12A.8 RADAR CHARACTERISTICS OF CONVECTION ALONG COLLIDING OUTFLOW BOUNDARIES OBSERVED DURING CRYSTAL-FACE

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1. INTRODUCTION

One area of concern associated with gust fronts is the convection that is often initiated or enhanced along their length. This process has been studied by investigators including Byers and Braham (1949) who were the first to observe a relationship between gust fronts and the initiation of convection, and Weckwerth and Wakimoto (1992) who presented the first case study that quantitatively analyzed convection initiation by a single gust front. Equally as important to the initiation of convection are the cases when two or more gust fronts collide. Wilson and Schreiber (1986) used a single Doppler radar to study convection associated with the collisions of low-level convergence boundaries, and found that colliding outflow boundaries intensified old storms or initiated new storms in 71% of their cases. Similar to this, Purdom and Marcus (1982) found that 73% of the storms affecting the southeastern U.S. were the result of collisions.

The goal of this study to identify the conditions that lead to new convection along the intersection between two or more of these outflows, and to find differences in measurable parameters between convective and non-convective collisions. In doing so, emphasis was placed on certain characteristics of outflow boundaries. Pertinent meteorological parameters were also quantified and compared to obtain a measurable difference between those collisions that do and do not initiate convection in an effort to characterize the difference in conditions between convective and non-convective outflows.

2. DATA

This study primarily relies upon data collected from NASA's polarimetric radar (NPOL) during the Cirrus Regional Study of Tropical Anvils and Cirrus Layers, Florida Area Cirrus Experiment (CRYSTAL-FACE) and was analyzed with the SIGMET Interactive Radar Information System (IRIS). NPOL is classified as an S-Band, dual-polarized, Doppler radar. NPOL transmits at a peak power of 875 kW and has a flat, mesh, 18 foot diameter (5.5 meter) antenna which produces a 1.4° beam width.

Over the course of 27 days in July 2002, NPOL collected over 5,000 volumes scans at a 10 minute temporal and 250 meter spatial resolution in support of CRYSTAL-FACE. During the study period, NPOL observed more than 60 thunderstorm outflows and 20 collisions between them. Of these collisions, only 9 triggered significant convection.

3. RESULTS AND DISCUSSION

Two areas of emphasis were examined through the course of this study: 1) the angle of the two gust fronts relative to each other prior to collision and 2) the relative direction in which the two boundaries were propagating before collision. Along with these two focuses, different meteorological parameters pertinent to the gust fronts and their collisions were summarized.

The first emphasis was dedicated to studying the angle in which the two boundaries collided relative to each other. Wilson and Schrieber (1986) performed a similar analysis on data collected near Denver, CO. In this study, collisions were categorized into three classifications; those that collided with each other head on or at angles less than 40°, those with a collision angle (CA) between 40° and 80°, and those with a CA greater than 80°. These angles are illustrated in the left-hand portion of Figure 1. For boundaries that collided head-on or at angles less than 40°, convection was initiated in 6 of the 8 occurrences (75%). For boundaries that collided at angles between 40° and 80°, convection initiated in 1 of the 5 occurrences (20%), and for boundaries that collided at angles greater than 80°, convection initiated in only 2 of the 7 occurrences (29%).

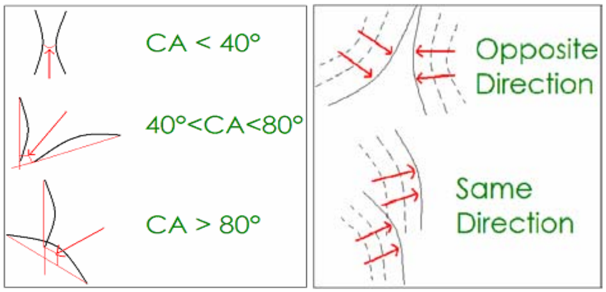

Figure 1. Diagram of CA categories (left) and classification of the propagation of two gust fronts prior to collision (right).

