A SATELLITE VIEW OF POSITIVE VORTICITY ADVECTION INDUCED CYCLOGENESIS

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1. INTRODUCTION

Prior to the dissemination of satellite pictures to the field, the forecaster relied on numerical guidance as his main tool in the prediction of positions and strength of short wave troughs and their associated positive vorticity advection (PVA) fields. He or she had no reliable method to do a real time verification of this prediction between map times.

The prediction of short wave trough positions and strength is a very critical forecast tool in forecasting cyclogenesis. Petterssen stated that "the overtaking by an upper level trough (with PVA in advance of it) of a frontal system in the lower troposphere is one of the most reliable indications of cyclonic development at sea level". This rule was vividly illustrated during the period 0000 GMT to 2400 GMT on January 17, 1976.

2. DISCUSSION

The 0000 GMT LFM initial 500 mb (Fig. 1) depicted a long wave trough stretching from James Bay to the Gulf of Mexico on January 17, 1976. Along the southern end of the trough was a strong short wave with a vorticity value of 20 x 10^{-5} units and a strong slug of PVA field ahead of it. The corresponding 300 mb analysis (Fig. 2) indicated a digging jet behind the short wave with a 140 kt jet maximum from eastern Kansas to northwest Louisiana. A weak surface low pressure system was over eastern Georgia existing on a polar front stretching from New York through Georgia. The 0030 GMT satellite picture (Fig. 3) did not indicate any significant development of PVA induced clouds ahead of the short wave. (In satellite imagery, a PVA induced cloud takes on a characteristic comma shape.)

The 0020 GMT Washington satellite interpretation message (SIM) mentioned some indication of a short wave over Georgia and a

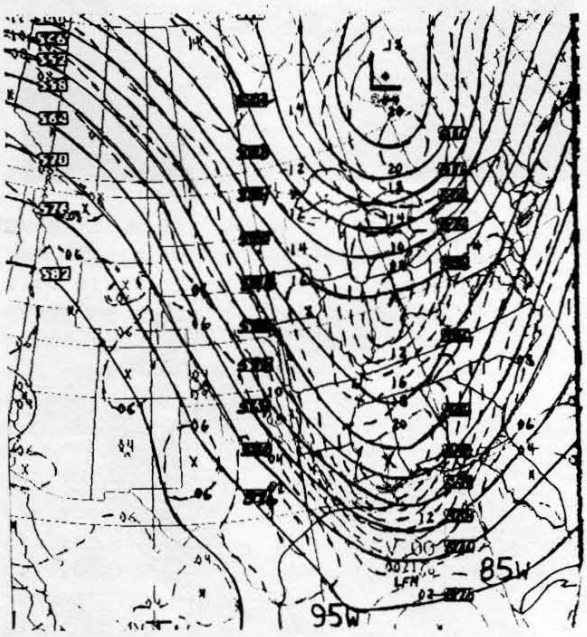

Figure 1. Initial 500mb LFM analysis, 0000 GMT 17 January 1976.

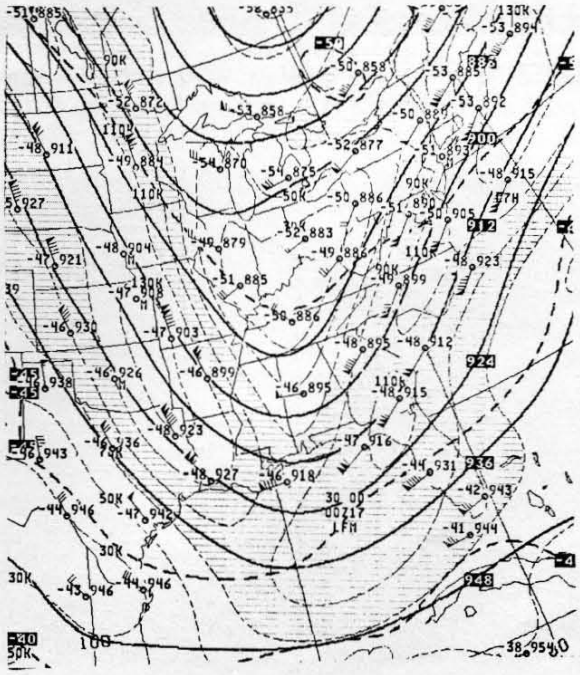

Figure 2. 300mb analysis, 0000 GMT, 17 January 1976.

