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Modelling the spatial structure of downstream change in river flood power: a new approach combining Flood Estimation procedures with Digital Elevation Models

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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 the spatially-variable catchment architectural properties of river slope covary with flood discharges to produce given longitudinal stream power distributions.

We address this research gap by developing a novel, integrated approach to quantify 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 bankfull discharge and S_f is floodplain slope. Particular strengths of the methodology are that longitudinally quasi-continuous data are delivered quickly to elucidate the full spatial structure of flood power at an unsurpassed resolution, and stream power values are calculated for the 2-year return period flood level – a highly significant event for erosion and sediment transport. To do this, the new approach couples spatially-continuous flood discharge data, from an improved and automated UK Flood Estimation Handbook dataset, with floodplain slope values derived from catchment Digital Elevation Mod-

els. Resultant catchment-scale flood power distributions are then tested against conceptual and numerical simulations. Power values can be validated against field surveys and alternative flood discharge assessments.

Results are presented for upland, piedmont and lowland catchments mainly in western and central Britain. First, absolute peak and mean power values tended to increase westwards from lowland basins towards upland Wales. Second, within individual catchments, flood power distributions showed a strong degree of organisation. Third, flood powers often peaked in a mid-basin position, providing some support for previous theoretical simulations, but other basins displayed multiple peaks which challenge existing models. Fourth, at reach scales, tributary junctions were also important components in the catchment architecture, and were sometimes characterised by significant, but transient subsidiary stream power peaks. Results have important implications for the explanation, prediction and management of river system instability, sediment and pollutant transport continuity at the basin scale, longitudinal distribution of fluvial processes and process-zone coupling, and freshwater habitat maintenance. The approach also shows great promise for wide international application.