The Role of X-band Radars in Rainfall Estimation for Complex Terrain Applications

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Project Overview

The San Francisco Bay Area is covered by two operational S-band NEXRAD: KMUX and KDAX. However, the KDAX radar beams are partially blocked at low elevation angles due to the mountainous terrain, whereas the KMUX radar is deployed at an elevation of over 1000 m, which can easily overshoot precipitation during the winter storm season in Northern California. As a result, these two radars are not sufficient to provide detailed precipitation information for quantitative hydrometeorological applications.

The National Oceanic and Atmospheric Administration's (NOAA) Advanced Quantitative Precipitation Information (AQPI) project aims to improve monitoring and forecasting of precipitation, streamflow, and coastal flooding in the San Francisco Bay Area using a combination of observations and numerical models.

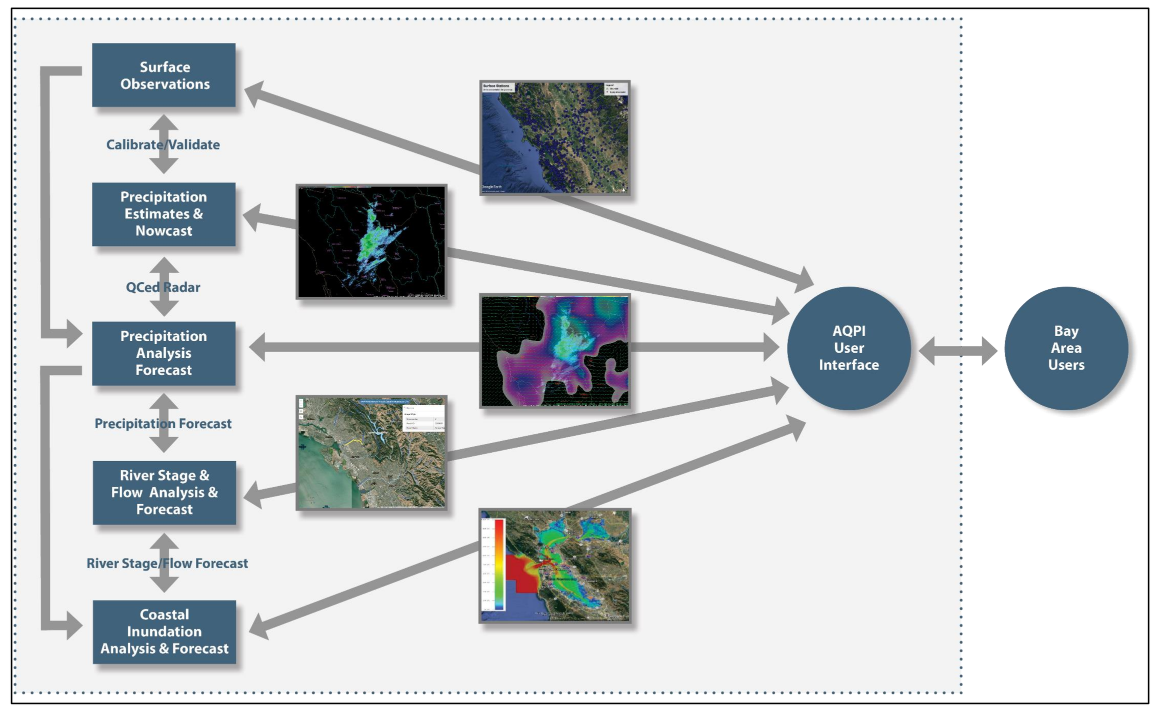

Fig. 1. AQPI System dataflow architecture.

AQPI is deploying 5 new polarimetric radar units strategically located to provide high-resolution coverage over populated and flood prone urban areas throughout the San Francisco Bay region and off shore.

