

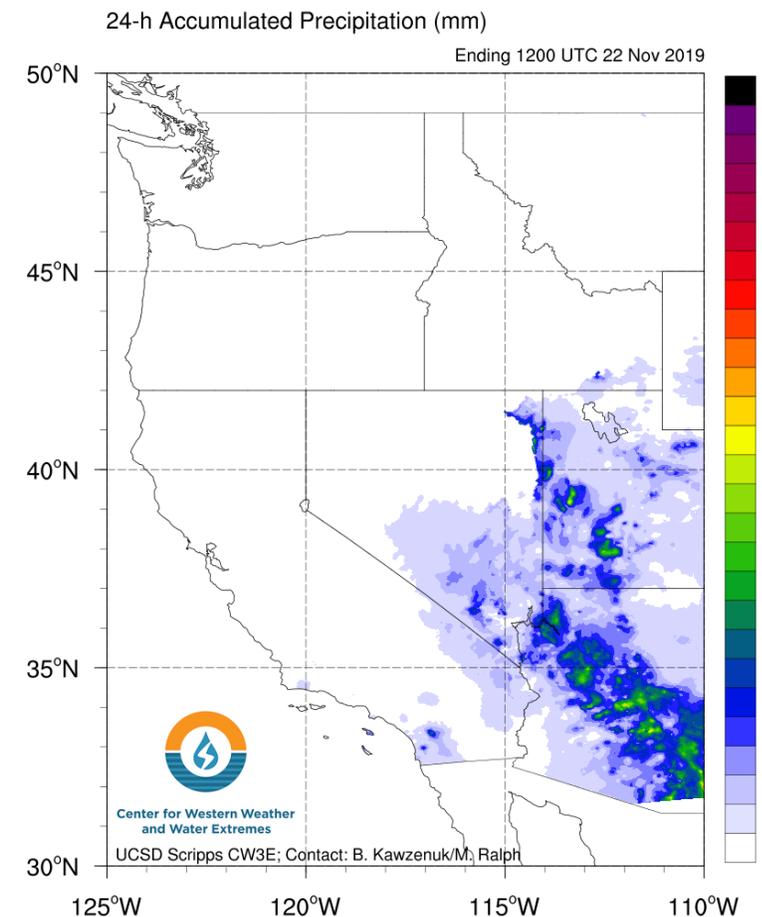
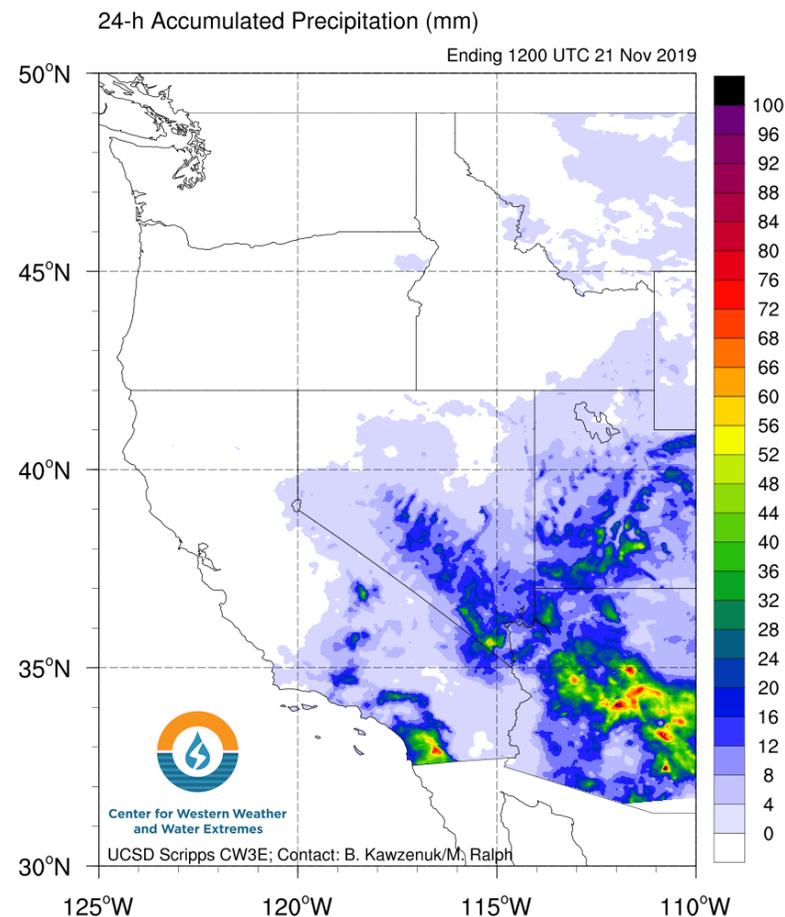
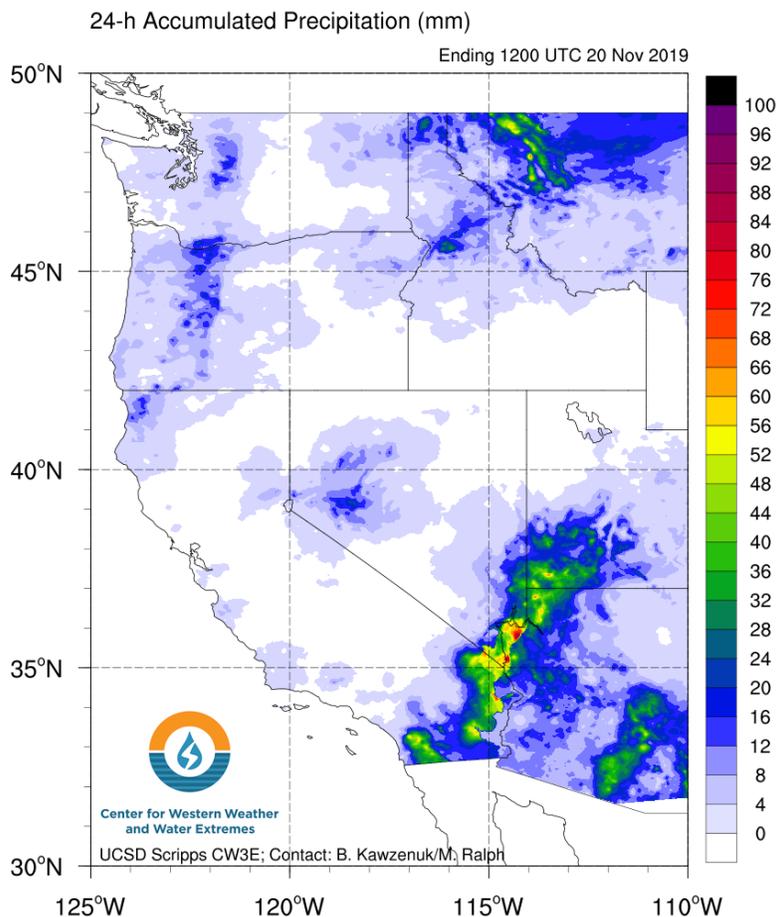
# CW3E Post Event Summary: 19–22 Nov 2019



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AT UC SAN DIEGO

## Cutoff low and subsequent storm bring heavy rainfall and mountain snow to the southwestern US

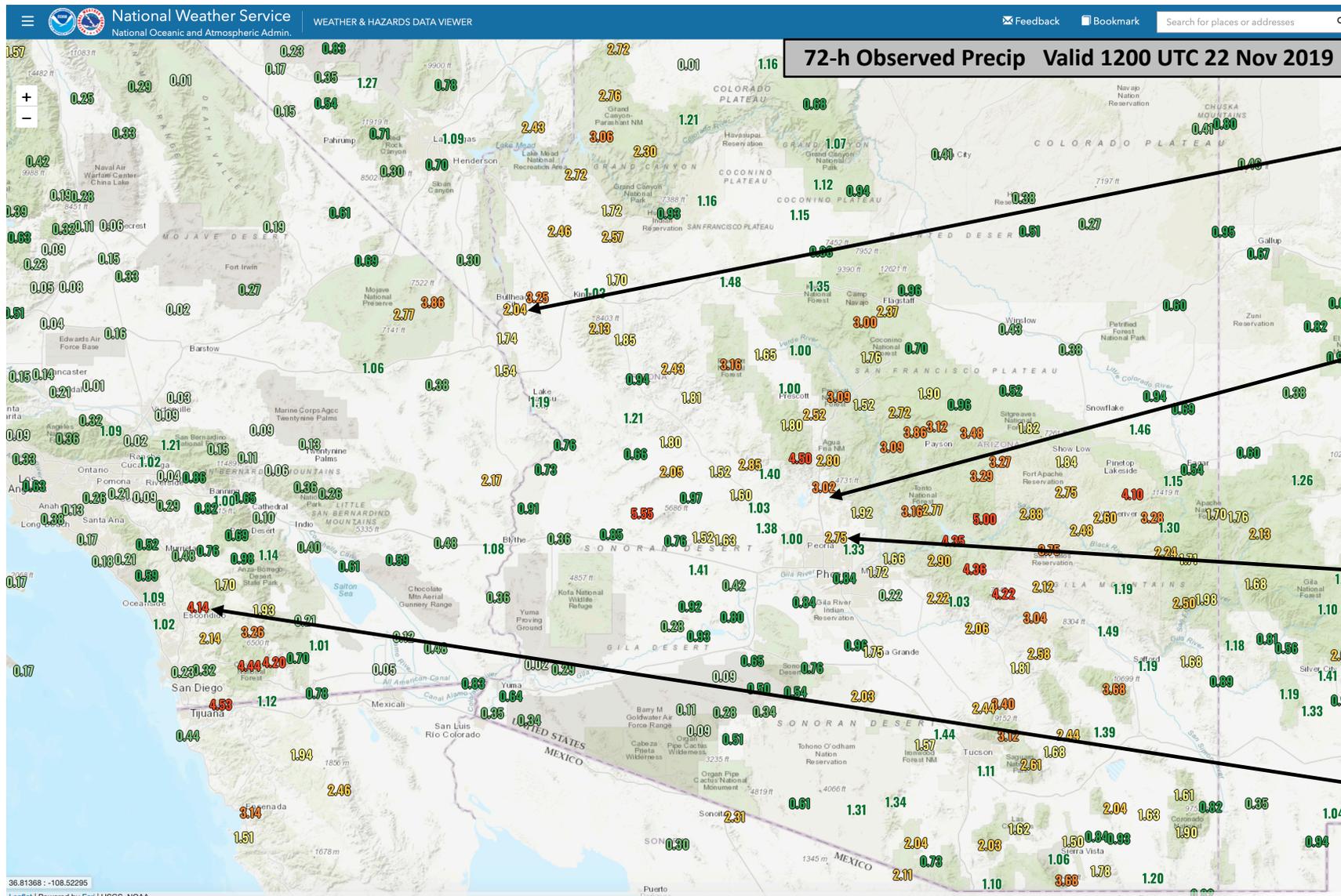
- This was the first major precipitation event of WY2020 for much of the southwestern US
- NWS Stage IV data indicates that 1-3 inches of precipitation fell over portions of AZ, southern CA, extreme southern NV, and southwestern UT, with as much as 3-5 inches in the higher elevations of San Diego County and central and eastern AZ
- Precipitation was associated with a cutoff low west of Baja California and a shortwave that propagated southward along the California coast



