THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON DETROIT, MICHIGAN

GLISA
GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

Key Challenges

Detroit is a city rich with cultural tradition. Surrounded by the beauty of the Great Lakes, it serves as a commercial, financial, and transportation center for the region.

Detroit will face many of the same changes in climate as the surrounding geographic area, but the city's specific vulnerabilities will be determined primarily by other factors. Land use, pre-existing infrastructure design, and socioeconomic capacity are among many characteristics that will either reveal strengths or pose obstacles in adapting to climate change.

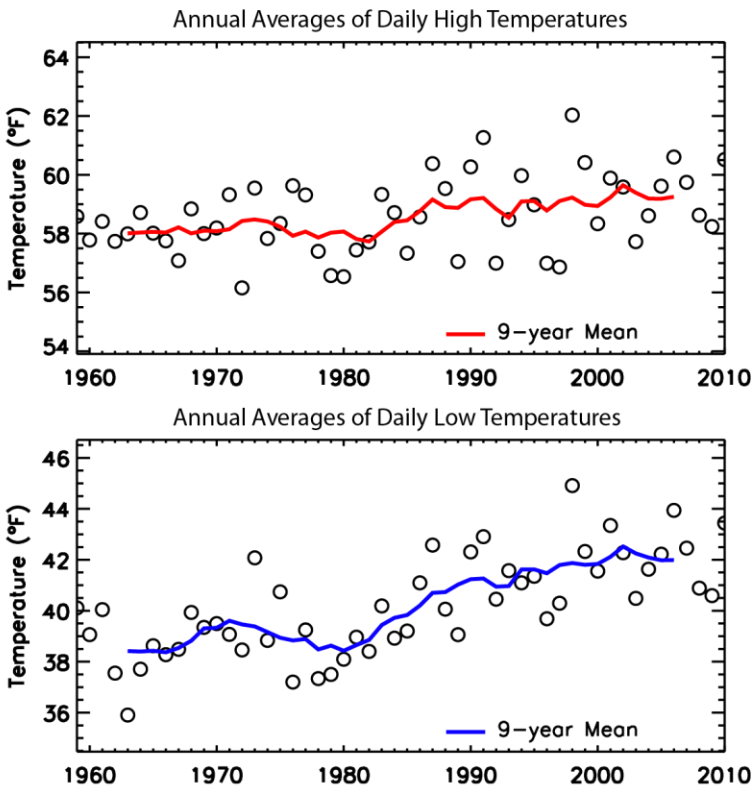
There are many potential impacts of climate change that cut across many sectors and jurisdictions. Detroit is expected to face the following critical challenges in the coming decades:

- ***As average temperatures rise throughout the region, the probability of heat waves and hot days will grow, increasing the risk of heat-related illnesses.***
- ***As severe rainstorms become more frequent and more intense, flooding will increase the risk of sewage overflows and water contamination.***
- ***Infrastructure will face challenges, such as direct damage due to weather and increasing demands for services during heat waves.***

Heat Waves and Hot Days

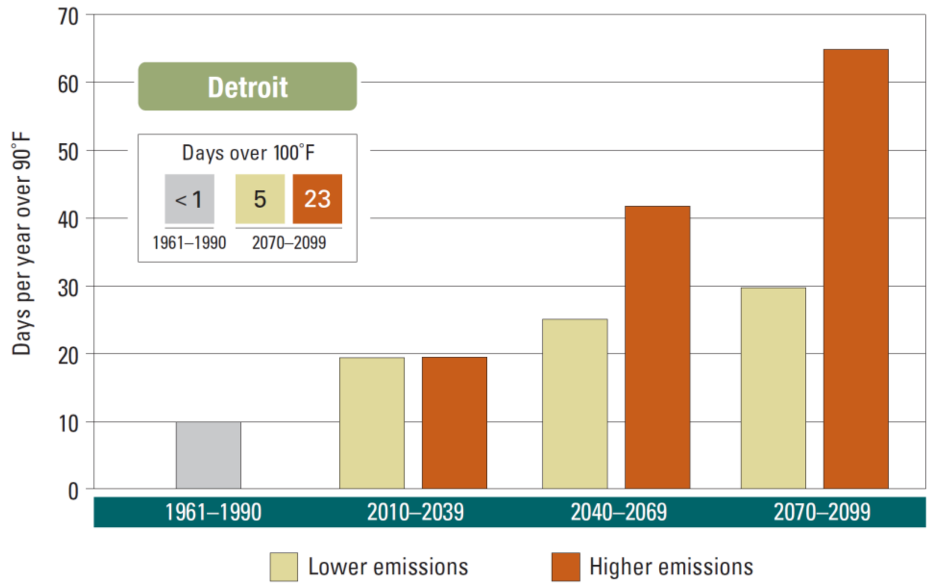
In Detroit, the 30-year average annual temperature increased by 1.4°F from the period 1961-1990 through the period 1981-2010. Most of this change has come from increases in overnight low temperatures (i.e., warmer nights), and from 1959-2011, average overnight temperatures on hot, dry days warmed 4.3°F.[1]