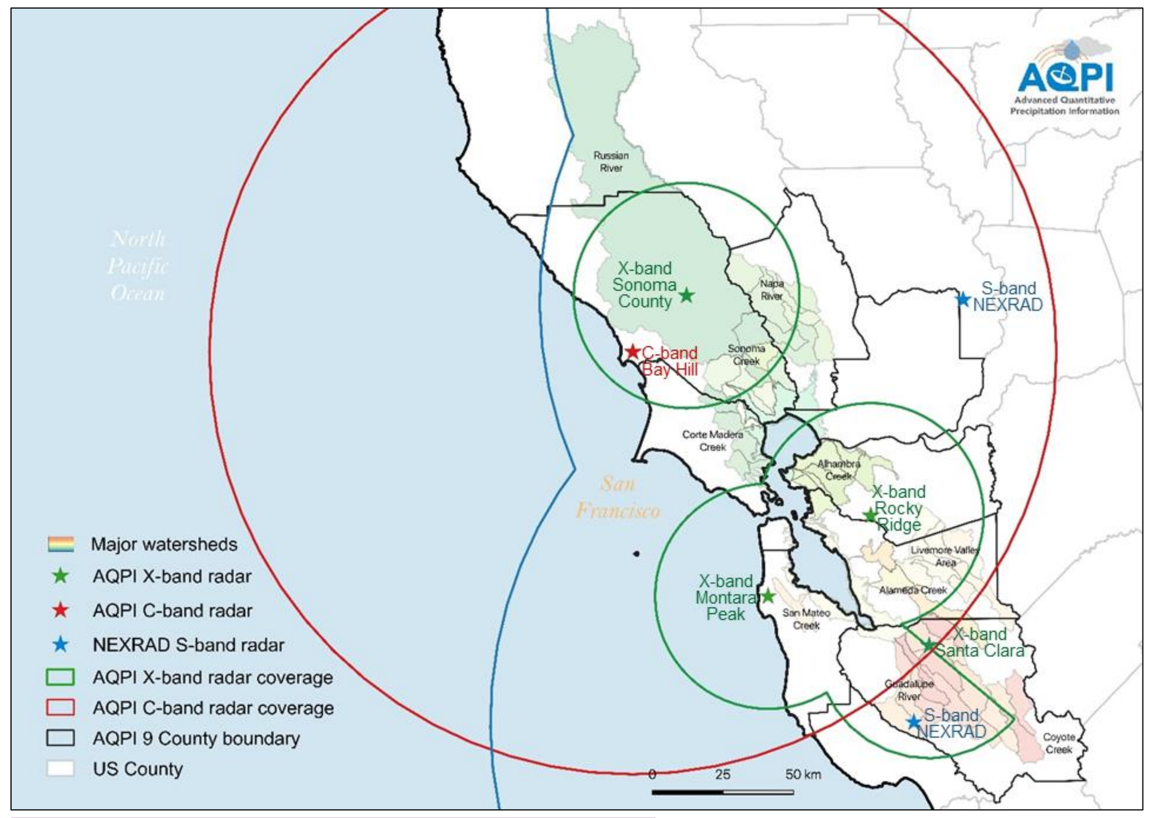

Fig. 2. The layout of AQPI radar network.

AQPI Radar Observations

Resolution	AQPI Radar	NEXRAD Radar
Temporal Resolution	<2 mins	5~6 mins
Range Gate Resolution	60 m	250 m (post-processed)
Product Resolution	250 m	1000 m

Funding for this project is provided by the California Department of Water Resources with in-kind matching resources provided by NOAA.

