

The use of intensity recurrence to investigate regional variation of seismic hazard in the UK

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ABSTRACT: The historical record of significant earthquakes in the United Kingdom has been reviewed. Iseismal maps for earthquakes surface wave magnitude $M_s \geq 4$ have been digitised and the intensity recurrence is calculated directly from the isoseismal data using an "overlying" technique. Contours of intensity recurrence have been plotted for IV and V MSK. These contained plots are used to study regional geographical variation and temporal variation in seismic hazard in the UK. Comparison with plots of maximum observed intensity indicate that the intensity recurrence maps provide a more useful method for studying regional variations in seismic hazard.

1.0 INTRODUCTION

Within intraplate regions such as the United Kingdom, large damaging earthquakes are rare. The instrumental data available for the UK covers an extremely short time span when compared with the geological time scale involved in the recurrence of large destructive intraplate earthquakes.

In order to extend the period of instrumental coverage of UK earthquakes use has been made of the well documented history of the country. Based on the "observed" data reported in historical sources including newspapers, memoirs etc. isoseismal maps have been developed for many earthquakes by various researches. An isoseismal map for the 1906 Swansea earthquake is shown in Figure 1.

This paper describes the use of isoseismal maps in studying the regional and temporal variation of seismic hazard in the UK. The work presented forms part of a "Preliminary Study of UK Seismic Hazard and Risk" completed for the Department of the Environment.

2.0 SOURCES OF HISTORICAL EARTHQUAKE DATA IN THE UK

Over the past 10 years there has been considerable interest in the historical seismicity of the UK, primarily as a result of site specific studies carried out for nuclear power plant sites. The following sources have been collated in order to form a historical earthquake catalogue for the UK:-

- Principia Mechanica Ltd (1982)
- Soil Mechanics Ltd (1982)
- Ambraseys (1985, 1988): Published Papers
- Melville (1983, 1984): Published Papers
- British Geological Survey (1984)
- Nuclear Electric Plc: Site Specific Studies
- British Petroleum: Site Specific Studies.

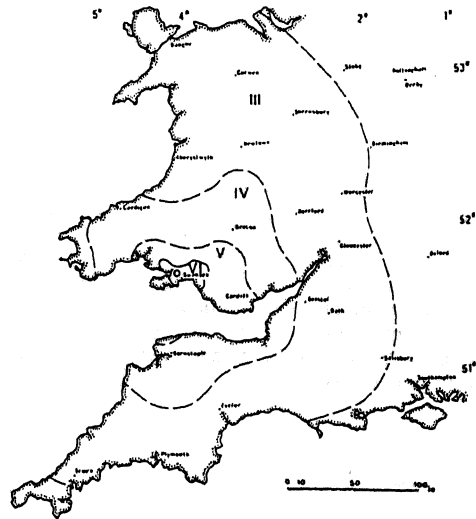


Figure 1. Isoseismal map in terms of MSK Intensity for Swansea earthquake of 27 June 1906 (after Ambraseys 1985)

Full references for the published data sources listed above are contained in the reference section at the end of this paper. The earthquake catalogue database computer program ECAT, developed by Ove Arup and Partners, has been used to store relevant information on each historical earthquake, including date of occurrence, geographical location, estimated surface wave magnitude, M_s , epicentral location, maximum observed intensity in the UK (MSK scale), area within isoseismal IV and, data sources.

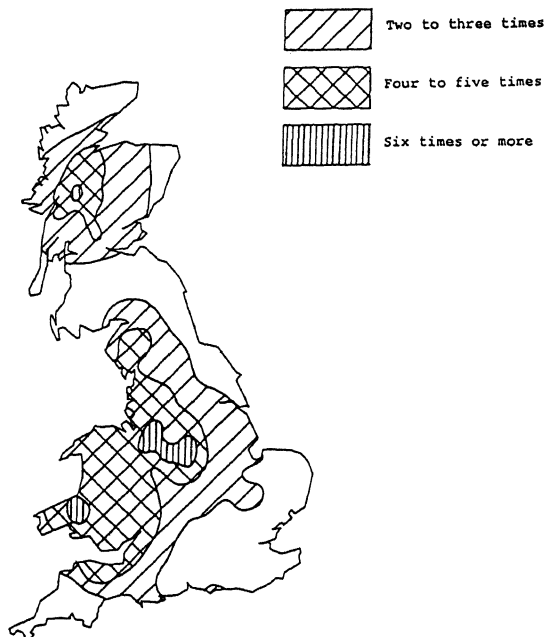


Figure 2. Observed Recurrence of MSK Intensity IV in the period 1800-1991 in units of number of times per century



