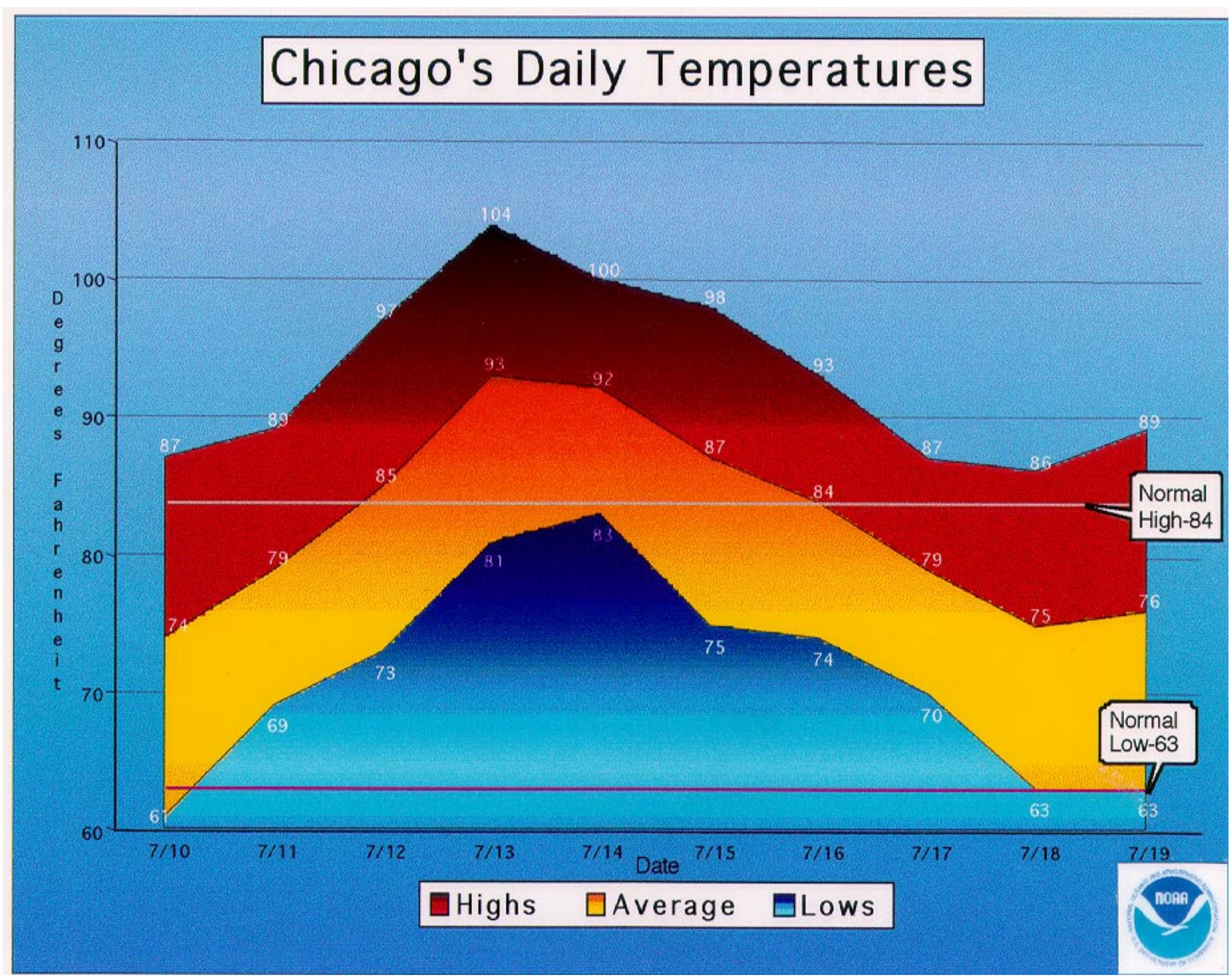
Natural Disaster Survey Report

July 1995 Heat Wave



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland

Front Cover: High, low, average, and normal temperatures for Chicago, Illinois, during the mid-July 1995 heat wave.

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December 1995

U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary

National Oceanic and Atmospheric Administration
Dr. D. James Baker, Administrator

National Weather Service
Dr. Elbert W. Friday, Jr., Assistant Administrator

PREFACE

Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. Among the large continental family of natural hazards, only the cold of winter—not lightning, hurricanes, tornadoes, floods, or earthquakes—takes a greater toll. In the disastrous heat wave of 1995, more than 1,000 people died.

I would like to express my gratitude to the National Oceanic and Atmospheric Administration (NOAA) Disaster Survey Team for their objectivity in producing this survey report on the performance of the National Weather Service (NWS) during the July 1995 heat wave. I am particularly grateful to the Centers for Disease Control and Prevention (CDC) for providing valuable insight into the health aspects of the heat wave.

Elbert W. Friday, Jr.
Assistant Administrator
for Weather Services

December 1995

FOREWORD

This report on the "July 1995 Heat Wave" was prepared by the NOAA Disaster Survey Team after numerous interviews and meetings with Federal, state, and local officials in Chicago, Illinois; Milwaukee, Wisconsin; Philadelphia, Pennsylvania; and St. Louis, Missouri.

Chicago and Milwaukee were selected due to the high heat-related death toll. Chicago experienced its worst weather-related disaster, with 465 heat-related deaths recorded during the period from July 11-27, 1995. Milwaukee also was severely affected, with 85 heat-related deaths recorded during the same time period. Philadelphia and St. Louis experienced deadly heat waves in 1993 and 1980, respectively, and were selected as complementary case studies.

The primary purpose of this disaster survey is to evaluate the performance of the NWS in fulfilling its mission of providing timely and accurate warnings, watches, forecasts, advisories, and statements during the July 1995 heat wave. NOAA and the NWS are dedicated to continuing improvements in warning and forecasting for these events to provide local and state officials with the lead time required to implement emergency heat response plans.

The team is grateful to the many individuals who took the time from their duties to share their impressions of the events during the heat wave.

The Disaster Survey Team

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ACRONYMS

CDC	Centers for Disease Control and Prevention
CDT	Central Daylight Time
F	Fahrenheit
MIC	Meteorologist in Charge
NOAA	National Oceanic and Atmospheric Administration
NWR	NOAA Weather Radio
NWS	National Weather Service
NWWS	NOAA Weather Wire Service
OLR	Outgoing Long-Wave Radiation
SSI	Surface Systems Incorporated
WCJIS	Wisconsin Criminal Justice Information System
WCM	Warning Coordination Meteorologist
WSH	Weather Service Headquarters
WSOM	Weather Service Operations Manual

GLOSSARY

Advisory	An Advisory is issued for less serious conditions that cause significant inconvenience and, if caution is not exercised, could lead to situations that may threaten life and/or property.
Extended Forecast	As part of a State Forecast, an Extended Forecast is valid for the third through fifth days after issuance.
Outlook	An Outlook is used to indicate a hazardous event may develop. It is intended to provide information to those who need considerable lead time to prepare for the event, typically 48 hours or more in advance.
Short Term Forecast	The Short Term Forecast can be valid up to 6 hours after issuance. For fast-breaking or convective situations, however, the valid time may be less, such as 1 to 2 hours after issuance.
Statement	Issued at frequent intervals, Special Weather Statements amplify warnings, watches, and advisories by reinforcing the message, indicating what is expected, and outlining appropriate response actions. During active weather, they should be issued more frequently to highlight existing conditions and how they might change in time. At forecaster discretion, Severe Weather Statements may be issued to heighten awareness and provide additional information for life-threatening conditions.
State Forecast	The same as a Zone Forecast (see below) except for part or all of a state and with additional extended forecast information.
Warning	A Warning is issued when a hazardous event is occurring, is imminent, or has a very high probability of occurrence. A Warning is used for conditions posing a threat to life or property.
Watch	A Watch is used when the risk of a hazardous event has increased significantly, but its occurrence, location, and/or timing is still uncertain. It is intended to provide enough lead time so those who need to set their plans in motion can do so, typically 12 to 36 hours in advance.
Zone Forecast	Zone Forecast is valid up to 36-48 hours after issuance. Periods within the forecast are usually 12 hours long. The first 12 hours, however, may be divided into sub-periods, usually 6 hours long.

THE JULY 1995 HEAT WAVE
NOAA DISASTER SURVEY TEAM

After a significant weather event, such as a heat wave, a disaster survey team may be assigned by NOAA to evaluate the role played by the NWS, provide an objective appraisal, and make findings and recommendations.

Team Members

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EXECUTIVE SUMMARY

Extreme heat may be one of the most underrated and least understood of the deadly weather phenomena. In contrast to the visible, destructive, and violent nature associated with "deadly weather," like floods, hurricanes, and tornadoes, a heat wave is a "silent disaster." Unlike violent weather events that cause extensive physical destruction and whose victims are easily discernible, the hazards of extreme heat are dramatically less apparent, especially at the onset.

During the 3-day period from July 13-15, 1995, approximately 70 daily maximum temperature records were set at locations from the central and northern Great Plains to the Atlantic coast. The July 1995 heat wave at Chicago and Milwaukee was a highly rare and, in some respects, unprecedented event in terms of both unusually high maximum and minimum temperatures and the accompanying high relative humidities. Chicago experienced its worst weather-related disaster, with 465 heat-related deaths recorded during the period from July 11-27. Milwaukee was also severely affected, with 85 heat-related deaths recorded during the same time period. The number of deaths in Chicago and Milwaukee exceeds the average number of lives lost each year in the United States to all floods, hurricanes, and tornadoes.

Large urban areas pose unique problems during excessive heat situations. Without the extent of urbanization in Chicago and Milwaukee, the July 1995 heat wave might have been outstanding rather than unprecedented. There is sufficient circumstantial evidence to conclude that the urban heat island was at least partially responsible for the severe conditions in Chicago's south side. In fact, the elderly and infirm residing in urban areas are in the greatest danger during heat waves.

Because of its nature, heat waves are easier to predict than more short-lived and highly localized weather events like tornadoes. In both Chicago and Milwaukee, NWS issued accurate warnings of the developing heat wave several days before it arrived, and these messages were quickly broadcast by the local media. Consequently, it might be argued that given this advance warning, many, if not all, of the heat-related deaths associated with this event were preventable. Unfortunately, a heat wave connotates discomfort, not violence; inconvenience, not alarm.

Despite timely NWS warnings, forecasts, advisories, and statements and effective media coverage of the event, this information either failed to reach or was not used effectively by the people who could have prevented heat-related deaths. This group of people includes the victims themselves, many of whom were isolated elderly. Because of their isolation, they are very difficult to reach by any mechanism. However, the group also includes the care providers for the victims as well as other persons in the communities. While these people may have been made aware of the heat emergency, it seems clear that they did not comprehend the potential health impact for those at risk.

City officials had neither the experience nor emergency response capabilities to translate the physical characteristics of the heat wave into human impact. Both Chicago and Milwaukee had extensive disaster preparedness plans for responding to more dramatic events, like floods or blizzards, but neither city possessed a well-developed plan for responding to heat emergencies. One reason for the general unpreparedness of the communities affected by the July heat wave was that neither local officials nor the community at large recognized the potentially lethal nature of extreme heat. In both Chicago and Milwaukee, extreme heat was initially viewed more as an inconvenience than as a public health emergency or disaster. While public health officials made efforts to mitigate the impact of the heat wave within their communities, neither city was prepared to respond to the heat emergency as a citywide disaster.

FINDINGS AND RECOMMENDATIONS

The following findings and recommendations are grouped by subject matter and are found within their appropriate chapters as indicated.

Meteorological/Climatological Analysis

***Finding*:** The July 1995 heat wave at Chicago and Milwaukee was a highly rare and, in some respects, unprecedented event in terms of both unusually high maximum and minimum temperatures and the accompanying high relative humidities.

***Finding*:** The principal cause of the July 1995 heat wave was a slow-moving, hot, and humid air mass produced by the chance occurrence at the same time of an unusually strong upper-level ridge of high pressure and unusually moist ground conditions.

***Finding*:** Long-term processes played no obvious role in the July 1995 heat wave. Given current forecasts skills, there is no reason to believe increased risk of the event could have been anticipated more than a week in advance or can be expected in the future.

***Finding*:** The July 1995 heat wave was exacerbated by local effects, including urbanization. This effect was especially notable in Chicago.

Health Impacts

***Finding*:** One of the difficulties with measuring the mortality associated with a heat emergency is the lack of definition for a heat-related death that is both standardized and practical. A standard definition for heat-related death, such as the one used in Chicago, should be developed and adopted for national use by all medical examiners.

***Finding*:** The awareness of heat-related deaths by local medical examiners in Chicago and Milwaukee in 1995 led to the initial recognition in those cities of excess deaths during heat-wave periods.

***Finding*:** In Chicago and Milwaukee, the people most affected by the heat were the elderly.

***Recommendation*:** Since the elderly in urban areas are in the greatest danger during heat waves, the NWS must proactively focus heat preparedness efforts toward this group.

***Finding*:** Heat waves are not clearly recognized as public health emergencies.

***Recommendation*:** Emergency response organizations at the Federal, state, and local levels should be encouraged to recognize severe heat waves as potential natural disasters, and areas at risk should be prompted to develop emergency response plans for severe heat waves. These plans should target the groups most often affected by the heat, including elderly persons, particularly those living alone; persons with chronic medical conditions, especially cardiovascular or pulmonary disease; and persons taking psychotropic medications.

***Recommendation*:** The analysis of morbidity during the July 1995 heat wave in Chicago and Milwaukee should be investigated by public health officials in order to provide useful public health information about the relationship of morbidity to mortality.

***Finding*:** The vulnerability of the elderly in urban core areas was underestimated during the heat wave.

***Recommendation*:** Forecasters should target Heat Warnings, Watches, Advisories, and Statements to those groups that are most vulnerable.

Provision of NWS Products and Services

- **Chicago, Illinois**

***Finding*:** The Extended Forecast Product issued by forecasters at the Chicago NWS Forecast Office communicated the likelihood of high levels of heat and humidity 48 hours prior to the event.

***Finding*:** Extended range forecasts of temperatures were generally within 3 to 5 degrees for high temperatures and 5 to 7 degrees for low temperatures.

***Finding*:** NWS forecasters at the Chicago Forecast Office communicated a forecast calling for high heat and humidities 36 to 48 hours prior to the event.

***Finding*:** Short-range temperature forecasts had state of the art accuracy. High temperature forecasts were accurate to within 3 degrees. Low temperature forecasts were accurate to within 6 degrees. Both were underestimates.

***Finding*:** Forecasters used descriptive terminology, such as "muggy" and "humid," to communicate important weather information.

***Finding*:** A Heat Outlook or Heat Watch was not issued as allowed for in WSOM Chapter C-44, Non-Precipitation Weather Hazards.

***Recommendation*:** The NWS should ensure that forecasters at all field offices understand the flexibility provided by WSOM Chapter C-44 to issue a variety of critical information products on heat-related issues.

***Finding*:** NWS forecasters at the Chicago Forecast Office issued accurate Short Term Forecasts that included temperature, humidity, and heat index levels.

***Finding*:** Heat Advisories were issued prior to and during the excessive heat event.

***Finding*:** The initial Heat Advisory issued at 3:30 p.m., CDT, July 12, was issued under an incorrect product title (Public Information Statement). A Non-Precipitation Weather Warning should have been issued.

***Finding*:** NWS-issued forecast products contained highly detailed and accurate meteorological information, including the heat index, but lacked call to action statements. Heat Advisories were the only products that contained information relating to the potential impact of anticipated weather conditions or call to action information.

***Recommendation*:** Forecasters should focus on the health hazards associated with heat in warnings, watches, forecasts, advisories, and statements. All products should include call to action statements.

***Recommendation*:** MICs and WCMs at all NWS forecast offices should work with state, city, and local health officials to determine threshold values for dangerous heat index levels tailored to their area.

Potential For Enhanced Service

Although the excessive heat was well forecast by forecasters at the NWS Forecast Office at Chicago, there are several ways in which service to the public could have been enhanced.

Enhancement Concept 1: Stress the dangerous nature of excessive heat in NWS

With forecast or actual temperatures near 100°F, dew points near 80°F, and heat index levels above 110°F, the seriousness of these weather conditions could have been stressed in Warnings, Watches, Advisories, and Statements.

Enhancement Concept 2: Keep a pulse on the community.

It was nearly impossible for forecasters to learn of the increasing heat-related deaths until after the peak period of temperature. The earliest indication of a developing crisis was an enormous increase in emergency room admissions. At one point, 18 Chicago-area hospitals were in bypass or unable to admit more people into the emergency room. This occurred relatively early in the event. During times of excessive heat, forecasters should establish contact with public health officials to obtain this information.

Enhancement Concept 3: Understand local problems of the community.

Early indications suggest that the elderly in urban areas were vulnerable to the excessive heat. Forecasters should issue targeted products addressed to the most vulnerable.

Enhancement Concept 4: Develop local studies for the community.

In some cases, there are thresholds of temperature, humidity, and hence heat index at which heat-related problems increase. Local studies, in cooperation with health officials, could better define these critical values. They will most likely vary from region to region and, perhaps, city to city.

Enhancement Concept 5: Keep the community well informed.

Once forecasters target specific groups and critical threshold heat values, keep the community informed via frequent statements.

Enhancement Concept 6: Work with commercial service providers.

Work with commercial service providers to develop a heat hazards training element for their radio and television customers to improve the on-air delivery of forecast information to the public.

- **Milwaukee, Wisconsin**

***Finding*:** The Extended Forecast Product issued by forecasters at the Milwaukee NWS Forecast Office clearly communicated the likelihood of unusually high levels of heat 5 days prior to the event.

