NOAA Technical Memorandum ERL ESG-9

1984 AIRBORNE INVESTIGATIONS OF MESOSCALE CONVECTIVE SYSTEMS (AIMCS): OPERATIONAL SUMMARY AND DATA INVENTORY

Staff, Weather Research Program

Environmental Sciences Group
Boulder, Colorado
January 1985

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UNITED STATES
DEPARTMENT OF COMMERCE

Malcolm Baldrige,
Secretary

NATIONAL OCEANIC AND
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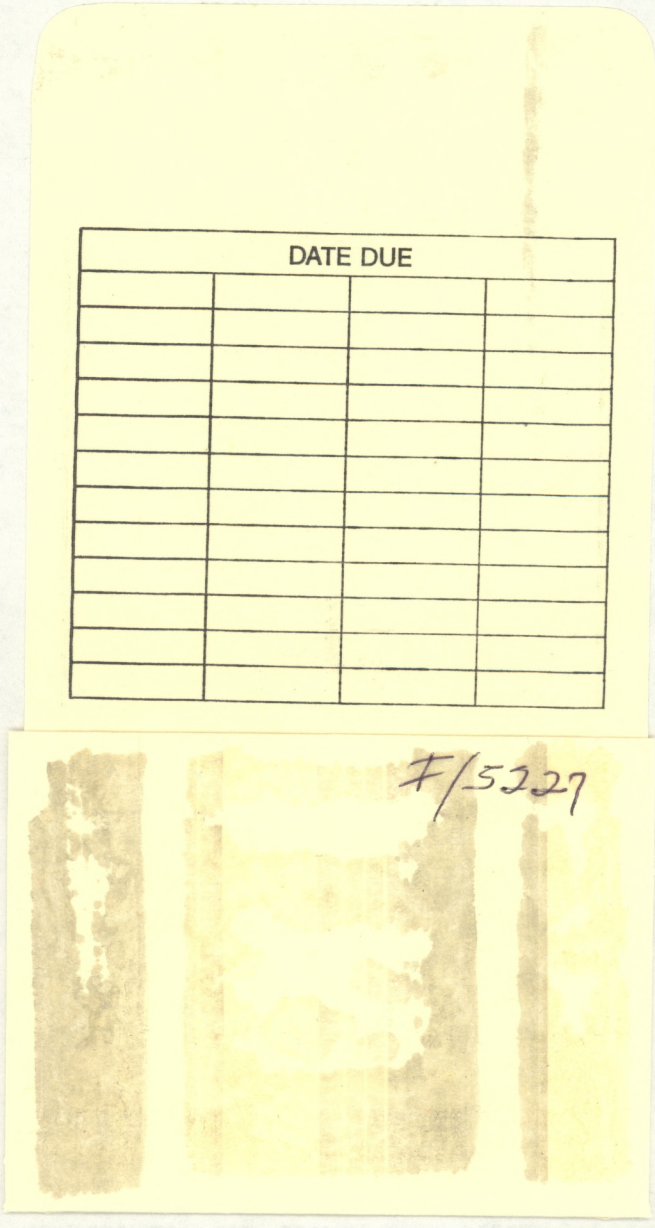

FOREWORD

This NOAA/ERL AIMCS Technical Memorandum is intended to serve as an index of information for researchers who are interested in using data that were obtained during the 1984 field program. This document is the result of the dedication of numerous individuals who contributed both to the writing of the text and by their participation during the program.

A special thanks is extended to the personnel of the various National Weather Service offices which contributed to the success of AIMCS, and in particular to the Denver National Weather Service Forecast Office which allowed us to operate the AIMCS control center from their facility.

José Meitín, Editor
January 1985

CONTENTS

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ABSTRACT

The Airborne Investigations of Mesoscale Convective Systems (AIMCS) Program-1984 is summarized; type, amount, and frequency are listed for the data obtained. Highlights and outlook for the future are discussed. Each flight mission and the six subprograms are described in detail.

I. INTRODUCTION

AIMCS-1984 was the first research effort to attempt aircraft measurements of slow-moving nocturnal mesoscale convective systems (MCS). The goals of the 1984 program were to determine the capabilities of research aircrafts to operate near and within MCSs and to begin studies of the dynamics of these systems through substantially better observational data than had been available. Table 1 presents a brief summary of the research flight missions and supplemental data for the AIMCS-84 program. Appendix I provides the daily chronology of the weather situation during the operational program.

Because of the many time zones involved in deploying a long-range aircraft over the mid-west United States, most times are given in Greenwich Time (GMT). GMT is 6 hours ahead of local daylight time at Denver, Colorado (MDT). Most of the data collected during the program reside at the Weather Research Program (WRP) of the Environmental Research Laboratories (ERL). Satellite data are archived at the National Environmental Satellite, Data, and Information Service, Regional and Mesoscale Meteorology Branch (NESDIS/RAMM) on the campus of the Colorado State University (CSU) and the cloud physics data are available from the Air Quality Division (AQD) of ERL's Air Resources Laboratory.

Table 1. Program for airborne investigation of mesoscale convective systems (AIMCS)

Date	Flight Number	Take-Off Time (GMT)	Return Time (GMT)	Research Area	Satellite RAPID Scan (5-Min + VAS)	Special[1] Upper Air Soundings	Wind Profilers Available
22 June	1	0420	1030	Eastern Kansas	Yes	Yes	4
29 June	2	0515	1130	Eastern Oklahoma	No	No	4
02 July	--	----	----	----	Yes	No	4
04 July	3	0335	1015	Central Nebraska	Yes[2]	No	3
07 July	4	0400	0730	Western Kansas	Yes	Yes	4
11 July	5	0420	1030	S.E. Kansas	Yes	Yes	2
13 July	--	----	----	----	Yes	No	2
15 July	6	0144	0835	Iowa	Yes	No	2

[1] Launch times 0300 and 0700 GMT.

[2] 15 min visible and infrared only, no VAS data.

II. OVERVIEW OF AIMCS

A. Forecast Operations

Forecasting responsibility for the AIMCS program was divided into two teams of 7 members each. Forecast duties were divided between the two teams on a rotating, 4-days-on/4-days-off basis. The duty team would assemble in the WRP Weather Room at 9:00 a.m. MDT as the 1200 GMT data began to arrive on the WRP facsimile circuit. Team members would reanalyze standard charts to highlight salient features to be used to forecast MCSs. Team leaders had the option to request additional data from NOAA's Program for Regional Observing and Forecasting Services (PROFS) in the form of automated skew-T sounding diagrams and/or AFOS hourly surface plots. Further guidance was received by telephone from Barry Schwartz of Techniques Development Laboratory (TDL), Washington, D.C., who described his interpretation of the Limited-area Fine-mesh Model (LFM) gridpoint output of selected low-level forecast fields.

Forecasts were developed for the following:

(a) Probable MCS development tonight.

(b) Probable MCS development tomorrow night (36 hours).

A positive forecast for tonight for (a) would usually place the aircraft crew on alert; a positive outlook for (b) would lead to calls for rapid-scan satellite data and special rawinsonde soundings for the next day. Daily weather briefings were held at 12:45 p.m. MDT and, on the basis of the forecast, the project leader would determine whether to alert the air crews for the day's operations. If MCS activity had been forecasted for the ensuing night, three or four members of the forecast team on duty drove to the Denver WSFO to prepare for aircrew briefing and flight support. These forecasters would remain on duty until termination of the research mission. Responsibility of the Denver forecast team was to provide the onboard scientists with updates on the weather situation, using dial-up radar information, 1/2-hourly satellite output, and hourly surface data. There were many days during the project for which the morning data yielded uncertain forecasts. On these days, the aircraft crew was placed on alert by the project leader and the forecast team remained on duty into the evening, basing the final decision on the 0000 GMT data.

B. Upper Air Observations

In order to observe and quantify the vertical and horizontal circulations associated with MCSs, special upper air observations were requested for special days at selected National Weather Service sites. These soundings were typically requested at two observing times, 0400 and 0800 GMT. After the field phase of AIMCS, all the upper air soundings taken during the period were archived at WRP. Kinematic calculations performed on the available case days will help us to understand some of the features of the circulation patterns in the middle and upper portions of the troposphere.

C. Special GOES Data Collection

During AIMCS 1984 GOES-East VISSR Atmospheric Sounder (VAS) data and 5-minute rapid scan VISSR (VIS and IR) data from GOES-West were archived at the NESDIS/RAMM branch located at Colorado State University. These data were collected from 1130 GMT through 1400 GMT the following day (1730 MDT through 2000 MDT). The approximate geographic coverage for data collection was 85° - 115° W and 30° - 50° N. Nearly all the rapid scan imagery was archived on 6250-bpi computer-compatible magnetic tapes. The VAS data were archived on 1600-bpi magnetic tapes; multi-spectral images (MSI) and dwell sounding data were recorded on separate tapes. Table 2 summarizes the research rapid scan data (RRSD) and VAS data archived at NESDIS/RAMM.

Table 2. Summary of NESDIS/RAMM satellite archive for AIMCS 1984

Date	RRSD	VAS	Flight	Comments
21-22 June	yes	yes	yes	
1-2 July	yes	yes	no	no data after 0500 GMT
3-4 July	yes	no	yes	only 15 minute, VIS and IR images
6-7 July	yes	yes	yes	
10-11 July	yes	yes	yes	
12-13 July	yes	yes	no	
14-15 July	yes	yes	yes	

D. Profiler Measurements

During AIMCS-84, experimental profilers were deployed at four sites in Colorado (Fig. 1). Profilers are remote sensing instruments developed at the Wave Propagation Laboratory (WPL) at the Environmental Research Laboratories in Boulder, Colorado. A complete profiler system is made up of two passive microwave radiometers and a multiple-beam Doppler radar to provide virtually continuous and automatic vertical profiles of wind, temperature, and humidity. Only the site at Denver-Stapleton has such a complete set. One radiometer, tuned to operate near 20 and 30 GHz, was designed to measure atmospheric humidity stratifications as well as bulk column measurements of integrated water vapor and liquid water. The other radiometer operates on four channels between 50 and 60 GHz and is designed to retrieve atmospheric temperature profiles. Geopotential heights of pressure surfaces and thickness information are also derivable from radiometer data at these channels. The radiometer data are available at 2-minute intervals. Highly accurate wind profiles at roughly a 5 km resolution are provided by double- or triple-beam Doppler radars. Two beams directed 15° off the zenith to the east and north measure the u and v components of the horizontal wind as a function of height. At sites where a third beam is available (Denver-Stapleton and Platteville only),

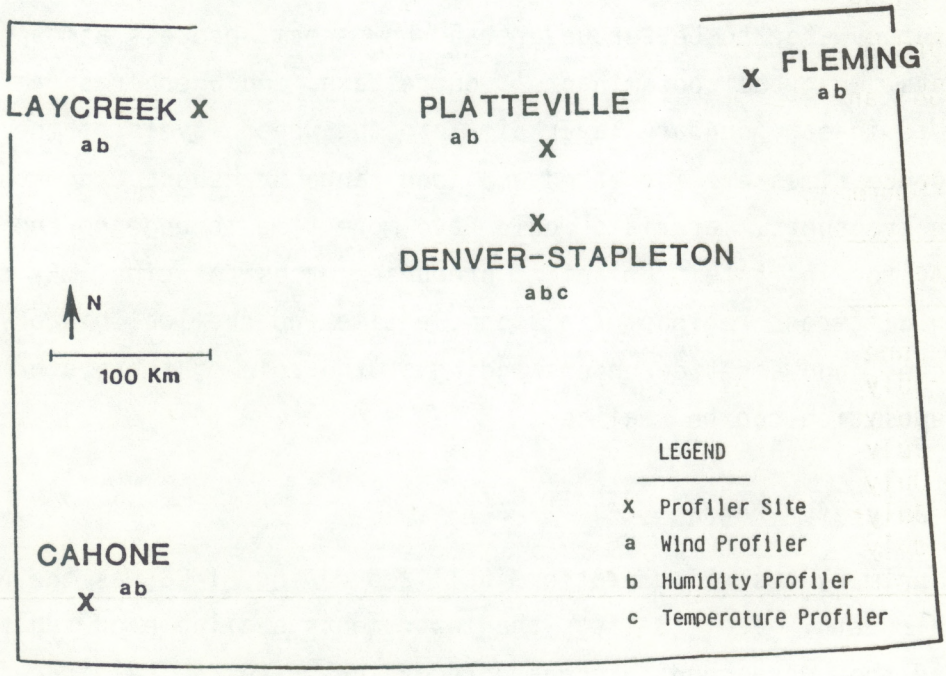


Fig. 1. Profiler sites in Colorado.

the vertical component of the wind (w) is measured from a vertically directed beam. The Doppler information also provides a fairly accurate estimate of the tropopause height. Wind profiles and tropopause height information are available at 1-hour intervals.

E. AIMCS Cloud Physics and Chemistry Program

One of the primary purposes of the cloud physics studies in AIMCS was to discern the interaction of microphysical processes with the dynamical processes within an MCS. This information will increase our understanding of the storms and improve model parameterizations. Preliminary evidence shows that the clouds in certain regions of the storm were remarkably isothermal and that aggregation occurred over a considerable depth and at colder temperatures than expected.

The instrumentation used at the cloud physics and chemistry station on board the NOAA P-3 aircraft during the AIMCS program consisted of wing-mounted PMS probes. Two-dimensional images of precipitation particles were continuously recorded, and bulk water collectors were used to collect cloud water and precipitation water for later chemical analysis.

Water samples were collected to determine the chemical composition and acidity of the water to better understand how storms process atmospheric contaminants, what the contaminants' sources are, and whether storm systems can serve to inject boundary layer air into the upper levels of the storm, so that residence times are increased and long range transport can occur. During long-range transport, materials would have more time to undergo chemical conversion, for instance from acidic precursor gases to acids. By collecting samples in different regions of a storm, a time and chemical history can be reconstructed, and a better understanding of the role of these storm systems in acid deposition can be realized.

F. Aircraft Program

The primary observing platform utilized during AIMCS was the NOAA P-3 research aircraft. Table 3 lists the instruments available during the summer of 1984 and the corresponding onboard recording system. The aircraft flew six missions in the period 18 June to 15 July; these are described in Section III.

Most flights were carried out within 500 to 1000 km of Denver's Stapleton Airport and this area is shown in Fig. 2.

The program operated 7 days a week for the full period of the experiment. Typically, after receiving the 1200 GMT forecast maps, the aircrew was apprised of the potential status for the day. By local noon the aircraft was either released for the day or placed on alert. If the decision was GO, final briefings, flight plans, and mission objectives were made 2-3 hours prior to take-off time. On some days, the alert status lingered late into the day so the 0000 GMT forecast products could be examined. On the day following a flight mission, the aircraft was automatically unavailable.

Table 3. Instrumentation onboard NOAA's P-3 during AIMCS 1984

Parameter	Sensor Type/Source	Manufacturer/Model	Data System
Time	Omega		State parameter
Latitude	Omega/Inertial	Delco/Northrop	State parameter
Longitude	Omega/Inertial	Delco/Northrop	State parameter
Ground speed N/S	Omega/Inertial	Delco/Northrop	State parameter
Ground speed E/W	Omega/Inertial	Delco/Northrop	State parameter
Heading	Omega/Inertial	Delco/Northrop	State parameter
Pitch	Omega/Inertial	Delco/Northrop	State parameter
Roll	Omega/Inertial	Delco/Northrop	State parameter
Ambient pressure	Transducer	Garrent PN2100776-1-1	State parameter
Dynamic pressure	Transducer	Garrent PN2100774-1-1	State parameter
True altitude	Radar	APN-159	State parameter
Temperature	Platinum	2 Rosemounts 102CH2AF	State parameter
Dew point	Cooled mirror	General Eastern 1011-51	State parameter
Air temperature	Side-looking radiometer	Barnes PRT-5 CO_2	State parameter
Vertical acceleration	Inertial	Delco/Northrop	State parameter
Cloud liquid water	Hot wire	Johnson Williams	State parameter
Cloud particle image	Optical	Particle Measurement Systems OAP2D-C	Cloud physics
Precip particle image	Optical	Particle Measurement Systems OAP2D-P	Cloud physics
Lower fuselage radar system	C-band (360° scan)	Cubic Corp.	Radar reflectivity
Tail reflectivity radar	X-band (360° scan in vertical)	Prototype	Radar reflectivity
Tail Doppler radar	X-band (360° scan in vertical)	Prototype	Doppler

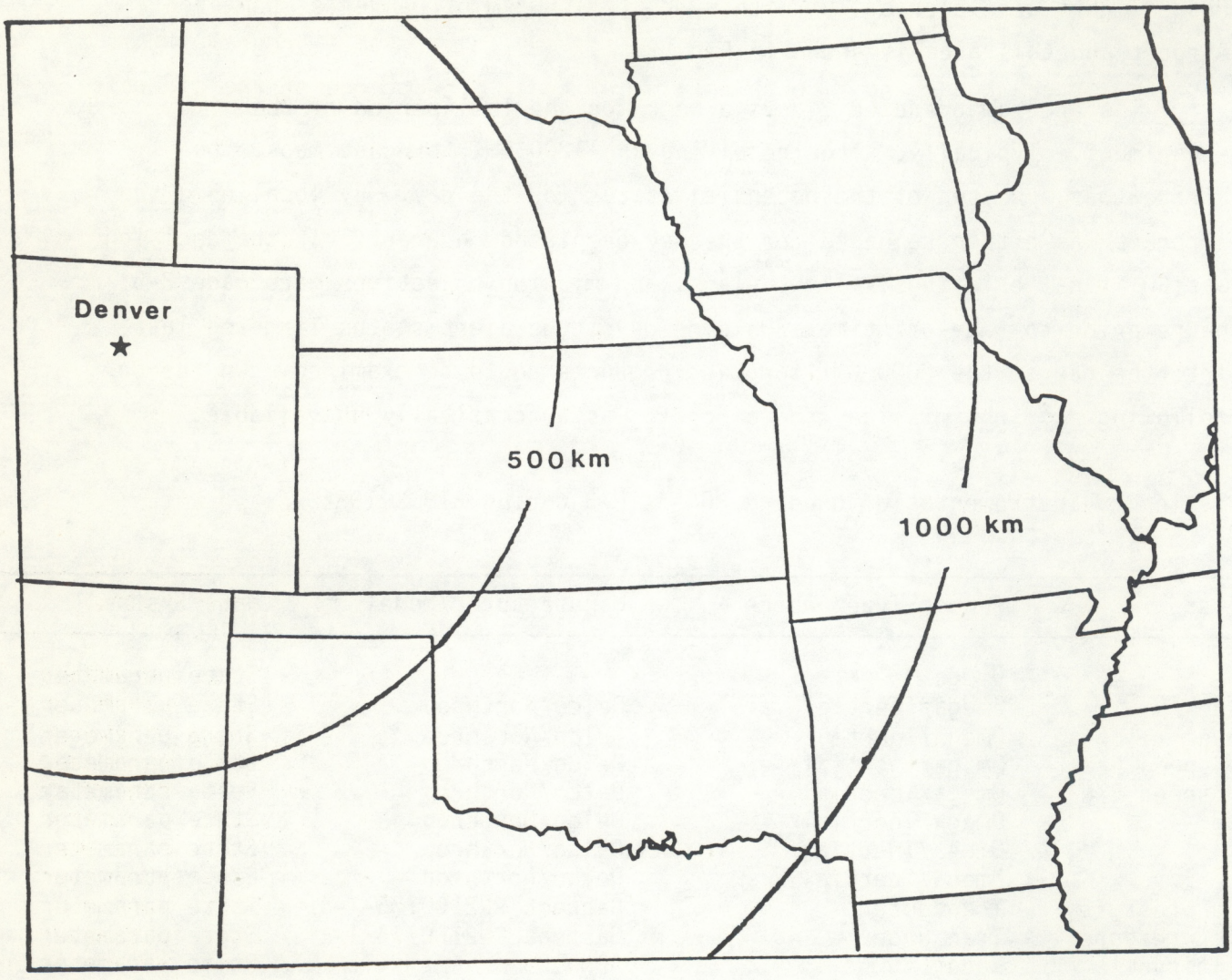


Fig. 2 AIMCS 84 flight research area.

III. AIMCS FLIGHT MISSIONS

A total of six research missions were flown in the AIMCS program. Most flights lasted about 6 to 7 hours because of the limited range of the aircraft when taking off from Denver, Colo. The following is a brief review of each flight with several figures depicting the weather situation, some in-situ measurements, and the flight track taken during the missions.

