normal AR activity over CA, especially Southern CA, but with lower confidence (< 75% ensemble agreement)

Models disagree on predicted AR activity over CA during Week 3 (24 Feb – 2 Mar)



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 (NCEP vs. ECMWF)

Forecasts Initialized 9 Feb 2023

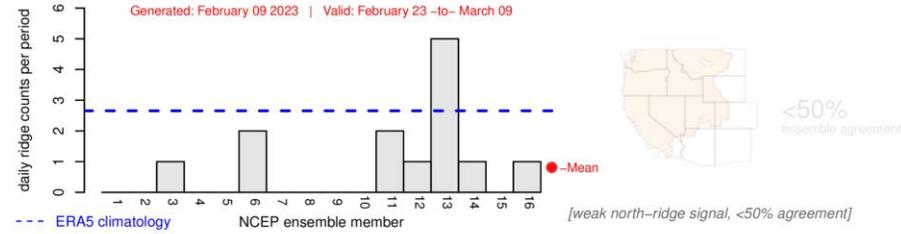
NCEP

CW3E Subseasonal Ridging Forecast

(Uses NCEP CFSv2 model)

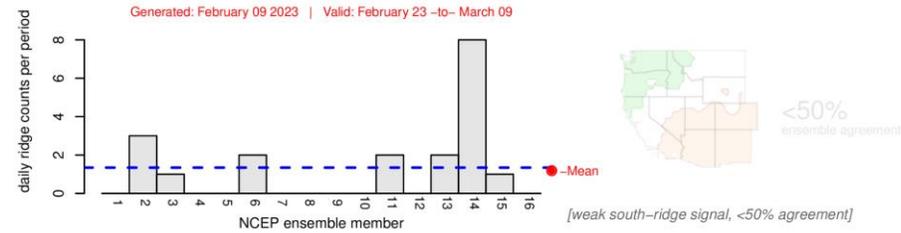
North-ridge type (lead time: weeks 3 & 4)

Generated: February 09 2023 | Valid: February 23 –to– March 09



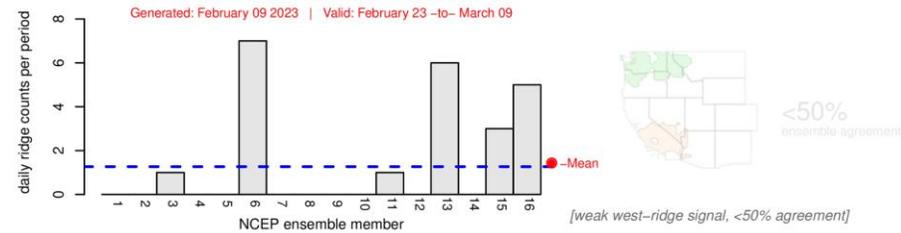
South-ridge type (Lead time: weeks 3 & 4)

Generated: February 09 2023 | Valid: February 23 –to– March 09



West-ridge type (Lead time: weeks 3 & 4)

Generated: February 09 2023 | Valid: February 23 –to– March 09



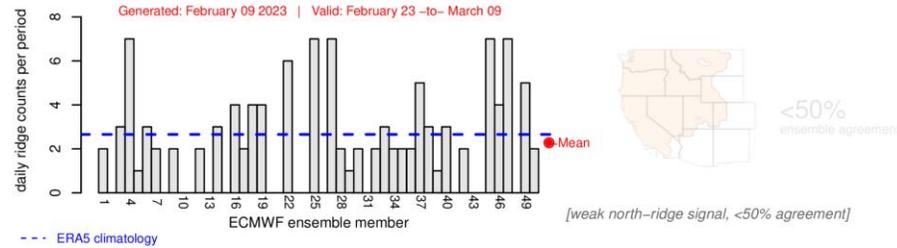
ECMWF

CW3E Subseasonal Ridging Forecast

(Uses ECMWF model)

