# CW3E Event Summary: 9-12 December 2022

Atmospheric River with Strong Dynamical Forcing Produced Heavy Precipitation Throughout California

- An upper-level trough over the Gulf of Alaska on 9 December deepened along the US West Coast producing a landfalling atmospheric river (AR) and heavy orographic precipitation
- The landfalling AR was ranked as an AR2 (based on the Ralph et al. 2019 AR Scale) along the Oregon coast and an AR1 along the Central California coast
- The deterministic GFS struggled to forecast the AR location, magnitude, and orientation at lead times > 3 days
- The storm produced heavy precipitation along the Central California coast between the San Francisco Bay area and Santa Barbara
- Mining Ridge received 12.80 inches of precipitation over a 72-hour period ending 9 AM 12 Dec; an R-Cat 2 according to the Ralph and Dettinger (2012) classification
- The largest snowfall totals (> 6 feet) were observed across the higher terrain of the Sierra Nevada with the Klamath mountains receiving 1-3 feet of snowfall
- CW3E's surface meteorology station at Seven Oaks Dam observed 1 inch of rain during the event. Approximately 20% of water year normal precipitation has fallen at the station
- Recent storms in California have been cold, efficient snow producers leading to a discrepancy between water year to date precipitation and current snowpack in the Sierra Nevada
- The AR resulted in multiple rainfall-related swift water rescues, snowfall-related road closures, and dangerous backcountry avalanche conditions
- As part of CW3E's ongoing Atmospheric River Reconnaissance research field campaign, two flights originating from Hawaii sampled atmospheric conditions upstream of this AR in the North Pacific

CW3E Event Summary: 9-12 December 2022

500-hPa, IWV, and IVT Analysis

(A) Valid 4 PM PT 10 Dec
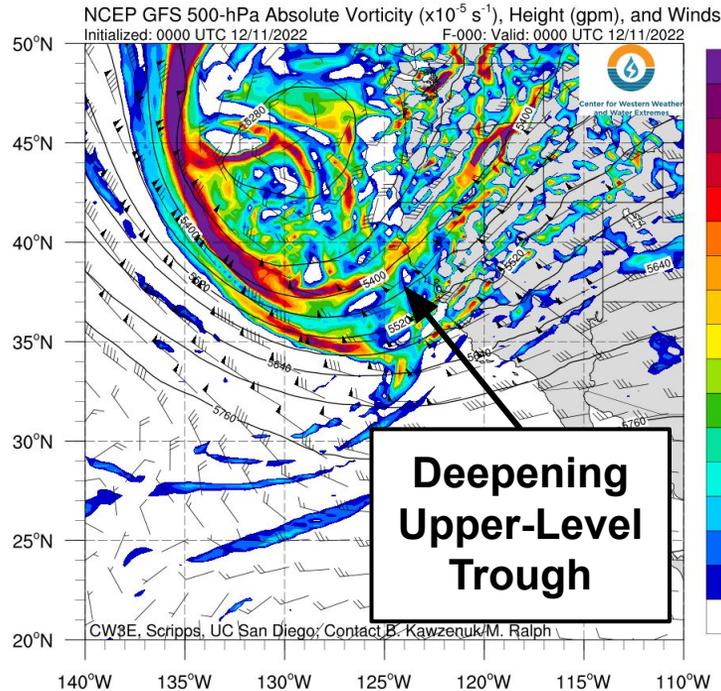
(B) Valid 4 PM PT 10 Dec
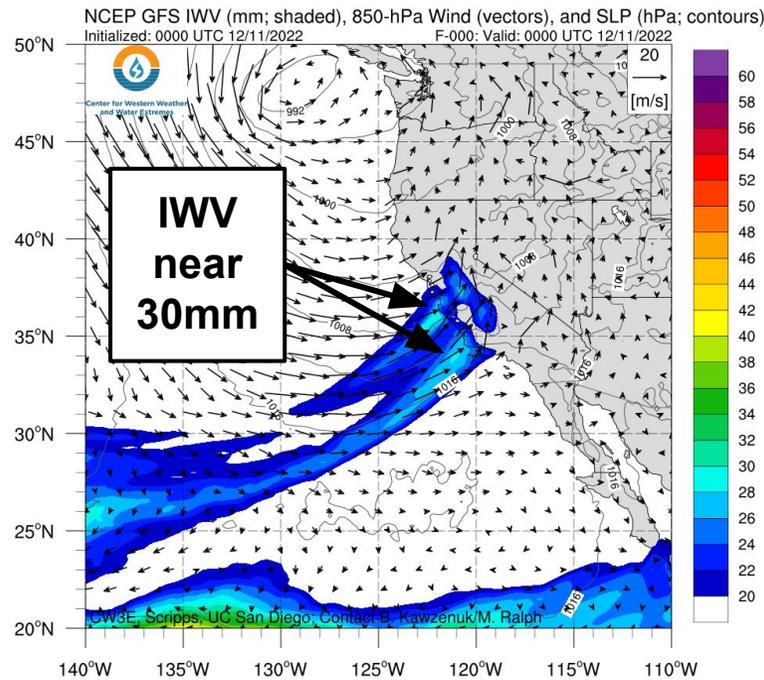
(C) Valid 4 PM PT 10 Dec
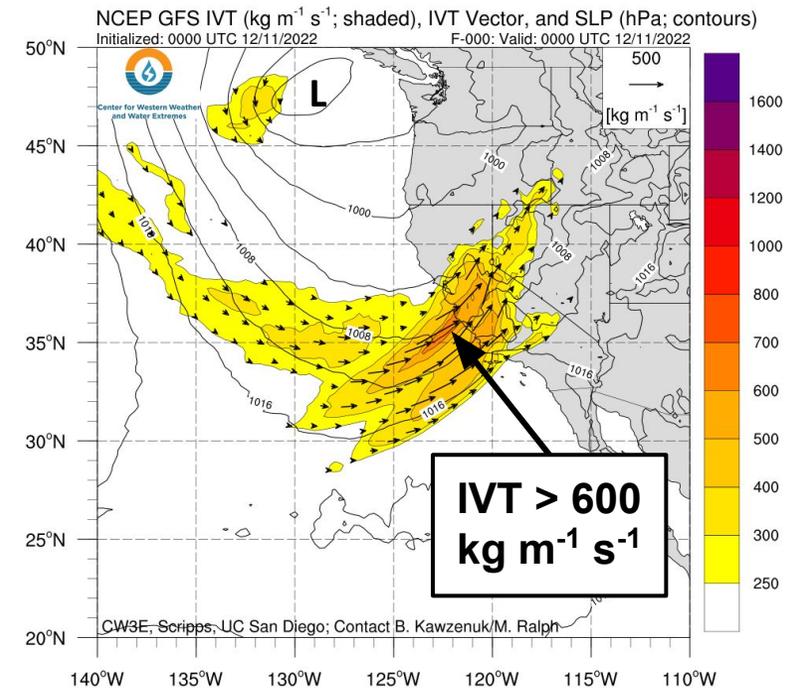
- An upper-level trough formed in the Gulf of Alaska (Figure A) and deepened as it moved south along the US West Coast
- The associated AR made landfall on 9 Dec along the Oregon coast, propagated south, and dissipated over Southern California on 12 Dec
- The landfalling AR was strongest over Central California when IWV values reached 30mm and IVT magnitudes exceeded 600 kg m^{-1} s^{-1} (Figures B and C)

