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Interactive comment on "Morphometric properties of alternate bars and water discharge: a laboratory investigation" *by* Marco Redolfi et al.

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We thank the referee for the stimulating questions and the important technical suggestions.

Here we provide a response to the four main questions:

1. Apparently, there are no significant effects of the near-critical Froude number. Specifically, at the beginning of the runs small two-dimensional bedforms are sometimes observable. These can be associated with the formation of upstream-migrating antidunes, which we clearly observed in experiments with similar Shields number and relative roughness, but in a wider flume that allowed for the formation of a multi-thread system (e.g., Redolfi et al., 2017). However, they

seem to be suppressed by the formation of bars. In general, the fact that alternate bars are not directly influenced by the Froude number is a very interesting topic, which we are currently addressing (M. Redolfi, M. Musa, M. Guala, submitted to Journal of Fluid Mechanics).

2. In our experiments, flow separation seems to occur at mid-to-low discharges, due to the presence of sharp diagonal fronts. In these cases, we also observe that no sediment transport occurs downstream of the fronts.

   According to linear theories (see Colombini and Stocchino, 2012), flow separation is not a necessary ingredient for the formation of alternate and diagonal bars, which suggests that this effect probably plays a minor role at the early stages of bar formation. However, separation may be potentially important in the dynamics of fully-developed bars. For example, this effect may have an impact on the reach-averaged sediment transport, as it can induce part of the shear stress to be absorbed as form drag.

   For alternate bars, the impact of flow separation is mainly "local", thus having a minor impact on the reach-averaged properties (Colombini et al., 1987). Therefore the main effect of bars on sediment transport is rather related to the non-uniform distribution of the shear stress, which tends to significantly increase the net sediment flux (Francalanci et al., 2012).

   For diagonal bars, the effect of the form drag may be more important, and may eventually prevail over the effect of the non-uniform shear stress distribution. Our measurements seem to suggest that the transport rate we measured at the highest flow rates is indeed lower than what is expected in flat bed conditions. However, we realized that data from our experiments are not sufficient to fully support this idea, and a set of specific experimental runs would be needed.

3. We fully agree that it is interesting that transition to three dimensional dunes (i.e. diagonal bars) occurs in conditions typical of gravel-bed rivers. Accord-

ing to the Colombini and Stocchino (2012) theory, the key parameter controlling the transition from two- to three-dimensional dunes is actually the relative roughness (d_{50}/D) or equivalently the Chèzy coefficient (defined in plane-bed conditions). Specifically, their perturbation theory reveals that two-dimensional bedforms develop when the relative roughness is small, while three-dimensional oblique dunes are expected when the sediment is comparatively coarse. This is also consistent with the experiments of Jaeggi (1984), showing the formation of diagonal bars in conditions that are typical of gravel bed rivers.

In our opinion, formation of diagonal bars in rivers is discouraged because of their relatively small amplitude. In real conditions (unsteady discharge, presence of channel curvature, poorly sorted sediment), the bed morphology is expected to depend on a competition among different kinds of bedforms (diagonal bars, free bars, forced bars, dunes). In this competition, diagonal bars can be easily suppressed by the formation of other, more prominent bed features. Therefore, we may expect that diagonal bars are rather ephemeral, and observable in particular conditions only.

In the new version of the manuscript we have added a couple of sentences in the Discussion Section, to briefly introduce these important considerations.

4. We agree that an experiment encompassing a wide range of conditions would be very interesting. Specifically, the part that would deserve most attention is the transition from two- to three-dimensional bedforms. To avoid excessive Shields stress and Froude number, an optimal design would imply a variable slope, and a discharge that is adjusted in order to maintain a nearly constant shear stress, (which would also imply a relatively constant Froude number). In this case, theoretical analysis provides a very useful tool to guide the choice of the experimental conditions. Our experimental facility is not ideal for this kind of experiment, because the slope of the flume is not easily adjustable, and the banks do not allow for a lateral view of the bed profile. However, we think that in general this experi-

ment is absolutely feasible.

In the revised manuscript we have addressed all the technical questions. Specifically:

- we have implemented all the suggested grammatical corrections, except for the British spelling (ESurf allows the author to use their preferred spelling);
- we have added Shields parameter and Rouse number to Table 1;
- we have used a more neutral term instead of "this kind of bedform";
- we have rearranged Section 2.4, to better explain what we changed with respect to the original formulation of Colombini et al. (1987).
- we have better explained the definition of ensemble bar;
- since we didn't find a memorable concluding message, we fully agree it is better to end the paper with the specific conclusion points.

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