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A COMPARISON BETWEEN GOES-1 IR DIGITAL DATA AND RADAR DATA FOR THE 4 APRIL 1977 SEVERE STORMS OUTBREAK

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ABSTRACT

The 4 April 1977 severe storms outbreak over Georgia and Alabama provided an excellent opportunity to examine the complementary characteristics between satellite and radar data.

INTRODUCTION

On 4 April 1977, an old thunderstorm boundary provided an environment conductive to the development of an intense mesosystem over Alabama and Georgia. Tornadoes, funnel clouds, large hail, and high winds were associated with severe local storms which developed along two parallel lines of activity between 1200 GMT and 2300GMT. A Southern Airways DC-9 crashed WNW of Atlanta, Georgia at 2117GMT after penetration of a mesolow - associated supercell. This event provided an opportunity to compare satellite and radar capabilities in examining features associated with severe thunderstorm cells.

PROCEDURE

GOES-1 infrared digital image data were displayed on the Atmospheric and Oceanographic Information Processing System (AOIPS) to infer cloud top heights and to examine line deformation, merging cells, and enhanced localized areas of mid to upper level cloudiness.

Hourly PPI reports of radar echo heights were compared to the corresponding satellite-derived cloud top heights of the coldest areas of the thunderstorm cells. When it was possible, satellite cloud top heights were acquired at 3 minute intervals and compared to the radar echo heights on the half hour to examine the relationship between the two techniques.

RESULTS

Figures 1 and 2 are examples of the enhanced infrared GOES-1 images for 1930GMT and 2100GMT. They were selected from the 44 image set to explain how areas of potential severe weather can be located using both conventional and satellite data. According to conventional analyses (Miller, 1978), a mesocyclone is intensifying in an area located between 33°00'N, 88°00'W and 34°30'N, 86°30'W. Increased local convergence and strong surface winds are contributing to strong vertical cell development. This development can be seen at 1930GMT in the aforementioned area. Satellite data show cloud top heights of 16.6km and 13.4km for the two coldest equivalent black body temperature areas. New cell growth can be seen along the southwest flank of the line due to strong moisture advection and local convergence. By 2100GMT (Fig. 2), the original cold areas have greatly expanded between 34°00'N, 87°00'W and 35°30'N, 84°00'W. Cloud top heights have decreased from their maximum peak values. The Birmingham tornado (33°31'N, 86°49'W) has occurred and the Rome, Ga. (34°14'N, 85°11'W) mesolow is increasing in intensity. By 2112GMT, these two cold areas appear to merge and a tornado has occurred at Rome. The examination of a series of enhanced infrared images assisted in locating areas of potential severe weather in this case study.

Additional interesting features in the infrared data are enhanced areas of upper level cloudiness which are located at (36°00'N, 90°00'W), (36°30'N, 88°00'W) and (38°00'N, 86°00'W) on the 1930GMT image. Preliminary investigation shows that these features are moving northeastward at 67 m sec^{-1} and are located between 9 and 11 km. These features appear to be reflections of upper tropospheric wind maxima which are moving at twice the speed of the thunderstorm cells moving along the Birmingham - Rome axis. Convective activity appears to intensify along this axis as these features move northeastward. Additional research is required to determine whether these features are associated with upper level divergence and positive vorticity advection (PVA) and whether they play a significant role in the production of severe weather along the Birmingham - Rome axis.

This case study also presented an excellent opportunity to examine the complementary characteristics of satellite and radar data. Table 1 shows 18 cases where satellite-derived cloud top heights were matched exactly in time to their radar echo tops. A local sounding (Centerville, Ala.) was used to convert IR black body temperature to height. The mean difference between the two methods was .775km with slightly higher satellite cloud top heights. Previous studies by Smith and Reynolds (1976) and Maddox et al. (1976) indicated that radar heights were consistently higher than the IR tops derived from an environmental sounding. Inadequate IR resolution was noted as a reason for this difference. Also, cumulonimbus tops are not necessarily at ambient temperature. There were also some differences among the three studies: (1) radar and satellite times were not coincident in the Smith & Reynolds paper, (2) different types of clouds were measured, and (3) the statistical samples varied for each study. On the assumption that there is no satellite calibration problem, the satellite cloud top heights may be higher than the radar tops since: (1) the coldest areas in the satellite data may not necessarily be the area of precipitation reflected by the radar echo, and (2) the radar operator may not stop the Range Height Indicator at the cell's highest point.

