Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
41st NOAA Annual Climate Diagnostics and Prediction Workshop
Orono, ME, 3-6 October 2016

Assessing Temperature Extreme Trends in Western ME and NH

Chris Kimble
National Weather Service – Gray, Maine

1. Motivation

One of the more visible aspects of National Weather Service (NWS) management of climate observing sites is the reporting of daily record highs and lows. It is these daily records which help place an extreme event in a historical context. Saying it has never been hotter or colder before is both dramatic and meaningful. These historical extremes help place brackets around our expectations of what weather is possible on any given day. It can be expected that there may be a change in frequency of setting record highs and lows as the climate at any location changes. In fact, several active social media followers of NWS Gray have taken note of an apparent trend in these records, mostly at Portland, Maine. It seems apparent to several followers that Portland rarely sets new record lows anymore, while record highs continue to fall. This project attempts to discover whether an observable trend exists, and point to some local factors which are likely to influence any trends observed. In an attempt to provide some context, the project was expanded beyond Portland, Maine to include the other two climate reporting locations in the NWS Gray forecast area for which records are routinely reported: Concord, New Hampshire and Augusta, Maine.

2. Methodology

For this project the database of record highs and lows was accessed for Portland, Concord, and Augusta. For each daily record high and low (through the end of 2015), the year in which the record occurred was recorded. Because some records occur in multiple years (ties), each year in which the record occurred was recorded in order to avoid favoring more recent records. This resulted in greater than the 366 record highs and 366 record lows for each location that would otherwise be reported. For each location, the number of times each year appeared in the record books was recorded.

In order to determine the change in frequency of record high and low temperatures with time, we must first understand a basic premise. That is that if all years were equal, then each year would occupy an approximately equal number of slots in the record books. That is to say there would not be a preference toward records set earlier in the period of record or a

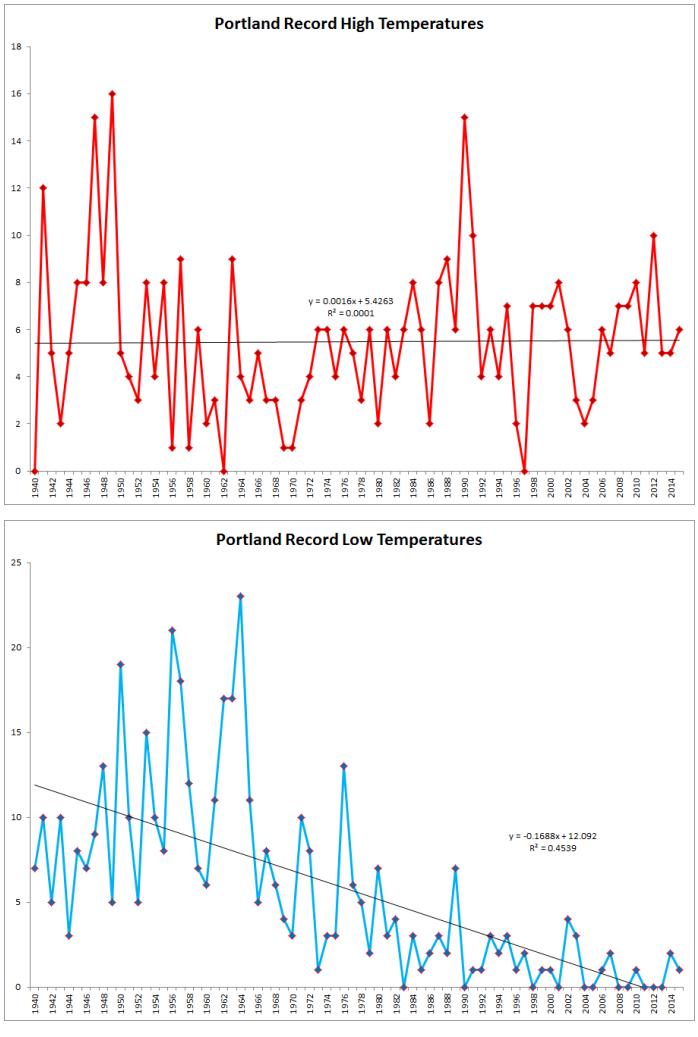

Fig. 1 (a) Record High Temperatures at Portland, ME show very little long term trend and a low correlation. (b) Record Low Temperatures at Portland, ME show a sharp downward trend and a strong correlation.

Correspondence to: Chris Kimble, National Weather Service – Gray, Maine; E-mail:

preference toward more recent records. Breaking a record which was set last year would be just as likely as breaking one set at the beginning of the period of record. The number of records set each year would be approximately equal to the total number of records divided by the total number of years in the period of record. The degree to which these assumptions break down will illustrate the variability from one year to the next and across several decades of a changing climate. Years which experience greater frequency in record highs or record lows would be seen as periods of more extreme warmth or cold, respectively.

