Use the Lack of Information to Generate Better Information

Lidar is inherently or, maybe I should say theoretically, a great way to generate shorelines at specific tide levels. The National Ocean Service (NOS) has done a lot of work on this and have the specifications down to produce the best shoreline possible; however, there are hundreds to thousands (??) of coastal lidar data sets that were not collected to the NOS standards and would provide great historical shorelines for coastal studies. I am presently working on a project looking at just this – high accuracy historical shorelines and want to include lidar-derived ones as well as imagery derived ones. I struggled with the consistency of the initial results, but knew the information was there.

OK, yeah I know, we have all made DEMs using the as-is lidar and generated shorelines; it is pretty easy in many cases – depending on the lidar collection conditions (a reoccurring theme for me) and how it was manually (yeah this still occurs) processed. In some cases and/or parts of the study area it can be really off the mark. The problem is that the area being studied does not necessarily have continuous data coverage. So, please read on if shorelines and lidar interest you.

The Tried and True?

What I was faced with is the common condition (Figure 1) where the lidar data were processed fairly well, but not strictly with the idea of doing shorelines, as NOS may do. Now, there are some issues in this lidar data set (I won't lie) with the water classification or lack thereof; there are water points classified as ground in the upper left, and ground that has been classified as water in the lower right, but, often, this is going to be the norm.

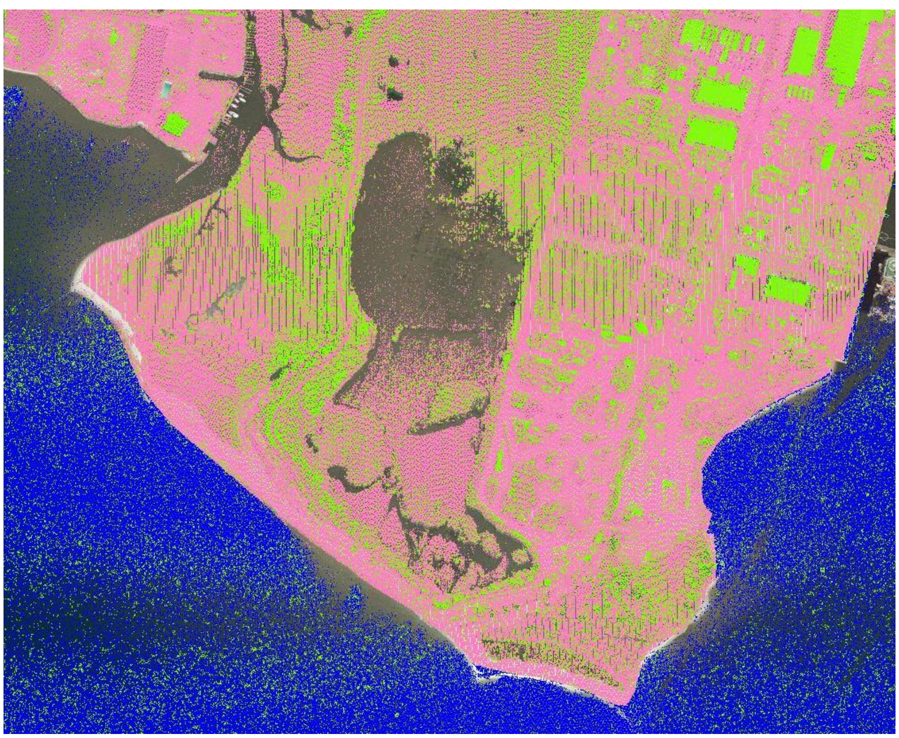

Figure 1. Common Lidar Product

So, as is common practice, I first used the ground points to create a DEM without interpolating too much; the results looked pretty decent (Figure 2), except the bayou (this is in MS) in the upper left is included in the DEM (not a huge problem if the elevations are low). Trying to generate a MHW shoreline from just the DEM, however, yields only a partial shoreline (Figure 2), which is the norm. The problem of non-continuous/or inconsistent data is the culprit; there are areas without ground classified points above and below the MHW value. It is a common issue and not a heck of lot that can be done to the base data. Maybe a bit of reclassification of water will help, but that is just hand digitizing a shoreline, which is what we are trying to avoid.

