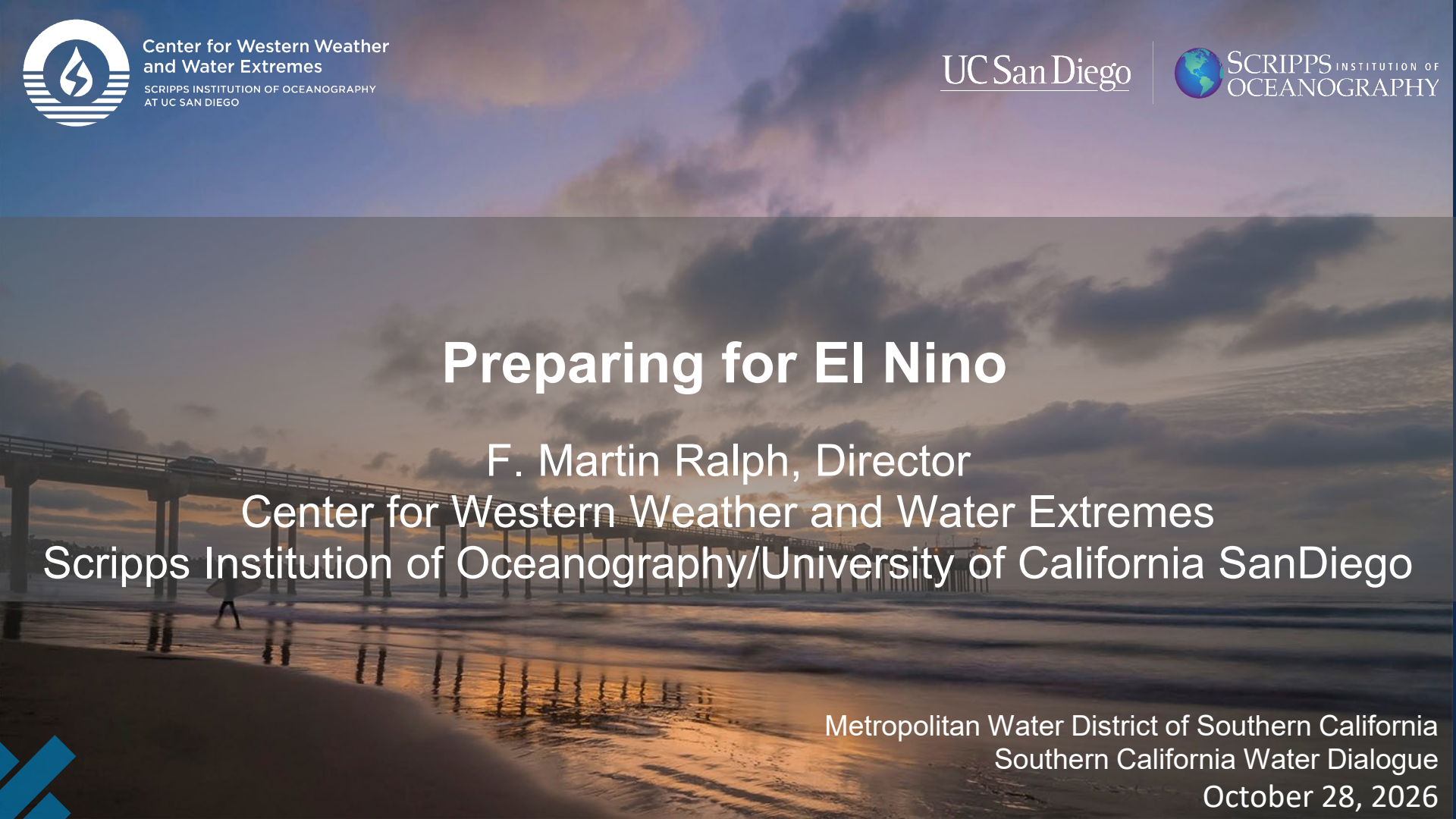


Preparing for El Nino

F. Martin Ralph, Director
Center for Western Weather and Water Extremes
Scripps Institution of Oceanography/University of California SanDiego

Metropolitan Water District of Southern California
Southern California Water Dialogue
October 28, 2026

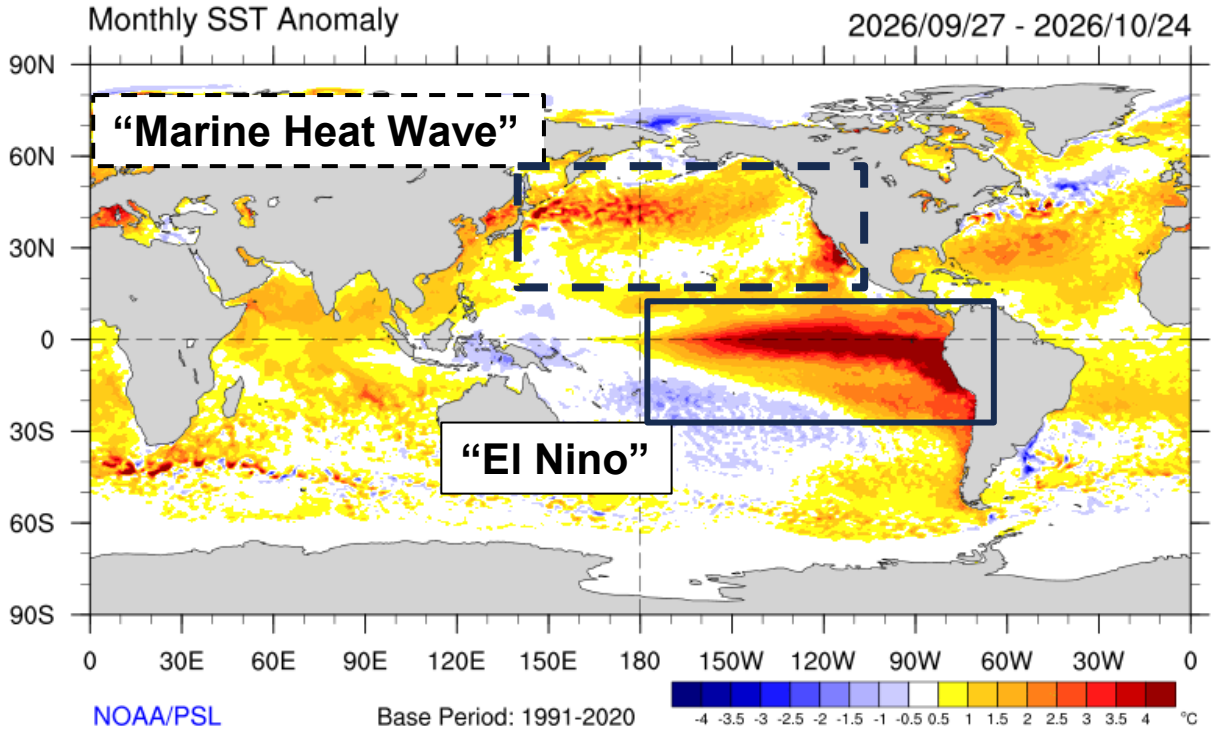
Outline



1 – **El Nino: Forecast and Expectations**

2 – Decision Support Tools

Current Monthly SST anomalies: 27 September 2026 - 24 October 2026



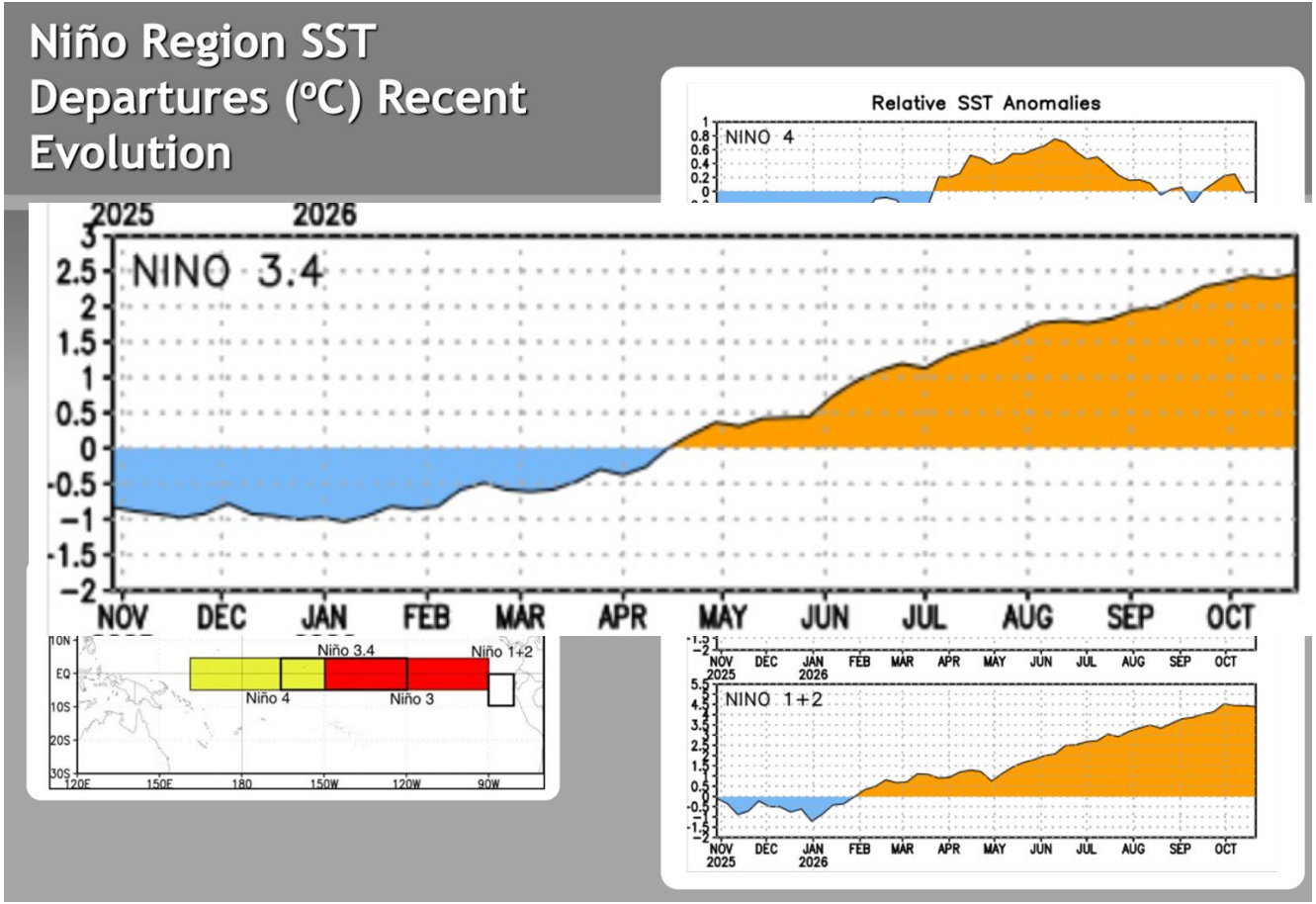
→ An El Niño has been officially declared as of June 2026

→ latest Niño3.4 index magnitude anomaly = 2.5°C (~4.5°F) (**very strong** category)

→ Warm sea surface temperature anomalies have persisted throughout most of the central and eastern tropical Pacific (where ENSO is defined).

→ Very warm sea surface temperatures have persisted off the California coast since spring 2026

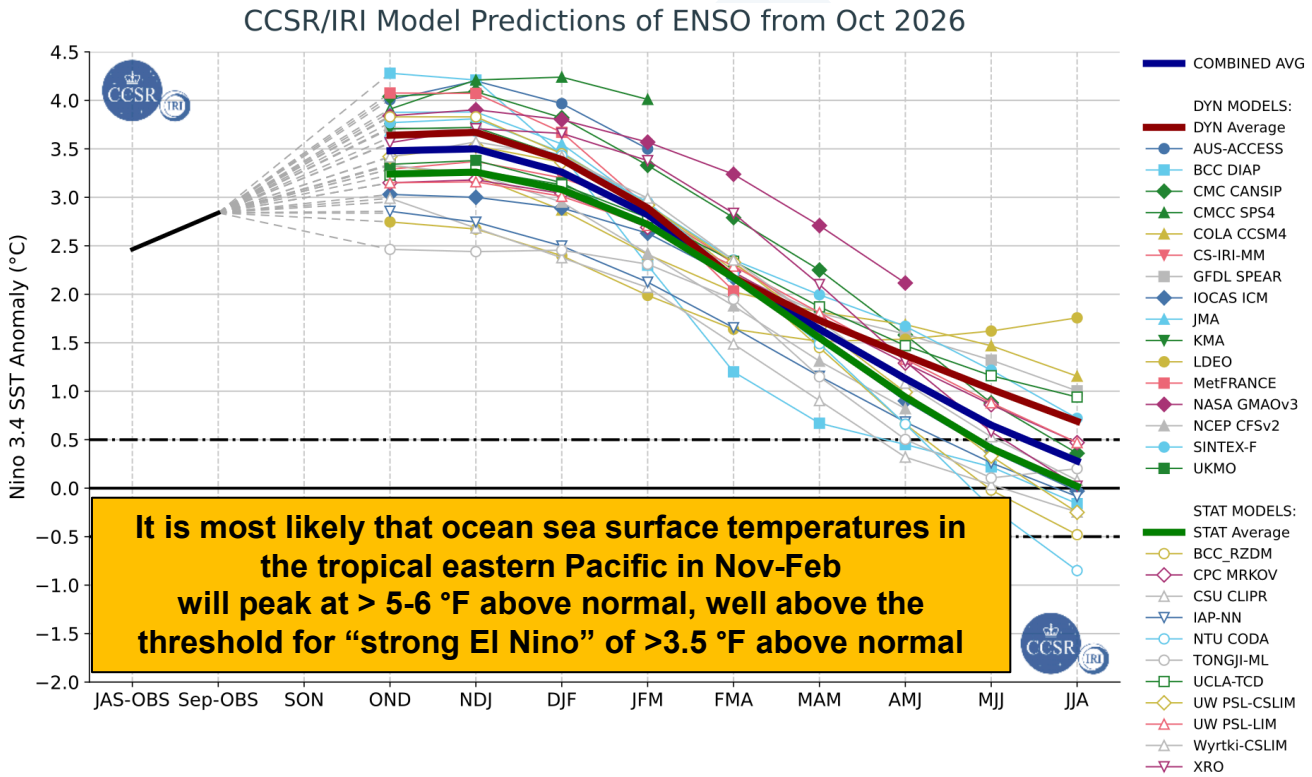
Recent evolution of El Niño strength



El Niño is still strengthening, but at a slower rate than during summer and early autumn.

