NWS-CR-TA-86-18

AWS TECHNICAL LIBRARY
FL 4414
SCOTT AFB IL 62225

CRH SSD
AUGUST 1986

CENTRAL REGION TECHNICAL ATTACHMENT 86-18

NOCTURNAL THUNDERSTORMS, SOMETIMES KNOWN AS MCC'S (MESOSCALE CONVECTIVE COMPLEXES)

Joseph T. Schaefer
National Weather Service Central Region
Scientific Services Division
Kansas City, Missouri

INTRODUCTION

Nocturnal thunderstorms present one of the most difficult summertime forecast problem in the region around the Missouri River Valley. Climatologically there is a favored development zone for these storms running northward from central and eastern Kansas to eastern North Dakota and Minnesota. After these storms have developed they often grow into MCC's and impact significant portions of the country. Forecasting nocturnal thunderstorms is not easy. In fact, the development and testing techniques to forecast these storms was a major emphasis of the 1985 Pre-Storm Project. The proposed STORM-Central Project will further explore this problem. However, we cannot wait for the results of such experiments. We must do the best we can at forecasting these storms with today's knowledge and data.

THE PRE-STORM ENVIRONMENT

As a start, let's review what is known about the nocturnal thunderstorm's synoptic environment. Essentially, these storms develop in a rather innocuous setting. At 850 mb, warm advection is the principal feature. This advection is often, but not always, accentuated by a broad frontal zone and/or a low level jet. The prime region for storm development is on or immediately upstream of the frontal zone, and on or immediately west of the axis of the low level jet. The air must be moist and convectively unstable with 850 mb dewpoints of about 11°C or greater positioned upstream from the warm advection zone.

Experience has shown that if the 700 mb temperature is warmer than about 12°C, the lower atmosphere is too stable to support organized convection. Also, 700 mb dewpoints of 1°C or more appear to be necessary for nocturnal storm development. While warm advection is still occurring at 700 mb, it is typically much weaker than it is in the lower levels. Since warm advection extends from the surface to 700 mb, there is a rapid veering of the low level winds.

The 500 mb pattern associated with nocturnal storms tends to be quite bland. While post-analysis typically indicates that a weak short wave triggers the convection, real time analysis (without the benefit of hindsight) usually only shows a basically straight flow that is without well developed thermal or vorticity patterns. At times a 500 mb wind maximum is present, but often a NMC forecast of upward vertical velocity is about the only indication that a weak short wave is present. Temperatures at 500 mb are not extreme, but are cool enough so that the Total Totals (TT) Index ($TT = T_{850} + Td_{850} - 2 * T_{500}$) has a value of about 50° or greater.

FORECASTING FROM 00Z DATA

Can these truisms be used to delineate areas of potential nocturnal thunderstorms? Consider 00Z on July 26, 1986 (Fig. 1). At 850 mb a broad frontal zone nearly 300 miles wide is stretched from Williston through North Platte to St. Louis and Indianapolis. Dewpoints greater than 10°C extend northwestward from Oklahoma City through the central Dakotas. Even though there is no indication of a low level jet, geostrophic warm air advection is quite strong in northwestern Kansas and southern Nebraska as the warm air is deflected cyclonically as it "overruns" the frontal zone. Thermal advection is rather weak elsewhere. The 12°C isotherm at 700 mb runs northward from Oklahoma City to Topeka and then westward to the mountains near Denver. While there is a lack of 700 mb moisture over eastern Kansas, western Kansas has relatively high 700 mb dewpoints. Very little is happening at 500 mb, and the analysis of any short wave in the nearly zonal flow over the Central Region would be based more on artistic skill than on data. However, the 41 kt wind at Denver is 15 kt faster than the winds at any surrounding station and indicates the possibility that some type of perturbation is present between North Platte and Denver. If this is a migrating feature, nocturnal storms are likely to form in north central Kansas and south central Nebraska as it passes. Figure 2 shows that storms indeed did develop. These storms grew into a MCC which traveled eastward along the 850 mb thermal gradient during the morning hours.

