Creating Base-Map Templates in OOM from LiDAR and other Sources

A Guide for Orienteering Mappers

Martin Hore, Suffolk Orienteering Club

Version 5, August 2024

Contents

Introduction

Welcome to version 5 of this guide to creating base map templates in Open Orienteering Mapper (OOM) Since I published Version 4 in 2022, OOM itself has not seen a further update, and I'm aware this has concerned some users. Personally, I'm still finding OOM very satisfactory as a tool for drawing orienteering maps, and it remains an economic alternative to subscription OCAD, especially for amateur mappers like myself. I hope that an updated edition of this guide will prove useful.

The guide describes the methods I'm currently using to create templates from UK Ordnance Survey mapping, aerial photographs and LiDAR data, which I then open in OOM. These are my first tasks when drawing a new or substantially updated orienteering map. I can then draw up an accurate and reasonably detailed base-map which saves a lot of surveying time in the field.

I've written this guide partly to serve as a reminder to myself. I only use these procedures when starting a new mapping project, and I don't always remember exactly what I've done from one map to the next! But I hope the guide will be helpful to others too, including orienteers new to mapping.

Mappers using OCAD software in its current subscription version can make use of OCAD's in-built tools for processing data from the above sources. OOM doesn't currently have an in-built facility to process this data. The procedures described here produce similar results to those obtained using the current OCAD. They work well with OOM, and should also be adaptable to use with earlier OCAD versions.

The main focus of this guide, in Chapters 1 – 11, is on producing accurately georeferenced templates from UK Ordnance Survey mapping, aerial photography from Google and other sources, and UK Environment Agency LiDAR data. I explain how LiDAR data can be analysed to produce a detailed picture of the relief of the terrain, including contour lines, as well as a useful indication of vegetation cover, including undergrowth. Chapter 1 contains some introductory remarks on the UK National Grid.

In Chapters 12 - 17, I've included supplementary notes on updating old orienteering maps, drawing up your base map prior to surveying in the field, using GPS tracks, and other associated topics, including a more detailed look at some issues relating to aerial photography. Readers are, of course, welcome to dip into the sections which interest them, although I have written the later chapters assuming that readers have already read the earlier ones.

Now I'm familiar with these procedures, it takes me between one and two hours, depending on the size of my map footprint, to source, process, and load into OOM, the templates I need for a new map. It will take a lot longer the first time of course. This is significantly longer than using the latest OCAD, but not, I think, excessively time-consuming compared to the overall time it takes to produce a new map.

Processing LiDAR data outside of OCAD requires the use of GIS (Geographical Information System) software. Several open-source GIS options are available free of charge. QGIS is perhaps the best known. Largely because it's where I started, I continue to use SAGA-GIS for processing most LiDAR data. I think SAGA-GIS is at least as well suited for this task. It offers great scope for controlling the way templates are displayed in OOM. However, I'm now using QGIS for several tasks for which SAGA-GIS does not appear to have the capacity. Other mappers use QGIS for processing LiDAR data as well, but I've kept with SAGA-GIS at present. I've used the procedures I describe here for processing LiDAR in SAGA-GIS for nearly twenty maps to date, with good results, and I feel confident to recommend them.

I've assumed readers have at least a basic familiarity with OOM, but I've given details of any procedures in OOM which relate specifically to these guidance notes. I've explained in detail what you need to know to use QGIS and SAGA-GIS to access OS mapping and aerial photography, and process LiDAR data.

I've illustrated the guide with examples from several orienteering venues in Suffolk, ranging from local country parks to large Forestry Commission plantations. You can follow the procedures described here on your own computer, either using the data relating to these venues, or, probably better, choosing a venue in your own area, ideally one you are about to update, or intend to map from scratch.

My first version of these notes was published in 2020, but I remain very much on a learning curve with this, and I find I'm picking up new tricks all the time. Since publishing Version 4 in September 2022, I've adopted QGIS for processing aerial photography and GPS tracks, as well as UK Ordnance Survey mapping. This has allowed me to improve how I handle source material which is based on different coordinate reference systems to UK Ordnance Survey and LiDAR data. I'm also now using QGIS to generate undergrowth templates from LiDAR point clouds. I've altered the sequencing of several chapters to align with the revised workflow I've now adopted.

The changes described in this version have allowed me to dispense with two software applications I used previously, namely MagicMap and LAStools. I'm also now only rarely making use of SASPlanet.

I've been using some of the procedures described for five or more years; others for just a few maps so far. If you encounter any problems, spot errors, or recognise anything that can be achieved more simply, please let me know (email address below) so that I can update the guide - and borrow your ideas!

I must acknowledge the help I've received in developing this guide from members of British Orienteering's Map Advisory Group, from fellow contributors to British Orienteering's mapping webinars in Spring 2021, from the authors of other guidance notes on the Mapping Resources page on the British Orienteering website, and from fellow club mappers in SUFFOC, NOR and WAOC. Many thanks to all.

A note on hardware and software.

I currently use a desktop PC with 8GB of RAM and an Intel Core i5 processor running Windows 10. Some of the processing tasks described involve quite large files – several hundred Megabytes is not unusual, and are fairly memory-intensive. I successfully managed the basic LiDAR processing using my old laptop with 4GB of RAM and an Intel Core i3 Processor. However, the laptop struggled with handling raw LiDAR point cloud data and high-resolution aerial photography.

All the software applications I use are free to download as are the sources of LiDAR, aerial photography. and, subject to a monthly limit, OS mapping. For ease of working, I've set up shortcuts on my desktop to each of these applications and websites. All the web links are below. Please note that I cannot guarantee that the processes described here will work with future updates of these applications, or that the links below will continue to function.

Open Orienteering Mapper (OOM): https://www.openorienteering.org/apps/mapper/. These guidance notes have been checked for compatibility with Version 0.9.5. (Issued 2021, but still current).

QGIS: https://www.qgis.org/en/site/forusers/download.html I'm using version 3.38.1 "Grenoble".

SAGA-GIS: https://sourceforge.net/projects/saga-gis/files/ I'm using Version 9.5.1, issued July 2024.

UK Environment Agency (DEFRA) LiDAR download site:
https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

Ordnance Survey Data Hub: https://osdatahub.os.uk/ See Chapter 2 for further information.

I've found my antivirus software reports some of the above sites as unknown or unsafe. But they are all established industry-standard software. I bypassed the warnings without adverse consequences.

A note for non-UK (or non-English) readers.

UK orienteering maps are generally drawn aligned to the OSGB36 coordinate reference system. The corresponding EPSG code is 27700. See Chapter 1 for a detailed explanation of this. All the UK LiDAR and Ordnance Survey data I use is aligned to this CRS. The methods described here will need to be adapted if either your final map, or your data sources, are based on other coordinate reference systems.

Many environmental matters in the UK are devolved government responsibilities. The Environment Agency (DEFRA) LiDAR sources I use are not necessarily available or matched outside of England.

Martin Hore, Suffolk Orienteering Club. August 2024. **martin.hore@virginmedia.com**

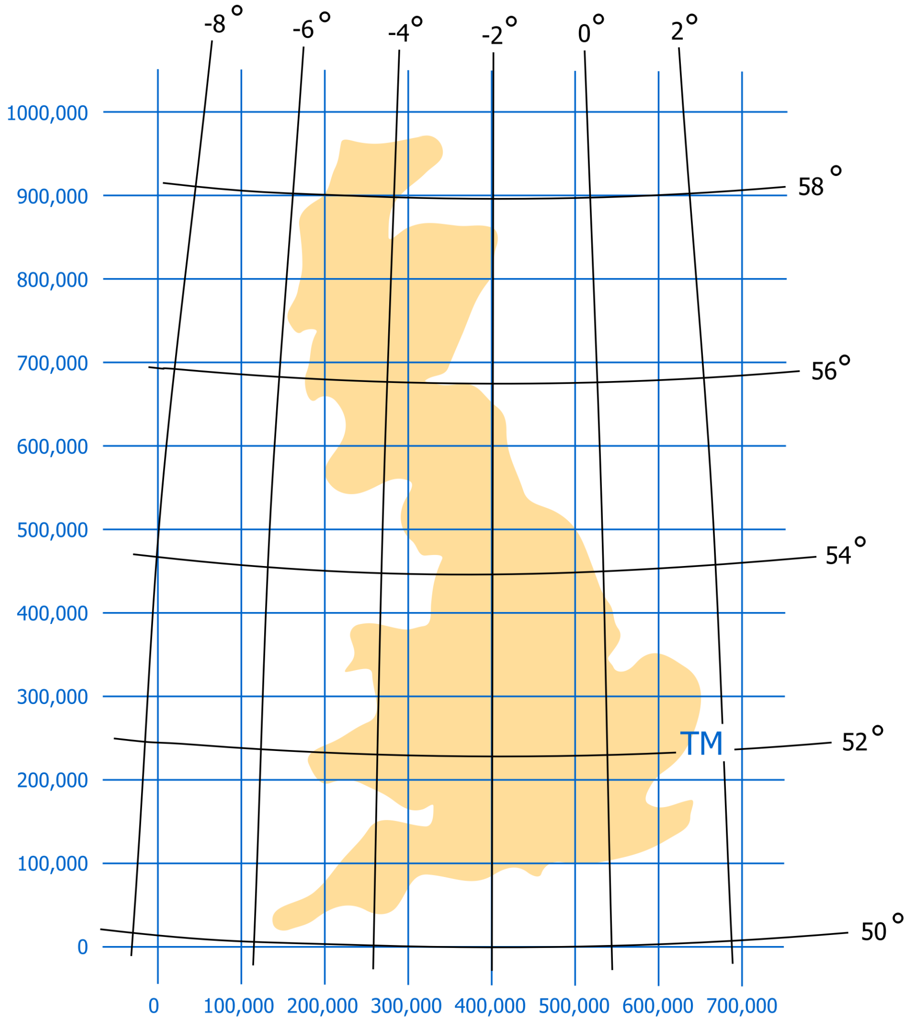
Chapter 1: The UK National Grid and the Meaning of "North"

Please feel free to skip this chapter if you are familiar with this topic. But I think it's useful to bring this information together at the start to introduce terms I'll be using throughout the guide. Map projections are a rather complicated topic that I don't claim to understand fully. I've attempted to simplify here the main points which we, as orienteering mappers, need to know about. The underlying challenge is how to project the curved surface of the earth onto a flat map or plane. Historically, this has been tackled in different ways, resulting in a variety of different coordinate reference systems ("CRS" for short).

The British were first to tackle this problem with regard to detailed topographical mapping. This means, unfortunately, that we are left in Britain using a system which is an outlier compared to the standards more recently adopted in the rest of the world. UK Ordnance Survey mapping is based on the UK National Grid (OSGB36), as is the LiDAR data from the UK Environment Agency. Most UK orienteering maps are aligned to this CRS, including those I've used as examples in this guide. Each CRS has an associated EPSG code by which it is commonly referred. The EPSG code for OSGB36 is 27700.

Unfortunately, this isn't the only CRS we need to be concerned with. The best available sources for aerial photography are based on the "Web Mercator" CRS which was designed for use with web-based applications such as Google Earth. Web Mercator is based closely on the 1984 World Geodetic System (WGS84) which defines a longitude and latitude for each point on the earth's surface. Importantly for us, Web Mercator or WGS84 is also the basis for Open Street Map, GPS systems, and the MapRun application, so we can't avoid it! The EPSG codes for Web Mercator are 3785 and 3857 and for WGS84, 4326, which, for our purposes, appear effectively interchangeable. I describe these in more detail later, in the relevant chapters. The remainder of this chapter refers to the OS National Grid (EPSG 27700).

The diagram below is probably familiar. It shows the relationship between the Ordnance Survey National Grid and geographic, or latitude and longitude, coordinates.



Latitude and longitude are measured in degrees, with longitudes west of the Greenwich Meridian displayed as negative on the diagram. OS grid coordinates are best measured for our purposes in metres, from 0 – 700,000 for the “x” coordinate (or “eastings”), and 0 – 1,000,000 for the “y” coordinate (or “northings”). The northings actually extend to 1,300,000 metres if you don’t ignore Shetland!

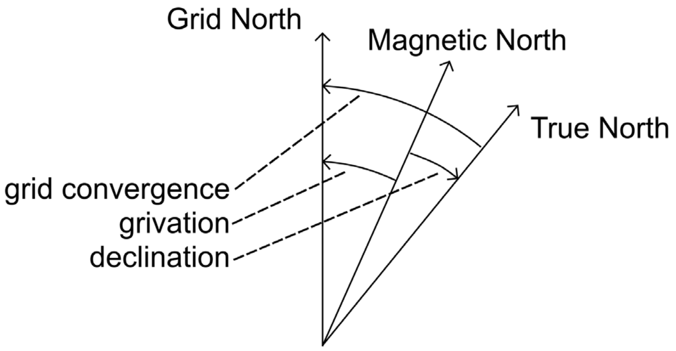
Each 100 km (100,000 metre) square on the OS Grid is given a 2-letter code. I’ve just shown one of these (“TM”). This is the grid square in which most of the orienteering maps I’ve use as examples in this guide are located. I’ll refer to this again in Chapter 6 when describing how to download LiDAR data.

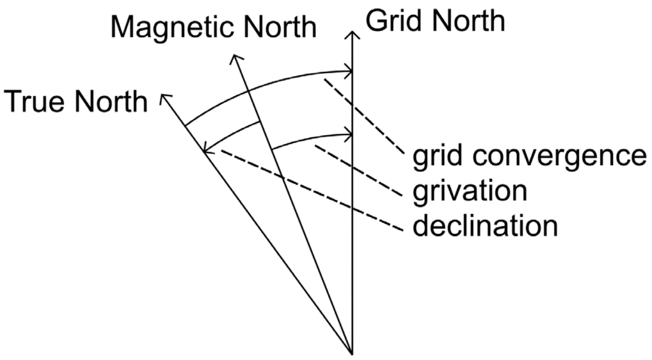
Different “Norths”

The three “Norths” we need to be concerned about are Grid North, True North and Magnetic North. Grid North is represented by the vertical blue OS grid lines in the diagram above; True North (geographic north) by the black lines of longitude or “meridians”.

The vertical OS grid line equating to x = 400,000 metres exactly follows the -2 º longitude meridian throughout its length, roughly from Poole to Aberdeen. East of that line, where x > 400,000, the Grid North lines are angled east of the lines of longitude that is east of “True North”. The converse is true for locations west this line, where x < 400,000. The exact angle between True North and Grid North varies as you move across the country, but is constant at any given location. This angle, the angle by which Grid North *diverges* from True North, is known, perversely, as “Grid Convergence”.

Unlike Grid North and True North, Magnetic North varies with time. Magnetic North in our lifetimes in the UK is moving east. It is currently between Grid North and True North over much of Britain. The two diagrams below show the current relationship between the three Norths in Cornwall (on the left) and Suffolk (on the right). The actual angles are exaggerated.





In more central parts of Britain, both True North and Magnetic North currently differ less from Grid North than in Suffolk and Cornwall, and their relative differences from Grid North may be reversed, with Magnetic North being further from Grid North, rather than True North being further from Grid North as in the above examples. If you work in an area where this is the case, you might find it helpful to draw your own version of the diagram, using the current figures for your location (see Chapter 3).

In OOM, the key angles involving Magnetic North are labelled “Declination” and “Grivation”. Declination is the angle between Magnetic North and True North. Grivation is the angle between Magnetic North and Grid North. Grivation is what is normally referred to as “magnetic variation” in the UK, but with the appropriate sign (“+” or “-“) affixed. Declination and Grivation are measured in the direction shown by the arrows in the diagrams above, with clockwise directions being negative and counter-clockwise positive. So, currently, in Cornwall (left diagram), Magnetic North is east of Grid North and Grivation is positive. In Suffolk, Magnetic North is west of Grid North and Grivation is negative.

If the correct signs are applied, the following mathematical relationships hold, throughout Britain:

Grivation = Declination + Grid Convergence **Declination = Grivation – Grid Convergence**

Note that if Magnetic North and True North are exactly aligned, which is currently true at some UK locations, Declination is zero and Grivation and Grid Convergence will have the same value. I describe in Chapter 3 how to determine the correct current values for these three angles at your location.

Chapter 2: Obtaining georeferenced UK Ordnance Survey mapping

I now commence a new mapping project by using QGIS to obtain a high-quality, large scale Ordnance Survey base map of the footprint for my new map. At the same time, also using QGIS, I can obtain a georeferenced aerial photograph. See Chapter 4 for how to do this. Starting this way, I can determine the bounding Ordnance Survey coordinates of my footprint at the same time as creating these key templates. I need these coordinates before I do any work in OOM. If you choose, you can also prepare a template from Open Street Map (OSM) as part of this process.

If you already know the bounding coordinates of your footprint, you may wish to move straight to Chapter 3 and set up your georeferenced map in OOM as your first task.

High quality, accurately georeferenced Ordnance Survey mapping is now available directly from the Ordnance Survey as single raster tiles large enough to cover any likely O-map footprint. These can be obtained from the OS Data Hub via the OS Application Programming Interface (API). There is a charge for this service, but the OS currently offers £1,000 worth of premium quality data per month via this service free of charge. This is more than most amateur club mappers could possibly use in one month. I'm grateful to Bruce Bryant of Octavian Droobers for alerting me to this.

Although I normally start by obtaining my Ordnance Survey base map, it's possible to start with a Google Earth aerial photo or a base map from Open Street Map and use one of these to determine your bounding coordinates. This could be useful if, as may occasionally be the case, the bounding coordinates are easier to determine on either the photo or the OSM image. But I would still first load the Ordnance Survey map into QGIS. Your QGIS project is then set, right at the start, to the Ordnance Survey coordinate reference system. QGIS will then transform the CRS of your Google Earth photo or OSM image to match the OS Grid automatically.

Setting up an account with the OS Datahub

I describe here how to establish an account with the OS Data Hub, and obtain an access key to the OS Maps API. This takes a while, but only needs to be done once. It's then set up for all your future mapping. (If you get stuck, there is more information at OS OpenData FAQ's | Account & API Access | OS Data Hub)

Open the OS Data Hub here and click on "Sign up for free" on the welcome screen. The next screen should display 3 "plans". The "Premium Plan" is the one we need. Click "Start for Free". You then need to enter an email address, click to receive a "verification code", enter the code when asked, and proceed by clicking "Next" – mostly familiar stuff, I expect.

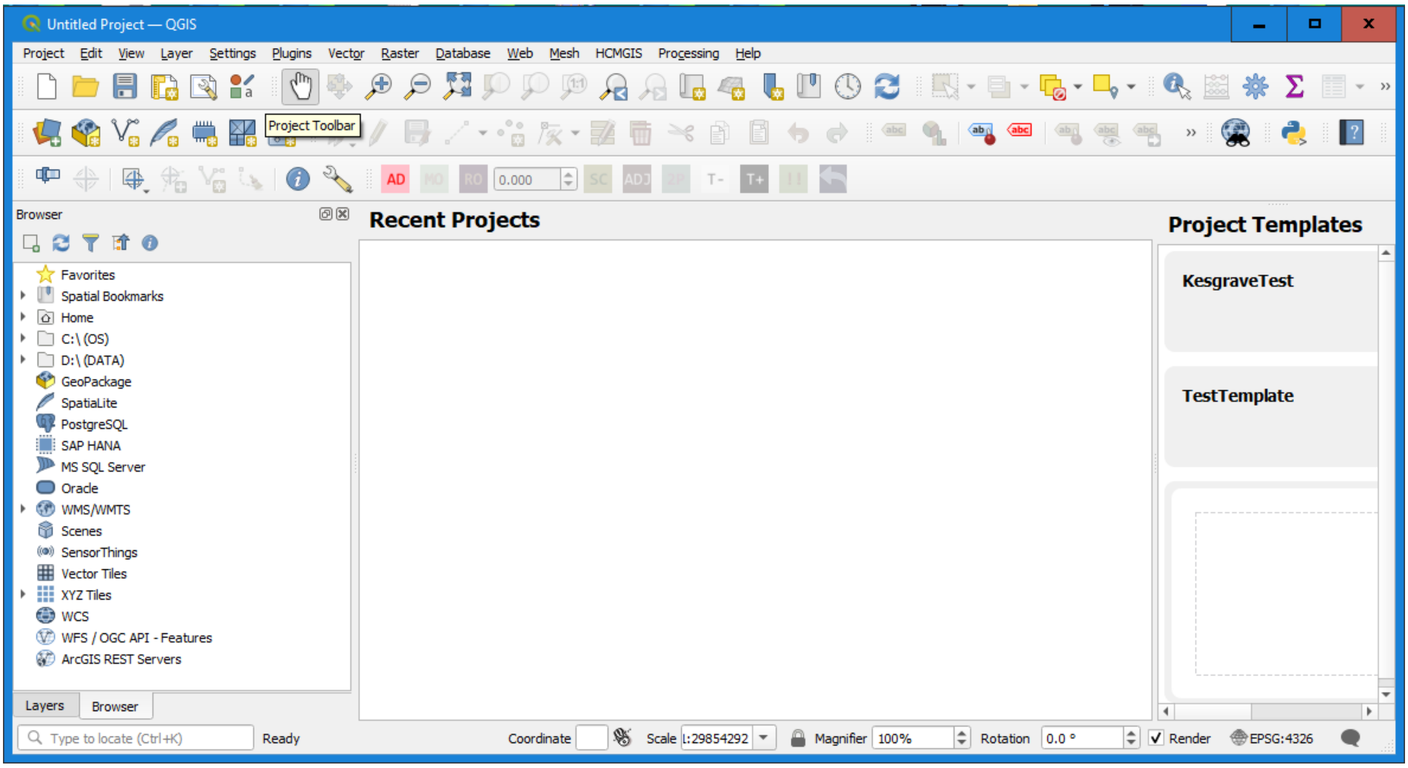
The next screen asks for personal details, password, marketing preferences, and acceptance of terms and conditions. There is, via a link from the terms and conditions page, some information on copyright which suggests that users are permitted to download single copies of web-pages from the site for their own use without copyright restrictions – though you should, of course, include the standard OS acknowledgement and licence number on your final map. You are then asked for some organisation details – I entered Suffolk Orienteering Club, and then for payment details which are only necessary to receive uninterrupted access. I skipped this by clicking "I'll enter payment details later" and therefore expect to be cut off if I exceed the monthly £1,000 limit, but I can start again from zero next month.

At the next screen (my "dashboard") I "create a new project". There may be more terms and conditions to accept. You can then enter a project name – perhaps related to your club. It should then be possible to use this project name for all subsequent access to the site – you don't need a separate project for each of your maps. Then you must add an API to the project. Select "OS Maps API" from the next list (it may be the last on the list) and you will finally obtain what you need – a "Project API Key", together with a "Secret" and two "Endpoint Addresses". I used the "WMTS API Endpoint address" which works best with QGIS. This Endpoint Address should be all you will need. It includes the "Key".

Having done all that once, you can then access the OS Maps API any number of times, provided your £1,000 monthly limit is not breached. You can check how much of that limit you have used at any time by signing in to the Data Hub and navigating to your API Dashboard. Other than that, there is no further need to enter the OS site. You are set up for all future maps.

Establishing a connection from QGIS to the OS Maps API

If you've not already done so, you need to download QGIS here. I'm currently using version 3.38.1 "Grenoble". QGIS should install a folder of shortcuts on your desktop. Open the "QGIS Desktop" shortcut. QGIS will open at the home page which should display similarly to the screenshot below:



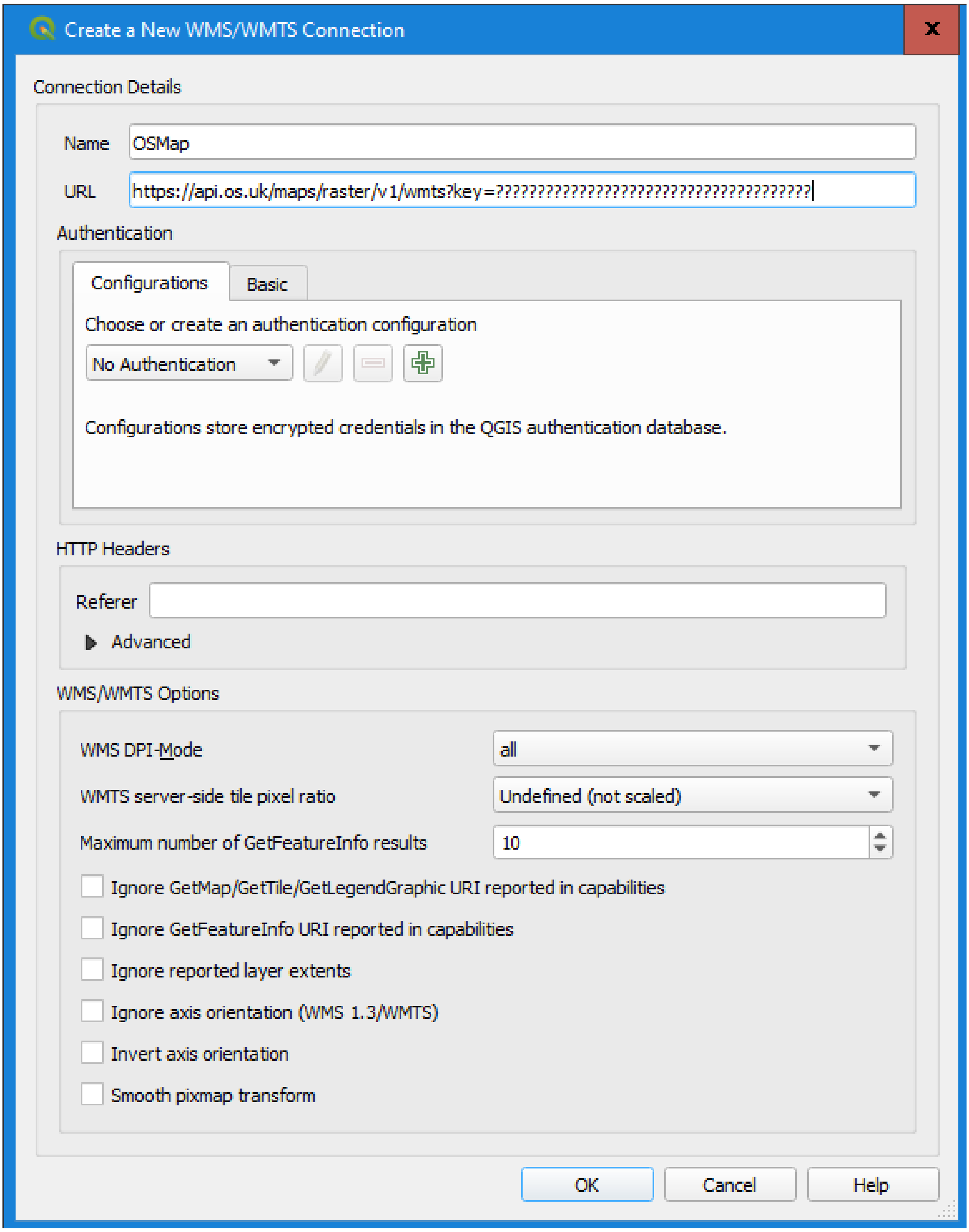
You will need access to the "Browser" and "Layers" panels. In the layout above, they are toggled at the lower left corner. If they are not displayed, select "View"/ "Panels" and tick these items. At the lower right corner, you will see that on opening QGIS the coordinate reference system (CRS) is set to EPSG 4326. This can be changed by selecting "File"/"Properties" but there is no need to do this. Opening the OS Maps API connection as your first layer, as described below, will automatically set this to EPSG 27700.

Next, right click WMS/WMTS in the Browser panel and select "New Connection". The dialogue overleaf should display: (If, when first opening QGIS, you don't see WMS/WTMS in the Browser Panel you can reach the same dialogue by selecting "Layer"/"Add Layer"/"Add WMS/WTMS Layer" from the menu bar and then selecting "New" in the next dialogue.)

The "Name" and "URL" lines will be blank. I've entered a name - "OSMap" - and the "URL" which is the full WMTS API Endpoint address I obtained from the OS Data Hub. Your Endpoint address will be unique to you of course. I've not revealed my full Endpoint Address in the screenshot. I've left everything else as default.

Click "OK" and your name ("OSMap" in my case) should appear in the Browser panel under "WMS/WMTS". If it doesn't, just click the arrow next to "WMS/WMTS" to see this. Once you have made the connection, your map name will appear here every time you re-open QGIS. Then right click your name ("OSMap" in my case) and a list of options will appear as per the lower screenshot overleaf.

These are all formats available from the OS Data Hub. You'll need to choose one of the "27700" options. They are fairly similar, but I find "Road_27700" gives the best results. Double click this and a map of Britain will appear in the map screen. You can zoom and pan the map as normal. At the lower right corner, you will see that the coordinate reference system (CRS) is now set to EPSG 27700. And in the Layers panel a single layer "Road 27700" should be listed.



Name: OSMap

URL: https://api.os.uk/maps/raster/v1/wmts?key=??????????????????????????????????????

No Authentication

Configurations store encrypted credentials in the QGIS authentication database.

Referer:

WMS DPI-Mode: all

WMTS server-side tile pixel ratio: Undefined (not scaled)

Maximum number of GetFeatureInfo results: 10

☐ Ignore GetMap/GetTile/GetLegendGraphic URI reported in capabilities

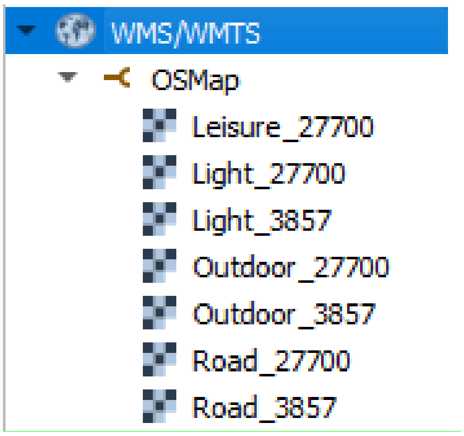
☐ Ignore GetFeatureInfo URI reported in capabilities

☐ Ignore reported layer extents

☐ Ignore axis orientation (WMS 1.3/WMTS)

☐ Invert axis orientation

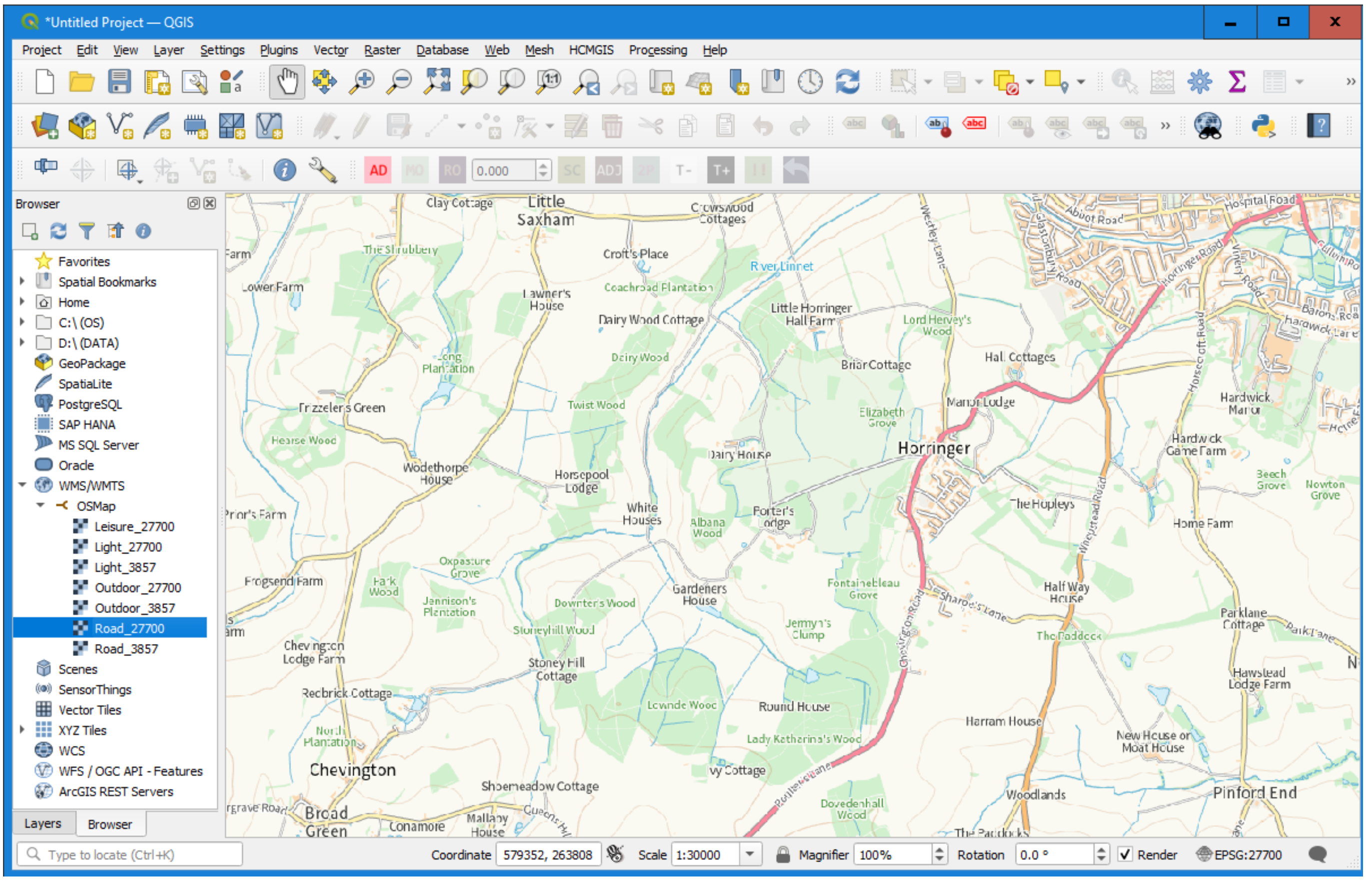
☐ Smooth pixmap transform



- WMS/WMTS
  - OSMap
    - Leisure_27700
    - Light_27700
    - Light_3857
    - Outdoor_27700
    - Outdoor_3857
    - Road_27700
    - Road_3857

Establishing your bounding coordinates.

The screenshot below shows the map zoomed in so that my final O-map footprint sits within the screen borders. I've chosen Ickworth Park, near Bury St Edmunds, for this example. This is a large (3.1km x 3.7km) footprint which just fits on A3 at 1:10,000. Our previous O-map of Ickworth Park was drawn with some help from LiDAR, but relied for OS mapping on 1:25,000 maps. Being a mixture of woodland, park and some built environment, it illustrates well the power of this method to produce a much more detailed and useful large scale OS map template. Don't worry that the map is not displayed at maximum resolution at this point. The final template image will be at the maximum scale available from the OS. You can view this by zooming in to maximum extent, then zooming out again to reposition your footprint within the screen borders.



Coordinate 579352, 263808 Scale 1:30000 Magnifier 100% Rotation 0.0 ° ☑ Render EPSG:27700

The QGIS map screen displays the coordinates of the cursor in the bottom margin. Provided the CRS is set to EPSG 27700, these will be OS metre coordinates. So, at this point, you can ascertain the west, east, south and north extents of your footprint. As mentioned earlier, although I normally do this using the OS map, if the boundary of your footprint is clearer on an aerial photo, you can import your aerial photo into QGIS as a second layer at this stage, following the procedure described in Chapter 4.

I round off the bounding coordinates to the nearest 100m outside the footprint, prefering even hundreds so that my map centre is also a rounded figure. For Ickworth Park these coordinates are:

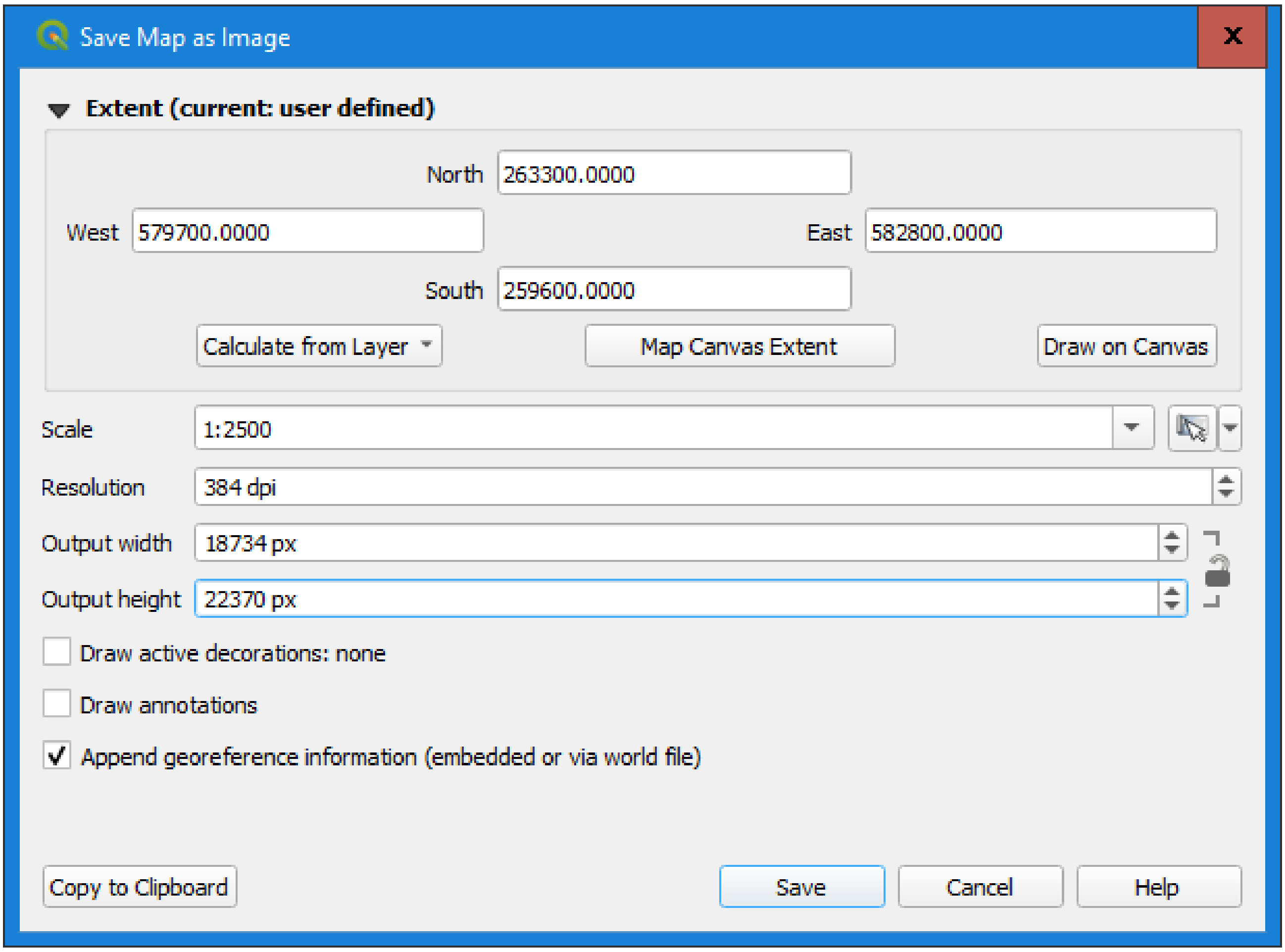
West	579600
East	582800
South	259600
North	263400

Therefore the map centre in this case is at 581200 East, 261500 North.

