A recurrence-based technique for detecting genuine extremes in instrumental temperature records

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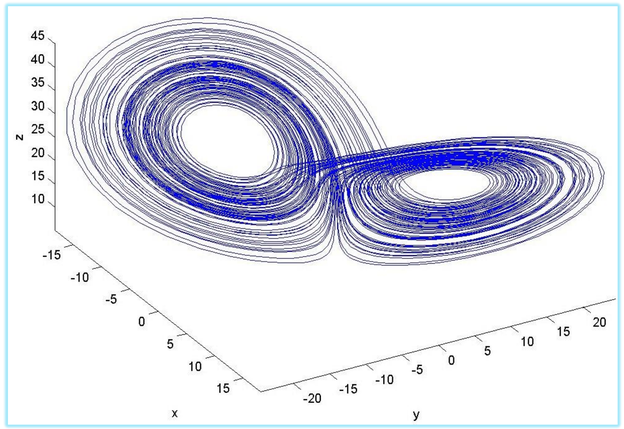
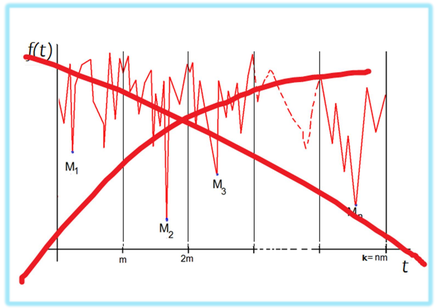
How to define extreme events in complex systems?

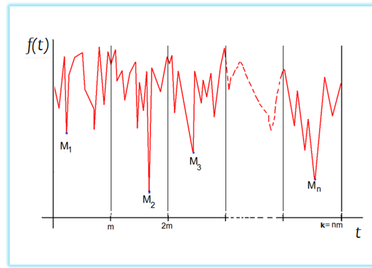
2. Atmospheric attractors are *Strange Attractors*

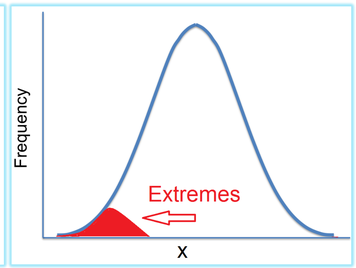




When we have complex objects (as **the Lorenz strange attractors** in the figure), the Block Minima approach does not seem insightful. **Maxima or Minima of the single variables do not represent dynamical features of the attractor!**

1. The traditional statistical approach for time series

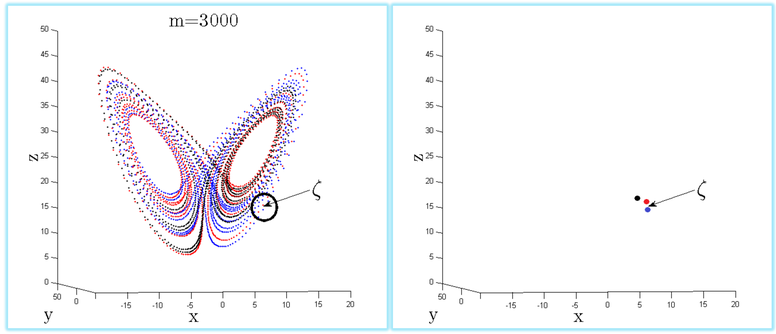




Block Minima

It is the standard approach used for series of Independent and Identically distributed variables. By using the **Block Minima** approach we get **Generalized Extreme Value** distributions.

3. Extremes as points visited sporadically

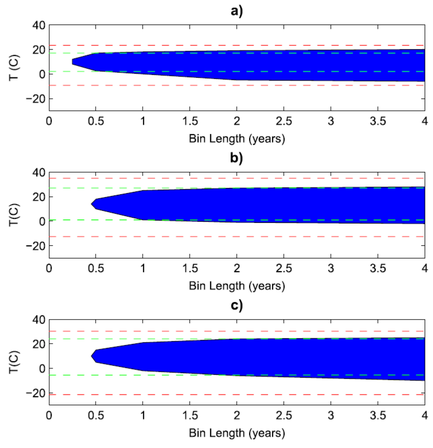


We can identify extremes of Attractors as points which are **visited rarely**. **The frequency of visit can be fixed by the Block Minima approach** as the length of the time interval in which we sample the statistics of the closest recurrences. By changing the bin length we can study the **typical interval of recurrence.**

4. Applications to Temperature Data

Normal and Extremes Temperatures

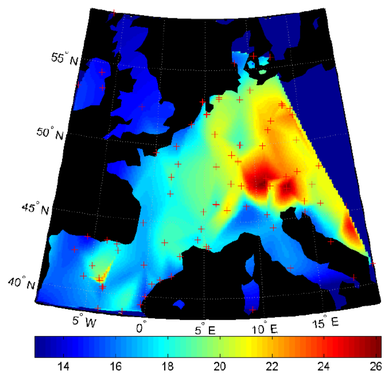
The experiments have been repeated for different bin lengths between 3 months and 4 years. In the figure, the blue area represents the reference temperatures ζ having enough recurrences for the chosen bin length. This temperature range is what we propose as a rigorous definition of normal variability.



Region of temperatures with normal recurrences fit (blue area) for different bin lengths. Red dotted lines: absolute extremes of the temperature series for (a) Armagh, (b) Milan, and (c) Vienna. Green dotted lines: thresholds detected with the classical GPD approach.

A map of European *Normal* Temperatures

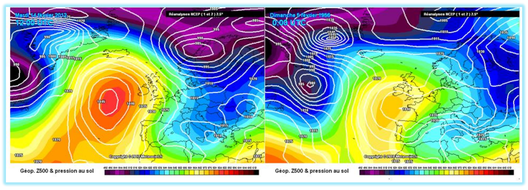
By plotting the length of the interval of convergent Temperatures at all the European locations for which at least 60 years of daily data are available, we can construct a climatological map of Europe. The results are reported in the figure for the bin length of 1 year. Different climatic regions are well highlighted.



Map of the range of *admissible temperature intervals* for the European region, obtained by considering the interval of temperature anomalies ζ such that the fit passes the *Lilliefors* test. The red crosses represent the location of the stations used for the analysis. The straight line near the right border represents the limit of the data set.

5. Outlook

A new definition of Weather Analogues



A natural extension of the method based on recurrences is **to define dynamical properties of analogues.**

A key question to answer is **whether sporadic points appear to happen more or less frequently in a climate change scenario.** Project in Collaboration with P. Yiou (LSCE – CEA SACLAY)

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