

# CW3E Event Summary: 20–22 March 2023

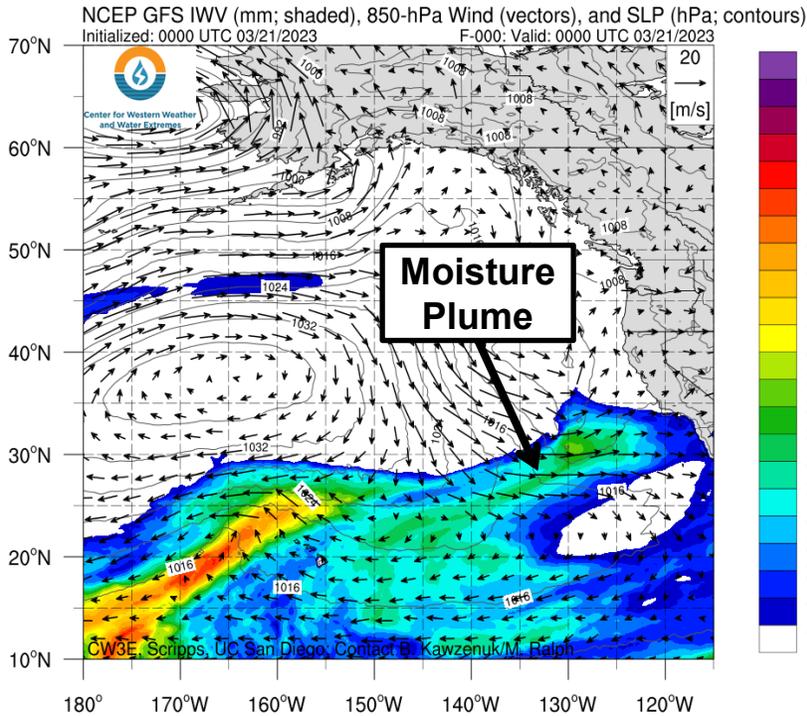
## Atmospheric River Brings More Rain and Flooding to California and Arizona

- An atmospheric river (AR) formed over the subtropical Northeast Pacific and made landfall in Southern California on 20 Mar
- A surface cyclone developed on the cold side of the AR and underwent rapid intensification as it approached the Bay Area
- AR2 conditions were observed in coastal San Diego County and southern Arizona
- The AR produced at least 1–3 inches of precipitation across coastal Southern CA and North Central AZ, with the highest amounts (> 4 inches) observed in the San Gabriel Mountains, CA and Coconino County, AZ
- Rainbands wrapping around the low-pressure center produced > 4 inches of precipitation in a 24-hour period in portions of San Mateo and Santa Cruz Counties
- Lower snow levels during this storm (compared to the two previous storms) allowed for significant snowfall accumulations (> 12 inches) in the higher terrain of the Transverse Ranges
- Two weak tornadoes were reported in California during this storm; an EF0 on 21 March in a trailer park near Carpinteria, CA and an EF1 on 22 March in an industrial area of Montebello, CA, both causing structural damage to multiple buildings
- According to ABC7 News Bay Area, at least 5 people died during this storm, all struck by falling trees. Two fatalities were reported in San Francisco and one in Oakland, Portola Valley, and Rossmoor respectively. <https://abc7news.com/storm-deaths-san-francisco-people-die-from-tuesday/12991694/>
- Damage due to high winds, heavy rain, and flooding were reported across Southern California and in parts of Arizona

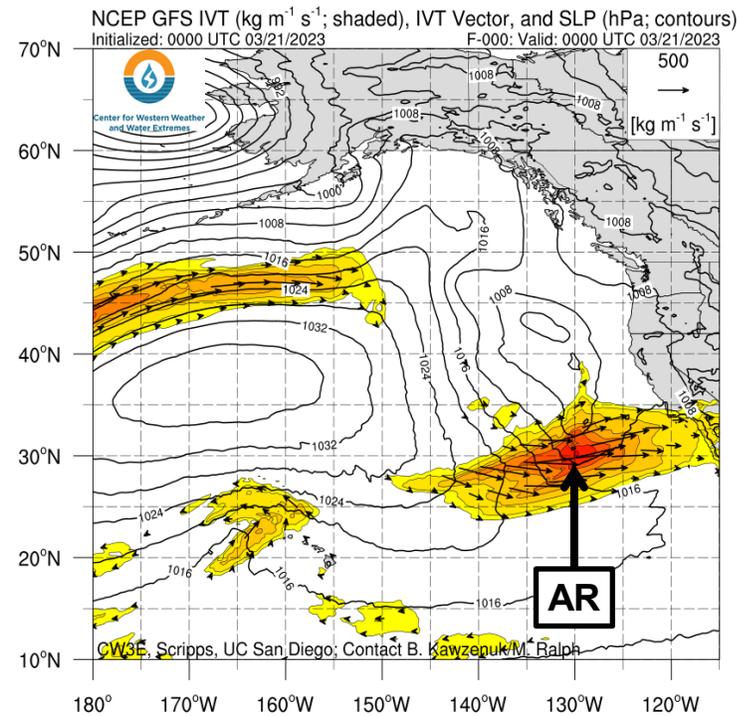
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## GFS Model Analyses: Valid 5 PM PT 20 March 2023