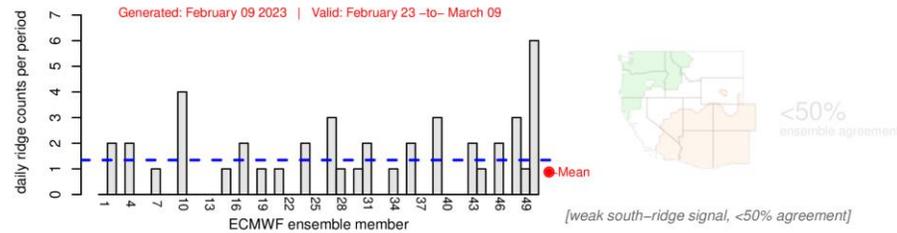
North-ridge type (lead time: weeks 3 & 4)

Generated: February 09 2023 | Valid: February 23 –to– March 09



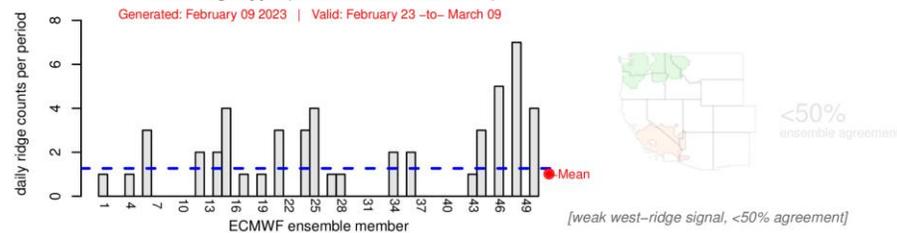
South-ridge type (Lead time: weeks 3 & 4)

Generated: February 09 2023 | Valid: February 23 –to– March 09



West-ridge type (Lead time: weeks 3 & 4)

Generated: February 09 2023 | Valid: February 23 –to– March 09

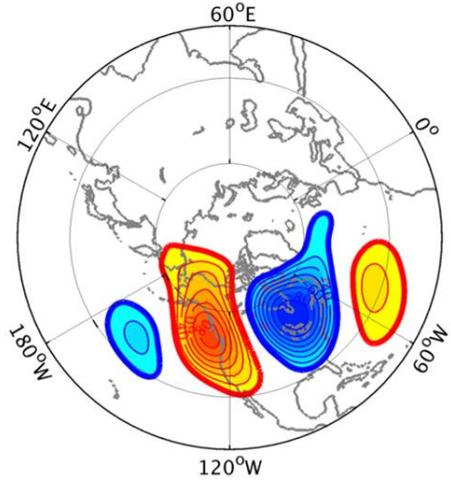


- Both NCEP and ECMWF are showing low likelihood (< 50% ensemble agreement) of above-normal ridging activity near the US West Coast during Weeks 3–4 (23 Feb – 9 Mar)
- ECMWF is predicting near-normal ridging activity during Weeks 3–4, but ensembles disagree on location of center of ridging

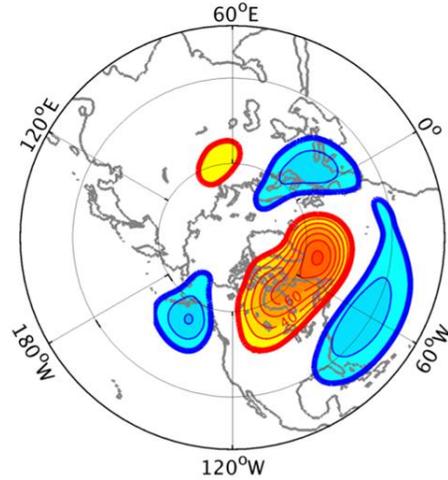
Low likelihood of persistent ridging activity near the US West Coast during Weeks 3–4

