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

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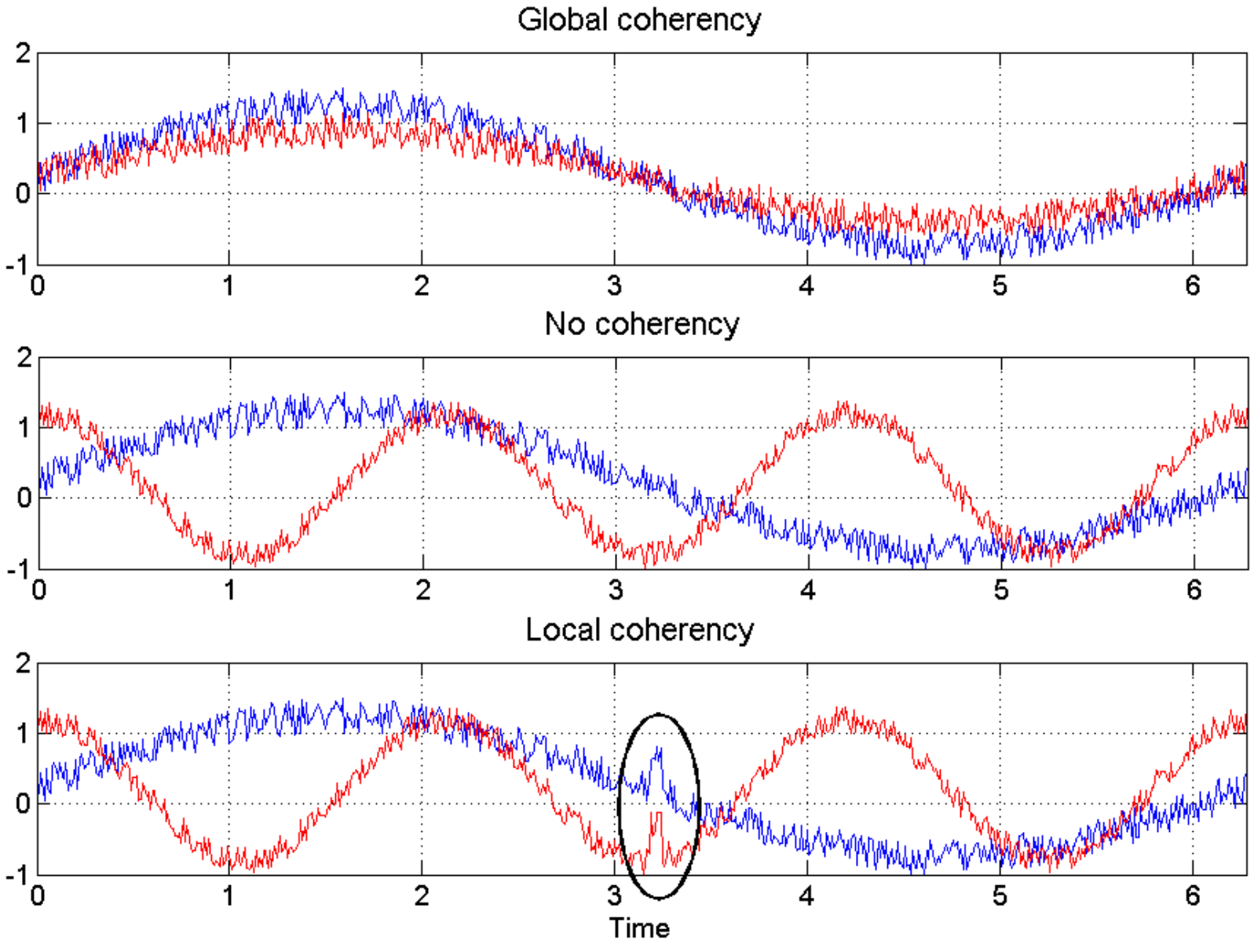
Global change detection

