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3D report

# KNK 4002, Ilulissat

Greenland

AS 30/2018

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## Contents

# 3D models of the graves



3D models of the graves have been created using photogrammetry technique from 2D photographs (Villa 2017, Villa and Jacobsen 2019).

3D models of the graves A and B have been obtained from the photographs taken by Chiara Villa using a Canon 5Ds-r and fixed lenses 24 mm or 35 mm. The camera and the lenses have been calibrated to account for the lens distortions and to guarantee an accurate and precise 3D model. The resulted 3D models are scaled and measureable.
*Photomodeler* was the software application used for creating the 3D models.

In appendix 1, some guidelines for taking "good" photographs to be used in photogrammetry post-processing are provided.

3D models could also be created from the photographs taken by Jens Fog Jensen using a Sony ILCE-7 at different focal lengths. The obtained 3D models have an unknown scale, accuracy and precision and we advise to use only for visualization purpose.
*Agisoft Metashape* software was the software application for generating the 3D models. This software can better account for photographs from uncalibrated cameras and with variable focal lengths.

The 3D models have been saved as point cloud (.pts) and mesh, i.e. surface, (.obj). Both the 3D models can be visualized with and without texture (i.e. the actual colour). *Meshlab* and *Cloud Compare* are the free software applications that can be used for visualizing mesh surfaces and point cloud, respectively. A short guideline with some basic commands for both the software applications is provided in the Appendix 2.

The 3D files can be found here:
https://drive.google.com/drive/folders/1vfCqnQpu6pGGfWxe_hu4AT0tnO3gd4_N?usp=sharing

The files will be keep on the drive until the end of June. Afterwards, the files are available upon request. A permanent copy will be kept on the Institute's hard drive.

### *Grave A*

Grave A was a multi-chamber grave, where five chambers were identified: A1, A2, A3, A4 and A5.

The following 3D models have been created:

- Entire grave, before the excavation (from Jens' photographs) – Fig. 1
- Entire grave, after the excavation (from Chiara's photographs) – Fig. 2
- Single chambers, after the excavation (from Chiara's photographs) - Figs 3-7

A combined 3D visualization of the different point cloud 3D models have been created: *A point cloud - Chiara's and Jens photos.bin*.

The 3D model of the grave before excavation does not perfectly align with the 3D model of the grave after the excavation due to imprecision in the first model from Jens' photographs.

