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Regional climate network analysis from irregularly sampled satellite data

Marc Wiedermann (1,2), Olga Sykioti (3), Constantinos Papadimitriou (3,4), George Balasis (3), Jürgen Kurths (1,2,5), and Reik V. Donner (1)

(1) Potsdam Institute for Climate Impact Research, Research Domain IV, Potsdam, Germany, (2) Department of Physics, Humboldt University, Berlin, Germany, (3) Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Penteli, Greece, (4) Section of Astrophysics, Astronomy and Mechanics, Department of Physics, University of Athens, Athens, Greece, (5) Institute for Complex Systems and Mathematical Biology, University of Aberdeen, Aberdeen, UK,

With the increasing availability of remote sensing data Earth System Analysis has taken a great step forward. This type of data, however, also harbors a variety of conceptual complications. First, depending on whether the satellite is orbiting on an ascending or descending path systematic biases are induced into the data, and both measurements cannot be evaluated simultaneously without an appropriate preprocessing. Second, remote sensing data are usually not produced with equidistant temporal sampling, but might contain huge gaps and irregular time steps. Third, the time period covered by the data is often too short to perform an appropriate seasonal detrending.

Here, we propose a general framework to create homogeneous anomalized time series for a (multivariate) satellite data set by combining time series from ascending and descending satellite paths or even different missions using principal component and singular spectrum analysis. We then exemplarily apply our method to sea surface temperature data obtained from the SMOS satellite
mission to study small-scale regional correlative patterns covering different parts of the Aegean Sea. 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 data set. By binarizing the thus obtained matrices, we obtain a network representation of the system's similarity structure. Ultimately, we 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. In a second step, we extend the study area to the whole Mediterranean and Black Sea and investigate lagged interactions between these two water bodies and subsets thereof.

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.