***Finding*:** Extended range forecasts of temperatures were initially 6 to 10 degrees low in the 3- to 5-day range but improved to within 2 degrees in the 1- to 2-day range.

***Finding*:** Two Special Weather Statements were issued 40 hours prior to the event and contained call to action information for the elderly and others at risk.

***Finding*:** NWS forecasters at the Milwaukee Forecast Office clearly, effectively, and accurately communicated a forecast calling for high heat and humidities 36 to 48 hours prior to the event.

***Finding*:** Short-range temperature forecasts were accurate. Initial errors in forecast accuracy improved to within 2 or 3 degrees at least 24 hours prior to the onset of the heat wave.

***Finding*:** Forecasters used descriptive terminology, such as "muggy" and "humid," to communicate important weather information.

***Finding*:** A Heat Advisory was issued for 2 consecutive days, providing local officials excellent planning information.

***Finding*:** NWS forecasters at the Milwaukee Forecast Office issued accurate Short Term Forecasts that included temperature, humidity, and heat index levels.

***Finding*:** Heat Advisories were issued prior to and during the excessive heat event.

***Finding*:** Heat index levels were provided in the first period (first 6 hours) of the Zone Forecasts.

***Finding*:** NWS-issued forecast products contained highly detailed and accurate meteorological information, including the heat index.

***Finding*:** NWS forecasters at the Milwaukee Forecast Office issued frequent Heat Advisories and Special Weather Statements to keep the community well informed.

***Finding*:** All warnings, forecasts, advisories, and statements were of high quality and contained accurate forecast details, including heat index levels.

***Recommendation*:** MICs and WCMs at all NWS forecast offices should work with state, city, and local health officials to determine threshold values for dangerous heat index levels tailored to their area.

Potential For Enhanced Service

Although forecasters at the NWS Forecast Office at Milwaukee kept the community well informed on the heat wave, there are a few ways in which service could have been enhanced.

Enhancement Concept 1: Focus on the highest at-risk groups.

Large urban areas pose unique problems during excessive heat situations. Forecasters are encouraged to provide frequent statements targeted to the groups at higher risk; in this case, the elderly and infirm residing in urban areas.

Enhancement Concept 2: Keep a pulse on the community.

It was nearly impossible for forecasters to learn of the increasing heat-related deaths until after the peak period of temperature. The earliest indication of a developing crisis was an enormous increase in emergency room admissions. At one point, several Milwaukee-area hospitals were in bypass or unable to admit more people into the emergency room. This occurred relatively early in the event. During times of excessive heat, forecasters should establish contact with public health officials to obtain this information.

Enhancement Concept 3: Develop local studies for the community.

In some cases, there are thresholds of temperature, humidity, and heat index at which heat-related problems are increased. Local studies, in cooperation with health officials, could better define these critical values.

Enhancement Concept 4: Work with commercial service providers.

Work with commercial service providers to develop a heat hazards training element for their radio and television customers to improve the on-air delivery of forecast information to the public.

Communication, Emergency Preparedness, and Community Response

***Finding*:** Despite timely NWS warnings, forecasts, advisories, statements, and effective media coverage of the event, city officials had neither the experience nor emergency response capabilities to translate the physical characteristics of the heat wave into human impact.

***Recommendation*:** NWS offices should work with local officials to develop a public awareness and community response plan for such events, especially among vulnerable or disadvantaged groups.

***Finding*:** Media coverage of the July 1995 heat wave in Chicago and Milwaukee was substantial from both meteorological and health angles.

***Finding*:** Staff meteorologists at radio and television stations gave the NWS high marks for timely and accurate forecasts and related services during the heat wave.

***Finding*:** The Chicago and Milwaukee media have not developed a public response to heat hazards as they have for other severe weather phenomena.

***Recommendation*:** The NWS must enhance its public education campaign regarding the use of the heat index and the dangers of heat. The media and the private sector should be enlisted as partners through professional associations, such as the American Meteorological Society and the National Weather Association.

***Finding*:** At the time of the July 1995 heat wave, the emergency preparedness program for extreme heat in Chicago was organized and administered from the public health department, which was different from other hazardous weather events.

***Finding*:** Officials in Chicago did not realize the difference between NWS weather warnings and private sector warnings.

***Recommendation*:** The Chicago NWS Forecast Office should work with Chicago officials to provide user training on NWS watch/warning products.

***Finding*:** Chicago and Milwaukee officials and the public did not fully understand the heat index or the extent of the threat from heat waves.

***Recommendation*:** The NWS must enhance its community education campaign regarding the use of the heat index and the dangers of heat.

Case Studies in Heat Wave Preparedness

***Recommendation*:** NOAA should actively encourage other Federal agencies, such as the Department of Health and Human Services, the Environmental Protection Agency, and the Federal Emergency Management Agency, to join in research on excessive heat, mortality, and morbidity.

***Recommendation*:** The NOAA Chief Scientist should convene a workshop comprised of interagency physical scientists, private sector providers, social scientists, and epidemiologists to provide operational research recommendations in light of the scientific advances made over the last decade. The relationship between heat-related mortality and the heat index, as well as other proposed predictors of heat stress, should be simultaneously evaluated to determine which method most accurately predicts the health consequences of a heat wave.

- **Philadelphia, Pennsylvania**

***Finding*:** Philadelphia's Heat Wave Preparedness Task Force developed an extensive and detailed plan for responding to heat emergencies.

***Finding*:** Philadelphia's Heat Response Emergency Plan is activated by Heat Warnings issued by the NWS.

***Finding*:** Emergency heat-related activities in Philadelphia are mobilized on the basis of predictions of an alternative model developed by Professor Laurence Kalkstein, Center for Climatic Research, University of Delaware.

***Finding*:** It is not clear how much better the Kalkstein model compares with other models in predicting the health effects of a heat wave.

***Recommendation*:** The Kalkstein model should be reviewed after its proposed expansion to Chicago, Illinois, and Atlanta, Georgia, in 1996.

***Finding*:** NWS forecasters clearly, effectively, aggressively, and accurately communicated a forecast for the Philadelphia area calling for dangerously high heat and humidities 36 to 48 hours prior to the event.

***Finding*:** Recognizing the unique situation of an urban center, NWS forecasters issued a Heat Warning for Philadelphia (the highest level possible) for a consecutive 2-day period. This action provided community officials with key planning information.

***Recommendation*:** NOAA should quantify the urban heat island effect to incorporate in NWS Heat Warnings, Watches, Advisories, and Statements.

■ St. Louis, Missouri

***Finding*:** St. Louis' Operation Weather Survival, a loose affiliation of agencies involved in responding to heat emergencies and coordinated by the local chapter of the United Way, developed an extensive and detailed plan for responding to heat emergencies.

***Finding*:** The St. Louis Heat Response Plan is activated by Heat Warnings jointly issued by the St. Louis Department of Health and the St. Louis County Health Department, based on readings of a wet bulb globe thermometer not by Heat Warnings issued by the NWS.

***Finding*:** NWS forecasters clearly and accurately communicated the likelihood of unusually high levels of heat for St. Louis 5 days prior to the event.

***Finding*:** NWS forecasters issued a Heat Advisory for St. Louis for a consecutive 2-day period. This action provided community officials with key planning information.

CHAPTER 1

METEOROLOGICAL/CLIMATOLOGICAL ANALYSIS

Major weather events, like the remarkable heat wave that blanketed major midwestern and eastern cities for several days in mid-July 1995, are often the result of a number of meteorological and climatological factors that operate on several different time and space scales. Sufficient evidence for this event is available to address several key questions, among them the roles of longer term phenomena, like trend, or the El Niño/Southern Oscillation system and the impact of urbanization. These issues will be discussed after the heat wave is first placed in a historical context at Chicago as well as three other major cities: Milwaukee, Wisconsin; Philadelphia, Pennsylvania; and St. Louis, Missouri. Chicago and Milwaukee were selected due to the high heat-related death toll. Philadelphia and St. Louis, having experienced deadly heat waves in 1993 and 1980, respectively, were selected as complementary case studies.

Historical Context

During the 3-day period from July 13 through 15, approximately 70 daily maximum temperature records were set at locations from the central and northern Great Plains to the Atlantic coast. To examine just how unusual the mid-July heat wave was at the four surveyed cities, the most readily available historical daily data set, maximum and minimum temperatures and their averages, was utilized. Table 1 depicts a chronology of the heat wave at each of the four cities over the appropriate 5-day period.

Table 1

Daily Maximum and Minimum Temperatures (°F) for the mid-July 1995 Heat Wave

		July					
		12	**13**	**14**	**15**	**16**	**17**
Chicago Midway Airport	MAX	97	106	102	98	93	
	MIN	75	81	84	77	76	
Chicago O'Hare Airport	MAX	97	104	100	98	93	
	MIN	73	81	83	75	74	
Milwaukee	MAX	91	103	103	92	88	
	MIN	65	78	84	69	68	
Philadelphia	MAX		94	98	103	91	94
	MIN		74	76	81	74	73
St. Louis	MAX	100	101	99	98	96	

Table 2 shows the all-record ranks of the mid-July 1995 2-day mean maximum, minimum, and daily average temperatures observed, respectively, for six records for the four cities. Over its long history, the official Chicago record has been measured in a number of locations, including Midway Airport from 1942 to 1979 and O'Hare International Airport from 1980 to present. Because high temperature extremes can occur from mid-May through mid-September, each year there are 120 days in which there is an opportunity for a specific temperature to be exceeded. Thus, a 40-year record represents about 4,800 opportunities, a 70-year record about 8,400, etc. These counts help put into perspective rankings in table 2 and later in table 4. The table demonstrates that this year's event at Chicago and Milwaukee was at least highly rare and, in several respects in both of these cities, totally unprecedented. To underscore this, one should note that the official average 2-day temperature of 92° Fahrenheit (F) observed at O'Hare International Airport for July 13 and 14 was the highest in 123 years. The peak 2-day period at Philadelphia was highly unusual for its 48-year record but not as outstanding as that for Chicago, especially in light of the longer records for Chicago. St. Louis experienced highly unusual minimum temperatures, but the mid-July ranks for 2-day mean maximum and average temperatures for its 48-year record do not rank among the top 20. The principal reason for these differences will be apparent from the discussion in the following sections. The relative severity of the heat wave between cities is also reflected in the daily maximum temperature records set at the four locations in mid-July, which are listed in table 3.

Table 2

Rank (if in top twenty) of Mean Temperatures for 2-day Periods in mid-July 1995 (ties in parentheses)

	July 12-13	July 13-14	July 14-15
		Maximum Temperature	
Chicago O'Hare Airport (38 years)	(4)	2	(7)
Chicago Midway Airport (48 years)	5	1	9
Chicago Official (123 years)	(11)	(3)	-
Milwaukee (48 years)	(17)	1	(11)
Philadelphia (48 years)	-	-	(4)
St. Louis (48 years)	-	-	-
		Minimum Temperature	
Chicago O'Hare Airport	(12)	1	(3)
Chicago Midway Airport	13	1	(2)
Chicago Official	-	4	(17)
Milwaukee	-	1	5
Philadelphia	-	-	(5)
St. Louis	(20)	(3)	(6)
		Average Temperature	
Chicago O'Hare Airport	(4)	1	3
Chicago Midway Airport	4	1	2
Chicago Official	(13)	1	(11)
Milwaukee	-	1	6
Philadelphia	-	-	(3)

Table 3

Daily Maximum Temperature Records Set at
Chicago, Milwaukee, and Philadelphia on July 12-15, 1995
(all-time daily maximum records in bold)

	July 12	July 13	July 14	July 15
Chicago/O'Hare	97	**104**	100	
Chicago/Midway		**106**		
Milwaukee			101	
Philadelphia				103

What ultimately distinguishes the 2-day period in mid-July at Chicago and Milwaukee from all others is the combination of both unusually high maximum and minimum temperatures. The principal factor for the elevated nighttime temperatures was the relatively high moisture content (i.e., humidity) in the air. Observed dew points, a direct measure of the moisture content, were extraordinarily high on three straight nights at Chicago's Midway Airport. The accompanying relative humidities, well above 90 percent in the late evenings, added substantially to the already considerable human stress implied by the high average observed temperatures. Data at several other locations in the Chicago metropolitan area and on a larger regional scale confirm that these extraordinary levels were largely a consequence of a very moist regional air mass but also may be partially attributable to additional local effects at Chicago and perhaps some other midwestern locations.

Of some interest also is the extended period of high heat surrounding the 2 key days that have been emphasized so far. Table 4 contains similar information as table 2 but for 3- to 5-day mean daily average temperatures. Data for St. Louis are not tabulated since the ranks are not in the top twenty. Note that at Chicago, the mid-July event still ranks first or second in all respects over the most recent 50 years but not when viewed from the perspective of the long-term record. Ferocious heat waves, lasting 5 and 6 days and exceeding the 1995 heat wave, occurred in 1911 and 1916, respectively. In contrast, conditions over 3- to 5-day periods in July 1995 at Milwaukee were exceeded in August 1988.

***Finding*: The July 1995 heat wave at Chicago and Milwaukee was a highly rare and, in some respects, unprecedented event in terms of both unusually high maximum and minimum temperatures and the accompanying high relative humidities.**

Table 4

Rank (if in top twenty) of Mean Daily Average Temperatures for 3- to 5-day Periods in mid-July 1995 (ties in parentheses) ("NC" means not calculated)

	3-Day Mean		
	12-14	**13-15**	**14-16**
Chicago O'Hare Airport (38 years)	2	1	5
Chicago Midway Airport (48 years)	2	1	4
Chicago Official (123 years)	5	4	-
Milwaukee (48 years)	4	2	(20)
Philadelphia (48 years)	NC	(5)	(12)

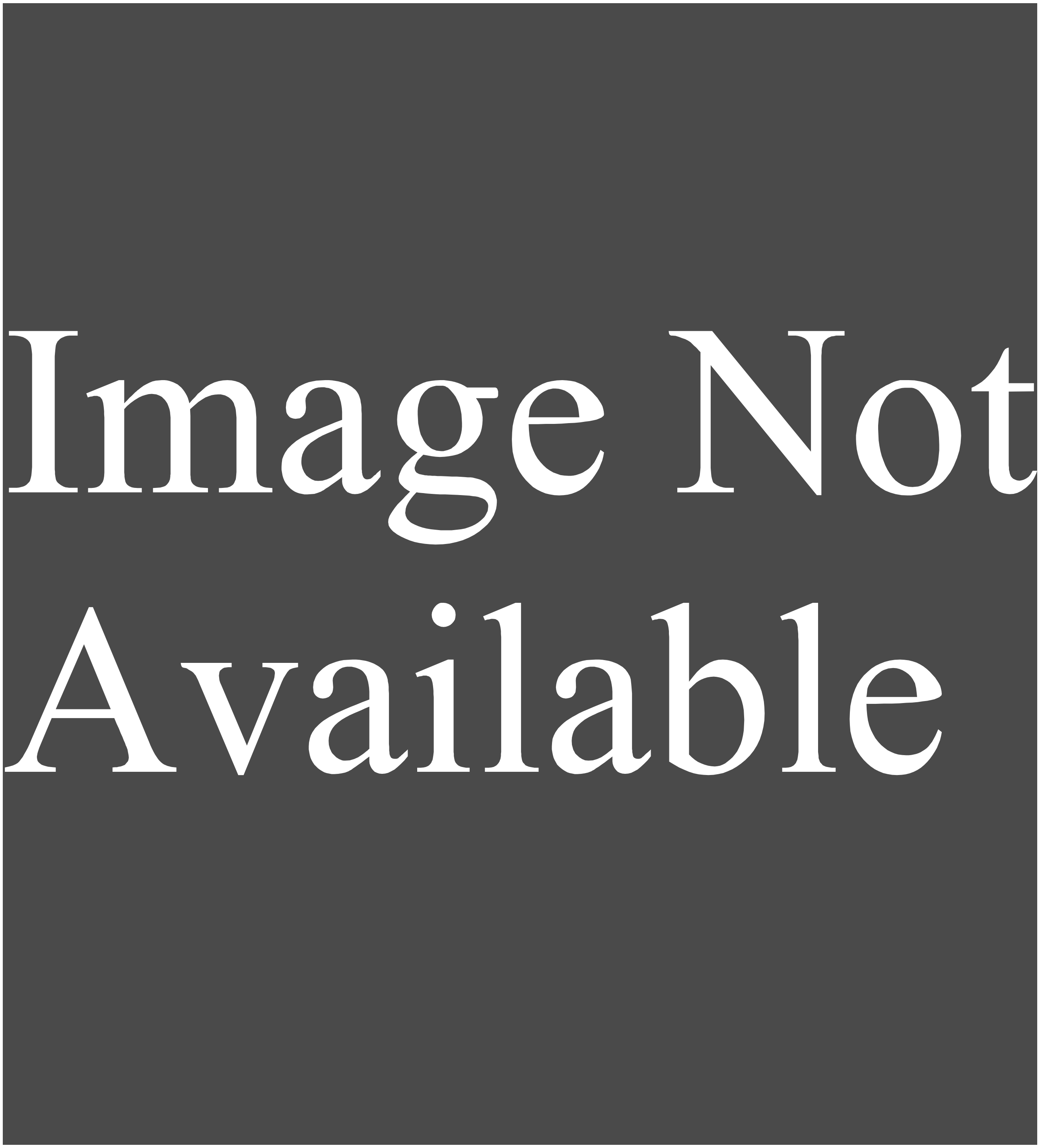
	4-Day Mean		
	12-15	**13-16**	**14-17**
Chicago O'Hare Airport	1	(2)	NC
Chicago Midway Airport	1	2	NC
Chicago Official	5	(6)	NC
Milwaukee	(3)	(3)	NC
Philadelphia	NC	(14)	(16)

