

# CW3E Atmospheric River Outlook: 6 March 2023

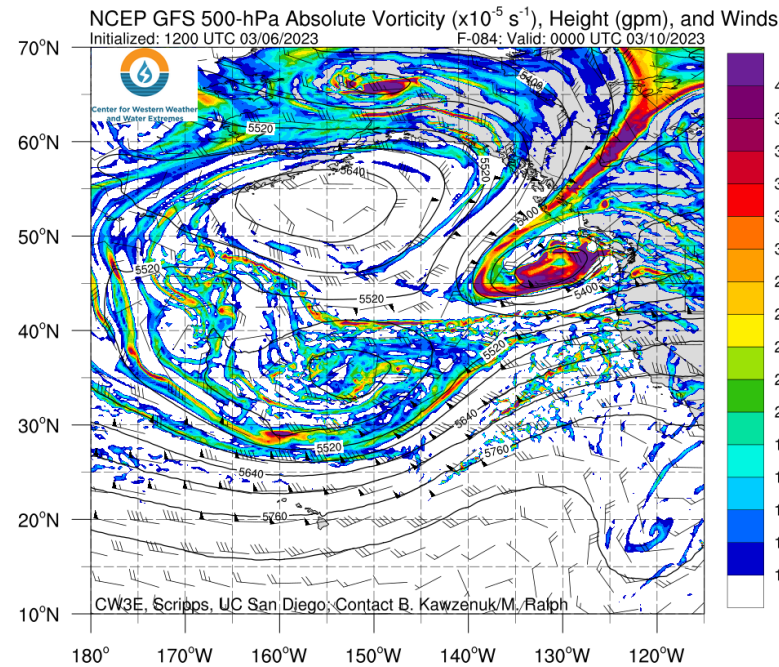
## Warm Atmospheric River to Bring Heavy Precipitation, Potential Flooding to California Later This Week

- An atmospheric river (AR) is forecast to make landfall in California later Thursday, bringing with it considerable rainfall to the region through Saturday
- IVT  $> 750 \text{ kg m}^{-1} \text{ s}^{-1}$  is forecast during AR landfall along the coast of California, bringing AR 3/AR 4 conditions (based on the Ralph et al. 2019 AR Scale) to Central and Northern California
- This AR is forecast to be a warm storm, with a broad region of 850-hPa temperatures  $> 0^\circ \text{ C}$  forecast over California during this storm period
- The 00Z ECMWF is forecasting a stronger AR at coastal locations in Central California as compared to the GFS, while the GFS is forecasting a slightly longer duration of AR conditions along the coast
- Models are showing low-to-moderate confidence in a second AR landfall in California early next week
- The NWS Weather Prediction Center (WPC) has forecast 48-hour precipitation totals  $> 3$  inches over the Coast Ranges of Northern and Central California and  $> 5$  inches over the Sierra Nevada in association with the first AR
- The 00Z ECMWF is forecasting considerably more precipitation (5.06 in) for the Russian River Watershed as compared to the 00Z GFS (1.32 in), highlighting significant model-to-model uncertainty with this event
- GEFS ensemble has forecast freezing levels to rise rapidly, to nearly 6,000 feet across Northern California and the Sierra Nevada ahead of this AR
- **The combination of high freezing levels, heavy precipitation, and existing snowpack conditions will likely result in a substantial amount of rain-on-snow, thereby increasing runoff and the potential for flooding**

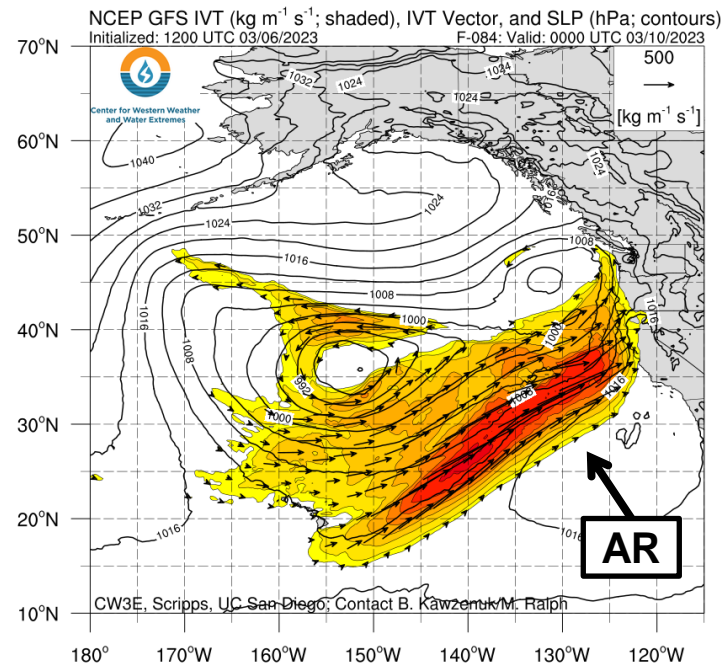
# CW3E AR Outlook: 6 March 2023

## GFS Model Forecast: Valid 4 PM PST 9 Mar (F-84)

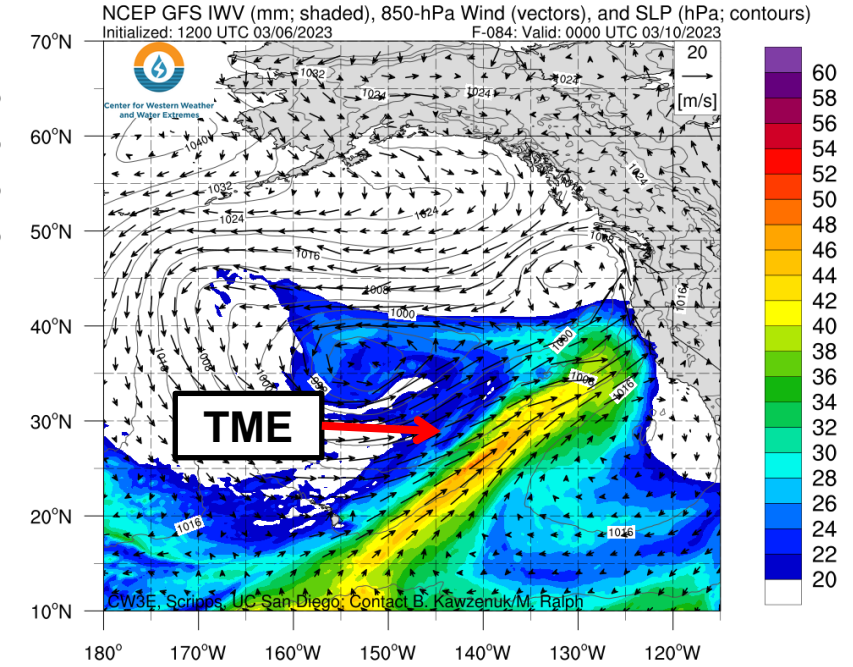
### 500-hPa Vorticity, Height, and Wind



### IVT and SLP



### IWV and 850-hPa Wind



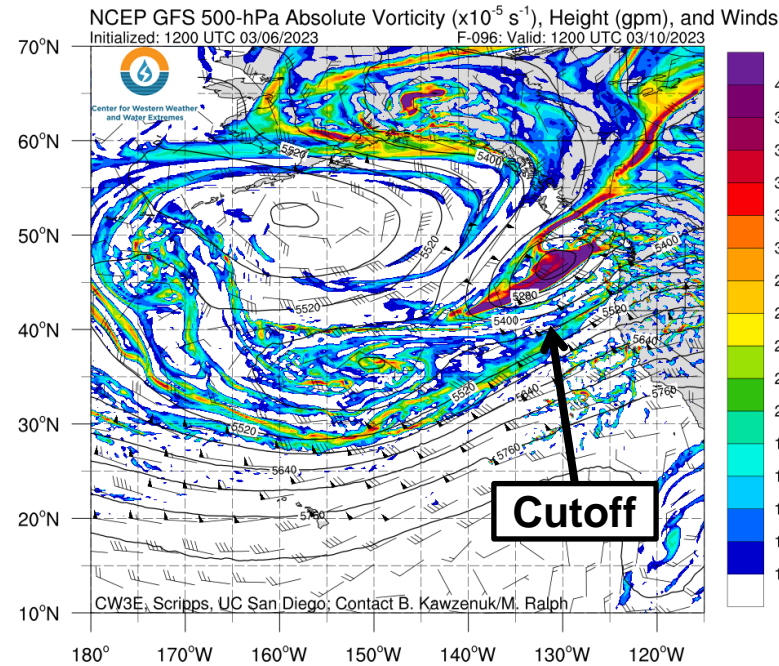
- A sharp mid-level trough is forecast to develop over Alaska and shift to the south over the Pacific Northwest by mid-week, while the trough positioned to the north of Hawaii will help steer the AR and associated moisture poleward, towards the US West Coast
- The AR is forecast to develop in the central North Pacific and propagate towards the US West Coast, with a broad region of IVT  $> 1000 \text{ kg m}^{-1} \text{ s}^{-1}$  in the core of the AR during landfall
- This AR is supported by a robust tropical moisture export (TME), with IWV values  $> 44 \text{ mm}$  in the core of the AR



