THUNDERSTORM DEVELOPMENT IN A JET STREAM DIFFLUENCE ZONE

Otto J. Karst

National Oceanic and Atmospheric Administration,
National Environmental Satellite Service, Synoptic Analysis Section,
Washington, D.C. 20233

ABSTRACT

The paper describes a typical case of thunderstorm development in unstable air beneath strong divergence aloft. The particular mechanism causing the divergence is a zone of diffluence between diverging jet streams. This case is illustrated with satellite imagery.

1. INTRODUCTION

On 20 April 1976, thunderstorms developed over the southern Mississippi Valley. This development was associated with an area of maximum diffluence between the polar and the subtropical jet. Thunderstorm development was inhibited equatorward of the axis of the subtropical jet. The locations of these jets and related thunderstorm activity are seen on imagery from the Geostationary Operational Environmental Satellite, GOES 1.

2. SURFACE ANALYSIS

A 1003 mb low pressure system was located over the Texas Panhandle at 0000 GMT, 20 April (Figure 1). A cold front stretched southward through western Texas to the Big Bend area. The air ahead of the front was quite moist with Waco, Texas (ACT) reporting air temperature/dew point temperature of 22°/19°C and Del Rio (DRT) 29°/14°C. Behind the front the air was extremely dry at Lubbock (LBB) (22°/-13°C) and at Amarilo (AMA) (18°/-5°C).

At 1200 GMT, 20 Arpil 1976, the storm center had moved into Oklahoma with the cold front stretching southward through central Texas. The moist air ahead of the front in eastern Texas had typical temperatures and dew points

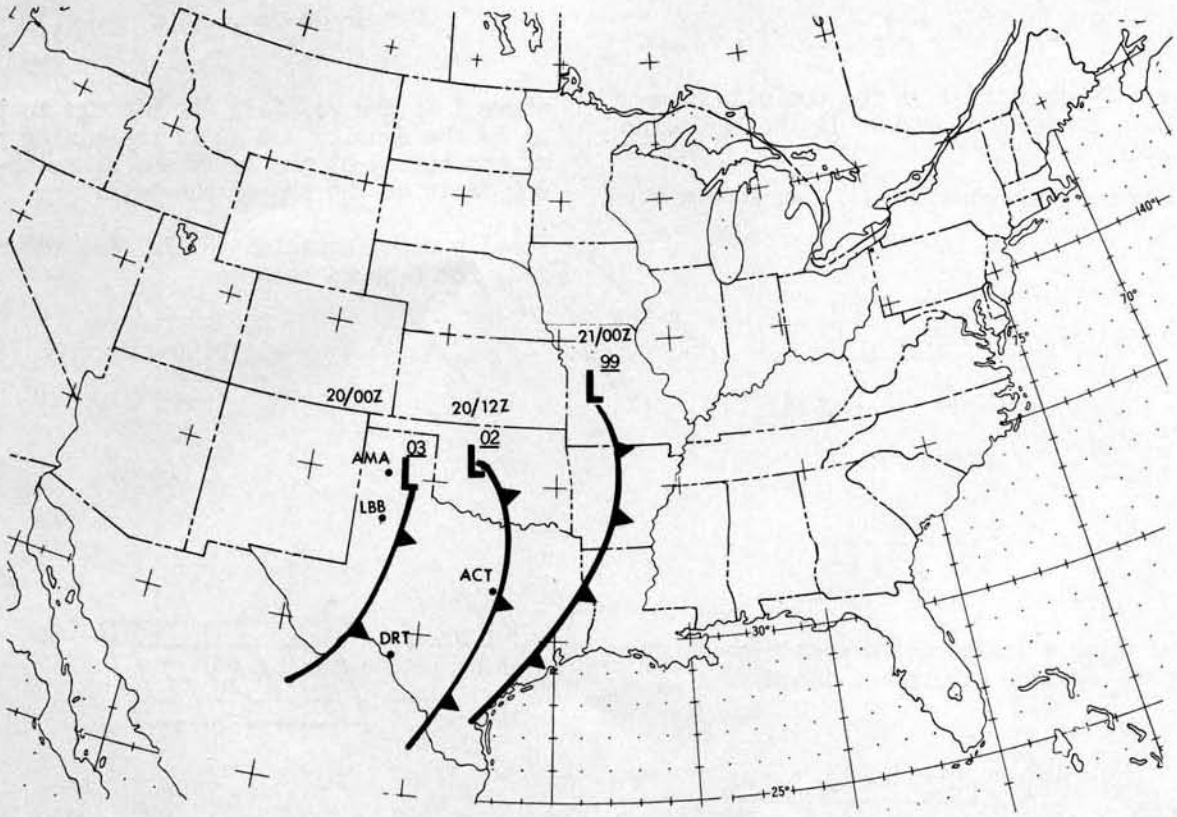

Figure 1 NMC Surface Frontal Positions for 0000 GMT and 1200 GMT 20 April 1976 and 0000 GMT 21 April 1976.

of 19°/17°C, while behind the front LBB reported 11°/6°C, and DRT 16°/6°C.

