USAFETAC/TN--92/003

# GULF WAR WEATHER



by

Kenneth R. Walters, Sr
Major Kathleen M. Traxler
Michael T. Gilford
Capt Richard D. Arnold
TSgt Richard C. Bonam
TSgt Kenneth R. Gibson

**MARCH 1992**

*APPROVED FOR PUBLIC RELEASE;*
*DISTRIBUTION IS UNLIMITED*





USAF
ENVIRONMENTAL TECHNICAL
APPLICATIONS CENTER

Scott Air Force Base, Illinois 62225-5438

## REVIEW AND APPROVAL STATEMENT

USAFETAC/TN--92/003, *Gulf War Weather*, March 1992, has been reviewed and is approved for public release. There is no objection to unlimited distribution of this document to the public at large, or by the Defense Technical Information Center (DTIC) to the National Technical Information Service (NTIS).

PARKE A. SMITH, Major, USAF
Chief, Environmental Applications

KENNETH R. WALTERS, Sr.
Chief, Readiness Support

FOR THE COMMANDER

WALTER S. BURGMANN
Scientific and Technical Information
Program Manager

## REPORT DOCUMENTATION PAGE

2. Report Date: March 1992

3. Report Type and Dates Covered: Technical Note, 8 August 1990--31 March 1991

4. Title: *Gulf War Weather*

6. Authors: Kenneth R. Walters, Sr., Maj Kathleen M. Traxler, Michael T. Gilford, Capt Richard D. Arnold, TSgt Richard C. Bonam, TSgt Kenneth R. Gibson

7. Performing Organization Names: USAF Environmental Technical Applications Center, (USAFETAC/ECR), Scott AFB, IL 62225-5438

8. Performing Organization Report Number: USAFETAC/TN--92/003

12. Distribution/Availability Statement: Approved for public release; distribution is unlimited.

13. Abstract: A daily history of weather that affected United States military operations from 8 August 1990 through 31 March 1991 in the conduct of the Persian Gulf War. Illustrations include weather satellite imagery of the study area, which comprised Saudi Arabia, Kuwait, Iraq, and areas immediately adjoining. Separate chapters describe the weather during Operations DESERT SHIELD, DESERT STORM, and PROVIDE COMFORT. Appendices summarize mean monthly temperatures (including wet-bulb globe and wind chill temperatures) for selected stations in the study area.

14. Subject Terms: CLIMATOLOGY, METEOROLOGY, WEATHER, SATELLITE PHOTOGRAPHY, METEOROLOGICAL SATELLITES, MILITARY OPERATIONS, WARFARE, GULF WAR, MIDDLE EAST, SAUDI ARABIA, IRAQ, IRAN, KUWAIT, PERSIAN GULF, DESERTS, temperature, winds, cloud, visibility, dust, sand, fog, thunderstorms, rain, snow, showers, wet-bulb globe temperature, wind chill temperature

15. Number of Pages: 245

17. Security Classification of Report: Unclassified

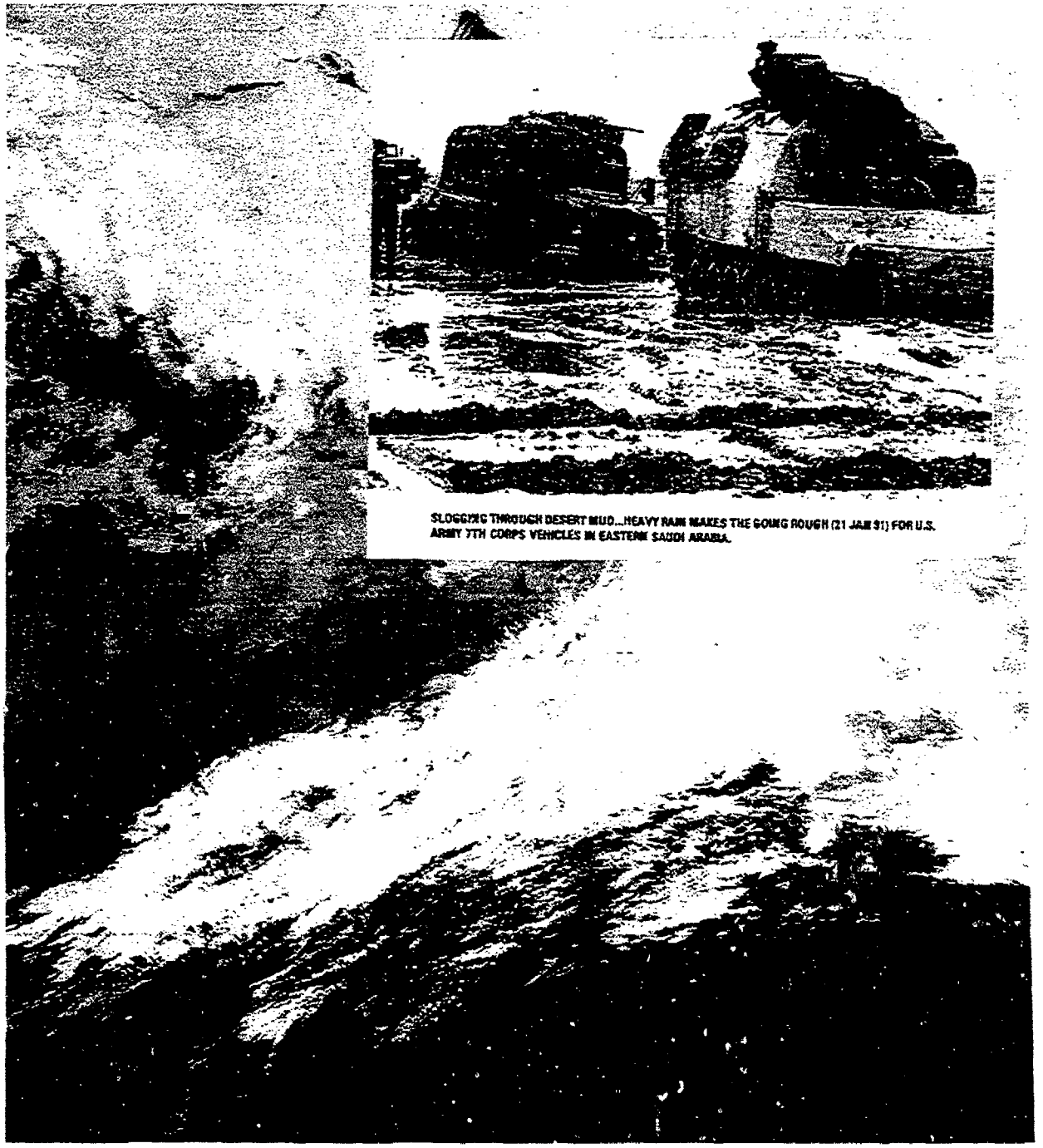
18. Security Classification of this Page: Unclassified

19. Security Classification of Abstract: Unclassified

20. Limitation of Abstract: UL

**Standard Form 298**

# FRONTISPIECE




**The 21 January satellite photo shows the intense area of thunderstorms that resulted in the "rough going" shown in the inset. "General Mud" once again plays his hand.**

## PREFACE

This report was prepared by the United States Air Force Environmental Technical Applications Center's Readiness Support Section (USAFETAC/ECR) in response to a support assistance request from Headquarters, Air Weather Service, Scott AFB, IL. It documents work done under USAFETAC project 9201-19.

This project would not have been possible without the dedicated support of many individuals and agencies. Please accept our sincere apologies if we have omitted anyone.

Thanks to Maj Thomas R. McPhail of the Air Staff's Directorate of Weather, Maj Glenn A. Riegelmann of the Air Weather Service Directorate of Readiness, Lt Col Kenneth A. Nash, the Air Force Global Weather Central's Deputy Chief of Operations, and Maj Parke A. Smith, USAFETAC's Environmental Applications Chief. Without them, we could not have obtained certain information vital to the report. Lt Col Nash was key to obtaining the satellite imagery used here.

Thanks to Lt Col John Erickson, Chief of USAFETAC's Global Climatology Branch, and staff for making available an observational dataset that was as complete as possible under the circumstances. Thanks also to Mr John Walsh of USAFETAC's Global Climatology for obtaining copies of the National Meteorological Center's archived analyses for the study period.

Thanks to Maj Chuck Tuttle and SSgt Drew Henderson of USAFETAC's Environmental Applications Section and to Miss Hilda Snelling and TSgt Rick Foster of the Engineering Meteorology Section for jointly providing the temperature data in the appendices.

Special thanks to the 1210th Field Printing Squadron--specifically, SMSgt Larry Reece, Mr Lenny Hayhurst, Mr Glen Dawson, and Mr Ralph Voss. Thanks also to Mr Mark Rice, Mr Bob Tobin, and Mrs Gladie Barnard of Team Xerox. Without the extraordinary technical and production support from these people and their co-workers, this document could not have been completed within the time constraints given. It certainly could not have included the high-quality reproduction of satellite imagery, all of which was done during an on-site test of the Xerox DocuTech publishing system.

Thanks to the AWS STINFO Program Manager and AWS Technical Library director Mr Walter S. Burgmann for his skilled help in organizing production of the satellite imagery.

Finally, thanks to USAFETAC's Technical Publications Production team: Mr George Horn, Mr Bob Van Veghel, and Sgt Corinne Kawa. After hours of edit, re-write, and re-edit, they somehow made all the fragmented pieces of manuscript text and raw graphics come together into the simple and readable document you see here--just another "routine outstanding" job.

## CONTENTS

## FIGURES

## Chapter 1

## INTRODUCTION

**Area of Interest.** This study describes the day-by-day weather of northern Saudi Arabia, the northern Persian Gulf, Iraq, eastern Jordan, southeastern Turkey, and southwestern Iran between 8 August 1990 and 31 March 1991. For the purposes of this study, the Persian Gulf region is divided into the two areas shown in Figure 1-1. Area A (the "Area of Interest") is discussed throughout the study. Area B (the "Area of Intense Interest") is only discussed in Chapter 3, "DESERT STORM." Figures 1-2, 1-3, and 1-4 show the major cities and topographical features of Iraq, Kuwait, and Saudi Arabia, respectively. For detailed topography, drainage, and urban geography, consult the appropriate Defense Mapping Agency Aeronautical charts.

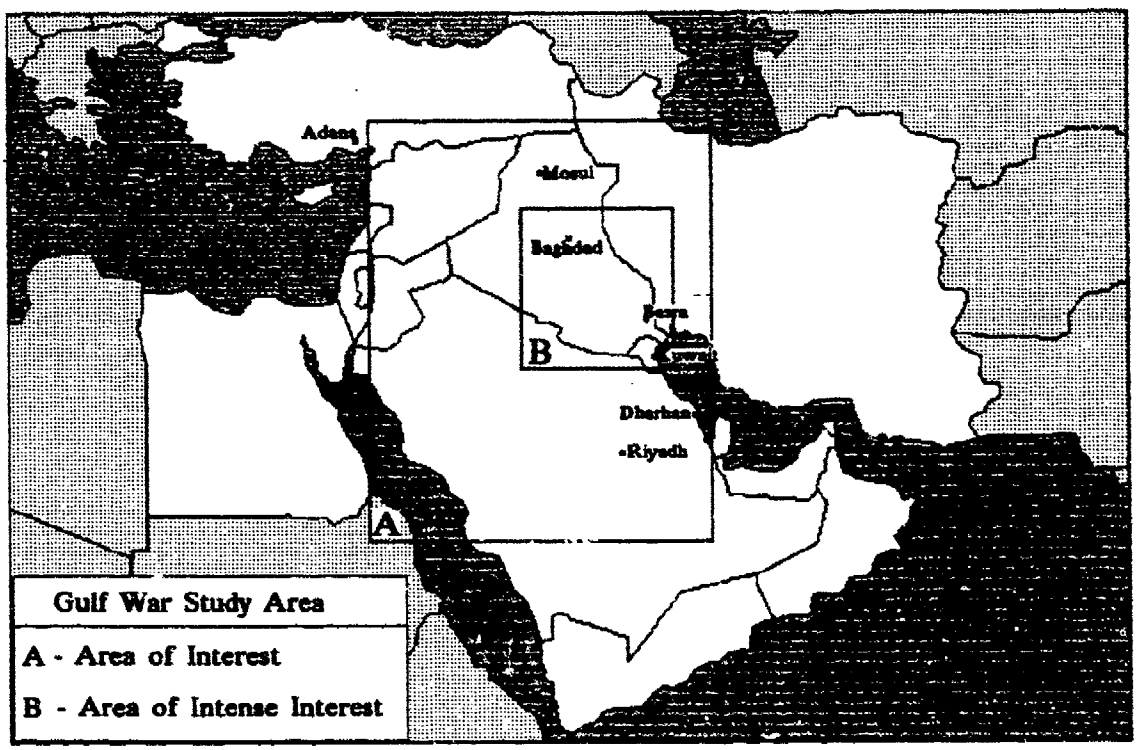



**Figure 1-1. Gulf War Study Areas.** Area A includes almost all of the Middle East, while Area B focuses on the Kuwaiti Theater of Operations and the areas immediately surrounding.

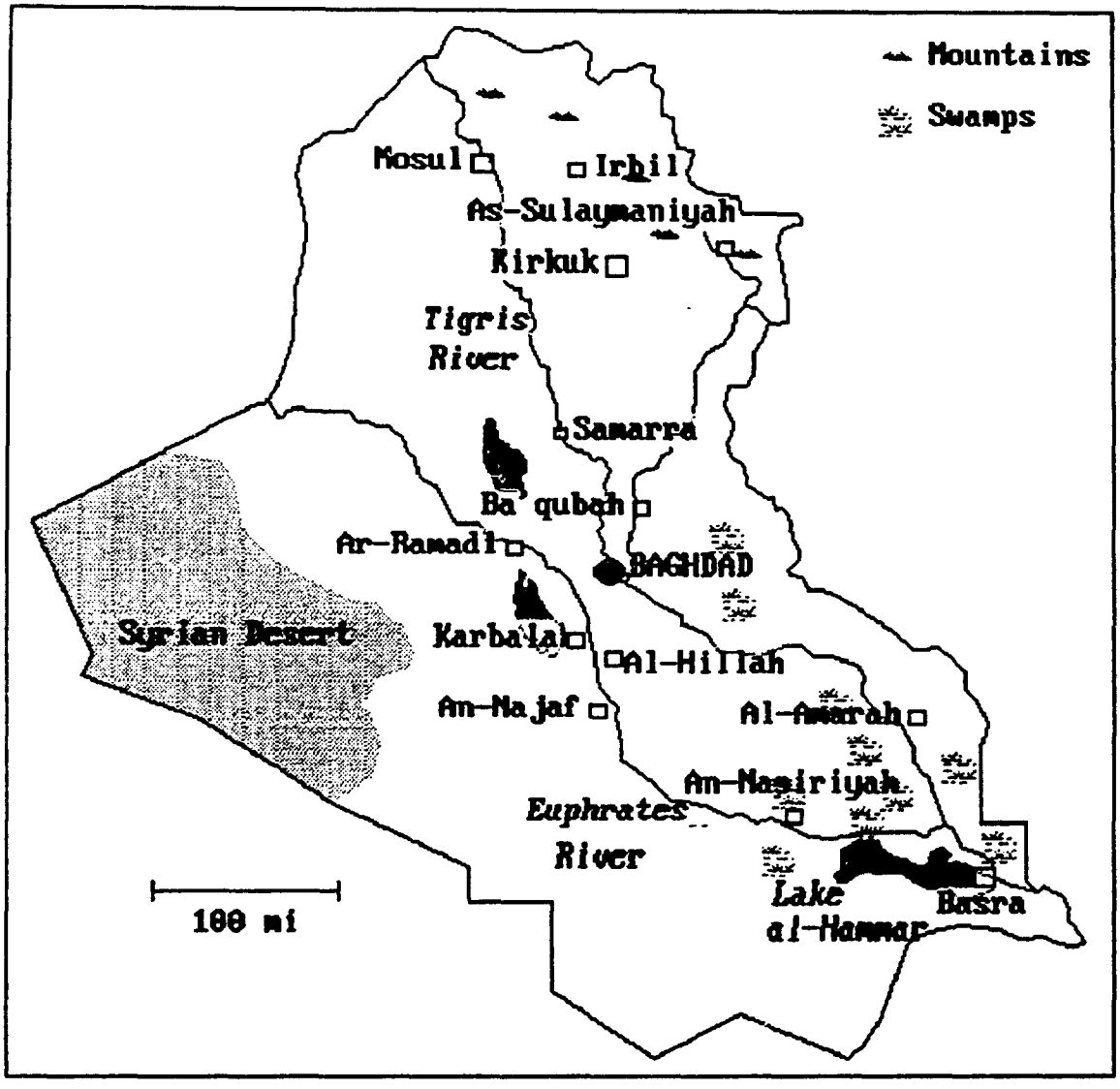



**Figure 1-2. Iraq.** Note the two lakes just west of Baghdad. They are prominent in most satellite imagery and help locate the city.

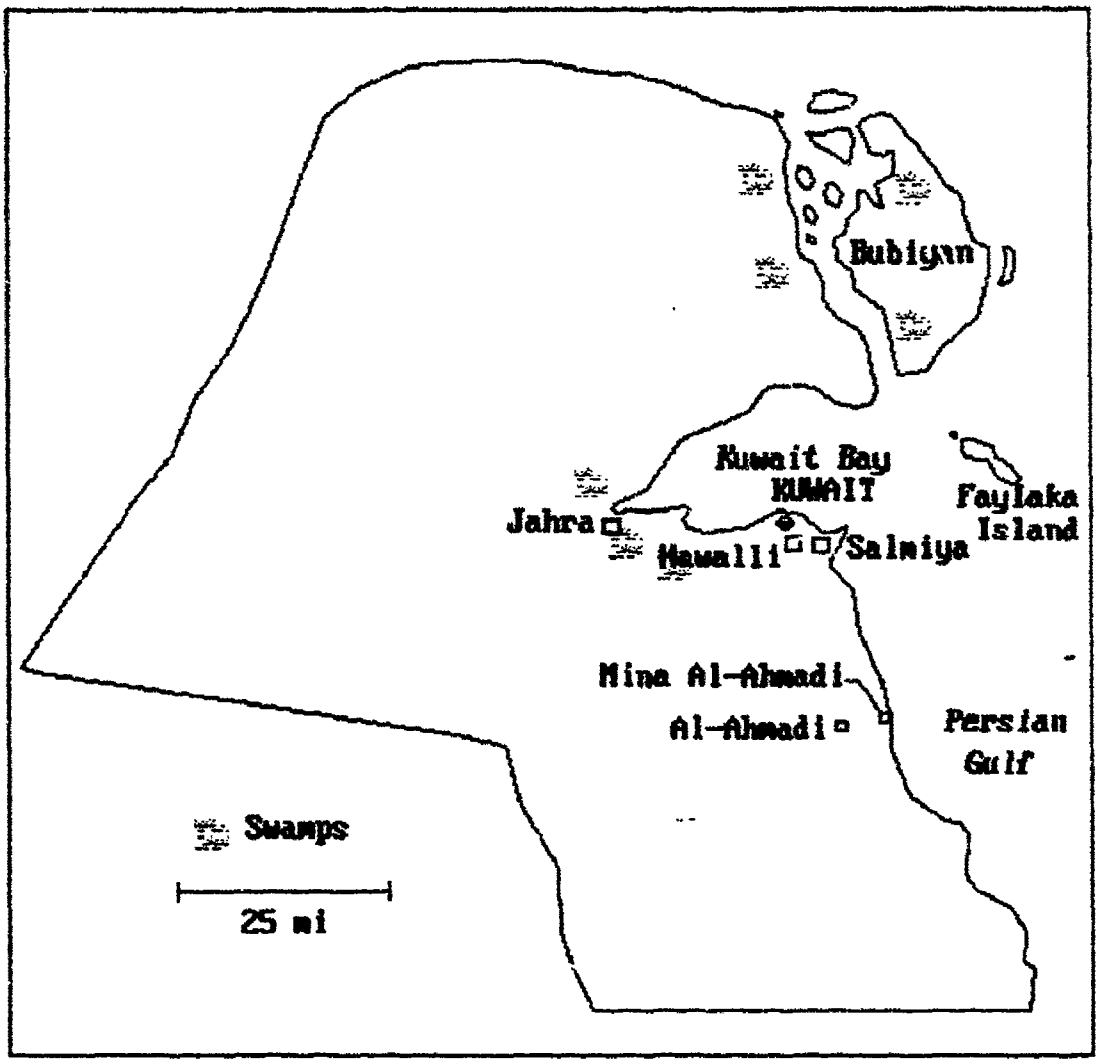



**Figure 1-3. Kuwait.** The tides in Kuwait Bay are much higher with strong easterly winds (and much lower with strong westerly winds) than the tide tables would indicate.

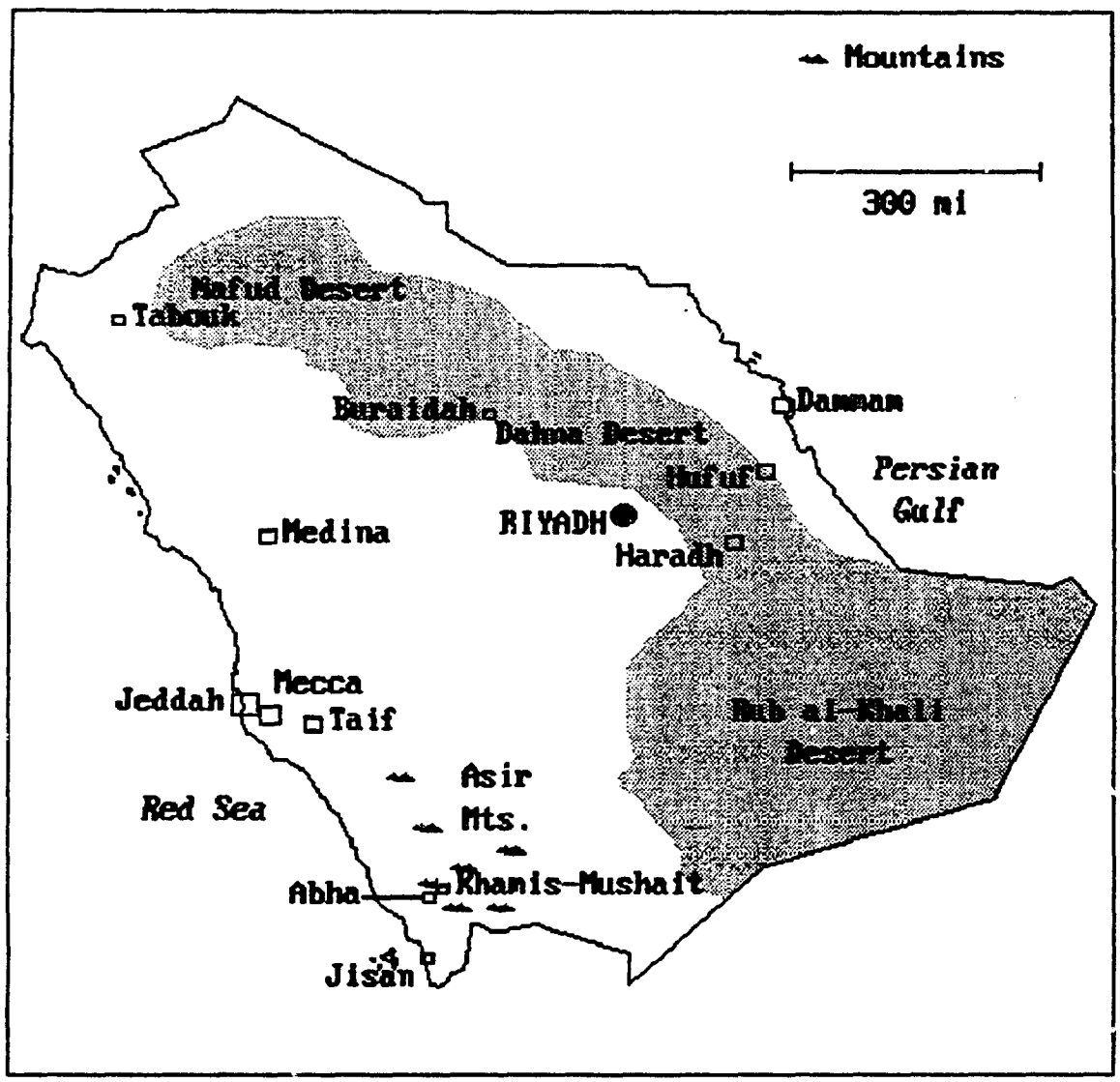



**Figure 1-4. Saudi Arabia.** Note the extensive desert areas. Saudi Arabia slopes up toward the west. Mountains along the Red Sea coast and the Yemeni border reach elevations near 8,000 feet. Temperatures are nearly always 5-10° cooler in the western mountains.

**Study Content.** The emphasis in this report is on sensible weather that could have affected the use of airpower in the region during the Persian Gulf War. Weather conditions that could have affected ground operations are mentioned whenever they are appropriate and known, especially during the ground war portion of Operation DESERT STORM. Representative satellite imagery was carefully selected to complement the text. Note that some pages in Chapters 2-4 have been left blank to provide better continuity from text to photograph.

***In Chapter 2*** (DESERT SHIELD, 8 August 1990--16 January 1991), the "general weather" of selected time periods is described. Daily discussions are provided as "significant weather events" only when day-to-day weather has departed significantly from the "general weather" discussions.

***In Chapter 3*** (DESERT STORM, 17 January--2 March 1991), Gulf weather is discussed day by day. Although hostilities ceased at 0500Z on 2 March, that day's discussion covers the entire 24 hours.

***In Chapter 4*** (PROVIDE COMFORT, 3 March 1991 through 31 March 1991), we use the same "general weather" and "significant weather events" as in Chapter 2, but with emphasis on Iraq and extreme southeastern Turkey.

***The bibliography*** gives major references used in study preparation--all are available through the authors, either directly or indirectly.

***Appendix A*** is a locator for the stations used to compile the climatological tables given in Appendices B, C, and D.

***Appendix B*** gives mean monthly maximum and minimum temperatures (including wet-bulb globe and wind-chill temperatures) for August 1990 through March 1991, the duration of the Gulf War.

***Appendix C*** gives maximum and minimum temperatures (including wet-bulb globe and wind-chill temperatures) for the entire period of record.

***Appendix D*** gives the hourly duration (inclusive hours of occurrence) that wet-bulb globe temperature (WBGT) was equal to or more than 85° F and 88° F at Bahrain, Jeddah, King Khalid Military City, and King Faud Air Base.

**Conventions.** All cloud heights are in feet. As they are discussed here, "low clouds" have bases from the surface to 6,500 feet above ground level (AGL). "Middle cloud" bases are between 7,000 and 19,000 feet AGL, while "high clouds" are those with bases above 20,000 feet AGL. Wind speeds are in knots. Visibilities through 4,800 meters are in hundreds of meters, but those of 5 kilometers and above are in kilometers (km). Temperatures are in degrees Celsius (C). Pressures are in millibars (mb). All times are in Greenwich Mean Time (Z).

**Data Sources.** The authors used a number of sources, including existing USAFETAC descriptive climatological studies covering the region, a large amount of meteorological satellite imagery (see below), observations and general information gathered by deployed Air Weather Service meteorologists and coalition aircrews, and special data summaries prepared by USAFETAC analysts. A selected list of sources is given in the bibliography. Author expertise in the area was also helpful; four of the six authors had prepared special studies during DESERT SHIELD and DESERT STORM, and one was assigned to the Desert Forecast Unit from mid-August 1990 through late March 1991.

**Satellite Imagery.** Satellite imagery was invaluable to researching and writing this history. Without it, we doubt that it could have been written at all. Images enhanced to detect blowing dust and sand were especially helpful. Through the foresight and assistance of Lt Col Gerry F. Reilly, AWS/DOJ, and Lt Col Kenneth A. Nash, AFGWC/ADO, satellite imagery received at the Desert Forecast Unit (DFU), Riyadh, Saudi Arabia, and at the Air Force Global Weather Central (AFGWC), Offutt AFB, Nebraska, during the course of the war was made available to us. Lt Col Nash also provided the image and picture used in the frontispiece, as well as additional DMSP/SSMI images for the ground war period of DESERT STORM. The authors examined a total of more than 2,550 images, both visual and infrared, from the Defense Meteorological Satellite Program (DMSP), the National Oceanographic and Atmospheric Administration (NOAA) polar orbiting satellites, and the European Space Agency's geosynchronous METEOSAT satellite. Whenever possible, DMSP and NOAA polar orbiter images were selected to illustrate the text, primarily because of foreshortening problems with METEOSAT images. A few METEOSAT pictures were used, however, to illustrate DESERT STORM when a rapidly moving system affected the Arabian Peninsula between polar orbiter images. METEOSAT was also extremely helpful in locating precipitation areas.

# Chapter 2

# DESERT SHIELD WEATHER

## 8 August 1990--16 January 1991

**General Weather.** The entire area was hot, dry, and dominated by low pressure. Skies were clear to scattered. Winds were northwesterly at 8-15 knots with occasional gusts to 25; at night, speeds dropped to less than 10 knots. General visibilities were 7-9 km in haze and dust. High temperatures were 34-45° C; lows, 23-30° C. The higher elevations of western Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***8 August:*** Suspended dust reduced morning visibilities to 4,800 meters across eastern Saudi Arabia.

***12-13 August:*** Suspended dust again reduced morning visibilities to 4,800 meters in eastern Saudi Arabia. Blowing sand and dust reduced afternoon and evening visibilities to 5-7 km. There were isolated reports of 3,200-meter visibilities in Kuwait and in northeast and north-central Saudi Arabia.

***14 August:*** Suspended dust reduced morning visibilities to 3,200 meters across eastern Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 5-7 km along the Iraq-Saudi Arabia border and in western and eastern Saudi Arabia. Isolated areas of blowing sand and dust further reduced afternoon visibilities to 4,000 meters across northeastern Saudi Arabia.

***15-17 August:*** Fog developed overnight along the Persian Gulf coast in and around Dhahran, as well as in northeastern and central Saudi Arabia. Visibility dropped to 3,200 meters, but returned to 7-9 km in haze several hours after sunrise. Broken clouds at 500 feet over the Gulf coast burned off after sunrise.

***15 August:*** Suspended dust reduced morning visibilities to 4,800 meters across central Saudi Arabia.

***16 August:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km across western Saudi Arabia.

***17 August:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km in Kuwait and in northeastern and western Saudi Arabia.

***18 August:*** Blowing sand and suspended dust reduced morning visibilities to as low as 3,200 meters across eastern, central, and western Saudi Arabia. Afternoon visibilities in western Saudi Arabia improved to 5-7 km.

***19 August:*** Suspended dust and haze reduced afternoon visibilities in eastern Saudi Arabia.

***20-22 August:*** Daytime winds gusted to 30 knots in areas along the Iraq-Saudi Arabia border and into Kuwait. Blowing sand and dust lowered visibilities to as little as 3,200 meters in some places.

***23-24 August:*** Blowing sand and dust again reduced afternoon visibilities in western Saudi Arabia to 5-7 km.

***25-28 August:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km in Kuwait and in northeast, north-central, and western Saudi Arabia.

***29 August:*** Blowing sand and dust reduced afternoon visibilities to 4,800 meters in central Iraq, central Saudi Arabia, and Kuwait.

***30 August:*** Blowing sand and dust lowered afternoon visibilities to 5 km in northeastern Saudi Arabia.

***31 August:*** Blowing sand and dust reduced afternoon visibilities to as low as 5 km in northeastern Saudi Arabia and the northern Persian Gulf.

**Figure 2–1. NOAA Visual, 8 September 1990, 1327Z.** Two distinct areas of blowing sand and dust over southeast Iraq, Kuwait, and the Persian Gulf are shown by the arrows. Visibilities here dropped to 1,600-3,200 meters.

**General Weather.** High pressure dominated Iraq and central Saudi Arabia. Skies were clear to scattered. Winds were northwesterly at 10-20 knots with occasional gusts to 25 knots. Speeds dropped to less than 10 knots at night. Haze and suspended dust reduced general visibilities to 7-9 km. High temperatures were 34-44° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***1 September:*** Haze reduced mid-morning visibilities to 4,800 meters in central Saudi Arabia. Fog developed late at night over northeastern and eastern Saudi Arabia; it reduced visibilities to 3,200 meters but burned off several hours after sunrise the next day.

***2 September:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km in Kuwait and southeastern Iraq. Haze reduced afternoon visibilities to 3,200 meters in northwestern Saudi Arabia. Fog again developed late at night over northeastern and eastern Saudi Arabia with 3,200-meter visibilities until after sunrise.

***3 September:*** Isolated afternoon thunderstorms developed over the southern half of Saudi Arabia's Red Sea coast.

***4 September:*** Haze reduced mid-morning visibility to 4,800 meters in central Saudi Arabia.

***6 September:*** Isolated afternoon thunderstorms developed over the southern half of the Saudi Arabian Red Sea coast and over the southwest mountains of Saudi Arabia.

***7 September:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km in Kuwait and the northern Persian Gulf.

***8 September:*** Suspended dust reduced morning visibilities to 5-7 km in central Saudi Arabia. Two distinct areas of blowing sand and dust over southeast Iraq and Kuwait into the Persian Gulf lowered visibilities to 1,600-3,000 meters--they are shown in Figure 2-1. Isolated afternoon thunderstorms developed over the western mountains of Saudi Arabia.

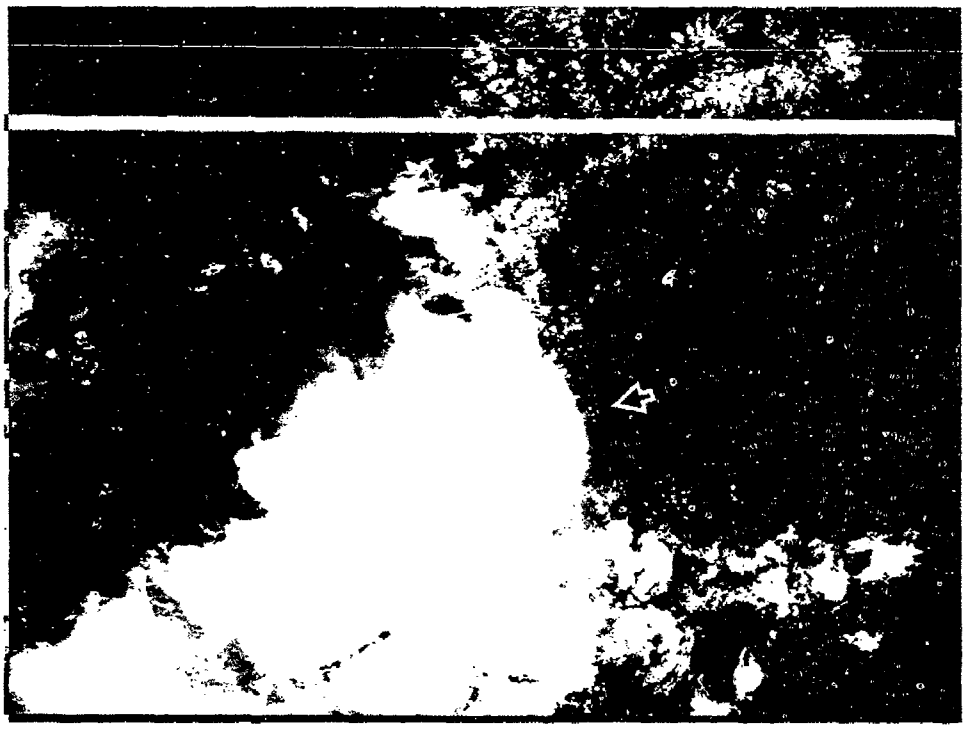


**Figure 2–2. NOAA Thermal, 10 September 1990, 1445Z.** The arrow marks an area of isolated afternoon thunderstorms over the southern half of the Saudi Arabian Red Sea coast.

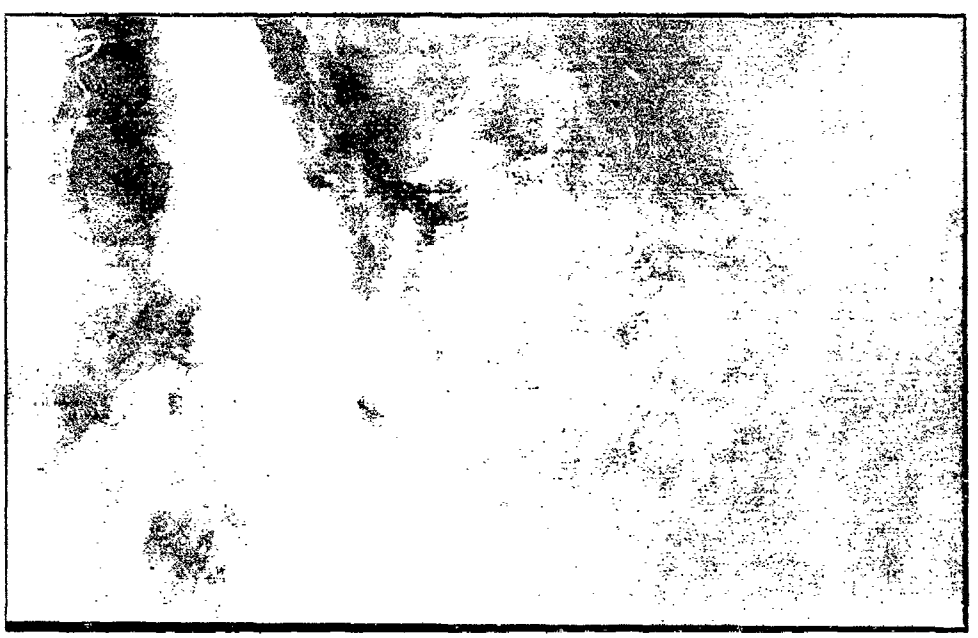


**Figure 2–3. NOAA Thermal, 11 September 1990, 1433Z.** A large area of isolated afternoon thunderstorms and rainshowers is shown over the western mountains of Saudi Arabia.

***9 September:*** The two areas of blowing sand and dust shown in Figure 2-1 persisted. Suspended dust reduced morning visibilities in eastern and central Saudi Arabia to 5-7 km. Blowing sand and dust lowered afternoon visibilities in western Saudi Arabia to 5-7 km. The two areas of blowing sand and dust shown in Figure 2-1 were still present.

***10 September:*** Figure 2-2 shows an area of isolated afternoon thunderstorms over the southern half of the Saudi Arabian Red Sea coast.

***11 September:*** Blowing sand and dust reduced morning and early afternoon visibilities to 5-7 km in Kuwait and the northern part of the Persian Gulf. Figure 2-3 shows a large area of isolated afternoon thunderstorms and rainshowers over the western mountains of Saudi Arabia.

***13 September:*** Blowing sand and dust reduced morning and early afternoon visibilities to 5-7 km in Kuwait, northeastern Saudi Arabia, and the northern part of the Persian Gulf. Isolated afternoon thunderstorms developed over the southern half of the Saudi Arabian Red Sea coast.

**DESERT SHIELD 14 September 1990**

**General Weather.** A dry cold front extended through central Iraq into northwestern Saudi Arabia, with an associated low-pressure center near Baghdad. Skies were clear to scattered. Winds were northerly; speeds along the front increased to 30 knots during the day. Haze and suspended dust reduced general visibilities to 7-9 km, but visibilities ahead of the front in southern Iraq and Kuwait were less than 3,200 meters. High temperatures were 33-40° C; lows, 20-27° C.

**DESERT SHIELD 15-22 September 1990**

**General Weather.** The cold front dissipated. High pressure dominated across Iraq and into central Saudi Arabia. Skies were clear to scattered. Winds were northwesterly at 10-20 knots with occasional gusts to 25, dropping to less than 10 knots at night. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 33-40° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Figure 2–4. NOAA Thermal, 17 September 1990, 1048Z.** The arrows mark the origins of blowing sand and dust that reduced afternoon visibilities to 5-7 km generally, but as low as 3,200 meters in isolated areas over southeast Iraq, northeast Saudi Arabia, Kuwait, and the northern part of the Persian Gulf. This image has been enhanced to make the blowing sand and dust more visible.

**Significant Weather Events**

***15 September:*** Isolated afternoon thunderstorms developed over the southern half of Saudi Arabia's Red Sea coast.

***16 September:*** Suspended dust reduced mid-morning and evening visibilities to 4,800 meters over central Saudi Arabia. Blowing sand and dust reduced most afternoon visibilities to 5-7 km, but as low as 3,200 meters in isolated areas of southeast Iraq, northeast Saudi Arabia, Kuwait, and the northern Persian Gulf. Afternoon visibilities were also reduced to 5-7 km in isolated parts of west-central Saudi Arabia. Isolated afternoon thunderstorms developed over the southern half of Saudi Arabia's Red Sea coast.

***17 September:*** Suspended dust again kept mid-morning and evening visibilities to 4,800 meters over central Saudi Arabia. Blowing sand and dust over northeast Saudi Arabia is shown in Figure 2-4. Afternoon visibilities were reduced to 5-7 km in isolated parts of west-central Saudi Arabia. Isolated afternoon thunderstorms developed over the southern third of the Saudi Arabian Red Sea coast. Suspended dust reduced afternoon visibilities to 5-7 km in western Saudi Arabia.

***18-19 September:*** Suspended dust reduced early- and late-morning visibilities to 4,800 meters in central Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 5-7 km in southeast Iraq, northeast Saudi Arabia, Kuwait, and the northern part of the Persian Gulf.

***19 September:*** Isolated afternoon thunderstorms developed over the southern half of Saudi Arabia's Red Sea coast.

***20 September:*** Isolated afternoon thunderstorms again developed over the southern half of Saudi Arabia's Red Sea coast. Blowing sand and dust reduced morning and early afternoon visibilities to 5-7 km in Kuwait and the northern part of the Persian Gulf.

***21 September:*** Early morning fog reduced visibilities to 4,800 meters in eastern Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 5 km, with isolated reports of 3,200 meters over west and northwest Saudi Arabia. Isolated afternoon thunderstorms developed over the southern third of Saudi Arabia's Red Sea coast.

**Figure 2–5. NOAA Thermal, 25 September 1990, 1242Z.** Blowing sand and dust originating at the arrows reduce afternoon visibilities to 5-7 km.

***22 September:*** Blowing sand and dust again reduced afternoon visibilities to 5 km. There were isolated reports of 3,200 meters over west and northwest Saudi Arabia. Isolated afternoon thunderstorms again developed over the southern third of Saudi Arabia's Red Sea coast.

**DESERT SHIELD 23-27 September 1990**

**General Weather.** High pressure continued to dominate, but a low-pressure system in southwestern Iran brought on-shore flow to the Gulf Coast of Saudi Arabia. Skies were clear to scattered, except for 800- to 1,000-foot ceilings that developed along the southern half of the Saudi Arabian Persian Gulf Coast during early morning and dissipated by late morning. Winds were northeasterly to easterly at 10-20 knots over eastern Saudi Arabia, but northwesterly at 10-20 knots elsewhere. There were occasional gusts to 25 knots. Speeds dropped to less than 10 knots at night. Haze and suspended dust lowered visibilities to 7-9 km generally, but early morning fog along the Saudi Arabian Persian Gulf coast resulted in visibilities as low as 800 meters. Visibilities in precipitation dropped as low as 6 km. High temperatures were 33-40° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***23 September:*** Blowing sand and dust reduced afternoon visibilities to 3,200-4,800 meters in northwestern Saudi Arabia.

***24-26 September:*** Suspended dust reduced morning visibilities to 3,200 meters in central Saudi Arabia. Figure 2-5 shows blowing sand and dust and reducing afternoon visibilities to 5-7 km. Visibilities were worse (3,200 meters) in isolated areas of Kuwait, eastern Saudi Arabia, and the northern part of the Persian Gulf.

***27 September:*** Fog reduced early morning visibilities to 4,800 meters in eastern Saudi Arabia, but in the northwestern part of the country, visibilities were 3,200 meters in blowing sand and dust. Afternoon visibilities in central and eastern Saudi Arabia were 5-7 km in suspended dust and haze. A light rainshower fell in northwestern Saudi Arabia.

**General Weather.** High pressure continued to dominate. Skies were clear to scattered. Winds were northwesterly at 10 to 20 knots with occasional gusts to 25 knots. Speeds were less than 10 knots at night. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 33-40° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***28 September:*** Fog reduced early morning visibilities to 4,800 meters over eastern Saudi Arabia. Suspended dust and haze reduced afternoon visibilities to 5-7 km in central and northeastern Saudi Arabia.

***29 September:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km in northern Saudi Arabia and southern Iraq.

## DESERT SHIELD 1-2 October 1990

**General Weather.** High pressure continued to dominate. Skies were clear to scattered. Winds were northwesterly at 10-20 knots with occasional gusts to 25 knots, diminishing to less than 10 knots at night. Visibilities were generally 7-9 km in haze and suspended dust, but blowing sand and dust in eastern Iraq and Kuwait reduced afternoon visibilities to 5-7 km. High temperatures were 30-39°; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***1 October:*** Suspended dust reduced morning visibilities in central Saudi Arabia to 4,800 meters, increasing to 5-7 km in the afternoon. In north-central Saudi Arabia, afternoon visibilities were 4,800 meters in suspended dust, but worse (3,200 meters) in blowing sand and dust over southeastern Iraq, Kuwait, and northeastern Saudi Arabia. Isolated afternoon and evening thunderstorms--tops to 50,000 feet--formed over the southern half of Saudi Arabia's Red Sea Coast.

***2 October:*** Suspended dust reduced afternoon visibilities to 4,800 meters over north-central Saudi Arabia.

## DESERT SHIELD 3-6 October 1990

**General Weather.** High pressure again dominated, but low pressure from heating over south-central Saudi Arabia developed during the day. A weak mid-level disturbance moved through southeastern Iraq and northeastern Saudi Arabia, producing scattered to broken middle and high clouds over southeast Iraq, north-central and northeast Saudi Arabia, and Kuwait that persisted through the 5th. Ceilings were 10,000-12,000 feet, but occasionally 4,000-6,000 feet. Winds were northwesterly at 5-15 knots, with occasional gusts to 25 knots. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 30-39° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***3 October:*** Figure 2-6 (next page) shows broken low to middle clouds in southeastern Iraq and northeastern Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 5-7 km along the Saudi Arabia-Iraq border. Isolated

**Figure 2–6. DMSP Thermal, 3 October 1990, 0403Z.** Broken low and middle clouds are shown over southeastern Iraq and northeastern Saudi Arabia.

afternoon and evening thunderstorms with tops to 50,000 feet developed over the southern third of the Saudi Arabian Red Sea Coast.