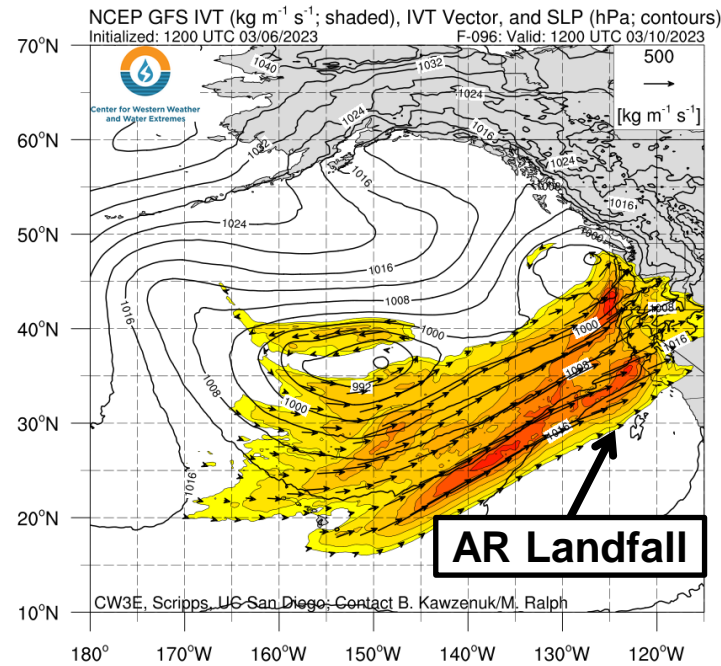
# CW3E AR Outlook: 6 March 2023

## GFS Model Forecast: Valid 4 AM PST 10 Mar (F-96)

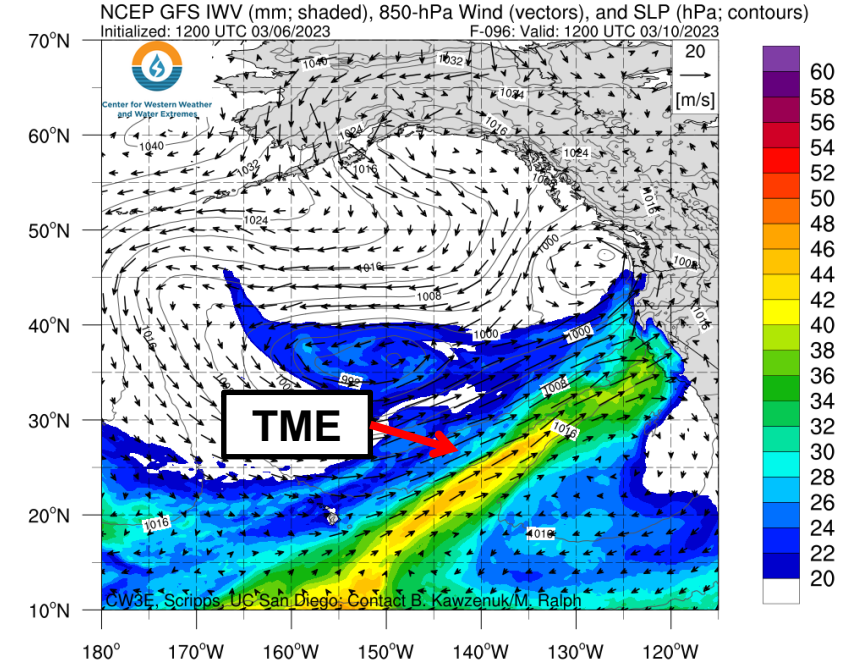
### 500-hPa Vorticity, Height, and Wind



### IVT and SLP



### IWV and 850-hPa Wind

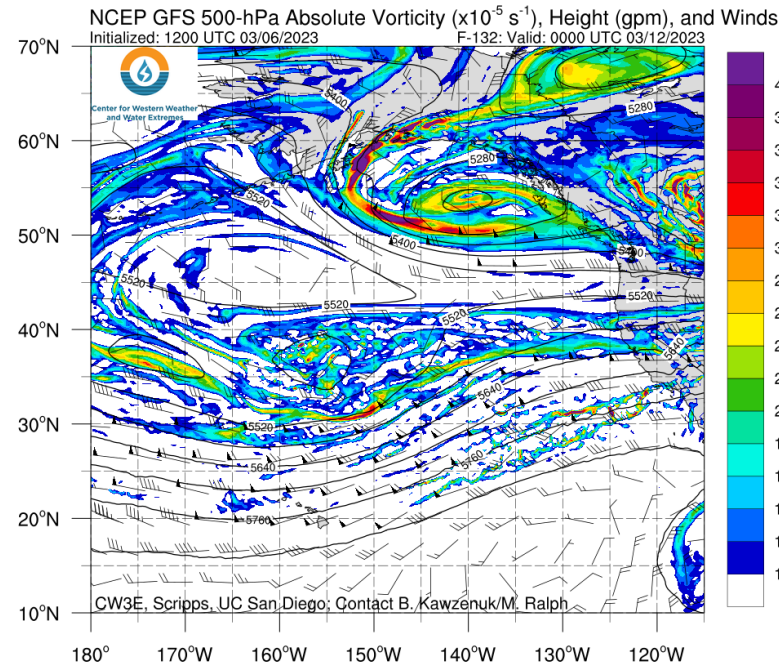


- The mid-level shortwave trough is forecast to develop into a cut-off over the Pacific Northwest, providing favorable forcing for ascent along the US West Coast along the northeastern portion of the AR
- Southwesterly IVT  $> 750 \text{ kg m}^{-1} \text{ s}^{-1}$  off the US West Coast during this AR will support with strong moisture transport into Northern and Central California from Thursday through Saturday
- The TME is forecast to remain in position, with IWV  $> 32 \text{ mm}$  reaching the US West Coast during this period

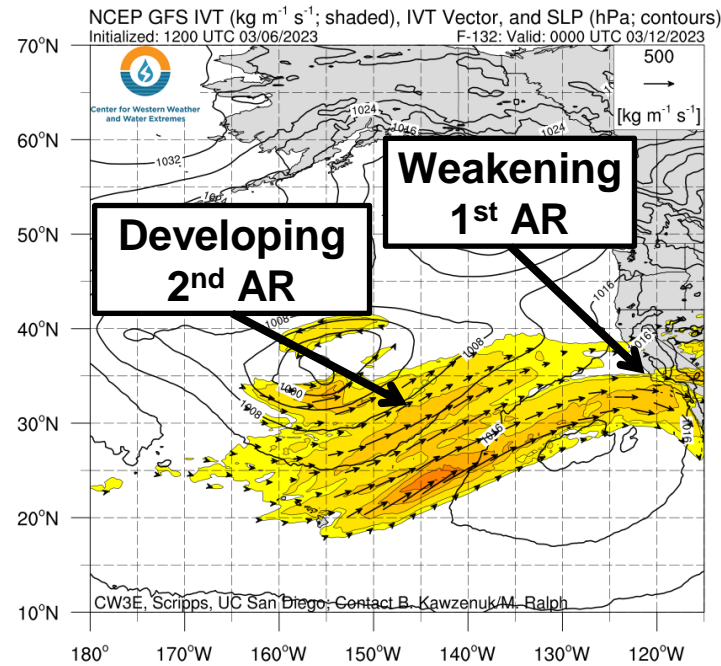
# CW3E AR Outlook: 6 March 2023

## GFS Model Forecast: Valid 4 PM PST 11 Mar (F-132)

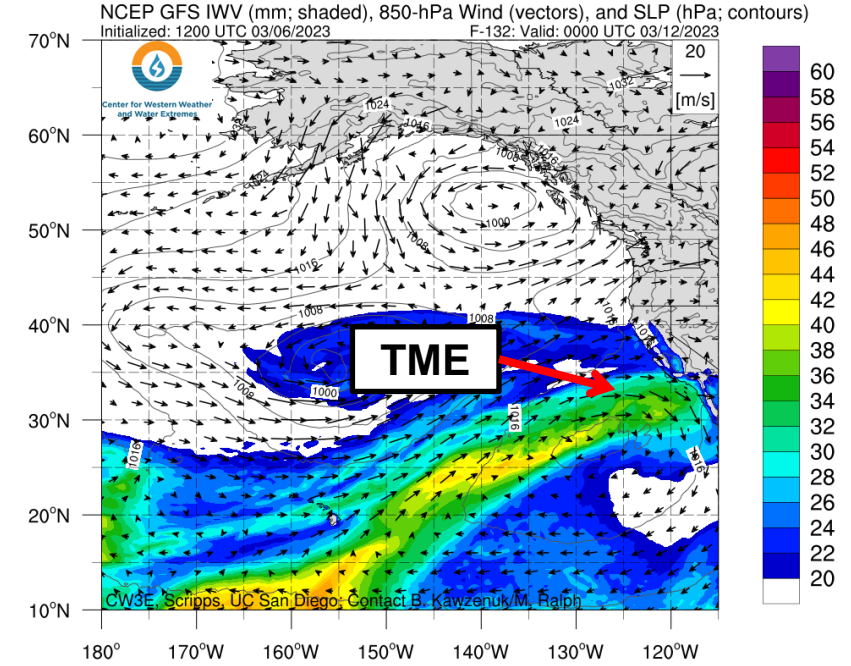
### 500-hPa Vorticity, Height, and Wind



### IVT and SLP



### IWV and 850-hPa Wind



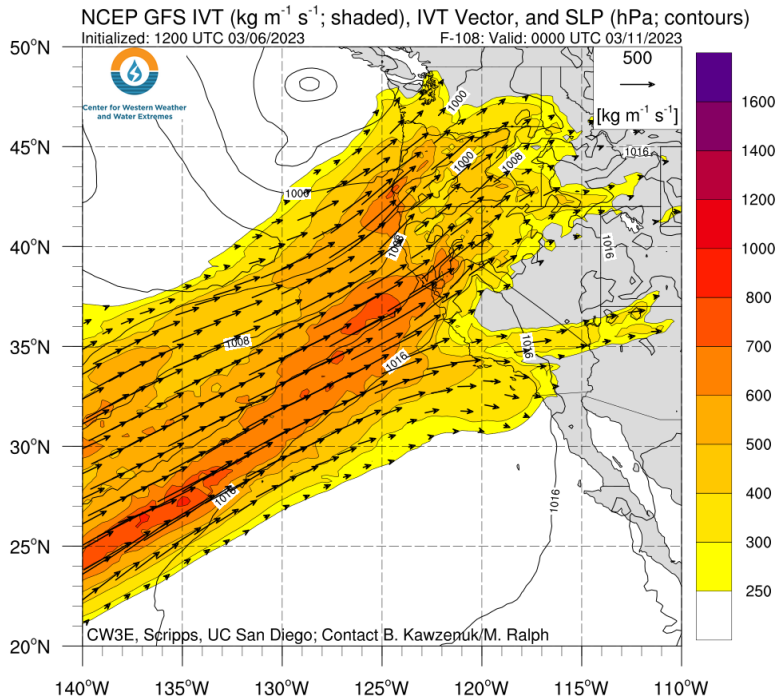
- The mid-level cutoff is forecast to lift to the northeast and exit the region early Saturday
- The 1<sup>st</sup> AR is forecast to dissipate over California on Saturday, with IVT  $> 400 \text{ kg m}^{-1} \text{ s}^{-1}$  over Southern California
- A 2<sup>nd</sup> AR is forecast to develop in the Central North Pacific, providing a secondary surge of moisture transport into California early next week, although uncertainty remains on the exact location, duration, and intensity of this event at landfall
- The strong TME is forecast to weaken as time progresses, although a plume of IWV  $> 30 \text{ mm}$  will remain off the US West Coast, providing additional moisture for the developing 2<sup>nd</sup> AR



