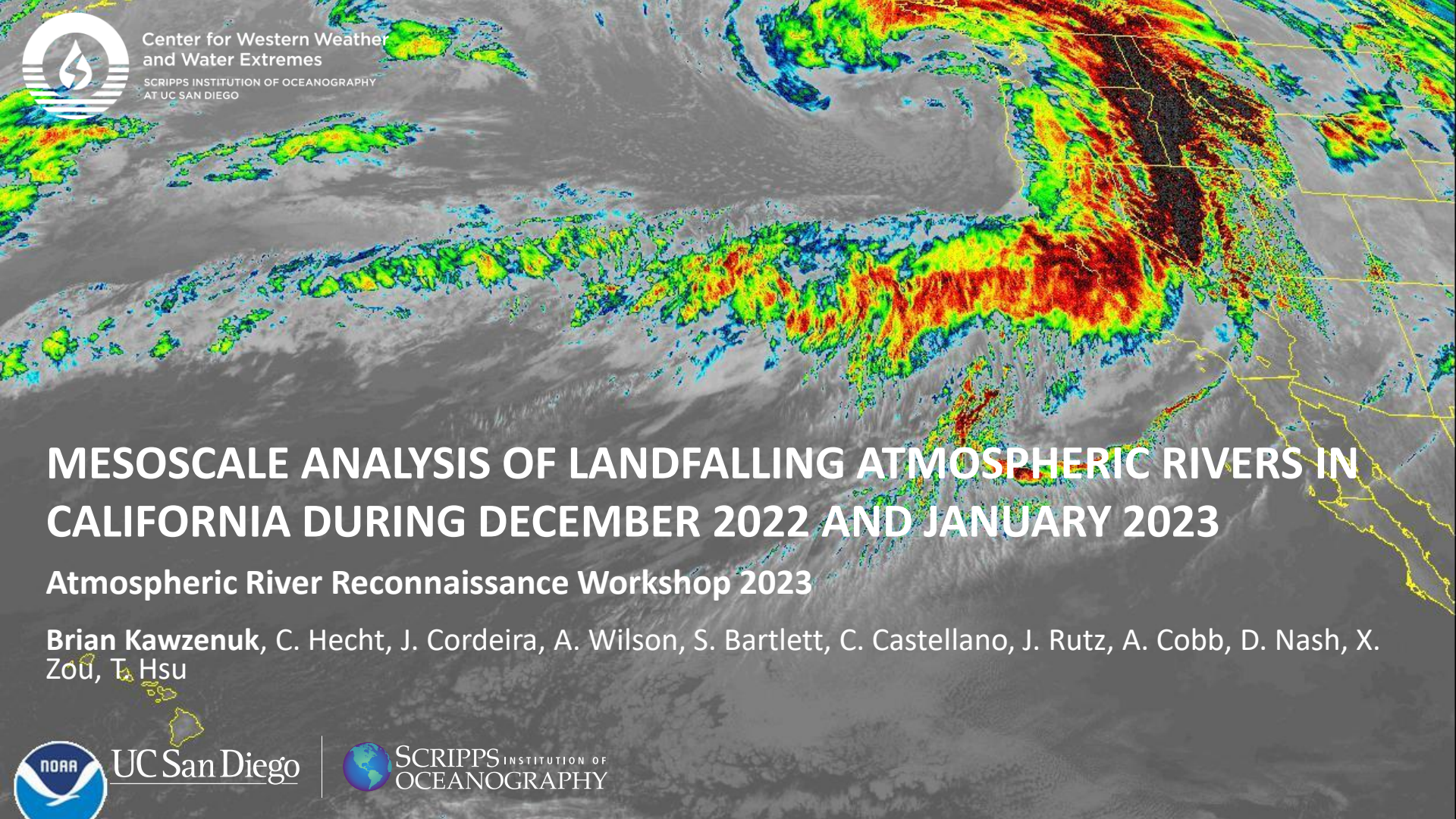


Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

# MESOSCALE ANALYSIS OF LANDFALLING ATMOSPHERIC RIVERS IN CALIFORNIA DURING DECEMBER 2022 AND JANUARY 2023

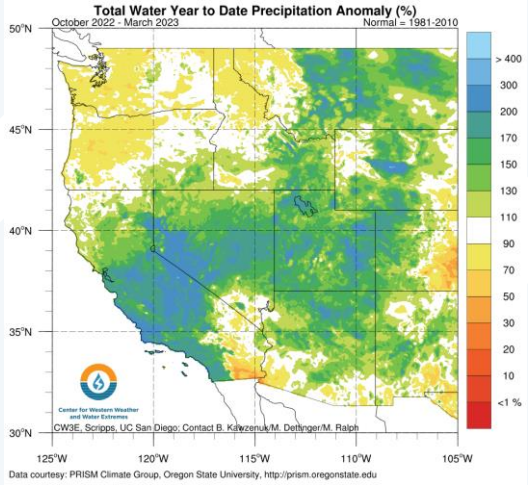
## Atmospheric River Reconnaissance Workshop 2023

**Brian Kawzenuk**, C. Hecht, J. Cordeira, A. Wilson, S. Bartlett, C. Castellano, J. Rutz, A. Cobb, D. Nash, X. Zou, T. Hsu

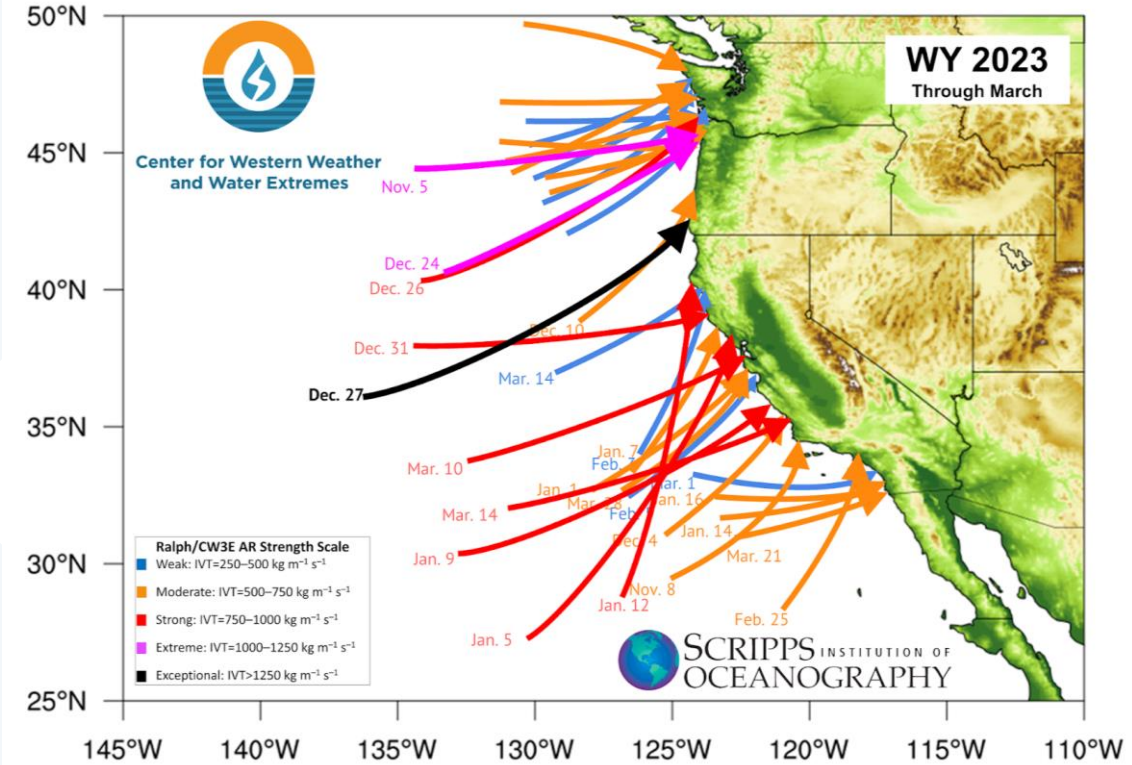
NOAA | UC San Diego | Scripps Institution of Oceanography

# Winter 2023 Summary

| Breakdown by strength | |
|---|---|
| Strength | Number of ARs |
| Weak | 11 |
| Moderate | 13 |
| Strong | 6 |
| Extreme | 1 |
| Exceptional | 0 |
| Total | 31 |

