EXTREME TEMPERATURES IN NORTH AMERICA

Have there been more frequent hot weather events during the past century?

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One of the projected negative consequences of global warming is a concomitant increase in climatic variability, including more frequent hot weather events. It is a relatively easy matter to either substantiate or refute such claims by examining trends in extreme temperatures over the past century or so; because if global warming has truly been occurring at an unprecedented rate over the past hundred years, as climate alarmists claim it has, temperature variability and extreme temperature events should be increasing, according to them. Therefore, this review investigates this issue as it pertains to locations in North America.

Starting in Canada, **Shabbar and Bonsal (2003)**[1] examined trends and variability in the frequency, duration, and intensity of winter cold and warm spells during the second half of the 20th century. For the period 1950-1998, they found that western Canada experienced *decreases* in the frequency, duration and intensity of winter cold spells. In the east, however, distinct *increases* in the frequency and duration of winter cold spells occurred. And with respect to winter warm spells, significant increases in both their frequency and duration were observed across most of Canada, with the exception of the extreme northeastern part of the country, where warm spells appear to be becoming shorter and less frequent. In the mean, therefore, there appear to be close-to-compensating trends in the frequency and intensity of winter cold spells in different parts of Canada, while winter warm spells appear to be increasing somewhat.

The maximum temperature values are getting less hot and minimum temperature values are getting less cold with time," signaling a reduction in overall temperature variability.

In introducing their study, **Khaliq *et al.* (2007)**[2] note that (1) "extreme climate events are receiving increased attention because of the possibility of increases in their frequency and severity in future climate as a result of enhanced concentrations of greenhouse gases in the atmosphere and associated atmospheric warming," and that (2) "transient climate change simulations performed with both Global Climate Models and Regional Climate Models suggest increased frequencies of extreme high temperature events." Against this backdrop, the group of five researchers assessed temporal changes in the frequency of occurrence and durations of heat waves based on data acquired at seven weather stations located in southern Quebec for the 60-year period 1941-2000. The results of this exercise indicated that for heat spells defined in terms of daily *maximum* air temperature, the majority of extreme events showed "a negative time-trend with statistically significant decreases (at 10% level)," while almost all of the heat spells defined in terms of daily *minimum* air temperature showed "a positive time-trend with many strong increases (i.e., statistically significant at 5% level) at all of the stations." As for what their findings imply, Khaliq *et al*. say "a possible interpretation of the observed trends is that the maximum temperature values are getting less hot and minimum temperature values are getting less cold with time," signaling a reduction in overall temperature variability.

[1] http://www.co2science.org/articles/V6/N28/C2.php.
[2] http://www.co2science.org/articles/V10/N16/C1.php.

Somewhat similar findings were reported several years earlier by Bonsal *et al*. (2001), who analyzed spatial and temporal characteristics of daily and extreme temperature-related variables across Canada over the period 1900-1998. In that earlier work, they found "significant trends toward fewer days with extreme low temperature during winter, spring, and summer," as well as "trends toward more days with extreme high temperature in winter and spring," but noting that "these are not as pronounced as the decreases to extreme low values." However, they add that there was "no indication of any consistent changes to the magnitude of extreme high daily maximum temperature during summer." And in discussing their findings, they report that, "in general, day-to-day temperature variability has decreased over most of southern Canada during the twentieth century," evidenced by a greater increase in daily minimum (as opposed to maximum) extreme temperature values.

Taking a much longer view of the subject, **Fallu *et al*. (2005)**[3] derived a 6700-year temperature history for northern Quebec, Canada; and upon examination of the record, they found that after an initial increase in temperature that lasted from 6400 to 4900 cal. yr BP, a warm phase set in that lasted from 4900 to ca. 1500 cal. yr BP. Furthermore, according to the researchers, the data obtained from this latter portion of the sediment core "suggest the most stable paleoclimatic conditions during this period." Then came what they call the "recent cooling," which lasted from ca. 1500 cal. yr BP to modern times, during which interval they report that "lake water temperature apparently became increasingly unstable." Thus, temperature variability in this region was shown to *decline* when the climate warmed.

