

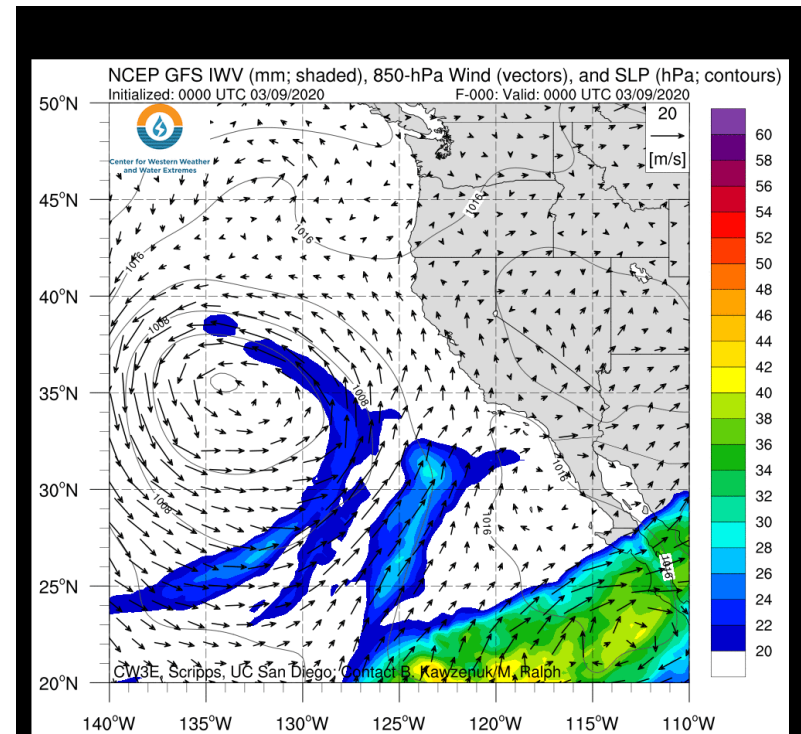
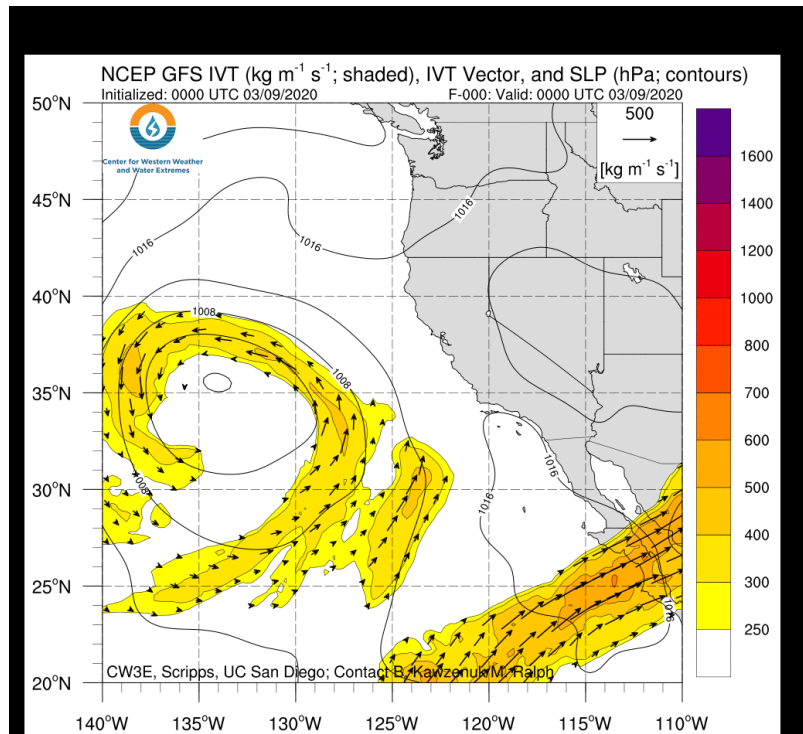
CW3E Event Summary: 9–13 Mar 2020



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Cutoff low and landfalling AR bring heavy rainfall to the southwestern U.S.

- A quasi-stationary cutoff low interacted with a region of tropical moisture over the Eastern Pacific Ocean, resulting in a long-duration atmospheric river (AR) over the Baja Peninsula
- Poleward moisture transport and strong synoptic-dynamic forcing for ascent produced multiple episodes of heavy rainfall across Southern California, Arizona, and southern Nevada
- Elevated sections of Southern California and central Arizona received 3–6 inches of total precipitation, with 1–3 inches at lower elevations

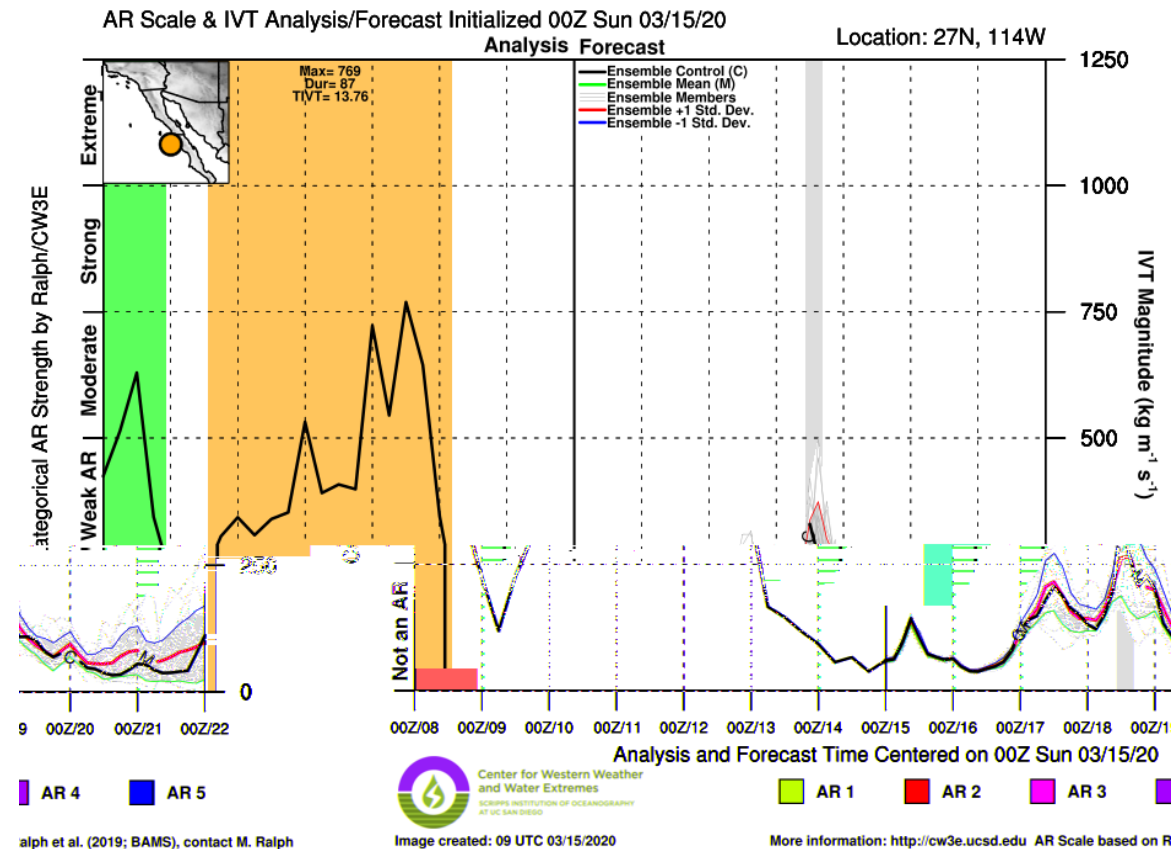
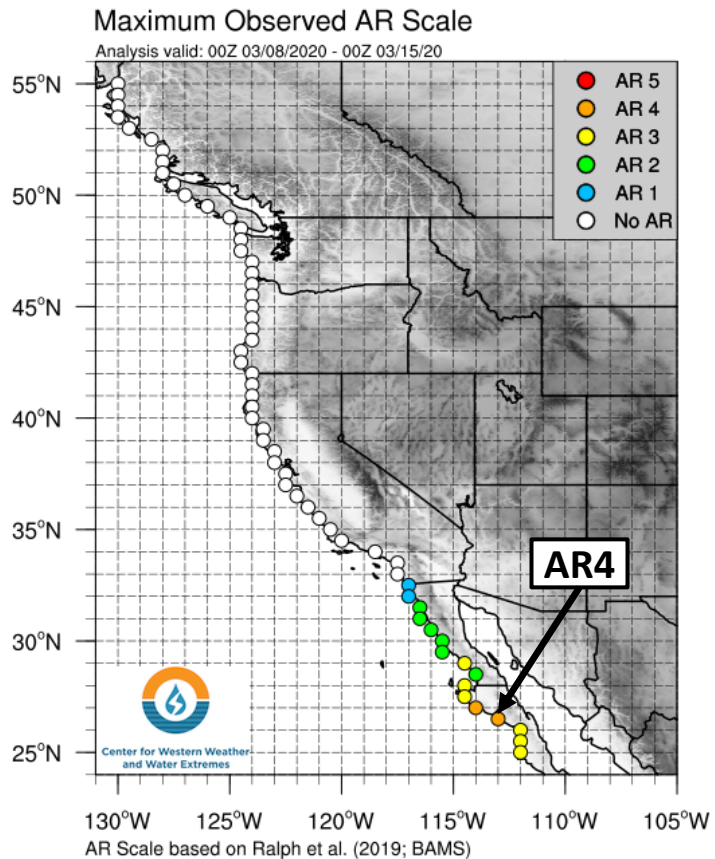