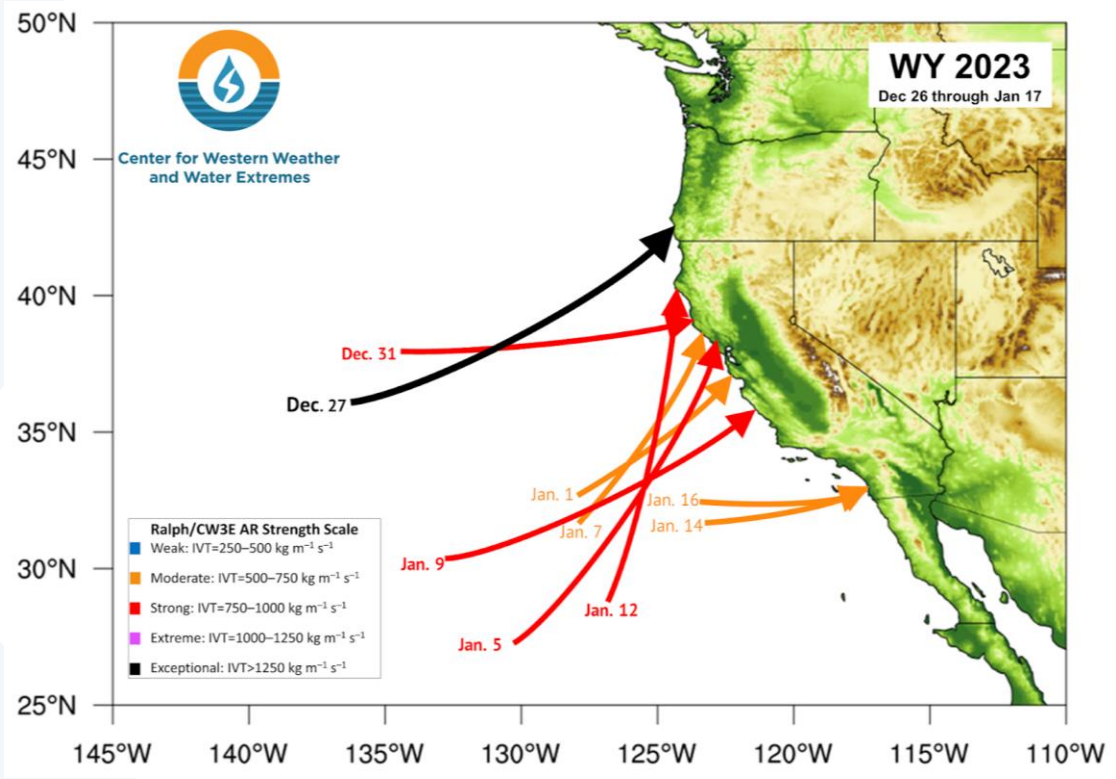



**31 atmospheric rivers** impacted California between October 1st, 2022, and March 31st, 2023

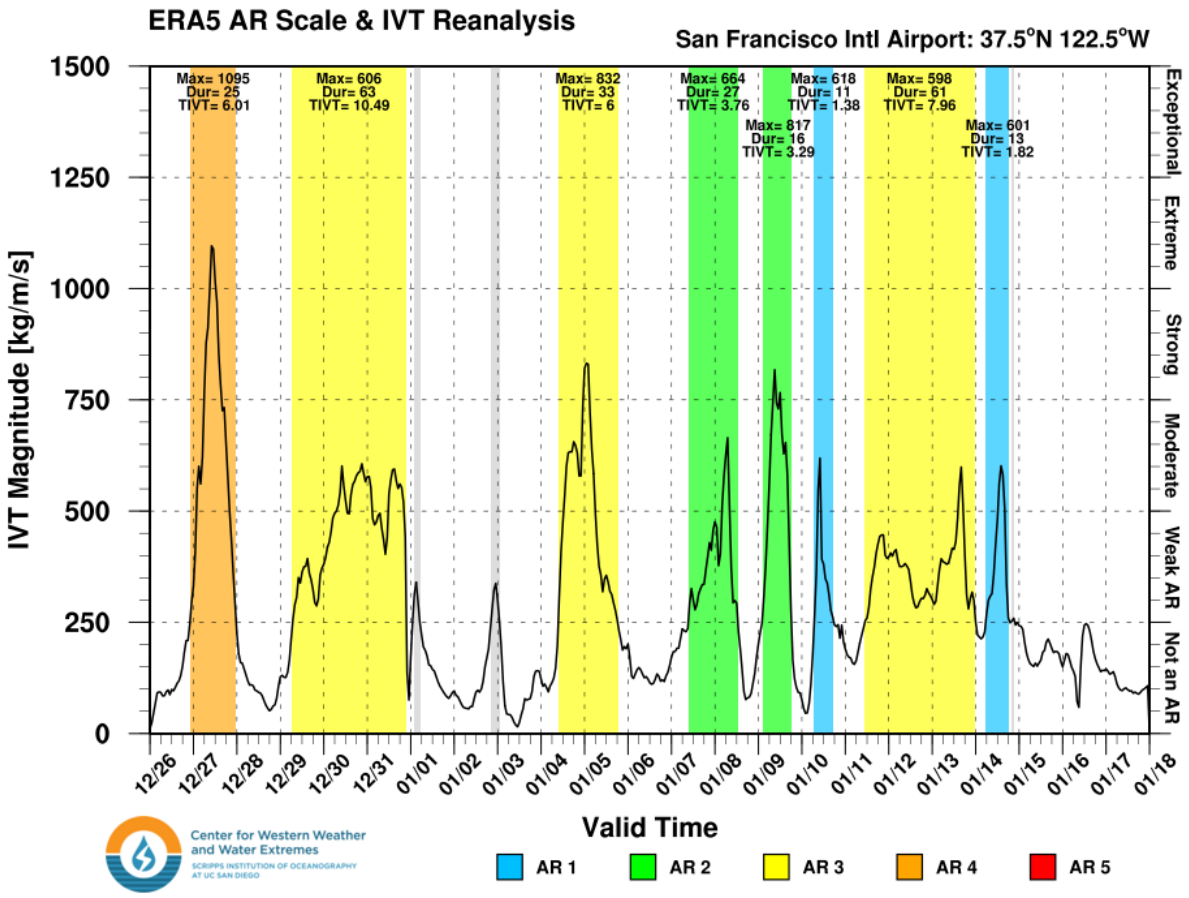


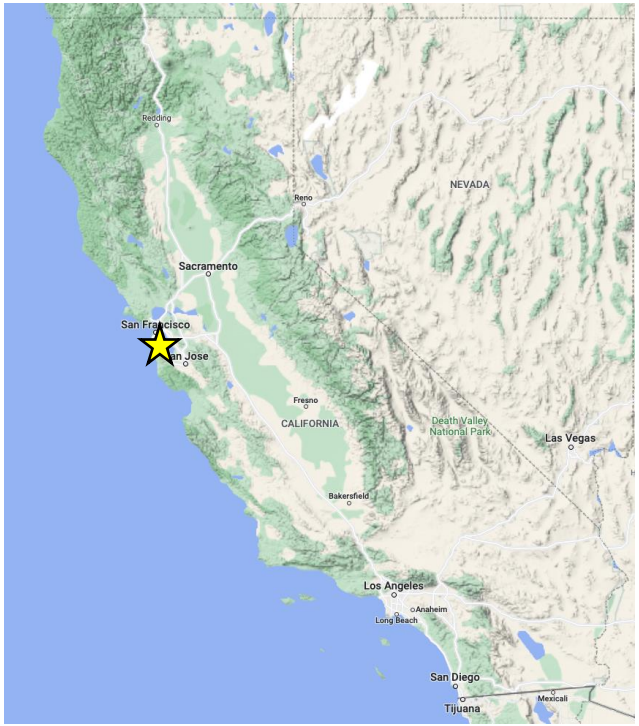
# December 27th through January 17th

- 9 Atmospheric Rivers made landfall between December 26 and January 17
- Of the 9 ARs, 5 were of strong or greater magnitude
- All 9 ARs were making landfall over CA during their time of maximum IVT
- California has averaged ~6 strong or greater magnitude ARs per water year since 2012