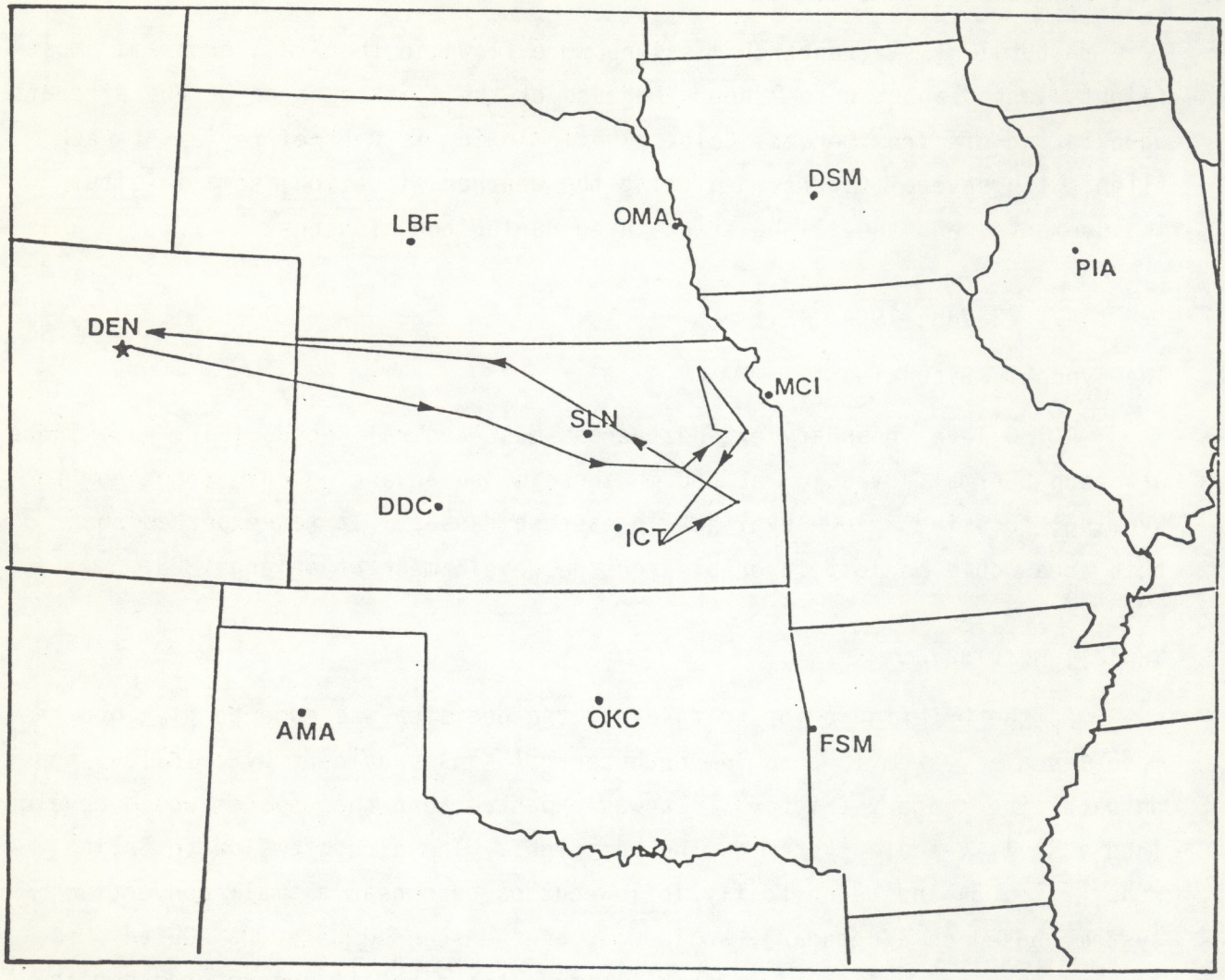
A. 22 June 1984

The Synoptic Situation:

A low level boundary extends across east-central Kansas (Fig. 4). There was good thermal advection at 850 mb ahead of an advancing cold front now in Wyoming, focusing a low-level jet in eastern Kansas. It was expected that this area would be most favorable for the development of a large MCS.

The Flight Plan:

At the briefing prior to take-off the decision was made to fly into the meso-β-scale system located in north-central Kansas evident by cold I.R. tops on satellite imagery (Fig. 6). It was expected that this system would develop into a small α-scale system during the night. The aircraft flew to Salina, Kans. (fig. 3) and began to fly inflow box pattern near a small convective system (based on a/c radar), at 10000', then descended to 4000' AGL to continue the box pattern. At that altitude the aircraft encountered severe turbulence in clear air, as shown in Fig. 7, about 20 km from the system. Communication with AIMCS control indicated that two convective systems were evident in the satellite photo, and that the eastern system, which the aircraft had been investigating, was decaying. Therefore, the aircraft flew to the west to a fairly stationary isolated system , completed one Doppler radar L-pattern around the system, and then returned to Denver.



AIMCS Flight #1 22 June 1984

TAKE OFF TIME: 10:20 PM MDT 21 June

RETURN TIME: 4:30 AM MDT 22 June

Fig. 3 Flight pattern for Flight #1.

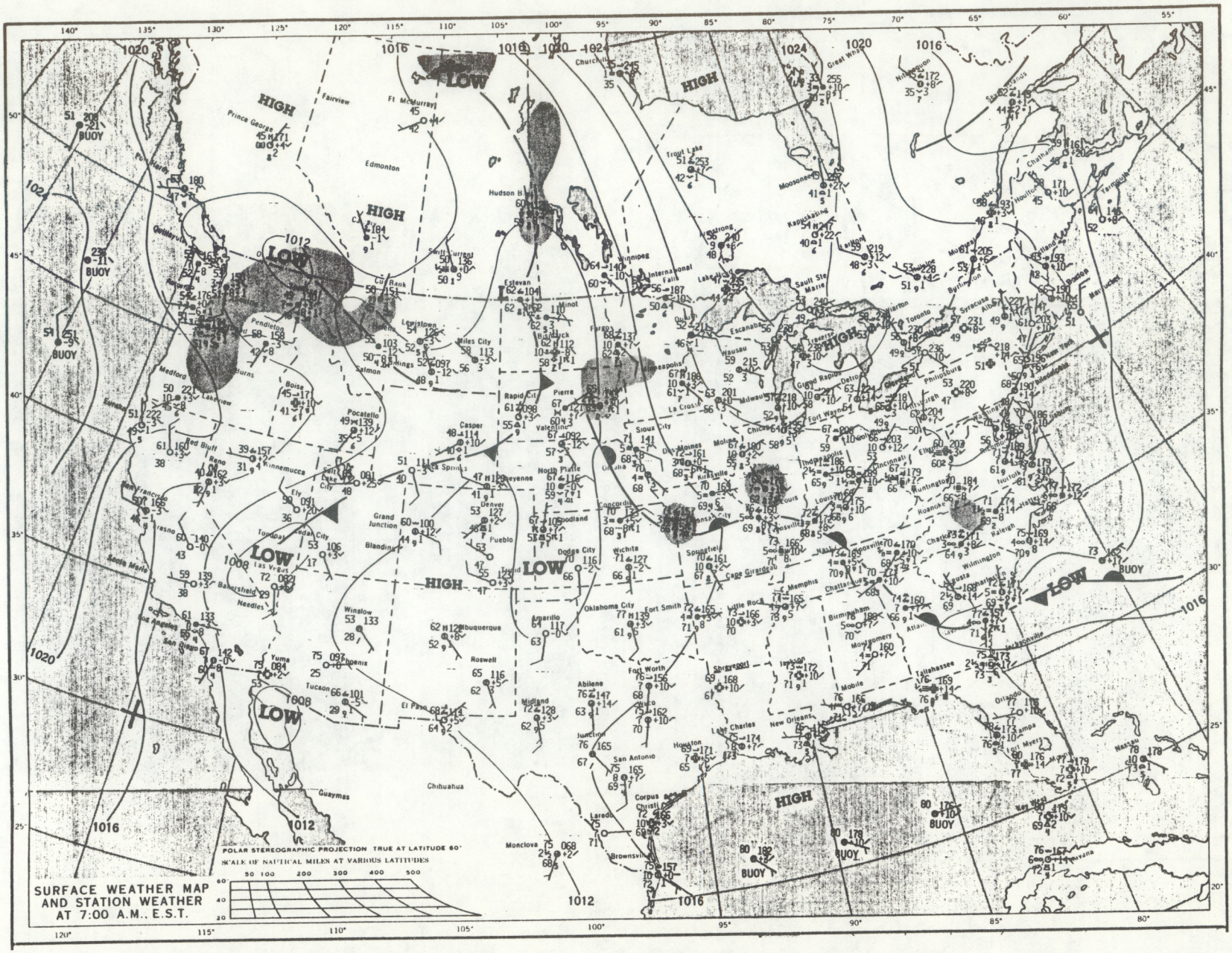


Fig. 4 NWS surface weather map for 1200 GMT, 21 June 1984

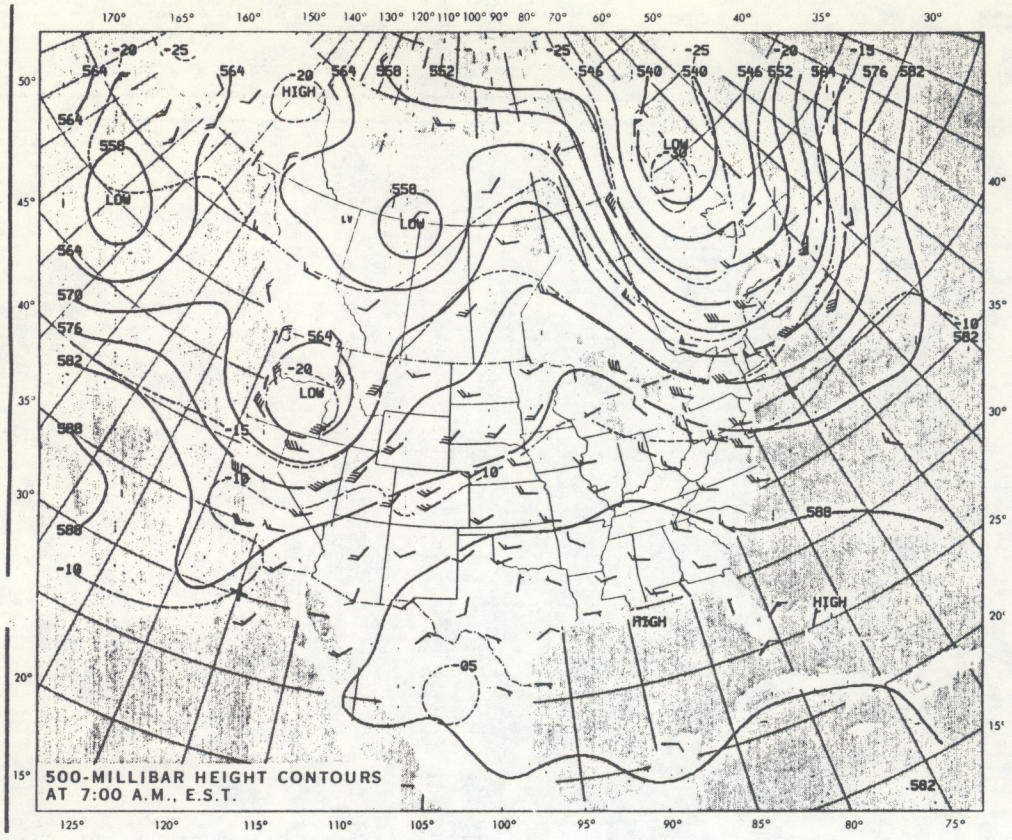


Fig. 5 NWS 500-mb chart for 1200 GMT, 21 June 1984.

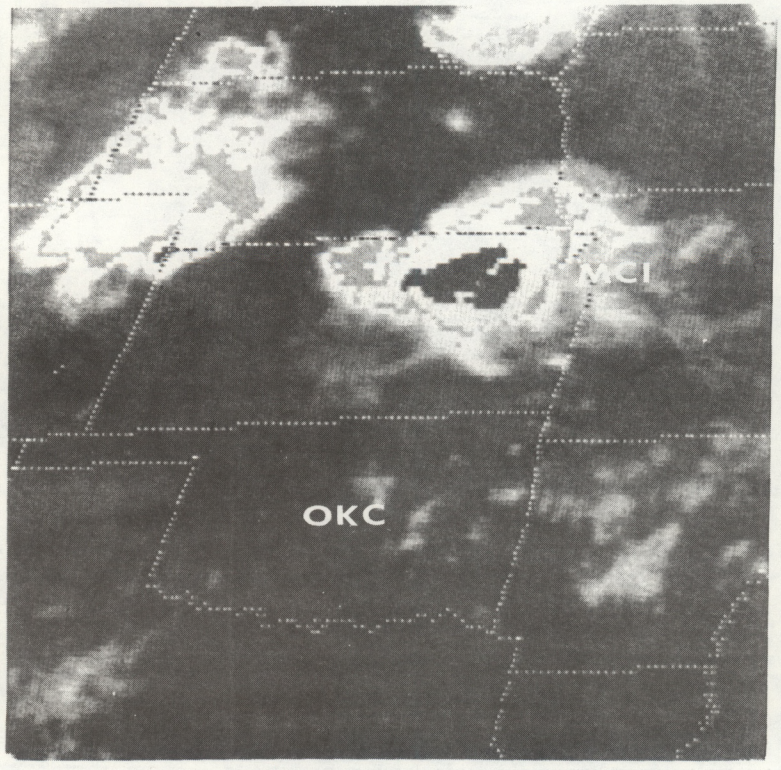


Fig. 6 Infrared satellite image (0630 GMT) of target system in east-central Kansas.

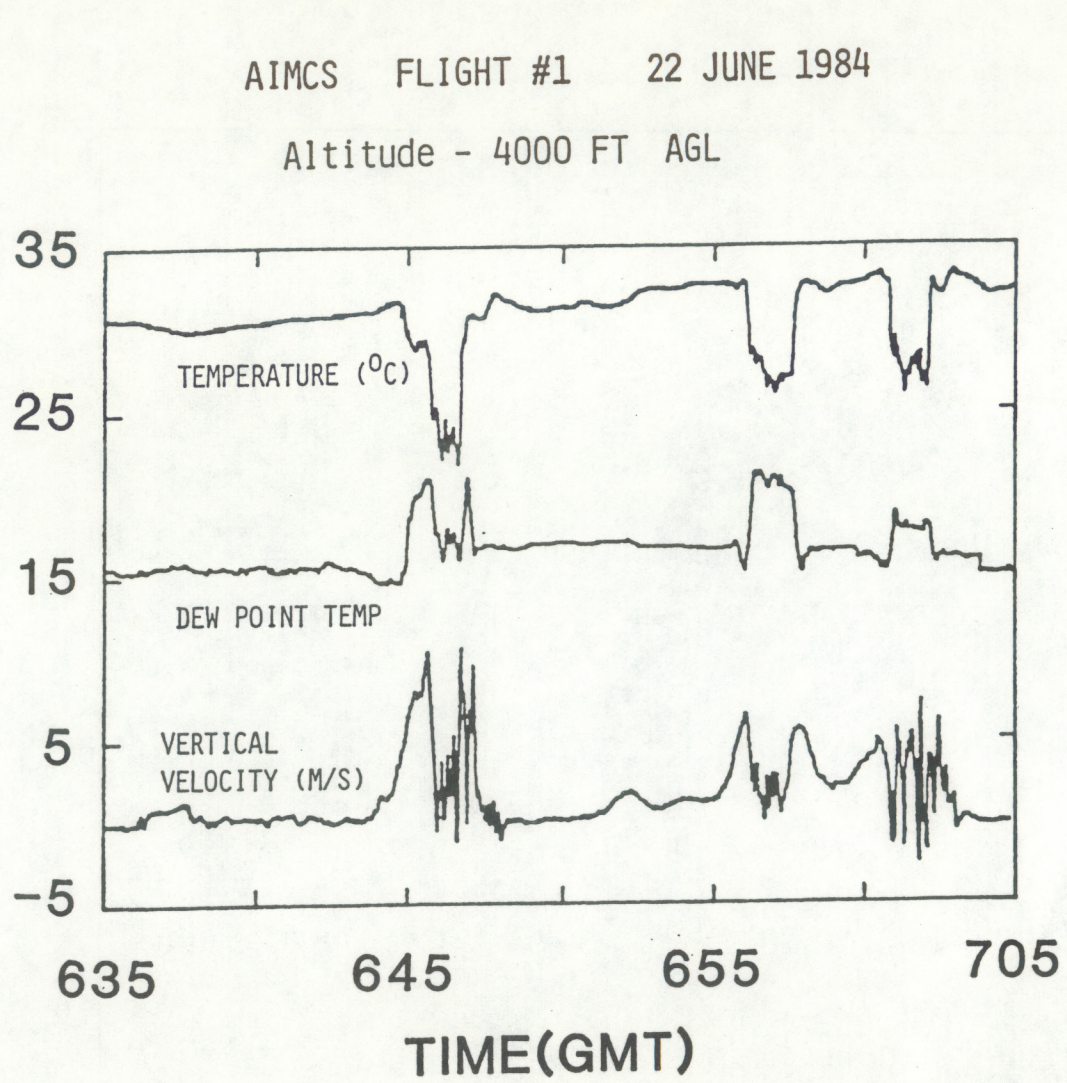


Fig. 7 Example of flight level measurements of temperature, dew point temperature, and vertical velocity during Flight #1 (0635-0705 GMT).

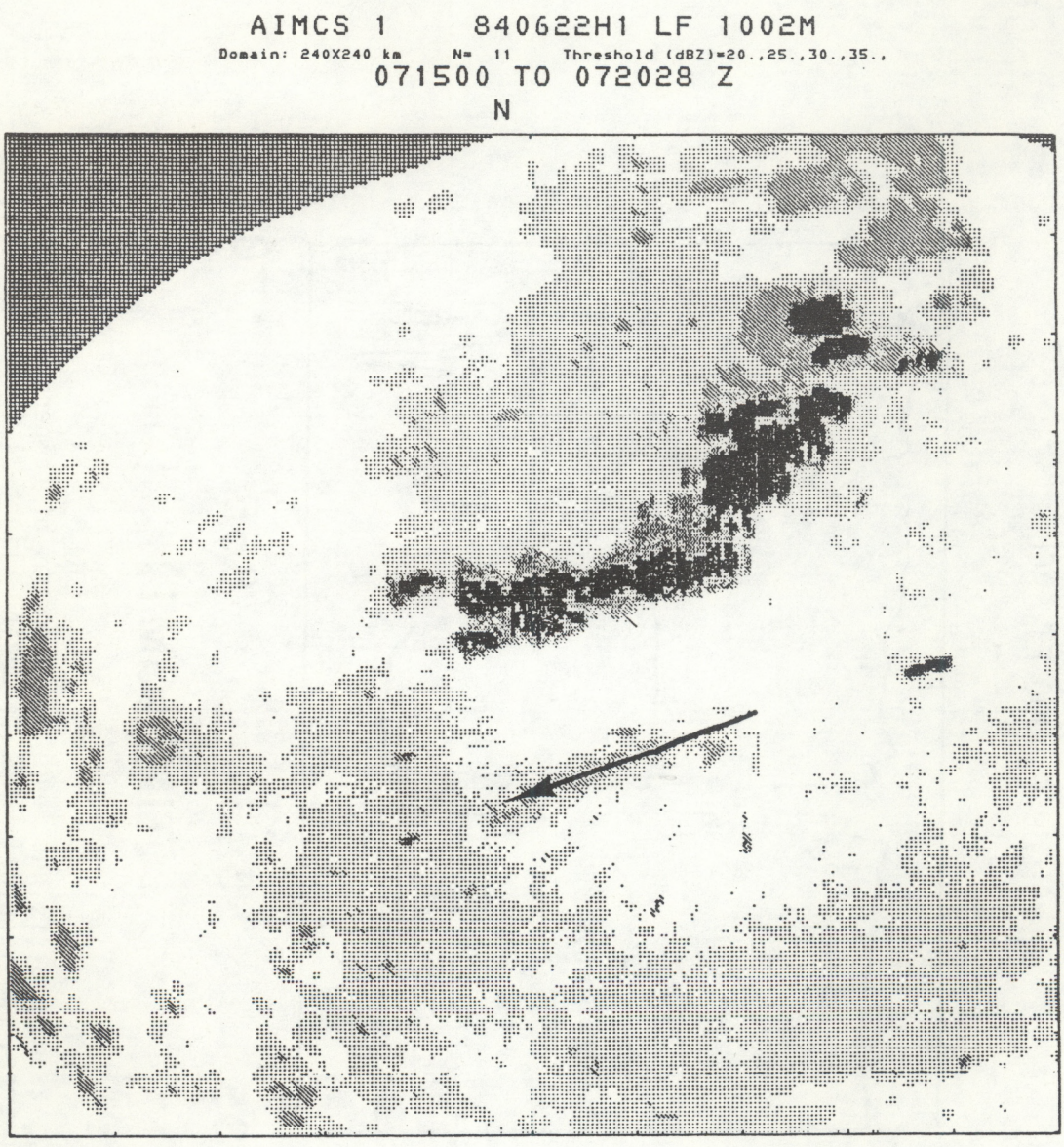


Fig. 8 Composite radar reflectivity map for Flight #1 in east-central Kansas.

