Direct Comparisons of Snow Water Equivalent from C-Band and S-Band Radar

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Motivation and Fundamentals

Empirically derived power law relations for rainfall rate from weather radar abound, while relations for snow water equivalent (SWE or S) rate are not as numerous. Previously, the coefficients of an $S(Z_{eH})$ relation were derived by Hassan et. al (2017); the coefficients for a $S(Z_{eH}, Z_{DR})$ were also derived using data from the Dual-Pol (DP) C-Band radar at King City (CWKR), where Z_{eH} is equivalent horizontal reflectivity and Z_{DR} is differential reflectivity. The algorithm output from CWKR using these derived coefficients was then correlated with ground measurements of snow accumulation in Southern Ontario.

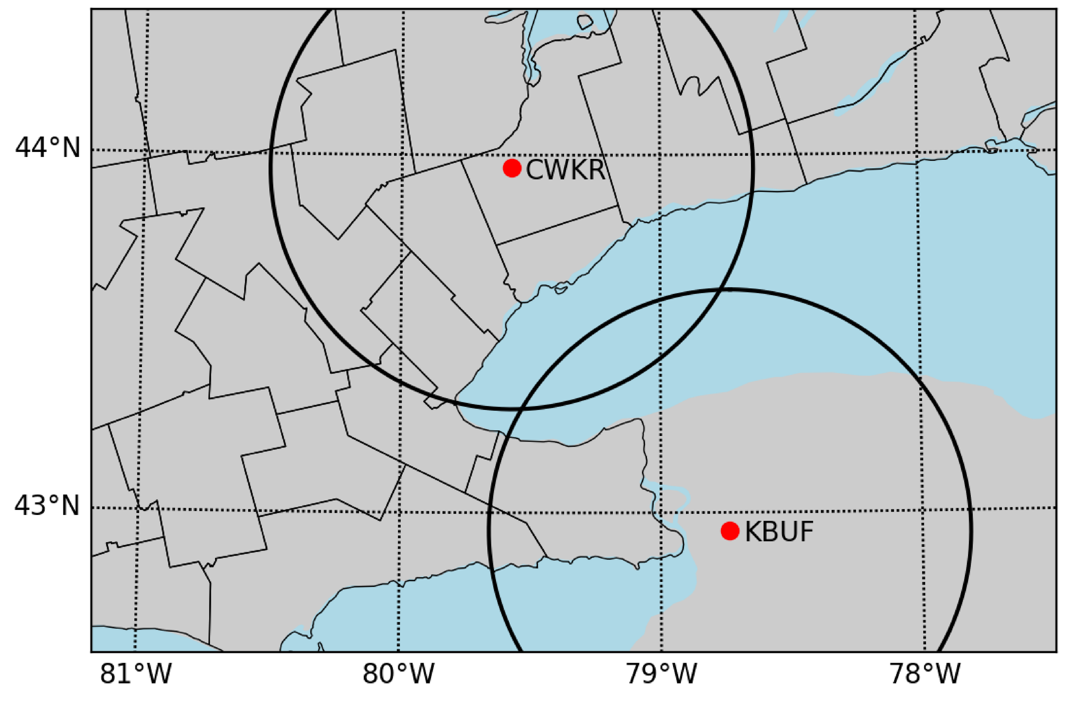

Figure 1: Map depicting the locations of the radars used in this study as red dots, with corresponding 75km range rings.

- Previous conclusions noted that the addition of Z_{DR} **did not** improve SWE estimates
- Hassan et. al (2017) coefficients performed **better** than Sekhon and Srivastava (1970) coefficients used at Environment Canada (EC)
- End goal here is to confirm the previous findings, but also demonstrate the value of Z_{DR} in a SWE relation

Here, radar data from CWKR is cross-compared with a neighboring radar to the south in the US, KBUF. Only data over Lake Ontario is considered, as the radars have similiar sampling volumes here. This overlap in coverage is shown Fig. 1. The corresponding data is then used as input in several algorithms for CWKR, and one baseline algorithm at KBUF.

Methodology

Radar data are transformed onto a common Cartesian grid using a Barnes distance-weighting scheme in Py-ART, with data over land masked to avoid ground clutter. Only horizontal distances are considered in the distance-weighting scheme, as only the lowest elevation angles are used. Five lake-effect snow events over Lake Ontario chosen for comparison, as shown in Table 1.

