

Are Record Temperatures Occurring More Often in the Conterminous United States?

You may have heard in news reports that record temperatures are regularly being set across the United States and that this is likely tied to global warming. Is this true?

A record temperature is simply the extreme value, either hot or cold, of a series of temperature readings. For example, if a dataset has daily readings for a station of the high temperature for every January 1st from 1895 to 2020, there would be 126 values from which the highest and lowest could be determined and identified as the “records” for January 1st. Each record would be associated with the year in which it occurred.

What Do the Data Indicate?

The U.S. has monitored weather conditions somewhat systematically since the late 1800s and the National Center for Environmental Information (NCEI) archives these observations. Scientists at NCEI identified a set of stations with long-term observations that are useful for answering questions like that posed above. These stations form the United States Historical Climate Network or USHCN. The USHCN stations are still archived, though the network does not formally carry the status it originally had.

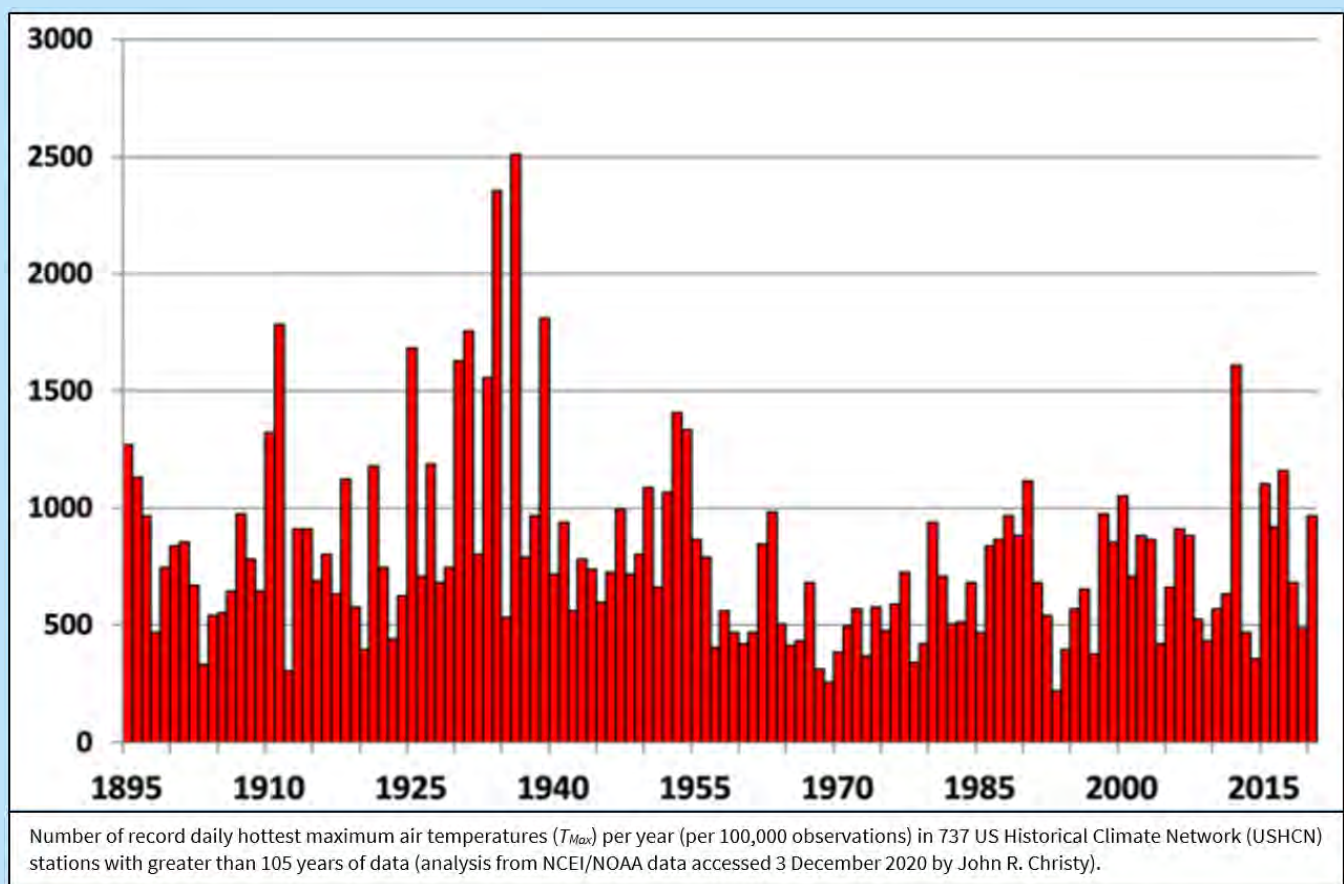
These stations reported the highest (usually occurring in late afternoon) and lowest (usually around sunrise) temperature for each day. These values are often referred to as the daily extremes and denoted as T_{Max} and T_{Min} respectively.