# CW3E Event Summary: 9-12 December 2022

GEFS AR Scale
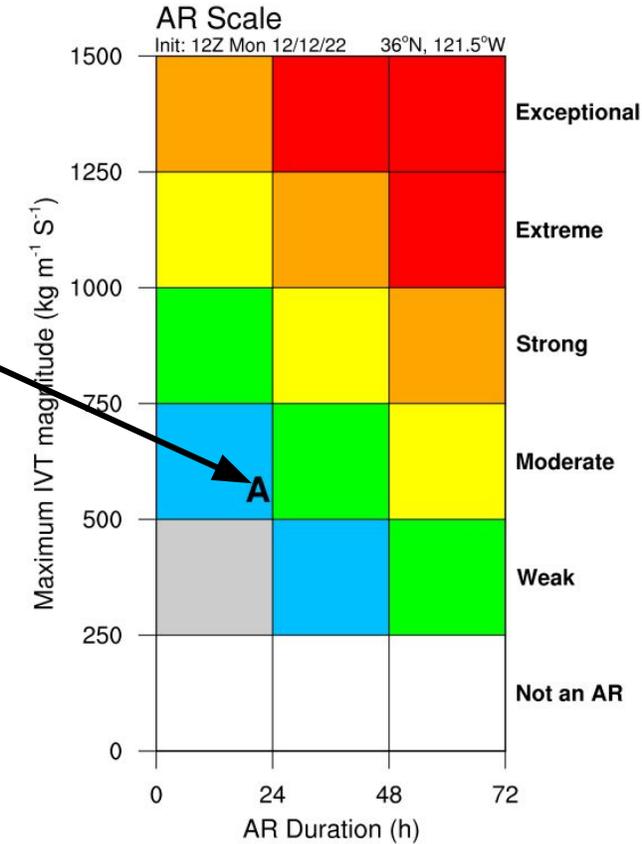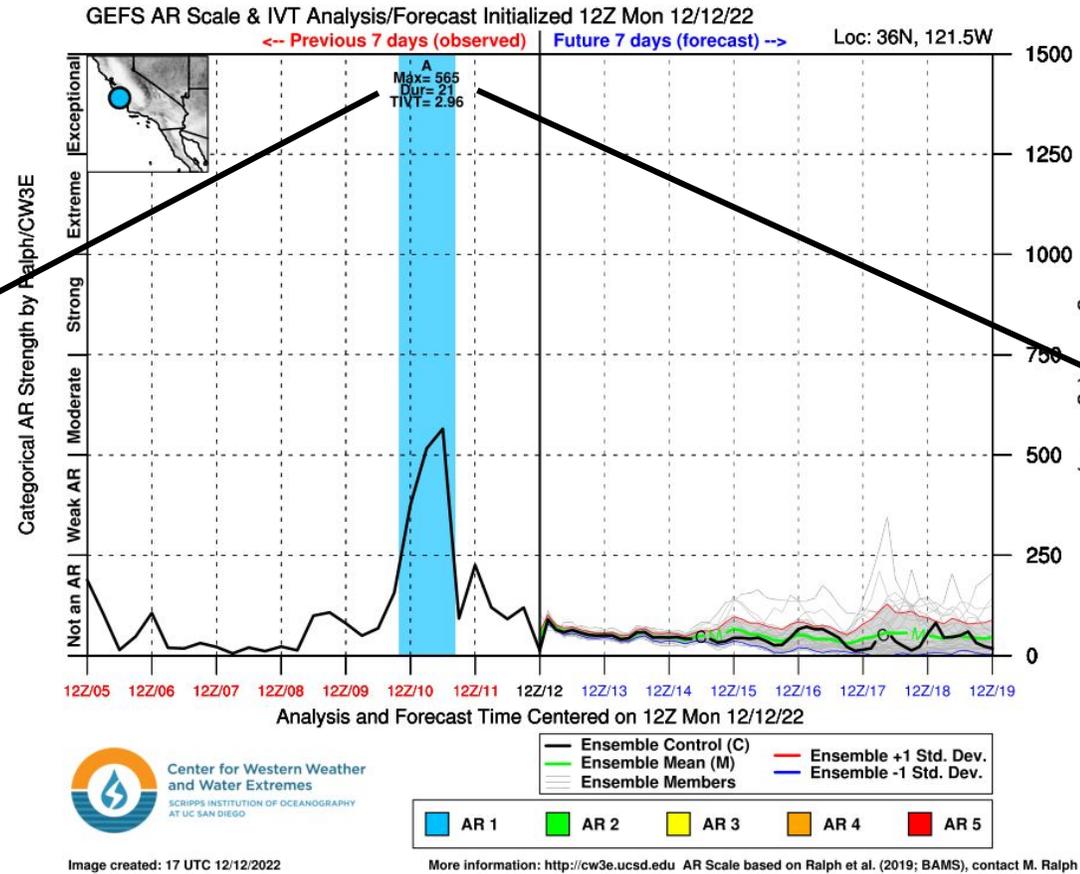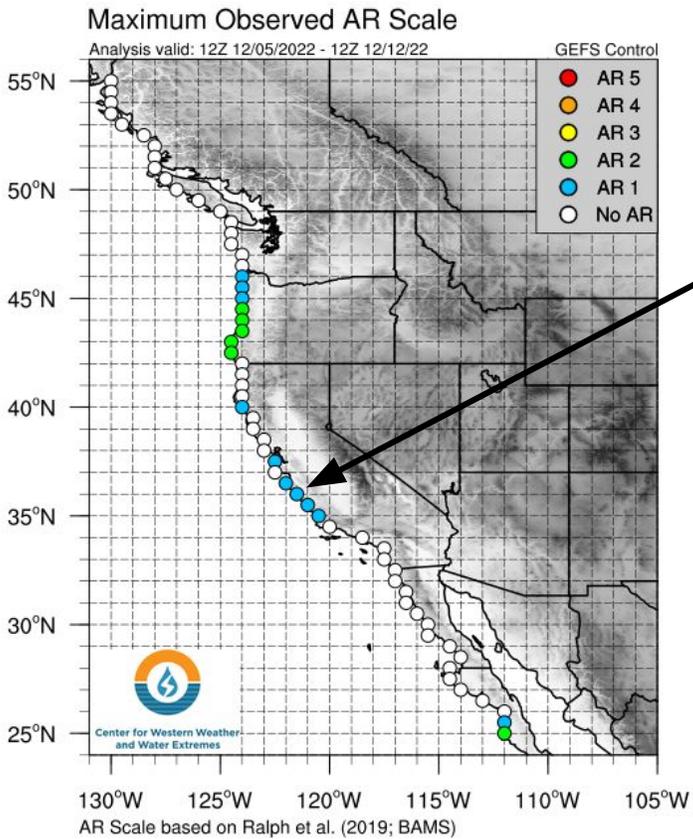
- AR 1/2 conditions were observed along coastal Oregon
- AR 1 conditions were observed along coastal Central California; 36N, 121.5W in Monterey County experienced a total of 21 hours of AR conditions with a maximum IVT magnitude of 565 kg m^{-1} s^{-1}

