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A NEW C-BAND POLARIMETRIC RADAR WITH SIMULTANEOUS TRANSMISSION FOR HYDROMETEOR CLASSIFICATION AND RAINFALL MEASUREMENT

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1. INTRODUCTION

Enterprise Electronics Cooperation (EEC) has developed a state-of-the-science C-band polarimetric radar based on simultaneous transmission of horizontal (Z_h) and vertical (Z_v) wavelengths for commercial applications, termed SIDPOL. Deployments of the SIDPOL include the United Kingdom Meteorological Service. Recently, as part of the SIDPOL system, Weather Decision Technologies (WDT) has work with the National Severe Storms Laboratory (NSSL) to integrate the hydrometeor classification algorithms slated to be part of the WSR-88D platform. This paper discusses the SIDPOL system and the NSSL algorithm components.

2. SIDPOL RADAR SYSTEM

The SIDPOL radar system as delivered to the UK Met office is a 250 kW magnetron transmitter with a power divider and the receiver/signal processor above the elevation axis. Figure 1 is a block diagram of the system and Table I summarizes the *system characteristics.

Description	Characteristic
Transmitter Type	Magnetron
Transmit Power	250 kW
Pulse Width	0.4,0.8,2.0 μs
PRF	300 - 2200 Hz
Clutter Rejection	40 dB
Antenna	4.3 m (14 ft)
Beamwidth	1.0 deg
Gain	45 dB
Sidelobes	-27 dB
Cross Pol Isolation	-29 dB
Receiver / Signal Processor	EDRP-9
MDS 2.0 μs Pulse 0.8 μs pulse 0.4 μs pulse	-114 dBm -112 dBm -107 dBm
dBZ0 @ 50 km 2.0 μs pulse 0.8 μs pulse 0.4 μs pulse	-17.1 dBZ -11.1 dBZ - 3.1 dBZ
Dynamic Range	100+ dB
Clutter Filters	3 pole elliptic 50 dB rejection

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The power divider used in the SIDPOL system is a four port, isolated power divider (not a "magic T") capable of handling 1 MW pulses.

The receiver and signal processor are within a hermetically sealed, environmentally controlled enclosure located at the end of one of the counterweight arms. As shown in Figure 2 shows the forward of the enclosure is the waveguide assembly. The waveguide assembly contains the power splitter, circulators, couplers, and switches to allow the transmission of the microwave energy in either horizontal or vertical polarization or both polarizations simultaneously. Reception is always in both polarizations simultaneously.

At the EEC facility, a similar system is online and operational. The major difference is transmit power of 1 MW. Imagery can be seen by going to the EEC website (http://www.eecradar.com). The SIDPOL system provides Z_h, Z_v, Z_{DR}, velocity, spectrum width, signal-to-noise ration, φ_{DP}, ρ_{hv}, K_{DP}, and L_{DR} for classification and analysis.

3. HYDROMETEOR CLASSIFICATON AND RAINFALL ESTIMATION

The classification algorithms integrated into the SIDPOL system have a long history of testing and development (Zrnic and Ryzhkov, 1999; Zrnic et al., 2001; Schuur et al., 2003; Ryzhkov et al., 2005). The classification scheme uses the available polarimetric variables and a fuzzy logic scheme based on a combination of weighted trapezoidal membership functions a vertical temperature profile. Figure 3 shows an example of the fuzzy logic approach using Z_H and Z_{DR}. Similar approaches have been derived among the remaining combinations of available polarimetric variables. Figure 4 shows an aggregate classification membership function. Figure 5 shows all the parameters used in the membership functions and the hydrometeor classes derived from these function. Figure 6 shows an example of the classification scheme applied to an RHI scan from the polarimetric testbed WSR-88D (KOUN). Rainfall estimations from the polarimetric algorithm suite are calculated using several variations of Z_H-R, Z_H-Z_{DR}, and Z_H-Z_{DR}-K_{DP} (Ryzhkov et al., 2005). Output of all results of the algorithms, including the rainfall estimates are in netcdf format.

