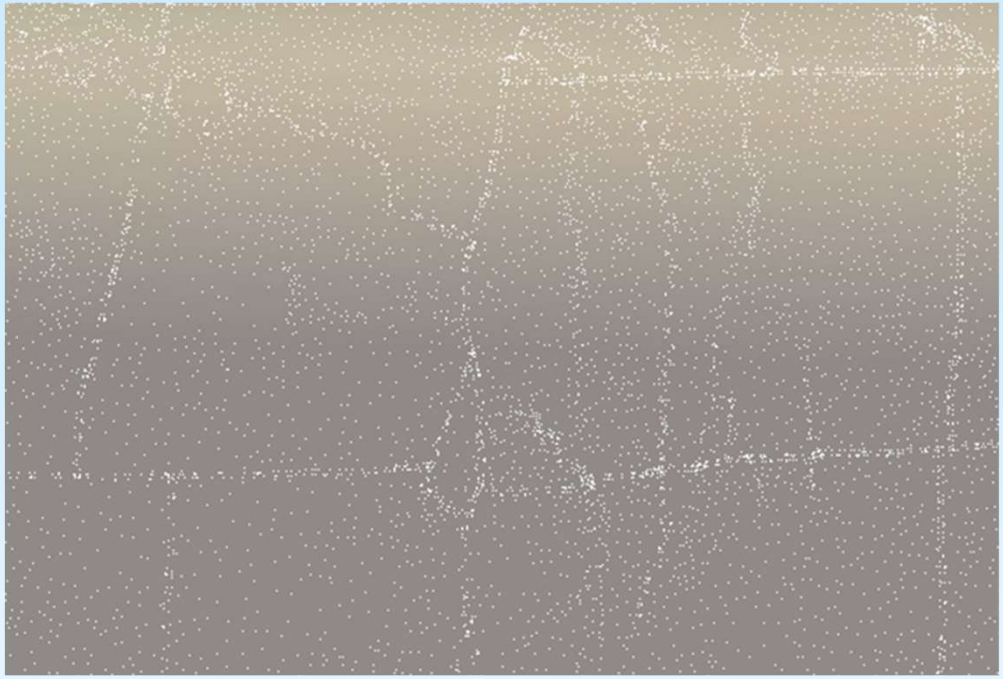
Assessment of Stability of Rock Slopes from Point Clouds by Facet Amalgamation Approach

