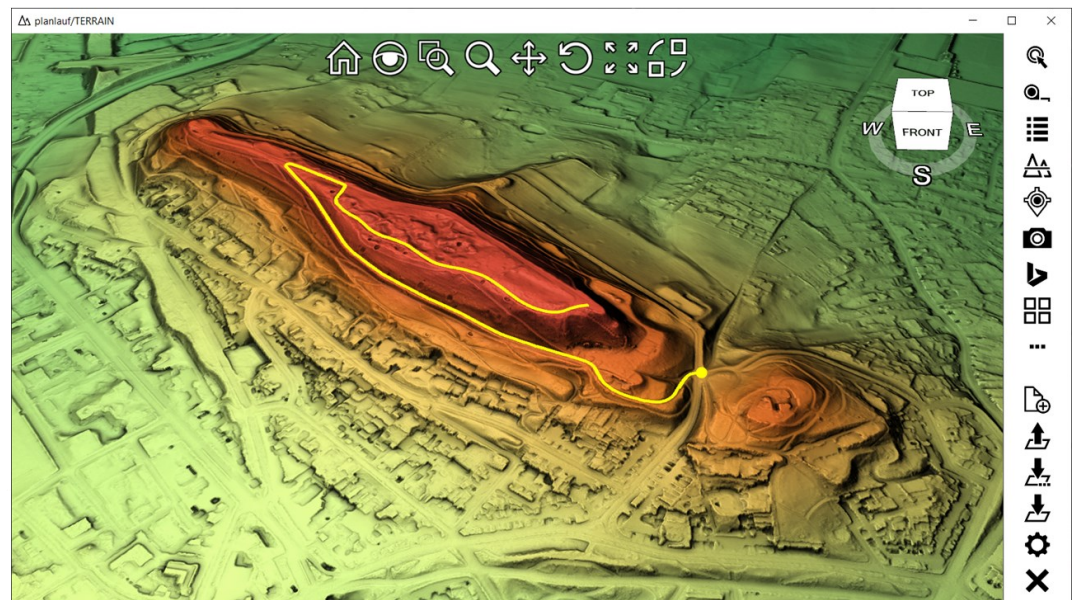


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planlauf/TERRAIN is an easy-to-use application for Windows 10/11 to visualize Digital Elevation Models (DEMs). Unlike other GIS software, planlauf/TERRAIN uses techniques from the gaming industry like 'Mesh Decimation', 'Normal Mapping' and 'Level of Detail' to reduce the size of the models significantly while preserving the visual details of the original model. This approach ensures that you can take high-resolution 3D terrain models on inexpensive Windows tablets into the field.

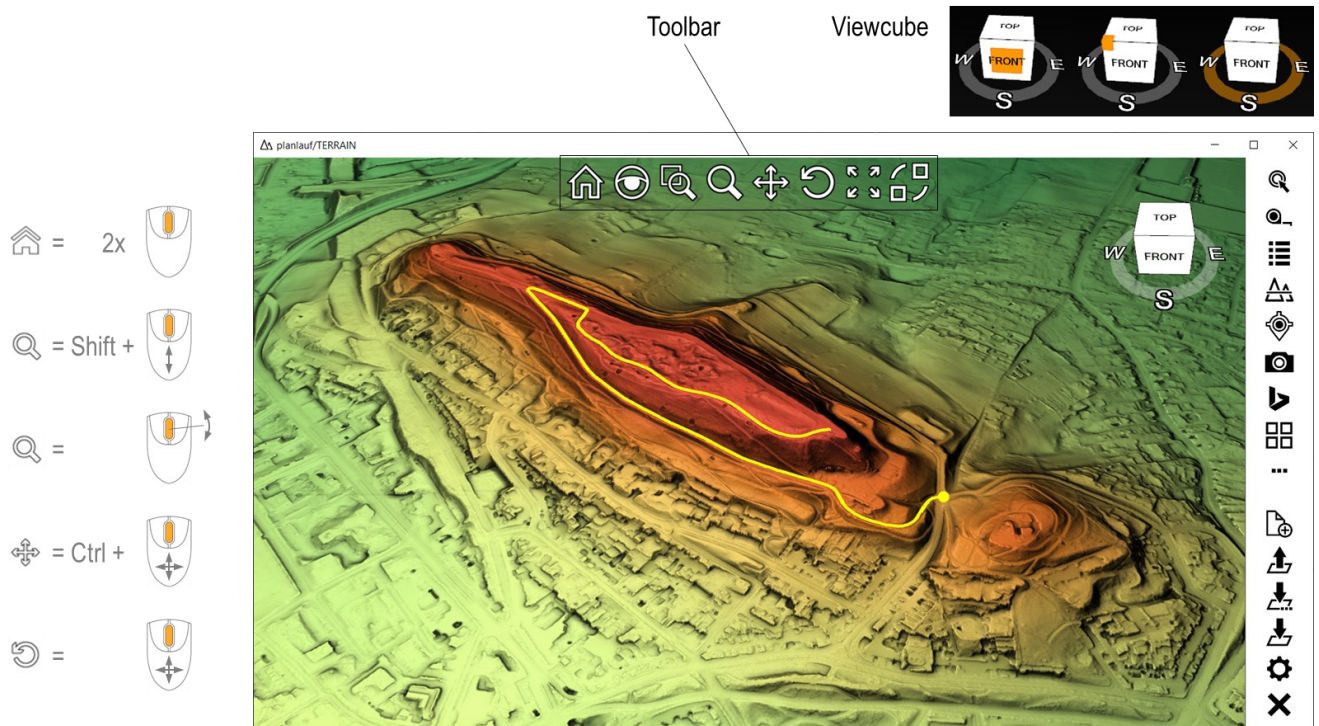


Here are some of the main features:

- Import raster data either directly or with our user-friendly GDAL-interface
- Import point clouds and generate Digital Surface/Terrain Models
- Mesh Decimation for small memory footprint and low load on the CPU and GPU
- Support for Bluetooth GPS receivers and integrated or plug-in webcams
- Log GPS tracks or create and edit tracks manually
- Video recording of Fly-throughs and Look-arounds with FFmpeg
- Local Relief visualization to highlight subtle landscape features
- Line-of-Sight and Viewshed analysis
- Export of Sketchfab models
- Export of Three.js HTML files
- Export of 2D and 3D maps for the planlauf/TERRAIN mobile app
- Presentation Mode

Requirements

- OpenGL 4.0
- Windows 10/11
- Microsoft .NET-Framework 4.8



3D Control

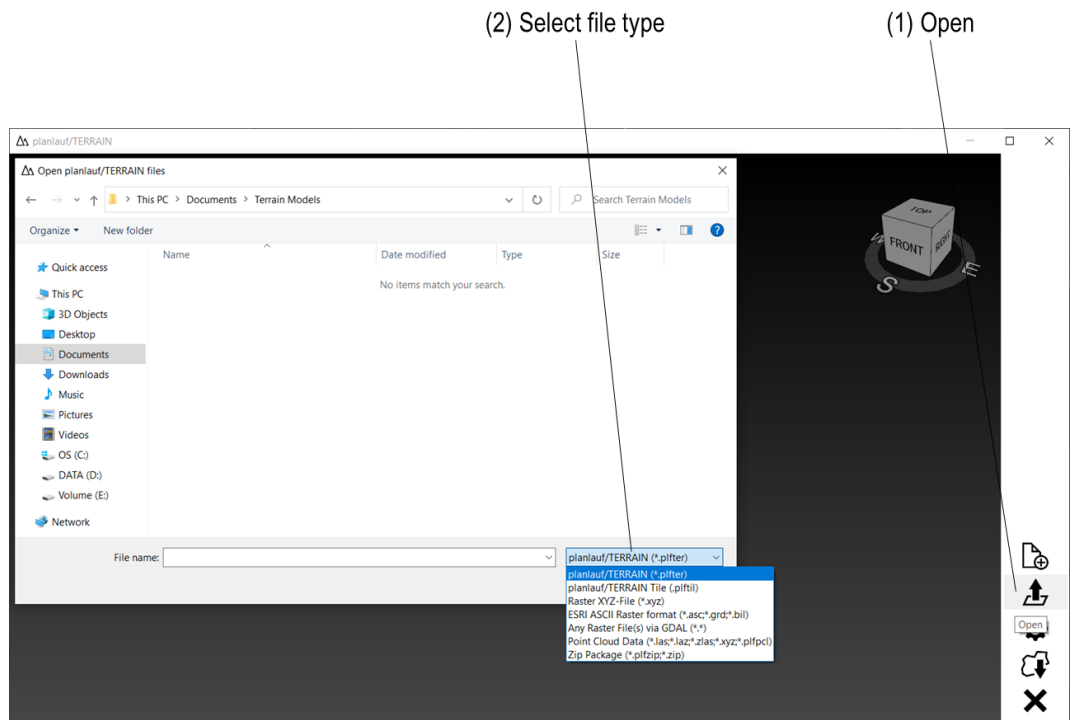
You can control the 3D view with a common mouse and the toolbar commands (see below) or with the middle mouse button (rotate) and optionally either the Shift (pan) or Control key (zoom). On tablets you can also use the touchscreen with one (rotate) or two fingers (pan, zoom).

Toolbar

- Home** resets the model to the home (= isometric) view.
- Use the **magnifying class** to look at details without zooming in.
- Zoom Window** to define an area to zoom into.
- Zoom** by pressing the left mouse button and moving the mouse up or down.
- Pan** by pressing the left mouse button and moving the mouse in every direction.
- Rotate** by pressing the left mouse button and moving the mouse in every direction.
- Zoom Fit** adjusts the view to fit the whole model into the viewport.
- Views** shows a dialog to save and restore views.

Viewcube

Click on a surface, edge or corner of the viewcube to get one of the standard views. You can also drag the ring to rotate the model around the vertical axis.



Click on **Open** in the menu bar and choose one of the following file types:

planlauf/TERRAIN (*.plfter)

A terrain file is a text-based file generated by planlauf/TERRAIN which contains all information in a project, e.g., used tile files (see below), pins, tracks and project specific settings.

planlauf/TERRAIN Tile (*.plftil)

A tile file is a binary file generated by planlauf/TERRAIN which contains the spatial data of a digital terrain/surface model, e.g., vertices, triangles, normal maps or local relief data. Multiple tile files can be used together as long as their projection is identical.

Raster XYZ-file (*.xyz)

An XYZ-file is a simple text file which contains X, Y and Z values (in geographic coordinates: easting, northing, elevation). Each line represents one vertex and the values can be separated by one of the following characters: space, tab, comma, semicolon. Please note that planlauf/TERRAIN works with raster data, so for raster XYZ-files the X and Y values have to be on an even grid.

```
32290000.00 5628000.00 231.07
```

```
32290000.00 5628001.00 230.71
```

ESRI ASCII Raster format (*.asc;*.grd;*.bil)

An Esri ASCII Grid-file is a text file with a simple raster format. Instead of explicit X and Y values, only the number of columns and rows, the lower left corner, the grid spacing and the elevation values are stored.

```
NCOLS 2000
```

```
NROWS 2000
```

```
XLLCORNER 2693000.000000000000
```

```
YLLCORNER 1256000.000000000000
```

```
CELLSIZE 0.500000000000
```

```
NODATA_VALUE -9999.0
```

```
583.72 583.78 583.78 583.75 583.76 583.63 583.69 583.68
```

```
583.64 583.48 583.47 583.61 583.62 583.62 583.62 583.65
```

Any Raster File via GDAL (*.*)

GDAL (Geospatial Data Abstraction Library) is an Open Source project by the Open Source Geospatial Foundation and is used by many GIS software packages. planlauf/TERRAIN contains a user-friendly GDAL interface to import any raster data that is not directly supported, e.g., GeoTIFF, IMG, ADF, FLT, DEM, HGT or BIL.

Point Cloud Data (*.las;*.laz;*.zlas*.xyz;*.plfpcl)

planlauf/TERRAIN can generate digital terrain/surface models from point cloud data. The most common file formats are LAS, LAZ and zLAS. The XYZ files have a structure similar to the raster XYZ files but there is no restriction of the points lying on an even grid.

Zip Package (*.plfzip;*.zip)

You can use planlauf/TERRAIN Zip Packages to share a complete project. The file contains the terrain file, the tile file(s), associated and geotagged images and image overlays. After clicking on **Open** you will be prompted to choose a folder to unzip the files to.

If you select one or more normal zip files, planlauf/TERRAIN will unzip them to their folder. If the unzipped files are either ESRI ASCII Grid (*.asc), Raster XYZ (*.xyz) or LAS/LAZ files, the open dialog will be shown with the respective file format filter. Raster files from OpenTopography.org are compressed into *.tar.gz files. You can also choose those files and unpack them automatically.

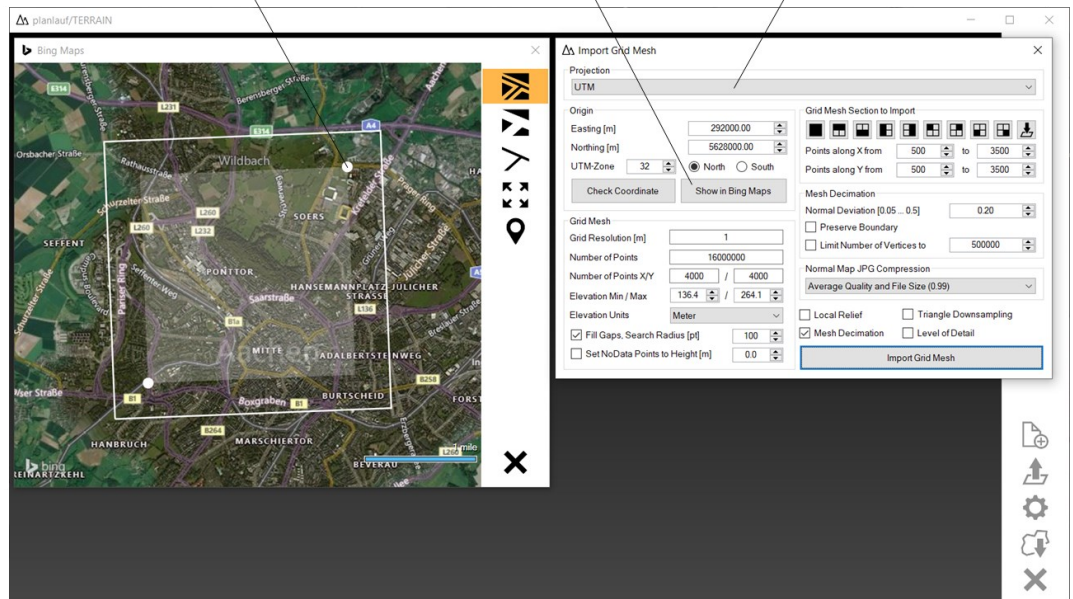
Selecting multiple files

You can select multiple files by pressing the control key while clicking on the filenames. You can also press Control+A to select all files in the current folder. Please note that selecting multiple files works only for the following raw file formats: XYZ, ASC, LAS, LAZ and zLAS and with the **Any Raster File via GDAL** option.

(3) Drag points to change selection

(2) Show in Bing Maps

(1) Choose projection



Click on **Open** in the menu bar and choose the **Raster XYZ-file (*.xyz)** or **ESRI ASCII Raster format (*.asc)** filter. Select one or more files and click on **Open**. The **Import Grid Mesh** dialog appears as soon as the data has been loaded.

Projection

Projections are mathematical functions that transform the curved surface of the earth to a map plane. There are thousands of projections worldwide, many are outdated and only a few are actually used for DEM datasets. planlauf/TERRAIN supports projections for which datasets are available and the implementation of both the forward and backward transformation are known. Please check with the data provider which projection has been used and choose the corresponding entry in the list.

Show in Bing Maps

To show the Bing Maps window click on the **Show in Bing Maps** button. The covered area is highlighted with a white frame and you can change the selected section by dragging the white dots. There are some options in the menu bar: **Aerial View with Labels**, **Aerial View**, **Road View**, **Zoom Fit** and **Center Map on Location**. If a valid GPS location in decimal latitude/longitude (e.g. 50.78628° 6.08091°) is in the clipboard, it will be used directly.

Grid Mesh

This box shows some statistics about the imported data. If you want to exclude points below or above a certain height, you can change the corresponding values for **Elevation Min / Max**. If the model's **Elevation Units** are different from meters you can choose either millimeter or centimeter in the list. The **Fill Gaps** option can be activated if there are small voids in the raw data. Those voids are then filled with an Inverse Distance Weighting algorithm. The **Search Radius** controls how big the voids can be in order to get filled. With the **Set NoData Points to Height** option, a constant height value is assigned to every empty point within the grid. A common combination of those options for coastal areas is to ignore all points below a height of 0.5 and set all NoData points to 0. This ensures that the sea wave patterns are ignored while the sea surface remains visible.

Grid Mesh Section to Import

If you don't want to use Bing Maps, you can use these commands to change the selection. Either enter minimum and maximum indices along the X and Y axis or choose one of the pre-defined sections.

Mesh Decimation

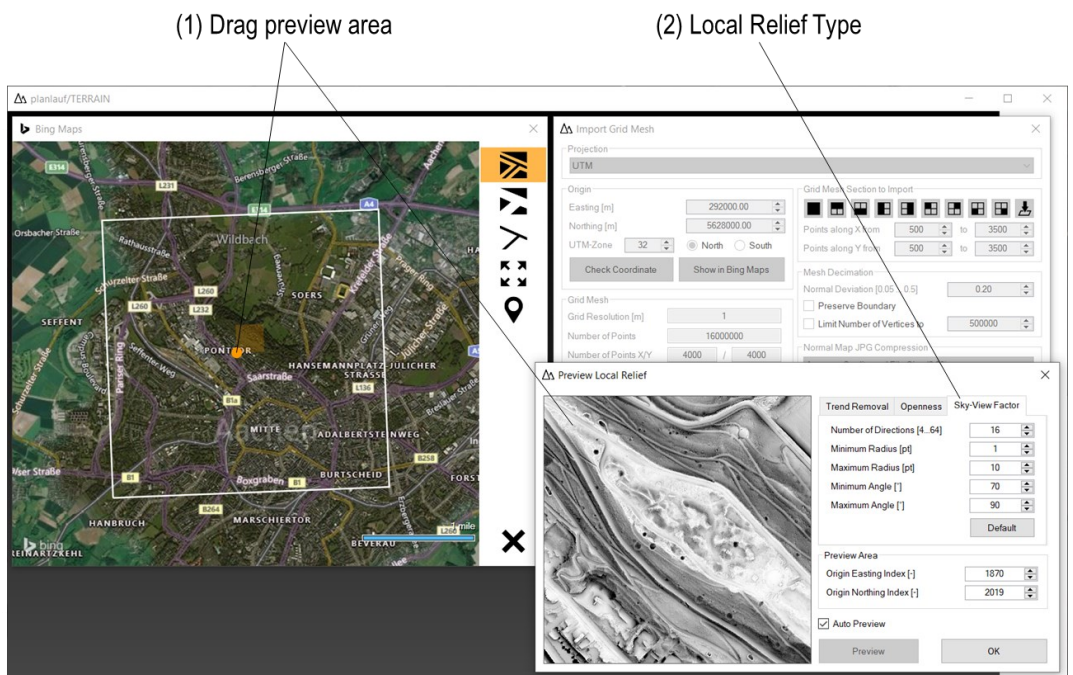
The number of vertices in a model is the most important driver of rendering performance and memory consumption. Mesh Decimation reduces the number of vertices while affecting the visual quality as little as possible. Preserving the visual details of a digital elevation model is achieved with normal mapping. The **Normal Deviation** defines the magnitude of the error between the triangles of the decimated and the original mesh. A good compromise between quality and performance is usually a normal deviation of 0.2. If you plan to use neighboring tile files in a terrain file, you can choose the **Preserve Boundary** option to ensure that the boundary vertices are not affected by the mesh decimation. The **Limit Number of Vertices** option ensures that the tile file after the mesh decimation does not contain more than the desired number of vertices even if the normal deviation has to be increased. A limit of 300,000 is appropriate if you want to use a tile file on an entry-level Windows tablet.

Normal Map JPG Compression

While the mesh can be decimated to 2% of the original vertex count, the normal map is stored with the original resolution to preserve all the visual details. To reduce the size of the tile file, you can choose a value of 0.95. Please note that this affects the rendering quality in flat areas where the JPG compression algorithm will lead to compression artifacts slightly visible as blocks.

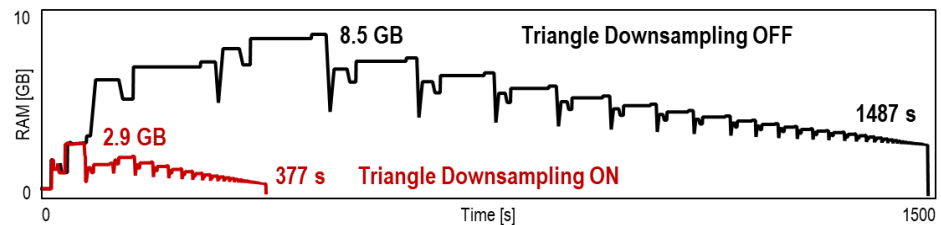
Local Relief

Check this option to calculate and include local relief data in the tile file (the option will then appear in the terrain file's **Tiles and Shading** dialog). Checking the box will show the preview window. If the Bing Maps window is visible, you can drag the preview area by clicking on the orange dot and moving the mouse. You can also move the area by panning the preview image in the dialog itself. There are three options for the local relief visualization: **Trend Removal**, **Positive Openness** and **Sky-View Factor** which you can select by clicking on the corresponding tab. If the **Auto Preview** option is checked the resulting local relief of the preview area will be calculated immediately. You might have to experiment with the parameters to get the best result for your data. Click on **Default** if you want to restore the standard values.



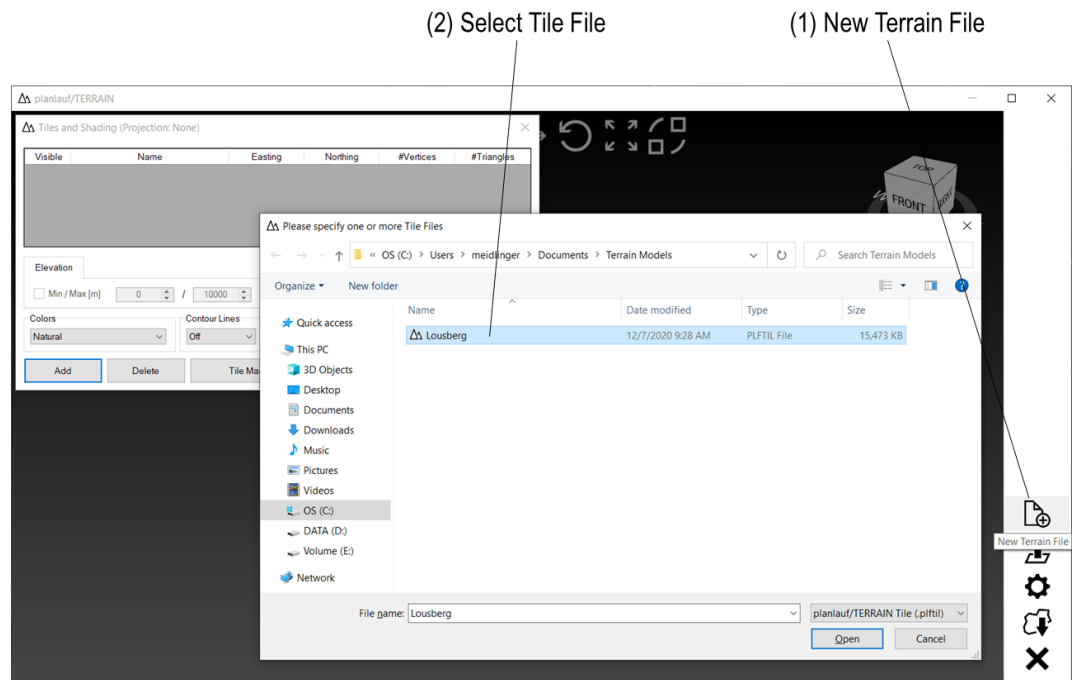
Triangle Downsampling

This option leaves out every other vertex in X and Y direction. The mesh decimation will start with only 1/4 of the vertices which reduces the memory consumption and speeds up the process. The normal maps and the local relief are not affected and show the full detail but the geometry might be slightly changed. For digital terrain models this effect is barely visible but for digital surface models it might become more apparent. You can use this option if you're running out of memory or are in a hurry. The example below shows the memory and time needed to perform a mesh decimation of about 60 million vertices with and without Triangle Downsampling.

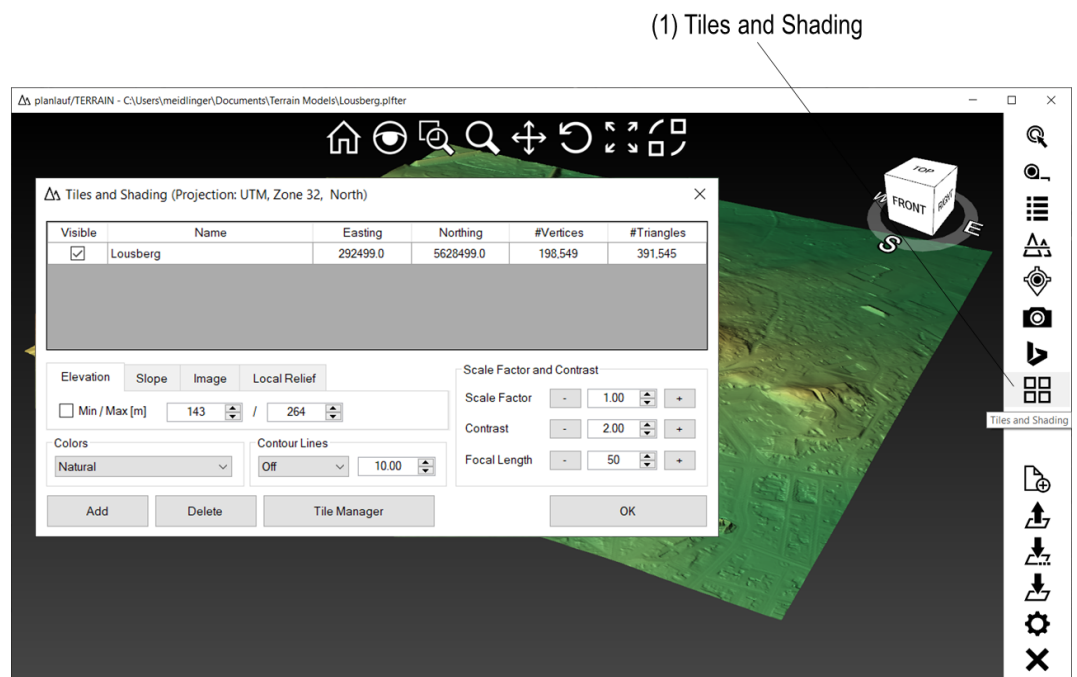


Mesh Decimation and Level of Detail

You can uncheck the **Mesh Decimation** box if you don't want to decimate the model. In this case you should check the **Level of Detail** option to make sure that the rendering performance is as good as possible. A combination of both options can improve the rendering performance of huge models. Click on **Import Grid Mesh** to start the process. Once the mesh decimation is finished, click on **Save** in the menubar and choose a filename for the tile file.



Click on **New Terrain File** in the menu bar and choose one or more tile files. The file(s) will appear in the list of the **Tiles and Shading** dialog. Please notice that there is an asterisk in the **OK** button. This indicates that the model has to be updated. Click **OK** to load the tile files in the list. Click on **Save** to save the terrain file.



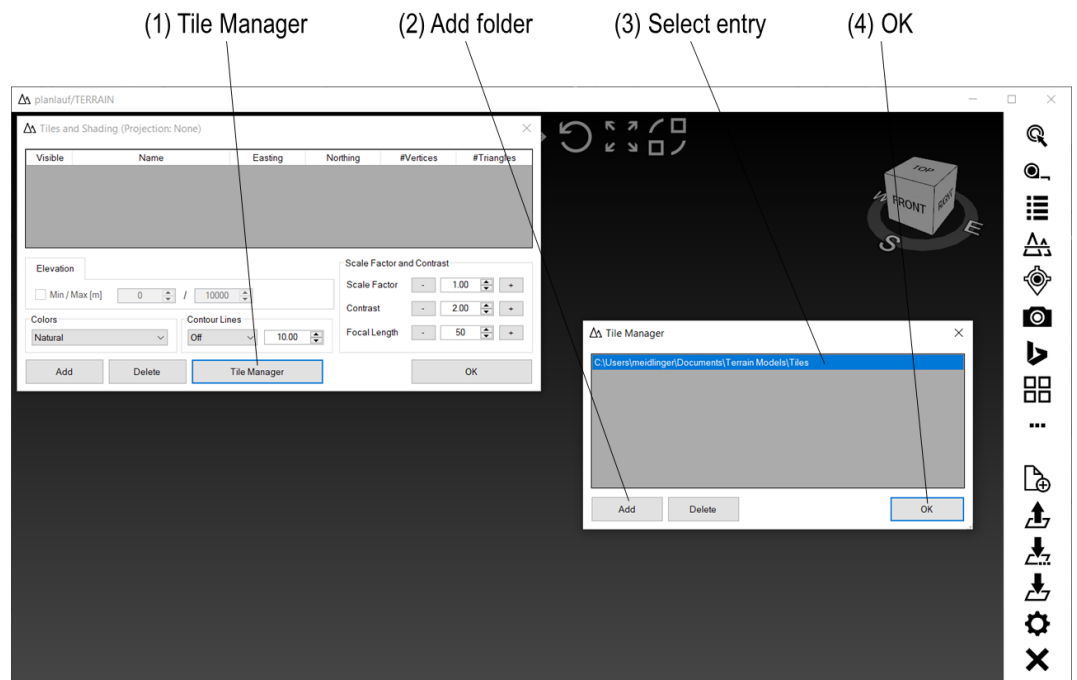
You can always display this dialog again by clicking on **Tiles and Shading**. If the tablet mode is active, the icon can be found in the **More** submenu. The dialog contains the following settings:

Tile File List

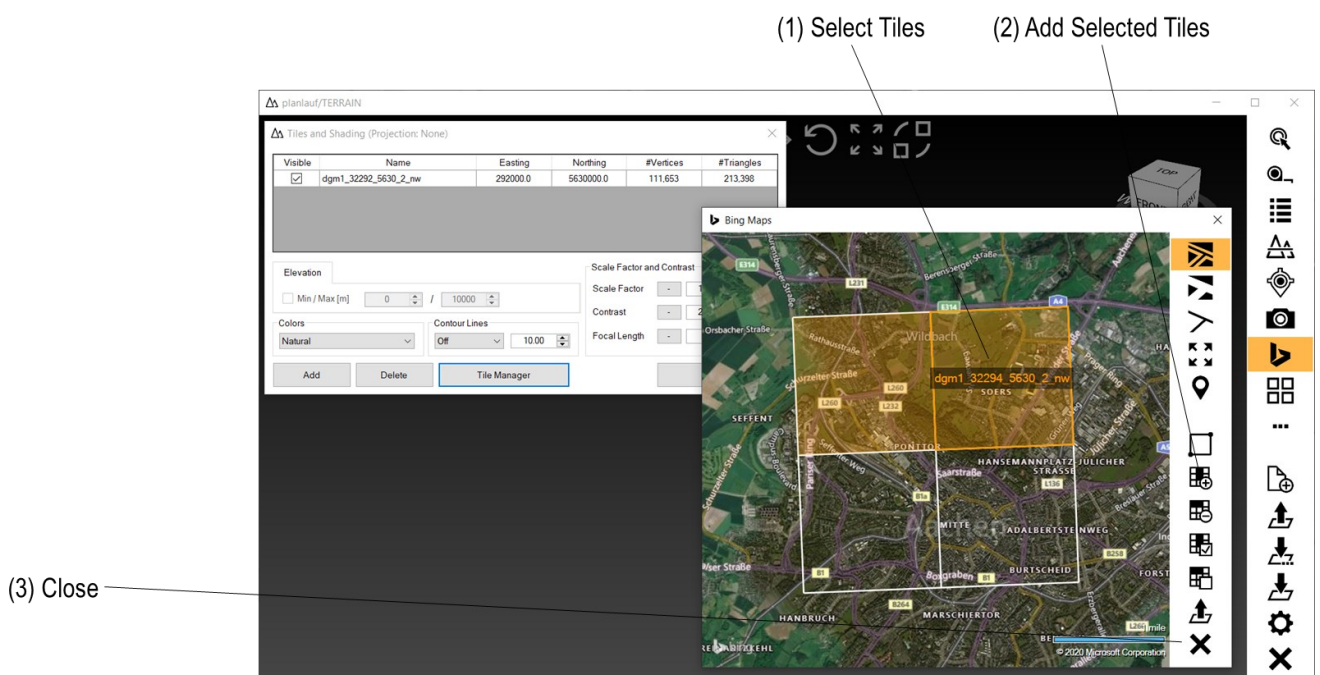
You can add tile files by clicking on the **Add** button at the bottom of the dialog. Select one or more rows in the list and click on **Delete** to remove the tile files. If you want to temporarily hide a tile file you can uncheck the box in the **Visible** column. Click **OK** to reload the data and update the viewport.

Tile Manager

If there are a number of tile files in a folder, the selection process by name might be a little bit complicated. In this case, the **Tile Manager** helps you to select the tile files for a terrain file. Click on **Tile Manager** in the **Tiles and Shading** dialog, add the folder with the tile files, select the entry in the list and click on **OK**. Please make sure that all tile files in a folder are in the same projection.

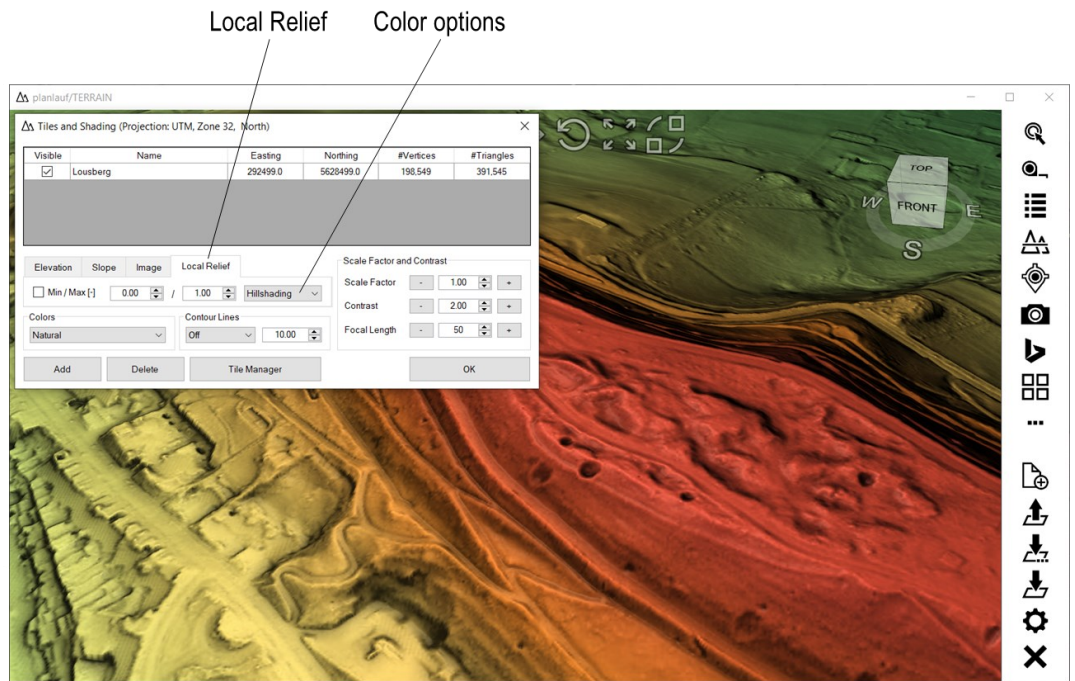


planlauf/TERRAIN will check the folder and display all tiles in the **Bing Maps** window. Select tiles by simply clicking on them or use the **Select Area** icon to draw a selection rectangle. The selected tiles will be highlighted in orange and you can click on **Add Selected Tiles** to add the tiles to the tile file list. **Close** the **Bing Maps** window and click on **OK** in the **Tiles and Shading** dialog to load and display the tile files.



Shaders

The available shaders are listed in the tabpage. The default shader is **Elevation** which colors the model according to the height. The **Slope** shader highlights slopes according to their steepness. The **Image** shader displays an image that is draped over the model (see **Image Overlay** section below) and the **Local Relief** shader visualizes the previously calculated local relief data. The color option **Hillshading** combines the **Elevation** color ramp with the **Local Relief** data. It works best with the **Sky-View Factor** visualization.



Colors

There are some pre-defined color scales (default: Natural). Choose one of those or click on the last entry in the list **Import Colors (*.txt;*.c3g)** to import a custom color scale. Choose a text file that contains the RGB values of each color in a row separated by a blank or tab:

190 170 240

135 155 235

115 190 225

planlauf/TERRAIN remembers the directory so you might want to create a folder with all your custom color scales in order to easily reuse them. Color palettes in C3G format can be found here: <http://soliton.vm.bytemark.co.uk/pub/cpt-city/>

Contour Lines

Check this option to display either dark or bright contour lines with the **Spacing [m]**. Contour lines are created in the shader so this value can be changed without having to do extensive calculations.

Scale Factor

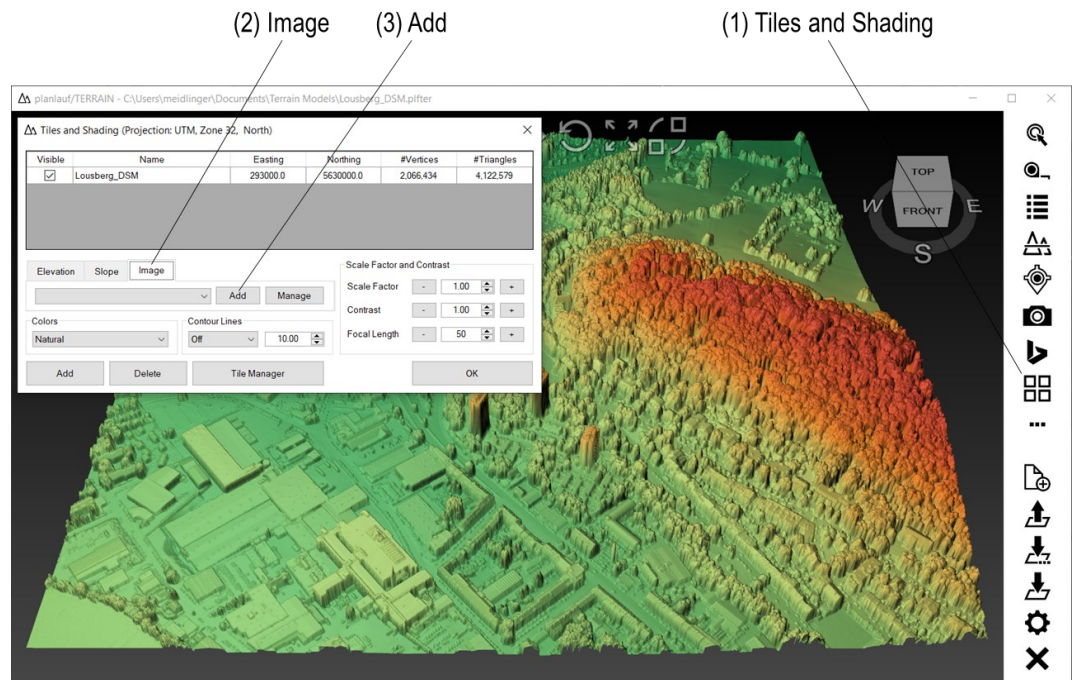
If you want to exaggerate the height of a terrain, you can choose a value larger than 1.

Contrast

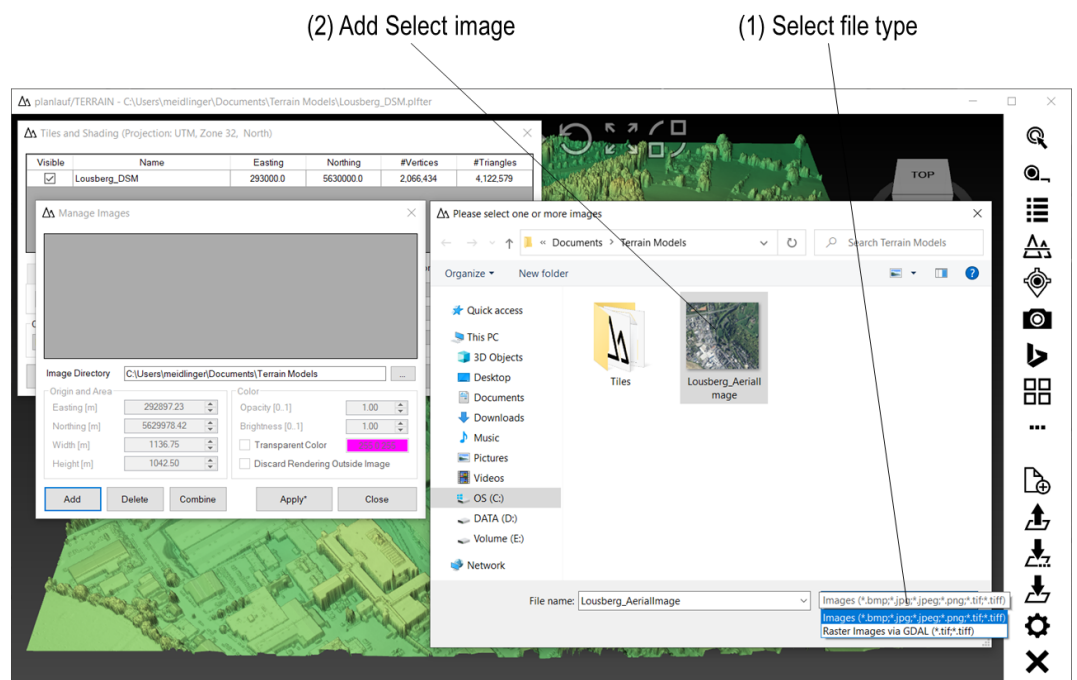
The contrast value controls the amplification of the normal maps. A value larger than 1 will make the terrain look steeper and enhance the visibility of details. Values lower than 1 will reduce this effect.

Focal Length

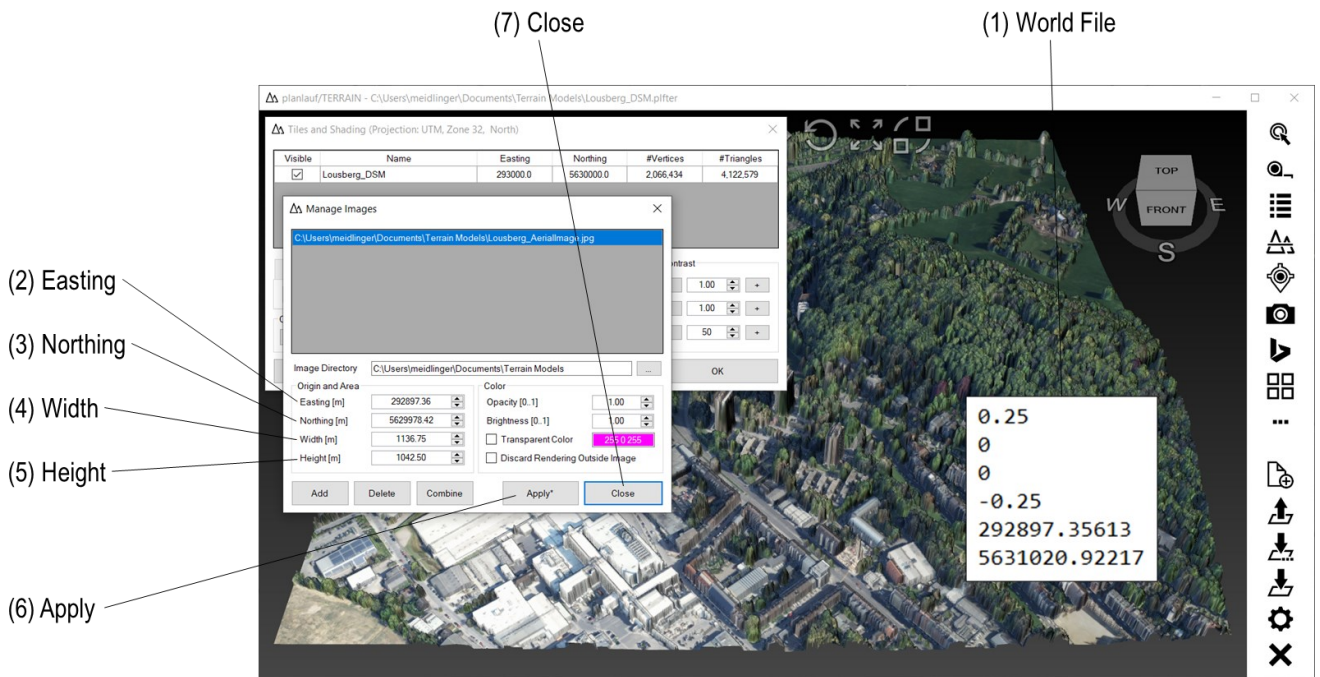
The focal length is used to define the field of view. The default value is 50, lower values will increase the perspective view. Larger values will lead to an orthographic view.



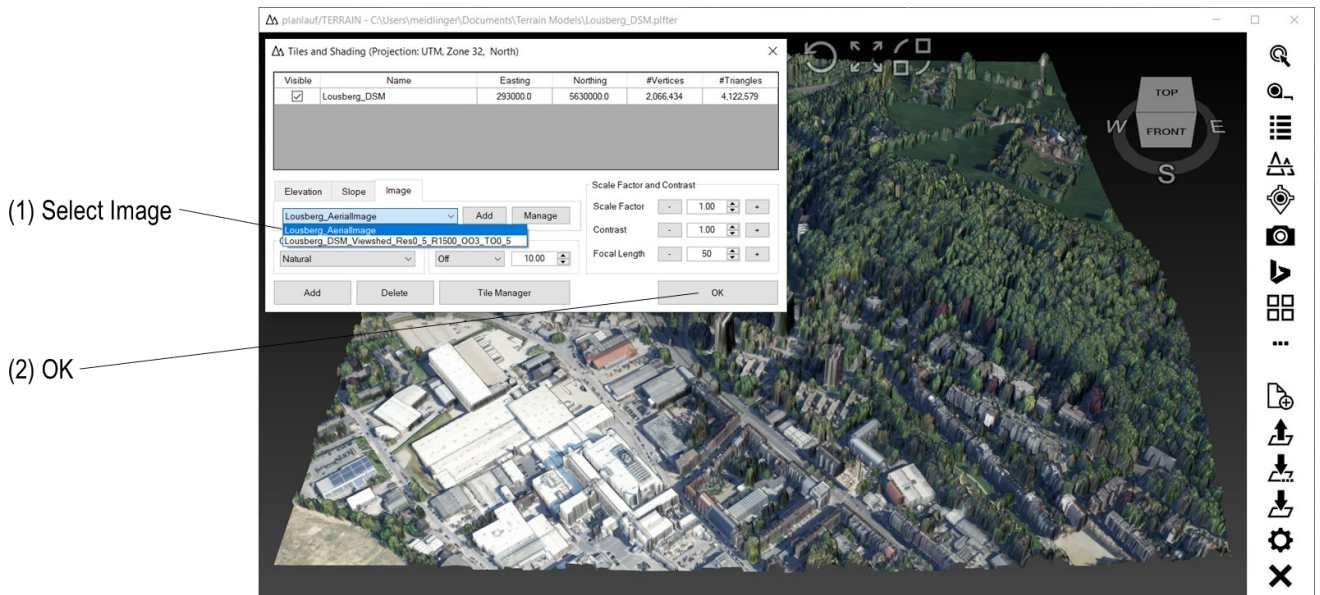
The **Image** shader displays an image that is draped over the model. Click on **Tiles and Shading**, choose the **Image** tab and click on **Add** to add a new image to the list.



