

Statistical early warning indicators based on Auto-Regressive Moving-Average processes

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We address the problem of defining early warning indicators of critical transition [Scheffer *et al.* (2009)]. To this purpose, we fit the relevant time series through a class of linear models, known as ARMA(p, q) models [Brockwell and Davis (2009)]. We define two indicators representing the total order and the total persistence of the process, linked, respectively, to the shape and to the characteristic decay time of the autocorrelation function of the process. We successfully test the method to detect transitions in a Langevin model and a 2D Ising model with nearest-neighbour interaction. We then apply the method to complex systems, namely for dynamo thresholds and financial crisis detection. In all the cases considered, the behavior of the indicators has shown to be an effective way to investigate the proximity of the system to a critical transition; thus, they seem to be a useful tool to study critical transitions, since their estimation involves well-known, standard statistical techniques characterized by a low computational cost and applicable to relatively short time series. On a theoretical level, one can use the technique to understand how transitions are modified when systems originally in equilibrium are driven out of equilibrium by forcing-dissipation mechanisms, starting from conceptual toy model of out-of-equilibrium Ising dynamics [Faranda *et al.* (2014)].

Références

- [Scheffer *et al.* (2009)] Scheffer, M., Bascompte, J., Brock, W. A., Brovkin, V., Carpenter, S. R., Dakos, V., ... & Sugihara, G. (2009). Early-warning signals for critical transitions. *Nature*, 461(7260), 53-59.
- [Brockwell and Davis (2009)] Brockwell, P. J., & Davis, R. A. (2009). *Time series : theory and methods*. Springer.
- [Faranda *et al.* (2014)] Faranda, D., Dubrulle, B., Saint-Michel, B., & Thalabard, S. (2014). Non equilibrium Ising dynamics under a temperature gradient field. arXiv preprint arXiv :1309.3437.