

GLOBAL CLIMATE CHANGE AND ILLINOIS

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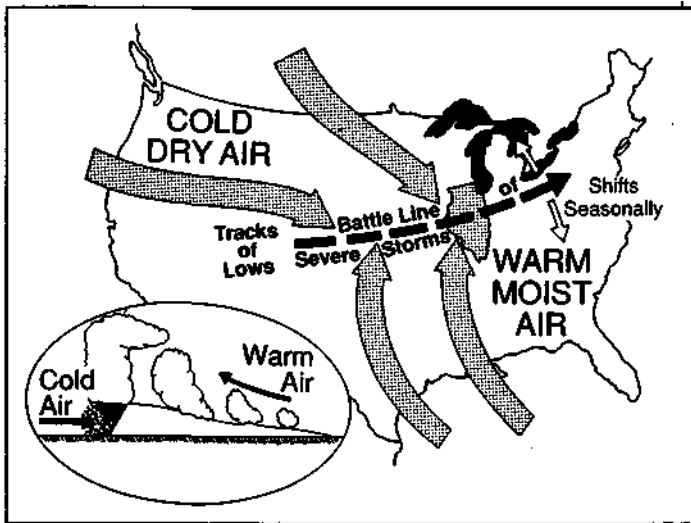
October 1991



GLOBAL CLIMATE CHANGE AND ILLINOIS

What controls Illinois' climate?

The climate of Illinois is greatly affected by the state's position in the middle of the North American continent, the third largest land mass on earth. The mountains in the western part of the continent are a formidable barrier to the prevailing westerly winds that circle the globe. But flat lands in the central United States permit air movement across the Midwest from both the



frozen lakes of northern Canada and the warm Gulf of Mexico. The shape, size, and surface topography of North America set the stage for Illinois' climate.

Up to six natural factors can interact to produce the climate, and five of them affect the Illinois climate. The most significant is solar energy. The considerable north-south length of Illinois brings about differential heating, with more warming in the south. The same differential heating characterizes the entire continent: it

is cool to the north and warm to the south. This affects air masses and leads to the development of major cyclonic storms over North America.

Mountains are the second climatic factor. Even the hills of extreme southern Illinois affect the region's local climate, making it somewhat cooler and rainier in the summer.

The oceans and their accompanying cold and warm currents are the third major climatic factor. The North Pacific Drift affects the continent's West Coast, the Gulf Stream affects the East Coast, and the Gulf of Mexico affects the central and eastern United States and Illinois in particular. The Great Lakes also affect the surrounding climates, including that of north-eastern Illinois.

Storms are a very active climatic control in Illinois. They result from major temperature and pressure differences in air masses that collide and produce much of our cloudiness and precipitation. Illinois storms include major winter cyclones and thunderstorms.

Air pressure over the continent and the adjacent oceans is the fifth climatic factor. Pressure distribution varies considerably due to major temperature differences over the continent and the oceans. These differences create the wind and air-mass patterns over Illinois and all of North America.

Warm, moist air from the south typically meets cold, dry air from the north somewhere over the central United States—often in Illinois. These continual air movements provide Illinois with an exceptional variety of weather extremes.

Weather events typical of Illinois' continental climate include droughts, floods, and every known form of severe weather. These extremes alternate with calm periods that may be sunny or cloudy.