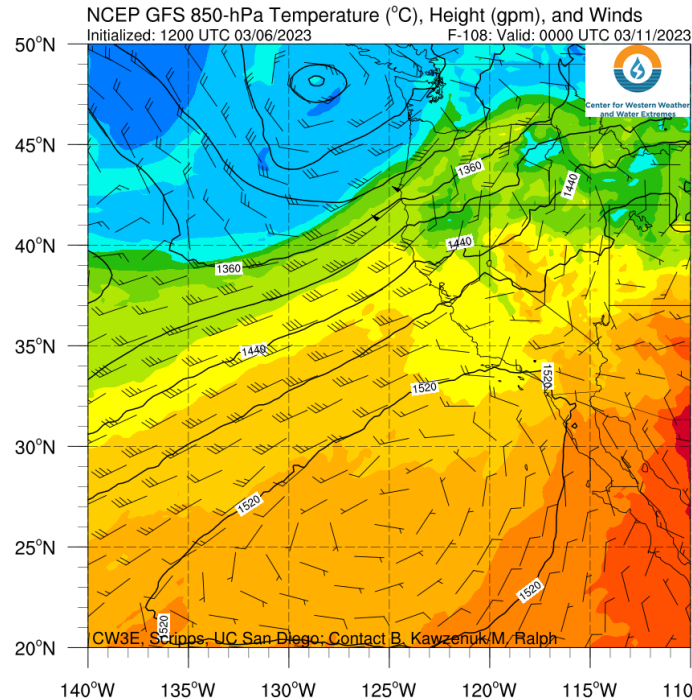
# CW3E AR Outlook: 6 March 2023

## GFS Model Forecast: Valid 4 PM PST 10 Mar (F-108)

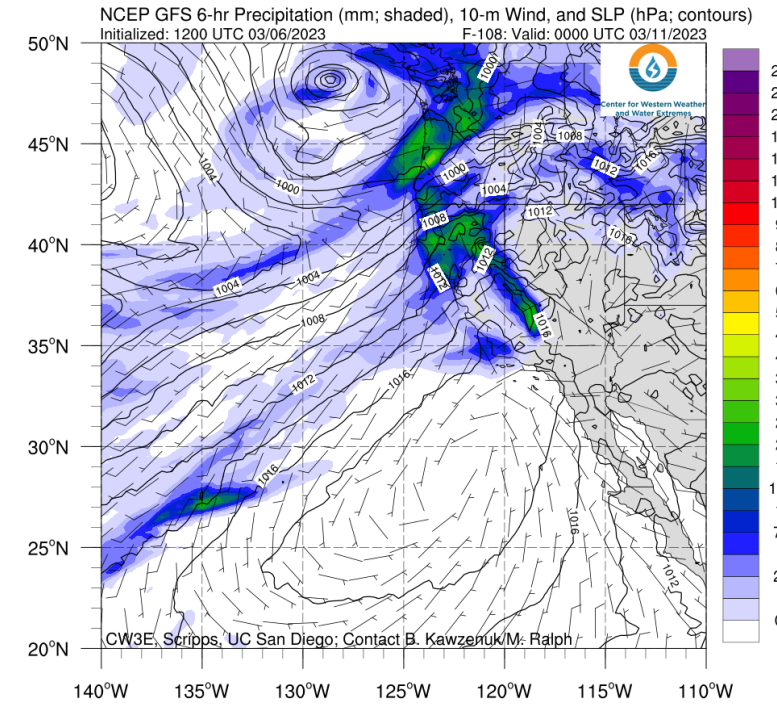
### IVT and SLP



### 850-hPa Temperature, Height, and Winds



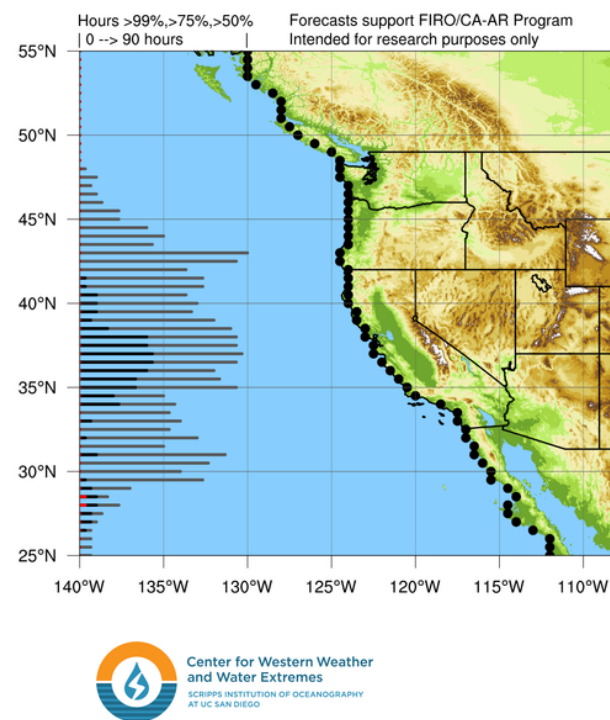
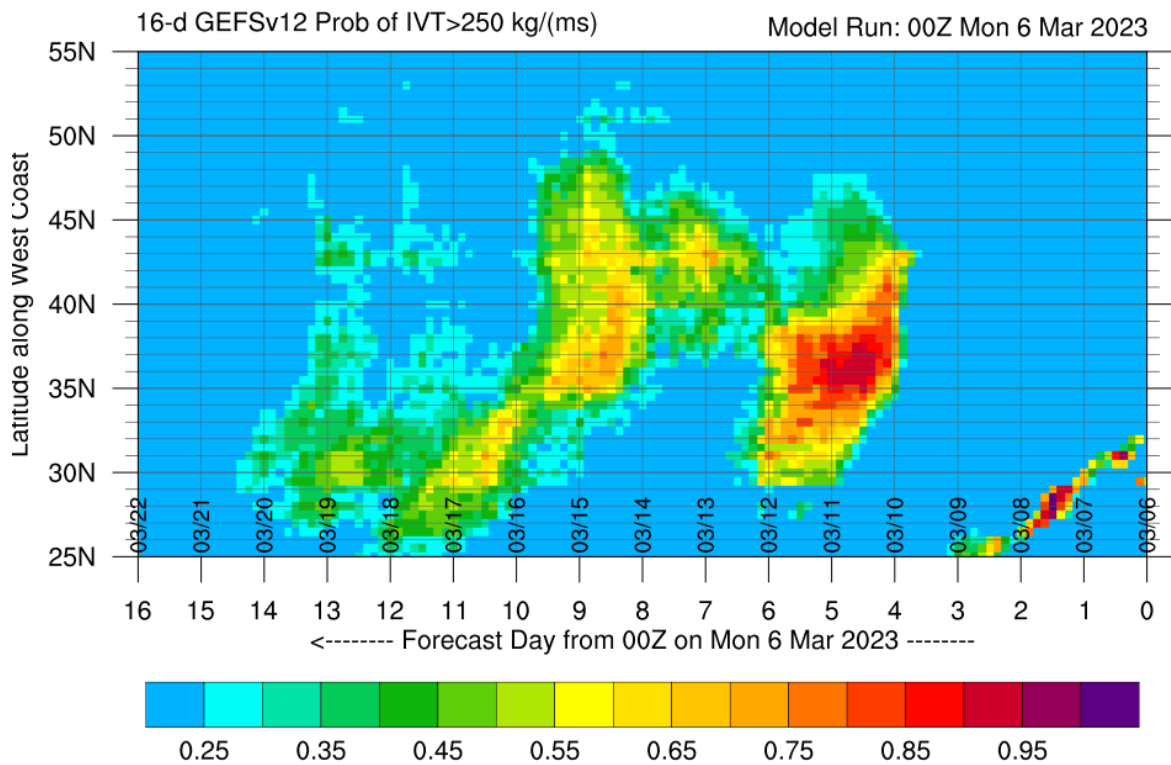
### 6-hr Precipitation, Wind, and SLP



