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Interactive comment on "Inertial drag and lift forces for coarse grains on rough alluvial beds" *by* Georgios Maniatis et al.

Anonymous Referee #2

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The manuscript by Maniatis is based on a study that uses two custom-built smart particles (one spherical and one elliptical in shape) that contain an accelerometer and gyroscope. The manuscript focuses on (1) presenting a method for putting the accelerations extracted in the particle's frame of reference to one from the perspective of a fixed observer and (2) presenting the lift and drag forces measured while the particle was in motion in a laboratory and field experiment.

The paper's strengths are the presentation of the mapping method between the two frames of reference and the introduction of the idea of inertial drag and lift impulses. The inertial drag and lift impulse are similar to the impulse idea put forward by Diplas et al. 2008 (Impulse = integral of force with respect to time applied to a particle), but is based on particle forces inferred from particle motion rather than particle forces inferred

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Discussion paper

from fluid measurements.

I believe the paper presents (1) useful methodology information for those using accelerometer data in particles, and (2) useful data pertaining to particle motion. At the same time, I have a few questions for the authors and some suggestions on the presentation of the work that I think should be addressed.

Scientific questions/concerns/suggestions

1. My primary suggestion, or concern, is that the authors make it explicitly clear that all of their force measurements (and impulse calculations) require that the particle be moving (if I am understanding things correctly). It would also be helpful if they expanded their discussion on the benefits and limitations of such measurements. Many of my presentation suggestions below reflect this desire for it to be clear that the forces measured are only those extracted from the particle accelerations.

2. It seems that you have the highest number of entrainment events for an inertial impulse of zero. Is this because the primary motivating impulse came at a time before that which could be measured by the particle?

3. Along these lines, do the potential travel paths of the particle dictate the forces measured? That is, are the F_L and F_D measurements sort of pre-determined by the orientation of the particle relative to others in the bed?

4. In equation 5, where is the contact force with the bed? Is it tied into the gravitational force terms? The critical drag and lift forces will depend on the submerged weight of the particle and the orientation of the grain within a pocket through the contact reaction force. The orientation of this force will also influence where it is more likely to have lift or drag dominate. How does it factor into equations 9 and 10? It should, shouldn't it?

5. Along with the preceding question, how is this contact force for accounted for throughout the range of a particle's motion as it moves and interacts with the bed?

6. Please provide a figure showing the experimental setup with flow depth and bed arrangement. I would think that τ_B has little meaning in terms of mobilization with your particular laboratory setup.

7. Terminology in Figure 2 and elsewhere. When do vibrations turn into motion? Does entrainment start when the particle reaches a distanced traveled of 1 diameter, or does entrainment start when the particle starts to move and then continues on a path that leads to it moving 1 particle diameter? Also, what is a non-entrainment event with a measured inertial impulse? Does that correspond to a case where the particle started to move out of the pocket but then fell back back down before reaching the apex?

8. In the discussion, I'd suggest non-dimensionalizing the force (maybe using submerged specific weight) when making the comparisons to other work. Also, how do your inertial forces compare to standard drag estimates using velocity, particle size, and a drag coefficient? What types of relative fluid/particle velocities are needed?

Presentation questions/concerns/suggestions

The paper is reasonably well written, but I do have some suggestions below that I think would help to improve the presentation of the work.

Abstract:

- L.1 Delete "been"

- L.4 Replace "on sediment" with "on a particle during"
- L.5-7 The sentence "Today, twenty years.... for the issue" is not needed in an abstract. Suggest deleting it
- L.9 Change "grains on" to "grain moving on"
- L.11 Change "resulting to the" to "resulting in a"

Introduction:

- overall I think you can shorten down the introduction
- L.38-41 I think you can remove the sentence that starts with "The term Lagrangian..." Most people know the difference between a Lagrangian and an Eulerian frame of reference
- L.44 Delete "(the exact definition of turbulence impulse)"
- L.72 Change opening sentence to: MEMS-IMU sensors ideally measure forces at the center of mass....
- L.74 change to "acting on the grain as it moves"
- L.83 suggest changing to, "...and electrical engineering. Modeling of IMU error..."
- L.91&92 suggest changing resolve and resolution to "map" and "mapping" or "rotate" and "rotation"

Frames of ref

- L.123 Suggest, "... frames is non-trivial. A widely-used method..."

- L.124 Suggest changing "to apply" to "the application of"
- L.129-end of the section. I'm torn here. I could see all of this being better suited for the appendix if the focus of the paper is on the data from the particles. However, if you want the paper to be about the mapping between the frames of reference then you should keep it here.
- L.157-158 Delete the beginning of the sentence that spans the text "As sediment" to "linear acceleration". Just start with a_r.

Inertial measurements

- L.211 change to T_i
- L.216 suggest changing "that mobilizes the particle" to "acting on the particle once it starts to move"

Lab and field experiments

- L.238 0.028 l/s is a discharge, not a rate of increase in discharge
- L.240 change "recorded" to "video of"
- Figure 4. If I'm correct, I think you reference figure 4 before referencing figure 3. It should be the other way around
- L.254 suggesting changing to, "...inertial impulses for cases were the grain started to move."

Discussion

L. 360 - I'd suggest making the extended analysis part of the discussion. Use subsection for the different components of the discussion such as comparison with other work and L.368 - delete one of the "of"s

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