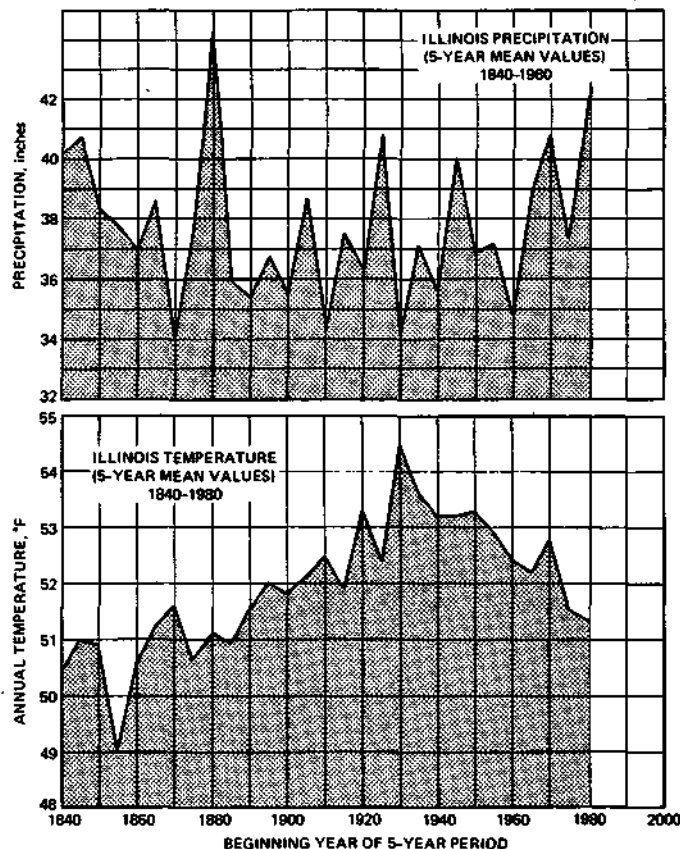
In recent decades we have discovered that major urban areas like Chicago and St. Louis also exert controls on the local climate. For example, the climates in and around large urban areas are warmer, windier, cloudier, and rainier than rural climates.

How does Illinois' current climate rate?

Measured over thousands of years, the current Illinois climate is relatively warm. About 160,000 years ago Illinois had a tropical climate with marshes and tropical vegetation. The ice ages of 10,000 to 100,000 years ago brought glaciers and tundralike conditions to Illinois. Much of northern Illinois was once buried under ice a mile thick. Thus, Illinois' past climates, like those around the world, have varied greatly. Our climate is always changing, shifting between warmer, colder, wetter, or drier conditions, with daily and yearly variability in the weather.

In the last 160 years Illinois' climate has shown interesting trends. A relative warming trend prevailed from the Civil War era until 1940, but temperatures have since become cooler. The state's precipitation since the 1940s shows a "see-saw" trend, with a series of alternating wet and dry periods, each ranging from 5 to 15 years.

Beginning in the late 1970s, the Illinois climate has shown a marked trend towards greater year-to-year variability with even more extremes. For example, three of the four coldest, stormiest winters on record in the last century occurred in the late 1970s (1976-77, 1978-79, and 1980-81). Then the state experienced a minor drought in 1980-81, followed by the five wettest consecutive years on record, 1982-86, and then two of the worst summer droughts on record, 1988 and 1991. Interspersed with these

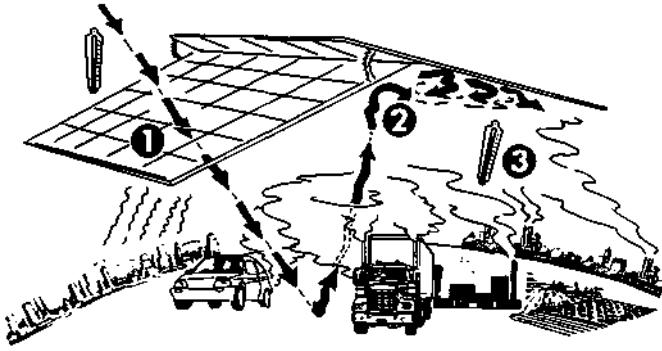


extreme annual events was a series of record low and high daily temperatures.

This "noisy" climate of the last 15 years and the great variability of the Illinois climate from season to season, year to year, decade to decade, and century to century has made it very difficult to detect major, long-term shifts in the climate. It is equally difficult to identify any human influences on climate, including those from the "greenhouse effect," other than what has been discovered around large urban areas.

What is the greenhouse effect?

The term "greenhouse effect" refers to the presence of certain trace gases in the atmosphere, which help keep the earth's temperature at a "livable" level. These gases are natural parts of the atmosphere, and their warming effect makes life on earth possible. Therefore, it can be said that we live in a "greenhouse" that encircles the globe to about two to three miles above its surface.



Carbon dioxide and other gases produced by industry and other man-made and natural sources accumulate in the atmosphere. These gases act like the glass panes of a greenhouse, letting in the sun's warming rays (1) and trapping the infrared energy that is radiated from the warming (2). As a result the air is heated (3).

The addition of more gases would tend to raise temperatures even more, causing the global climate to warm. As trace gases accumulate in the atmosphere, two things happen: they permit sunlight to pass through them and reach the earth, but they also trap some of the sun's warmth, keeping it close to the earth. Like the air inside a greenhouse on a hot summer day, the earth's atmosphere heats up. At a certain point, climatic changes will become apparent.