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**Bullhead City, Laughlin/Bullhead International Airport, AZ**  
 Year-to-Date Precip: 3.55 inches  
 72-h Precip: 2.04 inches (57% of YTD)

**New River near Rock Springs 6SE, AZ**  
 Year-to-Date Precip: 15.24 inches  
 72-h Precip: 4.44 inches (29% of YTD)

**Phoenix, Phoenix-Deer Valley Municipal Airport, AZ**  
 Year-to-Date Precip: 7.38 inches  
 72-h Precip: 2.75 inches (37% of YTD)

**Valley Center, CA**  
 Year-to-Date Precip: 20.24 inches  
 72-h Precip: 4.14 inches (20% of YTD)

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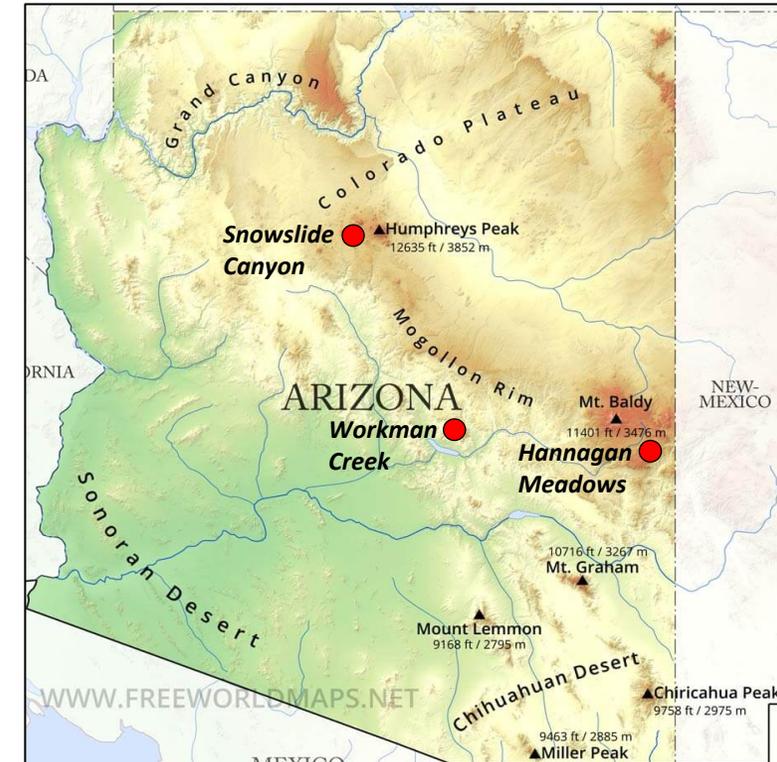
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- 4-day (valid 18–22 Nov) QPF and observed precipitation were very similar for select stations above 6,000 ft in Arizona
- Workman Creek and Hannagan Meadows received about 25% of the average total cool-season (Nov–Apr) precipitation during this event
- Despite reporting only a 9-inch increase in snow depth, Snowslide Canyon recorded an SWE increase of 2.7 inches

Station Name	Elevation	Forecast (Observed) Precipitation	Forecast (Observed) Precipitation % of Nov–Apr Average	Forecast (Observed) Snow Depth
Snowslide Canyon	9800 ft	2-3 in (2.7 in)	<b>10-15% (12%)</b> of 22 in	18-24 in (13 in)
Workman Creek	6900 ft	4-5 in (5.7 in)	<b>20-25% (25%)</b> of 23 in	2 in (2 in)
Hannagan Meadows	9000 ft	3-4 in (3.9 in)	<b>20-25% (24%)</b> of 16 in	10-15 in (12 in)

\*Precipitation and snow depth observations based on SNOTEL data

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



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- Storm totals exceeded and were in some cases more than double normal November precipitation at several Southwest locations
  - For the selected locations below, storm total precipitation was 10–19% of normal annual precipitation
- \* This storm not only ended a record 155-day dry streak, but also set a new daily precipitation record (1.29 inches on 20 Nov) for the month of November at St. George, UT

Station	Nov 19-22 Total Precip	Event Percent of Normal November Precip	Percent of Normal Annual Precip
Tucson AP, AZ	1.33 in	230%	11%
Phoenix AP, AZ	0.84 in	204%	10%
Flagstaff AP, AZ	2.37 in	135%	11%
St. George, UT*	1.71 in	241%	19%
Las Vegas AP, NV	0.70 in	194%	17%
Palomar Mtn, CA	3.08 in	124%	10%



Source: Applied Climate Information System, <http://scacis.rcc-acis.org/>

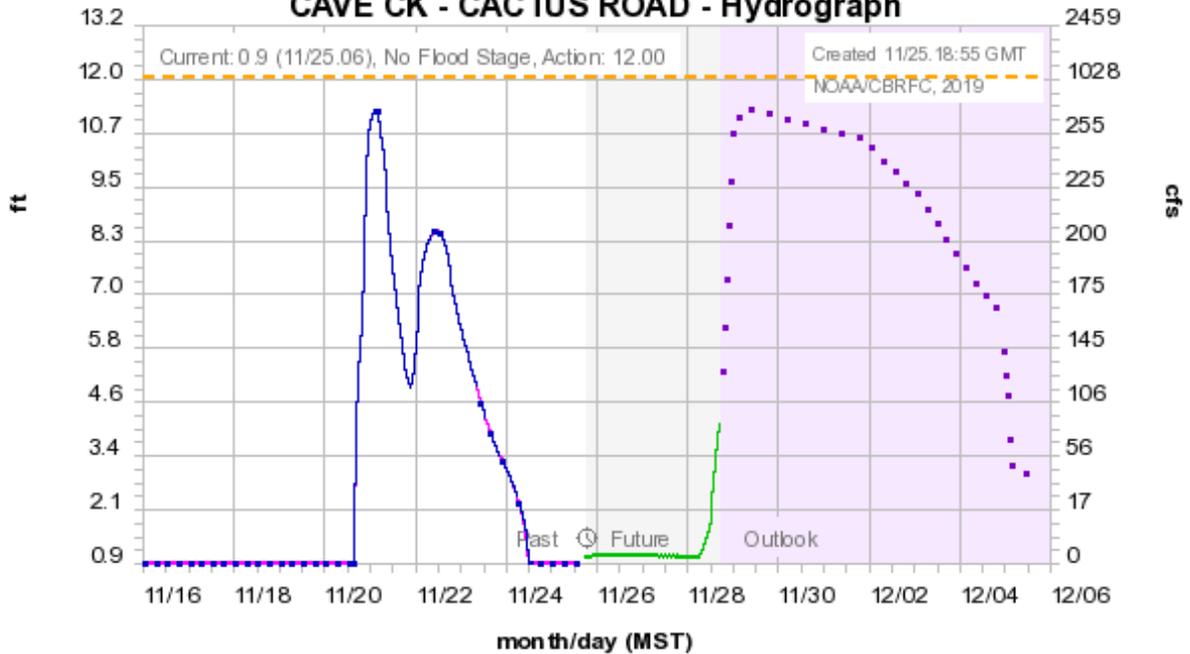
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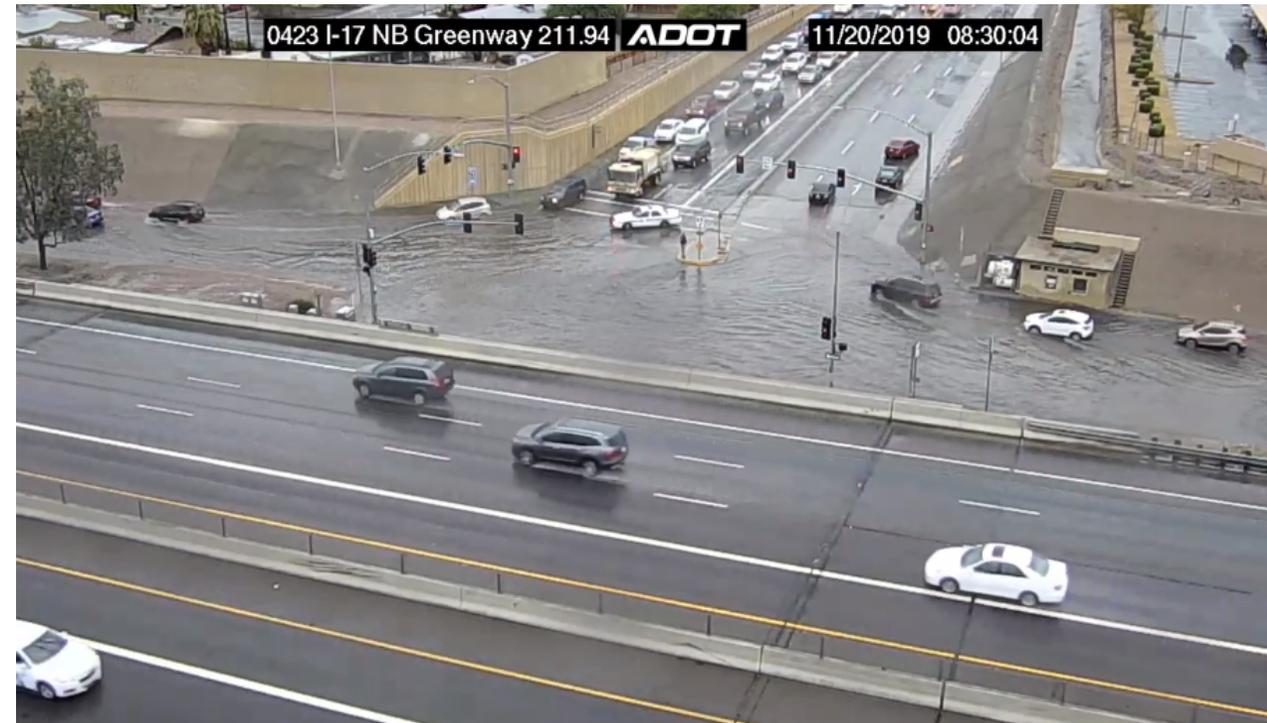
- NWS Phoenix received numerous reports of flash flooding and small hail in Maricopa County
- Heavy rainfall in northern Maricopa County on 20 Nov resulted in a gage height increase of more than 11 ft at Cave Creek/Cactus Road (near I-17)