Figure 3. Observed Recurrence of MSK Intensity V in the period 1800-1991 in units of number of times per century

For each event, an isoseismal map has been digitised and these data also stored within the ECAT program which enables isoseismal maps to be drawn. Where more than one source of isoseismal map is available for a particular earthquake the map from the most recent source has been adopted. This hierarchy assumes that the most recent map for a particular event has been constructed with the assistance/knowledge of the previously published data

3.0 INTENSITY RECURRENCE

The outlines of about 70 isoseismal maps for earthquakes since 1750 with surface wave magnitudes $M_s \geq 4$ have been digitised. The MSK Intensity scale has been adopted and all isoseismals of MSK Intensity IV and greater have been digitised.

The procedure developed for calculating intensity recurrence directly from the isoseismal data is as follows:-

- a rectangular grid of points (spacing 20km)
- the isoseismal maps are superimposed on the grid network
- for each point the computer counts the number of times each intensity has been experienced, or exceeded, over specified time periods

- contours of intensity recurrence across the UK are plotted graphically from the data for each grid point.

4.0 REGIONAL VARIATION IN UK SEISMIC HAZARD

Figures 2 and 3 show the intensity recurrence for intensities IV and V respectively based on isoseismal map data for historical earthquakes in the period 1800-1991.

Both figures indicate the same general trend of higher seismic activity in an arc containing Wales, the Midlands and Northwest England. An area of higher activity is also observed in the Highlands.

5.0 TEMPORAL VARIATION IN UK SEISMIC HAZARD

Figures 4 a), b) and 5 a), b) show the intensity recurrence for two time periods 1800-1899 and 1900-1991 for MSK Intensities IV and V respectively.

For both MSK Intensities IV and V the intensity recurrence is higher for the period 1900-1991 compared to 1800-1899, in northwest Wales and Midlands regions. The opposite trend is apparent for south Wales, where the intensity recurrence is higher for the period 1800-1899 compared to the period 1900-1991.

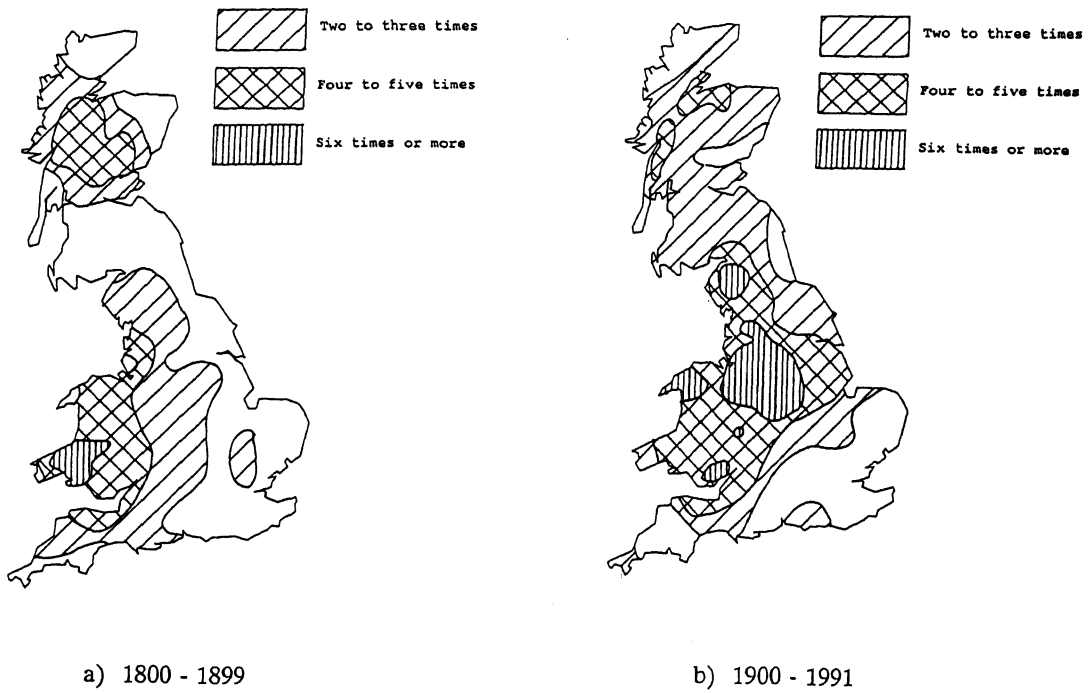


Figure 4. Recurrence of MSK Intensity IV in units of numbers of times per century

