

Illinois State Water Survey • Data/Case Study 2007-04



The April 2007 Hard Freeze in Illinois: Features and Impacts

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THE APRIL 2007 HARD FREEZE IN ILLINOIS: FEATURES AND IMPACTS

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ABSTRACT

Illinois experienced a significant hard freeze in early April 2007 that caused widespread damage, mainly the result of three factors. An abnormally warm March with temperatures 7.1°F above normal, encouraged plants to break dormancy and begin rapid development. Very cold air with lows of 17-24°F occurred after the passage of a strong low-pressure system in early April and a change in the atmospheric circulation pattern. Strong winds accompanied the freezing temperatures, enhancing heat loss from vegetation surfaces. The damages to certain sectors of agriculture were significant. Total losses were an estimated \$146 million: \$106 million (winter wheat), \$12.4 million (peaches), \$10 million (apples), and \$18 million (alfalfa). Other damages were likely but not documented well enough to estimate dollar losses.

ACKNOWLEDGMENTS

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INTRODUCTION

Spring temperatures in Illinois can be quite variable, with abrupt changes from mild to cold weather as strong cold fronts pass through the state. Usually, this high variability does not cause problems. Unique circumstances in March and early April 2007 produced widespread damage of fruit crops, forage crops, winter wheat, as well as home gardens and landscapes, however.

The stage was set when Illinois experienced the sixth warmest March on record since 1895. Those warm March temperatures, 7.1°F above normal, promoted early and rapid development of fruit and forage crops and winter wheat, leaving them extremely vulnerable to sub-freezing temperatures. On April 3, a very strong low-pressure system moved across the upper Midwest and produced snowfall amounts of 6 inches or more across northern Minnesota, Wisconsin, and Michigan. For Illinois, the cold air behind the low-pressure system persisted for several days, and temperatures dropped into the lower 20s and upper teens, conditions severe enough to cause extensive damage to crops and other vulnerable plants.

This case study reviews the unusual climate factors of spring 2007 and examines resulting impacts. Damage estimates are based on available data from the media and field experts. While the main report describes general conditions during the event, more detailed surface and upper air meteorological maps appear in the appendix. This particular case is an excellent example of how the combination of two unusual weather events can produce damages far exceeding what one would expect from either event separately.

DATA AND METHODOLOGY

Climate data used in this study were obtained from the Midwestern Regional Climate Center or MRCC (<http://mrcc.sws.uiuc.edu/>). Daily temperature data originated at the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) cooperative observer network for 134 sites across Illinois in March and April 2007. Additional historical climate data obtained were statewide monthly temperatures that began in 1895 and a specialized gridded dataset of daily temperatures and growing degree-days since 1900. Gridded data came from the MRCC Midwestern Climate Information System (MICIS) system (Kunkel et al., 1990). Hourly temperature and wind speed data from the National Climatic Data Center were obtained for the airport at Carbondale, Illinois. Daily weather maps were obtained from the NWS. Other surface and upper air maps were obtained from NOAA's Earth Systems Research Laboratory. Soil temperatures were obtained from the Illinois Climate Network.

Estimates of damage losses were obtained from the University of Illinois Cooperative Extension Service and local media. Estimates of crop acreage and value were obtained from the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS).

CLIMATE CONDITIONS BEFORE APRIL 2007 HARD FREEZE

Significant impacts of the April 2007 hard freeze were the result of a combination of unusual climate factors. The genesis of this event can be seen in Figure 1, which shows daily statewide average temperature departures from normal (1971-2000) in Illinois, March 1-April 30, 2007. Temperature swings typical for March occurred during the first half of the month. Beginning March 19, however, temperatures remained above normal until April 3. The warmest period, March 21-April 3, had temperatures 15.6°F above normal and was the second warmest such period since 1900, according to the MRCC gridded temperature data. An extended period of below-normal temperatures April 4-16 followed with temperatures on April 7 almost 21°F below normal. Individual features of this event are described in the following paragraphs. In some instances, features of the April 4-9 period are highlighted and represent the key period of damaging temperatures.

As already noted, March temperatures in Illinois were abnormally warm. The dominant circulation pattern in March was a trough of low pressure in the western United States and a ridge of high pressure over the eastern United States. The jet stream followed this pattern, dipping southward in the west and northward in the east, and served as the division between cold air to the north and warm air to the south. As a result, a steady flow of warm, moist air from the Gulf of Mexico reached into the Midwest, including Illinois (Figure 2).

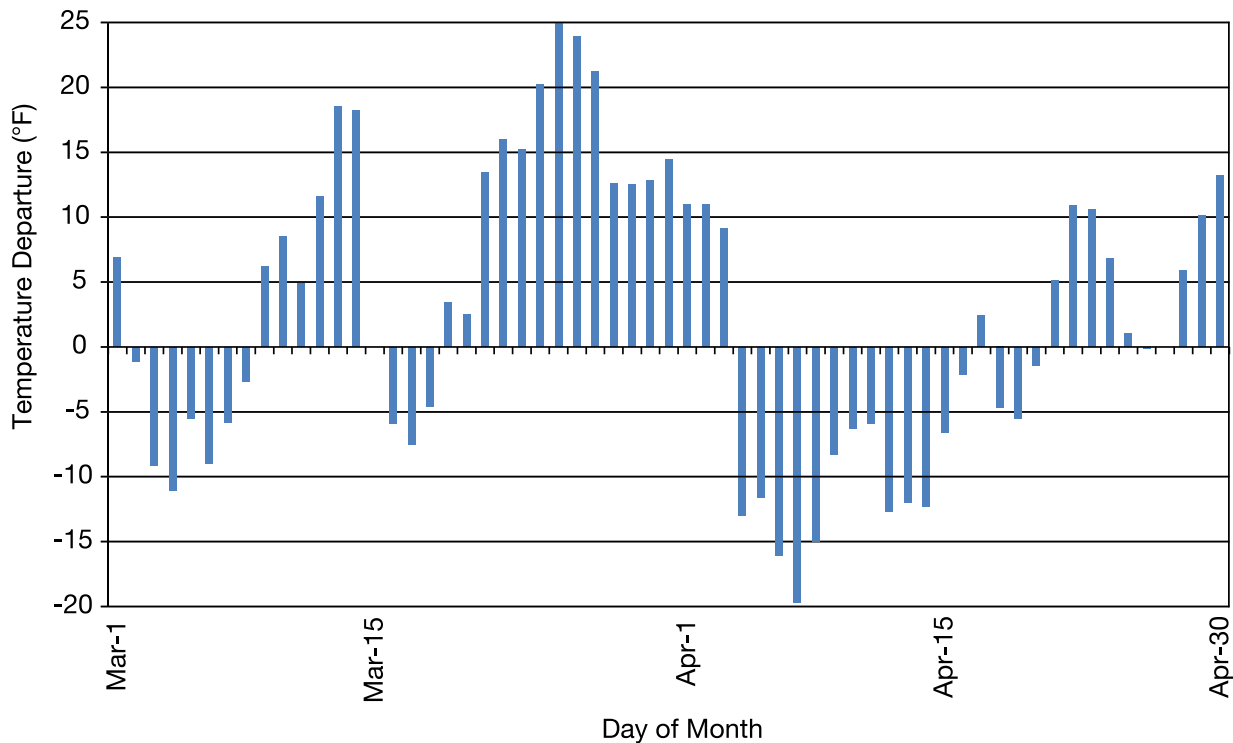


Figure 1. Daily statewide temperature departures from normal (1971-2000), March 1-April 30, 2007.

