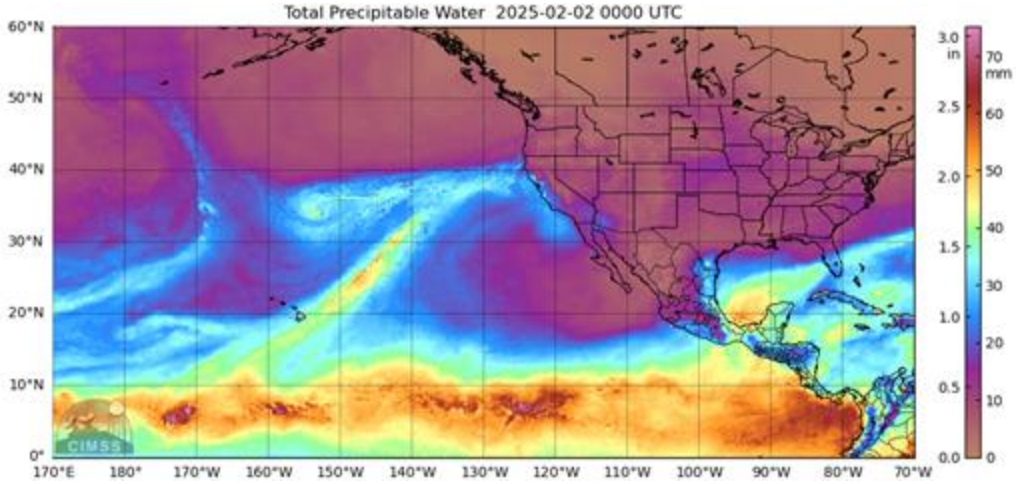
CW3E Event Summary: 31 January – 5 February 2025

Long-Duration Atmospheric River Produces Heavy Precipitation and Flooding in Northern California

The ARs:

- A weak atmospheric river (AR) associated with a tropical moisture export (TME) made landfall over Washington, Oregon, and Northern California late 30 Jan.
- A second AR associated with a much stronger TME made landfall early 1 Feb and stalled over Northern California for several days before finally dissipating early 5 Feb.
- An AR 4 (based on the Ralph et al. 2019 AR Scale) was observed in coastal Northern California, with some locations experiencing > 100 hours of continuous AR conditions.
- An AR 3 was also observed in northeastern California and northwestern Nevada due to inland penetration of the second AR.
- CW3E's AR Reconnaissance field campaign carried out eight IOPs that sampled both ARs, as well as nearby essential atmospheric structures and regions of forecast sensitivity.



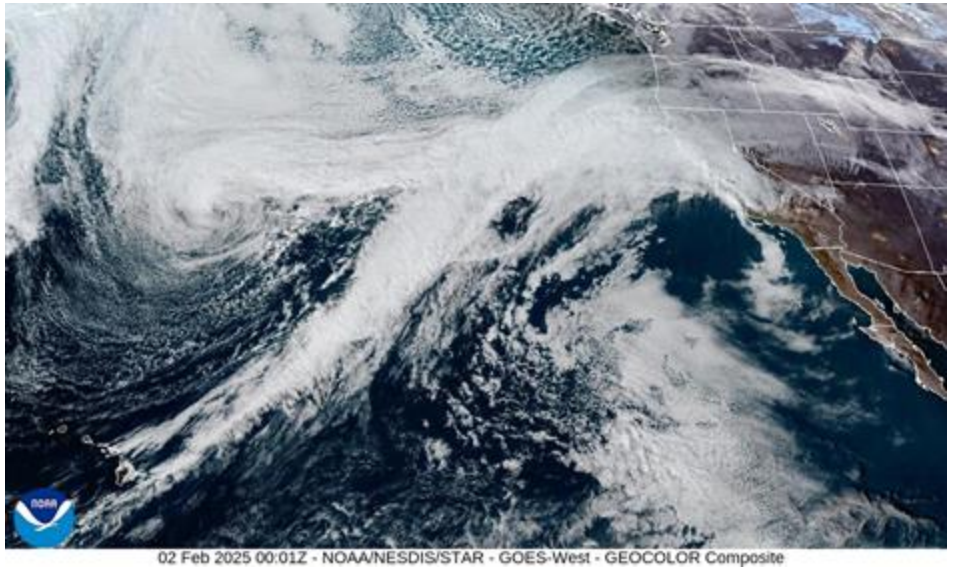
Source: Cooperative Institute for Meteorological Satellite Studies (CIMMS), University of Wisconsin-Madison

CW3E Event Summary: 31 January – 5 February 2025

Long-Duration Atmospheric River Produces Heavy Precipitation and Flooding in Northern California

Impacts:

- At least 6–15 inches of total precipitation fell over the Northern California Coast Ranges, Klamath Mountains, southern Cascades, and Northern Sierra Nevada. A few stations recorded > 20 inches of precipitation.
- While much of the precipitation in California fell as rain due to high freezing levels, these ARs produced an estimated 2–6 feet of snow in the highest elevations of the Klamath Mountains, southern Cascades, Northern Sierra Nevada, and Rocky Mountains in Central Idaho.
- Heavy rainfall over multiple days caused riverine flooding in Northern California. The Pit River near Canby exceeded major flood stage.
- The National Weather Service received numerous reports of landslides, debris flows, and flooding in Northern California.
- Heavy snow and strong winds caused hazardous travel conditions in the higher terrain.

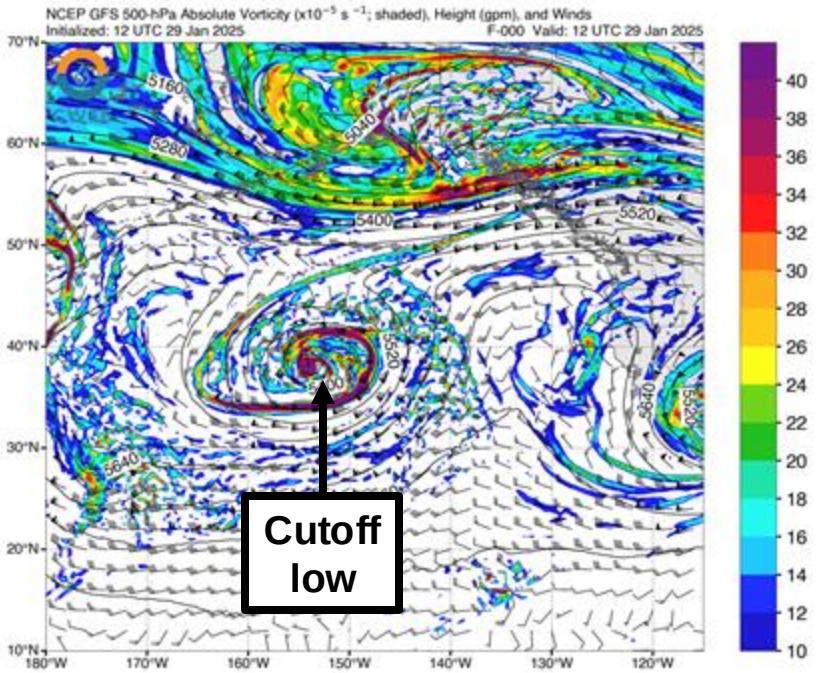


Source: NOAA/NESDIS Center for Satellite Applications and Research

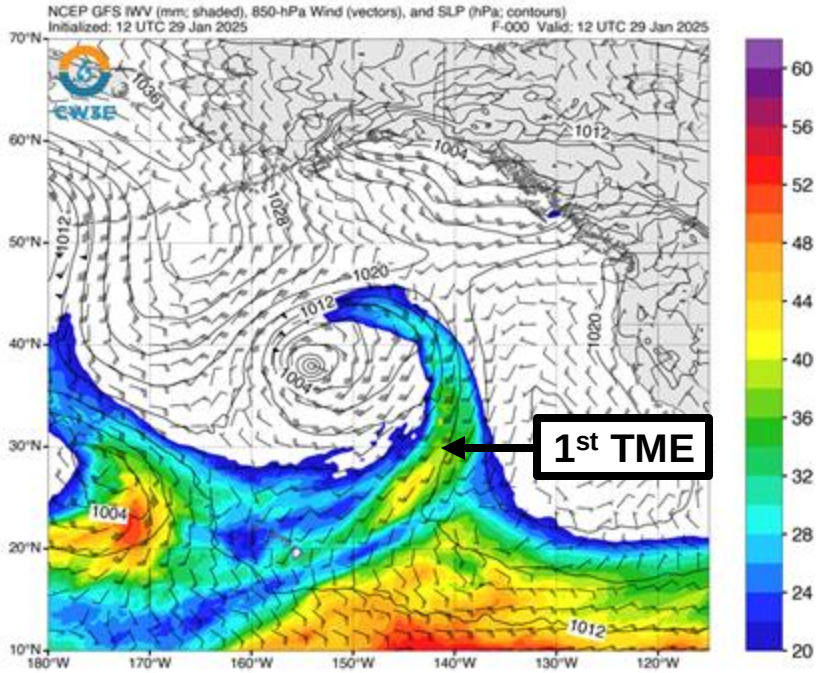
CW3E Event Summary: 31 January – 5 February 2025

GFS Analyses: Valid 4 AM PST 29 Jan

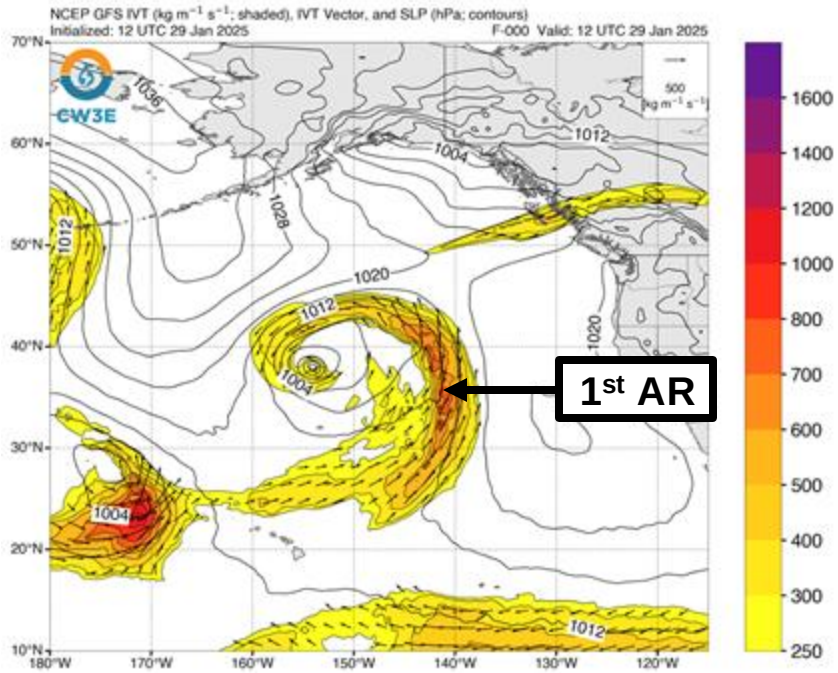
500-hPa Height/Vorticity



IWV & 850-hPa Wind



IVT & SLP

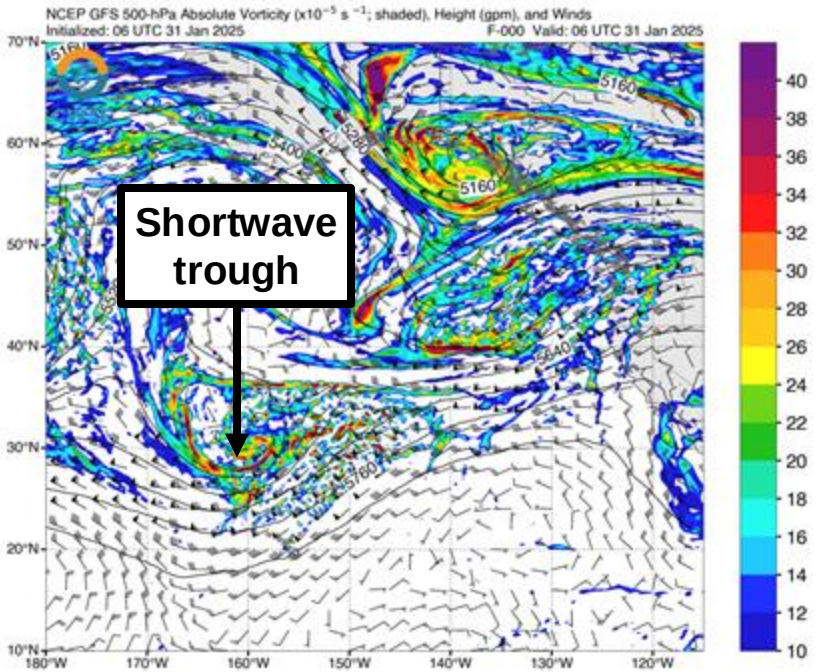


- After a prolonged period of ridging near the US West during much of January, a cyclonic wave-breaking event led to the formation of a cutoff low over the Northeast Pacific Ocean on Tue 28 Feb.
- Southerly flow downstream of the cutoff low facilitated the development of a tropical moisture export (TME) and atmospheric river (AR) near 140°W.

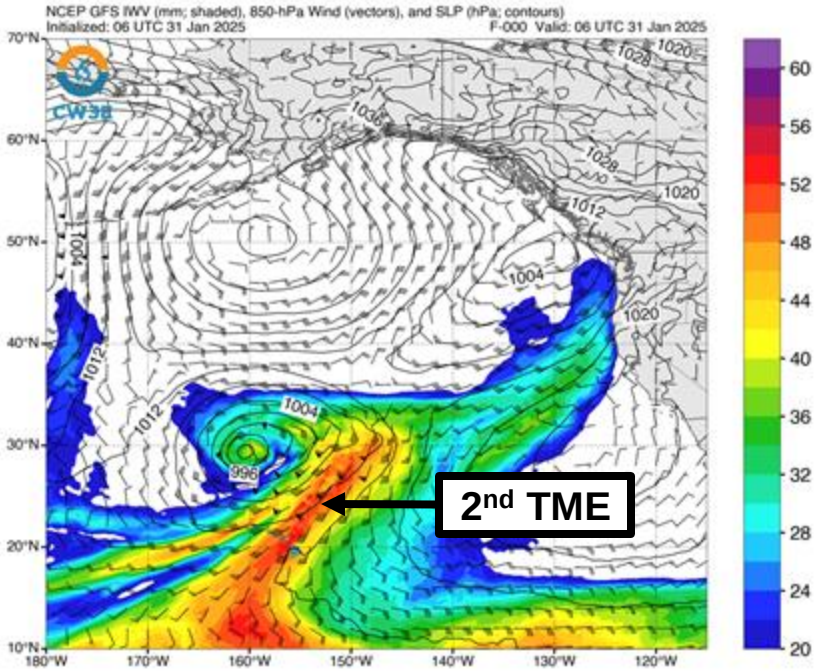
CW3E Event Summary: 31 January – 5 February 2025

GFS Analyses: Valid 10 PM PST 30 Jan

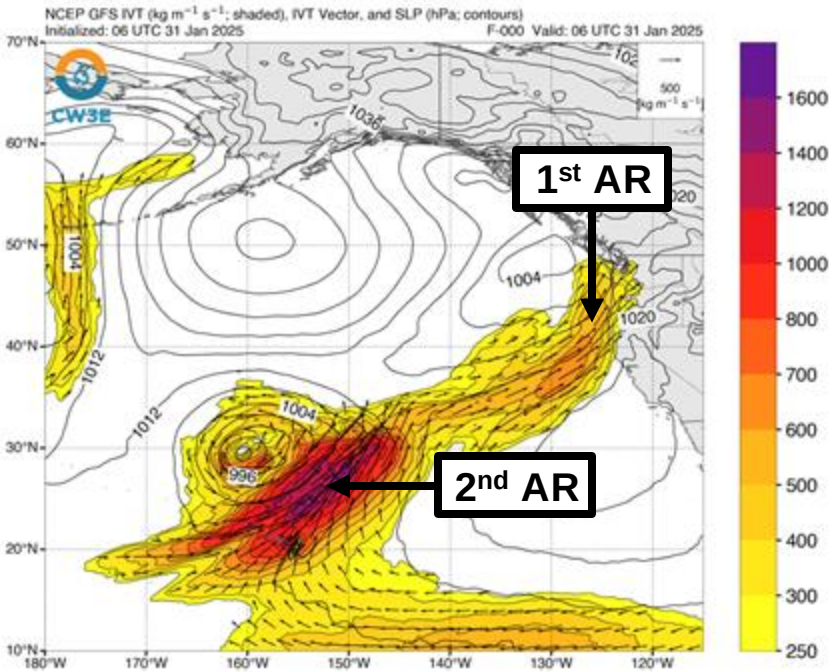
500-hPa Height/Vorticity



IWV & 850-hPa Wind



IVT & SLP

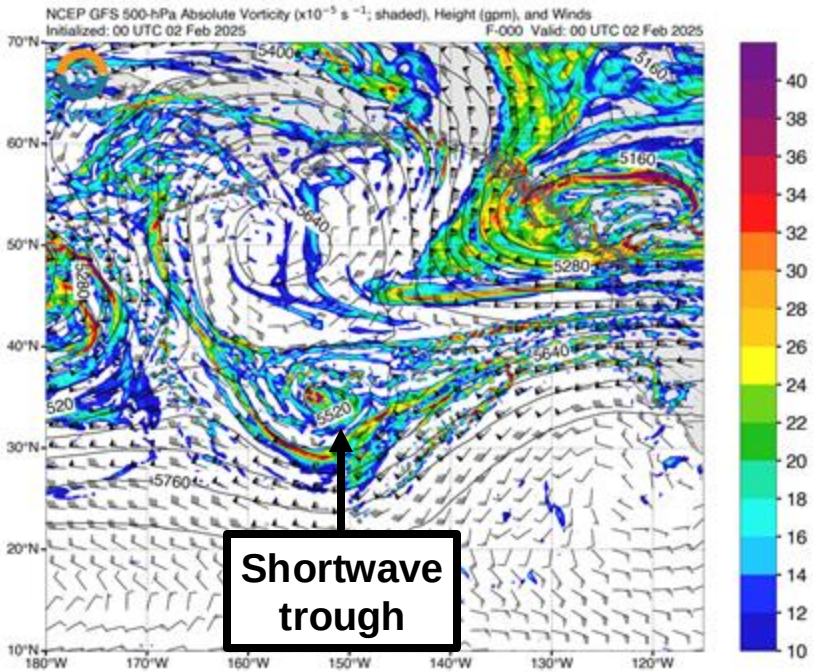


- The first AR propagated toward the US West Coast, making landfall late on Thu 30 Jan and bringing a period of weak AR conditions (IVT < 250 kg m^{-1} s^{-1}) to western Washington, western Oregon, and Northern California.
- Meanwhile, a strong surface cyclone developed north of Hawaii in association with a shortwave trough undercutting a blocking ridge over western Alaska.
- Strong low-to-midlevel southerly flow in the warm sector of the surface cyclone led to the formation of a much more impressive TME (IWV > 50 mm) and AR (IVT > 1400 kg m^{-1} s^{-1}).

