1.4. The identification of trends has its limitations

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For extreme events, the identification of trends meets with fundamental limits. The more seldom an event, the more difficult it is to establish a trend. Small changes in the frequency of very rare events are masked by natural climatic variations. The apparently more frequent occurrence of extreme events in recent years could either represent a real trend or be incidental. Thus extreme events are unsuitable indicators for assessing global climate change.

With its avalanche winter, Whitsun floods, summer thunderstorms with hail, and the Lothar winter storm, 1999 was an exceptional year seen in the context of the previous 30 years. In 1999, Switzerland suffered a record number of climate-related natural catastrophes of national importance. Is this an unnatural concentration of events – or perhaps even a sign of global climate change? What can the long-range instrument recordings tell us about this?

The most extensive series of climatic measurements in Switzerland go back to the early 19th century (e.g. Great Saint Bernhard Pass up to 1818). Coordinated meteorological measurement networks with substantially comparable measurement equipment were built up in the second half of the 19th century. Uninterrupted measurement series are available from these on a daily basis for some 100 stations at which the precipitation, and for 30 stations at which the temperature, was measured.[1,2] The data basis is less satisfactory for other observed quantities. Thus 100-year measurements of windspeed only exist for three stations (Bern, Basel and Zurich). Also, the numerous instrumental changes and those in the location of stations make it difficult to eliminate non-climatic effects (homogenisation) from the data.[3] However, in recent years intensive processing has enabled high-quality data series to be prepared for Switzerland. These dispose of the necessary temporal and spatial resolution, enabling long-range variations and trends in extreme events resulting from temperature and precipitation conditions to be examined.

Despite the generous data basis, the identification of trends in extreme events meets with fundamental limitations. These are given by the infrequency of the events and by the concomitant statistical uncertainty. To identify a trend, an assessment must be made as to whether the sequence of events observed results from a systematic change (i.e. signalises a trend) or from incidental causes (i.e. 'background' fluctuations of the climate). The rarer (extremer) the events, the more uncertain the distinction between signal and background fluctuations. The situation is comparable to that of a dice player who is required to decide whether his/her dice are loaded using only a few throws.

The limits of identifiability of trends in extreme events may be estimated theoretically. Thus for events with a return period of one year, a trend could only be identified if the probability of the event occurring during the century had

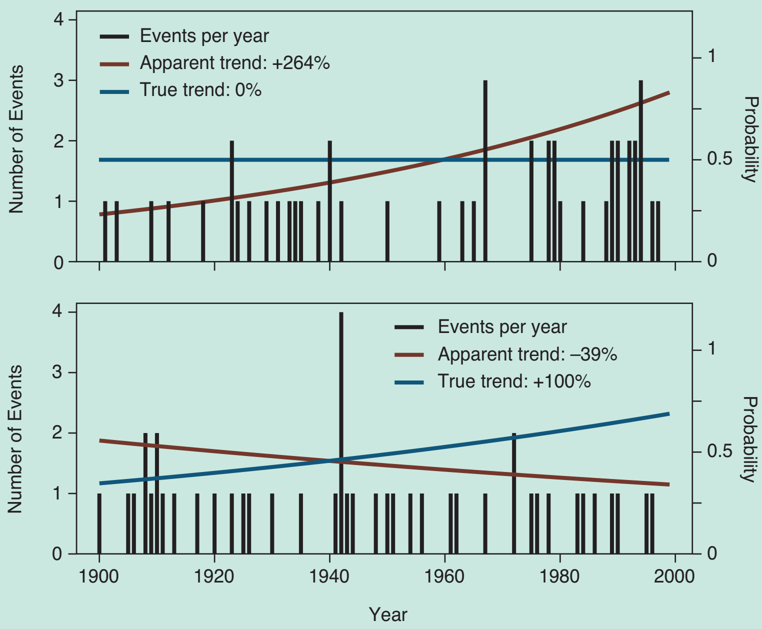

Fig. 8 Artificially generated time series of events in the 20th century. In the upper figure, constant probability of an event occurring was specified (blue line). The random bunching of events at the end of the century feigns an increase in probability of over 250% (red line). The opposite effect is shown in the lower figure, in which doubling of the probability of an event was specified (blue line). The chance distribution of the events leads to the erroneous conclusion of a decrease in the probability of an event by 39% (red line).