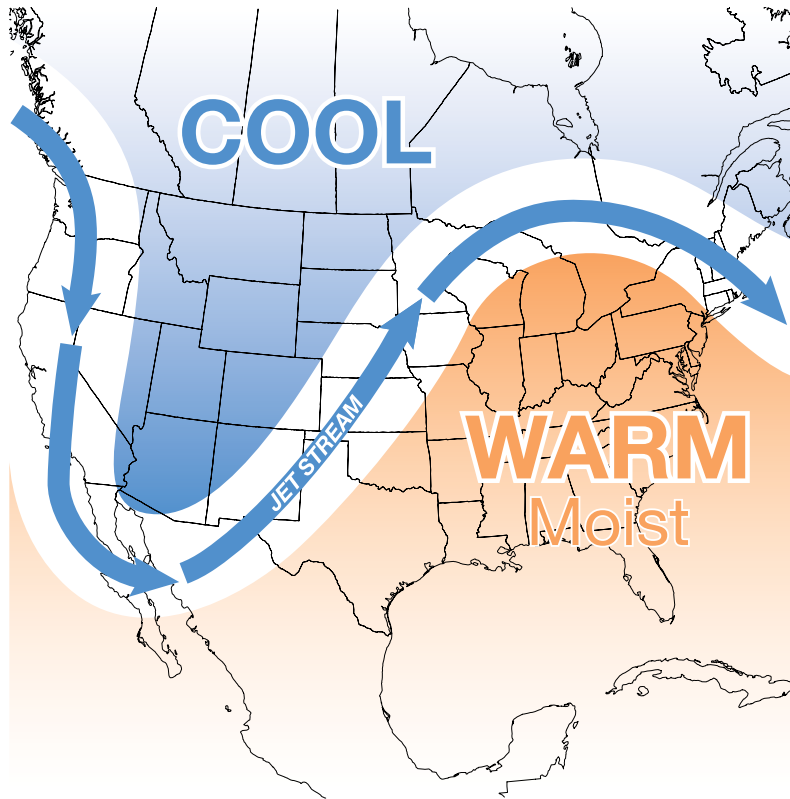


Figure 2. Key atmospheric circulation features persisted through much of March 2007. The jet stream divides warm and cold air masses, and this pattern allowed abnormally warm air to reach Illinois in March. This schematic is based on Figures A-1 and A-2 in the Appendix and other supporting evidence (not shown).

Overall, March temperatures were 47.6°F degrees, 7.1°F above normal, and the sixth warmest March since statewide records began in 1895. Not only were the average monthly temperatures well above normal, but many days in March were quite warm with highs at or greater than 70°F (Figure 3). Northern Illinois experienced 4-8 such days; central Illinois, 8-12 days; and southern Illinois, 12-16 days. Overall, locations in Illinois averaged 9.1 March days with temperatures at or above 70°F.

Data from three sites in Illinois show how unusual 70°F weather is in March. Sites chosen represent the three regions of the state from north to south. In northern Illinois, Rockford experienced four such days in March 2007, compared to its normal two days (based on the 1971-2000 average). In central Illinois, Springfield experienced 11 such days, compared to its normal 3 days. In southern Illinois, Carbondale experienced 15 days such days, compared to its normal 4 days. These data are evidence that the unusual nature of the warm March weather was more pronounced in southern Illinois.

The highest daily high temperatures in March across Illinois are shown (Figure 4). Highs in the upper 70s and low 80s were typical: 78-80°F (northern Illinois), 80-82°F (central Illinois), and 82-84°F (southern Illinois). The statewide average highest daily temperature for March was 80.3°F.

CLIMATE CONDITIONS DURING APRIL 2007 HARD FREEZE

Dramatically colder temperatures followed the warm temperatures in March and the first three days of April as the atmospheric circulation pattern changed to allow cold Arctic air into the region over an extended period. The surface low-pressure system moved through Illinois on April 3. The high temperature of 66°F at Champaign-Urbana on April 3 dropped to 36°F by midnight, continued to drop, and was 27°F the next morning.

The atmospheric circulation pattern during April 4-9, 2007, was a mirror image of that in March with a ridge of high pressure in the western United States and a trough of low pressure in the eastern United States. This pattern allowed cold Arctic to flow into much of the eastern two-thirds of the nation (Figure 5) as far south as Gulf Coast states.

Temperatures in the coldest period, April 4-9, averaged 14°F below normal, the second coldest such period since 1900. The lowest daily low temperatures for this period averaged 20.9°F

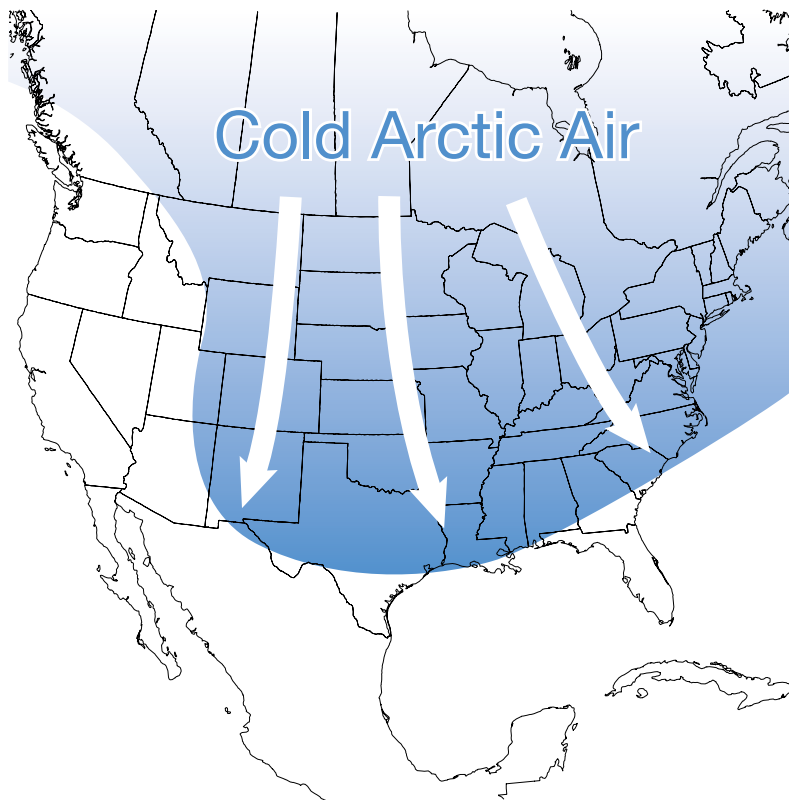


Figure 5. Cold Arctic air reached throughout the eastern two-thirds of the United States on April 4-9, 2007. Only the mountain ranges in the western United States limited the westward spread of the cold air. This figure is based on the April 7, 2007, surface weather map (Figure A-11), including the freezing line at 7 a.m. on that day. Highly modified Arctic air that remained slightly above freezing extended into the remaining Gulf states and Mexico.

statewide on April 7. In general, the lowest low temperatures (Figure 6) were 18-20°F (northern Illinois), 18-22°F (central Illinois), and 22-24°F (southern Illinois). Cold temperatures and windy conditions caused strong vertical and horizontal mixing of the atmosphere. As a result, even vegetation in sheltered locations suffered damage, and many traditional methods for protecting against freezes, such as covering plants or providing additional heat sources, failed.

April 3-10 hourly temperature and wind speed records at the airport in Carbondale, Illinois, the heart of the area most affected by the freeze, indicate that for 47 hours (noncontinuous) the temperature remained at or below 32°F, 25 hours at or below 28°F, and 3 hours at or below 24°F (Figure 7). Wind speeds during nighttime hours on April 7 were 10-18 mph.

While early April temperatures were unusually cold, timing of the freezing temperatures was not unusual. In fact, the historical probability of freezing temperatures in the first half of April in Illinois is high. The median date of the last spring occurrence of 32°F is April 7-14 (southern Illinois), April 14-21 (central Illinois), and April 21-28 (northern Illinois). By itself, damages from the early April freeze would have been minimal, but the exceptionally warm March served to increase those effects.

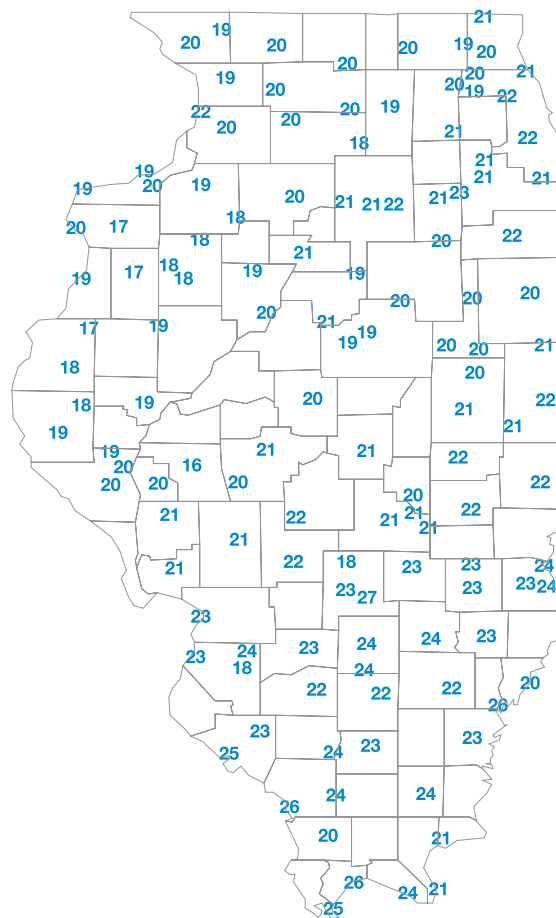


Figure 6. Lowest temperatures observed in April 2007.

