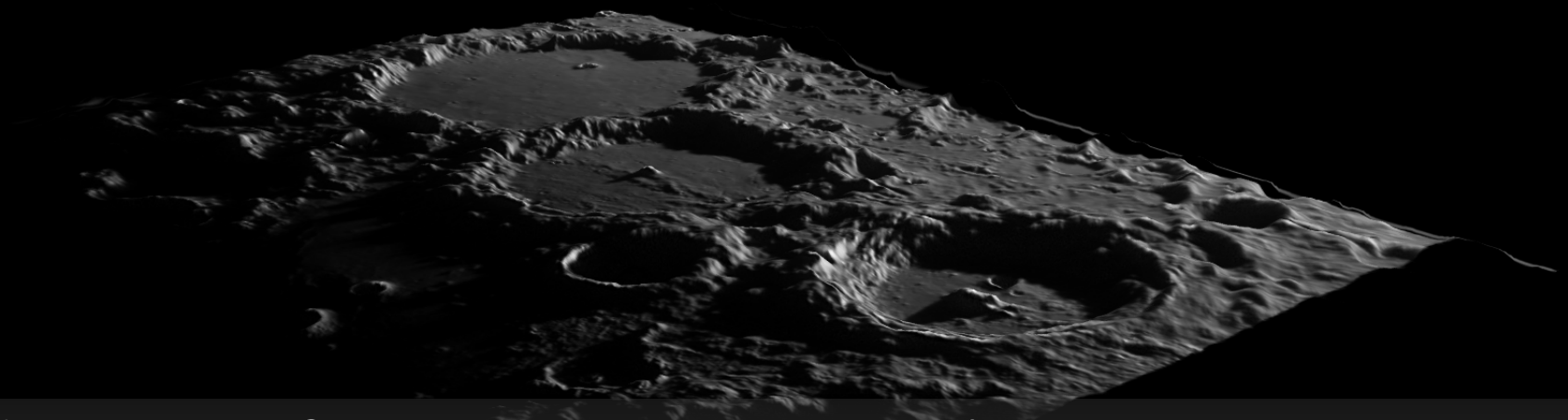
Creating interactive 3D Moon models with QGIS

Tommi Ropponen, URSA Solar system meeting

Feb 13th 2021, Finland



So, how do I georeference LRO DEM with Moon images and run the 3D model in a web browser?

Contents

Main topics for the presentation

- The goal
- Inspiration
- What tools do I need?
- What material do I need?
- Getting QGIS up and running with plugins
- Georeferencing
- 3D model workflow & an example of image quality
- 3D model examples
- Summary
- Contact information

The goal

What will you know after this presentation?

I will show you how to

- Obtain QGIS
- Install plugins
- Clip digital elevation model to your needs
- Georeference
- Build a 3D model

The goal

- Follow these instructions and make you own 3D model

Inspiration

How did I get myself into this?

It was early January 2017…

- I was reading Cloudy Nights forum and saw a post from Luc Cathala showing some amazing 3D models which Alain Paillou (easybob95 @ CN) had created from Luc's photos.
- As I saw that Alain had created the models with QGIS I was intrigued as I had been using QGIS at work to support visualization of different matters.
- Alain posted some more stuff including videos and it looked super cool! At this point I was committed.
- I did some research on 3D modelling with QGIS, but *I wanted more than just stationary renderings or videos in which the flight path is predetermined.* This is when I read about Qgis2threejs plugin for QGIS and thought about giving it a try…

My inspiration

- From Alain Paillou & Luc Cathala

What tools do I need?

Assuming you have a computer, of course

Requirements

- A computer (no need for heavy computing rig)
- QGIS
- QGIS plugins “Georeferencer” and “Qgis2threejs”
- Lunar Reconnaissance Orbiter (LRO) Digital Elevation Model (DEM)
- A high quality photo of the Moon
- A web browser
- Some time to learn the process (but once you get it dialed in, it’s pretty easy and does not take a lot of time)

The tools

- Besides a computer and Moon photos everything is open source or freely available

What material do I need?

Where do I get a Moon image and what is DEM?

You need to have these

- A photo of the Moon
  - This can be a closeup on some Lunar features such as a rille or a crater or a more wide field area of the surface
  - Take a look into your own library or ask a quality photo from your astroimaging colleague or use free images
- Digital elevation model or DEM for the topography of the Lunar surface features
  - Go to USGS Astropedia and download “the whole Moon” or ask for user account (it’s free!) and select which areas to download
  - Moon LRO LOLA DEM 118m v1 is a very large file
    - I have downloaded this in 2017 originally as a cub file but now it seems that one can download tiff file and avoid an extra step of converting it to tiff
    - My recommendation: Download the whole DEM as you only need to do this once

Tip:
As the USGS site is sometimes down, there are also alternative locations for data download such as http://imbrium.mit.edu/

If you end up working with orbiter images you may need to have more accurate DEM. In these cases you should check http://wms.lroc.asu.edu/lroc/view_rdr/WAC_GLD100 and probably the most detailed DEM version at https://pgda.gsfc.nasa.gov/products/54

Material

- A high quality photo of the Moon
- LRO DEM

Getting QGIS up and running with plugins

You only do this once

Get it running

- Configure it once and that’s it!

Getting started

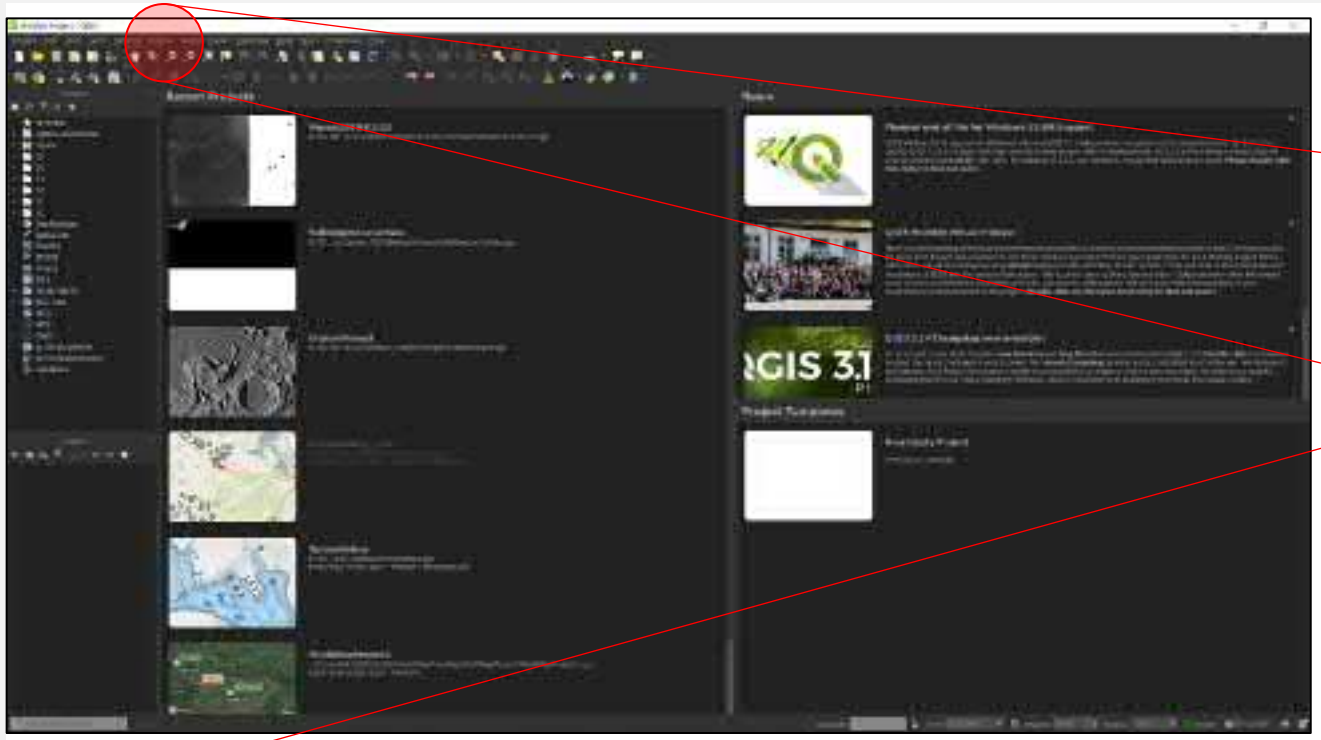
- Download QGIS of your choice
  - Depending on your needs you can choose current release, long term release of even some bleeding edge versions
  - My recommendation: use long term release to avoid updating the system all the time
  - I currently use QGIS 3.10 A Coruña LTR
- Enable / download QGIS plugins "Georeferencer" and "Qgis2threejs" via plugin manager
  - The first allows one do georeferencing i.e. align e.g. the digital elevation model and your photo – comes usually with the QGIS but you may need to enable it
  - The second allows one to create a 3D model that can be used interactively within any modern web browser – search for this in plugin manager

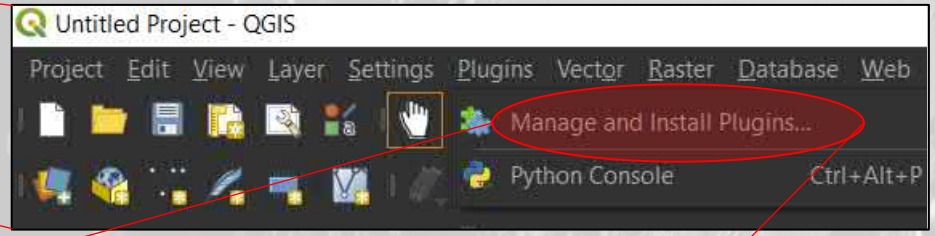
Get it running

- Configure it once and that's it!

Install plugins

- Install Qgis2threejs
- Make sure Georeferencer is enabled and found under Raster
- Now you're good to go





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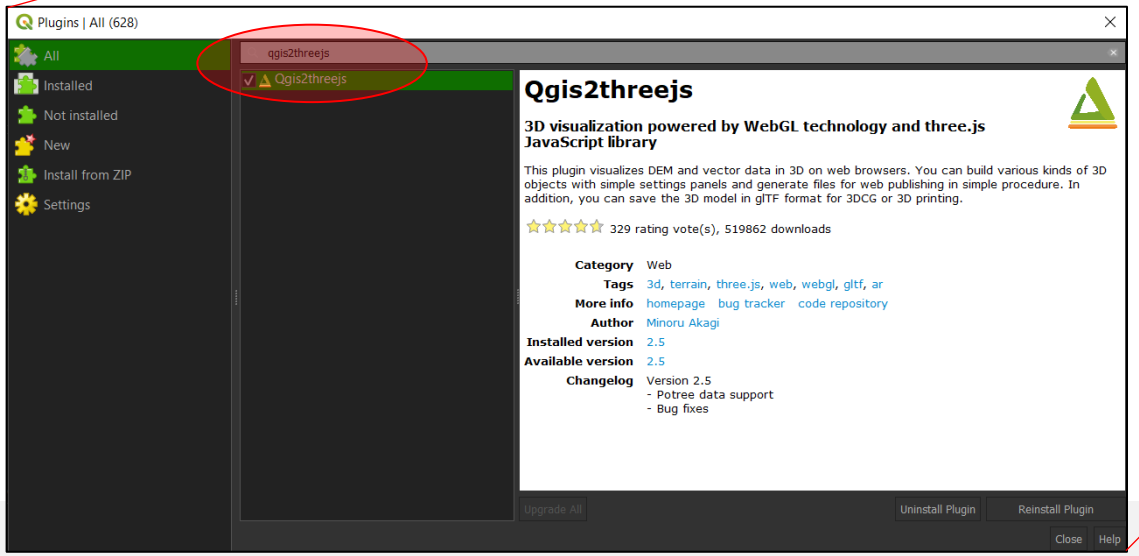


