Globolakes : Global coherence of lake water quality

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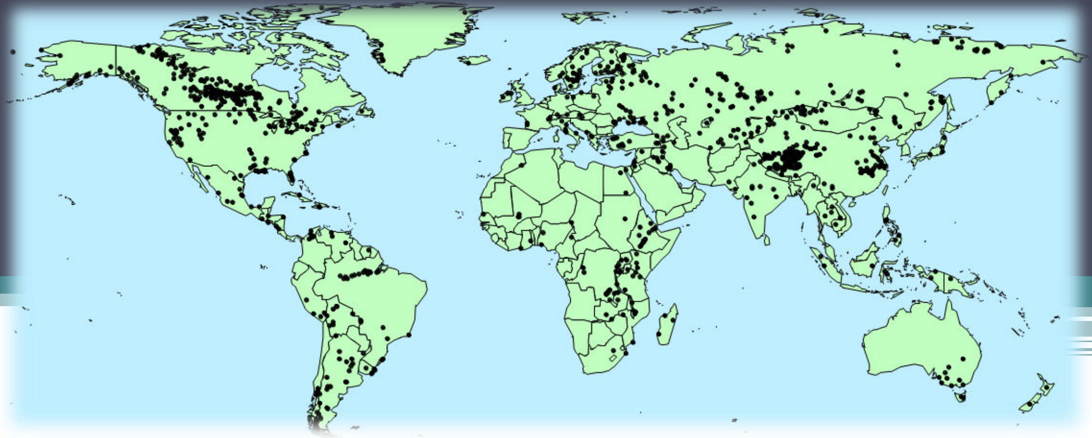

GloboLakes
Global Observatory of Lake Responses to Environmental Change

NERC SCIENCE OF THE ENVIRONMENT

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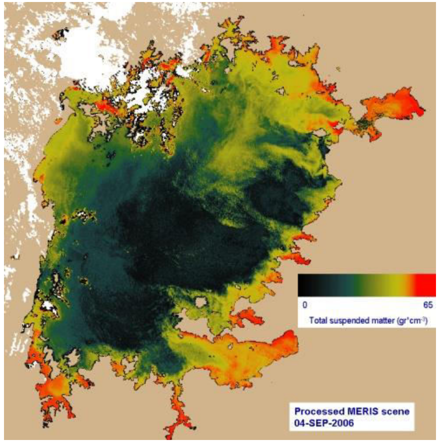
Globolakes (www.globolakes.ac.uk)

- **Globolakes** is a 5 year consortium project involving 6 UK research groups

- Our goal is to investigate the state of 1000 lakes and their response to climatic and other environmental drivers of change at a global scale using a 20 year archive of satellite based observations.

- One of our key aims is to identify patterns of temporal coherence for individual remotely sensed lake characteristics and the spatial extent of coherence for 1000 lakes.



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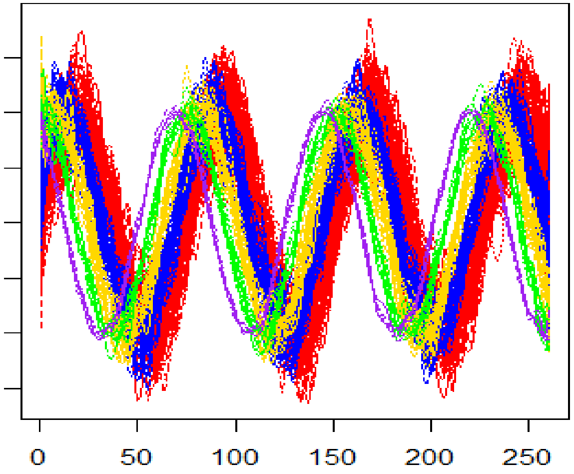
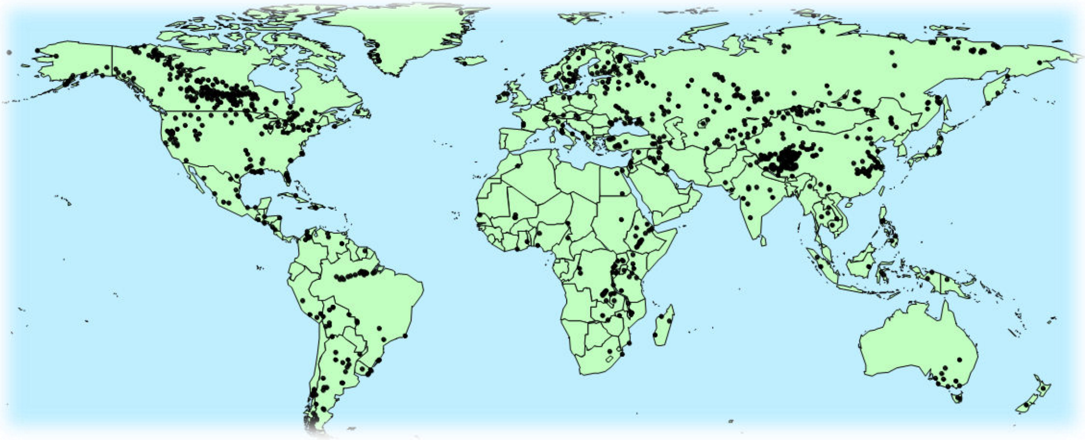
Coherence

