Geophysical Research Abstracts
Vol. 20, EGU2018-6978, 2018
EGU General Assembly 2018

Pattern formation in climate networks - from aquaplanet simulations to real climate

Frederik Wolf (1,2), Catrin Kirsch (1), Aiko Voigt (3,4), and Reik V. Donner (1)

(1) Potsdam Institute for Climate Impact Research, Potsdam, Germany (fwolf@pik-potsdam.de), (2) Department of Physics, Humboldt University, Berlin, Germany, (3) Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany, (4) Lamont-Doherty Earth Observatory, Columbia University, New York, USA

During the last years, it has been shown that tools from complex network theory can help identifying key spatio-temporal variability patterns from climate data. While a close linkage between classical empirical orthogonal functions and network degree has been analytically demonstrated in previous works [1,2,3], the interpretation of other higher-order network measures like betweenness in such climate networks has remained an open problem so far.

Here, we aim to disentangle the information on the underlying climate dynamics provided by various network measures. For this purpose, we study model datasets from aquaplanet simulations performed within the TRACMIP coordinated experiment [4], where an idealized planet is studied that consists of a thermodynamic slab ocean that allows for interactive sea-surface temperatures and air-sea coupling. Insolation follows an idealized version of the present-day annual cycle. In addition to the aquaplanet, setups with quadrupled atmospheric CO_2 and a flat rectangular equatorial continent are studied. Each dataset covers a simulation period of 30 to 45 years with monthly values and a spatial resolution of 1.875 degrees in both latitude and longitude (18,432 grid points).

We construct network representations based upon the spatial correlation structures of temperature, zonal and meridonal wind speed, geopotential height and precipitation fields and perform a detailed study of the resulting patterns exhibited by different topological and spatial network characteristics. This allows us to identify intrinsic interrelations between network measures and to separate them from specific spatial correlation structures in the aquaplanet scenario. By systematically investigating similarities and differences with respect to known processes in the Earth's real climate system, we contribute to a better understanding of pattern formation in climate networks.

As a specific research question, we address possible mechanisms controlling the seasonal change of the location of the inter-tropical convergence zone (ITCZ). Based on the previously established energetic framework, we connect our study to recent publications where the seasonal shift of the ITCZ is explained by cross-equatorial heat transport and the tropical sea-surface temperature gradient [5].

[1] J.F. Donges et al., How complex climate networks complement eigen techniques for the statistical analysis of climatological data, Climate Dynamics, 45, 2407, 2015
[2] M. Wiedermann et al., Hierarchical structures in Northern Hemispheric extratropical winter ocean-amosphere interactions, International Journal of Climatology, 37, 3821, 2017
[3] R.V. Donner et al., Complex network techniques for climatological data analysis. In: Nonlinear and Stochastic Climate Dynamics, ed. by C. Franzke and T. O'Kane, Cambridge University Press, Cambridge, 2017, pp. 159-183
[4] A. Voigt et al., The tropical rain belts with an annual cycle and a continent model intercomparison project: TRACMIP, Journal of Advances in Modeling Earth Systems, 8, 1868, 2016
[5] A. Donohoe et al., The Relationship between ITCZ Location and Cross-Equatorial Atmospheric Heat Transport: From the Seasonal Cycle to the Last Glacial Maximum, Journal of Climate, 26, 3597, 2013