A simple guide to processing LIDAR data in QGIS

Why write another guide? Aren't there enough out there already?
I've written this because all the guides that I've come across are based upon earlier versions of QGIS. Version 3 saw big changes in the software and while some things remained the same there are significant differences.

Background
There are two stages to producing a LIDAR map of your chosen location. The first is to download the data from the Environment Agency website. To view the LIDAR data (which at this stage is just numbers in a database) you will need to import it into mapping software. This guide shows you how to process LIDAR data using QGIS mapping software, available for free on the internet.

This guide is based on the Mac version of QGIS 3.10 *A Coruna*. Window versions are similar. There might be slight differences in the menus. QGIS is regularly updated and there might be new versions by the time you read this guide (produced in early 2023).

SECTION ONE - HOW TO DOWNLOAD LIDAR DATA

Environment Agency LIDAR can be downloaded for free here:
https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

Clicking on the above opens a map of the UK. Type in the place name you want in the 'Choose location or tile' box in the top left of the screen. This will zoom you into a map view.
To select an area, click on the funny square symbol (with small squares at each corner) in the right-hand menu that is titled 'Download your data'.
This allows you to draw a square around the area you want to download. Don't worry about being too precise because whatever you draw you will get all the data inside the full Ordnance Survey square (known as a tile). For example, the tile that covers the centre of Wheathampstead is TL11 SE.

Once you have made your selection the screen reformats itself and the area is shown in a yellow box. Click on *Available tile*s in the right menu box. You will get a list of all the LIDAR data that is held for this tile. In the case of the Wheathampstead example one of the available tiles are: LIDAR-DTM-50CM-2019-TL11se.

What does this mean?
Let's take a short pause while we learn about the different types of LIDAR data.
You are likely to find a combination of three available file types and three different resolutions:

DTM (Digital Terrain Map) and **DEM** (Digital Elevation Map) are confusingly the same thing – vegetation and trees are stripped out and the surface is revealed underneath – this is the most useful version for archaeologists
DSM (Digital Surface Map) – the survey stops at the top of tree and vegetation. This is not so useful even although LIDAR surveys are usually done in the winter.
Composite combining DTM and DSM.
Resolution: LIDAR data comes in different image resolutions. The highest resolution is 50cm and this is the best for archaeological interpretation. The other common survey resolutions are one metre and two metres.

The menu allows you to browse through *Product* (i.e. DTM or DSM), *Year* (when the survey took place) and *Resolution* (50cm, one or two metres). Incidentally, there might be limited or no coverage in some places. Note that only a limited number of areas have been surveyed at 50cm.

If you have been using my example you should have LIDAR-DTM-50CM-2019-TL11se in the 'Available tiles'. If you haven't got this file on your screen this is probably because the data has been updated. To use my example click on the 'resolution' menu and choose '50cm'. Choose 2019 in the *Year* menu and the file should appear. This is a 50cm Digital Terrain Mode survey done in 2019 and this is the best quality resolution.

Click on the file name and your chosen LIDAR file should appear in the download in the top right of the screen.

Congratulations! You've now got your data but you can't read it until you put it into QGIS mapping software. The next step is to download QGIS.

SECTION TWO – DOWNLOAD QGIS MAPPING SOFTWARE

LIDAR data is a database of digital height information. In order to view LIDAR it needs to be imported into geographical information service software for producing maps. QGIS is a free GIS software that is widely used by academic and students. It can be downloaded here:
https://www.qgis.org/en/site/forusers/download.html
Follow the instructions and download the app.

SECTION THREE – PROCESSING THE LIDAR DATA WITH QGIS

Opening a new project in QGIS
Open QGIS.
In the *Project* menu at the top click on *New*.
Scroll down to the *Coordinate Reference System* icon on the bottom right of the screen (next to the three dots). This will take you into the 'Project Properties/ CRS' menu. Select *OSGB*

1936/ British National Grid EPSG:27700. Click *Apply* and *OK*. This ensures that whatever you drop into your map will conform to the same mapping protocol.

Unzipping the data
Now go back to the LIDAR data that you downloaded from the Environment Agency website. This data will have been downloaded as a ZIP folder. This is a compressed file format. Click on the folder. This will create a second uncompressed folder with the same title but without the 'zip' suffix.

The next bit is really important for your sanity. Create a new folder with the project title you intend using. In my case this would be 'Wheathampstead 50cm 2019'. Place the unzipped folder with your LIDAR files into this folder.