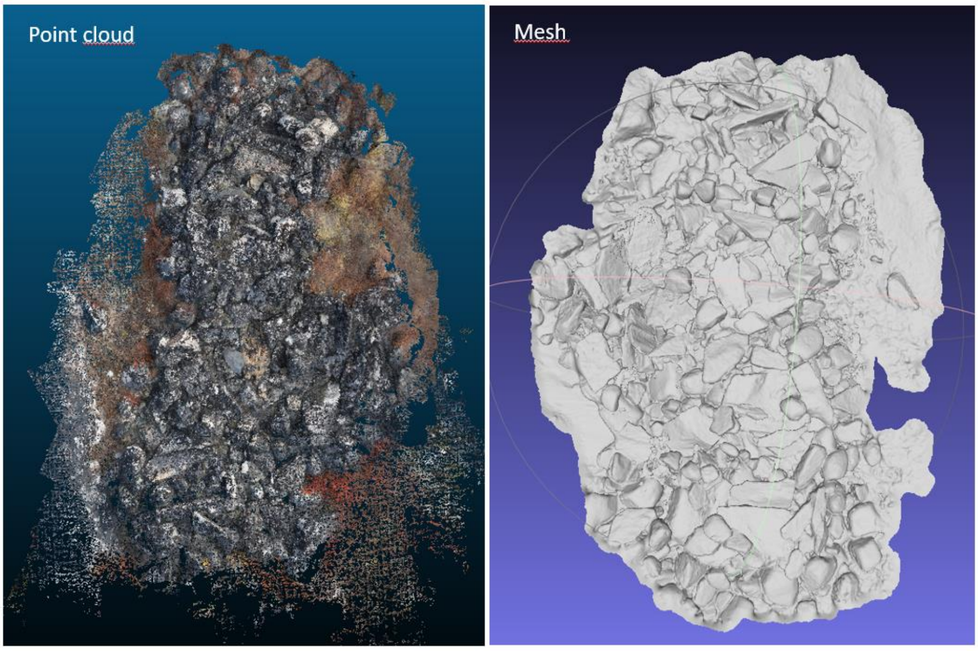



Fig. 1: grave A, before the excavation

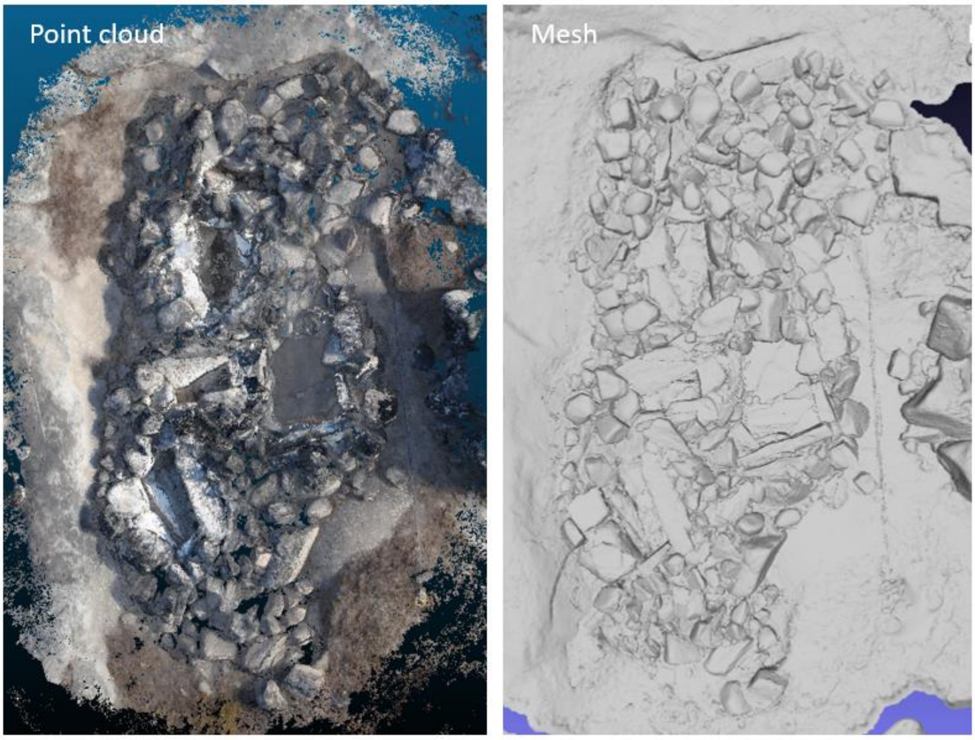



Fig. 2: grave A, after the excavation

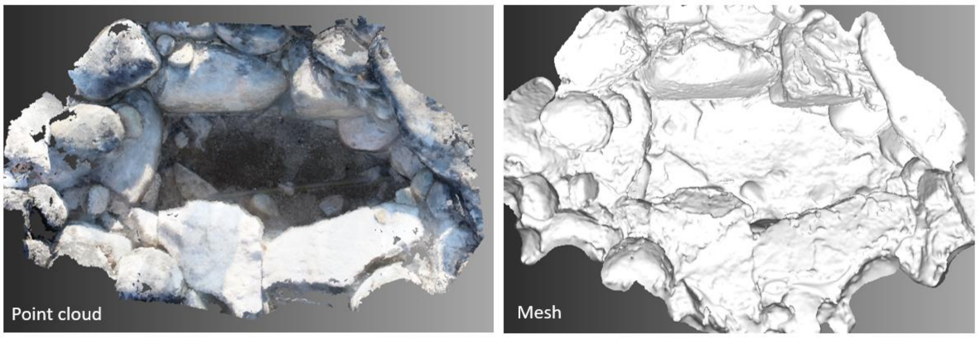



Fig. 3: chamber A1

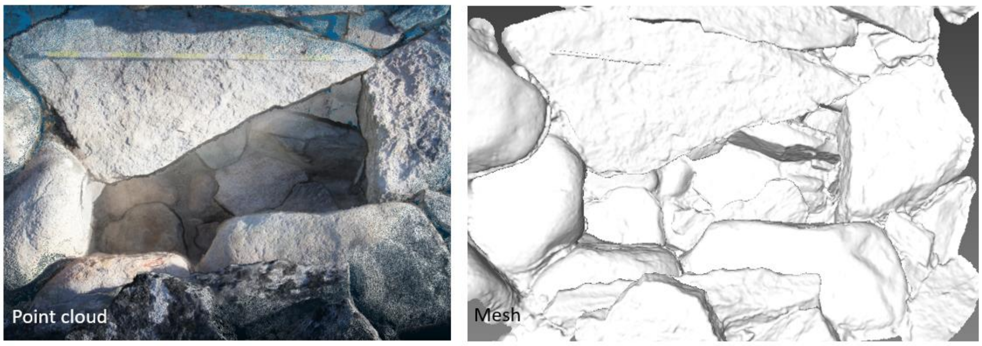



Fig. 4: chamber A2

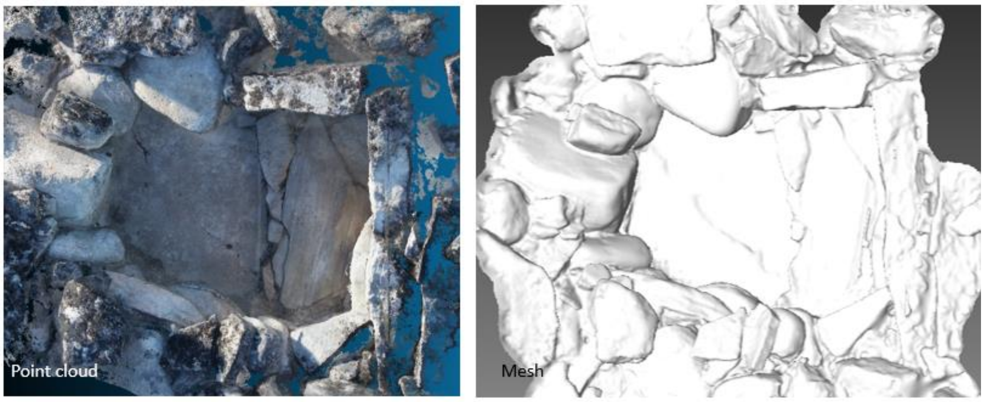



Fig. 5: chamber A3

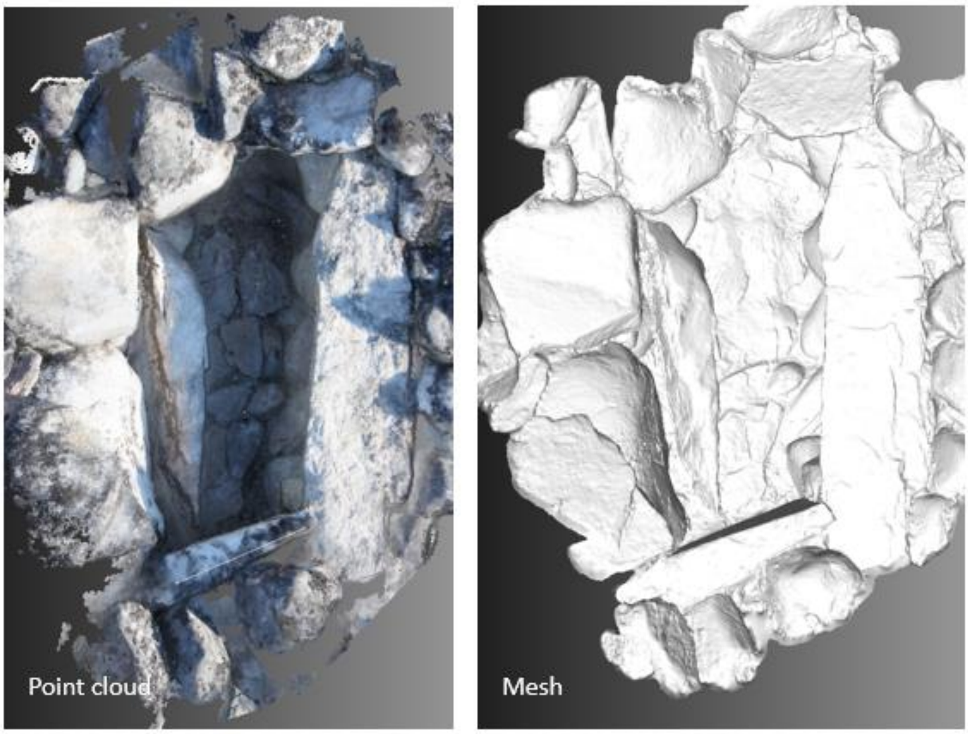



Fig. 6: chamber A4

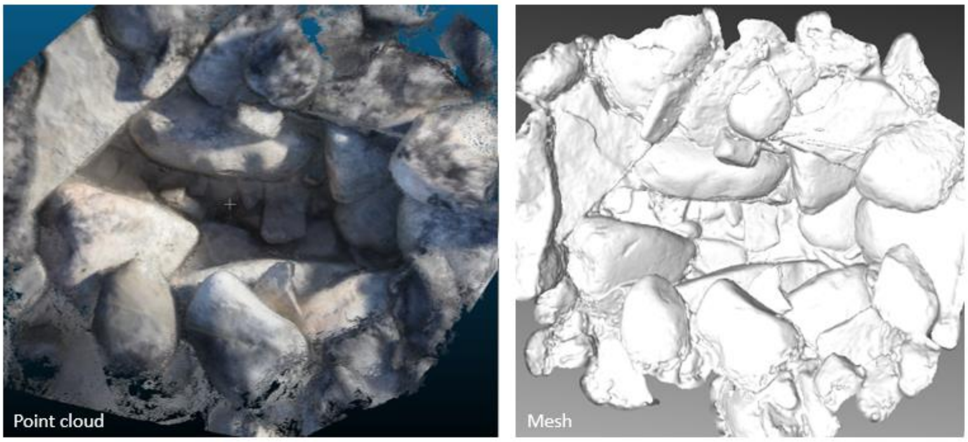



Fig. 7: chamber A5

### *Grave B*



The following 3D models have been created:

- Entire grave, before the excavation (from Chiara's photographs – Figs. 8,9

- Open grave with the skull visible (from Chiara's photographs) – Fig. 10

- Open grave with the skeleton visible (from Jen's photographs) – Fig. 11

A combined 3D visualization of the different point cloud 3D models have been created: *B point cloud - Chiara and Jens' photos.bin*.

The 3D models of the open grave obtained from Chiara's and Jen's photographs do not perfectly align, due to imprecision in the 3D model obtained from Jens' camera