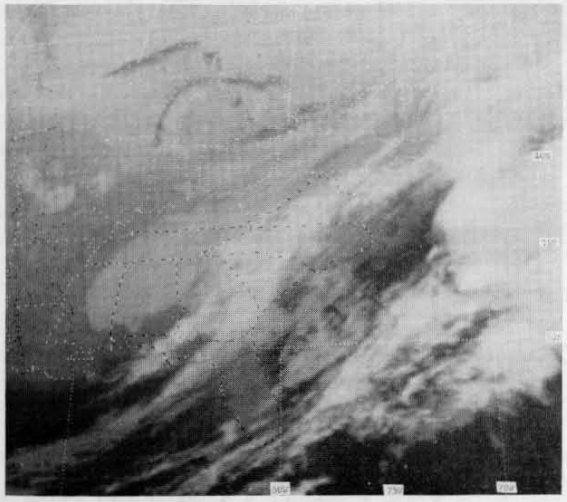

Figure 3. GOES-1 Infrared (IR) data, 0030 GMT 17 January 1976.

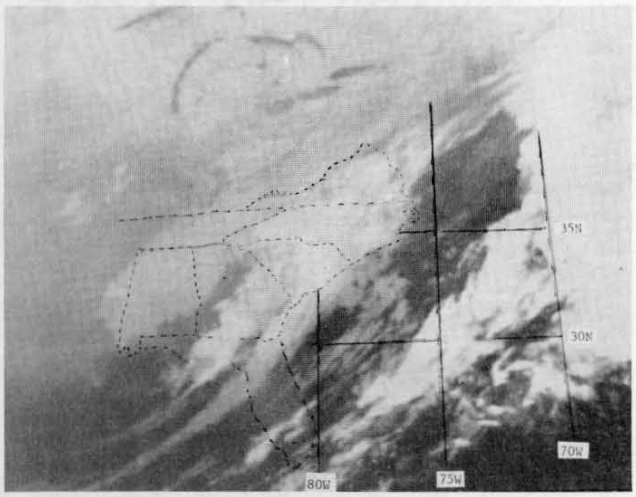

Figure 4. GOES-1 IR data, 0300 GMT, 17 January 1976.

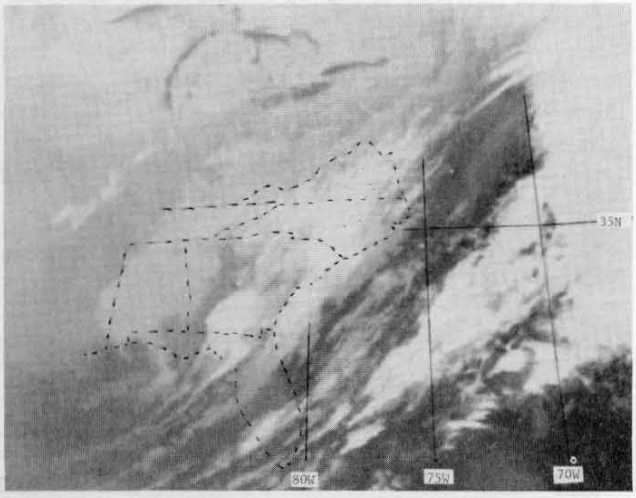

Figure 5. GOES-1 IR data, 0430 GMT, 17 January 1976.