Excessive buildup of these trace gases is chiefly the result of human industry and agriculture. Carbon dioxide (CO₂) accounts for almost half of the accumulated trace gases and is a major factor in the global climate. The gas comes from the burning of fossil fuels (coal, gas, and oil) and increasing industrial growth and world population, all leading to ever-increasing demands for energy and natural resources. This has led to vastly increased consumption of fossil fuels and to the depletion of the world's forests. For example, the burning of coal and oil for energy is largely responsible for a 25 percent increase in atmospheric concentrations of CO₂ in the last century. Deforestation also

indirectly contributes to CO₂ buildup since trees and plants absorb major amounts of the gas to grow. Without them, CO₂ remains in the atmosphere.

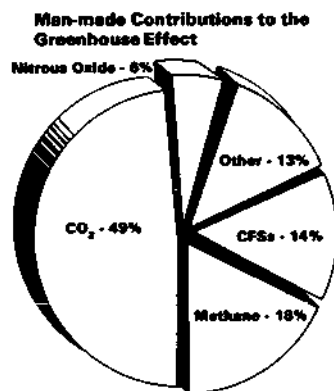
Methane, which accounts for 18 percent of the greenhouse gases, is generated by landfills, wetlands, animals, decaying plants, and underwater bacteria such as in rice paddies. Other major contributors to the greenhouse effect are nitrous oxide, which is emitted from autos, trucks, and chemical fertilizers; and chlorofluorocarbons (CFCs), which come from man-made chemicals used in refrigerants, air conditioners, and fast-food containers. The United States con-

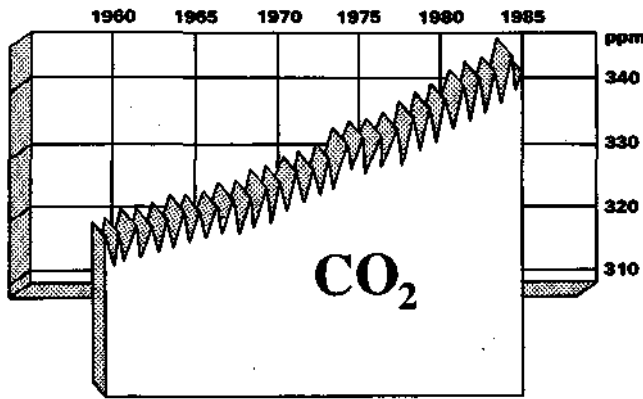
tributes about 25 percent of all the trace gases released to the atmosphere, and Illinois alone contributes 3 to 4 percent of all CO₂ emitted.

How do we estimate the impact of the greenhouse effect?

The greenhouse effect is a well accepted, documented process. The concentrations of trace gases in the atmosphere are increasing, and if they continue to accumulate at today's rates the earth's average surface temperature will likely increase. But no one can be certain *how much* it will increase, *when* or *how* the climate as a whole might react to these increases, or in what other ways our climate—and our environment—may change as a result of the buildup of more atmospheric gases.

Scientists can estimate how the greenhouse effect might influence our climate by using complex mathematical models of the atmosphere on supercomputers. These "global climate models" can calculate temperature, precipitation, relative humidity, cloudiness, winds, sunlight, and a host of weather variables at thousands of points on the earth's surface and at many levels rising above the earth. When more trace gases are simulated in these models, they indicate that the average global temperature would be 3 to 4°C (5 to 8°F) higher than today's temperatures.





Although they are the best tools we have for predicting climate change, these climate models are not without problems. They can simulate large-scale climate features, but they do not yet adequately represent regional features needed for making detailed climate projections.

Most scientists agree that a rise in temperatures will occur within the next century because of the added greenhouse effect. While this may not seem significant, consider this: in the ice age that ended 12,000 years ago, it was only about 9°F colder than today's average temperature. However, the global temperature increases that ended that ice age averaged only a few degrees over a *thousand* years. If the global models are correct and trace gases continue to build up, we could experience the same temperature change in less than a *hundred* years.

When estimating how additional heating could change the climate, we must project how much the greenhouse gases will increase in the future. For example, to estimate how much CO₂ will be added to the atmosphere, we must estimate such difficult factors as the amount of fuel emissions and the size of the populations using the fuel. We must also estimate how much added CO₂ will be taken up by the oceans, which is a major unknown. Thus, projecting future gas levels is difficult and controversial, but nonetheless critical. Only after making those determinations can scientists debate the effects of these gases on the earth's climate.

