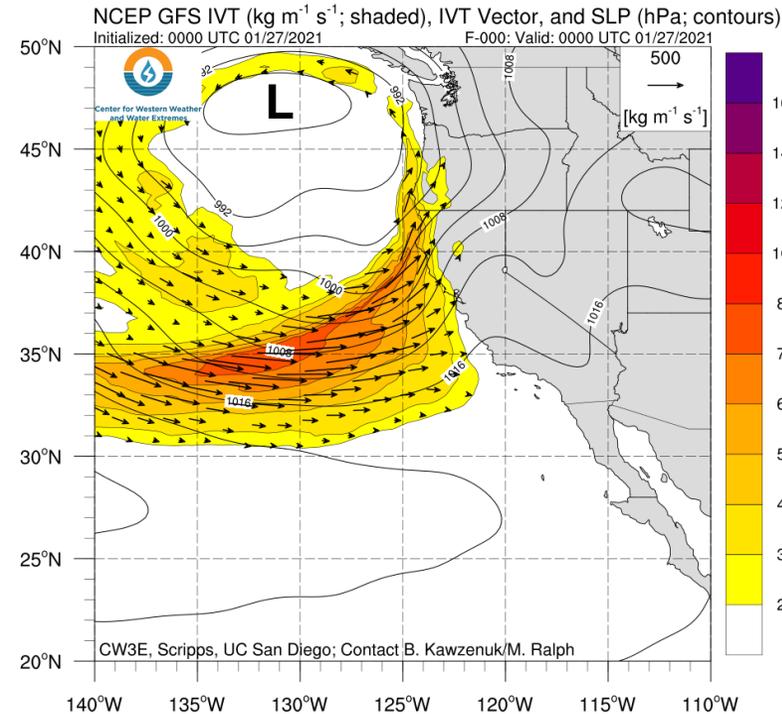


An Atmospheric River and a Strong Surface Cyclone Produced Significant Impacts Across much of California

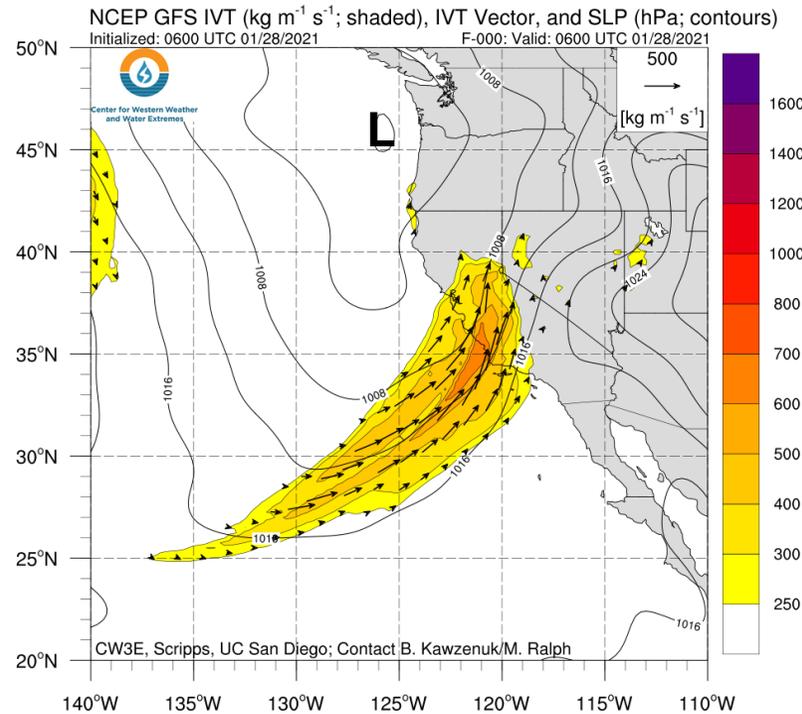
- The AR made landfall at ~00 UTC 27 January in association with a powerful surface cyclone over the Northeast Pacific Ocean
- Over the next few days, the AR gradually propagated southward along the coast of California, but not before pivoting and stalling over Central California
- Some areas in Central California experienced AR conditions for nearly 48 consecutive hours, resulting in an AR 2 (based on the Ralph et al. 2019 AR Scale)
- A strong low-level jet in the warm sector of the surface cyclone led to the development of a narrow cold-frontal rainband (NCFR)
- Intense rainfall on recent burn scars caused damaging debris flows in Central and Southern California
- More than 7 inches of precipitation fell in portions of the Sierra Nevada, Central California Coast Ranges, and western Transverse Ranges, with the highest observed amounts in western Monterey and San Luis Obispo Counties
- Several feet of snow accumulated across the Sierra Nevada, resulting in closures of major highways

GFS IVT & SLP Analyses

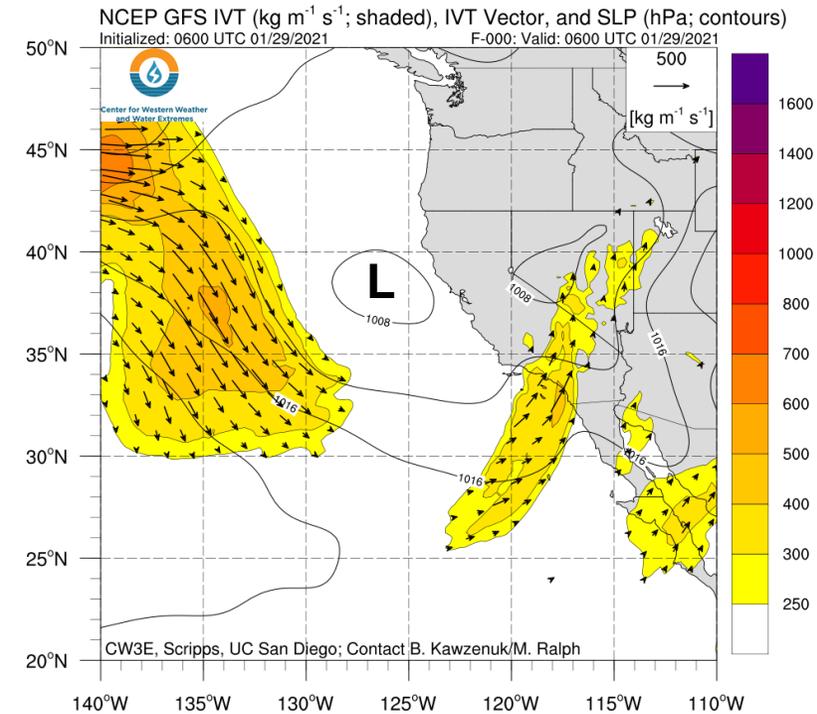
A) Valid: 0000 UTC 27 Jan 2021



B) Valid: 0600 UTC 28 Jan 2021



C) Valid: 0600 UTC 29 Jan 2021



- The AR formed on the southern periphery of a deepening surface cyclone and made landfall over coastal Northern California slightly before 00Z 27 Jan (4 PM PST 26 Jan; Figure A)
- As the AR began to migrate down the coast of California, an amplifying upper-level trough over the Northeast Pacific Ocean caused the AR to pivot over Central California and take on a more meridional orientation (Figure B)
- After temporarily stalling across Central California, the AR moved over Southern California and dissipated rapidly (Figure C)

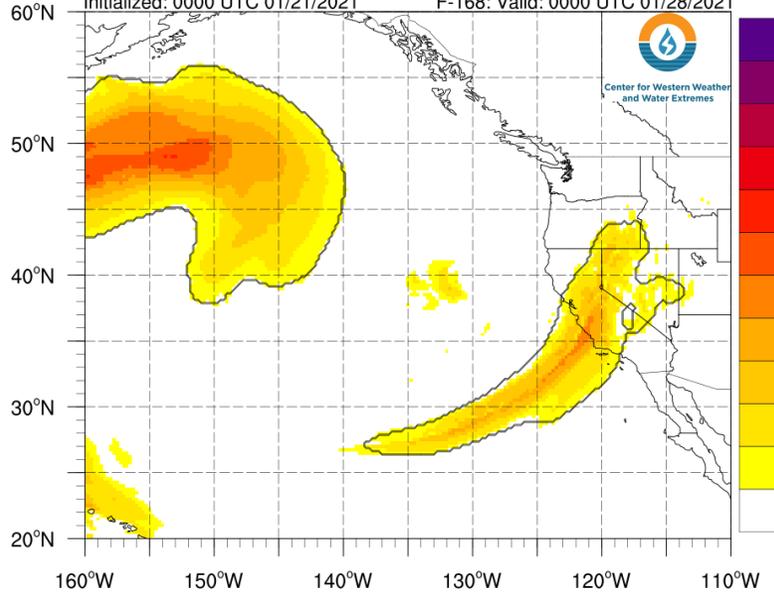
GFS AR/IVT Forecast Verification

GFS 168-h IVT Forecast

Initialized: 0000 UTC 21 Jan 2021

GFS IVT ($\text{kg m}^{-1} \text{s}^{-1}$)

