Processing drone images with WebODM

A Quick Guided Tour with Examples

Introduction

This tutorial will guide you through using WebODM, a user-friendly web interface for OpenDroneMap (ODM). ODM, an open-source processing engine, specializes in handling drone images to generate point clouds, 3D models, and orthophotos.

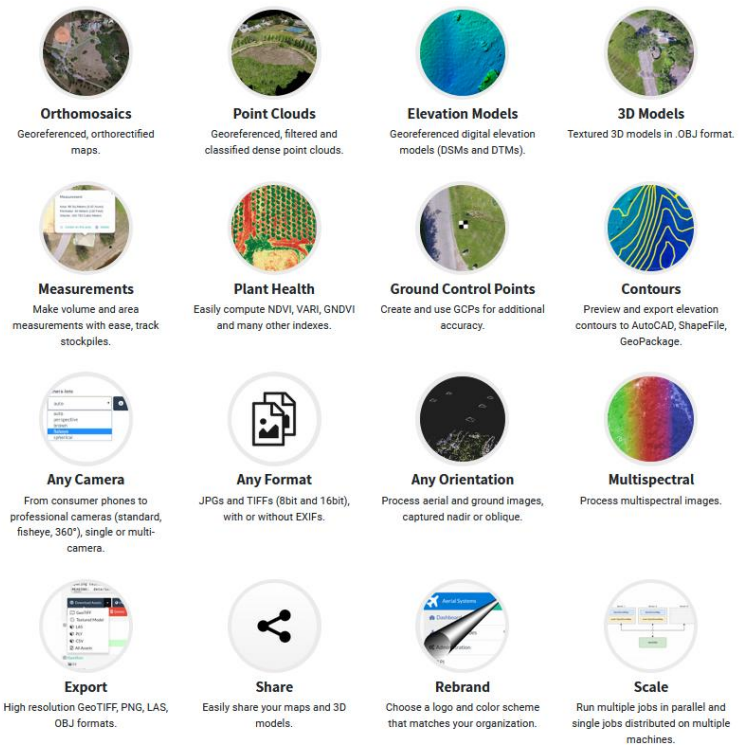
Learning objectives

After this tutorial you're able to:

- Use WebODM installed on a server
- Upload your drone images to WebODM
- Evaluate the most important task options
- Generate point clouds
- Generate Digitial Surface Models
- Generate orthophotos
- Visualise and evaluate results in WebODM
- Visualise and evaluate results in QGIS
- Compare results of different moments in time in QGIS

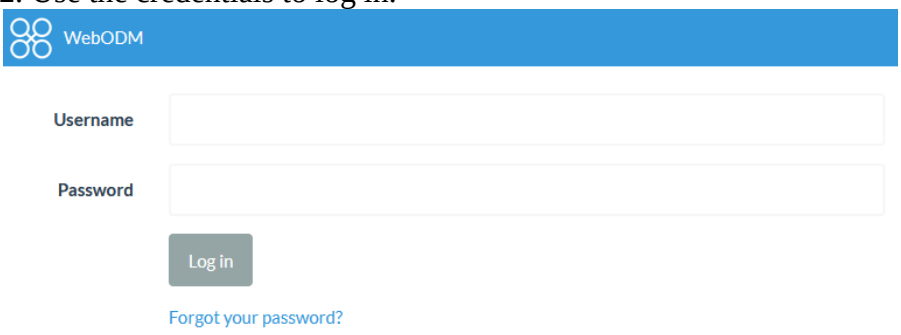
What can we do with WebODM?

WebODM is a user friendly web interface to ODM. These are the features of WebODM:

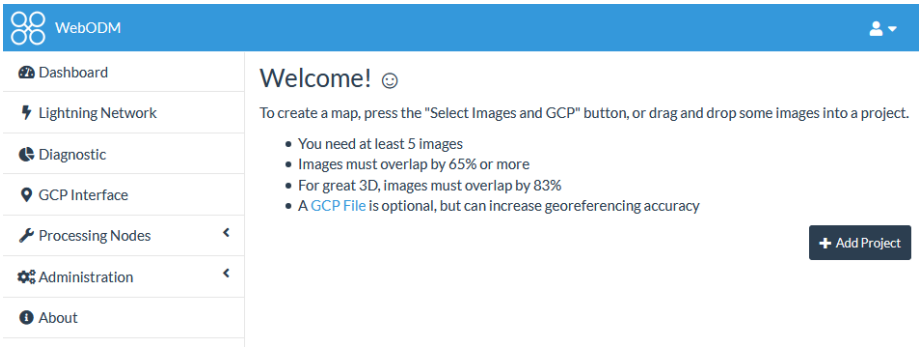


Starting with WebODM

- WebODM is open source and you can install it on your own computer or on a server. You can also get paid services to make things easier.
- You can find all options at the WebODM website. We'll not cover how to install WebODM on your computer, but if you're interested, you can check these instructions.
- 1. Go with your internet browser to your WebODM page.
- 2. Use the credentials to log in.



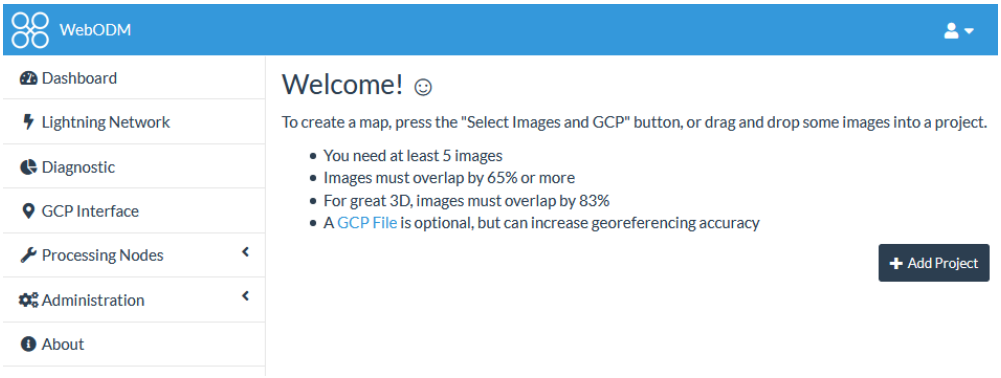
- 3. Click *Log in*
- Now you're logged in at WebODM and you can see the *Dashboard* page:



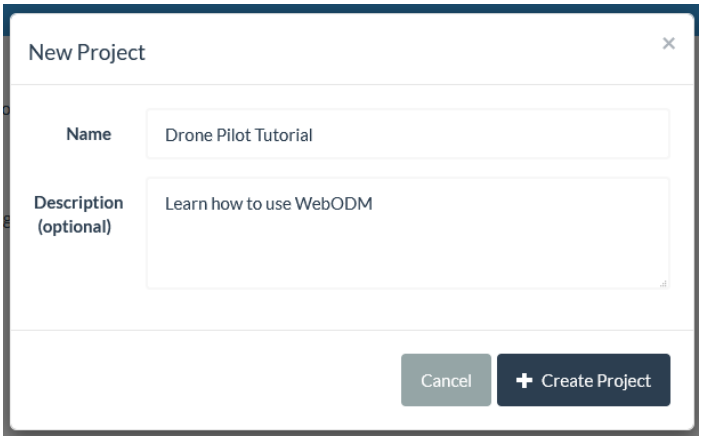
Add a new project

The first step is to add a new project to your account.

1. Click *Add project*.

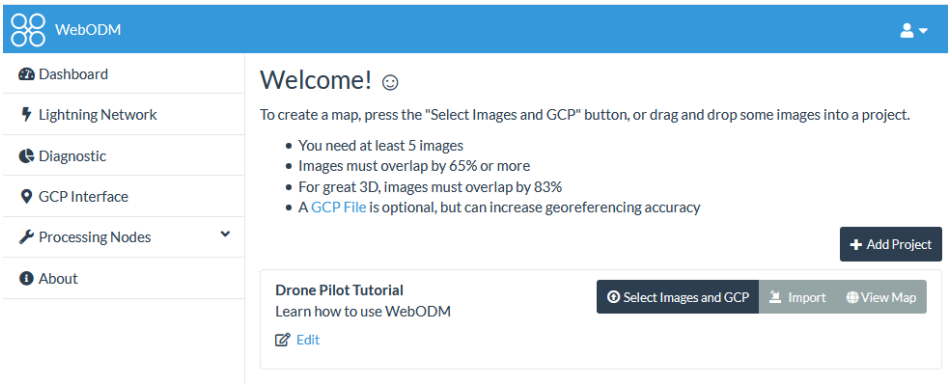


2. In the popup that appears, give your project a name and a description.



3. Click *Create Project*.

Now you see the project added to your Dashboard page:



You can still change the name and description by clicking *Edit*.

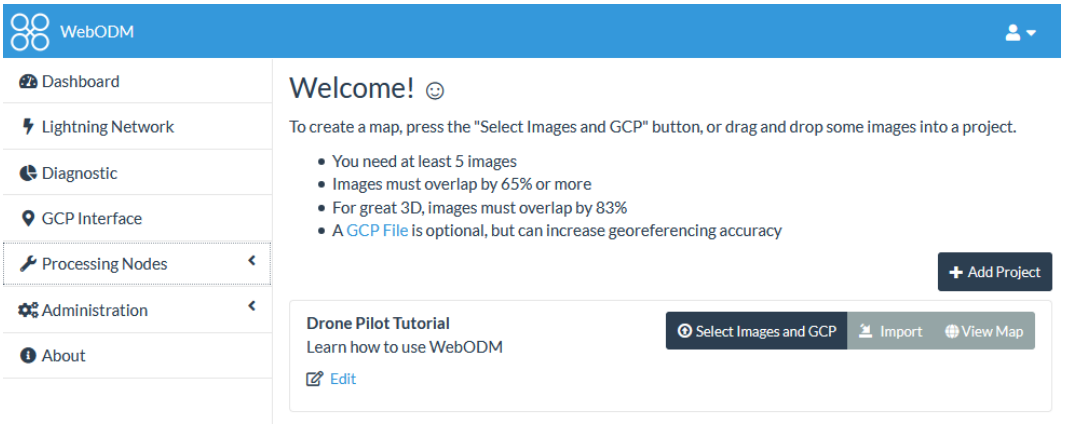
Select drone images

Now we're going to add the drone dataset from flights over an agricultural area in Moatize (Mozambique) for this tutorial. The dataset contains:

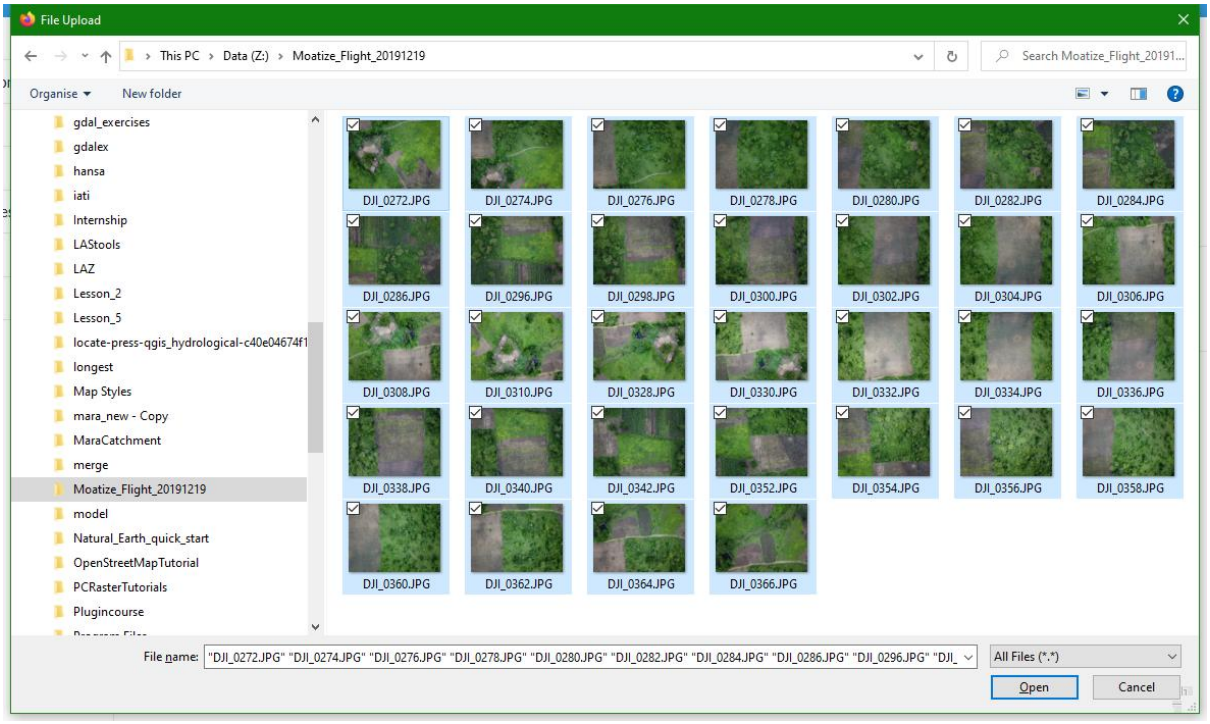
- Drone images taken on 19 December 2019
- Drone images taken on 22 January 2020
- Boundary of an area of interest

We'll first work with the images of 19 December 2019. Later you will repeat the procedure for the images of 22 January 2020.