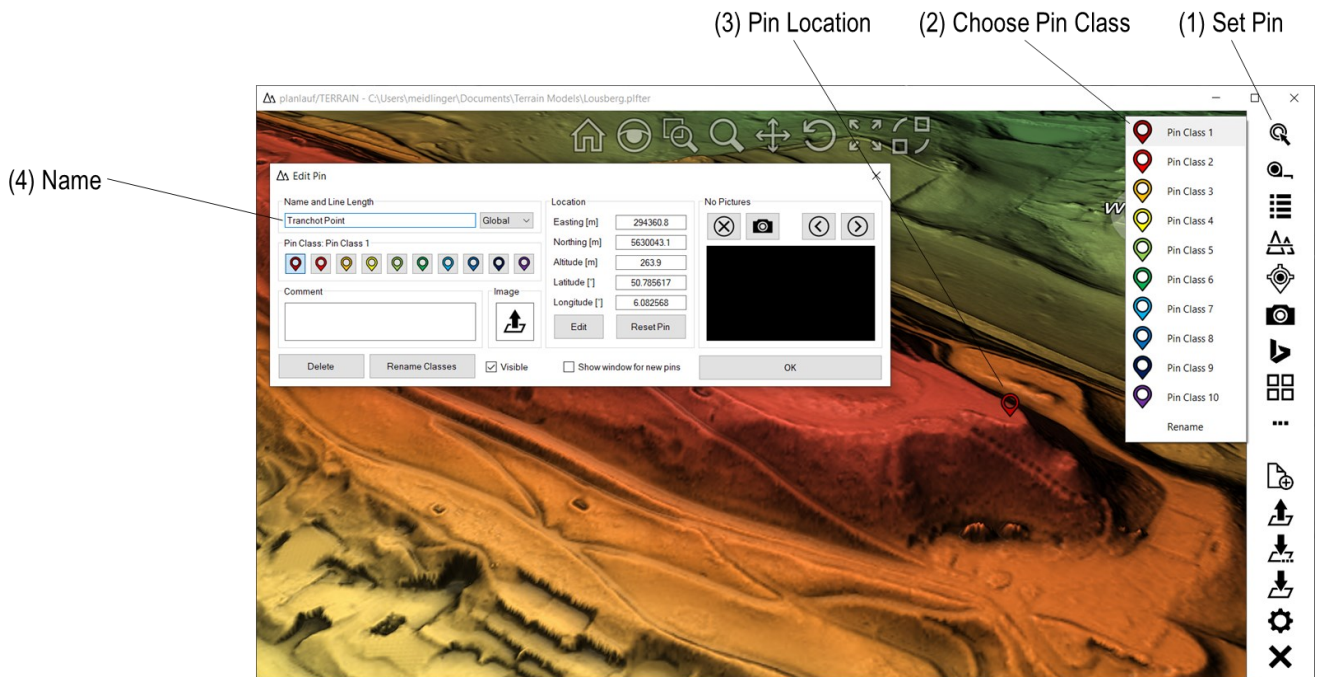
You can either select a common image type like Bitmap or JPG in the **file filter** or you can choose the GDAL option if you want to import a raster image format that is not directly supported. In the latter case, please make sure that GDAL is installed on your computer (see the **Settings** section). Select the image and click on **Open** to display the **Image Shader** dialog. Image overlay only works if the projections of model and image are identical.



The **Image Shader** dialog contains the information about how to drape the image over the model. The **Easting** and **Northing** values define the Origin (lower left corner). **Width** and **Height** in meters define the area that is covered by the image. Usually, images come together with a **World File**. planlauf/TERRAIN checks if such a file exists in the image's folder and sets all the values accordingly. If no world file is available, the image can automatically be positioned to cover the whole model. Click **Apply** and then on **Close** to load and display the image. You can get back to the **Image Shader** dialog by clicking **Manage** on the **Image** tab.

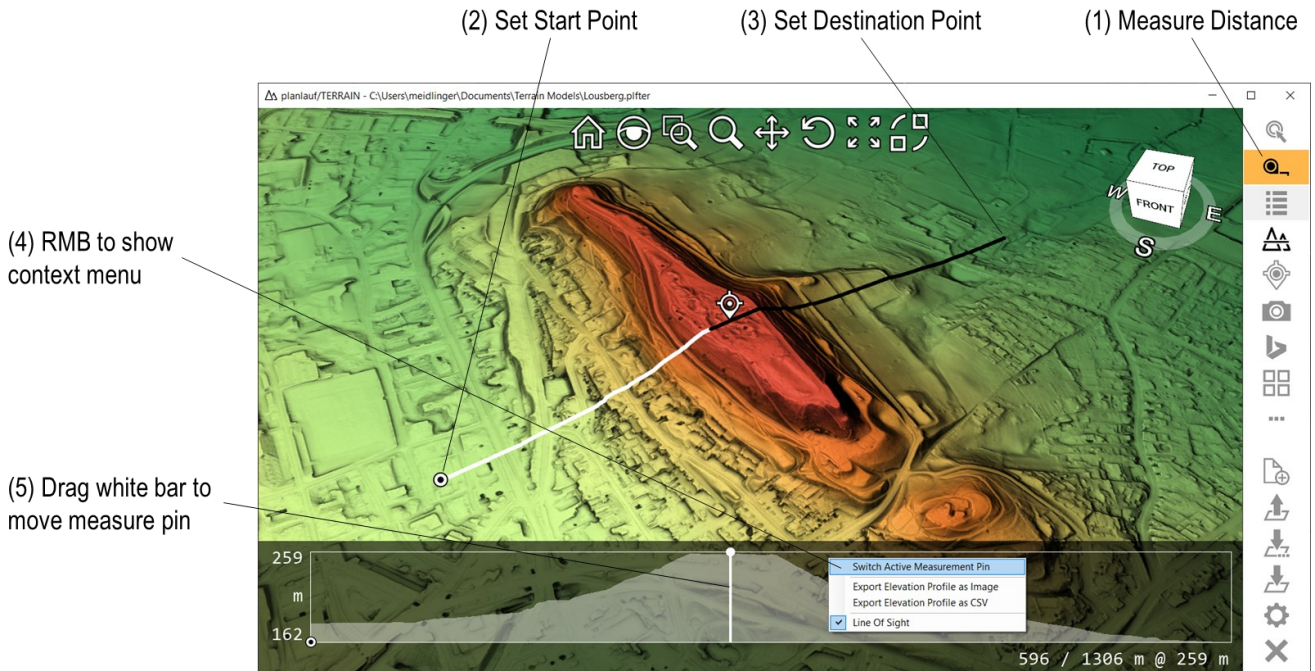


If there are multiple image overlays, click on the list and **select** an image to load and display. Click **OK** in the **Tiles and Shading** dialog to close it.



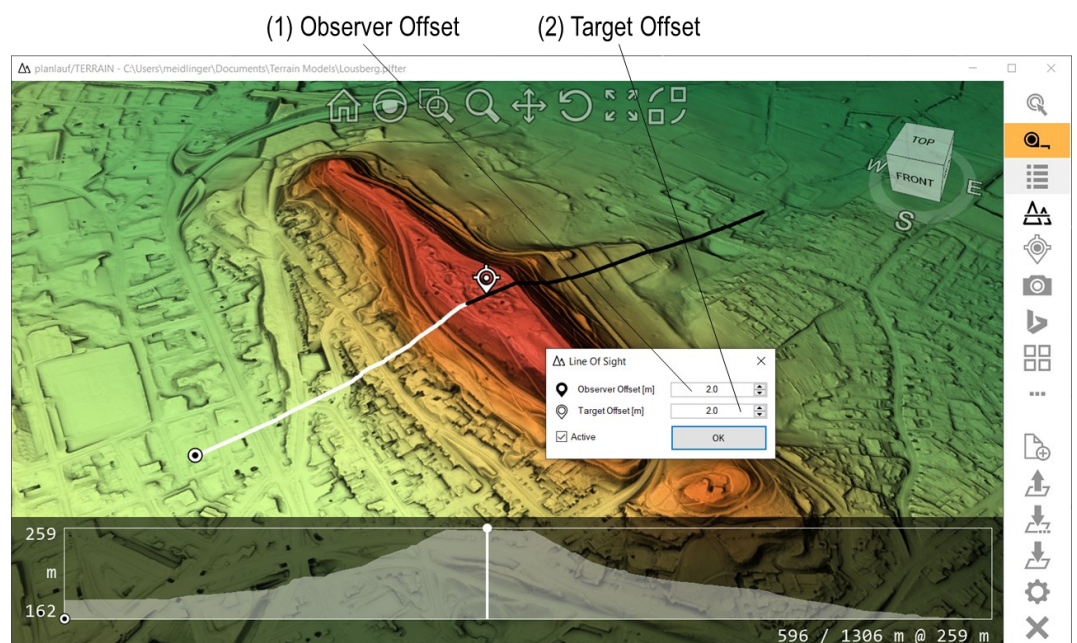
Click on **Set Pin** in the menu bar and choose one of the **Pin Classes**. Use zoom, pan and rotate to navigate the model and click on the location to set the pin. Enter the **Name** of the pin in the appearing **Edit Pin** dialog. If the pins are shown as text labels, you can override the **Line Length** with a pin specific value. You can show this dialog by clicking on a pin if the **Set Pin** command is not active. The following pin settings are possible:

- **Pin Class:** Each pin class is represented by a color.
- **Comment:** Enter a text to add a description.
- **Image:** You can use a custom image for the pin. PNG files with transparency work best.
- **Delete Pin:** Deletes this pin.
- **Rename Classes:** You can assign meaningful names to the pin classes.
- **Visible:** Uncheck this option to temporarily hide the pin.
- **Location:** Easting and northing are the coordinates in the current projection. Latitude and longitude are the usual GPS coordinates. Edit the values with the **Edit** command. Change the pin location by clicking on the **Reset Pin** button and then on the new location in the model.
- **Show window for new pins:** If this option is checked, the **Edit Pin** window is shown each time you set a new pin. This allows to enter a name directly.
- **Pictures:** If there are pictures associated with this location, a preview is shown in this area. Click on the **Camera** symbol to open a bigger viewer window with zoom and pan functionality. You can also show the next or previous picture. If you click on the **Delete** button, the association of the picture to the pin is removed but the picture file will not be deleted.
- **OK:** Close the dialog with **OK**. Please note that the **Set Pin** command is still active and you can set another pin. Press **Escape** or click on the **Set Pin** button in the menu bar again if you want to end this mode.



Click on **Measure Distance** in the menu bar. The active measurement pin is marked with a dot and can be set to an appropriate location. You can **switch the active pin** either with a right mouse click in the viewport or by left-clicking on one end of the line. Drag the white bar in the diagram to move the **measure pin** along the measurement line. By default, a **Line-of-Sight** calculation is automatically performed and the points that are visible from the start point with the dot are white, the obscured points are black. Right-click on the diagram to show the context menu. There are four options:

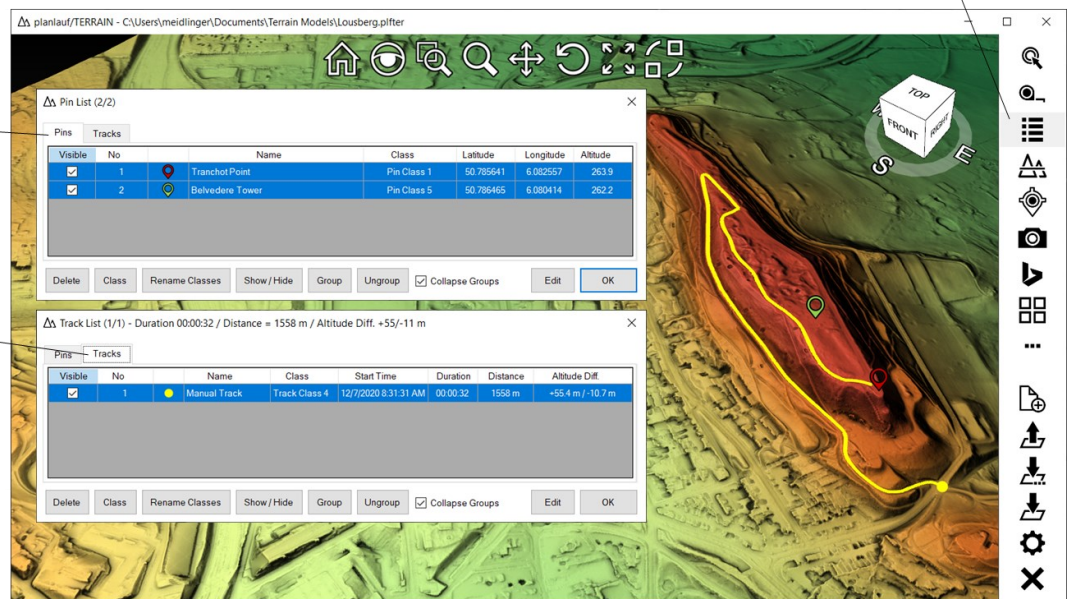
- **Switch Active Measurement Pin:** This is another way of switching the active pin.
- **Export Elevation Profile as Image:** Saves the current profile as a JPG, BMP or PNG file.
- **Export Elevation Profile as CSV:** Saves the current profile as a simple CSV file which can easily be edited with Microsoft Excel or other software.
- **Line Of Sight:** An **Observer Offset** of 2.0 m and a **Target Offset** of 1.0 m are good values to begin an LoS analysis. Uncheck the **Active** option to turn the automatic LoS off.



(1) Pin/Track List

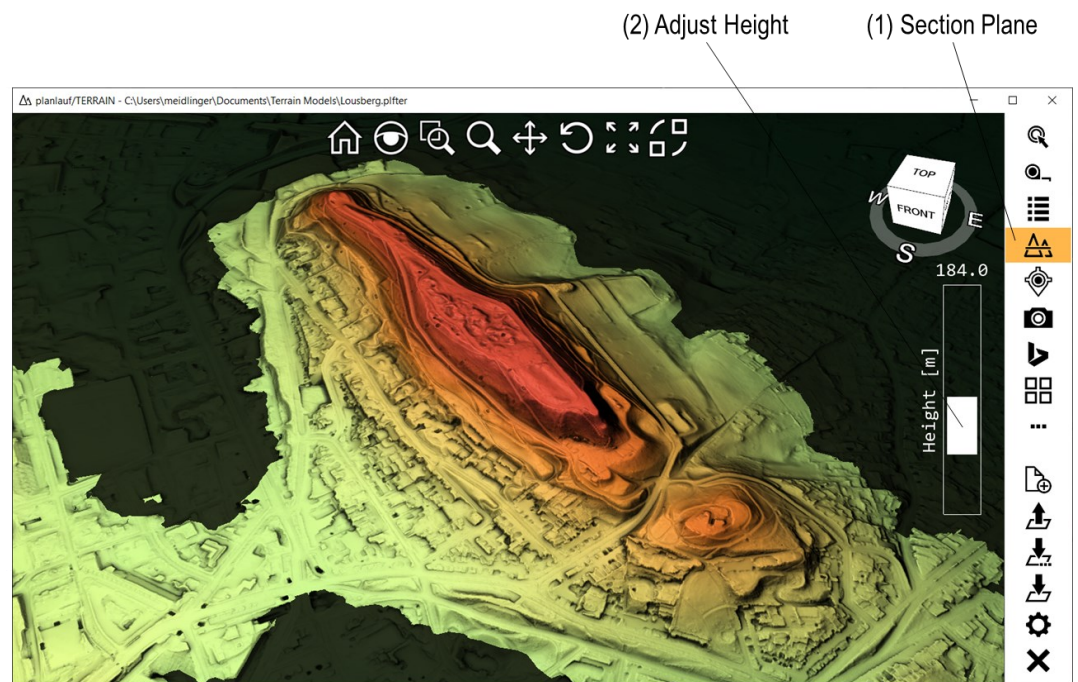
(2) Pins

(3) Tracks

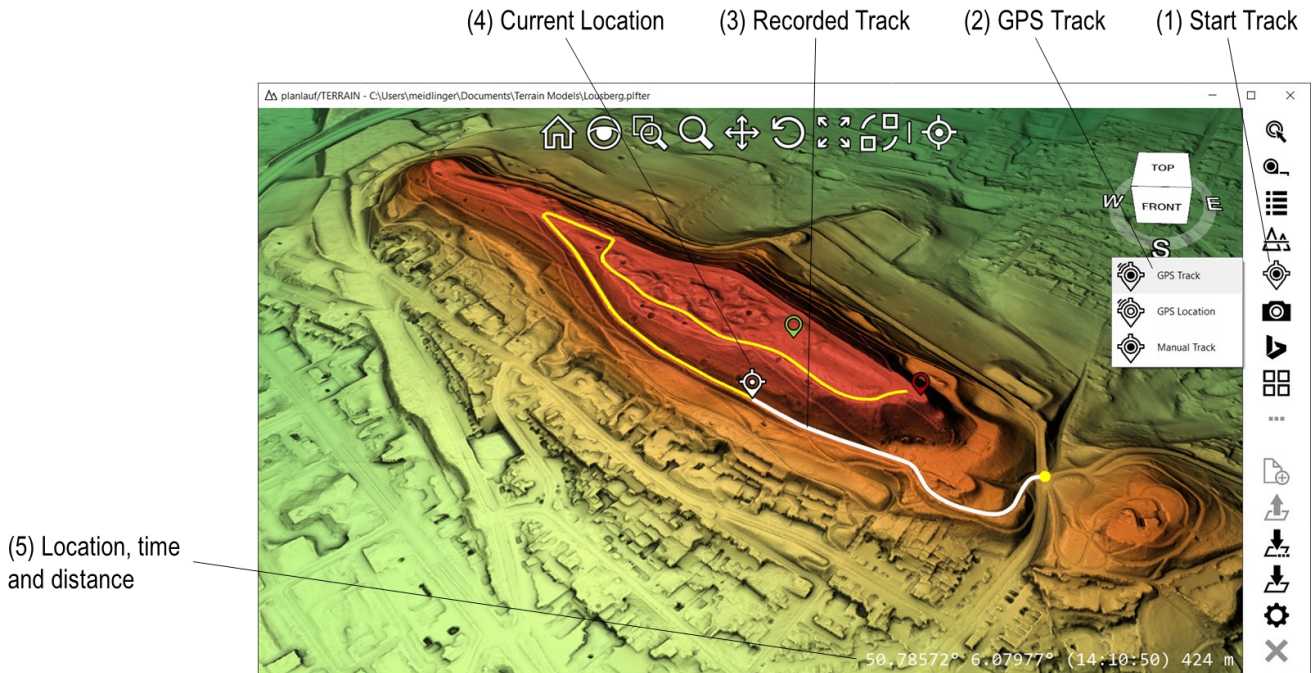


Click on **Pin/Track List** in the menu bar and choose either the **Pins** or the **Tracks** tab. There are a number of commands that apply to both categories:

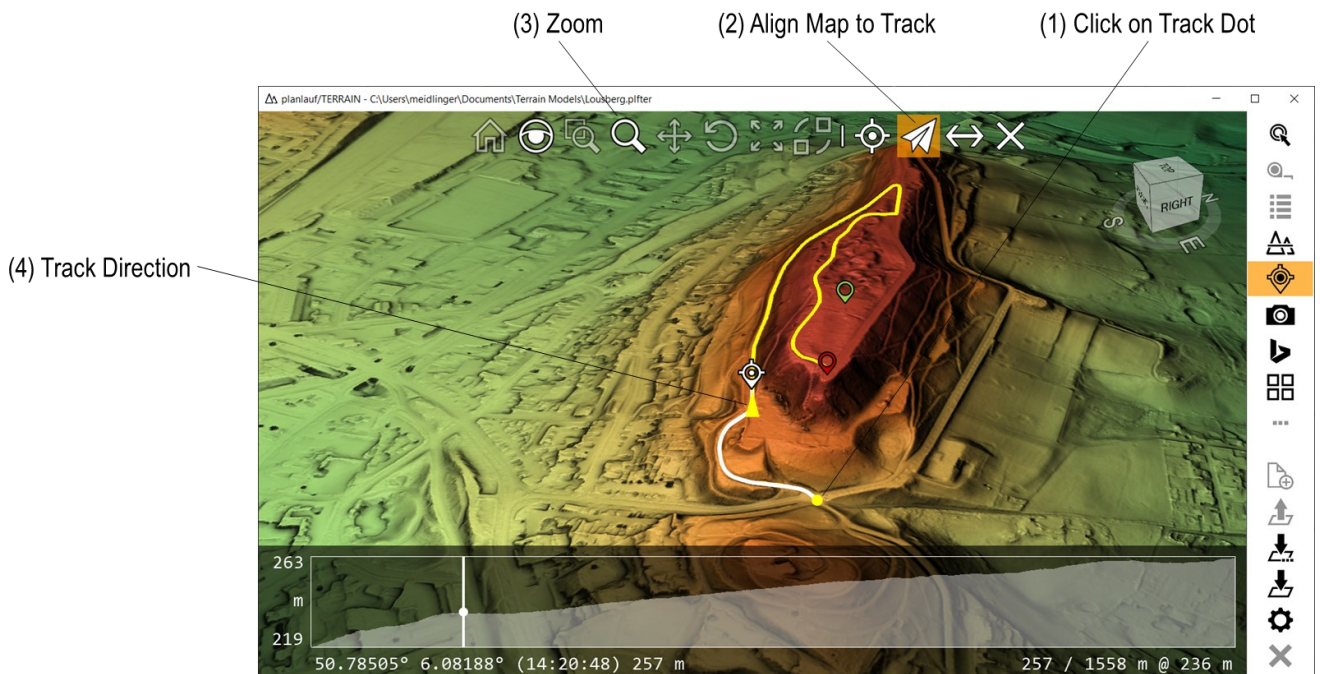
- **Delete:** Deletes the selection of pins or tracks. You can select multiple entries by pressing the Control key and clicking on them. Control+A selects all.
- **Class:** Changes the class for all selected entries.
- **Rename Classes:** Rename the class names which can be used for the optional legend.
- **Show/Hide:** Toggles the visibility of the selected entries. You can also check or uncheck the boxes in the first column of the table.
- **Group/Ungroup:** Groups or ungroups the selected pins or tracks. If the **Collapse Groups** option is selected, only one entry for each group appears at the end of the list.
- **Edit:** Shows the Edit dialog for the current row. Multiple selection is not possible for this command.



Click on **Section Plane** in the menu bar and adjust the height by pressing the left mouse button on the white slider rectangle and by moving the mouse up or down. You can also press the plus/minus keys without (1 m steps) or with the Shift key (0.1 m steps). The terrain below the section plane will be drawn with 20% of its usual brightness thus enabling to still see details below.

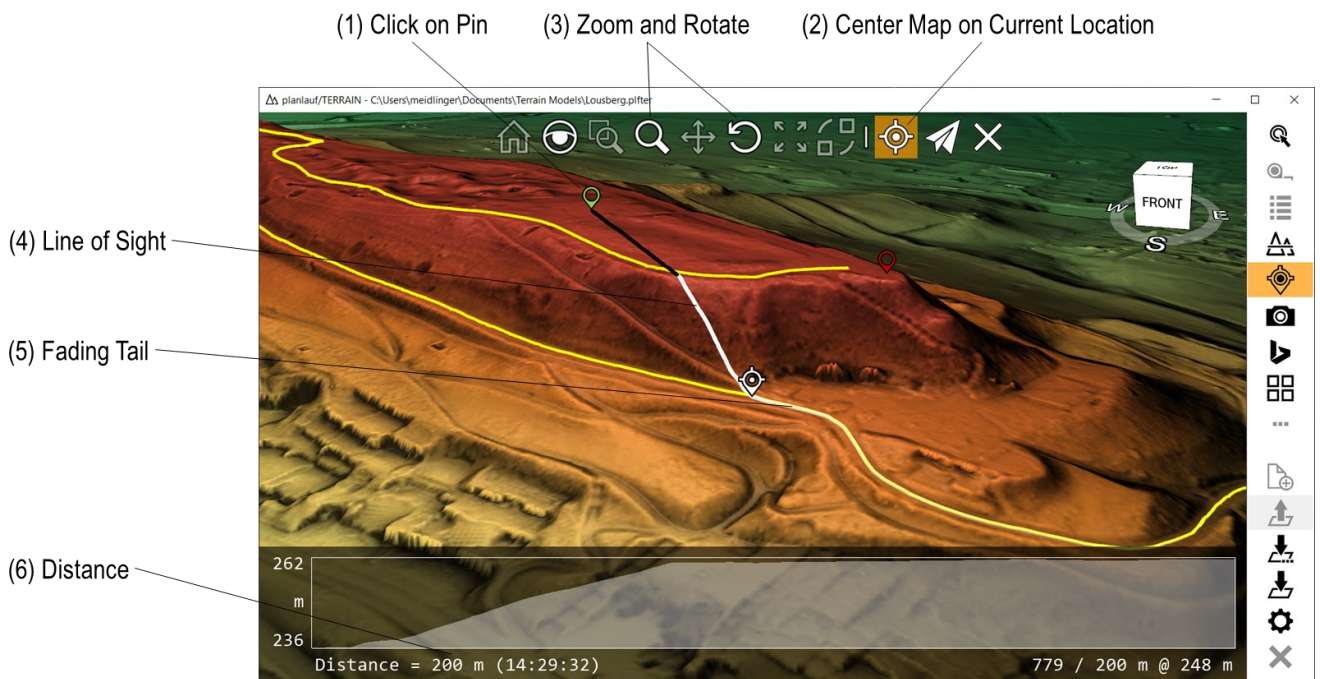


Click on **Start Track** in the menu bar and then on **GPS Track** in the submenu. If the GPS receiver is set up and turned on, the recording of the track is started immediately. Please take a look at the **Settings** section to learn how to initially set up a receiver. The recorded track is shown in white and a pin is shown at the current location. Additional information about the location, time and distance is shown in the lower right corner of the viewport.



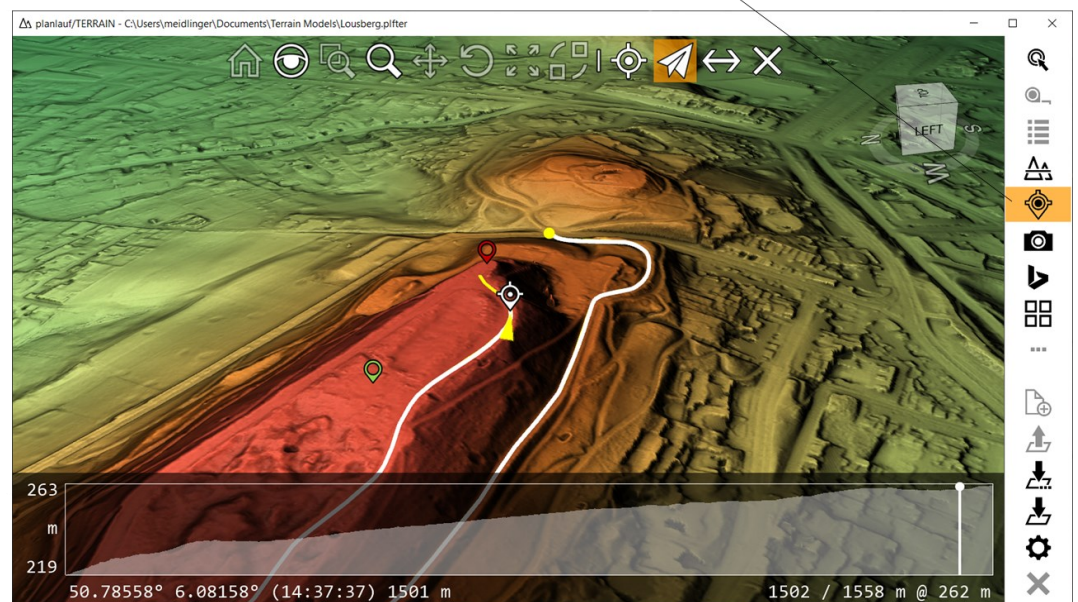
If the terrain file already contains a track, you can follow it by clicking on its **Track Dot** in the viewport. Some additional buttons are shown in the toolbar:

- 📍 **Center Map on Current Location** and rotate and zoom the model freely.
- 📏 **Align Map to Track** aligns the model and lets you zoom the model freely.
- ↔️ **Reverse Track Direction** if you want to follow the track in the opposite direction.
- ✕ **Close** will end following the track.

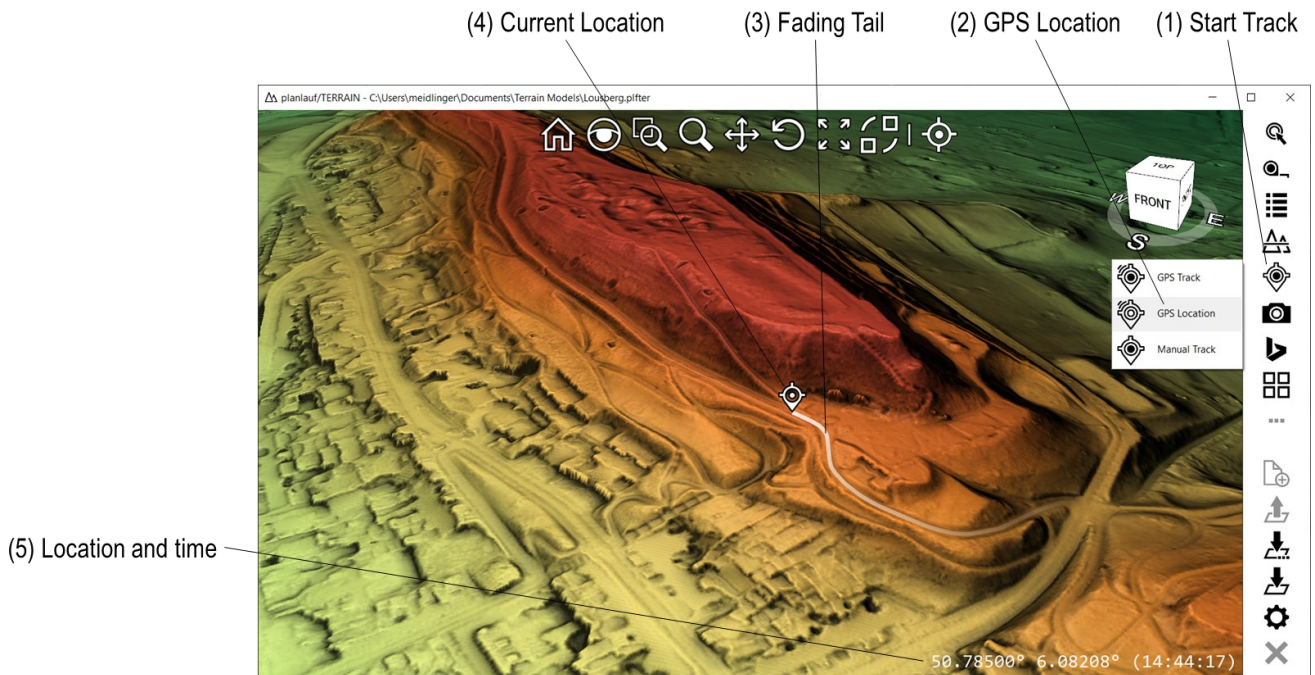


If you want to get to a specific location marked by a pin, you can click on it and the direct **Line of Sight** appears. The white parts of the line are visible from the current location, the black parts are obscured. You can use **Center Map on Current Location** or **Align Map to Track** to automatically update the model view while approaching the destination. To help orient yourself, a **Fading Tail** of the last 60 seconds is shown. In the example the line to the destination is almost perpendicular to the last 60 seconds, so you would have to climb the hill to your right for a direct approach. The remaining distance is shown in the lower right corner of the viewport. You will get different **acoustic signals** if you get closer than 30, 20 and 10 meters.

(1) Click on the highlighted Start Track button to end GPS Track mode

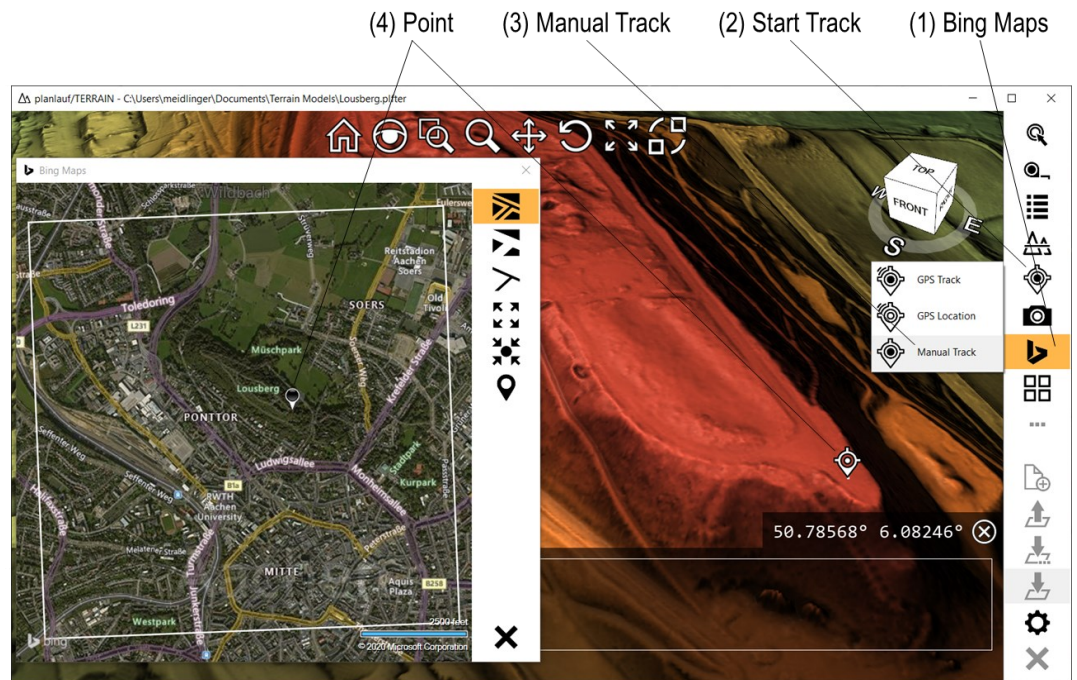


You can **end the GPS track recording** by pressing the **Escape** key or by clicking on the highlighted **Start Track** button in the menu bar.



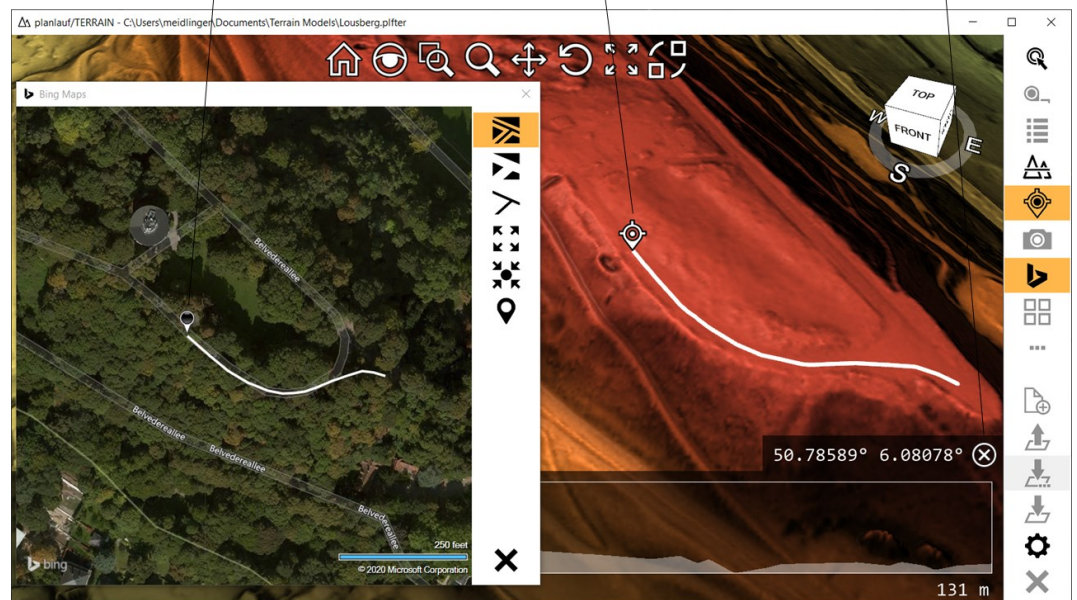
The difference between **GPS Track** and **GPS Location** mode is that with the latter the track is not recorded. Otherwise the functionality is identical. You can use this mode if you just want to follow a track or approach some locations marked with pins. Click on **Start Track** in the menu bar and then on **GPS Location** in the submenu. The current location is shown with a pin and the last 60 seconds are highlighted with a fading tail.

You can **end the GPS Location** mode by pressing the **Escape** key or by clicking on the highlighted **Start Track** button in the menu bar.

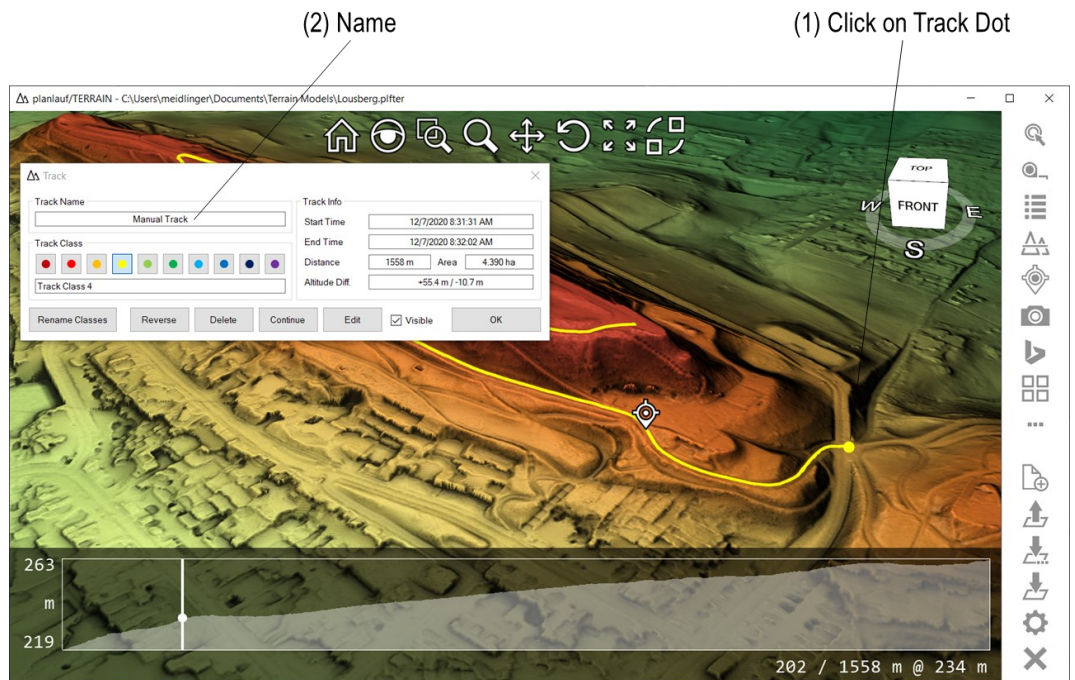


Click on **Start Track** in the menu bar and then on **Manual Track**. The pin indicating the current point is shown but please note that the first location of the manual track is defined not until its location is selected in the viewport. You can always show or hide the **Bing Maps** window.

- (2) Click on locations in Bing Maps (1) Click on locations in the viewport (3) Delete the last point



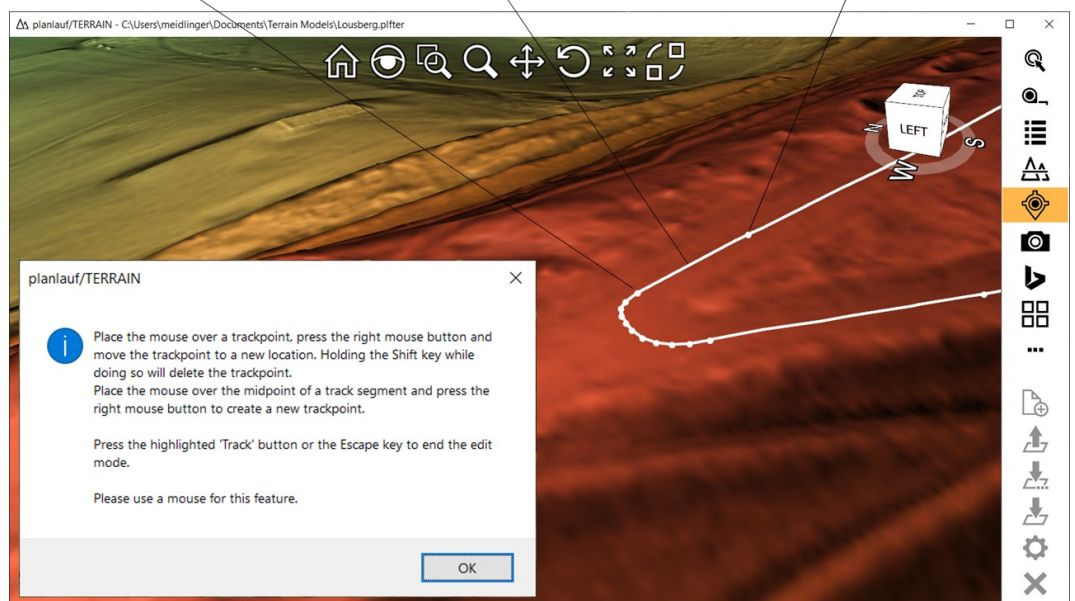
Define the manual track by clicking on the locations one after another either on the model or in the Bing Maps window. You can **delete** the last point by clicking on the symbol in the lower right corner of the viewport or by pressing the **Delete** key. Click on the **Start Track** button in the menu bar or press the **Escape** key to end the **Manual Track** mode.



Click on the **Track Dot** to show the **Track** dialog. The following track settings are possible:

- **Track Class:** Each track class is represented by a color.
- **Rename Classes:** You can assign meaningful names to the track classes.
- **Reverse:** Use this command to reverse the track direction.
- **Delete:** Deletes this track.
- **Continue:** Continue this track by adding more points.
- **Visible:** Uncheck this option to temporarily hide the track.
- **Edit:** Edit this track by adding, deleting and moving track points.

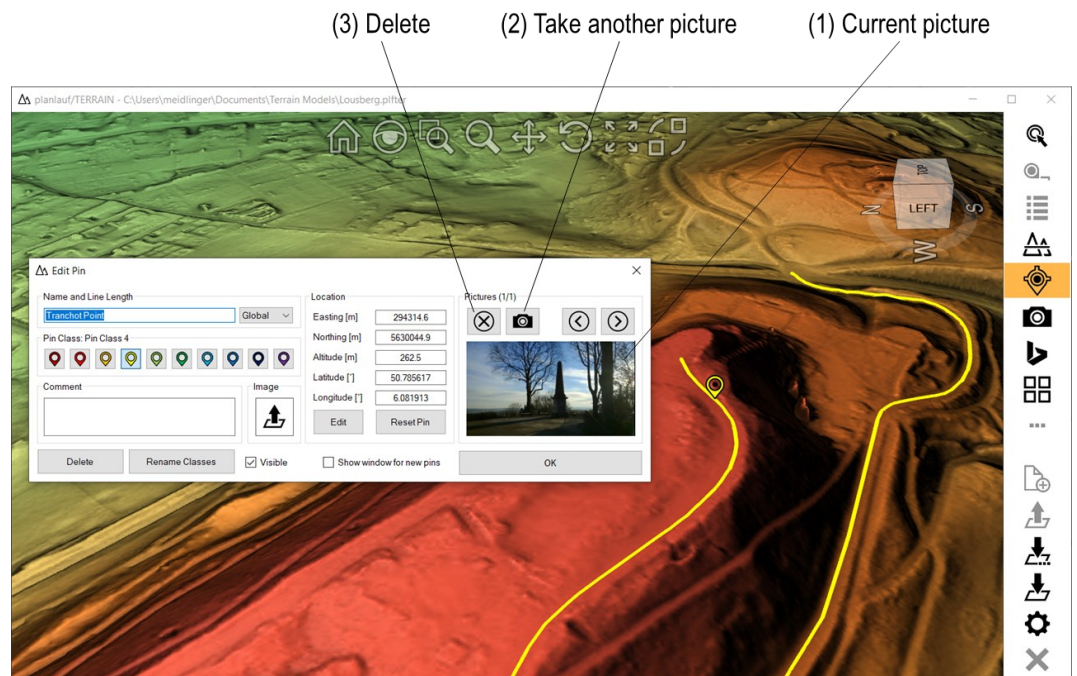
(1) RMB on point = move (2) RMB between points = new point (3) RMB + Shift on point = delete



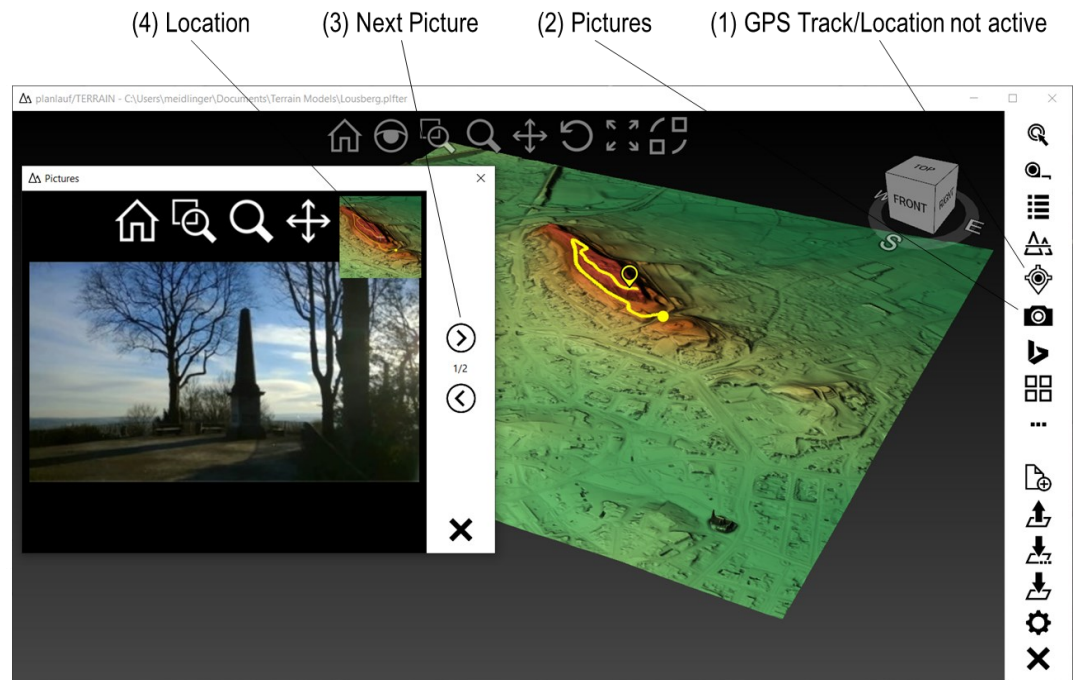
- **Press right mouse button** on a point and move the mouse = move this point.
- **Click right mouse button** between two points = create new point.
- **Click right mouse button and press shift** on point = delete this point.



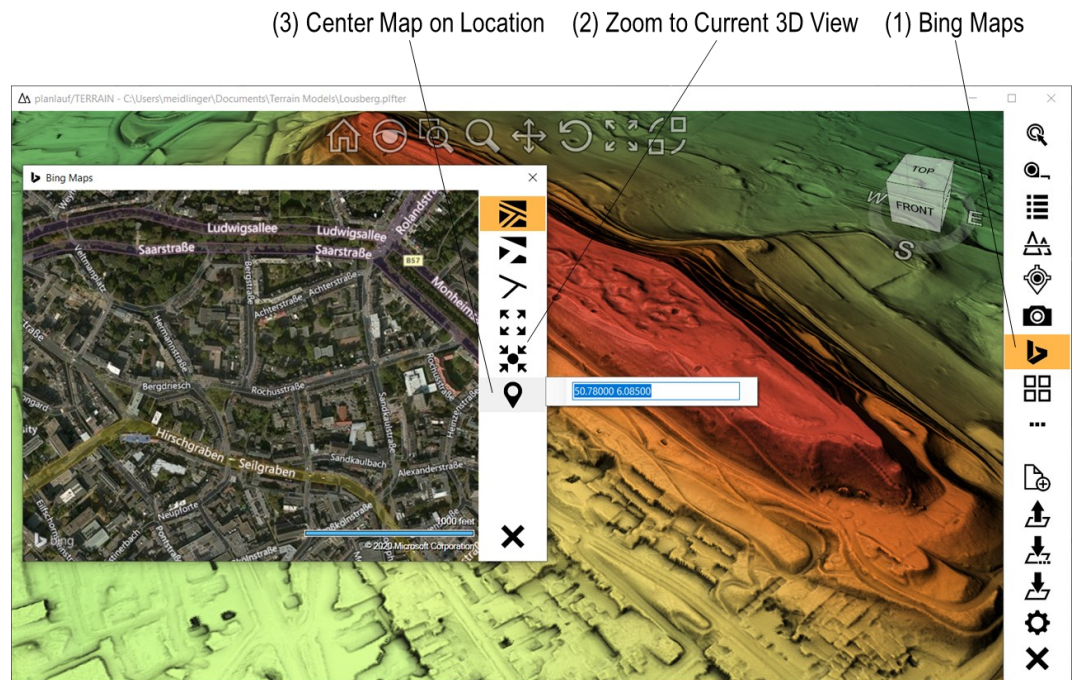
If GPS Track or GPS Location mode is active and you have set up a camera in the **Settings** (please see the **Settings** section below), you can take pictures by clicking on the **Pictures** button in the menu bar. The camera window appears and you can **rotate** the image if needed with the two buttons in the top right corner. Click on **Capture Picture** to create a pin at the current location, save the geotagged picture in the terrain file's folder and associate the picture with the pin.