4. APPLICATIONS AT C-BAND

Preliminary integration and testing of the NSSL polarmetric algorithms within the SIDPOL system have been implemented in a Redhat SUSE operating system. The netcdf output files of the algorithms are transferred into a format for display in the EEC Edge-5 system. Figure 7 shows an example of reflectivity from the SIDPOL radar and Figure 8 shows an example of the classification. The classification has been threshold on Z_h and Z_{DR}. Figure 8 shows the darkest blue regions that correspond to the highest reflectivities to be large drops. The figure shows preliminary results of the hydrometeor classification scheme. Further refinement of the classification weighting functions and method are ongoing.

The NSSL algorithms have been developed and tested specifically for the WSR-88D S-band. There are several challenges of applying the NSSL algorithms at C-band. Among them are attenuation correction and adjustments of the weights and membership functions to account for the significant resonance affects in regions of large drops.

5. CONCLUSIONS

A joint effort among WDT, EEC, and NSSL has resulted in the preliminary implementation of polarization diversity algorithms for hydrometeor classification and rainfall estimation on the EEC SIDPOL radar system. Data collection efforts are on-going at the EEC manufacturing facility in southern Alabama.

Testing and development continues in the realm of attenuation correction and specific weighting function applications for C-band data. Applications of L_{DR} for use as a standalone hydrometeor discriminator are also being applied.

6. REFERENCES

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Schuur, T.J., A.V. Ryzhkov, P.L. Heinselman, D.S. Znic, D.W. Burgess, and K.A. Scharfenberg, 2003: observations and classification of echoes with the polarimetric WSR-88D radar. National Severe Storms Laboratory Report, 46 pp.

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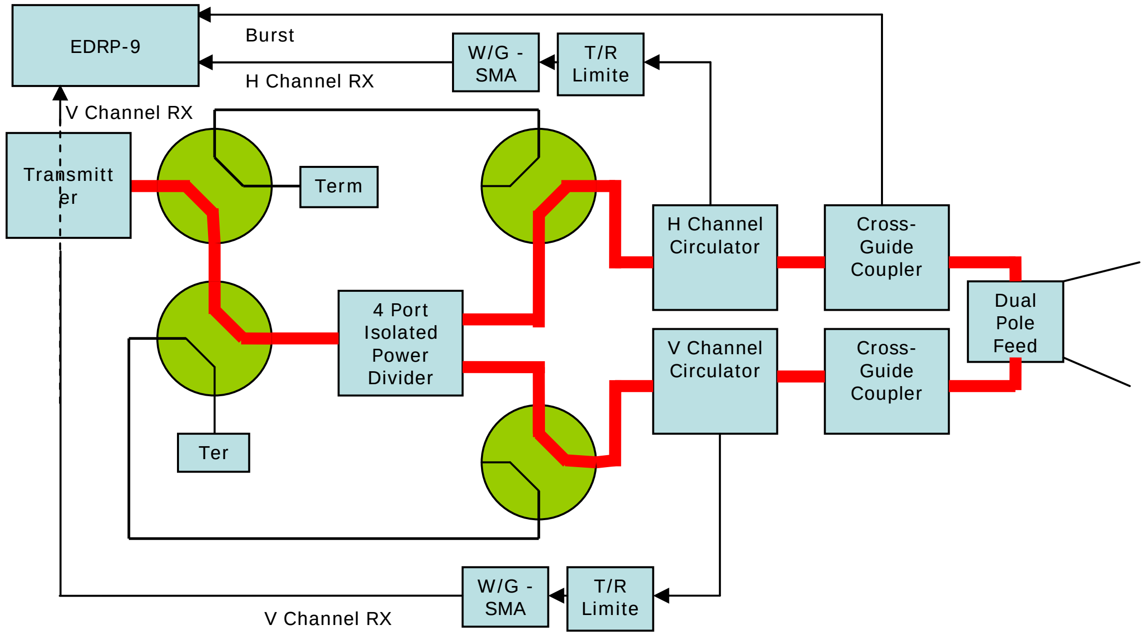

Figure 1. Block diagram of SIDPOL system.

