NOAA Technical Memorandum NWS WR-184

# COLLECTION AND USE OF LIGHTNING STRIKE DATA IN THE WESTERN U.S. DURING SUMMER 1983

Salt Lake City, Utah
February 1984

**U.S. DEPARTMENT OF COMMERCE** / National Oceanic and Atmospheric Administration / National Weather Service

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# COLLECTION AND USE OF LIGHTNING STRIKE DATA IN THE WESTERN U.S. DURING SUMMER 1983

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Scientific Services Division
National Weather Service Western Region
Salt Lake City, Utah
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# I. INTRODUCTION

Since 1977, the Bureau of Land Management (BLM) has operated an Automatic Lightning Detection system (ALDS) in the western United States. The primary use of the system has been by the BLM and other land management agencies for the detection of lightning caused wildfires. The system is designed to detect cloud-to-ground strikes only. A secondary use has been for thunderstorm forecasting by National Weather Service (NWS) forecasters. The references document some early NWS efforts to use the ALDS data. However, these efforts were hampered by the fact that the lightning strike information, in general, has not been made available to forecasters in the form of real-time displays that could be compared to other meteorological data.

During the summer of 1982, the NWS's Western Region conducted an experiment to determine (1) if the lightning strike data could be rapidly and economically distributed and displayed at NWS offices, and (2) whether or not the data were useful as diagnostic and forecasting tools. The experiment was confined to a small portion of the overall BLM system. It consisted of two of the twelve separate lightning networks operated by the BLM. These two were chosen because they were readily available to Western Region Headquarters from the BLM in Salt Lake City, Utah. Areal coverage consisted of most of Nevada, Utah, and Colorado, and parts of Idaho, Wyoming, Arizona, New Mexico, and California. The strikes were processed in real-time by a Nova 4/X minicomputer. Every half hour a one-half hour accumulation graphic was created and sent to the Western Region Automation of Field Operations and Services (AFOS) computer. The graphics were not transmitted on the AFOS regional distribution circuit and, therefore, were routinely available only to forecasters at WSFO Salt Lake City.

The graphics were found to be timely, reliable, and a useful supplement to satellite and radar observations for detecting and forecasting thunderstorms. They were especially helpful in areas where radar coverage is poor. Many such areas exist in the western United States due to wide spacing between radar sites and blockage of radar signals by mountain ranges. In such a limited experiment, it was not possible to relate significant rainfall rates to the concentration of lightning activity in a quantitative way. However, the lightning graphics did permit forecasters to determine accurately where the most active thunderstorm cells were located. They also proved more timely than either radar maps or satellite pictures. The lightning graphics were typically available to Salt Lake City forecasters within two minutes after the end of each half hour accumulation period.

Two Western Region technical attachments, demonstrating the usefulness of the 1982 lightning data, are included as attachments to this report (Appendices 1 and 2). They also serve to illustrate the display format used in 1982.

Due to the encouraging results of 1982, the experiment was expanded to include the entire BLM network for the summer of 1983. Again it was decided to use AFOS as the primary distribution and display device. Additionally, alphanumeric products, consisting of digits plotted in grid boxes to represent lightning activity level, were made available to dial-in users. This enabled non-AFOS sites to access lightning data using a variety of terminal devices.

The next section of this report describes the BLM ALDS system. The remainder of the report focuses on the 1983 experiment -- Section III describes how the data were processed and delivered to NWS forecasters; Section IV illustrates several examples of data collected. Finally, concluding remarks and recommendations for future use and improvements of the lightning strike network are made in Section V.

## II. ALDS SYSTEM OPERATION

The automated Lightning Detection System is manufactured by Lightning, Location, and Protection, Inc. The ALDS system consists of two major components: direction finders and position analyzers. A typical installation has four direction finders bordering the area of interest and one position analyzer. The direction finders consist of a flat plate antenna to detect signal strength and polarity and a loop antenna to detect direction. The direction finders are best located away from all external electrical and magnetic noise sources such as in an open field. Unfortunately, the majority of sensors must be placed in a secure area such as on the top of a building. This placement can induce errors in the data.

When lightning occurs, the direction finders wtihin a 400 kilometer radius will usually detect it. On flat land, the effective lightning detectibility is 80% at 400 kilometers. In mountainous country, it appears that mountain shadows can occur. The direction finder records the direction of the stroke as well as the magnitude of its electromagnetic signal. The direction finder performs waveform matching to determine if the stroke was a cloud-to-cloud or cloud-to-ground stroke. The electrical waveforms created by the lightning stroke have varying characteristics that differ between the two types of lightning. For example, if the rise time of the waveform is slow, the odds are that the stroke was a cloud-to-cloud. If the rise time of the waveform is fast, the stroke was probably a cloud-to-ground. Secondary flash magnitudes are also measured and used to determine lightning type. If the magnitude of the second peak is less than 60% of the first, the lightning is classified as cloud-to-ground. The reliability of detecting the type of lightning decreases with distance since the waveform is smoothed by the atmosphere. For example, a cloud-to-ground stroke at 50 km, may have a 95% probability that it is detected as a cloud-to-ground stroke. The same stroke detected at 300 km, may only have an 85% probability that it is detected as a cloud-to-ground stroke.

The direction finder by itself cannot locate the lightning stroke since it can only detect direction. There are usually four direction finders per position analyzer. A lightning stroke location is computed by the received direction and magnitude from two direction finders, using triangulation methods. The accuracy of the direction finder directions is about one degree. Hence, the accuracy of the located lightning is within several kilometers if the angles are ideal. If the perceived angles are within six degrees from the baseline (direct line between the two direction finders), the lightning is located on the baseline using the ratio of the stroke magnitudes to determine distance along the baseline. If the direction finders detect except between the hours of 15 and 20Z. These hours were avoided due to the already high volume of communication traffic. Four hour accumulations were transmitted five times daily, and a 24 hour accumulation was transmitted once a day. Examples of 30 minute and 24 hour accumulation AFOS products are presented in Figure 4. Legends on the AFOS products are interpreted as follows:

#S = Total number of strikes detected

Gs = Grid size in degrees latitude/longitude

Mc = Minimum activity level for which a contour is drawn

Ci = Contour interval

Dt = Minimum activity level for which a "+" is plotted

Mx = Minimum activity level for which a maximum value will be labeled. The maximum value is plotted with an "x" representing the location of the maximum value.

The Western Region lightning processing and dissemination program was implemented on the Nova minicomputer system on June 16, 1983. The system functioned with very few problems until the lightning network was de-activated for the winter on September 26, 1983.

Most of the problems encountered with the ALDS system had nothing to do with the Nova or its software. They were AFOS communications problems or problems with the BLM network. For example, if the AFOS system at WSFO Salt Lake City was down or went down during product transmission from the Nova, the ~~product was missed by all AFOS stations on the loop. This occurred~~ several times during the summer. Another problem was that occasionally a DF or PA would fail. When such a failure occurred, there was no automatic way to alert forecasters of the problem. Operators of the ALDS system at Boise were very helpful in identifying outages and notifying forecasters of such problems. However, an automated method for identifying DF and PA failures is needed.

As in 1982, no quantitative attempts were made in 1983 to correlate lightning activity levels with heavy rainfall amounts or with severe convective storms. Comments received from forecasters indicated that on several occasions the lightning data were helpful in the timely issuance of flash flood and severe thunderstorm warnings. More study is needed in this area.

# IV. 1983 CASE STUDIES

The following three examples serve to illustrate the usefulness of lightning strike graphics. They also demonstrate some problems encountered with the data. The lightning graphics used in the first two examples are single strike graphics generated specifically for this study. Each plotted dot represents a strike. The graphics in these two examples are not the same as those created for AFOS transmission. The third example uses the actual operational products as they were generated for AFOS transmission.

A. August 24, 1983 - The first example illustrates a problem noted in the northern Utah area. Figure 5 shows satellite pictures for 2015 and 2045Z, August 24, 1983. The 2015Z picture is a visual image while the one for 2045Z is a combination visual and enhanced infrared. Areas where cloud temperatures are below -30 degrees C appear enhanced. These areas also depict where thunderstorms are likely to be found. Figure 6 is a plot of all lightning strikes detected by the BLM network between 2015 and 2045Z. Each strike is represented by a dot. Three hundred strikes were detected during the 30 minute period, including out-of-range strikes (i.e., strikes having less than two DFs within 400 kms). In most areas there is good correspondence between the enhanced areas on satellite imagery and where lightning strikes were detected. For example, good correspondence exists in western Colorado, western New Mexico, and eastern Arizona. The same is true in the three corners area of Idaho, Oregon, and Nevada. In these areas the lightning strike data determined which clouds on the satellite photos were thunderstorm clouds and which were not. This distinction is important for pinpointing areas of strong convection that might lead to flash flooding and severe weather, especially in areas of poor radar detection like western Colorado and eastern Utah. The lightning strike data also help detect thunderstorms embedded in other clouds, which is important to the safe operation of aircraft.

Obviously, a problem exists in northern Utah. Several strikes are plotted in western Utah and near the southeastern shore of the Great Salt Lake where the satellite photos show the atmosphere to be cloud free. The errors in northern Utah may be due in part to the fact that none of the 30 direction finders are located in or very close to northern Utah (see Figure 1). One way to improve the accuracy of strike location in northern Utah would be to add another DF in that area.

To determine more precisely what factors may have contributed to the location errors in northern Utah, the lightning data from each of the position analyzers were plotted separately in Figure 7. Solid lines on the chart indicate the effective range of the PA, assumed to be that area within 400 kms of at least two DFs. Strikes outside the lines would have been eliminated from the operational products. The PAs that contributed erroneous strikes were in Colorado and Wyoming. the Rock Springs direction finder is common to these two PA systems. Late in the summer the Rock Springs DF was found to have a bad analog-to-digital converter that could have caused these large position errors. The problem was not corrected until September 1, 1983. Example C below illustrates a case in which lightning strikes occurred in northern Utah after the analog-to-digital converter was replaced. The remaining PAs, southern Nevada, southern Idaho, and northern Nevada, appear to be locating strikes quite accurately.

B. August 10, 1983 - The 0835Z radar chart (Figure 8) shows that the early morning hours of August 10 were convectively quite active. The 0815Z enhanced satellite picture (Figure 9) indicates the main areas of enhanced cold clouds (temperature less than -30 degrees C) to be in southern British Columbia, northeast Oregon, central Idaho, east central Utah, and northern Wyoming. The ALDS recorded 1422 cloud-to-ground strikes during the one hour period from 08 to 09Z (Figure 10). This total includes duplicate strikes and strikes outside the assumed 400 km range of the DFs.

In order to examine this situation more carefully, lightning strikes from several individual PAs were plotted separately in Figures 11-20. The heavy solid lines on these charts indicate the effective range of the PA. Strikes outside this line were eliminated from the operational products and should be ignored.

First of all, let's examine the activity in central and southern Arizona. Only one strike was observed in this area by the southern Nevada network (Figure 11) and none by the New Mexico PA (figure 12). Most of the activity in this area appears weak on radar (Figure 8) and may not have been producing much lightning. However, note also that coverage is poor in southern Arizona. This portion of the state is outside the effective range of both PAs. More DFs are needed in this area to adequately observe cloud-to-ground lightning.

In the north there are several areas of interest, and all active thunderstorm cells appear to be depicted accurately by the PAs in Montana, northern and southern Idaho, Washington, Oregon, and Wyoming Figures 13-18. The strong cell in central Idaho, with a cloud top temperature less than -55 degrees C, has a heavy concentration of strikes detected by the PAs in Wyoming, northern and southern Idaho, and Washington. The convection in northeast Oregon is nicely depicted by the strikes from the Oregon and Washington PAs. The Washington PA is also quite accurate in depicting lightning strikes in southern British Columbia, even though they were on the fringe of the coverage area. The Montana PA even shows strikes that line up remarkably well with radar echoes in southwest Montana. The Montana PA also recorded many strikes in northeast Wyoming where the enhanced satellite picture shows a large complex of thunderstorm cells.

However, as in the first example, problems are evident in the lightning data over northern Utah and also in southwest Wyoming. The PAs responsible for the errorneous strikes are again Colorado and Wyoming (Figures 18 and 19). And, as mentioned in the previous case, the one DF common to both PAs is the one at Rock Springs, Wyoming.

Figure 20 depicts an enlargement of the graphic sent on AFOS covering the 30 minute period 0810 - 0840Z. One grid box in southwest Wyoming had 30 strikes. Several areas in northern Utah and southwest Wyoming show activity levels exceeding three strikes per grid box. (Minimum contouring level is three strikes). Based on satellite imagery and radar, these strikes are badly misplaced, and the evidence points to problems with the Rock Springs DF. As mentioned in the previous example, this DF had a bad analog-to-digital converter that was replaced September 1, 1983.

C. September 3, 1983 - This case was chosen because it occurred after the hardware probem with the Rock Springs DF was corrected and because thunderstorms were in evidence over northern Utah. A sequence of satellite pictures, lightning graphics, and radar charts are shown in Figures 21-24. The satellite photograph, lightning chart, and radar summary in each figure are at approximately the same time. The satellite pictures and radar charts are valid at 45 and 35 minutes after the hour, respectively, while the lightning charts are 30 minute accumulations. Beginning time of the sequence is about 1400Z and ending time about 1800Z.

On the lightning graphics one or two strikes per grid box are represented by a plus sign. The first contouring level occurs where three or more strikes are recorded in a box. The contouring interval is 20, so the second contouring level occurs where ever 23 or more strikes per grid box are detected. Maximum values are noted by an "X" if they are 10 or greater.

The satellite pictures are a combination of visible at low levels and enhanced infrared at high levels. The warmest contoured temperature is -30 degrees C.

In this example, there is obviously a much better relationship between radar echoes, cold cloud temperatures on satellite pictures, and lightning strike locations in northern Utah than in the two previous examples.

For example, in Figure 21 along the Utah/Wyoming border north of Evanston, the radar echoes and enhanced cloud tops and shadow producing cumulonimbus on the satellite image are in areas where lighting strikes were detected. As the thunderstorms developed in northeast Nevada and northwest Utah, lightning strikes appeared in those areas (Figures 23 and 24). Similarly, lightning strikes were detected along and south of the Uinta Mountains of northeast Utah as convection increased and moved or developed eastward with time in that area (Figures 23-24).

