

AQPI Performance Evaluation for 20-23 2024 November Rainfall Event
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Issued: 31 Jan 2025

Meteorological and Hydrological Overview

A powerful storm and atmospheric river event impacted northern California from 20-24 Nov 2024. Northern portions of the AQPI domain, particularly in and around Sonoma County, saw enormous rainfall totals. The highest rainfall totals from this storm occurred in the Coast Ranges of Northern California, with a maximum of 22.57 inches at Venado in Sonoma County. NWS analysis shows the 3-day total of 12.47 inches in Downtown Santa Rosa qualifies as a 1 in 1,000 year event based on NOAA Atlas 14. According to analysis by the NWS California-Nevada RFC, the total 13.91 inches of rain at the Santa Rosa Airport was 41% of normal yearly rainfall. Storm-total rainfall also exceeded 20% of normal yearly rainfall at Ukiah (8.51 inches), Redding (7.18 inches), and Red Bluff (5.47 inches). Water-year-to-date precipitation over much of Northern California increased from < 70% of normal on 19 Nov to > 200% of normal on 24 Nov.

The heavy precipitation resulted in high streamflows across the area. Many CNRFC stream gauges exceeded their action/monitor stage, with several others observing minor flood conditions. A single gauge along the Eel River at Fernbridge eclipsed the moderate flood stage, rising to approximately 22 feet on 22 November. Reservoir levels also rose due to the heavy precipitation. Lake Sonoma exceeded 500 cfs for 20–25 Nov, peaking at 6,725 cfs on 21 Nov, greatly exceeding the -2.25 cfs average inflow from the previous month. Further south, Lake Oroville exceeded 9000 cfs for 21–25 Nov, peaking at 39,643 cfs on 22 Nov, far above the previous month’s average inflow of 2,131 cfs.

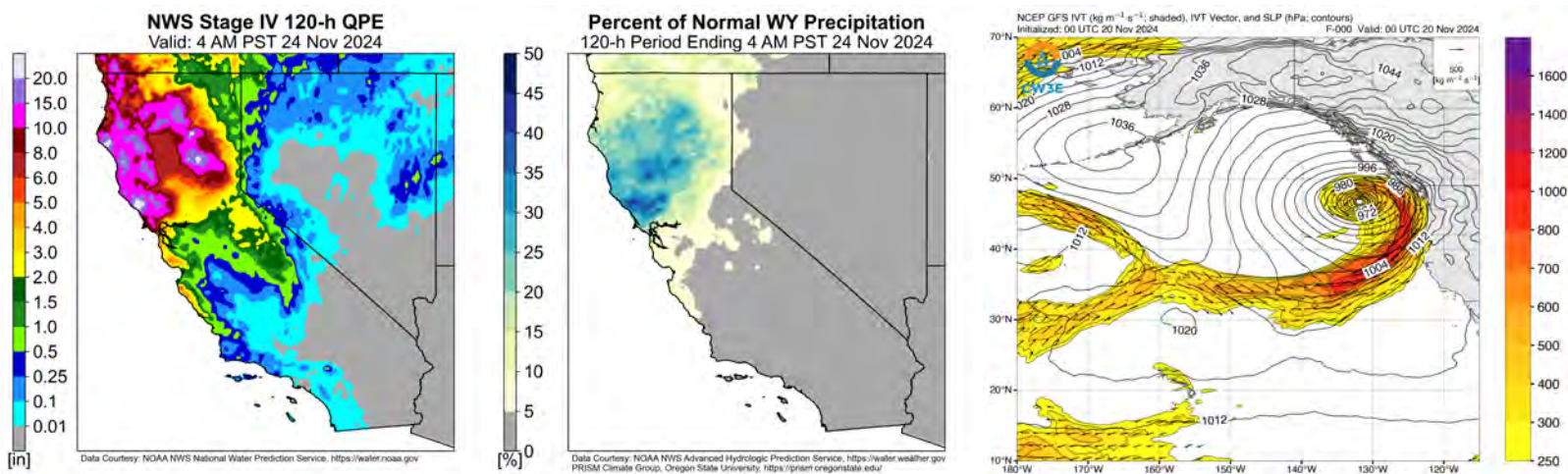


Figure 1: (left) 5-day rainfall total, (center) percent of normal water year precipitation, and (right) atmospheric water vapor transport, indicative of a strong atmospheric river impacting northern California.

