High-Resolution SPEI Analysis of Historical Drought Risk in Scotland

Sayali Pawar, Sarah Halliday, Miriam Glendel, Paola Ovando
Department of Energy, Environment and Society, University of Dundee, Nethergate, Dundee, DD1 5HN
Email:2436526@dundee.ac.uk
www.hydronationscholars.scot

Scottish Government gov.scot

Hydro Nation Scholars Programme

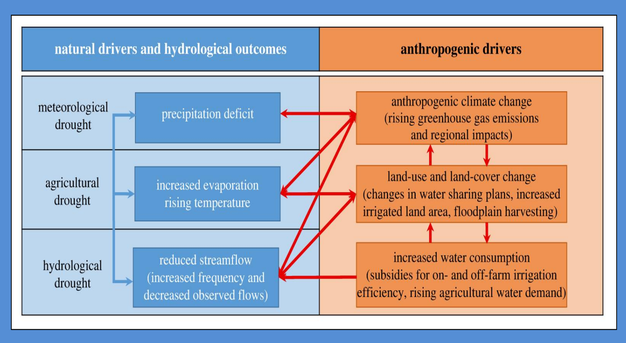
Drought Issues in Scotland


River Helmsdale in Sutherland, 2021

In early 2022, Scotland's east coast experienced its driest winter in over 80 years, resulting in record-low groundwater levels. (SEPA) took action to preserve local water environments by temporarily suspending water abstraction licenses in Fife's River Eden catchment. Previous years (2018, 2020, and 2021) also saw critical water scarcity issues. Understanding drought risk is crucial for adapting to changing climate patterns and ensuring the well-being of communities, ecosystems, and essential industries in Scotland. The Standardised Precipitation and Evapotranspiration Index (SPEI) is a valuable tool for assessing drought conditions, and this study aims to bridge a research gap by examining scarcity through the lens of meteorological drought, using a high-resolution approach.

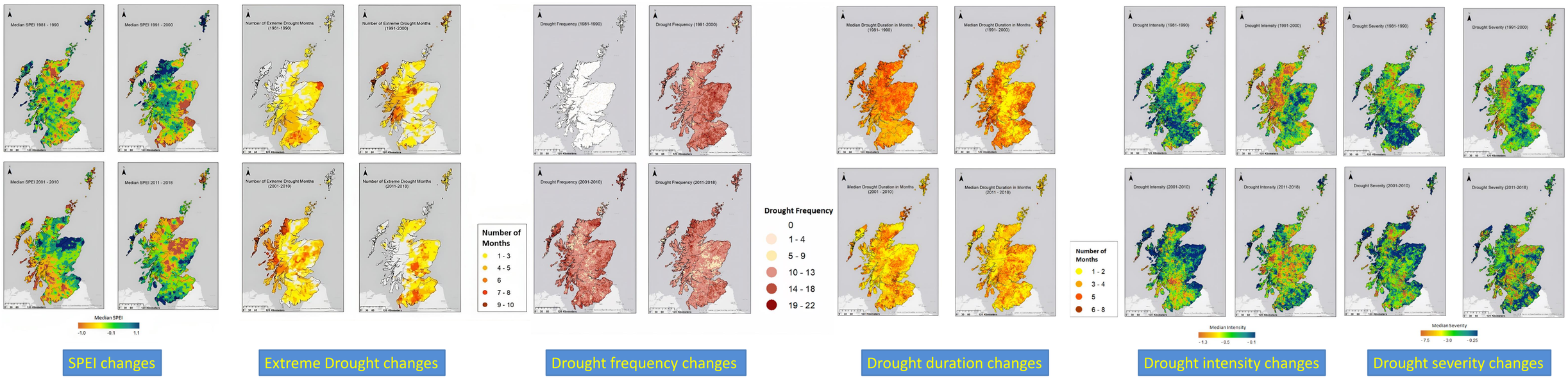
High-Resolution SPEI

1. **Data Collection:** Obtain 1 km resolution precipitation and temperature data for Scotland spanning from 1981 to 2018.
2. **Preprocessing:** Organize the data in a format compatible with R, ensuring it includes monthly values for both precipitation and temperature.
3. **Potential Evapotranspiration (PET) Calculation:** Employ the Thornthwaite method to compute PET for each month, aligning calculations with the chosen SPEI calculation period.
4. **SPEI Computation:** Utilize the 'SPEI' package in R, specifying the desired time scale and fitting distribution.



