Environment Agency LIDAR data

Technical Note

March 2016
Version 5

Background

The Environment Agency has been capturing Light Detection and Ranging (LIDAR) data regularly since 1998. We currently have over 10,000 discrete individual surveys, each ranging in coverage from a few square kilometres to hundreds of square kilometres.

We use aerial LIDAR, an airborne mapping technique, which accurately measures the height of the terrain and surface objects on the ground, through the use of a scanning laser that measures the distance between the aircraft and the ground. Tens to hundreds of thousands of measurements per second are made of the ground, allowing highly detailed terrain models to be generated at spatial resolutions of between 25cm and 2 metres.

The Environment Agency's LIDAR data archive contains digital elevation data derived from surveys carried out by the Environment Agency's specialist remote sensing team. Accurate elevation data is available for over 75% of England.

Data may be available at 2m, 1m, 50cm, and 25cm resolution. Historic data are available for some areas where we have carried out repeat surveys.

These can be supplied as a combined Digital Surface Model produced from the signal returned to the LIDAR (which includes heights of objects, such as vehicles, buildings and vegetation, as well as the terrain surface) and Digital Terrain Model (a "bare earth" model with surface objects filtered out of the DSM by applying bespoke software techniques).

Accuracy

We ensure all our LIDAR data meets high accuracy specifications.

Vertical (height) accuracy

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

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

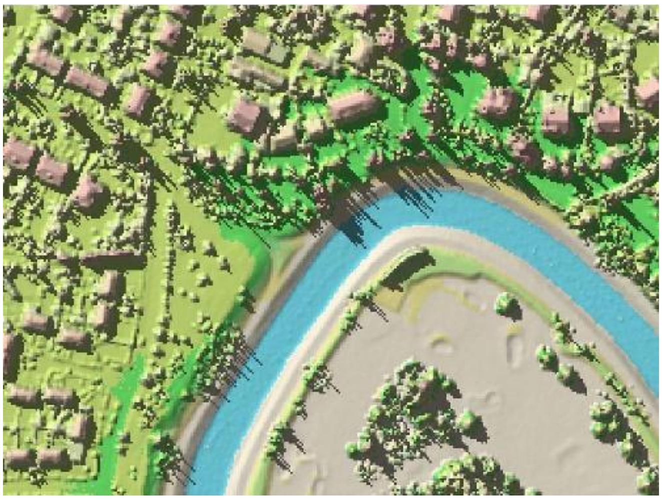
Horizontal (planar) accuracy

The absolute spatial error in our LIDAR data is ±40cm. For our datasets at 2m, 1m and 50cm resolution, this error is effectively absorbed in the pixels of the raster image.

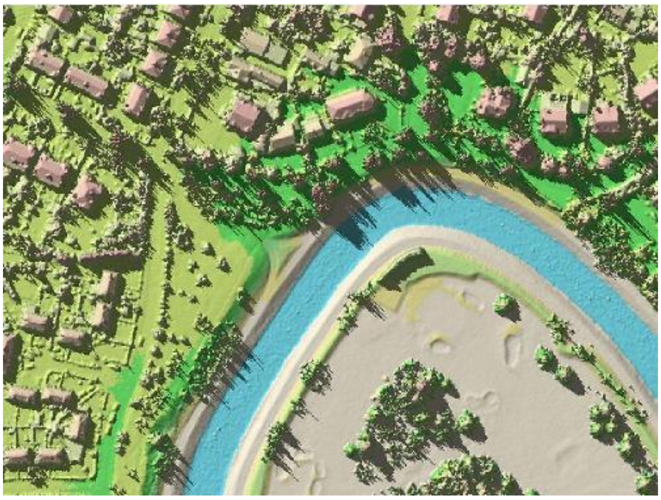
The relative horizontal accuracy of the LIDAR sensors we have been using over the past decade, as stated by the Instrument manufacturer, is 1/5500 x altitude (m Above Ground Level). For example, if the average survey height is 1000m AGL relative horizontal accuracy is 0.1818m.

