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Attachment #1

SWIS AND ENHANCING THE EL

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The Satellite Weather Interpretation System (SWIS) should add to the forecaster's tool box better methods for examining weather features in satellite imagery. Being able to animate pictures will add another dimension to our analysis of satellite data. Similarly, the ability to enhance specific grey shades in the imagery will allow us to highlight features of importance that previously might have escaped our attention with standard enhancement schemes.

Speaking further on the latter capability, SWIS will allow users to assign various shades of six basic colors (in addition to black, white, and grey shades) to specific grey shades inherent to the received picture. Here, however, it is important to understand that this does not mean assigning colors to specific temperatures or temperature ranges in infrared imagery. But rather, colors can be assigned to grey shades that are meant to represent those temperatures.

This is important because we are dealing with an analog (rather than digital) transmission signal. At times, there may be fluctuations in signal strength that cause variations (lightening or darkening) in the output of grey shades.

This should not present much of a problem if we are simply assigning colors to step contours of a standard enhancement curve (i.e. changing the black segment at -60 to -65 degrees C in the MB-curve to red). Where we can run into problems is in trying to specify (color enhance) an exact temperature range within a linearly enhanced segment of or in an unenhanced infrared image. Fluctuations in signal strength here could lead to false indications of warming or cooling of cloud top temperatures.

This limitation of the SWIS unit is not expected to be a major hindrance by any means. But a caution flag should arise whenever we attempt to provide fine detail to the infrared image using SWIS.

Enhancement limitations not withstanding, there's much to be gained by using the SWIS enhancement capability providing the user understands the most important features to be highlighted. The following two cases illustrate a relationship between the enhancement of specific temperature intervals and significant weather events. The relationship may not always hold, but it can serve as a starting point in the forecaster's search for meaningful data, instead of "nice-looking" pictures.

In forecasting convective weather, Doswell et al. (1982) and McCann (1982) have shown that in the analysis of radiosonde data, the Equilibrium Level (EL) is an important parameter for recognizing strong thunderstorms. Recall that in parcel theory, the EL is simply the level, at which a rising parcel of saturated air becomes colder than the environmental temperature and begins to decelerate (Figure 1).

Stone (1984) has provided a means using AFOS for the forecaster to quickly determine the EL. By knowing the approximate temperature of the EL and setting the enhancement of infrared imagery at or around this temperature, strong convection can be monitored, perhaps leading to the anticipation of severe weather.

CASE ONE:

On 17 August 1985, remnants of Hurricane Danny crossed the Carolinas. The 1530Z visible GOES picture (Figure 2) shows the cloud shield encompassing North Carolina and the surrounding area. It is difficult to distinguish vertical cloud development during midday with straight visible imagery. Furthermore, with visible imagery, changing sun angle makes it virtually impossible for the forecaster to quantify changes in thunderstorm cloud tops over time.

That morning, using Stone's stability analysis program, a representative EL temperature of minus 56 degrees Celsius had been determined for the area. On the basis of this EL temperature, an enhancement scheme was selected from the list of available enhancement techniques that would highlight temperatures near or above the level of the EL. The C3 composite visible/infrared enhancement fit this criteria because its threshold between visible and infrared coincided with the EL temperature.

It is worthwhile to note here that the current design of SWIS will not permit the forecaster to manipulate the threshold temperature on composite VIS/IR imagery. We will still be limited to the existing enhancement curves for this type of imagery coming from the Satellite Services Division of NESDIS in Washington. Where the forecaster can make adjustments to highlight clouds reaching the EL is on straight infrared imagery, linearly enhanced or completely unenhanced by the NESDIS computer.

At 1630Z (Figure 3), C3 enhanced imagery began showing cloud top temperatures at or above the EL over western South Carolina. Twenty minutes later, at 1650Z, a tornado first appeared northwest of Spartanburg, SC (see arrow) injuring 39 people, destroying 9 houses and 38 mobile homes.

With the old Unifax system for receiving satellite pictures, the 1630Z image would not have arrived to the forecaster until 15 minutes after the damage had occurred. With SWIS, the forecaster may have gotten a glimpse of the incoming picture at the same time the damage was occurring. With a direct satellite reception device, such as the University of Wisconsin-based McIDAS, and possibly with future upgraded SWIS equipment, the image would have been seen by the forecaster some 10 to 15 minutes prior to the event and might have played a role in the warning process.

By 1930Z (Figure 4), the imagery showed the same thunderstorm cluster with cloud top temperatures now reduced to minus 75 degrees. Even with delayed reception of satellite imagery, knowledge of thunderstorms that continue to overshoot the EL implying a strong persistent updraft, can play a role in the process of recognizing and warning for hazardous weather. Between 1630 and 1930Z, severe wind or tornado damage occurred in several locations across northwest South Carolina.