	5-Day Mean	
	12-16	**13-17**
Chicago O'Hare Airport	1	NC

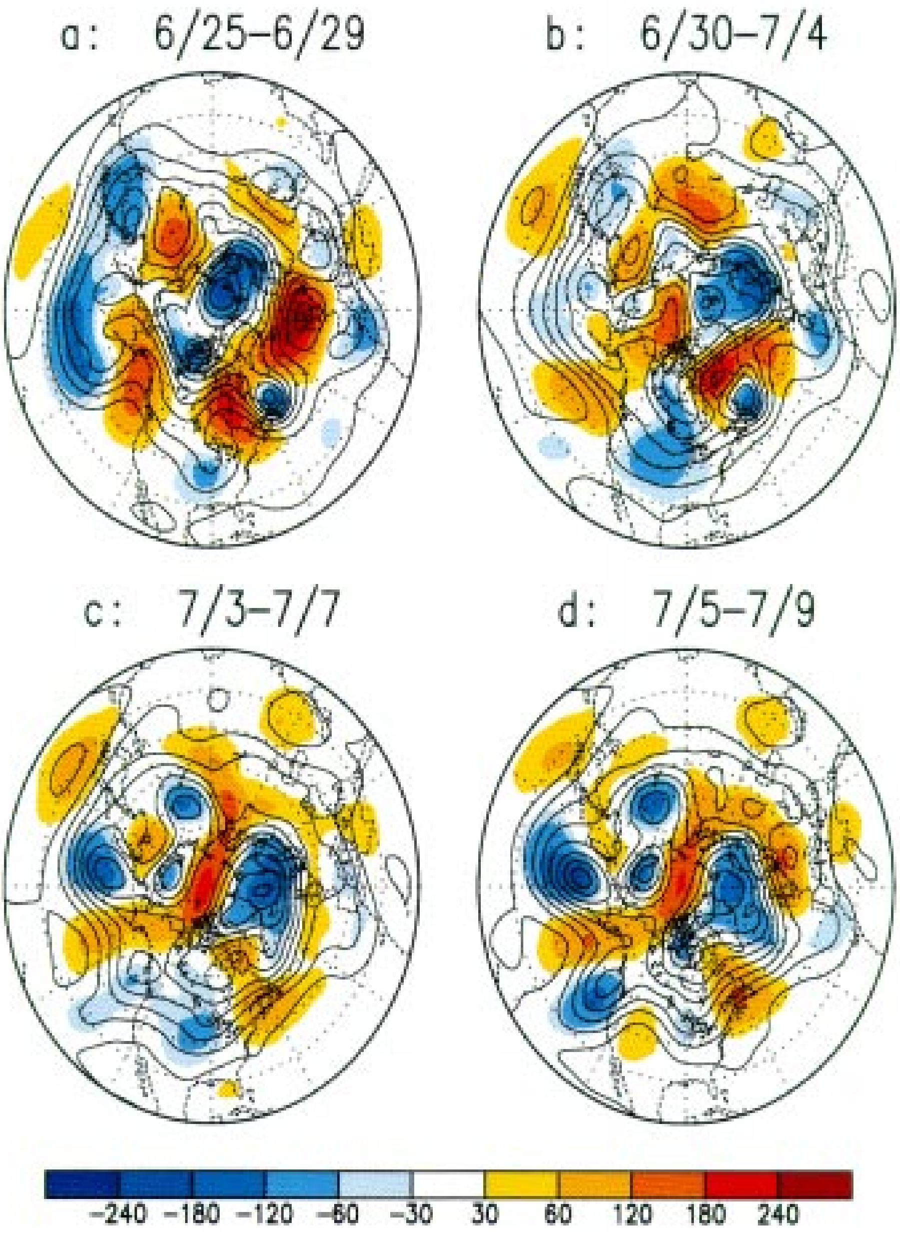
Development of the Meteorological Event

The principal cause and origin of the heat wave is straight-forward—a slow-moving, hot, and humid air mass (figure 1) was produced by a very strong upper-level ridge of high pressure. This ridge originated as an amplification of the climatologically normal weak ridge which exists in the western United States in July. Its growth was a downstream adjustment of the westerly winds to a major weather disturbance affecting the subtropical ridge in the western Pacific Ocean several days before.

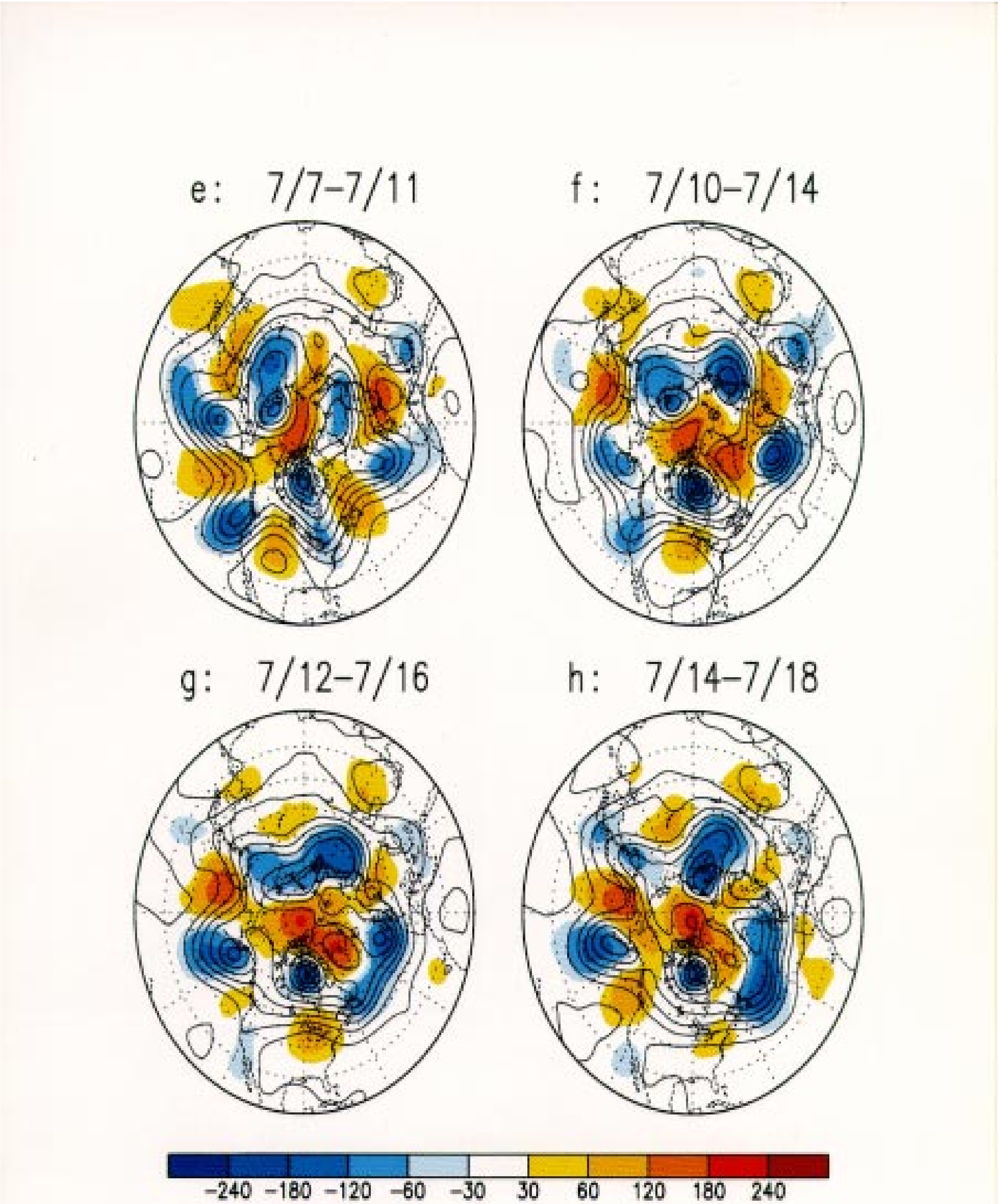
This sequence of events can be followed clearly in the series of 5-day mean charts in figures 2 and 3 which filter out day-to-day fluctuations. The pair of charts in figure 2 shows departures from normal of outgoing long-wave radiation (OLR), which are good proxies of anomalous rainfall and latent heating of the atmosphere in the tropics and subtropics. A significant flare-up of this heating off the coast of east Asia extending out into the Pacific is indicated by a substantial increase in negative OLR anomalies between



- Figure 1. Daily progression of the mid-July 1995 heat wave in terms of maximum apparent temperatures (heat index) at least 105 F and minimum temperatures at least 78 F.



Figures 3a, 3b, 3c, 3d. Sequence of 5-day mean upper-level pressure and flow conditions leading up to and including the heat wave. The lines depict the location of upper-level ridges and troughs of pressure in mid-latitudes and the colors anomalies in the pressure. Upper-level westerly winds flow along the lines with jets located where the lines are most closely spaced. The color scale indicates 500 millibars height departures from normal in meters.



Figures 3e, 3f, 3g, 3h. Sequence of 5-day mean upper-level pressure and flow conditions leading up to and including the heat wave. The lines depict the location of upper-level ridges and troughs of pressure in mid-latitudes and the colors anomalies in the pressure. Upper-level westerly winds flow along the lines with jets located where the lines are most closely spaced. The color scale indicates 500 millibars height departures from normal in meters.

the last week of June and the first week in July. This flare-up was accompanied by an increase in convection in the tropics to the south as well. However, this fact should not be taken as evidence that the tropical disturbance was the cause of the subtropical disturbance. The flow in the tropics (not shown) was not that expected in situations where a tropical rainfall anomaly is the source of a convective outburst to the north.

The upper-air flow and departures from normal of heights of the 500 millibar pressure surface, which correspond to ridges and troughs of pressure at a fixed upper level, for the time periods in figure 2 are shown in figures 3a and 3b, respectively. Note the increase in strength of the western Pacific ridge, indicated by the increase in the positive height anomaly between the two periods. This amplification continued for a few more days (figure 3c) and led immediately to a downstream flow adjustment across the entire north Pacific basin, which culminated several days later with enormous amplification of the western U.S. ridge (figures 3c, 3d, and 3e). The latter's slow eastward progression across the middle of the country, with the most anomalously high upper-air pressures across the northern half of the United States, can be followed clearly in figures 3c, 3d, 3e, 3f, 3g, and 3h. Apparent in the last two maps is that the maximum upper air height anomaly (and its attendant implications for heating of the atmosphere from sinking air and solar radiation) occurred as the anomaly passed over Lake Michigan (figure 3g); the anomaly subsequently lost strength as it moved into the mid-Atlantic region (figure 3h).

The trajectory of this anomalous feature (passing to the north of St. Louis, and its relative strength, strongest near Chicago and Milwaukee and a little weaker over Philadelphia) provides much of the explanation for the contrast in the uniqueness of the heat wave event at the four cities. The slow movement of the structure provided ample opportunity for the day by day heating, accumulation of moisture, and transport into the upper midwest, and later into the east, of the air necessary to produce the extreme conditions observed.

The occurrence of the unusually strong large-scale structure that led to the mid-July heat wave appears to have been the result of a complicated chain of events, whose initiation, the flare-up in the western Pacific/east Asia region, can be characterized as random. In this context, something resembling the structure could not have been predicted more than a week in advance. Of course, as illustrated below, both regional and local factors likely played roles in the conditions ultimately experienced in Chicago, Milwaukee, and possibly other locations. These factors only complicate the prediction problem further.

To understand the high water vapor content (dew points in the range of 75-80°+F) of the portion of the air mass that moved from Iowa, Missouri, and southern Minnesota through the lower Great Lakes into Pennsylvania requires consideration of the surface air trajectories for several days preceding the arrival of the air mass and the conditions of the surface over which it traveled. The sequence of surface weather charts in figure 4 depicts a weak but steady surface flow from first the south and later the southwest into the central Mississippi/lower Missouri Valleys region from as early as the evening of July 11 right up to the climax of the heat wave. A chart of soil-moisture conditions less than a week before the peak of the heat wave (figure 5) shows that the soil was quite wet for much of Kansas, Missouri, Iowa, and Illinois over which the air traveled. Moreover, the air originating or moving into and through this four-state area already carried dew points in the high 60s and lower 70s (figures 4a and 4b).

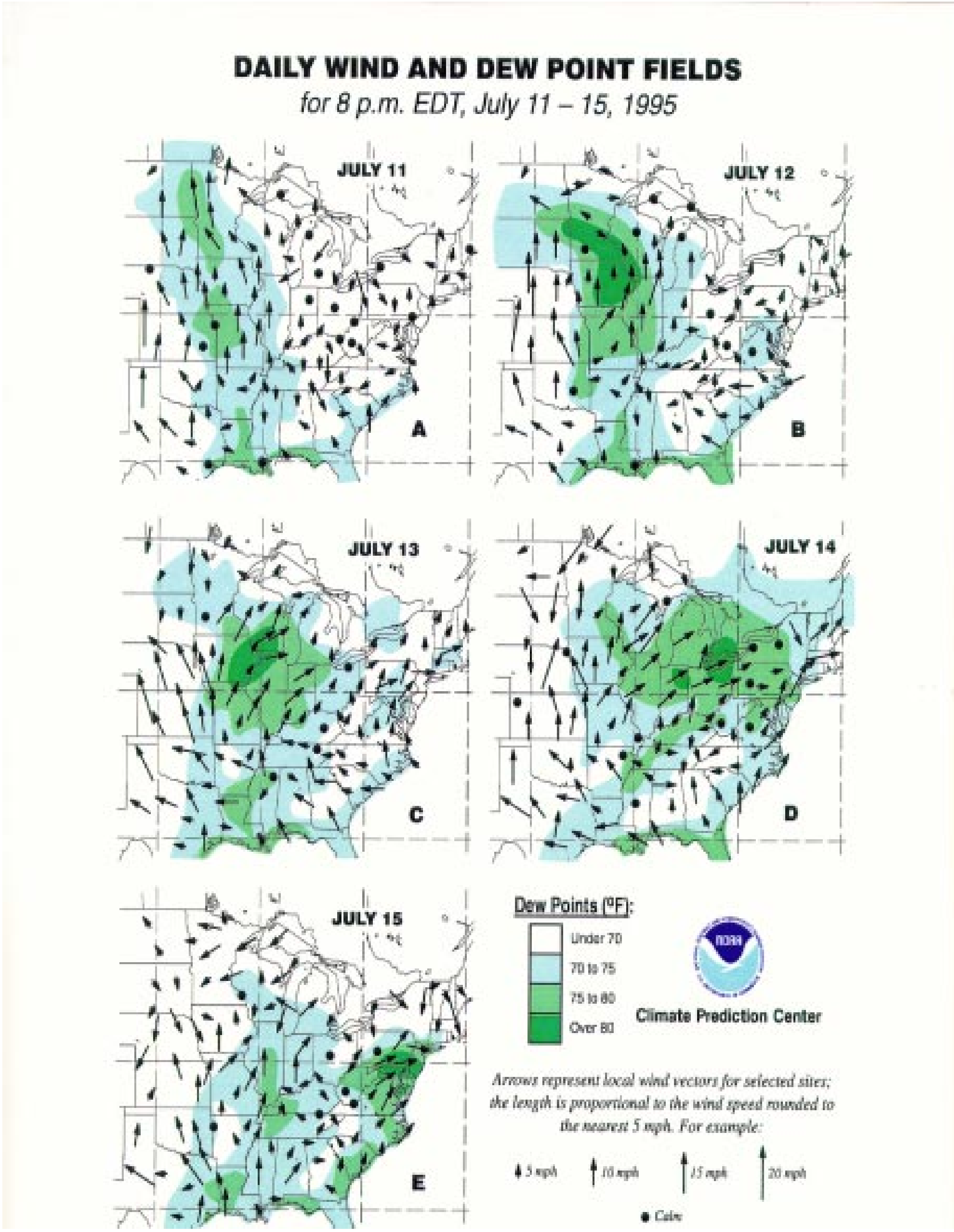


Figure 4. Early evening surface winds and water vapor contents (in terms of dew points in °F) for 5 consecutive days in mid-July 1995 at locations throughout the eastern United States. The former are generally light in the Midwest and Northeast. Values of the latter in excess of 75°F (green shades) can be considered unusually high.

