LANTMÄTERIET

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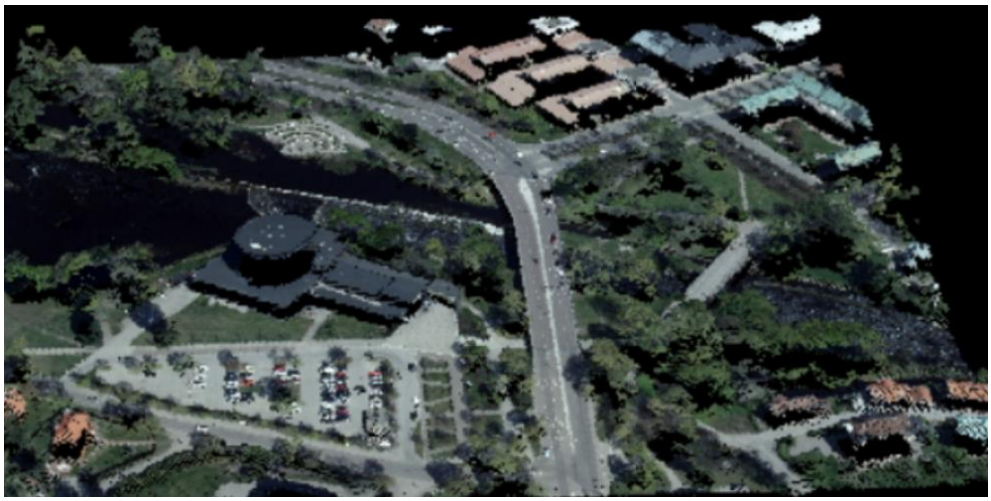
PRODUCT DESCRIPTION

Surface Model Download, from aerial photographs
Surface Model Download, from aerial photographs in colour

DOCUMENT VERSION: 1.4

Figure 1. Example Surface Model Download, from aerial photographs in colour



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1 General description

The surface model is a type of elevation model that describes a continuously surface that can be seen from the air. The top of vegetation, buildings, bridges and other artefacts above ground are included (unlike a terrain model, where these are omitted). For open spaces where there is no vegetation, buildings or other artefacts, the surface model shows the ground surface.

The points that make up the surface model are not a 3D swarm of points, it is a layer of elevation-based points (2.5D model).

1.1 Contents

The product contains elevation points from aerial image matching, which create a 2.5D surface model.

The product is available in two forms:

- *Surface Model Download, from aerial photographs in colour* is delivered with colours in 4-channels, consist of red, green, blue and infrared (IR). Surface model produced from aerial photos before year 2019 is delivered with colours from IR aerial photos - infrared (IR), red and green.
- *Surface Model Download, from aerial photographs* is delivered without colours.

Metadata is also delivered with the product.

1.2 Geographic coverage

The product covers the entire area of Sweden. Production speed follows The national image provision programme.

1.3 Delivery tiles

The tiles are 2.5 km x 2.5 km for both the surface model and metadata.

1.4 Reference system

In plane: SWEREF 99 TM

In height: RH 2000

2 Quality description

In Table 1 the quality is presented using the quality parameters described in the standard SS-EN ISO 19157:2013 Geographic information – Data quality. More detailed description of data capture and quality can be found in the text below.

Table 1. Quality themes and quality parameters for Surface Model Download, from aerial photographs.

Quality theme	Quality parameter	Quality achieved
Completeness	Omission	Due to the matching technology there are holes in the surface model produced before year 2019
Positional accuracy	Absolute accuracy	Average errors are expected to be approx. 1.7 times the resolution in the aerial photo.

2.1 Purpose and utility

The main areas of use with regard to the surface model are to visualise, analyse and establish elevation data in 3D. The data can be used to, for example, calculate forest growth, find changes or simulate how gas emissions travel.

The surface model is unsuitable for visualising or analysing water.

2.2 Data capture

2.2.1 LINEAGE

The images used in the production process are images from The national image provision programme.

The surface model is created through aerial image matching. This is when overlapping aerial images are matched against each other to find mutual image points. A point cloud is calculated, with an elevation value for each point.

The point cloud is then thinned out and re-sampled to a regular grid. Re-sampling takes the median elevation of the points close to the new point. Where there are several points, only the 30 highest points are used. Areas without comparable image points are filled with interpolated values. Interpolation has not been done in the surface model produced before year 2019 which means that the point cloud includes empty areas and does not provide full coverage, see Figure 5 below.

