Visibility graphs for testing reversibility of time series

J.F. Donges (1,2), R.V. Donner (1), J. Kurths (1,2)

(1) Potsdam Institute for Climate Impact Research, Transdisciplinary concepts and methods, Potsdam, Germany (donges@pik-potsdam.de), (2) Department of Physics, Humboldt University, Berlin, Germany

Reversibility or time reversal symmetry is a fundamental property of time series. Among other applications, it can be harnessed for selecting models that are consistent with observational or experimental time series data. Here, we propose a novel set of statistical tests against reversibility based on visibility graphs constructed from time series as well as on time-directed variants of common graph-theoretical measures like degree and local clustering coefficient. Unlike other tests against irreversibility, the technique proposed here has the advantage that it does not require the construction of surrogate time series. We investigate the performance of our statistical tests for time series from paradigmatic model systems with known time reversal properties and compare it to a traditional test against reversibility. Finally, our tests are applied to characterize the temporal structure of exemplary geoscientific time series.