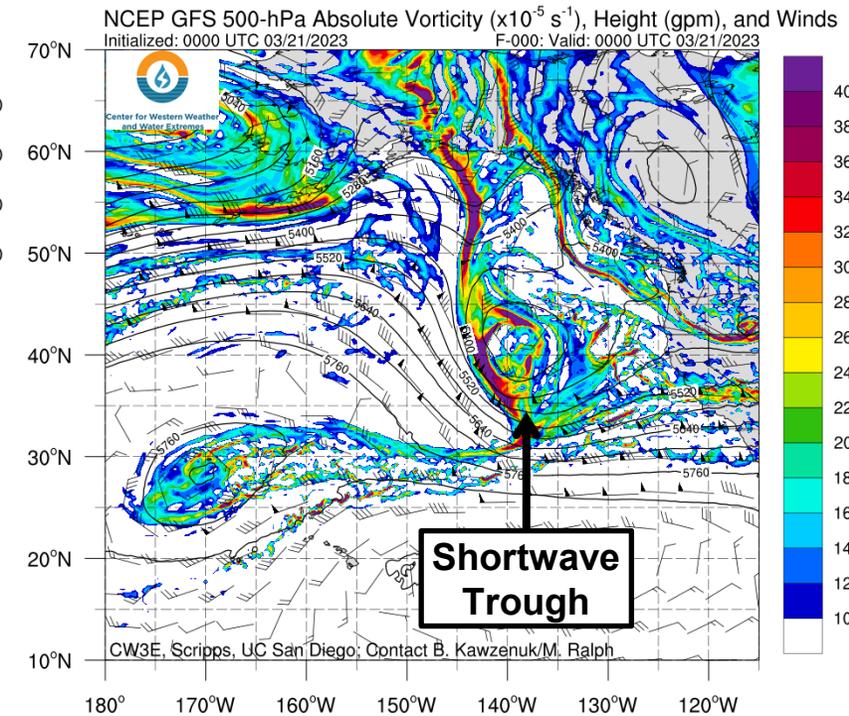
### IWV, SLP, and 850-hPa Winds



### IVT and SLP



### 500-hPa Vorticity, Height, and Wind

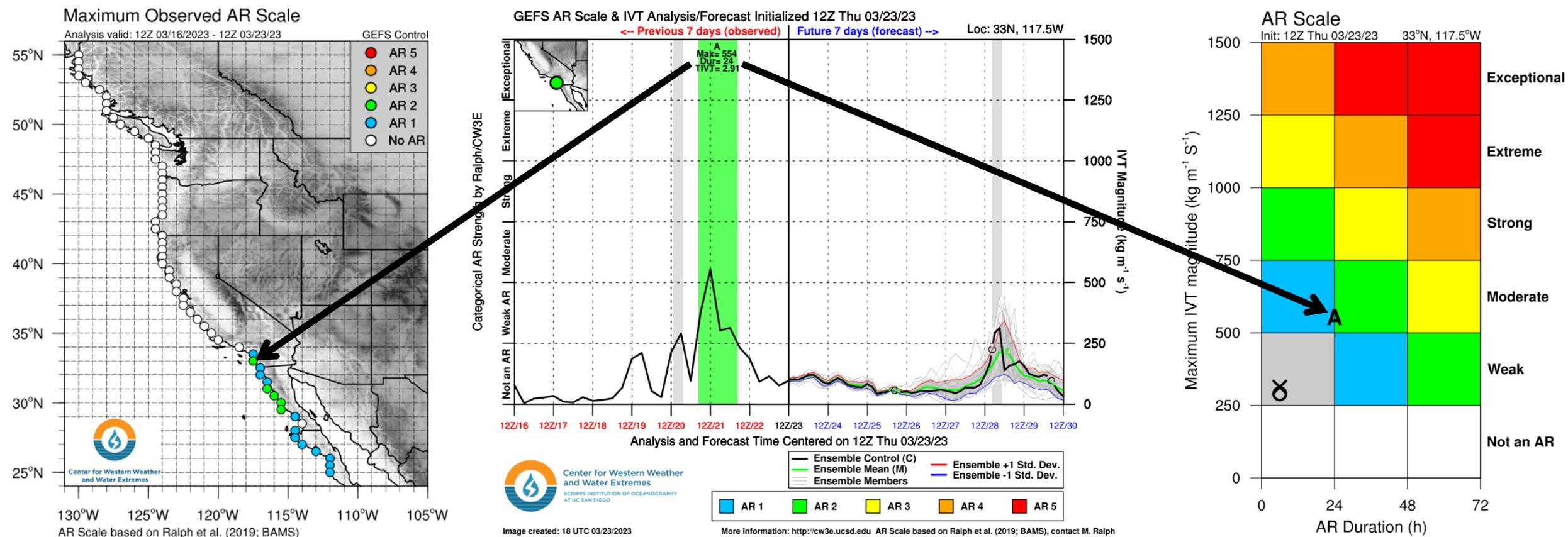


- The AR formed over the Northeast Pacific within a plume of subtropical moisture (IWV > 30 mm) and made landfall in Southern California on 20 Mar
- The AR intensified prior to making landfall due to a favorable interaction with an amplifying upper-level shortwave trough
- The interaction between the shortwave trough and AR also facilitated secondary cyclogenesis in the cold sector of the AR



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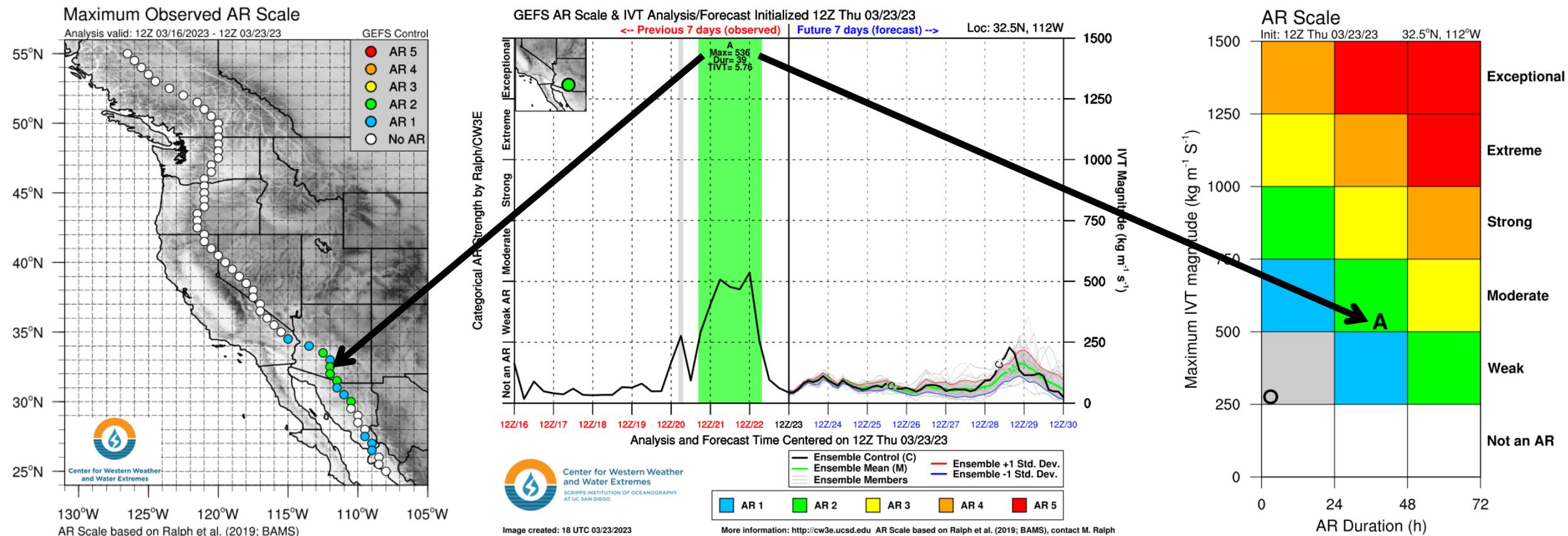
## GEFS AR Scale Analysis



- Based on the GEFS analysis, AR2 conditions were observed in San Diego County and Baja California
- A maximum IVT magnitude of  $554 \text{ kg m}^{-1} \text{ s}^{-1}$  and an AR duration of 24 hours were observed at  $33^\circ\text{N}$ ,  $117.5^\circ\text{W}$

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## GEFS AR Scale Analysis

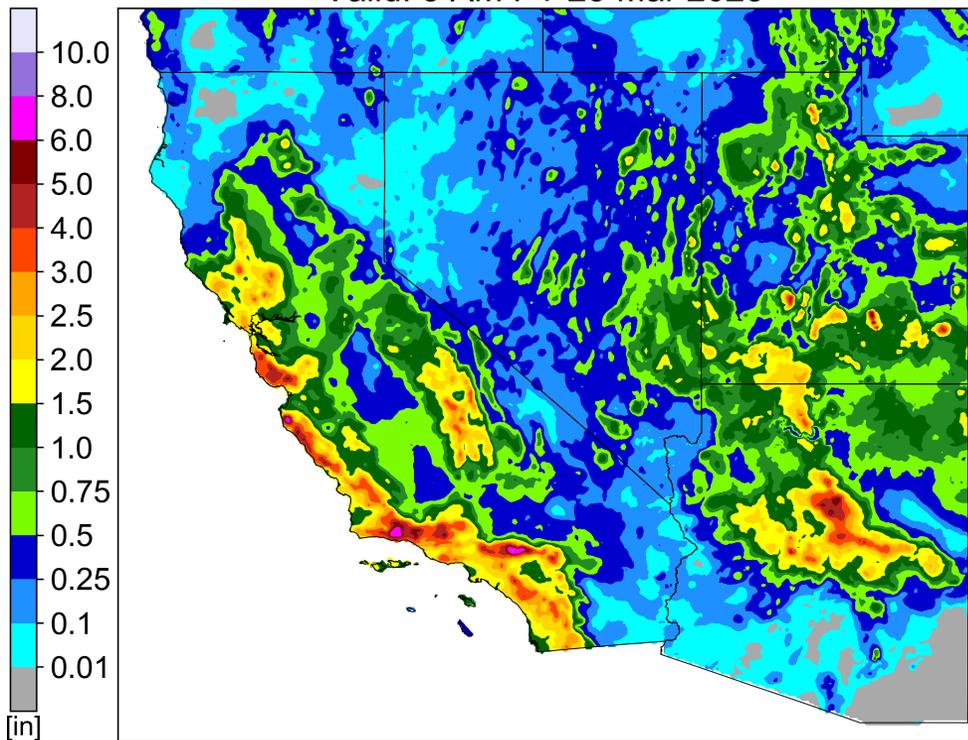


- Inland penetration of the AR across the Baja Peninsula also resulted in AR2 conditions in southern Arizona
- A maximum IVT magnitude of  $538 \text{ kg m}^{-1} \text{ s}^{-1}$  and an AR duration of 39 hours were observed at  $32.5^\circ\text{N}$ ,  $112^\circ\text{W}$

