CLIMATE CHANGE IN THE GREAT LAKES REGION: PAST, PRESENT, AND FUTURE

Derek Winstanley
Illinois State Water Survey, Champagne, Illinois

Dr. Derek Winstanley, Chief of the Illinois State Water Survey, provided valuable information about the regional texture of past climate, climate change, and climate variability in the Upper Great Lakes region. He presented information, which illustrated that while global temperatures may have risen in the last 100 years by 0.5 °C, not all regions have exhibited the same trend, and that the trend, even in regions where temperatures have increased, is certainly more complicated than a simple monotonical increase. For example, Figure 1 shows that in the Upper Great Lakes region, the mean annual temperature for the region does not exhibit any long term (e.g., multi-decadal) trends over the last 100 years[1]. In fact, what are more apparent than net changes over the last 100 years are the trends that last a decade or so, as well as the interannual variability.

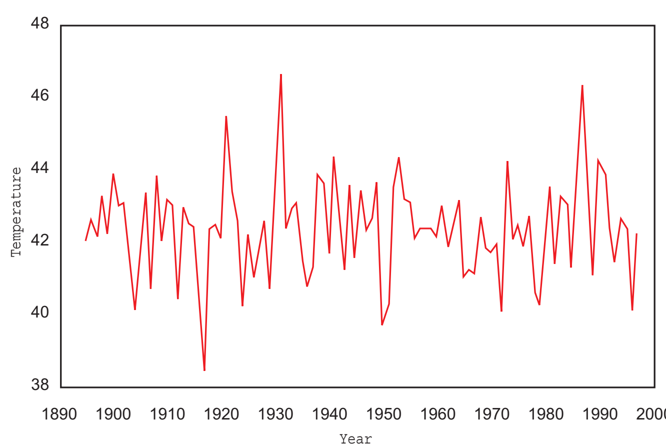

Figure 1: Annual mean temperature (ºF) for Minnesota, Wisconsin, and Michigan.

[1] *If only stations with filtered records (e.g., adjusted for station displacements, etc.) are included then the regional trend exhibited a 1-2º F increase.*

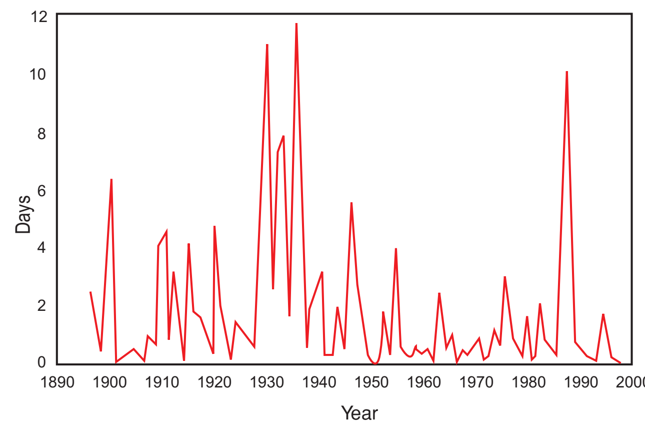

Figure 2: Number of days per year above 95°F for Minnesota, Wisconsin, and Michigan.

Temperature extremes across the region also have not shown a distinct trend over the last 100 years. Figure 2 shows that regarding heat waves, there have been only two years since 1950 where there have been more than four days with temperatures above 95 °F, while there have been ten such years between 1900 and 1950.

The high incidence of hot days is consistent with the distribution of three-day heat waves during the last century. Eleven of the fifteen greatest heat waves occurred between 1931 and

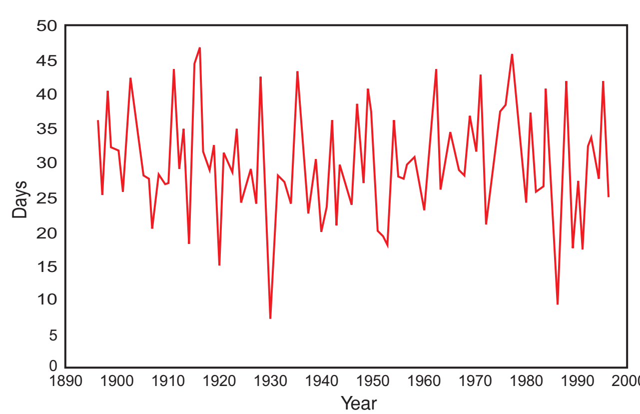

Figure 3: Number of days per year below 0°F for Minnesota, Wisconsin, and Michigan.