Small increases in average annual temperatures over time can greatly increase the probability of heat waves and hot days. The number of days per year with a high temperature above 90°F could increase from 15 at present to between 30 and more than 65 by the end of the century, while the maximum temperatures during those heat waves could rise as well.[2, 5]



Open circles represent the annual averages of daily high (top) and low (bottom) temperatures observed at Detroit Metropolitan Airport. Both have seen an increase since the 1930s, but overnight low temperatures have risen faster. Data source: NCDC, Station ID 94847.

By the end of the century, Detroit could face extremely dangerous heat waves multiple times per decade.[6] With more frequent, more intense heat waves, there is a greater risk of heat-related illness and death.



Detroit is projected to see a dramatic increase in the number of hot days exceeding 90°F (inset, 100°F), assuming current global greenhouse gas emissions trends continue (higher emissions). Assuming greenhouse gas emissions are significantly curtailed (lower emissions), the number of hot days will still increase but will be far fewer than under a high emissions scenario.[2]

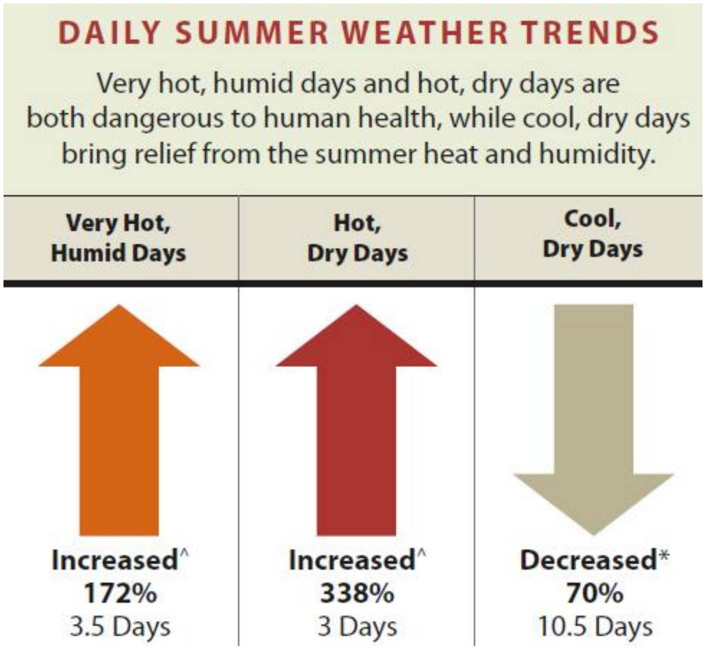
Heat-related Illness and Death

A number of factors raise the risk of heat-related illness in urban environments. People of lower socioeconomic status and people that live in areas of higher population density are at greater risk of exposure to extreme heat. In these neighborhoods, heat island effects amplify hot weather, vegetation tends to be sparse and provides little natural shade, and homes with air conditioners are less likely to be used.[7-10] These factors are all present in many Detroit neighborhoods.

Health conditions that can be triggered or exacerbated during hot weather range from mild heat-rashes to heat exhaustion, heatstroke, and death.[11, 12] Rising overnight temperatures during heat waves present the greatest risk for more severe illnesses, since residents are less able to find relief from sweltering temperatures.[13, 14]

Projected Deaths Each Year from Extreme Summer Heat	
2020-2029	255
2045-2055	291
2090-2099	701

The projected number of heat-related deaths per year for Detroit is expected to increase assuming a very high (A1F1) emissions scenario.[3]



The changing frequency of summer weather patterns from 1959-2011. A "^" denotes the trend was significant with 90% confidence. A "" denotes 95% confidence.*[1]