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Coastal AR Scale Analysis



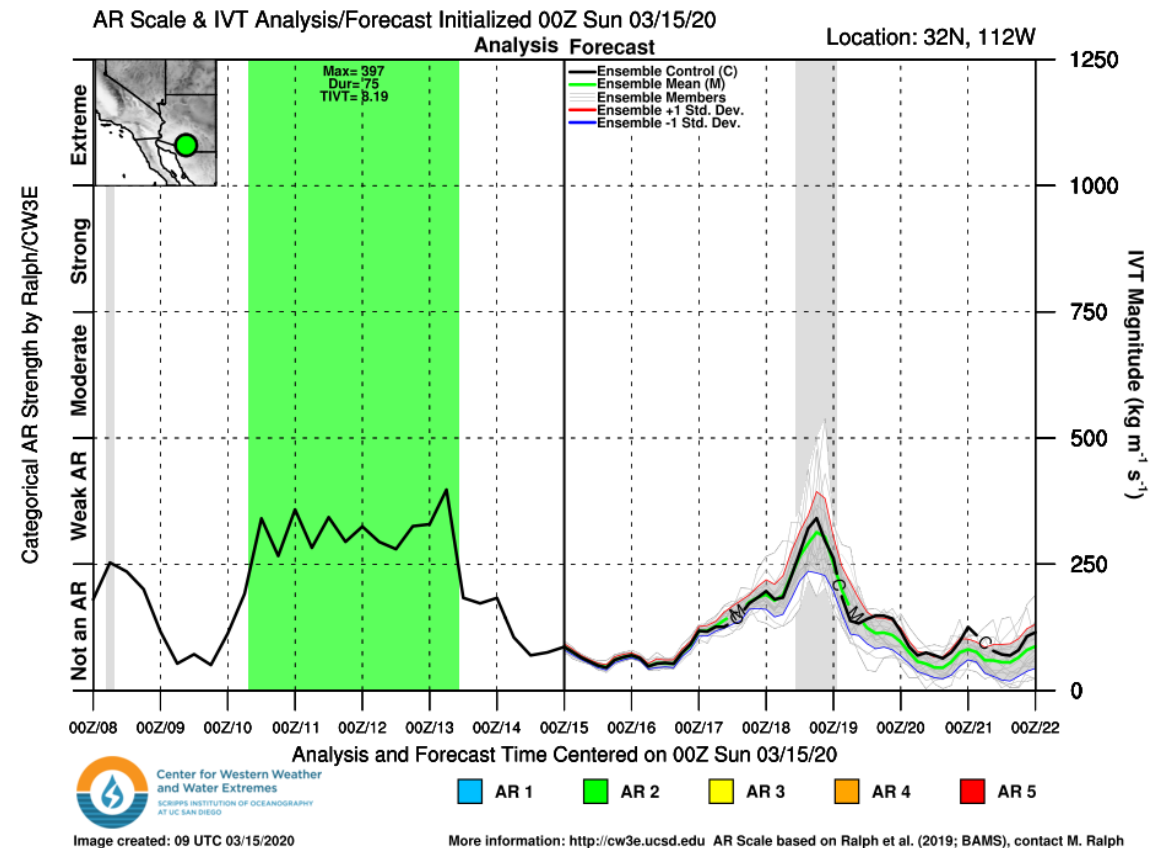
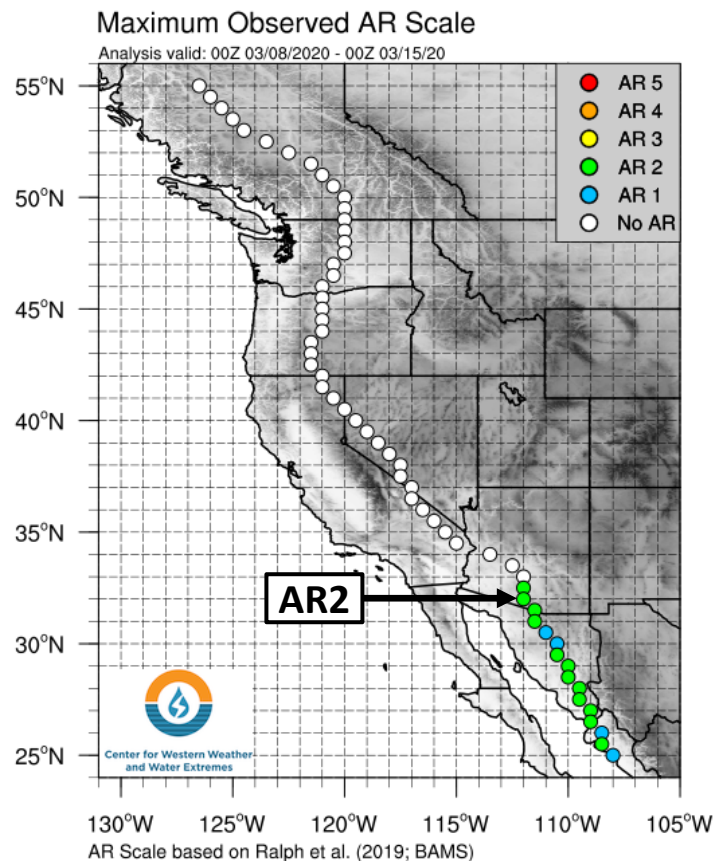
- A landfalling AR brought AR3/AR4 conditions to the Baja Peninsula, with some places experiencing AR conditions for more than 72 hours
- The total time-integrated IVT during this event was a remarkable $13.76 \times 10^7 \text{ kg m}^{-1}$ at 27°N, 114°W
- The rapid increase in IVT values after 1800 UTC 11 Mar preceded the 24-hour period (1200 UTC 12–13 Mar) with the most intense rainfall in Southern California and western Arizona

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Inland AR Scale Analysis



- Prolonged inland penetration of high IVT values resulted in AR2 conditions over southern Arizona, with some areas experiencing AR conditions for more than 72 hours

