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Fluvial experiments using inertial sensors.

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During the last four years we have announced results on the development of a smart pebble that is constructed and calibrated specifically for capturing the dynamics of coarse sediment motion in river beds, at a grain scale. In this presentation we report details of our experimental validation across a range of flow regimes.

The smart pebble contains Inertial Measurements Units (IMUs), which are sensors capable of recording the inertial acceleration and the angular velocity of the rigid bodies into which they are attached. IMUs are available across a range of performance levels, with commensurate increase in size, cost and performance as one progresses from integrated-circuit devices for use in commercial applications such as gaming and mobile phones, to larger brick-sized systems sometimes found in industrial applications such as vibration monitoring and quality control, or even the rack-mount equipment used in some aerospace and navigation applications (which can go as far as to include lasers and optical components). In parallel with developments in commercial and industrial settings, geomorphologists started recently to explore means of deploying IMUs in smart pebbles. The less-expensive, chip-scale IMUs have been shown to have adequate performance for this application, as well as offering a sufficiently compact form-factor.

Four prototype sensors have been developed so far, and the latest (400 g acceleration range, 50-200 Hz sampling frequency) has been tested in fluvial laboratory experiments. We present results from three different experimental regimes designed for the evaluation of this sensor: a) an entrainment threshold experiment ; b) a bed impact experiment ; and c) a rolling experiment. All experiments used a 100 mm spherical sensor, and set a) were repeated using an equivalent size elliptical sensor.

The experiments were conducted in the fluvial laboratory of the University of Glasgow (0.9 m wide flume) under different hydraulic conditions. The use of IMU results into direct parametrization of the inertial forces of grains which for the tested grain sizes were, as expected, always comparable to the independently measured hydrodynamic forces. However, the validity of IMU measurements is subjected to specific design, processing and experimental considerations, and we present the results of our analysis of these.