Now you have QGIS and required plugins available

Georeferencing

Making sure that the DEM is aligned with craters

Clip the LRO DEM

- Allows faster workflow
- Requires less processing time from the computer

Use suitable area of the DEM

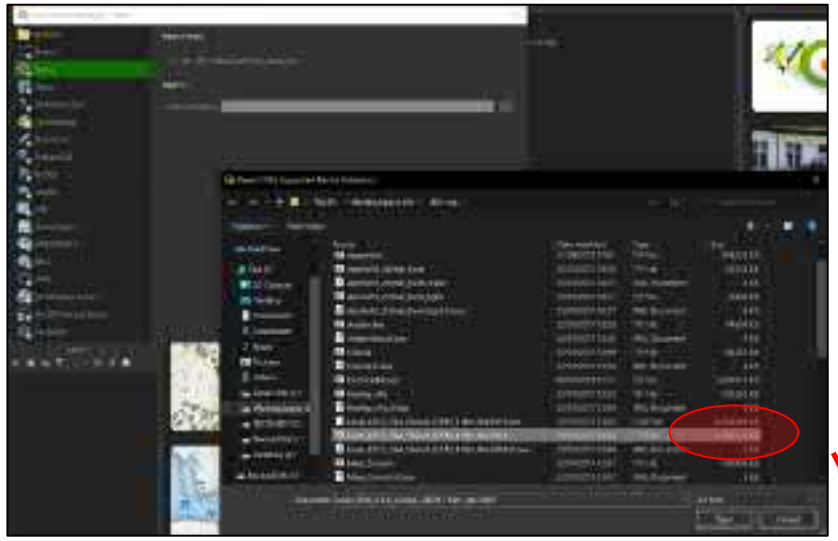
- Let's assume you have selected a photo which you want to model in 3D
- Select only the area which you are going to process by clipping the DEM
- *Let's work with Ari Haavisto's excellent image of Ptolemaeus, Alphonsus and Arzachel as an example*

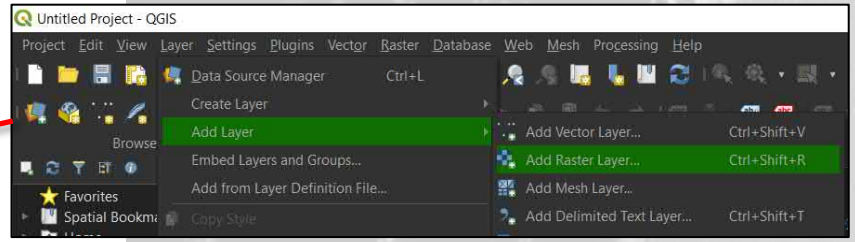
Tip:
Select slightly larger area in the DEM than in your image: you can always trim it later a bit more but you cannot import parts which have already been cut away

Clip the LRO DEM

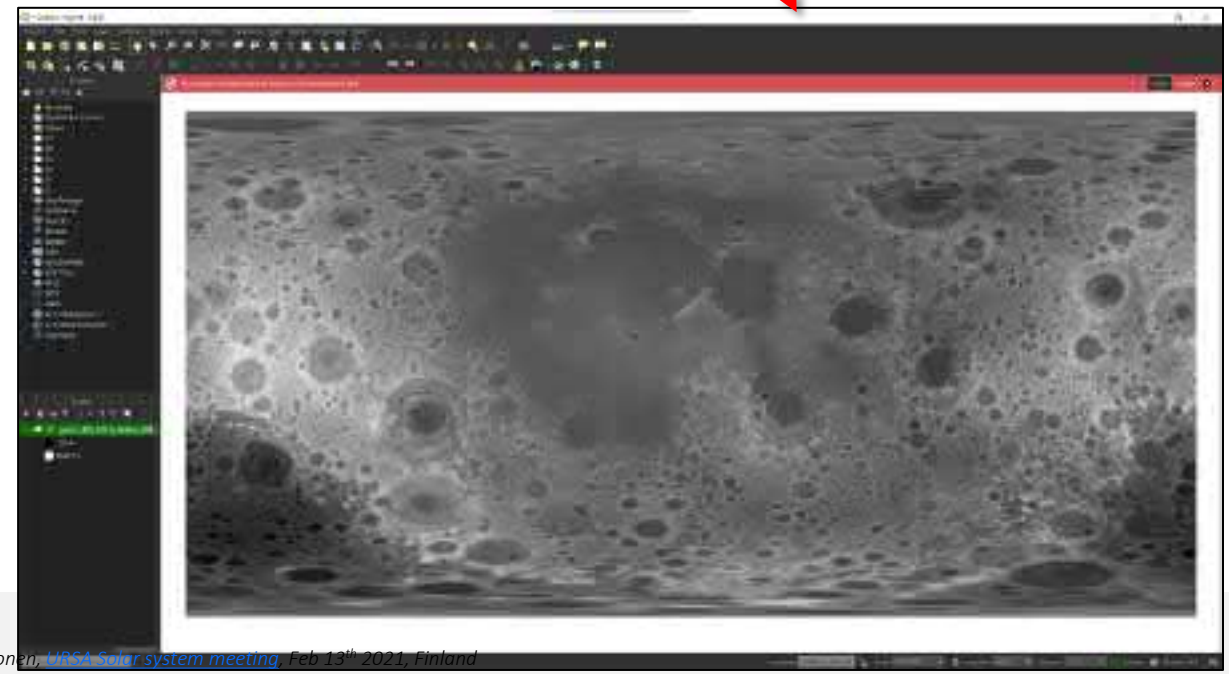
- Allows faster workflow
- Requires less processing time from the computer

Open QGIS and add LRO DEM as raster layer



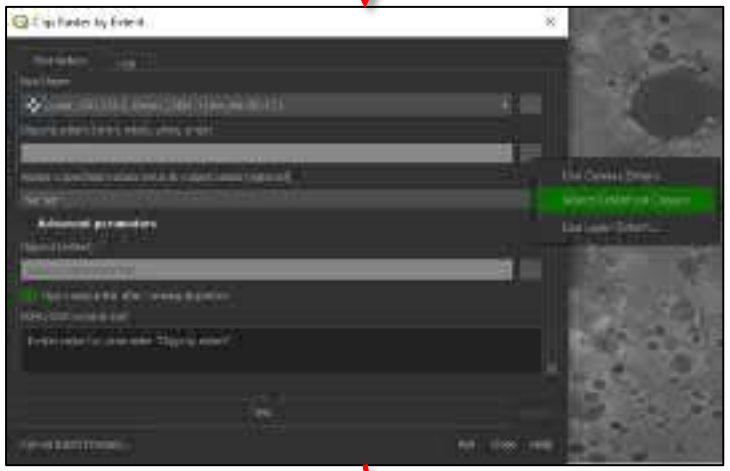


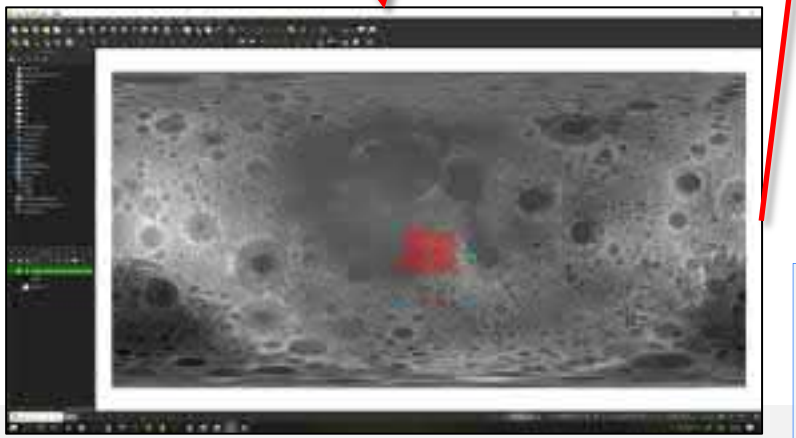
Full extent DEM in QGIS



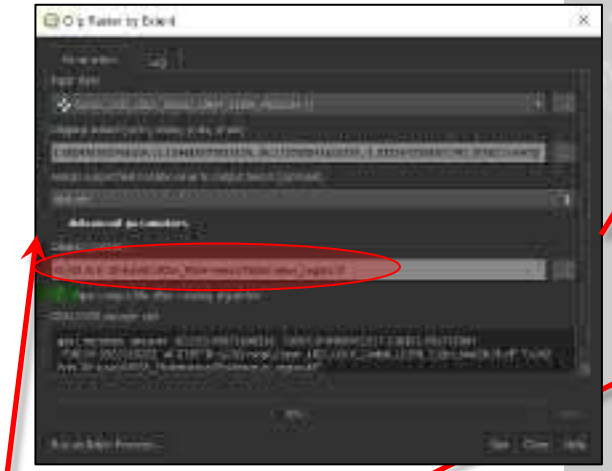
Clip the LRO DEM

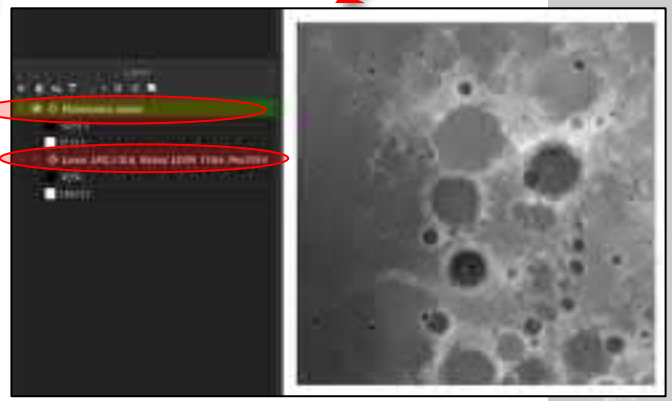
- Allows faster workflow
- Requires less processing time from the computer





1) Select a suitable area of the DEM clip it as a separate layer and save it as a new file





Clip the LRO DEM

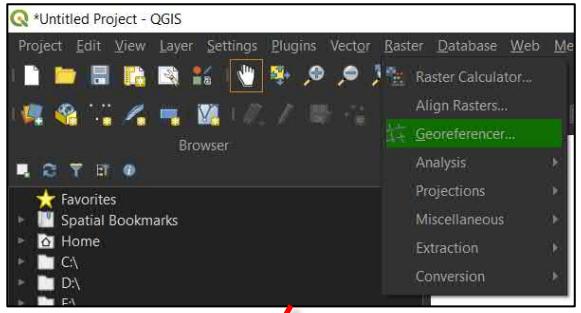
- Allows faster workflow
- Requires less processing time from the computer

2) Now you have two raster layers: Original LRO DEM and your smaller area DEM named here as *Ptolemaeus region*

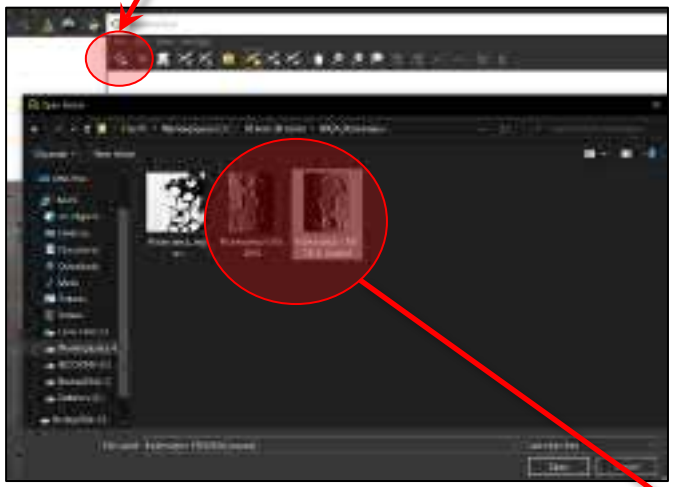

Now you have a smaller DEM to work with and its easier to continue

Align features

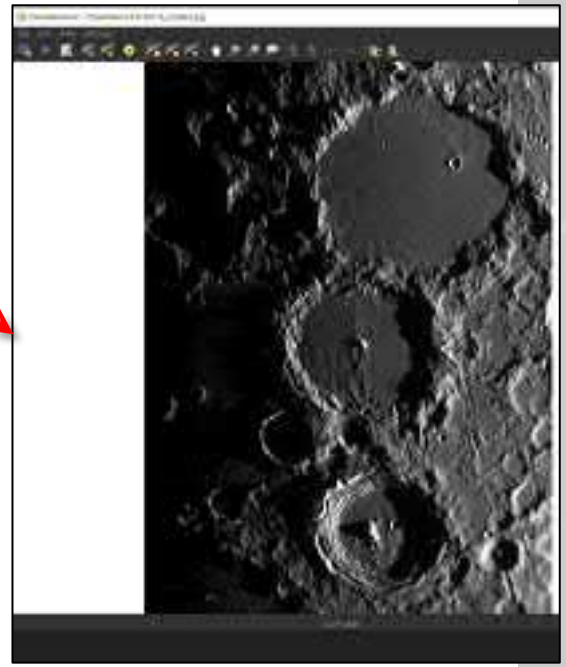
- Align Lunar surface features between your photo and the DEM



