# CW3E Analysis: Heavy Rain in San Diego, CA (22 Jan 2024)

- On January 22, 2024, a weak (AR0 on the Ralph et al. 2019 scale) atmospheric river (AR) moved across southern California and into Arizona.
- Broad light to moderate rain accompanied the AR, bringing notable rainfall amounts to the Southwest.
- An area of heavy rain developed offshore from San Diego and persisted for a few hours across the region.
- While IVT was not particularly high, heavy rainfall was supported by strong low-level moisture flux and mesoscale forcing for ascent beneath the left exit region of an upper-level jet.
- San Diego/Lindbergh Field (KSAN) recorded 2.73” of rain, which set a new daily record (previous record was 1.57” in 1963).
- This ranks as the 4th highest daily rainfall amount on record (since 1850).
- The rolling 3-hr precipitation (computed from 1-min data) peaked at 2.13”. Based on NOAA Atlas 14 data, this represents a return interval of 178 years (0.6% chance of occurring in a year).

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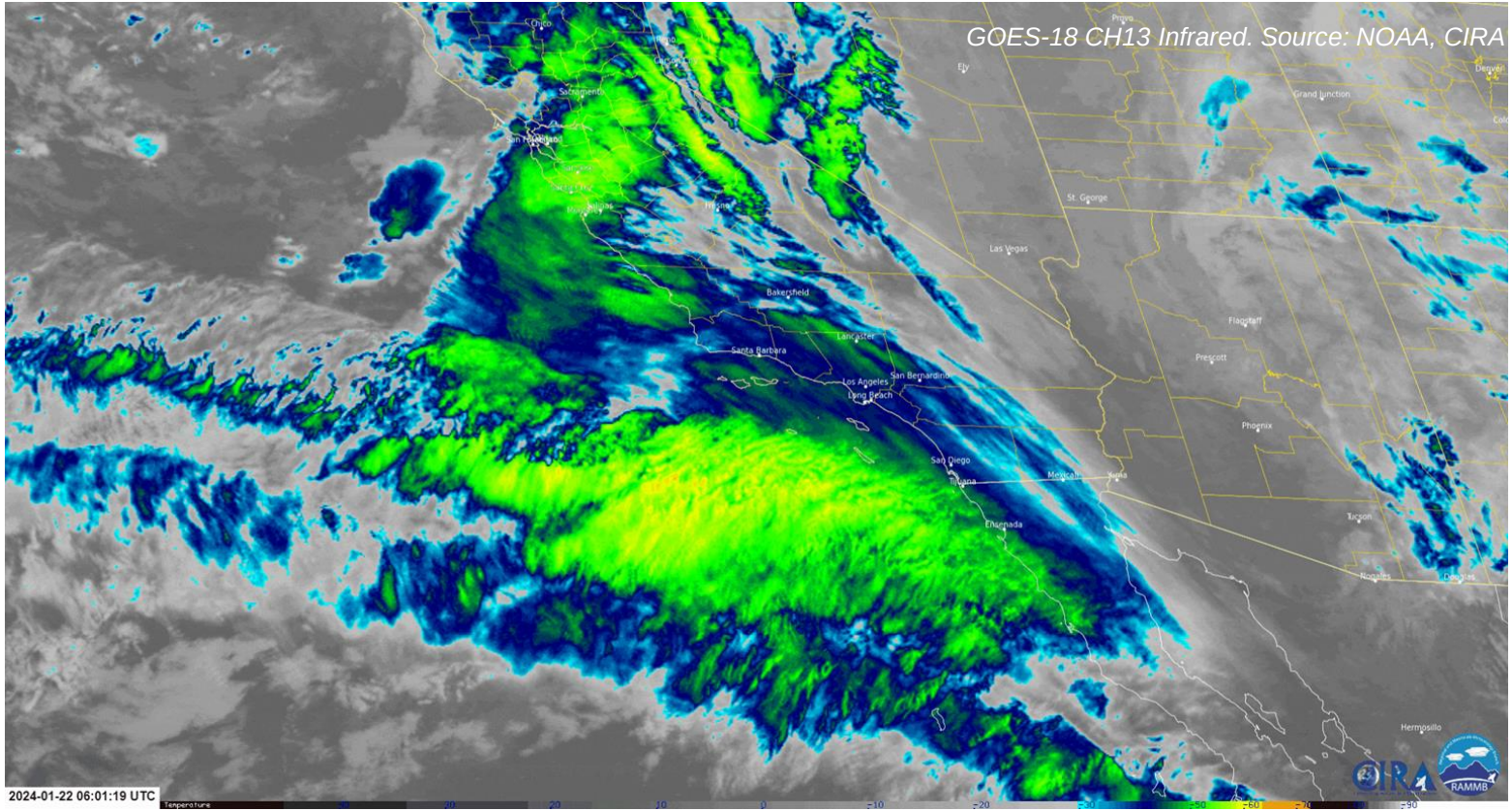


Infrared satellite data depicting the passage of the upper level low (counter- clockwise swirl traveling NW to SE) and clouds (blue/green shaded areas). Note just west of San Diego, a subtle and small new circulation develops which provided additional forcing for the heavy rain.

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*Composite Reflectivity. Source: MRMS*

A 24-hr (10 PM 22 Jan 2024 to 10 PM 23 Jan 2024) regional radar loop depicting the passage of precipitation associated with a rapidly developing shortwave.

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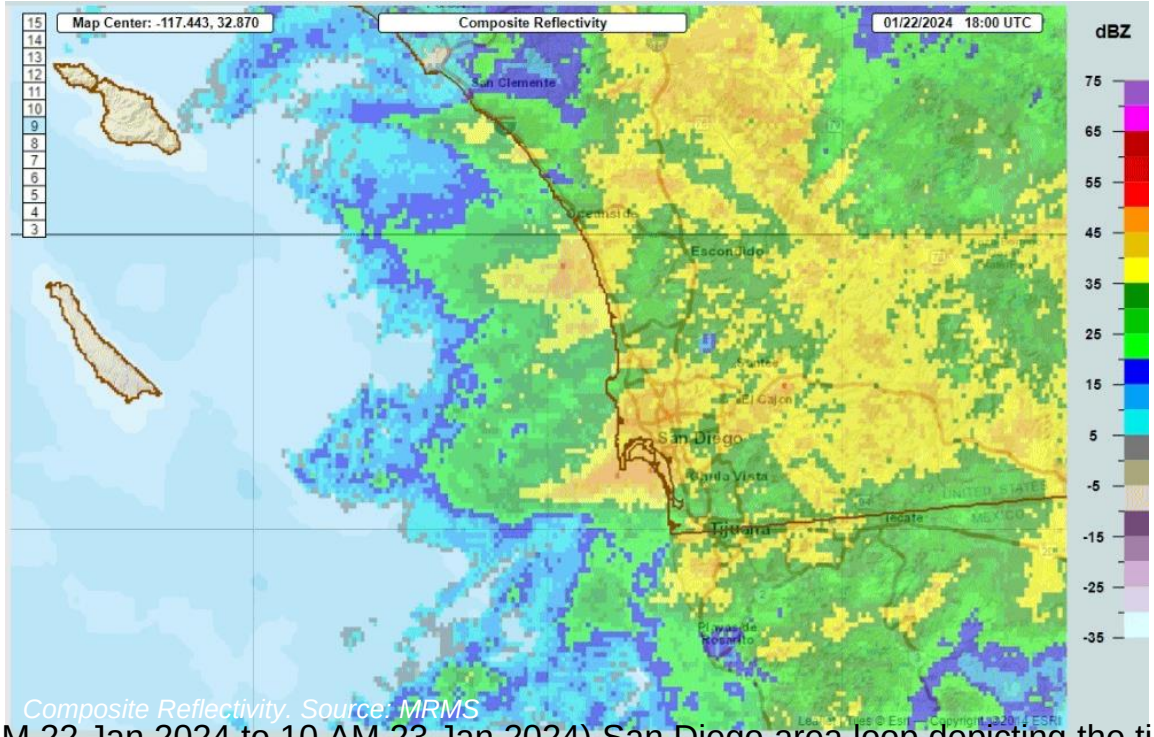