On the next night similar conditions prevail (Fig. 3). The 850 mb frontal zone is still positioned so that geostrophic warm advection is occurring across Nebraska and Kansas. Moisture is also still abundant with a pool of air having dewpoints greater than 16°C lying over eastern Nebraska. At 700 mb, a tongue of air warmer than 12°C is across Kansas into South Dakota; this eliminates all but the eastern and western portions of Nebraska from consideration for organized convection. A 500 mb thermal trough in Colorado and another isolated wind maximum at Denver indicate the presence of a short wave approaching Nebraska from the west. Nocturnal storms must again be considered a strong possibility for southeast Nebraska. As shown in Fig. 4, storms did develop there. However, small storms also formed in central and eastern Kansas. While one can rationalize these storms by hindcasting, the 00Z data gave no strong indication of the imminent development of the Kansas storms.

Large scale conditions were still similar on 00 GMT on July 28, but subtle subsynoptic changes had occurred. The strongest 850 mb thermal gradient had shifted so that it was positioned over southern Iowa. Moderate 850 mb geostrophic warm air advection not associated with the frontal zone is occurring over eastern Kansas, Missouri, and western Illinois (Fig. 5). Excessively warm 700 mb air (temperatures greater than 12°C) covers all of Kansas and much of Missouri. The 700 mb chart also shows relatively dry air (Td<0) lying across Kansas, Missouri and central Illinois. There are indications that a weak thermal trough lies from Minnesota through southwest Missouri (reflections of this trough are also found at 700 mb). Thus convection should only be expected on the eastern extremities of the 850 mb warm advection zone as the 500 mb short wave passes. During the night convective activity developed in two clusters (one in southeast Iowa/northeast Missouri and the other in southern Illinois) separated by the area where the 00Z 700 mb dewpoint was dry (Fig. 6).

While these charts were admittedly analyzed after the weather occurred, this sequence shows the value of careful upper air analysis in evaluating the potential of nocturnal thunderstorms. While centralized charts are not available to use in time for the evening forecast, AFOS applications program MANPLT in conjunction with a plotter (e.g., PMOD) can be used to obtain plotted upper level charts by about 01Z so that a "quick and dirty" analysis can be performed. While our scientific knowledge and our data base are not adequate to allow us to make a categorical forecast, we can try to do better than constantly using the phrase "chance of thunderstorms tonight" with a climatological 20% PoP.

LONGER TERM FORECASTS

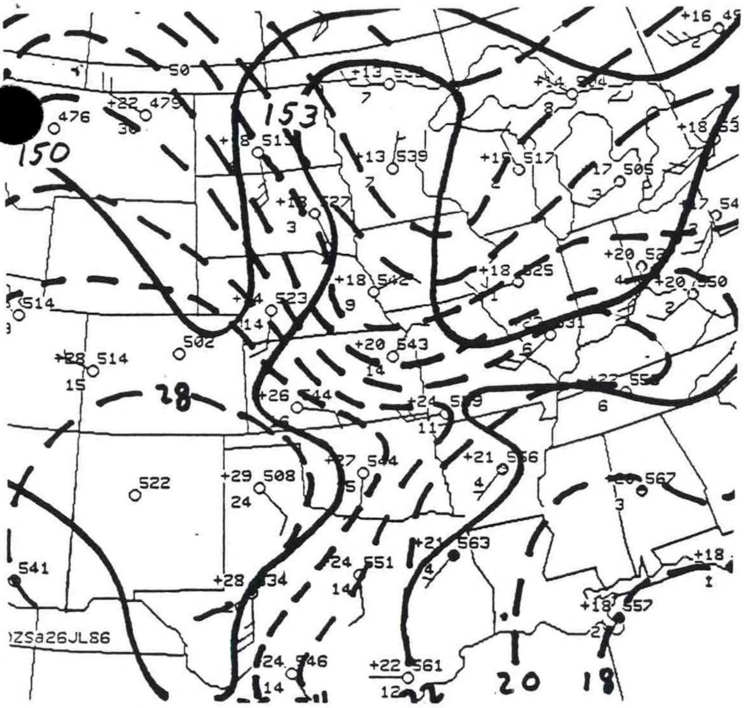
AFOS can also be used during the day to diagnose what the NMC models think about the nocturnal thunderstorm potential the next night. Ned Johnston (now a lead forecaster at WSFO MKE) wrote a paper in this technical attachment series (number 82-9) discussing a MCC forecast project at the Kansas City SFSS. During the study the SFSS meteorologists routinely examined the following to forecast nocturnal convection:

