Extreme Weather Events and Climate Change*

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Abstract

Research on climate change, in association with the enhanced greenhouse effect, has focused on trends in mean temperature. Surprisingly little attention has been devoted to changes in variability or in the relative frequency of extremes of temperature or of other climate variables such as precipitation. The inadequacy of scientific assessments of climate change, with respect to variability and extremes (e.g., Nicholls et al., 1996), is finally starting to be recognized (Karl et al., 1995). It is certainly the case that apparent trends in the economic impacts of weather extremes have received much attention, both in the insurance industry and in the news media, but changes in societal vulnerability act as a confounding factor making the attribution of such trends difficult (Pielke and Landsea, 1998). Despite its routine use in engineering design/risk assessment involving climate variables (for instance, precipitation), until recently extreme value theory has played virtually no role in the search for trends in extreme weather events.

It is somewhat bewildering that temperature extremes have received so little attention, given the well-documented trends in the mean. Uncertainty over whether temperature variability should be expected to increase or decrease is a contributing factor (Mahlman, 1997). In fact, it might well be that a concomitant decrease in temperature variability is masking the effects on extremes. Much is known about the statistical features of extreme temperature events under the present climate. For example, Brown and Katz (1995) made use of extreme value theory in performing a regional analysis of temperature extremes. They found that relative frequency of

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a given extreme event has a simple structure across space, suggesting a "spatial analog" for climate change. The "urban heat island" effect, another analog for climate change, provides an illustration of the fact that the standard deviation of temperature might well change along with any trend in the mean (Tarleton and Katz, 1995).

Given its intermittency over both time and space, precipitation is perhaps the most intriguing climate variable from the perspective of extreme value theory. Physical considerations and experiments using numerical models suggest an intensification of the hydrologic cycle as part of the enhanced greenhouse effect. Climate researchers are starting to realize that simply dealing with monthly or seasonal precipitation totals is inadequate (Trenberth, 1997). Empirical evidence from observations is not definitive, but subtle effects such as increased frequency of intense precipitation have been detected (Karl et al., 1995; Karl and Knight, 1998). Katz (1997) made use of extreme value theory for a "random" number of random variables to relate the parameters (e.g., probability of occurrence) of a stochastic model for time series of daily precipitation amounts to design values/return periods for extreme high precipitation events. One physically attractive approach to the treatment of precipitation extremes involves statistical "downscaling," or relating local precipitation to patterns in large-scale atmospheric circulation (e.g., El Nino events). Although not focused on extremes per se, some of this research indicates that mixtures of extreme value distributions ought to be fitted to precipitation extremes (Katz and Zheng, 1998).

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