CASE TWO:

On 24 June 1986, the stability analysis program with 1200Z radiosonde data from Greensboro showed the EL with a corresponding temperature of about minus 57 degrees Celsius. All of the standard stability indices indicated ample thermodynamic support for convection that day across North Carolina.

The C6 composite visible/infrared enhancement, routinely available that summer on the DA3 sector, had an infrared threshold (minus 54 C) approximating the EL with an additional black contour (minus 60 C) to indicate cloud tops in excess of the EL.

Prior to 1800Z, no infrared segments had been observed implying cloud tops had been warmer than minus 54, thus lower than the EL. At 1800Z (Figure 5), a convective cell just to the east of Raleigh-Durham (RDU) showed infrared enhancement. At 1825Z, three-inch diameter hail fell from the thunderstorm.

By 1900Z (Figure 6), a line of thunderstorms had developed over north-east North Carolina. Several cells had cloud top temperatures colder than the indicated EL temperature. Arrows in the picture show reports of severe weather that occurred within 15 minutes of the image time.

By 2000Z (Figure 7), the line of thunderstorms over eastern North Carolina had grown larger with indicated cloud tops well in excess of the EL. Arrows pinpoint numerous reports of severe weather having occurred during the ensuing hour. A thunderstorm in western North Carolina also began showing a cloud top colder than the EL. At the time of the image, baseball-sized hail had been occurring from that cell.

In subsequent hours, the thunderstorms continued to produce severe weather and imagery continued to show cloud tops well in excess of the EL.

FINAL THOUGHTS AND CONCLUSIONS:

With the capability to enhance specific temperature intervals and the prospects of earlier GOES imagery reception at the forecast office in the future, we should recognize the greater role satellite imagery could have in the warning process for severe or hazardous weather.

Also, though not explicitly discussed in this paper, animation of the imagery should provide the forecaster with a more accurate means of extrapolating the movement of weather features in the near term, thus leading to a better anticipation of significant weather events.

By highlighting the convective cloud tops that reach or exceed the equilibrium level, the forecaster will be helping to define those thunderstorms capable of producing severe or hazardous weather.

But in all of our analyses of satellite imagery, we must understand the limitations of the equipment and systems we are using. SWIS, at times, may give us false indications of warming or cooling of cloud top temperatures. Besides SWIS, there are limitations inherent in the GOES imagery (temperature averaging, sensor time response lag, displacement errors, etc) not discussed in this paper that the user should understand before attempting to use the data in realtime fashion for short-fused events. Additional references are listed below for this purpose.

Adler, R.F., M.J. Markus, D.D. Fenn and W.E. Shenk, 1982: Thunderstorm Top Structure Observed by Aircraft Overflights with an Infrared Radiometer. Preprints, 12th AMS Conf. Severe Local Storms, Amer. Meteor. Soc., San Antonio, 160-163.

Doswell, C.A., J.T. Schaefer, D. W. McCann, T.W. Schlatter, and H.B. Wobus, 1982: Thermodynamic Analysis Procedures at the National Severe Storms Forecast Center, Preprints, 9th Conf. Weather Forecasting and Analysis, Amer. Metor. Soc., Seattle, 304-309.

McCann, D.W., 1982: The Distribution of Severe Aviation Weather In and Near Thunderstorms Using Satellite Imagery. Preprints, 12th Conf. Severe Local Storms, Amer. Meteor. Soc., San Antonio, 479-482.

Stone, H.M., 1984: RANP: Stability Analysis Plot Program, NOAA Eastern Region Computer Programs and Problems NWS ERCP-No. 16, National Weather Service, Garden City, NY.

Warren, R., 1977: Displacement Error of Satellite Cloud Tops, Weather Service Forecasting Handbook No. 6, National Weather Service, Washington D.C., 1-C.

Weiss, C.E., 1978: Cloud Location Corrections Near the Horizon of an SMS Image, Weather Service Forecasting Handbook No. 6, National Weather Service, Washington D.C., 1-D.

(unauthored), 1986: Supplementary Information from NESDIS Files, compiled by P. Parke, Weather Service Forecasting Handbook No. 6, National Weather Service, Washington D.C., 1-E.