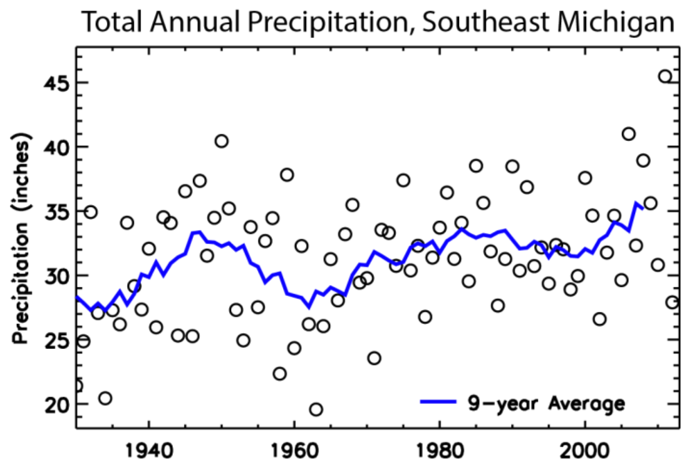
Air Quality

Ground-level ozone is a dangerous air pollutant and the main component of photochemical smog. Elevated ground-level ozone concentrations reduce lung function while aggravating heart and respiratory conditions. As ozone levels rise, so too does the number of hospitalizations for respiratory and cardiovascular conditions.[1]

The production of ground-level ozone is increased by the presence of local sources of fossil fuel emissions and by temperatures over approximately 90°F.[15] The Detroit area includes many such emission sources, and the region is projected to see an increase in the number of hot days that will increase ozone production. As a result, Detroit will likely see more days of unhealthy ozone levels than would occur in a world free of climate change.[1]

Another air contaminant of particular concern for Detroit is soot (small particulate pollution). Soot particles increase the severity of asthma attacks in children and increase the rate of heart attacks and hospitalizations.[1]

As temperatures rise and demand for electricity to run air conditioners increases, coal-fired power plants generate more soot. This feedback may amplify Detroit's existing air pollution and public health concerns.[1]



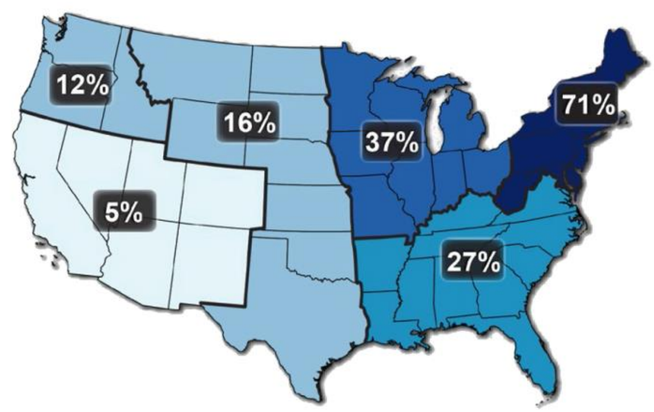
Total Annual Precipitation from Southeast Michigan, 1930-2013. Open circles represent annual totals. The solid blue line is the 9-year running average. Total annual precipitation increased by 9.5% from the 1961-1990 average to the 1981-2010 average. Data source: NCDC Michigan Climatic Division 10, nClimDiv dataset.

Precipitation

Southeast Michigan has seen an 11% increase in total annual precipitation from the 1961-1990 average to the 1981-2010 average.[16] Most models project that observed increases in total annual precipitation for the Midwest will continue. In most cases, summer precipitation is projected to increase only slightly or remain near present levels, while precipitation through the fall, winter, and spring are generally projected to increase.[17]

The form of precipitation will also change as winters become shorter and the climate warms. With higher winter and spring temperatures, more precipitation will fall in the form of rain rather than snow.[18]

If greenhouse gas emissions continue to increase at the current rate, Michigan is projected to see roughly half the number of snowfalls each year as compared to the 1961–1990 period.[2] This may bring some cost-saving impacts to the Detroit area, as snow-removal operations will likely become less intense, and roads may be salted for a shorter period each year.



The Midwest and Northeast have seen dramatic increases (37% and 71%, respectively) in the amount of rain falling in the heaviest 1% of precipitation events from 1958 to 2007.[4]

Throughout the region, the frequency and intensity of extreme storms has been increasing.[19-21] For

Southeast Michigan, the annual number of extreme 7-day precipitation events has increased since the 1930s, and heavy rains are twice as frequent now than a century ago.[2]

In the larger Midwestern and Northeast regions, the intensity of the heaviest 1% of precipitation events as increased by 31% and 67%, respectively, from 1958 to 2007.[22]

Flooding and Stormwater Management

An increase in the number and intensity of severe storms may further expose Detroit's existing vulnerabilities in stormwater management and water quality.

The majority of stormwater runoff from Detroit is directed through the city's combined sewer system which uses a single drainage network to transport waste from residences, industries and businesses along with stormwater drainage. During dry weather and periods of low precipitation, the combined sewers transport the flow to wastewater treatment facilities. During intense or prolonged periods of wet weather, however, the flow can exceed the treatment and transportation capacity of the sewer system, and combined sewage is released into the Detroit and Rouge Rivers at permitted locations.