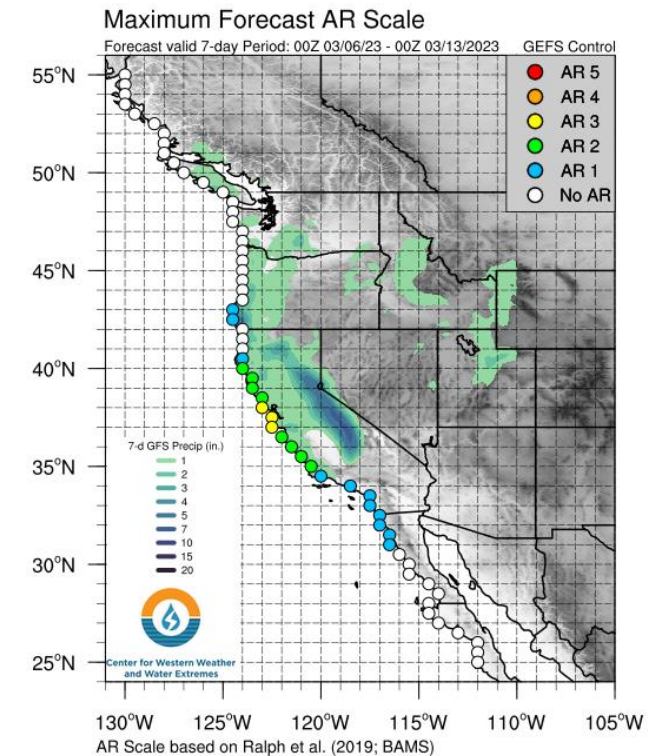
- IVT during this AR is forecast to remain southwesterly, which is favorable for orographic precipitation along the Coast Ranges in Northern California and the Sierra Nevada
- Low-level air temperatures are forecast remain warm during this event, with a broad warm air mass of temperatures greater than  $0^{\circ}\text{C}$  forecast remain over the western US in association with this AR
- Precipitation is forecast to be heaviest along the Coast Ranges of Northern California and in the Sierra Nevada during the AR

# CW3E AR Outlook: 6 March 2023

## Probability of AR Conditions Along Coast (GEFS)



## AR Scale

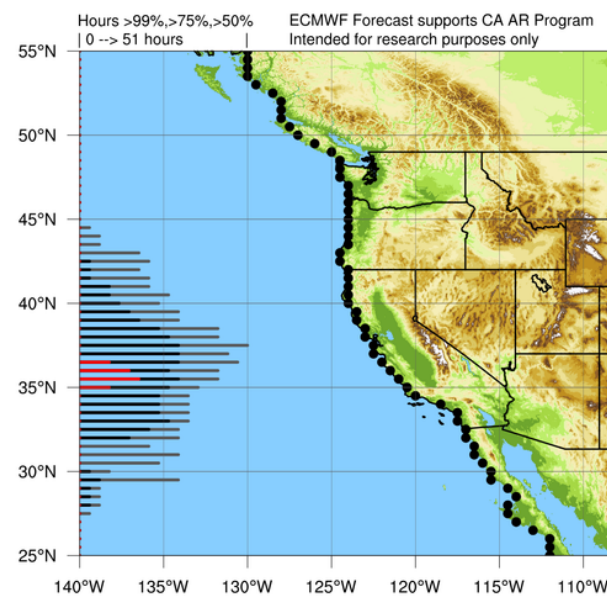
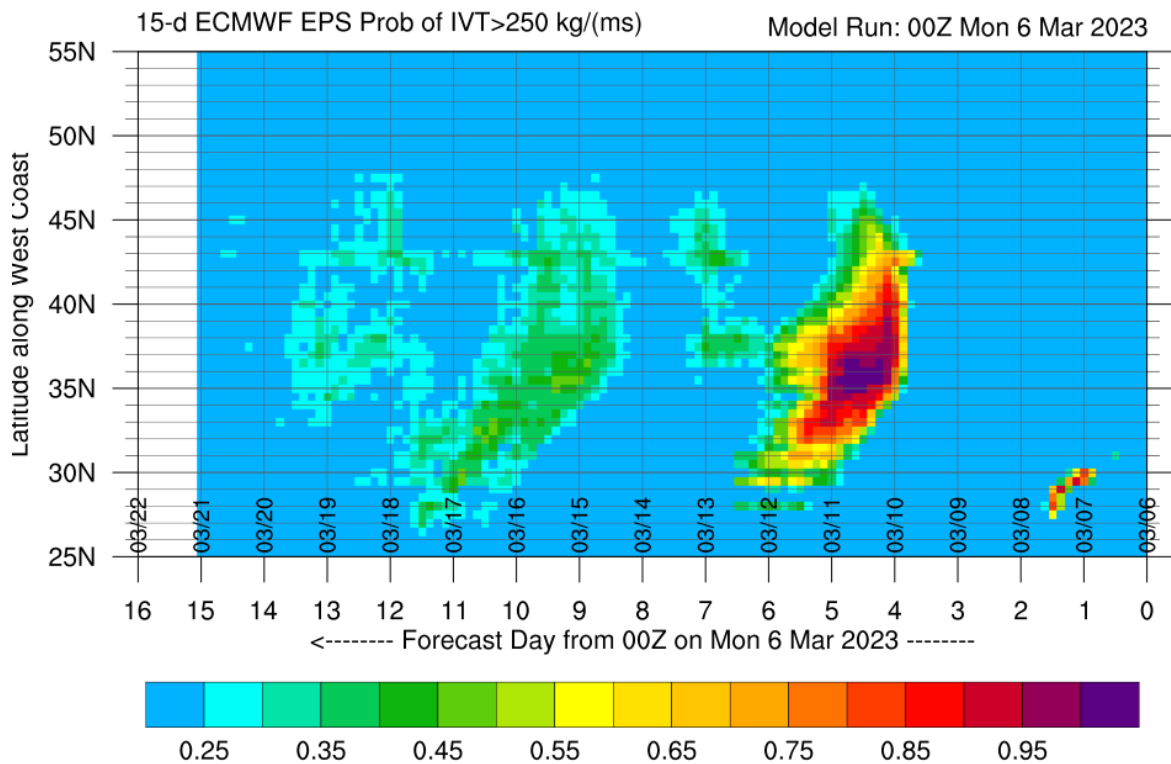


- The 00Z GEFS is showing high confidence (> 90%) in a period of AR conditions ( $IVT > 250 \text{ kg m}^{-1} \text{ s}^{-1}$ ) beginning Thursday for coastal locations in Northern and Central California
- The GEFS ensemble control member is forecasting AR 3 conditions for coastal locations in the Bay Area over the next 7 days
- There is moderate confidence (50–70%) in a secondary period of AR conditions for the GEFS ensemble forecast over Coastal California early next week (14-15 March)

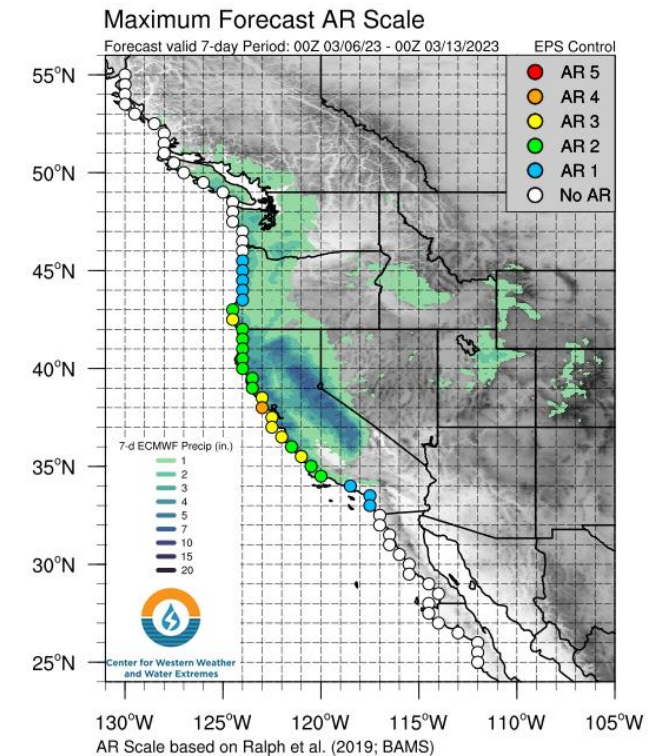


# CW3E AR Outlook: 6 March 2023

## Probability of AR Conditions Along Coast (ECMWF)



## AR Scale



- The 00Z ECMWF is showing very high confidence (> 95%) in a period of AR conditions ( $IVT > 250 \text{ kg m}^{-1} \text{ s}^{-1}$ ) in coastal Central and Northern California beginning Thursday through Saturday
- The ECMWF ensemble control member is forecasting AR 3 conditions for multiple coastal locations in Central California, with AR 4 conditions forecast for the coastal point just north of the Bay Area
- There is low confidence (30–40%) in a period of AR conditions in the ECMWF ensemble forecast for California early next week (14–15 March)