CW3E Event Summary: 9-12 December 2022

GFS AR/IVT Forecast Verification: Valid 0Z 11 Dec
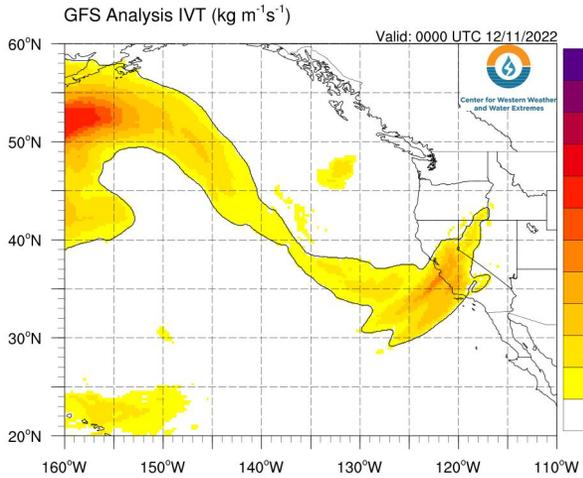
Model Analysis — **48-h Forecast** — **72-h Forecast** — **96-h Forecast**
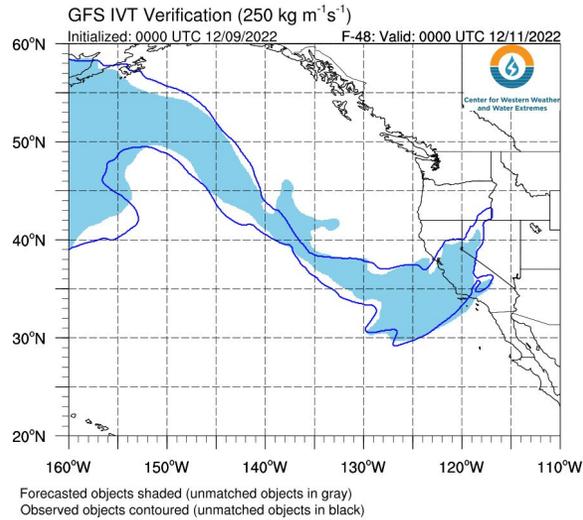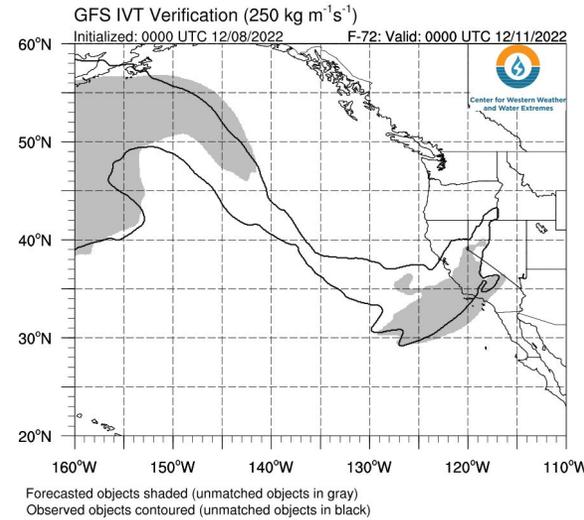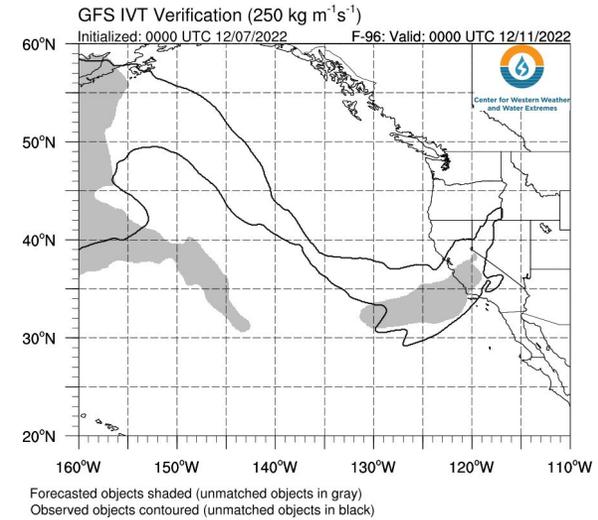
Forecast objects shaded (unmatched objects in grey)
Observed objects contoured (unmatched objects in black)
Objects defined based on IVT > 250 kg m^{-1} s^{-1}

- Using the Method for Object-Based Diagnostic Evaluation (MODE) with a 250 kg m^{-1} s^{-1} IVT threshold, the location of the AR over Central California was forecasted well by the deterministic GFS at a 48-hour lead time
- At 48-hours lead time the forecast AR was smaller in extent across Central California. The orientation of the AR was correct but the object was shifted to the south indicating a faster southward propagation
- At further lead times, the extent of the AR object becomes smaller and was not present over Central California altogether. At 96-hours lead time the AR was forecast for Central California but the orientation was more zonal.
- Overall, the deterministic GFS struggled to forecast the location, magnitude, and orientation of the AR at lead times > 3 days

Observed Precipitation

NCEP Stage IV 72-h QPE
Valid: 4 AM 12 Dec
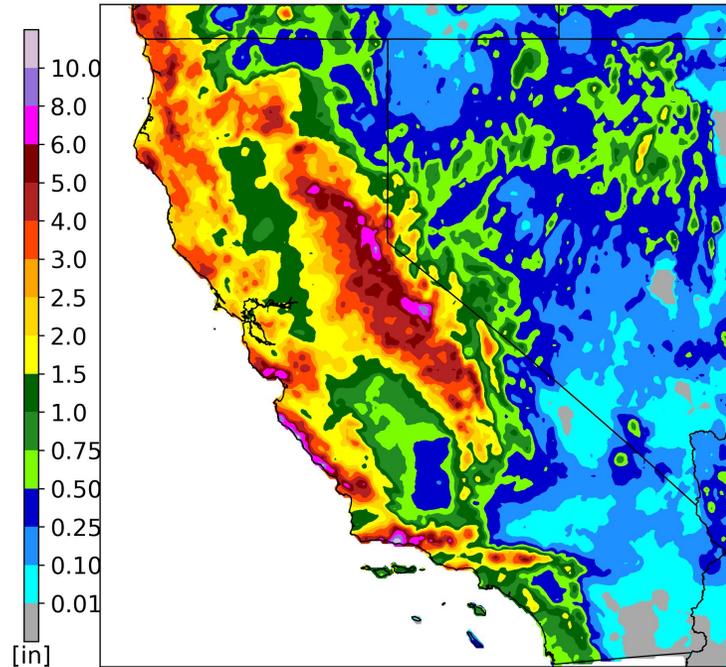
R-Cat report produced 2022/12/12 09:25:55

Largest 72-hour precipitation total
(ending 2022/12/12 09:00)
"Mining Ridge (MNRC1)"
12.80 inches (325.1 mm)
"R-cat 2" strength

72-hour Precipitation Totals:
R-Cat 1   R-Cat 2   R-Cat 3   R-Cat 4
7.9-12 in   12-16 in   16-20 in   >20 inches