The **Edit Pin** dialog is shown and you can either delete the association of the picture with it (the picture itself will not be deleted) or take **another picture** at the same GPS location. Pins with associated pictures will be marked with a small dot:



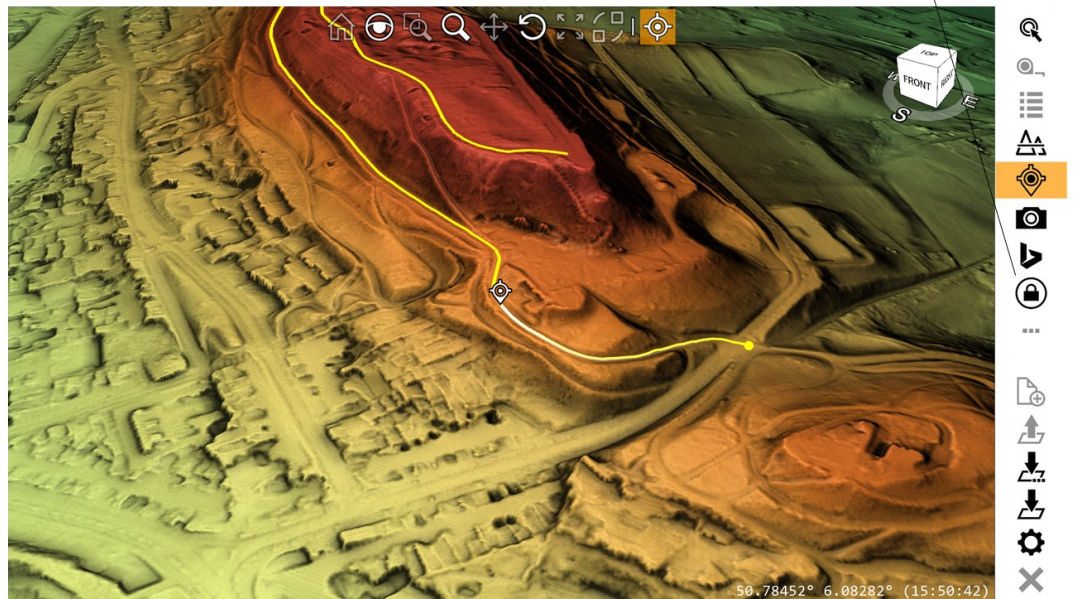
If GPS Track or GPS Location mode is not active and you have pictures associated to pins in the current terrain file, you can look at those pictures by clicking on the **Pictures** button in the menu bar. Click on **Next** or **Previous Picture** to browse all pictures. The **location** of the current picture is previewed in the upper right corner of the camera window.



Bing Maps can be used whenever you have access to the internet. Click on the **Bing Maps** button in the menu bar to open the window. The following commands are available:

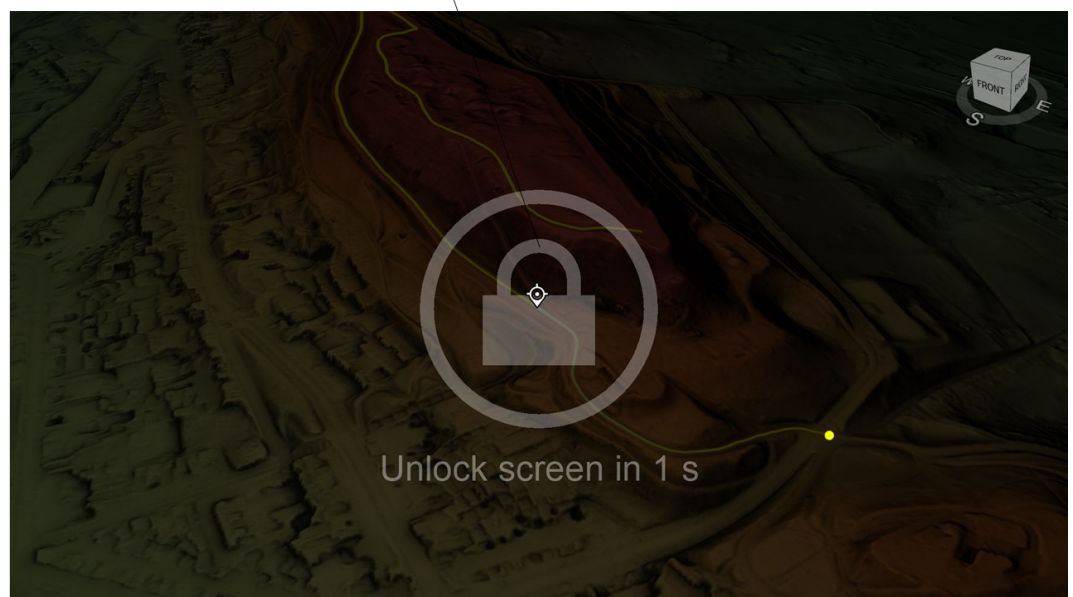
- **Aerial View with Labels:** The map shows satellite imagery and roads as overlay.
- **Aerial View:** The map shows satellite imagery only.
- **Road View:** The map shows roads only.
- **Zoom Fit:** Zooms the map to make the model extents fit into the window.
- **Zoom to Current 3D View:** Zooms the map to the current 3D view in the viewport.
- **Center Map on Location:** You can either enter a GPS location like $50.78^{\circ} 6.08^{\circ}$ into the textbox or put the location into the clipboard and click on the button. The map will be centered at this location.

(1) Lock Screen

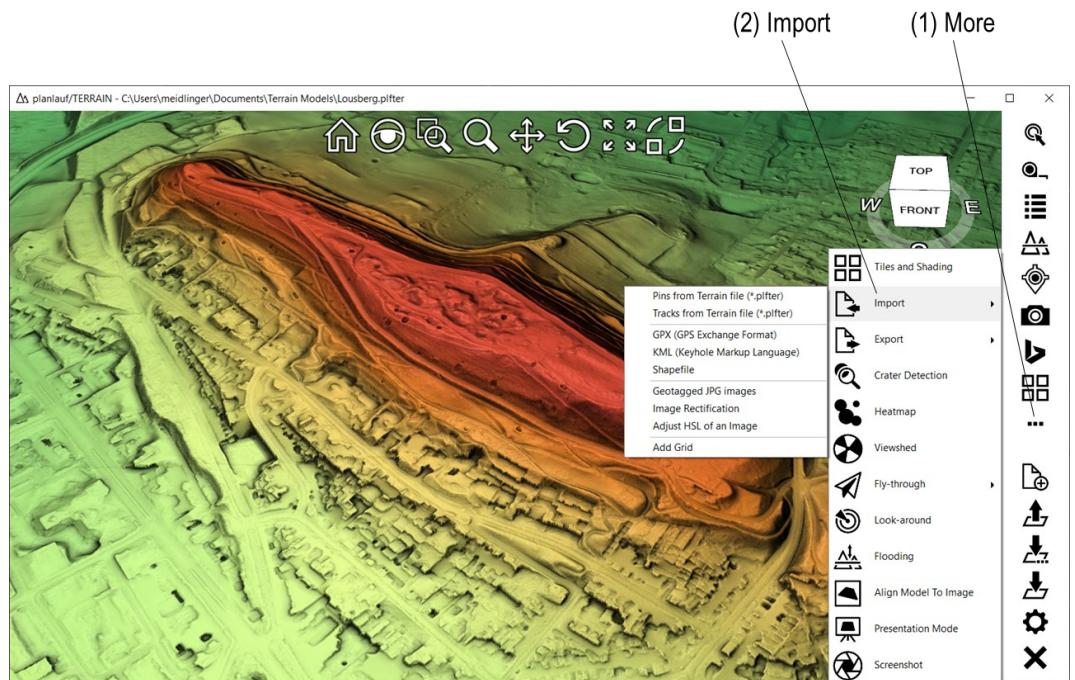


If you're using planlauf/TERRAIN for hiking you might want to avoid unwanted user interaction. Click on the **Lock Screen** button in the menu bar to lock the screen. The menu bar will be hidden but everything else will still be visible and the view will be updated whenever a new GPS location is available. Please note that the Lock Screen icon is only shown in the main menu when you're using the tablet mode (see Settings).

(1) Click on or touch the lock symbol for 3 seconds

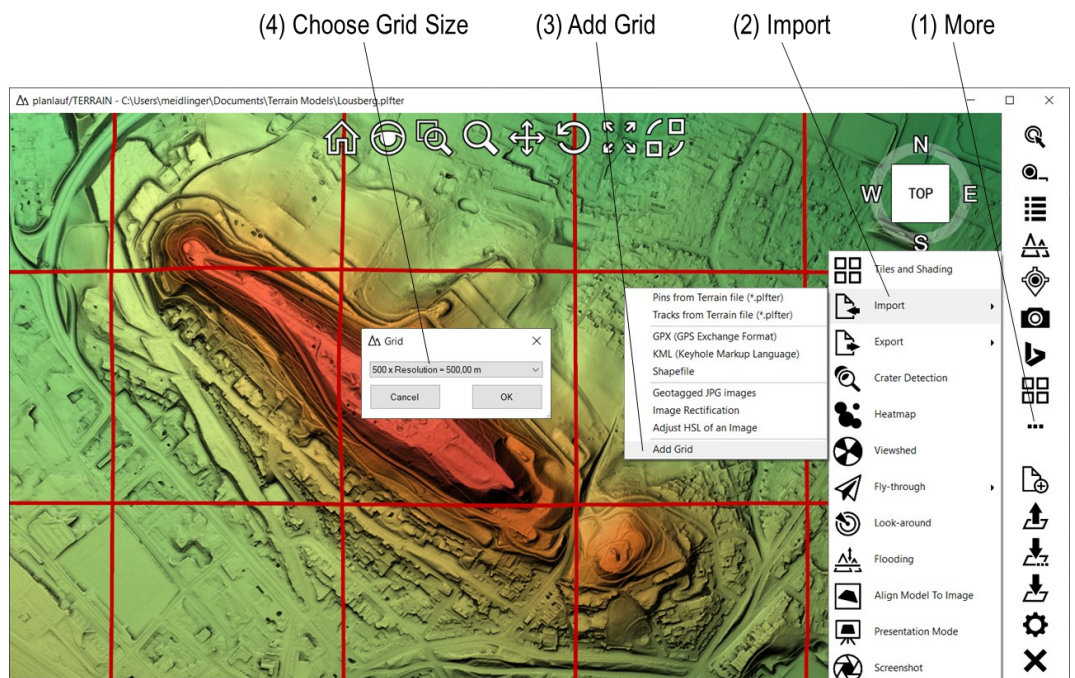


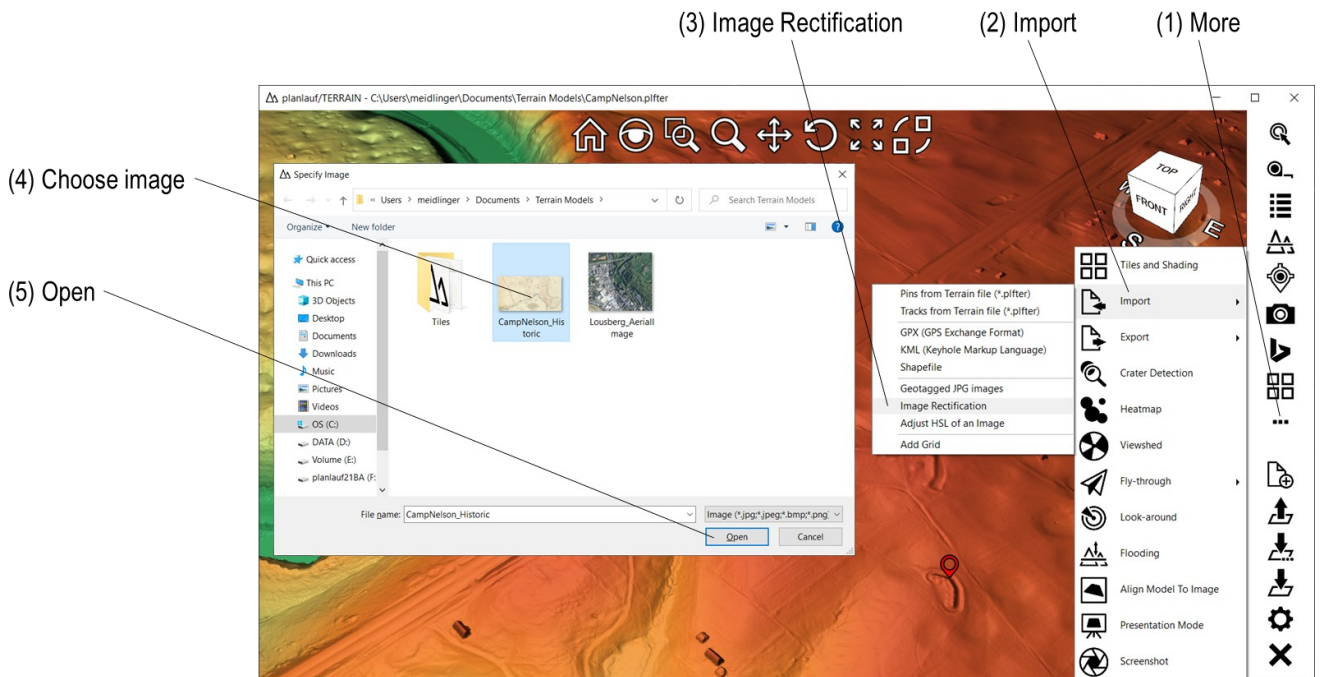
The lock symbol appears if you click on or touch the viewport. You can unlock the screen by clicking on or touching the **lock symbol** for 3 seconds. Any other click or touch will be ignored.



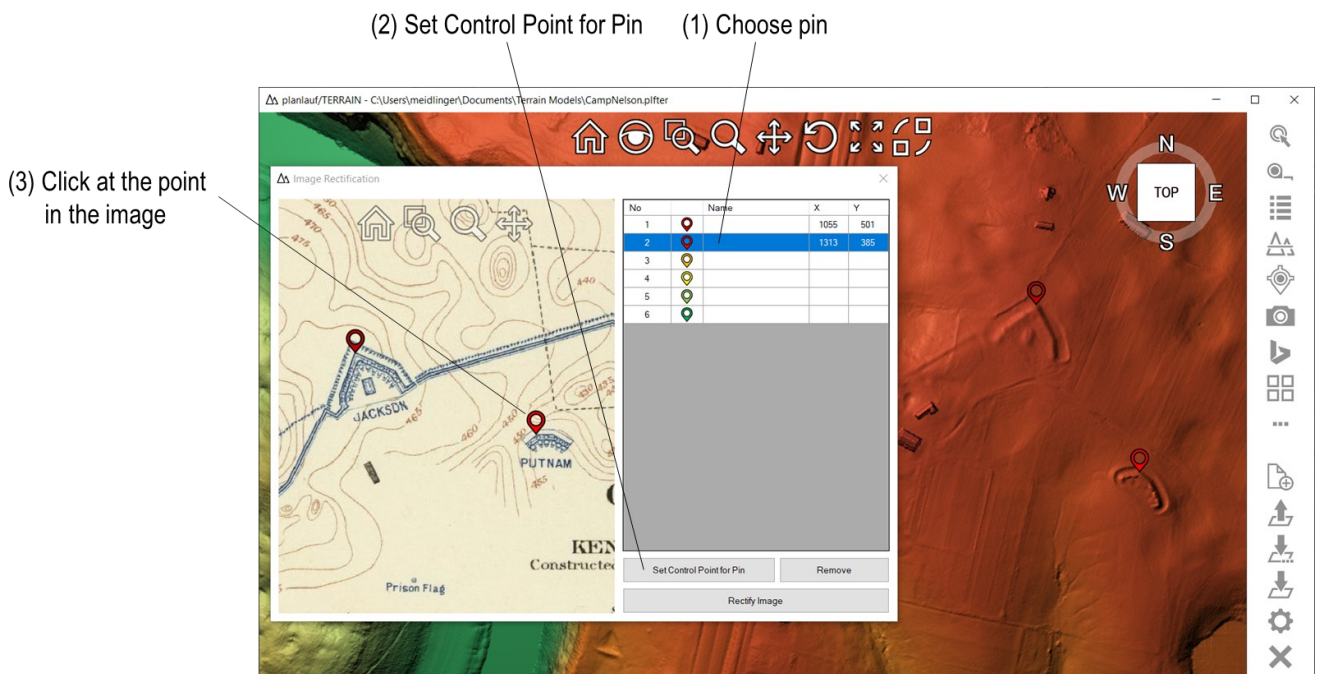
Click on **More** and then on **Import** to show the submenu for the import options:

- **Pins from Terrain file (*.plfter)**: Imports all pins from another terrain file.
- **Tracks from Terrain file (*.plfter)**: Imports all tracks from another terrain file.
- **GPX (GPS Exchange Format)**: Imports a GPX file and creates pins/tracks.
- **KML (Keyhole Markup Language)**: Imports a KML file and creates pins/tracks.
- **Shapefile**: Imports a shapefile (geometry only: point, polyline, polygon) and creates pins/tracks.
- **Geotagged JPG images**: Creates pins at the locations and associates the images with the pins.
- **Image Rectification**: Project an image to the current projection and use it as an image overlay.
- **Adjust HSL of an image**: Changes Hue, Saturation and Luminance of an image.
- **Add Grid**: Creates a grid track to support the analysis of large models.

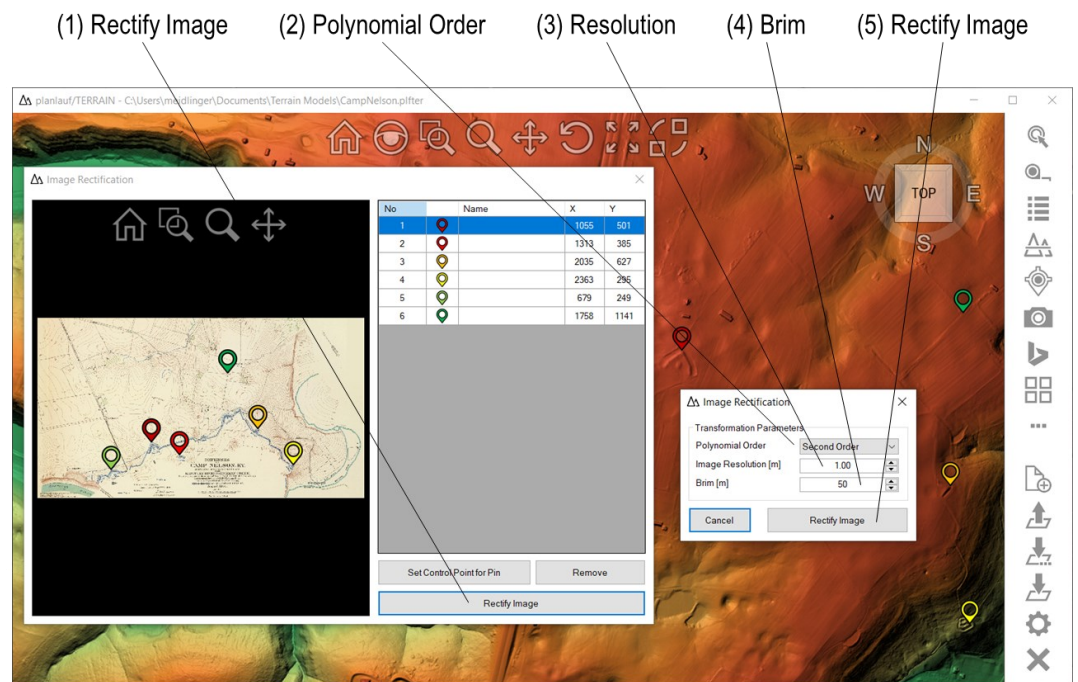




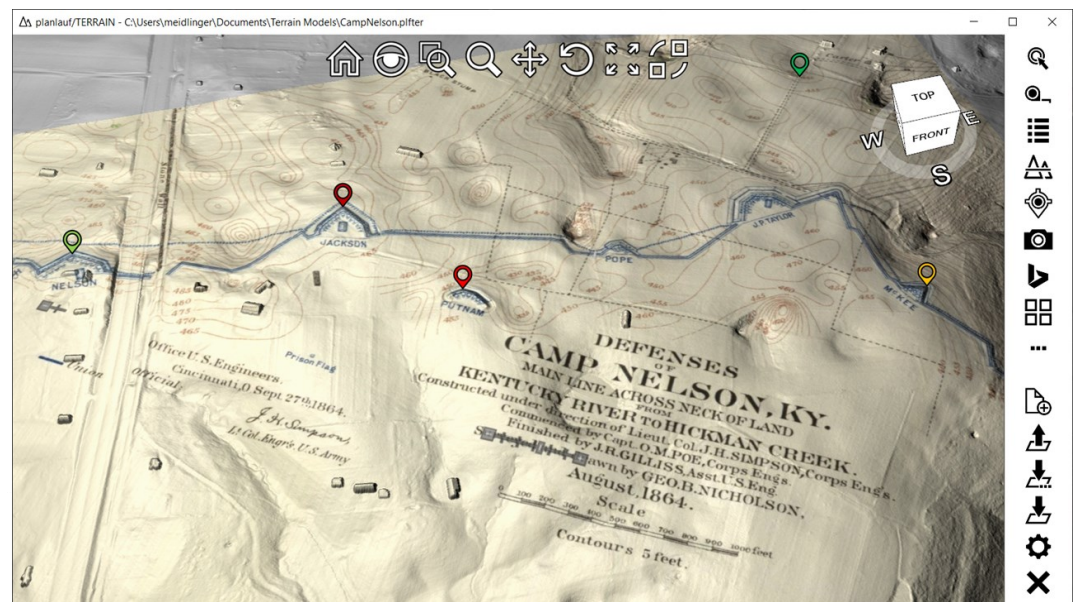
The image rectification can be used to project historical maps in another projection onto the digital terrain or surface model. The basic idea is to find corresponding points in the image and the DTM/DSM and then to apply a polynomial for the reprojection. First, create pins with different colors for the control points. Then, click on **More**, **Import** and **Image Rectification**. Choose the image and click on **Open**.

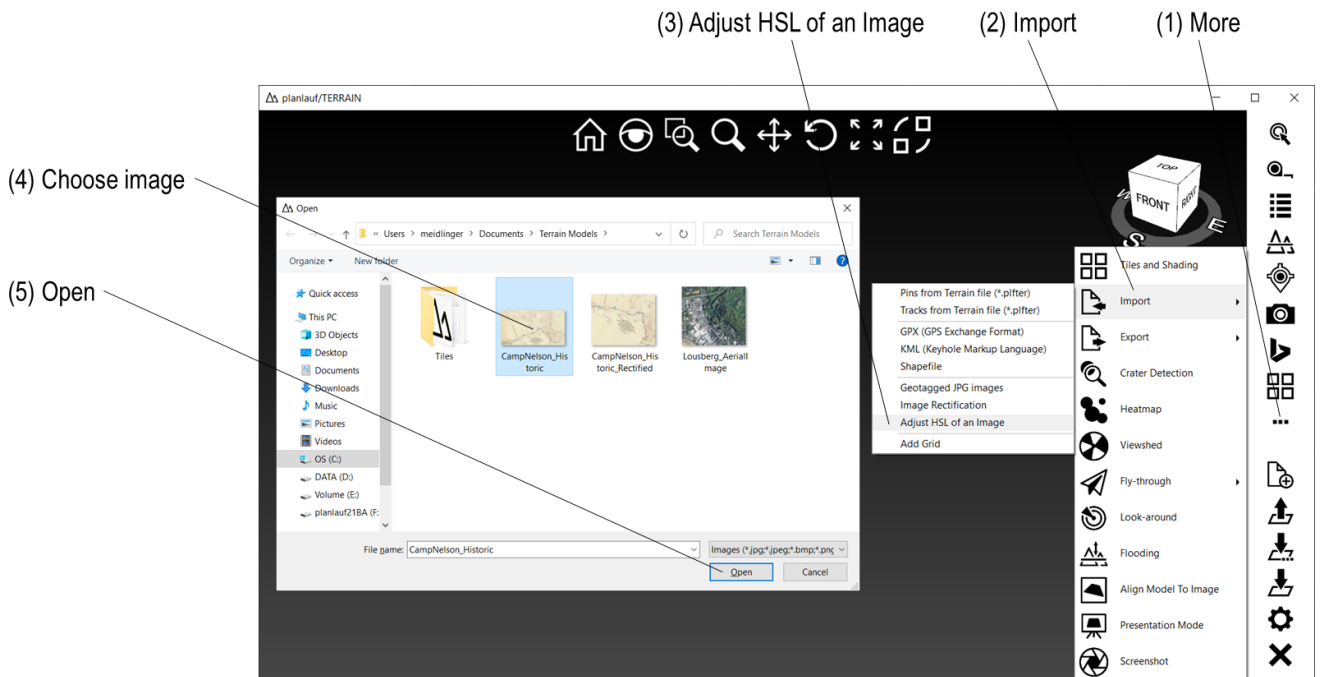


You can zoom and pan the image in the **Image Rectification** dialog with the standard commands. Choose a pin in the list, click on **Set Control Point for Pin** and then click at the corresponding location in the image. You can also double-click on the pin in the list to activate the **Set** mode. Repeat this procedure for the other pins.

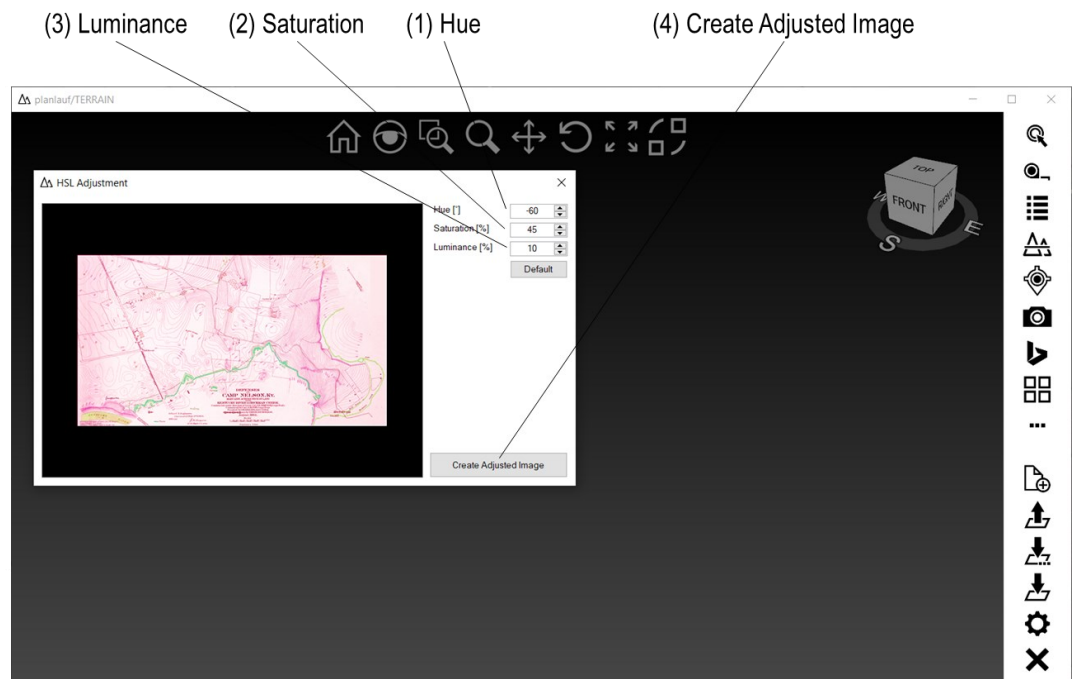


Click on **Rectify Image** and choose the **Polynomial Order**. For a first order polynomial, at least 3 control points are needed. The second order needs at least 6 and the third order 10 control points. Adjust the **Image Resolution** if needed. The default value is the resolution of the DTM/DSM but the image resolution might be better. The covered area in the image is defined by the control points. If you want to expand it, you can enter a value for the **Brim**. Please be careful with this value because the transformation polynomial might be very inaccurate outside its supporting points. Click on **Rectify Image** and wait for the calculation to finish. Enter the filename for the rectified image and click on **Save**. Click on **Yes** if you want to overlay the image directly.

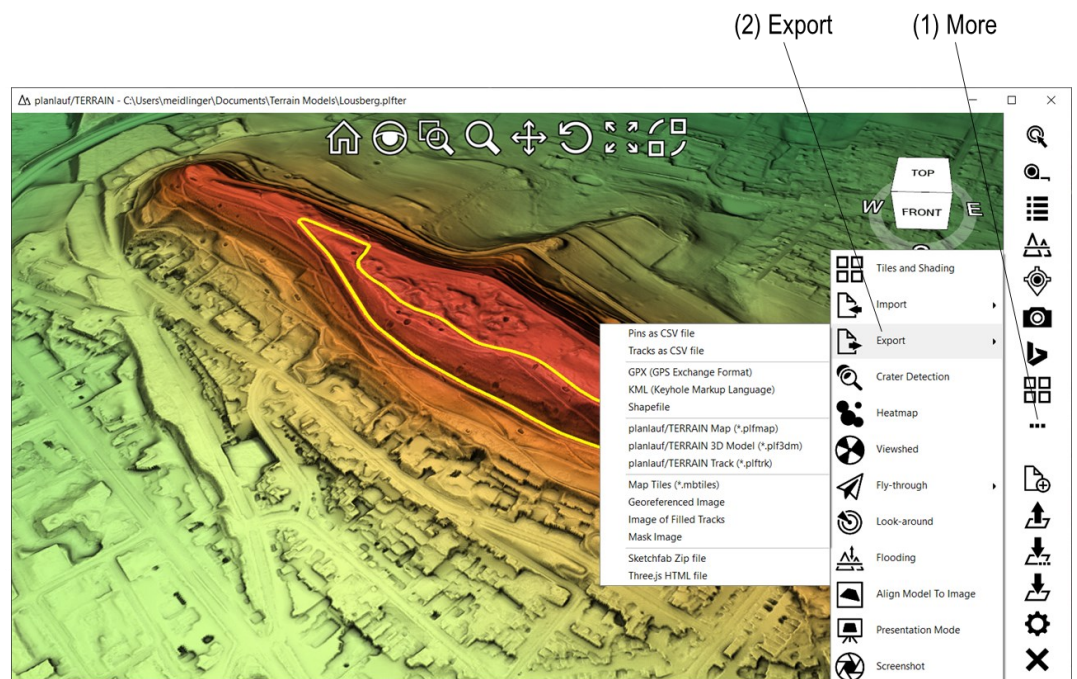




You can adjust hue, saturation and luminance of an image if the image is too bright or dark or if you want to increase the contrast or change the colors. Click on **More**, **Import** and then on **Adjust HSL of an Image**. Choose the image and click on **Open**.

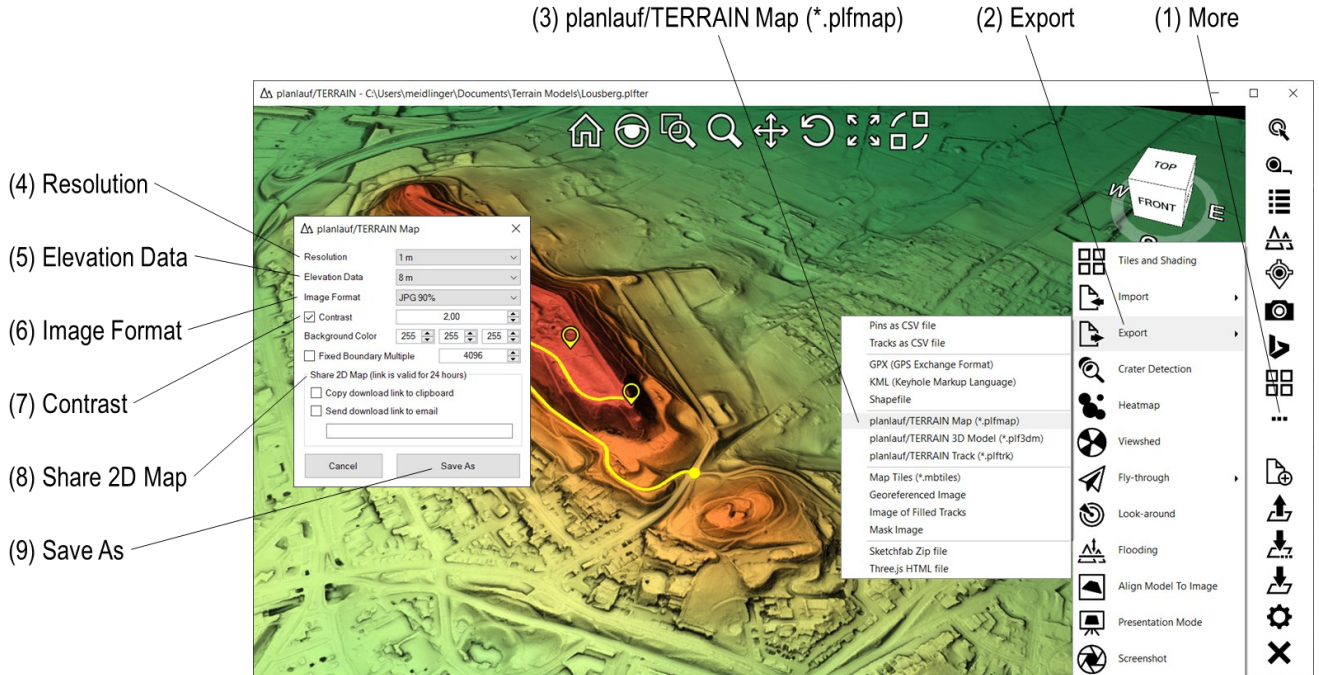


Adjust the values for **Hue**, **Saturation** and **Luminance** in the dialog and click on **Create Adjusted Image**. Choose a filename and click on **Save**.



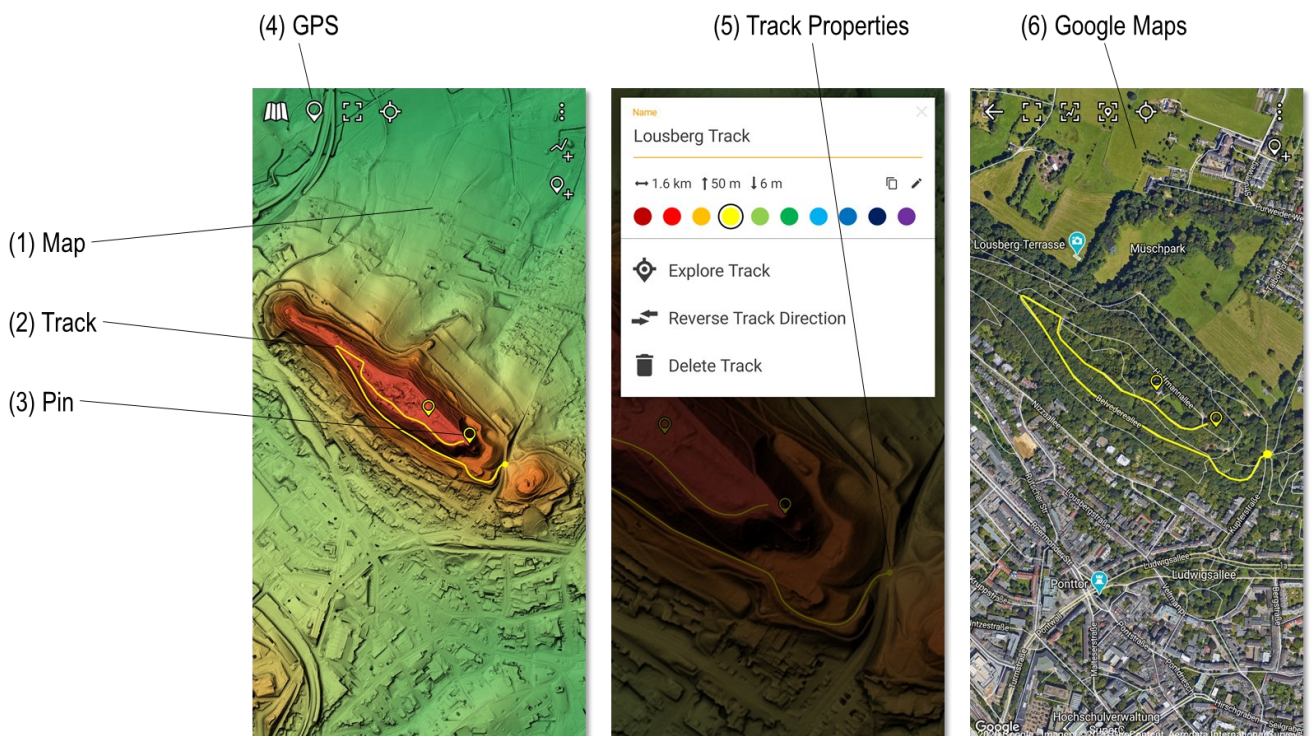
Click on **More** and then on **Export** to show the submenu for the export options (see detailed explanations on the following pages):

- **Pins as CSV file:** Exports all pins to the text-based CSV format.
- **Tracks as CSV file:** Exports all tracks to the text-based CSV format.
- **GPX (GPS Exchange Format):** Exports a GPX file including all pins and tracks.
- **KML (Keyhole Markup Language):** Exports a KML file including all pins and tracks.
- **Shapefile:** Exports a shapefile (geometry only: pins as points, tracks as polyline)
- **planlauf/TERRAIN Map (*.plfmap):** Exports a 2D map file for the planlauf/TERRAIN mobile app
- **planlauf/TERRAIN 3D Model (*.plf3dm):** Exports a 3D model file for the planlauf/TERRAIN mobile app
- **planlauf/TERRAIN Track (*.plftrk):** Exports a track file for the planlauf/TERRAIN mobile app
- **Map Tiles (*.mbtiles):** Exports the model as a 2D map in the MBTILES format
- **Georeferenced Image:** Creates a georeferenced image in JPG, PNG or GeoTIFF format.
- **Image of Filled Tracks:** Exports an image of the filled tracks. The first and last point of each track are connected.
- **Mask Image:** Creates a mask image with a semi-transparent color.
- **Sketchfab Zip file:** Creates a zip file containing all necessary files to create a Sketchfab model.
- **Three.js HTML file:** Creates a stand-alone HTML file containing the 3D model.

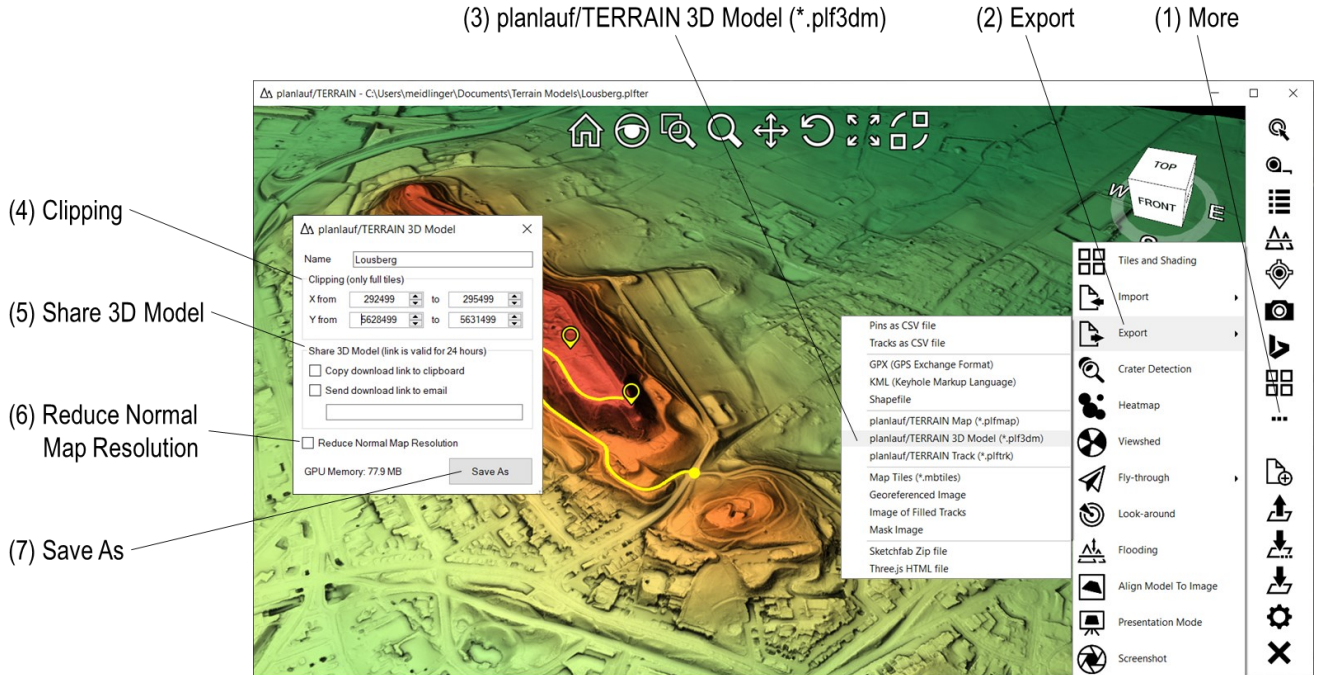


The planlauf/TERRAIN mobile app for **iOS** and **Android** is able to display 2D LiDAR maps that you can export with the Windows version of planlauf/TERRAIN. Click on **More** and then on **Export** and **planlauf/TERRAIN Map (*.plfmap)**. Choose the **Resolution** of the map and the **Elevation Data**, an **Image Format** and the **Contrast**. Click on **Save As** to create the LiDAR map.

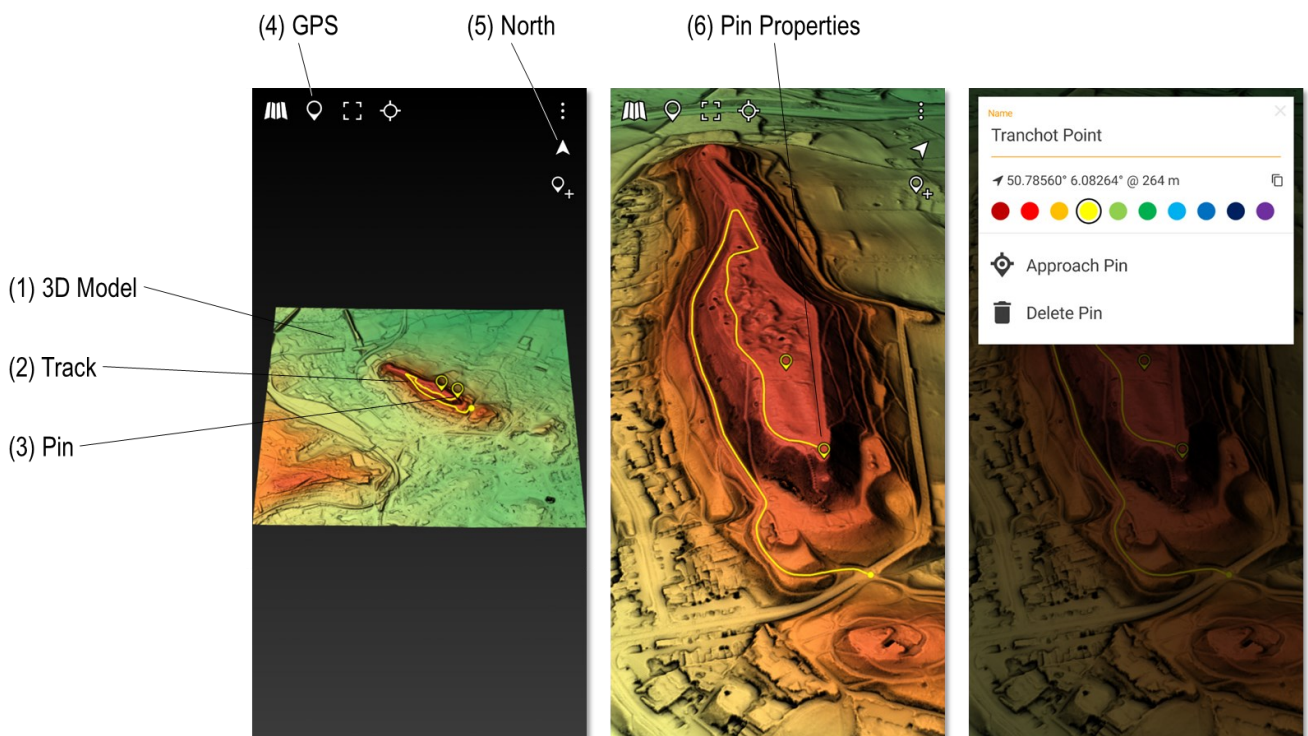
You can also upload the map to our server and share the download link by checking one of the two options in the **Share 2D Map** field. Please notice that the map will be deleted after 24 hours.

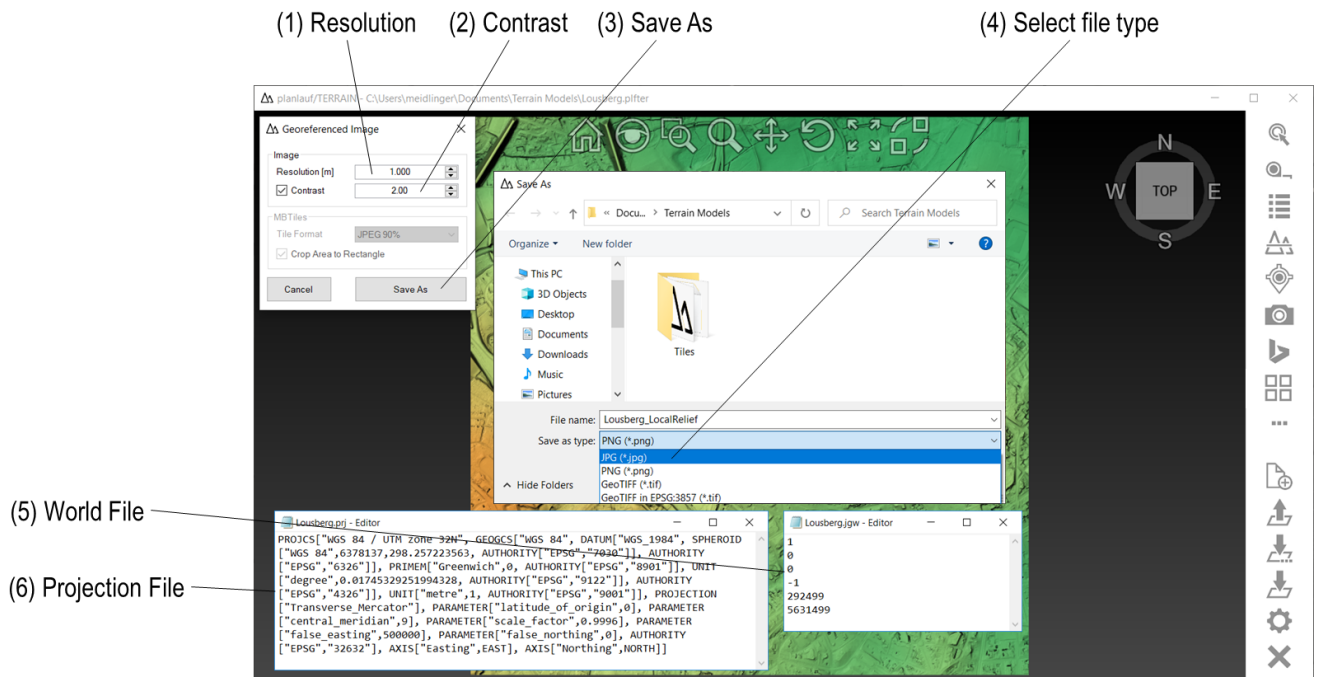


You can use the mobile app for hiking or exploring the landscape. If you're using the LiDAR maps, the app works completely **offline**. You can also open the integrated **Google Maps** viewer if you've got Wi-fi and zoom and pan the map to cover your area of interest. The viewer will cache the downloaded tiles and you will be able to use Google Maps even in airplane mode.