Open the Georeferencer under Raster …



… and open your actual photo of the Moon as a new raster layer within the georeferencer



Tip:
Rotate your photo, if necessary, to match the orientation of the DEM as it makes alignment much easier

Align features

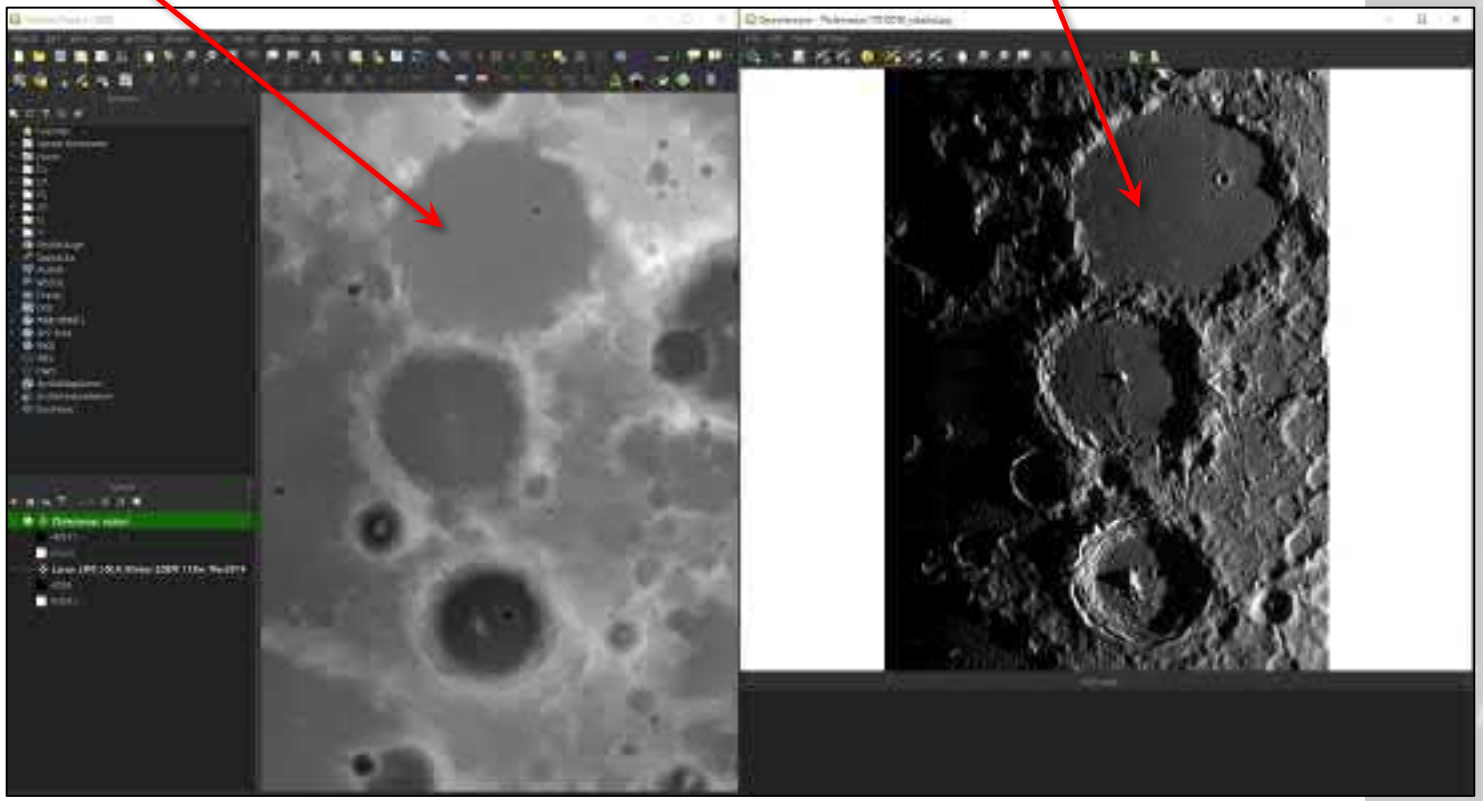
- Align Lunar surface features between your photo and the DEM

QGIS has now two windows open unless you have selected to dock the Georeferencer window in Georeferencer settings (which you can do if you like)

The actual work starts as you need to select same features from both the DEM and your photo…

DEM

Photo



Align features

- Align Lunar surface features between your photo and the DEM

Note: Yellow adds a point, red removes, blue allows you to adjust the location of the point in your photo

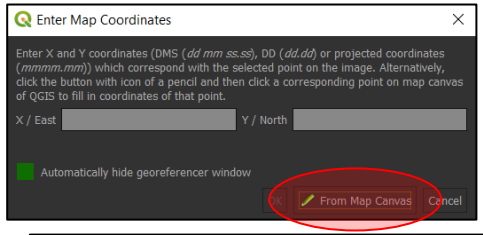
1) In the Georeferencer window choose to add a point

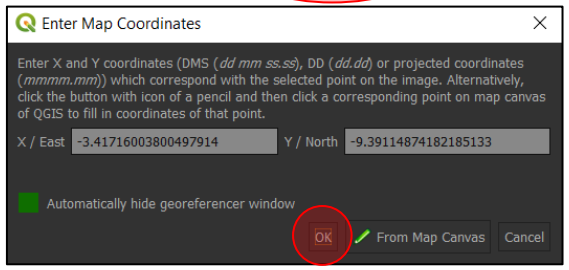
2) Select a feature on your photo such as a small crater and left click this feature

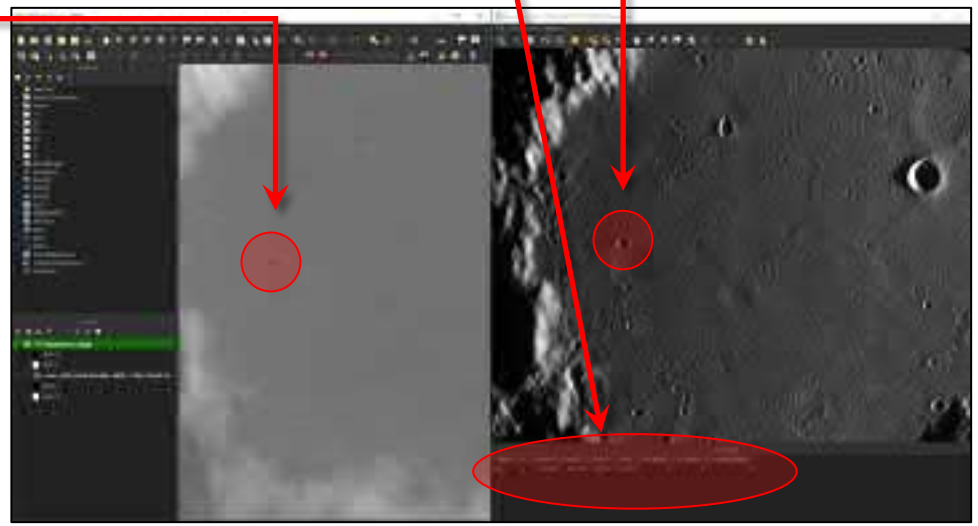
3) As the popup opens, select “From map canvas” and

4) Select the same feature location on the DEM window and click OK

5) Added points will show under your photo







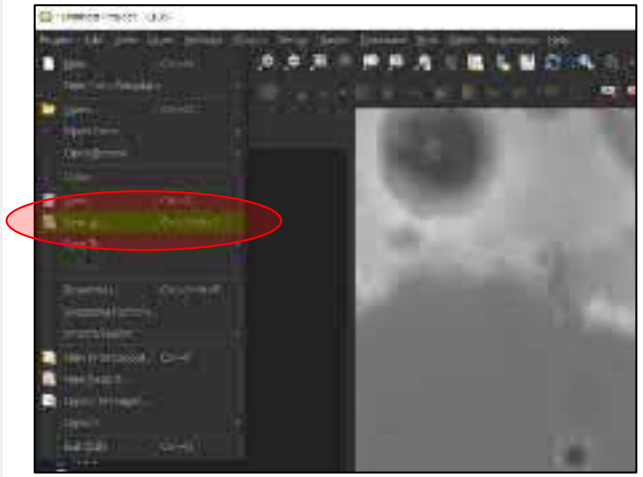
Tip:
Note: The normal procedure in any GIS software is to set Coordinate Reference System (CRS) at the start but if you don’t need exact Lunar coordinates, don’t bother as you don’t need that info to build the 3D model.

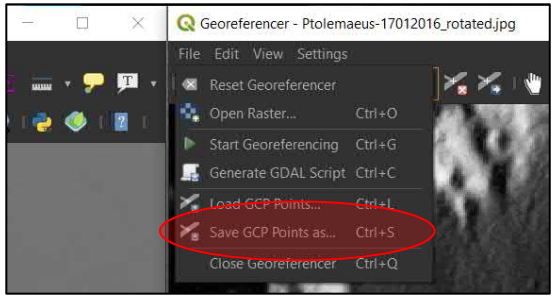
Align features

- Align Lunar surface features between your photo and the DEM

Remember to save your Ground Control Points (GCP) into a file and save the project.

QGIS 3.10 LTR is very stable but developer versions are more prone to crashing and you most likely don't want to set all GCPs manually again…





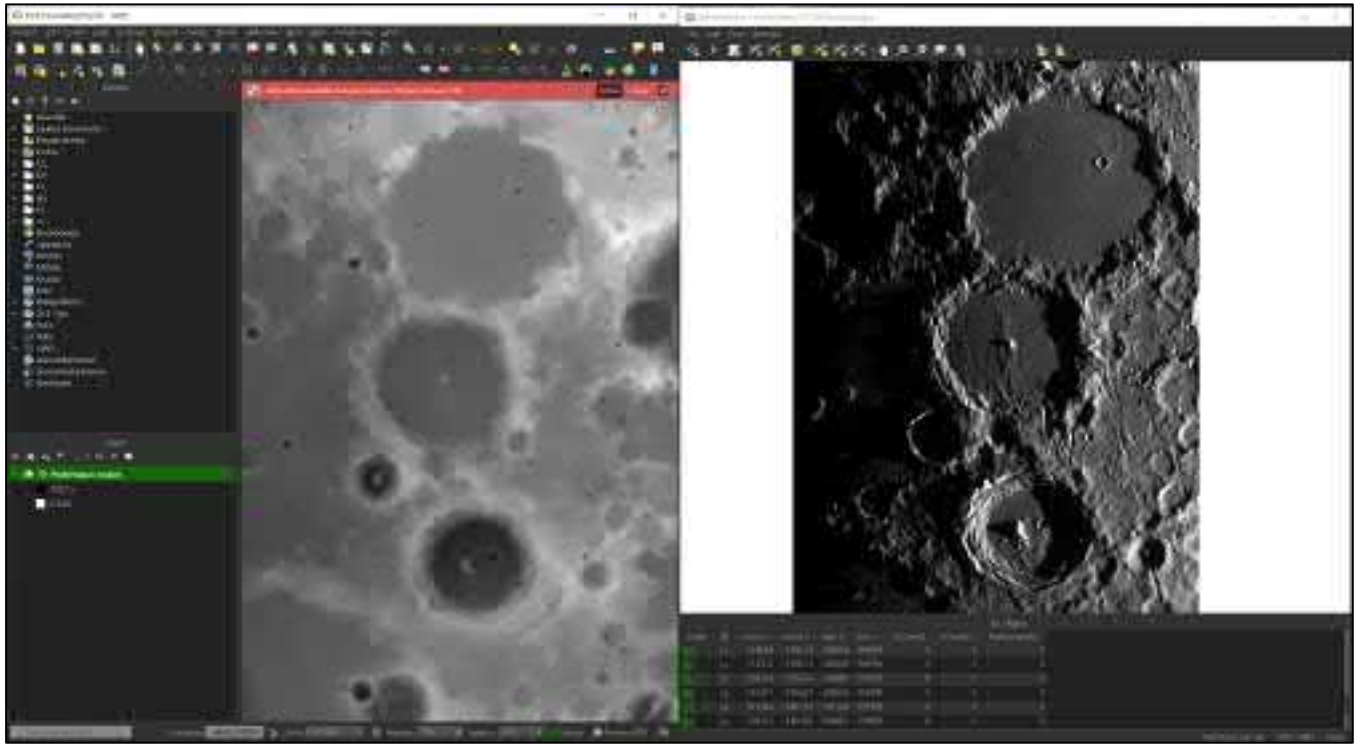
Align features

- Align Lunar surface features between your photo and the DEM

This example project of Ptolemaeus has 22 alignment points:

- Several points set as close to photo corners and edges as possible
- Several points set also at the small craters and other features

Note: When you select points at the edges and corners you'll get a better alignment and this is crucial in larger area projects and e.g. in close-up photos closer to the Moon poles or limb (the closer you go, the harder the process is for the algorithms).