Colorado Basin River Forecast Center  
 CAVE CK - CACTUS ROAD - Hydrograph



Simulated — Observed — Forecast (11/25.15:00) — Outlook (increasing uncertainty) — Action 12.00 —  
 Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10%

Source: NOAA/NWS CBRFC, <https://www.cbrfc.noaa.gov/>



Source: Arizona Department of Transportation

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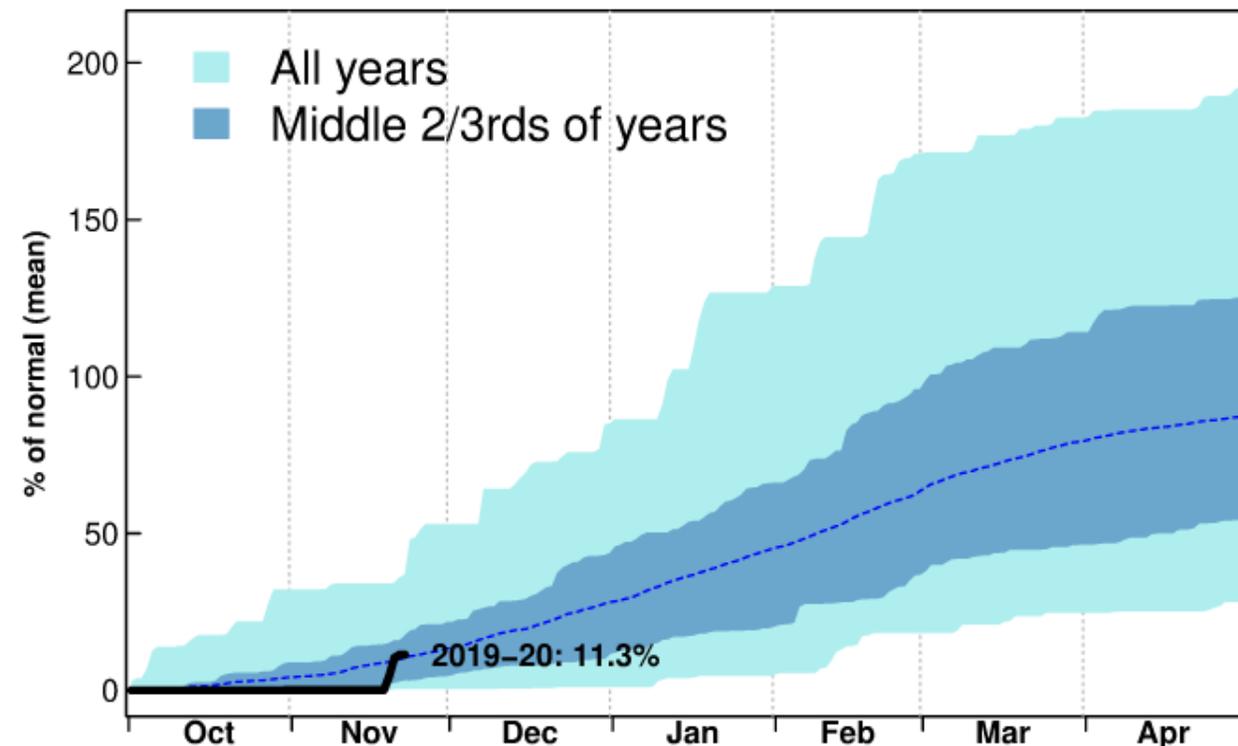


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- San Diego County received 11.3% of its normal total water year precipitation during this event
- Unfortunately, anomalously dry conditions persist across northern California
- The Northern Sierra Nevada region has received less than 1% of its normal total water year precipitation

