How good is LIDAR?

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LIDAR (**L**ight **D**etection **A**nd **R**anging; also called LiDAR or Lidar) is a surveying technique in which the distance to a target is measured by directing a pulse of laser light at it and measuring the time taken to bounce back. Airborne LIDAR, in which the laser is attached to an aeroplane, is currently the most detailed method available for creating digital elevation models. Ordnance Survey does not use LIDAR because the models lack the contextual information needed for mapping, but the Environment Agency has been using the technique for 17 years to assess coastal erosion and flood risk. In late 2015 it made all its data in England freely available to the public, followed in 2016 by Wales and a few small areas of Scotland. The accuracy statement on its website reads:

Our specifications require the absolute height error to be less than ±15cm. This is the root mean squared error or RMSE. It quantifies the error or difference between the Ground Truth Survey and the LIDAR data. With our more recent surveys we see this fall to about ±5cm.

We expect the relative height error (random error) to be no more than ±5cm.

This sounds fantastic, even after multiplying the figures by 3 to obtain a confidence interval comparable to the +/-3.3m accuracy of spot heights from photogrammetry. So, does that mean we can estimate the height and drop of a hill to decimal accuracy?

In favourable cases, but by no means always. The data is supplied as a grid of points spaced 1m or 2m apart (I have yet to find hill data at 50cm or 25cm resolution). This limits the accuracy of summit determination in rocky or uneven terrain. The RMSE values capture the instrumental error but not the uncertainty in estimating the height of the ground below wherever the laser pulse bounces back from, which on hills is often vegetation of some sort. Man-made features cannot always be identified in the data, so recourse is needed to maps and photographs and ideally a site visit.

Each LIDAR dataset is supplied in two forms, a digital terrain model (DTM) and a digital surface model (DSM). The DSM is created from the signal returned to the aircraft and includes heights of objects such as buildings, vehicles and vegetation. The DTM is a ‘bare earth’ model produced from the DSM by removing such objects. The DTM is created algorithmically, initially by classifying each data point according to the type of object or height of vegetation that has reflected the laser pulse. The process is fully automatic. For example, a classification as ‘ground’ will be based on various parameters that determine if a point can be described as ground e.g. angle to its neighbours. Manual editing is required to correct mistakes, e.g. a flat roof that has been mistaken for ground. Human intervention is an essential part of the process as the algorithms often get things wrong. I’ve seen rocks removed and large errors in the ground height below trees. On Moel Tryfan a 4m high pinnacle was flattened. Covered reservoirs and road surfaces are sometimes removed and sometimes not. The most spectacular error to date has been a ‘ghost peak’ on Y Gribin reported by Joe Nuttall: an 823.9m top with at least 15m drop at SH 65076 58628 that doesn’t exist. In this case the DTM has completely changed the shape of the ground. It would be unfair to blame the Environment Agency for such deficiencies, as they are presumably more concerned with correcting errors in flood plains than on mountains.

I am part way through evaluating the accuracy of LIDAR for determining summit and col heights, using the Environmental Agency datasets and the Survey Reports on the hill-bagging website. So far, I’ve come to the following conclusions.

- The rms error is 0.2m for summits after removing modelling errors, but the accuracy varies so much with terrain that a single figure is not very meaningful.
- The rms error of cols is 0.12m. There are fewer issues with unevenness of terrain than on summits, but care is needed in the vicinity of buildings and roads.
- LIDAR will not give accurate heights in trees.
- The DSM is the best model to use in rocky terrain, and in urban areas too as it is usually easy to identify buildings and walls. The DTM is preferable elsewhere, but the DSM should be inspected to check that the model is giving something sensible. In forests, the DSM will identify paths and firebreaks.
- LIDAR can save surveyors effort by scoping cols and large summit areas.

Links to the LIDAR datasets are given on the DoBIH website. If you do not have GIS software, you can import the data into Excel and use conditional formatting to visualise the topography. It is quite time consuming, so it would be good to see other Tump researchers take up the challenge!