

Spatial and temporal variability of flood seasonality across Wales

Neil Macdonald

e: Neil.Macdonald@liverpool.ac.uk

Dept. of Geography & Planning, School of Environmental Sciences, University of Liverpool, Liverpool, L69 7ZT, UK

Macdonald N., Phillips I.D. & Bale G., (2010), Spatial and temporal variability of flood seasonality in Wales, *Hydrology Processes*, 24 (13):1806-1820

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.

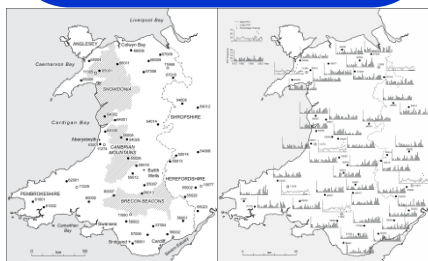


Figure 1: a) Selected locations, river gauging (solid black dots) and precipitation (white dots) stations. b) POT frequency plots for each gauging station and selected precipitation stations. The x-axis contains water years (1973-2002) and y-axis the frequency of river POT events (range of frequencies 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.

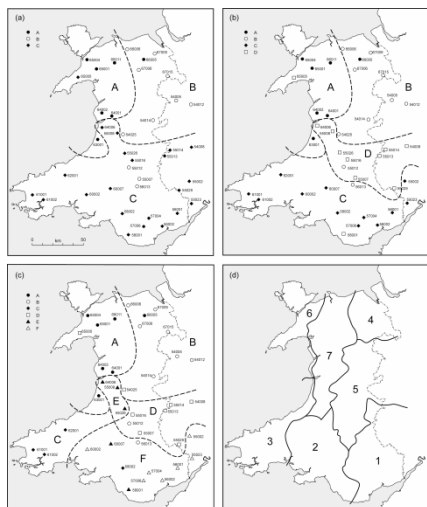


Figure 2: a) Division of Wales into regions based on a) three flood seasonality regions; b) four flood seasonality regions; c) six flood seasonality regimes; d) precipitation regions identified by Bonell and Sumner (1992)

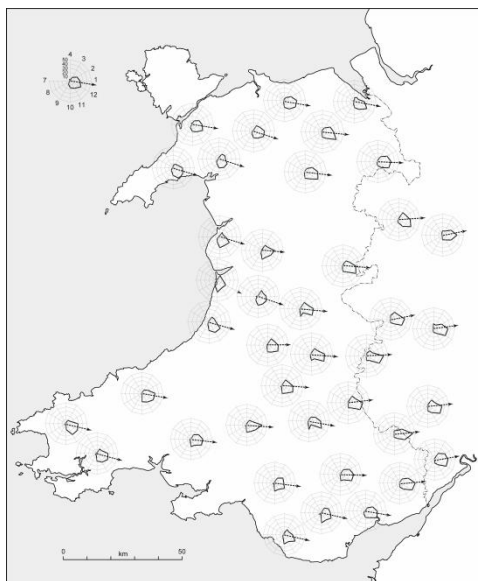


Figure 3: POT seasonality (solid line) and mean day of flood indicated by the dashed arrow for Wales (1973-2002)

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

Month	Percentage of events						All
	Region A	Region B	Region C	Region D	Region E	Region F	
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

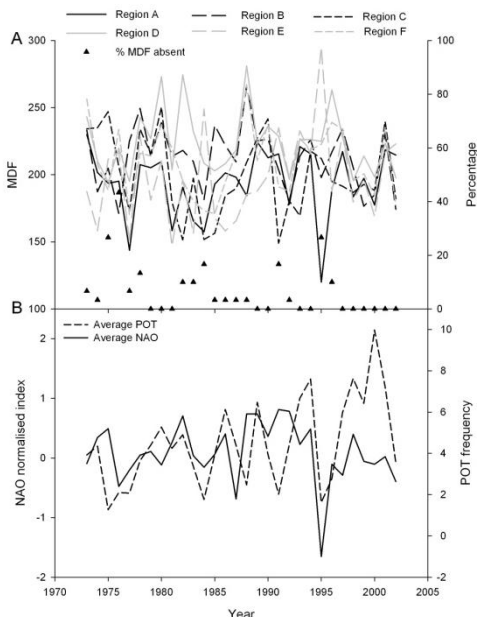


Figure 4: a) National and regional annual variability in MDF and frequency of non-exceedance of threshold resulting in no MDF being returned. b) Annual trends in POT frequency compared to NAOI (revised for year start 31st May). Data source for NAOI: Tiempo, 2007.

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).

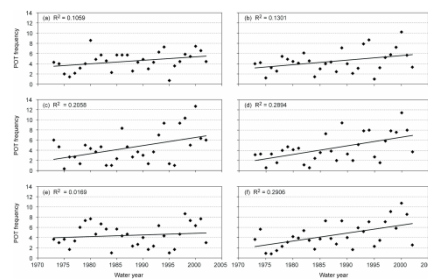


Figure 5: Change in the frequency of yearly POT events in Wales, 1973-2002 based on regions identified in Figure 2b

Discussion

- Analysis of temporal variability of MDF failed to determine significant trends (95% c.I.). 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 an 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: 773-782; Dixon H, Lawler DM and Shamseldin A. 2006. Streamflow trends in western Britain. *Geographical Research Letters*, 33: 1-19406; Fisher NI. 1993. *Statistical Analysis of Circular Data*. Cambridge University Press, Cambridge, UK.

Acknowledgements: The river discharge information is from HiFlows National River Flow Archives and the help of Felicity Sanderson at the NRFA CEH Wallingford is acknowledged. We are also grateful to the British Atmospheric Data Centre, which provided us with access to the Met Office – MIDAS Land Surface Station Data.