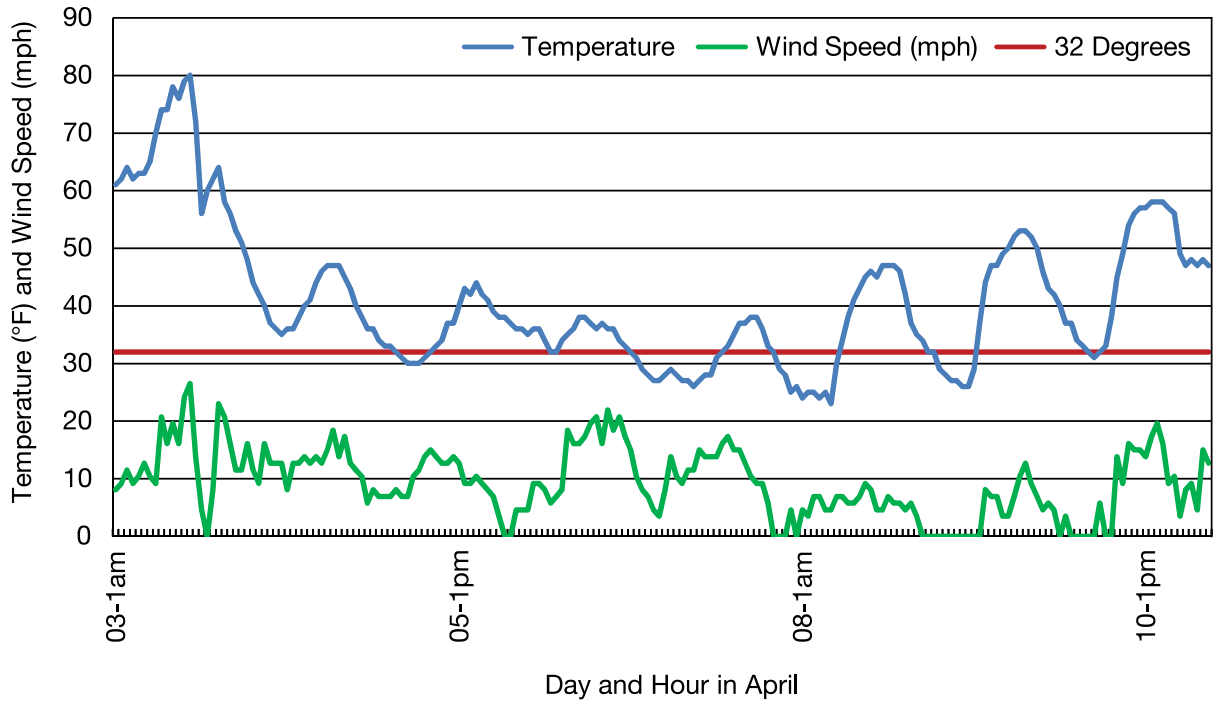


Figure 7. Hourly temperatures (°F) and wind speeds (mph) at Carbondale airport, April 3-10, 2007.

IMPACTS OF APRIL 2007 HARD FREEZE

On June 7, 2007, the U.S. Department of Agriculture granted Illinois Governor Rod Blagojevich's request to designate 55 Illinois counties as natural disaster areas (Figure 8). The press release noted that crops most affected by the freeze were Illinois peaches and winter wheat (Office of the Governor, 2007). Additional impacts are identified here along with estimated losses.

Winter Wheat

June 2007 NASS acreage for wheat reflects a 16.5 percent reduction in the acreage of harvested winter wheat. Approximately 80 percent of this reduction (about 130,000 acres) was due to the freeze.

The June report also projected yields of 55 bushels per acre (bu/acre) in Illinois. Given favorable weather in 2007 until the freeze, yields could have surpassed the record 68 bu/acre yield in 2006. Assuming the yield would have been 70 bu/acre without the freeze, Illinois would have harvested an estimated 21.25 million more bushels than at 55 bu/acre. At a cash price of \$5.00 per bushel at the end of June, the estimated loss due to the freeze would be \$106 million based on damage estimates (Emerson Nafziger, Extension agronomist, University of Illinois at Urbana-Champaign, Personal Communication, 2007).

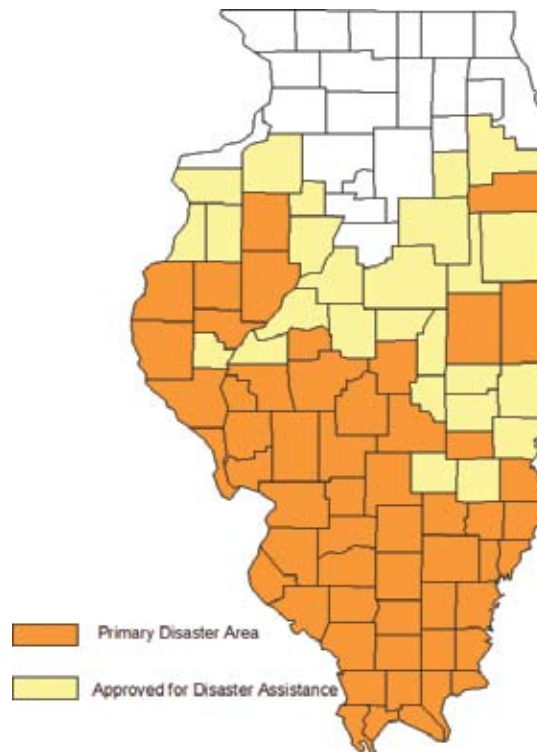


Figure 8. Illinois counties that were declared disaster areas or qualified for disaster assistance after the April 2007 freeze.

Corn

At the time of the freeze, corn planting in most of the state was just starting, and less than one percent of the acreage was planted as of the April 9 crop condition report. Some fields in southern Illinois were damaged, and some were replanted. While replanting occurred early and was followed by generally favorable weather over the next few weeks, the overall impact of the freeze on the corn harvest was unknown. Replanted fields possibly were more vulnerable to the drought that developed later in the growing season in southern Illinois (Emerson Nafziger, Extension agronomist, University of Illinois at Urbana-Champaign, Personal Communication, 2007).

Fruit Crops

While the April freeze severely damaged both peach and apple crops, the peach crop was hardest hit. Approximately 80 percent of the Illinois peach crop is grown south of Interstate I-64, a region with 100 percent losses from this event. The remaining 20 percent is grown in Calhoun County, and losses there were approximately 50-60 percent. Together, this resulted in an approximately 90 percent loss of the crop (Mosbah Kushad, Extension specialist in fruit and vegetable crops, University of Illinois at Urbana-Champaign, Personal Communication, 2007). According to NASS, the previous year's peach crop in Illinois was valued at \$13.8 million. Ninety percent of that amount equals \$12.4 million in losses from the April 2007 freeze.

The apple crop fared somewhat better. Only 65 percent of the apple crop is grown south of Interstate I-64. While that region experienced losses close to 100 percent from this event, the remaining 35 percent of the apple crop is grown across central and northern Illinois. Damage to the apple crop from the April freeze diminished northward because apple trees were not as far advanced in the colder climate. Damage reported in central Illinois was approximately 20 percent while none was reported in northern Illinois. Taken together, apple crop losses were approximately 70 percent (Mosbah Kushad, Extension specialist in fruit and vegetable crops, University of Illinois at Urbana-Champaign, Personal Communication, 2007). According to NASS, the previous year's apple crop in Illinois was valued at \$14.3 million. Seventy percent of that amount equals \$10 million in losses from the April freeze.