AQPI Radar System Performance

For this event, we used rain gauges to compare AQPI rain rate estimates to those of the legacy system (a merged and QC'd product; MRMS) across Sonoma County and surrounding areas (i.e., areas covered by the Santa Rosa X-band radar; we are still awaiting archived data from the other AQPI radars to complete this analysis). Figure 2 shows an example of a gauge (FVSC1) where the X-band greatly outperformed MRMS in representing rain rates and event cumulative rainfall.

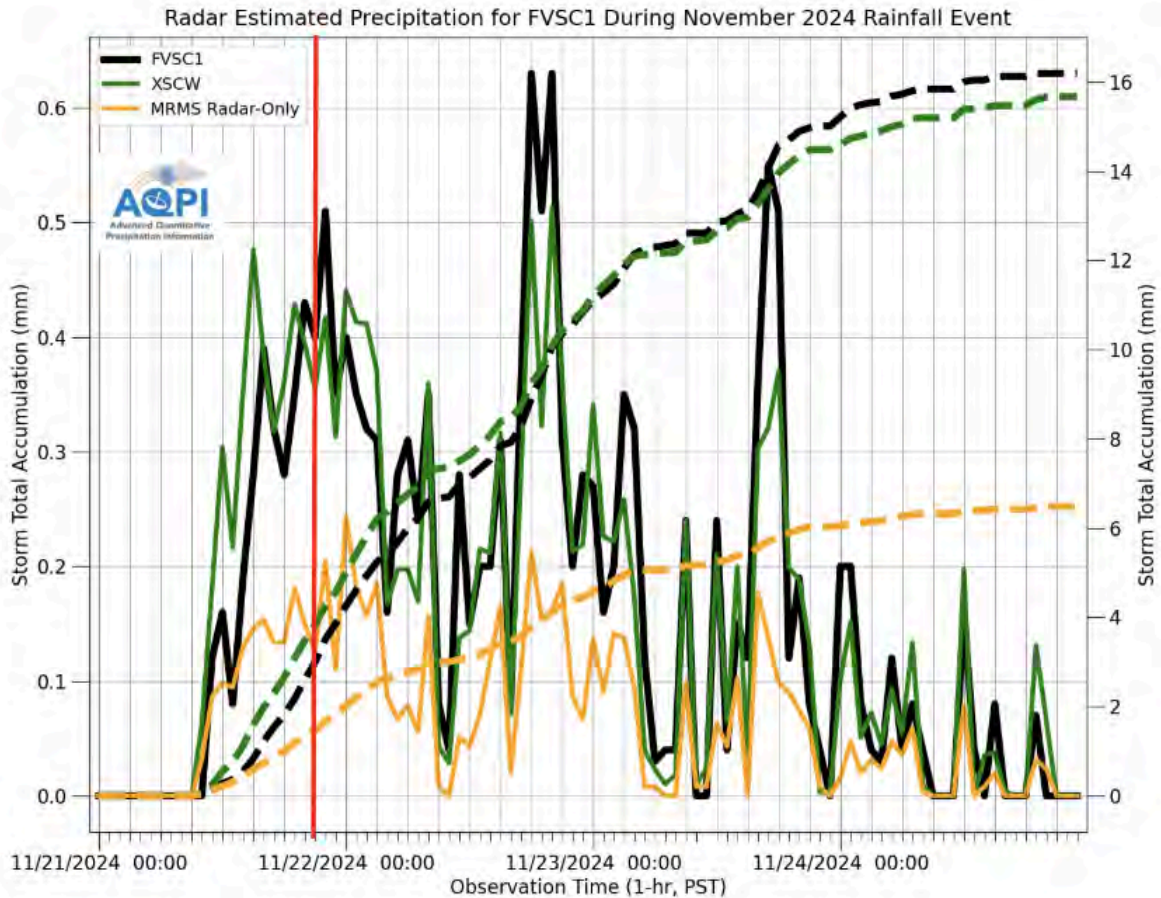


Figure 2: AQPI (green) and MRMS (gold) radar-estimated rain rates, as well as gauge-observed rain rates (black) at gauge FVSC1 during 21-24 Nov 2024. Thin vertical red line denotes a time step examined more closely in Figure 3.