Accumulated Precipitation at Mining Ridge
09 - 13 Dec
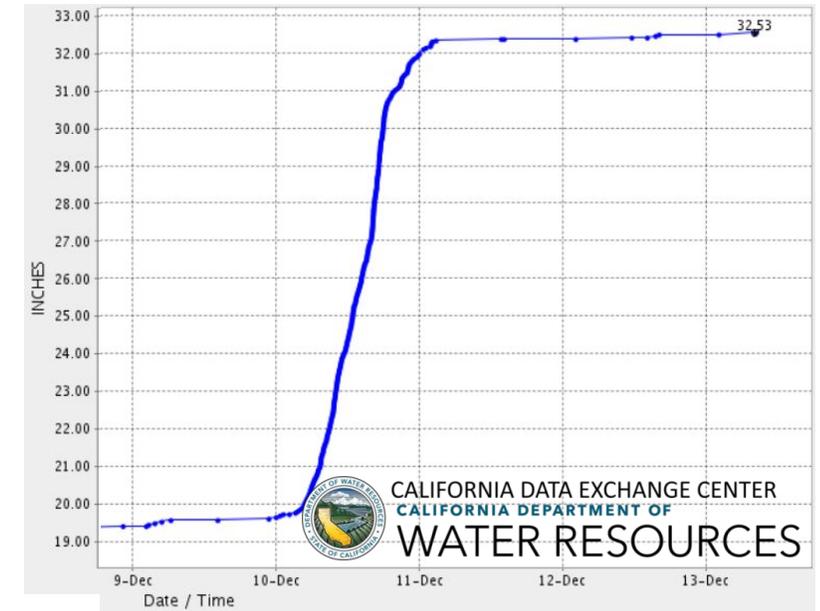
- The storm produced widespread precipitation amounts > 2 inches in California for the 72-hour period ending at 4 AM 12 Dec, with the heaviest precipitation (>6") in the Sierra and coastal locations in Central California
- Mining Ridge received 12.80 inches of precipitation over a 72-hour period ending 9 AM 12 Dec; an R-Cat 2 according to the Ralph and Dettinger (2012) classification
- Four stations in Central California experienced an R-Cat 1 storm, with the highest 72-hour precipitation recorded at Chalk Peak (9.06 inches)

CW3E Event Summary: 9-12 December 2022

Hydrologic Impacts
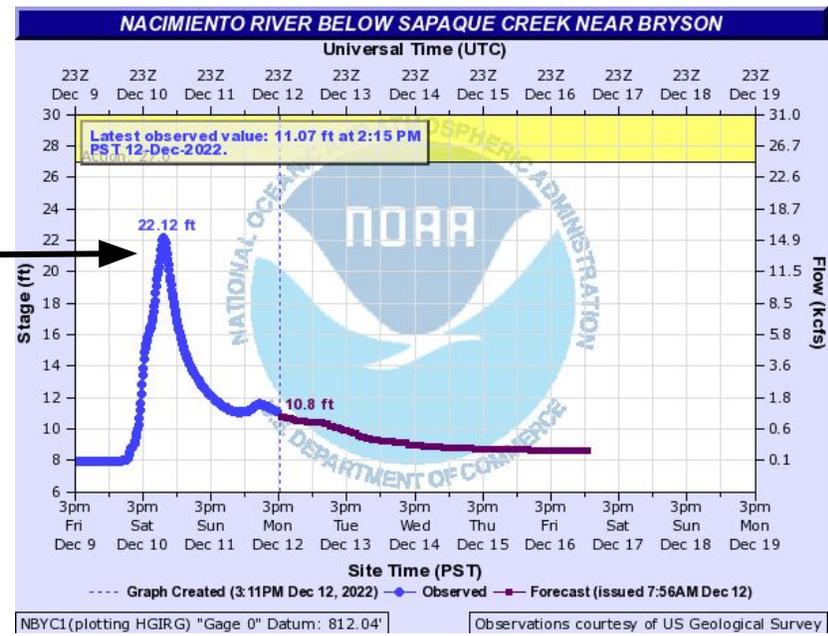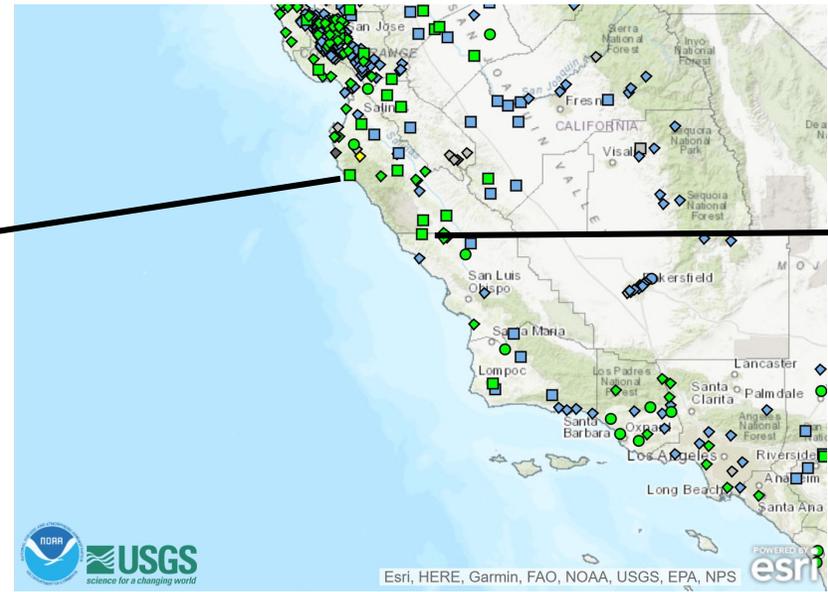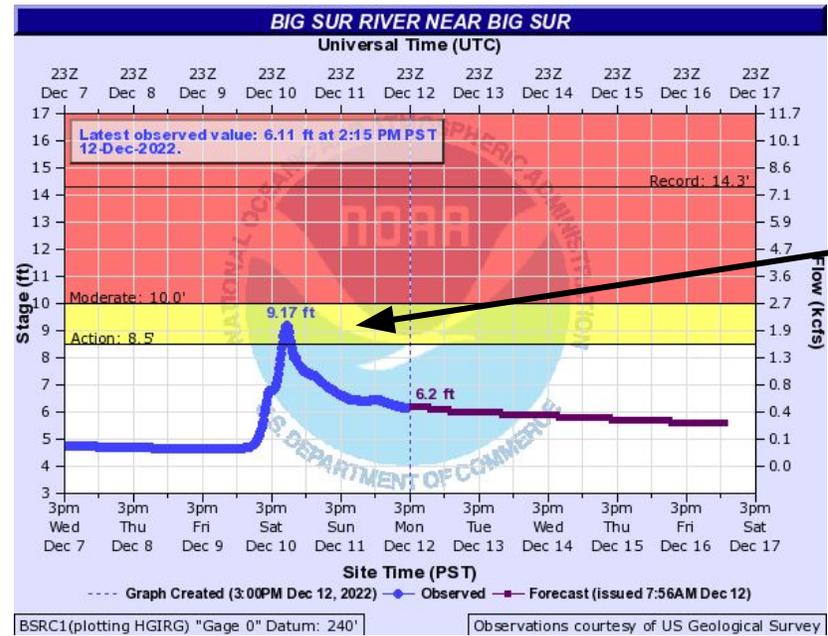
- The landfalling AR and associated precipitation produced sharp rises in coastal rivers
- The Big Sur River near Big Sur, CA rose to 9.17 feet (action stage)
- The Nacimiento River below Sapaque Creek rose approximately 14 feet, cresting at 22.12 feet (below action stage)

