COMMA CLOUD DEVELOPMENT RELATED TO MAJOR WINTER STORMS - TWO EX-ETC(U)
COMMA CLOUD DEVELOPMENT RELATED TO MAJOR WINTER STORMS - TWO EXAMPLES

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FOR THE COMMANDER

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This Technical Note discusses the relationship of comma cloud development over the southern Rockies and plain states to the developing storm system. Emphasis is placed on the likelihood that the storm system will soon recurve northeastward when the comma cloud becomes well-defined. A brief look at the structure and the development of the comma cloud is included. Two case studies are presented.
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INTRODUCTION

Comma cloud development associated with two short wave storm systems that occurred during the past year is presented in this Technical Note (TN). These two dynamic systems produced a variety of weather over large sections of the central CONUS. A comma cloud is indicative of a positive vorticity advection (PVA) maximum. When a PVA maximum approaches a surface disturbance the associated lifting will cause further development of the disturbance. Therefore the approach of a comma cloud formation is often a precursor of storm development. One of the problems faced by forecasters is the ability to predict when and where the developed storm system will recurve towards the northeast. We present two cases illustrating recurvature occurring just after the comma cloud becomes sharply defined in the vicinity of the surface disturbance; this is evident in both case studies. Perhaps forecasters with GOES satellite data may be able to use this information to predict recurvature of storms emerging from the Rockies. Forecasters who do not have a GOES or WFSO tap can still identify comma clouds on the synoptic scale by using satellite charts transmitted over the NWS facsimile network.

STRUCTURE AND DEVELOPMENT OF THE COMMA CLOUD

Before we discuss these two comma cloud events let's take a brief look at the structure and development of the comma cloud. The following information was extracted from two excellent publications on the application of satellite data (see references).

From "NWS Satellite Training Course Notes, April 1975", by R. B. Weldon: Figure 1 depicts a typical vorticity comma pattern. Weldon (1) uses the term "Vorticity Comma" to described the comma shaped cloud patterns.

![Fig 1] Typical Vorticity Comma Pattern and Definition of Parts

This drawing represents a typical comma pattern as seen by satellite IR data. The ratio of translation to rotation (the variance of which is important) is also typical - in the middle range.

Definitions:

The "Surge Region": This is the area of the comma pattern where the translation of the back cloud edge is large. If you visualize the pattern undergoing a twisting motion, the area indicated as the Surge Region would be moving northeastward most rapidly while the part to the left would be lagging and tending toward rotation. The part to the right would also lag with perhaps a more distinct cutoff between rapid movement and lag.

The Comma Head: That portion of clouds to the left of the axis of maximum wind speed. This portion tends to lag and shows the most tendency for rotation.

The Comma Tail or Vorticity Filament: That portion of the cloud pattern which...
trails out to the rear on the right side of the Surge Region. The Comma Tail becomes parallel to the axis of maximum winds with its edge just to the right of the axis. Note that the winds referred to are at or near the cloud top level. The wind speeds may increase with height to reach a 3-dimensional maximum far above the cloud top level. This upper level max - the jet axis - may not have the same relation to the lower level.

The clouds associated with these comma structure are often mid-level clouds.

The best indicator of the strength of the comma cloud system is the distinctiveness of the cloud system, not the overall size of the system, not the type of clouds, not the height of cloud tops involved.

When a system is strengthening, the cloud edges become better defined on all sides, however, the front side is likely to be feathered with plumes of debris (but they are also likely to cut off more distinctly at the ridge line).

From "Using Satellite Imagery to Detect and Track Comma Clouds and the Application of the Zone Technique in Forecasting Severe Storms" by Colonel Robert C. Miller, USAF, Ret and John A. McGinley (some of this information has been paraphrased):

Comma cloud systems are associated with frontal boundaries and frontal exit areas at mid and upper levels in the troposphere (Figure 2). The comma cloud identifies the zone of concentrated upward vertical motion and concentrated positive vorticity advection, associated with a short wave embedded in the westerlies. Comma clouds become increasingly well defined in the mid tropospheric frontal exit area in a zone ahead of which low level frontogenesis is taking place, Figure 2.

The west or upwind edge of the comma separates downward motion from upward motion to the east or downwind. The upward motion drives high speed upper level air to the surface. In a sense, the comma represents an upper front with potentially cool air to the west or upwind and warmer air to the east, Figure 2.

The comma may first appear as a thin line, a blob, cluster or an elongated band. The comma will become better defined with time and when it moves into the frontal exit area it often appears as a spiraled cloud mass, Figure 3. Occasionally a PVA maximum will not attain the distinctive comma cloud shape but will still initiate convective activity as it approaches and moves over favorable lower tropospheric features, Figure 4.

When the mid and upper tropospheric levels are too dry to support cloud formation the comma cloud is initially invisible, appearing only when thunderstorms develop. In these instances conventional data must be analyzed and close watch maintained for the first signs of line-cloud development on the satellite imagery. For example, a region of PVA shown on an LFM prog should be watched for this development. If the position of development disagrees with the prog, then the prog should be adjusted.

Observation shows that such initial cloud development is evident 2 or 3 hours prior to radar indications. As thunderstorms increase and transport low level moisture to
mid tropospheric levels, the comma shape becomes visually evident, Figure 5.

Figure 5: Invisible Comma

When cirrus clouds exhibit a comma shape, we expect a very high level density and wind discontinuity, which may or may not be reflected at lower levels. The changes in cloud distribution seen in a series of satellite images are related to the approach, interaction, and passage of comma cloud systems. When comma structures represent deep zones of density discontinuity, they will usually dominate the surface patterns, eventually producing a strong occluded cyclone with rapid air motion through a very large volume of the troposphere. This is consonant with theoretical dynamic meteorology.

