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Correlation-based similarity networks for unequally sampled data

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Complex networks present a promising and increasingly popular paradigm for the description and analysis of interactions within complex spatially extended systems in the geosciences. Typically, a network is constructed by thresholding a similarity matrix which is based on a set of time series representing the system's dynamics at different locations. In geoscientific applications such as paleoclimate records derived from ice and sediment cores or speleothems, however, researchers are inherently faced with irregularly and heterogenously sampled time series. For this type of data, standard similarity measures, e.g., Pearson correlation or mutual information, must fail. Most attention has been placed on frequency-based methods focussing on the derivation of power spectra, such as the Lomb-Scargle periodogram. In the context of paleoscientific network research correlation estimation is of high interest, but available methods require interpolation prior to analysis. Here we present a generalization of the Pearson correlation coefficient adapted to irregularly sampled time series and show that it has advantages over the standard approach. Characterizing the method in the application to model systems we further extend our scope to real world data and show that it offers new options for network research and provide novel insights into the functioning of the earth system.