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Recurrence of extreme temperatures in Switzerland from 1965 to 2018

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Extreme high temperatures have a strong impact on human well-being. In Switzerland, for instance, mortality has been shown to increase during strong heat waves (e.g., Ragettli et al., 2017) such as those that occurred in 2003, 2015, or 2018. Knowledge on the recurrence of such heat waves is therefore important, but conventional analysis of observational series is challenged by their rare occurrence (limited sampling), long-term trends, and strong seasonality (non-stationarity). This work presents a methodology, to derive reliable recurrence estimates of extreme maximum and minimum temperature events, taking account of gradual trends and seasonality in the data.

Temperature in Switzerland undergoes pronounced seasonal fluctuations, both in mean value and variance. In addition, a significant warming occurred over the last decades. To derive robust estimates on the rarity of a given extreme temperature event, it is important that these non-stationarities are formally modelled. Our modelling assumes that observed daily temperatures at stations are a superposition of a gradual, non-linear trend and residuals from a skewed T-distribution. The parameters of that distribution are assumed to vary over the year as second order harmonic functions. The model parameters are estimated using maximum likelihood. Thanks to this modelling, the existing daily temperature data can be transformed into a standard normal distribution, and the probability of an event can thus be assessed with respect to the climate at the time of measurement (year, calendar day).

With this methodology in hand, we analyze heat waves of the past, focusing on extreme temperatures at the beginning of summer when mortality risks are higher (Ragettli et al, 2017). We show how the risk of extreme heat has changed in the past, and how very rare events have become much more frequent in the present climate.

Ragettli, M., Vicedo-Cabrero, A. M., Schindler, C., and M. Rösli (2017): Exploring the association between heat and mortality in Switzerland between 1995 and 2013, *Environmental Research*, 158, 703-709, <https://doi.org/10.1016/j.envres.2017.07.021>.