P5.6 **The July 4 2001 Severe Weather Outbreak in Southern Ontario as Diagnosed by the New Radar Data Processing System of the National Radar Project of Canada**

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1. Introduction

A new radar software system (CARDS) is now operational in Canada (Joe et al, 2002). There were several main driving factors behind its development. One was the Canadian system for dealing with warnings. A typical Canadian region encompasses an area the size of 10 or more medium sized U.S. states. One or two meteorologists are responsible for issuing warnings for this large area. With the new radar system, now mostly in place (Lapczak et al, 1998), these individuals must monitor data from 5 to 8 Doppler radars in their region of responsibility. This forecaster could expect numerous days where warnings were required simultaneously in widely separated areas. They needed a single battle board view of their entire area. They needed help from computer algorithms to rank storms and priorize warnings. They then need the ability to quickly drill down to the scale of individual convective storms and see the algorithm outputs and radar displays in a way that helped them to recognize the patterns associated with severe events to make warning decisions.

The real challenge in the Canadian forecast environment is on those days when numerous storms of different characteristics occur across multiple radars. July 4 2001 was such a day. This paper will examine the July 4 event and improvements that might have been possible in the warning program using a CARDS type system.

2. The Events of July 4 2001

Figure 1 is a composite forecast map produced by the severe weather meteorologist from the Toronto Regional Forecast Office valid for 1800Z on July 4 2001. CAPE values in the 2500 range were indicated for much of southern Ontario ahead of the fronts. Shear values were conducive to organized storms perhaps supercells or short squall lines.

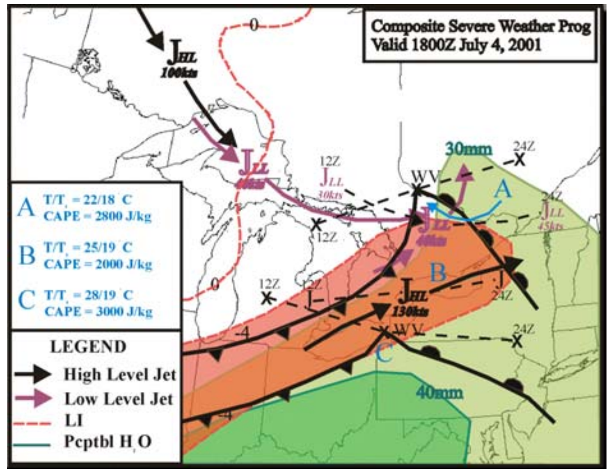

Figure 1: Severe Weather Composite Map for 4 July 2001.

Figure 2 is a plot of the reported storm damage that day. Between 1430Z and 2400Z several waves of severe storms broke out across an area encompassing 4 Ontario radars. Between 1430Z and 1630Z, an area of storms with long tracks and persistent mesocyclones, produced only golf ball size hail.

Figure 2: Damage locations. Mainly hail (H) but weak tornadoes (T) touched down.

Around 1800Z, two fairly small supercells produced two F1 tornadoes. Between 1900-2100Z, another large area of cells developed, with the mesocyclone algorithm triggering on a regular basis. There was little or no severe weather reported at the ground with this area. Then at

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2100Z another small supercell developed and produced an F1 tornado.

This scenario is obviously a tremendous challenge for the forecaster. We will examine the radar outputs from the last period 1900-2100Z in terms of two forecast decisions that were made and how the CARDS software might have influenced those decisions.

3. The Radar Data

Figure 3 is a MAXR depiction combining 3 Canadian radars of the storms occurring across southern Ontario at 2010Z July 4 2001. Tornado warnings were issued with the storm complex north of Lake Ontario. The circles indicate cells identified by the CELL ID algorithm.