3. In the Dashboard of WebODM click *Select Images and GCP*.

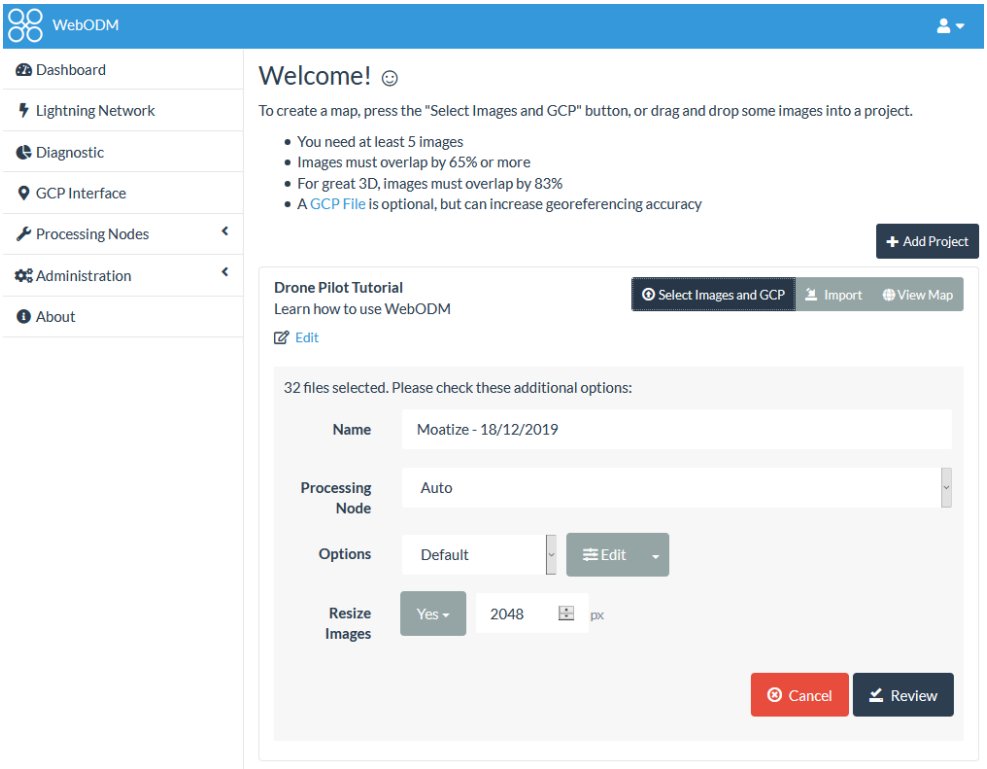


4. In the *File Upload* dialogue, select all images (Ctrl-A is a useful shortcut to select all) and click *Open*.



Alternatively, you can drag and drop files in WebODM. You can add more images from different folders by clicking Select Images and CGP again.

Now you see in the Dashboard that you've selected 32 files.



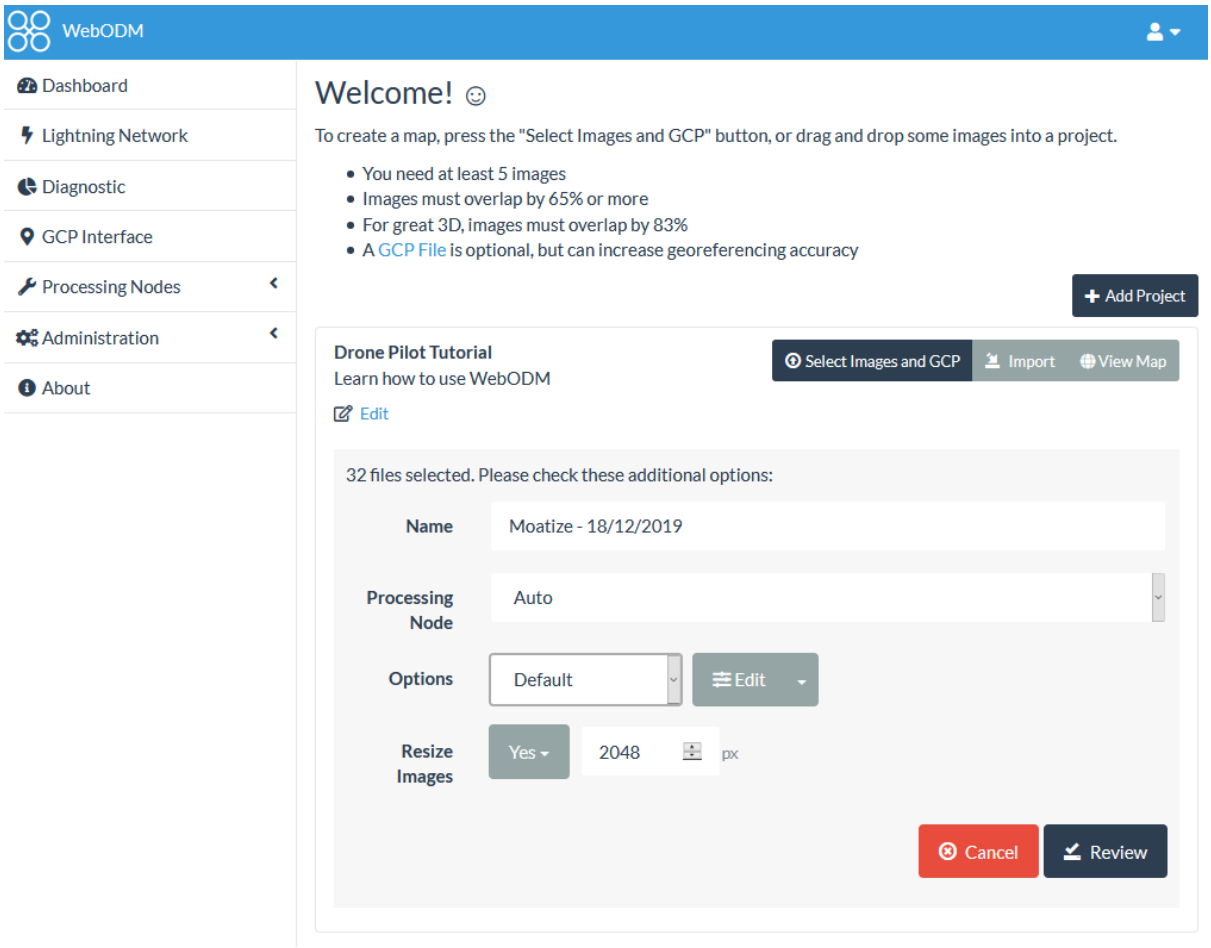
Review settings

Now we have selected the 32 drone image we need to review the settings for creating this new *Task* in your *Project*.

WebODM reads the metadata from the images. The metadata is stored in as EXIF tags in the JPG files. EXIF stands for Exchangeable Image File Format. The tags can include information of the location where the picture was taken. This information comes from the GPS of the drone.

Images with geolocation information in the EXIF tags can be used to produce **georeferenced orthophotos and elevation models**. If location info is missing you can still create point clouds and 3D models, but it's not possible to create georeferenced orthophotos and elevation models. Later we'll briefly discuss how to add Ground Control Points in WebODM to still use those images for producing georeferenced orthophotos and elevation models.

Let's look at the different settings in the dialogue.



Name : The default name of the task is generated by WebODM by using the EXIF location and time data. The coordinates were used to look up the place name. You can edit the name if needed. Here we keep the default name.

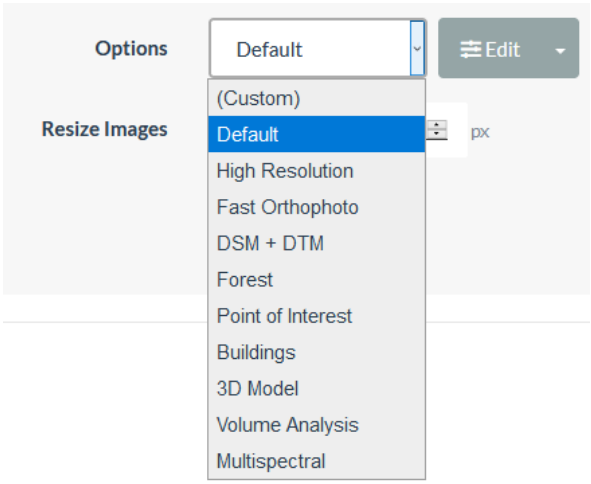
Processing Node: This the node where the calculation takes place. Your account is set up with a specific calculation node (you can see it when you use the dropdown menu), so you

can keep this on *Auto*. In another setup where you have multiple processing nodes available you can manually choose the one you want to use or use Auto to automatically select the node with the least number of running tasks.

Options: Here you can control the algorithms that are used to process your drone images. You can choose from a predefined list of presets. If you hover your mouse over the selected preset it will show which options are being used, but it's a bit cryptical.

- Default: create point cloud, orthophoto and DSM
- High Resolution: provides a higher resoltion output, but processing time will be longer
- Fast Orthophoto: if you're interested in an orthophoto only
- DSM + DTM: will generate a DTM besides a DSM
- Forest: will have a higher number of points and a higher quality to represent forests better
- Point of Interest / Building: better mesh representation to deal with man made structures
- 3D model: improved mesh
- Volume Analysis: improved DTM and DSM for volume calculations
- Multispectral: includes parameters for multispectral images, such as radiometric calibaration

You can also manually change the many task options that are available by clicking *Edit*. For now we keep the *Default* options.

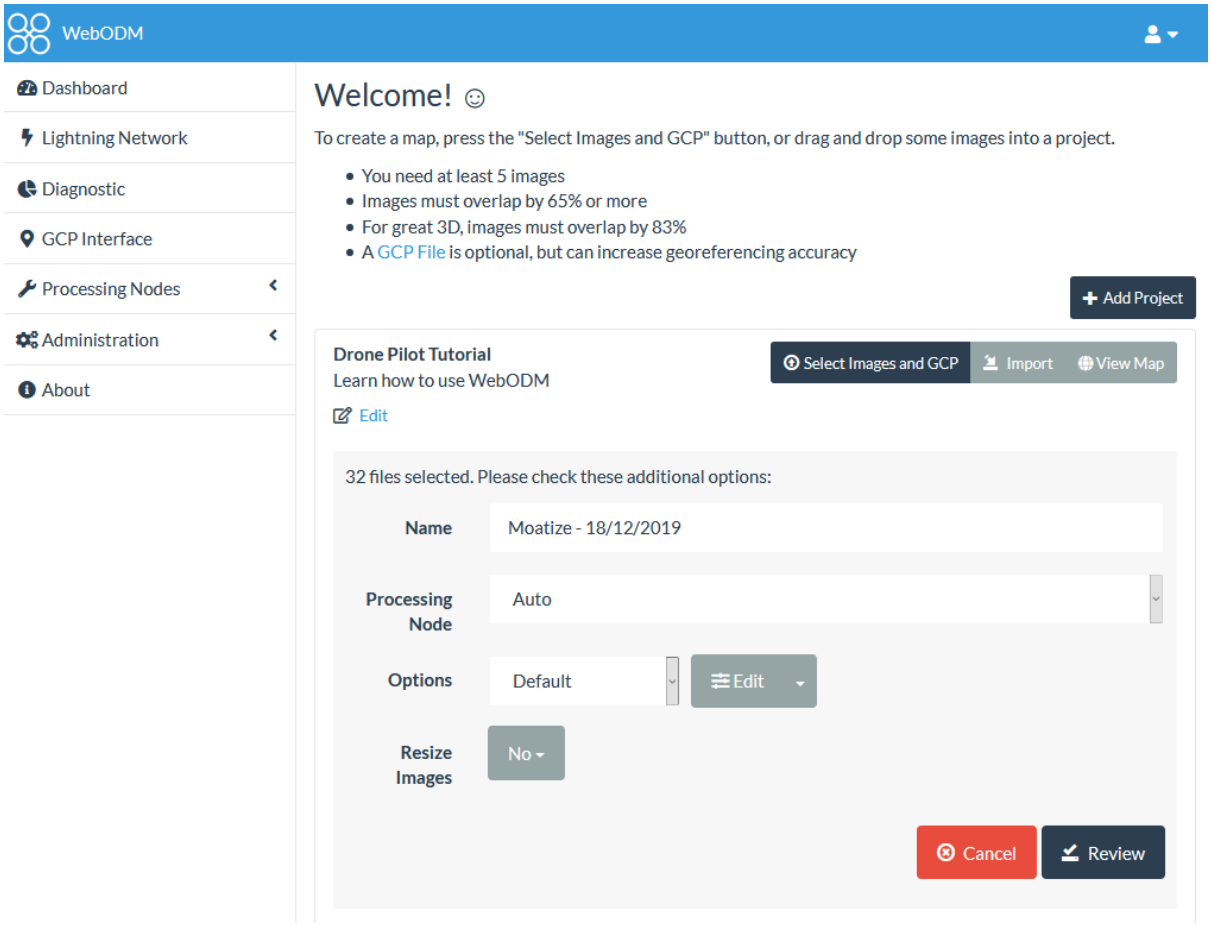


Resize images

You can reduce the size of all images by changing the settings here. This is useful to lower the amount of memory used and to increase the processing speed. This is of course a trade off with the quality of the results. Here we're not going to resize the images, because that has already been done for the purpose of this tutorial.

1. Select for *Resize ImagesNo*.

Now your setting should be like the screenshot below.

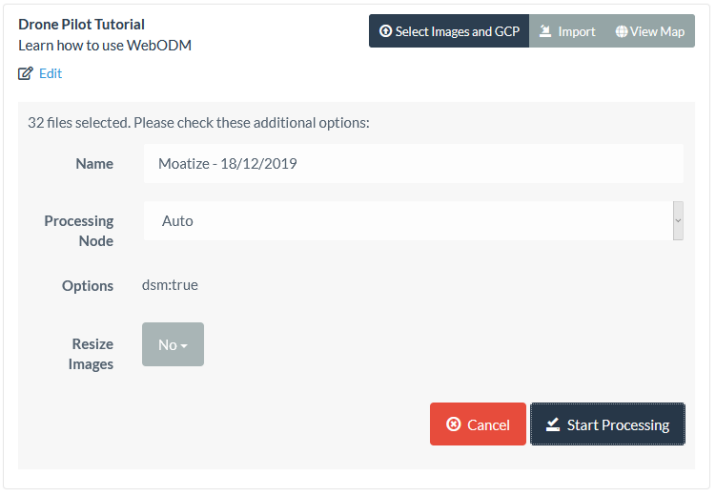


2. Click *Review* to proceed.

8. Start Processing

In this chapter we're going to process the images.

