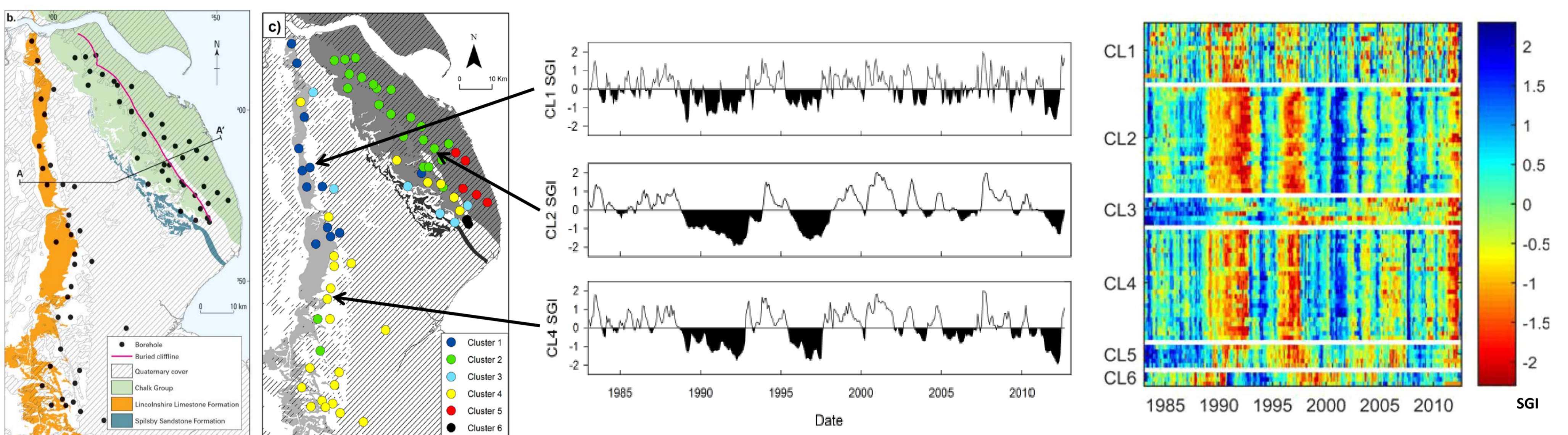


# Assessing regional variations in groundwater droughts

## 1. Aims of the study

There is a need for a better understanding of the heterogeneous spatio-temporal response of aquifers to major meteorological droughts. Using a case study from Lincolnshire, UK, this poster describes a method to analyse groundwater level hydrographs and to assess variations in the spatio-temporal response of groundwater systems to meteorological droughts at the regional scale. The methods are equally applicable at larger scales.

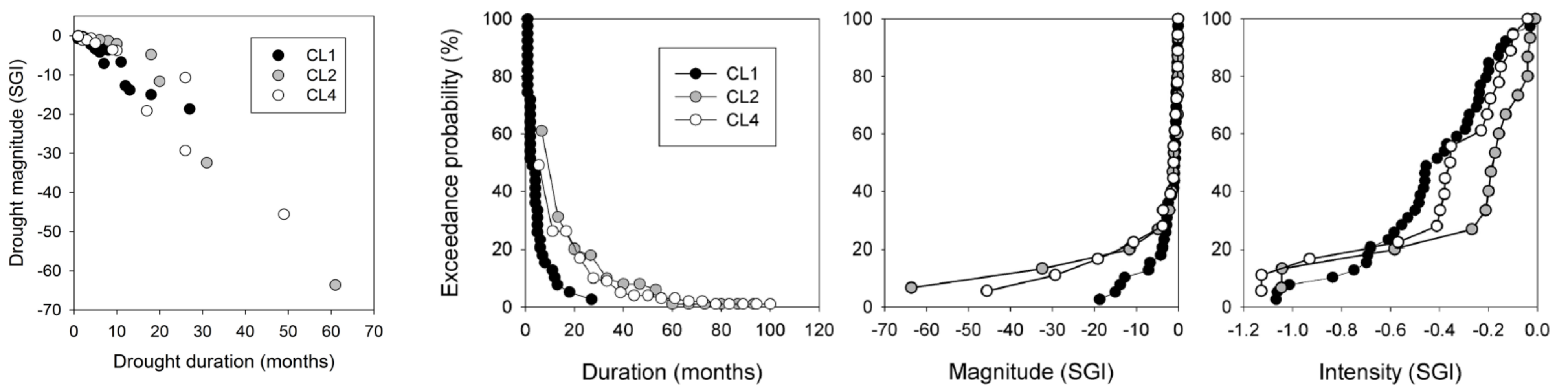


## 2. Study area and cluster analysis of hydrographs

There are three aquifers in the study region: the Lincolnshire Limestone, the Spilsby Sandstone and the Chalk. Monthly groundwater level hydrographs for 74 monitoring boreholes from 1983 to 2012 have been normalised to produce Standardised Groundwater level (SGI) time series for each site (Bloomfield and Marchant, 2013). *k*-means cluster analysis has then been performed and six clusters of normalised hydrographs have been identified, two primarily associated with each of the aquifers. Clusters 1, 2 and 4 (predominantly Lincolnshire Limestone and Chalk) account for ~80% of the sites and are inferred to be free from anthropogenic influences.

## 3. SGI time series for hydrograph clusters

Mean SGI time series for clusters 1, 2 and 4 (centre, above) exhibit broadly consistent drought histories with three episodes of major drought (1988 to 1992, 1995 to 1997 and 2010 to 2012). They differ primarily in their autocorrelation structure with cluster 2 showing the longest autocorrelation (23 months) and cluster 1 the shortest (15 months). A heatmap of SGI series for individual sites within the clusters (right, above) shows that the drought response (red colours) is more homogeneous within cluster 2 than the other two clusters and that the effects of groundwater drought during the 1988 and 1995 events persisted longer in sites in cluster 2 by about 6 to 9 months.



## 4. Duration, magnitude and intensity of groundwater droughts

There is a strong relationship between drought duration and magnitude for all three clusters where longer episodes of groundwater drought are associated with droughts of greater magnitude. Drought duration in all three clusters is highly positively skewed with many short drought events and relatively few long drought events. Cluster 1 exhibits shorter but generally more intense drought episodes compared with Cluster 2, with Cluster 4 drought events being of intermediate character.

## 5. Summary

- Cluster analysis provides a reliable approach to the regional analysis of groundwater droughts when applied to SGI time series.
- Clusters discriminate distinct groups of responses of groundwater levels to meteorological drought. Autocorrelation structure of mean cluster SGI time series is an important distinguishing feature of the clusters and previously has been shown (Bloomfield and Marchant, 2013) to be related catchment and aquifer characteristics.
- The methods described are flexible and can be applied in a wide range of hydrogeological settings where suitable hydrographs are available.

## References

Bloomfield JP and Marchant BP. 2013. Analysis of groundwater drought building on the standardised precipitation index approach, *Hydrol. Earth Syst. Sci.*, 17, 4769–4787  
Bloomfield JP, Marchant BP., Bricker SH and Morgan RB. 2015. Regional analysis of groundwater droughts using hydrograph classification, *Hydrol. Earth Syst. Sci.*, 19, 4327–4344

## Contact information

John Bloomfield: [jpb@bgs.ac.uk](mailto:jpb@bgs.ac.uk) & Ben Marchant : [benmarch@bgs.ac.uk](mailto:benmarch@bgs.ac.uk)