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Interactive comment on "Clast imbrications in coarse-grained sediments suggest changes from upper to lower flow regime conditions" *by* Fritz Schlunegger and Philippos Garefalakis

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We are grateful for this very constructive review by A. Wickert as it allows us to clarify two major concerns, which we mainly base on the limited explanations from our side. As a first point, the reviewer outlines to the differences between threshold flow strengths that are required to either (i) mobilize individual clasts on a gravel bar (incipient motion of sediment particles), or to (ii) modify the shape of a channel (channel-forming process). The reviewer correctly mentions that channel forming Shields stresses are up to 1.2 times larger than Shields stresses at the incipient motion of individual clasts, and that this aspects warrants a careful consideration. We agree on this and address this point in the section where we outline the methodological approach, and in a separate section where we discuss the consequences. Recalculations show that this will not change the general statement that water flow may shift to upper flow regime conditions for streams where channel gradients are steeper than c. $0.5^{\circ}\pm0.1^{\circ}$, and where the relative bed roughness exceeds a value of c. 0.06 ± 0.01. In addition, because imbrications mainly form as pivoting clasts come to a rest behind a large and stable constituent, our selection of the critical Shields stresses for the incipient motion of sediment particles rather channel-forming Shield stresses is likely to be valid. Indeed, while channel forming floods are mainly associated with equal mobility of sediment particles within a gravel bar, the formation of an imbricated fabric involves the clustering of individual clasts only.

The second point addresses possible protrusion effects that need to be considered for estimates of critical Shields stresses upon the entrainment of D84 and larger clasts. Indeed, as imbrications mainly involve the largest clasts of a gravel bar, possible protrusion effects could influence the outcome of our calculations, which thus warrants a careful consideration, and which we present in the revised manuscript. In particular, it has been proposed that the entrainment of the largest clasts most likely require lower flow strengths than the shift of median-sized sediment particles, particularly in cases where the material sorting is poor. Related φ–values may be as low as 0.03 as proposed by Lenzi et al. (2006) and van der Berg and Schlunegger (2012) for mountainous streams where the sorting of the material is poor and where the packing of large clasts is low. Our calculations predict that an upper flow regime is very unlikely to establish at these conditions (Figure 3 of the manuscript). However, we consider it unlikely that the formation of imbrications with steep dip angles, as we did encounter in the field, were associated with low thresholds. We base our inference on the observation that imbricated clasts in general, and the analyzed gravel bars in particular, form a well-sorted arrangement of large particles, which form a densely packed clast-supported fabric. This results in a high interlocking degree of sediment particles within these bars, which in turn requires that large threshold conditions need to be exceeded to shift the material. We thus propose that the use of φ–values of at least 0.0495, which is commonly applied for the entrainment of the D50, is adequate for the calculation of the hydrological conditions associated with the fabric as we have encountered in our examples.

Please the attached document (surf-2018-35-supplement.pdf) for a full and detailed response of how we have handled these points.

References:

Lenzi, M.A., Mao, I., and Comiti, F., When does bedload transport begin in steep boulder-bed streams?, Hydrol. Proc., 20, 3517–3533, 2006.

Van der Berg, F., and Schlunegger, F., Alluvial cover dynamics in response to floods of various magnitudes: The effect of the release of glaciogenic material in a Swiss Alpine catchment, Geomorphology, 141, 121-133, 2012.

Please also note the supplement to this comment:
https://www.earth-surf-dynam-discuss.net/esurf-2018-35/esurf-2018-35-AC2-supplement.pdf

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