However, there are also questionable areas of lightning strike data. For example, in Figure 22(a) an enhanced area of cloud tops colder than -30 degrees C appears in northwest Utah. No strikes were detected. Nothing conclusive can be said about this area, since it is possible no cloud-to-ground strikes occurred. The strikes plotted near the southeast shore of the Great Salt Lake in Figures 21(c) and 22(c) are also suspect. The airport observing station is located there, and the observer reported no cloud-to-ground strikes during the period 1410-1540Z. The observer could see CBs to the northeast and south through southeast, which is where most of the strikes were recorded. But strikes were not seen at the station.

In Figure 23(c) the southern-most strikes plotted in central Utah appear mislocated. Neither the satellite picture nor the radar chart support thunderstorm activity so far south.

This example shows that the severe mislocation errors that occurred on a regular basis prior to September 1 were no longer evident. However, it also indicates that significant location errors were still likely. The reason is not known for sure, but it is possible that the errors were due in part to the large spacing between DFs.

## V. CONCLUDING REMARKS AND RECOMMENDATIONS

The experiment conducted during the summer of 1983 demonstrated that cloud-to-ground lightning strike data from the BLM network could be collected and processed effectively and efficiently at a central location and then distributed to NWS users in near real time. No noticeable negative impact was evident on the AFOS system, which was used as the primary distribution and display system. Non-AFOS sites were also able to receive data on an alphanumeric display by dialing the central computer in Salt Lake City as needed.

The lightning data proved useful to forecasters in a number of ways. They helped fill gaps in the radar network. Gaps are a significant problem in the West due to wide spacing of radars and mountain blockage of radar signals. The data enabled forecasters to distinguish thunderstorm clouds from non-thunderstorm clouds. They also enabled forecasters to identify embedded thunderstorms that may have otherwise gone undetected. They also helped forecasters to pinpoint the location and movement of very active (in terms of number of strikes) thunderstorm cells. Although a relationship was not established between the level of lightning activity and rainfall rate, several cells with high frequencies of lightning activity did produce strong radar echoes and heavy precipitation amounts.

Several problems were encountered with the data. First of all, due to the large number of overlapping networks, numerous strikes were detected by two or more networks simultaneously. The majority of these duplicate strikes were identified and eliminated, but some duplicates no doubt went undetected. Secondly, it was impossible to automatically monitor the status of the various PAs and DFs. One or more PAs and/or DFs were sometimes inoperable without the user's knowledge. Third, several areas have poor or totally inadequate coverage. Northern Utah and western Nevada appear to have poor coverage. Although strikes are detected in these areas, location errors are probably large. Southern Arizona is an area with inadequate coverage. A large portion of southern Arizona does not have the necessary two DFs within 400 kms. A fourth problem is large positioning errors when a strike occurs on or near the baseline connecting two DFs.

All of the above problems could be overcome with some modifications to the existing network and system software. One position analyzer with 30 or more direction finders rather than 12 PAs each with three or four DFs would eliminate duplicate strikes. The software could be written such that only the two DFs detecting the strongest signal would be used in the triangulation process. If the strike occurred near the baseline connecting these two DFs, a third DF could be used to more accurately locate the strike. The software could also be modified to automatically report the operational status of the PAs and DFs. Finally, more DFs could be added to the network to improve the coverage. One is badly needed somewhere in northern Utah and another is needed in southern Arizona.

The results of the 1983 experiment are very encouraging. With improvements as described above, the lightning data could be even more useful. Also studies relating lightning strikes to heavy rainfall and severe convection should be conducted to see if the data can be used to improve NWS watch and warning programs.

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APPENDIX 1

## WESTERN REGION TECHNICAL ATTACHMENT
No. 82-32
July 27, 1982

# EXPERIMENTAL LIGHTNING DETECTION CHARTS HELP LOCATE THUNDERSTORMS

The Bureau of Land Management (BLM) has been operating a network of lightning direction-finding (DF) stations in the western United States for several years (Figure 1). The DF stations are designed to detect only cloud-to-ground strokes. It is estimated that the system detects between 80 and 90% of all cloud-to-ground flashes, and that only 1-2% of all triggers are caused by cloud discharges [1]. The data from several DF stations are transmitted to a central position-analyzing computer where the location of individualized flashes are computed automatically by triangulation. The automatic lightning detection system (ALDS) is used by BLM and other agencies to aid in detection of lightning caused fires.

Last summer Western Region TA No. 81-32 gave a status report of the ALDS and discussed an example of how the system is used in finding lightning caused fires [2]. However, output from ALDS has not been routinely available to NWS weather forecasters.

This summer, as an experiment, data from two of the many analyzers are being transmitted to the Western Region Headquarters over telephone line from the BLM in Salt Lake City. One analyzer is located in Las Vegas, Nevada and the other in Grand Junction, Colorado. The two analyzers are capable of detecting cloud-to-ground lightning strikes over most of Nevada, Utah, and Colorado, as well as parts of Idaho, Wyoming, Arizona, New Mexico, and California. Each lightning strike is plotted as a dot on a U.S. map background in AFOS. A map is produced every half hour and stored as a test graphic in the Western Region AFOS system (NMCGPHT21). Each map shows the lightning strikes that occurred during the half hour previous to the time shown on the map. A half hour strike total is presented in the upper left-hand corner. Figure 2 shows an example of such a map using a 1:1 zoom ratio.

The purpose of the experiment is to determine the utility of the lightning strike data to forecasters and to determine the best way(s) to display this information. As the following example illustrates, the data looks very useful as a supplement to radar and satellite data in detecting thunderstorms.

During the afternoon of Wednesday July 14, thunderstorms developed in several different places over the Great Basin within range of the DF stations. Figures 3 through 7 show a sequence of five ALDS charts, one mile visible satellite pictures, and Western Region radar maps, each an hour apart. Although the various displays are not valid at exactly the same time (the ALDS data is actually a half hour time composite), they are close enough in time to make some interesting comparisons.

First of all, note how the convection early in the afternoon (Figure 2) is orographically induced by the mountains in central Colorado, and northern New Mexico, and in northeast Utah by the Uinta Mountains and Book Cliffs. The ALDS system detected lightning strikes in many of these areas early in the day (not shown), and in some areas, before echoes appeared on radar. A strong correlation is apparent between lightning strikes and cloudy areas on satellite pictures during early and mid-afternoon in Figures 3 and 4.

Some cloudy areas, such as the Book Cliffs in northeast Utah, do not show lightning strikes. Perhaps convection had not reached a stage where thunderstorms were occurring.

The correlation is not as good between lightning strikes and radar echoes, particularly in western Colorado (Figures 3, 4, and 5). Even the national map (Figure 8), which includes stations not available on the Western Region map, cannot account for the strikes in many locations in western Colorado. This is not surprising since the probability of detection is low in that area (Figure 9).

Thus the lightning detection data proved useful in supplementing radar by providing additional information in poor detection areas. It also supplemented satellite pictures by differentiating thunderstorm clouds from other cloud types.

Later in the afternoon convection began developing along a weak frontal boundary located in a northeast to southwest line across northwest Utah into eastern Nevada (Figures 5, 6, and 7). The first cloud-to-ground stroke was detected between 2130 and 2200Z and was plotted on a map and available in AFOS by 2202Z (Figure 5A). This confirmed that the clouds seen on satellite (Figure 5B) were thunderstorms. Echoes were not seen by radar until 2335Z, and this chart (Figure 7C) was not available to forecasters until about 00Z, nearly two hours after the lightning data was available in AFOS.

We are currently experimenting in SSD with various display formats for lightning data and will be monitoring the utility and accuracy of this data. It appears to be very useful as a supplement to radar and satellite in detecting thunderstorms. We hope this data can be made routinely available to Western Region forecasters in the near future.

References:

[1] Krider, E.P., R. C. Nogle, A.E. Pifer, and D. L. Vance: "Lightning Direction-Finding Systems for Forest Fire Detection", Bulletin of the American Meteorological Society, Vol. 61, No. 9, September 1980, pp 980-986.

[2] Rea, James, and Jamie Getchell: "Status of the Western U.S. ALDS", Western Region Technical Attachment No. 81-32, August 25, 1981.

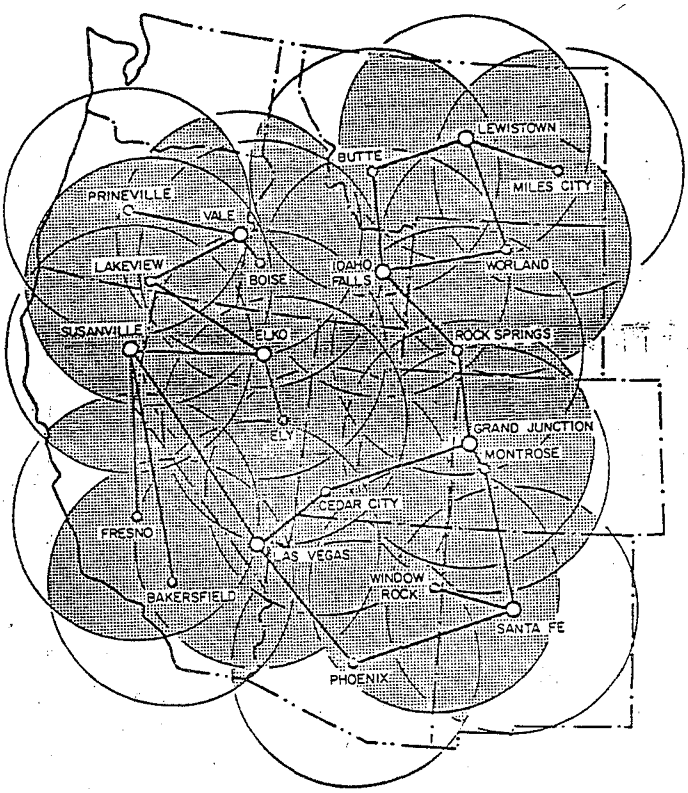


FIGURE 1. THE LOCATIONS OF LIGHTNING DF STATIONS IN THE WESTERN UNITED STATES. LARGE CIRCLES SHOW STATIONS THAT ALSO HAVE POSITION-ANALYZING COMPUTERS.

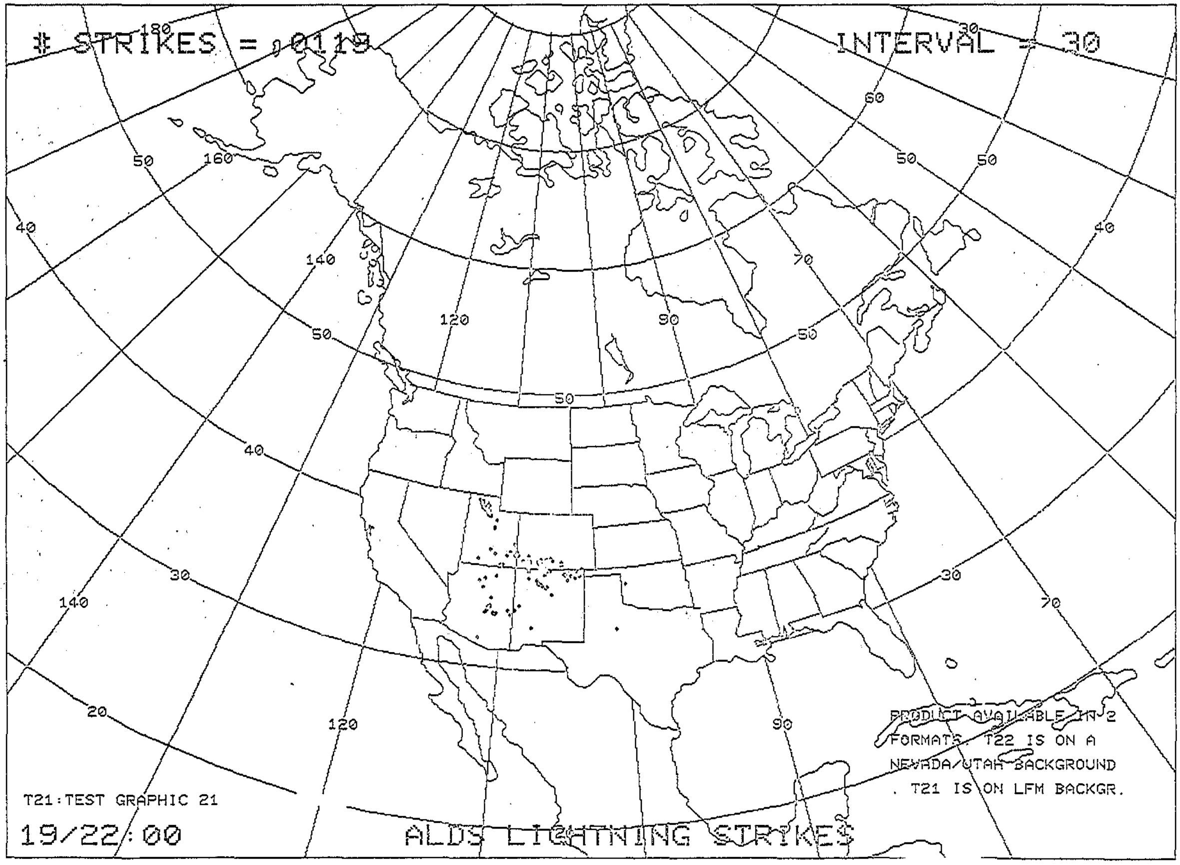


FIGURE 2. · LIGHTNING STRIKE PLOT FOR 30 MINUTE INTERVAL FROM 2130-2200Z, JULY 19, 1982

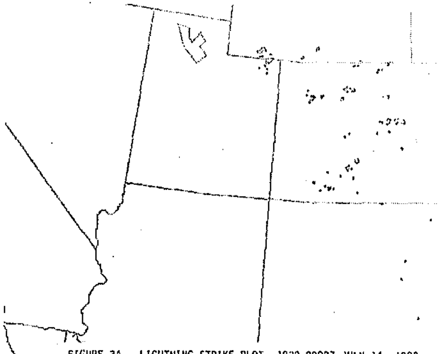
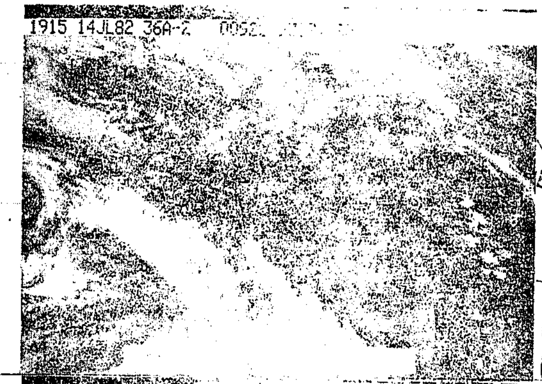