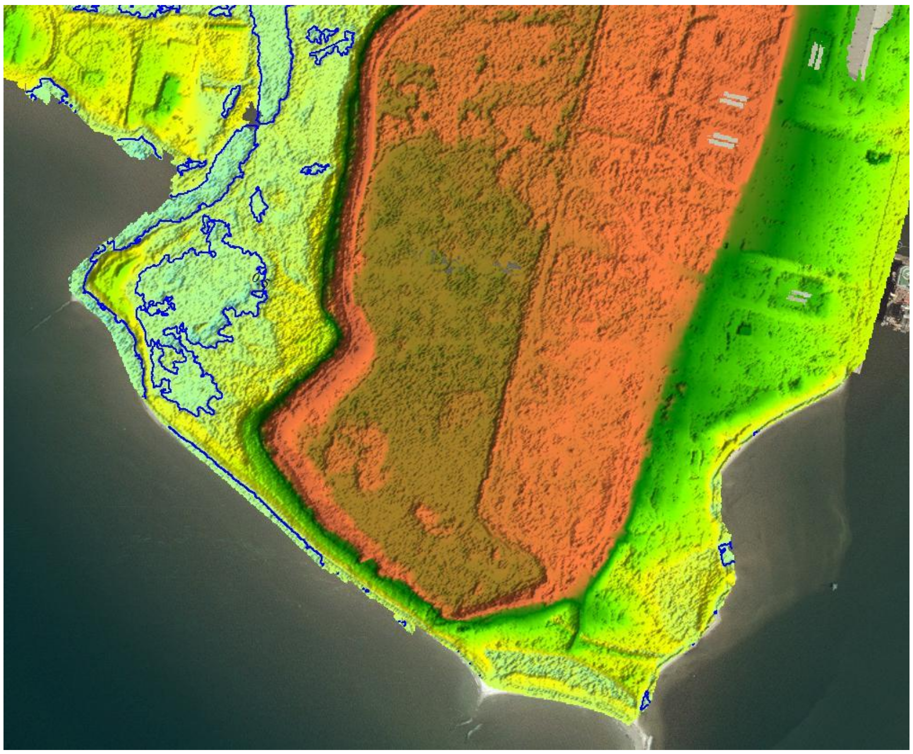

Figure 2. Bare Earth DEM with derived MHW shoreline in blue

The easy fix is to insert a water mask (hydro-flattening water areas) representing mean sea level, which helps and we get a continuous shoreline (Figure 3). Great, but is it a reasonable MHW shoreline, especially where before there was not enough data to generate one?

To answer that, I have overlain the DEM generated shoreline on imagery captured at about the same time as the lidar (Figure 4). My take – the shoreline is nowhere near useable as is and it going to take a lot of work to clean up. OK, there are some things I could probably have done to tweak this a bit – but each positive change would likely be offset by a negative one; some areas may get better, some worse. It is pretty much a zero-sum game.