Source: NOAA CPC (https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf)

Latest ENSO Forecasts: October 2026



Weak: 0.5 to 0.9° C
Moderate: 1.0 to 1.4°C
Strong: >1.5°C
Very Strong: >2.0°C (>3.6°F)

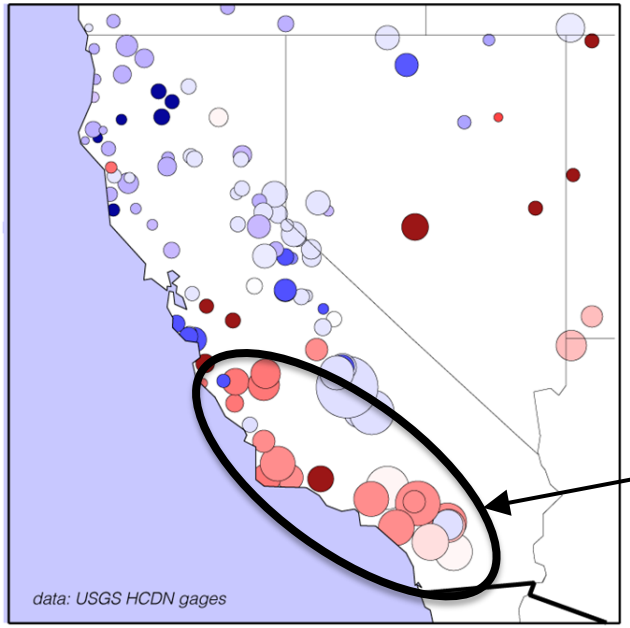
→ All dynamical and statistical models are predicting the very strong El Niño to persist in intensity through late autumn/early winter

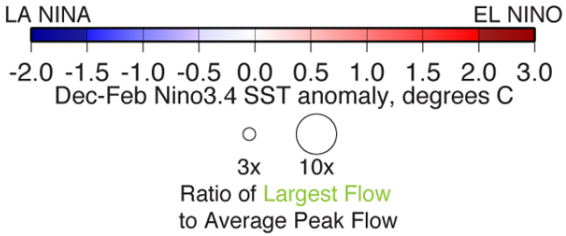
→ El Niño is predicted to begin weakening through mid-to-late winter and spring 2027

Years with Strong El Niño

Water Yr	PkRONI	Season	Statewide Precipitation	Apr 1 SWE
1958	2.02	DJF	**149%**	**171%**
1966	2.04	OND	84%	83%
1973	2.27	NDJ	113%	148%
1983	2.52	NDJ	**184%**	**227%**
1992	2.32	DJF	84%	60%
1998	2.38	SON	**167%**	**158%**
2016	2.37	NDJ	102%	85%

LARGEST ANNUAL-MAXIMUM DAILY STREAMFLOW,
PERIOD OF RECORD (or WY1915-2025, whichever is shorter)
[as fraction of 1951-2000 average of maximum annual flows]





In NorCal the largest annual streamflow corresponds with La Niña or not-Niño.

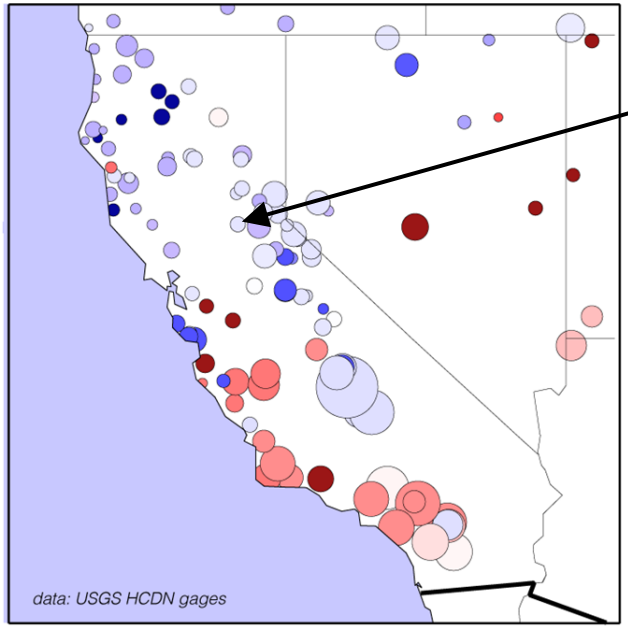
SoCal is where the largest annual streamflow corresponds with El Niño.

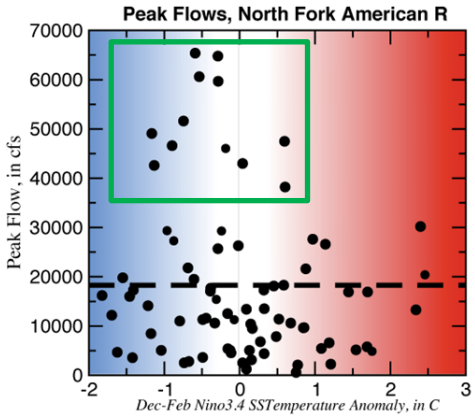
Analysis by Mike Dettinger

Map showing relations between magnitude of largest recorded flows at HCDN (natural) streamflow gaging stations and corresponding winter Nino3.4 sea-surface temperatures, with four graphs showing examples of overall distributions of annual peak-flows vs Nino3.4 temperatures. Historically, largest flows in southern California have occurred during weak to moderate El Ninos (red) and largest flows in northern California have occurred during weak La Ninas (blue).

Center for Western Weather and Water Extremes
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LARGEST ANNUAL-MAXIMUM DAILY STREAMFLOW,
PERIOD OF RECORD (or WY1915-2025, whichever is shorter)
[as fraction of 1951-2000 average of maximum annual flows]





NorCal:
Highest flows
mostly in La Niña

LA NINA EL NINO
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 3.0
Dec-Feb Nino3.4 SST anomaly, degrees C

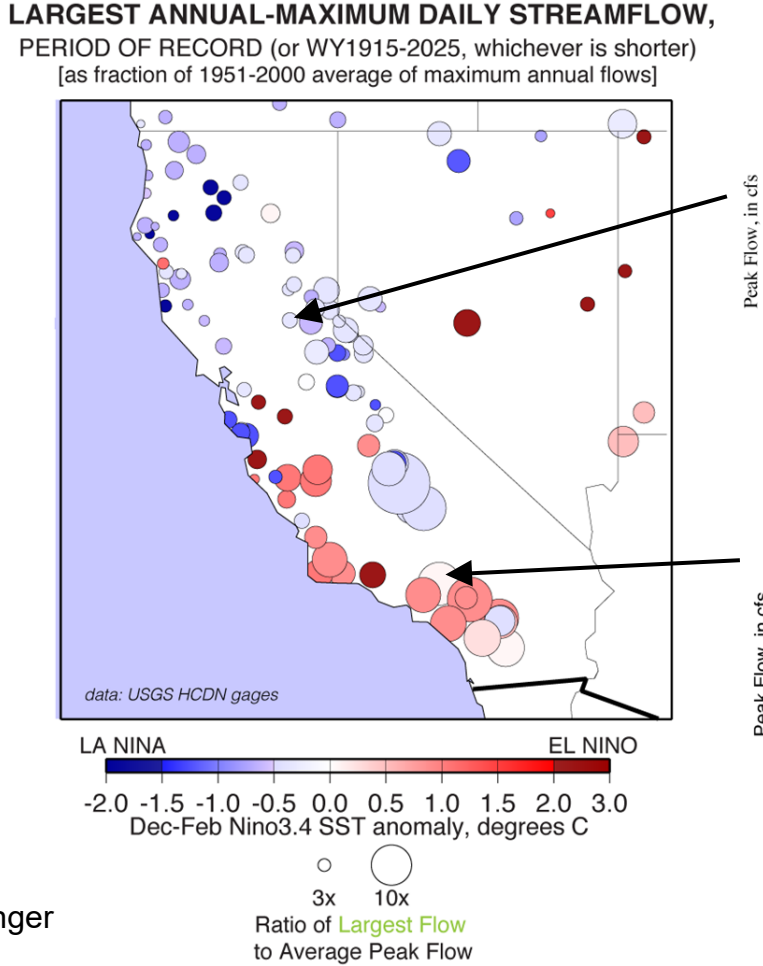
3x 10x
Ratio of Largest Flow
to Average Peak Flow

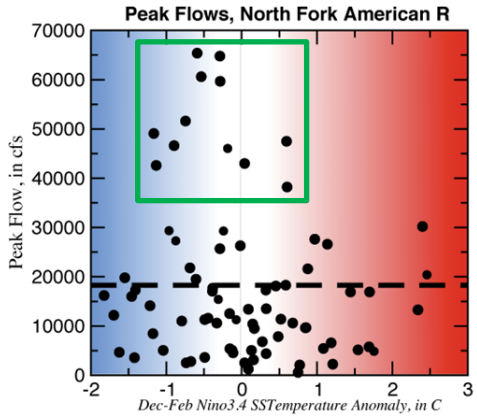
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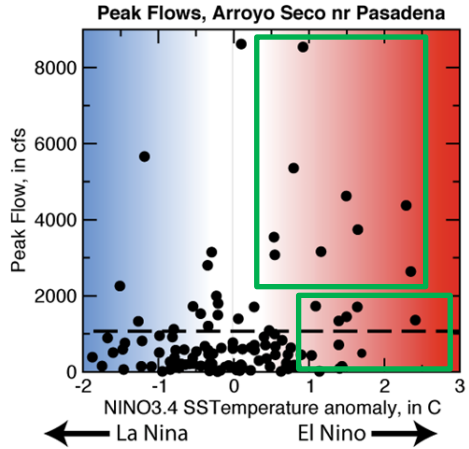
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

But…
All El Niño years do not have high annual max streamflow in SoCal





NorCal:
Highest flows mostly in weak La Niña or no Niño



SoCal:
Highest flows mostly in strong El Niño

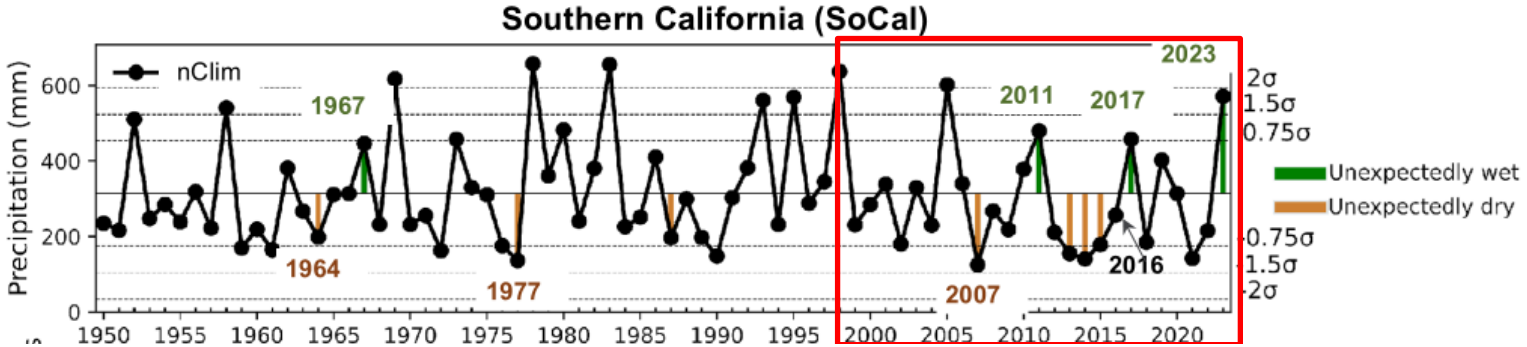
SoCal:
Peak flows are weak in some El Nino years

Analysis by Mike Dettinger

Map showing relations between magnitude of largest recorded flows at HCDN (natural) streamflow gaging stations and corresponding winter Nino3.4 sea-surface temperatures, with four graphs showing examples of overall distributions of annual peak-flows vs Nino3.4 temperatures. Historically, largest flows in southern California have occurred during weak to moderate El Ninos (red) and largest flows in northern California have occurred during weak La Ninas (blue).