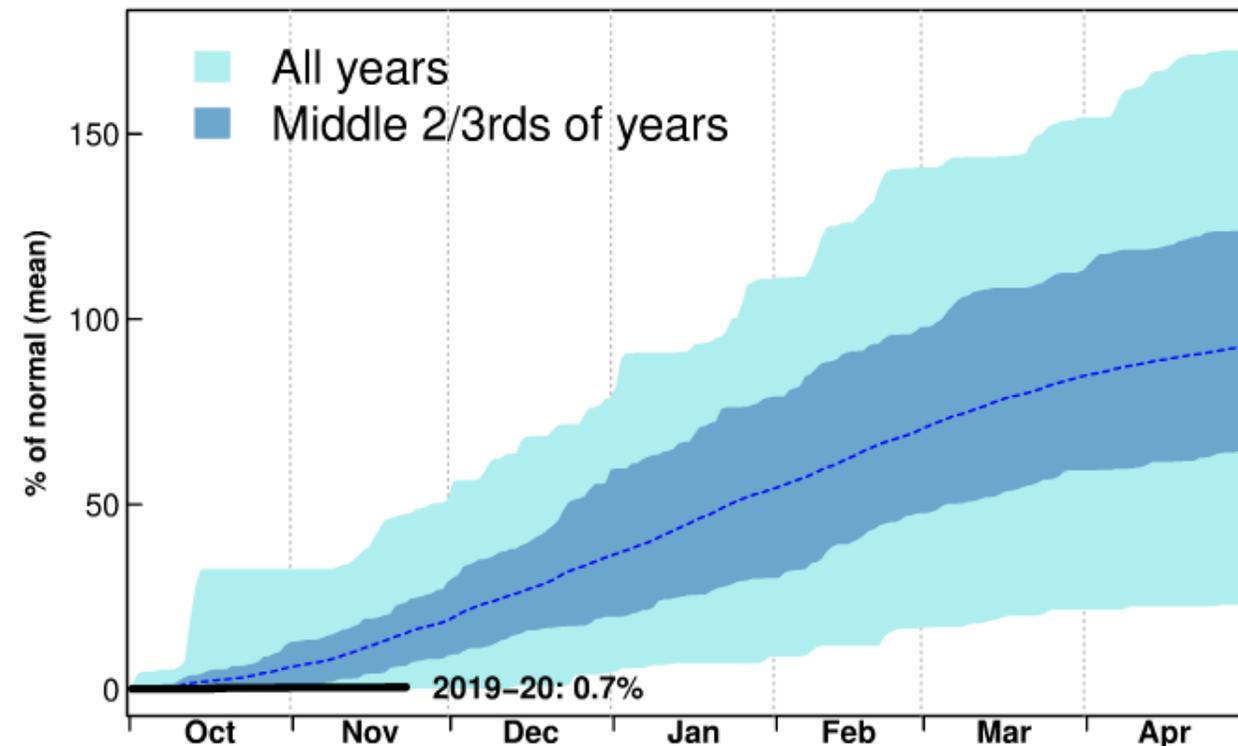
## San Diego County

SD\_county precip for all years, data through 2019/11/22



## Northern Sierra Nevada

8\_sta\_index precip for all years, data through 2019/11/22

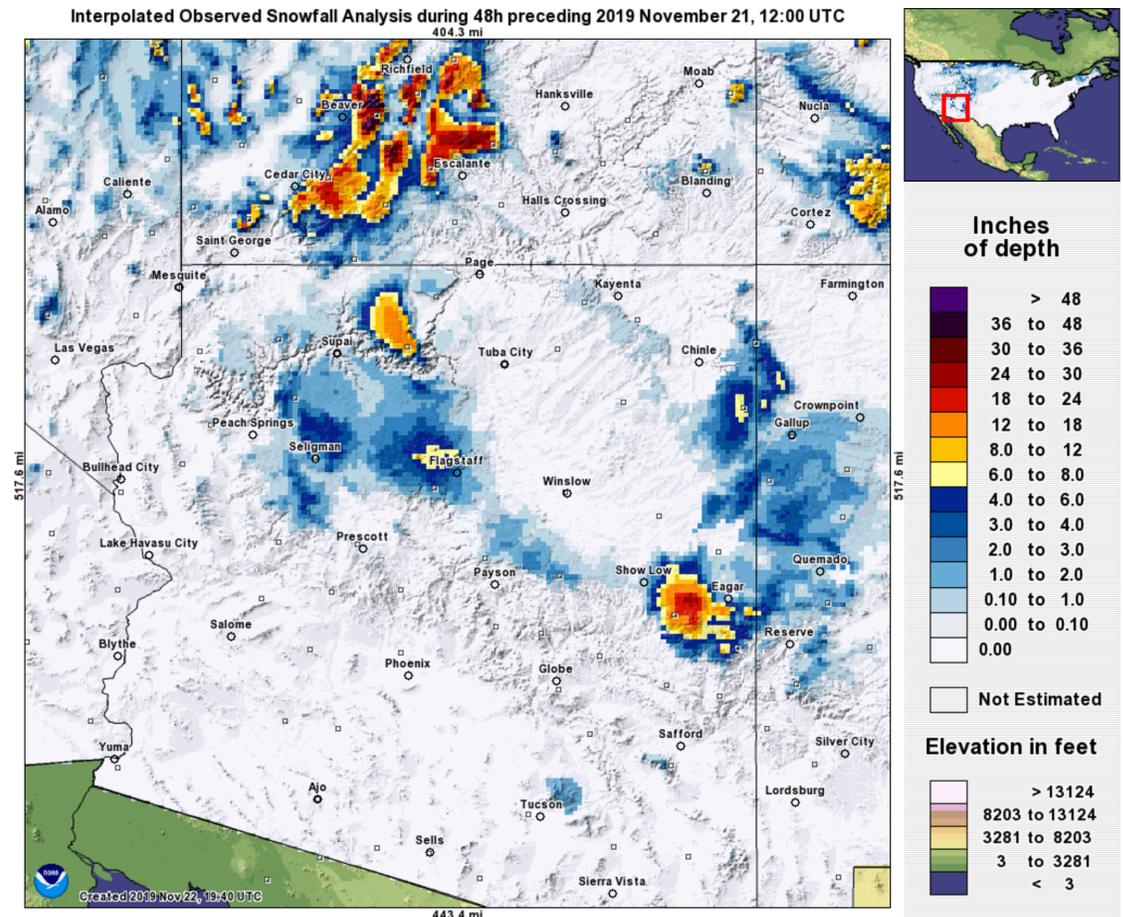
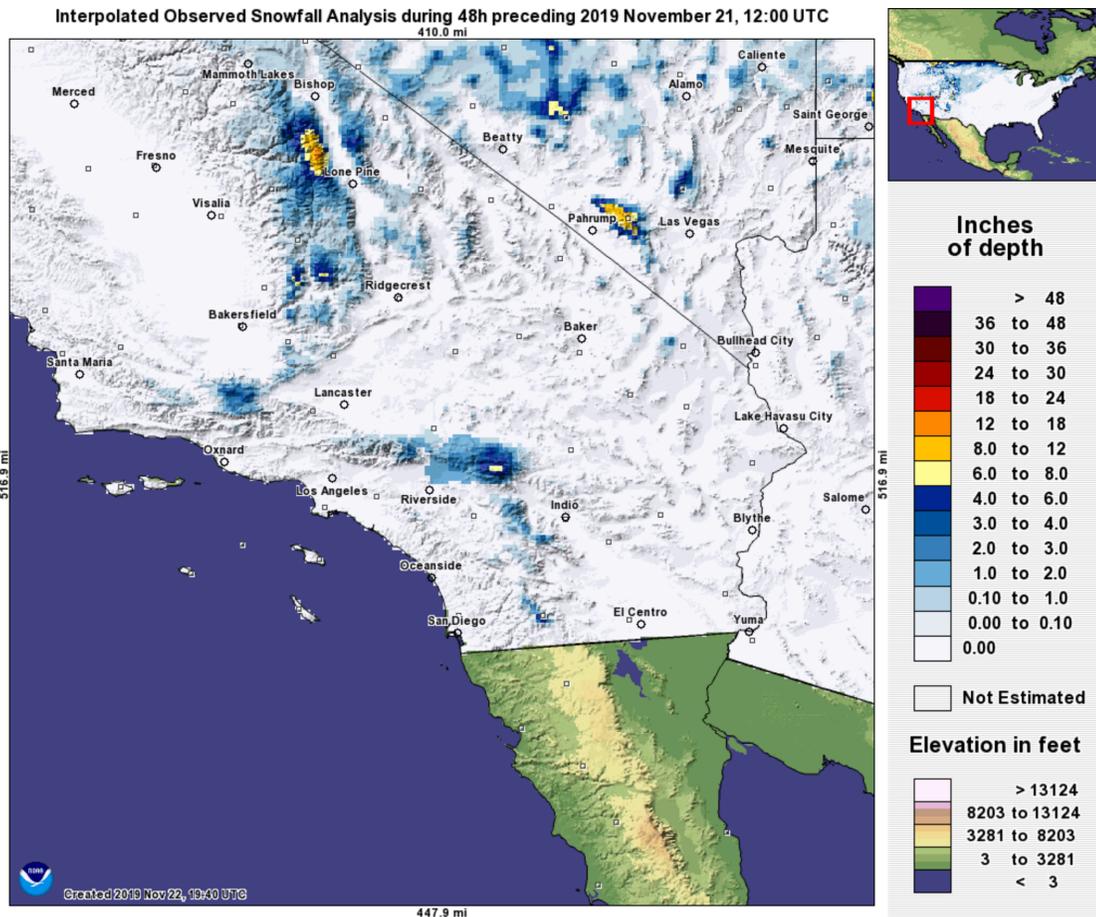


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- An estimated 1–2' of snowfall fell during the 48-hour period ending 1200 UTC 21 Nov over elevated portions of Arizona and Utah
- Lesser amounts (generally < 12") fell over the Sierra Nevada and southern California ranges
- As the event progressed, snow elevations eventually dropped below 6,000 feet in San Diego and Riverside Counties



Source: NOAA/NWS National Operational Hydrologic Remote Sensing Center , <https://www.nohrsc.noaa.gov>

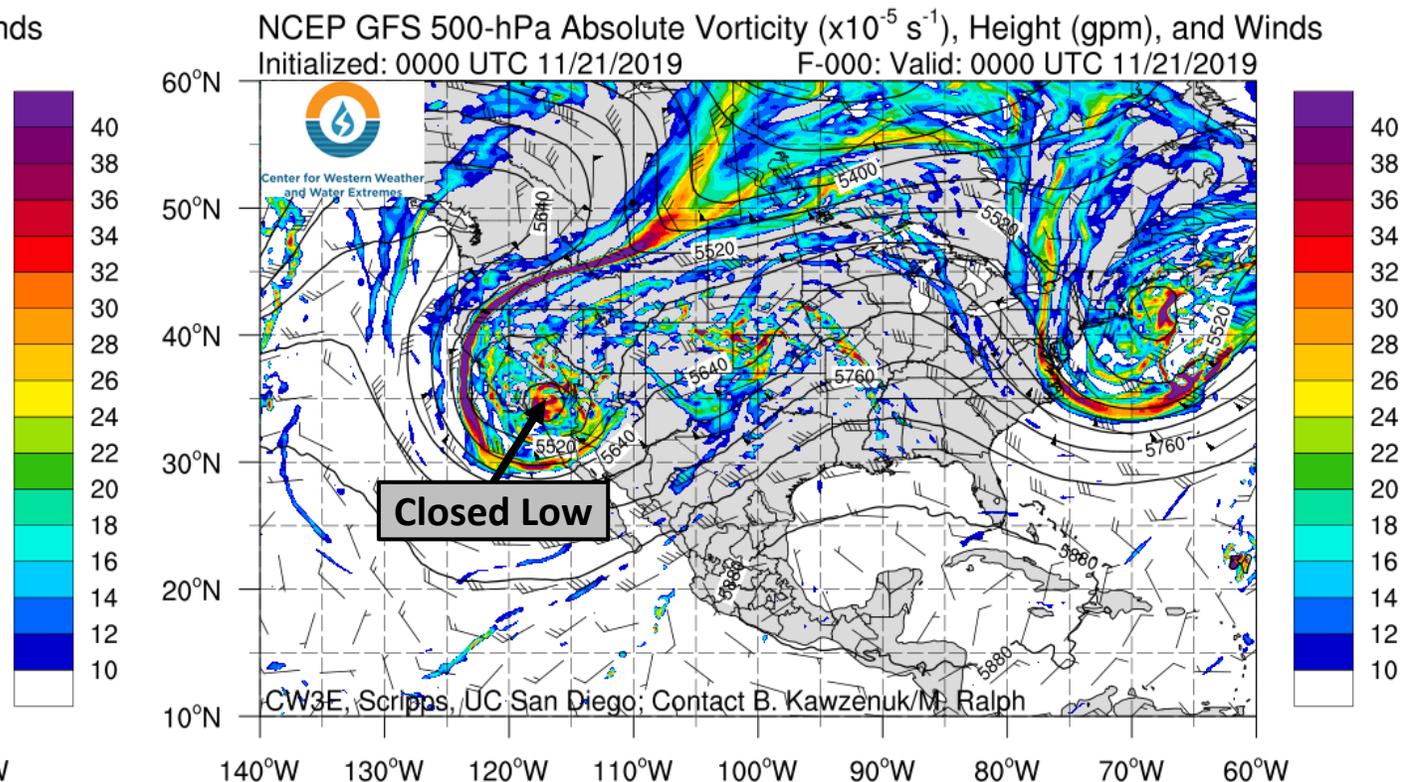
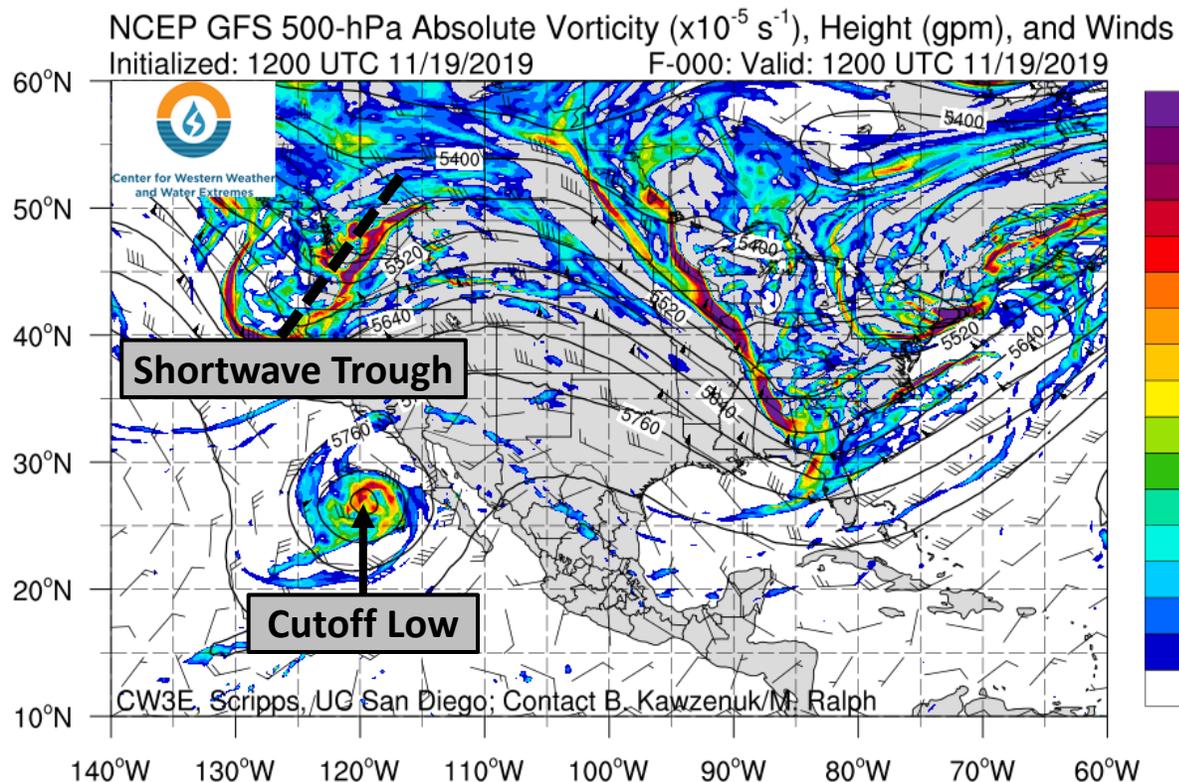
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- Heavy rainfall in the Lower Colorado River Basin on 19 Nov was associated with a cutoff low west of Baja California
- Over the next 24-48 hours, the cutoff low dissipated and a potent shortwave trough moved southward along the California Coast, eventually forming a closed low over the southwestern U.S.
- Precipitation associated with the shortwave/closed low on 20 and 21 Nov fell in the form of scattered rain/snow bands



