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Interactive comment

Interactive comment on "The Usumacinta-Grijalva beach-ridge plain in southern Mexico: a high-resolution archive of river discharge and precipitation" *by* Kees Nooren et al.

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We thank the two reviewers for their constructive comments on our paper "The Usumacinta-Grijalva beach-ridge plain in southern Mexico: a high-resolution archive of river discharge and precipitation". We agree with most of the issues raised. They will be addressed in the final version of the paper.

Here, we only give additional information related to the main points.

First of all, our manuscript focuses on a particular portion of the Usumacinta-Grijalva beach-ridge complex that is and has always been very close to main river mouths

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Discussion paper

of this double river system. Maybe we should more specifically call them ‘river-mouth beach-ridge plains’ or ‘promontory’ portions of the UG-delta In the paper we use Otvos’ (2000) broad definition of beach ridges (L75-78), and include all Holocene swash- and aeolian deposits within the beach-ridge plain deposits. The term “wave-dominated” (cf. Galloway, 1975) does indeed apply to the barrier-coastline morphology of the UG-delta as a whole (Figure 1a; manuscript). We could include this term when revising the introduction section, but in our opinion it is a too broad and general term to characterize the specific river-mouth beach ridge amalgamated promontory complex that is the object of study in the paper (and we purposely avoided using it so far).

RC1’s main point is that he is not convinced that Holocene fluvial sediment supply is the dominant sediment source for the construction of the beach-ridge plain. He refers to studies along the Northern Gulf of Mexico coast where shelf sand is considered an important sediment source. Also RC2 mentions a possible redistribution of shelf sand, connected to the role of tropical storms and hurricanes which likely played an important role along the Northern Gulf of Mexico coast. It should be realized that coastal wind and wave conditions in the Northern Gulf of Mexico are remarkably different then at the relatively protected southern Gulf coast. Hurricanes are a frequent phenomenon in the Gulf of Mexico (e.g., Kossin et al., 2010), but they generally pass over the middle and northern part, whereas landfall at or near the study site is rare (www.nhc.noaa.gov/data/#tracks_all). One should also realize that the beach-ridge plains along the Northern Gulf of Mexico coast are small compared to that of our study area (Fig. 1; this reply).

We agree that shelf transport adds to beach barrier plain build out and beach-ridge formation, and that it does so along the entire length of the UG-delta coast line (at the scale that wave-dominated delta terminology applies). We stress, however, that along the river mouths the beach-ridges accrete and build out at significantly larger rates and we postulate that at these proximal positions, it is the Holocene fluvial sediment supply that majorly adds to the shelf sand supply – both to subtidal (shoreface, foreshore) as well as to intertidal and supratidal (swash and aeolian processes). After fluvial processes delivered the sediment to the shallow sea, we agree with the reviewers that coastal wind and wave conditions take over and work up sediments (which in the direct vicinity of the river mouth we regard a mix of younger fluvial deliver and older shelf-derived components) to form the progradational beach-ridge series, most efficiently and at highest resolution closest to the river mouth.

In general, shelf sand in the near-shore zone should be regarded a temporary sediment storage to supply sand for beach-ridge construction and coastal progradation. Under conditions of late Holocene relative sea-level rise, this storage required a continuous long-term sediment supply from an indirect source. Few beach-ridge studies consider such an indirect sand source, including most studies cited by Taylor and Stone (1996); the work of Brooke et al. (2008) is one of the few exceptions. They demonstrated that 79% of the estimated long-term average annual bedload of the Fitzroy River, temporally stored in Keppel Bay, likely contributed to beach-ridge plain formation at Long Beach, Australia. In a recent study, Mammi et al. (2017) demonstrated fluvial input to be the main source of beach ridges at the Ombrone River delta (Italy), and that variations in beach ridge elevation are due to variations in fluvial sediment supply.