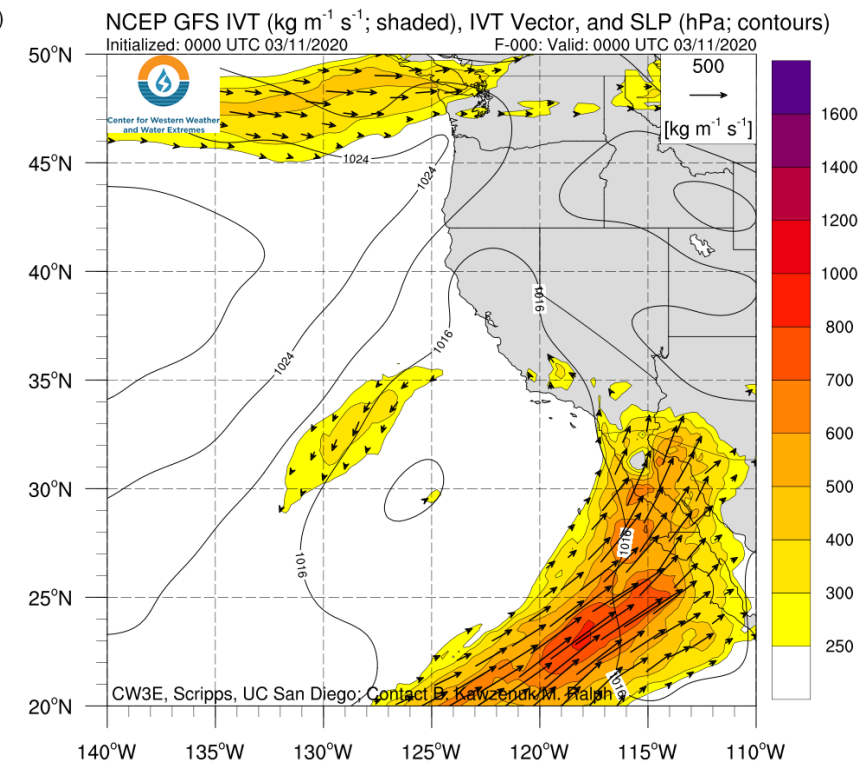
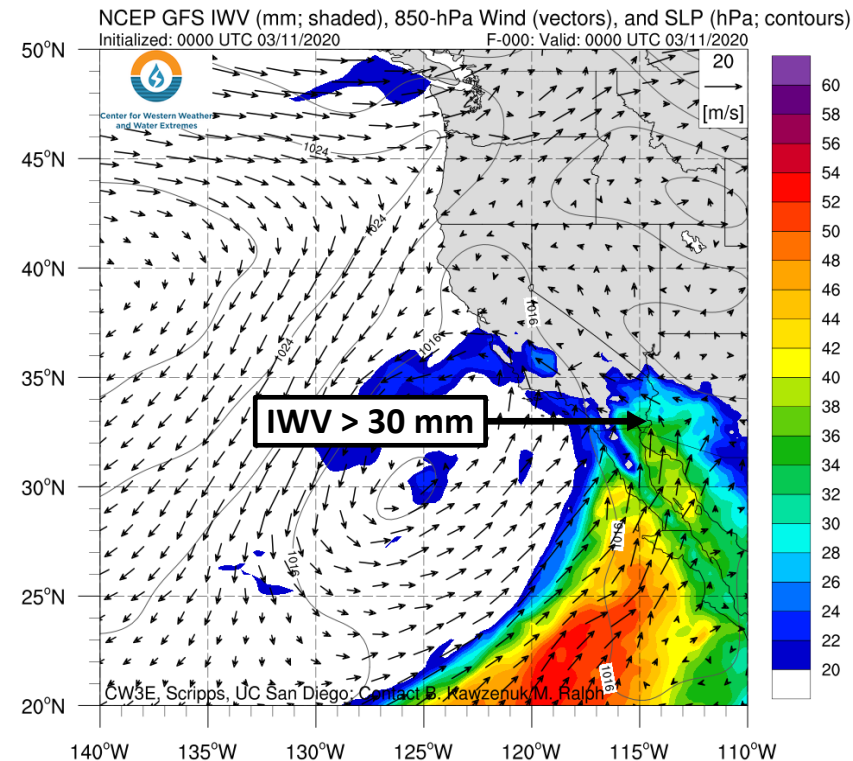
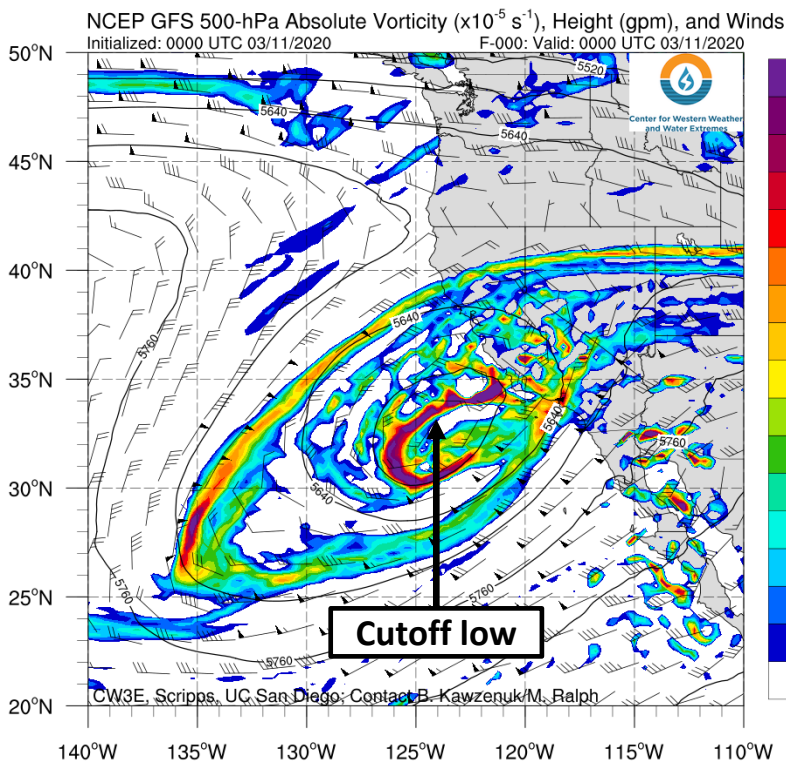
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GFS Analyses: Valid 0000 UTC 11 Mar



- This AR formed as a result of the interaction between a cutoff low west of Southern California and a region of deep tropical moisture over the Eastern Pacific Ocean
- 0000 UTC 11 Mar GFS analysis indicates that the first episode of heavy rainfall was associated with strong low-to-midlevel southwesterly flow downstream of the cutoff low that transported very moist air over extreme southeastern California and southwestern Arizona