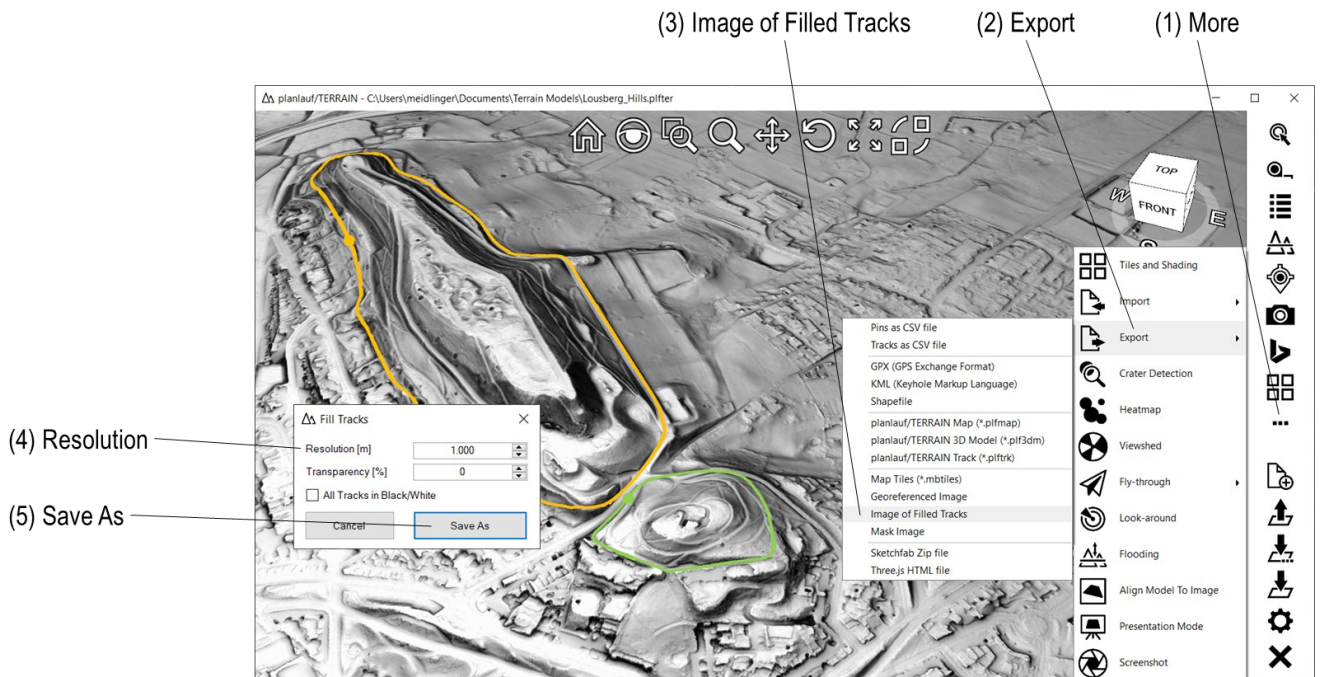


The planlauf/TERRAIN mobile app for **iOS** and **Android** is able to display 3D LiDAR models that you can export with the Windows version of planlauf/TERRAIN. Click on **More** and then on **Export** and **planlauf/TERRAIN 3D Model (*.plf3dm)**. The required **GPU memory** is shown at the bottom of the window. If your mobile device is not able to display the 3D model correctly, you might need to reduce the model extents with the **Clipping** option. You can also reduce the resolution of the **normal maps**. Click on **Save As** to create the 3D LiDAR model.

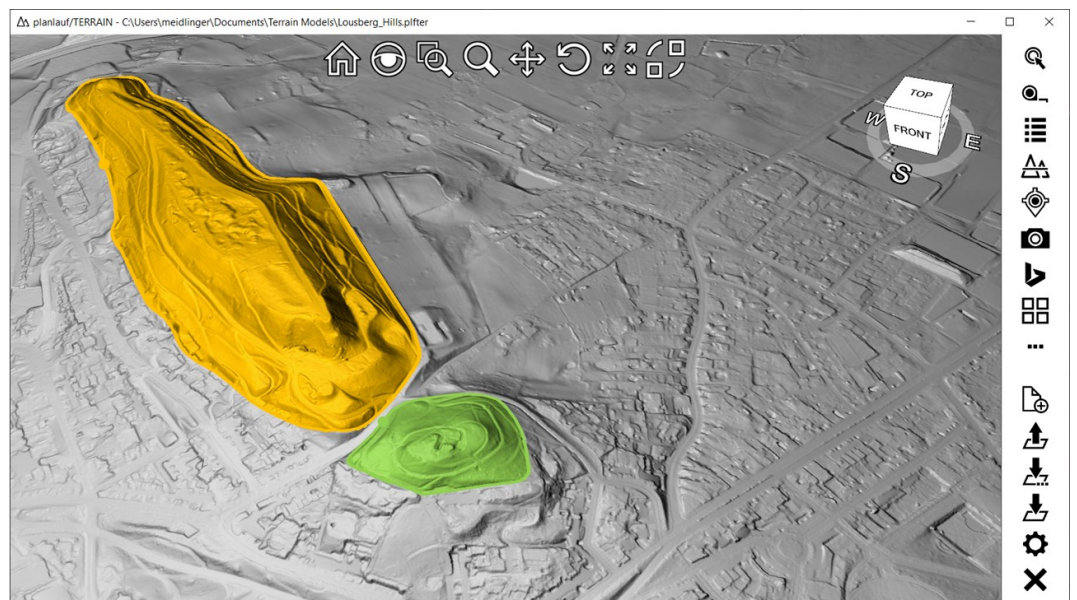




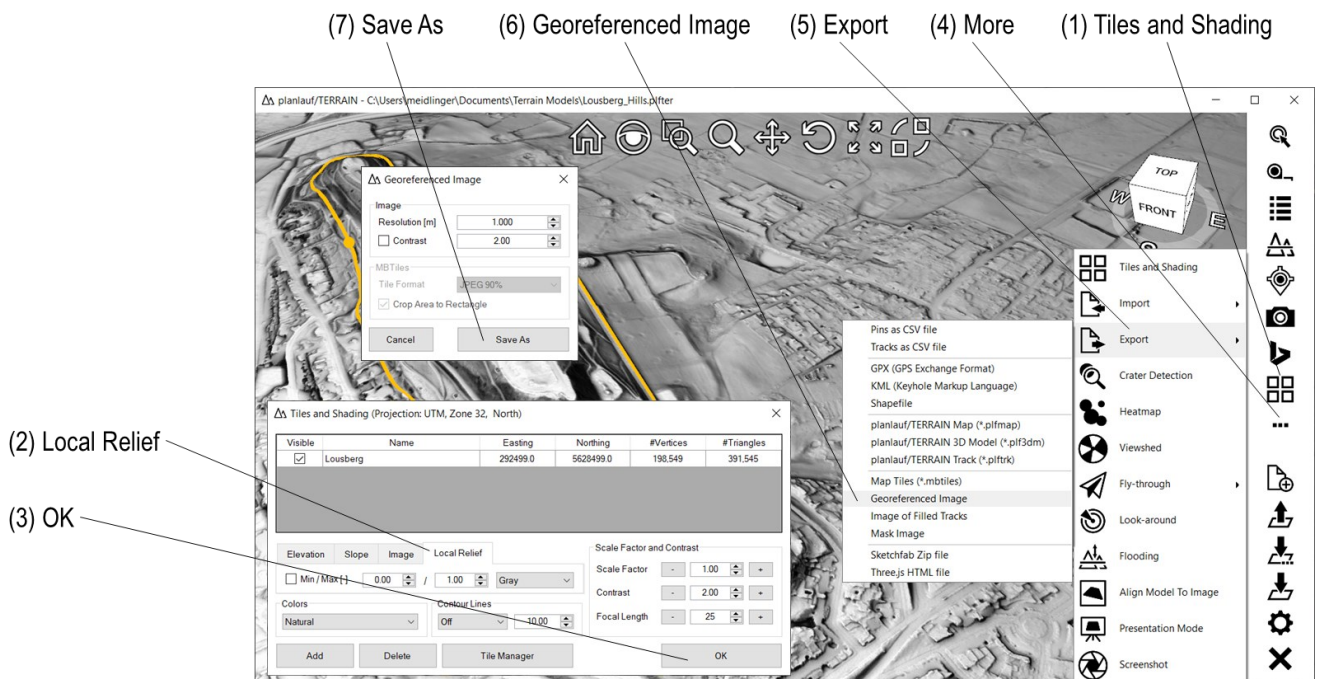
Choose the **Resolution** and the **Contrast**, click on **Save As** and select the **File Type**. The world and projection file for the JPG and PNG file formats can be used by another GIS software as a georeference. Areas without data are white in JPGs, transparent in PNGs and NoData values in GeoTIFFs. GDAL has to be installed if you want to use the GeoTIFF option.



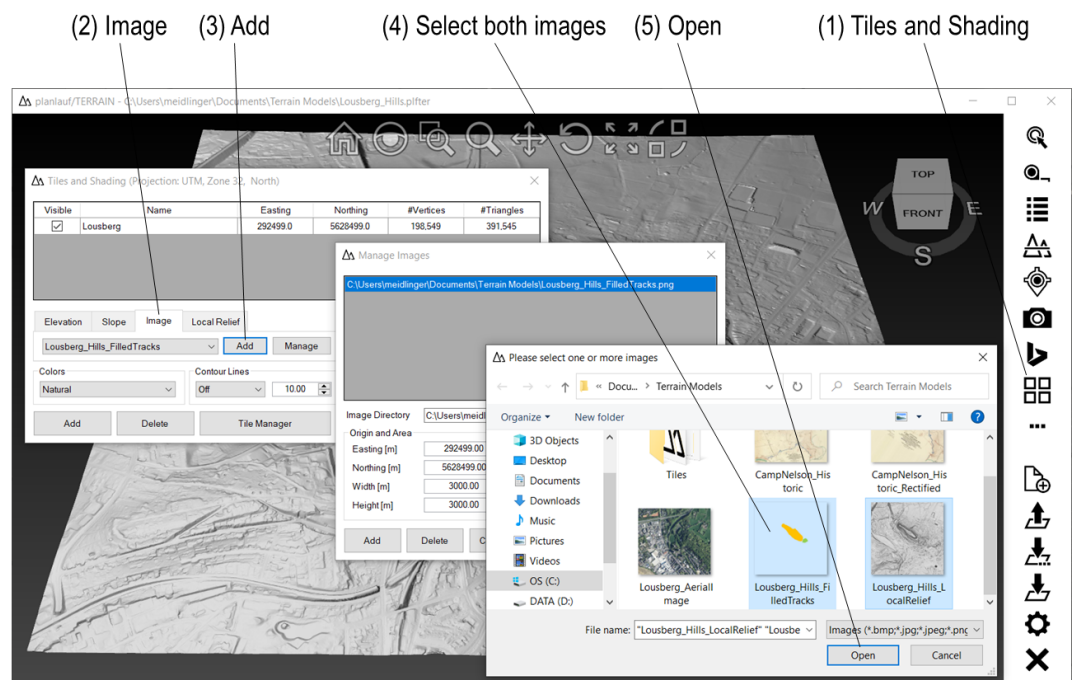
If you want to highlight areas, you can create an image of the filled tracks and use it as an image overlay. Click on **More**, **Export** and then on **Image of Filled Tracks**. The default value for the resolution is the resolution of the current tile file but you can increase the value if the resulting image would be too big. Changing the **Transparency** value adds an alpha channel to a PNG image. Click on **Save As**, enter a filename and click on **Save**. The image will then automatically be used as an image overlay.



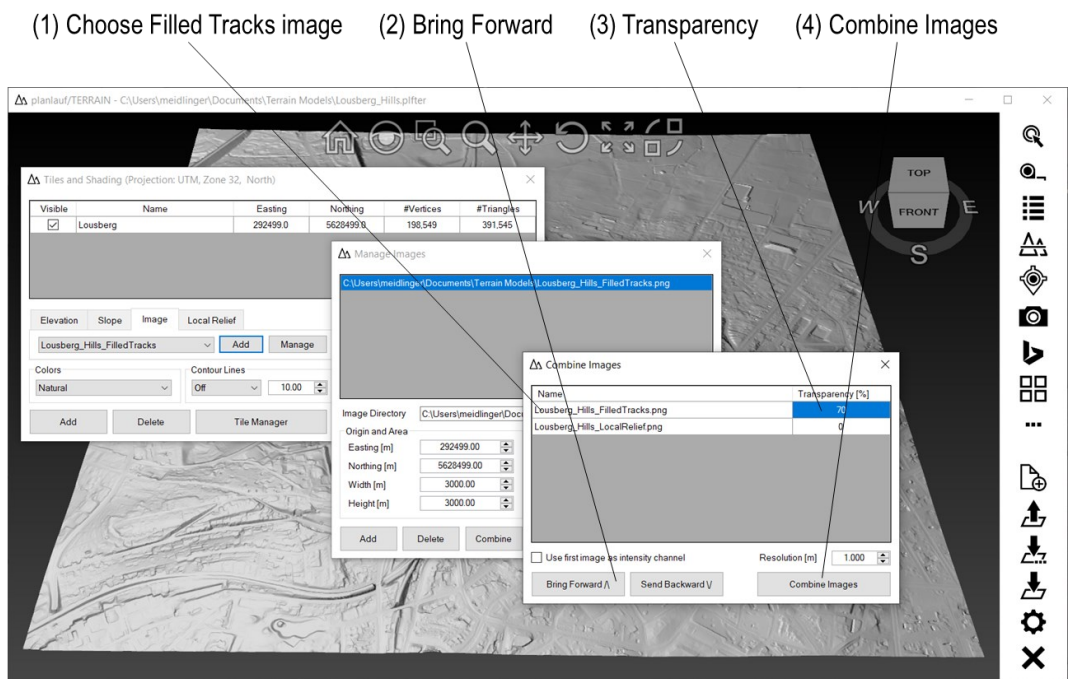
The default shader is the image shader so a simple hillshading will be used. If you want to combine the filled tracks with another visualization, you can combine two or more images.



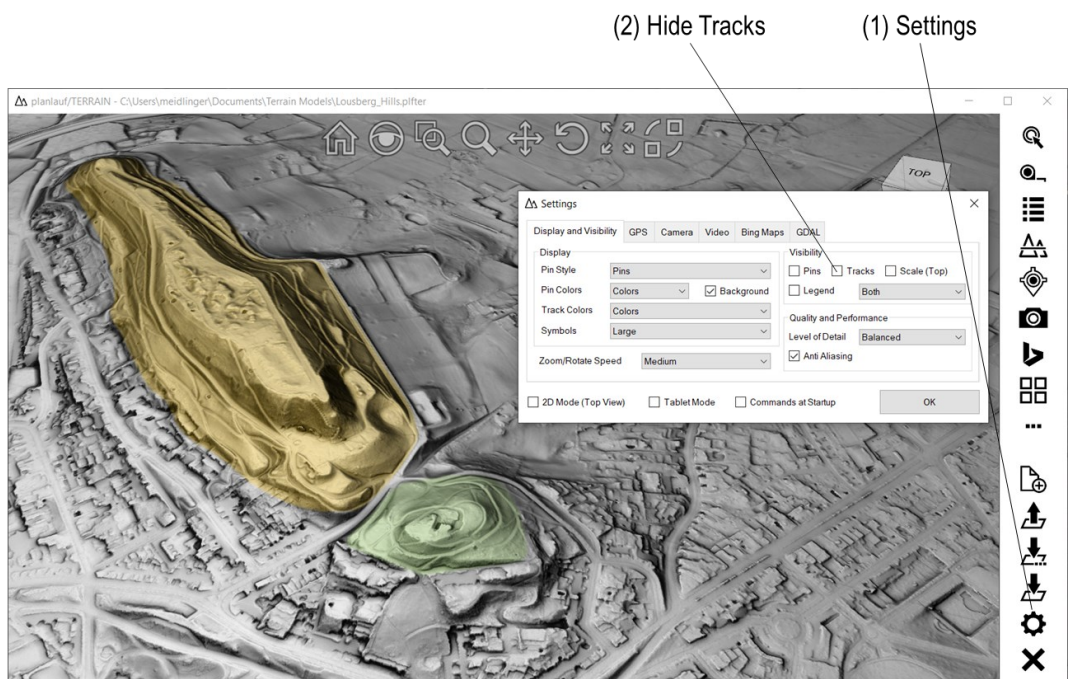
First, create a georeferenced image of the local relief visualization. Click on **Tiles and Shading**, choose the **Local Relief** shader tab and click on **OK**. Click on **More**, **Export** and then on **Georeferenced Image**. Accept the default settings and click on **Save As**, enter a filename and click on **Save**.



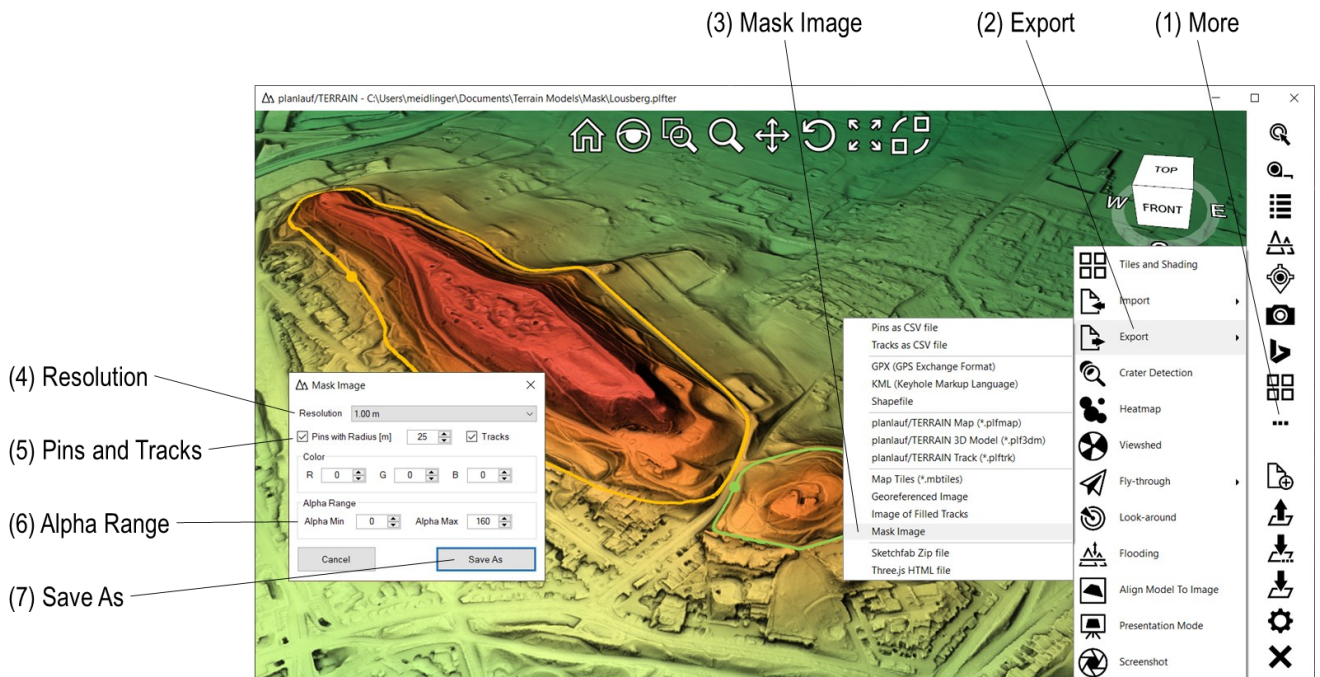
To create a combined image (filled tracks and local relief), click on **Tiles and Shading**, choose the **Image** shader tab and click on **Add**. Select both images and click on **Open**.



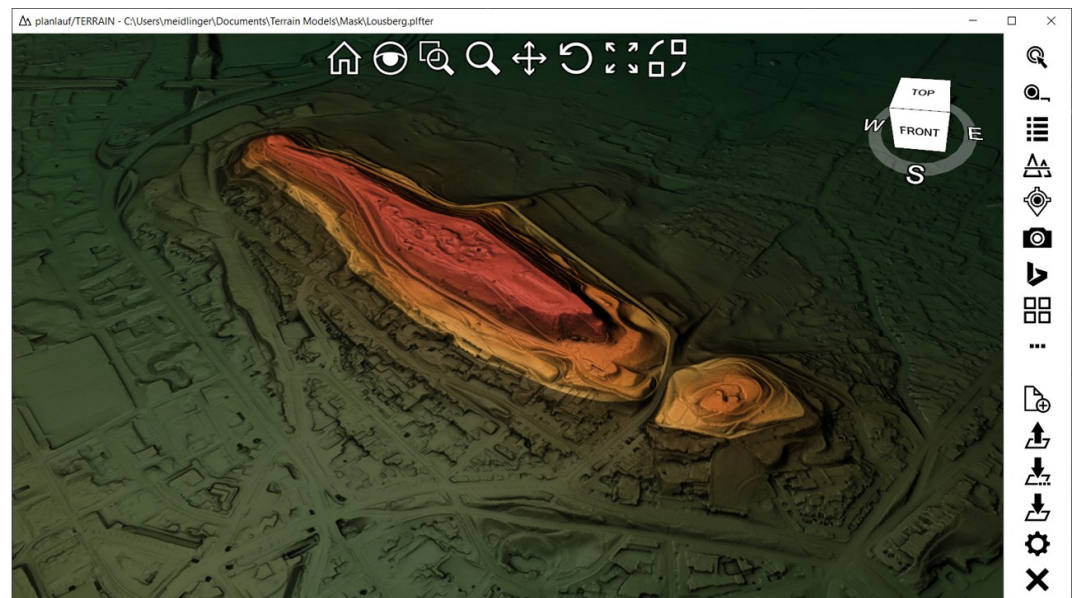
Choose the Filled Tracks image and click on **Bring Forward** to define the drawing order of the images. Enter a value for the **Transparency** and click on **Combine Images**. Enter a filename and click on **Save**.

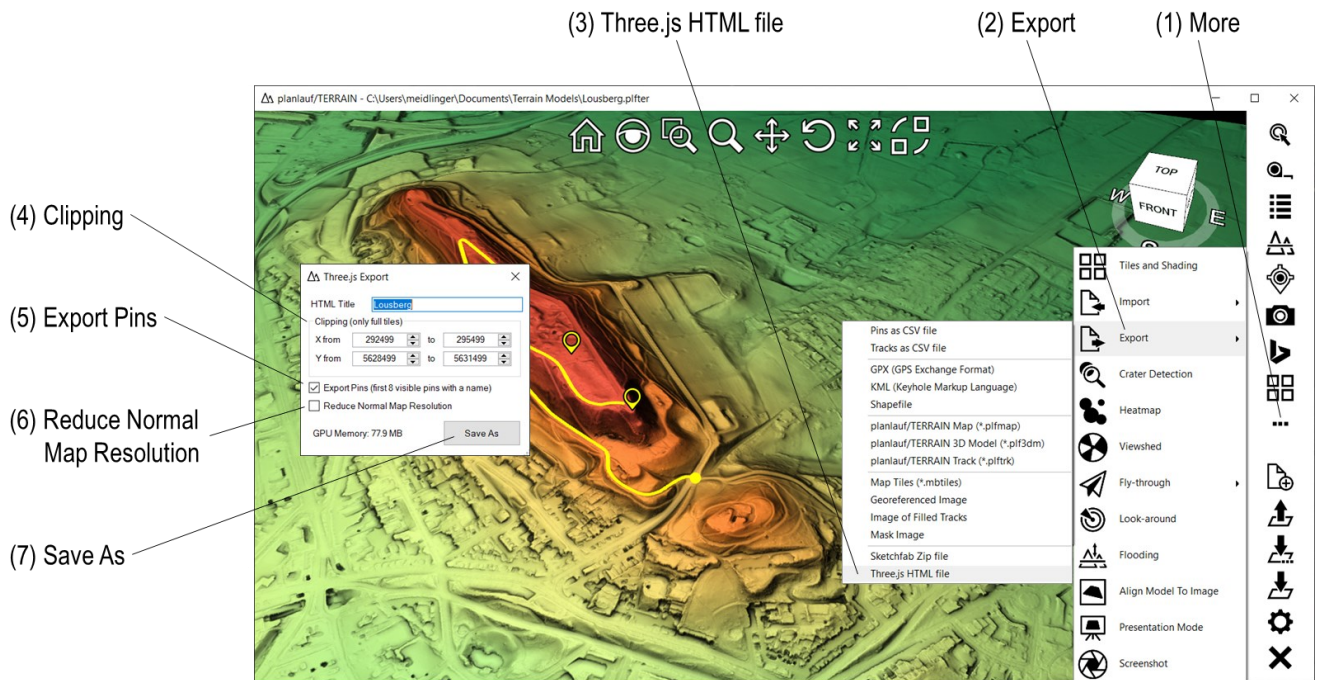


The combined image will automatically be used as an image overlay. Click on **Settings** and uncheck the **Tracks** option to hide the tracks. You can also hide specific tracks in the **Track List**.

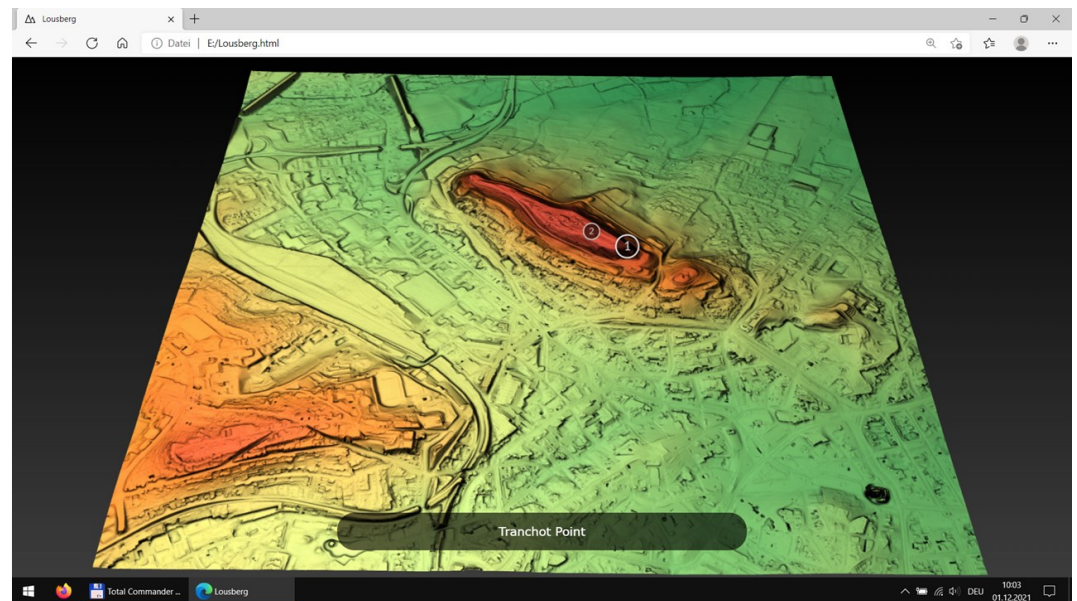


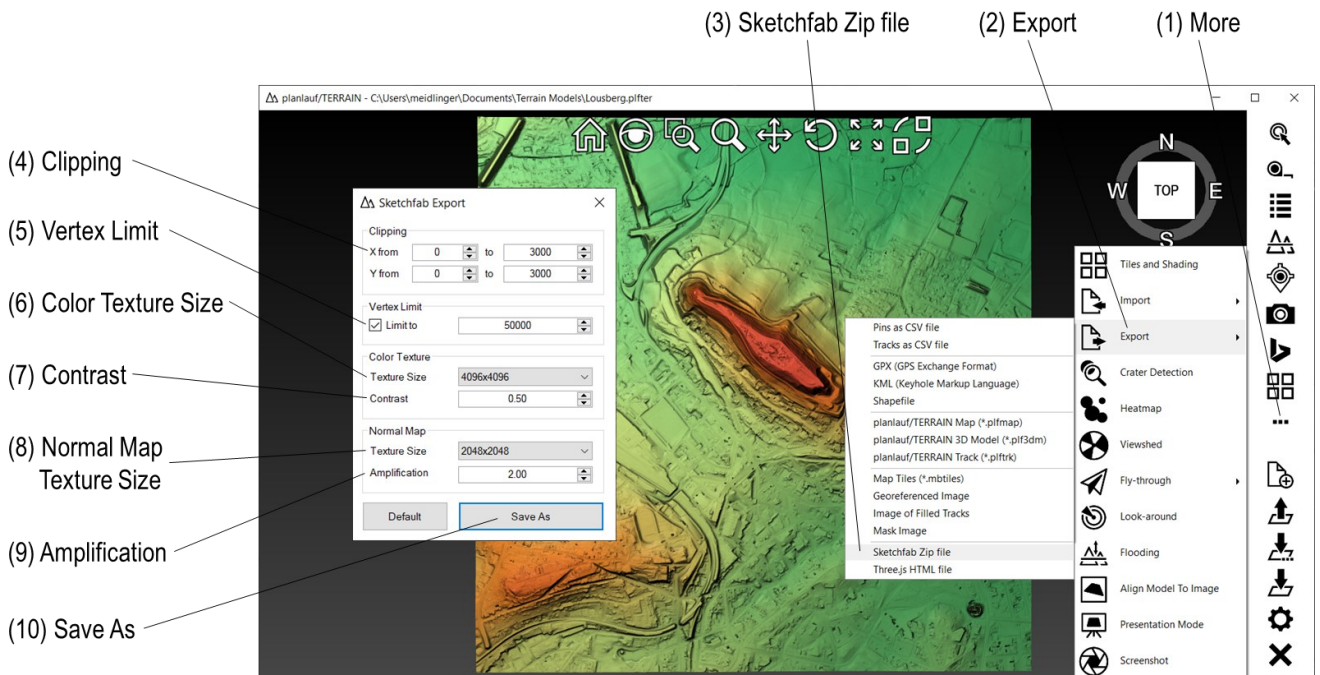
A mask image together with a georeferenced image can be used to highlight areas or points. Click on **More**, **Export** and then on **Mask Image**. Select the resolution and choose if pins and/or tracks should be included in the mask image. The **Alpha Range** defines how transparent the color will be for areas in- and outside of the tracks or around the pins. Click on **Save As** and specify the filename. Follow the steps in the previous section to create a combined image of the mask image and a georeferenced image with the local relief visualization. Please note that you don't need to enter a transparency value in the **Combine Images** dialog because the alpha channel is already included in the PNG file of the mask image. Just make sure that the mask image comes first in the list.





You can export a stand-alone HTML file which uses Three.js to display a 3D model with the original planlauf/TERRAIN shaders. Click on **More**, **Export** and then on **Three.js HTML file**. Clip the model if the file size is too big. You can also export up to 8 pins together with the 3D model. These pins will be displayed as numbers and their name will be shown if you click on them. You can display the 3D model locally or host it on your website.

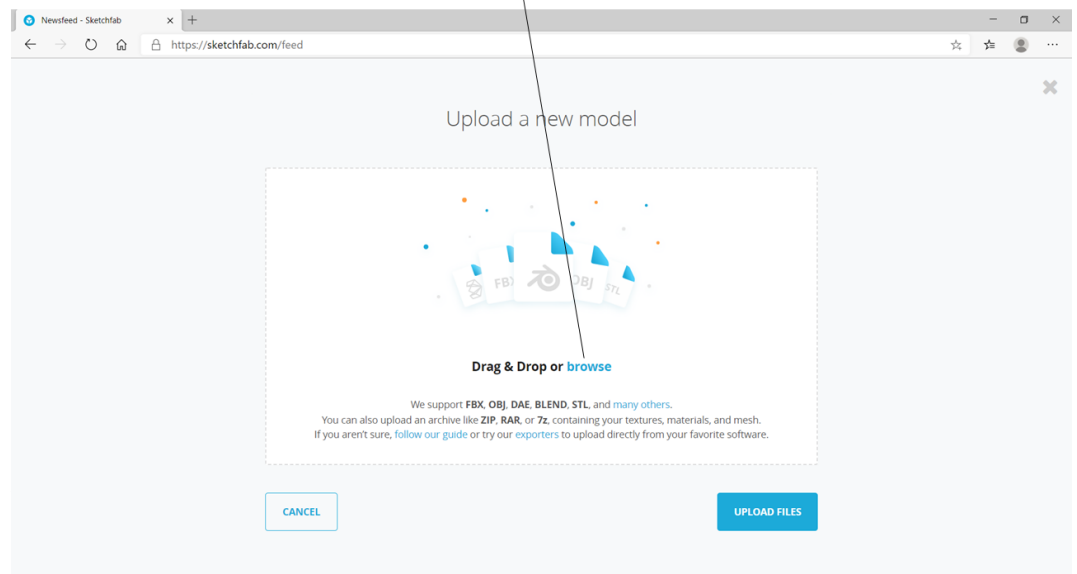




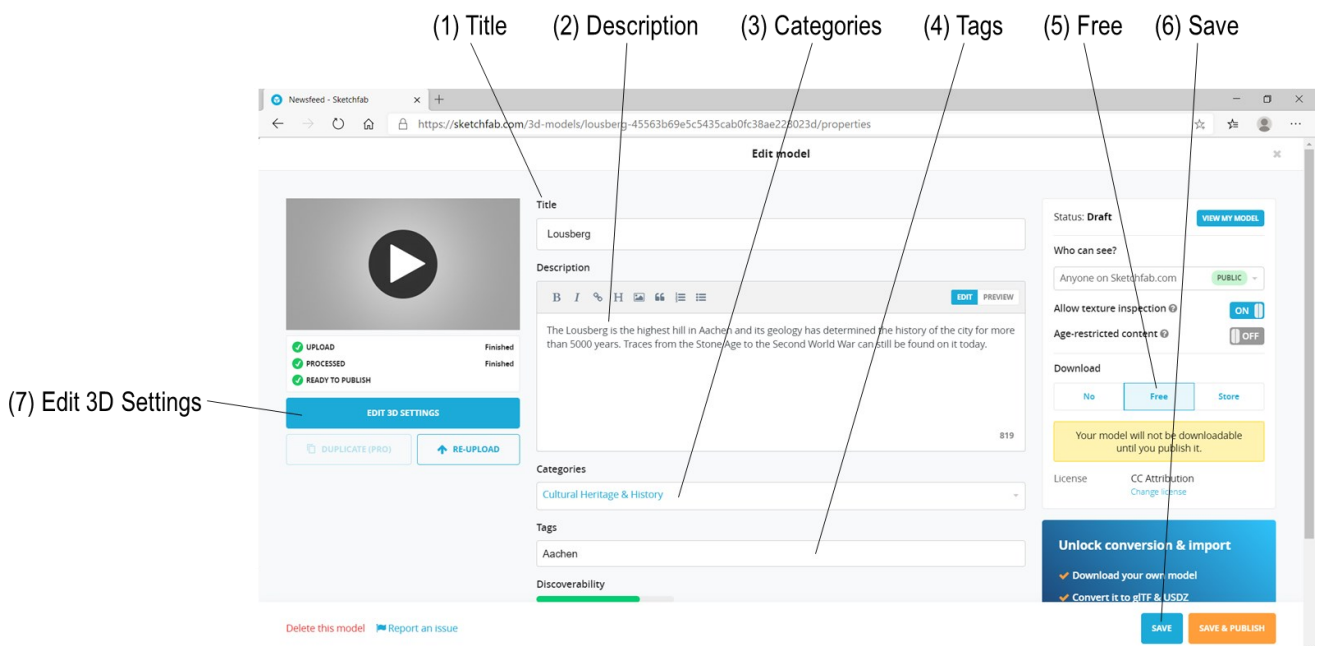
Sketchfab is an internet platform to publish and display 3D models. Click on **More**, **Export** and then on **Sketchfab Zip file** to show the **Sketchfab Export** dialog. planlauf/TERRAIN creates a folder with the necessary files and a zip archive which can be uploaded directly to Sketchfab. The following settings are available:

- **Clipping:** Clip the model with the four values if you don't want to upload the whole planlauf/TERRAIN model to Sketchfab.
- **Vertex Limit:** Rendering performance depends largely on the number of vertices of the model. planlauf/TERRAIN uses very efficient shaders and can display even large models smoothly. While the Sketchfab shaders are very versatile, their performance is lower and a further reduction of the vertex count might be necessary to ensure the Sketchfab model renders smoothly even on mobile platforms. Uncheck the box to export the original model.
- **Color Texture Size:** The color texture is the image of the model in the top view and represents the diffuse texture on Sketchfab. Depending on the currently used shader in **Tiles and Shading** this can be the default height coloring, slope coloring, an image overlay or the local relief. Choose a smaller texture size to reduce the file size and thus the loading time on Sketchfab but please be aware that this affects the quality.
- **Contrast:** Choose a low contrast value like 0.5 if you plan on using the normal map shading in Sketchfab. If you're going to use only a diffuse texture, a high value like 2.0 might look better.
- **Normal Map Texture Size:** The normal map defines how the lighting affects the appearance of the model. Choose a smaller texture size to reduce the file size. You can also choose **None** if you want to use a diffuse texture only.
- **Amplification:** This value amplifies the normals meaning that the lighting will be calculated as if the terrain was steeper.
- **Save As:** Click on Save As to decimate and export the model. Specify the file and folder name and click on **OK**.

(1) Browse and select the Sketchfab Zip file



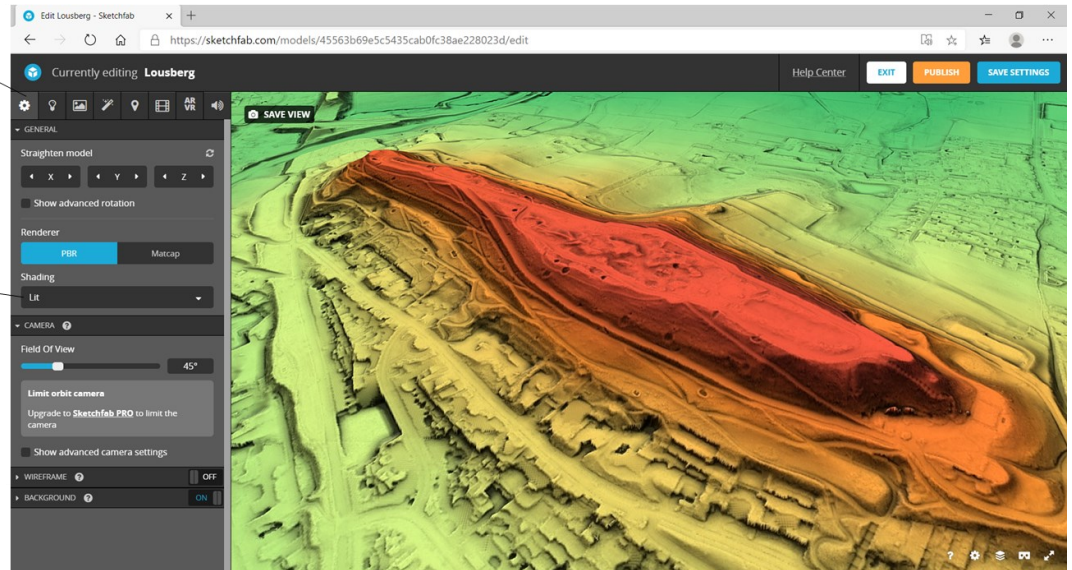
Go to **sketchfab.com** and click on **Upload** and then on **Browse**. Select the created **zip file** and click on **Open**. Click on **Upload Files** in the appearing **Upload a new Model** window to start the upload.



You might enter the model title and the description while uploading and processing as well as define some categories and tags to enhance the discoverability. Select **Free** as the download option and click on **Save** and then on **Edit 3D Settings** as soon as the processing is finished.

(1) Properties

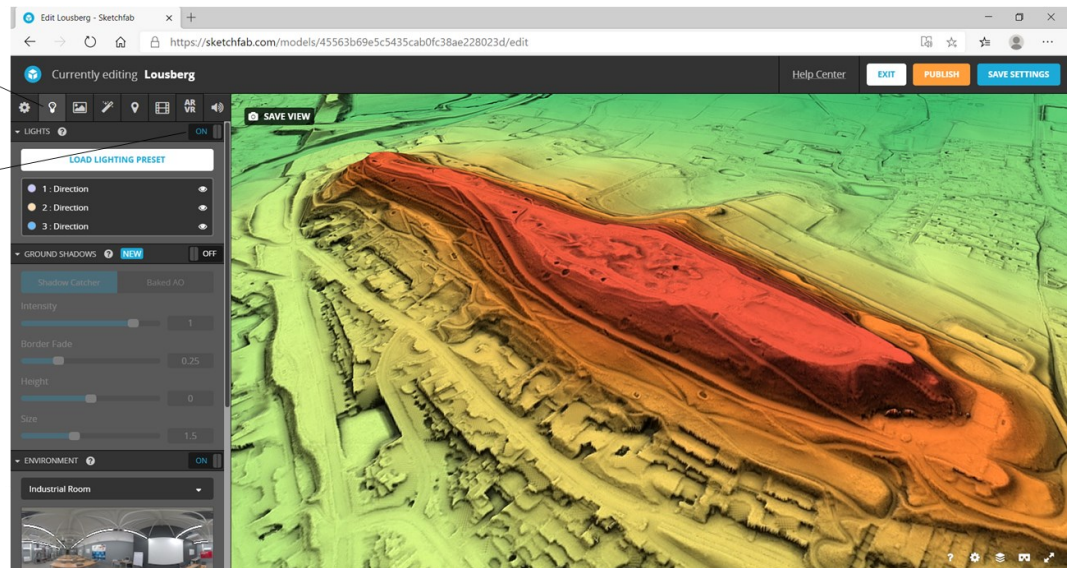
(2) Shading: Lit



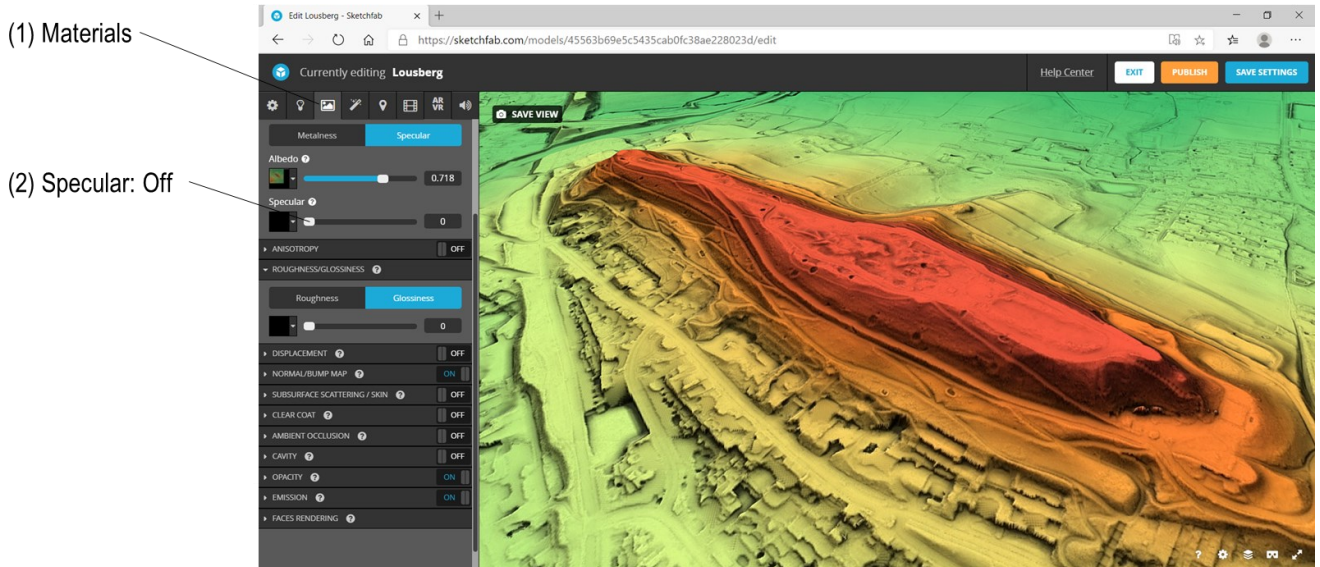
The Sketchfab workflow follows the menu bar from left to right. Choose the first tab **Properties** and set the **Shading** to **Lit**.

(1) Lighting

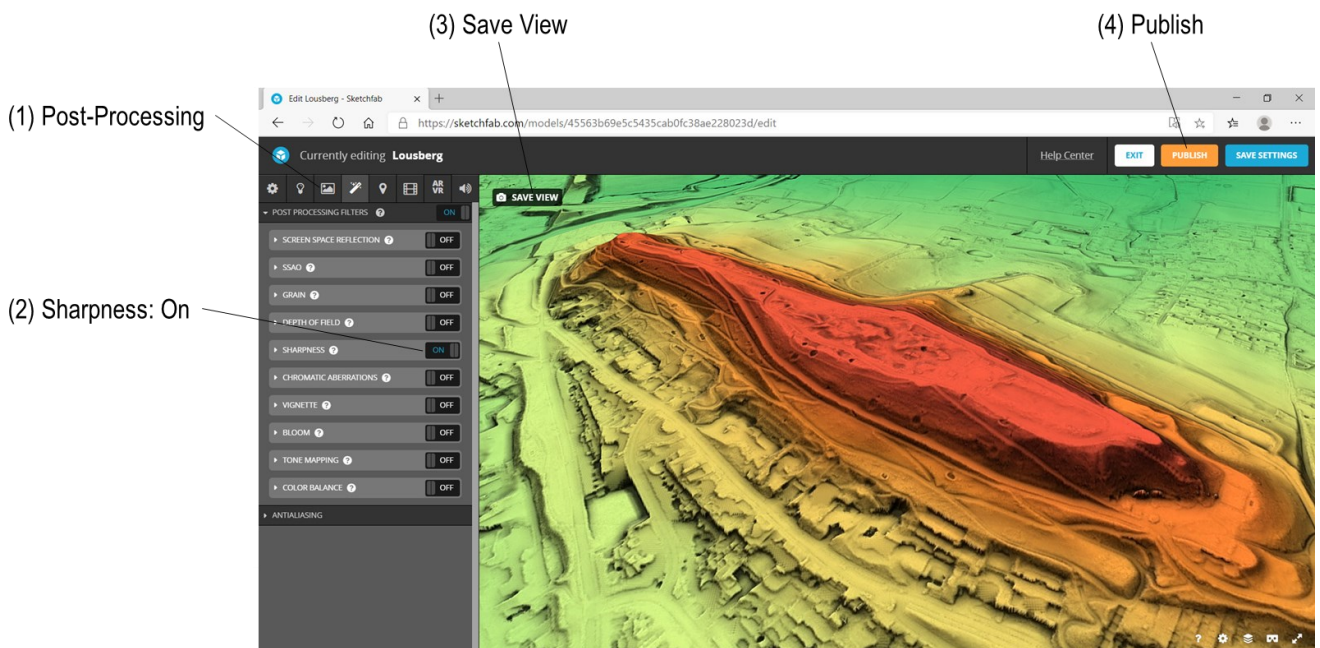
(2) Lights: On



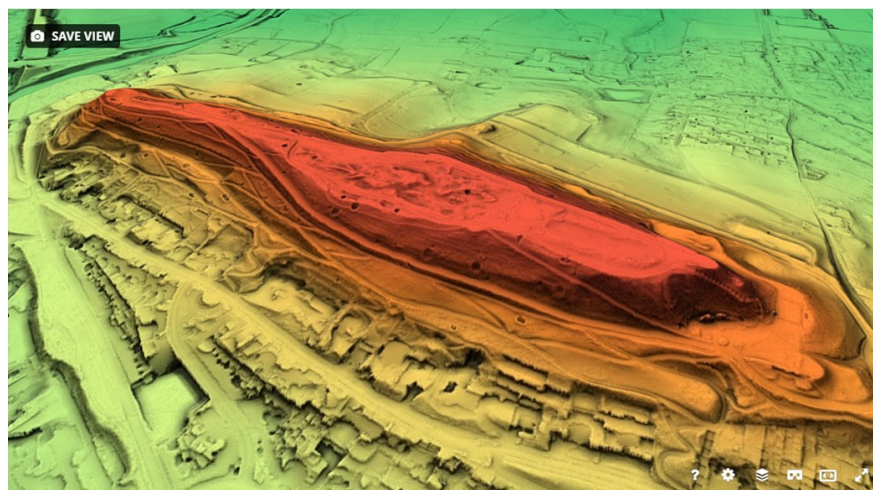
Choose the **Lighting** tab and switch the **Lights On**.

