EGU24-16007, updated on 08 Dec 2024
https://doi.org/10.5194/egusphere-egu24-16007
EGU General Assembly 2024

Investigating Early Warning Signals in Climate Simulations using Complex Networks

Laure Moinat, Jérôme Kasparian, and Maura Brunetti
Group of Applied Physics and Institute for Environmental Sciences, University of Geneva, Bd. Carl-Vogt 66, CH-1205 Geneva, Switzerland

Early Warning Signals (EWS) are indicators that can be used to anticipate tipping points i.e. abrupt changes in dynamical systems. Detecting EWS is a crucial part of climate science, especially in the context of climate change. Several methods are used to identify tipping points using time series of climate state variables (e.g. temperature, precipitation, etc), but few consider spatial correlations [1]. Spatial detection could identify the starting location of a transition process from a state to another and be directly applied to satellite observations. We consider different state variables on a numerical grid as a complex network, where grid points displaying correlation are connected and the temporal evolution of this network is studied.
We seek for network properties that can be used as EWS when approaching the state transition.

The network is generated and analysed using the pyUnicorn package [2], and compared to classical statistical methods. The networks are constructed using two methods: Pearson correlation coefficient and mutual information, allowing us to compare a linear and a causal approach. Multiple network indicators such as the degree of correlation, the average path length, and the area weighted connectivity are compared. To test the method robustness, we look at the network dependencies in terms of the time window, the interval over which the forcing is changed, and the effect of reducing the extent of the network (limited, for example, over polar or equatorial regions). These indicators show tipping points at the global scale, as simulated in a coupled-aquaplanet configuration with the MIT general circulation model, using as forcing parameter the atmospheric CO_2 content or the input of solar energy [3] . The application of such indicators as EWS is discussed.

[1] van der Mheen et al. Geophysical Research Letters 40, 11 (2013)

[2] Donges et al. Chaos 25, 113101 (2015)

[3] Brunetti \& Ragon, Physical Review E 107, 054214 (2023)