Why is this so important?
The reason is that when you save a QGIS project **you are not saving the data files that created it**.
For a saved project to re-open it needs to find a path to the data files that created it. If you move the data folder or rename it this will not happen and you will have effectively lost your project.
So, to avoid disaster I always create a project folder and place the unzipped LIDAR data folder into it before I open a new QGIS project. I'm getting ahead of myself but after I've created the new project file I save it into the same folder as the LIDAR data folder to ensure they can always find each other.

Importing the data file
You are now ready to drop the unzipped LIDAR data files into your *new project*. Simply pull the data files from the folder and dump them in the white centre of the QGIS screen. They should automatically transfer themselves into the *Layer panel* on the left (and if the *Layer* panel isn't visible go into the *View* menu and scroll down to *Panels*).

Once the data files are in the *Layers panel* you should see a hazy and unfocused image appear on the main screen. In the case of my Wheathampstead example it probably looks disconcertingly like coiled-up intestines. What you are looking at is unprocessed LIDAR data of a river valley. To make sense of it you need to apply *Hillshade*.

Applying hillshade
Hillshade is what turns the coiled-up intestines of raw LIDAR into something useful.

To apply *hillshade*, select a layer and do a right-click.
This opens a drop-down menu.
Click on *Properties* at the bottom and open the *Symbology* menu.
Change *Render type* to *Hillshade.*
Chose a suitable lighting azimuth (i.e. the direction the light is coming from). This is the most powerful tool in *Hillshade* because with the wrong light direction a feature might not appear at all. So, a bit of experimentation with the azimuth setting may be necessary.
It is also possible to set *multi-directional hillshade* but I'm not going to deal with this here.

Select a Z factor of 6 to increases the contrast. (It doesn't matter if this is too high or low because you can change all your selections in *Hillshade* after the event).
Ignore the *Colour Rendering* options.

Click on *Apply* and then *OK*. Admire the *hillshade*.

Merging layers. Is it a good idea?
The bad news is that my example has eight layers and you will need to apply hillshade to each one. Can you merge layers together and just apply *hillshade* to the top merged layer? Indeed, you can.

Don't do it!
There is a good reason to avoid merged layers. Merged layers are temporary scratch files and they cannot be saved when you close your project. When you reopen your project the original layers will still be there but your merged layer (and your *hillshade*) will have vanished.

Excellent! So why did you bother telling me about a merged layer? The answer is that working with merged multiple tiles could be a useful way of experimenting with *hillshade* and other settings. After finding the best setting you can apply it to each individual tile and delete the *merge* file. This way the project will reopen with your data intact.

I'm kind of convinced so how do I do a merged layer?
Click on the *Raster* menu. Go to *miscellaneous* and click on *merge*.
This opens the *Merge* box. Click on the three dots at the end of *Input layers*.
This will open the *Multiple selection* menu and a list of the layers. Tick the layers you want to merge and press *OK*. The box will disappear and be replaced by the *Merge* menu that will display the number of layers selected in the *Input layers* box.
BEWARE! On my Mac screen the *merge* menu opens at the back of the main QGIS screen where I can't see it! So, if it doesn't appear start looking for it on your desktop.
Once you've located the menu click *run* and a *merge* layer will appear on the *Layers* panel.

Missing bits on the map
At this stage in the demo you should be looking at a beautiful hill-shaded map. But what about the bit of the map that are missing? Did something go wrong? The sad fact is that there are gaps in the Environment Agency LIDAR surveys. This is particularly the case in the 50cm surveys my example is based upon. You might have better luck choosing either a one or two metre survey.

Adding a 'proper' map to help you navigate
The easiest map to add is *OpenStreetMap* in the *browser* panel (in the *View* menu next to Layers). It's probably best to avoid *Google Maps* because it is difficult/ impossible to remove labels advertising local businesses etc. But this might not matter if you are using the extra mapping for navigation purposes rather than incorporating it as part of your map.

Incidentally, you can also add maps and resources off the internet including those provided by the Dept. of the Environment, Ordnance Survey (and this includes topographical maps featuring contour layers) and also georeferenced maps off the National Library of Scotland collection that covers all of the UK. (Also see 'Loading NLS maps' in the 'Other useful stuff' section).

Applying contours
The LIDAR data can be used to create contours that can be very useful when trying to make sense of a landscape. This is how to do it:

Go to the *Raster* menu and scroll down to *Extract*. This opens the *Contour* menu. I change the *Interval between contour lines* to 6.000000. Press *Run* and the contours will appear. The colour of the contour lines will be selected at random so you will probably want to change them.