Tip:
The number of required alignment points depends on your photo:

- For closeup photos you may only need around 20 points (or less)
- For very large field of view photos you may need 100 points

Its all manual work so this is the time consuming part of the process

Align features

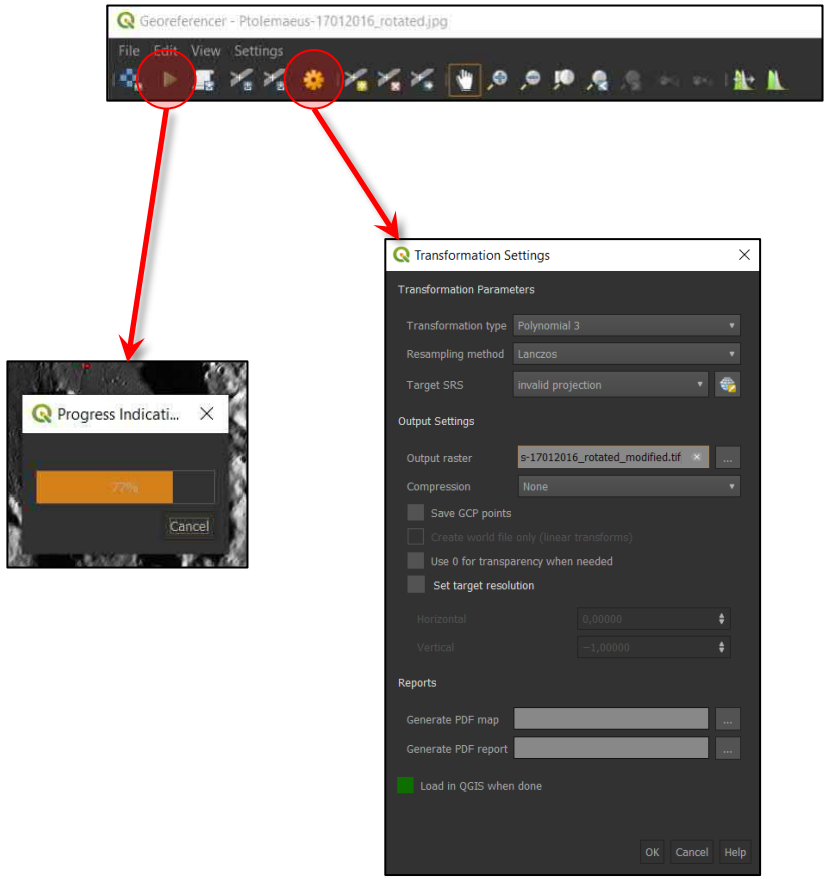
- Align Lunar surface features between your photo and the DEM


Now you’re done with the alignment points!

Georeferencing settings

- Select suitable settings
- Reference and compare
- Errors / issues show as lines instead of points

1) Set proper transformation settings
2) Check output raster name
3) Choose to load in QGIS when done
4) Run the georeferencing



Tip:
For best results I typically use
- Polynomial 3 as transformation type as it allows more elaborate stretching and transformation
- Lanczos as resampling method

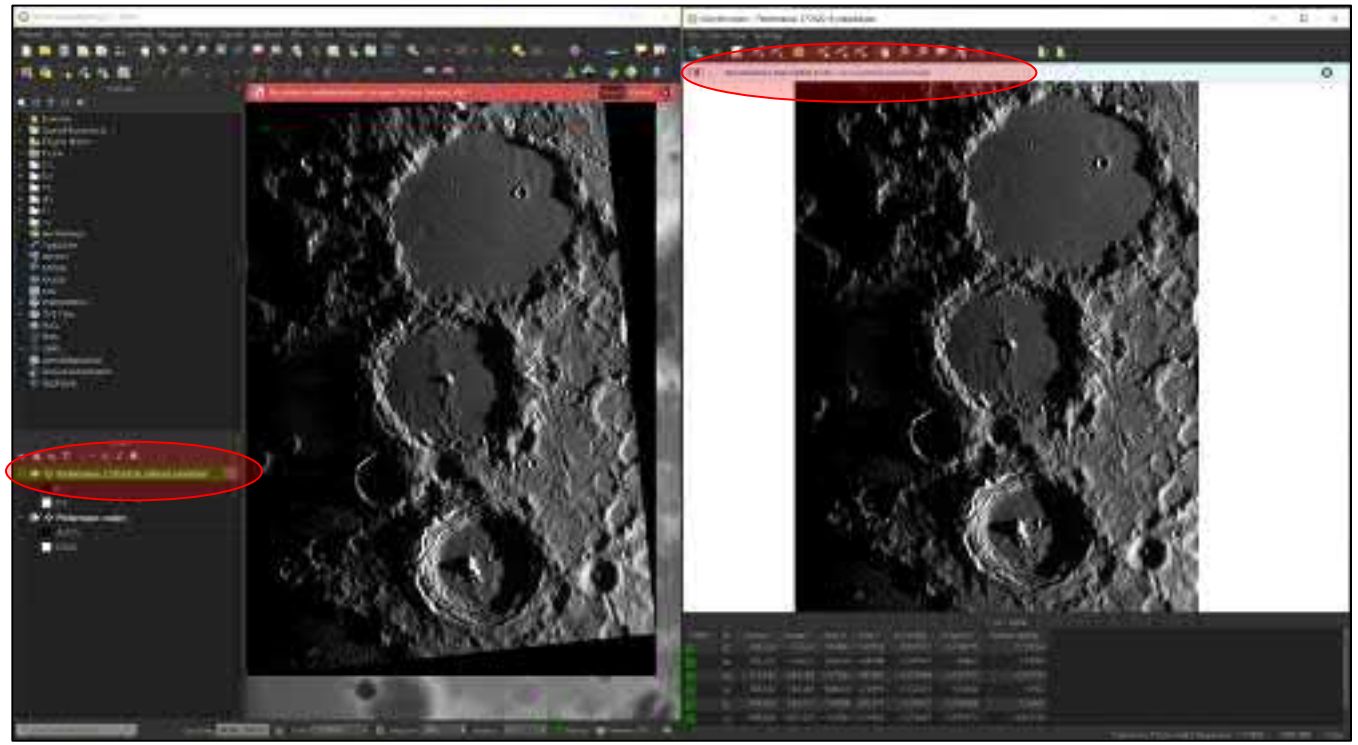
Georeferencing settings

- Select suitable settings
- Reference and compare
- Errors / issues show as lines instead of points

After successful georeferencing you will see

- a notification in the georeferencer window and
- A new raster layer in the layers pane (photo name with added “modified” at the end of the name)

At this point you can minimize the georeferencer window (or close it if you have saved all the alignment points)



Georeferencing settings

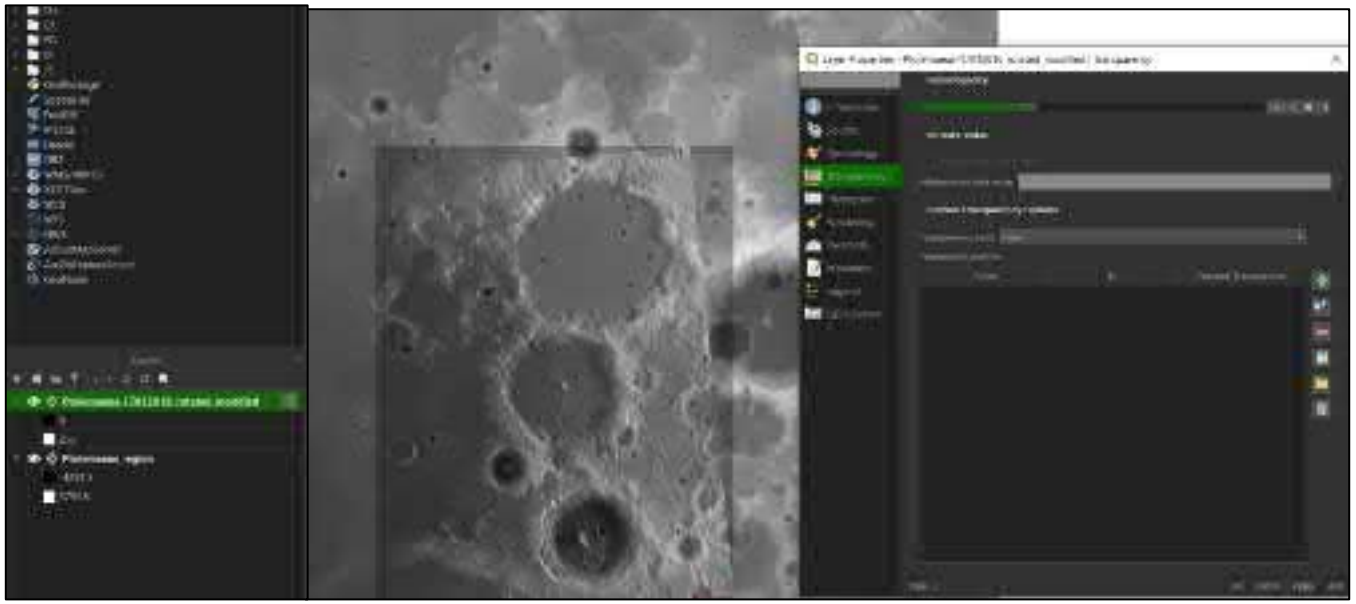
- Select suitable settings
- Reference and compare
- Errors / issues show as lines instead of points

Compare the georeferencing results with the DEM:

- Right click on the new georeferenced layer
- Select properties
- Adjust transparency and compare with the DEM layer underneath

If all is OK you can see a nice match of features!