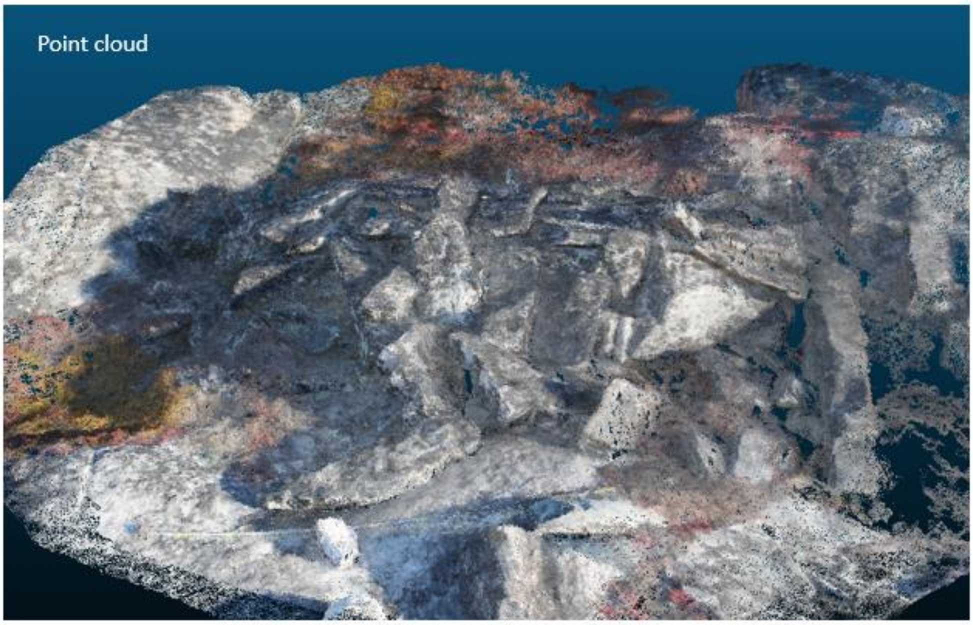



Fig. 8: Grave B, frontal view

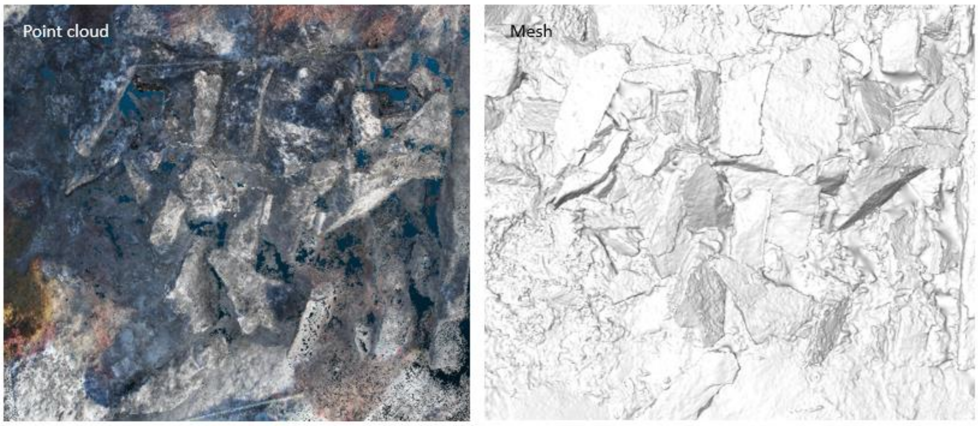



Fig. 9: Grave B, see from above

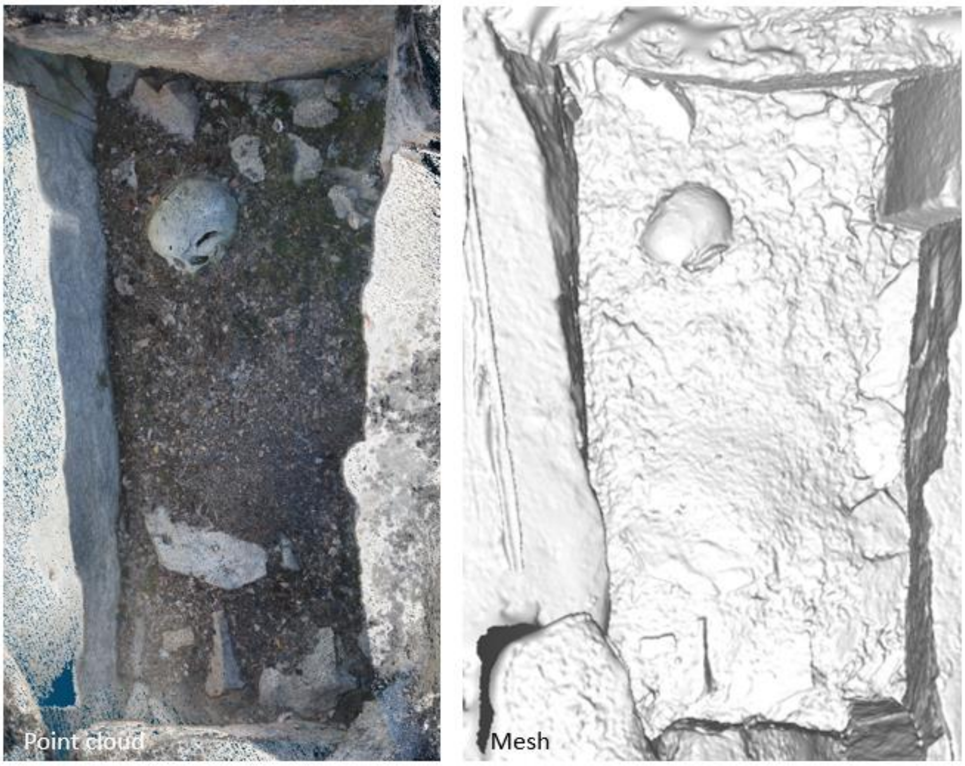



Fig. 10: Grave B, open

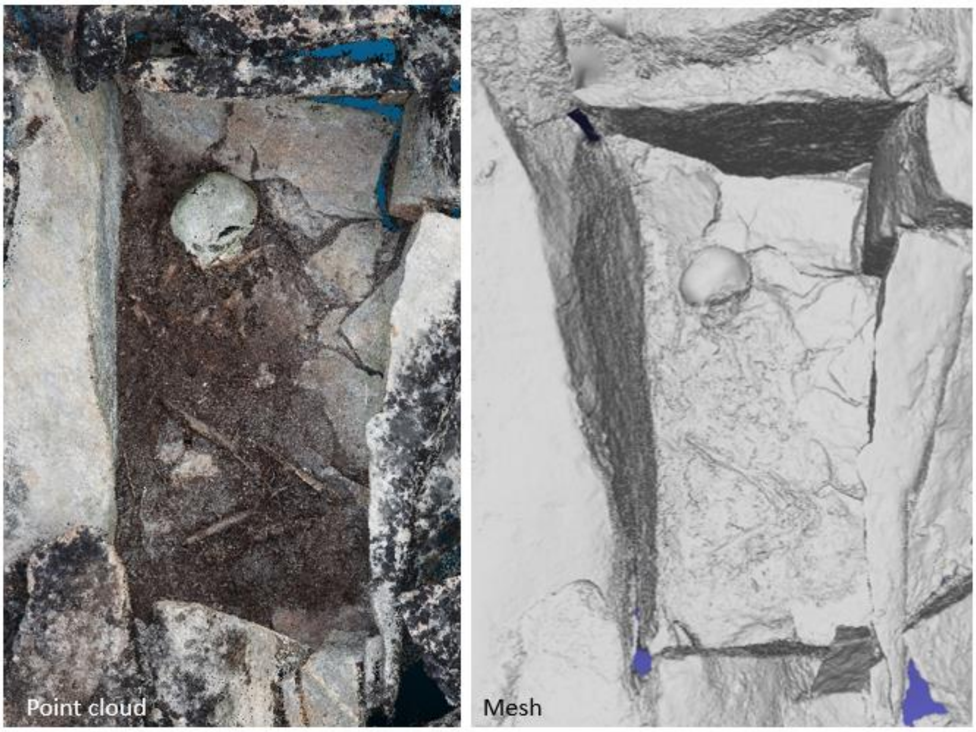



Fig. 11: Grave B with skeleton visible.

### *Grave C*



The following 3D models have been generated:

- Entire grave, before excavation (from Jens' photographs) – Fig. 12
- Entire grave, partially open (from Jens' photographs) – Fig. 13
- Entire grave with the skeleton visible (from Jens' photographs) – Figs. 14-15

A combined 3D visualization of the different point cloud 3D models have been created: *C point cloud - Jens' photos.bin*.

The 3D models do not perfectly align, due to imprecision in the 3D model obtained from Jens' camera

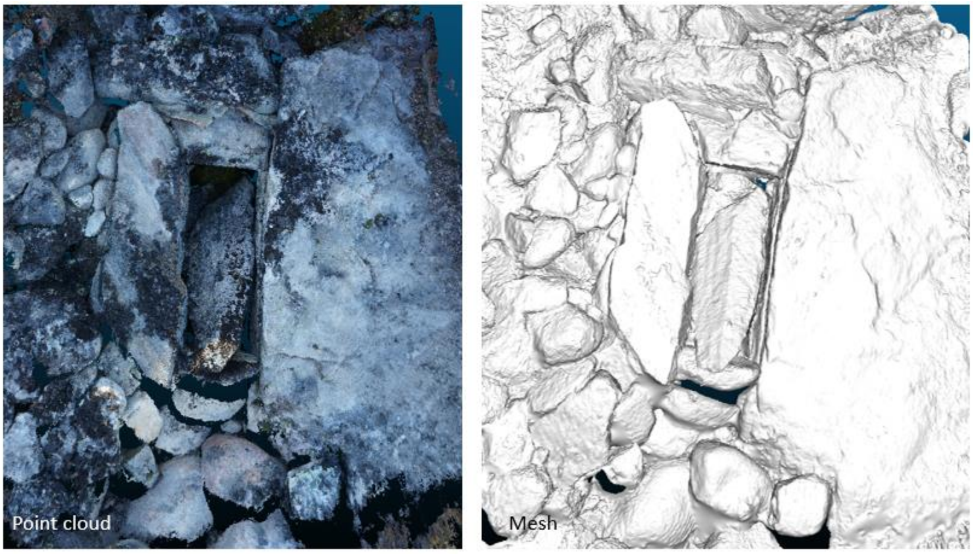



Fig. 12: Grave C, before the excavation

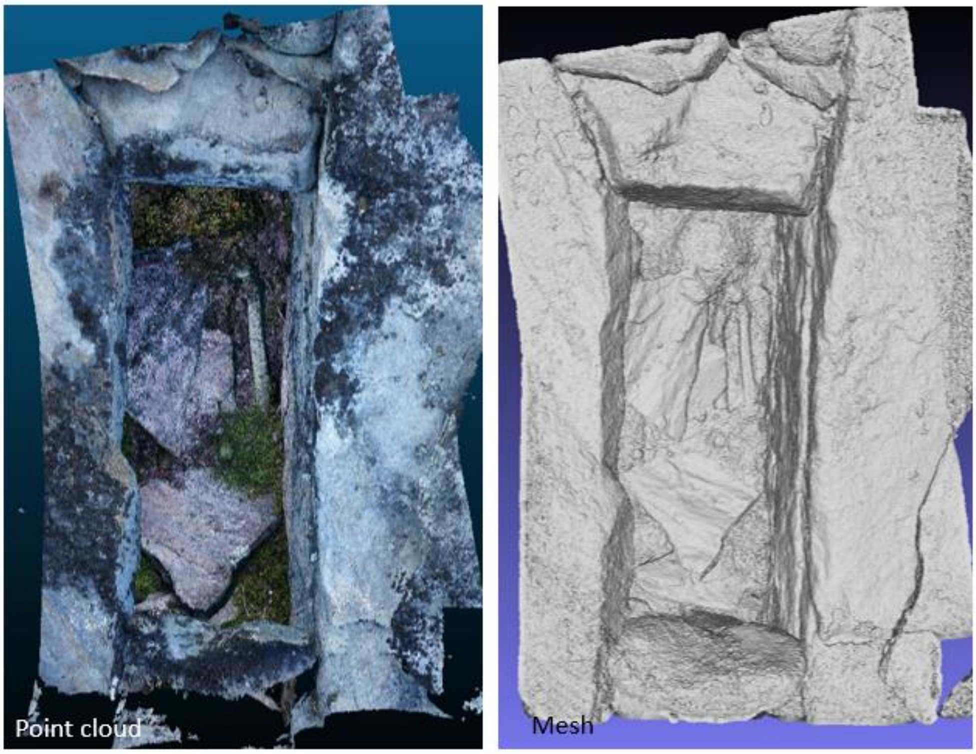



Fig. 13: Grave C, partially open

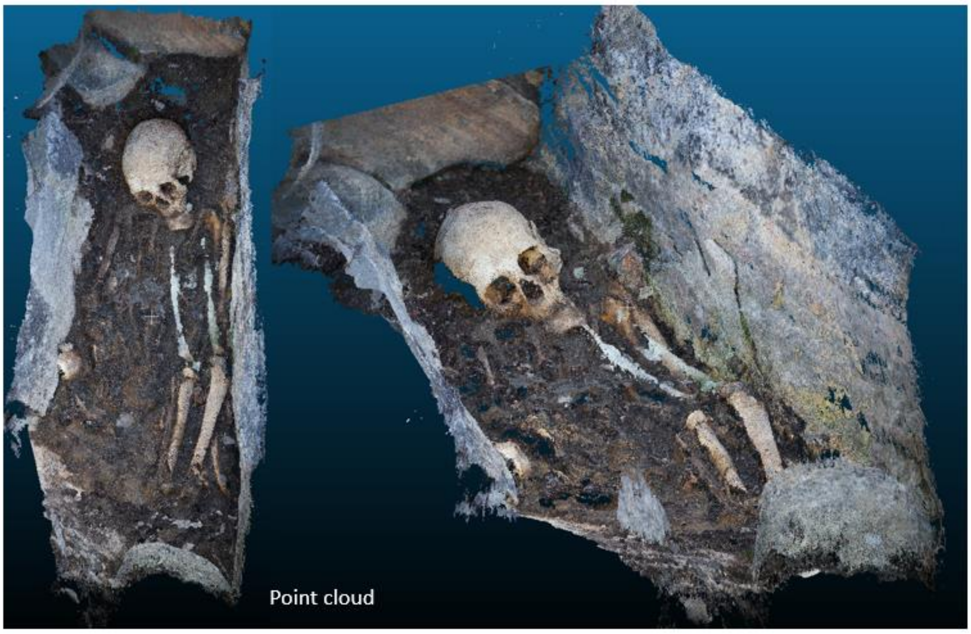



Fig. 14: Grave C, with the skeleton visible (point cloud)

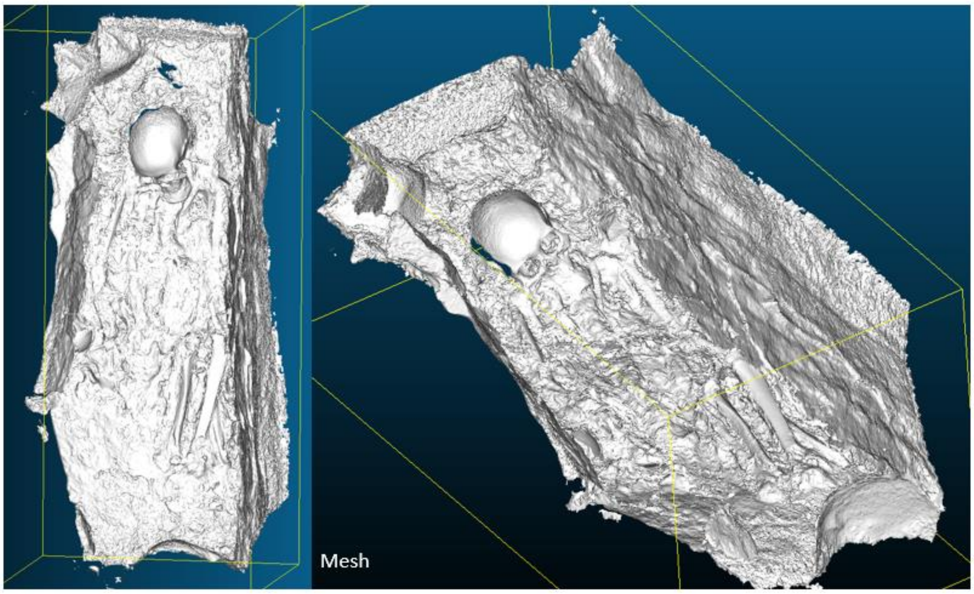



Fig. 15: Grave C, with the skeleton visible (mesh)

***Summary***



A summary of the 3D models obtained from the photographs taken from Chiara and Jens is show in table 1

| Grave | Point cloud | Mesh | Used photos | Scaled /Measurable |
|---|---|---|---|---|
| A - before excavation | YES | YES | Jens | Scaled but distorted |
| A - after excavation | YES | YES | Chiara | YES |
| A1 | YES | YES | Chiara | YES |
| A2 | YES | YES | Chiara | YES |
| A3 | YES | YES | Chiara | YES |
| A4 | YES | YES | Chiara | YES |
| A5 | YES | YES | Chiara | YES |
| | | | | |
| B - before excavation | YES | YES | Chiara | YES |
| B – open with skull | YES | YES | Chiara | YES |
| B - open with skeleton | YES | YES | Jens | Scaled but distorted |
| | | | | |
| C – before excavation | YES | YES | Jens | NO |
| C – partially open | YES | YES | Jens | NO |
| C - open with skeleton | YES | YES | Jens | NO |

Table 1

Chiara Villa

Chiara Villa
Associate Professor, Ph.D.
Copenhagen 23-5-2019

**References and software applications**

Villa C. 2017. Forensic 3D documentation of skin injuries. International journal of legal medicine 131:751-759.