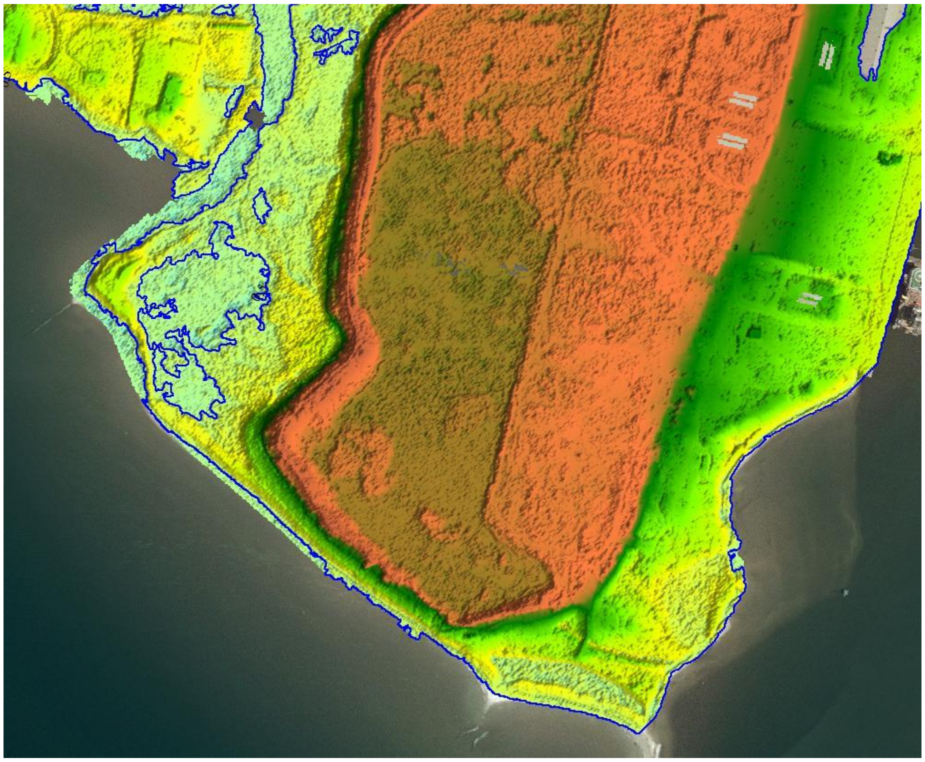

Figure 3. DEM with hydroflattened water (not shown) and the resulting shoreline (blue)

Figure 4. DEM derived shoreline overlain on aerial image from same time period

A Different Take – Use of Nothing to Make Something

OK, so looking at this from another perspective – we want to put a shoreline where the ground ends and water starts and know that in general lidar returns are much more prevalent from land than water. To do this we have to punt on the strict use of ground points only in the DEM, and to some degree the absolute value of the MHW elevation.

Here, instead, I concentrate on all the points above MHW (Figure 5) by filtering them by elevation only (remove all points lower than MHW). In this view it clear that some water points erroneously fall on land (bottom right of Figure 5) and that some of the erroneously ground points in the water (compare Figure 1 with Figure 5) have been filtered out. It is looking better in some areas, but you can also clearly see a significant amount of points in the water (and above MHW!) that would create havoc if we wanted to generate a shoreline from a traditional DEM of 'all' points.