- Set transparency back to normal



Georeferencing settings

- Select suitable settings
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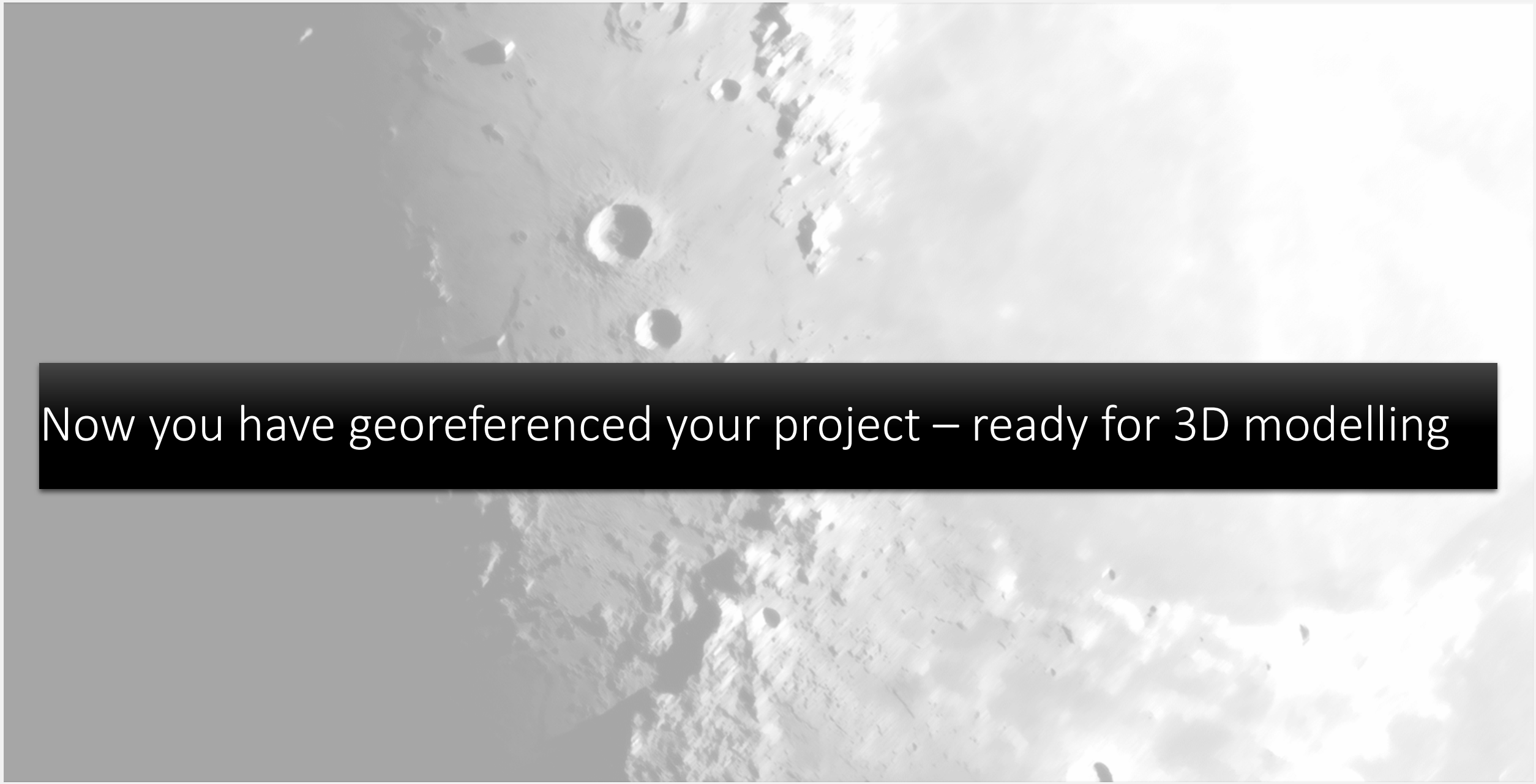
- Errors / issues show as lines instead of points



Now you have georeferenced your project – ready for 3D modelling

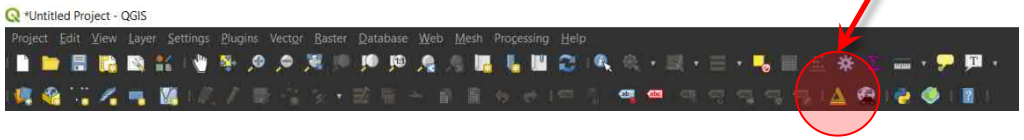
3D model workflow

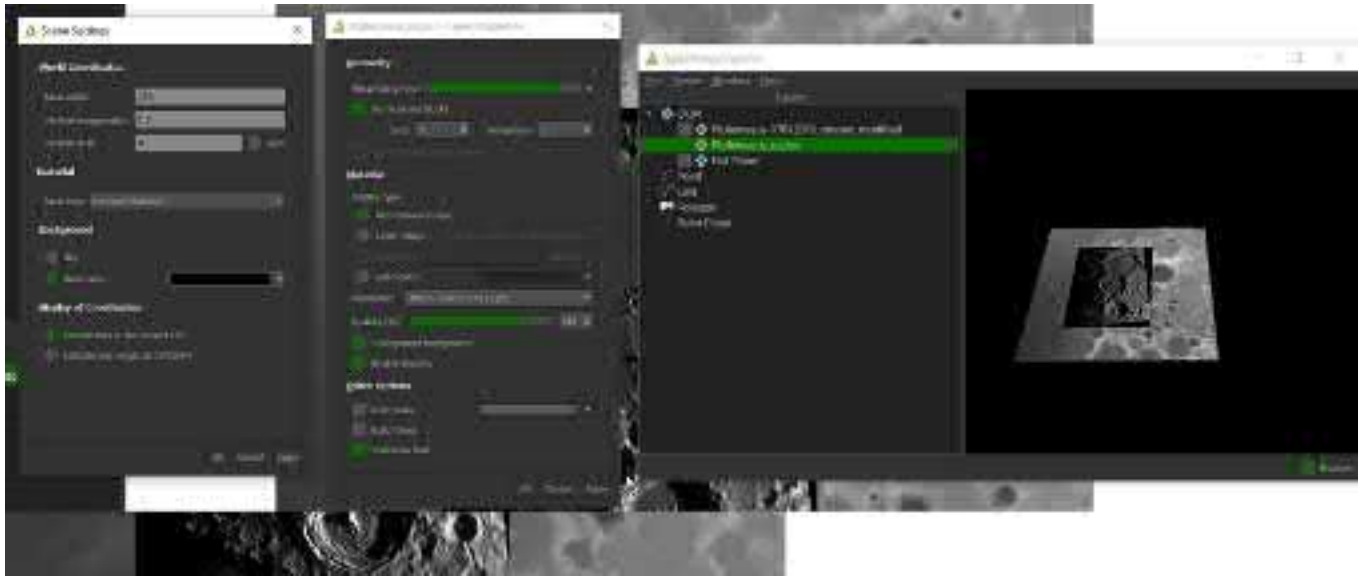
Parameters and visualization

Within Qgis2threejs you have to

- Select the DEM
- Adjust the DEM layer properties
- Adjust the scene settings

Start by opening Qgis2threejs by clicking on the triangular icon.





Qgis2threejs

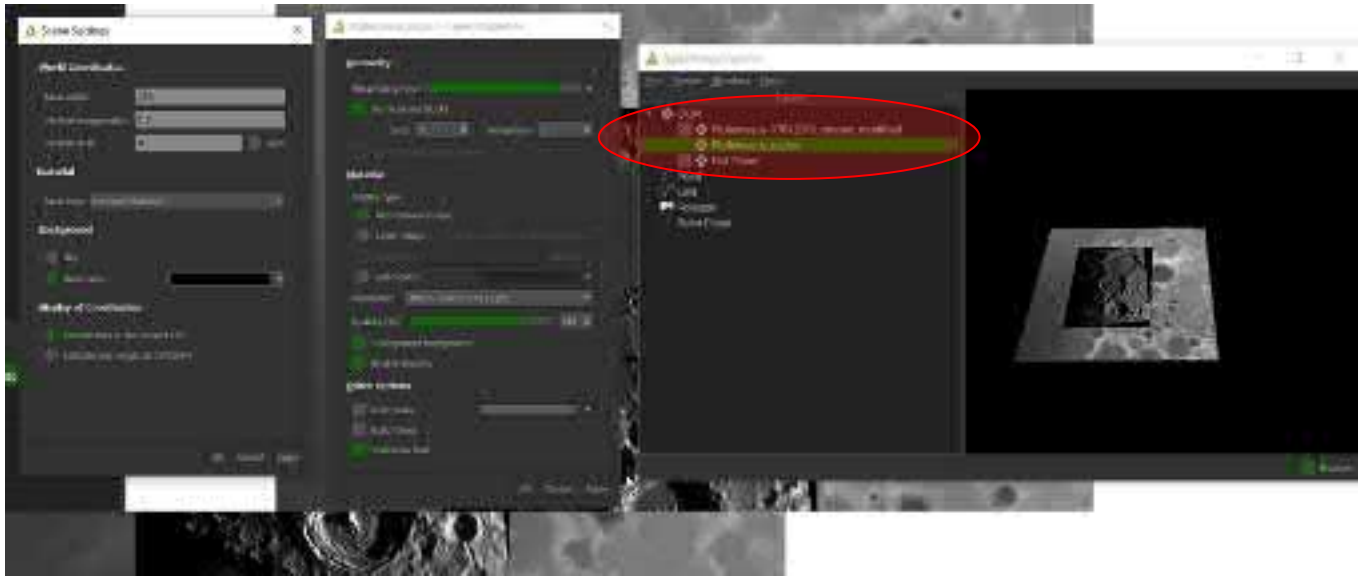
- Adjust parameters to your liking
- Preview within seconds

Selecting the DEM

Select which raster layer you want to use as DEM.

This example has three options

- Flat plane: no elevation
- Ptolemaeus-17012016_rotated_modified: The raster image of the Moon
- **Ptolemaeus_region**: DEM which was earlier clipped from the whole Moon DEM. This is what you need to choose!



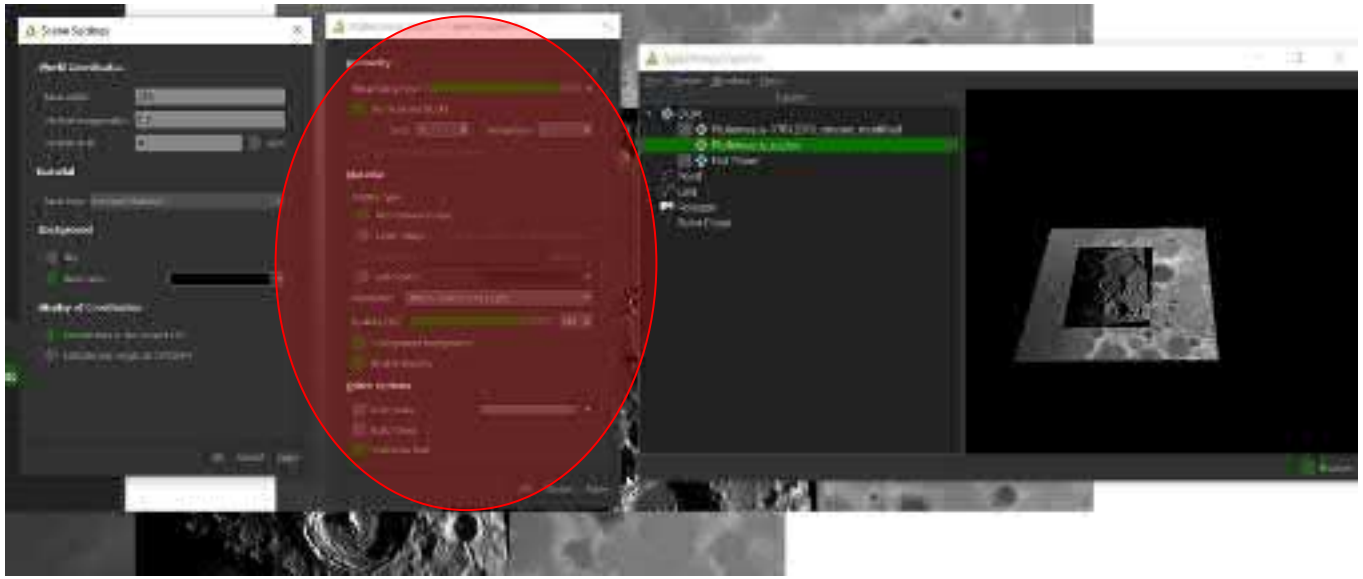
Qgis2threejs

- Adjust parameters to your liking
- Preview within seconds

Layer properties (adjusting the DEM)

- Right click on the DEM layer name and select properties
- My baseline settings are shown below
- Play around with the settings and you'll see the difference in your model!

Note: You may need to adjust these settings based on your image in order to make the model pleasant to use via web browser.