***5 October:*** Fog reduced early morning visibilities to as low as 400 meters in eastern Saudi Arabia. Figure 2-7 (next page) shows the broken low to middle clouds from Figure 2-6 dissipating--they were gone by evening. Suspended dust and haze reduced afternoon visibilities to 5-7 km in western and central Saudi Arabia; there were isolated reports of 3,200 meters.

***6 October:*** Blowing sand and dust reduced afternoon visibilities to 3,200 to 4,800 meters, with isolated reports of 200 meters in western and northwestern Saudi Arabia.

**DESERT SHIELD 7 October 1990**

**General Weather.** High pressure continued to dominate, but a weak mid-level disturbance moving across central Iraq caused some late morning showers--see Figure 2-8 on page 2-17. Cloud cover was limited to scattered low and middle clouds over central Iraq and western Saudi Arabia. Winds were northwesterly at 5-15 knots. Haze and suspended dust reduced visibilities to 7-9 km, but to 5-7 km in showers. Early morning fog on the Saudi Arabian Persian Gulf coast lowered visibility to 1,600 meters before burning off by mid-morning. High temperatures were 30-39° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.

**DESERT SHIELD 8-17 October 1990**

**General Weather.** High pressure still dominated. Skies were generally scattered over central Iraq and northern Saudi Arabia, but a 4,000-foot ceiling formed along the Iraq-Saudi Arabia border during the evening of 14 October and until the next morning. On the afternoon of the 15th, a broken ceiling at 10,000-12,000 feet developed from a weak mid-level disturbance over northern Saudi Arabia and southern Iraq. It persisted until the 16th. Winds were northwesterly at 5-15 knots, with occasional gusts to 25 knots. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 30-39° C; lows, 20-27°C. The western mountains of Saudi Arabia were 5-10° cooler.

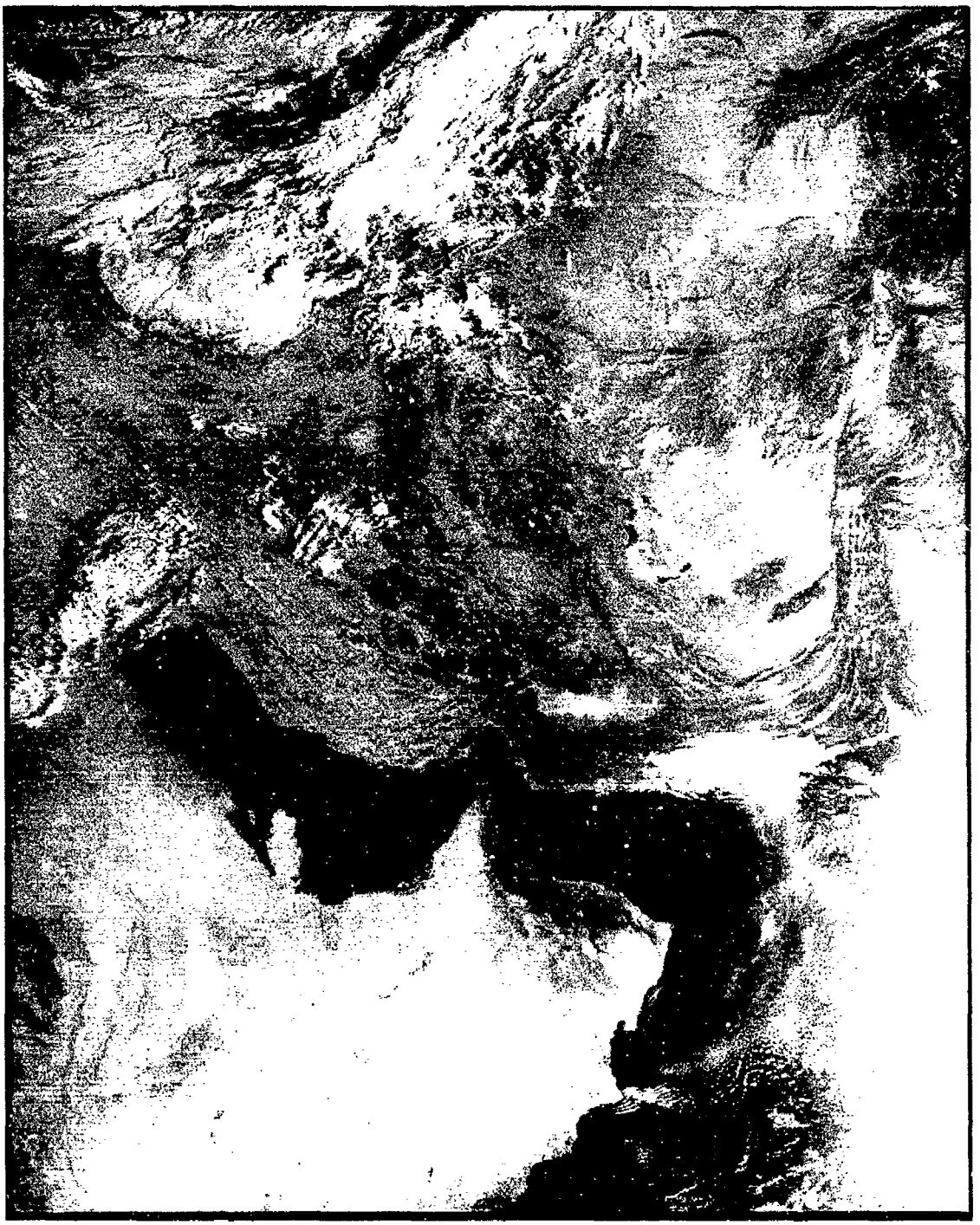


**Figure 2–7. NOAA Visual, 5 October 1990, 0257Z.** The area of broken low and middle cloud shown just northwest and north of Kuwait dissipated by evening.

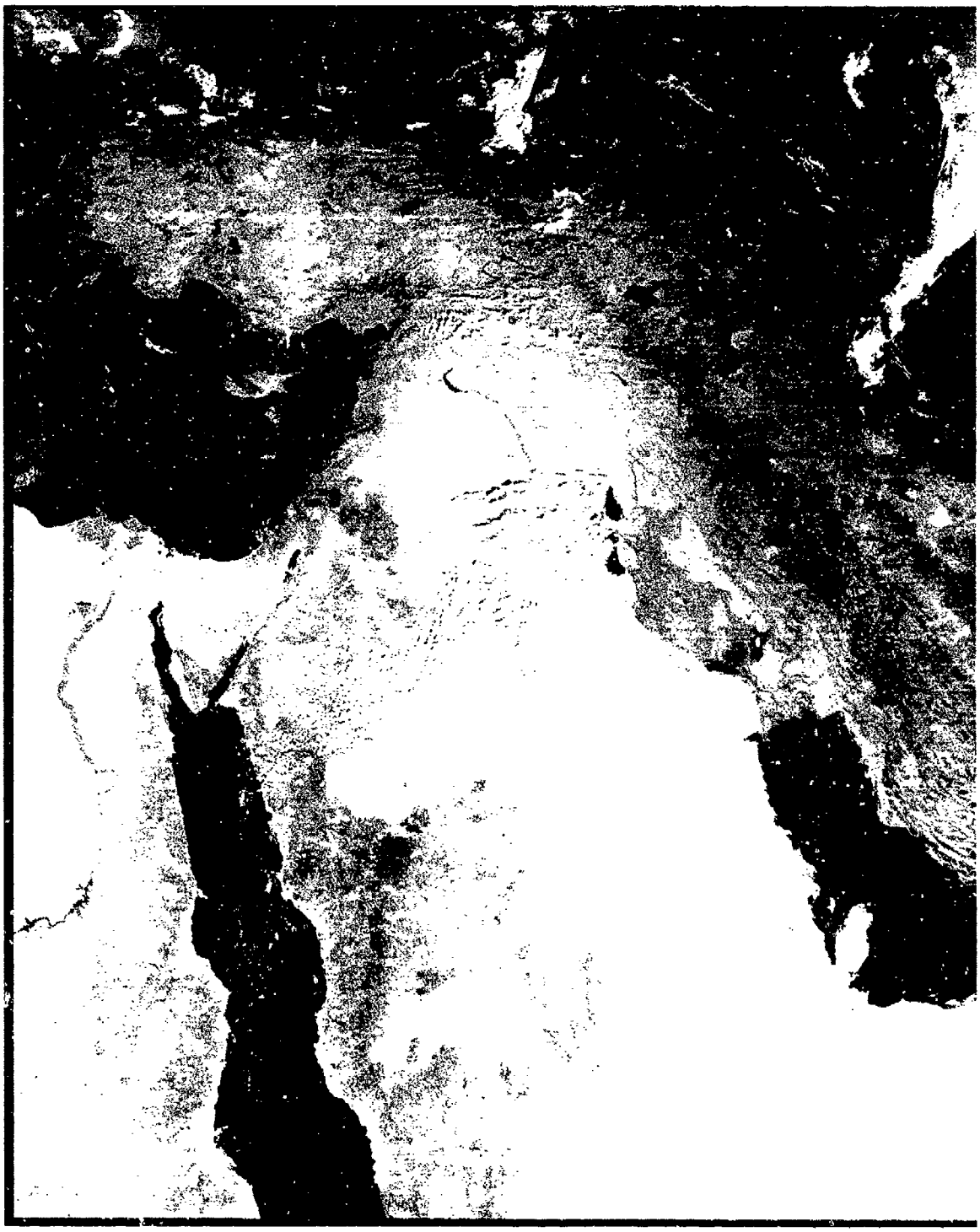


**Figure 2–8. DMSP Visual, 7 October 1990, 0612Z.** A weak mid-level disturbance is shown moving across central Iraq, where it caused some late morning showers.


**Figure 2–9. NOAA Visual, 14 October 1990, 1539Z.** Isolated afternoon and evening thunderstorms (A) with tops to 50,000 feet are visible over the southern half of Saudi Arabia's Red Sea Coast and western Saudi Arabia. The origins of blowing sand and dust that reduced visibilities to as low as 1,600 meters in eastern and southeastern Iraq, Kuwait, and northeastern Saudi Arabia are at B, C, and D.

**Significant Weather Events**

***9-10 October:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km in southeastern Iraq and Kuwait.

***12 October:*** Blowing sand and dust reduced afternoon visibilities to 3,200 meters over western Saudi Arabia.

***13 October:*** Fog reduced early morning visibilities to as low as 800 meters along the Saudi Arabian Persian Gulf coast. A 300-foot ceiling lifted and dissipated by mid-morning. Blowing sand and dust reduced afternoon visibilities to 5-7 km in north-central Saudi Arabia and to 3,200 meters in northeastern Saudi Arabia.

***14 October:*** Isolated afternoon and evening thunderstorms with tops to 50,000 feet developed over the southern half of the Saudi Arabia Red Sea Coast and western Saudi Arabia--see Figure 2-9. Blowing sand and dust reduced visibilities to as low as 1,600 meters in eastern and southeastern Iraq, Kuwait, and northeastern Saudi Arabia--see Figure 2-9.

***15-16 October:*** Early morning fog and low clouds again formed over the Saudi Arabian Persian Gulf coast. Visibilities were as low as 800 meters in some places; ceilings, as low as 100 feet. The fog and cloudiness dissipated by mid-morning. Blowing sand and dust reduced afternoon visibilities to 4,800 meters in north-central Saudi Arabia.

***17 October:*** Haze and suspended dust reduced visibilities in west-central Saudi Arabia to 5-7 km.

**DESERT SHIELD 18-30 October 1990**

**General Weather.** A low-pressure system moved into western Iraq, but high pressure still dominated the rest of the region. Cloud cover increased in western Iraq and northern Saudi Arabia. By the end of October, it had moved into eastern and southeastern Iraq. Ceilings were generally 8,000-10,000 feet, but 4,000-6,000 feet in precipitation. Isolated thunderstorms and rainshowers over Iraq and northern Saudi Arabia started on 18 October and continued through the 28th. The storms were least in early morning, peaking in the afternoon. Thunderstorm tops ranged from 30,000 to 40,000 feet. Winds were northwesterly in

southeastern Iraq and southeasterly in eastern Saudi Arabia--all at 10-20 knots. In thunderstorms, gusts reached 35 knots. Haze and suspended dust dropped general visibilities to 7-9 km. Visibility near thunderstorms was as low as 800 meters in rain, blowing sand, and suspended dust. High temperatures were 30-39° C; lows, 20-27° C. The mountains of western Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***18 October:*** Suspended dust reduced evening visibilities to 4,800 meters in north-central Saudi Arabia.

***19 October:*** Suspended dust reduced afternoon and evening visibilities to 4,800 meters in north-central Saudi Arabia.

***20 October:*** Fog reduced early morning visibilities to less than 1,600 meters in eastern Saudi Arabia. Suspended dust reduced afternoon visibilities to 4,800 meters in north-central Saudi Arabia. Haze reduced afternoon visibilities to 3,200 meters in northwestern Saudi Arabia.

***21 October:*** Early morning fog reduced visibilities to 1,600 meters in eastern Saudi Arabia. Blowing sand and dust reduced visibilities to 4,800 meters along the Iraq-Saudi Arabia border in the afternoon, and during the evening over north-central Saudi Arabia. Isolated afternoon and evening thunderstorms with tops to 40,000 feet formed over the northern half of the Red Sea.

***22 October:*** Blowing sand and dust reduced early morning visibilities to 2,000 meters in northwestern Saudi Arabia. Isolated afternoon and evening thunderstorms with tops to 40,000 feet formed in the northern third of the Red Sea. Blowing sand and dust reduced evening visibilities to 4,800 meters in north-central Saudi Arabia.

***23 October:*** Fog reduced early morning visibilities to 3,200 meters in Kuwait. Suspended dust reduced mid-morning and afternoon visibilities to 5-7 km in north-central Saudi Arabia.

***24 October:*** Blowing sand and dust reduced afternoon and evening visibilities to 4,800 meters in north-central Saudi Arabia.

***25 October:*** Fog reduced morning visibilities to 3,200 meters in eastern Saudi Arabia, southeastern Iraq, and Kuwait. Afternoon rainshowers fell over north-central Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 3,200-4,800 meters in northeastern Saudi Arabia and southeastern Iraq.

***26 October:*** Fog reduced early morning visibilities to 3,200 meters along the Saudi Arabian Persian Gulf coast.

***27 October:*** Light rain fell in north-central Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 2,000 to 3,200 meters in northern and northeastern Saudi Arabia and in southern Iraq.

***28 October:*** Fog reduced morning visibilities to 3,200 meters in southeastern Iraq and Kuwait. Figure 2-10 (next page) shows rainshower activity over central Iraq (A) and thunderstorms over eastern Iraq (B and C).

***29 October:*** Suspended dust reduced evening visibilities to 4,800 meters over central Saudi Arabia.

***30 October:*** Fog reduced early morning visibilities to 2,400 meters over eastern Saudi Arabia. Isolated rainshowers fell in northern Iraq.

**DESERT STORM** **31 October 1990**

**General Weather.** High pressure dominated. Skies were clear to scattered. Winds were northwesterly at 5-15 knots with occasional gusts to 25 knots. Haze and suspended dust dropped general visibilities to 7-9 km. Blowing sand and dust reduced afternoon visibilities over eastern Saudi Arabia to 4,800 meters. High temperatures were 30-39° C; lows, 20-27° C. The western mountains of Saudi Arabia were 5-10° cooler.


**Figure 2–10. DMSP Thermal, 28 October 1990, 1521Z.** Rainshower activity over central Iraq is shown at Point A. Thunderstorms over eastern Iraq are shown at Points B and C.

## DESERT SHIELD 1-6 November 1990

**General Weather.** High pressure dominated. Skies were generally clear to scattered, but the jet stream over northern Saudi Arabia and Iraq occasionally produced ceilings at 10,000-12,000 feet. Over Iraq and Kuwait, winds were northwesterly at 5-15 knots, but occasionally 25 knots. Winds over Saudi Arabia were easterly at 5-15 knots, also with gusts to 25. Speeds dropped to less than 10 knots after sunset. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 27-35°; lows, 18-22° C. The western mountains of Saudi Arabia were 10-15° cooler.

**Significant Weather Events**

***1 November:*** Blowing sand and dust reduced afternoon visibilities in Kuwait and the northern part of the Persian Gulf to 5-7 km.

***5 November:*** Haze and suspended dust reduced afternoon visibilities in western Saudi Arabia to 5-7 km.

## DESERT SHIELD 7-13 November 1990

**General Weather.** High pressure was still centered over Saudi Arabia. Skies were generally clear to scattered, but they were broken over Iraq and northern Saudi Arabia, where the subtropical jet stream combined with moisture from the Mediterranean to produce patchy 10,000- to 12,000-foot ceilings. Weak mid- and upper-level disturbances during the morning produced ceilings at 3,000-5,000 feet that continued into late evening every day. Winds were northwesterly over Iraq and Kuwait, but easterly over Saudi Arabia. Wind speeds were 5-15 knots with occasional gusts to 25 knots, dropping to less than 10 knots after sunset. Haze and suspended dust reduced visibilities to 7-9 km, but visibilities in rainshowers were as low as 4,800 meters. High temperatures were 27-35° C; lows, 18-22° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***7 November:*** Figure 2-11 (next page) shows an area of rainshowers and thick cloudiness over all of Iraq and the northwest and north-central parts of Saudi Arabia.

**Figure 2–11. DMSP Thermal, 7 November 1990, 1446Z.** An area of rainshowers and thick cloud covers Iraq, as well as the northwest and north-central parts of Saudi Arabia.

***8 November:*** Figure 2-12 (next page) shows rainshowers and thick clouds over Iraq and northern Saudi Arabia.

***9 November:*** Haze and suspended dust haze reduced afternoon visibilities over western Saudi Arabia to 5-7 km. Blowing sand and dust reduced afternoon visibilities to 4,800 meters over northwestern Saudi Arabia.

***10 November:*** Fog reduced early morning visibilities to 4,800 meters over eastern Saudi Arabia. Blowing sand and dust reduced afternoon visibilities to 4,800 meters along the Saudi Arabia-Iraq border. Evening fog reduced visibilities to 4,800 meters over northwestern Saudi Arabia.

***11 November:*** Haze reduced morning visibilities to 4,800 meters over north-central Saudi Arabia. Figure 2-13 on Page 2-27 shows an area of thunderstorms in eastern Iraq; tops are about 30,000 feet. Broken ceilings with bases at 4,000 feet formed during the afternoon and evening over northwestern Saudi Arabia and western Iraq. An overcast ceiling with bases at 2,000 feet developed during the evening over northeastern Saudi Arabia.

***12 November:*** Blowing sand and dust reduced afternoon visibilities to 4,800 meters over northeastern Saudi Arabia.

***13 November:*** Blowing sand and dust reduced morning visibilities to 4,800 meters over northeastern Saudi Arabia. Figure 2-14 on Page 2-28 shows an area of rainshowers over the northern part of the Persian Gulf. Blowing sand and dust reduced afternoon visibilities to 4,800 meters over northwestern Saudi Arabia. Blowing and suspended dust reduced evening visibilities to 4,000 meters over central Saudi Arabia.

## DESERT SHIELD 14-25 November 1990

**General Weather.** High pressure continued to dominate. The subtropical jet stream brought mid- and upper-level moisture across northern Saudi Arabia. Skies were clear to scattered with occasional broken ceilings at 20,000 feet over northern Saudi Arabia and Iraq. Winds were northwesterly at 5-15 knots, occasionally 25 knots, through the 19th, then southeasterly at 5-15 knots from the 20th to the 25th. Haze

and suspended dust reduced visibilities to 7-9 km. High temperatures were 22-30° C; lows, 13-20° C. The western mountains of Saudi Arabia were 5-10° cooler.

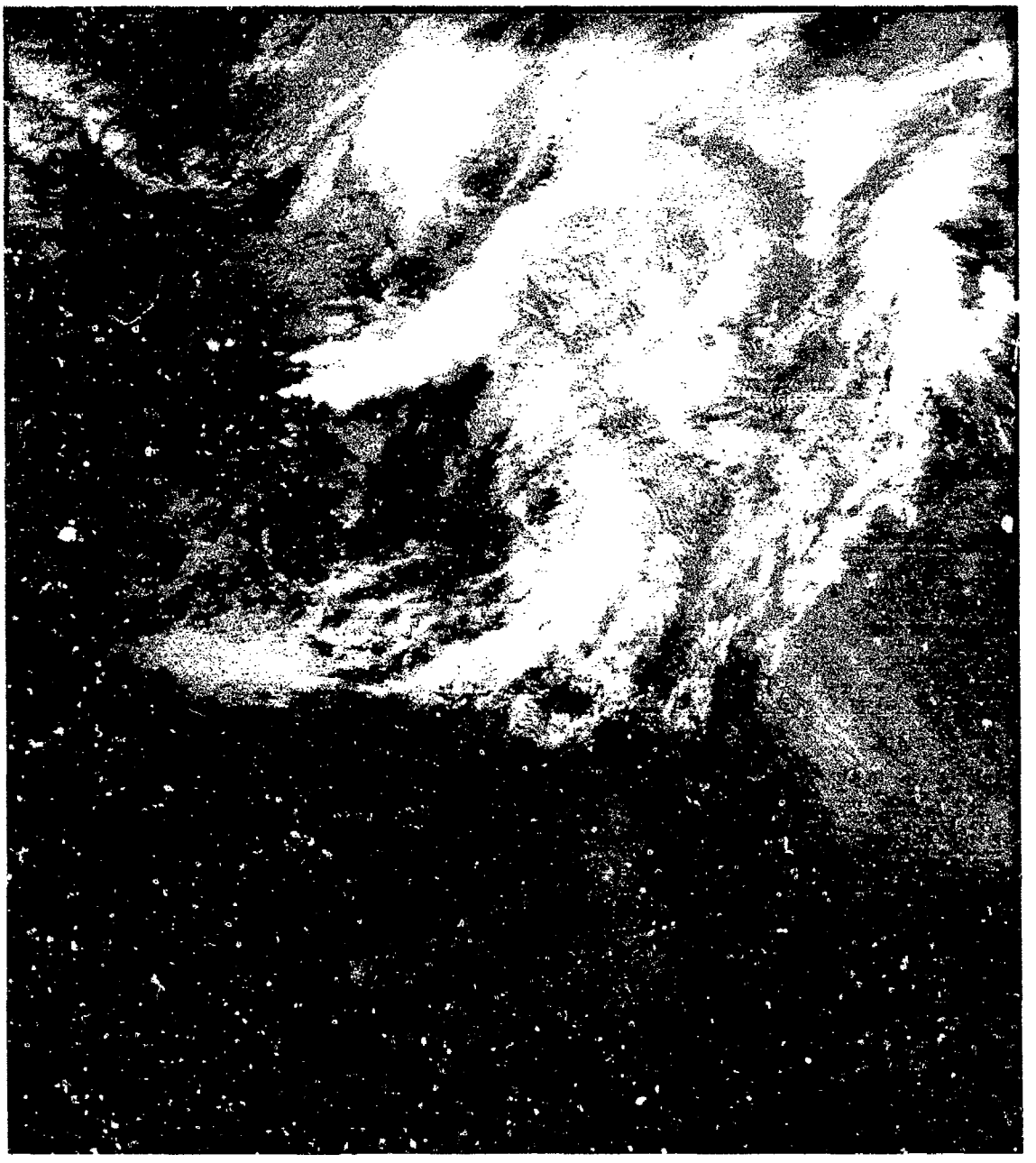


**Figure 2–12. DMSP Thermal, 8 November 1990, 0240Z.** Rainshowers and thick clouds over Iraq and northern Saudi Arabia.

**Figure 2–13. DMSP Thermal, 11 November 1990, 1733Z.** An area of thunderstorms covers eastern Iraq; tops are about 30,000 feet.

**Figure 2–14. DMSP Visual, 13 November 1990, 0502Z.** An area of rainshowers covers the northern part of the Persian Gulf.

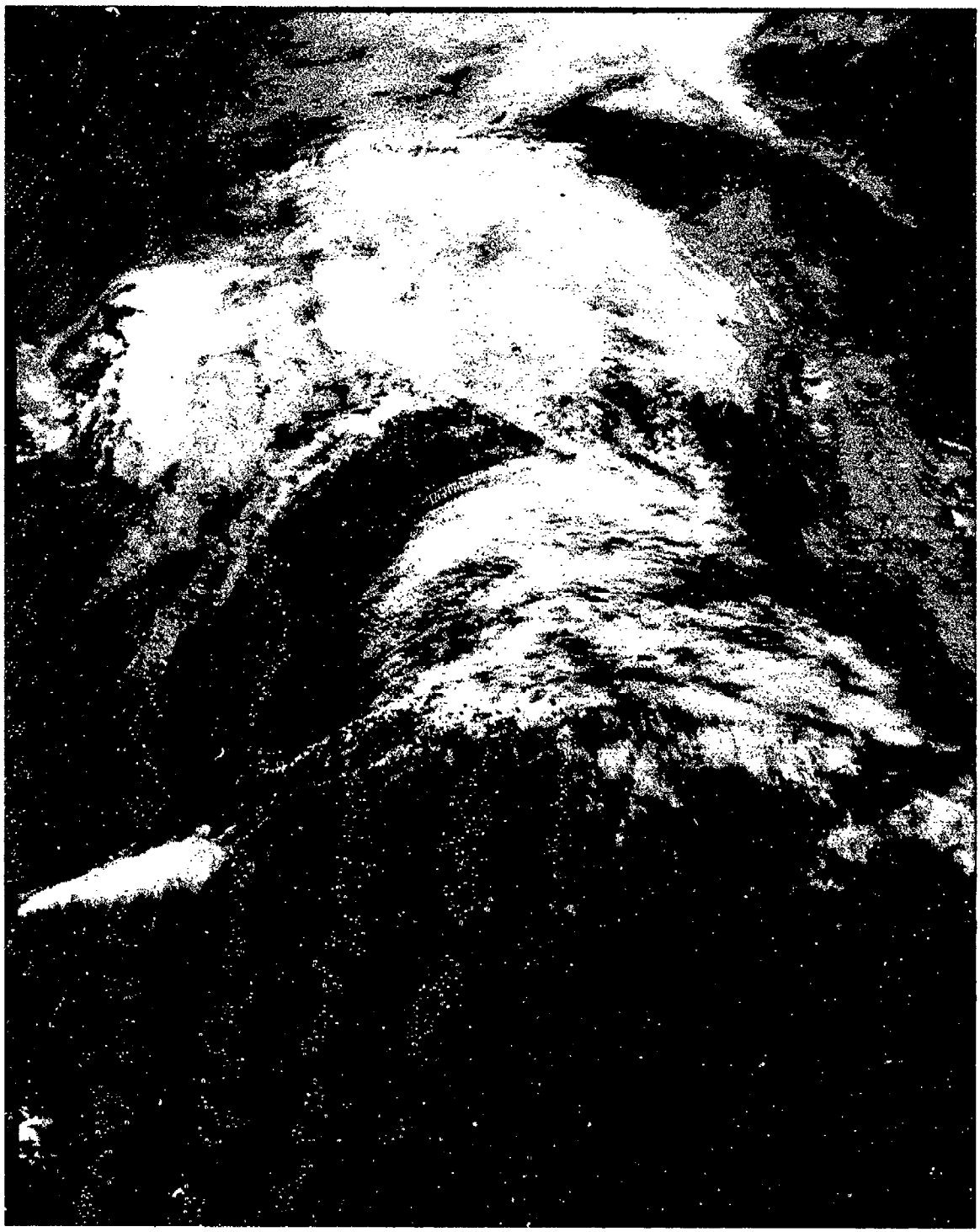


**Figure 2–15. DMSP Thermal, 20 November 1990, 0318Z.** Middle and high cloudiness with 10,000-12,000 feet ceilings covers Iraq and northern Saudi Arabia--clouds persisted until the 22nd.

**Significant Weather Events**

***14 November:*** Suspended dust reduced morning and afternoon visibilities to 4,800 meters over northwestern Saudi Arabia; dust also reduced visibilities in north-central Saudi Arabia to 4,800 meters in the afternoon.

***15-16 November:*** Suspended dust reduced morning and afternoon visibilities to 4,800 feet in western Saudi Arabia.

***18 November:*** Suspended dust reduced morning visibilities to 400 meters in eastern Saudi Arabia.

***19-21 November:*** Figure 2-15 on Page 2-29 shows middle and upper cloudiness with 10,000-12,000 feet ceilings over Iraq and northern Saudi Arabia on the evening of the 19th--it persisted until the 22nd.

***20 November:*** Blowing sand and dust reduced afternoon visibilities to 4,800 meters in north-central Saudi Arabia.

***21 November:*** Fog forming in late evening over eastern Saudi Arabia reduced visibilities from 4,800 to 2,000 meters by early morning of the 22nd.

***22 November:*** Suspended dust reduced mid-morning visibilities to 4,800 meters in north-central Saudi Arabia.

***24-25 November:*** Fog reduced early morning visibilities to 400-800 meters along the Saudi Arabian coast of the Persian Gulf.

**DESERT SHIELD 26-30 November 1990**

**General Weather.** High pressure continued to dominate. The subtropical jet stream, along with low- and mid-level flow, brought increased moisture from the Mediterranean to Iraq and northern Saudi Arabia. Cloud cover increased--ceilings were generally 8,000-12,000 feet, but 3,000-5,000 feet with daily thunderstorms and rainshowers over Iraq and the Persian Gulf. Ceilings over north-central Saudi Arabia were below 1,000 feet on the 26th, 29th and 30th. Thunderstorm tops reached 30,000 to 40,000 feet. Winds were easterly to southeasterly at 5-15 knots, except on 27 and 28 November, when they were westerly to northwesterly at 5-15 knots with

occasional gusts to 25 knots. Haze and suspended dust reduced visibilities to 7-9 km generally, but to as low as 3,200 meters in rainshowers. High temperatures were 22-30° C; lows, 13-20° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***26 November:*** Fog reduced early morning visibility to 400-800 meters along the Saudi Arabian coast of the Persian Gulf. Figure 2-16 on Page 2-32 shows broken middle and high clouds over Iraq and northern Saudi Arabia. Rainshowers and thundershowers fell over Iraq and the Persian Gulf; bases were as low as 3,000 feet with tops to 40,000 feet.

***27 November:*** Light rain and drizzle fell during early morning over north-central and northeastern Saudi Arabia. Rainshowers and thundershowers again fell over Iraq and the Persian Gulf; bases were as low as 3,000 feet with tops to 40,000 feet.

***28 November:*** Figure 2-17 on Page 2-33 shows an area of thunderstorms over the northern part of the Persian Gulf. Rainshowers and thundershowers still fell over Iraq and the Persian Gulf; bases were as low as 3,000 feet with tops to 40,000 feet.

***29 November:*** Fog reduced early morning visibilities to 4,000 meters over central Saudi Arabia. A broken ceiling at 2,000-4,000 feet formed over central and eastern Saudi Arabia, but lifted by afternoon. Haze reduced mid-morning visibilities to 4,800 meters over eastern Saudi Arabia. Rainshowers and thundershowers continued to fall over Iraq and the Persian Gulf; bases were as low as 3,000 feet with tops to 40,000 feet.

***30 November:*** Figure 2-18 on Page 2-34 shows an area of low ceilings over northern Saudi Arabia and southern Iraq. Rainshowers and thundershowers were still falling over Iraq and the Persian Gulf; bases were as low as 3,000 feet with tops to 40,000 feet.

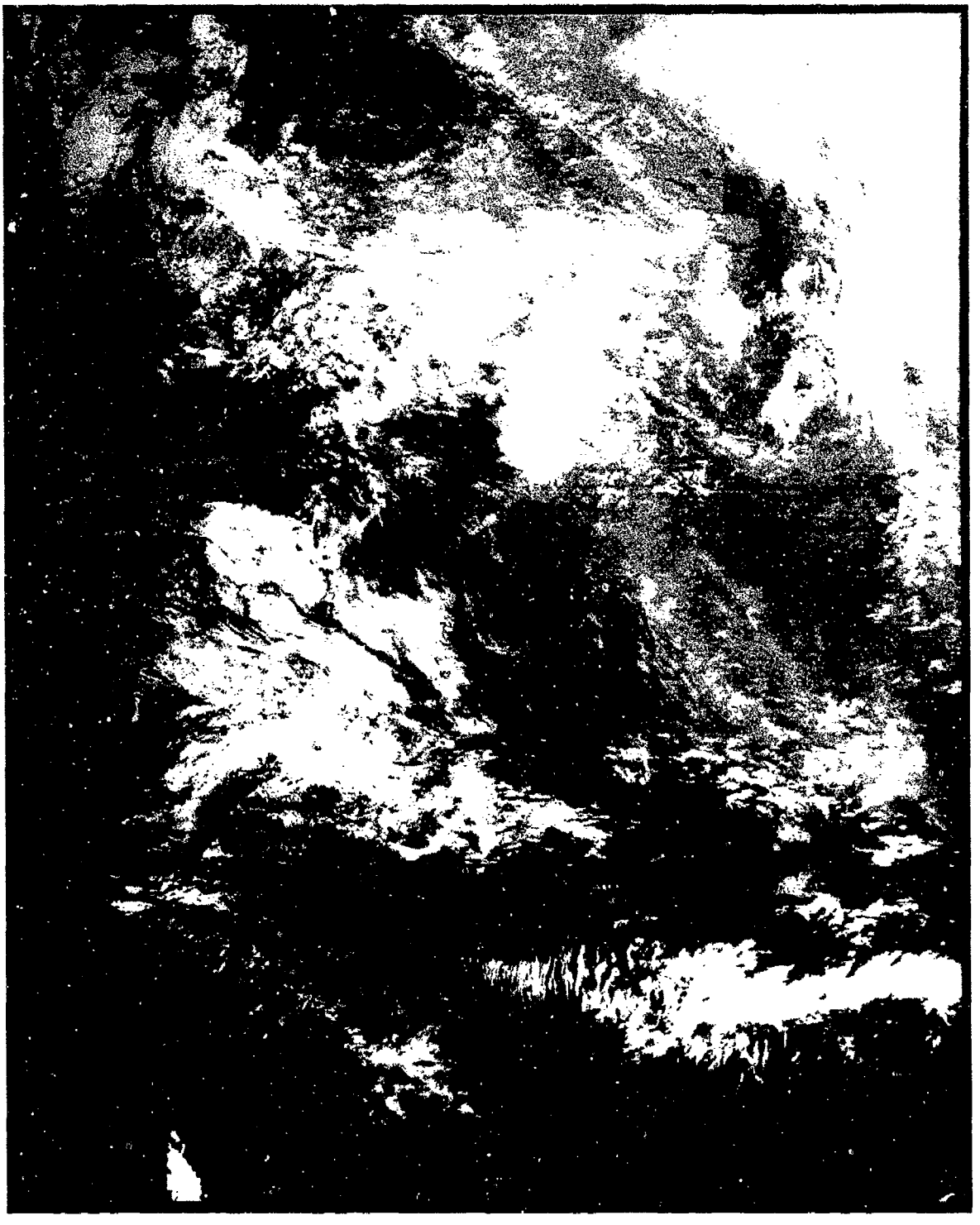


**Figure 2–16. NOAA Thermal, 26 November 1990, 1426Z.** Broken middle and high clouds cover Iraq and northern Saudi Arabia.

**Figure 2–17. DMSP Thermal, 28 November 1990, 0310Z.** An area of thunderstorms is shown over the northern part of the Persian Gulf.

**Figure 2–18. NOAA Visual, 30 November 1990, 1034Z.** An area of low ceilings covers northern Saudi Arabia and southern Iraq.

## DESERT SHIELD 1-6 December 1990

**General Weather.** High pressure continued to dominate, but the subtropical jet stream brought low- and mid-level moisture to Iraq and northern Saudi Arabia from the Mediterranean. Skies were scattered to broken. Ceilings were generally 8,000-12,000 feet, but 3,000-5,000 feet in isolated rainshowers falling in Iraq. Winds were normally northwesterly at 5-15 knots, with occasional gusts to 25 knots, but on 3-6 December they were from the east and southeast at 5-10 knots. Haze and suspended dust reduced visibilities to 7-9 km generally, but to 4,800 meters in showers. High temperatures were 18-25° C; lows, 5-12° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***1 December:*** Fog reduced early morning visibilities to 1,600-3,200 meters along the Saudi Arabian coast of the Persian Gulf.

***2 December:*** Fog reduced early morning visibilities to 2,000 meters in northwestern Saudi Arabia and to 3,200-6,000 meters along the Saudi Arabian coast of the Persian Gulf. Blowing sand and dust reduced afternoon visibilities to 5-7 km in Kuwait and in northeastern Saudi Arabia. Figure 2-19 on Page 2-37 shows evening rainshowers over west-central Iraq.

***3 December:*** Figure 2-20 on Page 2-38 shows morning rainshowers over central Iraq.

***4 December:*** Fog reduced early morning visibilities to 800 meters over eastern Saudi Arabia.

***5-6 December:*** Fog reduced early morning visibilities to 1,600 meters, but there were isolated areas of less than 100 meters in eastern Saudi Arabia and Kuwait. Visibilities improved to 4,800 meters by mid-afternoon.

## DESERT SHIELD 7-19 December 1990

**General Weather.** High pressure continued to dominate. Sky cover was limited to scattered middle and upper cloudiness over Iraq and northern Saudi Arabia, but broken

middle and high clouds with bases of 10,000-12,000 feet from the subtropical jet stream were observed over Iraq on 8 and 9 December (see Figure 2-21 on Page 2-39) and over northeastern Saudi Arabia and Iraq on 13-16 December. Winds were southerly to southwesterly at 5-15 knots over Saudi Arabia, but northwesterly at 5-15 knots, with occasional gusts to 25 knots, over the rest of the region. Winds after sunset were less than 10 knots. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 20-29° C; lows, 5 to 12° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***7-9 December:*** Fog reduced early morning visibilities to 4,000 meters, but there were scattered areas of 400-800 meters in eastern Saudi Arabia and Kuwait. Ceilings of 500 feet were reported over southeastern Iraq, Kuwait, and in localized areas of eastern Saudi Arabia during early morning.

***10 December:*** Fog reduced early morning visibilities to 800 meters in northeastern Saudi Arabia and to 1,600 meters in Kuwait. Isolated areas of blowing sand and dust reduced afternoon visibilities to 800-1,200 meters in Iraq and to 4,800 meters in eastern Saudi Arabia.

***11-14 December:*** Ceilings of 1,000-2,000 feet developed after midnight over eastern and east-central Saudi Arabia, but dissipated after sunrise.

***11 December:*** Haze reduced mid-morning visibilities to 4,800 meters over central Saudi Arabia.

***12-15 December:*** Fog reduced early morning visibilities to 800-1,600 meters over eastern and central Saudi Arabia.

***13 December:*** Blowing sand and dust reduced afternoon visibilities to 5-7 km, with isolated areas of 3,200 meters in Iraq and northwest to north-central Saudi Arabia.

***14 December:*** Blowing sand and dust reduced afternoon visibilities to 800 meters over northeastern Saudi Arabia.

**Figure 2–19. DMSP Thermal, 2 December 1990, 1837Z.** The imagery shows evening rainshowers over west-central Iraq.

**Figure 2–20. DMSP Visual, 3 December 1990, 0626Z.** Morning rainshowers are shown over central Iraq.

**Figure 2–21. DMSP Visual, 9 December 1990, 0600Z.** Sky cover was limited to middle and high scattered cloudiness over Iraq and northern Saudi Arabia, but broken middle and high clouds with bases of 10,000-12,000 feet from the subtropical jet stream were observed over Iraq on 8 and 9 December, as shown here.

***15 December:*** Haze, along with blowing sand and dust, reduced afternoon visibilities to 5-7 km generally, but there were isolated reports of 1,600-3,200 meters in east and northeast Saudi Arabia.

***16-17 December:*** Blowing sand and suspended dust reduced afternoon visibilities to 4,800 meters in northeastern Saudi Arabia.

***18-19 December:*** Fog reduced early morning visibilities to 3,200-4,800 meters along the Saudi Arabian Persian Gulf coast.

**DESERT SHIELD 20-23 December 1990**

**General Weather.** High pressure continued to dominate Saudi Arabia, while a weak low-pressure system in the eastern Mediterranean increased cloud cover over Iraq. Broken low and middle clouds with ceilings of from 2,000-4,000 feet to 10,000-12,000 feet were observed over Iraq and northern Saudi Arabia. Isolated light rainshowers fell over Iraq on 20 and 21 December. Light rain fell over northwestern and north-central Saudi Arabia on 23 December. Winds were easterly at 5-15 knots over central Saudi Arabia, but westerly to northwesterly at 5-15 knots and occasional gusts to 25 knots over the rest of the region. Winds dropped to less than 10 knots after sunset. Haze and suspended dust reduced visibilities to 7-9 km. High temperatures were 18-25° C; lows, 3-10° C. The western mountains of Saudi Arabia were 5-10° cooler.

**Significant Weather Events**

***20 December:*** Blowing sand and dust reduced afternoon visibilities to 3,200 meters in northern Saudi Arabia. Figure 2-22 shows isolated rainshowers and extensive cloud cover at all levels over Iraq.

***21 December:*** Figure 2-23 on Page 2-42 shows isolated rainshowers and low to middle ceilings over northern and eastern Iraq and Kuwait. Blowing sand and dust reduced morning visibilities to 4,800 meters in northeastern Saudi Arabia; afternoon and evening visibilities in east-central and central Saudi Arabia were 4,000 meters, with isolated reports of 800 meters.

**Figure 2–22. DMSP Thermal, 20 December 1990, 0314Z.** Isolated rainshowers and extensive cloud cover are shown at all levels over Iraq.

**Figure 2–23. DMSP Thermal, 21 December 1990, 0302Z.** Isolated rainshowers, along with low and middle cloud cover, are shown over northern and eastern Iraq and Kuwait.

***22 December:*** Fog reduced early morning visibilities to 1,600 meters in parts of east-central Saudi Arabia. Figure 2-24 (next page) shows low and middle cloud cover over northern Iraq. Blowing sand and dust reduced afternoon visibilities to 5-7 km in north-central Saudi Arabia.

***23 December:*** Fog reduced early morning visibilities to 1,600 meters in east-central Saudi Arabia. Ceilings at 300 feet formed during early morning over east-central Saudi Arabia, but dissipated by mid-morning.

**DESERT SHIELD** **24 December 1990**

**General Weather.** High pressure dominated Saudi Arabia as a weak frontal system moved through Iraq. Broken middle and upper clouds with ceilings at 10,000-12,000 feet were observed over Iraq, Kuwait and northern Saudi Arabia--see Figure 2-25 on Page 2-45. Light rain fell over western and eastern Iraq. Winds were southwesterly at 10-15 knots over central Saudi Arabia and Iraq, and northwesterly at 10-15 knots elsewhere. Haze and suspended dust reduced visibilities to 7-9 km generally, but lower (5-7 km) in rain over Iraq. Early morning fog lowered visibility to 1,600 meters in east-central Saudi Arabia. Blowing sand and dust reduced evening visibilities to 1,600 meters over northwestern Saudi Arabia. High temperatures were 18-25° C; lows, 3-10° C. The western mountains of Saudi Arabia were 5-10° cooler.

**DESERT SHIELD** **25-31 December 1990**

**General Weather.** High pressure continued to dominate Saudi Arabia as several weak mid-level disturbances pushed through Iraq, producing light rain and drizzle. Broken middle and high clouds with 10,000-12,000 foot ceilings formed over Iraq and northern Saudi Arabia. Light rain and drizzle fell over northwestern and western Saudi Arabia on the evening of 25 December, and in north-central, northwestern, and western Saudi Arabia on 31 December. Winds were southwesterly at 10-15 knots over central Saudi Arabia and northwesterly at 10-15 knots elsewhere, with occasional gusts to 25 knots. Speeds dropped below 10 knots at night. Haze and suspended dust reduced visibilities to 7-9 km, but lower (5-7 km) in rain and drizzle. High temperatures were 18-25° C; lows, 3-10° C. Western Saudi Arabia was 5-10° cooler.

**Figure 2–24. DMSP Thermal, 22 December 1990, 0430Z.** Low and middle cloudiness is shown over northern Iraq.

**Figure 2–25. NOAA Visual, 24 December 1990, 1111Z.** Broken middle and high cloud decks with ceilings at 10,000-12,000 feet are shown over Iraq, Kuwait, and northern Saudi Arabia

**Significant Weather Events**

***25 December:*** Blowing sand and dust reduced afternoon visibilities to 4,000 meters in northeastern and eastern Saudi Arabia; there were isolated reports of 1,000 meters.

***26 December:*** Figure 2-26 shows middle and high cloud cover over northern Saudi Arabia, southern Iraq, and Kuwait. Blowing sand and dust reduced afternoon visibilities over northeastern Saudi Arabia to 3,200-4,800 meters.

***27 December:*** Fog reduced early morning visibility to 1,600-3,200 meters along the Saudi Arabian Persian Gulf coast and to 4,800 meters in east-central Saudi Arabia. A 1,500-foot ceiling formed in early morning over east-central Saudi Arabia, but dissipated by late morning. Blowing sand and dust reduced afternoon visibilities in east-central and eastern Saudi Arabia to 5-7 km.

***28 December:*** Fog reduced early morning visibilities to 1,600-3,200 meters along the Saudi Arabian Persian Gulf coast. Blowing sand and dust lowered afternoon visibilities to 4,800 meters in northeastern Saudi Arabia.

***29-31 December:*** Fog reduced early morning visibilities to 1,600-3,200 meters in Kuwait and along the Saudi Arabian Persian Gulf coast.

