# GEOG2310 Wk21 and 22 – Landscape change analysis with SfM

The aim of this practical session is assess the geomorphic changes that took place in the landscape as a result of the dam break. You simulated this model scenario with the river-in-a-box physical model last week. From the photos you took before and after the event you will create 3D models with Structure from Motion (SfM) software, which will then be used to create topographic change map.

**Key datasets & sources:**

- Photos acquired by group Pigs 1 and 2 and group Goats before and after the dam break
- Old Agisoft project based on photos acquired by tutor before and after dam break
- GCP coordinates as measured from the River-in-a-box with total station
- Pre-prepared before and after dam break DEM group 2 (.tif)
- (Pre-prepared before and after dam break DEM old version (.tif)

**Key skills we will learn or develop in this session:**

- Image selection
- Building a 3D model from box imagery using SfM
- Georeferencing a 3D model using GCPs
- Creating a 'DEM of difference', showing changes in topography

# Part 1. Preliminaries

- Data for this practical is available via links in the folder for this week on Blackboard.
- Use the links in the Group Image Data folder on Blackboard to download the image data collected by your group. Download and unzip both the before and after data.
- Use Windows Photos to preview your photos and check their quality.
- Photos that suffer from blurring or other visual distortions can cause problems in the SfM process and should not be included in the analysis. Try to select as many suitable images as possible, which ideally cover the full surface of the box. Do this for both the before and after dam break situation. Store each set of photos in a separate folder.

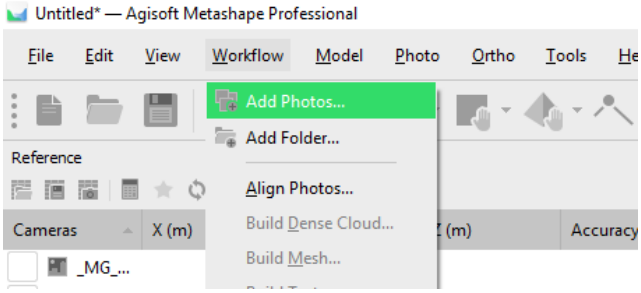
**Question:** Can you think of other reasons why you should reject certain photos? List them here:

# Part 2. Building a 3D Model from River-in-a-Box Photos

- Open the **Agisoft Metashape Professional** software.

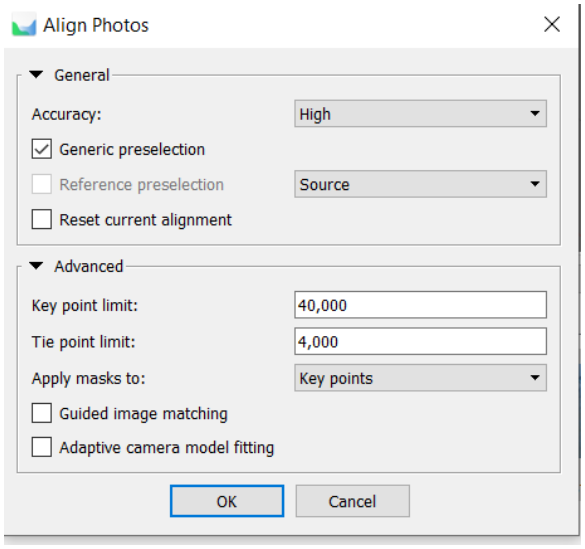
## 2a. Add Photos

- Select **Workflow > Add Photos** on the top menu bar. Select all photos from the folder with the high quality photos for the before dam break situation, which you created in a previous step. Click **Open** and the photos will appear in the long thin pane at the bottom of the window, and are listed in the **Reference** pane on the left hand side.




## 2b. Align Photos

- Next, select **Workflow > Align Photos**. Ensure you use the settings shown below.
  - **High Accuracy**: A 'high' accuracy alignment means the original images are used to identify prominent matching point between the overlapping images. The 'medium' setting would downscale the images by a factor of two and lower accuracy settings use even more downscaled images (Agisoft LLC, 2014). Higher accuracy settings take longer to process, but typically produce better quality results.
  - **Generic Pair Preselection**: This setting helps to speed up the alignment process by finding overlapping images by matching downscaled images first, and then performing the full scale image alignment using pairs of the original images.
  - Leave the **Advanced** alignment settings as you find them. This process should take around 5 minutes.

