

Confronting Climate Change in the Great Lakes Region

Technical Appendix Climate Change Projections

INTEGRATING HISTORICAL RECORDS WITH CLIMATE MODEL PROJECTIONS

Incorporation of historical climate is an important factor in projections of future climate and its impacts because it places model projections in the context of what has already happened in the past. For our study, historical data was obtained from the database maintained by the Midwestern Regional Climate Center at the Illinois State Water Survey (Kunkel et al. 1990, 1998). This data includes observations from over 300 stations dating back over a century. Using the analysis code developed for model data in conjunction with a sophisticated gridding program that averages randomly-spaced geographic locations into a uniform grid similar to model output, the historical data has been used to analyze past changes in the same climate characteristics calculated for the model data. Time series calculated by climate models were calibrated to the historical record using 1961-1990 average observed values. Through this calibration process, we were able to produce consistent time series for key climate characteristics spanning two centuries, from 1900 to 2100.

Integration of historical data enables a more balanced view of future changes in light of past climate in the region, such as the analysis of changes in the growing season from 1900-2100 (Figure 1). This analysis shows how the growing season will lengthen, continuing an already apparent trend. Since 1900, observational data shows that the growing season has increased by up to one week.

According to our model projections, the growing season in the Great Lakes region could continue to increase by 4-8 weeks by the end of the century.

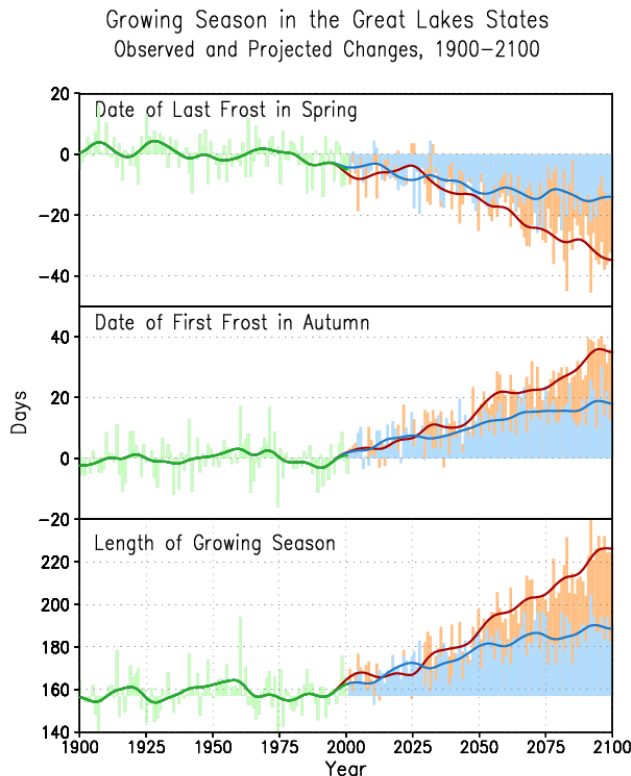
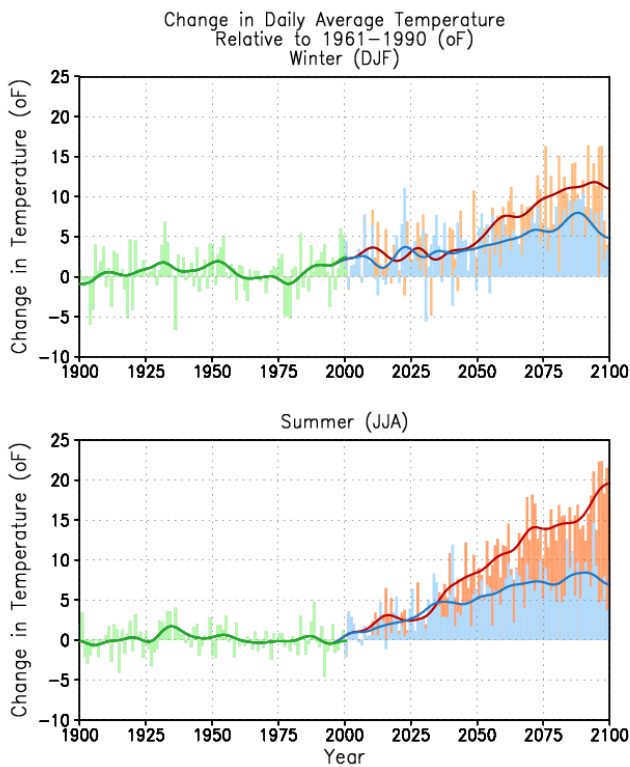


Figure 1. Historical observed data and HadCM3 model projections of the dates of first and last frost relative to 1960-1990 average, and the length of the growing season from 1900-2100. Coloured bars indicate the year-to-year anomalies while solid lines show the 10-year running means. Observed data is displayed in green, while model data is red (A1FI 'high' emissions scenario) and blue (B1 'low' emissions scenario).



