Spatial and temporal variability of flood seasonality across Wales

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Introduction

High magnitude floods across Europe over the last decade have resulted in the widespread reassessment of flood risk; coupled with the introduction of the Water Framework Directive (2000) has increased the need for a detailed understanding of seasonal variability in flood magnitude and frequency.

The spatial variations in flooding across Wales and adjacent counties are examined through three objectives: i) to identify the spatial and temporal patterns of flood seasonality across Wales; ii) to describe the spatial variability of flooding across Wales; and iii) to examine the relationship between flood seasonality (mean day of flood) and atmospheric drivers, e.g. North Atlantic Oscillation (NAO), weather types and rainfall.

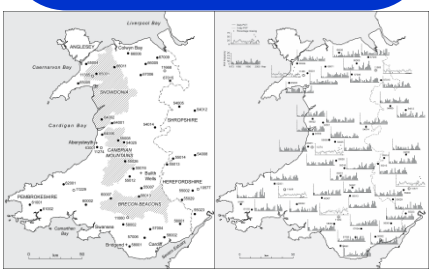

Figure 1: a) Selected locations, river gauging (solid black dots) and precipitation (white dots) stations. b) POT frequency plots for each gauging station and selected precipitation stations. The x-axis contains water years (1973-2002) and y-axis the frequency of river POT events (range of frequencies 0-20) or number of precipitation POT events at daily and three day intervals exceeding the 95th percentile (range of frequencies 0-75). The percentage of missing data for any given year are also given.

Methodology

- Two principal criteria applied to station selection (n=40): i) complete annual record of POT events for period; ii) station selection was most representative of Wales possible Fig. 1a)
- POT data extracted from the Hiflows-UK dataset for the period 1973 to 2002 (Fig. 1b), using the water year.
- Average threshold of 4.5 events per year applied for the 30 year period for all stations (higher than previous thresholds)
- Precipitation series from six sites across Wales (Fig.1b)
- At least 90% of the complete daily precipitation series (1973-2002). Daily/3-day precipitation (P) totals examined to characterise flood generating events.
- Study applies revised start date (31st May) advocated by Black and Werritty (1997).
- Seasonality of floods as described by directional statistics (Fisher, 1993)
- PCA conducted on MDF to identify the main geographic patterns in flood seasonality.

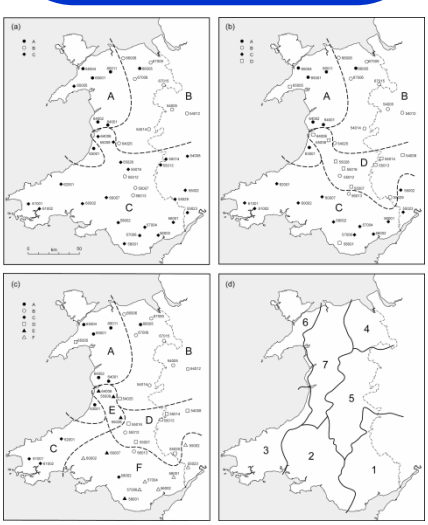

Figure 2: Division of Wales into regions based on **a)** three flood seasonality regions; **b)** four flood seasonality regions; **c)** six flood seasonality regimes; **d)** precipitation regions identified by Bonell and Sumner (1992)

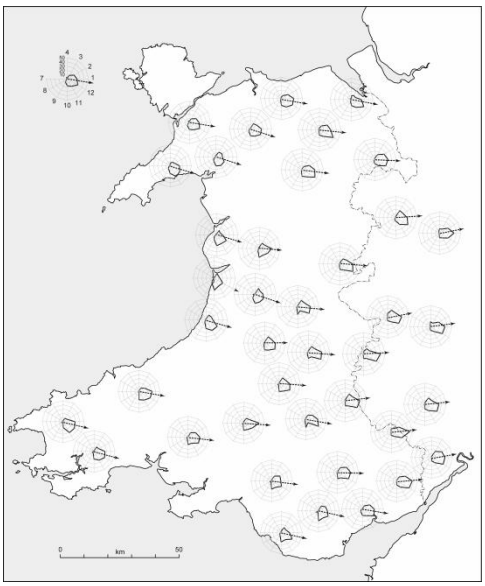

Figure 3: POT seasonality (solid line) and mean day of flood indicated by the dashed arrow for Wales (1973-2002)

Table 1: Regional total monthly flood frequencies (1973-2002) based on regional divisions identified in Figure 2c

Percentage of events

Month	Region A	Region B	Region C	Region D	Region E	Region F	All
6	0.7	1.0	1.5	0.2	1.7	0.1	0.7
7	1.2	0.4	0.0	0.1	1.7	0.4	0.6
8	2.4	1.0	3.0	1.1	1.7	2.2	1.8
9	6.2	2.6	1.2	1.7	6.5	2.1	3.2
10	14.5	9.7	12.8	8.8	16.2	11.8	11.8
11	17.0	12.9	19.2	10.5	15.2	12.1	13.6
12	19.2	23.7	22.4	23.0	18.2	22.6	22.0
1	15.3	21.5	20.9	24.9	14.2	22.0	20.5
2	10.7	14.3	9.6	14.2	10.7	14.7	13.1
3	9.1	9.2	7.4	10.5	11.5	9.7	9.6
4	2.2	3.3	1.2	4.3	1.0	1.9	2.5
5	1.5	0.4	0.7	0.5	1.2	0.4	0.7

