EGU21-3325, updated on 29 Jan 2022
https://doi.org/10.5194/egusphere-egu21-3325
EGU General Assembly 2021

Assessing thresholds for fluvial entrainment with instrumented particles

Khaldoon AlObaidi and Manousos Valyrakis
Water Engineering Lab, School of Engineering, University of Glasgow, Glasgow G12 8QQ, UK

Sediment transport is considered to be the governing process in many applications around the fields of geosciences and engineering as well as infrastructure and environment monitoring. Of a special interest to which scientists and engineers have dedicated a lot of time and experimental studies in the last century is the conditions for initiation of sediment entrainment, or incipient motion. In the literature, there are different criteria for determining the conditions that can result in initiation of sediment entrainment. Among these criteria, the impulse (or energy) criterion [1-2] captures the actual physics of sediment entrainment since it accounts for both the magnitude and the duration of the turbulent flow events that can result in initiation of a particle's motion. The experimental and field studies of incipient motion use relatively expensive tools, like Particle image velocimetry (PIV) or Acoustic Doppler velocimetry (ADV), with indirect methods to determine flow parameters that could be related to predicting sediment entrainment. However, technological developments in recent decades has made it possible to assess sediment entrainment directly. Recently, a number of research studies [3-4] have suggested linking micro-electromechanical system (MEMS) recordings that consist of accelerometers, gyroscopes and magnetometer as well as an internal digital motion processor that are interconnected forming inertial measurement units (IMUs) to the probability of entrainment of individual particles. The particles have been presented provide a direct, non-intrusive, low-cost and accessible method for assessing the probability of entrainment of individual sediment particles rather than inferred using near bed flow diagnostics. In this work, an instrumented particle of 3cm in diameter [5] is used to investigate experimentally the conditions that can result in initiation of sediment entrainment for a range of flowrates that represent the near threshold conditions. The data is used to derive metrics like frequency of entrainment that could be linked to the probability of entrainment of individual sediment particles which could be used as an indicator of the risk of riverbed destabilization based on well-established theories in hydraulic engineering. Additionally, the novelty of this work is explicitly linking the probability of entrainment to the flow hydrodynamics. In addition to that, a stochastic analysis is performed to identify the relevance of certain flow structures (sweeps) to the incipient entrainment of the instrumented particle.

[1] Valyrakis M., Diplas P., Dancey C.L., Greer K., Celik A.O. (2010). Role of Instantaneous Force Magnitude and Duration on Particle Entrainment. JGR, 115, 1-18.

[2] Valyrakis M., Diplas P., Dancey C.L. (2013). Entrainment of Coarse Particles in Turbulent Flows:

An Energy Approach. JGR- Earth Surf., 118, 42-53.

[3] Valyrakis, M., Alexakis, A. (2016). Development of a “smart-pebble” for tracking sediment transport. River Flow 2016, MO, USA.

[4] Al-Obaidi, K., Xu, Y., Valyrakis, M. (2020). The Design and Calibration of Instrumented Particles for Assessing Water Infrastructure Hazards. JSAN, 9, 3, 36.

[5] Al-Obaidi, K., Valyrakis, M. (2020). A sensory instrumented particle for environmental monitoring applications: development and calibration. IEEE sensors journal (accepted).