Evaluation of Operational Ze-S Relationships in Marquette, Michigan

Alex Blackmer[1], Ali Tokay[2]
[1]Department of Atmospheric Sciences, University of Utah, Salt Lake City, Utah
[2] Joint Center for Earth Systems Technology, UMBC, Baltimore, MD and
NASA Goddard Space Flight Center, Greenbelt, MD

One research activity of the NASA's Global Precipitation Measurement (GPM) mission ground validation (GV) program is to construct a precipitation product based on Validation Network (VN) over the United States and elsewhere. The VN consists of 70 + dual polarization weather radars, including most of the National Weather Service (NWS) operational S-band Weather Surveillance Radar – 88 Doppler (WSR-88D) east of the Rocky Mountains. A number of WSR-88Ds, including the one at Marquette, Michigan (KMQT), are subject to frozen precipitation. While the GPM-GV has been developed and evaluated its dual-polarization based rainfall algorithm, the radar-based snowfall estimate is an ongoing effort. The NWS uses five different reflectivity – snow water equivalent rate (Z_e-S) relationships based on geographical regions (e.g. Northeast US) and another four Z_e-S relationships based on precipitation phase (e.g. wet snow). Additionally, there are singular Z_e-S relationships used in NOAA's Multi Radar Multi Sensor product, Canadian and Finland weather services. This study employs these 12 operational and 4 particle habit (e.g. plate) based Z_e-S relationships and aims to provide guidance on which Z_e-S relationship to use given specific atmospheric conditions. This study was conducted using both equivalent radar reflectivity data and snow accumulation data from Marquette, Michigan. The radar data was collected using a WSR88-D Dual Polarization radar, and the accumulation data was collected using 9 Pluvio weighing gauges. Using Python, both datasets were downscaled to time-series with 1-minute interval. The reflectivity – snow water equivalent relationship used was $\mathbf{Z_e = aS^b}$, where Z_e is the equivalent radar reflectivity and S is the liquid water equivalent snowfall rate. The coefficient **a** and exponent **b** were given values from operational and habit-based relationship data sets, as well as event specific relationship data sets. Four similar events were studied, which were defined as lake effect storms with less than -10°C wet bulb temperatures, and dendrite dominated habits. For each of the 4 events analyzed, estimation accuracy trends were observed. After applying wind correction to Pluvio accumulation totals, almost all Ze-S relationships improved in estimation accuracy. Of the geographically based Ze-S relationships, MRMS and Finland consistently performed better than the NWS region relationships. For the set of 4 habit-based relationships, the Aggregate and Crystal relationships yielded the lowest error of the 4 which is expected as particle habit type distributions showed the storms to be primarily dendrite and needle dominated. PIP derived Ze-S relationships which were based on four different mass-diameter relationships and four different maximum versus equivalent particle diameter relationships, performed well, but there was large variation in estimation accuracy. Some of the best performing PIP-based relationships were close to the best performing operational relationships, but they always performed slightly worse.