SCIENTIFIC SERVICES DIVISION, ERH
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Attachments (Figures 1 through 7)

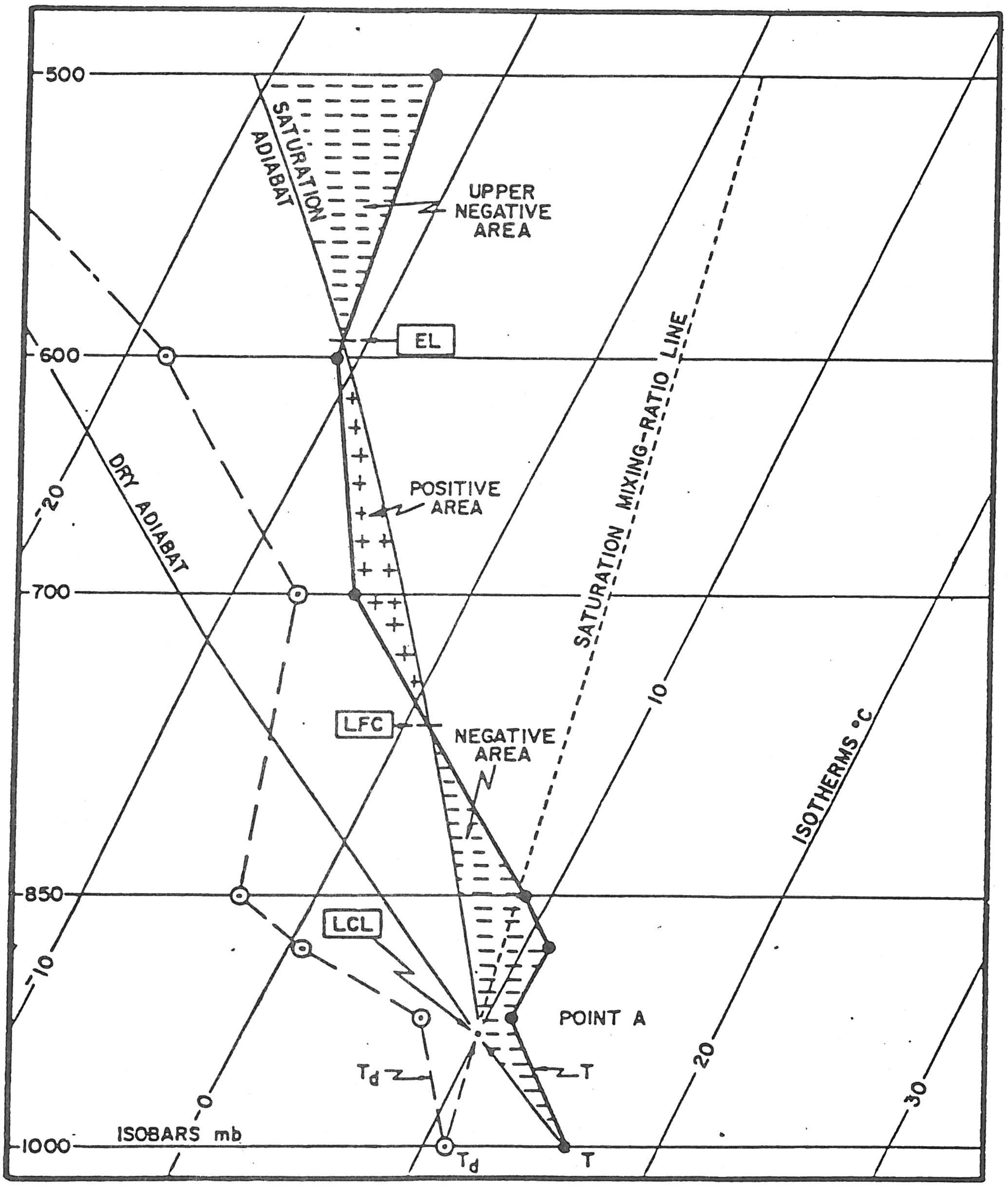

FIGURE 1:

FINDING THE EQUILIBRIUM LEVEL

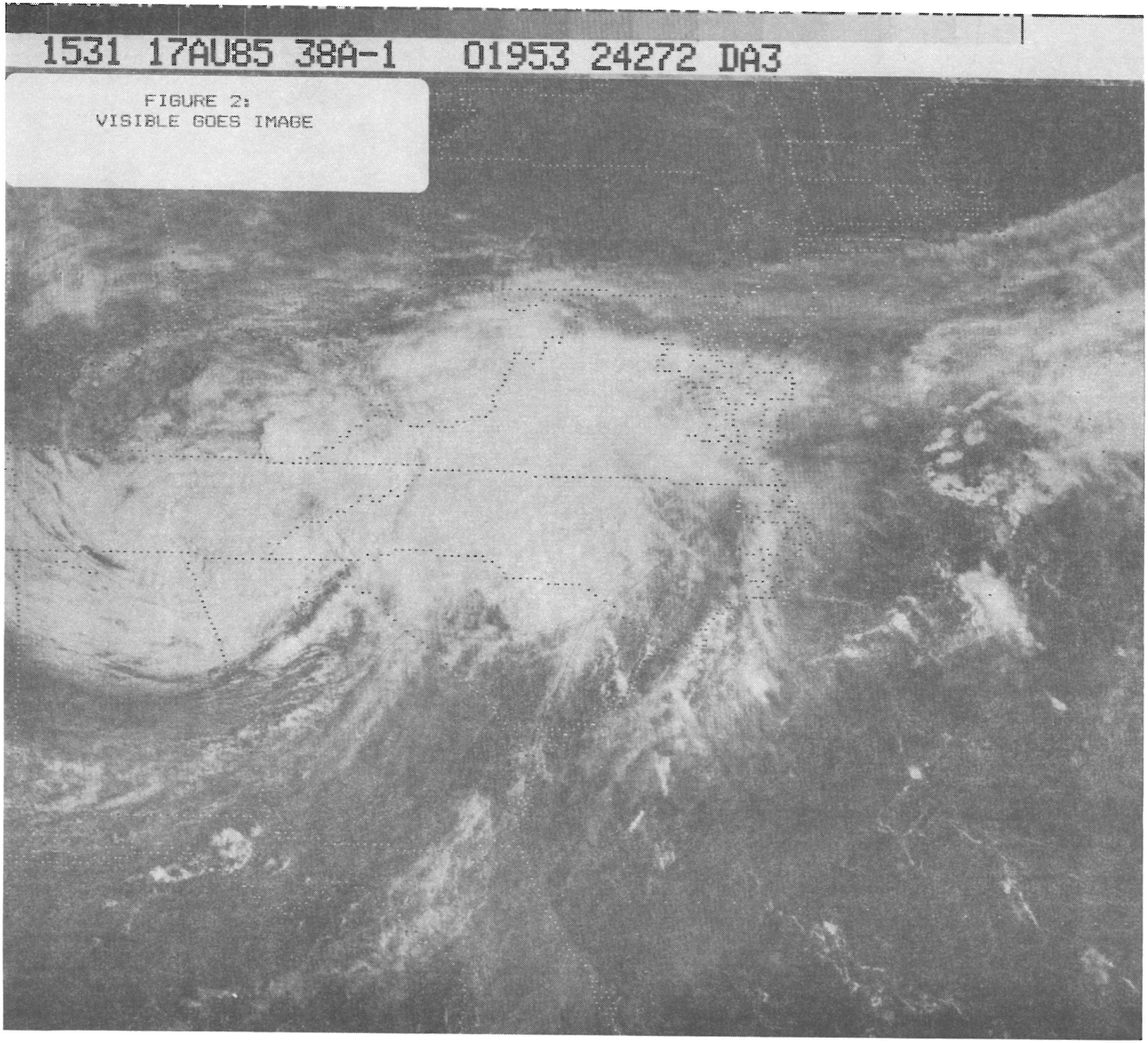

FIGURE 2:
VISIBLE GOES IMAGE

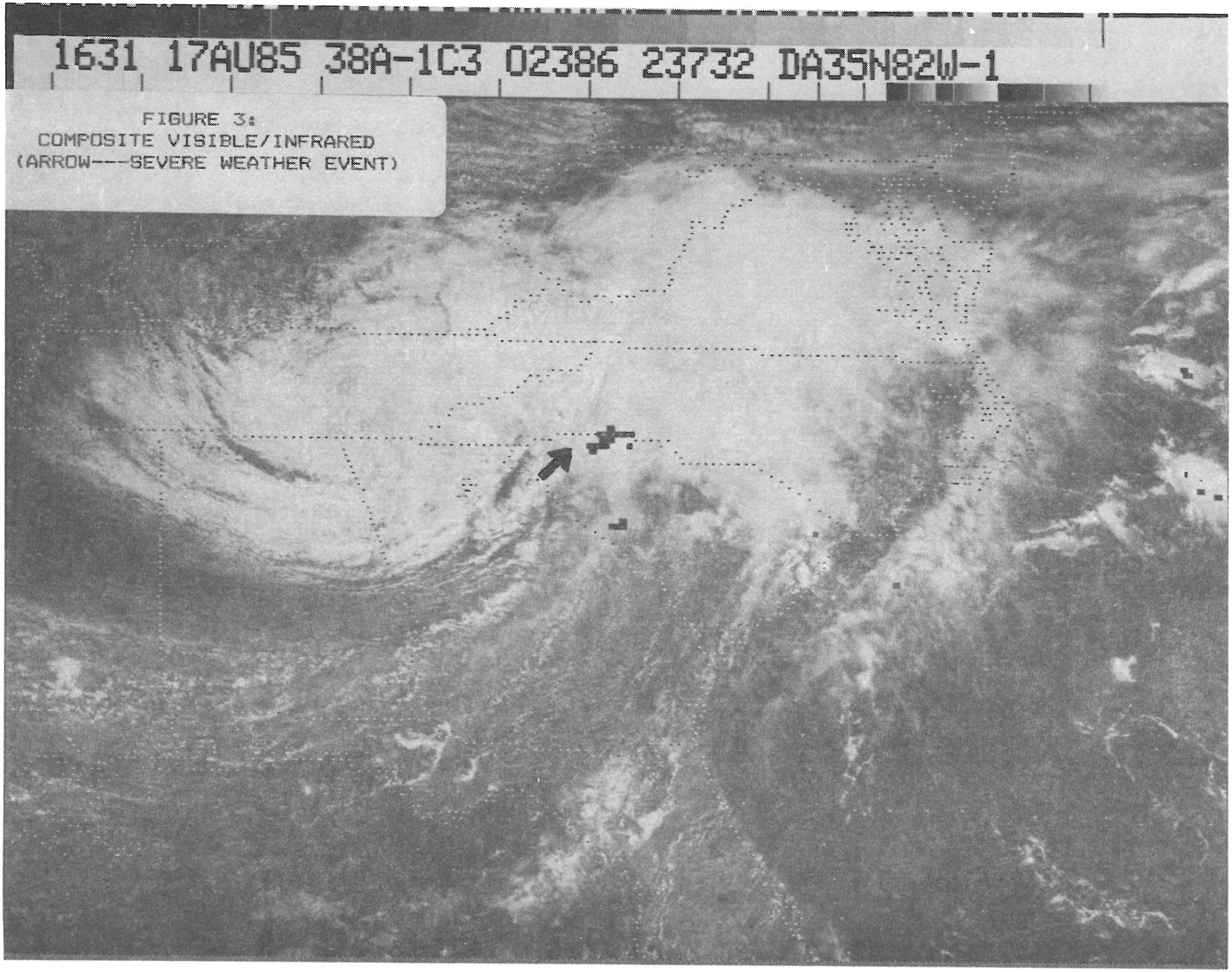

FIGURE 3:
COMPOSITE VISIBLE/INFRARED
(ARROW---SEVERE WEATHER EVENT)