1. Review if the settings are like the screenshot below. Click *Cancel* to make corrections if needed.

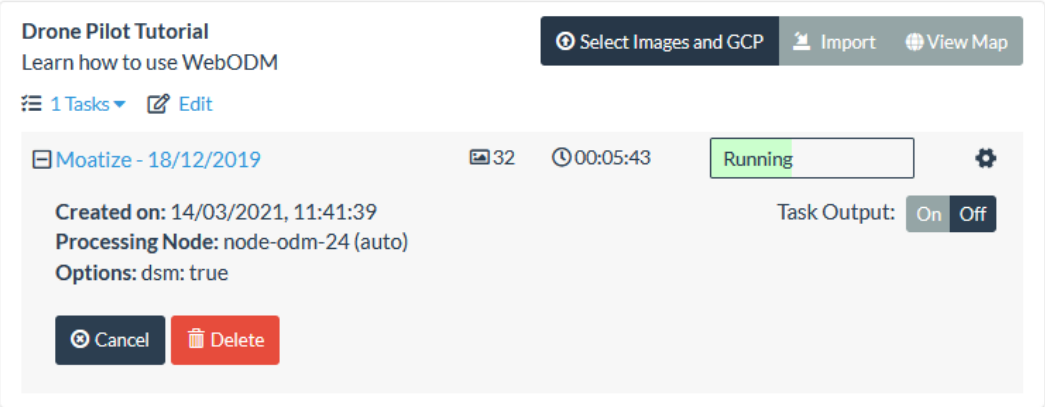


2. If the settings are correct, click *Start Processing*.

Now the task is executed, which will take a bit.

In the mean time we'll explain what is happening now.

First your images are uploaded to the correct folder on the server. Next, the images are sent to the selected processing node. These two steps are needed, because the processing nodes can be distributed over severall remote computers and the images need to be available at the node for further processing. Then the task is run on the node and the Dashboard will show the progress, including the elapsed time.



Viewing results in WebODM in 2D

Once the processing of our task has completed, we can view the results in WebODM. Later we'll download the results and visualse them in QGIS. Let's first have a look at our result in 2D.

Viewing results in WebODM in 2D

View orthophoto: Let's first have a look at the produced orthophoto.

1. Click *View Map*.

The WebODM interface now shows the orthophoto with Google Maps Hybrid as a backdrop:

2. Inspect the results by:

- Changing the Opacity with the slider at the bottom of the screen.
- Compare the results with different base maps using the  icon from the panel on the right of the screen.

You'll see that the ESRI Satellite image is not available for this area and OSM Mapnik (OpenStreetMap) has not much information either. So we can only compare with the Google Maps Hybrid layer.

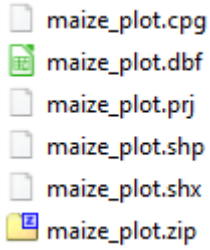
3. Zoom in an compare the resolution of the backdrop with the drone derived orthophoto. Which one is more detailed?

Viewing results in WebODM in 2D

Add vector data : We can also add vector data in GeoJSON or Shapefile format. Let's add the boundary of our area of interest.

WebODM only accepts a zipped shapefile.

3. Zip the files of the shapefile and call it maize_plot.zip



4. Go back to WebODM in your browser and click on the  icon in the panel on the right side of the screen to add the zipped shapefile.
5. Select the maize_plot.zip file and click *Open*.

Now you will see the polygon from the shapefile as overlay on your orthophoto.

Viewing results in WebODM in 2D

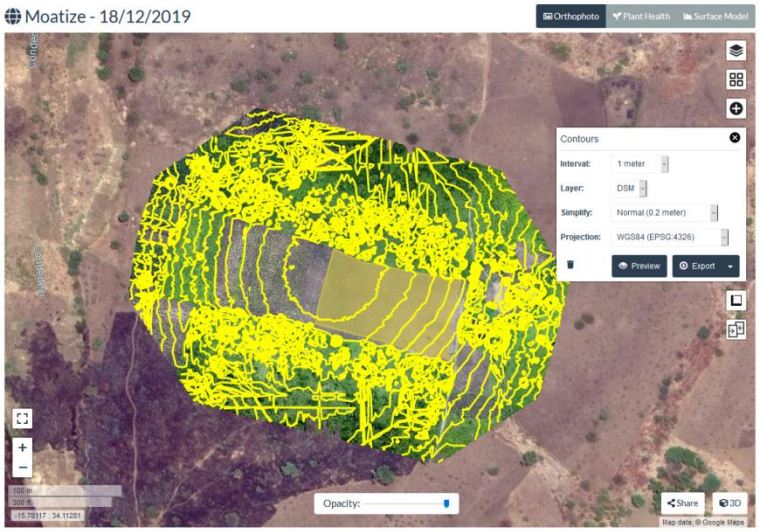
Derive contour lines: It's also possible to create contour lines.

1. Click the  icon in the panel on the right side of the screen.
Here you can set:

- The interval (equidistance) of the contour lines
- The layer from which it is derived. In our case we can only choose DSM, because the default processing that we used doesn't produce the DTM.
- Degree of simplification
- Output projection

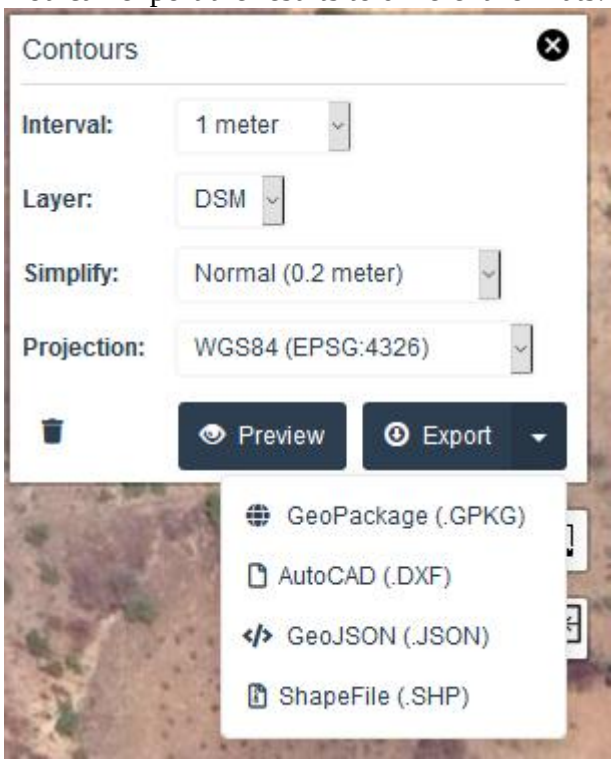
2. Keep the defaults and click *Preview*.

After some time this result will appear:



- What can you tell about the shape of our field of interest?

You can export the results to different formats:



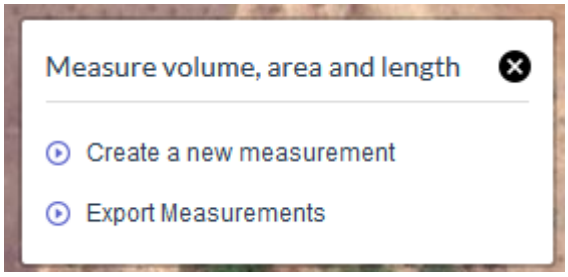
3. Save the contours as a GeoPackage and keep it for later when we're going to work with QGIS.

4. Click the icon to remove the preview.

Viewing results in WebODM in 2D

Measure length, area and volume: We can also do measurements of volume, area and length in the 2D View.

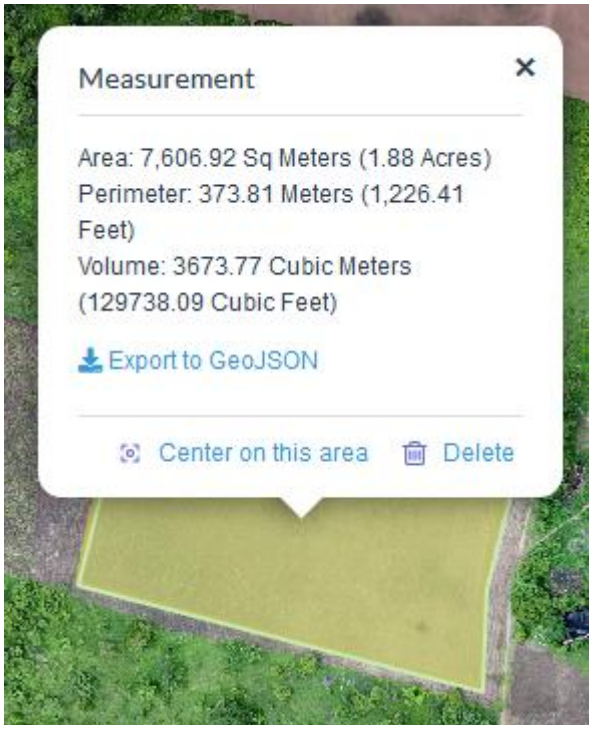
1. Click the icon in the panel on the right of the screen.
2. Select Create a new measurement



3. Create a polygon that follows the shape of our field of interest by putting nodes on the map.

4. Click *Finish measurement*.

After some calculation the result of the measurement is displayed on the map:

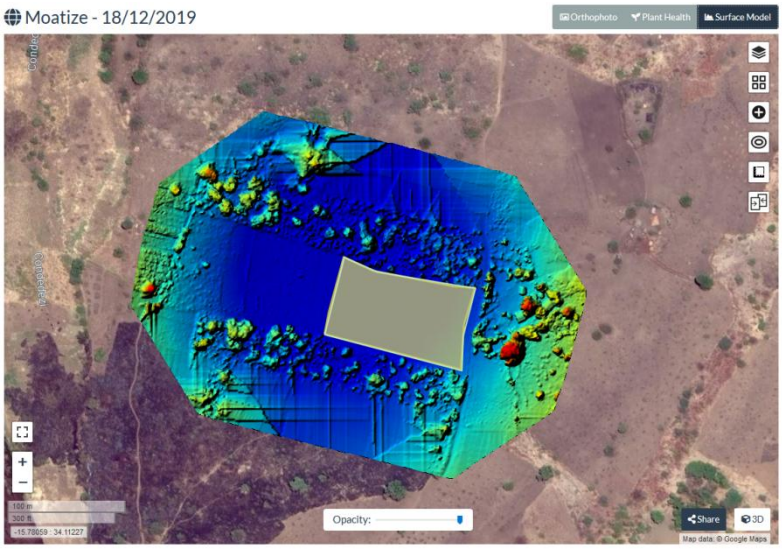


Viewing results in WebODM in 2D

View surface model in 2D: In the 2D View we can also visualise the derived DSM

1. In the upper right of the screen click on Surface Model.

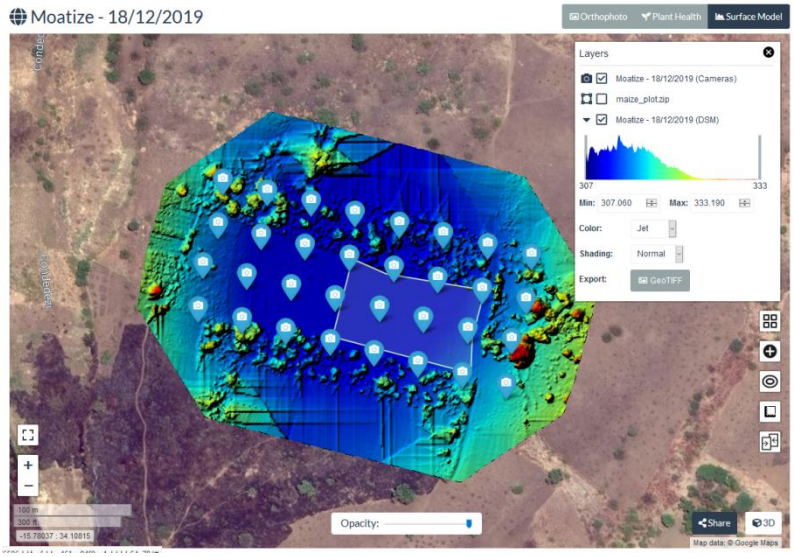
This will show the DSM of the area:



Now part of our view is covered by the polygon of our field of interest. Let's hide it.

2. Click on the  icon.

Here we can control which layers to visualise. We can for example switch off the polygon (maize_plot.zip) and add the camera locations where the drone made the pictures.

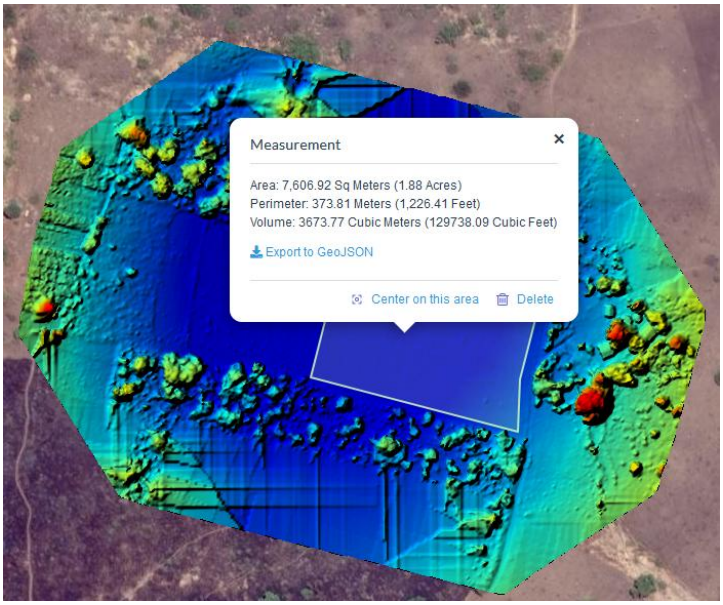


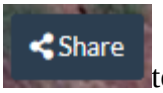
It also shows the elevations in a frequency histogram.

Under *Color* you can choose different colour ramps. With *Shading* you can change the shading of the elevation. You can also export the image as a GeoTiff to use in GIS.