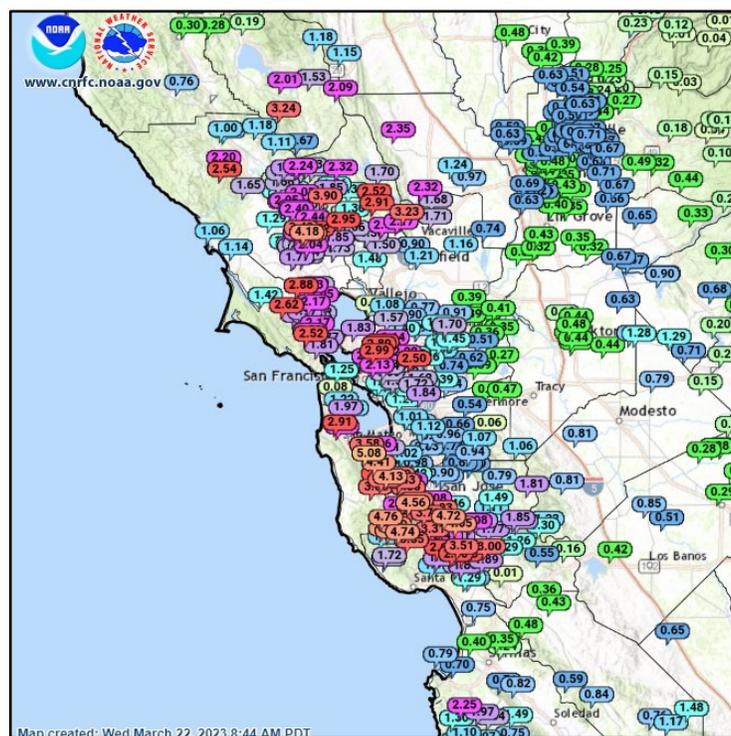
# CW3E Event Summary: 20–22 March 2023

## Observed Precipitation

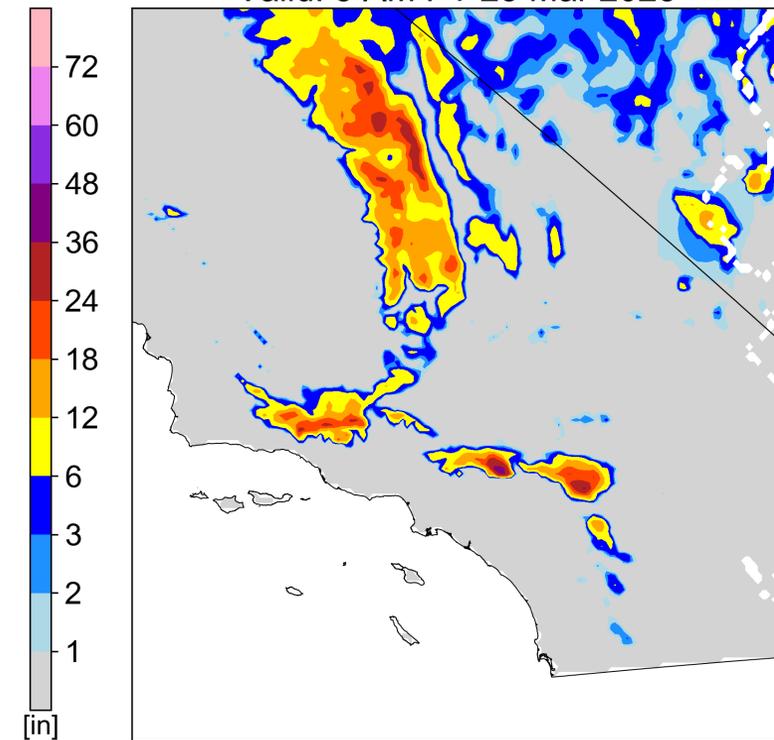
NWS Stage IV 72-h QPE  
Valid: 5 AM PT 23 Mar 2023



CNRFC 24-h QPE (Raw Observations)  
Valid: 5 AM PT 22 Mar 2023



NWS 72-h Snowfall Analysis  
Valid: 5 AM PT 23 Mar 2023

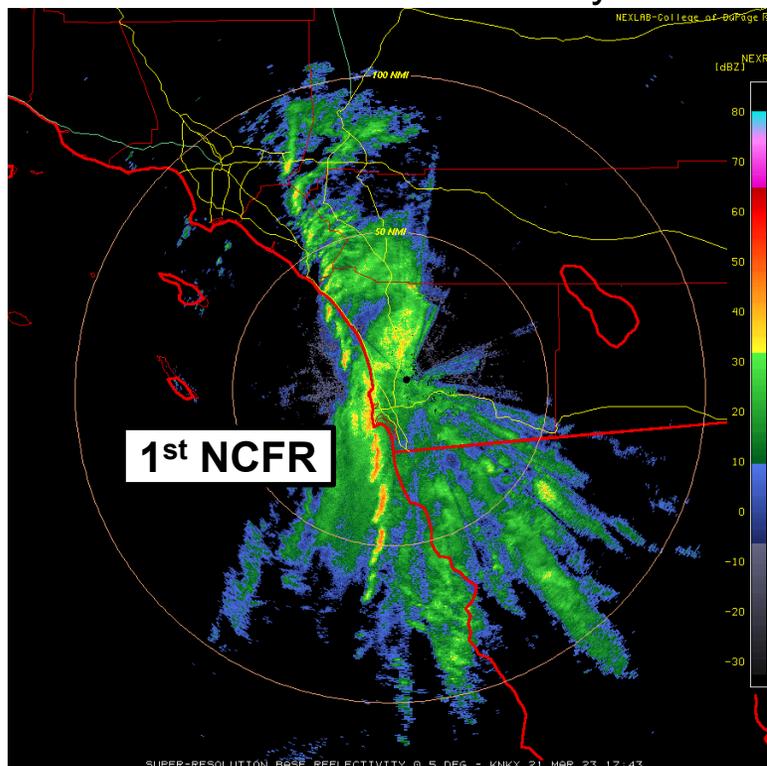


- The AR produced at least 1–3 inches of precipitation in coastal Southern California and North Central Arizona
- The heaviest AR-related precipitation (> 4 inches) fell in the San Gabriel Mountains, CA and southern Coconino County, AZ
- Rainbands wrapping around the surface low also produced > 4 inches of precipitation in a 24-hour period in San Mateo and Santa Cruz Counties
- An estimated 1–3 feet of total snow fell in the higher terrain of the Southern Sierra Nevada and the Transverse Ranges

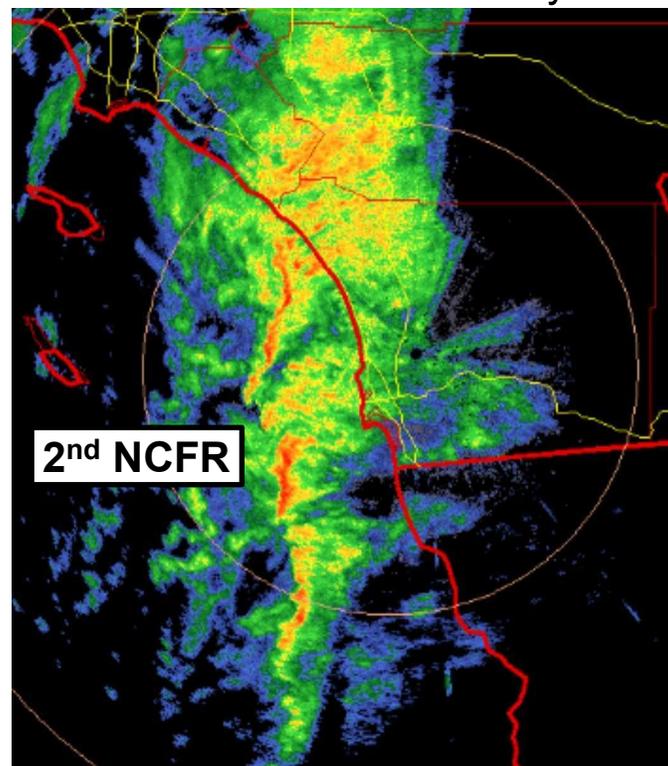
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## Mesoscale Features