*Composite Reflectivity. Source: MRMS*

A 3-hr (7 AM 22 Jan 2024 to 10 AM 23 Jan 2024) San Diego area loop depicting the time of most intense precipitation. A band of heavy rain developed along a convergence zone just west of Downtown San Diego then slowly moved onshore over the course of two hours.

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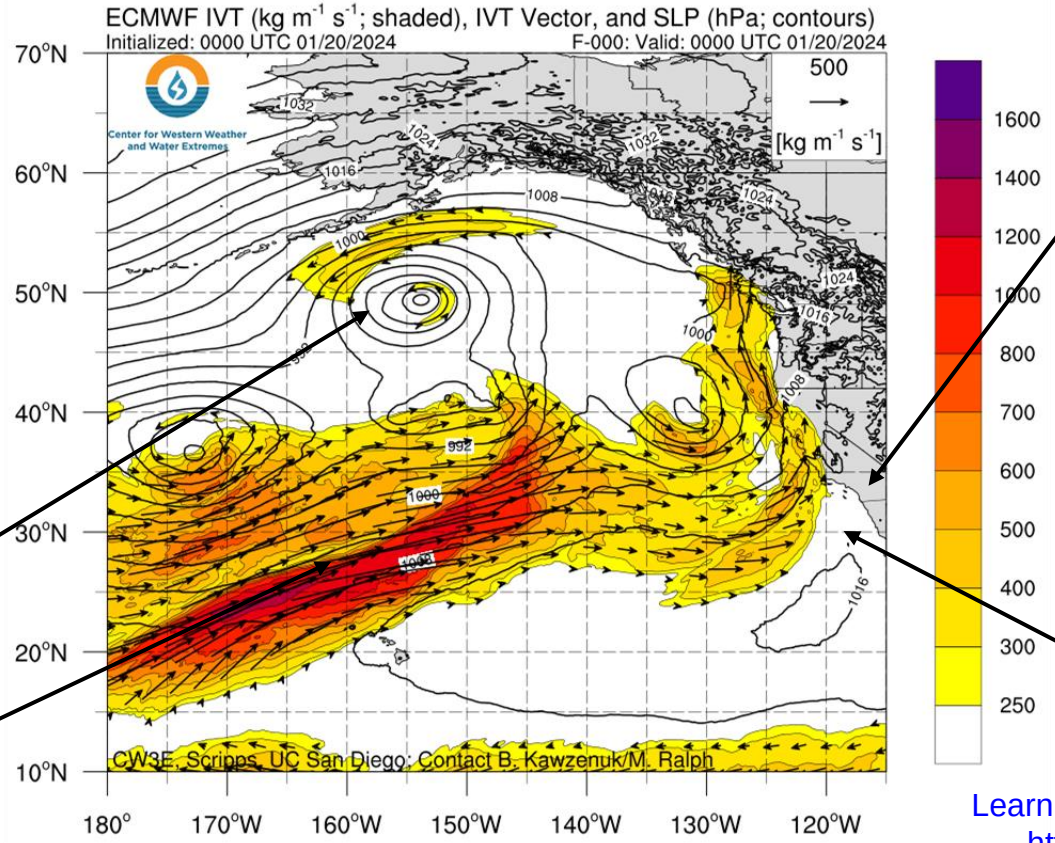
Integrated Water Vapor Transport (IVT) across the Northeast Pacific Ocean prior to and through the event. IVT values peaked at roughly 500 kg/(ms), considered “moderate” strength.




San Diego

Parent Low-Pressure System

Continued Generation of New Atmospheric Rivers

Atmospheric River (AR1 on AR Scale)

Learn More About the AR Scale at https://cw3e.ucsd.edu/arscale/

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Figure A

Shading is precipitable water anomalies (sigma)

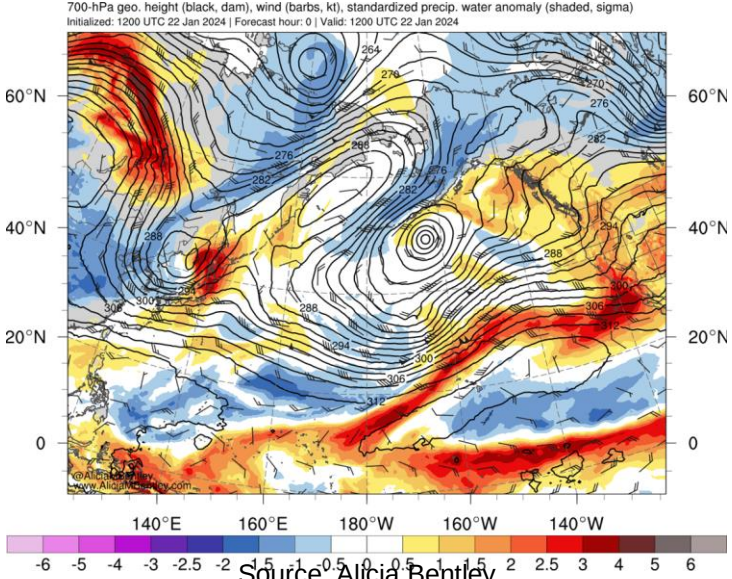
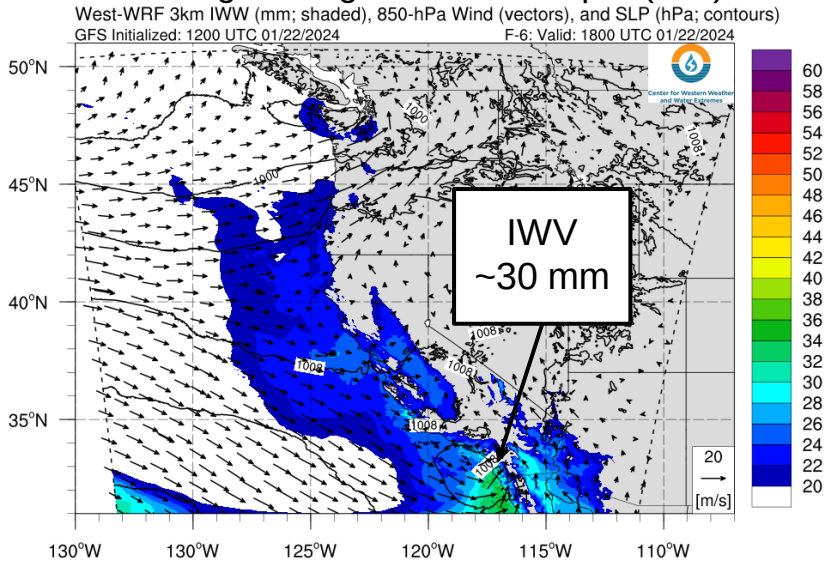