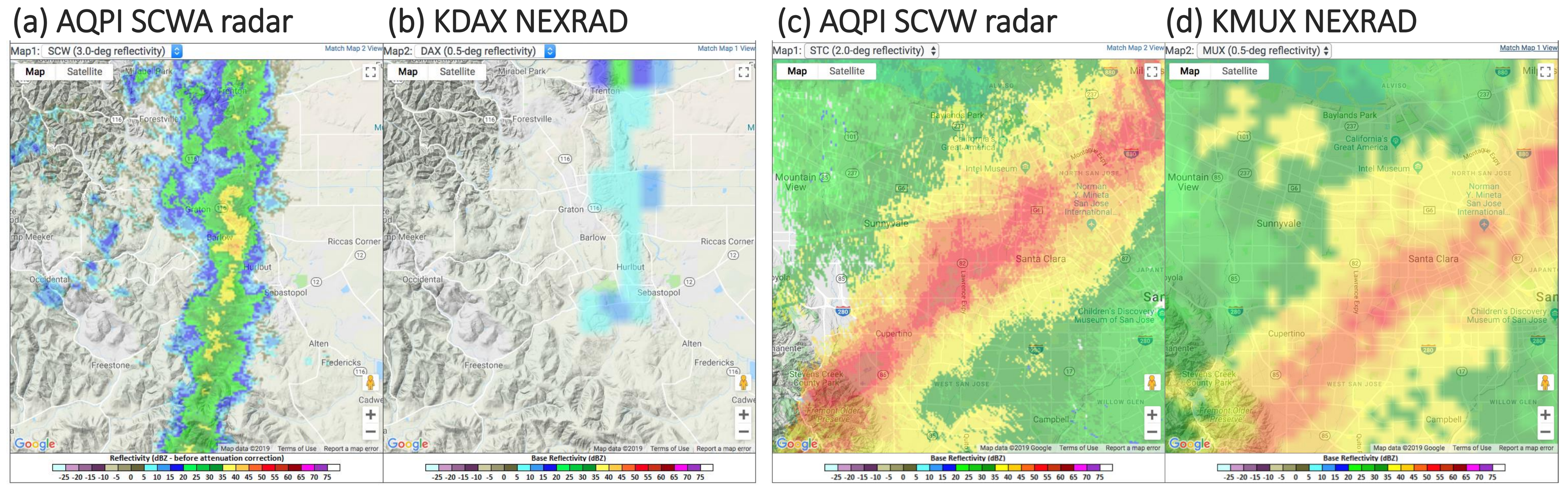

Fig. 3. Reflectivity observations from X-band AQPI radar versus S-band NEXRAD: (a)-(b) 2216UTC, 25 Feb 2019; (c)-(d) 0353UTC, 27 Nov 2019.

AQPI Radar Rainfall Product

Radar Rainfall Algorithm

$$R(K_{dp}) = aK_{dp}^{b}$$

- K_{dp}, in rain is more sensitive at X-band compared to lower frequencies such as S-band.
- $R(K_{dp})$ is less sensitive to raindrop size distribution (DSD) variation compared to those based on power terms such as Z and Z_{dr}.
- K_{dp} is immune to radar calibration, attenuation, and partial beam blockage issues.
- Even in the light rain regions (i.e., $Z < 30$ dBZ, or $K_{dp} < 0.3$ deg/km), $R(K_{dp})$ performs very well.