***31 December:*** Light rain fell during the afternoon and evening over northwestern Saudi Arabia.

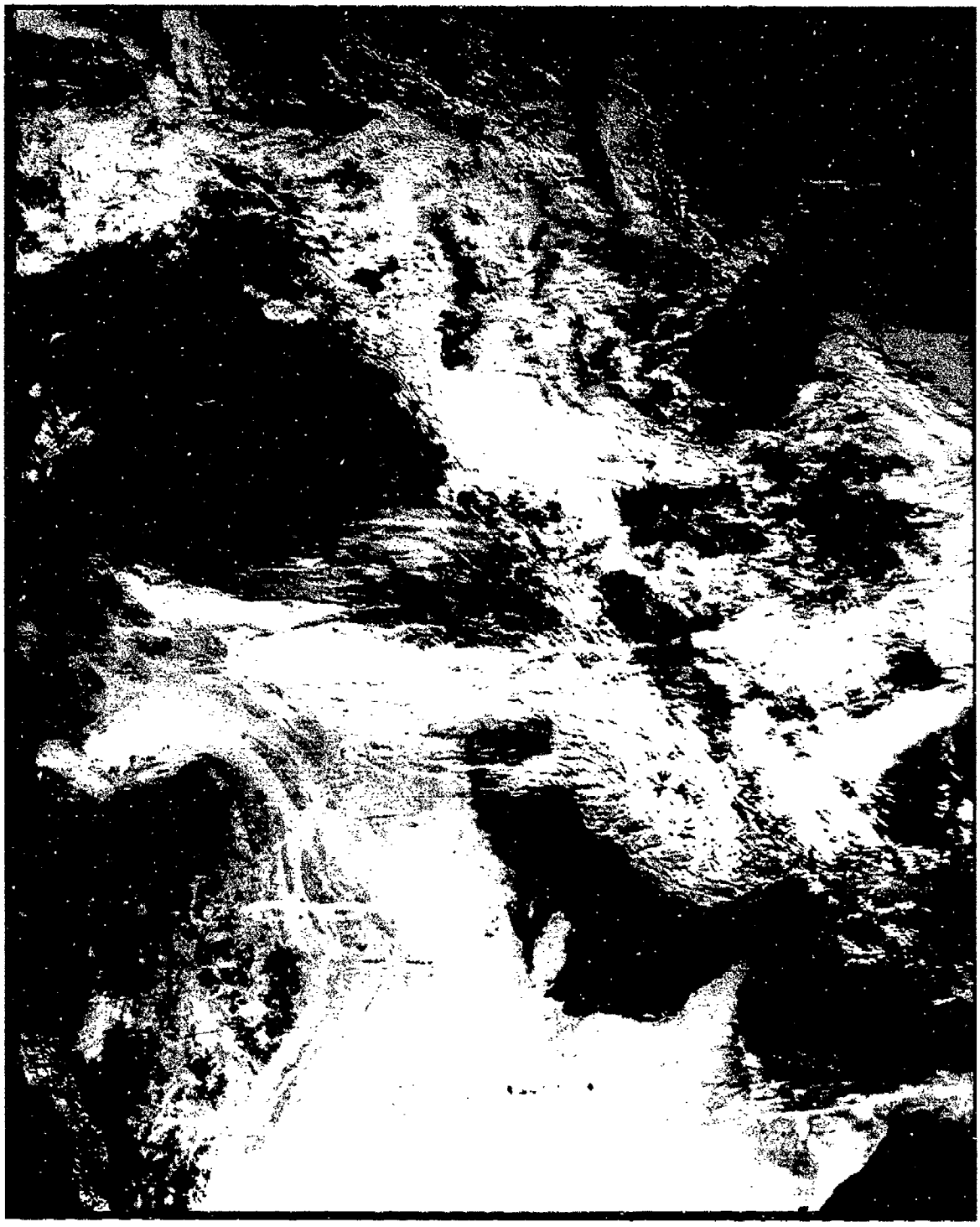


**Figure 2 26. NOAA Visual, 26 December 1990, 1048Z.** Middle and high clouds cover northern Saudi Arabia, southern Iraq, and Kuwait.

**DESERT SHIELD** **1 January 1991**

**General Weather.** High pressure continued to dominate Saudi Arabia, but the subtropical jet stream brought Mediterranean moisture into northern and central Saudi Arabia and Iraq. Sky cover consisted of broken middle and high clouds with ceilings of 10,000-12,000 feet over Iraq and northern Saudi Arabia. Ceilings lowered to 3,000-5,000 feet in precipitation. Light rain and drizzle fell over western Iraq and western, northwestern, and north-central Saudi Arabia. Winds were southerly to southwesterly at 10-15 knots with occasional gusts to 25 knots, but less than 10 knots at night. Haze and suspended dust reduced visibilities to 7-9 km. Visibilities dropped to 5-7 km in precipitation, with isolated reports of 1,600 meters. Blowing sand and dust reduced afternoon visibilities to 3,200 to 4,800 meters in north-central, east-central, and northeastern Saudi Arabia and Kuwait. High temperatures were 18-25° C; lows, 3-10° C.

**DESERT SHIELD** **2 January 1991**

**General Weather.** High pressure still dominated Saudi Arabia as a frontal system pushed through Iraq and northern Saudi Arabia. Skies were broken to overcast with middle and high clouds. Ceilings were 10,000-12,000 feet, but occasionally 4,000-6,000 feet. There were isolated reports of 1,500- to 2,000-foot ceilings over Iraq and northern and central Saudi Arabia--see Figure 2-27. Ceilings near thunderstorms were 4,000-6,000 feet--tops approached 35,000 feet. Light rain, drizzle, and isolated thunderstorms and rainshowers fell over central and southern Iraq, northern and central Saudi Arabia, and Kuwait. Winds changed from southerly to southwesterly at 10-15 knots to westerly to northwesterly at 10-15 knots as the front passed. There were occasional gusts to 25 knots. Speeds dropped to less than 10 knots at night. Visibilities in precipitation were to 5-7 km. Fog reduced mid-morning visibilities to 3,200 meters in north-central Saudi Arabia, but only to 4,800 meters in the northeast. Blowing sand and dust reduced afternoon visibilities to 400 to 800 meters in northern Saudi Arabia ahead of the front. Blowing sand and dust reduced afternoon visibilities to 4,800 meters and evening visibilities to 2,000 meters in east-central Saudi Arabia. High temperatures were 18-25° C; lows, 3-10° C.

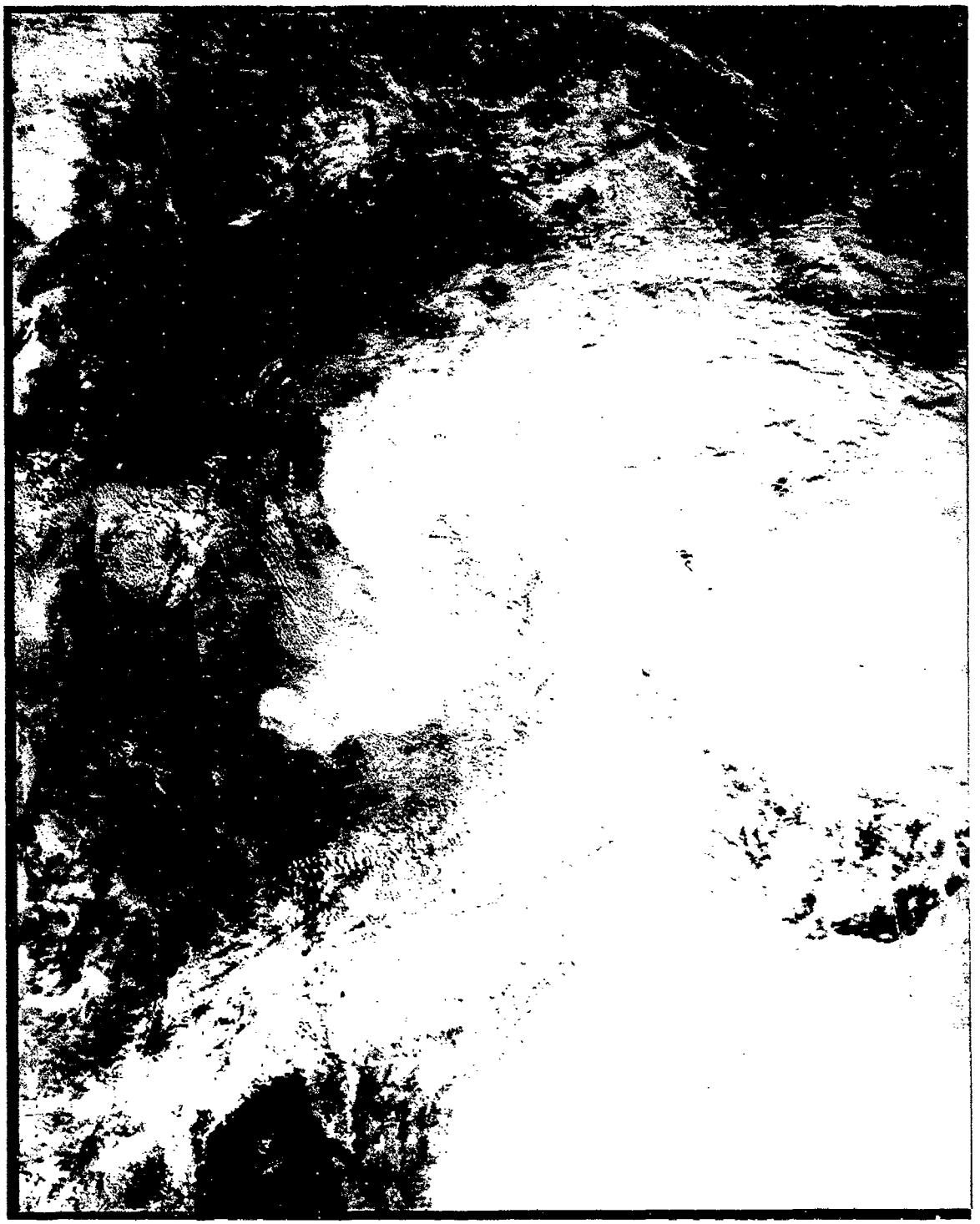


**Figure 2–27. DMSP Visual, 1 January 1991, 0621Z.** Middle and high clouds were broken to overcast with bases from 10,000 to 12,000 feet. Ceilings were occasionally 4,000-6,000 feet, with isolated reports of 1,500-2,000 feet over Iraq and northern and central Saudi Arabia.

**General Weather.** Although high pressure dominated Saudi Arabia, cloud cover was extensive. Broken to overcast low and middle clouds, with ceilings at 1,000 feet, prevailed during morning hours, with middle cloud ceilings of 10,000-12,000 in the afternoons and evenings. Light precipitation fell over northwestern and north-central Saudi Arabia and western Iraq on 4 January and along the Saudi Arabian Persian Gulf coast on the 5th and 9th. Winds were westerly to northwesterly at 10-15 knots with occasional gusts to 25 knots, becoming easterly to southeasterly from the 7th to the 9th. Speeds dropped to less than 10 knots at night. Visibilities in precipitation were limited to 5-7 km. High temperatures were 14-22° C; lows, 3-10° C.

**Significant Weather Events**

***3 January:*** Suspended dust reduced morning visibilities to 4,800 meters in eastern Saudi Arabia. Fog lowered mid-morning visibilities to 3,200 meters in western and north-central Saudi Arabia and to 200 meters in northwestern Saudi Arabia. Figure 2-28 shows thick low, middle, and high clouds over northeast and eastern Saudi Arabia, Kuwait, and southeastern Iraq.

***4 January:*** Fog reduced early morning visibilities as low as 800 meters on the Saudi Arabian Persian Gulf coast and in Kuwait. Visibilities in Kuwait were still 5-7 km through mid-afternoon. Blowing sand and dust reduced visibilities to 5-7 km in western Saudi Arabia.

***5 January***: Fog lowered early morning visibilities to 1,600-3,200 meters on the Saudi Arabian Persian Gulf coast and in Kuwait, and to 4,800 meters in east-central Saudi Arabia. Visibilities in Kuwait were 5-7 km through mid-afternoon. Fog reduced mid-morning to afternoon visibilities to 4,800 meters in north-central and northeastern Saudi Arabia. Figure 2-29 on Page 2-52 shows thick low and middle clouds over southwestern and central Iraq and northwestern Saudi Arabia. Suspended dust and haze reduced afternoon visibilities to 5-7 km in central Saudi Arabia.

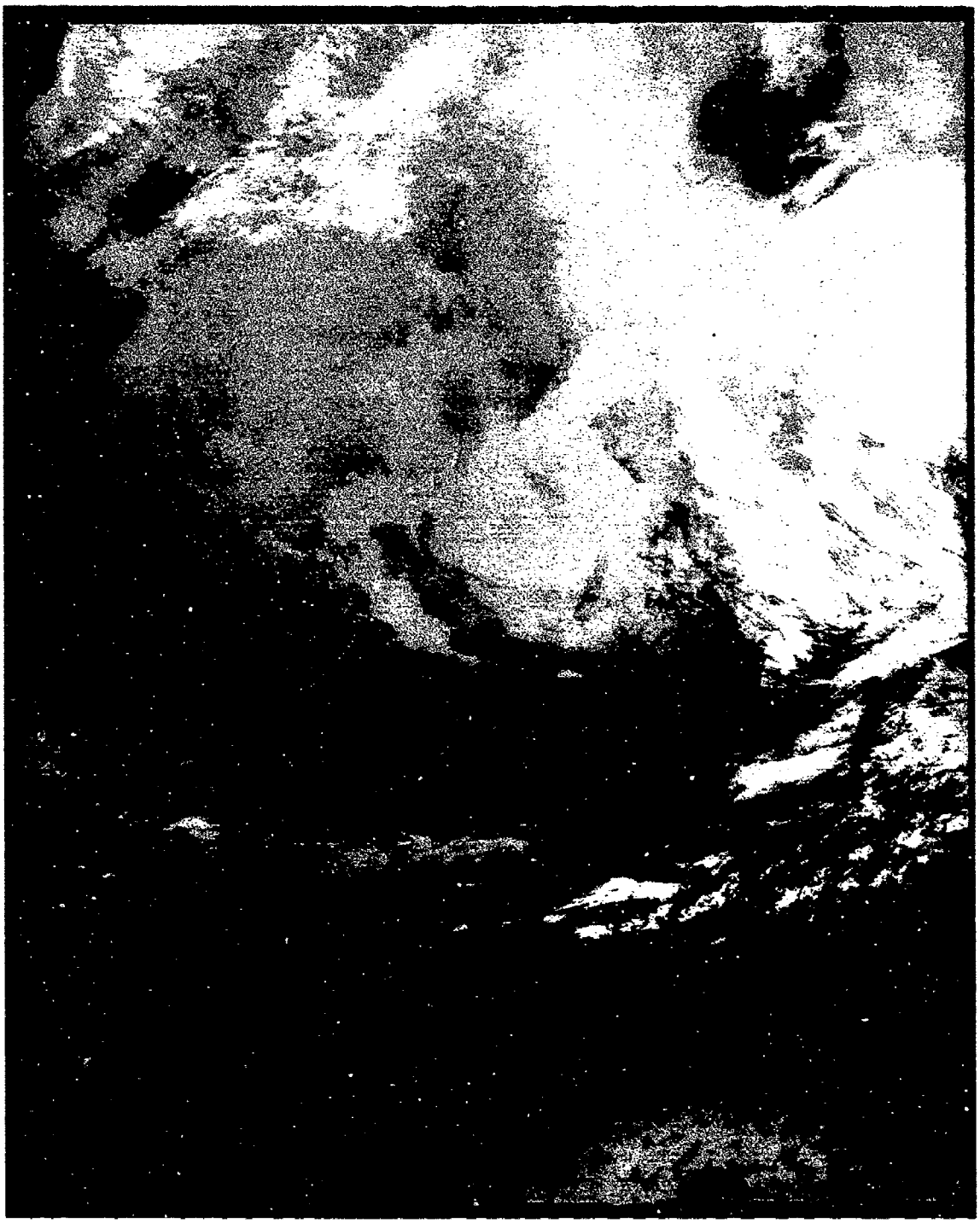


**Figure 2–28. DMSP Thermal, 3 January 1991, 0538Z.** Thick low, middle, and high clouds are shown over northeast and eastern Saudi Arabia, Kuwait, and southeastern Iraq.

**Figure 2–29. NOAA Visual, 5 January 1991, 1037Z.** Thick low and middle clouds are shown over southwestern and central Iraq and northwestern Saudi Arabia.

***6 January:*** Fog lowered early morning visibilities to 1,600-3,200 meters on the Saudi Arabian Persian Gulf coast and in Kuwait. In northwest and north-central Saudi Arabia, fog reduced early morning visibilities to as low as 2,000 meters, with isolated reports of 100 meters. Blowing sand and dust reduced afternoon visibilities to 5-7 km in western Saudi Arabia.

***7 January:*** Fog lowered early morning visibilities to 1,600-3,200 meters along the Saudi Arabian Persian Gulf coast and in Kuwait.

***8 January:*** Fog reduced early morning visibilities to 400-800 meters on the Saudi Arabian Persian Gulf coast and Kuwait.

***9 January:*** Fog decreased early morning visibilities to 1,600-3,200 meters in northern Saudi Arabia, the Saudi Arabian gulf coast, southeastern Iraq, and Kuwait, with isolated reports of 400 meters. Blowing sand and dust reduced evening visibilities to 4,800 meters (with isolated reports of 1,600 meters) in northeastern and east-central Saudi Arabia.

***10 January:*** Fog reduced early morning visibilities to 400-800 meters in north-central Saudi Arabia, along the Saudi Arabian Persian Gulf coast, and in Iraq and Kuwait. Haze and suspended dust reduced afternoon visibilities to 4,800 meters across central Saudi Arabia.

## DESERT SHIELD 11-14 January 1991

**General Weather.** High pressure moved to the southeastern part of the Saudi Arabian peninsula as a low-pressure system and associated frontal activity moved across southern Iraq and northern Saudi Arabia. Cloud coverage was extensive. Broken to overcast ceilings prevailed at 8,000-10,000 feet, occasionally lowering to 2,000-4,000 feet. There were isolated ceilings of 500 feet in precipitation. Light precipitation fell over central Saudi Arabia on 11 January and over north-central, central, eastern, and northeastern Saudi Arabia on 12 January. On 13 January, light rain fell over north, west, and eastern Saudi Arabia, southeastern Iraq, and Kuwait as isolated thunderstorms developed with tops to 30,000 feet. On 14 January, light rain and drizzle remained over central and

eastern Saudi Arabia. Thunderstorms with 30,000-foot tops were observed over Dhahran. Winds were easterly to southeasterly at 10-15 knots with occasional gusts to 25 knots, diminishing to less than 10 knots at night. Visibility in precipitation was limited to 5-7 km, with isolated reports of 800-1,600 meters in central Saudi Arabia on the 13th and 14th. High temperatures were 14-22° C; lows, 3-10° C.

**Significant Weather Events**

***11 January:*** Fog lowered early morning visibilities to 1,600-3,200 meters on the Saudi Arabian Persian Gulf coast and in southeast Iraq and Kuwait.

***12 January:*** Fog reduced early morning visibilities to 3,200-4,800 meters in east, central, and western Saudi Arabia. Blowing sand and dust reduced afternoon and evening visibilities to 2,000-4,800 meters in north-central Saudi Arabia.

***13 January:*** Fog lowered early morning to mid-afternoon visibilities to 3,200-4,800 meters (with isolated reports of 800 meters) in east and central Saudi Arabia. Suspended dust reduced early morning visibilities to 4,000 meters in north-central Saudi Arabia. Figure 2-30 on Page 2-56 shows thick low, middle, and high clouds across north and central Saudi Arabia, Iraq, and Kuwait. In northern Saudi Arabia, fog reduced visibilities to 400 meters from early evening until mid-morning the next day.

***14 January:*** In east-central Saudi Arabia, fog lowered early morning visibilities to 3,000 meters (with isolated reports of 200 meters), and to 3,000 meters in northwestern and northeastern Saudi Arabia.

**DESERT SHIELD** **15-16 January 1991**

**General Weather.** High pressure again dominated Saudi Arabia. On the 15th, cloud cover consisted of 1,000-foot ceilings over the northern Persian Gulf, broken ceilings at 7,000 feet over south-central Saudi Arabia, and scattered clouds elsewhere. But on 16 January, as the subtropical jet stream started bringing in mid- and upper-level moisture, broken middle cloud ceilings formed at 8,000-10,000 feet over northern and central Saudi Arabia and Iraq--see Figure 2-31

knots with occasional gusts to 25 knots, but less than 10 knots at night. Fog reduced early morning visibilities to 1,600-3,200 meters in southern and southeastern Iraq and Kuwait. High temperatures were 14-22° C; lows, 3-10° C.

**Figure 2–30. DMSP Thermal, 13 January 1991, 1547Z.** Thick low, middle, and high clouds are shown across north and central Saudi Arabia, Iraq, and Kuwait.

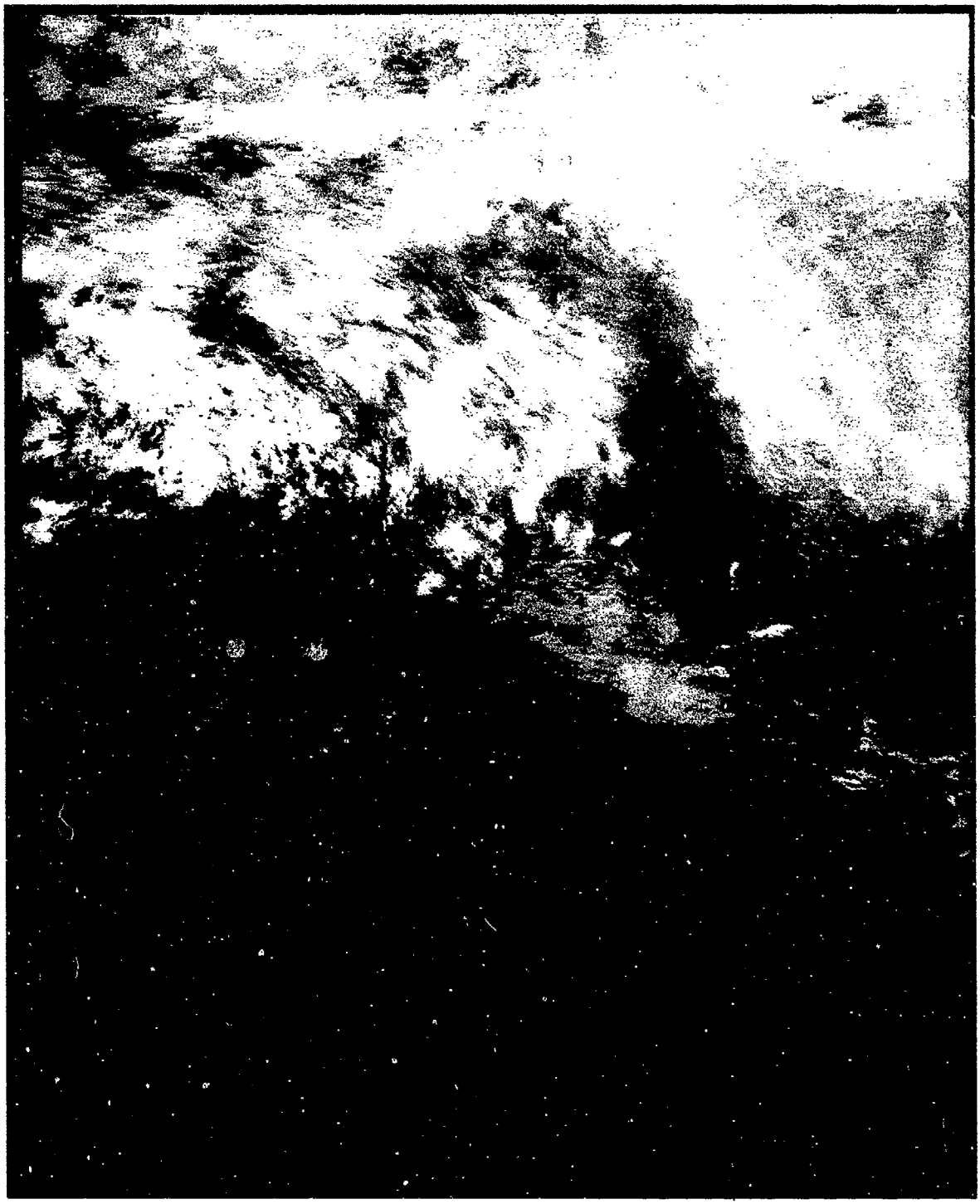


**Figure 2–31. DMSP Thermal, 16 January 1991, 1558Z.** Broken middle clouds with ceilings at 8,000 to 10,000 feet are shown over northern and central Saudi Arabia and Iraq.

# Chapter 3

# DESERT STORM WEATHER

17 January--2 March 1991

**General Weather.** With high pressure centered in north-central Saudi Arabia, a weak frontal system dragged across northern Iraq as the subtropical jet stream moved from Africa into northern Saudi Arabia. A fast-moving frontal system that had developed in Egypt moved into the area, causing widespread cloudiness. Figure 3-2 shows this system late in the day as it entered western Iraq.

**Area of Interest.** The weak frontal system in northern Iraq produced ceilings of 8,000 feet. An area of fog and low clouds in east-central Saudi Arabia and the United Arab Emirates, fed by moisture from the Persian Gulf, is shown in Figure 3-1. It dissipated gradually during the day. High clouds from Egypt moved in rapidly--ceilings were 20,000-25,000 feet early in the morning, becoming 10,000-15,000 feet by the end of the day. In late afternoon, 5,000-foot ceilings entered north-central Saudi Arabia from the Red Sea near Jeddah. Morning ground fog in north-western Saudi Arabia and western Iraq dropped visibilities to as low as 3,200 meters. Blowing sand and suspended dust lowered afternoon visibilities in north-central Saudi Arabia to 3,200 meters.

**Area of Intense Interest.** There was extensive early morning cloud cover over the entire area. Baghdad and the rest of Iraq north of 30° N was broken to overcast with ceilings from 12,000 to 25,000 feet, but the clouds moved out of the area by 1200Z. Skies over Kuwait and the rest of the area south of 30° N were broken to overcast with ceilings of 3,000 feet, becoming scattered near Rafha. These clouds gradually moved southward during the day as their bases raised to 8,000 feet. Broken to overcast high clouds from the approaching frontal system began to move in after 1200Z, quickly spreading over the entire area with ceilings from 20,000 to 25,000 feet. The high-cloud bases thickened and lowered to 10,000-15,000 feet by the end of the day.

Winds were from the south or southwest at 6-20 knots, becoming southeasterly after 1200Z and 3-12 knots after sunset.

Early-morning visibilities were as low as 3,200 meters with patchy ground fog in west-central Iraq. Blowing sand and suspended dust reduced visibility to 3,200 meters during the afternoon on the Saudi Arabia-Iraq border.

High temperatures were 13-22° C; lows, 6-10° C.

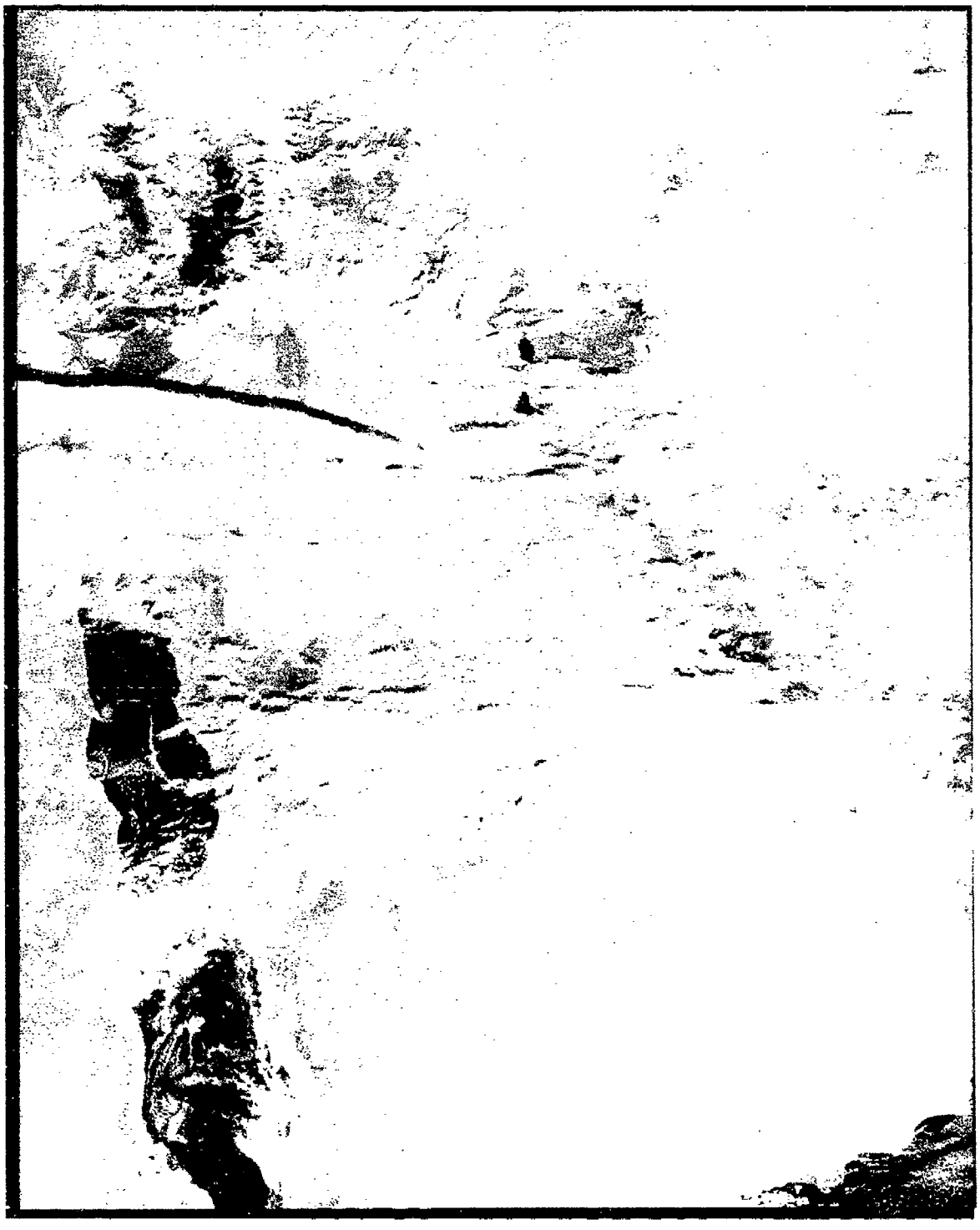


**Figure 3-1. DMSP Visual, 17 January 1991, 0555Z.** Fog and low clouds are visible in east central Saudi Arabia and the United Arab Emirates. The leading edge of the approaching frontal system can be seen over the northern Red Sea.

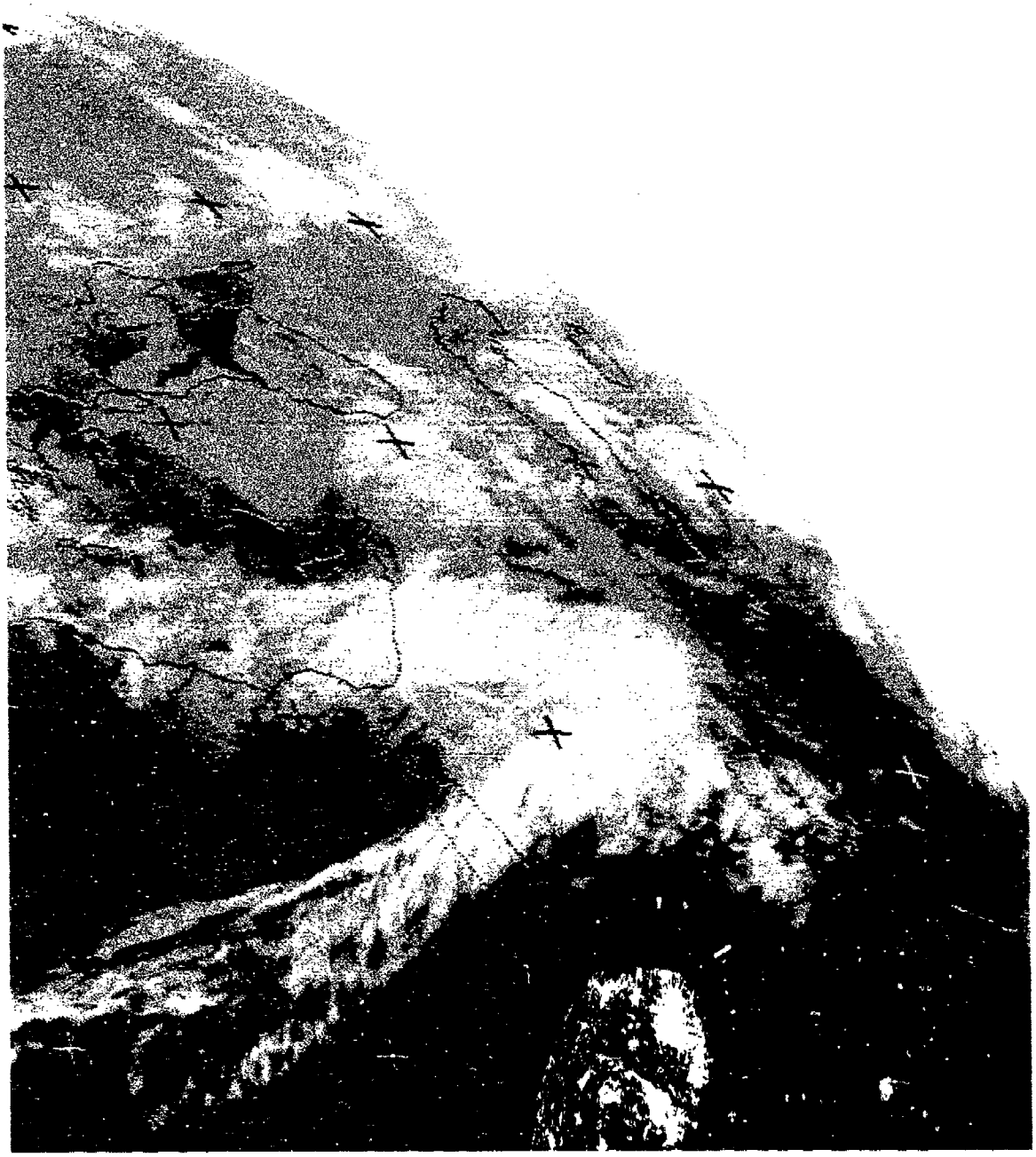


**Figure 3-2. METEOSAT IR, 17 January 1991, 2330Z.** A comma-shaped system spreads cloudiness over the area. The light gray clouds lying east-west at about 25° N are at 5,000 feet.

**General Weather.** High pressure dominated central Saudi Arabia, but a low-pressure system and an accompanying front raced across northwestern Saudi Arabia, most of Iraq, and Kuwait. The system became quasi-stationary along a line running from the northern Red sea to Kuwait and then to southeastern Iraq. This line also marked the subtropical jet stream axis. Another front moved across northern Iraq during the evening.

**Area of Interest.** Northern Iraq's 15,000-foot ceilings lowered to 8,000 feet through the morning and became scattered by 1200Z. A line of clouds associated with a weak front moved across northern Iraq in the evening, bringing 5,000-foot ceilings. In western Iraq and northwestern Saudi Arabia, 10,000 foot ceilings lowered rapidly to 4,000 feet; isolated areas of rain and ground fog lowered visibilities to 4,800 meters. Skies cleared over western Iraq by 1200Z and ceilings in northwestern Saudi Arabia rose to 20,000 feet. Clouds with 4,000-foot bases remained throughout the day from the Red Sea at Jeddah into north-central and north-eastern Saudi Arabia, where rain fell in the afternoon. Visibilities were 3,200 meters in rain and haze, with fog after sunset. In the rest of the area, skies were clear or high scattered. Occasional periods of blowing dust reduced visibilities to 4,800 meters in central Saudi Arabia.

**Area of Intense Interest.** The entire area was covered by clouds with bases of 10,000-15,000 feet--see Figure 3-3. These quickly lowered to 3,000 feet and, in some places, to as low as 1,500 feet. The western part of the area began clearing in the afternoon, but 200-foot ceilings formed throughout the area by the end of the day. Clouds were layered to 30,000 feet from central Iraq to southeastern Kuwait.

Light rain fell throughout the area, beginning as early as 0500Z and lasting past 1800Z in eastern Iraq.

Winds were east to southeasterly at 5-15 knots.

Visibilities were 5 km in morning ground fog and 3,200 meters in rain. After the rain passed, visibilities were as low as 4,800 meters in haze and fog, falling to 1,600 meters at the end of the day.

High temperatures were 16-22° C; lows, 08-13° C.

**Figure 3-3. NOAA Visual, 18 January 1991, 1133Z.** The subtropical jet stream and frontal system are visible across the Red Sea into northwestern Saudi Arabia, Iraq, and Kuwait. Clearing is evident in west-central Iraq.

**General Weather.** High pressure was centered in central Iraq and central Saudi Arabia. The subtropical jet stream continued across the northern Red Sea through Kuwait to southeastern Iraq. The stationary frontal system beneath the jet stream became active when an upper-air disturbance crossed it. A low-pressure cell developed and moved the front southward. Another weak low-pressure area formed in the eastern Mediterranean Sea.

**Area of Interest.** Skies in extreme northwestern Saudi Arabia, as well as in western and northern Iraq, were clear. The only exception was a broken 3,000-foot layer from the Mediterranean Sea that lingered all day along the Iraq-Jordan-Syria border. By 0300Z, fog and low clouds with bases of 500-1,000 feet reduced visibility to as low as 800 meters over northwestern Saudi Arabia, western Iraq, and most of northern Iraq. By 1200Z, these areas had cleared except along the northwestern Saudi Arabia-Iraq border, where low ceilings and visibilities persisted throughout the day. In northern Saudi Arabia eastward from 42° E, ceilings were 100-200 feet with visibilities near zero. At midday, ceilings and visibilities rose briefly to 1,500 feet and 3,200 meters in fog, then dropped quickly to 100 feet and 800 meters. Light drizzle persisted until late evening. Scattered to broken middle and high clouds, layered to 25,000 feet with bases at 10,000 feet, stretched from the Red Sea across northern and central Saudi Arabia. These clouds spread northward after 1200Z to cover northwestern Saudi Arabia and western Iraq, as well. Broken clouds with 4,000-foot bases continued to move from the Red Sea near Jeddah into north-central Saudi Arabia. The blowing dust that lowered visibilities to 4,800 meters in central Saudi Arabia during late morning extended into northeastern Saudi Arabia by afternoon.

**Area of Intense Interest.** As shown in Figure 3-4, The entire area was covered by low clouds with bases at 100-200 feet. By 1200Z, the northern part (including Baghdad) had cleared. Ceilings in the southern section rose briefly at midday to 1,000-1,500 feet, then returned to 500-1,000 feet for the rest of the day. After sunset, clouds spread northward into the Baghdad area, where ceilings were 1,500 feet. Middle and high clouds, layered to 25,000 feet with bases at 10,000 feet, were also present over the southern section throughout the day.

**Figure 3-4. NOAA Thermal, 19 January 1991, 2318Z.** Middle and high clouds stretch from the northern Red Sea to Iran. The large lakes west of Baghdad are still visible even though Baghdad is cloud-covered. The 3,000-foot clouds along the Iraq-Jordan-Syria border are clearly visible. Light drizzle fell throughout the southern section of the area during afternoon and early evening.

Winds were east to southeasterly at 5-15 knots, becoming north to northeasterly at 10-20 knots in the afternoon and diminishing to 3-10 knots after sunset.

Morning visibilities were near zero in dense fog throughout the area. The northern section cleared by 1200Z. Visibilities in the south rose to 3,200 meters at midday, then returned to as low as 800 meters for the rest of the day. Visibilities in the northern section were as low as 1,600 meters after sunset.

Temperatures fell in response to northerly winds. Highs were 10-18° C; lows, 0-10° C.

**General Weather.** A weakening low-pressure area moved southeastward down the Persian Gulf to the Strait of Hormuz. Cool, moist low-level air from the northern Persian Gulf moved southwest, west, and eventually northwestward behind a weak cold front moving southwest and west over the northeastern half of Saudi Arabia and extreme southwestern Iraq. Mid-level disturbances along the subtropical jet stream resulted in extensive middle and high cloudiness over northern Saudi Arabia and southern Iraq. By day's end, another low had crossed Syria toward western Iraq.

**Area of Interest.** Light rain (and light snow above 6,000 feet) began falling in western Syria by early evening. An extensive area of overcast low clouds, about 2,000 feet thick with bases from 100 to 1,000 feet, persisted all day in northeastern Saudi Arabia and extreme southwestern Iraq. Visibilities ranged from near zero to 1,500 meters. By early afternoon, broken low clouds moved into northern Iraq from the west; bases ranged from 1,500 to 2,500 feet, with tops below 5,000 feet. Broken layered middle and high clouds, with bases at 10,000 feet and tops to 30,000, persisted from northern Saudi Arabia northeastward into southern Iran. Isolated evening thundershowers developed in extreme western Saudi Arabia from a strong system crossing Egypt. Figure 3-5 provides a mid-afternoon overview.

**Area of Intense Interest.** At 0000Z, broken low clouds at 1,500 to 4,000 feet covered Baghdad and the Tigris-Euphrates river valley. These clouds cleared slowly from the northwest; by 2100Z, only broken middle and high clouds from 10,000 to 30,000 feet covered the southern half of the Valley. The northern half, including Baghdad, saw only thin high clouds. Broken clouds were layered from 1,500 through 25,000 feet over the western slopes of the Zagros mountains. Over the southern Zagros, tops reached 30,000 feet. Isolated afternoon and evening thunderstorms reached 35,000 feet in the extreme southeast near the Zagros Mountains. After 2100Z, patchy broken low clouds formed again over the northern part of the Tigris Valley and the immediate Baghdad area; bases were 1,000 to 1,500 feet; tops, 3,000 feet.

Light rain or showers fell over the southern half of the Tigris-Euphrates river valley and southwestern Iraq. There were isolated

**Figure 3-5. NOAA Visual, 20 January 1991, 1111Z.** Note the extensive middle and high clouds associated with the subtropical jet stream over Saudi Arabia, the northern Persian Gulf, and southern Iraq. Most of the extensive low cloud and fog over southwestern Iraq and extreme northeastern Saudi Arabia is hidden.

afternoon and evening thundershowers over the extreme southeast. Intermittent drizzle fell in the cool air moving west away from the northern Persian Gulf.

Winds were northwesterly to northerly over the Baghdad area, becoming northeasterly over the southern Tigris-Euphrates river valley. Over Kuwait and extreme southern Iraq, winds were northeasterly to easterly. Speeds diminished from 10-15 knots in the morning to 5-10 knots by mid-evening.

Visibilities in southern and southwestern Iraq and in extreme northeastern Saudi Arabia were near zero in fog during the night, but as high as 2,000 Meters in southern Iraq and Kuwait during mid-afternoon. After dark, they dropped rapidly to less than 500 meters. Visibilities in the Tigris-Euphrates river valley, northwest of the low clouds, improved to 10 km by late morning. Patchy dense river fog formed after 2100Z, dropping visibilities to less than 500 meters.

High temperatures were 7-10° C in the north and 18° C in the south. There were freezing temperatures in Iraq and northern Saudi Arabia, and subfreezing temperatures above 6,000 feet in the mountains of southeastern Turkey and northeastern Iraq. Central Saudi Arabian lows were 5-12° C.

**General Weather.** The weak low-pressure area just west of the Strait of Hormuz became quasi-stationary and weakened slowly. A quasi-stationary trough extended southwest from the low westward across the central Arabian peninsula. A vigorous low moved eastward into the eastern Mediterranean Sea; a series of troughs around it brought isolated showers and thundershowers to Egypt, the northern Red Sea, extreme northwestern Saudi Arabia, Israel, and western Jordan. A weak low moved through northeastern Syria into southern Turkey. Mid-level disturbances continued to move east-northeastward along the subtropical jet stream, crossing northern Saudi Arabia and Kuwait into Iran.

**Area of Interest.** Patchy dense fog and low clouds again plagued southwestern Iraq and extreme northeastern Saudi Arabia until they dissipated in late morning. Cloud bases were from zero to 1,000 feet; visibilities, from near zero to 500 meters. Layered middle and high clouds persisted from 10,000 to 32,000 feet over most of northern and central Saudi Arabia and the central Red Sea. Showers and thundershowers fell over Jordan, western Syria, and southern Turkey. Thunderstorm tops reached 35,000 feet. In northern Iraq and southeastern Turkey, clouds were layered to 7,000 feet; a middle cloud deck over southeastern Turkey moved northeastward out of the area by 1200Z. Mountains above 3,500 feet were obscured most of the day.

**Area of Intense Interest.** Extensive fog and low clouds also prevailed in this area. Cloud bases were from near zero to 500 meters, and tops reached 2,000 feet. The clouds and fog slowly dissipated by late morning over southwestern Iraq and northeastern Saudi Arabia as far east as Rafha and King Khalid Military City. Over northeastern Saudi Arabia, the low clouds and fog became broken with bases near 3,000 feet and tops at 6,000 feet by early afternoon. On the Saudi Arabian Persian Gulf coast, early morning ceilings were also near zero, but by late morning, most clouds had become scattered. Patchy fog and low clouds reformed throughout all of northeastern Saudi Arabia and extreme southwestern Iraq shortly after dark. Ceilings dropped to 200-500 feet by 2100Z. Layered middle and high clouds from 10,000-32,000 feet moved slowly southeastward over southern Iraq, northwestern Saudi Arabia, and Kuwait; by 2100Z, they were over central and northeastern Saudi Arabia just southeast of Kuwait. Infrared satellite imagery (Figure 3-6, Page 3-15) taken just before sunrise

in Kuwait shows these layered decks. A small thunderstorm cluster raced east-northeast across Riyadh, Kuwait, and extreme southern Iraq into the Zagros mountains northeast of Abadan, Iran, during the morning.

Precipitation, outside of thunderstorms and showers, was limited to light drizzle in areas of dense fog and low clouds.

Winds were northeasterly at 5-10 knots in southeastern Iraq and northeastern Saudi Arabia; they slowly became southeasterly at 5-10 knots in southwestern Iraq and in north-central and northwestern Saudi Arabia.

Early morning visibilities in the fog and low cloud area ranged from zero to 500 meters, improving to 1,000-3,000 meters by late morning and to 5-6 km by late afternoon. Visibilities were as low as 100 meters in denser fog patches. Patchy dense fog again formed after dark. The thickest fog was found along the Persian Gulf coastline and in shallow depressions inland where sand was still moist or where showers had occurred earlier in the day. On the Persian Gulf coast, visibilities improved from near zero at dawn to 1,000-2,000 meters by 0900Z, but dropped below 500 meters in fog by 1900Z. Patchy dense fog over and near the Tigris and Euphrates Rivers northwest of Basrah dissipated by 0600Z, but reformed after 1900Z.

