Seamless HSR

Radar QPEs are commonly calculated from the lowest radar bins that are not significantly blocked. Those bins constitute a 2-D polar grid called "hybrid scan" (O'Bannon 1997; Fulton et al. 1998). The hybrid scan reflectivity (HSR) in the operational WSR-88D Precipitation Processing System (PPS, Fulton et al. 1998) was derived from the lowest radar bins that have less than 50% blockage and the (3-dB) bottom of the bins clearing the ground by at least 150 m. The reflectivities in partially blocked bins are adjusted to compensate for the amount of power blockages. However, the compensation is not sufficient when the radar wave propagates differently under super-refractive conditions. This often results in discontinuities in radar rainfall accumulations over a period of time (e.g., several hours). Some examples of such discontinuities will be shown in the next section.

To mitigate the discontinuities introduced by blockages, a new "seamless" HSR (sHSR) is developed in the current study. The sHSR at any range/azimuth bin with partial blockages of 10 to 50% is a weighted mean of reflectivities from the PPS-type hybrid scan and from the next tilt above [Eq. (1)]. The weight (w) is a function of the blockage (w_{blk}) and height (w_{hgt}) of the radar bin [Eqs. (2a)-(2c)].

$$Z_{sHSR} = \frac{\sum_{k=hst,hst+1} w_k Z_k}{\sum_{k=hst,hst+1} w_k} \tag{1a}$$

$$h_{sHSR} = \frac{\sum_{k=hst,hst+1} w_k h_k}{\sum_{k=hst,hst+1} w_k} \tag{1b}$$

$$w = w_{blk} \cdot w_{hgt} \tag{2a}$$

$$w_{blk} = \begin{cases} 1 & \delta < 10\% \\ 1 - \delta/0.5 & 10\% \le \delta \le 50\% \\ 0 & \delta > 50\% \end{cases} \quad (2b)$$

$$w_{hgt} = \begin{cases} 1 & h < h_{0C} \\ \exp\left[-(h - h_{0C})/H\right] & h \ge h_{0C} \end{cases} \quad (2c)$$

The variables in Eqs.(1a) – (2c) are defined below:

$\boldsymbol{Z_{sHSR}}$: seamless hybrid scan reflectivity (in mm^6m^{-3});

$\boldsymbol{h_{sHSR}}$: height associated with $\boldsymbol{Z_{sHSR}}$;

$\boldsymbol{Z_k}$: VPR-corrected reflectivity (in mm^6m^{-3}) on the $\boldsymbol{k^{th}}$ tilt;

hst: hybrid scan tilt number;

$\boldsymbol{\delta}$: the amount of one-way power blockage (dimensionless; $\boldsymbol{\delta}$=0.5 for 50% blockage);

$\boldsymbol{h}$: beam center height; $\boldsymbol{h_{0C}}$: freezing level height;

$\boldsymbol{H}$: a height scale factor (default =1 km).