- 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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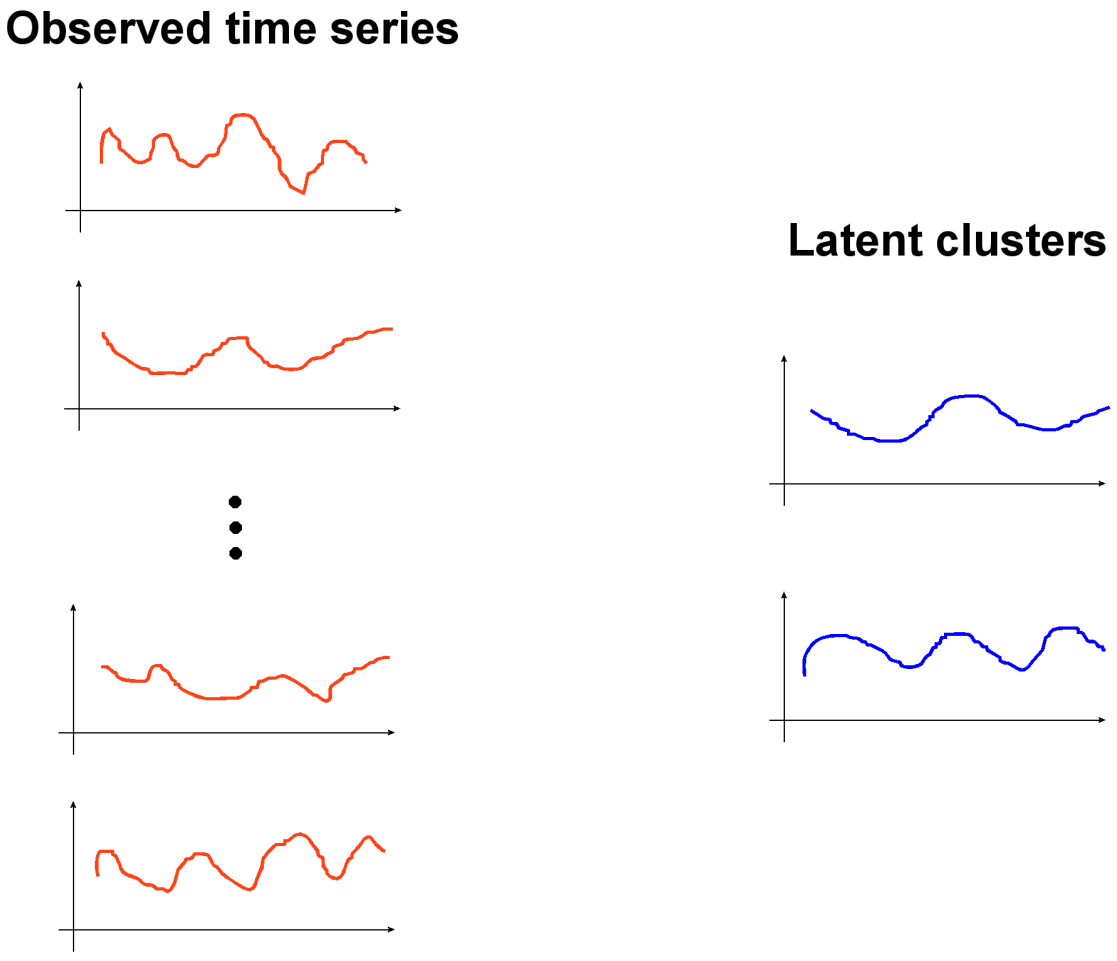
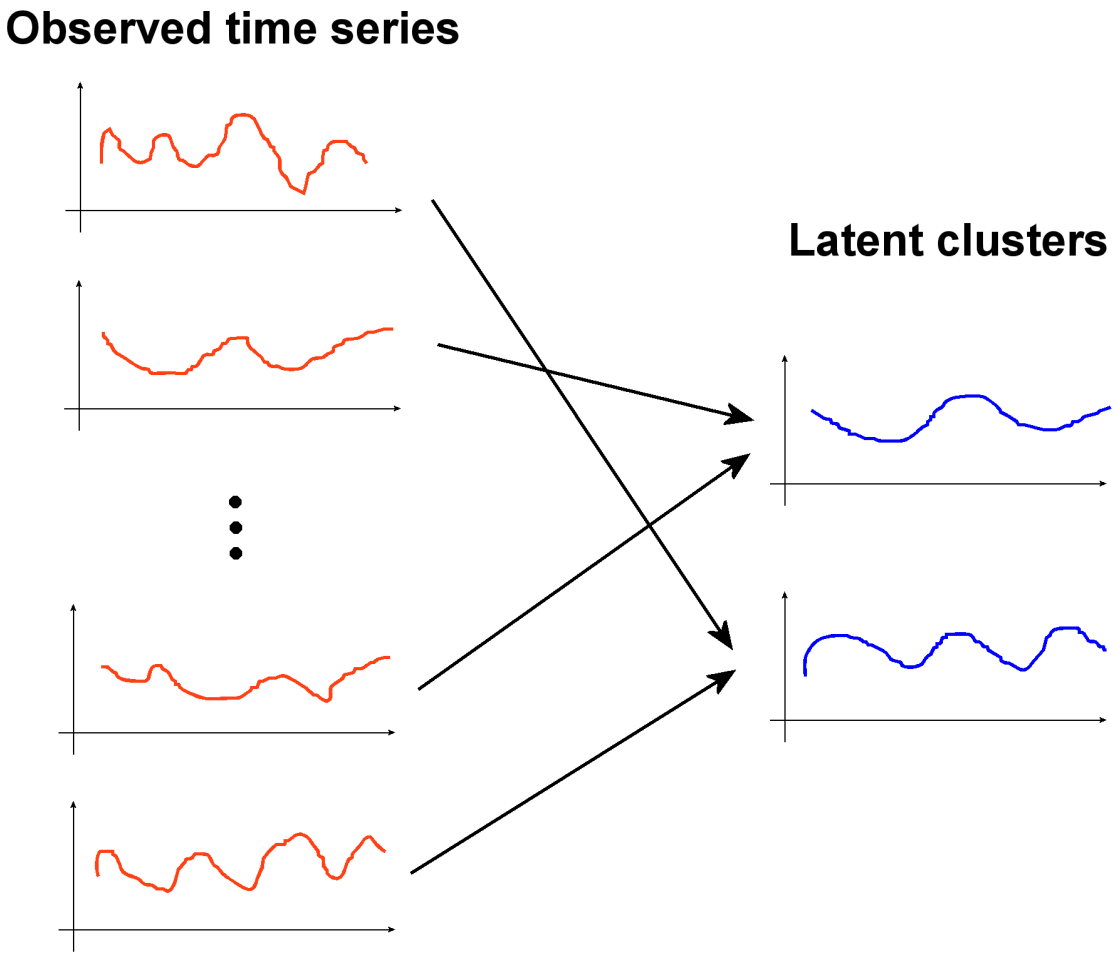
Time series clustering