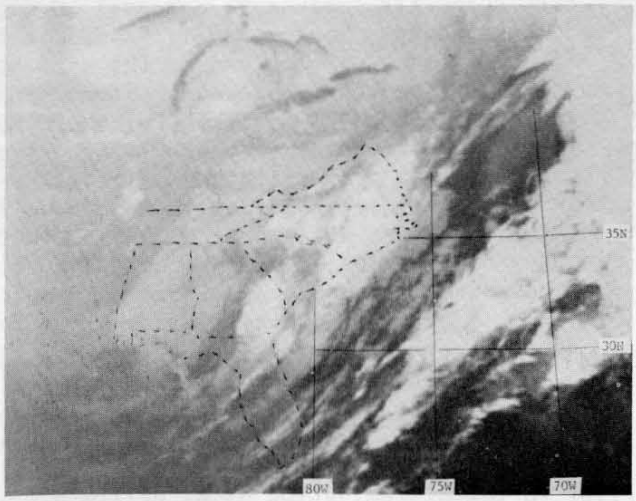

Figure 6. GOES-1 IR data, 0600 GMT, 17 January 1976.

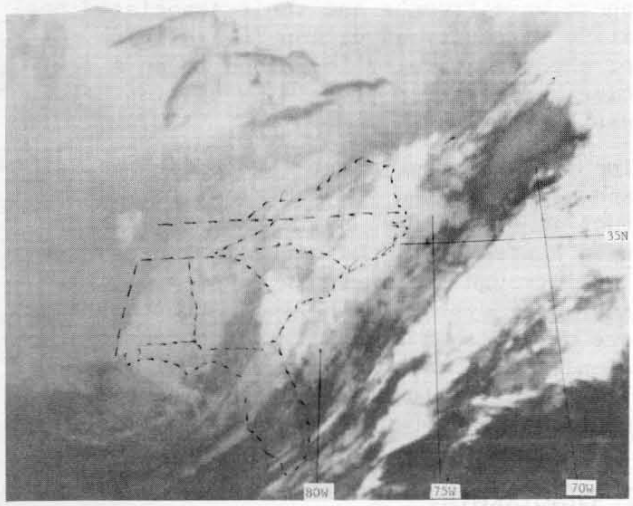

Figure 7. GOES-1 IR data, 0730 GMT, 17 January 1976.

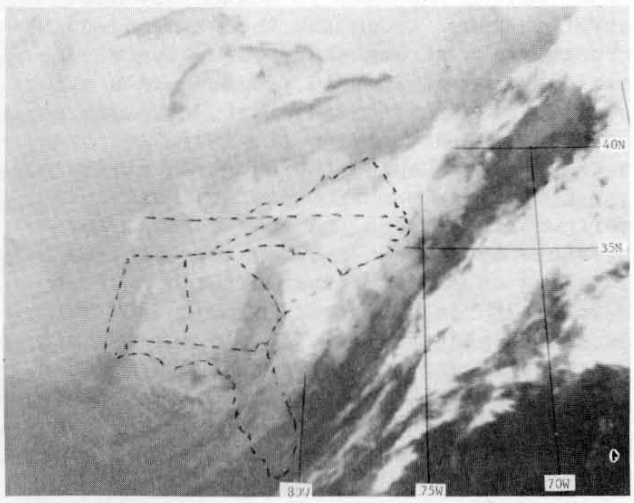

Figure 8. GOES-1 IR data, 0900 GMT, 17 January 1976.

weak low in the Carolinas. At 0300 GMT (Fig. 4), some rather interesting cloud development was taking place over northwest Florida, which by 0430 GMT (Fig. 5) was over southern Georgia. The cloud pattern was beginning to assume an oval shape with a developing, sharply defined, back edge. At 0600 GMT (Fig. 6), the cloud pattern was moving east northeastward over Georgia and was continuing to grow in size. More importantly the cloud edges were becoming better defined. According to Weldon, "The strength of a vorticity cloud pattern is defined by the distinctiveness of the cloud pattern. When a vorticity cloud pattern is strengthening: The cloud edges become better defined." The 0600 GMT surface analysis (not shown) analyzed a weak low pressure system over South Carolina, just west of Columbia, or to the northeast of the cloud pattern.