Examples of different spatial resolutions

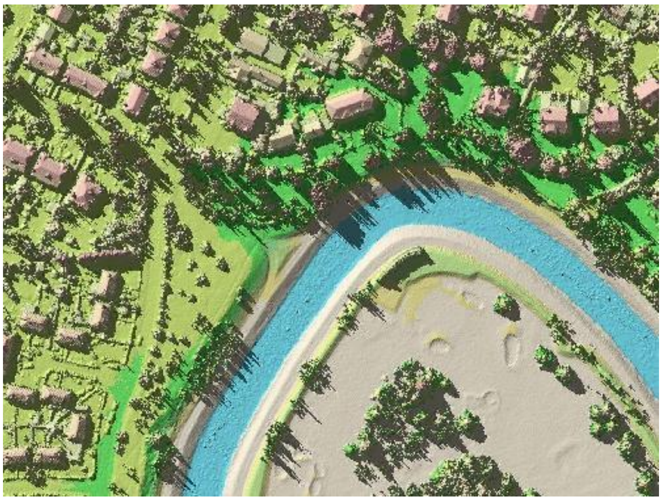
2m resolution LIDAR DSM



1m resolution LIDAR DSM



50cm resolution LIDAR DSM



25cm resolution LIDAR DSM

LIDAR Data Projection information

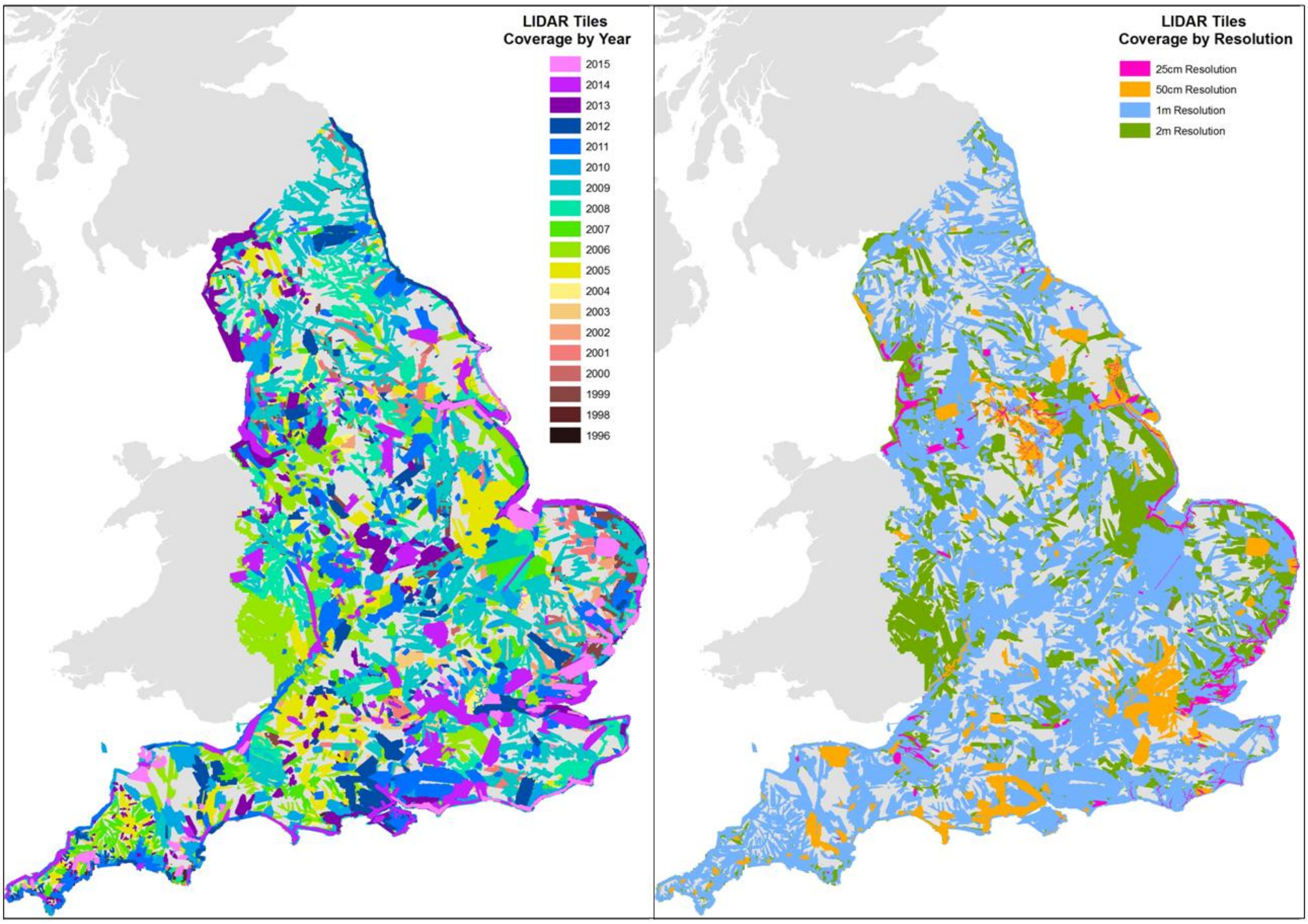
All our data is OSGB'36 British National Grid, with elevations recorded Above Ordnance Datum Newlyn (AODN).

Raster DSM and DTM's

LIDAR Tiles

LIDAR Tiles are our historic dataset, where the tiles are made up with data from just one specific, dated, survey. In some areas we have carried out repeat surveys and these will be accessible as separate datasets. Using repeat surveys you can build up a picture of change in the landscape - for example changes in beach morphology. The date stamped, survey specific LIDAR tiles are presented in millimetre units.