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Atmospheric Rivers as Disruptors of Seasonal Precipitation Forecasts over California



La Nina years

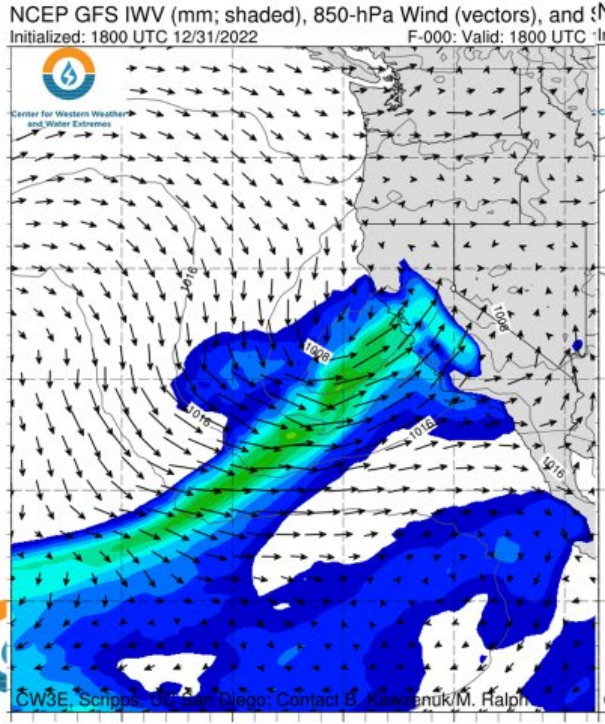
El Nino years

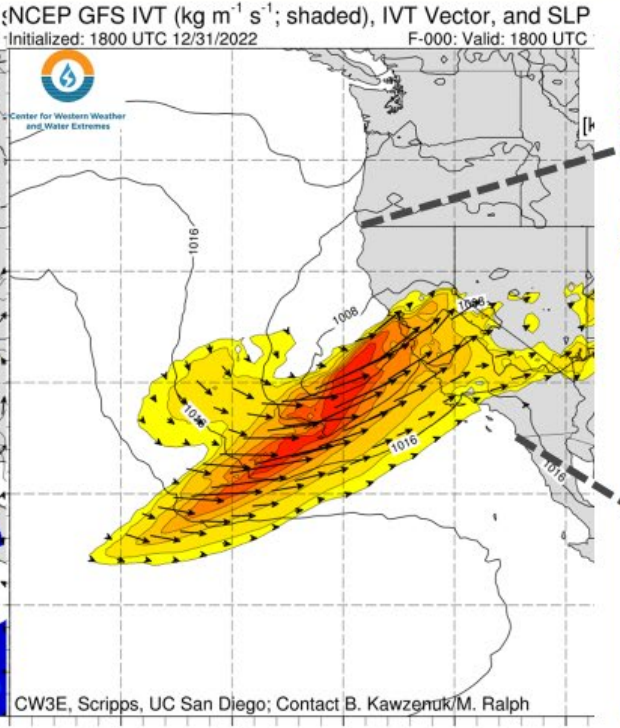
Luna Niño et al. (2025, Clim. Dyn.)

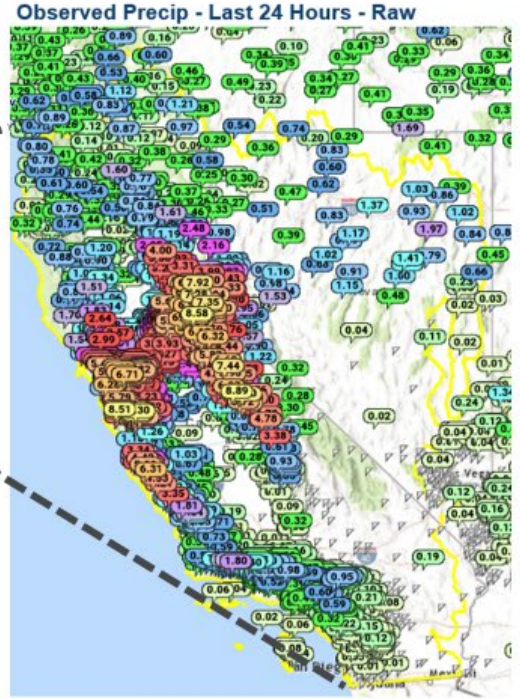
Center for Western Weather and Water Extremes

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New Years Day 2023 AR

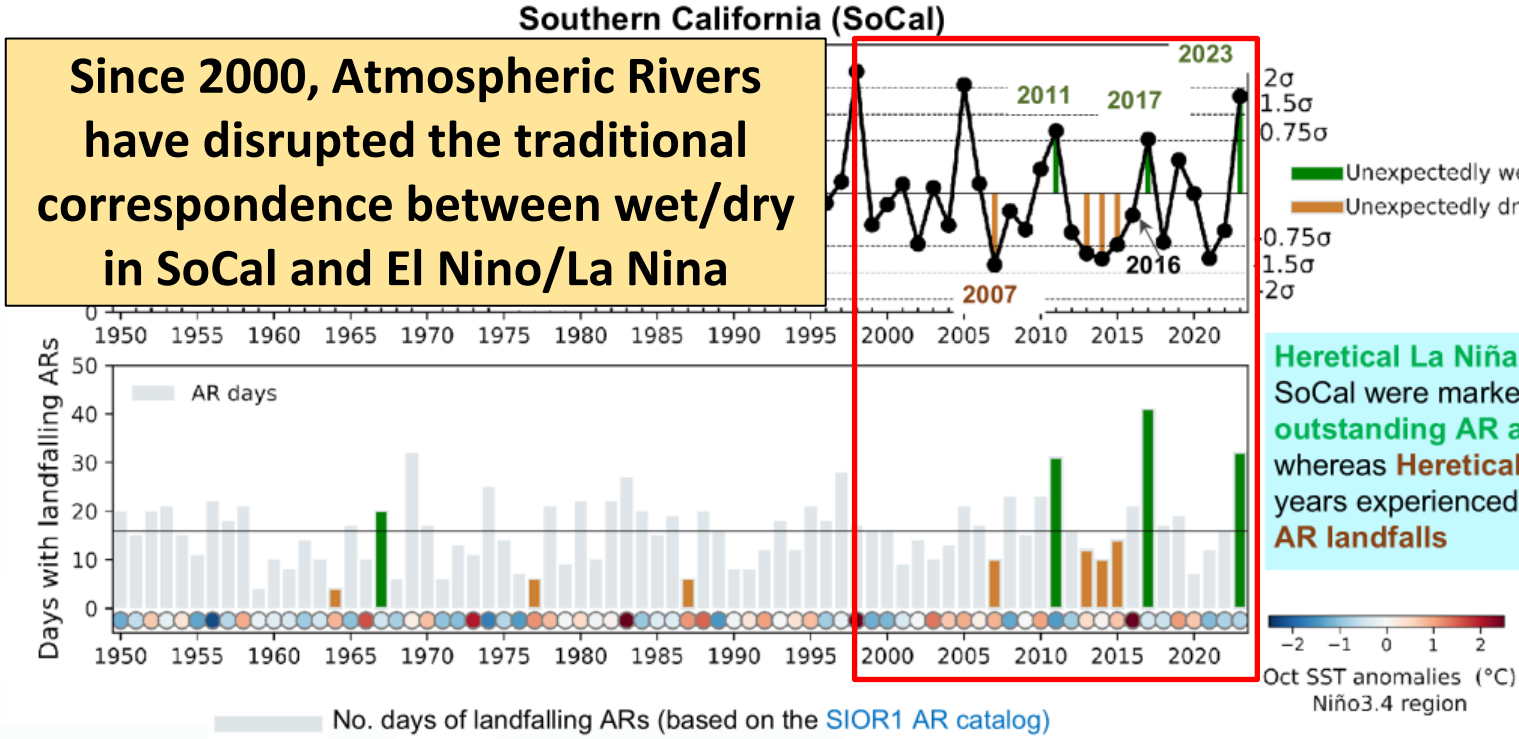


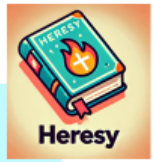




Atmospheric Rivers as Disruptors of Seasonal Precipitation Forecasts over California

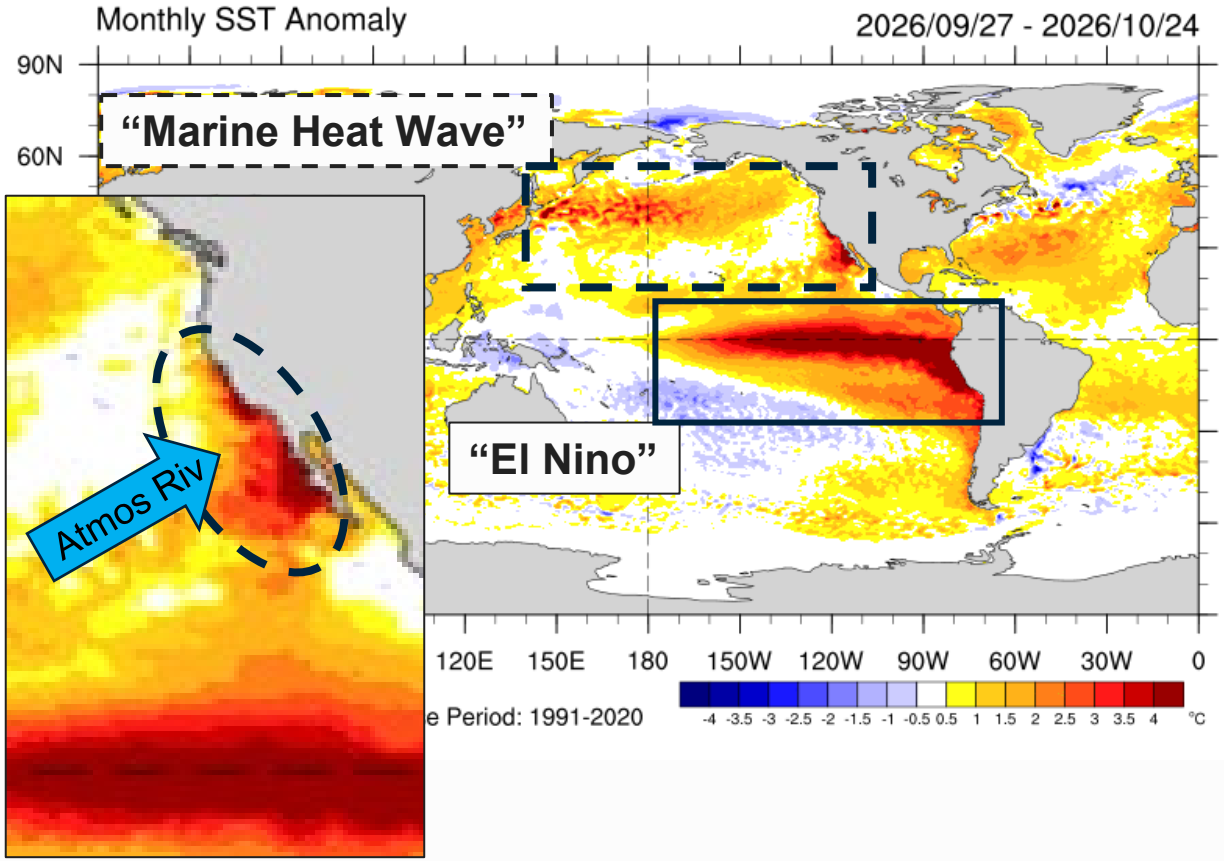
Since 2000, Atmospheric Rivers have disrupted the traditional correspondence between wet/dry in SoCal and El Nino/La Nina





Luna Niño et al. (2025, Clim. Dyn.)