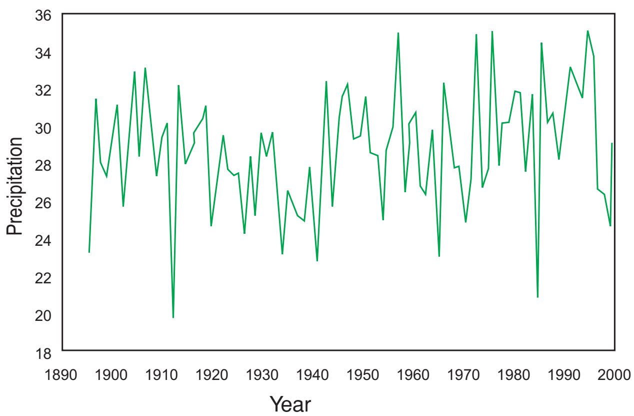

Figure 4: Average annual precipitation for Minnesota, Wisconsin, and Michigan.

1948. The great heat wave during the summer of 1995 ranks only 12th (out of 15) in terms of intensity.

Cold waves also have not shown any consistent trend over the last 100 years. The number of days per year where temperatures dropped below 0 °F decreased between 1910 and 1930 but increased between 1930 and 1980 (cf. Figure 3). First fall freeze dates, which are important from an agricultural standpoint, also have not changed - although last spring freeze dates have come earlier by about ten days since 1960.

Dr. Winstanley noted that precipitation (change) in the region is a much different story than temperature. Figures 4 and 5 show that while winter and spring precipitation for the region show no long-term trend, summer and fall precipitation does. Specifically, summer precipitation shows a decline from 1900 to the 1930s, an increase from the 1930s to the mid 1950s, a decrease from the mid 1950s to the mid 1960s, and then a gradual increase from the mid 1960s to the present. Fall precipitation shows more or less steady precipitation from 1900 to 1940, and then a slow increase from 1940 to the present. Figure 6 shows that the number of extreme precipitation events (as defined by events > 3.0 inches) has cycled over a period of about 40 years. Figure 7 shows that snowfall has

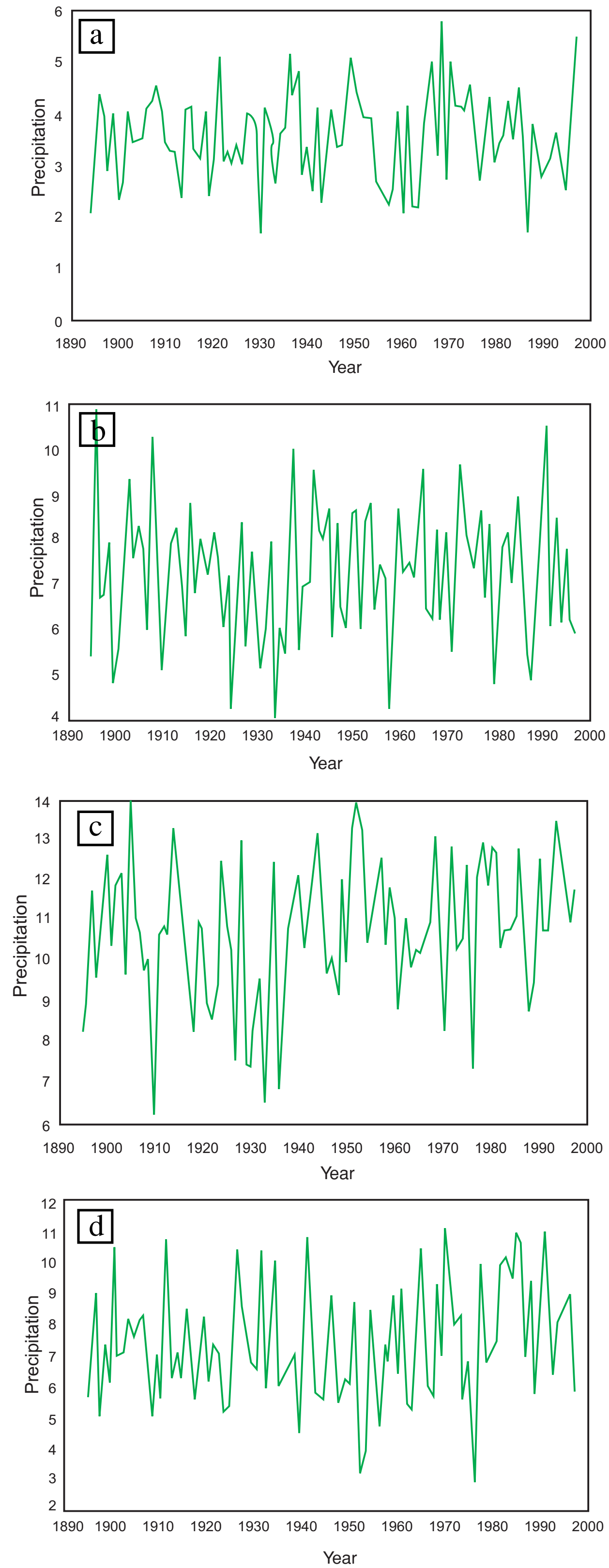

Figure 5: Average seasonal precipitation for Minnesota, Wisconsin, and Michigan. a) Winter, b) Spring, c) Summer, and d) Fall.