Villa C and Jacobsen C., The Application of Photogrammetry for Forensic 3D recording of Crime Scenes, Evidence and People (Chapter 1). In Essentials of Autopsy Practice, Volume 8, Ed. G. Rutty, 2019

Photomodeler: https://www.photomodeler.com

Agisoft Metashaper : https://www.agisoft.com/

Cloud compare: https://www.danielgm.net/cc/ open source

MeshLab http://www.meshlab.net/ open source

## Appendix 1: How to take good photographs for accurate and precise 3D models



*(an extract from the book chapter: Villa and Jacobsen, 2019)*

### *How does it work?*

The fundamental principle used by photogrammetry is triangulation. By taking overlapping photographs from at least two different spatial locations, lines of sight can be pointed from each camera to points on the object (Fig. 1.1). From the intersection of at least two corresponding lines, a point can be located in three dimensions. In stereophotogrammetry, two images are used to achieve this. In multi-image photogrammetry, the number of images can be unlimited. Thus, photogrammetry uses the position of the camera as it moves through 3D space to calculate 3D coordinates (x,y,z) of the objects; for that is also known as structure from motion (SfM) photogrammetry. In practice, an accurate, true-scale 3D model of an object can be created from a series of overlapping images taken from different positions. The final products of a photogrammetric analysis can be 3D models (point cloud or mesh), lines (sketches, maps), distances and areas. Volume and surface can be calculated also.

### *How to Take Good Photographs for Photogrammetry Processing*

A good photograph needs to be in-focus with the lowest noise possible and with a balanced exposure. **DSLR camera with fixed lens** or primer should be preferred. **Image stabilization, and chromatic aberration need to be turned off. The camera should be set to "aperture priority". The aperture should be kept fixed for the duration of the entire session**. It is preferable to use a higher f-number, thus to guarantee a greater depth of field. Play with shutter speed, and ISO or increase the light. It is not advisable to use the flash because the shadows move on the subject between photographs and create artefacts in the reconstructed 3D model. The use of a tripod may also be helpful in some conditions. In our experience, a shutter speed equal to or faster than 1/100 should be used with a hand-held camera to assure an in-focus photograph. However, this is very subjective and depends on the experience of the photographer. It is advisable to calibrate the white balance or use a colour checker during the taking of photographs (https://xritephoto.com/colorchecker-passport-photo).

Importantly, either **a ruler must be used during the photograph session or a precise distance of reference**, in case larger objects or scenes, need to be photographed. This measurement is fundamental during the post-processing of the photographs to scale the project, i.e. the set of photographs. It is advisable to have more than one measurement, preferably in the different axis (x, y, z), to check that the project is correctly scaled. The ruler does not need to be in all the photographs, but in a minimum of 6-10 photographs. We advice to moved the ruler around, such to have check measurements in all the area of interest.

The photographs must be taken with **a good overlap**: each point in the scene should be clearly visible in at least three photographs; the more, the better (Fig 1.1). An overlap of around 80-90% generally provides good coverage of the scene.

Some basic ideas about camera positions in different scenarios are shown in figure 1.2. It is desirable to repeat the steps at different positions heights as shown in Fig. 1.3.

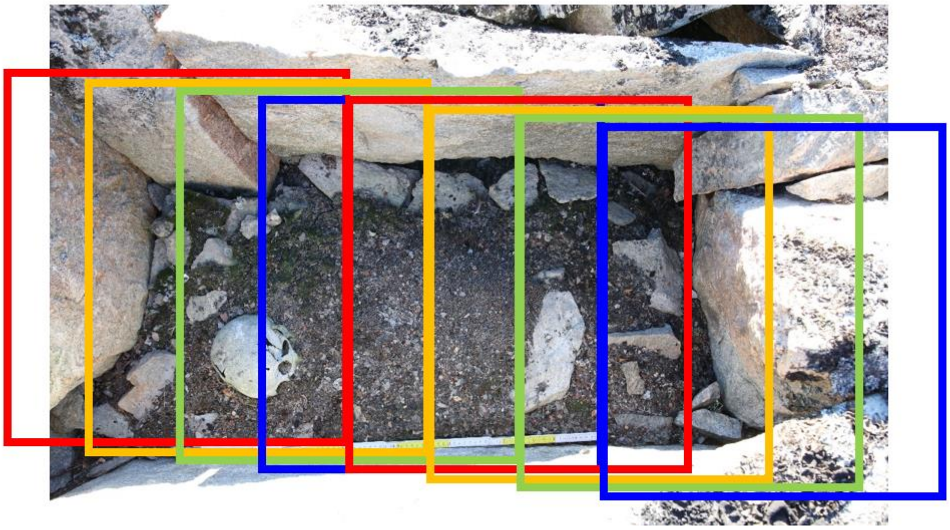


**Fig 1.1.** Example of good photogrammetry coverage of a shoe; each colour square represents a photograph.

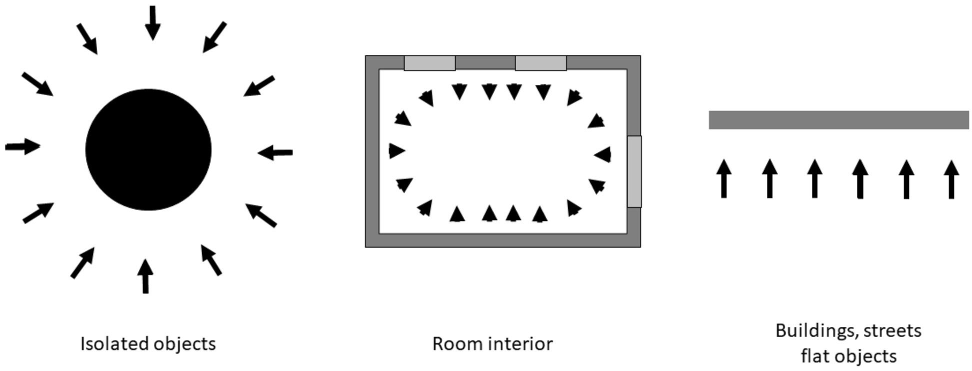



**Fig 1.2.** Recommended camera positions in the different scenarios

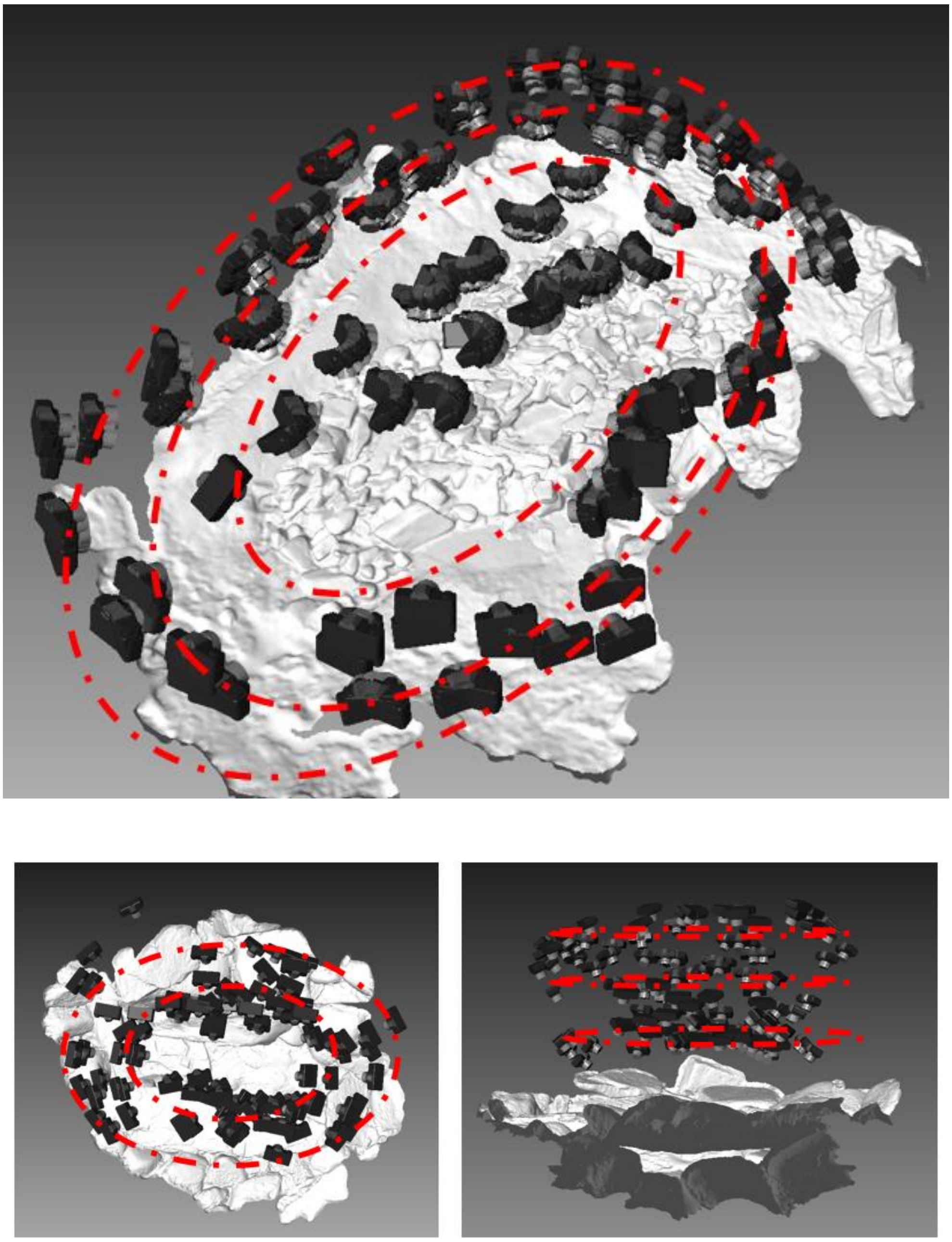


**Fig 1.3**. Recommended camera positions at different positions and heights

**Summary**



1) Set the ruler(s) and eventually a colour-checker;
2) Check the camera setting:
   - Turn off image stabilization
   - Turn off chromatic aberration
   - Set the camera to "aperture priority"
   - Set the aperture values to the smallest number possible (1/ 8; 1/16), checking the ISO (max 1600, ideally 400 or lower) and shutter speed setting (min 1/100)
3) Take pictures in a rotatory movement around the grave or the chamber. Move slowly and take a pictures every 3-5 steps (thus to keep an overlap of 70-80% between pictures);