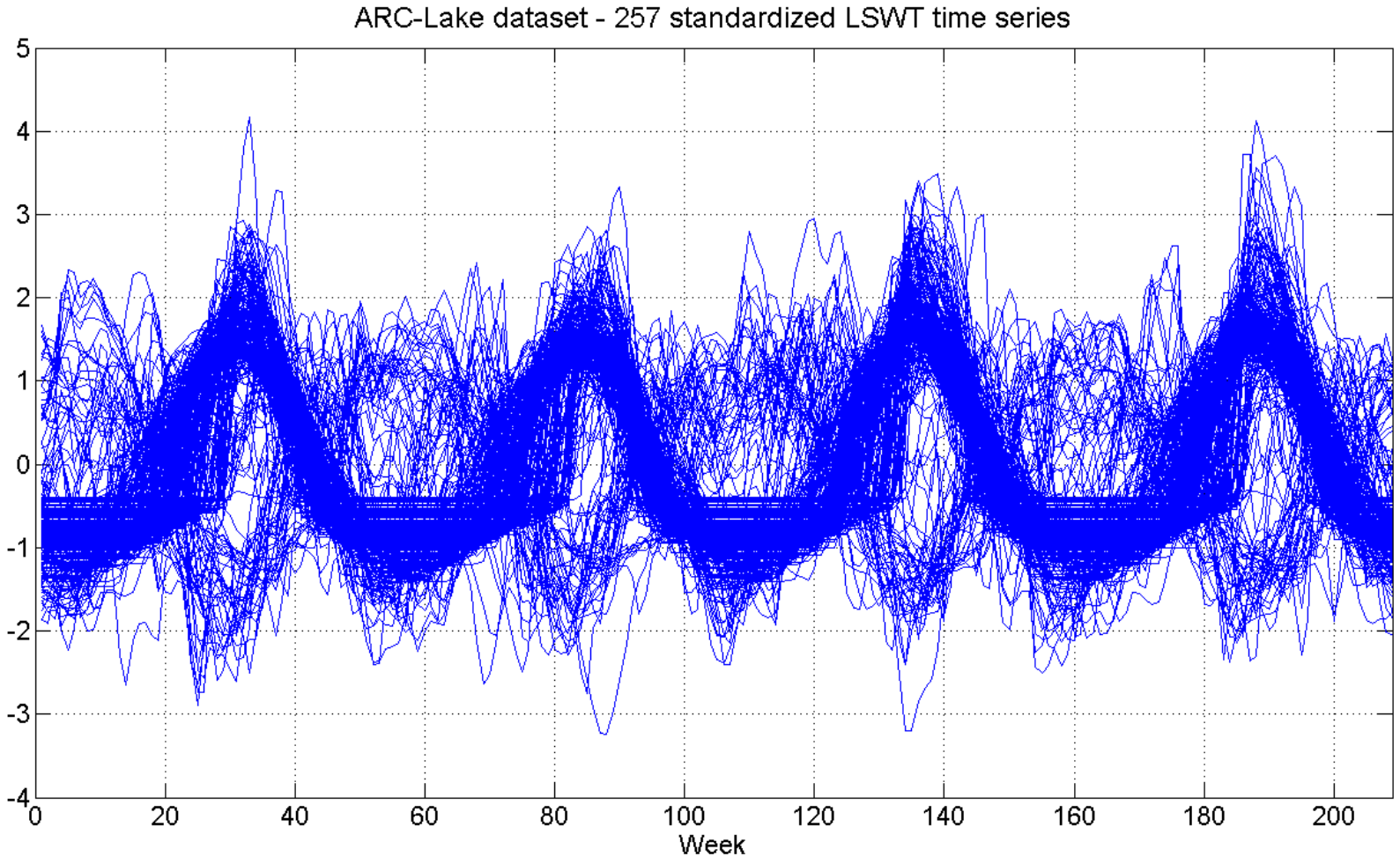


Time series clustering



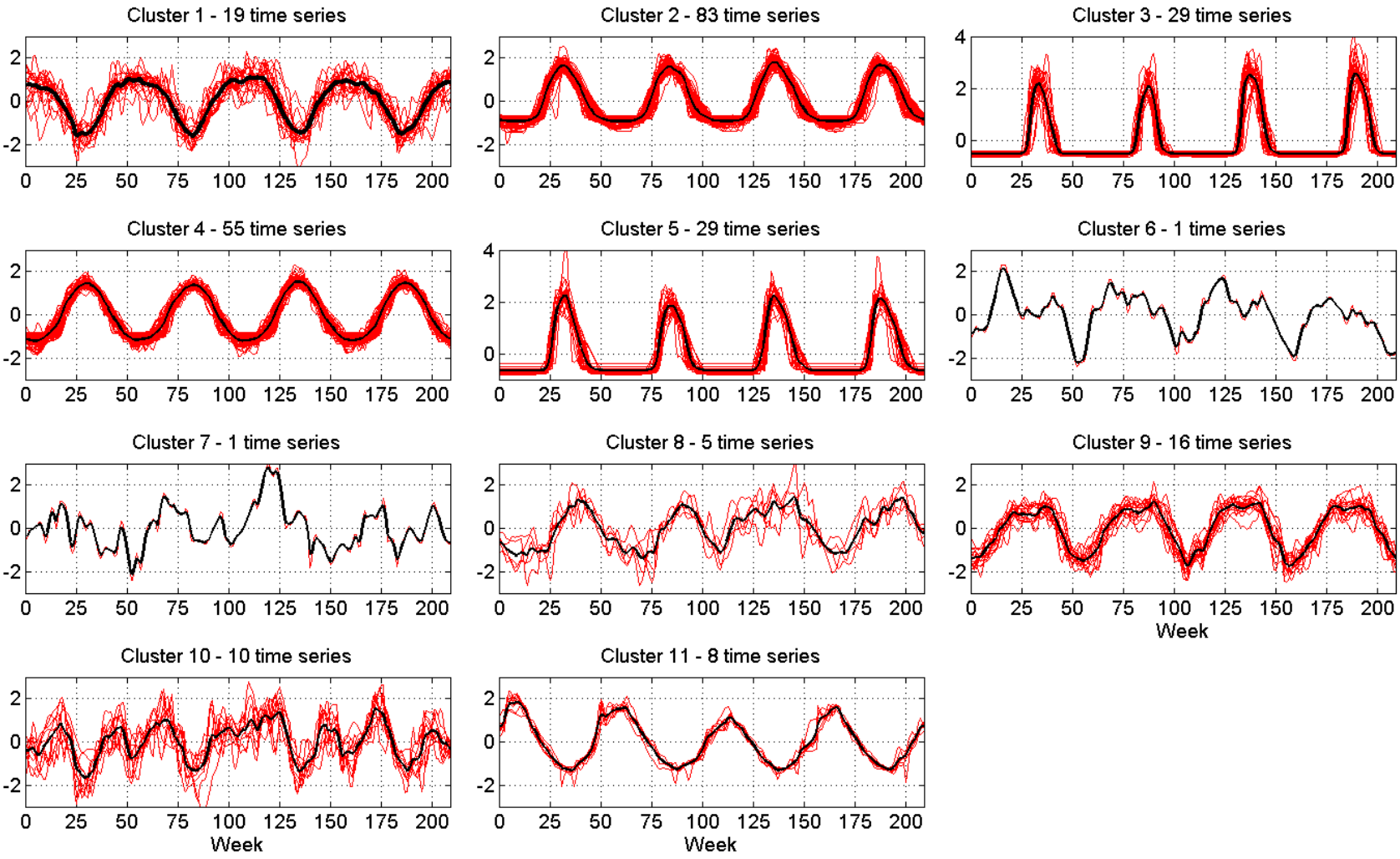
Case study