The comma head is always north of the main polar jet and overruns air that may be marginally unstable by the standards, discussed in AWSTR 200. However, the comma head is the focal point of the major dynamic atmospheric adjustments and is associated with the strongest PVA and most rapid horizontal cold advection aloft.

A comma shaped cloud mass approaching an open surface frontal wave is often associated with an upstream speed maximum embedded in the main polar jet. The surface low development can be seen in the improved definition and sharpness of the advancing comma cloud mass.

**COMMA CLOUD EVENT 1 - 3 MARCH 1979**

Cyclogenesis at 500mb within an eastward moving short wave over Arizona occurred by 12Z 2 March (Figure 6). Subsequent 12-hour 500mb analyses (Figures 7 and 8) depict low movement across the southern Rockies and plains states - an ideal track for subsequent storm development over the central plains. Twelve hour height falls and centers (X) are shown. This system recurved over northern Texas on 3 March as indicated by the height fall center (HFC) movements in Figures 7 and 8. Following HFCs and their magnitude changes to determine system recurvature is discussed in detail in 3WW TN 79-2, Major Midwest Snowstorms.
Figures 9 and 10 show 300mb jet stream positions during and after recurvature. The jet strengthened and shifted eastward across the central plains by 12Z 3 March (Figure 10).

Surface charts during recurvature are shown in Figures 11, 12 and 13*. In Figure 11, an extensive precipitation area is occurring from Texas northward to the Dakotas. The main surface low is shown over the Texas Panhandle which relates to the 500mb low in Figure 7. Six hours later (Figure 12), a new low appeared over north-central Oklahoma ahead of the Panhandle low. As will be shown later, the Oklahoma low will become the dynamic low; the Texas low will dissipate to be replaced by cold polar air from the central Rockies. Identification of the primary surface low is sometimes difficult when several lows exist within the development area. Maintaining continuity on vorticity and height fall centers can help determine where the primary low will appear or develop.

Recognition of certain cloud features on satellite charts provides forecasters with another tool in the possible identification of system recurvature. In this case study and the one that follows, satellite charts depict comma cloud development over New Mexico and northern Texas during and several hours before system recurvature. These comma clouds became well-defined during and after the bottoming out period (see figure 3).

Figure sequence 14 (a, b, c, d) shows the development of a comma cloud (white arrow in figures) over western Texas within a 2-hour period. Thunderstorms are occurring east of the developing comma cloud. In Figure 14d (3/0410Z), the comma cloud has become fully developed. The comma head is approaching Childress, TX (CDS) (Figure 14d) and is in agreement with the vorticity center track shown in Figure 15 (from the LFM 500mb initial analyses).

* All analyses shown in this TN were copied exactly from NWS facsimile analyses.
Figure 16 relates the developing comma cloud with surface low positions at 06Z 3 March and the two tracks shown in the previous figure (Figure 15). Note the low pressure formation over north-central Oklahoma 3 hours after the comma cloud formed. As mentioned earlier, the Texas Panhandle low dissipated. This storm system moved northeastward to Missouri and produced heavy snowfall from the Nebraska - central Kansas area and westward.

COMMA CLOUD EVENT 2 - 30 OCT 1979

This system is similar in development to the one just described. In this case however, the recurvature area and the appearance of the comma cloud were located further to the west than shown in Case 1. A 500mb low developed within a short wave over Nevada at 12Z 29 Oct (not shown). Subsequent low development and movement are shown in Figures 17 through 21. System recurvature occurred by 00Z 31 Oct as shown in Figure 19.
Jet stream positions (300mb) during the recurvature period are shown in Figures 22 and 23.

Surface low development and its subsequent intensification over the southern plains are shown in Figures 24 through 26.
Figure sequence 27 (a, b, c) and Figure 28 shows the developing comma cloud (see white arrows in each figure). The comma is well defined over eastern New Mexico as shown in Figures 27b and 27c. By 1745Z 30 Oct (Figure 28), the comma-shaped cloud is not noticeable. Apparently the cloud move northeastward and weakened or has merged with the frontal cloud system shown over the central plains.
The 12-hour vorticity and 500mb low center tracks (from the LCN analyses) are shown in Figure 29. Recurvature is evident over the eastern New Mexico – Texas Panhandle region. These two tracks were included again, along with the 30/000Z comma cloud and surface low positions, in a composite chart (Figure 30). The comma head appears with the 500mb low center rather than the vorticity center. The comma tail is ahead of the 30/12Z maximum vorticity center. The heavy dashed line in Figure 30 is the axis of maximum vorticity which usually coincides with the rear of the PNA area (1).

**Figure 29:** 500MB Low and Vorticity Tracks
30 Oct - 01 Nov 1977

Note the good comma cloud definition just prior to recurvature. A few hours later, the surface system begins to move northward as shown in Figure 30. The occlusion process occurred between 30/1800Z and 31/0300Z. This system produced heavy snowfall over eastern Colorado, northeastern Kansas and western Nebraska.

**CONCLUSION**

Forecasting the recurvature path of storm systems evolving from the Rocky Mountains has proven difficult for the midwestern forecaster, and this information is vital to correctly forecast the extent of heavy snow, rain, thunderstorms, etc. The two studies presented tend to verify previous observations that storm recurvature after being influenced by a well-defined vorticity core. It is hoped that further more intensive study, forecaster training, access to satellite data, and satellite data analysis will improve the accuracy of the storm path with greater frequency. Meanwhile, forecasters should study the event and use the concept cautiously.
REFERENCES


All satellite pictures courtesy of Air Force Global Weather Central.