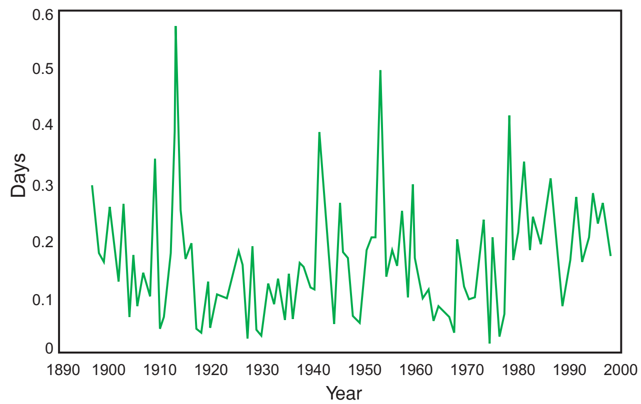

Figure 6: Number of days with precipitation greater than 3 inches for Michigan, Minnesota and Wisconsin.

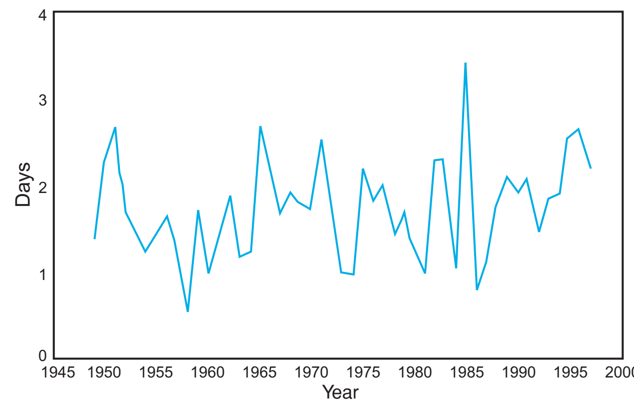

Figure 8: Number of days with snowfall greater than 5 inches for Michigan, Minnesota and Wisconsin.

increased since 1950, while Figure 8 shows that the number of heavy snowfall days (as defined by events > 5 inches) has cycled over a 30 year period.

Perhaps more striking than the recent precipitation trend for the region is the trend in lake levels (Figure 9). For example, lake levels for Lake Michigan and Lake Huron have basically decreased by 5 feet from 1890 to 1940 and have increased by 4 feet since then. The other four Great Lakes show similar trends.

Dr. Winstanley showed several correlation charts to indicate the relationship between average temperature, snow, cold days, and hot days. The chart for temperature vs. snow shown in Figure 10 suggests that a temperature increase of 3 °F would lead to a snow reduction of 20 inches, 12 fewer subzero days, and 5 more 90 °F-plus days.

While the temperature and precipitation trends over the last century across the Upper Great Lakes are not entirely consistent with global trends, they are reflective of national trends and variations. Figure 11 shows how winter temperatures on average have oscillated with a period of about 50 years for the whole U.S. The regional changes between the first 50 years and the second 50 years show warming in the western U.S. and cooling in the southeastern U.S. Dr. Winstanley presented several examples. One from the southeast (e.g.,

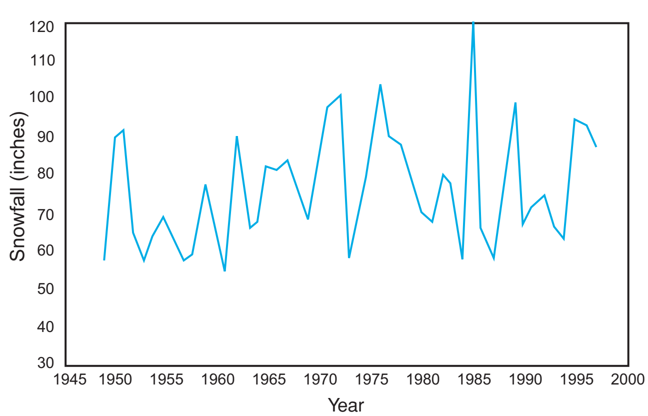

Figure 7: Total annual (January-December) snowfall (in) for Michigan, Minnesota and Wisconsin.