AMBASSADOR™
WRN
WEATHER-READY NATION

Observed Snowfall

NOHRSC 48-h Snowfall Analysis
Valid: 4 AM 12 Dec

> 72"
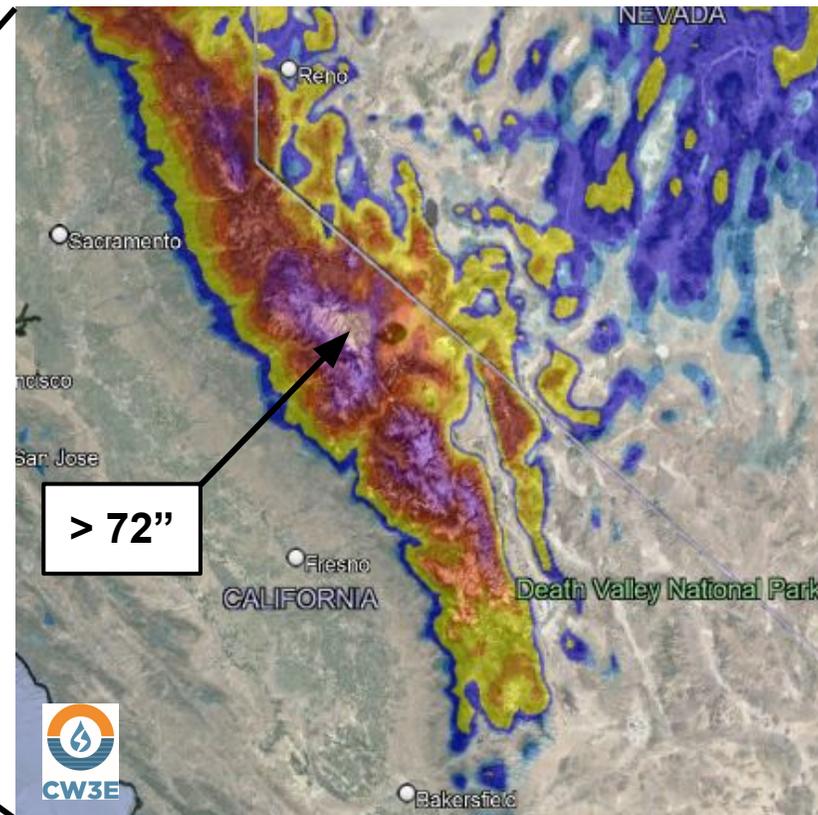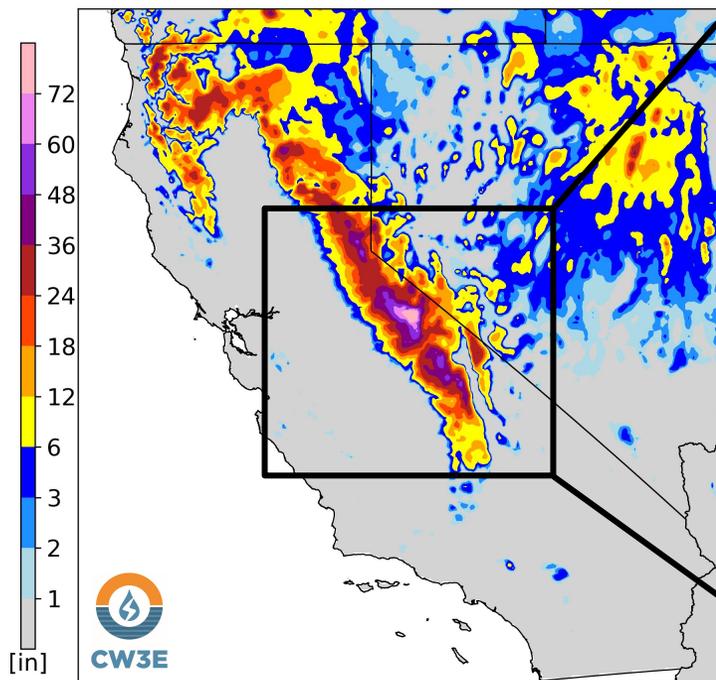
CNRFC 5-day SWE change
Valid: 4 AM 12 Dec
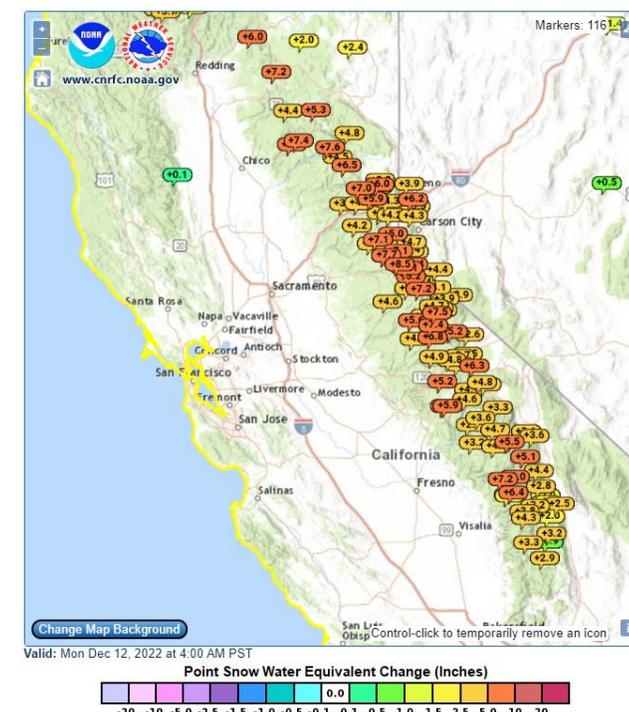
- The storm produced heavy snowfall (> 12") over the Klamath and Sierra Nevada mountains in California for the 72-hour period ending at 4 AM 12 Dec
- Snowfall totals > 4 feet were seen in parts of the Lake Tahoe Basin and Central and Southern Sierra
- More than 6 feet of snow fell in the Sierra west of the Mono Basin
- The storm provided SWE increases of 4-8 inches to the Sierra Nevada snowpack

CW3E Center for Western Weather and Water Extremes

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CW3E Event Summary: 9-12 December 2022

