Some Frequently Overlooked Severe Thunderstorm Characteristics Observed on GOES Imagery: a Topic for Future Research

by

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Abstract

Several examples of GOES visible satellite images depicting cloud features often associated with the transition to, or intensification of, supercell thunderstorms are presented. The accompanying discussion describes what is known about these features, and what is left to learn. The examples are presented to increase awareness among meteorologists of these potentially significant storm features.

1. Introduction

The role of satellite imagery in defining the near-storm environment of severe/tornadic thunderstorms has been well-documented over the past three decades (Purdom 1976, Weaver 1980, Weaver and Nelson 1982, Purdom 1983, Purdom and Scofield 1986, Weaver et al. 1994, Weaver and Purdom 1995, Browning et al. 1997, Weaver et al. 2000, Weaver et al. 2002, and Bikos et al. 2002). Much less has been written concerning severe thunderstorm structure as observed on visible satellite imagery. This note presents a few examples of certain features that seem to be a reflection of severe thunderstorm behavior. Specifically, the appearance of these cloud features seems to coincide with the transition to, or intensification of, supercell thunderstorms. The purpose of presenting these examples is twofold. First, the authors intend to increase awareness among severe storm meteorologists of these important storm characteristics. Second, we would like to generate community interest in discovering the mechanisms by which they are formed.

2. Flanking lines, rear flank downdrafts, and inflow feeder bands

Three components of severe thunderstorms that can frequently be seen on visible satellite imagery are described in this section. These include the flanking line, organized lines of cumulus congestus above the rear flank downdraft, and inflow feeder bands.

The flanking line has been a recognized part of severe thunderstorm nomenclature for many years (Lemon 1976, Doswell 1985, Bluestein 1986, Moller et al. 1994). The flanking line appears as a band of rapidly growing cumulus congestus that merges into the updraft region of the severe storm. It is often located, both in nature and in numerical simulations, above a storm-relative, quasi-stationary outflow boundary at the surface (Lemon 1976, Rotunno and Klemp 1985). This feature is illustrated schematically in Fig. 1 as it relates both to an idealized, low-level radar reflectivity core, and to the associated visible cloud.

Organized lines of towering cumulus have also been observed above the rear-flank downdraft (RFD) of severe thunderstorms (Fig. 1). They form above the rain-cooled outflow, and are separate from the flanking line. These lines were shown without comment in Scofield and Purdom (1986) (see their Fig. 7.12), and presented with discussion in Weaver and Purdom (1995), and in Weaver et al. (2002). Figure 3 from Weaver and Purdom (1995) is reproduced herein as Fig. 2. The arrow labeled "B" points to cumulus lines that had just formed above an invigorated rear-flank downdraft. Little is known concerning the specific mechanism by which these lines form, but observations suggest that they seem to appear soon after the RFD forms or intensifies.

Short, compact lines of towering cumulus have also been observed in the region of the inflow of supercell thunderstorms (Weaver et al. 1995, Fig. 3, and Fig. 2 herein). These inflow feeder clouds appear frequently on visible imagery (e.g., Figs. 3, 4), but have received little attention in the literature. As with the RFD towering cumulus lines, little is know concerning the mechanisms by which these inflow clouds form. Figure 4 shows 0.5 degree, base reflectivity from the Tulsa, OK WSR-88D for 22:02 UTC on 04 May 2003 an overlaid on a visible satellite image. Velocity data (not shown) confirm that a well-defined mesocyclone is associated with the southernmost storm. No attempt has been made to adjust the visible imagery for anvil top displacement, since we are concerned with low-level cloud features. In this case, inflow feeder clouds and the flanking line are clearly visible, while no cloud lines have formed over the outflow area on the west (left) side of the storm.

3. Topics for Future Research

Satellite meteorologists, studying the near storm environment of severe thunderstorms, have for some time been aware of features outside the precipitation regions of the cumulonimbus that signify transition to, or intensification of, supercell storms. The ability to view these features may be hampered by intervening anvil, and are generally not visible at night. However, when they are observed, they are often a harbinger of severe weather. Though the flanking line is well-documented, organized lines of convection above the RFD, and those that frequently appear in the vicinity of a supercell's updraft, are not. Appearing as they do near regions of intense vertical motion, a direct link to internal storm circulation is suggested. By showing a few examples of these phenomena, the authors hope to generate interest in research the research community in learning how such features form, and how they relate to supercell behavior. Future field research efforts might include: 1) pressure measurements southeast of the wall cloud to document possible correlations with inflow cloud development, 2) wind and pressure measurements to the west of the main precipitation core to document relationships between the developing RFD and multiple cloud lines, and 3) cloud photography and/or videography, from the middle-distance (e.g., 10-30 km), both east and west, of a supercell storm to record how these features develop in real time, from a ground-based perspective. Future theoretical research using high-resolution numerical models might focus on replicating these cloud features and diagnosing the mechanisms leading to their formation, intensification and dissipation.

