Response to Short Comment by M. Schmeeckle

Dynamics and Mechanics of Tracer Particles

by Colin B. Phillips, and Douglas J. Jerolmack

We thank M. Schmeeckle for his kind remarks and for his insightful questions. This supplementary file documents in detail our response to this short comment for the discussion paper titled: Dynamics and Mechanics of Tracer Particles. Throughout the following text M. Schmeeckle's comments are in plain text, and our responses are in *italics* following a '>' symbol.

Start M. Schmeeckle's comments:

The results of this field study are very useful and I am amazed at the particle recovery rates. I look forward to seeing the final version in ESurf. I will confine my short comment to one short section of the paper.

In Phillips et al. (2013, GRL) $I*$ is introduced as a "kind of transport length" because particle velocity has been shown to be linearly related to ($U*$ - $U*c$). However, the transport length of a particle over an appreciable distance is not only governed by the integral of velocity, when it is moving, but also by the many number of times that it starts and stops. As noted in by Roseberry et al. (2012, JGR-ES), as well as several others, the variation of particle velocity with shear stress is relatively weak, but the variation in particle activity (e.g. areal concentration of moving particles) with stress is dramatic. Thus, the number of times that a particle starts and stops is much more important in determining the transport length than a determination of the particle speed when it is moving. Also, the integral impulse imparted to a grain, start to stop and including particle-particle forces, is exactly zero. Transport rate formulas are designed to incorporate particle velocity and activity. So why not use a suitably non-dimensioned temporal integral of a transport rate formula as a kind of transport length, rather than $I*$? Meyer-Peter Mueller? Unfortunately doing so will dramatically increase the sensitivity of the resultant measure on the chosen threshold of motion, but it is the bane of gravel-bed geomorphologists that we must deal with a near vertical line when transport is plotted as a function [of] transport strength.

> The impulse ($I*$) is intended to serve as a cumulative metric of fluid momentum imparted to the stream bed and was originally intended to as a way to characterize the large scale fluctuations in the hydrograph. As we were interested in particle displacement we chose the simplest relation (we tried several forms). We agree that the number of times a particle moves is very important, and the results of this manuscript indicate that determining the number of times a particle moves would give a better estimate of the actual displacement. Interestingly, however, the Mameyes data indicate that the dominant mode of transport for these tracers is one step per flood. So, while some tracers appear to be entrained more than once per flood (based on their transport distance, but we can not really be certain), most are close to a single-step expectation. So indeed the number of times a particle starts and stops is very important – but it seems that number is close to one for the floods we observed.

We mean $I*$ to be a "fluid impulse", it is not a total accounting of the momentum in the problem but just a convenient proxy for applied fluid momentum that builds on the concept of Diplas et al. (2008). We are very interested in grain-grain forces, but of course cannot resolve them here. We change the text in the manuscript to be clear that this parameter is a proxy for "fluid impulse". Interestingly, as described by Phillips et al. (2013) the distribution of $U*$ for $U*>U*c$ is an exponential, thus allowing the integral to be replaced with the long term average $U*$ and recover identical scaling. The time component within $I*$ dominates the integral, because the dynamic range of $U*$ is small. One could

raise the quantity (U*-U*c) to a 3/2 power (a la MPM) and it does not alter the form of the scaling relationships determined. Perhaps at the single flood scale such a correction would produce better scaling relationships, however at this level one would also need an independent estimate of U*c for the start and end of transport. As the determination of the threshold of motion (another bane of fluvial geomorphology) represents a critical source of error.