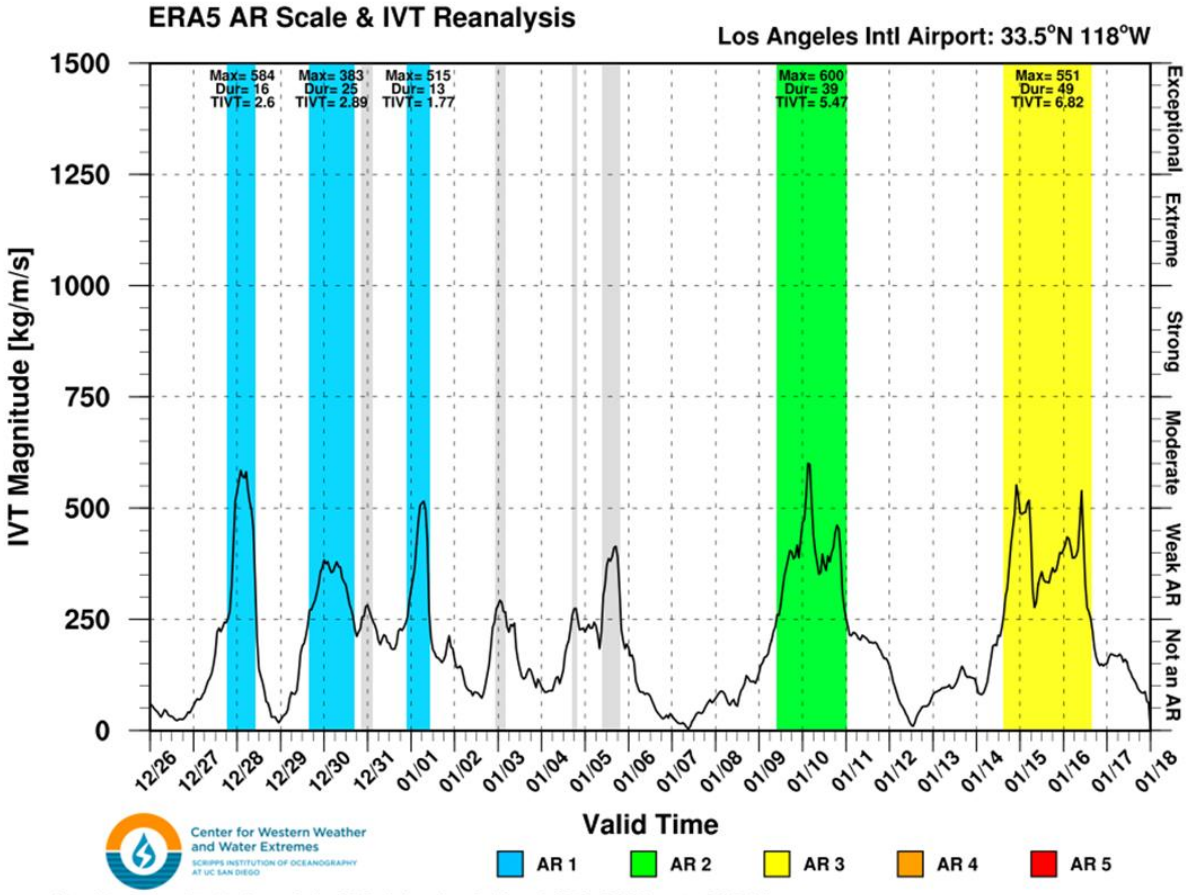


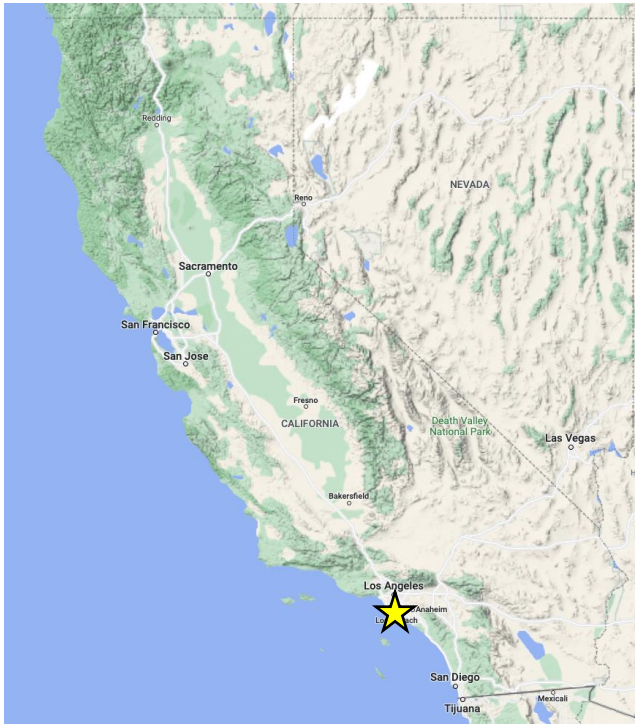
# December 27th through January 17th



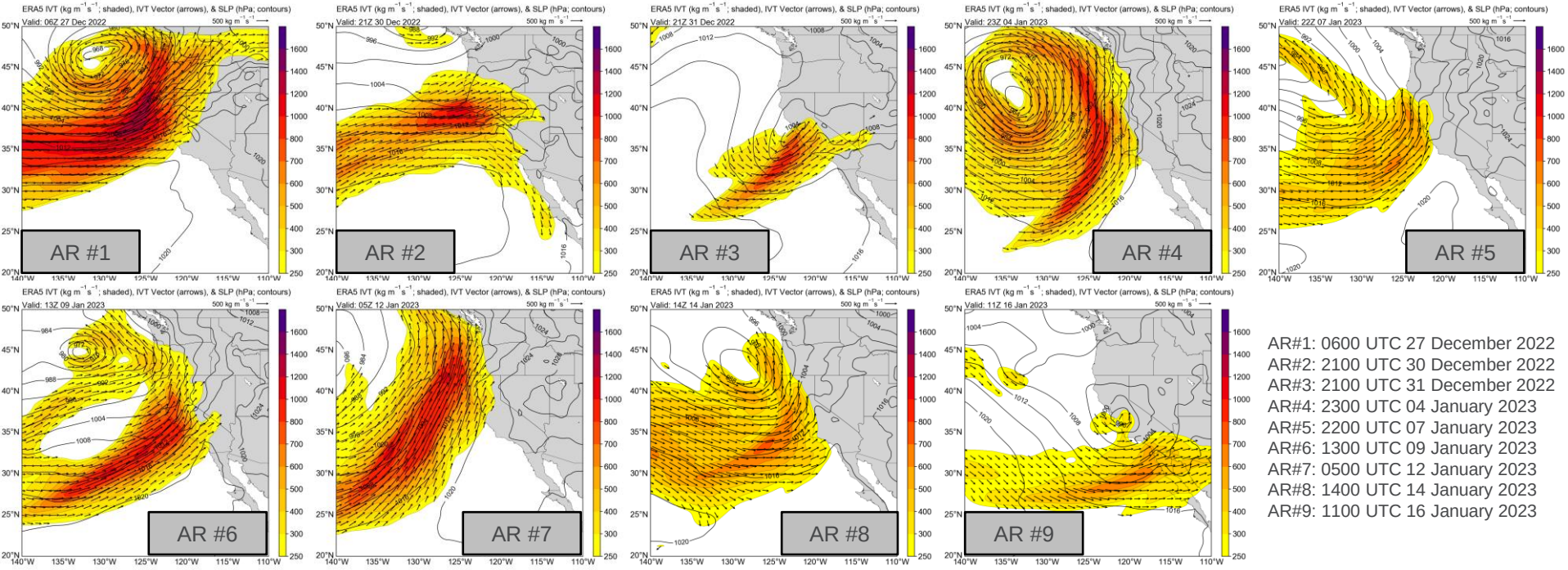



# December 27th through January 17th



# Landfalling ARs




AR#1: 0600 UTC 27 December 2022
AR#2: 2100 UTC 30 December 2022
AR#3: 2100 UTC 31 December 2022
AR#4: 2300 UTC 04 January 2023
AR#5: 2200 UTC 07 January 2023
AR#6: 1300 UTC 09 January 2023
AR#7: 0500 UTC 12 January 2023
AR#8: 1400 UTC 14 January 2023
AR#9: 1100 UTC 16 January 2023

*Integrated water vapor transport (IVT) magnitude (kg/ms; shaded according to scale) and direction (vectors according to reference; top right) with sea-level pressure (hPa; contours) at the time of maximum IVT magnitude over coastal California for each of the nine landfalling ARs on 27 December 2022 through 16 January 2023. Data source is the ECMWF ERA5.*

# Mesoscale Features

| | Mesoscale Frontal Wave? | Narrow Cold Frontal RainBand? | Sierra Barrier Jet? | Convection/ Thunderstorms? |
|---|---|---|---|---|
| AR #1 | | Y | Y | |
| AR #2 | Y | | Y | |
| AR #3 | Y | Y | | |
| AR #4 | | Y | | Y |
| AR #5 | | Y | Y | |
| AR #6 | Y | Y | Y | Y |
| AR #7 | | | Y | Y |
| AR #8 | Y | Y | Y | Y |
| AR #9 | Y | Y | Y | Y |

**Mesoscale Characteristics**

- Duration of precipitation, and impacts (e.g., flooding) exacerbated by mesoscale frontal waves. **5 of 9 landfalling ARs featured a MFW**.
- Intensity of precipitation modulated by narrow cold frontal rainbands. **7 of 9 landfalling ARs featured a NCFR**.
- Spatial distribution of precipitation in NorCal influenced by Sierra Barrier Jet. **7 of 9 landfalling ARs featured a SBJ**.
- Spatial distribution/intensity of precipitation influenced by convection. **5 of 9 landfalling ARs featured convection**.