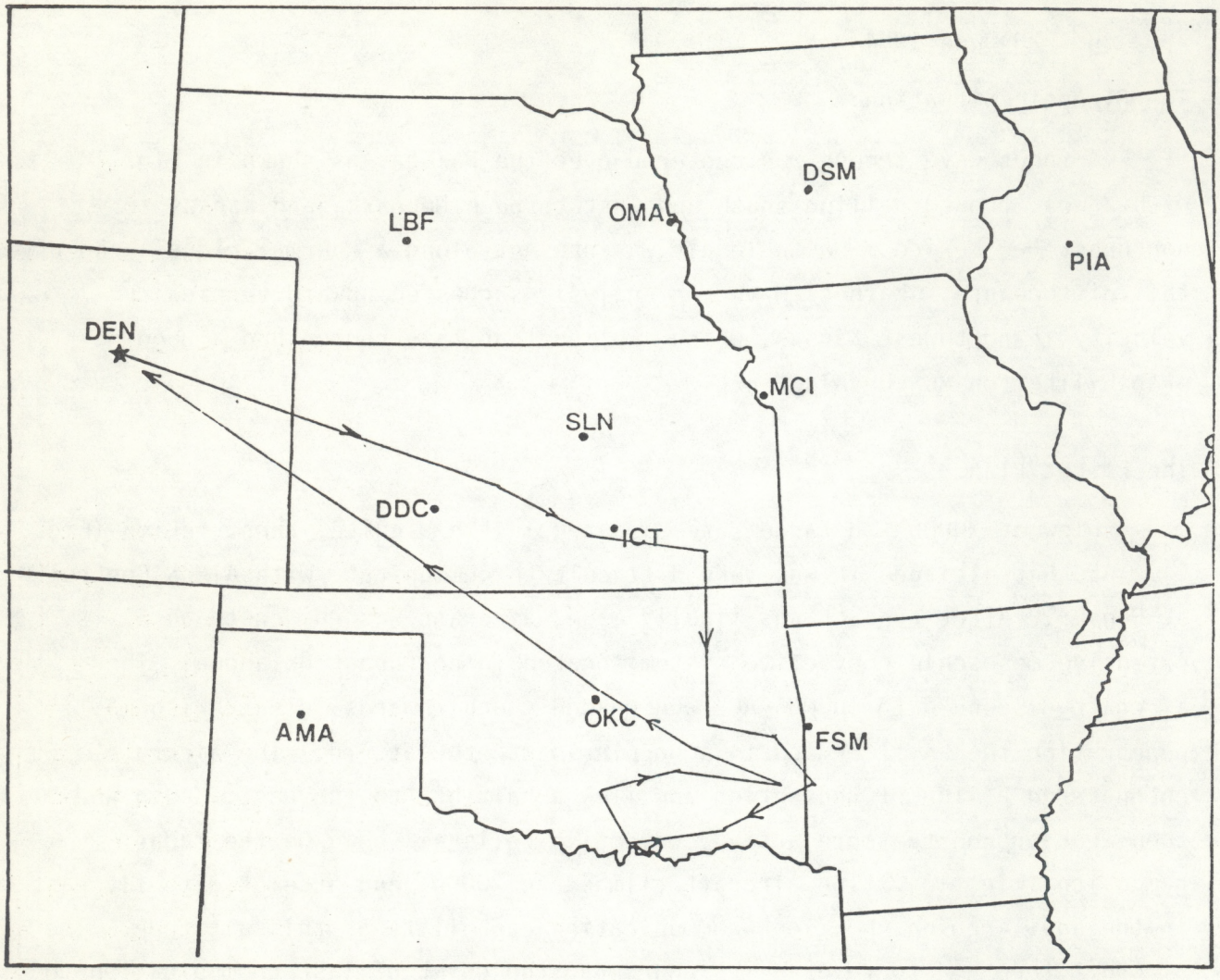
B. 29 June 1984

The Synoptic Situation:

A short wave trough was centered over the Dakotas as shown in Fig. 10 with a weak front trailing south and west through Nebraska and Kansas to northeast New Mexico. Unstable air was present along a thermal ridge ahead of this disturbance. Barnes' Q-vector analysis suggested upward vertical velocity in northwest Kansas, which implied that this region had a good probability for MCS development.

The Flight Plan:

Flew at 20000' to target area located in the Wichita, Kans. region (Fig. 9). At that altitude it was very difficult to communicate with AIMCS Control at Denver. After contact was finally made, aircraft was guided to an extensive mesoscale convective system located in northeast Oklahoma. The aircraft descended to 10000' AGL and headed south towards Tulsa, Oklahoma. penetrating the anvil region in a Doppler-sawtooth pattern. The aircraft encountered a line of convection and flew a half-box to the east, south and then west around the more active convective cells as shown on the radar composite (Fig. 13). The aircraft climbed to 20000' and attempted to fly east in the anvil region, but lost communication capability at this altitude. The aircraft then had to reverse its course to the point of last communication to try to contact control. By 0900 GMT communication with the FAA controller was reestablished and the aircraft descended to 10000'. Shortly after this time the system had dissipated so that we could never find a good stratiform precipitation region.



AIMCS Flight #2 29 June 1984

TAKE OFF TIME: 11:15 PM MDT 28 June

RETURN TIME: 5:30 AM MDT 29 June

Fig. 9 Flight pattern for AIMCS Flight #2.

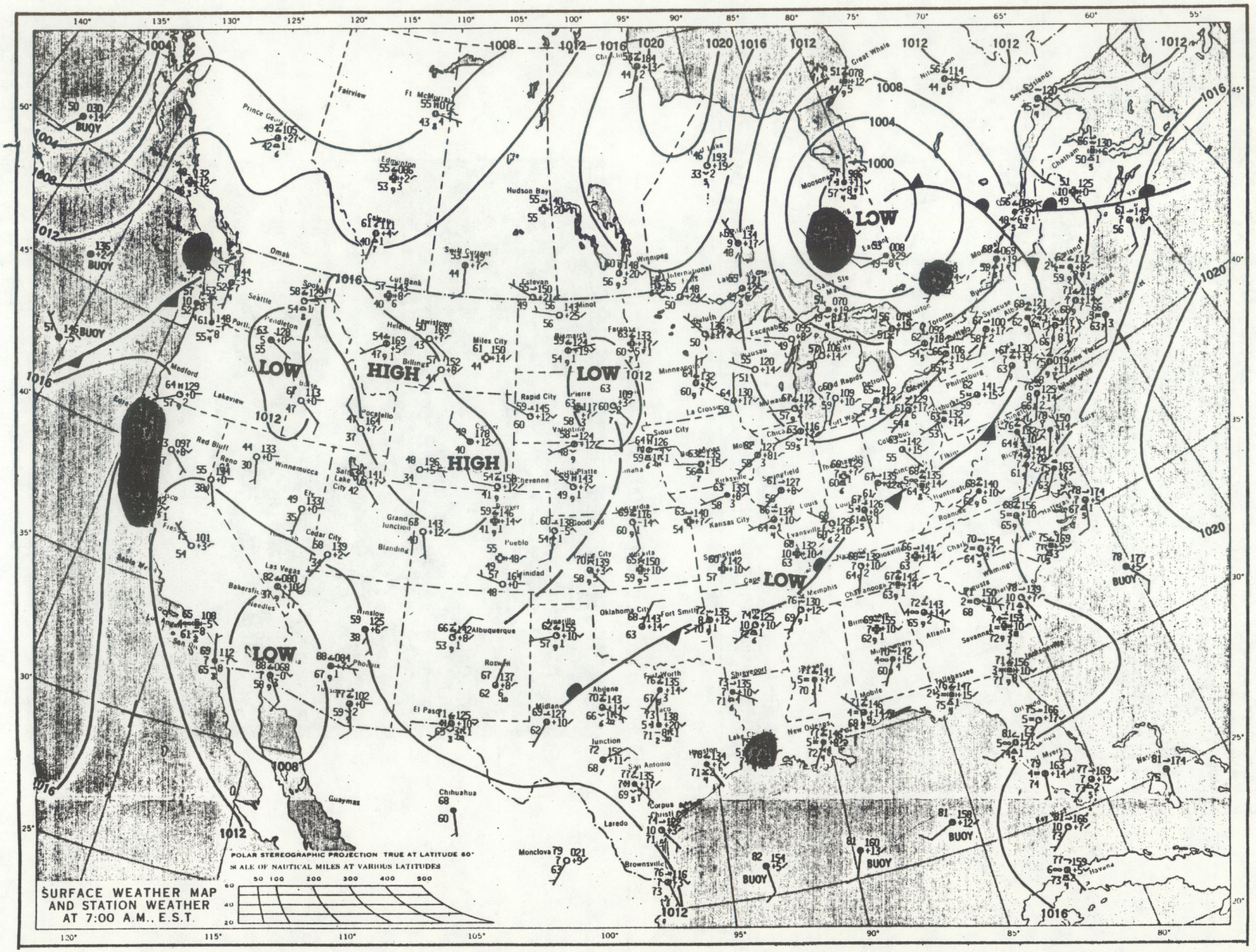


Fig. 10 NWS surface weather map for 1200 GMT, 28 June 1984.

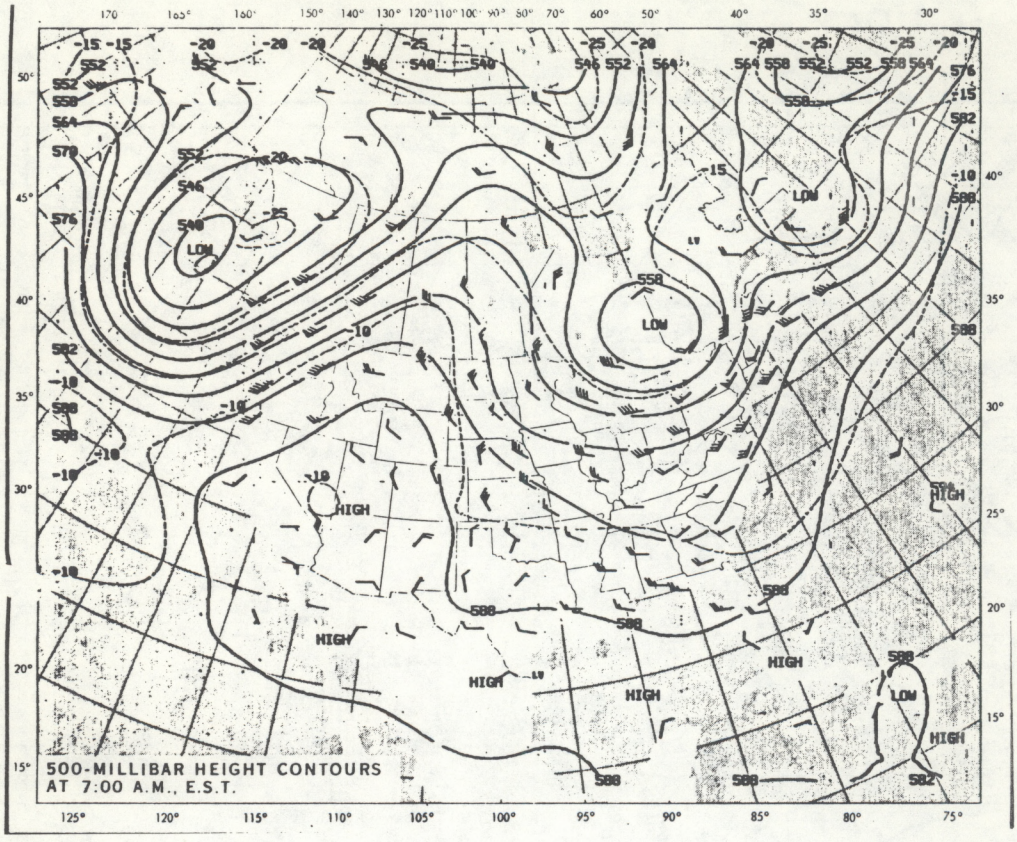


Fig. 11 NWS 500-mb chart for 1200 GMT, 28 June 1984.

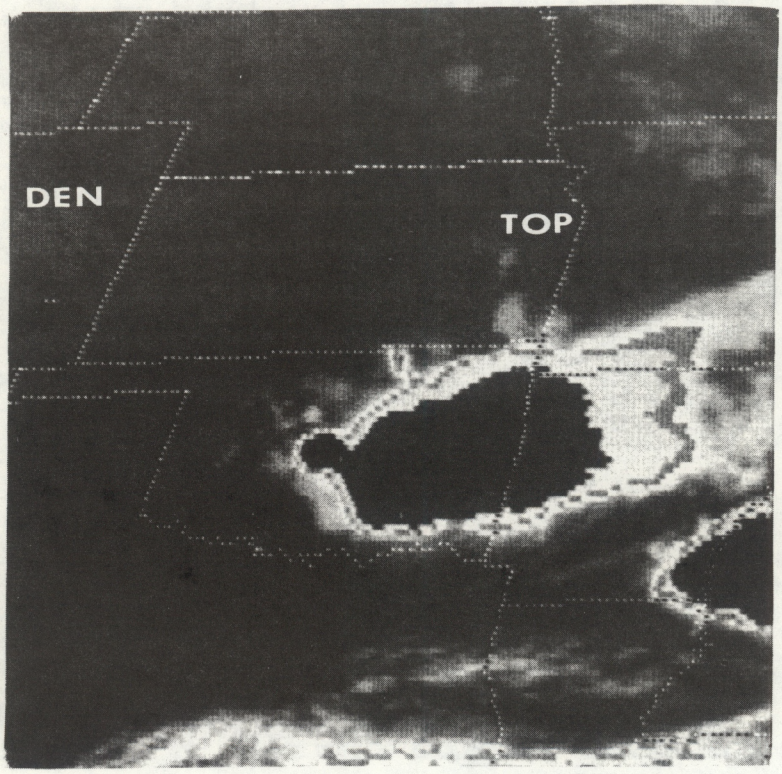


Fig. 12 Infrared satellite image (0730 GMT) of target system in eastern Oklahoma.

Fig. 13 Composite radar reflectivity map from Flight #2 in eastern Oklahoma.

C. 4 July 1984

The Synoptic Situation:

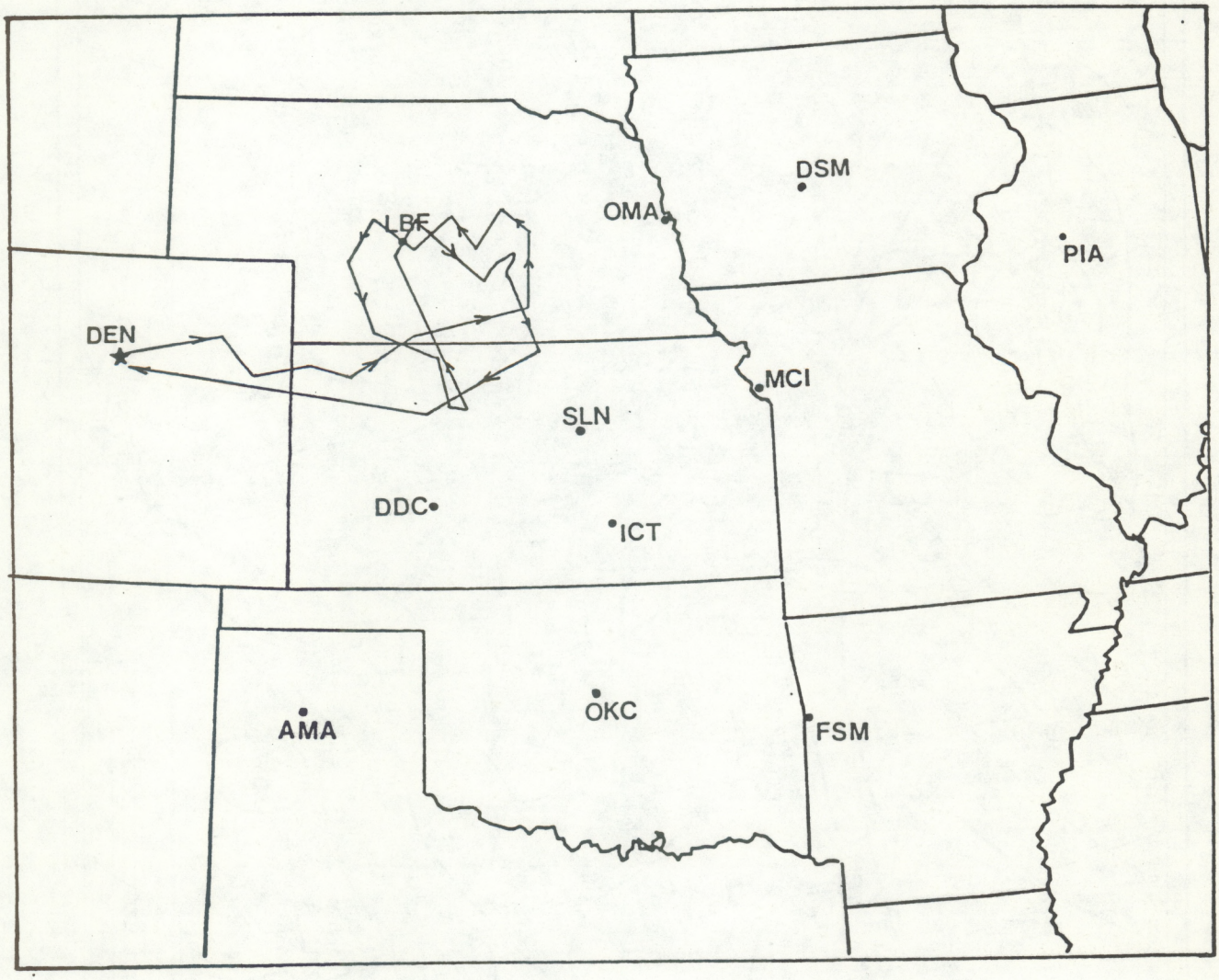
A frontal system was situated in western Wisconsin, extending southward through central Iowa into northern Colorado (Fig. 15). A short-wave trough at 500 mb in western Montana was moving eastward (Fig. 20). The airmass in the north-central Plains was more unstable than in previous days as moisture had increased over eastern Kansas and western Missouri. The best chance for MCS development appeared to be associated with a weak short wave that was moving from southwest South Dakota to northeast Colorado. A second large thunderstorm system developed along the frontal boundary in southeast Nebraska, northwest Missouri, and eastern Kansas, but this system was expected to die out by the time the aircraft began the mission.

The Flight Plan:

Prior to departure, the aircraft scientist were in a quandary, whether to investigate an impressive system in Kansas or go with the original forecast and fly the convective system developing in southern Nebraska. The aircrew filed for Denver, Akron, McCook to Grand Island, with a takeoff time of 0337 GMT and decided to fly into the southern Nebraska system. Just east of Akron, Colo., the aircraft intercepted a major line of convection, as shown on Fig. 18 that extended 200 nm to the east-northeast. The aircraft then proceeded along the southern flank of the line at 8000' AGL all the way to its eastern end. At this point (0505 GMT), they crossed the line to sample the anvil structure that was beginning to develop behind the system, executing saw-tooth patterns back toward the west into the stratiform region (Fig. 14). At 0607 GMT, the aircraft headed southwest toward the original position of the line with the plan to return to the initial convective area, but the system had evolved into mainly stratiform characteristics.

Contact was finally made with AIMCS Control which informed the aircrew that most of the convection was far to the east and south of the aircraft position. The decision was then made to continue working the "anvil" region and climb to 20000'. There, the crew lost all communication with center because of ionization of the aircraft skin. Near North Platte, Nebr., they circled for 20 to 30 min until contact was made and clearance could be obtained to descend back to 8000' AGL. After descent, the "anvil"

investigation was resumed toward the east and south, the flight returned to Denver at 1010 GMT. This mission was probably the most successful of the six flights, catching a portion of an MCS in its evolutionary stage from convective to stratiform characteristics.



AIMCS Flight #3 4 July 1984

TAKE OFF TIME: 9:35 PM MDT 3 July

RETURN TIME: 4:15 AM MDT 4 July

Fig. 14 Flight pattern for AIMCS Flight #3.

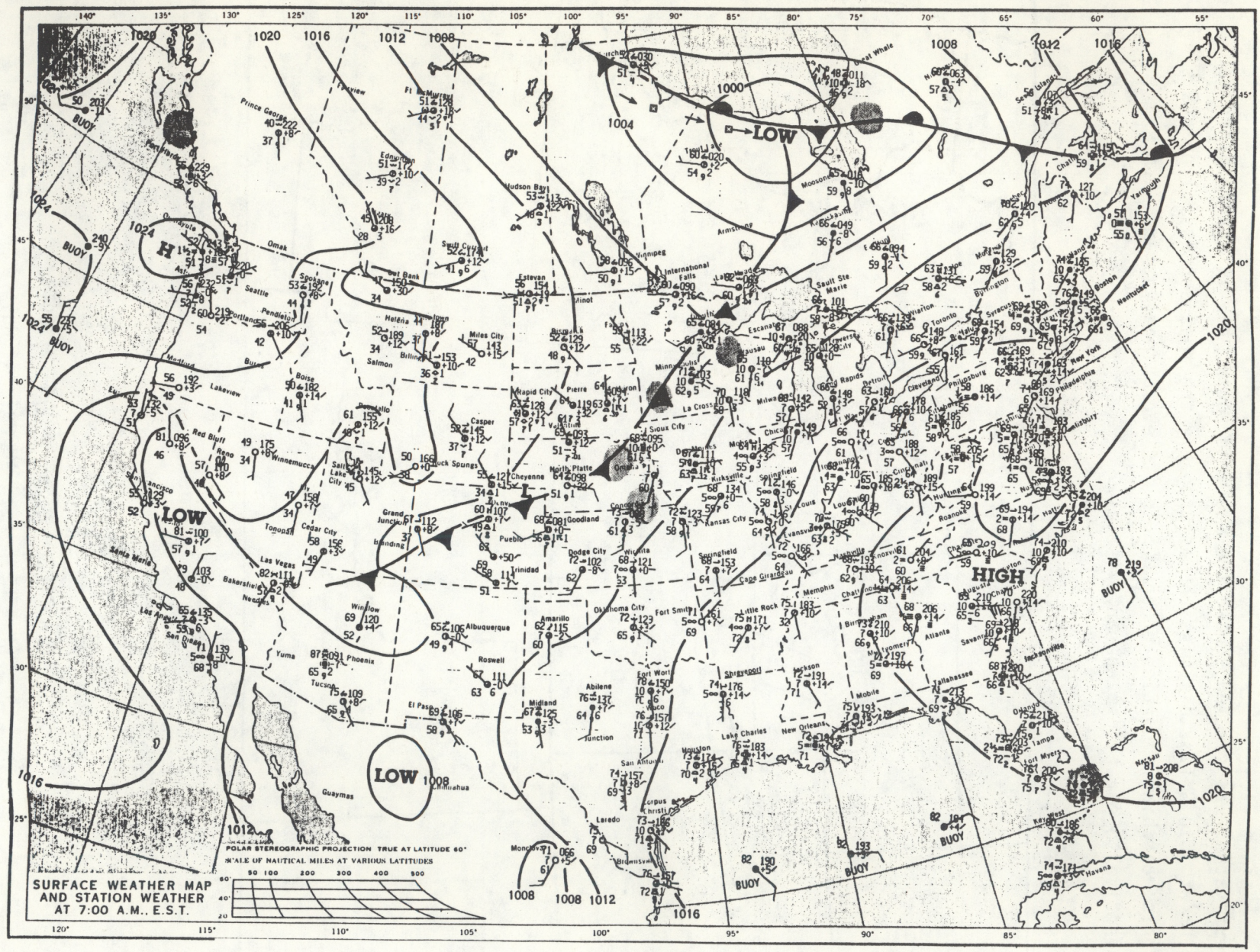


Fig. 15 NWS surface weather map for 1200 GMT, 3 July 1984.