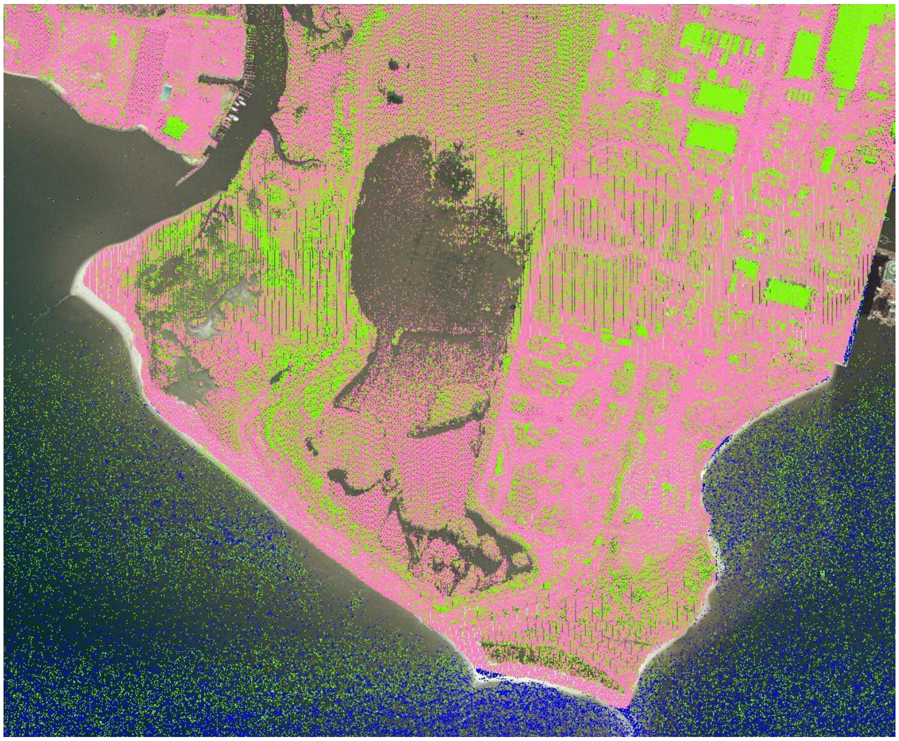

Figure 5. All points above MHW

And here is where this technique differs – instead of making a DEM of elevations, I make a DEM of point density (Figure 6). I am trying to take advantage of the fact that the density (pts/sq m) of lidar returns from water are typically less dense than those from land, and that many have been removed when filtering points below MHW. I am somewhat correct (Figure 6), with the 'land' point density about 1pt/sq meter and the 'water' point density from 0 to 0.3 pts/sq meter. Now, here comes the tricky part, and where we lose touch with the strict MHW definition, I can contour this Density DEM using some value between 1 pt/sq m and 0.3 pt/sq m but have lost strict control of the elevation value. In a perfect world it would be a black and white divide between 'ground' point density (1 pt/sq m) and the water point density (0 pt/sq m). It aint, so I decided on a value of 0.5 pts/sq meter to define the boundary between water and land above MHW (Figure 7). Choosing a slightly different point density contour will shift the shoreline slightly landward (higher density) or seaward (lower density).

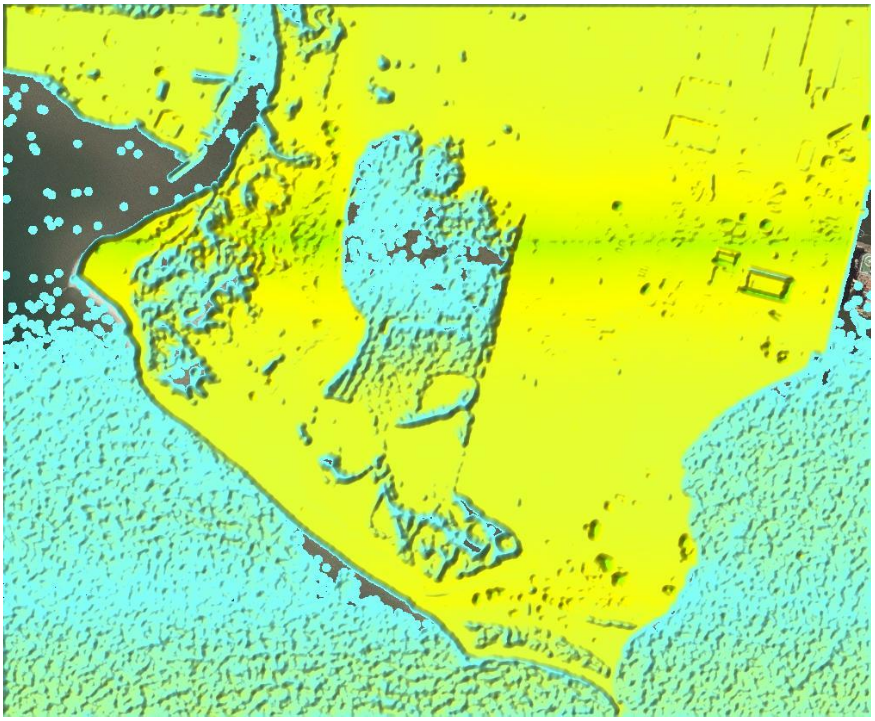

Figure 6. Point Density DEM

Figure 7. Density derived MHW shoreline

Anyway, the resulting contour/shoreline is, in my opinion, a big improvement on the elevation boundary and easier to edit (because it still needs some). Is it a MHW shoreline? Good question, I would suggest that it is as close as the strict elevation based MHW shoreline since all shorelines derived from lidar are interpolated to some degree anyway.

Tried and True vs. New and Weird

Comparing the two products (Figure 8) it is clear that neither is perfect, and again this is largely a function of the base product. The goal is to make the best out of what is provided in the most efficient way (so you can devote more time to manual editing maybe). One way that this technique could be used iteratively, since classifications were not used remove any points, is to now use the density derived MHW breaklines to reclassify water points (and this could be done by the lidar vendors to start with). This may help in some cases, others it won't. And you may wonder, well couldn't you just remove the previously 'classified' water points altogether – well, yes you could; but in this case there were water points on land and removing them would diminish the quality of the shoreline (See bottom part of Figure 5). And in general, trusting the classification of a lidar data set is not going to get you the best shoreline; that is not what the data were typically processed for.

So in the end I found that the density-derived contours were much easier, and cleaner, to work with as I began developing additional products from the lidar. I Hope this technique review helps and you are able to take advantage of lidar's wealth of information – even if that turns out to be a lack of information.

Figure 8. Comparison of elevation (Blue) and Density (Green) derived MHW shorelines