Merging historical data with model projections also enables us to directly compare past periods with future projections. For example, summer temperatures in the 1930's bear a startling similarity to those projected for the 2010's (Figure 2).

Figure 2. Historical observed data and HadCM3 model projections of daily maximum temperature anomalies relative to 1960-1990 average for winter (DJF) and summer (JJA). Coloured bars indicate the year-to-year anomalies while solid lines show the 10-year running means. Observed data is displayed in green, while model data is red (A1FI 'high' emissions scenario) and blue (B1 'low' emissions scenario).

The historical record is also of great value in estimating changes in other variables such as [extreme events](#) (temperature threshold exceedances, rain storms, floods, and droughts) that are not well-represented in current climate models. Through combining historical data with model projections, we obtain a more rounded picture of future climate than can be obtained from model projections alone. For example, in an analysis of heavy rainfall events we developed unique regional correlations between event frequencies and climate based on the historical record. These correlations were then used in conjunction with climate model analyses to infer the frequency of extreme events in the future. The results of this analysis shows that 24-hour and 7-day heavy precipitation events have become more frequent in the region and are likely to continue to increase in frequency (Figure 3). In addition, there is some indication that the intensity of these events may increase slightly.

The frequency of heavy rainfall events was determined by locating the 101 most dramatic events from 1900 to 2000, such that the average was one event per year. In some years, this meant that there were no events in certain areas while in other years there could be multiple events. The events were then averaged over the entire Great Lakes region and plotted according to the year in which they occurred. An analogy would be to search through Olympic and World records to find the 101 furthest long-jumps since 1900. Plotting these events by the year in which they occurred, it would then be possible to see whether humans have

improved their ability to jump long distances – a long-term trend. Similarly, plotting the heaviest rainfalls since 1900 clearly indicates an increase in frequency in both 1-day and 1-week events towards the end of the century, since the majority of historical events have occurred within the last few decades.

Frequency of future events was determined by counting the number of model-projected events that lay within the range of those 101 historical events previously located and normalizing them by the difference between modeled vs. observed historical events. Results from the two ‘mid-range’ climate scenarios (A2 and B2) show remarkably similar trends, with frequencies remaining well above average for the next few decades and more than doubling by the end of the century.

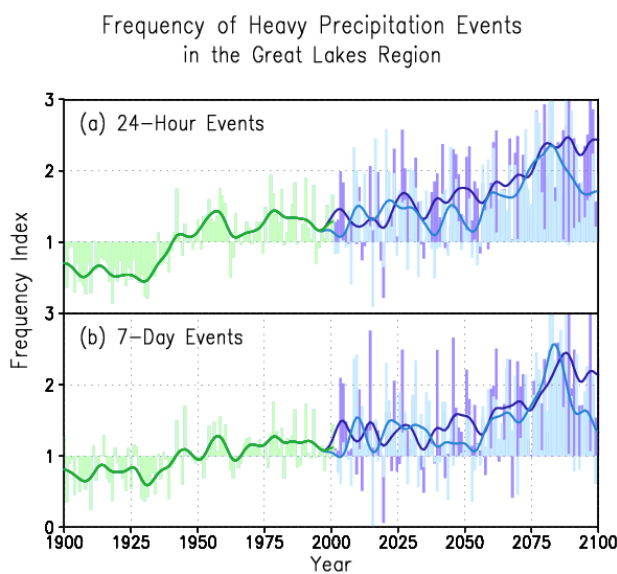


Figure 3. Historical observed data and HadCM3 model projections of frequency of heavy rainfall events within (a) 24 hours and (b) 7 days. A frequency anomaly index greater than one indicates a higher than average number of events that year, while an index less than one indicates a lower-than-average number of events. This average is determined based on the number of events recorded in the historical data over the past 101 years from 1900-2000. Coloured bars indicate the year-to-year anomalies while solid lines show the 10-year running means. Observed data is displayed in green, while model data is dark blue (A2 ‘higher mid-range’ emissions scenario) and light blue (B2 ‘lower mid-range’ emissions scenario).

References

Kunkel, K.E., Andsager, K., Conner, G., Decker, W.L., Hilaker Jr., H.J., Naber Knox, P., Nurnberger, F.V., Rogers, J.C., Scheeringa, K., Wendland, W.M., Zandlo, J. and Angel, J.R.: 1998, ‘An expanded digital daily database for climatic resources applications in the Midwestern United States’, *Bull. Amer. Meteor. Soc.* 79, 1357-66.

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