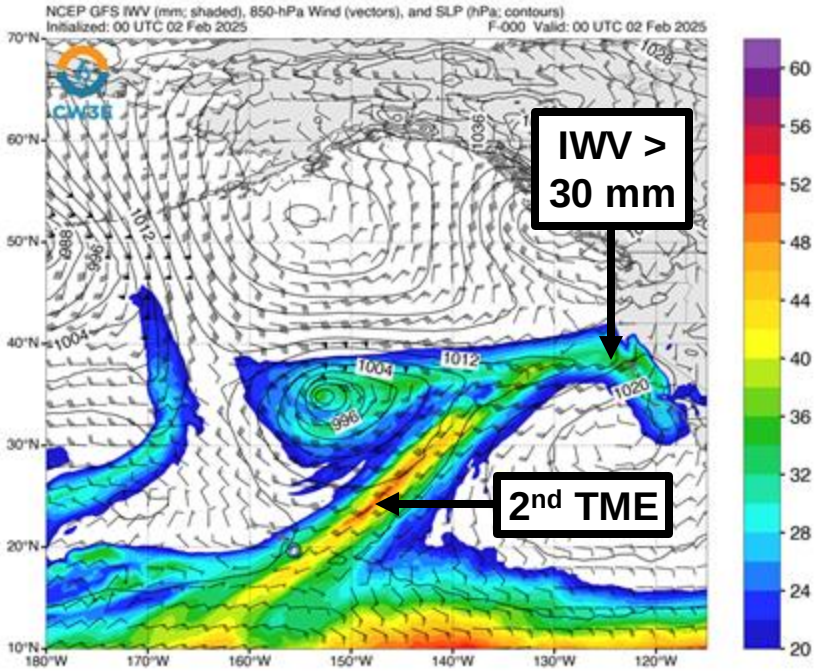
CW3E Event Summary: 31 January – 5 February 2025

GFS Analyses: Valid 4 PM PST 1 Feb

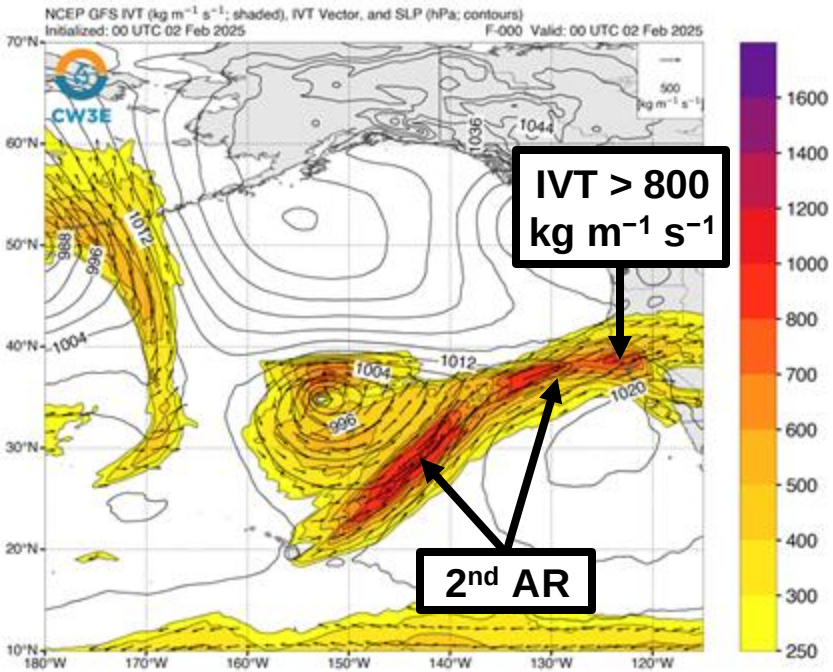
500-hPa Height/Vorticity



IWV & 850-hPa Wind



IVT & SLP

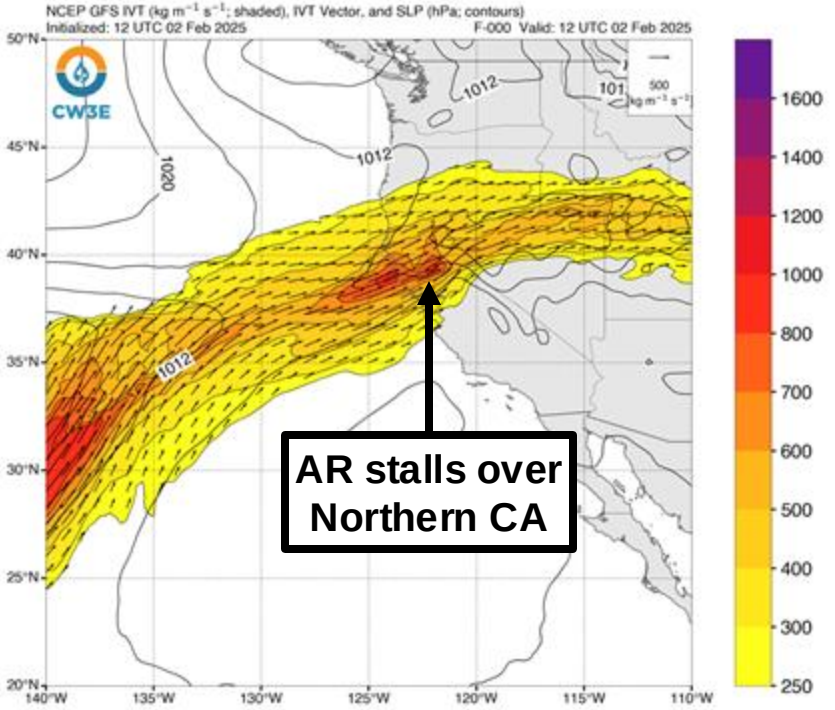


- The initial pulse of moisture transport associated with the second AR moved onshore on Sat 1 Feb, bringing a brief period of strong AR conditions (IVT ≥ 750 kg m^{-1} s^{-1}) to Sonoma County, CA.
- Strong west-southwesterly low-level winds (> 30 kts) and ample moisture (IWV > 30 mm) initially supported heavy precipitation over the Coast Ranges and Northern Sierra Nevada.
- Inland penetration of the second AR also facilitated heavy precipitation in northeastern California near the Nevada border.

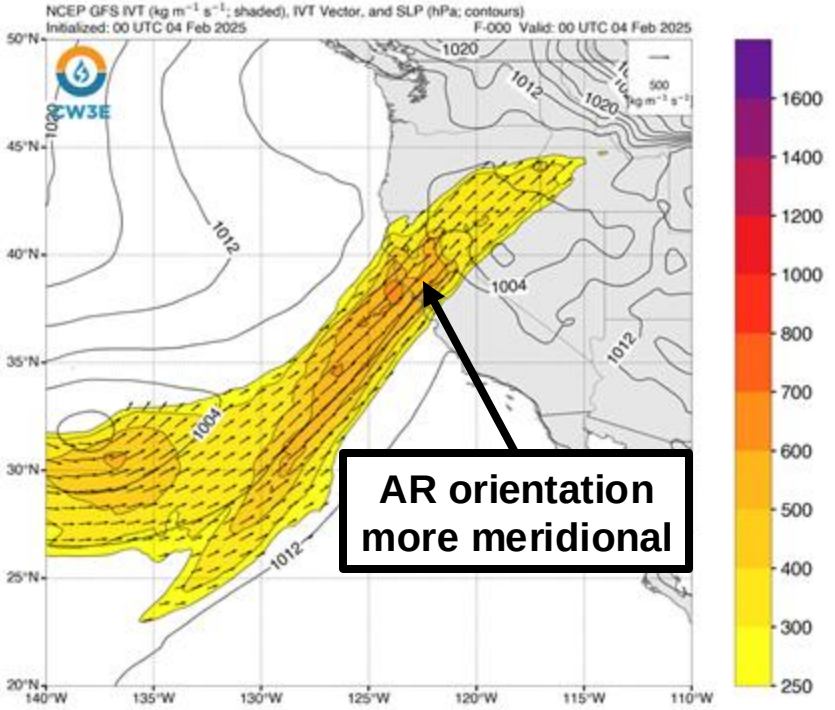
CW3E Event Summary: 31 January – 5 February 2025

GFS IVT & SLP Analyses

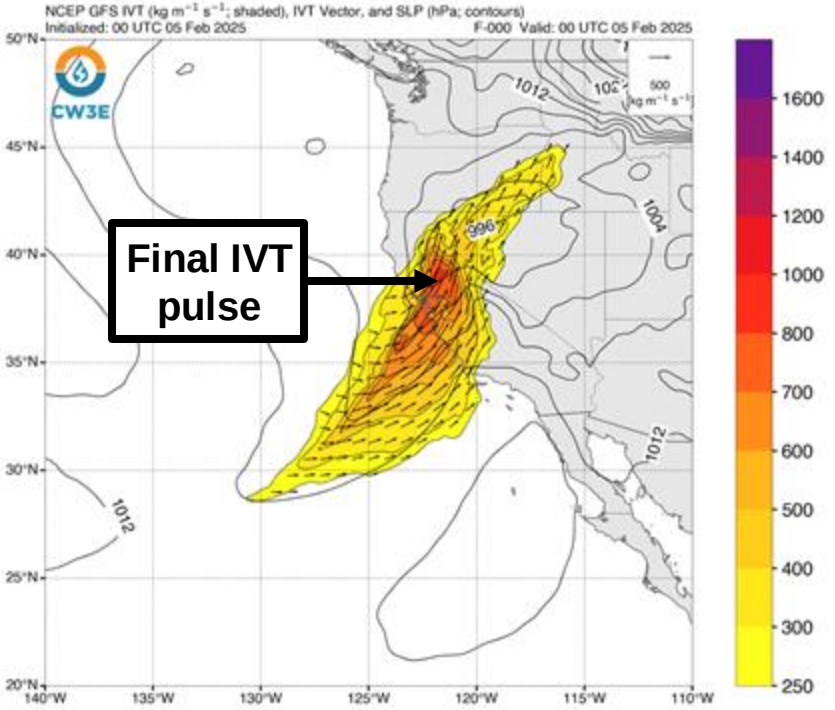
Valid 4 AM PST 2 Feb



Valid 4 PM PST 3 Feb



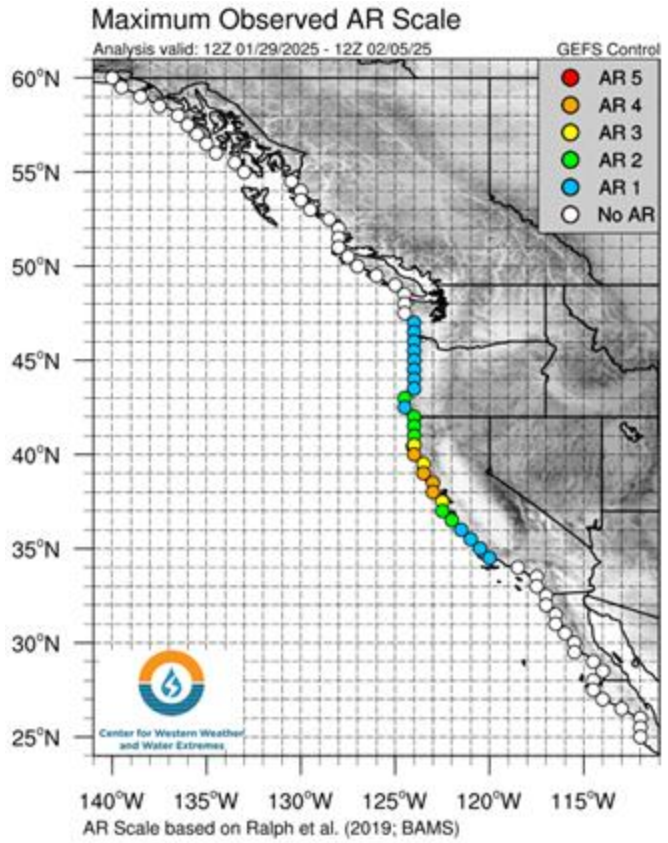
Valid 4 PM PST 4 Feb

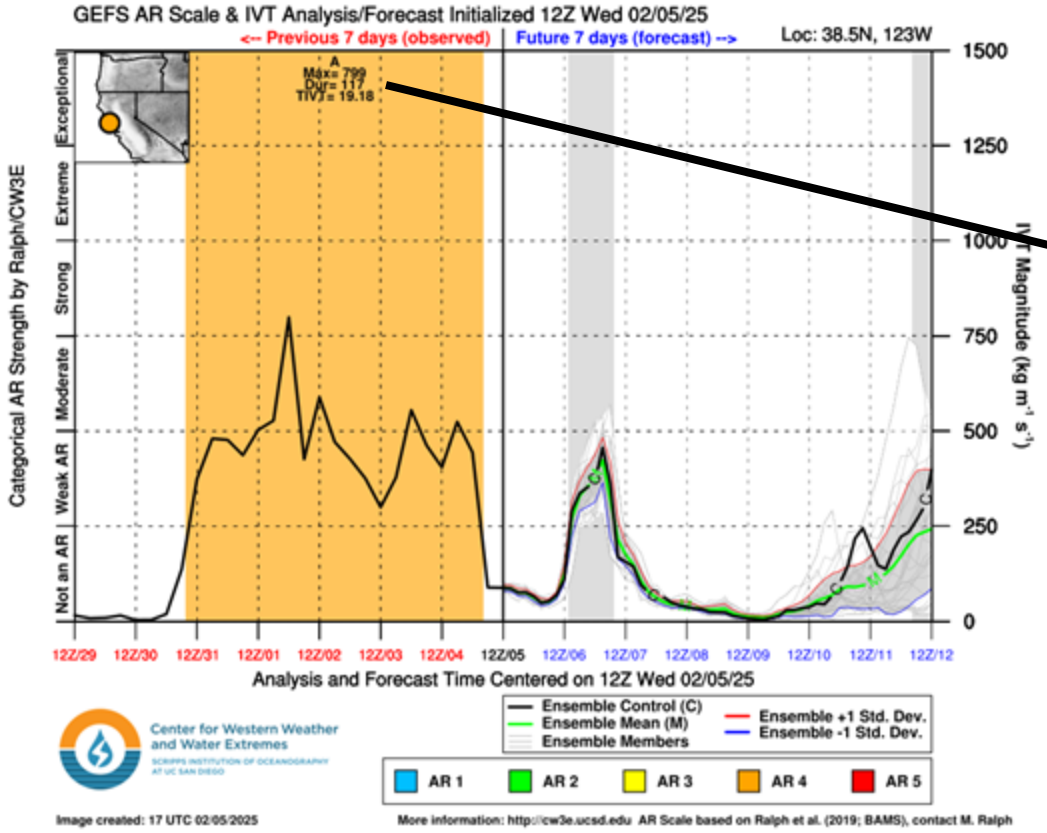


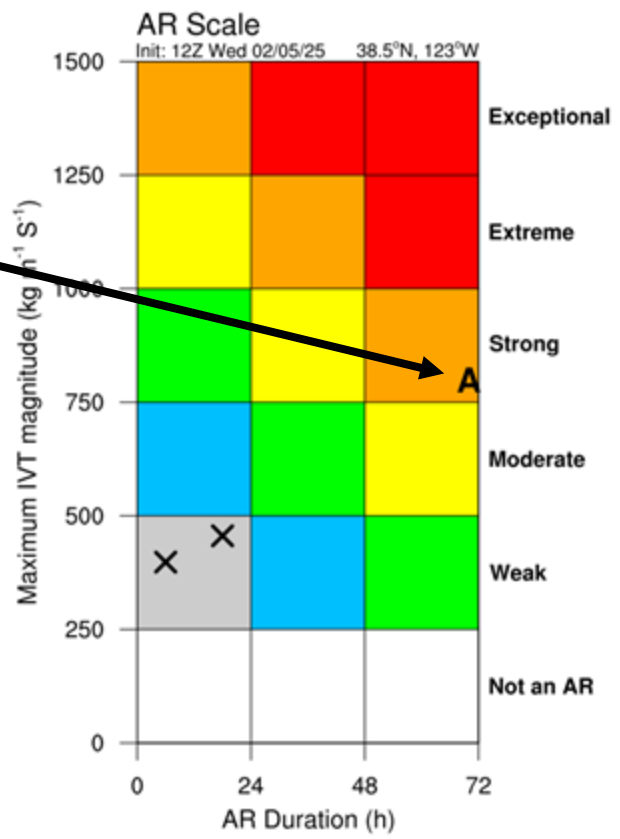
- The second AR subsequently stalled over Northern California, with three additional pulses of moisture transport moving onshore between Sun 2 Feb and Tue 4 Feb.
- As the last two moisture pulses moved onshore, the orientation of the AR became more meridional, which helped focus the heaviest precipitation over northern Sonoma County, the southern Cascades, and the Feather River Basin.
- The final moisture pulse brought a brief period of strong AR conditions to the Sacramento Valley.

CW3E Event Summary: 31 January – 5 February 2025

GEFS AR Scale Analysis (Coast)



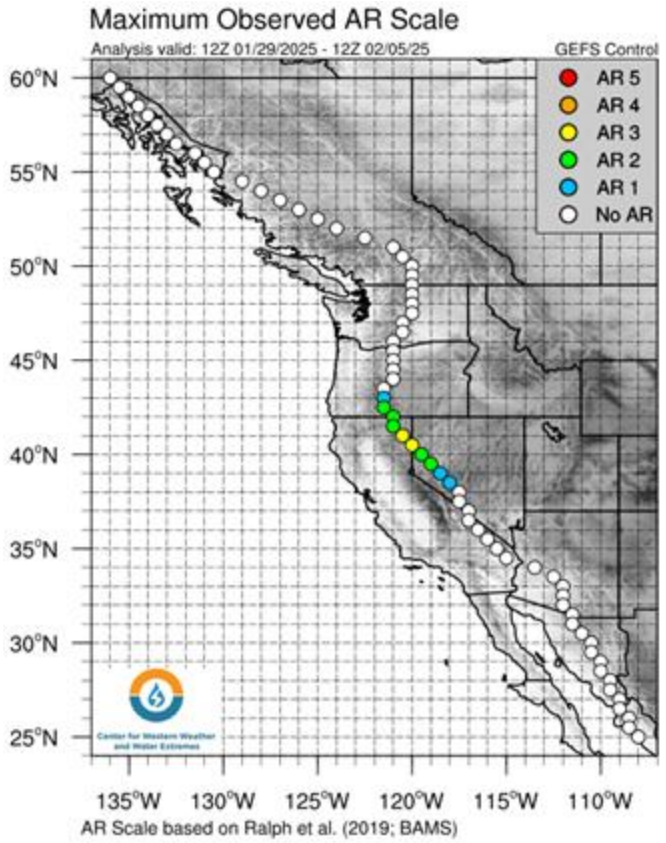


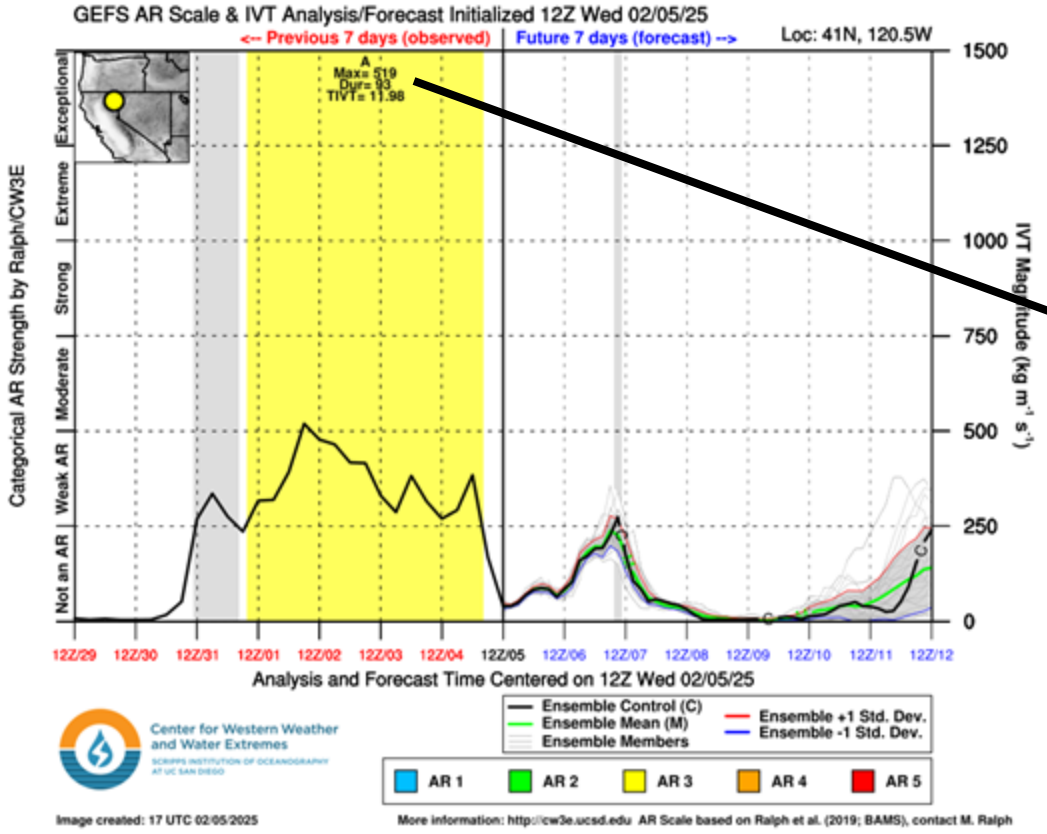


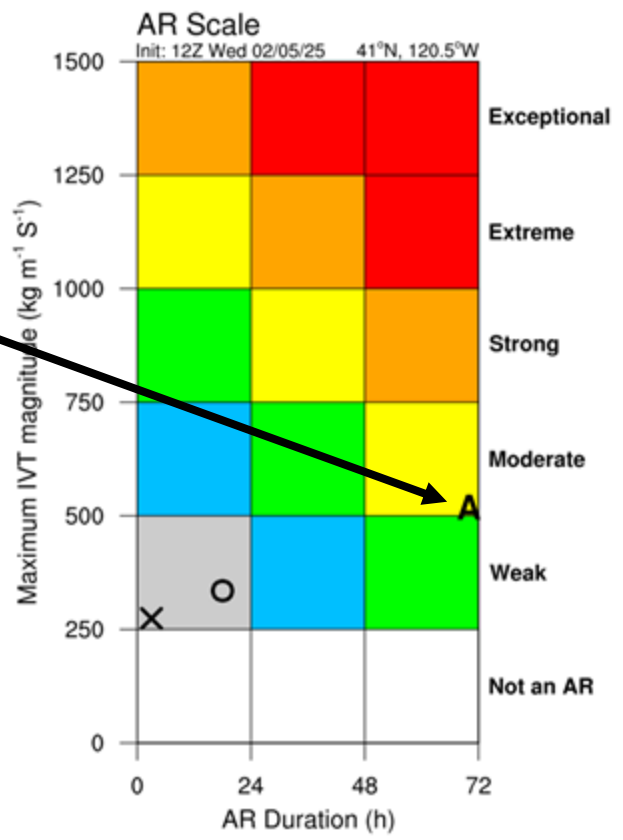
- An AR 4 (based on the Ralph et al. 2019 AR Scale) was observed over portions of coastal Northern California, with some locations experiencing > 100 hours of consecutive AR conditions.
- The GEFS AR Scale analysis shows a maximum IVT of 799 kg m^{-1} s^{-1} and an AR duration of 117 hours at 38.5°N 123°W (Sonoma County, CA).