FIGURE 3A. LIGHTNING STRIKE PLOT, 1930-2000Z JULY 14, 1982



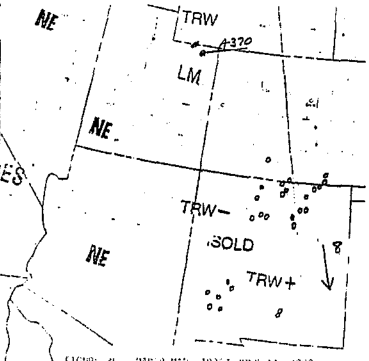


FIGURE 3C. RADAR MAP, 1935Z JULY 14, 1982

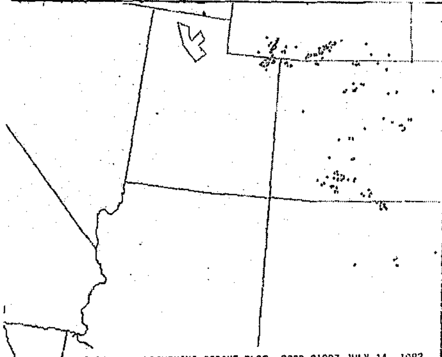
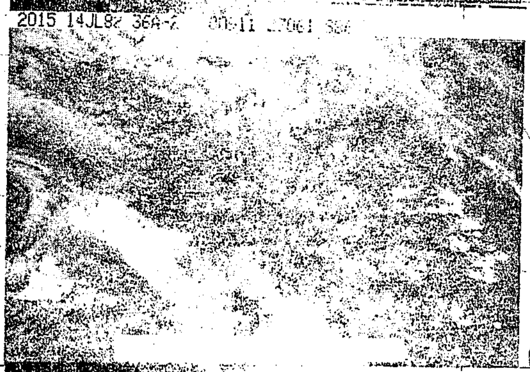


FIGURE 4A. LIGHTNING STRIKE PLOT, 2030-2100Z JULY 14, 1982



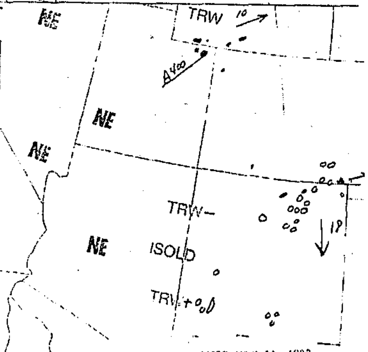


FIGURE 4C. RADAR MAP, 2035Z JULY 14, 1982

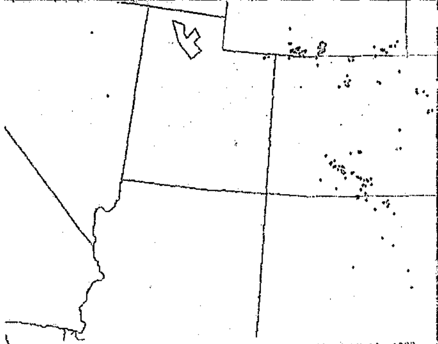
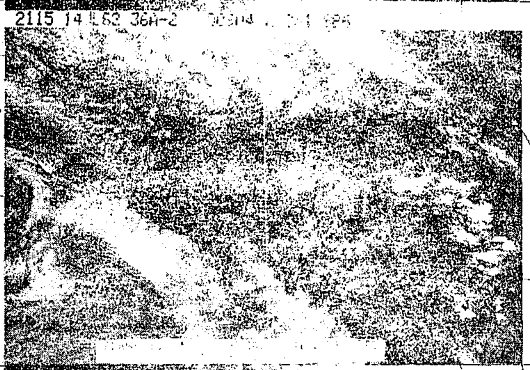


FIGURE 5A. LIGHTNING STRIKE PLOT, 2130-2200Z JULY 14, 1982



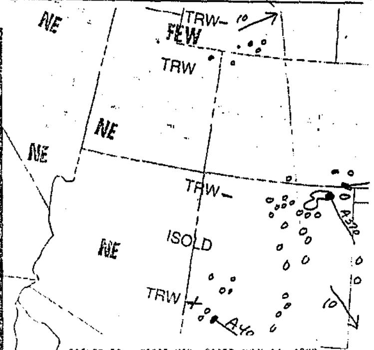


FIGURE 5C. RADAR MAP, 2135Z JULY 14, 1982

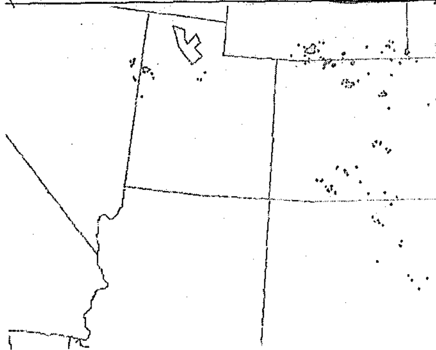


FIGURE 6A. LIGHTNING STRIKE PLOT, 2230-2300Z, JULY 14, 1982

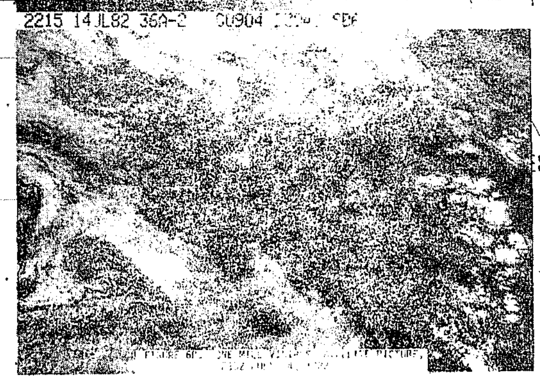


FIGURE 6B. ONE MILE VISUAL SATELLITE PICTURE, 2215Z JULY 14, 1982

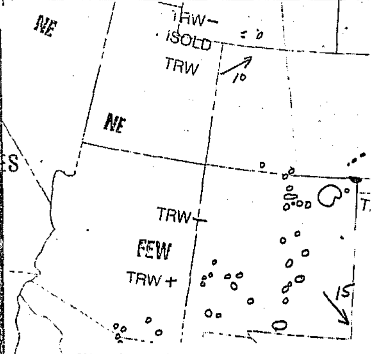


FIGURE 6C. RADAR MAP, 2235Z JULY 14, 1982

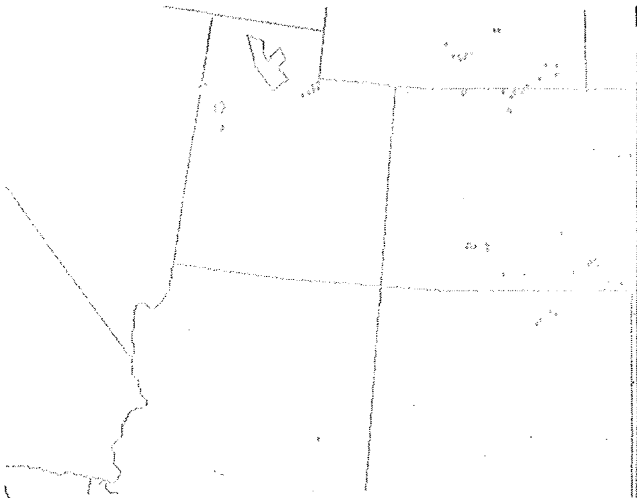


FIGURE 7A. LIGHTNING STRIKE PLOT, 2230-0000Z JULY 14, 1982

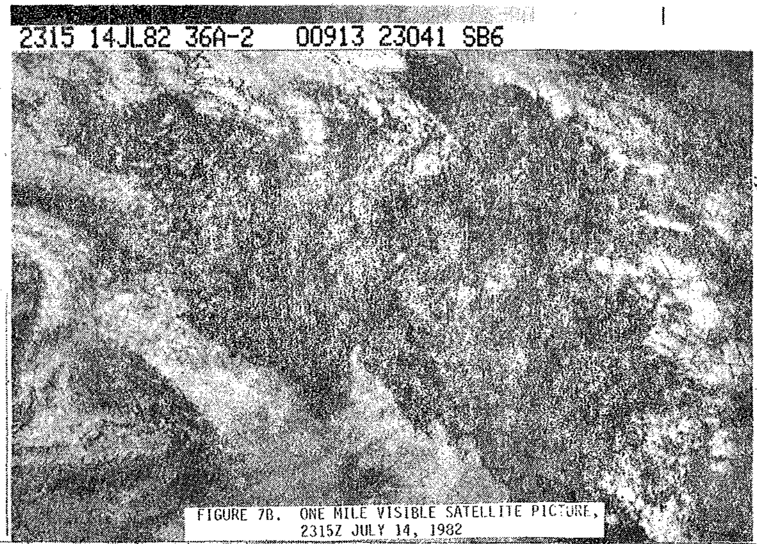


FIGURE 7B. ONE MILE VISIBLE SATELLITE PICTURE, 2315Z JULY 14, 1982

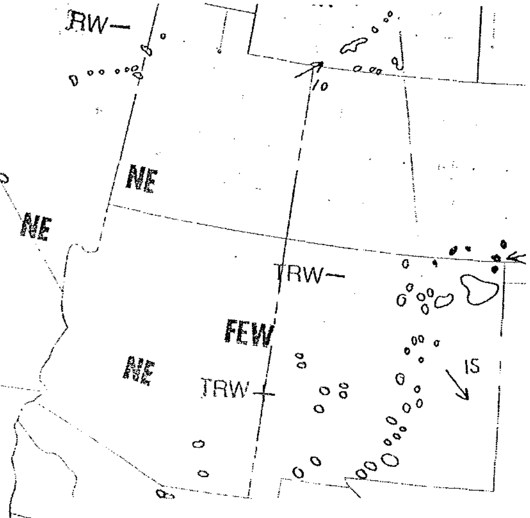
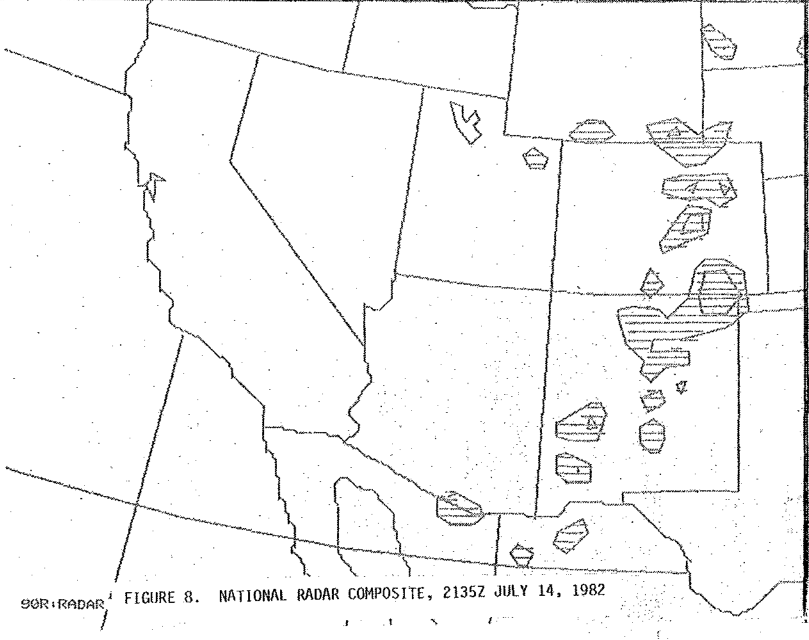


FIGURE 7C. RADAR MAP, 2335Z JULY 14, 1982



90R:RADAR FIGURE 8. NATIONAL RADAR COMPOSITE, 2135Z JULY 14, 1982

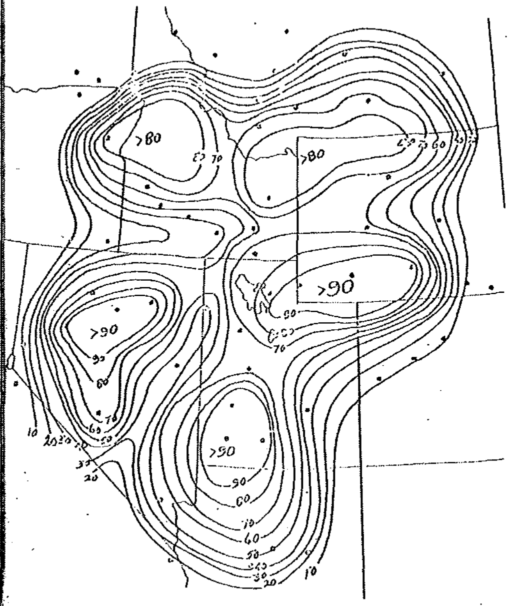


FIGURE 9. PROBABILITY OF DETECTION OF RAIN OR RAIN SHOWERS BY WESTERN U.S. ARTC RADAR

APPENDIX 2

# WESTERN REGION TECHNICAL ATTACHMENT
No. 82-37
August 10, 1982

## USING THE LIGHTNING DETECTION CHART IN REAL TIME . . . TWO CASES

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Salt Lake City, Utah WSFO

During a recent convective outbreak, the new lightning detection chart (T22) became an important real-time tool for the forecasters at WSFO Salt Lake City (see Western Region TA #82-32 for background). In one instance, potential flash flood producing cells were monitored closely with respect to movement and development. The data correlated well with satellite imagery and spotter reports. In the second, satellite imagery and radar were deficient in displaying convective development while T22 was most revealing.