Moving southward to the United States, **Kunkel *et al*. (1999)**[4] investigated the occurrence of intense heat and cold waves from 876 locations over the period 1931-1997. Their results indicated a decline in exceedance probability threshold since 1930 for heat waves, whereas no trend was identified for cold spells (see Figures 1 and 2 below). And as a result of these and other findings, Kunkel *et al*. concluded that there has been "no evidence of changes in the frequency of intense heat or cold waves."

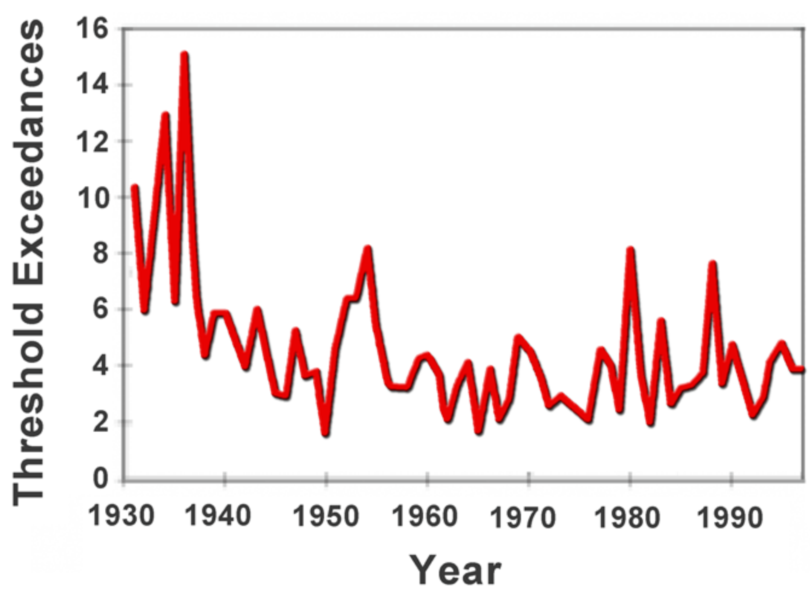

Figure 1: Heat wave exceedance threshold calculated as the number of days with a maximum temperature above the threshold for a 1.5% daily exceedance probability. The curve represents an average of 876 long-term stations in the USA. Adapted from Kunkel et al. (1999).

3 http://www.co2science.org/articles/V8/N3/C3.php.
4 http://www.co2science.org/articles/V2/N22/EDIT.php.

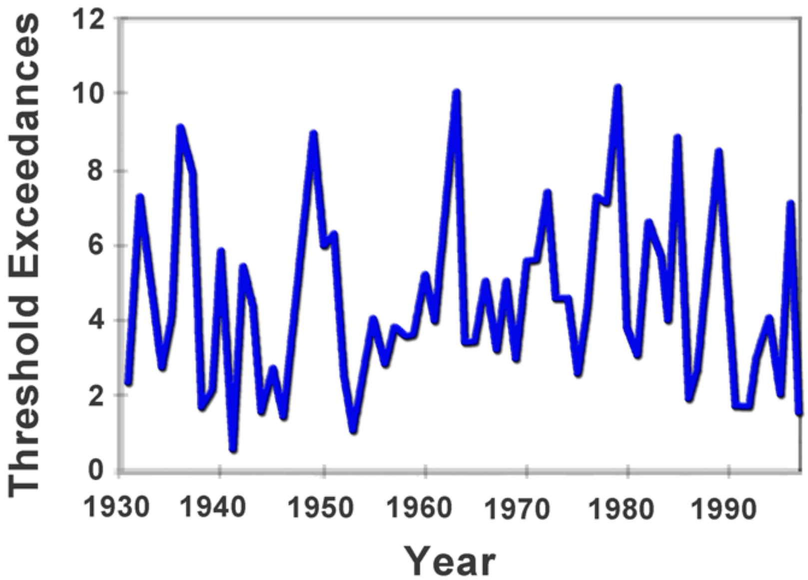

Figure 2: Cold wave exceedance threshold calculated as the number of days with a minimum temperature below the threshold for a 98.5% daily exceedance probability. The curve represents an average of 876 long-term stations from the USA. Adapted from Kunkel et al. (1999).