A subset of these stations having at least 105 years of data from 1895 to 2020 were examined for the question posed. There were 737 (738 for T_{Min}) stations which met the criteria. One station, while having enough T_{Min} observations, was missing enough T_{Max} values to be dropped from consideration for T_{Max} .

For each day of the year for each station, the record temperatures for each of T_{Max} (i.e. hottest day) and T_{Min} (coldest night) were calculated. The charts to follow depict the number of records that occurred each year for every 100,000 observations taken by these stations. If the climate were purely random and each station completely independent from the others, we would expect about 794 records in any given year. The results indicate some clear changes have occurred since 1895.

Trends in Maximum Daily Air Temperature

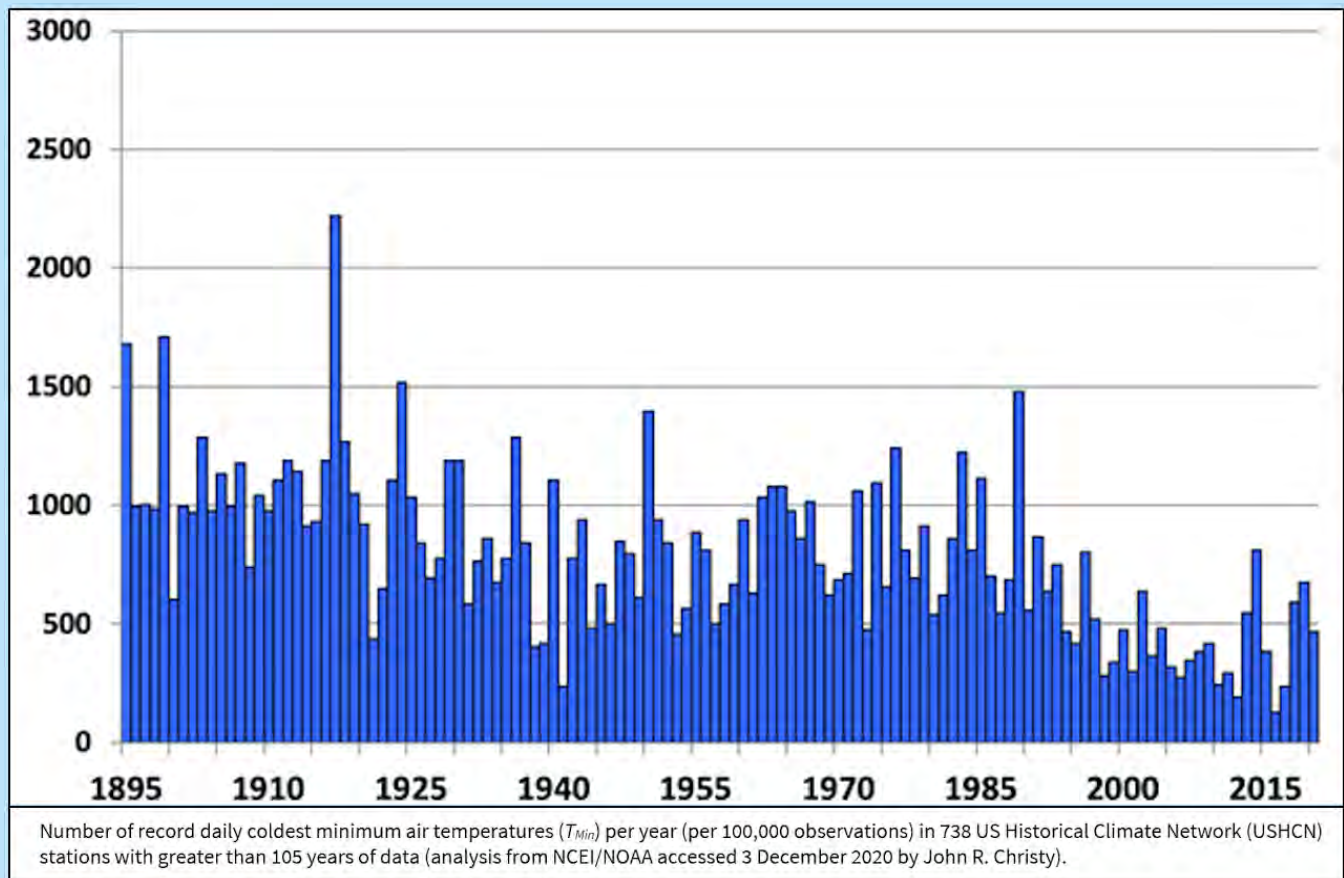
The first chart shows the yearly total of record high temperatures for T_{Max} . The 1930s stand out. In fact, of the 15 years with the most record high T_{Max} values, 14 occurred before 1955 and six in the decade of the 1930s alone. There is a slight downward tendency in the chart toward fewer record high temperatures, but the key results are that the 1930s was a remarkable decade for producing record hot days and the today's occurrences are no different than the frequency experienced at the beginning of the period. Record hot days are not occurring more often than before.