High temperatures were 6-12° C in northeastern Saudi Arabia and 20-24° C in central Iraq. Lows ranged from 3-6° C inland to 10-12° C along the Persian Gulf Coast.

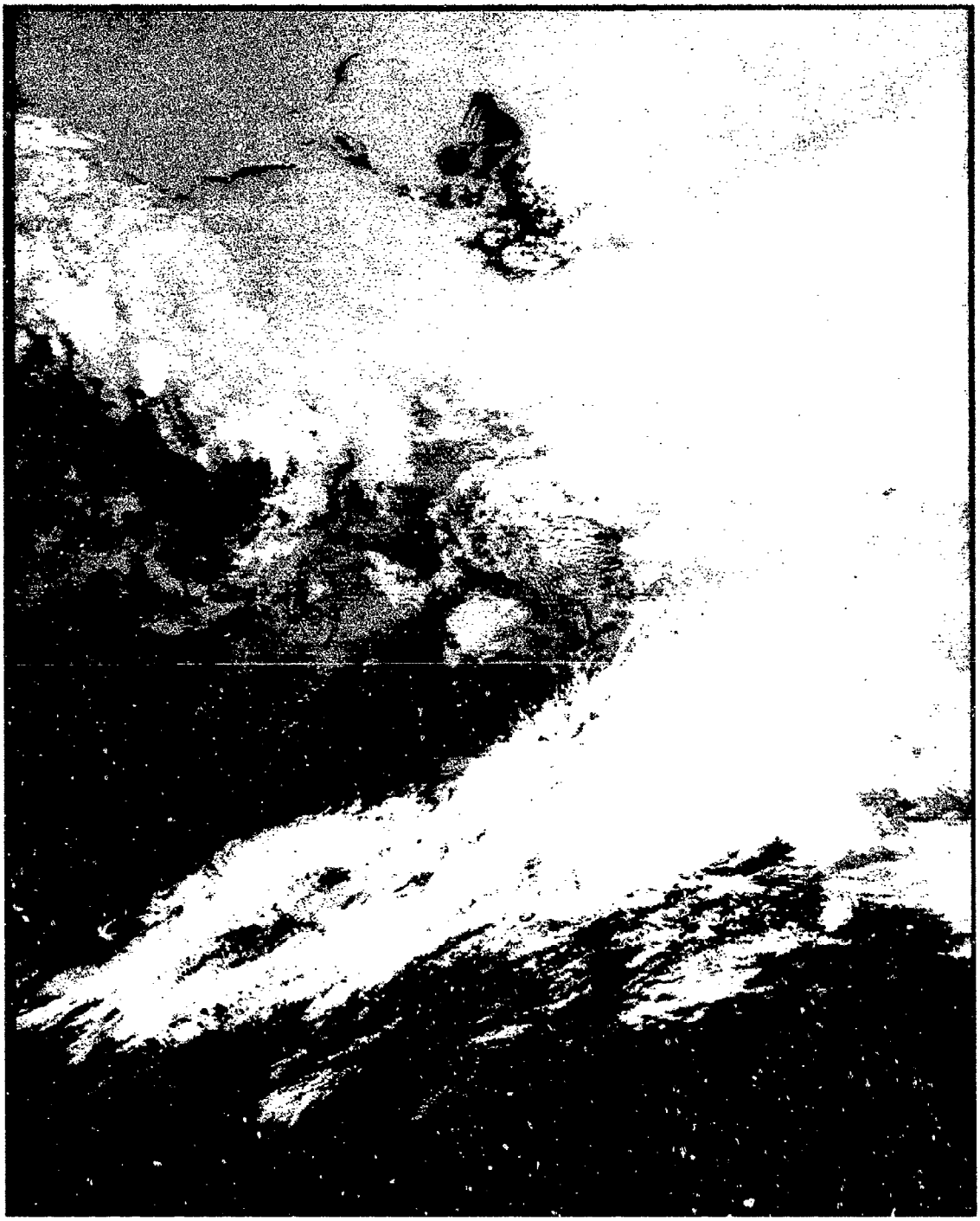


**Figure 3-6. DMSP Thermal, 21 January 1911, 0243Z.** Extensive layered clouds are shown just before dawn. Baghdad lies under the extreme northeastern edge, just east of the two lakes in central Iraq.

**General Weather.** Both the weak low near the Strait of Hormuz and the east-west cold front over central Saudi Arabia continued to weaken. Easterly to east-northeasterly low-level winds continued to bring moisture to west-central and northwest Saudi Arabia. A weakening low in the eastern Mediterranean Sea continued to move slowly east-northeastward toward Syria and southern Turkey. The subtropical jet stream slowly weakened, but it continued to bring middle and high clouds northeastward across the Arabian peninsula into Kuwait and southwestern Iran.

**Area of Interest.** Broken low clouds between 3,000 and 6,000 feet, along with multilayered broken middle and high clouds from 8,000 to 27,000 feet, persisted over extreme northern Iraq, Syria, northern Jordan, Israel, and Lebanon. By evening, the low and middle cloud layers, with tops to 18,000 feet, had moved southwestward into the northern Sinai. Broken low clouds, with bases of 2,000-4,000 feet and tops to 6,000 feet, had formed over the northwestern half of Iran by 1500Z. Multilayered broken middle and high clouds persisted over southwestern Iraq, the southern Persian Gulf, and central Saudi Arabia from 10,000 to 28,000 feet. Visibilities remained good except where mountains were obscured by cloud. Isolated rain (snow above 5,000 feet) fell over the mountains of northern Iraq, southern Turkey, western Syria, and Lebanon. Visibilities were as low as 500 meters in snow over higher mountains.

**Area of Intense Interest.** Fog and low clouds again persisted all night over northeastern Saudi Arabia, the northern Saudi Arabian Persian Gulf coast, and extreme southwestern Iraq. Ceilings were again from near zero to 500 feet. Low clouds slowly lifted and dissipated, moving to a small area southwest of Kuwait by late morning. Bases were now 3,000 feet, with tops to 7,000 feet. Isolated thunderstorms, with bases as low as 2,000 feet, formed in late morning and early afternoon in extreme northeastern Saudi Arabia, Kuwait, the northern Persian Gulf, and southwestern Iraq. Tops reached 40,000 feet. Layered broken middle and high clouds persisted from 10,000 to 27,000 feet throughout the day over central and northeastern Saudi Arabia, Kuwait, and extreme southwestern Iraq. Iraq northwest of Basrah was clear. A visual DMSP satellite image (Figure 3-7), taken shortly after sunrise in Kuwait, shows layered clouds with embedded thunderstorms over northern Saudi Arabia, the Persian Gulf, and southwestern Iran.

**Figure 3-7. DMSP Visual, 22 January 1991, 0435Z.** Note the extensive layered cloud decks with embedded thunderstorms over northeastern Saudi Arabia, the northern Persian Gulf, and southwestern Iraq. The advancing clouds associated with the system moving onshore out of the eastern Mediterranean are also clearly visible. Baghdad proper--just east of the lakes in the clear zone in the center of the image--is clear.

By sunset, low clouds and fog began to reform along the Iraq-Saudi Arabia border northwest as far as Rafha. By late evening, the fog had lifted into broken low clouds with bases from 1,000 to 2,000 feet and tops to 5,000 feet. These clouds had spread north and northeast as far as the central Tigris-Euphrates river valley by 2100Z.

Showers and thundershowers fell over northeastern Saudi Arabia, Kuwait, the northern Persian Gulf, and southwestern Iran. Patchy nighttime drizzle fell in areas of dense fog and low clouds.

Winds were northeasterly at 5 knots, becoming southeasterly at 5-10 knots after 0900Z.

Visibilities dropped to less than 100 meters in fog before dawn. In northeastern Saudi Arabia, early evening visibilities were briefly as low as 400 meters. Otherwise, visibilities were 3,000-4,800 meters in haze over northeastern Saudi Arabia and more than 10 km over the Tigris- Euphrates River valley northwest of Basrah.

High temperatures were 12-15° C beneath the cloud cover, but 22-25° C in central Iraq. Lows were 4-6° C.

**General Weather.** A frontal system moved south out of central Turkey into southern Iraq. A weak low moved into extreme northeastern Iraq, then northeastward into Iran. The cold front trailed southwestward across Syria into a weak low moving out of the eastern Mediterranean into southwestern Syria. By mid-afternoon, the frontal system had moved south of Baghdad. A weak high pressure center formed over Kuwait early in the day and moved slowly southeast in the northern Persian Gulf. The weak stationary frontal system in central Saudi Arabia weakened further. The southwest to northeast subtropical jet stream over central Saudi Arabia moved southeastward to Qatar by 2100Z.

**Area of Interest.** Broken to overcast multilayered clouds from 2,000 to 32,000 feet moved southeastward with the cold front from Turkey into northern Iraq. By 2000Z, these clouds covered most of Jordan, southern Syria, north-central Iraq, and western Iran. Clearing progressed southeastward over Iraq to about 60 miles north of Baghdad. An extensive area of layered broken clouds from 2,000 to 18,000 feet moved eastward from the Zagros Mountains of Iraq by dawn. Extensive broken to overcast cloud, layered from 10,000 to 27,000 feet, persisted along and southeast of the subtropical jet stream over southeastern Saudi Arabia, the southern Persian Gulf, and the southern third of Iran. Moderate to heavy rainshowers (snowshowers or snow in the Zagros and southeastern Turkish mountains above 5,000 feet) accompanied the frontal cloud bands over northern and central Iraq. Isolated blowing dust reduced visibilities to as low as 3,200 meters in western Iraq.

**Area of Intense Interest.** Extensive broken to overcast low clouds, with bases of 500-1,000 feet and tops 1,500-2,000 feet, covered northeastern and central Saudi Arabia. By early afternoon, skies were scattered to broken and bases had lifted to 3,000 feet. This layer dissipated shortly before sunset over northeastern Saudi Arabia, but reformed by 2000Z. In early evening, broken low clouds from 3,000 to 5,000 feet moved north and northeastward over Kuwait and the southern Tigris-Euphrates river valley in advance of the southward-moving cold front. By 1200Z, the leading edge of broken to overcast frontal cloud layers had moved south of Baghdad, with bases from 3,000 to 4,000 feet; tops were 12,000-15,000 feet with broken high clouds above. Isolated rainshowers along and just ahead of the front reached 20,000 feet. By 2000Z,

the leading edge of the frontal clouds had moved to near An Najaf in the Tigris-Euphrates river valley--the trailing edge was 60 miles north of Baghdad. Figure 3-8, a visual satellite image taken at 1037Z, shows these layered clouds well.

Isolated moderate to heavy rain showers fell in central Iraq along and within 100 miles either side of the southeastward-moving cold front. Patchy light drizzle fell in northeastern Saudi Arabia before 0500Z.

Winds were easterly at 5-7 knots before dawn, becoming southeasterly at 5-10 knots by late morning in extreme southern Iraq and northeastern Saudi Arabia. By 1700Z, winds had veered to southerly at 10-15 knots. In central Iraq, winds were light and variable until 1200Z, becoming southerly at 10-20 knots after 1500Z.

Visibilities over northeastern Saudi Arabia and the Tigris-Euphrates river valley dropped to as low as 200 meters in the early morning, but by 0800Z, they had improved to 8-10 km in haze. High temperatures ranged from 18-20° C under layered clouds to 30-32° C under clear skies in central Iraq ahead of the advancing frontal cloud layers. Lows were 4-6° C except along the immediate Saudi Arabian Persian Gulf coast and under the early morning low clouds in northeastern Saudi Arabia, where they were 10-13° C.

**Figure 3-8. NOAA Visual, 23 January 1991, 1037Z.** The frontal clouds associated with the southward-moving cold front over central Iraq are clearly visible.

**General Weather.** A weak cold front extended from central Iran across southern Iraq and extreme northern Saudi Arabia. A low developed in the eastern Mediterranean and moved eastward into western Syria. The subtropical jet stream crossed central Saudi Arabia and the Persian Gulf.

**Area of Interest.** Scattered to broken low clouds extended from western Iraq to the Mediterranean. Cloudiness increased near the Mediterranean Sea as the low developed. At 1200Z, heavy rain fell in extreme northern Saudi Arabia near the western Iraq border. Some light rain also fell in portions of Jordan. Fog formed during the night and through the morning in north-central Saudi Arabia, along the western Saudi Arabia-Iraq border, in northern Jordan, and in southern Syria. The subtropical jet stream produced two east-west lines of convection from Dhahran and Qatar into Iran with scattered showers near the coast and over the Persian Gulf.

**Area of Intense Interest.** As shown in Figure 3-9, low cloudiness prevailed along and behind the cold front during the first half of the day--ceilings were 2,000-2,500 feet with tops to 6,000 feet. Cloudiness gradually dissipated during the day, but low clouds from 2,500 to 6,000 feet, associated with the eastward-moving disturbance from the Mediterranean, entered the area in the evening.

Winds were westerly to northwesterly at 10 knots during the first 12 hours, becoming northerly to northeasterly at 10 knots later in the day.

Visibilities in fog were as low as 5 km from 0000 to 1000Z in Saudi Arabia.

High temperatures ranged from 12° C in the north to 19° C in the south. Lows were from 1 to 9° C.


**Figure 3-9. DMSP Visual, 24 January 1991, 0459Z.** Low clouds behind the cold front extend from Baghdad to the Zagros Mountains. The subtropical jet stream produces some cloudiness over Saudi Arabia and the Persian Gulf.

**General Weather.** A low moved east-northeast across Syria and Iraq, producing light snow and rain showers, blowing dust, and extensive cloudiness. Conditions improved toward the end of the day as the system moved into Iran. By the end of the day, another low had developed along the eastern Mediterranean coast, increasing cloudiness in western Iraq.

**Area of Interest.** The low produced light snow over western Iraq, northeastern Jordan, and Syria; light rainshowers fell in northwestern Saudi Arabia and Iraq. Winds to 20 knots in northern Saudi Arabia produced duststorms from 0900 to 1500Z as far south as 28° N. The lowest recorded visibility was 2,200 meters.

**Area of Intense Interest.** Cloud cover was extensive until evening, by which time the system had moved into Iran. Broken to overcast low and middle clouds, along with some high clouds, preceded the low and its cold front. Scattered to broken low clouds followed the front; ceilings were 2,000-3,000 feet, but as low as 500 feet in rainshowers. Low clouds extended to 6,000 feet; middle clouds from 8,000 to 18,000 feet; and high clouds from 25,000 to 30,000 feet. Figure 3-10 provides a mid-morning overview of the system.

Precipitation consisted of light rainshowers that developed with the frontal system. At 1100Z, Baghdad skies were overcast with rainshowers.

Winds were northerly to easterly, becoming northwesterly to westerly after the system moved through. Speeds were 10-15 knots, but a peak wind of 25 knots was observed along the western edge of the area.

Visibilities were generally 9 km in precipitation--the lowest observed was 5 km. From 0400 to 1100Z in Saudi Arabia, fog reduced visibility to as low as 3,600 meters. Fog redeveloped in the evening. Some dust may have been advected into the area from storms farther west.

High temperatures were only about 4° C in the north and 13° C in the south. Lows were near 0° C in the north and about 9° C in the south as the low-pressure system brought cooler air into the area during the afternoon and evening.

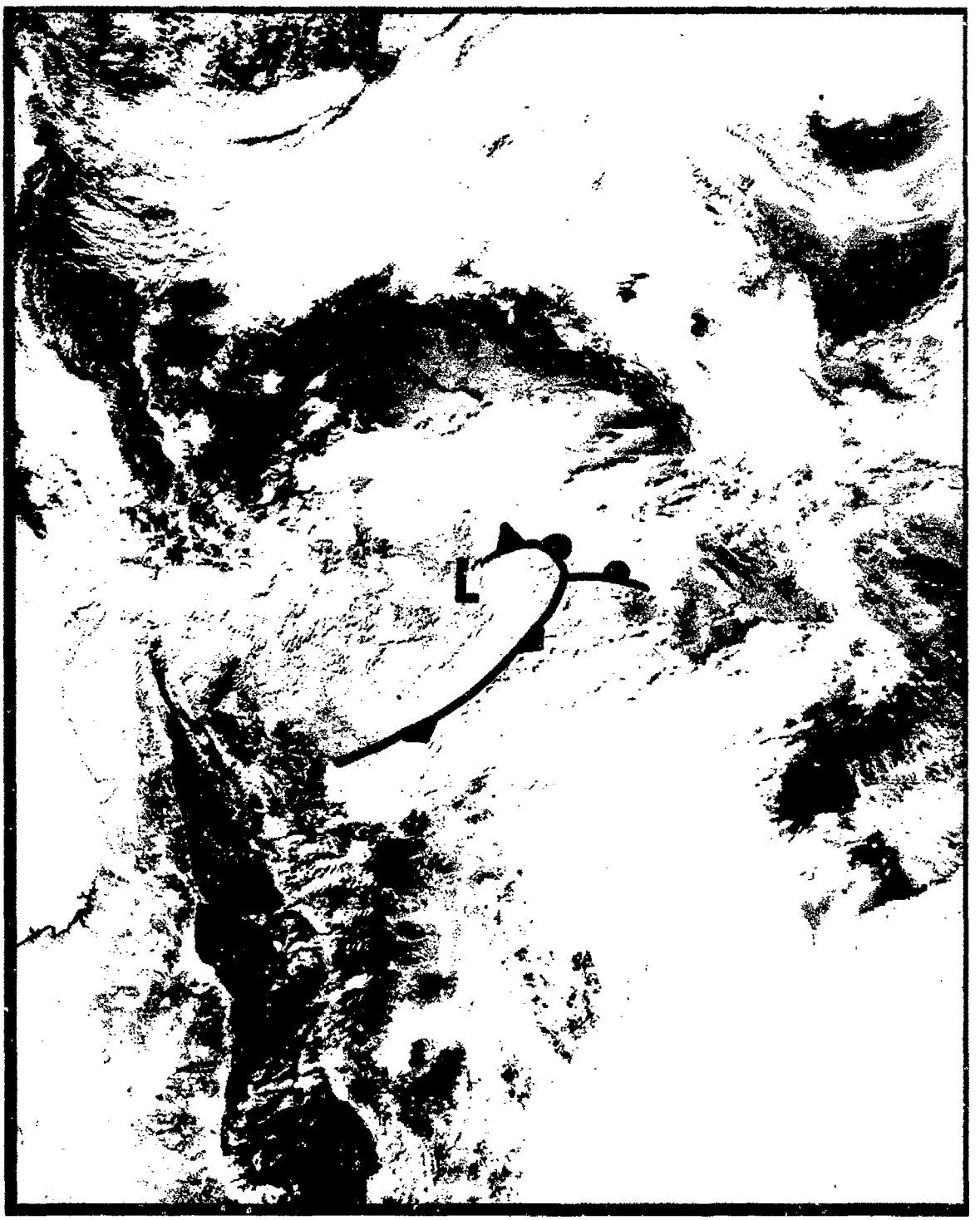


**Figure 3-10. DMSP Visual, 25 January 1991, 0618Z.** A low-pressure system over Iraq produces extensive cloudiness over Iraq, northern Saudi Arabia, and Kuwait.

**General Weather.** The low-pressure system shown in Figure 3-11 moved east-southeast across Jordan into northern Saudi Arabia by 1200Z. It then turned east and northeast to cross southern Iraq, where it produced showers and thundershowers from about 1600 to 2300Z, as shown in Figure 3-12. By 1800Z, a weak secondary low had formed along the front in Saudi Arabia near 27° N, 44° E, and drifted slowly east. High pressure moved in during the evening, clearing skies over Jordan, Syria, and western and central Iraq. The subtropical jet stream crossed central Saudi Arabia and the Persian Gulf.

**Area of Interest.** The low-pressure system produced light snow over southern Syria and light rainshowers in northern Saudi Arabia and western Iraq. Blowing dust south of the rain in Saudi Arabia reduced visibilities to 5 km. Winds were 20 knots around the low, but reached 30 knots with rain in northwestern Saudi Arabia.

**Area of Intense Interest.** Some cloud cover from the previous day's system remained in eastern Iraq east of 44° E. Broken low cloud with bases at 2,000 feet and tops to 6,000 feet persisted until 0900Z. The low moving across southern Iraq produced extensive cloudiness, as well as thunderstorms with bases at 2,000 feet and tops to 35,000 feet. Broken low clouds extended from 4,000 to 6,000 feet; broken middle clouds, from 10,000 to 18,000 feet. Ceilings were as low as 800 feet in rainshowers. The subtropical jet stream produced scattered to broken middle clouds from 10,000 to 15,000 feet and high clouds from 25,000 to 30,000 feet.

Precipitation fell as light rain and rainshowers in Saudi Arabia around the low. Rainshowers also fell in Iraq.

Winds were northwesterly at 5-15 knots most of the day, becoming northeasterly as the storm system approached and northwesterly again as it passed. Peak speeds were 23 knots, probably higher in Iraq.

Visibilities in eastern Iraq were 6 km in haze early in the day through 0600Z. Later in the day, visibilities on the south sides of showers and duststorms were reduced to 8 km.

High temperatures were only about 9° C in the north and southwest because of the front, but about 16° C in the southeast. Lows were near 0° C north, but near 10° C on the Persian Gulf coast.

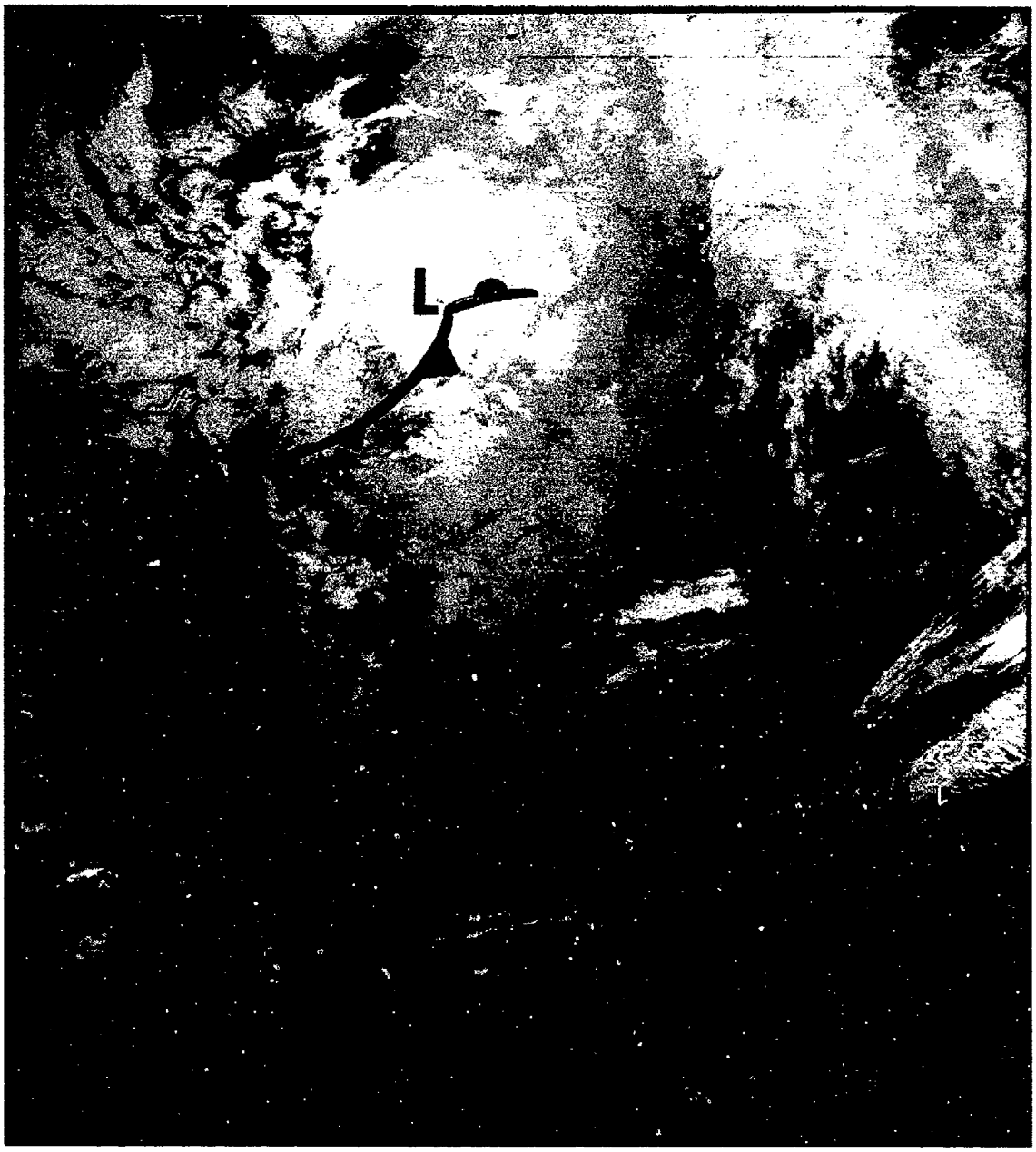



**Figure 3-11. DMSP Thermal, 26 January 1991, 0316Z.** A frontal system produced cloudiness over western Iraq, southern Syria, and Jordan. Low clouds and fog persisted over eastern Iraq and portions of northern Saudi Arabia. The subtropical jet stream produced middle and high clouds over the Persian Gulf.


**Figure 3-12. DMSP Thermal, 26 January 1991, 1747Z.** The low over southern Iraq produces showers southwest of Baghdad. The cold front extends back into northern Saudi Arabia.

**General Weather.** A low moving eastward from northeastern Saudi Arabia to the Persian Gulf coast produced extensive cloudiness over most of southeastern Iraq. The low gradually weakened throughout the day, leaving only some low clouds in the vicinity of the Gulf by late evening. A cold front extended west-southwest from the low across Saudi Arabia. A strong high moved into northwestern Saudi Arabia, driving the cold front into southern Saudi Arabia; strong winds behind the front produced duststorms.

**Area of Interest.** The storm system produced significant weather over large parts of Saudi Arabia. Light rain and rainshowers moving east with the low persisted at some Gulf coastal stations until 1900Z. The low produced multilayered clouds the first half of the day, but only low cloud the second half. Broken low and middle clouds extended roughly across 25° N to the Red Sea with the cold front in the morning, dissipating during the day. A low overcast with fog developed behind the front in northwestern Saudi Arabia; fog dropped visibilities to as low as 200 meters. Skies improved by mid-morning and cleared by afternoon. Strong winds behind the front produced duststorms. Visibilities in northwestern Saudi Arabia was near zero in early evening because of blowing dust in 35-knot winds. At Riyadh, 20-knot winds lowered visibility to 3 km in blowing dust. The subtropical jet stream produced broken low, middle, and high clouds over southern Saudi Arabia and the United Arab Emirates, but they drifted south during the day as the cold front approached.

**Area of Intense Interest.** Skies were initially overcast in the southeastern two-thirds of the area, but Baghdad and vicinity was clear. Low-cloud bases were at 3,000 feet (with tops to 6,000 feet), but there were some 800-foot ceilings. Middle-cloud bases were 7,000 feet, with tops to 18,000 feet. High-cloud bases were 20,000 feet, with tops to 28,000 feet. Middle and high clouds were only present the first half of the day; they dissipated and moved off to the east by 1200Z. The low clouds moved southeast during the day and were out of Iraq by 1500Z. After 1500Z, the low cloud remaining over Saudi Arabia and Kuwait was broken to overcast. Bases near the coast were 3,000 feet; tops, 5,000 feet. Bases and tops in the interior were lower, at 1,000 and 2,000 feet, respectively. Figure 3-13 provides a satellite view.

Precipitation fell from 0000 to 0600Z as light drizzle, rain, and rainshowers.

Winds were initially southeasterly at 10-15 knots ahead of the low, but northerly to northwesterly across Iraq behind the front. Winds shifted across the area by 1200Z; northerly to northwesterly winds were 10-20 knots with peak gusts to 30 knots. Speeds dropped to less than 10 knots during the evening.

Visibilities dropped to 9 km under the cloud cover in rain, fog, and haze.

Temperatures dropped to about -2° C in the northwest under clear skies. Highs in the northwest reached about 9° C, but evening temperatures fell back below freezing. Clouds in the southeast kept temperatures in the 7-9° C range in the early morning. They rose very little during the day and fell even farther in the evening as skies cleared and cold air moved in. Daily lows were recorded during the evening, dropping to around freezing by 0000Z.

**Figure 3-13. DMSP Visual, Baghdad Blowup, 27 January 1991, 0537Z.** A low-pressure system moving east to the Persian Gulf produces multiple cloud layers and overcast conditions over most of Southeastern Iraq. Skies in the Baghdad area were clear.

**General Weather.** High pressure began to dominate the weather over Iraq and northern Saudi Arabia, but parts of Saudi Arabia were still affected by weather left in the wake of the low-pressure system that prevailed on the 27th.

**Area of Interest.** Morning fog and low clouds north of Riyadh lowered ceilings and visibility to 2,000 feet and 8 km. There were some scattered to broken low clouds in the western Persian Gulf and at coastal stations. There was broken fog and stratus, with blowing dust, in southern Saudi Arabia. Blowing and suspended dust was still present in the vicinity of Qatar, where it lowered visibilities to 6 km.

**Area of Intense Interest.** Skies were generally clear except for thin scattered high cloud at 22,000-28,000 feet over northern Iraq and heavy black smoke over southern Iraq--see Figure 3-14. Winds were northwesterly at 3-10 knots, becoming more northerly toward the end of the day. Visibilities were as low as 1,500 meters over southern Iraq in the heavy smoke. High temperatures were 11-13° C. Lows varied from about -04° C in the north to 3° C in the southeast.

**Figure 3-14. NOAA Visual, 28 January 1991, 1123Z.** Skies are clear over most of the area. Thin scattered high cloud can be seen over northern Iraq, and the heavy black smoke (arrow) over southern Iraq is clearly visible.

**General Weather.** A high-pressure area over Saudi Arabia weakened as it moved southeast toward Qatar. A mid- to upper-level disturbance moved across the northern part of the region, resulting in extensive cloudiness over northern Iraq and Turkey--see Figure 3-15.

**Area of Interest.** The disturbance produced light rain and snow in Syria and snow in Turkey. There was extensive black smoke along the Persian Gulf coast. Remnants of the system that moved through on the 27th continued to produce some weather in Saudi Arabia. Moisture in central and eastern Saudi Arabia produced scattered to broken low cloud, with ceilings as low as 500 feet. Suspended dust still reduced visibility in southern Saudi Arabia.

**Area of Intense Interest.** Cloud cover associated with the disturbance was multilayered. Broken high cloud at 20,000 to 32,000 feet was present during the first half of the day. During the second half, scattered to broken low clouds at 3,000 to 6,000 feet and broken middle clouds at 10,000 to 18,000 feet moved in over the northern half of the area. Isolated evening thunderstorms from 3,000 to 35,000 feet developed over southeastern Iraq. Some formed southwest of Baghdad at 1800Z.

Winds were near calm during the night, becoming east-southeasterly at 5-10 knots in the morning and increasing to 10-20 knots during the afternoon. On the Persian Gulf coast, however, winds were northwesterly at 5-10 knots for the first half of the day before switching to east-southeast.

Visibilities were 8 km in blowing dust in the afternoon as the winds picked up. Black smoke reduced visibilities along the Persian Gulf coast--one station reported 9 km.

High temperatures ranged from 11° C in the north to 16° C in the south. Lows were -02° C in the north and 3° C in the southeast.

**Figure 3-15. NOAA Visual, 29 January 1991, 1112Z.** A mid- to upper-level disturbance produces extensive cloudiness over northern Iraq and Turkey. The trough extends across western Iraq into northern Saudi Arabia.

**General Weather.** A low-pressure system developed in the eastern Mediterranean and moved eastward across Syria, reaching western Iraq by the end of the day.

**Area of Interest.** The storm system produced extensive cloudiness over Turkey and Syria, as shown in Figure 3-16. Snow fell in Turkey, with rain in Syria and Jordan. Low clouds moved into western Iraq during the day with ceilings around 3,000 feet. The subtropical jet stream produced high clouds across central Saudi Arabia. Scattered to broken middle clouds formed over eastern Saudi Arabia.

**Area of Intense Interest.** Cloud cover from the previous day's disturbance remained over eastern Iraq and Kuwait; broken low clouds at 3,000-6,000 feet in the north around Baghdad dissipated by 1100Z. Over Kuwait, broken middle clouds from 8,000 to 14,000 feet moved off to the east by 0600Z. Broken to overcast low clouds with 3,000-foot ceilings and 6,000-foot tops entered the western part of the area in the evening.

With the storm system approaching, winds were southerly to southeasterly at 5-20 knots.

Visibilities were restricted, primarily by haze and smoke from burning oil. Morning fog reduced visibility to 5 km in spots; most haze restrictions were reported at 8 km. Some dust was raised during the day with increasing winds from the approaching system.

Temperatures increased in the warm flow ahead of the approaching system. Highs reached 20° C in the southeast, but only 10° C in the northeast, where low clouds were present through much of the day. Lows ranged from near freezing in the northwest to 8° C in the southeast.

**Figure 3-16. DMSP Visual, 30 January 1991, 0614Z.** A low in the eastern Mediterranean produces overcast conditions across Turkey and western Syria, with some low cloud reaching western Iraq. The low cloud around Baghdad was in the process of dissipating.

**General Weather.** A slow-moving low in the eastern Mediterranean Sea spread stormy weather throughout the Middle East as an associated frontal system passed through Iraq. At 0600Z, a secondary low-pressure cell was centered southwest of Baghdad. It rapidly moved northeast while the cold front moved south and weakened. Figure 3-17 shows the low and its frontal system in mid-afternoon. By 2300Z, the front had passed Riyadh and the low had moved into central Iran. A weak high moved into Iraq behind the front. In north-central Saudi Arabia, the strong subtropical jet stream spread extensive high clouds.

**Area of Interest.** Extensive low and middle clouds covered the northwest. Rain, occasionally heavy, fell in Syria and northern Iraq between 0000 and 1200Z. Snow fell above 4,000-foot elevations near the Turkey-Iraq border, obscuring higher terrain. After 0900Z, sporadic duststorms along the front lowered visibility to 4,000 meters from the Syrian Desert to Qatar.

**Area of Intense Interest.** Broken to overcast low clouds extended over the area until about 1600Z, with ceilings over Iraq as low as 3,000 feet and tops to 6,000 feet. Baghdad was affected between 0200 and 0900Z. Skies became clear in central Iraq and Kuwait after 1600Z as the front moved southward.

Isolated thunderstorms with tops to 35,000 feet passed northeast of Baghdad near 1100Z. Rain fell in western Iraq when the low-pressure cell moved through.

Winds were southwesterly at 5-10 knots before the front and westerly to northerly at 15-20 knots immediately behind it.

Visibilities were reduced to 4,000 meters by duststorms in Kuwait and southern Iraq as the front passed. Ground fog lowered visibilities to about 6 km in northeastern Saudi Arabia, Kuwait, and southern Iraq.

High temperatures were 10-16° C; lows, 4-9° C.

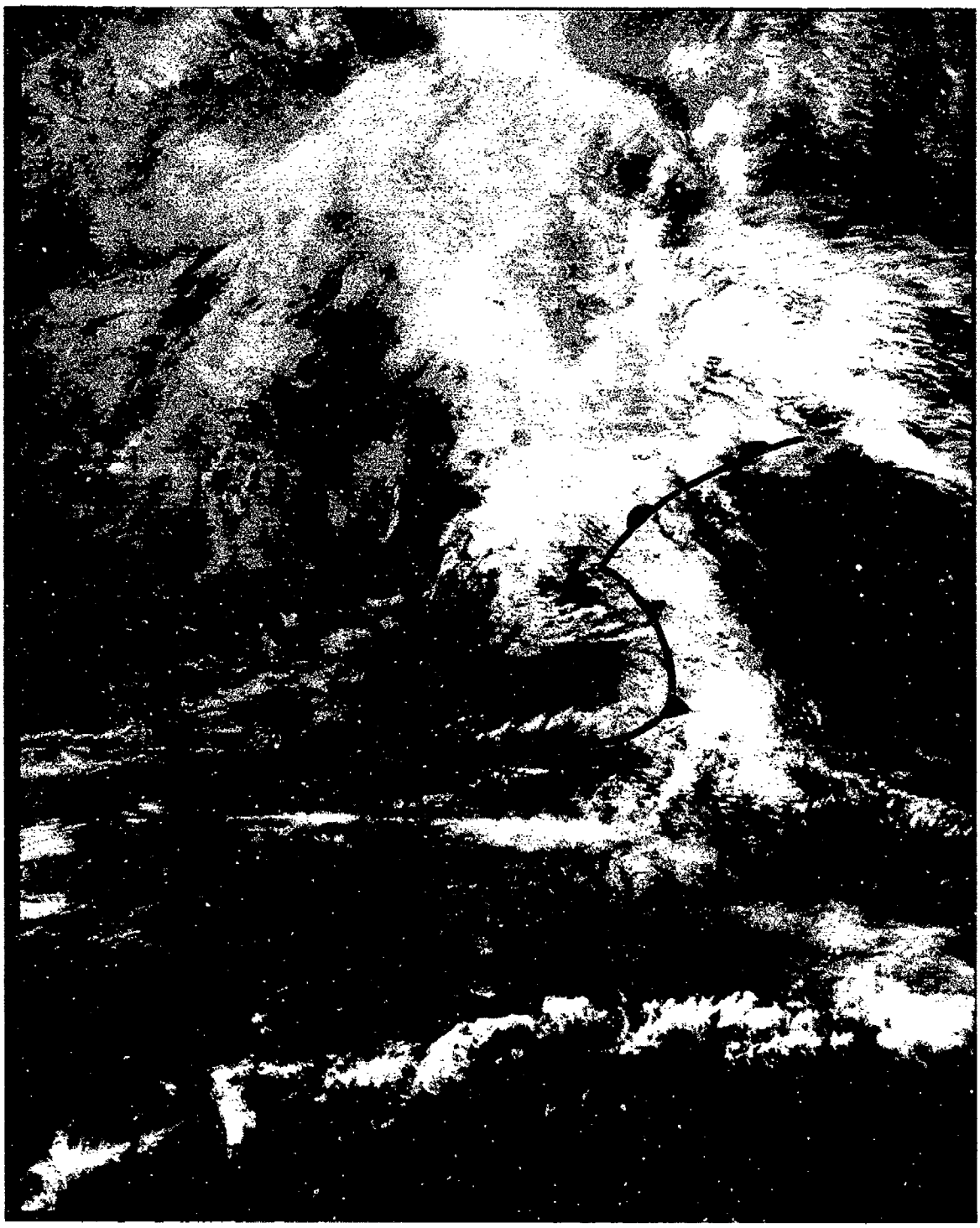


**Figure 3-17. NOAA Thermal, 31 January 1991, 1038Z.** The low-pressure system centered over central Iraq moves rapidly southeastward.

**General Weather.** High pressure was centered over northwestern Saudi Arabia, keeping central Iraq cloud-free. The weak cold front shown in Figure 3-18 extends from a low centered in north-central Iran. The front spread middle clouds from Qatar southwestward across Saudi Arabia. A slow-moving low-pressure system centered on the Turkey-Syria border caused rainshowers in western Iraq, Syria, and Jordan. By 1800Z, middle clouds from this low reached Baghdad. A weak low developed on the central Red Sea coast in response to an upper-air disturbance.

**Area of Interest.** Middle clouds covered the mountains to Iraq's west and north. Light rain fell in Syria and northern Iraq between 1800 and 2100Z. Extensive areas of mountain-wave turbulence developed in the west between 0300Z and 1500Z and reached as far east as 43° E. Early-morning ground fog formed in low-lying areas over most of the eastern Arabian Peninsula. Lowest visibilities were 2,000-4,000 meters.

**Area of Intense Interest.** Skies were clear to scattered before about 0900Z, except in the extreme northeast. Broken low clouds from the low in Turkey spread southward; by 1600Z, they had reached Baghdad, with 3,000-foot ceilings. Thin broken or scattered cirrus spread northeastward from the northern Red Sea, covering the area south of 31° N by 1100Z.

Winds were northeasterly at 5-10 knots in the south, westerly to the north. Afternoon winds were light and variable over central Iraq.

Visibilities were generally good, but morning ground fog reduced them to about 6 km in northeast Saudi Arabia, Kuwait, and southern Iraq.

High temperatures were 7-13° C; lows, 1-7° C. The lowest temperatures were in the eastern Nafud Desert.


**Figure 3-18. NOAA Visual, 1 February 1991, 1038Z.** High pressure dominates central Iraq as low pressure develops over the Red Sea. The clouds to the east suggest extensive mountain-wave turbulence.

**General Weather.** A trough of low pressure formed to the east of a high-pressure cell centered over eastern Saudi Arabia, causing low clouds in southern Iraq. The frontal system shown in Figure 3-19, with low centers in the southern Caspian Sea and in east-central Syria, extended along the northern Iraq border. The strong subtropical jet stream spread high and middle clouds over central Saudi Arabia.

**Area of Interest.** Low and middle clouds prevailed over northern and western Iraq. Light rain fell in Syria and northern Iraq throughout the day. Snow fell north of Mosul, obscuring terrain above 4,000 feet. Early-morning ground fog formed in low-lying areas over most of the eastern Arabian Peninsula. Reported visibilities were reduced to about 7 km. Extensive areas of mountain-wave turbulence developed near the Syria-Iraq border between 0300 and 1500Z and reached to 43° E.

**Area of Intense Interest.** The subtropical jet stream caused layered middle and high clouds over the area south of 32° N throughout the day. Ceilings were between 15,000 and 25,000 feet, with the lowest along the northern Persian Gulf. Frontal low clouds stretched along the Syria-Iraq border. The broken low clouds southwest of Baghdad included 4,000-foot ceilings and 6,000-foot tops. These clouds gradually moved east; by 2000Z, they were on the Kuwaiti coast. Another layer of low clouds with ceilings of about 3,000 feet formed over the Tigris-Euphrates river valley north of 31° N during the night.

Winds were easterly at 10-15 knots south of 30° N, southerly in the central area, and westerly north of 33° N. They were gusty in the southern areas.

Duststorms reduced visibilities in the northern Nafud Desert eastward to southern Kuwait between 1200 and 2000Z. Minimum visibility was about 2,400 meters. Dense smoke was reported in northwestern Kuwait before 0800Z--visibilities were probably below 2,000 meters.

High temperatures were 13-16° C; lows, 2-11° C.


**Figure 3-19. NOAA Visual, 2 February 1991, 1026Z.** A stationary frontal system extends through Syria. Most of Iraq is clear.

**General Weather.** The frontal system in eastern Syria began to move slowly eastward and break up, resulting in lowered ceilings and gusty winds. The nearly dry front passed Baghdad at 2000Z. The weak front shown in Figure 3-20 extended from central Iraq to near Riyadh, spreading low clouds to Iraq's eastern section. The subtropical jet stream became more westerly than northwesterly, leaving the northern Persian Gulf cloud-free but spreading scattered to broken middle and high clouds across Saudi Arabia.

**Area of Interest.** Isolated thunderstorms with tops to 35,000 feet affected the northern Iraq border between 0300 and 0600Z. Broken to overcast low clouds produced 3,000-foot ceilings north of 35° N in Iraq between 0630 and 1700Z. Light rain fell in Syria and Iraq near the Turkish border between 0800 and 2000Z. Sustained winds to 25 knots were reported in extreme northwestern Saudi Arabia as the front passed. Extensive duststorms reduced visibilities to 1,000 meters near the front in the Syrian and Nafud Deserts. Duststorms were also reported at 1500Z between Riyadh and Kuwait.

**Area of Intense Interest.** Middle and high clouds from the subtropical jet stream had moved out of the area by 1000Z. In the morning, scattered to broken low clouds covered Iraq east of 43° E and all of Kuwait. Some locations recorded 3,000-foot ceilings. By 1200Z, the clouds had moved eastward to the Iraq-Turkey border. A small area of low clouds with 3,000-foot ceilings formed about 100 miles west of Baghdad at 1600Z.

Winds were westerly at 10-25 knots west of 45° E, but southeasterly at 10-15 knots to the east. There were gusts to 35 knots near the front.

Duststorms reduced visibilities to as low as 500 meters at about 1500Z in southern Kuwait and northeastern Saudi Arabia. Elsewhere, visibilities were above 6 km.

High temperatures were 8-20° C; lows, 3-16° C.


**Figure 3-20. DMSP Visual, 3 February 1991, 0630Z.** The subtropical jet stream caused the extensive cloud deck in central Saudi Arabia. The large system in the eastern Mediterranean begins to lift to the northeast. The frontal system through Iraq and Saudi Arabia is dissipating.

**General Weather.** High pressure centered in southeastern Egypt strengthened and built into northwestern Saudi Arabia. The low-pressure system that had been affecting northern Iraq continued to move eastward. By 0900Z, the trough had moved southeastward to the south of Qatar. The subtropical jet stream, shown by the arrows in Figure 3-21, continued to spread high and middle clouds over the central Arabian Peninsula.

**Area of Interest.** Fog reduced visibilities to 1,500 meters in Qatar and on the United Arab Emirates coast before 0400Z and again after 2000Z. Gusty winds and scattered duststorms affected the eastern coast between Bahrain and Qatar between 1100 and 2100Z. Lowest visibilities were 5 km. Isolated rainshowers affected the coast between Qatar and the Strait of Hormuz. Cloud bases were 15,000 feet.

**Area of Intense Interest.** In the early morning, middle clouds produced 10,000-foot ceilings in a triangular area between 30° N and a southwest-northeast line running from 60 miles south of Baghdad, then eastward to the Iraq border. These clouds rapidly moved southeastward. By 0600Z, they affected only the coast of Kuwait. The area was almost cloud-free by 1000Z.

Winds were northeasterly at 10-15 knots inland, but northerly at 15-20 knots on the Kuwait coast. Inland, winds became northerly at 5-10 knots after 1800Z.

Visibilities were generally above 10 km, but scattered fires and smoke plumes reduced visibility in Kuwait to below 4 km. One smoke plume, originating in northern Kuwait, measured 35 miles long and 10-15 miles wide.

High temperatures were 3-13° C; lows, 2-8° C.