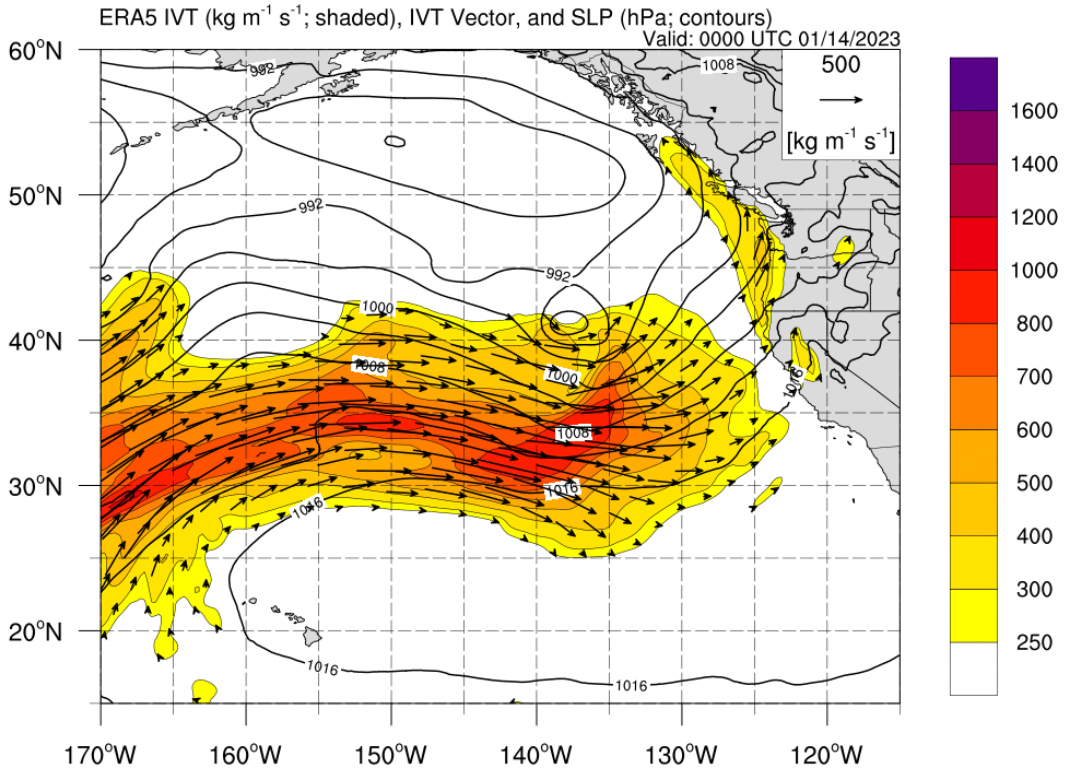
# Mesoscale Frontal Waves

**Five of the nine ARs featured a MFW**

- Around 00 UTC 15 Jan a secondary low began to develop along the AR near 150ºW
- The low and AR made landfall over CA at ~00 UTC 16 January
- The development of the low enhanced IVT prolonging AR conditions and precipitation

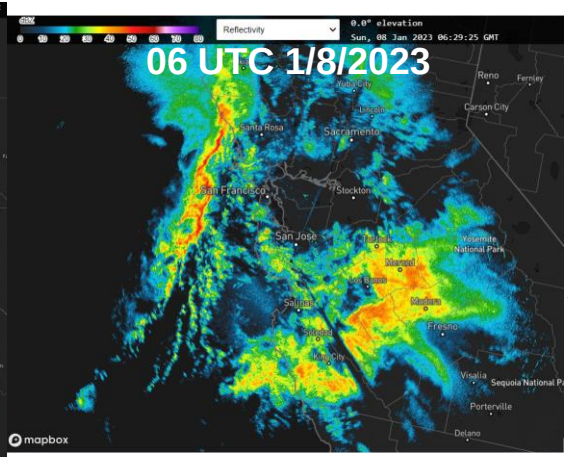
## ERA5 IVT and Sea Level Pressure

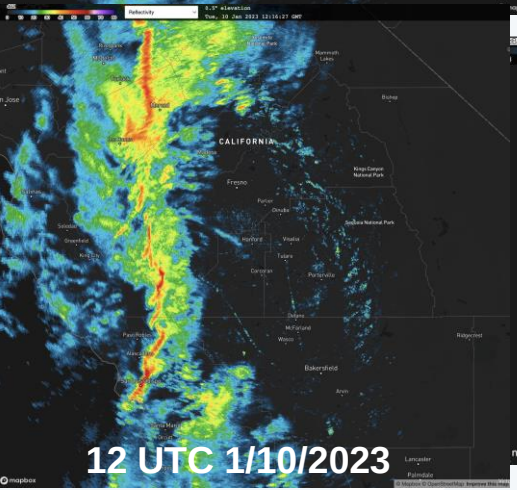
Valid: 00 UTC 14 Jan – 23 UTC 16 Jan

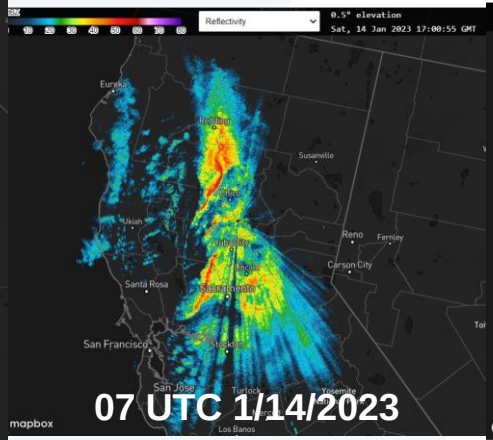


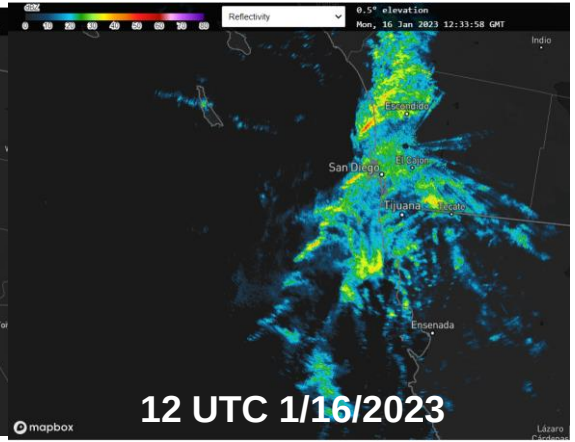
# Narrow Cold Frontal Rainbands





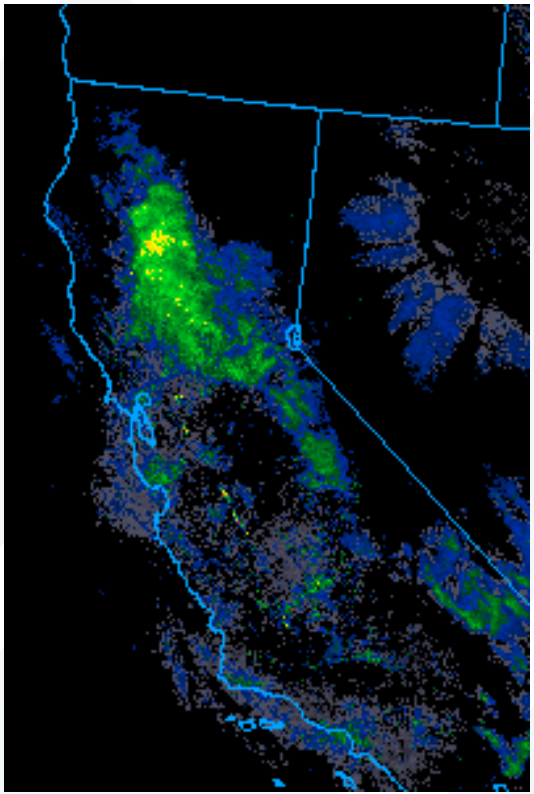




*Base reflectivity analyses of several examples of narrow cold frontal rainbands during landfalling ARs on 1, 5, 8, 10, 14, and 16 January 2023*