On July 27, 1982, Utah was in the midst of one of the most significant general flash flood situations in several years. Precipitable water values ranged in excess of 200% of normal and a dynamic trigger was approaching from Nevada. Figure 1A is the 700-mb analysis as of 27/12Z. A Flash Flood Watch was issued statewide at 1730Z for that afternoon and evening. By 1900Z, Figure 1B, lightning was detected over many areas of central Utah. The most active cells were apparently between Beaver (BVR) and Fillmore (FIL) as noted in satellite imagery, Figure 1C. Figures 2A through 2D chronicle the rapid expansion of convection in this area during the next hour or two. Lightning strikes indicate quite well where the most active cells are located and their subsequent propogation northward towards Nephi (NPH). At 2010Z a report from Greenville, 3 miles west of BVR, indicated rainfall of 1" in 20 minutes and 2.25" in one hour. Note the correlation between this and strike locations in Figure 1B and 2A and B. Other problems developed about 2100Z between Delta (U24) and Manti (MTI), when a state highway was washed out. Compare Figure 2C.

While concentration of cloud-to-ground lightning strikes does not necessarily indicate significant rainfall, it was a good indicator of exactly where the most active cells were. In this particular case, they produced excessive rainfall. Also note that potentially dangerous rainfall rates seem well matched with cloud top temperatures which reached the $-54^{\circ}$ to $-60^{\circ}$C threshold (see Figures 1C and 2D).

The next day, July 28, the scene shifted to the Wasatch Front during the predawn hours. Surface observation data is very sparse this time of day and the forecaster has to rely on satellite imagery, radar, and now T22 to follow convective developments. Very moist, tropical air covered northern Utah and an area of thunderstorms was occurring from the northeast shore of the Great Salt Lake into southeast Idaho. Figure 3 shows the situation a couple of hours after midnight. A well defined cyclonic circulation is shown approaching from northern Nevada (Figure 4).

The cells in northeast Utah would appear to be about stationary (in the vicinity of the col) although in actuality the flow across the area was in the process of changing from east or southeast to westerly. Figures 5-9 (from 0930Z to 1100Z) show the convection building southward along the Wasatch Front until it reached the Salt Lake airport about 0952Z. Satellite imagery does show development southward, however, the coldest tops remain well north of SLC and cells never appear to be as far south as the thunderstorms actually occurred. In a real-time environment, at 2 or 3 a.m. with no surface observations available except at HIF to north of SLC and those from the Highway Patrol, the true developmental tendency of these cells was in question and very critical to the early morning forecast.

The real monitor of this situation was T22. Figures 5 to 9 vividly show the rather explosive southward expansion of these cells towards SLC and a little beyond. The forecaster, by 0900Z, was able to determine that a threat was materializing rapidly to the north of his local forecast area and coming right at him!

Also, note the 1035Z radar plot at the height of the storm (Figure 10). The most important rain producing cells are barely evident. This was in part due to the fact that the SLC radar had its STC on and the echoes depicted are from the Rock Springs, Wyoming radar. The final result in the bucket was nothing short of record breaking -- 1.11 inches of rain fell at the Salt Lake airport in little over an hour. A new daily record was established and we were put on the threshold of setting a new all-time monthly precipitation record for July.

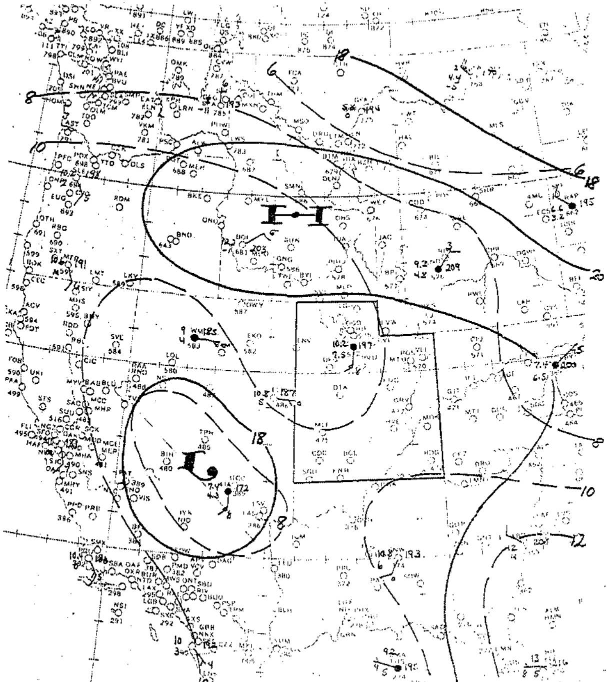


FIGURE 1A 700mb 12Z JULY 27, 1982

POLAR STEREOGRAPHIC PROJECTION, TRUE AT LATITUDE 60°

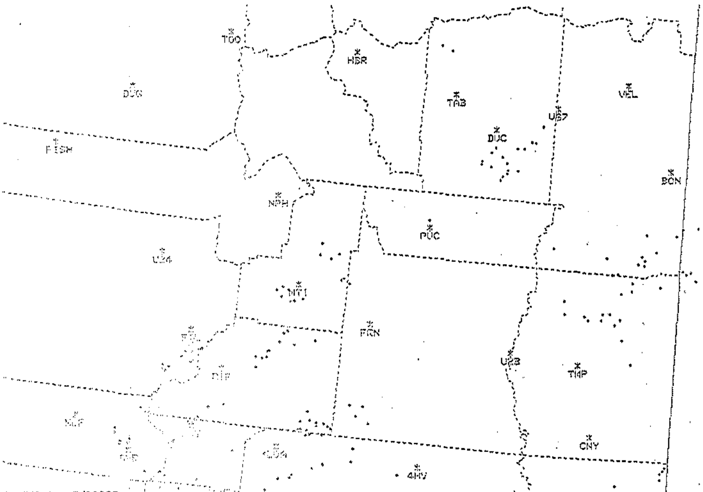
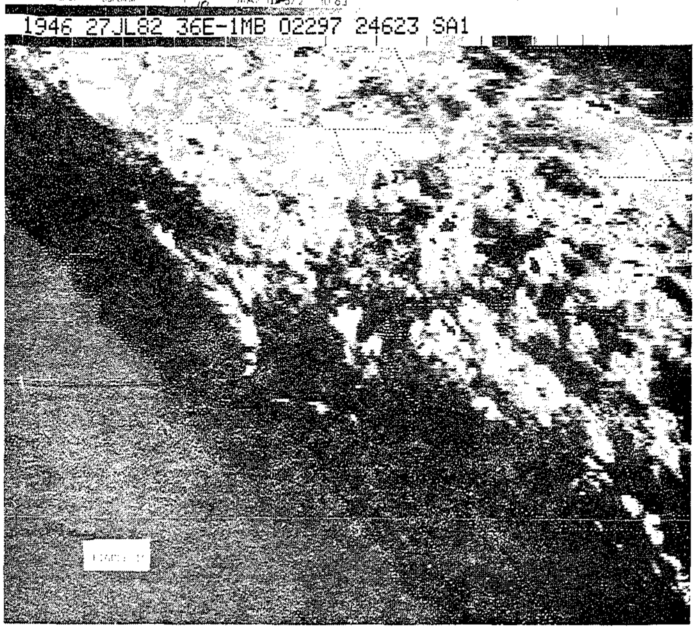


FIGURE 1B 27/1900Z



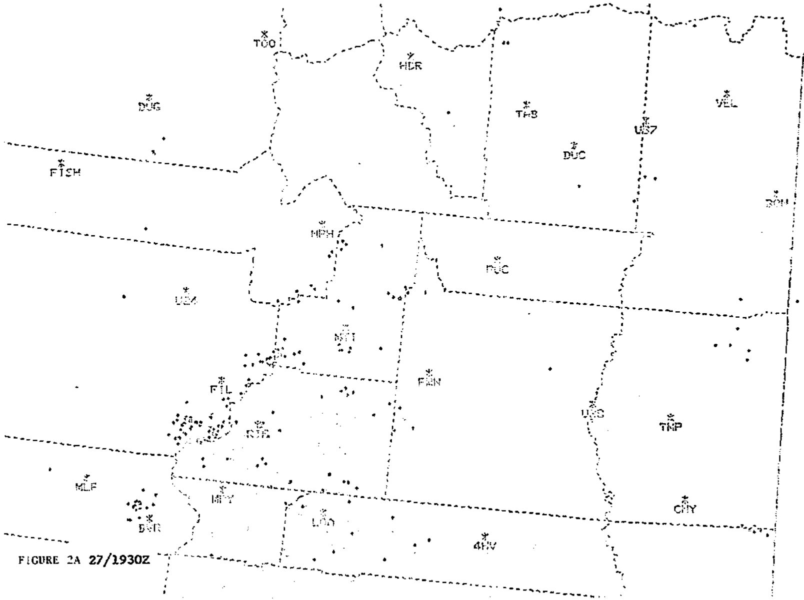


FIGURE 2A 27/1930Z

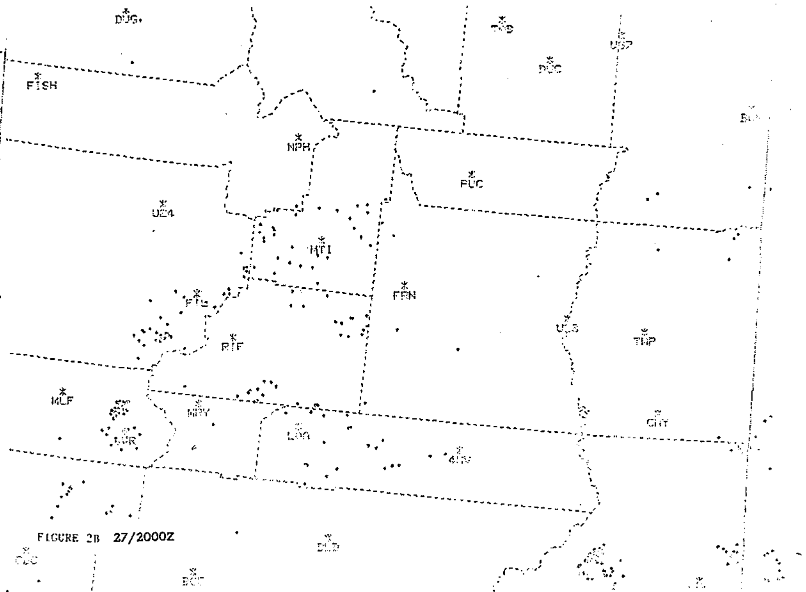
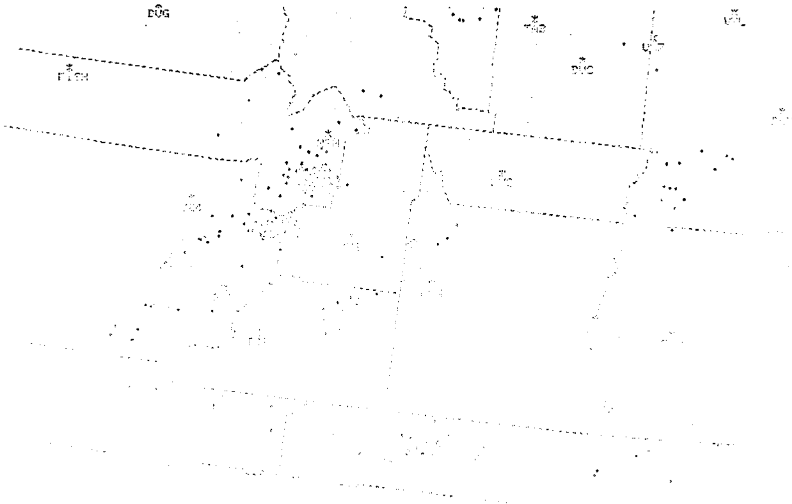
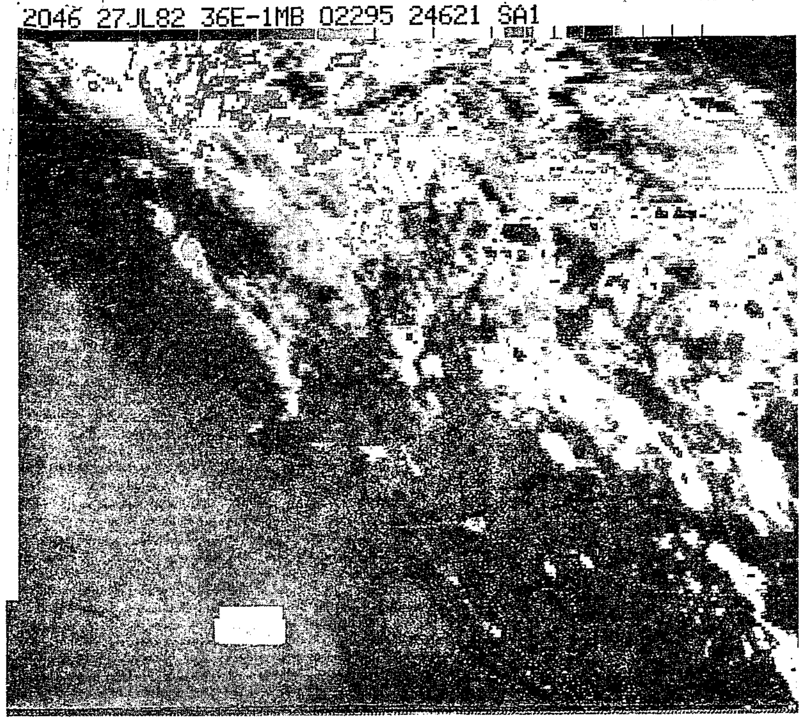