- Identifying both long-term change and phenological/seasonal changes is of great ecological importance.
- The synchrony between major fluctuations in a set of time series is often described as **temporal coherence.**
- Aim: group time series into a suitable number of clusters where two time series belong to the same cluster if they are coherent with each other.
- Focus on comparing a large number of time series and obtain groupings based on common features across time.
- A **functional data analysis** approach has been taken



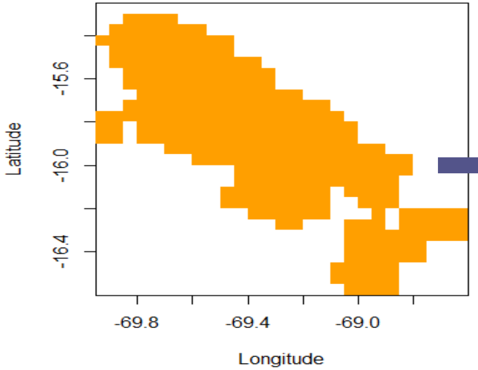
ARCLake data

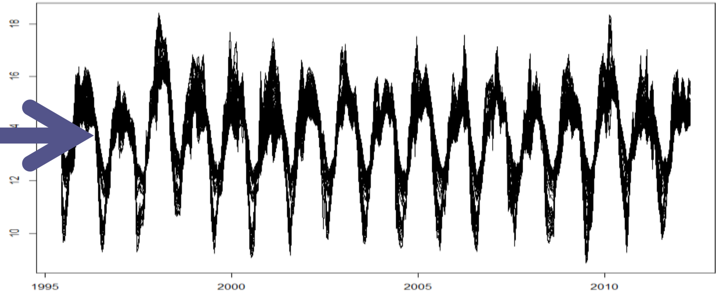
- Average lake surface water temperature data (processed using images from AATSR satellite)
- For global coherence, lake mean time series are considered
- Twice monthly observations covering an 18 year time period between 1995 and 2012
- Data on 700 lakes across entire time period
- Investigate clusters based on trend and seasonality together



ARClakes/Globolakes Lakes Locations

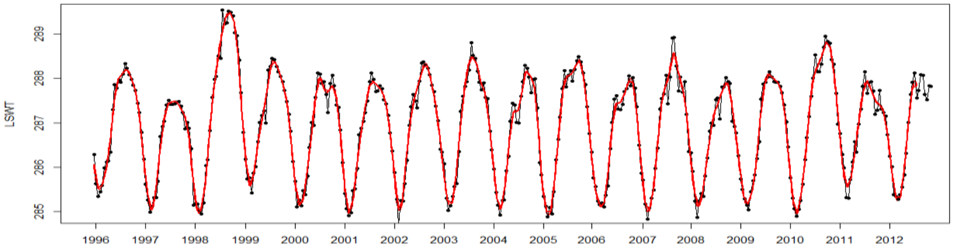
Functional Data Analysis





- Each time series corresponds to a pixel
- Compute mean curves
- Each time series can be smoothed – keep key features but remove local variability

- Smooth curves fitted to each lake means using a b-spline basis
- Model based clustering applied to the b-spline coefficients which define the smooth curves
- Results are data driven