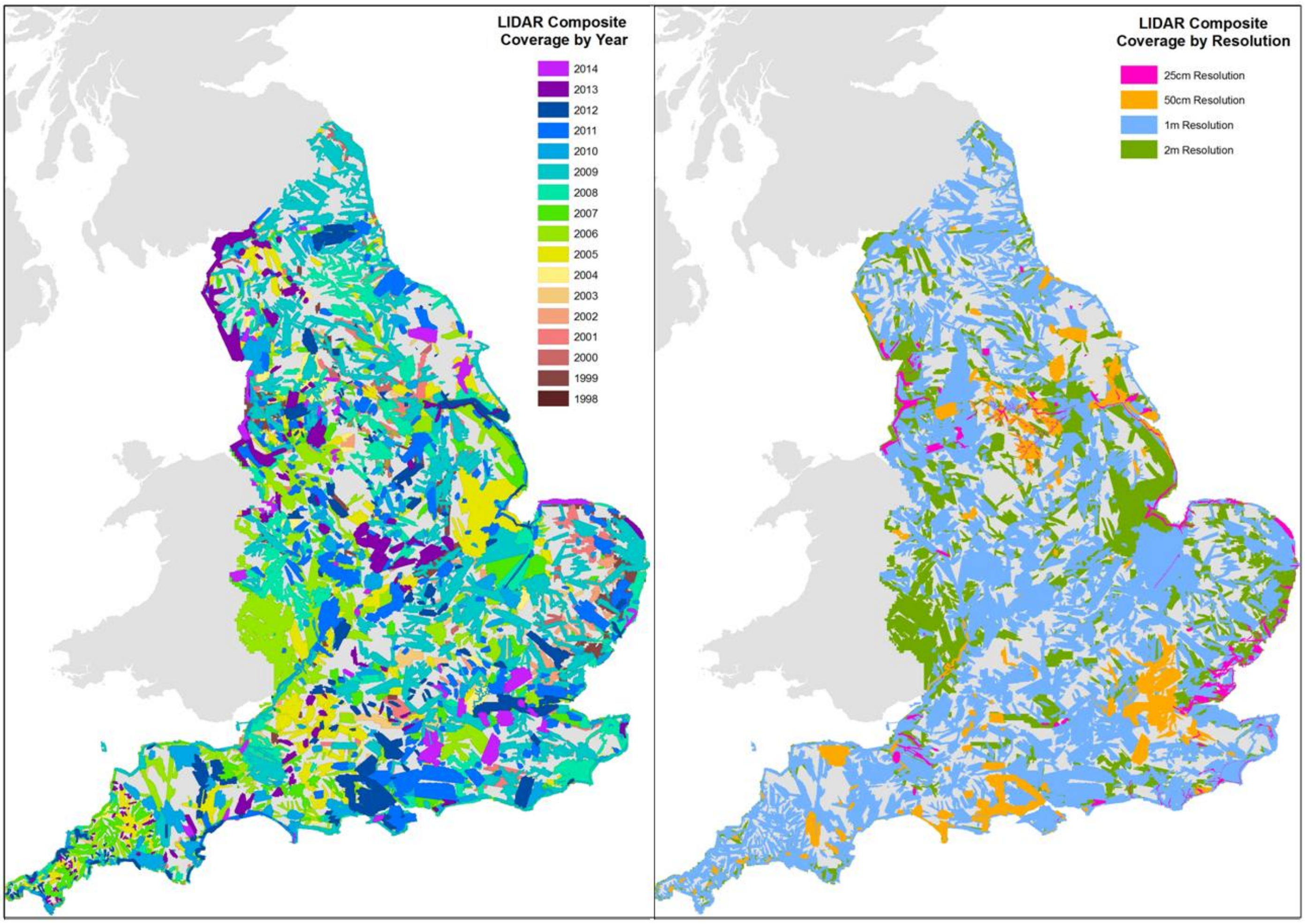
The maps below provide an overview of LIDAR Tiles coverage showing the year the data was flown and the resolution available.



LIDAR Composite

The LIDAR Composite is a merged product that we have made by merging together each survey to give a single seamless layer. Where there are repeat surveys, the newest survey is used. This composite is available at four spatial resolutions: 2m, 1m, 50cm and 25cm. The cell values for the ASCII files of the merged products are in metre units.

The maps below provide an overview of LIDAR composite coverage showing the year the data was flown and the resolution available.

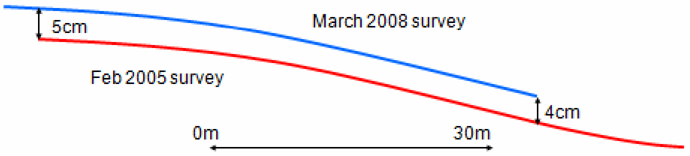


LIDAR Composite Process

The process involves taking data from different, overlapping surveys, at different resolutions, and merging them together. For 2 metre resolution data we use a 30 metre feathered buffer to ensure a seamless transition from one survey to the next. The newest and highest resolution data takes precedence in the merging process. If the input data were at a resolution finer than the delivered resolution, the data were re-sampled to the resolution of delivery using the bilinear interpolation method in ESRI's Spatial Analyst software. For 1 metre resolution data we use a 25 metre overlap, for 50cm resolution we use 20 metres, and for 25cm we use 15 metres.