The colour and size of the line can be changed by right clicking on the *Contour* layer and selecting *Properties* and then *Symbology*. Personally, I select *red line* in the symbol menu box underneath *Favorites*. I also change the *Width* option to 0.46000.
Press *Apply*.

You can also add contours using a downloaded Ordnance Survey topography map. The important difference is that OS contours derive from a traditional OS survey whereas the contours within QGIS derive from your LIDAR height data. One advantage of the OS topographical map is that it can be saved in the project file and easily switched on and off.

Exporting maps
When you've finished your project, how do you print it or send a copy to colleagues?
The easiest way is via *export* to create a jpeg or tif.

This is how you do it:
In the '*Project*' menu select '*layout*' and '*export as image*' and select the preferred file format. TIF is best because it's lossless and can be turned into Photoshop files but a JPEG is a good compromise that will open on any computer.. I also select '*Resolution*' and pick either 600 or 1200 tpi to produce a large file. I'm not sure if there is a better way of doing this but it seems to work for me.
I open TIF files in Adobe Photoshop and do any corrections such as contrast or clarity to make the LIDAR image easier to study.
I usually save and distribute the finished result as a JPEG.

What about sending a colleague my original project file so they can work on it?
You will need to send them the project file folder that contains **both** the saved project file and the data files that created them. Otherwise, the file will not open.

Problems with saving projects
It is worth repeating the point that I made earlier that a project will not reopen if it cannot find the files that created it. So always create a new project folder before you start work and place the data file folder into it. Save the new project into the same folder so that it's sitting next to the data file folder that created it and you should have no problems.

Don't forget that temporary scratch files will not save (although I suspect there may be ways of doing this that I have not found). Temporary scratch files include such things as merged layers and contours. If you attempt to save a project with temporary scratch files you will get this message (or similar):

"This project includes one or more temporary layers. These layers are not permanently saved and their contents will be lost. Are you sure you want to proceed?"

Whenever I see this message it reminds me that it would have been a good idea to delete the temporary layers before I started to save the project. Because I'm lazy I usually say 'yes' and close the project down.

The only problem with this pragmatic approach is that when you try and **reopen** the project file this will trigger the *Handle unavailable layer* menu. This is because the temporary files are still there (even though they cannot be opened). Highlight *Remove unavailable layer.* This will produce yet another menu like this:

"There are still unhandled layer(s). If they are not fixed, they will be disabled/deactivated until the project is opened again."

Press *OK* and the project file should open. Remind yourself that you could have avoided all this palaver by deleting any temporary layers which you were going to lose anyway.

Help! White screen problems when reopening a project.
If your project reopens with the layers intact but a white screen where your map should be, go to *Zoom full* in the *View* menu.

Other useful stuff

Simple relief map
This option flattens large relief features like hills in favour of emphasising lump and bumps. Highlight the layer you want to turn into an SRM and select *Raster* menu. Choose the *Relief Visualisation Toolbox*. (Note - If you cannot find this option, go to the *Plug-in* menu and select *Manage and instal plug-ins*. Search through the list in the menu and instal *Relief Visualisation Toolkit*.)

Clicking on the *Relief Visualisation Toolkit* will open a menu with a number of options. Select the file you want to turn into a SRM. Click on the *Simple Local Relief Model* and press *Start*. After the SRM is created apply *hillshade*. Try *multidirectional hillshade*.

Loading NLS maps
You can download geo-referenced Ordnance Survey maps from the national Livbrary of Scotland collection. Go to the NLS site and find the location of the map you need on the georeferenced map section.
Click on *Overlay* on the bottom menu. This opens a location menu. Select the county you want to add to your QGIS project. A new menu will open. Select *Desktop* and then *XYZ* in the menu above. This open a https link which you need to copy. Below is the https address link for the 19th century Hertfordshire 25" Ordnance Survey map.

https://mapseries-tilesets.s3.amazonaws.com/25_inch/hertfordshire/{z}/{x}/{y}.png

Open your QGIS project and select the *browser* menu (left hand side at the bottom). Right click on *ZYZ tiles* and select *XYZ connection*. Type in a name for the tile. I named it *25 inch OS*. Paste the https address link and press *OK*. This should load the tile into you *XYZ tile menu* in *browser* with the name you selected. Click on it and it will appear in the *Layers* menu.

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