Exporting your OS map template

You can now specify this footprint to export and use as a template in OOM, and set the scale and resolution of the template image.

If you have already imported other layers into QGIS, such as an aerial photo or Open Street Map extract, then you must first check that just the OS map layer is ticked in the QGIS Layers Panel (toggle to view this if necessary). Then open the “Save Map as Image” dialogue below by clicking the “Project” menu tab and selecting “Import/Export” and “Export Map to Image”:



Extent (current: user defined)

North 263300.0000
West 579700.0000
East 582800.0000
South 259600.0000

Scale 1:2500
Resolution 384 dpi
Output width 18734 px
Output height 22370 px

☐ Draw active decorations: none
☐ Draw annotations
☑ Append georeference information (embedded or via world file)

For this map, I first set the scale at 1:2,500. This has no connection with the scale of your final O map. 1:2,500 is the smallest scale that gives you the full quality OS data for rural areas. I then set the resolution, which defaults at 96 dpi, to four times that default value, or 384. Next, I enter the four bounding coordinates of my footprint as shown, and leave “append georeference information” ticked.

I then check the output width and height values. QGIS displays a warning that your image will be truncated if either value exceeds 32768 pixels. The warning seems to remain even if you then adjust the resolution or the bounding coordinates to bring the pixel count below that value, in which case you can ignore it. Using the scale and resoluition as above keeps both counts below the limit, even for this large footprint, and produces a very acceptable image. It may take a while to save, especially if your computer is of lower spec – mine has 8GB of RAM and an Intel Core i5 processor.

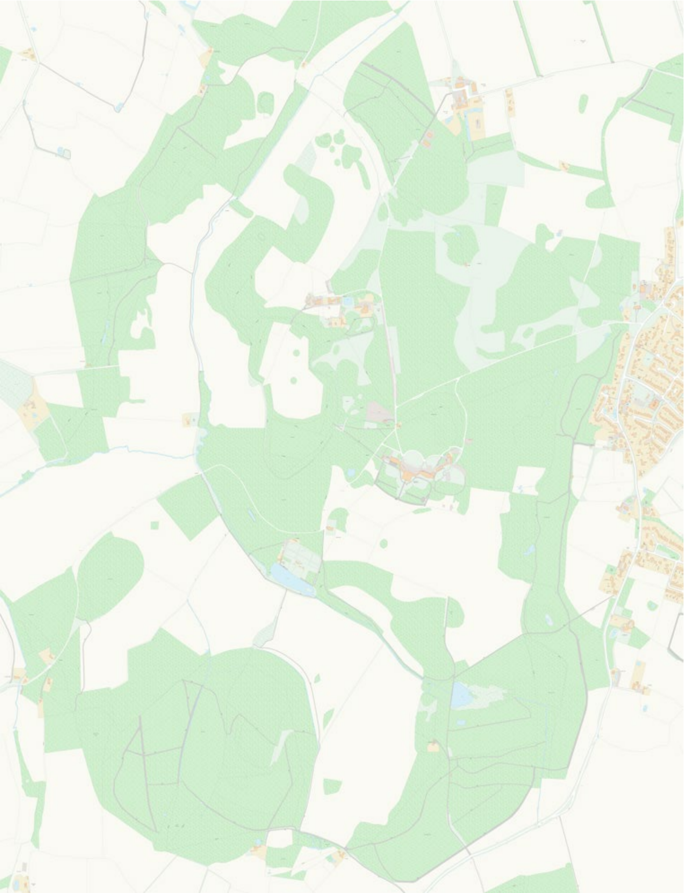
For smaller footprints, the resolution can be increased and/or the scale increased, but, annoyingly, if you alter the scale during the process you have to reset the coordinates, so it’s best to set the scale first. To get maximum data quality in urban areas, I normally set the scale to 1:1,250..

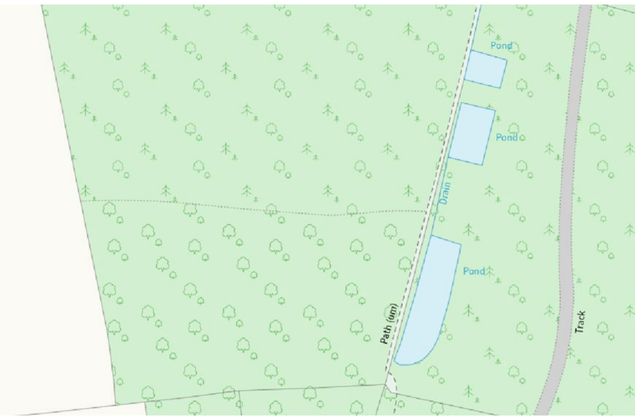
I generally set my resolution at 384 dpi for all scales, although you can achieve comparable results, by decreasing the resolution and enlarging the scale. I chose 384 dpi as a multiple of the default resolution, but resolutions that are not multiples of 96 dpi don’t seem to be a problem. For a very large footprint, you may need to accept a lower resolution to keep the pixel count below the limit, or export your image in two halves, though I think it’s unlikely many O-maps will exceed the footprint at Ickworth.

All that’s left now is to click Save, select the destination filename and folder, and wait. This export process can take a few minutes for a large footprint, It’s tempting to get on with other tasks on your computer during this time, but I’ve found that the the export will sometimes fail if my computer is not left to focus on this task alone. I saved this image with the filename “OSIckworth-2500-384” in a “Maps and Templates” sub-folder within a new folder created for this map project. It saves by default as a .png file (though you have other options). A second small .pgw file is also saved, with the same filename. This contains vital georeferencing information. The two files must be retained in the same folder.

It may be at this point that you are charged by the OS (only nominally, unless you have exceeded your £1,000 monthly free limit). So it’s best to check everything before pressing “Save”. This pretty large export cost me (nominally) less than £10.00. You can check your nominal spending progress at any point by re-opening the OS Datahub and signing in to the “API Dashboard”. Otherwise, if you use one project name for all your mapping, you never need to revisit the OS Datahub. You can just work in QGIS.

You can check your template by opening the .png file in image editing software. My .png files open by default in Microsoft “Photos”. The full Ickworth Park image is below on the left.





The two screenshots on the right show a zoomed extract of the image with built detail, where the advantage of this quailty of base-mapping is obvious, and a section of woodland, where there is less additional detail as compared to smaller scale OS mapping, but still worth having I think. The advantages of OS map templates of this quality are very clear when mapping for urban or Sprint-O maps.

Having followed the above procedure for obtaining my bounding and central coordinates, and my OS Map image, I normally next set up my georeferenced map in OOM and load my OS Map as my first template. I’ve described this procedure in Chapter 3. I don’t close QGIS though, because, as currently open, it’s ready to process an aerial photo of my footprint, as described in Chapter 4. You could reverse the procedures in Chapters 3 and 4 if you prefer.

When you do finally close QGIS, you are asked if you want to save or discard the current project. Provided your templates are safely loaded into OOM, you can select “discard”.

Chapter 3: Setting up a Georeferenced Map in OOM

A georeferenced map is one where the coordinates of every feature on the map, as displayed on-screen, match the coordinates of the same feature in the real world. The coordinates are defined by a coordinate reference system (CRS) which for UK mappers is normally the Ordnance Survey Grid (OSGB36 – EPSG 27700). Once an orienteering map is georeferenced, any templates or imported data will open exactly aligned, provided the imported data is georeferenced to the same CRS.

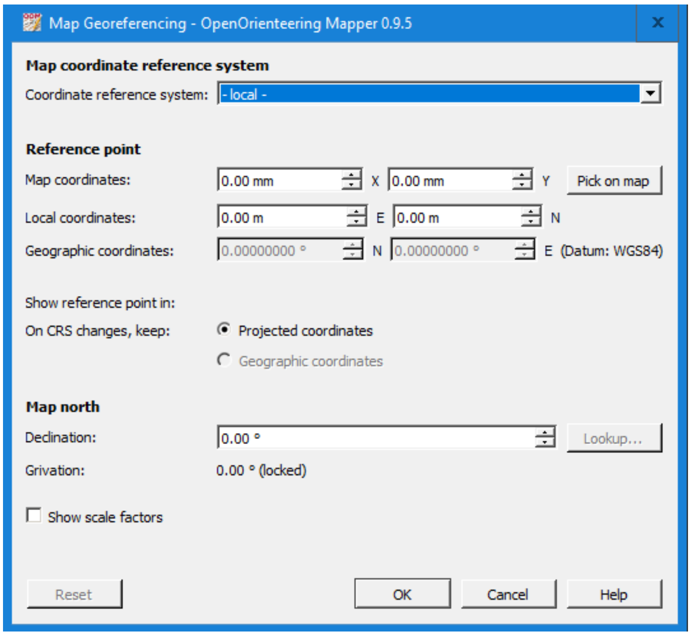
We are slowly updating SUFFOC’s orienteering maps, but many of our earlier maps are not geo-referenced at all, or not consistently georeferenced across the whole map. Other orienteering clubs may be in the same position. Producing the first georeferenced update of an old map may be time-consuming – it’s often easiest to do a full re-draw - but once the map has been accurately georeferenced, future updates should be much more straightforward.

Another advantage of accurately georeferencing orienteering maps is that this will facilitate the use of GPS to assist surveying in the field and allow accurate GPS location of control sites for virtual orienteering courses and MapRun events.

It’s possible to georeference a map in OOM automatically by opening your first georeferenced template, such as the OS Map obtained as described in the previous chapter. I prefer to georeference the map first, before opening any templates, provided I already know the bounding coordinates of my footprint.

To create a new map in OOM select “File”/“New” from the top menu bar. You then have to set the scale and symbol set. I chose 1:10,000 and ISOM 2017–2_10,000 for my Ickworth Park map, as illustrated here. The grey “ready to draw” screen appears.

I then select “Map”/”Georeferencing” from the menu bar to display the dialogue below on the left:



Map Georeferencing - OpenOrienteering Mapper 0.9.5

Map coordinate reference system

Coordinate reference system: - local -

Reference point

Map coordinates: 0.00 mm X 0.00 mm Y

Local coordinates: 0.00 m E 0.00 m N

Geographic coordinates: 0.00000000 ° N 0.00000000 ° E (Datum: WGS84)

Show reference point in:

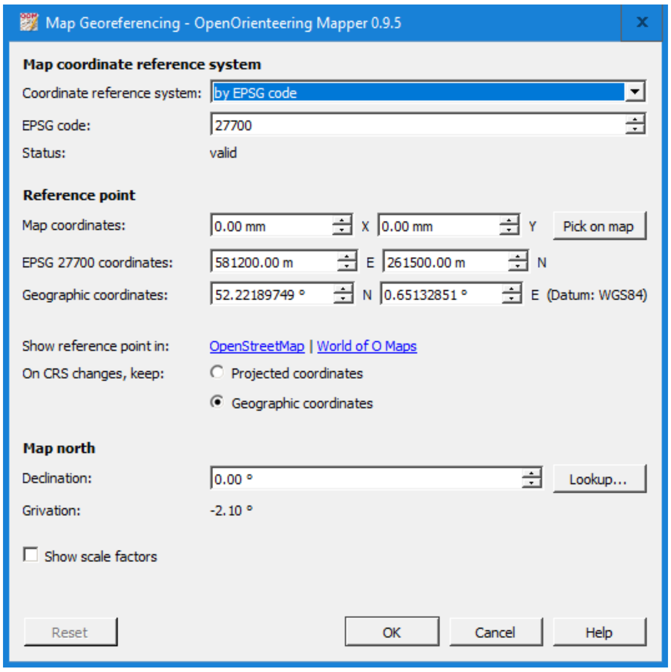
On CRS changes, keep: ● Projected coordinates ○ Geographic coordinates

Map north

Declination: 0.00 °

Grivation: 0.00 ° (locked)

☐ Show scale factors



Map Georeferencing - OpenOrienteering Mapper 0.9.5

Map coordinate reference system

Coordinate reference system: by EPSG code

EPSG code: 27700

Status: valid

Reference point

Map coordinates: 0.00 mm X 0.00 mm Y

EPSG 27700 coordinates: 581200.00 m E 261500.00 m N

Geographic coordinates: 52.22189749 ° N 0.65132851 ° E (Datum: WGS84)

Show reference point in: OpenStreetMap | World of O Maps

On CRS changes, keep: ○ Projected coordinates ● Geographic coordinates

Map north

Declination: 0.00 °

Grivation: -2.10 °

☐ Show scale factors

I’ve then made the following adjustments to obtain the amended dialogue on the right. I used the dropdown arrow to choose “by EPSG code” as the Coordinate reference system, and set this to 27700. Then, under “Reference Point”, I’ve set the “EPSG 27700 coordinates” to the coordinates of the centre of my Ickworth Park footprint. It’s not essential to use the centre of the footprint as the Reference point – I used to use the SW corner. But using the centre gives you the most accurate value for Grid Convergence which will vary slightly across the map, especially if your footprint is large, as here. I’ve left the ”Map coordinates” as zero which sets the map origin at the Reference point. The “Geographic coordinates” are set automatically.

After taking those steps, the Declination and Grivation figures in the dialogue may both still read zero. Select "Geographic coordinates" for "On CRS changes, keep:" to correct this.

The OOM map screen will, at this point, be aligned with True North vertically up the screen. OOM, by default, aligns the screen to Magnetic North, but, until told otherwise, assumes that Magnetic North and True North are identical, in other words that "Declination" (the difference between Magnetic and True North) is zero. Revisiting the formulae from Chapter 1:

Grivation = Declination + Grid Convergence **Declination = Grivation – Grid Convergence**

we see that when Declination is zero, Grivation = Grid Convergence, so the Grid Convergence at this location is -2.10 º. It's important to note down this figure. It will vary across the UK, and will be zero if your footprint lies on the line from Poole to Aberdeen (Longitude -2 º). Unlike Declination and Grivation, Grid Convergence at a given location does not vary with time.

Allowing for Magnetic Variation (or not)

At this point you have to decide whether you prefer to survey and draw with your map aligned to the current Magnetic North, or whether you prefer to keep your map aligned to OS Grid North during surveying and drawing.

The former approach has the advantage of setting your map correctly to Magnetic North right at the start. But, as Magnetic North changes with time, this may need further adjustment when the map is used for events in the future.

The latter approach has the advantage of keeping all your OS and LiDAR templates square on the screen. This is the method I personally prefer and is how all my OOM screenshots are shown in the remainder of this guide. I can then rotate my final map to the correct Magnetic North for the date of the first event. One disadvantage of this approach is that if you print your base map without adjustment, you must correct for magnetic variation every time you take a survey bearing in the field. As a regular user of Ordnance Survey maps, this is instinctive for me and I don't find it a problem, but you may prefer the first method for this reason. Another potential problem arises after an event if the planner has made changes to their rotated version which you as mapper will want to retain on the version kept on file, but this is fairly easily resolved by un-rotating the planner's version.

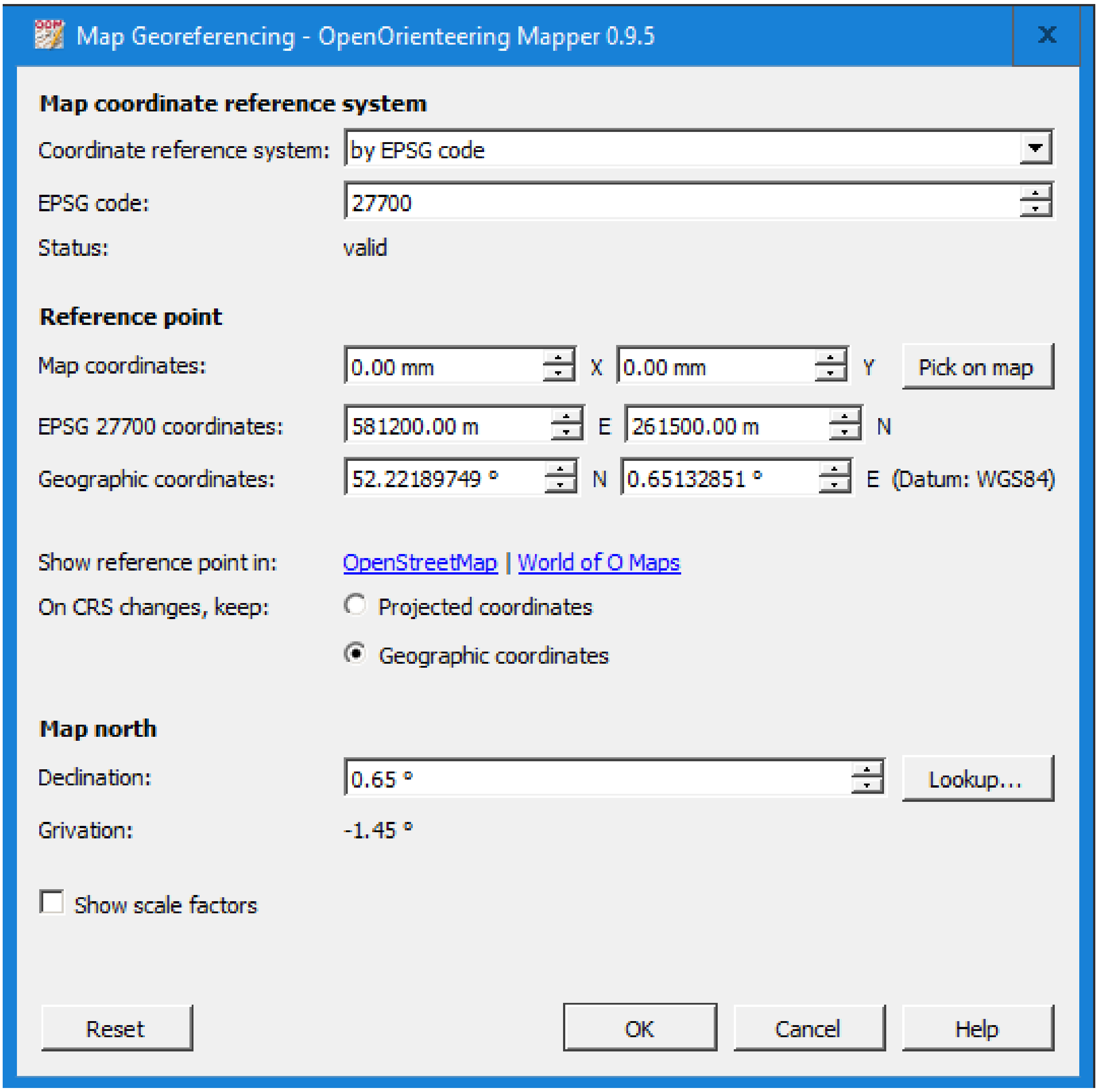
Guidance on how to draw up your map in OOM is outside the scope of this guide, but it's relevant here to mention that rotating a map is simplified if you create a separate "map part" for the "furniture" (ie the title, legend, border, scale bar and magnetic north lines etc.) That way, the map can be rotated without rotating the furniture. OOM's Help Manual explains how to set up two or more map parts.

To survey with the map aligned to Grid North, I just need to make a false entry in the "Declination" box to reset "Grivation" to zero. The value to enter is minus the value which is initially shown as "Grivation" (actually Grid Convergence) in the georeferencing dialogue box. So it's +2.10 º in this case. This has the effect of setting G*rid North* straight up the map. UK georeferenced templates will now open square on the screen. If you choose this approach, please ignore the next three paragraphs for now. But you may want to revisit them to rotate your map to Magnetic North later.

To align the map to Magnetic North, either at this stage or later, you first need to establish the correct "Declination" at your location. The "Lookup…" button on the OOM georeferencing dialogue should do this, but the link is currently broken. The correct URL for this world-wide site is here. This will provide the Declination value directly, stated as the number of degrees that Magnetic North is east or west of *True North*, east being positive. However, I prefer to use the value obtained from the British Geological Survey (BGS) here. I find this more accurate. BGS will give you the "magnetic variation" (ie the "Grivation") expressed as the number of degrees and minutes that Magnetic North is east, or west, of *Grid North*. You must first convert this to decimal degrees, and apply the correct sign to give the real value of Grivation. Again, east is positive. The value obtained must then be converted to Declination using the formula **Declination = Grivation – Grid Convergence.** As explained above, the *Grid Convergence* at this location is, confusingly, the number initially stated as *"Grivation"* in the geo-referencing dialogue box (ie. when *"Declination"* is zero).

So, putting in some real values for my Ickworth Park footprint, the Grid Convergence at this location is -2.10 º. From the BGS website I ascertained that Magnetic North in 2022 (when this map was first used) was 1 degree 27 minutes west of Grid North. So, the Grivation is -1.45 º. Therefore, the Declination = (-1.45 º) - (-2.10 º) = (+0.65 º). Take great care with the minus signs!

When you enter this value for Declination, you may be asked if you want to rotate the map content and the non-georeferenced templates – say yes to both. The georeferencing dialogue box will now display the correct values of Declination and Grivation, as shown in the next screenshot.



Map Georeferencing - OpenOrienteering Mapper 0.9.5

Map coordinate reference system

Coordinate reference system: by EPSG code

EPSG code: 27700

Status: valid

Reference point

Map coordinates: 0.00 mm X 0.00 mm Y

EPSG 27700 coordinates: 581200.00 m E 261500.00 m N

Geographic coordinates: 52.22189749 ° N 0.65132851 ° E (Datum: WGS84)

Show reference point in: OpenStreetMap | World of O Maps

On CRS changes, keep:
○ Projected coordinates
● Geographic coordinates

Map north

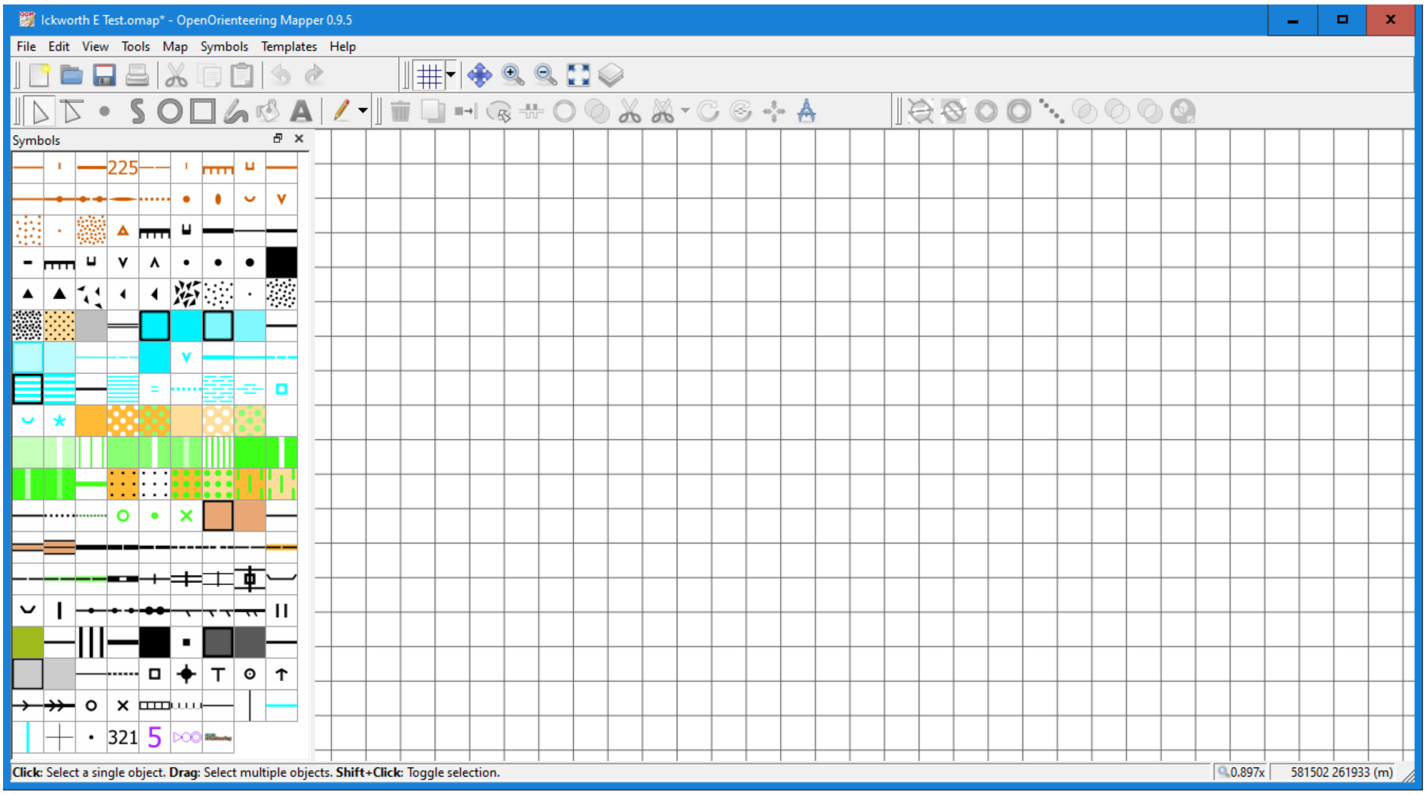
Declination: 0.65 °

Grivation: -1.45 °

☐ Show scale factors

Configuring the OOM Grid

Returning to the OOM map screen I now click the “Map” menu tab and select “Configure Grid”. I turn “Snap to grid” off, and set alignment to “Magnetic North”. Using my preferred method, I could set the alignment to “Grid North” here instead, with the same result, but this causes me problems later with my method of obtaining GPS locations when surveying in the field (see Chapter 14). I set the horizontal and vertical spacings to 100m. Using my preferred method, this provides a check that my templates are opened correctly as they should sit flush with the grid. Finally, I switch “Show grid” on and click “OK”. My map screen should now look as in the next screenshot. I’ve set the coordinate display (bottom right) to EPSG 27700 coordinates (right click to do this). The coordinates show the position of the cursor which is approximately centre screen in this case, although, as is always the case, the cursor is invisible in the screenshot.

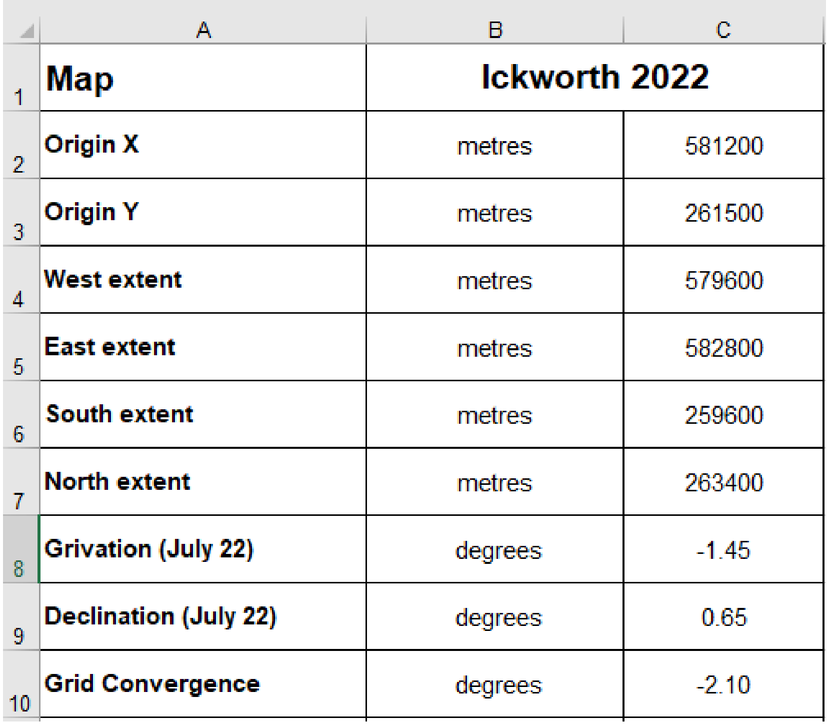


Click: Select a single object. **Drag:** Select multiple objects. **Shift+Click:** Toggle selection.

The new map is now ready to accept templates. As suggested in Chapter 2, I normally save it within a folder created for the new map project in a sub-folder named "Maps and Templates". I find that having the map file together with its associated templates in the same sub-folder is really useful if I later want to pass the map and templates to another mapper, or move them, or back them up, to another computer.

You may find it valuable at this stage to create one or two mirror copies of this map file, with the georeferencing set as above, but otherwise empty. I save one of these as "MicroContours" (see Chapter 8). A second copy may also be useful to use with GPS tracks, (see Chapters 14 and 17). I save them alongside the map file in my "Maps and Templates" sub-folder.

For later reference, I also find it useful to enter the key parameters established for this map so far in a table (easily created in Excel).



	A	B	C
1	**Map**	**Ickworth 2022**	
2	**Origin X**	metres	581200
3	**Origin Y**	metres	261500
4	**West extent**	metres	579600
5	**East extent**	metres	582800
6	**South extent**	metres	259600
7	**North extent**	metres	263400
8	**Grivation (July 22)**	degrees	-1.45
9	**Declination (July 22)**	degrees	0.65
10	**Grid Convergence**	degrees	-2.10

Opening your OS Map template.

I can now open my first template – the OS Map. Click the “Templates” menu tab and select “Open Template”. Then navigate to and open your .png file. OOM will automatically read the georeferencing information from the associated .pgw file, provided it’s in the same folder. The following dialogue windows will display. The first should open with “Georeferenced (World file)” pre-selected. Just click “Open”. The second should confirm that the coordinate reference system of your template is the same as your map. Just click “OK”. The template will now open – for a template this size you may wait a little while – and should appear as below. You may need to zoom in or out, or click the “Show whole map” toolbar icon, to get this view.

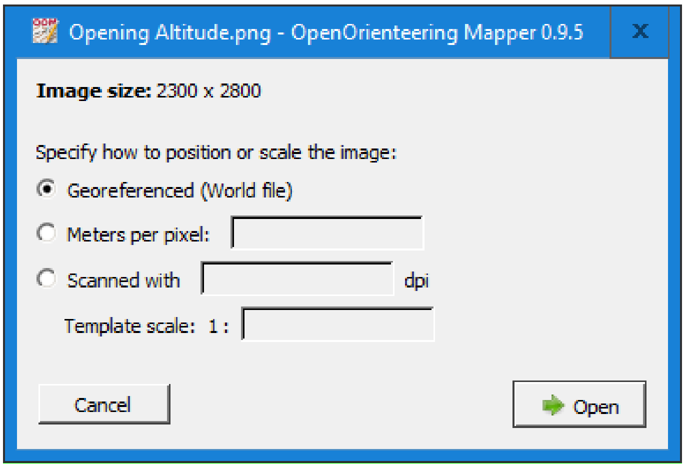
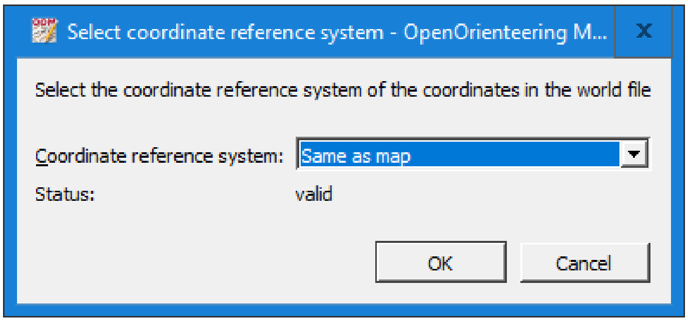

Opening Altitude.png - OpenOrienteering Mapper 0.9.5

Image size: 2300 x 2800

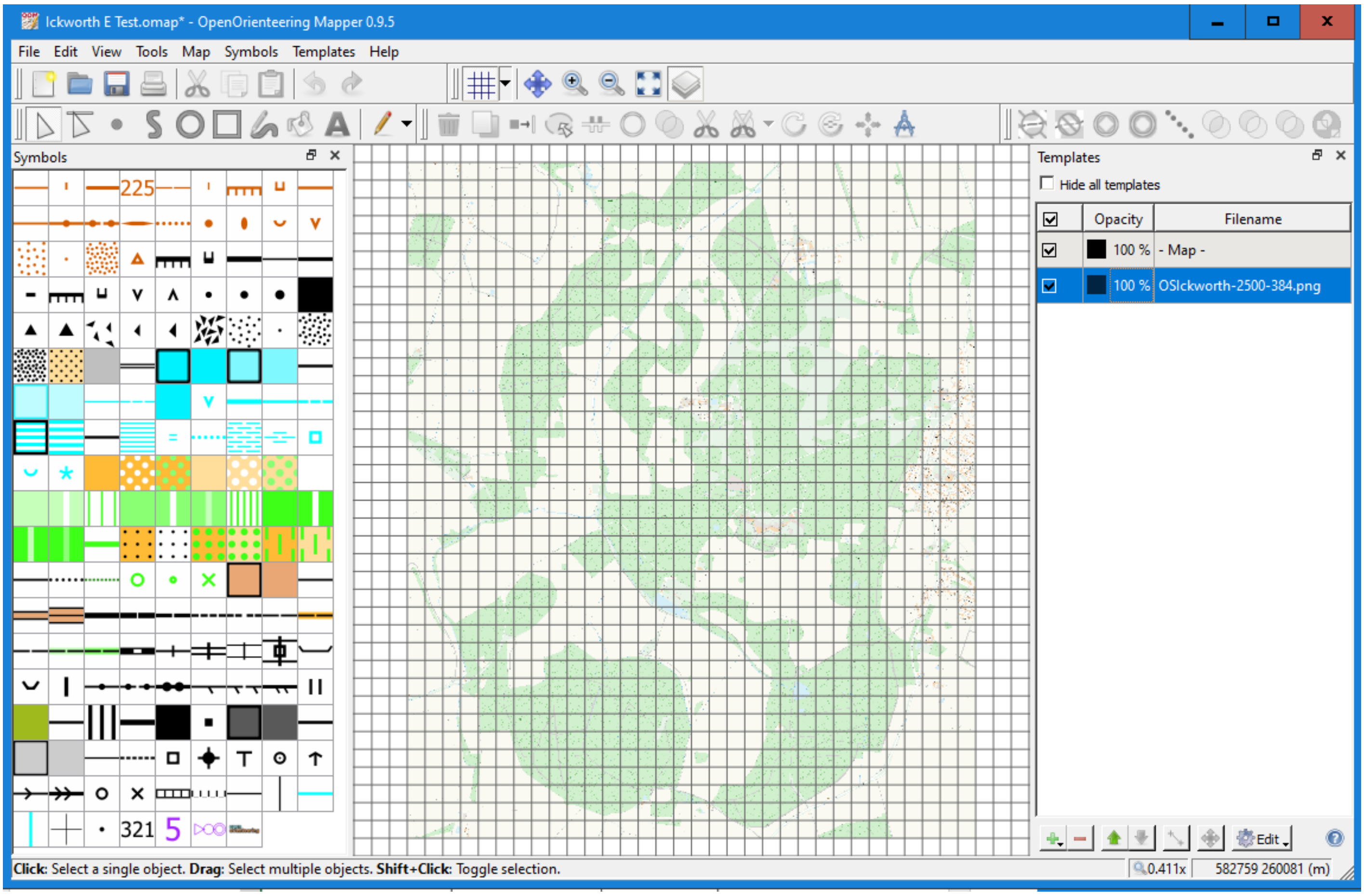
Specify how to position or scale the image:

● Georeferenced (World file)
○ Meters per pixel:
○ Scanned with dpi
Template scale: 1 :


Select coordinate reference system - OpenOrienteering M...

Select the coordinate reference system of the coordinates in the world file

Coordinate reference system: Same as map
Status: valid


Ickworth E Test.omap* - OpenOrienteering Mapper 0.9.5

☑	Opacity	Filename
☑	100 %	- Map -
☑	100 %	OSIckworth-2500-384.png

Click: Select a single object. **Drag:** Select multiple objects. **Shift+Click:** Toggle selection.

0.411x 582759 260081 (m)

Chapter 4: Obtaining a georeferenced aerial photo from Google Earth or similar

In this chapter I describe how I obtain georeferenced aerial photography templates via QGIS. This is now my standard method. Later, in Chapter 16, I consider some of the shortcomings of aerial photography obtained by this and other methods, and suggest how better results can sometimes be achieved in specific circumstances. For aerial photography, my go-to source is Google Earth. Although sometimes referred to as “Google Satellite”, I think the detailed imagery is mostly airborne photography. The method described below will also source photography from Bing or ESRI, which is also provided free of charge.

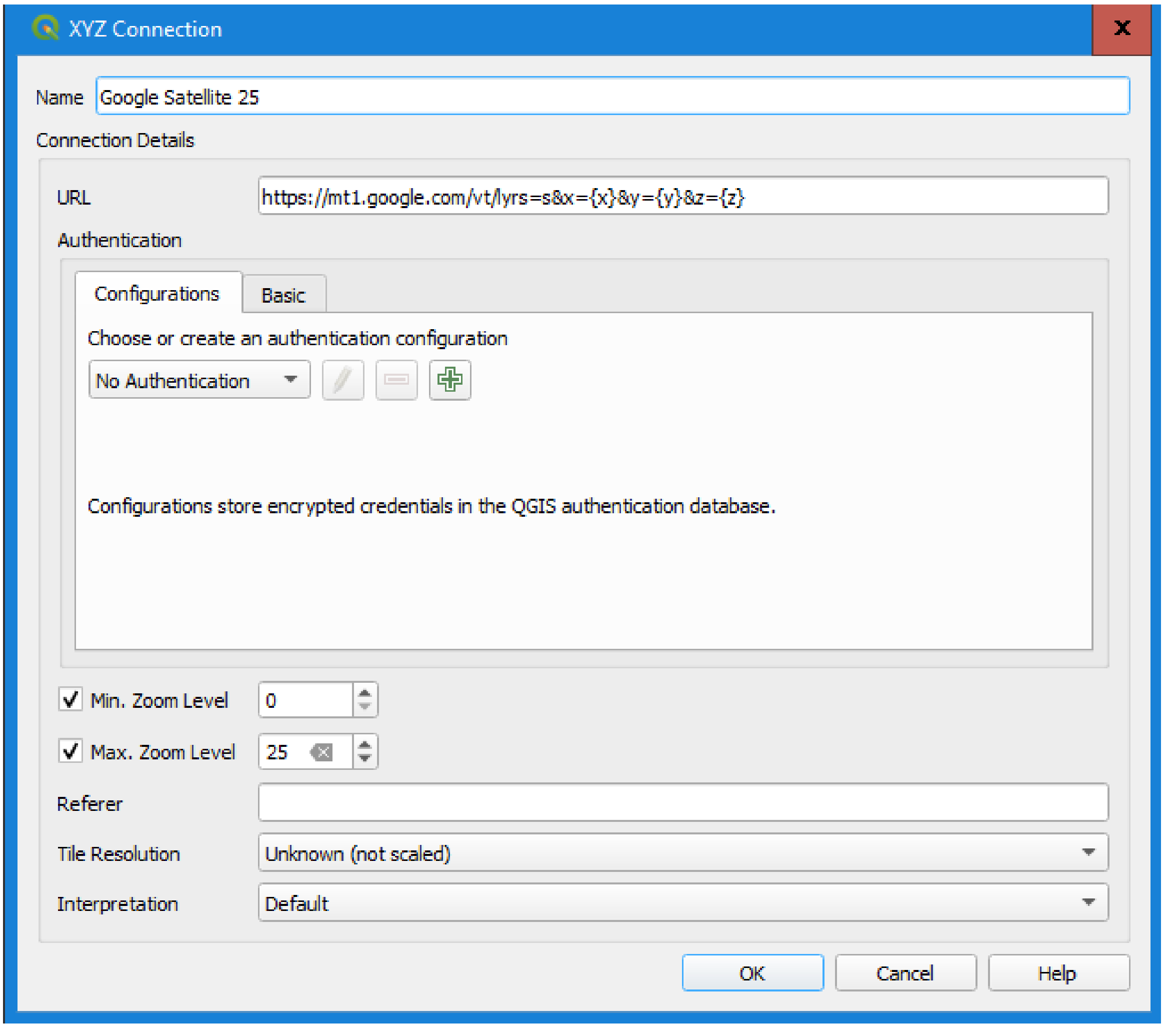
Establishing a connection from QGIS to Google Earth

QGIS allows you to set up a connection to Google Earth which, once established, is retained in QGIS for you to use on future occasions. The process for establishing the connection is, therefore a “once only” task, and is a lot simpler than the corresponding process to establish a connection to the OS Data Hub.