Combined losses from peach and apple crops were an estimated \$22.4 million. While damages in other fruit crops, for example, grapes, strawberries, blueberries, etc., also were likely, dollar amounts of these losses are unknown.

Forage Crops

According to NASS, Illinois had 400,000 acres in alfalfa and 330,000 acres in other kinds of hay, as of 2006. Media reports estimated that the April freeze may have reduced yields in the first cutting of alfalfa by 30-60 percent. Using an estimated normal yield of one ton per acre for the first cutting of alfalfa with an estimated value of \$100 per ton and 400,000 total acres, a 30 percent reduction equals a loss of \$12 million and a 60 percent reduction equals a loss of \$24 million. Losses to the remaining hay acreage are unknown (media reports of damages and Ray Wolfe, NWS, Personal Communication, 2007).

Losses in Other States

The April 2007 freeze was widespread across the Midwest and the Southeast. Agricultural damages were reported not only in Illinois but also in Alabama, Arkansas, Georgia, Indiana, Kansas, Kentucky, Missouri, North Carolina, Ohio, South Carolina, Tennessee, and Virginia. All these states had similar experiences: an abnormally warm March followed by a sudden drop in temperatures and high winds in early April.

Aggregate Losses

While an attempt was made to identify losses associated with the April freeze, not all losses are well documented, and additional losses could be significant. For example, wholesale nurseries and retail garden centers likely experienced losses in plant stock. Many homeowners suffered losses from fruit trees and damage or loss of weather-sensitive plants, shrubs, and trees.

Aggregating losses documented here yields estimated damages from the April 2007 freeze of \$146 million. This assumes losses of \$106 million (winter wheat), \$12.4 million (peaches), \$10 million (apples), and \$18 million (alfalfa). Note that the alfalfa total used is the middle range of estimated losses.

CONCLUSIONS

The April 2007 freeze and resulting damages were the result of several factors. Temperatures were 6.4°F above normal, and it was the sixth warmest March on record with many very warm days. The warmest period, March 21-April 3, 2007, was the second warmest such period since 1900. This was followed by very cold temperatures on April 4-9, and windy conditions. April 7, the coldest day of that period, had temperatures 21°F below normal. Temperatures in the lower 20s and upper teens occurred across the state during this period. The period of April 4-9, 2007, was the second coldest such period since 1900.

Winter wheat, peaches, apples, and alfalfa all had significant losses. Losses in other fruit and forage crops, and for nurseries and homeowners, were likely, but no dollar estimates could be made. Aggregating the available sources yielded a total damage estimate of \$146 million from the April 2007 freeze.

Spring freezes are part of the climate of Illinois. What made this event unique and so damaging was the combination of the sixth warmest March on record that led to early plant development, followed by a hard freeze in April, and the second coldest April 4-9 period on record. Combined with windy conditions during the freeze event, which foiled the usual protective measures, effects on vulnerable sectors of agriculture were devastating. While annual and seasonal temperature and precipitation have been the primary focus of most climate change and variability studies, this case serves as a reminder that shorter-term climate events also can have significant impacts. Their frequency, magnitude, and timing require closer study in the future.

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- Kunkel, K. E., S. A. Changnon, C. G. Lonquist and J. R. Angel. 1990. A Real-Time Climate Information System for the Midwestern United States. *Bulletin of the American Meteorological Society* **71**: 1601–1609.
- Office of the Governor. 2007. Gov. Blagojevich's Request for Agricultural Disaster Declaration Approved (<http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=1&RecNum=6022>, accessed June 2007).

APPENDIX. DETAILED METEOROLOGICAL MAPS OF APRIL 2007 HARD FREEZE

The primary focus of this report is on the general conditions and impacts of the April 2007 freeze event. Some readers may be interested in more specific meteorological conditions before, during, and after this event. Contained here are maps illustrating interesting features. Two Web sites provide a rich source of historical data for meteorological case studies. The first Web site (<http://www.hpc.ncep.noaa.gov/dailywxmap/index.html>) archives the weekly weather map series maintained by the NOAA NWS National Centers for Environmental Prediction, Hydrometeorological Prediction Center. The second Web site (<http://www.cdc.noaa.gov/cgi-bin/PublicData/getpage.pl>) is an interactive plotting and analysis service provided by the NOAA Earth System Research Laboratory.

Figures A-1 to A-4 represent conditions leading up to the April 2007 freeze. Figures A-5 to A-12 represent daily surface and 500 millibar features as the freeze event unfolded. Figures A-13 and A-14 summarize upper air circulation patterns found during the event. The daily weather maps represent the conditions at 7 a.m. Eastern Standard Time (EST) and show the surface analysis of pressure and fronts, the freezing line (blue dash), and areas of precipitation (green shading).

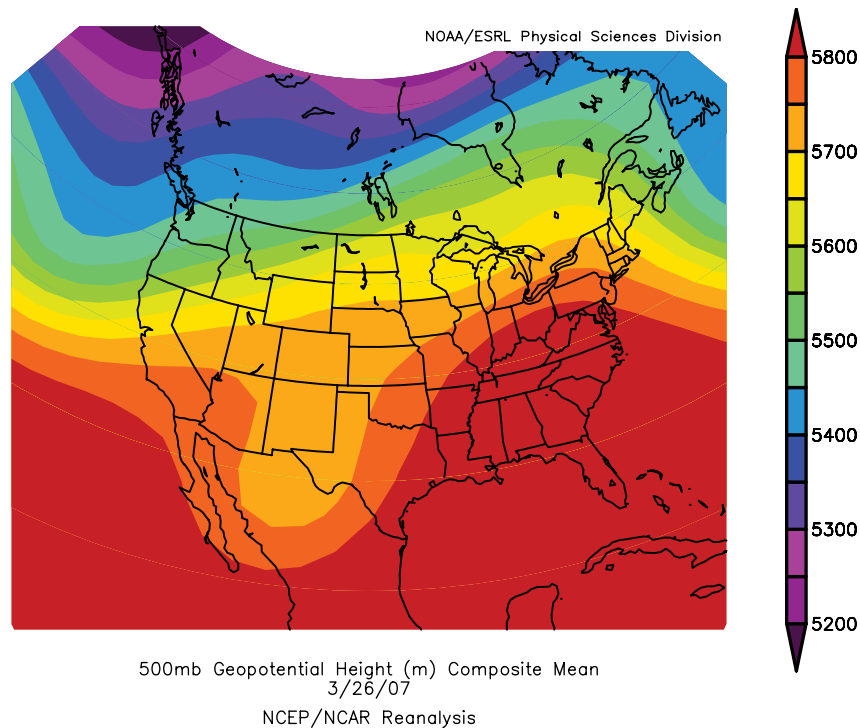


Figure A-1. Representing the upper air circulation pattern are the 500-mb heights in meters above sea level, 7:00 a.m. EST, March 26, 2007. Typical of March 2007, a trough of low pressure dominated the western United States while a ridge of high pressure dominated the eastern United States, allowing for the advection of both heat and moisture into the Midwest.

Source: NOAA National Centers for Environmental Prediction.