At 0730 GMT (Fig. 7), the PVA cloud pattern was pushing into South Carolina. The 0800 GMT satellite interpretation message (SIM) stated..."Short wave extends from 50N AYS to 30N 83W has been moving through SE Ga. 30 to 35 KTS and now is beginning to move northeastward." Notice the part of the cloud over southeast Georgia. Weak semicircular striations are becoming evident. This is an indication of "Rotation of the air with respect to itself...the physical parameter best related to the effect is vorticity" (Weldon).

The synoptic situation leading to the expected cyclogenesis assumed the Type 1 Meridonal Trough Cyclogenesis Configuration (Weldom) most prominent along the east coast. Timing is one of the problems with this type of cyclogenesis. According to Weldon, "When development does begin, it will be in response to one of the small or short-wave-scale vorticity maxima as it comes around into the front side of the trough."

At 0800 GMT, this short wave has been found via the satellite picture. The forecaster has now been given something concrete to work with between conventional map time, an impossibility just a few years ago.

The 0900 GMT satellite picture (Fig. 8) showed the vorticity cloud pattern to be over South Carolina, beginning to overtake the weak surface low (Fig. 9) which was located along the South Carolina coast with a central pressure of 1005 MBS. Snow and temperatures of less than 32 degrees were observed to the west, as close as Asheville, North Carolina. Concurrently, the North Carolina zone forecast package was being

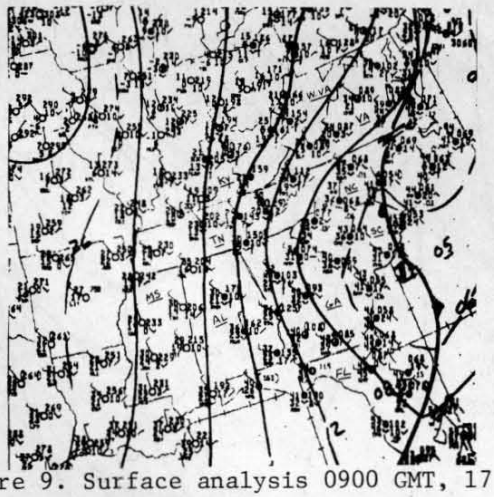

Figure 9. Surface analysis 0900 GMT, 17 January 1976.

prepared. The satellite pictures, showing the impending cyclogenesis, were used to confirm other guidance which indicated rain changing over to snow as the developing low pressure system ingested colder air lying to the east. Accordingly, rain changing to snow was indicated for the central and western sections of North Carolina.

Shortly after 1100 GMT, an updated satellite interpretation message was received. It stated, "...latest loop and stills show acceleration of short wave northeastward to near 40 KTS tilting to a N/S orientation along 80W between 30N and 35N."

The 1100 GMT satellite picture (Fig. 10) indicates that the vorticity cloud with a sharply defined back edge was over the deepening surface low (Fig. 11). The arrival of the PVA over the surface low had resulted in deepening the low to a pressure of 998 mb, a 7 mb fall in 3 hours, confirming the validity of Petterssen's Rule.

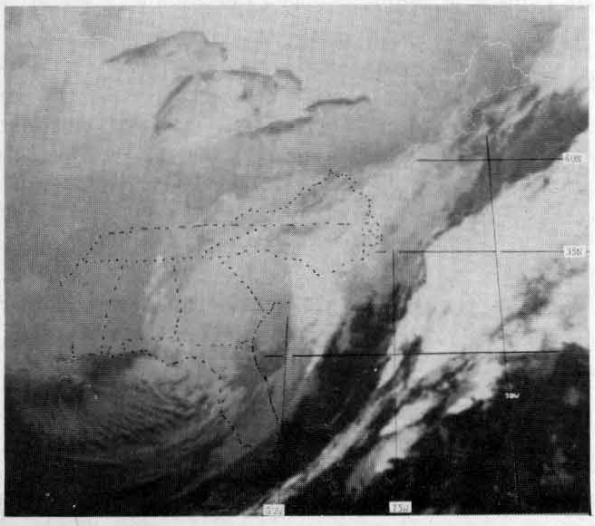

Figure 10. GOES-1 IR data, 1100 GMT, 17 January 1976.