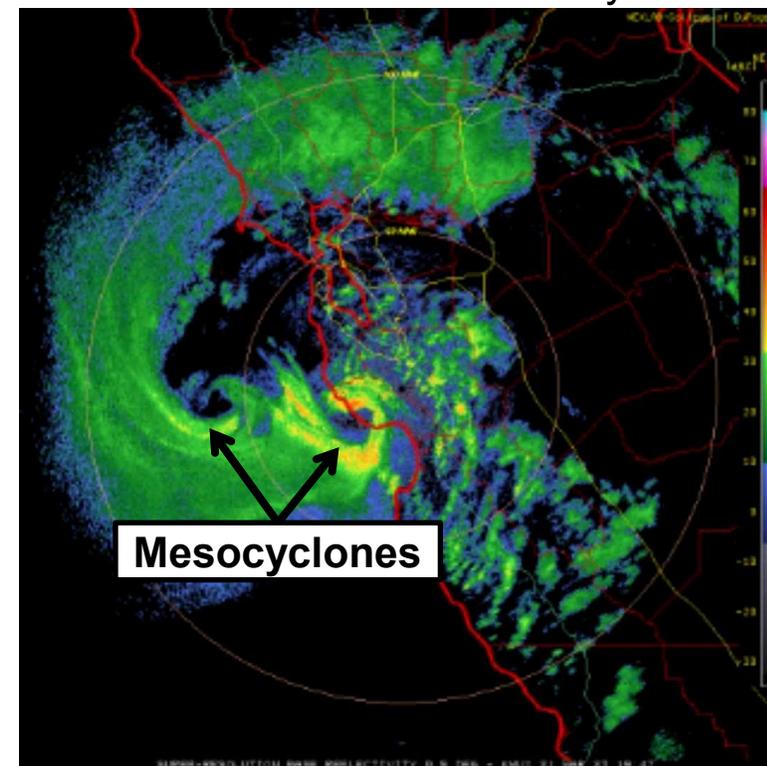
KNKX Base Reflectivity



KNKX Base Reflectivity



KMUX Base Reflectivity

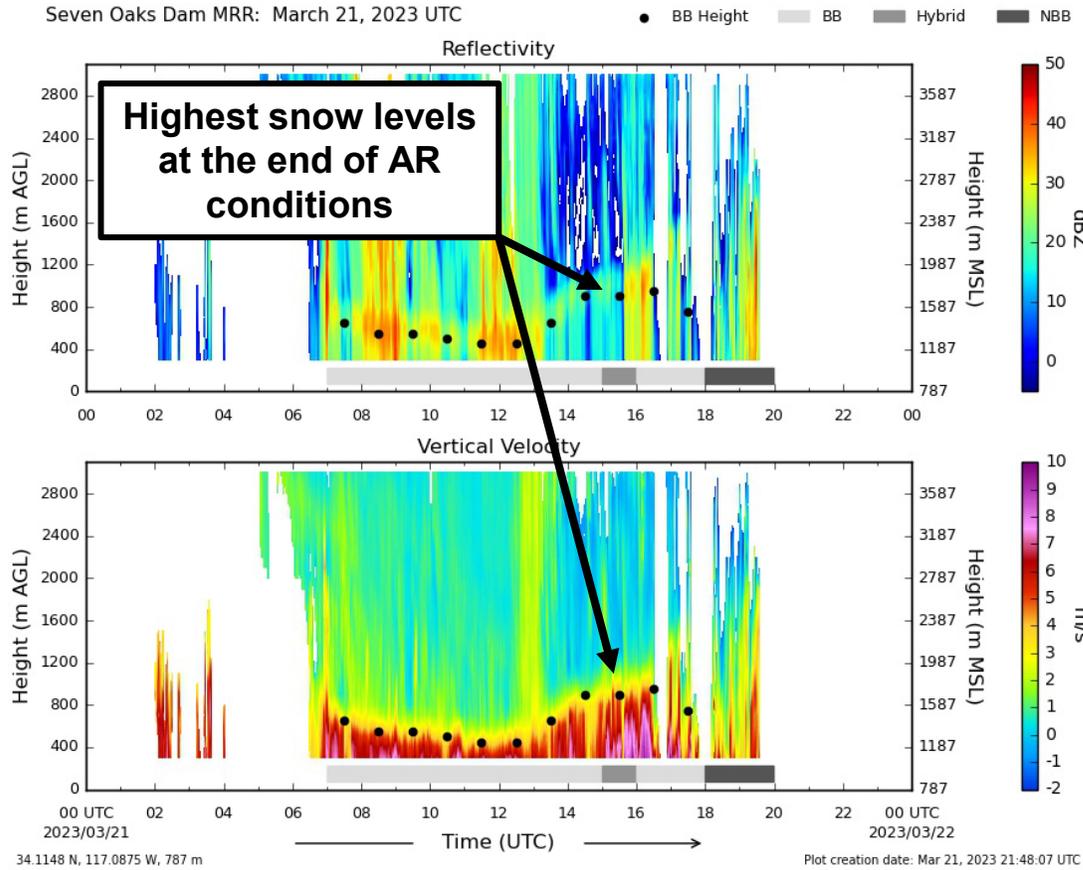


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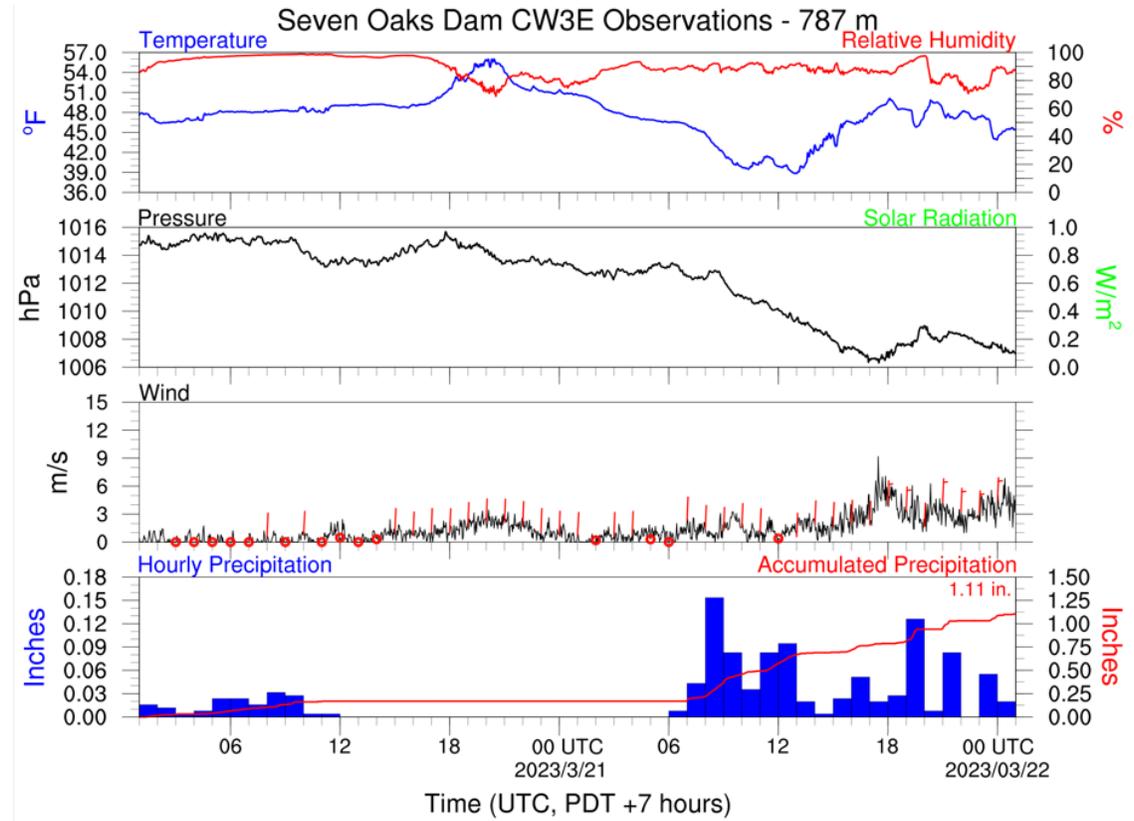
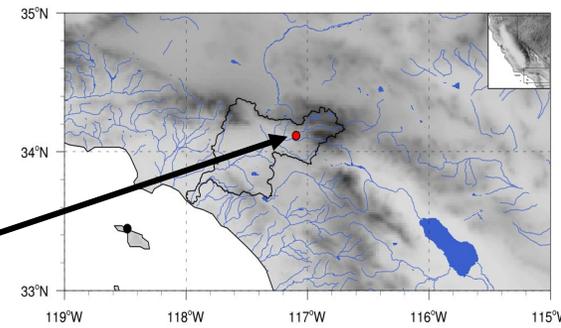
- A narrow cold-frontal rainband (NCFR) developed within the core of the AR and passed through San Diego around 11 AM PT 21 Mar (note the characteristic “gap and core” structure in the reflectivity image)
- A second NCFR developed behind the primary cold front and moved onshore around 7 PM PT 21 Mar
- Radar and satellite imagery also captured a rare Fujiwhara effect (i.e., two mesocyclones rotating around each other) as the low-pressure system entered the Bay Area