3. Results

3.1 Portland, Maine (1940 – present)

Temperature records taken from the Portland International Jetport from November 1940 through December 2015 were used for this study. While earlier records exist from locations "downtown," long-standing NWS policy excludes these records from current reports due to the strong differences observed between the two locations during a period of overlapping records. Since November 1940, temperature records were taken exclusively at the Portland International Jetport which has seen significant airport expansion and suburbanization of the surrounding area from the 1960s to present.

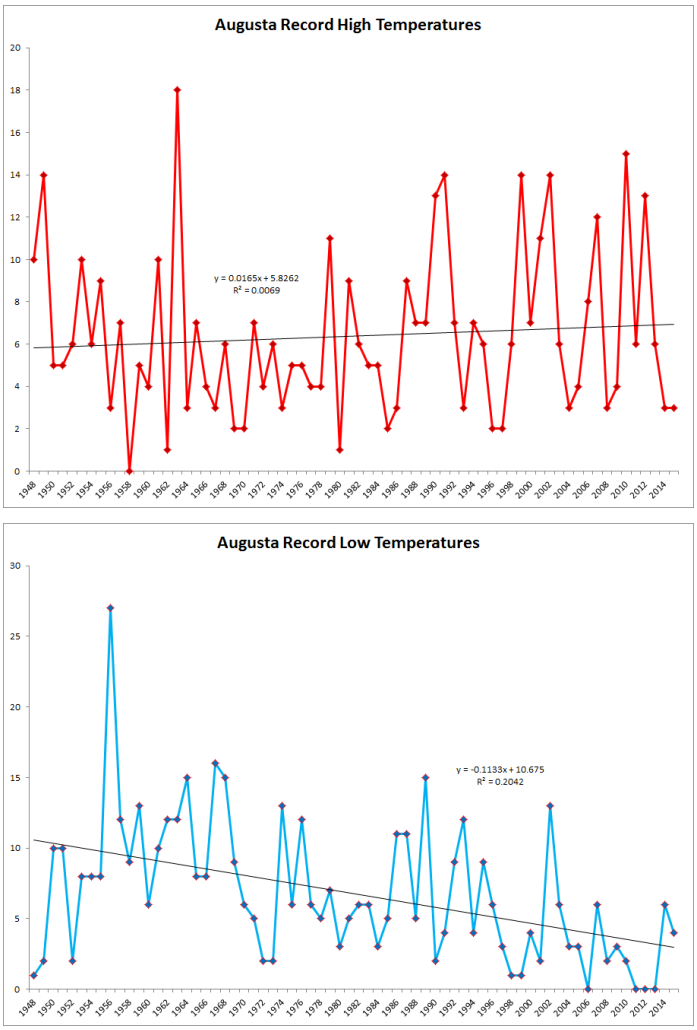

Fig. 2 (a) Record High Temperatures at Augusta, ME show very little long term trend and a low correlation. (b) Record Low Temperatures at Augusta, ME show a moderate downward trend and a moderate correlation.

Over the course of the 75-years of records, there were a total of 417 instances of record highs set or tied, yielding an average of 5.6 record highs set or tied per year. The most set in any one year was 16 in 1949. There were two full years which did not set or tie any record highs (1962 and 1997). Figure 1a charts the number of record highs in each year. There was no observable trend in record highs over the course of the period of record, as the slope of the regression line was near zero with very little of the variation explained by this regression line. There were a few years which stood out including several in the 1940s (1941, 1947, 1949), 1990, and 2012.

An analysis of the record lows showed a different story. There were 425 instances of record lows set or tied, yielding an average of 5.7 record lows set or tied per year. The most set in any one year was 23 in 1964. There were 11 years which did not set or tie any record lows, all of which were 1983 or later (most recently in 2013). Figure 1b charts the number of record lows in each year. There was a distinct downward trend in the frequency of record lows set over the course of the period of record. The slope of the regression line was sharply negative with a substantial amount of the variance explained by this regression line. During the first 30 years of records, it is common to see more than 10 record lows set or tied per year, while during the last 20 years it is common to see few or none. The most recent year to surpass the long term average of 5.7 record lows set or tied per year was 1989 when 7 such records occurred. There were a few years which stood out including 1948, 1950, 1953, 1956, 1957, 1958, 1962, 1963, 1964, and 1976.

3.2 Augusta, Maine (1948 – present)

This study used the temperature records available from the Augusta State Airport over the period June 1948 through December 2015. Since June 1948, temperature records were taken exclusively at the Augusta State Airport.

Over the course of the 69-years of records, there were a total of 435 instances of record highs set or tied, yielding an average of 6.4 record highs set or tied per year. The most set in any one year was 18 in 1963. There were no record highs set or tied in 1958. Figure 2a charts the number of record highs in each year. Although a slight upward trend is noted over the period of record, the slope of the regression line was very small with very little of the variation explained by that regression line. There were a handful of years which stood out including 1949, 1963, 1990, 1991, 1999, 2010, and 2012.