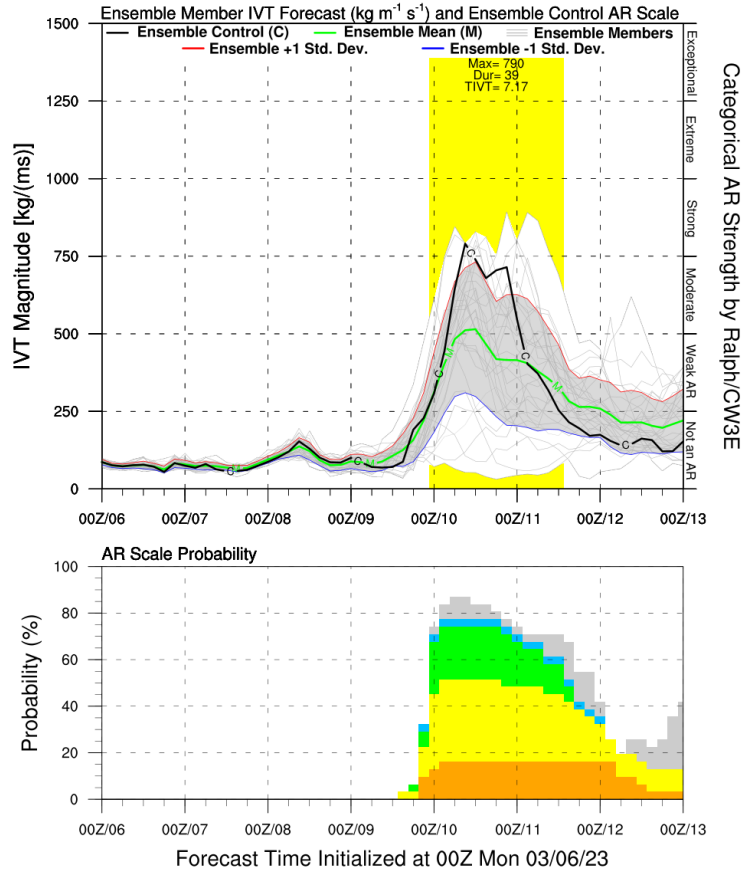
# CW3E AR Outlook: 6 March 2023

## 7-day AR Scale and IVT Forecast: 00Z GFS & ECMWF Ensemble

Landfall Point: 38.0°N, 123.0°W

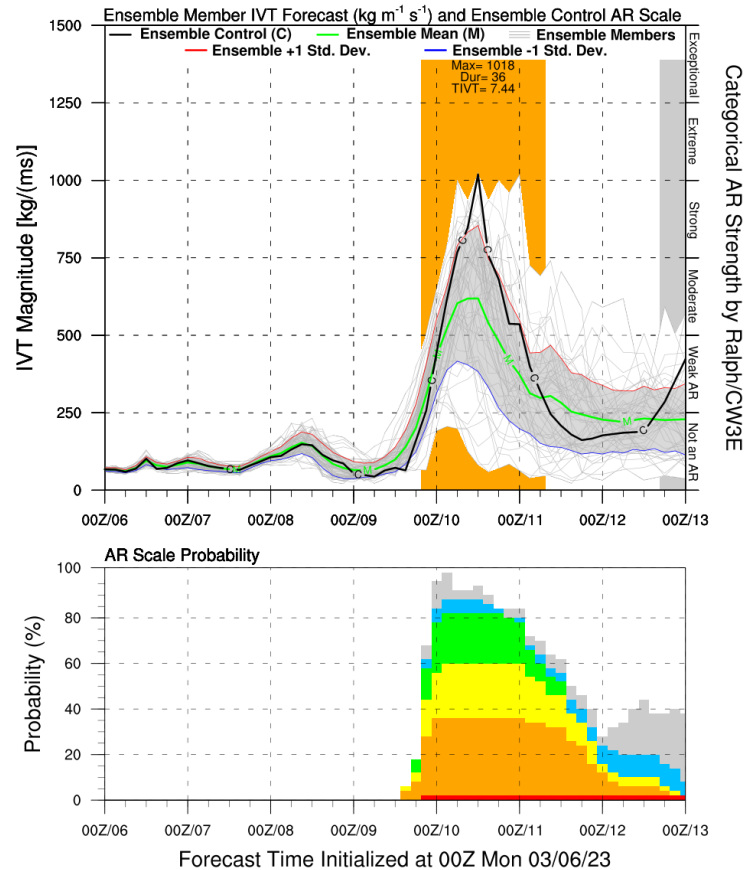
### GEFS Ensemble

GFS Ensemble Initialized: 00Z Mon 03/06/23



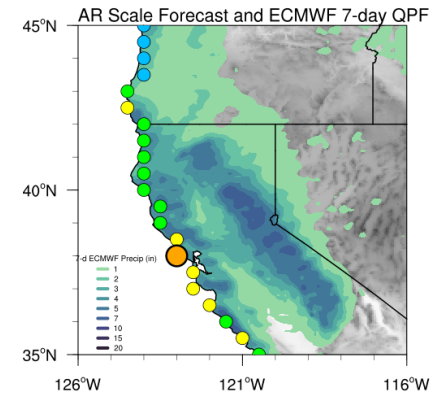
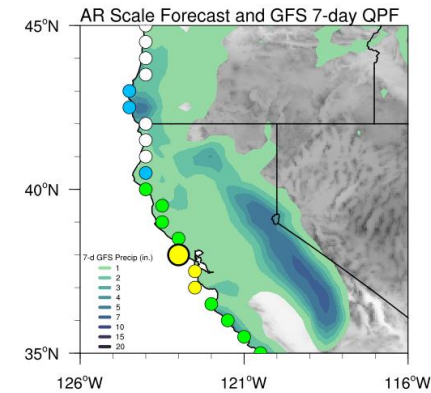
### ECMWF Ensemble

ECMWF Ensemble Initialized: 00Z Mon 03/06/23



### AR Ensemble Forecast

- 16/31 (52%) **GEFS ensemble** members are forecasting at least AR 3 conditions at this location.
- 30/51 (59%) **ECMWF ensemble** members are forecasting at least AR 3 conditions at this location
- The 00Z ECMWF ensemble is forecasting higher magnitude IVT during this event as compared to the GEFS ensemble, resulting in the AR 4 conditions for this location

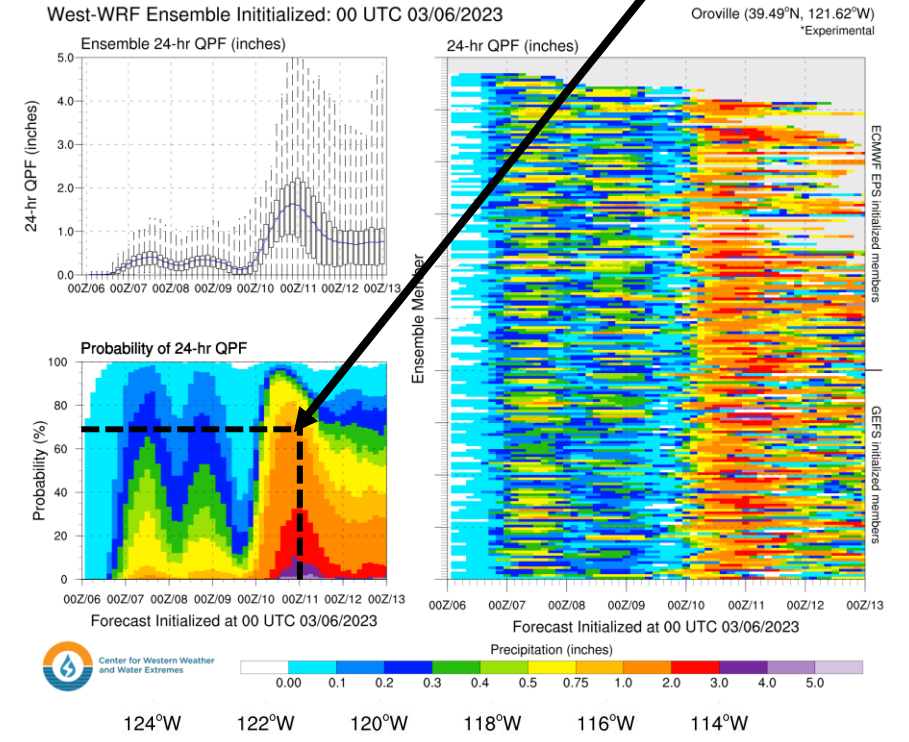
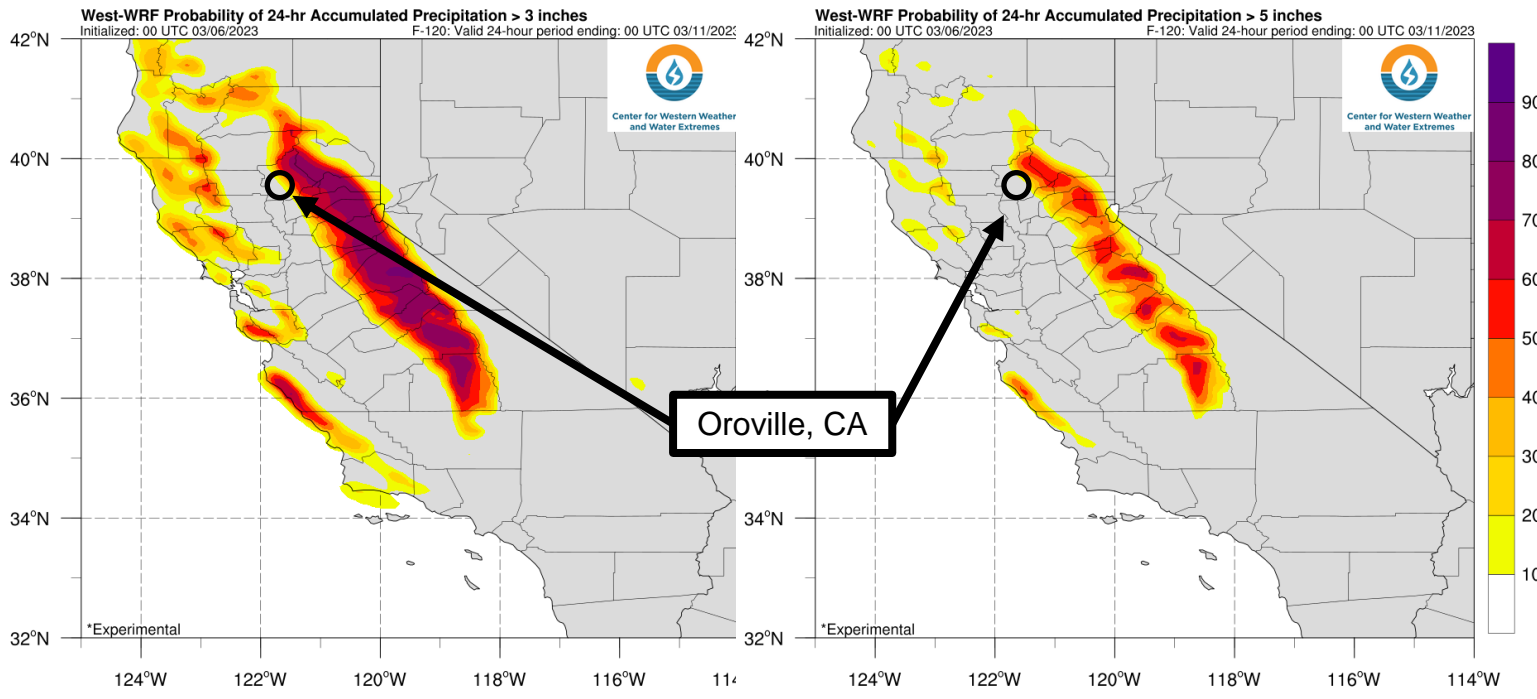




