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Reconstructing regional climate networks from irregularly sampled satellite data

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With the increasing availability of remote sensing data Earth System Analysis has taken a great step forward. Satellite data with high resolution in time and space allow for an in-depth analysis of small-scale processes in the climate as well as ecosystems. This data type, however, also harbors crucial conceptual complications. First, depending on whether the satellite is orbiting on an ascending or descending path systematic biases are induced into the dataset and both measurements can not be evaluated simultaneously without an appropriate preprocessing. Second, remote sensing data are usually not produced with equidistant temporal sampling, but might contain huge gaps, due to cloud cover or maintenance work and irregular time steps, due to the orbiting time of the satellite.

In this work, we utilize sea surface temperature (SST) data obtained from the SMOS satellite as part of ESA's Earth Explorer Mission to study small-scale regional interactions between different parts of the Mediterranean, Aegean and Black Sea. In a first step, we create homogeneous time series for each grid point by combining data from ascending and descending satellite paths by utilizing principal component and singular spectrum analysis. To address the issue of irregular temporal sampling we utilize a kernel weighted version of the linear cross-correlation function to compute lagged correlations between all pairs of grid points in the dataset. By setting a threshold to the thus obtained correlation matrix we obtain a binary matrix which can be interpreted as the adjacency matrix of a complex network. We then use tools from complex network theory to study regional interdependencies in the study area for different time lags of up to forty days.

We find that the obtained networks represent well the observed average wind directions and speeds and display interaction structures between small regions in the Aegean Sea, which are in good agreement with earlier observations. The methods presented in this work provide a general framework for dealing with remote sensing data that are unevenly sampled in time and is of high value to many fields of data analysis in Earth System science.