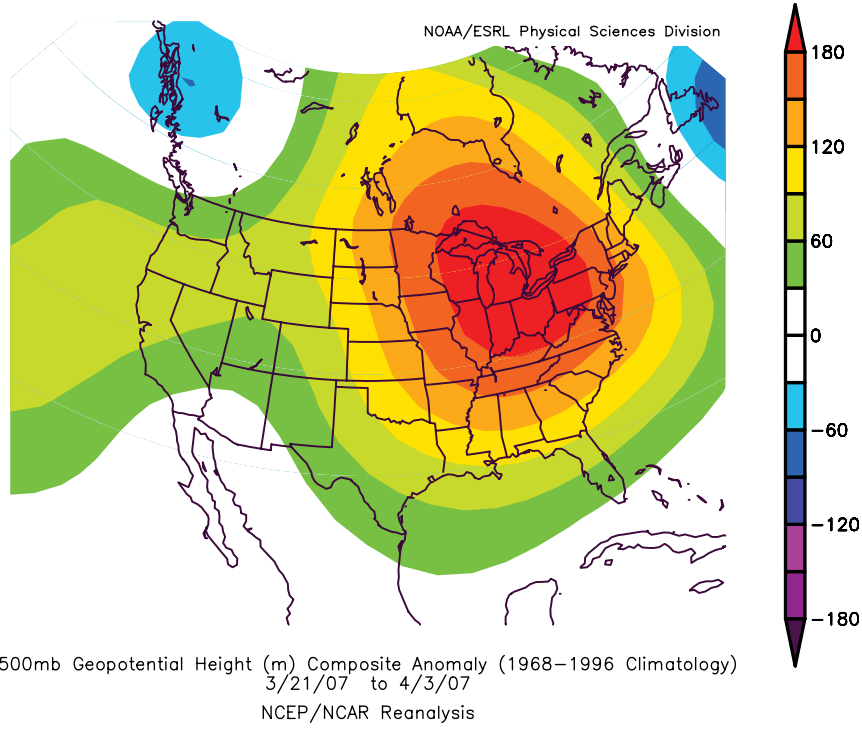
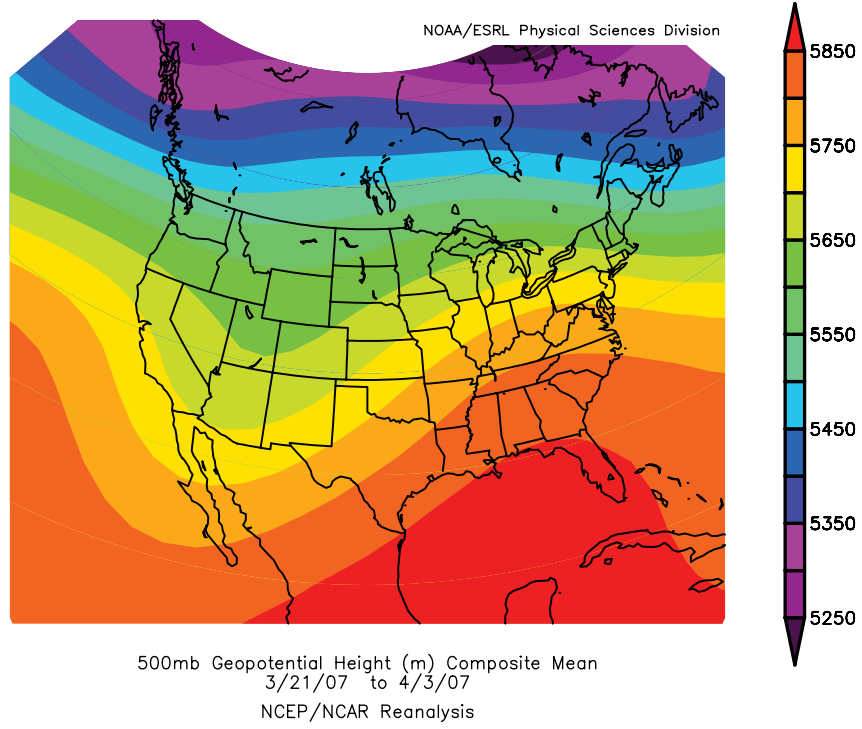


Figure A-2. Geopotential heights (top) and anomalies (bottom) in meters above sea level at 500 mb, March 21 – April 3, 2007, when the warming in Illinois was strongest.
Source: NOAA Earth System Research Laboratory.

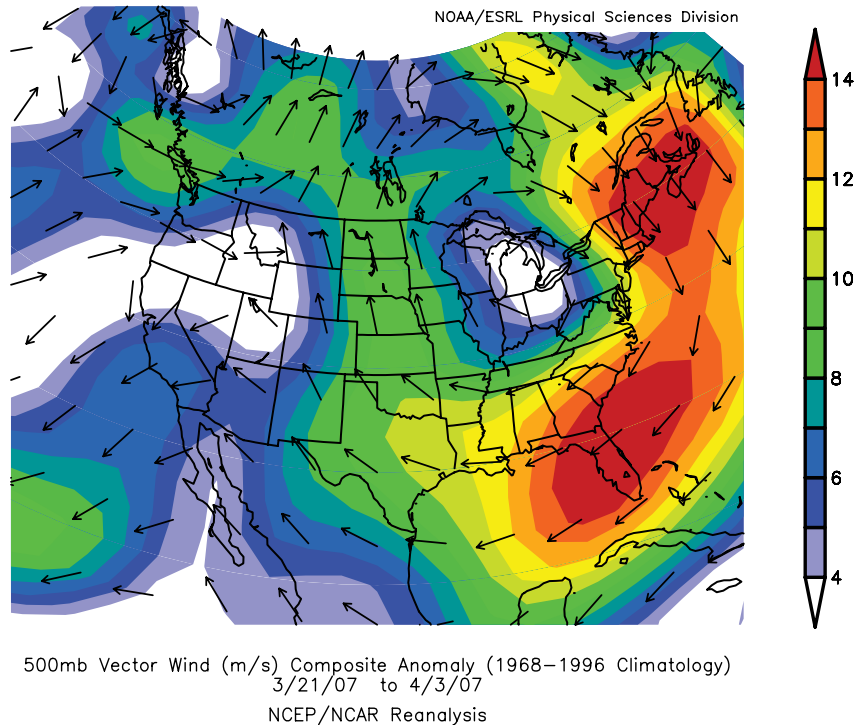


Figure A-3. Vector wind (m/s) anomaly (1968-1996 climatology) at 500 mb, March 21-April 3, 2007.
Source: NOAA Earth System Research Laboratory.

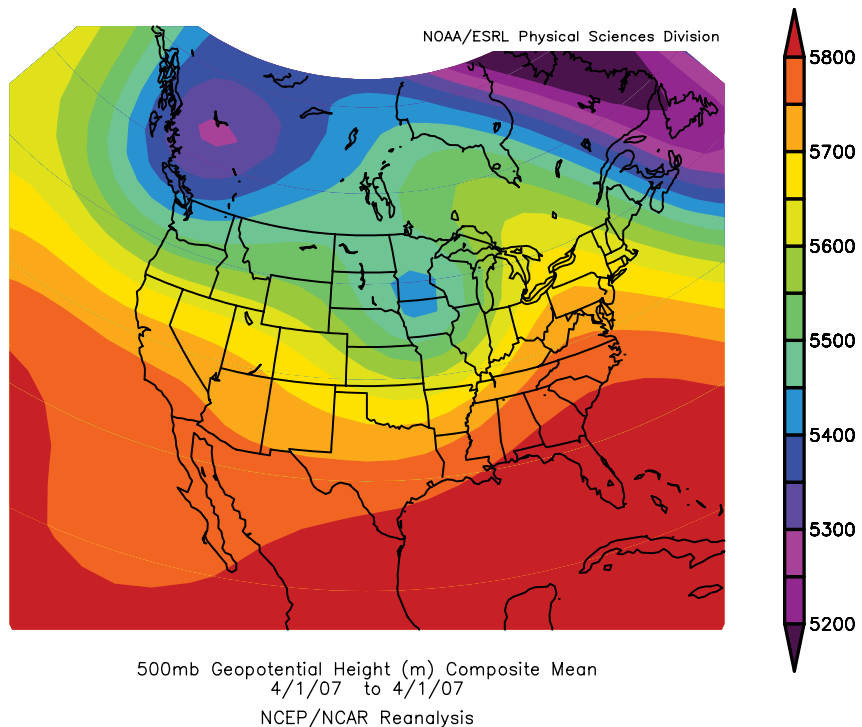


Figure A-4. Representing the upper air circulation pattern are the 500-mb heights in meters above sea level, 7:00 a.m. EST, April 1, 2007. At this point, the trough/ridge pattern that dominated in March 2007 is beginning to change, with the trough moving into the central United States and the ridge moving eastward. **Source:** NOAA National Centers for Environmental Prediction.