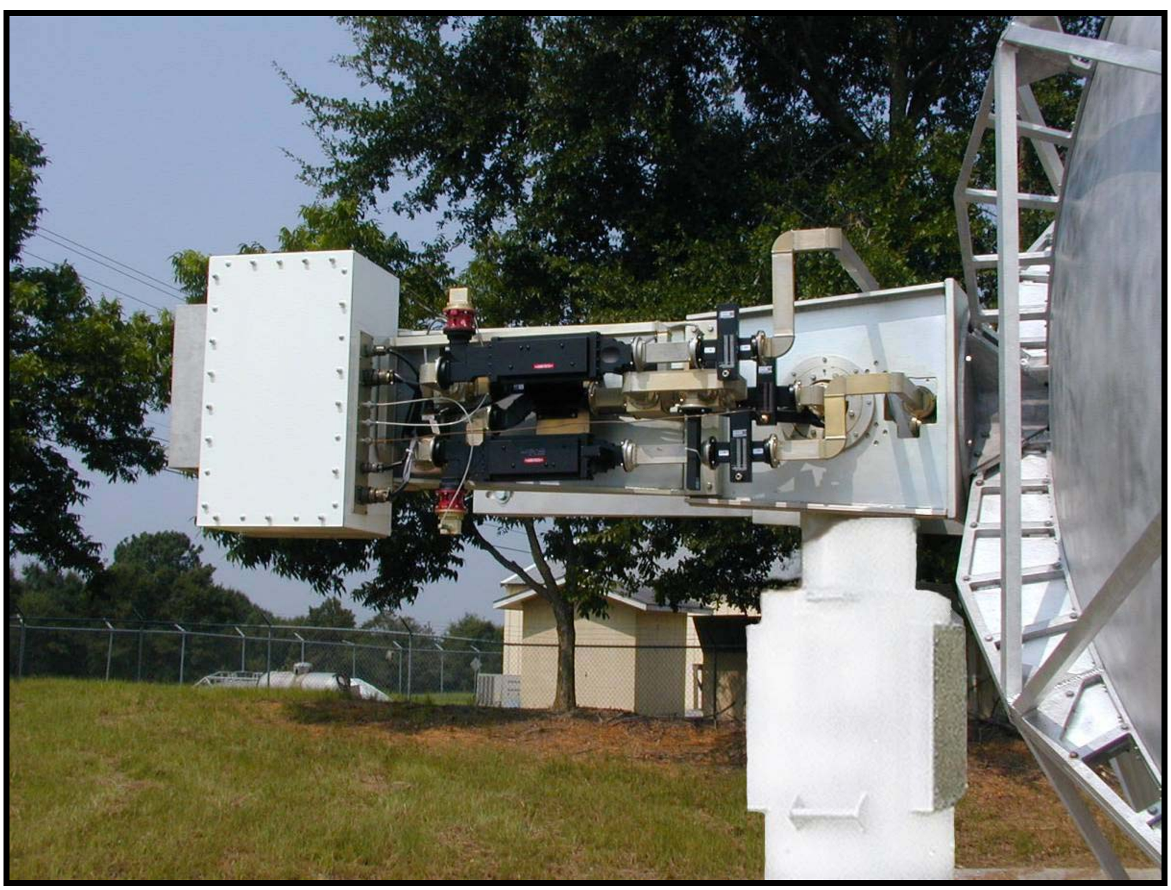

Figure 2. Photograph of SIDPOL waveguide assembly.