**Figure 3-21. DMSP Visual, 4 February 1991, 0610Z.** Striated clouds over northwestern Iraq suggest mountain wave turbulence. High clouds from the subtropical jet stream (arrows) obscure the northern Persian Gulf.

**General Weather.** High pressure centered in central Iraq kept skies clear or scattered most of the day, but clouds associated with the subtropical jet stream still spread high and middle clouds over the central Arabian Peninsula. These clouds were scattered in the morning, but denser clouds moved in from Egypt by 1000Z--see Figure 3-22.

**Area of Interest.** Morning haze reduced visibilities in central Saudi Arabia; Riyadh reported 4,800 meters at 0500Z, improving to 8 km by 0800Z. Duststorms after 2000Z were the result of 20-knot winds over the Syrian and Nafud deserts; they lowered visibility to 5 km.

**Area of Intense Interest.** Clouds were limited to scattered cirrus until about 1100Z, but the subtropical jet stream moved scattered to broken middle and high clouds into southwestern Iraq later in the day. These clouds had moved over Kuwait by 1600Z, producing 10,000-foot ceilings during the night.

Winds were northeasterly at 10-15 knots along the coast, but light and variable in Iraq. As the high shifted farther north after 0900Z, winds in the south became stronger and more easterly.

Visibilities were above 10 km except in Kuwait, where scattered fires and smoke plumes reduced visibility to below 4 km.

High temperatures were 9-17° C; lows, 0-6° C.

**Figure 3-22. DMSP Visual, 5 February 1991, 0548Z.** High pressure dominates central Iraq. The clouds in western Iraq indicate that mountain-wave turbulence reaches the Euphrates River.

**General Weather.** High pressure was centered in northwestern Iraq, with a weak low-pressure trough to the southeast between central Saudi Arabia--near Riyadh--and Israel. The subtropical jet stream remained over the northern Arabian Peninsula; associated high clouds became increasingly scattered after 0600Z.

**Area of Interest.** Haze and duststorms west of 48° E reduced visibilities in Saudi Arabia to 5 km between 0900Z and 1700Z.

**Area of Intense Interest.** At 0000Z, there were only scattered low, middle, and high clouds throughout the area. By 0300Z, the middle cloud deck had thickened; ceilings as low as 12,000 feet, with tops at about 18,000 feet, had formed over the southwestern half of Iraq. These clouds drifted eastward, and by 1900Z they were east of Baghdad and Kuwait. Middle and high clouds from the subtropical jet stream affected Kuwait and southern Iraq between 0400 and 1100Z; bases were at or above 10,000 feet, with tops to 32,000 feet. Figure 3-23 shows these clouds in mid-afternoon.

Winds were light and variable in Iraq, but easterly at 5-10 knots in Kuwait.

Morning fog, smoke, and dust reduced visibilities in Kuwait and southern Iraq to as low as 3,200 meters in spots. Afternoon visibilities in areas not affected by smoke were above 6 km.

Afternoon high temperatures were between 5 and 13° C. High pressure and almost clear skies drove morning low temperatures down to -2° C in the north and 7° C in the south.

**Figure 3-23. NOAA Visual, 6 February 1991, 1123Z.** The weak trough in northern Saudi Arabia spreads disorganized cloudiness over Iraq.

**General Weather.** A low-pressure system over northeastern Saudi Arabia resulted in afternoon and evening rainshowers and thunderstorms over Saudi Arabia and the Persian Gulf. The subtropical jet stream brought middle and upper cloudiness to central Saudi Arabia. Weak high pressure was centered over Iraq.

**Area of Interest.** Scattered low clouds, with some middle and high clouds that were occasionally broken, extended across central Saudi Arabia and the Persian Gulf. Ceilings varied from 10,000 to 25,000 feet. Broken low clouds with bases at 2,000 feet were evident early in the morning over western Iraq. Light afternoon rainshowers fell over east-central Saudi Arabia. Isolated late evening thunderstorms were reported over the west-central part of the Persian Gulf. Tops were about 30,000-35,000 feet. Visibilities in northwestern Saudi Arabia were 7-9 km in haze and suspended dust. Suspended dust also reduced early morning visibilities in east-central Saudi Arabia to 4,800 meters.

**Area of Intense Interest.** Early morning skies were generally clear, but scattered middle clouds from the west moved into central Iraq and Kuwait by mid-morning. The middle clouds over central Iraq went scattered to broken at 10,000 feet by late morning. Skies became scattered by early afternoon, as shown in Figure 3-24. By early evening, cloud cover over Kuwait and southeast Iraq became scattered, variable to broken, at 10,000-18,000 feet. Isolated evening thunderstorms developed over extreme northern Kuwait; tops reached 30,000 feet. Figure 3-24 shows these clouds well.

Early morning winds were light and variable, becoming northwesterly to northerly at 10-15 knots by late morning.

Haze and suspended dust reduced visibilities over central Iraq to 7-9 km. Smoke, haze, and suspended dust reduced visibilities in northern Kuwait to 5-7 km and to 1,600 meters in southern Kuwait--see Figure 3-24.

High temperatures were 7-15° C; lows, 0-6° C.

**Figure 3-24. NOAA Visual, 7 February 1991, 1111Z.** Scattered middle clouds are seen over Iraq and Saudi Arabia. Smoke from Kuwait is being blown southward into northeast Saudi Arabia. Note the thunderstorms over extreme northern Kuwait.

**General Weather.** The low-pressure system was now located over southeastern Saudi Arabia. The subtropical jet stream brought middle and high clouds across eastern Saudi Arabia. Weak high pressure was centered over Iraq.

**Area of Interest.** Although skies were generally clear, broken middle clouds at 10,000 to 12,000 feet were observed over east-southeastern Saudi Arabia during early morning. Skies were broken to overcast at 4,000-5,000 feet between 0500 and 1300Z over northwestern and north-central Saudi Arabia. Scattered middle clouds were observed over western Iraq in the morning and afternoon, becoming broken at 10,000-12,000 feet during the evening. Blowing sand and dust lowered visibilities to 5-7 km in east-central Saudi Arabia.

**Area of Intense Interest.** Skies were generally clear, but scattered middle clouds were observed over southeastern Iraq during early morning. By mid-afternoon, there were scattered middle clouds over central Iraq, as shown in Figure 3-25. By late night, these became scattered to broken at 10,000-12,000 feet.

Winds were light and variable in the morning, becoming northwesterly to northerly at 10-15 knots.

Visibilities in smoke over southern Kuwait and southeast Iraq was less than 1,600 meters--see Figure 3-25.

High temperatures were 7-15° C; lows, 0-6° C.

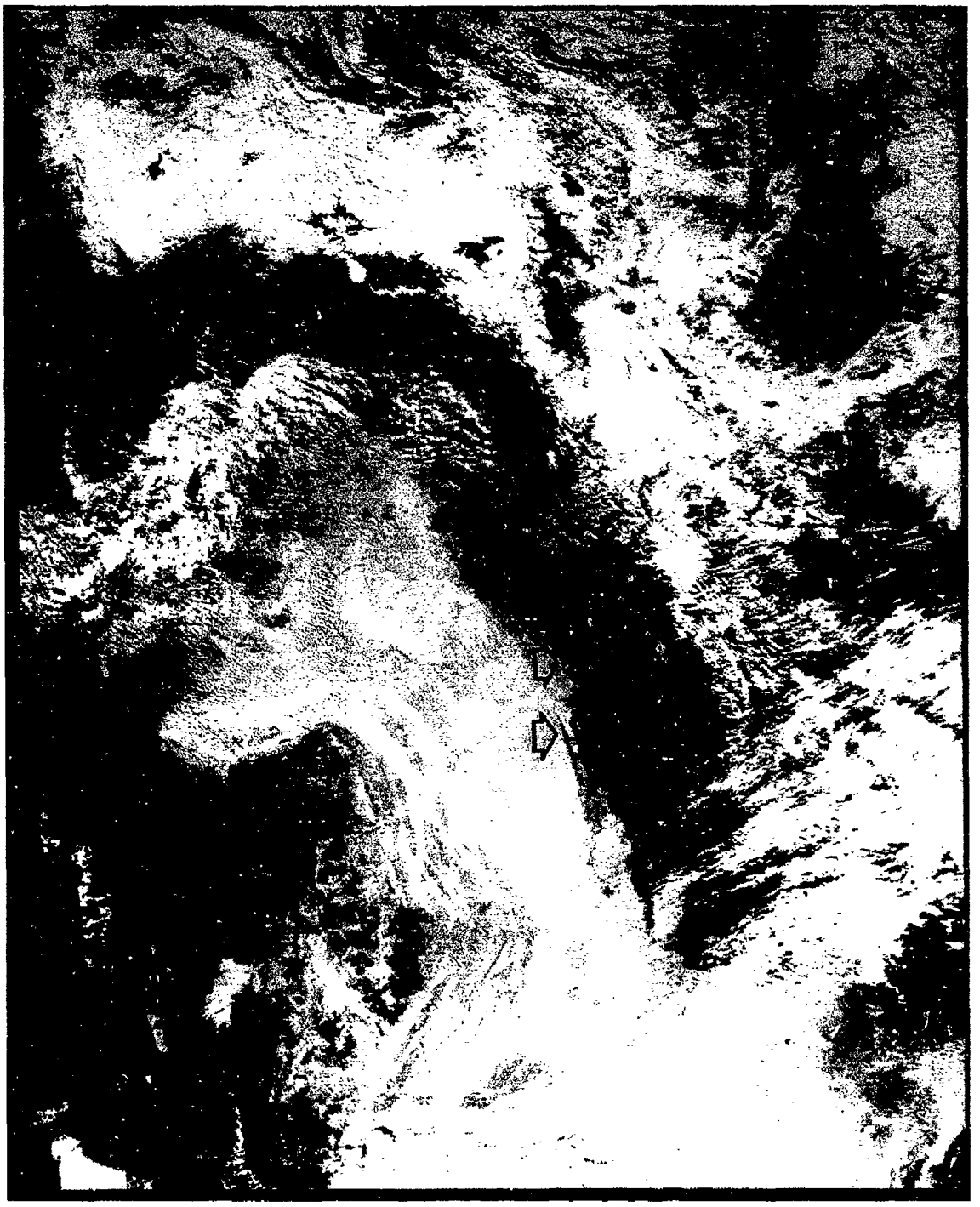


**Figure 3-25. NOAA Visual, 8 February 1991, 1100Z.** Scattered middle clouds are visible over north-central Iraq. Smoke plumes (arrows) can be seen over southeast Iraq and southern Kuwait.

**General Weather.** High pressure dominated the region--skies were generally clear.

**Area of Interest.** Skies were clear except for scattered low clouds over northwestern Saudi Arabia and western Iraq, as shown in Figure 3-26. Winds increased to 15 knots with gusts of 25 knots across northern Saudi Arabia, where afternoon visibilities decreased to 4,800 meters in blowing sand and dust. There were isolated reports of 400 meters.

**Area of Intense Interest.** Early morning skies over central Iraq were broken at 10,000-12,000 feet. The clouds slowly moved into southeastern Iraq and dissipated during the day--see Figure 3-26.

Winds were westerly to northwesterly at 10-20 knots.

Smoke and haze lowered visibilities in Kuwait to 5-7 km.

High temperatures were 12-20° C; lows, 2-8° C.

**Figure 3-26. DMSP Visual, 9 February 1991, 0616Z.** An area of broken middle cloud is evident over southeastern Iraq, with scattered low clouds over northwest Saudi Arabia and western Iraq.

**General Weather.** High pressure continued to dominate.

**Area of Interest.** Skies over Saudi Arabia and Iraq were clear during the day, but scattered to broken mid-level clouds with bases at 10,000-12,000 feet moved into western Iraq by late evening.

**Area of Intense Interest.** Skies were clear during the day, but by late evening, scattered to broken mid-level clouds with bases at 10,000-12,000 feet moved into central Iraq--see Figure 3-27.

Winds were northwesterly at 5-10 knots.

Thick smoke over east and southeast Iraq began to show in satellite photos by 0600Z and lasted until early evening--see Figure 3-27. Smoke from southern Kuwait was also still visible; visibilities in the smoke were 800-1,600 meters.

High temperatures were 10-15° C; lows, 0-5°C.

**Figure 3-27. DMSP Visual, 10 February 1991, 0544Z.** Thick smoke is visible over east and southeastern Iraq. Smoke plumes are also visible over southern Kuwait.

**General Weather.** High pressure was centered over southeastern Saudi Arabia, but low pressure formed over western Saudi Arabia. The subtropical jet stream brought increased moisture in the mid- and upper-levels to Iraq and northern Saudi Arabia. A mid-level disturbance moving over Iraq and northern Saudi Arabia caused the isolated thunderstorms and rainshowers shown in Figure 3-28.

**Area of Interest.** Scattered high clouds over western Iraq became broken with bases at 20,000 feet from mid-morning through afternoon. There were scattered low clouds over northwestern Saudi Arabia. Scattered low clouds also developed during the afternoon over northeastern and east-central Saudi Arabia, becoming broken with bases at 4,000-6,000 feet by late afternoon. Isolated late afternoon and evening thunderstorms with rainshowers formed over northeastern Saudi Arabia. Tops were about 35,000 feet. Light rain fell over east-central Saudi Arabia during late evening. Visibilities in precipitation were 5-7 km.

**Area of Intense Interest.** Scattered to broken upper clouds with bases at 22,000-25,000 feet were present during the morning and mid-afternoon over central Iraq. Morning skies were clear over Kuwait and southeast Iraq, but smoke plumes are visible in Figure 3-28. Cloudiness decreased in central Iraq during the day, but increased in southeastern Iraq and Kuwait. Skies became scattered to broken, occasionally overcast, at 4,000-6,000 feet. By late afternoon, thunderstorms (tops to 35,000 feet) and rainshowers had formed over Kuwait; they moved off to the east and dissipated by late evening.

Winds accompanying the thunderstorms in Kuwait reached 25-35 knots, but over the rest of the area, they were northwesterly at 10-15 knots.

Smoke and haze lowered morning visibilities to 4,800 meters in Kuwait and southeastern Iraq. Rain and rainshowers reduced evening visibilities to 1,600-3,200 meters.

High temperatures were 10-15° C; lows were 0-5° C.

**Figure 3-28. DMSP Visual, 11 February 1991, 0523Z.** Smoke plumes are clearly visible over Kuwait and southeastern Iraq. An area of isolated thunderstorms is shown over northern Iraq and northern Saudi Arabia.

**General Weather.** High pressure dominated, but a low-pressure system moved into the eastern Mediterranean by the end of the day, increasing cloudiness over western Iraq.

**Area of Interest.** Broken middle clouds at 8,000-10,000 feet were present over northeast, east and east-central Saudi Arabia and the Persian Gulf during the morning. By late evening, there were scattered to broken high clouds at 20,000-25,000 feet over western Iraq.

**Area of Intense Interest.** Broken middle clouds at 8,000-10,000 feet remained over Kuwait until mid-morning. Scattered upper clouds moved into central Iraq by late evening.

Winds were northwesterly to northerly at 10-15 knots.

Smoke plumes were visible over eastern Iraq and Kuwait--see Figure 3-29. Visibilities in Kuwait were 5-7 km due to smoke and haze.

High temperatures were 10-15° C; lows, 0-5° C.

**Figure 3-29. DMSP Visual, 12 February 1991, 0502Z.** Smoke plumes are visible over southeastern Iraq and Kuwait.

**General Weather.** High pressure dominated the Saudi Arabian peninsula, but low pressure centered over the eastern Mediterranean sent moisture into Iraq and northern Saudi Arabia. The low moved to the northeast as high pressure intensified behind it.

**Area of Interest.** Scattered skies became broken to overcast over western and northern Iraq. The 25,000-foot ceilings prevailing in the morning became 8,000-10,000 feet during the day. By the end of the day, skies were scattered again. Over northern Saudi Arabia, skies were scattered, but occasionally broken, at 20,000-25,000 feet.

**Area of Intense Interest.** Scattered skies became gradually broken over central, east-central, and southeast Iraq and Kuwait--see Figure 3-30. Smoke plumes were visible over southern Kuwait and the northern Saudi Arabian Gulf Coast.

Winds were northwesterly at 10-15 knots.

Visibilities in southeastern Iraq and Kuwait were 5-7 km in smoke and haze.

High temperatures were 13-16° C; lows, 1-4° C.

**Figure 3-30. DMSP Visual, 13 February 1991, 0630Z.** Extensive middle and high cloudiness over Iraq and northern Saudi Arabia is evident. Smoke plumes are visible over southern Kuwait.

**General Weather.** High-pressure over Iran and Syria resulted in fair weather across most of the region, as shown in Figure 3-31.

**Area of Interest.** Morning skies over northern Iraq were overcast with middle and high cloud; ceilings were as low as 10,000 feet. The clouds moved eastward and were over Iran by 1200Z. Broken low and middle clouds over central and southern Saudi Arabia produced 5,000-foot ceilings with scattered light rainshowers and 9-km visibilities. The clouds moved southeastward and became scattered after 1200Z. Visibilities in western and southern Iraq were as low as 6 km where 20-knot winds resulted in localized suspended and blowing dust.

**Area of Intense Interest.** Cloud cover consisted only of thin scattered high cloud over eastern Iraq and Kuwait; bases were 20,000 feet; tops, 25,000 feet. The high cloud moved east into Iran by 1200Z. Winds were light and variable in the early morning, becoming northerly to easterly at 5-15 knots during the day.

Morning visibilities along the Persian Gulf coast near Kuwait were 8 km in fog. Widespread haze over northern Saudi Arabia produced visibilities of 8 km.

High temperatures were 16-18° C; lows were 2-5° C.

**Figure 3-31. DMSP Visual, 14 February 1991, 0601Z.** Skies have cleared across most of Iraq, Kuwait, and northern Saudi Arabia. Scattered to broken low and middle clouds over central Saudi Arabia are moving southeastward and producing scattered rainshowers. Black smoke is visible over southern Iraq.

**General Weather.** High pressure over Iran and Turkey extended southward across most of the region.

**Area of Interest.** Broken high clouds passed through western Iraq to the east during the afternoon, followed in the evening by a large shield of high cloud entering from the west. Scattered to broken middle clouds over parts of central and southern Saudi Arabia--with bases between 9,000 and 12,000 feet--dissipated partially during the day. Blowing dust in northern and western Saudi Arabia reduced visibilities to as low as 5 km.

**Area of Intense Interest.** Broken high clouds passed through the area between 1300Z and 2100Z with bases at 24,000 feet and tops to 32,000 feet. They were followed by scattered high clouds that moved into central Iraq from the west by the end of the day. Scattered bases were at 24,000 feet with tops to 32,000 feet.

Winds were northerly at 5-10 knots through the morning, gradually shifting to easterly at 5-15 knots in the afternoon and evening.

Smoke that is clearly visible in Figure 3-32 restricted visibility up to 14,000 feet. Evening ground fog developed along the Kuwait coast, dropping visibility to 8 km.

High temperatures were near 20° C; lows varied from 2° C in the north to 8° C in the southeast.

**Figure 3-32. DMSP Visual, 15 February 1991, 0423Z.** Skies were clear across most of the region, but there are scattered to broken middle clouds over parts of central and southern Saudi Arabia. Black smoke is visible over Kuwait.

**General Weather.** High pressure over Iran weakened as the strong frontal system shown in Figure 3-33 approached from the west. The polar jet stream dipped southward into the eastern Mediterranean as the subtropical jet stream crossed Egypt and brought in upper-level moisture. A new low-pressure center formed on the front over Syria by 1500Z and moved southeast. The low and its accompanying cold front reached western Iraq by 1800Z.

**Area of Interest.** Multiple cloud layers covered the region southward to 25° N with scattered to broken low clouds and broken to overcast middle and high clouds. Light rain and rainshowers lowered ceilings to 1,000 feet and visibilities to 1,100 meters. The blowing dust already present in northwestern Saudi Arabia at 0000Z spread to include much of northern Saudi Arabia, especially south of the rain. Winds up to 30 knots produced duststorms with visibilities as low as 200 meters in northern Saudi Arabia, Syria, and western Iraq.

**Area of Intense Interest.** Cloud cover increased and ceilings lowered during the day. Skies were initially scattered with high clouds from 27,000 to 30,000 feet, but became broken to overcast by morning, with multiple layers between 25,000 and 35,000 feet. Bases lowered to 20,000 feet by 0700Z. Broken middle clouds reached central Iraq at about 1100Z with 12,000-foot bases and 18,000-foot tops. Scattered low clouds moved in by early evening with 2,000-foot bases and 6,000-foot tops; middle-cloud ceilings were down to 8,000 feet by then. Low clouds increased in the evening. Light rain and rainshowers lowered ceilings to 1,000 feet.

Winds varied from easterly to southerly with the approaching frontal system. Initial 5- to 10-knot speeds increased during the day. The highest reported sustained speed was 30 knots.

Visibilities worsened throughout the day. Dense black smoke over the southern half of Kuwait reduced visibilities to 6 km-- some pilots reported certain areas as "unworkable." Duststorms developed as wind speeds reached 20 knots around 0900Z; speeds to 30 knots dropped visibilities to as low as 200 meters later in the day. Local evening visibilities were as low as 1,100 meters.

High temperatures increased to 20-25° C as the front brought warm air into the region; lows were 6-8° C.

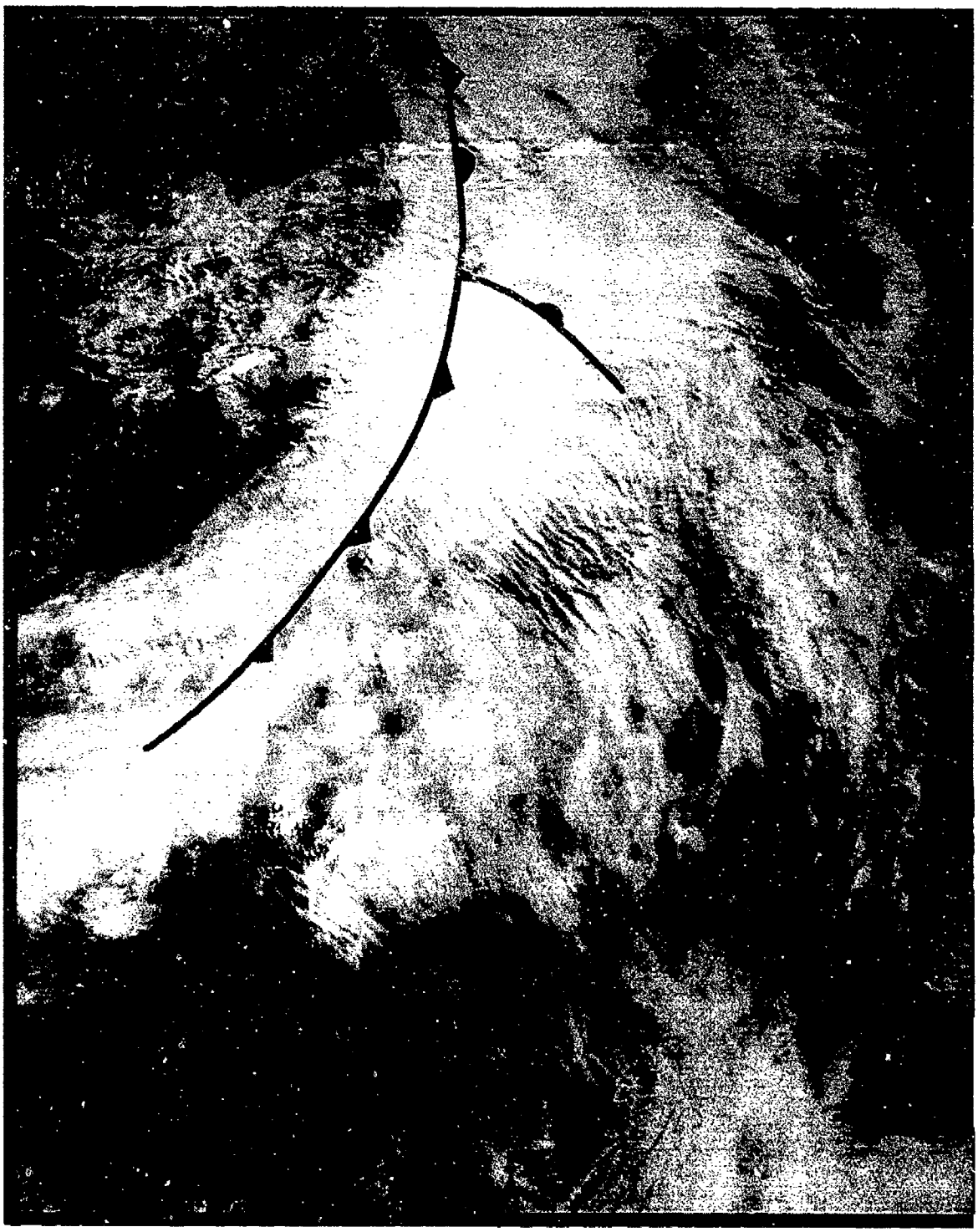


**Figure 3-33. NOAA Visual, 16 February 1991, 1112Z.** A frontal system extends southward from a low over the Black Sea, producing multilayered clouds. There were middle and high clouds over Iraq.

**General Weather.** A low-pressure area moved northeast from central Iraq across Iran as its cold front moved through most of Iraq. A weak secondary low (shown in Figure 3-34) formed along the front in south-central Iraq near the Saudi Arabian border. The cold front continued southward into central Saudi Arabia and weakened. High pressure intensified behind the front.

**Area of Interest.** Rain fell along the front in northern Saudi Arabia early in the day, but moved into central Saudi Arabia by evening. Visibilities were 8 km, but dropped to 4,700 meters in a 1500Z thunderstorm in west-central Saudi Arabia. Blowing dust ahead of the front reduced visibilities to as low as 1,700 meters. Duststorms behind the front dropped visibility as low as 900 meters in western Iraq. Skies over central Saudi Arabia were scattered at 4,000 feet, and broken to overcast at 10,000 feet.

**Area of Intense Interest.** Cloud cover from 0000 to 1100Z was broken to overcast with layered low and middle clouds; ceilings were 3,000 feet, tops to 15,000 feet. Skies over southern Iraq and Kuwait were overcast at between 20,000 and 35,000 feet. Skies in Iraq began to clear by 1100Z, leaving scattered low clouds from 3,000 to 6,000 feet that continued moving east and south; all of Iraq, except for its extreme eastern border, was clear after 1600Z.

Rain and rainshowers fell over northeastern Saudi Arabia, southeastern Iraq, and Kuwait. The bases of late-morning thunderstorms near the Saudi Arabia-Iraq border were 3,000 feet, with tops to 35,000 feet. The rain moved eastward by evening.

Winds were southerly to southeasterly at 5-15 knots ahead of the low and cold front, and northerly to northwesterly at 5-20 knots behind it. Speeds diminished to 5-10 knots in the evening.

Visibility in rain was 4,700 meters. Blowing dust in some areas of northeastern Saudi Arabia that had remained dry lowered visibilities to 6 km. Evening fog formed locally where rain had fallen, lowering visibilities to 6 km.

Daytime temperatures were highest (20° C) in the west where skies cleared first, but highs in the east were as low as 14° C. Daily lows were in the evening after the cold front had passed. Lows ranged from 6° C in the north to 12° C in the south.


**Figure 3-34. DMSP Visual, 17 February 1991, 0820Z.** The cold front and subtropical jet stream produces overcast skies across much of northern Saudi Arabia and Kuwait. Low and middle clouds keep skies overcast north of the low over much of eastern Iraq.

**General Weather.** A high-pressure cell moved over Iraq and dominated much of the region's weather.

**Area of Interest.** Morning fog developed over north-central and northwestern Saudi Arabia but dissipated by early afternoon. Clouds associated with yesterday's cold front were over central Saudi Arabia and the Persian Gulf, where they produced scattered light rain through the morning until moving into the Arabian Sea in the afternoon. Skies were scattered from 3,000 to 6,000 feet, broken from 10,000 to 18,000 feet, and broken from 28,000 to 33,000 feet. Figure 3-35 shows these layered clouds.

**Area of Intense Interest.** Thick morning ground fog lifted to form 1,000-foot ceilings that dissipated by about 1000Z. Broken middle clouds over southern Kuwait and northeastern Saudi Arabia moved off to the southeast during the first 6 hours of the day; ceilings were 7,000 feet with tops to 12,000 feet. Middle and high clouds moved into the region from the northwest during the second half of the day; scattered to broken middle clouds were from 8,000 to 18,000 feet, and thin broken high clouds were from 29,000 to 35,000 feet.

Winds were generally light and variable in the north, but northerly to northeasterly at 5-10 knots in the south.

Visibilities ranged from near zero to 2,000 meters in thick and extensive morning fog across portions of Iraq and Saudi Arabia. The fog, which was concentrated over (and to the west of) the Tigris-Euphrates river valley in Iraq, didn't burn off until about 1000Z. Fog formed again in the evening over northern Saudi Arabia and Kuwait, dropping visibilities to 4,800 meters.

High temperatures were 17-20° C; lows ranged from 5° C in clear areas to 11° C under the fog.

**Figure 3-35. DMSP Thermal, 18 February 1991, 0305Z.** Broken to overcast middle and high clouds lie over northeastern and central Saudi Arabia.

**General Weather.** A low-pressure area developed over Syria and moved eastward into northwestern Iraq. A secondary low developed in northwestern Saudi Arabia and moved eastward into northern Saudi Arabia. Two lines of strong thunderstorms--one over northern Saudi Arabia, one over Iraq--developed between 1500 and 1800Z and continued well into the next day--see Figure 3-36.

**Area of Interest.** Scattered low clouds over western Iraq and northern Saudi Arabia early in the day were from 3,000 to 5,000 feet--see Figure 3-37. Thin high clouds moved in that afternoon. Thunderstorm bases were at 3,000 feet, tops to 35,000 feet. Rain and rainshowers began after 1500Z. In Central Saudi Arabia, scattered to broken low and middle clouds, with bases at 4,000 and 10,000 feet, produced scattered evening rainshowers.

**Area of Intense Interest.** Cloud cover in the first 6 hours was limited to southeastern Iraq and Kuwait, where skies were scattered at 3,000 to 5,000 feet and thin broken from 20,000 to 25,000 feet. After these had cleared out in the afternoon, a new high thin broken layer at 22,000 to 25,000 feet moved in. Convective activity from the west entered the area at about 1800Z, producing bases that were generally 3,000 feet, but as low as 1,000 feet in thunderstorms; tops were to 35,000 feet. Convective cells consolidated to form a nearly solid, north-south line in central Iraq as another, similar line formed in northern Saudi Arabia. Middle-cloud ceilings outside showers were at 10,000 feet.

Thunderstorms produced localized moderate to heavy rain after 1800Z. Light rain and rainshowers fell outside the areas of strong convection.

Winds were east-southeasterly at 5-10 knots during the first half of the day, increasing to 15-20 knots by afternoon. Isolated gusts to 30 knots occurred with thunderstorms.

Visibilities were less than 1,000 meters in rain associated with thunderstorms, but 7 and 9 km elsewhere in rainshowers, black smoke from Kuwait, fog, and/or blowing dust.

High temperatures were 19-21° C; lows, 7-11° C.


**Figure 3-36. DMSP Thermal, 19 February 1991, 1829Z.** Thunderstorm activity (A) is shown developing in western Iraq and north-central Saudi Arabia. The white streaks to the southeast (arrow) are the high-cloud blowoff from the tops of thunderstorms.

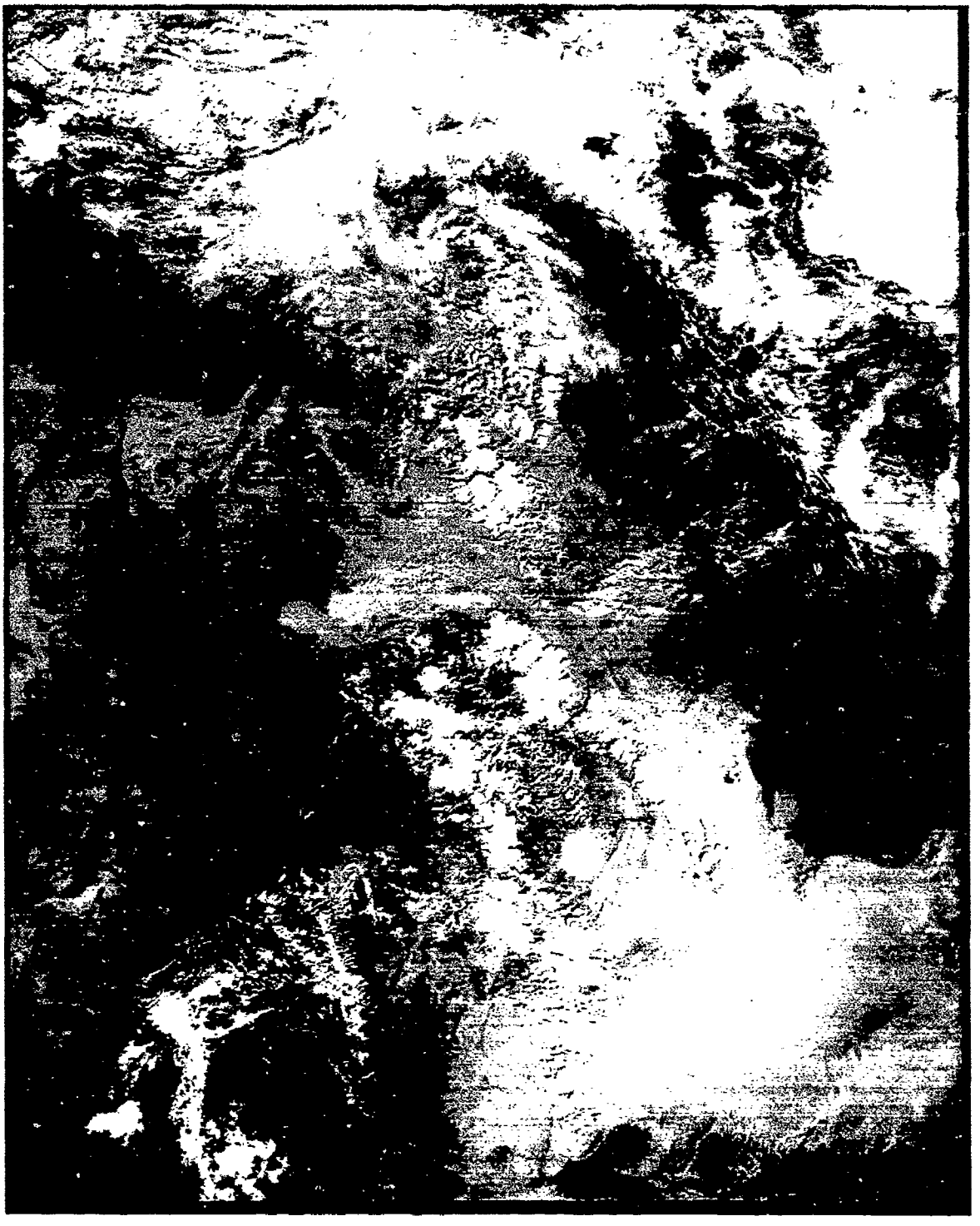


**Figure 3-37. DMSP Visual, 19 February 1991, 0600Z.** Scattered low clouds are visible over the western half of Iraq. Black smoke is evident over Kuwait and extreme northeastern Saudi Arabia.

**General Weather.** The low over Iraq moved eastward into Iran as the secondary low over northern Saudi Arabia moved southeast along the Persian Gulf coast. Thunderstorm activity that started the day before continued across eastern Iraq, Kuwait, and northeastern Saudi Arabia. Lines of thunderstorms moved gradually eastward as new cells developed on their southwestern ends.

**Area of Interest.** A cold front moved southeast across central and eastern Saudi Arabia, producing scattered rainshowers and visibilities as low as 800 meters in blowing dust. Skies were scattered from 4,000 to 6,000 feet, and broken from 10,000 to 15,000 feet. Thunderstorms that had been in Northern Iraq earlier in the day moved into Iran, followed by broken to overcast low and middle clouds with ceilings at 3,500 feet. Western Iraq remained generally clear. Figure 3-38 shows conditions in late morning.

**Area of Intense Interest.** Thunderstorms moved across the area from west to east. Bases were at 1,000 feet and tops reached 40,000 feet. Cloud cover outside thunderstorms was broken to overcast, and multilayered from 3,000 to 35,000 feet. Surface moisture helped produce low broken clouds west of the front in central Iraq; ceilings were 3,500 feet, with tops to 6,000 feet. There were also broken middle clouds from 10,000 to 15,000 feet. Parts of south-central Iraq and north-central Saudi Arabia cleared as the thunderstorms moved east.

Precipitation was moderate to heavy in thunderstorms, but light away from the strong cells.

Winds were east-southeasterly at 10-20 knots, becoming west-northwesterly at 10-25 knots as the storms moved through. Isolated gusts in thunderstorms were above 30 knots.

Visibilities were 9 km outside thunderstorms, but less than 1,000 meters in heavy thundershowers. Blowing dust in areas along the front that had not received much rain lowered visibilities to 7 km. Evening fog formed along the Persian Gulf coast, lowering visibilities to 1,500 meters by 2300Z.

High temperatures ranged from 24° C in the southeast ahead of the cold front to as low as 15° C in the northwest behind it. Lows were 9° C in the north and 14° C in the southeast.

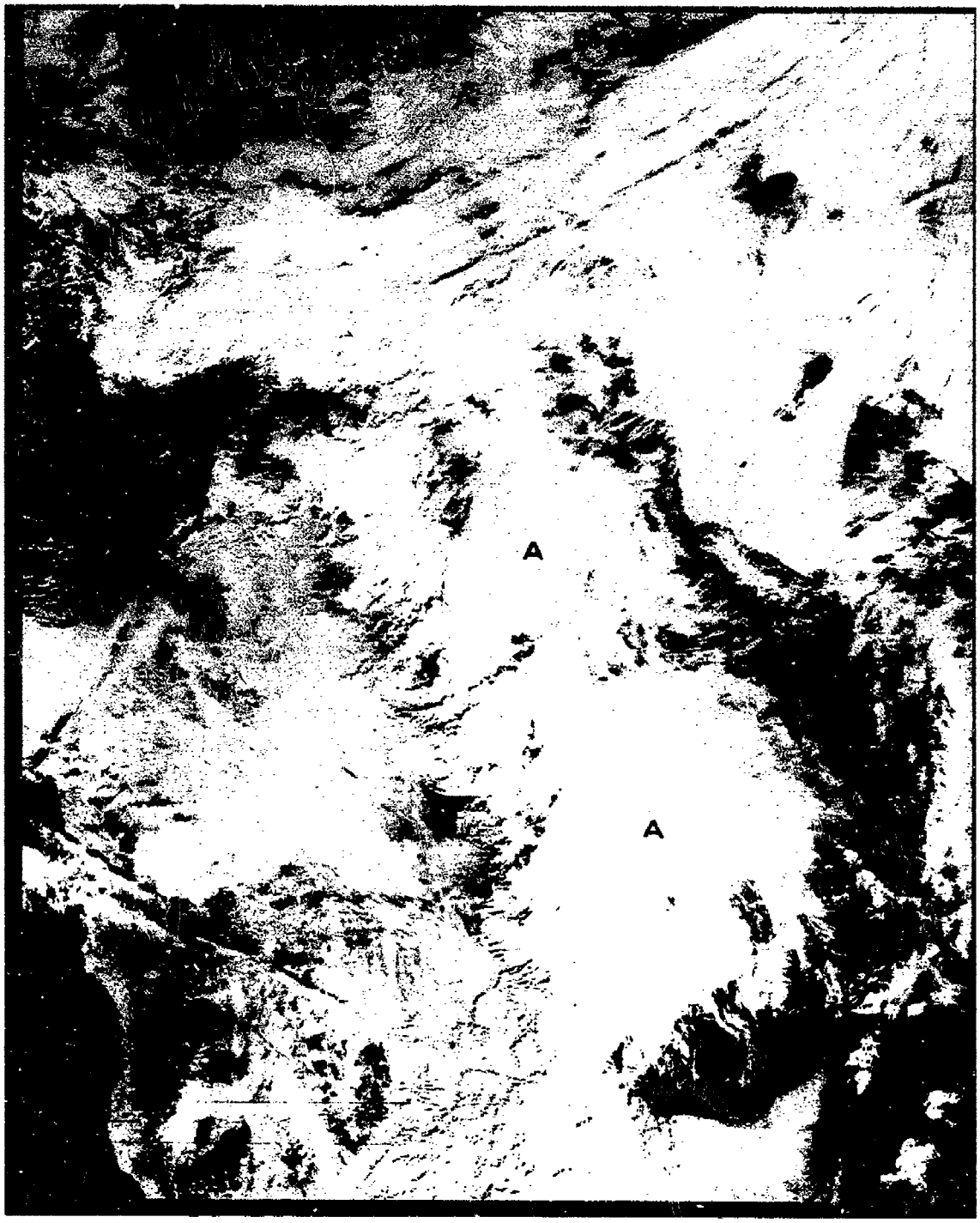



**Figure 3-38. DMSP Visual, 20 February 1991, 0534Z.** Thunderstorms (A) are visible over the eastern half of Iraq, Kuwait, and extreme northeastern Saudi Arabia.

**General Weather.** A low-pressure system moving south along the Persian Gulf neared Dhahran by 0300Z; by 1500Z, it was on the United Arab Emirates coast near 53° E. Its cloudless cold front extended southwest across the Arabian Peninsula. By 0900Z, an area of high pressure had formed in northwestern Saudi Arabia near the Iraqi border.

**Area of Interest.** The low-pressure system spread a wide area of clouds, rain, and isolated thunderstorms over the Persian Gulf and along the coast as it passed. Ceilings were generally 10,000 feet in rainshowers, but ceilings in thunderstorms were reported at 3,000 feet. Inland, the front caused duststorms as it passed, reducing visibilities in some places to 800 meters. Fog blanketed northern Saudi Arabia in the wake of the low-pressure system, but dissipated by 0800Z at most locations; visibilities were as low as 2,800 meters along the coast, but much lower in protected wadis. Along the eastern Saudi Arabian coast, visibilities were 4,800 meters in dense haze. Between 0500 and 1300Z, sporadic duststorms reduced visibilities to 6 km in the Syrian Desert.

**Area of Intense Interest.** An overcast layer of low clouds resulted in 500-foot ceilings over Kuwait and Iraq south of Baghdad. Cloud tops were about 1,200 feet. The clouds lifted to 1,000-3,000 feet by 0500Z and dissipated by 0700Z. South of 29° N, broken middle clouds with 10,000-foot bases persisted until about 0700Z. Skies were clear after 0900Z.

Winds were northeasterly or northerly at 10 knots in the south, easterly at 10-15 knots in the north. Central Iraq's winds were light and variable. Highest speeds--20 knots along the northeastern Saudi Arabian border--were reported at 1500Z.

Figure 3-39 shows the fog; visibilities of 500 meters were common. The fog dissipated in the northwest first, but lingered until 0800Z in Kuwait and Iraq south of 32° N. Dense smoke reduced visibilities in southern Kuwait and northern Saudi Arabia.

The afternoon high temperature was 15° C. Morning lows were 6-11° C, but by evening, temperatures in the north had fallen to about 3° C.

**Figure 3-39. DMSP Visual, Kuwait Blowup, 21 February 1991, 0515Z.** Fog covers Kuwait and southern Iraq. Smoke plumes from southern Kuwait are visible above the fog. The circle shows the location of Kuwait City.

**General Weather.** High pressure was centered over east-central Saudi Arabia. A cold front extending from a low in the eastern Mediterranean spread scattered to broken high clouds across Syria and northwestern Iraq. The system had moved into eastern Syria by 1600Z. A low-pressure system near the Strait of Hormuz brought low cloudiness and rain to the southeastern Arabian Peninsula.

**Area of Interest.** Scattered low clouds and scattered to broken middle clouds with 10,000-foot ceilings covered western Iraq, Syria, and Jordan after 1600Z; there were isolated ceilings at 4,000 feet. Scattered rainfall reduced visibilities to about 5 km. Isolated thunderstorms had 500-foot ceilings and tops to 35,000 feet. A dense band of smoke aloft extended from the northern Persian Gulf along the Saudi Arabian coast into the Rub al Khali. Bases were about 10,000 feet, tops to 18,000 feet. Low and middle clouds spread 10,000-foot ceilings over Oman. Isolated thunderstorms with tops to 35,000 feet lowered ceilings to 2,500 feet. Visibilities in rainshowers decreased to 5 km.

**Area of Intense Interest.** Skies were clear to scattered, but scattered to broken middle and high clouds moved over the extreme northeast by 1800Z. Ceilings, where present, were 10,000 feet with tops to 15,000 feet. The middle and high clouds were nearing Baghdad by 2300Z.

Visibilities were unrestricted except for areas affected by smoke, where they were generally about 6 km. Pilots reported smoke tops to about 15,000 feet and inflight visibilies as low as 1,000 feet. Figure 3-40 shows dense smoke over and south of Kuwait.

Winds were light and variable before 1500Z, becoming south-easterly to easterly at 5-10 knots to the east of the front after 1500Z. Elsewhere, winds remained light. After sunset, winds were nearly calm.

High temperatures were 13-18° C; lows, 1-8° C. The lowest temperatures were in the eastern Nafud Desert.

**Figure 3-40. NOAA Visual, 22 February 1991, 0414Z.** High pressure dominates. Note the dense smoke over Kuwait and coastal Saudi Arabia.

**General Weather.** High pressure centered over the eastern Arabian Peninsula moved southeastward into the Rub al Khali by 2000Z. Even though the frontal system dissipated as it moved across northwest Saudi Arabia, it still caused isolated light showers and duststorms. The subtropical jet stream brought middle and high clouds eastward over the area after 0900Z. Low pressure formed over the Red Sea.

**Area of Interest.** Fog reduced visibilities along the central Persian Gulf to about 1,000 meters between 0100 and 0400Z and re-formed after 2000Z. Scattered to broken low and middle clouds with light isolated rainshowers reduced visibilities to 10 km along the weak low-pressure system in the west. Duststorms caused 4,000-meter visibilities in the Syrian and Nafud Deserts between 0900 and 1700Z. Middle and high clouds produced 10,000-foot ceilings over northwestern Saudi Arabia after 0900Z. Smoke from the Kuwaiti oilfields had reached Qatar; although concentrated at 10,000-12,000 feet, the smoke mixed with haze at lower levels to produce 6-km visibilities.