The simplest way to obtain a connection from QGIS to Google Earth is from the QGIS Browser panel, using a URL which can be found by searching the internet. I searched for “QGIS Google” and found several sites with this information. Two URLs work currently for Google Earth, as below, with apparently identical results, but it is open to Google to change these at any time. See later in this chapter for an alternative approach if this should happen (which also enables a link to other photo sources).

https://mt1.google.com/vt/lyrs=s&x={x}&y={y}&z={z}
http://www.google.cn/maps/vt?lyrs=s@189&gl=cn&x={x}&y={y}&z={z}

In the QGIS Browser panel, you need to locate and right click “XYZ Tiles”. Select “New Connection” to display the following dialogue. Note that “XYZ Tiles” may appear expanded in the Browser panel to show a list of existing connections, such as Open Street Map, but it’s the “XYZ Tiles” heading you need to right click.



Name: Google Satellite 25

Connection Details

URL: https://mt1.google.com/vt/lyrs=s&x={x}&y={y}&z={z}

Authentication

Choose or create an authentication configuration

No Authentication

Configurations store encrypted credentials in the QGIS authentication database.

☑ Min. Zoom Level: 0

☑ Max. Zoom Level: 25

Referer:

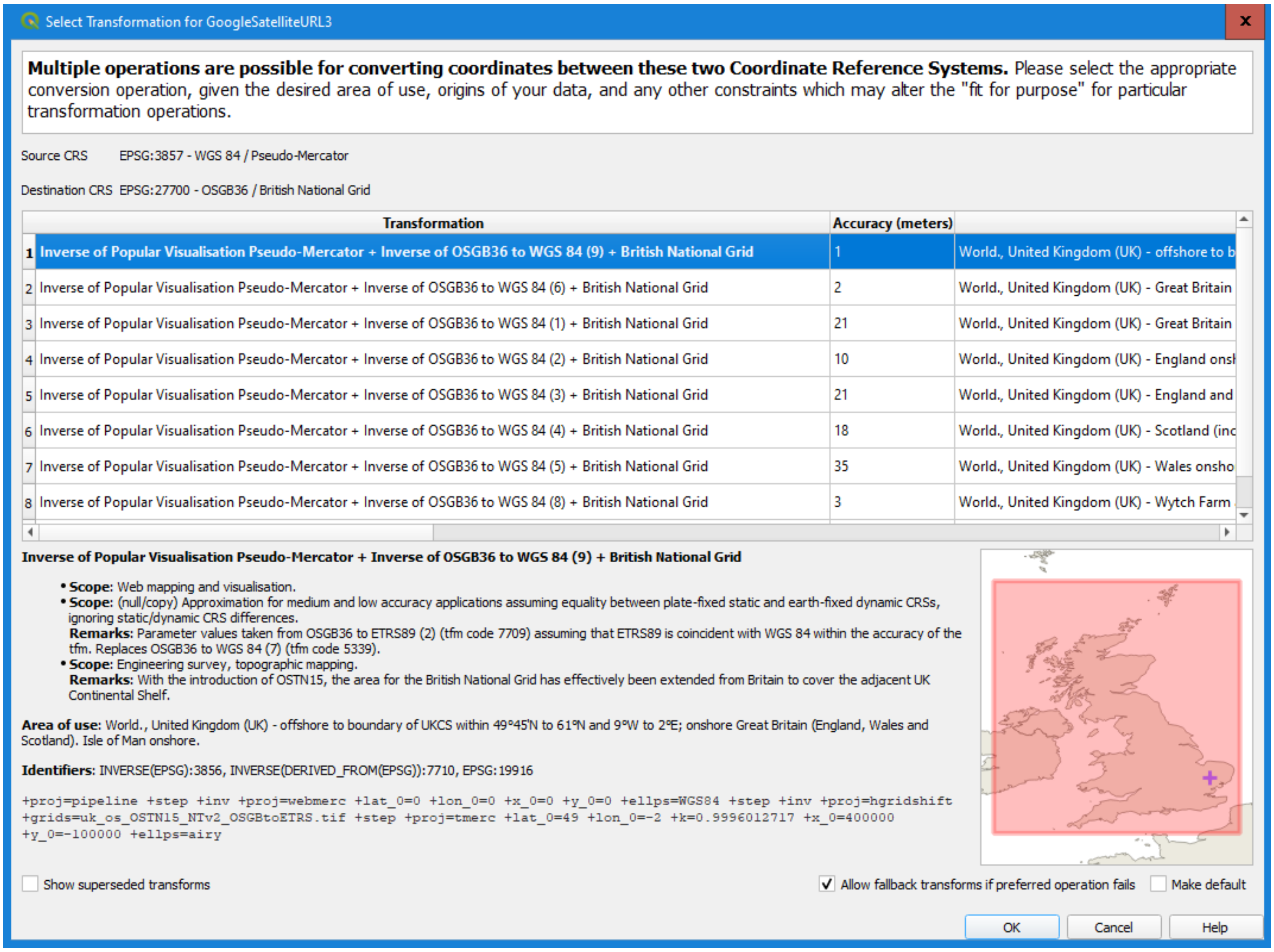
Tile Resolution: Unknown (not scaled)

Interpretation: Default

In the dialogue above, I've given a name to the connection and entered the URL. I've set the maximum zoom level at 25. Some sources recommend a maximum zoom level of 20, but I've found that 25 gives best results, with no increase in image file size. I've left everything else as default, which I've also found gives good results. Click "OK". Your new connection should now be listed under "XYZ Tiles" when expanded.

It's important at this point to have your OS map layer already opened in QGIS, as described in Chapter 2, and zoomed in on the screen to the approximate footprint of your new orienteering map. Otherwise, when you open your Google Satellite connection, it will open with the whole world on screen, and the CRS conversion to EPSG 27700 will fail, as the OS Grid is not defined outside of Britain. It is possible to open your Google Earth photograph first – only really sensible if you already have an OS map template from another source. It will then open displaying the whole world, and automatically set the QGIS Project CRS to EPSG 3857. In this case, you must zoom in to your approximate footprint first and set the CRS manually to EPSG 27700 using "File"/"Properties". This should take you to the step described below.

Assuming your OS map layer is already open, with the QGIS Project CRS automatically set to EPSG 27700, you can now double click your Google Earth connection name under "XYZ Tiles" in the Browser panel and the following dialogue will display.



Multiple operations are possible for converting coordinates between these two Coordinate Reference Systems. Please select the appropriate conversion operation, given the desired area of use, origins of your data, and any other constraints which may alter the "fit for purpose" for particular transformation operations.

Source CRS EPSG:3857 - WGS 84 / Pseudo-Mercator

Destination CRS EPSG:27700 - OSGB36 / British National Grid

	Transformation	Accuracy (meters)	
1	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (9) + British National Grid	1	World., United Kingdom (UK) - offshore to b
2	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (6) + British National Grid	2	World., United Kingdom (UK) - Great Britain
3	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (1) + British National Grid	21	World., United Kingdom (UK) - Great Britain
4	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (2) + British National Grid	10	World., United Kingdom (UK) - England onsl
5	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (3) + British National Grid	21	World., United Kingdom (UK) - England and
6	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (4) + British National Grid	18	World., United Kingdom (UK) - Scotland (inc
7	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (5) + British National Grid	35	World., United Kingdom (UK) - Wales onsho
8	Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (8) + British National Grid	3	World., United Kingdom (UK) - Wytch Farm

Inverse of Popular Visualisation Pseudo-Mercator + Inverse of OSGB36 to WGS 84 (9) + British National Grid

- **Scope**: Web mapping and visualisation.
- **Scope**: (null/copy) Approximation for medium and low accuracy applications assuming equality between plate-fixed static and earth-fixed dynamic CRSs, ignoring static/dynamic CRS differences.
  Remarks: Parameter values taken from OSGB36 to ETRS89 (2) (tfm code 7709) assuming that ETRS89 is coincident with WGS 84 within the accuracy of the tfm. Replaces OSGB36 to WGS 84 (7) (tfm code 5339).
- **Scope**: Engineering survey, topographic mapping.
  Remarks: With the introduction of OSTN15, the area for the British National Grid has effectively been extended from Britain to cover the adjacent UK Continental Shelf.

Area of use: World., United Kingdom (UK) - offshore to boundary of UKCS within 49°45'N to 61°N and 9°W to 2°E; onshore Great Britain (England, Wales and Scotland). Isle of Man onshore.

Identifiers: INVERSE(EPSG):3856, INVERSE(DERIVED_FROM(EPSG)):7710, EPSG:19916

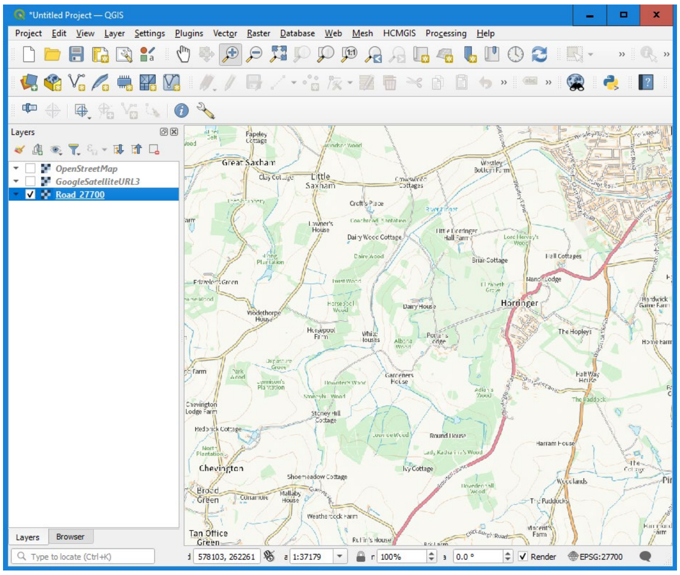
```
+proj=pipeline +step +inv +proj=webmerc +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +step +inv +proj=hgridshift
+grids=uk_os_OSTN15_NTv2_OSGBtoETRS.tif +step +proj=tmerc +lat_0=49 +lon_0=-2 +k=0.9996012717 +x_0=400000
+y_0=-100000 +ellps=airy
```

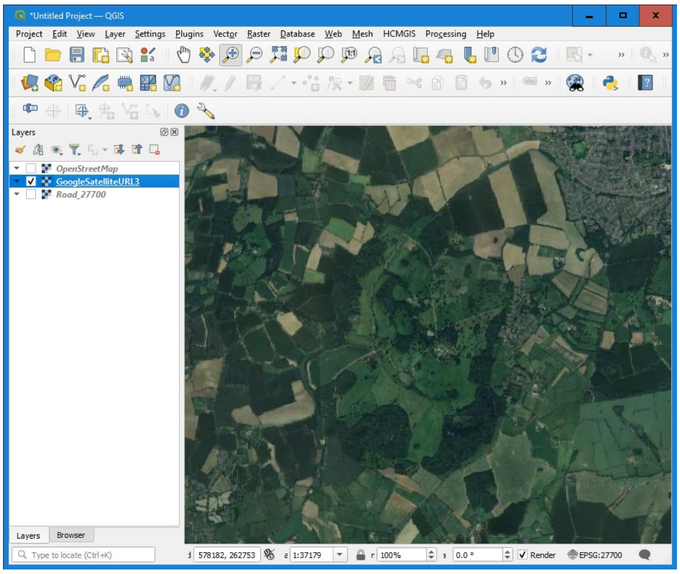
☐ Show superseded transforms ☑ Allow fallback transforms if preferred operation fails ☐ Make default

This important dialogue confirms which CRS transformation algorithm QGIS will use to convert from Google Earth's native CRS (WGS84 / EPSG 3857) to the Ordnance Survey CRS (EPSG 27700). The default, as highlighted, is the most accurate and can be confirmed by clicking "OK". The photo will be displayed on the QGIS map screen as a new layer, matching and overlaying the OS map layer.

If you wish, you can add an Open Street Map layer at this point just by double clicking "Open Street Map" which should be listed by default under "XYZ Tiles". A CRS conversion is also required but the algorithm you've already selected may be automatically chosen without you needing to confirm this.

In the Layers panel (toggle to view this if necessary) your two (or three) layers will now be listed and can be viewed by adjusting which is ticked, as per the screenshots below.





Exporting your aerial photo image

The procedure for exporting your aerial photo image for use as a template in OOM mirrors the procedure described in Chapter 2 for your OS Map template.

First check that only the aerial photo layer is ticked in the Layers panel. Then follow the same procedure, using the same bounding coordinates, as for your OS map. I generally use the same scale and resolution – 1:2500 and 384 dpi in this case - though you can experiment with varying these to see if larger scales and/or higher resolutions produce crisper images. You can compare the image you obtain in this way with a zoomed-in image viewed directly in Google Earth Pro. The left-hand screeshot below is a zoomed image exported from QGIS, and the right-hand image compares this with the maximum resolution obtainable directly in Google Earth Pro. There is little dfference apparent, except that the QGIS image appears slightly rotated and stretched as it’s been transformed to align with the OS Grid – a more complex transformation than just rotation and stretching, of course.

No adjustments in QGIS will produce a clearer image than the best available from Google Earth direct, so higher resolutions may just increase the file size, and the saving time, with no visible benefit. Very occasionally, though, I've found that I have to export the photo in two or more sections to achieve best resolution and not exceed the QGIS pixel limit.

As per my OS map template, I save the aerial photo image from QGIS in my Maps and Templates sub-folder as a .png file with a suitable filename. A small .pgw worldfile is also saved which must be kept in the same folder. The template will then open in OOM exactly as the OS map template. It should be closely aligned with the OS template, but there may be some small inconsistencies. I consider possible reasons for this in Chapter 16. One of the sources of innacuracy, which I mention in that chapter, is obvious in these zoomed screenshots. It's clearly an "oblique" photo, rather than one shot vertically, as the roof of Ickworth House is well out of line with its base.

At this resolution, for a footprint of this size, the exported file from QGIS is large – 496 Mb in this case. This is, however, an unusually large O-map footprint.

Alternative method of establishing a connection from QGIS to Google Earth and other sources

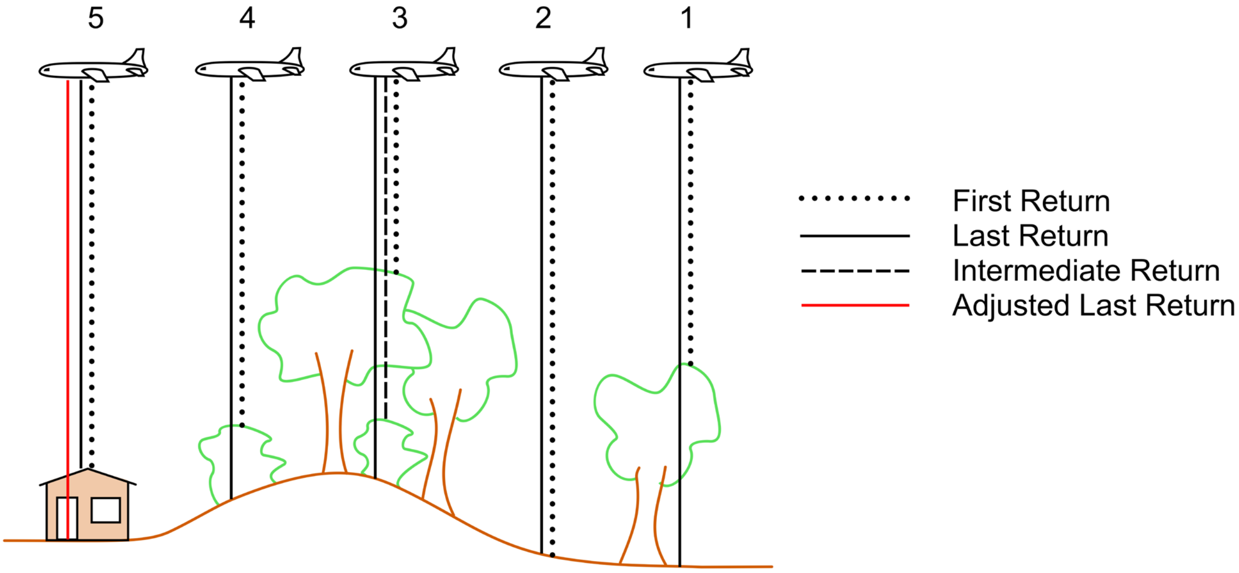
As mentioned above, the published URLs for connecting from QGIS to Google Earth are subject to revision by Google. Should that happen, the following work-around may solve the problem. First, from the QGIS menu bar, select "Plugins"/"Manage and Install Plugins". A dialogue will display with a long list of available plugins. Locate the "HCMGIS" plugin, select it, click "Install Plugin" (if it's not already installed) and check it's ticked. Close the dialogue and HCMGIS should appear as a new item in the top menu bar. Select this and then "Basemaps" and a list of available basemaps will display (including Bing and ESRI). To establish a connection to Google Earth aerial photography, click "Google Satellite". A familiar Google world view should appear on the map screen. Next close QGIS (clicking "disregard" as you go) and re-open. A new connection named "Google Satellite" should appear in the "XYZ Tiles" dropdown list in the Browser panel. Right click that and select "Edit Connection". This should take you to the XYZ Connection dialogue shown in the screenshot two pages back. It should have the URL and Name already entered. You can change the Name if you wish, and correct the Max Zoom Level to 25.

On my computer, I've not been able to work out how to permanently delete a connection from the XYZ Tiles dropdown list, so my list has grown like topsy while experimenting. I've renamed the important ones I use to distinguish them. Starting the name with a number will move the connection to the top of the list.

Chapter 5: A brief introduction to LiDAR

I explain briefly here the meaning of terms such as “First Return”, “Last Return”, “DSM” and “DTM” which relate to LiDAR survey data. Please feel free to skip this chapter if you are familiar with this topic. The terminology can, however, be confusing. For example, not all sources use “DSM” to mean the same thing. Some use “DEM” instead of “DTM”. This chapter introduces the various terms as they are used on the UK Environment Agency (DEFRA) LiDAR download site. More detailed information is available here: Environment Agency Geomatics Hub (arcgis.com)’

A LiDAR survey aircraft has several highly accurate instruments on board. A GPS locator gives the instantaneous horizontal (“x” and “y”) and altitude (“z”) coordinates of the aircraft. A laser emitter emits regular laser pulses vertically downwards. And a laser receiver times the interval (very short of course) between the pulse and each of its reflections (or “returns”). There may be many returns from each pulse, and each return is recorded as the x, y and z coordinates of the point which is reflecting the laser pulse.



With the aircraft at position 1 in the above diagram, the “First Return” records the altitude (above sea level) of the tree canopy, while the “Last Return” records the altitude of the ground. At position 2, there is no tree cover and the first and last returns are identical. Both record the altitude of the ground. Position 3 illustrates that there may be one or more intermediate returns from vegetation under the tree cover, and position 4 indicates the outcome if there is low vegetation cover in otherwise open terrain.

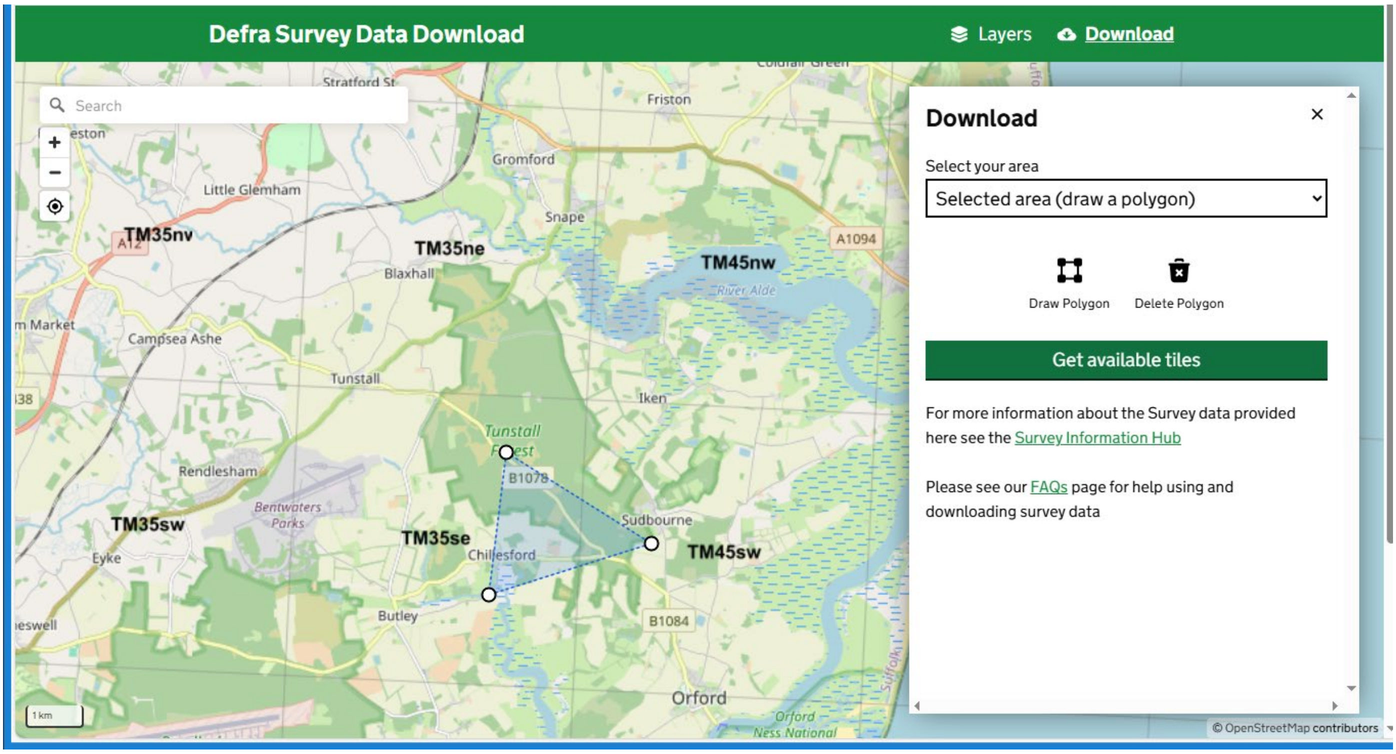
At position 5, both first and last returns are again identical. This time they both measure the altitude of the roof of the building since no light penetrates to the ground. But back in the laboratory, the data from adjacent pulses is cleverly analysed to remove the building (or anything else with vertical sides) and reveal the altitude of the ground – an “adjusted” last return.

Many more laser pulses are emitted in this small segment of the flight than the five shown above of course. Raw “Point Cloud” data includes an x, y, and z value for every return of each pulse, including all the intermediate returns. Processed data is then produced from the point cloud in various formats or “models”. Each model results from interpolating the data to give z values at regular horizontal spacing or “resolution”, usually 1m or 2m. The different models available from the DEFRA site are as follows:

- The Last Return Digital Surface Model (DSM) records the last reflections, as shown by the solid black lines in the diagram above. This is sometimes just referred to as “DSM”.
- The First Return Digital Surface Model (DSM) records the first reflections, as shown by the dotted lines in the diagram above.
- The Digital Terrain Model (DTM) records the adjusted last returns – ie the altitude of the ground.
- The Intensity Model records the strength of each reflection. Both First Return and Last Return Intensity models can be produced depending which returns are analysed. Only the Last Return Intensity model is currently provided by DEFRA.
- Point Cloud data contains all the raw data from the survey, including the intermediate returns.

Chapter 6: Downloading LiDAR data from the Environment Agency (DEFRA) website

The DEFRA LiDAR download site is here. The screenshot below shows the user interface with the map zoomed in and the two tiles I required for the map extension I'm currently working on at Tunstall Forest in East Suffolk selected. I used the "Draw Polygon" tool to make the selection. Note that I can draw any triangle (as shown shaded below) that includes sections of the two 5km square tiles I need. There's no advantage to drawing accurately around your map footprint.



Download

Select your area

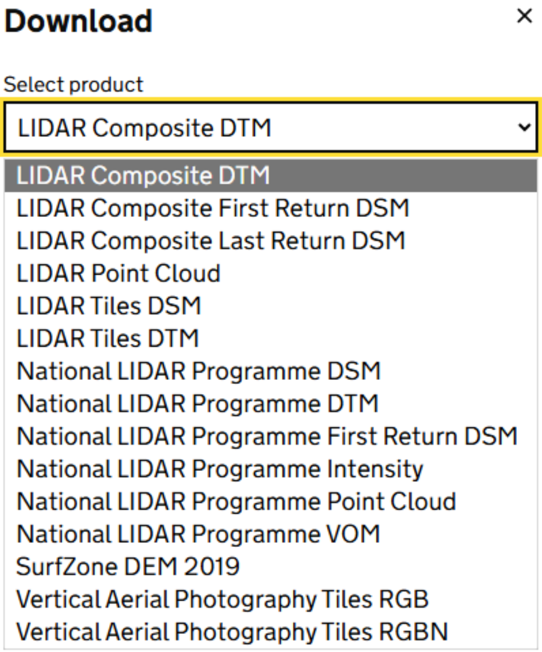
Selected area (draw a polygon)

For more information about the Survey data provided here see the Survey Information Hub

Please see our FAQs page for help using and downloading survey data

Each 5 km square tile is labelled on the map in the format "TM35se". TM35 is the 10km OS grid square with SW coordinates 630000, 250000 in 12 figure (1metre) format. TM35se is the south-eastern of the four 5km tiles within this 10km grid square.

Double click to confirm your polygon, then click "Get available tiles". the "Download" window will now display "Select product". Click the dropdown to display the available models for this area as in the screenshot below:



Download

Select product

LIDAR Composite DTM

- LIDAR Composite DTM
- LIDAR Composite First Return DSM
- LIDAR Composite Last Return DSM
- LIDAR Point Cloud
- LIDAR Tiles DSM
- LIDAR Tiles DTM
- National LIDAR Programme DSM
- National LIDAR Programme DTM
- National LIDAR Programme First Return DSM
- National LIDAR Programme Intensity
- National LIDAR Programme Point Cloud
- National LIDAR Programme VOM
- SurfZone DEM 2019
- Vertical Aerial Photography Tiles RGB
- Vertical Aerial Photography Tiles RGBN

The proliferation of LiDAR data offered by DEFRA can be quite confusing. The Environment Agency guidance linked in the previous chapter may help.

Until recently I've been exclusively using data from the National LiDAR Programme. This was completed for England by February 2023. The "Composite" data sets used to be older, but they are now being updated as new data becomes available, so they may increasingly become the more up to date source. In my experience, if the Composite dataset has a more recent date than the National LiDAR Programme dataset for your area of interest, then the Composite data will include newer surveys where available, while relying on National LiDAR Programme data where not. So, it should be the better source, and I'm now favouring it. An idea of the dates of the most recent LiDAR surveys can be found at Coverage Metadata - Survey Data. A good indication of which areas have been surveyed since the conclusion of the National Programme can be found by checking the "LiDAR Point Cloud Index" at this site. It shows that, in Suffolk at least, the most recent – post-National LiDAR Programme - surveys are mostly of coastal and/or flood-prone areas. If, as occasionally happens, your footprint overlaps National LiDAR Programme tiles with different survey dates, I have found that the Composite data sets can merge better.

Six formats or "models" are available within the National LiDAR Programme (or as Composite data sets), as indicated in the screenshot above. These correspond to the models listed in the previous chapter. Although the "Point Cloud" model contains all the raw data, I've only used point cloud data to produce undergrowth templates. When the ground or the treetop elevation is what we want to see, the other, processed, data models are easier to use.

The DTM data model, which records the altitude of the ground, can be processed to produce accurate contour maps as well as hillshade templates. Occasional anomalies do occur when the tree cover is so dense that no light reaches the ground, but these anomalies are mostly avoided by the UK Environment Agency by commissioning winter surveys.

"Last Return DSM" (or just "DSM") is equivalent to DTM, but without the removal of buildings. I've not found this useful myself, though it can highlight buildings well. I understand it can give valuable information in open moorland terrain with earthbank or stonewall boundaries.

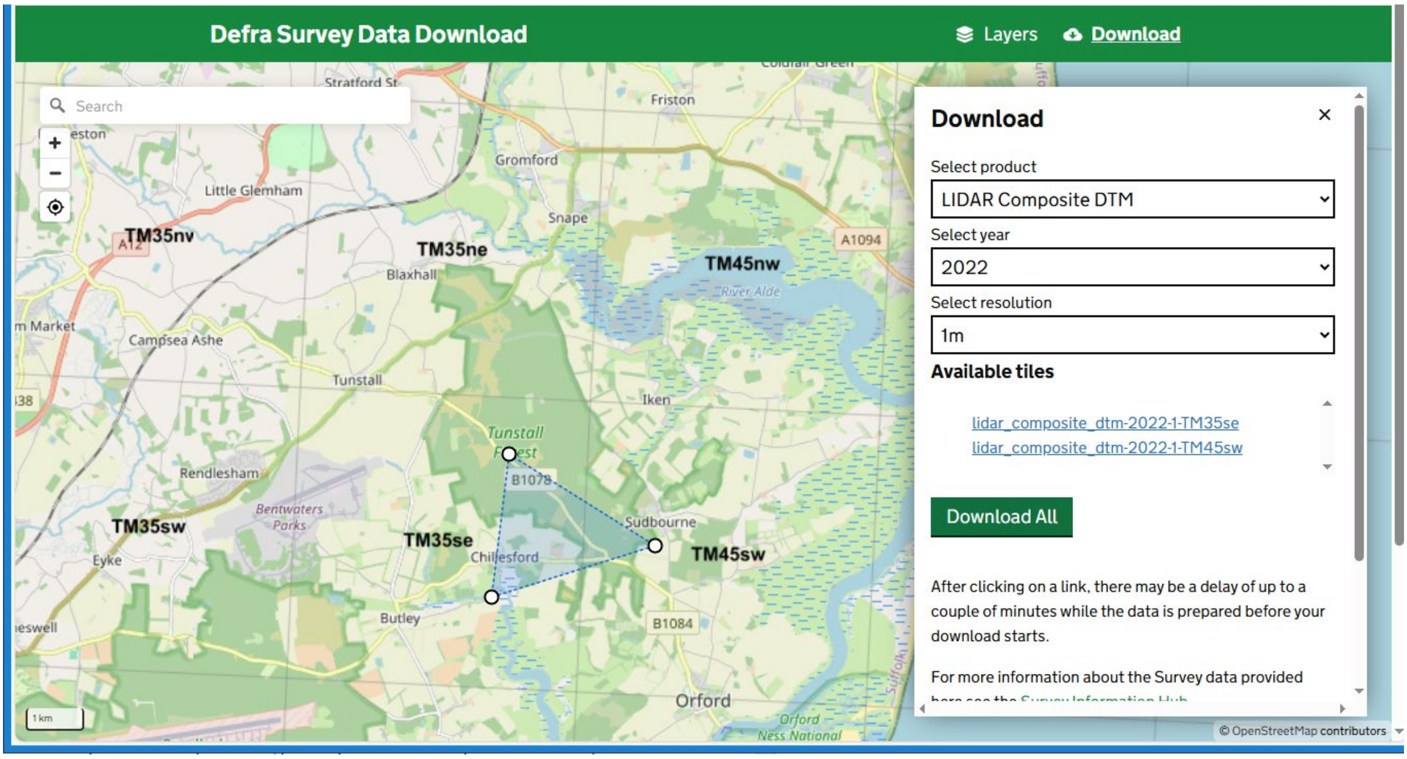
"First Return DSM" records the highest features that exist above ground level, such as treetops and roofs of buildings, which is very useful information.

All DSM data records absolute altitudes above sea level and must be "normalised" to show height above ground. This can be done in SAGA-GIS (see Chapter 10). A normalised First Return DSM template displays boundaries between different *heights* of vegetation well – usually better than aerial photos.

"VOM" is a new data model which equates roughly to a normalised First Return DSM, but ignores vegetation below 2.5m height. It's a little quicker to use than First Return DSM, but loses useful information below that height such as hedges, so I've not found it useful.

The "Intensity" data model records the reflectivity of the surface reflecting the last return. Templates derived from this data can provide a good indication of the boundaries between different *types* of vegetation, independent of vegetation *height*. Roads and other tarmac areas are also particularly clearly defined, as are compacted paths in open areas, or even sometimes under tree cover. Currently, Intensity data is only available in the National LiDAR Programme.

All the DEFRA LiDAR datasets are provided as 5km tiles. All except the point cloud data is downloaded in GeoTIFF (.tif) file format. In the screenshot below, I've selected the LiDAR Composite DTM model with a survey date of 2022 and resolution of 1m. Occasionally, the survey date for adjacent tiles will differ, and you'll need to check both, or all, the dates to get all the available tiles for your footprint. But, for this footprint, the two 5km Composite DTM tiles I need are both dated 2022. This doesn't mean that the whole 5km square was surveyed in 2022, just that part of it was. Composite datasets may include earlier survey data, usually from the National LiDAR Programme, which for these tiles dates from 2019.



Download

Select product: LIDAR Composite DTM

Select year: 2022

Select resolution: 1m

Available tiles

lidar_composite_dtm-2022-1-TM35se
lidar_composite_dtm-2022-1-TM45sw

Download All

After clicking on a link, there may be a delay of up to a couple of minutes while the data is prepared before your download starts.

For more information about the Survey data provided

The two available tiles, one for each 5km grid square, are displayed as hyperlinks. You can download both together by clicking “Download All” but you may have first to adjust the cookie and pop-up settings on your browser. I’ve found it simpler just to click once on each link – the result is the same. Each tile normally downloads as a zipped folder (though it may download unzipped on your computer). If so, you must first unzip it (right click and “Extract all” – **an important step**).

I then open the unzipped folder to display two files, a .tif “ image” file and a small .tfw file which contains geo-referencing information. The Composite datasets download with several additional small files which you can ignore. I then move the .tif and .tfw files into a “LiDAR” sub-folder in my project folder for the current map. This is the best file location if following the examples in these notes. Alternatively, you can drag and drop just the .tif file directly into the SAGA-GIS data window from your download folder (see the next Chapter). SAGA-GIS reads the .tfw file automatically on loading, provided it's in the same folder.

I then repeat the download for the other data models I intend to use, in this case the LiDAR Composite First Return DSM tile and the National LiDAR Programme Intensity tile. The Composite data does not currently include the Intensity model, at least not in Suffolk. I usually leave the point cloud format tiles for now. Clearly this is a quicker process when you only require one 5km tile in each format to cover your footprint. But you may be less fortunate and require 4 tiles in each format if your footprint straddles the intersection of four 5km grid squares.

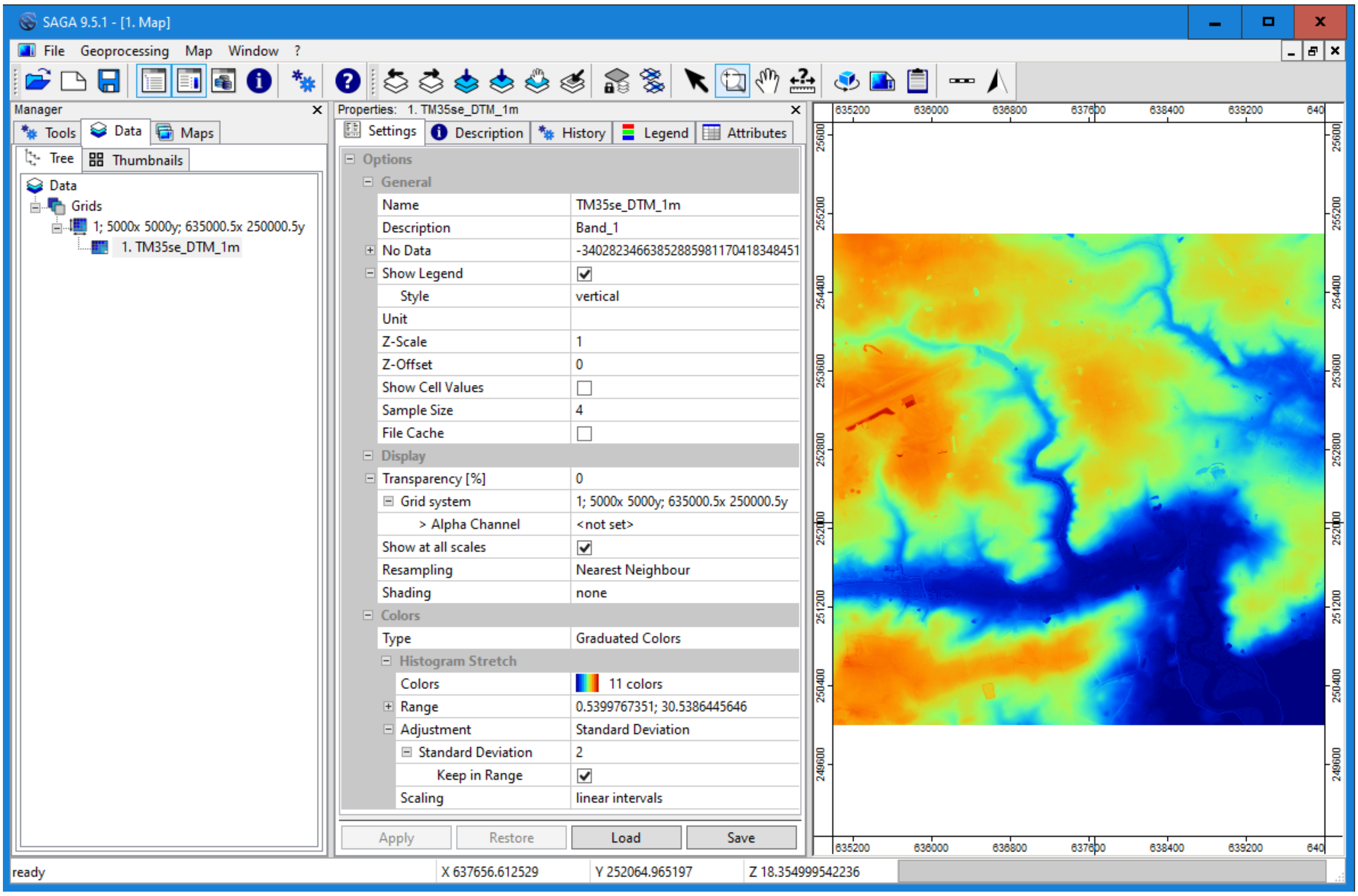
Chapter 7: An introduction to processing LiDAR data in SAGA-GIS.

