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Interactive comment on "Rarefied particle motions on hillslopes: 3. Entropy" *by* David Jon Furbish et al.

Anonymous Referee #2

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Paper Entitled: Rarefied particle motions on hillslopes: 3. Entropy Author: D. Furbish, S. Williams, and T. Doane Manuscript no.: https://doi.org/10.5194/esurf-2020-100

Recommendations: This paper presents a theoretical analysis based on generalization of energy based constraints and maximum entropy method to study particle motions on hillslopes. The authors suggest that the generalized Pareto distribution is a maximum entropy distribution and represents the most probable arrangement of particles on a surface based on their travel distances. In general, the paper is interesting and well written, however, I feel, based on its extensive (or to a certain degree, entirely) mathematical and physics based content, it doesn't fit very well in a geomorphology journal. Also, it appears most of the discussion in on gaseous particles and little is related to the field or experimental observations of sediment particle on hillslopes. Given

the data and methodology employed, the article is relevant to the journal, but major changes and clarifications ought to be made prior to its publication.

Here are my specific comments:

-"The generalized Pareto distribution is a maximum entropy distribution...." I believe this is true for a distribution for a given sample size? If we compare tails of two distributions, e.g. exponential vs. power-law, both truncated, for example, due to finite size of the system (e.g. flume length etc.), would exponential have higher entropy (Shannon) than power-law?

Page 2 Line 20: What does energetic cost represents physically in terms of a moving particle? Could higher energetic cost be associated with shorter but more frequent waiting times for a moving particle? Is this energetic cost independent of particle size? - Can heating or cooling of particle be related to acceleration or deceleration of that particle moving on a hillslope?

Page 7 Line 8: Not clear why j is defined as j = 0, 2,....n (even) whereas later in the discussion g1(x) is computed.

Page 9 Line 26-30: Again, I think it would be easier for a reader if these discussions are written in a more accessible way to geomorphology community as it gets confusing while reading (e.g. use of terminology such as net cooling vs. net heating) whether the discussion is about gaseous/heat particles or sediment particles moving down slope.

Page 10 Line 8/Figure 4: "...increases more slowly with increasing distance x." What does it indicate? Does it imply tracer particles require less energy if they travel further/longer? If this is true, is it because of the achieved momentum? In that case, I assume larger particles will have higher momentum once entrained and require less energetic cost. On the other hand, what would happen to smaller particles if the waiting time is not sufficiently long enough; would they not require more energy to overcome resistance caused by trapping/hiding etc. to travel the same distance? With these thoughts, I wonder, if this curve (Fig 4) is able to differentiate between particles coming from a wider GSD. Page 10 Line 9: Assuming tracer particles follow exponential distribution for travel distances; how would the hillslope surface look like? Would it be flat? Or in other words, if these particles were traveling on a river bed would we expect isothermal type of behavior for a plane bed conditions?

Page 13: Is there a range associated to energetic cost? What does it physically imply for a particle to have this cost as, for e.g., w = 3 vs w =10? -Is this cost defined by the system size (e.g. hillslope length scale)? But shouldn't it also depend on resistance encountered by a particle while moving down slope?

-Looking at Figs. 4 and 5, for an isothermal process, can it be said that the maximum travel distance (as energetic cost and travel distance follow linear relation based on Fig 4) for a particle is 7 unit? Does it relate to maximum hillslope length?

Page 13 Line 10: So far it is not clear whether these curves (Fig 4/Fig 5) are for sediment particles or gaseous particles!

Page 1-Line 8: "the many different ways to arrange a great number of particles into distance states where each arrangement satisfies the same fixed total energetic cost - the generalized Pareto distribution represents the most probable arrangement."

- I assume these observations are for a constant slope?

- I wonder if authors have looked at the topographic fluctuations of the surface where these particles traveled to see if the particle distribution and their associated spatial arrangement are related to topographic fluctuations. Or in other words, can one infer the shape of the distribution from the topographic fluctuations as it is easier to obtain topographic data compared to travel distance distribution? Also, it would be useful for readers to show as an example spatial arrangement of particles based on Pareto vs exponential distribution.

In my opinion, this paper, in the current form, will fit well in a more physics based journal

such as Phys. Rev or Phys. of fluids etc.

Certain times the paper also appears as a review paper with several discussions (e.g. Pages 9, 16, 17) based on previous published/ in-review papers.

Also, I apologize for not reading the other three companion papers in case if I missed something; however, I feel that this paper should be standalone in a way that one should get most out of it while only reading it.

-Minor:

Page 1 Line 15 (or I would say the whole abstract): I think, perhaps it would more accessible to geomorphology community if this is written more from a perspective of tracer particle movement vs heating or cooling of particles.

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