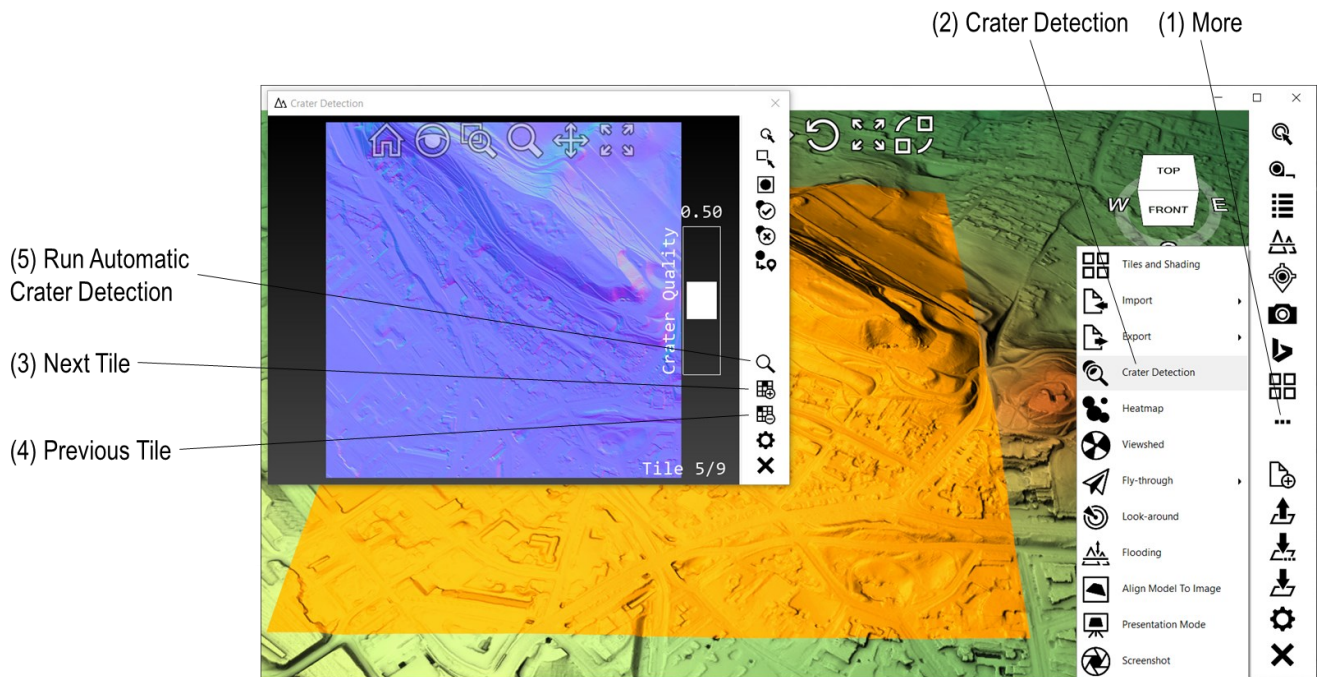


Choose the **Materials** tab and switch **Specular** off.

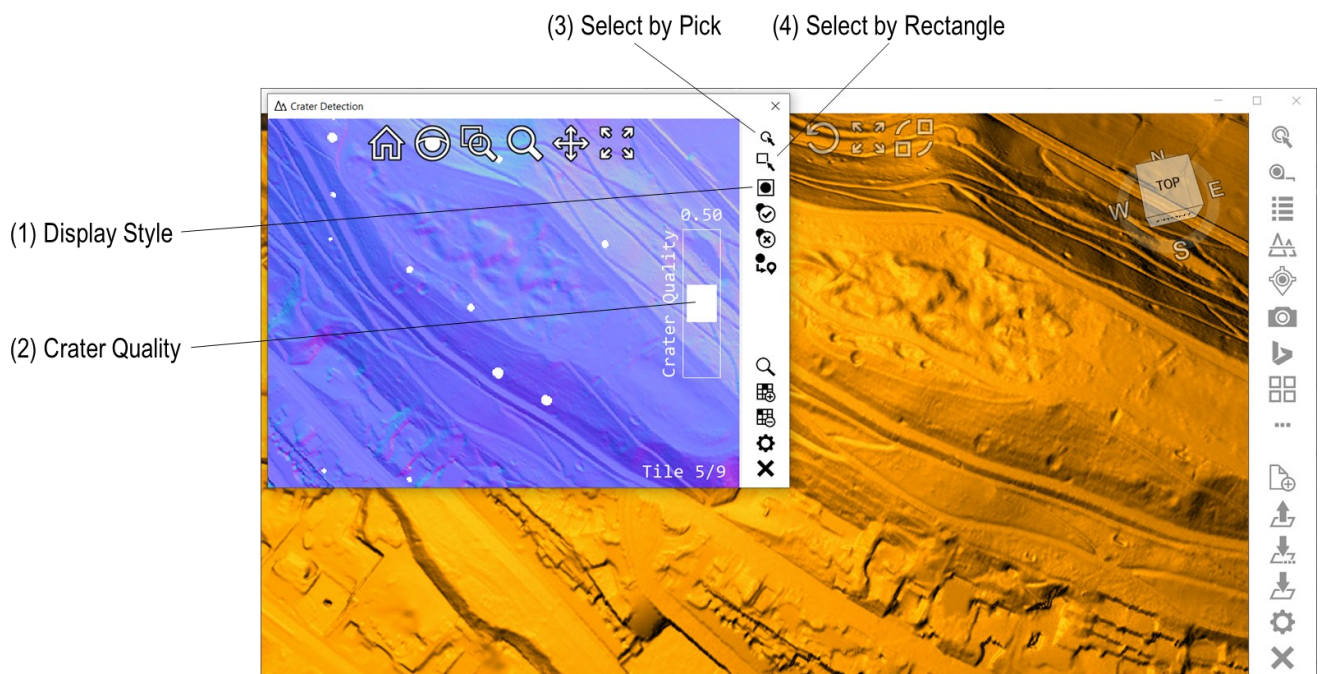


Choose the **Post Processing** tab and turn **Sharpness** on. Finally, click on **Save View** to define the initial view, **save the settings** and **publish** the model. A window appears with an embed link that you can use to share your model on Twitter or Facebook.



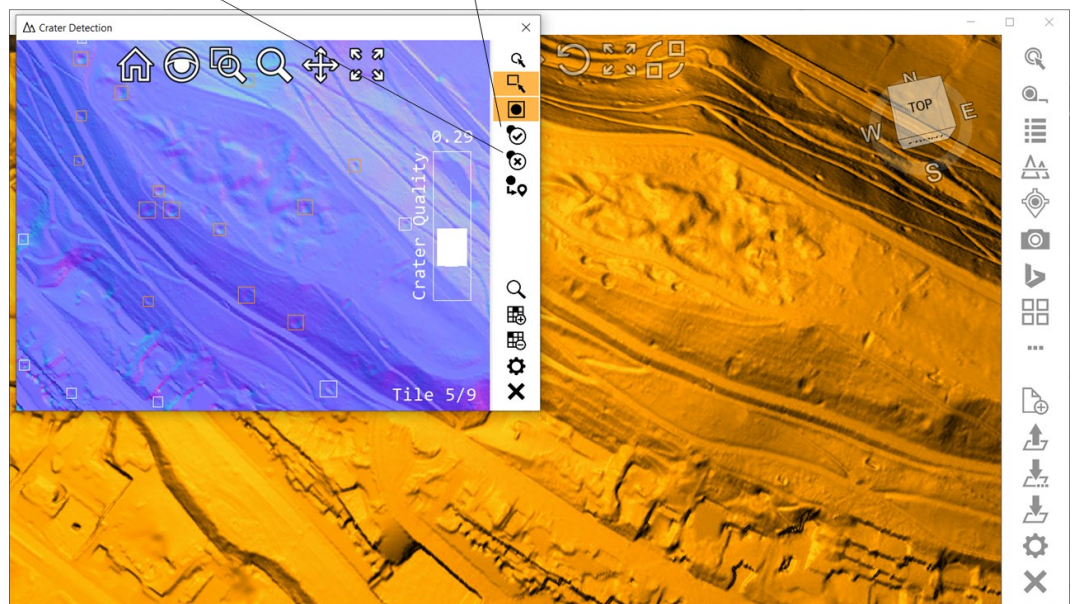


Crater Detection is a feature for conflict archaeologists to automatically detect bomb craters in digital terrain models. Click on **More** in the menu bar and then on **Crater Detection** to show the window. planlauf/TERRAIN uses the normal maps for the detection algorithm. Click on **Next Tile** and **Previous Tile** in the lower menu to get to the area of interest. The selected tile will be highlighted in the viewport and the normal map will be shown in the window. Click on **Run Automatic Crater Detection** to start the detection process.



The potential bomb craters are highlighted with white blobs in the normal map. If you want to take a closer look at their shape you can change the **Display Style** to an unfilled rectangle. Adjust the **Crater Quality** to show only craters above this quality threshold. Select the craters that should be marked in the model either by **Pick** or by **Rectangle**.

(2) Reject Selected Craters (1) Accept Selected Craters

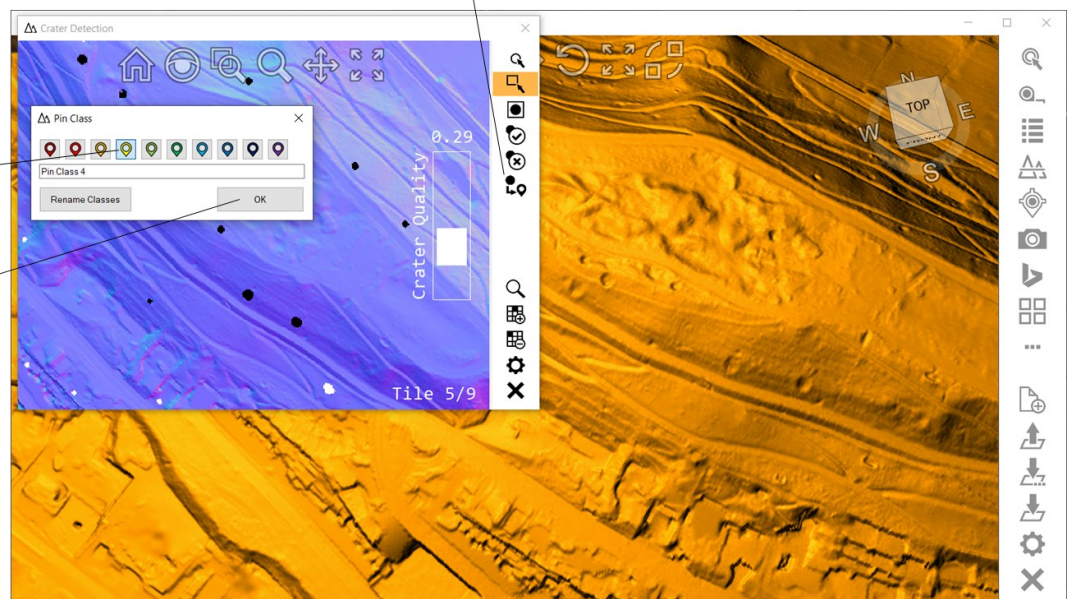


Add the selected craters to the list of craters that should be marked and click on **Accept Selected Craters**. The blobs will then be shown in black. If you want to remove the selected blobs from the list, you can click on **Reject Selected Craters**. You can also press the **Space** key to toggle the state of the selected blobs. Click on the highlighted selection button to end the picking mode.

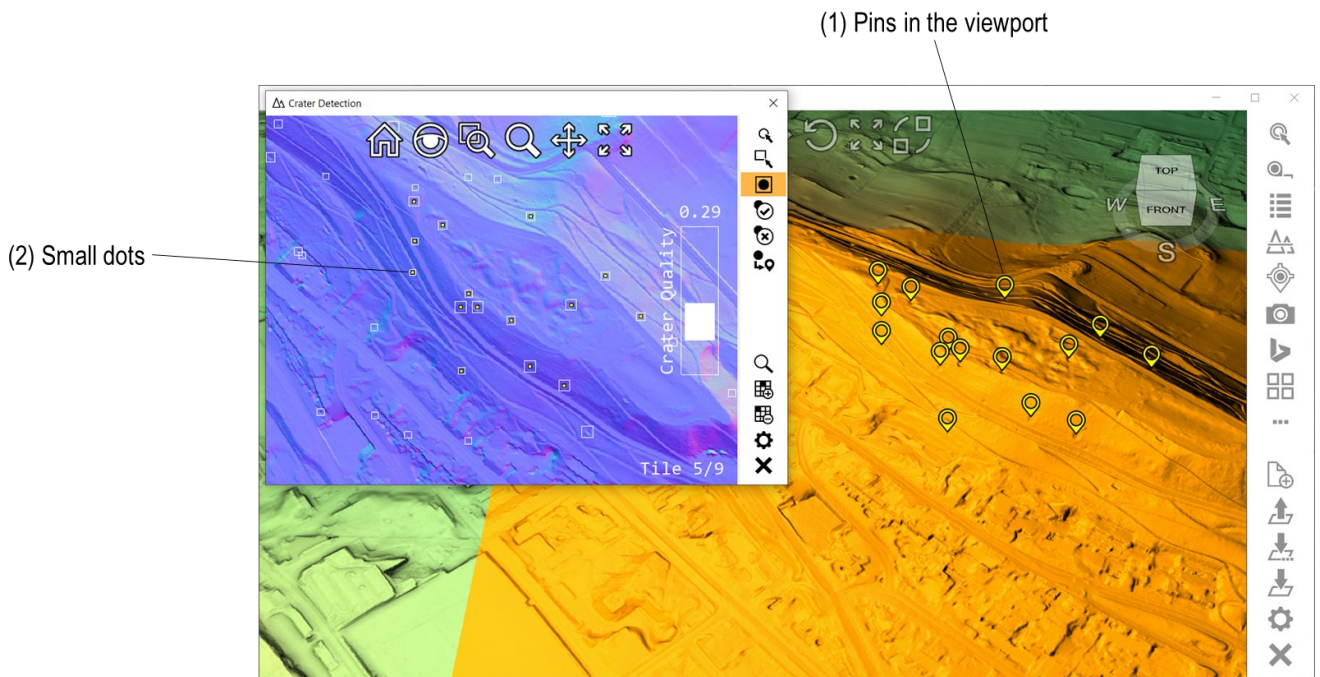
(1) Convert Selected Craters to Pins

(2) Select Class

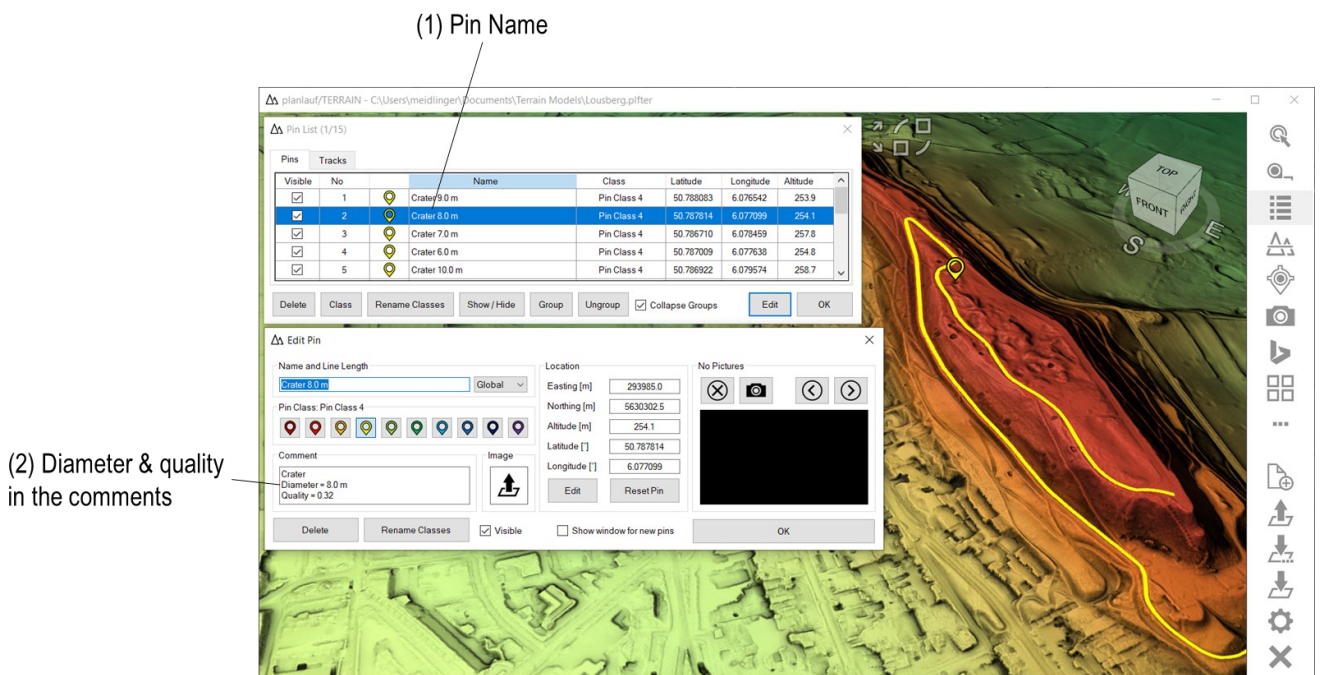
(3) OK



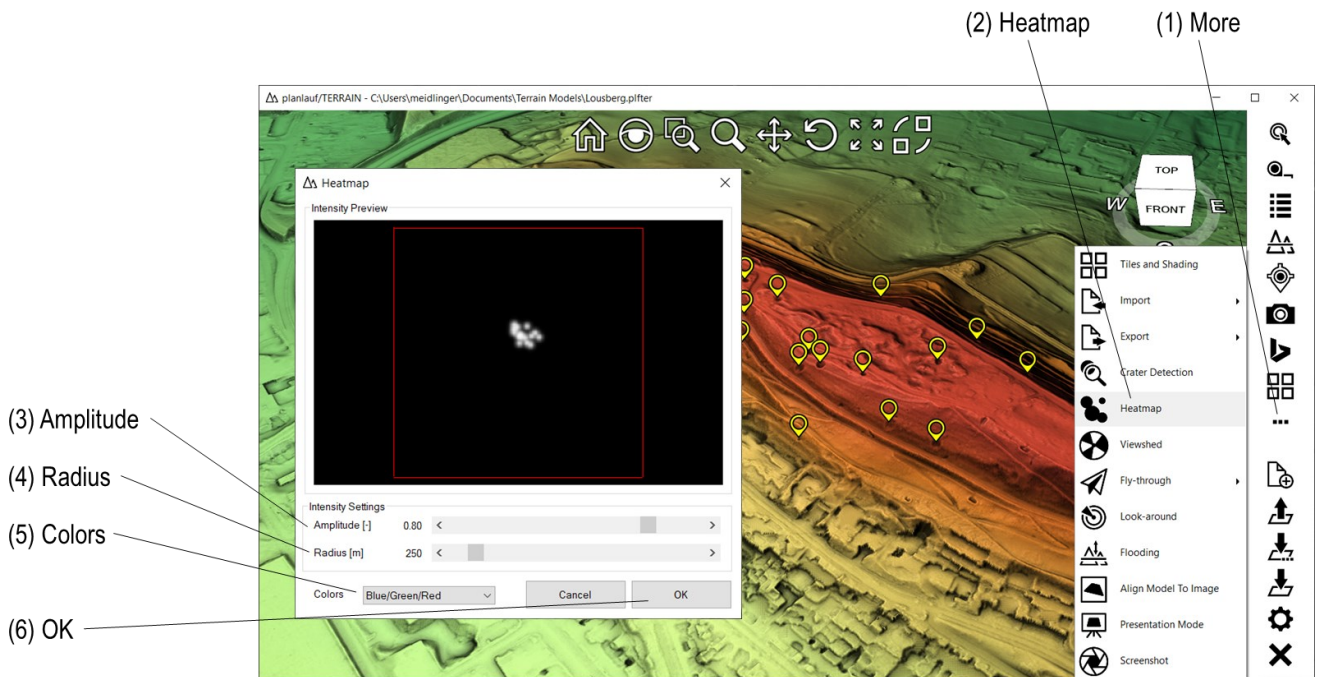
Click on **Convert Selected Craters to Pins**, select a class in the appearing dialog and click on **OK**.



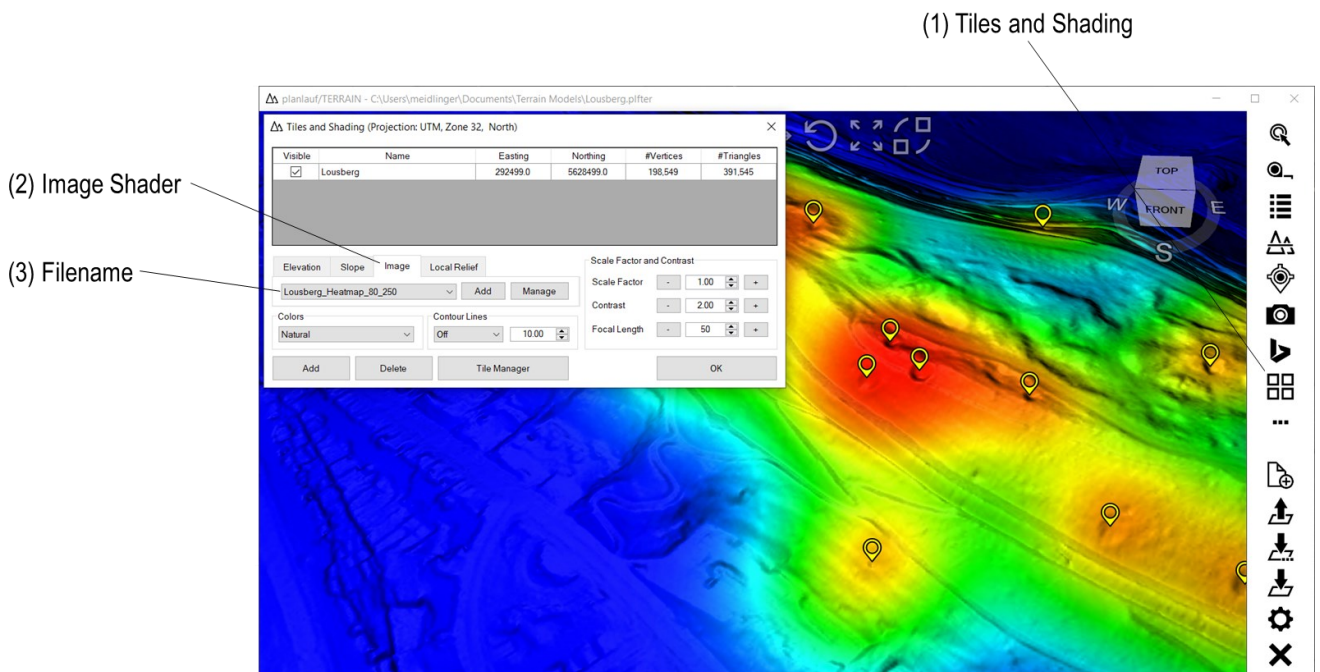
The created pins are immediately shown in the viewport. Additionally, they are shown in the **Crater Detection** window as small dots. You can continue the selection of craters either within the current or the next tile until you have covered the complete area of interest.



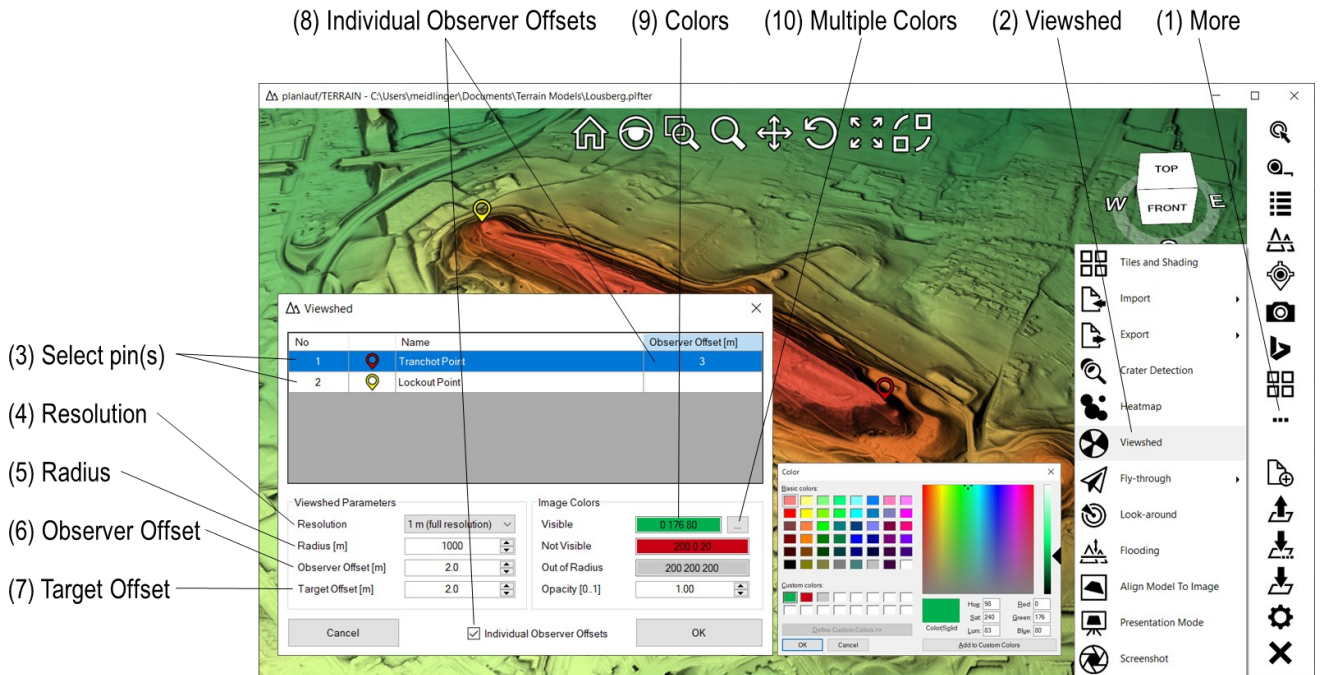
Automatically detected craters are named and the values for diameter and quality are stored in the comments.



A heatmap represents pins with a radius and a color gradient. Click on **More** in the menu bar and then on **Heatmap** to show the window. The **Amplitude** value increases the color intensity and the **Radius** defines the maximum area in which the colors are applied. Choose a color scale from the **Colors** list and click on **OK** to start the heatmap generation. Specify the **filename**, the **file format** (PNG, BMP or JPG) in the filter and click on **Save**.



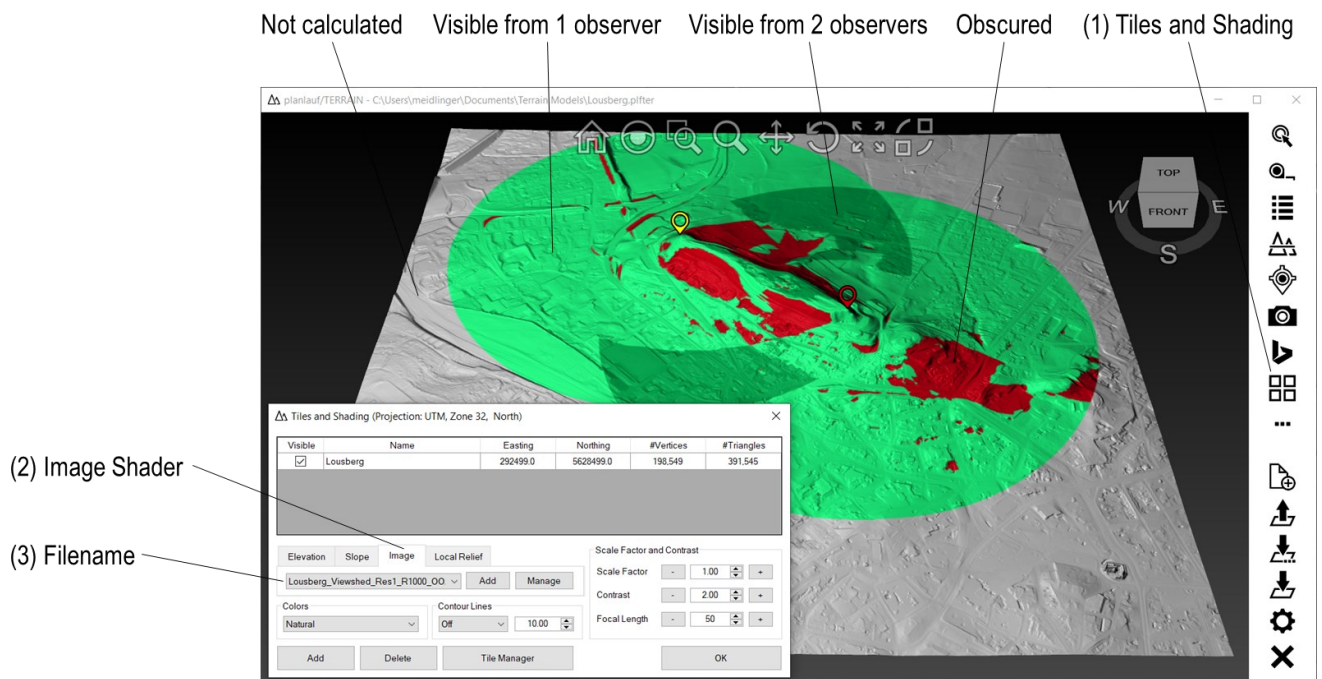
The created heatmap image is automatically assigned to the model and the **Image Shader** is set. You can check these settings by clicking on **Tiles and Shading**. Click on **Elevation** to switch back to the height coloring.



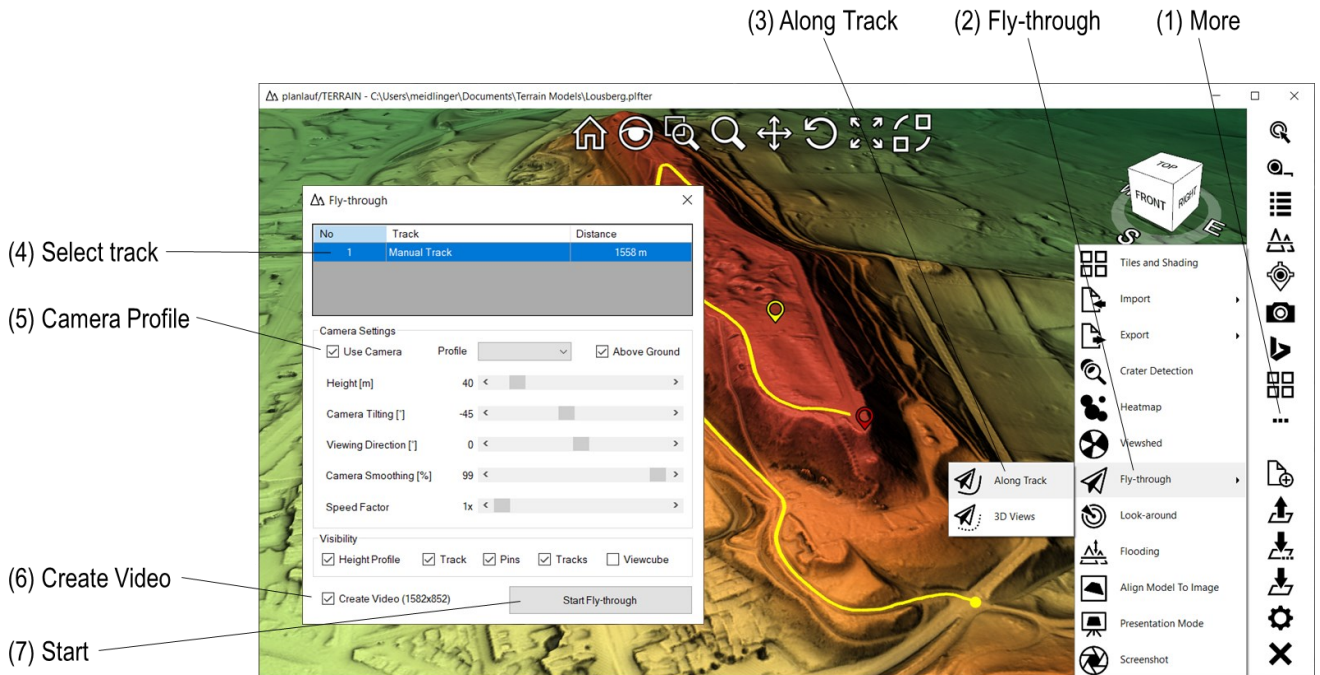
A viewshed is the area that is visible from one or more locations. Click on **More** and then on **Viewshed** to show the window. The following settings are available:

- **Pin list:** Select one or more pins to serve as observers.
- **Resolution:** Calculating a viewshed takes some time. Choose a lower resolution for a faster calculation but please be aware that the results won't be accurate.
- **Radius:** The radius limits the area that is tested around each pin for visibility.
- **Observer Offset:** A typical observer is not at ground level but on a certain height.
- **Target Offset:** Use this value to set the offset for visible target points.
- **Individual Observer Offsets:** Check this box to use individual observer offsets for the pins. Enter the individual offsets in the pin list. For empty cells, the global observer offset is used.
- **Colors:** Choose a color for visible points, obscured points and points that have not been tested. The opacity value is used for the image overlay settings in **Tiles and Shading**.
- **Multiple Colors:** If you have selected multiple observers, you can use different colors for points that are visible from one, two, three ... observers.

Click on **OK** to show the **Save** dialog. Specify the **filename**, the **file format** (PNG, BMP or JPG) in the filter and click on **Save** to create the viewshed.

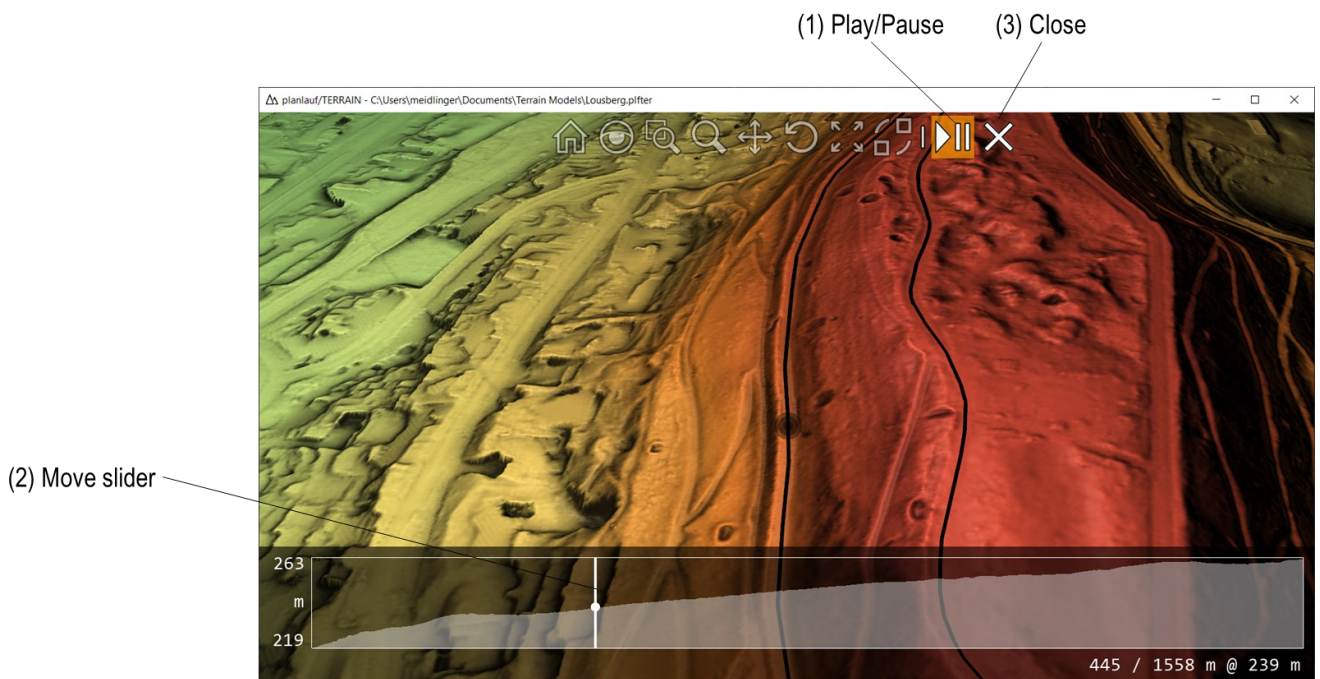


The created viewshed image is automatically assigned to the model and the **Image shader** is set. You can check these settings by clicking on **Tiles and Shading**. Click on **Elevation** to switch back to the height coloring.

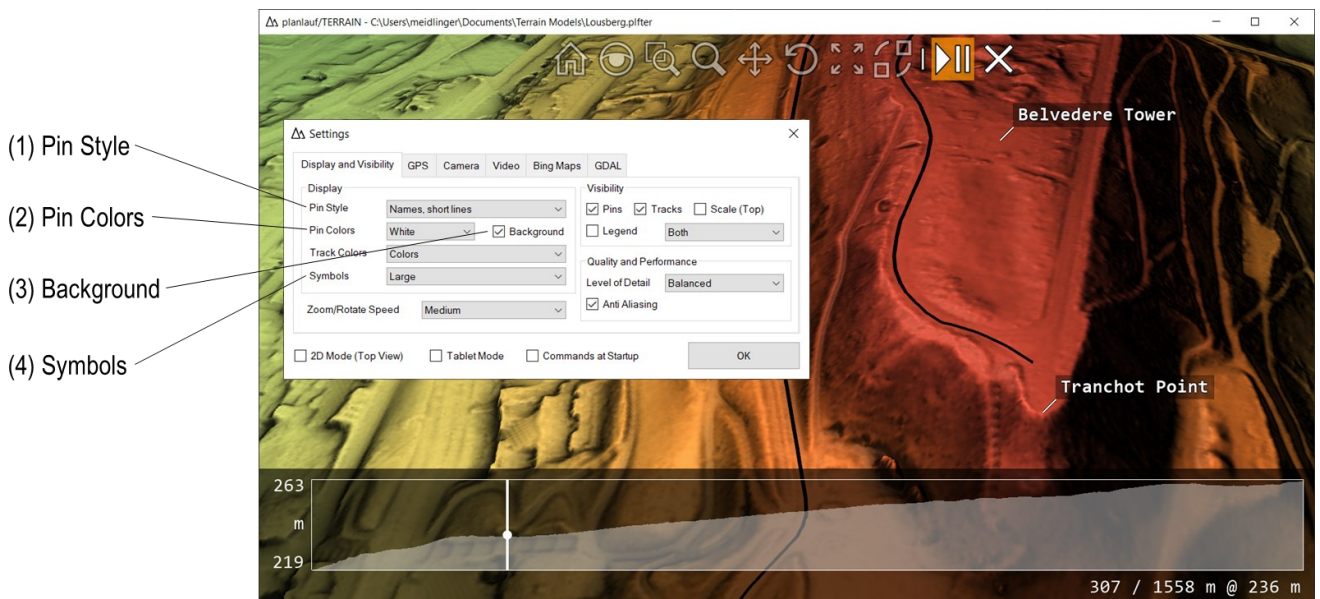


A Fly-through (Along Track) is a flight along an existing track with adjustable parameters like height above ground and viewing direction. Click on **More** and then on **Fly-through** and **Along Track** to show the window and select a track. The following settings are available:

- **Camera Profile:** Low, medium and high level profiles set appropriate values for height and tilting depending on the min and max height of the model.
- **Height:** Defines at which altitude or at which height above the ground (with the **Above Ground** option checked) the camera is placed.
- **Camera Tilting:** 0° is a horizontal view, -90° is a vertical view.
- **Viewing Direction:** -90° is a view to the left, +90° is a view to the right.
- **Camera Smoothing:** The camera follows the track very closely with a low **Camera Smoothing** value. A higher value will smooth out the path and avoid sudden changes of direction.
- **Speed Factor:** Speeds up the fly-through.
- **Visibility:** Shows or hides the height profile of the track and/or the track itself during the fly-through. Pins, tracks and the viewcube can also be shown or hidden.
- **Create Video:** If this option is checked and FFmpeg is set up (please see **Settings** section), a video will be recorded. You will be prompted to define a filename and the video format. Click on the filter to choose between the video formats AVI (e.g., for YouTube) and MP4 (e.g., for Twitter).

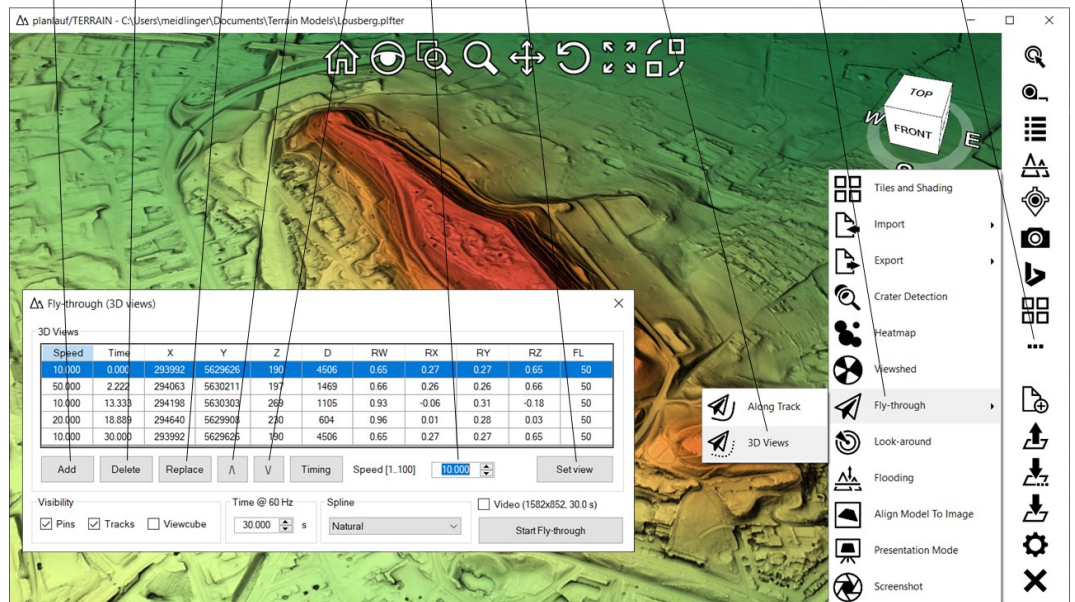


Click on **Play/Pause** or press the **Space** key during the fly-through to start or stop the flight. You can move the **slider** in the height profile to any point along the track. Press the **plus key** (**minus key**) to increase (decrease) the speed factor. Click on **Close** or press the **Escape** key to end the fly-through. If you create a video and selected the MP4 video format, the video will be converted after the fly-through and a FFmpeg command line window appears.



You can display the pins as text labels. Click on **Settings** in the lower menu bar and choose 'Names, short lines' as the **Pin Style**, White in the **Colors** list and check the **Background** option to get the result in the example above. Changing the **Symbols** size will also change the size of the text labels.

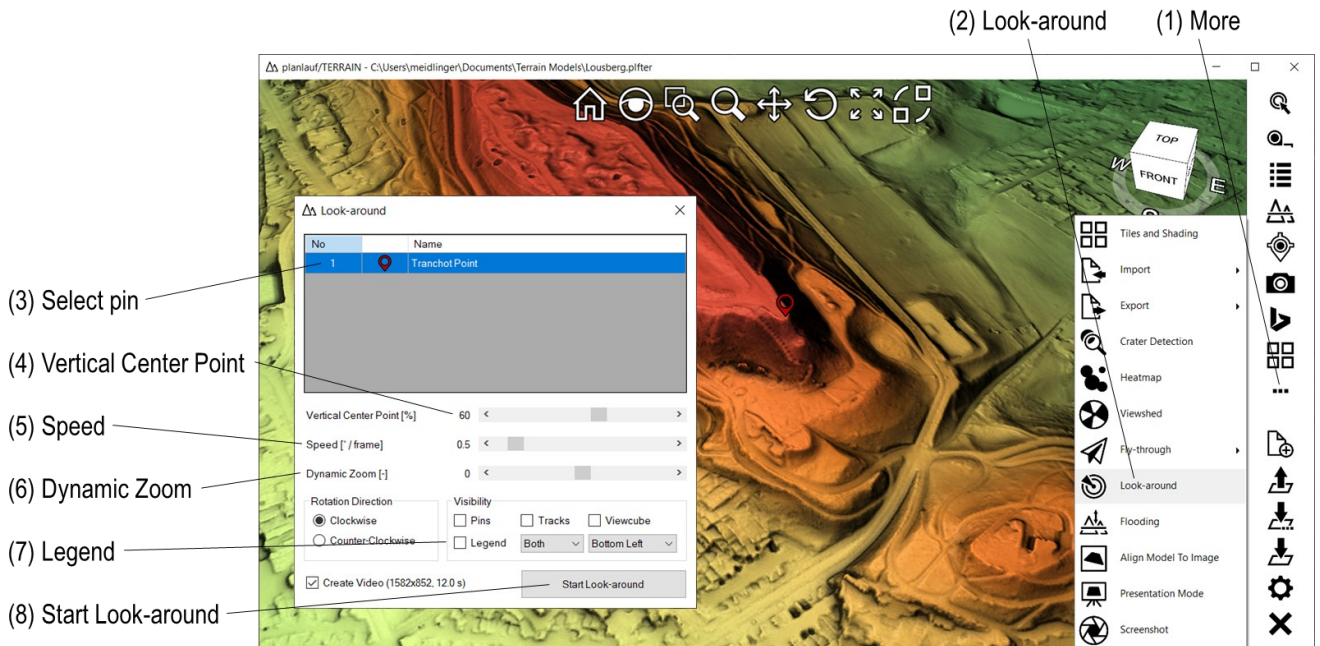
(4) Add Delete Replace Up Down Speed Set View (3) 3D Views (2) Fly-through (1) More



A Fly-through (3D Views) is a flight between user-defined views where the transitions between the views are based on splines to ensure a smooth motion. Click on **More** and then on **Fly-through** and **3D Views** to show the window with the parameters of the views.

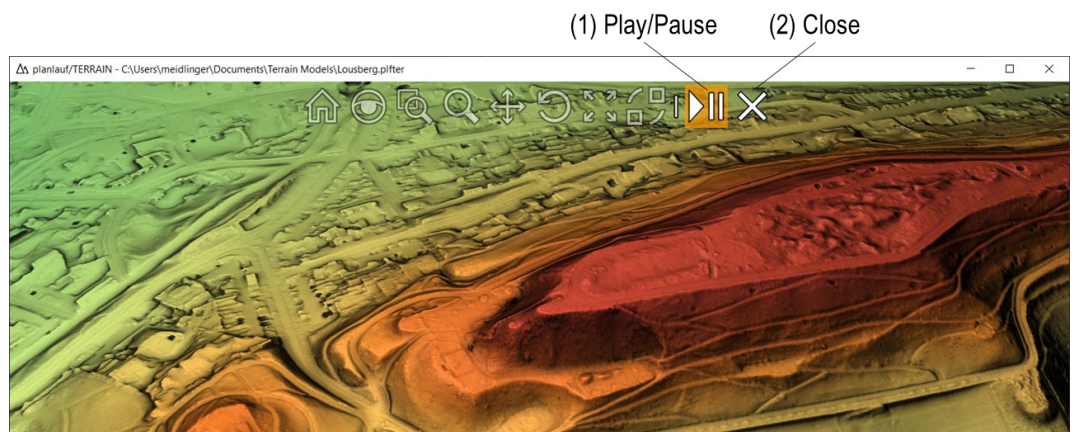
Zoom, pan and rotate the model in the viewport and click on **Add** to add this view to the list. Notice that the view is added after the currently highlighted row. Click on **Delete** to delete the highlighted row and on **Replace** to overwrite it with the current model view. The **Up** and **Down** buttons change the order of the highlighted view in the list. The **Speed** parameter can be defined for each view and controls how fast the transition to this view is. The default value is 10, 1 is a very slow and 100 a very fast transition. Click on **Set View** to restore the highlighted view in the viewport. You can also **double-click on a row** to restore its view. The following settings are available:

- **Visibility:** Shows or hides pins, tracks and the viewcube during the fly-through.
- **Time @ 60 Hz:** Defines the duration of the fly-through when using 60 frames per second.
- **Spline:** There are four spline options available. The **Natural** spline produces the smoothest motion but it might sometimes overshoot the desired view. The **Hermite** splines reduce the overshooting. Choose the **Hermite Tangents 0%** option to avoid any overshooting and stop briefly at each view.
- **Create Video:** If this option is checked and FFmpeg is set up (please see **Settings** section), a video will be recorded. You will be prompted to define a filename and the video format. Click on the filter to choose between the video formats AVI (e.g., for YouTube) and MP4 (e.g., for Twitter).