Sounding Time	Radar Times	Sfc. Temp	850mb Temp
2014-01-23 00Z	01-10Z	-22.5	-14.9
2015-01-06 12Z	12-17Z	-20.1	-11.7
2015-02-14 12Z	10-14Z	-14.9	-6.9
2015-02-18 12Z	21-00Z	-17.3	-10.1
2016-02-10 12Z	13-00Z	-10.5	-2.7

Table 1: Critical level temperatures (℃) from KBUF sounding launch closest to event

Radar Moments Comparison

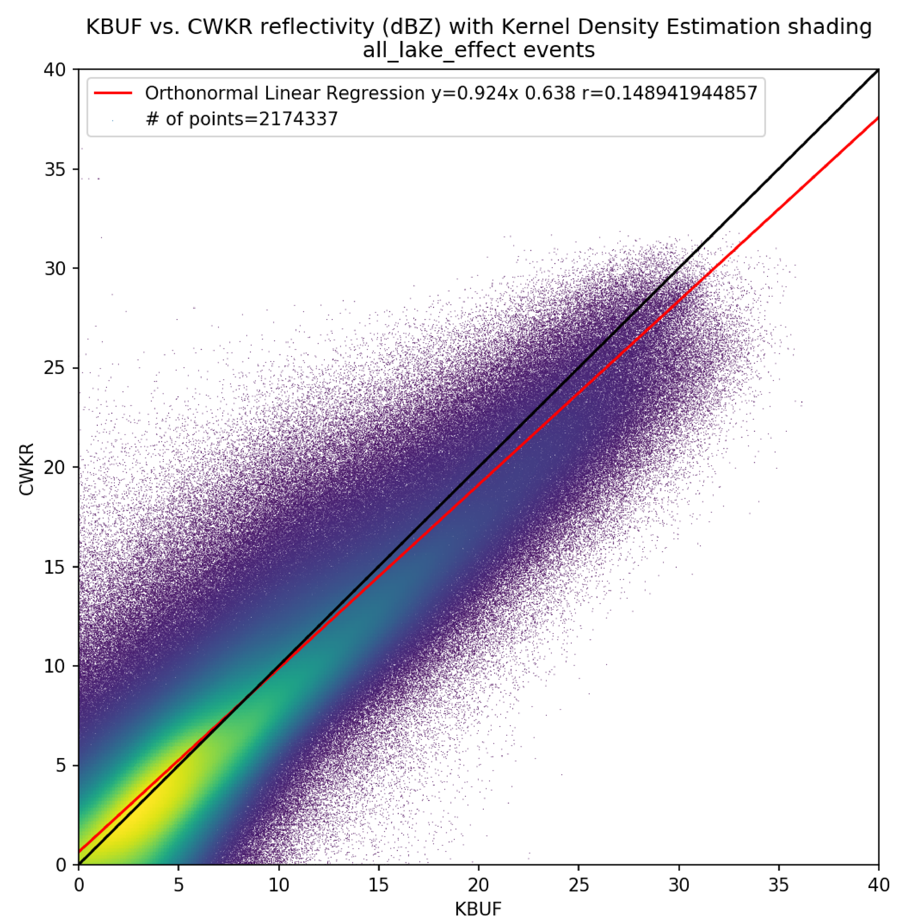

Figure 2: Scatterplot comparing all grid point reflectivity (dBZ) values as calculated from radar moments at KBUF vs. CWKR