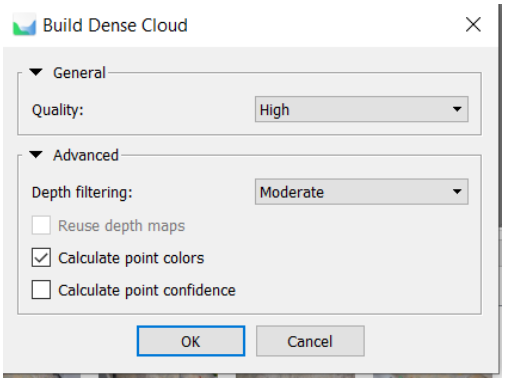



- Use the Trackball to navigate around the point cloud which has been created from the Image Alignment.
  - Zoom in and out using the mouse wheel
  - Pan across the scene by clicking and holding the right mouse button
  - Tilt and rotate the point cloud by clicking and holding the left mouse button

You should see the photo locations indicated by blue squares sitting over the point cloud of the river scene below. It doesn't look much like a 3D model yet, so we have some more work to do…

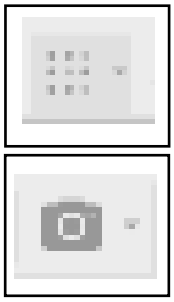
## 2c. Build Dense Point Cloud

- Select **Workflow > Build Dense Cloud** and use the settings below:

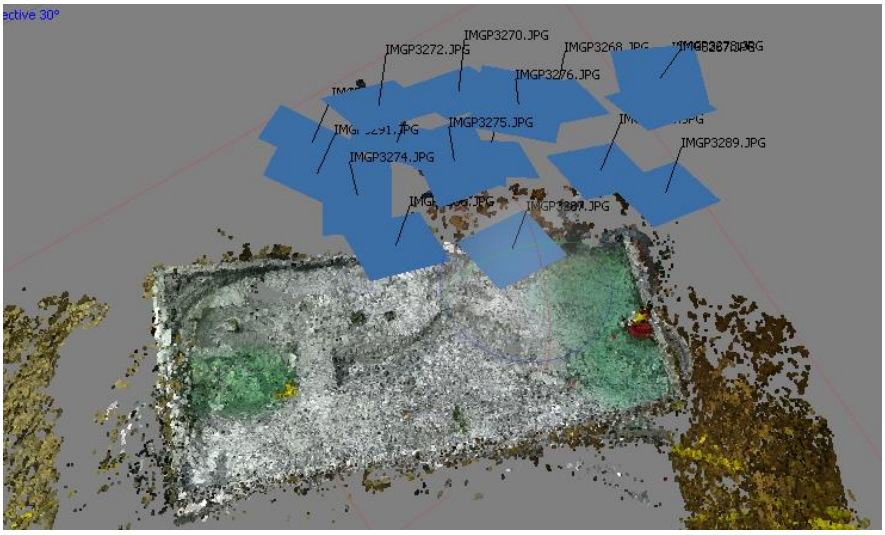



This process uses a multi-view stereo-reconstruction on the pixel values of the aligned images to build the geometry of the model and construct a dense point cloud. We are using the '*high*' quality setting (rather than *'very high'*) as a compromise between high accuracy and fast processing time. Check if the **Advanced** settings are set to *'Moderate'* and click OK. This process can take around 20mins. You may like to take a break while your computer is running.

- To show the dense cloud point cloud which has been created, click the '**Dense Cloud**' symbol, which can be found in the top menu bar.



The dense cloud of points, coloured by the input photos will now be shown and should look something like this… (You can turn on the Show Cameras button)

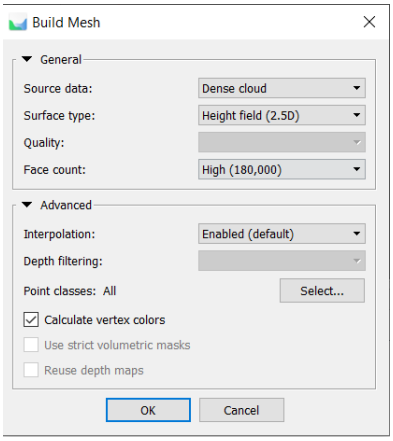



## 2d. Build a Mesh

- Next we want to build a mesh. This is essentially a process which creates a continuous surface between the points in the dense cloud. Select **Workflow > Build Mesh** and use the settings shown in the screenshot below.

