Statistical diagnosis of extreme events

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This section will briefly describe some statistical approaches for interpreting extreme events.

1- Point process modeling of simple extreme events

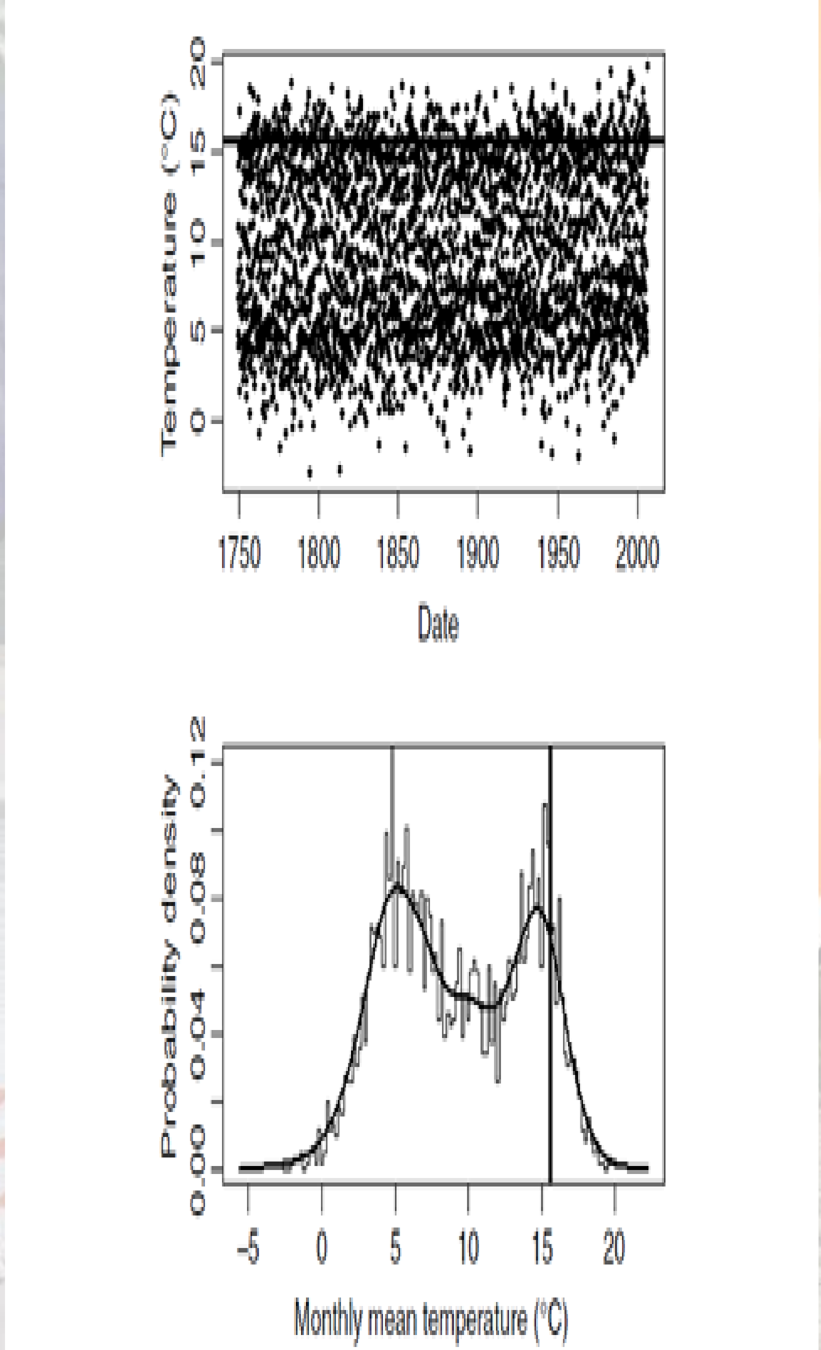
Point process methods have been widely used in various areas of science; for example, in providing a framework for earthquake risk assessment and prediction in seismology. Broadly speaking, this analysis is performed by considering statistical properties of the points, such as the number of events expected to occur per unit time interval (the rate/intensity of the process), statistical properties of the marks (the probability distribution of the excesses), and joint properties such as how the marks depend on the position and spacing of the points, the magnitude of preceding events, etc.