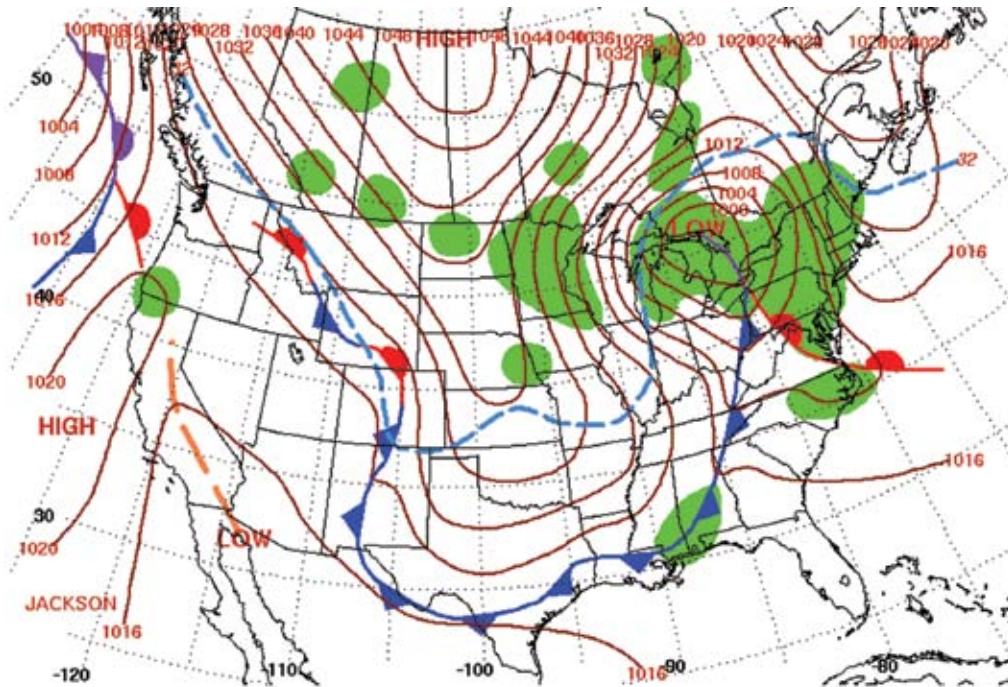


Figure A-5. Surface weather map, 7:00 a.m. EST, April 4, 2007.
Source: NOAA National Centers for Environmental Prediction.

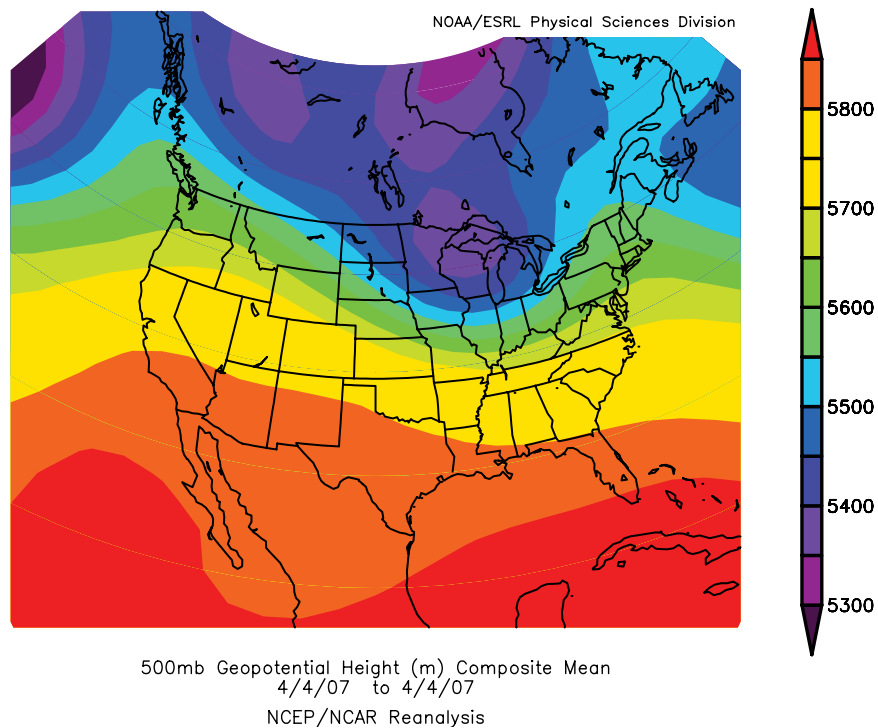


Figure A-6. Representing the upper air circulation pattern are the 500-mb heights in meters above sea level, 7:00 a.m. EST, April 4, 2007.
Source: NOAA National Centers for Environmental Prediction.

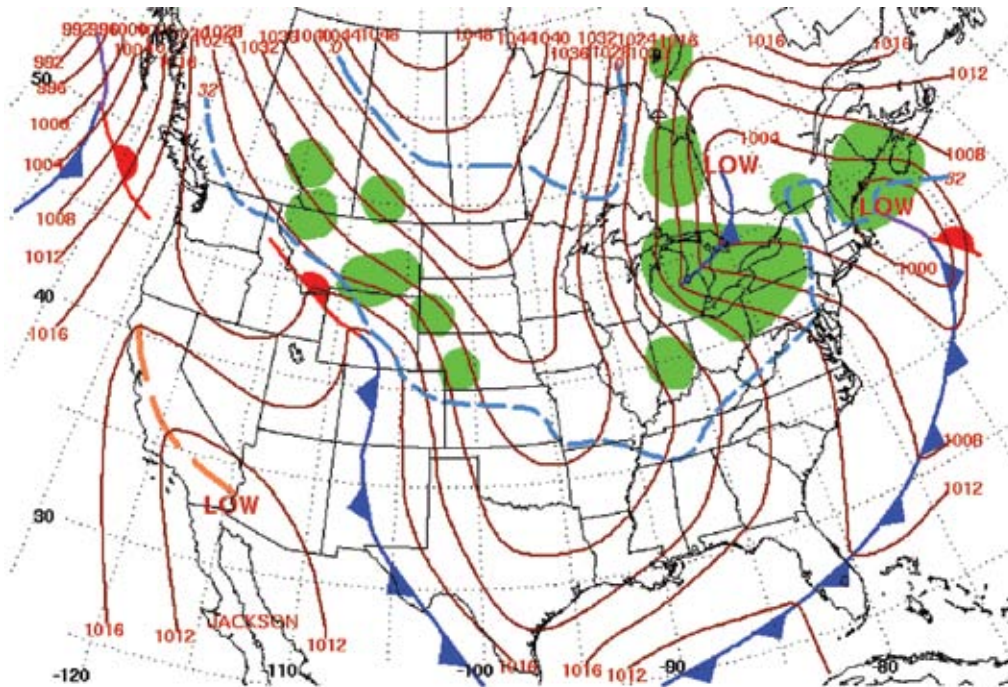


Figure A-7. Surface weather map, 7:00 a.m. EST, April 5, 2007.
Source: NOAA National Centers for Environmental Prediction.

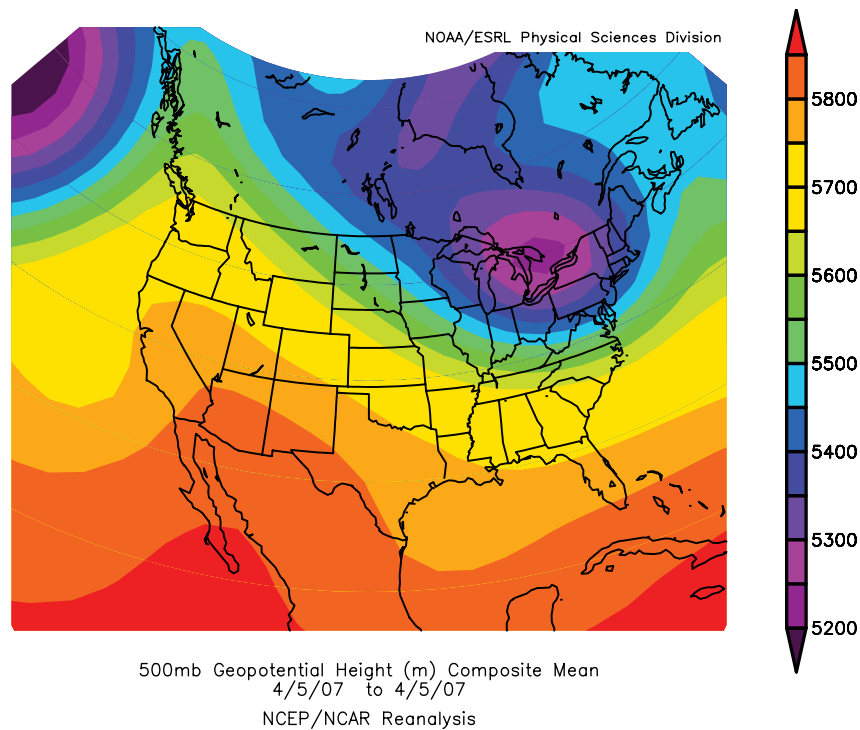


Figure A-8. Representing the upper air circulation pattern are the 500-mb heights in meters above sea level, 7:00 a.m. EST, April 5, 2007.
Source: NOAA National Centers for Environmental Prediction.