Current Monthly SST anomalies: 27 September 2026 - 24 October 2026

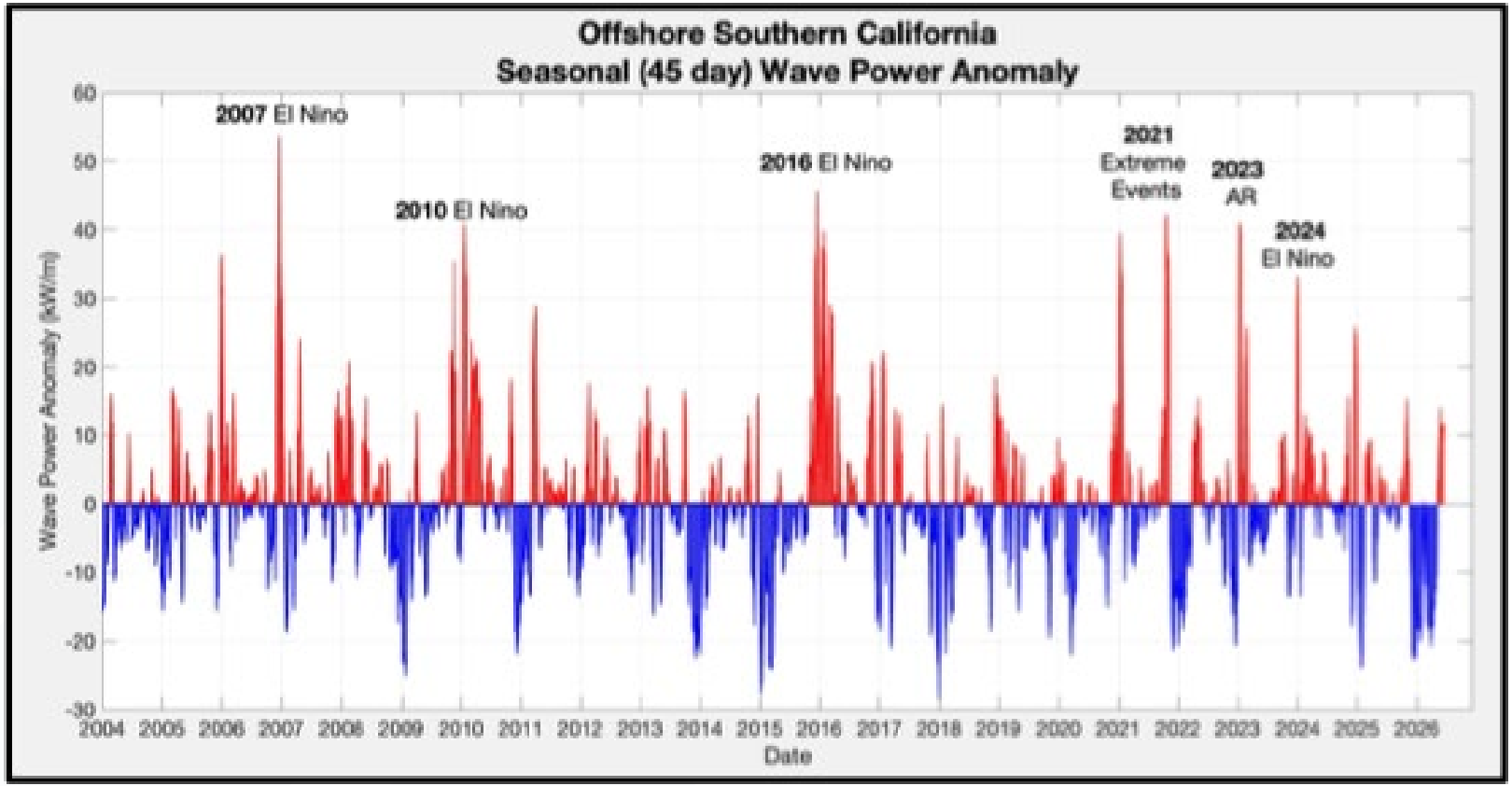


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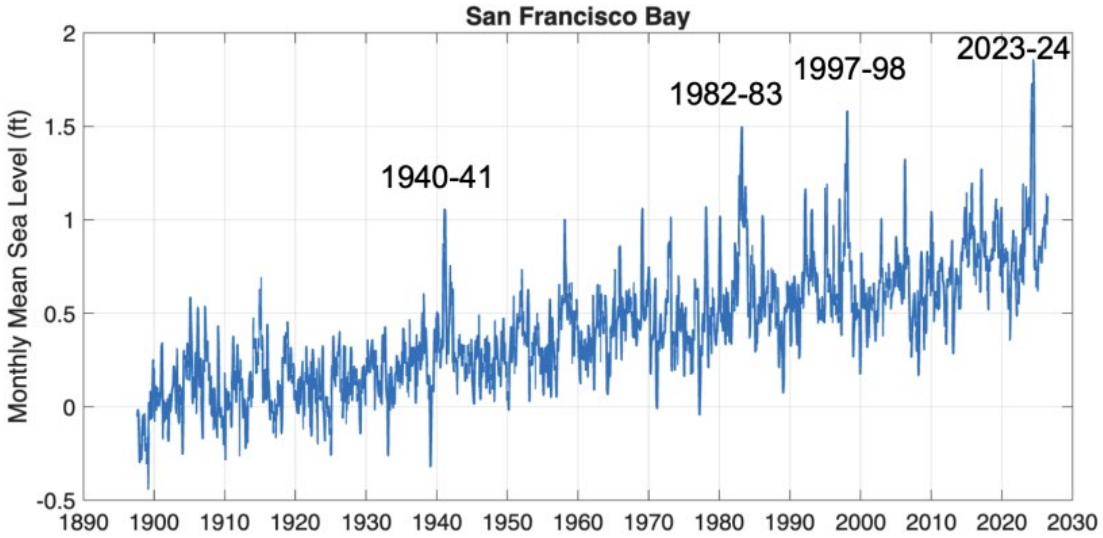
El Nino years produce powerful waves that can cause coastal erosion



Scripps Institution of Oceanography - Coastal Data Information Program (CDIP)

https://cdip.ucsd.edu/

El Niño years favor higher average sea level and larger surf off California coast



El Niño peak sea levels increase with sea-level rise. Credit: NOAA CO-OPS via the University of Hawaii Sea Level Center.



Erosion at Aliso Beach post-Hurricane Marie swell (Image credit: LA Times, 11 Sep 2026)



Mark Merrifield, Scripps Institution of Oceanography, Lead Coastal Inundation Program

https://scripps.ucsd.edu/news/el-nino

Observing California's coastal changes

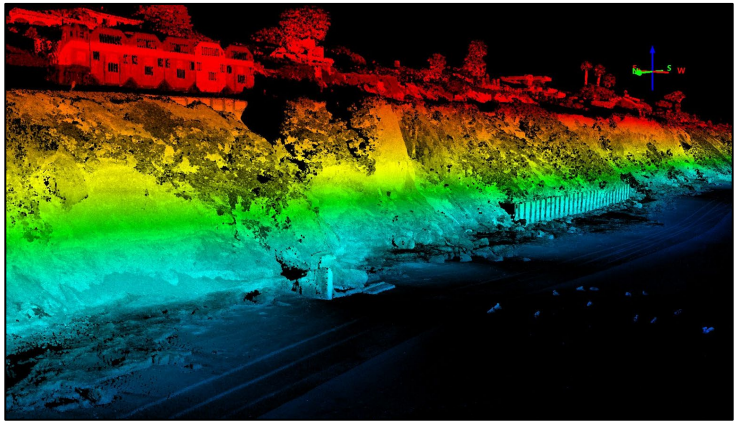
This El Niño has potential for serious impacts on the CA coast (flooding, beach/cliff erosion, landslides).

Regular monitoring program - statewide lidar mapping planned for Fall 2026 and post-El Niño winter (Spring 2027) for entire CA coastline.

Opportunities for additional research and observations: data is essential to improve our ability to predict hazards and plan for the future.

Adam Young, Scripps Institution of Oceanography, PI
Coastal Cliff Retreat Project





Outline



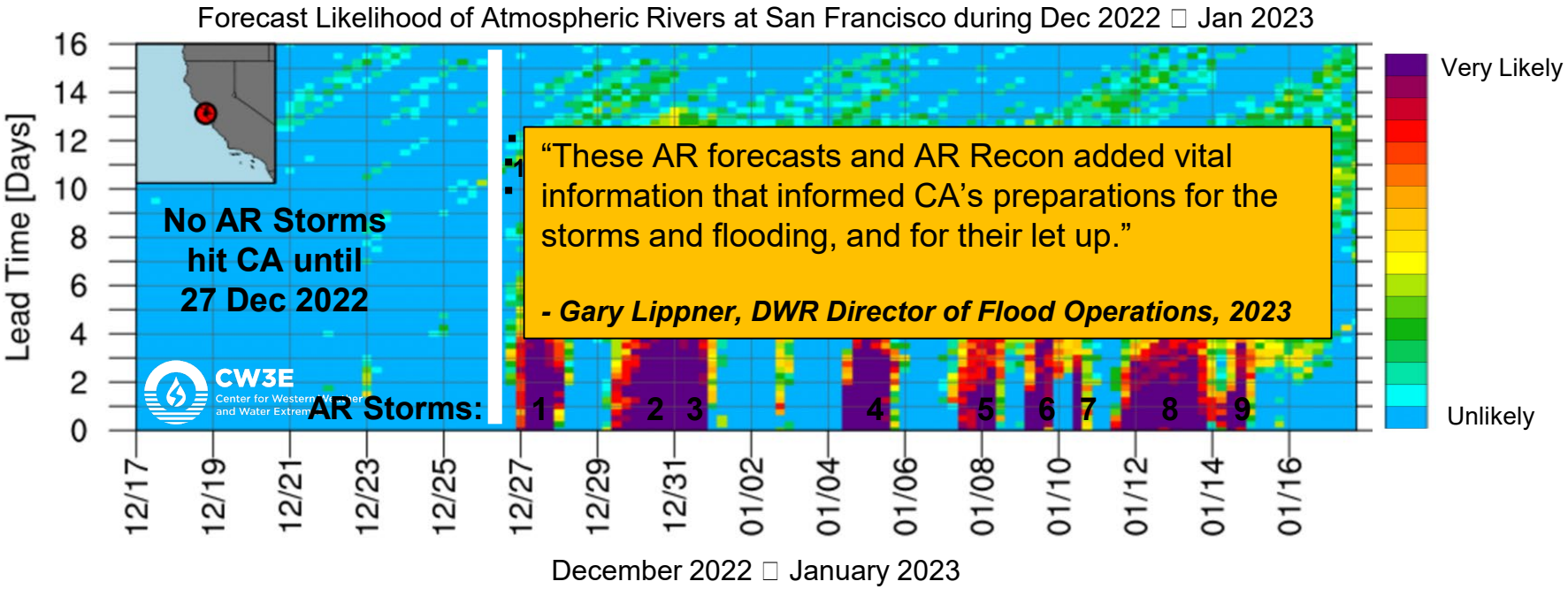
1 – El Nino: Forecast and Expectations

2 – CW3E Decision Support Tools (https://cw3e-sites.ucsd.edu/tools/)

Key sponsors of CW3E's AR tools, and capabilities:
California Dept. of Water Resources
Local Water Agencies
US Army Corps of Engineers
NOAA, US Navy, US Air Force

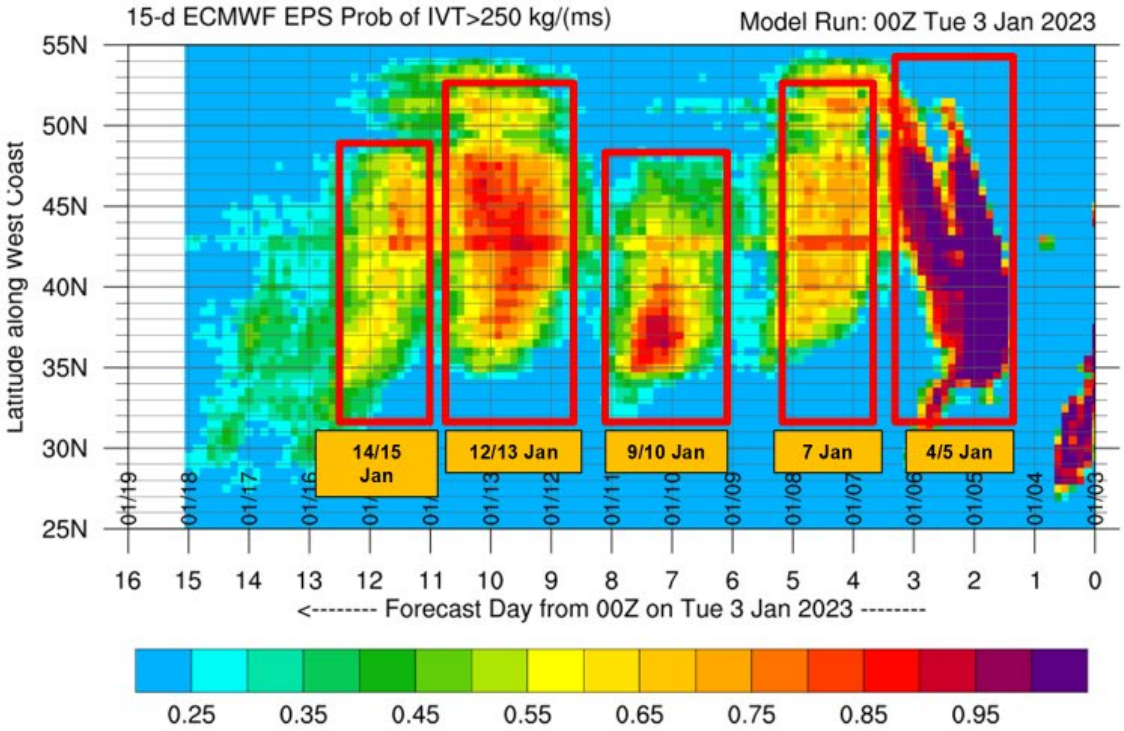
CW3E's Forecasting Tools Help Foresee ARs

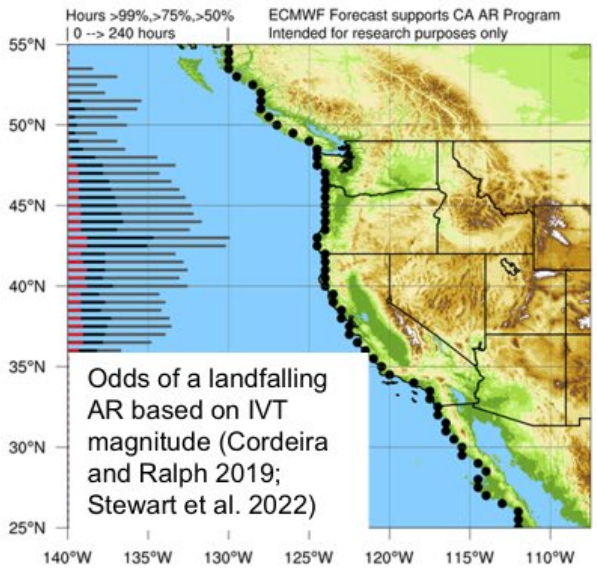
Past Example of predicting the onslaught of 9 ARs in 3 weeks that changed CA from drought to flood.
Atmospheric rivers were predicted along the U.S. West Coast reliably 6–8 days ahead, some were forecast 10–12 days ahead.



