Climate of Ohio

Introduction

This publication consists of a narrative that describes some of the principal climatic features and a number of climatological summaries for stations in various geographic regions of the State. The detailed information presented should be sufficient for general use; however, some users may require additional information.

The National Climatic Data Center (NCDC) located in Asheville, North Carolina is authorized to perform special services for other government agencies and for private clients at the expense of the requester. The amount charged in all cases is intended to solely defray the expenses incurred by the government in satisfying such specific requests to the best of its ability. It is essential that requesters furnish the NCDC with a precise statement describing the problem so that a mutual understanding of the specifications is reached.

Unpublished climatological summaries have been prepared for a wide variety of users to fit specific applications. These include wind and temperature studies at airports, heating and cooling degree day information for energy studies, and many others. Tabulations produced as by-products of major products often contain information useful for unrelated special problems.

The Means and Extremes of meteorological variables in the Climatography of the U.S. No.20 series are recorded by observers in the cooperative network. The Normals, Means and Extremes in the Local Climatological Data, annuals are computed from observations taken primarily at airports.

The editor of this publication expresses his thanks to those State Climatologists, who, over the years, have made significant and lasting contributions toward the development of this very useful series.

State and Station Normals are available at:
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Climate of Ohio

Topographic Features- Ohio has a rich and varied climate. Exposed equally to air from Canada and the Tropics, daily weather can change dramatically and a wide range of extremes often occur at some point in each season. Northern counties experience a variety of Lake Erie-induced weather and climate effects, and the northeastern counties experience a snowy winter as good as any occurring elsewhere in the country. The hilly southern and eastern portions of the State produce subtle local effects on weather and climate, and the vast flat to rolling terrain in the west and north provides endless vistas of the sky and weather.

The nearly 41,000 square miles of Ohio's surface are a testament to earlier ice-age climates that ended roughly 8,000 years ago. Kelleys Island, in Lake Erie, possesses the largest assortment of easily accessible glacial remnants visible anywhere in the world, at Glacial Grooves State Park. Hocking Hills State Park in the southeastern hills best represents geological terrain that remained unglaciated throughout the geologically recent two million-year era of periodic North American glaciations. The highest point in the State, east of Bellefontaine, lies at the site of merger of two lobes of glacial ice, nearly 2000 feet thick, protruding southward from the main Laurentide ice sheet some 20,000 years ago. The ice lobes were centered over western Ohio, extending past Dayton, and over central Ohio. They deposited huge amounts of rock, sand and stone glacial debris, called moraine, onto the large area around Bellefontaine that separated the tongues of ice. As the ice retreated over several centuries, the moraine debris remained and lies beneath the vegetated relatively high topography of that area. North of Bellefontaine glacial moraine deposits alternate with progressively larger lacustrine deposits made in what were once glacial lakes. The largest of these is an extensive area of early Lake Erie that extended far to the southwest of its current basin boundaries. The glaciers also shaped the flow of modern Ohio streams and rivers. The Scioto River for example forms on a hill of glacial moraine debris and immediately flows downward onto a topographically depressed and flat floor of a former glacial lake. It thereupon rapidly acquires more water from nearby creeks and tributaries, slowly wending its way southward toward the Ohio River.

