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

Associate Editor

We revised the manuscript to account for all the comments pointed out by the third reviewer. In the following, we provide the answer to the specific points. Thanks to the precise and constructive comments, we hope the general quality of the manuscript, as well as the clarity of text and illustrations, has been improved now making it suitable for publication.

Answer to Chris Stevenson

The reviewer's suggestions are kindly acknowledged since they have an encouraging purpose of improving the manuscript. Reply to the queries made by the reviewer and the answer given by the authors are listed below.

1. **Writing style**

The English of the paper has been reviewed.

2. **Structure**

> ***The aims of the paper are not clear. What is the bigger picture or generic learnings that the paper wants to address? Currently, it is difficult to pick out how the introduction links with the discussion and conclusions. This means that whilst there might be some good analysis made on your gravity flows, I don't see the point, i.e. how can the wider community use this work. This issue with structure feeds into several points below regarding methodology. For example, a major point in the paper is the analysis of entrainment dynamics, yet the introduction does not tell me why entrainment dynamics are important to understand and what key gaps in our knowledge there are.***

The importance of the entrainment dynamics has been explained by the following sentences, which have been added to the paper: "Small variations in the entrainment highly influence the flow dynamics (Traer et al., 2012). Due to the instabilities at the interface with the ambient fluid, the current entrains the lighter fluid and therefore it dilutes. "

The aims of the paper have been emphasized and made more explicit in the text particularly in the Introduction. The following sentences have been added: "To understand how lock-volume and lock-slope, which are initial trigger conditions of gravity currents, are linked with their transport capacity is thus of fundamental importance and it is the main objective of this paper. We show how shear stress at the boundaries is dependent to the set-up under which a gravity current forms, i.e. its initial and boundary conditions. Different initial conditions, representing configurations which can possibly be found in nature, are tested by varying the initial volume of denser fluid, and the lock geometry."

The gaps of knowledge that this paper aims to fill have been explicitly mentioned through the following sentences: "We were in search for a threshold at which an inversion of the leading forces of these currents would occur, which are gravitational forces and friction at the upper interface with the ambient fluid. Previous studies mainly focused separately on either low slopes or large slopes, missing the analysis of the transition which is here tested thanks to a specific experimental set-up which allows a wider range of configurations. Finally, we use a parameter previously defined in Zordan et al. (2018) for the evaluation of the bottom erosion capacity, as a surrogate to evaluate the influence of each different trigger condition on the erosion capacity of the currents."

3. **Ambient entrainment**

    This section presents a revised method for the estimation of ambient water entrainment. However, there is no justification as to why this revised approach is needed. As the section states, there is a great deal of work that has established entrainment dynamics with Gradient Richardson numbers. It is not clear why you need to use a 'surrogate' formulation when you could just as easily use well-established methods. Make this justification explicit in this section.

The advantages of using this model for water entrainment is the subject of the cited paper (Zordan et al., 2018b). The following sentence has been added in order to explain the main differences between the models: "Since bulk Richardson number is based on depth averaged quantities, it assumes that properties do not vary significantly along the vertical.

The quantity $\phi_{m,}$ a surrogate for entrainment capacity, relies to the instantaneous measurements of shear stress and therefore account for the unsteady behaviour of the currents."

4. **Results**

    There is a counterintuitive relationship between slope and flow speed. This is due to the significant increase in ambient entrainment as the slope increases. I think this may well be a product of the experimental set up. In the description of the flume tank set up, you state that the flume is filled to a depth of 0.2 m. Does this mean that when you put a steeper slope into the flume the top parts of the ramp (i.e. up to where the lock box sits) are in shallower water? This would mean that the same lock-box volume is being released into the tank but the thickness of the overlying ambient water column is reduced, which would increase the velocity of the return flow. This increase in return flow velocity (due to the modification of the slope) will drive increased upper surface entrainment. This is not so much a product of the relationship between slope and entrainment but the influence of focussing a high(er) velocity return flow over the gravity current. This aspect of the experimental set up needs to be explained clearly and if this is the case, then the results require discussion in this light.

The gravity current forms the instant the gate is opened. The head shapes at the slope-break and the current develops along the horizontal bottom where the thickness of the clear water is always the same for all tests. To clarify this point the following sentence has been added to Chapter 4.2: "The enhanced entrainment which has been verified for gravity currents formed downstream steep slopes is due to the shear at the interface with the ambient water. Gravity currents are likely experiencing two phases while flowing along the channel. An initial acceleration takes place due to the higher gravitational forces, then the current accelerates inducing an increment of shear stresses at the interface. The entrainment of clear water is therefore intensified and the current are diluted. At the point where the measurements are taken, the gravity currents are experiencing this second phase."

5. **Bottom erosion capacity**

I do not understand this method of estimating erosion capacity. Bed shear stress is a measure of erosion in that it is related to the critical shear stress of particle movement (and/or flow capacity). This depends on the particle size, distribution and bed roughness parameters. You can talk about bed shear stresses changing in your experiments, and how this might influence erosion patterns but as written the discussion reads as though the flows passed over erodible beds. They don't.

Indeed, the experiments presented in this manuscript are performed over a fixed bed. We use however the parameter defined in Zordan et al. (2018), where experimental work to characterize sediment entrainment by the passage of a saline current over erodible bed is analysed, as a surrogate to see here the effects of the changes in the initial lock geometry and current initial buoyancy. We added information on this replying to #1 and also further in the text as follows:

"Although the present experiments are over a fixed bed, this estimator will be used here to evaluate the influence of the lock initial conditions in the entrainment capacity of these flows."

6. Typos

Typos have been corrected.