Initialized: 0000 UTC 01/21/2021 F-168: Valid: 0000 UTC 01/28/2021

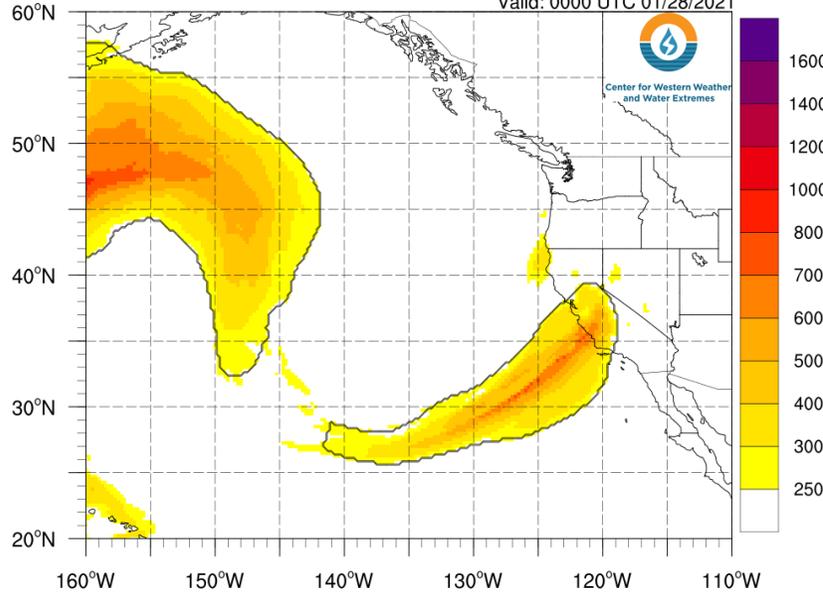


GFS IVT Analysis

Valid: 0000 UTC 28 Jan 2021

GFS Analysis IVT ($\text{kg m}^{-1} \text{s}^{-1}$)

Valid: 0000 UTC 01/28/2021

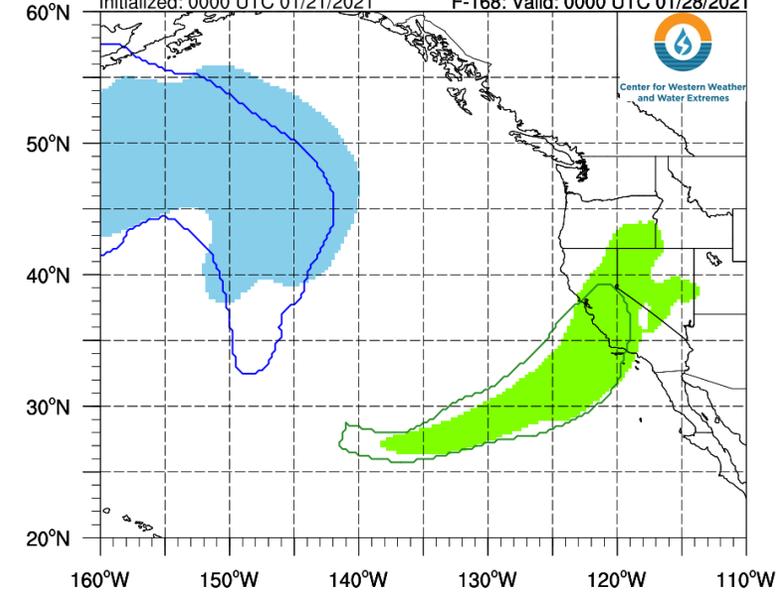


GFS IVT Object Verification

IVT $\geq 250 \text{ kg m}^{-1} \text{s}^{-1}$

GFS IVT Verification ($250 \text{ kg m}^{-1} \text{s}^{-1}$)

Initialized: 0000 UTC 01/21/2021 F-168: Valid: 0000 UTC 01/28/2021



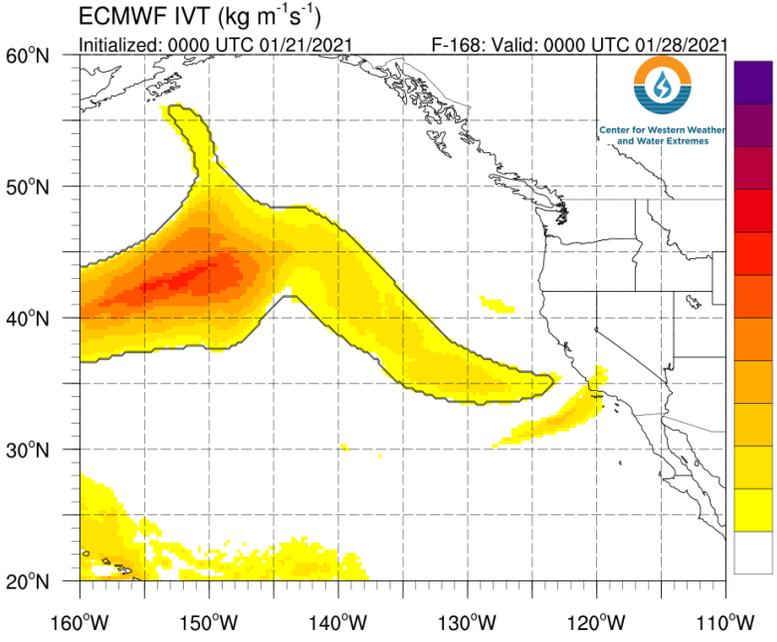
- The overall structure, IVT magnitude, and timing of the AR was well-forecasted by the GFS model at a 7-day (168-h) lead time
- The forecasted location of the AR core over Central California at 00Z 28 Jan was nearly identical to the analysis

Shading = forecasted AR objects (grey if no AR observed)

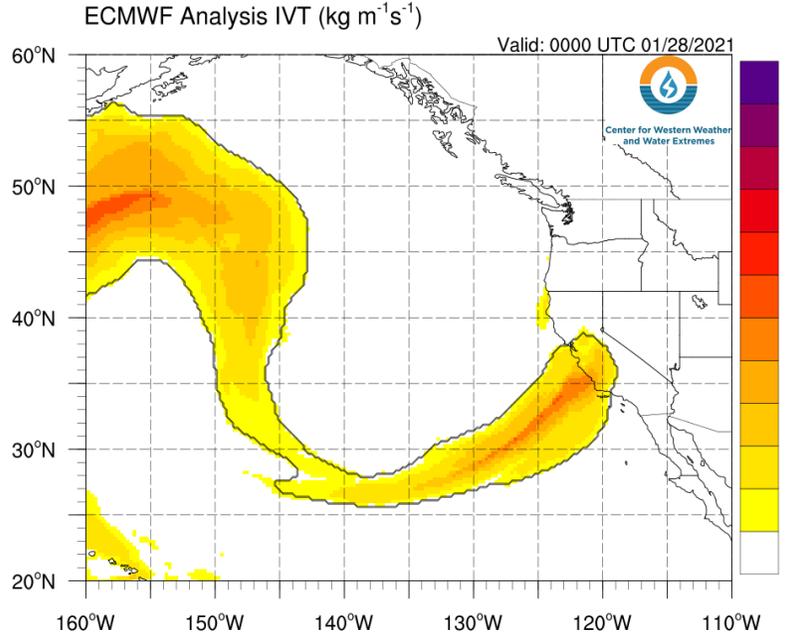
Contours = observed AR objects (black if no AR forecasted)

