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Climate of the Past Discussions

Interactive comment on "Technical note: Optimizing the utility of combined GPR, OSL, and LiDAR (GOaL) to extract paleoenvironmental records and decipher shoreline evolution" *by* Amy J. Dougherty et al.

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Hi Marc Hijma,

Glad you thought the paper was nice and thank you for taking the time to comment. In order to be sure that I address all of your feedback I will go through your remarks one by one below:

The paper focuses on beach ridges, but could easily include chenier plains as well where similar methods are applicable and have been used

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-Indeed, the GOaL method could similarly be applied to cheniers. In fact, I think this approach could be used to study the geomorphology and landscape evolution in a lot of different geologic settings. Also, in cheniers I would think that radiocarbon dating would be the preferred technique.

With respect to LIDAR: you could highlight that converting the data to hillshade images and 3D-surfaces (like with ArcScene) is also very helpful

-This is very impressive and can be useful in detecting and analyzing features. While it can help to visualize the data I have not found that it identified something that was missed in 2D and can be hard to display in print.

GPR: please inform the reader if it is possible to distinguish between storm surfaces with and without a lot of shells. Do shells have their own specific reflection?

-We have just worked on the first sandy system that actually has what I would call a lot of shell concentrations along individual beachfaces. I haven't been able to process the data in detail, but it didn't initially look any differently than other systems with little to no shell preserved in the beachface. Within the systems that I have worked on where there was shells and shell hash concentrated on the lower beachface, the signal looked similar to its upper beachface component that was composed solely of heavy minerals. Shells can sometime cause ringing (hyperbola) in the data, but if you are specifically interesting I would always ground-truth with an auger or core.

OSL-dating is very useful of course, and I have used in the Chenier Plain of Louisiana. The existing chronology was based on dating juvenile shells in the 1950's. To my surprise the new OSL-data matched the existing chronology very well, showing that dating juvenile shells was and is still a very useful method and superior to dating scarce organic matter.

-I have also found that OSL ages are similar to radiocarbon dates of shells within the beach or dune facies; however, there is a discrepancy between the ages when the

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organic matter dated is from the near shore or deeper. So yes if you can find shells in the beach facies, getting ages is probably easier, faster, and cheaper than using OSL. It is just that organic matter is often scarce and unless you have shells in the beachface throughout your barrier it might not be possible to date the specific features of interest. OSL on the other hand offers the possibility of dating the formation of any feature in the sandy system.

OSL-dating should always be done after extensive fieldwork so that is known what facies is being dated. Maybe that could be stressed a little more in the paper. Especially dating aeolian facies is tricky, since it could post data beach-ridge formation significantly.

-Agreed, this is why it is the final step in the methodology after the morphology from LiDAR has informed the GPR collection and the stratigraphy from the GPR has been ground-truthed with cores. At this point the evolution should be well understood and then chronology added to either date changes identified or collect a suite to identify a more consistent progradation. Also because of the accuracy of GPR it should he fairly easy to locate the approximate location of your OSL sample within geophysical stratigraphy and I advocate showing that location on the geophysical records. Personally, I take a printed copy of the processed GPR in the field, along with the GPR unit, to locate the exact layer I have targeted to sample.

For OSL-dating is also important to have some idea about groundwater levels since depositing. If the sand was always below average groundwater level or always above makes quite a difference for the final age

-True, this is an important consideration for incorporation.

With respect to storm events: dating washover deposits with OSL is also very informative about large storm events. In addition, on chenier plains the washover deposits rest directly on marshland that formed very close to sea level. So at least on chenier plain washover deposits can also be used as sea-level indicators

-Yes, washover deposits and OSL are informative about large storm events, but in systems where sediment supply great enough to causes progradation and a series of large dunes these features are not common. Since this paper focuses on prograded barriers that lack washovers a discussion of them is therefore not included. Again, with respect to cheniers there is great potential to extract sea level and storm histories that can be compared to sandy prograded systems to better understand paleoenvironmental factors and past coastal evolution. While I have done this in the past (Dougherty, 2011; Dougherty and Dickson; 2012; Dougherty, 2014), I have not had the opportunity to work extensively in cheniers as they are less common features. I am also not aware of a paper where GPR, OSL and LiDAR have all been used on a chenier plain, but if you know of one please share. Regardless, cheniers are not the focus of this paper and while there is much to be learned by comparing and contrasting these systems with proximal sandy barriers, their evolutionary differences are great enough that they were not included in this paper for the sake of being concise.

Section 3.2: it reads a little bit like discussion of a single paper (Olivier et al., 2017b). The authors provide many arguments why some parts of that paper are not so strong. I would prefer a bit more general discussion about dating storm events, including some other papers as well. That would make this section a little bit stronger.

-There are a few papers that discuss detecting and dating storm events, I cite some examples that have done this successfully using one or two of these techniques in the intro and methods (e.g. Buynevich et al., 2007; Buynevich et al., 2004; Dougherty et al., 2004; Dougherty, 2014; Nott and Hayne, 2001). A nice paper on this subject, that includes some of these references, was published last year in Earth Science Reviews (v.174: p.80-119) by Jerome Goslin and Lars B. Clemmensen entitled “Proxy records of Holocene storm events in coastal barrier systems: Storm-wave induced markers”. I had meant to add this reference to this paper before submitting, but already have it in the next draft. Along these lines I offer examples in the introduction that utilize GPR, OSL and LiDAR on prograded barriers, independently or in various combinations, that

have been able to: “(1) quantify frequency-intensity of storm records (e.g. Buynevich et al., 2007; Dougherty, 2014; Nott and Hayne, 2001), (2) construct sea-level curves (e.g. Nielsen et al., 2017; Rodriguez and Meyer, 2006; van Heteren et al., 2000), (3) calculate sediment budgets (Bristow and Pucillo, 2006; Dougherty et al., 2015; van Heteren et al., 1996), and (4) decipher coastal evolution (e.g. Barboza et al., 2009; Costas and FitzGerald, 2011; Hein et al., 2016).” These would be just a few suggestions of papers I recommend referencing for more particulars about acquiring similar records. The aim of Section 3 is not a discussion of how to do this, as it has already been done before. Rather, Section 3 is a discussion of three different papers that all came out in the previous year that combined GPR, OSL and LiDAR, each specifically to address one of the three aims of GOaL: sea level, storms and sediment supply/evolution. The critique highlights strengths and address common pitfalls so that future studies using GOaL can be optimized. Based on you comment I will reincorporate the appropriate references from the introduction into the end of the appropriate subsection of Section 3 to remind people where to look for recommended examples.

Hopefully that provided the insight you were seeking. Cheers, Amy

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