*'Height field'* is chosen as the **Surface type**. This option is recommended for planar image sequences, rather than the alternative *'Arbitrary'* setting which is more useful for modelling 3D objects. The

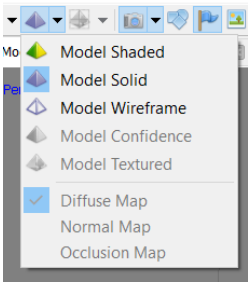
*'height field'* option results in the creation of a 2.5D surface, where a single elevation (z) value is produced for each planimetric (x, y) location.




*'Dense cloud'* is chosen as the **Source data**, rather than the sparse point cloud initially computed by the **Image Alignment** phase. This allows for a more detailed mesh to be created.

**Face count** specifies the maximum number of polygons which will be allowed within the output mesh. We choose the *'high'* setting to permit a greater level of detail within the output data.

Leave the **Advanced** settings as you find them. This process should take about 1 minute.

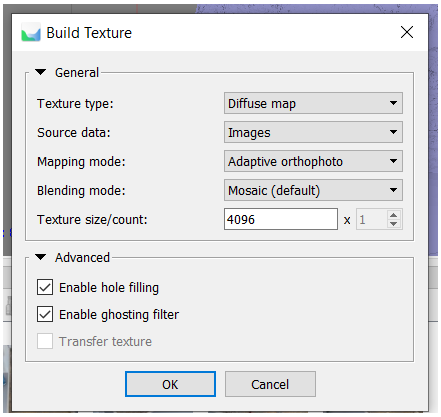



To view the mesh, select the '**Wireframe**' model from the top toolbar.

## 2e. Build the Model Texture

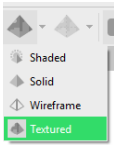
Next we want to build the model texture. This step effectively drapes the original input imagery over the model which we have created.

- Select *Workflow* > *Build Texture* and use the settings shown in the screenshot below:
  - The *'Adaptive orthophoto'* option within the **Mapping mode** textures the whole surface of the model using an orthographic projection and is the most appropriate setting for the aerial imagery that we are using here.
  - *'Mosaic'* is chosen as the **Blending mode**. This is recommended for orthophoto generation, as it does not mix pixel information from overlapping images like the 'average' mode, but instead uses a single image allowing the production of a better-quality mosaic.




  - Leave the **Texture size/count** and **Advanced** settings as default. This process should take about a minute.

- To show the textured model which has been created, click the *Textured* symbol, which can be found in the top menu bar.




**Question:** Explore the model by panning around, rotating and zooming in and out. How well do you think the model represents the real river-in-a-box?

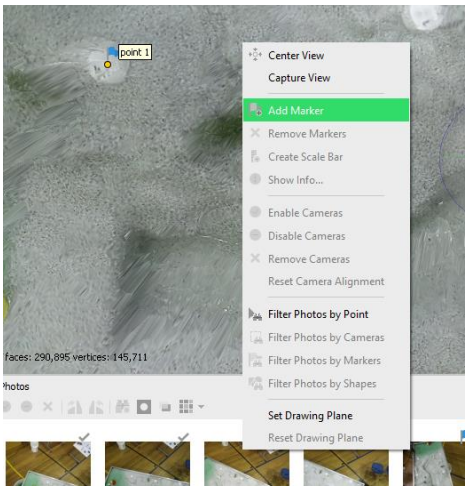
**Question:** Can you think of reasons why the model created from the photographs has not turned out so well?

# Part 3. Georeferencing

## 3a. Add Markers

The use of Ground Control Points (GCPs) is very important for providing scale and for positioning the model in 3D space. We need to identify these markers on the digital model and tell the software how to use them. During your experiment you positioned GCPs on the edges or the box. A problem with this approach is that the shiny aluminium box edges have not been modelled so well, but it looks like good models can still be produced.

- Use the trackball to ensure you are looking directly downwards at the model/scene.
- Zoom in on a marker and right click in its centre and select *'Add Marker'*, as shown below (note: your marker were the duplo blocks!). Make sure you zoom in close enough to accurately locate the marker centre – your final orthophoto will be compromised if you don't.
- A blue flag will appear over the marker location.