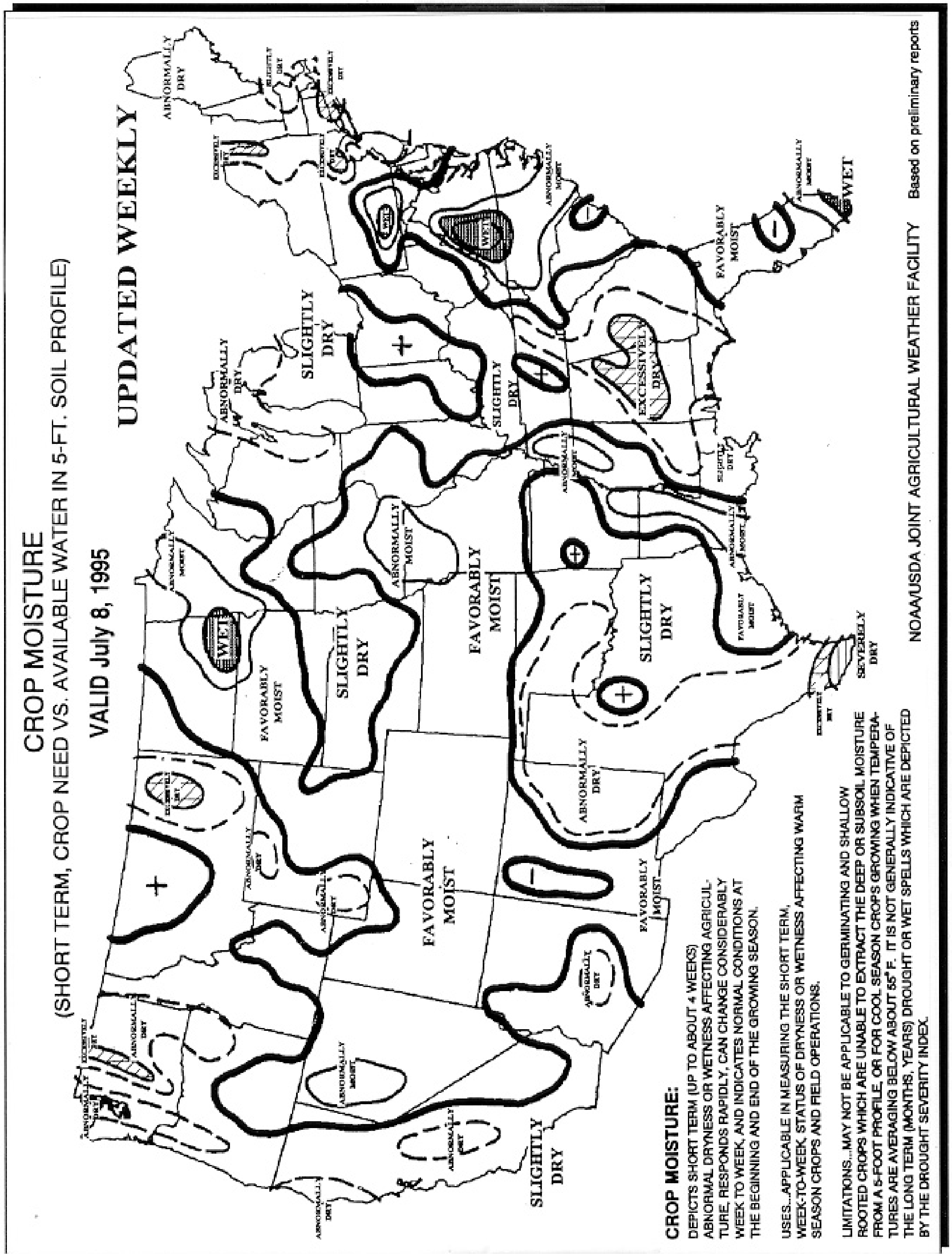


Figure 5. Soil moisture conditions less than 1 week before the onset of the heat wave. The ground over which the hottest part of the air mass moved was quite wet.

Thus, it is not surprising that, with the intense solar insolation and its potential for evaporation of water vapor accompanying the approaching mammoth upper-air ridge of high-pressure (figures 3f and 3g), a tongue of air w
ith dew points in excess of 75°F had formed by the evening of July 12 (figure 4b). This area corresponds closely to the region of pre-existing wet ground and contained a smaller area with dew points in excess of 80°F over eastern Iowa and southern Minnesota. This moisture-laden air spread mainly east, with its center passing over Chicago, Milwaukee, and finally Philadelphia over the next few days (figures 4c, 4d, and 4e) before moving offshore. Again, note that the core of the moistest air passed to the north of St. Louis, providing additional explanation for the somewhat less relative severity for conditions in that city.

Finding**: The principal cause of the July 1995 heat wave was a slow-moving, hot, and humid air mass produced by the chance occurrence at the same time of an unusually strong upper-level ridge of high pressure and unusually moist ground conditions.**

Role of Long-term Factors

In this section, two factors—El Niño/Southern Oscillation and long-term trends—are examined that are commonly associated with substantial departures from normal of surface conditions on monthly to seasonal time scales. This is important because monthly average temperature records were set at both Chicago and Philadelphia, and because some degree of predictability is implied when either factor is a significant influence. Moreover, if either played a role, additional inferences can be made about future vulnerability to similar events.

The link between climatic effects and El Niño is well established. The term "El Niño" has come to be reserved for exceptionally strong warm intervals that raise the water temperature across the equatorial Pacific. The term "Southern Oscillation" represents the ups and downs of the east-west seesaw in southern Pacific barometric pressure which is linked to dramatic changes in the distribution of rainfall in the tropics. The warm waters associated with El Niño and the pressure seesaw of the Southern Oscillation are part of the same phenomena referred to as the El Niño/Southern Oscillation.

There is little support for El Niño/Southern Oscillation as a contributing mechanism for the heat wave. Tropical equatorial Pacific Ocean sea-surface temperature anomalies were quite small both prior to and during the month of July, i.e., this was not an active El Niño summer. Additionally, recent studies that have examined the El Niño/Southern Oscillation signal when the system is active show little or no response for the upper-midwest or middle-Atlantic regions during the month of July.

The question of whether the monthly mean temperature records for July are symptomatic of longer term trends needs to be addressed separately for Chicago and Philadelphia. Note in figure 6 that the historical temperature ranks for July 1995 of the multistate regions encompassing the eastern seaboard are quite high, while those for the two regions covering the Ohio and upper Mississippi River Valleys are not even in the upper quintile. Further, note in figure 7 that this same regional contrast is reflected on average over the previous ten summers (i.e., the Atlantic coast has been quite warm on the average, while the Midwest has been cool or near normal). The former probably reflects an enhanced

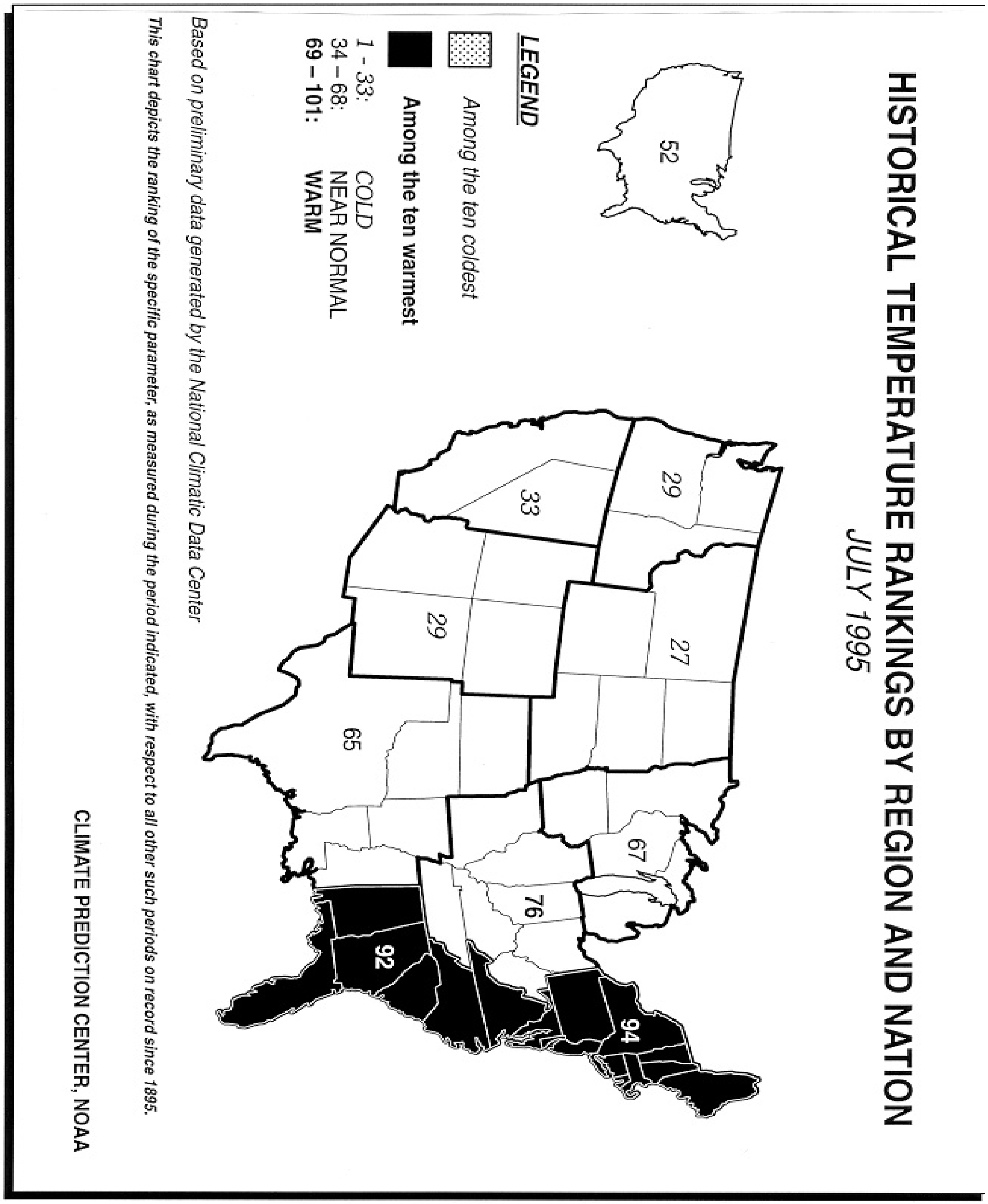


Figure 6. Historical rank of July 1995 average temperature by region and Nation. The month overall was exceptionally warm along the eastern seaboard but not unusually so in the Midwest.

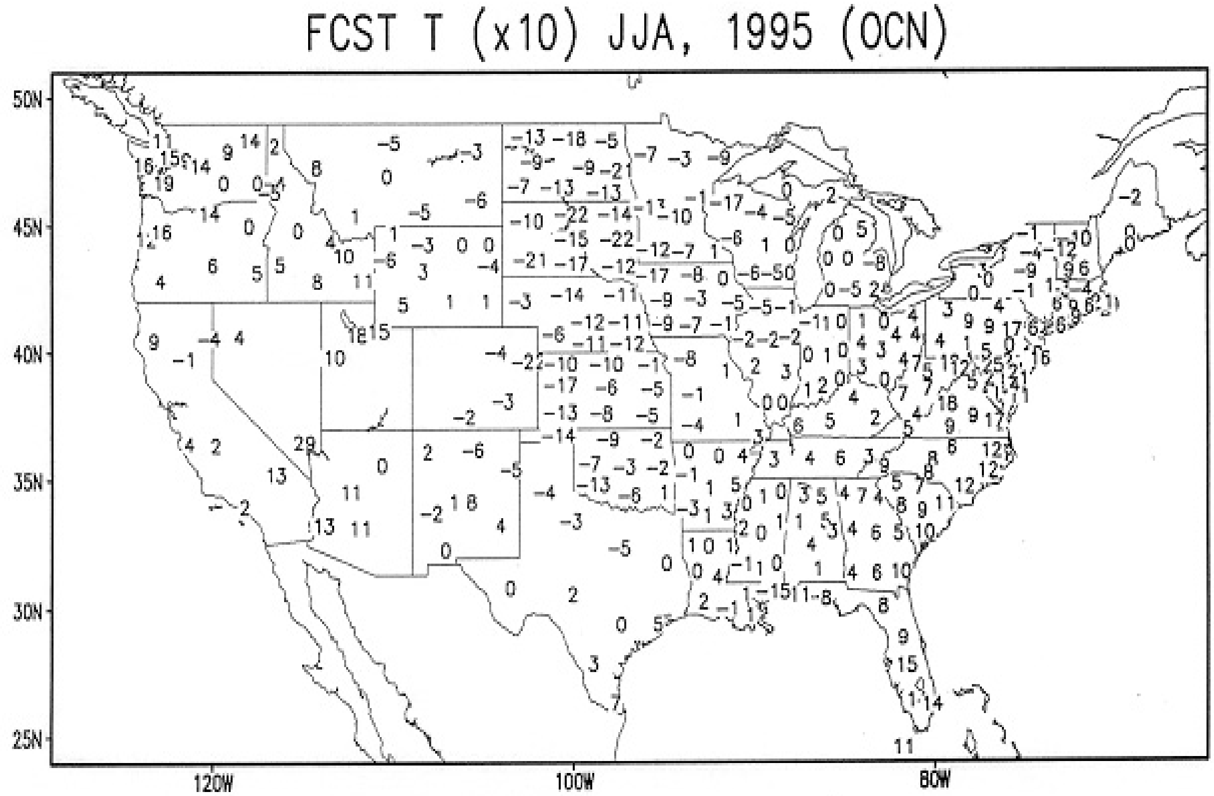


Figure 7. Average summertime (June, July, and August) departures from normal temperature (ºF times 10) for the 10 years preceding the summer of 1995. Note that recent trends around Lake Michigan have been for normal or slightly below normal temperatures but along the mid-Atlantic coast for above normal temperatures.

Bermuda high, which played no apparent role in the early to mid-July weather sequence described in the previous section.

Thus, the mid-July synoptic event, though not necessarily related to some longer term process, reinforced the 10-year tendency at Philadelphia but not at Chicago. Another argument against trend as an important factor for Chicago is the fact that the nearest rivals for the 2-day July 1995 event, in terms of average temperature, occurred in the summers of 1911 and 1916. In contrast, Philadelphia experienced a heat wave as recently as July 1993 that in many respects substantially exceeded the severity of the July 1995 occurrence. The most reasonable conclusion is that the July 1995 heat wave in Chicago was the result of a rare juxtaposition of an exceptionally strong upper-air ridge and unusually wet July soil in the nearby upstream air mass source region. Corollaries to this are that increased vulnerability to such a meteorological event could not have been anticipated in late June, nor should necessarily be expected in the future based on current information. Local effects, including urbanization, also may have played enough of an additional role in Chicago to make the event unprecedented.

***Finding*: Long-term processes played no obvious role in the July 1995 heat wave. Given current forecasts skills, there is no reason to believe increased risk of the event could have been anticipated more than a week in advance or can be expected in the future.**

Role of Microclimate Factors in Chicago

Conditions in the Chicago area differed from one location to another during the mid-July heat wave. This was already evident from table 1 which indicated more severe conditions at Midway Airport than O'Hare. This and even more pronounced local differences will now be examined more closely to clarify the role played by factors like the urban heat island, lake proximity, evapotranspiration, wind direction, etc.

For this survey, daily maximum and minimum temperature data at 11 locations in the Chicago metropolitan area were available, of which nine were considered useable, either because of observation times or credibility. In addition, detailed hourly observations at Chicago's O'Hare International and Midway Airports were available and proved enormously useful. The relative locations of these 11 sites, along with other features mentioned below, are mapped in figure 8.

Daytime maximum temperatures on July 13 and 14 are listed in table 5 for all 11 locations. Three locations with the highest maximum average temperature for the 2 days (the first three listed)—the two airports and Chicago Botanic Gardens—have two things in common. These locations are the three observation sites closest to downtown Chicago, Midway being the closest, followed by O'Hare, and the Botanic Gardens. They are three of the four points listed that are closest to Lake Michigan, with the Botanic Gardens adjacent to the lake, Midway somewhat inland, and O'Hare another several miles inland. Waukegan is also on Lake Michigan.

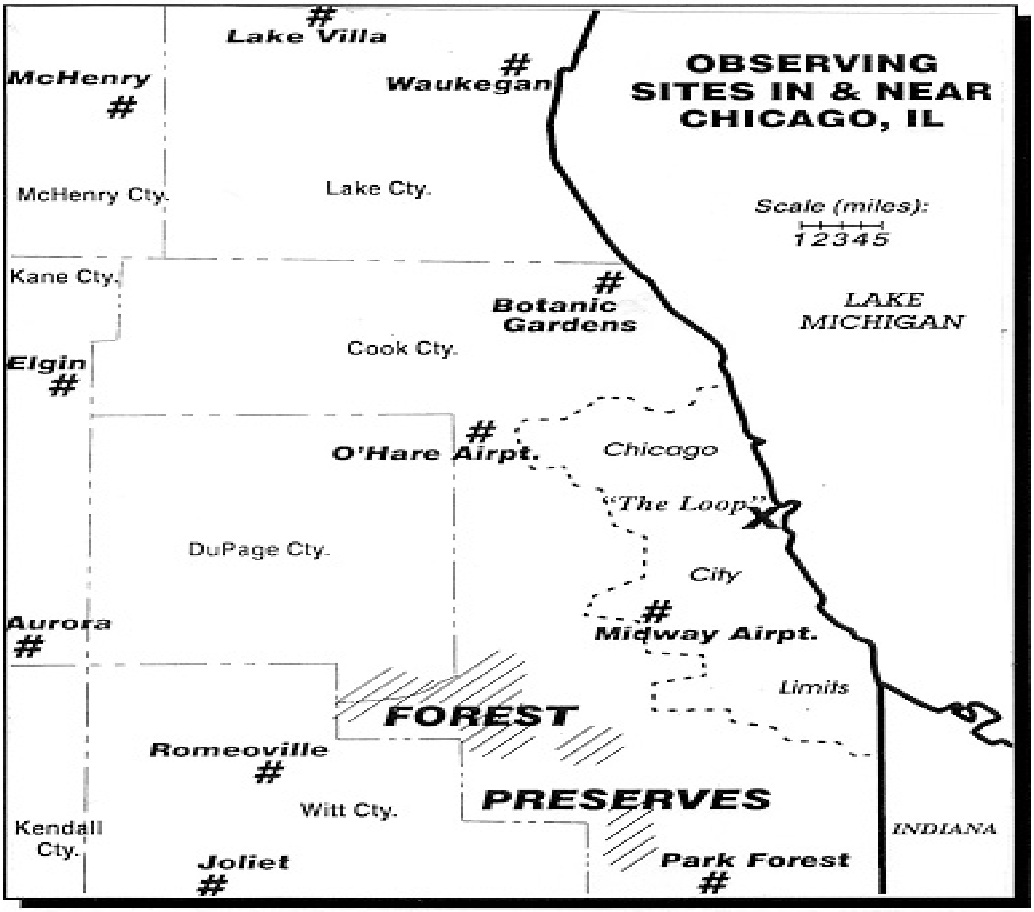


Figure 8. Locations of key features and observing sites in and near Chicago.