FIGURE 2B 27/2000Z



27/2100Z



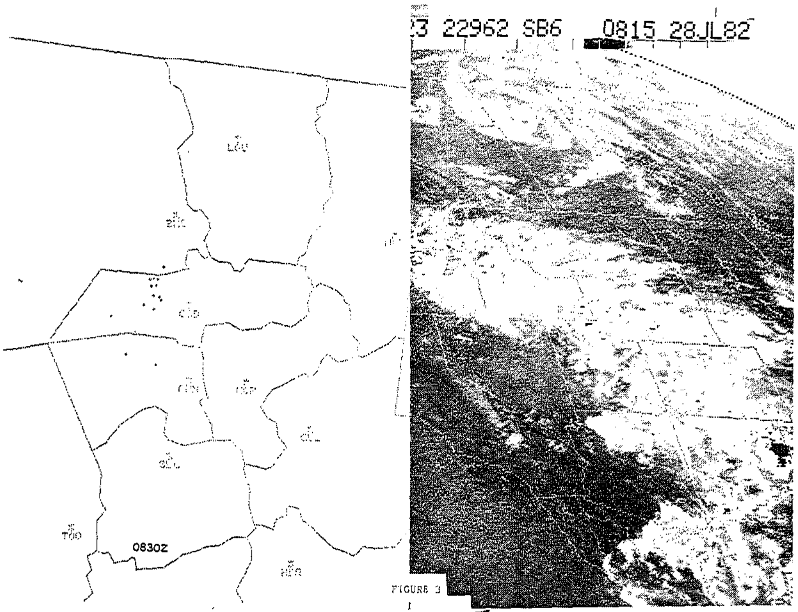
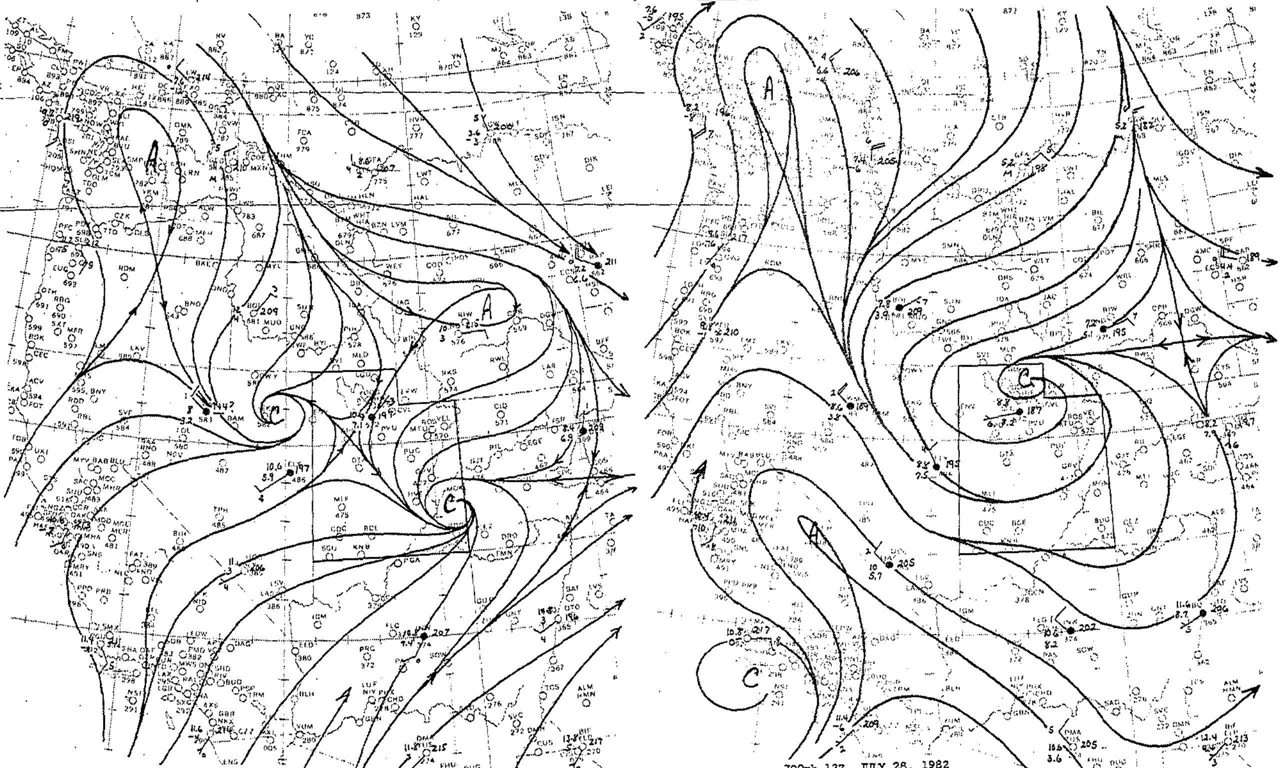


FIGURE 3



700mb 00Z JULY 28, 1982

SCALE 1:10,000,000

700mb 12Z JULY 28, 1982

SCALE 1:10,000,000

FIGURE 4

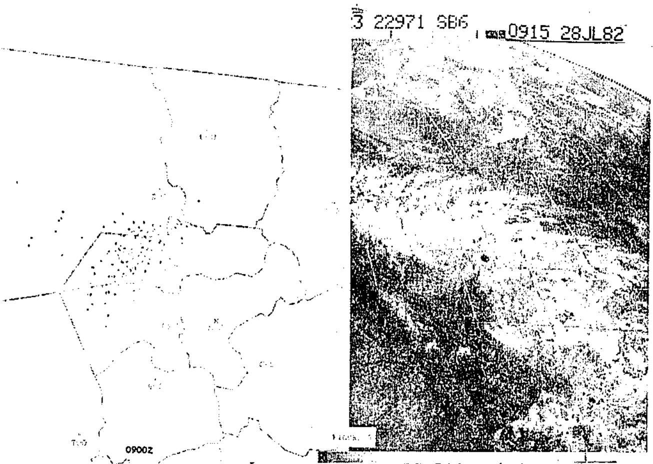


FIGURE [illegible]

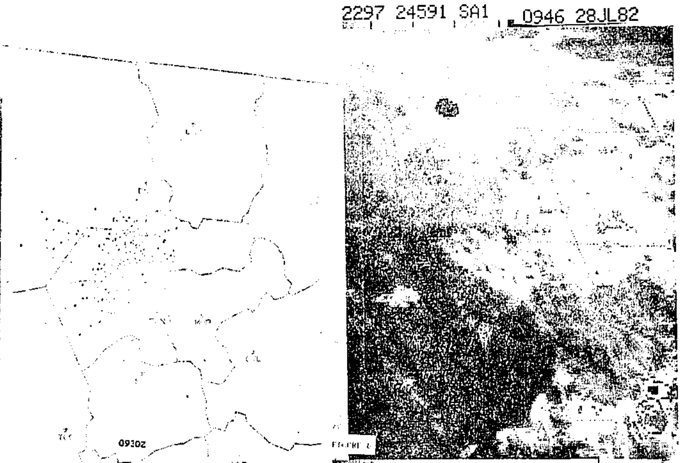


FIGURE 6

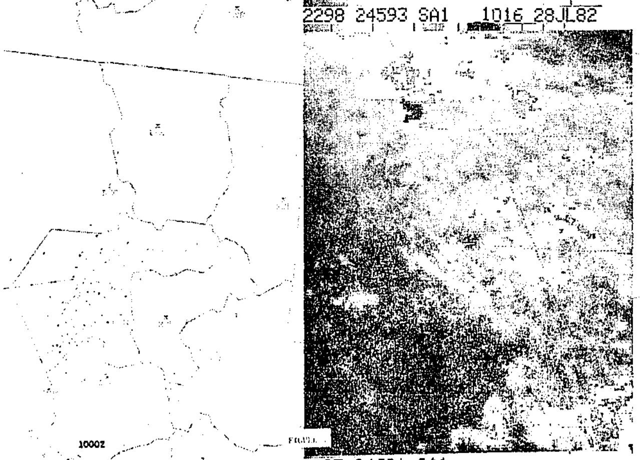


FIGURE [illegible]

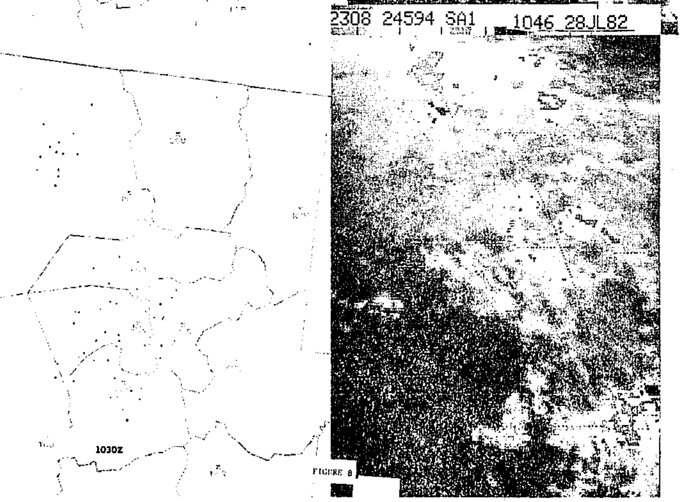


FIGURE 8

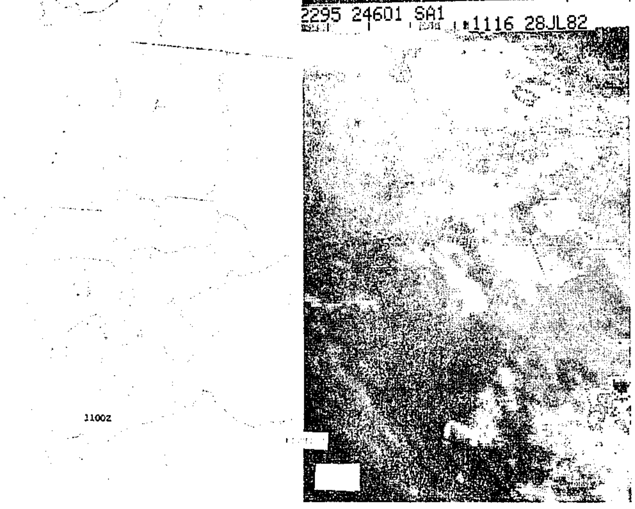


FIGURE [illegible]

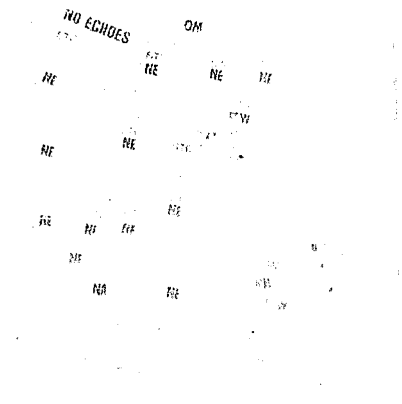


FIGURE 10 1035Z July 28, 1982

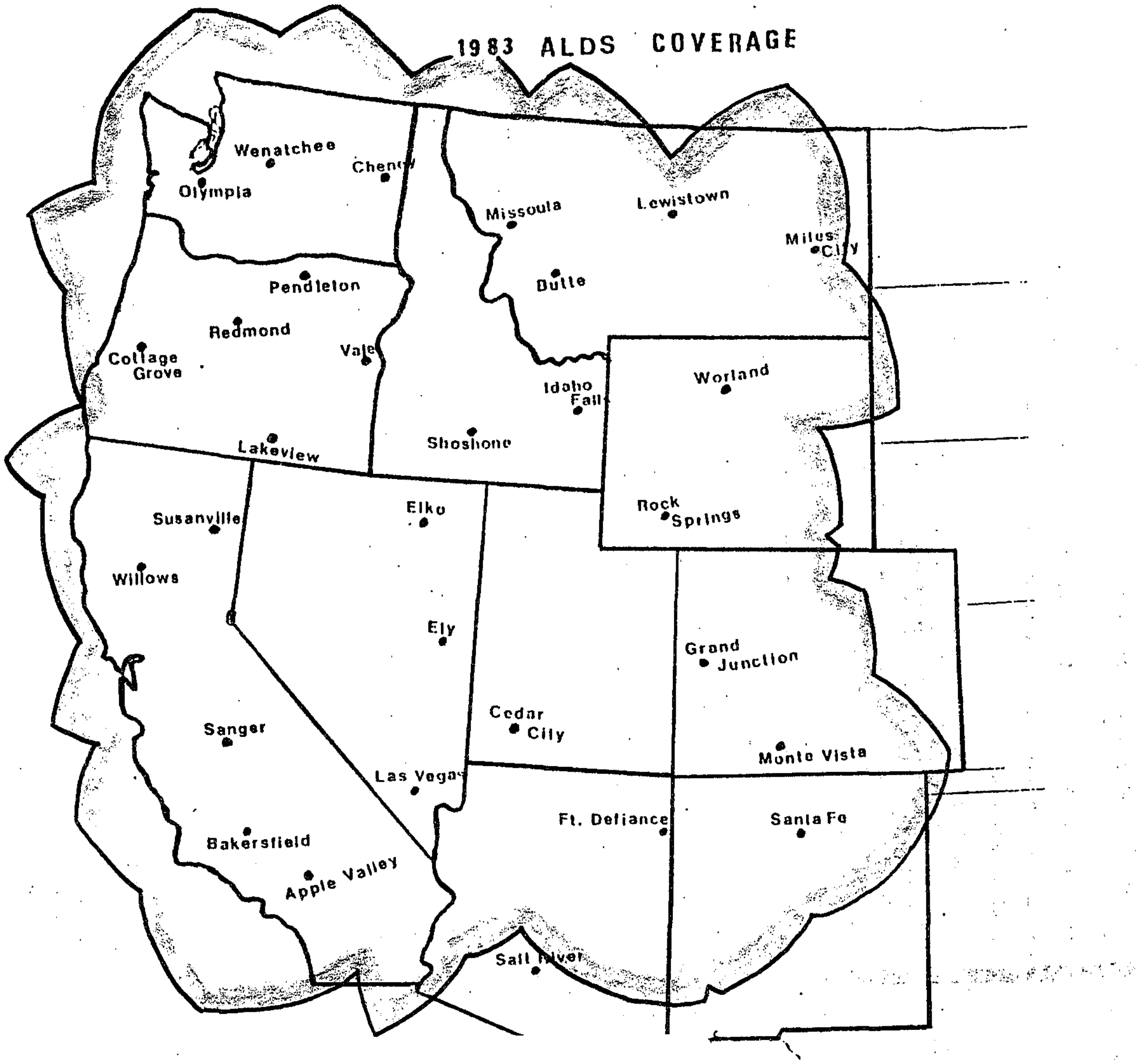
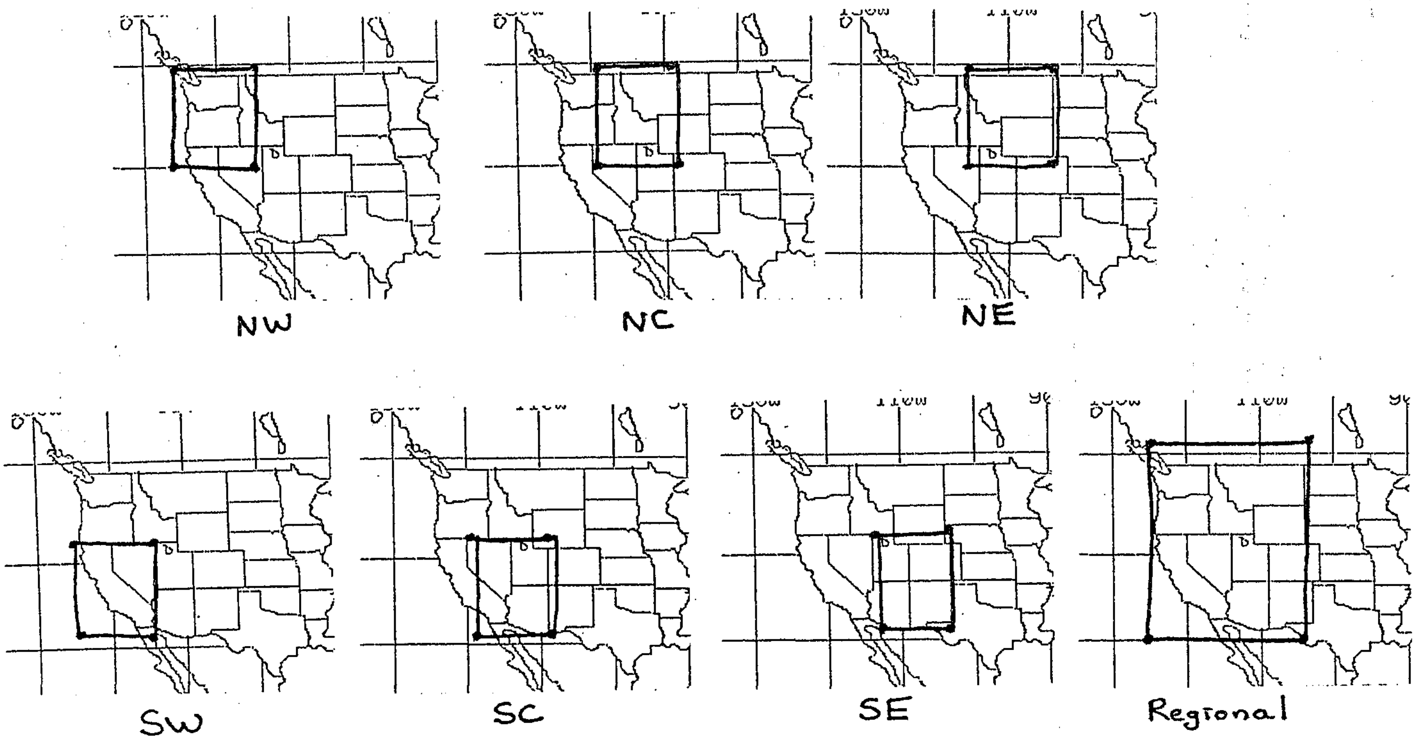