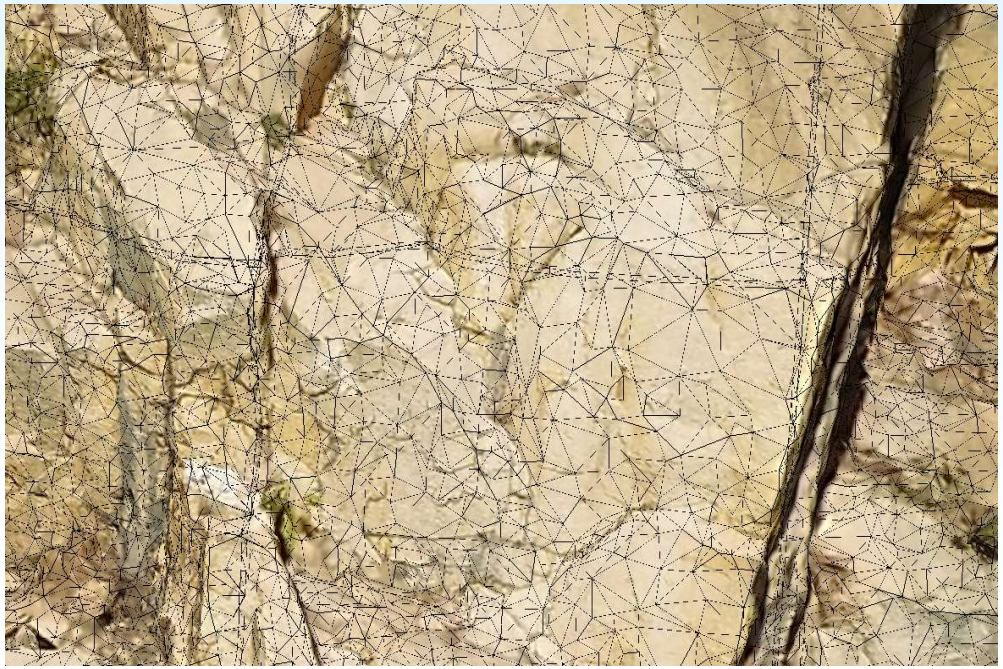
A.C.T. So


HELISERVICES

Point Cloud

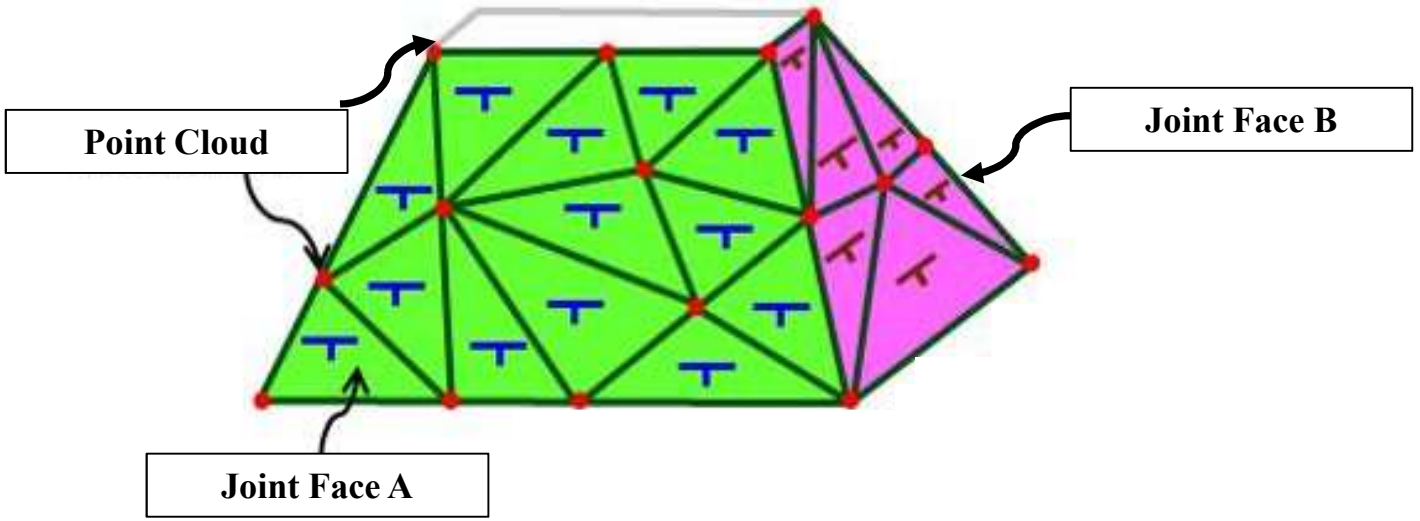


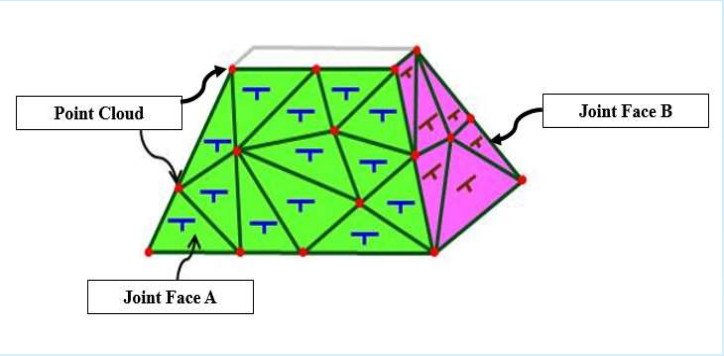
Point Cloud



Triangular Mesh generated from Point Cloud

Measurement of Orientations of Rock Joints by Facet Amalgamation Approach





Assumptions:

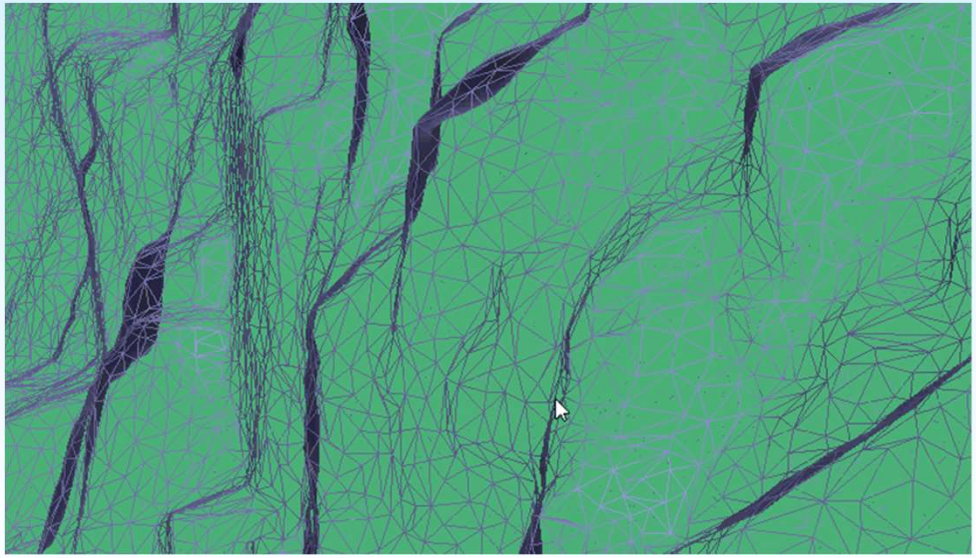
Each facet is formed by three points

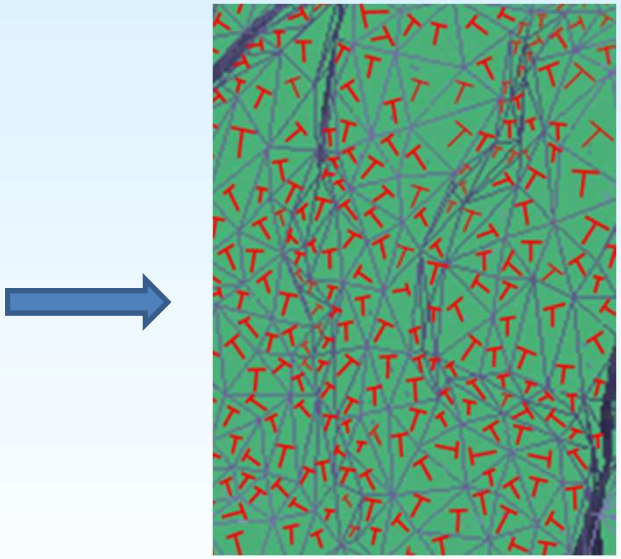
Facets belonging to a specific joint plane should have similar dips and dip directions

Stereoplots of all facets should give general orientations of major joint sets

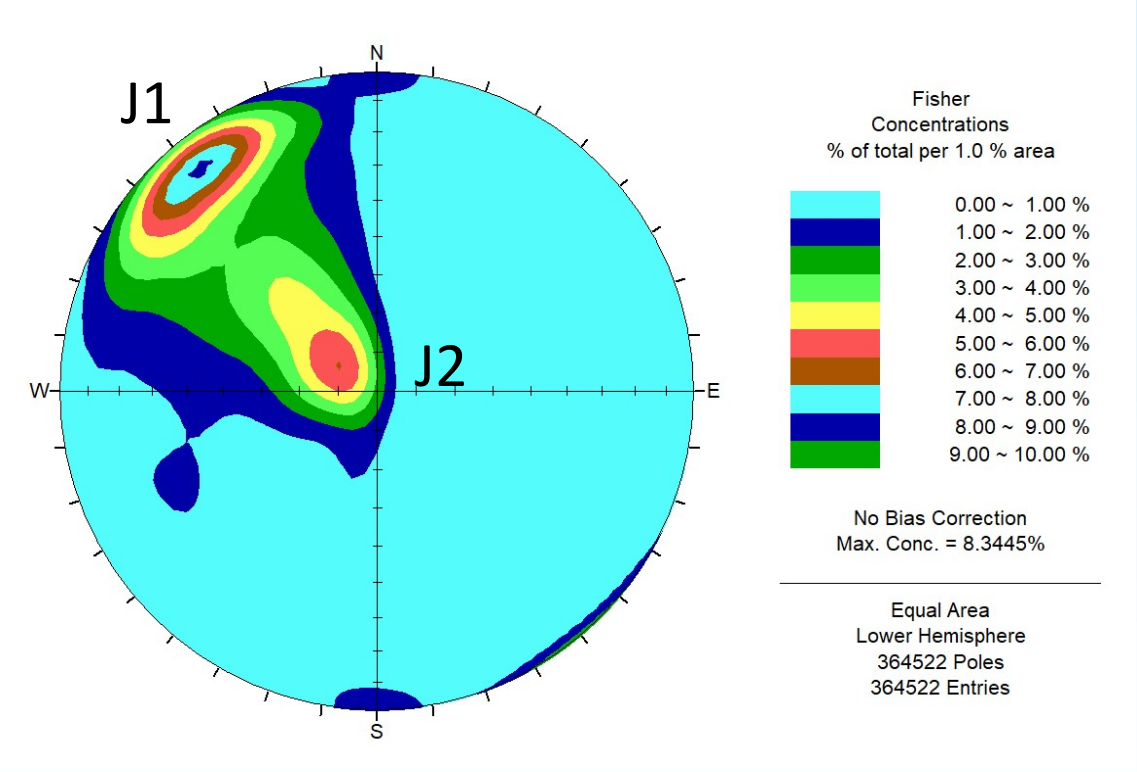
Generation of 3D mesh using point cloud using CloudCompare