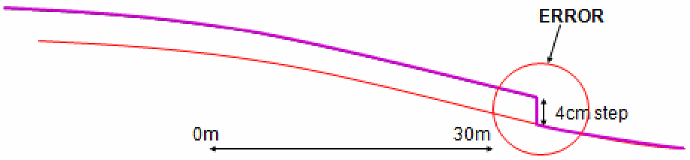
The images below give a graphic representation of how the merging is carried out and the results on the final composite:

Producing the composites – feathering at edges of overlapping surveys



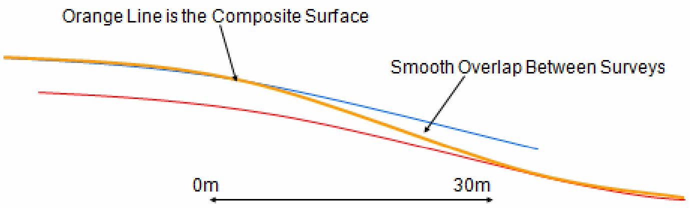
1.Two overlapping surveys, slight difference between these two surfaces

Producing the composites – feathering at edges of overlapping surveys



2. Just overlaying new surface over old surface would lead to a 4cm step in the output composite.

Producing the composites – feathering at edges of overlapping surveys



3. Feathering technique produces a smooth transition at the overlap area, much better for flood risk mapping and modelling.

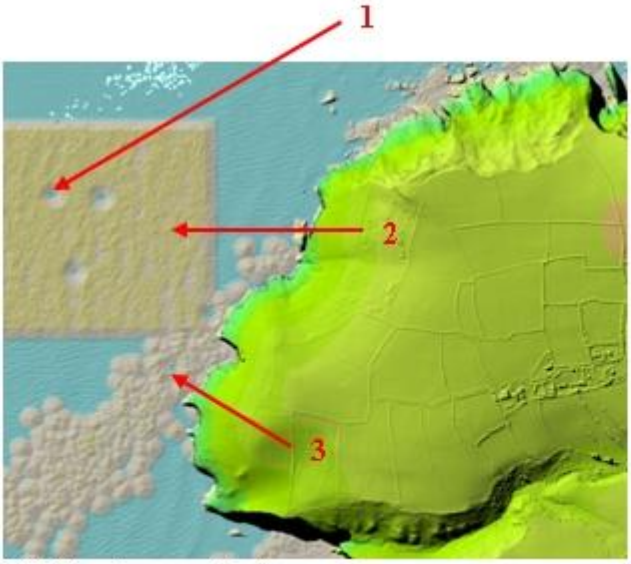
Known Issues with Composite

Coastal Areas

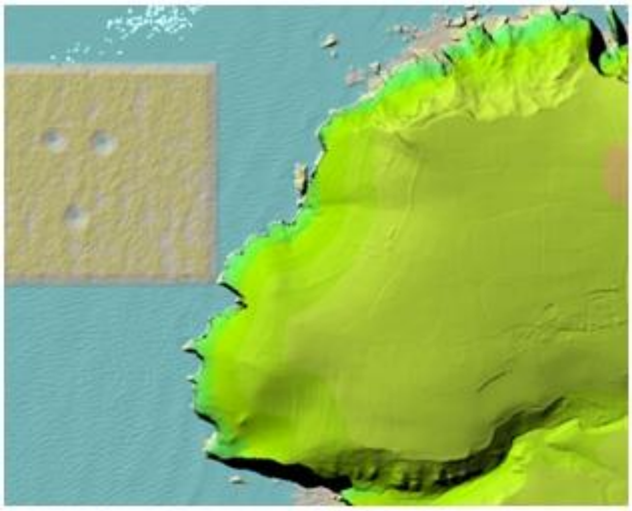
The images below show features in the DSM and DTM, which may be present in coastal areas of the merged LIDAR composite product.

Concave spots (1) and convex spots (3) in coastal areas are the result of the feathering process between different LIDAR surveys. For example, if in the most recent dataset captured there are gaps in the coverage over the sea, these gaps will be filled by pulling values from an older dataset. As the data will have been captured at different states of the tide, you will see a feathering up or down of the LIDAR surface at these points.

You may also see unexpected shapes over the sea (2), which again are due to an older dataset having been used to fill gaps where no coverage exists in the more recent dataset. The older dataset in this example has been flown at a time of higher tidal levels.



DSM at 2 m resolution


DTM at 2 m resolution

Other Areas

The two images below show LIDAR DSM and DTM tiles at 25cm resolution for an urban area.