Tip:
Check Qgis2threejs manual for details about parameter choices:
https://buildmedia.readthedocs.org/media/pdf/qgis2threejs/docs/qgis2threejs.pdf

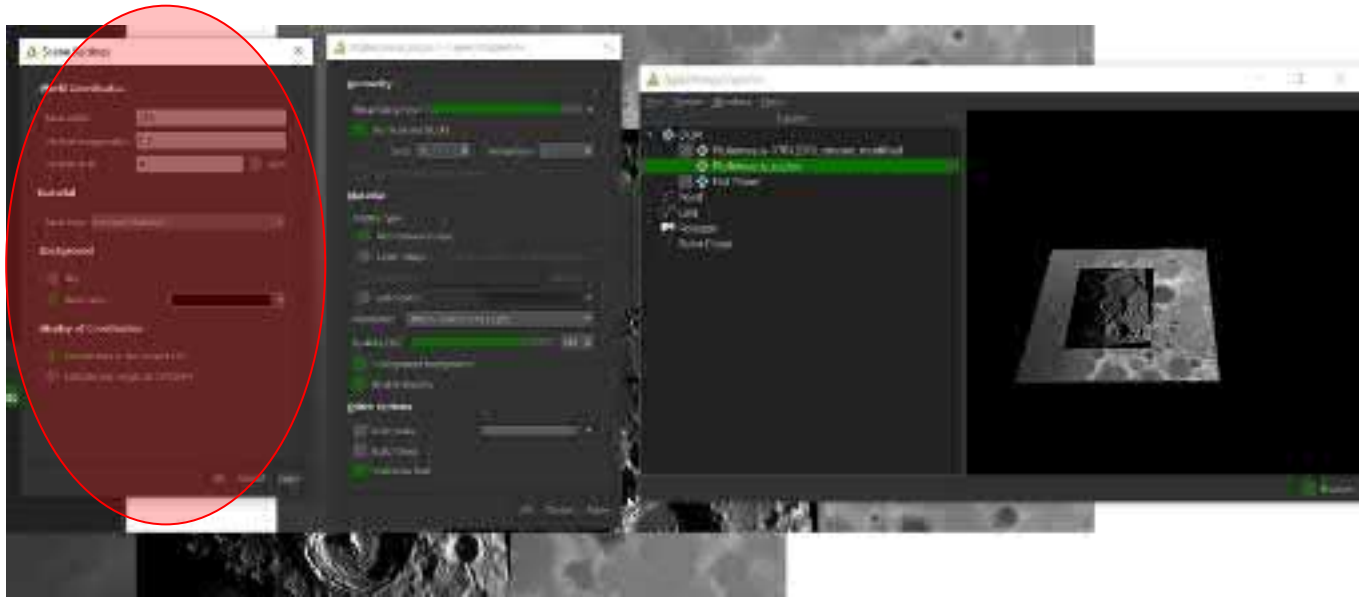
Note: I have not seen manual for Qgis2threejs v2.5 (the above is for 2.4 so some options are changed). However, the parameters are described in it properly.

Qgis2threejs

- Adjust parameters to your liking
- Preview within seconds

Scene settings (adjusting overall model appearance)

- If you want to emphasize the elevation increase *Vertical exaggeration* from 1.0 e.g. to 1.5
- I typically use 1.5 for improved visualization but for the most realistic view choose 1.0
- I tend to use black background for Moon images but you may choose it as you like



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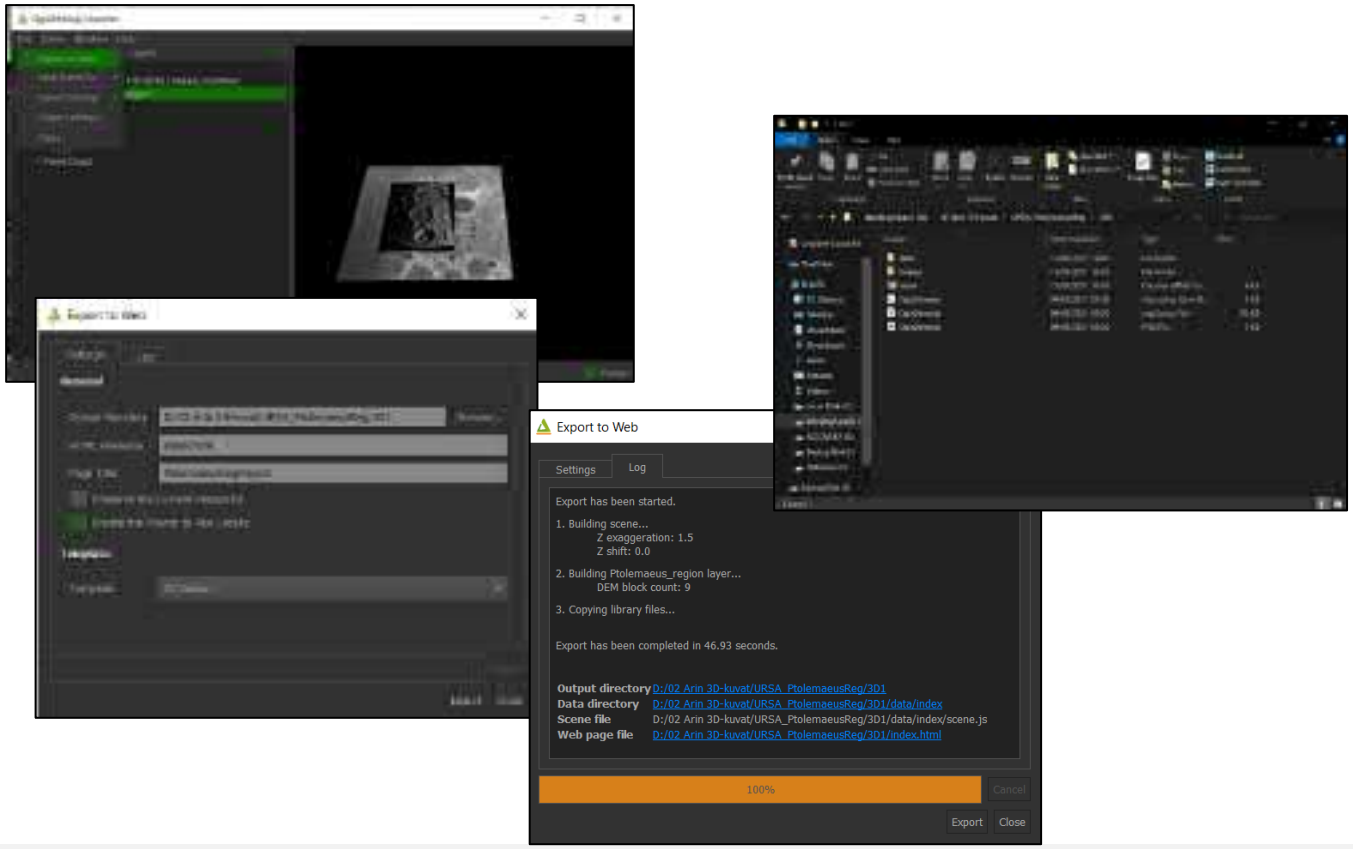
Qgis2threejs

- Adjust parameters to your liking
- Preview within seconds

Export the model

- File / Export to web produces a model which can be studied in a web browser
- Select “Enable the Viewer to Run Locally” otherwise most web browsers cannot load the project
- Note that html name is shown in the browser tab



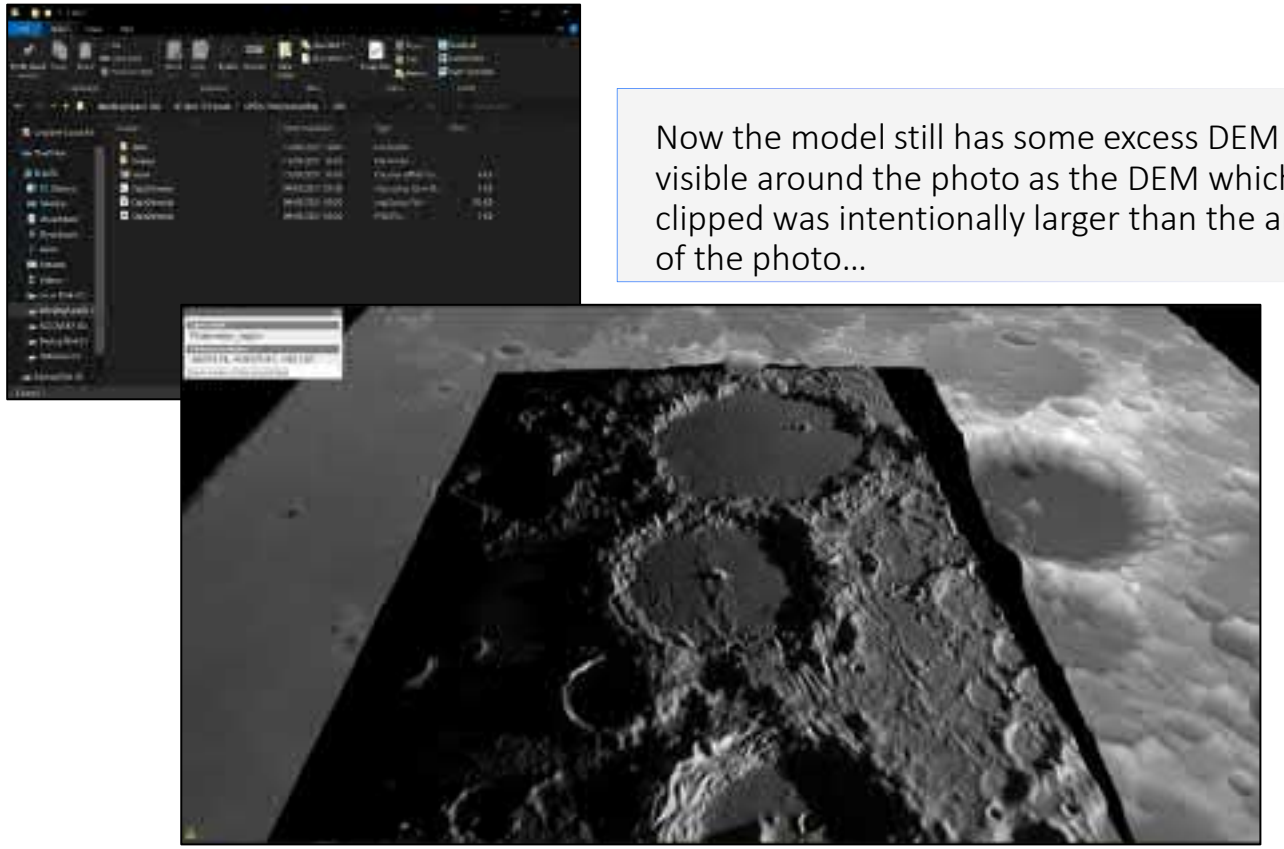
Tip:
Use such names for html and page title which you intend to use. You cannot change these afterwards by renaming the output files.

Qgis2threejs

- Adjust parameters to your liking
- Preview within seconds

Check the model

- Open the html file with your browser by double clicking the html file
- After loading a few seconds the model will show in the browser