SAGA-GIS is the GIS application which I've been using since I started working with LiDAR. QGIS is, I think, a more widely used alternative for this purpose, but I find SAGA-GIS does most of what I need very satisfactorily. It offers great scope for controlling the way templates are displayed in OOM. Both are free, open source, applications. I'm currently using SAGA-GIS version 9.5.1, downloadable here. (If you find that clicking "Download Latest Version" doesn't result in a correct installation, try navigating to an alternative download via "SAGA-9" / "SAGA-9.5.1" / "saga-9.5.1_x64_setup.exe")

If you are new to SAGA-GIS you may find it helpful to follow the procedures described in this chapter as an introduction. You will need to have one or more DTM LiDAR tiles downloaded into your LiDAR sub-folder ready to load into SAGA-GIS. The examples below use the two DTM tiles for Tunstall Forest, downloaded as described in Chapter 6.

Initially I found the scope of SAGA-GIS a little off-putting. It's capable of doing a vast amount more than orienteering mappers require. But I've now developed a set of routines in SAGA-GIS for processing LiDAR data which work well. There was a lot to learn initially, but now they've become familiar, the processes described here go quite quickly, and I'm very happy to recommend them.

To start SAGA-GIS open the file "saga_gui.exe" which is one of many files saved when you download the application. I've created a shortcut to this on my desktop. The screenshot below was taken after I'd started SAGA-GIS and loaded one of my two 5km DTM tiles for Tunstall Forest.



Options	
General	
Name	TM35se_DTM_1m
Description	Band_1
No Data	-340282346638528859811704183484516
Show Legend	☑
Style	vertical
Unit	
Z-Scale	1
Z-Offset	0
Show Cell Values	☐
Sample Size	4
File Cache	☐
Display	
Transparency [%]	0
Grid system	1; 5000x 5000y; 635000.5x 250000.5y
> Alpha Channel	<not set>
Show at all scales	☑
Resampling	Nearest Neighbour
Shading	none
Colors	
Type	Graduated Colors
Histogram Stretch	
Colors	11 colors
Range	0.5399767351; 30.5386445646
Adjustment	Standard Deviation
Standard Deviation	2
Keep in Range	☑
Scaling	linear intervals

X 637656.612529 Y 252064.965197 Z 18.354999542236

Three windows are visible. On the left is the "Manager" window, although I usually have it set with "Data" and "Tree" selected as shown and will refer to it as the "Data" window.

You can load LiDAR data tiles using "File" / "Open" or, more simply, by dragging and dropping your files into the Data window. If your computer downloads LiDAR data as a zipped folder, you must first unzip using "Extract All". For LiDAR tiles you only need to drag and drop the .tif file (the largest file). SAGA-GIS automatically reads the associated small .tfw file, provided it's in the same folder. Any other small files in the unzipped folder can be ignored.

The data window above displays two lines, under the heading “Grids”, for the 5km LiDAR tile I’ve loaded. First is the “Grid System”, in this case “1; 5000x 5000y; 635000.5x 250000.5y”. These figures indicate:

“1”	the size of each cell (or pixel) in metres
“5000x 5000y”	the number of columns and rows in the tile (5000 for a 5km tile).
“635000.5x 250000.5y”	the OS coordinates, in metres, of the SW corner of the tile.

The coordinates given are not of the actual SW corner of the tile, but the centre of the SW-most 1m cell – so 0.5m in from the corner. SAGA-GIS generally references tiles this way.

The second line in the data window just gives the filename of the tile I’ve downloaded from the DEFRA LiDAR download site. It’s identified here, for a Composite LiDAR tile, as “TM35se_DTM”, It’s slightly different for a National LiDAR Programme tile, where the same tile is identified by its SW corner, as TM3550, and the filename also includes the survey date. The initial “1” is added by SAGA-GIS to indicate that this is the first tile created under this Grid System. Individual data tiles are normally referred to in SAGA-GIS as a “grid”, though I’ll continue to use “tile”.

The central window in the SAGA-GIS screen displays the “Properties” of the selected tile. A single click on the tile name in the Data window, displays its properties. (A double click may sometimes be necessary). I’ve left these set to their default values for now.

The right hand “Map” window displays the current image. If this is not visible, double click the relevant tile name in the Data window and select “New” if prompted. The icons in the right-hand section of the top tool bar enable the actions of panning, zooming and zooming to full extent in the Map window. The axes of the map window depend on the Grid System. Here they display the OS 12 figure (1 metre) coordinates. Hover your curser over the Map window and the X, Y coordinates of your cursor position are displayed in the bottom bar, as is a “Z” value, which in this case – a DTM tile - measures altitude.

SAGA-GIS may open with other windows visible, for example the “Data Source” window and the “Messages” window. For clarity, I’ve closed these using icons in the left-hand section of the top tool bar. The bottom right-hand section of the screen displays a green progress bar when work is in progress.

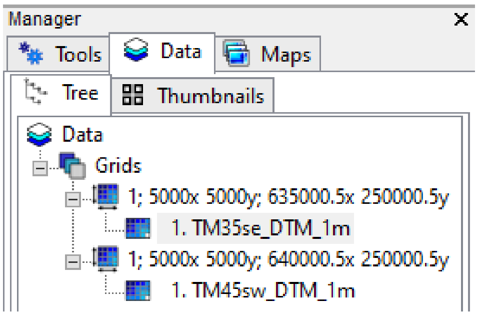
SAGA-GIS has several hundred tools for processing data of which I’ve so far only used a handful. In this introductory chapter, I will describe how to use the “Mosaicking” tool to merge and crop tiles. I will also give an example of how to alter the display parameters of the resulting tile in the Properties window. The following chapters then describe how to produce the range of different templates from LiDAR that I use to create base maps in OOM.

Merging and Cropping Tiles in SAGA-GIS

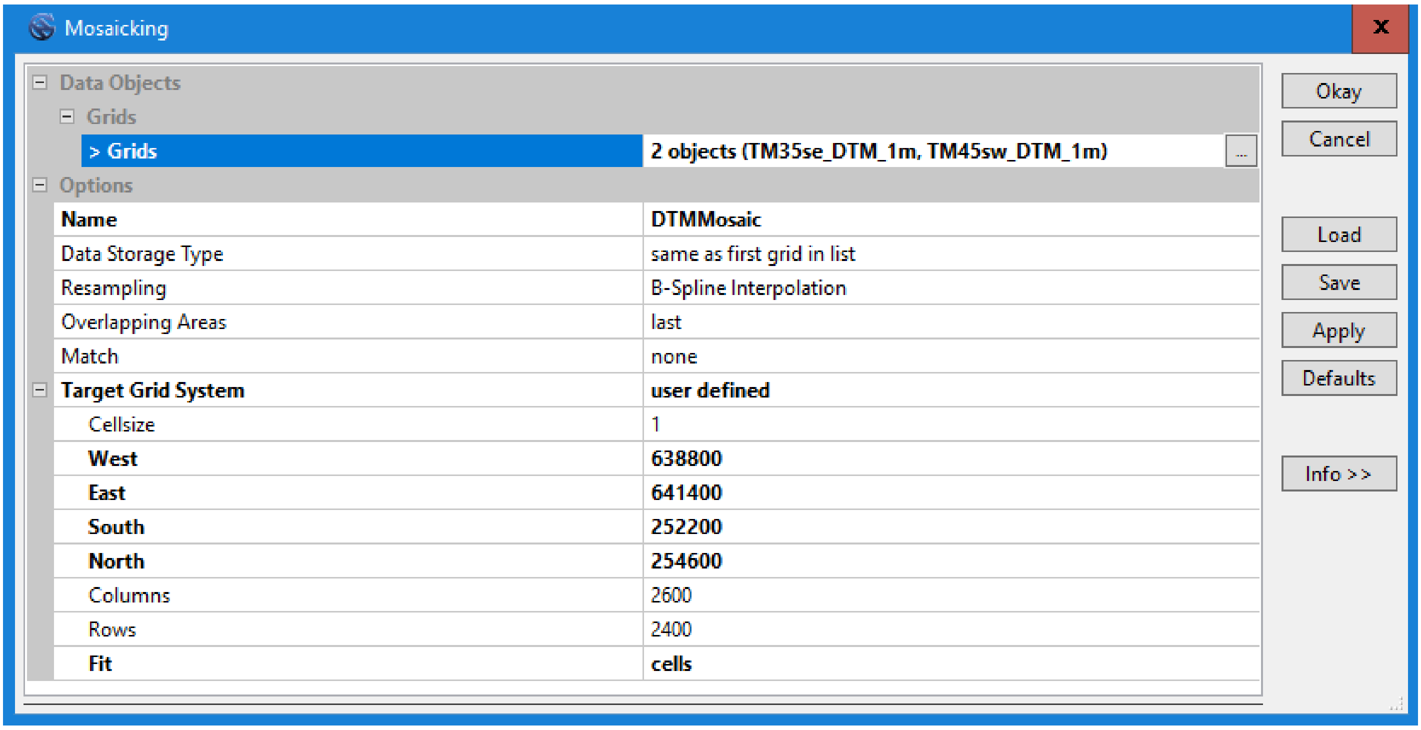
I’ll assume here that you have already recorded the bounding coordinates of your footprint as described in Chapter 2. For this Tunstall Forest footprint these coordinates are 638800, 641400, 252200 and 254600 -- in the order West, East, South, North.

If more than one 5km LiDAR tile is required to cover your map footprint, as at Tunstall Forest, you first need to merge the tiles using the SAGA-GIS “Mosaicking” tool which merges two or more tiles and also crops the merged image to your bounding rectangle. If you only need one 5km tile, you can also crop this to your bounding rectangle using the “Mosaicking” tool.

For Tunstall Forest, I must first load, or drag and drop, my second DTM tile into the SAGA-GIS data window. Each tile will be displayed with its own grid system as in the screen extract opposite. This step is omitted if you have only one tile.



SAGA-GIS tools can be selected by clicking the “Tools” button in the Data window, but this is not very helpful unless you know where the tool is located among the hundreds of tools in the SAGA-GIS filing system. Instead, I use the “Find and Run Tool” icon on the top toolbar (the cogs). Click this and you can then enter a few initial letters of the tool you want (eg “mos” for “mosaicking”). Click or double click “Okay”, and then choose the correct tool from a drop-down list. In this case, choose “[grid_tools] Mosaicking”. “[Grid Tools]” just refers to the folder in which the “Mosaicking” tool is located. The tool’s parameters are then displayed in the dialogue shown below.



Data Objects
Grids

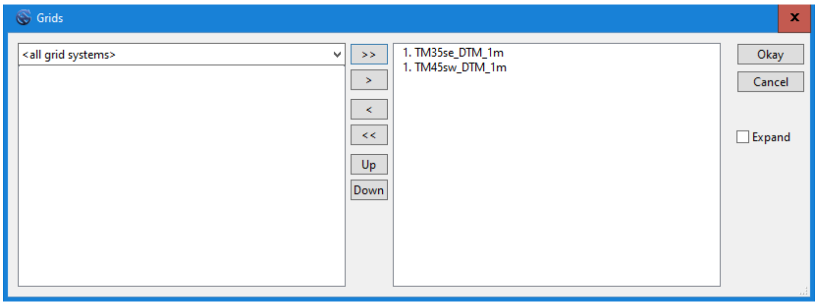
> Grids	**2 objects (TM35se_DTM_1m, TM45sw_DTM_1m)**

Options

Name	**DTMMosaic**
Data Storage Type	same as first grid in list
Resampling	B-Spline Interpolation
Overlapping Areas	last
Match	none
Target Grid System	**user defined**
Cellsize	1
West	**638800**
East	**641400**
South	**252200**
North	**254600**
Columns	2600
Rows	2400
Fit	**cells**

It’s worth noting here that entering parameters in SAGA-GIS is always done either by typing text (always clicking “Okay” or keying Enter to finish – twice if necessary), by selecting from a drop-down list, or by clicking an ellipsis (…) which opens another dialogue window.

For all tools you first need to confirm the tiles (or “Grids”) that you want the tool to operate on, in this case by selecting the “Grids” line and clicking the ellipsis (…). This displays a new dialogue box as shown opposite. I’ve moved the tiles I want – both in this case - over to the right-hand window. Clicking “Okay” loads both tiles into the “Grids” line as shown above.



<all grid systems>

1. TM35se_DTM_1m
1. TM45sw_DTM_1m

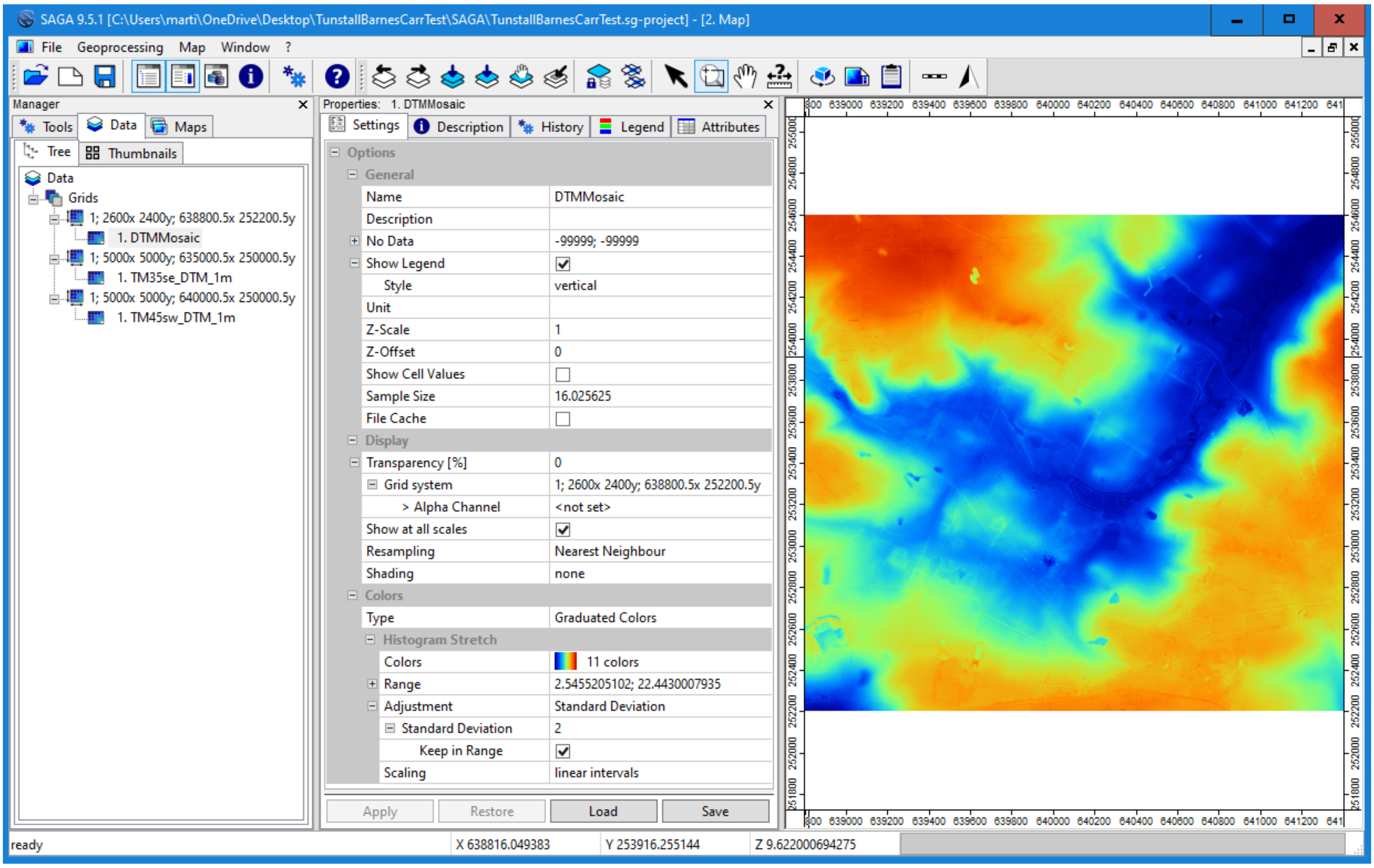
I then set “Target Grid System” to “user defined” and “Fit” to “cells”. I can then enter the bounding coordinates of the Tunstall Forest footprint as shown above. I also named the new merged tile “DTMMosaic”. I’ve left the other parameters set at their default values.

Click “Okay” (twice if necessary) and the mosaicking tool will merge the tiles, if you have more than one, and crop to the defined footprint in one go. A new Grid System with the DTMMosaic tile will appear in the Data window. Setting “Fit” to “cells” allows you to use whole number bounding coordinates to define your cropped footprint as in the screenshot. The new Grid System is automatically defined in the Data window by the coordinates of the centre of its SW-most cell, in this case 638800.5 and 252200.5.

Having completed this task, it’s worth saving your project. When working in SAGA-GIS, I regularly save using “File” / “Project” / “Save Project As” the first time, and just “Save” thereafter. Tick “Save All” if an additional window requesting this appears before saving. You need to save in a dedicated folder for this SAGA-GIS project as lots of files are saved. I usually save in a “SAGA” sub-folder in my project folder for the current map. I made the mistake once of saving a SAGA-GIS project straight to my desktop and filled the whole desktop with SAGA-GIS file icons!

You can then close SAGA-GIS if you need to, and re-open it in the same state later. The saved project should appear in a list of options when you re-open SAGA-GIS next time, or you can use “File” / “Project” / “Load Project”. The original downloaded tiles may not be saved when you save a project, but any processed tiles will be. I‘d advise keeping your work saved because I’ve found in the past that SAGA-GIS will very occasionally respond to a command it can’t execute by closing down without an error message. This hasn’t happened, though, with more recent SAGA-GIS versions.

The next screenshot shows the DTMMosaic tile for my Tunstall Forest footprint in the Map window. This is displayed by double clicking DTMMosaic in the Data window and selecting “New” in the next dialogue box if requested. I’ve left all the parameters in the Properties window set at their default values for now.


SAGA 9.5.1 [C:\Users\marti\OneDrive\Desktop\TunstallBarnesCarrTest\SAGA\TunstallBarnesCarrTest.sg-project] - [2. Map]

Data
- Grids
  - 1; 2600x 2400y; 638800.5x 252200.5y
    - 1. DTMMosaic
  - 1; 5000x 5000y; 635000.5x 250000.5y
    - 1. TM35se_DTM_1m
  - 1; 5000x 5000y; 640000.5x 250000.5y
    - 1. TM45sw_DTM_1m

Properties: 1. DTMMosaic

Options	
General	
Name	DTMMosaic
Description	
No Data	-99999; -99999
Show Legend	☑
Style	vertical
Unit	
Z-Scale	1
Z-Offset	0
Show Cell Values	☐
Sample Size	16.025625
File Cache	☐
Display	
Transparency [%]	0
Grid system	1; 2600x 2400y; 638800.5x 252200.5y
> Alpha Channel	<not set>
Show at all scales	☑
Resampling	Nearest Neighbour
Shading	none
Colors	
Type	Graduated Colors
Histogram Stretch	
Colors	11 colors
Range	2.5455205102; 22.4430007935
Adjustment	Standard Deviation
Standard Deviation	2
Keep in Range	☑
Scaling	linear intervals

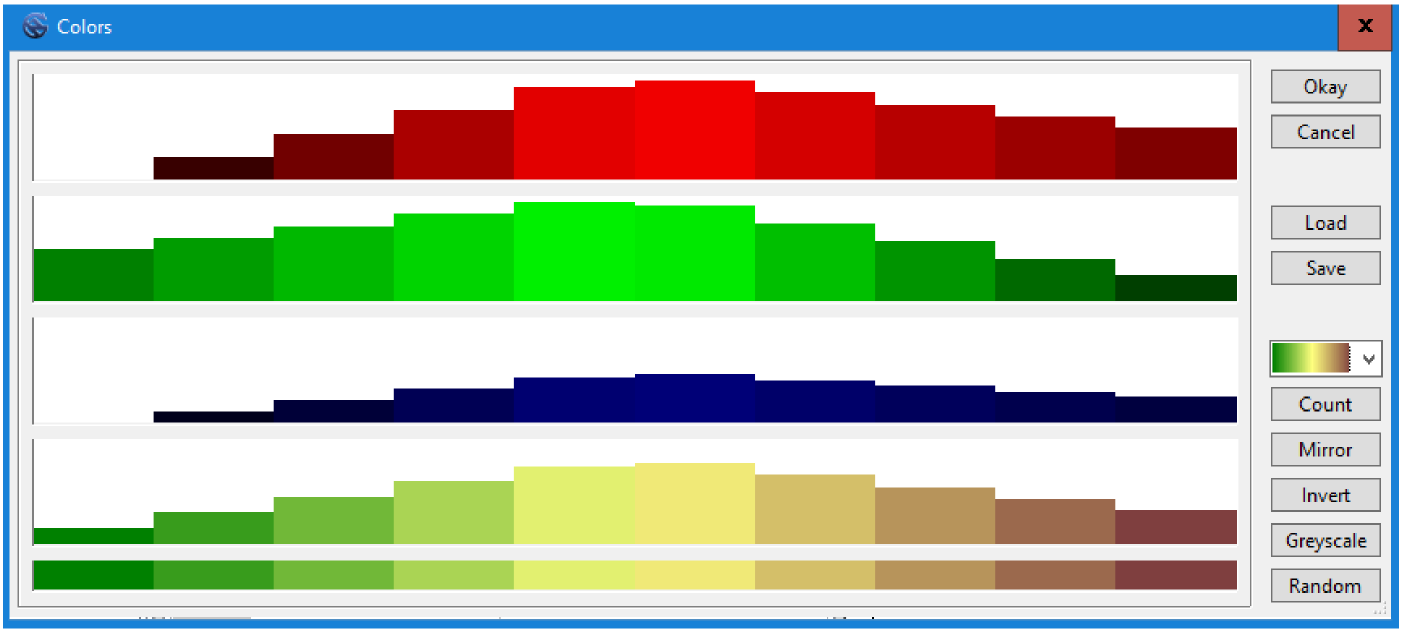
ready | X 638816.049383 | Y 253916.255144 | Z 9.622000694275

Creating a template for opening in OOM

I describe next how to adjust the parameters in the Properties window to “improve” an image before saving it as a template. The screenshot overleaf shows the same cropped Tunstall footprint after the following adjustments.

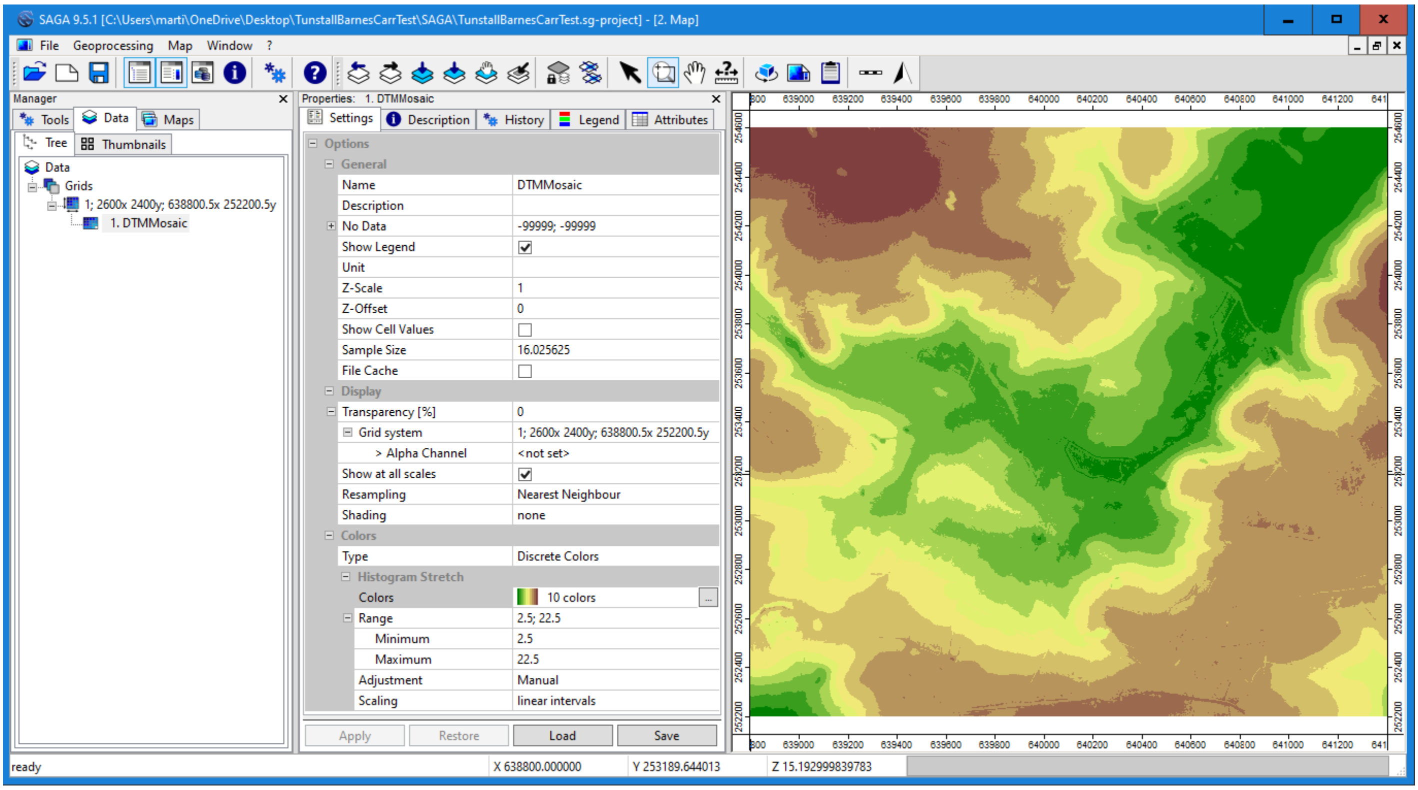
To obtain the image overleaf, I made adjustments in the “Colors” section of the Properties window (forgive the American spellings). I set the “Type” to “Discrete Colors”. The “Range” initially shows the minimum and maximum altitudes recorded in this tile. I’ve rounded these to 2.5m – 22.5m. I then chose the actual colours by clicking the ellipsis (…) in the “Colors” line which opens the first window overleaf.

In this window, I’ve set the “Count” = 10. I’ve then chosen the green / yellow / brown colourway from the rainbow dropdown which gives a familiar green = low, brown = high relief map. (Scroll down first, and it’s the 11th option up from the bottom of the palette). I then clicked “Okay”. It’s best to select the colourway after selecting the “Count”.



The DTM data for this footprint conveniently allowed me to set the “Range” and “Count” figures so that the colour interval is 2.5m, which divides exactly into my final contour interval for this map, which will be 5m. It won’t always fit that easily, and isn’t critical. The Count is best set between 10 and 20 if possible.

To save changes in the Properties window you must first key “Enter” after the last change, then click “Apply” at the bottom of the Properties Window. If your changes don’t display in the Map window just double click the relevant tile in the Data Window and select “New”.



SAGA 9.5.1 [C:\Users\marti\OneDrive\Desktop\TunstallBarnesCarrTest\SAGA\TunstallBarnesCarrTest.sg-project] - [2. Map]

Data
Grids
1; 2600x 2400y; 638800.5x 252200.5y
1. DTMMosaic

Options	
General	
Name	DTMMosaic
Description	
No Data	-99999; -99999
Show Legend	☑
Unit	
Z-Scale	1
Z-Offset	0
Show Cell Values	☐
Sample Size	16.025625
File Cache	☐
Display	
Transparency [%]	0
Grid system	1; 2600x 2400y; 638800.5x 252200.5y
> Alpha Channel	<not set>
Show at all scales	☑
Resampling	Nearest Neighbour
Shading	none
Colors	
Type	Discrete Colors
Histogram Stretch	
Colors	10 colors
Range	2.5; 22.5
Minimum	2.5
Maximum	22.5
Adjustment	Manual
Scaling	linear intervals

ready X 638800.000000 Y 253189.644013 Z 15.192999839783

Saving your Template

I keep all my finished templates in my dedicated “Maps and Templates” sub-folder in the project folder for this map. To save this image as a template, right click “DTMMosaic” in the Data window and click “Save as Image” to save in your templates folder. I save this template in .png format, with the filename “Altitude”. In the next dialogue window tick to save the “Georeference” but not the “Legend”. This will create a small .pgw file with the geo-referencing information which must be kept with the .png file.

Creating a coloured relief template like this makes a good introduction to the basic processes for handling LiDAR data in SAGA-GIS. However, I’ve not found it a particularly useful template in practice. I’ve sometimes found it useful in complex contour areas to confirm what’s “up” and what’s “down”. But for most relief features I rely on contour and hillshade templates as described in the next chapters. I also describe there how to “smooth” the excessively jagged edges evident in this image.

Opening your template in OOM.

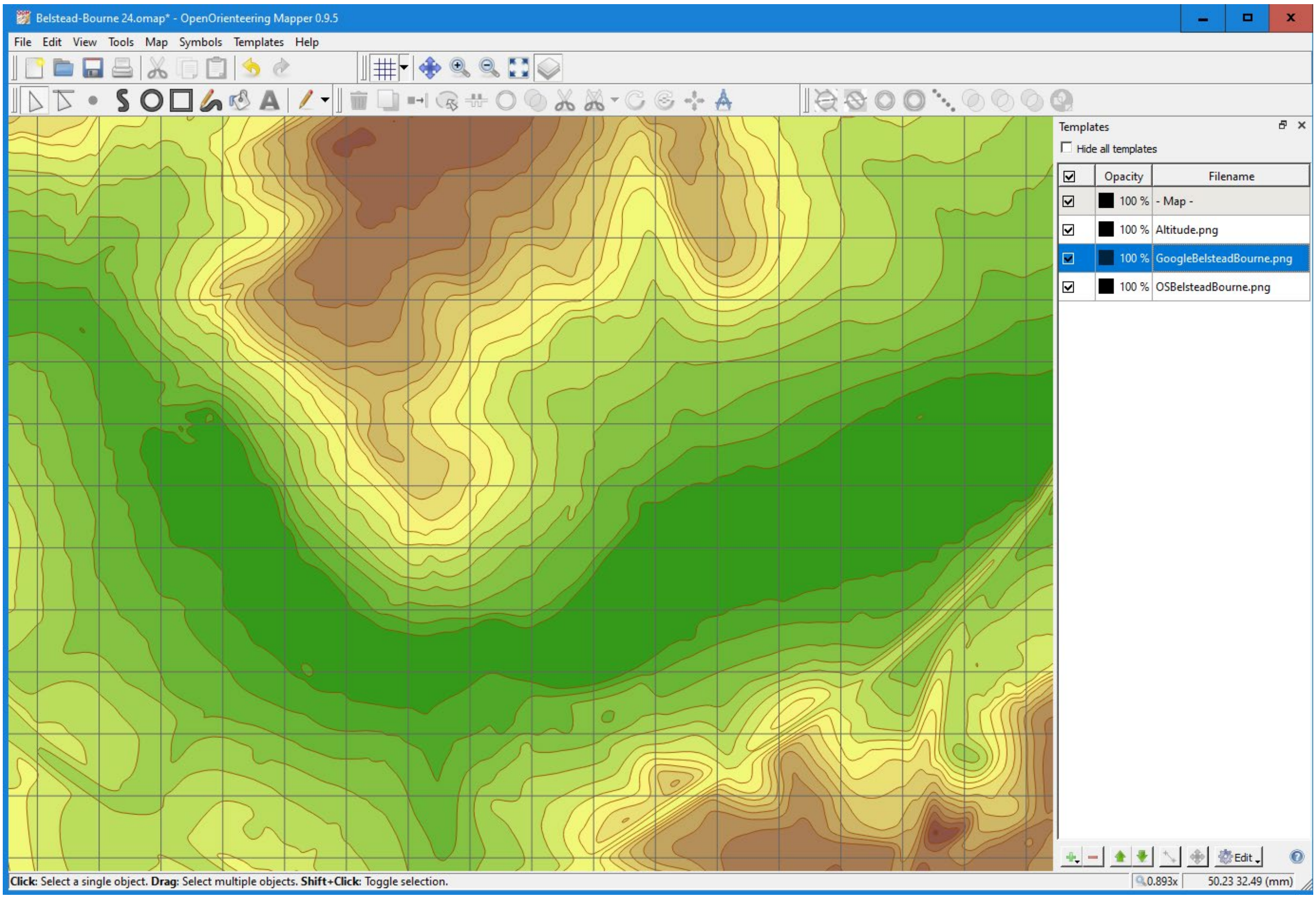
I’ve assumed here that you have followed the procedure described in Chapter 3 and already have your new georeferenced map prepared, with at least your OS template loaded. The notes and screenshots below, and in the following chapters, assume that you’ve set a false “declination” so that the map’s grid aligns to OS grid north. If you’ve chosen to align your base map to magnetic north the LiDAR templates will open skewed on the screen, but they are still perfectly useable.

To open your Altitude template in OOM you just need to follow the same procedure as for your OS Map template, as described in Chapter 3.

The template should appear in the correct location and correctly aligned. Provided you’ve used the same footprint coordinates as for your OS map and Google photo templates it will exactly overlay those. It will also be listed in the OOM template setup window.

The following screenshot illustrates the result to expect in OOM. This is a zoomed extract from a new 1:4000 map I’m currently working on of a country park in Ipswich. This actually shows a “smoothed” altitude template layered underneath similarly smoothed imported contours. In this rather hillier terrain, close to the Orwell estuary, my rounded altitude Range was 0m – 40m, the contour interval I want for the final map is 2.5m, and I chose a Count of 16 which nicely equalises my contour and colour intervals.

In the next chapter I describe how to produce smoothed altitude templates and contour lines from DTM data in SAGA-GIS.



☐ Hide all templates

☑	Opacity	Filename
☑	100 %	- Map -
☑	100 %	Altitude.png
☑	100 %	GoogleBelsteadBourne.png
☑	100 %	OSBelsteadBourne.png

Click: Select a single object. **Drag:** Select multiple objects. **Shift+Click:** Toggle selection.

0.893x 50.23 32.49 (mm)

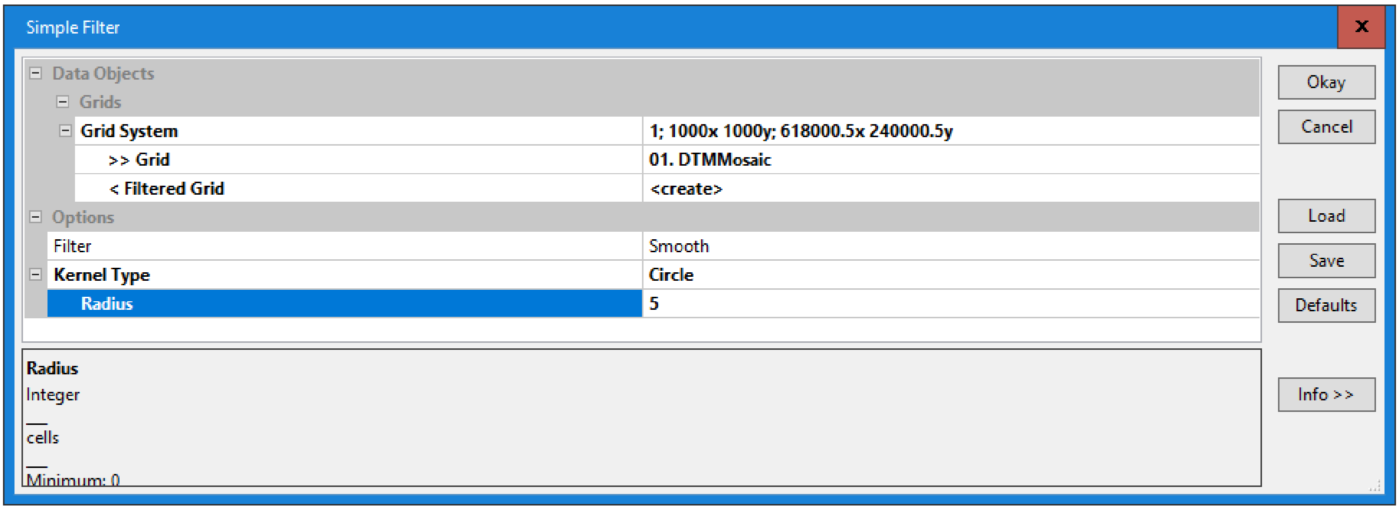
Chapter 8: Obtaining Contours from LiDAR

I’ve used Bridge Wood, near Ipswich, to illustrate this chapter as it is a much hillier area than Tunstall Forest. My Bridge Wood footprint is completely contained within one 5km DTM LiDAR tile. No merging of tiles is required but I used the mosaicking tool in SAGA-GIS to crop the 5km tile to match the Bridge Wood footprint, as described in the previous Chapter. The footprint coincides with the 1km OS grid square TM1840. The bounding coordinates are 618000, 619000, 240000 and 241000.

I first create contour lines at the final contour interval for the map – normally 5m or 2.5m. Some mappers prefer to use these as a template to trace over, but I prefer to import these directly into OOM. I then produce a “Micro-Contour” template at a smaller vertical interval. This acts as a guide to make fine adjustments to the imported contours and add form lines where appropriate. Smaller interval contour templates can also pick out accurately the positions of features such as small pits and knolls.

Contours can be created in SAGA-GIS straight from a DTM LiDAR tile, but these tend to be rather jagged with a lot of “noisy” detail which is not evident on the ground. For better results I first apply some “smoothing” in SAGA-GIS using the “Simple Filter” tool.

Confusingly, there are two “Simple Filter” tools in the current SAGA-GIS toolkit. The correct one is prefixed “[Grid Filter]” and has the parameter options as set out in the next screenshot. The incorrect one has an extra line.



Data Objects
- Grids
  - Grid System: 1; 1000x 1000y; 618000.5x 240000.5y
    - >> Grid: 01. DTMMosaic
    - < Filtered Grid: <create>

Options
- Filter: Smooth
- Kernel Type: Circle
  - Radius: 5

Radius
Integer
cells
Minimum: 0

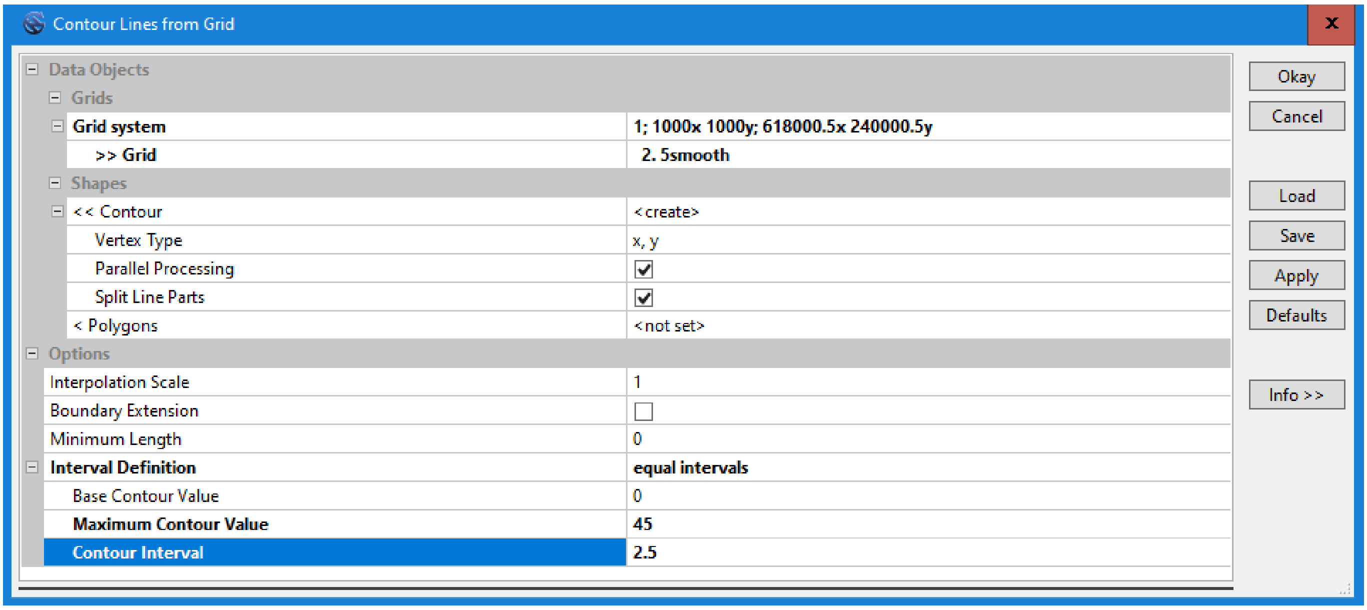
The screenshot shows the Grid System and Grid already set. I’m using here the “DTMMosaic” tile that I’ve created for Bridge Wood following the procedure in Chapter 7. **“Filtered Grid” is set to “create” – this is important.** “Filter” and “Kernel Type are set to their default values. The key setting is “Radius”.

