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Erosion and deposition caused by gravity currents over a mobile bed *(2014-2017)*

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SEDITRANS

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In this project the formation of a European network allows the coordination of the research and training activities on sediment transport in the fluvial, estuarine and coastal environment, with the aim of increasing the European competitiveness in this important field.

Introduction

Gravity currents are buoyancy driven flows in which the density gradient between two fluids is due to temperature differences, dissolved substances or particles in suspension, among others. These phenomena frequently occur in many natural and industrial situations. Some examples are pyroclastic flows, avalanches, sand storms, accidental dense gas releases and emission of industrial pollutants. In water, natural gravity currents can be formed from differences in temperature and salinity (oceanic fronts) or caused during flood events due to high concentration of suspended particles (turbidity currents).
Sediment-laden gravity currents have been found as a primary cause of distal transport of sediments and of reservoir sedimentation since they erode and transport considerable sediment volumes along the reservoir bed. When traveling downstream, the current entrains sediments from the bottom on a rate that depends on its hydrodynamics. The erosion, distal transport and deposition of sediment provoked by a gravity current are here studied experimentally. Saline currents, which are dynamically similar to turbidity currents, made of several initial buoyancies are reproduced through the lock-exchange technique. Several size classes of fine sediment, composing an erodible reach over which the current flows, are tested.

Objectives

The highly turbulent dynamics of density-driven flows are complex and still not completely understood. Their mechanism coupled with the presence of a mobile bed, so far little investigated, is here examined focusing on the erosion, transport and deposition of fine sediment composing an erodible bed, operated by the passage of saline gravity currents of different buoyancy. The authors of picking up of sediment and of their transport downstream are here identified.

Research methods

The saline currents are here performed in a 7.5 m long and 0.275 m wide flume, divided into two sections of comparable volumes by a sliding gate. At 2.5 meters from the gate it is located a depression of the bottom, for a length of 0.6 m. It is fulfilled by sediments in order to create a horizontal mobile bed.

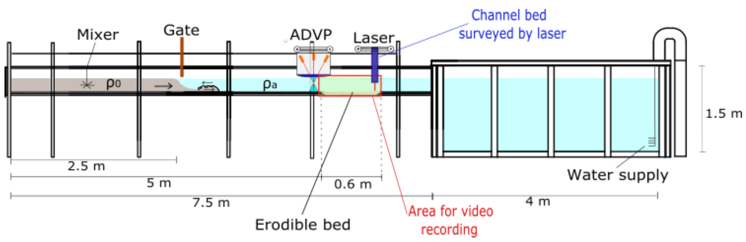

Figure 1: Experimental set-up.

The so called lock exchange technique is used: when the gate is removed, differences in the hydrostatic pressure cause the denser fluid to flow in one direction into the ambient lighter fluid along the bottom boundary of the tank, while the lighter fluid flows in the opposite direction along the top boundary of the tank.

A schematic representation of the set-up is presented in Figure 1. To obtain a full understanding of the processes the following determinants parameters identified for gravity currents will be varied:

- particles size
- turbidity current initial density
- fix or mobile bed
- volume of the lock
- longitudinal slope

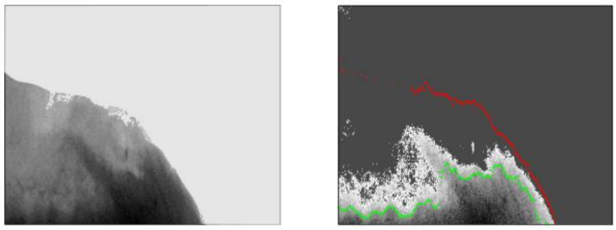

Figure 2: Detection of relevant flow interfaces. Original image (left) and post-processed image (right) with the interfaces between the clear water and the current (red line) and the current and the sediments (green line).

3D instantaneous velocity measurements are recorded with the ADVP (Acoustic Doppler Velocity Profiler) along a vertical during the passage of the current. A laser technique combined with photogrammetry are used to measure the sediment morphology of the bottom in order to evaluate the distribution of deposits and eroded zones, their extent and thickness. The coupling between the evolution of the gravity current and that of the underlying substrate is explored by analyzing the videos recorded from the side (Figure 2) and the velocity profiles as collected with the ADVP (Figure 3).

The turbulence structure of the flow is studied in order to explain the interaction between the current and the sediment layer on the bed (erosion and deposition of particles). The role of the vertical component of the velocity and of the current bed shear stress in the erosion processes are identified with the aim of determining the responsible force for the picking up of sediments and for the displacement within the current flow. Furthermore, the vortical movement of the current is expected to influence the deposition. Particular deposition patterns, that take the form of longitudinal streaks, are commonly observed in nature and their reproduction under controlled experimental conditions is here attempted.

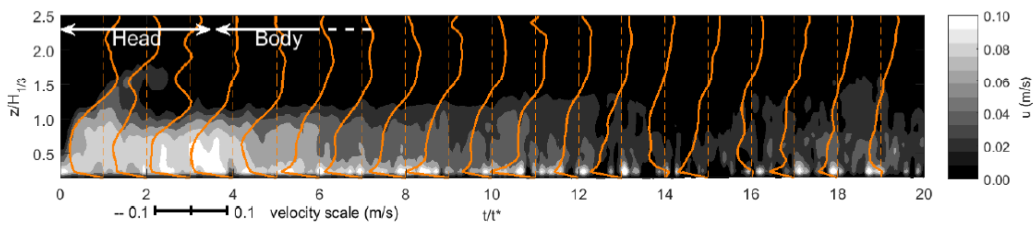

Figure 3: Vertical profiles of the time-averaged downstream velocity are plotted on the downstream velocity map. The head and the body of the currents are put in evidence on the top of the figure.