2-Example: central England temperature observations

Typical time series resemble . Rather than being recorded continuously, many meteorological variables are generally recorded and stored on computers at regular discrete time intervals. Strictly speaking, this is a special type of marked point process in which the points occur on a discrete set of regularly spaced times (e.g., daily values) rather than at any possible time. The occurrence of an exceedance in such cases can be modeled by using a discrete-time Markov chain

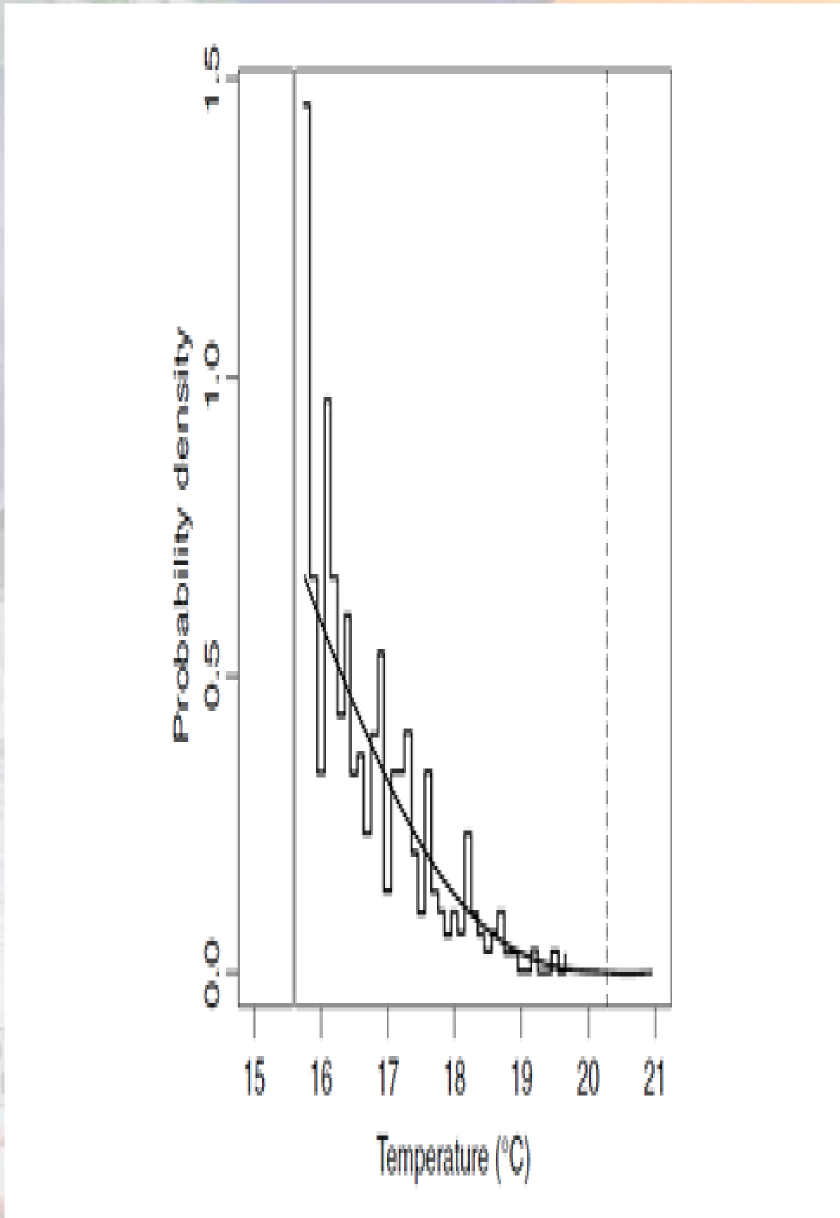
3- Choice of threshold

The high threshold used to define the extreme events can be chosen in many different ways. The simplest approach is to choose a constant absolute threshold related to impacts



4-Magnitude of the extreme events (distribution of the marks)

The magnitude of the extreme events can most easily be summarized by calculating summary statistics of the sample of excesses; for example, themean excess above the threshold. However, such an approach does not allow one to make inferences about as-yet-unobserved extreme values or provide probability estimates of extreme values that have reliable uncertainty estimates.



