Intercomparison Between Polarimetric Radar and Satellite Indicators of Storm Severity in a Tornadic Supercell

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Motivation

In an effort to upgrade the WSR-88D network to dual-polarization capabilities and the forthcoming launch of GOES-R, novel potential new tools that can be used to learn more about storm severity. Specifically, enhanced values of differential reflectivity (ZDR) above the freezing level (ZDR column) in convective storms are indicative of a storm updraft. In addition, the launch of GOES-R will couple new tools that can be used to interrogate severe storms in real-time with increased spatial and temporal resolution. Combined, these remote sensing tools may eventually serve as nowcasting aids for forecasters in determining if severe weather is imminent. While polarimetric radar data and new GOES-R products have been used to study severe storms, the radar and satellite products have not yet been compared with each other during a storm life cycle.

Objective

Use polarimetric radar and satellite data to examine how multiple proxies for a storm updraft compare to each other during the life cycle of a tornadic supercell thunderstorm. The focus of this work is on: the relationship between ZDR column height and CTC values, how ZDR column heights change when OTs are detected, and how trends in the ZDR column height and OT products compare during the tornado life cycle.

Data and Methods

- **Radar:**
  - KFDR data were analyzed from 1900-2300 UTC on 19 May 2015 for a twocord tornado supercell (see below for storm details).
  - A novel ZDR column algorithm (Snyder et al. 2015) was run on the KFDR data. The algorithm provides the approximate altitude above mean sea level of the top of the 1 dB ZDR column.
- **Satellite:**
  - Data from GOES-14 run in Super Rapid Scan Operations for GOES-R (SRSSR) mode were analyzed. SRSOR mode is meant to mimic the increased temporal resolution of GOES-R with 1-1.5 min updates, 1-min data from 1900-2300 UTC were analyzed.
  - The UW-CTC algorithm (Siegaff et al. 2014) and GOES-R OT (Bedka et al. 2012) algorithms were used in this study. For the former, a 15-min running normalized difference of BT was used, and for the latter, the binary OT and OT magnitude products were investigated.

**Observations**

19 May 2015 Red River Supercell:

The storm question formed on NW Texas prior to 1900 UTC on 19 May 2015 (not shown). By 2000 UTC, it began to take on supercell characteristics (Fig. 2a). Shortly thereafter, a brief EPO tornado was estimated to have formed at 2033 UTC in Wichita County, TX, just S of the Red River (Fig. 2b). This second tornado was observed by several spotters at ~2054 UTC in Tillman County, OK, NE of the Red River (Fig. 2c). This second tornado was larger and lasted for ~10 min; it also was rated F0 due to a lack of observed damage. Following the dissipation of the second tornado, the storm took on the appearance of an HP supercell (Fig. 2d,e) before it interacted with another supercell to its south (Fig. 2f) and then evolved into a convective line segment after 2300 UTC (not shown).

**Algorithm comparison during tornado life cycles:**

Prior to both tornades, the maximum ZDR column height increased and the magnitude of the OT temperature difference with the surrounding anvil decreased. Previous studies have not established a link between ZDR column height and tornado life cycles; however, there are several previous observations of OT “collapse” prior to tornado formation. One downside of using a point value to represent ZDR column height is that the general structure and areal values associated with the column are neglected. In the case of the second tornado, the general size, shape, and height values within the column remain similar, though the mean height value does increase, prior to and through its life cycle (Fig. 7).

Future Work

Much additional work is necessary before any conclusions can be drawn about the relationship between radar and satellite products that are thought to act as proxies for a storm updraft or may indicate changes in updraft strength.

1. More SRSOR cases are needed to increase the data sample in order to rigorously assess statistical relationships among the products.
2. Incorporation of other observationally-based updraft proxies is planned, including radar updraft products currently under development and the lightning jump product.
3. Additional focus on storm processes beyond tornado formation/dissipation, including storm intensification, which may exhibit more robust signals and offer more operational utility.
4. Exploration of potential symbiotic relationships among various updraft products that may enhance operational confidence that updraft strength is being correctly inferred.

Acknowledgments:

This work was supported by NASA grant NNX15AQ99G. The second author was supported with funding provided by NOAA/OAR/Office of Oceanic and Atmospheric Research under NOAA University of Oklahoma Cooperative Agreement #NA11OAR4320072, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

(For the times that an OT was detected in GOES-14 data, the OT magnitude, which measures how much colder the OT is than the adjacent anvil in K, also was interrogated. An ~1 hour time series shows the ZDR column height and OT magnitudes during the mature stage of the supercell, including during both tornadoes (Fig. 6). ZDR column height generally increased and OT magnitude consistently decreased during this time period. This result complicates any attempt to establish a formal relationship between OT and ZDR column height from this one case.)