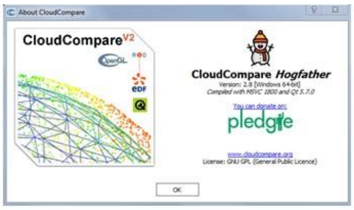
   N.B. Do not rotate the camera during the photograph session.
4) Repeat the rotation with the camera at different heights.

## Appendix 2: Short guide to visualize 3D models of the Graves in Cloud Compare and Meshlab



For further info, please refer to https://www.danielgm.net/cc/

# Instruction to see and take measurements on Point clouds (.pts)

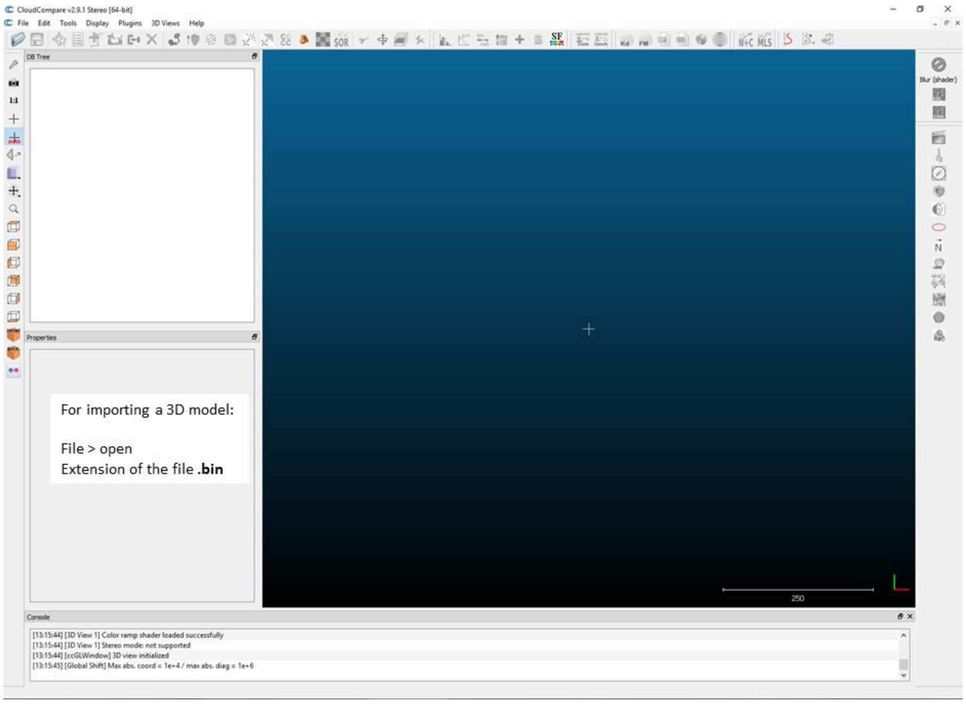


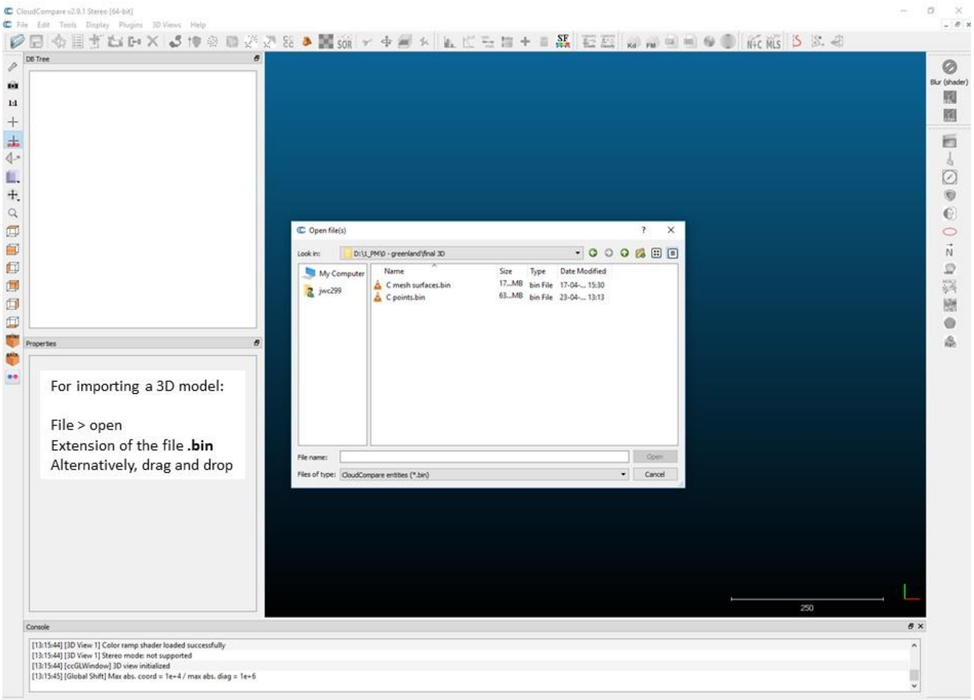

Basic commands

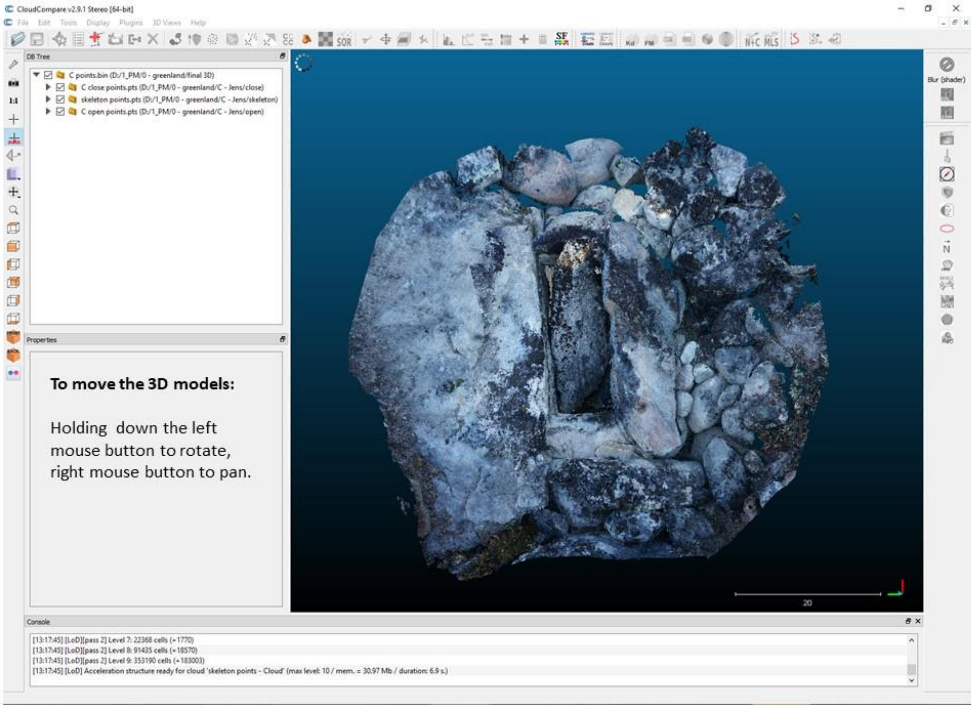
### 3D view toolbar

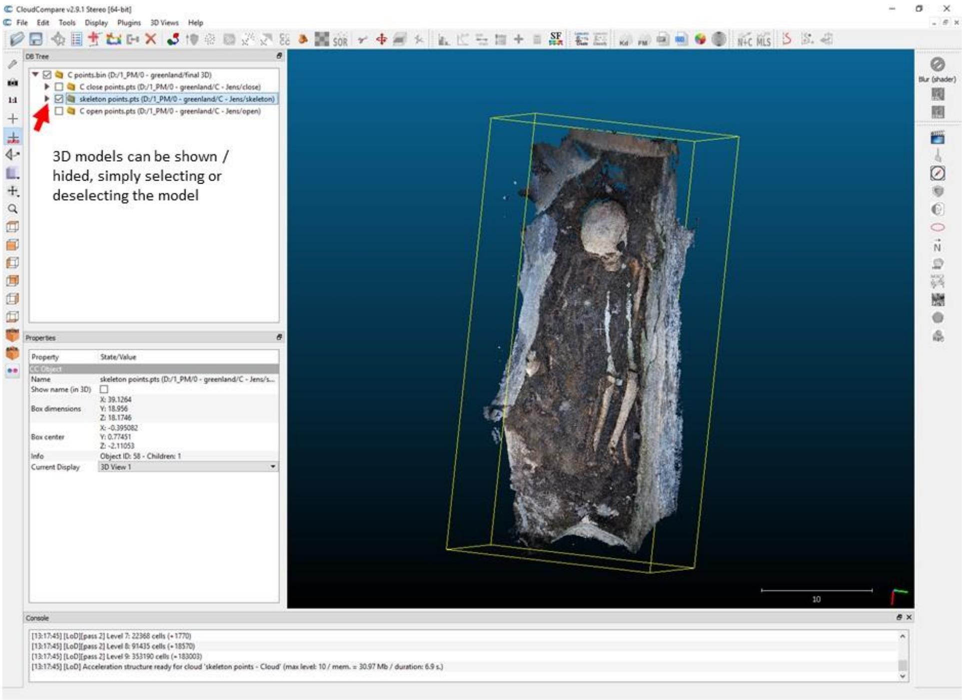

- Display settings (lights, materials, colors, etc.)
- Camera settings (active 3D view)
- 1:1 Full scene zoom (active 3D view)
- Pick a point as rotation center (active 3D view) - works also on meshes/triangles
- Select projection mode (orthographic / perspective)
- Set rotation symbol visibility
- Zoom (and center) on selected entities
- Set camera to top view
- Set camera to front view
- Set camera to left view
- Set camera to back view
- Set camera to right view
- Set camera to bottom view
- Set camera to iso view (front)
- Set camera to iso view (back)
- Enable stereo (anaglyph) mode

