

# Evidence

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## The spatial coherence of European droughts

Evidence Summary SC070079/S

Some of the most important UK droughts have also been significant droughts across much of Europe. Researchers from the Centre for Ecology & Hydrology (CEH), the Walker Institute and JBA Consulting have investigated potential relationships in the occurrence, development and extent of droughts in the UK and mainland Europe with a view to assessing whether UK drought forecasting can be improved.

The project, which was jointly funded by the Environment Agency and Defra, sought to develop new approaches to forecasting drought by asking:

- Is there any systematic time lag between the onset and development of droughts in different parts of Europe?
- Can the onset and development of droughts in some parts of Europe provide an early warning for the development of droughts in other parts of Europe, and in particular, in the UK?
- Can these relationships be used to build reliable and robust operational tools for UK drought forecasting?

### Method

The research team drew on a unique archive of flow and rainfall data from across much of Europe in an approach that involved the following steps.

1. Calculate a normalised deficiency index for each site – a measure of drought that allows comparison between locations with different climatological and hydrological regimes.
2. Group catchments with similar drought characteristics into regions.
3. Develop standardised flow and rainfall deficiency indices for these regions.
4. Analyse relationships between regions and develop statistical models to predict drought.

Twenty-four regions with simultaneous streamflow deficiencies were identified across Europe (Figure 1). Four distinct geographical regions emerged in Britain.<sup>1</sup> South East Great Britain was subsequently split into two

regions depending on whether the catchments were dominated by groundwater or not.

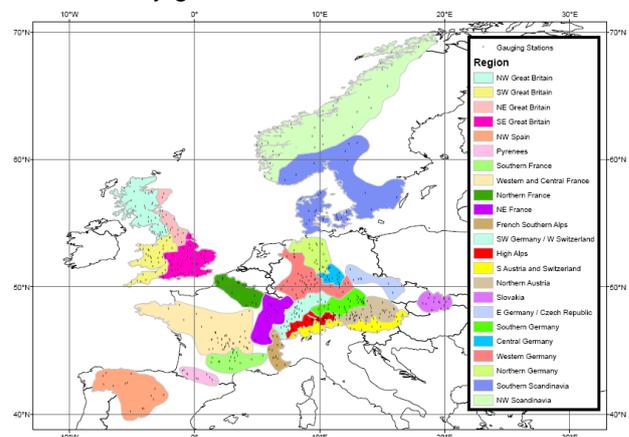


Figure 1 Map of regions

For each region, time series of regional streamflow and rainfall deficits were defined to develop a catalogue of regional drought severity. This capture of all the major droughts of the 20th century enabled analyses of drought length, seasonality and severity to generate European and UK drought catalogues for each region from 1901 to 2005. Summaries of the information on the extent and spatio-temporal development of five major European droughts (1962–1964, 1975–1976, 1988–1992, 1995–1997, 2003) were also compiled.

### Analysis

Most droughts appear to have different characteristics, length and strength. For example, a contrast was found between the 1976 drought, which was spatially consistent across northern Europe and was combined with a rainfall deficiency in the preceding winter (1975) and a heatwave in the summer (1976), and the 1995–1997 drought which was interspersed by wet episodes and had little long-lasting spatial coherence over Europe.

Correlation analysis, multidimensional scaling and statistical modelling revealed that:

- there are weak correlations between regional drought deficiency time series of different regions;

<sup>1</sup> Northern Ireland was not covered by the analysis.

- the correlation patterns for hydrological and meteorological droughts are similar – albeit slightly higher for the latter.

The strongest relationships are among adjacent regions:

- Correlations with the rest of Europe are stronger in winter than in summer for northern and western Britain, but are of similar magnitude all year round for south-east England.
- In general, lagged correlations are weaker than simultaneous ones, with no marked seasonality.
- Lagged correlations are not significant for north-west Scotland where droughts are generally short.
- Weak relationships exist between the length of a UK drought and the number of regions experiencing drought elsewhere in Europe at the same time.
- Some significant relationships exist between drought severity and temperature in the UK.
- Some long droughts result from a combination of both winter and summer deficiencies.

For each UK region, a separate statistical model was built to calculate the number of drought months that may occur in the next six months. The model forecasts droughts in groundwater-dominated catchments in south-east England reasonably well (Figure 2) but, in north-west Britain, the predictive capability is less good.

### Conclusion

The complex and distinctive spatio-temporal evolution of the major droughts observed in Europe since the 1960s makes it challenging to predict drought in the UK on the basis of the occurrence of droughts in Europe. However, some clear modes of variability of drought occurrence have emerged and offer potential for further research. The project's findings can be summarised as follows:

- Developed models forecast droughts in most UK regions relatively well, especially in groundwater-dominated regions.
- No systematic mechanism for drought development has emerged from this approach.
- Droughts tend to develop in the UK before they reach high severity in western Europe.
- The method enables forecasting of winter as well as summer droughts.
- The end of droughts is relatively well predicted.
- Models could be used to forecast the potential intensification and/or end of long multi-season droughts.
- Some similarities exist between drought occurrence and large-scale atmospheric modes.
- More work on circulation patterns associated with different drought types is needed.

The project's findings offer the Environment Agency, Met Office and others the possibility of improved drought forecasting in the UK including when drought conditions will cease. The regional indicators developed by the project could also be applied to UK drought monitoring systems. A number of practical issues – including the need for timely data supply from across Europe – would need to be addressed before the project approach and models could evolve into operational tools.

This summary relates to information from project SC070079, reported in detail in the following output(s):

**Report:** SC070079/R1

**Title:** The spatial coherence of European droughts – UK and European drought catalogues

**December 2011**

**Report Product Code:** SCHO1211BUVT-E-E

**Report:** SC070079/R3

**Title:** The spatial coherence of European droughts – final report

**December 2011**

**Report Product Code:** SCHO1211BUVU-E-E

**Report:** SC070079/R4

**Title:** The spatial coherence of European droughts – summaries of major historical droughts

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*Figure 2 Number of drought months in the next six months – observed (black) and modelled (red) – for groundwater-dominated catchments in SE England*