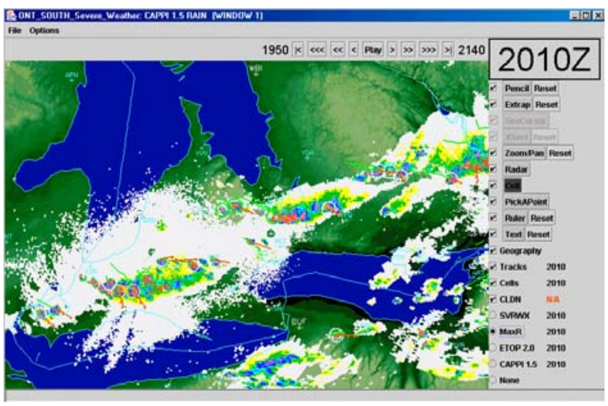

Figure 3: MAXR Composite of three radars (Exeter, King City and Franktown). Cells and tracks are overplotted.

Figure 4 shows only the CELL ID's and the SCIT table for 2010 GMT (modified version of the SCIT of Johnson et al, 1998). Cells are colour coded in stop light fashion (white, green, yellow, red) to indicate increasing level of severity. In this battleboard view of the situation, the forecaster has been alerted that a storm north of Lake Ontario is the most intense storm in his/her area of responsibility.

The software allows the forecaster to "drill down" to this storm. Figure 5 shows 12 geographically linked conventional reflectivity thumbnail views (60km x 60km) of the storm in question. On the left are an ensemble product of the severe weather algorithms with two automatically determined cross-sections. Second from the left are CAPPI's at 1.5, 3, 7, 9km (bottom to top). The middle column shows two reflectivity gradient, MAXR and echo top products. Second from the right shows VIL density, hail, BWER and the height of the 45 dBZ echo top images. On the right are time trends of the maximum VIL, hail, areal extent and 45 dBZ echo top height.

Figure 6 shows 12 Doppler derived views of the storm. The left column is the same as that in Fig. 5. Second from the left are radial velocity images (0.3, 0.5, 1.5 and 3.5 degree PPI's). Middle column shows the corresponding reflectivity images. Second from the right shows the gust potential with downburst detections overlaid and three spectral width images. Mesocyclone detections are overlaid on the middle of the spectral width images. Time trends of gust potential, downburst intensity, mesocyclone intensity and maximum reflectivity are on the right.

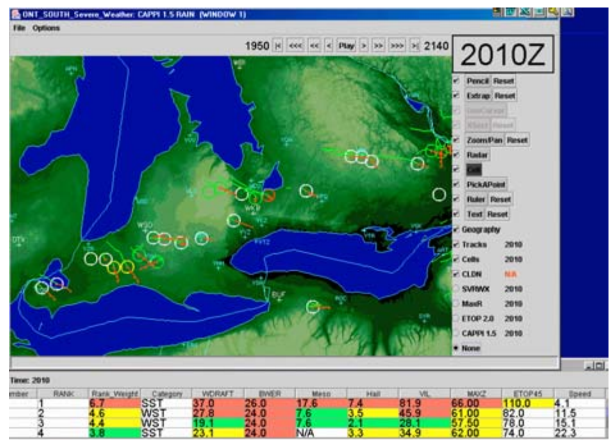

Figure 4: The software allows a rapid toggling of products. Only severity coloured cells and tracks are shown. A SCIT table is shown at the bottom.

4. Diagnosis and Warning

On July 4, the forecaster issued a tornado warning because these cells were very intense and had persistent mesocyclones associated with them. They had been preceded by a couple of confirmed tornadoes.

Close inspection of the cell view in this case showed that the cross section indicated storms tilting upshear and that the meso algorithm and algorithms associated with downbursts were triggered on the leading edge of the storm. These fit more the pattern of a line with perhaps the beginnings of a descending jet. Based on this assessment this storm certainly had the potential to produce strong winds and hail but did not fit the pattern of the classic tornado. The storms north of Lake Ontario remained strong for the next hour but did not produce any significant severe weather.