Comprehensive studies of the relationship between radar echo heights and satellite cloud top heights are needed to resolve any ambiguities in data interpretation. Since height variations of overshooting tops can be detected in rapid scan (3 - 5 minute interval) geostationary satellite images (Adler and Fenn, 1978), it is important to understand what these height variations mean in the terms of thermodynamic and physical processes and what role they play in the production of severe weather.

CONCLUSIONS

An attempt was made to emphasize the unique and complementary characteristics of conventional and satellite data in examining areas of potential severe local storm development. The enhanced IR data assisted conventional and radar reports in locating the most likely area of severe weather on 4 April 1977 in Alabama and Georgia. A comparison between satellite cloud top heights and radar echo heights showed small differences in reported heights.

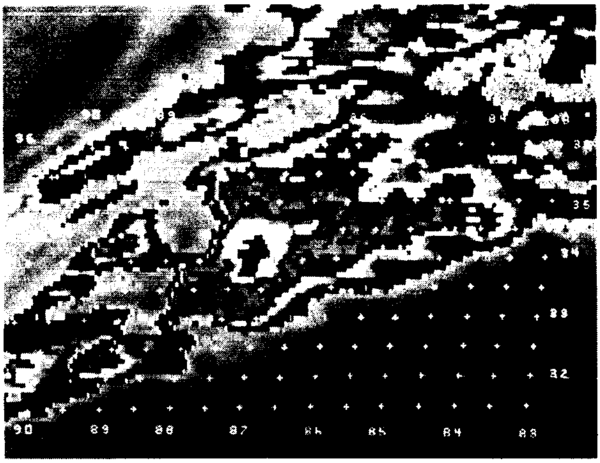

Figure 1. Enhanced IR digital image for 1930GMT on 4 April 1977.

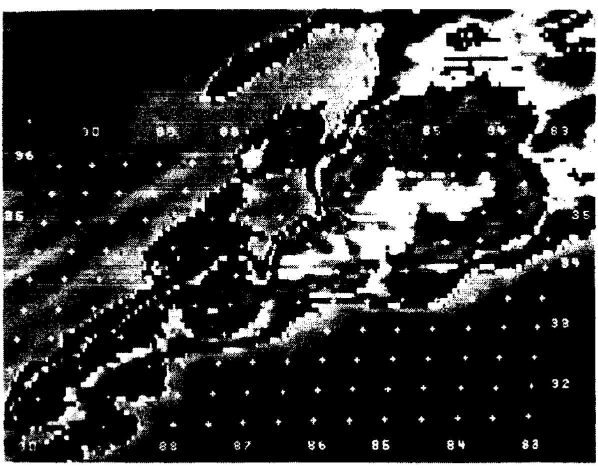

Figure 2. Enhanced IR digital image for 2100GMT on 4 April 1977.

Table 1
A Comparison Between Radar Heights and Satellite-Derived Cloud Top Heights

Coldest Area	Radar Height (km)	Satellite-Derived Height (km)	Satellite Height - Radar Height (km)
1	15.2	16.2	+1.0
2	15.2	14.8	-0.4
3	12.5	14.1	+1.6
4	15.2	16.4	+1.2
5	14.0	13.4	-0.6
6	11.9	13.3	+1.4
7	13.7	13.3	-0.4
8	14.3	16.2	+1.9
9	15.2	16.2	+1.0
10	12.8	15.1	+2.3
11	12.2	15.1	+2.9
12	13.1	13.1	0.0
13	14.0	13.3	-0.7
14	12.2	15.2	+3.0
15	14.0	15.4	+1.4
16	13.1	13.3	+0.2
17	13.7	13.3	-0.4
18	12.8	13.1	+0.3

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