11.3 CALIBRATION OF SCANNING RADARS USING VERTICALLY POINTING PROFILERS AND SURFACE DISDROMETERS

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1. INTRODUCTION

The quantitative measurement of surface rainfall from scanning radar observations is dependent on the transformation of radar observables into hydrologic estimates. The most common transformation is the Z-R transformation that converts measured radar reflectivity into estimates of surface rainfall rate. While there are many Z-R relationships used by radar meteorologists around the globe, the utility of this transformation is dependent on the absolute calibration of the scanning radar.

Our technique called up-scaling calibration enables scanning radars to be absolutely calibrated through the combination of surface disdrometers and vertically pointing profilers. The surface disdrometer measures the rain drop size distribution (DSD) at the surface and is used to estimate the surface reflectivity, rain rate, and mean rain drop size. Through simultaneous surface disdrometer and profiler observations, the profiler calibration is adjusted until the observations in the lowest range gates of the profiler agree with the surface observations. The absolute calibration of the scanning radar is achieved by comparing the profiler with scanning radar reflectivities in commonly sampled volumes.

2. OBSERVATIONS

The NOAA Aeronomy Laboratory deployed vertically pointing precipitation profilers operating at 915 and 2835 MHz in support of the Ground Validation Program of the NASA Tropical Rainfall Measuring Mission (TRMM) (Gage et al. 2002, 2003). The profilers and surface disdrometers were within about 35 km of either research polarmetric scanning radars or operational NEXRAD scanning radars. As a means of an example of up-scaling calibration, this paper uses observations made in April 1998 to calibrate the Houston Texas NEXRAD scanning radar.

2.1 Disdrometer

The RD-69 impact disdrometer manufactured by Didromet, Switzerland, was used as the calibration standard at the profiler site. The RD-69 disdrometer is also called the Joss-Waldvogel disdrometer (Joss and Waldvogel, 1967). The Joss-Waldvogel disdrometer (JWD) estimates the number and size of rain drops reaching the surface. For each minute observation, the number of counts in each drop size category is used to estimate the drop size distribution (DSD) of the surface precipitation. The DSDs are used to estimate the surface radar reflectivity at a one minute resolution.

2.2 Profiler

The vertically pointing profilers operated at 915 and 2835 MHz and were sensitive to the precipitating cloud systems that passed overhead (Carter et al. 1995, Ecklund et al. 1999). While either of the two profiler observations could be used for the calibration of the scanning radars, only the 915 MHz profiler observations are shown in this extended abstract. The 915 MHz profiler operated in a single mode during the Texas deployment and had a pulse length of 100 meters and a range gate spacing of 100 meters. Two profiles were collected every minute.

2.3 Scanning Radar

In this study, the observations from the operational Houston, Texas, NEXRAD radar is used to show the utility of this calibration method to operational systems. The NEXRAD observations were processed to produce reflectivities at 500 meter vertical resolution directly over the profiler.

3. UP-SCALING CALIBRATION

Up-scaling calibration uses the surface disdrometer to calibrate the profiler and the profiler to calibrate the scanning radar. In this scenario, the surface disdrometer is the reference and the profiler is the transfer standard used to calibrate the scanning radar.

3.1 *Profiler Calibration using Disdrometer*

The profiler calibration is determined by comparing the simultaneous one-minute disdrometer and profiler observations. Figure 1 shows the reflectivity difference between the profiler and disdrometer as a function of disdrometer reflectivity for the 18 April 1998 rain event. The profiler observations from the first fully recovered range gate are used in Figure 1 and have been adjusted until there was zero mean

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reflectivity difference between the two instruments at JWD reflectivities greater than about 25 dBZ. The two line plots in Figure 1 show the probability frequency distributions (PDFs) of the disdrometer reflectivity and reflectivity difference, and the scatter plot shows the two-dimensional distribution of these data. More details of calibrating the profiler using the surface disdrometer are given at this conference by Clark et al. (2003).

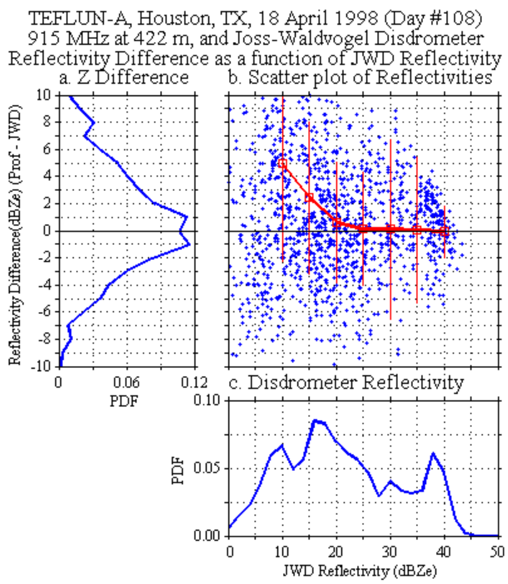

Figure 1. Reflectivity difference between the profiler and disdrometer as a function of the disdrometer reflectivity.