Figure 3 below compares AQPI (left) and MRMS (right) radar-estimated rain rates at ~8:52pm PST on 21 Nov 2024, as denoted by the vertical red line in Figure 2. This is during a period when the AQPI estimates very closely matched gauge observations, whereas the MRMS estimates were far too low.

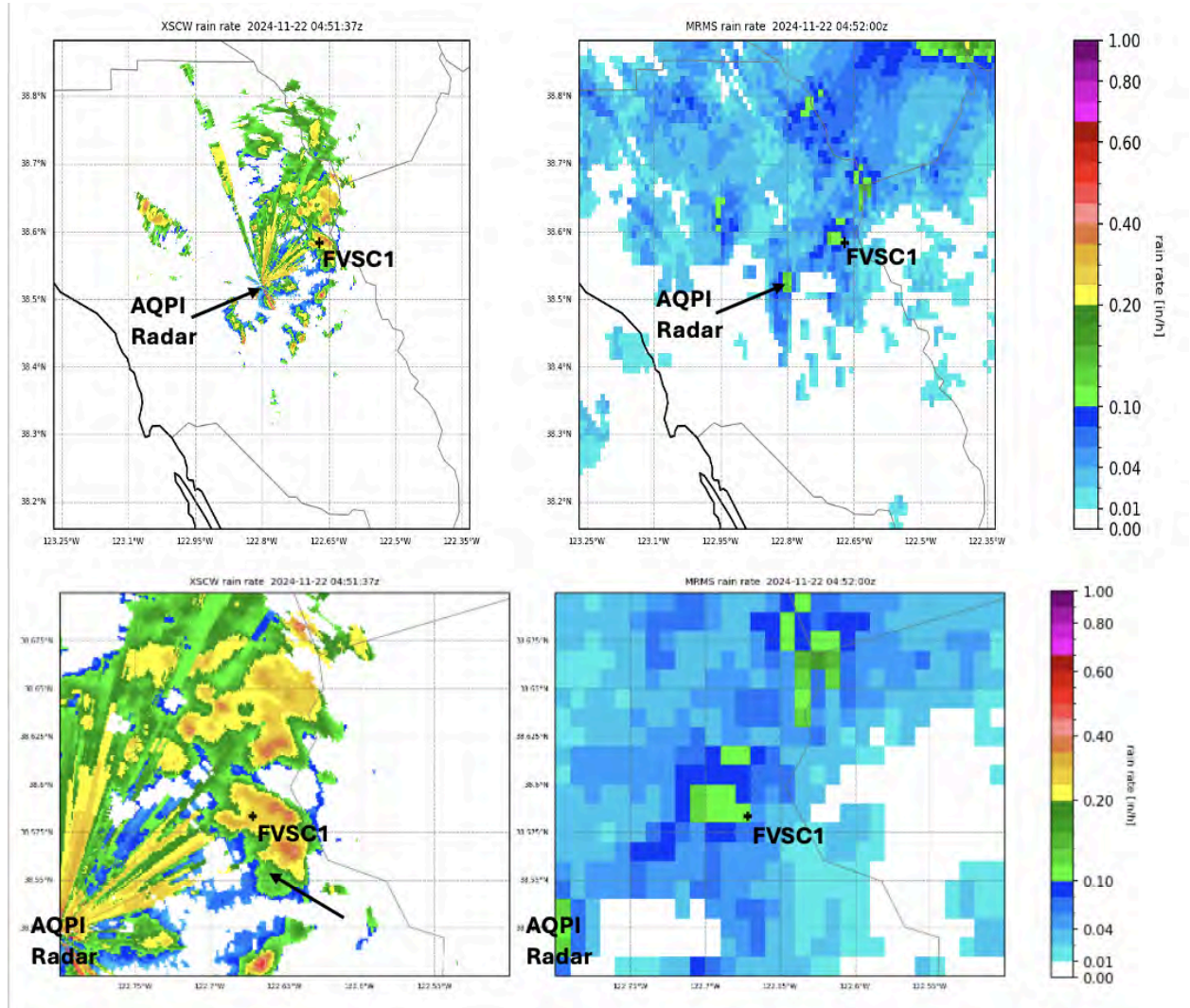


Figure 3: AQPI (left) and MRMS (right) radar-estimated rain rates at ~8:52pm PST on 21 Nov 2024. Locations of the AQPI X-Band in Santa Rosa, CA and the FVSC1 gauge are highlighted. Thin grey lines denote county boundaries.

