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Can citizen science, conventional monitoring and inferred data be used to investigate the impact of hydrology on river temperatures in a rural catchment in Scotland?

Ina Pohle (1), Rachel Helliwell (1), Caroline Aube (1), Luigi Spezia (2), Sheila Gibbs (1), and Michael Spencer (3)

(1) The James Hutton Institute, Environmental and Biochemical Sciences, Aberdeen, United Kingdom (ina.pohle@hutton.ac.uk), (2) Biomathematics & Statistics Scotland, Aberdeen, United Kingdom, (3) Scotland's Rural College, Land Economy, Environment and Society (LEES) Research Group, Edinburgh, United Kingdom

Climate change will affect hydrologic and thermal regimes of rivers, having a direct impact on freshwater ecosystems and human water use. Planning to mitigate the effects of climate change on river flows and temperature requires a thorough investigation of the contribution of different drivers (e.g. air temperature, snowmelt, discharge, water demand). For such an analysis, long-term records of river flow, temperature, hydroclimatic drivers are necessary but often sparse. Here we supplemented conventional datasets with data collated through citizen science and model results.

River temperatures and levels have been monitored by ghillies (fishing attendants) at four locations during the fishing season (February to September) since 1912 at the Tulchan Sporting Estate. Continuous daily precipitation and air temperature were obtained from the MetOffice UKCP09 data set for grid cells (25 km2, 1960–2015). For earlier years (1922-1960), these variables were reconstructed from nearby weather stations by statistical relationships. Effective precipitation, snow accumulation and snow melt were simulated based on air temperature and precipitation using a process-based model which is also underpinned by citizen science (Spencer et al. 2014).Daily observed discharge data are available from 1953-2015 at one gauging station 10 km upstream and one gauging station 30 km downstream of the fishing locations. For the period where observations are not available (1922-1952) at gauging stations and for the monitoring sites on the Tulchan Estate, discharge has been simulated by a hydrological model (TUWModel, modified to take into account effective precipitation simulated by the snow model).

The data base used to investigate impacts on river flow and temperature of the Spey consists of (i) continuous daily air temperature, precipitation, effective precipitation, snow accumulation, snow melt and discharge for the respective subcatchments of the fishing locations on the Estate and the gauging stations for 1922-2015 and (ii) water temperatures and water levels at the fishing locations during the fishing season for 1912-2015.

An initial analysis of the data set showed that summer water levels have been declining and summer water temperatures have been rising during the past decades. Increasing air temperatures especially in spring, less snow accumulation during winter, and earlier snow melt (ca. 2 days earlier per decade) contribute to rising water temperatures. However, declining water levels in the summer months cannot be primarily attributed to hydroclimatic changes, but rather to human intervention (e.g. related to increase in population, irrigation, industry, and hydro-electric generation). Therefore, in a next step, anthropogenic influences will be included in the data basis and the analysis.

Citizen science delivered a dataset that filled a vital knowledge gap in the long term historical assessment of river temperatures. Combined with more conventional, high resolution data the results are potentially important to Estate managers, policy makers and regulators as they need to understand not only the root of the problem but management options to enhance the resilience of rivers to change.

Reference

Spencer, M., Essery, R., Chambers, L., Hogg, S., 2014. The Historical Snow Survey of Great Britain: Digitised Data for Scotland. Scottish Geogr. J. 130, 252–265