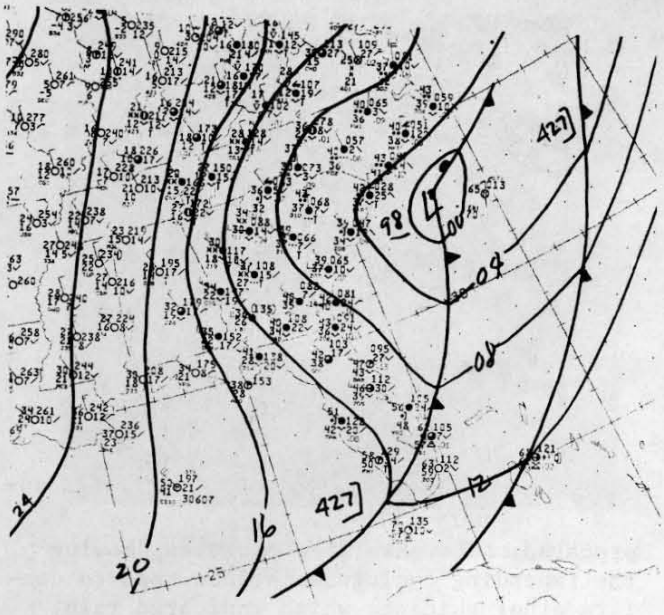

Figure 11. Surface analysis, 1200 GMT, 17 January 1976.

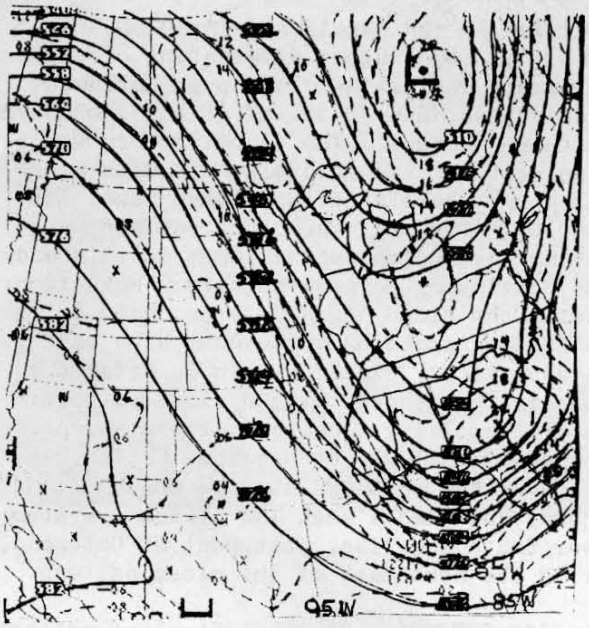

Figure 12. Initial 500mb LFM analysis, 1200 GMT, 17 January 1976.

The 1200 GMT LFM initial 500 mb Map (Fig. 12) dramatically confirms what the satellite pictures showed during the night and their immense value in locating short waves between the 12 hour map times. The short wave, with an increased vorticity value of 22 x 10^{-5} units, is located in extreme southeast Georgia, with the vorticity ridge running east southeast. The vorticity cloud pattern which was tracked all night, is just ahead of the short wave in the strong PVA field preceding it. By 1800 GMT, with the low out to sea, the rain had changed to snow as far east as Cape Hatteras. Snowfalls up to 2 inches were reported in the coastal sections of North Carolina. By 0000 GMT January 18th, the low had deepened to 980 mb. This fall of pressure amounted to 16 mb from the 1800 GMT reading of 996 mb.

3. REFERENCES

Petterssen, Sverre, 1956: *Weather Analysis and Forecasting. Volume I.* McGraw-Hill Book Co., New York, N.Y. 422 pp.

Weldon, R.B., 1975: National Weather Service Training Notes on Satellite Interpretation, National Environmental Satellite Service, unpublished.