Iskenderian and Rosen (2000)[5] studied two mid-tropospheric temperature data sets spanning the last forty years, calculating day-to-day variability within each month, season and year. Averaged over the entire Northern Hemisphere, they found that mid-tropospheric temperature variability exhibited a slight upward trend since the late 1950s in one of the data sets; but, as they note, "this trend is significant in the spring season only." They also admit that "the robustness of this springtime trend is in doubt," because the trend obtained from the other data set was negative. For the conterminous United States, however, the two data sets both showed "mostly small positive trends in most seasons." But, again, none of these trends were statistically significant. Therefore, Iskenderian and Rosen acknowledge that they "cannot state with confidence that there has been a change in synoptic-scale temperature variance in the mid-troposphere over the United States since 1958."

Two years later, in a study based on daily maximum (max), minimum (min) and mean air temperatures (T) from 1062 stations of the U.S. Historical Climatology Network, Robeson (2002)[6] computed the slopes of the relationships defined by plots of daily air temperature standard deviation vs. daily mean air temperature for each month of the year for the period 1948-1997. This protocol revealed, in Robeson's words, that "for most of the contiguous USA, the slope of the relationship between the monthly mean and monthly standard deviation of daily Tmax and Tmin - the variance response - is either negative or near-zero," which means, as they describe it, that "for most of the contiguous USA, a warming climate should produce either reduced air-temperature variability or no change in air-temperature variability." He also reports that the negative relationships are "fairly strong, with typical reductions in standard deviation ranging from 0.2 to 0.5°C for every 1°C increase in mean temperature."

Also working with data from the United States Historical Climatology Network (USHCN), in a contemporaneous study, DeGaetano and Allen (2002b)[7] first created a Daily Historical Climatology

[5] http://www.co2science.org/articles/V3/N19/C2.php.
[6] http://www.co2science.org/articles/V5/N47/C2.php.
[7] http://www.co2science.org/articles/V6/N9/EDIT.php.

Network for Extreme Temperature (HCN-XT) dataset (DeGaetano and Allen, 2002a), which they used to determine how both hot and cold temperature extremes - defined in terms of the number of exceedances of the 90th, 95th and 99th percentiles of their respective databases - have varied across the contiguous United States over a number of different time scales. So what did they find?

Over the period 1960-96, DeGaetano and Allen determined that "a large majority of stations show increases in warm extreme temperature exceedances," which would seem to corroborate the claims of the world's climate alarmists. They also report that "about 20% of the stations experience *significant* [italics added] increases in warm maximum temperature occurrence," again in seeming vindication of climate-alarmist claims. Furthermore, they note that "similar increases in the number of >=2 and >=3 runs of extreme temperatures occur across the country," apparently substantiating climate-alarmist claims of an increasing frequency of deadly heat waves. However, when the two scientists extended their analyses further back in time, some quite different results were obtained. Adding another 30 years of data onto the front ends of their databases, DeGaetano and Allen discovered there were "predominantly *decreasing* [italics added] warm exceedance trends across the country during the 1930-96 period." In fact, they found that "in the 1930-96 period *70% of the stations* [italics added] exhibit decreasing high extreme maximum temperature trends."

It is clear that when it comes to extreme warm temperature events over the USA, they are no more prevalent currently than they were in the 1930s. In fact, they may well be even less prevalent nowadays.