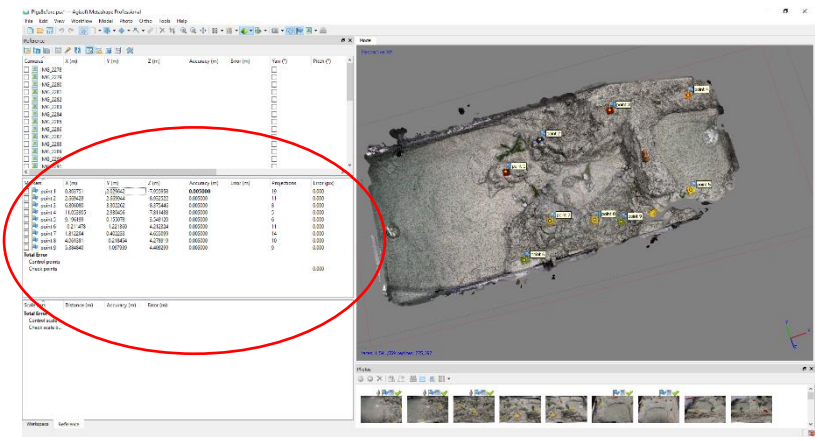


We need a minimum of 3 markers (or GCPs) to conduct the next step, but more markers are better. You can place the markers in the model, or you can place markers in the individual photos, which will then appear in the model. You can view individual photos by double clicking on individual photos in the Photos pane. Repeat this process for all the markers you can see within the model. These will

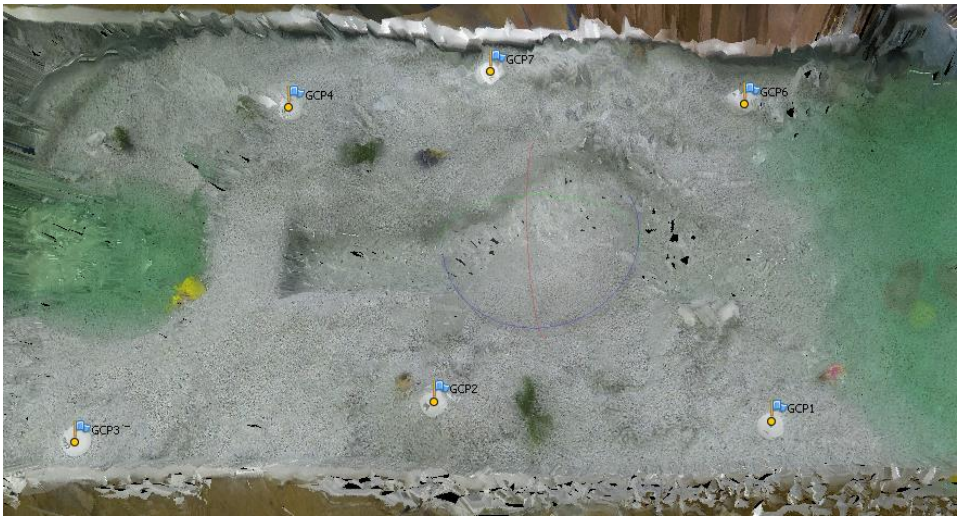
appear as a list in the **Markers** pane on the left-hand side of the screen, within the **Reference** *tab,* as shown below.

Make sure that for each GCP you add a new marker only once. To help the modelling you can locate the same GCP in multiple photos, right click on each and select Place marker > Select marker > [click on appropriate marker number].

If you make a mistake, delete the marker by right clicking on it in the markers pane on the left-hand side.