Temperature- The climate of Ohio is continental, characterized by a relatively large range of seasonal variability with cold winters and warm, humid, summers. It is affected by warm maritime tropical air masses that bring summer heat and humidity but which also produce occasional mild winter days. Hot and dry air masses periodically envelop the State and produced the State's record high temperature of 113 degrees Fahrenheit (° F) on July 21, 1934. The State is also frequented by cold dry continental polar air masses that bring cool and bright summer days and very cold winter days. Extraordinarily cold Arctic air masses, originating in Siberia, occasionally cross the Arctic Ocean and Canada bringing bitterly cold air to Ohio and many other states; leading for example to Ohio's lowest minimum temperature of -39° F, reached most recently on January 22, 1994. The State is affected by wave cyclones, or mid-latitude storms, many of which originate in Alberta, Canada, Colorado and the western Gulf of Mexico. "Alberta clippers" frequently sweep southeastward across the Great Lakes in most months of the year, carrying relatively small amounts of precipitation. In winter they bring Ohio several inches of snow if they move on a track south of Lake Erie. Colorado/Texas panhandle storms move northeastward toward the western Great Lakes from October through April and bring unseasonably warm weather to Ohio, occasional thunderstorms and frontal precipitation. Most Gulf of Mexico storms sweep across the southeastern states during the colder months and travel along the United States' east coast, affecting Ohio minimally with light precipitation. On rare occasions however, a Gulf of Mexico storm will proceed northward, remaining west of the Appalachians. These storms often bring copious amounts of moisture into the State which, when lifted over cold air penetrating the western flank of the cyclone, produce heavy snows. This was the origin of a late-January 1978 blizzard, the most extraordinary storm of this type to strike Ohio during the 20th century.

Mean annual temperatures vary across the State, ranging from about 55° F in the southernmost areas near the Ohio River to 49 in the northeast hills. This south to north variation extends through each season. In January, the mean temperature in southern Ohio approaches 30° F while it is near 25 in the north. Daytime high temperatures in January average above freezing over most of the State except in the northwest. Summer temperature variability is lower. Daytime highs average 84 to 86° F in the western part of the State while overnight lows range from 62 to 66° F. Only in northeastern Ohio are temperatures a bit lower, with highs of 80 to 82° F and minima of 58 to 60° F. Lake Erie plays a considerable role in keeping mean temperatures lower in coastal northeastern Ohio during the spring and early summer.

The calendar dates of the last spring and first autumn freezes define the length of the growing season. The freeze-free period in Ohio ranges on average from 160 days in northern Ohio, away from Lake Erie, to 180 days in the southern portion of the State. In an extreme case, when a late spring and early autumn freeze may occur in one year, the freeze-free period may be reduced to 125 days in the north and 155 days in the south. A widespread and severe late-season freeze from May 19 to 22, 2002 reminded Ohio growers that it is safest to consider the start of the growing season as some time after May 20 in most parts of the State. Lake Erie has a beneficial effect on the freeze-free season, from the standpoint of agriculture, extending the average growing season to as much as 200 days in coastal areas. It does so by moderating cold outbreaks occurring in late spring or during autumn.

Although relative humidity is the best-known measure of the moisture content of the air, it is also the most misleading. The word "relative" refers to the ratio between actual moisture content of the air and the maximum moisture content possible given the current air temperature, expressed as a percentage. The maximum possible water content of the air, in the denominator of the ratio, is larger for higher temperatures. Thus relative humidity is relative to the time of year and even to the time of day, since temperature often varies with a diurnal cycle, but it is always inversely proportional to air temperature. A 75 percent relative humidity, which is approximately the statewide average through the year, represents the fact that the actual moisture content is currently 75 percent of maximum achievable given the current temperature. In this circumstance, there is much more moisture in the air during summer than during winter. Relative humidity near sunrise in Ohio, often the coldest part of a day, ranges from nearly 80 percent in winter to about 90 percent in summer, while late afternoon values are near 55 percent in summer to 70 percent in winter.

Dew point temperature is a widely reported measure of actual moisture content of the air. Unlike relative humidity, dew point will not change as dramatically during the course of a day, simply because air moisture content typically does not change unless a front or other weather system passes through. Dew point temperature is always lower than or equal to the air temperature, and the magnitude of the difference between it and the air temperature is an estimator of the relative humidity. During summer, dew points will exceed 70° F on the most humid days, while a humid winter day has dew points that are nearly identical to the air temperature, often near or below freezing. A dry Ohio summer day has dew points of 55 to 62° F while dry winter days can be characterized by extremely low dew points. Both situations reflect the fact that there is much more moisture in the air in summer compared to winter.

