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

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

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

Source: NOAA | NWS Western Regional Headquarters, https://www.weather.gov/wrh
**CW3E Post Event Summary: 19–22 Nov 2019**

- 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

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

*Precipitation and snow depth observations based on SNOTEL data

Source: USDA | NRCS National Water and Climate Center, [https://www.wcc.nrcs.usda.gov/snow/](https://www.wcc.nrcs.usda.gov/snow/)
**CW3E Post Event Summary: 19–22 Nov 2019**

- 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

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

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).
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.

Source: California-Nevada Climate Applications Program, [https://scripps.ucsd.edu/programs/cnap/](https://scripps.ucsd.edu/programs/cnap/)
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.

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.
Cut-off low becomes a trough and moves away northeastward

Strong closed low forms over CA

Trough moves in from the north

Cut-off low moves northeastward

Initial cut-off low spins in place for days

NCEP GFS Analysis 500-hPa Geo. Heights (gpm) and Vorticity (s⁻¹)

Valid: 00 UTC 19 Nov. 19

Valid: 00 UTC 20 Nov. 19

Valid: 00 UTC 21 Nov. 19

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

7-Day Precipitation ending 12Z 22 Nov.
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.
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.

CW3E Post Event Summary: 19–22 Nov 2019

Tropical Moisture Export Contributed from Near Gulf of California
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 < −2σ) resulted in high lapse rates and conditional instability in the lower troposphere.