Parameter	AFOS Call
850/700 warm advection	82(H,T); 84(H,T); 70(H,T); K2K; K4K
Low level jet	L2M; L4M
Moist unstable air upstream	I2L; I4L
Deep Moisture	I2D; I4D
Upward Vertical Velocity	72V; 74V
500 mb short wave	52(H,V); 54(H,V)
Surface boundary progs	Ø2I, L2M; Ø4I, L4M

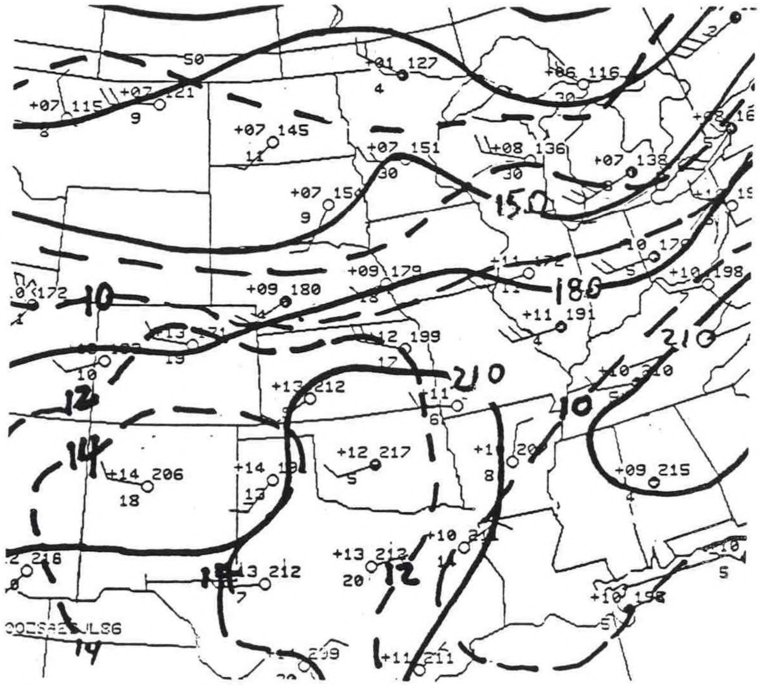
Obviously, this type analysis will only be as good as the model. Also, since there are no 700 mb temperature forecasts available on AFOS, "eyeball" forecasts are necessary.

In an unpublished discussion of the results of this forecast study, it was noted that the skill of a morning forecast for thunderstorms during the ensuing night was comparable to the skill of the SELS convective outlook. While this is far from perfect, it is a good start.