Summaries of AR forecast tools and landfalling AR prediction skill along the U.S. West Coast by Cordeira et al. (2017; BAMS), Cordeira and Ralph (2021; WAF), Stewart et al. (2022; WAF)

How far in advance can we predict landfalling ARs?





Odds of a landfalling AR based on IVT magnitude (Cordeira and Ralph 2019; Stewart et al. 2022)

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Providing Guidance at Week 2-4 Lead Time on Surplus or Deficit of ARs

Situational Awareness Tools 2-4 Weeks Ahead

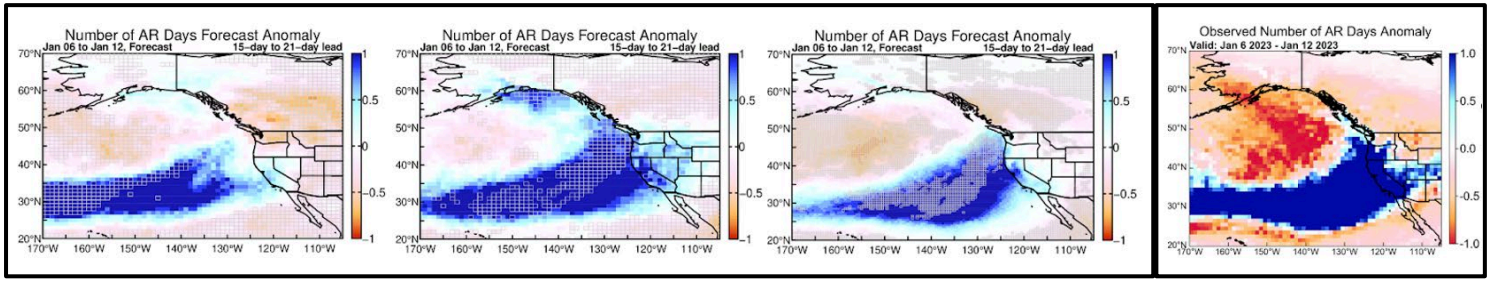
Forecasts initialized 22 Dec 2022
Valid 6-12 Jan 2023

3 Different Forecast Models

Actual Outcome

3 Weeks Ahead, Accurate Forecast ✓

Week-3 AR forecast and verification



Weeks 2-4 forecast summary table

Forecasts Initialized 22 Dec 2022

		NCEP[1,2,3]	ECCC[1]	ECMWF[1,2]	Multi-Model Forecast
Week 2 (30 Dec – 5 Jan)	WA/OR				
	Northern CA				
	Central CA				
	Southern CA				
		NCEP[1,2,3]	ECCC[1]	ECMWF[1,2]	Multi-Model Forecast
Week 3 (6–12 Jan)	WA/OR				
	Northern CA				
	Central CA				
	Southern CA				
		NCEP[2,3]	ECCC	ECMWF[2]	Multi-Model Forecast
Week 4 (13–19 Jan)	WA/OR		N/A		
	Northern CA		N/A		
	Central CA		N/A		
	Southern CA		N/A		

Subseasonal products included in this table:
[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)

Highlights consistent AR signals, regional differences, and forecast confidence

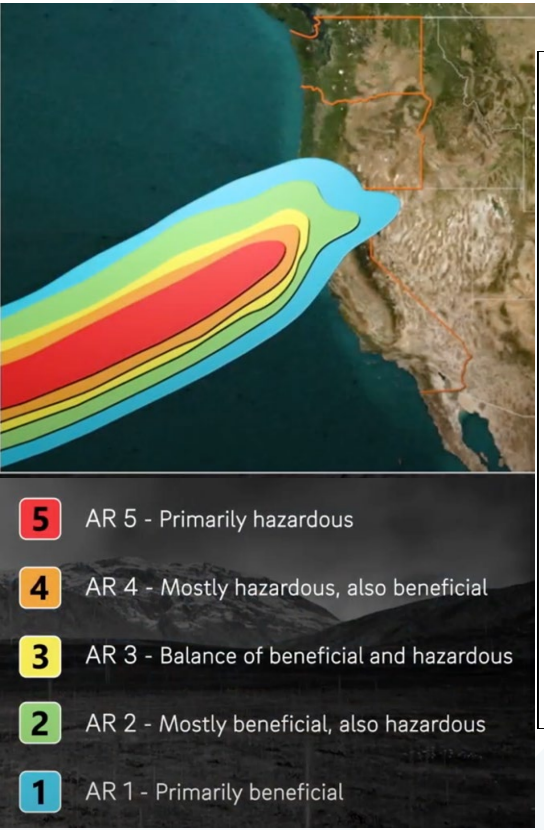
Higher Confidence | Lower Confidence

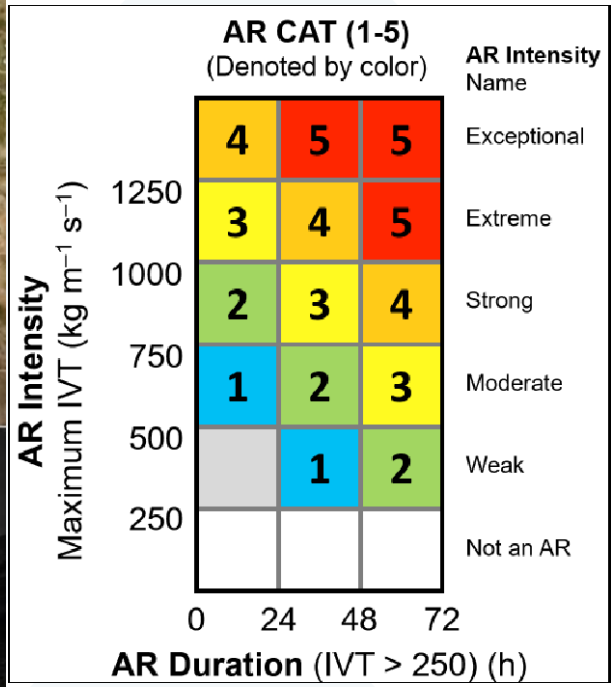
- Below normal
- Near normal
- Above normal
- Uncertain/lack of skill

Summary of subseasonal forecasts of historic AR family impacting California during Winter 2022-2023 described in DeFlorio et al. 2024 (BAMS)

"These tools were invaluable this past winter. In fact, our Week 2 hazards forecasters here at the Climate Prediction Center (CPC) made extensive use of them. Further, these tools greatly enhanced the confidence level of our Key Messaging for the AR events in California as they unfolded. We are deeply grateful and appreciative for all of the efforts and progress that CW3E has made."
- Anonymous Peer Reviewer from NOAA CPC

AR SCALE





Ralph et al. (2019)

WY 2023: DEC 27, 2022 – JAN 19: A FAMILY OF 9ARs

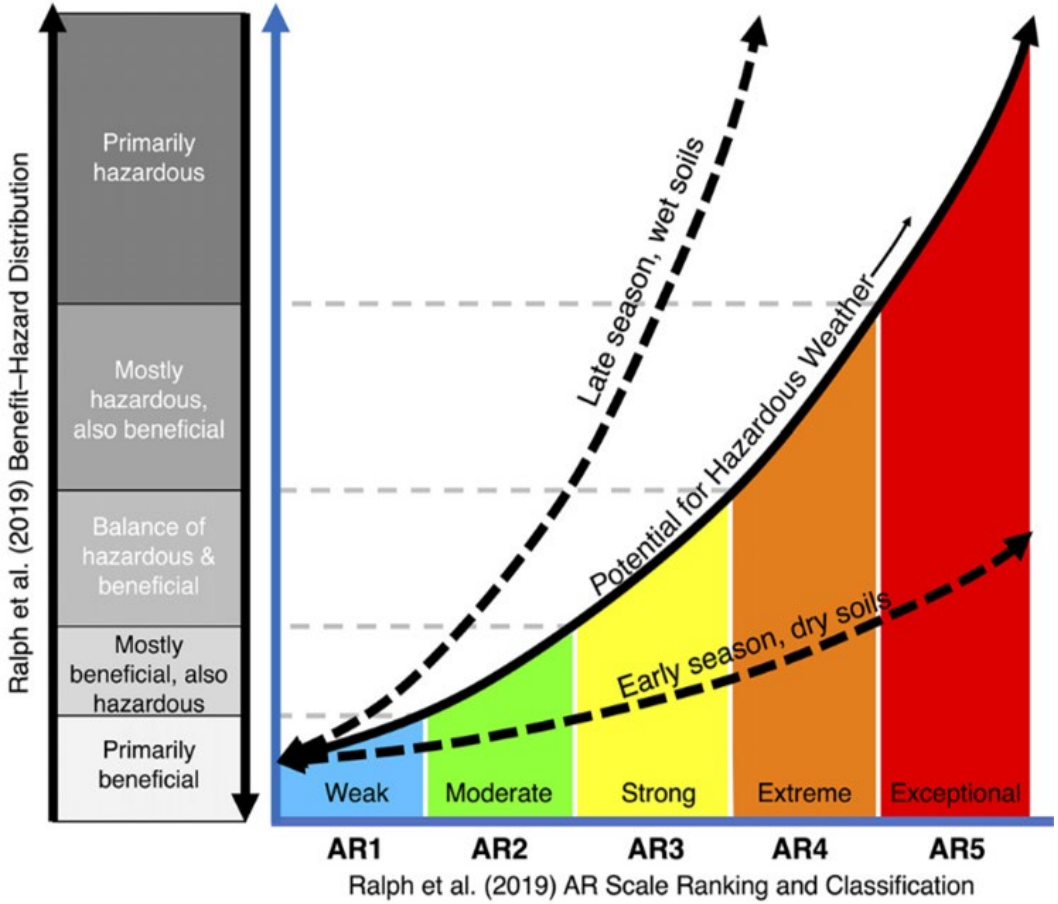
AR Family Timing, Location, and Strength



C. Hecht

More AR3 or stronger storms hit CA in 3 weeks as would normally hit in an entire winter

ARs Can Be Hazardous and/or Beneficial



Antecedent Conditions Strongly Modulate AR Impacts

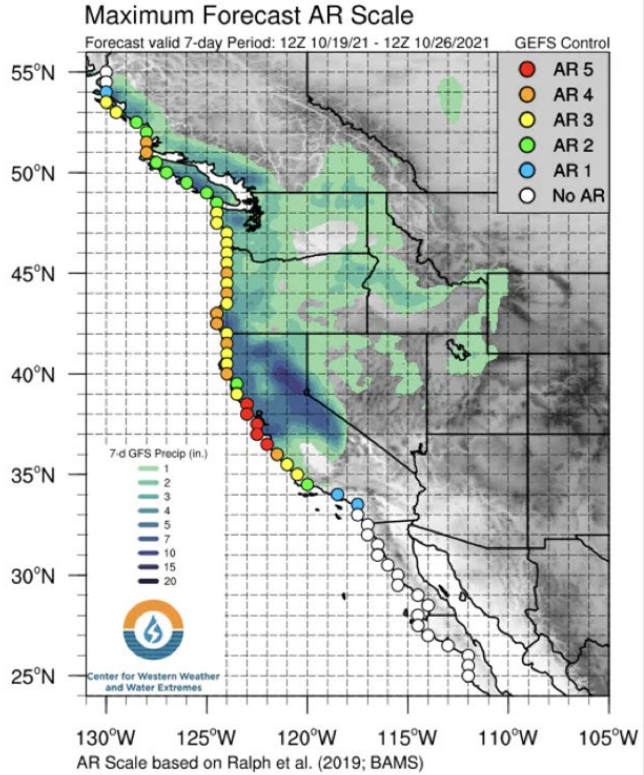
- soil wetness
- snowpack
- river and reservoir levels

