Discovery of Climate Patterns with Complex Networks

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Abstract
Climate scientists have applied various clustering methods to discover patterns in historical data, for example regions that share some common climatological behavior. However, such approaches are limited in that they (i) often only consider a single variable (ii) view time series data as multi-dimensional feature vector (iii) lack the ability to capture long-range relationships. We address these issues by employing a complex network (graph) representation of the data. Nodes correspond to physical locations around the globe, and edges are placed between them based solely on their climatologic similarities; to incorporate the temporal nature of the data, a multivariate cross correlation function is used to weight the network edges. This weighted network approach offers a more powerful and versatile representation of the data.

We start with 60 years of historical data for temperature, precipitable water, pressure, and relative humidity, divide it into 5-year windows, and construct a separate network from each period to study the network dynamics over time. We then apply a community detection algorithm to each network to identify climate regions and show that these "communities" have a climatological interpretation; for example, we are able to find teleconnections between South America, Africa, and India that are likely linked to the El Nino Southern Oscillation. Tracking communities over consecutive periods allows us to study structural changes, and disturbances in structure can be an indicator of climate events. Finally, we discuss how this model can be extended for the discovery of more complex concepts such as dependence structure between climate extremes or discovery of multivariate climate indices.