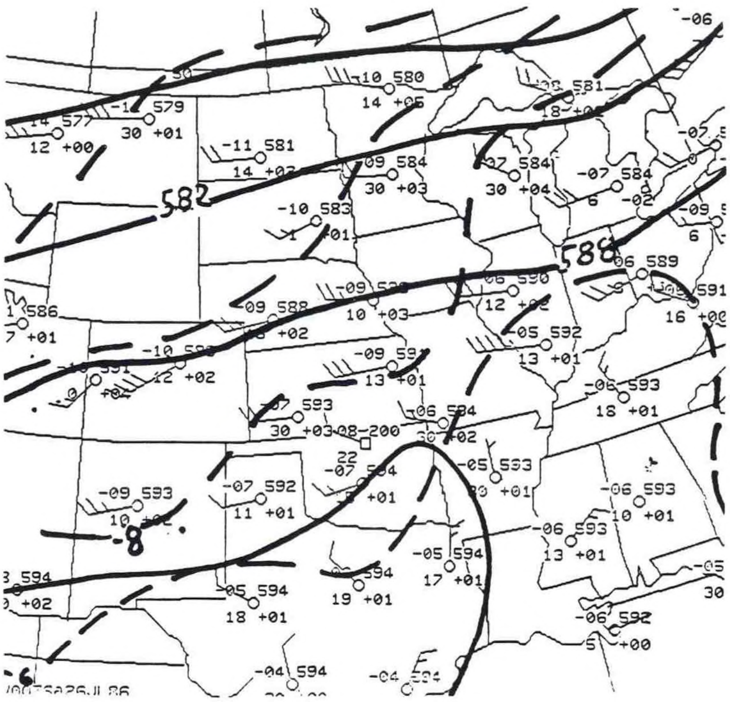
The future holds promise for improving our forecast ability. Measurements from the experimental wind profiler network should be available during 1989. The data should aid in detecting both warm advection (inferred from the veering of the wind with height) and small short waves. Perhaps we will even find low level jets that presently go undetected by the coarse spatial and temporal resolution of the rawinsonde network. Hopefully, this new technology will allow us to make more definitive short range forecasts of nocturnal thunderstorms.



A

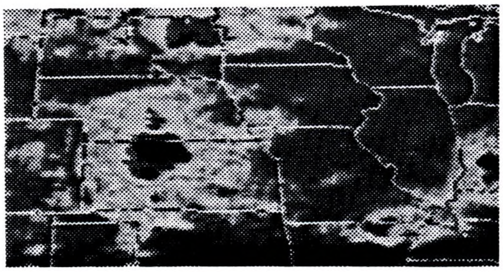


B

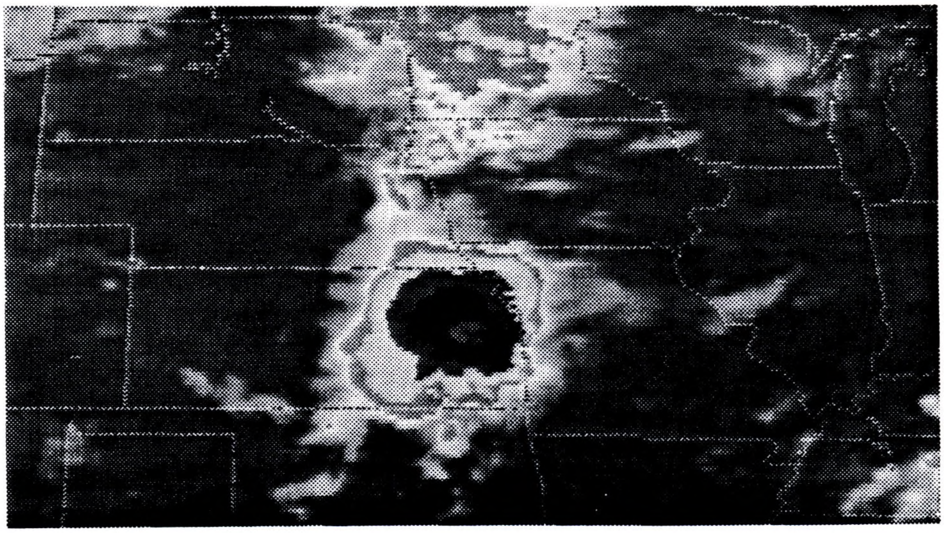


C

Fig. 1. 00Z Charts, July 26, 1986: (a) 850 mb - contours (every 30 m) solid, isotherms (every 2°C) dashed; (b) 700 mb - contours every 30 m) solid, isotherms (every 2°C dashed; and (c) 500 mb - contours (every 60 m) solid, isotherms (every 2°C) dashed.

