THE USE OF CLOUD RELATIVE ANIMATION IN THE ANALYSIS OF SATELLITE DATA

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1.0 INTRODUCTION

When analyzing satellite imagery in animation, an interpreter often faces a very difficult task. Because a cloud field or system is moving across the earth at a very rapid speed as it develops, it is difficult to separate movement from development. In addition, accurate analysis becomes increasingly critical the more intense the weather systems become. However, such systems are often characterized by multi-level clouds and strong vertical and horizontal shear. When those complications in cloud motion are coupled with a systems movement, an analysts ability to extract mesoscale detail about the system can become overwhelmed.

A technique to aid in the analysis of animated satellite imagery has been developed at CIRA using the VDUC Wide Word Workstation running PC McIDAS. The technique allows for the removal of a constant velocity vector from a cloud field, resulting in an animated image sequence in which the cloud field remains relatively static while features on the surface of the earth move. This allows for the diagnosis of mesoscale features within an evolving cloud field. When satellite imagery is viewed in this cloud relative mode, it becomes easier to detect a number of storm related features. For example, much of the horizontal shear in a vorticity center appears as rotation when viewed in cloud system relative mode: this allows for very accurate positioning of the vorticity center at cloud level. In addition, flow at different levels relative to a thunderstorm system is easily diagnosed in this mode, thus helping delineate severe from non-severe environments. Targets for cloud tracking are easily located. Often when the objective is cloud tracking for the production of cloud drift winds, it is necessary to localize a target during the animation sequence. This is very difficult in regions of strong winds with their characteristic strong horizontal and vertical wind shears. When the mean motion of cloudiness about a jet axis is removed from the animation sequence, the shears and locations of the fastest moving clouds are easily located and tagged.

2.0 TECHNIQUE

Software to provide the capability of viewing a series of satellite images in storm relative mode was developed using PC McIDAS and the VDUC Wide Word Workstation located at CIRA. The software allows extraction of a storm relative vector from an image series in several ways: 1) by cursor; 2) by specified latitude and longitude coordinates; or 3) by the specification of the direction and speed of the vector. In method 1, the cursor mode, the user simply uses the mouse/cursor to select a common cloud feature to align on any two images in the series. In method 2, the latitude and longitude of a feature are given, again for any two images in the series (for example the location of a vorticity center at two different times). In method 3, the user specifies a starting position for the vector on any image in the series, then enters the direction and speed of the vector to extract.

After the input has been given using one of the three methods, the motion vector to extract from each image is calculated based on the time difference between each image and the base image, as well as on the time of the scan line at the specified point. The image series is reloaded with the cloud relative point at the center of the screen. Any fine tuning can be repeated on the new image series using the same technique. The powerful interactive capabilities of the workstation allow for the completion of the entire process in a few minutes or less: the limiting factor is image frame load time.

3.0 ANALYSIS

When viewing the satellite imagery from both the Plainfield (August 28, 1990) and Andover (April 25, 1991) tornadoes, complex flow features and intersecting storm boundaries made it difficult to ascertain specific mesoscale flow features contributing to each storm's development.

However, when time series loops of visible satellite imagery from these storms were reviewed in cloud relative mode, several circulation patterns became apparent.

3.1 August 28, 1991

In this situation, Figure 1, a band of cirrus extended from west to east across the storm development region. Two nearby rawinsonde stations Peoria (PIA) and Green Bay (GRB) showed strong winds across the region at both 12Z and 00Z. It was known that the jet stream was in the vicinity and that it would play an important role in severe storm development during the day. The jet axis location was easily isolated through cloud tracking in cirrus relative mode. In Figure 1, note the large number of tracers (wind barbs), that were detectable, as well as the strong shear across the area. While both the cloud targets and shear were easily detected when animation was performed in a cirrus relative mode, this was not the case when analysis was performed in an earth relative mode. It is interesting to note that the maximum winds at GRB and PIA at 12Z were 78 and 69 kts, respectively, and were 85 and 67 kts, respectively by 00Z. Furthermore, there is evidence of blocking of the upper level flow by the storm, similar to that found by Purdom and Weaver (1992) in studying the 26 April 1991 tornado outbreak.
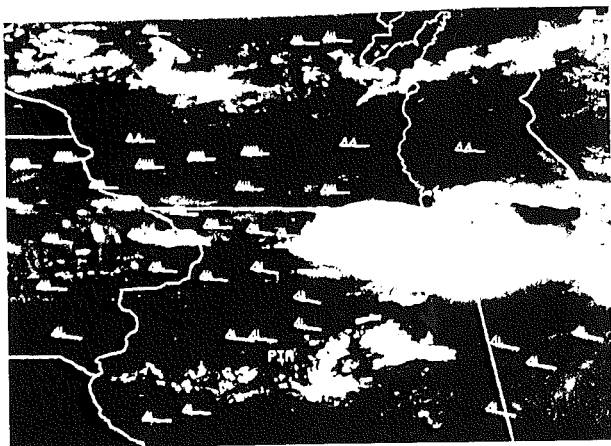

Figure 1. GOES 1 km resolution visible image with wind barbs, in knots, depicting cirrus cloud motions.

3.2 April 26, 1991

On April 26, 1991, an area of strong thunderstorms developed over Oklahoma and Kansas. That systems development was studied by Purdom and Weaver (1992) and is reported else where in these Proceedings. The following is taken from that paper: "An area of cyclonic rotation at mid-levels was readily detectable when the imagery was viewed in cloud relative mode... When cirrus relative animation was performed, it was apparent that the cirrus slowed down as it approached the thunderstorms,

provided strong evidence that the storms blocked the flow at upper levels. When a vector of 234 degrees at 85 knots was removed from cirrus motions, the effect of this blocking was dramatically apparent... Based on measurements from rapid scan imagery, storm motion at 1846 was from 215 degrees at 35 knots. When that vector was removed from the rapid scan sequence and animation was performed in a storm relative mode, the cumulus to cirrus level shear was found to be greater to the south [the region where the tornadic storms formed]."

4.0 CONCLUSIONS

A method for routinely displaying animated satellite imagery in a cloud relative mode has been developed. Relative motion allows for the diagnosis of mesoscale features within an evolving cloud field. When satellite imagery is viewed in this cloud relative mode, it becomes easier to detect a number of storm related features. A number of applications have been tested:
a) positioning of vorticity centers;
b) delineation of severe from non-severe thunderstorm environments;
c) detection of rotation at cloud top for tornadic thunderstorms;
d) improved mesoscale cloud tracking.

The software for that technique has been transferred to other locations with similar analysis equipment: the National Severe Storm Forecast Center in Kansas City, the National Hurricane Center in Miami and the Synoptic Analysis Branch at the World Weather Building in Washington, D.C.

5. ACKNOWLEDGEMENTS

6. REFERENCES

Purdom, J.F.W., and Weaver, J.F., 1992: A satellite perspective of the 26 April 1991 tornado outbreak over Kansas and Oklahoma. Preprints, 6th Conference on Satellite Meteorology and Oceanography, 5-10 January, 1992, Atlanta, GA, Amer. Met. Soc.