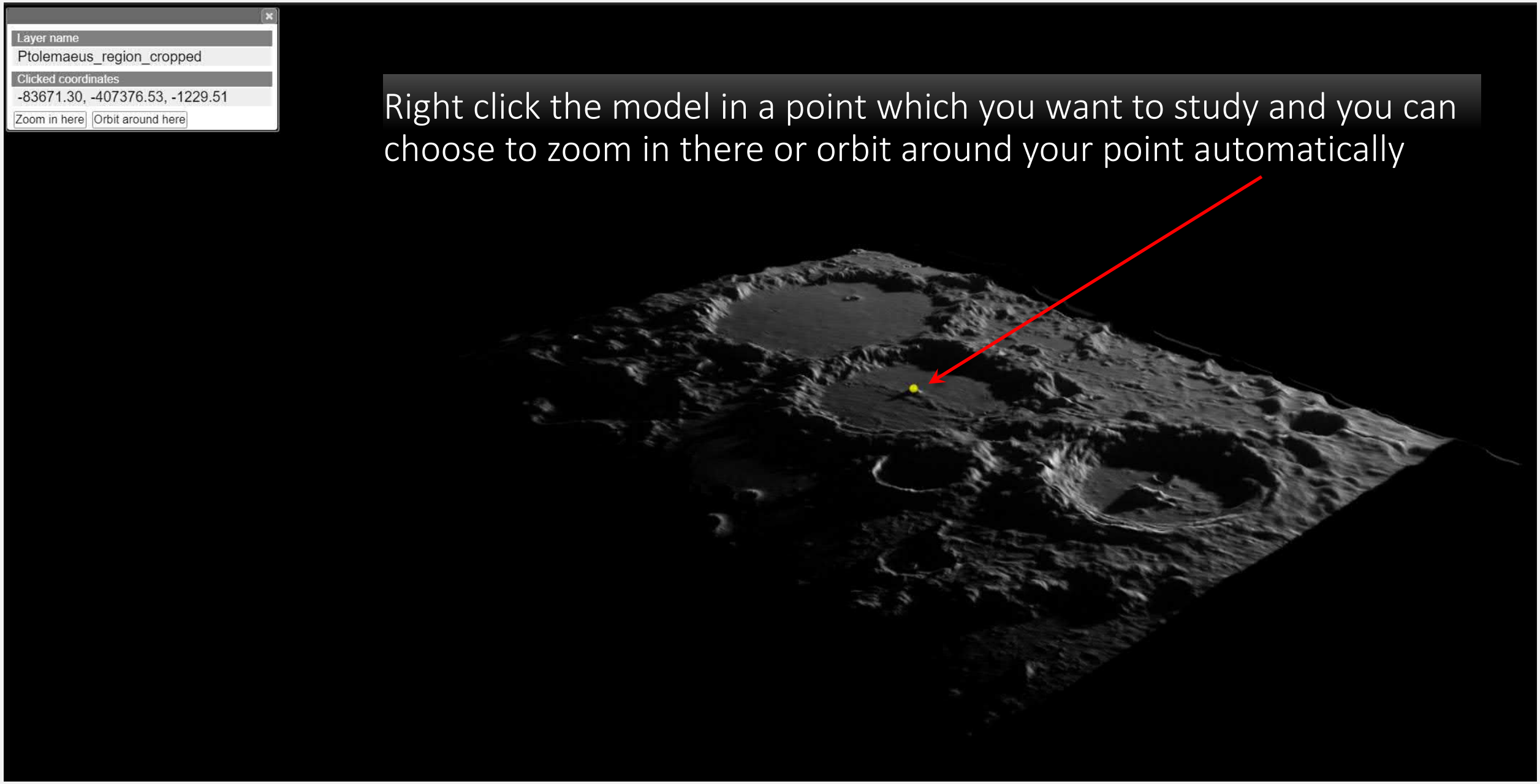


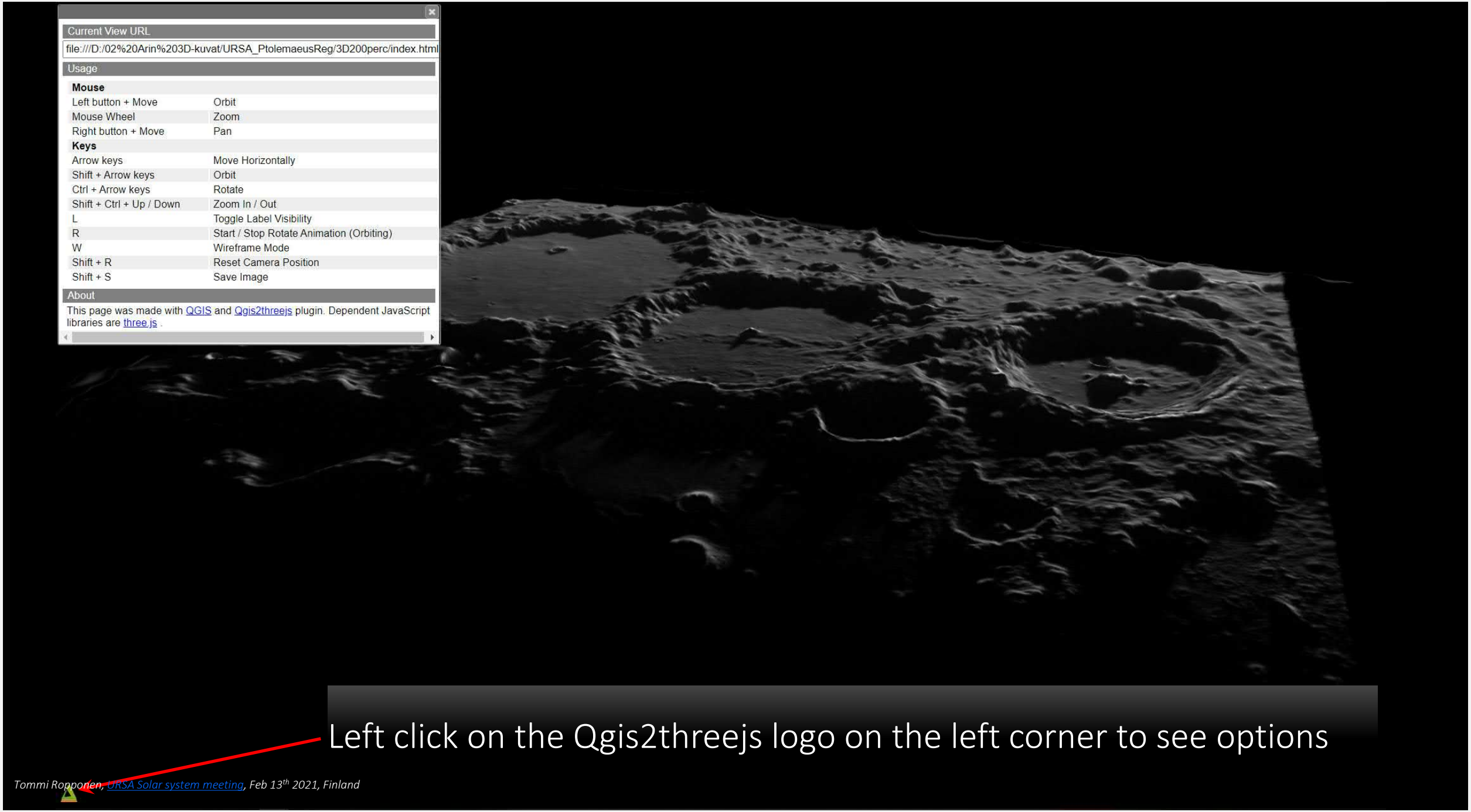
Now the model still has some excess DEM visible around the photo as the DEM which I clipped was intentionally larger than the area of the photo…

Qgis2threejs

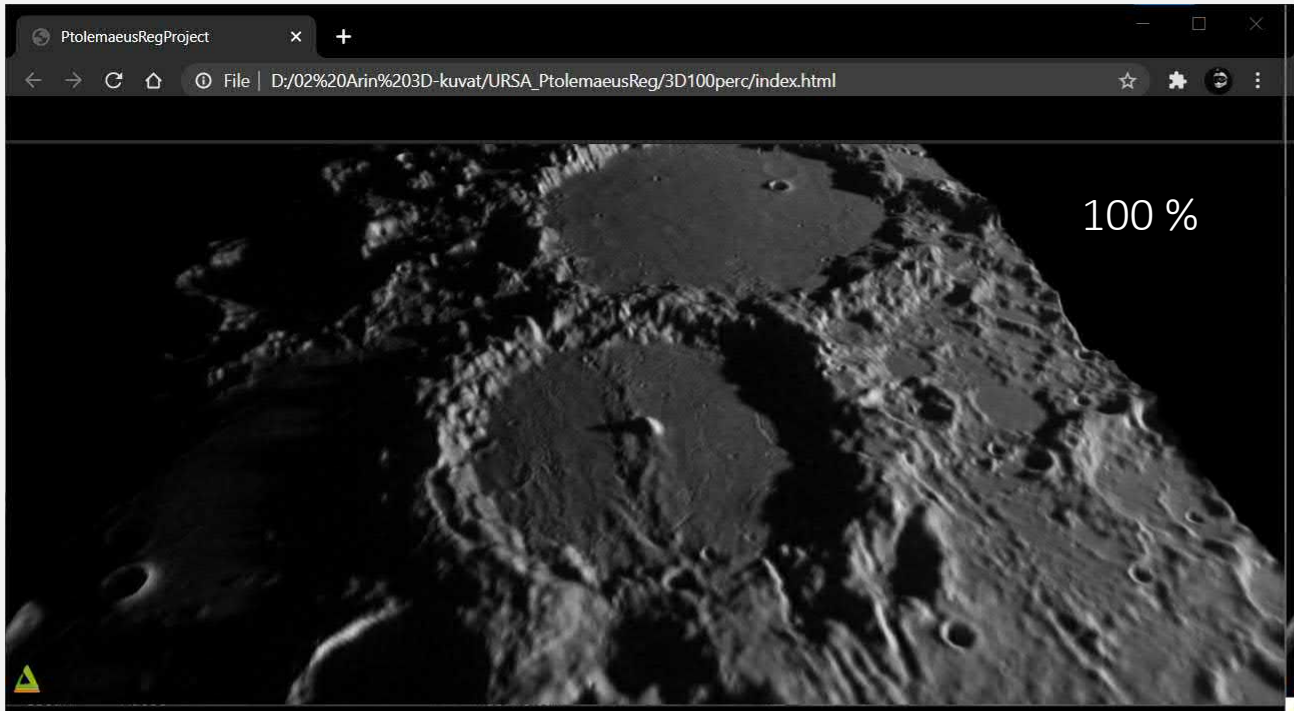
- Adjust parameters to your liking
- Preview within seconds

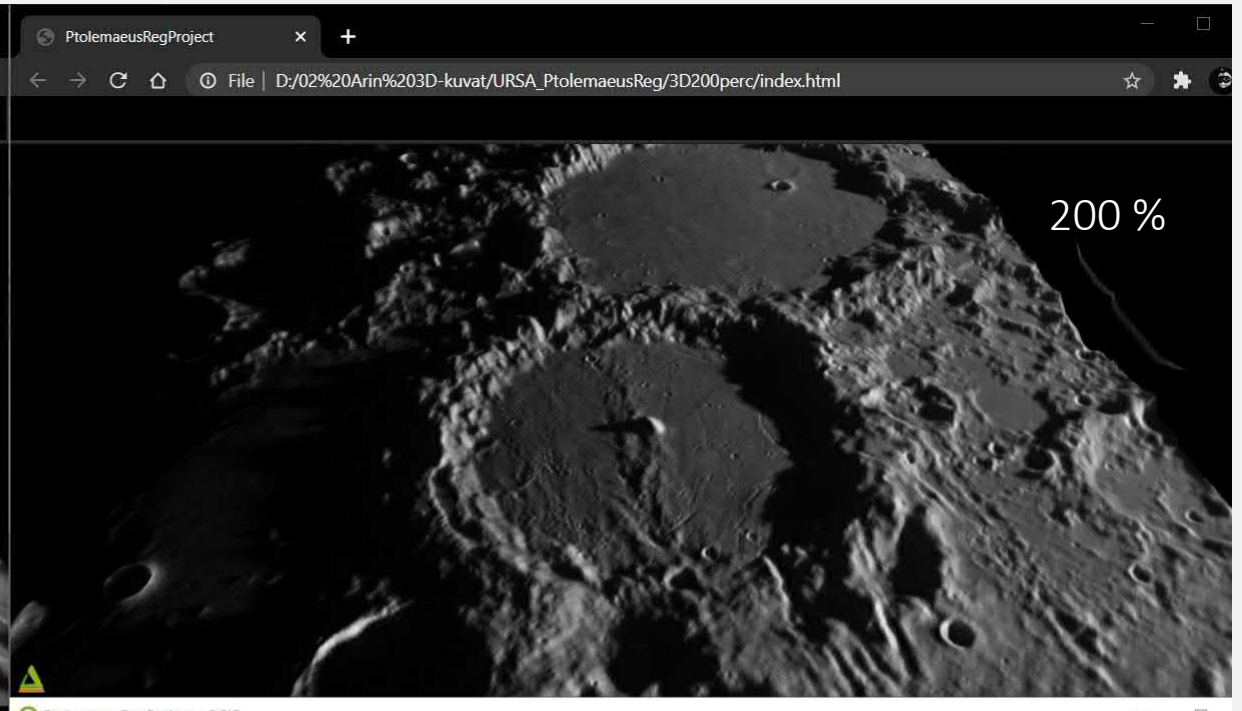
At this point I modified the model a bit by clipping the DEM again with the same method as was shown earlier to cut excess parts and run Qgis2threejs again to build the final model