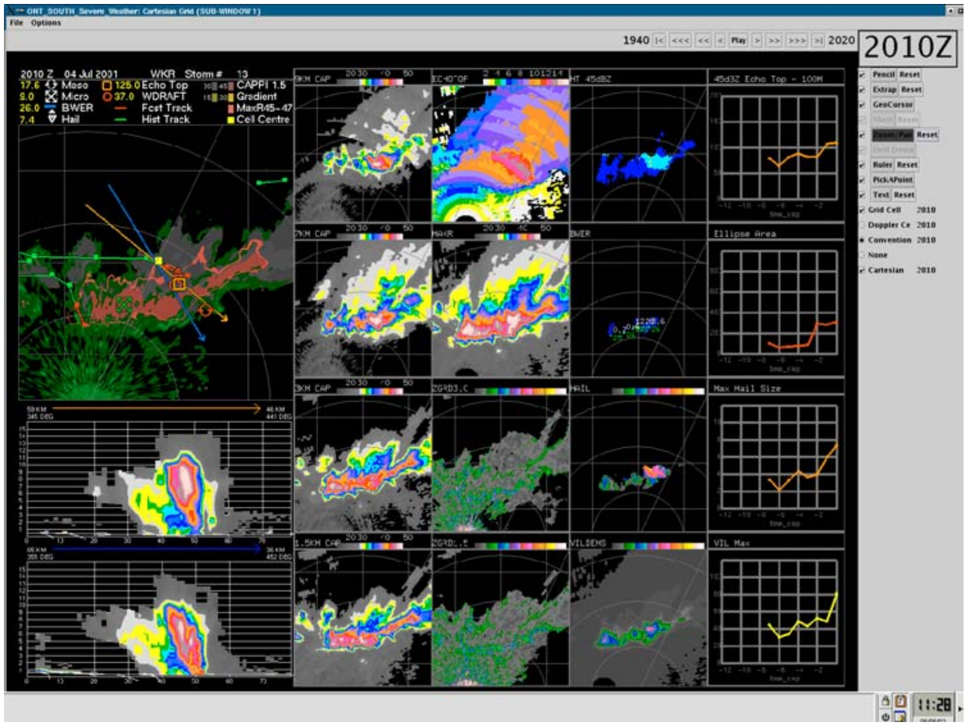

Figure 5: Multi-panel display of a single cell with mainly reflectivity derived products - see text for details.

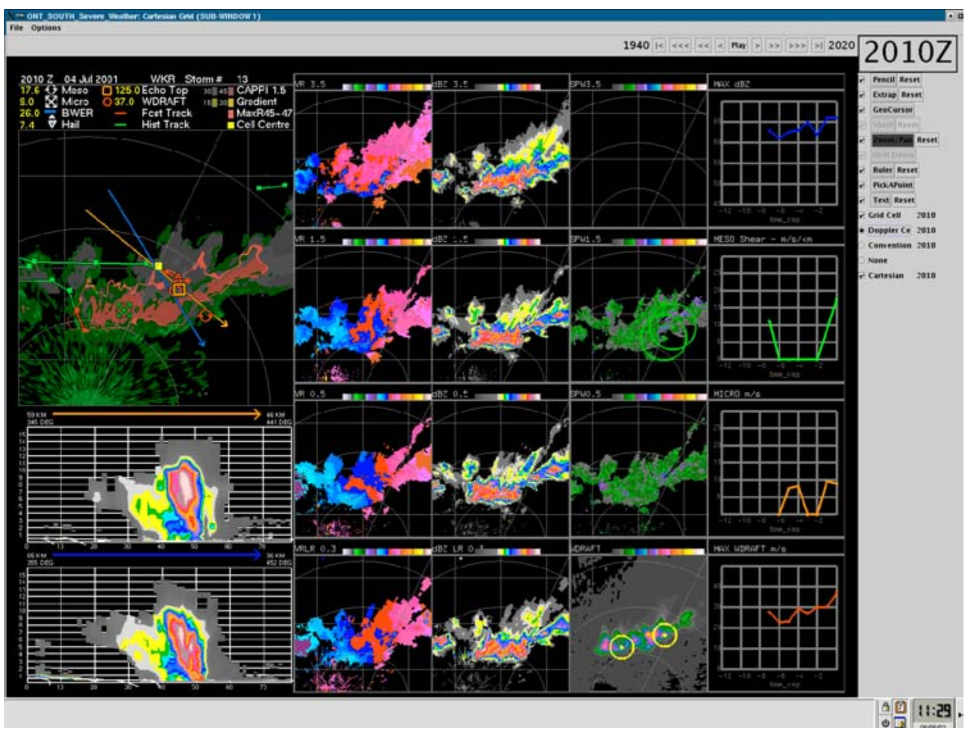

Figure 6: Multi-panel display of a single cell with mainly Doppler products - see text for details.