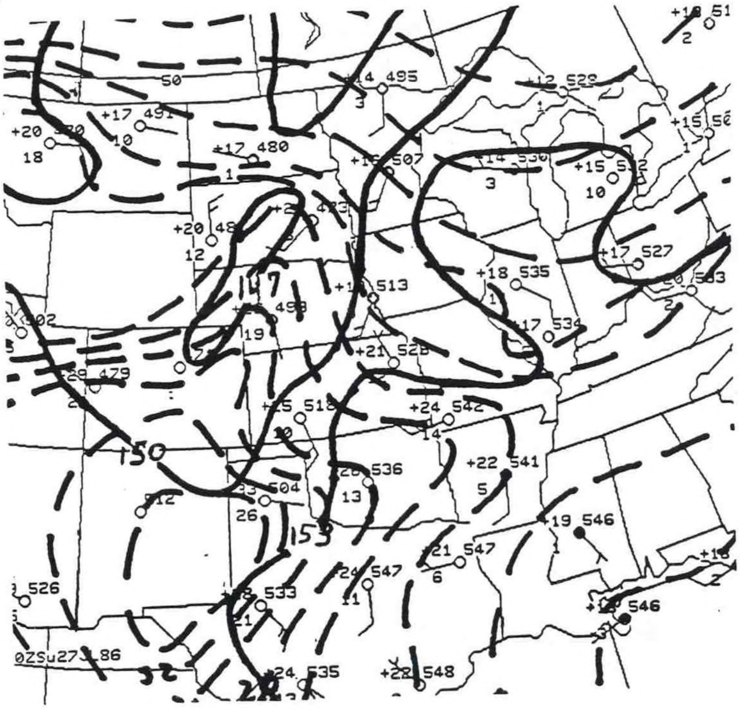


A

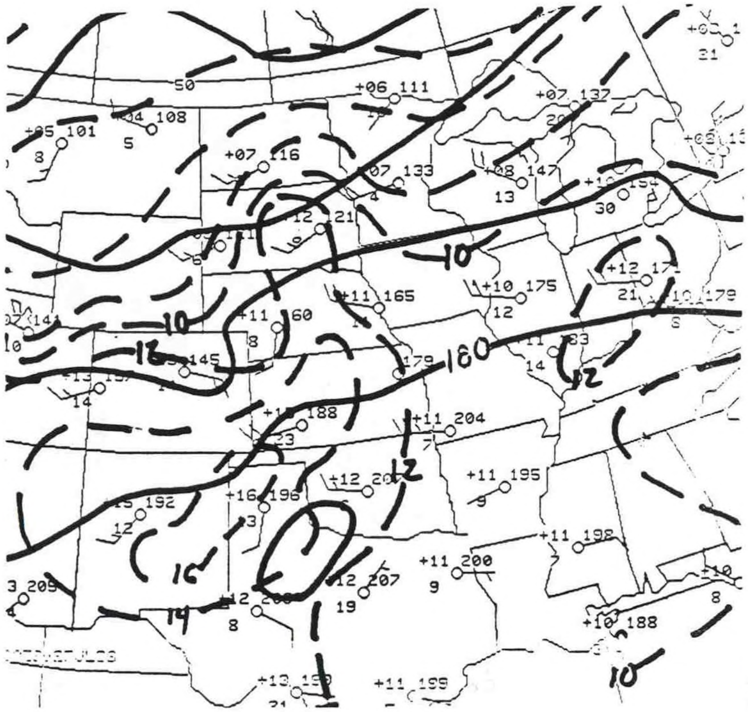


B

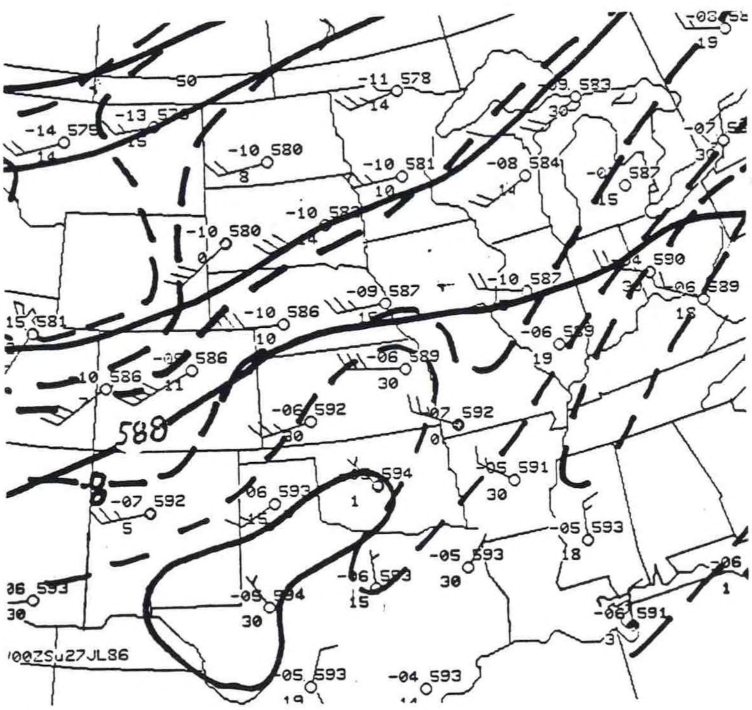
Fig. 2. GOES IR imagery, July 26, 1986: (a) 0500Z and (b) 1101Z.



A

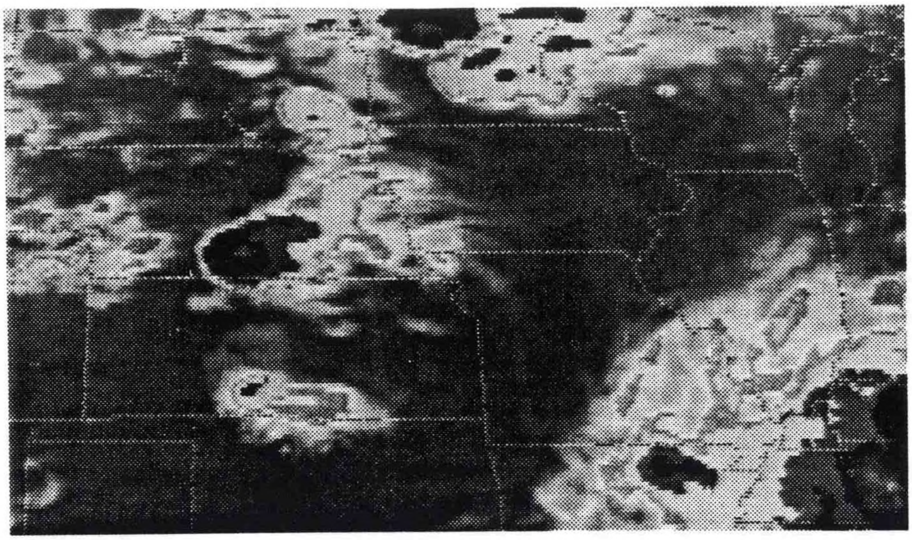


B



C

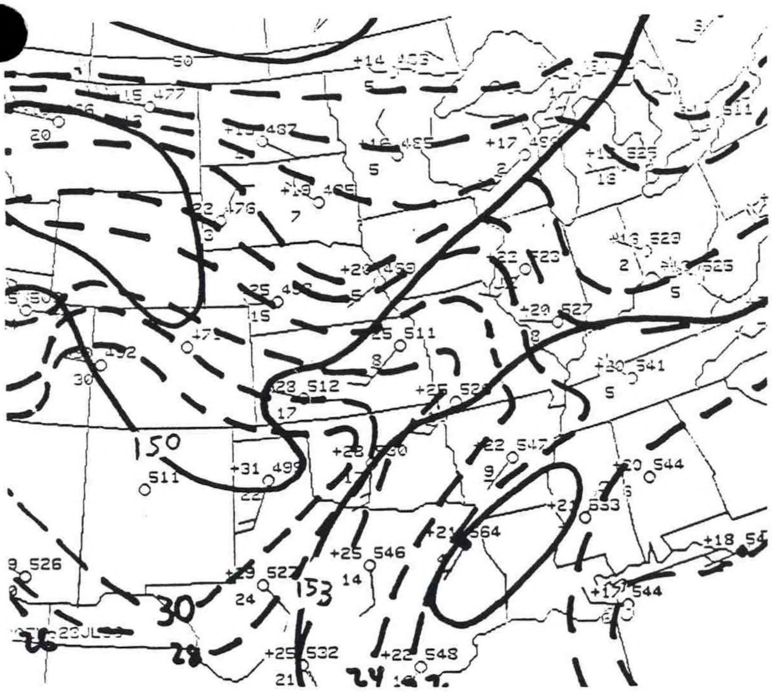
Fig. 3. 00Z Charts, July 27, 1986: (a) 850 mb - contours (every 30 m) solid, isotherms (every 2°C) dashed; (b) 700 mb - contours every 30 m) solid, isotherms (every 2°C dashed; and (c) 500 mb - contours (every 60 m) solid, isotherms (every 2°C) dashed.