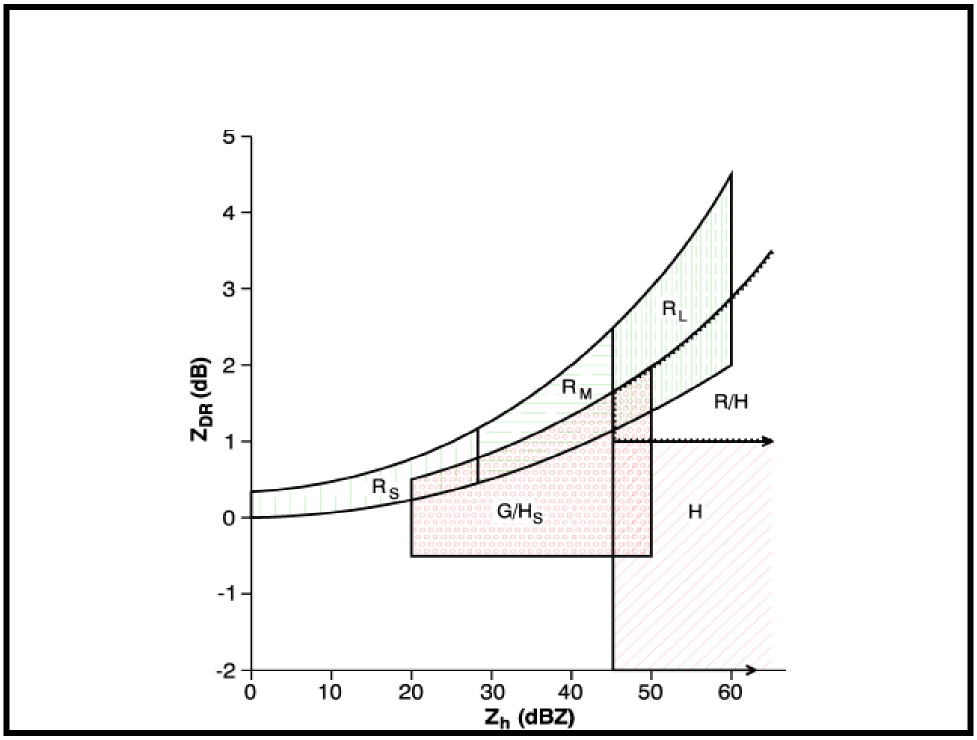

Figure 3. Example of fuzzy logic scheme for Z_h and Z_{DR}

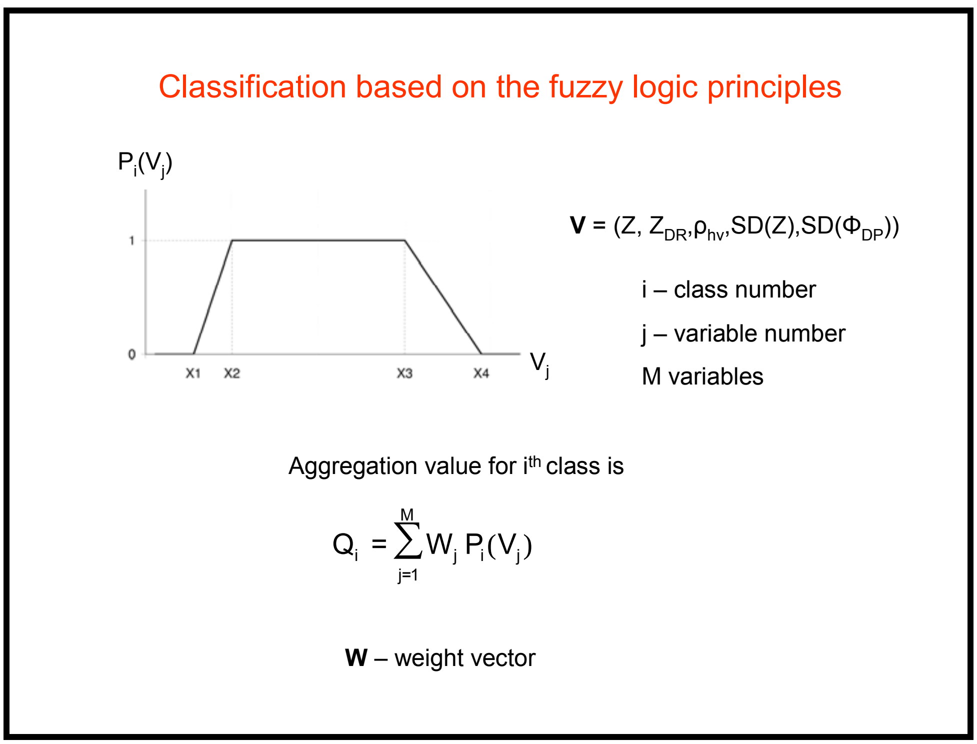

Figure 4. Example aggregate classification scheme.

