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Earth Surface Dynamics Discussions

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Interactive comment

Interactive comment on "Scales of collective entrainment and intermittent transport in collision-driven bed load" *by* Dylan B. Lee and Douglas Jerolmack

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Dear authors,

I am not an official reviewer. However, because the findings in your paper seem to support major hypotheses of two of my recent papers,

[1] Pähtz & Durán (PR Fluids, 2017, doi: 10.1103/PhysRevFluids.2.074303)
[2] Pähtz & Durán (https://arxiv.org/abs/1602.07079) (this paper is still under review),

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Discussion paper

I decided to give you review-like comments, which I hope you may consider in revisions of your paper.

Entrainment by particle-bed impacts (page 3, lines 15-25)

1. Reference [1] is not the only study reporting a crucial role of impact entrainment. Vowinckel et al. (JHR, 2016, doi: 10.1080/00221686.2016.1140683) carried out DNS/DEM simulations and found that the probability of entrainment by turbulent sweep events is strongly increased when a particle-bed collision preceded the event.

2. In contrast to what your writing seems to suggest, the results we reported in Ref. [1] are independent of lubrication forces (and thus the Stokes number) in the case of bedload transport. In fact, we found nearly identical behavior for simulations with restitution coefficients $e = 0.9$ (no viscous damping) and $e = 0.01$ (nearly maximal viscous damping). We also found that impact entrainment dominates entrainment by the mean turbulent flow for sufficiently large 'impact number' $\mathrm{Im} = \sqrt{R+0.5}\sqrt{(R-1)gD^3}/\nu$. I guess you may have been mislead by one of our statements in Ref. [1], where we mention that the impact number may be interpreted as a Stokes-like number. However, this statement does not mean that the impact number is the same as the Stokes number.

Influence of feeding rate (Figs. 5B, 7, and 8; and page 16, line 27 and following)

The results in Fig. 8, namely the bimodal distribution at low feeding rates and more continuous distribution at large feeding rates, are very similar to those we reported in Ref. [2] (e.g., see Fig. 9 in Ref. [2]) and seem to support the following hypothesis: We hypothesized that the probability that bed surface particles are entrained by an impactor and subsequently acquire an energy sufficiently high to become a saltator depends on the impact frequency. To understand the background of this hypothesis, one can think of two impactors hitting a bed surface particle in short sequence. In this situation, the second impact obviously has a higher probability of entraining the bed surface particle and promoting it to a saltator provided the bed surface particle does not fully recover from the first impact. More generally, we argued that the larger the impact frequency the larger the creeping and fluctuation motion of the bed surface (as bed surface particles do not fully recover between particle-bed impacts), which weakens the links between neighboring bed surface particles and thus makes them more susceptible to receiving momentum from an impactor (associated with an increased probability of entrainment and promotion to saltators). At low feeding rates (i.e., low impact frequency), bed surface particles are strongly linked with each other and thus become very seldom saltators (hence, the bimodal distribution), whereas at large feeding rates (i.e., high impact frequency), bed surface particles are weakly linked and thus are readily promoted to saltators (hence, the more continuous distribution). We further argued that the characteristic creep and fluctuation velocity of bed surface particles reaches a critical value $\sim \sqrt{(R-1)gD/(R+0.5)}$, at which bed surface particles are at the brink of being mobilized (the weakest possible link to their neighbors), when a critical impact frequency is exceeded. A further increase of the impact frequency then does not anymore weaken the link between bed surface particles, and thus does not anymore increase the probability of impact entrainment and subsequent promotion to saltators by single impactors; only the trivial proportionality of overall impact entrainment to the number of transported particles remains. This hypothesis is consistent with Figs. 5B and 7: at large feeding rates the statistics of single particle-bed impacts are independent of the feeding rate and thus one expects the trivial proportionality to $1/f_{\text{input}}$; whereas at low feeding rates the probability of entrainment by single particle-bed impacts increases with the feeding rate and one thus expects a upward-deviation from the trivial proportionality to $1/f_{\text{input}}$. Hence, this hypothesis may complete what you call an incomplete picture in page 16, line 27 and following.

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Discussion paper

I believe your paper would strongly benefit from a discussion like the one I outlined above because the idea that particle-bed impacts are dominating entrainment in bedload transport is very new and often not taken seriously in the community (as I have experienced numerous times myself). Showing that experimental results support a hypothesized mechanism that had been previously suggested by numerical simulations from a different research group would add a very strong argument in favor of the impact entrainment idea.

Thomas Pähtz

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