We do not wish to exclude non-fluvial sandy sediment sources, but multiple arguments have been presented (L676-694) that, during beach-ridge formation phase 2, the Usumacinta River was likely the main source of sediment for the construction of the old SP y SP promontory. Although we believe that weathered Los Chocoyos ignimbrites are an important sandy sediment source (L569-594), RC1 suggests that it is unlikely that quartz grains are from weathered volcanic rock, because volcanic quartz from certain types of volcanoes has inappropriate OSL properties for dating (e.g. Tsukamoto et al., 2003). However, Pietsch et al. (2008) demonstrated that OSL sensitivity of quartz increases linearly with fluvial transport distance for the Castlereagh River in Australia. Such a sensitization effect might explain the decent OSL sensitivity of our samples, even if they started as ignimbrites with poor OSL sensitivity in the upper catchment

(∼1100 km). Another explanation could be sought in a secondary source of quartz with high luminescence sensitivity. Even if the bulk of the sediment is from ignimbrites, a minor component from another source may be responsible for the observed OSL signal.

We understand RC1's and RC2's point (1) that the interface between the aeolian and swash facies seems somewhat arbitrarily set at a constant height of 0.5 m above the mean sea level at the time of deposition. Indeed, given the temporal and spatial variability in run-up height, the uncertainties in the absolute elevation of beach ridge sand samples, late Holocene estimated RSL rise, and the limited number of grain size data, defining it as a bandwidth of 0.5 $\pm$ 0.5 would be more appropriate. We will correct this in the paper and will mention that our calculated aeolian accretion rates are indicative only.

We agree with point (2) of RC2 on the limited presence of descriptive statistics on grain size data in the paper. We will repair this and will add two additional figures (Figs. 2 and 3; this reply).

The grain size statistics (Fig. 3.; cf. Martins, 2003) indicate that aeolian beach and dune sands can be distinguished from the swash sands by a better sorting and an increased skewness (more symmetrically skewed). Sand deposited during phase 3B (Fig. 2) has similar sorting and skewness characteristics but has a coarser mean grain size (smaller (phi)), due to the contribution of reworked sand from the eroding SP y SP promontory.

RC1 is correct that the scour holes cannot be recognized in Fig. 2. We will therefore include a new figure (Fig. 4) to illustrate the presence of scour holes along the beach ridge formed around 1450 CE.

RC1 misses core logs. However because sediment lithology is very uniform at all core locations, and sedimentary microstructures not recovered in Van der Staay hand corings, there is little need to present them.

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RC1 misses an extended discussion on river discharge, precipitation and climate change. In view of the already considerable length of the paper, we prefer to discuss these subjects elsewhere (Nooren et al., in prep.).

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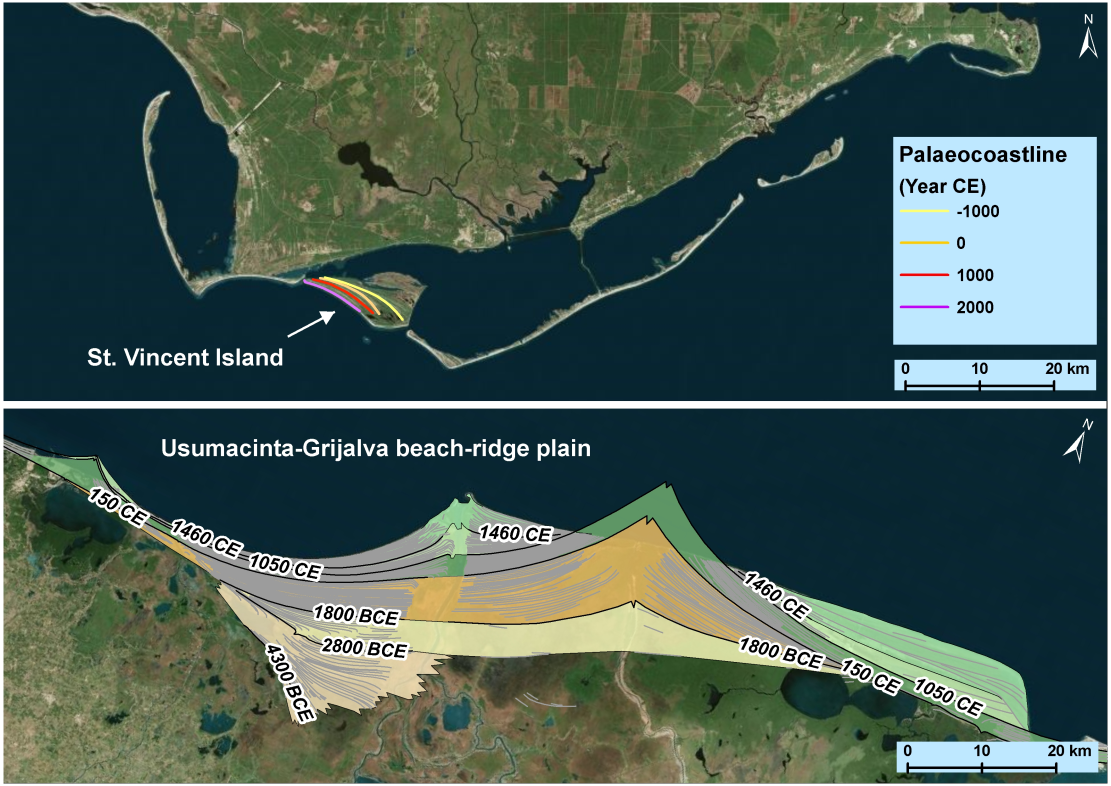