ECMWF AR/IVT Forecast Verification

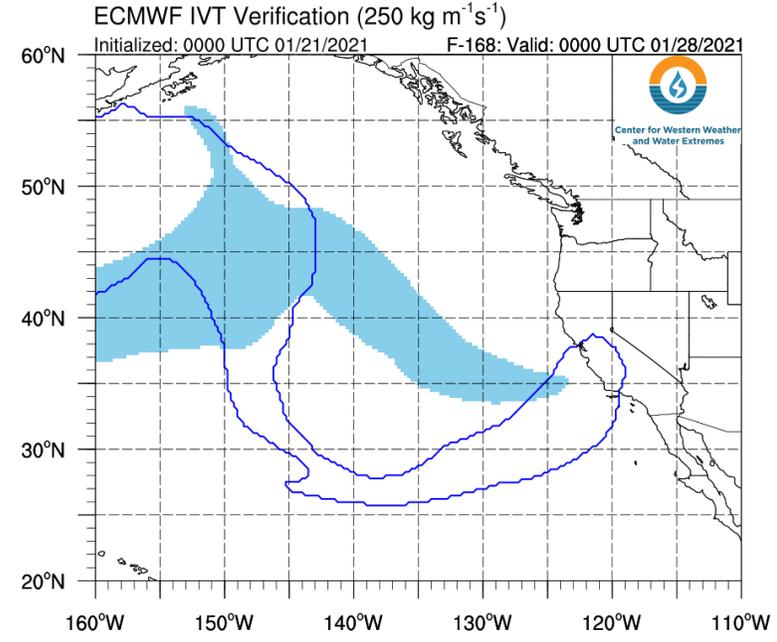
ECMWF 168-h IVT Forecast
Initialized: 0000 UTC 21 Jan 2021



ECMWF IVT Analysis
Valid: 0000 UTC 28 Jan 2021



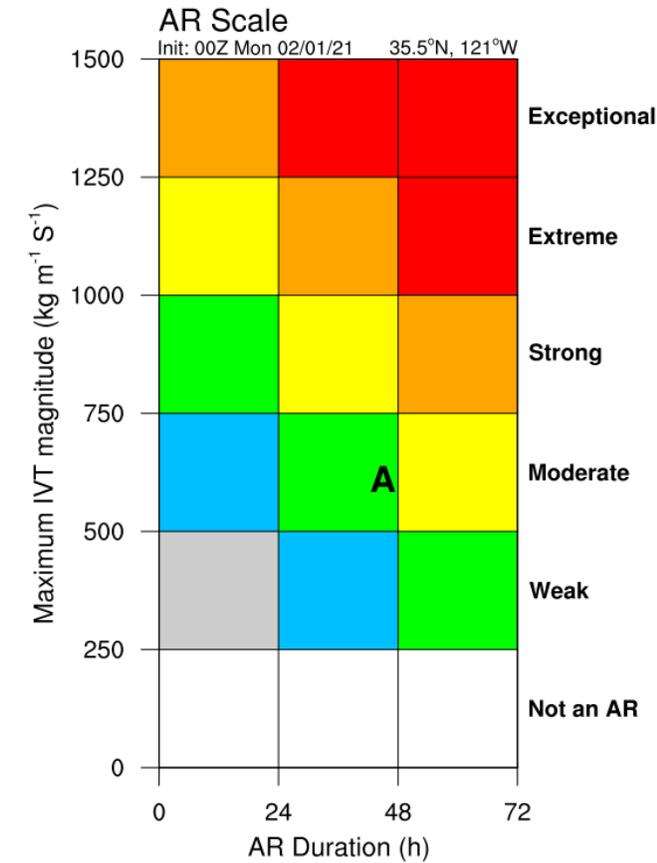
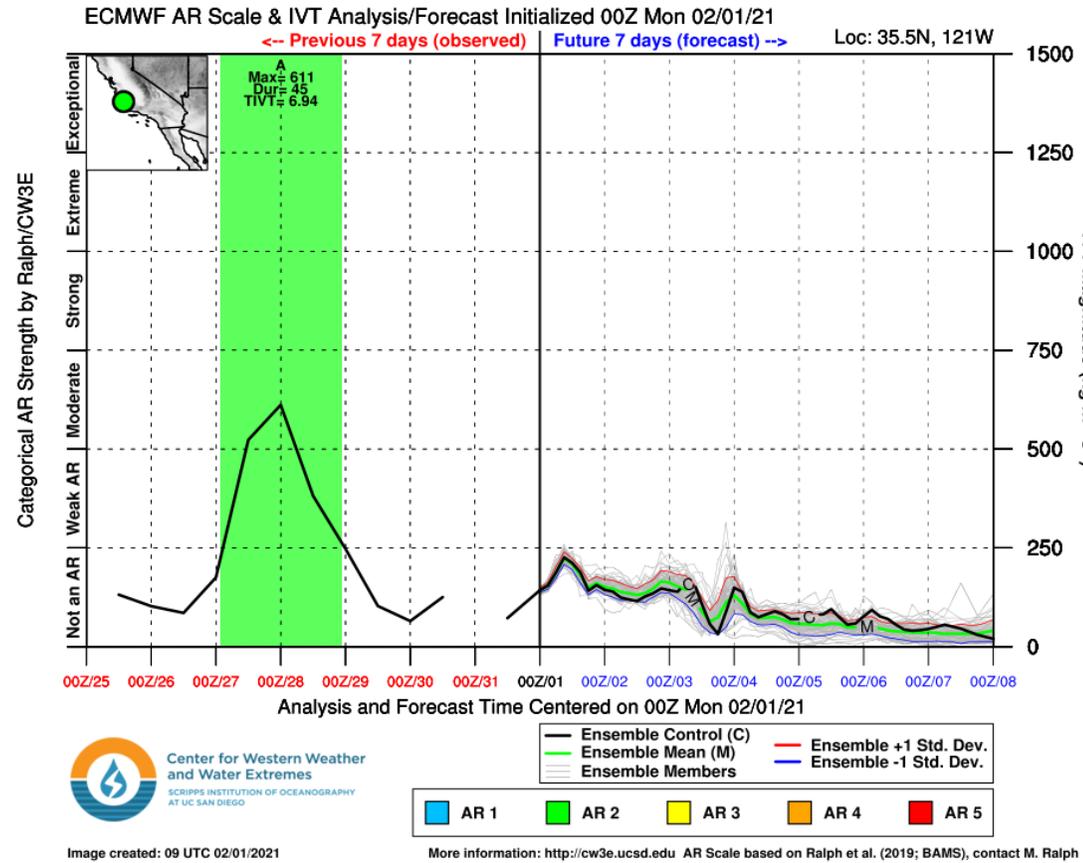
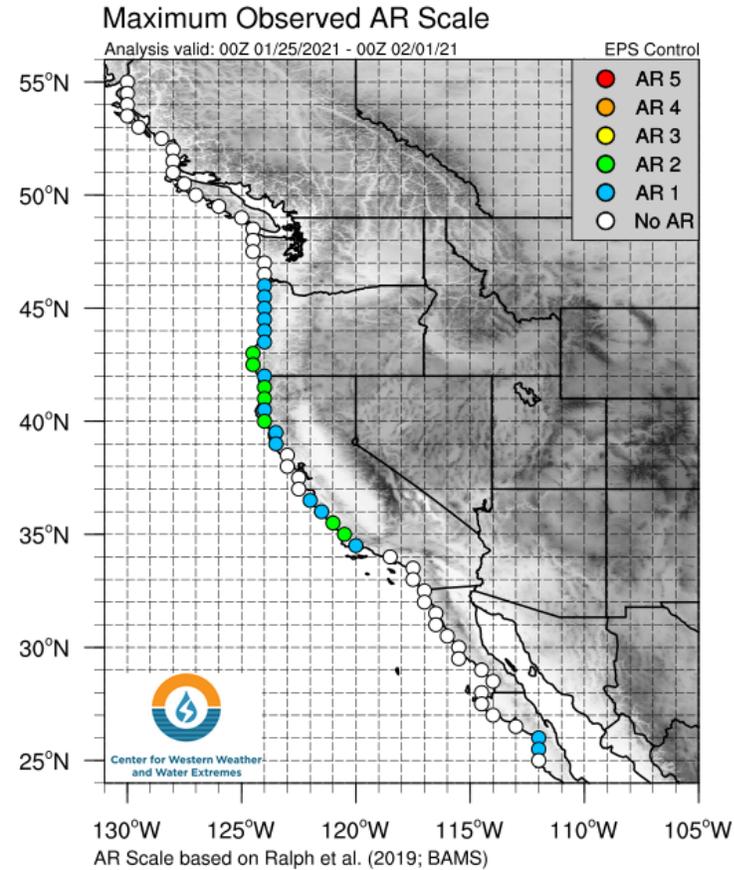
ECMWF IVT Object Verification
IVT $\geq 250 \text{ kg m}^{-1} \text{ s}^{-1}$