4. Acknowledgements

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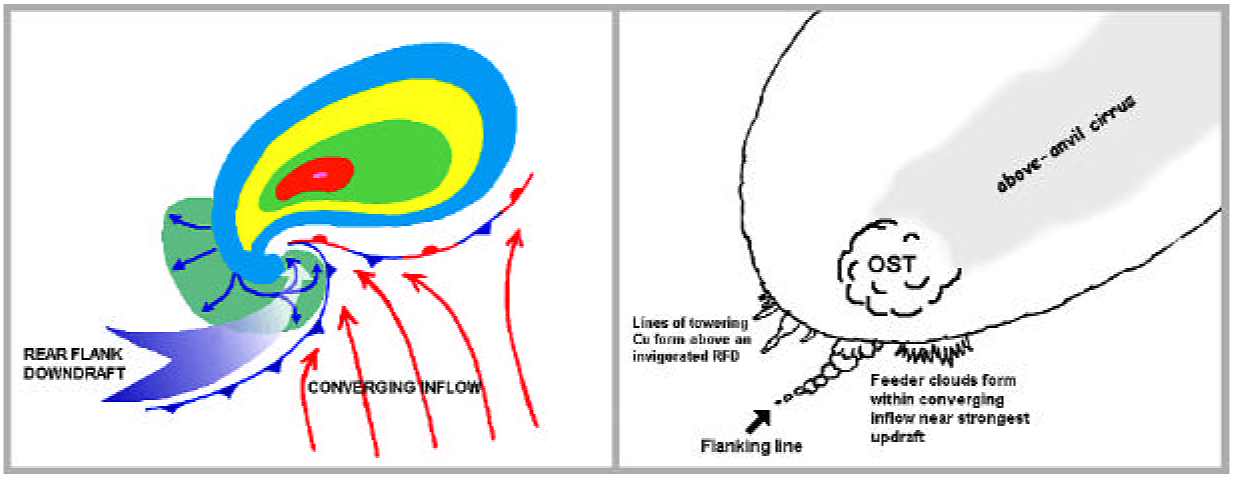
Figure Captions

Figure 1. Idealized diagram of certain aspects of a supercell thunderstorm. a) Idealized, base-reflectivity radar echo, the location of the descending rear flank downdraft (RFD), the associated cold at the surface (green), converging low-level inflow streamlines, and quasi-stationary, storm-related fronts. b) Visible satellite representation of the same storm showing the overshooting top (OST), above-anvil cirrus, cumulus congestus above the rear-flank outflow (i.e., the flanking line), lines of towering cumulus over the new or invigorated RFD, and short compact lines of cumulus congestus towers associated with the intense inflow.

Figure 2. GOES-7 visible satellite image from 13 March 1990 at 22:31 UTC over southern Kansas. Location of Wichita, Kansas is labeled “ICT.” Image shows a supercell thunderstorm just before it produces an F5 tornado in Hesston, KS. Arrow A points to compact lines of towering cumulus – or feeder clouds – associated with the storm’s intense inflow, arrow B points to lines of towering cumulus forming above a newly-formed rear flank downdraft upstream from the primary flanking line.

Figure 3. GOES-7 visible wavelength view of the inflow region of a tornadic storm near Plainfield, IL taken at 21:01 UTC on 28 August 1990. Arrow A points to compact lines of towering cumulus – or feeder clouds – associated with the storm’s intense inflow, arrow B points to lines of towering cumulus forming above a newly-formed rear flank downdraft upstream from the primary flanking line.

Figure 4. Visible satellite image from 22:02 UTC on 04 May 2003 over northeastern Oklahoma with Tulsa, OK WSR-88D base reflectivity overlaid. Storm has formed on a dryline, and is moving into a region of cloud streets. Velocity data (not shown) confirm that a well-defined mesocyclone is associated with the southernmost storm in this line. Note inflow feeder clouds along the southeastern edge of this core. In this case, no obvious RFD lines are visible.