Case Study: 1 February 2019

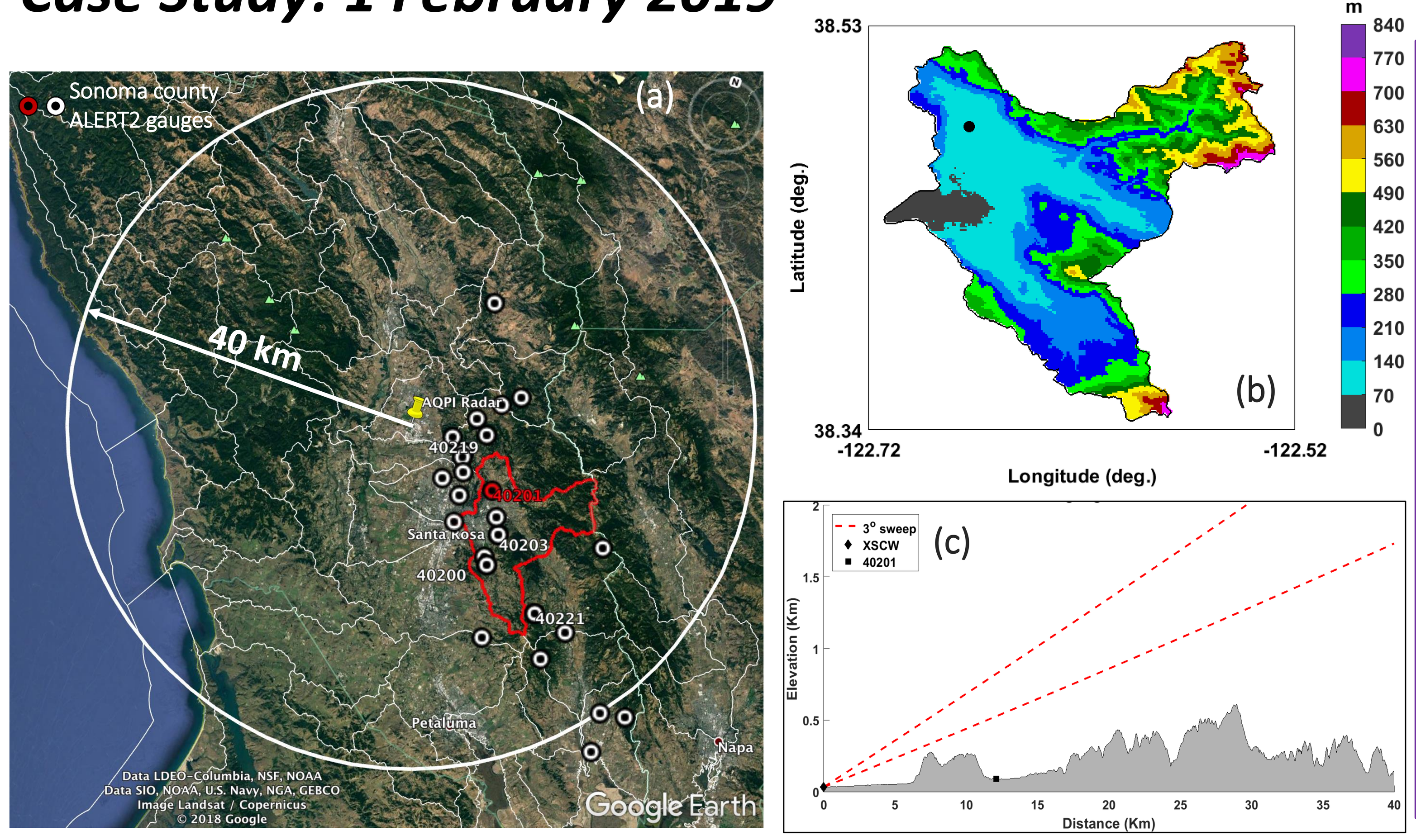

Fig. 4. (a) AQPI radar in Sonoma county: white circle indicates the 40 km coverage range; red and thin white contours indicate watershed boundaries. (b) terrain in a selected watershed. (c) radar sampling geometry pointing to a gauge station in the selected watershed.

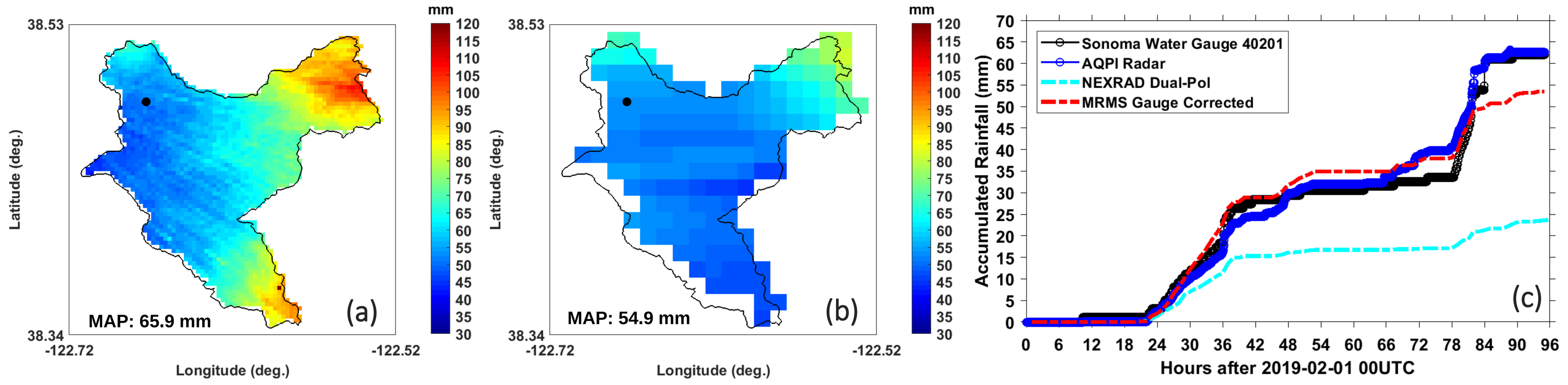

Fig. 5. Rainfall totals and mean areal precipitation (MAP) from (a) AQPI radar and (b) MRMS system (gauge-corrected) during 1-4 Feb 2019. (c) Rainfall accumulations at a selected gauge station.

