Interactive comment on "Potential erosion capacity of gravity currents created by changing initial conditions" by Jessica Zordan et al.

Associate Editor

We appreciate the comments to our paper and we hope to answer through this document the last points which have been identified as needing more clarity.

Our answers to the specific comments on the response to Reviewer 2 are as following:

4. "Gravity currents are LIKELY experiencing two phases...an initial acceleraton takes place...then the current accelerates...At the point where the measurements are taken, the gravity currents are experiencing this second phase."

-> It seems that this is something that the authors should know, rather than guess about. I get that the ADV measurements are at a fixed point, but the aren't there at least movies or photographs showing the propagation of the head in order to deduce the front speed through time?

Unfortunately we did not record any video of the tests which could help deducing the front speed. Since this information is missing, the discussion concerning the initial acceleration is a hypothesis supported by previous experiments as discussed by Beghin et al. (1981). We changed the sentence to:

"According to Beghin et al. (1981), gravity currents are experiencing two phases while flowing along the channel."

-> As for the reviwer's concern about return flow, this could be checked with the velocity profile, right? In other words, if flow velocity becomes negative at or above the current interface - and if this effect becomes larger for steeper slopes - then the reviewer's point is valid. Showing that this does NOT happen would demonstrate that the reviewer's concern is not important. From figure 5 it looks like there is significant return flow, and that it might be dependent on slope. Please explain.

The return flow cannot be influenced by the set-up since it has been conceived in order to have the same water depth for all tests (0.2m). The velocity field shown in Figure 5 is anyway confirming that the mean velocity of the return flow for tests performed with the inclined bottom is higher than for the correspondent tests on the horizontal. As discussed in the paper, the gravity currents flowing an inclined bottom experience subsequent phases: (i) at the beginning an acceleration as a consequence of their increased gravitational forces; (ii) the acceleration induces the acceleration of the return flow and it enhances ambient water entrainment from the interface which causes the dilution and, accordingly, (iii) a deceleration of the gravity current. Higher return flows velocities prove the passage through phase (ii).

General comment on "readability"

The paper have been reviewed and many paragraph have been improved in order to improve their understanding.

Specific comments

Abstract:

Some motivation sentence should come FIRST, before the sentence that states the experiments that were run.

Experimental sentence is not clear, for example: "...for horizontal and four inclinations".

The second sentence (motivation) is also unclear: you talk about changing the slope upstream of a lock gate, but the reader has not been introduced to the experiment so does not know what this means. It seems to me that the motivation is that you want to examine the influence of initial conditions of a gravity current on its runout and entrainment capacity over a horizontal bed. You can then explain how you modify these initial conditions; in this experiment you examine primarily the slope. ALSO, your sentence discussing the main point of the experiments does not agree completely with the title; for consistency, you should talk about transport capacity or entrainment potential, but NOT BOTH. It becomes confusing to the reader.

The rest of the abstract does not include results and a conclusion; it talks about what will be discussed in the paper, rather than summarizing the paper. As such, the abstract is not that helpful. I suggest a re-structuring:

1. Motivation of the runout and entrainment of gravity currents, and how the initial conditions may govern these dynamics - including pointing out something that is uknown or unexpolored.

2. Then say that you have built an experiment to explicitly test the control of some factors (identified in the first sentence) on the flow dynamics and sediment entrainment potential of gravity currents. You should also make clear that your gravity currents are saline and nor particulate.

3. What was the range of conditions explored?

4. What were the main findings?

5. End with a sentence about the implications of your work for broader considerations of turbidity currents.

The order of the sentences, the grammar and the incongruences of terminology have been corrected by a complete revision of the Abstract which consider these last 5 points.

