Beam occultation impacts on quantitative precipitation estimates from the Purdue University X-band Teaching and Research Radar (XTRRA)

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Will Masking Radar Blockages Help Improve QPE Error?

The X-band Teaching and Research Radar (XTRRA) at Purdue University is located 210 meters above sea level. Despite this, XTRRA still faces a constantly-changing blockage environment due to deciduous vegetation and construction of new buildings. We hypothesized that filtering blockage-contaminated data would help improve the radar-based precipitation estimates. Purdue's Department of Civil Engineering periodically maps the Lafayette area using airborne, high resolution lidar scanners. We used this lidar data to construct a blockage lookup table for XTRRA. Afterward, this table was used to mask the XTRRA-based precipitation estimates from 2021. The new masked precipitation estimates were then compared to ground observations from 110 rain gauges spread across Tippecanoe county, where Purdue is located.

Figure 1. Image of Purdue University's X-band Teaching and Research Radar.

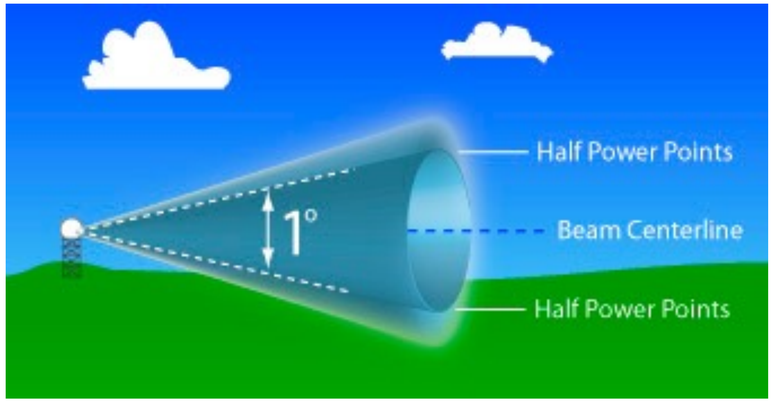

Figure 2. Visualization of XTRRA's 1° Doppler radar beam as a spotlight. (National Weather Service, 2022).

Occultation Fraction Calculation

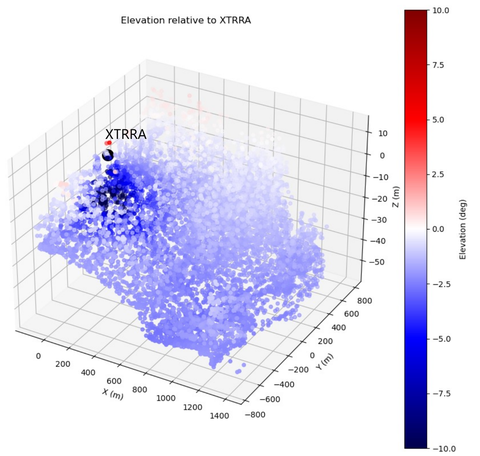

Figure 3. Elevation of topography immediately surrounding XTRRA.

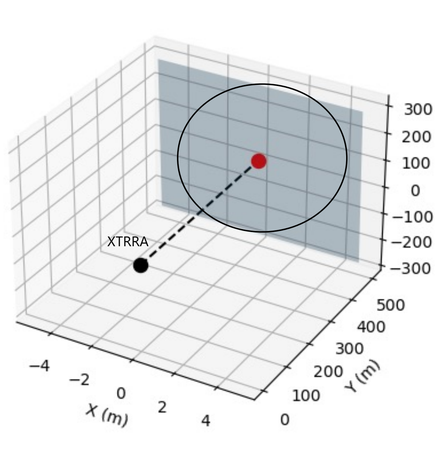

Figure 4. Spotlight projection method used in Python environment.

