

## Chapter 4: Data and Methodology

### 4.1 NCAR S–Pol Radar

The "S–Pol" radar is an S–band, portable research polarimetric radar operated by the National Center for Atmospheric Research (NCAR). The S–Pol radar is capable of a variety of scan strategies, including sectorized plan position indicator (PPI), sectorized range height indicator (RHI), or surveillance (SUR) scans. The specific scan strategies, pulse repetition frequencies (PRF), and scan rates employed can be tailored to the goals of the project.

### 4.2 STEPS and PRECIP98 Studies

The thunderstorms in this study were scanned by the S–Pol during two separate field campaigns (Figure 4.1). Though neither study had the specific goal of studying downbursts, several thunderstorms were under intense observation by S–Pol when downbursts occurred.



Figure 4.1. Locations of the S–Pol radar during the STEPS and PRECIP98 projects.

S–Pol was deployed near Idalia, Colorado during the spring and early summer of 2000 for the Severe Thunderstorm Electrification and Precipitation Studies (STEPS) project. The STEPS project focused on increasing the understanding of the interactions between kinematics, precipitation production, and electrification in severe thunderstorms on the High Plains. S–Pol was used, in part, to determine the hydrometeor structure of the thunderstorms studied.

During STEPS, S–Pol typically used a PRF of  $960 \text{ s}^{-1}$  with a scan rate of  $6 \text{ deg s}^{-1}$ . Beam spacing was held between  $0.8$  and  $1.0 \text{ deg}$ . Range gates were typically  $150 \text{ m}$  in length. S–Pol, as one member of a triple Doppler radar network, often participated in coordinated scans. The coordinated scans focused sectorized PPI and RHI scans over a thunderstorm of interest. Usually, a volume of sectorized PPI scans at different elevation angles was followed by a series of RHI scans separated by  $1 \text{ degree}$  in azimuth.

Another project, known as PRECIP98, involved the deployment of the S–Pol radar near Melbourne, Florida during the summer of 1998. The goal of PRECIP98 was to improve remote sensing techniques of convection throughout the tropics by studying rainfall production and rain rate in tropical convection. As in STEPS, S–Pol was used primarily to determine the hydrometeor characteristics of the thunderstorms under intense observation. During PRECIP98, S–Pol typically employed scan strategies very similar to those used during STEPS. During PRECIP98, however, favor was given to volumes of PPI sector scans over RHI scans.

#### *4.3 Identification of microburst times and impact locations*

The issues of the National Climate Data Center publication Storm Data covering the periods and locations of the STEPS and PRECIP98 projects were examined for

reports of wind damage or thunderstorm wind gusts in excess of  $25 \text{ ms}^{-1}$ . When a report was found, WSR-88D composites and S-Pol "quick look" images, available on the internet, were examined to determine the character of the thunderstorm responsible for the report. Because this study focuses on downbursts from "pulse-type" thunderstorms, cases of organized mesoscale convective systems were discarded. In some other cases, the S-Pol radar was not functioning, or the thunderstorm responsible for the Storm Data report was not the same as the thunderstorm being intensely observed by the radar. Finally, some thunderstorms were excluded because they were too far from the S-Pol radar to observe a low-level, divergent velocity signature, and the location and time of downburst impact could not be easily determined.

Once a candidate thunderstorm was identified, Doppler radial velocity images were studied. The goal was to determine the time and location a "radar-indicated microburst" (see Chapter 3) was first detected. In many cases, the report was far removed in time and space from the first radar-indicated microburst. In these cases, the radar imagery was examined to assure a microburst's outflow spread out beyond 4 km at ground level, and the Storm Data report was in the resulting area of macroburst winds. This study examines PR trends surrounding the time and location of the radar-indicated microburst impact, not the time and location of the Storm Data report.

The vertical structure in the  $Z$ ,  $Z_{DR}$ ,  $K_{DP}$ ,  $\rho_{HV}(0)$ , and radial velocity fields, and their temporal trends, were examined in the area and time surrounding the appearance of the radar-indicated microburst. These data were used to deduce the evolution of hydrometeor characteristics in and near the downdraft column. Additional attention was paid to the presence (or lack) of conventional radar signatures typically found in microburst-producing storms, and whether a  $Z_{DR}$  "hole" was detected.

All of the thunderstorms examined in this study exhibited very large Z values before, during, and after the time of the radar–indicated microburst, so it is safe to say that these events can be classified as "wet microbursts". As stated in S87, diabatic cooling due to melting hail can be a large contributor to downward accelerations in the case of wet microbursts. Therefore, before or near the time of the radar–indicated microburst impact, the PR data will likely show bulk hydrometeor characteristics consistent with melting hail somewhere in the downdraft column. Since R84 showed melting hailstones shed water drops of varied size and shape, the PR data may also show signatures consistent with a mixture of rain and hail.

#### *4.4 Study limitations*

There are a number of limitations of this study that should be noted. First, "null" cases are not considered. Null cases incorporate thunderstorms that produce a microburst but did not produce the expected PR signatures, and also cases where the expected PR signatures are found in thunderstorms that do not produce a microburst. This limitation should not be minimized. Clearly the differentiation between thunderstorms that do produce a microburst and those that do not is a fundamental goal in the improvement of severe thunderstorm warnings. This concern is tempered, however, by another limitation: there are not enough downburst–producing storms that have been observed in this manner to make statistics or thresholds meaningful.

Second, when using the definition of a radar–indicated microburst, the exact time and location of microburst impact can still not be certain. Some microbursts may be "slanted" or asymmetric (Fujita 1985), so determining the orientation of the downdraft column, and its relation to the near–surface microburst radar indication may be subject to

some error.

Finally, there are a number of other radar limitations to consider. Most importantly, S87 found the time scale of a wet microburst from time of initiation to ground impact is often less than 10 minutes. Most of the S-Pol volume scans in STEPS and PRECIP98 took about 5 minutes to complete, so the temporal resolution of the storm's evolution is necessarily coarse. In addition, WB88 noted that the  $Z_{DR}$  holes associated with downdraft columns were often only about 1 km in diameter. For the S-Pol radar, the half-power beamwidth reaches 500 m at approximately 31.5 km range, and reaches 1 km at approximately 63 km range. Therefore, a microburst column at longer range may be more narrow than the radar beamwidth, leading to poor sampling of the associated rapid horizontal gradient in hydrometeor characteristics.