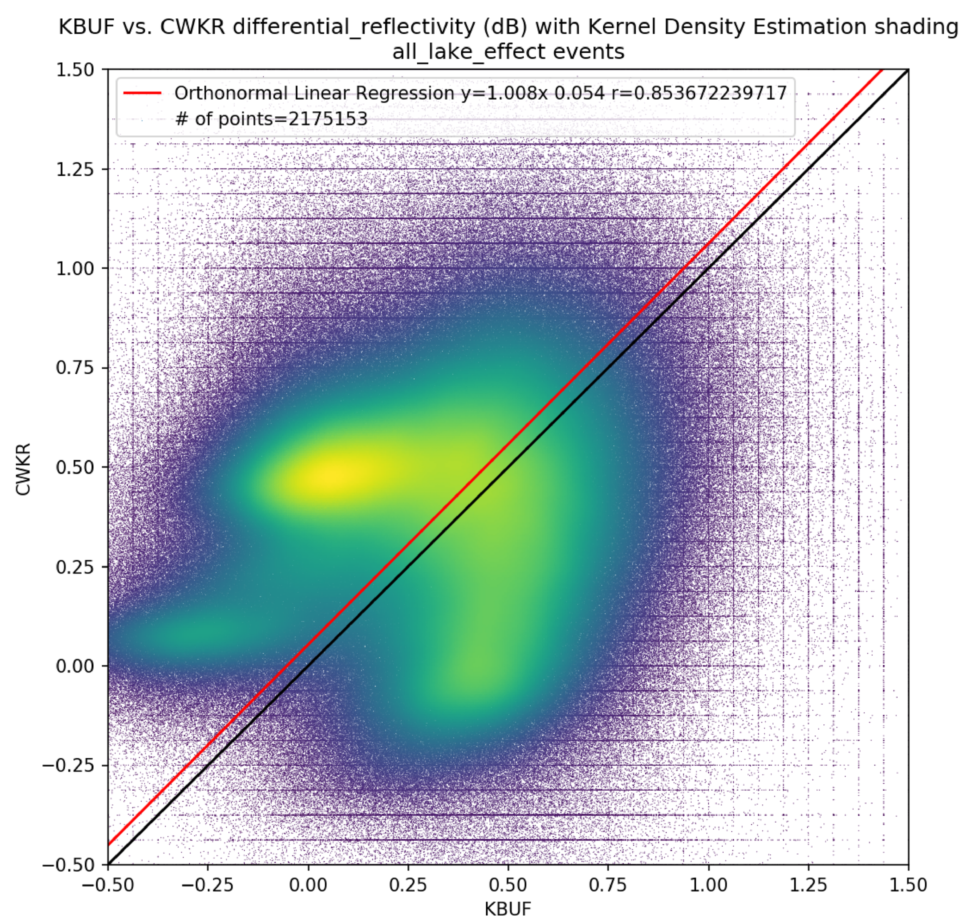

Figure 3: Scatterplot comparing all grid point differential reflectivity (dB) values as calculated from radar moments at KBUF vs. CWKR