CW3E Event Summary: 31 January – 5 February 2025

GEFS AR Scale Analysis (Inland)







- Inland penetration and stalling of the second AR produced AR 2-3 conditions over northeastern California and northwestern Nevada.
- The GEFS AR Scale analysis shows a maximum IVT of 519 kg m^{-1} s^{-1} and an AR duration of 93 hours at 41°N 120.5°W (Lassen County, CA).

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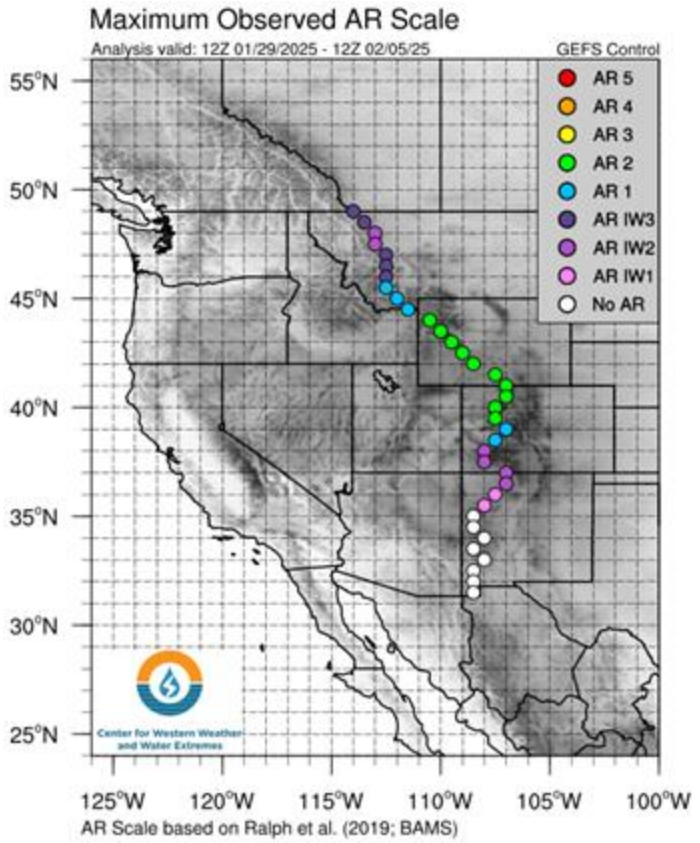
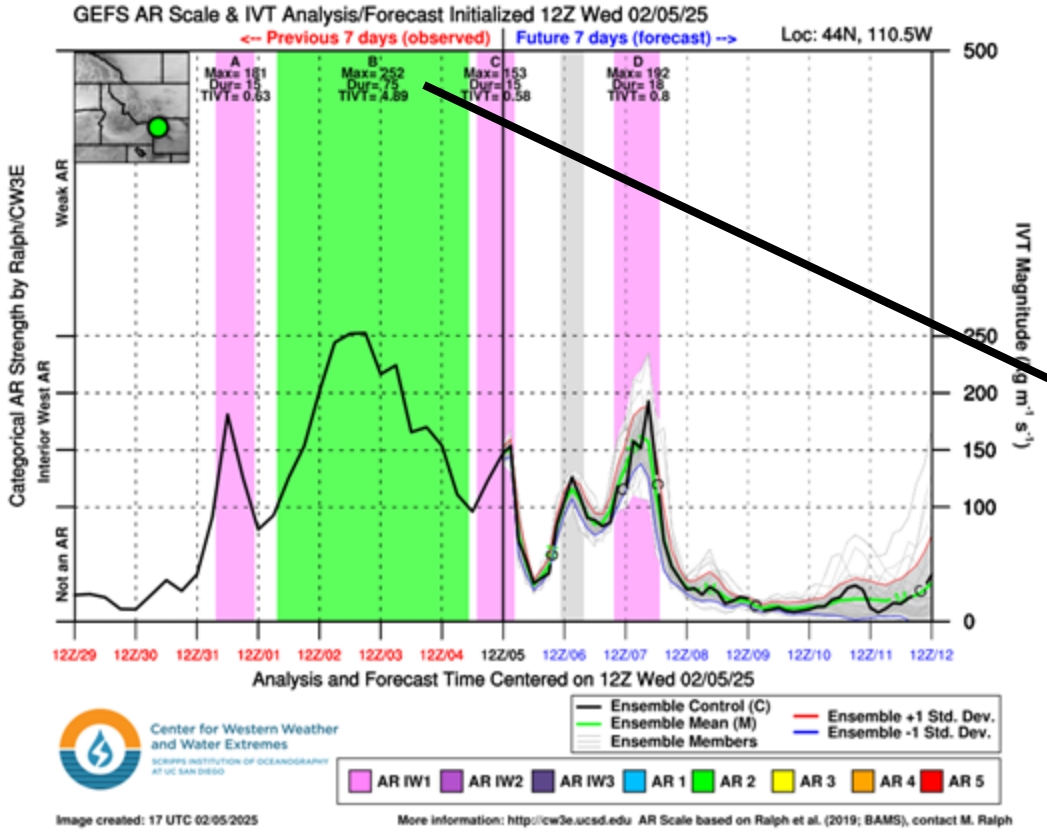
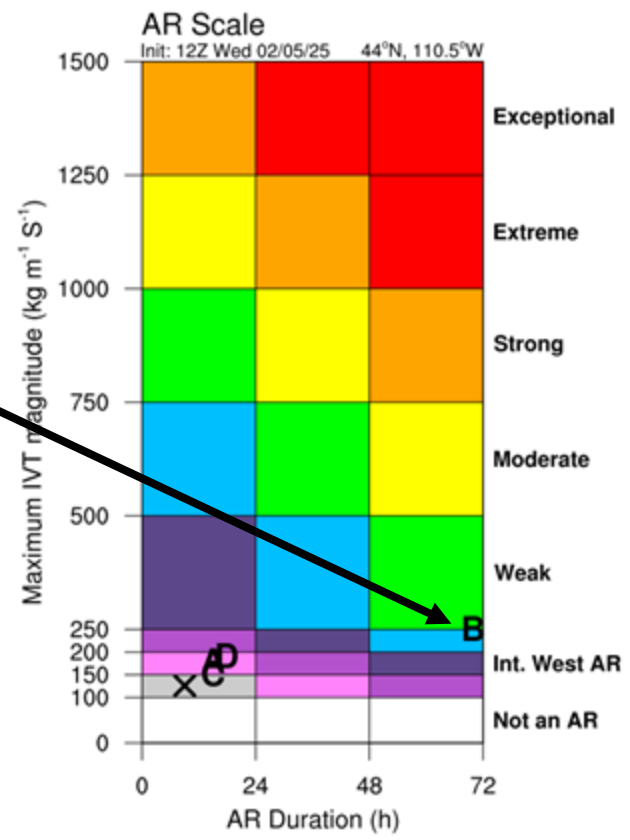
GEFS AR Scale Analysis (Interior West)







- Enhanced moisture transport within the second AR extended all the way to the Rocky Mountains in Wyoming and northern Colorado.
- The GEFS AR Scale analysis shows a maximum IVT of 252 kg m^{-1} s^{-1} and 75 hours of IVT ≥ 100 kg m^{-1} s^{-1} at 44°N 110.5°W (Teton County, WY), meeting the criteria for an AR 2 based on the Interior West version of the AR Scale.

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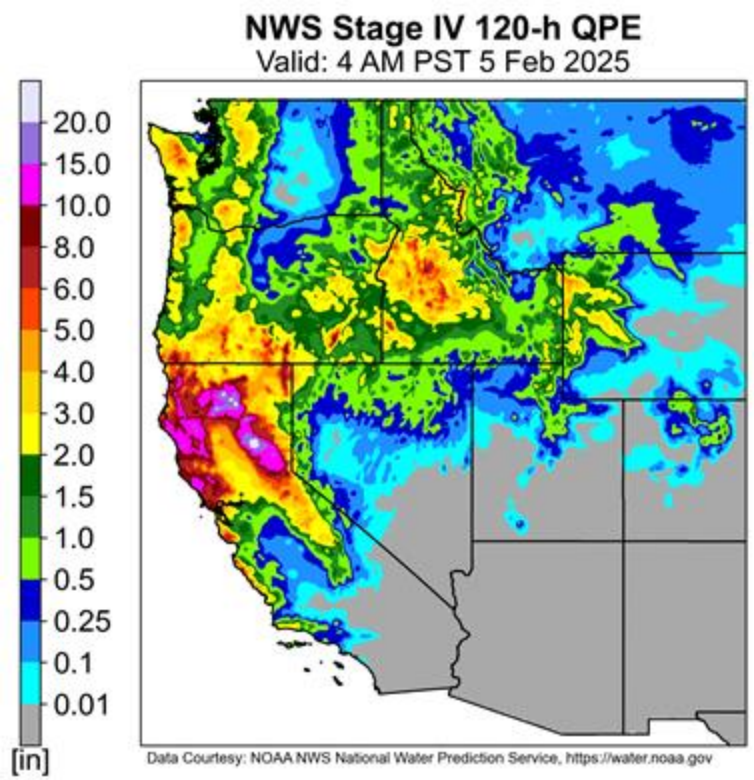
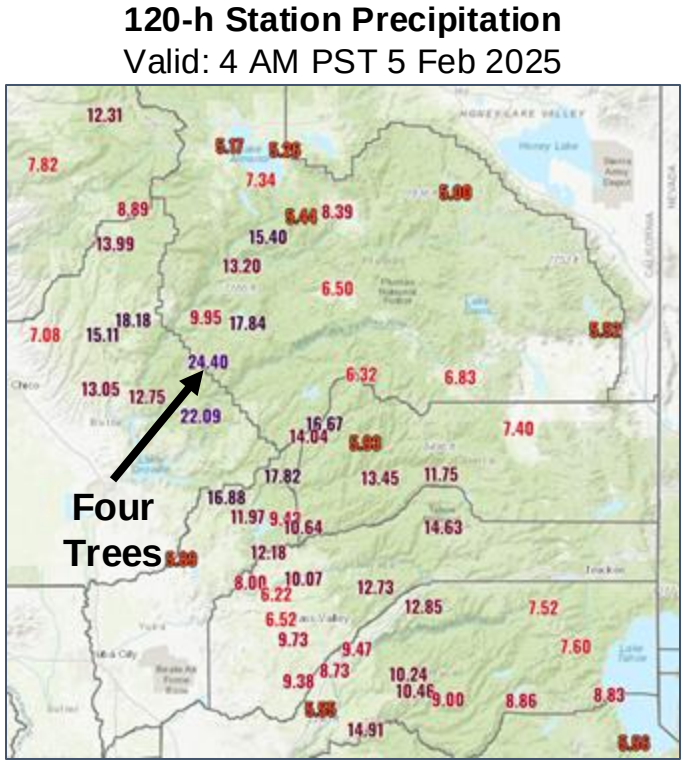
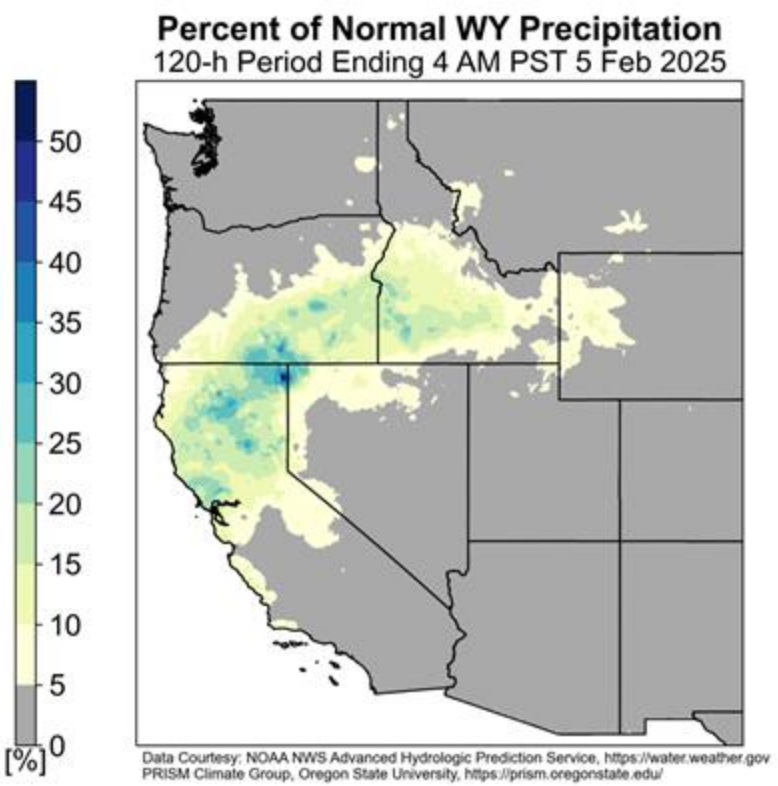
Observed Precipitation





Credit: NOAA/NWS Western Region



- These ARs produced at least 6–15 inches of precipitation over the Northern California Coast Ranges, Klamath Mountains, southern Cascades, and Northern Sierra Nevada. An event maximum of 24.4 inches was recorded at Four Trees in the North Fork Feather watershed.
- Alturas, CA (2.13 inches) recorded its wettest February day and 2nd wettest calendar day overall on Sun 2 Feb.
- Redding Airport (4.33 inches) also recorded its wettest February day and 6th wettest calendar day overall on Sun 2 Feb.
- Some locations in Northern California received >25% of normal annual precipitation in a 5-day period.

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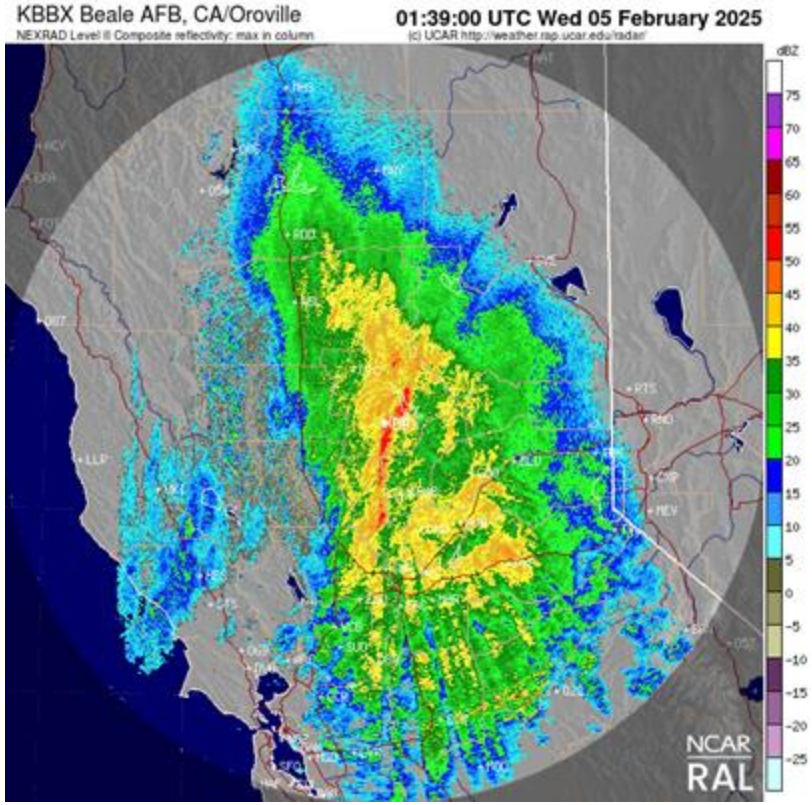
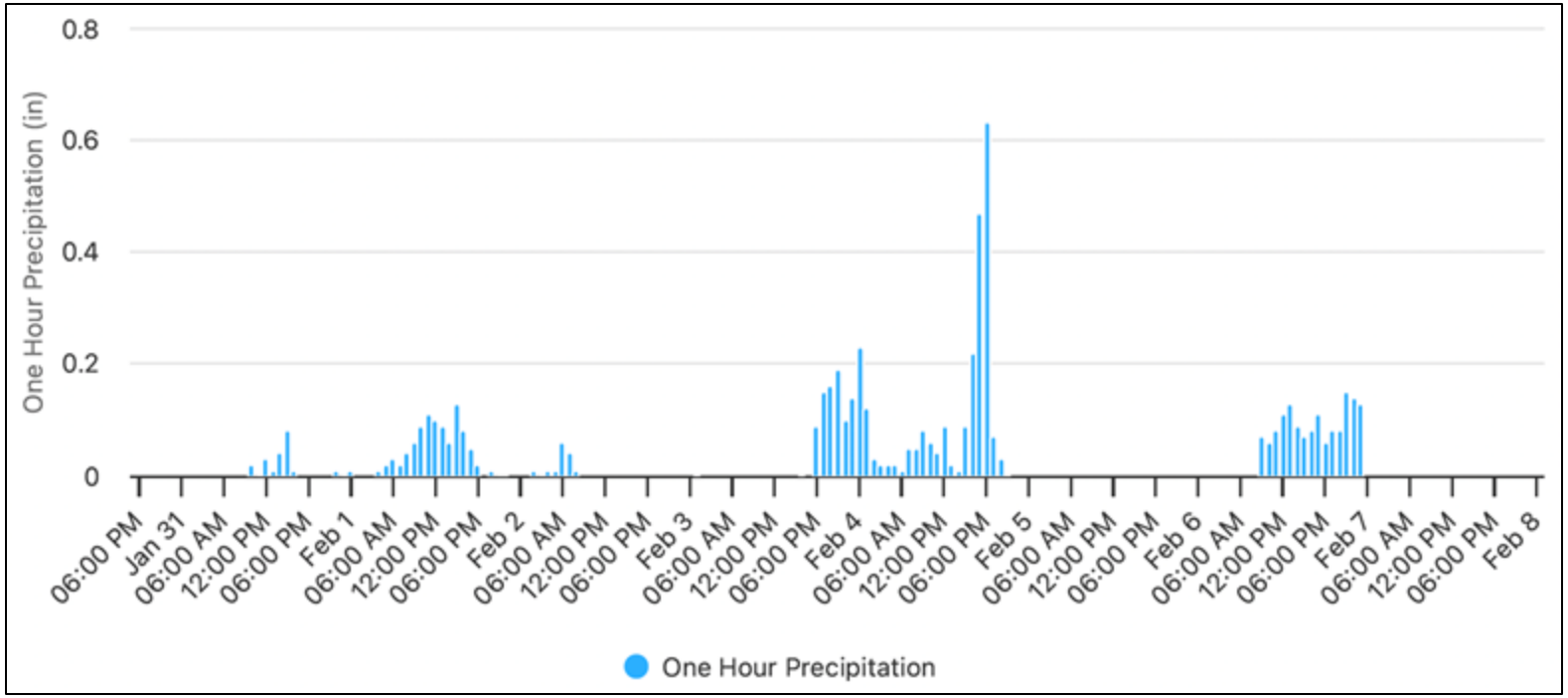
Observed Precipitation



Hourly Precipitation: Oroville Airport (OVE)



Credit: NOAA/NWS Western Region

- Mesoscale rainbands that formed within the final pulse of moisture transport produced some of the highest rainfall intensities during this event.
- NEXRAD radar at Beale Air Force Base (KBBX) captured feature resembling a narrow cold-frontal rainband (NCFR) propagating eastward across the Sacramento Valley during late afternoon/early evening on Tue 4 Feb.
- Oroville Airport (OVE) recorded 0.63 inches of precipitation during the hour ending 6 PM PST Tue 4 Feb.