- Unlike the GFS, the ECMWF model failed to forecast the AR landfall over California at a 7-day lead time
- As the event drew closer, the ECMWF forecasts gradually trended toward the GFS forecasts
- The large differences between the 168-h GFS and ECMWF forecasts were driven by uncertainty in the evolution of the flow over the Central Pacific that included an upstream shortwave trough and a predecessor AR north of Hawaii

Shading = forecasted AR objects (grey if no AR observed)
Contours = observed AR objects (black if no AR forecasted)

ECMWF AR Scale & IVT Analyses



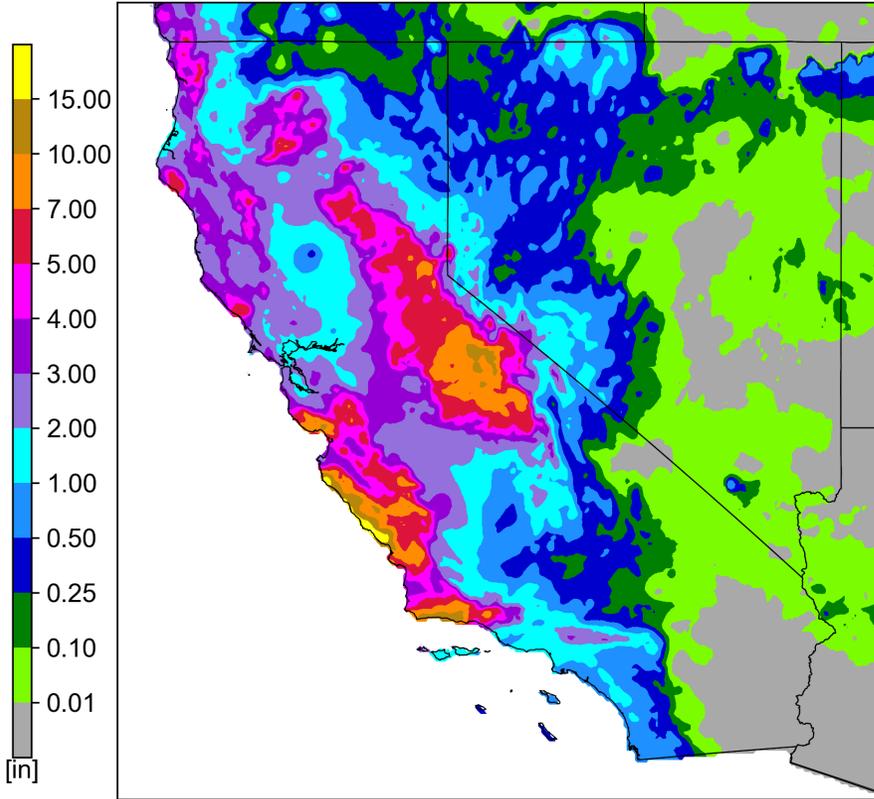
- This AR produced AR 1/AR 2 conditions along the coast of Central California
- A maximum IVT value of $611 \text{ kg m}^{-1} \text{ s}^{-1}$ and an AR duration of 45 hours were observed at 35.5°N , 121°W (near Morro Bay, CA)

Event Summary: 26–29 Jan 2021

For California DWR's AR Program

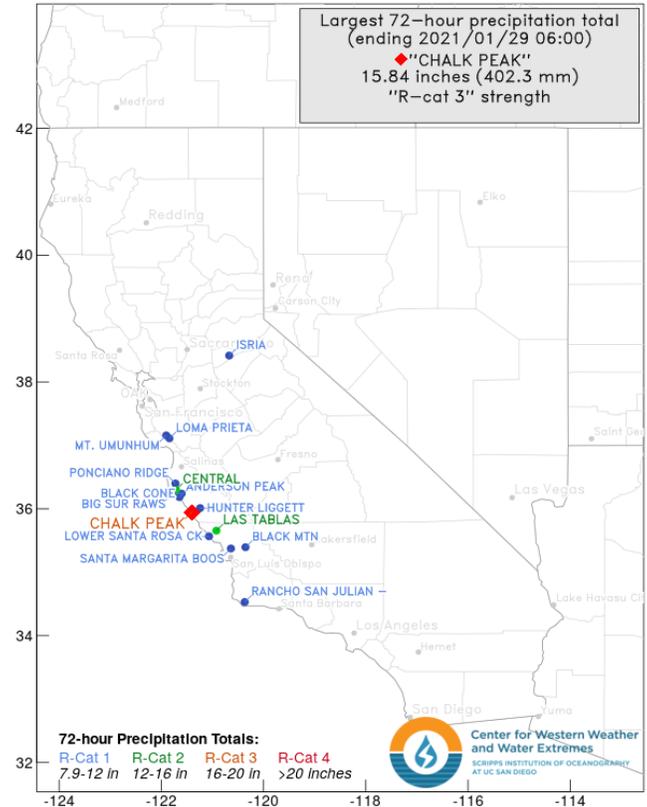
NCEP Stage IV 72-h QPE

Valid: 1200 UTC 26–29 Jan



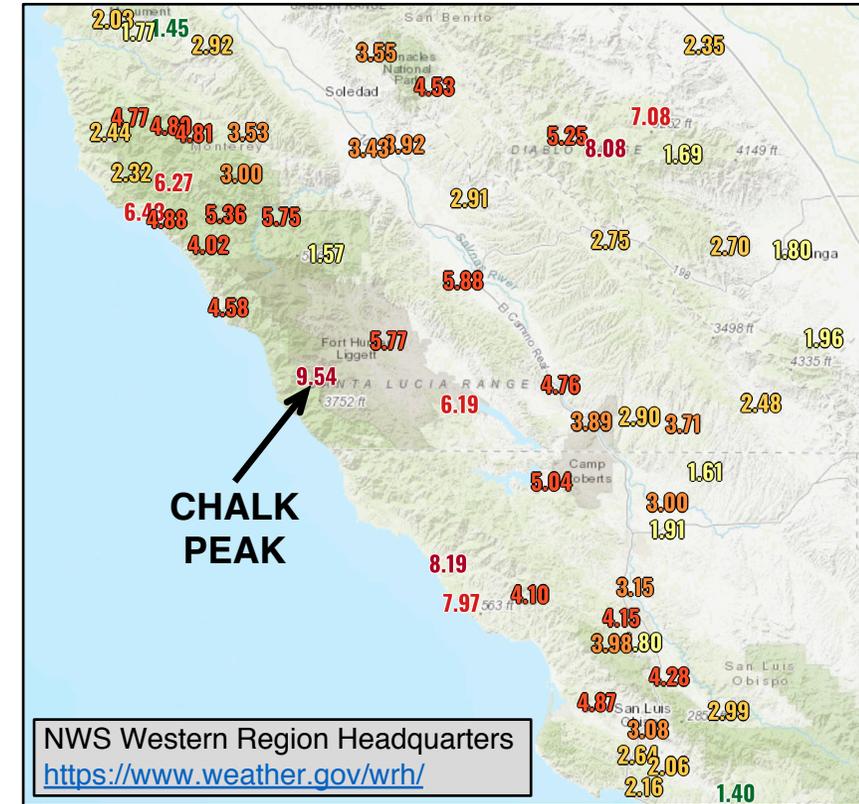
72-h Rainfall Category (R-CAT)

Ending: 6 AM PST 29 Jan



24-h Observed Precipitation

Valid: 1200 UTC 27–28 Jan



- More than 7 inches of precipitation fell in portions of the Sierra Nevada, Central California Coast Ranges, and western Transverse Ranges during the 72-h period ending at 1200 UTC (4 AM PST) 29 Jan
- The highest precipitation amounts were observed in western Monterey and San Luis Obispo Counties
- Chalk Peak recorded 15.84 inches in a 72-h period [R-Cat 3 on the Ralph and Dettinger (2012) Rainfall Category scale]
- The heaviest rainfall occurred as the AR pivoted over Central California, resulting in a 24-h accumulation of 9.54 inches at Chalk Peak