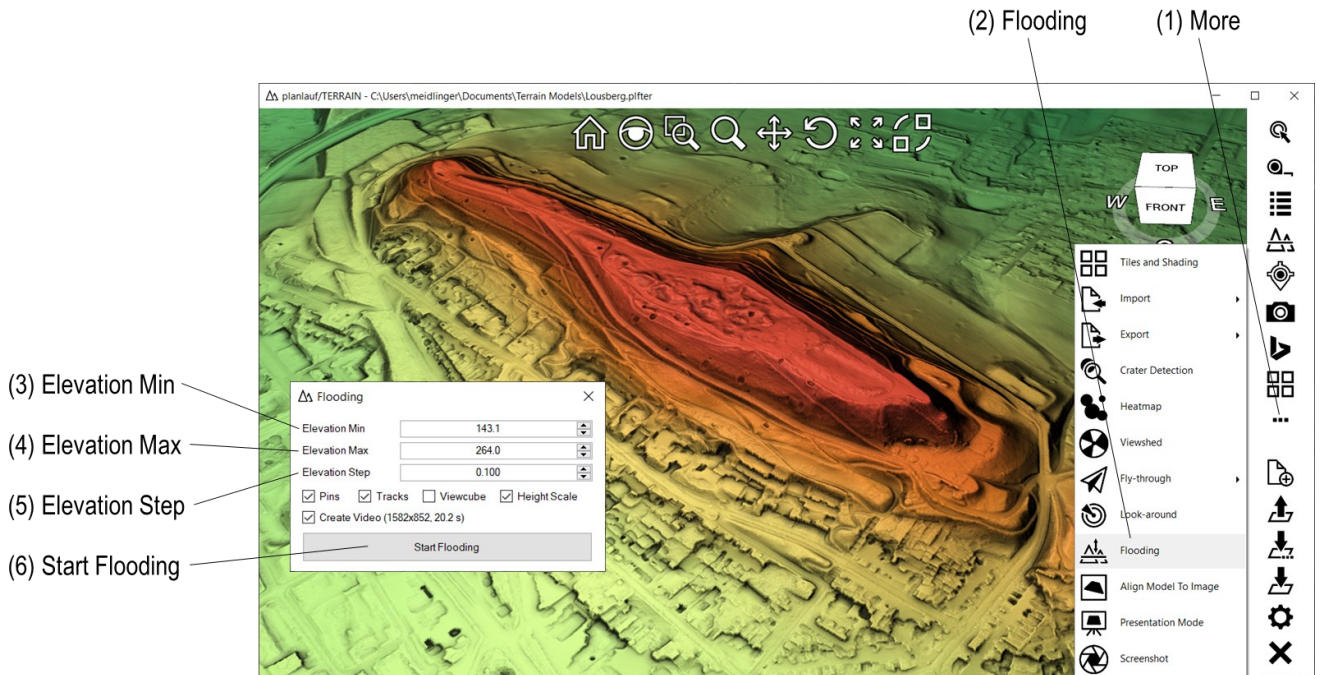


A Look-around is a rotation of the model around a pin at the current zoom and rotate values. Click on **More** and then on **Look-around** and select a pin. The following settings are available:

- **Vertical Center Point:** Moves the model up or down to adjust the location of the pin. This option can be used to adjust the view for different types of terrain like plains, hills and mountains.
- **Speed:** This value defines the speed of the rotation.
- **Dynamic Zoom:** A negative value zooms in at the beginning of the look-around and out towards the end. With a positive value, it's vice versa. This option helps to show an overview and some details of the model. You should always start with negative values close to zero to avoid zooming in too much and right through the model.
- **Visibility:** Shows or hides the pins, tracks, the viewcube and the legend during the look-around.
- **Legend:** Check this option if you want to display the legend with the pin and track classes.
- **Rotation Direction:** Choose either clockwise or counter-clockwise direction.
- **Create Video:** If this option is checked and FFmpeg is set up (please see **Settings** section), a video will be recorded. You will be prompted to define a filename and the video format. Click on the filter to choose between the video formats AVI (e.g., for YouTube) and MP4 (e.g., for Twitter).

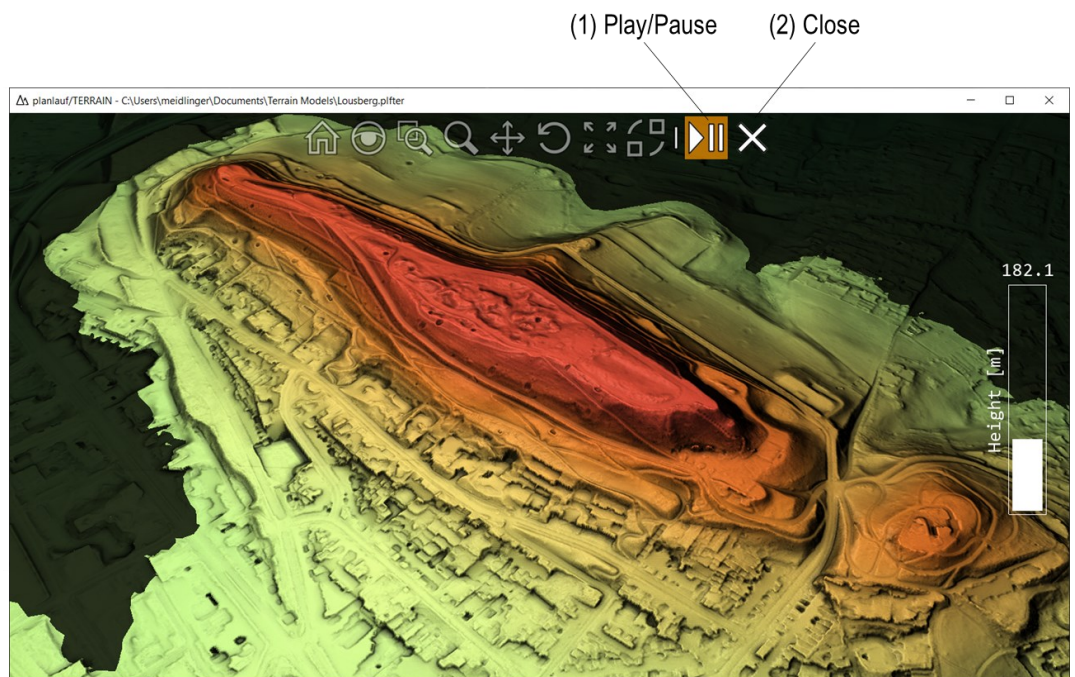


Click on **Play/Pause** or press the **Space** key during the look-around to start or stop the rotation. Click on **Close** or press the **Escape** key to end it.

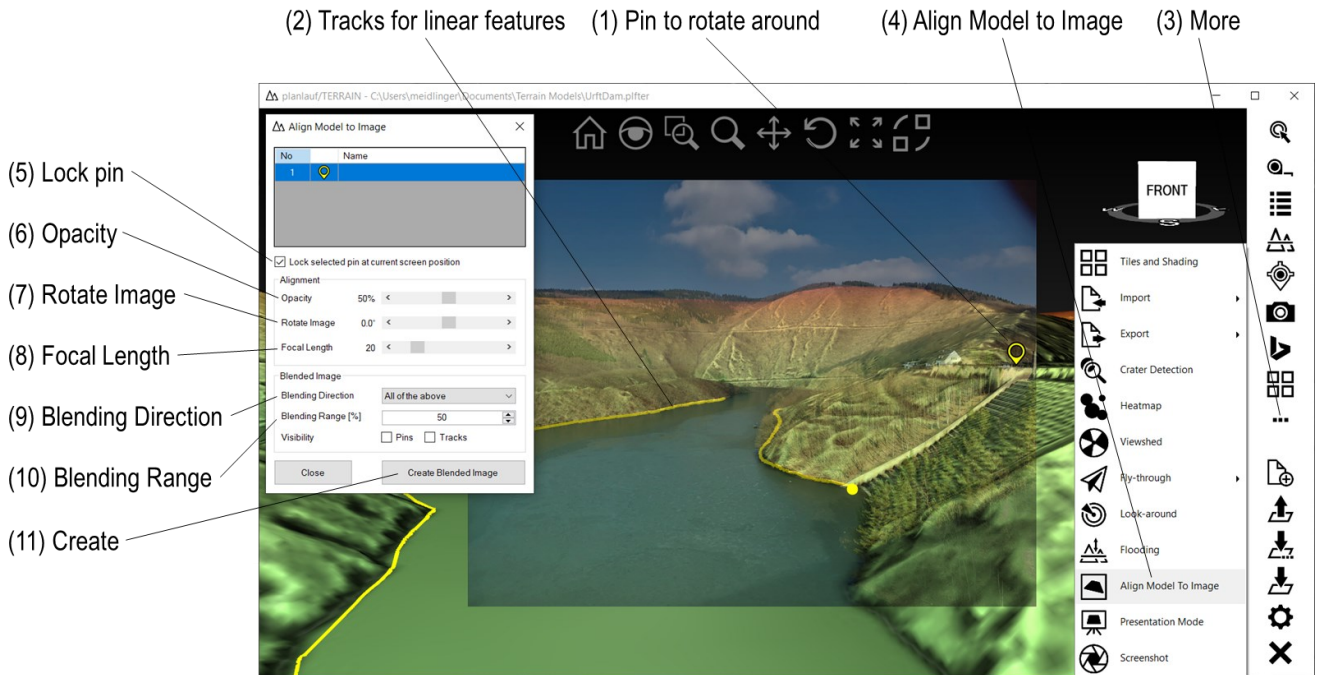


The Flooding feature moves the section plane between the min and max elevation values. Click on **More** and then on **Flooding**. The following settings are available:

- **Elevation Min/Max:** The animation runs between those two values. Adjusting one of the values automatically updates the viewport.
- **Elevation step:** This value defines the speed of the animation.
- **Pins / Tracks:** Shows or hides the pins and tracks in the model during animation.
- **Height Scale:** Check this option to display the height scale during the animation.
- **Create Video:** If this option is checked and FFmpeg is set up (please see **Settings** section), a video will be recorded. You will be prompted to define a filename and the video format. Click on the filter to choose between the video formats AVI (e.g. for YouTube) and MP4 (e.g. for Twitter).



Click on **Play/Pause** or press the **Space** key during the flooding to start or stop the animation. Click on **Close** or press the **Escape** key to end it.



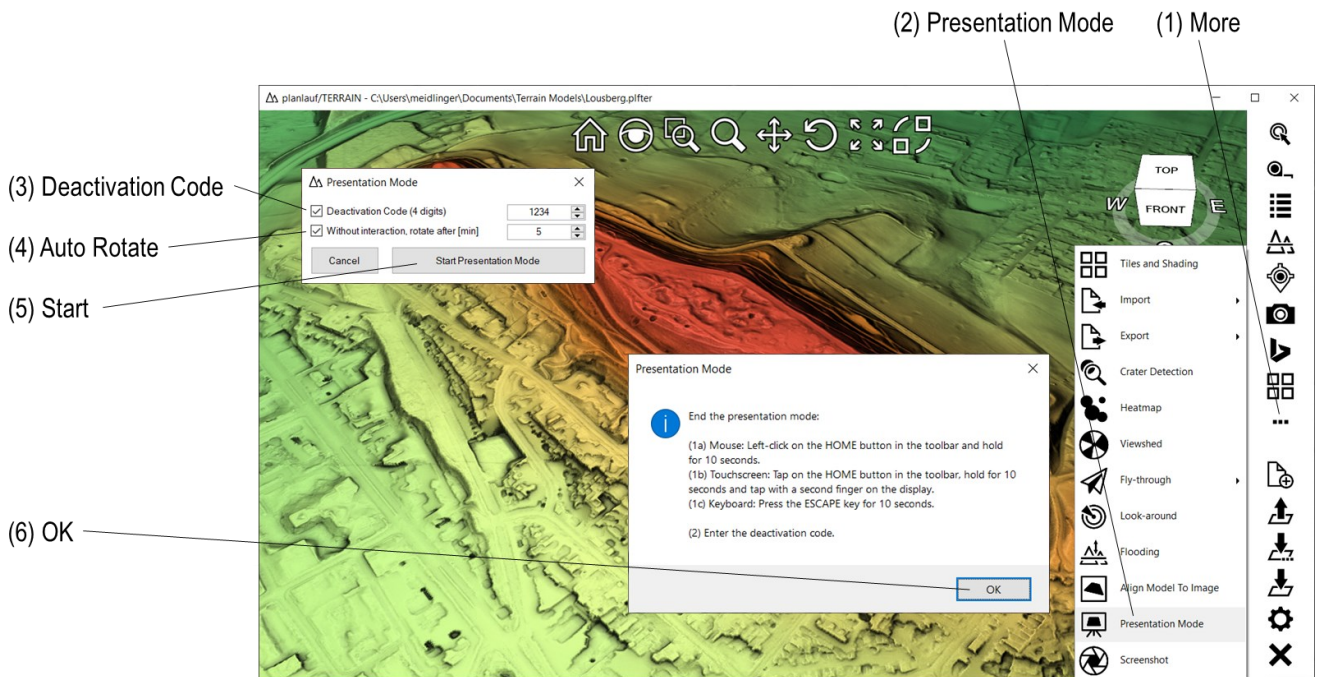
This feature enables you to create blends between digital terrain or surface models and aerial images. First, create a pin and one or more tracks for linear features that are visible both in the model and in the aerial image. Click on **More** and then on **Align Model to Image** and choose the aerial image. This image will be drawn as an overlay in the viewport and you can adjust the **Opacity** with the slider in the dialog. Pan the model until the pin is at the location of the pivot point in the image and check the box in the dialog to **Lock** the model at this location.

To get a good match it is important to know the **Focal Length** of the camera the image was taken with. If you don't know the exact value, you'll have to experiment with it and try to get the ratio between width and height of the linear features right. For images taken with drones or some mobile phones, a focal length of 20 might be a good start.

After setting up the focal length, you can rotate and zoom until the linear features align with the image. This is an iterative process that gets easier the more practice you have. If the image was not taken horizontally, you might **Rotate** the image with the slider.

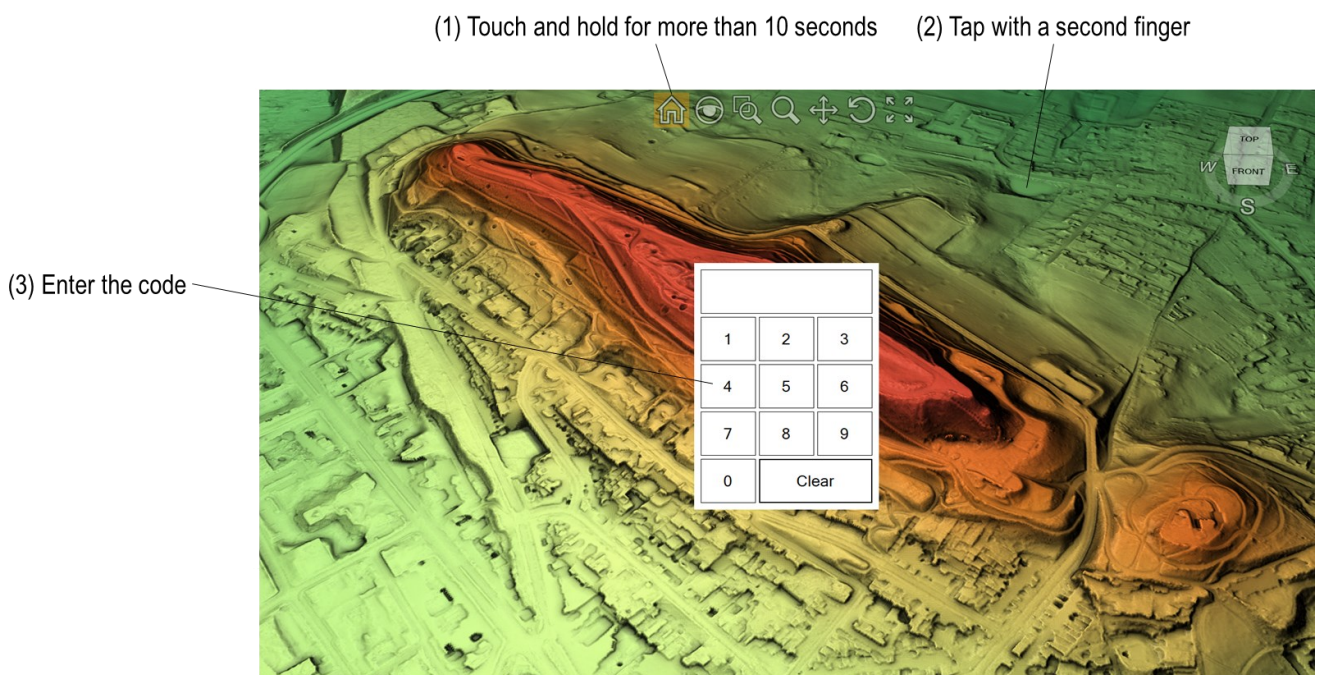
Choose one of the **Blending Directions**. Top – Bottom means that the resulting image will have the aerial image at the top and the model at the bottom. The **Blending Range** determines in which percentage of the image size the blending will be done. A value of 0 will give a sharp edge while a value of 100 will blend the two images over the complete size.

Click on **Create Blended Image** to save the result and choose one of the available image formats. If you want to create additional blends at a later moment, you can save the current view with the button in the toolbar.

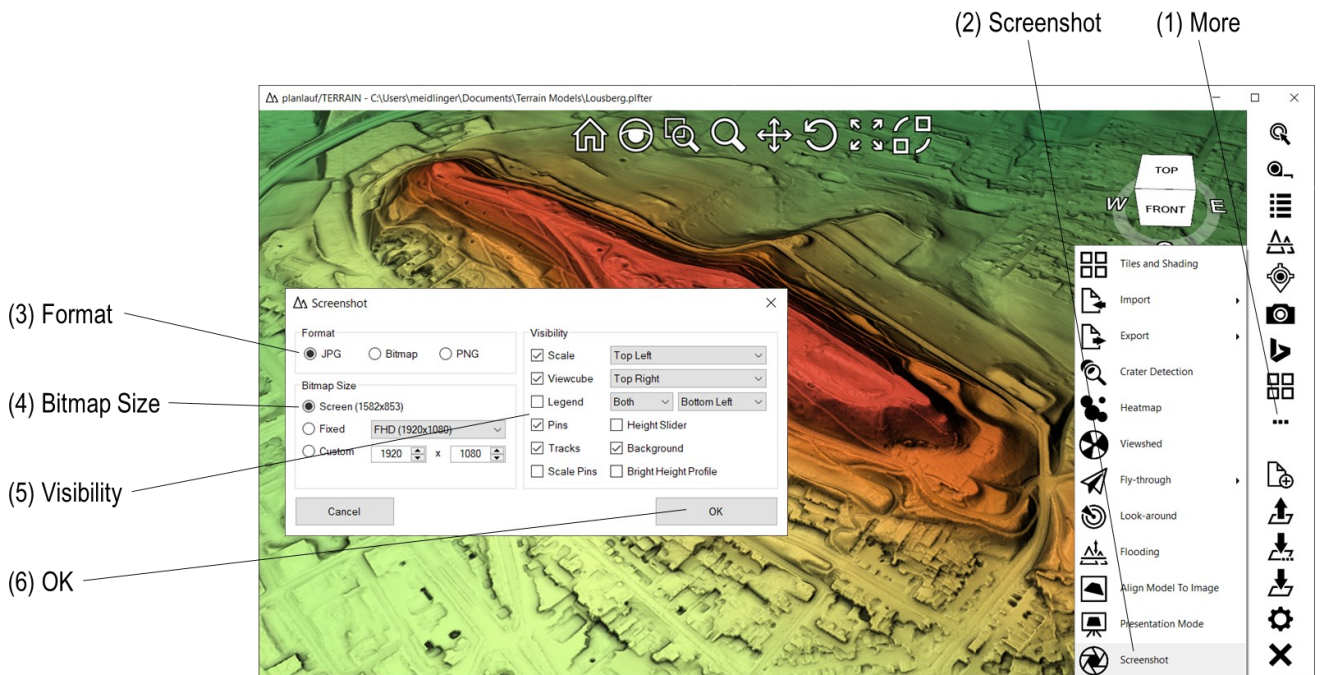


The **Presentation Mode** displays the model in fullscreen mode and hides the Windows taskbar and all buttons except for the toolbar. This feature is useful if you want to present a digital elevation model on a tablet, e.g., during an exhibition, without the user being able to change it.

Check the **Deactivation Code** option and enter a 4-digit number to ensure that only authorized people can deactivate it. Check the **Auto Rotate** option to restore a 3D view and let the model rotate after a lapse of time without user interaction. After clicking on **Start Presentation Mode**, there will be a window with a reminder about how to deactivate the mode again.



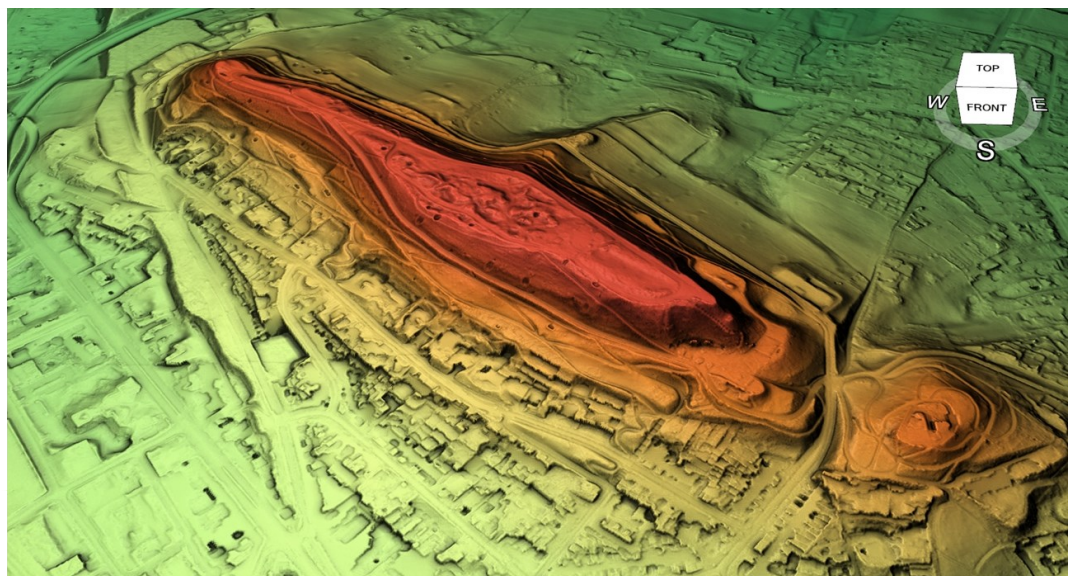
On a touchscreen, touch and hold the **Home** button in the toolbar for more than 10 seconds, tap with a second finger somewhere on the screen and enter the 4-digit deactivation code in the appearing dialog. If you're using a mouse, click on the **Home** button and hold for 10 seconds. You can also press the **ESCAPE** key on a keyboard for 10 seconds if available. (Tip: you can disable edge swipes in Windows 10 only by creating a registry key, google for 'AllowEdgeSwipe'.)

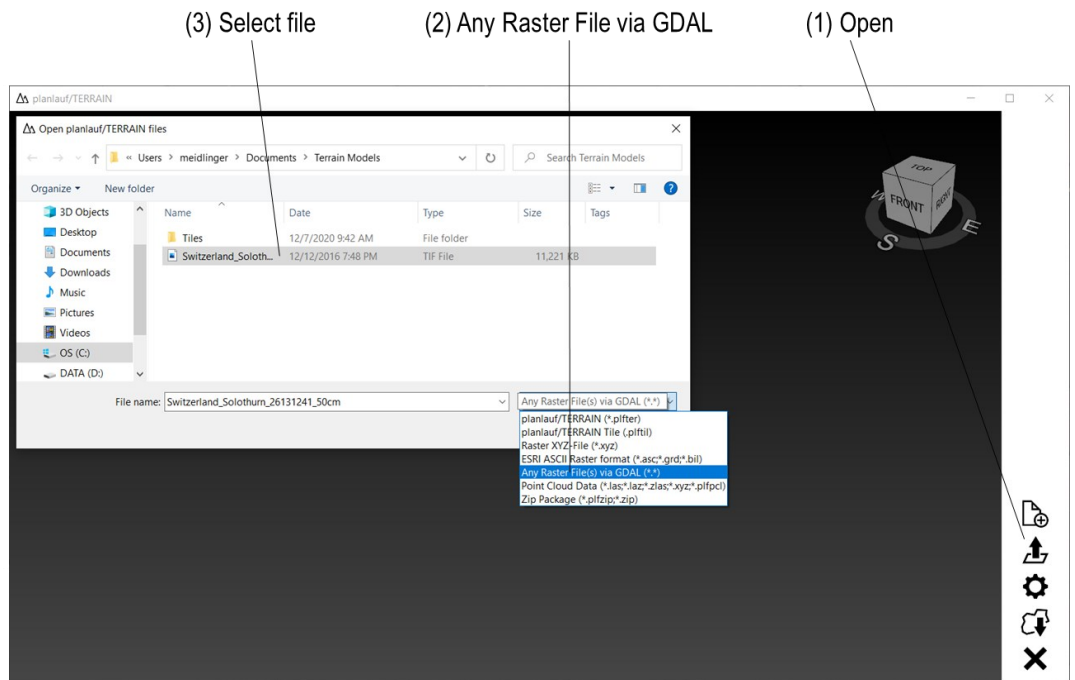


Create screenshots of the current view by clicking on **More** and then on **Screenshot** or by pressing **Control+P**. The following settings are available:

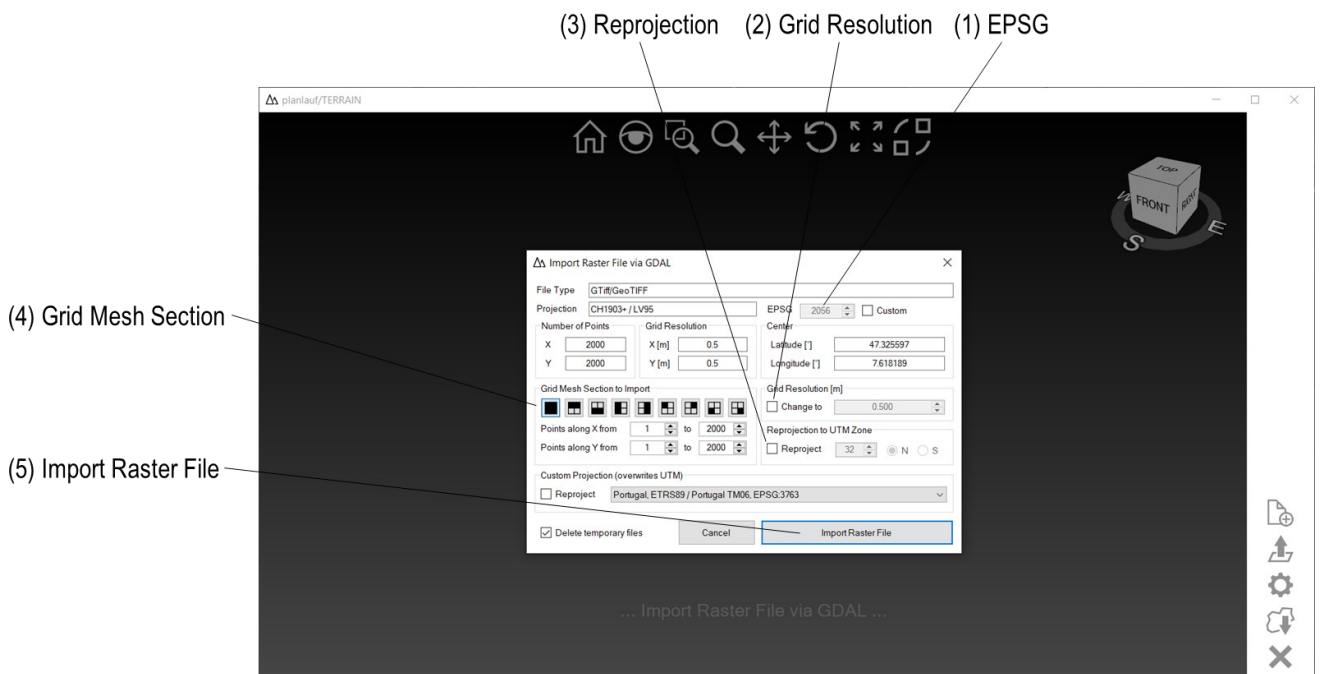
- **Format:** Select JPG, Bitmap or PNG.
- **Bitmap Size:** Choose one of the three size options screen, fixed or custom.
- **Visibility:** Hide or show the **Scale**, the **Viewcube** or the **Legend** and select their position. You can also control the visibility of **Pins**, **Tracks** and the **Height Slider**. Uncheck the **Background** option to get a plain white background in the image. The **Scale Pins** option scales the pins in high resolution images. The **Bright Height Profile** option draws the height profile in bright instead of the default dark color.

Click on **OK** and enter a filename to save the image.





GDAL (Geospatial Data Abstraction Library) is an Open Source project by the Open Source Geospatial Foundation and is used by many GIS software packages. planlauf/TERRAIN contains a GDAL interface to import any raster data that is not directly supported, e.g., GeoTIFF, IMG, ADF, FLT, DEM, HGT or BIL. Click on **Open** in the menu bar, choose the **Any Raster File via GDAL (*.*)** option and select one or more files. If you select more than one file, planlauf/TERRAIN will merge them into a single file with the help of GDAL.

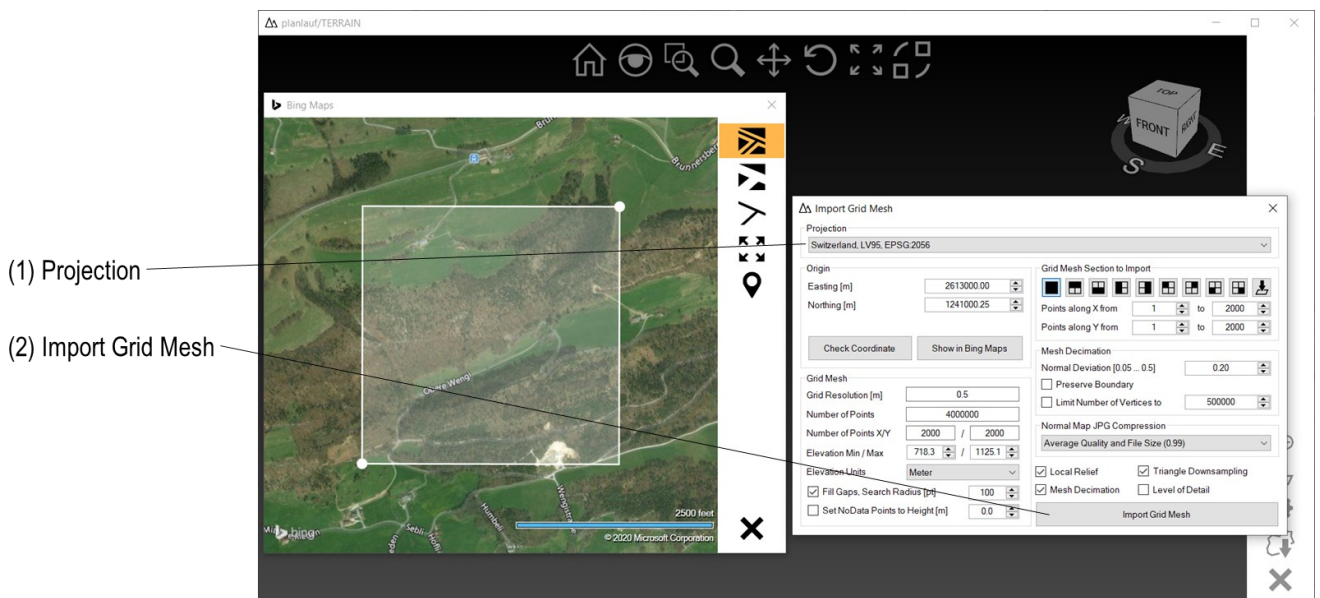


The following settings are available in the **Import Raster File via GDAL** dialog:

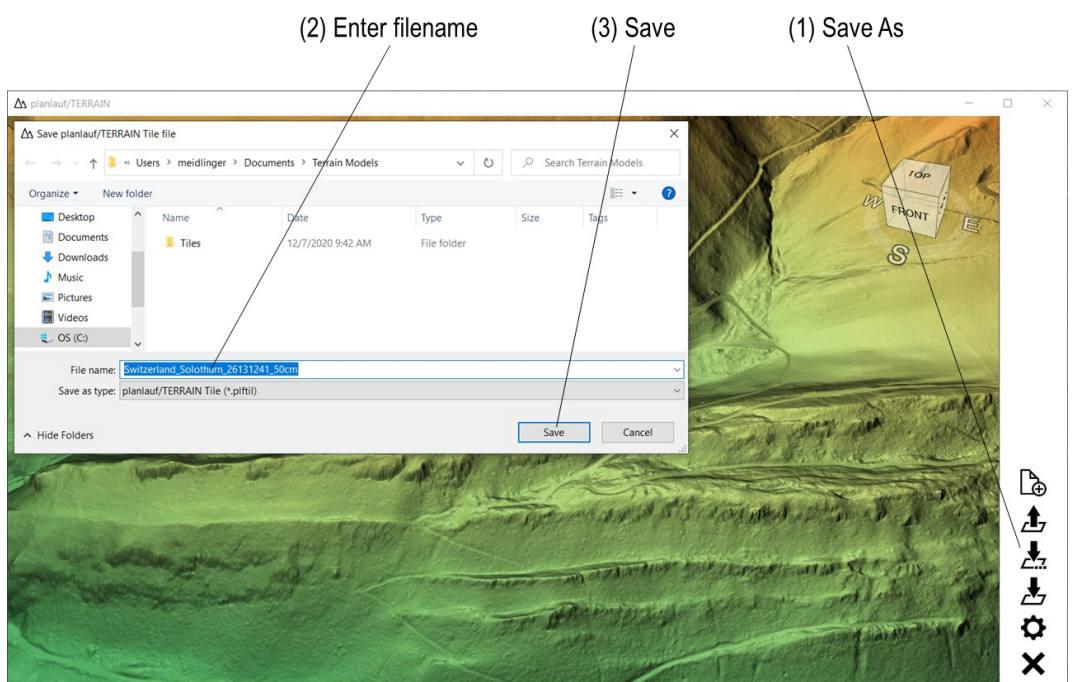
- **EPSG:** If the projection information is included in the raw data and the projection is recognized by planlauf/TERRAIN, the EPSG code is shown. If no projection could be detected, the EPSG code is set to -1. You can manually assign an EPSG code by checking the **Custom** box and entering it into the textbox.

- **Grid Resolution:** If you want to change the resolution of the digital elevation model, you can check the **Change to** box and enter the value into the textbox.
- **Re-Projection to UTM Zone:** Check this box and enter the UTM zone and choose the northern or southern hemisphere to reproject the data.
- **Grid Mesh Section:** Select one of the predefined sections or enter the min/max indices for the X and Y values to import only part of the original data.
- **Custom Projection:** Select this option to reproject the data to a custom projection.

Click on **Import Raster File** to start the conversion process. GDAL creates a binary ESRI BIL file (*.bil) which will automatically be imported by planlauf/TERRAIN.

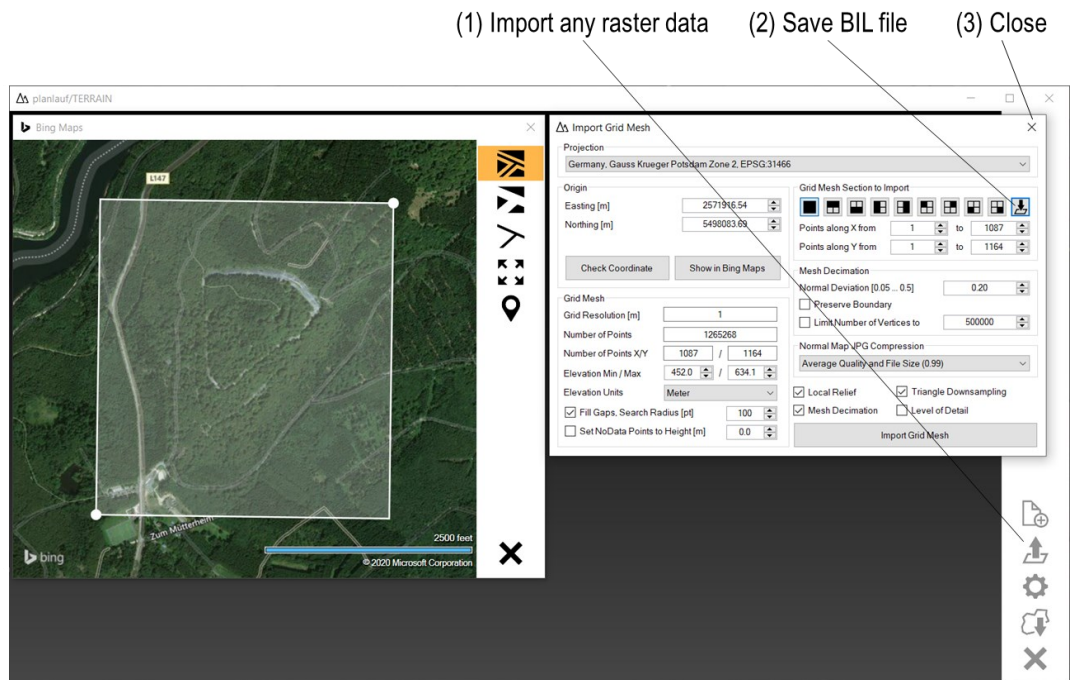


Please see the **Import Raster XYZ or ESRI ASCII Grid Files** section in this manual for further information about the appearing **Import Grid Mesh** dialog but please note that the projection is automatically set. Click on **Import Grid Mesh** to start the mesh decimation.

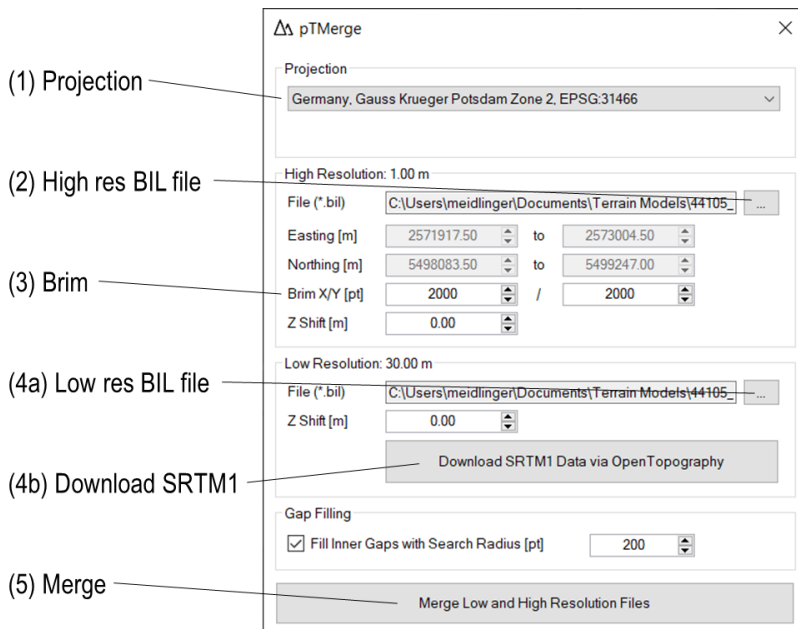


Click on **Save As** or **Save** as soon as the mesh decimation is finished, enter a filename and click on **Save** to save the tile file. Please see the **Create a Terrain File** section in this manual to learn about how to proceed.

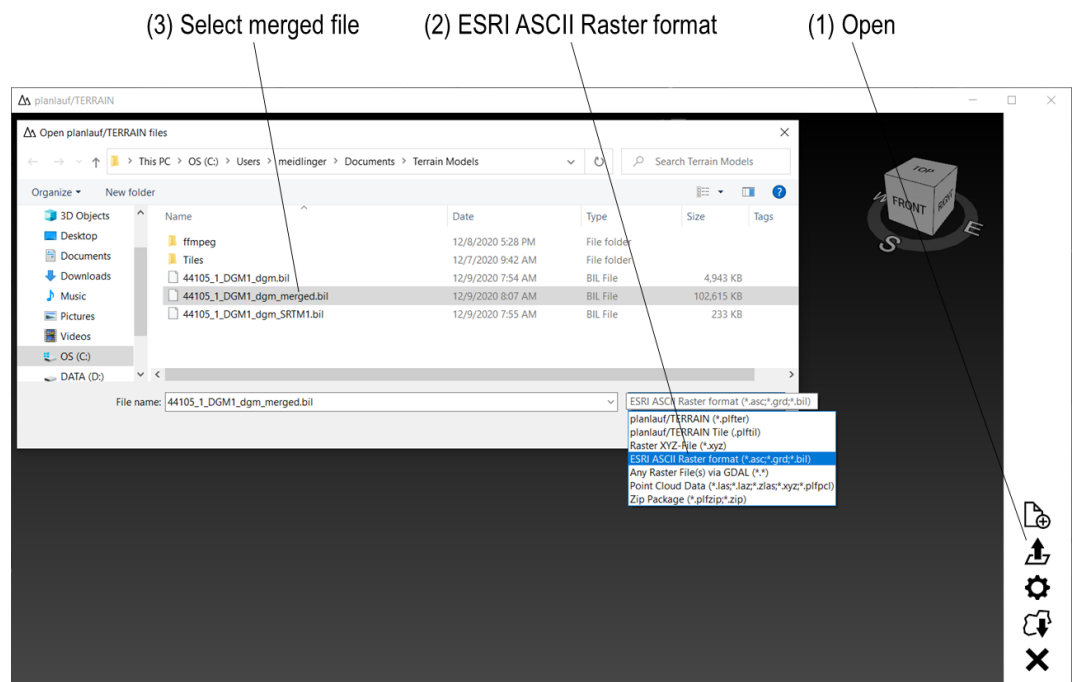
planlauf/TERRAIN comes together with a small software called **pTMerge**. **pTMerge** can merge high and low resolution raster data in the **BIL format**. This is especially useful if the high resolution data contains large voids or if you want to enlarge the model extents.



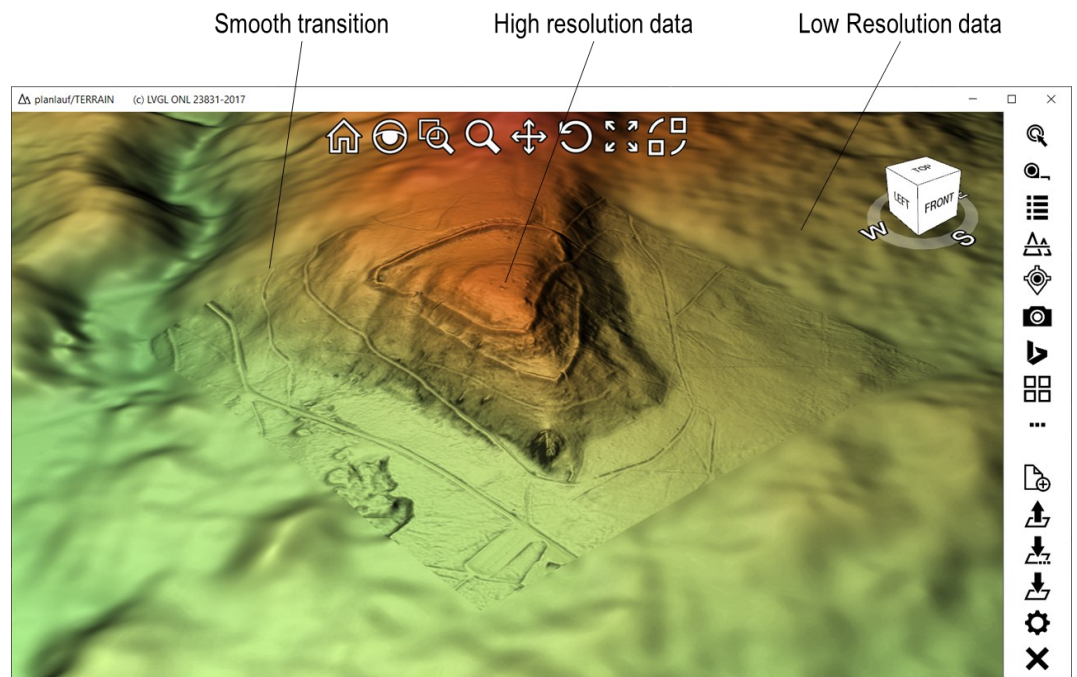
You can create the required BIL files by importing any raster data and clicking on the **Save BIL file** button in the top right corner of the **Import Grid Mesh** dialog. Close the window after saving the file.



Start **pTMerge**, enter the **projection** and specify the **high resolution BIL file**. If you want to enlarge the model extents, you can enter values for the **brim** in X- and Y-direction. Specify the **low resolution BIL file** or click on **Download SRTM1 Data via OpenTopography**. The latter option requires GDAL to be installed (see **Settings** section) because the data has to be reprojected. Click on **Merge Low and High Resolution Files** and enter a filename.



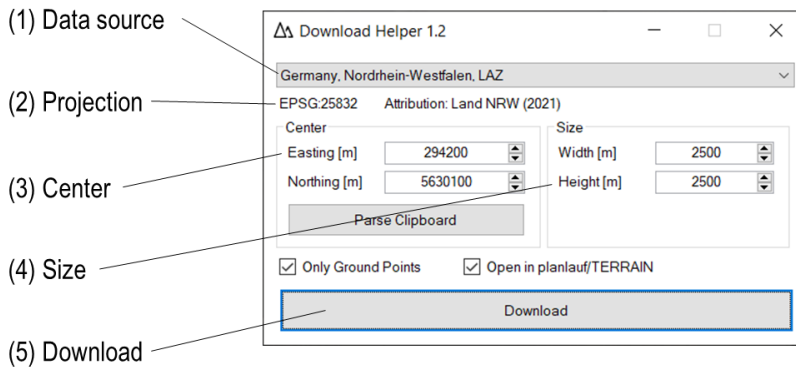
Click on **Open** in the menu bar, choose the **ESRI ASCII Raster format (*.asc;*.grd;*.bil)** option and select the merged BIL file.

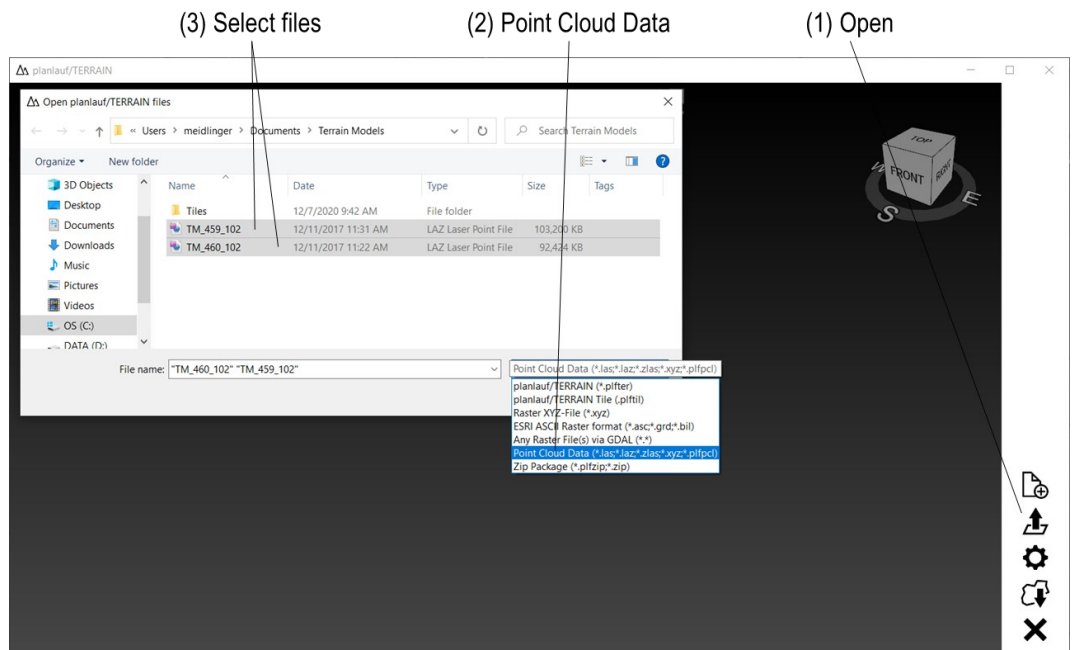


The algorithm will create **smooth transitions** between the two datasets by shifting the low resolution data to match the high resolution data.