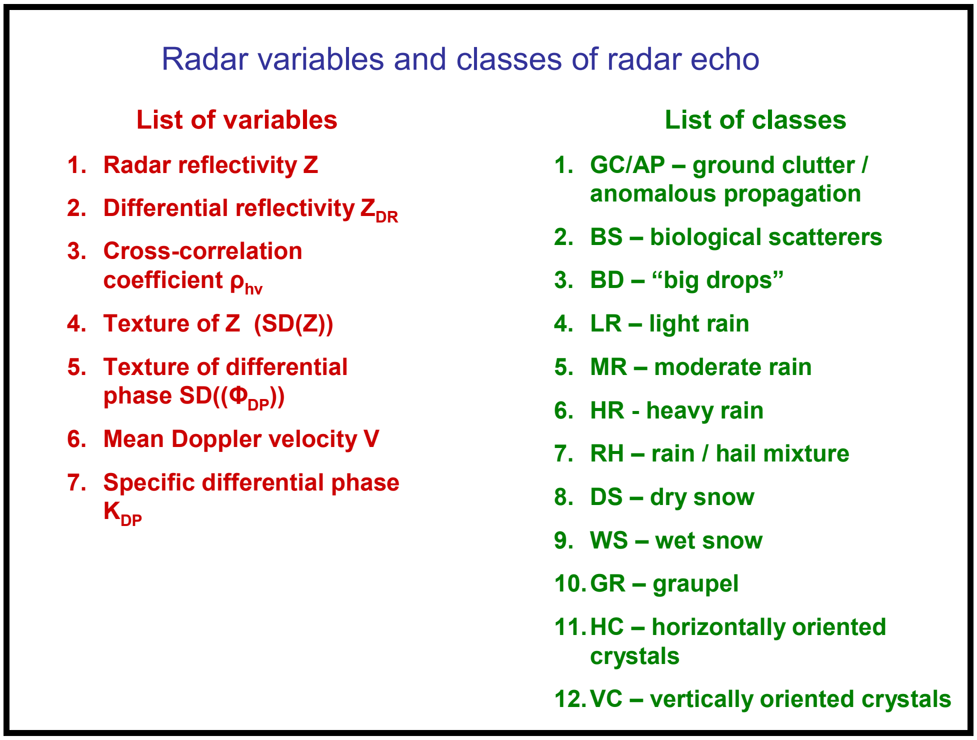

Figure 5. List of radar variables used in the classification scheme and the classification categories derived from the variables.

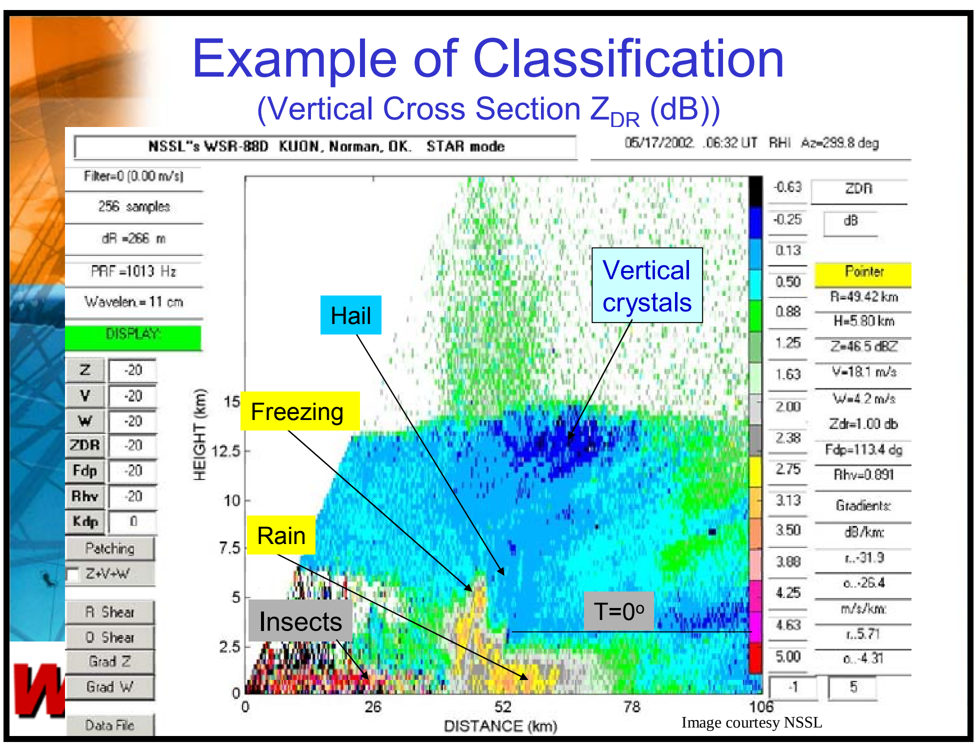

Figure 6. Example of classification scheme from WSR-88D (KOUN) RHI.