Storm-Total Precipitation

Station	3-day Precip (in)	Normal Annual Precip (in)	% of Normal Annual Precip
Big Sur	13.38	44.88	29.8%
Santa Cruz	6.32	31.35	20.2%
Paso Robles	5.88	15.20	38.7%
King City	4.55	12.06	37.7%
Modesto	3.70	13.11	28.2%
Friant Government Camp	3.47	14.93	23.2%
Salinas	3.06	12.83	23.9%
Los Banos	2.96	9.95	29.7%
Merced	2.83	12.50	22.6%
Coalinga	2.53	8.25	30.7%

Daily Precipitation Records

Station	Record Precip (in) 27 Jan	Record Precip (in) 28 Jan
Fresno		1.78
Hanford		1.47
Merced	1.42	1.41
Modesto	2.49	0.94
Paso Robles	1.39	2.94
Santa Barbara		2.24
Santa Maria		2.30
Stockton	1.37	1.43

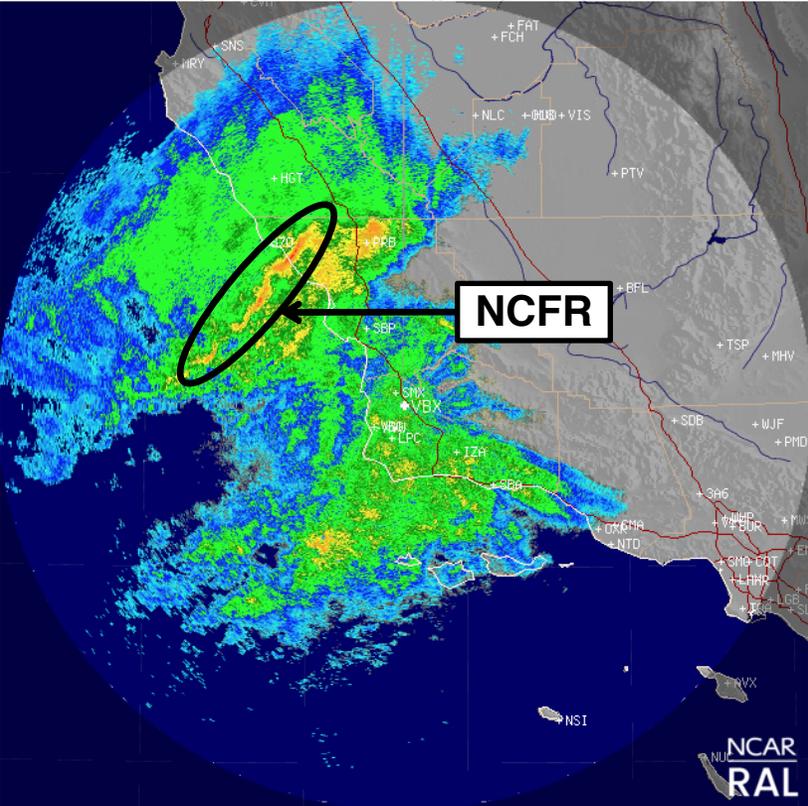
Sources: NOAA/NWS Hanford, <https://www.weather.gov/hnx/>
 NOAA/NWS Los Angeles, <https://www.weather.gov/lox/>
 NOAA/NWS Sacramento, <https://www.weather.gov/sto/>
 NOAA/NWS San Francisco, <https://www.weather.gov/mtr/>

- Several locations received more than 20% of their average annual precipitation over a 3-day period
- New daily precipitation records were set at Merced, Modesto, Paso Robles, and Stockton on both 27 Jan and 28 Jan
- New daily precipitation records were also set at Fresno, Hanford, Santa Barbara, and Santa Maria on 28 Jan

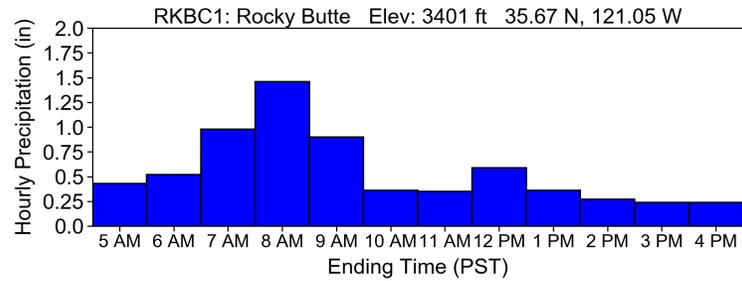
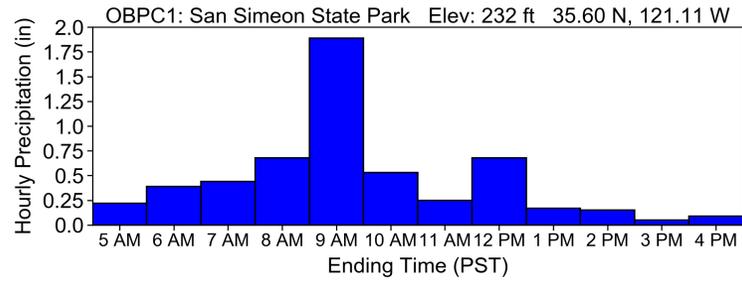
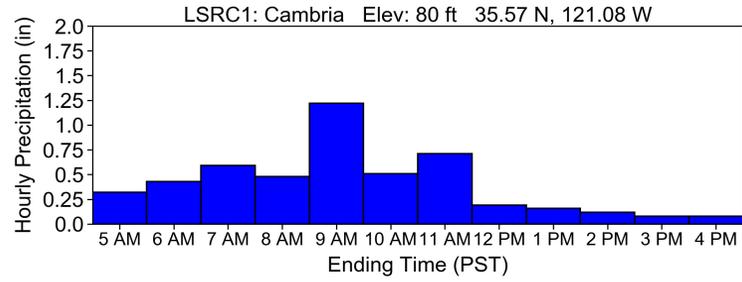
Event Summary: 26–29 Jan 2021

For California DWR's AR Program

KVBX Vandenberg AFB, CA/Orcutt Oil Field 16:03:56 UTC Wed 27 January 2021
 NEXRAD Level II Base reflectivity: 0.5 degrees (c) UCAR <http://weather.rap.ucar.edu/radar/>

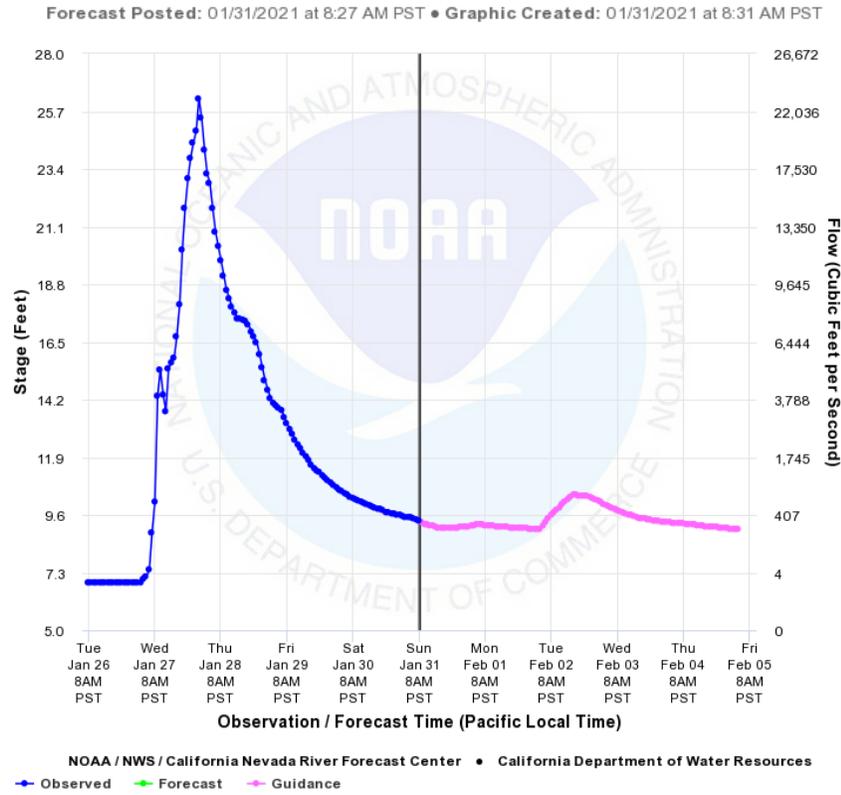


Source: NCAR RAL, <https://ral.ucar.edu/>



Source: NOAA/NWS CNRFC, <https://www.cnrfc.noaa.gov/>

Nacimiento River - Sapaque (NBYC1) River Forecast Plot



- A narrow cold-frontal rainband (NCFR) produced very intense rainfall over northern San Luis Obispo County during the morning of 27 Jan
- Several automated stations in the vicinity of this NCFR recorded precipitation rates in excess of 1 inch/hour
- The Nacimiento River (below Sapaque Creek) rose 20 feet in a 24-hour period, reaching a maximum stage height of 26.79 ft around 12 AM PST 28 Jan
- The peak discharge (24,200 cfs) was the highest discharge recorded at this gage since 3 Feb 1998

Landslide on Highway 1 near Big Sur, CA



Source: Heath Johnston, Caltrans

NATIONAL WEATHER SERVICE

Flash Flood Watch

Valid through Thursday Afternoon

Published: January 27, 2021

Heavy rainfall may lead to debris flows & flash flooding in and near recent burn areas.