To produce smoothed contours for direct import into OOM I’ve set the radius to 5. The contours then normally require little further smoothing in OOM. Some undoing of the smoothing may be needed to match detail that has been smoothed out in areas with complex contour detail, but I find this easier than starting with too little smoothing and having to adjust the contours to impose it across the entire map in OOM. You may want to experiment with different smoothing levels to achieve a result that works best for you. I often use radius 10 instead of 5 as I’ve found it works better in less hilly areas - ie most of Suffolk!

For “Micro-Contour” templates at smaller intervals, I normally process the DTMMosaic tile a second time with the radius set at 2. This reduces the jaggedness without smoothing out useful detail. Don’t forget to set “Filtered Grid” to “create”; otherwise SAGA-GIS will overwrite the previous tile. You may prefer to use 1 as this second radius value to create micro-contour templates, or just stick with the unsmoothed tile.

With the parameters set, click “Okay” to generate a new tile in the Data window called “DTMMosaic [Smoothed]” (with a new serial number). I rename these as eg. “5smooth” or “2smooth”. To do this, just edit the name in the Properties window, and key Enter twice.

The contour lines themselves are created using the “Contour Lines from Grid” tool. The next screenshot shows the parameters set to produce contours from the “5smooth” tile to import directly into OOM at a final 2.5m interval. I’ve set the contour interval to 2.5m and expanded the “Base” and “Maximum” values as necessary to fit this interval. “Contour” is set to “create”.



Data Objects	
Grids	
Grid system	**1; 1000x 1000y; 618000.5x 240000.5y**
>> Grid	**2. 5smooth**
Shapes	
<< Contour	<create>
Vertex Type	x, y
Parallel Processing	☑
Split Line Parts	☑
< Polygons	<not set>
Options	
Interpolation Scale	1
Boundary Extension	☐
Minimum Length	0
Interval Definition	**equal intervals**
Base Contour Value	0
Maximum Contour Value	**45**
Contour Interval	**2.5**

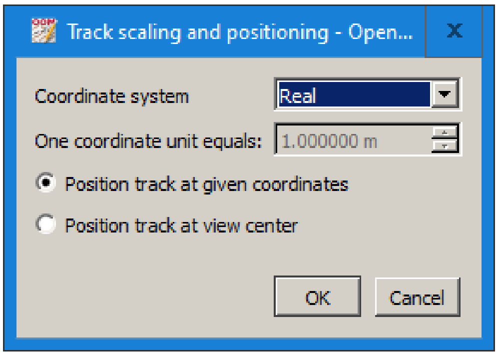
Contour tiles are vector files (“shapefiles”) rather than raster (pixel) images. Click “Okay” and a new shapefile will appear in the Data window under the sub-heading “Shapes”. If you double click this to view the contours in the map window the contours may be an odd colour but you can ignore this.

I then repeat the process to produce one or more additional shapefiles with reduced contour intervals from which I can create my “micro-contour” template. For these I start from the “2smooth” tile. **Remember to set “Contour” to “create” in the tool parameter window to avoid overwriting the previous contours**. I normally produce two additional shapefiles for this purpose. If my final contour interval will be 2.5m, as at Bridge Wood, I normally produce these at 0.5m and 0.1m intervals. If the final contour interval is to be 5.0m, I normally produce one at 1.0m interval and one at 0.2m interval. These shapefiles may take a while to prepare. There is a green progress indicator to reassure you.

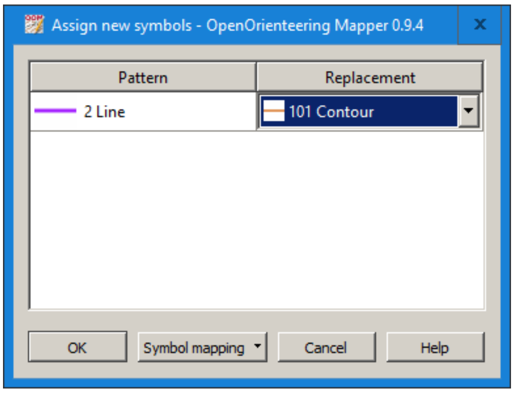
To save a shapefile, right click on it in the Data window and “Save as” (rather than “Save as Image”) in a “Shapefiles” sub-folder in your project folder. My computer automatically truncates shapefile names at a decimal point, so I normally rename them using eg “50cm” rather than “0.5m”. Several files are saved each time. The .shp file holds the data but the other files should also be kept in the sub-folder.

Loading the contours in OOM

The smoothed contours at the final contour interval can now be imported directly into the georeferenced OOM map. I find this best to do before drawing other features on the map. In OOM I select “File / Import” from the menu bar, and navigate to and open the correct .shp file. I then just click “OK” in the next window below, if it appears, and select the contour symbol in the second window. Click “No” when then asked if you want to save the cross-reference table.



Coordinate system: Real
One coordinate unit equals: 1.000000 m
● Position track at given coordinates
○ Position track at view center



Pattern	Replacement
2 Line	101 Contour

The imported contours should then appear as map objects, correctly positioned. They should all be selected, but, if not, you can easily select them all in the normal way, especially if nothing else has been drawn on the map. I then use OOM's "convert to curves" tool followed by the "simplify path" tool to simplify the contour lines – this doesn't significantly displace them, but it makes them less memory-intensive and much easier to edit. "Convert to curves" can take a few minutes for a large map footprint. You can then change every fifth contour to an index contour. It's possible to automate this, by creating and importing an additional shapefile at the index contour interval, but we have relatively few contours on most SUFFOC maps so I find it's easier to do it by hand. The full process, as described above, is not especially quick, but it's a lot quicker than manually drawing the contours by tracing over templates.

Producing a Micro-Contour template.

The shapefiles generated at smaller contour intervals can be opened as individual templates in OOM. Select "Templates" / "Open Template", and navigate to and open the correct .shp file.

However, my standard practice now is to create a single micro-contour template as a separate OOM file. I find it easier to handle having just one template. I can also adjust the line thicknesses to make it easier to read – the lines in small-interval contour templates saved directly from SAGA-GIS are often too thick and just merge into solid purple on steep ground. Another advantage is that, when I'm finished, I can delete my shapefiles sub-folder which otherwise takes up significant memory on my hard drive.

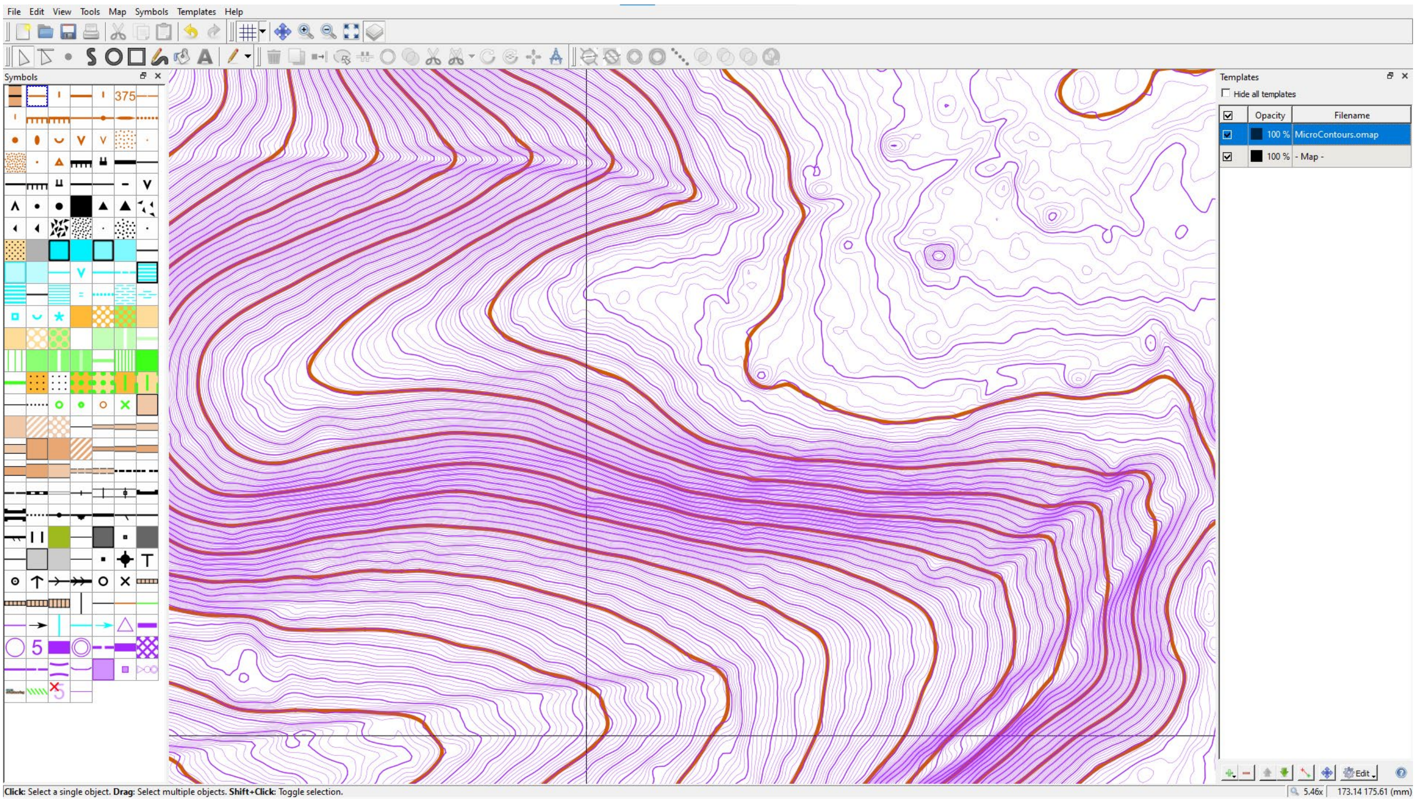
In Chapter 3, I recommended creating an OOM file named "MicroContours", as a mirror copy of the original georeferenced, but otherwise blank, map file. I do this before adding any templates or map objects. (If you've not already done this, you can create a copy of the OOM map file at this stage, name it "MicroContours", and then delete from the copy all map objects drawn so far, and all templates. **Make sure it's the *copy* you are working on before doing this, not your main map file!** To delete all map objects, select "Edit"/ "Select All" and press Delete. To delete templates, select the template in the template setup window, and click the "-" sign at the foot of the window.)

Then, in my "MicroContours" OOM file, I first create two new line symbols – easiest by creating a duplicate of a suitable existing line symbol and editing its properties. (Right click on the symbol to edit or duplicate). I choose purple as the line colour for both symbols, and 0.02mm and 0.05mm as the respective line widths. These are deliberately very thin lines which may not display unless zoomed in. You may prefer different line widths depending on the nature of your terrain – 0.01mm is the narrowest permitted. I then *import* the two shapefiles I've created at smaller contour intervals, as described for the main contours above. I import the smaller and the larger micro-interval contours as the narrower and less narrow of my two new line symbols, respectively. I omit the "convert to curves" and "simplify paths" actions, mentioned above. They take forever with these micro-contours and are not necessary. I then save the "MicroContours" OOM file in my Maps and Templates sub-folder. It may be quite large.

Returning to the main OOM map file, I can now open the MicroContours OOM file as a template. There may be nothing to show unless you zoom in. Unlike other templates, which I leave below the map in the Templates set-up window, I normally move the MicroContours template *above* the map, as shown in the next screenshot, using the up and down arrows at the foot of the window.

I was initially wary of trusting LiDAR-based contour templates at sub-metre vertical intervals. Intuitively, it didn't seem possible that data sampled at 1m horizontal resolution could produce meaningful contours at such small vertical intervals. However, having now checked in a variety of locations against actual terrain in the field, I'm finding these micro-contour templates very valuable, particularly in identifying the location of pits, knolls, small re-entrants and spurs. Many such features will not be prominent enough to appear on the final map without over-cluttering it, and sometimes LiDAR will introduce misleading artefacts. But, in complex areas, I'm finding that having everything laid out in a remarkably accurate high resolution contour map is a good start from which I can then interpret in the field and generalise for the final map.

The following screenshots show combinations of contours and contour templates to illustrate how the templates assist in creating the base map. The first shows the 2.5m map contours at Bridge Wood with the micro-contours template overlaid. I've zoomed in to show detail. I wouldn't on this basis be making many changes to the map contours in this area. The smoothing looks about right. The template highlights a few “between contour” relief features that are worth noting on the base map for checking in the field.

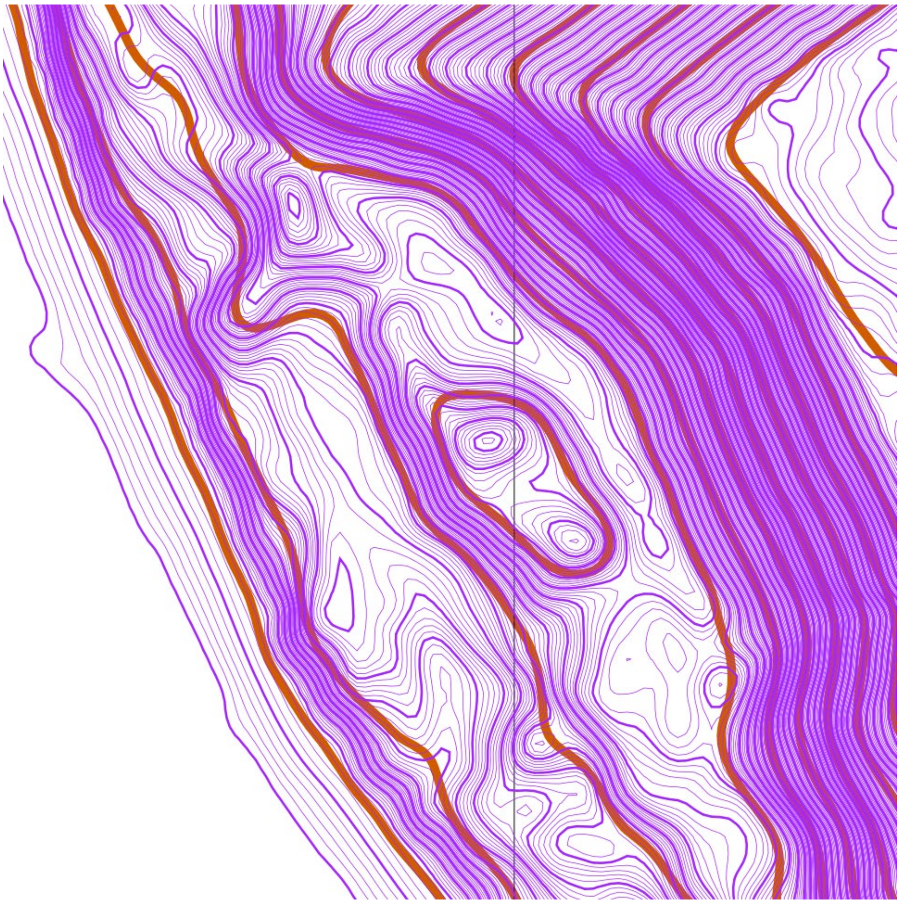


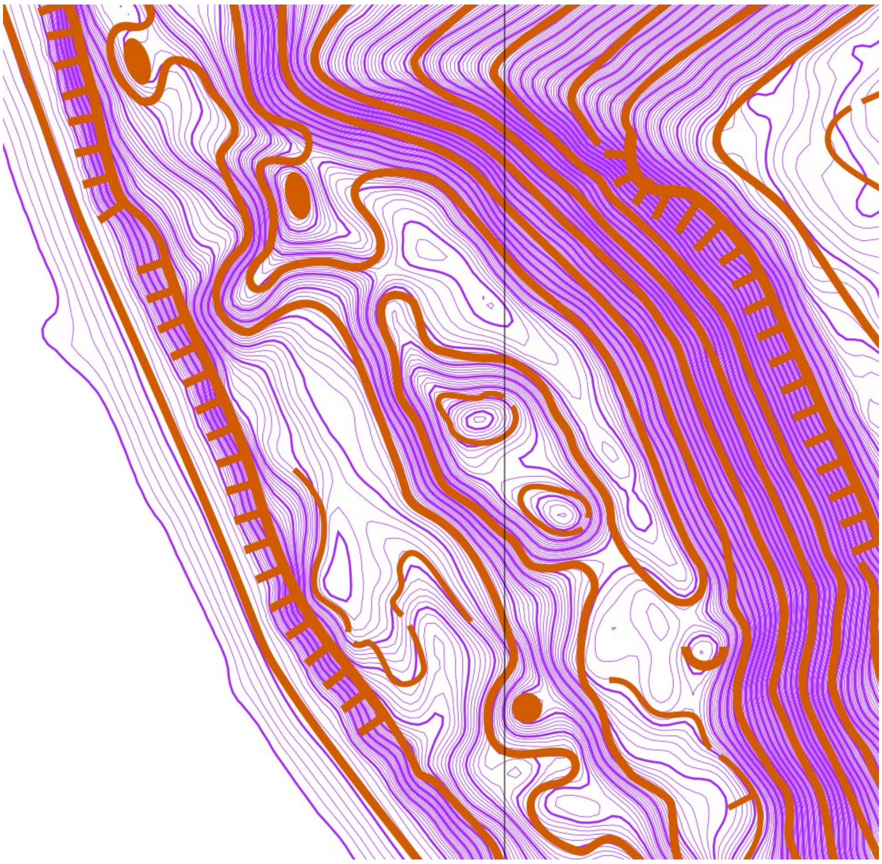
☐ Hide all templates

☑	Opacity	Filename
☑	100 %	MicroContours.omap
☑	100 %	- Map -

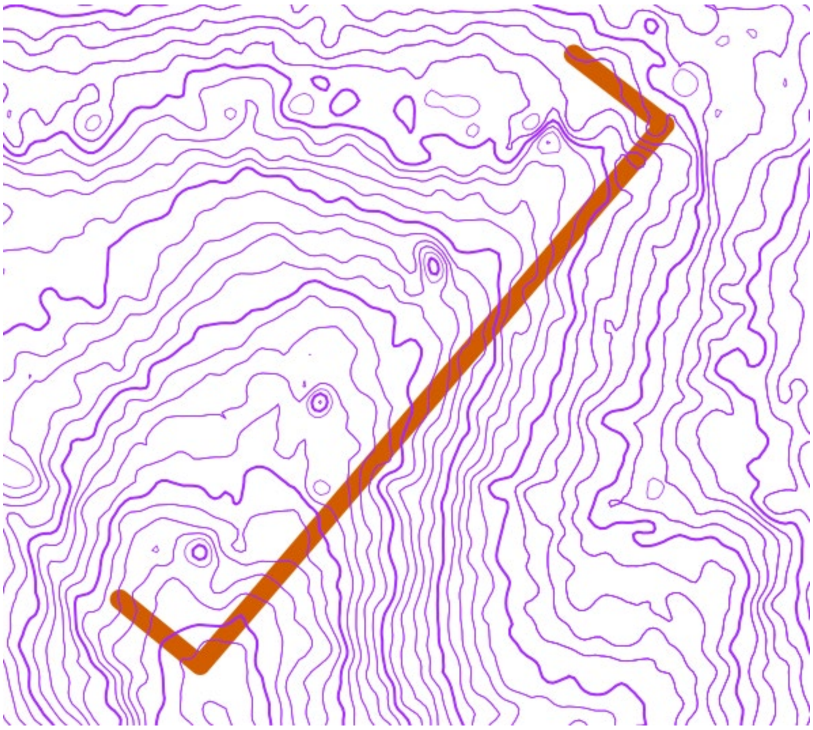
Click: Select a single object. **Drag**: Select multiple objects. **Shift+Click**: Toggle selection.

The second pair of screenshots show the map contours and my micro-contour template zoomed further in to show the most complex part of the map. The first screenshot shows the 2.5m contours as obtained from LiDAR. The second screenshot shows my attempt to interpret the terrain from the micro-contours, and also benefits from a survey visit which confirmed that the micro-contours were remarkably accurate.





The last screenshot shows a small, fairly flat, section of Tunstall Forest where a micro-contour template neatly picks out a line of 4 pits, probably left by bombs discarded from a war-time plane returning to the nearby Bentwaters airfield. We knew they were there from previous mapping, 15 years ago, but didn’t have the positions quite right. They make excellent control sites.



The four pits are clearly defined by several micro-contours in each case. But a lot of the other contour detail apparently revealed here is either “noise” or features which, if they exist, are too small to be shown on a finished map at 1:10,000.

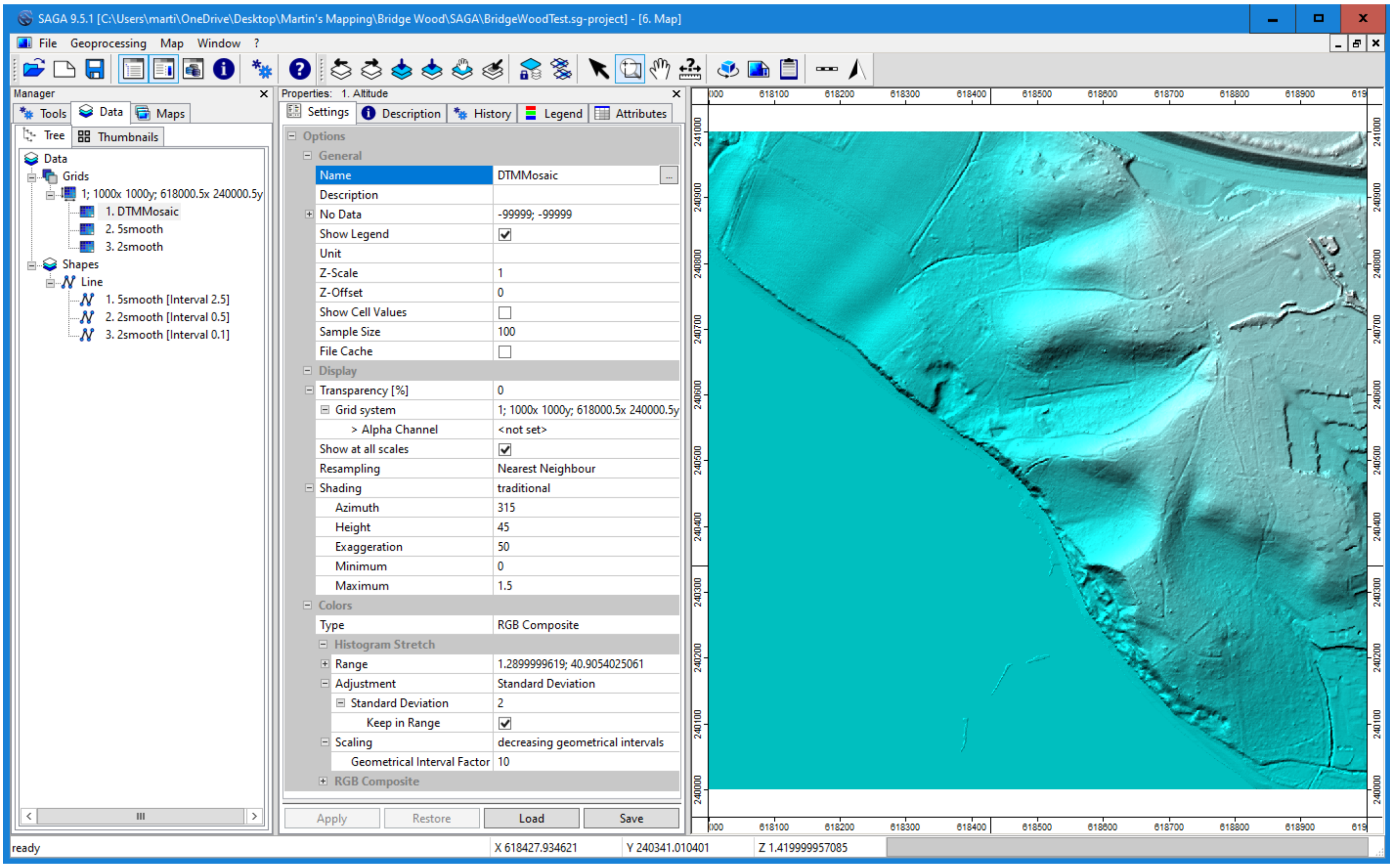
Chapter 9: Obtaining Hillshade Templates from LiDAR

Hillshade templates are very useful for identifying line features such as ditches and earthbanks. They will also highlight footpaths where the line of the path is slightly raised or sunken compared to the surrounding terrain - which it often is. This is very useful in forested terrain where these features are often invisible to aerial photography.

A hillshade template shows darker colours where the terrain is shaded from an imaginary light source. (I'll call it the "sun"). An alternative option, giving similar information, are "slope gradient" templates which show darker colours (or lighter – you can choose) where the gradient is steeper. I generally prefer hillshade templates which are produced directly from DTM LiDAR data as described below. I generally ignore slope gradient templates which are more complicated to produce requiring an additional processing stage in SAGA-GIS using the "Slope, Aspect, Curvature" tool. Readers may like to experiment with this.

Obtaining hillshade templates.

No new SAGA-GIS tool is required to produce simple hillshade templates, just some editing of the properties of the unsmoothed DTMMosaic tile. (Using a smoothed tile gives a less good result). Double click the DTMMosaic tile to display its properties in the Properties window and image in the Map window. (Click "New" if prompted).



SAGA 9.5.1 [C:\Users\marti\OneDrive\Desktop\Martin's Mapping\Bridge Wood\SAGA\BridgeWoodTest.sg-project] - [6. Map]

Properties: 1. Altitude

Options	
General	
Name	DTMMosaic
Description	
No Data	-99999; -99999
Show Legend	☑
Unit	
Z-Scale	1
Z-Offset	0
Show Cell Values	☐
Sample Size	100
File Cache	☐
Display	
Transparency [%]	0
Grid system	1; 1000x 1000y; 618000.5x 240000.5y
> Alpha Channel	<not set>
Show at all scales	☑
Resampling	Nearest Neighbour
Shading	traditional
Azimuth	315
Height	45
Exaggeration	50
Minimum	0
Maximum	1.5
Colors	
Type	RGB Composite
Histogram Stretch	
Range	1.2899999619; 40.9054025061
Adjustment	Standard Deviation
Standard Deviation	2
Keep in Range	☑
Scaling	decreasing geometrical intervals
Geometrical Interval Factor	10
RGB Composite	

ready X 618427.934621 Y 240341.010401 Z 1.419999957085

This screenshot shows the result at Bridge Wood after the appropriate parameters have been set and applied as shown in the Properties window. Some linear features, including paths, are clearly visible. Zooming in displays these more clearly.

The key changes in the Properties window are to "Shading". I've set "Shading" to "traditional". (I mention the alternative "multidirectional" option below). I've set Exaggeration = 50. I've found values between 30 and 150 work well. It's a balance between under-shading small features such as ditches and earthbanks and over-shading hillsides. Higher values work best in flatter areas – Bridge Wood is quite hilly (for Suffolk!) and works well with Exaggeration set at 50. For Tunstall Forest I used 150.

I’ve left “Height” and “Min.” and “Max.” unchanged here from their default values. Height is the virtual sun’s altitude and I’ve sometimes found a lower value, such as 35, is preferable. It may also be worth experimenting with altering the “Max” value a little.

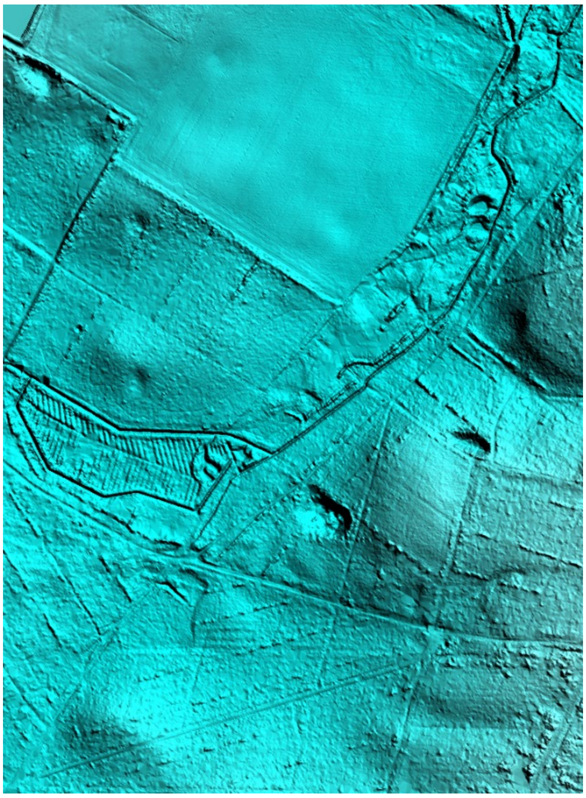
I’ve kept “Azimuth” set at 315 for this template. Azimuth is the direction of the virtual sun, NW in this case. I normally then repeat the process (quickly done) with Azimuth set at 45 (NE). Each resulting template best highlights features running perpendicular to the sun’s direction. You may find it less important to produce two hillshade templates if you choose the “multidirectional” shading option, but I’m not yet convinced. Earlier versions of SAGA-GIS had only one option – “normal”. Hillshade images with SE and SW azimuths are also possible but display an optical illusion. Our brains are used to seeing images lit from above so, in these templates, ditches appear as earthbanks and knolls as pits (unless you invert your screen – or your head!

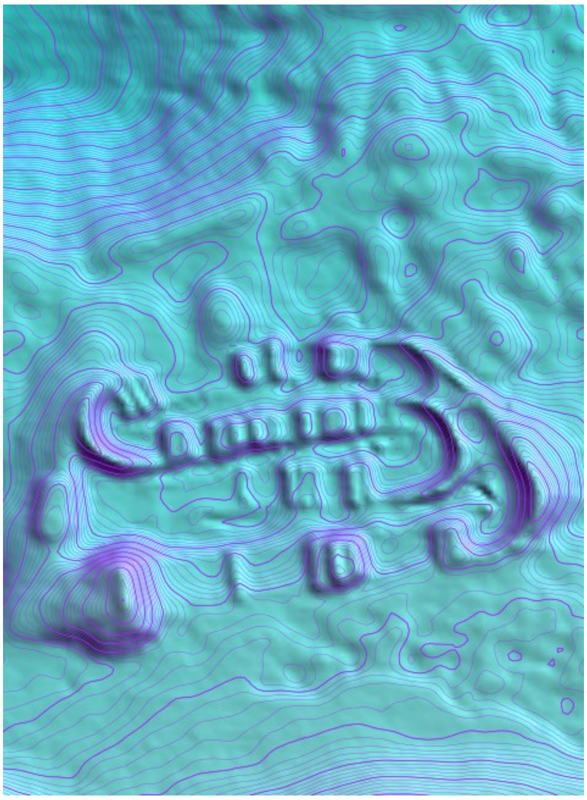
In the above screenshot I’ve also set Color “Type” to “RGB Composite”. I’ve left “Range” as its default, but altered “Scaling” to “deceasing geometric intervals”. This reduces the brightness on sun-facing slopes.

You can experiment with the settings to get the results you prefer. If you select “Single Symbol” as the Color “Type” you can adjust the colour. In “RGB composite” it defaults to cyan. You can set the “Type” to “discrete colors” and adjust the Value Range and the Color window to create a shaded version of the Altitude template described in Chapter 7. It looks very nice, and you might prefer it, but I favour separate templates – a coloured Altitude template without shading, and two cyan Hillshade versions with shading at different azimuths – NW and NE.

This is now ready to be “Saved as Image” exactly as described in Chapter 7. I name my templates “HillshadeNW” etc. For comparison, a section of my recent Tunstall Forest hillshade template is shown below. It shows the main paths quite well, but also many smaller paths, ditches and earthbanks, including rootstock banks. The deep ditches present in this area show up really well. This is a “NE” hillshade template. The corresponding “NW” template gives a useful complementary view.

Sometimes the best results can be obtained by overlaying a micro-contour template over a hillshade template in OOM, as in the second, zoomed in, screenshot of a BMX circuit in Landseer Park Ipswich. This one poses an interesting challenge – how to depict this on the map – possibly just OOB?



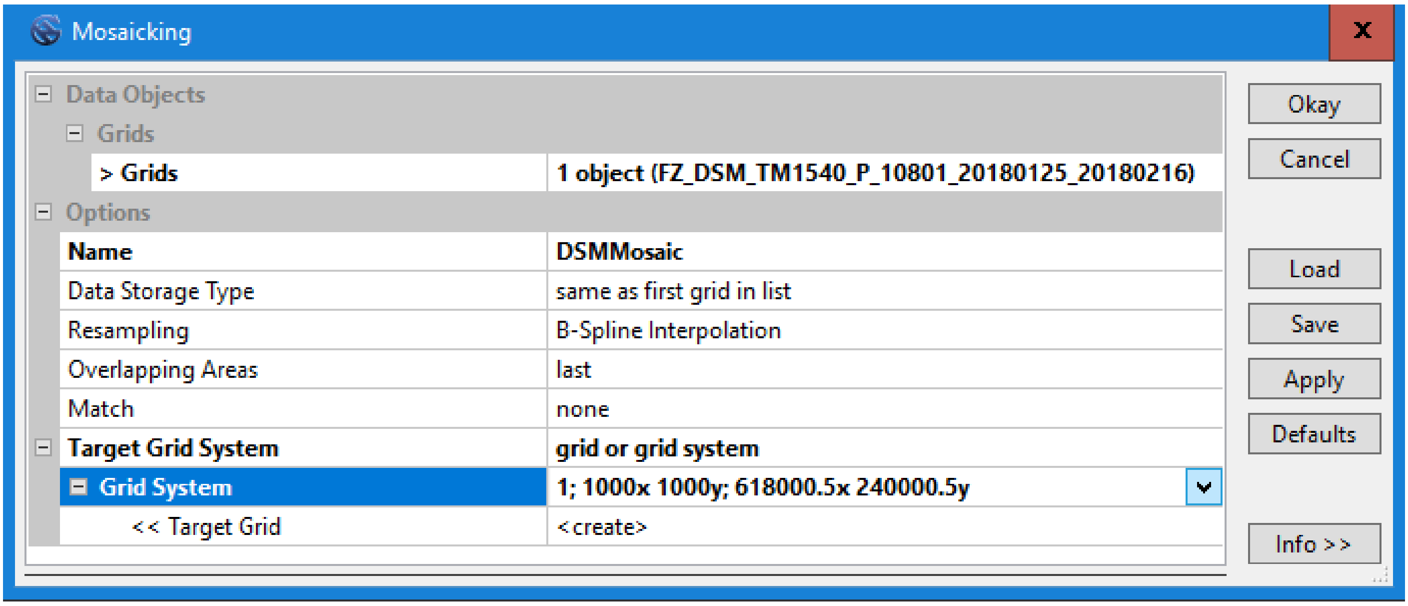


Chapter 10: Obtaining Vegetation and Intensity Templates from LiDAR

In 2020 I wrote: “We are currently fortunate in Suffolk in having relatively recent (2018 - 2020) LiDAR surveys available from the DEFRA National LiDAR Programme”. This is no longer so recent of course, although we do have more recent LiDAR data for some areas in the “Composite” LiDAR datasets. Terrain (DTM) detail tends to change little over time and should remain substantially accurate for many years. Vegetation, however, changes markedly with the season and noticeably from year to year. But currently I find the templates described in this chapter very useful – well worth the effort to produce them.

I normally download DSM and Intensity tiles from the DEFRA LiDAR site at the same time as my DTM tiles. I can then either merge and crop all three datasets in SAGA-GIS in the same session, or leave the DSM and Intensity tiles till later as I’ve done here. All three datasets should end up listed in the SAGA-GIS data window under the same Grid System.

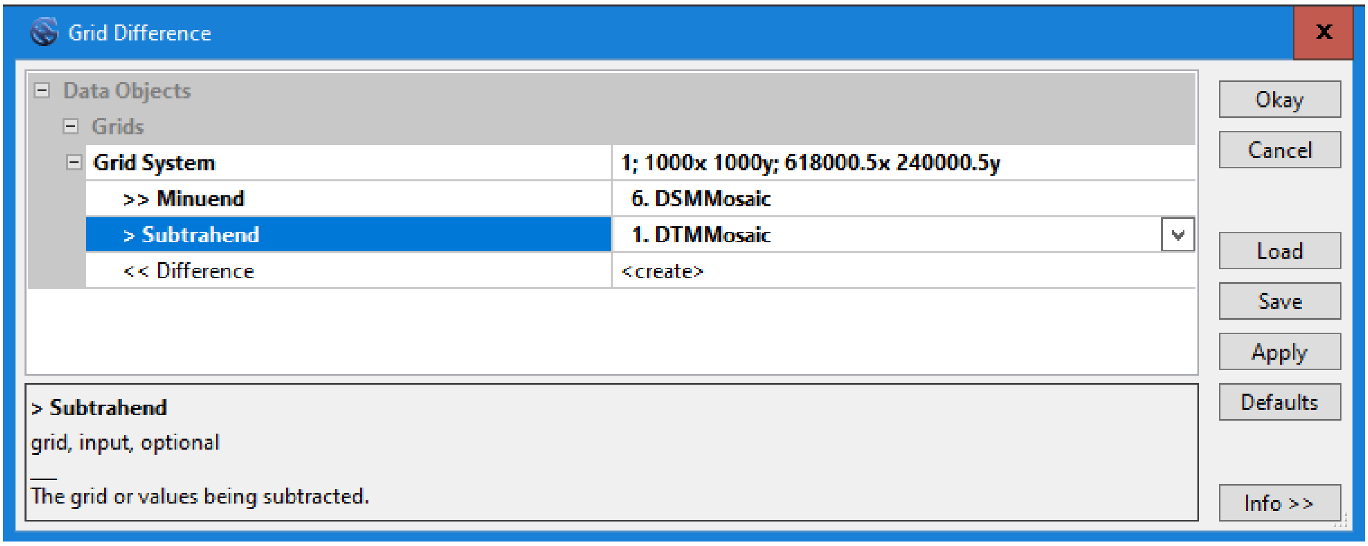
For vegetation templates I use one of the “First Return DSM” datasets from the DEFRA download site. The screenshot below shows the Mosaicking tool with the single National LiDAR Programme First Return DSM tile for Bridge Wood selected as the input “Grid”. As I’ve already cropped my DTM tile to fit my Bridge Wood map footprint, I can just select “grid or grid system” as my “Target Grid System”, and select the same cropped grid as my “Grid System” for this DSM tile. (Click in the relevant line to see the dropdown). I don’t need to enter the coordinates again. I’ve named the new cropped tile DSMMosaic. **“Target Grid” must be set to “create” as shown.** Then click “Okay”, twice if necessary. Note: **i**f you have a larger footprint with more than one tile for each dataset, as at Tunstall, then you must bring in all the DSM tiles as input grids, as described for DTM tiles in Chapter 7.