**Area of Intense Interest.** In the west, the low-pressure system caused scattered to broken clouds at 10,000 feet until about 0600Z, when they became scattered. By 1200Z, middle and high clouds began to move into the area south of 31° N, causing broken to overcast ceilings at 10,000 to 12,000 feet. These clouds were east of 45° E by 1900Z. Between 0400 and 1600Z, another band of middle and high clouds formed along the Iran-Iraq border north of 32° N. Ceilings were about 8,000 feet, with tops to 32,000 feet. Isolated thunderstorms formed over Kuwait by 2000Z, with 2,500-foot bases and tops to 35,000 feet.

Winds were northerly to northwesterly at 10-15 knots east of 45° E. Elsewhere, winds were easterly at 5-10 knots.

Duststorms reduced visibilities to 8 km along the Iraq-Saudi Arabia border between 0800 and 1500Z. Dense smoke--shown in Figure 3-41--covered eastern Kuwait and reduced visibilities generally to less than 8 km, with isolated cases as low as 1,000 meters.

High temperatures were 13-16° C; lows, 7-13° C.

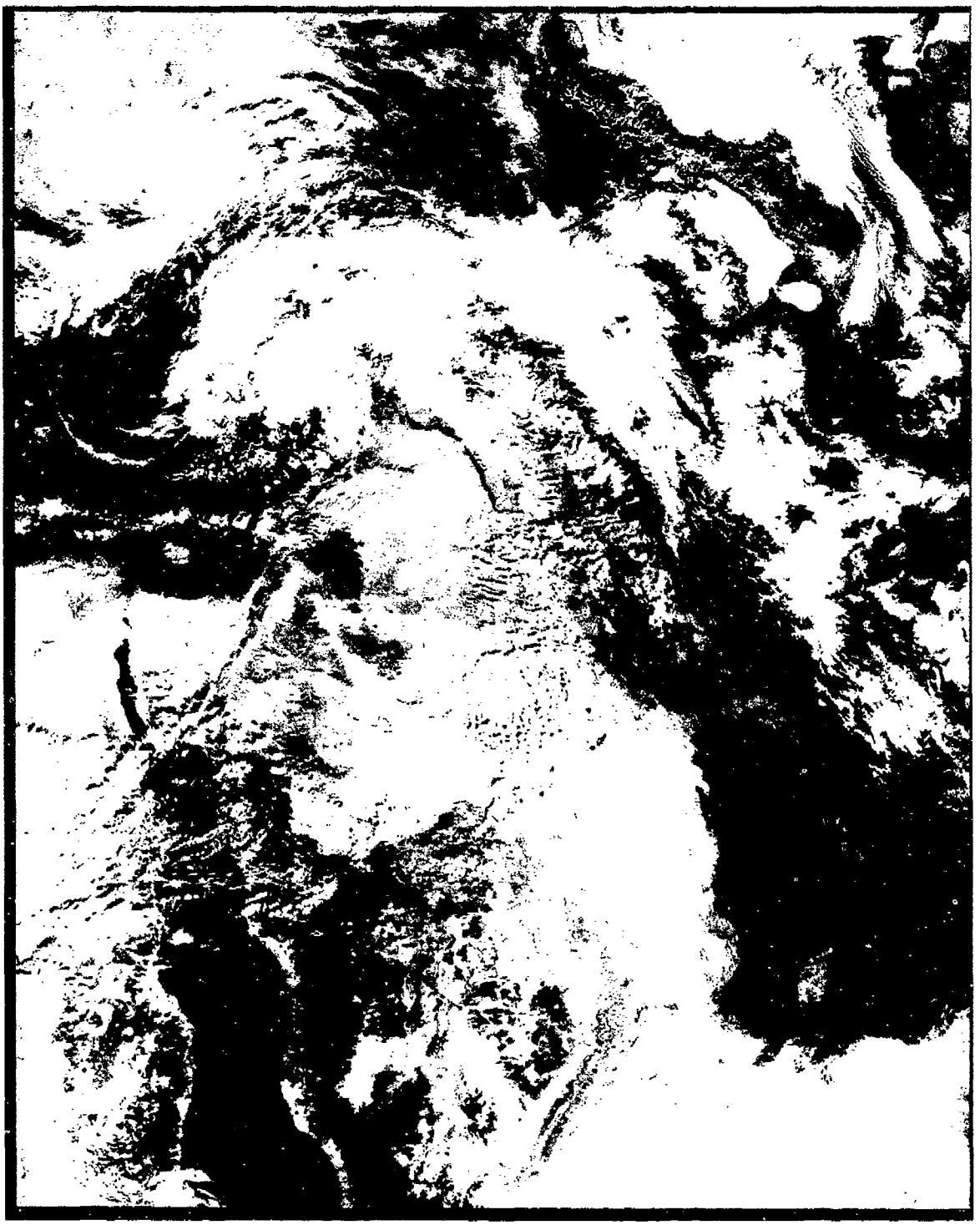


**Figure 3-41. NOAA Visual, 23 February 1991, 0612Z.** Dense smoke obscures the Persian Gulf's western coast.

**General Weather.** A low-pressure system moved slowly eastward along the Iraq-Saudi Arabia border--see Figure 3-42. High pressure was still centered over the southeastern Arabian Peninsula. The subtropical jet stream's middle and high clouds moved eastward over the northern Persian Gulf. They were out of the area by about 1900Z, but another upper-level disturbance brought more high and middle clouds eastward. At 1500Z, these clouds were in north-central Saudi Arabia.

**Area of Interest.** Morning fog again blanketed the central Persian Gulf coast between Dhahran and the Strait of Hormuz. Visibility was poorest (2,000 meters) south of Qatar. Gusty winds and blowing dust accompanied the low near the northern Saudi Arabian border where 15- to 20-knot winds raised dust that reduced visibilities to 6 km. Broken to overcast middle clouds produced 8,000-foot ceilings over the northern Persian Gulf, but embedded low clouds resulted in isolated ceilings at 3,000 feet. Isolated rainshowers fell near the low, reducing visibilities to 8 km. Isolated thunderstorms, with bases at 2,500 feet and tops to 30,000 feet, developed southwest of Riyadh between 1500 and 2200Z. Smoke reduced visibilities and obscured skies along the Persian Gulf as far south as 23° N. Broken to overcast low clouds with 2,000-foot ceilings in extreme northern Iraq and Syria dissipated by 1500Z. Figure 3-42 shows mid-afternoon cloudiness.

**Area of Intense Interest.** In Kuwait and southern Iraq, skies were broken to overcast with 8,000-foot ceilings until about 0500Z. Tops of these multilayered clouds reached 35,000 feet. There were isolated 2,500-foot ceilings. By 0500Z, the higher clouds had moved east, leaving scattered to broken low clouds over Kuwait. In the evening, more middle and high clouds began to move into the southern half from the west. They reached western Kuwait by 2000Z, bringing 9,000-foot ceilings and tops to 30,000 feet.

Isolated rainshowers and thunderstorms affected Kuwait and southeastern Iraq until 0600Z. Rain, heavy at times, reduced visibility to 5 km.

Winds in Saudi Arabia and western Iraq were southwesterly to westerly at 10-15 knots, increasing to 15-25 knots by 0900Z south of 32° N, with gusts to 30 knots. By 2100Z, speeds had diminished

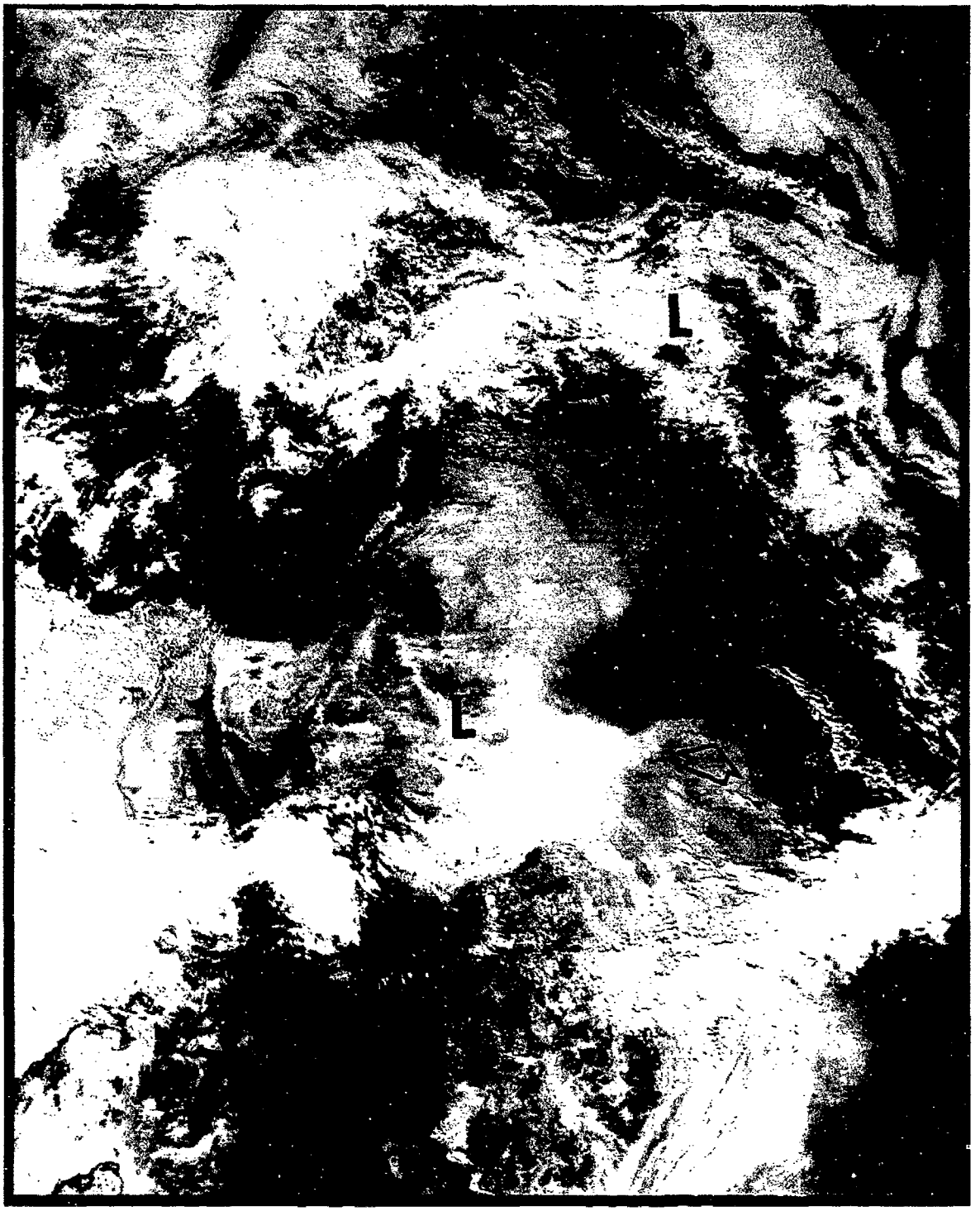



**Figure 3-42. DMSP Visual, 24 February 1991, 1123Z.** Smoke (arrow) spreads from Kuwait to central Iraq. The upper-air disturbance that affected Kuwait in the morning is now over the Persian Gulf, and the disturbance affecting it in the evening is now over the Red Sea.

to 10-15 knots. Winds in the Tigris-Euphrates river valley were southeasterly at 10-20 knots, but dropped to 3-5 knots after sunset.

Duststorms reduced visibilities to as low as 1,000 meters in Kuwait and southern Iraq between 0900 and 2100Z. Dense smoke from the Kuwaiti oil fires moved northwestward--see Figure 3-42. Visibilities just south of Baghdad were less than 3,000 meters. Fog formed after 2100Z in Kuwait and southern Iraq, reducing visibilities to less than 4,000 meters.

Afternoon high temperatures were 10-21° C; morning lows ranged from 1° C in the northeast to 15° C in the southeast.

**General Weather.** As shown in Figure 3-43, An upper-air disturbance moving northeastward spread stormy weather over the northern Arabian Peninsula; by 0900Z, most of the region was covered with clouds. A low-pressure system lingered over northwestern Saudi Arabia as the high-pressure cell in the southeast moved eastward. Low pressure moving east from the northeastern Mediterranean spread clouds southeastward over northern Iraq.

**Area of Interest.** Fog reduced visibilities to as low as 1,500 meters from northeastern Saudi Arabia to the United Arab Emirates coast (and to as low as 500 meters in the Tigris-Euphrates river valley) before 0400Z and again after 2000Z. Broken middle and high multilayered clouds with tops to 30,000 feet spread 9,000-foot ceilings from the northern Red Sea to the northern Persian Gulf and along the Iran-Iraq border. Isolated thunderstorms and rainshowers formed over northwestern Saudi Arabia throughout the day--see Figure 3-44, Page 3-93. They were most intense and widespread at about 1600Z northwest of Riyadh, along the southern Iraq-Iran border, and in extreme western Iraq near the Jordan border. Some of these storms were dry, creating intense, localized duststorms that reduced visibilities to well below 1,000 meters. Widespread duststorms were reported in the northern Arabian Peninsula and the Syrian Desert between 0900 and 2000Z with visibilities as low as 4,000 meters. Prevailing winds were as high as 30 knots in northeastern Saudi Arabia.

**Area of Intense Interest.** At 0300Z, broken high clouds with 24,000-foot ceilings prevailed over Iraq and Kuwait; but as denser clouds continued to move in, a solid overcast from 7,000 to 33,000 feet formed throughout southern Iraq and Kuwait. After 1300Z, isolated thunderstorms with tops to 35,000 feet developed in the area's southern half; skies in the heaviest storms were obscured. Conditions over southern Iraq and Kuwait improved after 1800Z. In southwestern Iraq between the Tigris River and the Iranian border, skies were scattered with isolated low clouds from 2,000 to 20,000 feet. South of 30° N, skies were broken to overcast with 20,000-foot ceilings; there were also isolated low clouds from 10,000 to 35,000 feet. Elsewhere, skies remained overcast between 8,000 and 35,000 feet.

At 0500Z, a line of rainshowers spread from west-central Saudi Arabia northeastward to the Saudi Arabia-Iraq border and eastward into southern Kuwait. The line expanded and intensified to cover most of Kuwait, southern Iraq, and north-central Saudi Arabia by 1600Z. Intermittent precipitation fell the rest of the day.

Winds were southeasterly at 5-10 knots until 0900Z. Afternoon winds were stronger at 15-20 knots, with gusts to 40.

Fog and smoke reduced visibilities to below 2,000 meters in southern Iraq and Kuwait. Visibilities improved to 8 km by 0600Z, but sporadic duststorms in the afternoon reduced them to 4,000 meters.

High temperatures were 14-21° C; lows, 3-16° C.


**Figure 3-43. DMSP Thermal, 25 February 1991, 0320Z.** An upper-air disturbance enters the area. Smoke obscures the northern Persian Gulf.

**Figure 3-44. NOAA Visual, 25 February 1991, 1619Z.** Thunderstorms affect southern Iraq, northern Saudi Arabia, and Kuwait.

**General Weather.** As the upper-air disturbance moved northeast, it continued to produce heavy rainshowers and duststorms over the area. A surface trough formed between the low-pressure area in central Saudi Arabia and another moving through southern Turkey. By 2100Z, the trough stretched through Iraq along 43° E. An area of high pressure was located in central Iran and the extreme southeastern Arabian Peninsula.

**Area of Interest.** Several lines of rainshowers and thunderstorms moved through the northern Arabian Peninsula throughout the day. Between 0000 and 0300Z, an area of thunderstorms spread from the Red Sea near 25° N to the Iraq-Saudi Arabia border near 45° E. Another formed in northeastern Iraq near the Iranian border. By 0900Z, a third area had formed over northeastern Saudi Arabia at 28° N, 47° E. Bases were at 2,500 feet and tops reached 35,000 feet. Thunderstorms were embedded in scattered to broken middle clouds west of 45° E. Multilayered clouds were broken to overcast from 8,000 to 33,000 feet north of 25° N. By 1100Z, the northern area had spread southwestward and the southern areas had moved southeastward. Storm intensity and coverage increased throughout the day until 1600Z, when a line of isolated thunderstorms extended from the northern Persian Gulf to southwest of Riyadh. Areas west of 43° E had cleared. Clouds, rainshowers, and thunderstorms spread southeastward again in the evening, reaching as far southwest as 20° N, 44° E, by 1900Z.

Fog reduced visibilities to 4,000 meters in the Tigris-Euphrates river valley between eastern Syria and Baghdad until about 0800Z. It also formed in sheltered inland areas after rainshowers ended, reducing visibilities to as low as 2,000 meters. Some thunderstorms produced localized duststorms with visibilities below 1,000 meters. More extensive duststorms formed south of 25° N, where visibilities were reduced to 6 km.

**Area of Intense Interest.** Broken to overcast clouds between 8,000 and 20,000 feet covered the entire area before 0300Z. The lower cloud deck gradually dissipated in the northwest, leaving scattered skies over most of Iraq, and high clouds with tops to 32,000 feet over southern Iraq and Kuwait. Scattered to broken clouds between 4,000 and 6,000 feet formed over central Iraq between 0500 and 1600Z. At 1100Z, there were isolated thunderstorms or rainshowers embedded in these clouds in a line

from 35° N, 45' E, to 31° N, 41' E--they are shown in Figure 3-45. Thunderstorms also formed over eastern Kuwait and extreme southwestern Iraq after 1500Z. Cloud bases were 3,000 feet and tops reached 35,000 feet.

Intermittent rainshowers and thunderstorms fell southeast of a line extending from 34° N, 46' E, to 31° N, 42' E, throughout the day.

Winds were southeasterly at 10-15 knots, but by 1200Z, speeds in the east reached 20-30 knots. Winds in the west shifted to northwesterly at 10-15 knots as the trough moved eastward.

Fog and smoke reduced visibilities to below 2,000 meters from the central Tigris-Euphrates river valley to Kuwait. Visibilities improved to 8 km by 0600Z, but sporadic duststorms in the afternoon reduced visibilities to 4,000 meters. Visibilities in heavy rainshowers may have dropped to as low as 1,000 meters.

High temperatures were 17-21° C; lows, 7-16° C.

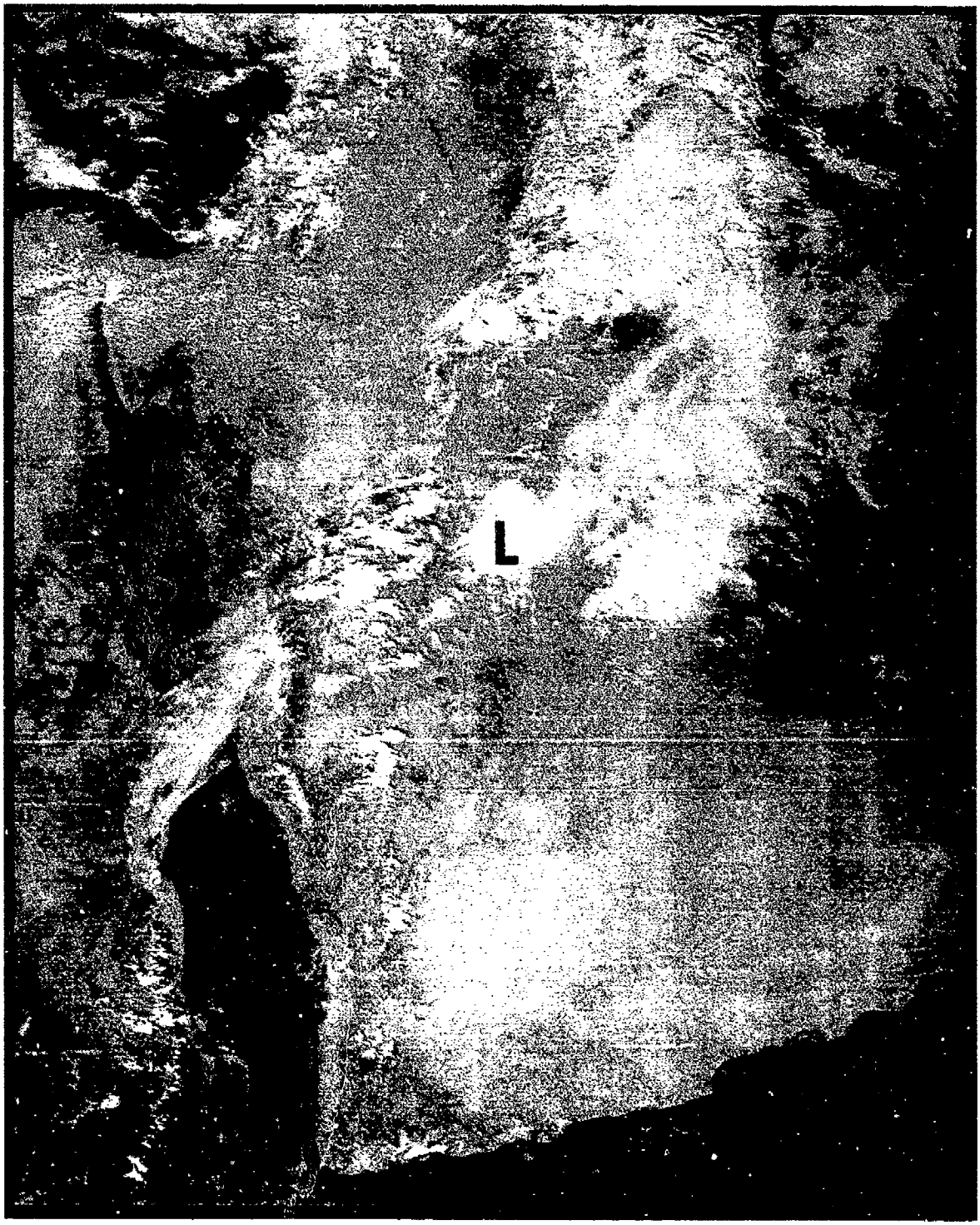



**Figure 3-45. DMSP Thermal, 26 February 1991, 1105Z.** Storms lingered over Kuwait. There is a line of thunderstorms near Baghdad.

**General Weather.** A low-pressure cell that had been centered in southeastern Iraq at 0000Z slid southeastward into the Persian Gulf throughout the day. A weak frontal system in the eastern Mediterranean Sea moved onshore and was in central Iraq by the end of the day.

**Area of Interest.** In northern Iraq, broken clouds with bases of 8,000 feet persisted until late morning, when they became scattered at 3,000 feet and eventually developed into afternoon thunderstorms that moved northeast. In western Iraq and northwestern Saudi Arabia, skies were scattered with bases at 10,000 feet throughout the morning. Clouds from the front approaching from the Mediterranean began moving in by 1100Z, forming ceilings rapidly. Rain began lowering visibilities to 5 km by 1300Z. Thunderstorms developed in the afternoon as the clouds moved eastward. By the end of the day, clouds and rain were confined to the western Saudi Arabia-Iraq border. In north-central and northeastern Saudi Arabia, broken clouds, multilayered from 3,000 to 25,000 feet with rainshowers and thunderstorms, prevailed. Visibilities were 4,800 meters in ground fog, rain, and haze, but near zero in blowing dust from thunderstorms. Clouds moved slowly southeast to east-central Saudi Arabia by day's end.

**Area of Intense Interest.** Broken multilayered clouds from 3,000 to 25,000 feet covered the southern half of the area, but cleared from the northwest by noon, leaving scattered clouds at 3,000 feet and broken clouds at 6,000-8,000 feet over southeast Iraq and Kuwait. These also cleared by 1900Z. A smoke layer at 2,500 feet covered most of central and southern Kuwait throughout the day. A line of broken 4,000-foot clouds associated with the front from the Mediterranean invaded the western part of the area by noon. The line was past Baghdad and into north-central Saudi Arabia by the end of the day.

Rainshowers and thunderstorms were widespread in the southern half of the area through the morning, as shown in Figure 3-46. Light rain fell in the western half as the front passed.

Winds were northwesterly to northeasterly at 5-15 knots (but up to 25 knots in thunderstorms) in the southern half of the area. In the northern half, they were westerly to northwesterly at 3-10 knots.

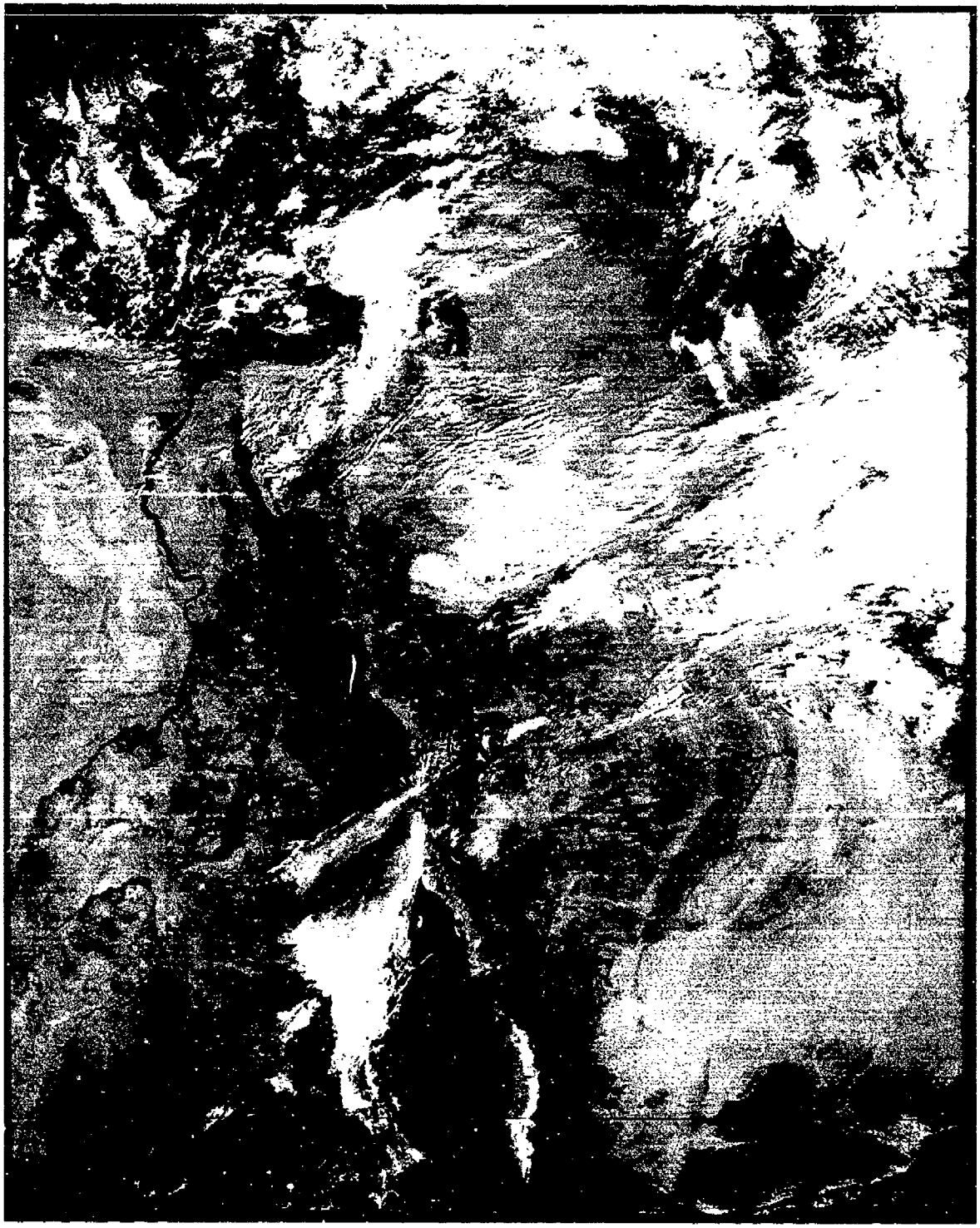


**Figure 3-46. DMSP Visual, 27 February 1991, 0642Z.** The frontal system in the eastern Mediterranean Sea is shown moving onshore and across Jordan. Note the area of rainshowers and thunderstorms in southeastern Iraq, Kuwait, and northeastern Saudi Arabia.

Winds became southwesterly at 5-15 knots as the front approached, and northwesterly at 8-20 knots behind it.

Visibilities were near zero in dense fog along the Tigris-Euphrates river basin. They were also near zero In the southern half of the area, where thunderstorms produced blowing dust. Elsewhere, morning visibilities were 5 km in ground fog, rain, and haze. Rain lowered visibilities to 4,800 meters in the western half of the area as the front passed. Smoke limited visibility aloft to 1,600 meters over Kuwait.

High temperatures were 13-20° C; lows, 07-16° C.

**General Weather.** Low pressure was centered over the southeastern part of the Saudi Arabian peninsula while high pressure intensified in the rest of the region. Remnants of a weak frontal system remained in northern Saudi Arabia and southern Iraq.

**Area of Interest.** Skies were broken to overcast over north-central, northeastern, east, and east-central Saudi Arabia. Ceiling heights were 3,000-4,000 feet. By evening, skies were mostly clear to scattered. Light rain and drizzle fell over north-central and eastern Saudi Arabia. Thunderstorms with tops to 35,000 feet were observed over east-central Saudi Arabia and the northern part of the Persian Gulf during early morning--see Figure 3-47, next page. Winds were northwesterly at 10-20 knots with gusts to 25 knots. Fog lowered morning visibilities to 4,800 meters in east-central Saudi Arabia. Fog reduced early afternoon visibilities to 3,200 meters in northeastern Saudi Arabia, which improved to 6-8 km in smoke and haze by late afternoon. A sandstorm in east-central Saudi Arabia, with wind speeds of 30-40 knots, is visible in Figure 3-48 on Page 3-102. The storm reduced late afternoon and early evening visibilities to 1,600-4,000 meters, with isolated reports of 100 meters.

**Area of Intense Interest.** Skies were broken to overcast over southern and southeastern Iraq and Kuwait--ceilings were 3,000 to 4,000 feet, but 800 feet in showers. By early evening, skies were clear to scattered. Isolated afternoon thunderstorms (tops to 35,000 feet) and rainshowers were present over southeastern Iraq and Kuwait.

Winds were northwesterly to northerly at 10-20 knots, with gusts to 35 knots near thunderstorms.

In Kuwait, visibilities were less than 3,200 meters in smoke and 2,000 meters in thunderstorms.

High temperatures were 13-18° C; lows, 5-10° C.

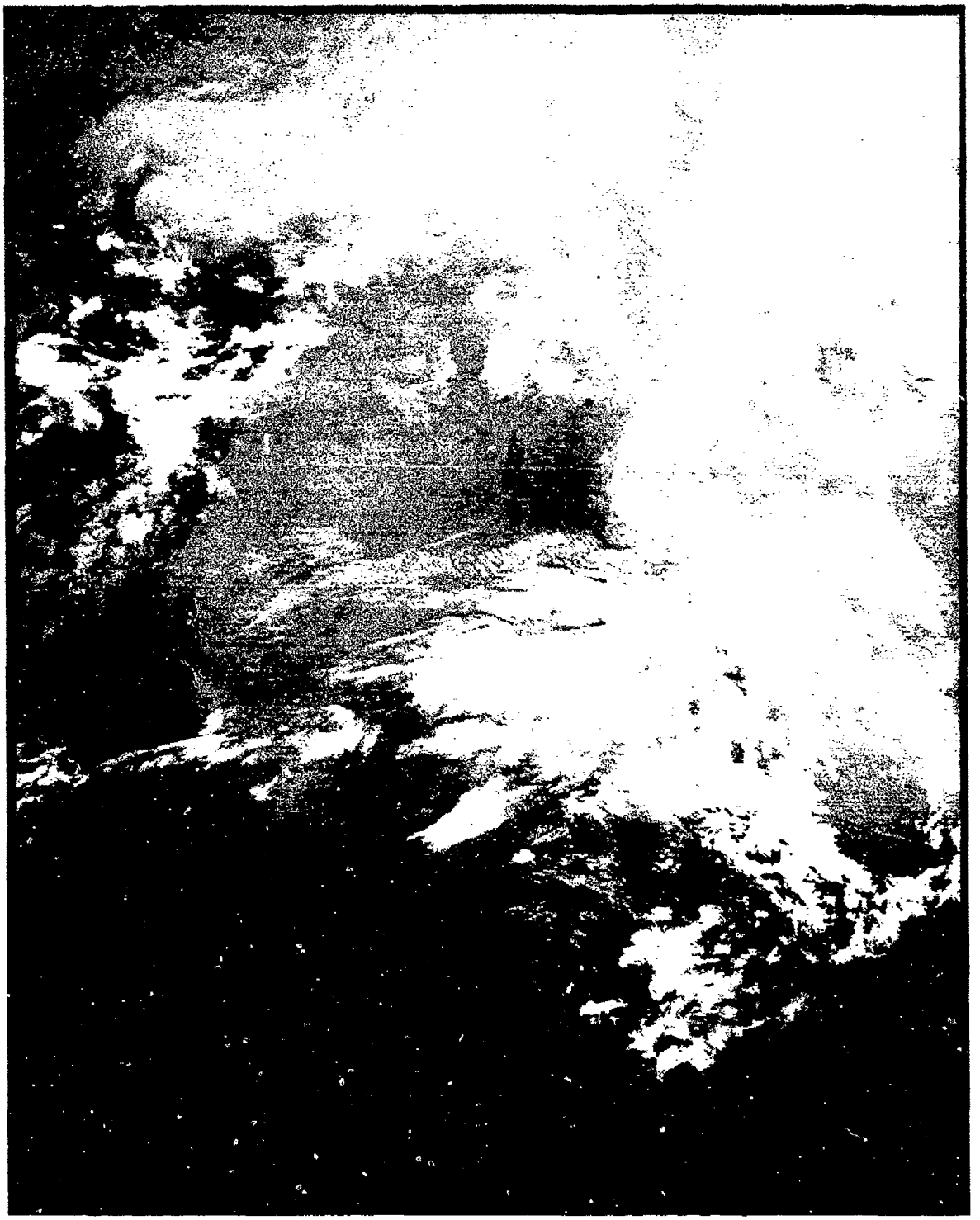


**Figure 3-47. DMSP Thermal, 28 February 1991, 0255Z.** Thunderstorms are visible over the northern part of the Persian Gulf.

**Figure 3-48. DMSP Thermal, 28 February 1991, 1515Z.** The front edge of the sandstorm (shown by the arrow) is visible over east-central Saudi Arabia. (The manual gridding was added by forecasters at the Riyadh Desert Forecast Center.)

**General Weather.** High pressure dominated, but a low-pressure system developed over the eastern Mediterranean by the end of the day, sending moisture into western areas.

**Area of Interest.** Skies were clear to scattered over most of the area, but scattered to broken at 1,000-2,000 feet over northeast and eastern Saudi Arabia due to smoke--see Figure 3-49. Scattered to broken low clouds at 3,000 feet, with occasionally broken middle and high ceilings, moved into western Iraq and northwestern Saudi Arabia by mid-afternoon. Winds were northwesterly to northerly at 10-15 knots. Visibilities in northeastern Saudi Arabia were 6-8 km in smoke and haze. Blowing sand and dust reduced early morning visibilities to 3,200 meters in east-central and eastern Saudi Arabia.

**Area of Intense Interest.** Scattered, occasionally broken, middle clouds at 8,000-10,000 feet moved into central Iraq by mid-afternoon.

Winds were northwesterly at 10-15 knots.

Smoke and haze reduced visibilities in Kuwait to 5-7 km, occasionally to 3,200 meters.

High temperatures were 15-20° C; lows, 5-10° C.

**Figure 3-49. DMSP Visual, 1 March 1991, 0546Z.** The arrows mark smoke from Kuwait over northeastern and south-central Saudi Arabia as it comes off the Persian Gulf.

**General Weather.** High pressure dominated as a low-pressure system moved northeast and brought moisture across Iraq and northern Saudi Arabia.

**Area of Interest.** Skies were broken to overcast at 8,000-10,000 feet, but early morning ceilings were 3,000-5,000 feet in showers over western and northern Iraq. Smoke formed a broken layer at 2,000-3,000 feet over northeast and east-central Saudi Arabia during the morning--see Figure 3-50. Skies over the rest of the area were clear to scattered. Isolated rainshowers and thunderstorms with tops to 35,000 feet developed during early morning in northern Iraq. Visibilities were 6-8 km in precipitation. Haze reduced morning visibilities to 4,800 meters in east-central Saudi Arabia. Smoke reduced morning visibilities in eastern Saudi Arabia to 4,800 meters; in the afternoon and evening, to 4,000 meters.

**Area of Intense Interest.** Over central Iraq, skies were broken with middle clouds at 8,000-10,000 feet in the early morning, becoming scattered in early afternoon--see Figure 3-50.

Winds were northwesterly at 10-15 knots.

Smoke reduced visibilities in Kuwait to 5-7 km, with isolated areas of less than 1,600 meters.

High temperatures were 15-20° C; lows, 5-10° C.

**Figure 3-50. DMSP Visual, 2 March 1991, 0530Z.** Smoke from Kuwait is visible as it moves off the Persian Gulf along the Saudi Arabian coast and into eastern Saudi Arabia.

## Chapter 4

# PROVIDE COMFORT WEATHER

3-31 March 1991

**General Weather.** High pressure dominated; skies were clear to scattered. Most cloud cover was associated with the subtropical jet stream extending over central Saudi Arabia--see Figure 4-1. Isolated wind gusts to 25 knots produced blowing dust that reduced visibilities to as low as 1,600 meters over Saudi Arabia, Kuwait, and southern Iraq.

Scattered clouds with bases as low as 3,000 feet prevailed north of 32° N; isolated ceilings were reported. Middle and high clouds formed along the jet stream over Saudi Arabia. Bases were as low as 8,000 feet, but there were only isolated reports of ceilings.

Winds were variable at 10 knots or less at night. In and around Syria, winds were light and variable all day. Afternoon winds were northwesterly at 5-15 knots over Iraq, Iran, Kuwait, and the east coast of the Arabian Peninsula. They were also northwesterly over the peninsula's west coast, but speeds were higher, at 15-20 knots. In interior Saudi Arabia, winds were southeasterly at 5-15 knots.

Visibilities were generally good, but smoke along the Persian Gulf resulted in local visibilities less than 1,600 meters. Haze and suspended dust (especially blowing dust) caused isolated visibilities between 1,600 and 4,800 meters over Kuwait, southern Iraq, and Saudi Arabia's deserts.

Temperatures near the coasts ranged from 18 to 27° C during the afternoon and from 10 to 21° C in the morning. The lowest were in western Syria. Interior temperatures ranged from 10 to 27° C in the afternoon and from 2 to 16° C in the morning. The lowest were in Iraq. The mountains of Turkey, Iraq, and northwestern Iran were colder--nights were below freezing at elevations above 4,000 feet.

**Figure 4-1. NOAA Visual, 3 March 1991, 1144Z.** A storm system is shown moving east over Libya and the central Mediterranean. Scattered to broken cumulus cloud is visible over Iraq. The middle and high clouds over Egypt and central Saudi Arabia are associated with the subtropical jet stream.

**General Weather.** A passing frontal system controlled this period's weather; its movement can be followed in Figures 4-2 through 4-4. The main low-pressure center moved east-northeast across Jordan on the evening of 4 March while the associated warm front extended southeast into Saudi Arabia; the cold front extended southwest into Egypt. On the evening of the 5th, the low moved into northern Iraq as a second frontal low intensified just northwest of Kuwait. The low in the north continued northeastward, entering northwestern Iran on the morning of the 6th. The second low near Kuwait moved east-southeast with its cold front to affect the Persian Gulf and much of the Arabian Peninsula. It passed Qatar on the evening of the 6th.

Approach of the frontal system brought ceilings of 10,000 (occasionally 3,000) feet. During and after passage, the system produced ceilings at 3,500 feet (occasionally 2,000 feet) north of 30° N. Ceilings at or below 2,000 feet were common along the Persian Gulf as the system passed. There were also isolated reports of ceilings as low as 2,000 feet across much of central Saudi Arabia as the frontal system's approach enhanced subtropical jet stream cloudiness. Most ceilings along the jet stream were at or above 8,000 feet.

Low and middle clouds occurring throughout the period were accompanied by rain and rainshowers. There were isolated to few thunderstorms with tops to 40,000 feet along and near the frontal system.

Winds were south-southeasterly east of the system and west-northwesterly to the west, generally at 10-15 knots. Speeds near the front were 15-30 knots with gusts to 45 knots.

Visibilities in precipitation and fog were mostly above 3,200 meters. Blowing dust near the frontal system was the primary cause of lowered visibilities, which were often at or below 1,600 meters in the deserts. Flow ahead of the frontal system caused the smoke from Kuwait to move north-northwest through Iraq and into southern Turkey on the 4th and 5th; shifting winds drove the smoke east-southeastward on the 6th. Strong winds generally kept smoke from reducing visibilities below 1,600 meters.


**Figure 4-2. NOAA Visual, 4 March 1991, 1133Z.** The storm system is over Egypt and the eastern Mediterranean. Subtropical jet stream clouds (A) have thickened over Saudi Arabia.

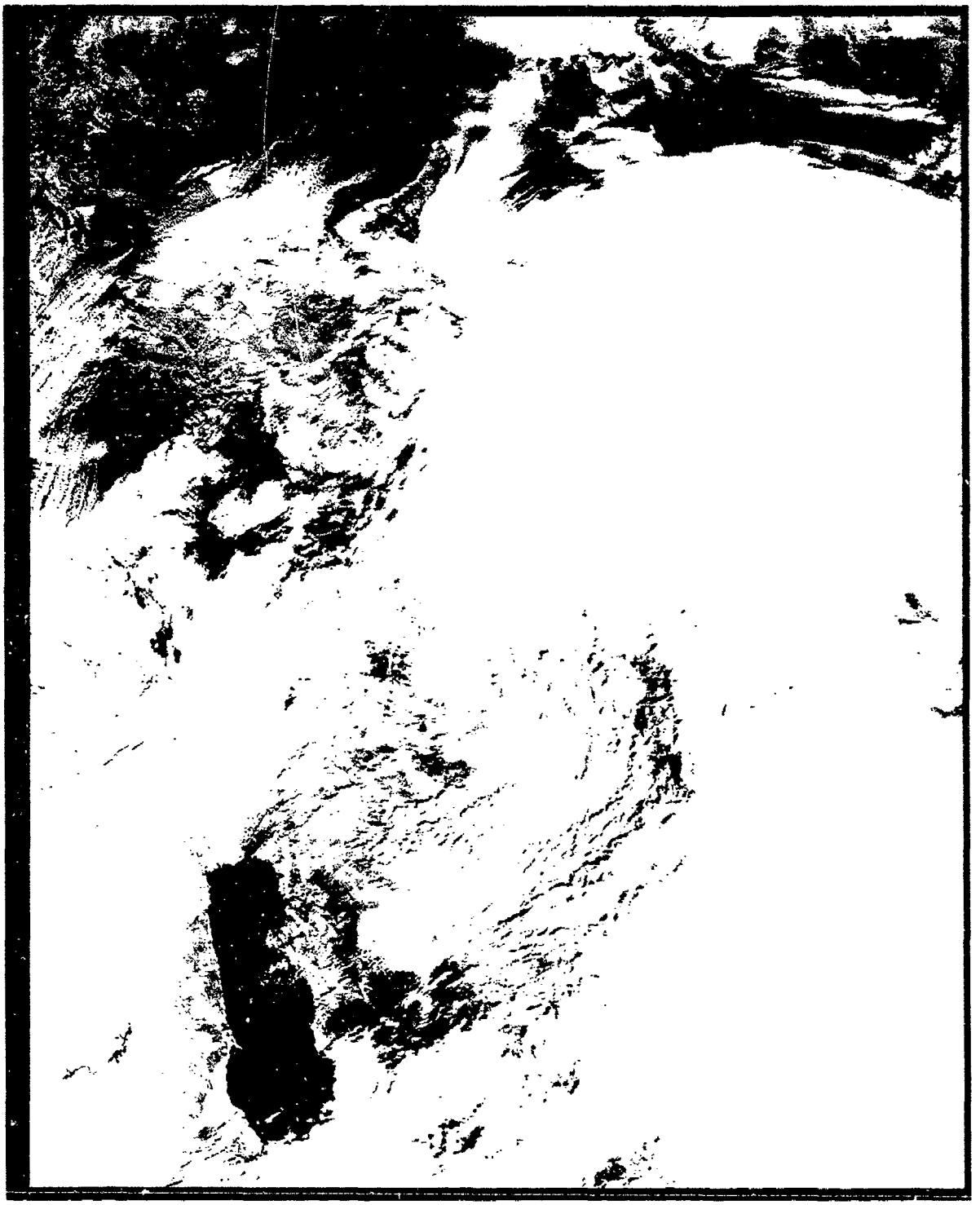


**Figure 4-3. DMSP Visual, 5 March 1991, 0601Z.** The storm system has moved rapidly and grown. It now affects most of the region.


**Figure 4-4. DMSP Visual, 6 March 1991, 0540Z.** The primary low-pressure system has moved out of the region, but clouds are enhanced in and near the Persian Gulf because of a second low, shown here.

Temperatures near coasts were 15-27° C during the afternoon and 15-21° C in the morning, with the lowest near the Mediterranean. Temperatures inland were 10-27° C in the afternoon and 2-21° C in the morning; the lowest were in Iraq. On clear nights, the mountains of eastern Turkey, northeastern Iraq, and northwestern Iran were below freezing above elevations as low as 4,000 feet.

**Significant Weather Events**

***4 March.*** A weak disturbance along the polar jet stream produced low clouds in Turkey and on the northern fringes of Syria, Iraq, and Iran; reported ceilings were mostly 8,000 feet, but occasionally 3,500 feet. The approach of the major system brought 10,000-foot ceilings (some to 3,000 feet) over and near Syria and Jordan. Isolated thunderstorms formed in the evening. Visibilities in precipitation and fog were mostly above 3,200 meters. Most of the blowing dust was in northwestern Saudi Arabia, where reported visibilities were less than 1,600 meters in the afternoon and evening.