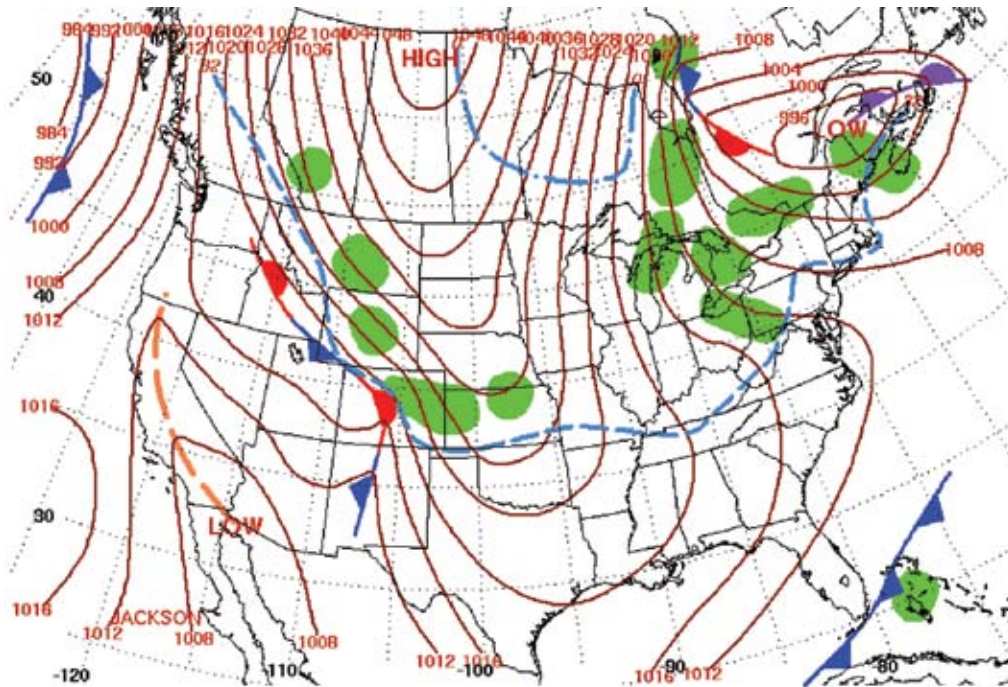


Figure A-9. Surface weather map, 7:00 a.m. EST, April 6, 2007.
Source: NOAA National Centers for Environmental Prediction.

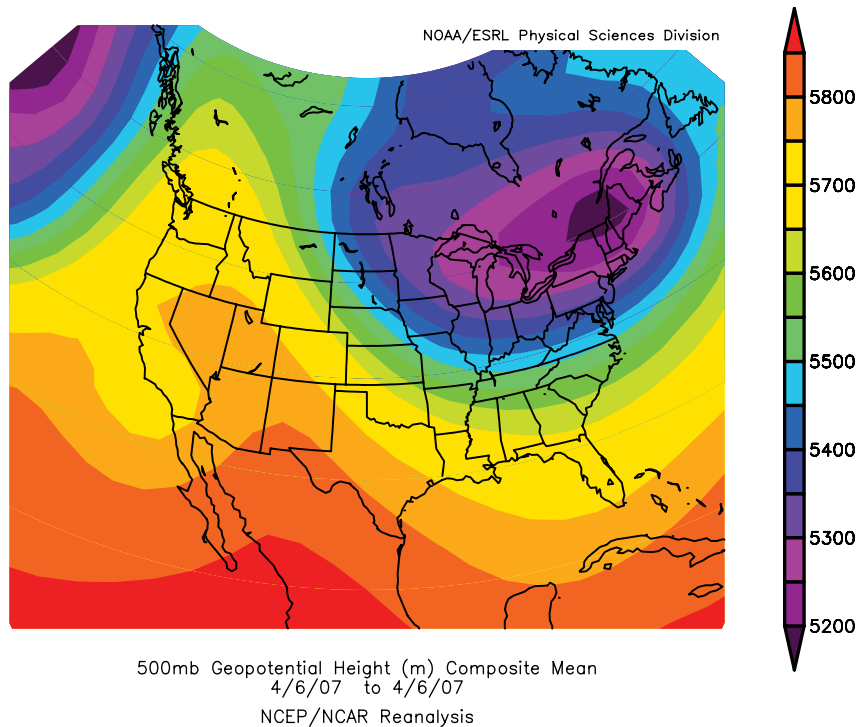


Figure A-10. Representing the upper air circulation pattern are the 500-mb heights in meters above sea level, 7:00 a.m. EST, April 6, 2007.
Source: NOAA National Centers for Environmental Prediction.

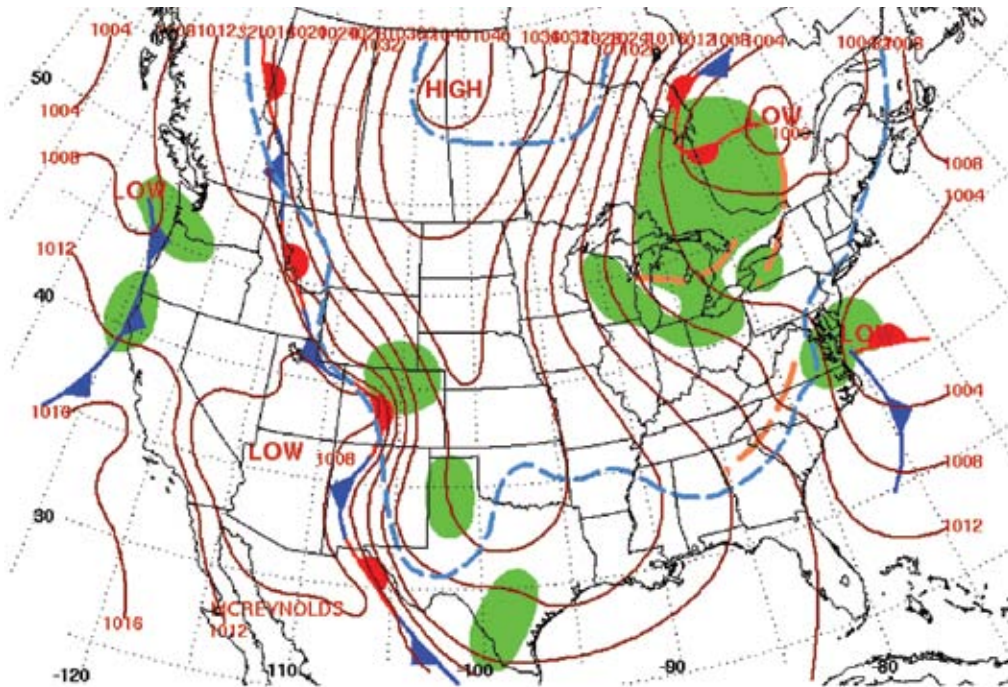


Figure A-11. Surface weather map, 7:00 a.m. EST, April 7, 2007.
Source: NOAA National Centers for Environmental Prediction.