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## CW3E Meteorological Observations (Seven Oaks Dam)



Seven Oaks Dam

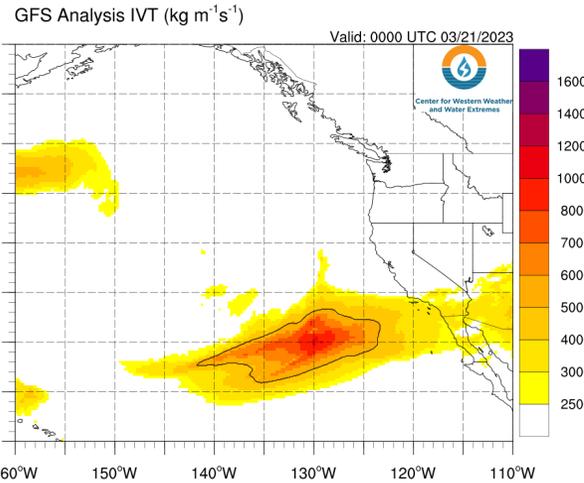


- Snow levels at CW3E’s MicroRain Radar (MRR) at Seven Oaks Dam rose approximately 500 meters towards the end of the AR
- CW3E’s surface meteorology station at the same location showed rising surface temperatures prior to the lowest barometric pressure as well as approximately 0.9 inches of rain on 21 March