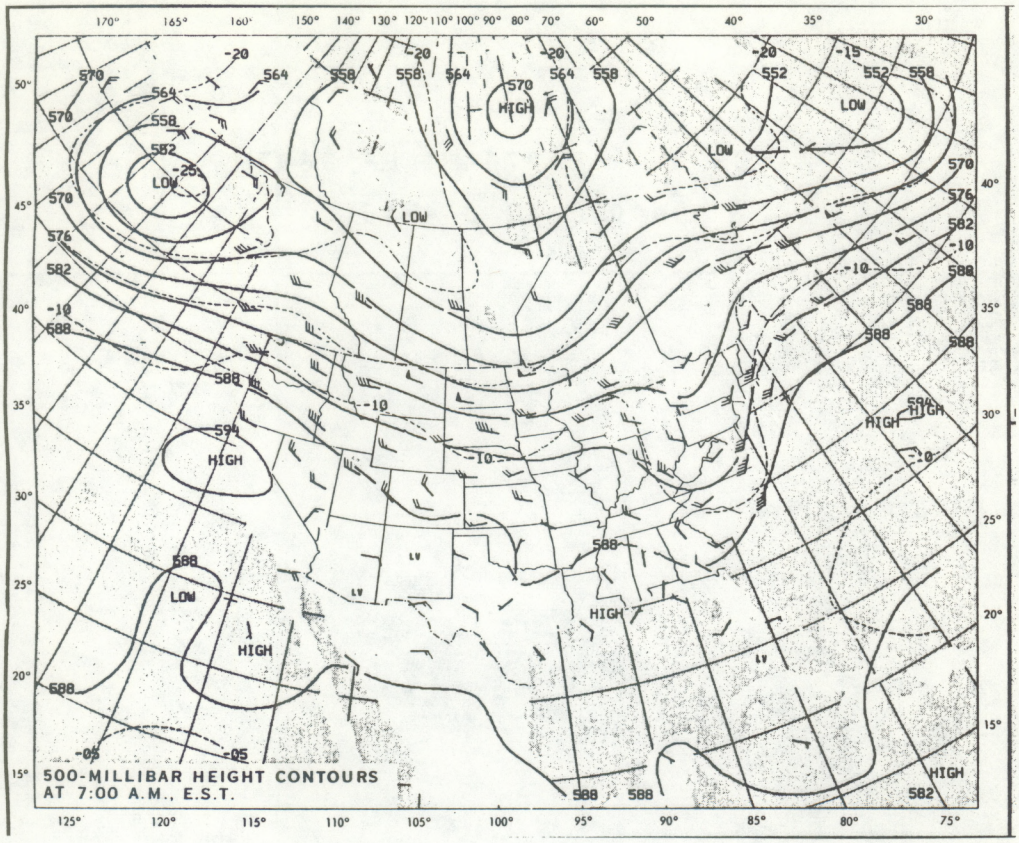


Fig. 16. NWS 500-mb chart for 1200 GMT, 3 July 1984.

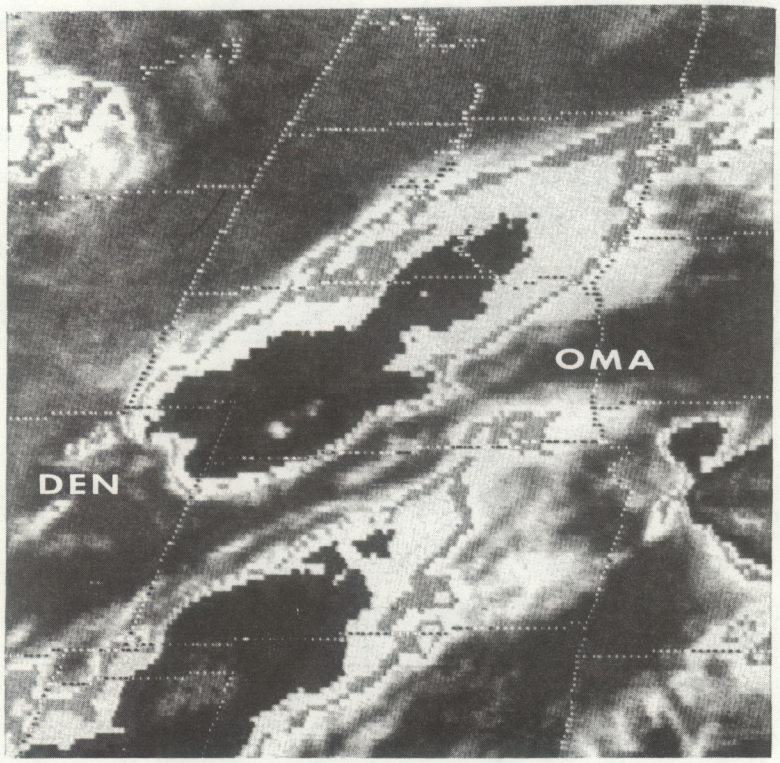


Fig. 17 Infrared satellite image (0430 GMT) of target system in Nebraska.

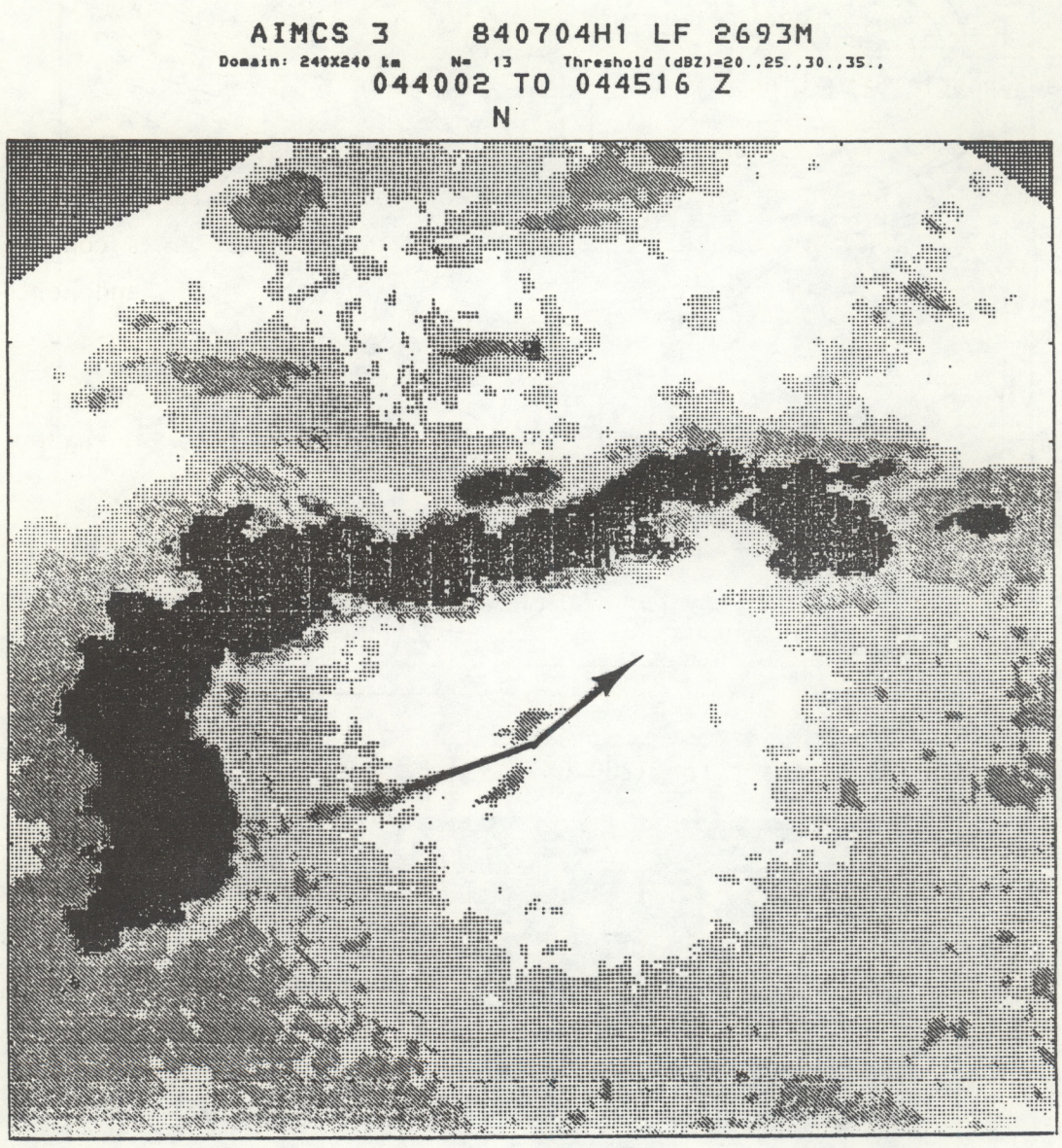


Fig. 18 Composite radar reflectivity map for Flight #3 in central Nebraska.

D. 7 July 1984

The Synoptic Situation:

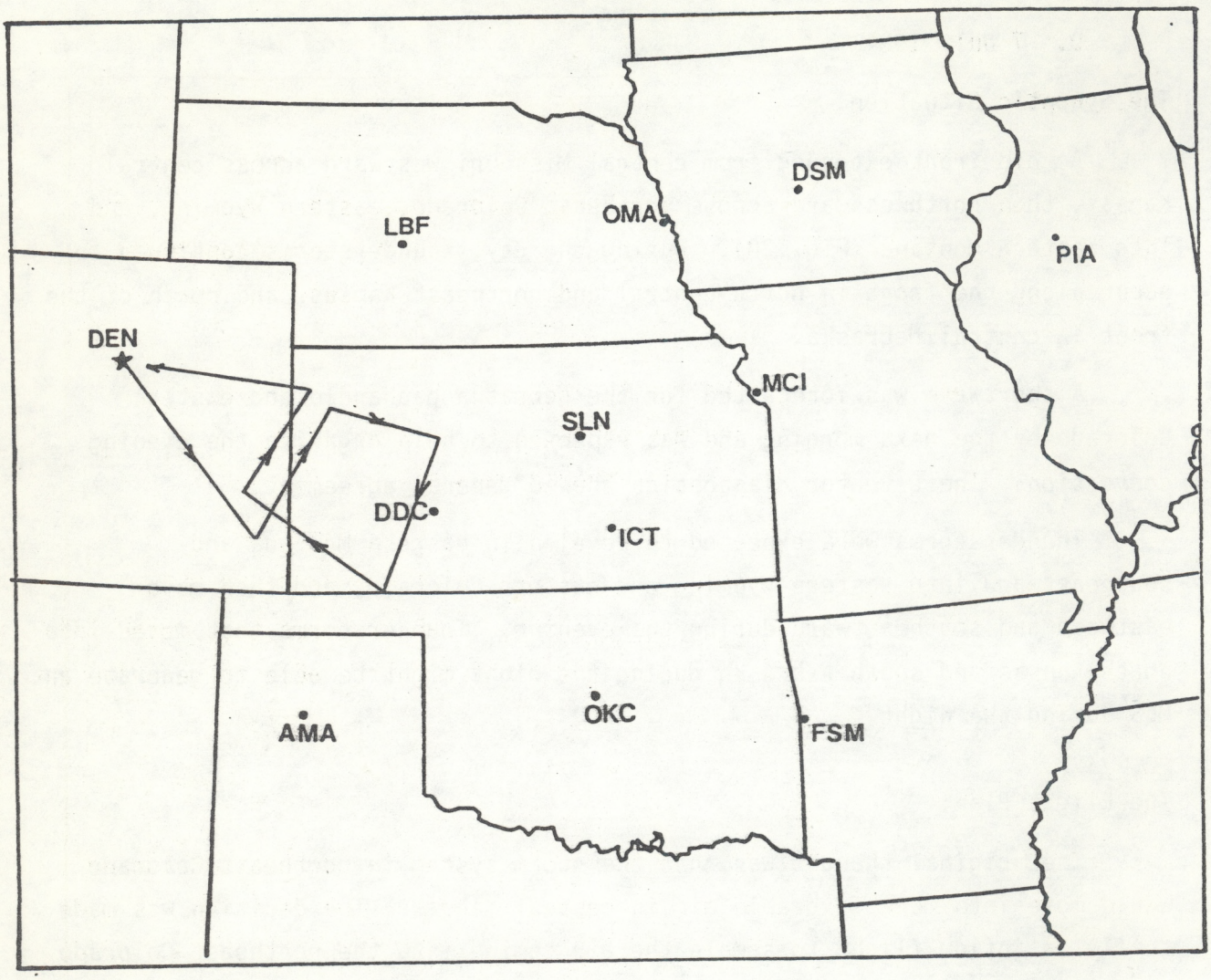
A cold front extended from central Missouri westward across central Kansas, then northwestward across northeast Colorado, eastern Wyoming, and into eastern Montana (Fig. 20). During the day, thunderstorms continued to occur along the front in north-central and northeast Kansas, and north of the front in central Nebraska.

A shortwave was forecasted for the Nebraska panhandle and eastern Colorado by the next morning and was expected to help organize the evening convection. The Q-vector diagnostics showed general agreement.

Thunderstorms were expected to develop in eastern Montana and southeastward into eastern Wyoming and eastern Colorado, and then move eastward and southeastward during the evening. Thunderstorms that moved into north Kansas and south Nebraska during the night might be able to generate an MCS during the night.

The Flight Plan:

The original thought was that the storm system in northeast Colorado would move into more favorable air in central Kansas. The decision was made to fly an inflow flight to sample the air coming into the northeast Colorado system (Fig. 22) until it expanded; however, the convection died out early with no MCS formation. The flight was canceled, and the aircraft returned to Denver. NBC Today Show personnel were on board to document the flight. They were disappointed that the flight was cut short, but did put together a nice video clip of the flight, with some emphasis on the difficulty of forecasting MCSs.



AIMCS Flight #4 7 July 1984

TAKE OFF TIME: 10:00 PM MDT 6 July

RETURN TIME: 1:30 AM MDT 7 July

Fig. 19 Flight pattern for Flight #4.

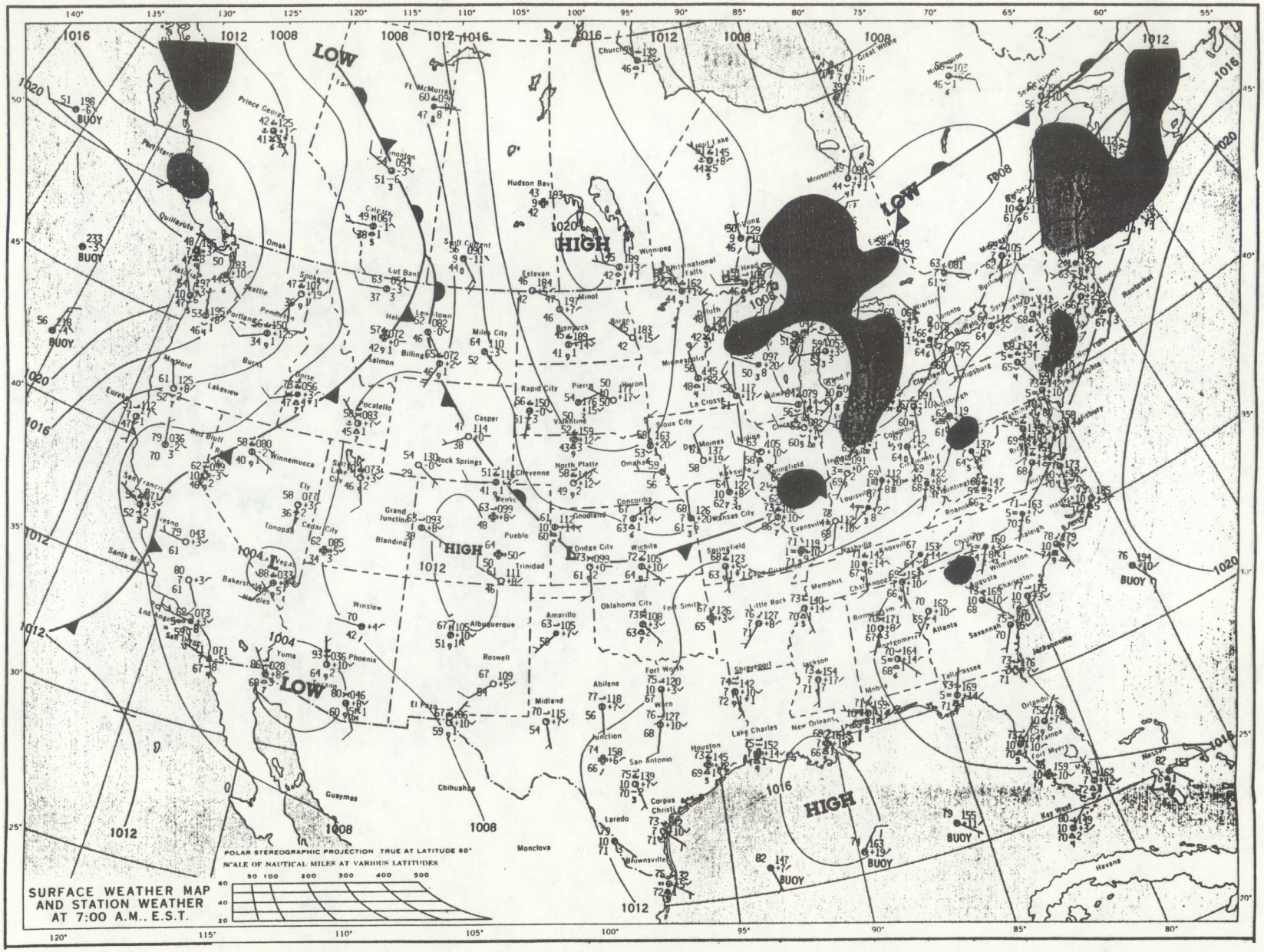


Fig. 20 NWS surface weather map for 1200 GMT, 6 July 1984.

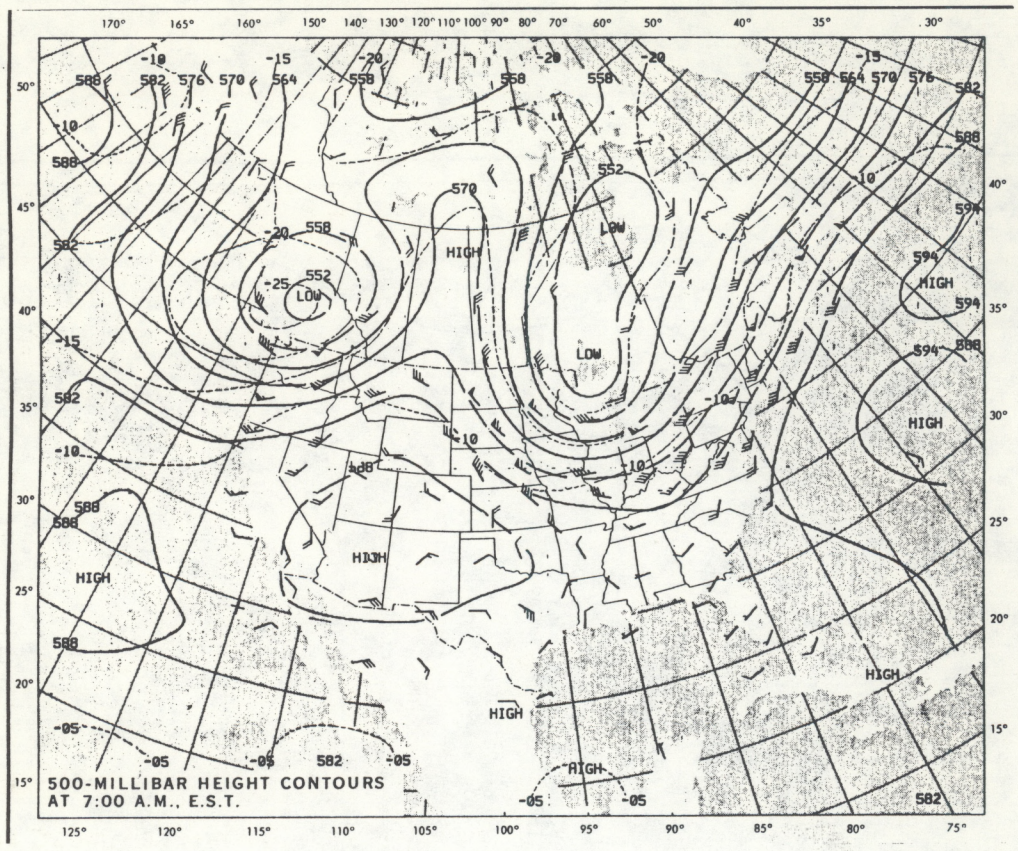


Fig. 21 NWS 500-mb chart for 1200 GMT, 6 July 1984.