Case Study: 13 February 2019

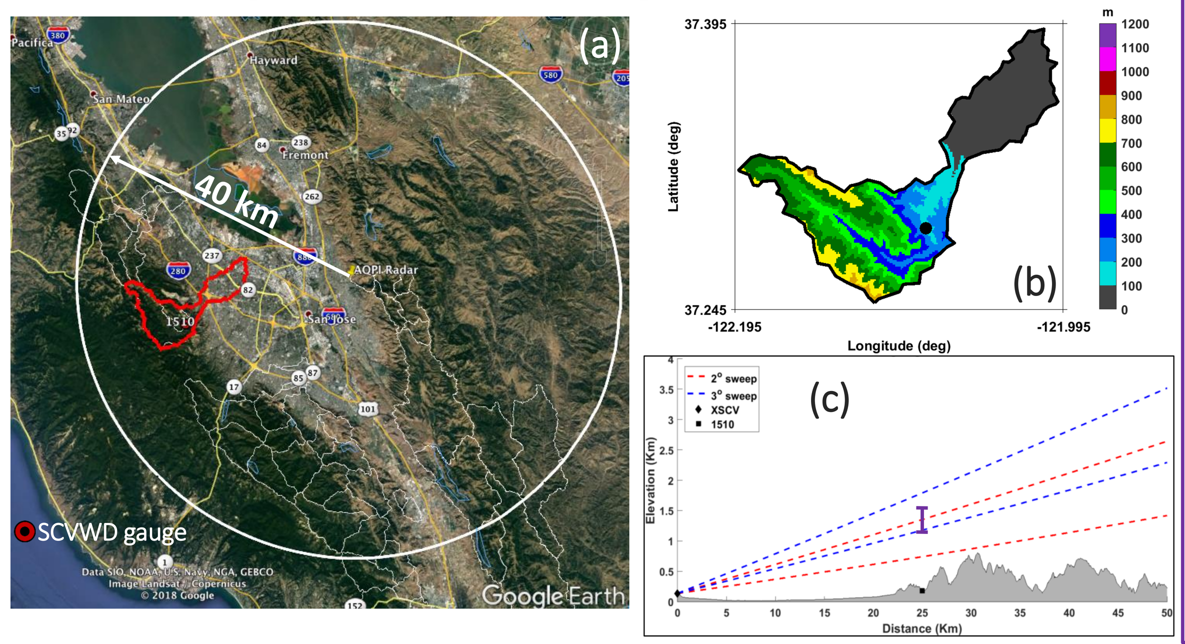

Fig. 6. (a) AQPI radar in Santa Clara; red and thin white contours indicate watershed boundaries. (b) terrain in a selected watershed. (c) radar sampling geometry pointing to a gauge station in the selected watershed. Purple bar indicates KMUX radar 0.5-deg beam height over the gauge location.

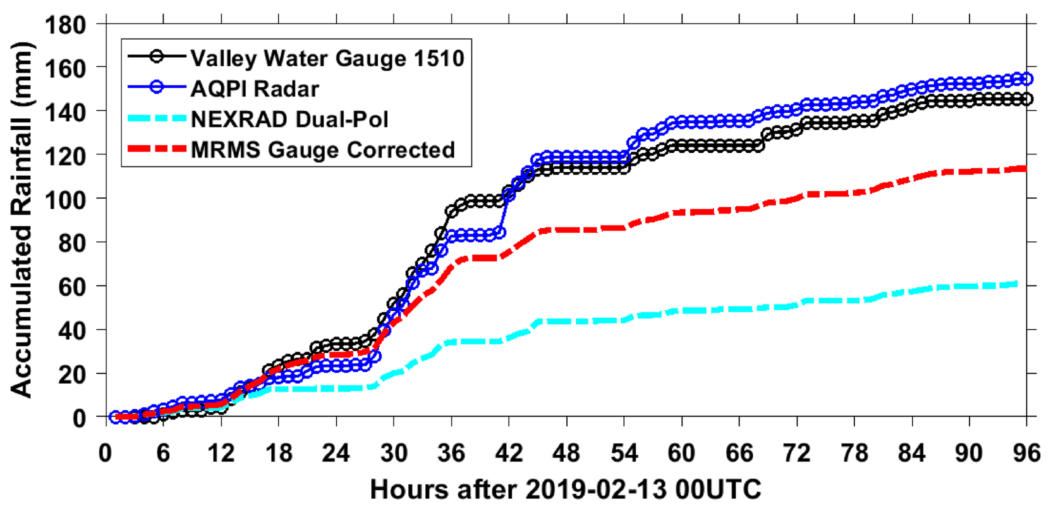

Fig. 7. Rainfall accumulations at a selected gauge station during 13-16 Feb 2019.