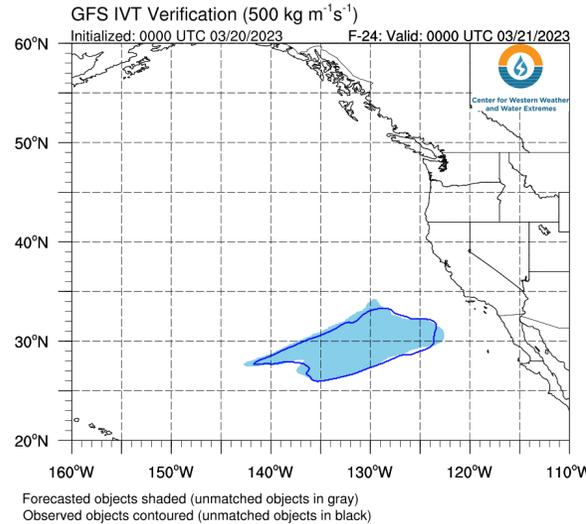
# CW3E Event Summary: 20–22 March 2023

## GFS AR/IVT Forecast Verification: Valid 00Z 22 March

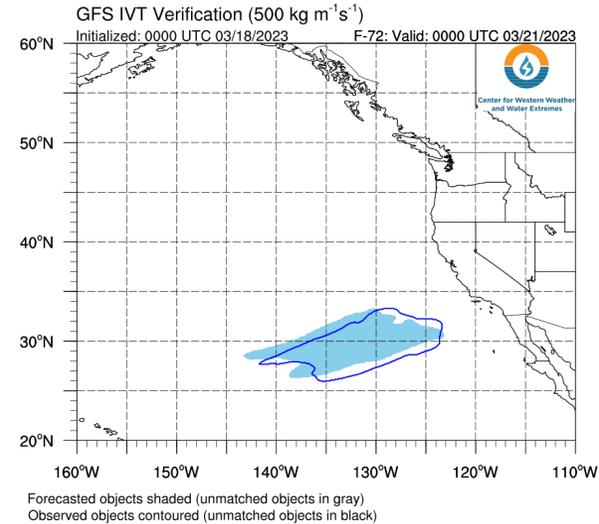
### Model Analysis



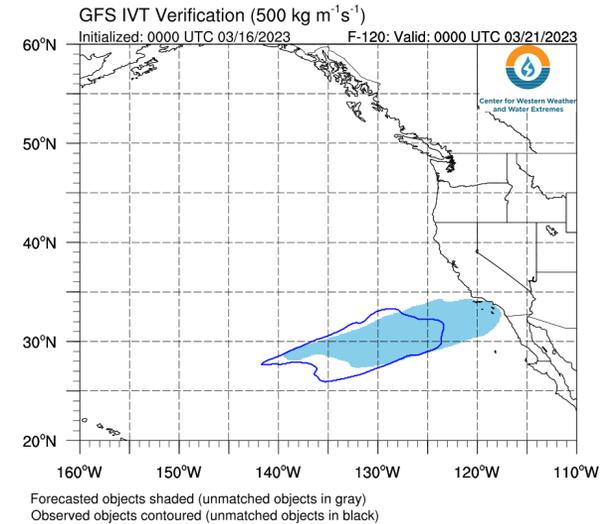
### 24-h Forecast



### 72-h Forecast



### 120-h Forecast

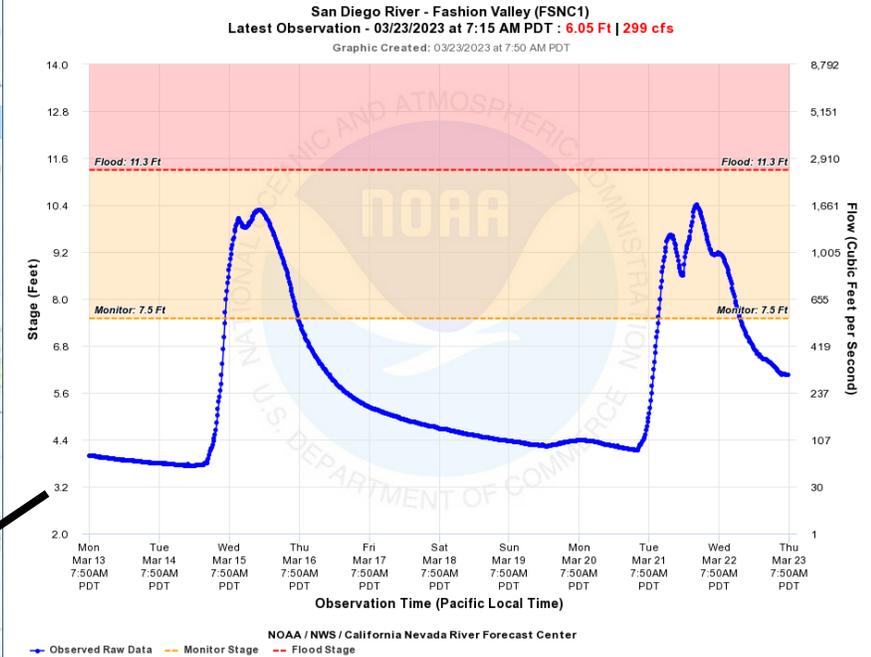
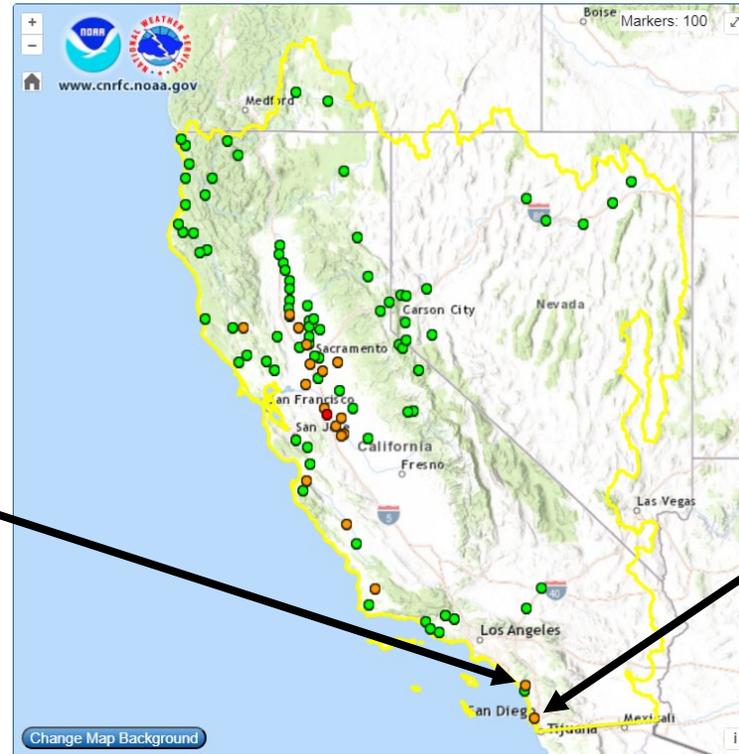
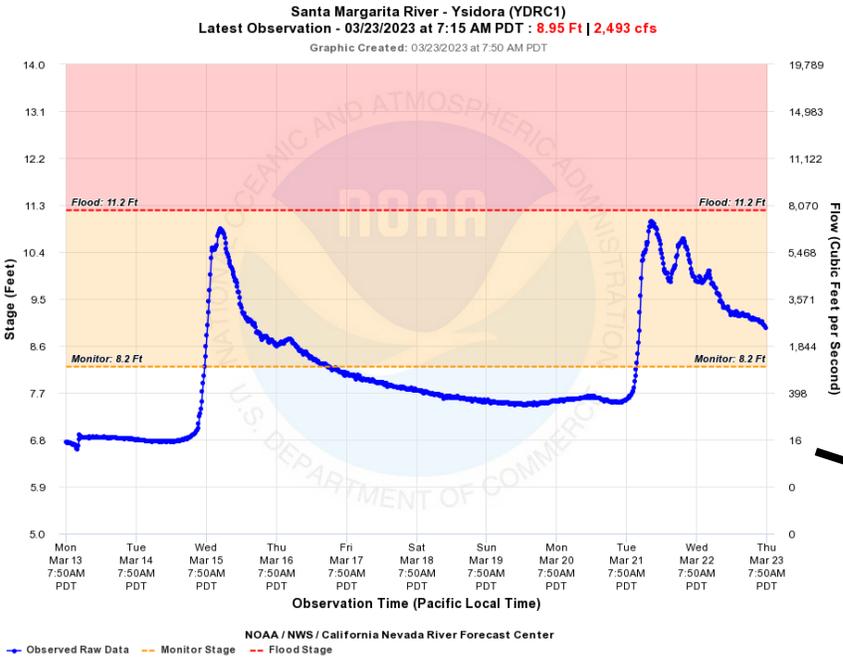


*Forecast objects shaded (unmatched objects in gray)  
Observed objects contoured (unmatched objects in black)  
Objects defined based on  $IVT > 250 \text{ kg m}^{-1} \text{ s}^{-1}$*

- The Method for Object-Based Diagnostic Evaluation (MODE) with a  $500 \text{ kg m}^{-1} \text{ s}^{-1}$  IVT threshold shows that the location of the AR was well forecasted at a 24-hour lead time
- The 48-hour (not shown) and 72-hour forecasts were very similar with respect to shifting the AR object north and west as compared to the analysis object
- Examination of the 72-hour forecast shows the AR object much further east and making landfall in Southern California
- The 96-hour, 144-hour, and 168-hour forecasts (not shown) struggled with the location and extent of the AR object.

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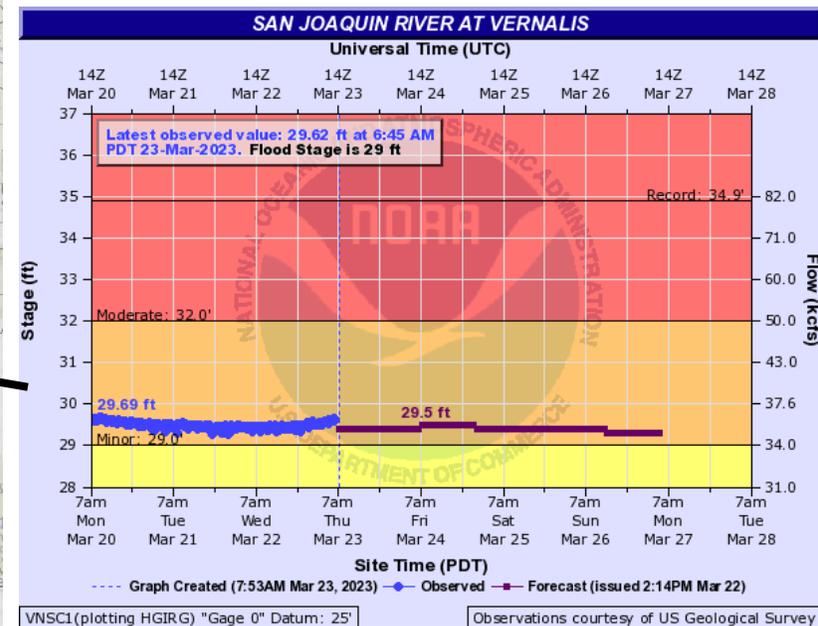
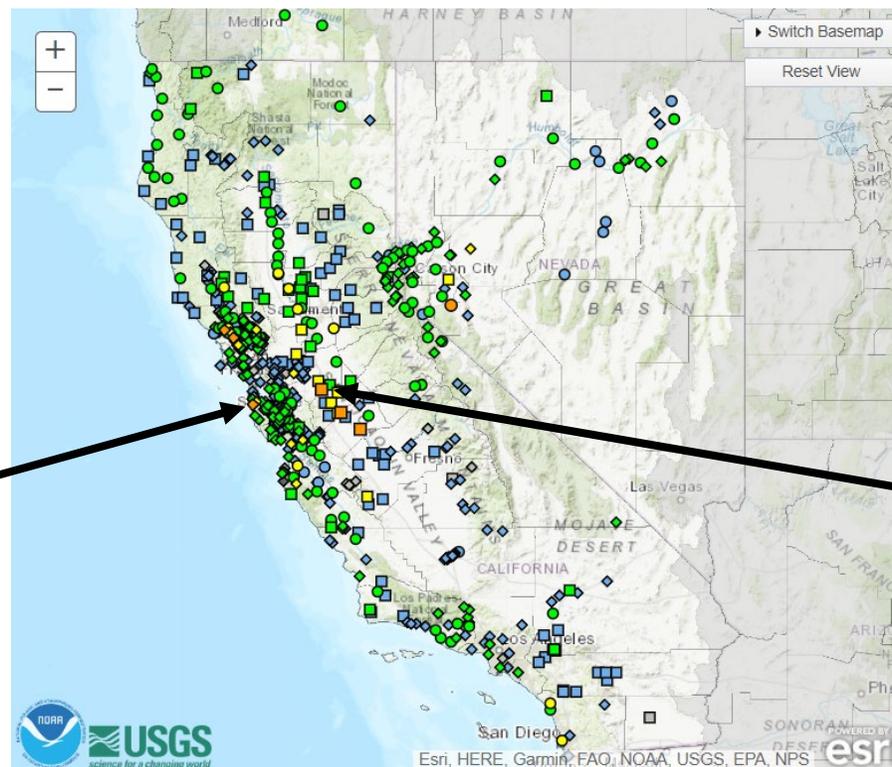
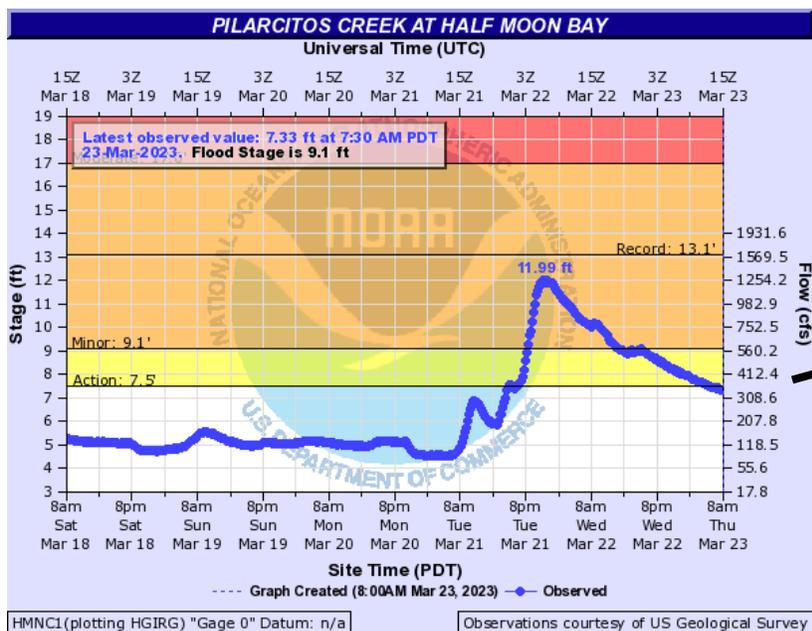
## Hydrologic Impacts