The pattern shown by Figure 2 was fairly typical across the area, as shown in Figure 4, with the X-band outperforming MRMS at 60/68 (~88% of) gauge locations. The best X-band performance relative to MRMS was generally in areas closest to the X-band itself, whereas the worst X-band performance relative to MRMS was generally in areas near the edge of the X-bands range. The most extreme case of X-band underperformance, at gauge MSHC1, is a higher-elevation mountaintop, and it makes sense that the X-band located in the valley would not perform as well here due to limited “sight” (note that the C-band install this year will mitigate this weakness). Hence, the AQPI radar is performing exactly as planned by improving rainfall observations in lower-elevation, densely-populated urban areas, while the legacy network is complementary at other locales.

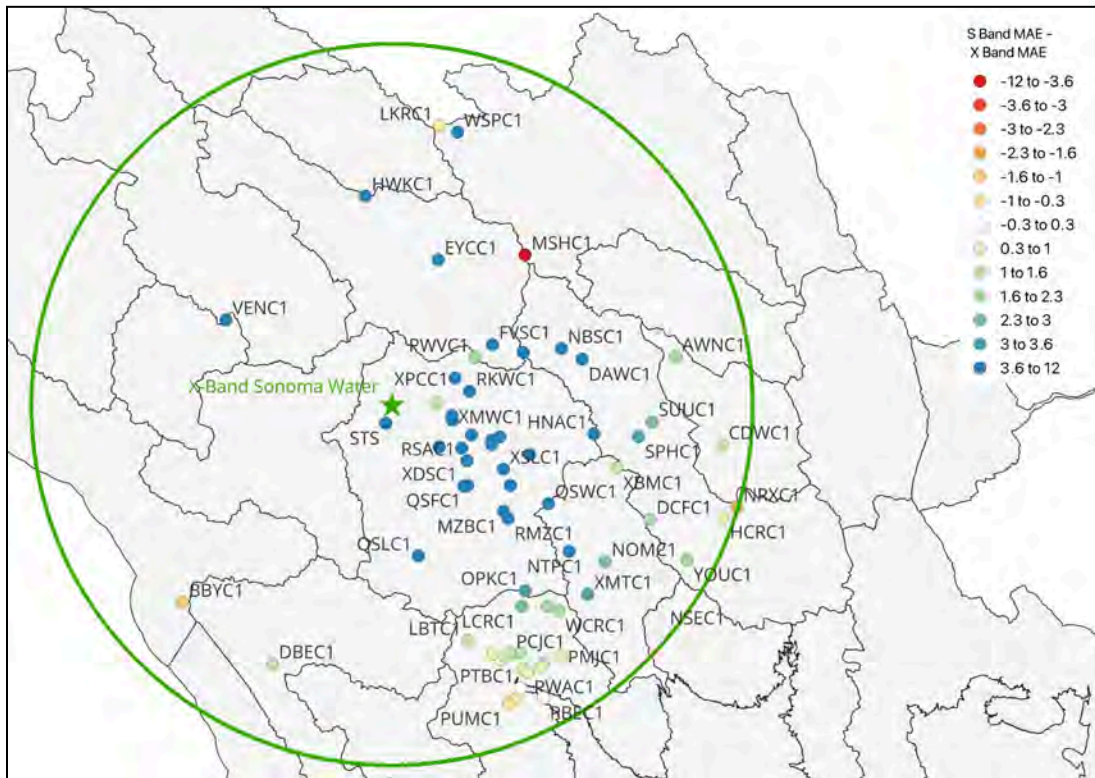


Figure 4: Difference between errors in AQPI and MRMS radar rain rate estimates at gauge locations across Sonoma County and surroundings during 21-24 Nov 2024 (color-shaded circles); blues & greens indicate better performance by AQPI and reds & yellows indicate better performance by MRMS. The green star shows the location of the AQPI X-band radar located in Santa Rosa, CA and the green ring indicates its range. The thin grey lines indicate HUC-10 level watersheds.