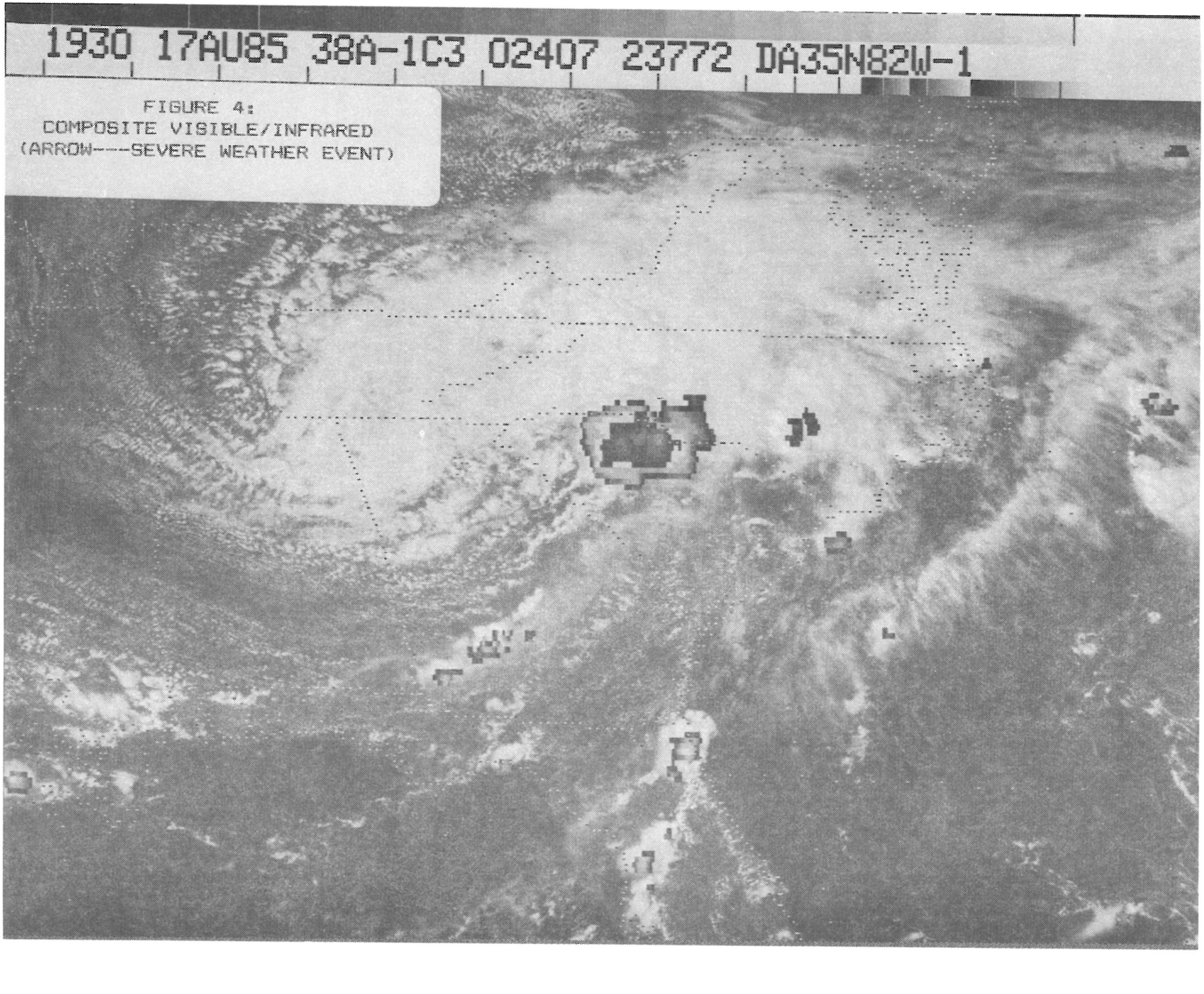

FIGURE 4:
COMPOSITE VISIBLE/INFRARED
(ARROW---SEVERE WEATHER EVENT)