The lines highlighted in the DSM (4) are the result of 'spikes' within the data. These spikes can be caused by objects such as birds, pylons, clouds and kites. Spikes are removed from the DTM during the filtering process.

DSM at 25 cm resolution


DTM at 25 cm resolution

Metadata

The shapefile “lidar_used_in_merging_process_yyyy_opendata.shp" shows the actual coverage of the individual LIDAR Tiles that have gone into the process to make the Composite products. As well as the coverage of the tile, there are attribute fields present that show the date flown and the resolution of the file.

Each resolution also has a grid index shapefile which details the Ordnance Survey name and percentage coverage for each tile.

The ASCII raster file format

The ASCII raster file format is a simple format that can be used to transfer raster data between various applications. It is a few lines of header data followed by lists of cell values. The header data includes the following keywords and values:

ncols	number of columns in the data set.
nrows	number of rows in the data set.
xllcenter or xllcorner	X coordinate of the centre or lower left corner of the lower left cell
yllcenter or yllcorner	Y coordinate of the centre or lower left corner of the lower left cell
cellsize	cell size for the data set (resolution)
nodata_value	value in the file assigned to cells whose value is unknown. This keyword and value is optional. The nodata_value defaults to -9999.

For example:

ncols 1000

nrows 1000

xllcorner 460000

yllcorner 210000

cellsize 1

nodata_value -9999

66.760 66.770 66.770 66.780 66.780 66.740 66.760 etc

66.730 66.680 66.660 66.660 66.660 66.660 66.670 etc

etc

The first row of data is at the top of the data set, moving from left to right. Cell values should be delimited by spaces. No carriage returns are necessary at the end of each row in the data set. The number of columns in the header is used to determine when a new row begins. The number of cell values must be equal to the number of rows times the number of columns.

How to Open LIDAR Data

LIDAR data is a technical Geographic Information System (GIS) dataset and will need specialist software in order to open it.

There are a number of free tools available that can be used to visualise LIDAR data https://en.wikipedia.org/wiki/List_of_geographic_information_systems_software

How to import ASCII data

Importing ASCII data into GIS software may require the ASCII LIDAR files to be converted to binary rasters (Float) first, before any mosaic / analysis work is performed (ASCII is an exchange format only).

Your GIS may allow the ASCII raster files to be added directly but this does not allow for the data type and stats to be calculated. For example if the data type (integer or raster) is determined from the first few pixels in the top left corner of the tile and these pixels are “No Data” values, or have a uniform value of 0 (or another integer), then the whole tile will potentially be treated as an integer – even if there are lots of floating point values elsewhere in the tile.

The date stamped, survey specific LIDAR tiles are presented in millimetre units, these tiles need to be divided by 1,000 to convert to metre units.

How to import LIDAR data into CAD

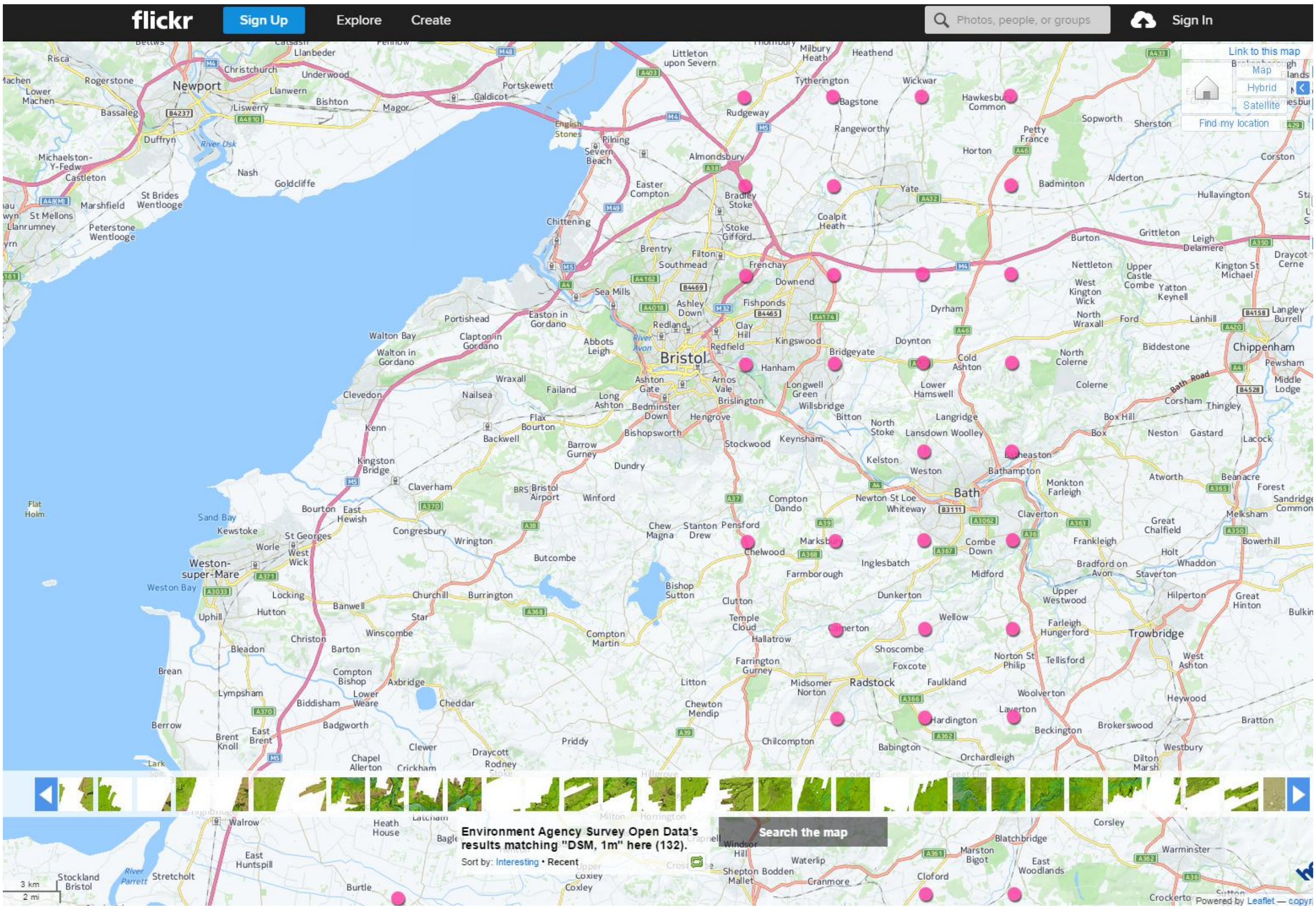
LIDAR data is a GIS dataset and importing it into CAD can be difficult as not many CAD packages can handle LIDAR data. We would recommend that you carry out a web search into the best current methods of doing this.