Background Info: IRI Subseasonal Weather Regime Forecasts

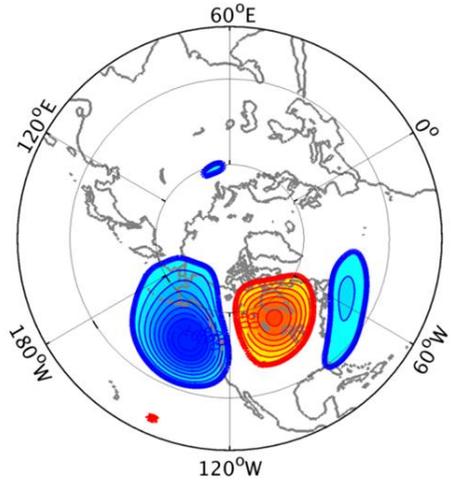
a) WR 1: West Coast Ridge



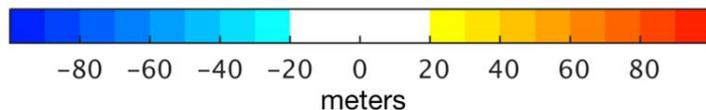
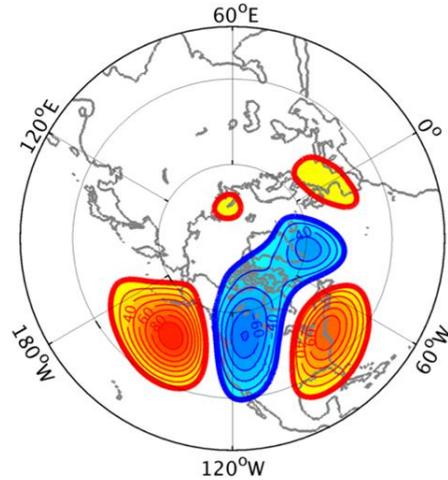
b) WR 2: Greenland High