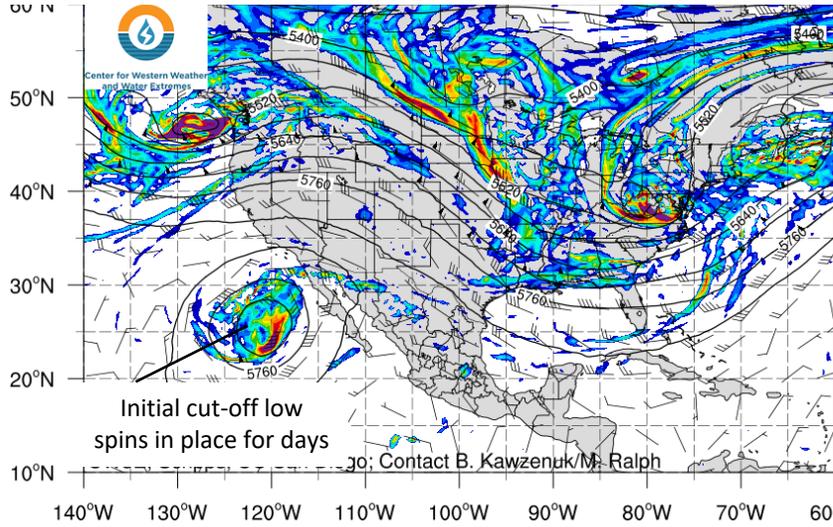
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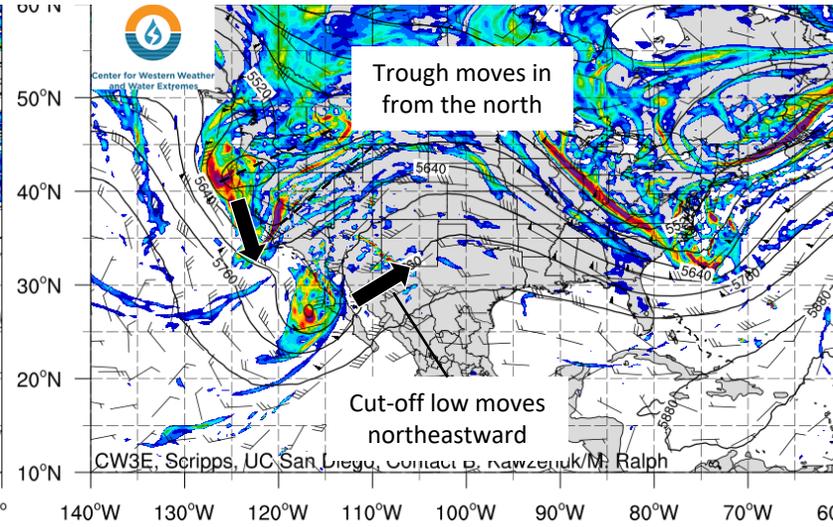
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NCEP GFS Analysis 500-hPa Geo. Heights (gpm) and Vorticity ( $s^{-1}$ )

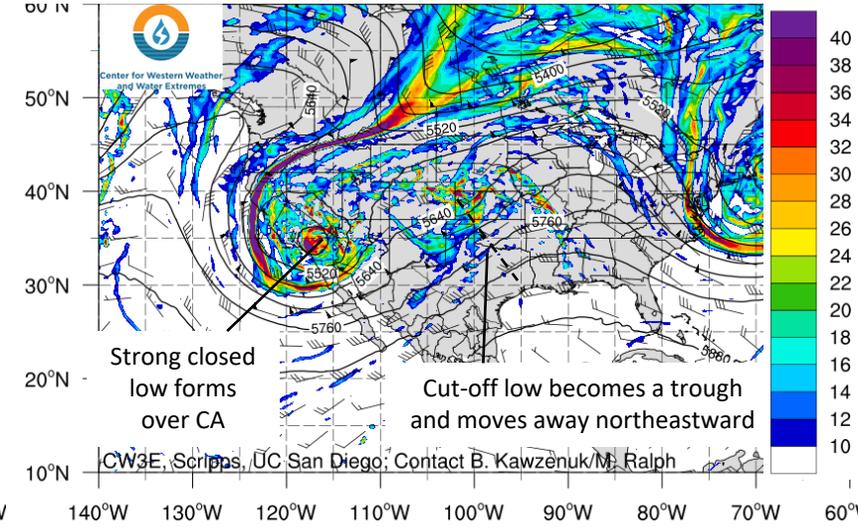
Valid: 00 UTC 19 Nov. 19



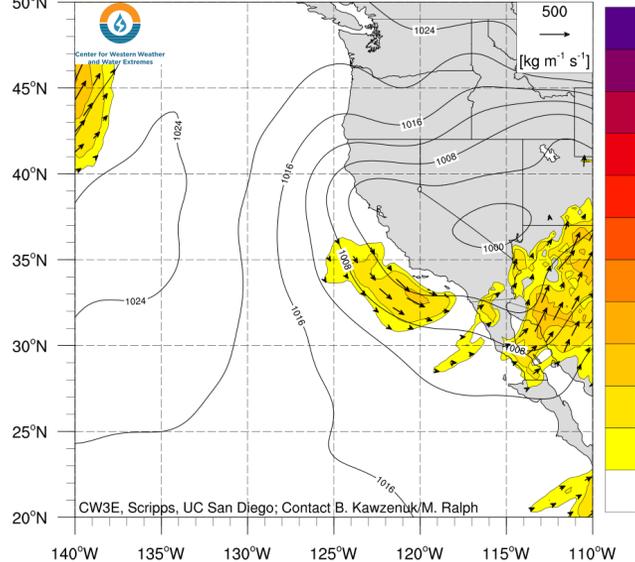
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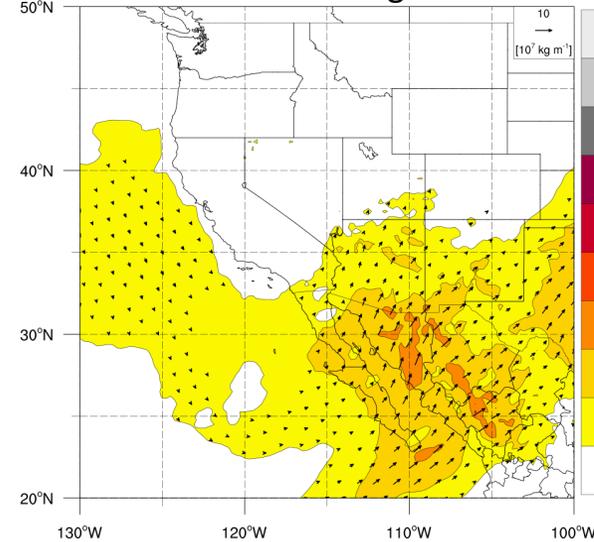
Valid: 00 UTC 21 Nov. 19



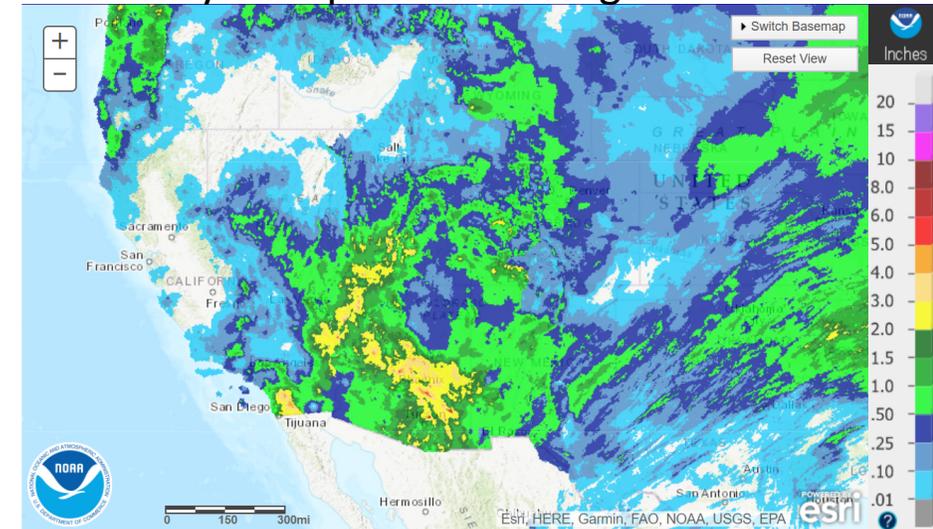
NCEP GFS IVT ( $kg\ m^{-1}\ s^{-1}$ ; shaded), IVT Vector, and SLP (hPa; contours)



72-hour TIVT Valid Ending: 18 UTC 21 Nov.



