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An image classification and geoprocessing workflow to facilitate network analysis of multichannel rivers

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Braided rivers are some of the most dynamic geomorphic systems on Earth. Such dynamism means that these rivers pose notable problems for the people that live by and interact with them, however we still have large gaps in our understanding of braided river dynamics that stem, in part, from the spatio-temporal limitations of field-based braided river research. The increased availability of archival satellite remote sensing data, for example Landsat, provides a potential means to circumvent these issues, yet we require new analytical techniques to deal with such large-scale, multi-temporal data. Graph theory, the branch of mathematics tailored to network analysis, offers exciting possibilities for the characterisation of multichannel river network structure and behaviour and linkage to causal processes but methodological developments are required to facilitate this. In this paper we present a workflow to derive graph representations of multichannel rivers from remotely sensed imagery. The workflow is adaptable, allowing for different types of imagery (air photos, multispectral satellite data, hybrid, etc.) and classification techniques, but is exemplified here using Object-Based Image Analysis (OBIA) techniques for fast, accurate classification of Landsat or Sentinel imagery that extracts the three land covers of greatest morphological interest in braided river studies: water (braided channels), vegetation and gravel. Simple geoprocessing techniques (applied in ArcGIS) are used to extract channel centrelines from the classified channel network. These centrelines also capture the connectivity between channels via the bifurcations and confluences that give braided rivers their distinctive planform. The connectivity between channels is derived and recorded within an attribute table as a "from" and "to" field for each pair of connected channels. These connectivity lists are used to generate graph models of braided river networks that can subsequently be analysed using graph theory. A wide range of graph theory metrics and indices have been developed in diverse fields of research. We have identified a suite of these measures that are likely to have a morphological interpretation and, finally, present some results highlighting the utility of indices derived using graph analysis for understanding change in a gravel bed braided river (the River Tagliamento, Italy).