Figure B

Shading is integrated water vapor (mm)




Source: Alicia Bentley

- While IVT was not particularly impressive over CA, ample moisture supported heavy precipitation in San Diego County.
- GFS analysis at 12Z (4 AM PT) 22 Jan shows precipitable water anomalies 2–4 standard deviations above normal within the core of the AR and extending into Southern CA (Fig A).
- The West-WRF 6-h forecast (valid 10 AM PT 22 Jan) had shown an area of IWV greater than 30 mm with southwesterly winds at 850-hPa approaching 20 m/s along the coast, implying strong low-level water vapor flux over San Diego (Fig B).

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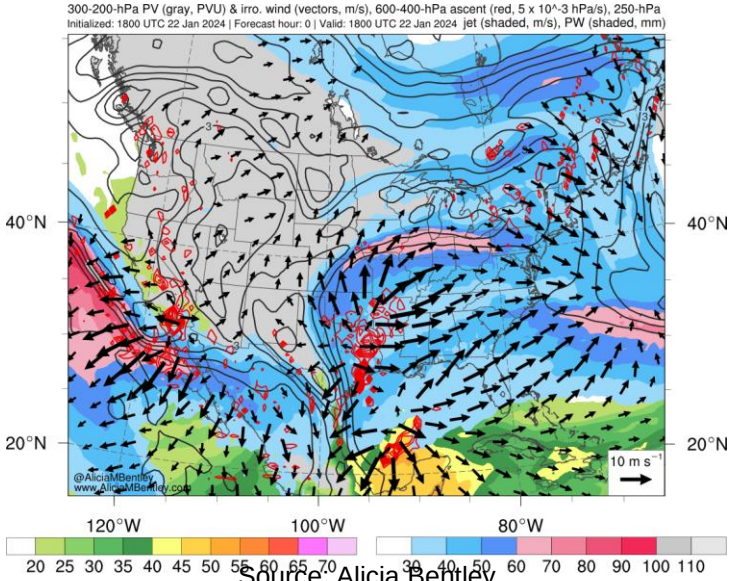
Figure A

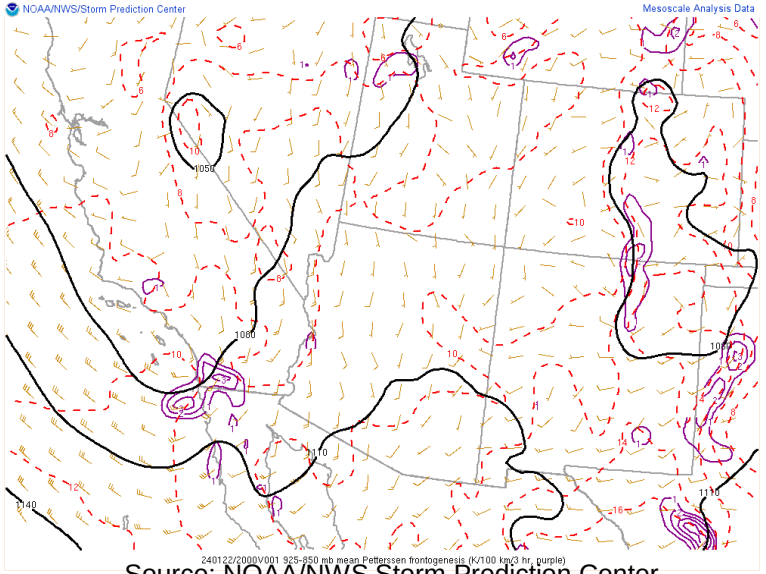
300-200 hPa PV and Irrotational Winds




Source: Alicia Bentley

Figure B

925-850 hPa frontogenesis (purple contours)




Source: NOAA/NWS Storm Prediction Center

- In addition, strong mesoscale forcing played an important role in producing sustained moderate-to-heavy rainfall rates.
- GFS analysis at 18Z (10 AM PT) 22 Jan shows a small region of enhanced upward vertical motion over San Diego County, beneath the left exit region of an upper-level jet extending across the North Pacific Ocean (Fig A).
- The heaviest rainfall was also co-located with an area of low-level frontogenesis and moisture convergence (Fig B).

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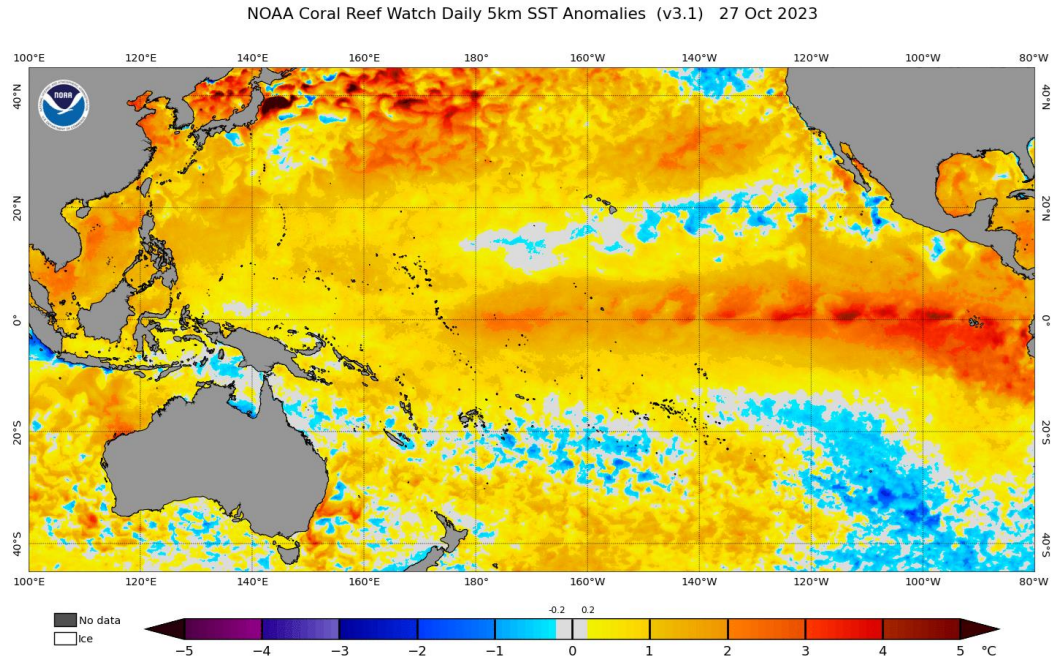


