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

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I want to thank the commenter for his contribution. I just wish this came a bit earlier in the discussion timeline so we can have a truly interactive discussion. If he doesn't get the chance to reply to my comment before the end of the discussion period, I commit to take into account his comments and include them in the review process.

My general response is that the forces captured by the accelerometer (which are not described in the literature of hydraulics and need special treatment, O'Reilly, 2008) are not the forces (or impulses) described in the works cited by the author to support his arguments. They relate but they are not the same (Lines 212-216 of the paper under review). This is why we discuss specifically the difference between inertial impulses

(as derived by the accelerometer) and hydraulic impulses (as defined in the works quantifying the response of the particle to the flow). Our work relates more to particle force measurements (e.g. Schmeeckle et al., 2007; Lamb et al., 2017) rather than the quantification of flow turbulence. Overall, the concept of impulse is general (force over time), so the definition of forces becomes crucial for the interpretations of relevant results.

For the above reasons, many of the comments below are not valid. We define the forces in a different context and from a different frame of reference. I decided to answer those comments quickly because they imply significant misunderstandings regarding the physics of accelerometers (and inertial sensors in general). However, this discussion is definitely not over. This is a quite technical issue.

More specifically Comment 1: The resisting forces (FDcr and FLcr) are not fixed nor are equal to the initial resisting force (which can vary significantly) while the particle is transported (as has even been shown for the case of incipient entrainment) [1].

Response: That is true, the forces acting on the particle are neither fixed nor equal to the initial position. However, after calculating successive orientations (using the angular velocities) they can be transformed to a static frame (frame r in the paper) and this is what we present (sections 2 and 3 of the paper).

Comment 2: Lines 210-215: The authors' claim that impulses can be calculated directly from particle's motion (sensor's readings) is not valid, as according to Valyrakis et al. [3] and Celik et al. [4] the flow impulses (or energetic flow events) impart momentum (or energy respectively) for a particle's motion at a certain efficiency (depending on the characteristics of the flow structure driving the particle's motion). Thus, the impulses the authors refer to are not flow impulses according to the theories being cited [5,6,2].

Response: The commenter's conclusion here is correct. This paper doesn't quantify the same impulses to the works he cites (Lines 210 to 216 of the paper).

Comment 3: It would be interesting to have flow hydrodynamic measurements so as to enable comparison of the inertial impulses the authors estimate with flow impulses

Response: Here it is clear to the commenter that inertial impulses are different to the flow impulses. This contradicts significantly his comments above. However, it is true that this link is important. I am looking forward to reading the commenter's contribution from the experiments he conducts.

Comment 4: Details around the flow conditions in the controlled flume experiments are missing. In particular: The flow seems to be non-uniform because of the locally raised bed where the particle rests and also the presence of a smooth bed upstream this section combined with the short length of the raised bed render the flow not fully developed.

Response: There are hydraulic measurements presented in the appendices. We didn't have the capacity for detailed flow measurements, but that there are no physics to suggest that this affects the accelerometer model we present and the measurements for the conditions we captured. Here it is useful to look at the comments from Reviewer 1 who mentions explicitly that the conditions are closer to boulder motion rather than gravel. This is a very useful observation which doesn't affect the calculations but their interpretation. And I agree that more work is needed on that front and repetition of the experiments under varied conditions.

Comment 5: The flow depth and the range of flow conditions tested are not mentioned; this is even more important if the flow depth is of the same order of the particle's size, as in this case the particle may interact with the free water surface and the mechanics of entrainment are different from what the traditional hydraulic literature on incipient motion is discussing.

Response: This is not true. Firstly, we didn't' test a range of flow conditions in the lab, we repeated one experiment 12 times (the hydraulics are presented in the appendices). Secondly, the mechanics of entrainment we present are exactly the same to

the literature (Lines 169-174 in the paper). They are just linked to an accelerometer model and rotated to a different frame of reference in order to make the accelerometer measurement comprehensive.

Comment 6: The authors do not measure any flow hydrodynamics that could be linked to the sensor's metrics they present. Bed shear stress which is based on the bed surface slope is mentioned but it is not commented on how bed slope value was obtained (measured or estimated and how)

Response: The slope was measured in the flume and estimated in the field (and that is documented in the paper). But I will insist that this has nothing to do with the validity of the definitions and the measurements as the commenter argues from the start of this commentary.

Comment 7: For the ellipsoid there is a strong effect of the orientation of the initial placement on the dominance of the forces and the resulting mode of entrainment. More emphasis on this dependency could be discussed in this works.

Response: I apologise for the repetition: There will be a big effect on the numbers derived under different orientations, but the same (or a similar) model should be applied. And the model we present accounts for the orientation specifically since we can measure it directly (quaternions).

Comment 8: For the field work there is no comprehensive description of the flow and bed surface characteristics over which the particle is being transported.

Response: It is not easy (or even possible sometimes) to take detailed flow measurements in shallow streams. For the stream we conducted the experiments (Erlenbach) there are numerous references in the literature where the commenter can find a lot of details about the topography and the bathymetry. We just placed the sensor on a plain bedrock and the conditions were typical of a riffle and pool setting. We also remove the first second from the measurements to minimise the effect of the local topography, we are interested into the forces during transport. For the purpose of this paper (demonstrating the calculation of inertial impulses) the slope and the shear stress should suffice for an understanding of the hydraulic forcing.

References

O'Reilly, O. M.: Intermediate dynamics for engineers: a unified treatment of Newton-Euler and Lagrangian mechanics, AMC, 10, 12, 2008.

Schmeeckle, M. W., Nelson, J. M., and Shreve, R. L.: Forces on stationary particles in near-bed turbulent flows, Journal of Geophysical Research: Earth Surface (2003–2012), 112, https://doi.org/10.1029/2006JF000536, 2007.

Lamb, M. P., Brun, F., and Fuller, B. M.: Direct measurements of lift and drag on shallowly submerged cobbles in steep streams: Implications for flow resistance and sediment transport, Water Resources Research, 53, 7607–7629, 2017.

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