Potsdam Institute for Climate Impact Research

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Pattern recognition in complex networks
based on spatialy embedded time series

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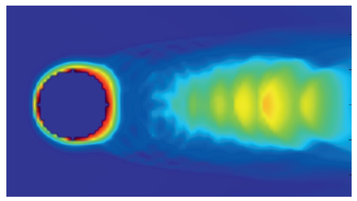
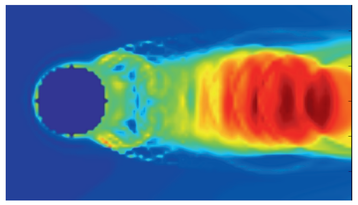
Time series

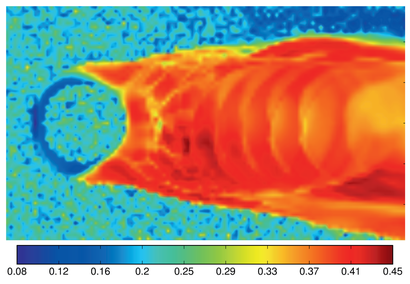


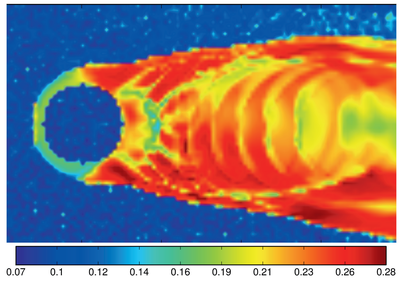
Mean Value



Standard deviation

Cross Correlation





The System

The concerned system is an advection-reaction-diffusion (ARD) - system of plankton population, already under investigation by Sandeulescu & al. (Tellus, 2006). It is motivated by hydrodynamical conditions of coastal upwelling and eddies near the Canary Islands. Studies have shown the enclosure of nutritiens and plankton to be crucial for the functioning of the ecosystem and stability of the area.
Depending on the species, inflow conditions and set parameters, very different realizations of patterns are created. Thereby, the system exhibits a great variety of highly non-linear phenomena, although being fully described by the equations of population dynamics and Navier-Stokes-Equations.
Furthermore, Transport dynamics of particles across the wake (governed 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 nonlinear dynamics.

Method In a Nutshell

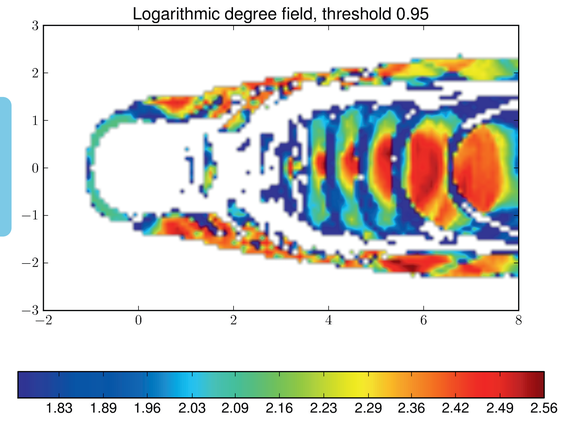
Natural (ARD) System

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

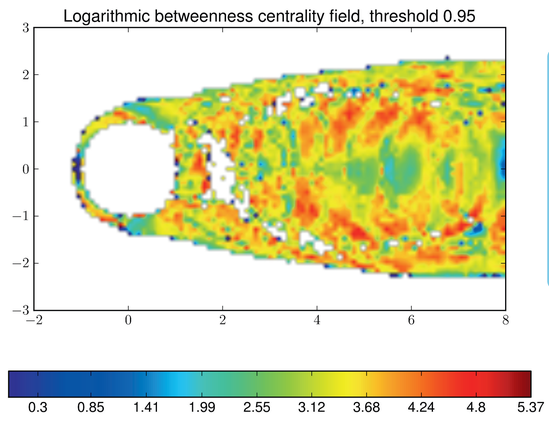
Statistical inference of system dynamics by the use of network measures and identification of highly non-trivial transport paths

Complex Network

Degree



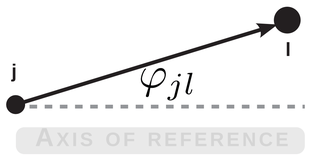
Betweenness Cetrality

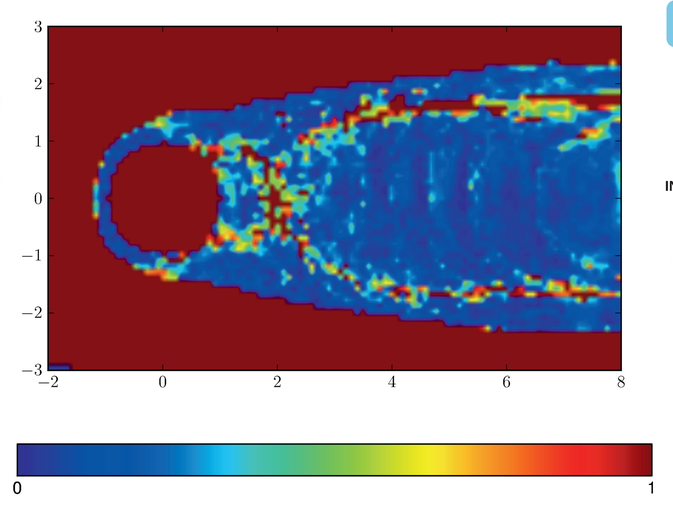


Edge Anisotropy

$$R_j = \frac{1}{k_j} \sum_{l=1}^{N} a_{jl} \exp\left(-i\varphi_{jl}\right)$$

of node k with edge angle φ_{jl} against x-axis





Remarks

The outer vortex regions of high degree and betweenness centrality reveal directed transport paths, in combination with a strong edge anisotropy. Regions of poorer anisotropy are found in the regions of the plankton enclosing vortices. These do not contribute to directed propagation in this ARD - system.
In this example, we show that complex network analysis is capable of revealing important dynamical features.When dealing with systems of even greater complexity, such as the earth's climate system, this approach is valuable due to lacks of understanding and exactly describing the system's parameters.

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Research Domain IV: Transdisciplinary Concepts and Methods

ECONS Evolving Complex Networks

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