- The Santa Margarita River at Ysidora (left) rose above monitor stage (8.2 ft) on 21 March with a crest of 11.0 ft, just below flood stage of 11.2 ft, and is expected to stay above monitor stage until 4pm PT 23 March. Minor flooding resulted in a road on Camp Pendleton to be closed
- The San Diego River at Fashion Valley (right) rose above monitor stage (7.5 ft) on 21 March with a crest of 10.4 ft. Rising waters forced some local roads to be closed

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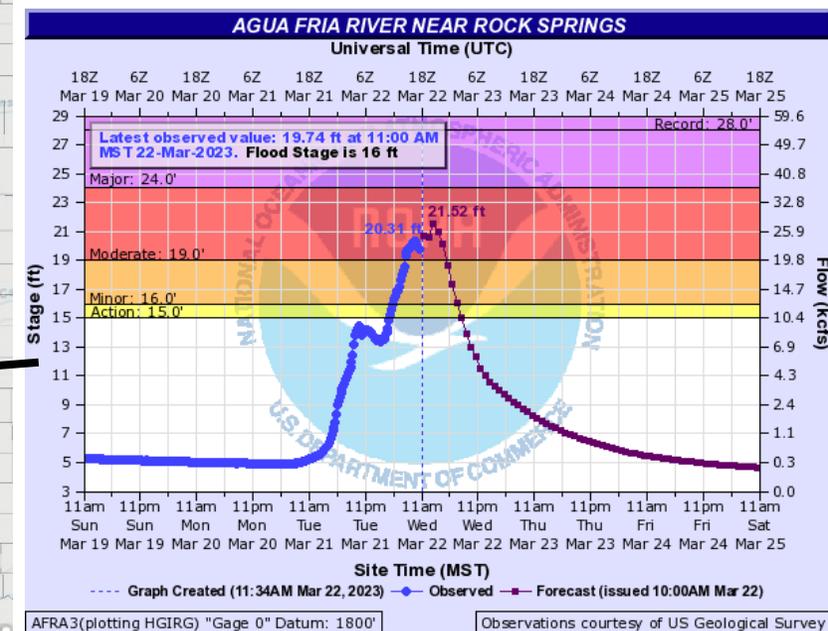
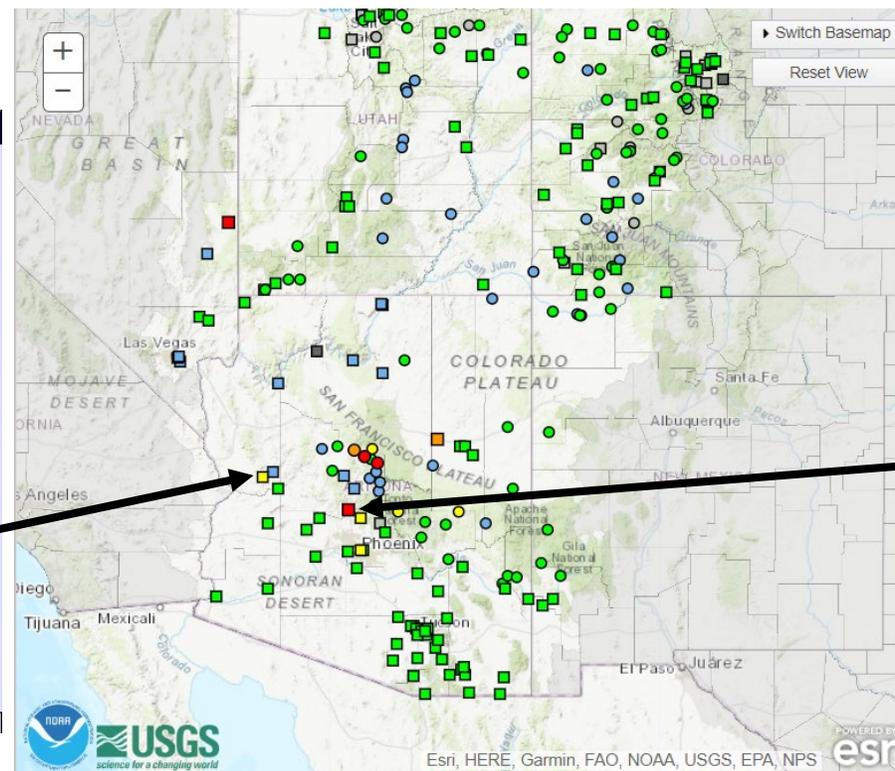
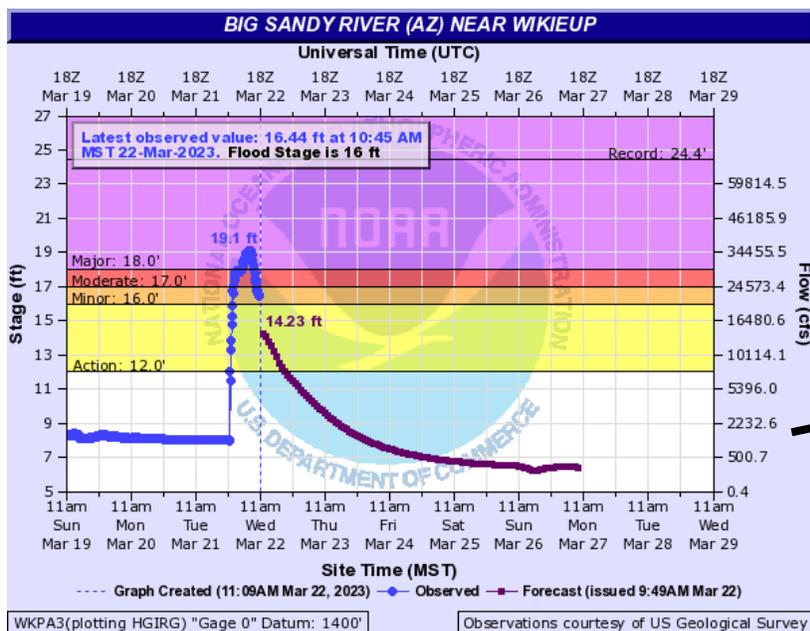
## Hydrologic Impacts



- The Pilarcitos Creek at Half Moon Bay (left) rose above minor flood stage (9.1 ft) on 21 March and crested at 11.99 ft, 1.1 ft below the record
- The San Joaquin River at Vernalis (right) has been above minor flood stage (29.0 ft) since 17 March. The river crested at 29.8 ft on 19 March and may stay above minor flood stage (29.0 ft) until at least the end of March.