Fig. 1. Two large beach-ridge plains along the GOM coast. Reconstructed palaeocoastlines (upper panel) after Tanner (1992), López and Rink (2008), Rink and López (2010), Otvos (2005), and Forrest (2007).

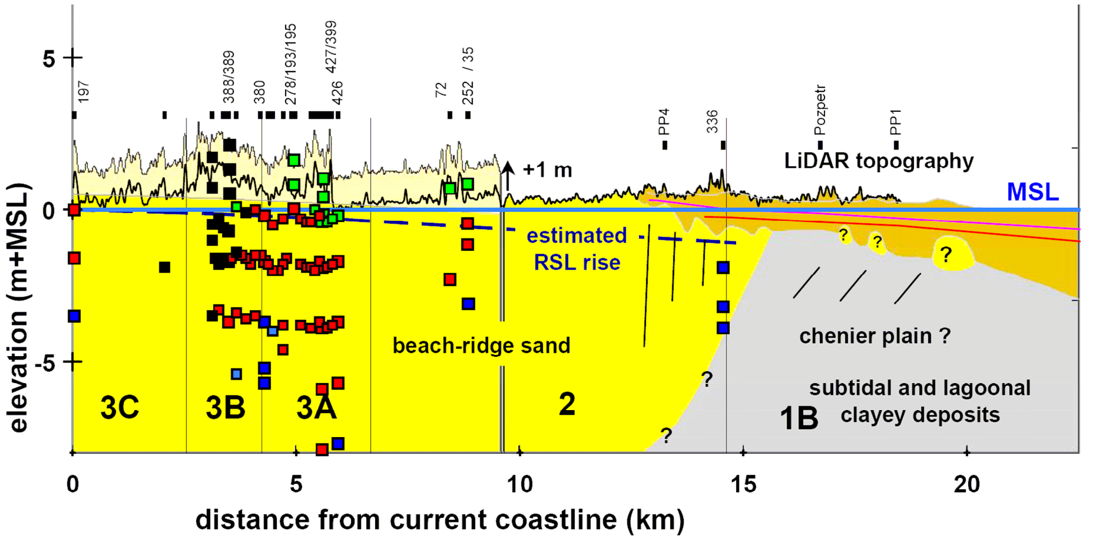

Fig. 2. : Sand samples along transect A for which grain size parameters are indicated in Fig. 3. See Fig. 3 for explanation of symbols.