“We investigate to which extent initial conditions (in terms of buoyancy and geometry) of saline gravity currents flowing over a horizontal bottom influence their run-out and entrainment capacity. In particular, to which extent the effect of the introduction of an inclined channel reach, just upstream from the lock gate, influences the hydrodynamics of gravity currents and consequently its potential erosion capacity is still an open question. The investigation herein presented focus on the unknown effects of an inclined lock on the geometry of the current, on the streamwise velocity, on bed shear stress and on the mechanisms of entrainment and mass exchange. Gravity currents were reproduced in laboratory, through the lock-exchange technique, and systematic tests were performed with different initial densities, combined with five initial volumes of release on horizontal and sloped locks. The inclination of the upstream reach of the channel (the lock) was varied from 0% to 16% while the lock-length was reduced up to ¼ of the initial

reference case. We observed that the shape of the current is modified due to the enhanced entrainment of ambient water, being the body the region of the current where this most happens. A counter-intuitive relation between slope and mean streamwise velocity was found, supporting previous findings which hypothesized that gravity currents flowing down small slopes experience an initial acceleration followed by a deceleration. For the steepest slope tested, two opposite mechanisms of mas exchange are identified and discussed, i.e. the current entrainment of water from the upper surface due to the enhanced friction at the interface and the head feeding by a rear fed current. The bed shear stress and the corresponding potential erosion capacity are discussed giving insights into the geomorphological implications of natural gravity currents caused in different topographies settings."

Introduction

Multiple sentences have been modified all along the paper and particularly in the introduction, resulting in a considerable enhancement of the manuscript readability.

-First sentence is almost impossible to read.

The sentence have been rewritten: "Gravity currents are common phenomena which may occur spontaneously in nature or triggered by human activities."

-Many of these sentences are written in a rather indirect way. Sentence structure should be more simple, direct and make use of more straightforward words. For example, I notice the authors changed the sentence on katabatic winds from the first draft to make it more readable, but it is now even LESS readable. A better style would be "Katabatic winds are an example of an atmospheric gravity current, which arises due to...".

The sentence has been rewritten: "Examples of gravity currents generated in the atmosphere are katabatic winds which are created by temperature inhomogeneities that originate the density gradient.".

-Sand storms are NOT examples of particulate gravity currents. The sand concentrations are too low to contribute to density contrast. Rather, cold atmospheric currents can be gravity currents that pick up sand and dust - but the particles act as tracers of the flow, not drivers of it.

The example of sand storms have been removed.

-Top of page 2: "...able to self-sustaining itself and to outrun the slower moving body of the flow..."

First, "self-sustaining itself" must be changed. Second, how does this new idea relate to the classic Parker work of auto-suspension and also the process they have outlined for heads breaking away from the bodies of currents?

Azpiroz-Zabala et al. 2017 defined a new turbidity current structure which substantially differs from what has been presented by Parker. Azpiroz-Zabala et al. said that in many laboratory-scale flows, as it has been performed by Parker, "short-lived experimental flows (termed surges)" generates in which "the head does not outrun the body, and the body is rather poorly developed".

The following sentence have been added to the introduction for clarifying the two positions: "The difference between the two concepts mainly comes from the observation time frame which is of the order

of hours for the experimentally reproduced gravity currents while it's of days for the observations that Azpiroz-Zabala et al. (2017) made in Congo Canyon.".

p.2 line 18: The lock-exchange component is an experimental initial condition. The paper makes it sound as if lock conditions are an important component for gravity currents in nature. They are not. Rather, experiments choose a lock exchange geometry simply because it is controllable and reproducible. So it is not of "fundamental importance" generally for gravity currents.

The sentence has been modified: "Lock-volume and lock-slope are initial trigger conditions of the experimentally reproduced gravity currents and the main objective of the paper is to understand their influence into the transport capacity of the flows.".

p. 2 bottom: I do not know what "increment of friction means".

The expression "increment of friction" has been replaced with "enhanced friction at the interface" or "enhanced shear stress".

p.4. Please define all variables as they are presented.

A list of symbols with their definition and unit of measures have been added to the paper.