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How to analyse irregularly sampled geophysical time series?

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One of the challenges of time series analysis is to detect dynamical changes in the dynamics of the underlying system.There are numerous methods that can be used to detect such regime changes in regular sampled times series. Here we present a new approach, that can be applied, when the time series is irregular sampled. Such data sets occur frequently in real world applications as in paleo climate proxy records.

The basic idea follows Victor and Purpura [1] and considers segments of the time series. For each segment we compute the cost of transforming the segment into the following one. If the time series is from one dynamical regime the cost of transformation should be similar for each segment of the data. Dramatic changes in the cost time series indicate a change in the underlying dynamics. Any kind of analysis can be applicable to the cost time series since it is a regularly sampled time series. While recurrence plots are not the best choice for irregular sampled data with some measurement noise component, we show that a recurrence plot analysis based on the cost time series can successfully identify the changes in the dynamics of the system.

We tested this method using synthetically created time series and will use these results to highlight the performance of our method. Furthermore we present our analysis of a suite of calcite and aragonite stalagmites located in the eastern Kimberley region of tropical Western Australia. This oxygen isotopic data is a proxy for the monsoon activity over the last 8,000 years. In this time series our method picks up several so far undetected changes from wet to dry in the monsoon system and therefore enables us to get a better understanding of the monsoon dynamics in the North-East of Australia over the last couple of thousand years.

[1] J. D. Victor and K. P. Purpura, Network: Computation in Neural Systems 8, 127 (1997)