There were 460 instances of record lows set or tied, yielding an average of 6.8 record lows set or tied per year. The most in any one year was 27 in 1956. There were no record lows set or tied in four years (2006, 2011, 2012, and 2013). Figure 2b charts the number of record lows in each year. There was a downward trend in frequency of record lows set over the course of the period of record indicated by the negative slope of the regression line. A significant amount of the variance is explained by the regression line, though this correlation is about half as strong as is seen at Portland. The years that stood out included 1956, 1959, 1964, 1967, 1968, 1974, 1989, and 2002.

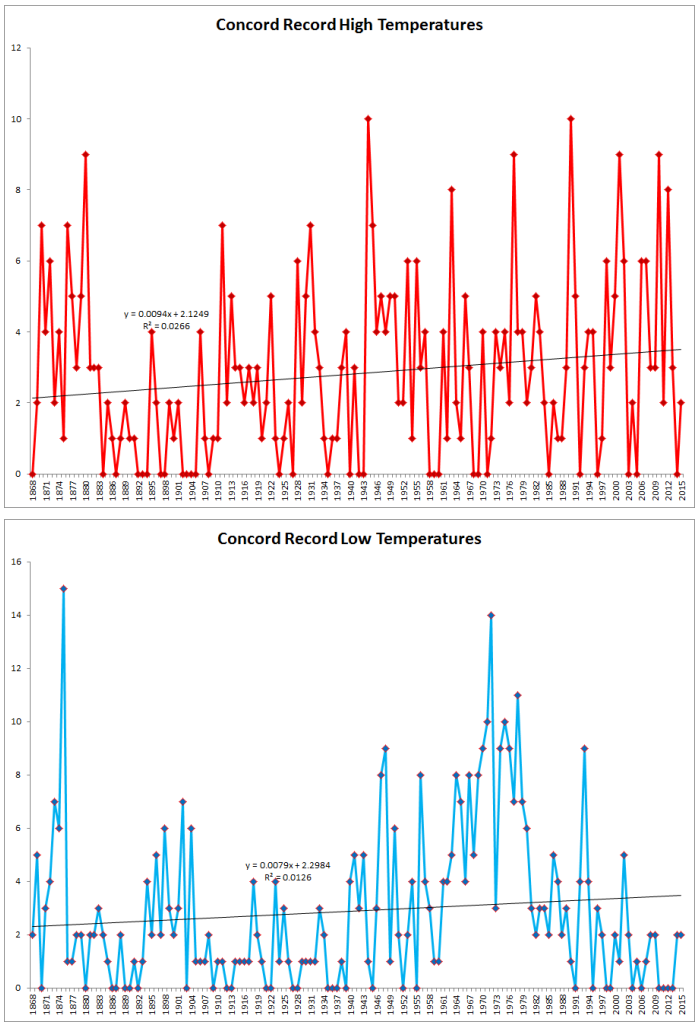

Fig. 3 (a) Record High Temperatures at Concord, NH show very little long term trend and a low correlation. (b) Record Low Temperatures at Concord, NH show very little long term trend and a low correlation. There is a notable drop from the 1970s to present.

3.3 Concord, New Hampshire (1868 – present)

Temperature records at Concord come from a variety of locations near Concord from 1868 to present. From 1868 to 1941, most of the observations came from locations in the downtown core of Concord. From 1941 until the present, observations were taken at the nearby Concord Municipal Airport.

Over the course of the 148-years of records at Concord, there were a total of 418 instances of record highs set or tied, yielding an average of 2.8 records set or tied per year. The most set in any one year was 10 in 1990 and 1944. There were 31 individual years which do not have a record high set or tied. Figure 3a charts the number of record highs in each year. Although a slight upward trend is noted over the period of record, the slope of the regression line was small explaining very little of the variation. A handful of years stood out including 1880, 1944, 1963, 1977, 1990, 2001, 2010, and 2012.

There were 427 record lows set or tied, yielding an average of 2.9 set or tied per year. The most in any one year was 15 in 1875. There were 32 years which do not have a record low set or tied. Figure 3b charts the number of record lows in each year. Although there is a slight upward trend in the linear regression line, the slope is very small with very little of the variation explained by this line. There was a period of numerous record lows set in the 1960s and especially the 1970s, which being in the last half of the 148-year record

cause the linear regression line to tilt upward. The years which stood out as having set or tied many record lows include 1875, 1948, 1970, 1971, 1972, 1975, 1976, 1978, and 1993.

4. Conclusions

A look at the trends in record temperatures at these three locations reveals no substantial trend in the frequency of record high temperatures. Record highs are still being set at about the same rate as earlier years in the record database.

There is a general downward trend in the frequency of record low temperatures. The most frequent record lows were observed in the third quarter of the 20th century with a sharp downward trend continuing into the present. This downward trend is most obvious at Portland and Augusta where a shorter period of record prevents a broader view. A longer period of record available at Concord reveals periods of extreme cold in the more distant past along with periods which set few record lows. Suburbanization and airport expansion likely affect Portland's modern records, leading to fewer extreme cold temperature records.

Acknowledgements. This analysis could not have been completed without the assistance of Ryan Colantonio of the Ohio State University who spent hours performing quality checks on the record databases. Other staff members at NWS Gray also contributed including Justin Arnott, John Jensenius, and Nikki Becker.