7-Day Precipitation ending 12Z 22 Nov.



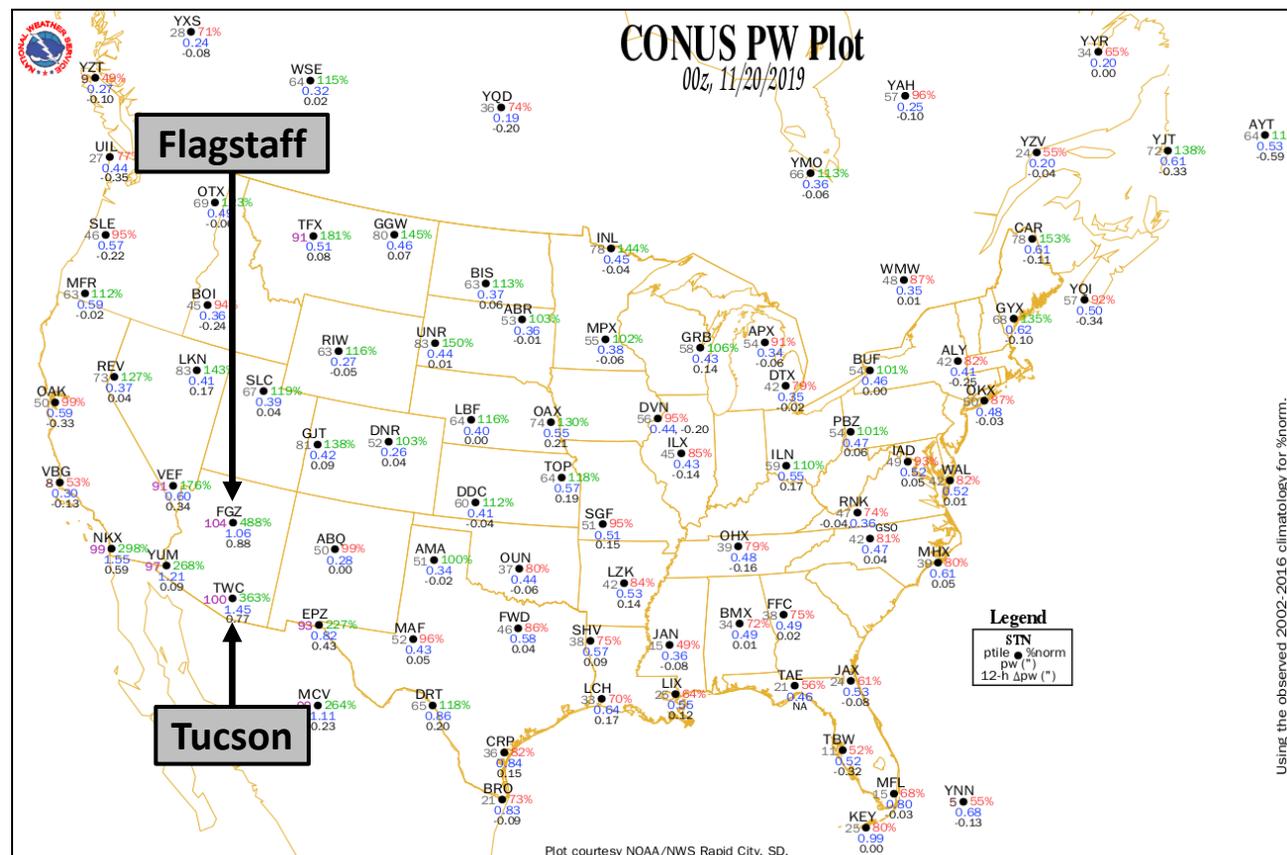
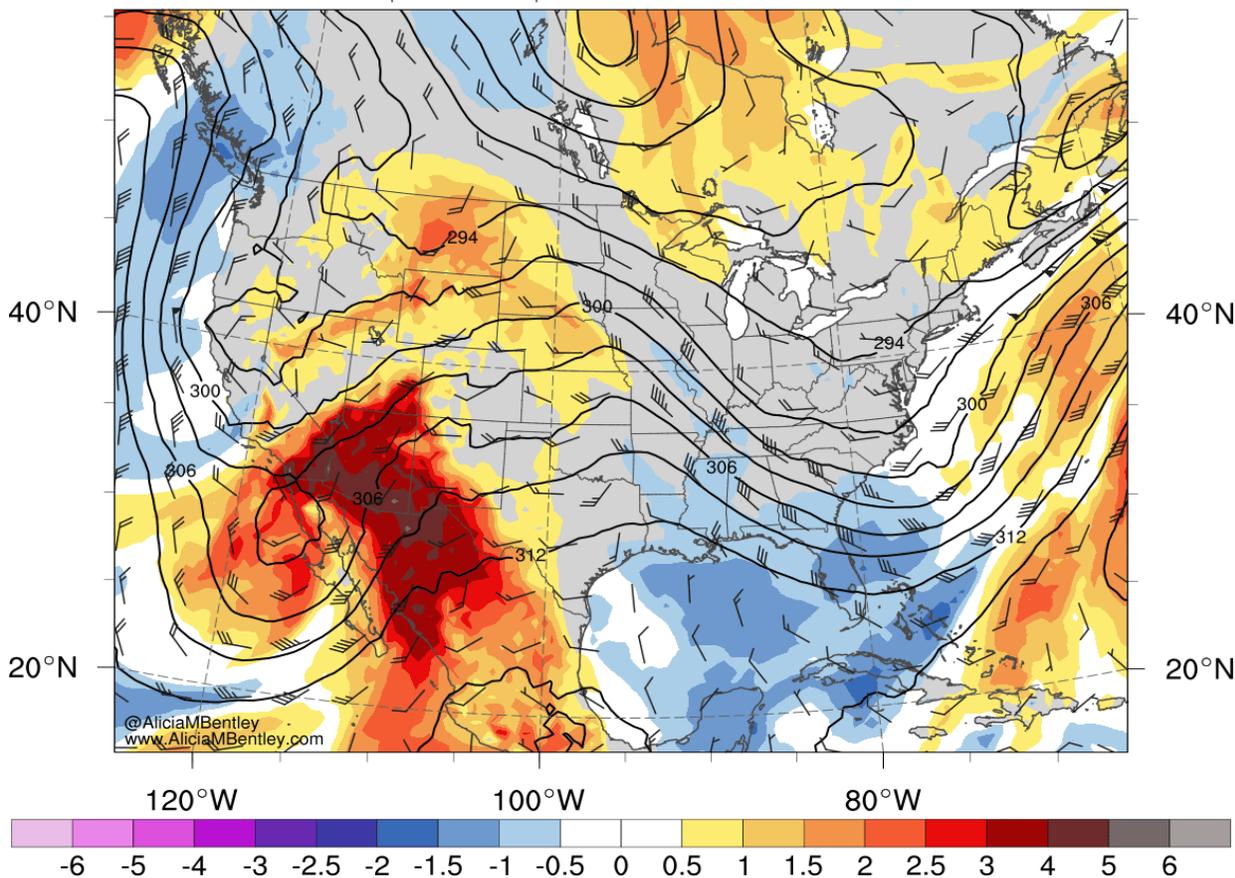
# CW3E Post Event Summary: 19–22 Nov 2019



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- The first episode of heavy rainfall was associated with an anomalously moist air mass over the southern California and Arizona
- At 0000 UTC 20 Nov, standardized precipitable water (PW) anomalies were approaching  $+5 \sigma$
- Radiosonde data from Flagstaff (FGZ) and Tucson (TWC) indicated PW values  $> 300\%$  of normal

700-hPa geo. height (black, dam), wind (barbs, kt), standardized precip. water anomaly (shaded, sigma)  
 Initialized: 0000 UTC 20 Nov 2019 | Forecast hour: 0 | Valid: 0000 UTC 20 Nov 2019