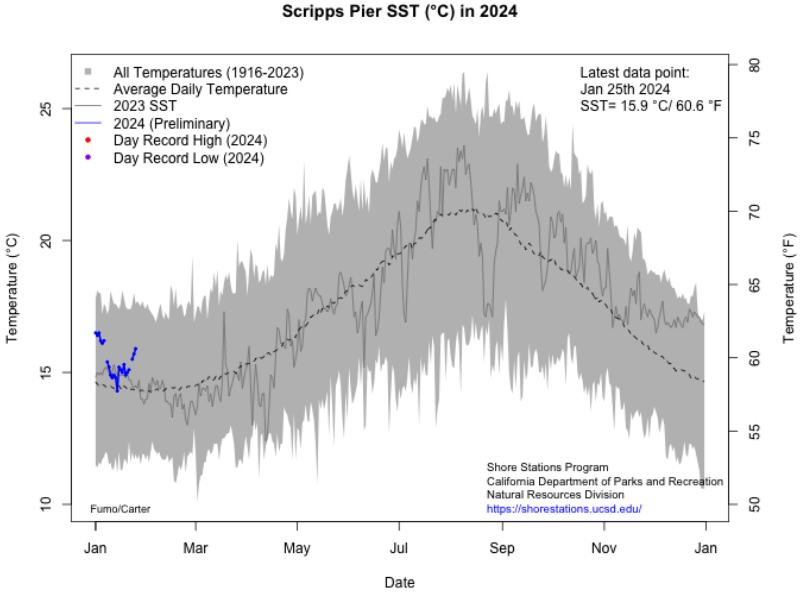


- [Left] Sea surface temperatures (SSTs) warmer-than-usual (warm colors) were common during the past several weeks. The El Niño signal can be clearly seen as a long-reaching plume of warmer-than-usual waters emanating from the far eastern equatorial waters. Much warmer-than-usual water is seen east of Japan associated with a persistent pattern of a robust East Asian Jet. Waters along the West Coast have remained consistently warmer than usual for several months.
- [Right] Observed SST at the Scripps pier have remained warmer-than-usual so far in 2024.

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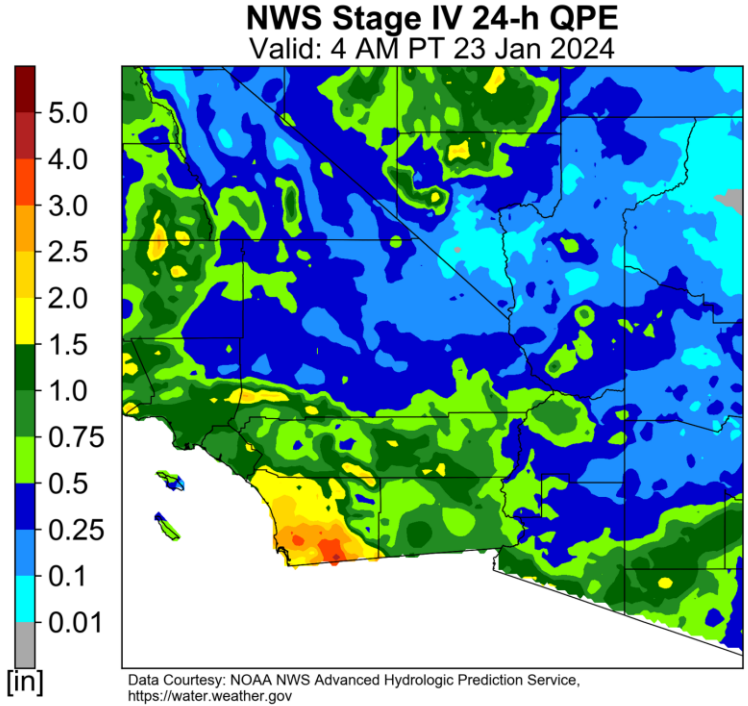


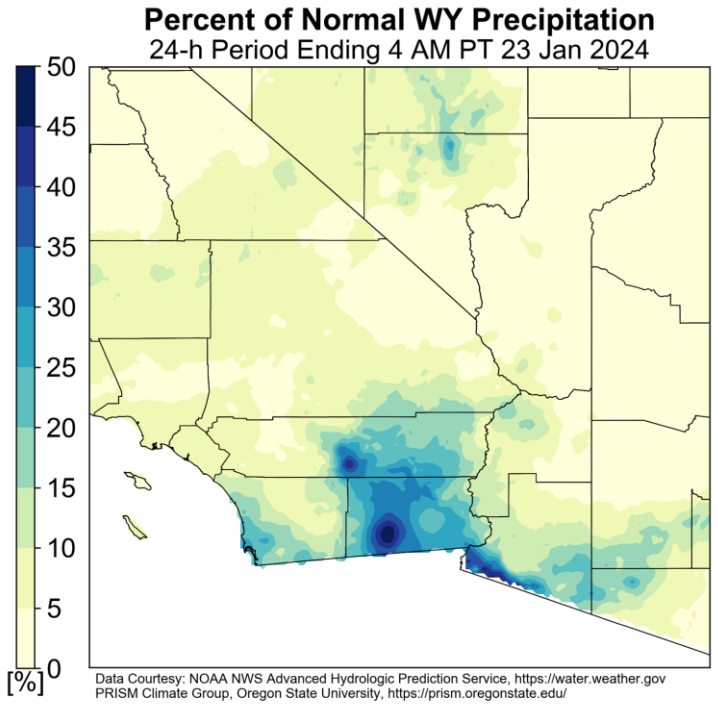


- This storm produced 2–4 inches of precipitation in portions of San Diego County, as well as 0.5–1.5 inches of precipitation in the desert regions of Riverside County, Imperial County, and southwestern AZ.
- Some locations received 25–50% of their normal annual precipitation in a 24-hour period.

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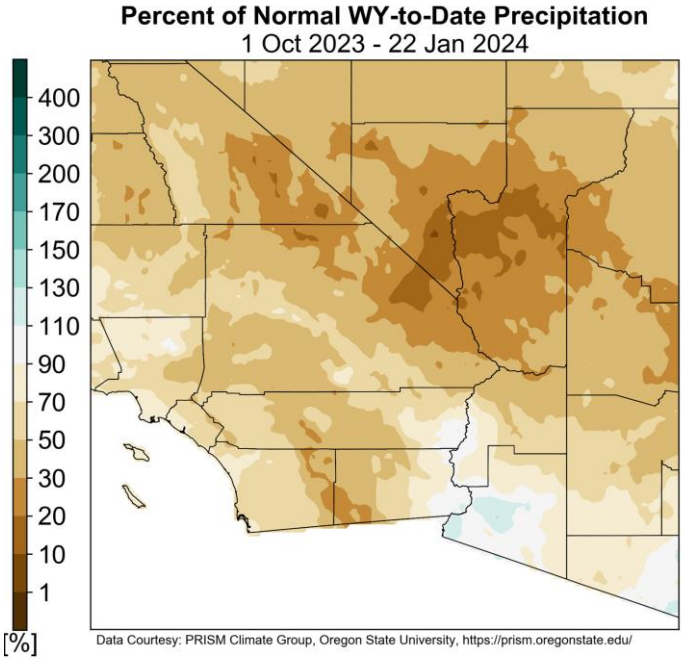