Seven Oaks Dam - CW3E Observations
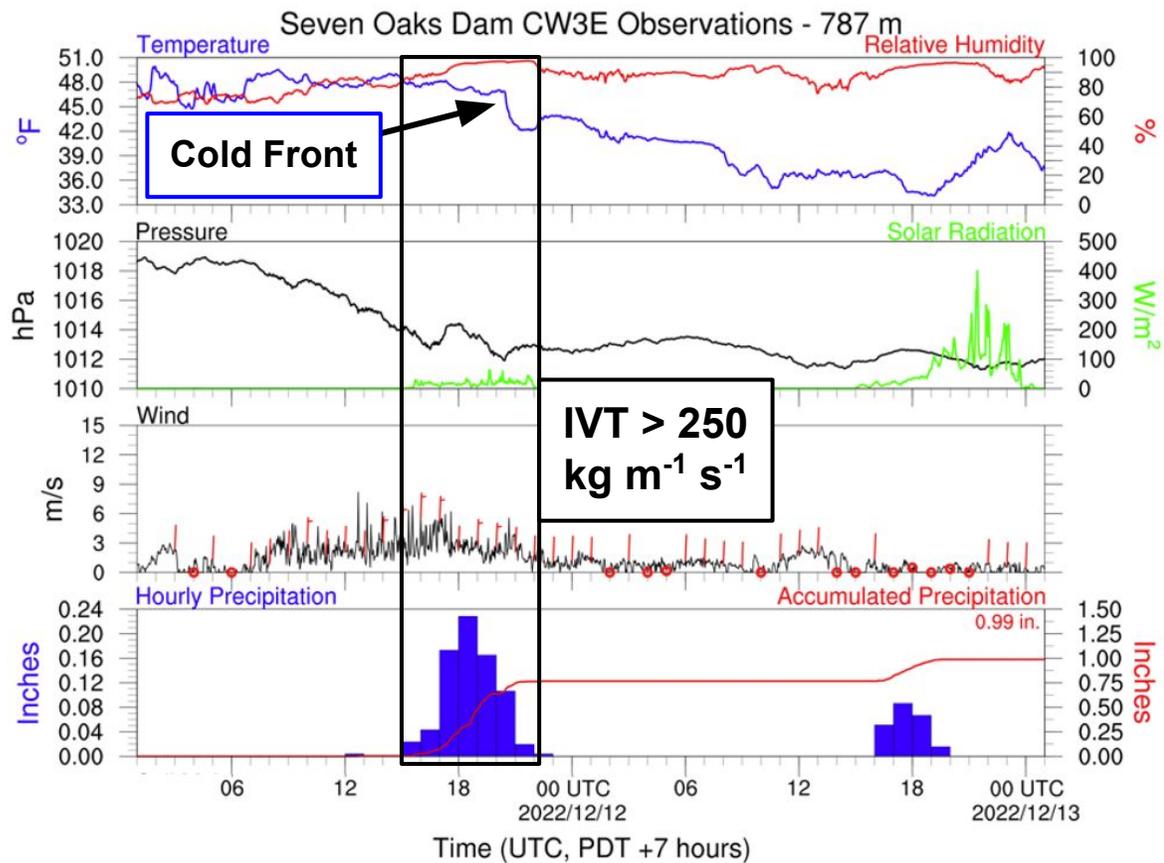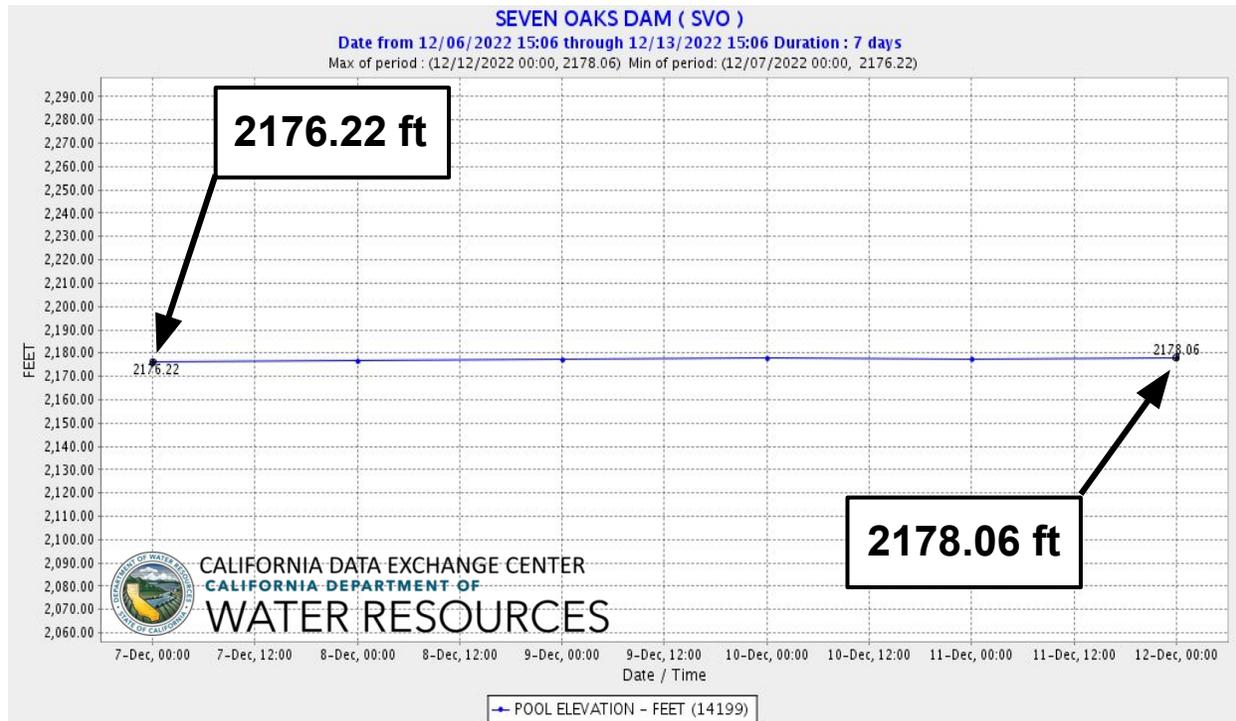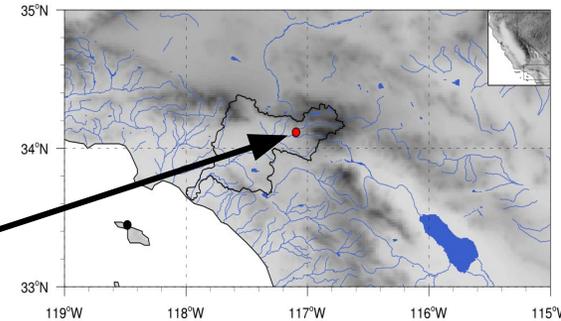
Seven Oaks Dam

- The landfalling AR produced IVT magnitudes > 250 kg m^{-1} s^{-1} for 12 hours on 11 Dec at the Seven Oaks Dam near San Bernardino
- Landfalling AR and cold frontal passage was associated with 0.99 inches of precipitation and a 5°F decrease in temperature
- Elevation of the Seven Oaks Reservoir increased by 1.84 feet from 7 Dec to 12 Dec