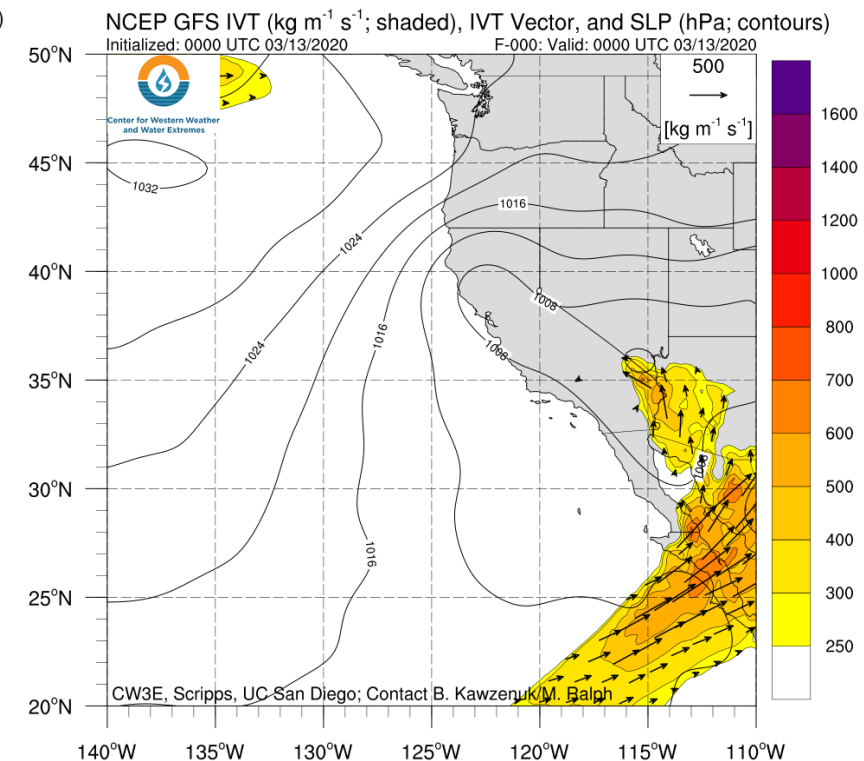
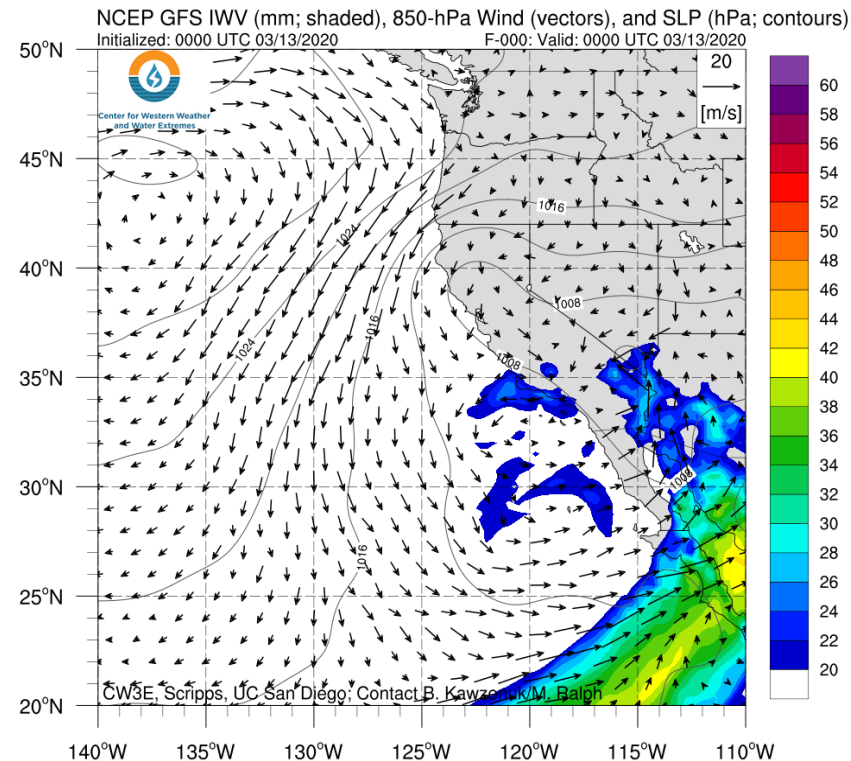
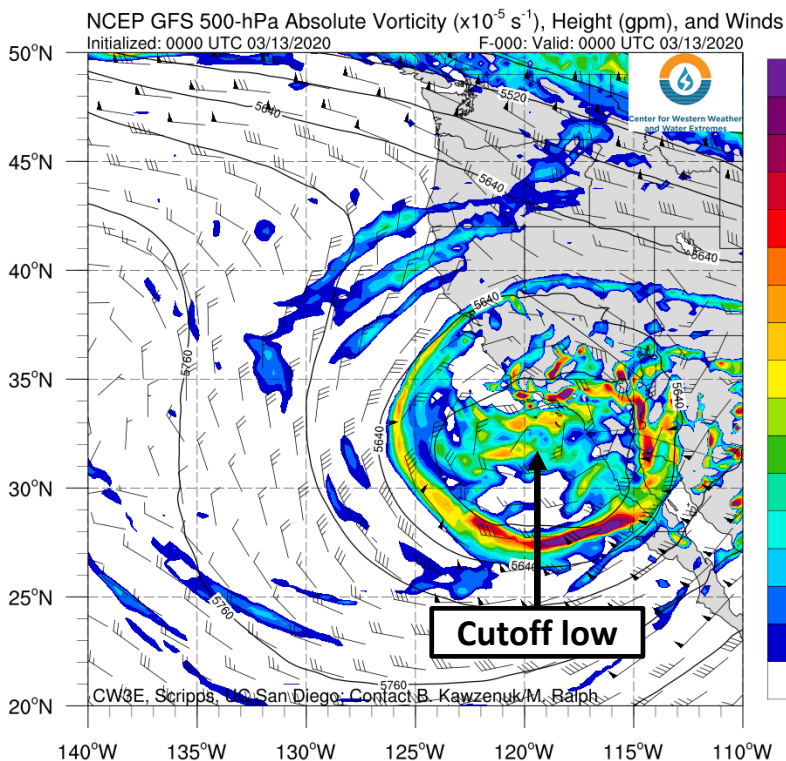
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GFS Analyses: Valid 0000 UTC 13 Mar



- As time progressed, the cutoff low slowly propagated eastward, and the moisture plume began to dissipate
- 0000 UTC 13 Mar GFS analysis suggests that the second episode of heavy rainfall was associated with a secondary region of enhanced and cyclonically curved IVT that developed immediately east of the cutoff low
- During both episodes of heavy rainfall, synoptic-dynamic forcing for ascent (via differential cyclonic vorticity advection) also played an important role

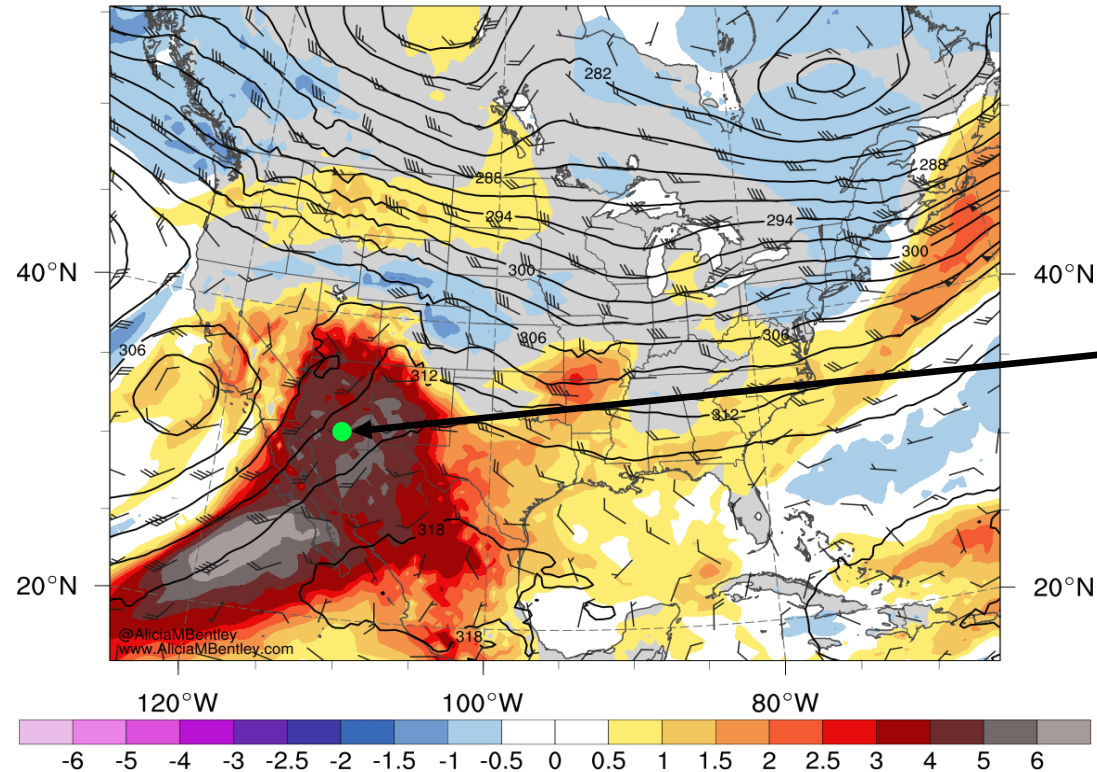
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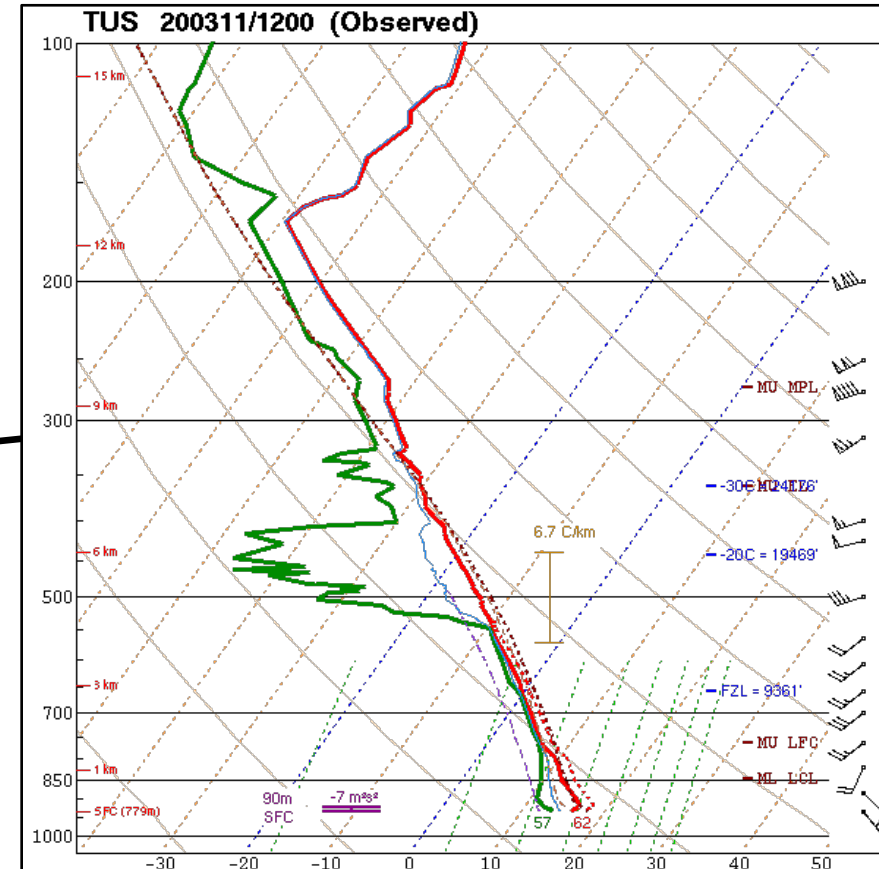
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GFS Standardized PWAT Anomaly : 1200 UTC 11 Mar Analysis