c) WR 3: Pacific Trough



d) WR 4: Pacific Ridge



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

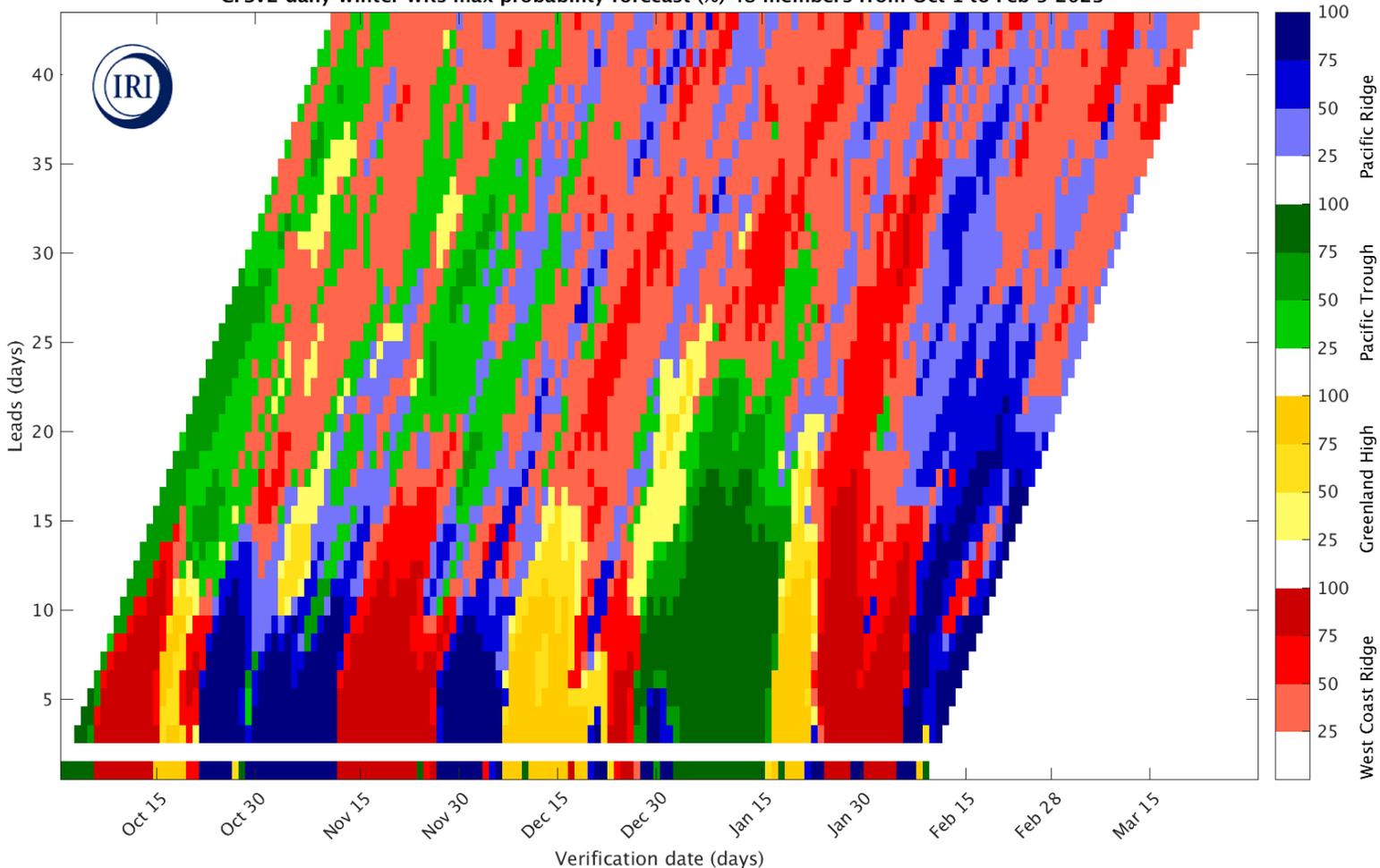
- Four dominant weather regimes identified using cluster analysis on daily 500-hPa geopotential height anomalies from MERRA data (1981–2015)

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

Subseasonal Outlooks: IRI North American Weather Regime Forecasts

Forecast Initialized 9 Feb 2023

CFSv2 daily winter WRs max probability forecast (%) 48 members from Oct 1 to Feb 9 2023