Rapid ponding of water in urban and poor drainage areas possible. Cannot rule out mudslides/washouts in steep terrain.

DO NOT ATTEMPT TO CROSS FLOODED ROADWAYS!!

Flash Flood Warning

- Dolan Burn Scar: Until 3:30 PM
- Carmel and River Burn Scars: Until 3:15 PM
- CZU Burn Scar: Until 6:30 PM

San Francisco Bay Area/Monterey
weather.gov/bayarea

The graphic includes a map of the San Francisco Bay Area and Monterey region with various burn scar areas highlighted in red and yellow. Labels on the map include Santa Rosa, Nap, Concord, San Francisco, Livermore, Half Moon Bay, San Jose, Santa Cruz, Gilroy, Salinas, Monterey, Carmel/River Burn Scars, Big Sur, Dolan Burn Scar, SCU Burn Scar, and King City. Social media icons for Twitter, Facebook, and YouTube are at the bottom left.

- Intense rainfall on 27 Jan triggered a debris flow that washed out a portion of Highway 1 at Rat Creek, roughly 20 miles south of Big Sur, CA
- This debris flow occurred within the burn scar region of the August 2020 Dolan Fire

Mudslide along River Road near Salinas, CA



Source: Brian Emfinger, Live Storms Media

Home Damaged by Mudslide near River Road



Source: Monterey County Regional Fire Department

- Intense rainfall also caused debris flows within the River Fire burn scar near Salinas, CA
- The collapse of the hillside above River Road resulted in an extensive mudflow that damaged at least 20 homes

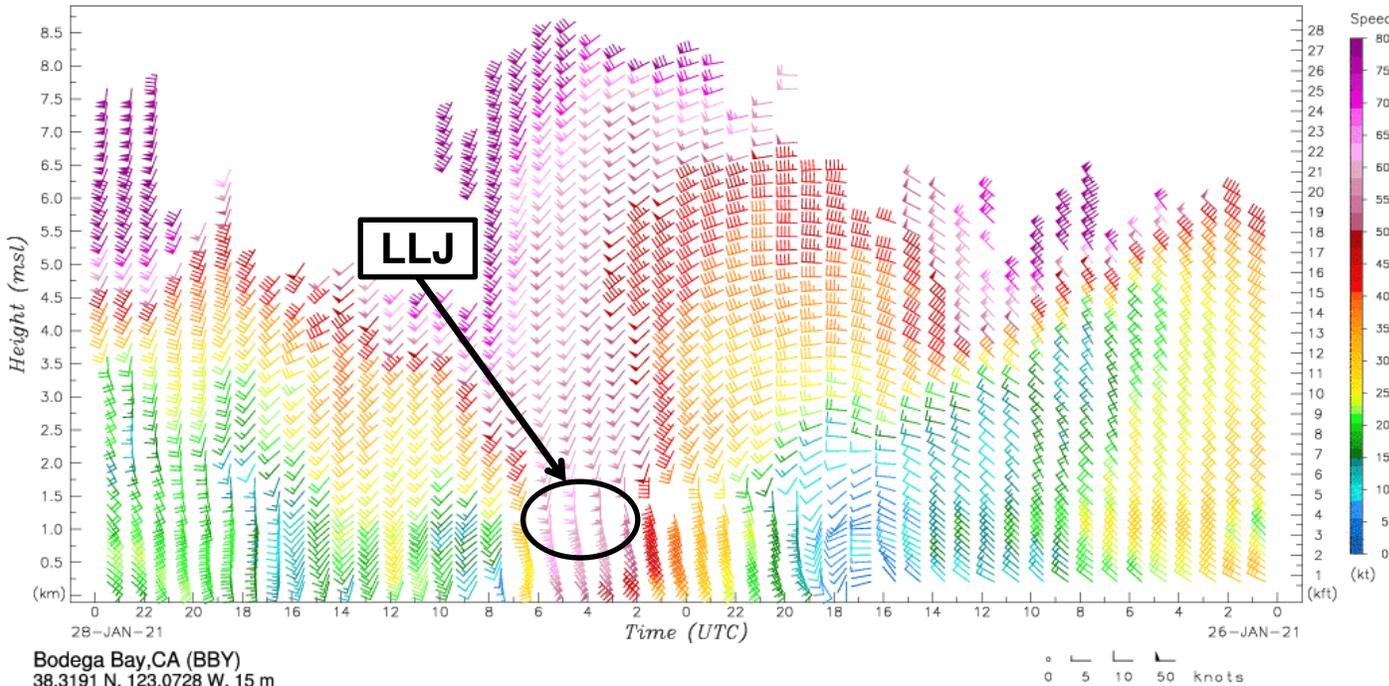
ESRL Physical Sciences Laboratory
449-MHz Wind Profiling Radar



Home Damaged by Fallen Tree in Sacramento



Source: Daniel Kim, Sacramento Bee



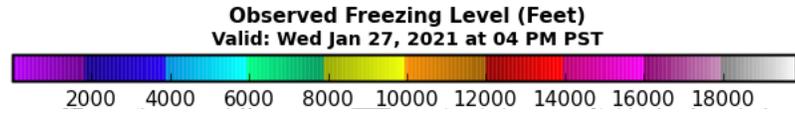
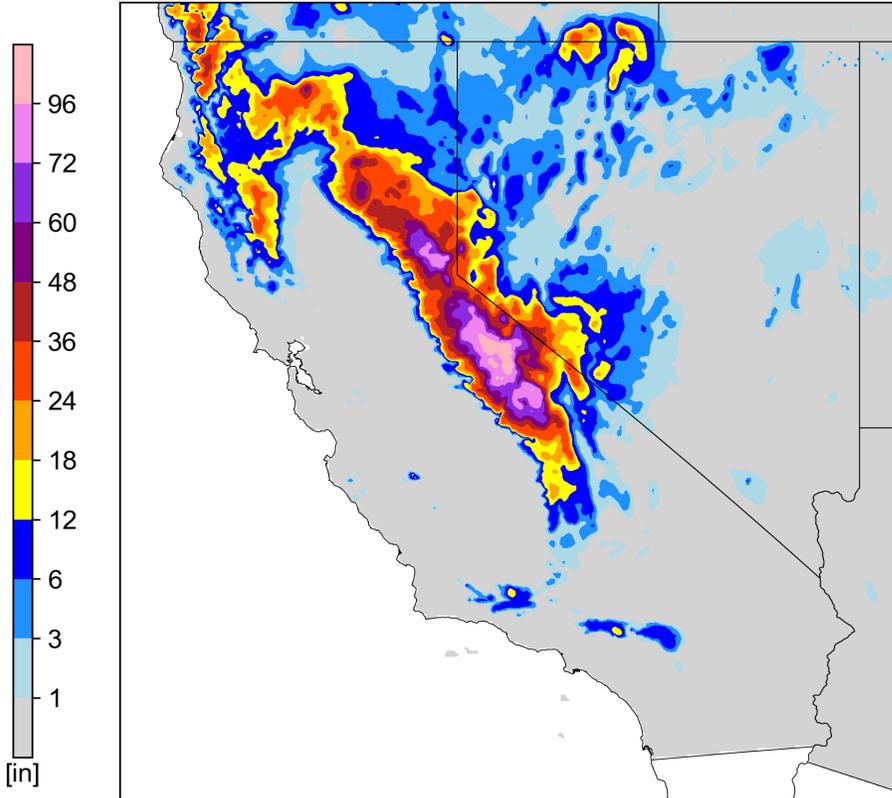
Bodega Bay, CA (BBY)
38.3191 N, 123.0728 W, 15 m