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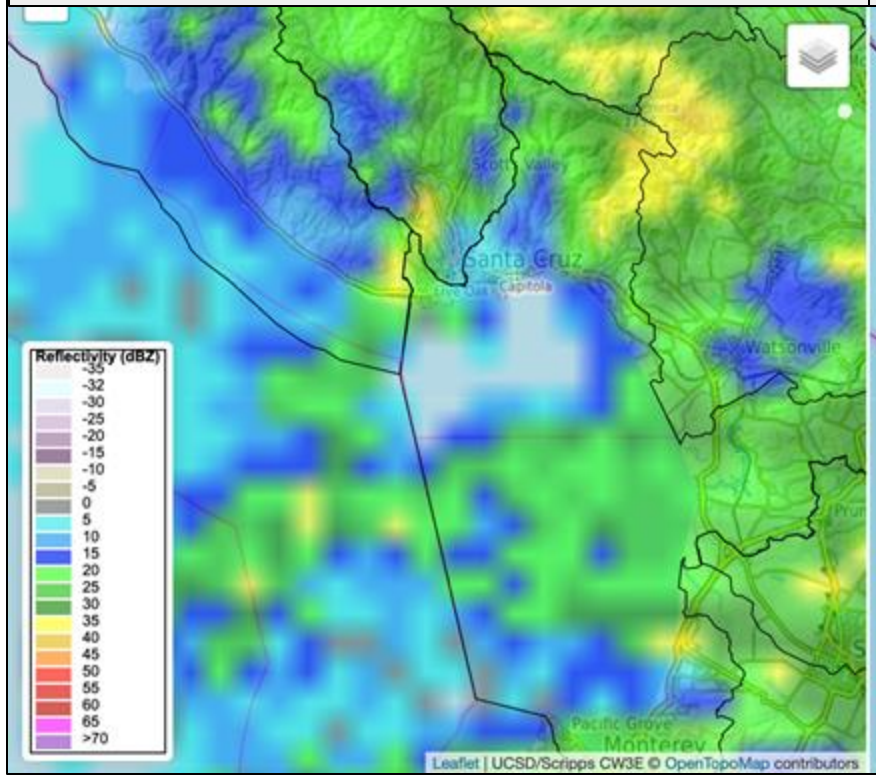
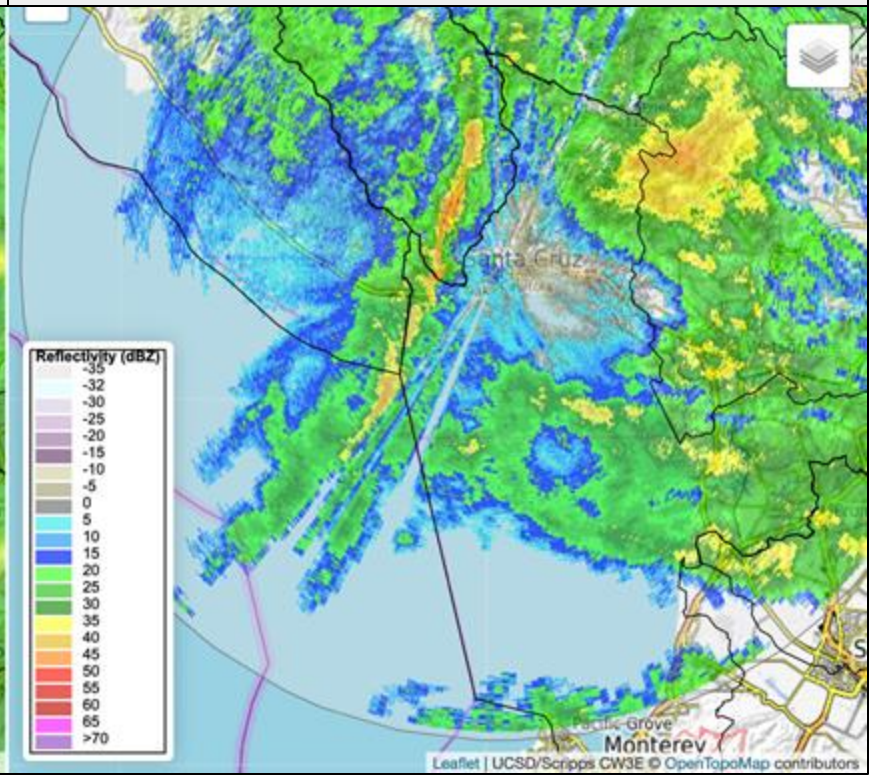
AQPI Observations

NEXRAD Radar	AQPI Radar
	

Comparison of NEXRAD (left) and AQPI (right) radar reflectivity near Santa Cruz, CA at 5:45 PM PST 4 Feb 2025. Note the narrow band of heavy precipitation (brighter colors) clearly seen by the AQPI radar.

- AQPI radar across the San Francisco Bay Area operates at a higher spatiotemporal resolution than the legacy NEXRAD radar network.
- This enables better identification of key precipitation features for short-term forecasting, and better precipitation estimation in areas without rain gauges.

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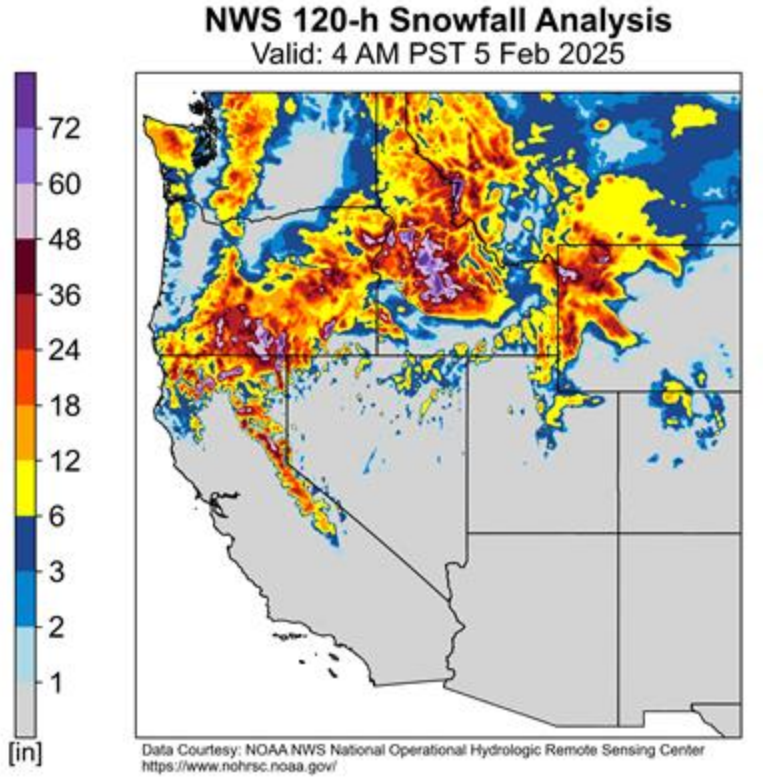
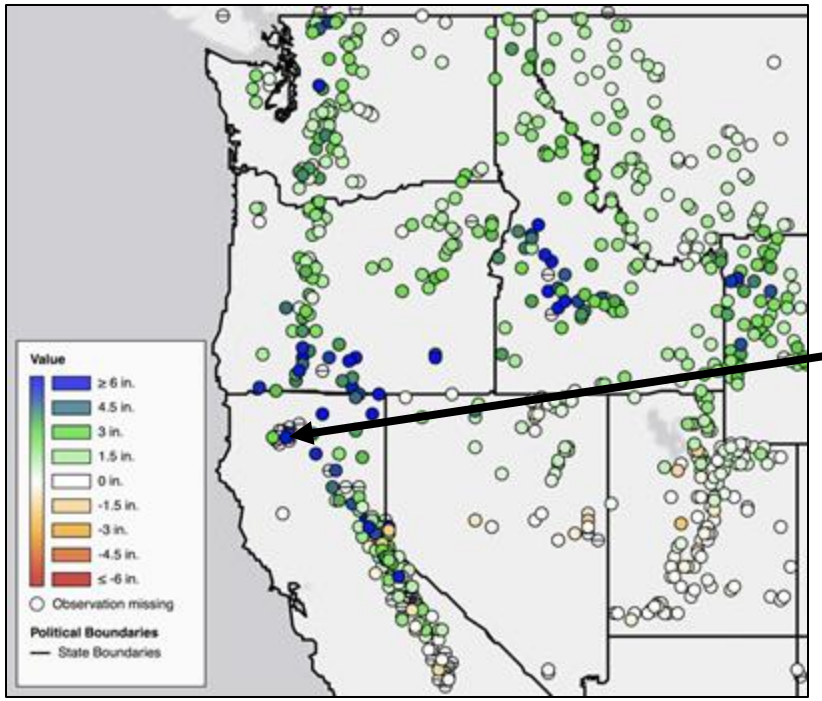
Observed Snowfall

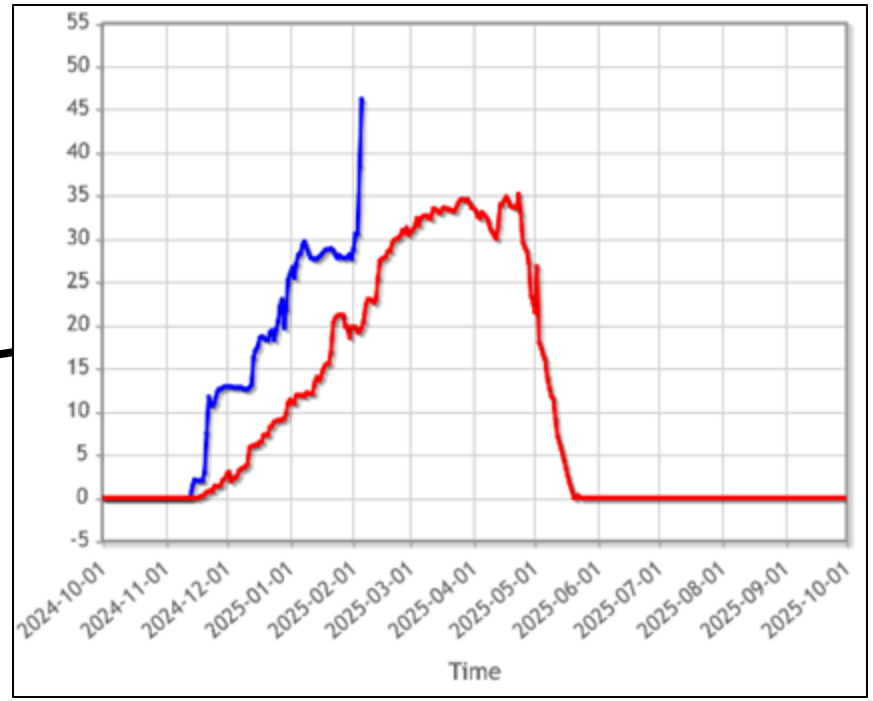


5-day SWE Change: Valid First of Day 5 Feb



Credit: USDA NRCS National Water & Climate Center

WY 2025 SWE: Bonanza King (Elev: 6,540 ft)



Credit: USDA NRCS National Water & Climate Center

- While much of the precipitation in California fell as rain due to high freezing levels, these ARs produced an estimated 2–6 feet of snow in the highest elevations of the Klamath Mountains, southern Cascades, and Northern Sierra Nevada.
- Inland penetration of the second AR also produced an estimated 4+ feet of snow in Central Idaho.
- Several SNOTEL and cooperator snow sensor stations in Northern California, southern Oregon, and Central Idaho recorded snow water equivalent (SWE) increases of 6 inches or more between Fri 31 Jan and Wed 5 Feb.
- Bonanza King (Trinity County, CA) recorded a 2-day SWE increase (15.6 inches) equivalent to 45% of the climatological median peak SWE (34.6 inches) between Mon 3 Feb and Wed 5 Feb.

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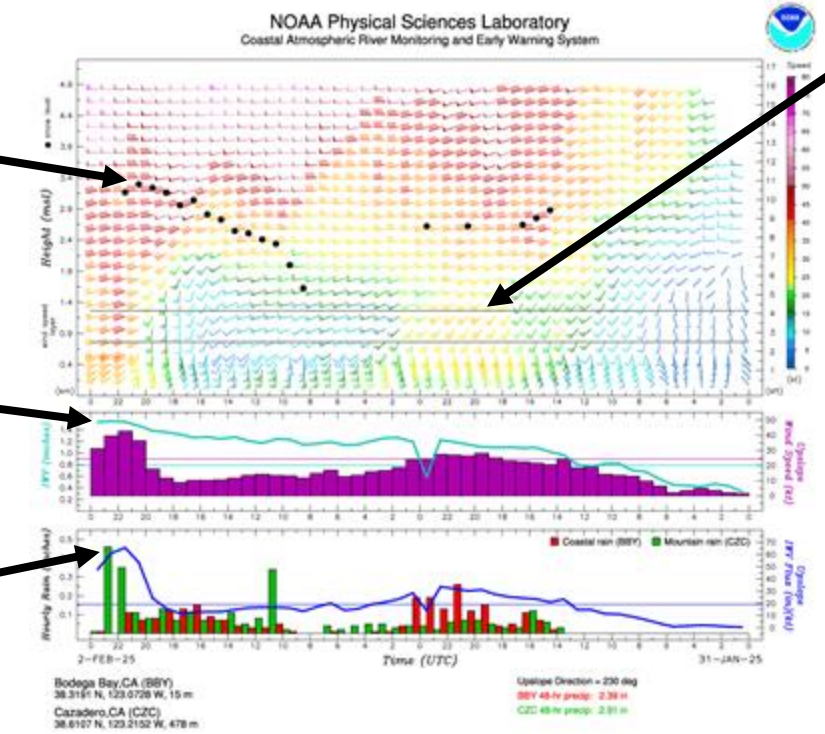
Wind Profiler and GPS-Derived IWV: Bodega Bay (BBY)

Valid 00Z 31 Jan - 00Z 2 Feb



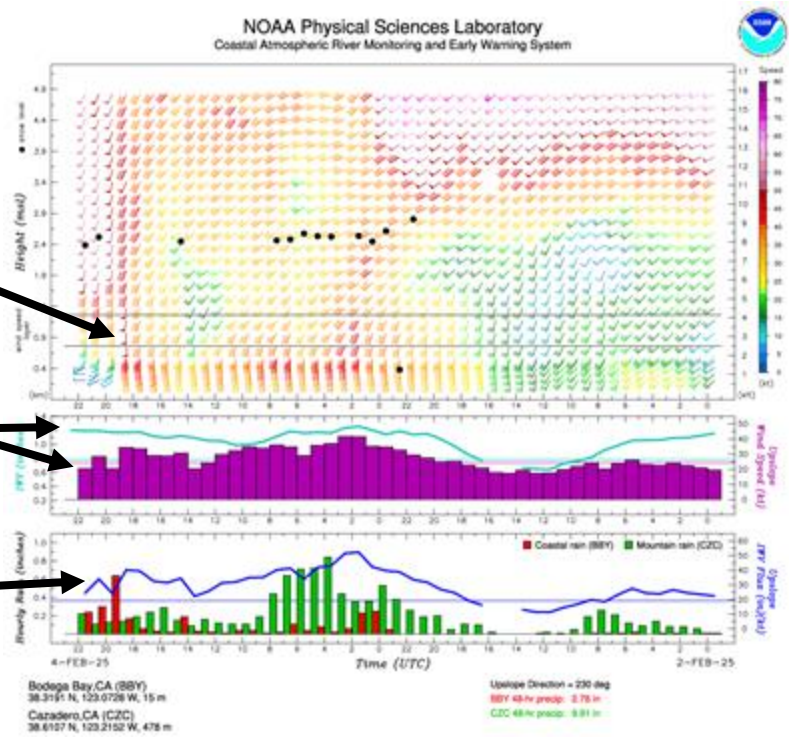
1.5 km rise in snow level

Moderate Southwesterly winds at 1km

Increasing IWV

Strong upslope moisture flux

Valid 00Z 2 - 00Z 4 Feb



Strong Southwesterly winds at 1km

Strong upslope wind and high IWV values

Strong upslope moisture flux

- The Bodega Bay (BBY) and Cazadero (CZC) wind profilers were able to measure the conditions that helped drive the extreme precipitation in Northern California.
- On 1 Feb, the profiler observed a 1.5 km (~4,900 ft) rise in the snow level (black dots) in approximately 12 hours.
- The profiler observed strong upslope moisture flux for most of 2–4 Feb due to the combination of IWV values above 25 mm and southwesterly upslope winds exceeding 20 knots. The snow level was near 2.4 km (7,900 ft) on 3 Feb.

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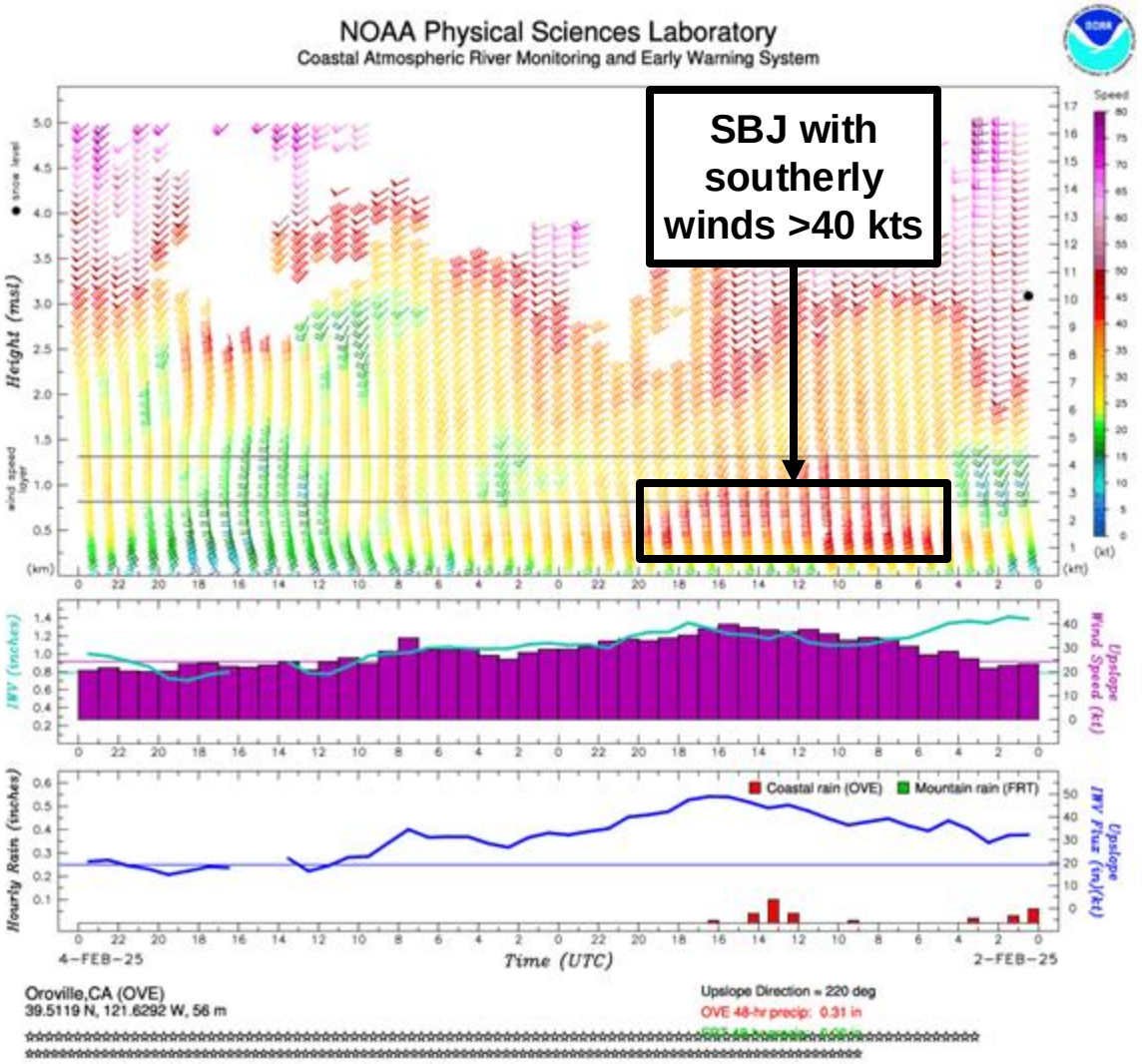
Wind Profiler and GPS-Derived IWV: Oroville (OVE)



- The wind profiler at Oroville (OVE) captured the formation of a strong Sierra barrier jet (SBJ) shortly after the second AR landfall.
- An event stronger SBJ was recorded during the final pulse of moisture transport on Tue 4 Feb (wind profiler plot is unavailable for the 4–5 Feb period).
- The presence of these SBJs may have enhanced precipitation amounts at the northern end of the Sacramento Valley, as well as over portions of the southern Cascades and Feather River basin.