What could happen to our climate?

It is widely expected that global warming with surface temperatures 5 to 8°F higher will also change the wind patterns and ocean currents that determine climate. Global precipitation will generally increase, but when and where it falls will change. The frequency of extreme weather events such as droughts, hurricanes, and extremely hot days would also change in the mid-latitudes where Illinois is located.

Studies of the potential effects of such climate change reveal that all facets of agriculture, natural ecosystems, energy consumption, industry, transportation, and population distribution would be somehow affected. An expected rise in sea level would threaten coastal development and wetlands. Storm and flood damage to natural environments and to man-made structures would increase. Expansion of grasslands and deserts, the decline of forest ecosystems, more forest fires, and species losses could ac-

Estimated number of days temperature will exceed 100°F for selected U.S. cities by the middle of next century
(Number of days 100°F is now exceeded)

Washington, D.C.	12	(1)
Chicago	6	(0)
Omaha	21	(3)
New York	4	(0)
Denver	16	(0)
Los Angeles	4	(1)
Memphis	42	(4)
Dallas	78	(19)

company the warming. Some irrigation and hydroelectric projects would receive inadequate rainfall, while others would overflow.

Most current estimates suggest that important agricultural areas in the mid-western and southeastern United States would be warmer and drier during the growing season.

Changes in agricultural production and irrigation usage are likely to result

from higher temperatures, lower soil moisture, longer growing seasons, and modified rainfall patterns.

The greenhouse effect will not exert the same influence everywhere. The climate effects will be greatest at the North and South Poles, least at the Equator. Some areas will actually benefit from a climate change, but Illinois is not one of them.

What could happen in Illinois?

Changes in weather patterns and the hydrologic cycle brought on by climate change would have enormous implications for Illinois, affecting nearly every activity in the state. This is what could happen:



Climate. It is widely expected that a global climate change from added trace gases will mean a warmer climate for Illinois within the next 50 years. Winters will be warmer and so will summers, which will have more 90°F+ days. Future average summers will resemble the hot and dry summers of 1988 and 1991. The amount of precipitation may be slightly higher, but the seasonal amounts will shift: there will be less in the summer and more in the winter and spring. In addition, scientists now believe that even small global weather shifts could translate into more frequent, extreme weather conditions. This means that Illinois will experience more severe storms and higher winds.



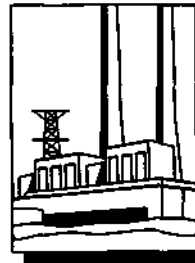
Water resources. Illinois hydrologic cycle will be changed as runoff patterns and river flows are altered, and quantities and locations of ground water change. A 2°F increase in the state's annual temperature coupled with a 10 percent decrease in its precipitation would cause a 25 percent reduction in the average annual runoff into river basins in some areas. In other areas, the wanner weather could alter spring runoff patterns by causing an earlier snowmelt, thus drastically intensifying flood conditions.



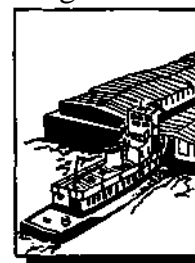
Agriculture. Higher temperatures, lower soil moisture, longer growing seasons, modified summer rainfall patterns, and increased CO₂ concentrations would mean an increased need for water, leading to more irrigation and shifts in crop production. As CO₂ concentrations increase, photosynthesis and

plant growth are enhanced but plant transpiration is reduced. The changes would modify vegetation patterns which, in turn, would alter the soil's ability to hold moisture, further changing runoff and water distribution.

If Illinois agriculture continues to rely on corn and soybean production, hardier species will be required. But they would be unlikely to match today's yields. It may be that cultivation of some crops will move to the more northern latitudes of the United States—or even into southern Canada. Illinois agriculture would most likely shift to more drought-resistant crops such as wheat. These changes will certainly impact the state's current position as an agricultural leader.



Energy. Energy users and producers are likely to face mixed consequences. A longer summer with many more 90°F+ days will mean a greater demand for air conditioning. Conversely, milder, shorter winters will mean a falling demand for winter heating. These changes in energy demand will require utilities to alter their production patterns. Utilities that depend on reservoir or lake water for cooling will also have to contend with less water and higher surface water temperatures.



