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Riverbed image simulation for a better exploration of coarse-grained sediment sizing image analysis methods

Jean-Stephane Bailly (1) and Carole Delenne (2)

(1) AgroParisTech, UMR TETIS, 34093, Montpellier, France (bailly@teledetection.fr), (2) HydroSciences Montpellier UMR 5569 (CNRS, IRD, UM1, UM2), Universite Montpellier 2, Montpellier, France (delenne@msem.univ-montp2.fr)

Grain size spatial variability on riverbed is a key element for many fluvial environment topics: fresh water habitats, sediment transport and budget, hydraulics, etc. But, as announced by Graham et al. (2005), "the spatial variability of grain size at a variety of scales makes the characterization of fluvial sediment notoriously difficult. Large sample sizes are necessary to ensure adequate representation of the coarse-grained sediment population and sampling is therefore time consuming, laborious and costly". The development of techniques that can achieve a satisfactory characterization of grain size distribution whilst simultaneously reducing the time spent in both the field and laboratory is highly desirable. For that purpose, several researchers have used images from proxy-detection (Rubbin, 2004; Rollet et al., 2005) or aerial remote sensing (Carbonneau et al., 2004) to reduce field time and estimate efficiently grain size statistics, mainly the median diameter d_{50} statistic. The image analysis methods used are numerous and can be divided in 2 main groups: some are based on object delineation from image using binary thresholding, edge detection, image segmentation or mathematical morphology operators (Graham et al., 2005); others are based on texture indices using semi-variance, auto-correlation (Carbonneau et al., 2004; Buscombe, 2008), or spectral analysis via Fourier transform (Lewis, 1988). In order to assess objectively the performances of an image analysis method in the various conditions that can be encountered in a fluvial environment, it is necessary to apply it on a large sample of images 1) with various but controlled characteristics (grain size distribution, image size and resolution, sun elevation conditions, water properties, etc) and 2) representative of fluvial environments and lighting conditions. To do so, we chose to first develop a bank of realistic images of riverbed, where parameters of coarse-grained gravels as well as lighting parameters are perfectly controlled. In this study, the ray-tracing software POV-Ray (Persistence of Vision Pty. Ltd., 2004) was used to produce a bank of 3000 simulated color images with different grain size distributions, randomly generated from Gaussian laws, and with fix lighting and image characteristics (resolution, extent). A Latin hypercube sampling design on the mean radius and the standard deviation of Gaussian parameters was used with 30 strata and 10 replications per strata. Laws and ranges for mean and standard deviation parameters were inferred from ground truth data on the Durance gravel-bed river, South of France. For each of the 300 distributions, ten images were generated with a random placement of the grains, using an algorithm based on the routine *Pebbles* developed by J. Hunt. From this bank image, the performance of semi-variance and Fourier transform image analysis methods to retrieve the d_{50} gravel size statistic is under study. Firsts results are encouraging as they highlight a positive correlation between d_{50} and the range of semi-variogram.