Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC2
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Comment on esurf-2022-4

Anonymous Referee #2

Referee comment on "Probabilistic description of bedload fluxes from the aggregate dynamics of individual grains" by J. Kevin Pierce et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2022-4-RC2, 2022

This paper present a theoretical analysis of the set of equation governing the motion of bedload particles subjected to noise (white noise for acceleration, and dichotomous noise for entrainment/deposition). The main contribution of the paper is in the simultaneous treatment of these 2 source of fluctuation, and there impact on the mean bedload flux.

The paper is well written, clear and concise. The approach is sound and standard mathematical tools are briefly introduced before or after they are used, which helps to understand the main ideas behind technical derivations. Main equations however miss a detailed physical explanation, term by term, to be understood by the readership.

The title should be more precise, several stochastic description of bedload having been already proposed.

A general concern is that the stochastic approach, although theoretically sound, is weakly linked to actual statistics of sediment transport by bedload, and thus the relevance of such complicated form of the bedload flux (eq 21!) is questionable for realistic transport conditions. In particular, there is no discussion on the actual values of Péclet number and the importance of considering both velocity fluctuations and entrainment/deposition as processes acting on similar time scales. There are considerable simplifications when decoupling both, so the authors should better point why such coupled approach is necessary. By doing so, the authors should also consider comparing their results with existing experimental or numerical data.

Other comments :

12 : drop “really”, and precise why /when fluctuations matter ?

16 : What is a “classic” description ? Deterministic ?

17-19 : I do not get the point here. The approach followed by the authors is also mainly kinematic in that no discussion is made on the forces (gravitational, drag, friction, collision,…) acting on particles.

20 The original “probabilistic” description …

21 Later ☐ replace by “more recently” (there were a lot a probabilistic studies between Einstein and Lisle)

22 “ by promoting his instantaneous steps to intervals of motion with constant velocity” I do not get the meaning of promoting hear.

75 – 85 No mention of Continuous Time Random Walks model is made. Authors should compare their approach with for instance (Schumer, R., Meerschaert, M. M., & Baeumer, B. (2009). Fractional advectionâ☐☐dispersion equations for modeling transport at the Earth surface. *Journal of Geophysical Research: Earth Surface*, *114*(F4))

l115 : Better explain how this equation can be physically understood, notably the presence of k and ke with time derivatives.

l137 Is the overdamped approximation similar to adiabatic elimination of the fast variable ? A deeper discussion is needed here, notably the validity of such approximation with respect to typical bedload transport scales.

l 143 : How does such expression compare with a spatio-temporal markov process, for instance eq 4.4 in Ancey & Heyman JFM 2014 ?

l217 : Why would velocity fluctuation during motion decrease diffusion at small time scales ? I would have imagined the reverse.

l230 Rewriting the Péclet in its usual form (diffusion time scale over advection time scale) would help understanding the transport process the authors are trying to characterize. In there definition of Peclet, the important length scale is the mean particle jump length. This should appear somewhere.

l264 : can you give an physical interpretation of why the flux is higher at the beginning ? Do we have a higher probability to sample particles in motion at short time scales ?

Figure 4a : why is there a plateau between 1-100 s? Is the mean flux only dependent on Péclet and observation time ? If yes, can you make it appear clearly in eq 21. If not, what are the fixed parameter in this figure ? Can you compare with experimental/numerical (DEM) data ?

Figure 4b If the distribution is Poissonian, you should be able to rescale it by its mean and have a single time-independent distribution. Could you plot this ?