

ACT Stage Topic 2 - Critical transitions in complex scenarios

Stage topic Description

Complex system theory studies how the relationships between a systems parts give rise to its collective behaviour. Complex systems are studied in many disciplines including climate system science, meteorology, economics, molecular biology, artificial intelligence, chemistry, computer science, earthquake prediction, neuroscience, physics, psychology and sociology.

The term “tipping point” commonly refers to a critical threshold at which a tiny perturbation can alter the state or development of a system. Here we introduce the term “tipping element” to describe large-scale components of natural and social systems which may pass a tipping point. For this study tipping elements in different complex systems (i.e. Stock Markets, Climate Changes, Biological and Natural Systems) will be identified.

Time series analyses (TSA) are trend forecasting (extrapolation) techniques (such as autoregression analysis, exponential smoothing, moving averages) based on the assumption that "the best estimate for tomorrow is the continuation of the yesterday's trend". The usage of time series analysis is twofold: obtain an understanding of the underlying forces and structure that produced the observed data and fit a model and proceed to forecasting, monitoring or even feedback and feedforward control.

Few studies have been performed with time series analyses to find signs of upcoming critical transitions between alternative stable states[1]. The approach of critical points in complex systems can be detected by monitoring the systems behaviour for lag-1 autocorrelation, variance and 'flickering'. Flickering is the repeatable transition back and forth between two alternative stable states as a system enters the bistable region which leads to bifurcation [2].

The target of this study is to validate and compare these behaviours as methods of forecasting critical transitions. The strengths and weaknesses of these methods will be explored, and ways of improvement will be considered.

For this stage, time series analysis will be performed on data sets which come from simulated and/or real data of critical transitions in complex systems.

Candidate's tasks

- Provide data in case the candidate has already been conducting studies on (biological, molecular biological or ecological) complex systems, otherwise datasets will be selected at the beginning of the stage.
- Time series analysis on real and/or simulated datasets in the vicinity of tipping points/ critical transitions.

The ideal candidate

- Candidates should have experience in and knowledge about time series analysis.
- Previous work with complex systems in biology or ecology is a plus, but not strictly necessary.
- It will be appreciated if the candidate provide data on (biological, molecular biological or ecological) critical transitions in complex systems, for example from his/her previous studies.
- Matlab, R or other tools to analyse time series are required.

References

- [1] V. Dakos et al. , Slowing down as an early warning signal for abrupt climate change, PNAS, Vol. 105 No.38,2008.
- [2] M. Scheffer, Critical Transitions in Nature and Society, Princeton University Press, 2009.