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Multiplex Recurrence Networks

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The complex nature of a variety of phenomena in physical, biological, or earth sciences is driven by a large number of degrees of freedom which are strongly interconnected. Although the evolution of such systems is described by multivariate time series (MTS), so far research mostly focuses on analyzing these components one by one.

Recurrence based analyses are powerful methods to understand the underlying dynamics of a dynamical system and have been used for many successful applications including examples from earth science, economics, or chemical reactions. The backbone of these techniques is creating the phase space of the system. However, increasing the dimension of a system requires increasing the length of the time series in order get significant and reliable results. This requirement is one of the challenges in many disciplines, in particular in palaeoclimate, thus, it is not easy to create a phase space from measured MTS due to the limited number of available obervations (samples). To overcome this problem, we suggest to create recurrence networks from each component of the system and combine them into a multiplex network structure, the *multiplex recurrence network (MRN)*. We test the MRN by using prototypical mathematical models and demonstrate its use by studying high-dimensional palaeoclimate dynamics derived from pollen data from the Bear Lake (Utah, US). By using the MRN, we can distinguish typical climate transition events, e.g., such between Marine Isotope Stages.