# CW3E AR Outlook: 6 March 2023

## West-WRF Probabilistic Precipitation Accumulation Forecast & Meteogram

70% probability of 24-hour accumulated precipitation > 1 inch at Oroville, CA valid for the 24-hour period ending at 00 UTC 11 March

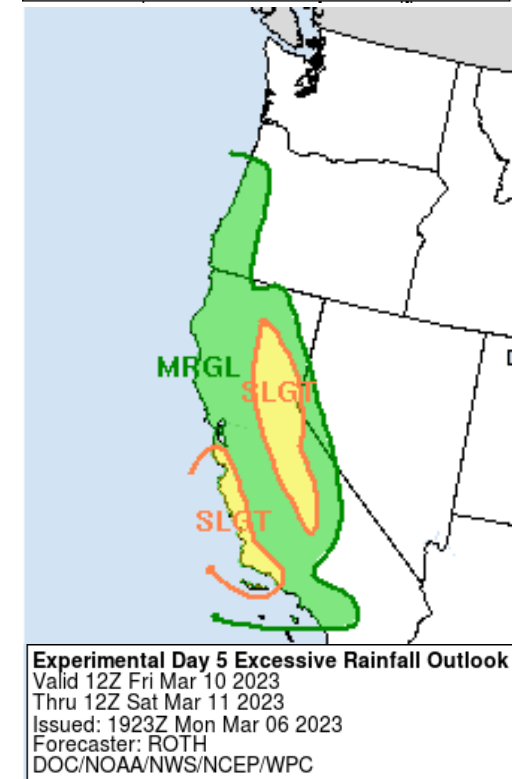
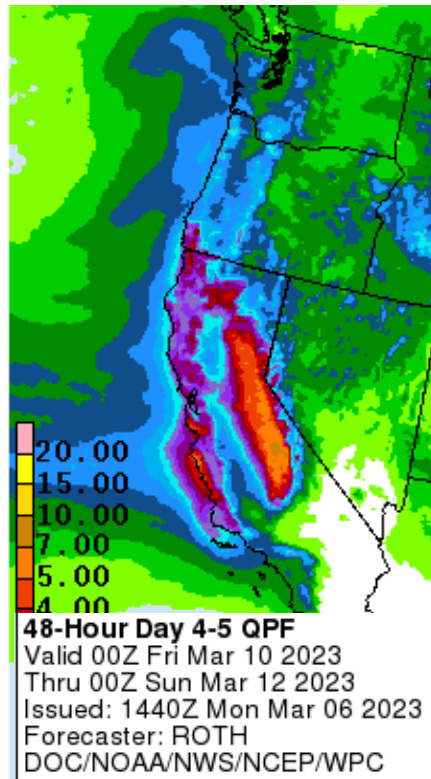
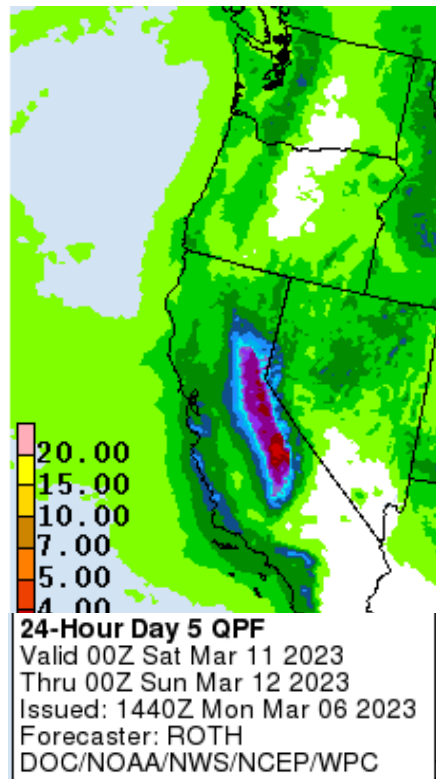
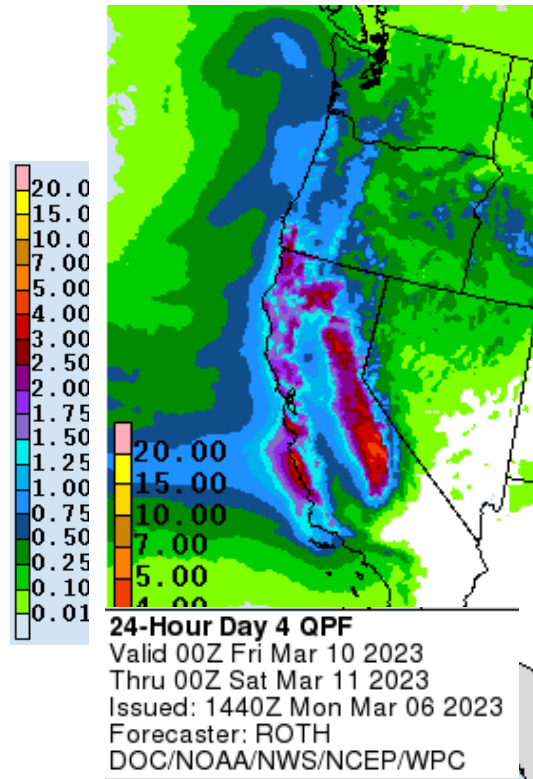


- CW3E's 200 member West-WRF ensemble model is forecasting high confidence (>80%) in 24-hr accumulations > 3 inches along the Sierra Nevada and medium confidence (>50%) in the Coast Ranges of Northern and Central California valid 00 UTC 11 March
- West-WRF's forecast is showing moderate confidence (>50%) in 24-hour accumulated precipitation > 5 inches for high elevations in the Sierra Nevada and Coast Ranges in Monterrey and San Luis Obispo Counties during the same period.
- West-WRF's meteogram for Oroville, CA illustrates a 70% probability of 24-hour accumulated precipitation > 1 inch during this AR, with a 30% chance of > 2 inches for the 24-hour period ending at 00 UTC 11 March

# CW3E AR Outlook: 6 March 2023

## WPC Quantitative Precipitation Forecasts and Excessive Rainfall Outlook

Risk of rainfall exceeding flash flood guidance within 25 miles of a point  
**MDT: At Least 40%** **MRGL: At Least 5%**  
**SLGT: At Least 15%**

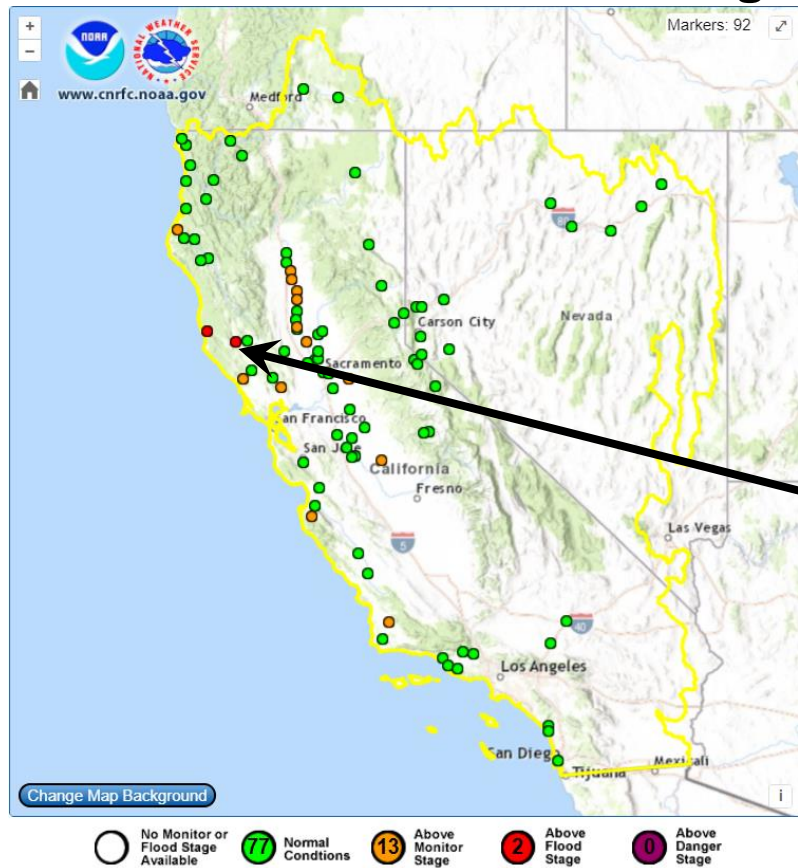


- NWS WPC is forecasting 48-hour precipitation totals > 3 inches over the Coast Ranges of Northern and Central California and > 5 inches over the Sierra Nevada, with the highest precipitation totals in the Southern Sierra Nevada during this AR
- Additionally, experimental excessive rainfall outlooks have been issued for the period including Thursday, Friday, and Saturday with marginal risk (At Least 5%) over Northern and Central California and a broad area of slight risk (At Least 15%) of exceeding flash flood guidance along the Coast Ranges of Southern and Central California and the Sierra Nevada