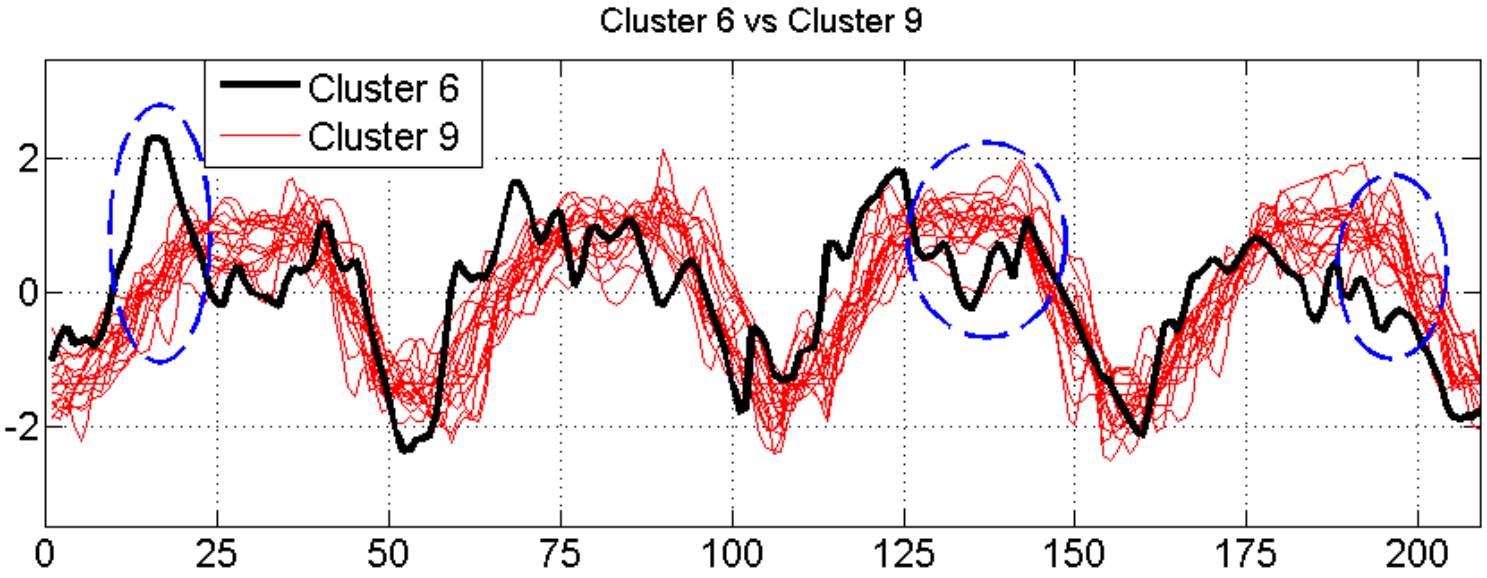
ARC-Lake dataset - LWST time series

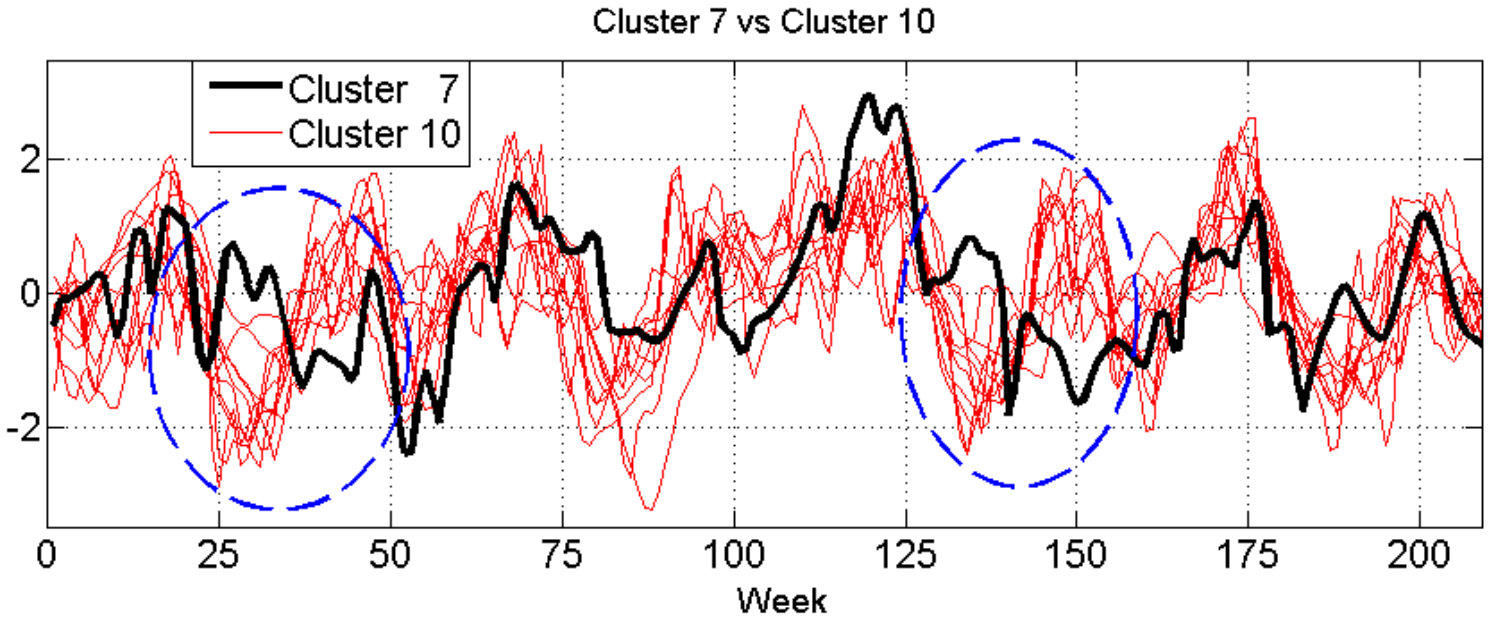


http://www.geos.ed.ac.uk/arclake/data.html