By 0000 GMT, 21 Arpil, the surface low had moved westward into western Missouri with a central pressure of 999 mb. The cold front extended into the lower Mississippi Valley, but the sharp dew point contrast across the front had diminished to only 5°C.

The NMC surface frontal analyses, the 500 mb low centers and polar and subtropical jet positions are shown on the GOES 1 Infrared (IR) satellite pictures for the 0000 GMT and 1200 GMT, 20 April, and 0000 GMT, 21 April 1976 times (Figures 2a, 2b, and 2c). Thunderstorm activity was occuring 100 nm eastward of the cold front during the period.

3. UPPER AIR ANALYSES

At 0000 GMT, 20 April, the 500 mb low center was located on the New Mexico-Texas border with a 5600 meter minimum height at AMA, while the surface low center was located over the Texas Panhandle. This indicated a slight vertical tilt to the system (Figure 2a).

In twelve hours, the low deepened to a 5500 meter cut-off low over the eastern portion of the Oklahoma Panhandle as the trough axis moved into Central Texas (Figure 2b), and the 500 mb low became more nearly vertical with the surface low.

By 0000 GMT, 21 April (Figure 2c), the 500 mb low was cut-off from the westerlies to the north as the center moved to extreme northwestern Arkansas. The associated trough axis continued to push eastward through Texas and weakened.

The 500 mb centers are shown on the satellite pictures for the three time periods. The comma-shaped configuration around the 500 mb low sharpened by the 1200 GMT, 20 April picture in Figure 2b, at about the time the 500 mb low center was analyzed as a cut-off cyclone. This picture would imply that the cyclone had deepened: i.e. the cloud band over Nebraska, Kansas, and Oklahoma developed a smooth northern edge around the comma head. By 0000 GMT, 21 April, the 500 mb low reached the mature storm stage over the Great Plains.

Figures 3a,b, and c, show the speed, direction, and height of the maximum winds for the indicated radiosonde stations over the Central and Southern U.S. for the three synoptic times coincident with those of the GOES 1 pictures in Figures 2a,b,and c. The height is given in thousands of feet and the wind speed in knots. The polar jet is analyzed as a solid arrow head line on the maximum wind charts and on the three satellite pictures.

At 0000 GMT, 20 April (Figure 3a) the height of the polar jet lowered from 34,000 feet over Salt Lake City, Utah to 30,000 feet at the base of the trough in western Texas. In the anticyclonic flow over Oklahoma and Missouri the polar jet again rises to 42,000 ft. Twelve hours later (Figure 3b) the polar jet lowered to 28,000 feet over central Texas near the time of maximum deepening of the trough. The winds over central Oklahoma backed as the trough approached.

The subtropical jet was analyzed on Figure 3a, b, and c as a dashed black arrow head line and is also traced on the three satellite pictures. A wind maximum moved across southern Texas at 1200 GMT, 20 April, with 105 kts reported at Brownsville (Figure 3b).

A cursory look at the satellite pictures for 0000 GMT, 20 April would place the subtropical jet through point (A) in central Texas (Figure 2a). Yet the GOES 1 movie loop through the period showed that this branch of the jet weakened, and by 1200 GMT, 20 April, had moved northward into the lower Mississippi Valley through point (B) (Figure 2b). The subtropical jet stream was placed through extreme southern Texas because the axis of the cirrus clouds remained a stationary feature during the time period. This jet axis was located slightly equatorward of the northern edge of the cirrus band, because experience with conventional data has shown this to be the optimum position for a subtropical jet axis.

4. DISCUSSION

Thunderstorms were occurring, at 0000 GMT 20 April, from northeast Texas to eastern Oklahoma and Kansas. As the 500 mb low deepened and the trough axis moved eastward through central Texas, the thunderstorms occurred in the region of maximum diffluence aloft over the lower Mississippi Valley. Thunderstorm activity started to diminish when the 500 mb trough moved eastward and the diffluence was not as pronounced as earlier. (See the upper air charts for 0000 GMT, 20 April.)