Source: NOAA/NWS Rapid City, SD, <https://www.weather.gov/unr/>

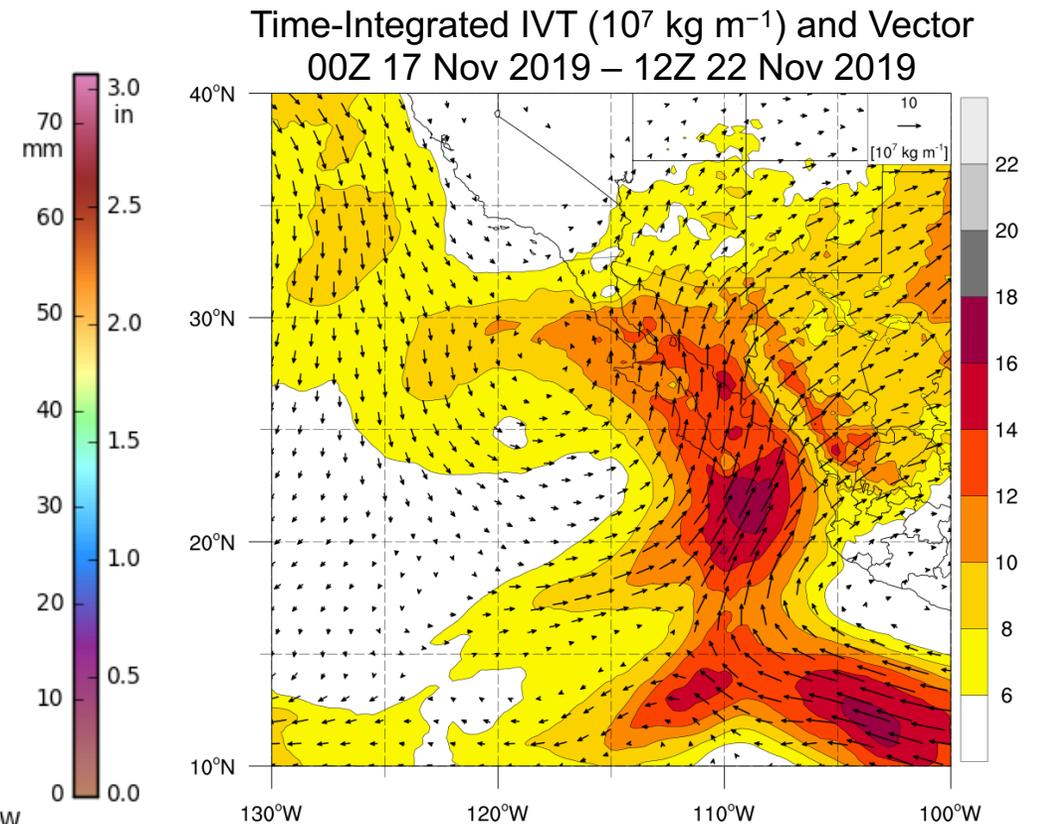
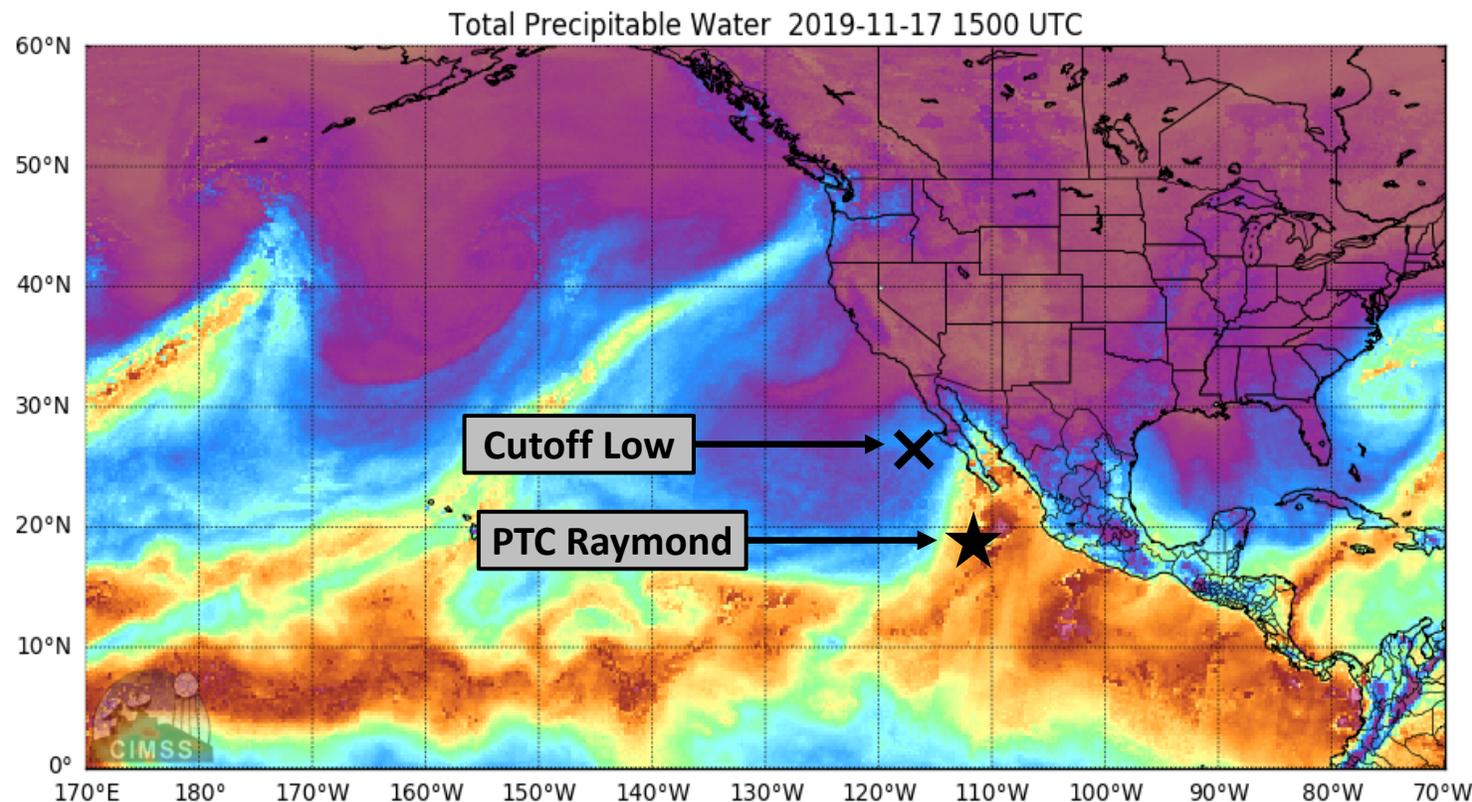
Source: Alicia Bentley, <http://www.atmos.albany.edu/student/abentley/index.html>

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- Satellite imagery indicates a strong tropical contribution for the anomalously moist air over the southwestern U.S.
- At 1500 UTC 17 Nov, post-tropical cyclone Raymond was located about 430 km SSW of Baja California
- During the next 48 hours, moisture from the remnants of TC Raymond was transported poleward by southerly flow on the east side of a cutoff low near Baja California
- The subsequent shortwave trough/closed low supported additional moisture transport during the remainder of the event

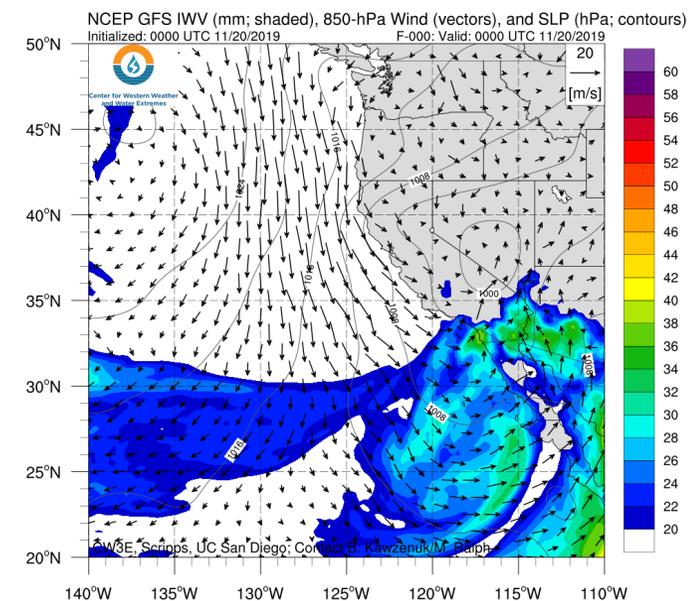
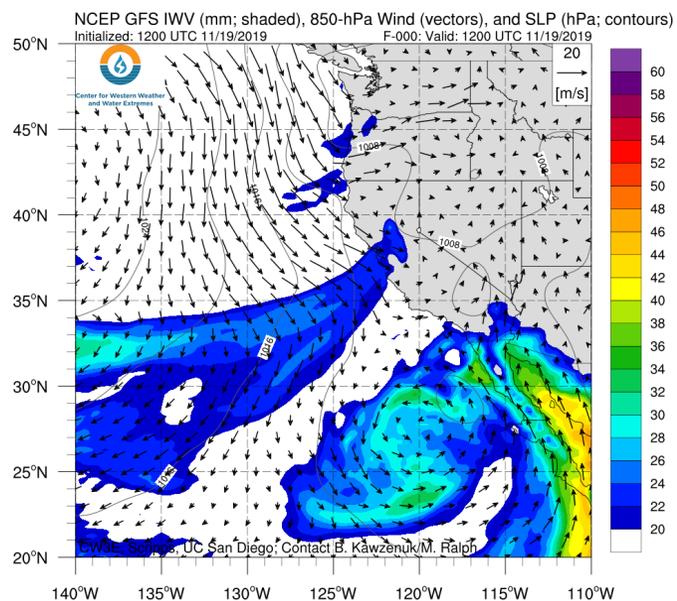
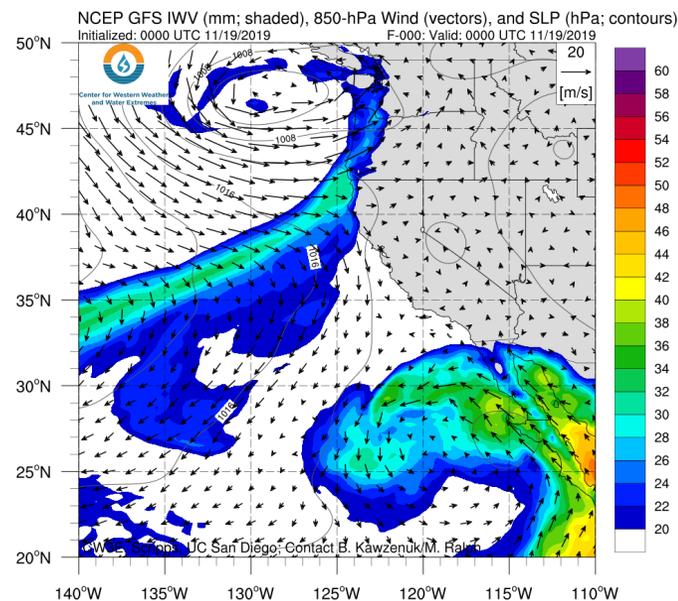
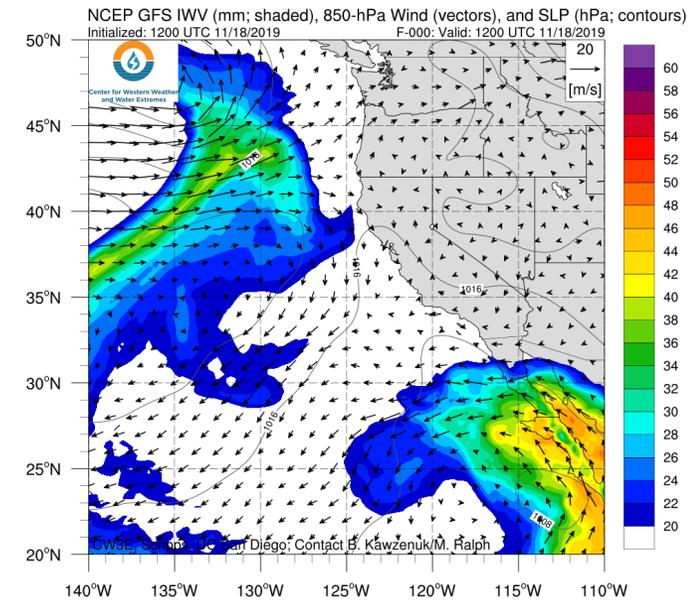
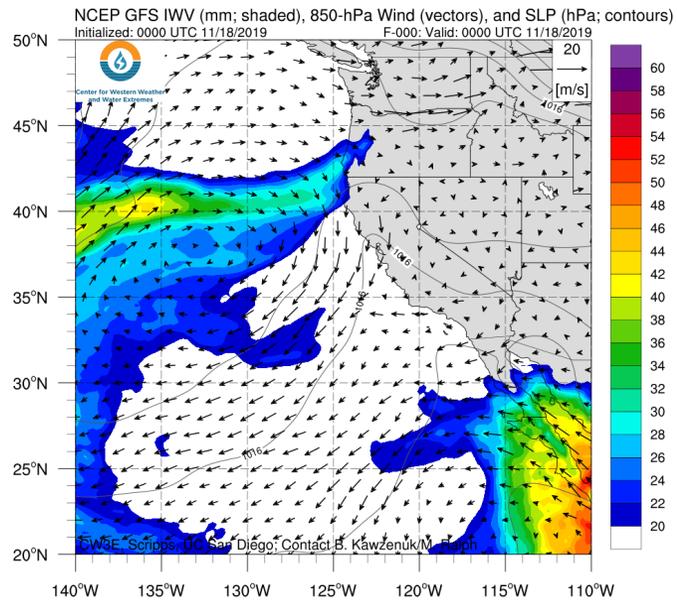
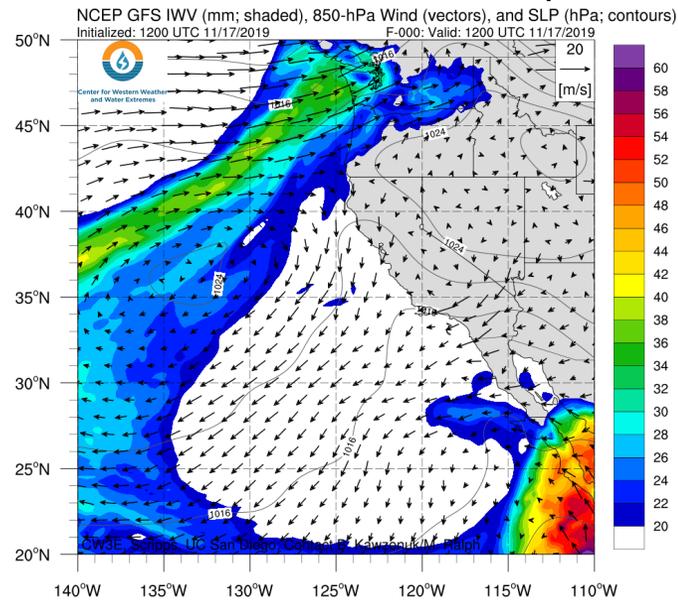