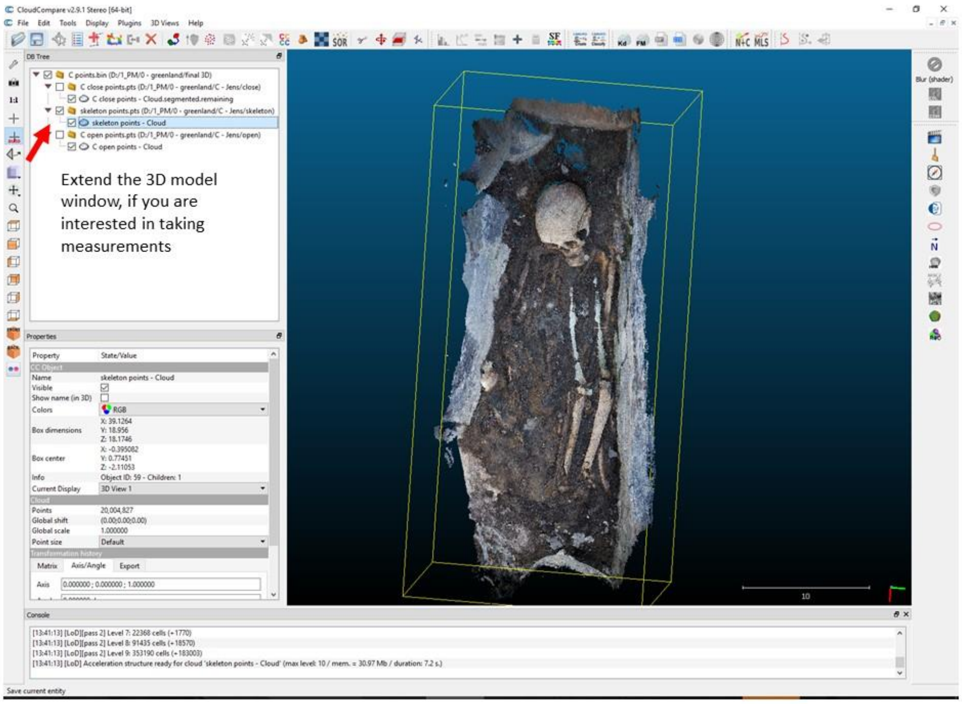
Note: this toolbar is situated on the left side by default.

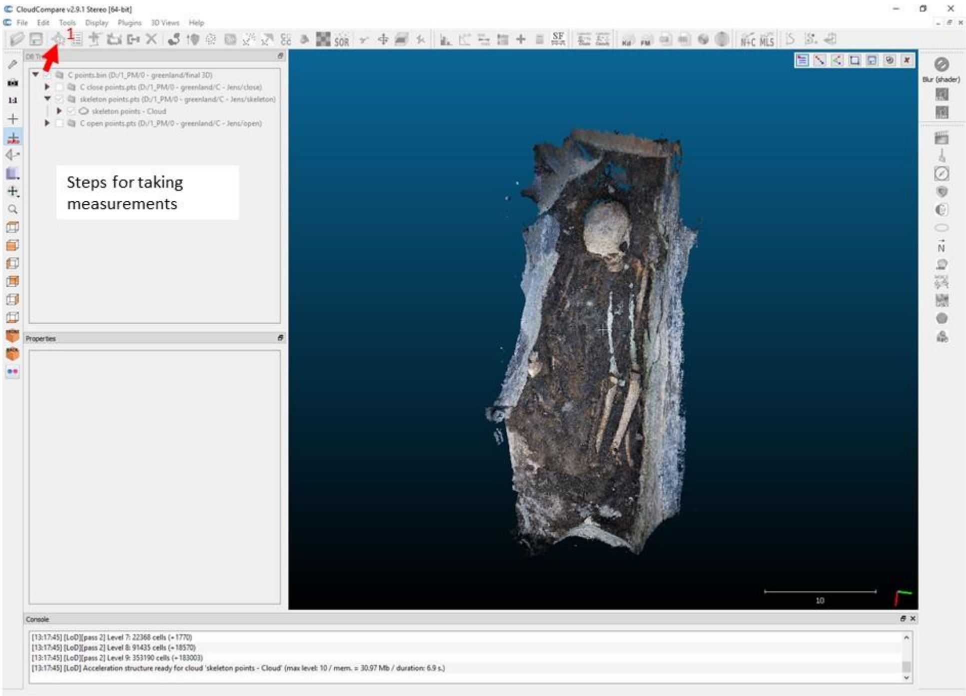

For importing a 3D model:
File > open
Extension of the file .bin

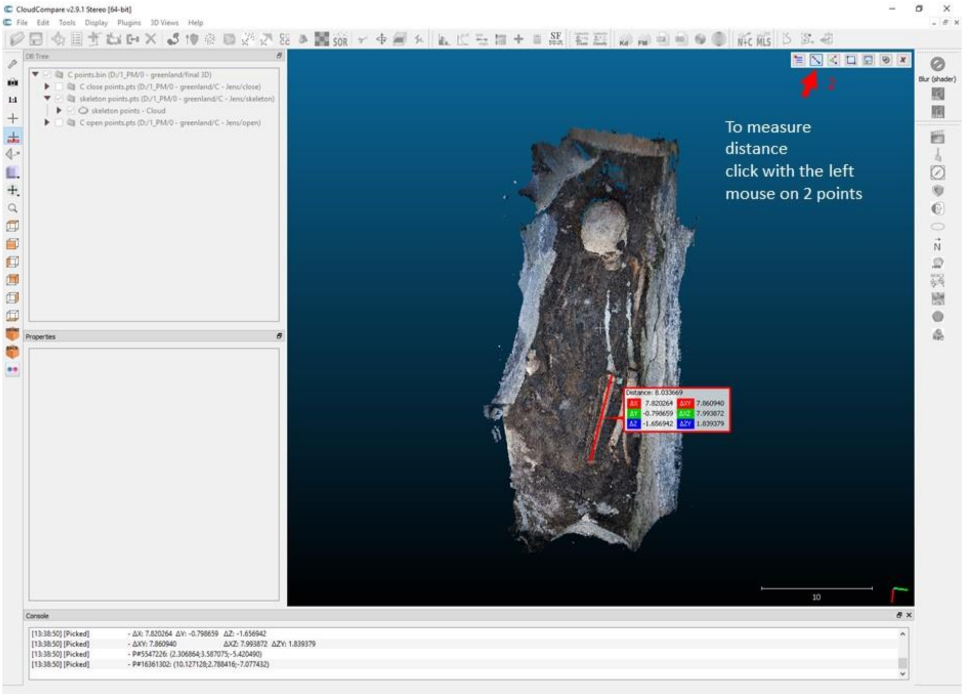

For importing a 3D model:
File > open
Extension of the file .bin
Alternatively, drag and drop

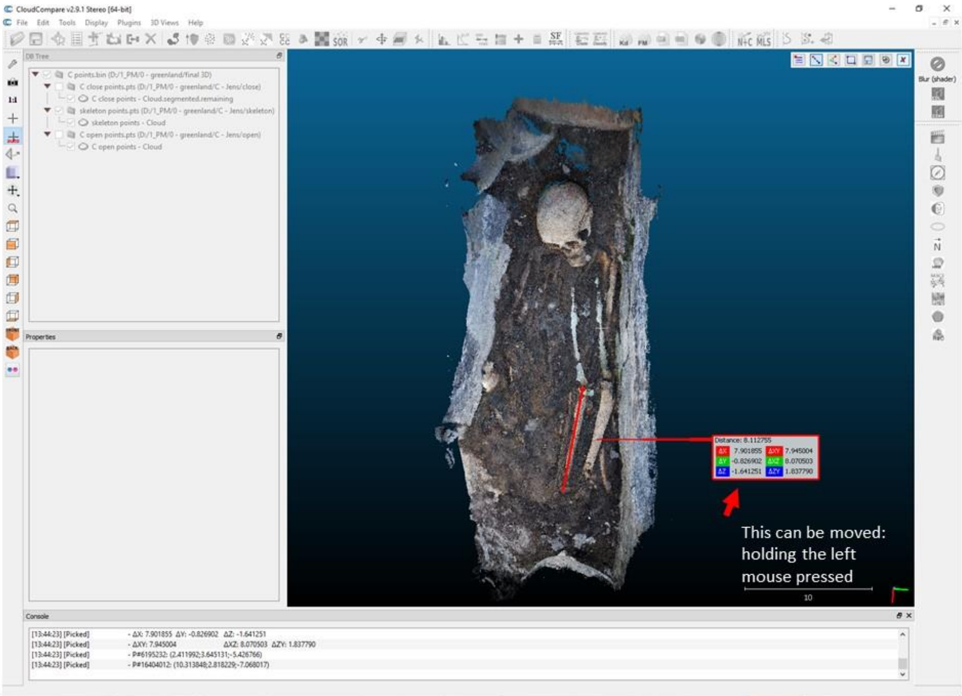

CloudCompare v2.9.1 Stereo [64-bit]
To move the 3D models:
Holding down the left mouse button to rotate, right mouse button to pan.