Back-to-Back ARs or Stalling of an AR Amplifies Their Impacts

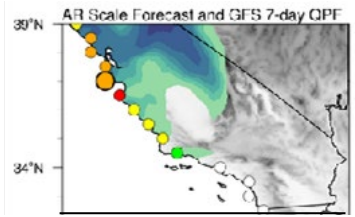
From Bartlett and Cordeira, 2021

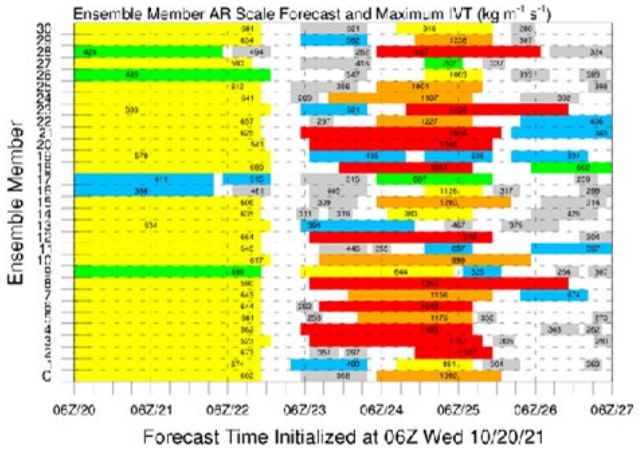
The Washington Post

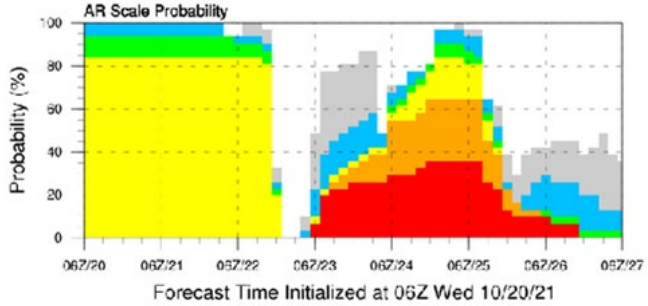
Democracy Dies in Darkness



Forecast for the maximum atmospheric river (AR) intensity over the next week. (Center for







GEFS + EPS = 80 members

AR5: 30%

AR4: 35%

AR3: 30%

AR4 or AR5: 65%

AR3, 4 or 5: 95%

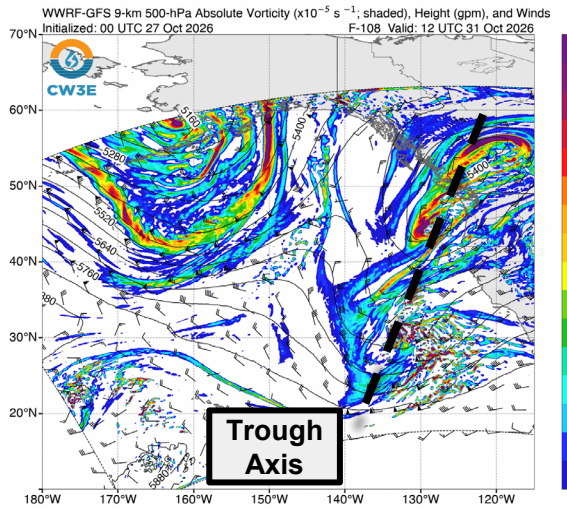
Atmospheric River Struck as an "AR5" on CW3E's AR Scale

Record daily rainfall at key locations, and **record of 13% of annual rain for N. Sierra - <u>in 1 day</u>**

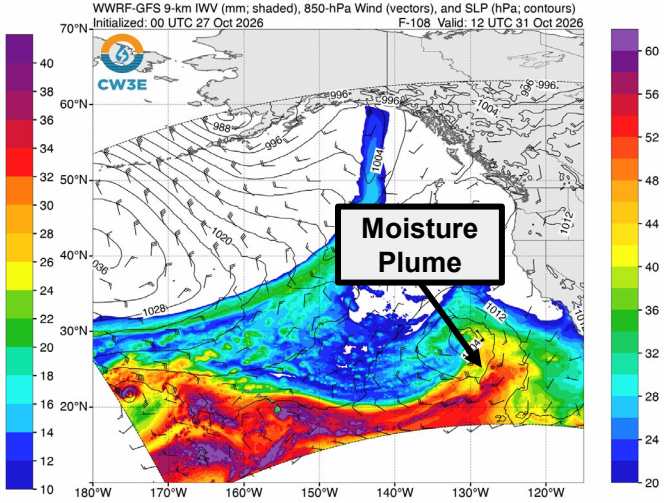
CW3E Precipitation Outlook: 27 October 2026

West-WRF GFS 500 hPa, IWV, and IVT Forecast: Initialized 00 UTC 27 Oct 2026

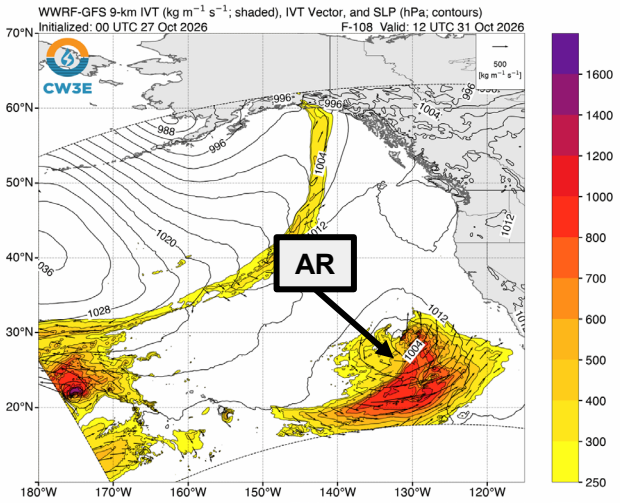
5 AM PT Sat 31 Oct



5 AM PT Sat 31 Oct



5 AM PT Sat 31 Oct

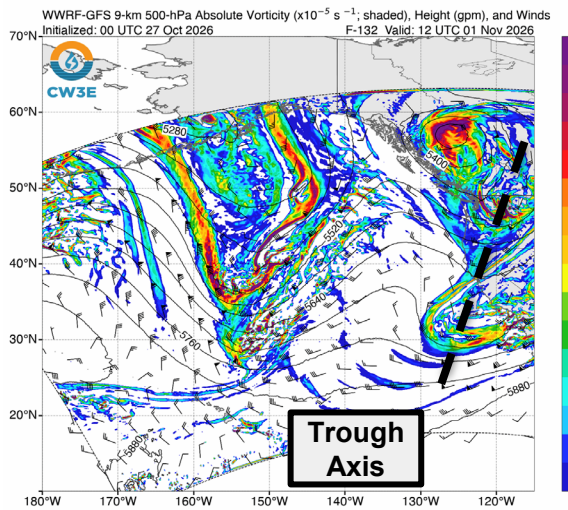


- Troughing is forecast to continue over the Western US with the overall pattern shifting eastward by 31 Nov (left).
- At the base of the trough, a surface low-pressure is forecast to develop with an associated atmospheric river (AR) tapping into significant tropical moisture (center).
- The AR is forecast to strengthen, with IVT > 800 kg m^{-1} s^{-1} along the central axis of moisture transport (right).

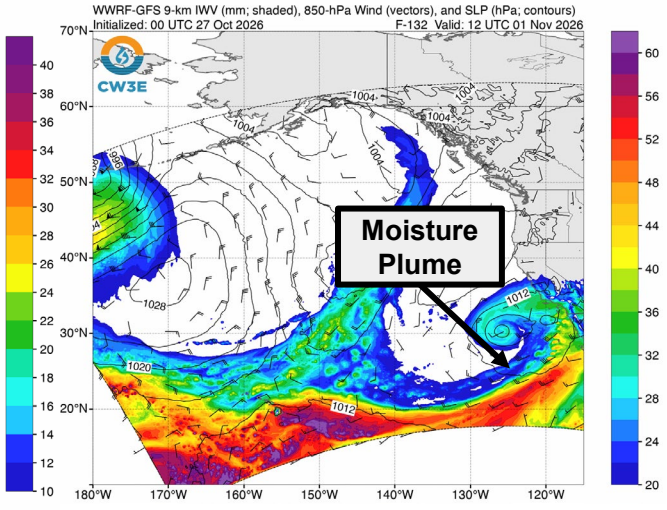
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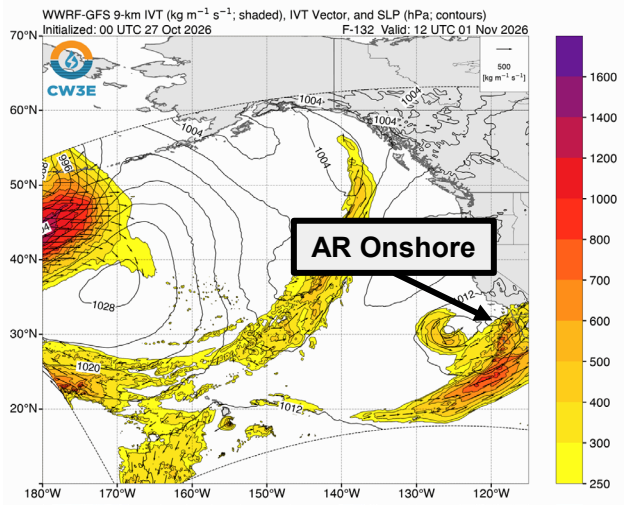
4 AM PT Sun 1 Nov



4 AM PT Sun 1 Nov



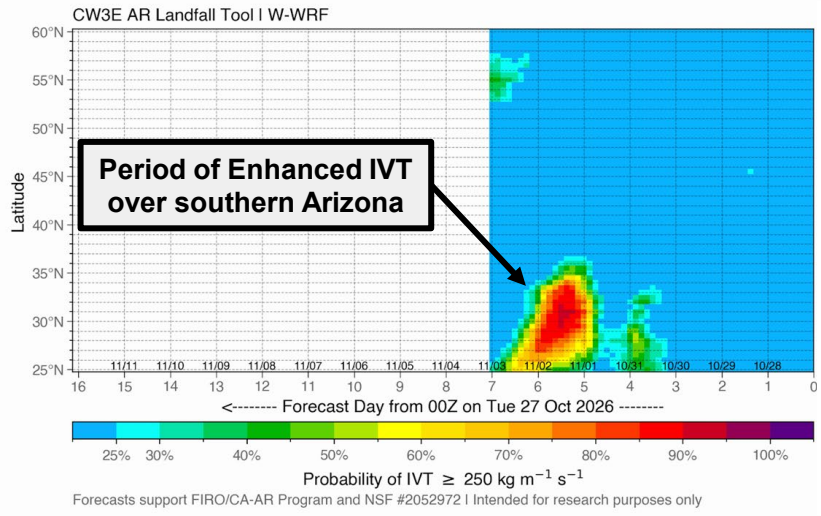
4 AM PT Sun 1 Nov

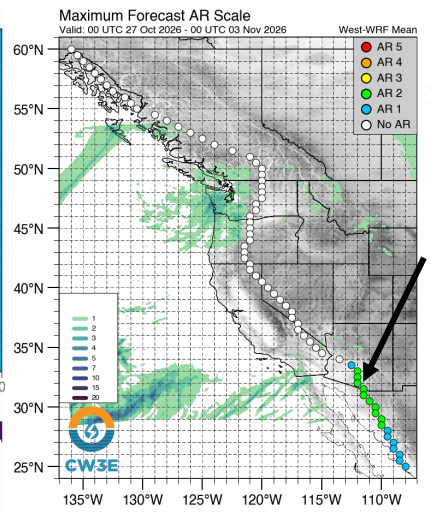


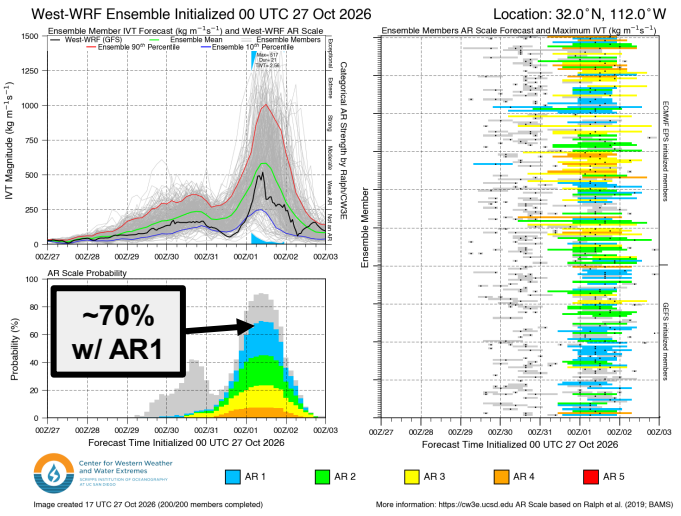
- The trough is forecast to continue progressing over the western US, although there is uncertainty as to the exact timing and progression of the overall pattern which will lead to uncertainty in the forecast impacts for the western US (left).
- The AR and it's associated moisture corridor are forecast to shift eastward and make landfall along Baja California on 1 Nov, with a region of southwesterly IVT > 500 kg m^{-1} s^{-1} forecast to shift inland over the Southwestern US, fueling precipitation over the region (right).
- There is some uncertainty as to how far northward the AR and it's moisture will progress.