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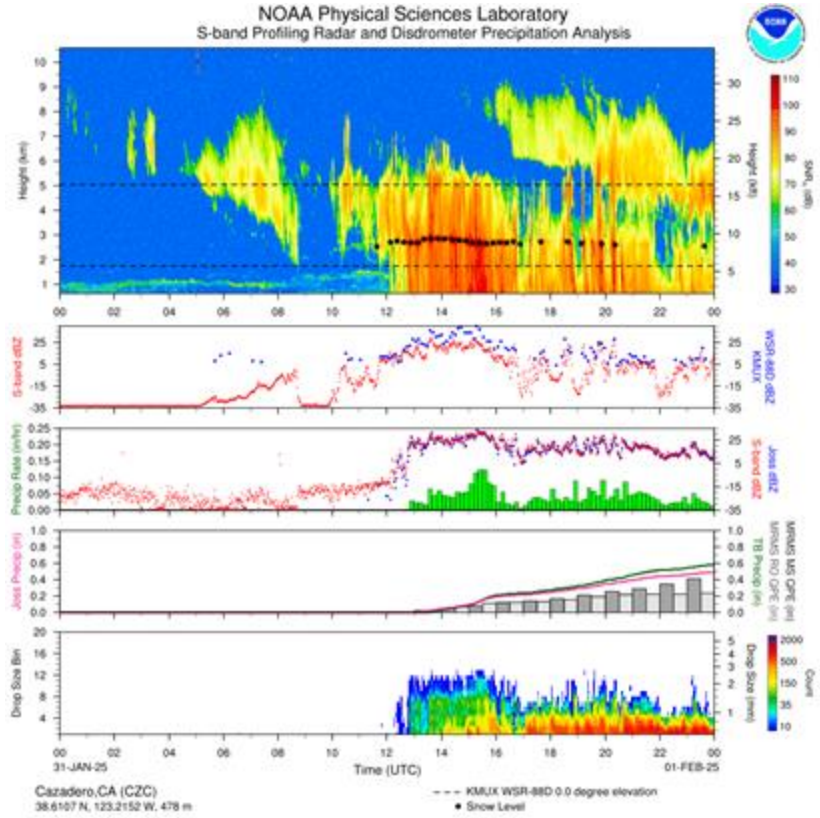
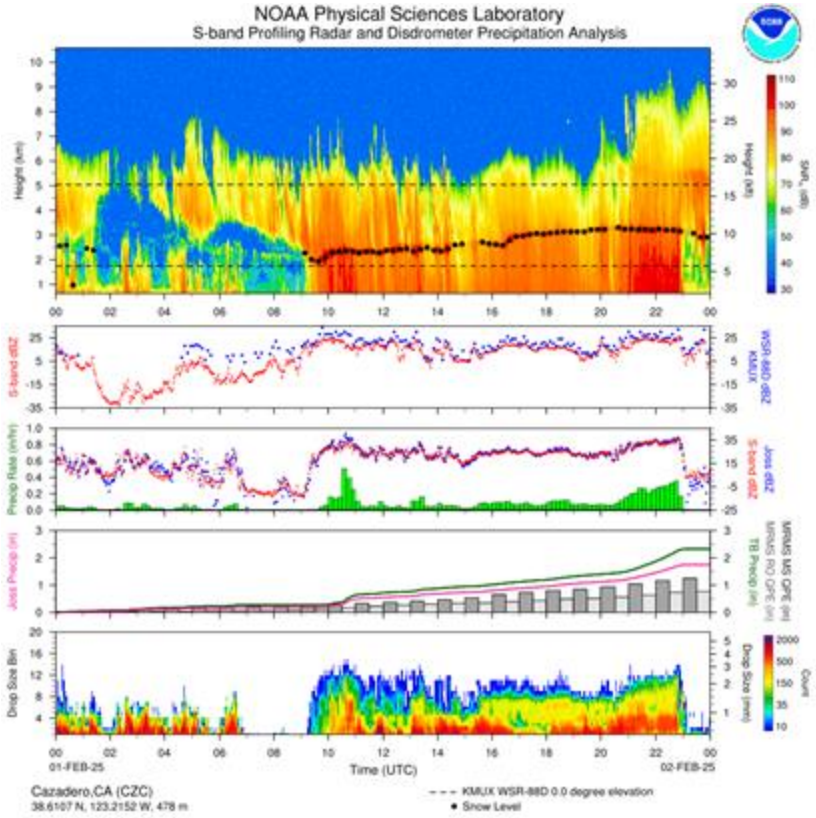
S-Band Profiling Radar and Disdrometer: Cazadero (CZC)

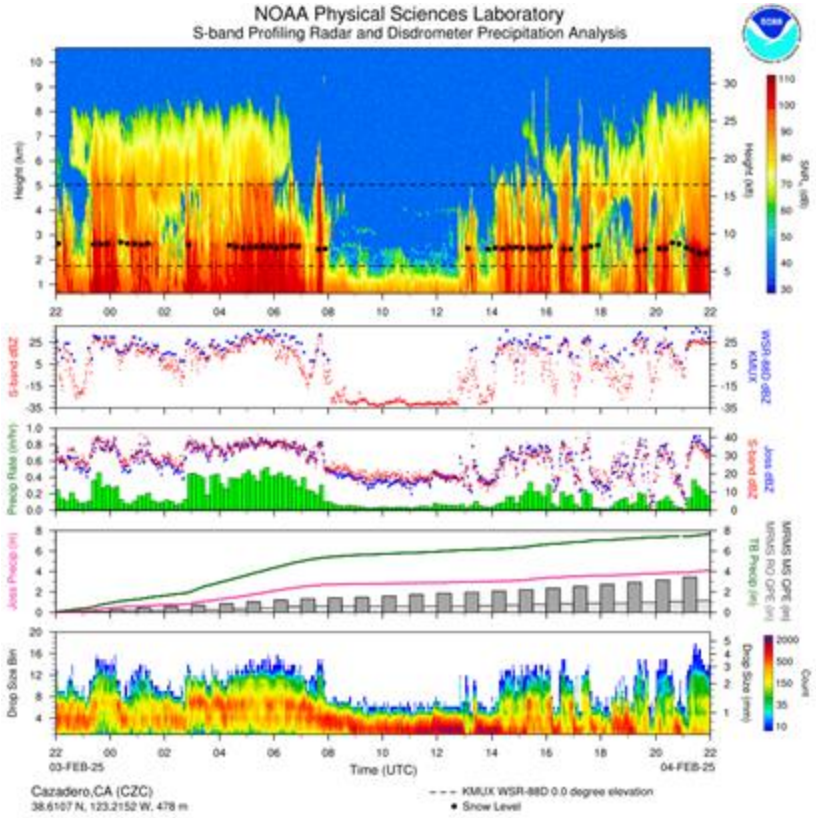
Valid 00Z 31 Jan - 00Z Feb



Valid 00Z 1 - 00Z 2 Feb



Valid 00Z 3 - 00Z 4 Feb



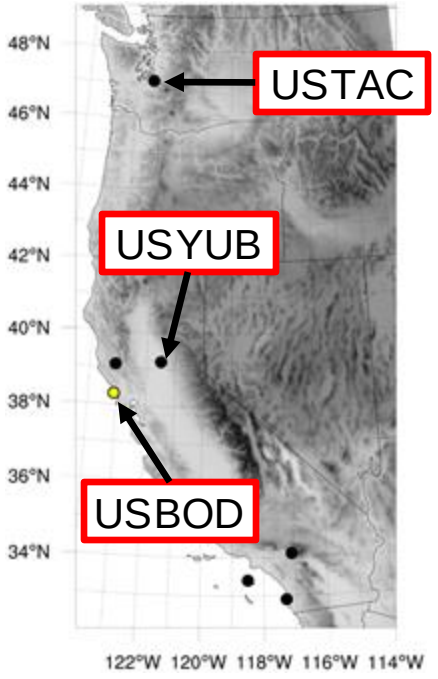
- The S-band profiling radar at CZC captured the persistent light-to-moderate rain with up to 0.5 inches/hour precipitation rates that resulted in ~15 inches of total precipitation as measured by the CZC rain gauge (3rd and 4th plots from top).
- The radar measured a rise in the snow level (top plot, black dots) on 1 Feb of approximately 1 km (~3,300 ft), similar to the BBY profiler.

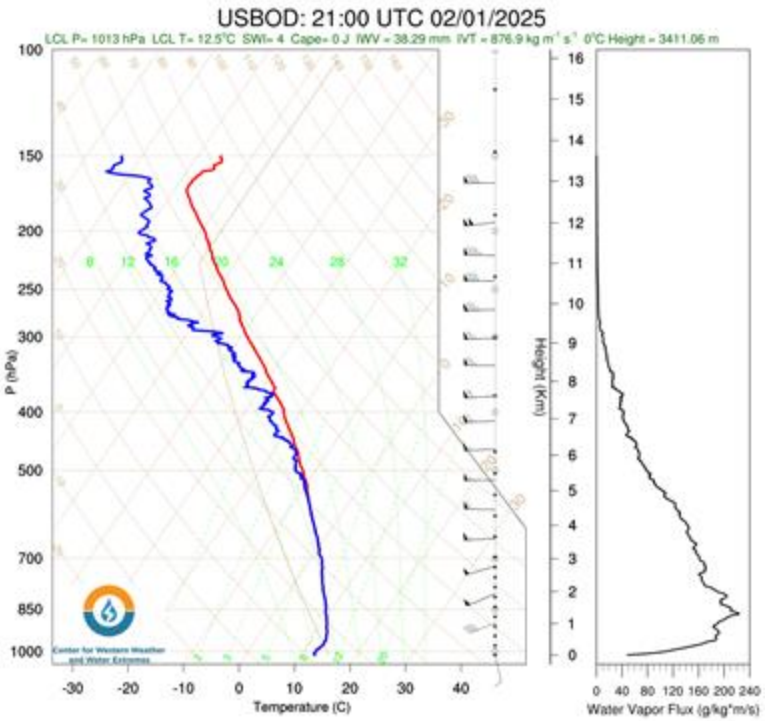
CW3E Event Summary: 31 January – 5 February 2025

CW3E Observations: Radiosondes

Site	End Date/Time	End Date/Time	Max IWV (mm)	Max IVT [(kg/(ms)]	Duration of AR Conditions (h)	AR Scale	Sondes
USTAC	03Z 31 Jan	03Z 1 Feb	18.51	357.0	21	0	9
USBOD	09Z 31 Jan	03Z 5 Feb	38.29	876.9	111	4	39
USYUB	12Z 31 Jan	06Z 5 Feb	35.54	825.4	111	4	39

- CW3E staff and partners launched a total of 87 radiosondes at Tacoma (USTAC), Bodega Bay (USBOD), and Marysville (USYUB) during this event.
- These radiosondes measured an AR 4 at USBOD and USYUB, with AR conditions lasting >100 hours and a maximum IVT >800 kg m^{-1} s^{-1}) at both locations.
- Local news crews filmed launches at Bodega Bay and Tacoma.

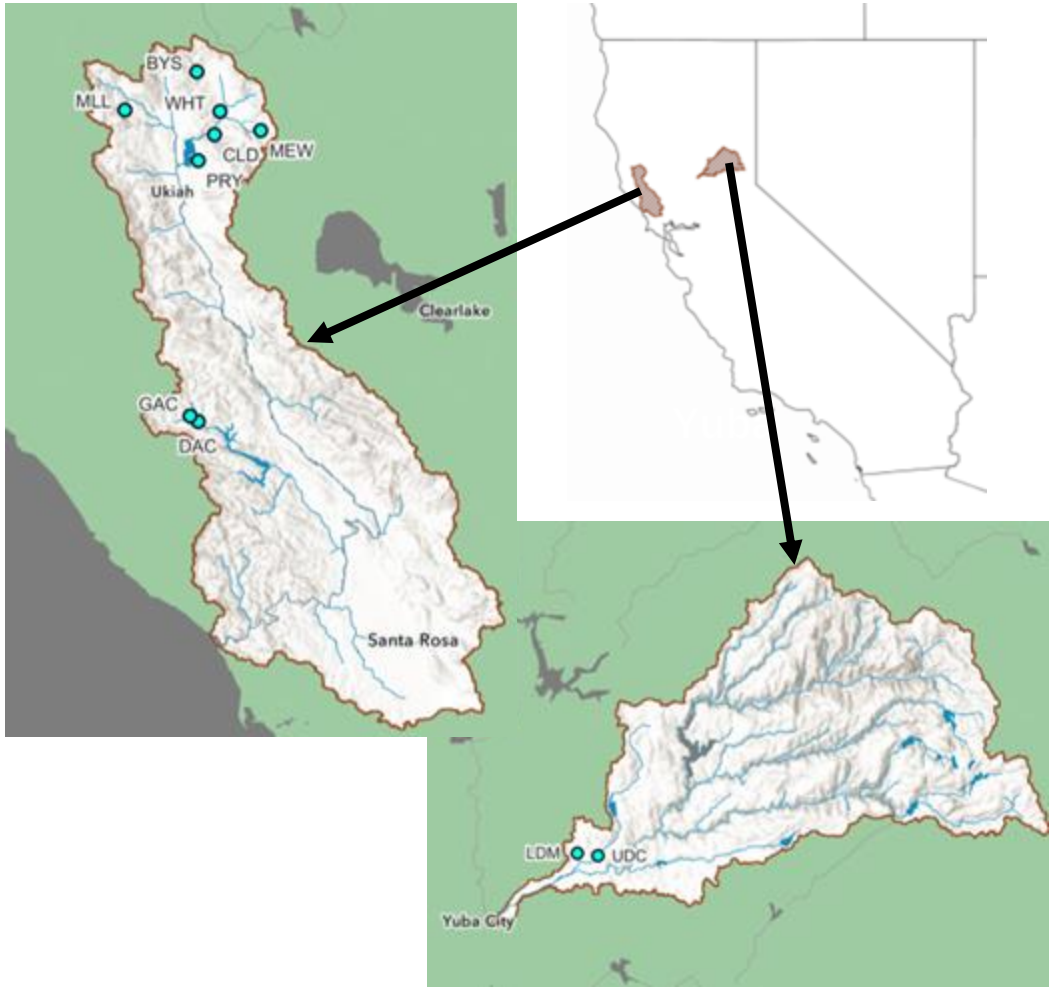




CW3E Event Summary: 31 January – 5 February 2025

CW3E Observations: Streamflow

- CW3E Field Team took manual stream discharge measurements in the Russian (8 sites) and Yuba (3 sites) watersheds. High flows were observed at all 11 sites.
- Perry Creek (PRY) measured 40.6 cfs (previous highest measured was 21.7 cfs).
- Little Dry Creek at Marysville Rd (LDM) measured ~240 cfs (previous highest measured was 56.6 cfs,



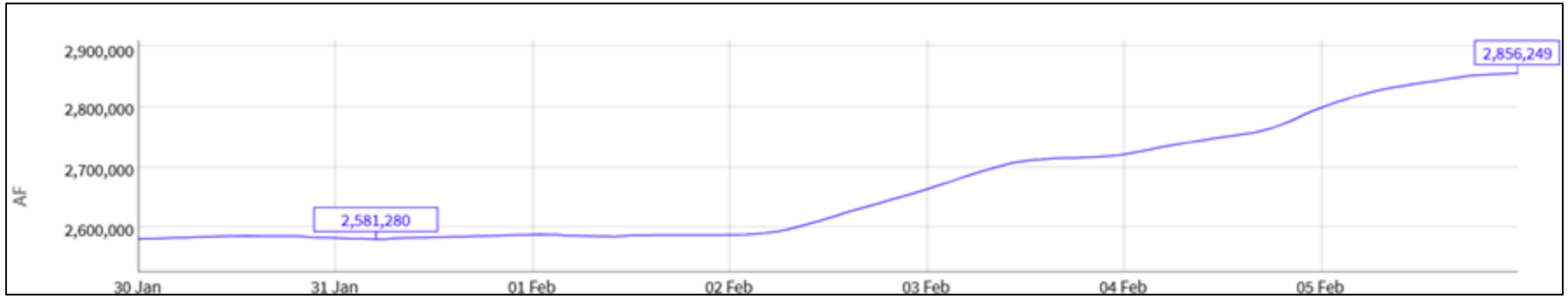
CW3E Event Summary: 31 January – 5 February 2025

Reservoir Operations: Lake Oroville

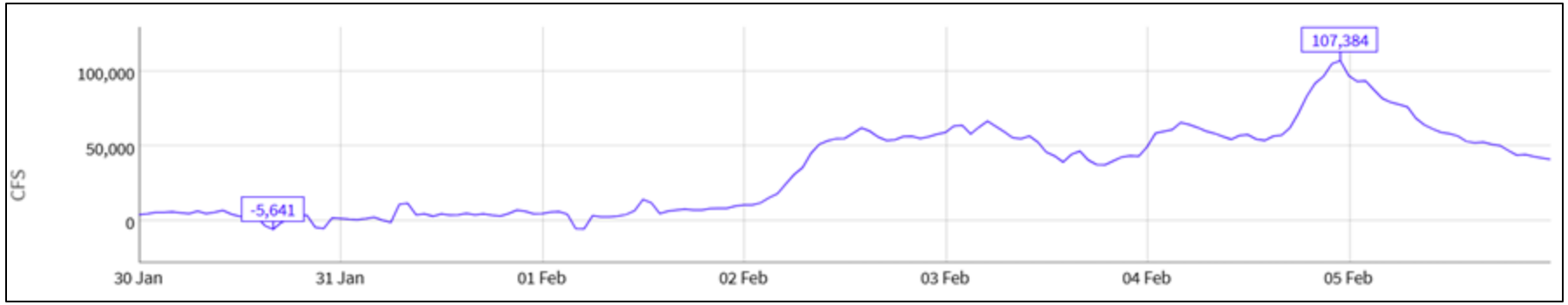
OROVILLE DAM (ORO)

Date from 01/30/2025 00:00 through 02/06/2025 00:00 Duration: 7 days

Reservoir Storage



Reservoir Inflow



- Reservoir storage at Oroville Dam increased 274,969 AF from Jan 31 to 12 AM PST Feb 6.
- As of 12 AM PST Feb 6, reservoir storage was 83% of capacity and 137% of normal.
- Reservoir inflows exceeded 50,000 cfs for the majority of hours after 9 AM PST 2 Feb, peaking at 107,384 cfs late 5 Feb.