FIGURE 1. Bureau of Land Management ALDS netowrk. Dots represent direction finder (DF) locations. Area inside solid line is where at least two DFs are within 400 kms.



NW

NC

NE

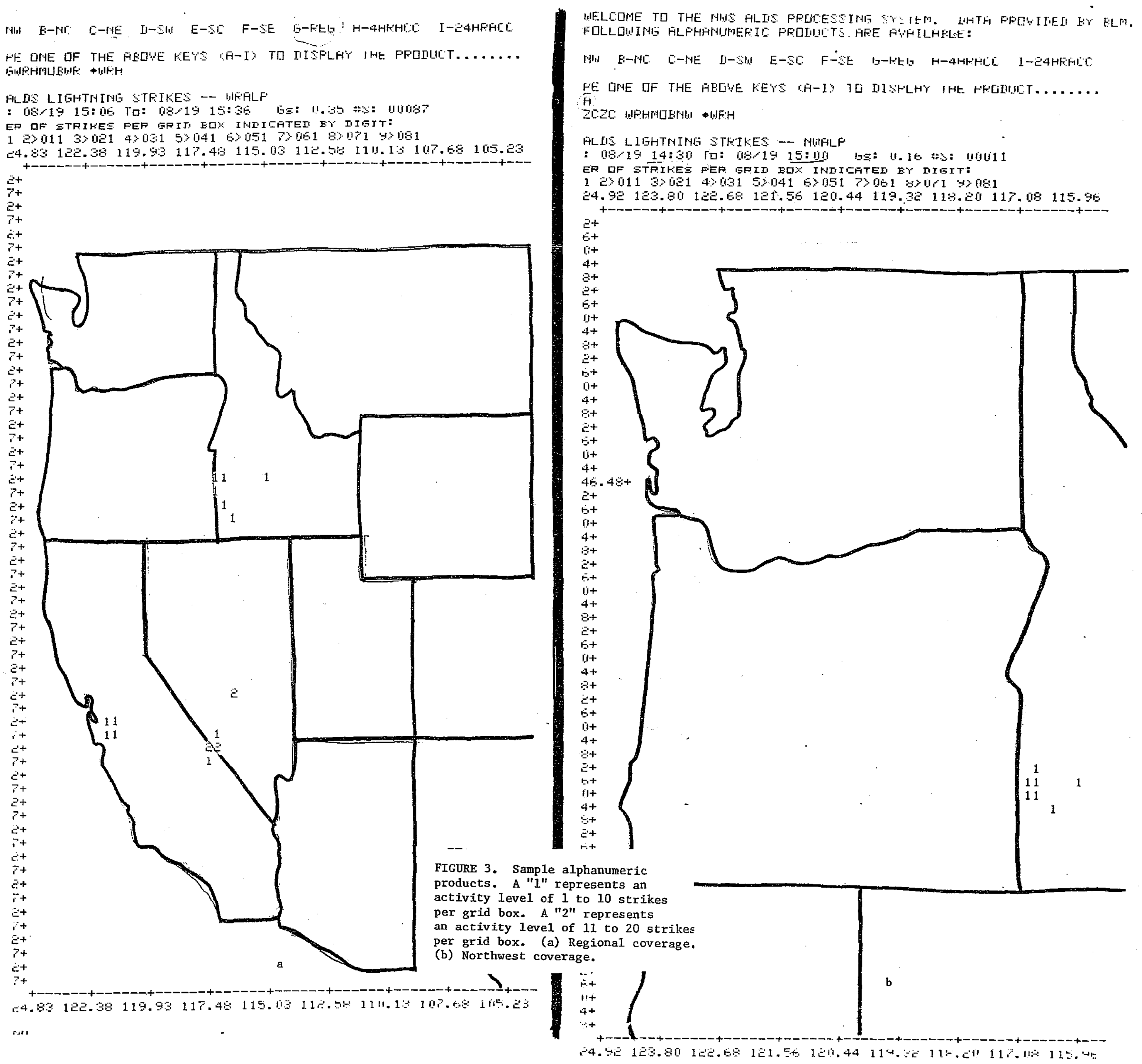
SW

SC

SE

Regional

FIGURE 2. Coverage areas for ALDS alphanumeric products.



```
NW  B-NC  C-NE  D-SW  E-SC  F-SE  G-REG  H-4HRACC  I-24HRACC

PE ONE OF THE ABOVE KEYS (A-I) TO DISPLAY THE PRODUCT........
GWRHMUBWR +WRH

ALDS LIGHTNING STRIKES -- WRALP
: 08/19 15:06 To: 08/19 15:36   Gs: 0.35 #S: 00087
ER OF STRIKES PER GRID BOX INDICATED BY DIGIT:
1 2>011 3>021 4>031 5>041 6>051 7>061 8>071 9>081
24.83 122.38 119.93 117.48 115.03 112.58 110.13 107.68 105.23
```

```
24.83 122.38 119.93 117.48 115.03 112.58 110.13 107.68 105.23
```

a

```
WELCOME TO THE NWS ALDS PROCESSING SYSTEM.  DATA PROVIDED BY BLM.
FOLLOWING ALPHANUMERIC PRODUCTS ARE AVAILABLE:

NW  B-NC  C-NE  D-SW  E-SC  F-SE  G-REG  H-4HRACC  I-24HRACC

PE ONE OF THE ABOVE KEYS (A-I) TO DISPLAY THE PRODUCT........
A
ZCZC WRHMOBNW +WRH

ALDS LIGHTNING STRIKES -- NWALP
: 08/19 14:30 To: 08/19 15:00   Gs: 0.16 #S: 00011
ER OF STRIKES PER GRID BOX INDICATED BY DIGIT:
1 2>011 3>021 4>031 5>041 6>051 7>061 8>071 9>081
24.92 123.80 122.68 121.56 120.44 119.32 118.20 117.08 115.96
```

```
24.92 123.80 122.68 121.56 120.44 119.32 118.20 117.08 115.96
```

b

FIGURE 3. Sample alphanumeric products. A "1" represents an activity level of 1 to 10 strikes per grid box. A "2" represents an activity level of 11 to 20 strikes per grid box. (a) Regional coverage. (b) Northwest coverage.

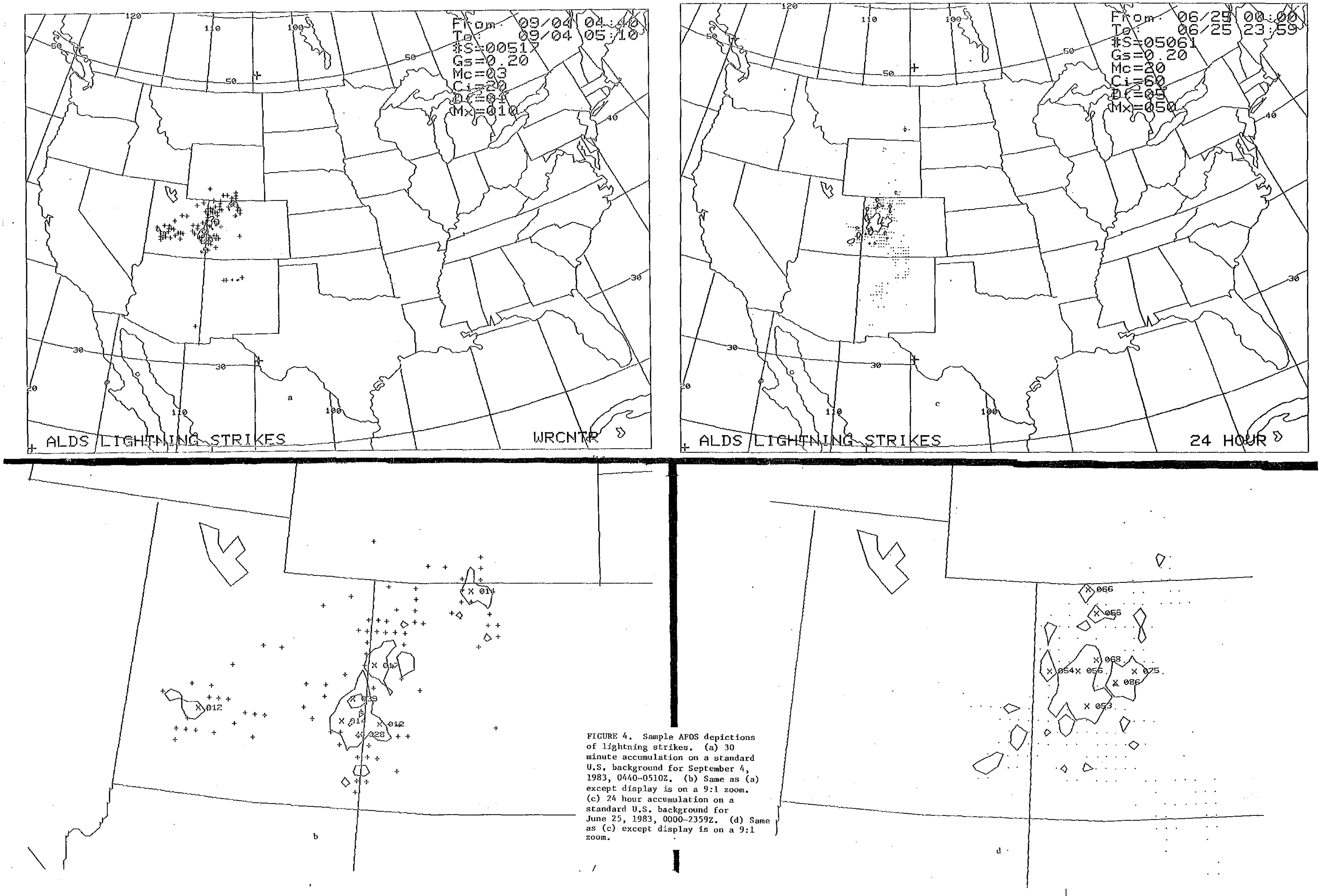


FIGURE 4. Sample AFOS depictions of lightning strikes. (a) 30 minute accumulation on a standard U.S. background for September 4, 1983, 0440-0510Z. (b) Same as (a) except display is on a 9:1 zoom. (c) 24 hour accumulation on a standard U.S. background for June 25, 1983, 0000-2359Z. (d) Same as (c) except display is on a 9:1 zoom.

FIGURE 5. Half-mile satellite pictures. (a) Visible image, 2015Z, August 24, 1983. (b) Combination visible and enhanced infrared image, 2045Z, August 24, 1983.