***5-6 March.*** The front brought deteriorating weather conditions southeastward over the region. In southeastern Iraq, Kuwait, and along the borders of Saudi Arabia, ceilings were as low as 800 feet from the evening of the 5th through early morning of the 6th as the second frontal low formed near Kuwait. There were also isolated thunderstorms and reports of ceilings as low as 2,000 feet over central Saudi Arabia as the front approached the subtropical jet stream. Ceilings associated with the front were variable in the mountains of Turkey, northeastern Iraq, and northwestern Iran, where most cloud bases were between 3,000 and 4,000 feet; elevations above these heights were often obscured. The mountains also got heavy snow at elevations above about 6,000 feet, with mixed rain and snow down to 4,000 feet. Most of the region north of about 30° N had fog and drizzle after frontal passage. The front caused blowing dust to reduce visibilities to as low as 200 meters in northern Saudi Arabia.

**General Weather.** High pressure dominated most of the region, but a weak disturbance coupled with terrain effects resulted in patchy ceilings and isolated precipitation north of 29° N.

Skies were clear to partly cloudy--see Figures 4-5 through 4-8 starting on Page 4-11. North of 29° N, there were brief periods of broken to overcast low and middle clouds with 10,000-foot (occasionally 3,000-foot) ceilings. The mountains of Turkey, northeastern Iraq, and northwestern Iran were obscured above 10,000 feet. The subtropical jet stream brought high broken clouds to central Saudi Arabia by the 10th.

In the north, occasional precipitation fell from clouds with bases below 10,000 feet on the 8th and 9th, mostly over hilly or mountainous terrain. Rain, rainshowers, and patchy drizzle fell below 3,000 feet, with mixed rain and snow through 5,000 feet and snow above 5,000 feet.

Winds were northwesterly at 10-15 knots at night and 15-20 knots during the day; afternoon gusts reached 30 knots. An exception was near Qatar on the 8th, 9th, and 10th, where winds were southerly at 10 knots or less.

Precipitation and morning fog, patchy north of about 30° N, generally didn't reduce visibilities below 3,200 meters, but there were isolated reports of less than 1,600 meters in fog. Smoke from Kuwait moved south-southeast, lowering visibilities to below 1,600 meters over Kuwait and along Saudi Arabia's Gulf coast. Blowing dust, suspended dust, and haze reduced visibilities below 4,800 meters (occasionally below 1,600 meters) during afternoons over southeastern Iraq, Kuwait, and Saudi Arabia's deserts.

Temperatures near coasts were 15-27° C during the afternoon and 7-18° C in the morning; the lowest were in western Syria. Afternoon temperatures inland ranged from 7° C in Iraq to 29° C in central Saudi Arabia. Morning temperatures in northeastern Iraq were at or below freezing at elevations as low as 3,000 feet, while morning temperatures in interior Saudi Arabia were as high as 13° C.

**Significant Weather Events**

***7 March:*** Afternoon wind gusts to 30 knots caused blowing dust and visibilities below 1,600 meters near the Persian Gulf. Ceilings at 10,000 feet over Syria, Jordan, western Iraq, and northwestern Saudi Arabia were produced by mountain wave turbulence.

***8 March:*** Afternoon wind gusts to 30 knots caused blowing dust that reduced visibilities to less than 1,600 meters in north-central Saudi Arabia. Again, the middle clouds over Syria, Jordan, western Iraq, and northwestern Saudi Arabia were produced by mountain wave turbulence. The mountains of Turkey, northeastern Iraq, and northwestern Iran had snow above about 5,000 feet, as well as isolated thunderstorms with tops to 35,000 feet.

***9-10 March:*** Afternoon wind gusts to 30 knots caused blowing dust and lowered visibilities below 1,600 meters in north-central Saudi Arabia. Snow and isolated thunderstorms occurred in the mountains of Turkey, northeastern Iraq, and northwestern Iran.

**Figure 4-5. DMSP Visual, 7 March 1991, 0427Z.** An extensive area of low clouds remains over Turkey and northern Iraq.

**Figure 4-6. NOAA Visual, 8 March 1991, 1047Z.** Widespread clouds remain over Turkey and northern Iraq.

**Figure 4-7. DMSP Visual, 9 March 1991, 0617Z.** A disturbance enhances clouds over eastern Turkey, northern Iraq, and northern Iran. Black smoke is evident along the Persian Gulf coast.

**Figure 4-8. DMSP Visual, 10 March 1991, 0437Z.** A large area of clouds remains over Turkey, northeastern Iraq, and northwestern Iran. The large area of black smoke around Kuwait is evident.

**General Weather.** High pressure dominated, but a weak upper-level disturbance crossed the region north of 30° N, bringing mostly middle and high clouds--see Figure 4-9, next page. There was little or no precipitation, and winds were light.

The upper-level disturbance resulted in brief periods of 10,000-foot ceilings over Syria and Iraq, with isolated reports of 3,000 feet. The mountains of Turkey, northeastern Iraq, and northwestern Iran were obscured briefly above 3,000 feet. Other areas had scattered clouds at 3,000-4,000 feet and at 10,000 feet. There were patchy 10,000-foot ceilings along 25° N latitude in Saudi Arabia.

Isolated light rain--snow above 4,000 feet--fell over Syria and Iraq.

Winds were light and variable at night. In Iraq, daytime winds were light and variable; in the rest of the region, winds were easterly at 10-20 knots, with gusts to 25 knots.

Visibilities were generally good, but smoke in Kuwait and adjoining areas of Saudi Arabia dropped visibilities below 1,600 meters--see Figure 4-9. Blowing dust, suspended dust, and haze caused isolated reductions to 4,800 meters and occasionally to 1,600 meters over and near Saudi Arabia's deserts.

Temperatures along coasts were 10-21° C in the morning and 18-27° C in the afternoon, but lowest in western Syria. Interior temperatures were 2-21° C in the morning and 10-27° C in the afternoon. Freezing temperatures occurred at night at elevations above about 4,000 feet in eastern Turkey, northeastern Iraq, and northwestern Iran.

**Figure 4-9. DMSP Visual, 11 March 1991, 0535Z.** The polar jet stream causes high clouds over Turkey, northern Iraq, and northwestern Iran. Southward-moving black smoke curves westward into Saudi Arabia.

**General Weather.** A weak system crossing the region resulted in significant afternoon weather. The primary low-pressure center entered Jordan on the evening of the 11th and moved into southeastern Iraq by late afternoon and evening of the 12th. By then, the low (and an associated trough) were causing a narrow band of clouds and precipitation from eastern Turkey through south-central Saudi Arabia along about 45° E longitude. The low then passed through southern Iraq and Kuwait, entering Iran on the evening of the 13th. The trough extended south across the Persian Gulf, arcing westward along about 23° N latitude.

Figures 4-10 and 4-11 on pages 4-19 and 4-20 show mostly clear to scattered skies. The passing system caused significant cloud cover only during late afternoons and evenings. Ceilings were occasionally 8,000 feet, with brief periods at or below 3,000 feet. Similar ceilings, independent of the disturbance, occurred over Syria, Jordan, western Iraq, and northwestern Saudi Arabia on the 13th.

Afternoon rain, rainshowers, and isolated thunderstorms developed along the system; associated nighttime precipitation was very isolated. Snow fell in the northeastern Iraqi, northwestern Iranian, and southeastern Turkish mountains on the 13th, along with light rain and drizzle in Iraq, Syria, and Jordan.

Morning winds were easterly at 10-15 knots over Syria, Jordan, and Iraq, westerly at 10-20 knots along the Persian Gulf, and light and variable over interior Saudi Arabia. Afternoon winds were variable in Syria, southeasterly at 5-15 knots in Iraq and along the Persian Gulf, and westerly at 10-20 knots over Jordan and interior Saudi Arabia. Wind gusts reached 30 knots near thunderstorms.

Blowing dust, suspended dust, and haze occasionally reduced visibilities below 4,800 meters; isolated visibilities below 1,600 meters were reported in Saudi Arabia, Kuwait, and eastern Iraq near the surface trough. Smoke was concentrated in eastern Iraq, with visibilities below 1,600 meters likely. Visibilities in precipitation were below 6 km, but there were isolated cases of less th : 2,400 meters.

Coastal temperatures ranged from highs of 16-27° C during afternoons to lows of 10-18° C during mornings. Afternoon interior temperatures ranged from highs of 10° C in Iraq to 32° C in central Saudi Arabia. Lows ranged from 2° C in Iraq to 21° C in central Saudi Arabia. On clear nights, temperatures were below freezing at elevations above 4,000 feet in eastern Turkey, northeastern Iraq, and northwestern Iran.

**Significant Weather Events**

***12 March:*** A north-south band of isolated late afternoon and evening thunderstorms formed along 45-46° E longitude.

***13 March:*** Another band of isolated late afternoon and evening thunderstorms developed along the Iraq-Iran border, southward over the northern Persian Gulf and the adjoining Saudi Arabian coast, then westward between 22 and 24° N. A few southward- and westward-facing mountain slopes in Turkey, Iraq, and Iran were obscured above 3,000 feet during the late afternoon and evening. Snow, mostly light, fell in the mountains of eastern Turkey, northeastern Iraq, and northwestern Iran above 6,000 feet; between 4,000 and 6,000 feet, precipitation was rain and snow mixed. Mountain wave turbulence was associated with the cloudiness over Syria, Jordan, western Iraq, and northwestern Saudi Arabia.

**Figure 4-10. NOAA Visual, 12 March, 1145Z.** An extensive area of cloudiness lies over Turkey, northeastern Iraq, and western Iran.

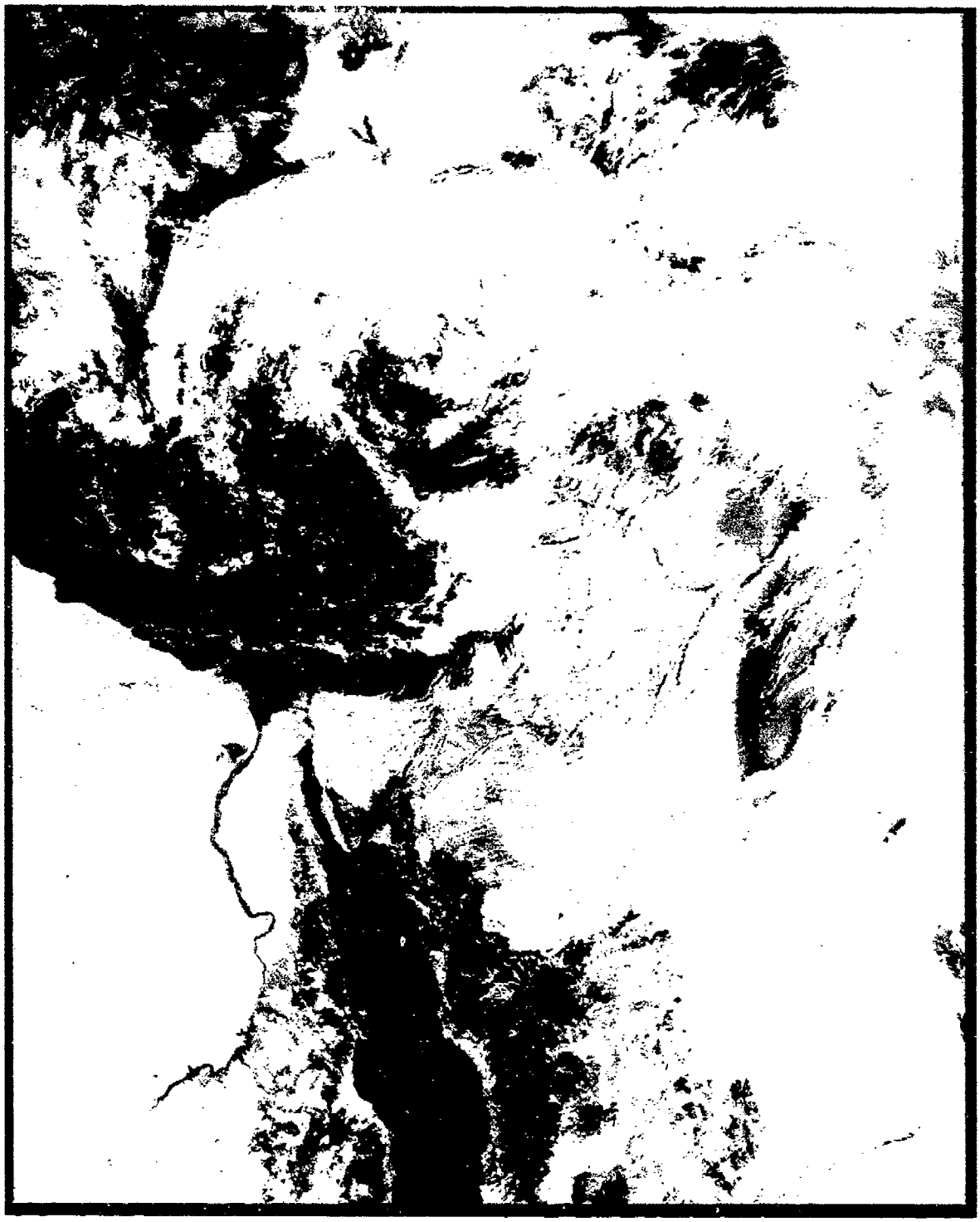


**Figure 4-11. DMSP Visual, 13 March, 0633Z.** Clouds remain over Turkey, Iraq, and western Iran. The scattered low and middle clouds over much of Iraq and Saudi Arabia are remnants of the disturbance-associated activity from the previous day.

**General Weather.** High pressure dominated as a weak upper-level disturbance passed over Turkey, Syria, and Iraq, causing isolated clouds and precipitation.

Skies were clear to partly cloudy, as shown in Figures 4-12 through 4-14, pages 4-23 to 4-25. The few clouds over Turkey and Syria on the 14th and 15th had bases between 2,000 and 10,000 feet. The widespread middle and high clouds over the region on the 16th resulted from the eastward movement of the polar and subtropical jet streams.

Isolated rainshowers were reported throughout the period in or near the Persian Gulf. Otherwise, precipitation was sparse and only associated with the passing upper-level disturbance in the north.

Winds at night were northerly at 10-15 knots along the Persian Gulf, light and variable elsewhere. Persian Gulf winds increased slightly during the day. Elsewhere, afternoon winds were west-southwesterly at 10-20 knots, except on the 16th when the winds in and around Syria switched to southeasterly at 10-20 knots. Gusts throughout the region reached 30 knots.

Blowing dust, suspended dust, and haze occasionally dropped visibilities below 6 km; isolated reductions to 3,200 meters or less were reported near the Persian Gulf. Smoke over Kuwait and Saudi Arabia resulted in visibilities below 1,600 meters. Visibilities in precipitation were generally above 3,200 meters.

Temperatures along coasts ranged from 15 to 29° C during afternoons and from 10 to 21° C during mornings, with the lowest in western Syria. High temperatures in the interior were 13-32° C; lows were 4-21° C. The lowest temperatures were in Iraq; the highest, in central Saudi Arabia. On clear nights, temperatures were below freezing at elevations above 5,000 feet in eastern Turkey, northeastern Iraq, and northwestern Iran.

**Significant Weather Events**

***14-15 March:*** Isolated ceilings were as low as 2,000 feet over Turkey and Syria. There were isolated afternoon and evening thunderstorms over eastern Turkey and northwestern Iran; they were also reported in the Persian Gulf. Snow fell at elevations above 7,000 feet in eastern Turkey, northern Iraq, and northwestern Iran; a mixture of rain and snow fell between 5,000 and 7,000 feet.

***16 March:*** The broad north-to-south cloud band shown in Figure 4-14, page 4-25, was associated with the eastward movement of the polar jet stream. The lowest reported ceilings were 10,000 feet.

**Figure 4-12. DMSP Visual, 14 March 1991, 0612Z.** The most prominent feature is the smoke being advected southward into Saudi Arabia.

**Figure 4-13. DMSP Visual, 15 March 1991, 0551Z.** This picture shows the heavy black smoke with light winds.


**Figure 4-14. NOAA Visual, 16 March 1991, 1058Z.** Extensive middle and high clouds (A) cover much of the region as the polar jet stream dips south over Iraq. The high clouds (B) shown over and near the northern Red Sea are associated with the subtropical jet stream.

**General Weather.** A low from the Mediterranean Sea moved eastward into southwestern Iraq on the afternoon of the 18th. After crossing southern Iraq, it entered Iran on the afternoon of the 19th. The low and its south-southwesterly trailing cold front produced a broad area of broken cloud and precipitation.

Ceilings associated with the system were mostly 10,000 feet, but were occasionally 3,000 feet north of 25° N and 4,000 feet south of 25° N. There were isolated reports of thunderstorm bases at 2,000 feet, with tops to 40,000 feet.

The frontal system brought rain, rainshowers, and isolated thunderstorms into Syria and Jordan on the 17th. Precipitation spread east and southeast over the region on the 18th. Only a few isolated rainshowers and thunderstorms remained in Iraq and the Arabian Peninsula by the afternoon of the 19th.

Winds were light and variable at night, but there were isolated reports of speeds over 15 knots near the frontal system. Winds were also light and variable in Syria and northern Iraq during the day. South-southeasterly winds at 10-20 knots preceded the front; behind it, winds were westerly at 10-20 knots. Gusts reached 35 knots.

Visibilities in precipitation were generally good, with only isolated areas of less than 4,800 meters. Blowing dust, suspended dust, and haze reduced visibilities below 4,800 meters near the front; they were occasionally below 1,600 meters in the afternoon and evening. Fog formed north of the low, dropping visibilities below 1,600 meters. The ever-present smoke from burning Kuwaiti oil wells dropped visibilities below 1,600 meters in Kuwait and on Saudi Arabia's gulf coast.

Coastal temperatures ranged from highs of 16-32° C to lows of 13-27° C. High interior temperatures ranged from 10° C in Iraq to 38° C in central Saudi Arabia, while morning lows ranged from 7° C in Iraq to 27° C in central Saudi Arabia. On clear nights, temperatures were below freezing at elevations above 6,000 feet in eastern Turkey, northeastern Iraq, and northwestern Iran.

**Significant Weather Events**

***17 March:*** The clouds shown in Figure 4-15 produced rain, rainshowers, and isolated thunderstorms in and near Turkey, Syria, and Jordan. Blowing dust occasionally reduced visibilities to below 1,600 meters in northern Saudi Arabia during the afternoon and evening.

***13 March:*** The cloud cover shown in Figure 4-16, Page 4-29, has moved eastward; in the morning, there were scattered rain, rainshowers, drizzle, and thunderstorms in Syria, Jordan, Iraq, and northwestern Saudi Arabia. Precipitation spread east-southeast into central and eastern Saudi Arabia through the day; it ended in Syria and Jordan by mid-afternoon. Afternoon and evening snow fell in the mountains of eastern Turkey, northeastern Iraq, and northwestern Iran above 8,000 feet; a mixture of rain and snow fell between 6,000 and 8,000 feet. Showers and thunderstorms dropped visibilities to as low as 100 meters in Saudi Arabia. Blowing dust occasionally reduced visibilities to less than 1,600 meters in southeastern Iraq, Kuwait, and the deserts of Saudi Arabia during the afternoon and evening. Visibilities in fog were below 1,600 meters in Syria, Jordan, and Iraq. Some southward- through westward-facing slopes in Turkey, Iraq, and Iran were obscured by clouds above 3,000 feet.

***19 March:*** Figure 4-17, Page 4-30, shows where clouds and precipitation associated with the weakened front were located over eastern Iraq, Kuwait, the Persian Gulf, and much of Saudi Arabia west of Qatar in the morning. Only a few isolated rainshowers and thunderstorms remained over the region in the afternoon after the front had moved into Iran. Some southward- through westward-facing slopes in Turkey, Iraq, and Iran were obscured by clouds above 3,000 feet in the morning. Snow fell during the morning above 8,000 feet in the mountains of eastern Turkey, northeastern Iraq, and northwestern Iran; a mixture of rain and snow fell between 6,000 and 8,000 feet. Fog reduced morning visibilities below 1,600 meters in Iraq during the morning. Blowing dust occasionally reduced visibilities to less than 1,600 meters in southeastern Iraq, Kuwait, and the deserts of Saudi Arabia during the day.

**Figure 4-15. NOAA Visual, 17 March 1991, 1047Z.** Frontal cloudiness covers most of Turkey, Syria, Jordan, and Iraq. Patchy smoke extends southward from Kuwait.

**Figure 4-16. DMSP Visual, 18 March 1991, 0629Z.** Clouds associated with the front reach farther into Iraq and Saudi Arabia.

**Figure 4-17. DMSP Visual, 19 March 1991, 0618Z.** Skies behind the front are clear to partly cloudy.

**General Weather.** High pressure dominated. The only significant weather was from local effects or associated with the remnants of the previous system.

Surface moisture left by the previous disturbance was responsible for early-morning ceilings as low as 700 feet in northern Saudi Arabia; similar isolated conditions probably occurred over much of the area north of 29° N. Otherwise, as shown in Figure 4-18, next page, skies were mostly clear to scattered. Isolated afternoon ceilings were 3,500 feet in rainshowers and thunderstorms over the Persian Gulf area and the mountains of Iran.

Winds were variable at 5-15 knots, gusting to 25 knots.

Visibilities in patchy morning fog were below 1,600 meters north of 29° N and as low as 3,200 meters in isolated areas of blowing dust, suspended dust, haze, and precipitation.

Temperatures near coasts ranged from 21 to 32° C during the afternoon and from 13 to 24° C during the morning, with the lowest temperatures in western Syria. Interior temperatures, which were lowest in Iraq, ranged from 16-38° C in the afternoon to 7-24° C in the morning. In the mountains at elevations above 7,000 feet, nighttime temperatures were at or below freezing.

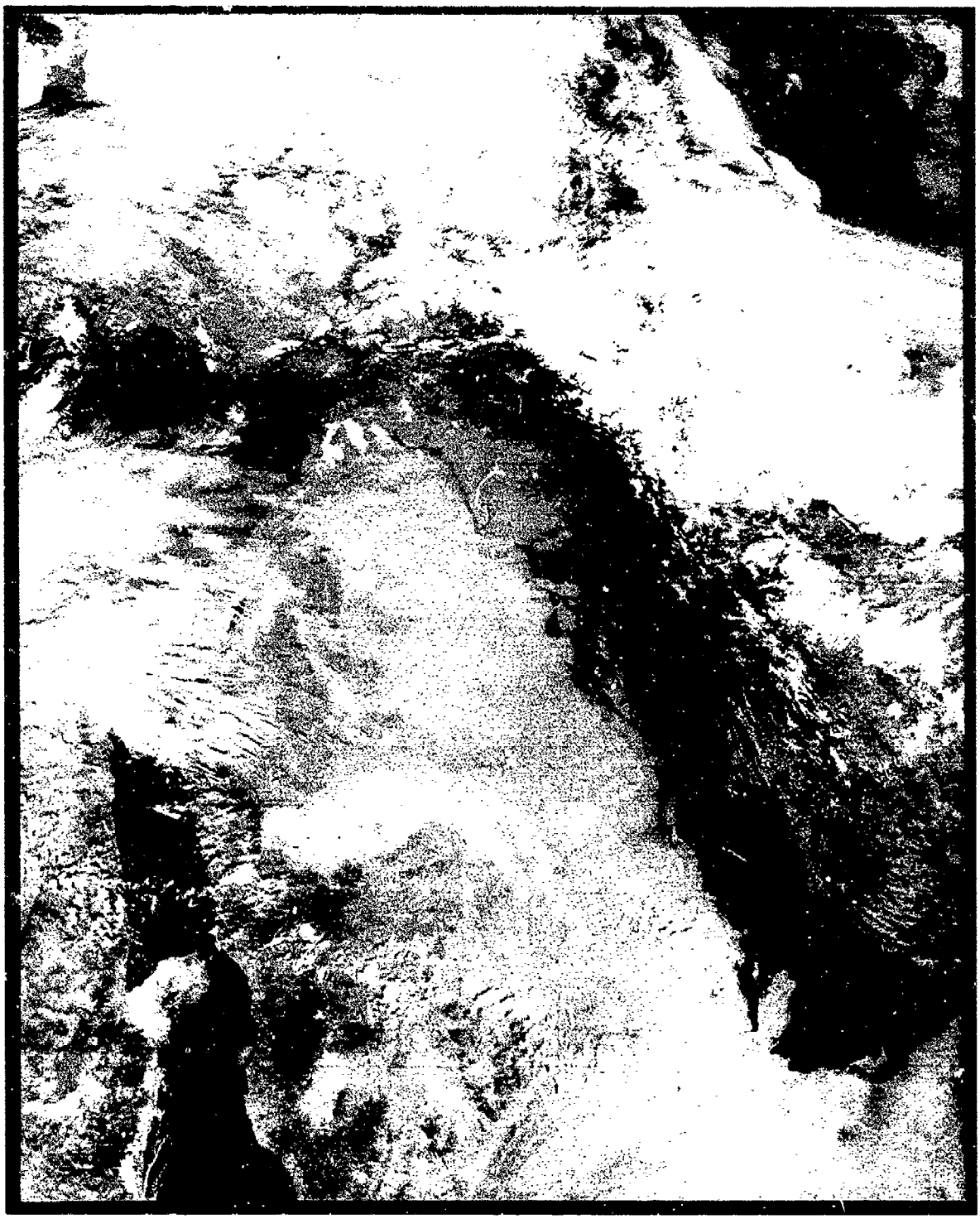


**Figure 4-18. DMSP Visual, 20 March 1991, 0600Z.** Clear skies prevailed. Middle and high clouds to the west are associated with an approaching frontal system.

**General Weather.** The strongest frontal system of the month began to affect the area's weather on the 21st. On the evening of the 22nd, the primary low entered Syria and Jordan while a secondary low formed along the cold front over north-central Saudi Arabia. The primary low weakened and moved east-northeast to leave northern Iraq on the evening of the 24th. The secondary low, with its cold front trailing southwestward, moved east and southeast, passing Qatar on the evening of the 24th.

Ceilings of 4,000 feet were common ahead of the system, but most were at 8,000 and 20,000 feet. Most ceilings near the front were 2,000-4,000 feet; the lowest were north of 27° N. Post-frontal ceilings--often below 3,000 feet--were common from the 22nd through the 24th; some were as low as 500 feet. Ceilings were below 2,000 feet with precipitation north of 27° N. The mountains of Turkey, Iraq, and northwestern Iran were obscured above 2,000-4,000 feet from the 22nd to the 24th.

Precipitation was most extensive near the frontal system. Most low and middle clouds produced drizzle, rain, and rainshowers. Thunderstorm tops reached 45,000 feet. Heavy snow fell at elevations above 7,000 feet from the 22nd to the 24th, with a mixture of rain and snow between 6,000 and 7,000 feet.

The front affected winds from the 22nd to the 24th; they were southeasterly ahead of the system and west-northwesterly behind it. Speeds were 10-20 knots with gusts to 25 knots in the morning, and 15-30 knots with gusts to 45 knots in the afternoon.

Visibilities in precipitation and fog were mostly above 4,800 meters, but below 400 meters with precipitation in the mountains and near the front. Visibilities in blowing dust, suspended dust, and haze ranged from 6 to 8 km at night to below 1,600 meters near the front during the day. The worst visibilities were in areas along and behind the front. Smoke from burning Kuwait oil wells resulted in visibilities below 3,200 meters; occasionally, below 1,600 meters.

Coastal temperatures were 13-29° C afternoons and 10-26° C mornings, with lowest temperatures near the Mediterranean coast. Temperatures in the interior were 13-38° C afternoons and 10-26° C mornings, with the lowest in Iraq. Temperatures above 7,000 feet were below freezing in the mountains of eastern Turkey, northeastern Iraq, and northwestern Iran.

**Significant Weather Events**

***21 March:*** The clouds shown in Figure 4-19 on Page 4-36 brought drizzle, rain, and rainshowers with isolated thunderstorms that spread eastward from Syria, Jordan, and northwestern Saudi Arabia into Iraq. Winds were variable from 5 knots at night to 10-15 knots (with gusts to 25) during the day.

***22 March:*** Weather continued to deteriorate as the storm system shown in Figure 4-20 on Page 4-37 entered the region. Mountains above 4,000 feet were obscured by clouds. Fog, drizzle, rain, rainshowers, and thunderstorms--especially along the cold front--covered most of the region north of 25° N. Above 7,000 feet, snow began to fall in the mountains of Turkey, Iraq, and Iran; rain mixed with snow fell between 6,000 and 7,000 feet. Visibilities in frontal fog and precipitation were often below 1,600 meters. Fog behind the front lowered visibilities to 1,600-4,800 meters at night. Visibilities ahead of the front were below 1,600 meters in blowing dust. Winds were 10-20 knots at night and 15-30 knots (with gusts to 45) during the day.

***23 March:*** The mountains of Turkey, Iraq, and northwestern Iran above 2,000 feet were obscured by clouds. The weakening cold front still caused rain, rainshowers, and thunderstorms throughout Iraq, Kuwait, central and eastern Saudi Arabia, and the Persian Gulf. Visibilities were as low as 400 meters. Heavy snow continued to fall in the mountains of Turkey, Iraq, and Iran above 7,000 feet, with a mixture of rain and snow between 6,000 and 7,000 feet. Patchy areas of rain, drizzle, fog and low ceilings were widespread near the original low and well behind the front, as shown in Figure 4-21 on Page 4-38. Visibilities were as low as 1,600 meters and ceilings as low as 500 feet in the morning and 2,500 feet in the afternoon. Blowing dust dropped visibilities below 1,600 meters ahead of the front during the day. Winds were 10-20 knots at night and 15-30 knots (with gusts to 45) during the day.

***24 March:*** Some of the mountains of Turkey, Iraq, and northwestern Iran were obscured by clouds above 2,000 feet. Isolated thunderstorms formed along the mountains after frontal passage. As shown in Figure 4-22 on Page 4-39, the weakening front produced rain, rainshowers, and isolated thunderstorms in eastern Iraq, Kuwait, eastern Saudi Arabia, and the Persian Gulf; visibilities were as low as 400 meters. Snow fell in the mountains of Turkey, Iraq, and Iran above 7,000 feet; mixed rain and snow fell between 6,000 and 7,000 feet. Patchy areas of rain, drizzle, fog, and low ceilings continued behind the system; visibilities were as low as 1,600 meters; ceilings were as low as 1,000 feet in the morning and 2,500 feet in the afternoon. Winds were 5-15 knots at night and 15-25 knots (with gusts to 40) near the front during the day.

**Figure 4-19. DMSP Visual, 21 March 1991, 0536Z.** The approaching storm system results in middle and high clouds west of Iraq.

**Figure 4-20. DMSP Visual, 22 March 1991, 0603Z.** The approaching storm is centered over Egypt.


**Figure 4-21. DMSP Visual, 23 March 1991, 0634Z.** The original low-pressure center, now separated from the front, is over Syria and Jordan. Turkey, Iraq, Kuwait, Iran, and much of Saudi Arabia are being affected by the new low-pressure center and its associated front.

**Figure 4-22. DMSP Visual, 24 March 1991, 0613Z.** Cloud cover breaks up as the entire system weakens.

**General Weather.** High pressure dominated, but remnants of the 21-24 March frontal system left clouds and surface moisture that affected cloud cover and visibilities.

Figures 4-23 through 4-26 on Pages 4-42 to 4-45 show that skies were mostly clear to scattered. Most moisture for cloud cover came from the rainfall that occurred during the previous few days; daytime heating lifted the moisture into scattered convective clouds to form isolated showers and thunderstorms. Patchy low and middle clouds continued over the area, especially north of 30° N and near the Persian Gulf. These were mostly scattered at 4,000 and 10,000 feet.

Precipitation was very isolated, initially falling in Iraq and near the Persian Gulf, then over Saudi Arabia as isolated late afternoon rainshowers and thunderstorms. Maximum tops were 35,000 feet.

Winds throughout the period depended on local effects. They were generally light and variable at night, and variable at 5-15 knots (gusting to 25 knots) during the day.

Surface moisture produced morning fog that reduced visibilities to as low as 400 meters on the 25th; visibilities progressively improved on 26, 27, and 28 March. Surface moisture reduced the effects and aerial coverage of blowing dust and dust, but isolated areas in Saudi Arabia had visibilities down to 3,200 meters. Isolated afternoon thunderstorms reduced visibilities to as low as 3,200 meters. Smoke from burning oil wells in Kuwait reduced visibilities to below 1,600 meters in Kuwait, over the Persian Gulf, and in adjoining areas of Saudi Arabia.

Temperatures along coasts ranged from 21 to 29° C afternoons and from 13 to 21° C mornings. Interior temperatures ranged from afternoon highs of 18 to 32° C to morning lows of 10 to 21° C, with the lowest in Iraq and the highest in central Saudi Arabia. Temperatures were below freezing at elevations above 7,000 feet in eastern Turkey, northeastern Iraq, and northwestern Iran.

**Significant Weather Events**

***25 March:*** Isolated 7,000-foot ceilings occurred over Syria, Jordan, Iraq, Kuwait, extreme northern Saudi Arabia, and along the Persian Gulf; the same areas had light showers and visibilities as low as 400 meters in morning fog.

***26-27 March:*** There were patchy ceilings at 10,000 feet over Iraq, the Persian Gulf, and over Saudi Arabia west of Qatar. Morning fog reduced visibilities below 800 meters in Syria, Jordan, Iraq, Kuwait, and northern Saudi Arabia.

***28 March:*** Morning fog reduced visibilities to 3,200 meters in Syria, Jordan, Iraq, and northwestern Saudi Arabia.

**Figure 4-23. DMSP Visual, 25 March 1991, 0552Z.** Clouds associated with the remains of a frontal system extend from southern Iran to Yemen. Scattered to broken low and middle clouds are north of about 30° N. Black smoke extends south from Kuwait into Saudi Arabia.

**Figure 4-24. DMSP Visual, 26 March 1991, 1054Z.** Scattered to broken clouds remain over Iraq and Saudi Arabia's gulf coast.

**Figure 4-25. DMSP Visual, 27 March 1991, 05132.** Scattered to broken middle clouds (A) lie on the east coast of Saudi Arabia near Qatar.

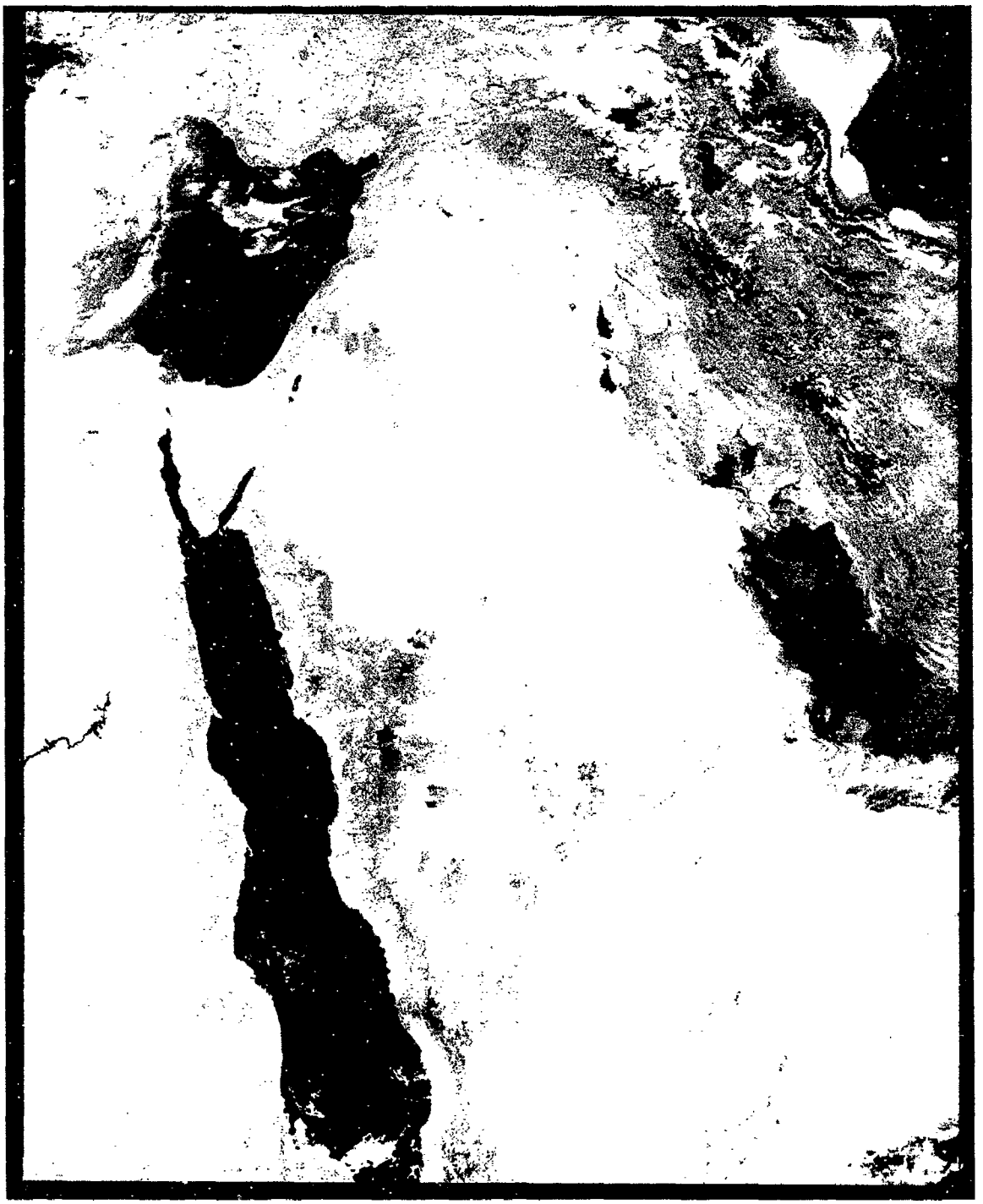


**Figure 4-26. DMSP Visual, 28 March 1991, 0632Z.** The region is now dominated by clear skies.

**General Weather.** Weak upper-level disturbances crossed the region. One reached west-central Saudi Arabia on the 29th and moved east-southeast. Another caused a narrow band of clouds and isolated precipitation to cross the region north of 30° N on the 30th and 31st.

Patchy 10,000-foot ceilings (occasionally 5,000 feet) and patchy light rain, rainshowers, and afternoon and evening thunderstorms accompanied these disturbances, but in northern Saudi Arabia and Kuwait, located between the two centers of activity, skies were clear to scattered with little or no rainfall. Afternoon thunderstorms with tops to 40,000 feet produced isolated moderate rainfall in Turkey, Syria, Iraq, Iran, and central Saudi Arabia. Snow fell in the mountains of Turkey, Iraq, and northwestern Iran on the 30th and 31st.

Winds were light and variable at night, variable at 5-15 knots with gusts to 20 knots during the day.

Visibilities were generally good, but morning fog reduced them to 1,600-3,200 meters in Jordan and along the Persian Gulf coast. During the day, visibilities dropped to 3,200 meters in thunderstorms and in blowing dust. Smoke lowered visibilities to less than 1,600 meters in and near Kuwait.

Coastal high temperatures were 21-29° C; lows, 13-21° C. Interior temperatures were lowest in Iraq; highs were 18-32° C; lows, 10-21° C. Nighttime temperatures were at or below freezing at mountain elevations above 7,000 feet.

**Significant Weather Events**

***29 March:*** The polar jet stream caused ceilings above 10,000 feet over Syria. The clouds shown over west-central Saudi Arabia in Figure 4-27 on Page 4-48 produced 10,000-foot ceilings, occasionally 5,000 feet. Isolated afternoon thunderstorms formed along and east of the central and southern Hijaz mountains.

***30 March:*** The ceilings shown in Figure 4-28 over central Saudi Arabia were predominantly at 10,000 feet; but occasionally 5,000 feet in isolated afternoon and evening thunderstorms. In Turkey, Syria, Iraq, and western Iran,

isolated afternoon and evening thunderstorms caused brief episodes of ceilings as low as 5,000 feet. There were scattered low clouds at 1,500 feet in the morning over northwestern Saudi Arabia. Snow fell above 8,000 feet in the mountains of Turkey, Iraq, and northwestern Iran; mixed rain and snow fell between 6,000 and 8,000 feet.

***31 March:*** The isolated afternoon and evening thunderstorms that accompanied the disturbance in the north (see Figure 4-29 on Page 4-50) produced ceilings at 10,000 feet (occasionally 5,000 feet) over Turkey, Iraq, and Iran. Snow fell above 8,000 feet in the mountains of Turkey, Iraq, and northwestern Iran; mixed rain and snow fell between 6,000 and 8,000 feet. Morning fog produced 3,200 meter visibilities along the Persian Gulf coast.

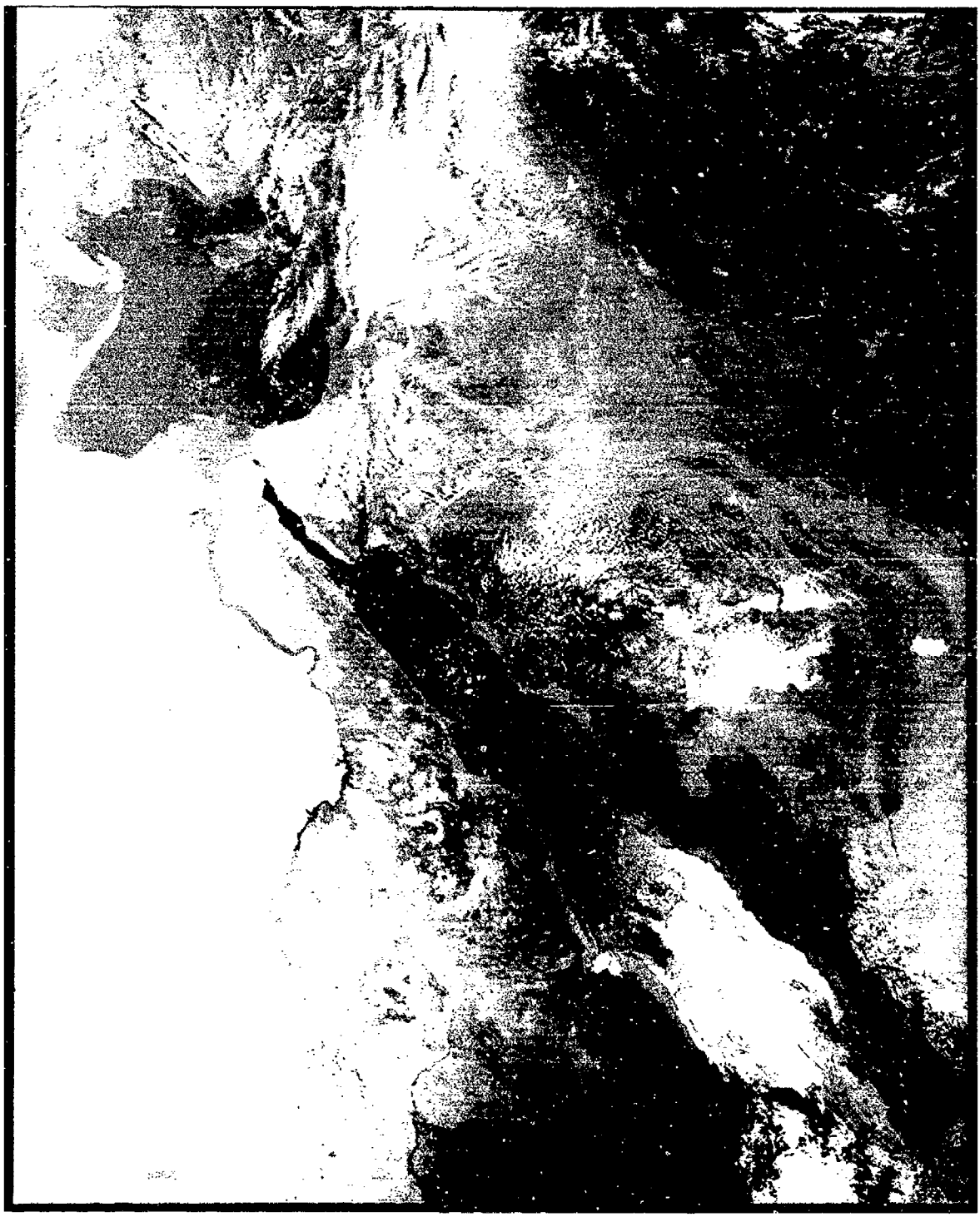


**Figure 4-27. DMSP, 29 March 1991, 0553Z.** Middle and high clouds lie over Syria. The clouds over west-central Saudi Arabia are the first signs of an approaching disturbance.

**Figure 4-28. DMSP, 30 March 1991, 0546Z.** A broad unorganized band of low, middle, and high clouds extends across central Saudi Arabia.

**Figure 4-29. DMSP, 31 March 1991, 0453Z.** The clouds over Saudi Arabia have moved south and east. The scattered to broken band of low, middle, and high clouds over Turkey and Iraq is associated with an eastward-moving disturbance.

# BIBLIOGRAPHY


Air Force Global Weather Central (AFGWC), Satellite Data Handling System (SDHS) products, 1 to 28 February 1991.

Air Force Global Weather Central (AFGWC), Staff Weather Officer (SWO) bulletin forecasts, 3 August 1990 through 17 September 1990.

Air Force Global Weather Central (AFGWC), Special Sensor Microwave Imagery (SSMI), 22-27 February 1991.

Central Air Forces (CENTAF) Tactical Forecast Unit (TFU), Joint Operational Area Forecast (JOAF) and Nephanalysis, 24 September 1990 through 18 March 1991.

Combat Military Pilot Reports, 17 January to 2 March 1991.

Defense Meteorological Satellite Program (DMSP) visual and infrared satellite imagery, 1807Z 3 September 1990 through 1929Z 31 March 1991.

European Space Agency METEOSAT visual, infrared, and water vapor satellite imagery, 1500Z 12 September 1990 through 2300Z 17 March 1991.

Foreign weather observations at 13 locations, 0000Z 7 August 1990 through 2123Z 31 March 1991.

Military weather observations at 24 locations, 0000Z 1 December 1990 through 2300Z 31 March 1991,

National Oceanic and Atmospheric Administration (NOAA), visual and infrared satellite imagery, 0221Z 4 September 1990 through 0628Z 18 March 1991.

NOAA National Meteorological Center (NMC), surface and 500-mb tropical analysis, 1200Z 7 August 1990 through 1200Z 31 March 1991.

PC Globe, Inc. Tempe, AZ, USA.

*The Persian Gulf--A Climatological Study,* USAFETAC/TN-88/002, May 1988.

Royal, Staff Sergeant (USAF), Case Study (Arabian Peninsula), 13 March 1991.