Seven Oaks Dam - CW3E Observations
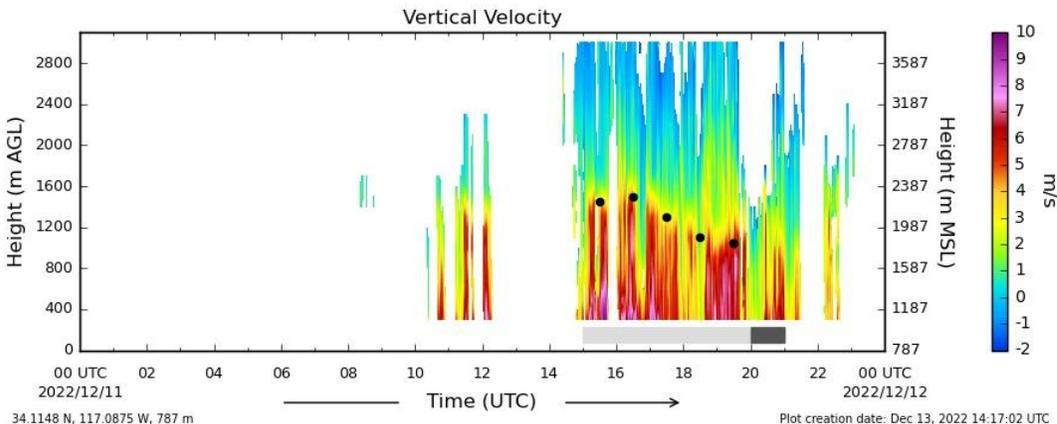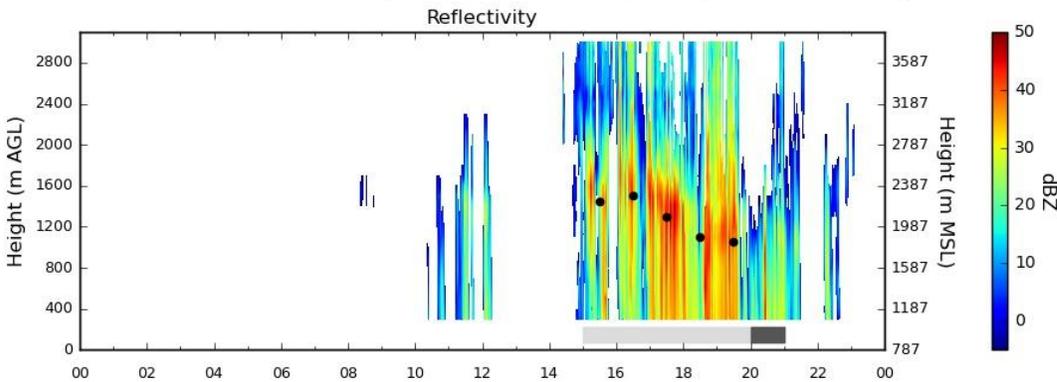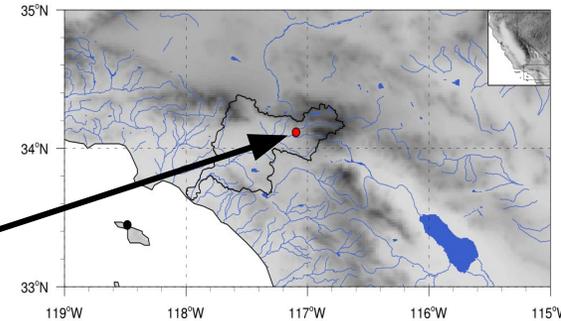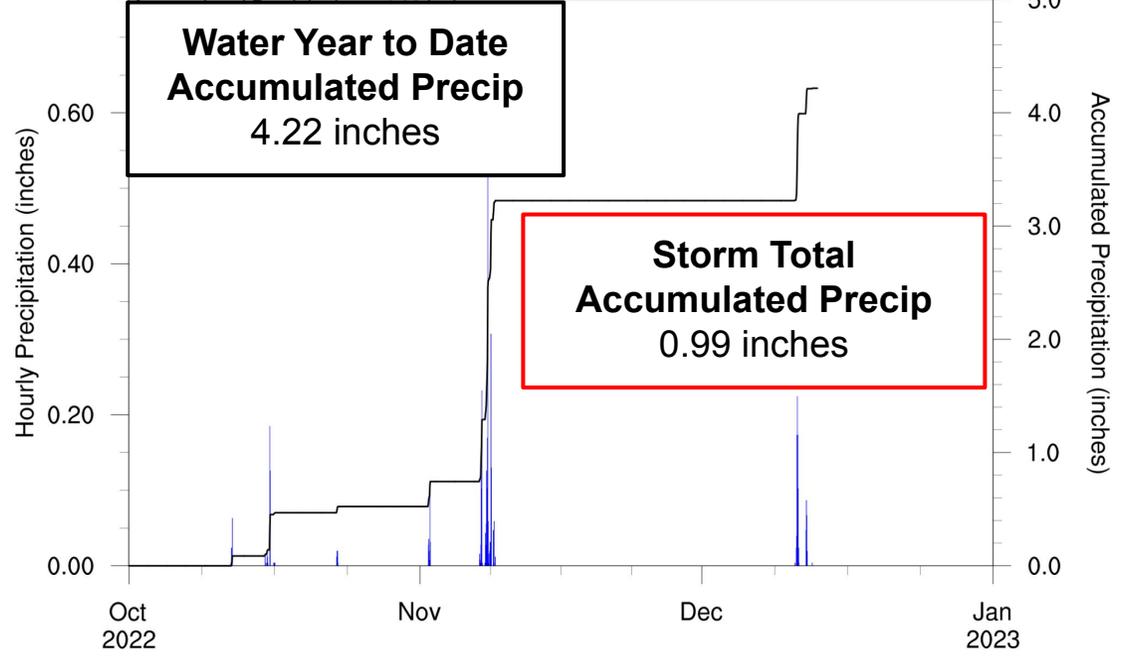
Seven Oaks Dam

- CW3E's Seven Oaks Dam vertically-pointing K-band Micro Rain Radar identified a brightband between 1,600 and 2,350 m MSL signifying the elevation of the melting level
- Approximately 1 inch of rain fell between 12Z 11 Dec to 18Z 12 Dec
- Water year to date precipitation (4.22 in) is approximately 20% of normal (~21 in) at this station (per PRISM data)

Water Year to Date: Precipitation & Snowpack

DAILY STATEWIDE HYDROLOGIC UPDATE

City: % of Normal Precip (Since Oct. 1)

Mount Shasta 70%
Eureka 80%
Redding 60%
South Lake Tahoe 95%
Sacramento 107%
Stockton 133%
Santa Rosa 59%
Yosemite Village n/a
San Francisco 67%
Fresno 140%
Death Valley 0%
Monterey 195%
Paso Robles 186%
Bakersfield 81%
Los Angeles 131%
Riverside 134%
Palm Springs 39%
San Diego 97%

Sacramento Region Summary

Precip: 8-Station Index		
Season to Date	100%	%Avg year	23%

| Northern Sierra Snow Water Content		
% to Date	195%	%Apr 1	36%

Reservoir Storage			
Reservoir	%Hist.Avg.	%Capacity	*Encrch
Shasta	57%	32%	-1814
Oroville	57%	29%	-1975
New Bullards	100%	60%	-219
Folsom	71%	28%	-290

San Joaquin Region Summary

Precip: 5-Station Index		
Season to Date	116%	%Avg year	24%

Central Sierra Snow Water Content		
% to Date	204%	%Apr 1	43%

Reservoir Storage			
Reservoir	%Hist.Avg.	%Capacity	*Encrch
New Melones	46%	25%	-1362
Don Pedro	77%	51%	n/a
Exchequer	46%	20%	n/a
Millerton	124%	60%	n/a

Tulare Lake Region Summary

Precip: Tulare Precipitation Index		
Season to Date	134%	%Avg year	27%

Southern Sierra Snow Water Content		
% to Date	242%	%Apr 1	47%

Reservoir Storage			
Reservoir	%Hist.Avg.	%Capacity	*Encrch
Pine Flat	61%	19%	-466
Terminus	155%	13%	16
Success	108%	12%	-0
Isabella	30%	7%	-128