700-hPa geo. height (black, dam), wind (barbs, kt), standardized precip. water anomaly (shaded, sigma)
Initialized: 1200 UTC 11 Mar 2020 | Forecast hour: 0 | Valid: 1200 UTC 11 Mar 2020



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



Source: NOAA/NWS SPC, <http://www.spc.noaa.gov/>

- The AR associated with the cutoff low transported deep moisture into the Desert Southwest, with precipitable water (PWAT) values exceeding 4 standard deviations above normal across Arizona and New Mexico
- The 1200 UTC 11 Mar atmospheric sounding from Tucson, AZ (TUS), shows nearly saturated conditions between 800-hPa and 550-hPa
- TUS set a new record March PWAT value of 1.14 inches (> 300% of normal)

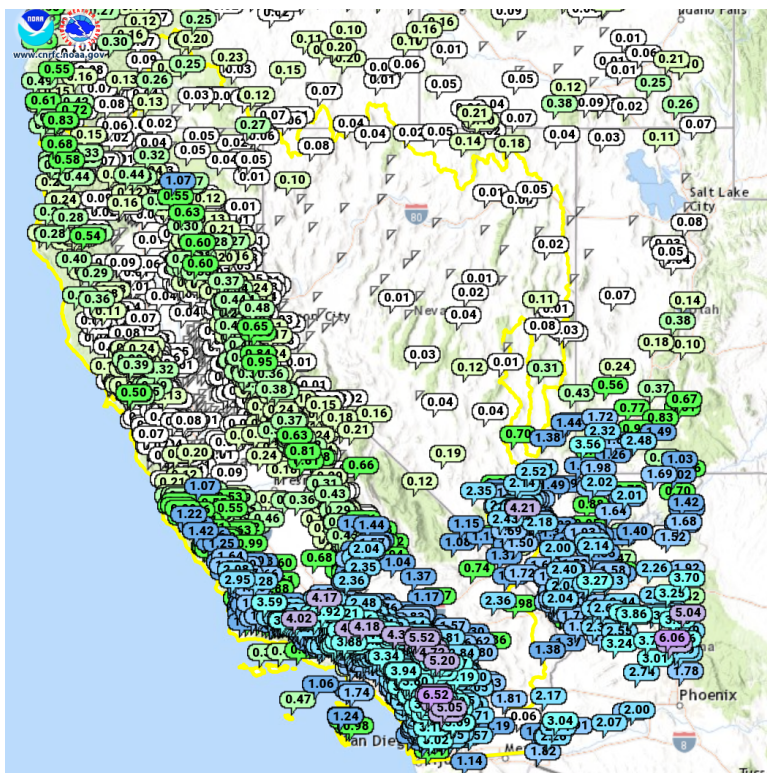
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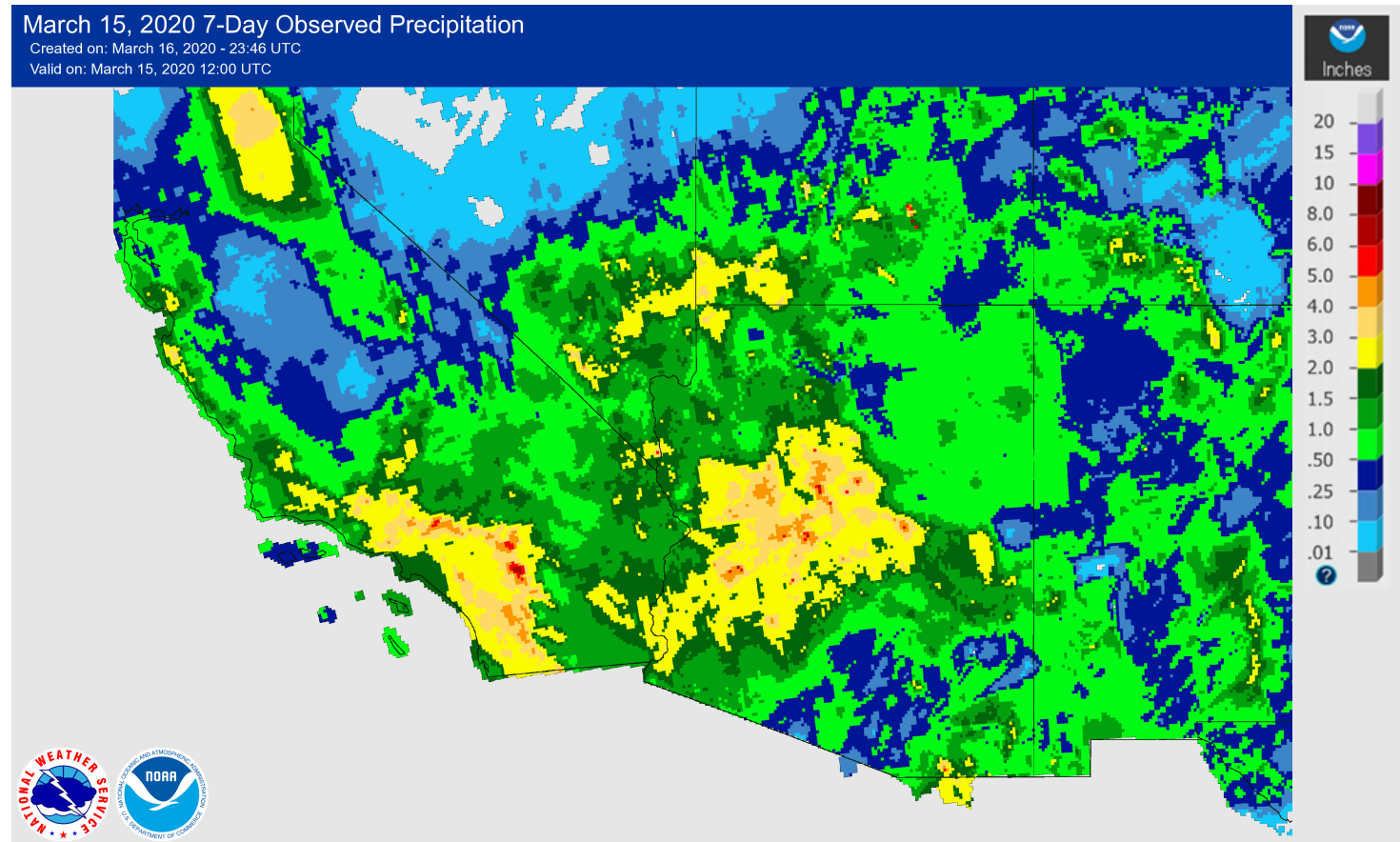
CNRF 120-h Observed (Raw) Precipitation: Valid 9 AM PDT 14 Mar



Source: NOAA/NWS CNRFC, <https://www.cnrfc.noaa.gov/>

March 15, 2020 7-Day Observed Precipitation

Created on: March 16, 2020 - 23:46 UTC
Valid on: March 15, 2020 12:00 UTC



Source: NOAA/NWS Advanced Hydrologic Prediction Service, <https://water.weather.gov/ahps/>