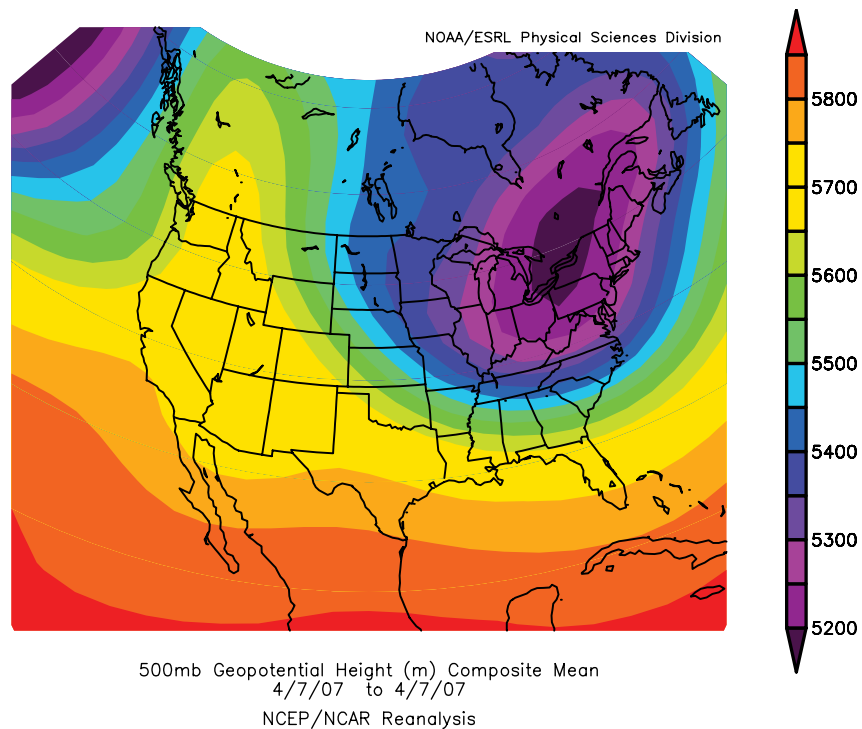


Figure A-12. Representing the upper air circulation pattern are the 500-mb heights in meters above sea level, 7:00 a.m. EST, April 7, 2007.
Source: NOAA National Centers for Environmental Prediction.

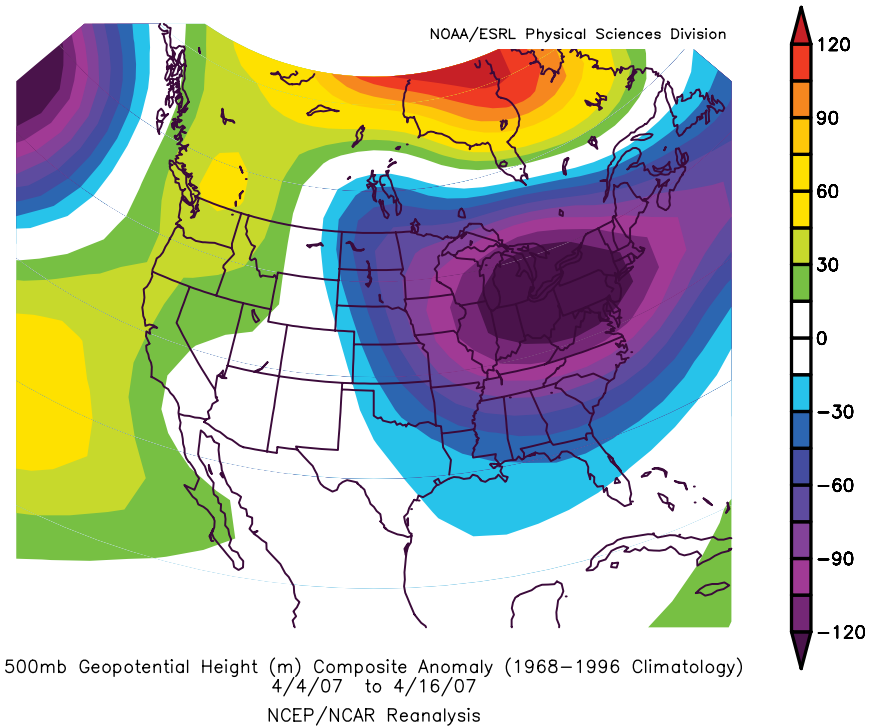
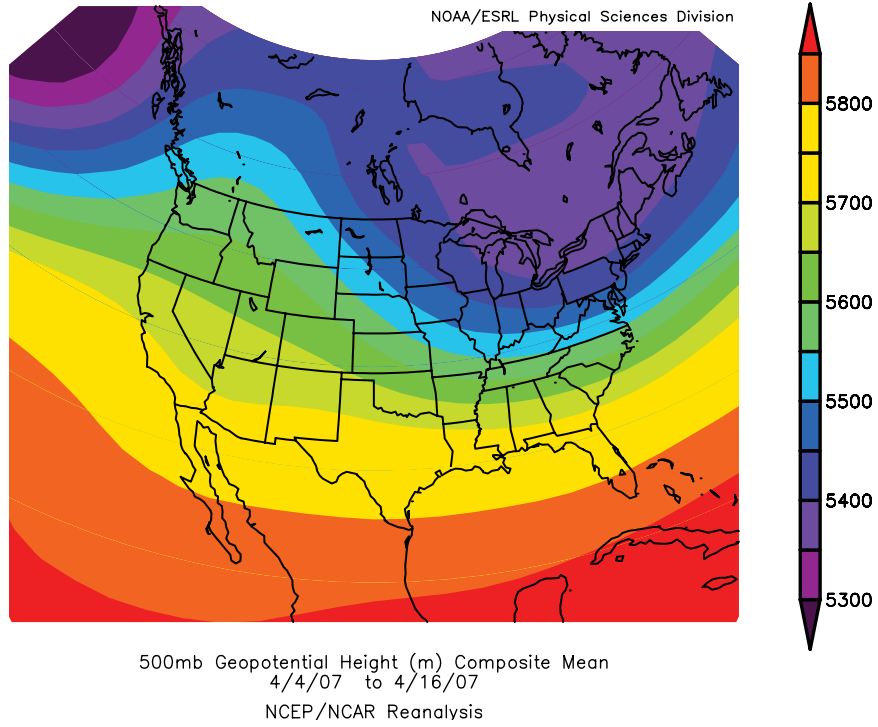


Figure A-13. Geopotential heights (top) and anomalies (bottom) in meters above sea level at 500 mb, April 4 – 16, 2007, when temperatures in Illinois were below normal.

Source: NOAA Earth System Research Laboratory.

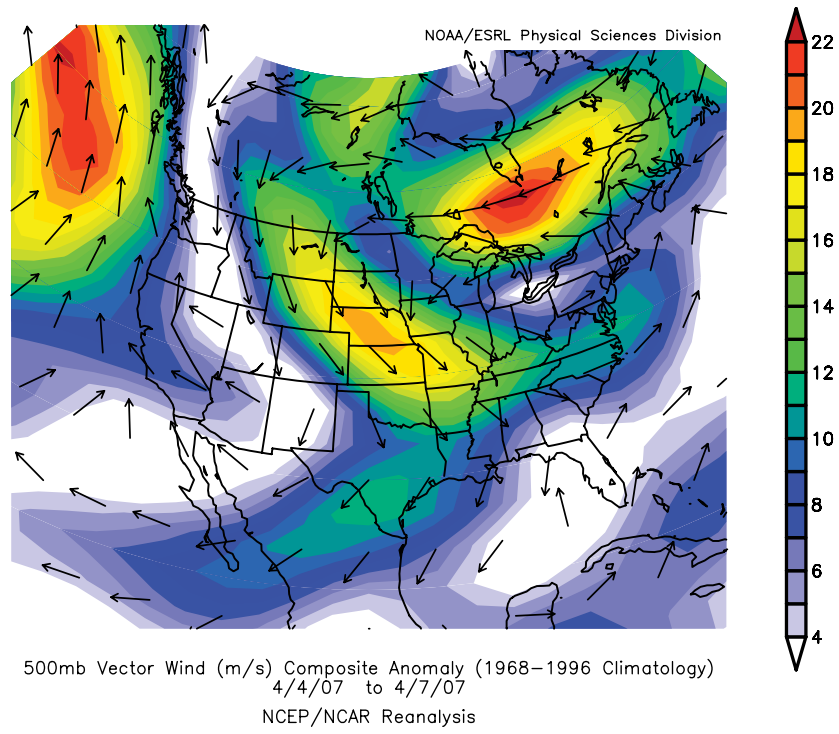


Figure A-14. Vector wind (m/s) anomaly (1968-1996 climatology) at 500 mb, April 4-7, 2007.
Source: NOAA Earth System Research Laboratory.

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