NOTES AND CORRESPONDENCE

Comments on "Recent Trends in Maximum and Minimum Temperature Threshold Exceedences in the Northeastern United States"

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DeGaetano (1996) has presented a detailed analysis of the warming and cooling effects in recent years based on the annual number of exceedences of given threshold temperature values and the daily maximum and minimum temperature records at 22 primarily rural sites in the northeastern United States. After the homogenization of available records, the changes of annual exceedences are presented and then visually appearing trends are depicted through linear regression. Such a study is most welcome and is especially useful for the study of climate change scenarios worldwide. Although general circulation models of any type are very useful tools in the assessment of possible climate change, areal studies based on meteorological records including temperature measurements also help to identify local or limited areal changes. In fact, record-based studies must not be considered as a single meteorological factor only; in order to draw more effective conclusions, they must also examine the relationship to other meteorological factors. From this respect, the paper presented by DeGaetano (1996) reflects the warming and cooling effects only with the decrease in the number of annual exceedences toward recent years. However, for future research the following points should be addressed.

(1) Is it enough to base the warming or cooling conclusions on the number of temperature exceedences only? It might be that the number of exceedences have recently decreased, but what about the magnitudes of these temperatures? In other words, one should also consider the summation of the temperature exceedences in centigrade for all the possible exceedences during one year. This summation is similar to the cooling or warming degree days depending on the exceedences of maximum or minimum temperatures. In general, if the threshold temperature value is denoted by T_0, provided that there are i exceedences during a specific year, then the summation of the temperature exceedence magnitudes, S_i, yields

$$S_i = \sum_{t=1}^{i} (T_i - T_0). \qquad (1)$$

It is obvious from the DeGaetano (1996) study that time series of annual exceedences (days) of maximum temperature have decreasing trends even visually, but it would be more illuminating if the change of annual quantity in Eq. (1) were related to the annual number of exceedences. It would then be possible to deduce affirmative conclusions as to the cooling or warming effects in the climate change studies. It is possible that several years might have more or less the same number of annual exceedences, but this does not mean that each one of these years has the same warming or cooling properties. Besides, it is not clear why the author adopts three threshold values for the maximum and minimum temperature records. However, the existence of any trend with one of the threshold values will imply the same type of trend, perhaps with different linear regression coefficients. Since the aim is to know whether there is a decrease or increase in the annual number of exceedences, only one threshold temperature value seems to be sufficient to arrive at the desired target.

(2) The number of exceedences divided by the number of days in a year gives the exceedence probability and hence the time series of annual exceedences can be regarded as the series of exceedence probabilities provided that each annual number of exceedence is divided by 365. Hence, warming or cooling effects are natural consequences of increase or decrease in the exceedence probabilities with years. Once the exceedence probability p_j for year j is known then the expected number of exceedences N_j can be easily predicted as $N_j = 365p_j$. If the daily exceedences within one year are assumed independently from one another then the expectation of exceedence magnitude summation S_e can be expressed simply as $S_e = 365p_i\langle(T_i - T_t)\rangle$, where $\langle\cdot\rangle$ means arith-

