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Evaluating the accuracy of low cost UAV generated topography and its effectiveness for geomorphic change detection

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With the recent explosion in the use and availability of unmanned aerial vehicle platforms and development of easy to use structure from motion (SfM) software, UAV based photogrammetry is increasingly being adopted to produce high resolution topography for the study of surface processes. UAV systems can vary substantially in price and complexity, but the tradeoffs between these and the quality of the resulting data are not well constrained. We look at one end of this spectrum and evaluate the effectiveness of a simple low cost UAV setup for obtaining high resolution topography in a challenging field setting. Our study site is the Daan River gorge in western Taiwan, a rapidly eroding bedrock gorge that we have monitored with terrestrial Lidar since 2009. The site presents challenges for the generation and analysis of high resolution topography, including vertical gorge walls, vegetation, wide variation in surface roughness, and a complicated 3D morphology. In order to evaluate the accuracy of the UAV-derived topography, we compare it with terrestrial Lidar data collected during the same survey period. Our UAV setup combines a DJI Phantom 2 quadcopter with a 16 megapixel Canon Powershot camera for a total platform cost of less than $850. The quadcopter is flown manually, and the camera is programmed to take a photograph every 4 seconds, yielding 200-250 pictures per flight. We measured ground control points and targets for both the Lidar scans and the aerial surveys using a Leica RTK GPS with 1-2 cm accuracy. UAV derived point clouds were obtained using Agisoft Photoscan software. We conducted both Lidar and UAV surveys before and after the 2014 typhoon season, allowing us to evaluate the reliability of the UAV survey to detect geomorphic changes in the range of one to several meters. The accuracy of the SfM point clouds depends strongly on the characteristics of the surface being considered, with vegetation and small scale texture causing inaccuracies. However, we find that this simple UAV setup can yield point clouds with 78% of points within 20 cm and 60% within 10 cm of the Lidar point clouds, with the higher errors dominated by vegetation effects. Well-distributed and accurately located ground control points are critical, but we achieve good accuracy with even with relatively few ground control points (25) over a 150,000 sq m area. The large number of photographs taken during each flight also allows us to explore the reproducibility of the UAV-derived topography by generating point clouds from different subsets of photographs taken of the same area during a single survey. These results show the same pattern of higher errors due to vegetation, but bedrock surfaces generally have errors of less than 4 cm. These results suggest that even very basic UAV surveys can yield data suitable for measuring geomorphic change on the scale of a channel reach.