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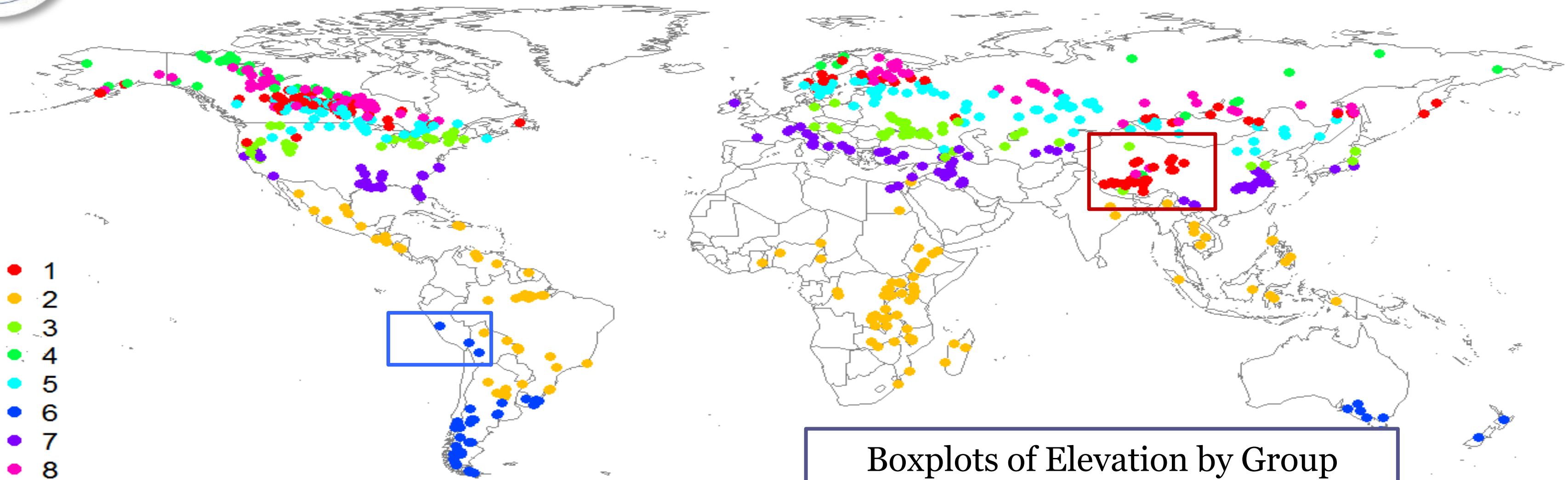
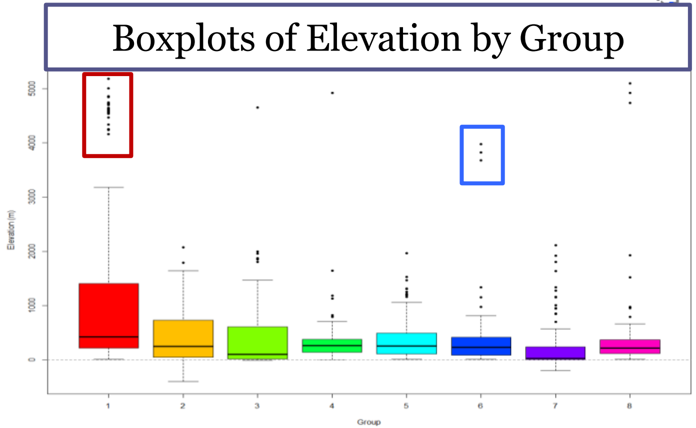
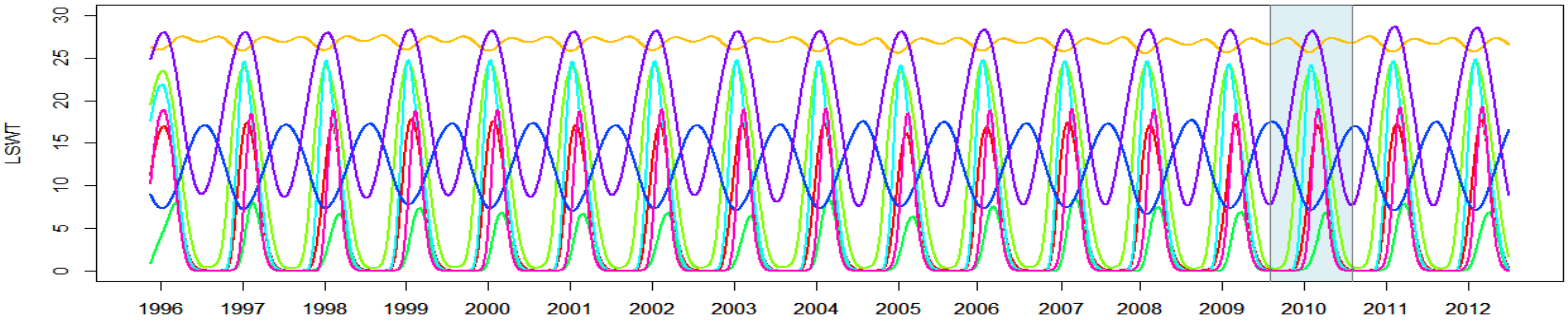
Results: Global Coherence