The satellite pictures show that the diffluence between the subtropical jet and the polar jet had an influence on thunderstorm development, and the subtropical jet acted as a barrier against further thunderstorm development south of the jet axis.

5. CONCLUSIONS

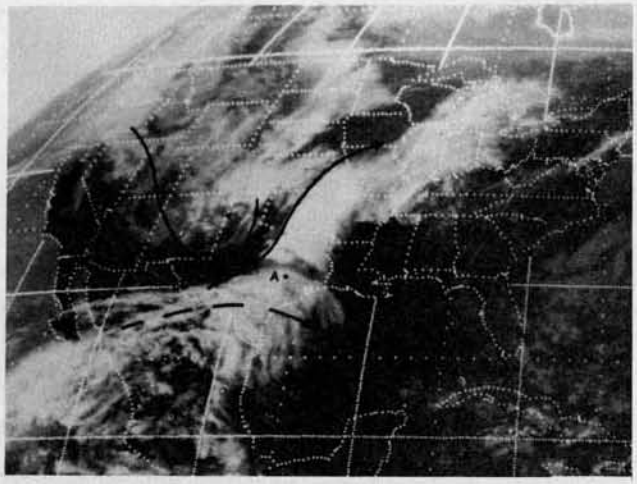

Figure 2a. GOES 1 Infrared Satellite Data for 0000 GMT 20 April 1976 with analyzed frontal position, 500mb low center (dot), polar (solid) and subtropical (dashed) jet positions.

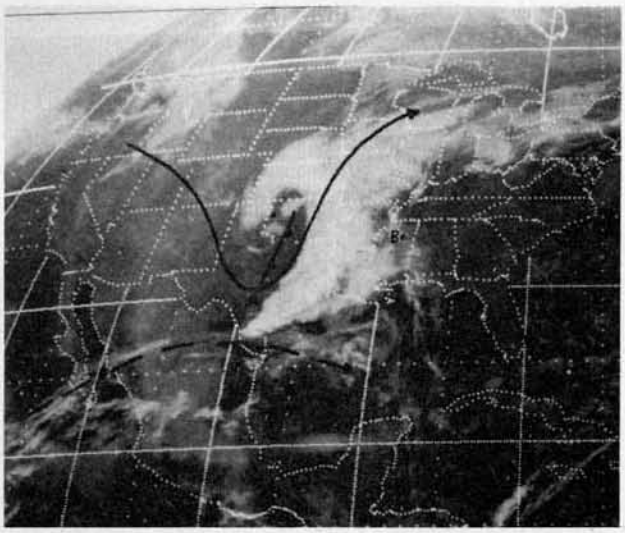

Figure 2b. GOES 1 Infrared Data for 1200 GMT 20 April 1976. (see Fig 2a.)

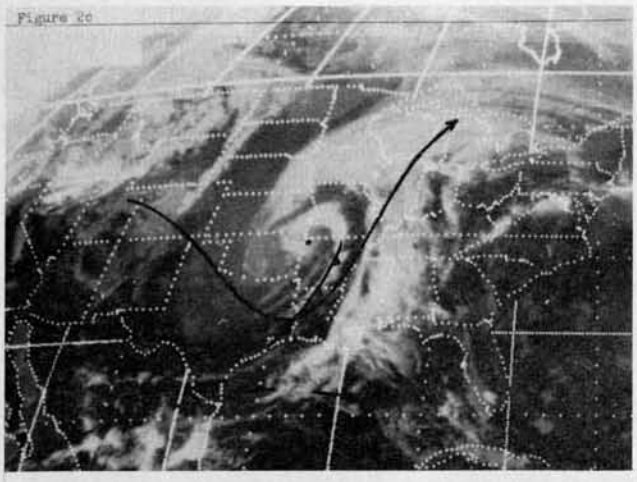

Figure 2c GOES 1 Infrared Data for 0000 GMT 21 April 1976. (see Fig 2a.)

This case is typical of many which indicate the effect of the polar and subtropical jets on thunderstorm development. These storms develop in the warm air ahead of the cold front under the diffluent zone between the two jets, and the activity diminishes as the 500 mb trough weakens. Continuity of the satellite data may be used as an additional tool by the forecaster to assist him in determining the location and timing of anticipated weather activity.

Figure 3a. Maximum Winds Aloft, 0000 GMT 20 April 1976 speed in knots and heights in thousands of feet.

Figure 3b. Maximum Winds Aloft, 1200 GMT 20 April 1976. (See Fig. 3a)

Figure 3c. Maximum Winds Aloft, 0000 GMT 20 April 1976. (see Fig. 3a)