Credit: CDEC, California Department of Water Resources

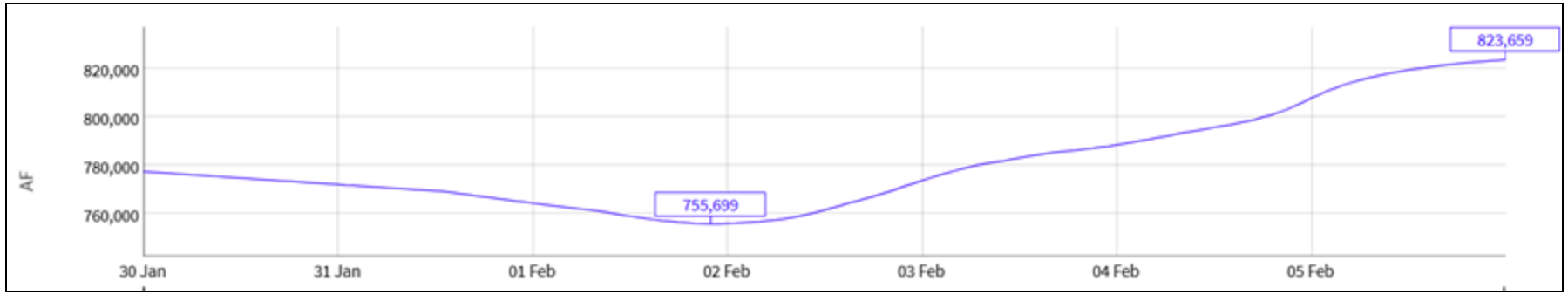
CW3E Event Summary: 31 January – 5 February 2025

Reservoir Operations: New Bullards Bar

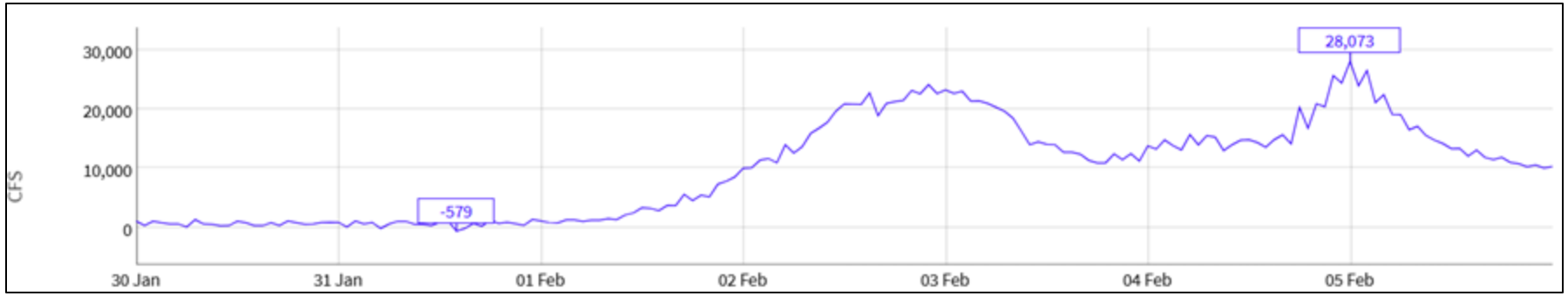
NEW BULLARDS BAR (BUL)

Date from 01/30/2025 00:00 through 02/06/2025 00:00 Duration: 7 days

Reservoir Storage



Reservoir Inflow

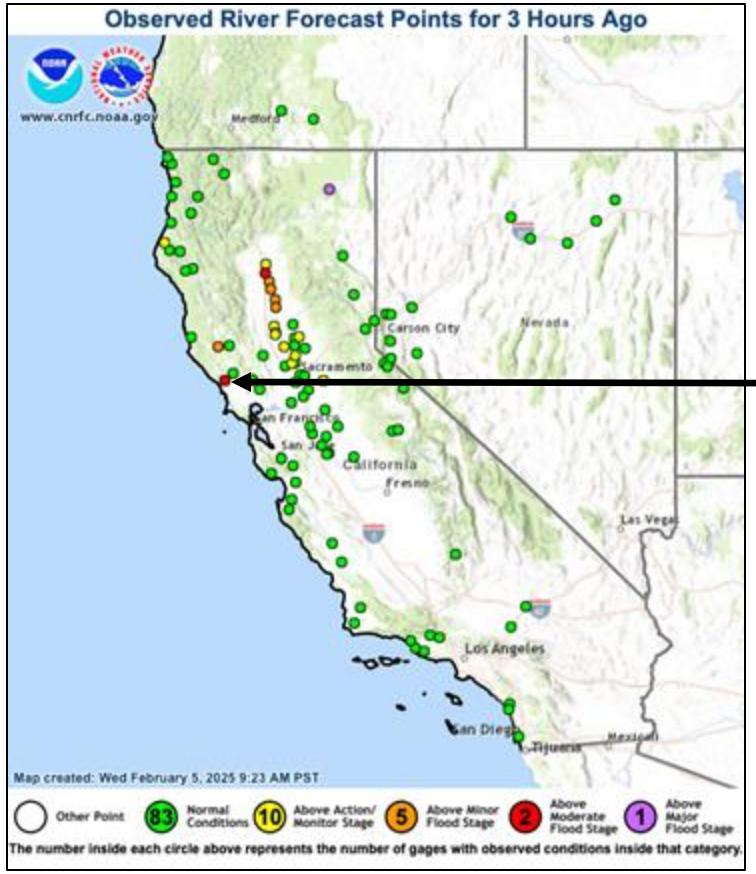


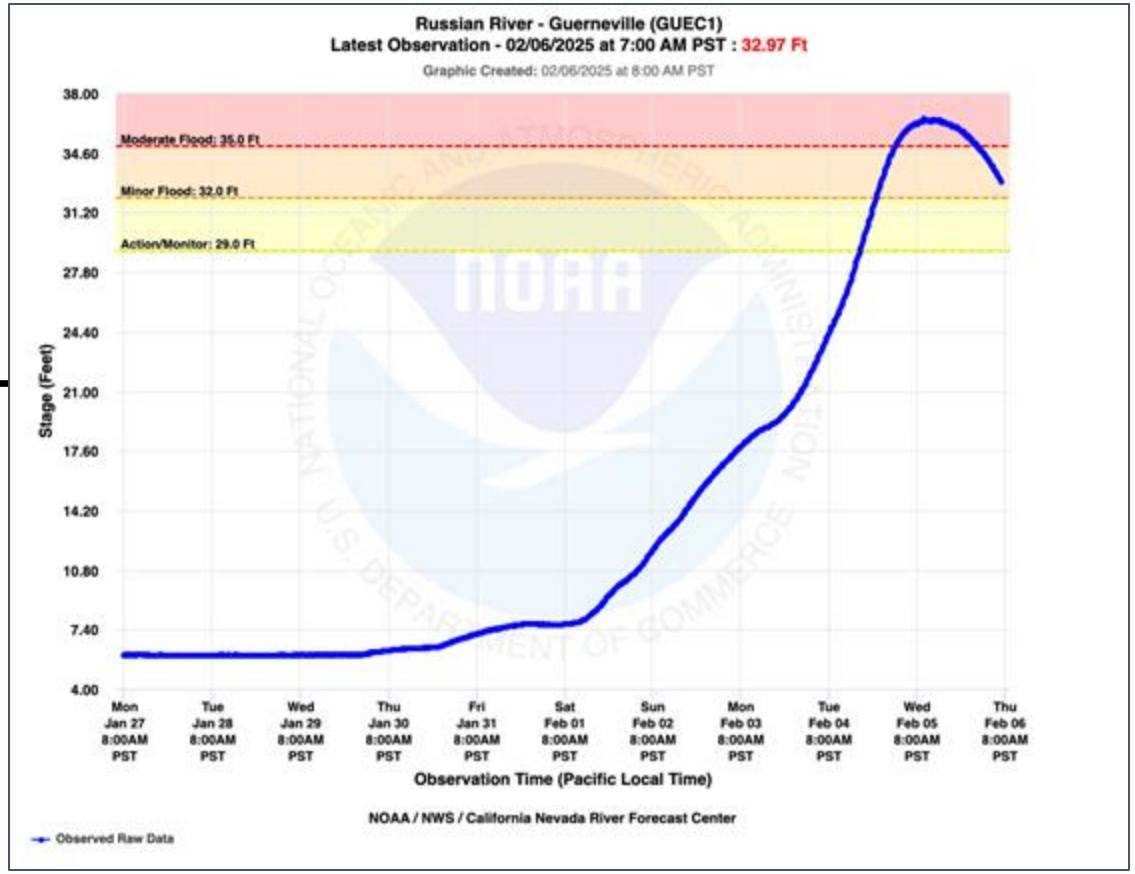
- Reservoir storage at New Bullards Bar increased 67,960 AF from late Feb 1 to 12 AM PST Feb 6.
- As of 12 AM PST Feb 6, reservoir storage was 85% of capacity and 128% of normal.
- Reservoir inflows exceeded 10,000 cfs for the majority of hours after 12 AM PST 2 Feb, peaking at 28,073 cfs around 12 AM PST 5 Feb.

Credit: CDEC, California Department of Water Resources

CW3E Event Summary: 31 January – 5 February 2025

Hydrologic Impacts

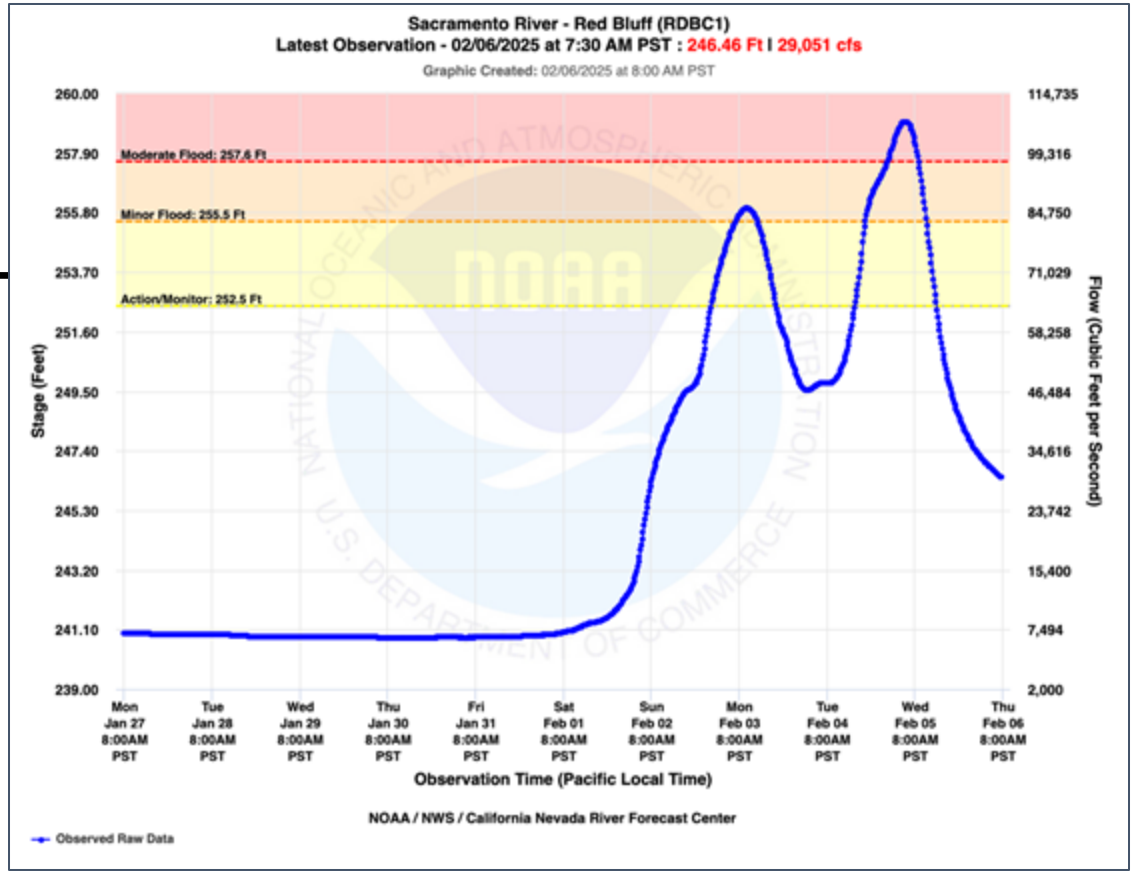




- Heavy rainfall over multiple days caused widespread riverine flooding in Northern California.
- The Russian River at Guerneville rose about 29 feet over a 5-day period, cresting above **moderate flood stage** (36.0 feet) around midday on Wed 5 Feb.
- The peak stage of 36.49 feet ranks as the 4th highest peak stage at this location since 2000.

CW3E Event Summary: 31 January – 5 February 2025

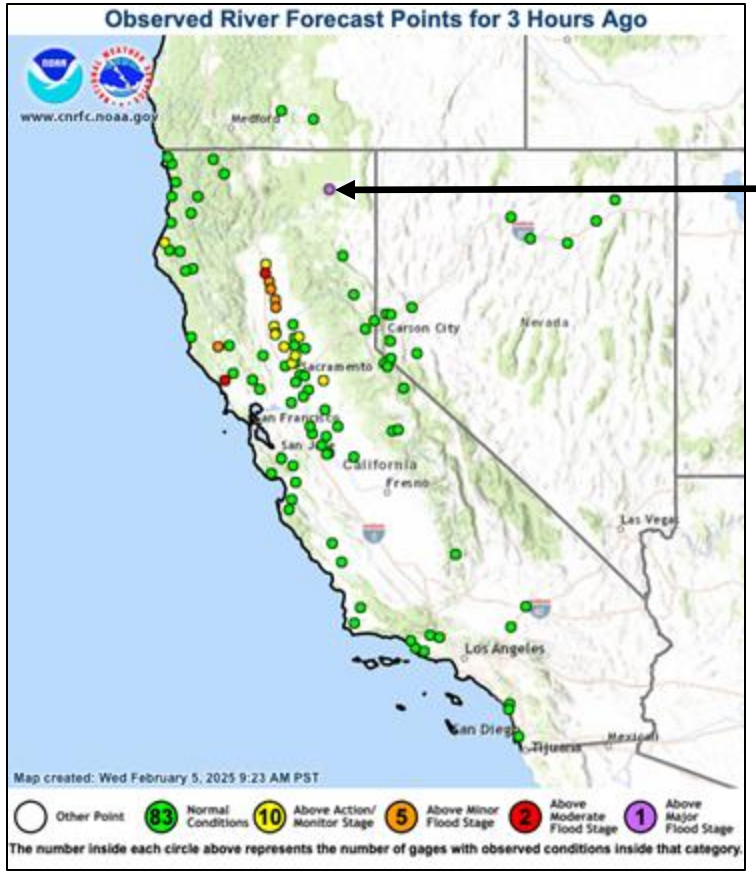
Hydrologic Impacts

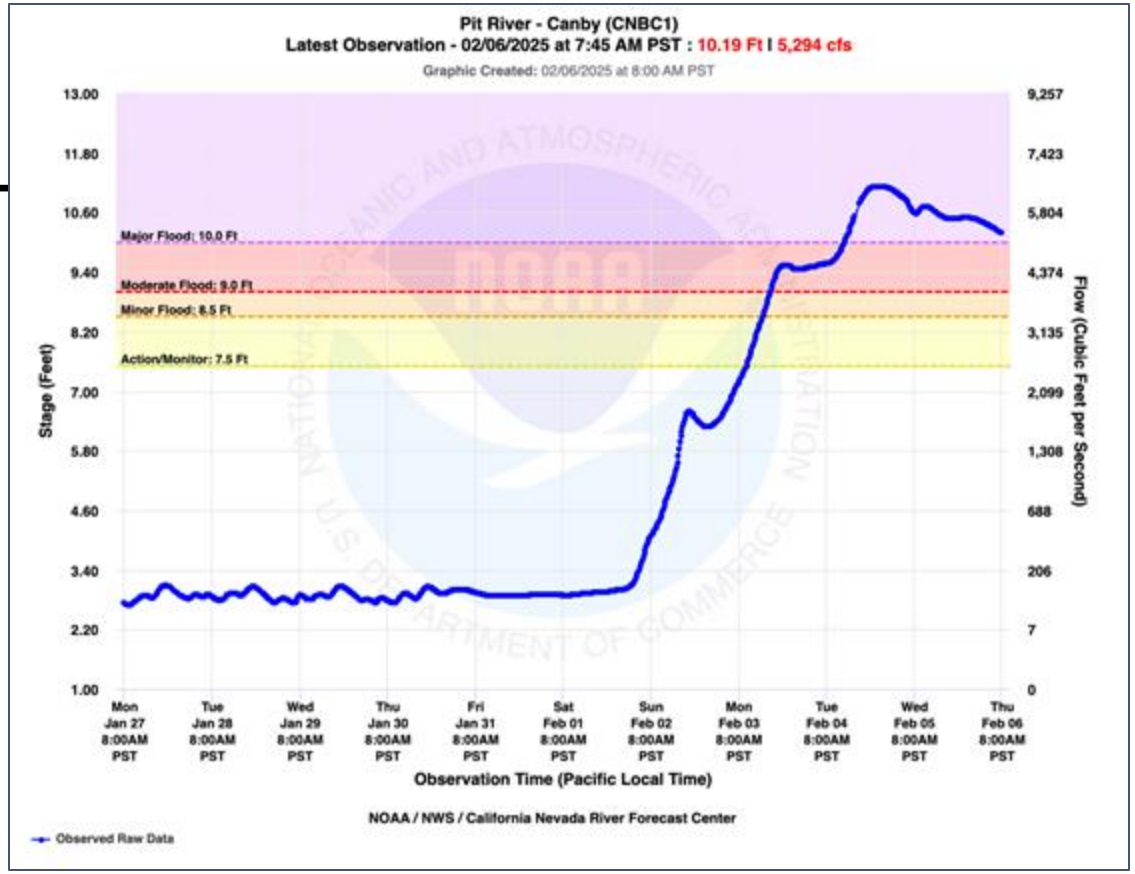


- The Sacramento River at Red Bluff experienced two distinct peaks in streamflow during this event.
- The first peak occurred late morning Mon 3 Feb, with the river reaching **minor flood stage** (255.5 feet).
- The second peak occurred early morning Wed 5 Feb following the final pulse of moisture transport, with the river cresting above **moderate flood stage** (257.6 feet). This ranks as the 2nd highest peak stage at this location since records began in 2000.

CW3E Event Summary: 31 January – 5 February 2025

Hydrologic Impacts

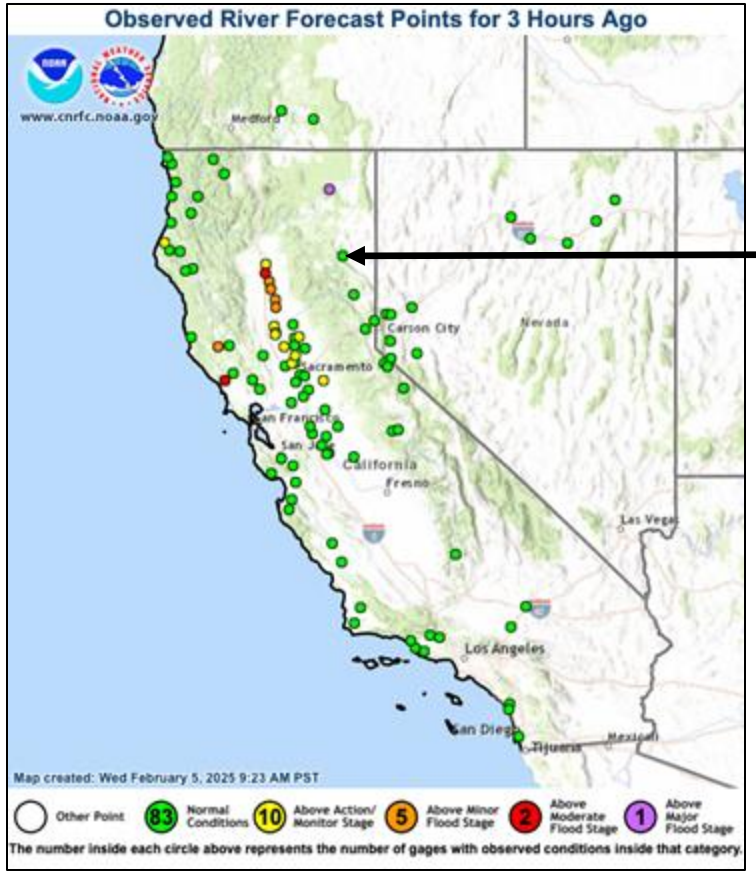


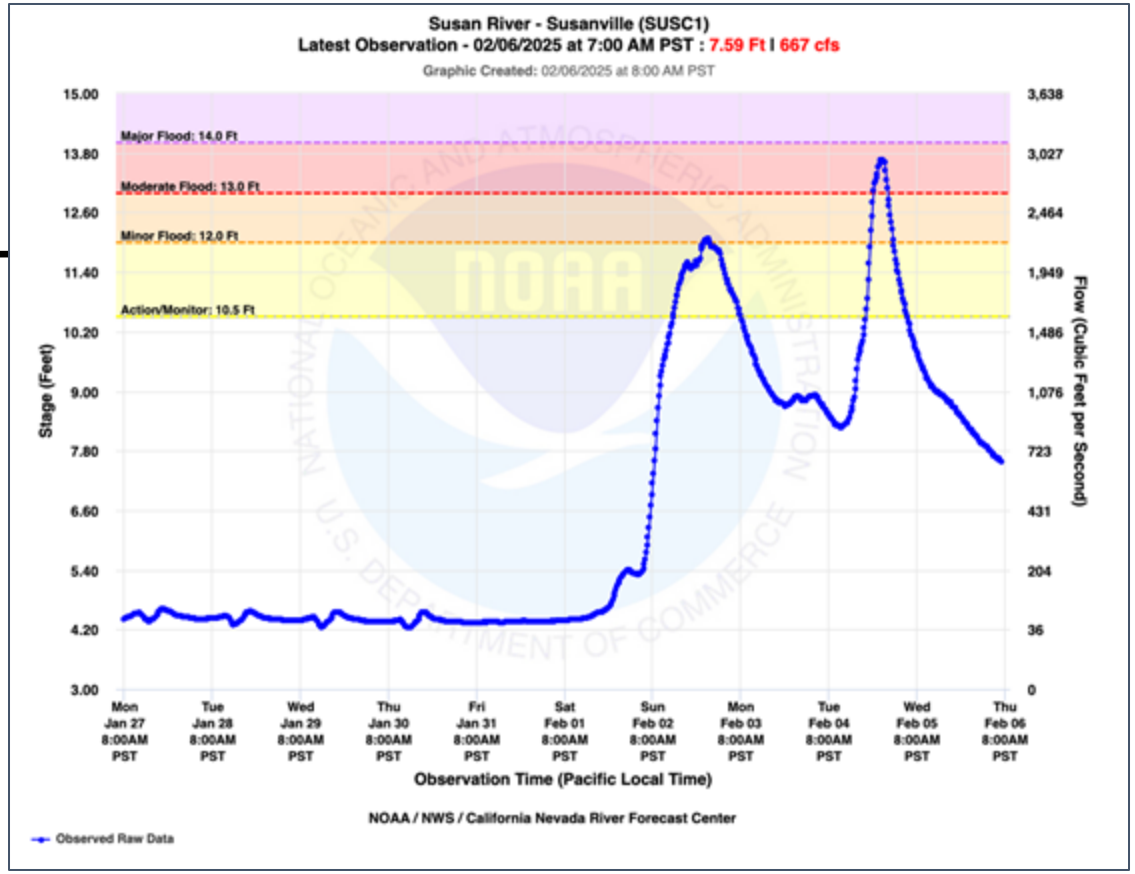


- Heavy precipitation resulting from the inland penetration of the second AR also caused flooding in northeastern California.
- The Pit River near Canby steadily rose after the second AR landfall on Sat 1 Feb, eventually cresting above **major flood stage** (10.0 feet) during the evening of Tue 4 Feb.
- The peak stage of 11.13 feet ranks as the 4th highest peak stage at this location since continuous records began in 1932.