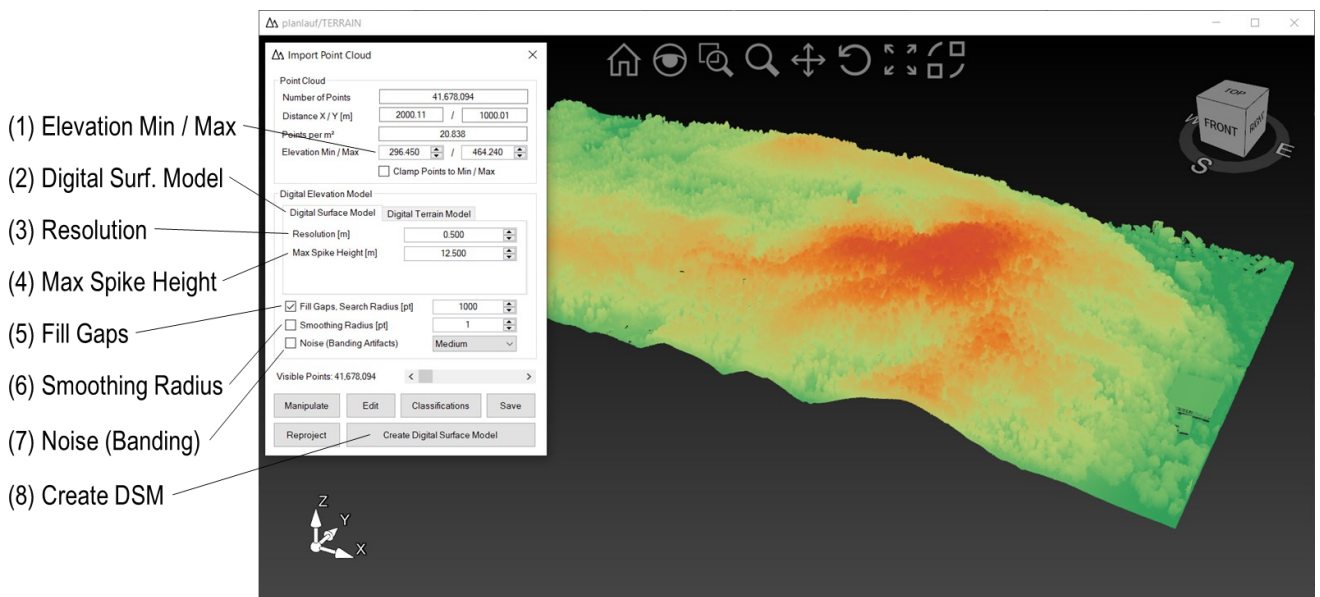
planlauf/TERRAIN comes together with a small software called **Download Helper**. This piece of software can make downloading point cloud and raster data from some LiDAR sources much easier. Choose the **data source** and enter the **center** and **size** of your area of interest. Please notice that you can **parse** the contents of the clipboard for a valid projection coordinate or a latitude and longitude pair. In the latter case, the values will automatically be reprojected into the data source's projection.

The **Download Helper** will download the required files and merge the data. You can limit the output file to ground points if you're downloading point cloud data.





planlauf/TERRAIN is able to generate digital terrain/surface models from point cloud data. Click on **Open** in the menu bar, choose the **Point Cloud Data** option, select the files to import and click on **Open** to start the import. You can use Control+A to select all files in a folder.

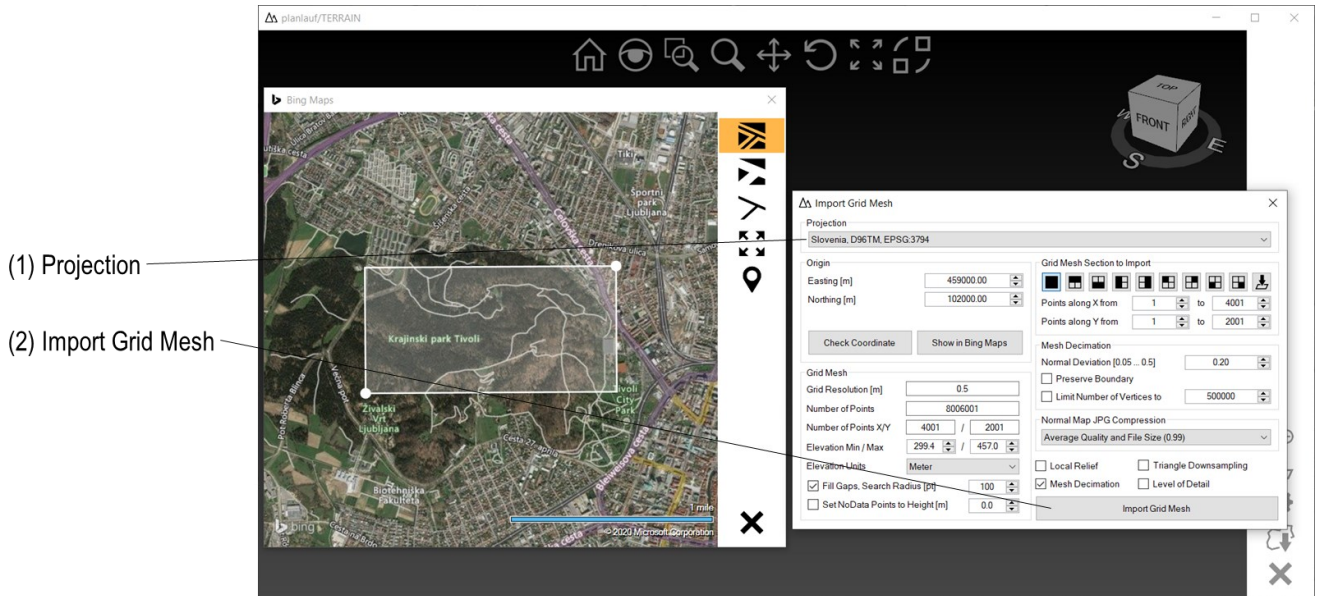


The following settings are available in the **Import Point Cloud** dialog:

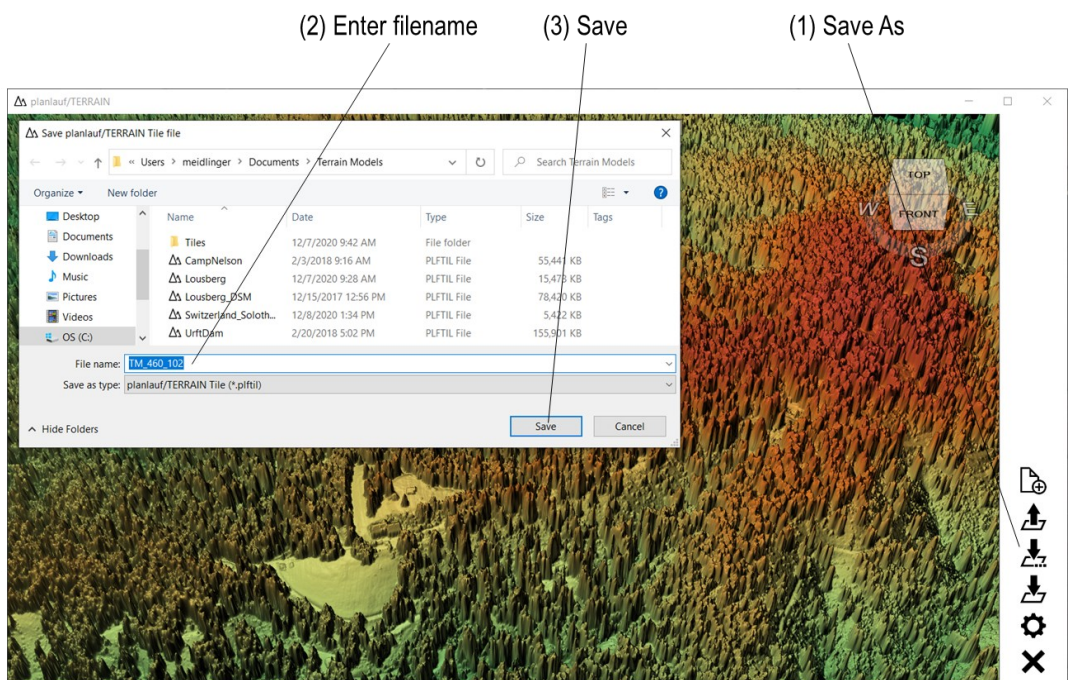
- **Elevation Min / Max:** Point clouds might have noise with very large or very small height values. Adjust the Min (Max) value to exclude points below (above). If you want to clamp the points to the limits instead of deleting them, you can choose the **Clamp Points to Min / Max** option.
- **Digital Surface / Terrain Model:** Choose the Digital Surface Model tab to create a DSM.
- **Resolution:** planlauf/TERRAIN suggests a resolution based on the number of points per m². If you select a finer resolution, the model might contain gaps or holes or simply appear coarse.
- **Max Spike Height:** A smaller value reduces spikes in the model but also affects the sharpness of steep slopes. The default value for a DSM is resolution*25.
- **Fill Gaps:** Check this option to fill gaps in the model using the Inverse Distance Weighting algorithm. The **Search Radius** defines the points around a gap that are taken into account. A large value might slow down the DSM generation.

- **Smoothing Radius:** Check this option to smooth each point in the model with the specified radius. Without smoothing details might be more visible but also the LiDAR scan lines will eventually be more apparent.
- **Noise (Banding Artifacts):** If banding artifacts are visible in the DSM, you can use this option.
- **Visible Points:** If the number of points is too big for the graphics card to handle smoothly, you can adjust this slider to reduce the number of visible points.

Click on **Create Digital Surface Model** to start the process.

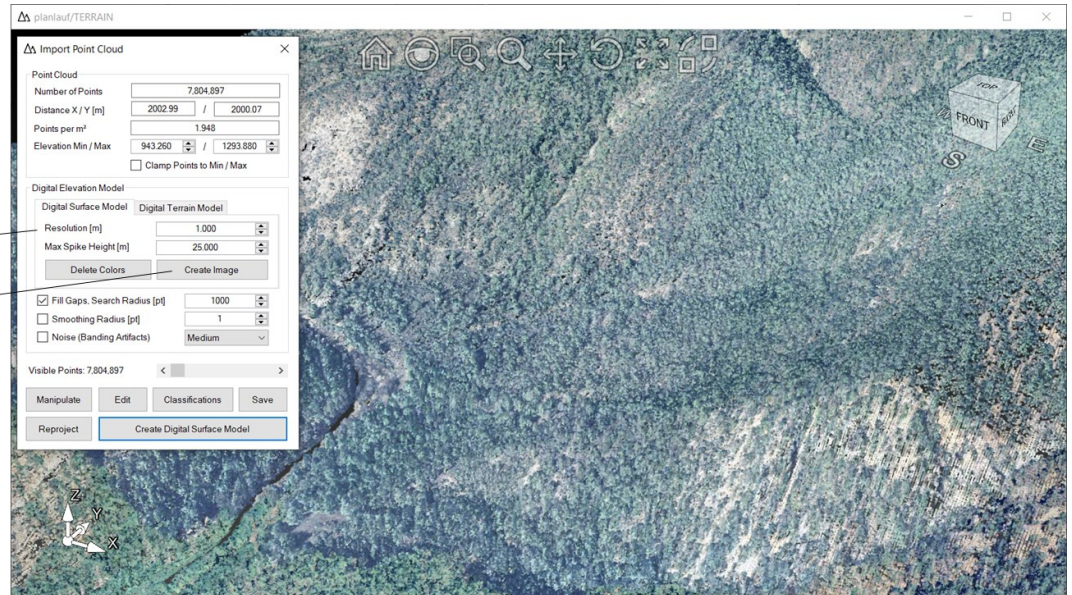


Please see the **Import Raster XYZ or ESRI ASCII Grid Files** section in this manual for further information about the appearing **Import Grid Mesh** dialog. LAS files might include the projection information. In this case, the projection will automatically be selected in the dialog. Click on **Import Grid Mesh** to start the mesh decimation.

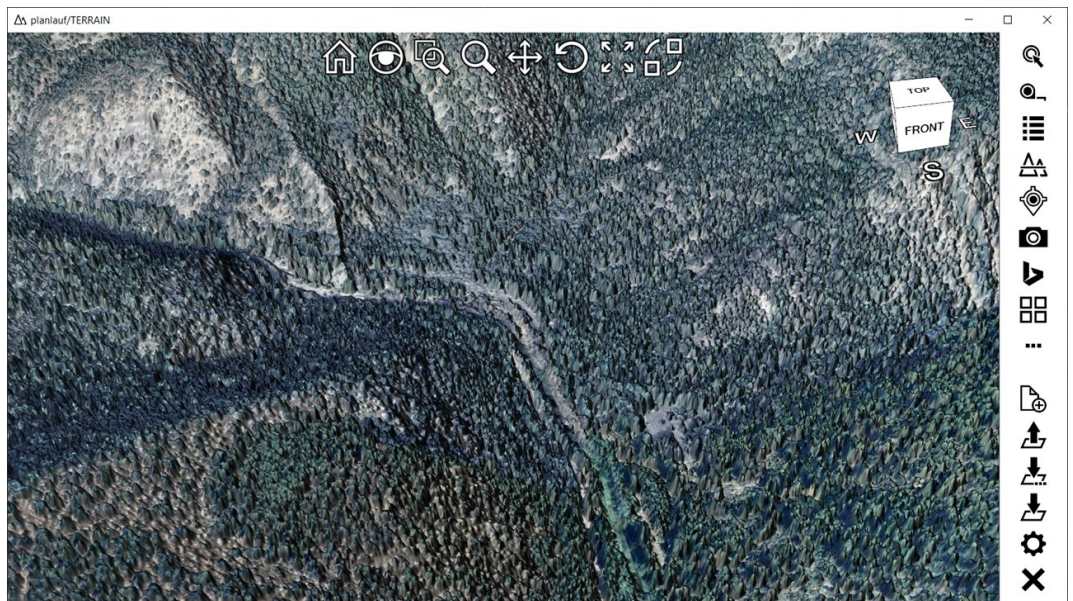


Click on **Save As** as soon as the mesh decimation is finished, enter a filename and click on **Save** to save the tile file. Please see the **Create a Terrain File** section to learn about how to proceed.

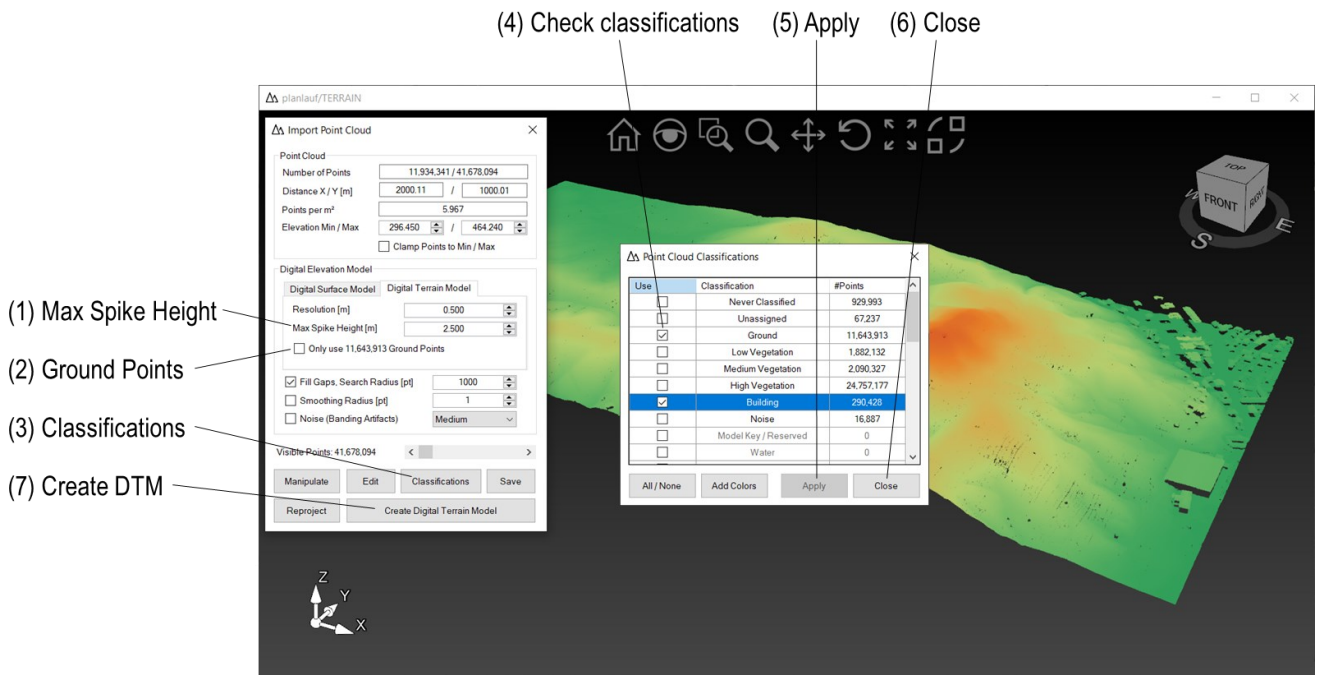
- (1) Resolution
- (2) Create Image



LAS, LAZ and zLAS files can contain point clouds with colors. If the colors are included, an overlay image can be created from the data. Adjust the **Resolution**, click on **Create Image** and enter a filename.



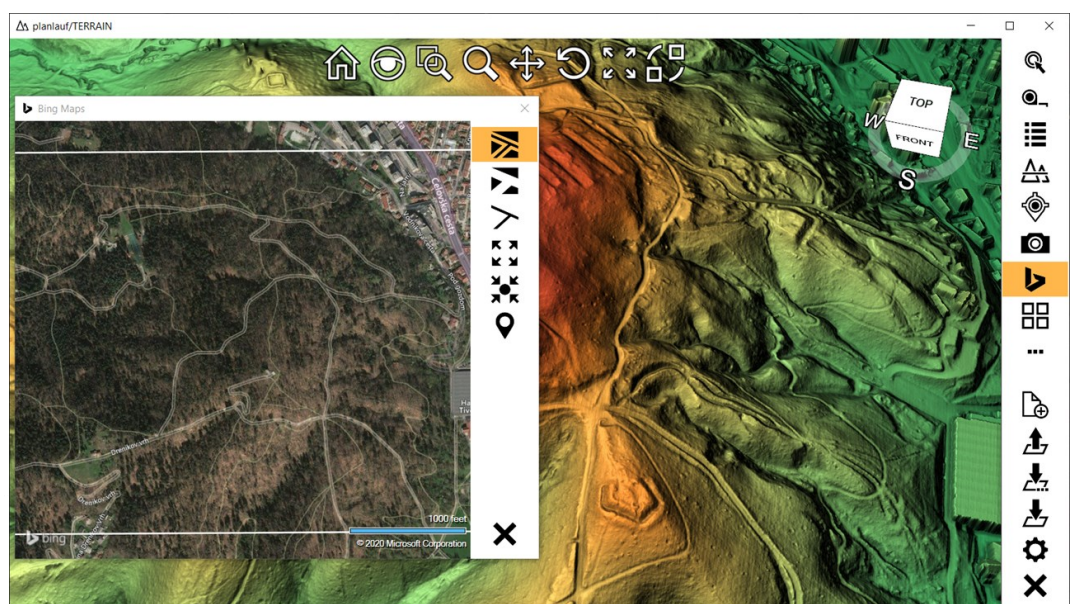
Once the digital surface model is created, you can use the image as an overlay.

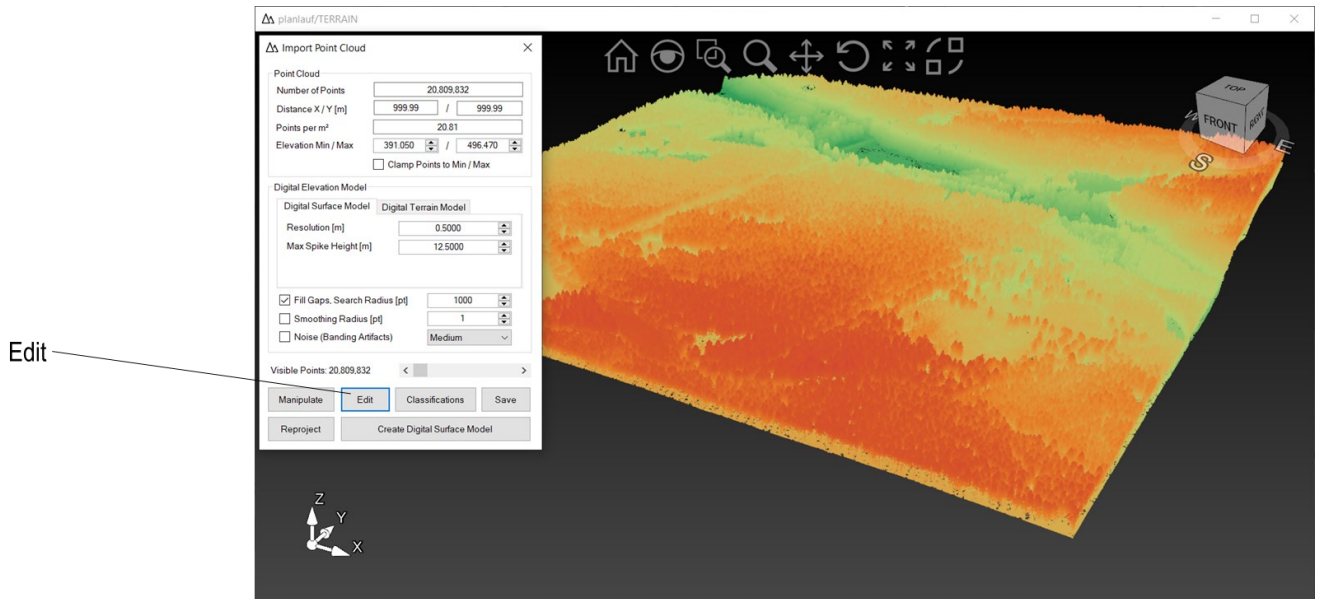


Please see the section **Create a DSM from Point Cloud Data** in this manual to learn about how to open the point cloud raw data. The **Import Point Cloud** dialog differs for the DTM generation from the DSM in two ways:

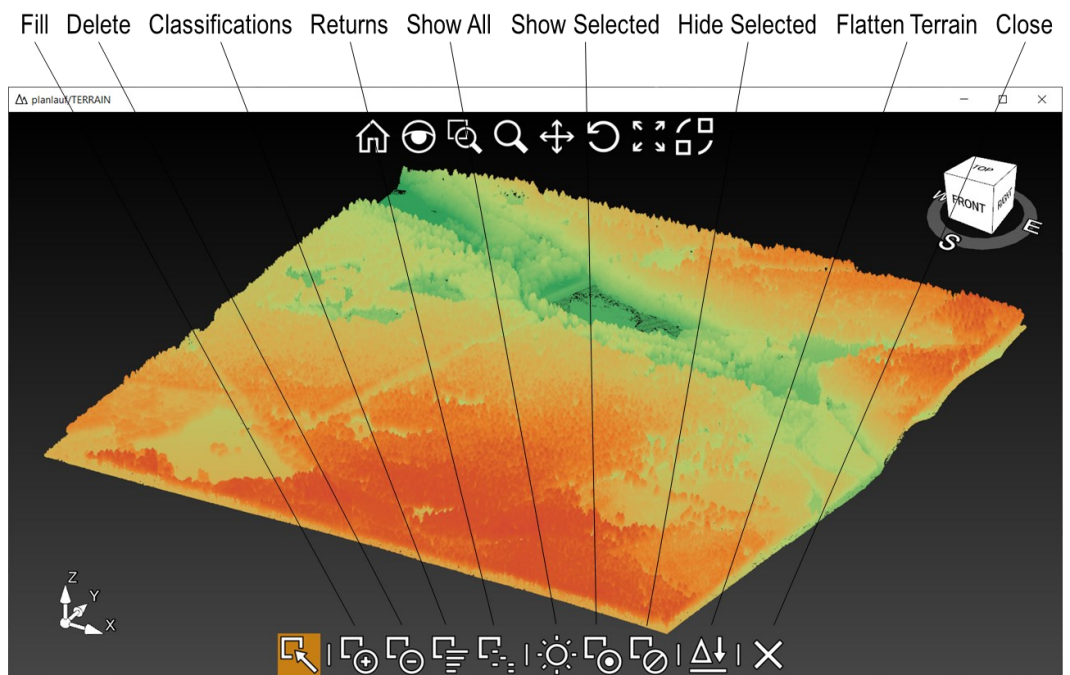
- **Max Spike Height:** A smaller value reduces spikes in the model but also affects the sharpness of steep slopes. The default value for a DTM is resolution*5.
- **Only use Ground Points:** If the point cloud raw data contains classification data, you can check this option that ignores every other classification except for ground in the DTM generation

Click on the **Classifications** button to show the available classification data and check rows that you want to keep for the DTM generation. Click on **Apply** to update the visible points in the viewport and on **Close** to close the Point Cloud Classifications Dialog. Click on **Create Digital Terrain Model** to start the process. Please see the **Import Raster XYZ or ESRI ASCII Grid Files** and the **Create a Terrain File** sections in this manual for further information about the next steps.

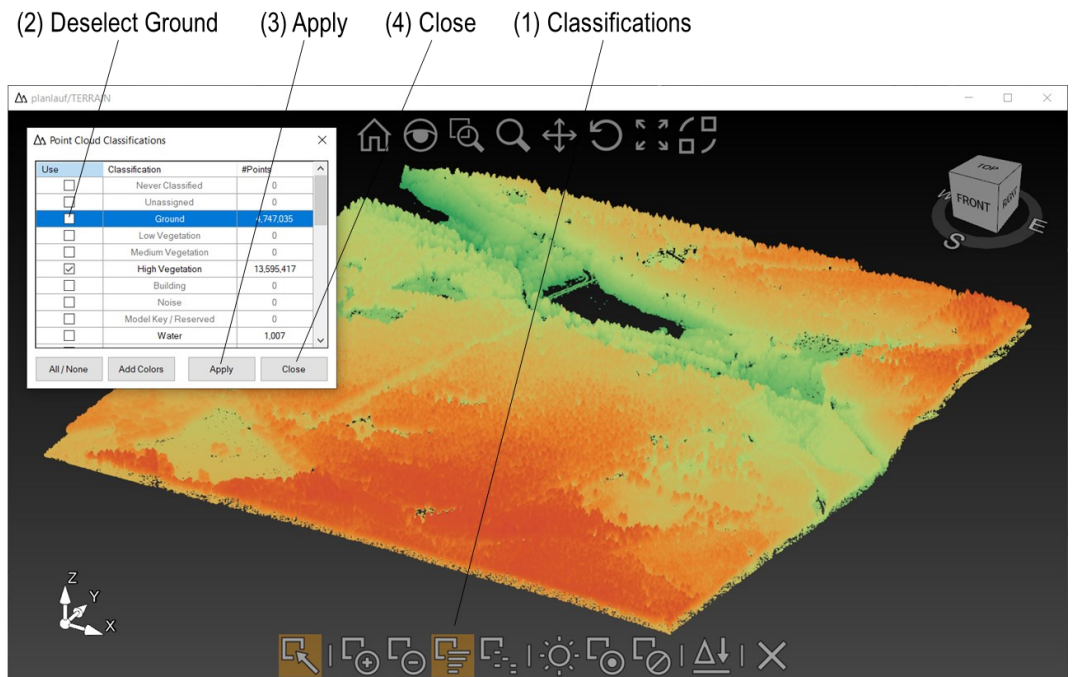




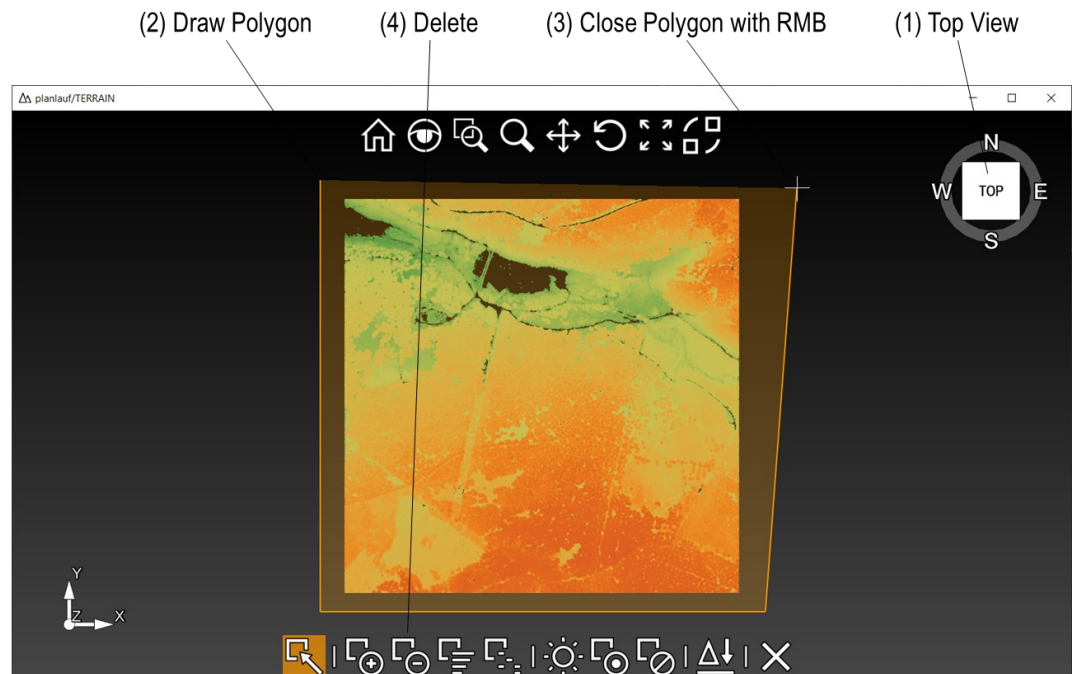
You can edit point clouds by **adding or deleting** points, changing **classifications** or by using the **Flatten Terrain** feature to extract ground points. Please see the section **Create a DSM from Point Cloud Data** in this manual to learn about how to open the point cloud raw data. Click on **Edit** in the **Import Point Cloud** dialog to start the edit mode.



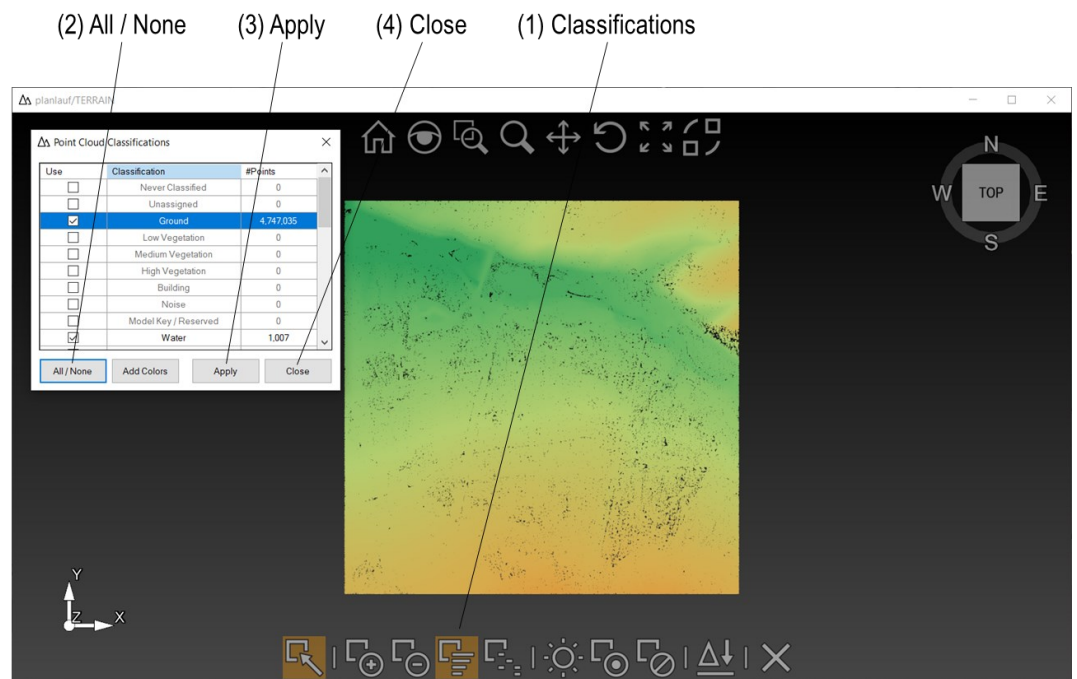
The **Editing Tools** are placed in the toolbar at the bottom of the viewport. If you hover over them, the tooltips are shown. You can **select points** by drawing a polygon with the left mouse button. Please use a right click to close the polygon. The selection works in any view but please be aware that once you change the orientation of the model, the selection polygon will be deleted. Selecting points in a 2D view will be significantly faster than in a 3D view. Clear a selection by pressing the **Escape** key.



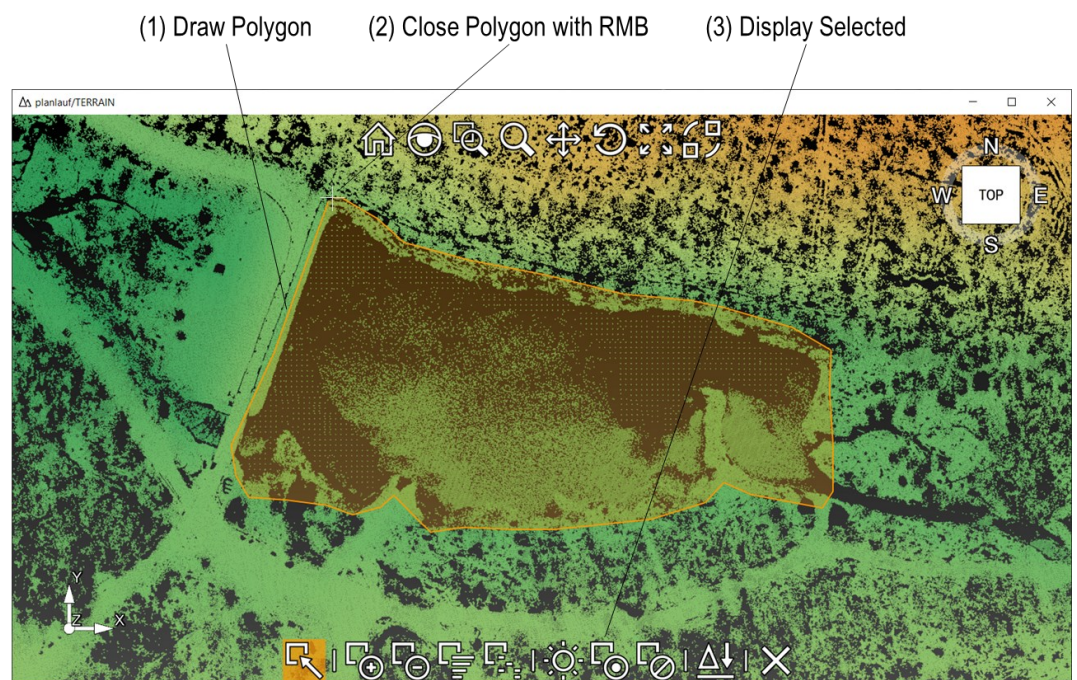
Clear the selection by pressing the **Escape** key and then click on **Classifications**. This opens the **Point Cloud Classifications** dialog and you can deselect the classifications which you'd like to keep for a digital terrain model. In the example, the classifications **Ground**, **Water** and **Bridge Deck** are deselected. By clicking on **Apply** the viewport is updated and **Close** hides the dialog. Please note that you can change the **classification of selected points** by drawing a selection polygon, closing it and then by clicking on the **Classifications** button in the toolbar.



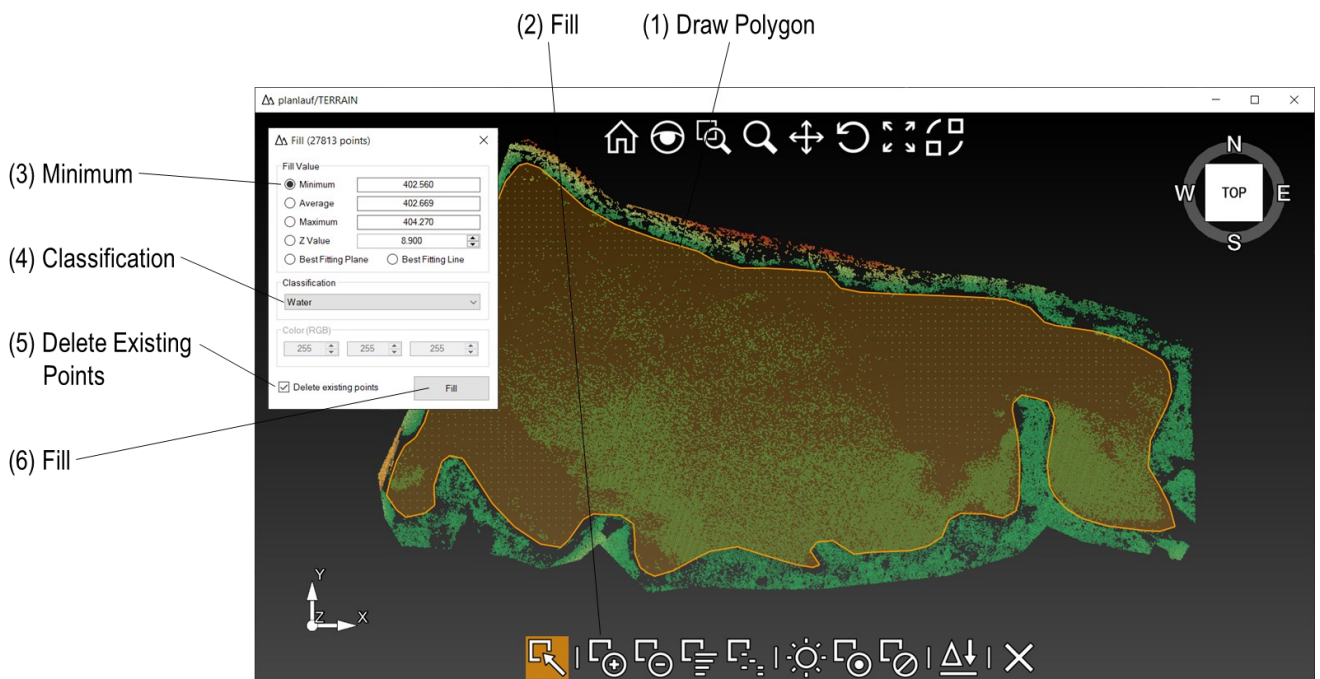
Click on the **Top View** of the viewcube and zoom out a little. Draw the selection polygon and note that by pressing the **Shift** key you can force the line segments to be vertical or horizontal. Close the polygon by pressing the right mouse button. Click on **Delete** in the toolbar at the bottom to delete the visible points within the selection polygon.



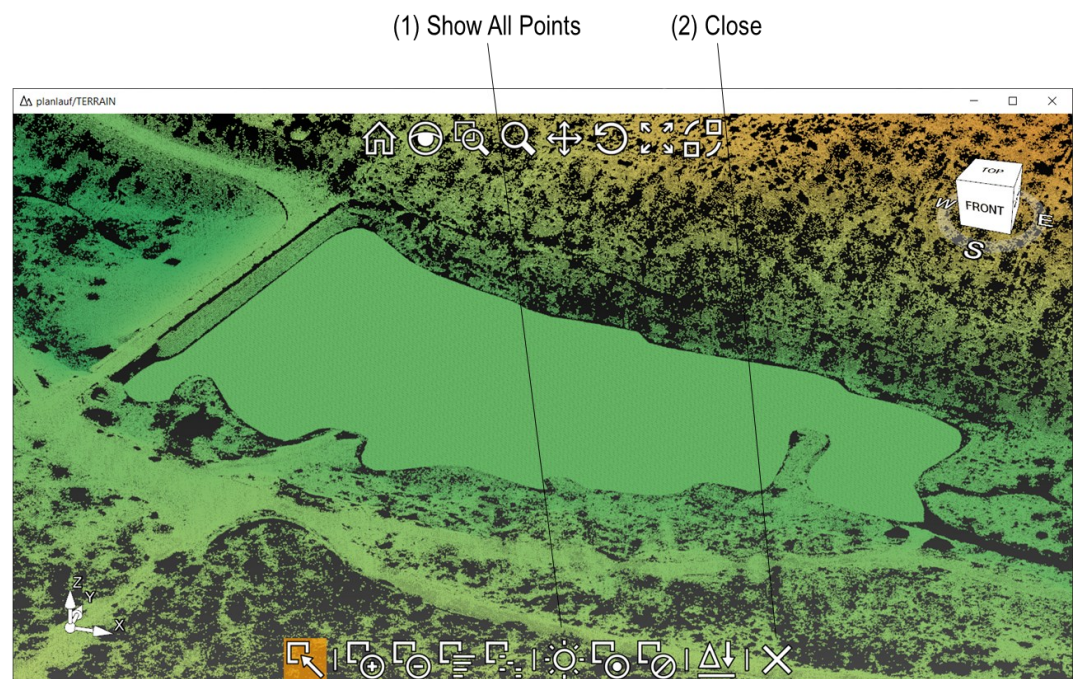
After deleting the visible points, the viewport is empty. Click on **Classifications** and then on **All / None** to toggle the check marks. Make sure that all remaining classifications are selected and click on **Apply** and then on **Close**.



In the next step, we're going to fill the lake with points at the same elevation to create a smooth surface. Draw a selection polygon around the lake, close it with the right mouse button and click on **Display Selected** to show only the selected points.

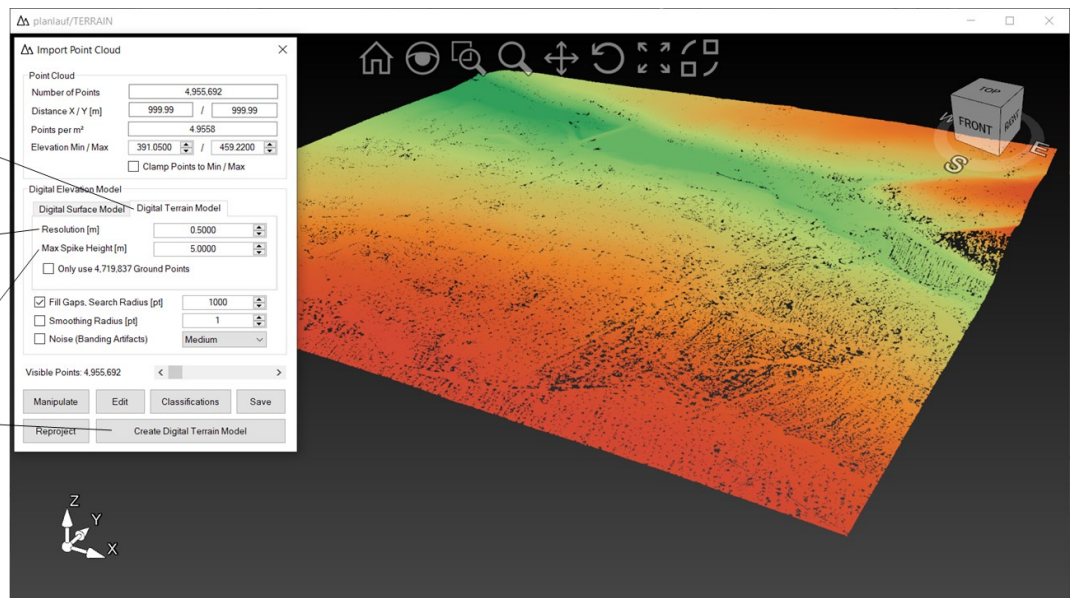


Draw a polygon for the water surface of the lake, close it and click on **Fill** in the toolbar. Please note that the fill algorithm works best if you use a 2D view for this selection. You can either fill the selected area with points at a **constant elevation** (minimum, average, maximum or constant Z value) or with points lying on a **best fitting plane or line**. The latter uses the selected points to determine the orientation of the plane or line. Select **Water** as the classification for the new points and make sure that the **Delete Existing Points** option is checked. Click on the **Fill** button to create the points.

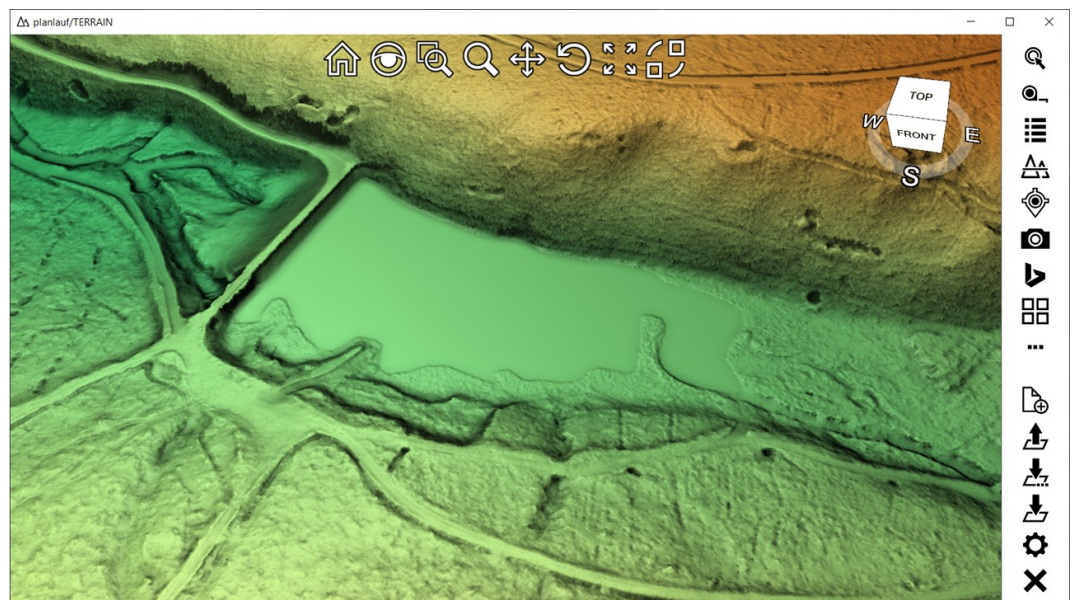


Click on **Show All Points** in the toolbar and then on **Close** to end the point cloud editing.

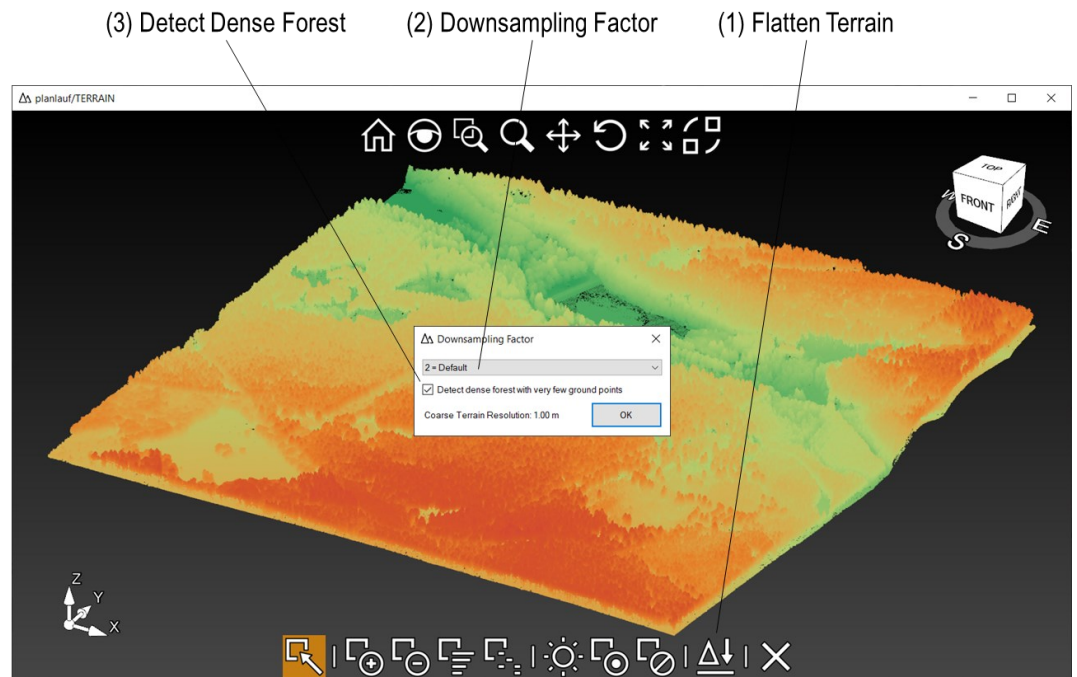
- (1) Digital Terrain Model
- (2) Resolution
- (3) Max Spike Height
- (4) Create Digital Terrain Model



Choose the **Digital Terrain Model** tab and enter a **Resolution** of 0.5 m and a **Max Spike Height** of 5.0 m. Click on **Create Digital Terrain Model** to start the process.