The second emphasis was placed on the observed direction of propagation relative to each boundary before collision. Prior to collision, the motions of both gust fronts involved were classified as either moving in the opposite or in the same direction relative to each other. This is illustrated in the right-hand portion of Figure 1. Analysis of the 20 collision cases indicated that the direction of propagation was opposite for nearly all of the collisions occurring at angles less than 80°, the reverse for those collisions occurring at angles greater

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than 80°. Furthermore, it was found that new convection was triggered in 9 of the 14 occurrences (64%) when the boundaries were moving in opposite directions prior to collision. An even higher likelihood of convection was found if an emphasis was placed on the angle of collision; for a CA's less than 40°, new convection formed again 75% of the time. For the occurrences where the direction of movement prior to collision was in the same direction, no new convection was observed.

Along with the two main points of emphasis, several different radar observables relating to the collisions and their gust fronts were examined. One such parameter studied was the reflectivity observed within each gust front at the time of collision. Gust fronts are often seen in the reflectivity field as thin line echoes with reflectivity values ranging anywhere from 10 dBZ to 30 dBZ. For both boundaries involved in a collision, the maximum reflectivity values were recorded and averaged together to quantify the reflectivity values for collisions producing convection as well as for those that did not. This process was then repeated for every collision observed. It was found through this analysis that the average maximum reflectivities were consistently larger for convective collisions (22.1 dBZ) than for non-convective collisions (21.2 dBZ).

Outflow boundaries can also be observed in the radial velocity field of a radar. Due to the limitations of a single Doppler radar, the velocities that are measured are somewhat arbitrary. However, the motion of the scatterers within each gust front can still be measured. Using the method described above, average velocities were found to be higher for convective collisions (15.8 m/s) than non-convective collisions (12.0 m/s), implying the movement of the particles within convective gust fronts was more active than those within non-convective collisions.

The propagation speed of each boundary prior to collision was also examined. It was found that on average, gust front pairs that initiated convection moved faster (5.3 m/s) than non-convective pairs of gust fronts (4.0 m/s).

Another parameter examined was the distance that the collision took place with respect to each gust front's parent storm. Analysis of this field shows that convective collisions took place at a farther distance (21.7 km) than non-convective collisions (14.0 km).

Other gust front properties such as height and length were also studied. On average, height was found to be slightly larger for convective collisions (1.5 km) than for non-convective collisions (1.4 km), as was length (35.1 km for convective and 31.2 km for non-convective collisions).

The final two values that were examined occur only for boundary collisions that produced convection. For each new convective cell produced, the maximum reflectivity was compared to the maximum reflectivity of the parent storm at the time of gust front formation. While the average maximum reflectivity for the parent storms was 48.5 dBZ, the average for the storms initiated by gust front collisions was 50.7 dBZ, showing that on average, storms generated from convective collisions are stronger than the storms that produced the gust fronts themselves.

The time lapse from collision to maximum reflectivity observed was on average 38 minutes. This time is comparable with time lapses found by others such as Byers and Braham (1949) (20-30 minutes before the initiation of convection) and Wilson and Schreiber (1986) (24 minutes to grow to 30 dBZ). The major findings of this study are summarized in Table 1.

Table 1. Summary of parameter averages.

	Convective	Non-Convective
Max dBZ	22.1 dBZ	21.2 dBZ
Max Radial Velocity	15.8 m/s	12.0 m/s
Max Height	1.5 km	1.4 km
Max Length	35.1 km	31.2 km
Distance from Parent Storm	21.7 km	14.0 km
Propagation Speed	5.3 m/s	4.0 m/s

4. CONCLUSIONS

The object of this study was to identify reasons or conditions that were favorable for the initiation of convection along colliding outflow boundaries. In doing so, two main emphases were studied along with a quantification of several meteorological parameters.

In the first emphasis, the angles at which the gust fronts collided were examined. Through this analysis, it was found that new convection was more likely to form if the CA between the two boundaries was head on or less than 40° than if the CA was greater than 40°.

Through analysis of the second emphasis, which examined the direction of movement of the boundaries relative to each other before collision, it was found that new convection was triggered only from the collisions of gust fronts moving in opposite directions, an even higher likelihood if the gust fronts also met with a CA less than 40°. In the occasions when the gust fronts were moving in the same relative direction prior to collision, no new convection was formed.

Future work on this topic will likely include an investigation into the thermodynamic conditions of the environment at the time of gust front collision, possibly through a survey of popular stability indices.

5. REFERENCES

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