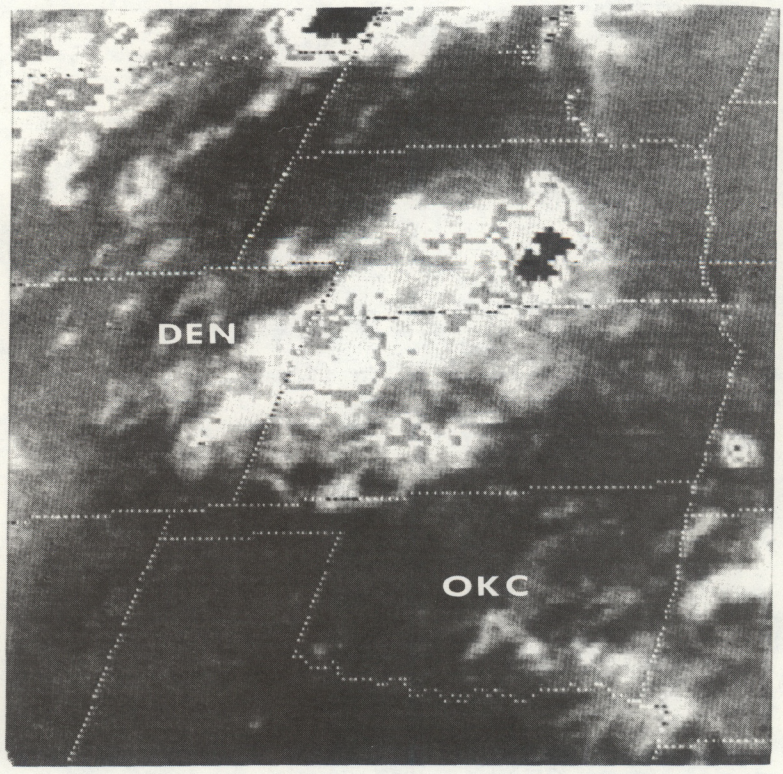


Fig. 22 Infrared satellite image (0730 GMT) for flight system in northwest Kansas.

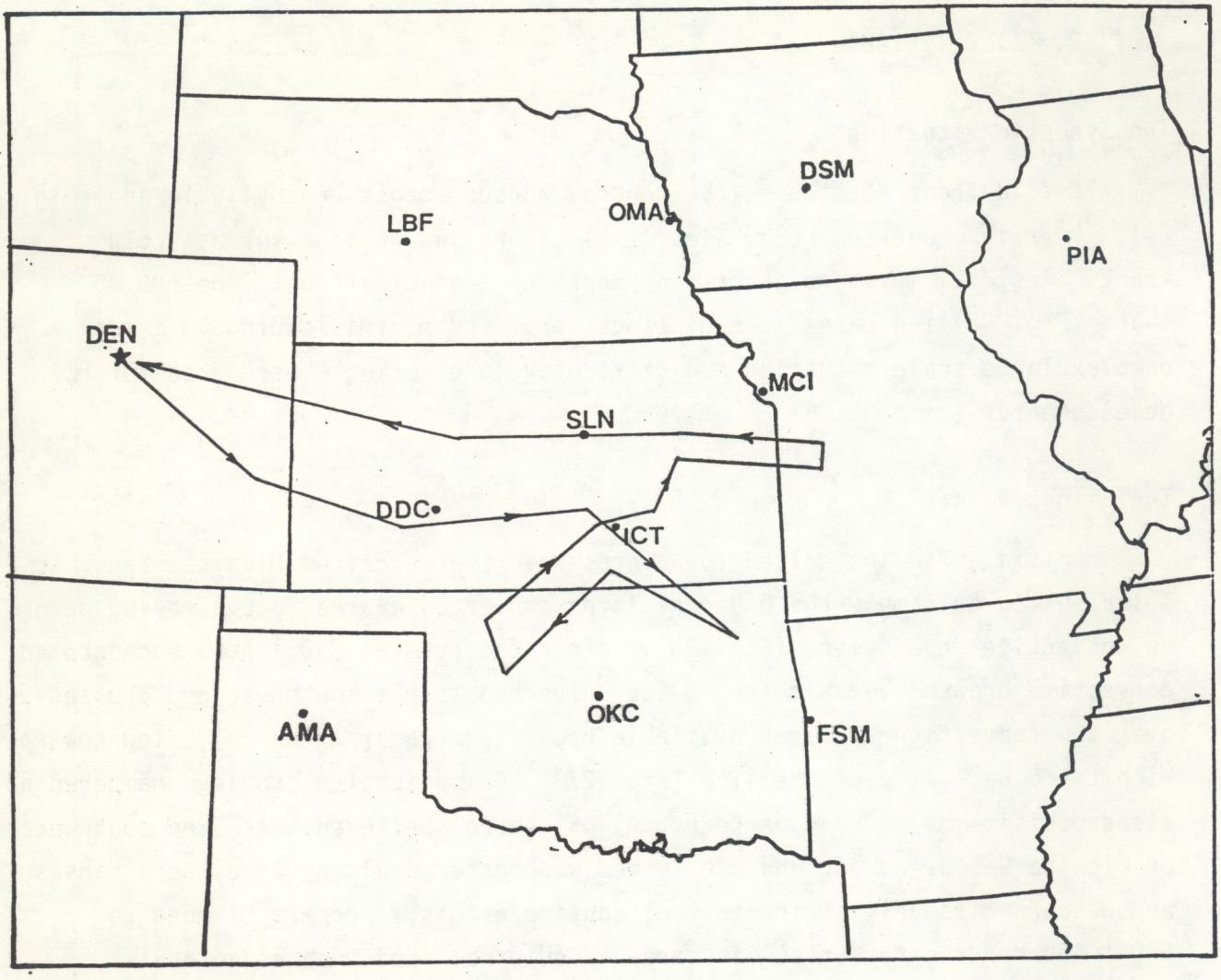
E. 11 July 1984

The Synoptic Situation:

A cold front stretches from central Kansas across central Colorado (Fig. 24). Overnight outflow boundaries linger south and west of surface cold front. Residual moisture is present north of synoptic front. The 500 mb chart (Fig. 25) indicates four distinct vorticity maxima leading to a very complex large scale situation and difficulty in choosing "best" area for MCS development.

The Flight Plan:

Initial briefing called for a cross-over pattern from Wichita, Kans. to Tulsa, Okla. to sample the boundary layer convergence area in the region prior to convective development (Fig. 23). After one pass at 3500' AGL, encountered convective growth over Wichita region, diverted to the southwest and crossed over the convection at first available break (a/c radar guidance), flew toward Wichita on back side of the line (Fig. 27). Communication problems hampered a clear decision as to next pattern. AIMCS control believed that line southwest of Wichita was dying out and the system was better evolving in eastern Kansas and western Missouri. Owing to fuel considerations, aircraft climbed to 8000' AGL heading to Kansas City area. Could not find much of an anvil structure; therefore climbed to 24000' AGL near Sedalia, Mo. and returned to Denver.



AIMCS Flight #5 11 July 1984

TAKE OFF TIME: 10:20 PM MDT 10 July

RETURN TIME: 4:30 AM MDT 11 July

Fig. 23 Flight pattern for Flight #5.

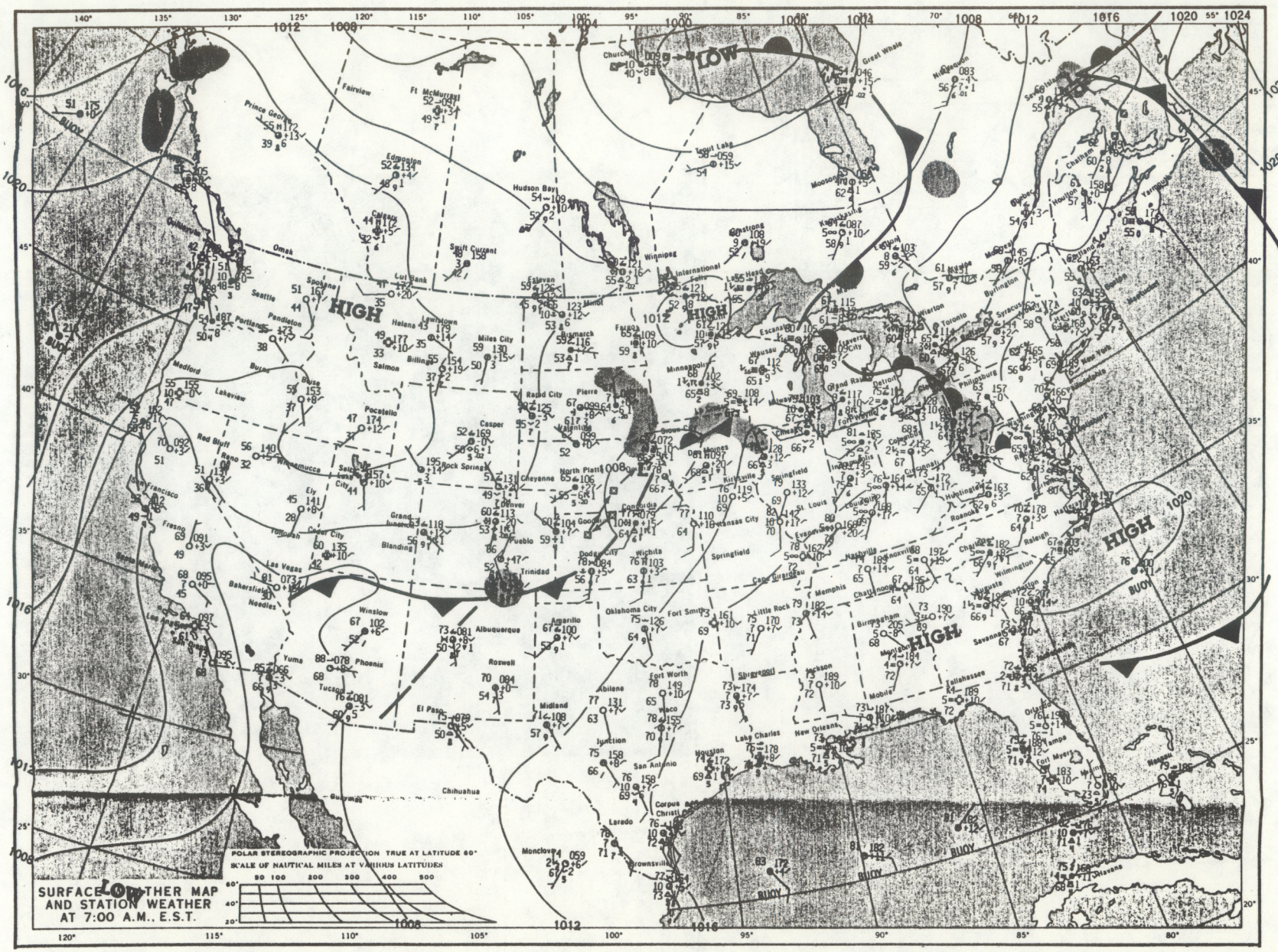


Fig. 24 NWS surface weather map for 1200 GMT, 10 July 1984

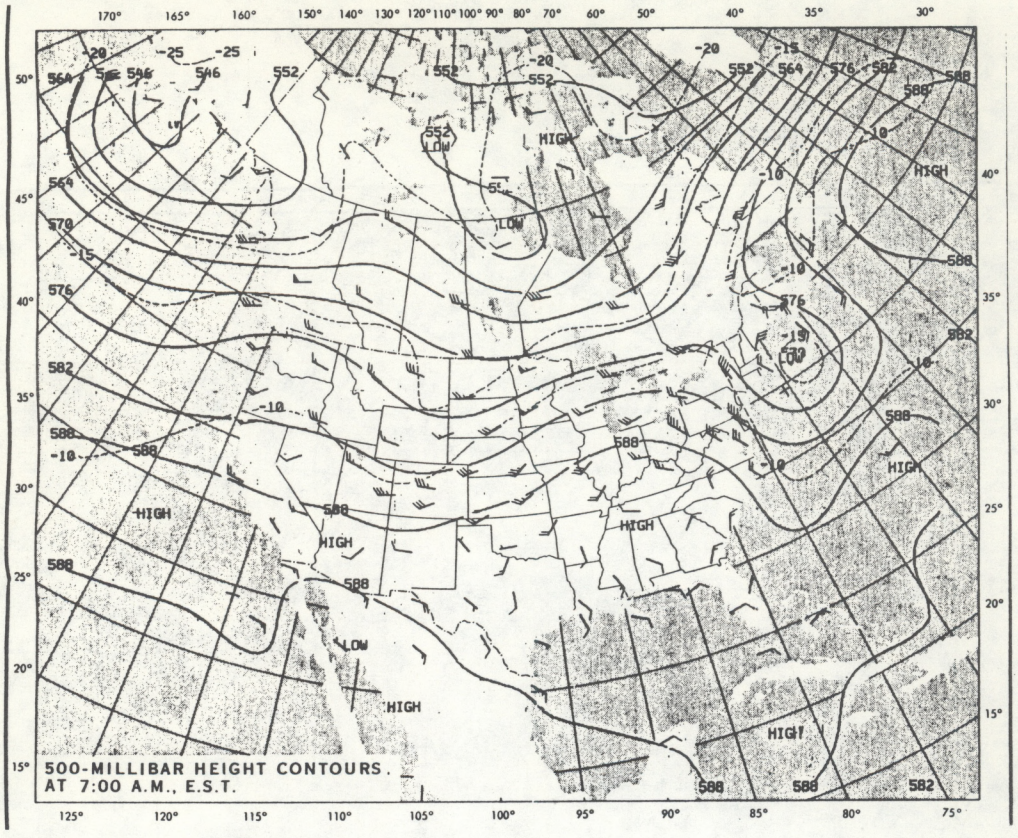


Fig. 25 NWS 500-mb chart for 1200 GMT, 10 July 1984.

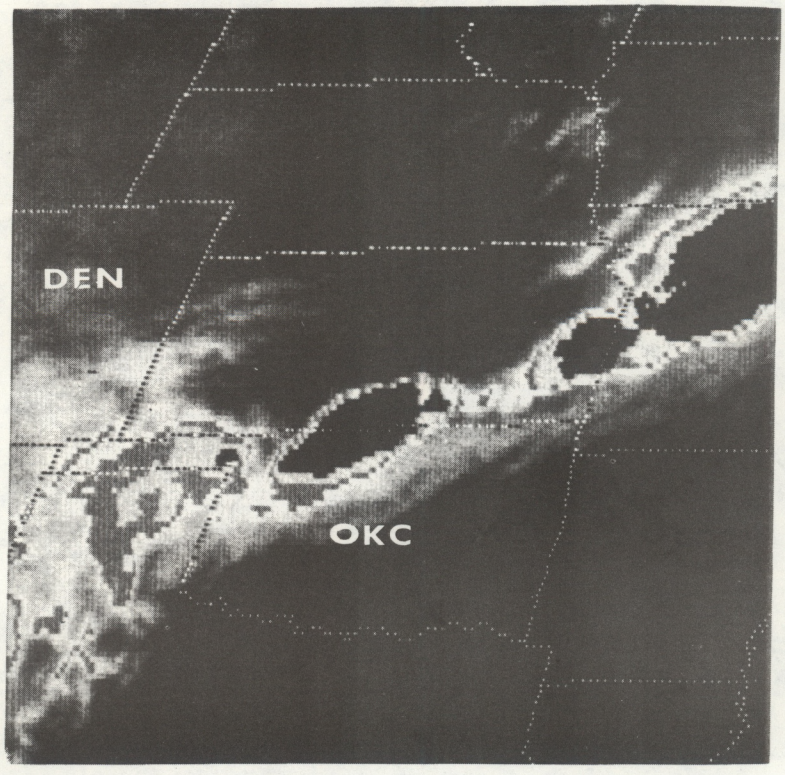


Fig. 26 Infrared satellite image (0630 GMT) of target system in south central Kansas.

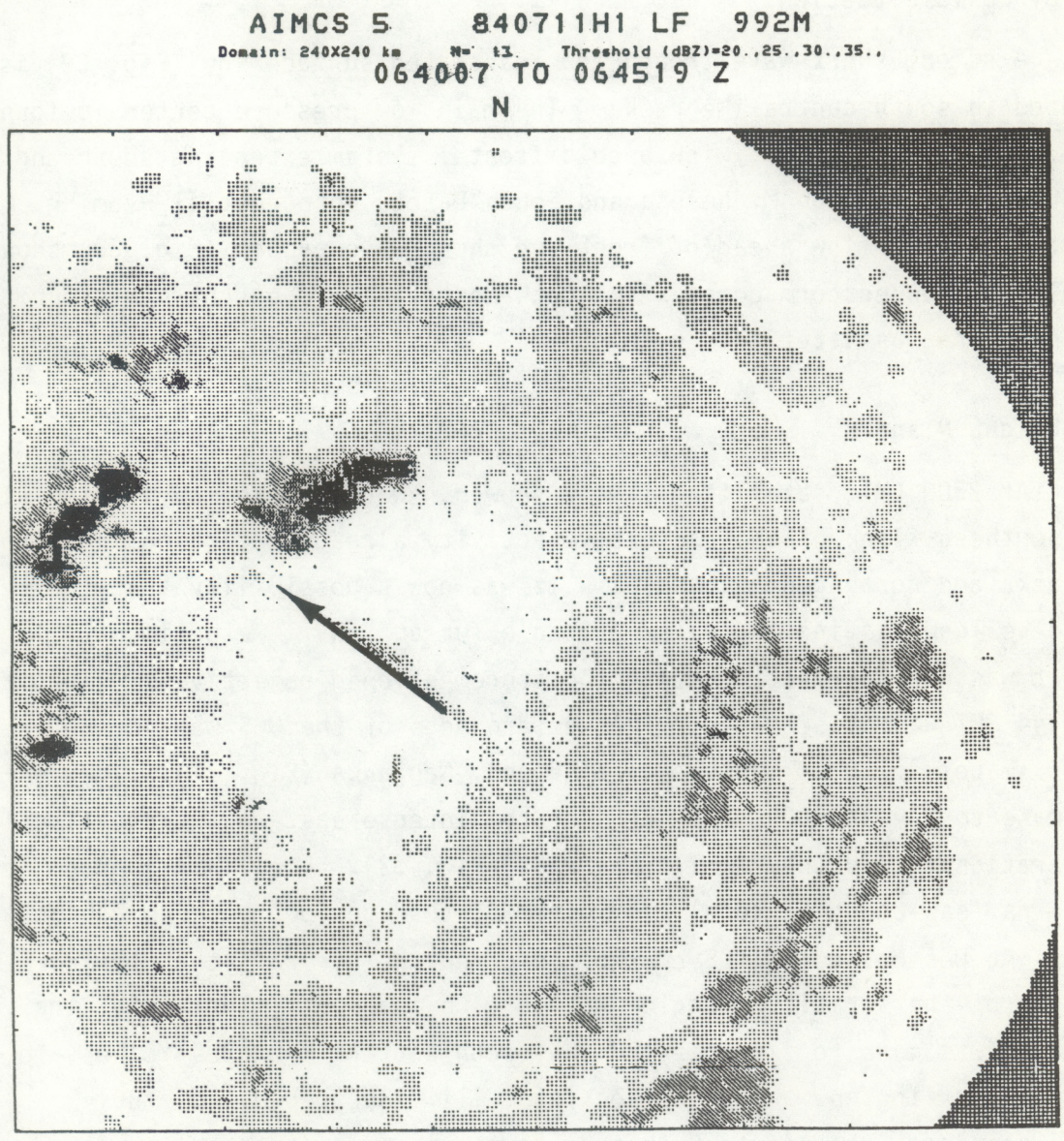


Fig. 27 Composite radar reflectivity map for Flight #5 in the vicinity of Wichita, Kans.

F. 15 July 1984

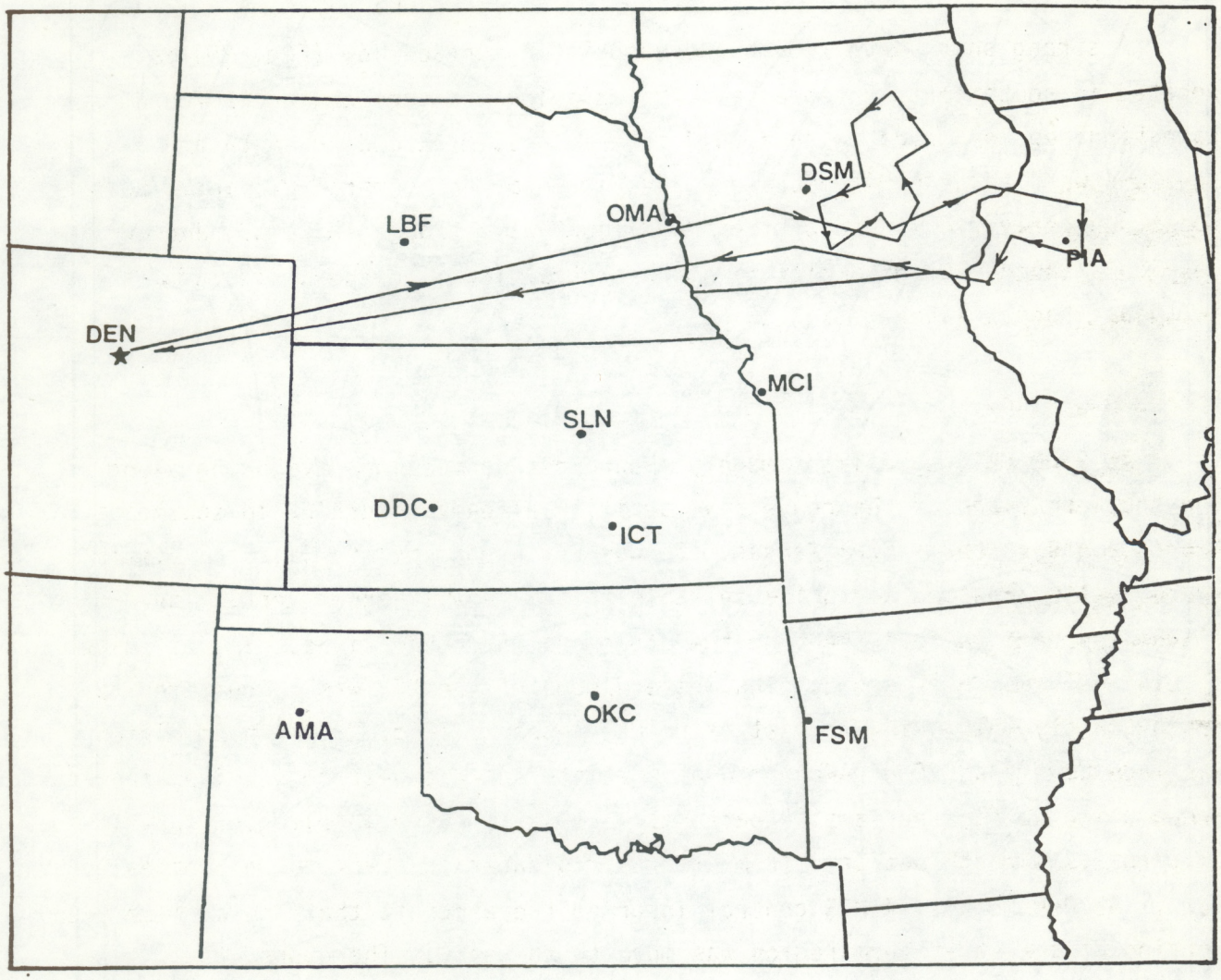
The Synoptic Situation:

A strong short-wave trough and associated surface low (Fig. 29) is located in south-central Nebraska. The main low pressure center is found near Lake Winnipeg in Canada, with a cold frontal system extending south and southwestward through Minnesota and South Dakota into central Wyoming. Warm moist southerly flow ahead of front and short-wave trough (Fig. 30) should develop a thunderstorm complex in south-central Iowa, northern Missouri, and northeast Kansas later this evening.