3. Play with the color and shading settings.

4. Delete the measurement polygon that we have created earlier by clicking on it and choosing delete in the popup.



5. If you're happy with the result, you can click 

to share the link with others. People with the link can only view your result in an interactive way.

Viewing results with the 3D View

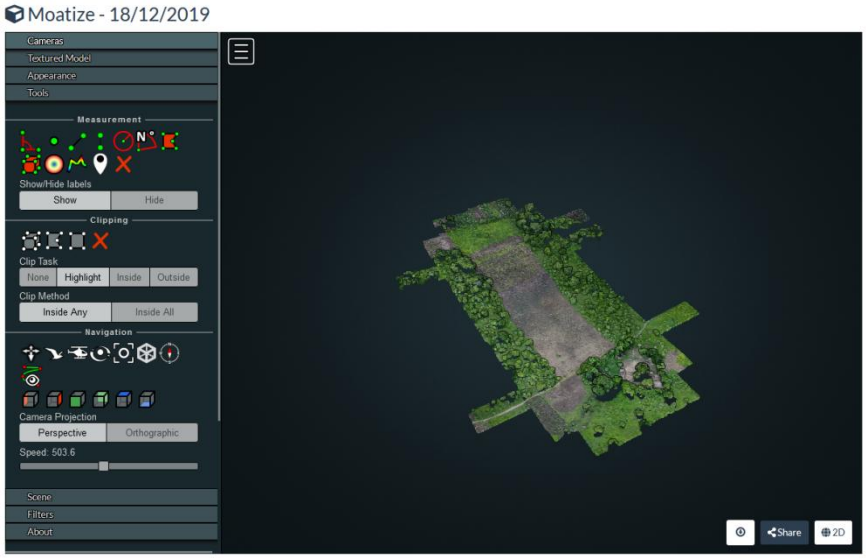
In the previous chapter we have explored the 2D View of WebODM. Here we'll have a look at the 3D View.

1. Go to the 3D View. You can do this in different ways:

- If you are still in the 2D View, click 

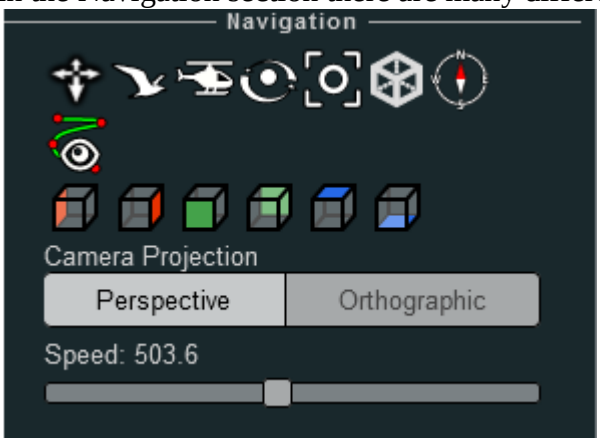
to switch to the 3D View.
- If you are in the Dashboard, click *View 3D Model*.

Now you'll see the 3D View with the point cloud of the area:



2. Zoom in well using the scroll of your mouse to see the points of the point cloud. Move around with the mouse and try to get familiar with the navigation.

In the Navigation section there are many different options to navigate the 3D scene:



3. Explore the different options for navigation

Features of the 3D View

The 3D View has nice features to visualise the data in 3D.

Let's first visualise the position of the camera of the drone when the images were taken.

1. Under *Cameras* check the box *Show Cameras* and inspect the result

We can also visualise texture instead of the point cloud with the RGB colours.

2. Switch off the cameras.

3. Under *Textured Model* check the box *Show Model*.

This will take a little time to show up.

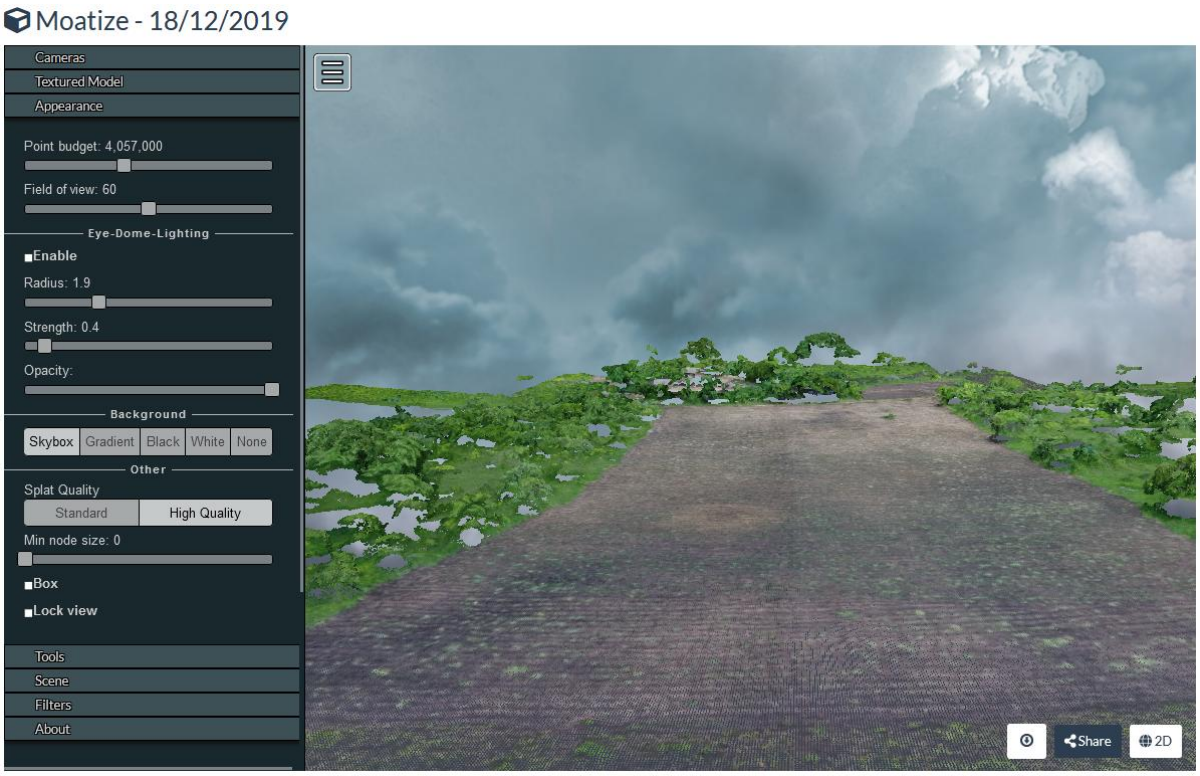
4. Check the result. What do you observe at the boundaries of the image?

We can also change the appearance of the point cloud.

5. Uncheck the *Show Model* under *Textured Model*, so we can see the point cloud again.

6. Under Appearance you can play with different settings, such as:

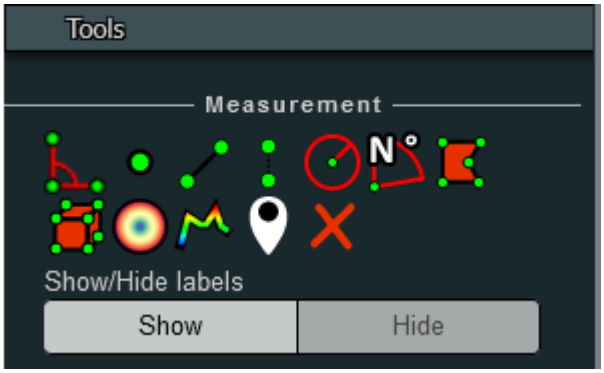
- Point budget: the amount of points to visualise
- Field of view determines how much of the scene is visible from our point of view
- You can disable *Eye-Dome-Lighting* to see the points without shading effect
- Change the background to Skybox to get a dramatic sky over the scene



Measurements in the 3D View

The 3D View comes with a set of measurement tools.

1. Expand the *Tools* section.



You can explore these tools for different measurements in the 3D space:

 Measure angles between different 3D points you select in the scene

 Point measurement: returns the x, y and z coordinate of a selected location

 Distance measurement between selected points

 Height measurement: difference in height of two selected points

 Cirkel measurement

 Measure the angle between 2 points in degrees of the compass

 Measure areas of polygons

 Measure volumes

 Measure volumes

 Draw a height profile

 Add annotations

 Remove all measurements

2. Try these tools to do measurements in the 3D View.

Clipping

Sometimes we're not interested in the entire scene. In our case we're only interested in the field of interest. There are different clipping tools available.

1. Expand the *Clipping* section.

The different methods are:

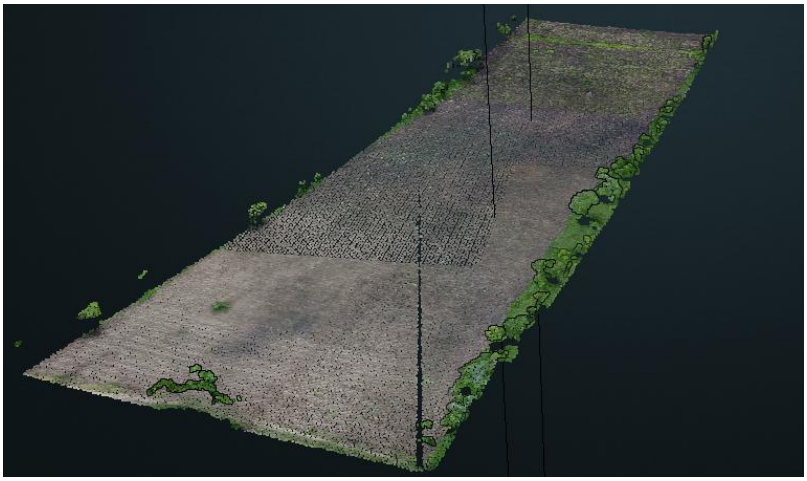
 Clip a volume

 Clip a polygon

 Draw a selection box. For this method you need to switch to *Orthographic* view under *Navigation*.

Under *Clip Task* you can indicate if you want to *Highlight* the points inside the polygon, show the points only *Inside* the polygon or show only points *Outside* the polygon.

2. Use this a tool to show only the points inside the maize field of our interest.

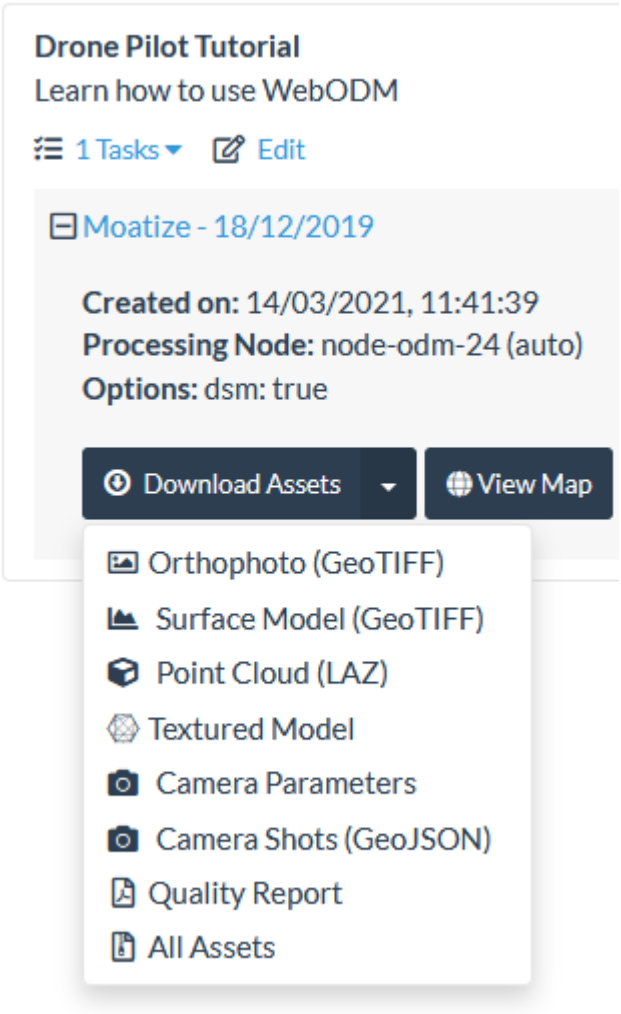


Download Assets

Although WebODM has some nice tools for visualising data and to do measurements, you might want to do further processing in GIS.

You can download the data (assets) from different places in WebODM:

- If you're still in the 3D View you can click on  in the lower right of the window.
- If you're in the Dashboard you can click on *Download Assets*



1. Download the Orthophoto

2. Download the Surface Model

Both GeoTIFF files can be opened in QGIS, which we'll do in the next chapter. It's best to save them to the same folder as our boundary shapefile.

From QGIS 3.18 you can also open Point Cloud (LAZ) files. At this moment this version of QGIS is still very exerimental and will not be covered in this tutorial.

Use the results in QGIS: Now we have downloaded the data from WebODM, we can visualise and process the results in QGIS.