Overall, most of the AQPI-estimated rainfall totals are fairly reliable, as indicated by Figure 5, although substantial underestimates ($> \sim 5$ "") are noted for approximately ~ 7 locations. Note that the 4 green dots located along the horizontal "zero line" near the bottom of the plot are likely the result of gauge errors. In contrast, most of the MRMS-estimated rainfall totals are not, with underestimates that increase as a function of increasing gauge-observed precipitation.

All Product Estimated Precipitation Compared to Station Accumulations During November 2024 Rainfall Event

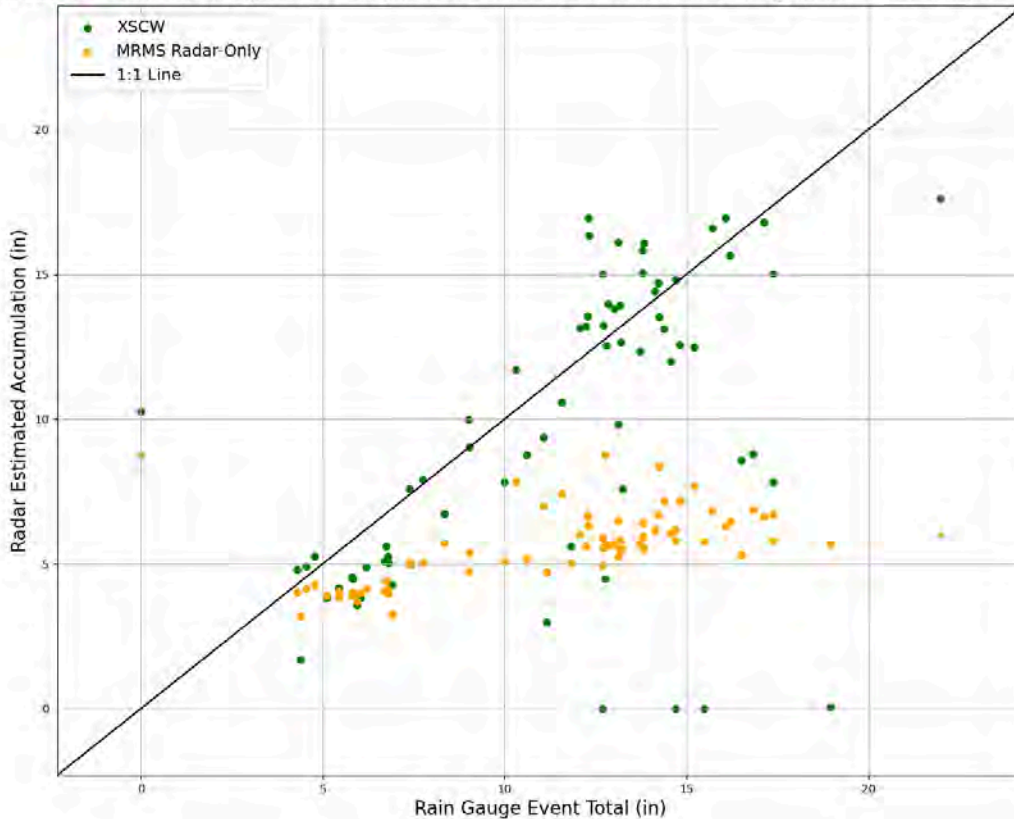


Figure 5: AQPI (green) and MRMS (gold) radar-estimated total rainfall vs. gauge-observed rainfall at gauge locations across Sonoma County and surroundings during 21-24 Nov 2024. The black diagonal line indicates where circles would lie if the radar estimate perfectly matched the gauge observation.

Future Effort: At the time of this analysis, only data from the Santa Rosa X-band was available. We are working to get a data set that covers the entire region so that we can also investigate results for areas covered by the Rocky Ridge, Santa Clara, and Santa Cruz radars.

Additional Considerations:

- Visit <https://www.weather.gov/nwrfc/> and <https://www.weather.gov/cnrfc/> for specific river and stream forecasts and <https://www.weather.gov/> for point specific watches, warnings, and forecasts.
- Visit AQPI User Interface for real time radar imagery, other observations and relevant forecast products: <https://cw3e.ucsd.edu/Projects/AQPI/main.html>