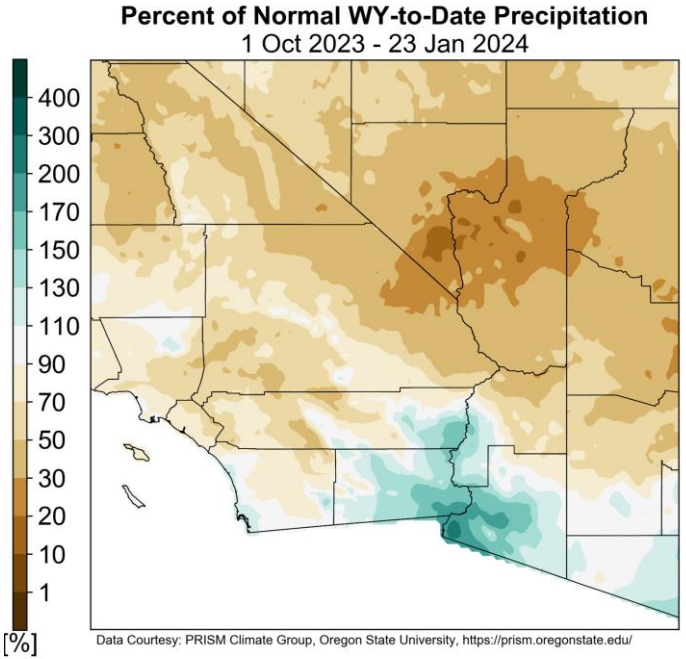


- Precipitation so far this water year (since Oct 1) for 22 Jan 2024 (left) and 23 Jan 2024 (right) expressed as a percent of the normal water year-to-date amount.
- WY-to-date precipitation increased from 20–70% to 50–130% of normal in San Diego County, and from 70–130% to 130–200% of normal in the Lower Colorado River Valley along the CA/AZ border.

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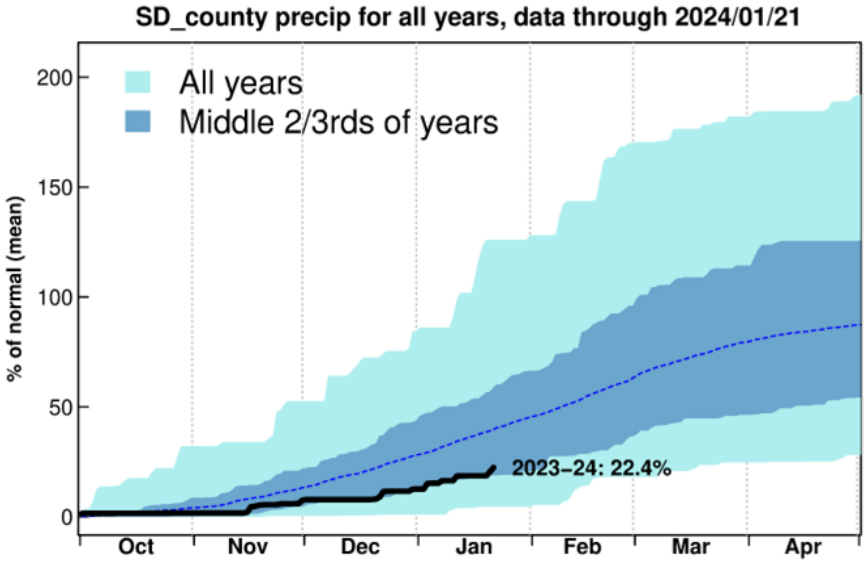


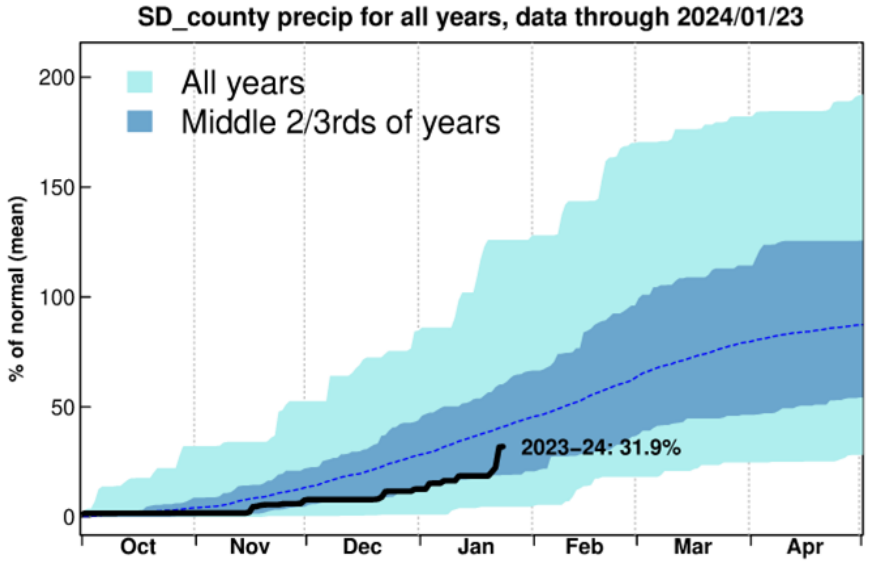


- Precipitation so far this water year (since Oct 1) for 21 Jan 2024 (left) and 23 Jan 2024 (right) in San Diego County expressed as a percent of the normal total water year precipitation.
- This event contributed more than 9% of the normal total water year precipitation countywide.

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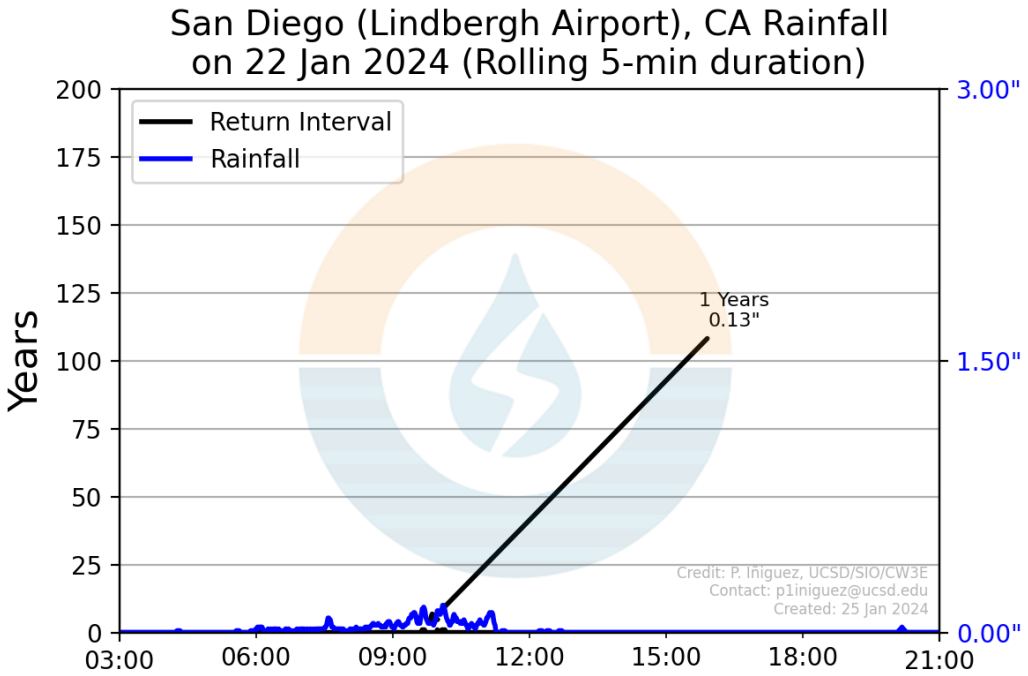


**For 5-min duration, the RI peaked at 1 year (100% chance to occur in a year).**

Precipitation (blue) return interval (RI, black) analysis for San Diego based on 1-min sampling (times are local).