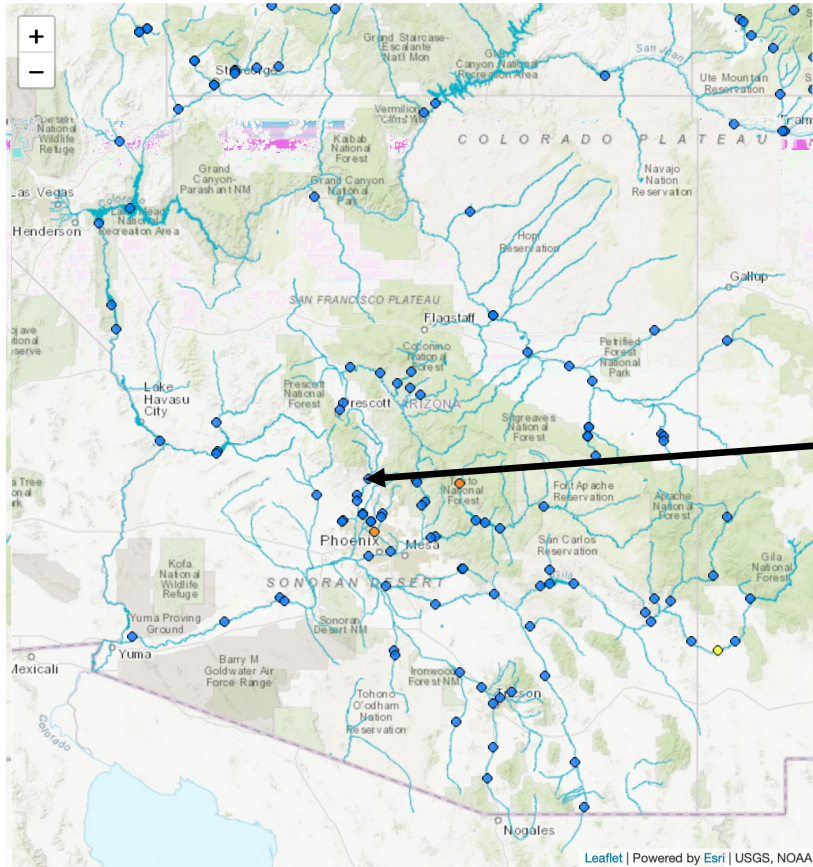
- The heaviest precipitation (3–6 inches) fell across the Transverse and Peninsular Ranges in Southern California, as well as the higher terrain in west-central Arizona
- Coastal, valley, and desert areas received about 1–3 inches of total rainfall
- McCarran International Airport (KLAS) and Yuma International Airport (KYUM) both set daily precipitation records on 10 Mar and 12 Mar
- North Las Vegas Airport (KVGT) and KYUM recorded more than 50% of their average annual rainfall from this event

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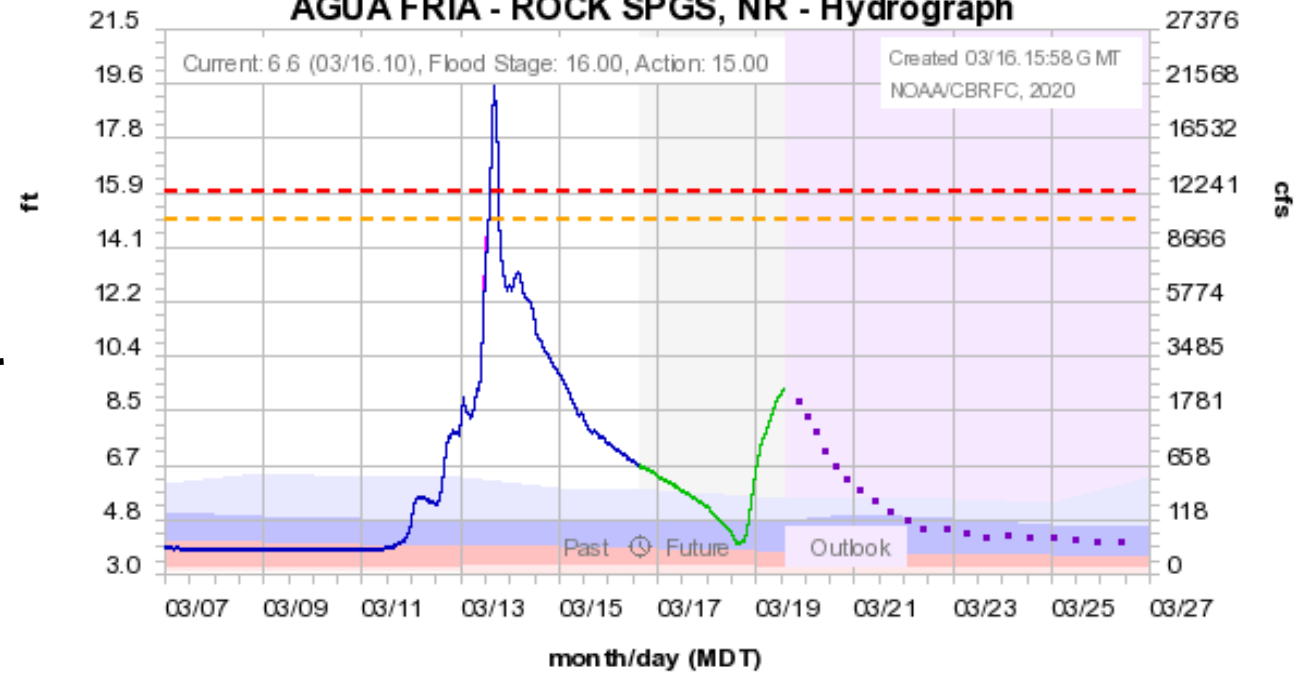
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Source: NOAA/NWS Colorado Basin River Forecast Center, <https://www.cbrfc.noaa.gov/>

Colorado Basin River Forecast Center AGUA FRIA - ROCK SPGS, NR - Hydrograph

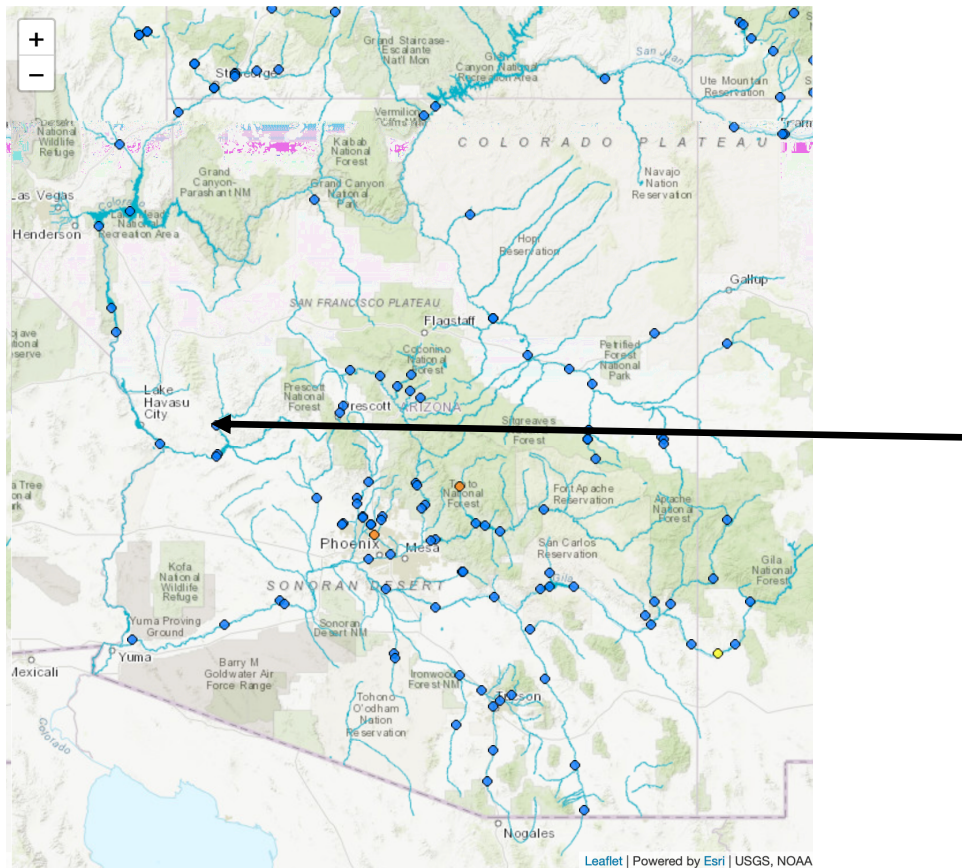


- NWS Phoenix received numerous reports of flash flooding in Imperial County, CA, and Maricopa County, AZ, on 12–13 Mar
- Heavy rainfall triggered a rapid streamflow response on many rivers in western and central Arizona during the morning of 13 Mar
- The Agua Fria River (near Rock Springs, AZ) rose more than 10 feet in a 6-hour period and briefly exceeded moderate flood stage