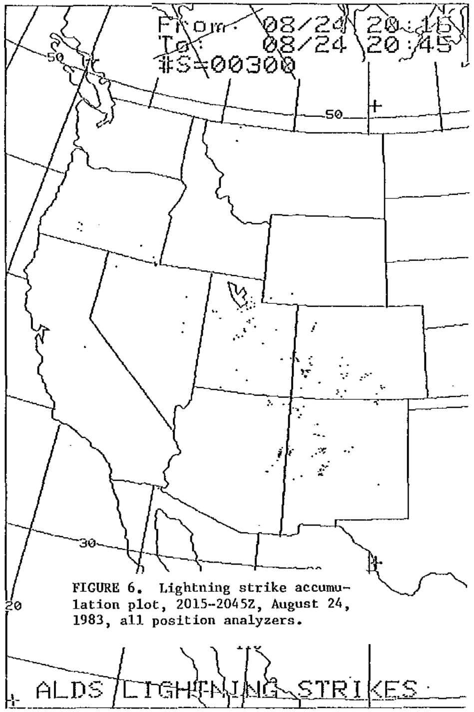
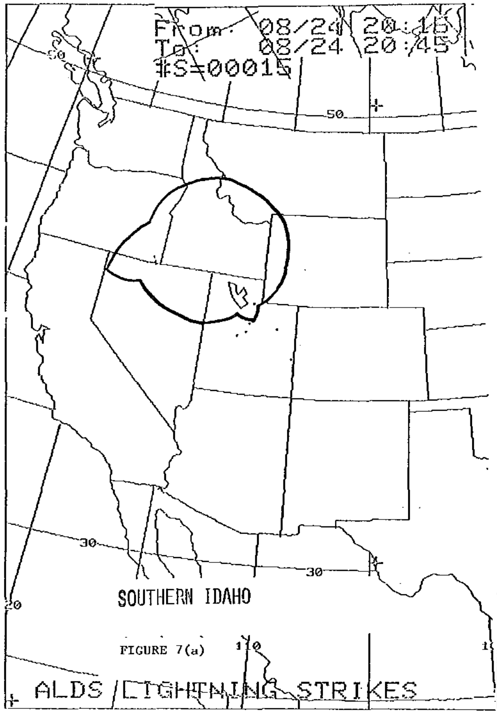
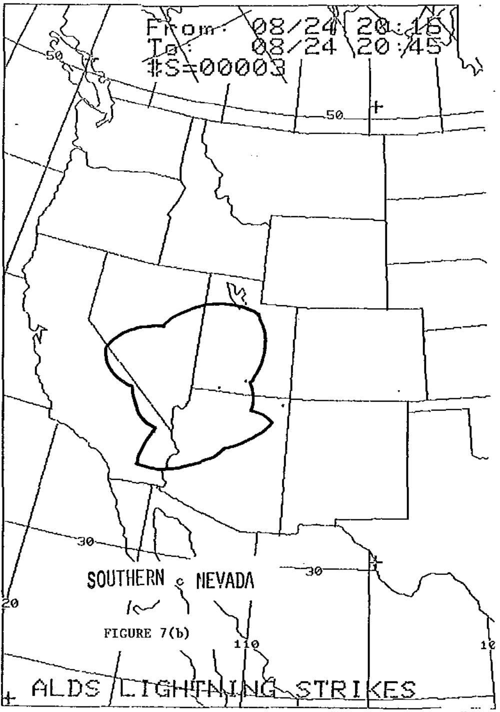


FIGURE 6. Lightning strike accumulation plot, 2015-2045Z, August 24, 1983, all position analyzers.



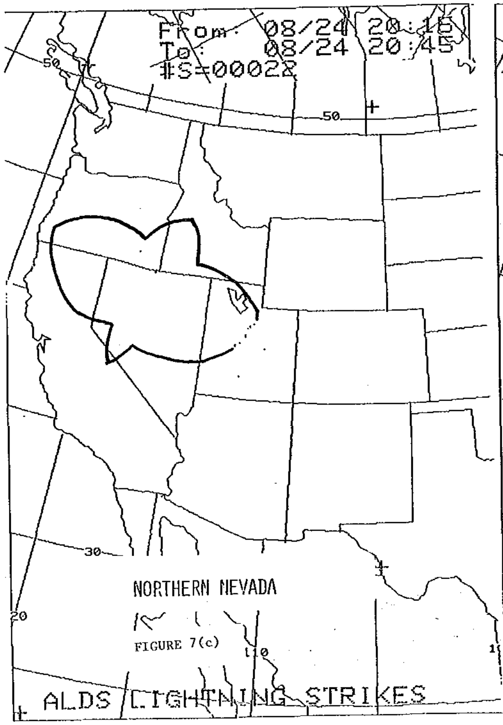
SOUTHERN IDAHO

FIGURE 7(a)



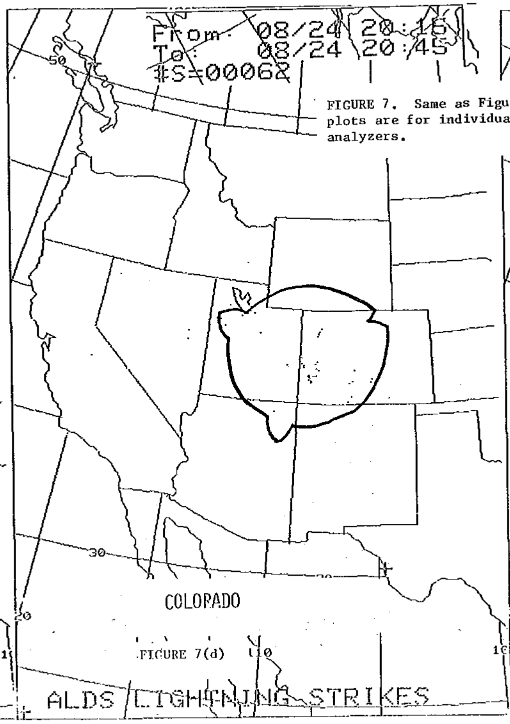
SOUTHERN NEVADA

FIGURE 7(b)



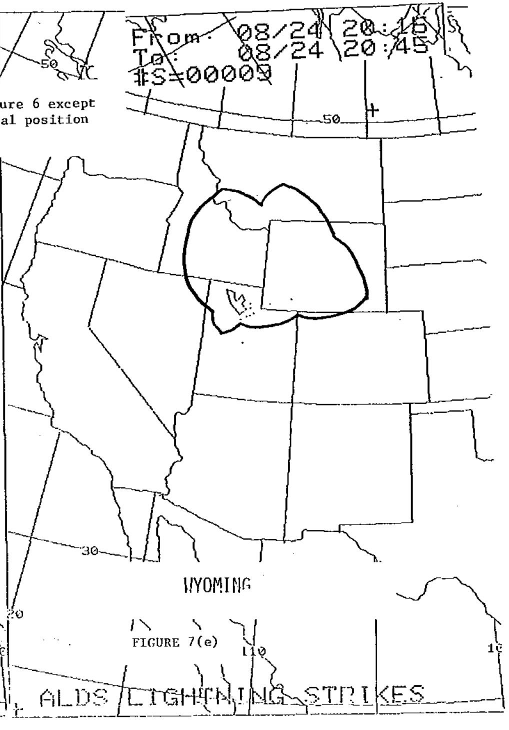
NORTHERN NEVADA

FIGURE 7(c)



COLORADO

FIGURE 7(d)



WYOMING

FIGURE 7(e)

FIGURE 7. Same as Figure 6 except plots are for individual position analyzers.

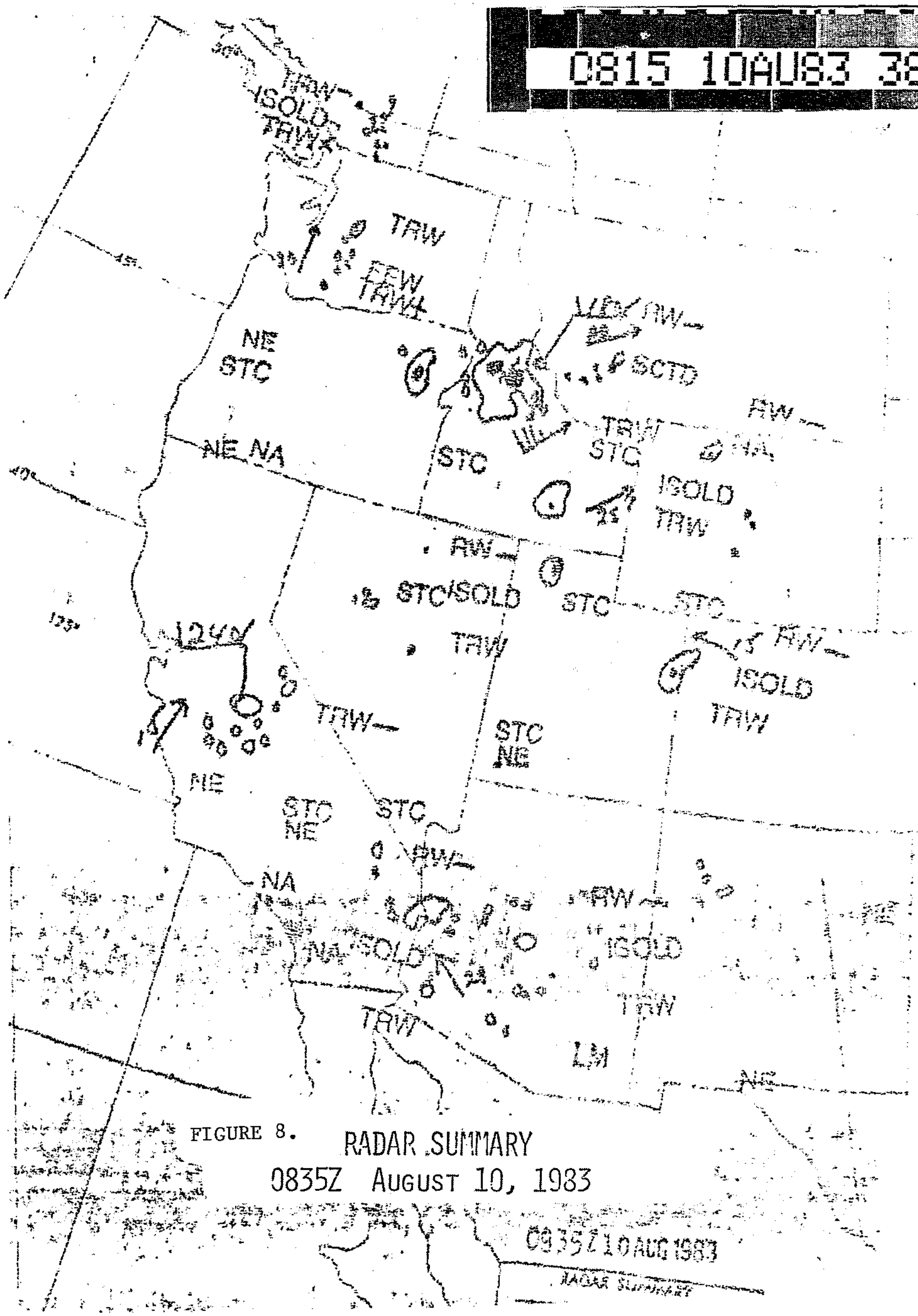


FIGURE 8. RADAR SUMMARY 0835Z AUGUST 10, 1983

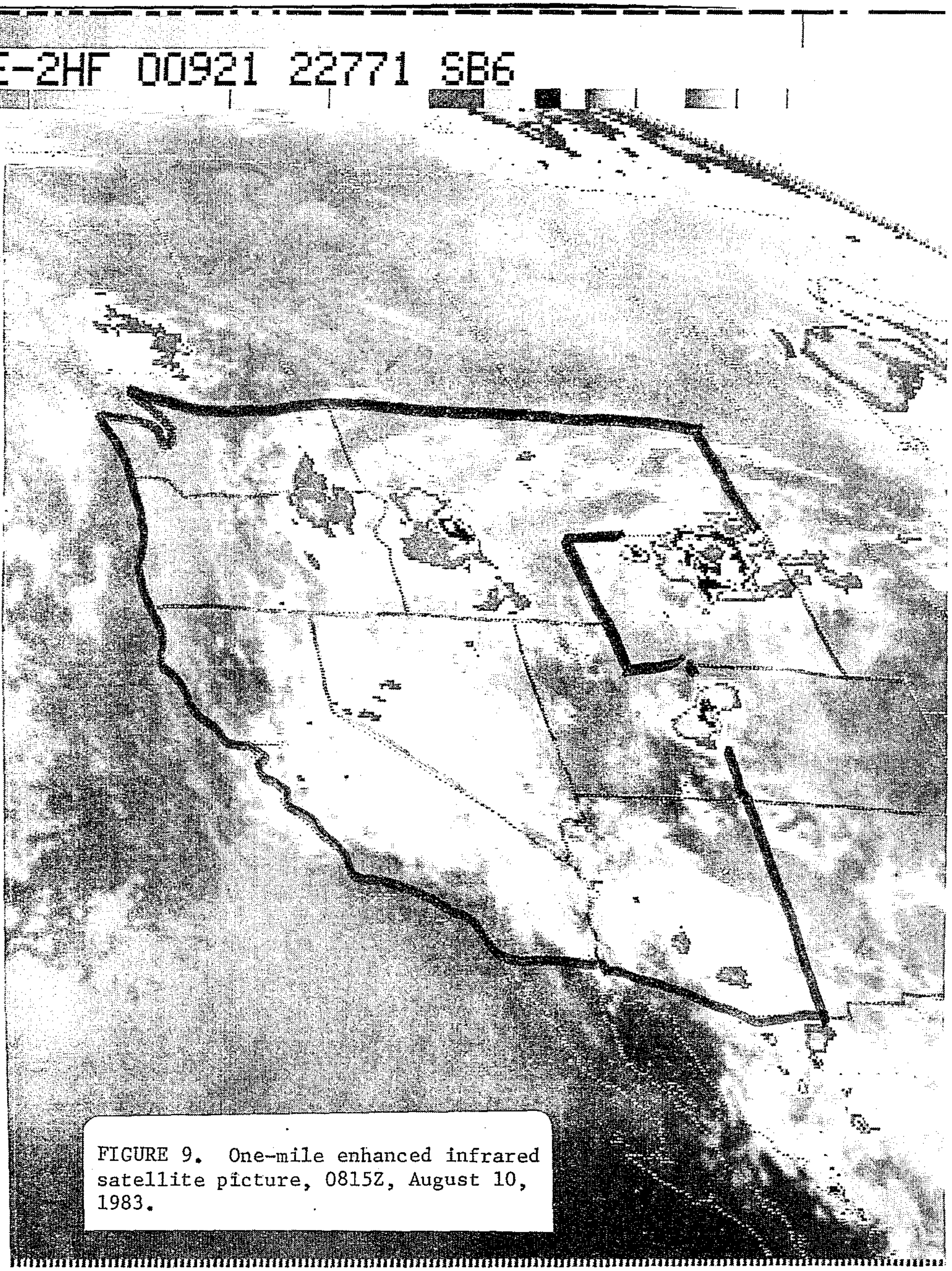


FIGURE 9. One-mile enhanced infrared satellite picture, 0815Z, August 10, 1983.