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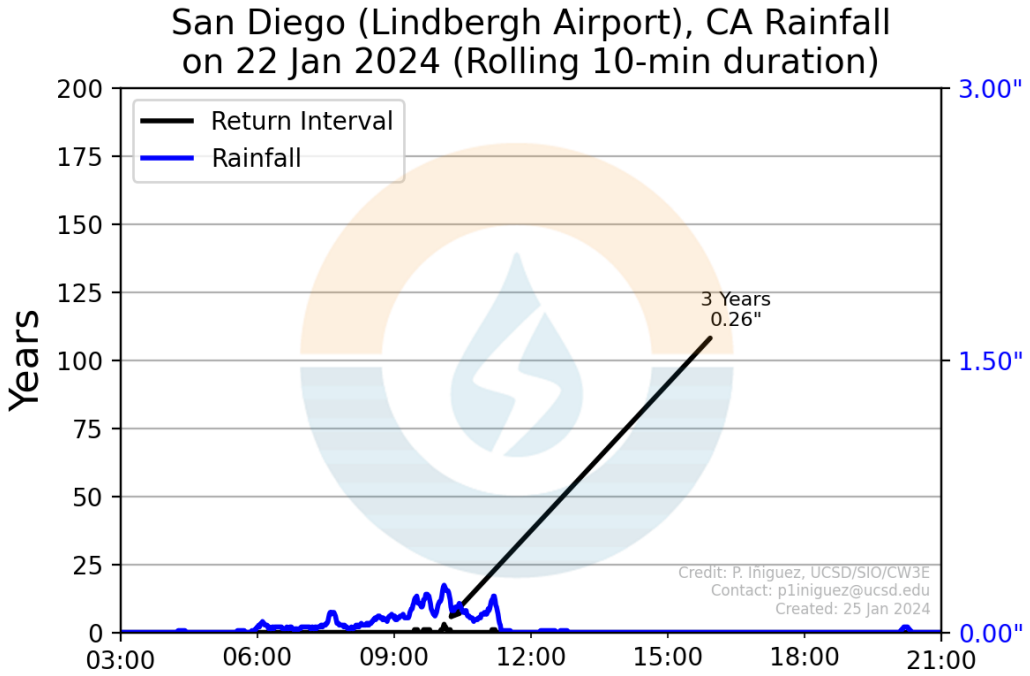
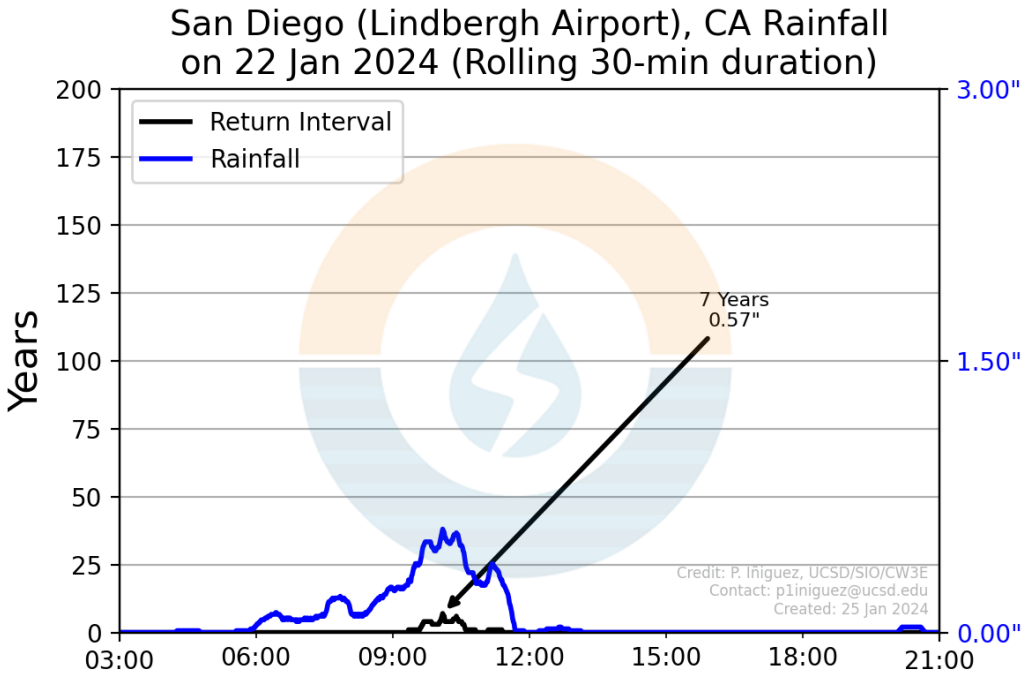



**For 10-min duration, the RI peaked at 3 years (33% chance to occur in a year).**

Precipitation (blue) return interval (RI, black) analysis for San Diego based on 1-min sampling (times are local).

# CW3E Analysis: Heavy Rain in San Diego, CA (22 Jan 2024)




**For 30-min duration, the RI peaked at 7 years (14% chance to occur in a year).**

Precipitation (blue) return interval (RI, black) analysis for San Diego based on 1-min sampling (times are local).