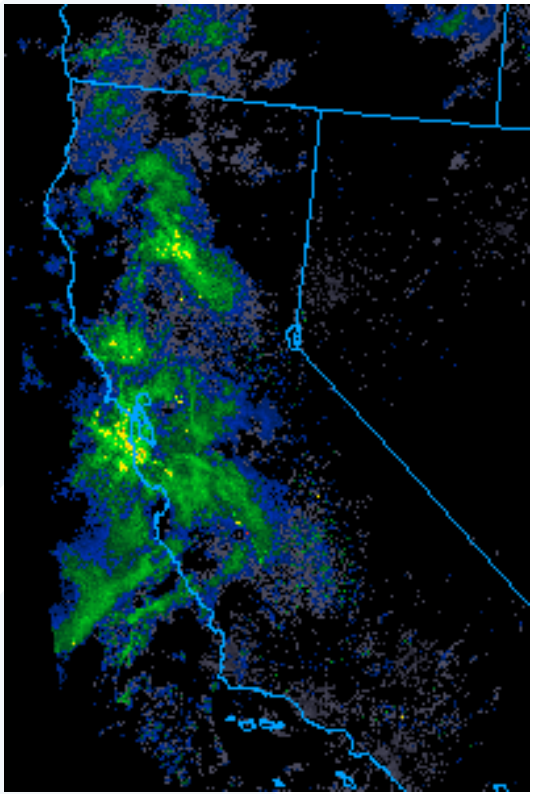
*Source: QuadWeather and NOAA Nexrad Level II*

# Narrow Cold Frontal Rainbands

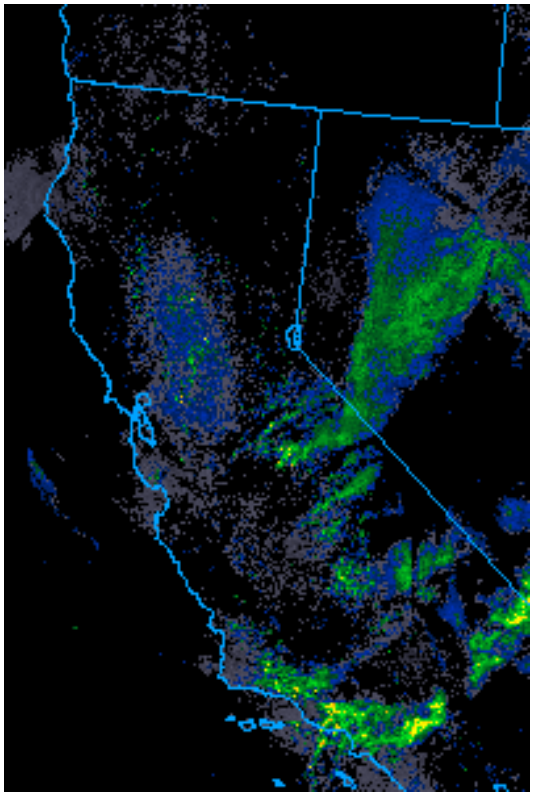
18 UTC 4 Jan – 15 UTC 5 Jan



0 – 12 UTC 8 Jan



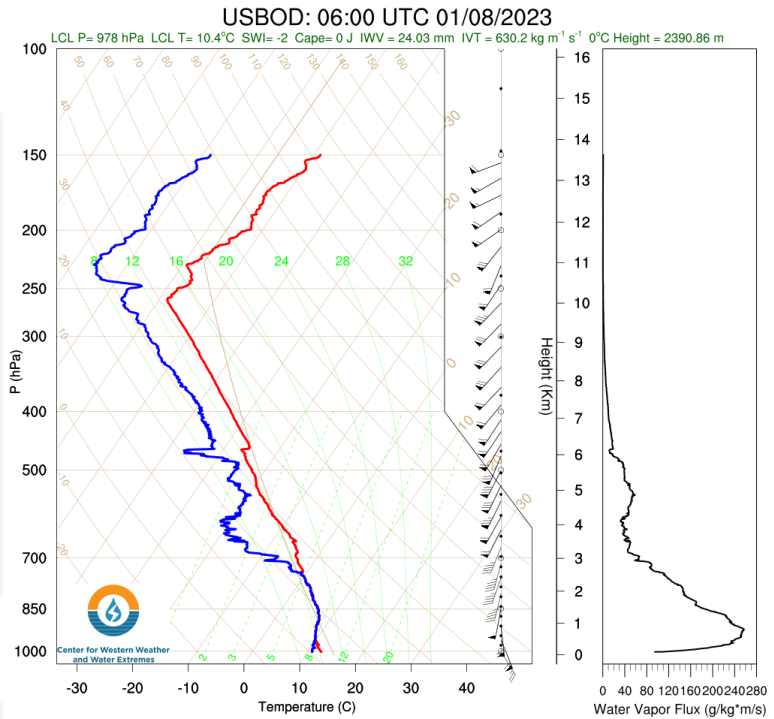
6 – 15 UTC 10 Jan



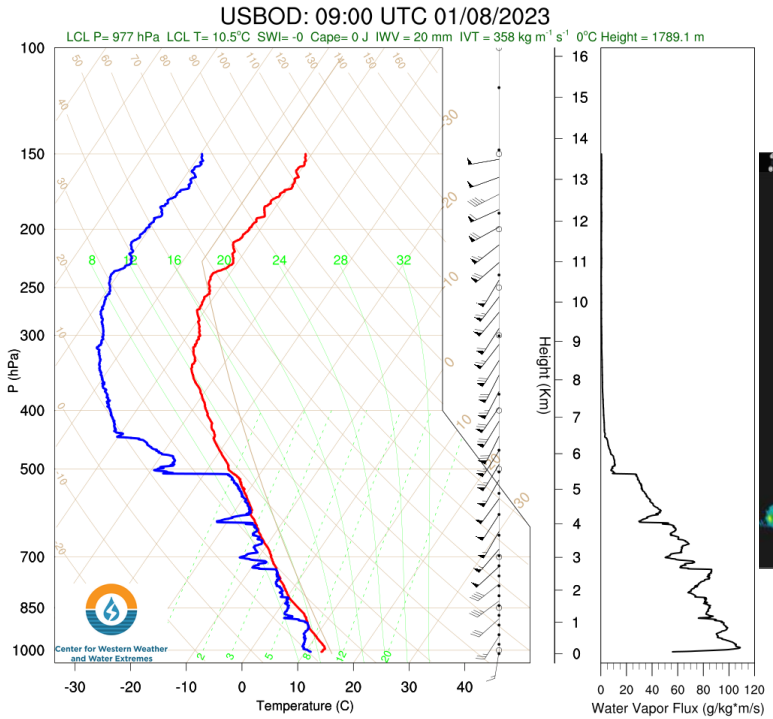
*Source: UCAR Mesoscale and Microscale Meteorology Laboratory*