Table 5

Maximum Temperatures (°F) for the Chicago Metropolitan Area on July 13 and 14, 1995

	July	
	13	**14**
Midway Airport	106	102
Botanic Gardens	105	102
O'Hare Airport	104	100
Joliet	103	101
Aurora	102	100
Lake Villa	102	100
Waukegan	102	100
McHenryville	101	100
Park Forest	102	99
Elgin	101	98

The contrast between close-in locations and sites more distant from Chicago's Loop is again apparent in table 6 which contains minimum temperatures for the two calendar, 24-hour periods (i.e., observations taken at midnight) at three points where they were reported as such and the two airports where hourly data were available. These tables contain sufficient circumstantial evidence to conclude that the urban heat island was at least partially responsible for the severe conditions in Chicago's south side (near Midway Airport), but other factors, like advective effects, locally strong evapotranspiration, and proximity to Lake Michigan, cannot be completely discounted as additional microclimatic influences.

Table 6

Minimum Temperatures (°F) for the Chicago Metropolitan Area on July 13 and 14, 1995

	July	
	13	14
Midway Airport	81	84
O'Hare Airport	81	83
Lake Villa	77	81
Romeoville	77	78

Additional clues as to whether any of these other factors (just mentioned) affected nighttime temperatures are contained in table 7, which lists minimum temperatures from the 24 hours prior to early morning observation times (ranging from 6 a.m. to 8 a.m., local time). Again, Midway stands out on all three of the evenings, while O'Hare, Botanic Gardens, and Waukegan are noticeably warmer on the evenings of July 13 and 14.

Table 7

Minimum Temperatures (°F) and Maximum Dew Points (°F) (in parentheses) for the Chicago Metropolitan Area for the 24 Hours Preceding Morning (6 to 8 a.m.) Observation Times on July 13-15, 1995

		July	
	13	14	15
Midway Airport	81 (81)	84 (83)	83 (83)
O'Hare Airport	81 (77)	83 (79)	79 (78)
Waukegan	78	83	78
Botanic Gardens	78	82	78
Joliet	73	78	79
Elgin	71	80	78
Park Forest	73	80	76

During the critical period, peak winds were mostly from the south and southwest, so one explanation for the high minima at the Botanic Gardens and Waukegan is that they were downwind of the city core, at least much more so than any other sites. This factor was strongest on the evening of July 12, less so on the evening of July 13, and least so on the evening of July 14, as the winds shifted from the south to dominantly southwest. The overall decrease in the difference in minima between the two lakeside stations and the other four locations (excluding the airports) from the evening of July 12 through the evening of July 14 is consistent with this wind shift. Nevertheless, winds were also generally quite light, so it is not implausible that Lake Michigan served as an additional source of water vapor for observation sites next to it. The light winds also imply reduced surface mixing of the lake water and the possibility of surface water temperatures well above normal. Moreover, as the winds shifted from more southerly to more southwesterly, lake proximity would have had less relative impact, again consistent with the trend of the differences in minima between the Botanic Gardens and Waukegan and four other locations well removed from both the lake and the city core.

Maximum dew points are also listed for the two airports in table 7, while the minima at the other six sites serve as approximate upper bounds for the dew points there. Dew points at Midway Airport turn out to be substantially higher than those recorded at O'Hare. In view of prevailing wind directions, it is doubtful that Lake Michigan was an important source of moisture for Midway, so an additional source of water vapor needs to be identified. One appealing candidate is heavy evapotranspiration over the nearby Palos Forest Preserves, with its extensive woods and many sloughs located south and west of Midway—i.e., upwind of Midway—during much of the heat wave. This idea is consistent with attribution of the high minima at the lakeside locations also to downwind advective processes.

Clearly, these data are insufficient to resolve clearly the extent to which certain microclimatic factors contributed to the highly severe conditions in south Chicago. However, they provide sufficient evidence to support a role for local effects, particularly for an urban heat island effect. Without the extent of urbanization in Chicago, the mid-July heat wave might have been quite outstanding rather than unprecedented.

***Finding*: The July 1995 heat wave was exacerbated by local effects, including urbanization. This effect was especially notable in Chicago.**

Conclusions

The mid-July heat wave that brought unprecedented conditions to Chicago and Milwaukee, dangerous conditions to Philadelphia, and harsh (but often observed) conditions to St. Louis was mainly a result of the fortuitous juxtaposition of two important factors, namely a very strong, slow-moving upper-air ridge of high pressure and a conveniently located source region of high soil moisture content. Chicago and Milwaukee were ideally located to feel the full effects of this combination of factors. In at least Chicago, near-record conditions were probably exacerbated to record conditions by local microclimatic factors, including most certainly urbanization. The genesis and form of the event suggest that it was a weather event whose occurrence, or probability of occurrence, is not easily related to longer term processes, like

El Niño/Southern Oscillation or climatic trends. At this time, the occurrence or probability of such an event probably cannot be forecast beyond the theoretical limit of dynamic predictability of 2 weeks, or practically not currently beyond about 1 week.

CHAPTER 2

HEALTH IMPACTS

During and immediately following the heat wave, increased numbers of deaths, many of them attributed directly to the heat, were reported in both Chicago and Milwaukee. There were 465 heat-related deaths recorded for the Chicago area alone (CDC, 1995). This exceeds the average number of lives lost each year in the United States to all floods, hurricanes, and tornadoes.

Methods

In both Chicago and Milwaukee, the first indication of the magnitude of the health effects of the heat wave came from the medical examiner's office, where bodies that had been found dead in overheated dwellings began to be delivered on approximately the second day of the heat wave. While information about deaths reported by the medical examiner provided a rapid indicator of a potential problem, such information must be interpreted carefully because only 20 percent of deaths are usually seen by medical examiners, and these deaths are not normally representative of the whole population. However, when a severe heat wave occurred in Philadelphia in July 1993, a retrospective review of the death certificates for that period found that of the approximately 110 certificates, which listed a heat-related cause or condition, more than 90 percent of them had been included in the initial reports from the Philadelphia Medical Examiners's Office. This suggests that, for heat-related deaths, medical examiner data provides a rapid and sensitive indicator.

Definition of Heat-related Death

One of the difficulties in measuring the mortality associated with a heat emergency is the lack of definition for heat-related death that is both standardized and practical. Using the strict definition of hyperthermia as the basis for classifying deaths requires that a core body temperature of 105°F or above be measured at the time of, or immediately following, death. However, deaths frequently occur that, judging by the circumstances of death, are clearly heat related but a core body temperature is either unavailable or not meaningful (because the body was not discovered until hours or days after death) and which, thus, cannot be strictly called hyperthermia deaths. Because of the obvious insensitivity of the strict definition given above in these types of situations, the medical examiners of several cities (including the four visited in this assessment) use a less restrictive definition for heat-related deaths that allows them to include those deaths which, while not meeting the body temperature criteria, are judged to be heat related on the basis of circumstantial evidence.

The Medical Examiner of Cook County, Illinois, who is responsible for investigating deaths occurring in Chicago, classified deaths as being heat related if any of the following conditions were met:

- a body temperature of 105°F or above was measured at/shortly after the time of death; or
- evidence of high environmental temperature in the place where the body was found was noted by rescuers; or
- the body was found in a decomposed state and was last seen alive at the time of the peak of the heat wave.

Similar definitions are used by the medical examiners in Milwaukee, Philadelphia, and St. Louis. However, not all medical examiners use this definition. Consequently, it is difficult to compare the numbers of heat-related deaths from one city to another or from one heat wave to the next. It is recommended that a standard definition for heat-related death, such as the one used in Chicago, be developed and adopted for national use.

■ Chicago, Illinois

Heat waves and heat-related deaths are not new to Chicago. In 1988, there were at least 77 heat-related deaths. However, when on July 12, 1995, the NWS predicted a maximum heat index of greater than 100°F for the following day and issued a Heat Advisory, few people considered it a potential medical emergency. Even the Chicago Department of Health, which had been monitoring the weather and had recommended that people modify their behavior because of the heat, expected that only a few people would experience anything more than discomfort as a result of the hot weather. The first indication of trouble came when the Chicago Police Department and Chicago Medical Examiner reported increased numbers of non-violent deaths throughout the city. In Cook County (which includes Chicago), there are usually 65-70 deaths a day from all causes, of which 17-20 are seen by the medical examiner. On July 15 alone, 162 heat-related deaths were reported by the medical examiner's office (figure 9). For the period of July 12-27, a total of 465 heat-related deaths were recorded. In contrast, no heat-related deaths were reported for the week of July 4-10.

At the same time that bodies were beginning to accumulate in the city morgue, hospitals were also being inundated with people who had been affected by the heat. Some hospital emergency departments began to turn away ambulances on July 12 because they had insufficient capacity to accept additional patients; by July 14th, 18 hospitals were on "bypass status" (figure 10). During very busy periods when an emergency room does not have the capacity to accept additional patients, the hospital may go on "bypass status," referring all incoming ambulances to less busy facilities. A planned review of the emergency room records from selected hospitals for the heat-wave period will provide information on the characteristics of the people who became sick because of the heat. It will be particularly useful to the public health community to compare the characteristics of those who became sick but recovered to those who died to determine if, or how, the two groups differed. It also will be valuable to determine whether the increase in heat-related

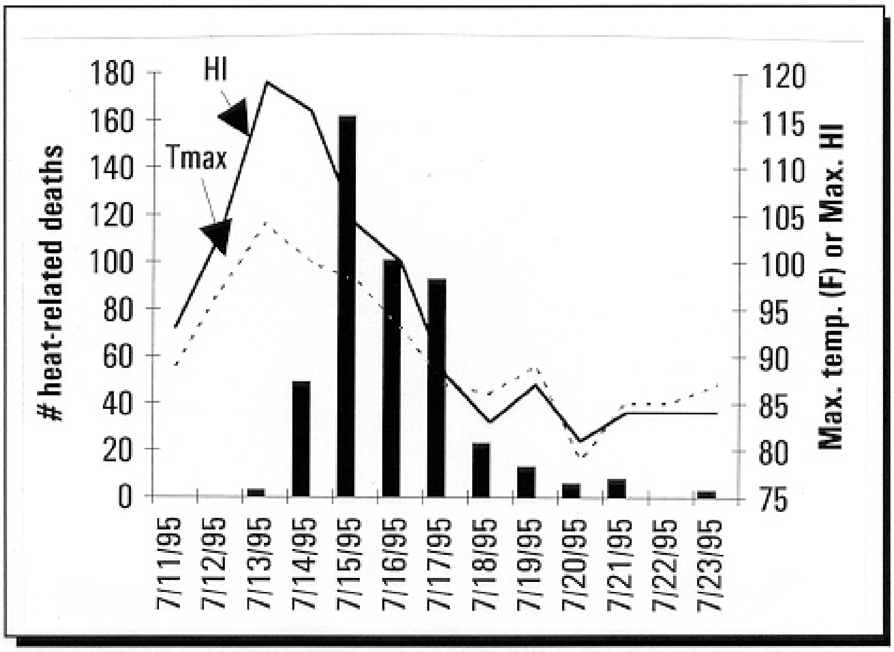


Figure 9. Heat-related deaths, Maximum Temperature (Tmax) and Heat Index (HI), Chicago, July 11-23, 1995. (As reported by the Office of the Medical Examiner.)

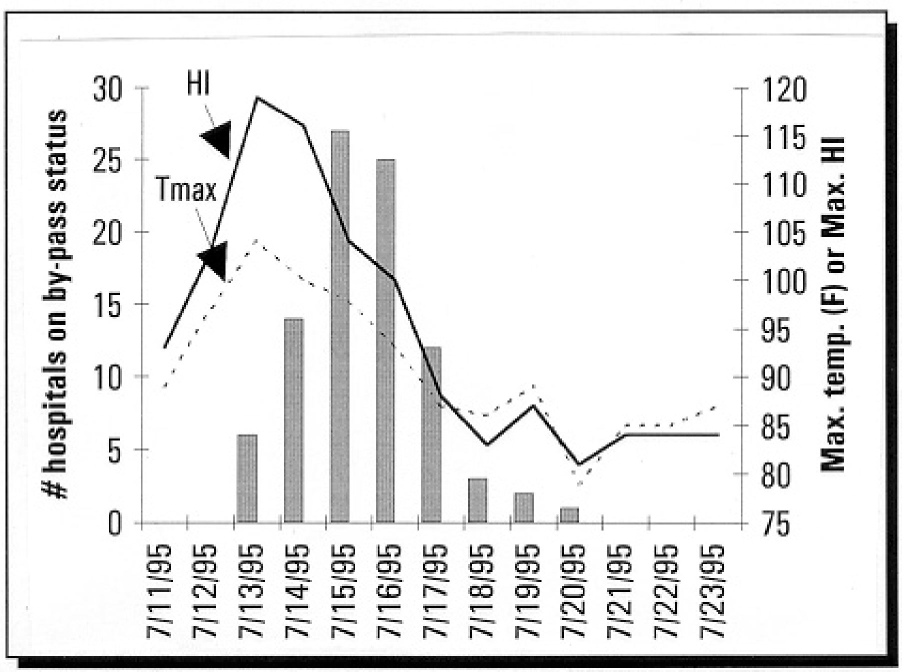


Figure 10. Hospitals on bypass status, Maximum Temperature (Tmax) and Heat Index (HI), Chicago, July 11-23, 1995.

illnesses (morbidity) preceded the increase in heat-related deaths (mortality) and, if so, whether such information could be used to monitor developing heat emergencies.

Examining the characteristics of those whose deaths were classified as heat related, it was observed that the people most often affected by the heat were the elderly, particularly those living alone. While only 15 deaths were recorded for people under 44 years of age, 101 deaths were reported for those between 65 and 74 years of age, and 222 deaths occurred among those over 74 years of age (figure 11). Looking at these numbers relative to the proportion of the population made up by each age category, the danger to the elderly becomes even more clear. The estimated risk of death for those under 45 for the period July 12 through July 27 was 20 per 100,000 persons. In contrast, the risk of death for persons 65 through 74 years of age was 53 per 100,000, and for those greater than 74 years of age, it was 183 per 100,000. Deaths occurred throughout the city, with a slight clustering on the south side. With a cumulative mortality of 19 per 100,000, males were more often affected than females, whose risk of death was 14 per 100,000. Although more blacks died (229) than whites (216), the rates for the two races do not differ significantly. Very few heat-related deaths (less than 6 percent of the total number of heat-related deaths) occurred among Hispanics relative to their representation in the total population. The reason for this is not clear, but it is speculated that strong community or family networks within Hispanic communities may have played a protective role.

Chicago and Illinois health officials are working with investigators from CDC to better determine the characteristics of the people who died during the heat wave, so that this information can be used in future heat waves to better target preventive measures at persons at increased risk for heat-related illness or death. In addition to the deaths that were directly attributed to the heat, it is likely, given the experience in other heat waves, that there were additional unmeasured increases in cardiovascular deaths which can be indirectly attributed to the heat; these excess deaths should also be determined to better estimate the total health impact of the heat wave.

■ Milwaukee, Wisconsin

With weather patterns similar to those of Chicago, heat waves are not unusual in Milwaukee either. A 1988 heat wave claimed 11 lives, and in 1936, which was a drought year, 529 deaths were attributed to the heat. Other notable heat waves occurred in 1947, 1955, 1968, and 1970. These previous heat waves led the city to develop contingency plans for responding to such events, and a Heat Task Force has been in existence since 1986. Consequently, on the afternoon of July 12 when the NWS predicted heat index values of up to 120°F in the Milwaukee area and issued a Heat Advisory, the members of the Task Force were ready for action. They first met as a group on July 14. Agencies participating in the task force included the American Red Cross, the Salvation Army, the Office of Emergency Government, the Milwaukee Department of Health, and the public utility companies.