# CW3E Event Summary: 20–22 March 2023

## Hydrologic Impacts

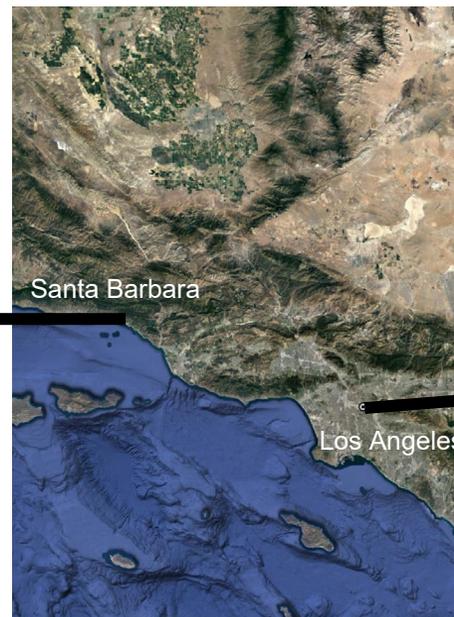
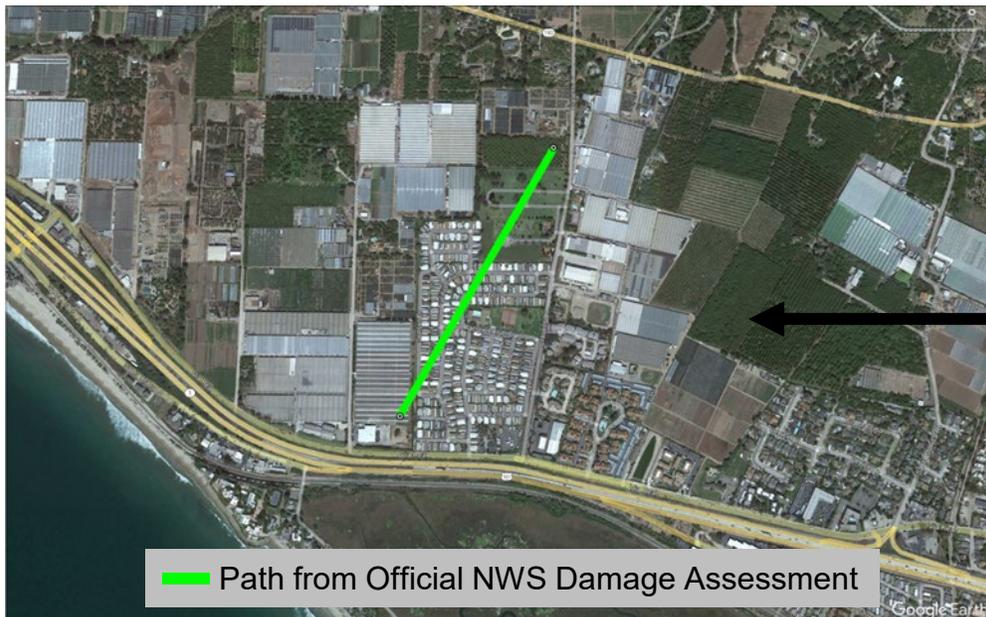


- The Big Sandy River at Wikieup (left) rose 11 feet to above major flood stage (18.0 ft) on 22 March
- The peak stage of 19.1 feet makes this the 5<sup>th</sup> highest peak and highest since 2010
- The Agua Fria River near Rock Springs (right) rose 15 feet to above moderate flood stage on 22 March
- Even with the large increases in flow, each station remained about 5 feet below record levels

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Official Data: NWS Los Angeles  
Imagery: Google Earth

## Tornadoes



### Carpinteria, CA – 3/21/2023

- An EF0 tornado touched down in a trailer park in Santa Barbara County Tuesday evening
- 25 mobile homes were damaged, with additional damage in an adjacent Cemetery
- The tornado had an estimated peak wind speed of 75 mph, with an approximate path length of 0.47 miles

Tornado in Montebello was the **strongest tornado in the Los Angeles Metro since 1983** according to the NWS Los Angeles

### Montebello, CA – 3/22/2023

- An EF1 tornado touched down in an industrial district of the Los Angeles Metro Area
- 17 structures were damaged, with 11 of those being so severe they were listed as “red tagged” meaning they are too dangerous to inhabit
- The tornado had an estimated peak wind speed of 110 mph, with an approximate path length of 0.42 miles

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## Impacts: California



Firefighters had to extricate two people from a vehicle after a eucalyptus tree fell on their vehicle in the city of Newark, CA  
*Alameda County Fire*



At least 5 people were killed across the Bay Area by falling trees during this storm according to ABC 7 News Bay Area, with an on-duty San Francisco Police officer receiving life-threatening injuries as a result of a falling tree  
*San Francisco Fire Department*  
*San Francisco Police Department*  
*ABC 7 News Bay Area ([LINK](https://twitter.com/SFFDPIO/status/1638334955536412672))*



A semi truck overturned due to high winds on the San Francisco/Oakland Bay Bridge  
*CHP San Francisco*

# CW3E Event Summary: 20–22 March 2023

## Impacts: California



Severe damage was caused to a roadway in Marin County due to a hill slope failure, resulting in buckling of the road  
*Olompali State Historic State Park*



A landslide resulted in a closure along SR-18 in the San Bernardino National Forest  
*Caltrans District 8*



Strong winds and high surf caused multiple barges to break away from moorings and drift into the Third Street Bridge in San Francisco, causing damage to the structure  
*San Francisco Public Works*

# CW3E Event Summary: 20–22 March 2023

## Impacts: Arizona



<https://twitter.com/ArizonaDOT/status/1638304512476876801>

Debris blocking roadway in Oak Creek Canyon on SR 89A, north of Sedona *Arizona DOT*



<https://twitter.com/DaisyMtnFire/status/1638570450669412352>

Driver rescued after attempting to cross flooded roadway *Daisy Mtn Fire & Medical*



<https://www.facebook.com/photo/?fbid=590534679785007>

Lowland flooding at a campground in the Coconino National Forest *Coconino NF*

# CW3E Event Summary: 20–22 March 2023

## Impacts: Arizona

Helicopter rescue performed on the Salt River in Maricopa County due to rising floodwaters  
*Maricopa County Sheriff*



<https://twitter.com/SgtJEnriquez/status/1637572229851648000>

<https://www.facebook.com/photo/?fbid=541224081468880>



A flood advisory was issued by the NWS for the Oak Creek near the City of Sedona due to rising river levels  
*City of Sedona Government*

Lake levels at Watson Lake rose above the spillway and the City of Prescott conducted controlled releases from Watson Dam  
*Yavapai County Flood Control District*



[https://twitter.com/YavapaiAZ\\_Flood/status/1638576561862635521](https://twitter.com/YavapaiAZ_Flood/status/1638576561862635521)