The Flight Plan:

At 2300 GMT, satellite imagery showed new convection developing along the southern flank of the convective activity already occurring in southeast Nebraska and north-central Kansas. It was now a possibility that the system would be long lasting and quite suitable for an "anvil" experiment. The flight was near perfect, meeting the aforementioned objectives. Takeoff time at 0144 GMT was on schedule. The western edge of the MCS was encountered at approximately 0310 GMT just east of Omaha, Nebraska (Fig. 28). The decision was made to fly at 9000' AGL north of the intense east-west convective line in preparation to fly the "anvil" patterns (Fig. 32). Flew fairly good "anvil" patterns (saw-tooth pattern) from Ottumwa, to Waterloo, back to Des Moines, Iowa. At Des Moines, AIMCS control informed the aircraft that the more mature portion of the stratiform region was more to the east. Therefore, the decision was made to fly a second saw-tooth pattern from Des Moines, to Ottumwa, Burlington, and on to Rockford, Ill. But because of fuel considerations, the leg to Rockford was terminated near Kewanee, Ill., and the aircraft returned to Burlington.

At Burlington, the aircraft climbed to 22000' for microphysics measurement as well as sounding data through the stratiform cloud. On the return flight to Denver, broke clear of clouds (at 22000') near Ottumwa, Iowa.



AIMCS Flight #6 15 July 1984

TAKE OFF TIME: 7:44 PM MDT 14 July

RETURN TIME: 2:35 AM MDT 15 July

Fig. 28 Flight pattern for Flight #6.

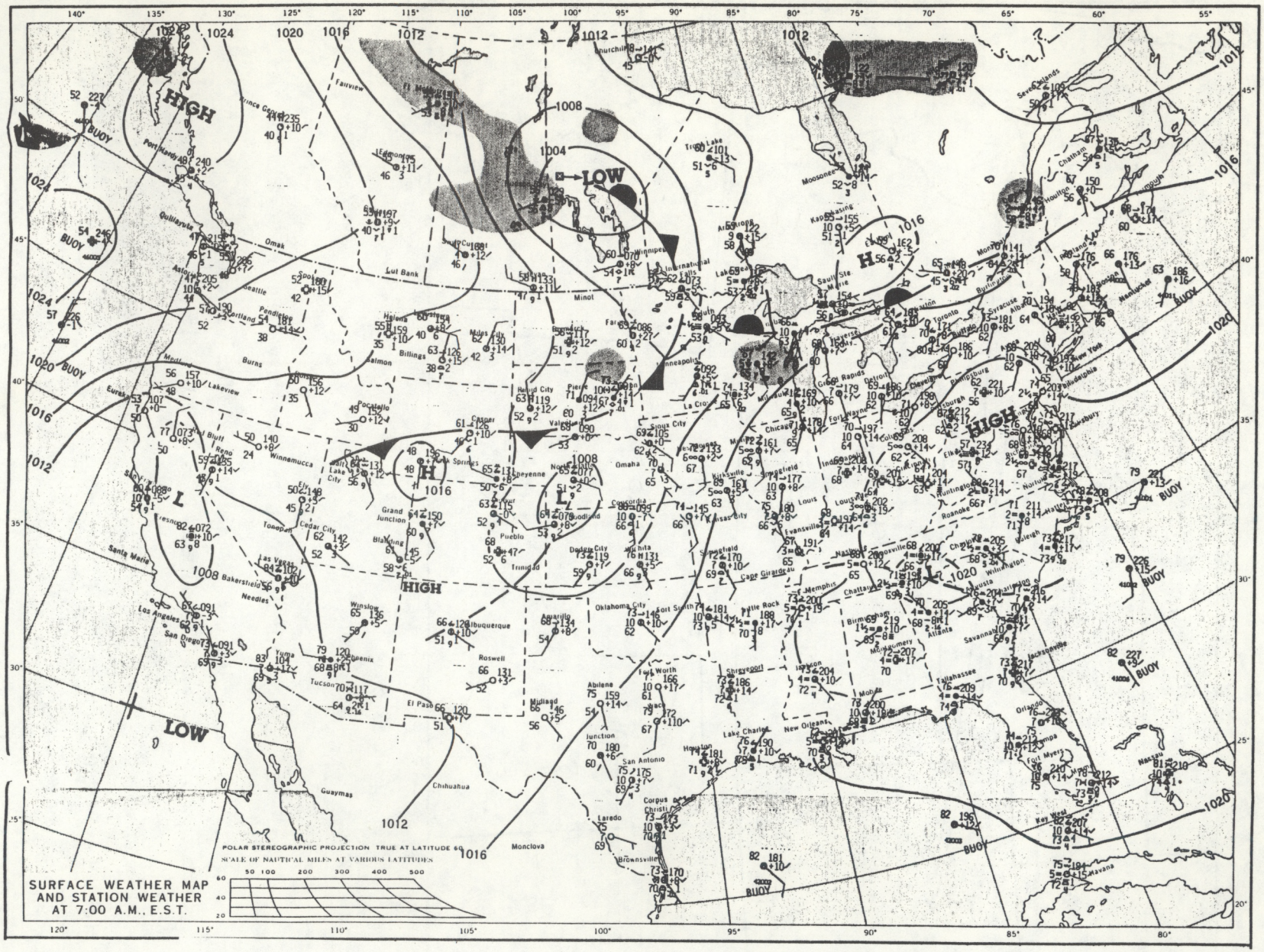


Fig. 29 NWS surface weather map for 1200 GMT, 15 July 1984.

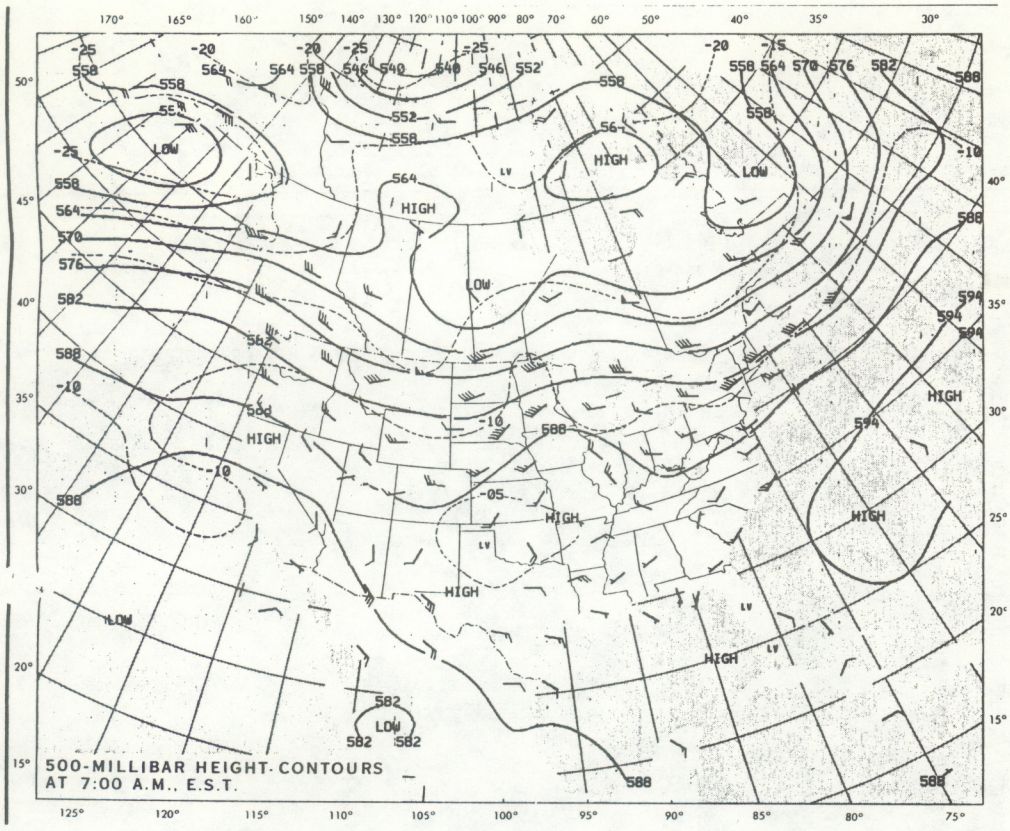


Fig. 30 NWS 500-mb chart for 1200 GMT, 14 July 1984.

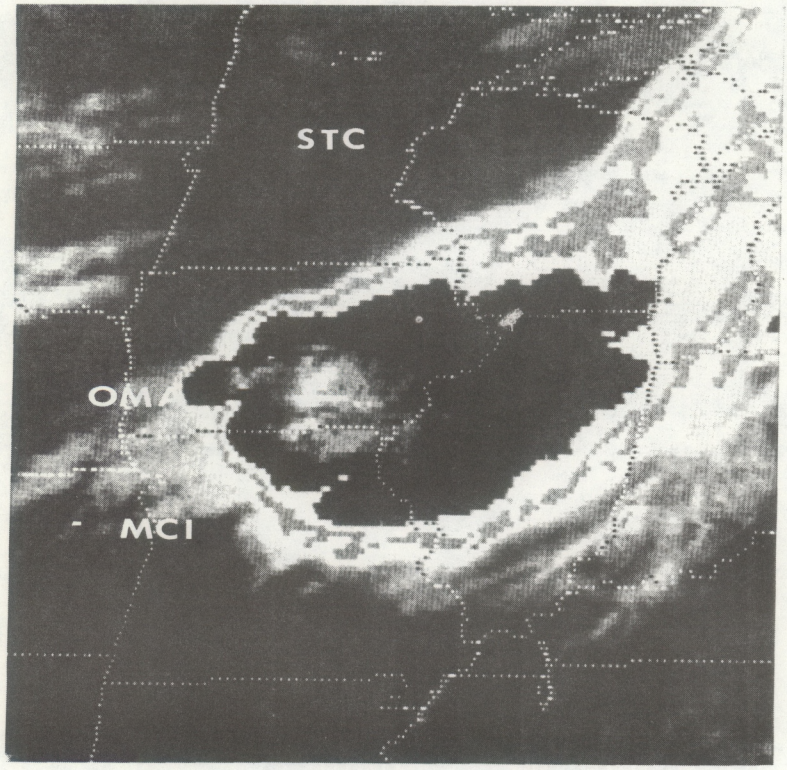


Fig. 31 Infrared satellite image (0300 GMT) of target system in central Iowa.

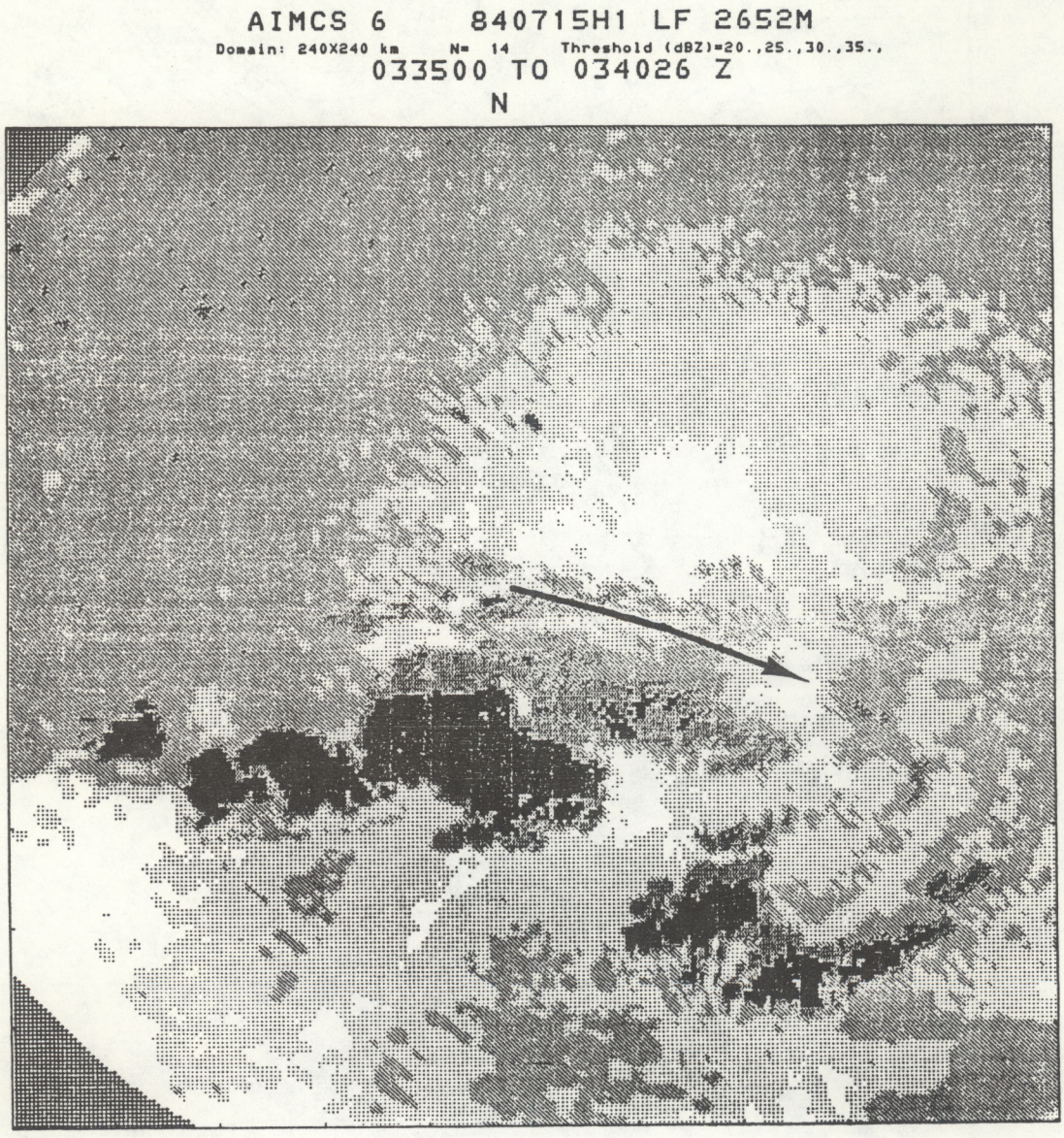
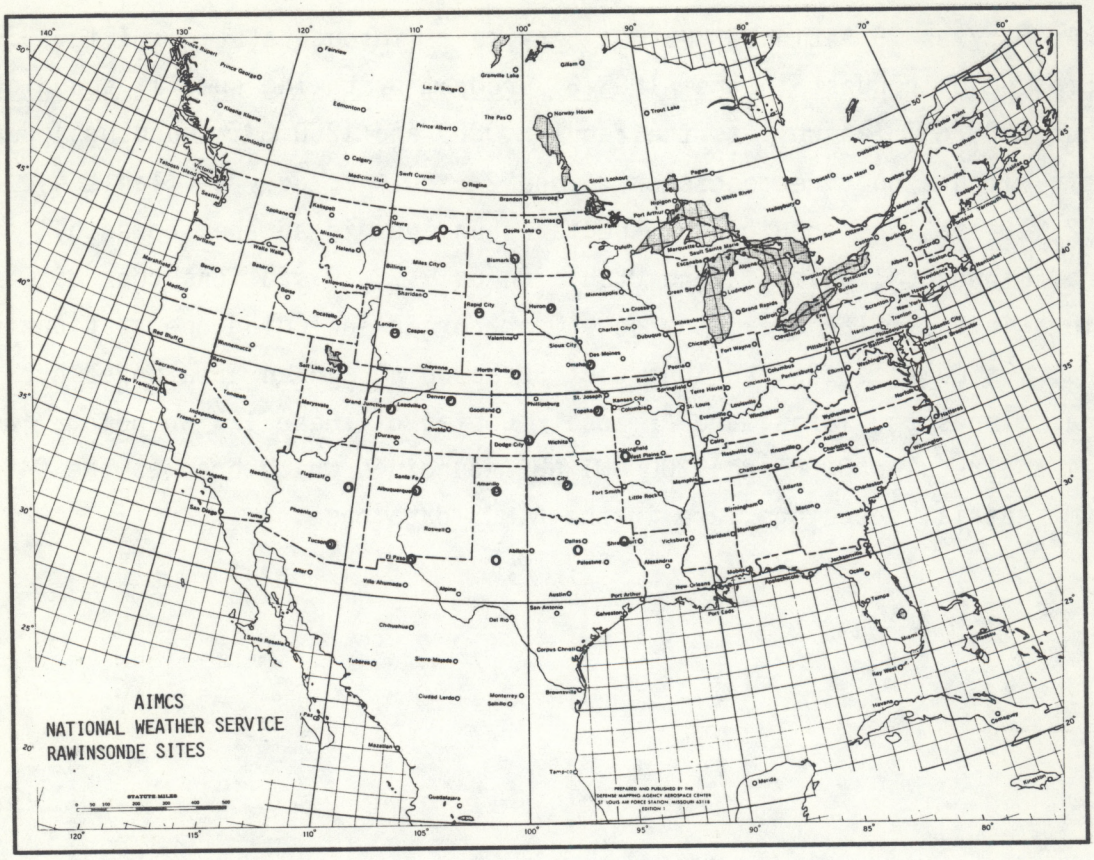


Fig. 32 Composite radar reflectivity map for Flight #6 near Des Moines, Iowa.

IV. AIMCS DATA SUMMARY

A. Special Upper Air Observations

As many as 25 National Weather Service rawinsonde stations (Fig. 33) participated on request in the AIMCS-84 program by taking special soundings at 0400 and 0800 GMT (as well as the regular 0000 and 1200 GMT soundings) during aircraft flights on three occasions: June 22; July 7; July 11 (Table 4). On June 22, 19 stations acquired 38 special soundings in an area boxed by Montana, Minnesota, Oklahoma and Utah. On July 7, 20 stations took 39 soundings in a similar area, the southwest corner including one station in Arizona. On July 11, 25 stations took 50 soundings in an area boxed by Montana, Minnesota, Texas, and Arizona. Copies of these 127 soundings, as well as the regular 0000 and 1200 GMT NWS soundings which bracket the 0400 and 0800 GMT special soundings, are in the AIMCS data base.



DEN	Denver, Colorado	GGW	Glasgow, Montana
GJT	Grand Junction, Colorado	GTF	Great Falls, Montana
TOP	Topeka, Kansas	ABQ	Albuquerque, New Mexico
DDC	Dodge City, Kansas	SLC	Salt Lake City, Utah
LBF	North Platte, Nebraska	OKC	Oklahoma City, Oklahoma
3NO	Omaha, Nebraska	AMA	Amarillo, Texas
LND	Lander, Wyoming	SEP	Stephenville, Texas
HON	Huron, South Dakota	GGG	Longview, Texas
RAP	Rapid City, South Dakota	ELP	El Paso, Texas
BIS	Bismark, North Dakota	MAF	Midland, Texas
INL	International Falls, Minnesota	TUS	Tucson, Arizona
STC	Saint Cloud, Minnesota	INW	Winslow, Arizona
		UMN	Monnett, Missouri

Fig. 33 National Weather Service offices participating in the AIMCS program

Table 4. Upper-air observations available for 0000, 0400, 0800, and 1200.

22 June	7 July	11 July	Station
✓	✓	✓	DEN
✓	✓	✓	GJT
✓	✓	✓	TOP
✓	✓	✓	LND
✓	✓	✓	LBF
✓	✓	✓	3NO
✓	✓	✓	HON
✓	✓	✓	RAP
✓	✓	✓	BIS
✓	✓	✓	INL
✓	✓	✓	STC
✓	✓	✓	SLC
✓	✓	✓	GGW
✓	✓*	✓	GTF
✓	✓	✓	DDC
✓	✓	✓	UMN
✓	✓	✓	ABQ
✓	✓	✓	OKC
✓	✓	✓	AMA
X	X	✓	ELP
X	X	✓	GGG
X	X	✓	MAF
X	X	✓	SEP
X	X	✓	TUS
X	✓	✓	INW

✓ : Upper-air observations are available.
X : Upper-air observations were not available.
✓*: No upper-air observations at 0800 GMT.