Data Objects	
Grids	
> Grids	1 object (FZ_DSM_TM1540_P_10801_20180125_20180216)
Options	
Name	DSMMosaic
Data Storage Type	same as first grid in list
Resampling	B-Spline Interpolation
Overlapping Areas	last
Match	none
Target Grid System	grid or grid system
Grid System	1; 1000x 1000y; 618000.5x 240000.5y
<< Target Grid	<create>

If you now double click the new DSM Mosaic tile in the data window, the map which displays is similar to the DTM tile seen earlier. This is not surprising as First Return DSM data records the height of tree tops as altitude above sea level – generally not very different to the altitude of the ground beneath. The new tile now needs to be “normalised” to show the height of tree tops, more usefully, as height above ground. This is the difference between the First Return DSM and the DTM values for each corresponding cell (pixel) in the Grid System. You can normalise DSM data in SAGA-GIS using the “Grid Difference” tool, shown in the next screenshot.

SAGA-GIS 9.5.1 uses the terms “Minuend” and “Subtrahend” for the two numbers in a subtraction. Click on each term to see a definition if you’ve not met them before – I hadn’t, and I used to teach maths! I’ve entered the DSMMosaic tile as the Minuend and the DTMMosaic tile as the Subtrahend, as below.



Grid Difference

Data Objects	
Grids	
Grid System	1; 1000x 1000y; 618000.5x 240000.5y
>> Minuend	6. DSMMosaic
> Subtrahend	1. DTMMosaic
<< Difference	<create>

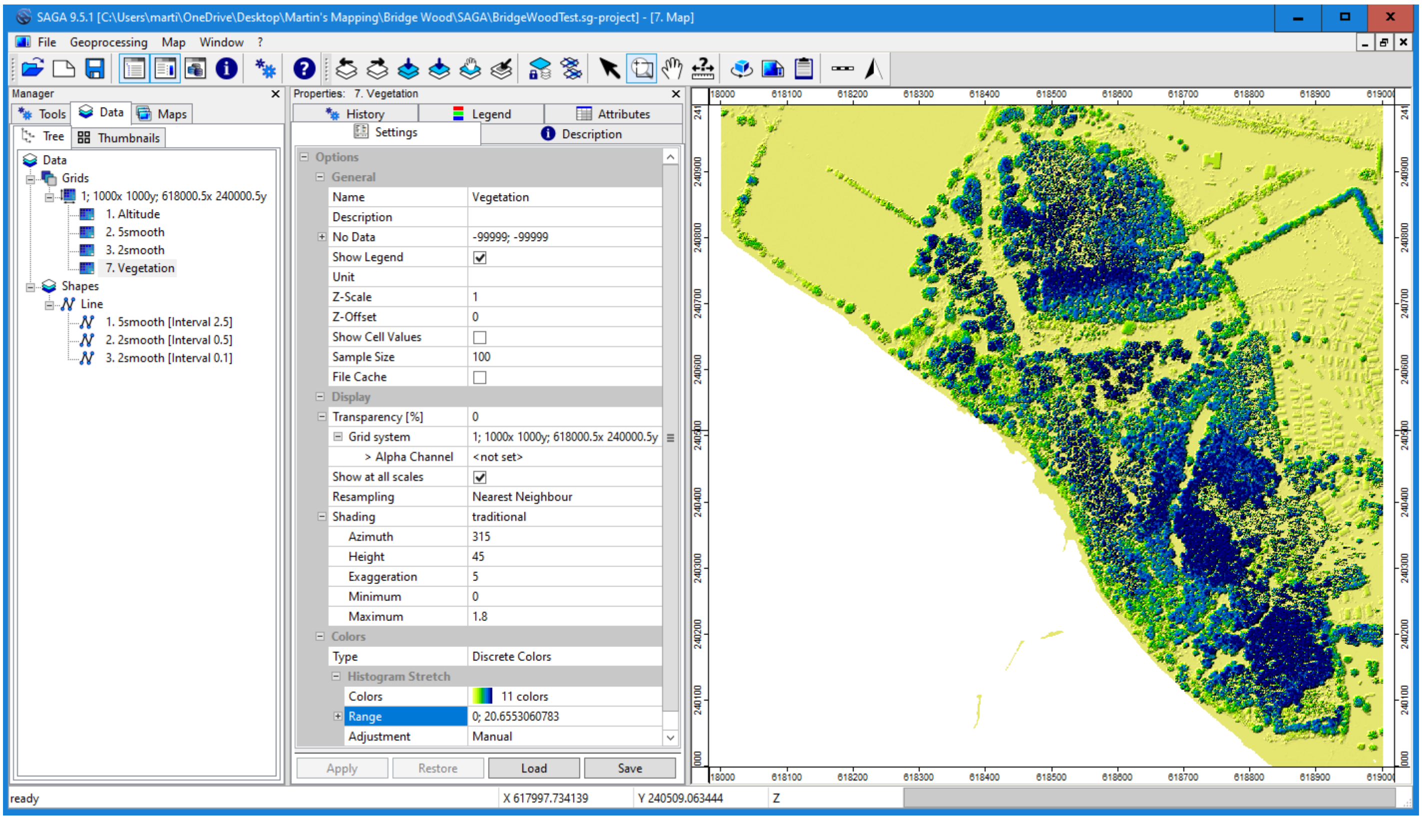
> Subtrahend

grid, input, optional

The grid or values being subtracted.

Selecting “create” against “Difference” will create a new normalised DSM tile named “Difference” under the same Grid System. I then delete both the non-normalised and the un-cropped DSM tiles and rename the new “Difference” tile in its Properties window as “Vegetation”. I’ve also, at this point, re-named the DTMMosaic tile “Altitude” – neater, but not necessary.

The Vegetation tile, set with its default properties, displays in unhelpful colours. The next screenshot shows the new Vegetation tile with its properties edited to produce a more user-friendly template. Note that water - the Orwell estuary in this case – normally displays white.



SAGA 9.5.1 [C:\Users\marti\OneDrive\Desktop\Martin's Mapping\Bridge Wood\SAGA\BridgeWoodTest.sg-project] - [7. Map]

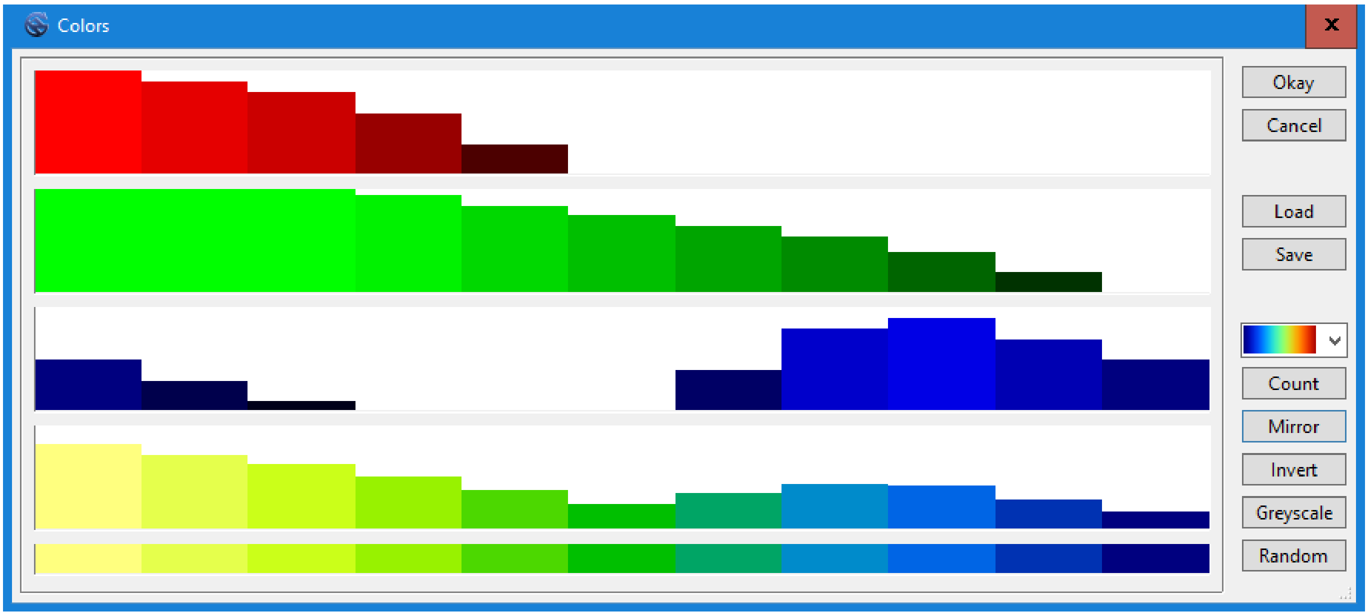
- Data
  - Grids
    - 1; 1000x 1000y; 618000.5x 240000.5y
      - 1. Altitude
      - 2. 5smooth
      - 3. 2smooth
      - 7. Vegetation
  - Shapes
    - Line
      - 1. 5smooth [Interval 2.5]
      - 2. 2smooth [Interval 0.5]
      - 3. 2smooth [Interval 0.1]

Properties: 7. Vegetation

Options	
General	
Name	Vegetation
Description	
No Data	-99999; -99999
Show Legend	☑
Unit	
Z-Scale	1
Z-Offset	0
Show Cell Values	☐
Sample Size	100
File Cache	☐
Display	
Transparency [%]	0
Grid system	1; 1000x 1000y; 618000.5x 240000.5y
> Alpha Channel	<not set>
Show at all scales	☑
Resampling	Nearest Neighbour
Shading	traditional
Azimuth	315
Height	45
Exaggeration	5
Minimum	0
Maximum	1.8
Colors	
Type	Discrete Colors
Histogram Stretch	
Colors	11 colors
Range	0; 20.6553060783
Adjustment	Manual

ready X 617997.734139 Y 240509.063444 Z

I first changed “Shading” to “traditional” – “multi-directional” also works - and set Exaggeration = 5, Minimum = 0, and Maximum = 1.8. This adds emphasis to vegetation boundaries. I set the minimum “Range” value to 0, and left the maximum unchanged. I left the Color “Type” as “Graduated Colors” – the default - then clicked in “Colors” and clicked the ellipsis (…) to open the Colors window.



The screenshot shows the Colors window after I've clicked the rainbow dropdown, scrolled down, and chosen the bottom but one colourway from the palette (blue – green – yellow). I then clicked "Mirror" to reverse the colours so we have yellow for open land and shades of green/blue for the trees – a very rough approximation to what we expect as orienteers. I've left "Count" as 11. Then clicked "Okay", and, back in the Properties window, clicked "Apply" to display the adjusted template. I then saved the template as normal.

Experimenting with different shading properties and colours creates a myriad of different effects which may or may not improve the "readability" of your template in OOM. The above parameters are my normal choice, although I sometimes set the "scaling" to "increasing -" or "decreasing - geometric intervals".

This is a February 2018 National LiDAR Programme survey. I originally drew this map in 2020, although I've updated these notes to match the current version of SAGA-GIS. Using this winter survey, a few apparently open or semi-open areas proved in the field to be leafless deciduous trees which the laser pulses missed. I actually got a more accurate vegetation template for Bridge Wood from an earlier composite DSM LiDAR dataset which had survey data from a different season. Being alongside the Orwell estuary, which is potentially flood-sensitive, this footprint now has more recent LiDAR data in the 2022 Composite dataset.

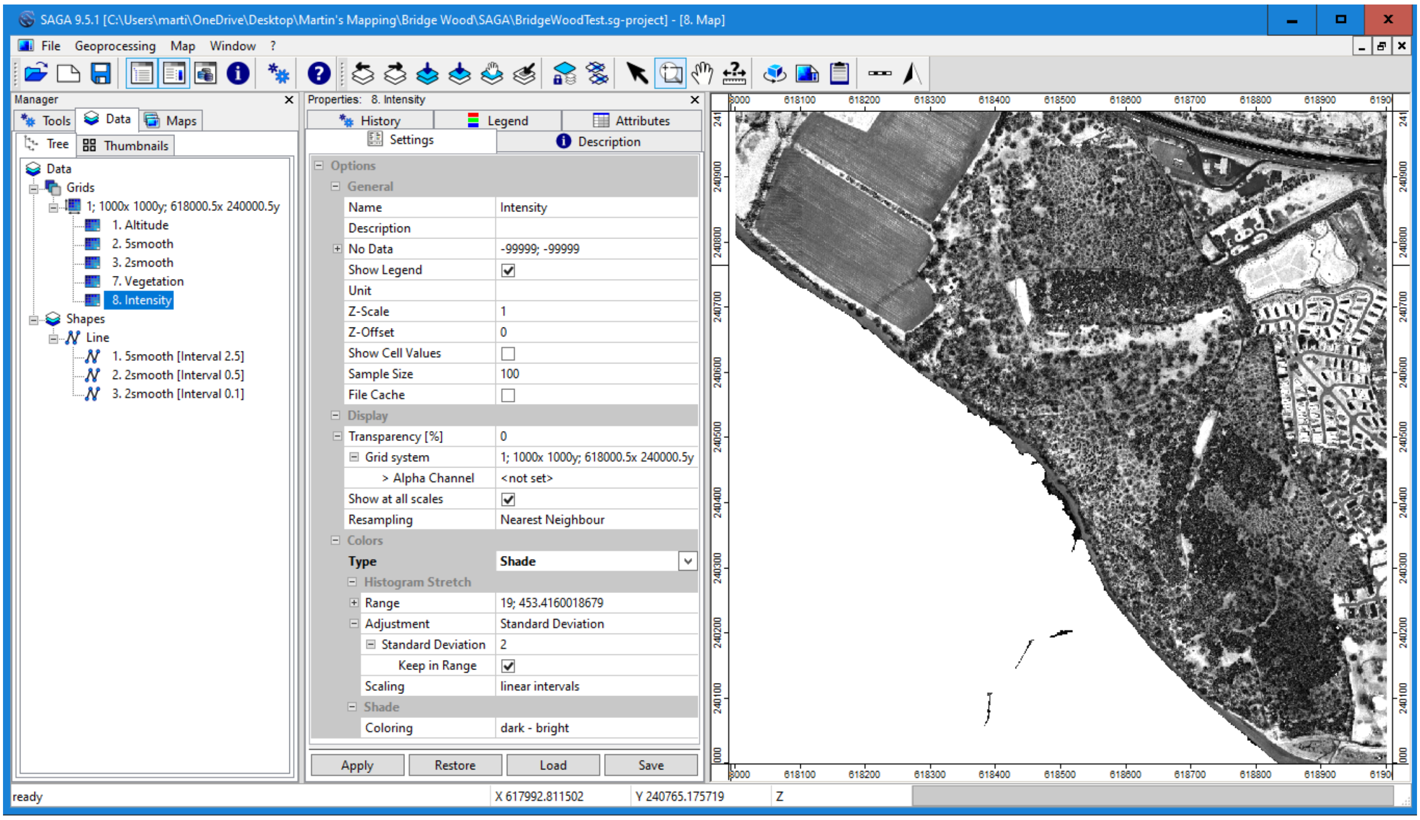
As well as identifying vegetation boundaries, this template is especially useful for accurately locating trees in open parkland, without the shadows which can mislead in aerial photographs.

LiDAR Intensity Data.

The Intensity dataset records the intensity of the laser return, independent of altitude, so the tile does not need normalising. Merging and cropping can be done with the Mosaicking tool as normal. The screenshot below shows a greyscale image obtained from the Intensity tile with the Properties set as shown. I've set the colour "Type" to "Shade" and "Coloring" to "dark - bright". All other parameters are left at their default values. I use these settings, but many other options are possible, as always.

I've found this template quite useful in identifying boundaries between different types of vegetation of similar height. It also shows paved areas and buildings well, and picks out paths in open areas, and even under light tree cover, sometimes better and/or more accurately than an aerial photo.

Note that, as Intensity data is only currently available, at least in Suffolk, in the DEFRA National LiDAR Programme, it may increasingly become more out of date than the other LiDAR models which are being updated in the Composite datasets.



SAGA 9.5.1 [C:\Users\marti\OneDrive\Desktop\Martin's Mapping\Bridge Wood\SAGA\BridgeWoodTest.sg-project] - [8. Map]

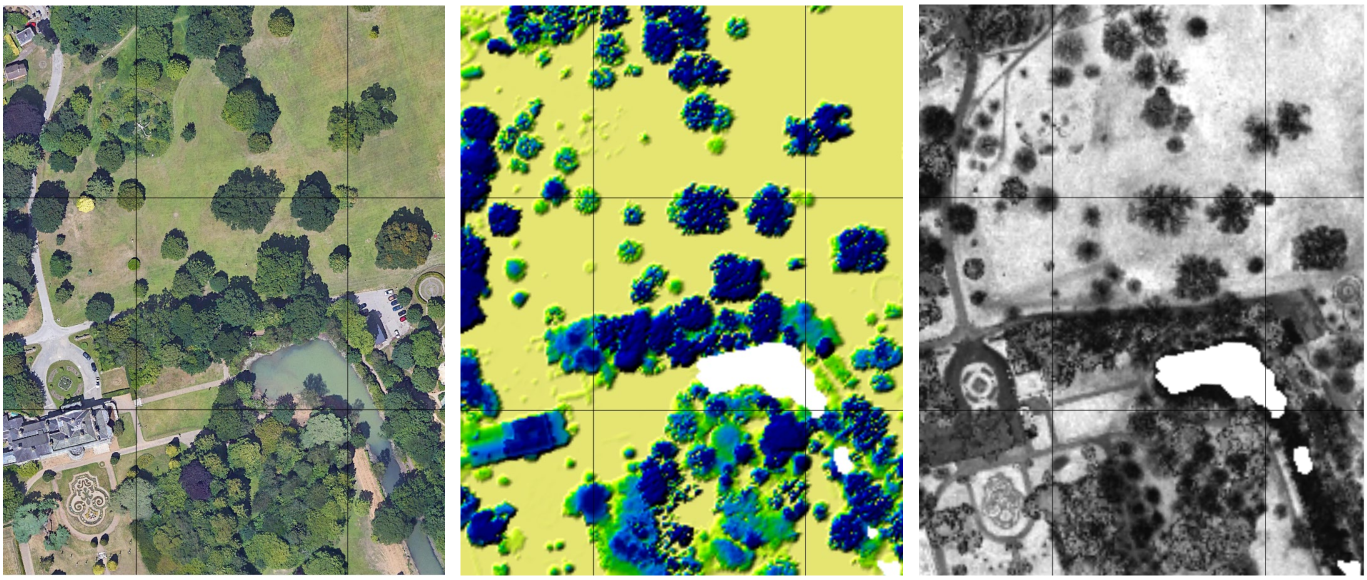
Data
- Grids
  - 1; 1000x 1000y; 618000.5x 240000.5y
    - 1. Altitude
    - 2. 5smooth
    - 3. 2smooth
    - 7. Vegetation
    - 8. Intensity
- Shapes
  - Line
    - 1. 5smooth [Interval 2.5]
    - 2. 2smooth [Interval 0.5]
    - 3. 2smooth [Interval 0.1]

Options	
General	
Name	Intensity
Description	
No Data	-99999; -99999
Show Legend	☑
Unit	
Z-Scale	1
Z-Offset	0
Show Cell Values	☐
Sample Size	100
File Cache	☐
Display	
Transparency [%]	0
Grid system	1; 1000x 1000y; 618000.5x 240000.5y
> Alpha Channel	<not set>
Show at all scales	☑
Resampling	Nearest Neighbour
Colors	
Type	**Shade**
Histogram Stretch	
Range	19; 453.4160018679
Adjustment	Standard Deviation
Standard Deviation	2
Keep in Range	☑
Scaling	linear intervals
Shade	
Coloring	dark - bright

X 617992.811502 Y 240765.175719 Z

The vegetation and intensity LiDAR templates described in this chapter suffer from the disadvantage of not “seeing” well through the tree cover. In this respect they are no improvement on aerial photographs. However, in contrast to aerial photographs, they “see” vertically downwards so they don’t distort the position of treetops and roofs of tall buildings relative to the ground. And they also have no shadows. Because of the way it’s surveyed, LiDAR data is usually more accurately georeferenced than aerial photography.

A comparison between an aerial photo template from Google Earth a LiDAR vegetation template, and a LiDAR intensity template, is shown below, each zoomed in with the same 100m OOM grid displayed.



You can see how the vegetation template, without shadows, allows a more accurate location of the trees in open land and the clearings in the SE corner, and the intensity template shows some additional small path lines notably in the NW corner. The LIDAR templates were surveyed earlier, and show a few discrepancies in the tree cover with the aerial photo, which needed to be checked out in the field.

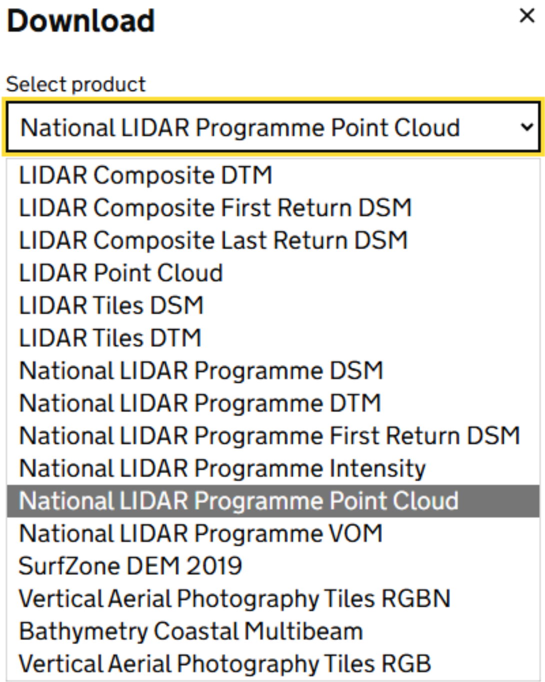
It’s a bit more effort, but I like to have all three of these templates available.

Chapter 11: Obtaining a LiDAR undergrowth template using QGIS

To display any vegetation below the tree cover, you need to process raw LiDAR point cloud data. In previous versions of this guide, I described using LAStools software to do this. Recent QGIS versions offer a much simpler method to obtain similar results. QGIS offers a little less control, but I've found the resulting templates to be equally satisfactory and obtained with much less effort.

Although most of the useful LiDAR data to create templates in OOM is obtained from DTM and DSM tiles, these models ignore any intermediate laser returns between the first return (the tree tops) and the last return (the ground). For an estimation of runnability in forested terrain we need to analyse the intermediate returns which only the raw point cloud data records.

Downloading LiDAR data from the UK Environment Agency (DEFRA) site is described in Chapter 6. The data models available for your footprint will be those displayed in the "Select product" dropdown.



Download

Select product: National LIDAR Programme Point Cloud

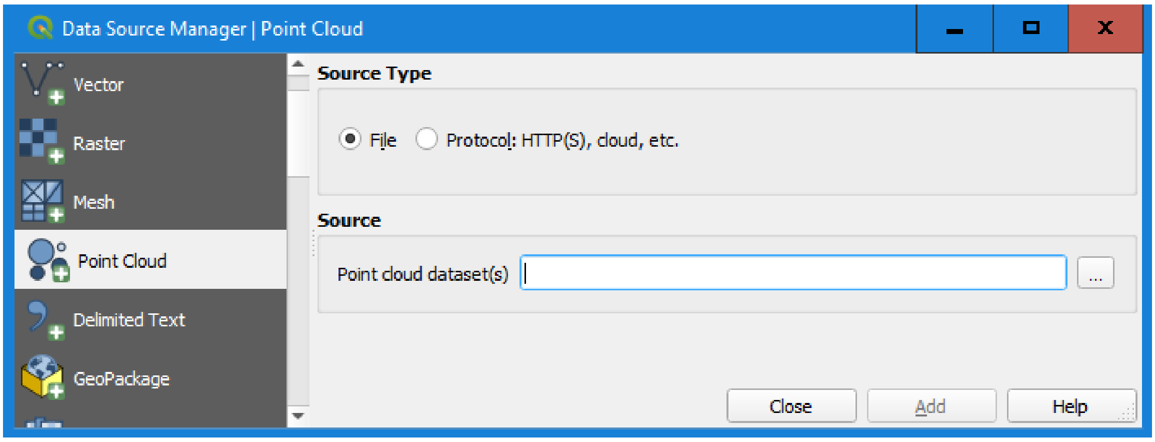
For this footprint (Tunstall Forest) I have a choice of "National LiDAR Programme Point Cloud", dated 2019, or "LiDAR Point Cloud", dated 2021 or 2020. LiDAR Point Cloud data may, as here, be available covering more than one year, in which case both years may contain useful data. However, for much of the country, outside of recently surveyed coastal and flood-prone areas, the available LiDAR Point Cloud data will be older than National LiDAR Programme data, and not worth downloading.

The "National LiDAR Programme Point Cloud" product downloads on my computer as a zip folder containing one .laz file (sometimes in a sub-folder) covering a whole 5km grid square. .laz is the standard file format for point cloud data. Where available, the "LiDAR Point Cloud" product downloads as one zip folder containing a number of .laz files, each covering a 2km square, often with overlap into adjacent 5km tiles. This product only contains data from survey flights within the stated year and may not cover the whole 2km square. I normally download both products if available. They may not be quick to download as .laz files are large.

It's important to unzip each zip folder (right click and "Extract All"). I then transfer my unzipped files to my LiDAR sub-folder which I can delete at the end of the process to save disc space. Alternatively, keep them in your "Downloads" folder. You can immediately delete any of the 2km square files from the LiDAR Point Cloud product which are not included in your footprint – possibly most of them – though it's not that easy to work out which they are. (Hint: look at the 2nd and 3rd figures of your 6 figure metre coordinates).

I then open QGIS as usual, opening the OS Map layer and zooming in to my approximate footprint. Your unzipped .laz file(s) can then be simply dragged and dropped onto your QGIS map screen, all at once to save time, though they may load better individually. There is a progress bar to re-assure you. This process can take quite a long time, and I've found it's best not to undertake other tasks on the computer but leave it to focus on processing these files. No CRS transformation will be required if you have already opened the OS Map, as DEFRA LiDAR data is also aligned to OSGB36 (EPSG 27700). The process may generate a "cloud optimised point cloud" (copc.laz) file which I ignore.

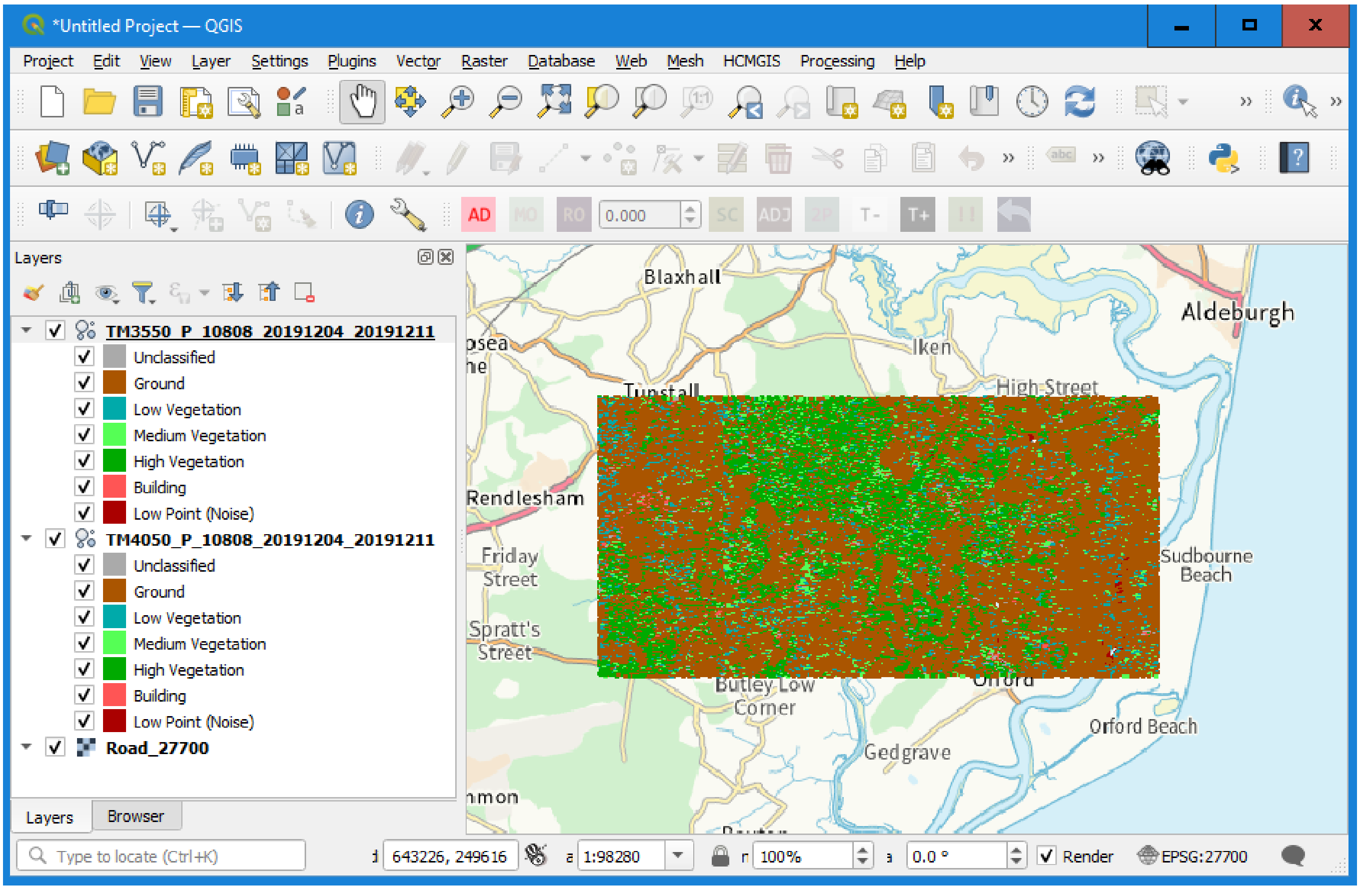
Alternatively, you can select "Layer"/"Add Layer"/"Add Point Cloud Layer" from the QGIS menu bar to display the following dialogue:



● File ○ Protocol: HTTP(S), cloud, etc.

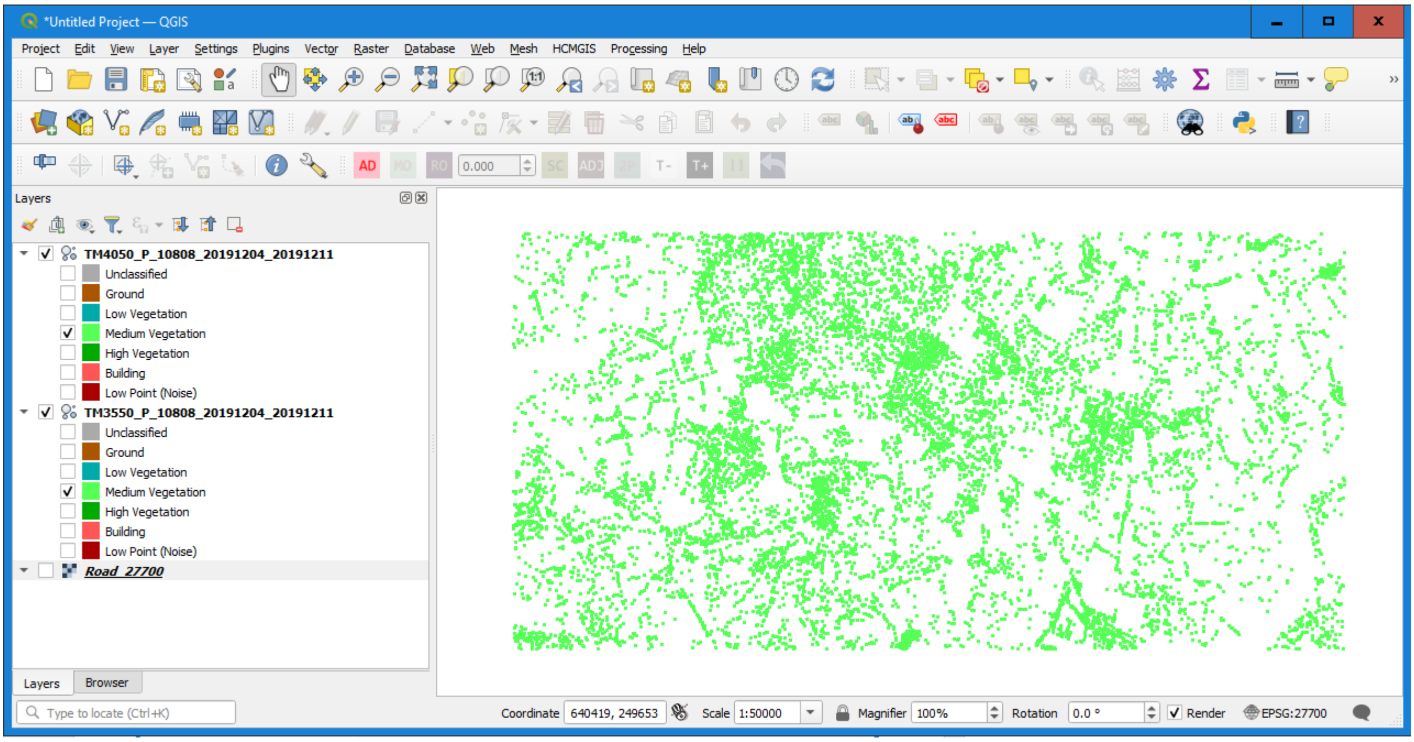
Click the ellipsis (…) in the Point cloud dataset(s) line and navigate to your LiDAR folder. Again, you can select all the unzipped .laz files you want and open them in one action, but they may load better individually. Then click "Add" and wait a while. Again, there is a progress bar. As with the "drag and drop" method, no CRS transformation should be required if you have already opened the OS Map.

The QGIS screen should then display as below: I've toggled to show the "Layers" panel.



I've opened the two National LiDAR Point Cloud tiles for the southern extension to my Tunstall Forest map here. The Layers Panel displays the OS Map "Road 27700" tile plus the two LiDAR tiles, each of which has 7 sub-layers. I then untick all the sub-layers in each LiDAR tile except "Medium Vegetation".

Alternatively, right-clicking one sub-layer and selecting “Hide All Items” – then ticking “Medium Vegetation” achieves the same result. I’ve unticked the OS map in the screenshot below as the point cloud layer is transparent. I’ve experimented with leaving “low vegetation” and/or “high vegetation” ticked but I’ve found that “medium vegetation”, on its own, gives the most useful result.



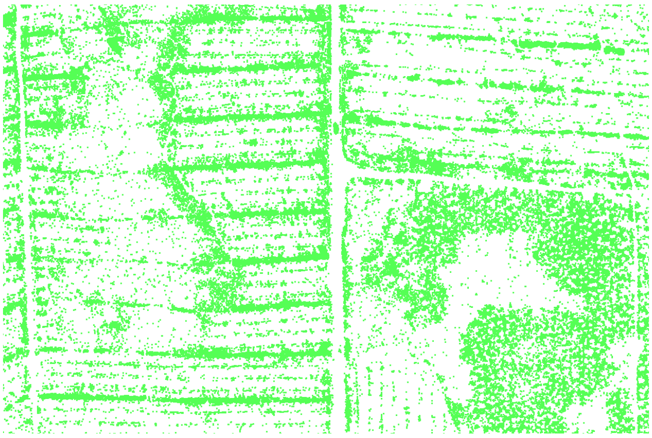
☑ TM4050_P_10808_20191204_20191211
- ☐ Unclassified
- ☐ Ground
- ☐ Low Vegetation
- ☑ Medium Vegetation
- ☐ High Vegetation
- ☐ Building
- ☐ Low Point (Noise)

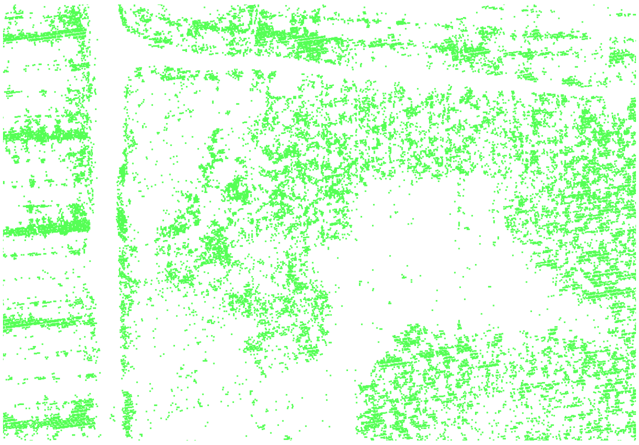
☑ TM3550_P_10808_20191204_20191211
- ☐ Unclassified
- ☐ Ground
- ☐ Low Vegetation
- ☑ Medium Vegetation
- ☐ High Vegetation
- ☐ Building
- ☐ Low Point (Noise)

☐ Road_27700

Coordinate 640419, 249653 Scale 1:50000 Magnifier 100% Rotation 0.0 ° ☑ Render EPSG:27700

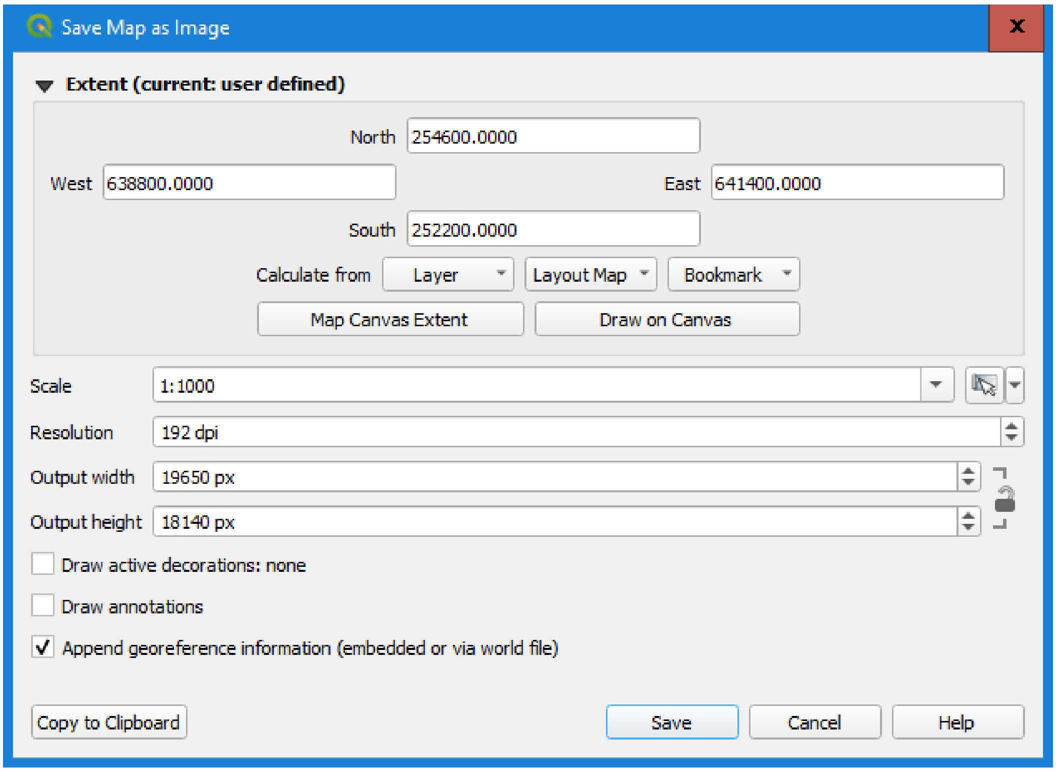
It’s now worth zooming in which has an unusual effect, as seen below at 1:2000, on the left, and 1:1000, on the right. The point cloud dots stay the same size, so each image is not just an enlargement of the previous one. A lot more detail is displayed in the 1:1000 version. Zooming in further than this displays individual point cloud dots, but produces an image which I’ve found too feint to use as a template.