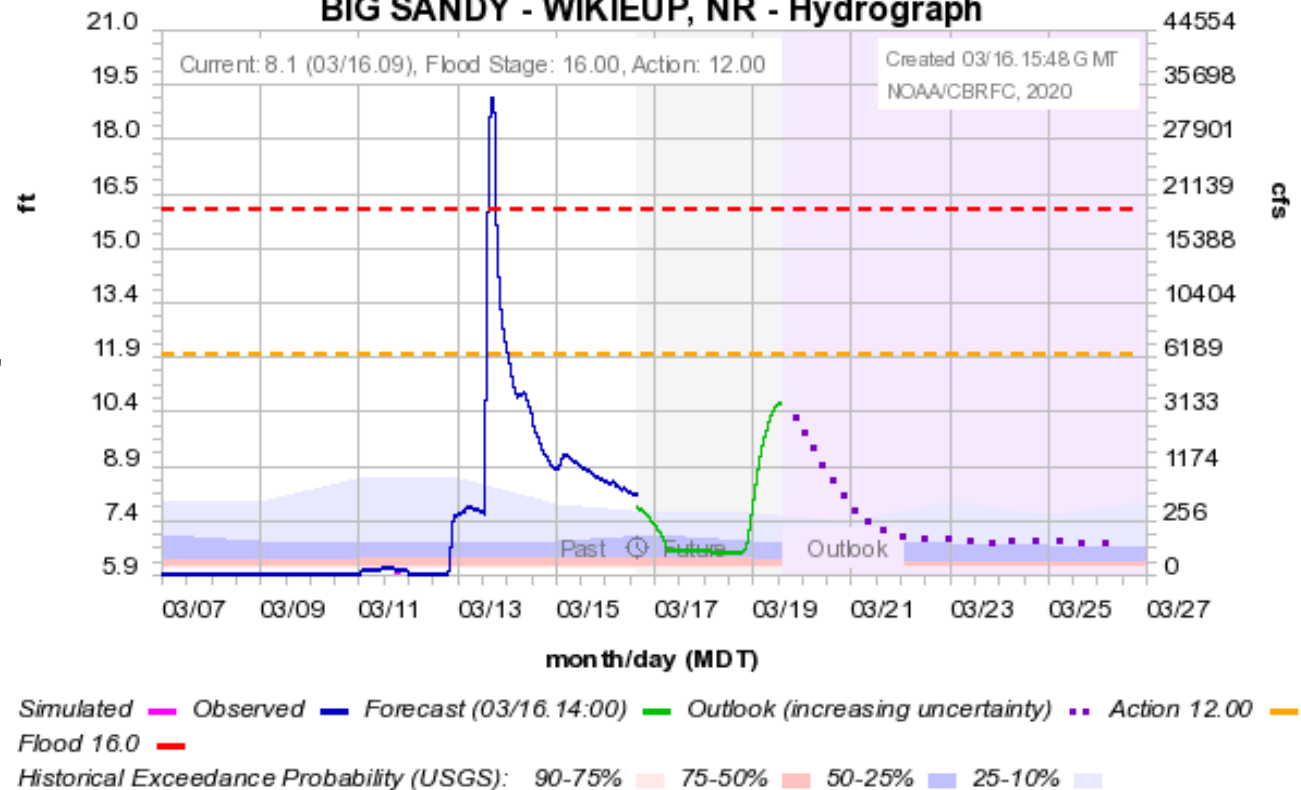
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Colorado Basin River Forecast Center BIG SANDY - WIKIEUP, NR - Hydrograph



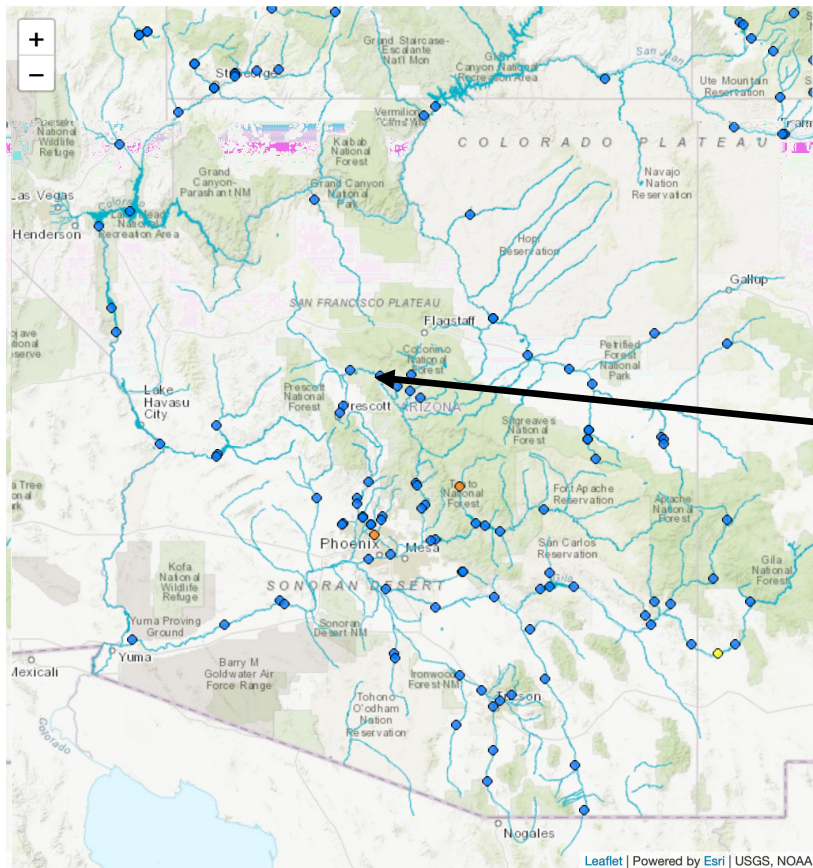
Source: NOAA/NWS Colorado Basin River Forecast Center, <https://www.cbrfc.noaa.gov/>

- The Big Sandy River (near Wikieup, AZ) rose more than 11 feet in a 3-hour period and recorded its all-time maximum stage height (19.06 ft) and its highest peak discharge (33,400 cfs) over the past 10 water years (since 1 Oct 2010)