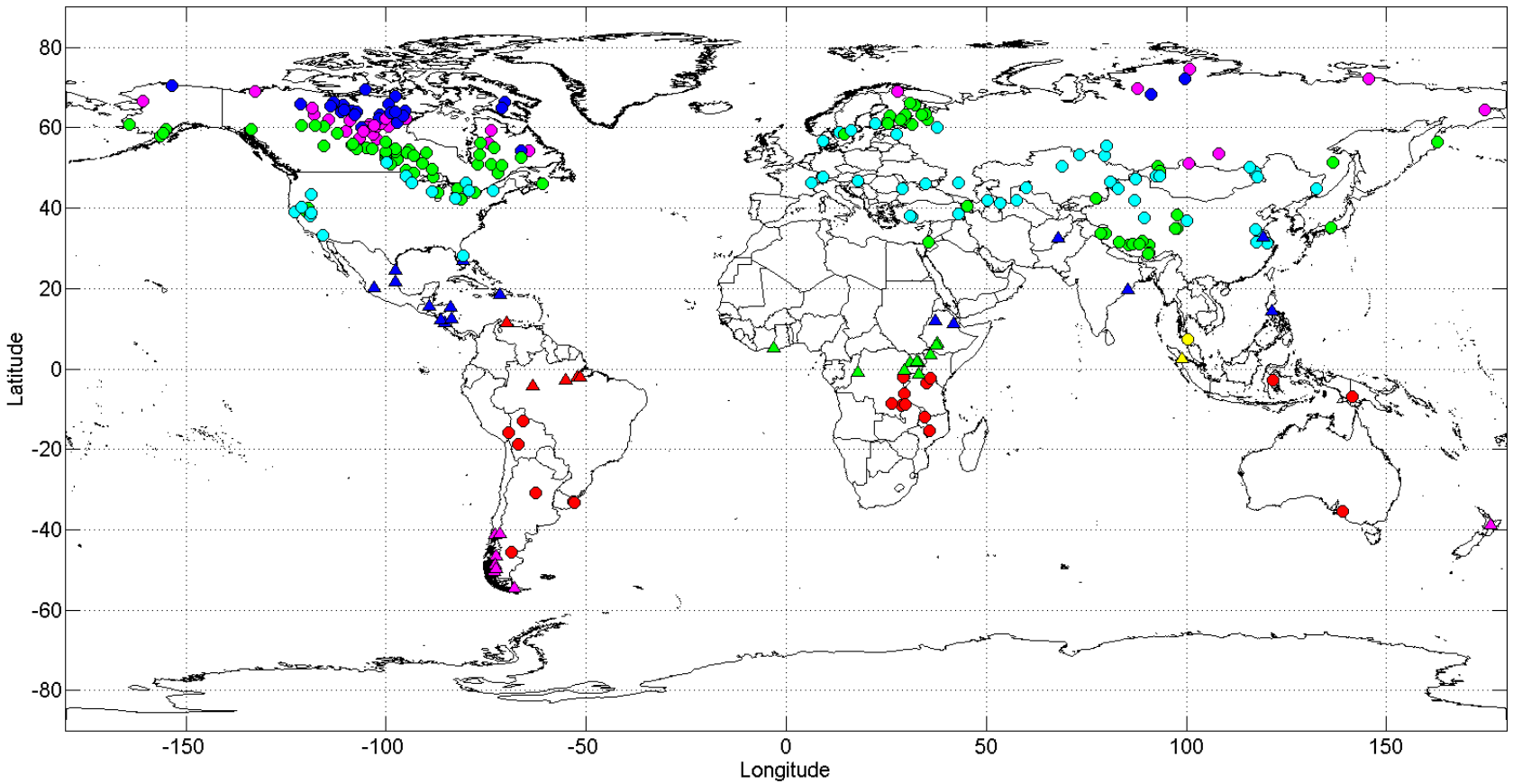
Clustering result

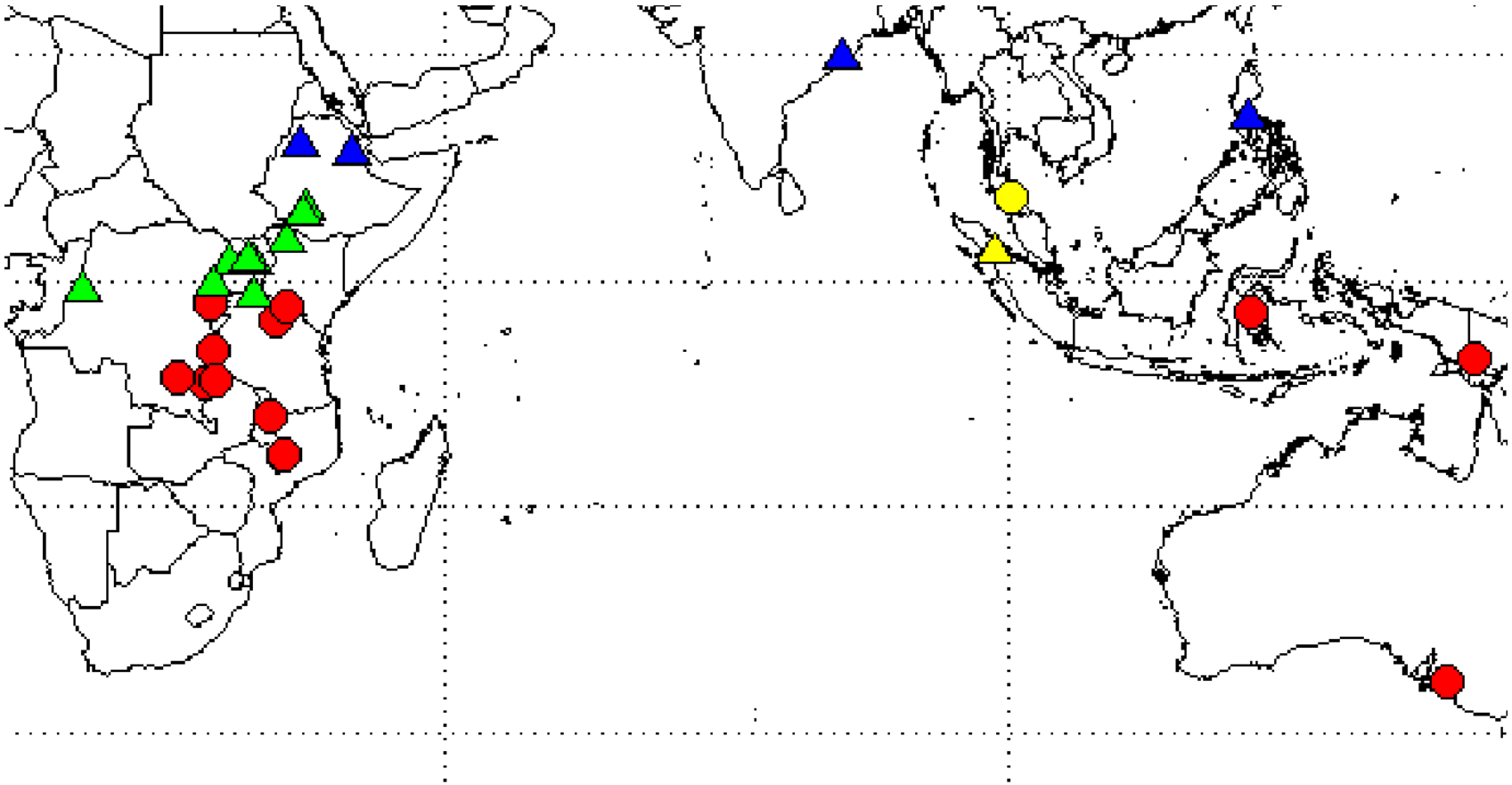



Cluster 6 vs Cluster 9
Cluster 6
Cluster 9
2
0
-2
0
25
50
75
100
125
150
175
200


Cluster 7 vs Cluster 10
Cluster 7
Cluster 10
2
0
-2
0
25
50
75
100
125
150
175
200
Week

