<u>REPLY TO THE COMMENTS OF REFEREE #2</u>

by Saletti Matteo et al.

We would like to thank Professor Chris Paola for his insightful review and his helpful comments. Here is how we intend to address them:

One thing that is left to the reader to infer is the relation between particle entrainment/deposition and changes in bed topography. I assume this is as simple as I imagine: that when a particle is deposited, the elevation (Z_{ij} in the paper) is incremented by a unit amount, and vice versa for erosion. But this should be stated explicitly.

> This is correct: erosion/deposition change the local topography by reducing/incrementing the local elevation Z_{ij}. This will be stated clearly in the revised manuscript.

The authors' choice of probabilities for a particle moving straight downstream as opposed to stepping left or right (2.2.2) seem a bit arbitrary. Are there any observations of particle paths in steep streams that could be used to constrain these? How much does the choice of weights matter for the observed model outcomes?

> Our choice of probability for lateral displacement has been guided by the assumption that the straight direction of movement must be prevalent but at the same time we did want to consider the (small) chance for lateral movements as well. We are not aware of any study able to help us to constrain this value: therefore, we have tested different values in what we considered a reasonable range (i.e. probability of lateral displacements < 20%) and observed that below roughly 10% the final outcome of the model does not change. A further increase in this value has the effect of enhancing deposition (because of more particle-particle collisions) and so to increase the equilibrium slope for a given set of parameters. We will clarify this in the revised manuscript.

The authors state (2.3) that, in the jamming model, once the jamming condition is met, all the particles across the jammed section are 'locked' in place. A little later the text says the process is 'permanent'. I took this to mean that they were deposited and could never move again, but reading on and thinking about the results reported later, I don't see how this could be right. This is an important point, since the inclusion of jamming is an important part of the paper, so it must be explained clearly. I think what the authors mean is that all the particles in that section are considered to be deposited, i.e. stop moving, regardless of the local relative elevation. But then, I assume, the jammed particles can be entrained again according to the same criterion used for all the other particles, i.e. there is nothing special about particles that were deposited through jamming. Whether this is correct or not, the authors should explain *clearly what if any conditions are needed to re-entrain particles deposited through the jamming criterion.*

We agree with the referee that this is a crucial point in our analyses that needs to be clarified. The process of jamming leads to a permanent deposition without any further possibility of re-entrainment in a given model run. These grains become keystones in the context of Church and Zimmermann (2007). This aims to represent, for sure in an extreme way, the increased stability of step structures given by granular forces (as implied in the jammed-state hypothesis). However, in the same cross-section entrainment and deposition are still possible except for grains that have been deposited after a jamming event. In the revised manuscript we intend to explain this more clearly, also discussing the implications/limitations of such a choice.

In section 2.2.2, it appears that deposition occurs if a particle in motion collides with another particle in transport. This seems inconsistent with the original simple condition for deposition, which is simply that the particle arrives in a pocket (relative elevation deficit). This should be clarified. Also, when there is a collision between two moving particles, are both deposited, or only one? It would also be interesting, and in my view still in keeping with the aim of a simplest-possible model, to see whether changing the entrainment condition to account for particle collision (e.g. by letting the entrainment probability increase upon arrival of a moving particle) would change the model behavior.

We realize that the conditions leading to deposition in the model need to be explained better. Both mechanisms described by the referee in his comment lead to deposition: a particle can deposit because it arrives in a pocket or because of a collision with another particle (or with the channel banks); when two particles collide they both deposit. This second mechanism is much less important than the first one because particle-particle collisions can only happen when at least one of the particles moves laterally, i.e. when they are trying to occupy the same space.

If we have understood correctly the second part of the comment, the referee is asking to take into account what in the literature can be called as “collective entrainment” (e.g. in C. Ancey’s work), i.e. the fact than when a particle deposits on the bed it hits the surrounding particles enhancing their chance of being entrained. At the moment we do not account for this effect, but we will check the implications of this process on the results.