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An approach to predict water quality in data-sparse catchments using hydrological catchment similarity

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An understanding of catchment response to climate and land use change at a regional scale is necessary for the assessment of mitigation and adaptation options addressing diffuse nutrient pollution. It is well documented that the physicochemical properties of a river ecosystem respond to change in a non-linear fashion. This is particularly important when threshold water concentrations, relevant to national and EU legislation, are exceeded. Large scale (regional) model assessments required for regulatory purposes must represent the key processes and mechanisms that are more readily understood in catchments with water quantity and water quality data monitored at high spatial and temporal resolution.
While daily discharge data are available for most catchments in Scotland, nitrate and phosphorus are mostly available on a monthly basis only, as typified by regulatory monitoring. However, high resolution (hourly to daily) water quantity and water quality data exist for a limited number of research catchments. To successfully implement adaptation measures across Scotland, an upscaling from data-rich to data-sparse catchments is required. In addition, the widespread availability of spatial datasets affecting hydrological and biogeochemical responses (e.g. soils, topography/geomorphology, land use, vegetation etc.) provide an opportunity to transfer predictions between data-rich and data-sparse areas by linking processes and responses to catchment attributes.
Here, we develop a framework of catchment typologies as a prerequisite for transferring information from data-rich to data-sparse catchments by focusing on how hydrological catchment similarity can be used as an indicator of grouped behaviours in water quality response. As indicators of hydrological catchment similarity we use flow indices derived from observed discharge data across Scotland as well as hydrological model parameters. For the latter, we calibrated the lumped rainfall-runoff model TUWModel using multiple objective functions. The relationships between indicators of hydrological catchment similarity, physical catchment characteristics and nitrate and phosphorus concentrations in rivers are then investigated using multivariate statistics.
This understanding of the relationship between catchment characteristics, hydrological processes and water quality will allow us to implement more efficient regulatory water quality monitoring strategies, to improve existing water quality models and to model mitigation and adaptation scenarios to global change in data-sparse catchments.