In the next sections you'll:

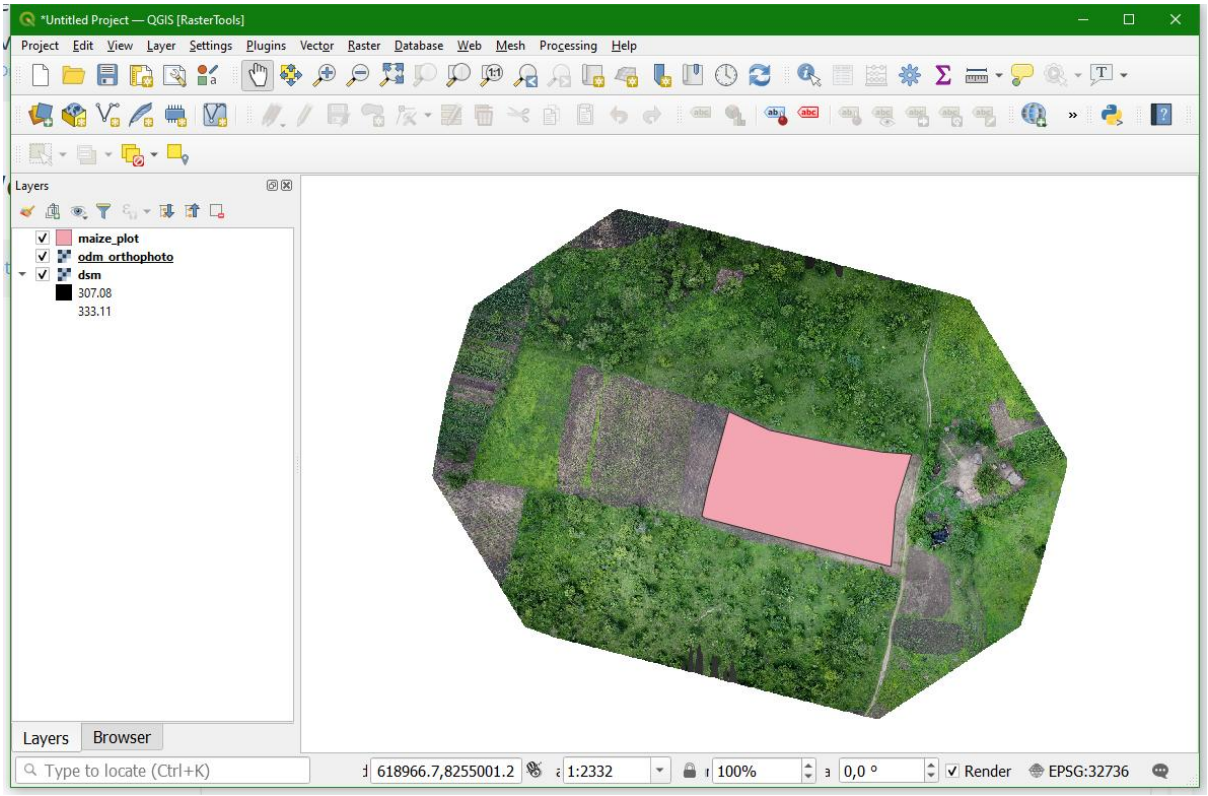
- Load the layers in QGIS and compare it with satellite images
- Visualise the DSM in 2D and 3D

View results in QGIS in 2D

Let's visualise our orthophoto and Digital Surface Model in QGIS.

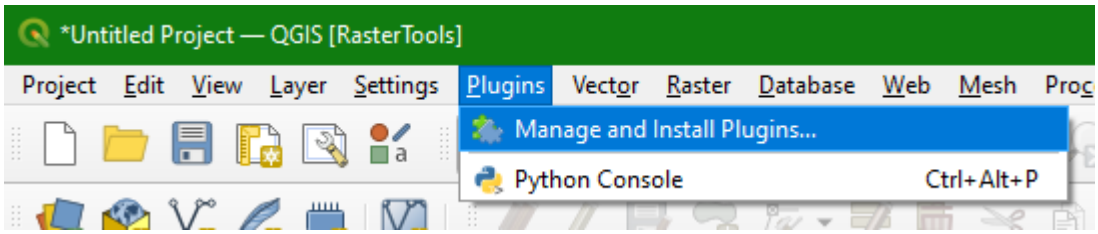
1. Start QGIS Desktop

2. Add odm_orthophoto.tif, dsm.tif and maize_plot.shp to the map canvas

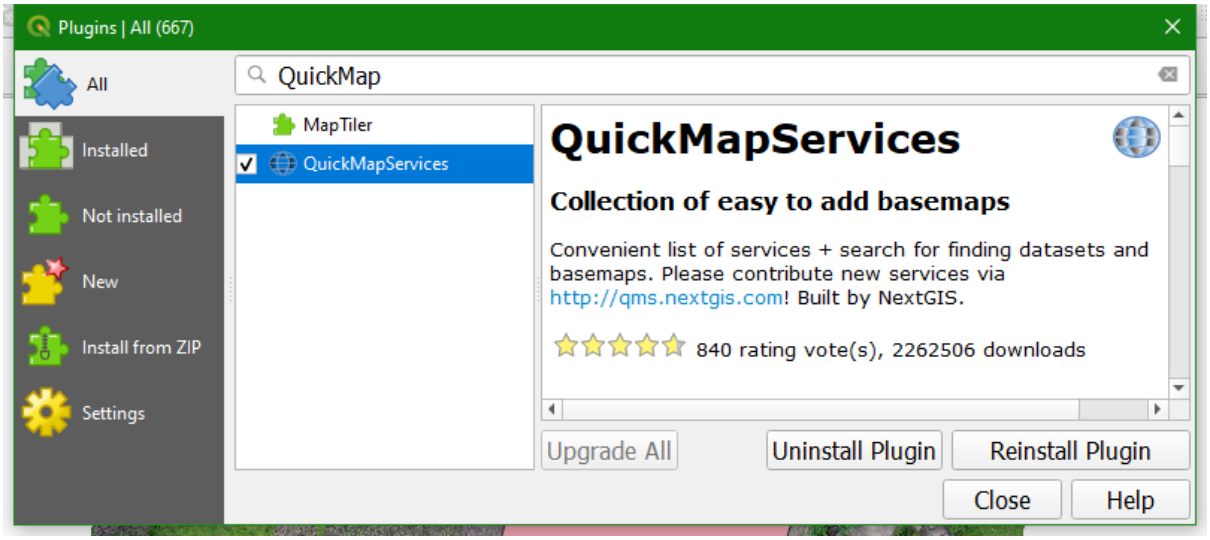


Let's also add a backdrop to see more context around our study area. We're going to install the QuickMapServices plugin.

3. In the main menu go to **Plugins | Manage and Install Plugins...**

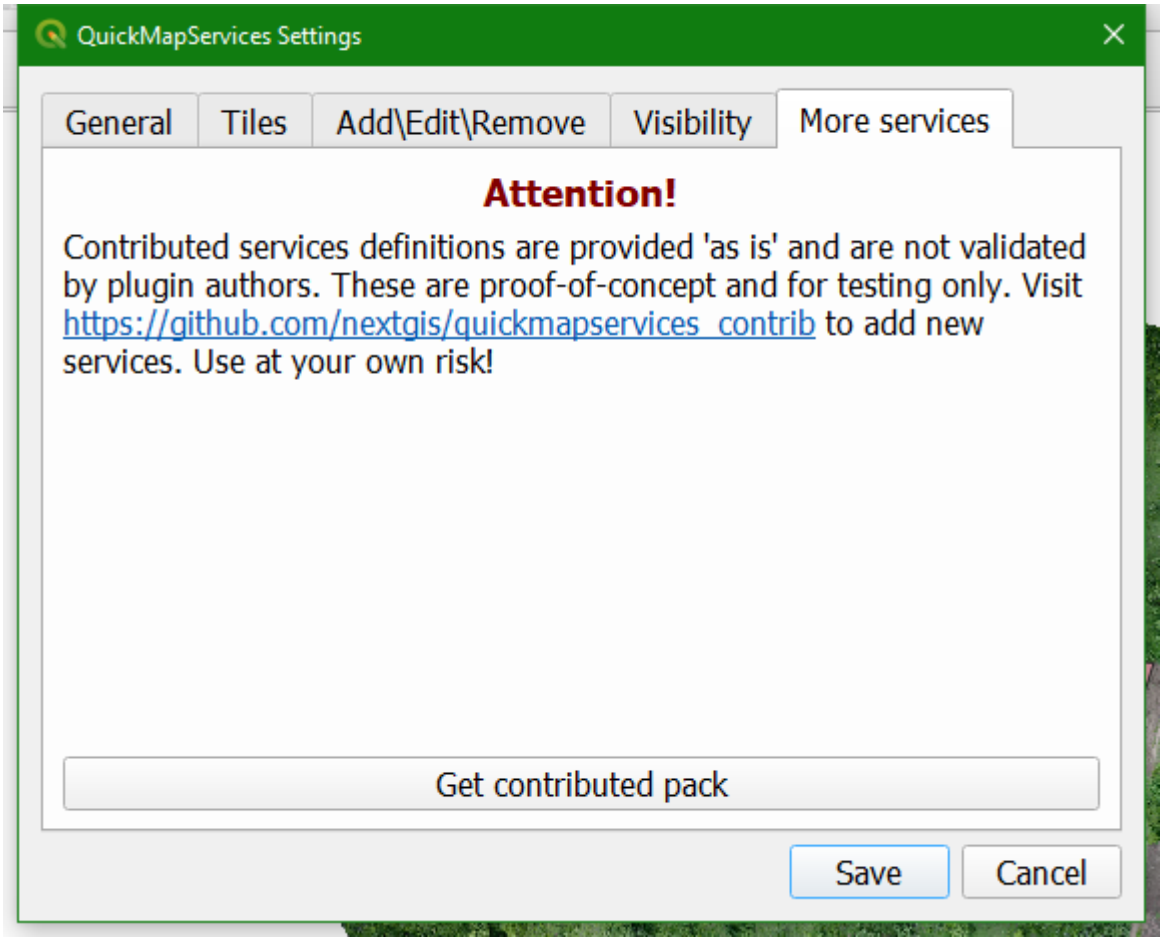


4. Install the QuickMapServices Plugin



5. In the main menu go to **Web | QuickMapServices | Settings**

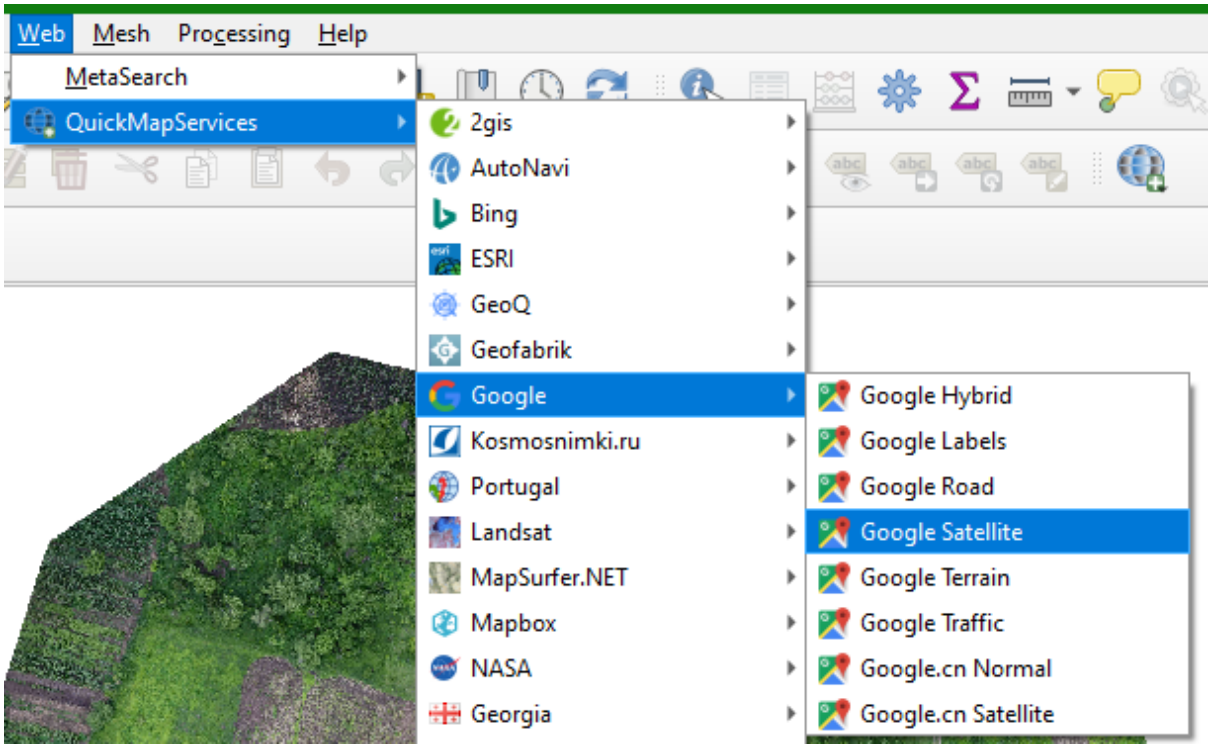
6. Go to the *More services* tab



7. Click *Get contributed pack*

8. Click *Save*

9. In the main menu go to **Web | QuickMapServices | Google | Google Satellite**



10. In the same way also add the Bing Satellite layer and compare the orthophoto with both satellite images.

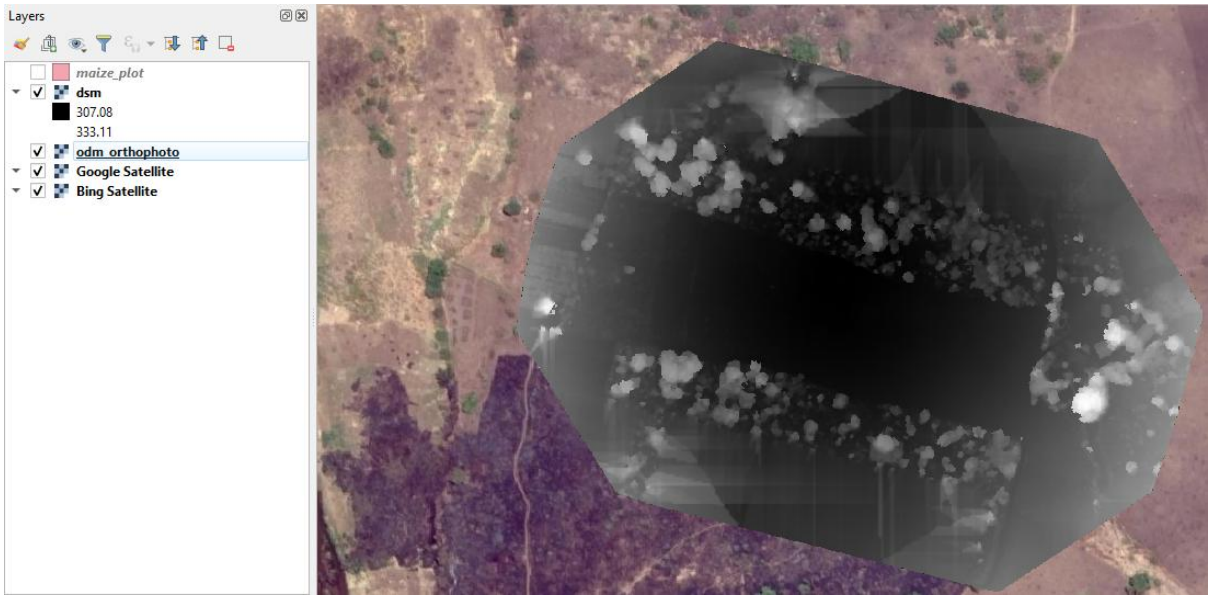
- What is the projection of the products created in WebODM?
- What is the spatial resolution of the products?

