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Quantifying the morphodynamics of river restoration schemes using Unmanned Aerial Vehicles (UAVs)

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River restoration schemes are particularly sensitive to morphological adjustment during the first set of high-flow events that they are subjected to. Quantifying elevation change associated with morphological adjustment can contribute to improved adaptive decision making to ensure river restoration scheme objectives are achieved. To date the relatively high cost, technical demands and challenging logistics associated with acquiring repeat, high-resolution topographic surveys has resulted in a significant barrier to monitoring the three-dimensional morphodynamics of river restoration schemes. The availability of low-cost, consumer grade Unmanned Aerial Vehicles that are capable of acquiring imagery for processing using Structure-from-Motion Multi-View Stereo (SfM MVS) photogrammetry has the potential to transform the survey the morphodynamics of river restoration schemes. Application guidance does, however, need to be developed to fully exploit the advances of UAV technology and SfM MVS processing techniques. In particular, there is a need to quantify the effect of the number and spatial distribution of ground targets on vertical error. This is particularly significant because vertical errors propagate when mapping morphological change, and thus determine the evidence that is available for decision making.

This presentation presents results from a study that investigated how the number and spatial distribution of targets influenced vertical error, and then used the findings to determine survey protocols for a monitoring campaign that has quantified morphological change across a number of restoration schemes. At the Swindale river restoration scheme, Cumbria, England, 31 targets were distributed across a 700 m long reach and the centre of each target was surveyed using RTK-GPS. Using the targets as General Control Points (GCPs) or checkpoints, they were divided into three different spatial patterns (centre, edge and random) and used for processing images acquired from a SenseFly Swinglet CAM UAV with a Canon IXUS 240 HS camera. Results indicate that if targets were distributed centrally then vertical distortions would be most notable in outer region of the processing domain; if an edge pattern was used then vertical errors were greatest in the central region of the processing domain; if targets were distributed randomly then errors were more evenly distributed. For this optimal random layout, vertical errors were lowest when 15 to 23 targets were used as GCPs. The best solution achieved planimetric (XY) errors of 0.006 m and vertical (Z) errors of 0.05 m. This result was used to determine target density and distribution for repeat surveys on two other restoration schemes, Whit Beck (Cumbria, England) and Allt Lorgy (Highlands, Scotland). These repeat surveys have been processed to produce DEMs of Difference (DoDs). The DoDs have been used to quantify the spatial distribution of erosion and deposition of these schemes due to high-flow events. Broader interpretation enables insight into patterns of morphological sensitivity that are related to scheme design.