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ABSTRACT

Detecting very shallow surface flows by means of thermal tracers: results from laboratory and field tests

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Shallow surface flows can occur in natural and urbanized basins (e.g. hillslopes, drainage systems) and their accurate detection and characterization have been of great concern to the hydro-environmental research community, aiming at better understanding and modelling the dynamics of sediment and pollutant transport.

Recent developments have been made in sensing technology (e.g. acoustic, ultrasonic, microwave), resulting in a wide spectrum of powerful and versatile tools for high accuracy flow velocity measurements. However, such tools often have limitations when operating outside their ideal measurement conditions. Particularly for very shallow surface flows, the characterization of the velocity fields is complicated, mostly because of their small depth (i.e. from millimeters to a few centimeters). For a long time, tracer techniques (e.g. dyes, salts, particles) have been used in estimating these velocities. A more recent approach uses thermal tracers (e.g. water hotter or colder than the flow, ice cubes, cold oil droplets) that can be detected by an infrared sensor (e.g. infrared video camera).

This study presents results of several thermal tracer applications to detect very shallow surface flows and estimate their velocity. Experiments were conducted both in the laboratory and in the field, in natural (e.g. bare soil, grass vegetated soil, soil covered by tree leafs) and urbanized (e.g. smooth acrylic, asphalt pavements, concrete sidewalks) surfaces and considering very shallow flows from 1 mm to 5 cm depth. Hand-held infrared video cameras were used to detect the thermal tracer in the flow. This more recent thermal tracer technique was compared to more traditional and well-established dye and salt tracer techniques, using optical video cameras and electric conductivity sensors.

The different tracer techniques yielded very similar results. One advantage of the thermal tracer was the higher visibility of the movement of the tracer with the flow in the thermal videos compared with the real image's videos. Thermal tracers also measure flow velocities in a cleaner way, leaving less residue in the water or the soil. In very shallow flows, velocity estimation using thermal tracers contains a large amount of uncertainty and caution must be taken in these measurements, especially in the field studies, where these variables greatly vary in space and time.