Algorithm Output Comparison

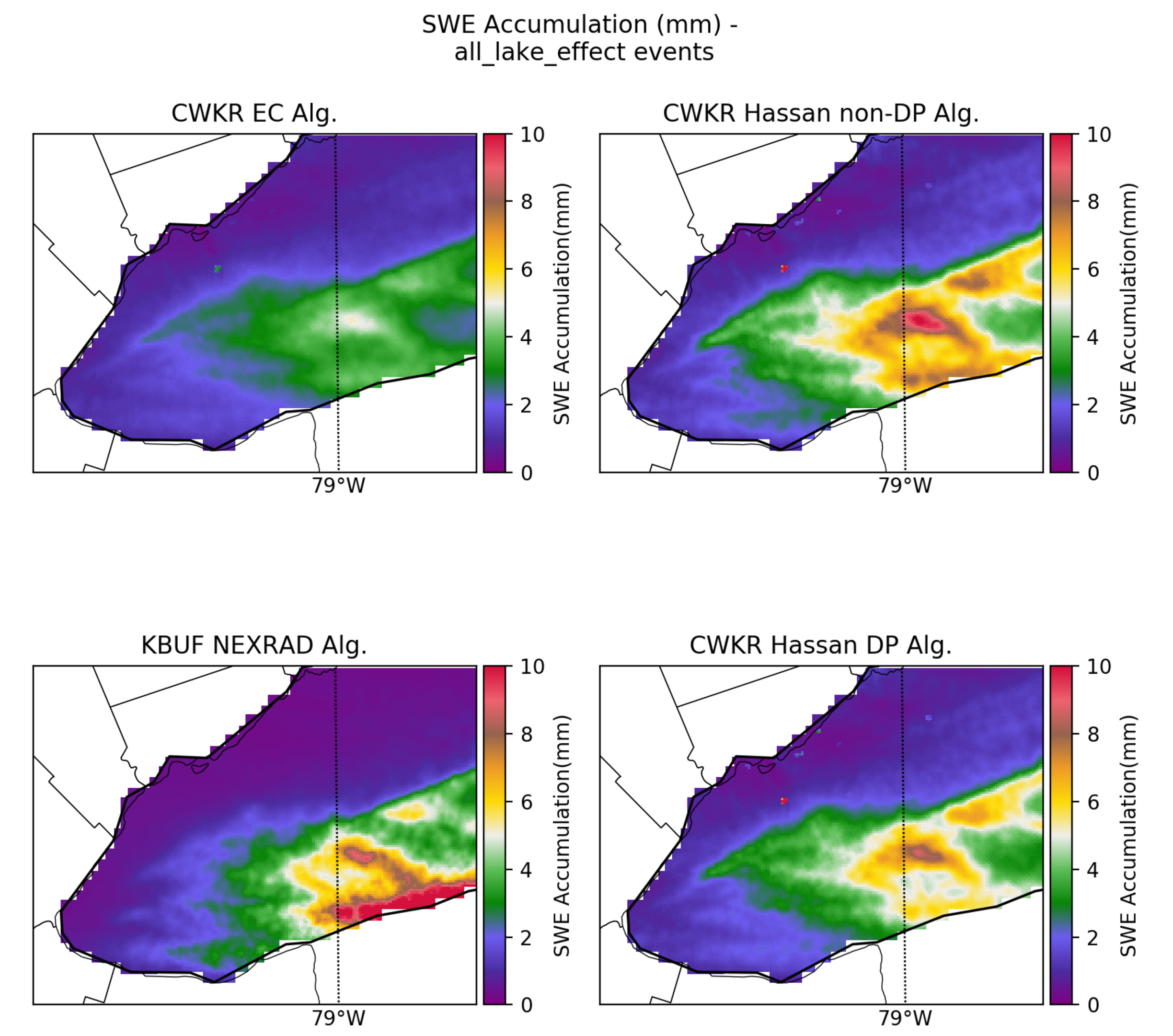

Figure 4: Maps comparing SWE accumulation (mm) from four different algorithms

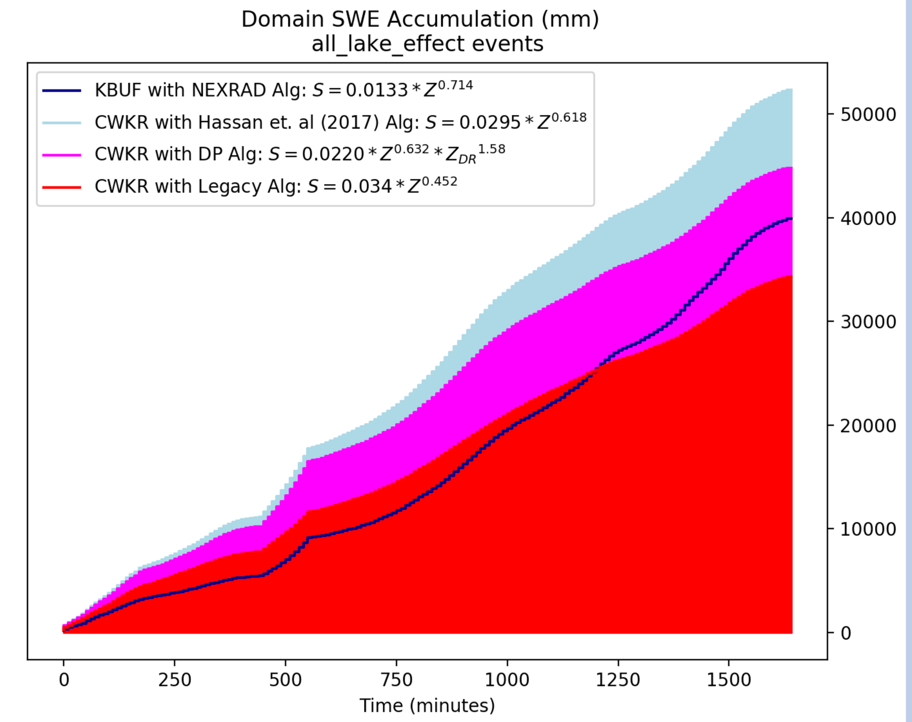

Figure 5: All events combined time series of accumulated SWE (mm) over Lake Ontario

General form of algorithms used

$$S(Z_{eH}) = \alpha Z_{eH}^{\beta}$$
$$S(Z_{eH}, Z_{DR}) = \alpha Z_{eH}^{\beta} Z_{DR}^{\gamma}$$

Discussion

- Fig. 2 shows good agreement between radars for the common grid Z_{eH} values. This means that algorithms based on reflectivity can be reliably compared between radars.
- Fig. 3 shows that the grid differential reflectivity is highly uncorrelated. This could be due to calibration differences at the radar, or attenuation at C-Band.
- In Fig. 4, it is shown that the good spatial agreement between, while the Legacy EC algorithm at CWKR is underestimating SWE in comparison with the NEXRAD algorithm at KBUF.
- In the final Fig. 5, the progression in time of SWE accumulation shows that initially, the legacy algorithm at CWKR follows closer with the NEXRAD algorithm at KBUF, but in the end the Hassan DP algorithm matches the closest with NEXRAD. Also of note is that the non-DP algorithm overestimates SWE in comparison with the DP algorithm and NEXRAD.

Conclusions

1. It has been shown that is is possible to make bulk, direct comparisons between these two radar systems, at least in terms of Z_{eH}.
2. On longer time scales, i.e. for purposes of hydrology, the addition of Z_{DR} can reduce the overestimation of SWE in dry snow.
3. The performance of the the Hassan algorithm set has been proven versus the legacy EC algorithm
4. Differences in Z_{DR} observed is worth more investigation

References

Hassan, D., Taylor, P. A. and Isaac, G. A. (2017), Snowfall Rate Estimation Using C-Band Polarimetric Radars. Met. Apps, 24: 142–156. DOI:10.1002/met.1613

Sekhon, R.S. and R.C. Srivastava, 1970: Snow Size Spectra and Radar Reflectivity. J. Atmos. Sci., 27, 299-307, DOI:10.1175/1520-0469(1970)027⟨0299:SSSARR⟩2.0.CO;2

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