Trends in Minimum Daily Air Temperature

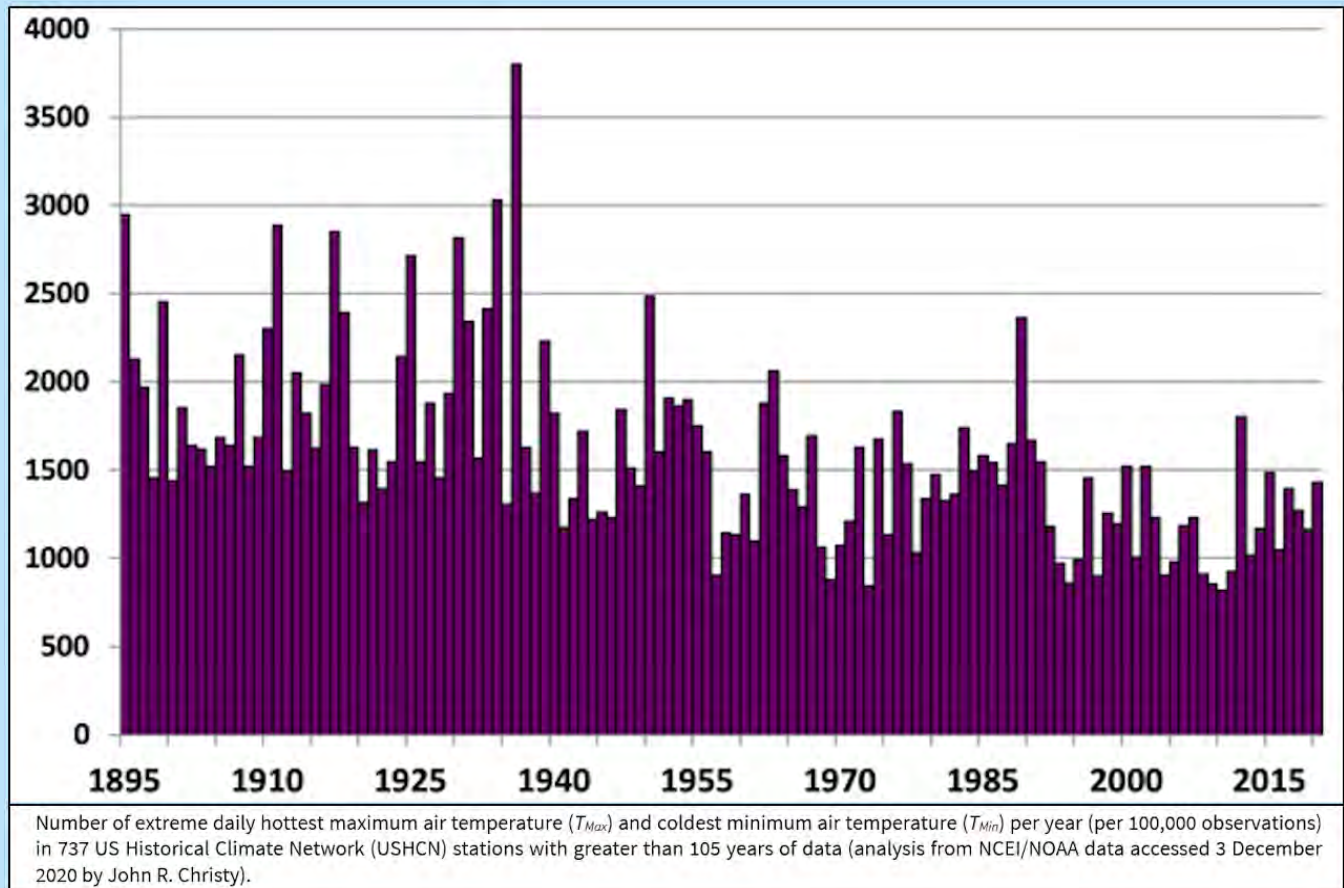
The story for the coldest nights is more substantial regarding long term change. Here we see a distinct and highly significant downward trend with fewer and fewer stations recording record low values of T_{Min} since 1895. Of the 15 years with the fewest record values, 14 occurred just since 1997. This combined situation - record hot days are trending slightly downward (thanks to a hot 1930s) while record cold days are almost disappearing - is an example of the way human development around the stations (i.e. roads, buildings, cities, etc.) has led to warmer and warmer nights. For reasons too complicated for this discussion, it is known that such increasing amounts of

infrastructure around a station has a strong warming influence on T_{Min} but not as much on T_{Max} . Consequently, one can have more confidence that long-term changes in the general climate are better assessed using T_{Max} .



Trends in Daily Air Temperature Extremes

Adding the two charts together gives us the information needed to answer the question: “Are record temperatures occurring more often?” The answer is no, they are in fact decreasing – and by a significant amount, thanks primarily to the falling number of record cold nights. The tendency over the last 126 years is that the occurrence of these extremes is dropping around 77 days per decade (recall the average is 1588 for day and night together.) It is interesting to note that 1936 had the 7th highest number of coldest nights and the highest number of hottest days that when added together produced the year with the most extremes overall, over twice the expected average.



Conclusion

The climate of the past 126 years is a tiny slice of time relative to the full set of climate variations and trends that the land on which the conterminous U.S. stands has experienced through the millennia. With a climate system that is so highly dynamic, such circumstances as the hot decade like the 1930s or the brutal year of 1936 can certainly happen again, and likely be even worse.

Dr. John R. Christy, Professor of Atmospheric Science, University of Alabama-Huntsville

For Further Information

Christy, J.R., and R.T. McNider (2016): Time series construction of summer surface temperatures for Alabama, 1883-2014, and comparisons with tropospheric temperature and climate model simulations. *Journal of Applied Meteorology and Climatology*, **55**(3), 811-826.

Christy, J.R., W.B. Norris, K. Redmond, and K.P. Gallo (2006): Methodology and results of calculating Central California surface temperature trends: Evidence of Human-induced climate change? *Journal of Climate*, **19**(4), 548-563.

For information on the data, see: <https://www.ncdc.noaa.gov/ushcn/introduction>