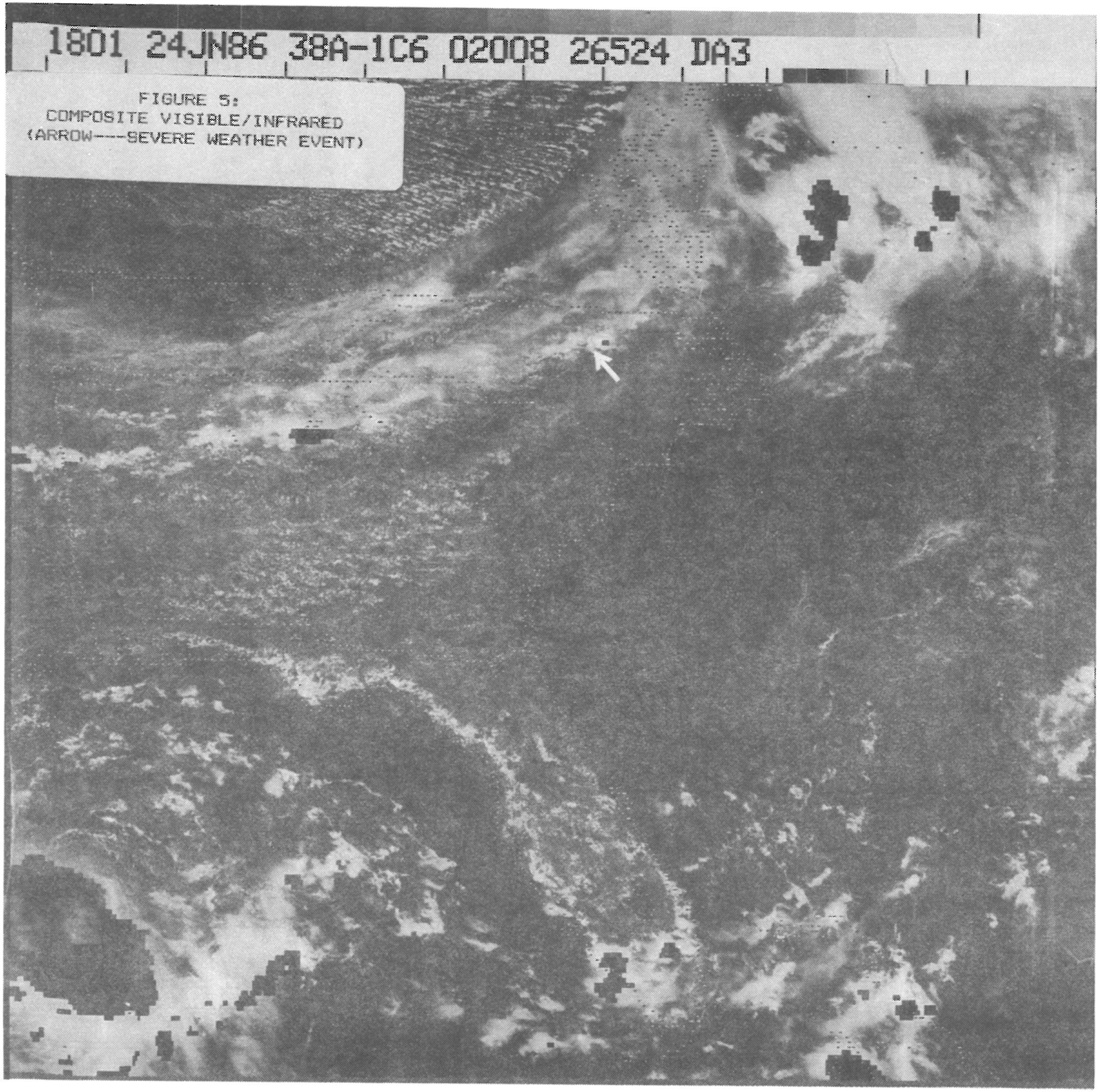

FIGURE 5:
COMPOSITE VISIBLE/INFRARED
(ARROW----SEVERE WEATHER EVENT)