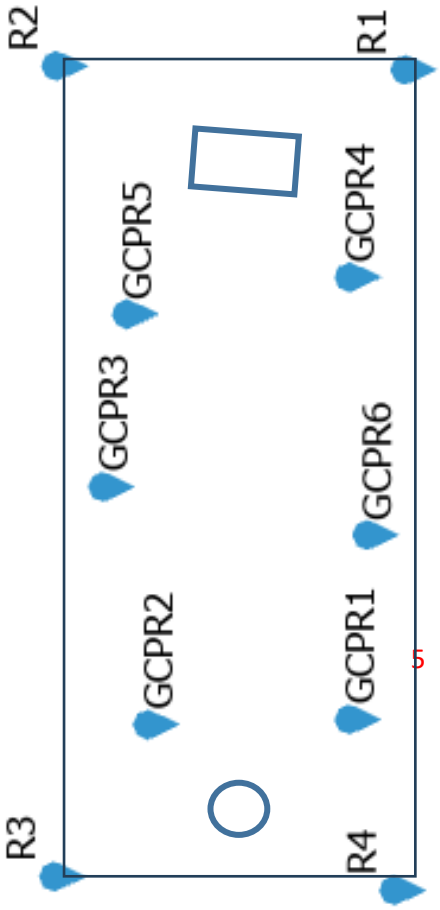


Next we need to tell the software the XYZ co-ordinates of each of these markers. Use the maps below to work out which markers you have identified on your 3D model, and rename each marker by double-clicking on the marker name in the '**Markers'** window.

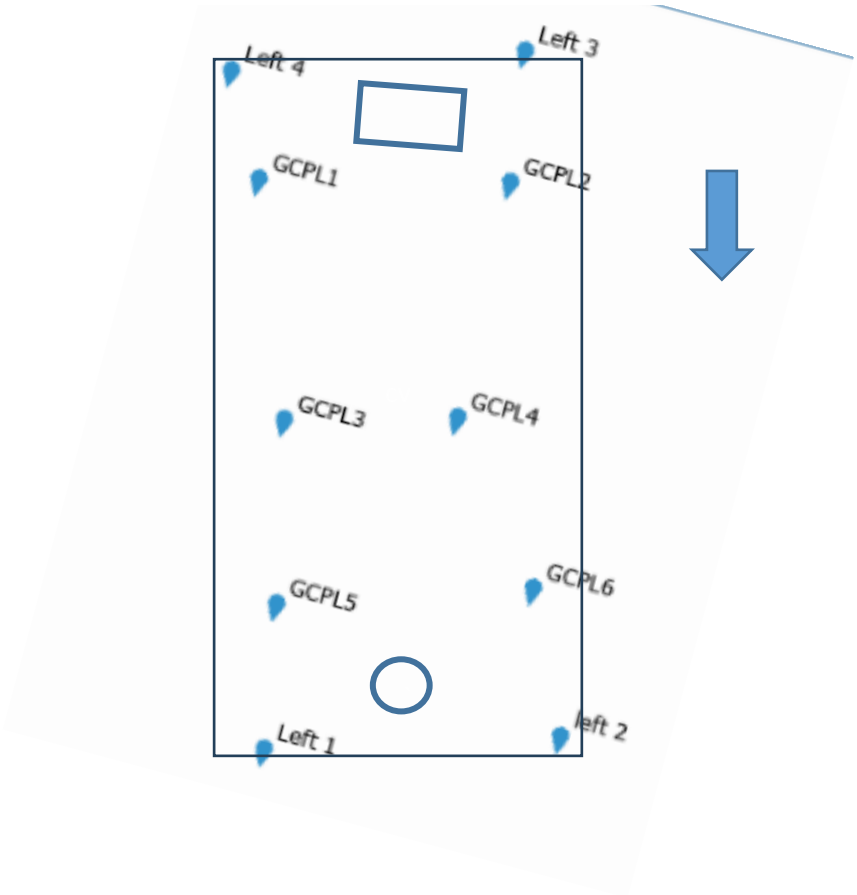



Use the figures below to find exactly which marker is located where in the model and find their exact names (the blue arrows indicate direction of flow). The numbers in red are the numbers as written on the actual marker (which may be visible in the photos/model). The numbers in black are the names as you entered them in the Total station. This name needs to be used in the software.