An increase in multi-day and heavy rain events across the Midwest states has already been observed, leading to more stormwater management problems.[19-21] With more intense and more frequent severe storms, Detroit will see more combined sewage overflows, increasing the risk for waterborne disease outbreaks when untreated sewage is released into surface water.[23]

Impervious surfaces, such as paved parking lots, exacerbate stormwater issues by channeling flows into concentrated areas. As expanses of impervious surfaces are neglected and abandoned, high-volume flows become less predictable and more difficult to manage. In many cases degrading surfaces may inadvertently direct stormwater away from the appropriate drainage systems.[24]

Flooding occurs throughout the year in Detroit. More intense storms, lake level changes, and decreased shoreline ice cover can increase flood risks. Mild and nuisance flooding often occurs following moderate periods of precipitation and snowmelt events, while more severe inland flooding is caused primarily by intense, localized thunderstorms, usually during the spring and summer.[25]

In portions of the city that border the Detroit River, Lake Erie, or Lake St. Clair, high lake and river levels along with easterly winds produce conditions for flooding. Some of the most damaging floods on record have occurred as a result of this combination. Severe flooding occurred along the shoreline in 1954, 1973, 1985, and 1986. In March and April, 1985, high lake

A combined sewage overflow plume in the Detroit River. Credit: Robert Burns, Detroit Riverkeeper

Lake Erie algal bloom, Oct. 20, 2011. Warmer lake surface temperatures conspire with nutrients from runoff and combined sewer overflows to exacerbate toxic algal blooms and raise public health concerns. Photo courtesy of NASA.

waters of Lakes Erie and St. Clair were driven ashore, damaging more than 1,300 homes and causing about $2 million in damages in several communities, including the Charter Township of Brownstown, the Cities of Ecorse, Gibraltar, Grosse Pointe, Grosse Pointe Park, the Township of Grosse Ile, and the northeastern portion of the City of Detroit.[25]

Throughout the year, projected changes in the timing, form, frequency, and intensity of precipitation could amplify existing inland flooding risks. During periods of high water levels, shoreline areas will remain particularly vulnerable.

Water Quality

Flooding leads to more erosion and greater chances of overloading sewage systems, both of which reduce water quality in lakes and rivers, and increase the risk of waterborne disease.[21, 23, 24] Faster moving flood waters during severe storms transport more pollutants farther, often resulting in more severe localized flooding. In Detroit, as in many Midwestern cities, direct property damage is often avoided by either allowing flood water to collect in less sensitive areas or by diverting it through combined sewage systems

In combination with agricultural and urban runoff, sewage overflows that are released into the Detroit River and eventually Lake Erie severely compromise water quality, leading to beach closures and public health warnings. In the future, warmer surface water temperatures may conspire with increased runoff to produce conditions ripe for more toxic algal blooms, oxygen-depleted “dead zones”, and fish kills.[23]

Future land use changes could have a far greater impact on water quality than climate change.[24] Proper land management and natural resources conservation can alleviate the increased risks to water quality from climate change, but other land use changes could also amplify the negative impacts.

Roadways in the Upper Midwest are susceptible to freeze-thaw damage in the winter months (left) and expansion buckling during summer heat (right). Changes in winter impacts to roads are uncertain, but damage from heat may be more probable with an increasing number of hot days. Photos: AP

Impacts to Transportation Infrastructure

There is a wide array of concerns about the impacts of rising temperatures and more extreme precipitation on transportation infrastructure.[26, 27] Although little research has focused directly on the effects of climate change on roadways in the Great Lakes region, damage to paved surfaces, including expansion buckling during extreme heat events, softening of asphalt, and increased stress on bridge joints will become more probable as the number of extremely hot days increases.[28] With increasing precipitation and stronger storms, flooding risks to roadways are also a concern. The impacts associated with cold-weather events, such as freeze-thaw damage, remain largely unstudied.

In the Great Lakes region, marine shipping is of particular concern as it carries large implications for industrial productivity throughout Southeastern Michigan and Northern Ohio.[29] Projections of Great Lakes lake levels continue to receive scrutiny, and it is unclear if lake levels will continue their observed decline in recent years.[30]

If lake levels do continue to decline, ships may have to reduce their capacity, and if lake levels rise, river velocities in the connecting channels could increase, making navigation more difficult.[23, 31] The potential impacts are not entirely negative, however, as a shorter winter and less Great Lakes ice cover may effectively extend the shipping season. Under extreme emissions scenarios and greater warming, year-round shipping may become possible.[32, 33]

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