11. Now you can also add the contour lines from section 9.3 from the GeoPackage to the map canvas.

View results in QGIS in 3D

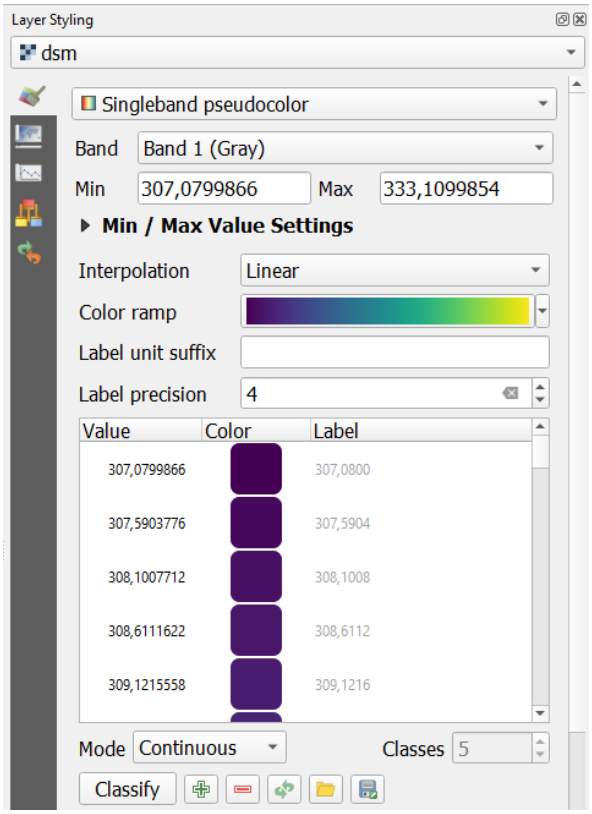
Let's have a closer look at the DSM.

1. Make sure we can see the DSM by moving it to the top and/or switching off the other layers.

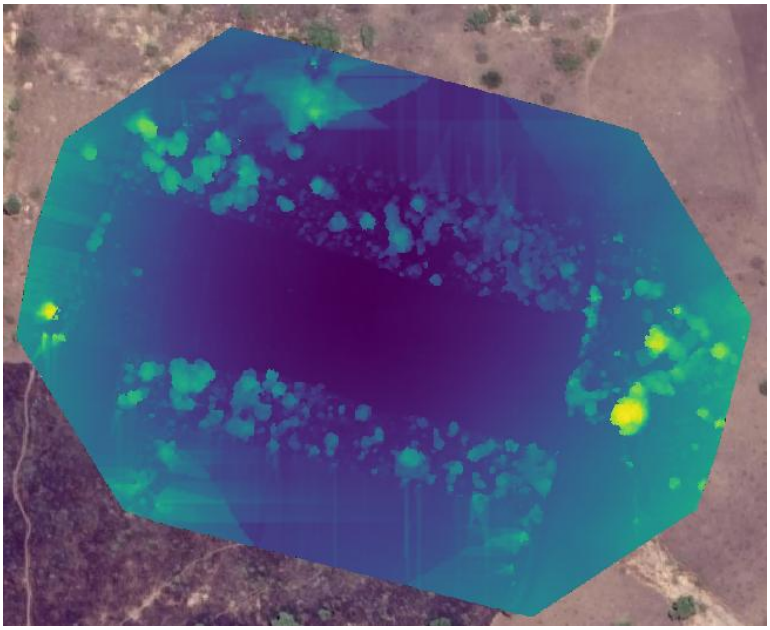


2. Select the *dsm* layer in the *Layers* panel and click to open the *Layer Styling* panel.

3. Choose the Singlebandpseudocolor renderer and style the layer with the Viridis colour ramp.

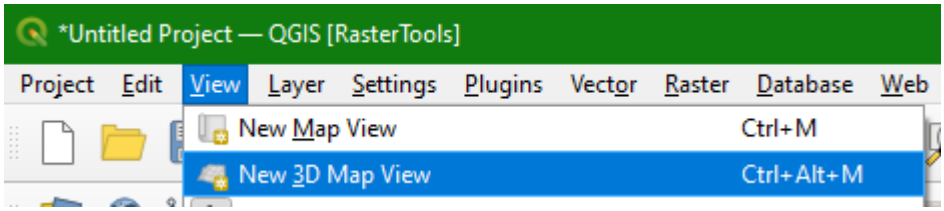


The result now looks like the screenshot below:



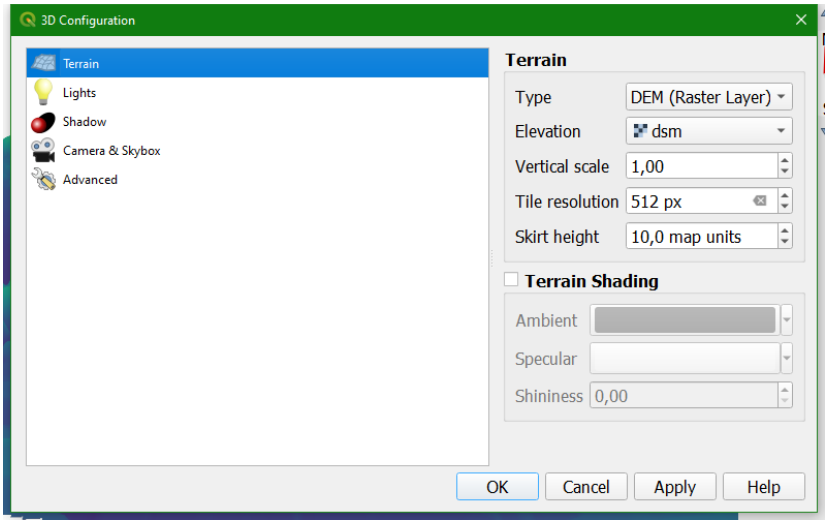
Let's now visualise the elevation in the QGIS 3D View.

4. In the main menu choose **View | New 3D Map View**

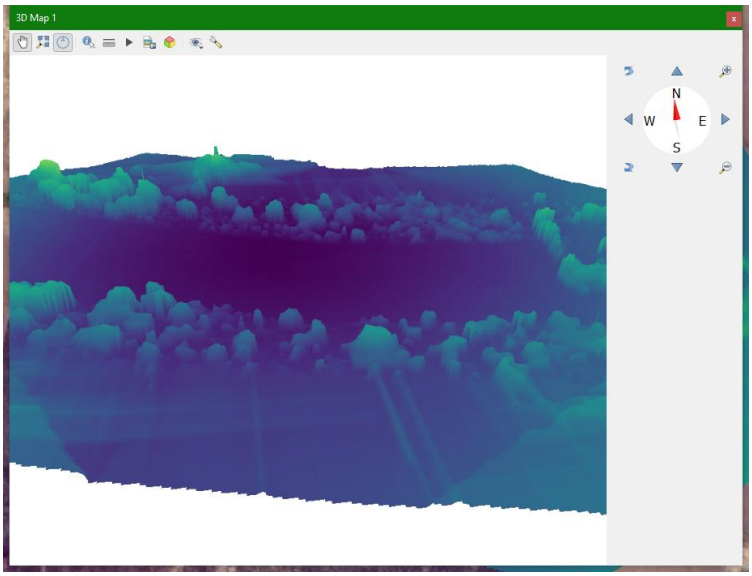


5. Click on  to go to the settings.

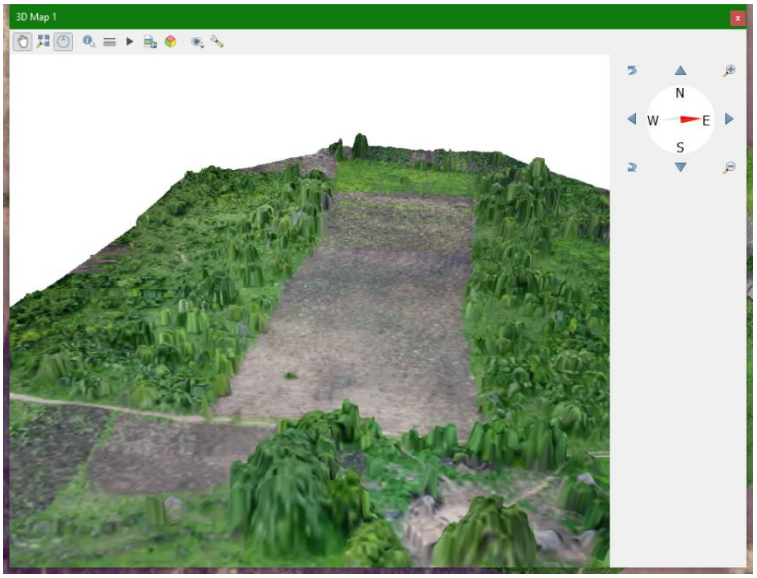
6. Fill in the dialogue as the screenshot below and click *OK*.



Now you'll see the scene in 3D:



7. Enable the orthophoto in the *Layers* panel and the 3D View will update so you can see the orthophoto in 3D.

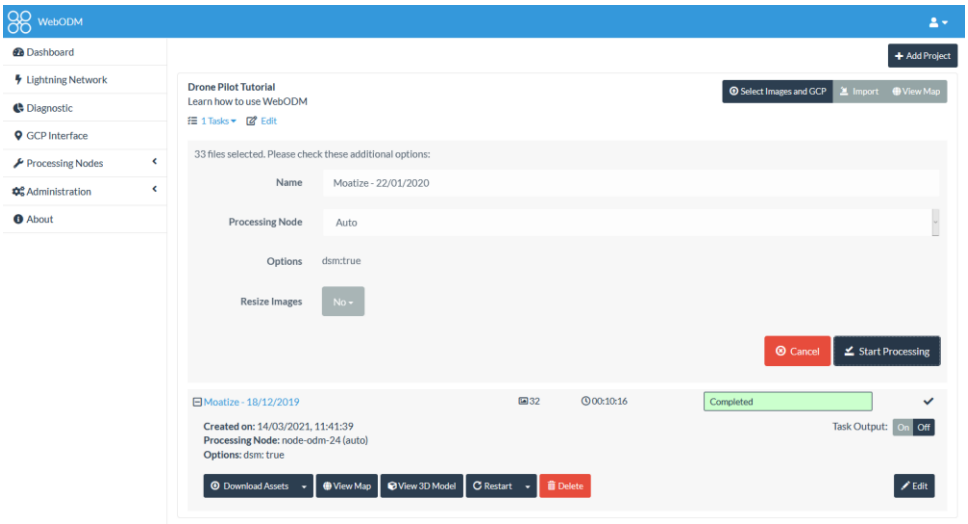


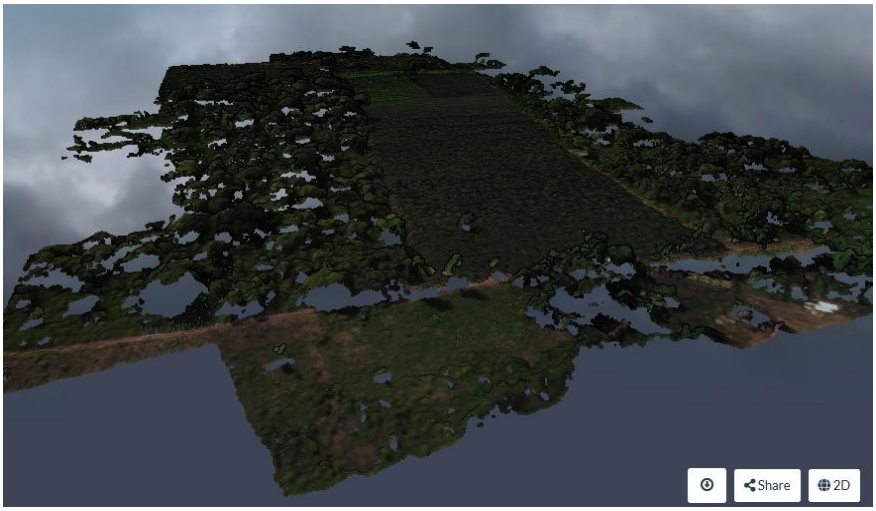
8. Save the QGIS project. We're now going to process the images of 2020. Later we'll compare the results here in QGIS.

Process the images of 2020

Now repeat the procedure to derive the orthophoto and DSM for the images of 2020

- Describe the differences that you observe.