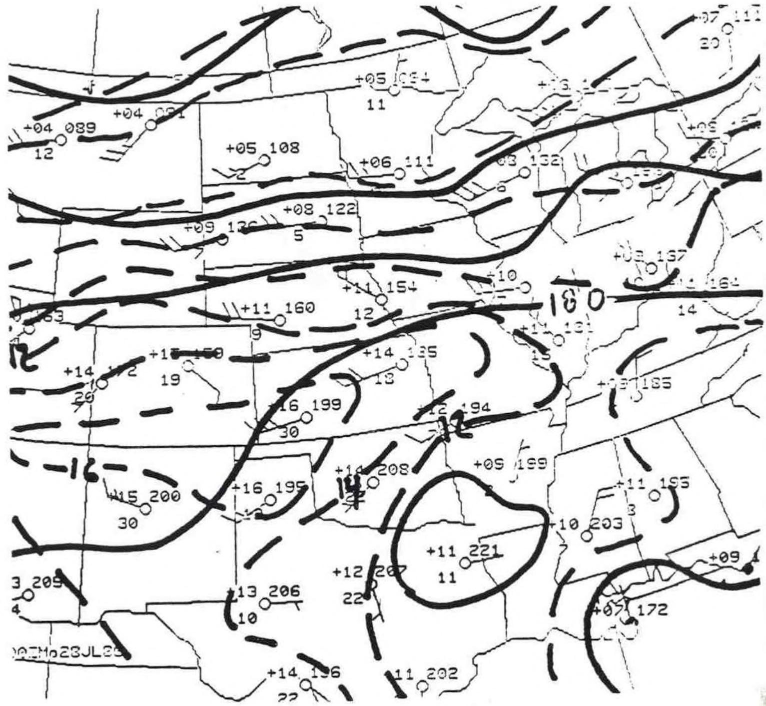
A

B

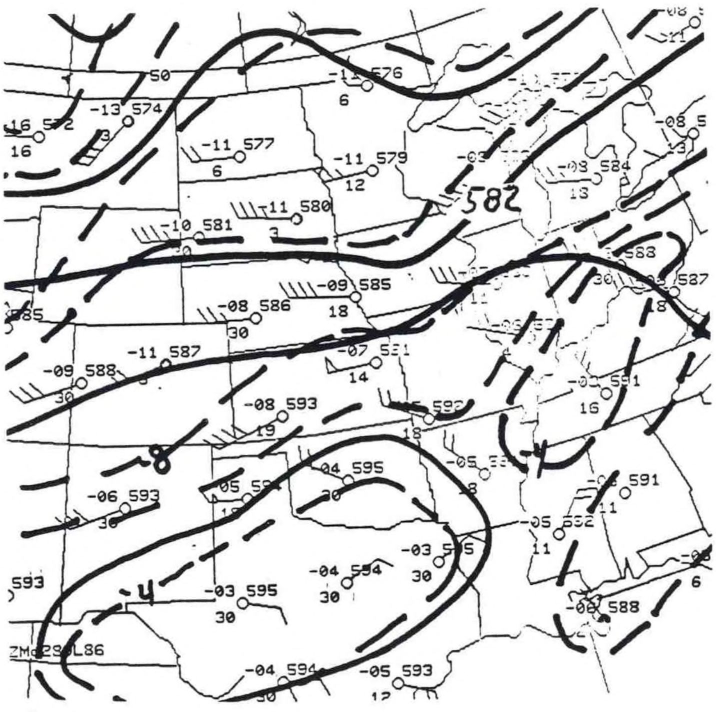
Fig. 4. GOES IR imagery, July 27, 1986: (a) 0500Z and (b) 1101Z.