Fog represents a major restriction to transportation and there is some seasonality to its occurrence in Ohio. Heavy fog, in which visibility is under ¼ mile, peaks in occurrence in September and October over much of the State, and then again in January. Frequencies may reach three days per month in autumn to two days in winter. A relative heavy fog minimum occurs in April and May. Winter advection fogs are often induced by warm southerly air flowing over snow covered ground. Ground fog, also called radiation fog, is in contrast caused by extensive nighttime cooling on clear nights after rainy weather, especially during the longer nights of autumn. A notable exception to this distribution occurs near Lake Erie where fog frequency peaks in winter and has a minimum in summer and autumn.

Ohio is one of the cloudiest places on the planet during winter months, an unfortunate distinction given the fact that it earns none of the accolades for such a climate as are enjoyed by places such as England or Iceland. The long-term average cloudiest Ohio month is December, when sunshine is received only about 30 percent of the time. Generally between 20 and 22 overcast days occur in that month, while only three to six days are clear and the remainder partly cloudy. Conditions improve slowly from that point and Ohio enjoys a broad June through September peak in sunshine and relatively cloud-free conditions, each month receiving slightly more than 60 percent of maximum possible sunshine. July holds a slight advantage among these four months with fully six to eight clear days, 11 to 13 partly cloudy, and the remainder nearly or fully overcast. Although spatial variations are subtle, the western portion of the State has more clear days on an annual basis, and effects brought about by Lake Erie induce slightly higher cloud conditions in coastal counties in autumn but fewer clouds in spring.

Precipitation- Ohio's climate is favored with an abundance of precipitation throughout the year, brought about by two primary atmospheric mechanisms. Precipitation from October through March occurs due to mid-latitude wave cyclones traversing the country while the remainder of the year experiences varying amounts of convective thunderstorm rainfall. The dual mechanisms ensure a constant supply of moisture, some precipitation usually falling on one day in three. Each month averages at least two inches of rainfall, although none average more than five inches. The driest months are October and January/February with just over two inches, while the wettest extend from April through July having just over four inches. The statewide annual average is about 38.15 inches since 1895. The State's mean value has ranged from 26.59 inches in the drought year 1930 to 51.36 inches in 1990. Annual precipitation ranges from 32 to 42 inches across the State, with larger amounts in southern Ohio, which lies closer to the Gulf of Mexico moisture source region. One exception to this pattern occurs in the extreme northeastern counties where lake effect precipitation creates a relatively wet local climate, inland of the lake shore, from August through December that leads to an annual total around 40 to 42 inches.

Ohio winter snowfall ranges from under 16 inches in the southern counties to around 35 inches at Toledo in the northwest, to over 90 inches in the extreme northeastern counties where lake effect snowfall dominates. The northeastern snow maximum begins in the eastern suburbs of Cleveland, where over 40 inches fall in a typical year, extending eastward to a mean of 94 inches at Chardon. Lake effect snow starts with moisture evaporating into cold, dry air moving southeastward from Canada across Lake Erie. As the air moves inland from the shoreline, additional physical processes assist in producing uplift that generates copious amounts of snow. In particular, land-induced frictional drag on the moisture-laden air forces it upward leading to more precipitation (snow) development as the air continues farther inland. The process is further accentuated by forced uplift of the air as it rises from about 580 feet above sea level at Lake Erie to as much as 1200 to 1400 feet above sea level in the northeastern hills. These collective uplift processes cool the humid air and create more condensation and snow formation. In one remarkable spell of weather from November 9 to 16, 1996, Chardon received 47 inches of snow and Kirtland-Holden had 56.7 inches. The most snow in 24 hours is 20.7 inches at Youngstown on November 24 and 25, 1950. More recently, Portsmouth received 18.5 inches in 24 hours on January 16 and 17, 1994. Areas of northwestern Ohio may occasionally be subjected to lake-effect snow originating over Lake Michigan.