Index Value	Classification
2.0 and above	Extremely Wet
0 to 2.0	Wet
- 0.99 to -2.0	Dry
- 2.0 and below	Extremely Dry

Interdecadal Variability in Drought Metrics



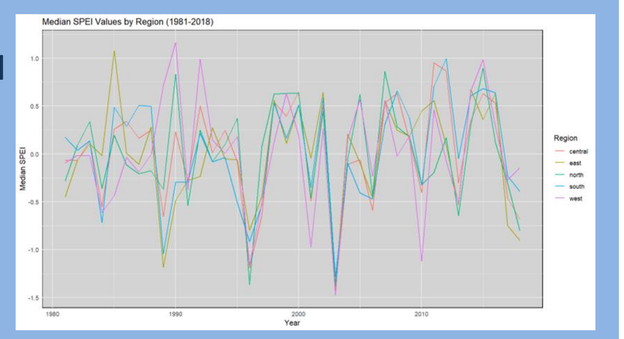
Trends and Dynamics

- ✓ Drought frequency indicates a shift towards more frequent and widespread drought events, with distinct spatial patterns
- ✓ Drought duration reveals intriguing temporal variations, suggesting complex interactions between climatic drivers
- ✓ Regions along the east coast, specifically near Fife and Angus, consistently exhibited intensifying trends in drought severity

Region	Number of Drought Events
West	19073
East	18637
North	16693
South	11232
Central	13191

The observed spatial and temporal variations underscore the dynamic nature of drought patterns in Scotland. This necessitates flexible and adaptable strategies for drought mitigation and water resource management.

- This study has produced the first high-resolution (1km) SPEI dataset for Scotland.
- These findings provide essential insights for policymakers, water resource managers, and stakeholders, facilitating informed decision-making in water resource planning and management



References

1. Beguería, S. and Vicente-Serrano, S. M. (2017) 'Package "SPEI"', R-Package, (March), p. 16. doi: 10.1175/2009JCLI2909.1.http.
2. Fennell, J. et al. (2020) 'Lessons from the 2018 drought for management of local water supplies in upland areas: A tracer-based assessment', Hydrological Processes, 34(22), pp. 4190–4210. doi: 10.1002/hyp.13867.
3. Hollis, D. et al. (2019) 'HadUK - Grid — A new UK dataset of gridded climate observations', (July), pp. 151–159. doi: 10.1002/gdj3.78.
4. Kirkpatrick, B. F., Partridge, J. S. and Spray, D. (2021) 'Anticipating and mitigating projected climate-driven increases in extreme drought in Scotland , 2021-2040', NatureScot Research Report No.1228., (1228), pp. 2021–2040.
5. Rivington, M. et al. (2008) 'Downscaling regional climate model estimates of daily precipitation, temperature and solar radiation data', Climate Research, 35(3), pp. 181–202. doi: 10.3354/cr00705.
6. Scottish Environment Protection Agency (2022) 'Water Scarcity Report', Scottish Environment Protection Agency, (August), pp. 1–10. Available at: https://www.sepa.org.uk/environment/water/water-scarcity/.
7. Turner, S. et al. (2021) 'The 2018/2019 drought in the UK: a hydrological appraisal', Weather, 76(8), pp. 248–253. doi: 10.1002/wea.4003.
8. Vicente-Serrano, S. M., Beguería, S. and López-Moreno, J. I. (2010) 'A multiscalar drought index sensitive to global warming: The standardized precipitation evapotranspiration index', Journal of Climate, 23(7), pp. 1696–1718. doi: 10.1175/2009JCLI2909.1.
9. UN/ISDR and (UNISDR), U. N. secretariat of the I. S. for D. R. (2007) 'Drought Risk Reduction, Framework and Practices, Contributing to the Implementation of the Hyogo Framework for Action, Preliminary Version, May 2007', (May), p. 97.

Acknowledgements

I would like to extend my heartfelt gratitude to the James Hutton Institute for their invaluable support and resources provided for this research endeavour.

The James Hutton Institute

Scottish Funding Council
Comhairle Maoineachaidh na h-Alb

University of Dundee