Transportation. As recent droughts illustrated, less water in the state's hydrologic system means more frequent low flows in major streams and rivers. The transport of bulk commodities such as grains, petroleum, and coal on the Midwest's complex barge system may have to be greatly curtailed. This could mean more business for the region's railroads and Great Lakes shipping.

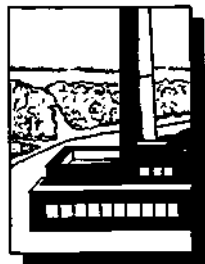


Natural resources. All natural resources in Illinois will be affected by a significant climate change. The rapid shift in climate of the magnitude suspected in 50 to 100 years could be devastating to many plant species that simply

could not adjust in time. For example, trees such as birches could not survive in the new warmer, drier climate and would likely disappear. Many wetlands and the life that thrives in and around them would also disappear. Entire ecosystems would change.



Society. People will also have to adapt—particularly those in urban areas—or move to more northerly climates. More than 80 percent of Illinoisans live in communities of 100,000 or more, including 7 million in the Chicago metropolitan area. A projected increase in summer temperatures of 5 to 8°F, coupled with temperatures above 90°F on two-thirds of all summer days, will make living and working in our metropolitan areas much more difficult, costly, and generally less pleasant



Business and industry.

Efforts to lessen the climate changes or curb the greenhouse effect through fuel conservation and reductions of trace gas emissions will influence all activities that emit trace gases, including industry and transportation. Regulations on the burning of fossil fuels and releases of CFCs and nitrous oxides will certainly be enacted as the climate changes. Adaptation to the climate changes may or may not be acceptable.

The Water Survey's Global Climate Change Program

The issue of climate change is critical to the life and economy of Illinois. In response to the serious questions it raises for us, the Illinois State Water Survey has established the Global Climate Change Program.

As the primary agency in Illinois concerned with water and weather resources, the Water Survey has a long history of expertise in climate research. For more than a century, the Survey has helped maintain climate monitoring stations throughout the state, measuring temperature,

precipitation, winds, storms, and much more. And the Survey is our state's record-keeper for weather observations that date back to the early 1800s. Altogether this information constitutes a valuable historic climate database needed to assess our climate and how it is changing.

The Water Survey's Global Climate Change Program coordinates research expertise and resources for a statewide approach to the possibility of climate change and how it will affect Illinois. Some research projects focus on the atmospheric processes involved in global climate change, others focus on how change will affect Illinois. Still other projects are studying past data to help determine the beginning of climate change.

Because Illinois' climate varies so much from year to year, better monitoring systems are essential to detect change. But this is difficult because short-term fluctuations mask the long-term trends that might indicate climate change due to global warming. Also, the climate is not stable—it has always shifted and fluctuated over decades and centuries. Thus, Water Survey scientists are experimenting with entirely new monitoring techniques, such as measuring ground-water temperatures deep below the earth's surface, which may detect trends difficult to find in air temperatures.

And as part of the Water Survey's public service mission to the state, scientists will also concentrate on the impacts of climate change on the people of Illinois. If CO₂ emissions must be reduced, Illinois industry and transportation would be greatly affected. If global warming occurs, our lives would change: life in our cities could become very difficult, and agriculture and energy production would also change drastically.

Our water resources are the key. What would Chicago be like if Lake Michigan were to shrink because water levels dropped 9 feet? How would 50 percent less flow in the Illinois or Mississippi Rivers affect agriculture and our historic riverside cities? The water resources contained in our rivers and lakes and in our vast subsurface aquifers are essential to Illinois.

Commercial shipping, water supplies, recreation, industry, and agriculture could all be very different only five decades from now.

The Global Climate Change Program at the Illinois State Water Survey will serve as a clearinghouse for scientific information. Members of the public, Illinois water resource managers, educators, government policy makers, and those involved in industry and agriculture are invited to contact the Water Survey for more information. □

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A Division of the Illinois Department of
Energy and Natural Resources

The Illinois State Water Survey was founded in 1895. It is the primary agency in Illinois concerned with water and atmospheric resources. Research and service programs encompass the assessment and evaluation of ground, surface, and atmospheric water resources as to quantity, quality, and use. Scientific research anticipates and reacts to practical problems in the state of Illinois. Much of the Survey's work is facilitated by an extensive database collected and developed over the course of a century.

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