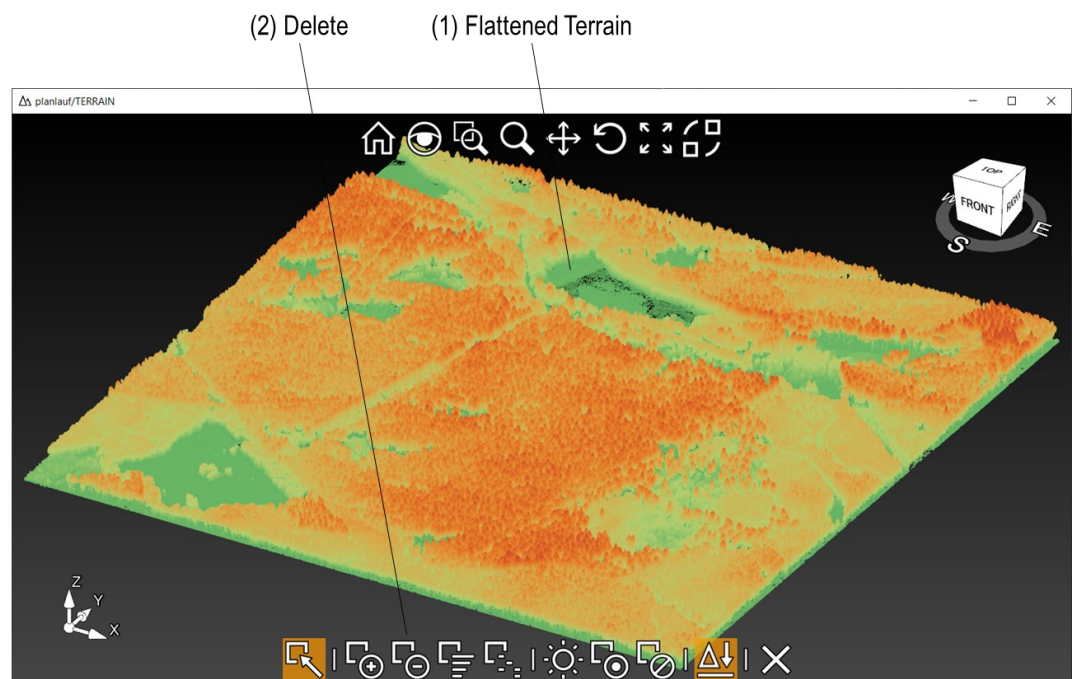


After the import of the created DTM and the set-up of the terrain file, the smooth water surface of the lakes becomes visible.

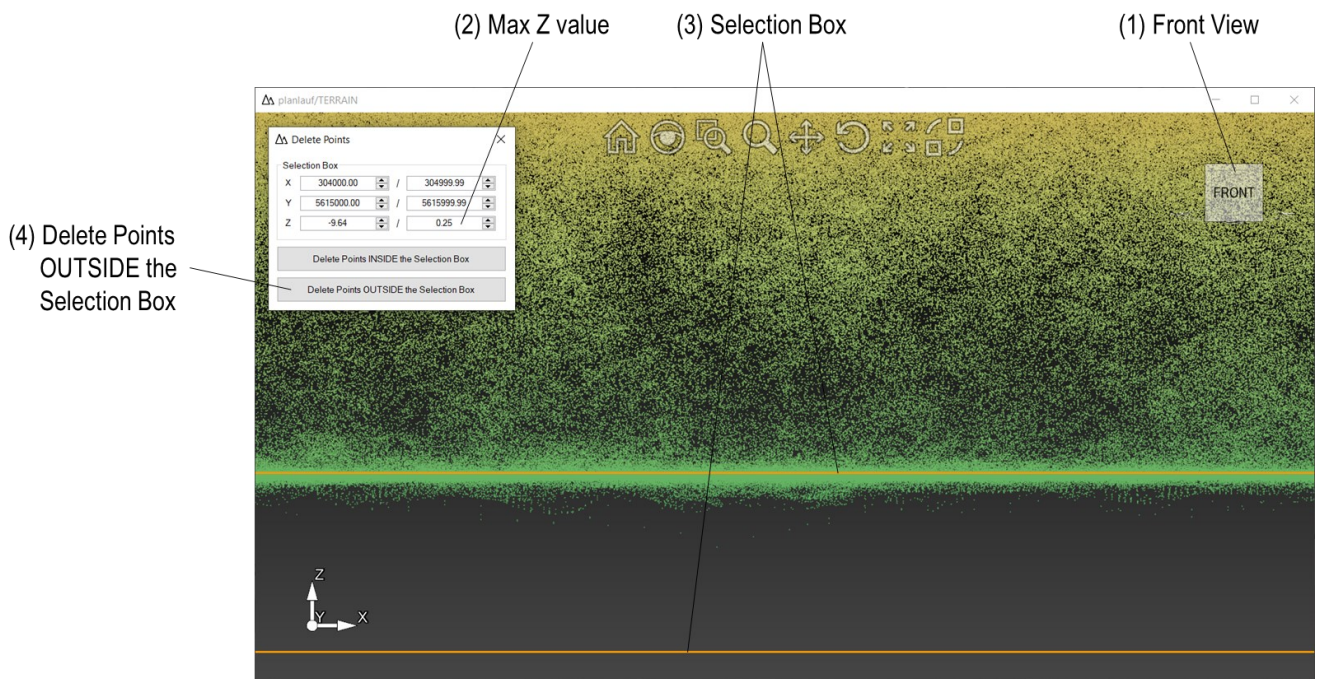


Terrain Flattening is an algorithm to extract ground points from unclassified point cloud data. It is able to preserve more ground points than other algorithms but there might be more vegetation artifacts which have to be deleted manually. Start editing the point cloud (see previous section) and click on **Flatten Terrain** in the toolbar at the bottom.

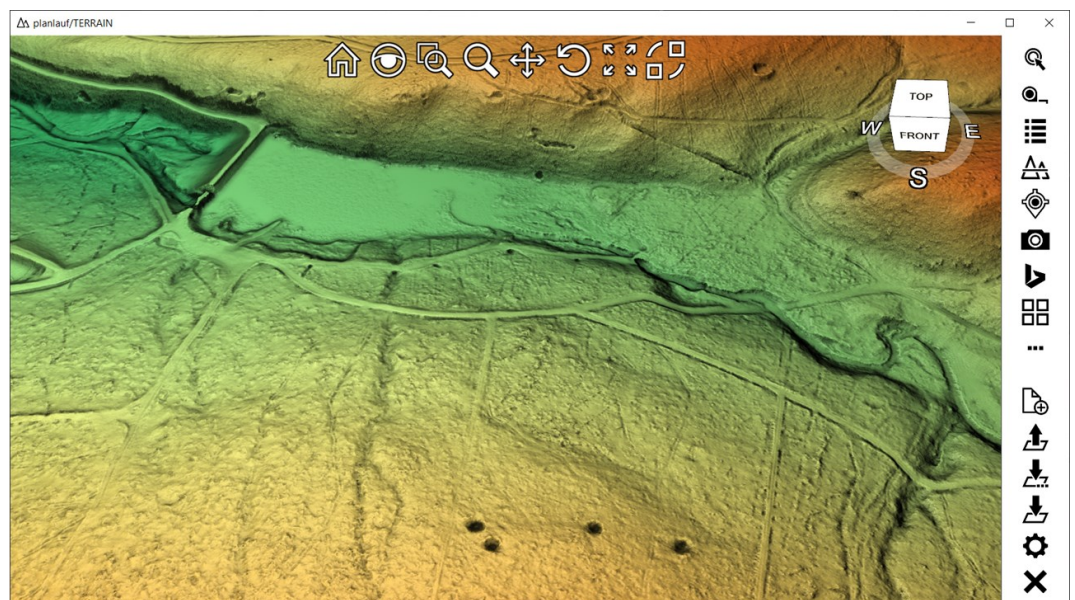
The **Downsampling Factor** determines the resolution of the coarse terrain model. The finer the resolution, the more ground points are preserved but the more vegetation artifacts remain as well. The **Detect Dense Forest** option helps to reduce these artifacts. Click on **OK** to start the process.



The result of the terrain flattening is a point cloud with all the ground points slightly above and below the Z value of zero. Clear a possible selection with the **Escape** key and click on the **Delete** button in the toolbar.

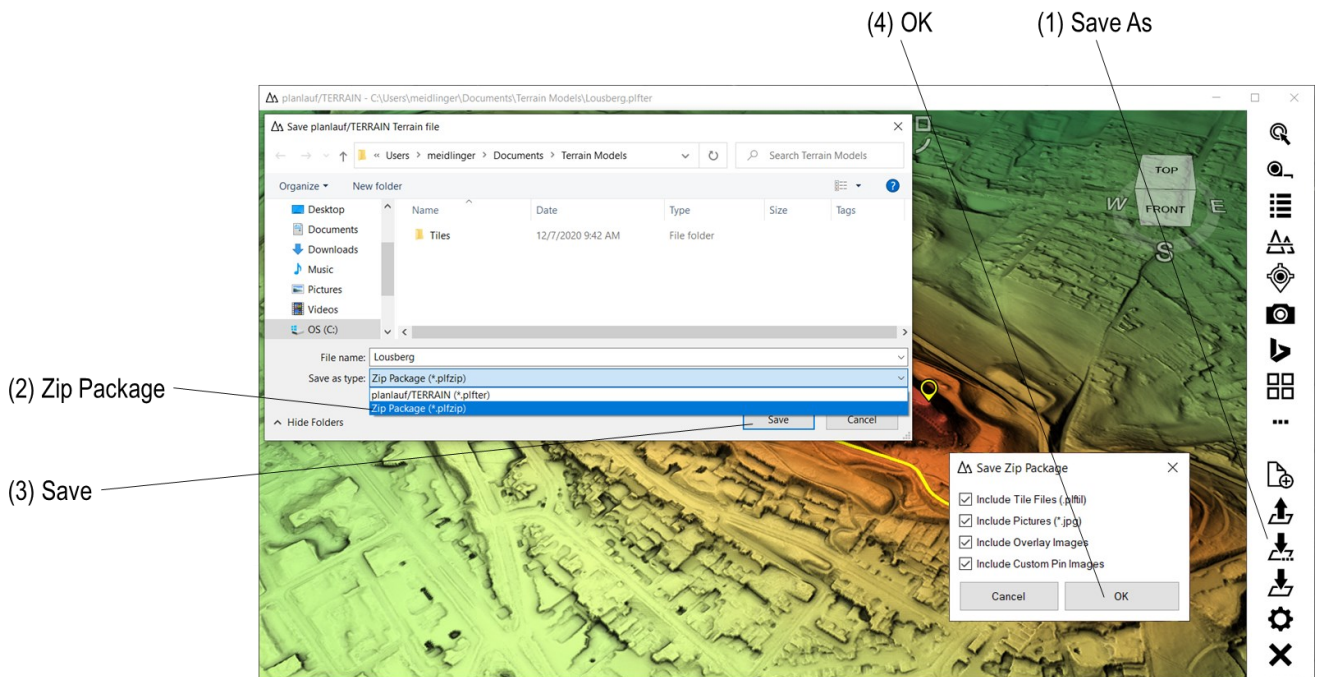


Click on the **Front View** of the viewcube and zoom in so that you can see the clustering of the ground points near the Z value of zero. A good start for the **Max Z value** is the vertical accuracy of the point cloud data. In the example, a value of 0.25 m is appropriate. Leave the **Min Z value** as it is to ensure that depressions are preserved. Click on **Delete Points OUTSIDE the Selection Box** to delete the non-ground points. Click on the **Flatten Terrain** button in the toolbar again to display the resulting point cloud. If there are still a lot of vegetation artifacts, it might be necessary to repeat the process of flattening the terrain and deleting the points a couple of times with the same parameters.

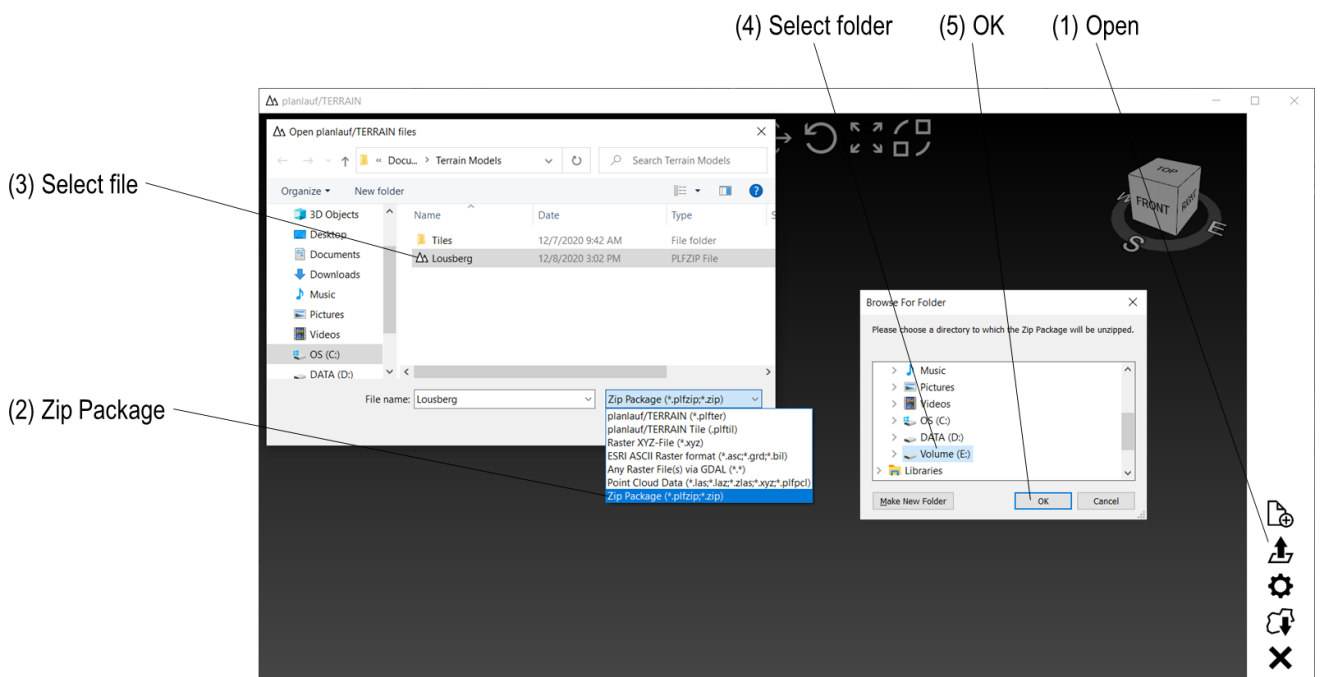


planlauf/TERRAIN

planlauf/TERRAIN Zip Package



You can share models as planlauf/TERRAIN Zip Packages which contain the terrain file, the tile file(s), pictures, image overlays and custom pin images. Click on **Save As** in the menu bar, choose the **Zip Package** filter option and enter a filename if you don't want to use the terrain file's name. Click on **Save**, select what you want to include in the zip file and click on **OK**.



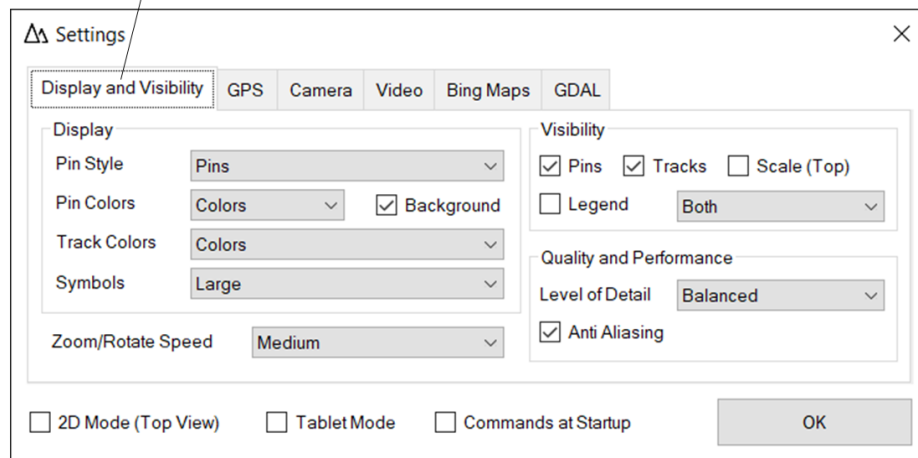
To open a planlauf/TERRAIN Zip Package you can use a **double-click** on the file, **drag it into the viewport** or click on **Open** in the menu bar. Choose the **Zip Package** filter option, select the file and click on **Open**. Specify the folder to which the zip file should be unzipped to. The terrain file will then automatically be loaded.



Click on **Settings** in the lower menu bar. The most frequently used tab at the top is **Display and Visibility**. There are some options that are available regardless of the chosen tab:

- **2D Mode (Top View):** Check this option if you want to work in 2D mode. The model will be locked to the top view and you can pan by simply pressing the middle mouse button.
- **Tablet Mode:** planlauf/TERRAIN runs in full screen mode if this option is checked. Additionally, the tablet keyboard is shown whenever a textbox is touched.
- **Commands at Startup:** A list of command shortcuts is shown at startup if this option is active.

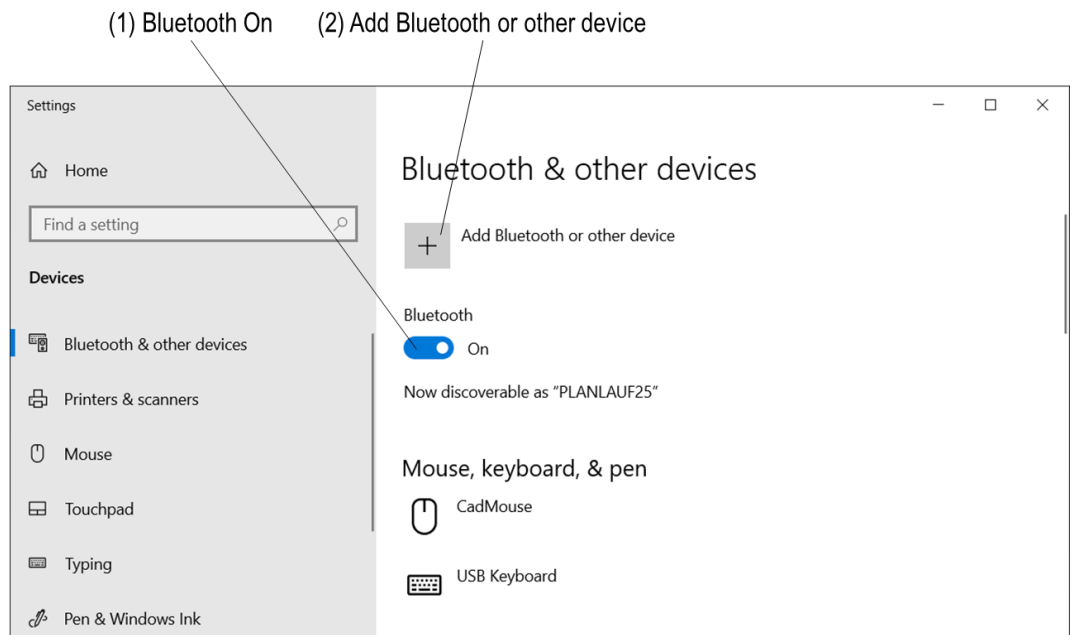
Display and Visibility



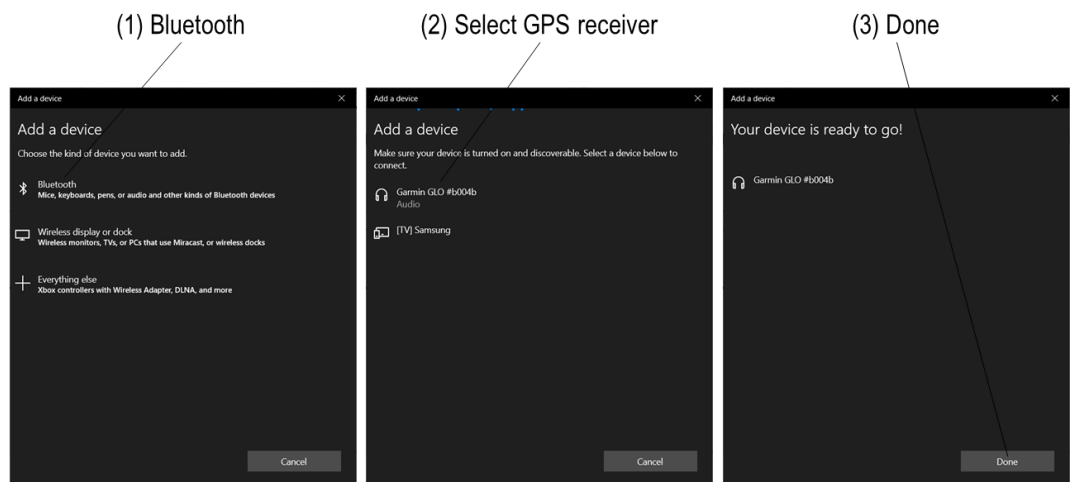
The following options are available in the **Display and Visibility** tab:

- **Pin Style:** Pins can be displayed as **Pins**, **Dots**, or **Names** with different line lengths.
- **Pin Colors:** The **Colors** option displays the pins with their class colors. **Black** and **White** use the respective color for all pins.
- **Background:** With pins displayed with their **Names**, this option draws a semi-transparent background rectangle to increase the visibility of the label.
- **Track Colors:** The **Colors** option displays the tracks with their class colors. **Black** and **White** use the respective color for all tracks.
- **Symbols:** This option controls the size of all GUI elements like toolbar or viewcube and the size of the pins and the line thickness of the tracks.
- **Zoom/Rotate Speed:** Choose the **Low** option if you're not yet familiar with the 3D control either with a mouse or a touchscreen.
- **Visibility:** Show or hide all **Pins** and **Tracks**, the **Scale** in top view and the **Legend**.
- **Level of Detail:** LoD controls how much details are drawn depending on the zoom level. Parts of the model that are far away from the viewer will appear small on the screen and thus don't need to be drawn in full detail. This option is especially important for tile files that were generated without mesh decimation or very large mesh decimated models. The default value is **Balanced**, if you experience performance problems, you might want to choose **Best Performance** instead.
- **Anti-Aliasing:** This option increases the quality of the rendering because it smooths track lines and edges of the model. On the other hand, it affects performance so you should choose this option only if your hardware is good enough.

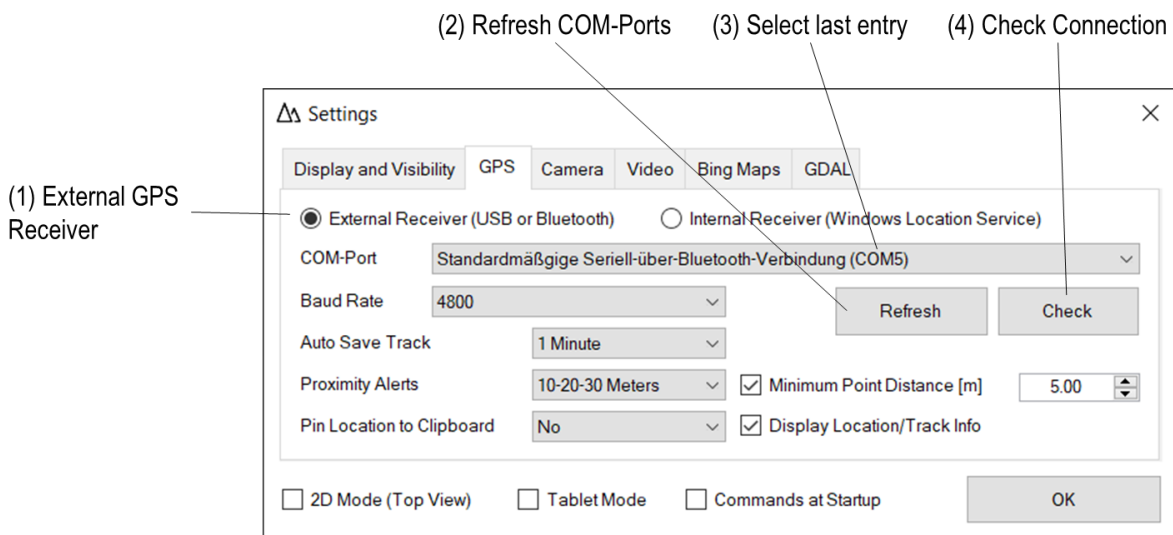
planlauf/TERRAIN supports internal (Windows Location Service) and external (USB or Bluetooth) GPS receivers. Please check your receiver's manual to learn about its specific installation procedure. To set up a Bluetooth GPS receiver please follow the instructions below.



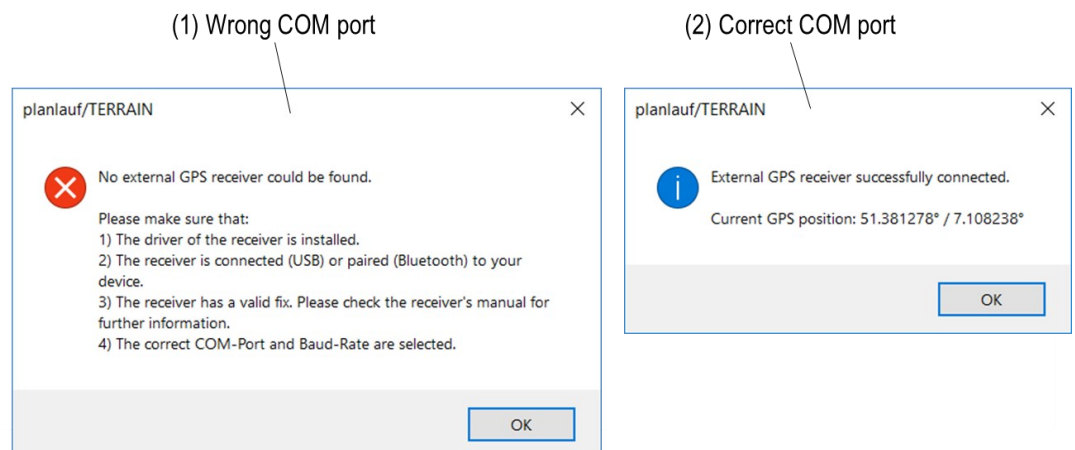
On Windows 10 right-click on the Windows symbol in the lower left corner and choose **Settings** and then **Devices** to show the window above. Turn your GPS receiver on and make sure that Bluetooth is activated on your computer. Click on **Add Bluetooth or other device**.



Choose **Bluetooth** in the **Add Device** dialog, select your GPS receiver from the list and click on **Done**.

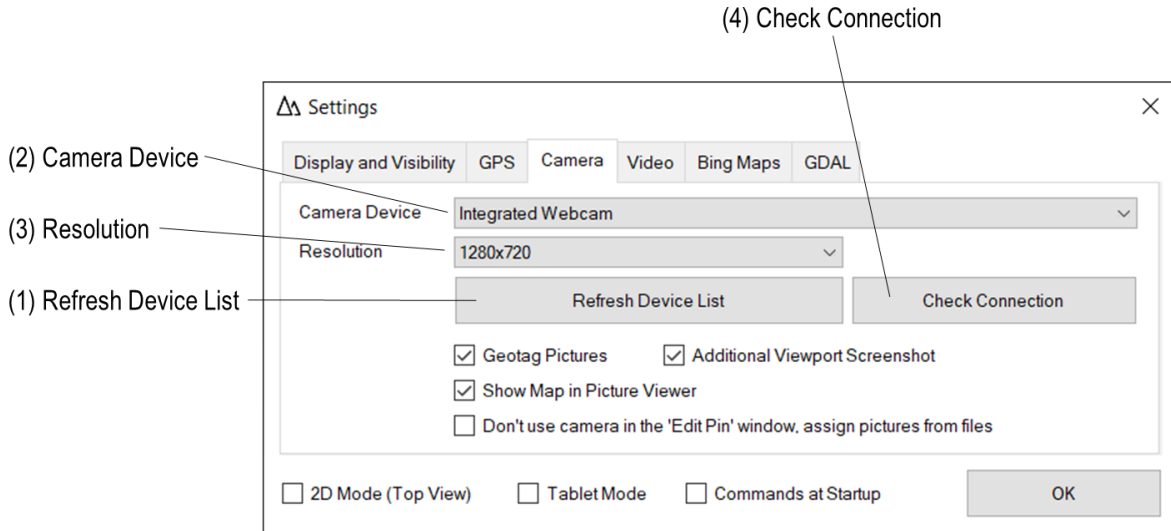


Choose the **External GPS Receiver** option in the **GPS Receiver** settings and click on **Refresh COM-Ports** to update the list. Windows assigns COM ports quite randomly and doesn't give them names that allow to see which port is assigned to the GPS receiver so you have to try each port. Select the last entry in the COM-Port list and click on **Check Connection**. If you get an error message, select the second to last entry and check the connection again. Repeat this procedure until you get a confirmation that the GPS receiver was successfully connected. Once the receiver is set up, you can use **GPS Track** and **GPS Location** mode.



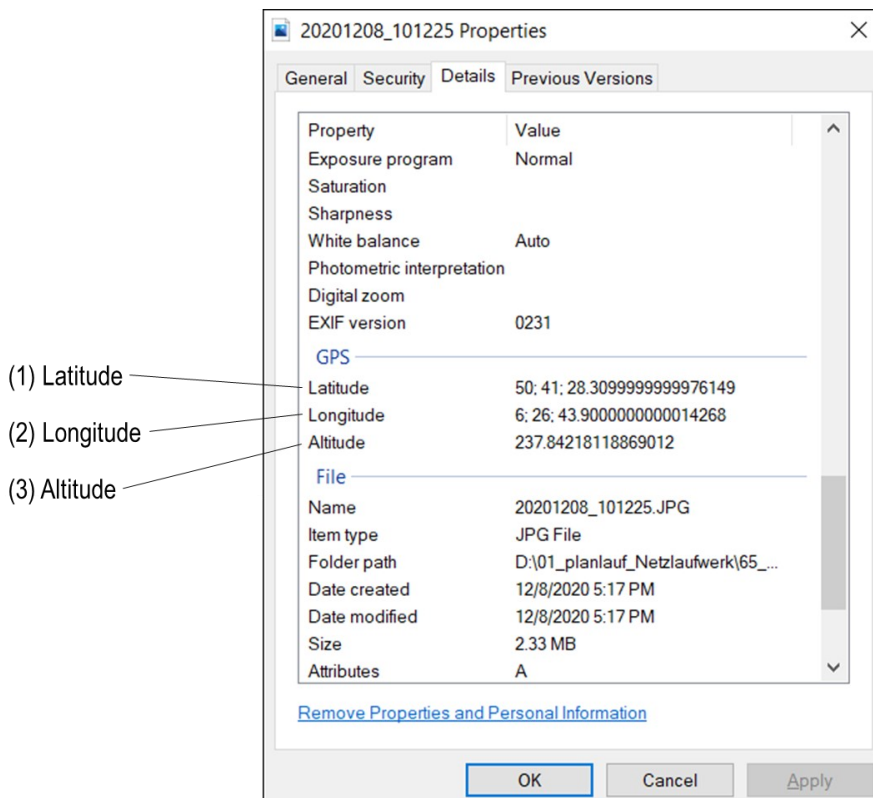
There are some additional options in the GPS Receiver tab:

- **Baud Rate:** Most GPS receivers will work with the default value. If you're having trouble connecting your receiver, please have a look at its manual to see whether it requires a different Baud rate and set the value accordingly.
- **Auto Save Track:** During GPS logging in **GPS Track** mode, the terrain file will be saved at the selected interval. You can also turn this option off.
- **Proximity Alerts:** If you select a pin during **GPS Track** or **GPS Location** mode, you will get three different acoustic signals as soon as you're within one of the three distances. This option defines the ranges or lets you switch the alerts off.
- **Minimum Point Distance:** If you choose this option, only GPS locations with the minimum distance value will be stored when you record a track with the **GPS Track** feature. Please note that the display of the white tail will still show all GPS locations that the GPS receiver is able to provide.
- **Display Location/Track Info:** Unchecking this option hides the location in the viewport.



planlauf/TERRAIN works with integrated or USB cameras. Click on **Refresh Device List**, select an entry in the **Camera Device** list and choose a **resolution**. Click on **Check Connection** to make sure the camera is properly set up and to show the camera's settings. Once the camera is set up, you can take pictures by clicking on the **Camera** button in the menu bar whilst being in **GPS Track** or **GPS Location** mode.

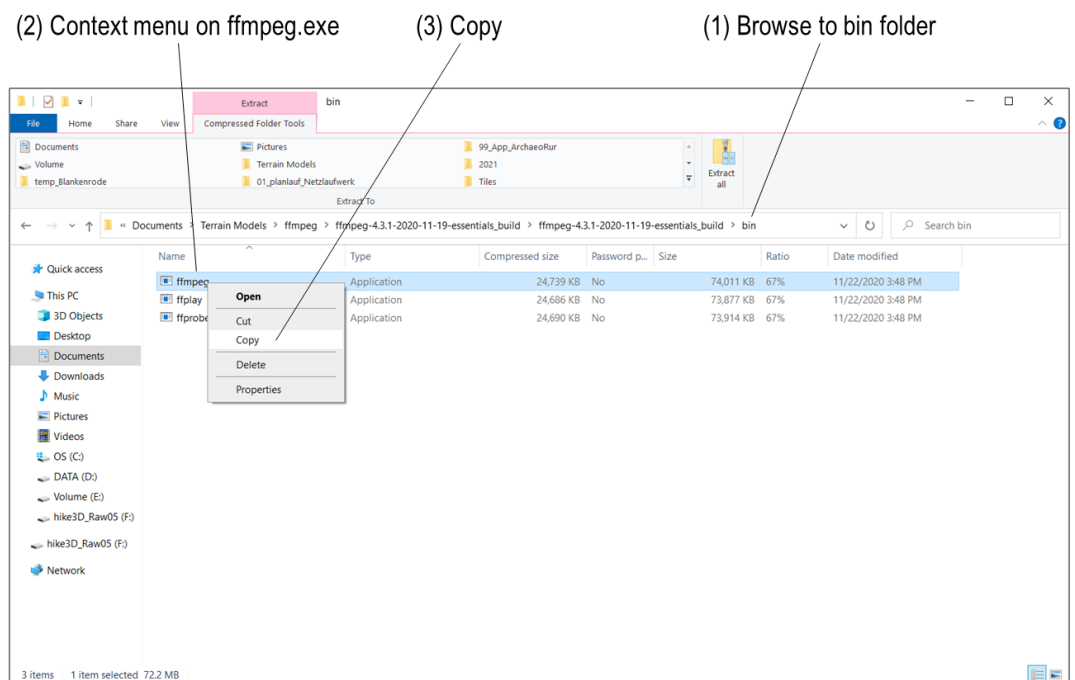
The **Geotag Pictures** option adds latitude, longitude and altitude to the EXIF properties of the JPG file. Check **Show Map in Picture Viewer** if you want to display a portion of the model with the marked location of the image in the **Picture Viewer**. You can assign picture files to pins if you check the **Don't use camera** option. Click in the **Edit Pin** window on the camera symbol to specify the file. Check the **Additional Viewport Screenshot** option to create a screenshot of the current model view whenever you take a picture. The screenshot will be saved to the same folder as the camera picture.



planlauf/TERRAIN can record videos of Fly-throughs, Look-arounds and Floodings with the help of FFmpeg. You can download FFmpeg from here: <https://www.gyan.dev/ffmpeg/builds/>

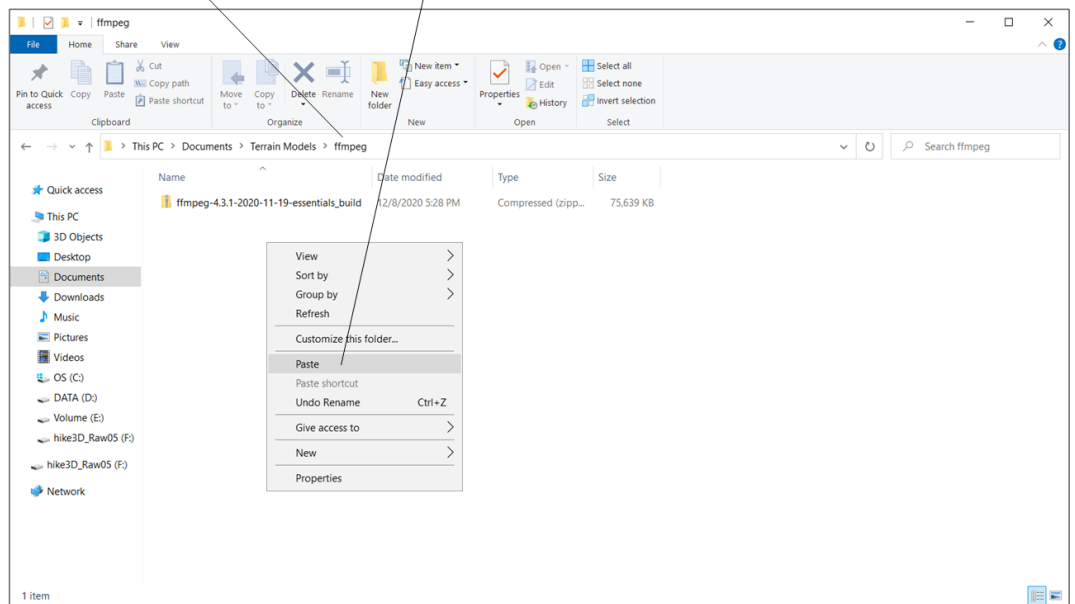


Download the file **ffmpeg-release-essentials.zip** in the **release** section.



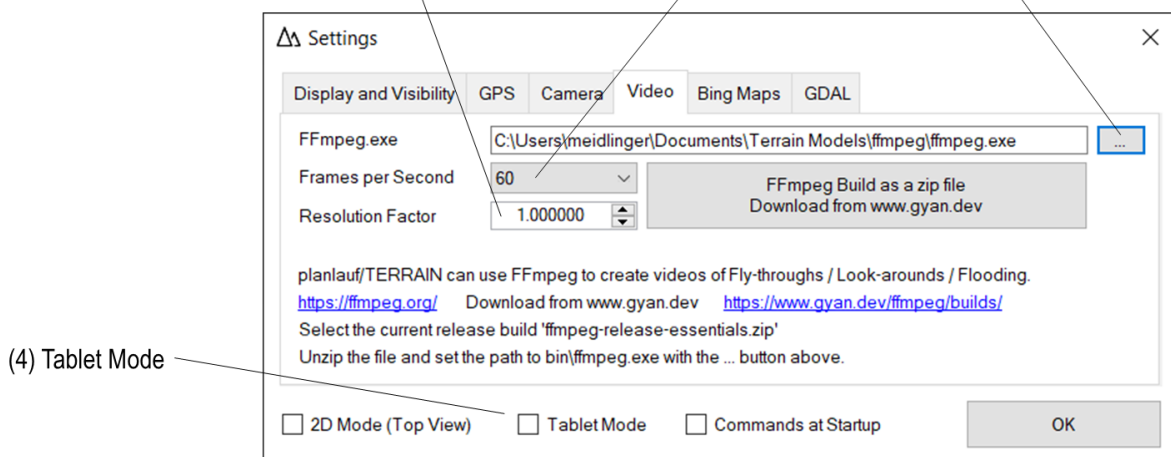
Open the zip file with a double click and browse to the folder '**bin**'. Open the **context menu** on the file **ffmpeg.exe** and choose **Copy** to put the file into the clipboard.

- (1) Create a folder for FFmpeg (2) Paste



Create a folder for FFmpeg and **paste** the file FFmpeg.exe into it.

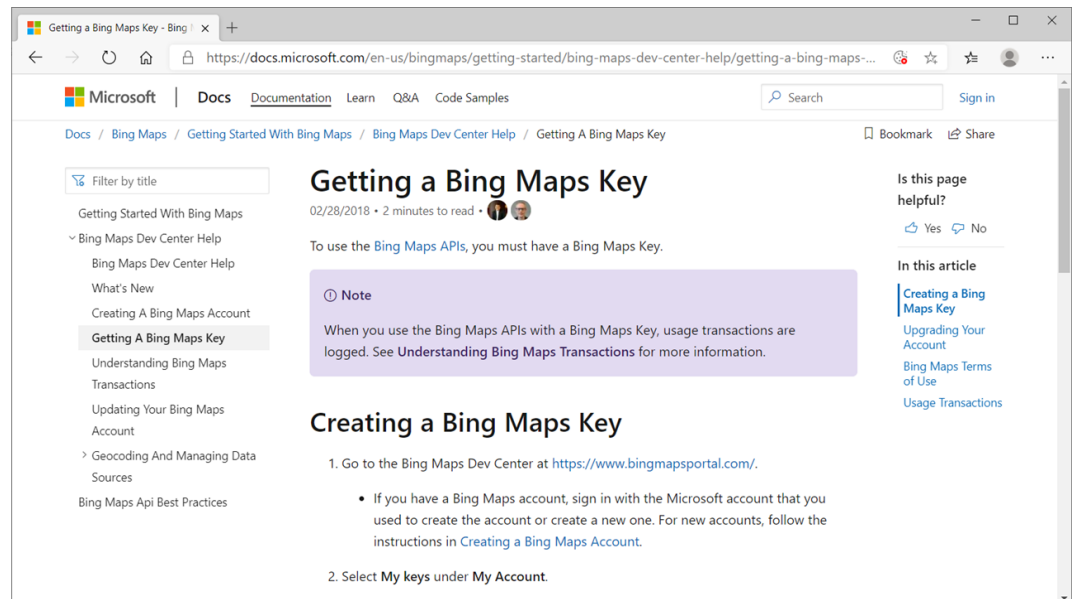
- (3) Resolution Factor (2) Frames per Second (1) Select FFmpeg.exe



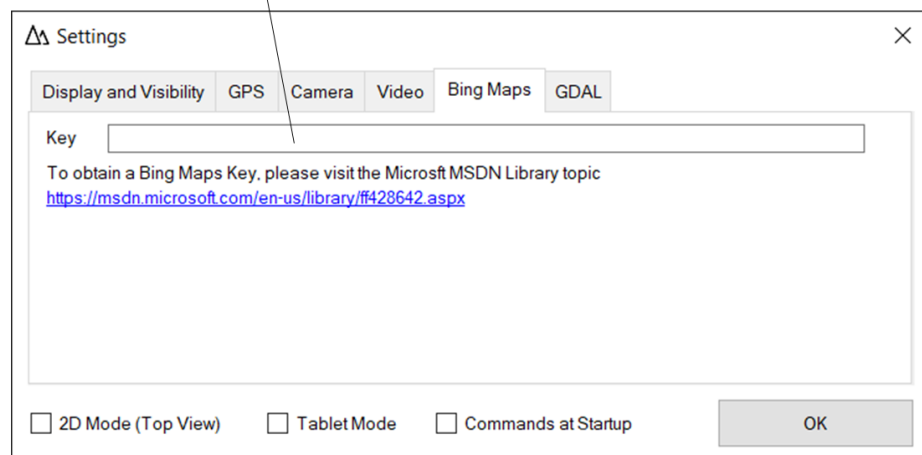
Click on the **Select FFmpeg.exe** button in the **Video** tab and choose the file. You can also copy FFmpeg.exe to the planlauf/TERRAIN directory in the Windows program folder if you have the appropriate write permissions. In this directory FFmpeg will automatically be detected. If you want to produce high quality videos, you might want to choose the 60 **Frames per Second** option. You can click on the **Download from www.gyan.dev** button to download and unzip FFmpeg automatically.

planlauf/TERRAIN records the videos in the viewport's resolution by default. You can adjust the **Resolution Factor** to change the size while maintaining the aspect ratio. Record a 2160p video on a 1080p monitor with a resolution factor of 2 with an activated **Tablet Mode** to hide the Windows taskbar and enlarge the viewport to the screen's extents.

The popular Bing Maps web services can be used in planlauf/TERRAIN. You need to obtain a free license key directly from Microsoft: <https://msdn.microsoft.com/en-us/library/ff428642.aspx>



Bing Maps Key



Enter the license key in the **Bing Maps** tab.

GDAL (Geospatial Data Abstraction Library) is an Open Source project by the Open Source Geospatial Foundation. Tamas Szekeres maintains a website from which you can download the latest GDAL builds: <http://www.gisinternals.com/>

Archive Versions



Click on **Archive Versions**.

Msvc 2017 x64 for 64-bit Windows



Select one of the last two entries for the MSVC 2017 compiler depending on whether you have a 32-bit or a **64-bit** Windows. Any GDAL version above 2.3.3 will work.

Generic installer for the GDAL core components

GISInternals Support Site

https://gisinternals.com/query.html?content=filesystem&file=release-1911-x64-gdal-3-1-4-mapserver-7-6-1.zip

Available downloads (release-1911-x64-gdal-3-1-4-mapserver-7-6-1):

File name	File date	Size	Description
release-1911-x64-gdal-3-1-4-mapserver-7-6-1.zip	2020-11-15 21:40:10	46092 kB	Compiled binaries in a single .zip package
release-1911-x64-gdal-3-1-4-mapserver-7-6-1-src.zip	2020-11-15 21:48:59	46275 kB	GDAL and MapServer sources
release-1911-x64-gdal-3-1-4-mapserver-7-6-1-libs.zip	2020-11-15 21:42:18	29110 kB	Compiled libraries and headers
GDAL-3.1.4.win-amd64-py3.5.msi	2020-11-15 21:40:14	836 kB	Installer for the GDAL python bindings (requires to install the GDAL core)
gdal-301-1911-x64-oracle.msi	2020-11-15 21:40:48	1024 kB	Installer for the GDAL Oracle plugin (must be installed to the same directory as the GDAL core)
gdal-301-1911-x64-ecw-33.msi	2020-11-15 21:40:40	1492 kB	Installer for the GDAL ECW 3.3 plugin (must be installed to the same directory as the GDAL core, the 3.3 and 5.x versions cannot be installed side by side)
GDAL-3.1.4.win-amd64-py3.4.msi	2020-11-15 21:40:13	800 kB	Installer for the GDAL python bindings (requires to install the GDAL core)
gdal-301-1911-x64-core.msi	2020-11-15 21:40:39	33312 kB	Generic installer for the GDAL core components
GDAL-3.1.4.win-amd64-py3.7.msi	2020-11-15 21:40:16	836 kB	Installer for the GDAL python bindings (requires to install the GDAL core)
GDAL-3.1.4.win-amd64-py2.7.msi	2020-11-15 21:40:12	800 kB	Installer for the GDAL python bindings (requires to install the GDAL core)
mapserver-7.6.1-1911-x64-core.msi	2020-11-15 21:41:09	36456 kB	MapServer installer with IIS registration support
GDAL-3.1.4.win-amd64-py3.6.msi	2020-11-15 21:40:15	836 kB	Installer for the GDAL python bindings (requires to install the GDAL core)

Download the **generic installer for the GDAL core components** and run the file to install GDAL.

Select GDAL folder

Settings

Display and Visibility GPS Camera Video Bing Maps **GDAL**

GDAL Directory

planlauf/TERRAIN can use GDAL to import data formats which are not directly supported. The Geospatial Data Abstraction Library (GDAL) is a computer software library for reading and writing geospatial data formats by the Open Source Geospatial Foundation. <http://www.gdal.org/>

You can download installer packages from Tamas Szekeres' site: <http://www.gisinternals.com/>

GDAL Windows 64bit installer
Download from GISInternals

Under "Stable Releases" you will find the appropriate installer (e.g. gdal-300-1911-x64-core.msi for 64 bit). GDAL 2.3.3 or up is recommended

☐ 2D Mode (Top View) ☐ Tablet Mode ☐ Commands at Startup

OK

If the GDAL install directory is not the usual C:\Program Files\GDAL you'll have to specify the directory in the **GDAL** tab. Otherwise, it will be recognized by planlauf/TERRAIN automatically. You can also click on the **Download from GISInternals** button to download and unzip GDAL automatically.