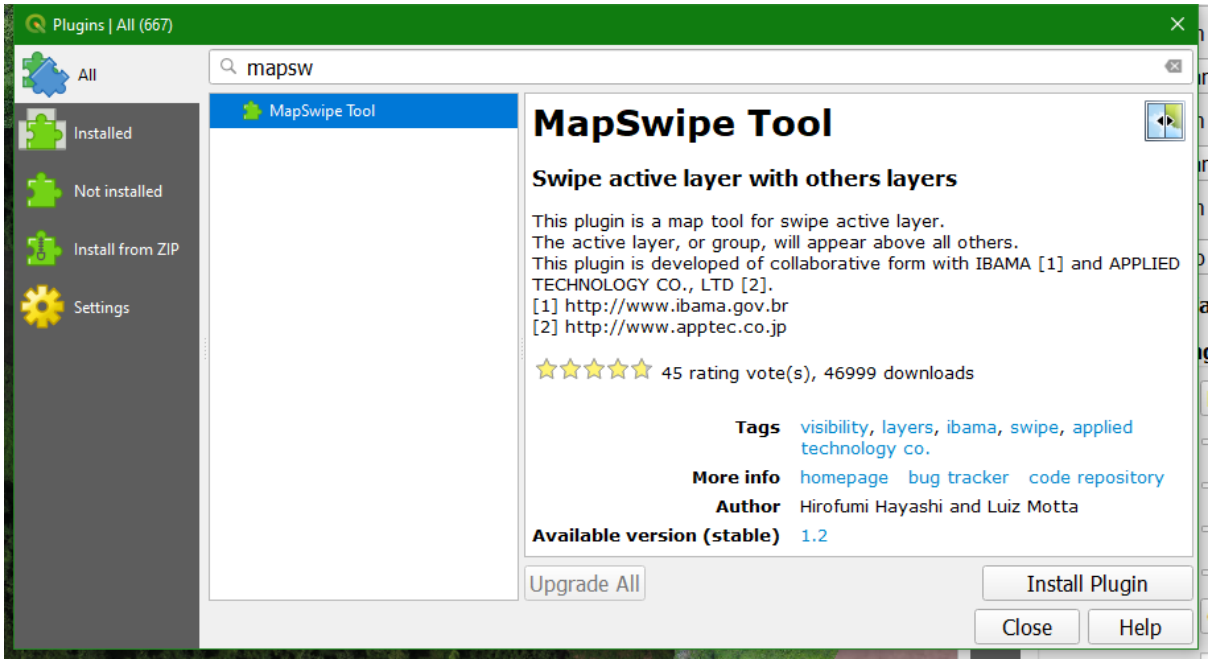
Compare results in QGIS

Now we've processed the images of 2019 and of 2020 we can compare the results in QGIS.

1. Start QGIS Desktop
2. Open the project that you have saved in section 12.2
3. Add the DSM and orthophoto of 2020 to the project
4. Compare the 2 orthophotos and DSM's.

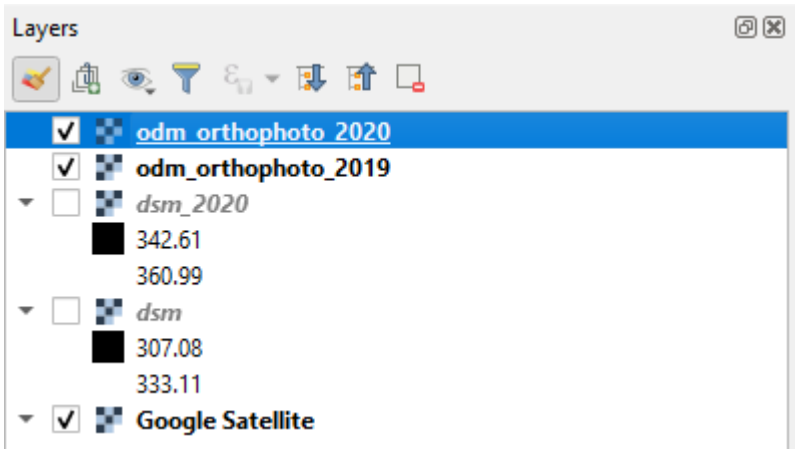
To make the comparison easier, we're going to install the MapSwipe Tool plugin.

5. In the main menu go to **Plugins | Manage and install plugins...**
6. Install the MapSwipe Tool plugin



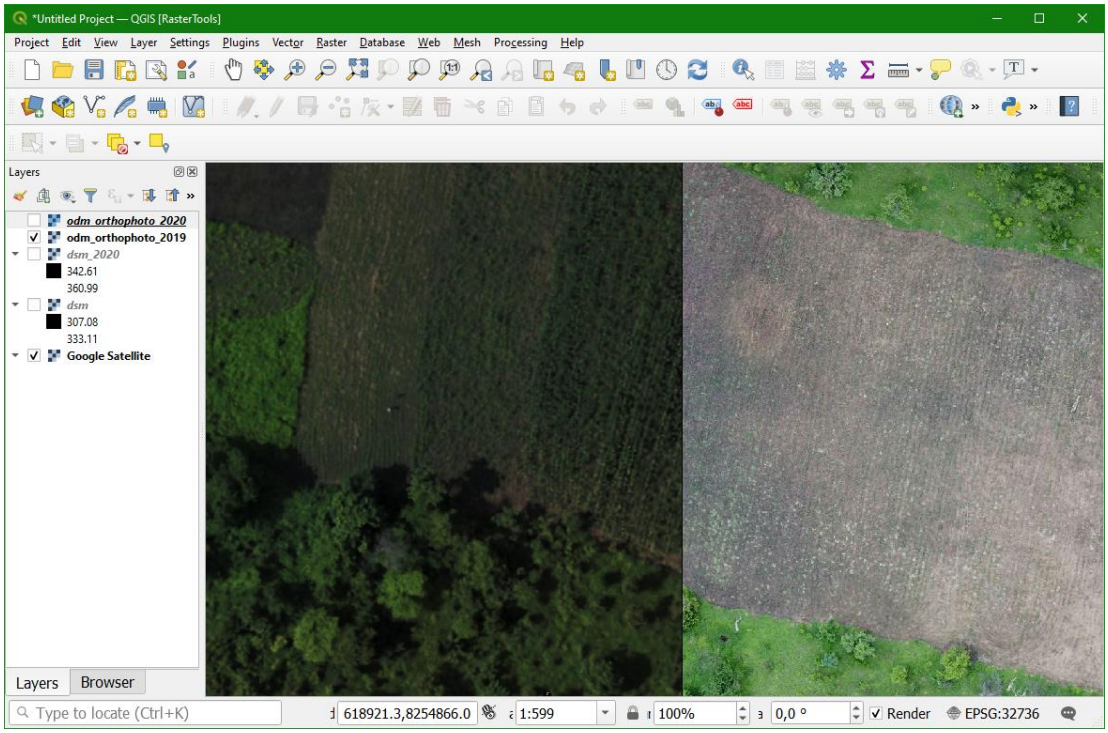
7. Make sure that the orthophotos are on top of the layers list. You can rename them in such a way that you can see to which year they belong.

8. Select the orthophoto of 2020



9. Click on the  icon in the toolbar to activate the MapSwipe Tool plugin.

10. Click in the map canvas and drag the mouse from left to right or from up to down.



- Describe the differences

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Tutorial - crop monitoring using vegetation indices

Learning objectives

After this tutorial you're able to:

- Generate various Vegetation indices
- Visualize in the 2D map view of WebODM
- Adjust the color palette in WebODM
- Download the vegetation indices as GeoTiff
- Visualise the indices and clip to Maize field boundary in QGIS
- Produce histogram of these indices over two dates
- Calculate univariate statistics from these indices

2. Theory

Vegetation indices are widely used to understand the vegetation coverage in the study area. For applications related to precision agriculture, it gives information about crop health and growth parameters.

The most common vegetation index in Normalized Difference Vegetation Index which is computed using the Red and Near InfraRed (NIR) reflectance bands. The NDVI is computed using the following equation: **NIR - Red/NIR + Red**

However the drone flights we used for monitoring Maize field in Moatize has only RGB camera, which means there is **NO** NIR spectral images available for these flights dated **18/12/2019** and **22/01/2020**.

There are vegetation indices computed from Red, Green and Blue (RGB) bands. In this tutorial we will cover the following vegetation indices as shown in the below figure:

VARI – Visual Atmospheric Resistance Index

$$\mathrm{VARI} = \frac{G - R}{G + R - B}$$

EXG – Excess Green index

$$\mathrm{EXG} = 2 * G - (R + B)$$

GLI – Green Leaf Index

$$\mathrm{GLI} = \frac{(2*G) - R - B}{(2*G) + R + B}$$

Read more about these indices in these papers:

VARI

Gitelson, A. A., Kaufman, Y. J., Stark, R., and Rundquist, D. (2002). Novel algorithms for remote estimation of vegetation fraction. Remote Sens. Environ. 80, 76–87. doi: 10.1016/S0034-4257(01)00289-9

EXG

Woebbecke, D. M., Meyer, G. E., VonBargen, K., and Mortensen, D. A. (1995). Color indices for weed identification under various soil, residue, and lighting conditions. *Trans. ASAE* 38, 259–269. doi: 10.13031/2013.27838

GLI

Louhaichi, M., Borman, M. M., and Johnson, D. E. (2001). Spatially located platform and aerial photography for documentation of grazing impacts on wheat. Geocarto Int. 16, 65–70. doi: 10.1080/10106040108542184

3. Vegetation Indices in WebODM

The main advantage of using WebODM is that, it comes with pre-defined vegetation indices which can be derived from multi-band ortho photo. In this tutorial you will generate the three vegetation Indices VARI, EXG and GLI in the WebODM interface.

Following sub-sections in this chapter takes you through following topics

3.1 Generate vegetation indices

3.2 Import Maize field boundary

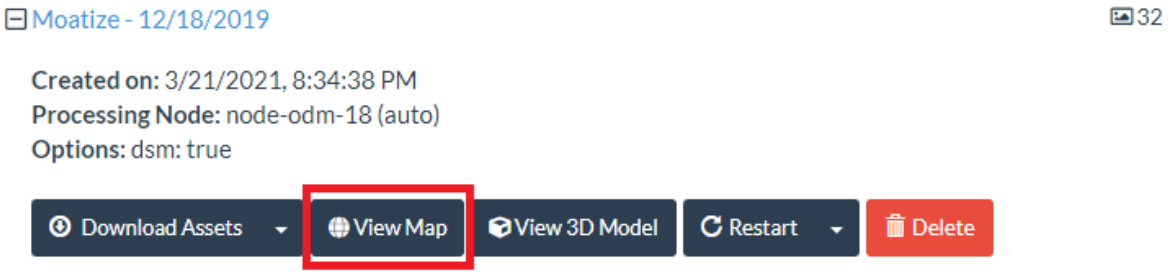
3. Vegetation Indices in WebODM

3.1. Generate vegetation indices

1. Visualizing maps in WebODM

Once the processing of both date images (18/12/2019 and 22/01/2020) are finished the WebODM interface will look like the following screenshot:

Now lets go to the task - "Moatize - 12/18/2019" and open the "View Map" to open the 2D map interface.

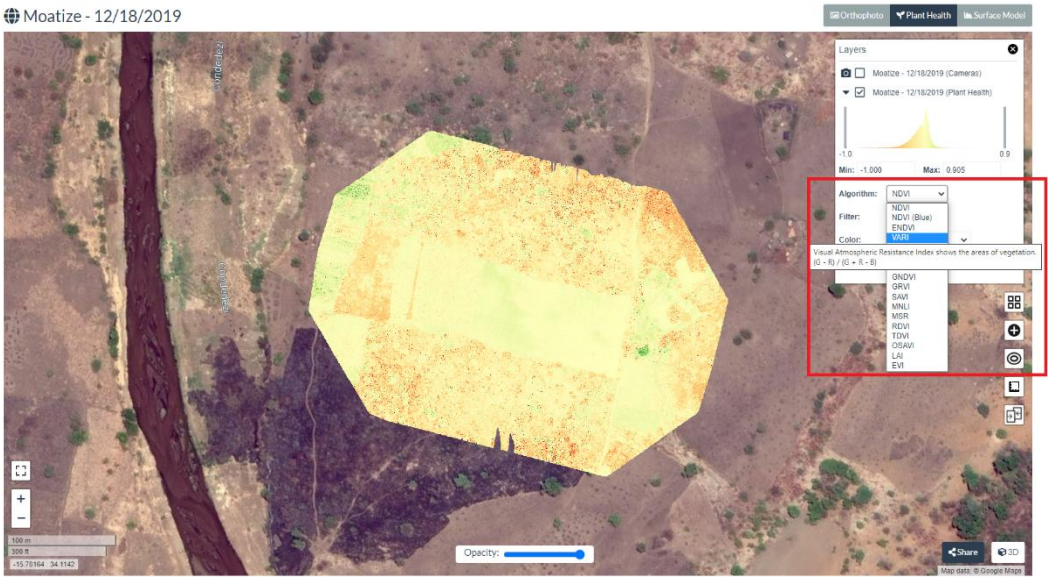


In the 2D map interface on the right top, you will see three tabs: "Orthophoto", "Plant Health" and "Surface Model". By default the interface opens with "Orthophoto" selected.

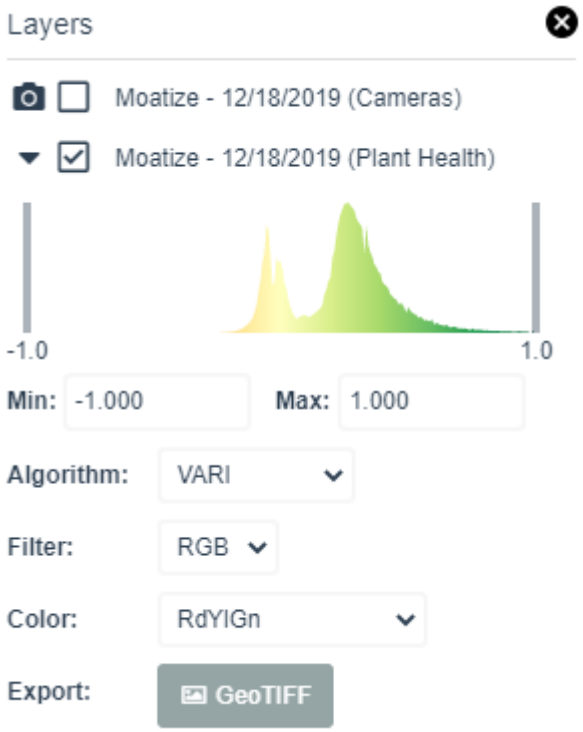
From the above window select "Plant Health" tab to generate various Vegetation indices.

