EGU21-7847, updated on 05 Dec 2022
https://doi.org/10.5194/egusphere-egu21-7847
EGU General Assembly 2021

Ordinal partition transition network based complexity measures for climate data analysis

Yong Zou[1], Elbert Macau[2], and Reik Donner[3]
[1]East China Normal University, Department of Physics, Shanghai, China (yzou@phy.ecnu.edu.cn)
[2]Federal University of Sao Paulo, Sao Jose dos Campos, Brazil
[3]Magdeburg-Stendal University of Applied Sciences, Magdeburg, Germany

Complex network approaches have been recently emerging as novel and complementary concepts of nonlinear time series analysis which are able to unveil many features that are hidden to more traditional analysis methods. In this talk, we focus on one particular approach of ordinal pattern transition networks (OPTNs) for characterizing time series data. In particular, we introduce a suite of OPTN based complexity measures to infer the coupling direction between two dynamical systems from pairs of time series. For several examples of both coupled stochastic processes and chaotic Henon maps, we demonstrate that our approach is able to successfully identify interaction delays of both unidirectional and bidirectional coupling configurations.

Furthermore, we focus on applying these methods to characterize the recent extreme drought events in the semiarid region of Northeast Brazil (NEB) where has been experiencing a continuous dry condition since 2012. Therefore, we propose a three-step strategy to establish the episodic coupling directions on intraseasonal time scales from the surrounding ocean to the precipitation patterns in the NEB, focusing on the distinctive roles of the oceans during the recent extreme drought events of 2012-2013 and 2015-2016. Our algorithm involves: (i) computing drought period length from daily precipitation anomalies to capture extreme drought events, (ii) characterizing the episodic coupling delays from the surrounding oceans to the precipitation by applying Kullback-Leibler divergence (KLD) of complexity measure which is based on OPTN representation of time series, and (iii) calculating the ratio of high temperature in the ocean during the extreme drought events with proper time lags that are identified by KLD measures. From the viewpoint of climatology, our analysis provides data-based evidence of showing significant influence from the North Atlantic in 2012-2013 to the NEB, but in 2015-2016 the Pacific played a dominant role than that of the Atlantic. The episodic intra-seasonal time scale properties are potential for monitoring and forecasting droughts in the NEB, in order to propose strategies for drought impacts reduction.

In conclusion, our results suggest that ordinal partition transition networks can be used as complementary tools for causal inference tasks and provide insights into the potentials and theoretical foundations of time series networks.

References:

[1] H. Y. Wu, Y. Zou, L. M. Alves, E. E. N. Macau, G. Sampaio, and J. A. Marengo. Uncovering episodic influence of oceans on extreme drought events in Northeast Brazil by ordinal partition network approaches. Chaos, 30, 053104, 2020.

[2] Y. J. Ruan, R. V. Donner, S. G. Guan, and Y. Zou. Ordinal partition transition network based complexity measures for inferring coupling direction and delay from time series. Chaos, 29, 043111, 2019.

[3] Y. Zou, R. V. Donner, N. Marwan, J. F. Donges, and J. Kurths. Complex network approaches to nonlinear time series analysis. Physics Reports, 787, 1 – 97, 2019.