CW3E Precipitation Outlook: 27 October 2026

West-WRF AR Forecasts - Inland



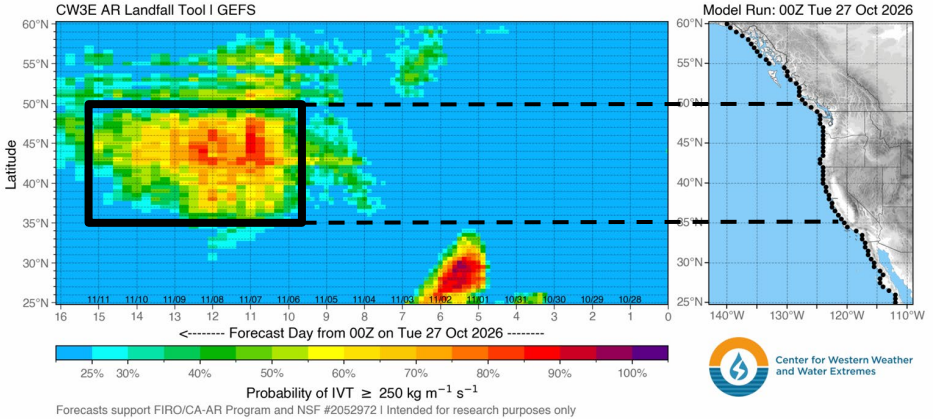


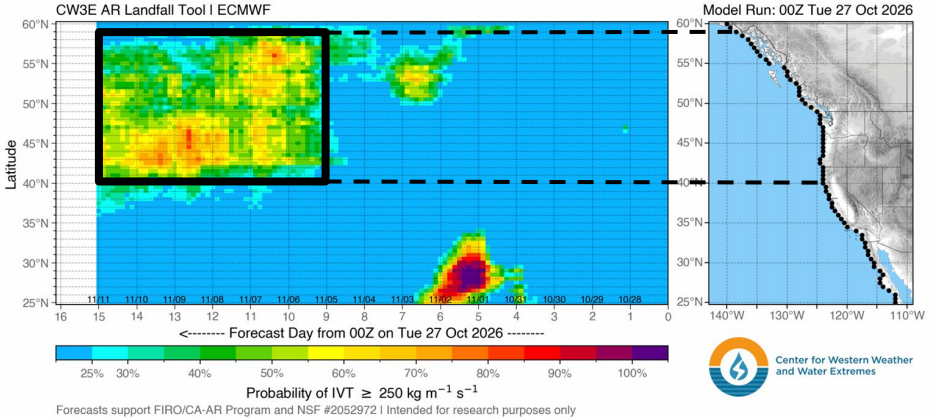


- CW3E's AR Landfall Tool based on 200-member West-WRF ensemble is showing high probabilities (> 80%) of IVT > 250 kg m^{-1} s^{-1} along an inland transect over southern Arizona, highlighting the significant moisture flux between 00Z 1 Nov–00Z 2 Nov.
- ~70% of the West-WRF ensemble members are suggesting the potential for at least AR1 conditions over the region based on the Ralph et al. 2019 AR Scale, with ~40% suggesting AR2 conditions for a point in Arizona along the border (32.0 N, 112.0 W).

CW3E Precipitation Outlook: 27 October 2026

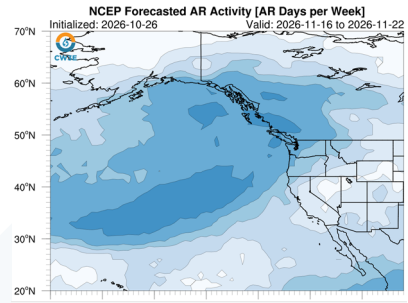
GEFS & EPS Ensemble AR Landfall Tool - Coastal

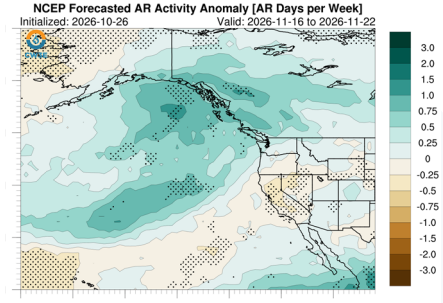




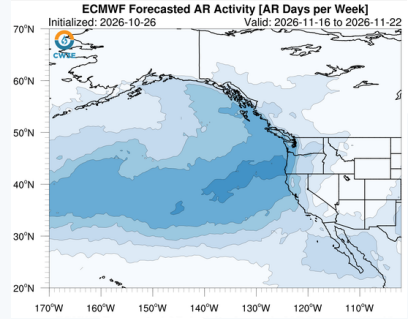
- CW3E's AR Landfall tool from both the GEFS and ECMWF ensembles are showing high probabilities of IVT > 250 kg m^{-1} s^{-1} along coastal Baja California between 00Z 1 Nov–00Z 2 Nov, although there is higher confidence from the ECMWF ensemble (right, 90–100%) as compared to the GEFS ensemble (left, 80–90%).
- The GEFS and ECMWF ensembles are both highlighting a period of AR conditions between 40°–45°N after 6 Nov, although there is some uncertainty with this forecast.
- Probabilities are higher in the GEFS over Northern California and the Pacific Northwest (left) as compared to the ECMWF ensemble which has the highest probability over Northern California and British Columbia (right).

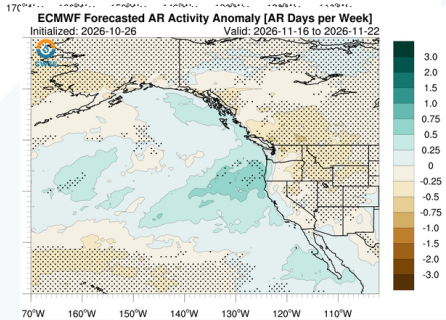
AR Activity Forecasts: Week 4 (ECCC vs. NCEP)



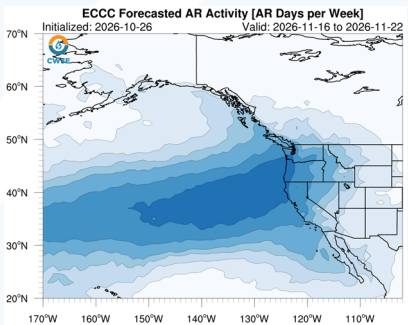


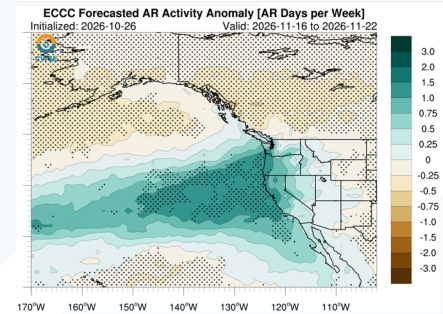
US Model





European Model





Canadian Model

Above normal

Near normal

Below normal

Forecasts Initialized 26 Oct 2026

Models disagree on AR activity over CA in Week 4

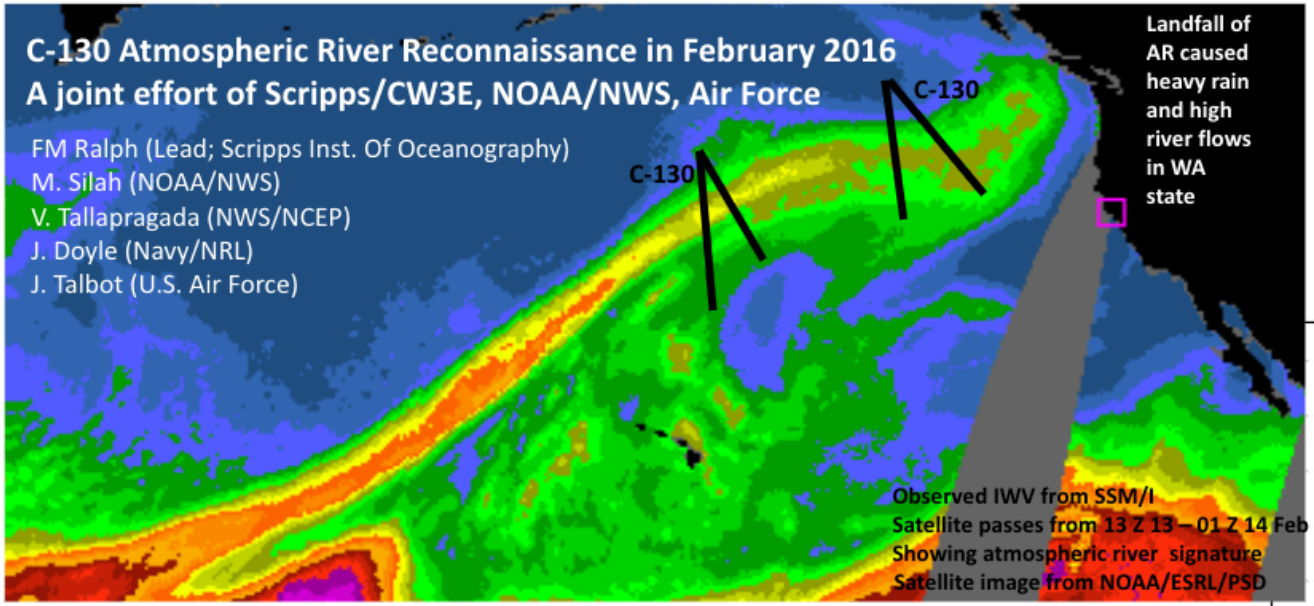
AR activity level in 3-4 weeks, from 16-22 Nov is uncertain

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)

Center for Western Weather and Water Extremes

AMBASSADOR™ WRN WEATHER-READY NATION

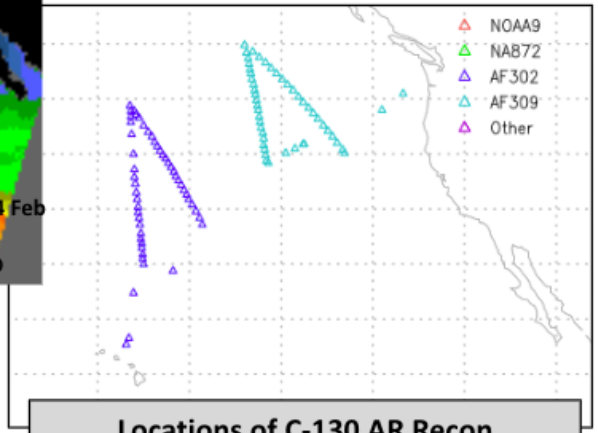
Atmospheric River Reconnaissance began as a pilot study in the strong El Nino of 2016, and is now an ongoing program



14 Feb 2016

https://www.washingtonpost.com/news/capital-weather-gang/wp/2016/02/18/hurricane-hunters-fly-into-atmospheric-rivers-for-first-time-key-to-weather-extremes-in-the-west/

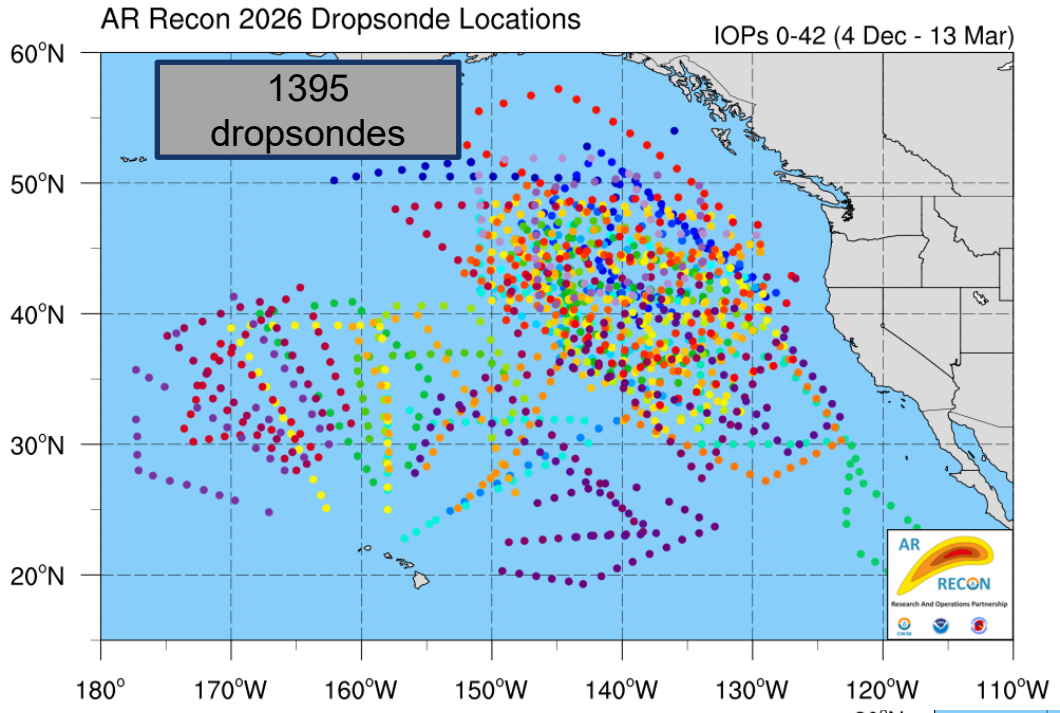
1st C-130 AR Recon Mission
13-14 Feb 2016
Dropsondes released for the 0000 UTC 14 Feb 2016 GFS data assimilation window