Clustering result - Global map





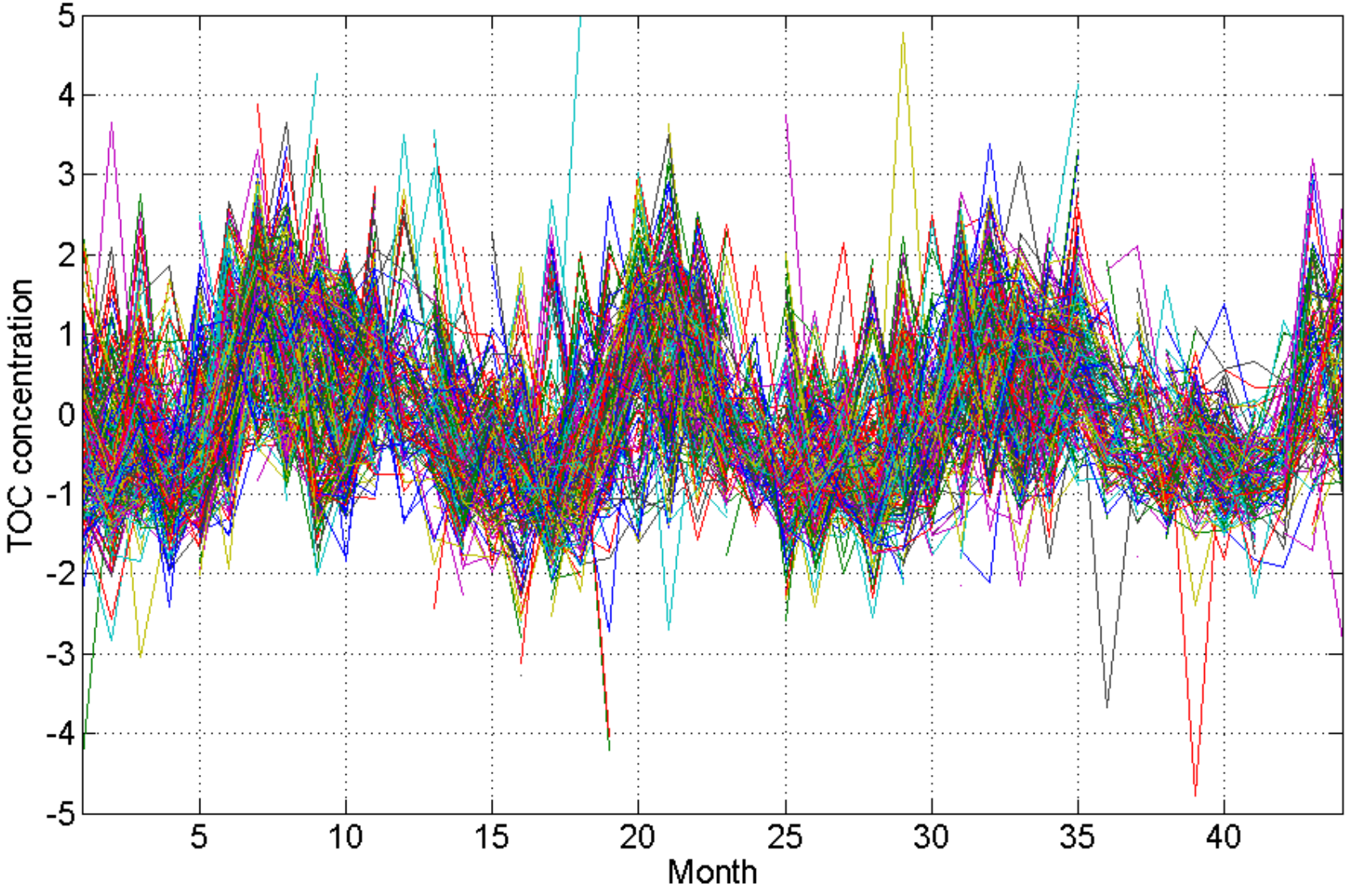
D-STEM software

- 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
  - Available at `http://code.google.com/p/d-stem/`