# January 8 NCFR

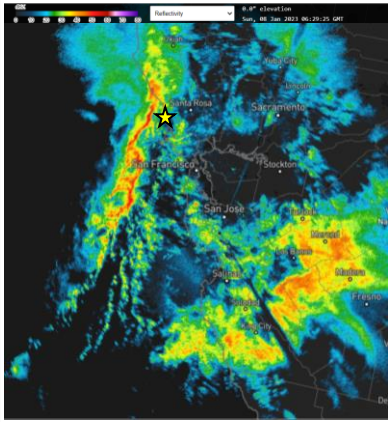
## Before NCRF




## After NCRF

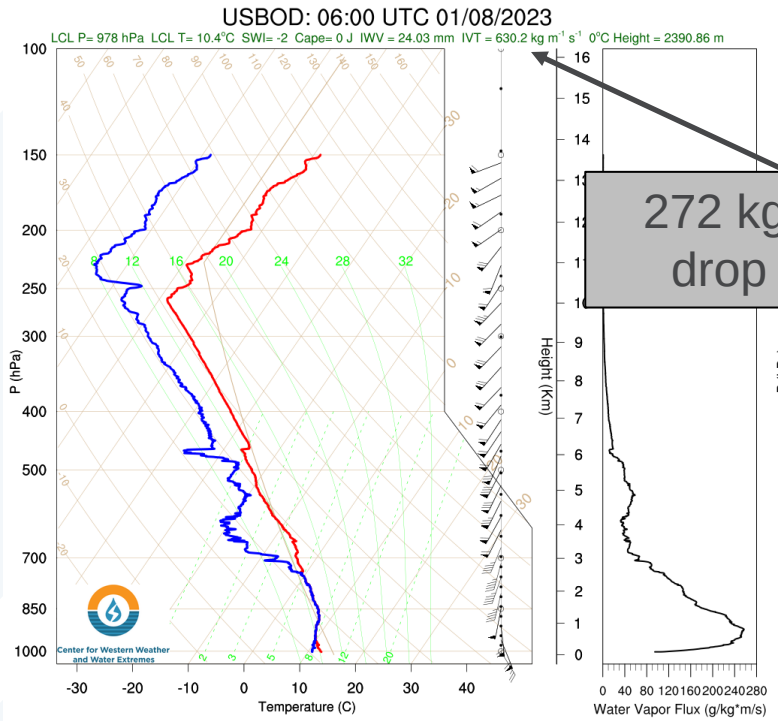



06 UTC 8 Jan 2023



# January 8 NCFR

## Before NCRF

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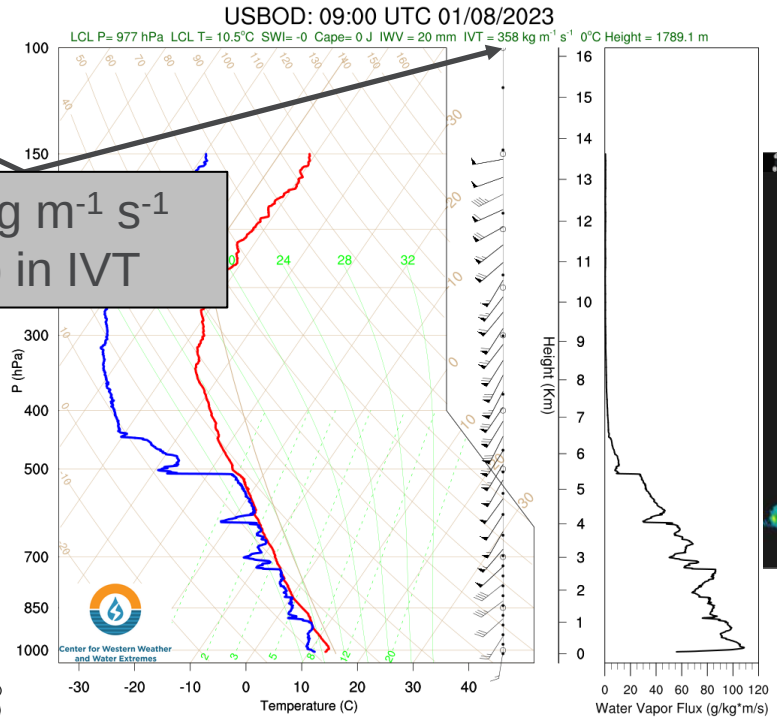
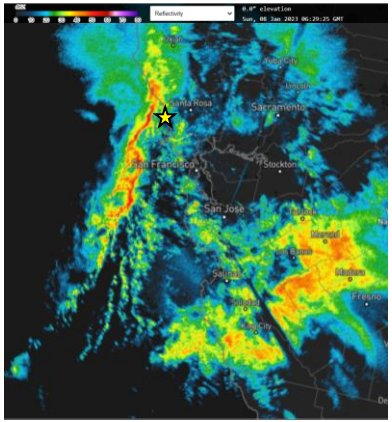


