Authors' Comment to Dr. Kleinhans's Interactive Comment on "Comparison between experimental and numerical stratigraphy emplaced by prograding bedforms with a downstream slip face"

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We sincerely thank Dr. Kleinhans for his review that will definitely help in improving the paper. We respond to Dr. Kleinhans's comments below.

1) "<u>The results are not surprising</u>". We definitely agree with this statement. To our knowledge, however, this is the first numerical model validated against experimental data that is able to reconstruct the stratigraphy of the entire delta deposit. The model is built by coupling three different modules, and each module has been previously validated with laboratory experiments and field data. What we should clearly state in the text is that the model has been applied without tuning the model parameters, e.g. the bedload relation for non-uniform material, the active layer closure, the parameter to determine the grain size distribution of the sediment transferred to the substrate during aggradation of the delta top, and the closure to compute frictional resistances in the bed region.

2) We are more than willing to change the title of the paper in "Comparison between experimental and numerical stratigraphy emplaced by a prograding delta".

3) We will remove all the references to Dr. Kleinhans' thesis and we will refer to the proper journal papers.

4) Figure 8 with sorting. We can try to improve the quality of the figure but there is a reason for not using any software (matlab)-based interpolation. In our previous work we have been plotting stratigraphy using different interpolation procedures embedded in commercial software. The resulting plots always showed some strange features without any physical meaning, or justification based on the input data. Thus, to prevent the formation of strange features, we decided not to use an interpolation function in our stratigraphy plots. We acknowledge that the results are not as pretty as they could be with the use of interpolation functions, but we are certain that with this plotting procedure we represent our data correctly. We can try different colour schemes to improve the sorting figure.

5) Apparent downstream coarsening. We thank the reviewer for pointing out that the discussion on the spatial variation of the grain size distribution within the delta deposit has to be rewritten. The procedures for sediment storage have been published elsewhere and thus we decided to refer to our previous work. In addition, this helped us in keeping the paper within the limit of 5,000-7,000 words. In Ferrer-Boix et al. (2013) experiments the delta top slope remained reasonably constant and, after an initial adjustment of the profile there was very limited aggradation on the delta top. Thus, at least from an overall mass balance prospective, the sediment transport rate reaching the brinkpoint was very similar to the total (i.e. summed over all the grain sizes) sediment feed rate. Due to the lack of measurements, we do not know if the grain size distribution of the sediment arriving at the brinkpoint changed in time. However, since significant changes in the grain size distribution of the bed surface were not observed by Ferrer-Boix et al. (2013), it seems logical to assume that the grain size distribution of the sediment at the brinkpoint also did not change significantly in time. What in Ferrer-Boix et al. experiment is not constant in time is the height of the delta front, as the experiment was performed on a sloping basement. Due to the increase in time of the height of the delta front, over time the brinkpoint load became distributed over a larger height, which, due to the discrete sampling

resulted in an apparent downstream coarsening within the front deposit in both measured and predicted data. We are more than willing to add this information in the discussion session of the manuscript.

6) Sensitivity analysis. We did not present any sensitivity analysis 1) to respect the length constraints of the paper, 2) because we did not have to tune any model parameter in our simulation, and 3) because sensitivity analyses for the three modules have been already presented elsewhere. In particular, several flavours of the delta growth submodel have been applied at laboratory and field scale in the past decade (e.g. Swenson et al., 2000 and 2005, Kostic and Parker, 2003a and b, Wright and Parker, 2005a and b, Parker et al., 2008a and b, and Kim et al., 2009). The grain size specific mass conservation model was first presented by Parker in 1991 (Parker, 1991a and b) and it has been applied since then in several models at laboratory and field scale (e.g., Cui and Parker 1998, Parker and Toro-Escobar, 2002, Cui 2007, Eke et al., 2011). The Parker 1991 model was coupled with the procedure for the storage of stratigraphy in fluvial environment at laboratory (Viparelli et al., 2010a and b) and field (Viparelli et al., 2011) scale. Finally, the sensitivity of the lee face sorting model to different parameters is discussed in Blom and Kleinhans (2006).

We agree with the reviewer that the choice of the bedload relation, and consequently of the hiding/exposure factor, is a delicate part of the problem. The bedload relation controls the predictions 1) the grain size distribution of the active (or surface) layer, 2) the grain size distribution of the bedload, 3) the grain size distribution of the bedload at the brinkpoint (or shoreline), and thus the grain size distribution of the entire deposit. This is the reason why we have the discussion on page 1169 on the differences between bedload relations obtained in sediment feed or sediment recirculating flumes.

In general, the choice of the load relation in applied problems depends on the field/laboratory settings and on the grain size characteristics of the sediment. Once the bedload relation is chosen, it can be calibrated with the available data, see for example what Viparelli et al. (2011) did to use Wilcock and Crowe (2003) relation on the Trinity River in California, or Nittrouer et al. (2011) did to use the Ashida and Michiue (1972) relation (for uniform sediment) on the Mississippi River. If we had to try different bedload relations or hiding functions for our laboratory set up, we would find that the slope of the delta top, the grain size distribution of the delta top surface, as well as the grain size distributions of the bedload at the brinkpoint and within deposit changes. This, however, will hardly add something to the description of the phenomenon or will give us any insight on how to choose a bedload relation for other applications, since we do not have data to compare our numerical results with, or combinations of flow rates and sediment feed rates that describe a field or laboratory example.

In short, we agree with the reviewer on the importance of a proper choice of a bedload relation, but we consider that a sensitivity analysis on the bedload relation and on the hiding/exposure function goes well beyond the scope of the present paper.

7) Equal mobility. Parker and Wilcock (1993) compare the conditions of mobile bed equilibrium (and thus the bedload relations) in a sediment feed and in a sediment recirculating flume. At mobile bed equilibrium, in every section of a sediment feed flume the bedload transport rate and its grain size distribution is equal to the rate and grain size distribution of the sediment feed, whereas in a sediment recirculating flume partial transport conditions can be obtained. Yet, such conditions in a feed flume in which the rate and GSD of feed and load are equal are not necessarily governed by equal mobility. Equal mobility is the situation in which all grain sizes in a mixture become mobile at the same grain shear stress. In other words, under conditions of equal mobility hiding-exposure effects are so strong that the effect of mass on incipient motion is fully compensated by hiding-exposure effects. Yet, in a feed flume, the fact that the rate and grain size distribution of feed and load are equal does not necessarily arise due to equal mobility but is more likely to arise due to coarsening of the bed surface (mobile armouring).

In our case of a prograding delta, sediment is generally deposited on the delta top (i.e. aggradational conditions prevail over the fluvial reach), so that conditions of mobile bed equilibrium cannot be strictly achieved. When the grain size distribution of the substrate emplaced by delta top aggradation is similar to the grain size distribution of the feed, in agreement with Parker and Klingeman (1982) and in the context of the similarity hypothesis, equal mobility in terms of the subpavement is approached. Under conditions of equal mobility in terms of the subpavement, however, a thin and relatively coarse pavement forms on the delta top. This pavement "*acts as a thin buffer zone that regulates the availability of subpavement grains to the bedload*" (Parker and Klingeman, 1982).

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