CW3E Event Summary: 31 January – 5 February 2025

Hydrologic Impacts



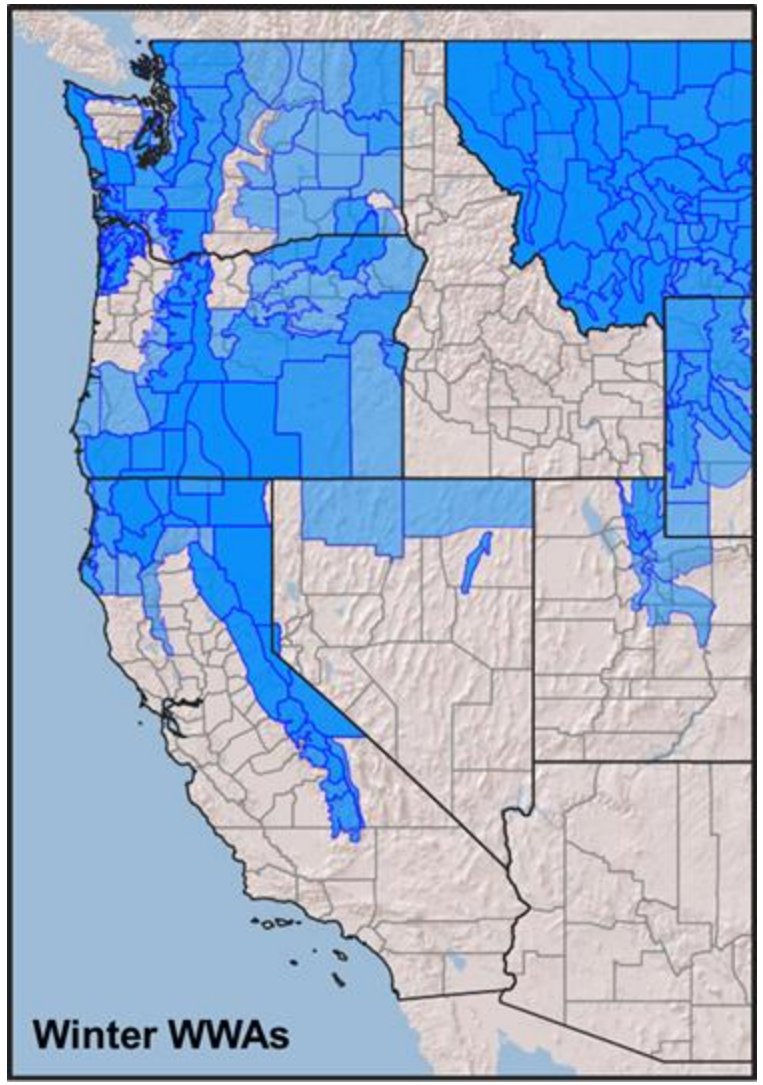


- The Susan River at Susanville experienced two distinct peaks in streamflow during this event.
- The first peak occurred late Sat 1 Feb following the second AR landfall, with the river reaching **minor flood stage** (12.0 feet).
- The second peak occurred late Tue 4 Feb following the final pulse of moisture transport, with the river cresting above **moderate flood stage** (13.0 feet).

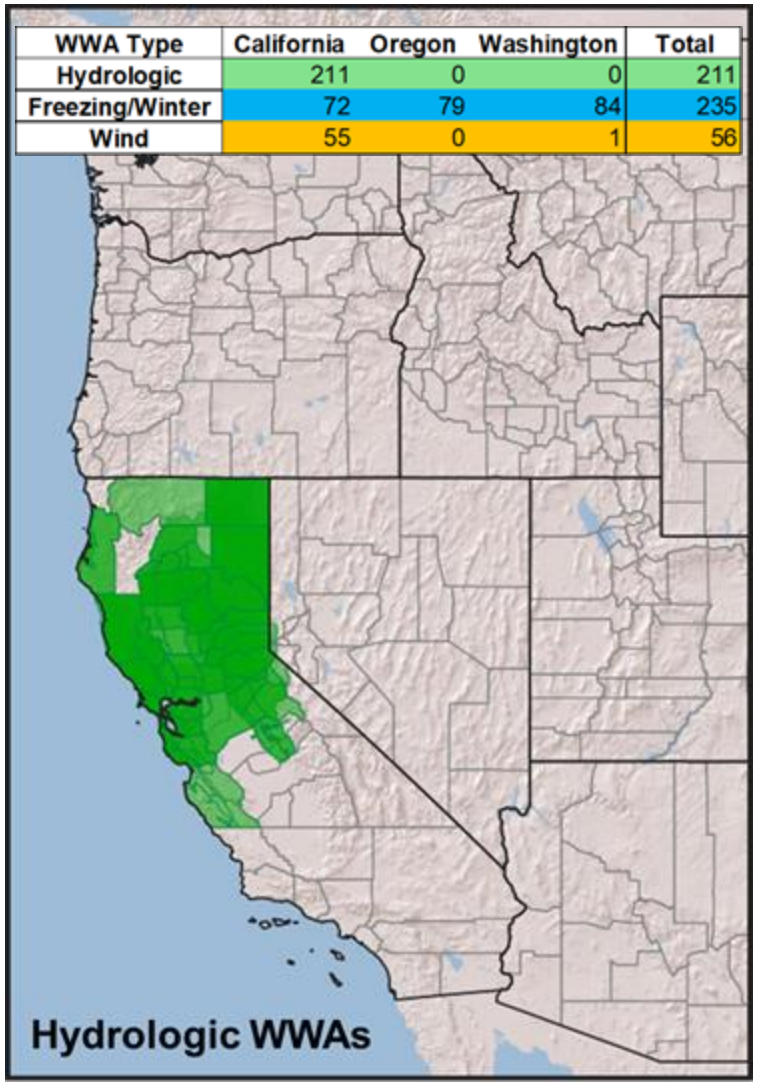
CW3E Event Summary: 31 January – 5 February 2025

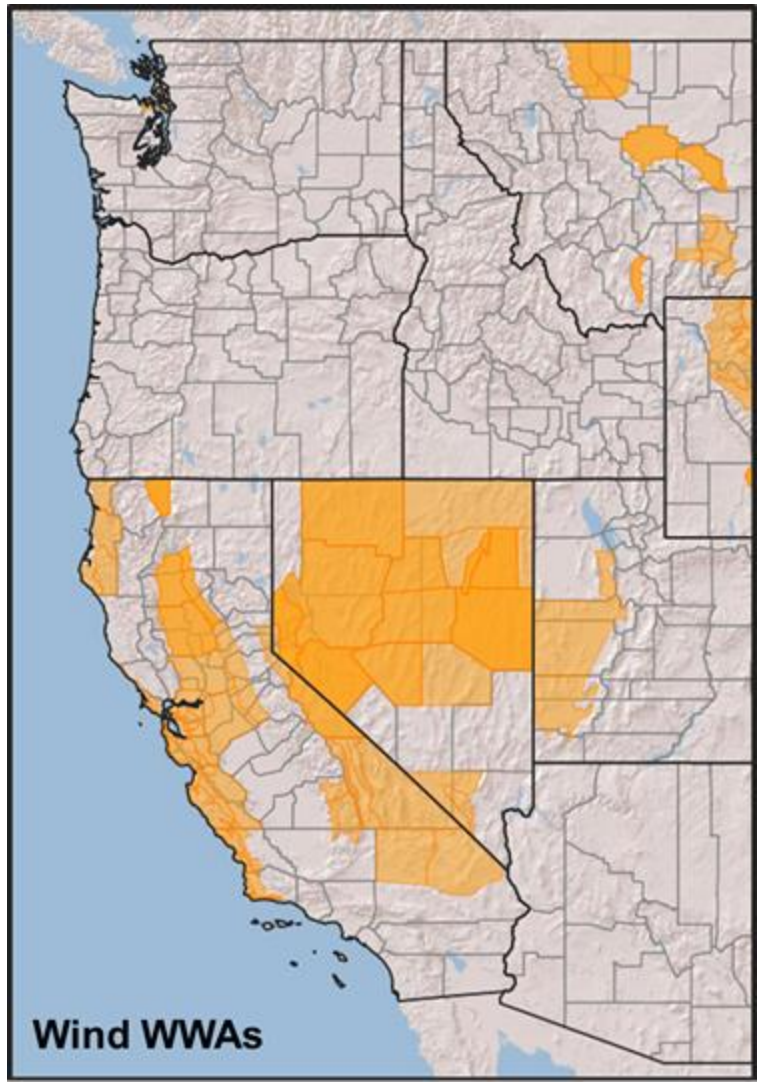
NWS Local Storm Reports accessed via Iowa State Archive
https://mesonet.agron.iastate.edu/request/gis/lsrs.phtml

Impacts: NWS Watches, Warnings, and Advisories - Valid: 4 PM 30 Jan - 4 PM 04 Feb 2025



WWA Type	California	Oregon	Washington	Total
Hydrologic	211	0	0	211
Freezing/Winter	72	79	84	235
Wind	55	0	1	56

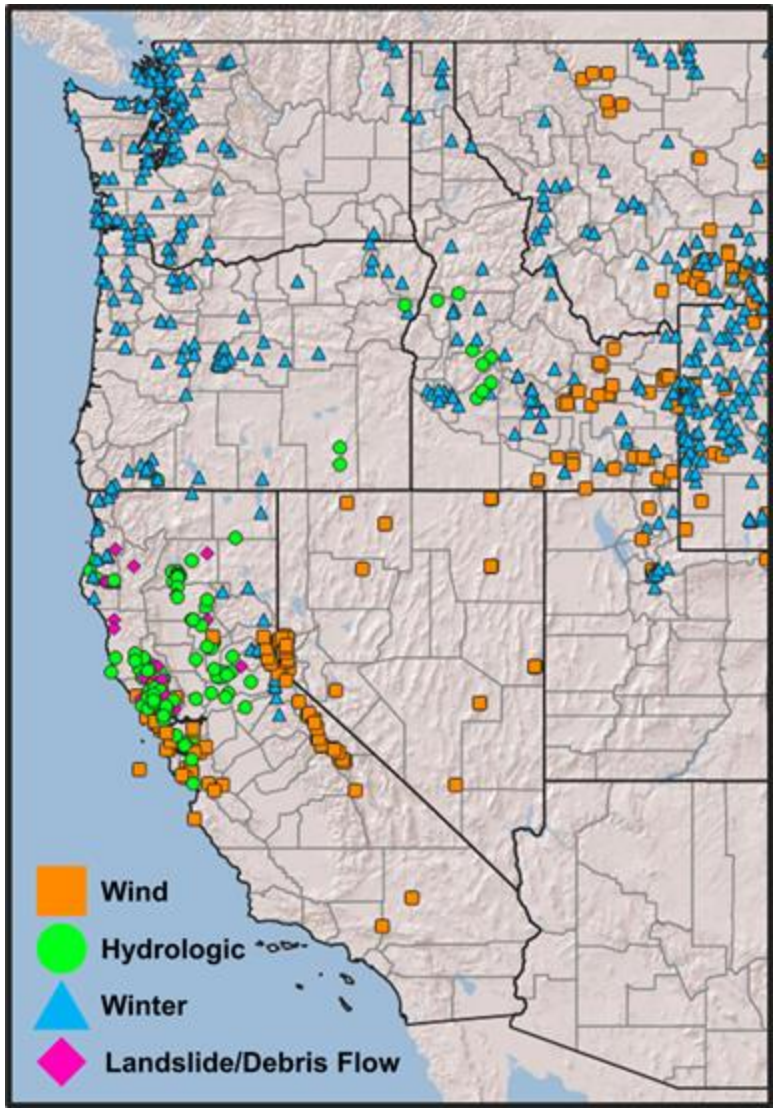




CW3E Event Summary: 31 January – 5 February 2025

NWS Watches, Warnings, Advisories via Iowa State Archive
https://mesonet.agron.iastate.edu/request/gis/watchwarn.phtml

Impacts: NWS Local Storm Reports: Valid 4 PM 30 Jan – 4 PM 4 Feb 2025



- Numerous landslides and debris flows were reported in Lake, Marin, Mendocino, Napa, and Sonoma Counties in coastal Northern California.
- Flood-related local storm reports (LSRs) were reported primarily over the Coast Ranges of Northern California, the Sacramento Valley, and the foothills of the Northern Sierra Nevada.
- Strong wind gusts were reported along the peaks of terrain in the Coast Ranges and Sierra Nevada.

LSR Type	California	Oregon	Washington	Total
Hydrologic	99	4	1	104
Freezing/Winter	65	75	104	244
Wind	80	0	0	80
Landslide/DebrisFlow	35	0	0	35

CW3E Event Summary: 31 January – 5 February 2025

Impacts: Flooding

Credit: ABC7 News (https://abc7news.com/post/forestville-mudslide-landslide-russian-river-atmospheric-river-california/15865461/)

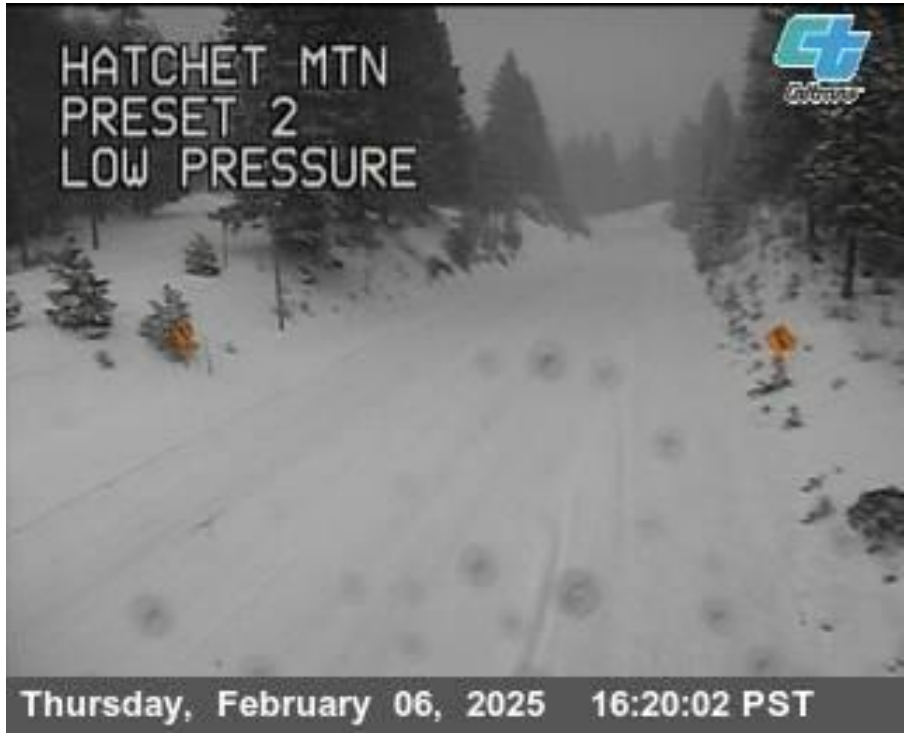
Credit: Tayfun Coskun/Anadolu via Getty Images (https://www.msn.com/en-us/weather/topstories/heavy-rain-and-landslides-force-road-closures-in-california-and-more-rain-is-on-the-way/ar-AA1ys4K7)

- The flooding in Northern California resulted in road closures, debris flows, and also caused several homes to get swept away (e.g., home along Russian River, left).

- The Sonoma County Sheriff's Office confirmed two fatalities in Sonoma County from flood waters associated with heavy rainfall during the final IVT pulse.

CW3E Event Summary: 31 January – 5 February 2025

Impacts: Mountain Snow



Credit: NWS Sacramento (https://x.com/NWSSacramento/status/1887659056325927395)

Credit: Central Sierra Snow Lab (https://x.com/UCB_CSSL/status/1886817054902399407)

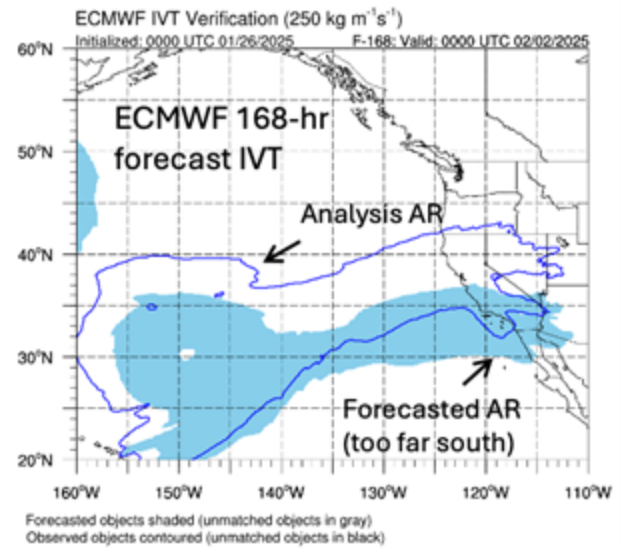
- Heavy mountain snow led to many high-elevation roads being extremely unsafe to travel or completely inaccessible.

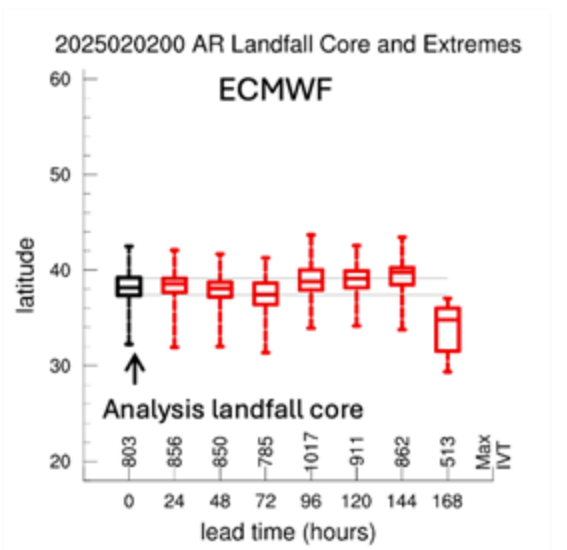
- The heavy snow combined with strong winds made travel around the mountains hazardous for much of the week.