These images actually show a section of my earlier, northern, Tunstall Forest footprint, which is entirely under tree cover so little of this detail is displayed in any other templates. A lot this area is quite runnable, but I wanted to show the vegetation reasonably accurately to allow orienteers fair route choice options. A clear boundary is evident in both screenshots where a fast runnable area is almost surrounded by heavy seasonal bracken, which I showed as slow undergrowth for a late autumn event. I exported the 1:1000 version which I found very helpful when undertaking my field survey. Even though there have, of course, been changes since the 2019 survey date, I was able to fairly quickly confirm that boundary with sufficient accuracy. The parallel, straight lines of undergrowth shown in these images mark the lines of vegetated rootstock banks with runnable forest either side – also useful information.

I export these images using the same method as per my OS map and Google aerial photo. The following screenshot shows the values I set for this image. I set the scale first, at 1:1000 or 1:2000, and then set my bounding coordinates for the footprint, and a resolution which keeps width and height within the pixel limit. In fact, I'm finding that leaving the resolution at its default value of 96 is quite satisfactory for these point cloud images.



Extent (current: user defined)

North 254600.0000

West 638800.0000

East 641400.0000

South 252200.0000

Scale 1:1000

Resolution 192 dpi

Output width 19650 px

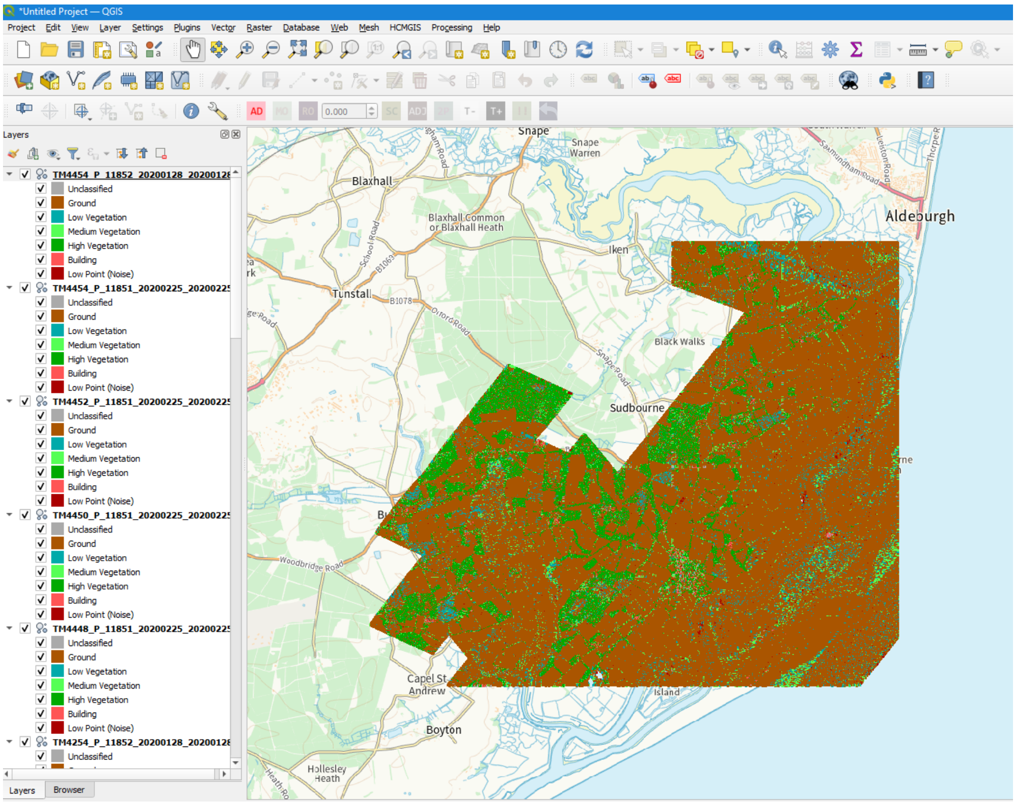
Output height 18140 px

☐ Draw active decorations: none

☐ Draw annotations

☑ Append georeference information (embedded or via world file)

I repeated the whole procedure starting with my slightly more recent LiDAR Point Cloud tiles. As mentioned above, there were more .laz files in each extracted .zip file., but they can all be dragged or loaded into QGIS in one go from my temporaray folder. The result was as below.



Sadly, the limited resulting coverage this time includes very little of my Tunstall O-map footprint. But if you find that more recent LiDAR point cloud data than that available in the National LiDAR programme, does cover your footprint, then this is probably worth obtaining.

Chapter 12: Updating Old Orienteering Maps

In the preceding chapters I've described how I obtain all the templates I use to start work on an orienteering map of a brand-new area. If the area has been previously mapped for orienteering, as is frequently the case in Suffolk, then I will also have an earlier version of the orienteering map to refer to.

If the most recent version was drawn to modern standards, and fully georeferenced, then I can simply start from that, open any updated templates behind it, and update the map features as required.

But, in most cases, the old map will not have been accurately georeferenced. I then have two choices. I can "rubber-sheet" the old map to georeference it as accurately as possible and then amend the rubber-sheeted version. Or I can decide to do a complete redraw from scratch, just using the old map as one of my templates, after adjusting it to best fit.

OOM has a limited capability to rubber-sheet maps or templates. The map itself can be translated (moved), rotated and scaled, but nothing more complicated is possible. Its shape will remain the same. OOM's "adjust" facility for templates has the same restrictions. With templates, you can fix any number of "passpoints" but the result will be only the closest result that is "similar" to the original, that is moved, scaled and/or rotated, but otherwise the same shape.

Most of SUFFOC's old maps were drawn in OCAD 9 or earlier. OCAD 9 does have a slightly more sophisticated rubber-sheeting facility, which potentially produces better results. OCAD 9's "transform map" and "adjust template" tools do allow stretching in a single dimension, as well as "shearing". That equates, in geometric terminology, to transforming a square into a rectangle, or a parallelogram. This still limits the ability to fully align an old map, although it's possible that later OCAD versions – which I don't have - may have improved further on this.

Currently, my "go-to" approach, where the old map is not georeferenced to current standards, is to accept I will need to re-draw. I can open the old map (OCAD or OOM) as one of my templates in the new OOM map, and adjust it as best as possible, using perhaps 5 passpoints. It's possible, if time consuming, to re-do this several times as you draw up your base map, so as to align the old O-map template more closely with each small section of the new map you are working on at the time.

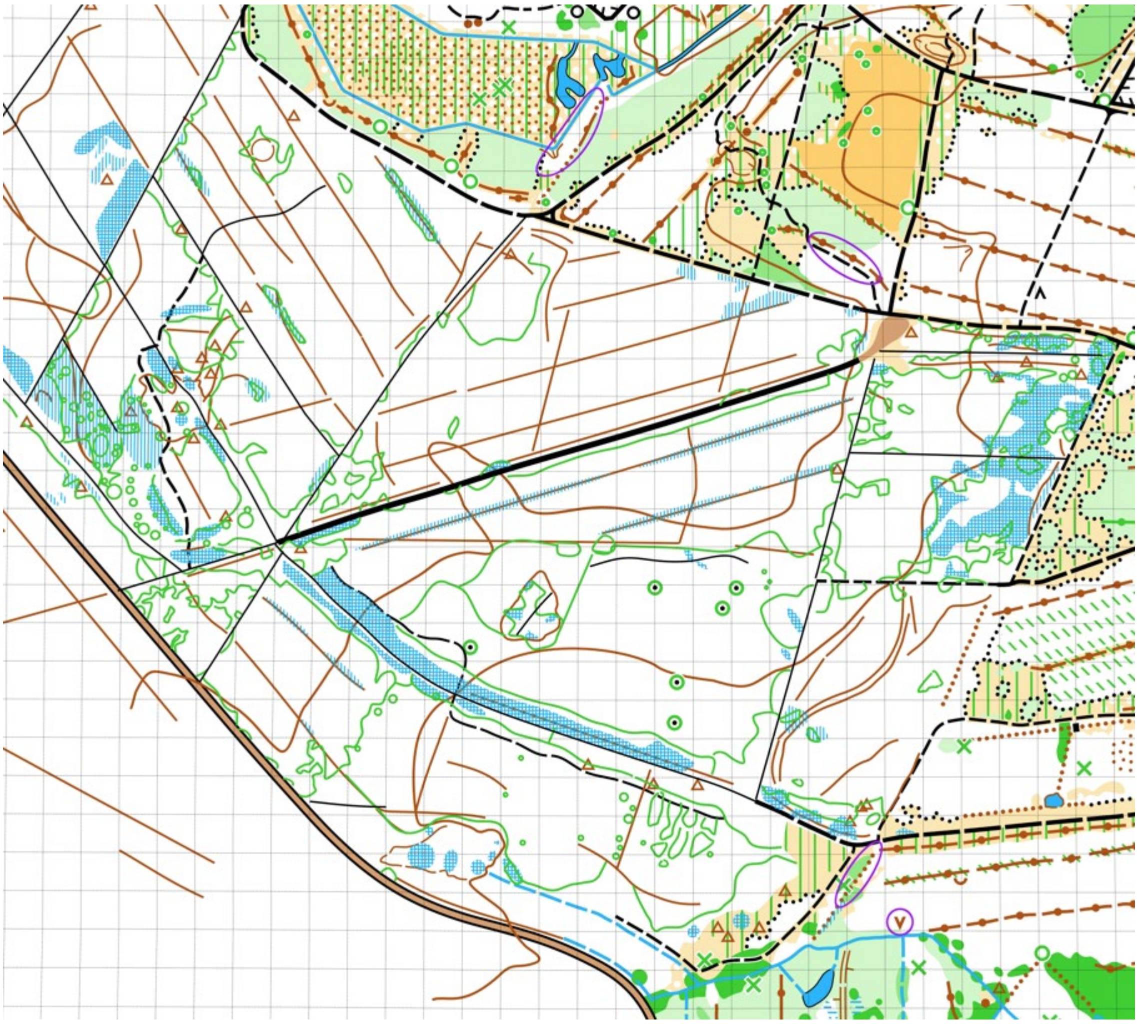
If the old map is drawn in OCAD - most of ours are in OCAD 9 - I get a better result by first transforming the old map within OCAD 9 to best match my OS template. I must first open my OS map image as a background template in the OCAD file. The OS image needs to be in .bmp or .jpg format to do this – OCAD 9 does not open .png files. (You can save a .png file in .jpg format just by opening it – eg in Microsoft Photos – and using "Save As"). I then transform the old OCAD map, in OCAD9, to best match the OS template – using 5 or more passpoints. Back in OOM, I can now open the transformed OCAD map as a template. This new template will not be georeferenced, so I will need to use OOM's template adjust facility to align it. Just two passpoints is normally sufficient at this stage if the map has first been transformed in OCAD to best fit the OS template. This method can produce good results if the old map is reasonably consistently aligned within itself (which most, but not all, of ours are).

With this approach, I can never assume that a feature on the old map is exactly in the right place. But I can normally assume that if something is marked on the old map, I will find something corresponding reasonably close by. Often, the correct alignment of a line feature, or the location of a point feature, will be obvious on one of my geo-referenced LiDAR or aerial photo templates. At other times I have to mark it as "position uncertain" on my base map, and search for it in the field.

In future, I hope that updating our current maps will be much easier as they will be correctly georeferenced, drawn to modern standards, and use current symbol sets.

Chapter 13: Preparing the Base-Map

Having prepared all the templates I think will be useful for the map I'm working on – not necessarily all the ones described above - I can then draw up my base-map in OOM. Orienteering mappers will have their own personal preferences as to how they survey in the field and this will will influence how they draw up the base-map. I've shown an example of mine below, part of Tunstall Forest.



I've marked, with standard IOF symbols, any features I'm already pretty sure about, mostly from earlier survey visits, but including the contours imported from LiDAR, and prominent roads and paths which are clear and consistent on at least two templates. Other, less definite, features I've drawn at this stage with thin drafting lines (for line features) or small triangles (for point features), using appropriate colours – brown for relief, green for vegetation, black for man-made. I've shown areas which my undergrowth template has picked out with a light blue hatch.

With an Android tablet, you can load this OOM base map onto the tablet, together with key templates, and draw direct in the field using a stylus. Not possessing an Android tablet, I'm a bit behind the curve on this and still draw my field survey on a paper print of my base map. I find this quite satisfactory though. I do have a copy of the basemap on my iPhone, so I can check my position using the phone's GPS.

I match everything up by printing the base map with the OOM grid and including the same grid on the map on my phone. The screenshot above is actually a .kmz image file for transfer to my iPhone, as I don't keep my basemaps once I've drawn them up after my survey visits – hence why the grid is not completely square. I use a grid spacing which is, a little unusually I think, based on my pacing. I walk at close to 60 double paces per 100m and use a grid spacing of 33.3m equating to 20 double paces. If I print the base map at 1:3333, the grid spacing on the printed map is 10mm and each millimetre on the printed map equates to 2 double paces. For detailed areas or urban/sprint maps I print the base map at 1:1667 so each millimetre on the printed map equates to 1 double pace. These scales give me plenty of space to draw on my printed base map, but I have to be very careful not to survey too much detail.

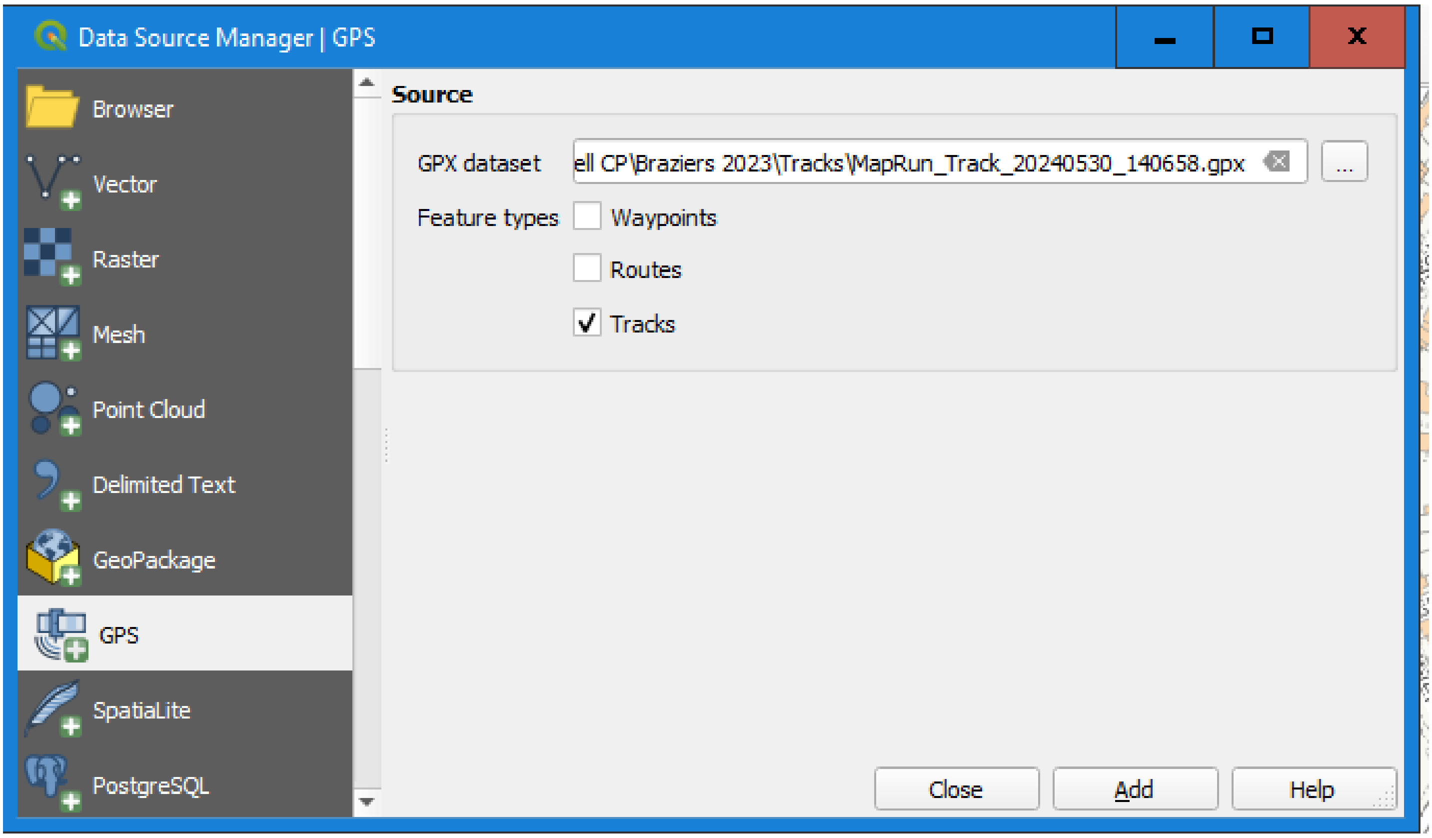
Chapter 14: Displaying GPS Tracks

As well as showing me my approximate position as I survey in the field, my iPhone records a GPS track of my wanderings. Although this is not accurate enough to overrule other evidence – eg from LiDAR – I still find it useful to overlay my GPS track when drawing up my survey in OOM. Not having an Android device, I use the MapRun "checksites" facility to transfer my basemap onto my iPhone and record my GPS track. GPS tracks, whether, as in my case, generated by MapRun, or from another source, are normally produced as .gpx files.

I now use QGIS to convert my .gpx file to a template-ready format. I prefer this to my previous method using OOM only. This has the advantage that QGIS performs the CRS transformation required to align the GPS track with the OS grid, using its more accurate transformation algorithm.

As with all my work in QGIS, I first create my OS map layer as described in Chapter 2 and zoom in to my approximate footprint. This ensures that any further layers will be automatically transformed to EPSG 27700 on loading into QGIS using parameters appropriate to my location.

I then select "Layer"/"Add Layer"/"Add GPX Layer" from the menu bar. The Data Source manager dialogue will appear, as below. Click the ellipsis (…) on the GPX dataset line, and navigate to your .gpx file. Check "Tracks" is selected, uncheck the other "Feature Type" options, then click "Add".



Source

GPX dataset: ell CP\Braziers 2023\Tracks\MapRun_Track_20240530_140658.gpx ...

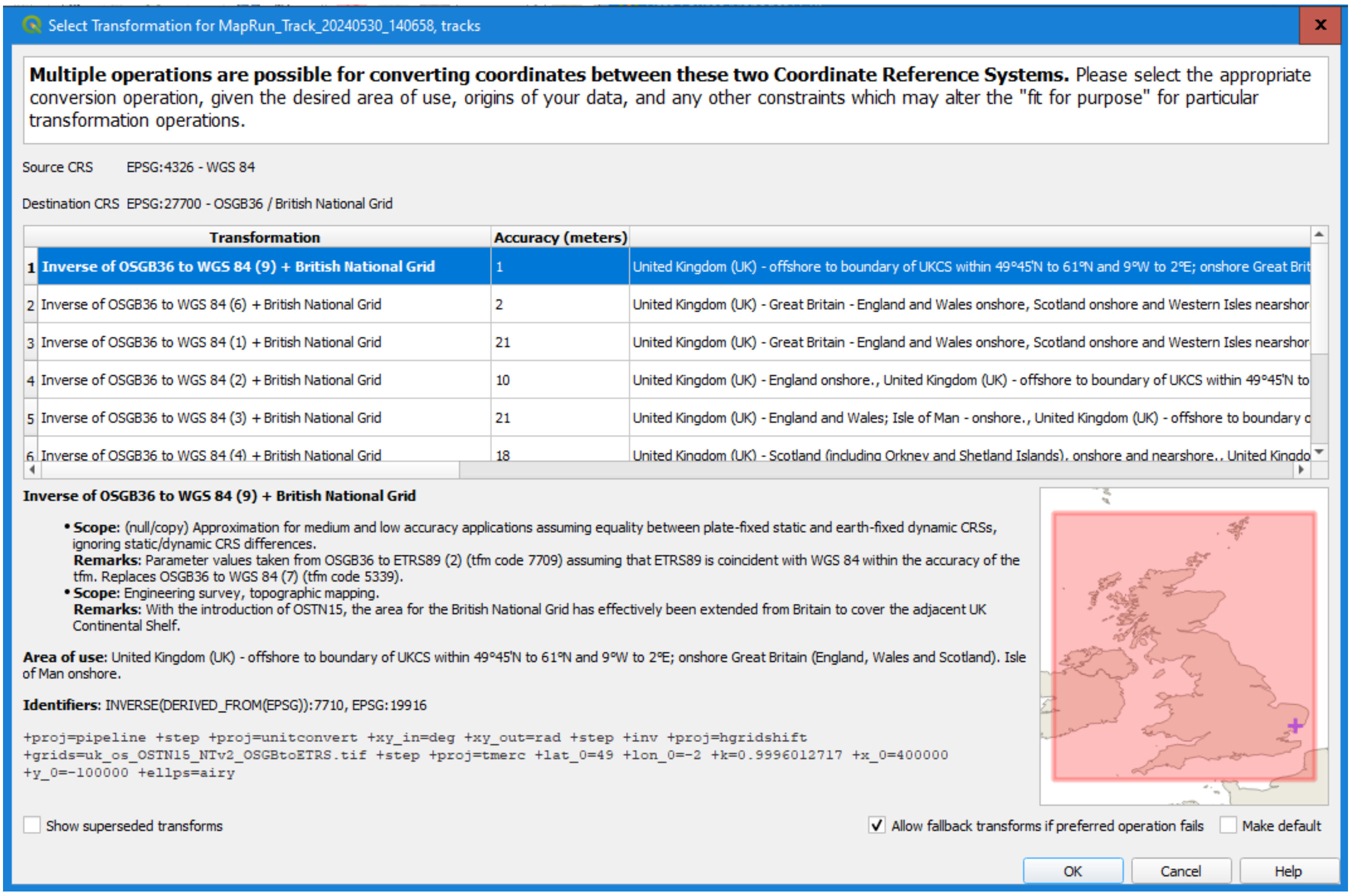
Feature types ☐ Waypoints

☐ Routes

☑ Tracks

Alternatively, you can simply drag and drop your .gpx file to the QGIS map screen. You will have to select "tracks", only, in the dialogue which then appears.

Provided you have already loaded your OS layer, the following dialogue should appear confirming that the preferred transformation algorithm will be used. It will be familiar if you have already used QGIS to process your Google aerial photograph as per Chapter 4. Click "OK", and your track should open accurately superimposed on the OS map. You can ignore the colour it displays.



Select Transformation for MapRun_Track_20240530_140658, tracks

Multiple operations are possible for converting coordinates between these two Coordinate Reference Systems. Please select the appropriate conversion operation, given the desired area of use, origins of your data, and any other constraints which may alter the "fit for purpose" for particular transformation operations.

Source CRS EPSG:4326 - WGS 84

Destination CRS EPSG:27700 - OSGB36 / British National Grid

	Transformation	Accuracy (meters)	
1	**Inverse of OSGB36 to WGS 84 (9) + British National Grid**	1	United Kingdom (UK) - offshore to boundary of UKCS within 49°45'N to 61°N and 9°W to 2°E; onshore Great Brit
2	Inverse of OSGB36 to WGS 84 (6) + British National Grid	2	United Kingdom (UK) - Great Britain - England and Wales onshore, Scotland onshore and Western Isles nearshor
3	Inverse of OSGB36 to WGS 84 (1) + British National Grid	21	United Kingdom (UK) - Great Britain - England and Wales onshore, Scotland onshore and Western Isles nearshor
4	Inverse of OSGB36 to WGS 84 (2) + British National Grid	10	United Kingdom (UK) - England onshore., United Kingdom (UK) - offshore to boundary of UKCS within 49°45'N to
5	Inverse of OSGB36 to WGS 84 (3) + British National Grid	21	United Kingdom (UK) - England and Wales; Isle of Man - onshore., United Kingdom (UK) - offshore to boundary o
6	Inverse of OSGB36 to WGS 84 (4) + British National Grid	18	United Kingdom (UK) - Scotland (including Orkney and Shetland Islands), onshore and nearshore., United Kingdo

Inverse of OSGB36 to WGS 84 (9) + British National Grid

- **Scope:** (null/copy) Approximation for medium and low accuracy applications assuming equality between plate-fixed static and earth-fixed dynamic CRSs, ignoring static/dynamic CRS differences.
  Remarks: Parameter values taken from OSGB36 to ETRS89 (2) (tfm code 7709) assuming that ETRS89 is coincident with WGS 84 within the accuracy of the tfm. Replaces OSGB36 to WGS 84 (7) (tfm code 5339).
- **Scope:** Engineering survey, topographic mapping.
  Remarks: With the introduction of OSTN15, the area for the British National Grid has effectively been extended from Britain to cover the adjacent UK Continental Shelf.

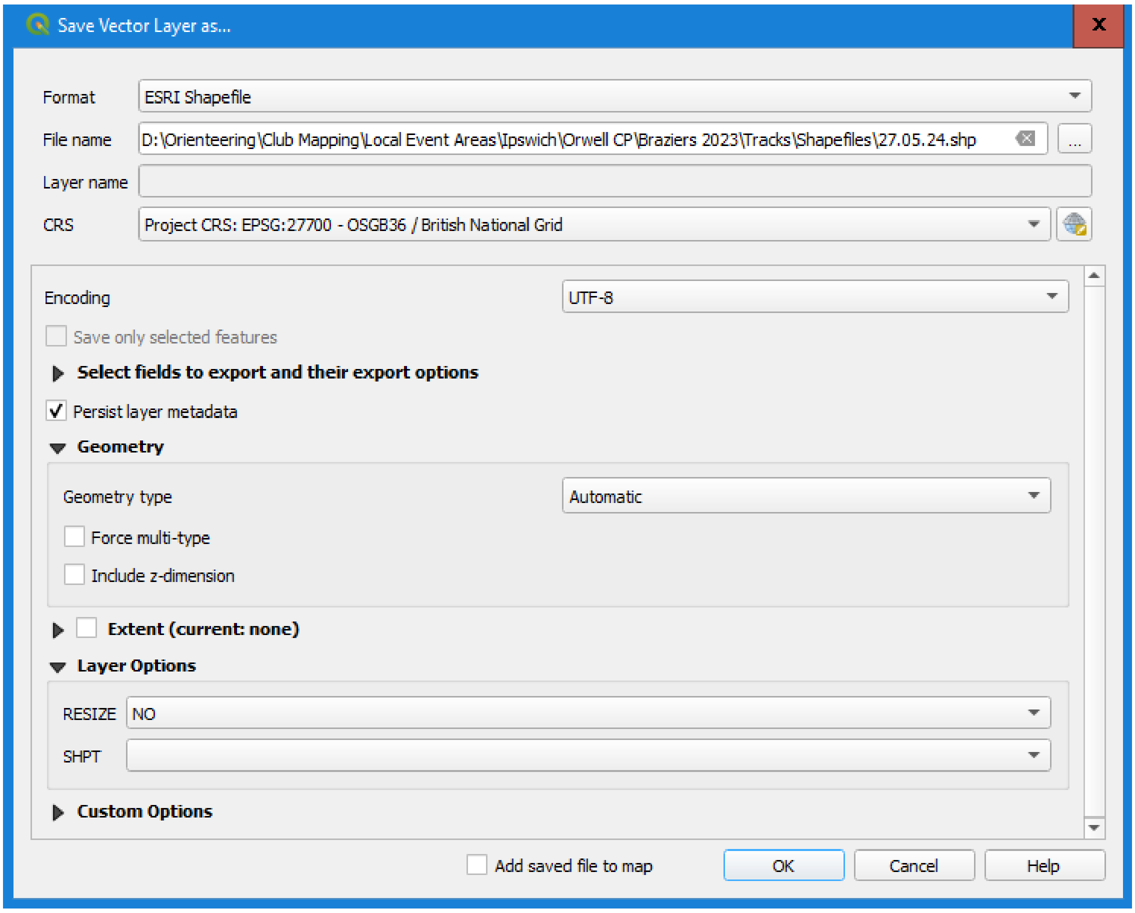
Area of use: United Kingdom (UK) - offshore to boundary of UKCS within 49°45'N to 61°N and 9°W to 2°E; onshore Great Britain (England, Wales and Scotland). Isle of Man onshore.

Identifiers: INVERSE(DERIVED_FROM(EPSG)):7710, EPSG:19916

```
+proj=pipeline +step +proj=unitconvert +xy_in=deg +xy_out=rad +step +inv +proj=hgridshift
+grids=uk_os_OSTN15_NTv2_OSGBtoETRS.tif +step +proj=tmerc +lat_0=49 +lon_0=-2 +k=0.9996012717 +x_0=400000
+y_0=-100000 +ellps=airy
```

☐ Show superseded transforms ☑ Allow fallback transforms if preferred operation fails ☐ Make default

To save the track, I first untick the OS layer in the Layers panel so that just the track layer is displayed. You could then export this layer as a .png image file, as normal, but this will export white background as well as the track which is not helpful. Instead, select “Layer”/”Save as” from the menu bar to display the following dialogue.



Save Vector Layer as...

Format: ESRI Shapefile

File name: D:\Orienteering\Club Mapping\Local Event Areas\Ipswich\Orwell CP\Braziers 2023\Tracks\Shapefiles\27.05.24.shp

Layer name:

CRS: Project CRS: EPSG:27700 - OSGB36 / British National Grid

Encoding: UTF-8

☐ Save only selected features

▶ **Select fields to export and their export options**

☑ Persist layer metadata

▼ **Geometry**

Geometry type: Automatic

☐ Force multi-type

☐ Include z-dimension

▶ ☐ **Extent (current: none)**

▼ **Layer Options**

RESIZE: NO

SHPT:

▶ **Custom Options**

☐ Add saved file to map

Leave “Format” as the default which is “ESRI Shapefile”. Use the ellipsis (…) to browse to the folder where you want to store the file and give it a name (just the date in my case). I’m storing GPS shapefiles in a dedicated sub-folder as several files are stored for each track. Set the CRS to EPSG 27700 as shown (which will be a drop-down option if you already have your OS map loaded). I unchecked “Add saved file to map” as I won’t need this. Everything else is left as default. Click “OK”.

Six files are normally saved. Only one has substantial content. This is the .shp file. But others must be retained with the .shp file in the same folder. The .shp file can now be opened as a template in OOM in the normal way. It should be accurately georeferenced, and will display in purple. I move my GPS track templates above my map in the OOM templates list so that the track, when displayed, sits on top of the map. The result should appear as below: I’ve shown a GPS track superimposed over a final O-map with the map’s opacity reduced so the track can be seen. The sort of errors I experience with my GPS system can be spotted. Part of the track was in my car – I didn’t walk down the middle of the main road!

The only disadvantage I’ve found to this method occurs if, as often happens, I forget to turn the MapRun app off when I finish my field survey. My iPhone’s GPS will then record my journey home and include that in my track, which will then extend well beyond my O-map footprint. If you make this mistake and want to tidy up, you can *import* the .shp file into a mirror OOM file with identical georeferencing to your actual map file. This is why I suggested pre-preparing a spare mirror file in Chapter 3, at the same time as your Micro-Contours mirror file. An imported .shp shapefile displays in OOM as an editable map object. You can then cut this to delete the unwanted segment, save the mirror OOM file with a recognisable name such as the date of the track, and open this OOM file as your template, rather than the original .shp file. One advantage of doing this is that you can then delete your shapefile folder.

Chapter 15: Comparing the accuracy of templates from various sources

All the templates created as described in this guide will contain errors – some are more error prone than others.

OS Mapping

The OS mapping available from the OS Data Hub, as described in Chapter 2, is continuously updated. In urban areas this will show new buildings and associated developments within months of their construction. Indeed, I've even found developments shown in advance of their construction! OS mapping is relied on for land registry and planning purposes, so buildings and property boundaries will normally be shown with greater accuracy than we, as orienteers, require. However, outside of urban areas, detail may not be recently surveyed, and significant inaccuracies in OS mapping exist.

Aerial Photography

Inaccuracies exist in aerial photography from sources such as Google Earth. The camera doesn't lie, but what it sees may not correspond to what exists today, and not just because of changes since the survey date. I've included a further consideration of potential errors in aerial photography in the next chapters.

LiDAR Data.

LiDAR images are normally very accurately georeferenced, but the way the LiDAR data is interpreted to produce DTM and DSM models can introduce artifacts. One example, which was fairly common with older LiDAR data, is where tree cover is so dense that no returns are received from the ground. In this case, the data will be interpreted to show a non-existent hill at the height of the tree cover. This has become less of an issue more recently as UK LiDAR surveys are now carried out exclusively during the winter months. Older LIDAR data will, of course, not reveal any changes since the survey date. This is particularly obvious in relation to vegetation.

GPS Data

The accuracy of GPS data depends, obviously, on the quality of the GPS receiver in your phone, tablet, or other device. With my rather old iPhone I find I get around 5m accuracy in open areas and 10m in forest. Standing still, or moving away and returning to the same position, will often improve things. As mentioned, I use the MapRun app to transfer my OOM base map onto my phone. You can shortcut this stage if you have an Android device. At a point feature unlikely to show on LiDAR, such as a prominent rootstock, I normally walk around it, mark its position on my base map approximately, based on my GPS red dot, and then use the GPS track later to position it at the centre of my walk-around circle. I'm not using compass and pacing very much these days, except when seeking greater accuracy, for example when several map-worthy features exist close together, and their relative positions are important.

One of my SUFFOC colleagues uses an "Ardusimple" device which allows differential comparison between his own GPS position and the nearest RTK network base station. This gives significantly greater accuracy, but at some purchase cost.

CRS Transformation Errors

I consider these in detail in Chapter 17. Working, as I do, in the OSGB36 coordinate reference system (EPSG 27700), CRS transformation errors may compromise the accuracy of aerial photography and GPS data which is natively aligned to a different CRS.

Prioritising Data Sources

If any two of OS mapping, aerial photography and LiDAR agree on the position of a feature, I'll normally accept that as accurate, provided my GPS track is not far away. If more than one data source is available, but they don't agree, then I'll normally favour the LiDAR, followed by the OS Map, then the aerial photography and finally the GPS track. But I may adjust that order of priority, depending on the age of the data, if the feature is something that may have changed in the intervening period.

Chapter 16. Additional notes on aerial photography

This chapter looks at errors which can arise in aerial photography templates and describes some measures to reduce these.

Oblique (and similar) errors

Most aerial photographs I use (eg from Google) will have been taken from aircraft, despite the “Google Satellite” tag. While the centre of each camera frame should be a vertical view the edges will be an oblique view. Lens distortion and stitching errors will hopefully have been largely corrected. But oblique errors in sections of the frame which were not shot vertically cannot be corrected for.

In the example below, the shot is noticeably oblique. The top of the church tower is several metres out of line with its base and the rear end of the church roof appears to overhang the road. This is easily spotted and allowed for, but the same distortion applies to tall trees where it’s not at all obvious. (Logically, it might also apply to higher ground, but I’ve not spotted this, and it may possibly have been corrected for). The photo below also illustrates how shadows can confuse, particularly when looking at trees. So, in general, if the position of a feature on a photo template is out of line with the same feature on a LiDAR template, I tend to favour the LiDAR evidence.

Another significant, more complicated, error applies to all data not natively aligned to the OS Grid (EPSG 27700) and is explained in the next chapter.

Google Earth Historical Imagery

When obtaining Google Earth photos in QGIS via a connection URL, the connection will normally be to the best Google coverage for the full area of your footprint. But this is not always the most recent coverage. I normally check in Google Earth Pro to compare. In Google Earth Pro, select “View”/ ”Historical Imagery” to toggle through the various historical photos available. When you locate the image that corresponds to the QGIS connection you will see the date on which it was surveyed. Zooming in on this image will give an idea of the best resolution that can be obtained. Normally, unless my footprint is unusually large, I find I can obtain very close to this best resolution when creating my template in QGIS, following the procedure I describe in Chapter 4. Occasionally. I’ve found that I have to export the photo in two or more sections to achieve this best resolution and not exceed the QGIS pixel limit.

You can download an image directly from Google Earth by selecting “File”/”Save”/”Save image” and adjusting the “Map Options” and “Resolution” parameters, but this will not be georeferenced. It’s possible, but rather tedious to resolve this, and in my experience the quality of georeferencing, other than via QGIS (or SASPlanet) will be poor. If I spot a historical image which will give me useful additional data, either more or less recent than the one obtained via QGIS, I sometimes do download a direct, non-georeferenced, image from Google Earth, and open this as a template in OOM using OOM's adjust template facility to position it as best as possible for each small section of the map. I've found this particularly useful when one of the historical photos shows detail in open terrain before a new forest plantation has grown.

Google Earth 3D Buildings

With historical imagery in Google Earth switched off, you can switch on (tick) the "3D Buildings" layer which, in some urban areas only in the UK at present, will give you a remarkable opportunity to see round corners. Experiment with the mouse for the full effect. I've provided some examples below. You can't download these images to use as templates, but, especially when drawing a map for urban orienteering, I keep Google Earth Pro open so I can refer to these images when helpful.

The top image below is a georeferenced vertical (non 3D) view processed via QGIS. The additional images below, of the same junctions, are taken direct from Google Earth with 3D Buildings switched on.

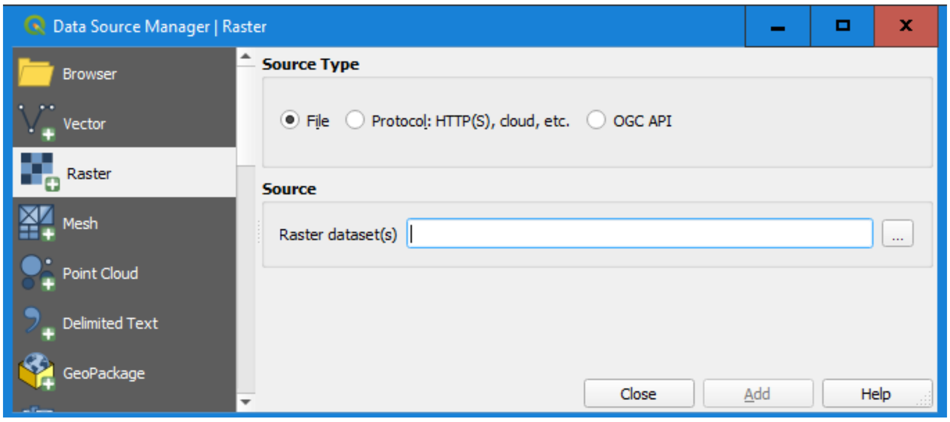
UK Environment Agency Vertical Aerial Photography.

When downloading your LiDAR data from the UK Environment Agency (DEFRA) site, you may also see an option to download Vertical Aerial Photography tiles. Currently, these are mainly available in coastal areas, or other areas of the UK prone to flooding. Vertical aerial photographs from this source have the advantage being accurately georeferenced to the OS Grid. Also, being shot vertically, these photos do not displace the tops of trees and buildings relative to the ground.