Around 2030Z, a storm developed further to the southwest. Between 2040Z and 2050Z, it jumped from being the tenth to fifth most severe storm and jumped from a rank weight of 1.8 to 3.7 (rank weight is a severity scale 1-8+ with 4 being a severe storm). The SCIT table and cell views indicated a mesocyclone was associated with this storm at 2030Z and 2050Z.

Figure 7 and 8 are the drill downs to this cell at 2050Z. Reflectivity data shows that this is a small storm with tops around 10 km. The automatic cross section does not reveal a BWER however a manual cross section (not shown) does pick up possibly a small BWER.

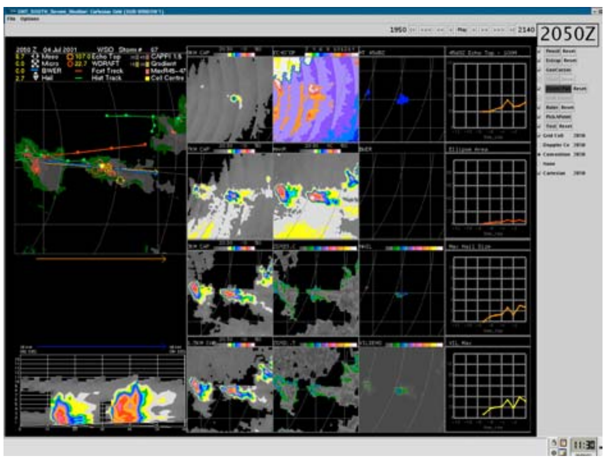

Figure 7: Conventional ell view of a small tornadic cell.

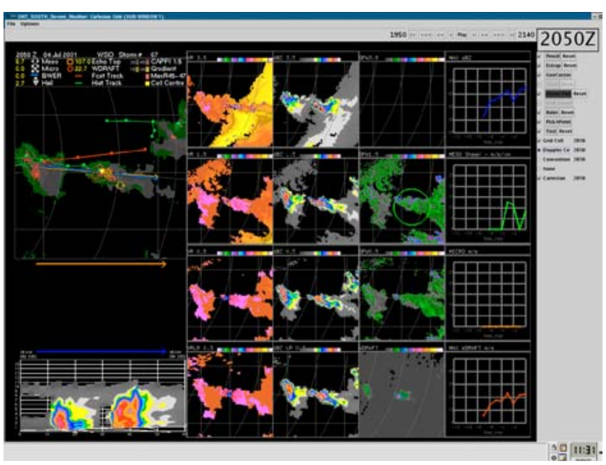

Figure 8: Doppler cell view of a small tornadic cell.

On figure 8, we see that the algorithm detected a mesocyclone but it did not fit well with our conceptual model for mesocyclones and supercells, however close examination of the radial velocity displays does show a small rotation couplet near the right rear flank of the storm. An unwarned tornado was reported with this storm at 2100Z.

5. Discussion and Summary

The new radar processing software, which attempts to intelligently use algorithmic outputs and the superior decision making capability of the forecaster, provides the capability to maintain situational awareness on the large scale and also the ability to easily focus and diagnose the severe weather properties of a single thunderstorm cell. The software calls attention to the most severe of the storms through the multi-radar SCIT table. Cell views are produced to allow the forecaster to diagnose storms and make better warning decisions. These multi-radar and algorithmic cell radar products are critically important to support the warning decision of the Canadian forecaster who must warn for several million square kilometers of space.

This paper described the use of the software in a situation where the cell views presented the information in a fashion that indicated that perhaps a warning should not have been issued and called attention to a very small cell that normally would have been missed. The data is presented in a fashion that allows the forecaster to match the data with existing conceptual models. This gave the forecaster a "chance" of catching this storm. On a day when other similar "small" supercells had produced tornadoes perhaps a warning could have been issued.

It is anticipated that this tool will aid the warning process but also provide greater insight into the nature of severe storms and revise existing conceptual thunderstorm models.

6. References

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