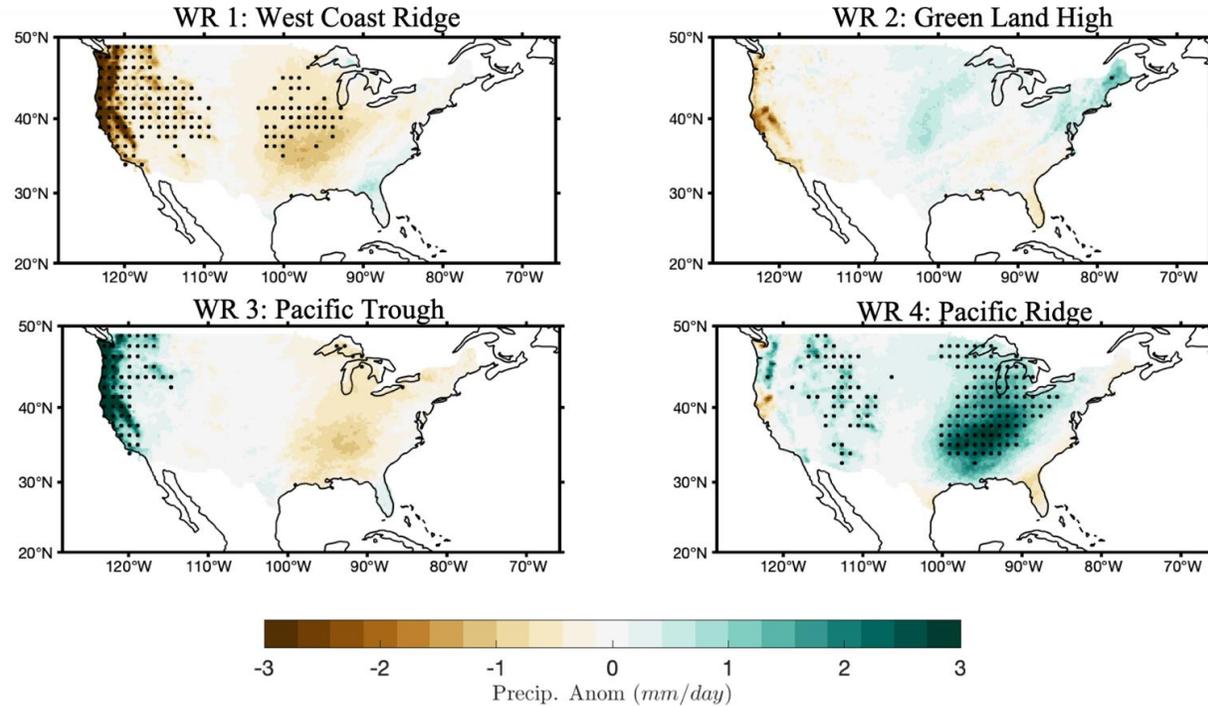


- Daily forecast out to 45-day lead time based on NCEP CFSv2 ensemble
- High likelihood (> 75%) of Pacific Ridge conditions during Weeks 1–2
- Moderate likelihood (> 50%) of Pacific Ridge conditions continuing into Week 3
- Pacific Ridge forecast to continue through Week 4, but with low confidence (< 50% ensemble agreement)
- Despite uncertainty in center of action of ridging beyond Week 3, a plurality of CFSv2 members are forecasting ridging over the Northeast Pacific or US West Coast

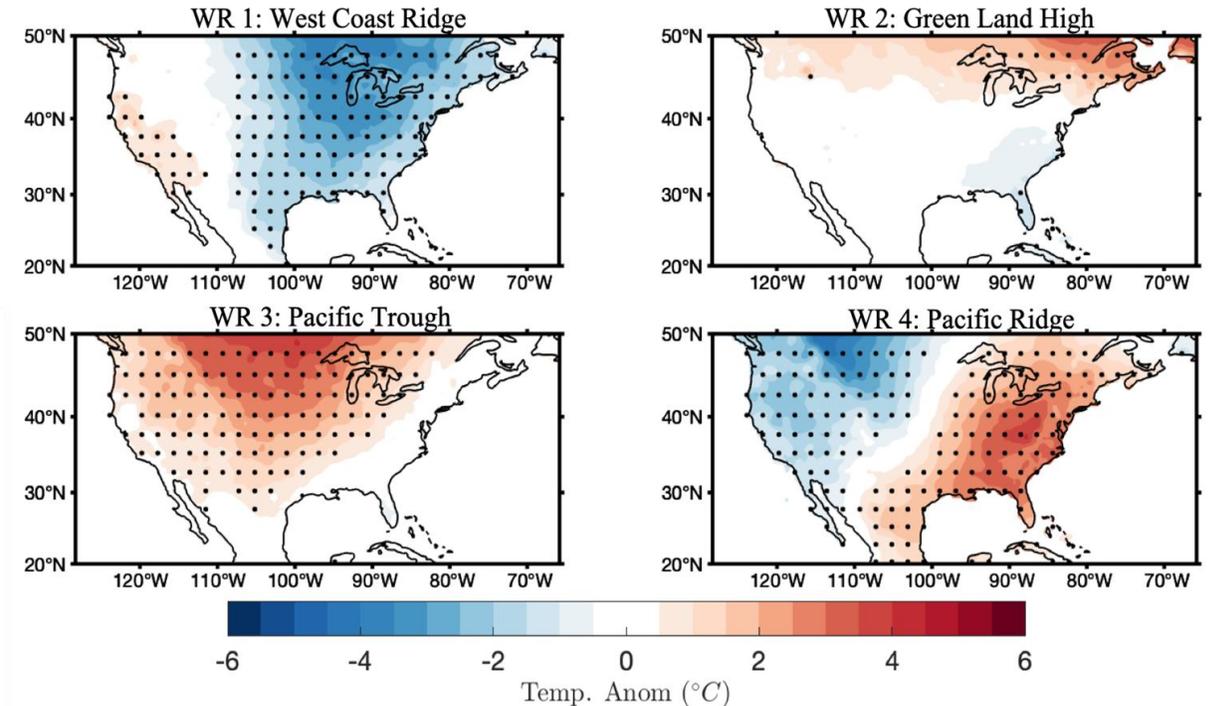
This graphic shows the which of the four North American weather regimes (different colors) is most likely to occur over the next 45 days. Darker (lighter) shading denotes higher (lower) probability of a particular regime.