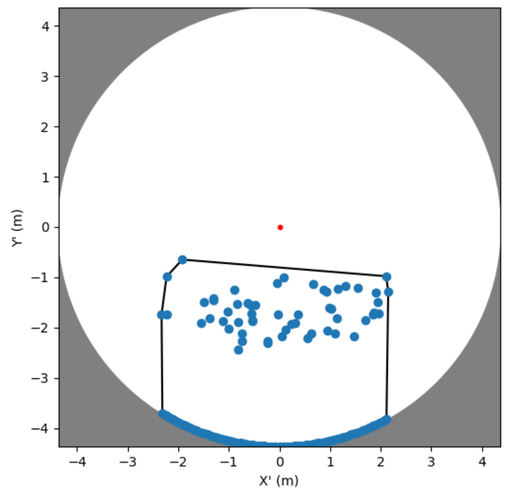

Figure 5. Spotlight projection in 2-D with LiDAR data points, connected to form a shape.

Occultation Lookup Table Conclusions

Masking ≥70% occulted gates resulted in modest improvements to RMSEs relative to rain gauge data, but it also removed nearly 67% of available gauge data from the validation workflow. Using high-resolution lidar scans of Purdue campus, we were able to construct an occultation lookup table for XTRRA using the spotlight conceptual model shown in Figure 4. This technique can be applied anywhere with recent, high-resolution lidar data available around the radar site, using open-source Python software.

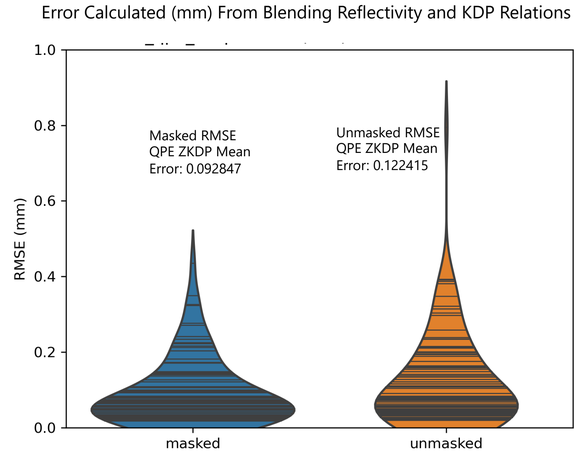

Figure 6. Normalized-area violin plots of RMSE (in mm per 15 min) of estimated rainfall based on XTRRA Z and KDP, relative to WHIN (Wabash Heartland Innovation Network) rain gauge measurements for 2021. "Masked" means that XTRRA gates that are more than 70% occulted at 0.5°. Improbable outliers were excluded from both data sets as instrumentation error.

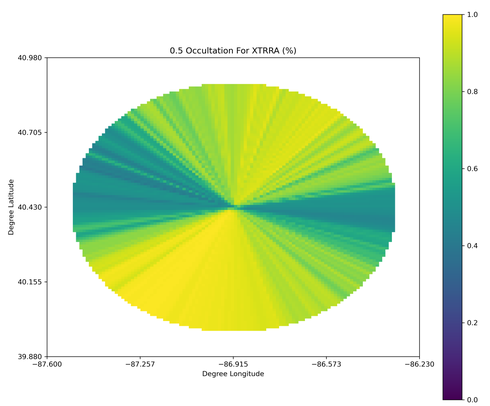

Figure 7. Occultation values surrounding XTRRA at 0.5° elevation angle.

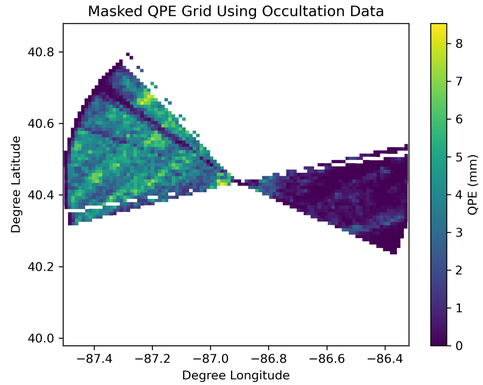

Figure 8. Masked QPE grid using a 70% occultation cutoff value.

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