Points considered as very large errors are classified as low or high noise. Very large error is everything lower than -100 m or higher than 200 m

relative to the national elevation model. Very large errors also include points that are lower than -5 m or higher than 50 m relative to the national elevation model and cover an area smaller than 28 m². Before year 2019 these points have been deleted during the production process.

Classes presented in the point metadata-file

0 – Unclassified point
1 – Interpolated point (only from year 2019)
7 – Noise, low (only from year 2019)
18 – Noise, high (only from year 2019)

The matching points obtain their colours from pixel values in the aerial photos. Colour values are red, green, blue and IR. Before year 2019 the values are IR, red and green. The colour represents the average values from the points in the re-sampling.

In Table 2 the programme software for each stage of the production process will be presented. The production method version number can be found in the metadata file.

Table 2. Programme software for each stage of the production process.

Production method, version	Matching program	Thinning out program	Filtering program	Comments
1	Sure, version 1	Sure, version 1	Developed by Lantmäteriet	Sure uses the Semi Global Matching (SGM) algorithm for the matching. For thinning out, a method based on the selection per cell with help from the percentage value is used.
2	Sure, version 3	Sure, version 3	See above	4-channels colour, colour taken from "the best" aerial photo. Interpolation is used where matching fails.

To read more about image matching techniques, please see the training compendium *Geodetisk och fotogrammetrisk mätnings- och beräkningsteknik* (pdf) at Lantmäteriet's website.

2.3 Maintenance

2.3.1 MAINTENANCE FREQUENCY

Maintenance frequency follows The national image provision programme. New data will be added annually, due to new aerial photos becoming available, with approximately one-third of Sweden each year.

A specification of the tiles available from each year, in addition to a rough production plan, is presented under Planer och utfall at Lantmäteriet's website.

2.4 Data quality

2.4.1 RESOLUTION

The distance between the points depending on resolution in aerial photos which varies with year and area. The light green area in the map represent high resolution areas and the blue represent low resolution areas.

The distance between the points in high resolution areas is 0.25 respectively 0.5 m depending on whether the source has been aerial photo with resolution of 0.15 respectively 0.24 m. The distance between the points in low resolution areas is 0.5 respectively 1 m depending on whether the source has been aerial photo with resolution of 0.37 respectively 0.48 m.

Figure 2. Areas with high and low resolution.

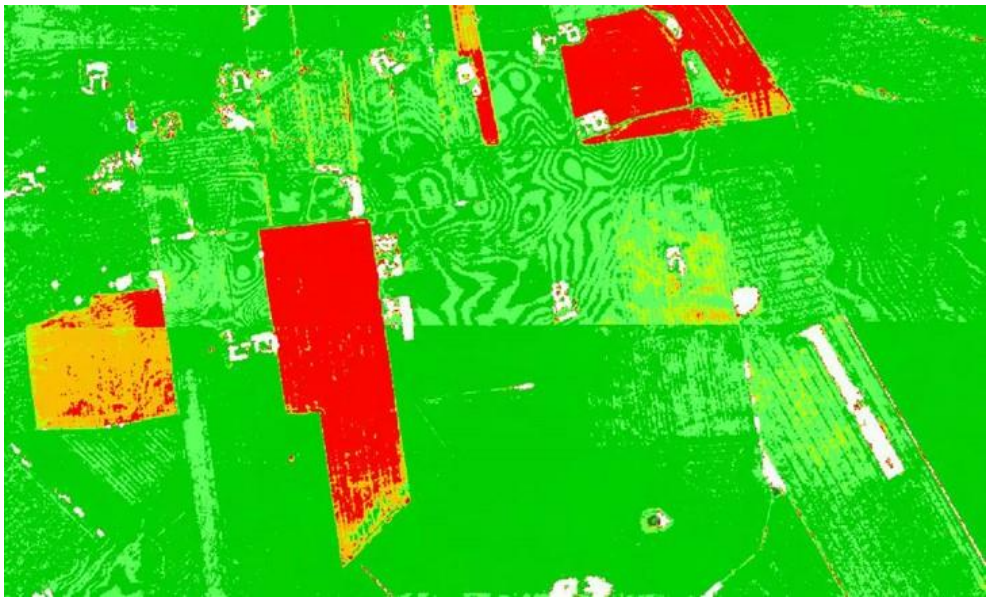
2.4.2 POSITIONAL ACCURACY

The absolute positional accuracy is influenced by two main factors, image orientation and matching. As a rule, image orientation generates an error margin (RMSE) of approx. 1.5 pixels vertically and 1 pixel horizontally. Matching often provides a good result, but also includes large errors, some of which remain even after filtering. This means that the points in the surface model can be expected to have an error of approx. 1,7 times resolution in aerial photos. The image orientation sometimes includes local elevation displacements but viewed across the entire block the given figures apply.