2. Vegetation indices in WebODM

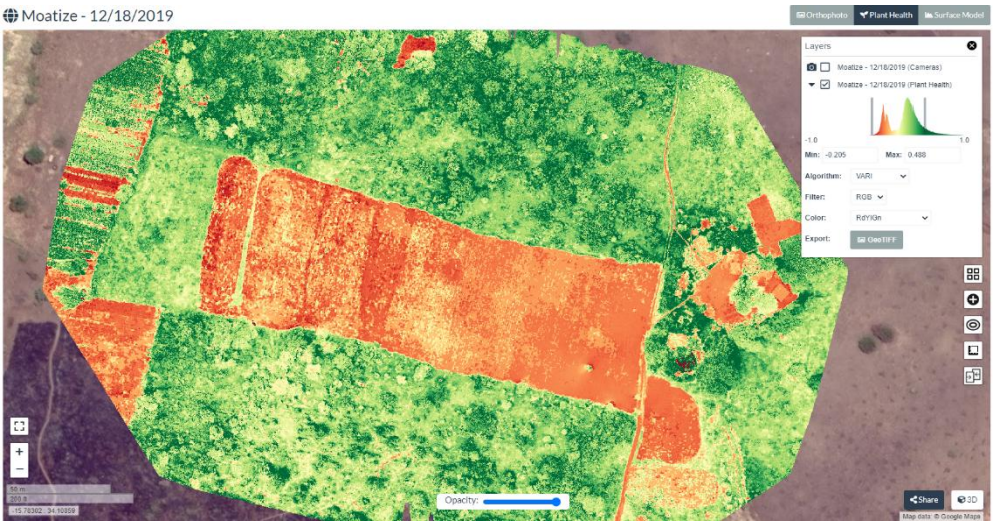
Once you select "Plant Health" you will see the below map which by default the NDVI index generated by WebODM. However as there is no NIR band let us explore other indices as explained before. Click on  icon for layer manager and also where you can select various indices.



As shown in the above screenshot select the index from the drop down which will be generated and visualized in the map upon selection. Select VARI to generate and visualize this index. Note that as you hover the drop down the equation behind each index is displayed.



Adjust the color palette to increase the contrast to see the heterogeneity in the field. Adjust the two bars in the color histogram to stretch or sharpen the colors. Map after adjusting the color palette is shown below.



3.2. Import Maize field boundary

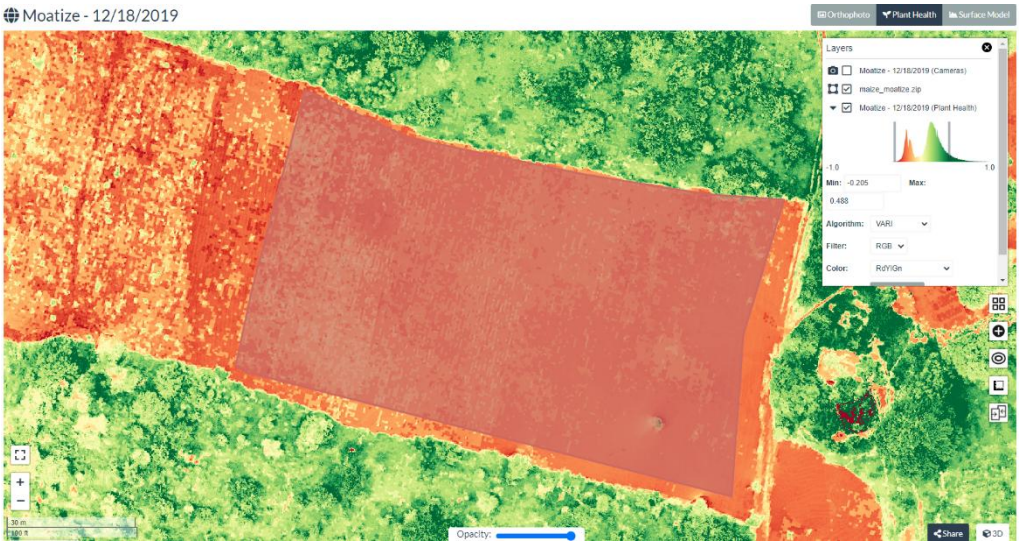
1. Import shapefile to WebODM

In webODM, it is possible to import the shapefile representing a boundary which will help us in focused analysis. In this case let us import the maize boundary which we will will further analyse in QGIS as well.

To import the shapfile:

- Prepare a zip file with the shape file(s) of the Maize boundary. You can download it from here.
- Upload the zip file using the ⊕ icon on the right side of the interface

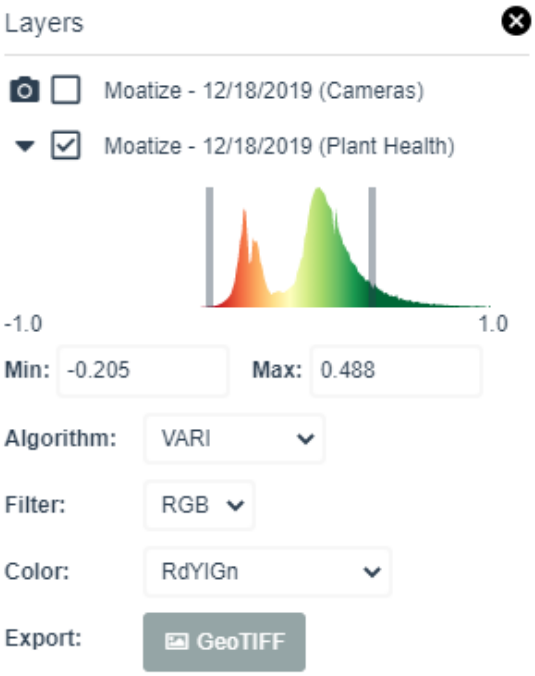
The below screenshot shows imported maize boundary over VARI.



2. Download the vegetation index - VARI as GeoTIFF, for further analysis in QGIS

Click on the Export: 

button in the layer manager to save as geotiff into your local drive. **Note the folder where you are saving the geotiff file.**



3. Your tasks

- Generate the two other indices EXG and GLI for the date 18/12/2019
- Download these two indices as geotiff files

4. Analyzing vegetation index in QGIS

Once you have the vegetation indices downloaded from WebODM, we can perform further analysis in QGIS to understand the vegetation status in the Maize field.

Following sub-sections in this chapter takes you through following topics

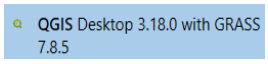
4.1 Clip the vegetation index

4.2 Histogram and univariate statistics

4.1. Clip the vegetation index

1. Visualize VARI geotiff raster image in QGIS

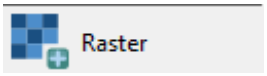
Open "QGIS with GRASS GIS" by clicking on the following logo in the programs.



(Note that the following steps should work other QGIS versions as well (greater than version 3.12)

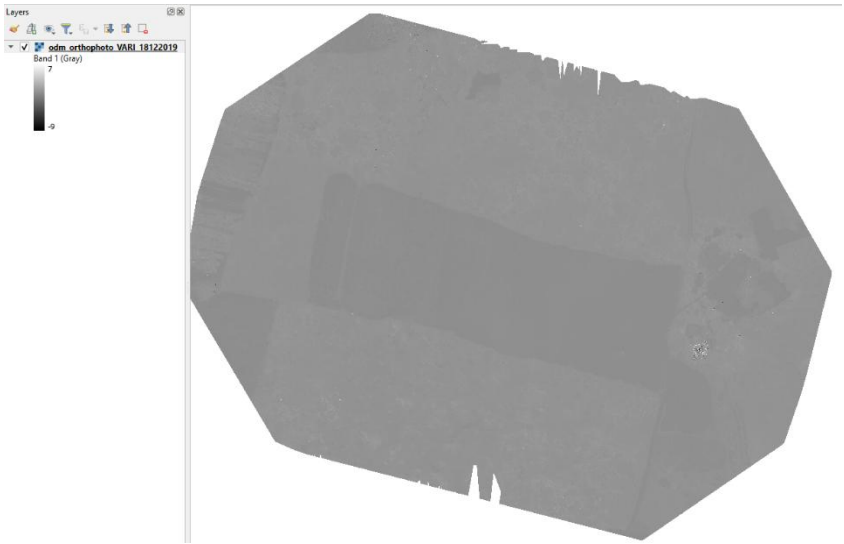
Once the QGIS is open, start a "New Empty Project"

"Open Data Source Manager" in QGIS using the  icon

Select 

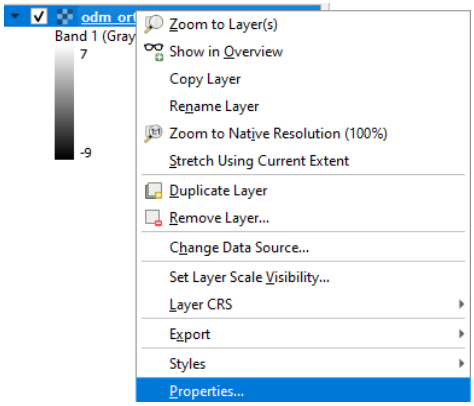
on the left side and browse to the folder where the VARI GeoTIFF file is saved, click "Add" to see the VARI image in Map view in QGIS.

The VARI image will appear in gray scale as shown below:



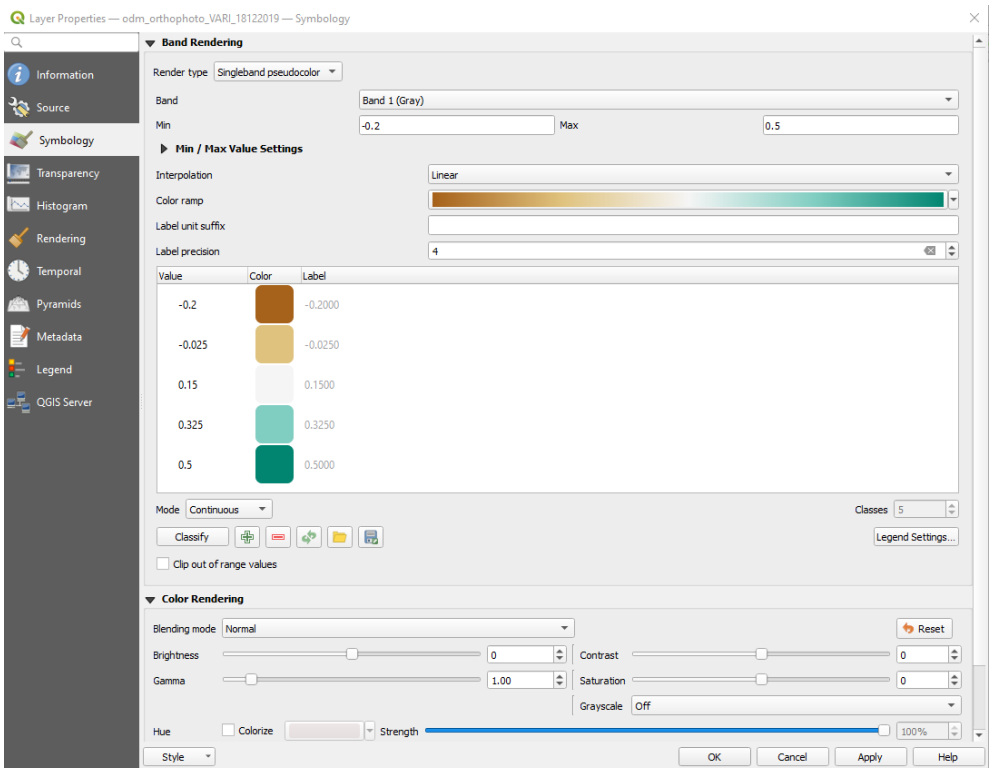
Change the styling:

- Right click on the VARI image in the Layer manager and select properties.

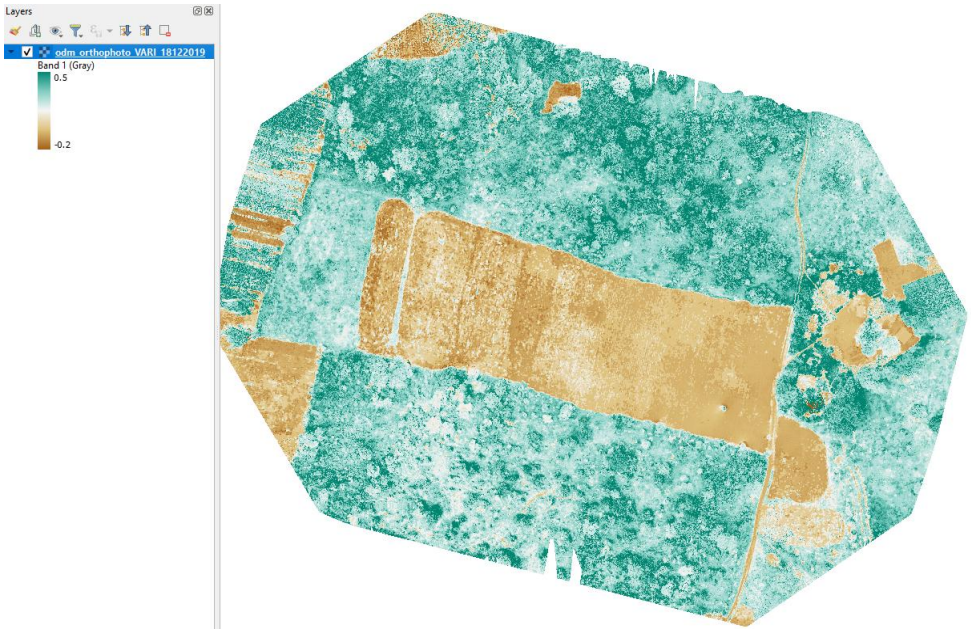


- In the properties panel select "Symbology" tab on left side. Select Render type as "Singlebandpseudocolor". Change the Min and Mac values to -0.2 and 0.5. Select the

color ramp you prefer and click on "Classify" to set values to palette. Once the settings are done, click on "Apply"



Here is the VARI map after applying the symbology:



2. Your tasks

Perform these steps for EXG and GLI indices for the date 18/12/2019