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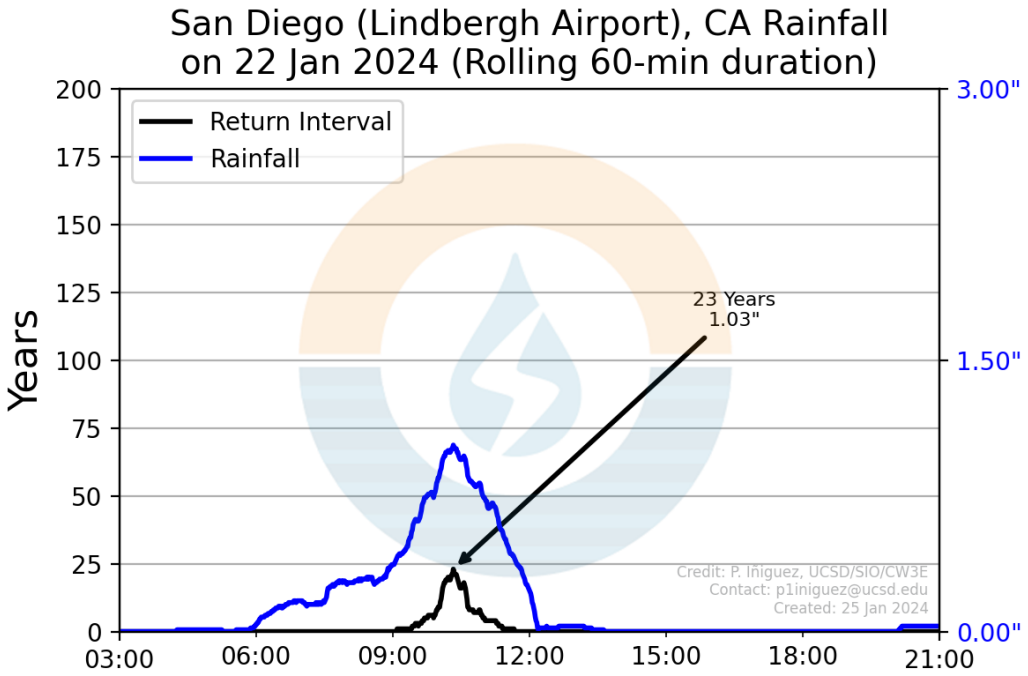


**For 60-min duration, the RI peaked at 23 years (4% chance to occur in a year).**

Precipitation (blue) return interval (RI, black) analysis for San Diego based on 1-min sampling (times are local).

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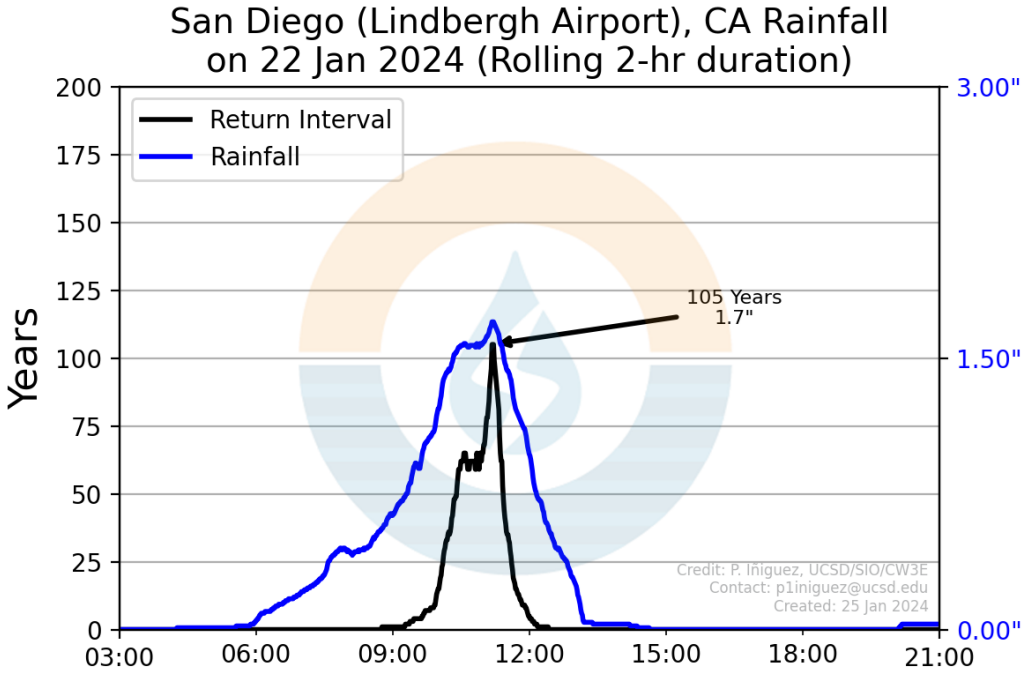


**For 2-hr duration, the RI peaked at 105 years (1% chance to occur in a year).**

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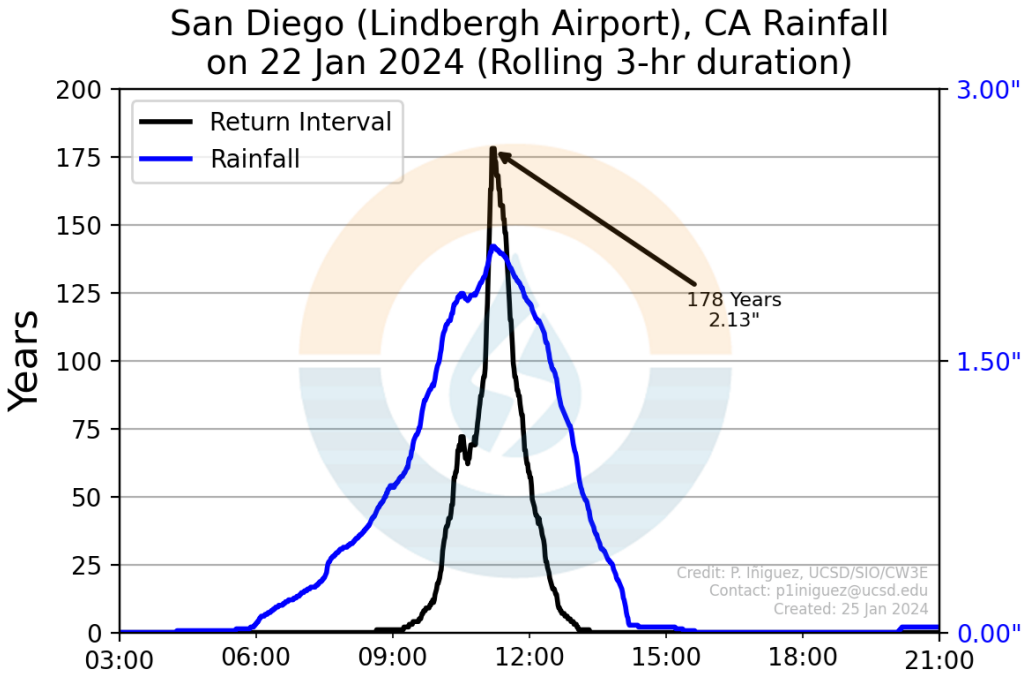


**For 3-hr duration, the RI peaked at 178 years (0.6% chance to occur in a year).**

Precipitation (blue) return interval (RI, black) analysis for San Diego based on 1-min sampling (times are local).