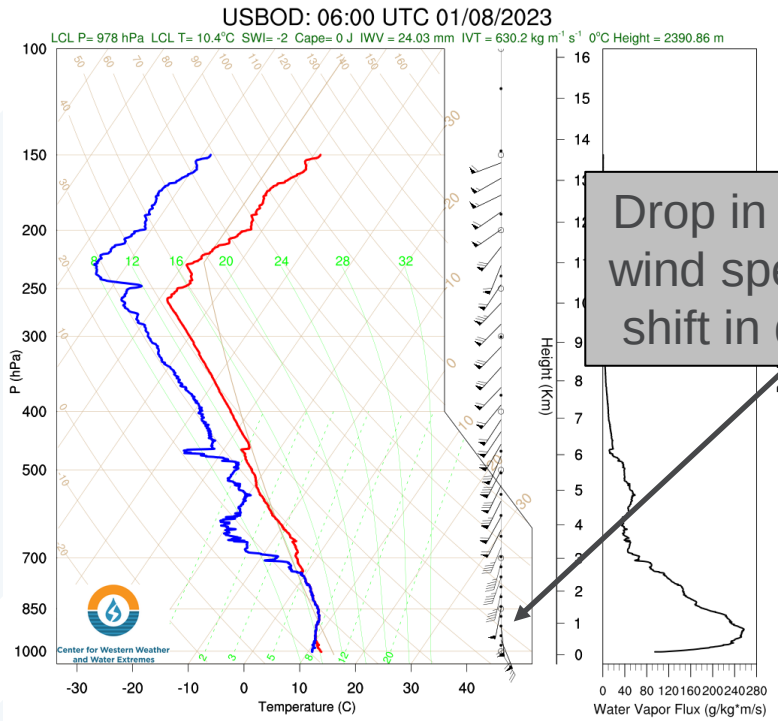

272 kg m$^{-1}$ s$^{-1}$ drop in IVT

06 UTC 8 Jan 2023

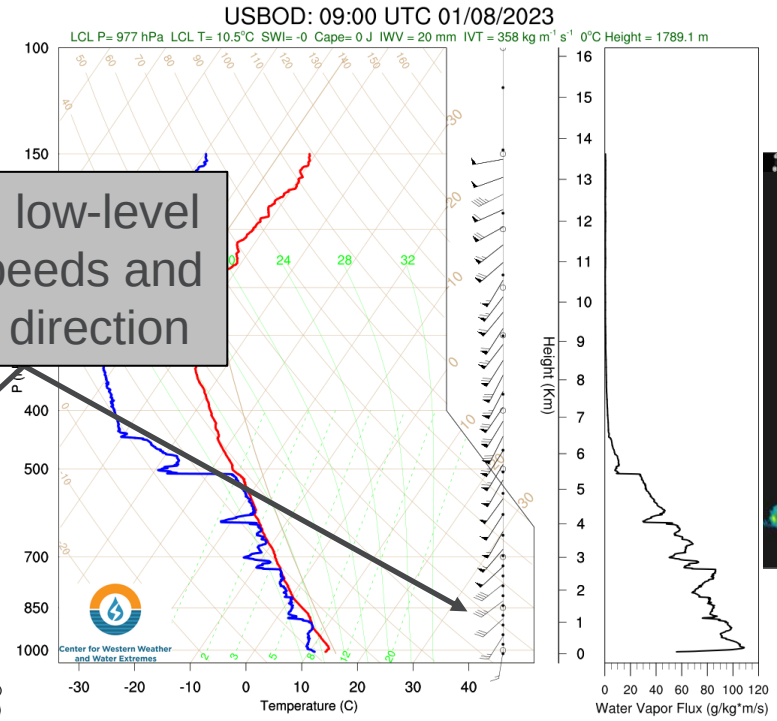


# January 8 NCFR

## Before NCRF

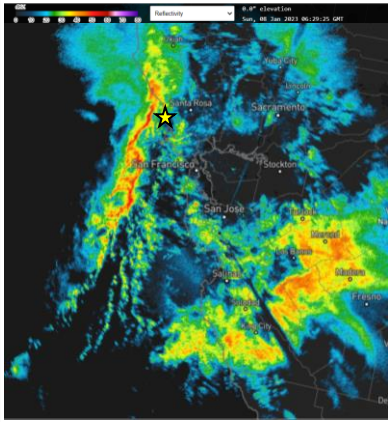



## After NCRF



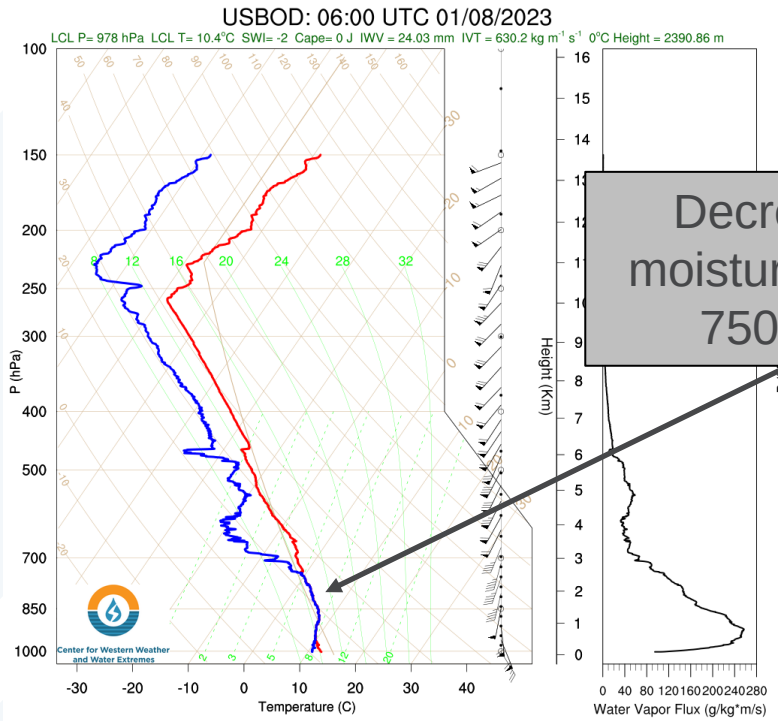

Drop in low-level wind speeds and shift in direction

06 UTC 8 Jan 2023

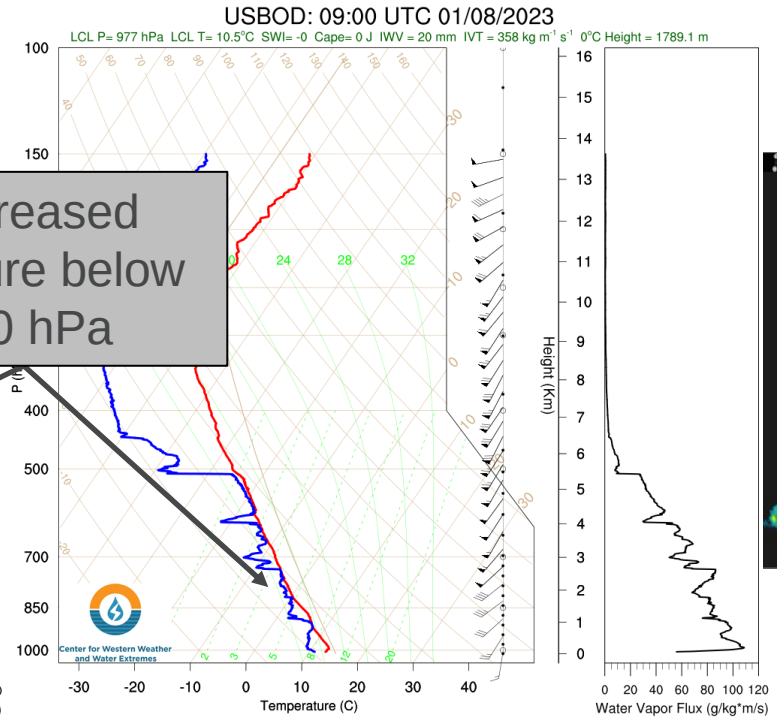


# January 8 NCFR

## Before NCRF

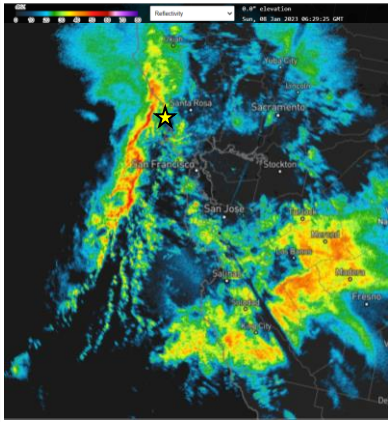



## After NCRF



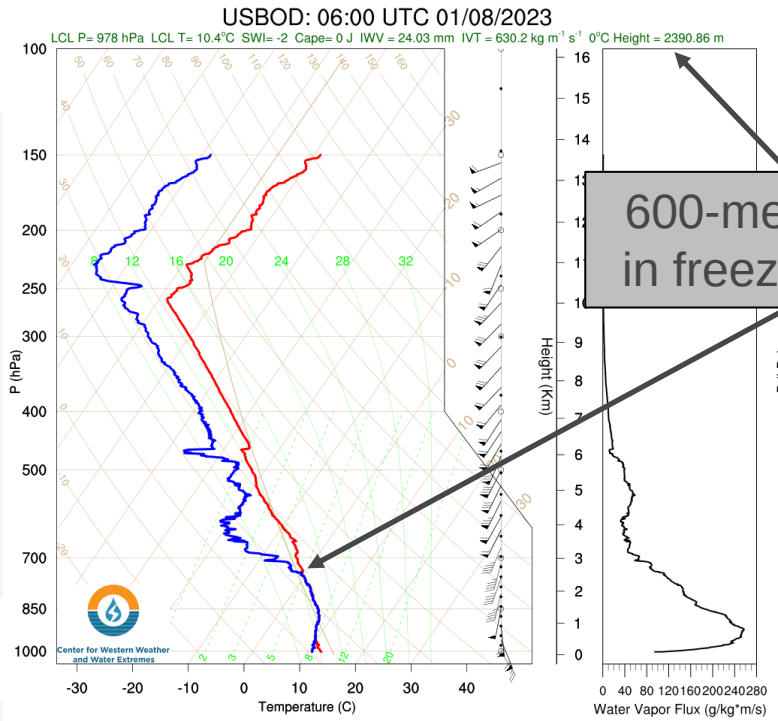

Decreased moisture below 750 hPa

06 UTC 8 Jan 2023

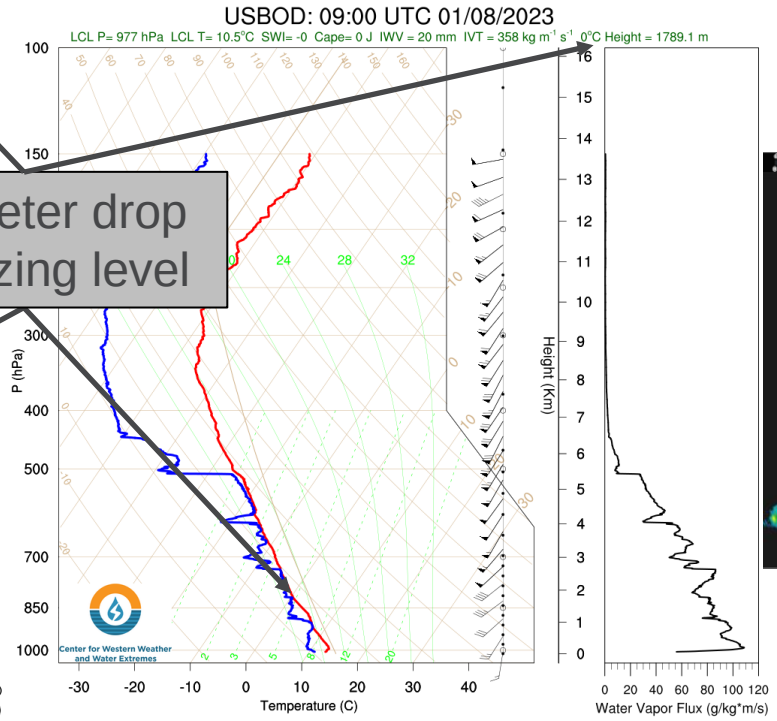


# January 8 NCFR

## Before NCRF

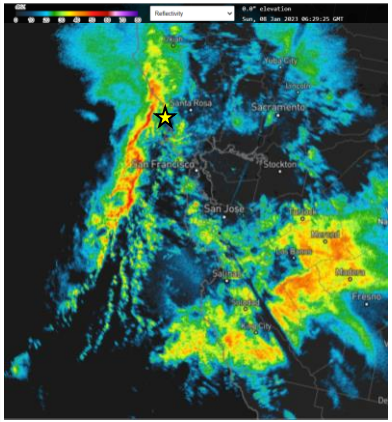



## After NCRF

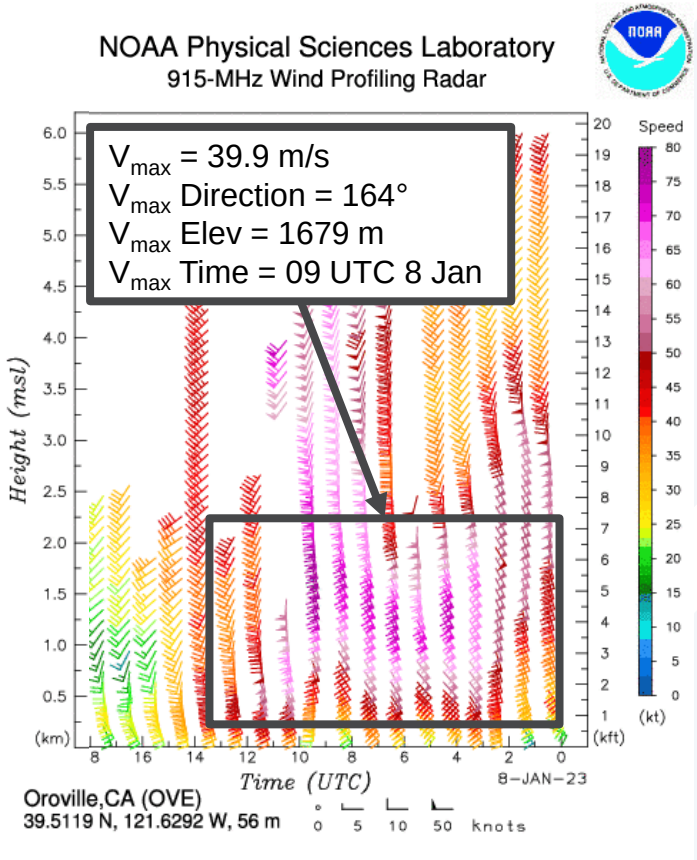


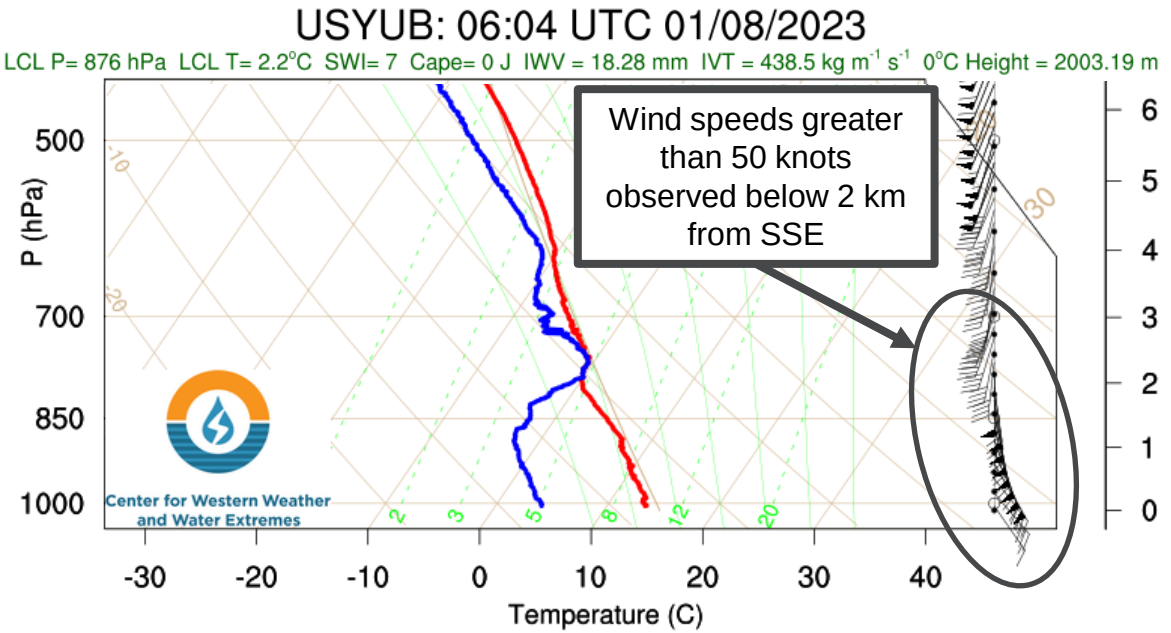

600-meter drop in freezing level

06 UTC 8 Jan 2023



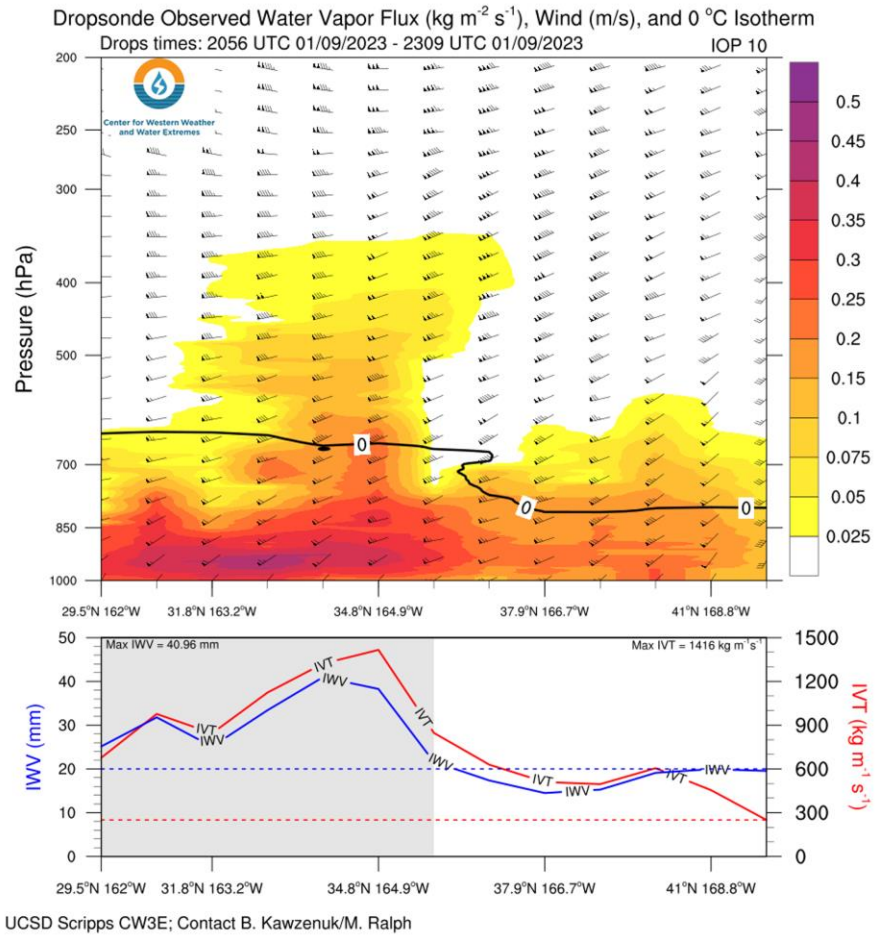
# January 8 Sierra Barrier Jet



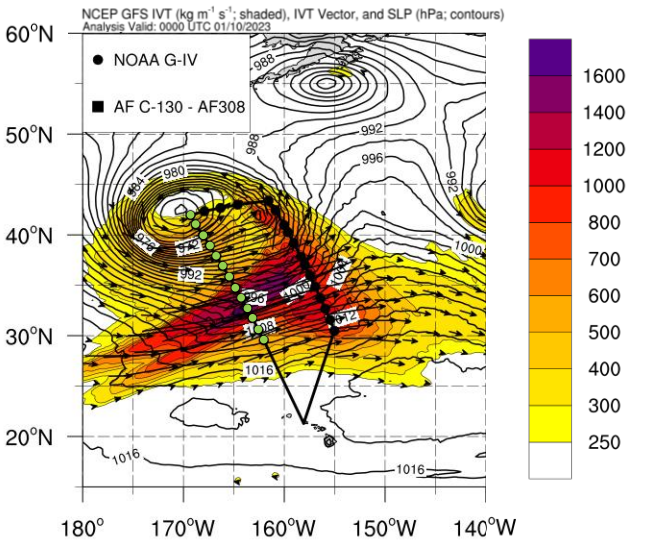