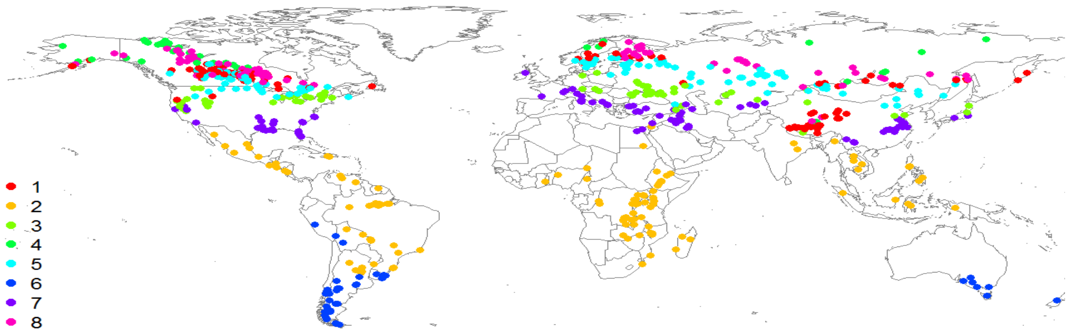


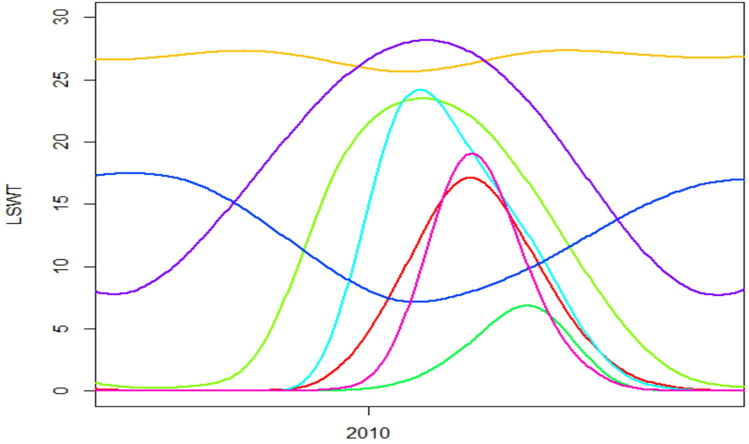
- 8 clusters identified as statistically optimal
- Map shows distribution of clusters
- Only temperature data underpins the formation of the clusters



Results: Global Coherence

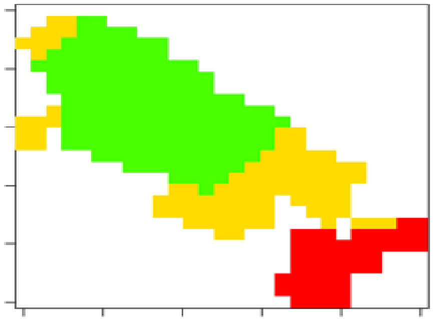


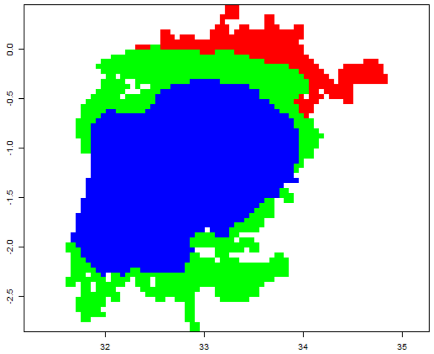


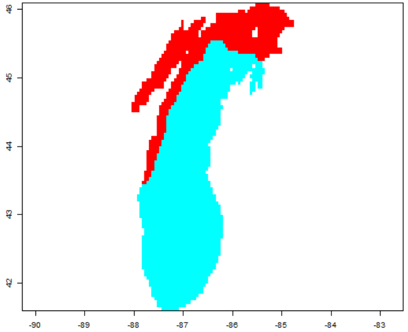


Within Lake Coherence

- Investigate the similarities of different areas within lakes
- Large lakes may have several basins/areas within them that have different characteristics in terms of the trends, seasonal patterns and levels of determinands present
- How do we identify these different areas?
- We have taken a two stage approach;
  - Functional Principal Component Analysis (FPCA)
- Use FPCA to find dominant modes of variation in the data (known as principal components or PCs)
- Keep a small number of these PCs in order to approximate the original data