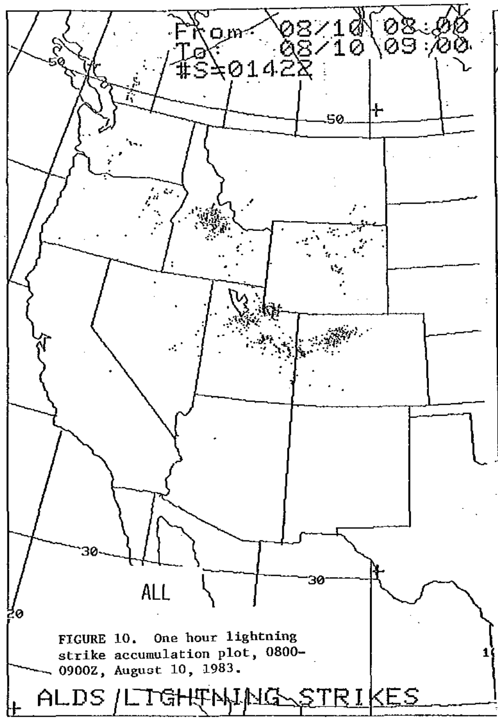


FIGURE 10. One hour lightning strike accumulation plot, 0800-0900Z, August 10, 1983.

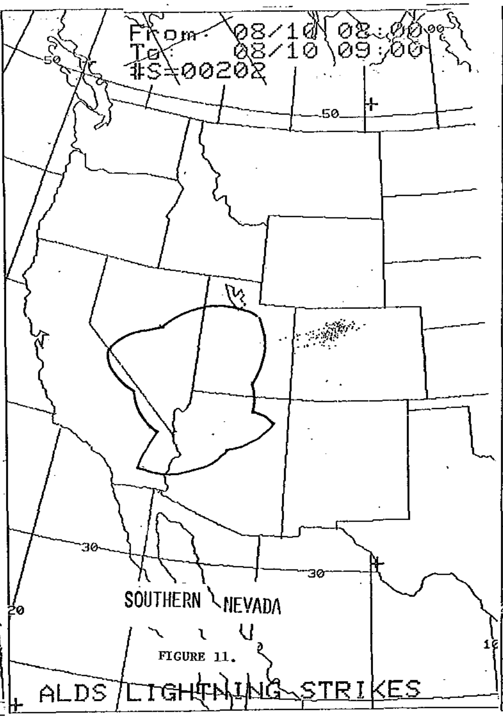


FIGURE 11.

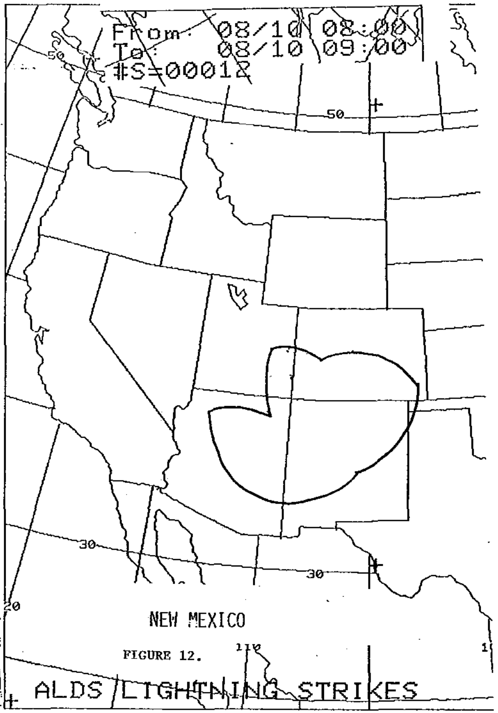


FIGURE 12.

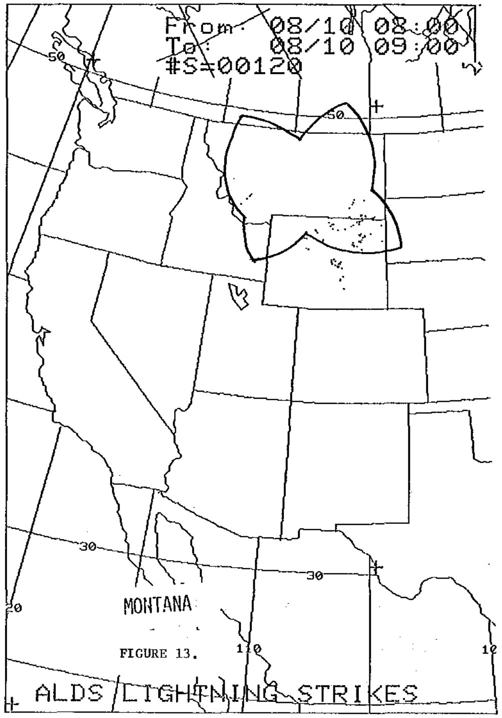


FIGURE 13.

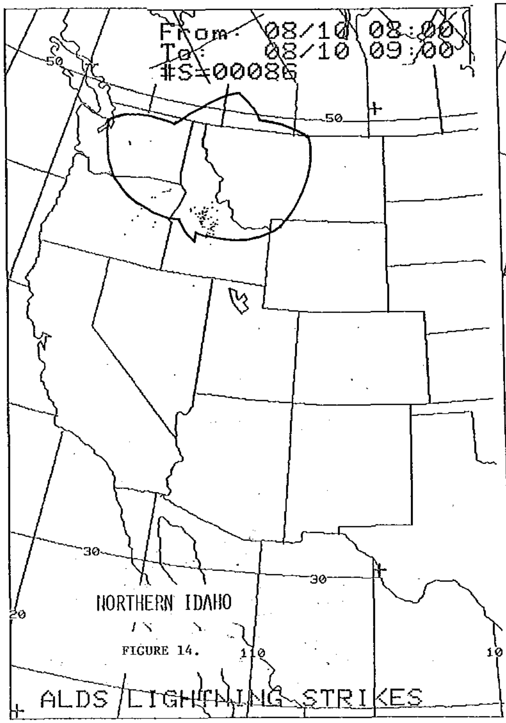


FIGURE 14.

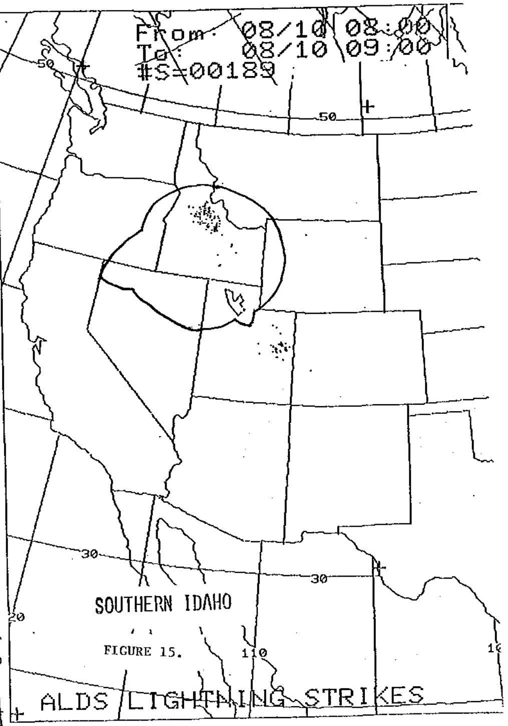
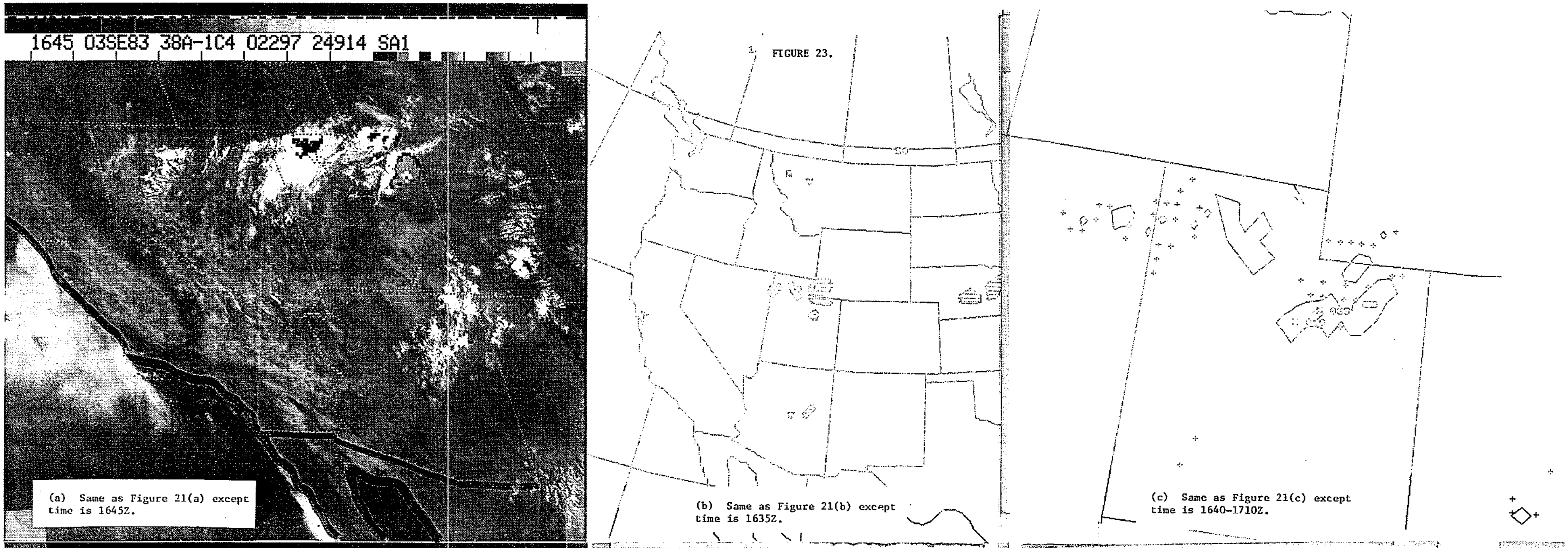


FIGURE 15.

FIGURE 23.

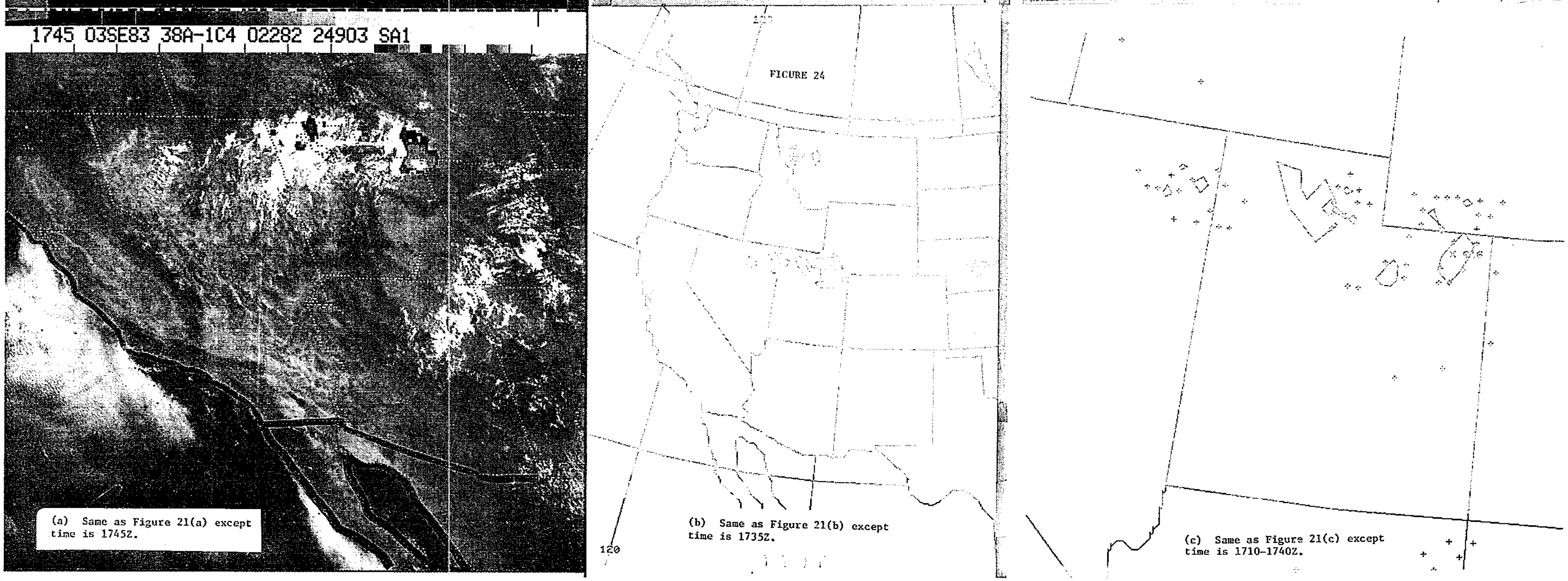


(a) Same as Figure 21(a) except time is 1645Z.

(b) Same as Figure 21(b) except time is 1635Z.

(c) Same as Figure 21(c) except time is 1640-1710Z.

FIGURE 24



(a) Same as Figure 21(a) except time is 1745Z.

(b) Same as Figure 21(b) except time is 1735Z.

(c) Same as Figure 21(c) except time is 1710-1740Z.

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