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Modelling downstream change in river flood power: a novel approach combining hydrological flood estimation systems with DEMs and new channel width data sources

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Stream power is a strong control of several fluvial and ecological processes, including: river channel instability and pattern; bank erosion rates and processes; bedrock channel incision; sediment transport; flood defence stability; water quality issues; and habitat development. However, little is known about the spatial structure of flood power distributions at the basin scale because of outstanding numerical simulation and measurement problems. Therefore it is presently very difficult to assess directly the full control of stream power distributions on fluvial processes. It has also been uncertain how spatially-variable channel slopes covary with flood discharges to produce given longitudinal stream power distributions.

We address this research gap by developing a novel approach which combines hydrological approaches (UK catchment flood estimation algorithms) with geomorphological (slope) data from Digital Elevation Models in a GIS framework. This quantifies basin-scale downstream distributions of gross Flood Power, Ω_f, defined as ρgQS_f, where ρ is fluid density, g is gravitational acceleration, Q is 2-year return period flood discharge, QMED, and S_f is floodplain slope. The methodology allows full spatial structure of flood power to be delivered at an unsurpassed 50-70m spatial resolution

along entire river basins. Resultant catchment-scale flood power distributions are then tested against conceptual and numerical simulations. Specific stream power can also be obtained from a new channel width data source available for UK rivers.

Results have been obtained for several active upland, piedmont and lowland catchments throughout western, northern and central Britain. First, absolute peak and mean power values tended to increase westwards from lowland basins towards upland Wales. Second, in most basins power minima were found both in basin headwaters and outlets, with a peak at some intermediate catchment location, providing some support for previous theoretical simulations. Third, in half of the basins studied, the flood power peak was attained in a mid-basin position. Fourth, at reach scales, tributary junctions were also important components in the catchment architecture, and were sometimes characterized by significant, transient subsidiary stream power peaks. Results have important implications for the explanation, prediction and management of river system instability, fluvial adjustment at tributary junctions, hydrological and geomorphological impacts on sediment and pollutant transport continuity at basin and reach scales, longitudinal distribution of fluvial processes and process-zone coupling, and freshwater habitat maintenance. The approach also shows great promise for wider international application.