Optical remote sensing of gravel sediment transport under waves.

Report for the International Association of Sedimentologists

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The IAS student grant was used to fund a series of experiments looking into coarse-grain transport on a gravel barrier beach (Slapton, Devon, UK) in early May 2008. The aim of the experiment was to investigate the fundamentals of sediment entrainment under natural conditions in 2-3m water depth under shoaling waves on a steep gravel beach. Models for such processes are poorly developed, and existing models for sand transport under waves have been shown to poorly predict the direction and magnitude of sediment motion. This is because the physics of coarse grain sediment transport are fundamentally different under waves compared to sand-sized material. For example, it is hypothesised that coarser particles will move further and faster than finer grains nestled in the interstices, because of small pivot angles and relative boundary layer protrusion. This phenomenon is known as 'overpassing' and thus far has not been included into models of coastal sediment transport.

The experiment was the first of its kind in this environment and water depth. In the absence of sand suspension in this high energy environment, the water under the unbroken waves was clear, allowing for images of remarkable clarity and resolution. Four 1Mpixel digital cameras in underwater housings were arranged as two stereo pairs, 60cm above the bed, inclined inwards at 20 degrees, giving an overlapping field-of-view of some 50cm^2 at sub-millimetre resolution. Each camera sent images at 25 Hz over firewire connections to a separate computer in an underwater housing. A fifth computer was used for time synchronisation. Hard-drives in a separate underwater housing were used to store the greyscale images which amounted to 100MB per second! A 3D acoustic Doppler velocimeter was used to quantify near-bed flow turbulence.

Correspondence points will be used to solve the fundamental matrix problem in order to construct digital micro-elevation models of the gravel bed, 25 times per second! In addition, each stereo pair had a common field-of-view with a member of the other pair. This will allow the trifocal tensor problem to be solved for very accurate depth-perception in this near-field stereo photogrammetry. Using this set up, it should be possible to reconstruct the 3D image plane, useful for DEM construction, roughness quantification, bed elevation changes, sediment size and shape information, and particle tracking. This information will be used to quantify the physics of granular controls on coarse particle transport, including the contribution of form and skin friction to turbulence and energy dissipation at the bed.

IAS funds were used to buy clamps and poles to make a solid frame (rig) for the cameras, and cases for computers and hard-drives. In addition, the funds paid for use of the velocimeter, purchase of physical memory and some transport costs. The prospect of the new sedimentological information the experiment promises to yield is very exciting, and has already generated some interest! The experiment would not have been possible without the support of the IAS so I am grateful and indebted.