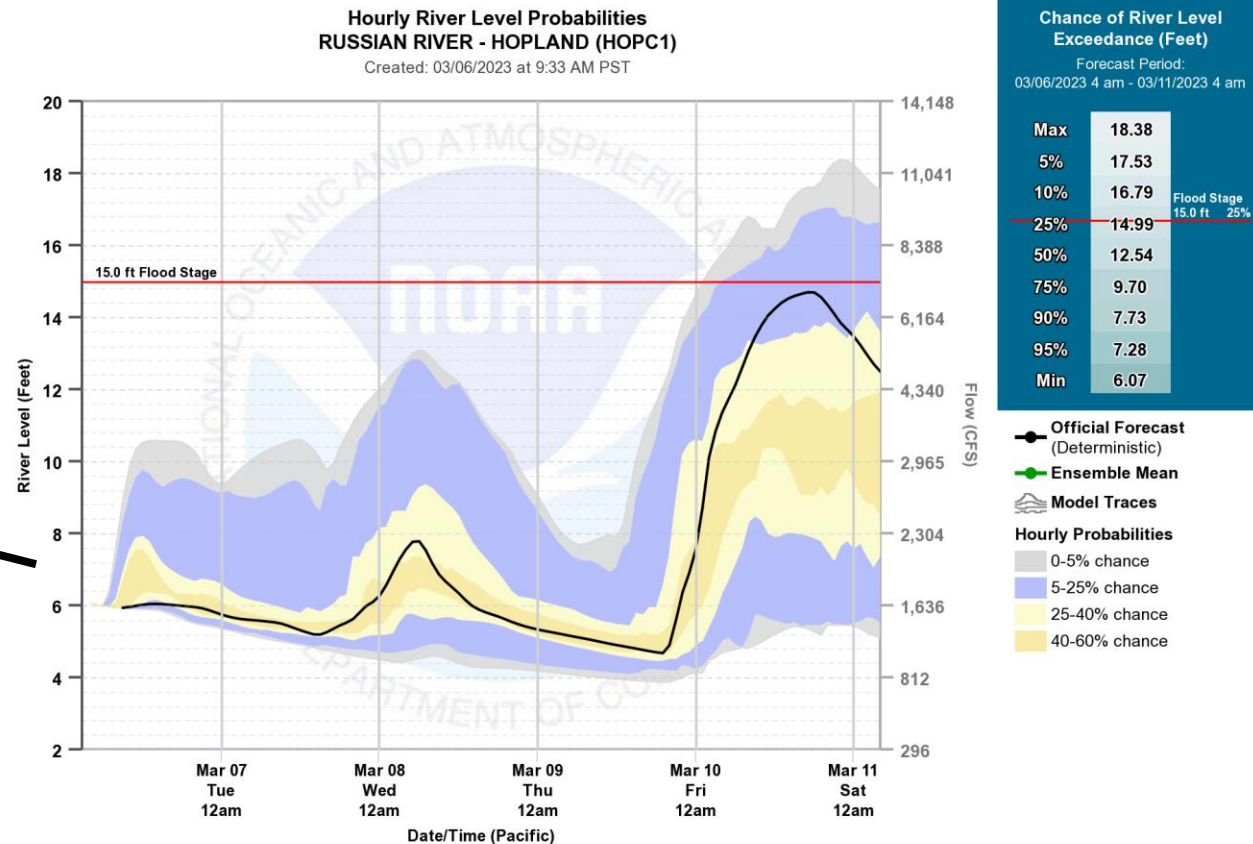


# CW3E AR Outlook: 6 March 2023

## NOAA/NWS CNRFC River Stage Forecast



Issuance Time: 06 Mar 9:33 AM PST

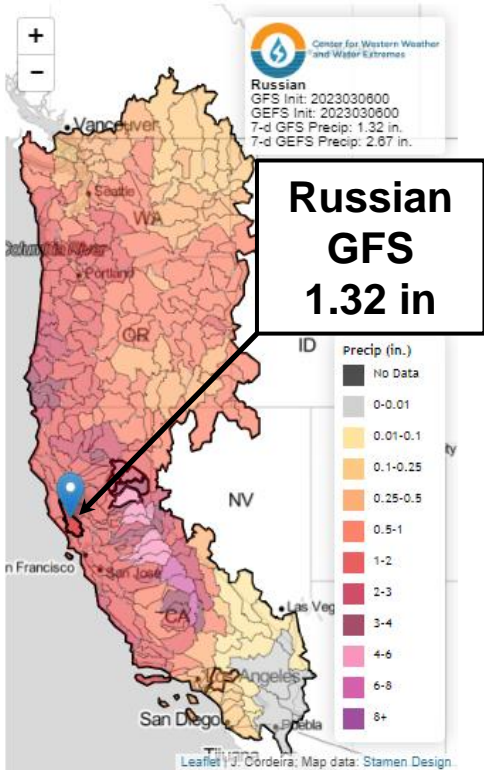


- Using ensemble-based forecasts valid 06 Mar 2023 at 9:53 AM PST and a 10% peak exceedance probability over the next 5 days, the CNRFC is showing 2 locations above flood stage and 13 above monitor stage
- There is a 25% chance for the Russian River at Hopland to exceed above flood stage (15 ft) on 10 March, local time, due to heavy rainfall and high snow levels with this AR. The official deterministic forecast has a peak stage of 14.69 feet.
- Uncertainty in the forecast river levels remains high at most sites in Northern and Central California