B. Special GOES Schedule C Data Collection

The nominal NESDIS operations schedules assigned to AIMCS (Schedule "C") for the GOES-East VAS data and the GOES-West imagery are shown in Tables 5 and 6. In Table 5 the information preceding the semicolon indicates the channels in which MSI data are taken for the first 15 minutes of the period. The information after the semicolon indicates the type of data taken in the second 15 minutes, namely, dwell soundings (DS), dwell images (DI), visible and thermal infrared imagery (Full Disc), or multi-spectral imagery in channels 3, 4, and 5 (3, 4, 5). Trilat refers to measurements for orbit determination. Times when the 6.7-μm moisture data were taken are noted by an asterisk in Table 5 and by WV in Table 6. In Table 6 it can be seen that the 5-min VIS and IR data are actually at 5-min intervals for only portions of selected hours.

Several satellite products were archived at Colorado State University. GOES-East multi-spectral imagery from three channels were archived every half hour starting at 1130 GMT on the experimental day and continuing through 1300 GMT on the following day. The three channels are the visible (0.5-0.7 μm) and two infrared channels: channel 7, the IR window (12.6 μm) and channel 10, the water vapor channel (6.7 μm). Dwell sounding data from GOES-East were archived for the times listed in Table 7. The VISSR on GOES-West was operated in a rapid scan mode. Thus, the visible and thermal IR imagery were collected at 15-minute intervals starting at 2000 GMT on the experimental day through 1400 GMT on the following day. During these hours, four 1-hour periods of 5-minute imagery were archived starting at 2000, 2200, 0400, and 0700 GMT. Since the VAS data-receiving capability at CSU was just completed the week before the data collection started, some minor data gaps may have occurred. A weak signal from the satellite also caused some data gaps.

The NESDIS Advanced Satellite Products Project at Madison, Wis., processed VAS retrievals on the six flight days. The retrievals for the area of 90°-150° W and 35°-45° N were archived at CSU/CIRA on an IBM PC micro-computer. They consist nominally of VAS-derived pressure, temperature, dew point, geopotential heights and winds for 60-125 cloud-free locations. With the exception of the winds, each parameter is computed for 12 to 14 pressure levels, namely, 100, 150, 200, 250, 300, 400, 500, 670, 700, 780, 850 and 920

mb, 1000 mb (if possible) and the surface. Wind speed and direction, when included are for a thermal wind at 850, 500 and 300 mb. In addition to retrievals, the brightness temperatures in each of the 12 VAS channels are archived. Table 8 is a list of retrievals available for the six days on which VAS data were collected.

Data tapes and data logs reside at Colorado State University, Department of Atmospheric Sciences Groundstation, Fort Collins, CO 80523. For further information, contact NESDIS/RAMM Branch personnel (J. Purdom, R. Green, J. Weaver, and R. Zehr) at 303-491-8446 or FTS 323-5285.

Table 5. GOES-East Transparent VAS Mode Operations, Schedule C

Time (GMT)	Activity (Channels; Type of data)
1000	3,4; 3,4,5
1030	7,10; DS(N)
1100	7,10; DS(S)
1130	10,7,12; DI(N)*
1200	7,10; Trilat (Full Disc)
1230	7,12; DI(N)
1300	7,10; DI(S)
1330	7,10; DS(N)
1400	7,10; DS(S)
1430	7,10; DI(N)
1500	7,10; DI(N)
1530	7,10; Synoptic (FD)
1600	7,10; DI(S)
1630	7,10; DS(N)
1700	7,10; DS(S)
1730	10,7,12; DI(N)
1800	7,10; Trilat (Full Disc)
1830	7,12; DI(N)
1900	7,10; DI(S)
1930	7,10; DS(N)
2000	7,10; DS(S)
2030	7,10; DI(N)
2100	7,10; Synoptic (Full Disc)
2130	7,10; 3,4,5
2200	3,4; 3,4,5
2230	7,10; DS(N)
2300	7,10; DS(S)
2330	10,7,12; DI(N)*
0000	7,10; Synoptic (Full Disc)
0030	7,12; DI(N)
0100	7,10; DI(S)

Table 5. (Continued)

Time (GMT)	Activity (Channels; Type of data)
0130	7,10; DS(N)
0200	7,10; DS(S)
0230	7,10; DI(N)
0300	7,10; (Full Disc)
0330	7,12; DI(N)
0400	7,10; DI(S)
0430	7,10; DS(N)
0500	7,10; DS(S)
0530	10,7,12*; DI(N)
0600	7,10; (Full Disc)
0630	7,12; DI(N)
0700	7,10; DI(S)
0730	7,10; DS(N)
0800	7,10; DS(S)
0830	7,10; DI(N)
0900	7,10; Synoptic (Full Disc)
0930	7,10; 3,4,5
1000	3,4; 3,4,5
1030	7,10; DS(N)
1100	7,10; DS(S)
1130	10,7,12*
1200	7,10; Synoptic (Full Disc)
1230	7,12; DI(N)
1300	7,10; DI(S)
1330	7,10; DS(N)
1400	7,10; DS(S)
1430	7,10; Transition
1500	

DI - Dwell Image
DS - Dwell Sound
(N) - North
(S) - South
*VISSR S/DB - Moisture Channel Support

Table 6. GOES-West RRSD, Schedule C

Time (GMT)	# Lines	Time (GMT)	# Lines	Time (GMT)	# Lines
1945	1200	0115	1200	0715	1200
1959	450	0130	1200	0729	450
2004	450	0145	1200	0734	450
2009	450	0200	1200	0739	450
2015	1200	0215	1200	0745	1200
2029	450	0230	1200	0800	1200
2034	450	0245	1200	0815	1200
2039	450	0300	1200	0830	1200
2045	1200	0315	1200	0845	1200
2100	1200	0330	1200	0900	1200
2115	Full Disc	0345	Full Disc	0915	1200
2145	1200	0415	1200	0930	1200
2159	450	0429	450	0945	1200
2204	450	0434	450	1000	1200
2209	450	0439	450	1015	Full Disc
2215	1200	0445	1200	1045	1200
2229	450	0459	450	1100	1200
2234	450	0504	450	1115	1200 (W.V.)
2239	450	0509	450	1130	1200
2245	1200	0515	1200 (W.V.)	1145	1200
2300	1200	0530	1200	1200	1200
2315	1200 (W.V.)	0545	1200	1215	1200
2330	1200	0600	1200	1230	1200
2345	1200	0615	1200	1245	Full Disc
0000	1200	0630	1200	1315	1200
0015	1200	0645	1200	1345	1200
0030	1200	0659	450	1400	1200
0045	Full Disc	0704	450	1415	Full Disc
		0709	450		

W.V. - Water Vapor

Table 7. Colorado State University data collection schedule of dwell sounding data from GOES-East

1030 GMT	0030 GMT (next day)
1100 GMT	0100 GMT
1230 GMT	0130 GMT
1300 GMT	0200 GMT
1330 GMT	0300 GMT
1400 GMT	0430 GMT
1630 GMT	0500 GMT
1700 GMT	0630 GMT
1930 GMT	0700 GMT
2000 GMT	0730 GMT
2300 GMT	0800 GMT
	0830 GMT

Table 8. Times of VAS retrievals

21-22 June 84	03 July 84	06-07 July 84
1118 GMT	1118 GMT	1118 GMT
1318 GMT	1348 GMT	1418 GMT
1418 GMT	1718 GMT	1718 GMT
1718 GMT		2019 GMT
1948 GMT		2318 GMT
2318 GMT		0218 GMT
0118 GMT		0518 GMT
0218 GMT		
0418 GMT		
0518 GMT		
1448 GMT		

10-11 July 84	12-13 July 84	14-15 July 84
1118 GMT	1118 GMT	1048 GMT
1418 GMT	1318 GMT	1148 GMT
1718 GMT	1418 GMT	1418 GMT
2018 GMT	1718 GMT	1718 GMT
2318 GMT	2018 GMT	2018 GMT
0218 GMT	2318 GMT	2318 GMT
0518 GMT	0218 GMT	0218 GMT
0748 GMT	0518 GMT	0518 GMT
1118 GMT	1118 GMT	0818 GMT
		1118 GMT
		1418 GMT

C. Profiler Data

Table 9 is an inventory of wind data from the four operating experimental sites during the AIMCS-84 period. Only the Denver-Stapleton and Platteville sites were in near-continuous operation during AIMCS-84. The operation of the other two sites was sporadic for a variety of reasons. Wind data for the times listed in Table 9 have been received from WPL and are currently being checked and soon will be analyzed. The only radiometric data that have been ordered are the Denver integrated water vapor and liquid water; however, the other radiometer data are available from WPL upon request.

Table 9. Profiler wind data during AIMCS

	Denver Stapleton	Lay Creek	Platteville	Cahone	Fleming
June 18	✓	X	✓	✓	X
19	✓	X	✓	✓	X
20	✓	X	✓	✓	✓
21	✓	X	✓	✓	✓
22	✓	X	✓	✓	✓
23	✓	X	✓	✓	✓
24	✓	X	✓	X	✓
25	✓	X	✓	X	✓
26	✓	X	✓	✓	✓
27	✓	X	✓	✓	✓
28	✓	X	✓	✓	✓
29	✓	X	✓	✓	✓
30	✓	X	✓	✓	✓
July 1	✓	X	✓	✓	X
2	✓	X	✓	✓	X
3	✓	X	✓	✓	X
4	✓	X	✓	X	X
5	✓	X	✓	✓	✓
6	✓	X	✓	✓	✓
7	✓	X	✓	✓	✓
8	✓	X	✓	✓	✓
9	✓	X	✓	X	X
10	✓	X	✓	X	X
11	✓	X	✓	X	X
12	✓	X	✓	X	X
13	✓	X	✓	X	X
14	✓	X	✓	X	X
15	✓	X	✓	X	X
16	✓	X	✓	X	X
17	✓	X	✓	X	X
18	✓	X	✓	X	X

X: not available

D. Cloud Physics and Chemistry Data

The samples collected by the cloud and precipitation water samplers are summarized in Table 10. The PMS probes used were the 2DC and 2DP. The data from these probes were recorded on tape whenever the aircraft was near or in the clouds under investigation. Table 11 summarizes the data collected. The data tapes are in the hands of Dr. Joe Boatman (NOAA/AOD) for final reduction and have been transcribed to 2400-ft tapes. The water collectors could not be used simultaneously because only one sampler port was available. A precipitation scoop was used whenever precipitation was encountered (both rain and snow), and the cloud water collector was used whenever the aircraft was in cloud for at least 10 minutes. The cloud water collector could be cooled with liquid nitrogen to collect cloud droplets by impaction when temperatures were above freezing, or used directly when ambient temperatures were well below freezing.

Few samples were collected, and little water was obtained in each sample. This was a result of the primary goals of the missions, to fly near the storm and obtain a radar map of the storm wind fields and structure. Thus little time was actually spent in clouds or under them where precipitation was occurring. The best samples were collected below and in the anvil region. The samples are awaiting analysis at the U.S. Geological Survey Denver Center Laboratory. Future studies of this kind can be fruitful with better collection techniques and flight time dedicated to water collection.

Table 10. Summary of samples collected by the cloud and precipitation water samplers

Date	AIMCS Flight #	Sample ID	Sample Description
22 June	1	None	No water collected
29 June	2	Bot-1	25 ml precip 07000-07500
		Bot-2	Approx. 10 ml 0750-0830 precip clear ice
		CW-1	1 ml 0845-0915
4 July	3	Bot-1	Snow 0355-0725
		Bot-2	40 ml rain 0800-0900
		Bot-3	No sample 0900-1010
7 July	4	None	No water collected
11 July	5	Bot-2	Anvil collection by precip scoop
		Bot-A	Rinse water of scoop
15 July	6	Bot-1	8 ml 0318-0601

Table 11. Summary of PMS 2DC and 2DP probe data collected

Flight #	Start Time (GMT)	End Time (GMT)
1	0427	0913
2	0647	1000
3	0359	0702
	0702	0933
4	0414	0625
5	0556	0930
6	0315	0658

E. Ground-Based Radar Film

The National Weather Service routinely generates 16-mm films of the PPI displays at network radar sites. The interval between pictures is usually 5 minutes except during periods of severe weather when the interval becomes 1 minute. Figure 34 is a catalog of the NWS radar sites and film archive obtained from NOAA/NTIS by the WRP staff. Selection of the films archived was based on the occurrence of mesoscale convective systems in which NOAA P-3 flight operations were conducted and were within range of the NWS radar.

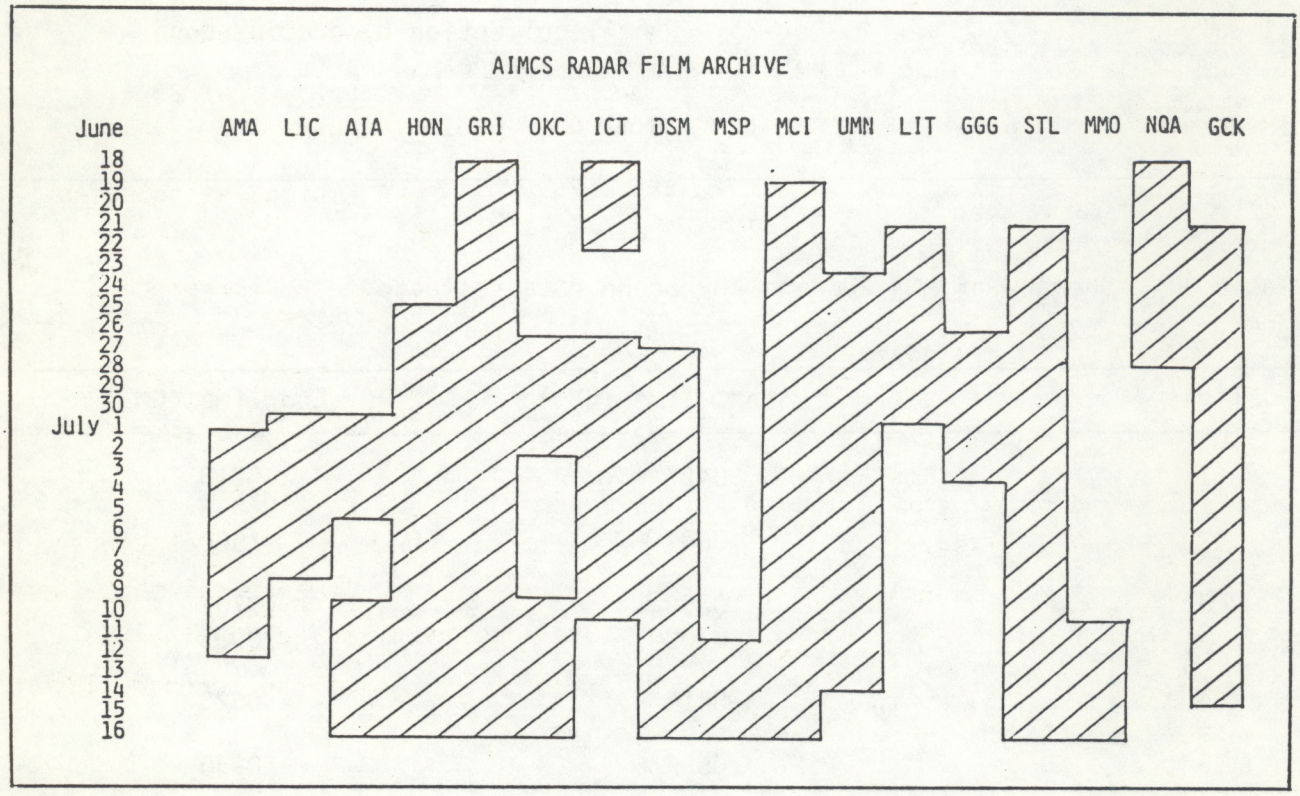


Fig. 34 Summary of radar film collected (shading) during AIMCS program.

V. PLANS

The field research phase of AIMCS will continue during FY-85. WRP has been granted 200 flight hours and both NOAA P-3 aircraft for a major research effort during May and June of 1985. It is intended that this unique data base collected from both the 1984 and 1985 field programs be considered one complete data set for the research studies outlined in the objectives.

A dense network of surface, upper air, and radar observations will be located in Oklahoma and Kansas during the 1985 field phase. Aircraft operations will be based at Oklahoma City. The research effort will focus on a limited set of objectives. Two main activities have been identified for next spring's program:

a) Investigate the development, evolution, and structure of MCSs.

b) Evaluate new sensing systems and develop observational strategies.

The development and evolution of an MCS is a highly complex process involving many scales of motion. The 1985 program will enable researchers to investigate certain physical processes that will yield insights about how an MCS develops and interacts with the environment.

New sensing systems have been developed over the past several years, such as wind profilers and airborne Doppler radar. However, most of these sensors have not been tested in an MCS environment. It is critical that these sensors be field tested and evaluated prior to STORM-Central. Various strategies for measuring fields such as surface properties and boundary layer characteristics combining all sensors will also be evaluated.

APPENDIX I

DAILY CHRONOLOGY

20 June 1984

Situation at 1200 GMT

Weak front lying east-west across northern Kansas and continuing through eastern Wyoming and Montana. Very unstable air (Totals ~ 56 in eastern Montana), focusing low-level jet, abundant moisture, including warm-air advection in Dakotas and eastern Montana.

Evening Forecast

Very unstable air, abundant moisture and weak forcing all come together this evening over Dakotas. LFM forecasting wave too fast. Stratus and fog currently over North Dakota keeping east-west boundary strong.

Action

None.

Extended Outlook

LFM too fast. Eastward shift of tropical clouds and cool air over the plains will allow instability in the vicinity of low-level jet to build up. Hotter temperatures in central Plains should let MCS action zone shift southeastward tomorrow evening.

Action

Rapid scan satellite data requested.

Alert for rawinsonde soundings.

21 June 1984

Situation at 1200 GMT

Boundary across east-central Kansas extending into low pressure center in North Dakota. Advancing cold front extends through Wyoming into southern Nevada. Low-level jet focusing on boundary in eastern Kansas. Twenty-five knots maximum at 850 mb with good thermal advection ahead of cold front in Dakotas. Southwest flow over boundaries from Kansas to North Dakota. Weak short-wave through Dakotas down into south-central Nebraska.

Evening Forecast

MCS formation along Kansas/Nebraska border.

Action

GO for aircraft flight.

Soundings scheduled for north and central plains.

Extended Forecast

Cold front moving into central Plains.

Post-Experiment Analysis

AIMCS Flight #1 flew meso-β scale MCS from near Salina, Kans., southeastward to Missouri state line. System did not develop into meso-α proportions, possibly because of low-level diffluence over area at 850 mb at 22/0000 GMT. However, there were reports of hail and minor flash flooding. System in Dakotas did develop into a meso-α scale MCS active system as it moved across the northern Plains.

22 June 1984

Situation at 1200 GMT

Frontal system moving across northern Plains from the eastern Dakotas southward through northern Colorado. Moist tongue from west-central Texas to Dakotas with strongest warm-air advection in the eastern Dakotas and Minnesota. Unstable air is reflected in the Totals-index from west Kansas to North Dakota.

Evening Forecast

Cold front passing through Plains today with pre-frontal activity likely especially central Kansas north-northeastward to Minnesota.

Action

Aircraft down after Flight #1.

Extended Outlook

Cool, stable air will dominate central/northern Plains tomorrow. Front will become E-W stationary in Oklahoma/Texas Panhandle by late tomorrow with some improvement in moisture and convergence. Overall, the area will probably be lacking in instability and dynamics for a large system.

Action

None.

23 June 1984

Situation at 1200 GMT

Frontal system extends from Duluth, Minn., southward through central Kansas into Oklahoma Panhandle. High pressure is centered in Montana. Moisture extends northward through the Texas Panhandle and Colorado and then eastward across Kansas. Warm advection occurs across the Texas Panhandle and into northeast Oklahoma. Totals-indices are greater than 50 from Amarillo, Tex., to North Platte, Nebr.

Evening Forecast

Minor threat for MCS development over Oklahoma/Texas Panhandle and adjacent areas of southwest Kansas, southeast Colorado, and northeast New Mexico. Moist ENE flow going upslope in the area behind slow-moving cold front. Expect zone of convection along and to rear of front with small β clusters. Stronger storms outside of flight range over southeast Oklahoma and southern Missouri.

Action

None.

Extended Outlook

Return flow of low-level moisture into eastern Colorado with increased chances of convection. Warm advection at low levels setting in over central Plains, but needs time to bring back low-level moisture.

Action

None.

24 June 1984

Situation at 1200 GMT

Frontal system extends across lower Mississippi Valley westward across central Texas into New Mexico, then curving northward into Colorado to central Montana. The high pressure center is located on the Kansas/Nebraska border with return flow and weak tongue of moisture extending into southeast Colorado. Highest Totals index is 50 near front at Dallas, Tex. Right-rear quadrant of upper-level jet is over southeast Colorado.

Evening Forecast

Thunderstorms developing in southeast Colorado associated with moist tongue, return flow on backside of high, and right-rear quadrant of jet. Not likely to organize into α-scale system. System will move east into stable air, decreasing likelihood of a long-lived convective system.

Action

None.

Extended Outlook

Cold high over Plains will move east. Moisture should recover into central Plains later on Monday (25 June). LFM sends vigorous short-wave trough through Colorado into Kansas by tomorrow night. Warm advection improving in central Plains. Activity will occur in eastern Kansas with a slight chance of MCS development.

Action

None.