2.4.3 KNOWN ARTEFACTS

Some artefacts in the surface model can be seen with help from images that show an elevation difference between the surface model and the national elevation model. Occasionally, an irregular striped pattern appears and sometimes seams are seen, "elevation jumps", between stereo models and between flight paths. The striped pattern shows a known effect that originates from image matching (SGM algorithm). The elevation jumps are a result of image orientation and underlying models and calibrations. See Figure 4.

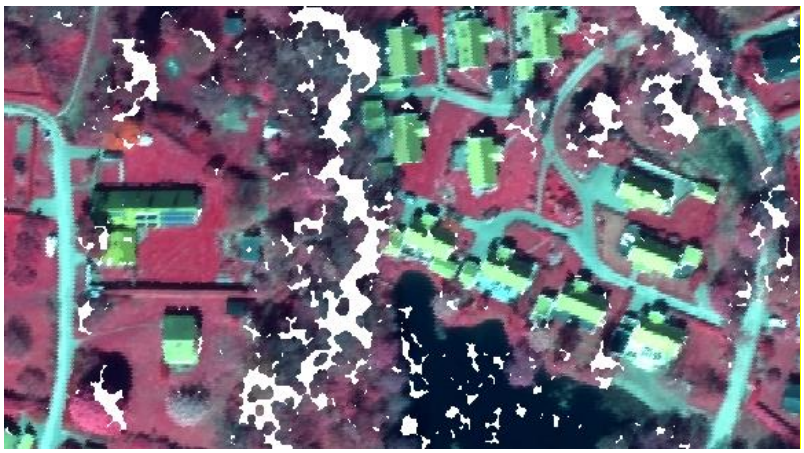
Figure 3. Artefacts present in the elevation differences between the surface model and national elevation model (a terrain model). Where the ground area can be seen in the image, a dark green tone is used where elevation differences are low. Increasing elevation differences are shown using the following sequence of colours: light green, orange, red and white. The seams between two stereo models can be seen from right to left in the centre of the image and the irregular striped pattern is clear in the upper section. The image also shows natural elevation differences, such as crops being grown (big red and orange fields). White areas can be forest.



2.4.4 COMPLETENESS - OMISSION

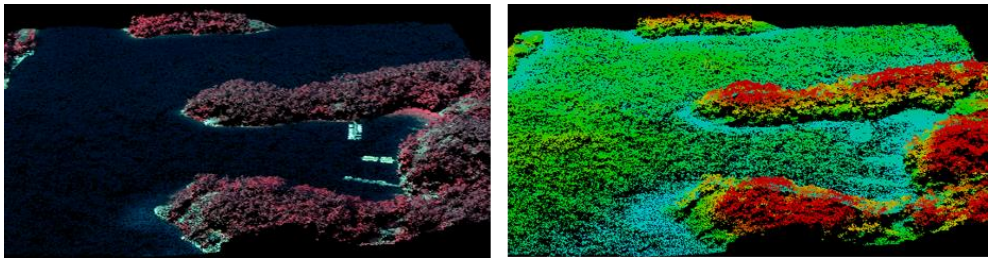
Surface model produced before year 2019 only contains points where matching has been successful. There will be holes in the surface model where matching has been unsuccessful. Holes in the surface model are the result of it not always being possible to find comparable image points in the two current aerial photos. This can be found here and there in the surface model, see Figure 5 below. From year 2019 those holes are filled with interpolated values.

Figure 4. There will be holes in the surface model where matching has been unsuccessful. The holes can be clearly seen against a white background and can also be seen in the image on the front page of this document.