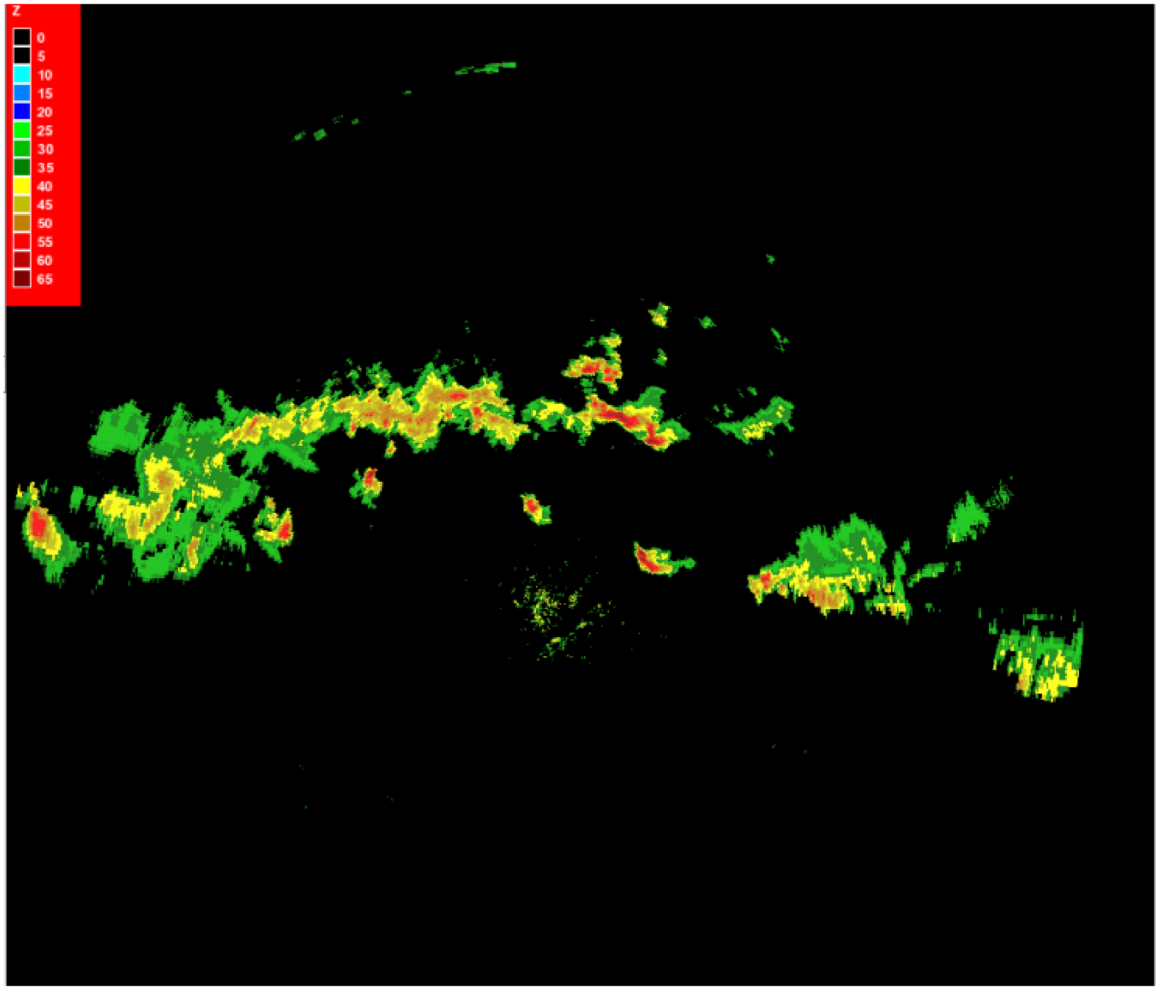

Figure 7. Reflectivity field collected with SIDPOL radar on April 22, 2005.

