A novel approach for the study of the temporal coherence of global time series

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Introduction

Global change detection

- The study of the temporal coherence of global phenomena can help the detection and the understanding of (possible) global changes.
  - What is temporal coherence?
  - How can it be helpful?
  - How to study temporal coherence?
Temporal coherence - Loose definition

- Two phenomena are temporally coherent if they share a similar temporal pattern
  - Global coherence
  - Local coherence
Global coherency

No coherency

Local coherency

Time
How can coherence be helpful?

- The study of coherence may be useful in detecting global changes. Why?
  - It may be difficult to detect a global change by looking at a single time series (noise or signal?)
  - It may be difficult to detect a global change by looking at a large number of time series
  - It should be easier to detect a global chance by looking at coherent time series
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How to study temporal (global) coherence?

- **Coherence** is usually defined between pairs of time series and
  - it is often used as a synonym of temporal cross correlation
  - it has a precise formulation in signal processing which extends the definition of temporal correlation

- What if we are dealing with a large number of time series?
  - In general, a large number of time series is not jointly coherent
  - Pairwise temporal correlation gives rise to a (large) matrix not easy to interpret
  - It is useful to identify groups of coherent time series
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A new definition of coherence

- A group of time series are jointly coherent when, apart from random noise, they share the same temporal pattern along the entire temporal frame of observation.

- The study of the temporal coherence consists in
  - Estimating the number of groups of temporally coherent series
  - Allocating each time series to belong to a group

- In other words: cluster analysis
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Time series clustering

Observed time series

Latent clusters
Time series clustering

Observed time series

Latent clusters
Case study
ARC-Lake dataset - LWST time series

http://www.geos.ed.ac.uk/arclake/data.html
D-STEM software

- **D-STEM**: Distributed Space Time Expectation Maximization
  - Matlab® software for the statistical modelling of space-time data
  - Distributed and parallel computing
  - Large datasets - Tested up to 20’000 time series
  - Now includes clustering capabilities
Conclusions

- The clustering of global time series can be a fundamental step in the detection of global changes.

- We developed a clustering technique:
  - Based on a sound statistical model
  - Able to provide the number of clusters and the cluster membership
  - Able to work with large datasets
  - Implemented within the D-STEM software

- Future applications: highly noisy data and missing data (TOC dataset)
TOC dataset

Month vs. TOC concentration
TOC dataset - Preliminary results

Cluster 1 - 140 time series

Cluster 2 - 66 time series

Cluster 3 - 63 time series

Cluster 4 - 64 time series

Month
TOC dataset - Preliminary results
References