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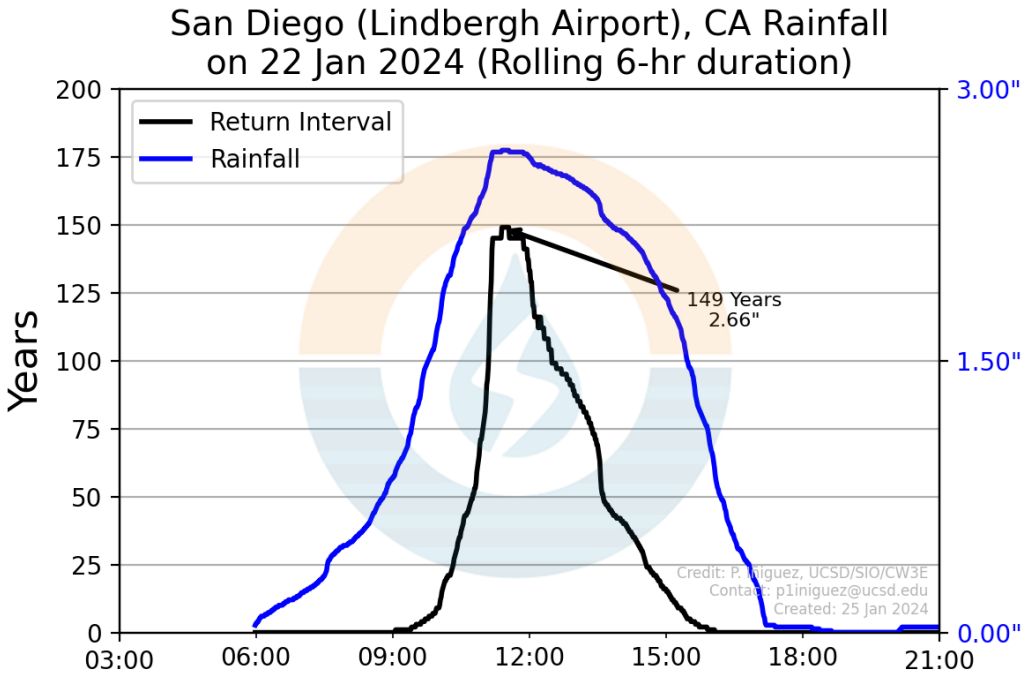


**For 6-hr duration, the RI peaked at 149 years (0.7% chance to occur in a year).**

Precipitation (blue) return interval (RI, black) analysis for San Diego based on 1-min sampling (times are local).

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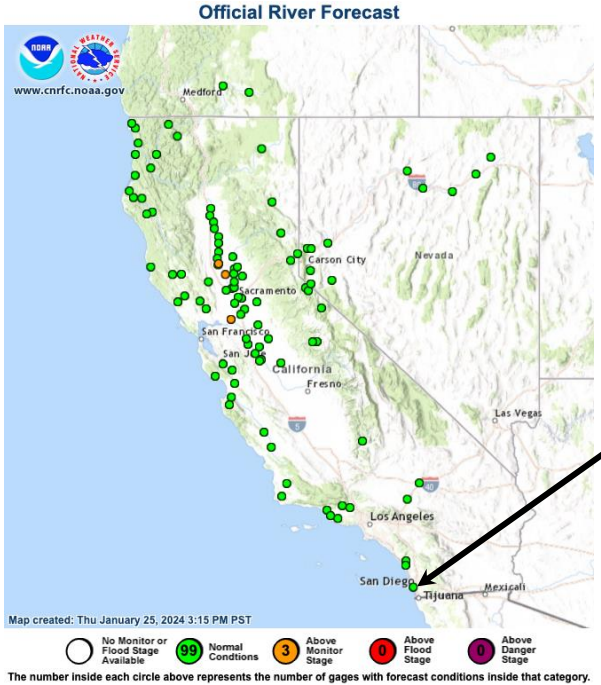


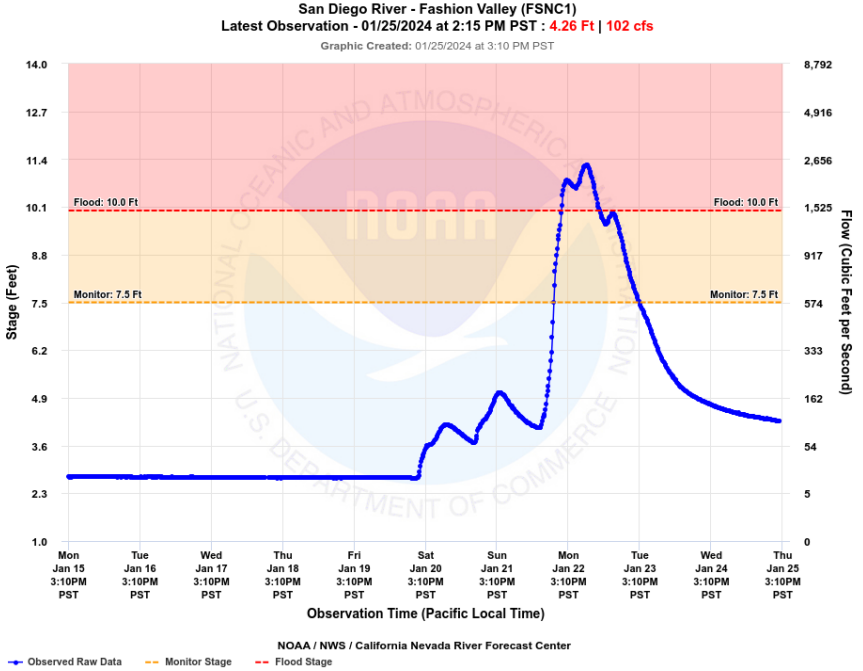


- Intense rainfall during the morning of 22 Jan caused a rapid streamflow response on the San Diego River.
- The San Diego River at Fashion Valley rose above flood stage during the afternoon, reaching a peak stage of 11.25 ft at 9:30 PM PT.

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**Caltrans San Diego workers remove debris from the side of the highway during the storm**

*Caltrans San Diego*
*https://twitter.com/SDCaltrans/status/1749966056863805889*


**Police officers perform water rescues in waist-deep flood waters using a paddle board**

*San Diego Police Department*
*https://twitter.com/SanDiegoPD/status/1749910156836757533*

**Firefighters perform a swiftwater rescue of two motorists trapped after their vehicle was overwhelmed by floodwaters**

*Cal Fire*
*https://twitter.com/CAL_FIRE/status/1749967332028657741*

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**Rescuers survey damaged vehicles that have been shifted and stacked on top of one another due to strong currents within fast-moving floodwaters**

*San Diego Fire-Rescue Department*
*https://twitter.com/SDFD/status/1749658900453052725*


**Firefighters use an extended ladder to reach individuals trapped in a building due to rising floodwaters**

*San Diego Fire-Rescue Department*
*https://twitter.com/SDFD/status/1749658900453052725*

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*Damage of Orange Line in the Encanto neighborhood.*
*https://twitter.com/sdmts/status/1749954566798582222*

@sdmts

#MTSAlert Riders: Thanks for your continued patience as we work to restore service following Monday's rain. We have some good news looking ahead, as well as some significant service news for the Orange Line for the foreseeable future.

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**Various lines of silt deposits illustrate the depth of floodwaters in a neighborhood in San Diego County**

*The County of San Diego*
*https://twitter.com/SanDiegoCounty/status/1749982286890561971*

**Manhole covers over stormwater drain pipes were lifted from their position as floodwaters overwhelmed drainage**

*San Diego Police Department*
*https://twitter.com/SanDiegoPD/status/1749910156836757533*

**Mud and other items cluttering a roadway and railroad crossing in an area of San Diego County impacted by floodwaters**

*The County of San Diego*
*https://twitter.com/SanDiegoCounty/status/1749982286890561971*