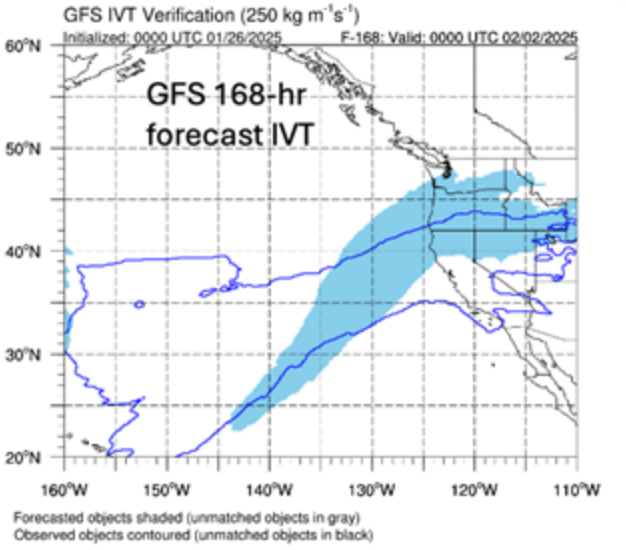
CW3E Event Summary: 31 January – 5 February 2025

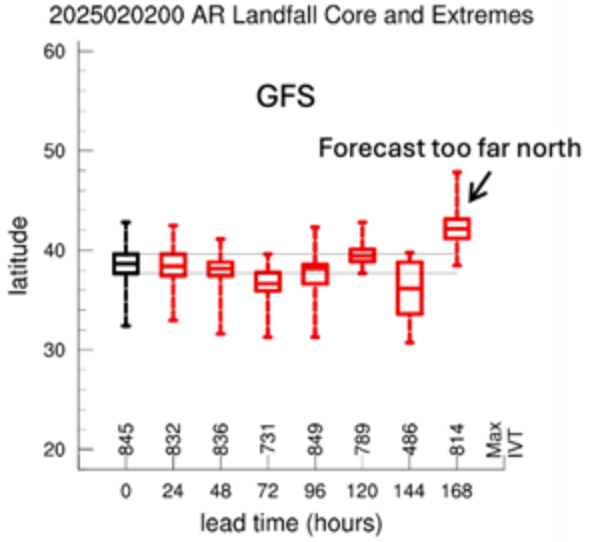
AR Landfall Verification
Valid: 00Z 2 Feb

- At a 7-day lead time, the ECMWF and GFS forecasts had large differences in landfall location and intensity, with the ECMWF prediction too far south and too weak, while the GFS prediction was too far north with fairly accurate intensity.
- At 5-day and 6-day lead times, the ECMWF forecast was relatively stable and accurate, while the GFS forecast fluctuated.
- Within a 4-day lead time, the forecasts converged on a similar prediction, with increasing accuracy on the landfall location.





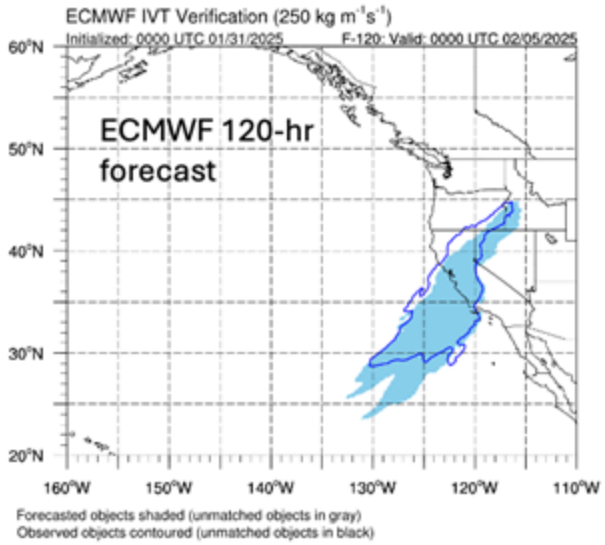


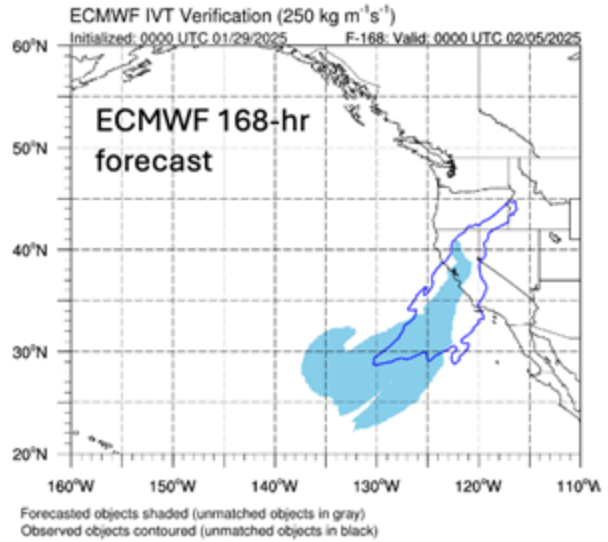


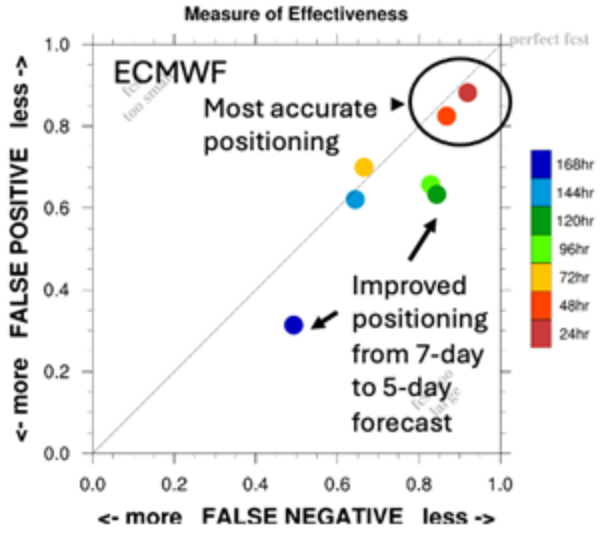
CW3E Event Summary: 31 January – 5 February 2025

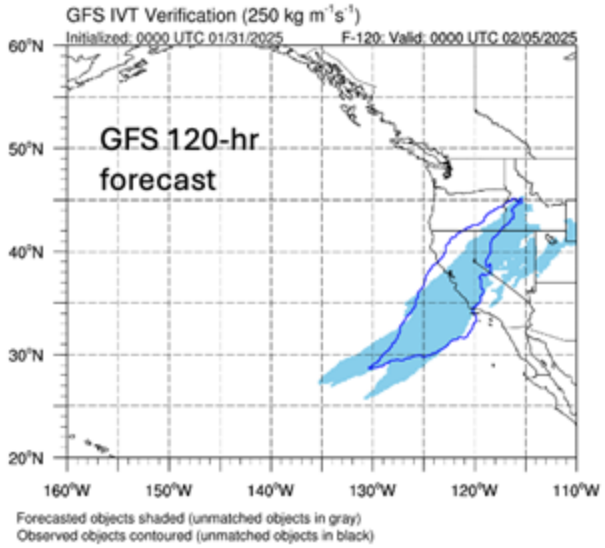
AR Landfall Verification
Valid: 00Z 5 Feb

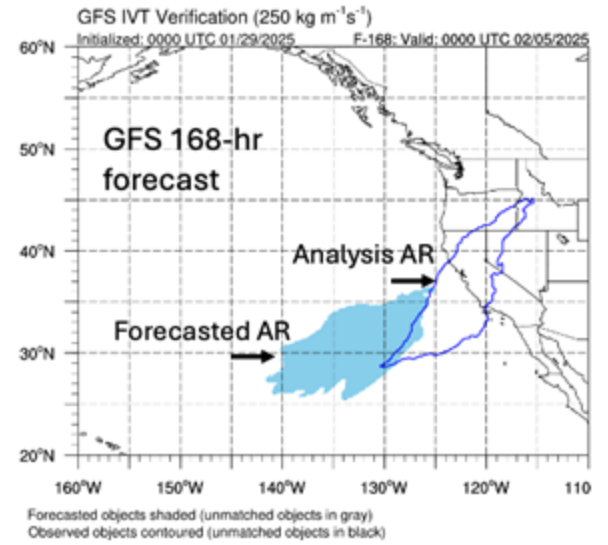
- Both models showed the AR too far south and west at a 7-day lead time.
- At a lead time of 5 days, both models had greatly improved the forecast location of the AR, however the most accurate forecasts only occurred at a 2-day lead time.

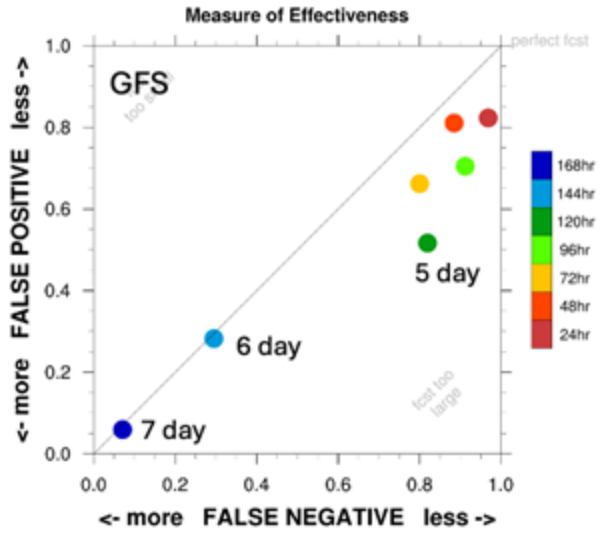








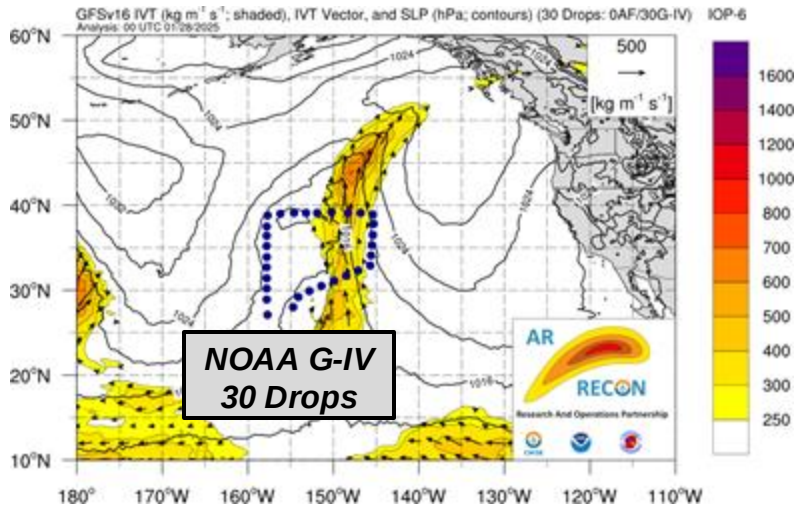




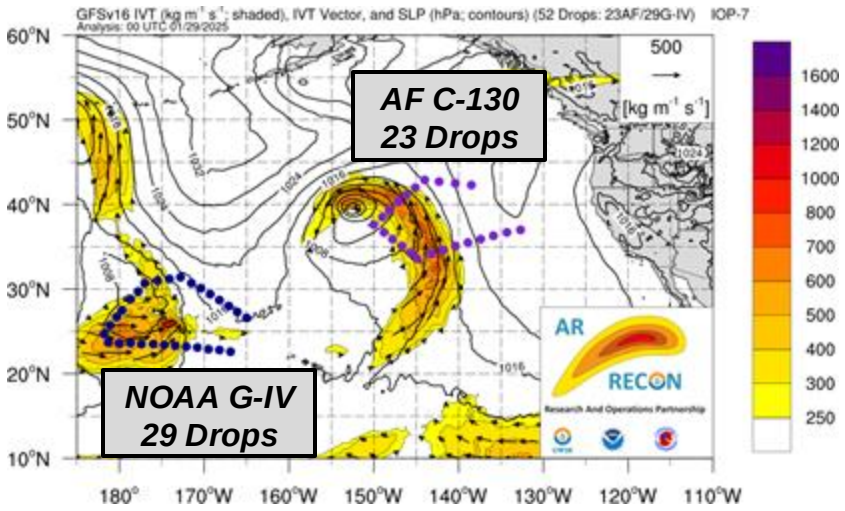
CW3E Event Summary: 31 January – 5 February 2025

AR Recon Flights

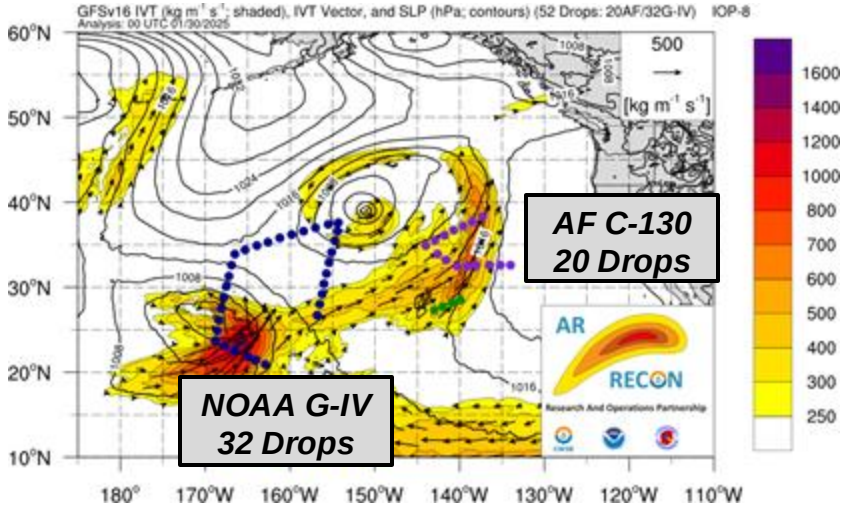
IOP-6: 28 Jan 2025



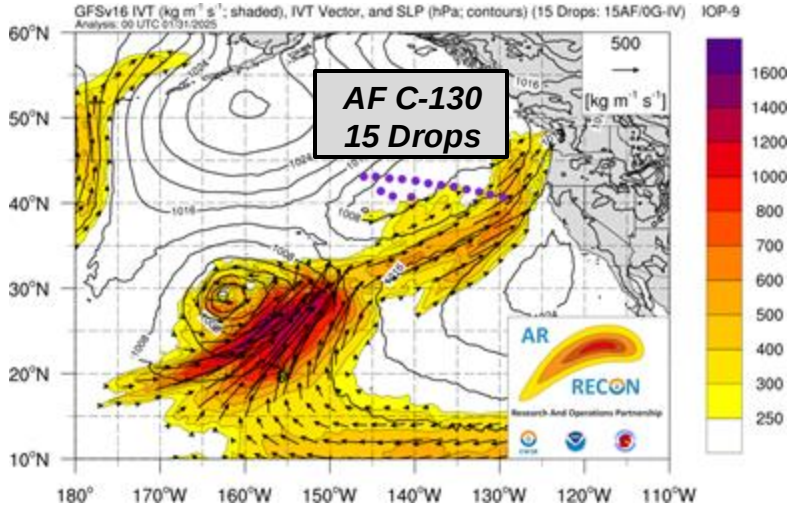
IOP-7: 29 Jan 2025



IOP-8: 30 Jan 2025



IOP-9: 31 Jan 2025



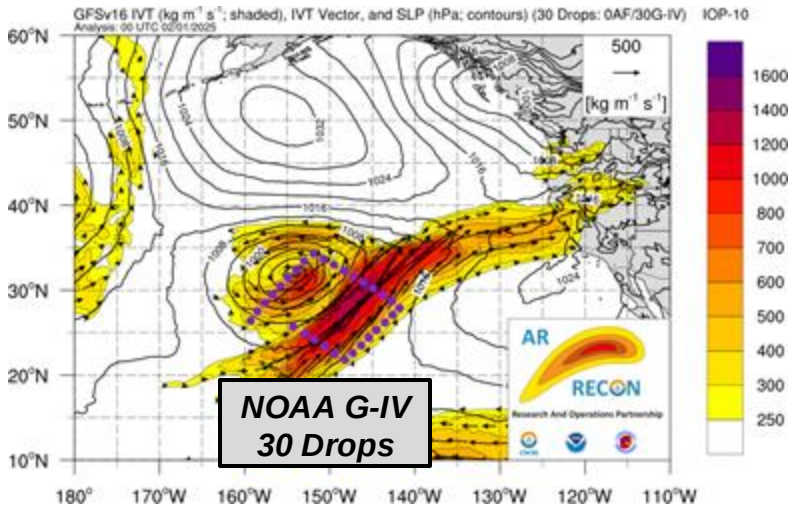
- In coordination with NOAA and the Air Force, CW3E's Atmospheric River Reconnaissance (AR Recon) field campaign successfully carried out a sequence of eight IOPs between 28 Jan and 4 Feb.
- These AR Recon flights sampled both ARs, as well as nearby essential atmospheric features and regions of high forecast sensitivity.

F. Martin Ralph (UCSD/SIO/CW3E) - PI
Vijay Tallapragada (NWS/NCEP) - Co-PI
Anna Wilson (UCSD/SIO/CW3E) - Coordinator

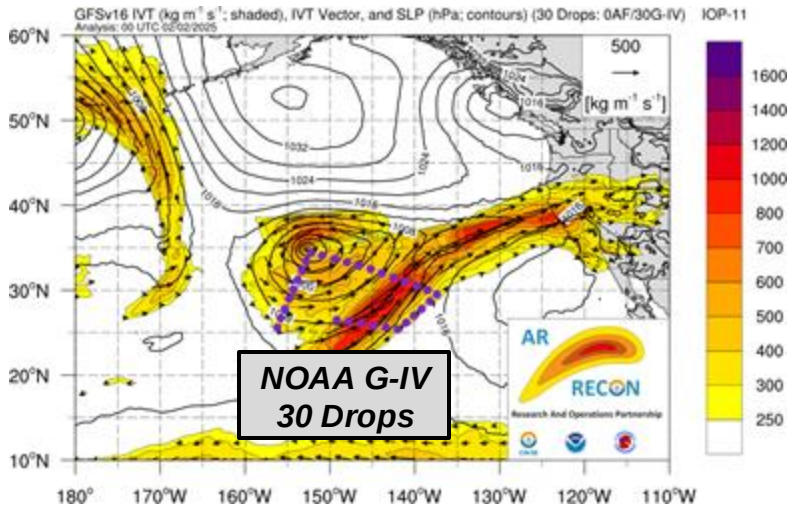
CW3E Event Summary: 31 January – 5 February 2025

AR Recon Flights

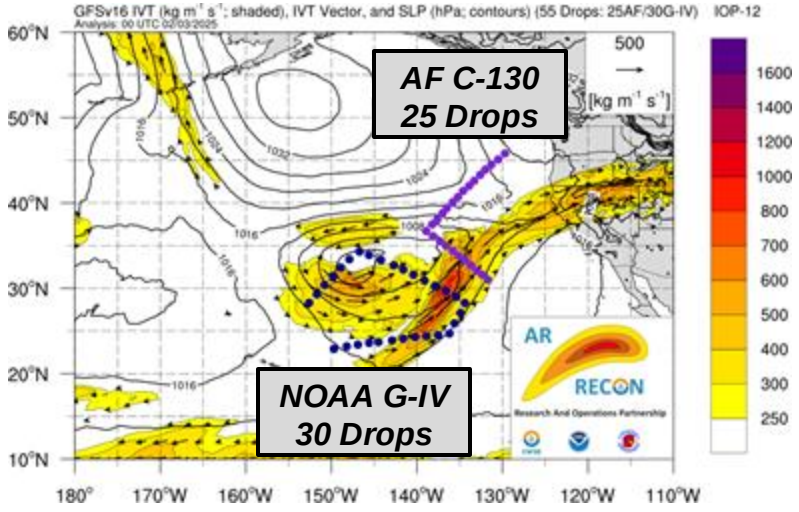
IOP-10: 1 Feb 2025



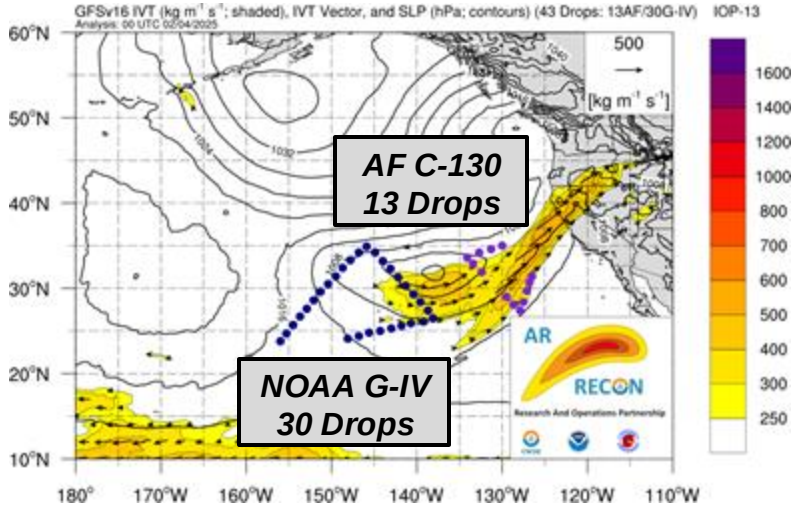
IOP-11: 2 Feb 2025



IOP-12: 3 Feb 2025



IOP-12: 4 Feb 2025



- More than 300 dropsondes were successfully deployed across 12 flights (7 with the NOAA G-IV; 5 with the Air Force C-130).
- Data from these flights were assimilated in near-real time into global forecast models and will be archived for future research purposes.

F. Martin Ralph (UCSD/SIO/CW3E) - PI
Vijay Tallapragada (NWS/NCEP) - Co-PI
Anna Wilson (UCSD/SIO/CW3E) - Coordinator