LIDAR JPEGs

These are now available to download from Flickr:

https://www.flickr.com/photos/environmentagencyopensurveydata/collections

https://www.flickr.com/photos/environmentagencyopensurveydata/map



Click on "Search the map".

Filter search by selecting "Environment Agency Survey Open Data's items" only.

Filter results by using one or more of the following Tags: DSM, DTM, 2m, 1m, 50cm, 25cm.

Points will only be displayed for images that appear in the scrollable photo bar that appears at the bottom of the screen. More LIDAR images may be available by scrolling along the bar.

LIDAR Point Cloud

What is a LIDAR point cloud?

A point cloud is a collection of hundreds of millions, or sometimes billions, of laser points collected by our aerial LIDAR systems and post-processed to highly accurate 3-dimensional x,y,z points and component attributes. Gridded raster products such as our DSM and DTM surfaces are then derived from this point cloud.

What datasets are available?

The first sets of point data to be made available will be the 16 months of LIDAR surveys between July 2014 and November 2015. Surveys going back to 2005 will be made available by end of June 2016. Please be aware there will not necessarily be a matching point cloud tile available for every DSM/DTM raster surface. This is because historically the DSM/DTM was the primary product and the point cloud was not always retained.

The LAS/LAZ File format

The LAS(er) (LAS) file format is an industry standard and internationally recognised method of exchanging LIDAR point cloud data defined by the American Society of Photogrammetry and Remote Sensing (ASPRS). It enables storage of extremely large datasets, whilst maintaining component attribute information specific to the nature of LIDAR data. All LIDAR point cloud data is supplied in an open, compressed version of LAS, known as LAZ, produced by Rapidlasso GmbH.

What are the attributes of LIDAR point clouds?

The LIDAR point cloud contains more than just the 3-dimensional x,y,z coordinates of each point. Each laser pulse returned contains attributes that can provide invaluable information for scientific research and analysis. The Environment Agency has been collecting LIDAR data since the earliest systems were available. Over this time the ability of the sensors to record increasing types of attributes and the mediums to store such information have continued to evolve. As a result our LAS point cloud archive is a mix of datasets containing different component attributes. For example, our earliest datasets pre-date the LAS file format and have been converted from simple x,y,z txt files whilst our most recent datasets (2010 onwards) are captured from the latest LIDAR sensors and have a rich resource of attributes associated with them, including:

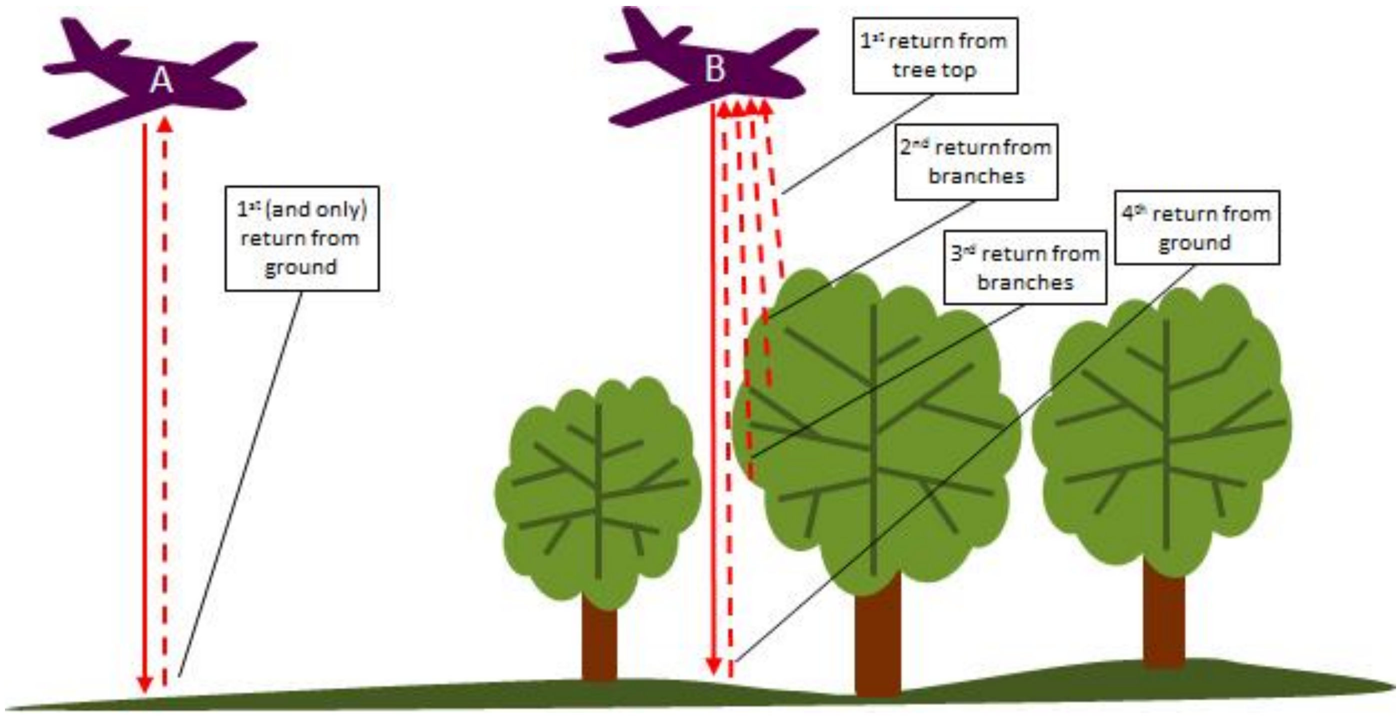
Intensity

Intensity is a measure of the amount of laser light from each laser pulse reflecting from an object. This reflectivity is a function of the near infrared wavelength used and varies with the composition of the surface object reflecting the return and angle of incidence. Viewing the point cloud by its intensity produces a greyscale image where darker surfaces such as roads reflect less light than other surfaces such as vegetation.

Laser returns

Laser pulses emitted from a LIDAR system reflect from objects both on and above the ground surface. Each laser pulse can return to the LIDAR sensor as one or many returns, as it encounters multiple reflections from surface objects as it travels to the ground. Our current sensors can have up to 8 returns per laser pulse.

All derived DTM and DSM products have been generated from the last return of the laser pulse or the only returned single reflection, as this provides the optimum chance of the laser reaching the 'true' ground surface. In the diagram below for example the last return used in the DTM and DSM products for Plane A would be the first and only return recorded and for Plane B would be the fourth return.



Classification

Every LIDAR point can have a classification assigned to it which defines the type of object or height of vegetation that has reflected the laser pulse. Bespoke algorithms have been developed to assign a classification code to the attribute information for each of these LIDAR points. The settings are outlined in the table below.

The classification is a fully automatic process. There is no manual editing if the algorithm assigns an incorrect class code to a LIDAR pulse. An example of this might be where a large flat rooftop is classified as 'ground' as it meets all the parameters that define what ground should be. When producing a DTM surface from these ground points, the building object will remain present within this surface. Manual editing of the raster surface is then carried out using two versions of the ground classification to remove or retain object(s) incorrectly classified in the DTM surface. However it will remain classified as 'ground' in the point cloud. It will not be possible therefore, to recreate exactly the time stamped DTM surfaces from the point cloud data.

Classification Code	Parameters
1 – Default	All points that do not fall within the parameters below
2 - Ground	The algorithms best estimate as to which laser returns are on the ground, based on various parameters that determine if a point can be described as ground i.e angle to its neighbours
3 – Low surface object	0.05 => Ground =< 0.15
4 – Medium surface object	0.15 => Ground =< 5
5 – High surface object	5 => Ground =< 100
8 – Model keypoints	Thinned version of the ground model with reduced point density on flat surfaces and retained point density in areas of relief change.