Source: NOAA ESRL, <https://www.esrl.noaa.gov/>

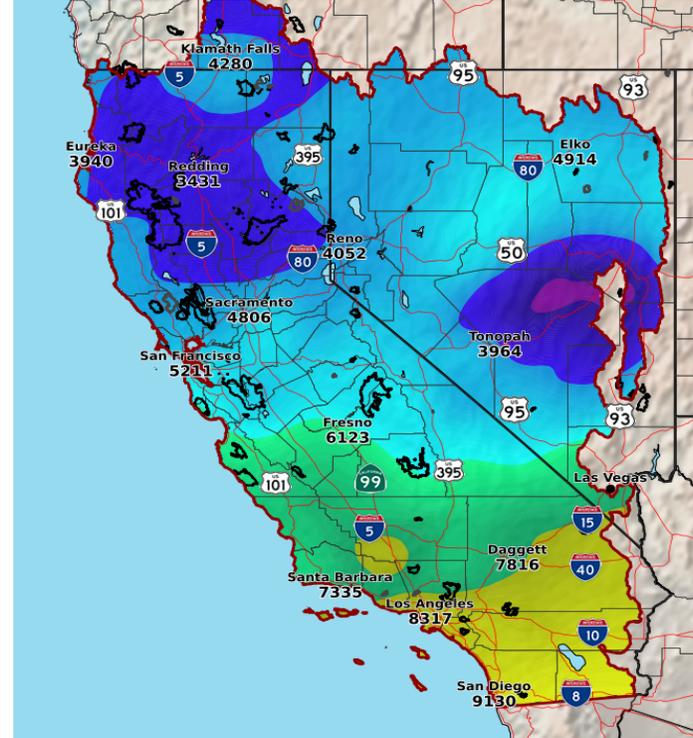
- The formation of the narrow cold-frontal rainband (NCFR) was facilitated by a strong southerly low-level jet (LLJ) in the warm sector of the surface cyclone
- High winds ahead of the cold front downed trees and caused property damage in the Bay Area and the Central Valley
- A San Jose State University mesonet station near Mt. Diablo recorded a wind gust of 80 mph shortly after midnight on 27 Jan

NOHRSC 72-h Interpolated Snowfall

Valid: 1200 UTC 26–29 Jan

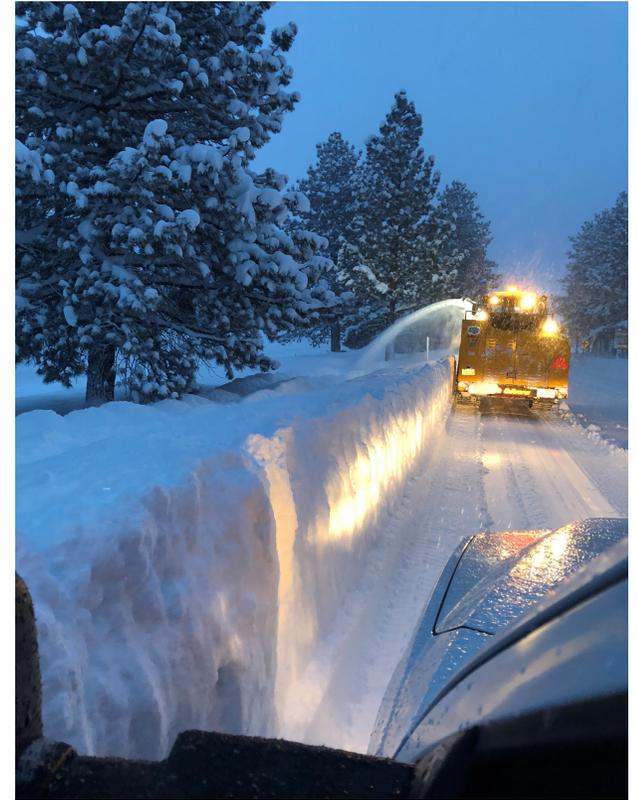


Observed Freezing Level (Feet)
Valid: Wed Jan 27, 2021 at 04 PM PST



National Weather Service
CNRFC - Sacramento, CA
Created: 01/28/2021 08:03 AM PST
www.cnrfc.noaa.gov

Snow Removal on US-395



Source: Don Conde, Caltrans

- More than 2 feet of snow fell across much of the Sierra Nevada, with the highest accumulations (> 8 feet) in the vicinity of Mammoth Lakes and Yosemite National Park
- A storm-total snowfall of 107 inches was recorded at the summit of Mammoth Mountain (94 inches at base elevation)
- Low freezing levels allowed for significant snowfall accumulations below 6,000 ft, as well as accumulating snow in the Sonoma County mountains and near the floor of the Sacramento Valley (1.5 inches at Redding Airport)
- Heavy snow resulted in numerous highway closures in the Sierra Nevada, including sections of Interstate 80 and US-395