5-Timing of the extreme events (distribution of the points)

There are two main approaches for estimating the rate of a point process: the counting specification, based on counting the number of points in fixed time intervals, and the interval specification, based on estimating the mean time interval between successive points (see Cox and Isham, 2000, p. 11).

The simplest counting specification approach involves dividing the time axis into a set of non-overlapping, equally spaced bins and then counting the number of points that fall into each bin. This approach gives rather noisy results due to the sharp bin edges. More efficient and smoother rate estimates can be obtained by using smooth local weighting based on a smooth kernel function rather than a sharp-edged bin .

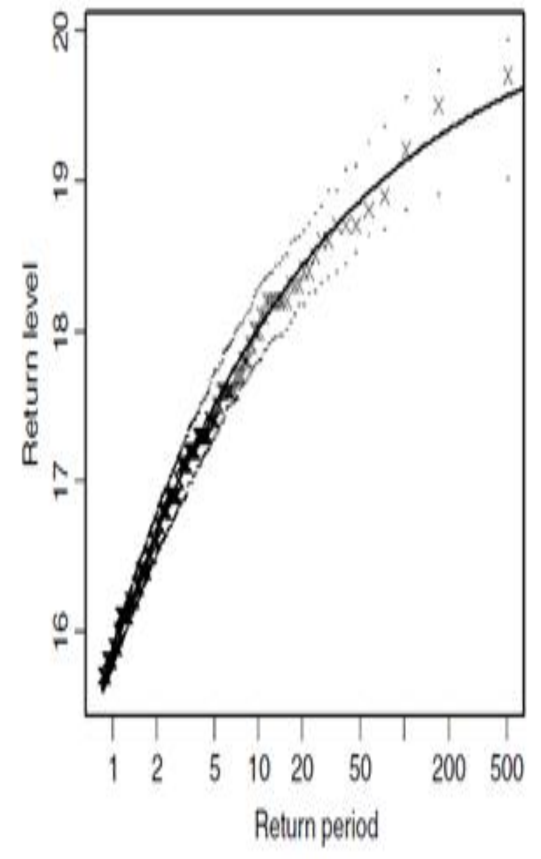


Figure 1.4. Return level plot for the central England temperature series from 1750 through 2006. The return period is the reciprocal of the probability of a monthly temperature value exceeding the return level. The crosses denote the 308 empirical quantiles and probabilities, and the solid curve is the GPD fit. Note the concavity of the curve, which is characteristic of a tail distribution having a negative shape parameter.

6-Some ideas for future work

Statistical analysis of extreme events generally focuses on a given set of extreme events and tends to neglect how such events came into existence.

This is a strength in that it makes extreme value techniques more universally applicable to different areas of science no matter how the extremes formed. However, this approach also has a weakness in that it ignores information about the process that led to the extreme events that could help improve inference. How moderately large events evolve into extreme events can provide clues into the very nature of the extreme events. The dynamical knowledge about underlying formation processes should be exploited in the statistical analysis.

The origin of extreme events

Understanding the processes that lead to the creation of extreme events and how they might change in the future is a key goal of climate science.

To help tackle the problem of the origin of extremes, I propose two guiding principles.

* The evolutionary principle. Extreme events do not arise spontaneously: instead, they evolve continuously from less extreme events and they stop evolving to become even more extreme events.

* The stationary principle. Extremes such as local maxima and minima are quasistationary states in which the rate of change of their amplitude is zero. This characteristic implies that there is an interesting balance between forcing and dissipation tendencies for such extreme events.

There are various processes that can give rise to extreme events:

* Rapid growth due to instabilities caused by positive feedbacks; for example, the rapid growth of storms due to convective and baroclinic instability.

* Displacement of a weather system into a new spatial location (e.g., a hurricane in Boston) or into a different time period (e.g., a late frost in spring).

* Simultaneous coincidence of several non-extreme conditions (e.g., freak waves caused by several waves occurring together).

* Localization of activity into intermittent regions (e.g., precipitation in intertropical convergence zones).

* Persistence or frequent recurrence of weather leading to chronic extremes as caused by slower variations in the climate system (e.g., surface boundary conditions).

* Natural stochastic/chaotic variation that will lead to more extreme values being recorded as the time length of the record increases.


Thank You
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