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Fragmented canopies control the regimes of gravity current development

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Wetlands are regions of high biological productivity but they are one of the world's most threatened ecosystems. Wetlands are characterized by aquatic vegetation which has adapted to high salinity levels and climatic variations. Wetland canopies buffer these hydrodynamic and atmospheric variations and help retain sediment by reducing current velocity during sea storms or runoff after periods of rain.

This work focuses on the effect the presence a gap (i.e. non-vegetated zone) parallel to the direction of the main current has on the sedimentation and hydrodynamics of a gravity current. The study aims to determine 1) the behaviour of a gravity current in a vegetated region compared to one without vegetation (i.e. the gap), 2) determine the effect gap size has on how a gravity current evolves and, 3) determine the effect gap sizes have on the sedimentary rates from a gravity current.

Laboratory experiments were carried out in a flume using four different sediment concentrations, four different simulated canopies with densities (884, 354, 177 and 0 plants•m-2) and three different gap widths (H/2, H and 1.5H where H is the height of the water). The simulated canopies were rigid PVC emergent vegetation.

As already found in previous works, gravity currents propagating in bare soils undertake an inertial regime, where the velocity of the gravity current is constant, is followed by a viscous regime, where viscous forces overcome inertial forces and the velocity decreases with time. However, gravity currents propagating in vegetated areas undertake an inertial regime that lasts shorter than in the bare soil case. The inertial regime is followed by a drag dominated regime, where the drag forces overcome inertial forces and the velocity decreases with time. After a certain time, the viscous forces dominate and the viscous regime is attained, with a greater decrease in the velocity with time than in the drag dominated regime. The gravity current exhibits the same behaviour in both the vegetated region and the gap. Furthermore, while current dynamics in experiments with wide gaps are similar to the non-vegetated case, for small gaps the dynamics are close to the fully-vegetated case. The analysis of the results demonstrates that the gravity current's evolution and its sedimentary rates depend on the fractional volume occupied by the vegetation (ad, where a is the frontal area of the cylinders per unit volume and d is the stem diameter). This work has established a threshold in which fragmentation is not significant for the system. When ad> 2.5, both the hydrodynamics and the sedimentary rates are not affected by the gap. In sustainable management of wetland ecosystems, this threshold should be considered as an indicator of the quality of the system. When 0.75<ad< 2.5, the effect of the width of the gap starts to be noticed and increases with the increase of fractional volume occupied by vegetation. For ad<0.75 the vegetation does not provide any shelter against gravity currents and sediment deposition and gravity current hydrodynamics are the same as the without-plants case.