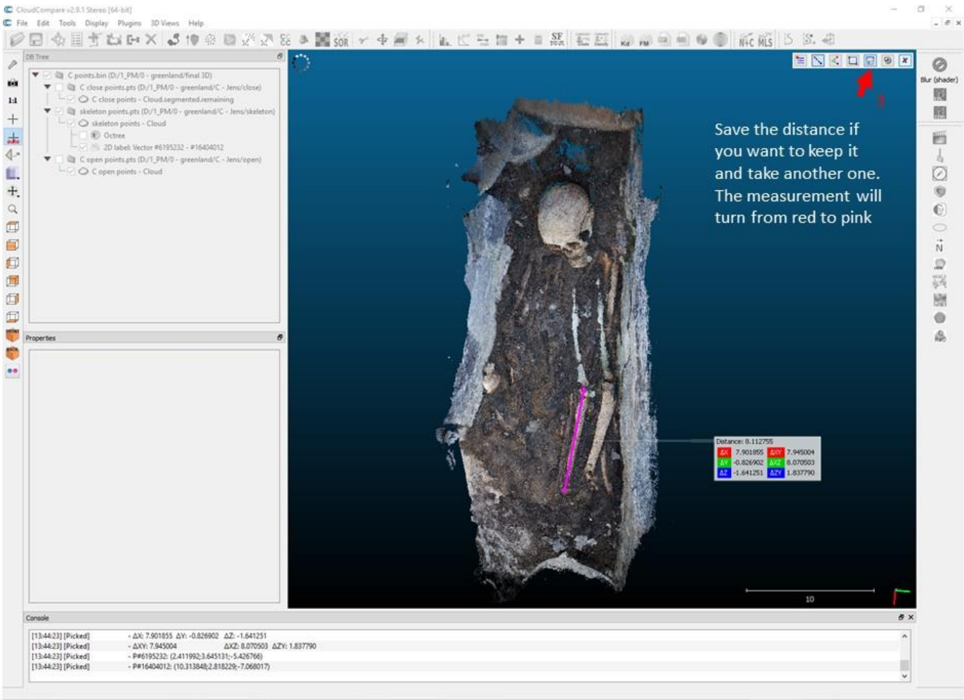

CloudCompare v2.9.1 Stereo [64-bit]
3D models can be shown / hided, simply selecting or deselecting the model

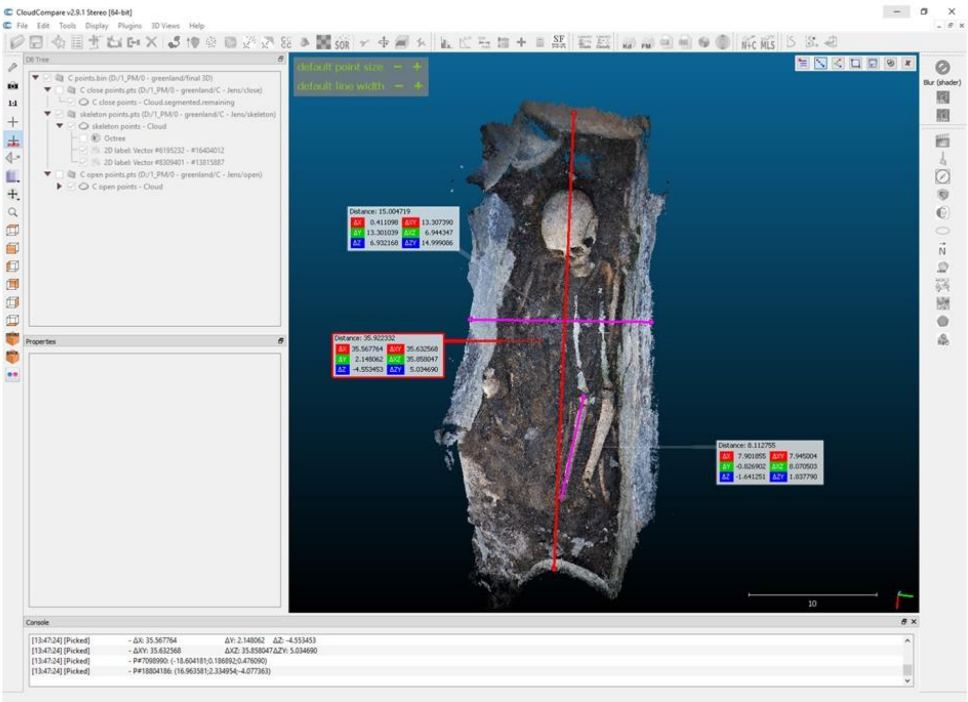

Extend the 3D model window, if you are interested in taking measurements

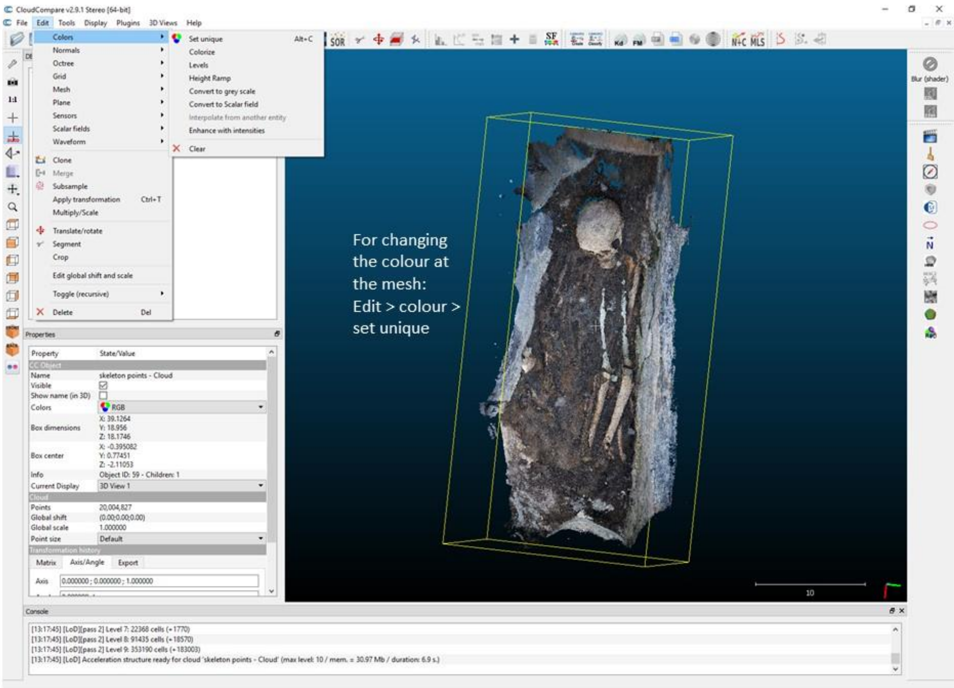

Steps for taking measurements


To measure
distance
click with the left
mouse on 2 points

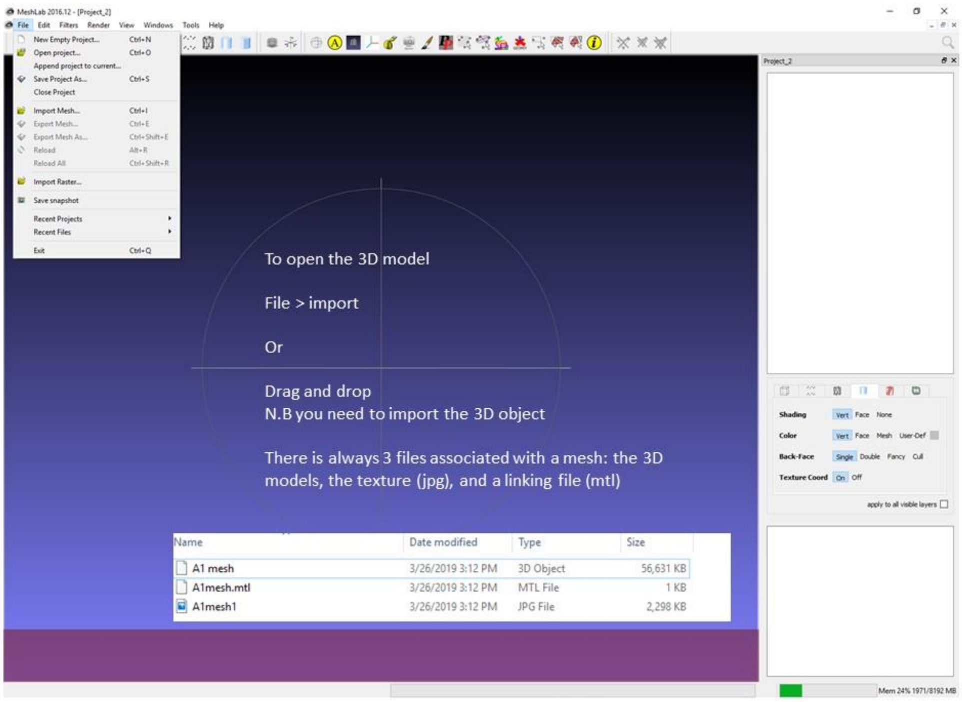

This can be moved:
holding the left
mouse pressed

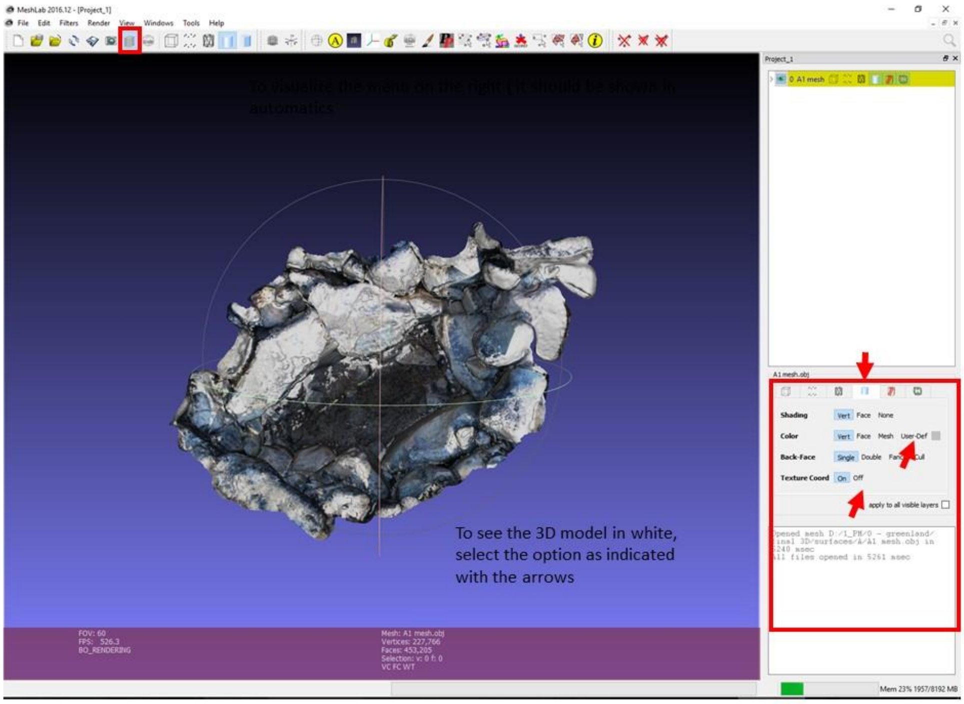

Save the distance if
you want to keep it
and take another one.
The measurement will
turn from red to pink

