Pattern recognition in complex networks based on spatially embedded time series

The System

The considered system is an advection-reaction-diffusion (ARD) - system of plankton population, already under investigation by Bunde et al. (Trull et al., 2005). It is motivated by hydrodynamical conditions of coastal upwelling and eddies near the Canary Islands. Studies have shown the enclosure of nutrients and plankton to be crucial for the functioning of the ecosystem and stability of the area. Furthermore, the transport dynamics of particles across the wake (generated by a chaotic saddle in the wake and a set of intersecting stable and unstable manifolds) reveal surprising insights in parallels between structures in complex networks and non-linear dynamics.

Method in a Nutshell

- Natural (ARD) System
  - Similarity measure of grid point time series
  - Cross correlation
  - Threshold-based adjacency matrix (with respect to inherent noise)

- Complex Network
  - Statistical inference of system dynamics by the use of network measures and identification of highly non-linear transport paths

The outer vortex regions of high degree and betweenness centrality reveal directed transport in this in combination with a strong edge anisotropy. Regions of low degree and betweenness centrality present in the regions of plankton forming vortices. These do not contribute to directed propagation in this ARD system.

In this example, we show that complex networks are capable of revealing important dynamical features. When dealing with systems of even greater complexity, such as the earth’s climate system, this approach may help to close the gaps in understanding and exactly describing the system’s parameters.

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