Evaporation from the ground is a direct function of the overlying air temperature. Consequently, a large amount of the precipitation that falls on Ohio is evaporated from the soil and water surfaces during the period from March through October, coinciding with the period of maximum sunshine and cloud-free conditions. While measurement of evaporation is only done in a limited number of places, typical Ohio values range from around 30 inches in the southeast near the Ohio River, increasing to just over 34 inches in the northwest. Since Ohio's average March to October precipitation averages about 27.5 inches, the State develops some degree of soil water shortage each growing season. In relatively wetter summers this water deficit is either absent, due to an abundance of rainfall, or is met through groundwater withdrawal. However, in drier summers, vegetation will experience varying degrees of water stress due to water shortage, including such physiological effects as decreased growth, leaf curling, wilting or discoloration. Supplementation of water by irrigation is a potential, albeit expensive, solution that is not as widely employed in Ohio as it is in the much drier Plains states.

Drought can take a devastating toll on the normal agricultural abundance of Ohio and it also affects water supplies, stream flow and water recreation. Ohio drought tends to develop during spring and summer months and it is most likely ameliorated in autumn and winter when cyclonic storms become more intense. Drought occurs an average of two times per decade, occurring in 1901, 1904, 1924 - 1925, 1930 - 1931, 1934 - 1936, 1940, 1952 - 1954, 1962 - 1965, 1988, 1991 - 1992, 1999 and 2002. The droughts of the 1930s were the worst in terms of agricultural damage and societal impacts, followed by the protracted 1952 - 1954 drought. The 1988 drought was unusually severe but it lasted only four months, ending in statewide flooding, and it ended a long (23 year) drought-free period in Ohio's climate. The driest 12-month period on record, from April 1930 through March 1931, only experienced a statewide mean precipitation of 21.93 inches.

Floods in Ohio occur due to the combination of excessive precipitation and wet saturated ground, a combination that can occur any time of year but most typically in winter and early spring. In spring, these two factors occasionally combine with snow melting to produce unusually severe conditions. In summer, wet weather leading to flooding can occur during a period of continual wave cyclone and frontal passages. More commonly, highly localized flooding is produced over hilly terrain by thunderstorm cells continually rebuilding over one area within a period of a few hours. This situation occurred during the June 14, 1990 Shadyside, Ohio, flood when topography and slow upper level winds helped anchor thunderstorms over the headwaters of Wegee and Pipe creeks. Most flooding occurs with relatively rare high precipitation events that greatly exceed climatic normal, assuring that streams cannot be contained within their banks. The January 1937 flood on southern Ohio rivers was associated with six to 12 inches of rain over a ten-day period, falling within the climatological ten-day-event 100 year recurrence interval of nine to 10 inches. The March 1997 floods in southern Ohio occurred when three to eight inches of rain fell in four days, whereas the 100-year recurrence interval for this time span is about seven to eight inches. Ohio is occasionally subjected to tropical cyclone remnants, such as that of Frederick in September 1979, which brought four to five inches of rain over large parts of the State within a 24-hour period. This amount is precisely the climatological 25-year recurrence interval for a 24 hour rain event of about 4.5 inches.

The primary wind direction over much of Ohio is from the southwest, as measured at National Weather Service sites at larger cities. Some variability occurs but most weather stations report long-term average winds from a direction between south and west-southwest. The wind can blow from any direction on any given day however, primarily due to Ohio's location with respect to the position of large high pressure areas and storm systems that are continually moving across the continent. The average daily wind velocity around Ohio is approximately nine mph. Wind velocity varies however by season and location, being faster in winter than in summer and faster in the northern half of the State than in the southern in any given season. Specifically, higher velocities average 12 mph in winter in the north while lowest speeds are six to eight mph in summer in the south. High wind gusts typically occur in conjunction with wave cyclones, and with spring and summer thunderstorms. Sustained high-wind velocities associated with winter and early spring wave cyclones passing north of Ohio create windy days that make March and April a great time for kite flying. Some stations around Ohio have long-term high wind gusts that are still under 60 mph, but the peak wind gust on record at Toledo reached 75 mph (from the southeast) in an August 1988 thunderstorm. Winds in thunderstorms associated with tornadoes and straight-line winds have exceeded 200 mph in Ohio for very brief moments in time and over very small areas. No Ohio weather station however has ever come within close proximity to these storms in order to register an official peak wind gust exceeding 75 mph.