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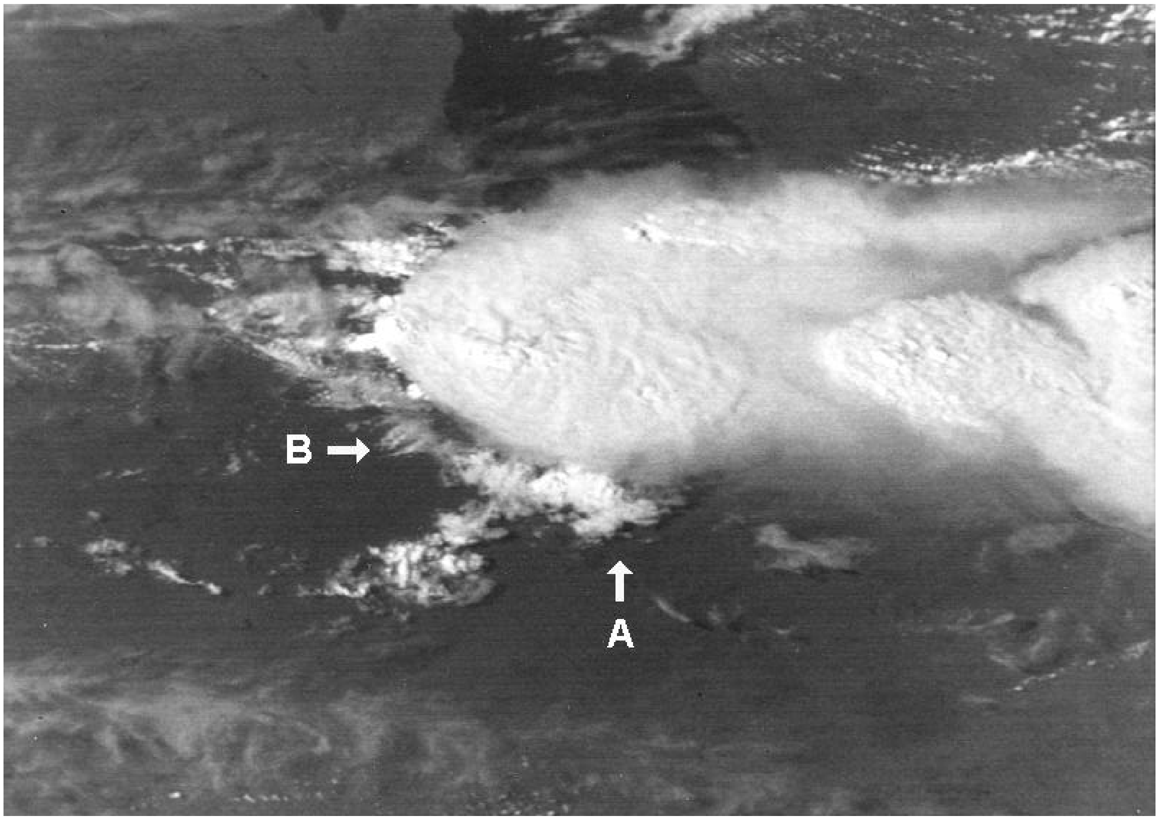

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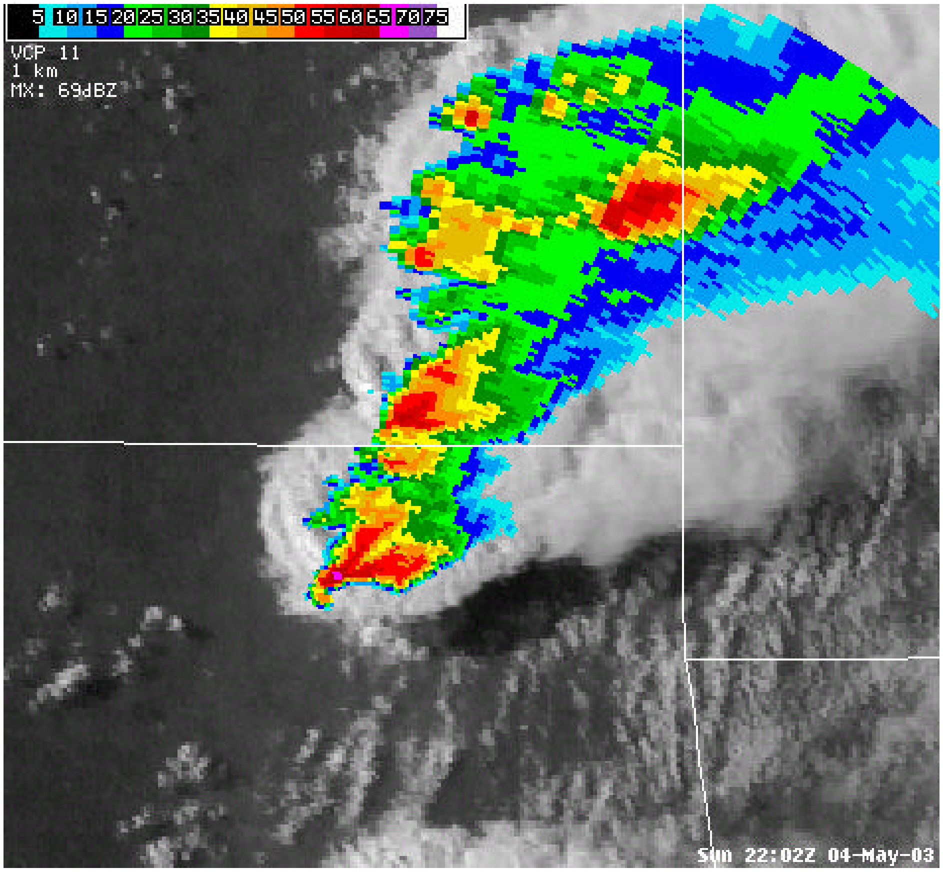

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