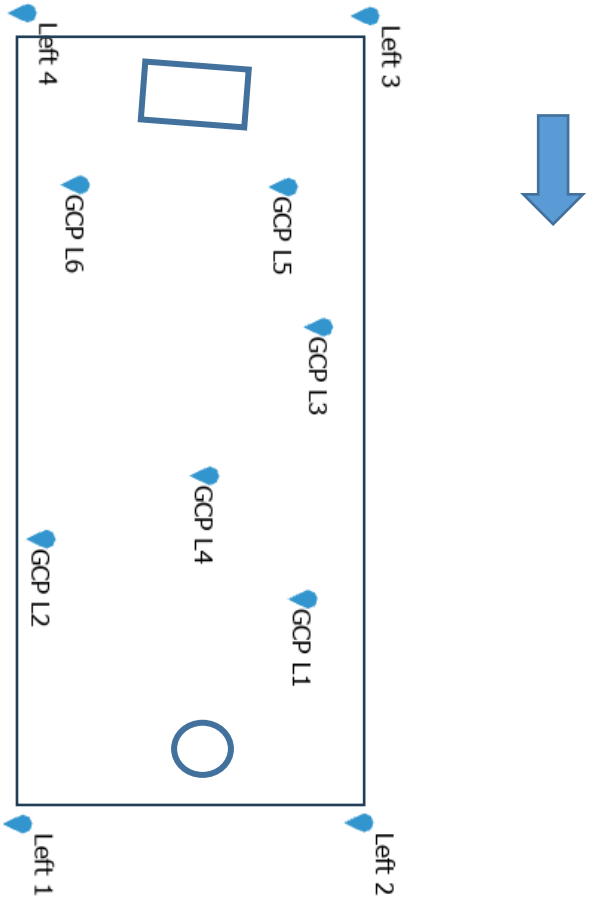
Goats 1




Pigs 2

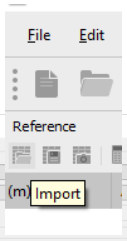


# Pigs 1




Once you have correctly labelled each marker, we need to tell the software where each marker is located in 3D space. That means each marker needs an X, Y and Z co-ordinate. The XYZ co-ordinates of each of these markers are saved in a CSV file called (e.g.) *'Goats1'* which is located in the main data folder.

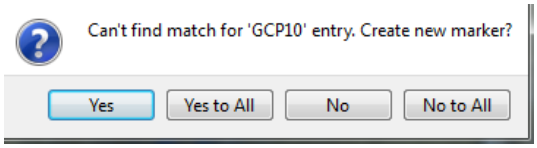
- To add the co-ordinates to your model, click the *Import* symbol on the Reference pane (top left), then select the CSV file you have just downloaded.




- We need to specify to the import tool that the co-ordinate system we are using is **Local Coordinates (m)**, that the file is **comma delimited** and to **start the import at row 2** (because the first line contains the headings).




- If you get the following waring, say: No to All



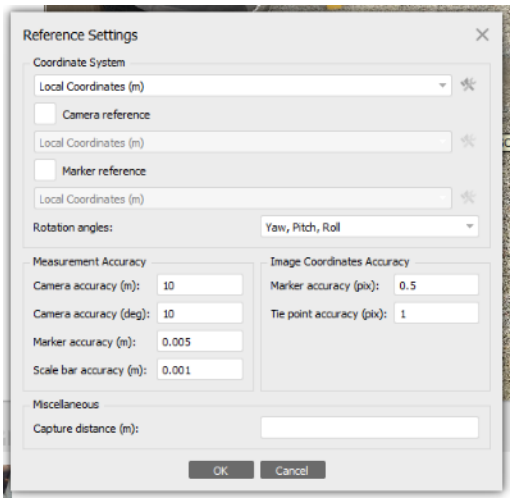

## 3b. Reference Settings

Next we need to specify our reference settings in the software. We do this by clicking the **Settings** tool on the **Reference toolbar**.



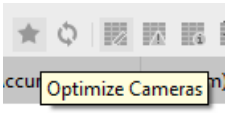
You will then be presented with a dialogue box, where you can change the settings to those specified below

- Firstly, ensure the **Co-ordinate System** is set to *Local Coordinates (m)*.
- The **Camera Accuracy** fields are set to a rough estimate of 10, because this value is otherwise unknown.
- The **Marker Accuracy** refers to the accuracy of the X, Y, Z positions of each GCP marker. These positions were determined using a total station so we would expect a high accuracy, such as the estimated 5mm suggested below.
- Leave the other settings as you find them or change them to match the numbers below if they are different.




### 3c. Camera Optimisation

Now that we have specified the reference settings, we are ready to use the GCPs to optimise the alignment of the cameras. Essentially this means we can use the known GCP positions to help improve the estimates of the camera positions and improve the alignment of photos and any subsequent measurements we take from them. It also helps to reduce errors resulting from the camera lens.




