EGU2020-1534
https://doi.org/10.5194/egusphere-egu2020-1534
EGU General Assembly 2020

Assessing the accuracy of river channel bathymetry measurements using an RTK rotary-winged Unmanned Aerial Vehicle (UAV) with varying Ground Control Point (GCP) number and placement

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Previous studies have established the ability to map river channel bathymetry accurately in clear water, shallow wadeable streams using imagery from Unmanned Aerial Vehicles (UAVs), Structure-from-Motion (SfM) photogrammetry and the application of refraction correction. However, because standard rotary-winged UAVs geotag imagery at a relatively low accuracy, there has been a need to use Ground Control Points (GCPs) to georeference the Digital Elevation Model (DEM). This is problematic in that is requires the operators to navigate around the site to place, survey and collect the GCPs which can be very time consuming and/or hazardous. A potential solution lies with the recent introduction of lower cost rotary-winged drones fitted with higher accuracy on-board RTK GPS sensors. These have raised the possibility of conducting UAV surveys with the use of very few or no GCPs across the survey site, saving time and removing the need to access all areas for GCP placement.

To test this possibility, we flew a 250 metre reach of the River Teme (max depth ~1m) on the English-Welsh border at 40m in July 2019 with two drones, i.e. a DJI Phantom 4 RTK UAV and base station and a DJI Phantom 4 PRO (non-rtk). The Phantom 4 RTK UAV was flown three times, i) using the flight program's 2D option (nadir only and one flight path) ii) using the 3D option (camera angled at 60° and flown in two directions) and iii) using the RTK off option and then using post-processing (PPK) to correct the image locations. 20 GCPs were placed across the site and their locations surveyed with a Trimble R8 dGPS and an additional 20 Independent Validation Points (IVPs) were surveyed along the floodplain for terrestrial validation points and 100 points within the channel were surveyed submerged area validation points.

Imagery was processed with Agisoft Metashape (v1.5.5). A total of 28 DEMs were produced using the imagery from the two drones, different flight paths and different combinations of numbers and location of GCPs. These included reducing the number of GCPs from 20, to 10, 5, 3, 1 and 0. When using three GCPs, DEMs were produced by having them i) spread throughout the reach and ii) clustered close to one another. The bed heights of the submerged locations were corrected using the simple refraction correction first used by Westaway et al (2001) and then compared to the measured heights in the field. Accuracy was quantified using linear regression.

The results of this analysis demonstrated the ability to obtain accurate surveys of bathymetry in depths upto 1m using a DJI Phantom 4 RTK UAV and base station and a significantly reduced number of GCPS, combined with the application of refraction correction. This study confirms that considerable time saving in terms of fieldwork can be gained from the use of an RTK rotary-winged drone and base station. This technology can also be beneficial for obtaining accurate survey data in locations where it may be unsafe or impossible to place GCPs due to the hazardous nature of the terrain.