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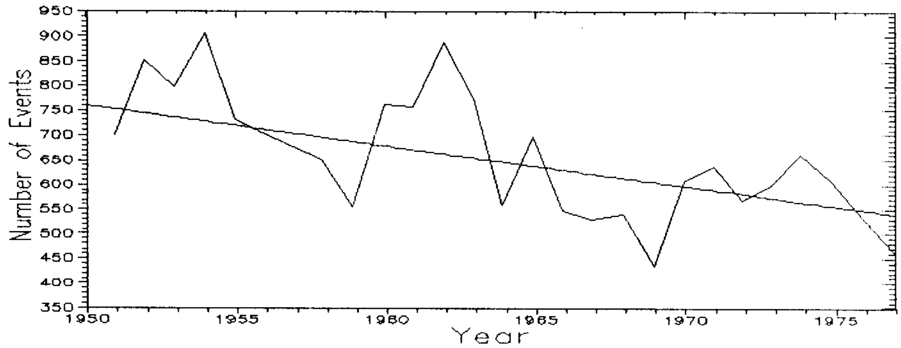
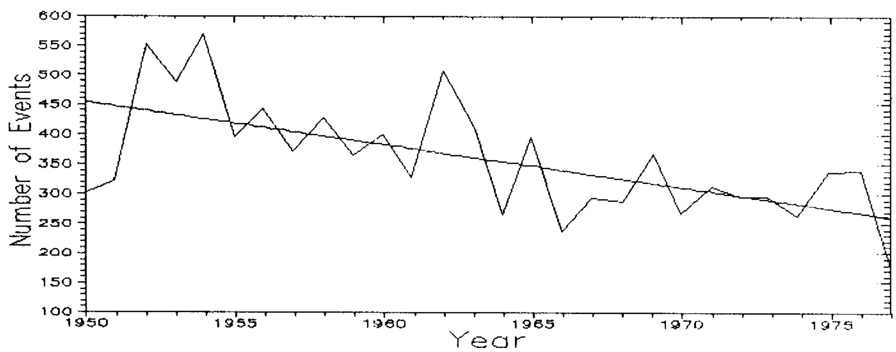
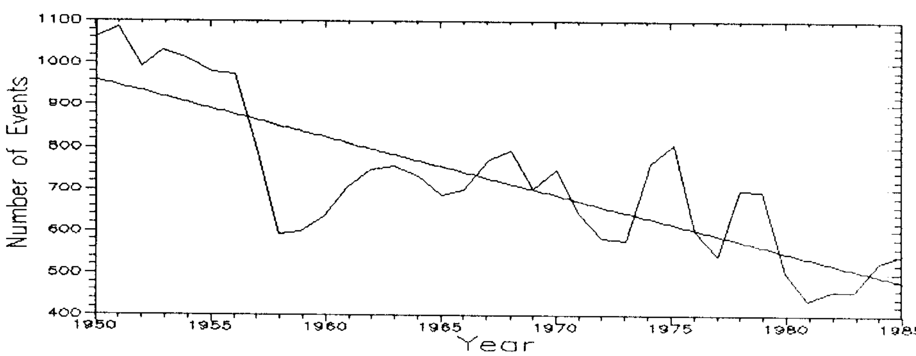


(a)



(b)



(c)

FIG. 1. Annual change of cyclone and anticyclone numbers. (a) Northern Hemisphere (NH) surface cyclones. (b) NH surface anticyclones. (c) 500 mb anticyclones in the western half of the NH.

metic average—that is, expectation of the argument. It is, therefore, obvious that the expected value of total exceedence magnitude is proportional not only with the number of exceedences but also with the average exceedence magnitude. Hence, the assessment of annual cooling or warming changes are not a function of the annual exceedence number only but equally a function of the average exceedence magnitude. Unfortunately, this point was not considered in the paper.

On the other hand, the successive occurrences of exceedences in daily temperature records are not independent from one another. In such a case if the successive occurrences abide with the red noise (Markov process), then the serial correlation function plays a dominant role in the number of exceedences as well as in the exceedence magnitudes.

(3) Is the number of exceedences distributed according to Gaussian or a symmetric distribution function? If not, how then is it possible to apply least squares linear regression method in depicting the linear trends?

(4) Are there any physical explanations of, say, maximum temperature decreases recently as shown by linear trends in their Fig. 3 or minimum temperature increase as presented in their Fig. 5? For instance, as explained

by Agee (1980, 1991) there are cyclonic and anticyclonic climate cooling or warming causative mechanisms. The cyclone and anticyclone occurrences affect various weather phenomena and, therefore, their annual frequency of occurrences—that is, the number of annual occurrences plays a key role in many meteorological events such as climate change including cooling or warming. To benefit from their relationships with meteorological events, such as temperature, humidity, and precipitation occurrences, many researchers have investigated their characteristics on the basis of observed data. Alpert et al. (1990) have shown that the frequencies of annual cyclone numbers change with location and time. Figures 1a and 1b indicate the annual changes of surface cyclone and anticyclone numbers in the Northern Hemisphere as given by Agee (1991). It is obvious that there is a generally decreasing trend throughout the years. Comparison of this figure with DeGaetano's (1996) Fig. 3 shows that there is a close relationship between the surface cyclone and anticyclone trends and the annual exceedence number of maximum temperatures. However, there is an exception for the Patchogne, New York, station. Even 500-mb anticyclones for the western half of the Northern Hemisphere as presented in Fig. 1c have similar trends. On the other hand, the change in the number of surface cyclones in the United States has very similar increasing trends in DeGaetano's Fig. 4 except at Stroudsburg, Pennsylvania.

It will be interesting to investigate the relationships between the number of exceedence days of certain temperature thresholds. Only such studies may lead to physically plausible explanations based on meteorological events concerning the exceedence numbers of temperatures.

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