A Sierra Barrier Jet during the AR on 8 January 2023 was observed by both vertically pointed radars (left) and CW3E radiosondes at Marysville, CA (right)

# IOP 10: January 10, 2023




**During IOP 10 (Jan 10, 2023) the NOAA GIV sampled an exceptional strength AR and the associated cyclone with surface pressure < 960 hPa.**



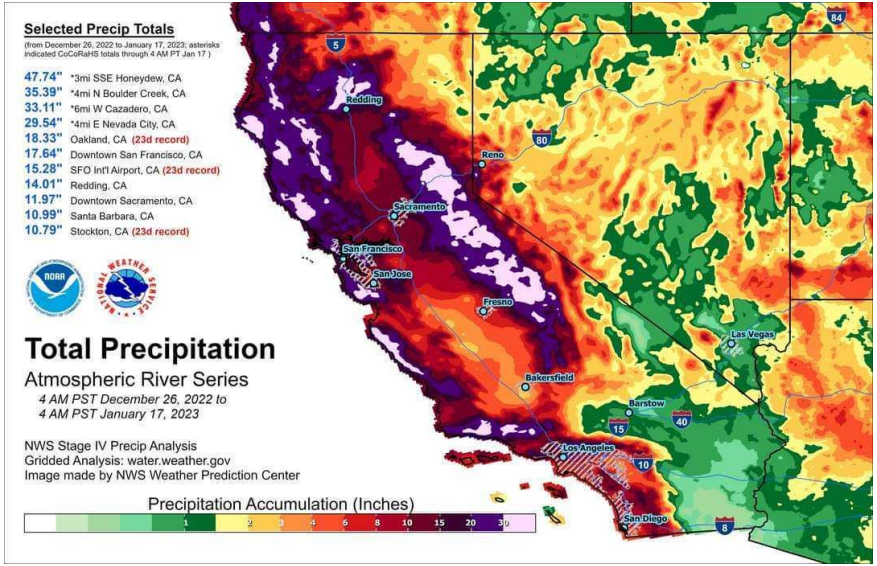

This transect observed:

- Max IVT of 1416 kg $m^{-1}$ $s^{-1}$ and max IWV of 40.96 mm
  - **Highest IVT observed by AR Recon dropsondes**
- Strong cold front on the poleward side of the AR
- Elevated moisture transport up to ~400 hPa with maximum transport ~900 hPa
- Jet streak with wind speeds >150 knots

# Additional Information

**Additional information about these events is available on the CW3E website:**

- CW3E AR Updates: https://cw3e.ucsd.edu/news/
- AR Recon Data: https://cw3e.ucsd.edu/arrecon_data/
- AR Family Story Map: *coming soon*




**Poster Session:**

- The Landfalling Atmospheric Rivers of Water Year 2023; C. Hecht
- The Atmospheric Pattern and Record Precipitation across the Western U.S. during Winter 2022/2023; J. Rutz