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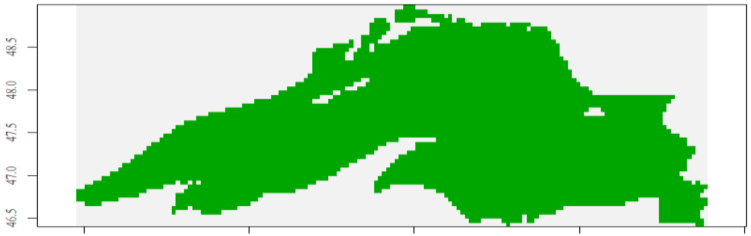
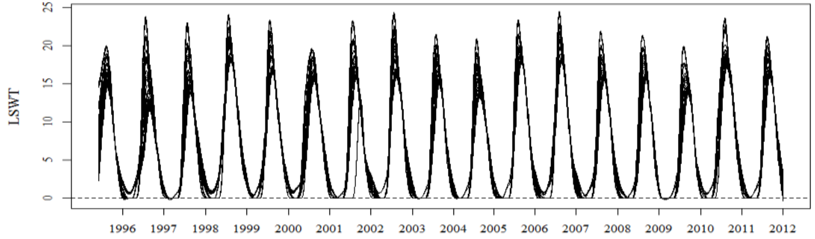
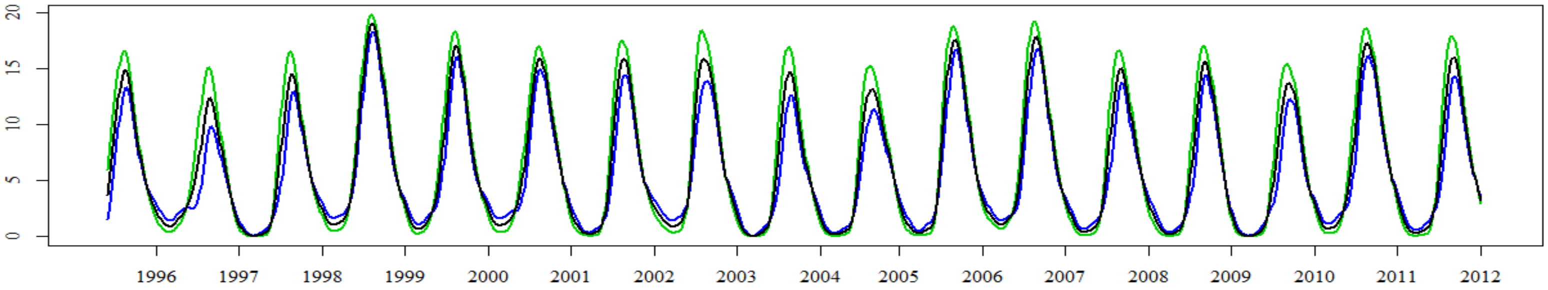
Within Lake Coherence: Example

- Example: Lake Superior - 4094 pixels
- Smooth the time series for each pixel – 4094 smooth curves
- First two FPC scores explain 86% of the variability in the curves