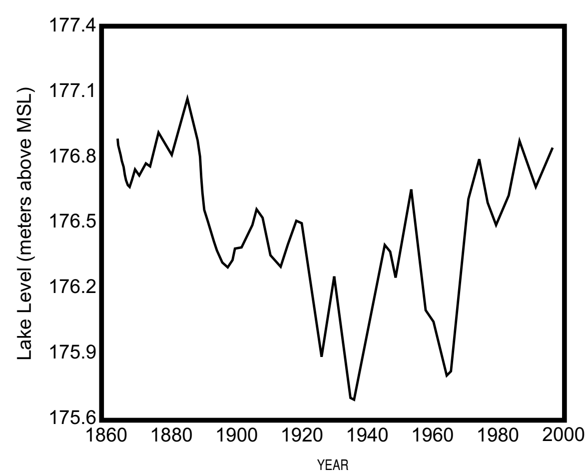

Figure 9: Historic levels on the Great Lakes.

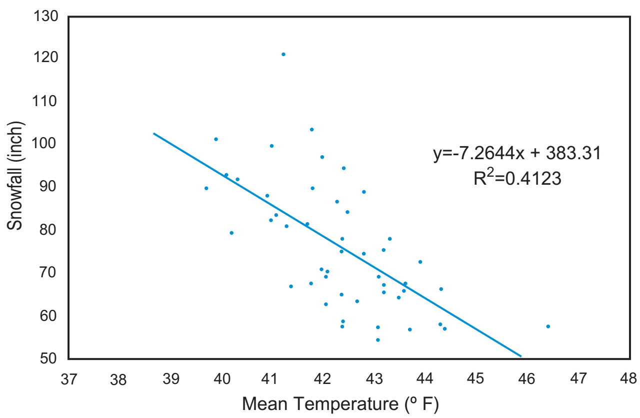

Figure 10: Mean annual temperature (ºF) vs. total annual snowfall (in) for Michigan, Minnesota and Wisconsin.

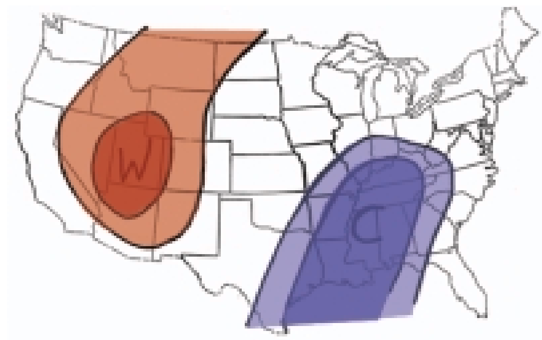

Figure. 11: Temperature trends from the period of 1900-1949 to the period 1950-1998. A "W" indicateds warming during the last ~50 years, a "C" indicates cooling over the last ~50 years.

Mississippi) showed how the cooling occurred abruptly in the late 1950s (e.g., 2 °F in about 5 years) and has since weakened slightly. Another example showed a similar trend farther north, (e.g., in Illinois) where temperature anomalies dropped from +1.5 °C to -0.5 °C from 1940 to 1980. Other places in the Northern Hemisphere have also shown temperature decreases over the last 30 years, for example, in the Arctic, as shown in Figure 14.

Dr. Winstanley noted that the regional textures and the areas of cooling shown in Figure 11 are easier to understand when one considers what else in addition to increases in carbon dioxide (CO_2) are affecting temperatures. While CO_2 increases are more or less global in extent and would suggest warming, the presence of aerosols (as part of the products that result from the burning which has increased the CO_2) in differing concentrations would suggest cooling. The short-term impacts of aerosols have been confirmed by many numerical simulations using General Circulation Models. That is, while the simulations show slight cooling trends for selected regions of the U.S. (e.g., Northeast, West Coast, Southeast) during the latter part of the 20th century, the simulations show warming everywhere across the U.S. by the beginning of the 21st century.

Dr. Winstanley concluded his talk by emphasizing five major points:

- Natural climate variability on a decadal scale is high.
- Natural climate variability on a century scale is not well known.
- No simple regional climate response to 50% increase in greenhouse gas concentrations is known.
- Future climate is likely to continue being highly variable.
- Regional response to cumulative forcing by all human activities remains highly uncertain.

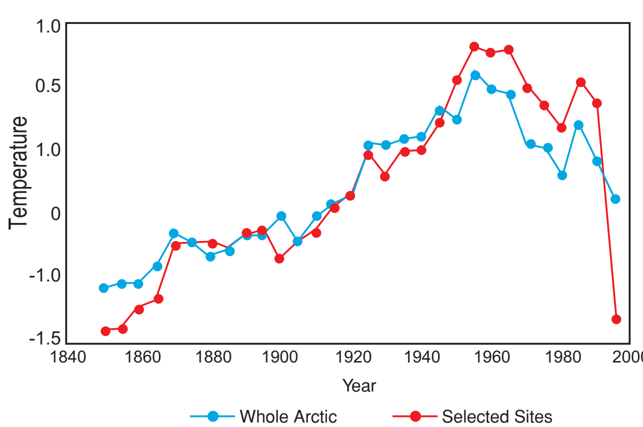

Figure 12: Temperature is this absolute or relative (of) vs. Time (1850-Present) for the arctic region.