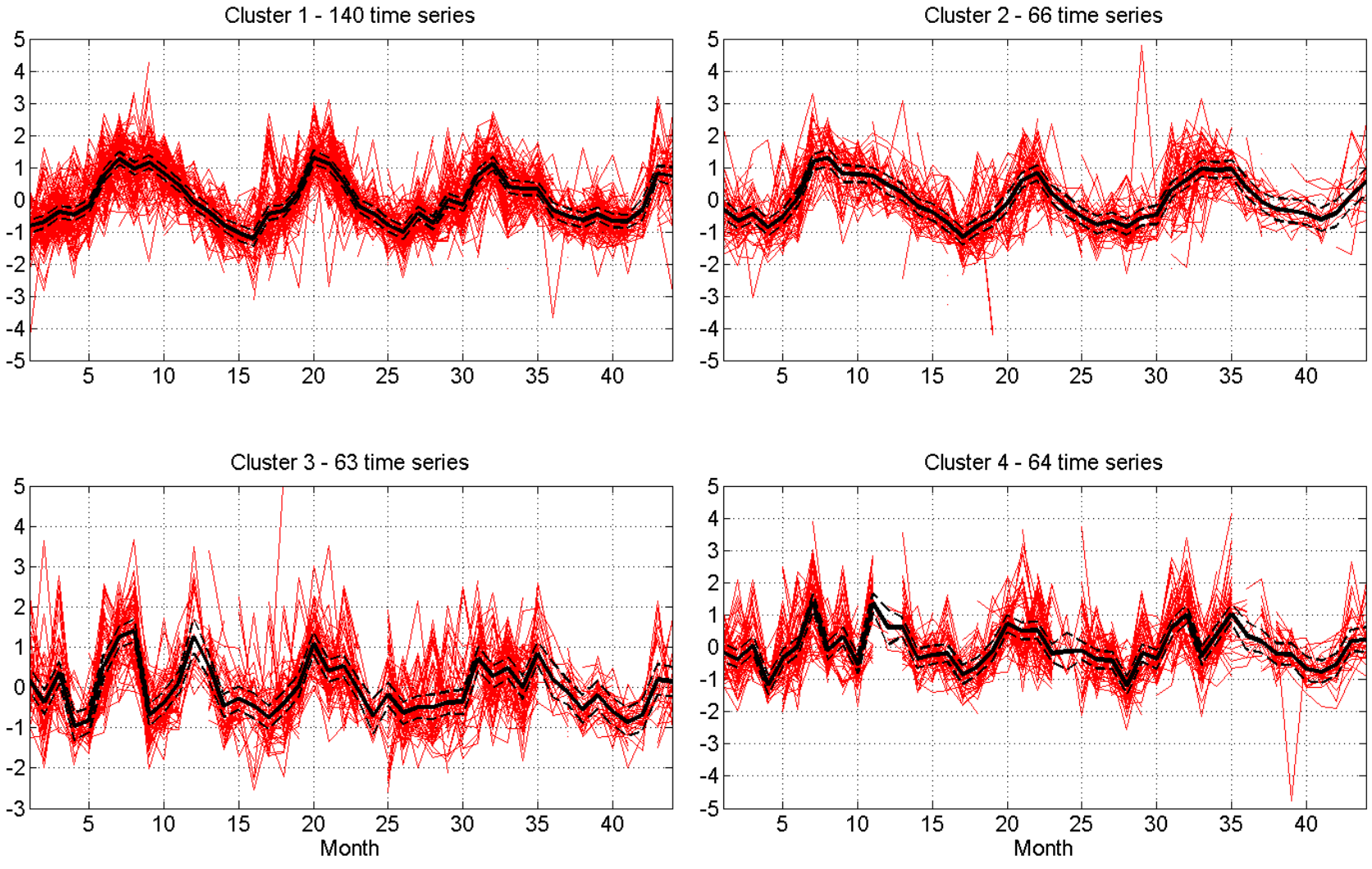
Conclusions

- 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



TOC dataset - Preliminary results



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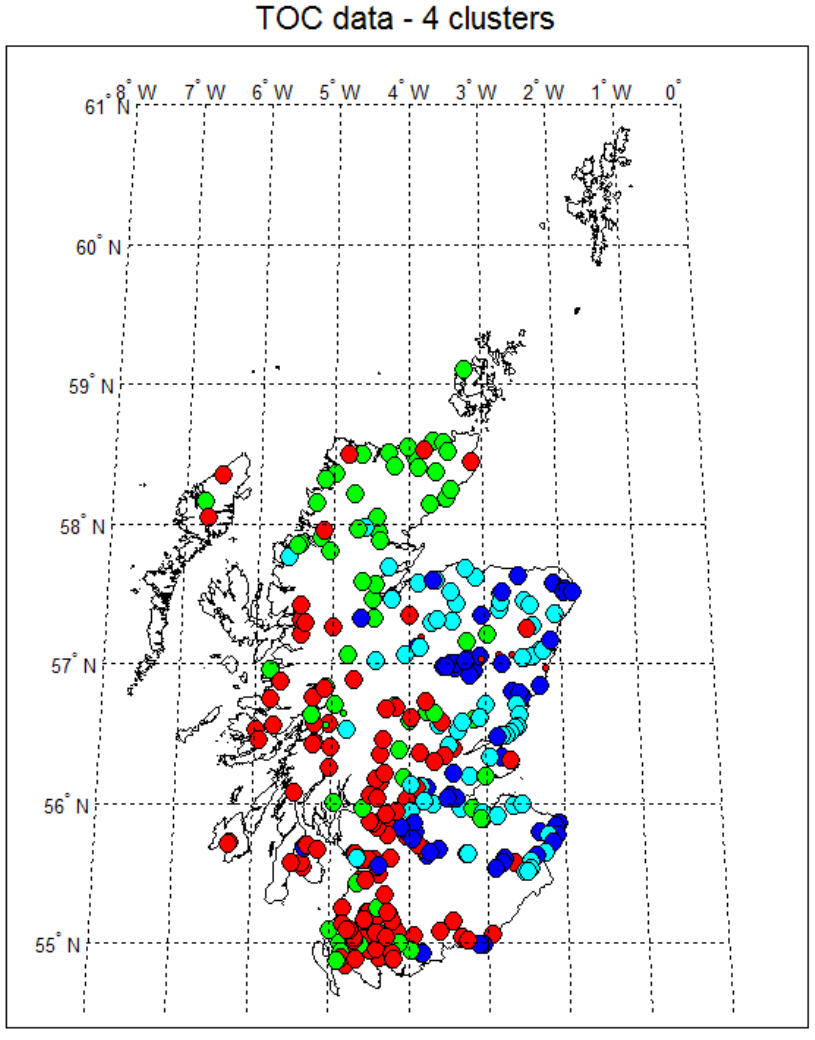

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