Despite what appeared to be a reasonably good level of preparedness, on the evening of July 14 (at about the same time that excess deaths were beginning to be reported in Chicago) the Milwaukee County Medical Examiner's Office observed a higher number of deaths than usual, many of them obviously heat related. From July 14 to 17, the

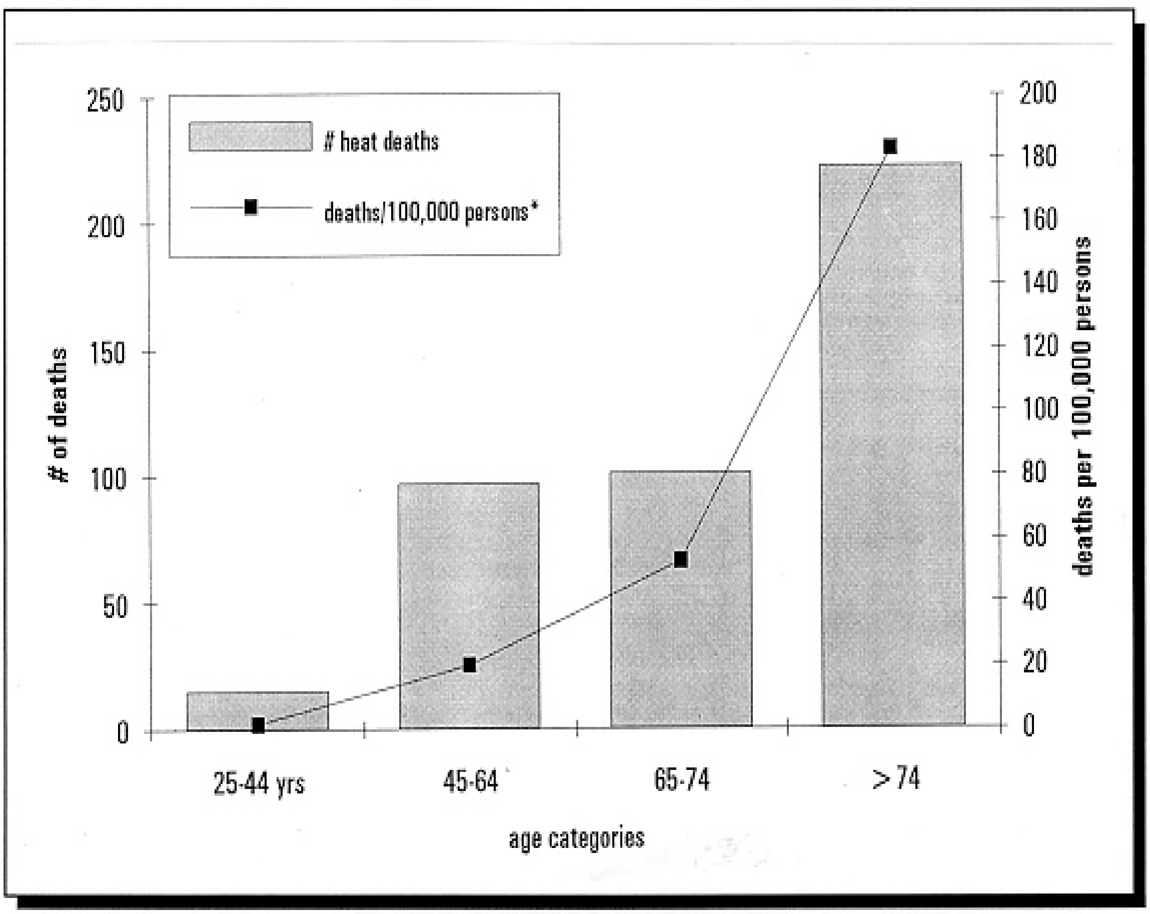


Figure 11. Deaths by age, Chicago, July 12-27, 1995.

The age-specific risk of dying of a heat-related cause during the heat wave period (July 12-27, 1995) was calculated by dividing the number of heat-related deaths reported for an age group during that period by the total number of persons in that age group as recorded in the census.

Milwaukee County Medical Examiner reviewed 129 deaths (versus a normal average of 30 deaths for a similar 4-day time period). Eighty-five (85) of these deaths were attributed to the heat, of which 30 were classified as environmental hyperthermia (strict definition with measured core body temperature greater or equal to 105°F). The other 55 deaths occurred among older persons with pre-existing conditions where circumstantial evidence indicated that elevated environmental temperatures had contributed to the deaths. Forty-eight (48) of the 85 heat-related deaths occurred within the city limits; the remainder occurred elsewhere in the county. Victims ranged in age from 24 to 88 years. At least 12 of the victims were known to be taking psychotropic (mind-altering) drugs which may impair thermoregulatory function or inhibit perspiration and increase a person's susceptibility to heat-related illness or death. At least two deaths occurred in group homes for the mentally ill, raising questions regarding the regulation and licensure of such accommodations. Emergency rooms were reported to have been very busy, and some had to be closed for a period of time during the heat wave because they were full to capacity. However, use of a computer system allowed emergency medical system managers to adjust to the closure of specific emergency departments.

***Finding*: One of the difficulties with measuring the mortality associated with a heat emergency is the lack of definition for a heat-related death that is both standardized and practical. A standard definition for heat-related death, such as the one used in Chicago, should be developed and adopted for national use by all medical examiners.**

***Finding*: The awareness of heat-related deaths by local medical examiners in Chicago and Milwaukee in 1995 led to the initial recognition in those cities of excess deaths during heat-wave periods.**

***Finding*: In Chicago and Milwaukee, the people most affected by the heat were the elderly.**

***Recommendation*: Since the elderly in urban areas are in the greatest danger during heat waves, the NWS must proactively focus heat preparedness efforts toward this group.**

***Finding*: Heat waves are not clearly recognized as public health emergencies.**

***Recommendation*: Emergency response organizations at the Federal, state, and local levels should be encouraged to recognize severe heat waves as potential natural disasters, and areas at risk should be prompted to develop emergency response plans for severe heat waves. These plans should target the groups most often affected by the heat, including elderly persons, particularly those living alone; persons with chronic medical conditions, especially cardiovascular or pulmonary disease; and persons taking psychotropic medications.**

***Recommendation*: The analysis of morbidity during the July 1995 heat wave in Chicago and Milwaukee should be investigated by public health officials in order to provide useful public health information about the relationship of morbidity to mortality.**

The vulnerability of the elderly in urban core areas was underestimated. Although it is known that the elderly are more susceptible to heat-related illness because of their decreased physical ability to adapt to extreme changes in environmental temperature, information collected for this assessment suggests that, for some elderly in the urban core, there were additional social and behavioral factors which further increased their vulnerability. Specifically, it was found that those most likely to be affected were those who were: (1) unlikely to receive warnings and forecasts disseminated in the normal fashion; (2) unable to fully appreciate the significance of the warnings and forecasts; (3) uninformed about proper precautions and actions that they should take to protect themselves from the effects of the heat; (4) too poor to have adequate air conditioning or to operate it even if available; (5) too frightened of crime to leave their windows opened; (6) or too weak, infirm, or frightened to seek public shelter. Most fundamentally, those at risk were isolated and lacked a concerned network of family and friends and, as a last resort, attention from social agencies.

***Finding*: The vulnerability of the elderly in urban core areas was underestimated during the heat wave.**

***Recommendation*: Forecasters should target Heat Warnings, Watches, Advisories, and Statements to those groups that are most vulnerable.**

CHAPTER 3

PROVISION OF NWS PRODUCTS AND SERVICES

Since the mid-July heat wave brought unprecedented conditions to Chicago and Milwaukee, this chapter will focus on the products and services provided by the NWS Forecast Offices at Chicago, Illinois, and Milwaukee, Wisconsin. The review criteria for NWS products, services, and actions are described in appendix A.

■ Chicago, Illinois

Forecasters at the Chicago NWS Forecast Office provided forecasts of state of the art accuracy as much as 5 days in advance of the excessive heat. This information clearly conveyed important details concerning excessive temperatures and high humidities but understated the severity of what would prove to be a record event. A Heat Advisory was in effect prior to and throughout the event. As the event neared, forecasters issued follow-up statements that relayed both emergency and climatological information to the community. However, neither the Chicago forecasters nor local officials recognized the potential for significant loss of life.

Extended Forecast Review

Information on expected weather conditions, generally greater than 48 hours in advance of the event, was communicated through the NWS Extended Forecast Product. The extended forecast products issued by forecasters at the Chicago NWS Forecast Office clearly called for hot, as well as humid, conditions well in advance (as early as July 7). In fact, forecasters focused on humid conditions—an often difficult task this far in advance.

***Finding*: The Extended Forecast Product issued by forecasters at the Chicago NWS Forecast Office communicated the likelihood of high levels of heat and humidity 48 hours prior to the event.**

***Finding*: Extended range forecasts of temperatures were generally within 3 to 5 degrees for high temperatures and 5 to 7 degrees for low temperatures.**

Forecast Review

Forty-eight hours prior to the event, emphasis focuses on the provision of accurate forecasts of weather conditions and the communication of potential public hazards relating to the anticipated heat. In addition, the Weather Service Operations Manual (WSOM) Chapter C-44, Non-Precipitation Weather Hazards, allows for the issuance of an Outlook or Watch for excessive heat to provide early planning information for both key officials as well as the general community. However, a Heat Outlook or Heat Watch was not issued.

NWS forecasters at Chicago issued accurate and timely forecasts relating to the anticipated heat and humidity. High temperature forecasts during this time frame were accurate to within 3 degrees. Low temperature forecasts were accurate to within 6 degrees. The forecasts included descriptive wording that added extra detail to the forecasts. Nonetheless, these forecasts understated the conditions that actually occurred and forecasters (as well as local officials) were not aware of the impact these conditions would have on the general public.

***Finding*: NWS forecasters at the Chicago Forecast Office communicated a forecast calling for high heat and humidities 36 to 48 hours prior to the event.**

***Finding*: Short-range temperature forecasts had state of the art accuracy. High temperature forecasts were accurate to within 3 degrees. Low temperature forecasts were accurate to within 6 degrees. Both were underestimates.**

***Finding*: Forecasters used descriptive terminology, such as "muggy" and "humid," to communicate important weather information.**

***Finding*: A Heat Outlook or Heat Watch was not issued as allowed for in WSOM Chapter C-44, Non-Precipitation Weather Hazards.**

***Recommendation*: The NWS should ensure that forecasters at all field offices understand the flexibility provided by WSOM Chapter C-44 to issue a variety of critical information products on heat-related issues.**

Short Term Forecast Review

During the event, forecasters are expected to issue accurate meteorological, climatological, and safety information on a frequent basis. Short-range temperature forecasts for Chicago were highly accurate. High temperature forecasts were accurate to within 2 degrees. Low temperature forecasts were accurate to within 4 degrees. A Heat Advisory was issued for the city of Chicago 12 hours or more in advance of the worst physical conditions and most heat-related deaths. Numerous statements were issued to inform the community on the climatological aspects of the event. Fewer statements were issued, detailing safety aspects and specific call to action information.

The wording of several forecasts was excellent. In particular, the Zone Forecasts issued at 4 a.m., Central Daylight Time (CDT), July 13, contained enhanced heat caution wording as well as specific forecast heat index levels. For example, the headline highlighted "HEAT ADVISORY TODAY FOR A HEAT INDEX OF 110 TO 120," and the forecast called for "OPPRESSIVE HEAT AND HUMIDITY."

Heat Advisories were issued daily. The first advisory was issued at 3:30 p.m., CDT, July 12, with subsequent advisories issued at 4:15 a.m., CDT, July 13, and 5:15 a.m., CDT, July 14. Two excellent statements were issued at 4:15 a.m., CDT, July 13, and 5:15 a.m., CDT, July 14, which contained both accurate forecasts as well as call to action information.

***Finding*:   NWS forecasters at the Chicago Forecast Office issued accurate Short Term Forecasts that included temperature, humidity, and heat index levels.**

***Finding*:   Heat Advisories were issued prior to and during the excessive heat event.**

***Finding*:   The initial Heat Advisory issued at 3:30 p.m., CDT, July 12, was issued under an incorrect product title (Public Information Statement). A Non-Precipitation Weather Warning should have been issued.**

The Short Term Forecast, routinely issued every 3 or 4 hours, was the primary product issued to distribute specific heat-related weather information and to follow up on previously issued Heat Advisories. These forecasts contained little, if any, information relating to the potential impact of anticipated weather conditions or call to action safety guidelines. The only attempt to target groups at risk was in the daily Heat Advisory issuance.

***Finding*:   NWS-issued forecast products contained highly detailed and accurate meteorological information, including the heat index, but lacked call to action statements. Heat Advisories were the only products that contained information relating to the potential impact of anticipated weather conditions or call to action information.**

***Recommendation*:   Forecasters should focus on the health hazards associated with heat in warnings, watches, forecasts, advisories, and statements. All products should include call to action statements.**

***Recommendation*:   MICs and WCMs at all NWS forecast offices should work with state, city, and local health officials to determine threshold values for dangerous heat index levels tailored to their area.**

Potential For Enhanced Service

Although the excessive heat was well forecast by forecasters at the NWS Forecast Office at Chicago, there are several ways in which service to the public could have been enhanced.

Enhancement Concept 1:   Stress the dangerous nature of excessive heat in

With forecast or actual temperatures near 100°F, dew points near 80°F, and heat index levels above 110°F, the seriousness of these weather conditions could have been stressed in Warnings, Watches, Advisories, and Statements.

Enhancement Concept 2: Keep a pulse on the community.

It was nearly impossible for forecasters to learn of the increasing heat-related deaths until after the peak period of temperature. The earliest indication of a developing crisis was an enormous increase in emergency room admissions. At one point, 18 Chicago-area hospitals were in bypass or unable to admit more people into the emergency room. This occurred relatively early in the event. During times of excessive heat, forecasters should establish contact with public health officials to obtain this information.

Enhancement Concept 3: Understand local problems of the community.

Early indications suggest that the elderly in urban areas were vulnerable to the excessive heat. Forecasters should issue targeted products addressed to the most vulnerable.

Enhancement Concept 4: Develop local studies for the community.

In some cases, there are thresholds of temperature, humidity, and hence heat index at which heat-related problems increase. Local studies, in cooperation with health officials, could better define these critical values. They will most likely vary from region to region and, perhaps, city to city.

Enhancement Concept 5: Keep the community well informed.

Once forecasters target specific groups and critical threshold heat values, keep the community informed via frequent statements.

Enhancement Concept 6: Work with commercial service providers.

Work with commercial service providers to develop a heat hazards training element for their radio and television customers to improve the on-air delivery of forecast information to the public.

Post-event Coordination

The MIC and WCM at the Chicago NWS Forecast Office have been closely involved with state, city, and local health and emergency management officials since the July heat wave and are members of the Mayor's Commission on Extreme Weather Conditions. As a result, significant progress has been made towards improvement of weather warning and forecast services to the community during extreme weather events, including heat.

■ Milwaukee, Wisconsin

Forecasters at the Milwaukee NWS Forecast Office provided accurate and timely forecast information as much as 5 days in advance of the excessive heat. This information clearly conveyed important details regarding excessive temperatures and high humidities. A Heat Advisory was in effect prior to and throughout the event. As the event neared, forecasters frequently issued a variety of well-written statements that relayed emergency and safety information to the community. However, neither Milwaukee forecasters nor local officials recognized the significant potential for loss of life.

Milwaukee NWS forecasters exceeded operational requirements in keeping the community informed. Heat Advisories were issued for a consecutive 2-day period. This action, based on sound professional judgment, conveyed important information on the anticipated duration of the event. Additionally, an Outlook indicated the likelihood of 100°F temperatures over 40 hours in advance.

Extended Forecast Review

Information on expected weather conditions, generally greater than 48 hours in advance of the event, was communicated through the NWS Extended Forecast Product. The Extended Forecast Products issued by forecasters at the Milwaukee NWS Forecast Office clearly called for hot conditions well in advance (as early as July 8). Extended forecasts did not emphasize humid conditions. Demonstrating extra initiative, NWS forecasters at Milwaukee issued two Special Weather Statements, indicating the likelihood of dangerous heat. Special Weather Statements issued at 3:45 p.m., CDT, July 11, and 5:15 a.m., CDT, July 12, were timely and accurate. Both contained information targeting the elderly (for example, "the elderly, very young, and persons with heart problems are most at risk in extreme heat"). These statements, issued 40 hours prior to the event, provided the community advance notice of the expected heat and raised awareness of physiological risk.

***Finding*: The Extended Forecast Product issued by forecasters at the Milwaukee NWS Forecast Office clearly communicated the likelihood of unusually high levels of heat 5 days prior to the event.**

***Finding*: Extended range forecasts of temperatures were initially 6 to 10 degrees low in the 3- to 5-day range but improved to within 2 degrees in the 1- to 2-day range.**

***Finding*: Two Special Weather Statements were issued 40 hours prior to the event and contained call to action information for the elderly and others at risk.**

Forecast Review

Forty-eight hours prior to the event, emphasis focuses on the provision of accurate forecasts of weather conditions and the communication of potential public hazards relating to the anticipated heat. In an aggressive maneuver, the Milwaukee NWS forecasters issued a Heat Advisory for 2 consecutive days. This action provided local officials with excellent planning information. Forecasts were accurate, timely, and focused on the anticipated heat and humidity. Temperature forecasts during this time frame were accurate to within 2 or 3 degrees. The quality of forecasts was high, with forecasters including descriptive wording that added extra detail to the forecasts. Nonetheless, similar to Chicago, forecasters (as well as local officials) did not appreciate clearly the impact these conditions could and did have.

***Finding*:** **NWS forecasters at the Milwaukee Forecast Office clearly, effectively, and accurately communicated a forecast calling for high heat and humidities 36 to 48 hours prior to the event.**

***Finding*:** **Short-range temperature forecasts were accurate. Initial errors in forecast accuracy improved to within 2 or 3 degrees at least 24 hours prior to the onset of the heat wave.**

***Finding*:** **Forecasters used descriptive terminology, such as "muggy" and "humid," to communicate important weather information.**

***Finding*:** **A Heat Advisory was issued for 2 consecutive days, providing local officials excellent planning information.**

Short Term Forecast Review

During the event, forecasters are expected to issue accurate meteorological, climatological, and safety information on a frequent basis. Short-range temperature forecasts for Milwaukee were highly accurate. Temperature forecasts were accurate to within 0 to 3 degrees. NWS forecasters at Milwaukee took an integrated, multi-tier approach to informing the community of the impending dangerous heat. Heat wave safety rules were disseminated as early as July 13 in warnings, forecasts, and statements. A Heat Advisory was issued for the city of Milwaukee 12 hours or more in advance of most heat-related deaths. Additional Heat Advisories were issued twice daily in conjunction with the early morning and late afternoon forecasts. Specifically, advisories were issued at 12:35 p.m., CDT, July 12; 5:15 a.m., CDT, July 13; 3:35 p.m., CDT, July 13; 4:25 p.m., CDT, July 14; 3:30 p.m., CDT, July 14; and 4:20 a.m., CDT, July 15. All advisories contained detailed temperature, humidity, and heat index information in addition to call to action statements for the elderly, the very young, and the infirm.

