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Quantifying braided river morphodynamics through a sequence of high-flow events

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Quantifying braided river morphology and morphological change is a key task for understanding braided river behaviour. In the last decade, developments in geomatics technologies and associated data processing toolboxes have transformed the potential for producing precise, reach-scale topographic datasets. Moreover, since fast data acquisition rates enable surveys to be undertaken at frequencies that are commensurate with individual flood events, it is now possible to map morphological change for sequences of high-flow events over considerable spatial extents. The application of high-resolution remote sensing technologies to monitor braided river dynamics thus has the potential to provide considerable insight into the relationships between forcing discharges, sediment transport and morphological evolution. In this paper we present a set of Digital Elevation Models (DEMs) that have been produced by monitoring the evolution of a 2.5 x 0.7 km braided study area of the Rees River, New Zealand, through a sequence of ten high-flow events over an eight-month period. We then use the morphological approach to produce a sediment budget for the study area.

The morphological evolution of the Rees River braided study area was monitored after each storm event using a combination of two remote sensing methodologies. First, dry areas of the braidplain were surveyed using a Terrestrial Laser Scanner (TLS) mounted on an Argo Amphibious All Terrain Vehicle. Second, since the TLS was not water penetrating, bathymetry was mapped using an empirically calibrated optical method, based on non-metric vertical aerial photos acquired from a helicopter and an acoustic depth survey along primary anabranches. The resulting data were fused together to produce high quality DEMs, with sub-cm and sub-decimetre vertical standard deviations of error for the TLS and optical-empirical bathymetric components respectively. The resulting set of DEMs enabled the quantification of morphological change through the sequence of ten storm events, whose discharge varied by up to several orders of magnitude relative to baseflow.

The high-resolution, precise DEMs of the braided study area were subtracted from one another to construct storm-by-storm DEMs of Difference. These three-dimensional maps of morphological change show the distribution of erosion and deposition and also provide the necessary data to quantify sediment budgets. During the observation period, sediment was mobilised across 78% of the study area's extent and 50% of the study area experienced at least one compensating cycle of cut and fill. Overall, integrating the net volume of cut and fill on a storm-by-storm basis produces a volume of change three times greater than that calculated by simply calculating the net change during the observation period. At a finer resolution, the storm-by-storm sediment budgets reveal complex, non-linear relationships between driving hydraulics, sediment transport and morphological change. Results from sediment budgeting therefore reveal a fascinating insight into braided river dynamics but also indicate that sediment budgets using the morphological approach are likely to be highly dependent upon the relative frequency of morphological surveys and storm events.