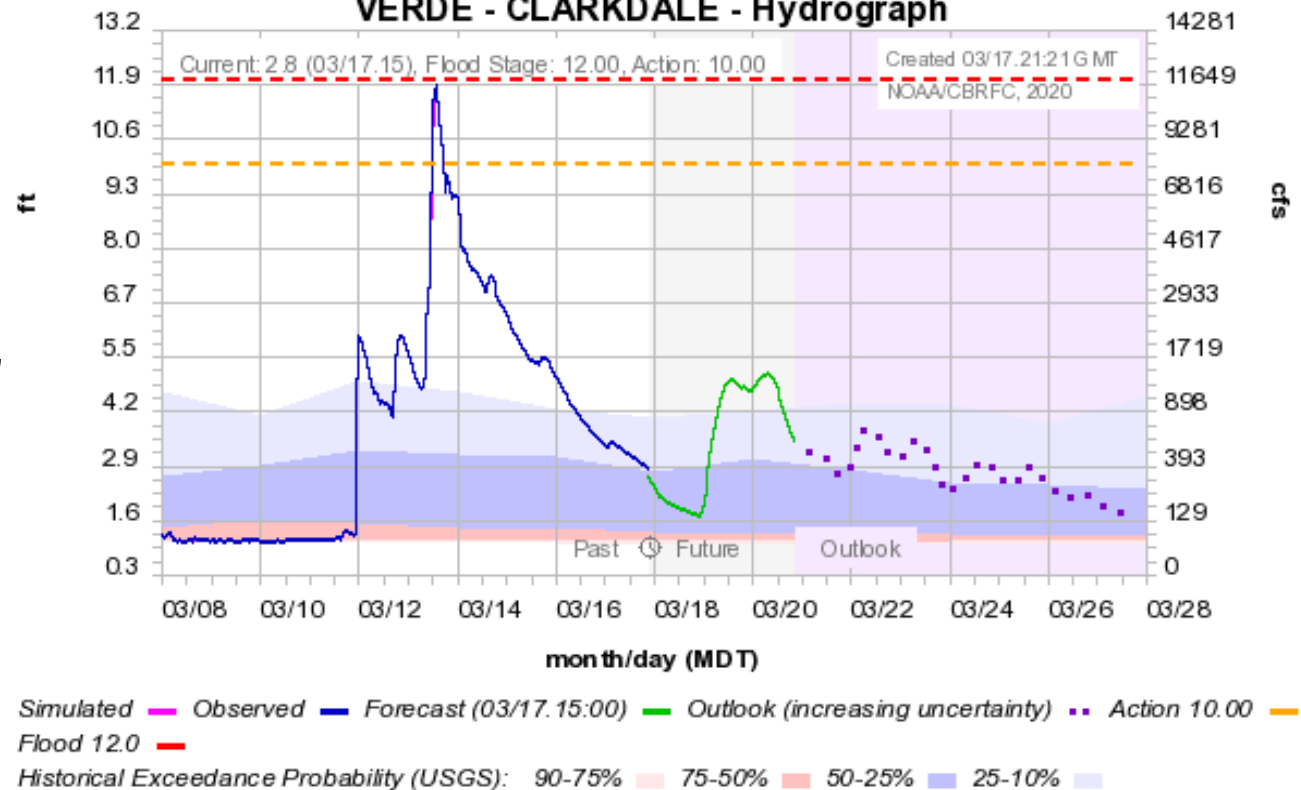
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Colorado Basin River Forecast Center VERDE - CLARKDALE - Hydrograph



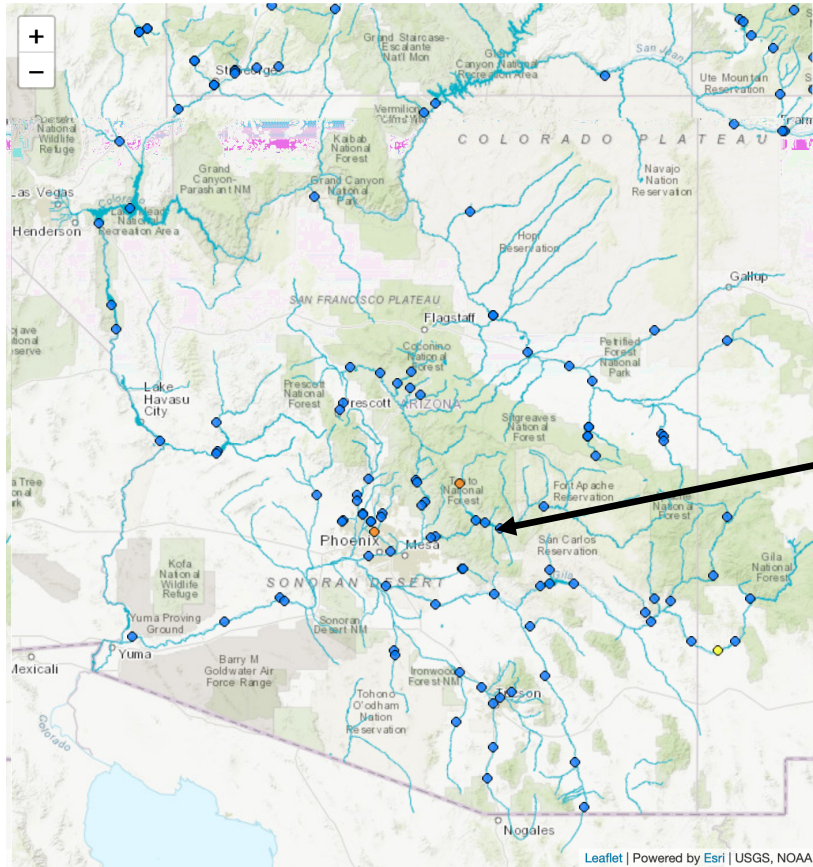
Source: NOAA/NWS Colorado Basin River Forecast Center, <https://www.cbrfc.noaa.gov/>

- The Verde River (near Clarkdale, AZ) recorded its second-highest peak discharge (10,700 cfs) and daily mean discharge (5,550 cfs) over the past 10 water years

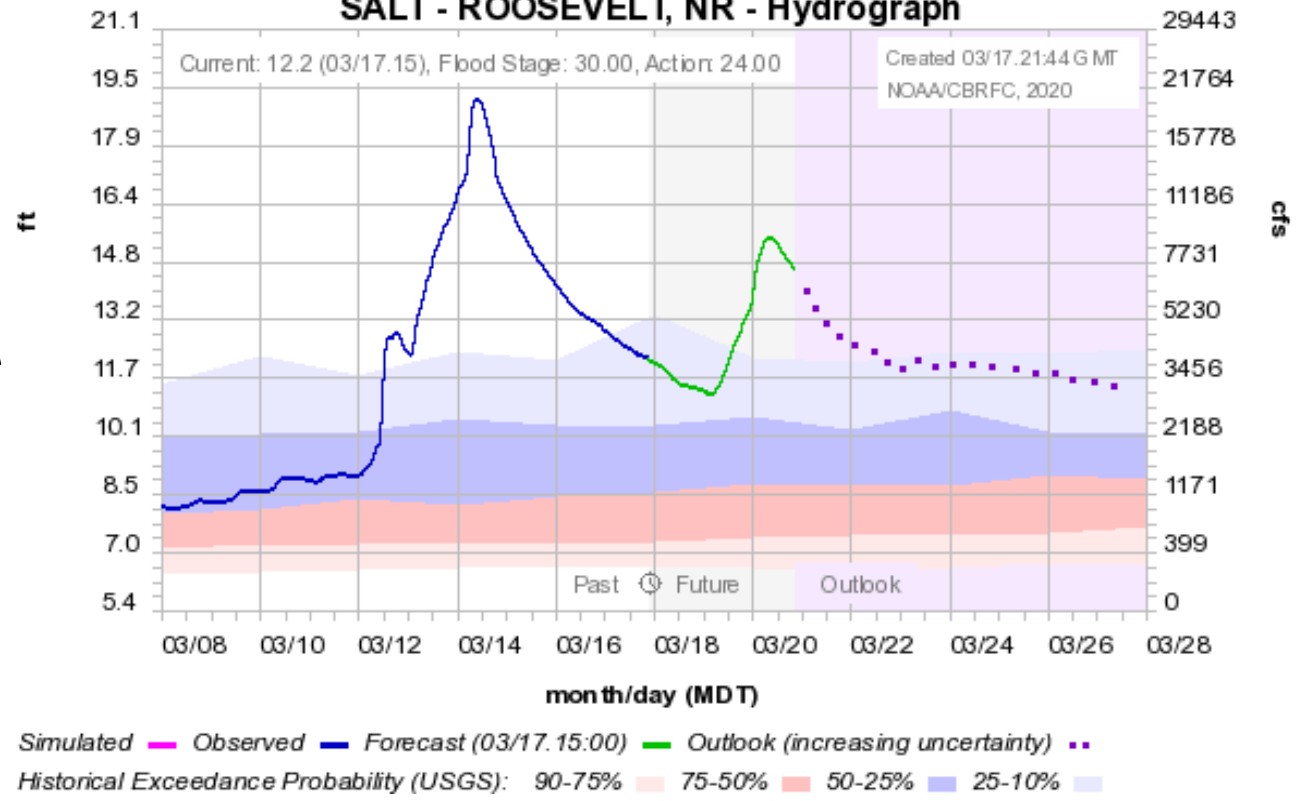
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Colorado Basin River Forecast Center SALT - ROOSEVELT, NR - Hydrograph



Source: NOAA/NWS Colorado Basin River Forecast Center, <https://www.cbrfc.noaa.gov/>

• The Salt River (near Roosevelt, AZ) recorded its highest peak discharge (20,300 cfs) and daily mean discharge (14,400 cfs) over the past 10 water years