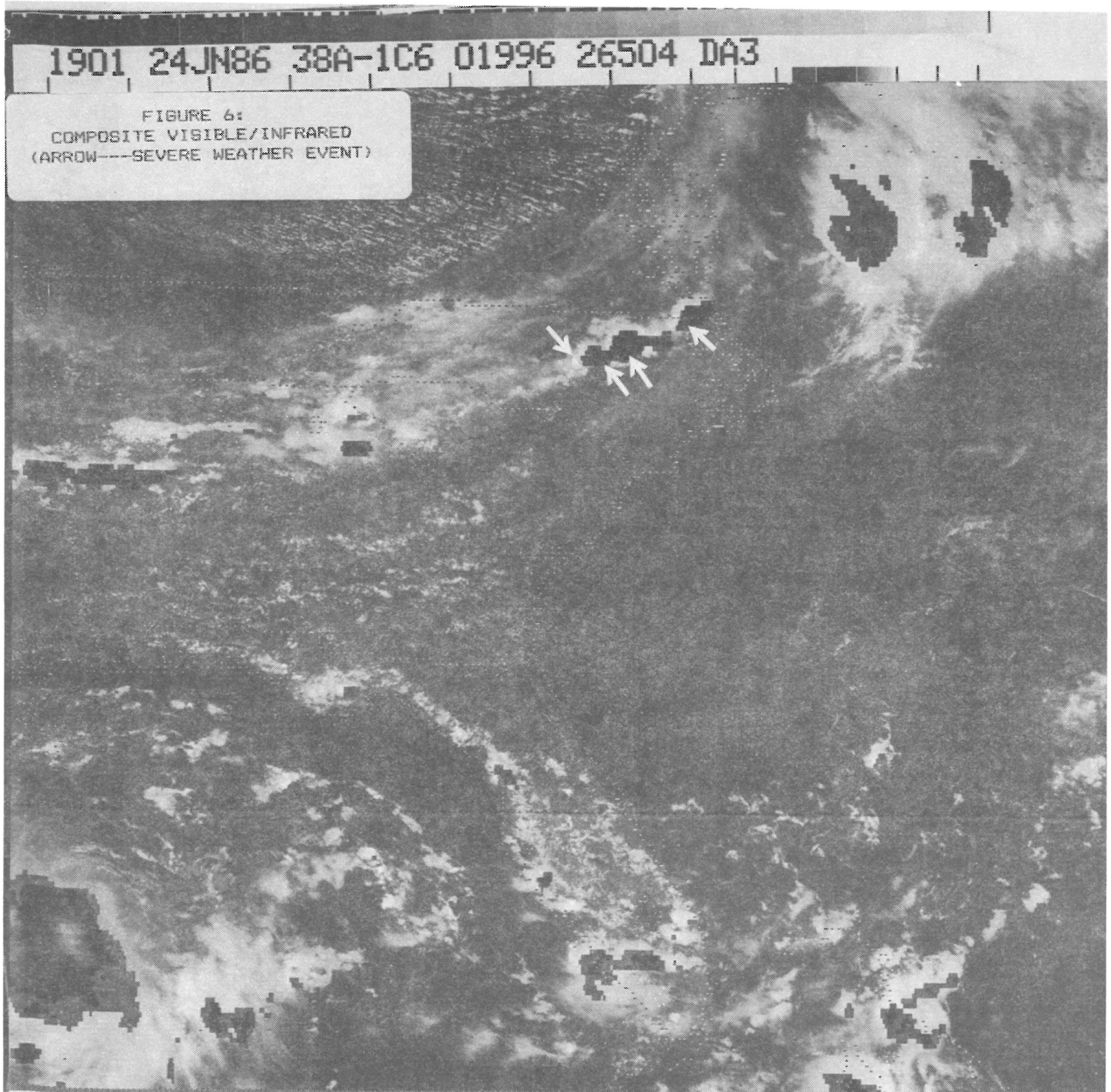

FIGURE 6:
COMPOSITE VISIBLE/INFRARED
(ARROW---SEVERE WEATHER EVENT)