A

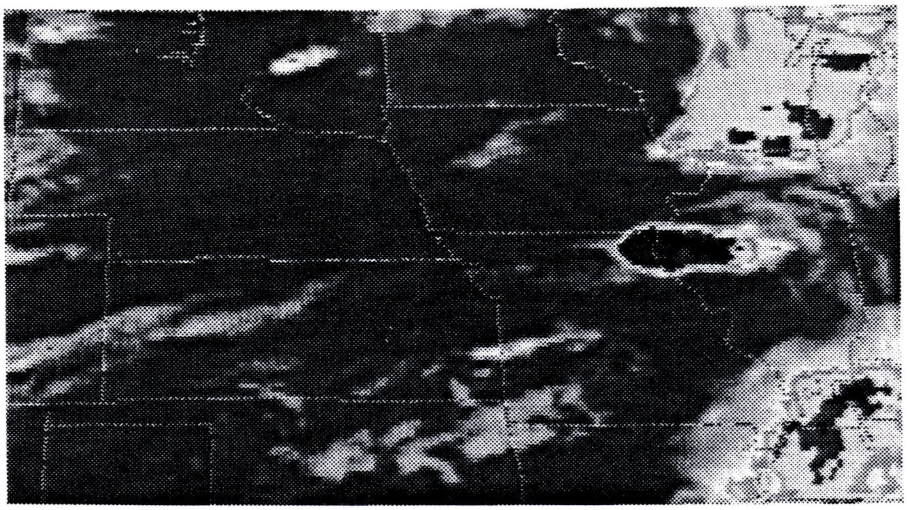


B

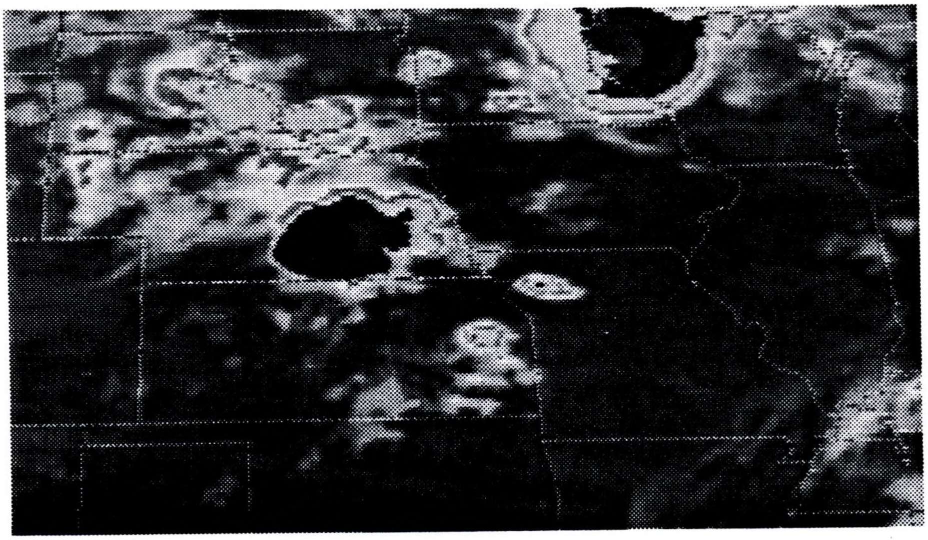


C

Fig. 5. 00Z Charts, July 28, 1986: (a) 850 mb - contours (every 30 m) solid, isotherms (every 2°C) dashed; (b) 700 mb - contours every 30 m) solid, isotherms (every 2°C dashed; and (c) 500 mb - contours (every 60 m) solid, isotherms (every 2°C) dashed.



A



B

Fig. 6. GOES IR imagery, July 28, 1986: (a) 0500Z and (b) 1101Z.