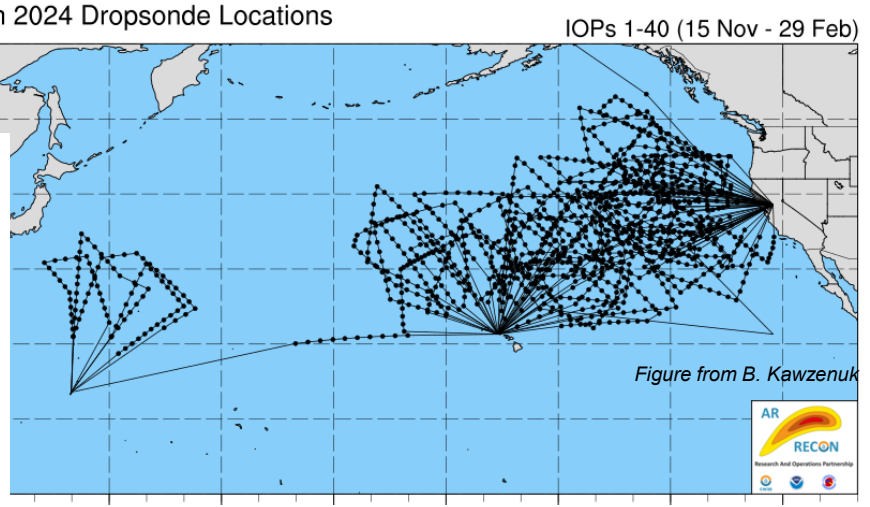


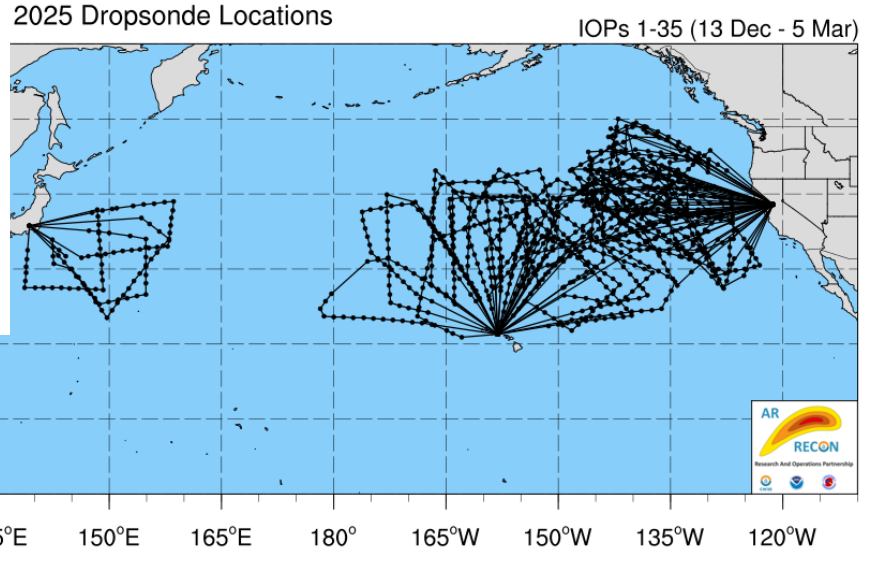
Locations of C-130 AR Recon dropsondes received and assimilated into global operational numerical weather prediction models


Air Force C-130 Aircraft – Weather Recon' Squadron

AR Recon: Vertical Profiles







New Weather Radars – Bay Area

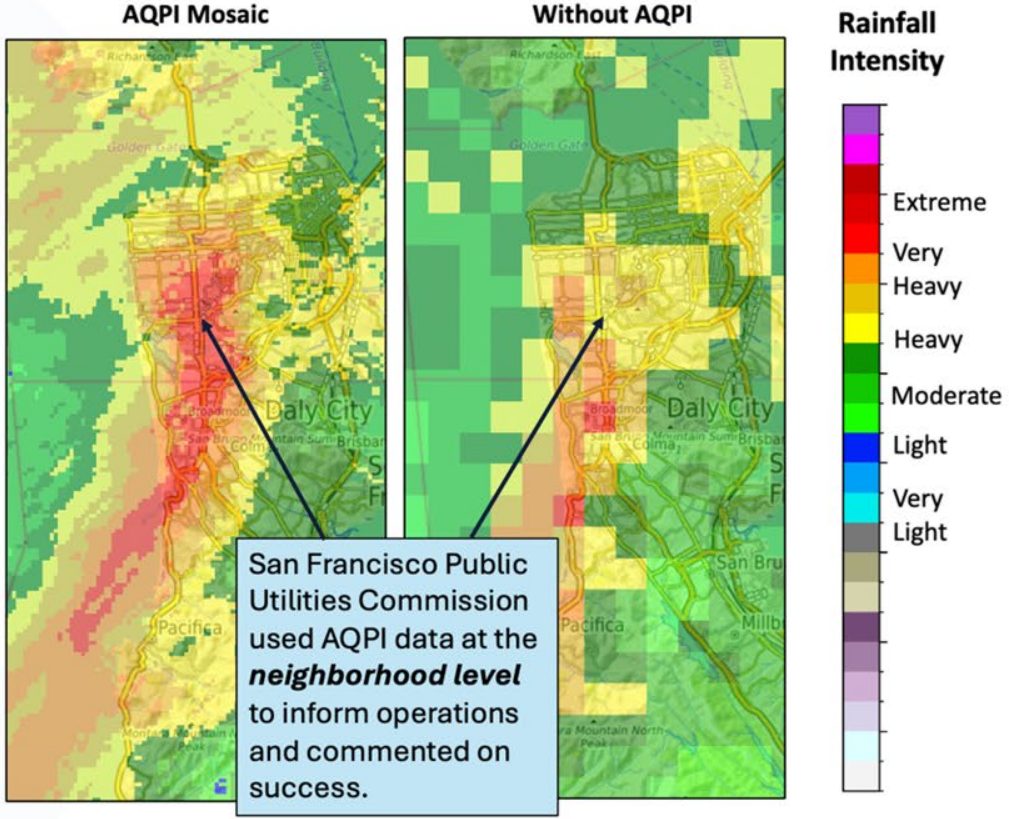
Advanced Quantitative Precipitation Information (AQPI)

The AQPI radar network (5 X-bands and 1 C-band) strategically complements the existing NWS radar network by filling gaps in coverage and providing more accurate rainfall data across the region. The program benefits from a nowcast, customized forecast data, and additional decision support tools.



X-band scanning radar used in the Advanced Quantitative Precipitation Information (AQPI) demonstration of a gap-filling radar network in a mountainous, urban area. Credit: Cooperative Institute for Research in Atmosphere.

San Francisco area at 2:20am PST Dec 25, 2025



Soil Moisture Observations in the Upper Colorado River Basin

The Y-BASIN Project: Monitoring Soi
Resource Management in the Uppe



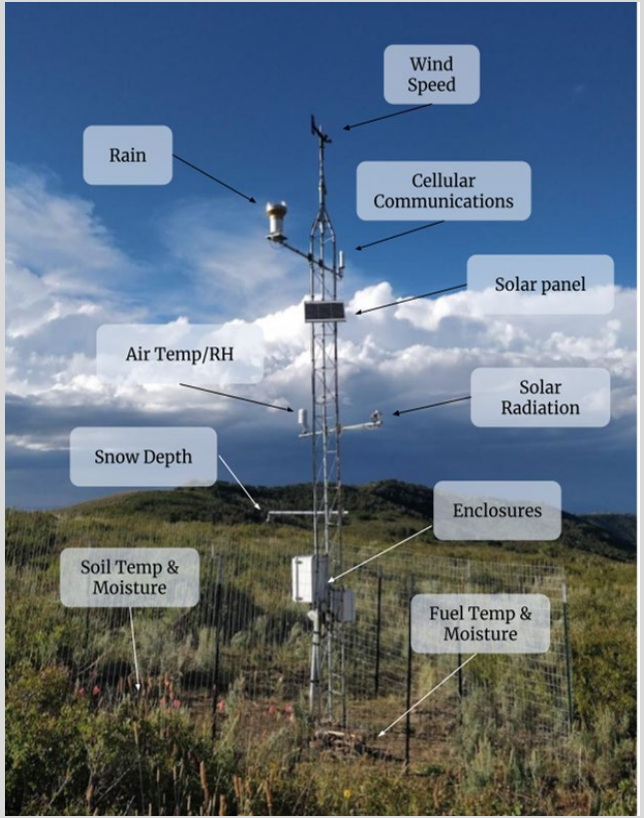
Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

UPPER YAMPA WATER CONSERVANCY DISTRICT

W
R
C

Pilot study with 20 stations

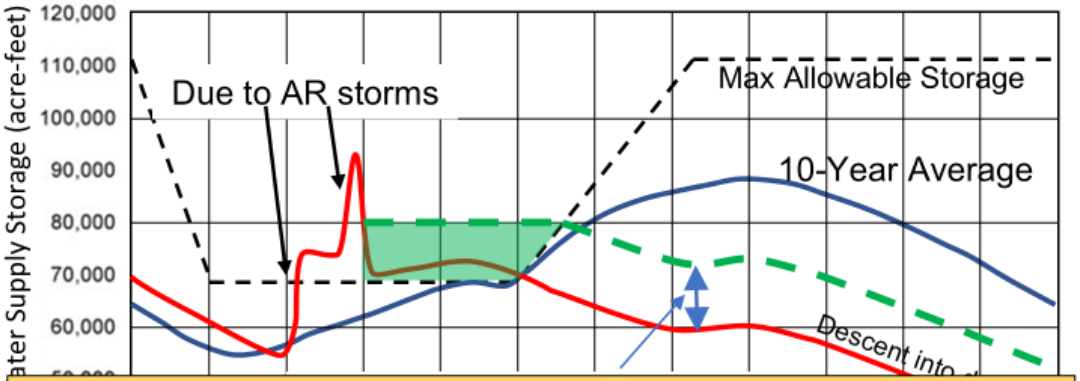




More Flexible Reservoir Operations

Lake Mendocino Forecast-Informed Reservoir Operations (FIRO)

Hypothetical estimate of extra water retained unless an AR storm is predicted to hit the watershed; requires reliable AR prediction at 5-day lead time



FIRO has contributed approximately **130,500** additional ac-ft of water to Lake Mendocino and Lake Sonoma since WY 2017 to WY 2026.

Projected to yield 250,000 to 500,000 acre-feet per year across California's 20 largest reservoirs.
(Corringham et al. 2026)

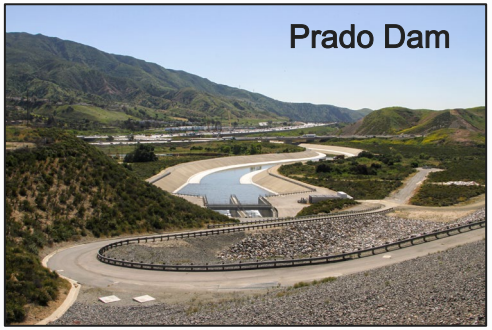
FIRO Program/USACE
PI: F. M. Ralph
Phase 1: 2015-2019
Phase 2: 2019-2023
Phase 3: 2023-2028
Phase 4: in planning
"National Implementation"

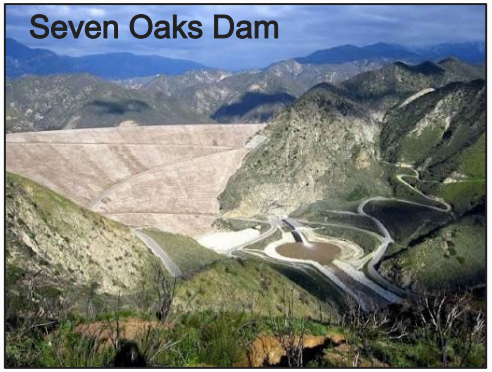
CW3E

FIRO at Prado Dam and Seven Oaks Dam on the Santa Ana River

- Prado Dam
  - Final Viability Assessment completed in November 2023 and WCM update is underway
  - Currently operating under FIRO deviation to a 508' buffer pool

- Seven Oaks Dam
  - Preliminary Viability Assessment, completed in August 2026, found that FIRO is viable and provides improvements for groundwater recharge without compromising flood risk management
  - FIRO benefits would make more water available during wet years for recharge using SBVMWD's enhanced recharge facility
  - Final Viability Assessment is underway and scheduled to be published in September 2028





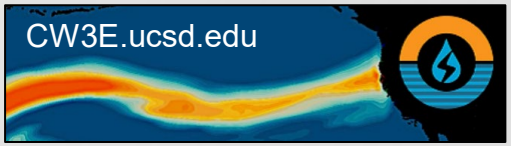
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FIRO viability assessments are conducted as a Research And Operations Partnership between CW3E, USACE, Orange County Water District (Prado Dam), San Bernardino Valley Municipal Water District (Seven Oaks Dam) and Western Municipal Water District (Seven Oaks)

DWR Flood Preparedness

- 12 workshops hosted by local County Offices of Emergency Services, developed and facilitated by DWR (29 Sept through Nov 2026)
- Workshops provide overview of available assistance and resources, opportunity to share concerns
- **CA Water Watch: observed statewide precipitation, snowpack, reservoir levels for the Water Year to date (cww.water.ca.gov/)**
- Presentations from DWR, County OES, CalOES, CCC, CalFire, USACE, NWS
- Specialized Atmospheric River and Extreme Precipitation forecasting from CW3E at UC San Diego/Scripps Institution of Oceanography, including the AR Scale





CALIFORNIA DEPARTMENT OF
WATER RESOURCES


What I’m Looking Out For Most This Winter…
- Stronger ARs that stall
- Multiple ARs back-to-back
- Narrow Cold Frontal Rainbands
- Wet Colorado Rockies
- Large coastal waves/erosion

Center for Western Weather and Water Extremes (CW3E)
Annual Meeting June 2026



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

Director (Founding)
F. Martin Ralph