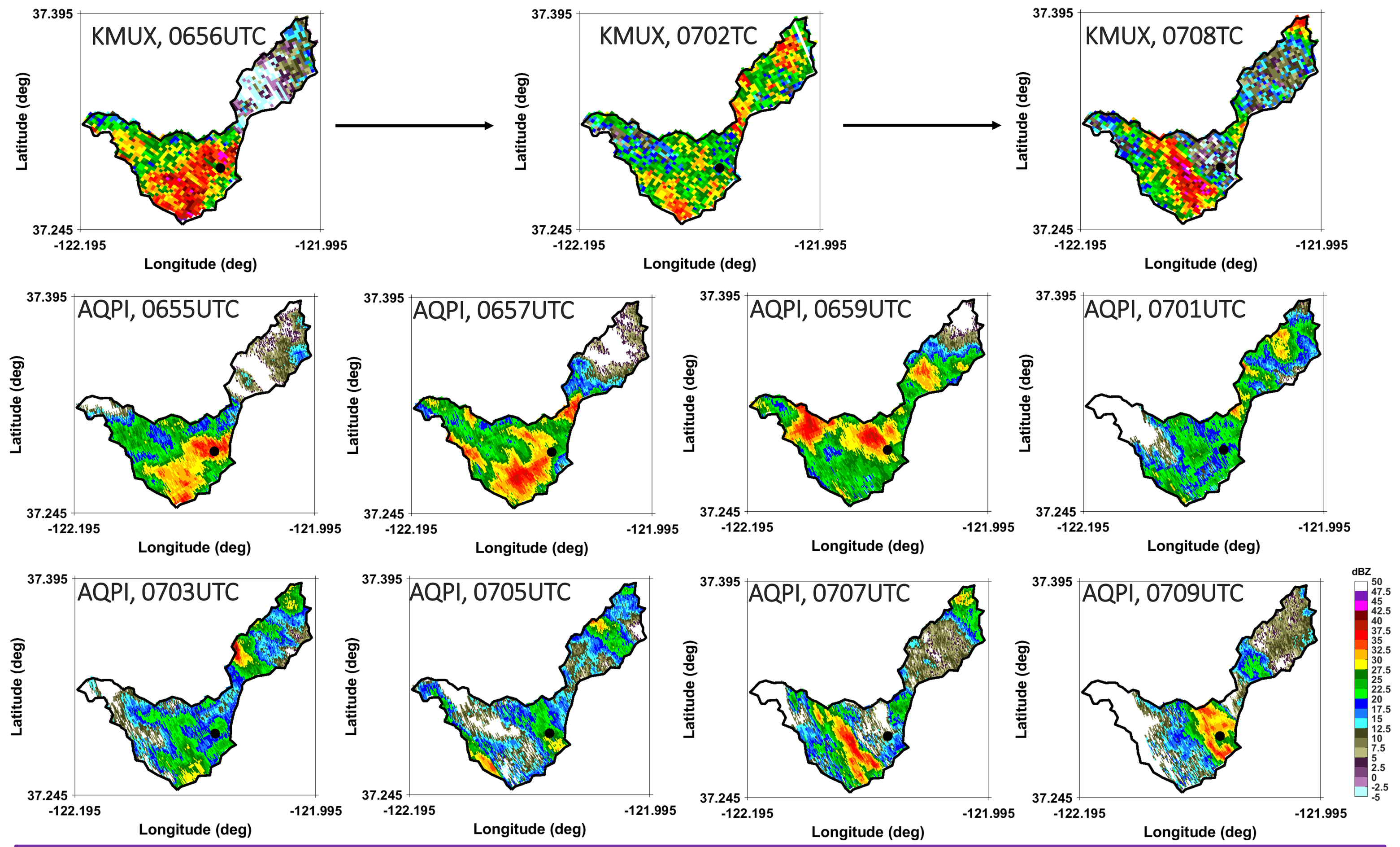

Fig. 8. Comparison of reflectivity evolution observed by AQPI radar and NEXRAD on 14 Feb 2019. Critical evolving features may be missed by NEXRAD due to coarse temporal resolution, leading to underestimation in QPE.

Summary

- To date, AQPI has deployed two X-band radar systems; two more are scheduled for installation in the next few months.
- The radar information is being used by local water managers for situational awareness and to inform decision making.
- The AQPI X-band radar provides reasonable QPE without gauge-based correction compared to gauge measurements.
- The AQPI radar QPE has much higher spatiotemporal resolution so it observes much more variability within watersheds compared to NEXRAD QPE.
- Research is underway to assess the streamflow sensitivity to different precipitation inputs (see Poster H43I-2115).
- For more information about AQPI, visit https://www.esrl.noaa.gov/psd/aqpi/