Concealed, delusive or true trend?

Owing to the infrequency of extreme events, trends may only be established very imprecisely. In fact, chance bunching of such events at the beginning or end of an observation period can feign a trend that is in reality nonexistent ('delusive' trend). In contrast, a real trend can be masked to such an extent by chance variations that statistical analysis of the measurement series is unable to identify it (concealed trend).

Fig. 8 illustrates possible false conclusions from trend analysis. The figure shows artificially generated time series of extreme events over a 100-year period (number of events per year shown in black, referred to the left-hand ordinate). In the top example, it was specified in generating the series that the probability of an event (blue line, right-hand ordinate) is constant, i.e. that no real trend exists. On average, one event occurs every two years. However, the calculated trend for the data sequence shown (red curve) implies an increase in probability of greater than 250% over the 100 years. This 'delusive' trend results from the chance bunching of events at the end of the period. The same would apply if random bunching had occurred at the beginning of the time period, leading to the erroneous conclusion of a declining trend.

In the bottom example, it was specified in generating the time series that the probability should double over the 100 years (blue curve). However, the sequence of events so generated hardly reproduces this requirement owing to the fact that, contrary to the 'true' trend specified, a chance bunching of events has occurred at the beginning of the period. The statistical analysis of this time series in fact shows a decrease of approx. 40% (red curve). Here, the 'true' trend is concealed and is therefore not identified. The more seldom the events examined, the lower the chance of identifying a real trend.

Christoph Frei

at least doubled.[4] For events of the severity of those in 1999, with return periods from 10 to over 100 years, changes of several times would be necessary. Weaker trends are concealed by background fluctuations of the natural climate.

The problem of identification may influence both scientific research and the public debate on the relationship between climate change and extreme events in several ways:

(a) The apparent concentration of extreme events in recent years could either indicate a real trend, or simply be a delusive trend resulting from random factors. For statistical reasons, precise conclusions cannot at present be drawn on these very rare events.

(b) Extreme events are unsuitable indicators of global climate change. Though the attention given in the media to the climate problem whenever extreme events occur suggests a relationship, this can neither be proven nor disproven. There is therefore a danger that in periods with frequent extreme events the climate problem will be dramatised in the public mind, and in periods with less frequent events be seen as harmless (possibly unjustifiably).

(c) Conclusions on trends during the measurement period are based on an assessment of intensive events not necessarily leading to damage. Thus for intensive precipitation having an average return period of 30 days, a significant increase in winter and autumn of 20-80% was found.[4] In the northern part of the Central Lowlands, this is clearly distinguishable from the random fluctuations. However, the results for intensive events cannot simply be applied to extreme events. Furthermore, the trends alone do not represent proof that the climate change is of human origin: this may also be attributable to natural long-term climate variations. They cannot therefore be simply extrapolated into the future.

(d) Predictions on future changes in the probability of very seldom extreme events are of very limited use, at least at the regional level. Even fairlysubstantial future changes can be masked by the random component. A possible increase in the risk following from global climate change will not necessarily manifest noticeably in the decades to come. Irrespectively of this, technical measures for protection against higher risks can have useful effects within shorter periods. As an example, the measures taken in Brigue following the floods of 1993 proved very effective in autumn 2000, when flooding again occurred.

(e) The isolated analysis of long-term observations is not sufficient to gain a deeper understanding of the relationship between climate change and extreme events. Rather, scientific progress must be sought in a better understanding of the climate mechanisms, to which numerical climate models are making an important contribution.

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