Matching does not work well on low-textured surfaces (surface patterns) as it is also difficult to find comparable points. Consequently, the surface model may be uneven for asphalted areas, certain fields etc. The surface model is to be used with caution for water areas. These may be uneven or include gaps as wave movements often cause the matching results to be blurry (see Figure 6 below).

Figure 5. In the left image with IR colour, it is difficult to see that the matching has resulted in blurring over the water. It becomes clearer when the surface model is coloured based on elevation, like in the right image.



When matching images of areas that are predominantly covered by water surfaces may be missing. The software initially interprets the large water-covered areas as areas where nothing can be found to match between the images and then stop searching further. When the software ignores matching a current stereo model, it means that islands, rocky islets and irregularities within the area are not included as the entire area is left blank. Shape-files showing which areas are affected by this problem, see Planer och utfall – Saknade ytor at Lantmäteriet's website.

A delivery of such area is supplied with a GeoTiff image showing where data is missing.

2.5 Metadata

Metadata is supplied for each 2.5 km tile with polygon attributes as shown below.

Scheman GeoJSON-fil for download

Table 3. Description of contents in the metadata file.

Field	Description	Example
flygfotoar	Year of aerial image for entire block.	2019
upplosningFlyg-bild	Aerial image resolution in relative metres on the ground.	0.15
block	Name of the block the surface model has been created from.	19X215_O
produktionsme-todVersion	Version of the production process.	2
ruta	Name of 2.5 km tile as per the index tile system	729_90_7500
datumFran	Earliest date of aerial image the sur-face model has been created from.	2019-06-15
datumTill	Most recent date of aerial image the surface model has been created from.	2019-06-15
bildId	List of image ID. State which images the surface model has been created from.	19x215zx56_51~ 2019-06-15_114140_2715
upplosningYt-modell	The surface model resolution in me-tres on the ground, where there are points.	0.25
farg	Colour information for the surface model, state as “RGBI”, ”CIR”* or ”Ingen_farg” (meaning “no colour”).	rgbi
bildoverlapp	Image overlap within the area as a percentage.	60
kameratyp	Type of aerial camera.	UCEM3

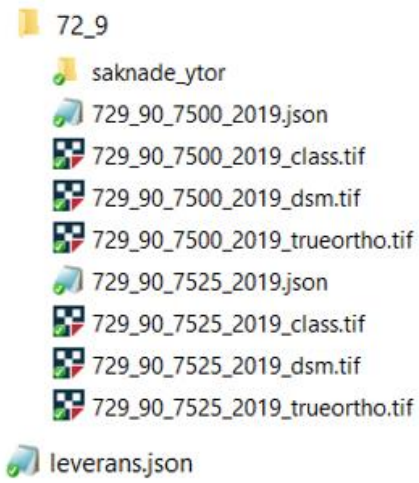
*CIR = colour infrared (IR, red and green).

3 Contents of the delivery

3.1 Folder structure at delivery

The surface model and metadata are supplied as below.

Figure 6. Example of contents in a delivery with colour



When an area with production errors is delivered (read more in section "Completeness – omission") an additional folder (saknade_ytor) will be applied containing GeoTIFF image showing where data is missing, marked with cerise and yellow stripes.

3.2 Delivery format

The product is supplied in GeoTIFF-format (LZW-compressed).

The GeoJSON format is used for metadata.

3.3 Set of files and contents

Table 4. Description of files included in the delivery.

Filename (example)	Description
729_90_7525_2019_dsm.tif 729_90_7525_2019_class.tif 729_90_7525_2019_trueortho.tif (LZW-compressed)	The files are named using the co-ordinates of the lower left corner of the tile, the year the aerial image was produced and type of file. Type of file dsm – height values, nodata-value -9999 class – point metadata, nodata-value 255 trueortho – colour information, 3 or 4 channels, nodata-value 0. Included in delivery with color. Where information is missing in the files it is marked with nodata-value.
729_90_7525_2019.tif	GeoTIFF image showing where data is missing. Included when an area with production errors is delivered.
729_90_7525_2019.json	Metadata as described in section Metadata. Scheman GeoJSON-fil (metadata)
leverans.json	Metadata describe the whole delivery, tiles and files Scheman GeoJSON-fil (leverans)

The *Surface model Download, from aerial photographs in colour* is supplied with "CIR" respectively "RGBI" depending on the source.

The *Surface model Download, from aerial photographs* is delivered without colour information (without trueortho-file).