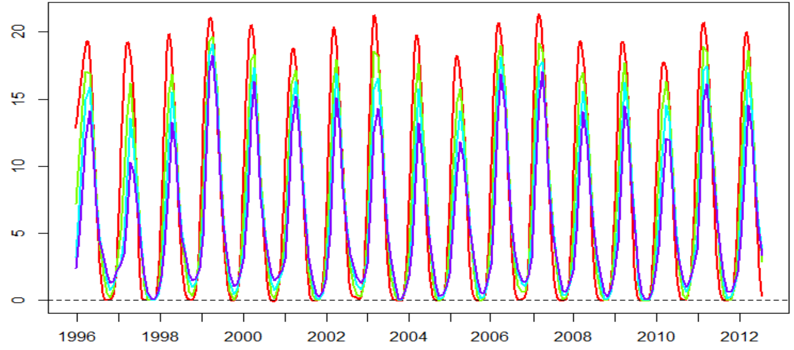


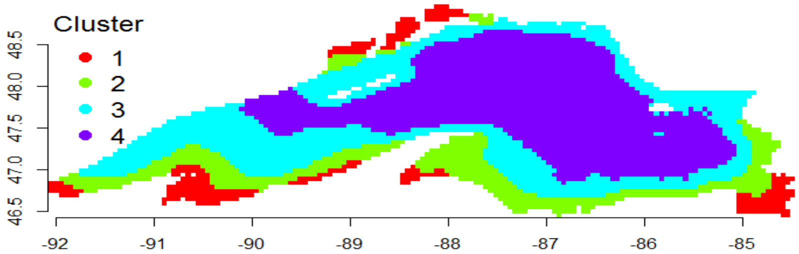
PC function
(Percentage of variability 77)

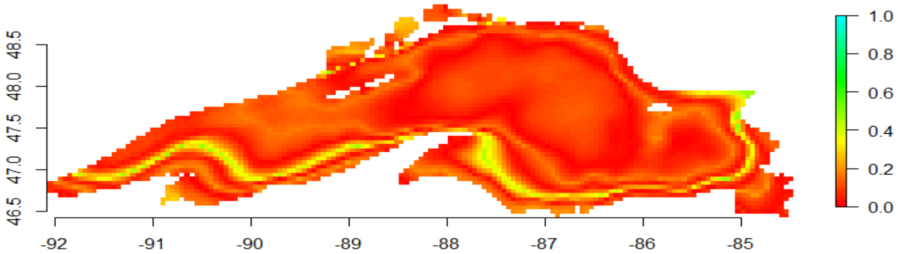


Within Lake Coherence: Example

- 4 clusters identified as statistically optimal
- Clear distinctions between the mean functions corresponding to these four groups
- Key discrepancy is amplitude of the seasonal patterns each year.





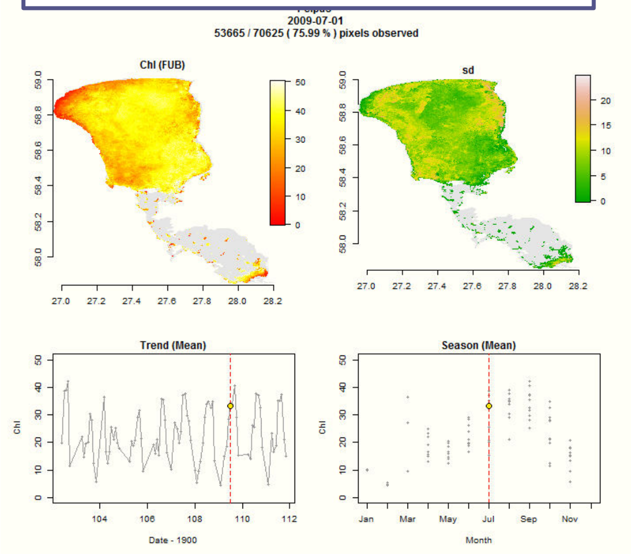


Summary

- Our approach enables clusters of curves to be identified which are coherent in terms of temporal dynamics.
- Functional data analysis reduces dimensionality while retaining important information
- The methods are very computationally efficient (run on standard desktop)
- Model based clustering can be used to identify statistically optimal (data driven) number of clusters
- Uncertainty in cluster classification is also obtained

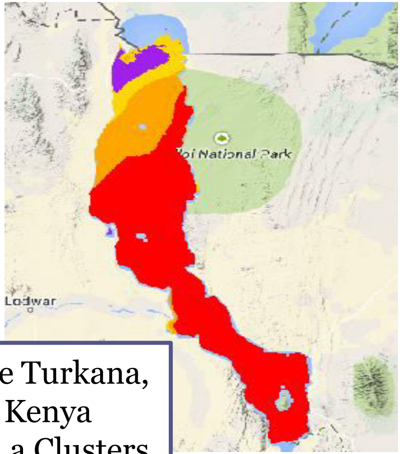
Next Steps

Chlorophyll at Lake Peipsi, Estonia
Monthly obs, 2002-2012
(Data from DIVERSITY II project)



Analysis of lake mean curves gives us an overview of global coherence

Within lake clustering captures smaller scale detail - our ultimate goal is to incorporate within lake clustering results into global coherence



Lake Turkana, Kenya
Chl a Clusters

We will also explore more variables such as chlorophyll and coloured dissolved organic matter at a much finer resolution.

Missing data through time and in space present new statistical challenges

References

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