- Click the **Optimise Cameras** tool within the **Reference** pane. Leave all the settings unchanged and click **ok**.

The current model geometry will be cleared and you will be left with a sparse point cloud again. Next, we would normally re-build the model now that it has been optimised. However the quality of models produced was not sufficient to do the further analysis, so we will be working with a historic dataset.

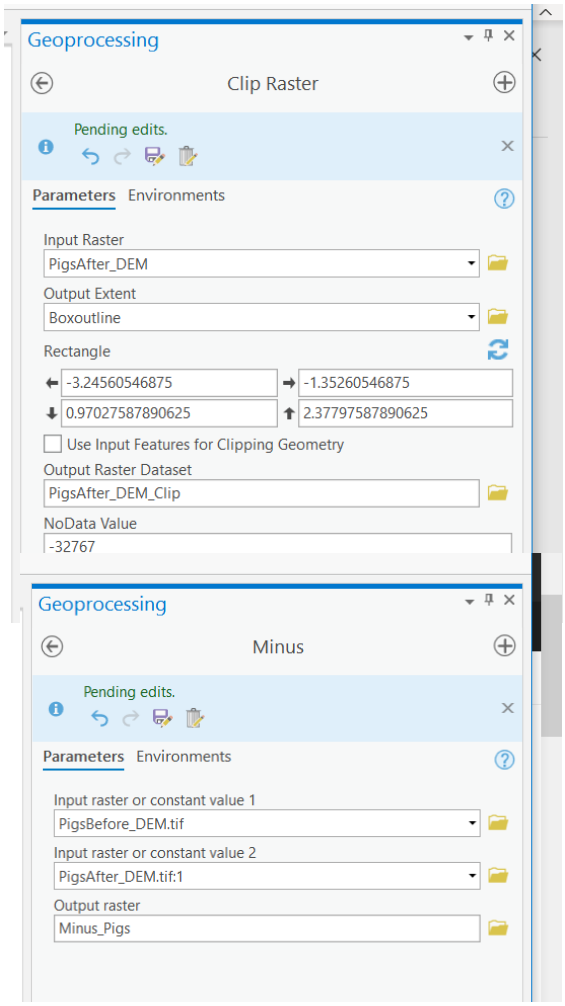
If you did manage to produce a satisfactory model you can produce an orthophoto (georectified aerial image) and a digital elevation model (DEM) using **Workflow > Build Orthomosaic**… and **Workflow > Build DEM**. The default settings for these tools is generally fine. The resulting data layers can then be exported in a format suitable for use in other software (e.g. .tif), using **File > Export Orthomosaic** and **File > Export DEM**.

# Part 4. Creating a DEM of difference (DoD)

### 3a. Cropping the model

- Open ArcGIS Pro and create a new project using **Blank Templates > Map**. Next use **Map > Add data** to add the two DEMs that have been created from dam break images of last year's practical to your Contents list. The files are located in the main data folder and called: Pigs1beforeDEM.tif and Pigs1afterDEM.tif.

The digital 3D model contains a lot of unnecessary information surrounding the box, which should get rid of. We therefore first want to crop both models to the box surface area only.




- Use **Analysis > Tools** search for the **Clip (Data Management)** tool and create a layer that only includes the river-in-a-box surface as follows, using a template shapefile called *Boxoutline.shp*. Make sure you tick the '**Maintain Clipping Extent**' box:
- Run **Clip** on both the before and after DEMs.
- Use the Search tab to find the **Minus** tool. This tool can be used to subtract two DEMs and create a DEM of Difference (DoD). Note which order you need to enter the data sets!
- Right click on the Minus layer name in the TOC. Select **Symbology > Primary Symbology > Classify** and select **5 classes** as output. Select **Method > Manual Interval** and then select the **Histogram** tab, to manually adjust the boundaries of the five classes, to effectively display the variation in erosion and deposition in the flume. I recommend you use the red-yellow-blue colour ramp here, so that red colours represent negative values (erosion), yellow colours no change and blue colours positive values (deposition).
- Use the Search tab to find the **Hillshade** tool. Apply the tool to both elevation models. It will help visualizing the topography for before and after the event.

**Question:** Looking at your DoD and the hillshaded elevation models from before and after the event. Did erosion and deposition occur in the locations where you were expecting it?

You have just done your first quantitative geomorphological change assessment.

Well done!

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