Subseasonal Outlooks: IRI North American Weather Regime Forecasts

Precipitation



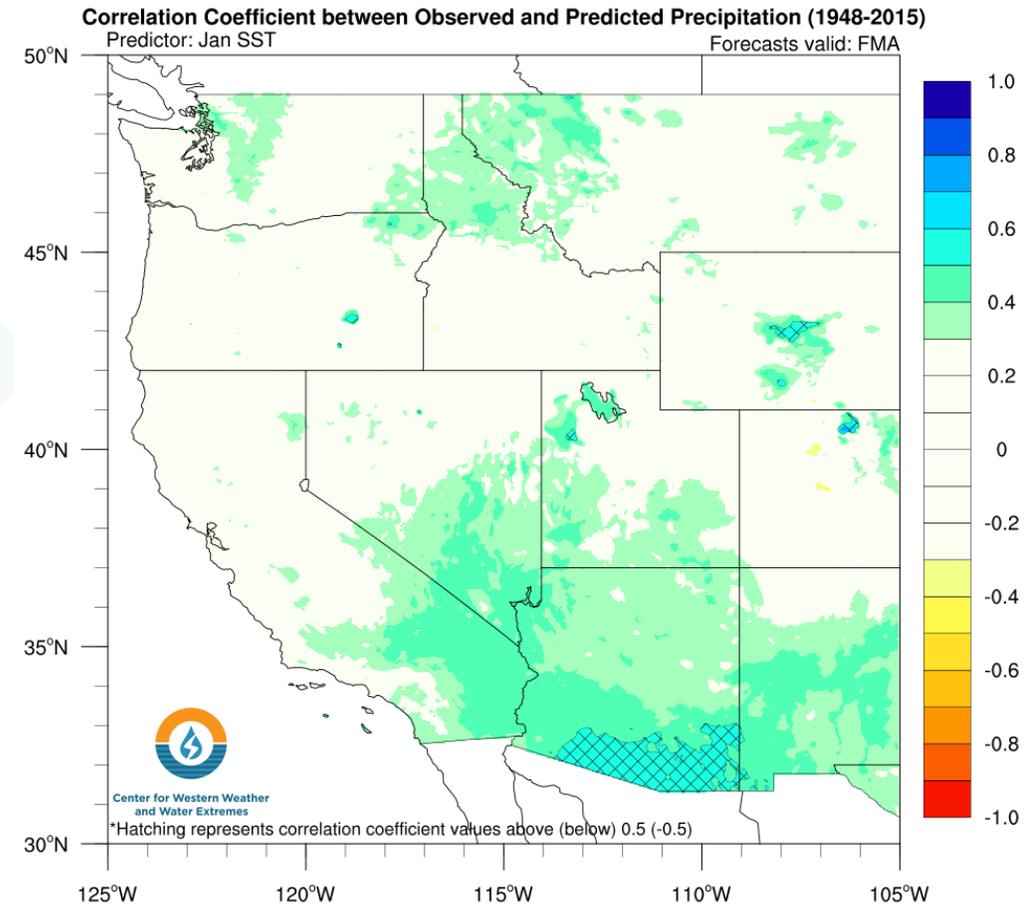
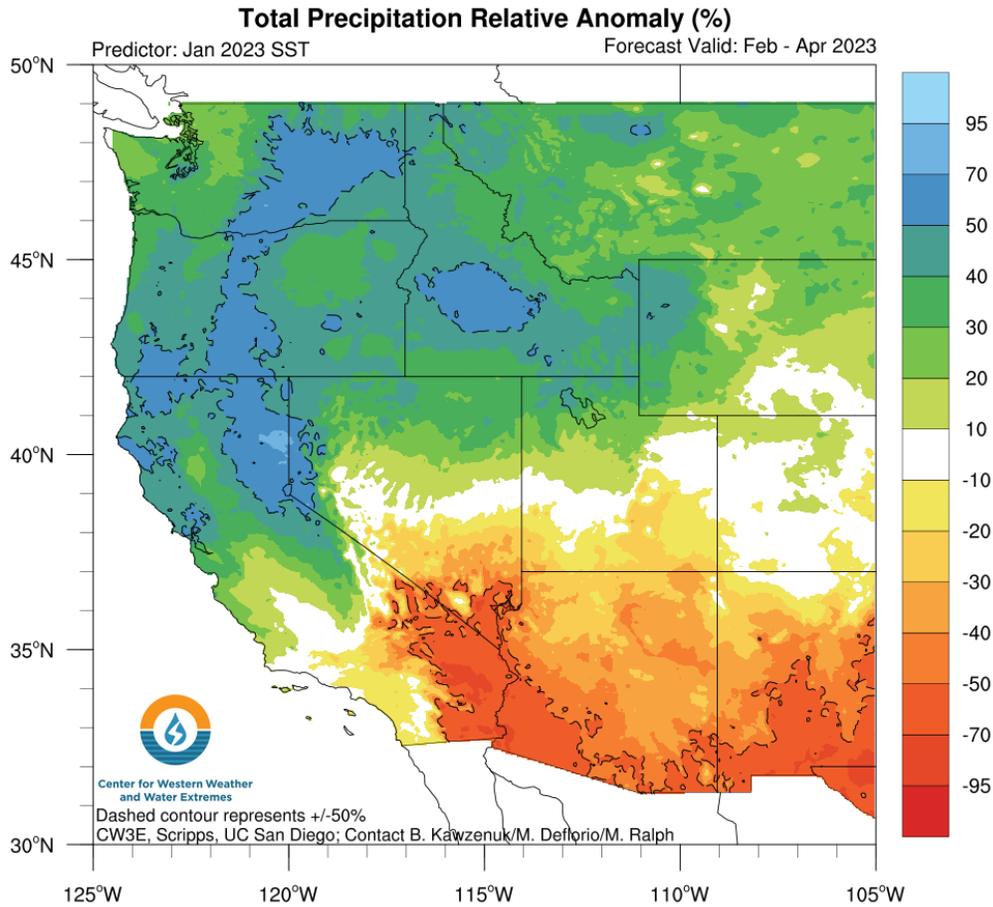
Temperature



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

- Anomalously cold conditions and near-normal precipitation are predicted over California for the remainder of February with moderate-to-high confidence
- Anomalously cold conditions and near-normal precipitation are predicted over California in early-to-mid-March with low confidence

Seasonal CCA Outlook: Feb–Apr 2023 Precipitation



- CW3E statistical model based on Jan SST is predicting above-normal Feb–Apr 2023 precipitation over WA, OR, and Northern CA, and below-normal Feb–Apr 2023 precipitation over interior 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 information)

Above-normal: $>+30\%$; **Below-normal:** $<-30\%$