***Finding*:** **NWS forecasters at the Milwaukee Forecast Office issued accurate Short Term Forecasts that included temperature, humidity, and heat index levels.**

***Finding*:** **Heat Advisories were issued prior to and during the excessive heat event.**

***Finding*:** **Heat index levels were provided in the first period (first 6 hours) of the Zone Forecasts.**

NWS forecasters at Milwaukee used a combination of Short Term Forecasts, Heat Advisories, Special Weather Statements, and one Severe Weather Statement to convey urgent excessive heat information. All Short Term Forecasts contained public safety information. Heat Advisories were issued at 4 a.m. and

4 p.m., CDT, with follow-up special weather statements issued at 10 a.m. and 10 p.m., CDT. These issuances provided a continuum of information to the community. Several statements targeted high risk groups, such as the elderly, the very young, and the infirm. However, there was minimal targeting of specific areas at risk, such as the urban core. Numerous climatological information statements were also issued.

***Finding*: NWS-issued forecast products contained highly detailed and accurate meteorological information, including the heat index.**

***Finding*: NWS forecasters at the Milwaukee Forecast Office issued frequent Heat Advisories and Special Weather Statements to keep the community well informed.**

***Finding*: All warnings, forecasts, advisories, and statements were of high quality and contained accurate forecast details, including heat index levels.**

***Recommendation*: MICs and WCMs at all NWS forecast offices should work with state, city, and local health officials to determine threshold values for dangerous heat index levels tailored to their area.**

Potential For Enhanced Service

Although forecasters at the NWS Forecast Office at Milwaukee kept the community well informed on the heat wave, there are a few ways in which service could have been enhanced.

Enhancement Concept 1: Focus on the highest at-risk groups.

Large urban areas pose unique problems during excessive heat situations. Forecasters are encouraged to provide frequent statements targeted to the groups at higher risk; in this case, the elderly and infirm residing in urban areas.

Enhancement Concept 2: Keep a pulse on the community.

It was nearly impossible for forecasters to learn of the increasing heat-related deaths until after the peak period of temperature. The earliest indication of a developing crisis was an enormous increase in emergency room admissions. At one point, several Milwaukee-area hospitals were in bypass or unable to admit more people into the emergency room. This occurred relatively early in the event. During times of excessive heat, forecasters should establish contact with public health officials to obtain this information.

Enhancement Concept 3: Develop local studies for the community.

In some cases, there are thresholds of temperature, humidity, and heat index at which heat-related problems are increased. Local studies, in cooperation with health officials, could better define these critical values.

Enhancement Concept 4: Work with commercial service providers.

Work with commercial service providers to develop a heat hazards training element for their radio and television customers to improve the on-air delivery of forecast information to the public.

Post-event Coordination

Since the July heat wave, the MIC and WCM at the Milwaukee NWS Forecast Office have been closely involved in coordinating emergency preparedness plans with local officials for extreme heat events.

CHAPTER 4

COMMUNICATION, EMERGENCY PREPAREDNESS, AND COMMUNITY RESPONSE

"We knew it was going to be hot...but we had no idea it could be that deadly."
Local Emergency Official

Extreme heat may be the most underrated and least understood of the deadly weather phenomena. The communities of Chicago and Milwaukee had in place extensive disaster preparedness plans and response procedures for many weather and flood hazards. However, as seen in the July heat wave, extreme heat was not one of the disasters they were prepared to respond to effectively. Local officials clearly did not understand the connection between very high heat and humidity and high death rates. In fact, the exact definition of heat-related deaths and illnesses and the extent of the mortality and morbidity associated with extreme heat is a debated topic in the medical, forensic, and public health communities.

The effects of a heat wave are often delayed in terms of: (1) increased illness and mortality and (2) the detection of these increases by the medical, public health, and public safety monitoring systems in communities. Heat is not like a flood, hurricane, or tornado that is a visible phenomenon which dramatically impacts a community, leaving identifiable victims who receive immediate emergency medical treatment.

In both Chicago and Milwaukee, extreme heat was viewed as a public health concern, not as a major community emergency or disaster. Therefore, this event fell within the purview of the local health department to provide planning for and coordinate community response to these events. Heat waves were outside the realm of local disaster or emergency operations plans of the emergency management officials and the traditional disaster response systems. This shaped the nature and extent of each community's actions during the July heat wave.

To better understand how local officials prepared for and responded to this event, the communication, emergency preparedness, and community response actions will be reviewed for Chicago and Milwaukee based on interviews with local health and emergency response officials. The media response to this event will also be discussed in terms of how they provided the public with: (1) NWS warnings, forecasts, advisories, and statements; (2) the risks of excessive heat; and (3) safety tips.

In general, the warning process involves a series of interdependent actions in order to achieve its goal—to maximize the number of people who take timely and appropriate protective action. This warning process may be viewed as an integrated warning system comprised of three functional components: (1) scientific detection and prediction; (2) emergency response, including warning; and (3) correct protective public response.

If any one of these components fails, the entire system can fail. The first component has been reviewed in preceding chapters; we focus here on factors affecting the second and third components.

Communication

The communication process involves two steps: (1) the communication of critical weather information by the NWS to emergency managers, the news media, and other agencies that are part of the public warning process; and (2) the communication of this information via emergency preparedness organizations and the media to those affected. The goal of effective communication is to maximize the number of people who take timely and appropriate protective action.

In the case of the July 1995 heat wave, it appears that the first step of this process went satisfactorily at both Chicago and Milwaukee. Unlike small, highly-localized, short-lived but violent phenomena, such as tornadoes, the nature of a heat wave—its broad extent, gradual development, and slow subsequent motion—was such that it was forecast accurately days in advance. Thus, the performance of rapid response communications links (such as NOAA Weather Radio [NWR], NOAA Weather Wire Service [NWWS], and the Emergency Broadcast System) was not an issue here.

Despite timely NWS warnings, forecasts, advisories, statements, and effective media coverage of the event, the communication process failed in Chicago and Milwaukee during the second step. There was a failure by city officials to translate the physical character of the heat wave (maximum temperatures, minimum temperatures, humidities, spatial extent, and duration) into human impacts. Emergency preparedness for Chicago and Milwaukee will be reviewed in the next section.

***Finding*: Despite timely NWS warnings, forecasts, advisories, statements, and effective media coverage of the event, city officials had neither the experience nor emergency response capabilities to translate the physical characteristics of the heat wave into human impact.**

***Recommendation*: NWS offices should work with local officials to develop a public awareness and community response plan for such events, especially among vulnerable or disadvantaged groups.**

Media Coverage

The July 1995 heat wave was a unique meteorological event for the Chicago and Milwaukee media. While the electronic (radio and television) and print media provided heat-wave forecasts and health-related reports, they failed to foresee the number of deaths that would result from this unprecedented weather event. Media representatives interviewed in Chicago and Milwaukee reported good working relationships with their respective NWS offices and were satisfied with the level of service provided.

The Chicago and Milwaukee media received weather information from both the NWS and a variety of commercial weather vendors. Staff meteorologists at radio and television stations gave the NWS high marks for timely and accurate forecasts and related services during the heat wave. They found NWS forecasts to be consistent with their own. According to Chicago's WGN-TV meteorologist Tom Skilling, "The NWS made it absolutely clear that this extremely hot air mass was coming our way."

Radio and television stations provided the public with weather-related information through two different venues: weather and news reporting. While media coverage reported dangerous heat levels and offered tips on staying cool, no one anticipated the number of deaths that would accompany the event. An article in the Milwaukee Journal Sentinel (July 25, 1995) noted, "Milwaukee's TV weathercasters did their job well in letting us know that killer heat was on its way. What viewers did with that information helped determine how well they coped with the heat."

Several media representatives noted that people understand watch/warning terminology for thunderstorms and winter storms but not for heat. A few voiced concerns about the heat index. For others, triple digit temperatures, not the heat index, made the weather the top story. All said they reflected severity of the event in their terminology and in changes of story context from "uncomfortable heat" to "dangerous heat."

***Finding*: Media coverage of the July 1995 heat wave in Chicago and Milwaukee was substantial from both meteorological and health angles.**

***Finding*: Staff meteorologists at radio and television stations gave the NWS high marks for timely and accurate forecasts and related services during the heat wave.**

***Finding*: The Chicago and Milwaukee media have not developed a public response to heat hazards as they have for other severe weather phenomena.**

***Recommendation*: The NWS must enhance its public education campaign regarding the use of the heat index and the dangers of heat. The media and the private sector should be enlisted as partners through professional associations, such as the American Meteorological Society and the National Weather Association.**

■ Chicago, Illinois

Emergency Preparedness

Chicago's disaster preparedness planning responsibility rests in the Chicago Fire Department. Their Office of Emergency Management maintains the city's emergency operations plan. It addresses the major disasters believed to threaten Chicago. A disaster is an event that causes community impacts which outstrip any single agency's ability to respond and meet the demands for help or resources. Extreme temperatures were not identified as one of the hazards that could cause a disaster in Chicago; a heat wave was viewed as a health emergency. An emergency is defined as heavily taxing the response capabilities of an agency or governmental function, such as emergency medical services, fire suppression, or crowd control. Hot weather, considered a health emergency, falls under the responsibility of the Chicago Department of Health. Therefore, the city's response to extremely hot temperatures is not addressed in the citywide disaster preparedness process.

The Chicago Health Department's plan for heat waves that was in effect July 14 and 15 had three basic components. First, public service announcements on heat safety actions are sent to the media outlets in early June as a general preparedness measure for the coming summer. Second, forecasts for excessive heat are brought to the attention of the media news departments by the health department. These are monitored through weather forecasts on radio and television. Third, the Department of Human Services, the Department of Aging, and the Chicago Police Department are notified by the Department of Health of heat wave forecasts. When excessive heat is forecast, cooling centers are activated to provide service to the elderly at community centers.

Additionally, individual city agencies have internal heat wave response plans. These include such actions as relief for firefighters battling blazes, precautions for public works and sanitation crews working outdoors in the heat, police awareness to heat-related problems, and spraying water on metal bridges to prevent buckling. The city also has in place a medical emergency plan, covering both patient transport and hospital response to mass casualty incidents. This plan is designed to provide a coordinated delivery of medical services in case of a disaster that would overload hospitals with victims. The goal is to simultaneously activate the area hospitals' individual disaster plans and coordinate patient transport to hospitals based on patient need and available medical resources.

Chicago has a long history of meteorological forecast support from the private sector. This has traditionally focused around winter weather and city snow removal operations. The Chicago Department of Streets and Sanitation, Bureau of Street Operations, serves as the focal point for all weather forecasts and information for the city. Their dispatch center is staffed around the clock, 7 days a week. The city contracts for meteorological support from three different companies. They receive, via telephone facsimile, forecasts three times daily from Murray and Trettel, Incorporated. This firm also issues its own storm warnings for severe summer weather and snow and ice storms and sends them to the Bureau of Street Operations. The storm warnings are faxed out by Street Operations to most city agencies. The dispatchers do not know the differences or similarities between these private storm warnings and NWS warnings. Chicago also purchased a series of street surface sensors and meteorological support services from Surface Systems Incorporated (SSI). This firm provides real-time access to the sensors in the city and surrounding area. They also provide computer access to NWS forecast products that can be printed and NWS Doppler weather surveillance radar products through a Next Generation Radar Information Dissemination Service vendor. The dispatchers must actively retrieve weather information, warnings, watches, and forecasts on this computer system. The third company the city uses is Compu-Weather, and it receives forecasts twice daily from this firm.

Chicago receives NWS warnings, watches, and forecasts indirectly via The Weather Channel, which is constantly monitored in the dispatch center and over the SSI weather computer. There was no direct link to the Chicago NWS Forecast Office. The dispatch center does not subscribe to the NWWS nor does it monitor NWR.

***Finding*:** **At the time of the July 1995 heat wave, the emergency preparedness program for extreme heat in Chicago was organized and administered from the public health department, which was different from other hazardous weather events.**

***Finding*:** **Officials in Chicago did not realize the difference between NWS weather warnings and private sector warnings.**

***Recommendation*:** **The Chicago NWS Forecast Office should work with Chicago officials to provide user training on NWS watch/warning products.**

Community Response

Chicago officials were aware that the forecast was for hot weather July 13 and 14, but they did not fully understand the meaning of the heat index forecast nor did the forecast clearly convey the true severity of what would occur. Moreover, they could not anticipate the potentially catastrophic nature of such an extreme heat wave and the extent of the threat to public health. It was beyond anyone's realm of experience. Officials indicated that even if warnings for excessive heat had been issued by the Chicago NWS Forecast Office, they would not have changed their response. Community centers stayed open as cooling facilities for the elderly but appeared to have been only slightly used. Public service announcements were sent out about the cooling centers. Individual city agencies activated their heat response operating procedures, stressing the safety of their personnel. The city prepared for several days of very uncomfortable weather that would affect city service operations. Weather forecasts for extreme heat were received in the Bureau of Street Operations dispatch center. However, there was no city protocol for relaying Warnings, Watches, Forecasts, Advisories, and Statements to other city agencies. The heat wave was not identified as a major weather or public health threat. Therefore, the Chicago Department of Health relied on media-relayed NWS forecasts and periodic NWS briefings via telephone.

The real-time tracking of increased demand for emergency medical services did not detect the increased hospital load during the heat wave. Therefore, the city's medical emergency plan was not activated. Individual hospitals did implement their individual patient overload response plans, which called for ambulances with patients to bypass emergency rooms that were full. The patients were taken to less crowded hospitals. The transportation and treatment of patients suffering heat-related illnesses was not coordinated citywide.

The first indication of the catastrophic impact of the heat wave was the arrival of large numbers of victims at the Chicago Medical Examiner's Office. The true nature of the disaster revealed itself as more and more victims were discovered in their homes. In many ways, this was a silent disaster, quietly killing hundreds of people who did not escape the deadly heat. When it was all over, Chicago had experienced its worst weather-related disaster with 465 heat-related deaths that occurred from July 11-27.

Recovery

Immediately after the impact of the heat wave was recognized, Chicago officials began a new program of short-term actions for a citywide heat response program. These included an interim Heat Emergency Plan and a proactive city response to heat waves. A Mayoral Commission on Extreme Weather Conditions was convened, with the task of recommending long-term plans for preparing for and responding to heat waves and other weather hazards.

In parallel with the Commission, officials at the Chicago Department of Health began immediately after the event to develop a detailed interim Heat Emergency Plan and a proactive city response to heat waves. This included daily monitoring of private sector and NWS forecasts by health officials. The city has directed Murray and Trettel, Incorporated, to provide a 5-day forecast for the heat index based on the NWS computational formula. These daily forecasts are faxed to the Chicago Department of Health and other city agencies. The Chicago Department of Health also developed a Heat Emergency Plan which calls for the health department to issue Heat Alert, Heat Warning, and Heat Emergency messages to the public based on NWS forecasts of heat index temperatures. Many agencies have stepped up their surveillance of those citizens at risk from heat-related illness and death. The Heat Emergency Plan also establishes a city command post and phone bank if heat index temperatures exceed 105°F.

The Commission was created to advise the Mayor of Chicago on proposals for dealing with all types of hazardous weather that affect Chicago. Its mission is to document the past occurrence and future risk of hazardous weather conditions and develop emergency response capability as part of the city's emergency planning. Members for all city agencies are appointed to the Commission as is the MIC from the Chicago NWS Forecast Office. The Commission is divided into six committees: weather, mortality and morbidity, geriatric behavior, role of the government, role of the private sector, and public education and outreach. Members of the Commission have talked with representatives from both Philadelphia, Pennsylvania, and St. Louis, Missouri, to study their community heat response plans and operations. Chicago officials have identified these two cities as having effective community heat response programs.

■ Milwaukee, Wisconsin

Emergency Preparedness

The emergency management structure for Milwaukee is located in the Milwaukee County Division of Emergency Government. Local emergency management is well organized, has a very good relationship with the Milwaukee NWS office, and generally appears to be quite responsive to weather emergencies. However, local decision-makers do not receive weather information directly from the NWS via the NWWS or NWR. For routine weather information, local officials rely solely on the media. Local emergency officials receive emergency weather information for tornadoes, severe thunderstorms, and flash flooding via the Wisconsin Criminal Justice Information System (WCJIS), which has a fully-automated interface with NWWS to disseminate warnings and watches to all local law enforcement agencies. Printed warnings and watches are received by local officials. Other critical information (heat waves, winter weather, etc.) is not relayed by WCJIS.

The city of Milwaukee's heat wave preparedness and response is coordinated by the Milwaukee Health Department. Several years ago, they brought together the Hot Weather Task Force, representing various public and private organizations, to develop a coordinated response plan to extreme and prolonged high temperatures. The plan calls for the issuance of Heat Warnings and Heat Alerts based on a forecast of hot weather for 2 or more consecutive days. These issuances, designed to alert the media, public, and other response agencies, include information on air-conditioned public facilities, cool spots (i.e., libraries), pools, cooling centers, and senior centers that are open. They also include phone numbers for various agencies, providing health advice during heat waves and specific health facts and tips. These issuances are disseminated to the media independent of NWS products.

Community Response

In Milwaukee, the community response to the heat wave was similar to that of Chicago. Local officials expected the predicted July heat wave to involve very hot weather and oppressive humidity with some health risks for the elderly. The event was not viewed as extremely dangerous and potentially deadly.