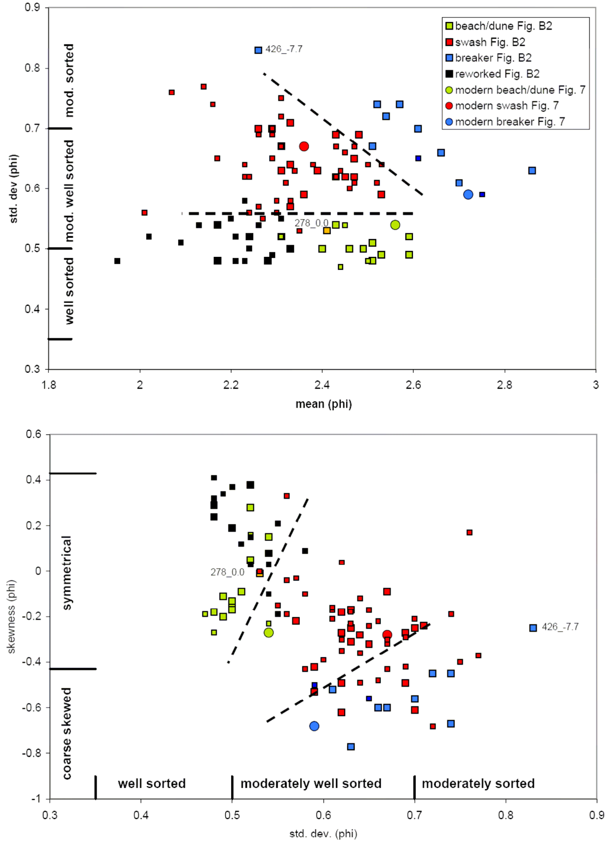

Fig. 3. Grain size statistical parameters, calculated conform the logarithmic method of moments (Blott and Pye, 1975).

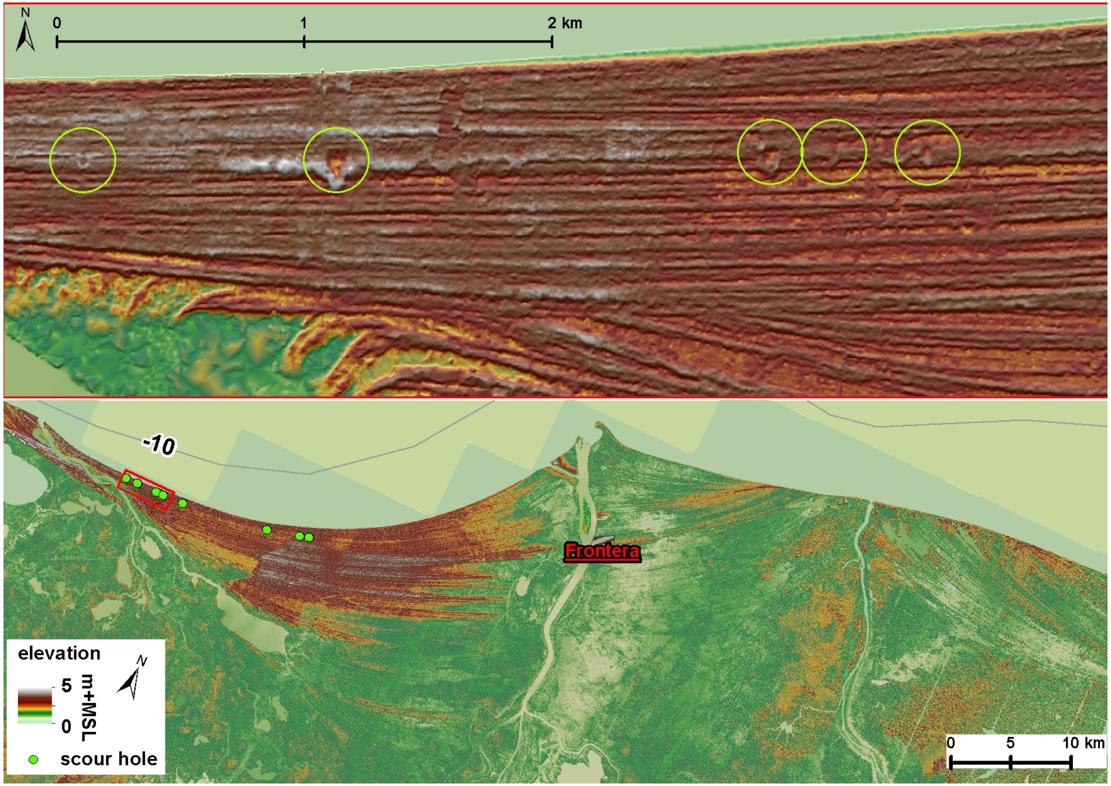

Fig. 4. Scour holes along a beach ridge formed around 1450 CE.