Project 3 – Evolving network analysis of European winter temperatures

Oscillations are ubiquitous in nature and also play a key role in weather and climate variability. The Quasi-Biennial Oscillation (QBO) is a temporal change in the direction of the zonal wind in the equatorial lower stratosphere with periods of slightly more than two years (28 months). These directional changes have a significant influence on the atmospheric circulation pattern in the mid-latitudes and on the temperature profile over Europe. However, the mechanisms are poorly understood, making it difficult to estimate the influence of global warming on QBO and winter temperatures in Europe.
We provide you with an ERA 5 temperature data set that covers the period between 1981-2020 with hourly resolution for the whole European continent. The data set contains NaN-values which you can treat as 'missing at random' by discarding pairs of values that contain NaNs for the computation of correlations. It could turn out to be helpful to average the time series over daily-weekly time scale to save computation time or denoise the variability. To obtain an evolving representation of winter temperatures, constrain annual time series to a sufficient time window that contains winter temperatures only and do not subtract seasonality as this time, this is what we are interested in.

- **Network construction –** can one construct a complex network based on joint recurrences?
  Dynamic networks of a system with spatio-temporal variability are usually based on a similarity measure that allows to generate an adjacency matrix. Both linear (e.g. Pearson correlation) and nonlinear correlations (e.g. mutual information) have been applied to construct climate networks. Can you construct a climate network by using joint recurrences between the European winter temperature time series? Does the resulting network uncover features missed with Pearson correlation?
  (Possible tools: correlations, complex networks)

- **Nonstationary network features** – are some network properties varying in periodical manner or indicating continuous or abrupt shifts in European winter temperature variability?
  A complex network computed from correlations between time series is a static and aggregated representation of the underlying system. The correlations used to define the adjacency matrix can actually undergo quite drastic variations and render the spatiotemporal covariance structure nonstationary. By generating a network for shorter time episodes and analyzing each network separately, one can study these variations (sliding window analysis). Can you generate such an evolving network for European winter temperatures and analyse it by means of some network property, e.g. centrality?
  (Possible tools: complex networks)

The report should be designed like a research paper. The introduction can very briefly give a general understanding of substantial knowledge on European temperature variability and past advances in applying complex networks to similar systems. Please outline which methods you have used in which way next and also don't hesitate to point out where you have faced issues. Your results can be a few key figures which you would like to discuss while supporting figures can be added in a supplement or just shown in your jupyter notebook. If you actually identified something novel: Heureka! Briefly discuss & conclude these findings and we will discuss together wether it could potentially be published. Have fun!