Event Summary: 26–29 Jan 2021

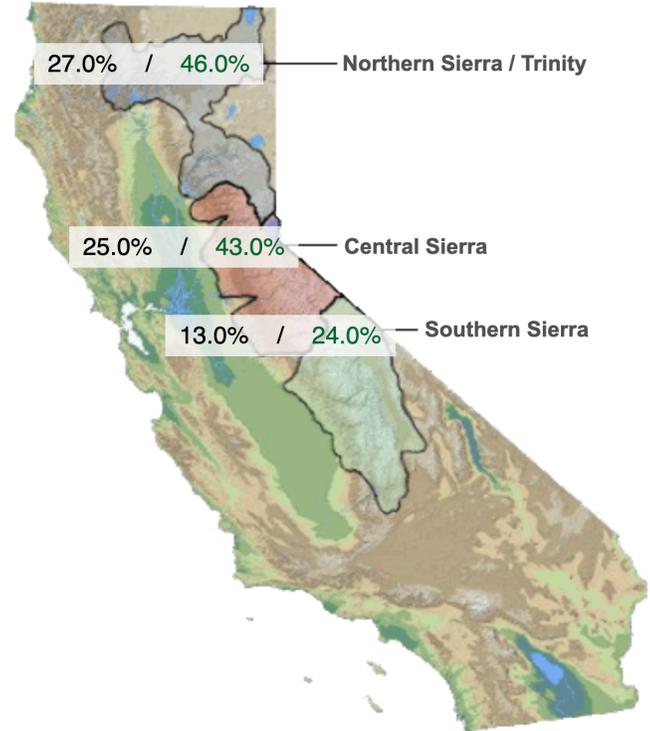
For California DWR's AR Program

Snowpack Monitoring

Provided by the California Cooperative Snow Surveys

Data For: 26-Jan-2021

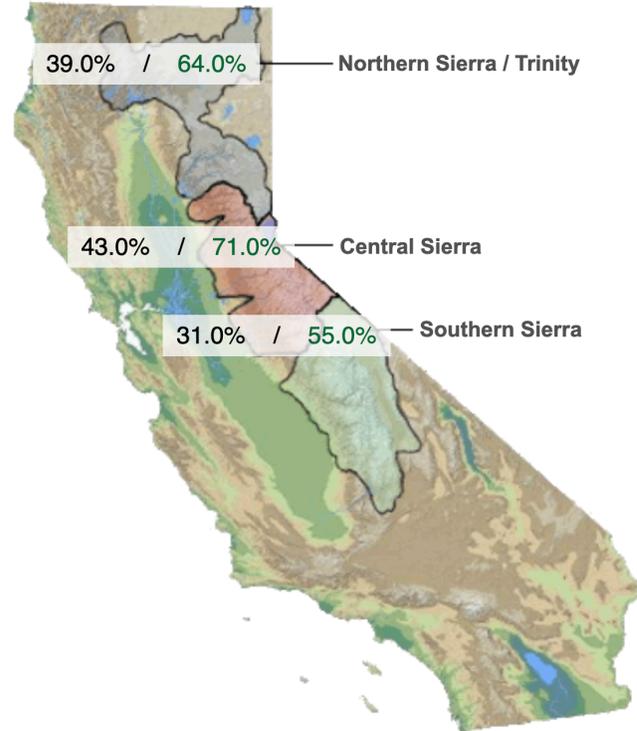
% Apr 1 Avg. / % Normal for this Date



Provided by the California Cooperative Snow Surveys

Data For: 29-Jan-2021

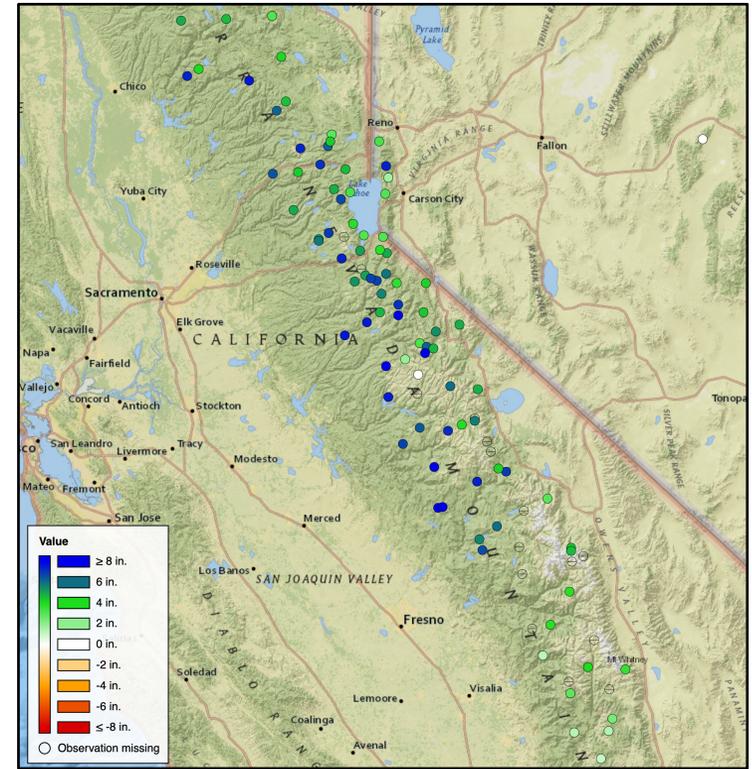
% Apr 1 Avg. / % Normal for this Date



Source: California Department of Water Resources, <https://water.ca.gov/>

3-day SWE Change

Valid: 26–29 Jan (Start of Day)

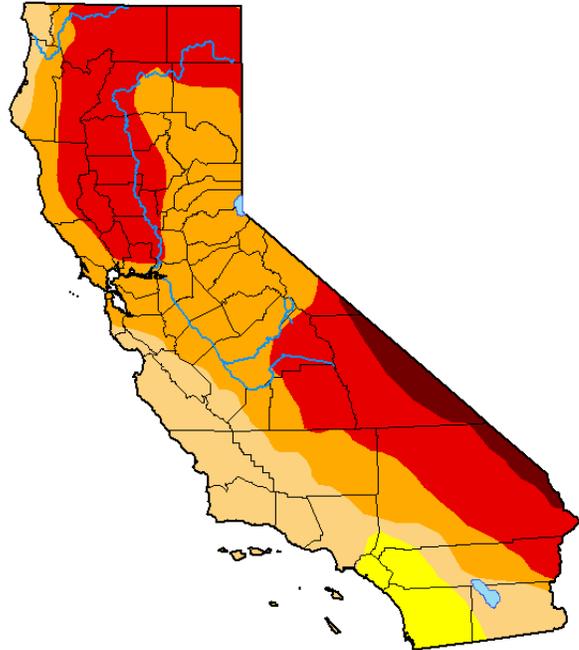


Source: USDA NRCS National Water and Climate Center, <https://www.wcc.nrcs.usda.gov/>

- Before this storm, all three regions of the Sierra Nevada were reporting less than 50% of normal year-to-date snowpack conditions
- Statewide snowpack increased from 42% of normal on 26 Jan to 66% of normal on 29 Jan (still well-below normal)
- Snow water equivalent (SWE) increased by more than 8 inches at several snow monitoring sites during this 3-day period

U.S. Drought Monitor: 26 Jan 2021

U.S. Drought Monitor California



January 26, 2021
(Released Thursday, Jan. 28, 2021)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	95.20	75.74	39.46	3.86
Last Week 01-19-2021	0.00	100.00	95.20	78.12	39.46	1.19
3 Months Ago 10-27-2020	15.40	84.60	67.54	35.61	12.74	0.00
Start of Calendar Year 12-29-2020	0.00	100.00	95.17	74.34	33.75	1.19
Start of Water Year 09-29-2020	15.35	84.65	67.65	35.62	12.74	0.00
One Year Ago 01-28-2020	65.72	34.28	0.00	0.00	0.00	0.00

Intensity:
 None (White) D2 Severe Drought (Orange)
 D0 Abnormally Dry (Yellow) D3 Extreme Drought (Red)
 D1 Moderate Drought (Light Orange) D4 Exceptional Drought (Dark Red)

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>

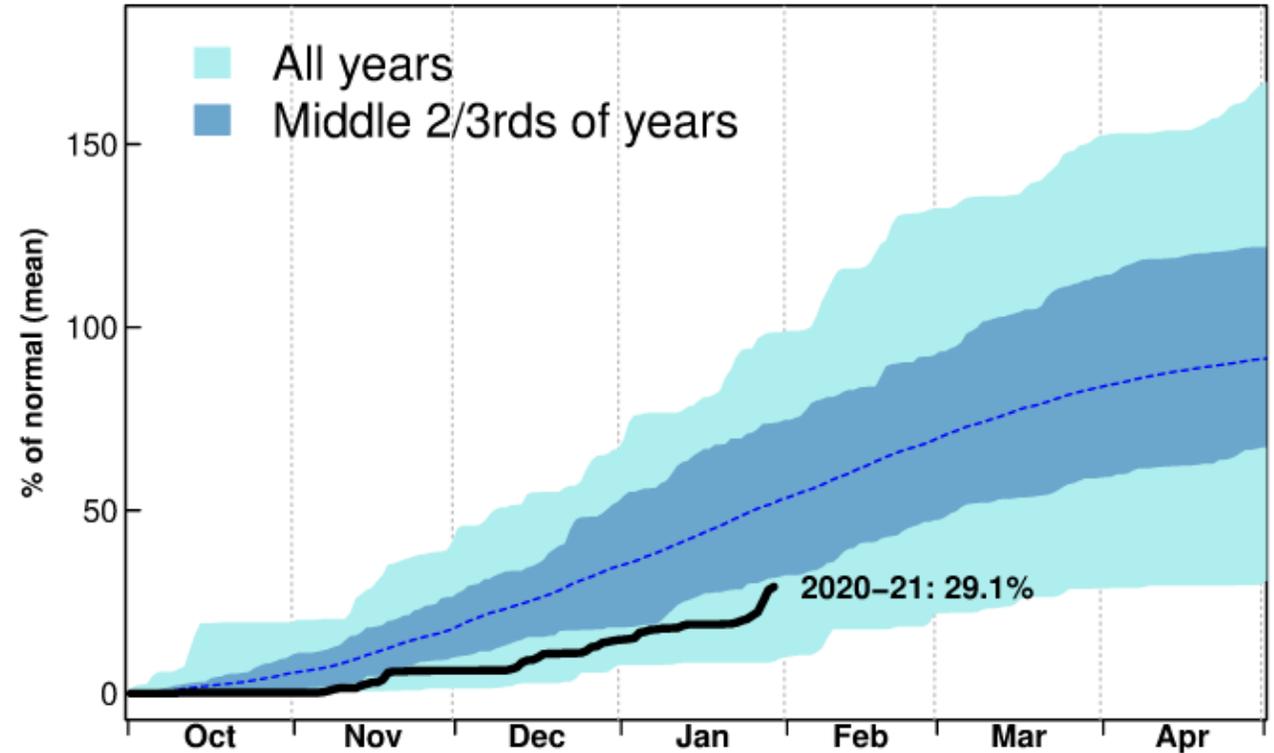
Author:
Richard Tinker
CPC/NOAA/NWS/NCEP



droughtmonitor.unl.edu

California Precip Tracking: 1 Oct 2020 – 29 Jan 2021

all_CA precip for all years, data through 2021/01/29



Source: California–Nevada Applications Program, <https://cnap.ucsd.edu/>

- Prior to this event, 95% of California was experiencing drought conditions, with severe-to-extreme drought conditions in much of Northern and Central California
- California received 7.6% of its normal total water year (Oct–Sep) precipitation between 26 Jan and 29 Jan
- Statewide cumulative precipitation increased from 21.5% to 29.1% of the normal water year total during this 3-day period, but despite the improvement, still remains well-below normal for this time of year