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## Tropical Moisture Export Contributed from Near Gulf of California

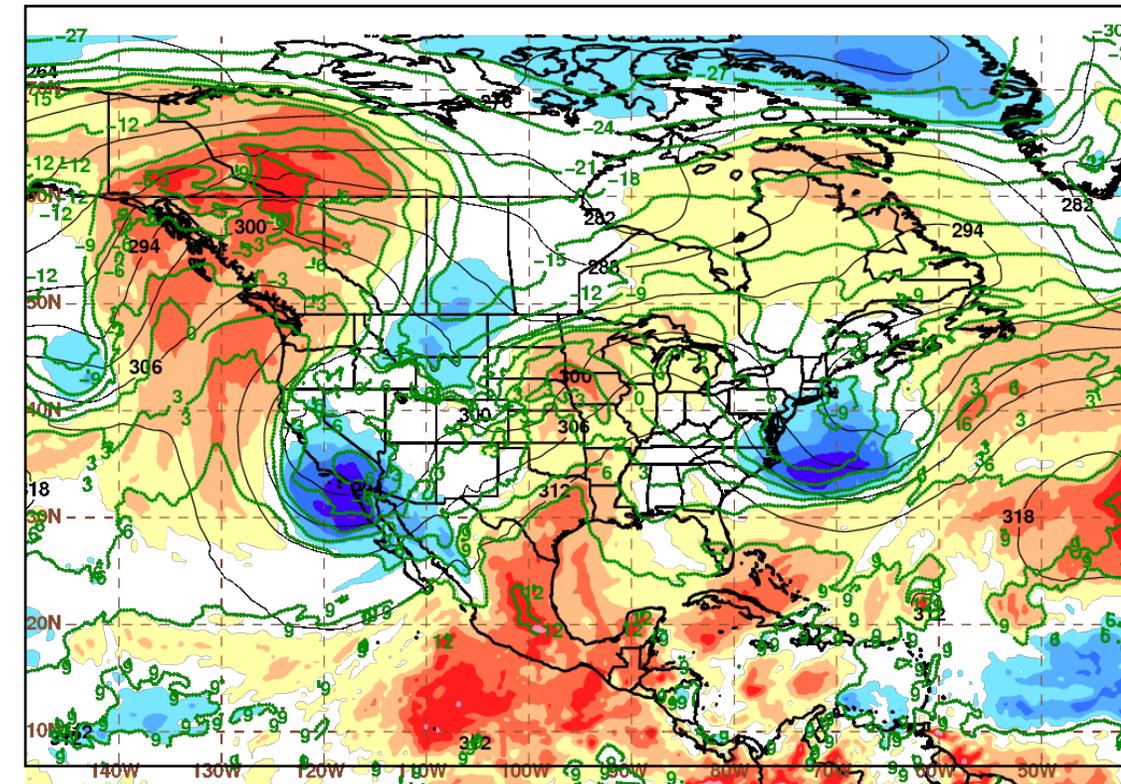
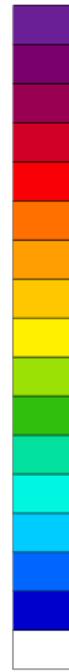
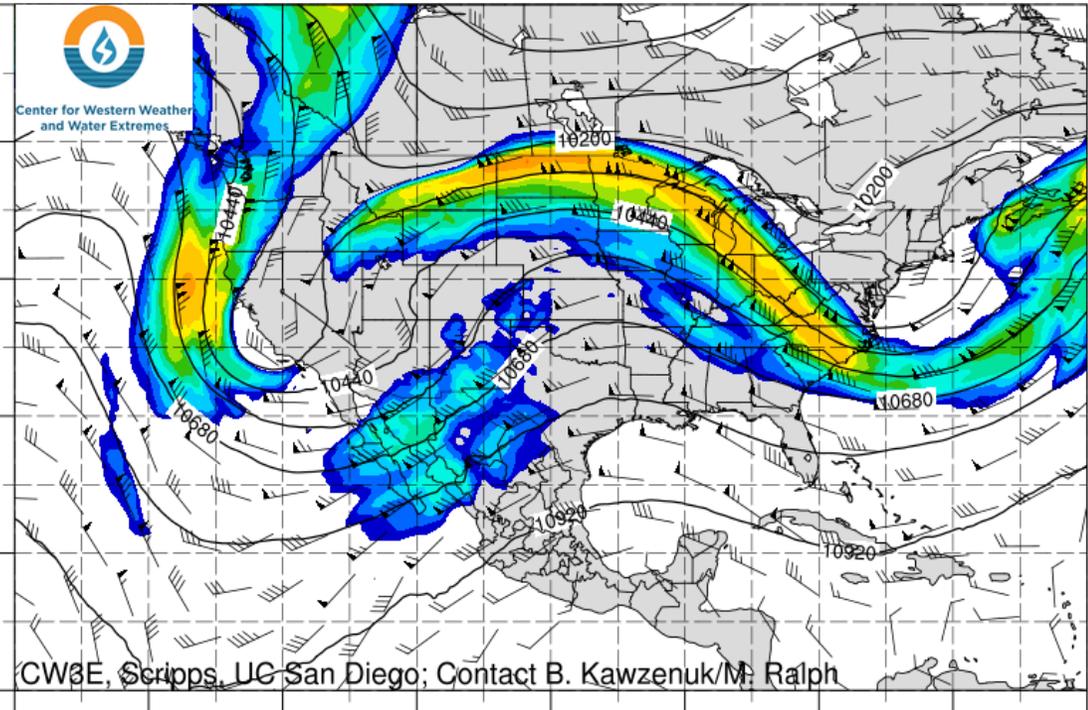


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- Although IVT was not particularly high over southern California, the synoptic-scale environment provided strong forcing for ascent
- At 1200 UTC 20 Nov, southern California was located beneath the diffluent exit region of a 250-hPa jet streak, a region favorable for ascent via a thermally indirect vertical circulation
- Cold air aloft (700-hPa temperature anomalies  $< -2 \sigma$ ) resulted in high lapse rates and conditional instability in the lower troposphere

NCEP GFS 250-hPa Winds (knots) and Height (gpm)  
Initialized: 1200 UTC 11/20/2019 F-000: Valid: 1200 UTC 11/20/2019



191121/0000V000 700 hPa Std. Anom of Temps; Heights  
-5.0 -4.0 -3.0 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 3.0 4.0 5.0