There may be RGB tiles and/or RGBN tiles (which include near Infrared) available. The RGBN tiles are the more recent in the Ipswich area (which being coastal/low-lying has reasonable coverage). If there is vertical photo coverage anywhere within the 5km square (or squares) identified by your polygon, your download will be a zip file from which you can extract (right click and "Extract All") one folder with up to 25 files in .ecw format, one for each 1km tile. Unfortunately, the files are not identified by grid reference but by a serial number. This is not, as far as I can tell, linked in any way to the grid reference - rather it refers to the date and sequence of the flight. The tiles are unlikely to cover the whole of a 5km grid square and may therefore not cover your actual footprint, even if they are shown as "available".

You can see the approximate coverage here [Coverage Metadata - Survey Data](). But I've found it more useful to import all of the tiles I've downloaded into QGIS, in one action, and immediately see the coverage in detail.

First, open QGIS, and, as usual, load the OS Map layer and zoom in to your approximate footprint. You can then drag and drop the .ecw files into the QGIS map screen. Alternatively, from the menu bar select "Layer"/"Add Layer"/"Add Raster Layer" to display the following dialogue with "Raster" pre-selected.



Data Source Manager | Raster

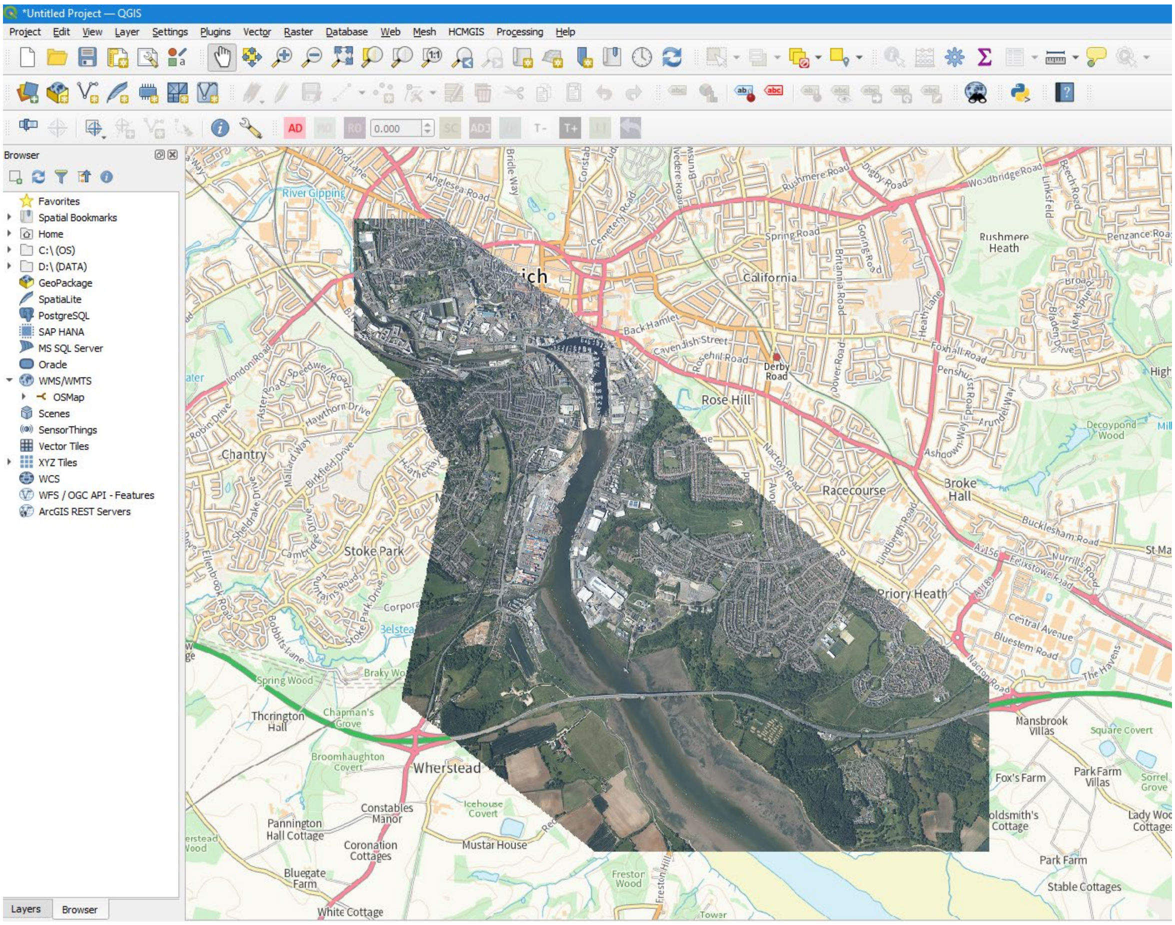
Source Type

● File ○ Protocol: HTTP(S), cloud, etc. ○ OGC API

Source

Raster dataset(s)

Clicking the "Raster database(s)" ellipsis (…) allows you to navigate to your downloaded and extracted folder of .ecw files. You then need to select all the tiles, click "Open" again, and then "Add", to load all the tiles in one go into QGIS. The result will be a composite photo as in the next screenshot.



Provided your OS Map is opened in QGIS first, no CRS conversion will be required as the photo is already georeferenced to the OS grid (EPSG 27700). The screenshot shows the total, somewhat limited, coverage within OS 5km square TM14se. You can see it's focussed on the Orwell estuary. But usefully, it covers Bridge Wood, as well as the neighbouring part of the Orwell Country Park and the Ravenswood estate, north of the A14, which is one of my more recent mapping projects.

Any portion of this photo can now be extracted as a .png image file, as per usual. NB: the Layers panel will show all (up to 25) layers of the photo plus the OS Map layer ("Road 27700"). The OS map layer must first be switched off before extracting the image. Keeping all the photo layers ticked will ensure they are included in the exported image file, provided they lie within your footprint.

The following screenshots show an identical portion of my new Orwell Country Park / Ravenswood footprint. The first is the OS Map. The other two are the Google Earth photo on the right and the UK Environment Agency vertical aerial photo on the left. The Google photo has better resolution, but the vertical photo is usually better aligned, with minimal oblique errors. I find it worth having both as templates if the vertical photo is available.

<u>Obtaining aerial photography via SASPlanet</u>

The SASPlanet application offers an alternative method to QGIS for obtaining high-resolution, georeferenced aerial photography from Google and other sources. Acknowledgements to Alex Finch for pointing me to this source. It's no longer my preferred method, as using QGIS is a little simpler and offers a more accurate CRS transformation. With SASPlanet you rely on the in-built CRS transformation facility in OOM. Also, I've not been able to download SASPlanet beyond its 30/12/21 version, though this does link to up-to-date Google Earth photography.

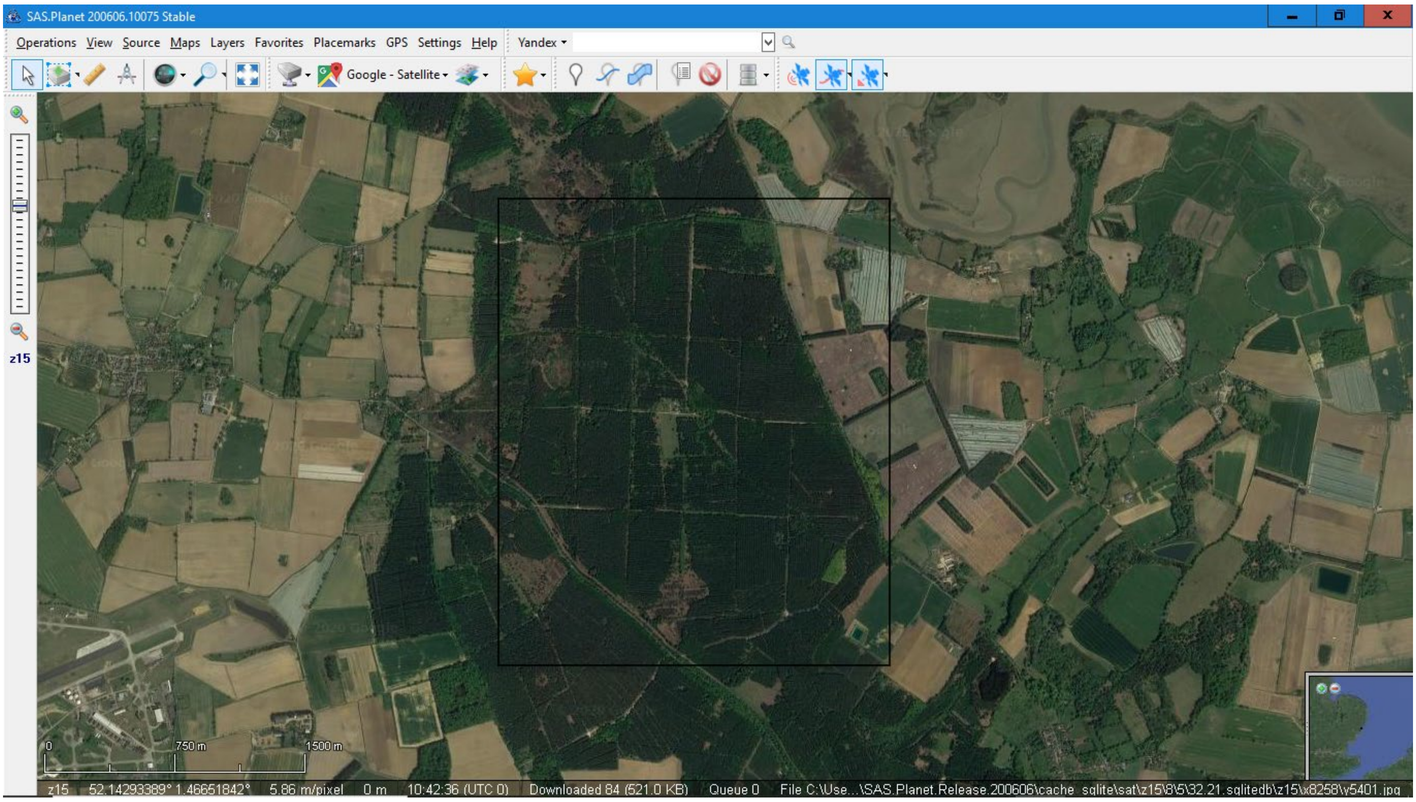
Generally, you can obtain maximum resolution Google Earth photography via both routes and the results are indistinguishable (apart from the CRS offset described in the next chapter). However, SASPlanet and QGIS don't always link to the same Google Earth photography. One or other image may be more recent, or better for our purposes. And, for exceptionally large footprints, you may find that the pixel limit in QGIS prevents exporting the full footprint at maximum resolution, whereas the same limitation doesn't appear to apply to SASPlanet. So, it's useful to have both options.

SASPlanet downloads directly here. I'm using the 30/12/21 version which is currently the last stable release listed at this site. Scroll down in the link to see this. It downloads as a zipped folder which you will need to extract to an appropriate folder on your computer. You can then open the SASPlanet application (.exe) file which is one of the extracted files. I created a shortcut to it. There are more recent SASPlanet versions listed on this site, but I think these are not stable releases. They are more complicated to download and don't appear to give access to any more recent aerial photography.

SASPlanet links to an extensive catalogue of maps and aerial photos – though many are not relevant to the UK. SASPlanet appears to be Russian software. I've looked at the photos in SASPlanet sourced from Google and Bing. Which of these provides the best template may vary from area to area. I've found that Google generally offers the clearest and most recent aerial photography of East Suffolk.

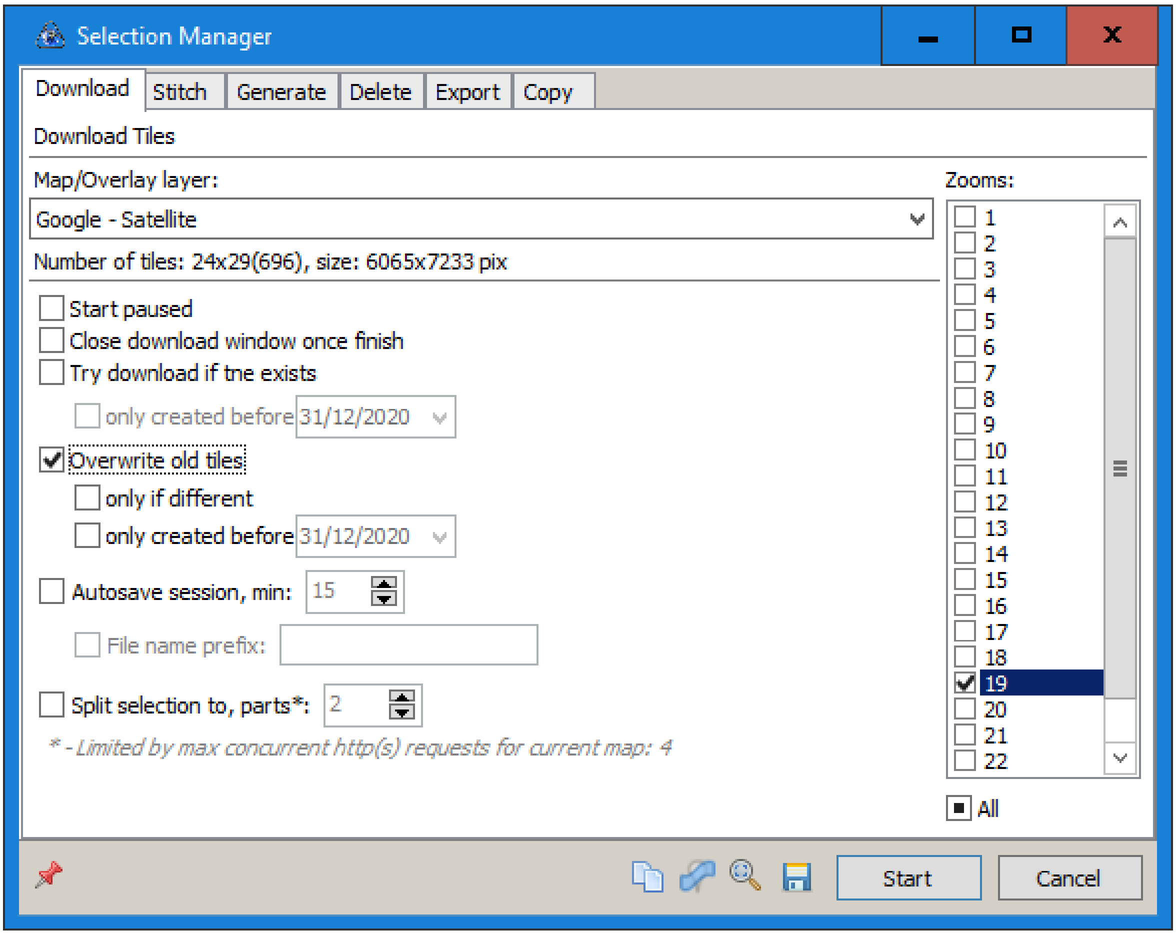
To extract a photo from SASPlanet open the application and navigate to your area. You will need to have "selected basemap" set in the top toolbar to a source that has coverage in your area. "Google / Satellite" gives Google Earth's worldwide coverage and so is a good starting point.

Then press alt + R to draw a rectangle around your map footprint. Click one corner, then move and click the opposite corner. The screenshot shows this completed for my original footprint in Tunstall Forest.



You can zoom in further to compare the various photo sources available for your footprint and select the optimum zoom level for your download (indicated on the left side of the screen). I use z20 as the standard zoom for SASPlanet photos, although the photos illustrated here were sourced at z19 which produces smaller files. Greater zoom levels than 20 can exceed the maximum definition of the photo and fail to add clarity, while slowing the process and adding greatly to the downloaded file size.

Now press ctrl + B to bring up the next screen (it may display automatically) and click the “Download” tab (normally the default).



Map/Overlay layer: Google - Satellite

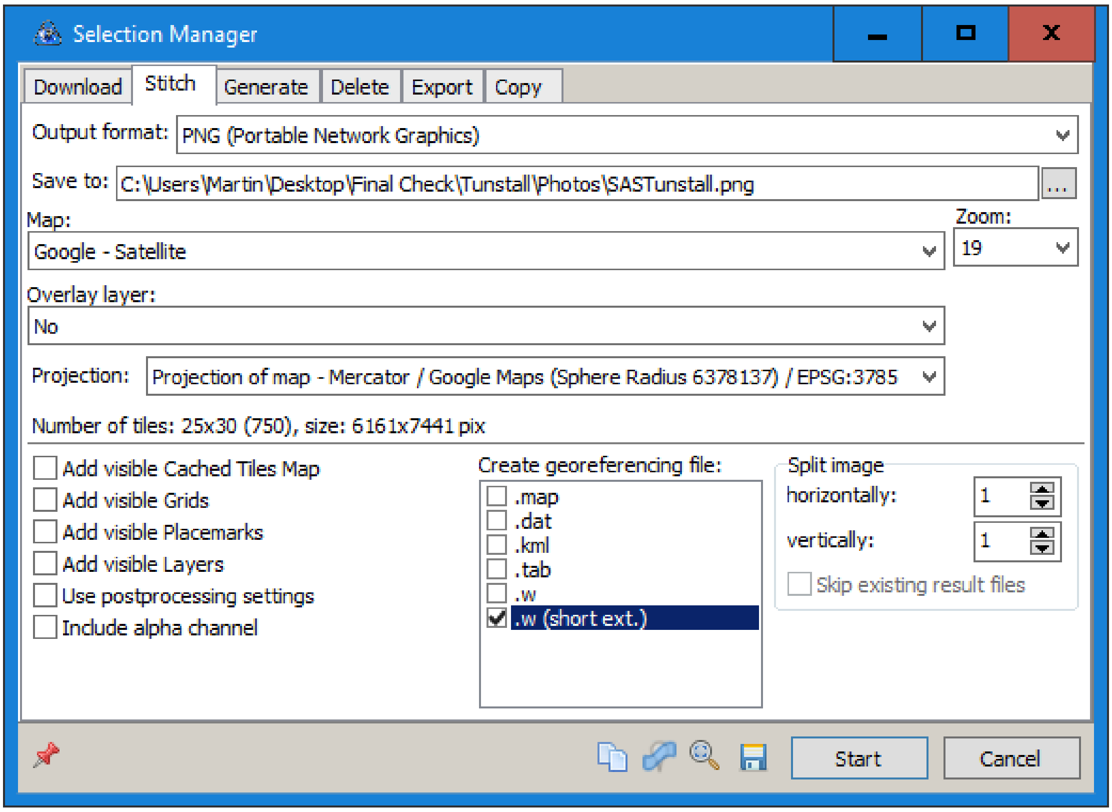
Number of tiles: 24x29(696), size: 6065x7233 pix

☐ Start paused
☐ Close download window once finish
☐ Try download if tne exists
  ☐ only created before 31/12/2020
☑ Overwrite old tiles
  ☐ only if different
  ☐ only created before 31/12/2020
☐ Autosave session, min: 15
  ☐ File name prefix:
☐ Split selection to, parts*: 2

** - Limited by max concurrent http(s) requests for current map: 4*

Zooms:
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ 6
☐ 7
☐ 8
☐ 9
☐ 10
☐ 11
☐ 12
☐ 13
☐ 14
☐ 15
☐ 16
☐ 17
☐ 18
☑ 19
☐ 20
☐ 21
☐ 22
■ All

I’ve set the zoom at 19 here and ticked “overwrite old files”. Then press “Start”. You’ll see a progress window which shows how many files (tiles) are being downloaded – a surprisingly large number. On completion click “Quit” to close the progress window. Then press ctrl + B again. And click the “Stitch” tab.



Output format: PNG (Portable Network Graphics)

Save to: C:\Users\Martin\Desktop\Final Check\Tunstall\Photos\SASTunstall.png

Map: Google - Satellite

Zoom: 19

Overlay layer: No

Projection: Projection of map - Mercator / Google Maps (Sphere Radius 6378137) / EPSG:3785

Number of tiles: 25x30 (750), size: 6161x7441 pix

☐ Add visible Cached Tiles Map
☐ Add visible Grids
☐ Add visible Placemarks
☐ Add visible Layers
☐ Use postprocessing settings
☐ Include alpha channel

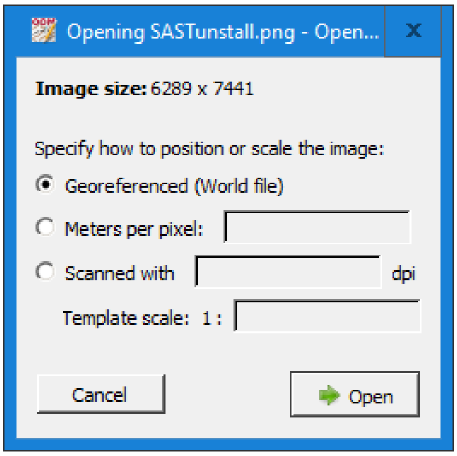
Create georeferencing file:
☐ .map
☐ .dat
☐ .kml
☐ .tab
☐ .w
☑ .w (short ext.)

Split image
horizontally: 1
vertically: 1
☐ Skip existing result files

I've set "Output format" to PNG. SASPlanet will download in various formats, including ECW and GeoTIFF, but I've found PNG gives the best result in OOM. In the "Save to" line click the ellipsis (…), navigate to your "Maps and Templates" sub-folder, and enter a filename. You need to reset "Zoom" to 19 or 20 again, leave "Projection" as "Projection of map" and note the EPSG number – 3785 in this case. The dropdown gives alternative projections, but OSGB36 (EPSG 27700) is not available. I've also ticked ".w(short ext.)" in the geo-referencing table. This will save a small .pgw file which OOM will read alongside the not so small .png image file (83Mb in this case – roughly four times this if you opt for z20 rather than z19).

Click "Start" again and watch progress – or take a break! Additional files may be saved as well as the .png and .pgw files. You can delete these, but you must keep the .pgw file.

Then, with my georeferenced OOM file open, I click "Open Template" and navigate to and open my saved SASPlanet photo. Click "Open" in the first dialogue window below as usual. In the second dialogue window select "by EPSG code" and enter "3785" as shown.



Opening SASTunstall.png - Open...

Image size: 6289 x 7441

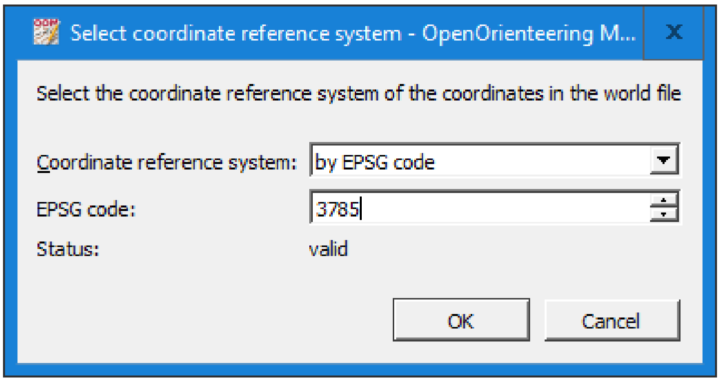
Specify how to position or scale the image:

● Georeferenced (World file)

○ Meters per pixel:

○ Scanned with dpi

Template scale: 1 :



Select coordinate reference system - OpenOrienteering M...

Select the coordinate reference system of the coordinates in the world file

Coordinate reference system: by EPSG code

EPSG code: 3785

Status: valid

OOM will now convert the image from its native coordinate reference system (EPSG 3785) to the coordinate reference system of your map (EPSG 27700), and then open the photo template which should open correctly georeferenced. It will be skewed on the screen as its native projection has been altered. It will normally also open offset by a small amount as explained in the next chapter.

Chapter 17: Compensating for Coordinate Reference System Transformation Errors

This Chapter is not relevant if you are not concerned about map errors of a few metres - which most orienteers in competition will never notice. But I find errors of this nature annoying, and worth addressing where possible.

A brief (rather simplistic) note on CRS transformation algorithms

As mentioned in Chapter 1, The UK Ordnance Survey coordinate reference system (OSGB36 / EPSG 27700) is something of an outlier. It's not readily compatible with the World Geodetic System (WGS84) which determines the longitude and latitude of each point on the earth's surface. Fortunately, the other data sources we may want to use, are all, to a good approximation, compatible with WGS84. These are Google Earth and similar sources of aerial photography, Open Street Map and GPS. The first two use the "Web Mercator" CRS, while GPS uses WGS84 longitude and latitude coordinates directly. So, we only need to be concerned with CRS transformations from WGS84 to OSGB36 and vice versa.

OOM has an inbuilt facility to convert between OSGB36 (EPSG 27700) and WGS84 (eg EPSG 3785 or 3857). However, the transformation algorithm used by OOM (drawn from the "PROJ4" library) is not particularly accurate. The quoted accuracy is 3 metres, though I have discovered that this can be optimistic. No CRS transformation algorithm can be completely accurate, but some are better than others. I understand that the advantage of the PROJ4 library is that the algorithms are relatively light on computer processing resources, important in web-based applications.

I now effect most CRS transformations in QGIS, as described in the earlier Chapters of this guide. QGIS offers a range of CRS transformation algorithms. QGIS's default algorithm for converting from WGS84 to OSGB36 claims an accuracy of 1m.

CRS transformation errors are most obvious when comparing georeferenced aerial photographs with OS mapping or LiDAR images of the same footprint. Using the PROJ4 algorithm in OOM to effect the transformation will often - depending on your location – lead to a consistent error of a few metres across the map footprint which I've found, in Suffolk, is worth correcting for. Even using QGIS to effect the transformation, small errors will still be apparent. But, in practice, these do not seem to be consistent across an O-map footprint. They may be caused by small CRS transformation errors, but, equally possibly, by errors in the alignment of the aerial photography. Often, if you toggle two recent "historical images" in Google Earth Pro, you find that the same feature is not located identically on the screen in both images – they can't both be correct!

I do not try to correct for transformation errors when using QGIS to process the templates. However, I still occasionally use OOM to effect a transformation when obtaining an aerial photo via SASPlanet. And I regularly use OOM to perform a reverse transformation from OSGB36 to WGS84 when creating a .kmz version of my map for use in MapRun. MapRun is largely outside the scope of this guidance, but I do need to create a .kmz file to use with the "checksites" facility in MapRun, in order to get my OOM map onto my iPhone to use when surveying in the field. The errors inherent in this process are worth correcting for, so I've retained the description of how I make this correction below. It's logical, though I've not been able to check this, that the same error will occur when opening an OOM file on an Android device and attempting to match this with your GPS position in the field.

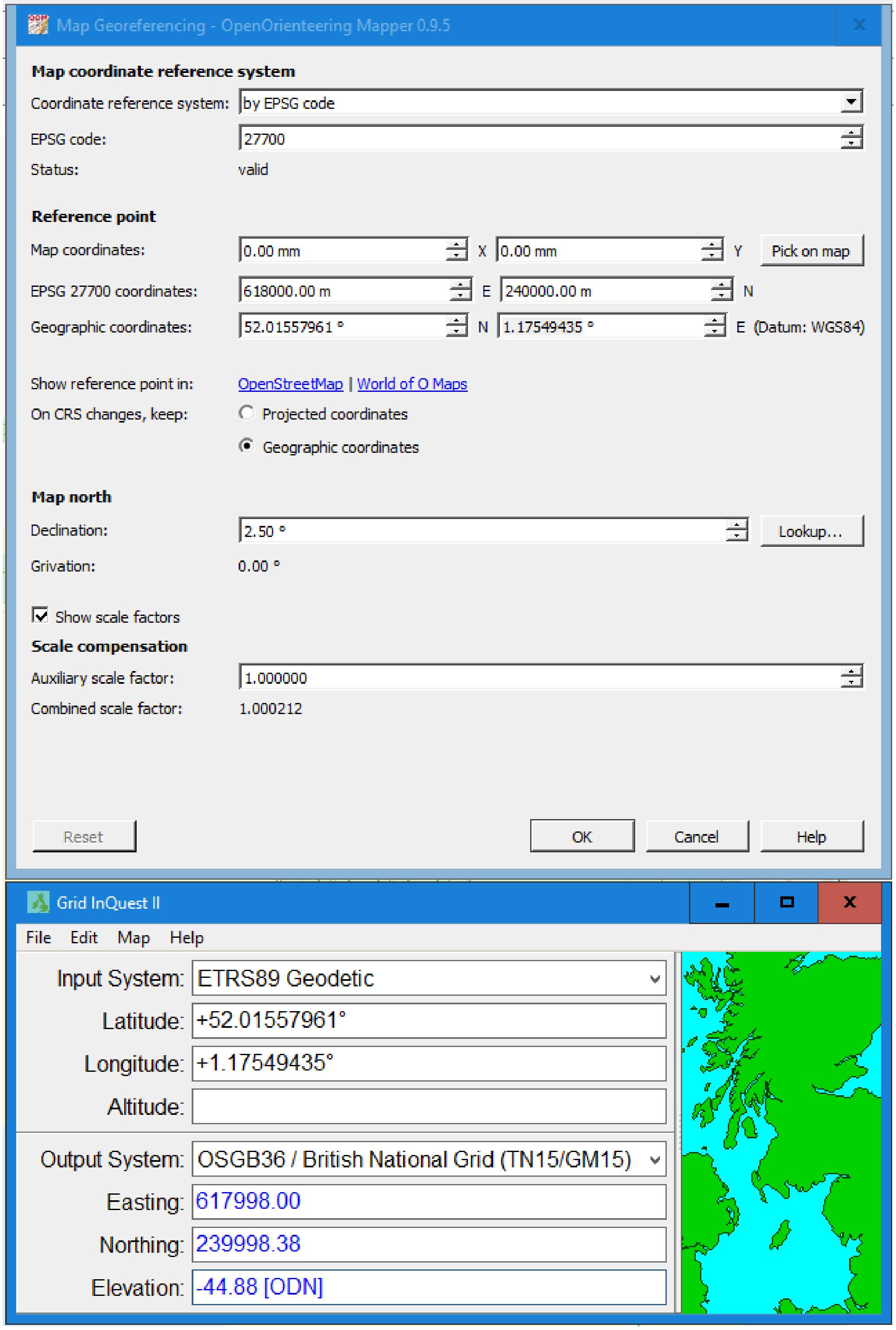
How to correct for transformation errors when using OOM to make the transformation.

The Ordnance Survey provides an app called "Grid Inquest II" for converting single points between the WGS84-determined longitude and latitude, and EPSG 27700 coordinates. Grid Inquest II can be downloaded at https://www.ordnancesurvey.co.uk/business-government/tools-support/os-net/transformation. The algorithm used in Grid Inquest II appears to produce results that are indistinguishable, at least to the level of accuracy we need as orienteering mappers, from the default transformation algorithm used by QGIS.

So, before exporting an OOM map as a .kmz file I use Grid Inquest II to establish the transformation error at my map origin and then make the appropriate correction. The correction required varies significantly across the UK in no obviously predictable way, but it should not vary significantly across a single O-map footprint. The method I use is as follows.

Once you have georeferenced your map, you can open the georeferencing dialogue window again at any time. I display this together, ideally on the same screen, with the Grid Inquest II application. I'm using Bridge Wood again here as my example in the screenshot below.

In the georeferencing window, the EPSG 27700 coordinates shown are the coordinates of the origin of my map which I set, in this case, at the SW corner of my footprint. These are the coordinates I will ask Grid Inquest II to transform. For a larger footprint, you may achieve a better result, averaged across the map, by using the coordinates of the centre of the map instead. For this and other reasons, I now tend to use the centre of my map as my map origin and reference point, as explained in [Chapter 3.](#)



Map coordinate reference system

Coordinate reference system: by EPSG code
EPSG code: 27700
Status: valid

Reference point

Map coordinates: 0.00 mm X 0.00 mm Y
EPSG 27700 coordinates: 618000.00 m E 240000.00 m N
Geographic coordinates: 52.01557961 ° N 1.17549435 ° E (Datum: WGS84)
Show reference point in: OpenStreetMap | World of O Maps
On CRS changes, keep: ○ Projected coordinates ● Geographic coordinates

Map north

Declination: 2.50 °
Grivation: 0.00 °

☑ Show scale factors

Scale compensation

Auxiliary scale factor: 1.000000
Combined scale factor: 1.000212

Input System: ETRS89 Geodetic
Latitude: +52.01557961°
Longitude: +1.17549435°
Altitude:
Output System: OSGB36 / British National Grid (TN15/GM15)
Easting: 617998.00
Northing: 239998.38
Elevation: -44.88 [ODN]

The top screenshot shows that OOM has already transformed the EPSG 27700 coordinates into approximately equivalent WGS84 geographic coordinates, using its PROJ4 algorithm.

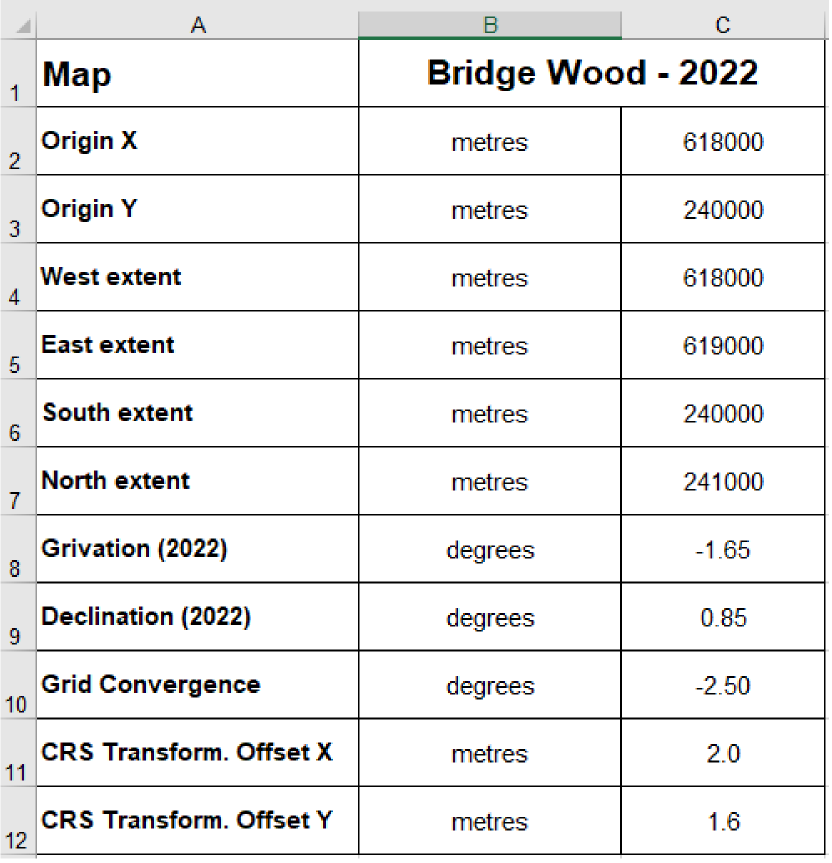
In Grid Inquest II, I've set the Input System to "ETRS89 Geodetic". This is equivalent to WGS84, updated, I believe, to allow for 5 years' worth (a few centimetres) of continental drift! I've set the Output System to OSGB36. I've then copied and pasted my "geographic coordinates" from the OOM georeferencing dialogue window into the Input lines in Grid Inquest II. Don't try to copy the degree symbol – just the numbers and the "-" sign if present. Grid Inquest II adds the degree symbol automatically.

Grid Inquest II then transforms the geographic coordinates back to OSGB36 (EPSG 27700) using its more accurate algorithm. The EPSG 27700 / OSGB36 coordinates in the two windows are not identical. The difference between the two sets of EPSG 27700 coordinates gives my required correction.

The differences I need are obtained by subtracting the figures in the Grid Inquest II Output from the corresponding figures in the OOM georeferencing dialogue. Accuracy to one decimal place is plenty, so in this case I get offsets of +2.0m East and +1.6m North. Measured this way, both "x" and "y" offsets are positive in Suffolk, but that will not be the case everywhere in the UK. To create a .kmz file for MapRun which will accurately align with Google Earth I need to temporarily add these offsets to the EPSG 27700 coordinates in the OOM georeferencing dialogue before exporting to .kmz. (achieved by selecting "File"/"Export as"/"KMZ"). Although these figures seem rather small, the effect is quite noticeable.

Using Purple Pen to create MapRun courses is outside the scope of this document, but making the same adjustment in the OOM georeferencing dialogue before linking the map to Purple Pen also produces correct GPS control alignment for a MapRun event. Don't worry if you've already created the course in Purple Pen. Re-linking to the adjusted map will not move the controls relative to the map, just relative to the earth. Lawrie Brown's guide here is my go-to reference for creating MapRuns. It has a section on using Purple Pen.

Having determined the offsets, I can now complete my map data table for Bridge Wood as follows:



	A	B	C
1	**Map**	**Bridge Wood - 2022**	
2	**Origin X**	metres	618000
3	**Origin Y**	metres	240000
4	**West extent**	metres	618000
5	**East extent**	metres	619000
6	**South extent**	metres	240000
7	**North extent**	metres	241000
8	**Grivation (2022)**	degrees	-1.65
9	**Declination (2022)**	degrees	0.85
10	**Grid Convergence**	degrees	-2.50
11	**CRS Transform. Offset X**	metres	2.0
12	**CRS Transform. Offset Y**	metres	1.6

Adjusting aerial photo images from SASPlanet

I always correct for this transformation error if using SASPlanet to obtain georeferenced aerial photography from Google. You can do this as follows:.

Select the photo template in the OOM template setup window. Switch off its georeferencing using the “Edit” button at the foot of the window, and click the “Move by Hand” button (next to the edit button). If you make a mistake, you can revert to the georeferenced template by first deleting it (select it and click the red “-“ button) and then re-opening it from the version on file.

You can then move the template to match a feature in the photo with the same feature on your OS map, LiDAR template or a DEFRA vertical photo if you have one. Using this method, it’s important to use a ground level feature. Using a rooftop, or similar, will introduce oblique errors.

Even so, you may get different results matching different features across your footprint. So, I normally find it best to move the image by the exact offset correction established above. The easiest way to do this is to temporarily reconfigure the OOM grid to show horizontal and vertical spacings equal to these x and y offsets. Then use the “Move by Hand” button to move the photo image by one grid square. It will be in the opposite direction to that established using Grid Inquest II as above – ie SW in this Suffolk case.

Immediately after reconfiguring the grid with such small spacings, the grid lines may blackout the map screen. Just zoom in to resolve this.

Even using the QGIS route described in Chapter 4, your Google aerial photo template may be offset from the OS map and LiDAR templates by a small but noticeable amount. Usually, this offset is pretty insignificant and is fairly random across the footprint. If so, it cannot be corrected, except by the time-consuming method of re-positioning the photo template for each small section of the map.

Adjusting GPS tracks.

I now routinely load my GPS tracks into OOM via QGIS as described in Chapter 14. No significant transformation errors will result using this method. However, if you load GPS tracks directly into OOM as templates, the same transformation error will result as with photos obtained via SASPlanet. Usually, GPS errors will swamp any transformation errors, but I still found it worthwhile making this correction, when I used to load my GPS tracks directly into OOM, so as not to compound the errors.

GPS tracks are shapefiles which, if loaded as templates, cannot be adjusted using the “Move by Hand” tool. So, I overcame this by *importing* the .gpx file into a mirror OOM file and then using the mirror OOM file as my template. See the reference in Chapter 3 to mirror files.

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