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Uncertainty in Morphological Sediment Budgeting of Rivers

by

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ABSTRACT

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Repeat topographic surveys are often used to monitor geomorphological change in rivers. Such surveys can yield Digital elevation models (DEMs), which are differenced against each other to produce spatially distributed maps of elevation changes called DEMs of difference (DoD). Both areal and volumetric budgets of erosion and deposition can be calculated from DoDs. However, questions arise about the reliability of the analyses and what they mean. This thesis presents two new methodological advances to address these two uncertainties.

The question of reliabilities (reliability uncertainty) was addressed through the development of a flexible technique for estimating the spatially variable surface representation uncertainties in individual DEMs. A fuzzy inference system is used to quantify uncertainty in DEMs and the individual error estimates are propagated into the DoD on a cell-by-cell basis. This is converted into a probabilistic estimate of DoD uncertainty. This estimate can be improved using Bayes theorem and an analysis of the spatial coherence of erosion and deposition units within the DoD. The resulting probabilistic estimate of DoD uncertainty reflects the spatial variability of uncertainty, and can be used to threshold the DoD at user-specified confidence intervals. This addresses reliability by allowing the distinction between real and undetectable changes.

The question of what the thresholded DoDs mean, geomorphically, is a fundamental one and what originally motivated the development of morphological sediment budgeting techniques. Herein, a range of masking tools were developed, which allow the quantitative interrogation of these rich spatial datasets and their patterns based on various classification systems and/or the expert-judgment of a trained geomorphologist. The tools extend the traditional DoD interpretation of whether a reach is net aggradational or net degradational to a detailed quantitative segregation of the DoD budget into the mechanisms responsible for the changes at the bar-scale.

The utility of both these methodological developments were tested on three different data sets representing event-based monitoring (Sulphur Creek, California), restoration monitoring (Mokelumne River, California), and annual-monitoring of a natural dynamic system (River Feshie, Scotland). One of the themes that emerges across the application of these tools in the three different settings is the sharp contrast between which geomorphological mechanisms of change are dominant in areal versus volumetric terms. The tools extend what can reliably be inferred about geomorphological change from repeat topographic surveys.