Another significant finding of the DeGaetano and Allen paper is their discovery that "trends in the occurrence of maximum and minimum temperatures greater than the 90th, 95th, and 99th percentile across the United States are strongly influenced by urbanization." With respect to daily warm *minimum* temperatures, for example, the slope of the regression line fit to the data of a plot of the annual number of 95th percentile exceedances vs. year over the period 1960-96 was found to be +0.09 exceedances per year for rural stations, +0.16 for suburban stations, and +0.26 for urban stations, making the rate of increase in extreme warm minimum temperatures at urban stations *nearly three times greater* than the increase at rural stations less affected by growing urban heat islands. Likewise, the rate of increase in the annual number of daily *maximum* temperature 95th percentile exceedances per year over the same time period was found to be 50% greater at urban stations than it was at rural stations. Yet in spite of this vast uncorrected-for-bias, when computed over the much longer 1930-96 period, 70% of all stations in the HCN-XT data set *still* exhibited "decreasing high extreme maximum temperature trends."

In light of such findings as those of DeGaetano and Allen, it is clear that when it comes to extreme warm temperature events over the USA, they are no more prevalent currently than they were in the 1930s. In fact, they may well be even *less* prevalent nowadays. Also, there is strong evidence implicating the growing influence of intensifying urban heat islands as being responsible for the apparent rapid increase in the mean annual temperatures of many locations over the last two decades of the 20th century. Hence, even for the part of the world that shows little, if any, net warming over the past 70-some years, what little there may or may not be is likely *still* too much.

Focusing on extreme temperatures experienced during heat waves, **Redner and Petersen (2006)**[8] note that "almost every summer, there is a heat wave somewhere in the United States that garners popular media attention," and that it is only natural to wonder if global warming played a role in producing it. Driven by this same curiosity, the two scientists set out to investigate "how systematic climatic changes, such as global warming, affect the magnitude and frequency of record-breaking temperatures," after which they assessed the potential of global warming to produce such temperatures by comparing their predictions to a set of Monte Carlo simulation results and to 126 years of real-world temperature data from the city of Philadelphia.

At the end of their mathematical analysis, the two researchers concluded that "the current warming rate is insufficient to measurably influence the frequency of record temperature events, a conclusion that is supported by numerical simulations and by the Philadelphia data." Hence, they state that they "cannot *yet* distinguish between the effects of random fluctuations and long-term systematic trends on the frequency of record-breaking temperatures," even with 126 years of real-world data. Such findings suggest that it is therefore not yet statistically justifiable to attribute any individual heat wave or "proliferation of record-breaking temperature events" to historical global warming, be it CO_2-induced or otherwise.

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Finally, in an attempt to determine the role that might have been played by the planet's *mean* temperature in influencing temperature *variability* over the latter half of the 20th century, **Higgins *et al*. (2002)**[9] examined the influence of two important sources of Northern Hemispheric climate variability - the El Niño/Southern Oscillation (ENSO) and the Arctic Oscillation - on winter (Jan-Mar) daily temperature extremes over the conterminous United States from 1950 to 1999. With respect to the Arctic Oscillation, there was basically no difference in the number of extreme temperature days between its positive and negative phases. With respect to the ENSO phenomenon, however, Higgins *et al*. found that during El Niño years, the total number of extreme temperature days was found to *decrease* by around 10%, while during La Niña years they *increased* by around 5%. With respect to winter temperatures across the conterminous United States, therefore, the climate-alarmist contention that warmer global temperatures - such as are typically experienced during El Niño years - will produce more extreme weather conditions is found to be unsupported, as just the *opposite* was found to be true by Higgins *et al*.

In conclusion, it appears from the results of the studies referenced above that, contrary to model projections, a warmer climate does *not* tend to produce a more variable climate. In fact, the data presented above suggest that a warmer climate may very well be *less* variable, if any change occurs at all. Consequently, climate-alarmist projections of more frequent and more intense summer heat waves do *not* appear to be supported by the majority of the pertinent scientific literature.

[8] http://www.co2science.org/articles/V10/N49/C1.php.
[9] http://www.co2science.org/articles/V5/N39/C1.php.

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