Geophysical Research Abstracts
Vol. 14, EGU2012-8397, 2012
EGU General Assembly 2012

Connectivity, topology and dynamics in climate networks

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Complex network theory allows for novel analyses of multivariate and spatio-temporal data [1]. Mutual dependencies between corresponding subsystems can be represented as a discrete structure – a weighted graph - where each subsystem is represented by a single vertex and each dependence by a connection (a weighted edge) between two such vertices. Then the graph theory is used to identify important features of the studied systems such as scale-free or small-world topology, highly connected hubs and modularity, and helps to understand information or mass transfers among the subsystems.
Constructing the complex networks from multivariate time series, however, the choice of a measure of dependence (the “connectivity measure”) is critical and can influence the topology of the resulted network representation. Interplay of intrinsic properties of a connectivity measure and used time series can generate interesting, but spurious phenomena resembling highly-connected hubs or small-world topology. For instance, the bias due to dynamical memory (serial correlations) [2] in an association/dependence measure (absolute crosscorrelation) can be demonstrated in model data and identified in time series of meteorological variables used for construction of climate networks. Accounting for such bias in inferring links of the climate network markedly changes the network topology and allows to observe previously hidden phenomena in climate network evolution. In particular, the role of the North Atlantic Oscillation in connectivity of the global climate networks is sharply increased at the cost of the role of the El Nino Southern Oscillation [3].

Acknowledgement
This study is supported by the Czech Science Foundation, Project No. P103/11/J068.

References

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