State Region Summary

Precip: Statewide Precipitation Index		
Season to Date	n/a	%Avg year	n/a

Statewide Snow Water Content		
% to Date	213%	%Apr 1	42%

Reservoir Storage			
Reservoir	%Hist.Avg.	%Capacity	*Encrch

STATEWIDE SNOW WATER CONTENT

% of April 1 Average / % of Normal for This Date

36% / 184% — Northern Sierra / Trinity
43% / 195% — Central Sierra
47% / 235% — Southern Sierra

NORTH

Data as of December 14, 2022	
Number of Stations Reporting	32
Average snow water equivalent (Inches)	10.3
Percent of April 1 Average (%)	36
Percent of normal for this date (%)	184

CENTRAL

Data as of December 14, 2022	
Number of Stations Reporting	54
Average snow water equivalent (Inches)	12.0
Percent of April 1 Average (%)	43
Percent of normal for this date (%)	195

SOUTH

Data as of December 14, 2022	
Number of Stations Reporting	33
Average snow water equivalent (Inches)	10.7
Percent of April 1 Average (%)	47
Percent of normal for this date (%)	235

STATE

Data as of December 14, 2022	
Number of Stations Reporting	119
Average snow water equivalent (Inches)	11.2
Percent of April 1 Average (%)	42
Percent of normal for this date (%)	204

- Recent storms in California have been cold, efficient snow producers in the Sierra Nevada
- Water Year to Date precipitation is currently 100%, 116%, and 134% of normal in the Sacramento, San Joaquin, and Tulare Lake regions, respectively
- Percent of normal snowpack observations across the Sierra are higher, currently 184–235% of normal for this date

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Water rescue on the Santa Ana River

Orange County Fire Authority
https://twitter.com/OCFireAuthority/status/1602108466558308352

Whiteout conditions at Donner Summit

Caltrans District 3
https://twitter.com/CaltransDist3/status/1601730814827319297

Avalanche near Lake Tahoe, CA

Public, via Sierra Avalanche Center

- Flooding in metropolitan areas resulted in multiple swift water rescues along urban rivers
- Heavy snowfall and high winds in the Sierra Nevada prompted road closures in mountain passes due to snow-covered roads and dangerous white-out conditions
- Avalanche conditions were also observed at high elevations in Northern California by the Sierra Avalanche Center, who also highlighted the hazard posed from wind loaded avalanches along peaks in the area

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CW3E Event Summary: 9-12 December 2022

## Atmospheric River Reconnaissance IOP3 & IOP4
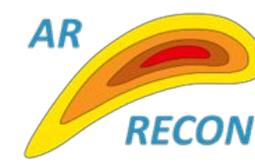
- The NOAA G-IV deployed from Honolulu, HI on 8 Dec (IOP3) and 9 Dec (IOP4), local time

- IOP3 and IOP4 each successfully deployed 29 dropsondes over the North Pacific, providing additional observations for the global forecast models and collecting valuable data for future research

IOP = Intensive Observation Period

Photo: Lt. Kevin Doremus / NOAA

IOP3 - Centered at 0Z 9 Dec

NCEP GFS IVT (kg m⁻¹ s⁻¹; shaded), IVT Vector, and SLP (hPa; contours)
Initialized: 0000 UTC 12/07/2022   IOP 3: F-048: Valid: 0000 UTC 12/09/2022
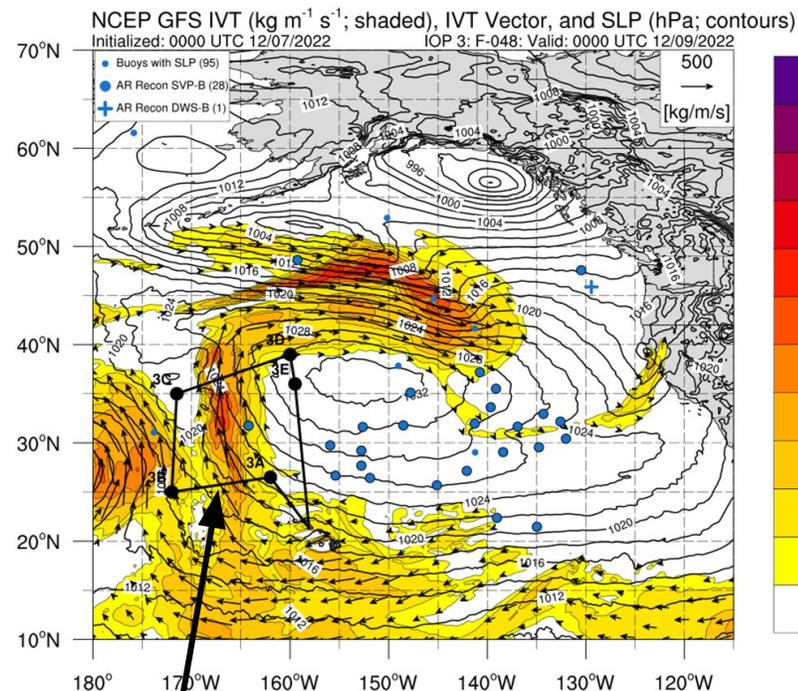
Flight Track

IOP4 - Centered at 0Z 10 Dec

NCEP GFS IVT (kg m⁻¹ s⁻¹; shaded), IVT Vector, and SLP (hPa; contours)
Initialized: 0000 UTC 12/08/2022   IOP 4: F-048: Valid: 0000 UTC 12/10/2022
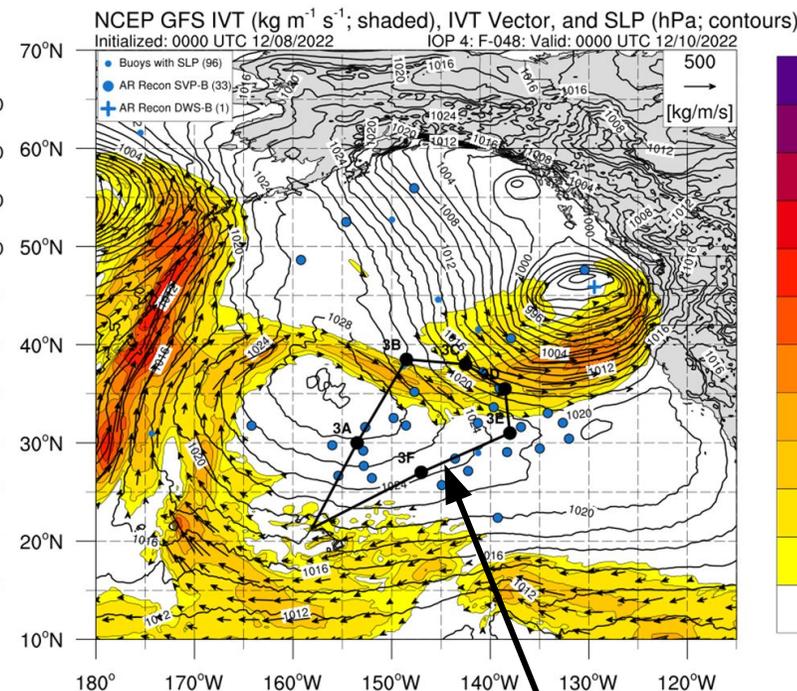
Flight Track

As part of CW3E's ongoing Atmospheric River Reconnaissance field campaign, two flights originating from Hawaii sampled atmospheric conditions upstream of this AR in the North Pacific.