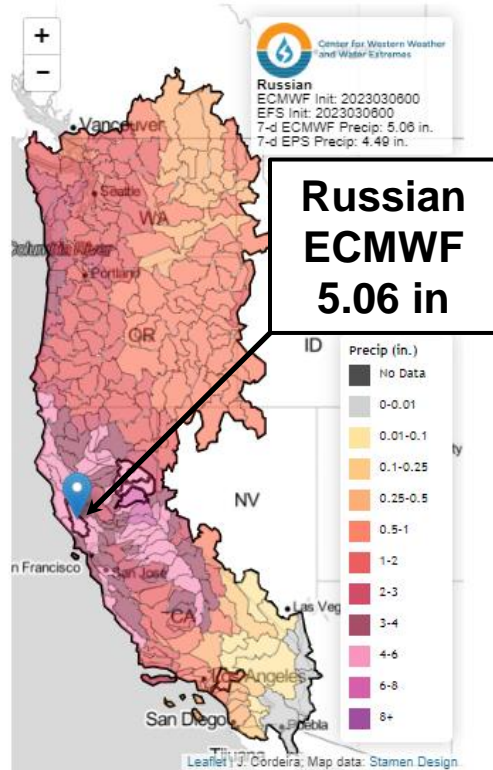
# CW3E AR Outlook: 6 March 2023

## 7-day Watershed Precipitation Forecasts (Initialized 4 PM PT 5 Mar)

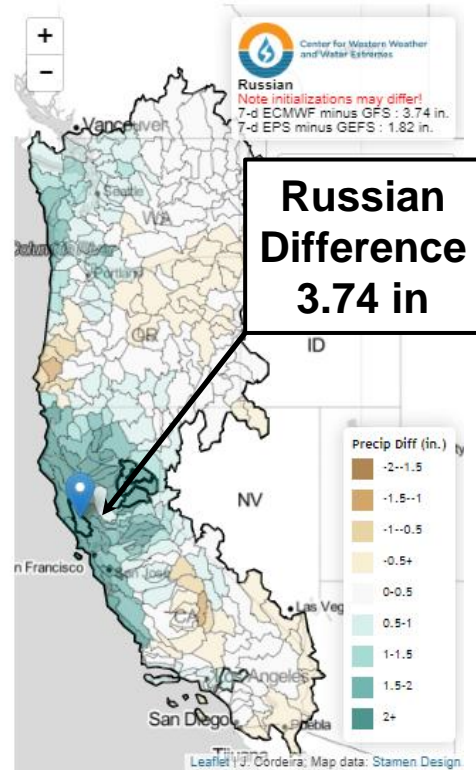
### GFS



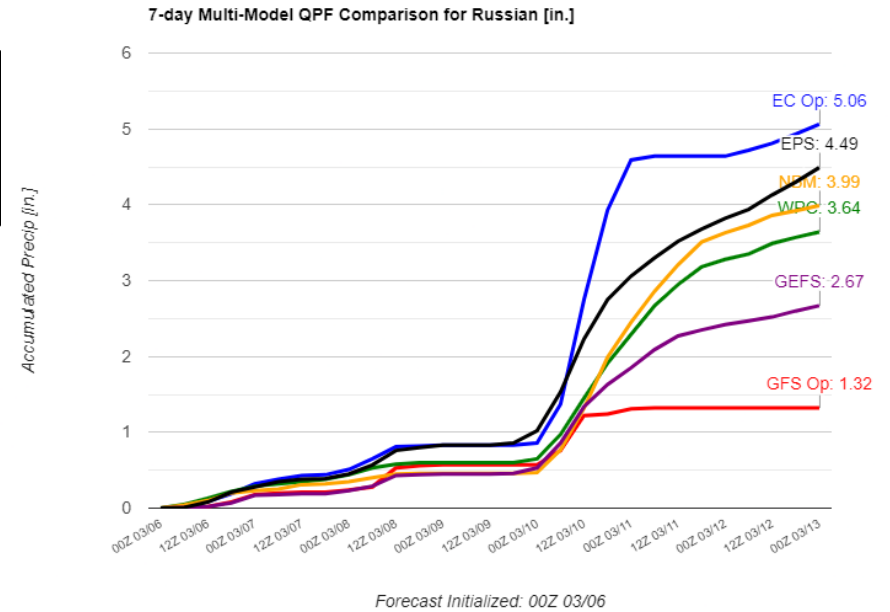
### ECMWF



### ECMWF minus GFS



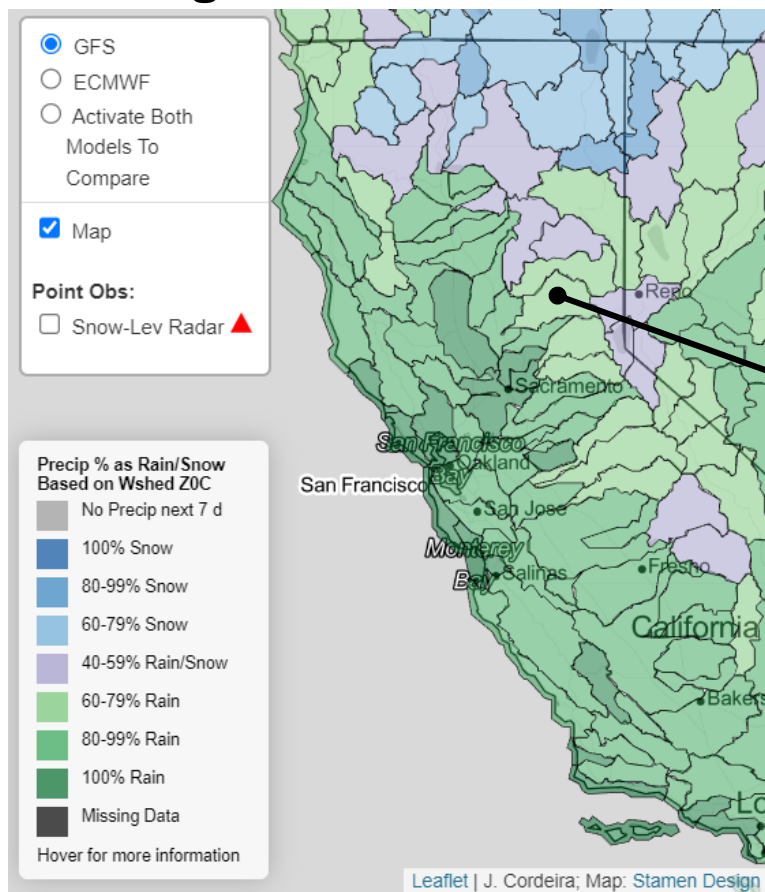
## Multi-Model Precipitation Comparison for Russian



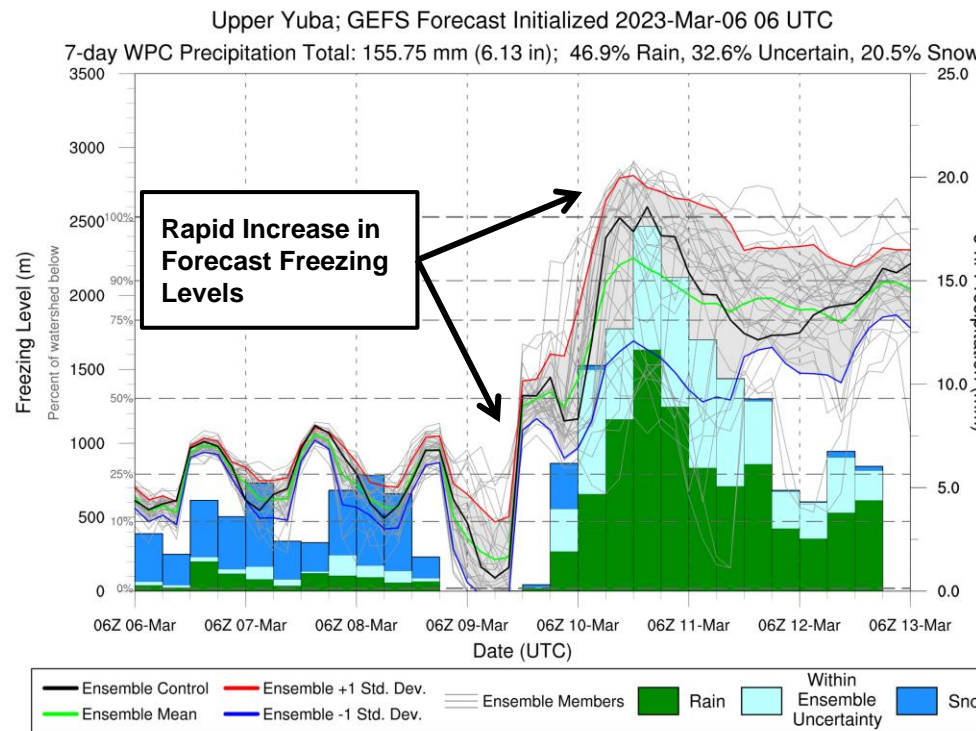
- The 00Z GFS is forecasting lower 7-day watershed precipitation totals throughout coastal Central and Northern California and the Central and Northern Sierra Nevada than the 00Z ECMWF but more in the Southern Sierra
- The 00Z GFS is forecasting 1.32 inches of mean areal precipitation in the Russian Watershed over the next 7 days, while the 00Z ECMWF is forecasting 5.06 inches over the same watershed



## Freezing Level Forecast



Upper Yuba Watershed

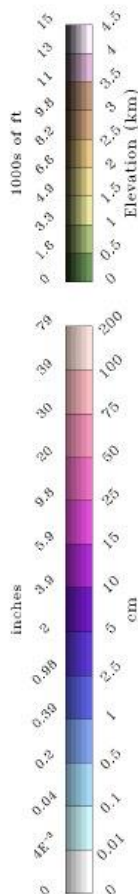
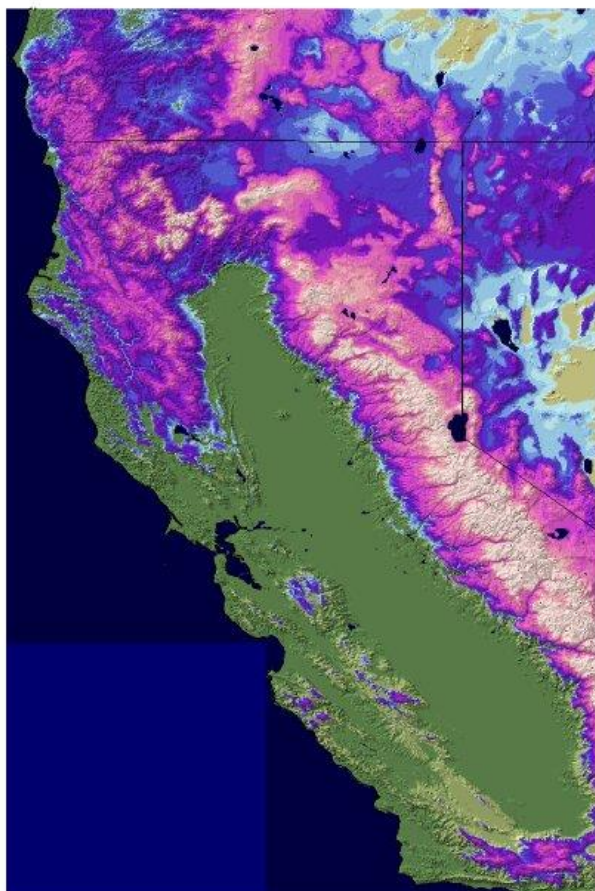


- The 06Z GEFS ensemble is forecasting freezing levels to rise rapidly ahead of the AR to near 6,000 feet for much of Northern California and the Sierra Nevada Mountains
- Uncertainty in the forecast remains high with freezing levels possibly reaching 10,000 feet in some Sierra Nevada watersheds
- Freezing levels are expected to remain high for the duration of the storm

## Snowpack Conditions

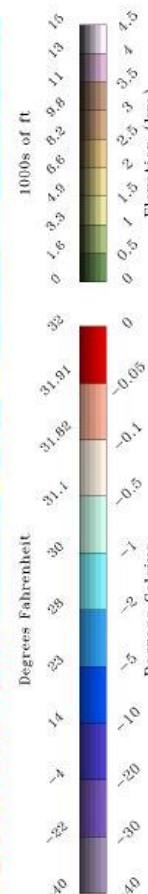
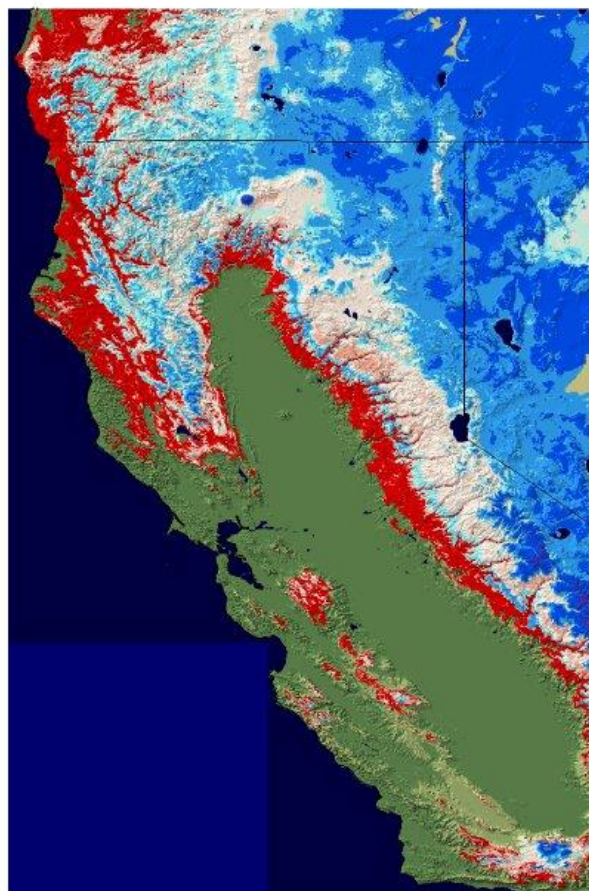
Snow Water Equivalent

2023-03-06 06 UTC



Average Snowpack Temperature

24-Hour Average Ending 2023-03-06 06 UTC



- Recent cold storms have produced significant snowfall accumulations at lower elevations in the Sierra Nevada and Northern California Coast Ranges
- Estimated snowpack temperature in these locations is very marginal (near 0°C) and thus prime for melting
- The combination of high freezing levels, heavy precipitation, and existing snowpack conditions will likely result in a substantial amount of rain-on-snow, thereby increasing runoff and the potential for flooding