Because of the prominence of convective weather during the warm season, Ohio is subjected to thunderstorm-induced severe weather. The dominant damage comes from the occurrence of hail, tornadoes and high winds. Hail damage is relatively localized and random across the State, but causes extensive agricultural and property damage a few times per year. About 700 tornadoes have occurred in Ohio since 1950, many causing relatively small amounts of damage and having winds less than 110 mph. Tornado frequency has ranged from no tornadoes during the 1988 drought year to 61 in 1992. Most tornadoes occur from April through July, although they have been observed in every month of the year at one point in time or another. They have been observed at all hours of the day or night, but their climatologically preferred time of occurrence is late afternoon or early evening. Geographically, tornadoes are least likely to occur in southeastern Ohio, where a combination of hilly terrain and comparatively sparse population reduce the number of events and sightings. Although Ohio ranks 21st in the nation in number of tornadoes, it ranks ninth in the number of tornado deaths. Killer tornadoes, though relatively rare, have still resulted in about 340 Ohio deaths since 1916, and have produced much of the property damage associated with all tornadoes. The high death and destruction totals in these tornadoes are due to the high winds often in excess of 110 mph that can peak above 200 mph. The most notorious storms have included the Sandusky-Lorain tornado of 1924 that killed 85, the Palm Sunday outbreak in 1965 that killed 57, and the Xenia tornado that killed 37 in 1974. The relative infrequency of extremely severe tornado weather occurs because of Ohio's geographic location away from the dry line and Great Plains low level jet, which make tornadoes much more frequent in the Plains states.

Ohio is, however, right at the climatological heart of the national peak in thunderstorm high wind events, those exceeding 50 knots (58 mph) that primarily occur in midsummer months (July and August). High wind events come in a variety of observed forms. Straight lines winds occur in severe thunderstorms, more often than not accompanying tornadoes. These comprise relatively few of Ohio's high wind events however. More common are the high winds accompanying thunderstorm squall lines. Squall line thunderstorms are typically wind producers, less often are they tornado-producers. Some line storms begin to bulge or bow, forming bow (arc shaped) echoes on weather radar. Another common feature linked to wind events is the line echo wave pattern which is comprised of a bow echo with a northeastward extending line of echoes typically associated with high winds and hail.

Public awareness of the effect of El Niño and La Niña on United States weather and climate has grown in recent years, and Ohio is not immune from their impact. El Niño is a warming of the equatorial Pacific Ocean and La Niña a cooling of the ocean, and both affect the atmospheric circulation and jet streams over the United States, especially during winter. Based upon the long-term climate record since 1895, there is little consistent impact from El Niño and La Niña on Ohio's winter temperature, nor that of any other season. El Niño's such as those of 1982 - 1983 and 1997 - 1998 have been associated with mild Ohio winters, but so have some La Niña events (e.g., 1998 - 1999). The 1976 - 1977 El Niño was associated with Ohio's coldest winter on record, and the El Niño in winter 2002 - 2003 was unusually cold. The biggest impact from the equatorial Pacific in Ohio is instead on winter precipitation from December through March. Ohio El Niño winters are almost always drier than normal while La Niña winters tend to be wetter than normal. The dryness leading up to an El Niño winter may occur to a lesser degree during the preceding summer and autumn, as the event begins to unfold, thereby potentially affecting the growing season. The wet La Niña winters are characterized by repeated incursions of slow moving, and even quasi-stationary, cyclones and frontal systems across the Mississippi and Ohio River valleys producing high winter precipitation amounts. Statewide, precipitation is especially affected by these events in the southern and central portions of the State, and much less so in the north or the northeast where the lake dominates winter precipitation processes. Winter precipitation totals in the south may not vary by more than six inches between the dry El Niño and wet La Niña events, but Ohio stream flow is more notably affected. Often the river flow during La Niña winters is double that of El Niño events and this effect continues downstream along the Ohio and Mississippi rivers.