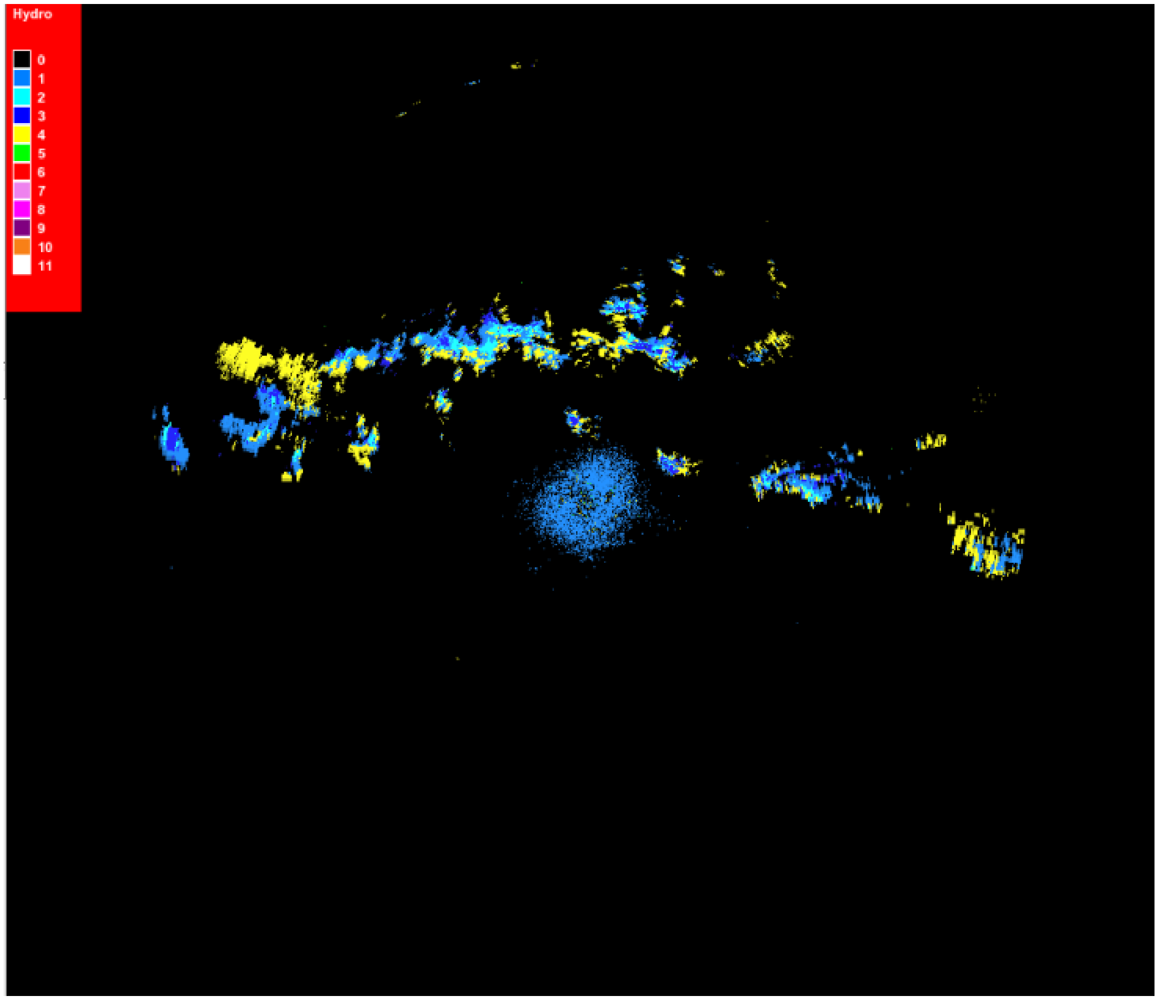

Figure 8. Hydrometeor classification scheme applied to SIDPOL data shown in Figure 7. The color scale in the upper right corresponds with the classification parameters in Figure 5.