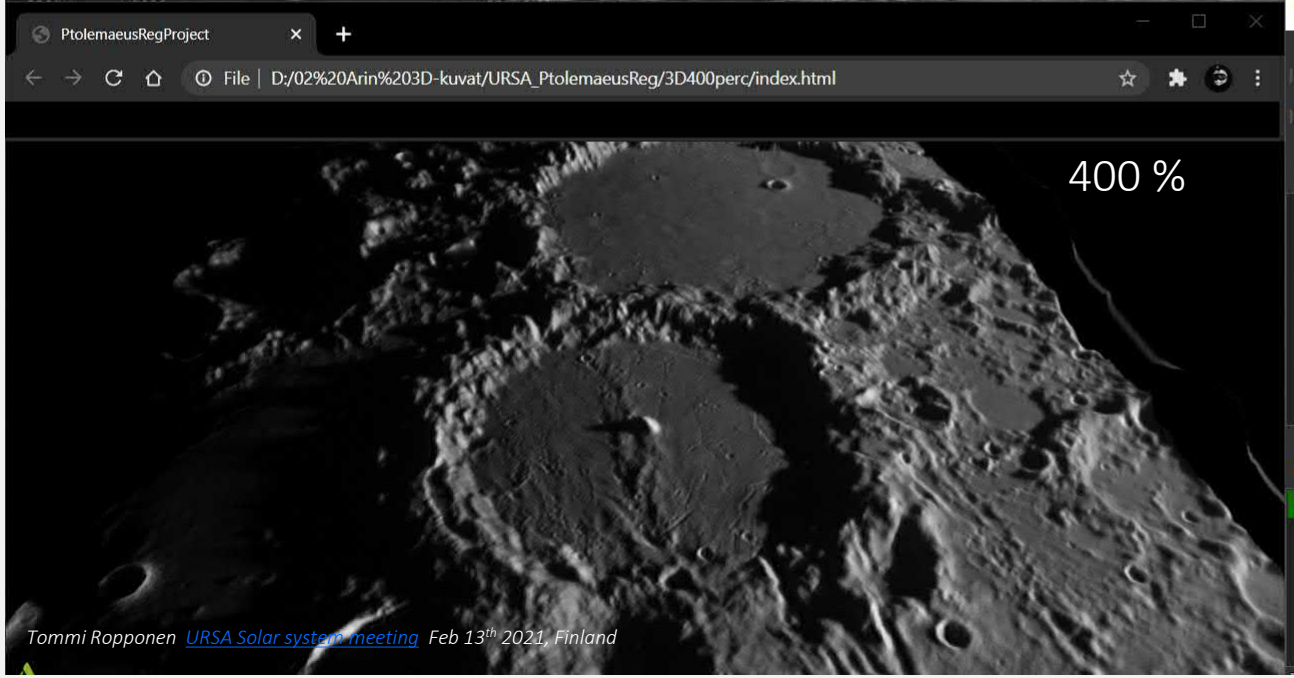

Layer name
Ptolemaeus_region_cropped
Clicked coordinates
-83671.30, -407376.53, -1229.51
Zoom in here
Orbit around here
Right click the model in a point which you want to study and you can choose to zoom in there or orbit around your point automatically

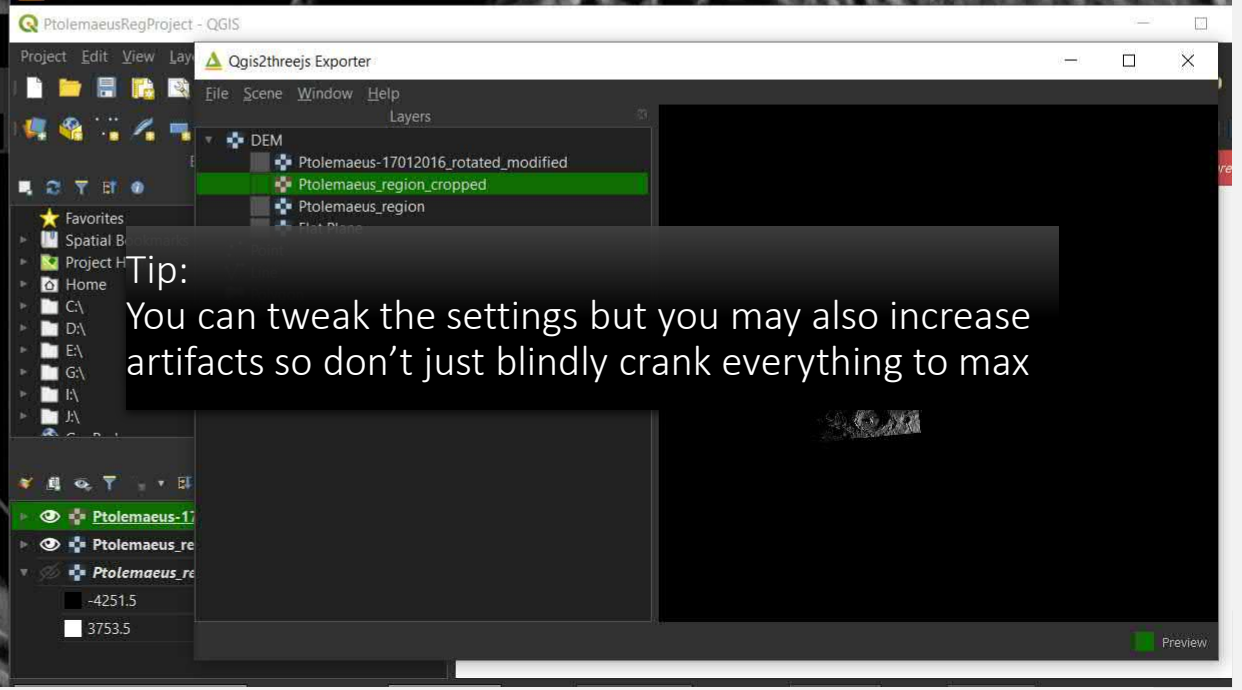

Current View URL
file:///D:/02%20Arin%203D-kuvat/URSA_PtolemaeusReg/3D200perc/index.html
Usage
Mouse
Left button + Move
Orbit
Mouse Wheel
Zoom
Right button + Move
Pan
Keys
Arrow keys
Move Horizontally
Shift + Arrow keys
Orbit
Ctrl + Arrow keys
Rotate
Shift + Ctrl + Up / Down
Zoom In / Out
L
Toggle Label Visibility
R
Start / Stop Rotate Animation (Orbiting)
W
Wireframe Mode
Shift + R
Reset Camera Position
Shift + S
Save Image
About
This page was made with QGIS and Qgis2threejs plugin. Dependent JavaScript libraries are three.js .
Left click on the Qgis2threejs logo on the left corner to see options

Example: Image quality change as a function of DEM layer resolution


PtolemaeusRegProject
File | D:/02%20Arin%203D-kuvat/URSA_PtolemaeusReg/3D100perc/index.html
100 %


PtolemaeusRegProject
File | D:/02%20Arin%203D-kuvat/URSA_PtolemaeusReg/3D200perc/index.html
200 %


PtolemaeusRegProject
File | D:/02%20Arin%203D-kuvat/URSA_PtolemaeusReg/3D400perc/index.html
400 %
Tommi Ropponen URSA Solar system meeting Feb 13th 2021, Finland

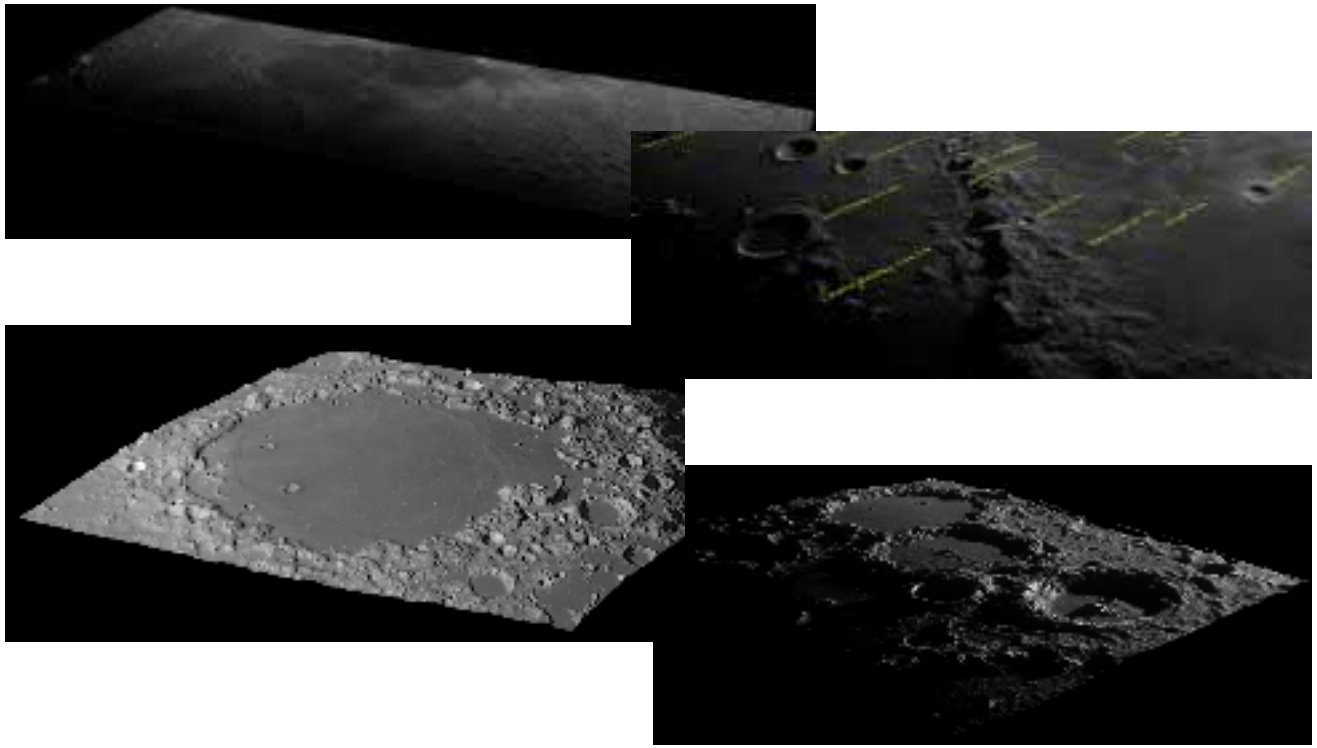

PtolemaeusRegProject - QGIS
Qgis2threejs Exporter
File Scene Window Help
Layers
DEM
Ptolemaeus-17012016_rotated_modified
Ptolemaeus_region_cropped
Ptolemaeus_region
Favorites
Home
-4251.5
3753.5
Preview
Tip:
You can tweak the settings but you may also increase artifacts so don't just blindly crank everything to max

3D model examples

From wide field to crater details

Let’s see how these look like in a web browser:

- Wide field: The terminator area from north to south
- Medium wide field: Montes Apenninus region
- Mare details: Mare Crisium
- Crater details: Ptolemaeus region



3D model examples

- From wide field to crater details

Building an interactive 3D Moon model

- Select a suitable photo
- Clip a matching part from the LRO DEM *(≈ 5 min)*
- Georeference and especially add alignment points also to the corners and edge areas *(≈ 20 min – 90 min)*
- Remember to save the ground control points and the project so you can tweak it later without the need to go through the georeferencing again
- Use Qgis2threejs plugin to build a 3D model from the georeferenced photo and clip the DEM again if needed *(≈ 15 min)*
- Export to web (or other formats if you like)

Tip:
You can also make models e.g.

- from Mars using orbiter photos and Mars DEM https://astrogeology.usgs.gov/search?pmi-target=mars or
- from your summer cottage area using Open Street Map and DEM (in Finland see e.g. https://tiedostopalvelu.maanmittauslaitos.fi/tp/kartta)

Summary

To put it short…

Acknowledgment

- Ari Haavisto for providing excellent photos which made my life much easier during testing and for server space storing the models for www usage
- Teemu Öhman for comments and providing alternative download options for the DEMs

And if needed you can reach me

- As *cmas* at Tähdet ja Avaruus forum (in Finnish)
  - 3D model thread
- As *cmas* at Cloudy Nights forum
  - 3D model thread
- Via email at tommi.ropponen@gmail.com