3.2 *Scanning Radar Calibration using Profiler*

Figure 2 shows the profiler reflectivity (top) and the NEXRAD scanning radar reflectivities (bottom) over the profiler during the rain event on 18 April 1998. The profiler vertical resolution of 100 meters and 30 seconds provides details not resolved in the NEXRAD 500 meter vertical and 6 minute resolution observations. Note that both instruments resolve the brightband near 3.5 km indicating stratifrom rain.

Using the same format as Figure 1, the difference in reflectivity between the profiler and scanning radar is shown in Figure 3. The profiler reflectivity is used as the reference and is shown on the horizontal axis and the reflectivity difference is shown on the vertical axis. The profiler observations have been degraded to the 500 meter and 6 minute resolution of the scanning radar. Figure 3 utilizes over 600 coincident profiler and scanning radar observations including above, below, and in the melting layer.

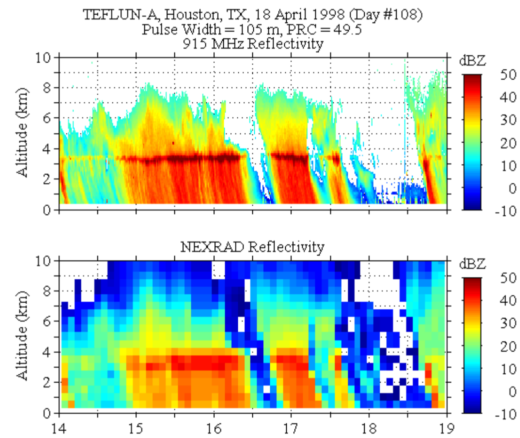

Figure 2. Time-altitude cross-sections of reflectivity from the 915 MHz profiler (top) and from the NEXRAD scanning radar over the profiler (bottom).

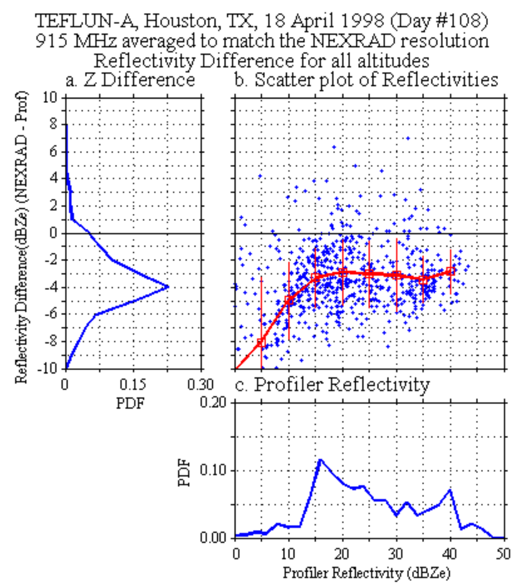

Figure 3. Reflectivity difference between the scanning radar and profiler as a function of the profiler reflectivity.

From Figure 3, the scanning radar reflectivity is about 3 dB lower than the profiler reflectivity. Thus, through the up-scaling calibration, the NEXRAD scanning radar reflectivity is approximately 3 dB lower than the surface disdrometer reflectivity.

4. CONCLUDING REMARKS

Up-scaling calibration uses a surface disdrometer and a vertical pointing precipitation profiler to calibrate scanning radars. The surface disdrometer reflectivities are considered the reference observations. Using simultaneous disdrometer and profiler observations, the calibration of the vertical pointing profiler is adjusted until the profiler reflectivity agrees with the surface disdrometer reflectivity. Using coincident profiler and scanning radar observations over the profiler, the difference in reflectivities indicates the offset in calibration of the scanning radar relative to the surface disdrometer observations.

The up-scaling calibration procedure was applied to observations made during one precipitation event in Houston, Texas, on 18 April 1998. The observations suggest that the Houston NEXRAD scanning radar reflectivity was approximately 3 dB below the surface Joss-Waldvogel disdrometer observations. The up-scaling calibration presented in this work is independent of the calibration operations performed by the NOAA National Weather Service. The up-scaling calibration of the NEXRAD scanning radar was performed using only one precipitation event. A more complete calibration of the NEXRAD scanning radar would require the sampling of more precipitation events to improve the statistics and to sample the range of different rain regimes observed throughout the whole year.

5. ACKNOWLEDGMENTS

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