Quantifying the dynamics of sandy braided rivers using aerial imagery

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Sandy braided rivers possess significant bedforms, such as dunes, which play a key role in determining spatial and temporal variations in local bed roughness and flow structures, exchange between bedload and suspended sediment, and bar growth through bedform amalgamation. Our current understanding of the response of bedforms to changes in channel geometry and flow stage is relatively poor because it is often difficult to quantify the evolution of bed topography at sufficient spatial and temporal resolution. This paper reports on the use of repeat Unmanned Aerial Vehicle (UAV) and airplane sorties to quantify morphological change and bedform migration rates within the South Saskatchewan River, Canada.

The South Saskatchewan River, near Outlook (SK), is ~600 m wide with a very well sorted medium sand ($D_{50} = 0.3$ mm) bed and negligible clay. The Gardiner Dam, 20 km upstream of the study reach, traps much of the very fine sediment so that the waters are clear at low flow, rendering the river bed entirely visible. Fieldwork campaigns in 2015, 2016 and 2017 captured: (i) 1:5000 aerial colour photographs of the river bed over a 17.5 km reach; (ii) high temporal frequency repeat imagery, obtained using quadcopter and fixed-wing UAV platforms for multiple 100 x 500 m sub-reaches. Airplane images were processed via Structure from Motion (SfM) photogrammetric techniques using Pix4D and analysed using ArcGIS and Global Mapper. The resulting point cloud was corrected for tilt and filtered in MATLAB at multiple spatial scales to remove noise. Elevations in sub-aqueous zones were obtained using a statistical model, relating image brightness to water depth, developed using single beam echo-sounder data collected near to the flight time. The final Digital Surface Model (DSM) for the airplane imagery combines these two methods, yielding a 0.5 m spatial resolution and vertical accuracy of ~0.06 m. UAV imagery was also processed using Pix4D with application of a diffraction water depth correction, and yields a resulting vertical accuracy of 0.02m.

Initial results highlight the following issues: (i) there are a series of technical challenges that must be overcome to produce final DSMs from UAV or plane imagery; (ii) tracking of individual dunes using UAV orthophoto mosaics is relatively easy, and reveals that migration rates are spatially highly variable; (iii) dune migration rates follow a well-defined, positively-skewed distribution; (iv) two reaches of contrasting planform and bed geometry show markedly different bedform migration rates; (v) it may be difficult to convert bedform migration rates to bedload transport rates using UAV imagery alone because of the over-estimation of bedform leeside depths. This paper will quantify the spatial and temporal variation in dune dynamics – including recent high flow surveys - and illustrate how the data generated can be used for validation of a 2D morphodynamic model of sand-bed braided river evolution.