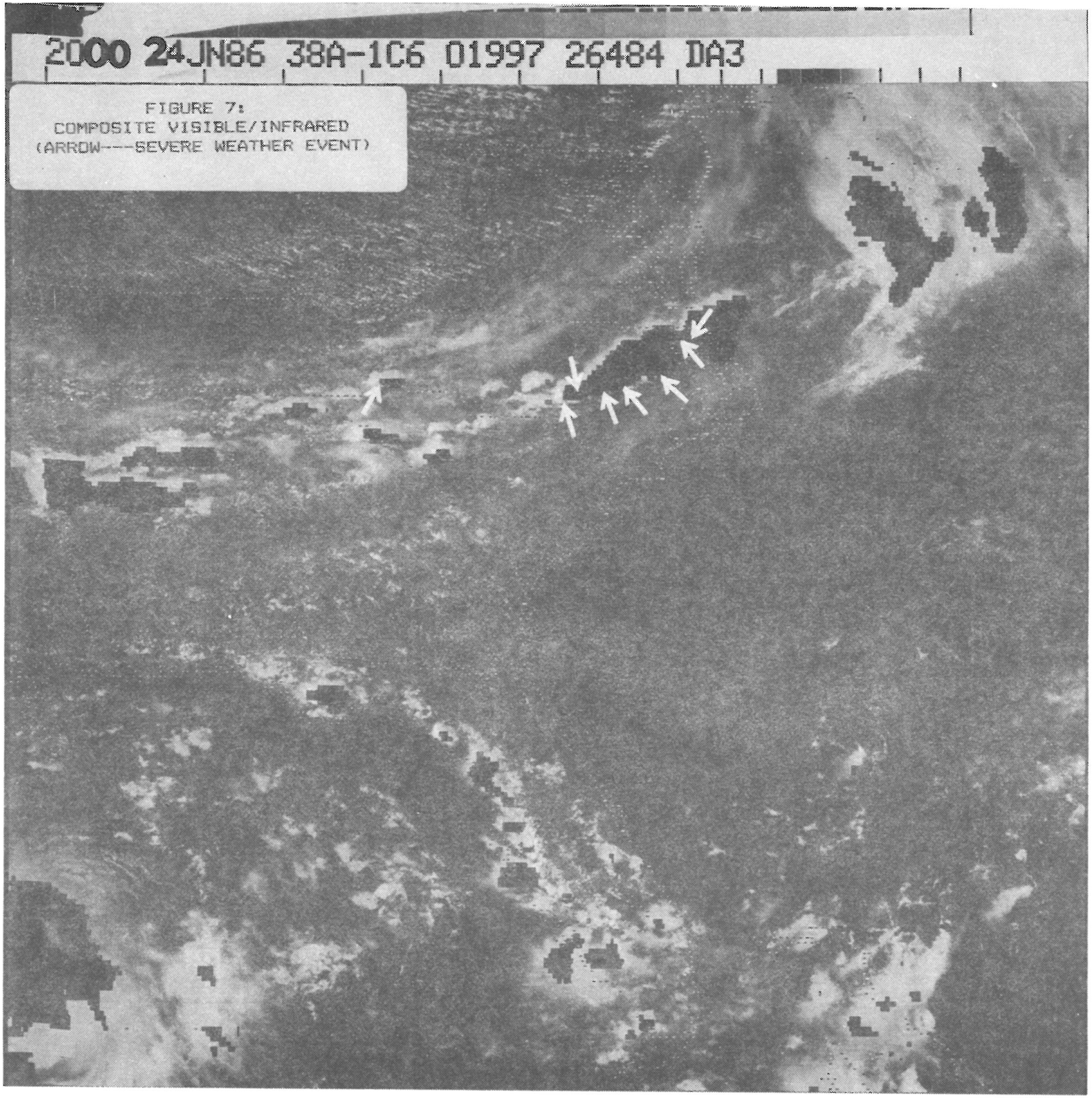

FIGURE 7:
COMPOSITE VISIBLE/INFRARED
(ARROW---SEVERE WEATHER EVENT)