GPS Time

The GPS time for each laser pulse is stored as either 'GPS Seconds of the Week' or 'GPS Absolute Time'. 'GPS Seconds of the Week' represents the number of seconds into a week, starting at 0 seconds every Midnight Saturday/Sunday, upto 604800 seconds. 'GPS Absolute Time' started at 0 on 6th January 1980.

Point Source ID

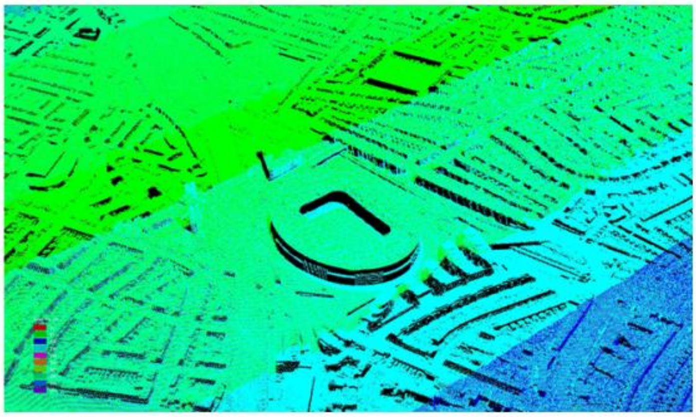
Each laser pulse can have a point source id value assigned to it. This tells you which flightline each laser point came from and is useful when analysing datasets that are made up of surveys spanning different days.

Examples of LIDAR point attributes

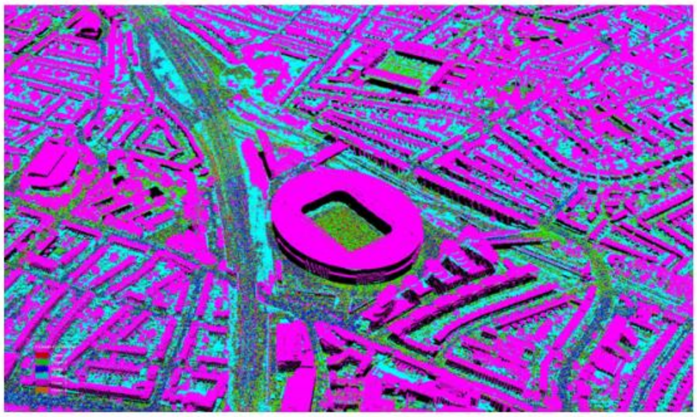
Intensity

Laser Return

Point Source ID



Classification



LIDAR Tiles

The LIDAR point cloud is supplied in survey specific tiles aligned to the OS National Grid, in the same way as our date stamped raster products (‘LIDAR Tiles’). All datasets pre July 2014 are supplied in 1km x 1km tiles. After this date all datasets are supplied in the same tile size as the gridded raster product.

What is the resolution of point cloud data?

The resolution of the point cloud is described as a combination of its average point density and point spacing. Unlike the derived DSM and DTM surface models, the point cloud is not a regularly spaced dataset and as such the laser points are not equally distributed. The resolution of the final surface dictates the capture parameters that influence the resolution of the point cloud.

How to Open and view point cloud data

There are many free viewers for point clouds, both standalone install and web based. Please search the internet for 'free lidar viewer' to find some. Although the majority of software available will handle the compressed LAZ file format, you can uncompress LAZ data into LAS using open source, freely available tools available on the internet.

Metadata

The shapefile "OSGB_Point_Cloud_Archive.shp" shows the coverage of the individual LIDAR tiles available. As well as the coverage of the tile there are attribute fields that show the date flown, the number of points and average point spacing of each tile and what component attributes are contained with the tile.

Glossary

ASCII

The ESRI ASCII grid raster file format is a simple format which can be used to transfer raster data between various applications. The file consists of a few lines of header data followed by lists of cell values. The cell values for the ASCII files of the merged products are in Metres Above Ordnance Datumn Newlyn.

Raster

Raster. A grid of regular sized cells arranged in rows and columns. Each cell contains a single attribute and location coordinates. For a LIDAR DSM/DTM Raster the size of each cell represents the resolution of the data and the attribute is the elevation of that cell.

DEM

Digital Elevation Model. A digital representation of continuous elevation values over a landscape, in a raster format (an array of numbers that represent height).

DSM

Digital Surface Model. This is a DEM of the terrain plus surface objects such as vegetation, buildings and vehicles.

DTM

Digital Terrain Model. This is a DEM of the terrain with all surface objects such as vegetation, buildings and vehicles removed – this is the "bare-earth model".

Resolution

The x,y spatial resolution of LIDAR data is expressed in metres or centimetres (2m, 1m, 50cm, 25cm).

Point Cloud

Point Cloud. A collection of highly accurate 3-dimensional x,y,z laser points collected by our LIDAR systems.

LAS

LAS(er). A file format for storing point cloud data.