25 June 1984

Situation at 1200 GMT

High pressure center located in northwest Arkansas with weak return flow and narrow moist tongue extending into northeast Kansas. 850-mb flow is somewhat diffluent in eastern Kansas countering 25-kn jet in the Texas Panhandle and southwest Kansas. A boundary from last night's showers and thunderstorm activity over eastern Nebraska and Iowa has moved southward to

central Missouri and northern Kansas. In northern Kansas the boundary lies under right-rear entrance region of upper-level jet.

Evening Forecast

LFM forecast products show weak short-wave trough on Colorado/Kansas border tonight moving southeastward with time. Thunderstorms developing in northern Kansas spreading slowly southeastward tonight. Weak low-level flow, weak thermal advection and weak PVA suggest little development at surface with forcing probably too weak for α-scale system.

Action

Flight crews held for possible flight until approximately 0130 GMT.

Post-Experiment Analysis

Several small β-systems over Oklahoma and Kansas merged into α-system at 0400 GMT maintaining itself through 26/1500 GMT.

Extended Outlook

Weak short-wave trough moving southeastward into Oklahoma but low-level flow looks weak and overrunning configuration is questionable. Zone of thunderstorms likely to continue movement into northeast Oklahoma, northwest Arkansas, southeast Kansas, and southwest Missouri. Convection not likely to organize into β- or α-systems.

Action

None.

26 June 1984

Situation at 1200 GMT

Meso-β system over Oklahoma with boundary from central Arkansas, through northern Texas into Texas Panhandle. Moist air returning along western boundary of β system into southwest Oklahoma and Texas Panhandle. Possible 700-mb cutoff low over Texas Panhandle, and weak cold air advection in eastern New Mexico. Cold front extending from Minnesota west-southwestward through South Dakota.

Evening Forecast

Moist air returning along western boundary of old meso-β system into southwest Oklahoma and Texas Panhandle. Trough at 700 mb in southeast Colorado, northern New Mexico expected to move southeastward into Panhandle area. New convection likely to develop in Texas Panhandle and move southward with cells moving toward the east southeast. Meso-β system possibly forming in southwest Oklahoma, southern Texas Panhandle, Texas southern Plains.

Thunderstorms likely to develop along front over Iowa and eastern Nebraska and move southeast into northeast Kansas and Missouri. Depending on how far west this line develops, there may be a possibility for a meso-β zone in this vicinity, but action will be fast-moving with a tendency for linearity.

Action

Flight crews held for possible flight until approximately 0315 GMT.

Post-Experiment Analysis

Neither area actually got organized. Greatest action occurred between Fort Worth and Austin, Texas.

Extended Forecast

Forecast products indicate easterly flow with moisture extending into eastern New Mexico and west Texas by tomorrow morning. Low-level flow is weak however. Weak PVA into region will produce thunderstorm activity over mountains and high plains of New Mexico. Cold front moving eastward beyond range of aircraft by tomorrow. Forecast products suggest weak PVA moving through the western ridge along with available moisture will support thunderstorm activity over southeast Wyoming, Nebraska Panhandle southward into eastern Colorado. Flow is weak and not likely to support an organized system.

Action

None.

27 June 1984

Situation at 1200 GMT

Northwesterly flow over the Plains at middle and upper levels with a front extending from the Great Lakes into southern Nebraska/northern Kansas. Weak outflow boundaries from recent convection across southern Missouri/Kansas and northern Louisiana. Low-level flow ahead of front is weak and chaotic, partly as a result of a pre-frontal system (especially prominent at 700 mb) in southern Oklahoma. Very unstable at DDC (60 Totals, -8 LI, 47 K-index), AMA, SEP.

Evening Forecast

Weak low-level forcing precludes chances of intense mesosystem unless one develops a strong outflow thereby providing its own low-level relative inflow. Areas to watch are southwest Kansas, Oklahoma, and Texas.

Action

Aircrew held on alert status until 0100 GMT.

Extended Forecast

Basic situation is not good and getting worse. The surface boundary is likely to push southeastward well ahead of short-wave trough at 500 mb forecasted to move into Kansas by tomorrow morning. Thus, the good instability is not likely to line up well with the good upper level dynamics. Low-level flow/forcing is likely to remain weak or unfavorable through period.

Action

None.

28 June 1984

Situation at 1200 GMT

Best feature is short-wave trough in Dakotas, with the thermal ridge ahead of disturbance creating instabilities (Totals > 50 along axis DDC-HON). There is a possible mesolow in southeast Nebraska with associated surface boundaries, which will force early activity in central Kansas. Barnes Q-vector output suggests upward vertical velocity in northwest Kansas, with

axis of dry destabilization along MSP-GRI-ICT axis. Dew point axis at 850 mb is greater than 8°C through central Kansas into eastern South Dakota.

Evening Forecast

LFM shows slow progression of short-wave trough across unstable air during evening. This may help increase southerly flow, and the air over Oklahoma is really juicy. The short wave, as it moves southeastward, will be setting up low-level boundaries in Kansas, which should offer the chance for more organized convection. A problem is the possibility of linear, rather than elliptical convection.

Action

Aircrew held on alert status.

Post-Experiment Analysis

AIMCS Flight #2.

Extended Outlook

Short-wave trough should push moisture and instability too far south. Further, the advancing major wave to the west is pushing up the ridge ahead of it, reducing the threat of any embedded short-wave troughs affecting the area of interest. Thus, we should be dynamically and thermodynamically shut down.

Action

None.

29 June 1984

Situation at 1200 GMT

With the passage of yesterday's significant short-wave trough through the northwesterly flow, the airmass over the northern and central Plains has stabilized substantially. Totals have fallen back to values <50. The southern Plains remain quite unstable; with AMA and OKC are still well above 50 Totals. Surface boundary in the vicinity of the Red River will probably light up today. The major system entering the west coast remains ill-defined, but the ridging ahead of it is proceeding as expected, with high mid-tropospheric temperatures extending well into Canada. Some residual moisture remains in spite of the decreases in lapse rate, with a moist tongue just

ahead of the thermal ridge at 850 mb into the central Dakotas and beyond. The low-level flow is southerly, with moderate speeds (~ 20 kn) along the moist tongue, but still weak northerly flow at 700 mb.

Evening Forecast

Thunderstorms a possibility in southern Plains into Texas Panhandle.

Action

Down day after Flight #2.

Extended Forecast

The advancing system to the west shows much potential for the weekend. The problem with a tomorrow "go" is that (a) there are indications that the LFM may be too fast with the surface system and (b) the likely high risk area is along the driving cold front pushing through the Dakotas (a better situation for squall lines). If, as we suspect, the major wave will be slower and have more energy in its base than forecast, the chances for an E-W boundary nearby with strong, moist low-level flow into it are quite good, starting on Sunday (1 July) and perhaps continuing for a few days.

Action

None.

30 June 1984

Situation at 1200 GMT

Situation developing more or less as expected. With massive ridge ahead of major wave, instability is currently weak, with Totals in the low- to mid-40's throughout the Plains. LFM agrees that major drive behind front will be north of here.

Evening Forecast

The front will be most active in eastern Montana and the Dakotas gradually pushing into central Colorado overnight. There remains some chance of convection tonight, but weak instability and absence of 850-mb thermal advection indicates little chance for long-lived intense system. Any convection that develops may actually help for tomorrow providing some focusing boundaries. Major problems for tomorrow's forecast are tied to

actual short-wave trough evolution (as opposed to predicted). Instability is a weak point, unless it develops by tonight.

Action

Down day in preparation for flight tomorrow.

Extended Outlook

LFM forecast products (24- and 36-h) in basic agreement with yesterday's discussion. It looks as if the front will be laid out quasistationary across northwestern Kansas and central Colorado, or slightly south of that position. LFM is showing some weak short-wave troughs that may influence the area.

Action

Alert for special soundings.

Rapid scan satellite data requested.

1 July 1984

Situation at 1200 GMT

The worst fears of yesterday have been realized! We have lost our instability and there is no sign of any mechanism to get it back. The cool air at 500 mb upstream has disappeared; therefore, we are working with -7°C 500-mb temperature and that's not good enough. The surface front is orientated northeast-southwest across Kansas and Nebraska.

Evening Forecast

There will be convection, especially south of Denver, but it is unlikely to develop the desired MCS structure.

Action

Canceled alert for special rawinsondes in central plains.

Extended Outlook

Reestablishment of strong ridge over southwest, with strong flow over the top across Pacific Northwest, precludes any real threat of important systems for a couple of days. Pattern has conspired to remove instability, and it will take at least a day or so to reestablish an unstable thermodynamic

situation.

Action

None.

2 July 1984

Situation at 1200 GMT

Short-wave trough moving southeastward across Kansas-Oklahoma-New Mexico is expected to continue southeastward today. Cold front moving across Dakotas today with strong 110 kn jet maximum over extreme northwest United States.

Evening Forecast

Thunderstorm activity expected to intensify in west Texas and Big Bend Country and move slowly into southern Texas tonight. Meso-β MCS is likely with this activity but slipping out of flight operations area. Pool of moisture over Dakotas will allow thunderstorms to develop in late afternoon from northwest Minnesota to south-central South Dakota. Zone of thunderstorms moving southward tonight across eastern Nebraska and western Iowa into east and central Kansas by morning. Other isolated thunderstorms likely to develop along edge of hot air over southwest Nebraska and northwest Kansas. Weak low pressure expected to develop in southeast Colorado, southwest Kansas, Texas Panhandle area by morning, with best chance for MCS structure over east and central Kansas, southeast Nebraska, and extreme western Missouri late tonight and early tomorrow.

Action

Crew held for alert until 0200 GMT.

Extended Outlook

Short-wave trough moving southeastward away from operations area during the day. Next vorticity maximum will be moving into Oregon-Idaho area tomorrow night. Thunderstorm activity is likely to develop in eastern Kansas across Oklahoma into northeast New Mexico. Meso-β scale system likely but decreasing dynamics make large system improbable.

Action

None.

3 July 1984

Situation at 1200 GMT

Thunderstorm activity moved southward across eastern Nebraska and western Iowa into northeast and north-central Kansas by early this morning. Airmass is more unstable today as moisture has increased over eastern Kansas and western Missouri. There is a frontal system in western Wisconsin southward through central Iowa into northern Colorado. A short-wave trough in western Montana is moving eastward.

Evening Forecast

Weak 1008-mb low is forecast to be over Kansas by evening with a nearly stationary front from southeast Nebraska to northwest Kansas. Moisture spreading westward into Nebraska Panhandle is expected to produce thunderstorms from the Black Hills southward into northeast Colorado, with other thunderstorm activity redeveloping along old squall line in north-central and northeast Kansas. Best chance for MCS development appears to be with the convective activity from southwest South Dakota to northeast Colorado as it moves east-southeastward into zone of thunderstorm activity developing along frontal boundary. Location of mature MCS would be southeast Nebraska, northwest Missouri, and eastern Kansas.

Action

Crew alerted for possible take-off at 0100 GMT. Flight #3 actually flew meso-α MCS in extreme northeast Colorado, northern Kansas, and much of Nebraska.

Extended Outlook

Short-wave trough leaving operations area. Next short-wave trough is too far west to affect operations area as yet. Forecast products show weakening with time of surface low over central Plains and strength of low-level flow. Very few ingredients to organize activity tomorrow. Looking better for Thursday (5 July).

Action

None.

4 July 1984

Situation at 1200 GMT

Thunderstorm activity moved east-southeastward across southern Nebraska as a meso-β system while another larger meso-β system developed in northern Missouri and remained nearly stationary. The Nebraska system eventually merged with the Missouri system during the early morning before dissipating. Morning data suggest that a strong jetlet north of the convective area was strongly enhanced by the activity.

Evening Forecast

Thunderstorms a possibility in central Plains.

Action

Down day after Flight #3.

Extended Outlook

Between short-wave troughs tomorrow with good thermodynamics pushed to southern Plains. No up motion forecasted and low-level flow extremely weak. Southerly flow just beginning to strengthen in Dakotas near end of period.

Action

None.

5 July 1984

Situation at 1200 GMT

Little change noted in large-scale circulation. Moisture has started to return northward over Texas Panhandle and western Kansas which produced a few thunderstorms over central Nebraska and western Kansas this morning. Low-level moisture expected to reach east-west frontal system in northern Iowa-Nebraska-South Dakota border by afternoon with a few thunderstorms developing and moving southeast.

Evening Forecasts

Meso-β system likely in eastern Nebraska and western Iowa.

Action

Down day with great expectations for tomorrow night.

Extended Outlook

Low pressure forming Chadron/Rapid City area tomorrow evening with strong thickness advection from south-central Nebraska northward. Short-wave trough moving into western Dakotas, western Nebraska, and eastern Colorado tomorrow night. Reasonably good chance for zone of thunderstorms to develop tomorrow afternoon and evening from eastern Colorado northward across western Dakotas moving eastward and merging with frontal thunderstorms in northern Nebraska and southern South Dakota, with possible MCS development in central and eastern Nebraska northward into South Dakota.

Action

Rapid-scan satellite data requested.

Alert all special rawinsondes stations.

6 July 1984

Situation at 1200 GMT

Cold front has spread southward during the night and is located from central Missouri westward across Kansas through northeast Colorado northward into eastern Wyoming and eastern Montana. Thunderstorms continue to occur along front in north-central and northeast Kansas and north of front in central Nebraska. A slow moving cold front extends from central Montana southwestward to northern Nevada. Airmass shows LI of -6 over a wide area of Kansas and Oklahoma.

Evening Forecast

Forecast products sounding for north-central Kansas show LI of -10 by evening. A short-wave trough over Utah/Nevada area this morning is predicted to be in Nebraska Panhandle/eastern Colorado by tomorrow morning and should help organize convection tonight. Diagnostics (Q-vector) point to destabilization and up motion over western Nebraska and northwest Kansas.

Thunderstorms expected to develop in eastern Montana southward into eastern Wyoming and eastern Colorado and move east and southeast during the evening. Thunderstorms are also expected to reintensify along and to the rear of the frontal zone in northern Kansas and southern Nebraska, with zone

remaining nearly stationary. Thunderstorms moving southeastward into this stationary zone of storms could generate MCS tonight.

Action

Rawinsondes in north and central plains reconfirmed for special soundings tonight. Aircrew alerted for takeoff at 0300 GMT (Flight #4).

Extended Outlook

Low pressure center will move northeast into eastern North Dakota in 48 hours with thermal advection retreating northward with the low. No evidence of any significant short-wave troughs behind the one moving out.

Action

None.

7 July 1984

Situation at 1200 GMT

Weakening cold front in the northern Plains with a pronounced but very shallow warm front in western Kansas, western Nebraska into eastern Montana.

Evening Forecast

Weak short-wave trough moves out over Plains, but stability very marginal for MCS development.

Action

Down day after Flight #4.

Extended Forecast

Front will be orientated east-west along the Dakotas border. A weak short-wave trough in northern flow and a disturbance moving up out of the subtropics are forecasted to merge in central Montana. Best area for long-lived nocturnal activity will be in eastern Montana and North Dakota. Secondary area will be in the lower Missouri Basin eastward along northwest portion of old warm front.

Action

None.

8 July 1984

Situation at 1200 GMT

Currently the cold front is located in northwest South Dakota stretching southwestward to northern Utah. The warm front is situated from central Missouri to northwest South Dakota. The thermal trough is found from Valentine, Nebr., southwestward through Amarillo, Tex. The most unstable air is over the central Plains. However, it is strongly capped.

Evening Forecast

Good low-level forcing but significant cap. Nocturnal activity should be late and well to the east. Best area appears to be southeast Minnesota, western Wisconsin, and northeast Iowa.

Action

None.

Extended Outlook

Synoptic setting improves considerably as frontal system pushes to South Dakota/Nebraska border. Moisture that has lingered in lower Missouri Basin troughs should move northwestward into central Plains. Two short-wave troughs should move into region.

Action

Requested rapid-scan satellite data but, owing to technical problems at Wallops Island, request was denied.

9 July 1984

1200 GMT Discussion

A weak front is located from the Dakotas to southeast Colorado. A stronger front is beginning to advance across the northern Dakotas and Wyoming and on into the Great Basin. There is a weak 500-mb short-wave trough over Colorado moving into the Plains. Very unstable air over all of intermountain regions plus the central and northern Plains.

Evening Forecast

More unstable airmass leads to higher probabilities for meso-α system tonight. Anticipate strong thunderstorms over Cheyenne Ridge in Nebraska Panhandle that will move east-northeast and grow into nocturnal system.

Action

None.

Extended Outlook

Main short-wave trough on west coast will move eastward, with trailing portion of wave moving along frontal zone in Plains tomorrow night. It appears that this setup has potential for severe thunderstorms in southeast Colorado. These storms should grow into a meso-α system over central Kansas. Potential problems include the fronts' plunging too far south and feedback into area from tropical system over Mexico and southwest Texas.

Action

Rapid-scan satellite data requested. All rawinsonde stations alerted for special soundings.

10 July 1984

1200 GMT Discussion

Cold front is in central Kansas stretching across central Colorado. Last night's outflow boundaries are found over southeast Colorado and northeast New Mexico into southwest Kansas. Residual moisture lingers well to the northwest and north of synoptic front. Four distinct vorticity maxima are embedded in the 500-mb flow, one near the North Dakota/Canadian border, one in the vicinity of Sioux Falls, S.D., one near Douglas, Wyo., and one in southwest Colorado. All this leads to a very complicated large-scale setting. OKC, AMA, and DDC soundings are very unstable.

Evening Forecast

Seventy percent probability of MCS development tonight. The very complex situation leads to difficulty in choosing "best" area. Prime region for development appears to be east-central Kansas and northern Oklahoma.

Action

Flight crew alerted for possible 0300 GMT takeoff (Flight #5).

Extended Outlook

Frontal system nearly stationary across western Missouri to Texas Panhandle, with vorticity maximum moving far to the east outside of operations area. Most likely area of development is eastern Kansas and northeast Missouri.

Action

None.

11 July 1984

Situation at 1200 GMT

Current situation is dominated by fronts becoming stationary from the Big Bend Region across Oklahoma northeastward into Ohio. Behind front, widespread dry air and conditions unfavorable for convection over north and central Plains and mountains. Moist conditions continue through Arizona and New Mexico, and south of front.

Evening Forecast

Front is likely scene for major convective activity. Activity likely to be meso-β systems along and ahead of front but meso-α system is unlikely, owing to linear forcing.

Action

Down day after Flight #5.

Extended Outlook

No LFM available until 1900-1930 GMT. The 48-h LFM and 60-h spectral from 1100 to 0000 GMT indicate area of 850-700 mb warm advection in central Plains. There is reason to expect moderate instability and weak to moderate dynamics tomorrow night. Several questions arise, the most important being the availability of moisture.

Action

Rapid-scan satellite data were requested.

No money available for special rawinsonde soundings.

12 July 1984

Situation at 1200 GMT

Old cold front has become stationary over southern Arkansas westward into northeast Texas and New Mexico. New cold front moving eastward over central Montana extending southwestward into northern California.

Evening Forecast

Short-wave trough in northwest United States is forecasted to be in eastern Montana by morning with smaller vorticity maximum expected to move rapidly eastward across North Dakota late this afternoon and evening. Expect thunderstorms to move across North Dakota this evening. It is possible that thunderstorms will continue or regenerate over western South Dakota and Nebraska Panhandle late tonight. Best chance of MCS development appears to be eastern Dakotas and Minnesota.

Action

Aircraft alert canceled at 2300 GMT. Potential system was out of the research area.

Extended Outlook

Forecast products show short-wave trough moving northeastward from southern California and southern Nevada area reaching Utah-Colorado border tomorrow evening. Cold front moves to about North Platte-Boulder by tomorrow evening; good up-motion forecast in southeast Wyoming, northeast Colorado, and Nebraska Panhandle. Air mass should improve by tomorrow as Texas moisture flows back northward.

Action

Rapid-scan satellite data were requested.

13 July 1984

Situation at 1200 GMT

A moderately strong cold front associated with a short-wave trough is currently moving across Wyoming into an airmass that supported a β-scale convective system in eastern South Dakota last night. The Totals-index in this area is about 50. An east-west stationary front remains in central Oklahoma where dew points are high (70's) but very warm air is present at 500 mb. Instability and low-level forcing are weak.

Evening Forecast

The 850-mb cold front will initiate convection in the high terrain of eastern Wyoming which should grow into a β-system once the storms move out from the inhibiting cap at 700 mb and into the more favorable air to the east in north-central Nebraska to northwest Iowa. Low-level moisture is meager, but activity is supported aloft by divergence associated with the trailing right-rear quadrant of jet maximum. A long-lived α-scale system is unlikely.

Action

Alert canceled at 0115 GMT. MCS did not develop.

Extended Outlook

Short-wave trough moving across north-central Plains by tomorrow night with surface frontal boundary extending from Great Lakes to western Oklahoma Panhandle. Weak surface wave in Kansas will produce weak warm advection in eastern Kansas but will move eastward, with moderate threat area moving out of operations region.

Action

None.

14 July 1984

Situation at 1200 GMT

Strong short-wave trough and associated surface low in south-central Nebraska. Main low pressure center is situated over Lake Winnipeg with a triple point near Lake Superior and front extending southwestward into southeast Colorado.

Evening Forecast

Surface low and short-wave trough in south-central Nebraska expected to move to southeast Nebraska by evening. Jetstream maximum of 90 kn centered near Rapid City expected to move east-southeastward to northwest Iowa tonight. Thunderstorms will occur in central Wisconsin, northwest Iowa, southeast Nebraska. Strong thunderstorms forming β-scale system likely to be located in central and southwest Iowa, extreme northwest Missouri and southeast Nebraska, moving southeastward into northeast Kansas and northern Missouri tonight.

Action

Aircraft stand-by for 0130 GMT takeoff (Flight #6).