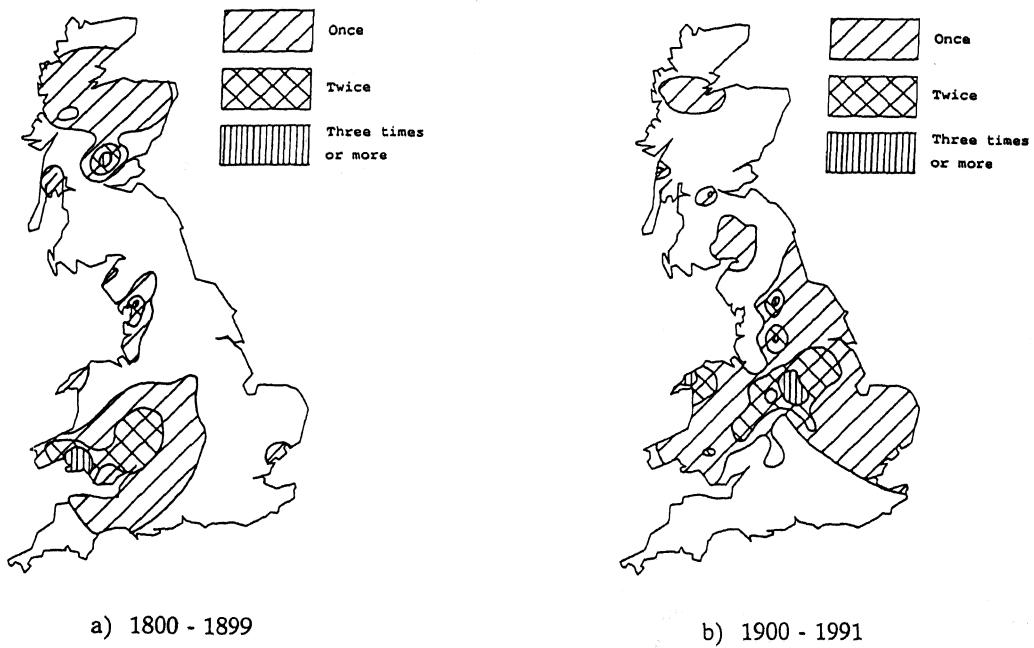


Figure 5. Recurrence of MSK Intensity V in units of numbers of times per century

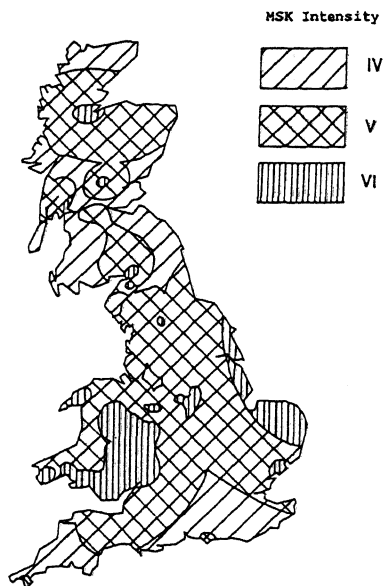


Figure 6. Maximum observed MSK Intensity over the period 1800-1991

It is apparent that while the same general areas are showing more seismic activity the centres of activity have moved significantly over the two centuries.

6.0 COMPARISON OF INTENSITY RECURRENCE AND MAXIMUM OBSERVED INTENSITY

The maximum observed intensity for the UK over the period 1800-1991 is shown in Figure 6. This indicates the east of England has a maximum observed MSK Intensity of VI (due to a single event, the 1931 North Sea earthquake). Using the maximum observed intensity plot it could be deduced that eastern England has a similar level of seismic hazard to Wales and the Midlands. However, this deduction is probably misleading as eastern England is generally believed to be one of the regions of lowest seismic activity in the UK. The intensity recurrence plots in Figures 2 to 5 however show this area to have lower than average seismicity.

7.0 CONCLUSIONS

The proposed methodology for determining intensity recurrence directly from isoseismal maps data can be used directly to study the regional and temporal variation in seismic hazard. This methodology is useful in regions where substantial historical data is available.

Graphical plots showing intensity recurrence provide a more useful measure of regional seismic hazard than maps of maximum observed intensity.

ACKNOWLEDGEMENTS

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