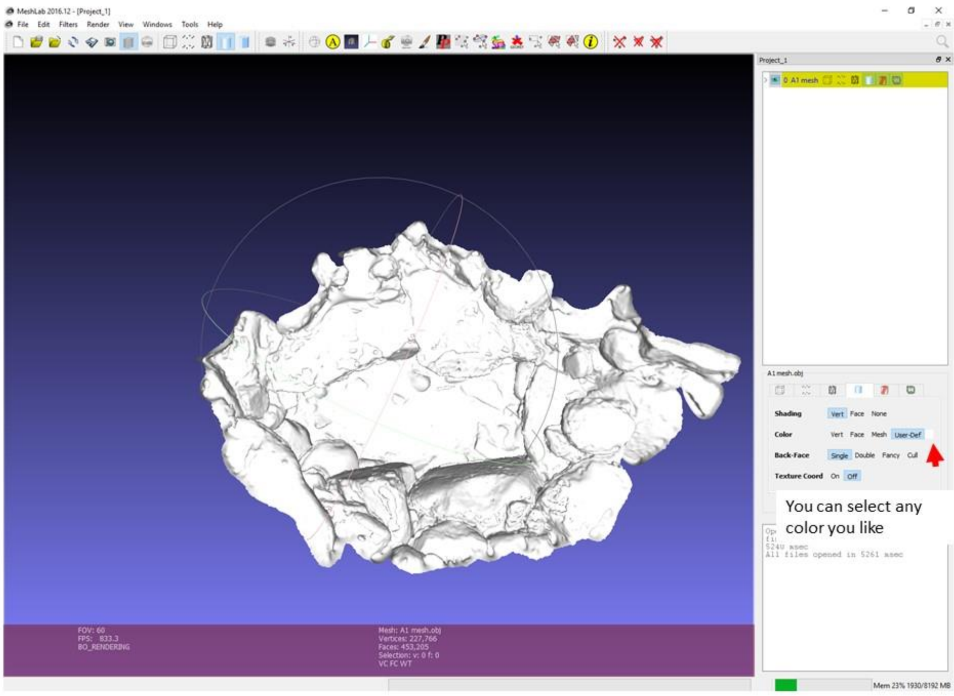


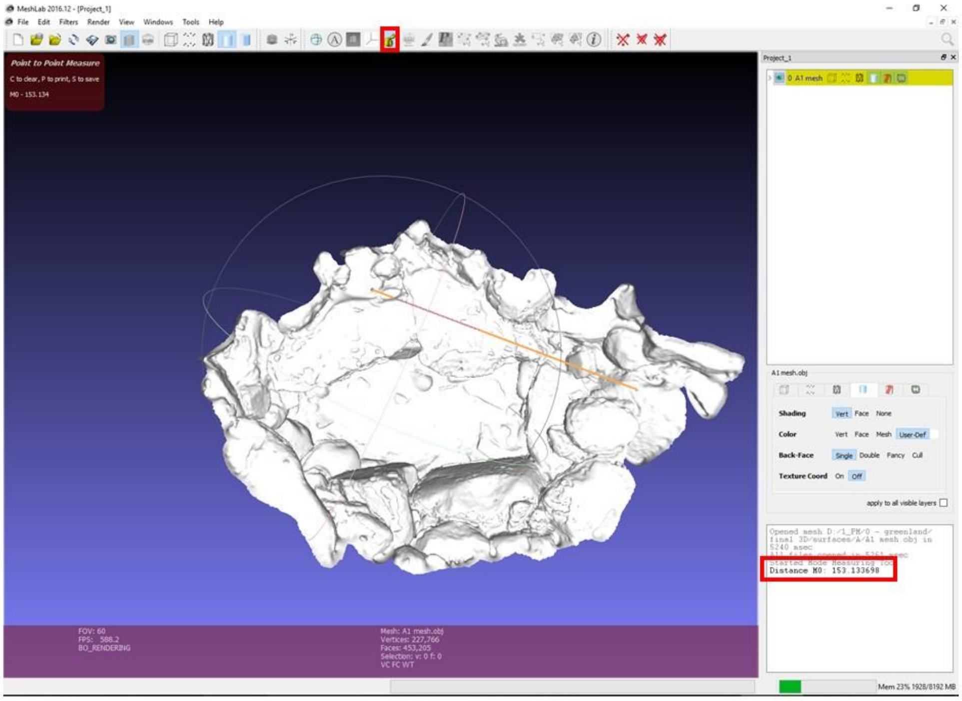

CloudCompare v2.9.1 Stereo [64-bit]
For changing the colour at the mesh: Edit > colour > set unique

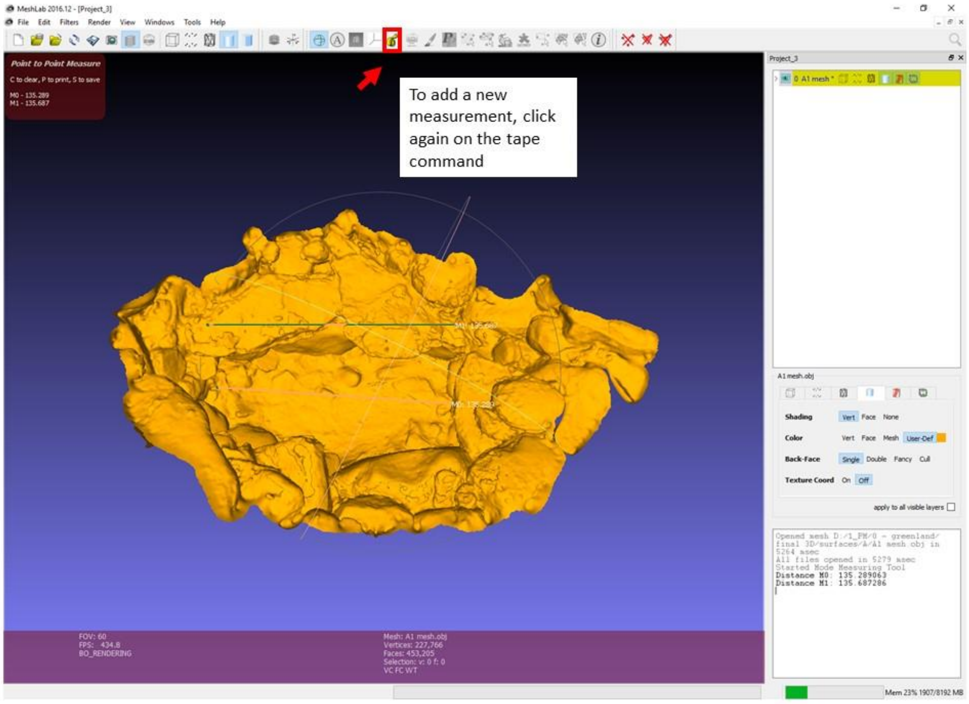
# Instruction to see and take measurements on mesh surface(.obj) using MESHLAB

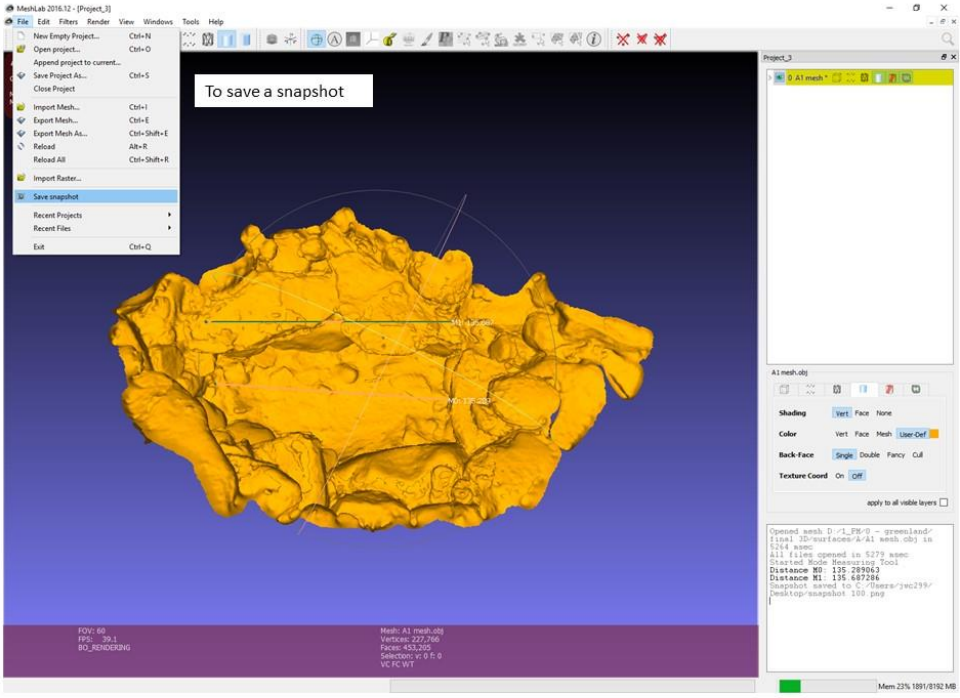



To see the 3D model in white,
select the option as indicated
with the arrows


You can select any
color you like


Point to Point Measure
C to clear, P to print, S to save
M0 - 153.134
Distance M0: 153.133698


Point to Point Measure
C to clear, P to print, S to save
M0 - 135.289
M1 - 135.687
To add a new measurement, click again on the tape command
Distance M0: 135.289063
Distance M1: 135.687286


MeshLab 2016.12 - [Project_3]
File
Edit
Filters
Render
View
Windows
Tools
Help
New Empty Project... Ctrl+N
Open project... Ctrl+O
Append project to current...
Save Project As... Ctrl+S
Close Project
Import Mesh... Ctrl+I
Export Mesh... Ctrl+E
Export Mesh As... Ctrl+Shift+E
Reload Alt+R
Reload All Ctrl+Shift+R
Import Raster...
Save snapshot
Recent Projects
Recent Files
Exit Ctrl+Q
To save a snapshot
Project_3
A1 mesh.obj
Shading
Vert
Face
None
Color
Mesh
User-Def
Back-Face
Single
Double
Fancy
Cull
Texture Coord
On
Off
apply to all visible layers
Distance M0: 135.289063
Distance M1: 135.687286
Mesh: A1 mesh.obj
Vertices: 227,766
Faces: 453,205
FOV: 60
BO_RENDERING