One of the greatest public concerns regarding the future is whether global warming will have an impact on Ohio climate and economic growth. Global warming is thought to be a result of continuing anthropogenic emissions of carbon dioxide, produced by fossil fuel consumption and deforestation. Methane (produced by animals) and nitrous oxide (car) emissions are also likely causes. It is possible that the effects of global warming are becoming noticeable in Ohio. For example, six of the 14 winters between 1990 and 2003 have fallen within a group comprised of the warmest 20 percent of winters since 1895. Ohio mean temperature, when averaged annually for all months of the year, shows a similar pattern. Six years between 1990 - 2002 (1990, 1991, 1998, 1999, 2001 and 2002) are among the warmest 20 percent since 1895, and 1998 has the distinction of being Ohio's warmest year on record. Four summers in between 1990 and 2003 were among the warmest 20 percent of all summers. Ohio's very warmest summers continue to be those of the 1930s, wherein 1931, 1933, 1934 and 1936 fall among the warmest 20 percent. However, modern summers are making inroads on this record. Recent Ohio summer precipitation also exhibits considerable variability. Four summers (1990, 1992, 1997 and 1998) fall among the wettest 20 percent of summers since 1895 while the drought summers of 1991, 1999 and 2002 and among the driest 20 percent. These Ohio climate patterns are typical for other parts of the eastern United States, an area of our planet that had not shown much evidence of global warming prior to 1990. Although there is still a possibility that the recent warming trend is just part of natural climate variability, the regions of the world where climate is cooling are diminishing. Numerical models of the atmosphere have suggested that the enhanced greenhouse effect will cause a warming of at least two to five degrees by the end of the 21st century, producing reductions in summer precipitation throughout central North America. In combination with lower precipitation, higher future temperatures would be associated with increased summer evaporation and more frequent summer drought. The increased maximum potential moisture content of the warmer future climate will lead to lower relative humidity. Snow will become less frequent in winter, although warmer Ohio winters have in the past tended to be relatively wetter winters with frequent rainfall.

Climate and the Economy- Ohio, by virtue of its location and prevailing atmospheric conditions, is a water rich State. This provides endless opportunities for people both in commerce and agriculture as well as for recreation. The State boasts 74 state parks, 34 with marinas and 60,000 miles of streams. Lake Erie lies along 262 miles of its northern border and the Ohio River spans 436 miles of the southern border. A great beneficiary of Ohio's water rich environment is agriculture. Corn and soybeans are the top Ohio crops, followed by dairy products, greenhouse and nursery products. Ohio leads the country in egg and cheese production and ranks among the top State producers of flowers, especially poinsettias. Other crops include: winter wheat, hay, tomatoes for processing, apples, grapes, sweet corn, mushrooms, maple syrup and more. Ohio also harvests and exports a significant amount of its hardwood forests in the southeastern hills.

<u>Internet Climate and weather sources for Ohio</u>

http://www.erh.noaa.gov/iln/ National weather service office at Wilmington, OH www.erh.noaa.gov/cle National Weather Service Office at Cleveland, OH

www.oardc.ohio-state.edu/centernet/weather.htm Automated weather stations operated by the Ohio Agricultural Research and Development Center at Wooster, OH

www.bestplaces.net/html/climateus1.asp For climate profiles of Ohio and U.S. cities

http://mcc.sws.uiuc.edu The Midwestern Climate Center

http://thoth.sbs.ohio-state.edu/faculty/rogers/statclim.html State Climatologist for Ohio