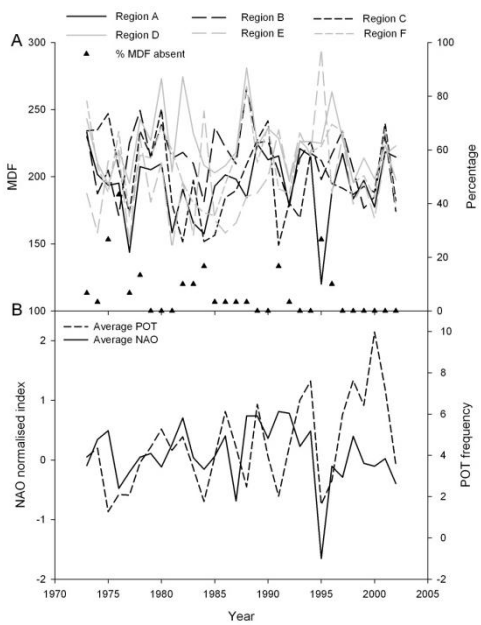

Figure 4: a) National and regional annual variability in MDF and frequency of non-exceedance of threshold resulting in no MDF being returned. **b)** Annual trends in POT frequency compared to NAOI (revised for year start 31st May). Data source for NAOI: Tiempo, 2007.

Results

- PCA derived total of 7 different precipitation regions in Wales (Fig. 2)
- Clear seasonality patterns across Wales; MDF ranges from 11th December to the 10th January (Fig. 3), with spatial variability in start of flood season (Table 1)
- Increase in flood POT as near present
- Analysis of national changes in flooding identifies a significant (p<0.05) rise in flood activity from 1973 to 2002 (r^2 = 0.246), which supports findings of Dixon *et al.* (2006).

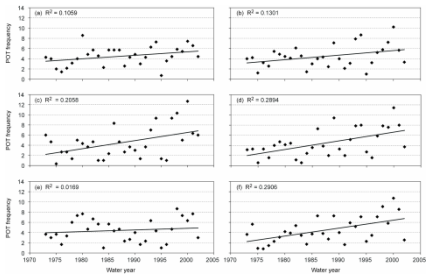

Figure 5: Change in the frequency of yearly POT events in Wales, 1973-2002 based on regions identified in Figure 2b

Discussion

- Analysis of temporal variability of MDF failed to determine significant trends (95% c.l.). Regions A, D and F show very weak patterns in MDF; region B & C show a downward trend in MDF, though weaker in B, whilst region E exhibits a upward MDF trend (Fig. 4).
- Variations in yearly POT frequencies are, in general, fairly uniform across Wales (Figure 5).

Analysis of flood frequencies in regions A & B positively associated with frequency of W weather types; lack of significant relationships in other in four regions attributed to: i) grouping of LWTs and concentration of W rather than number of events.

- Analysis of annual MDF and annual NAOI indicates significant correlations ($p < 0.05$) in region A (positive) and region E (negative), while other regions show little correlation (Figure 4).
- Catchment size may be an important aspect in MDF and NAOI relationships, as two regions exhibiting significant correlations between MDF and NAOI both consist of smaller mean catchment sizes.
- No significant correlation exists ($r = 0.21$) nationally between NAOI and flood frequency over the timescales considered within this paper (Figure 4b).

Conclusions

- This study has identified that whilst no significant trends are identified in the temporal variability of seasonality across Wales (1973-2002), clear spatial patterns in flood seasonality exist.
- Whilst no significant trends were determined patterns are present within the series, particularly in regions B and C with a decreasing MDF and region E with an increasing MDF through the study period.
- An analysis of regional MDF identifies that considerable seasonal variability is present.
- Considerable spatial variability in flood seasonality across Wales.
- The MDF varies from the 11th December to the 10th January across Wales, with a general west-east gradient in flood seasonality
- Strong regional variability in summer flooding
- A number of determinant factors play a role in the complex climate system that dictates flood seasonality across Wales with considerable spatial variability.
- Significant upward trend in annual POT frequency

References: Black AR and Werritty A. 1997. Seasonality of flooding: a case study of North Britain. *J. of Hydrology*. 195: 1-25; Bonell M and Sumner G. 1992. Autumn and winter daily precipitation areas in Wales, 1982-1983 to 1986-1987. *International J. of Climatology*. 12: 77-102; Dixon H, Lawler DM and Shamseldin A. 2006. Streamflow trends in western Britain. *Geophysical Research Letters*. 33: L19406;Fisher NI. 1993. *Statistical Analysis of Circular Data*. Cambridge University Press. Cambridge, UK.

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