*Southwest Asia-Northeast Africa, Volume II, The Middle East Peninsula,* USAFETAC/TN-91/002, February 1991.

# APPENDIX A

## Station Locator List

This table lists the stations used to compile the temperature statistics given in Appendices B, C, and D.

| Station | Latitude | Longitude | Elevation |
|---|---|---|---|
| Abadan, IR | 30° 22' N | 48° 15' E | 10 feet (3 meters) |
| Al Jouf, SD | 29° 47' N | 40° 06' E | 2,260 feet (689 meters) |
| Al Kharj, SD | 24° 12' N | 47° 18' E | 1,440 feet (439 meters) |
| Arar, SD | 30° 54' N | 41° 08' E | 1,815 feet (553 meters) |
| Babulsar, IR | 36° 43' N | 52° 39' E | -69 feet (-21 meters) |
| Bahrain Int'l, BN | 26° 17' N | 50° 37' E | 6 feet (2 meters) |
| Bakhtaran, IR | 34° 19' N | 47° 04' E | missing |
| Dhahran, SD | 26° 16' N | 50° 10' E | 84 feet (26 meters) |
| Diyarbakir, TU | 34° 53' N | 40° 12' E | 2,251 feet (686 meters) |
| Doha IAP, QT | 25° 15' N | 51° 34' E | 35 feet (11 meters) |
| Esfahan, IR | 32° 37' N | 51° 42' E | 5,238 feet (1,536 meters) |
| Gassim, SD | 26° 18' N | 43° 46' E | 2,132 feet (650 meters) |
| Hafr Al Batin, SD | 28° 20' N | 46° 07' E | 1,167 feet (355 meters) |
| Incirlik AFB, TU | 37° 00' N | 35° 26' E | 239 feet (73 meters) |
| Jeddah, SD | 21° 30' N | 39° 12' E | 56 feet (15 meters) |
| King Fahd AB, SD | 26° 28' N | 49° 48' E | 66 feet (20 meters) |
| King Khalid MC, SD | 27° 54' N | 45° 32' E | 1,352 feet (412 meters) |
| Kuwait City, KU | 29° 14' N | 47° 59' E | 180 feet (55 meters) |
| Orumieh, IR | 37° 32' N | 45° 05' E | 4,303 feet (1,311 meters) |
| Rafha, SD | 29° 39' N | 43° 29' E | 1,466 feet (447 meters) |
| Ras Al Mishab | 28° 05' N | 48° 36' E | 110 feet (110 meters) |
| Rasht, IR | 37° 20' N | 49° 37' E | -30 feet (-9 meters) |
| Riyadh, SD | 24° 43' N | 46° 44' E | 2,082 feet (634 meters) |
| Saghez, IR | 36° 15' N | 46° 16' E | 1,493 feet (455 meters) |
| Sanandaj, IR | 35° 20' N | 47° 00' E | 4,570 feet (1,393 meters) |
| Shaikh Isa, BN | 25° 55' N | 50° 35' E | 110 feet (34 meters) |
| Tabuk, SD | 28° 22' N | 36° 35' E | 2,551 feet (777 meters) |
| Tehran, IR | 35° 41' N | 51° 19' E | 3,963 feet (1,208 meters) |
| Turaif, SD | 31° 41' N | 38° 40' E | 2,667 feet (813 meters) |

# APPENDIX B

## Mean Temperatures
## August 1990–March 1991

Mean Min - Mean monthly minimum
Mean Max - Mean monthly maximum
WBGT - Wet-Bulb Globe Temperature
WCT - Wind Chill Temperature

| *AUGUST* Station | Mean Min | Mean Max | Max WBGT |
|---|---|---|---|
| Al Jouf, SD | 76 | 103 | --- |
| Dhahran, SD | 82 | 106 | --- |
| Gassim, SD | 77 | 108 | --- |
| Hafr Al Batin, SD | 82 | 109 | --- |
| Rafha, SD | 76 | 106 | --- |
| Riyadh, SD | 79 | 108 | --- |
| Shaikh ISA, BN | 84 | 103 | 92 |
| Tabuk, SD | 72 | 99 | --- |

| *SEPTEMBER* Station | Mean Min | Mean Max | Max WBGT |
|---|---|---|---|
| Al Jouf, SD | 71 | 100 | --- |
| Dhahran, SD | 79 | 103 | --- |
| Doha IAP, QT | 79 | 99 | 93 |
| Gassim, SD | 73 | 104 | --- |
| Hafr Al Batin, SD | 76 | 105 | --- |
| Jeddah, SD | -- | --- | 92 |
| Rafha, SD | 72 | 103 | --- |
| Shaikh ISA, BN | -- | --- | 94 |
| Tabuk, SD | 68 | 97 | 83 |

| *OCTOBER* Station | Mean Min | Mean Max | Max WBGT |
|---|---|---|---|
| Al Jouf, SD | 67 | 89 | --- |
| Dhahran, SD | 72 | 96 | --- |
| Doha IAP, QT | 76 | 95 | 94 |
| Gassim, SD | 66 | 96 | --- |
| Hafr Al Batin, SD | 69 | 97 | --- |
| Jeddah, SD | 74 | 97 | 93 |
| King Fahd AB, SD | 73 | 100 | 94 |
| King Khalid MC, SD | 68 | 97 | 87 |
| Rafha, SD | 66 | 93 | --- |
| Riyadh, SD | 67 | 96 | --- |
| Shaikh ISA, BN | 76 | 93 | 91 |
| Tabuk, SD | 63 | 91 | 81 |

| *NOVEMBER* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Al Jouf, SD | 56 | 78 | --- |
| Bakhtaran, IR | --- | --- | 26 |
| Dhahran, SD | 64 | 85 | --- |
| Doha IAP, QT | 69 | 85 | --- |
| Gassim, SD | 54 | 83 | --- |
| Hafr Al Batin, SD | 57 | 82 | --- |
| Jeddah, SD | 72 | 93 | --- |
| King Fahd AB, SD | 63 | 88 | --- |
| King Khalid MC, SD | 54 | 83 | --- |
| Orumieh, IR | --- | --- | 31 |
| Rafha, SD | 55 | 80 | --- |
| Rasht, IR | --- | --- | 46 |
| Riyadh, SD | 56 | 84 | --- |
| Sanandaj, IR | --- | --- | 31 |
| Shaikh ISA, BN | 68 | 82 | --- |
| Tabuk, SD | 54 | 81 | --- |

| *DECEMBER* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Al Jouf, SD | 46 | 69 | --- |
| Al Kharj, SD | 52 | 77 | --- |
| Bakhtaran, IR | --- | --- | 6 |
| Dhahran, SD | 56 | 78 | --- |
| Doha IAP, QT | 61 | 79 | --- |
| Gassim, SD | 47 | 76 | --- |
| Hafr Al Batin, SD | 49 | 73 | --- |
| Jeddah, SD | 69 | 90 | --- |
| King Fahd AB, SD | 55 | 80 | --- |
| King Khalid MC, SD | 47 | 75 | --- |
| Orumieh, IR | --- | --- | -9 |
| Rafha, SD | 46 | 70 | --- |
| Rasht, IR | --- | --- | 16 |
| Riyadh, SD | 50 | 76 | --- |
| Sanandaj, IR | --- | --- | 6 |
| Shaikh ISA, BN | 60 | 75 | --- |
| Tabuk, SD | 47 | 74 | --- |

| *JANUARY* Station | Mean Min | Mean Max | Min WCT |
|---|---|---|---|
| Al Jouf, SD | 39 | 55 | 11 |
| Al Kharj, SD | 52 | 68 | --- |
| Arar, SD | --- | --- | 11 |
| Bakhtaran, IR | --- | --- | 11 |
| Dhahran, SD | 54 | 69 | --- |
| Diyarbakir, TU | --- | --- | -4 |
| Doha IAP, QT | 56 | 70 | --- |
| Gassim, SD | 44 | 62 | --- |
| Hafr Al Batin, SD | 45 | 59 | --- |
| Jeddah, SD | 66 | 79 | --- |
| King Fahd AB, SD | 52 | 68 | --- |
| King Khalid MC, SD | 43 | 58 | 21 |
| Orumieh, IR | --- | --- | 11 |
| Rafha, SD | 41 | 58 | --- |
| Rasht, IR | --- | --- | 31 |
| Riyadh, SD | 49 | 67 | --- |
| Sanandaj, IR | --- | --- | 1 |
| Shaikh ISA, BN | 56 | 65 | 31 |
| Tabuk, SD | 42 | 59 | 6 |

| *FEBRUARY* Station | Mean Min | Mean Max | Min WCT |
|---|---|---|---|
| Al Jouf, SD | 42 | 64 | 16 |
| Al Kharj SD | 53 | 78 | --- |
| Arar, SD | --- | --- | 16 |
| Bakhtaran, IR | --- | --- | 6 |
| Dhahran, SD | 55 | 71 | --- |
| Diyarbakir, TU | 28 | 46 | -14 |
| Doha IAP, QT | 59 | 72 | --- |
| Gassim, SD | 48 | 69 | --- |
| Hafr Al Batin, SD | 47 | 65 | --- |
| Jeddah, SD | 65 | 85 | --- |
| King Fahd AB, SD | 54 | 72 | --- |
| Orumieh, IR | --- | --- | 11 |
| Rafha SD | 45 | 65 | --- |
| Ras Al Mishab, SD | 51 | 55 | --- |
| Riyadh, SD | 51 | 73 | --- |
| Sanandaj, IR | --- | --- | 1 |
| Shaikh ISA, BN | 57 | 69 | 36 |
| Tabuk, SD | 45 | 68 | 21 |

| *MARCH* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Abadan, IR | 62 | 73 | --- |
| Al Jouf, SD | --- | --- | 31 |
| Bakhtaran, IR | 40 | 56 | 21 |
| Diyarbakir, TU | 39 | 57 | -4 |
| Orumieh, IR | --- | --- | 26 |
| Rasht, IR | 46 | 52 | --- |
| Saghez, IR | 37 | 48 | --- |
| Sanandaj, IR | 38 | 53 | 21 |
| Shaikh ISA, BN | --- | --- | 41 |
| Tabuk, SD | --- | --- | 21 |

# APPENDIX C

## Climatological Temperatures

### (Full Period of Record)

Mean Min - Mean monthly minimum
Mean Max - Mean monthly maximum
WBGT - Wet-Bulb Globe Temperature
WCT - Wind Chill Temperature

| *AUGUST* Station | Mean Min | Mean Max | Max WBGT |
|---|---|---|---|
| Al Jouf, SD | 78 | 100 | 90 |
| Al Kharj, SD | 88 | 99 | 100 |
| Arar, SD | --- | --- | 91 |
| Bahrain Int'l, BN | 88 | 100 | 99 |
| Dhahran, SD | 84 | 108 | 101 |
| Doha IAP, QT | 84 | 108 | --- |
| Gassim, SD | 81 | 104 | 97 |
| Hafr Al Batin, SD | 84 | 108 | 94 |
| Jeddah, SD | 81 | 98 | 99 |
| King Khalid MC, SD | --- | --- | 91 |
| Kuwait City, KU | 81 | 113 | 100 |
| Rafha, SD | 79 | 105 | 95 |
| Riyadh, SD | 82 | 107 | 96 |
| Shaikh ISA, BN | 88 | 100 | 99 |
| Tabuk, SD | 73 | 99 | 89 |
| Turaif, SD | 71 | 96 | 90 |

| *SEPTEMBER* Station | Mean Min | Mean Max | Max WBGT |
|---|---|---|---|
| Al Jouf, SD | 74 | 98 | 87 |
| Al Kharj, SD | 84 | 96 | 95 |
| Arar, SD | --- | --- | 88 |
| Bahrain Int'l, BN | 84 | 96 | 97 |
| Dhahran, SD | 79 | 103 | 100 |
| Doha IAP, QT | 79 | 103 | --- |
| Gassim, SD | 77 | 101 | 94 |
| Hafr Al Batin, SD | 80 | 105 | 91 |
| Jeddah, SD | 79 | 96 | 97 |
| King Khalid MC, SD | --- | --- | 89 |
| Kuwait City, KU | 73 | 106 | 98 |
| Rafha, SD | 76 | 102 | 93 |
| Riyadh, SD | 77 | 104 | 91 |
| Shaikh ISA, BN | 84 | 96 | 99 |
| Tabuk, SD | 68 | 97 | 87 |
| Turaif, SD | 66 | 93 | 90 |

| *OCTOBER* | Mean | Mean | Max |
|---|---|---|---|
| Station | Min | Max | WBGT |
| Al Jouf, SD | 64 | 86 | 82 |
| Al Kharj, SD | 78 | 91 | 94 |
| Arar, SD | --- | --- | 83 |
| Bahrain Int'l, BN | 78 | 90 | 95 |
| Dhahran, SD | 72 | 95 | 94 |
| Doha IAP, QT | 72 | 95 | 95 |
| Gassim, SD | 67 | 91 | 88 |
| Hafr Al Batin, SD | 70 | 94 | 86 |
| Jeddah, SD | 75 | 94 | 96 |
| King Fahd AB, SD | 72 | 95 | --- |
| King Khalid MC, SD | --- | --- | 94 |
| Kuwait City, KU | 64 | 97 | 95 |
| Rafha, SD | 67 | 90 | 86 |
| Riyadh, SD | 68 | 94 | 87 |
| Shaikh ISA, BN | 78 | 90 | --- |
| Tabuk, SD | 59 | 88 | 83 |
| Turaif, SD | 57 | 81 | 82 |

| *NOVEMBER* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Abadan, IR | 55 | 81 | 21 |
| Al Jouf, SD | 51 | 71 | --- |
| Al Kharj, SD | 70 | 82 | --- |
| Babulsar, IR | 47 | 63 | 36 |
| Bakhtaran, IR | 41 | 61 | 16 |
| Dhahran, SD | 65 | 84 | --- |
| Diyarbakir, TU | 40 | 62 | 11 |
| Doha IAP, QT | 65 | 84 | --- |
| Esfahan, IR | 36 | 63 | 6 |
| Gassim, SD | 57 | 77 | --- |
| Hafr Al Batin, SD | 57 | 77 | --- |
| Incirlik AFB, TU | 51 | 71 | 16 |
| Jeddah, SD | 72 | 90 | --- |
| King Fahd AB, SD | 65 | 84 | --- |
| Kuwait City, KU | 55 | 79 | --- |
| Orumieh, IR | 36 | 51 | 11 |
| Rafha, SD | 54 | 74 | --- |
| Rasht, IR | 54 | 60 | --- |
| Riyadh, SD | 58 | 81 | --- |
| Sanandaj, IR | 39 | 56 | 16 |
| Shaikh ISA, BN | 71 | 81 | --- |
| Tabuk, SD | 49 | 76 | --- |
| Tehran, IR | 41 | 59 | 1 |
| Turaif, SD | 46 | 68 | --- |

| *DECEMBER* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Abadan, IR | 47 | 67 | 16 |
| Al Jouf, SD | 43 | 62 | --- |
| Al Kharj, SD | 65 | 75 | --- |
| Babulsar, IR | 41 | 56 | 16 |
| Bakhtaran, IR | 34 | 47 | 6 |
| Dhahran, SD | 56 | 73 | --- |
| Diyarbakir, TU | 31 | 49 | -4 |
| Doha IAP, QT | 56 | 73 | --- |
| Esfahan, IR | 28 | 50 | 1 |
| Gassim, SD | 48 | 68 | --- |
| Hafr Al Batin, SD | 48 | 66 | --- |
| Incirlik AFB, TU | 45 | 61 | 6 |
| Jeddah, SD | 68 | 85 | --- |
| King Fahd AB, SD | 56 | 73 | --- |
| Kuwait City, KU | 48 | 68 | --- |
| Orumieh, IR | 30 | 41 | 11 |
| Rafha, SD | 44 | 63 | --- |
| Rasht, IR | 45 | 51 | --- |
| Riyadh, SD | 50 | 71 | --- |
| Sanandaj, IR | 33 | 44 | 16 |
| Shaikh ISA, BN | 62 | 71 | --- |
| Tabuk, SD | 42 | 66 | --- |
| Tehran, IR | 33 | 50 | -9 |
| Turaif, SD | 39 | 58 | --- |

| *DECEMBER* Station | Mean Min | Mean Max | Min WCT |
|---|---|---|---|
| Abadan, IR | 47 | 67 | 16 |
| Al Jouf, SD | 43 | 62 | --- |
| Al Kharj, SD | 65 | 75 | --- |
| Babulsar, IR | 41 | 56 | 16 |
| Bakhtaran, IR | 34 | 47 | 6 |
| Dhahran, SD | 56 | 73 | --- |
| Diyarbakir, TU | 31 | 49 | -4 |
| Doha IAP, QT | 56 | 73 | --- |
| Esfahan, IR | 28 | 50 | 1 |
| Gassim, SD | 48 | 68 | --- |
| Hafr Al Batin, SD | 48 | 66 | --- |
| Incirlik AFB, TU | 45 | 61 | 6 |
| Jeddah, SD | 68 | 85 | --- |
| King Fahd AB, SD | 56 | 73 | --- |
| Kuwait City, KU | 48 | 68 | --- |
| Orumieh, IR | 30 | 41 | 11 |
| Rafha, SD | 44 | 63 | --- |
| Rasht, IR | 45 | 51 | --- |
| Riyadh, SD | 50 | 71 | --- |
| Sanandaj, IR | 33 | 44 | 16 |
| Shaikh ISA, BN | 62 | 71 | --- |
| Tabuk, SD | 42 | 66 | --- |
| Tehran, IR | 33 | 50 | -9 |
| Turaif, SD | 39 | 58 | --- |

| *FEBRUARY* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Abadan, IR | 48 | 68 | 11 |
| Al Jouf, SD | 44 | 64 | --- |
| Al Kharj, SD | 63 | 74 | --- |
| Babulsar, IR | 41 | 54 | 21 |
| Bakhtaran, IR | 28 | 45 | 1 |
| Dhahran, SD | 54 | 72 | --- |
| Diyarbakir, TU | 30 | 48 | -19 |
| Doha IAP, QT | 54 | 72 | --- |
| Esfahan, IR | 32 | 57 | 1 |
| Gassim, SD | 49 | 70 | --- |
| Hafr Al Batin, SD | 49 | 68 | --- |
| Incirlik AFB, TU | 42 | 59 | -4 |
| Jeddah, SD | 66 | 83 | --- |
| King Fahd AB, SD | 54 | 72 | --- |
| Kuwait City, KU | 46 | 70 | --- |
| Orumieh, IR | 24 | 35 | -19 |
| Rafha SD | 45 | 66 | --- |
| Rasht, IR | 40 | 47 | --- |
| Riyadh, SD | 51 | 74 | --- |
| Sanandaj, IR | 29 | 40 | 1 |
| Shaikh ISA, BN | 60 | 70 | --- |
| Tabuk, SD | 44 | 68 | --- |
| Tehran, IR | 32 | 51 | -9 |
| Turaif, SD | 39 | 58 | --- |

| *MARCH* | Mean | Mean | Min |
|---|---|---|---|
| Station | Min | Max | WCT |
| Abadan, IR | 54 | 77 | 11 |
| Al Jouf, SD | 51 | 70 | --- |
| Al Kharj, SD | 68 | 80 | --- |
| Babulsar, IR | 44 | 55 | 21 |
| Bakhtaran, IR | 38 | 56 | 1 |
| Dhahran, SD | 60 | 79 | --- |
| Diyarbakir, TU | 35 | 57 | -14 |
| Esfahan, IR | 39 | 64 | 6 |
| Gassim, SD | 56 | 77 | --- |
| Hafr Al Batin, SD | 56 | 76 | --- |
| Incirlik AFB, TU | 46 | 65 | 6 |
| Jeddah, SD | 67 | 87 | --- |
| Kuwait City, KU | 55 | 79 | --- |
| Orumieh, IR | 34 | 48 | -4 |
| Rafha, SD | 52 | 74 | --- |
| Rasht, IR | 46 | 52 | --- |
| Riyadh, SD | 58 | 82 | --- |
| Saghez, IR | 39 | 48 | --- |
| Sanandaj, IR | 39 | 51 | 1 |
| Shaikh ISA, BN | 65 | 76 | --- |
| Tabuk, SD | 50 | 76 | --- |
| Tehran, IR | 40 | 59 | -9 |
| Turaif, SD | 45 | 65 | --- |

# APPENDIX D

## Selected Wet-Bulb Globe Temperature (WBGT) Data

These tables show the hourly duration (inclusive hours of occurrence) that the WBGT was equal to or more than 85° F and 88° F. They also show maximum daily WBGT. Page D-1 gives WBGT data for Bahrain; page D-2, for Jeddah and page D-3, for King Khalid Military City and for King Fahd Air Base.

## BAHRAIN

| *AUGUST* | | Hourly Duration | |
|---|---|---|---|
| **Date** | **MaxWBGT** | **≥85° F** | **≥88° F** |
| 23 | 92 | 07-17 | 08-16 |
| 24 | 89 | 10-14 | 10-14 |
| 25 | 90 | 09-15 | 11-14 |
| 26 | 90 | 08-16 | 10-13 |
| 27 | 92 | 07-15 | 11-12 |
| 28 | 89 | 10-15 | 12 |
| 29 | 88 | 09-14 | 13 |
| 30 | 88 | 12-17 | 12 |
| 31 | 92 | 07-17 | 8-16 |

| *SEPTEMBER* | | Hourly Duration | |
|---|---|---|---|
| **Date** | **MaxWBGT** | **≥85° F** | **≥88° F** |
| 1 | 94 | 09-12 | 11-12 |
| 2 | 84 | | |
| 3 | 87 | 09-16 | |
| 4 | 87 | 10-13 | |
| 5 | 83 | | |
| 6 | 86 | 10-13 | |
| 7 | 92 | 08-17 | 10-16 |
| 8 | 89 | 08-14 | 09-13 |
| 9 | 87 | 10-14 | |
| 10 | 85 | 16 | |
| 11 | 90 | 09-17 | 12-16 |
| 12 | 89 | 07-15 | 8-13 |
| 13 | 86 | 17 | |
| 14 | 87 | 09-10 | |
| 15 | 87 | 09 | |
| 16 | 84 | | |
| 17 | 78 | | |
| 18 | 83 | | |
| 19 | 78 | | |
| 20 | 82 | | |
| 21 | 86 | 10 | |
| 22 | 84 | | |
| 23 | 81 | | |
| 24 | 81 | | |
| 25 | 81 | | |
| 26 | 84 | | |
| 27 | 83 | | |
| 28 | 81 | | |
| 29 | 81 | | |
| 30 | 83 | | |

| *OCTOBER* | | Hourly Duration | |
|---|---|---|---|
| **Date** | **MaxWBGT** | **≥85° F** | **≥88° F** |
| 1 | 83 | | |
| 2 | 82 | | |
| 3 | 87 | 11-13 | |
| 4 | 88 | 10-12 | 11 |
| 5 | 91 | 08-11 | 08-11 |
| 6 | 87 | 09-11 | |
| 7 | 81 | | |
| 8 | 87 | 10-14 | |
| 9 | 86 | 11-12 | |
| 10 | 82 | | |
| 11 | 81 | | |
| 12 | 84 | | |
| 13 | 86 | 08-10 | |
| 14 | 87 | 11-13 | |
| 15 | 86 | 09-13 | |
| 16 | 87 | 09-10 | |
| 17 | 85 | 12 | |
| 18 | 79 | | |
| 19 | 85 | 12 | |
| 20 | 86 | 09-11 | |
| 21 | 88 | 13 | |
| 22 | 86 | 08 | |
| 23 | 78 | | |
| 24 | 82 | | |
| 25 | 81 | | |
| 26 | 79 | | |
| 27 | 83 | | |
| 28 | 83 | | |
| 29 | 81 | | |
| 30 | 84 | | |
| 31 | 76 | | |

# JEDDAH

| *SEPTEMBER* | | Hourly Duration | |
|---|---|---|---|
| Date | MaxWBGT | ≥85° F | ≥88° F |
| 24 | 89 | 11-12 | 11-12 |
| 25 | 87 | 13-16 | |
| 26 | 90 | 10-14 | 10-11 |
| 27 | 91 | 09-17 | 09-15 |
| 28 | 89 | 09-11 | 10-11 |
| 29 | 89 | 09-15 | 10-13 |
| 30 | 91 | 10-16 | 10-14 |

| *OCTOBER* | | Hourly Duration | |
|---|---|---|---|
| Date | MaxWBGT | ≥85° F | ≥88° F |
| 1 | 91 | 09-16 | 10-14 |
| 2 | 90 | 14-16 | 14 |
| 3 | 89 | 11-15 | 12-13 |
| 4 | 89 | 12-16 | 14 |
| 5 | 90 | 10-15 | 11-13 |
| 6 | 92 | 10-16 | 10-15 |
| 7 | 85 | 15 | |
| 8 | 87 | 12-14 | |
| 9 | 92 | 10-14 | 11-13 |
| 10 | 93 | 09-17 | 09-16 |
| 11 | 90 | 10-14 | 10-13 |
| 12 | 88 | 11-16 | 12 |
| 13 | 90 | 11-16 | 12-14 |
| 14 | 89 | 10-16 | 12-14 |
| 15 | 86 | 15 | |
| 16 | 89 | 10-16 | 11-14 |
| 17 | 88 | 12-15 | 12 |
| 18 | 84 | | |
| 19 | 88 | 09-12 | 10-12 |
| 20 | 86 | 13-14 | |
| 21 | 85 | 10 | |
| 22 | 88 | 09-14 | 12 |
| 23 | 87 | 11-12 | |
| 24 | 87 | 10-14 | |
| 25 | 87 | 11 | |
| 26 | 86 | 10-14 | |
| 27 | 86 | 11-13 | |
| 28 | 84 | | |
| 29 | 85 | 12 | |
| 30 | 86 | 11-12 | |
| 31 | 77 | 10-15 | |

| *NOVEMBER* | | Hourly Duration | |
|---|---|---|---|
| Date | MaxWBGT | ≥85° F | ≥88° F |
| 1 | 88 | 10-14 | 11-12 |
| 2 | 80 | | |
| 3 | 81 | | |
| 4 | 86 | 09-13 | |
| 5 | 87 | 11-13 | |
| 6 | 83 | | |
| 7 | 86 | 10 | |
| 8 | 82 | | |
| 9 | 86 | 11 | |
| 10 | 85 | 11 | |
| 11 | 80 | | |
| 12 | 83 | | |
| 13 | 81 | | |
| 14 | 85 | 10 | |
| 15 | 82 | | |
| 16 | 85 | 14 | |
| 17 | 87 | 11-14 | |
| 18 | 83 | | |
| 19 | 83 | | |
| 20 | 85 | 13 | |
| 21 | 80 | | |
| 22 | 85 | 11 | |
| 23 | 84 | | |
| 24 | 78 | | |
| 25 | 79 | | |
| 26 | 81 | | |
| 27 | 82 | | |
| 28 | 86 | 13 | |
| 29 | 84 | | |
| 30 | 79 | | |

## KING KHALID

| *OCTOBER* | | Hourly Duration | |
|---|---|---|---|
| Date | MaxWBGT | ≥85° F | ≥88° F |
| 1 | 81 | | |
| 2 | 86 | 13 | |
| 3 | 86 | 12-15 | |
| 4 | 81 | | |
| 5 | 81 | | |
| 6 | 81 | | |
| 7 | 77 | | |
| 8 | 86 | 12-14 | |
| 9 | 82 | | |
| 10 | 83 | | |
| 11 | 86 | 12-14 | |
| 12 | 86 | 15 | |
| 13 | 78 | | |
| 14 | 80 | | |
| 15 | 77 | | |
| 16 | 80 | | |
| 17 | 85 | 13 | |
| 18 | 79 | | |
| 19 | 85 | 14 | |
| 20 | 83 | | |
| 21 | 80 | | |
| 22 | 87 | 12-13 | |
| 23 | 78 | | |
| 24 | 87 | 13 | |
| 25 | 77 | | |
| 26 | 77 | | |
| 27 | 81 | | |
| 28 | 74 | | |
| 29 | 77 | | |
| 30 | 71 | | |
| 31 | 72 | | |

## KING FAHD

| *OCTOBER* | | Hourly Duration | |
|---|---|---|---|
| Date | MaxWBGT | ≥85° F | ≥88° F |
| 1 | 86 | 14 | |
| 2 | 86 | 11 | |
| 3 | 90 | 11-14 | 12 |
| 4 | 94 | 10-15 | 10-15 |
| 5 | 92 | 09-13 | 10-11 |
| 6 | 85 | 13 | |
| 7 | 83 | | |
| 8 | 84 | | |
| 9 | 89 | 11-13 | 12 |
| 10 | 81 | | |
| 11 | 84 | | |
| 12 | 89 | 11-14 | 12 |
| 13 | 86 | 14 | |
| 14 | 93 | 11-15 | 12-15 |
| 15 | 92 | 10-13 | 11-13 |
| 16 | 85 | 13 | |
| 17 | 86 | 12-13 | |
| 18 | 82 | | |
| 19 | 89 | 11-13 | 11 |
| 20 | 81 | | |
| 21 | 84 | | |
| 22 | 90 | 08-10 | 10 |
| 23 | 82 | | |
| 24 | 84 | | |
| 25 | 84 | | |
| 26 | 85 | 12 | |
| 27 | 87 | 13-14 | |
| 28 | 81 | | |
| 29 | 77 | | |
| 30 | 82 | | |
| 31 | 77 | | |

# DISTRIBUTION

HQ AF/XOW, Pentagon, Washington, DC 20301 ..... 1
HQ USAF/XOOCW, Washington, DC 20330-5054 ..... 1
OSAF/SS, Rm 4C1052, Pentagon, Attn: Weather, Washington, DC 20330-6560 .. 1
USTC J3/J4-OW, Scott AFB, IL 62225-7001 ..... 1
AWS/XT/DO/XTX/HO, Scott AFB, IL 62225-5008 ..... 1
Det 3, DOXW, PO Box 95004, Henderson, NV 89009-5004 ..... 1
Det 4, AWS, Bldg 91027, Hurlburt Fld, FL 32544-5000 ..... 1
Det 5, HQ AWS, Keesler AFB, MS 39534-5000 ..... 1
OL-B, HQ AWS, Hanscom AFB, MA 01731-5000 ..... 1
OL-C, HQ AWS, Stop 16, Chanute AFB, IL 61868-5000 ..... 1
HQ AFGWC/DO/SY/RM, MEB39, 106 Peacekeeper Dr.,
Offutt AFB, NE 86113-4039 ..... 1
OL-A, AFGWC, FLENUMOCEANCEN, Monterey CA 93943-5995 ..... 1
AFSFC/DOM, Stop 82, Bldg 715, Falcon AFB, CO 80912-5000 ..... 1
USAFETAC, Scott AFB, IL 62225-5000 ..... 6
OL-A, USAFETAC, Federal Building, Asheville, NC 28801-2723 ..... 1
NCDC Library (D542X2), Federal Building, Asheville, NC 28801-2723 ..... 1
AFSPACECOM/DOW, Stop 7, Peterson AFB, CO 80914-5000 ..... 1
1 CACS/DOW, Stop 4, Cheyenne Mt Complex, CO 80914-5000 ..... 1
50 OSS/DOW, Stop 82, Falcon AFB, CO 80912-5000 ..... 1
45WS, Patrick AFB, FL 32925-6537 ..... 1
AFTAC/DOW, Patrick AFB, FL 32925-5000 ..... 1
730WS, Vandenberg AFB, CA 93437-5000 ..... 1
3 SSW/AMW, Stop 22, Peterson AFB, CO 80914-5000 ..... 1
SSD/MWA, PO Box 92966, Los Angeles, CA 90009-2960 ..... 1
SSD/IMO, PO Box 92960, Los Angeles, CA 90009-2960 ..... 1
USAICS, Attn: ATSI-CDW, Ft Huachuca, AZ 85613-6000 ..... 1
CSTC/WE, PO Box 3430, Onizuka AFB, CA 94088-3430 ..... 1
OD 4/DX, Onizuka AFB, CA 94088-3430 ..... 1
SSD OD 4, Onizuka AFB, CA 94088-3430 ..... 1
USAFA/DFP, Attn: Capt Paul Bellaire, Colorado Springs, CO 80840-5701 ..... 1
HQ AFSC/WE, Andrews AFB, MD 20334-5000 ..... 1
AFMC/DOW, Bldg 266, Wright-Patterson AFB, OH 45433-5000 ..... 1
ASD/WE, Bldg 91, Wright-Patterson AFB, OH 45433-6503 ..... 1
WL/DOW, Wright Patterson AFB, OH 45433-6543 ..... 1
PL/WE, Kirtland AFB, NM 87117-5000 ..... 1
AFESC/WE, Tyndall AFB, FL 32403-5000 ..... 1
ESD/WE, Bldg 1624, Hanscom AFB, MA 01731-5000 ..... 1
PL/TSML, 4 Library, Hanscom AFB, MA 01731-5000 ..... 1
PL/OL-AA/SULLA, Hanscom AFB, MA 01731-5000 ..... 1
3246TW/DOW, Bldg 60, Rm 60, Eglin AFB, FL 32542-5000 ..... 1
AFDTC/WE, Eglin AFB, FL 32543-5000 ..... 1
AFFTC/WE, Edwards AFB, CA 93523-5000 ..... 1
SSD/SDW, PO Box 92960, Los Angeles AFB, CA 90009-2960 ..... 1
USAFA/CWOSW, USAF Academy, CO 80840-5000 ..... 1
USCENTCOM/J3-2, MacDill AFB, FL 33608-5000 ..... 1
USAFALCENT RA, Pope AFB, NC 28308-5000 ..... 1
304 ARRS/DOOR, Portland IAP, OR 97218-2797 ..... 1
AFOSR/NL, Bolling AFB, DC 20332-5000 ..... 1
TFWC/WE, Nellis AFB, NV 89191-5000 ..... 1
MAC/XOW, Bldg P40 N, Scott AFB, IL 62225-5000 ..... 1
438 OSS/WX, Bldg 1907, McGuire AFB, NJ 08641-5002 ..... 1
60 OSS/WX, Bldg P4, Travis AFB, CA 94535-5986 ..... 1
AFSOC/DOW, Hurlburt AFB, FL 32544-5000 ..... 1
ATC/DOW, Randolph AFB, TX 78150-5000 ..... 1
12FTW/DOW, Ran3395TCHTG/TTKO-MV, Keesler AFB, MS 39534-5000 ..... 1
3350TCHTG/TTGU-W, Stop 62, Chanute AFB, IL 61868-5000 ..... 1
PACAF/DOW, Hickam AFB, HI 96853-5000 ..... 1
Det 1, HQ PACAF, COMNAVMAR, PSC 489, Box 20, FPO AP 96540-0051 .... 1
11WS, 6900 9th Ste 205, Elmendorf AFB, AK 99506-5000 ..... 1
20WS, APO AP 96328-5000 ..... 1
SAC/DOW, Washington SQ, Ste 6, Offutt AFB, NE 68113-5000 ..... 1
15 AF/DOW, March AFB, CA 92518-5000 ..... 1
8 AF/DOW, Barksdale AFB, LA 71110-5002 ..... 1
TAC/DOW, Bldg 21, Langley AFB, VA 23655-5524 ..... 1
24WS, Unit 0640, APO Miami 34001-5000 ..... 1
363 FW/DOMX, Shaw AFB, SC 29152-5070 ..... 1
67RW/DOM, Bergstrom AFB, TX 78743-5000 ..... 1
24WS/CC, APO AA 34001-5000 ..... 1
OL-AA, 5WS, Libby AAF, Ft Huachuca, AZ 85613-6000 ..... 1
ATSI/CDW, US Army Intel, Ft Huachuca AI, AZ 85613-5000 ..... 1
US Central Comm CCJ3, MacDill AFB, FL 33608-7001 ..... 1
US Spec Op Comm Cent, MacDill AFB, FL 33608-7001 ..... 1
US Spec Op Comm SOJ3, MacDill AFB, FL 33608-7001 ..... 1

5WS, FCWE/SWO, Bldg 168, Ft McPherson, GA 30300-5000 ..... 1
Det 1, 5WS, Ft Campbell, KY 42223-5000 ..... 1
Det 3, 5WS, Ft Bragg AIN, NC 28307-5000 ..... 1
CDR USASOC, Attn: AOIN-ST, Ft Bragg, NC 28307-5200 ..... 1
JSOC/Weather, P.O. Box 70239, Ft Bragg, NC 28307-5000 ..... 1
Det 5, 5WS, Ft Knox, KY 40121-5540 ..... 1
Det 6, 5WS, Bldg 3082, Airport Dr., Ft Lewis, WA 98433-5000 ..... 1
Det 7, 5WS, Ft Ord, CA 93941-5111 ..... 1
Det 8, 5WS, 743 Ray Place, Ft Riley, KS 66442-5317 ..... 1
Det 10, 5WS, Ft Benning, GA 31905-6034 ..... 1
75th RGR (Attn: SWO), Ft Benning, GA 31905-5000 ..... 1
Det 12, 5WS, Ft Devens, MA 01433-5310 ..... 1
Det 14, 5WS, Ft Hood, TX 76544-5076 ..... 1
OL-A, Det 14, 5WS, Ft Bliss, TX 79916-2418 ..... 1
OL-A, Det 21, 5WS, Ft Stewart, GA 31314-5000 ..... 1
Det 31, 5WS, Ft Polk, LA 71459-6250 ..... 1
Det 58, 5WS, Bldg 9601, Butts AAF, Ft Carson, CO 80913-6403 ..... 1
HQ 5th U.S. Army, AFKB-OP (SWO), Ft Sam Houston, TX 78234-7001 ..... 1
USAFE/DOW, Unit 3050, Box 15, APO AE 09094-5000 ..... 1
USAFE/DOWO, Unit 3050, Box 500, APO AE 09094-5000 ..... 1
17AF/DOW, Unit 4065, APO AE 09136-5000 ..... 1
HQ EUCOM ECJ3/WE, Unit 30400, Box 1000, APO AE 09128-4209 ..... 1
7WS, CINCUSAREUR/AREAWX, APO AE 09403-5000 ..... 1
7WS, Unit 29351, APO AE 09014-5000 ..... 1
3AF/DOW, Unit 4838, APO AE 09459-5000 ..... 1
16AF/SWO, Unit 6365, APO AE 09641-5000 ..... 1
39 TACG/DOM, Unit 7090, PSC 115, APO AE 09824-5090 ..... 1
OL-A, Det 6, 2WW, APO AE 09050-5000 ..... 1
HQ 3AF/DOW, APO AE 09459-5000 ..... 1
48 Weather Flight, APO AE 09464-5000 ..... 1
101 Weather Flight, Otis ANGB, MA 02542-5001 ..... 1
104 Weather Flight, Bldg P 929, Ft Meade, MD 20755-5430 ..... 1
105 Weather Flight, Smyrna APT, TN 37167-2091 ..... 1
107 Weather Flight, Selfridge ANGB, MI 48045-5024 ..... 1
110 Weather Flight, MO ANG, 131TFW, Bridgeton, MO 63044-2371 ..... 1
111 Weather Flight, Ellington ANGB, TX 77034-5586 ..... 1
113 Weather Flight, Hulman Fld, Terre Haute, IN 47830-5000 ..... 1
116 Weather Flight, WA ANG, Bldg 304, McChord AFB, WA 98433-5000 ..... 1
119 Weather Flight, McGuire AFB, NJ 08641-6004 ..... 1
120 Weather Flight, Buckley ANGB, CO 80011-9599 ..... 1
121 Weather Flight, Andrews AFB, MD 20331-6539 ..... 1
122 Weather Flight, New Orleans NAS, LA 70143-0200 ..... 1
123 Weather Flight, Portland IAP, OR 97218-2797 ..... 1
125 Weather Flight, PO Box 580340, Tulsa AFS, OK 74158-0340 ..... 1
126 Weather Flight, WIANG, 350 E College, Milwukee, WI 53207-6298 ..... 1
127 Weather Flight, Forbes Fld, Topeak, KS 66619-5000 ..... 1
130 Weather Flight, Yeager Apt, Charleston, WV 25311-5000 ..... 1
131 Weather Flight, Barnes Map, Westfield, MA 01085-1385 ..... 1
140 Weather Flight, Willow Grove NAS, PA 19090-5105 ..... 1
146 Weather Flight, GTR Pittsburg ANG AN, PA 15231-0459 ..... 1
154 Weather Flight, Camp Robinson, North Little Rock, AR 72118-2200 ..... 1
155 Weather Flight, Jackson, TN 38301-5000 ..... 1
156 Weather Flight, 5225 Morris Fld Dr., Charlotte, NC 28208-5797 ..... 1
163 Weather Flight, Ft Wayne Mpt, IN 46809-5000 ..... 1
164 Weather Flight, Rickenbecker ANGB, OH 43217-5007 ..... 1
165 Weather Flight, Standiford Fld, Louisville, KY 40213-2678 ..... 1
181 Weather Flight, 8150 W Jefferson Blv, Dallas, TX 75211-9570 ..... 1
182 Weather Flight, Kelly AFB, TX 78241-7001 ..... 1
195 Weather Flight, 8030 Balboa Blvd, Van Nuys, CA 91406-1195 ..... 1
199 Weather Flight, Wheeler AFB, HI 96854-5000 ..... 1
201 Weather Flight, Suffolk CO ANGB, NY 11978-1294 ..... 1
202 Weather Flight, Otis AFB, MA 02542-5001 ..... 1
203 Weather Flight, Ft Indiantown GAP, Annville, PA 17003-5002 ..... 1
204 Weather Flight, McGuire AFB, NJ 08641-6004 ..... 1
207 Weather Flight, RR2, Box 124, Shelbyville, IN 46176-4914 ..... 1
208 Weather Flight, 206 Airport DE, St Paul, MN 55107-4098 ..... 1
209 Weather Flight, PO Box 5218, Austin, TX 78763-5218 ..... 1
210 Weather Flight, Ontario ANGB, CA 91761-7627 ..... 1
COMNAVOCEANCOM, Code N312, Stennis Space Ctr, MS 39529-5000 ..... 2
COMNAVOCEANCOM, Capt Brown, Code N332, Stennis Space Ctr,
MS 39529-5001 ..... 1
NAVOCEANO (Rusty Russum), Stennis Space Ctr, MS 39522-5001 ..... 2
NAVOCEANO, Code 9220 (Tony Ortolano), Stennis Space Ctr, MS 39529-5001 . 1

Maury Oceanographic Library (NOC), Code XJL, Stennis Space Ctr, MS 39529-5001 ..... 1
NOARL West, Monterey, CA 93943-5006 ..... 1
Naval Research Laboratory, Code 4323, Washington, DC 20375 ..... 1
Naval Postgraduate School, Chmn, Dept of Meteorology, Code 63, Monterey, CA 93943-5000 ..... 1
Naval Eastern Oceanography Ctr, U117 McCAdy Bldg, Norfolk NAS, Norfolk, VA 23511-5000 ..... 1
Naval Western Oceanography Ctr, Box 113, Attn: Tech Library, Pearl Harbor, HI 96860-5000 ..... 1
Naval Oceanography Command Ctr, COMNAVMAR Box 12, FPO San Francisco, CA 96630-5000 ..... 1
Naval Oceanography Command Ctr, Box 31, USNAVSTA FPO New York, NY 09540-3000 ..... 1
NAVOCEANCOMDET, Federal Building, Asheville, NC 28801-2723 ..... 1
NAVOCEANCOMPAC, NAS North Island, San Diego, CA 92135-5130 ..... 1
Naval Air Warfare Center-Weapons Division, Geophysical Sciences Branch, Code 3254, Attn: Mr. Roger Helvey, Point Mugu, CA 93042-5001 ..... 1
USCINCPAC (J37), Box 13, Camp H.M. Smith, HI 96861-5025 ..... 1
COMMANDANT, USMC, (Attn: AS2-44 Capt R.M. Fields), HQ USMC, Washington, DC 20381-0001 ..... 1
WSO, H & HS Marine Station Wea, MCAS Tustin CA 92710-5000 ..... 1
Armed Forces Medical Intelligence Agency, Info Svcs Div., Bldg 1607, R Detrick, Frederick, MD 21701-5114 ..... 1
Atmospheric Sciences Laboratory (SLCAS-AT-AB), Aberdeen Proving Grounds, MD 21005-5001 ..... 1
Atmospheric Sciences Laboratory (SLCAS-AS-I 3 10-2c), White Sands Missile Range, NM 88002-5501 ..... 1
Army Missile Command, ATTN: AMSMI-RD-TE-F, Redstone Arsenal, AL 35898-5250 ..... 1
Commander and Director, U.S. Army CEETL, Attn: GL-AE, Fort Belvoir, VA 22060-5546 ..... 1
Technical Library, Dugway Proving Ground, Dugway, UT 84022-5000 ..... 1
OFCM, Suite 900, 6110 Executive Blvd, Rockville, MD 20852 ..... 1
HQ NATO Staff Meteorological Officer IMS/OPS APO AE 09724 ..... 1
NOAA Library-EOC4W5C4, Attn: ACQ, 6009 Executive Blvd, Rockville, MD 20852 ..... 1
NIST Pubs Production, Rm A-405, Admin Bldg, Gaithersburg, MD 20899 ..... 1
DTIC-FDAC, Cameron Station, Alexandria, VA 22304-6145 ..... 2
AUL/LSE, Maxwell AFB, AL 36112-5564 ..... 1
AWSTL, Scott AFB, IL 62225-5438 ..... 125

# SUPPLEMENTARY

# INFORMATION

ERRATA

AD A248571

ERRATA--March 1992

# USAFETAC/TN--92/003

# GULF WAR WEATHER

**Please make the following corrections--**

•On top of Page 2-55, add the following first line to complete the sentence begun on the bottom of Page 2-54:

"on Page 2-57. Winds were southwesterly to westerly at 10-15"

•On Page 3-52, in "Area of Intense Interest," next to last line, delete "extreme northern."

•On Page 3-53, last line of figure caption, delete "extreme northern."

•On Page 3-61, last line of figure caption, change "northern Iraq" to "southwestern Iraq."

The lead author also wishes to apologize for misspelling two key names:

On Page v, Maj Thomas R. *MacPhail*

On page 1-6, Lt Col Gerry F. *Riley*



USAF ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER
Scott Air Force Base, Illinois 62225-5438