On July 11, the Milwaukee Department of Health issued a Hot Weather Advisory for the impending heat wave. The advisory was based on NWS forecasts for high temperatures and humidity. Lists of air-conditioned cooling centers at community centers, public facilities, and libraries were in the advisory. The heat information telephone lines were staffed from July 12 to 14 to answer health-related questions from the public. The city advisory was forwarded to area health facilities and the media. Agencies that were part of the Milwaukee Department of Health Heat Disaster Plan were notified of the advisory. There was a sense of informal cooperation among the agencies but no formal coordination of efforts.

The magnitude of the problem only became apparent when health officials noticed the increase in heat-related morbidity and mortality. The city activated its Emergency Medical Services response plan, and individual hospitals activated their disaster plans. The scope of the disaster was not fully realized until the death toll rapidly rose. The city opened more shelter space to help residents escape the deadly heat. The Milwaukee Division of Emergency Government became aware of the disaster when they received a request for cots for the cooling shelters. Once again, the silent killer of extreme heat had struck before the danger had been fully recognized by local officials. In Milwaukee, 85 heat-related deaths were recorded from July 14-17, 1995.

On July 14, the Milwaukee Department of Health, using its own criteria (3 consecutive days with heat indexes above 95°F), issued a health warning. It is not clear if or how the warning was perceived differently from the NWS Heat Advisory by the media and the public. According to health department officials, there was at most minimal confusion resulting from having warning messages from different sources using different wording. They believe that the messages, rather than conflicting with each other, served to emphasize the heat concern in the public's consciousness. Activities that were in operation prior to or soon after the start of the heat wave included a fan distribution program, the operation of cooling centers, and contacting of shut-ins.

Recovery

In Milwaukee, a Community Task Force on Summer Weather Emergencies was convened immediately after the heat wave. The Task Force consists of participants from the NWS; state, county, and city divisions of emergency government and public health; emergency medical groups; utilities; volunteer organizations (Salvation Army, American Red Cross, etc.); and the media. The Task Force is investigating improvements in preparedness and response to summer weather hazards.

***Finding*: Chicago and Milwaukee officials and the public did not fully understand the heat index or the extent of the threat from heat waves.**

***Recommendation*: The NWS must enhance its community education campaign regarding the use of the heat index and the dangers of heat.**

CHAPTER 5

CASE STUDIES IN HEAT WAVE PREPAREDNESS

In addition to Chicago and Milwaukee, the NOAA Disaster Survey Team visited Philadelphia, Pennsylvania, and St. Louis, Missouri. These cities experienced deadly heat waves in 1993 and 1980, respectively. The Survey Team wanted to determine whether previous experience during heat emergencies affected the impact of the July 1995 heat wave in these two cities.

***Recommendation*: NOAA should actively encourage other Federal agencies, such as the Department of Health and Human Services, the Environmental Protection Agency, and the Federal Emergency Management Agency, to join in research on excessive heat, mortality, and morbidity.**

***Recommendation*: The NOAA Chief Scientist should convene a workshop comprised of interagency physical scientists, private sector providers, social scientists, and epidemiologists to provide operational research recommendations in light of the scientific advances made over the last decade. The relationship between heat-related mortality and the heat index, as well as other proposed predictors of heat stress, should be simultaneously evaluated to determine which method most accurately predicts the health consequences of a heat wave.**

■ Philadelphia, Pennsylvania

During a 3-week period in July 1993, the Philadelphia County Medical Examiner reported approximately 118 heat-related deaths (CDC, 1994; CDC, 1993). Although the medical examiner was initially criticized for overestimating the number of deaths, a subsequent evaluation by CDC investigators confirmed the findings. In fact, it was found that similar increases in deaths during the heat wave had occurred in other urban areas near Philadelphia although they had not been recognized at the time.

From July 12 through August 17, 1995, 72 deaths in Philadelphia were attributed to the heat. Forty-two (42) of these occurred between July 13-21 when the same heat that had affected Chicago and Milwaukee blanketed Philadelphia. Of the 72 deaths, 54 (75 percent) occurred in persons over 60 years of age. Many of the deceased had pre-existing medical conditions which may have made them, for physiologic or behavioral reasons, more susceptible to the effects of the heat.

As a result of its experience during the 1993 heat wave, the city of Philadelphia established a Heat Wave Preparedness Task Force which developed an extensive and detailed Heat Response Emergency Plan for reacting to heat emergencies. The Plan provides a comprehensive system of prompt notification and mobilization of agencies during an excessive heat event. Participants in the heat Plan include not only the Philadelphia Department of Health but also the Philadelphia Corporation on Aging, the Pennsylvania Emergency Management Agency, the American Red Cross, representatives of the public utilities, and the NWS. Year-round preparedness is emphasized, and participating groups meet throughout the year to plan and coordinate their activities. The Heat Hotline, established during the 1993 heat wave, is the backbone of the emergency response and is managed by the Philadelphia Corporation on Aging. In response to calls received by the Hotline, teams consisting of a nurse and an environmental health practitioner evaluate the residences of persons potentially at risk and assess the resident's health and their ability to cope with the heat. Other activities of the Heat Wave Preparedness Task Force include the establishment of a plan for assisting the homeless during a heat emergency and modification of local ordinances to require landlords of multiunit residences housing the elderly to maintain temperatures below a certain threshold.

Philadelphia's Heat Response Emergency Plan is activated by Heat Warnings issued by the NWS. Emergency activities are mobilized on the basis of a coordinated prediction plan between the NWS and the University of Delaware. The University of Delaware uses an alternative model developed by Professor Laurence Kalkstein, Center for Climatic Research, University of Delaware, and funded by the Environmental Protection Agency (Kalkstein and Smoyer, 1993; Kalkstein, 1993; Kalkstein, 1991; Kalkstein and Davis, 1989; Kalkstein and Valimont, 1986). The Kalkstein model first identifies commonly occurring types of summer air masses. This is done through a statistically based classification system which considers several weather forecast variables (air temperature, dew point temperature, atmospheric pressure, cloud cover, wind speed, and direction) at four time points in each 24-hour period. For many cities, Kalkstein claims that one type of air mass is associated with the greatest increase in mortality. For Philadelphia, this air mass is identified as maritime tropical, oppressive. However, not all days within this air mass type are associated with elevated mortality totals. The model further identifies which days within the high risk air mass will have elevated mortality. In Philadelphia, the factors that contribute to high daily mortality when the high risk air mass is present include the number of consecutive days within the air mass, the date in the season, and maximum temperature. Ironically, the air mass described in chapter 1 that produced the severe conditions on July 14 and 15 in Philadelphia was not maritime tropical.

In 1994, the NWS initiated a new Health Watch/Warning System in coordination with Pennsylvania emergency management officials. In 1995, the city of Philadelphia started an enhanced Health Watch/Warning System based on the Kalkstein model. The system consists of three levels: Health Watch, Health Alert, and Health Warning. A Health Watch is issued by the Philadelphia Health Commissioner 2 days prior to the forecasted arrival of a high risk air mass. A Health Alert is issued 1 day prior to the forecasted arrival of a high risk air mass. These issuances are coordinated with the NWS Forecast Office at Mt. Holly, New Jersey. A Health Warning is issued by the Philadelphia Health Commissioner either the afternoon before or the morning of the forecasted occurrence of a high risk air mass. Depending on the number of excess deaths predicted by the model, one of three Health Warnings is issued. A Level One warning is issued if one to four heat-related deaths are predicted; a Level Two warning, if five to fourteen deaths are predicted; and a Level Three warning, if fifteen or more deaths are predicted. The Health Warning is only issued in conjunction with the issuance of a Heat Warning by the NWS.

These Heat Warnings are based on heat index values reaching 105°F for 3 hours or more for 2 consecutive days.

Advocates of Kalkstein's work believe that this model can better predict the true health risks associated with a specific day than can the heat index criteria used by the NWS. This is because it models the relationship between meteorological characteristics and mortality and takes into account the effect of additional non-meteorological variables. There is not yet sufficient data to demonstrate clearly whether in fact the Kalkstein method is consistently better at predicting the health effects of a heat wave. For example, between July 12 and August 16, 1995, the Kalkstein model recommended the issuance of Health Warnings on 15 days in Philadelphia. On nine of these days, the NWS also issued warnings. Of the 70 heat-related deaths that were recorded during that period, 17 (24 percent) occurred on days when warnings were issued by the NWS and recommended by Professor Kalkstein; 15 (21 percent) occurred on days when only Professor Kalkstein recommended a warning; 38 (54 percent) occurred on days when no warnings were issued. The extent to which mortality was mitigated by appropriate community response based on these warnings is also not known.

With the heightened awareness of city officials to the implications of high heat index values in conjunction with a re-evaluation of Heat Advisory thresholds currently used by the NWS, the heat index, with or without modification, may be as predictive as any proposed alternative models. Before being adopted on a wide scale, any alternative method for predicting Heat Warnings needs to be thoroughly evaluated. It is recommended that the relationship between heat-related mortality and the heat index, as well as other proposed predictors of heat stress, should be simultaneously evaluated to determine which method most accurately predicts the health consequences of a heat wave.

There has been significant research in the area of the health effects of extreme heat since the current NWS heat index and warning/watch/advisory criteria was established. Many of the publications have appeared since WSOM chapters were written. Research has been in the fields of public health, epidemiology, climatology, meteorology, gerontology, sociology, and geography (Kilbourne, 1989; Kalkstein, 1991; Lee, 1980; Riebsame, 1985; Riebsame, et al., 1986). This indicates the need for review of current knowledge on the impact of heat to health and public safety as well as a review of NWS operations.

***Finding*: Philadelphia's Heat Wave Preparedness Task Force developed an extensive and detailed plan for responding to heat emergencies.**

***Finding*: Philadelphia's Heat Response Emergency Plan is activated by Heat Warnings issued by the NWS.**

***Finding*: Emergency heat-related activities in Philadelphia are mobilized on the basis of predictions of an alternative model developed by Professor Laurence Kalkstein, Center for Climatic Research, University of Delaware.**

***Finding*: It is not clear how much better the Kalkstein model compares with other models in predicting the health effects of a heat wave.**

***Recommendation*: The Kalkstein model should be reviewed after its proposed expansion to Chicago, Illinois, and Atlanta, Georgia, in 1996.**

The NOAA Disaster Survey Team believes the following recommendation to be of particular importance.

NWS Actions

During the July 1995 heat wave, forecasters at the NWS Forecast Office at Mt. Holly, New Jersey (whose responsibility includes the Philadelphia metropolitan area), took aggressive actions to inform their community of the dangerous heat wave. Accurate and timely forecast information was provided as much as 5 days in advance of the excessive heat. Products issued by NWS forecasters clearly conveyed important and accurate forecast information regarding excessive temperature and high humidities. A Heat Warning/Advisory was in effect throughout the event. In fact, Heat Warnings/Advisories were issued for a consecutive 2-day period. This action, based on sound professional judgment, conveyed important information on the anticipated duration of this event.

As the event neared, the office issued a variety of frequent, well-written statements that relayed emergency and safety information to the community. Statements were often targeted to high risk groups and areas. NWS forecasters exceeded operational requirements in keeping the community informed. An Outlook product indicated the likelihood of dangerous heat over 48 hours in advance of highest temperatures. In an unusual and highly successful move even prior to the issuance of a Heat Advisory, Zone Forecasts were highlighted to reflect the anticipated dangerous heat. Temperature forecasts were highly accurate and generally verified to within 2 or 3 degrees. NWS forecasters were also in contact with state, city, and local officials during the event.

***Finding*: NWS forecasters clearly, effectively, aggressively, and accurately communicated a forecast for the Philadelphia area calling for dangerously high heat and humidities 36 to 48 hours prior to the event.**

***Finding*: Recognizing the unique situation of an urban center, NWS forecasters issued a Heat Warning for Philadelphia (the highest level possible) for a consecutive 2-day period. This action provided community officials with key planning information.**

***Recommendation*: NOAA should quantify the urban heat island effect to incorporate in NWS Heat Warnings, Watches, Advisories, and Statements.**

Media Coverage

Philadelphia summers are hot and humid, and the media are extremely knowledgeable about the dangers of excessive heat. During the July 1995 heat wave, the citizens of Philadelphia received excellent and thorough coverage of the event.

■ St. Louis, Missouri

As in Philadelphia, most long-term residents of St. Louis have had personal experience with at least one severe heat wave. The killer heat wave of 1980 claimed 113 lives (Kilbourne, et al., 1982; Jones, et al., 1982). The number of deaths attributed to a 1966 heat wave was estimated to be as high as 400. Since 1981, Missouri has required that heat-related deaths or illnesses be reported to the State Health Department. In 1981, the city of St. Louis established Operation Weather Survival, a loose affiliation of agencies involved in responding to heat emergencies and coordinated by the local chapter of the United Way.

During the summer of 1995, there were 27 heat-related deaths in St. Louis City and 4 in St. Louis County. Of these 31 deaths, 22 occurred between July 14 and July 19. The victims ranged in age from 36 to 89 years.

Similar to Philadelphia's Heat Wave Preparedness Task Force, Operation Weather Survival includes outreach programs, an air conditioner distribution program, and the establishment of cooling centers when required. Environmental health monitors visit addresses where heat deaths have occurred to determine if there are additional people at risk. A computer-operated calling system was used for the first time in 1995 to check on elderly residents.

Operation Weather Survival's Heat Response Plan is activated by Heat Warnings issued jointly by the St. Louis Department of Health and the St. Louis County Health Department rather than warnings issued by the NWS. Although warnings issued by St. Louis City and County and the NWS often coincide, the city's Heat Warnings are based on readings of a wet bulb globe thermometer monitored by the St. Louis Department of Health. The wet bulb globe thermometer, developed in 1957 to set limits to military training during hot weather, gives a temperature which is adjusted to reflect heat loss/gain due to evaporative and radiative mechanisms (Departments of the Army and the Air Force, 1970; Hislop, 1960). In St. Louis, the decision to issue a warning is made at 11 a.m., based on two readings from that morning and two readings from the previous afternoon. When the average of those readings is above 85°F, a heat warning is issued accompanied by increased surveillance of emergency rooms to detect increases in heat-related illnesses or deaths. The next level of warning, a heat alert, requires the opening of cooling shelters and the notification of the Salvation Army and the American Red Cross. The highest level of warning, a heat emergency (which can only be activated by the mayor of St. Louis, the St. Louis County executive, or the governor) is based on information obtained from Operation Weather Survival, the state, city, and county health departments.

***Finding*: St. Louis' Operation Weather Survival, a loose affiliation of agencies involved in responding to heat emergencies and coordinated by the local chapter of the United Way, developed an extensive and detailed plan for responding to heat emergencies.**

***Finding*: The St. Louis Heat Response Plan is activated by Heat Warnings jointly issued by the St. Louis Department of Health and the St. Louis County Health Department, based on readings of a wet bulb globe thermometer not by Heat Warnings issued by the NWS.**

NWS Actions

During the July 1995 heat wave, forecasters at the NWS Forecast Office at St. Louis issued high quality forecasts and statements that informed their community of the dangerous heat wave. Accurate and timely forecast information was provided as much as 5 days in advance of the excessive heat. Products issued by NWS forecasters clearly conveyed important and accurate forecast information regarding excessive temperatures. A Heat Advisory was in effect well prior to and throughout the event. In fact, Heat Advisories were issued for a consecutive 2-day period. This action, based on sound professional judgment, conveyed important information on the anticipated duration of this event.

As the event neared, the office issued a variety of frequent, well-written statements that relayed emergency and safety information to the community. Statements were often targeted to high risk groups. NWS forecasters issued a number of extra products that provided climate and other information to the community. NWS forecasters were also in contact with state, city, and local officials during the event.

***Finding*: NWS forecasters clearly and accurately communicated the likelihood of unusually high levels of heat for St. Louis 5 days prior to the event.**

***Finding*: NWS forecasters issued a Heat Advisory for St. Louis for a consecutive 2-day period. This action provided community officials with key planning information.**

Media Coverage

The St. Louis media recognize the dangers of excessive summer heat and reflect this in their frequent reporting. The media covered the July 1995 heat wave from both the meteorological and news perspectives. In fact, the St. Louis media found it difficult to find different story angles as the heat wave lingered.

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APPENDIX A

REVIEW CRITERIA FOR NWS PRODUCTS, SERVICES, AND ACTIONS

In a review of NWS forecast office products and services, both objective and subjective actors must be considered. Objective actions include compliance with WSOM chapters that serve as baseline instructions for forecast offices. Subjective factors also play a critical role, especially during high impact meteorological events. Subjective actions include those actions taken by forecasters above and beyond what is specified by written guidance.

Objective Review

- General compliance with WSOM Chapter C-44, Non-Precipitation Weather Hazards, and related guidelines and policies.
- Frequency of statement issuance.
- Accuracy of forecasts.

Subjective Review

A subjective review of forecast office actions is a more complex task. It must consider forecaster response that at times is based on limited information. It might include the following.

- Appropriateness of actions.
- Recognition of magnitude of event.
- Responsiveness.
- Proper transition from an unusual into a critical weather event.
- Quality of forecasts.
- Quality of statements.

Time Sequence Review

In addition to these objective and subjective factors, this review will be defined further by the following time sequences.

- Extended Forecast Review: Period of time generally greater than 48 hours prior to the onset of the excessive heat event.
- Forecast Review: Period of time generally between 36 and 48 hours prior to the onset of the period of review.
- Short Term Forecast Review: Period of time within the excessive heat event.
- Post-event Review: Period of time after the excessive heat event.