Calculate dip and dip direction of each facet using in-house algorithm

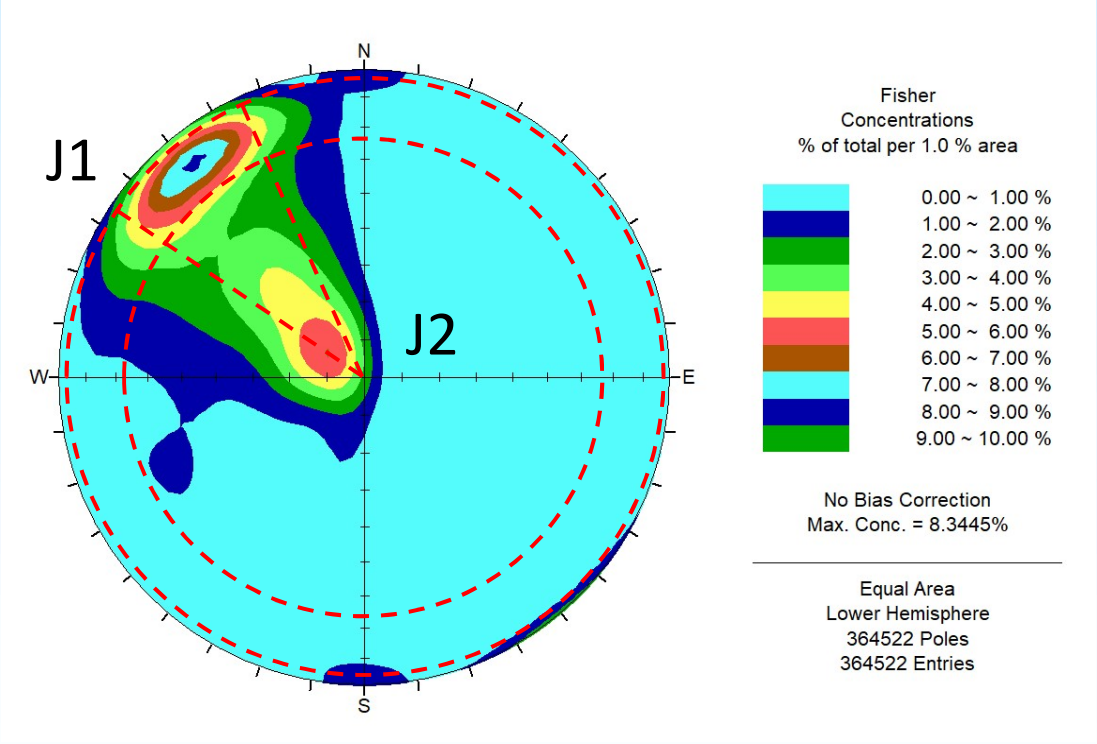




Sub-vertical Joints J1 and Sub-horizontal Joints J2

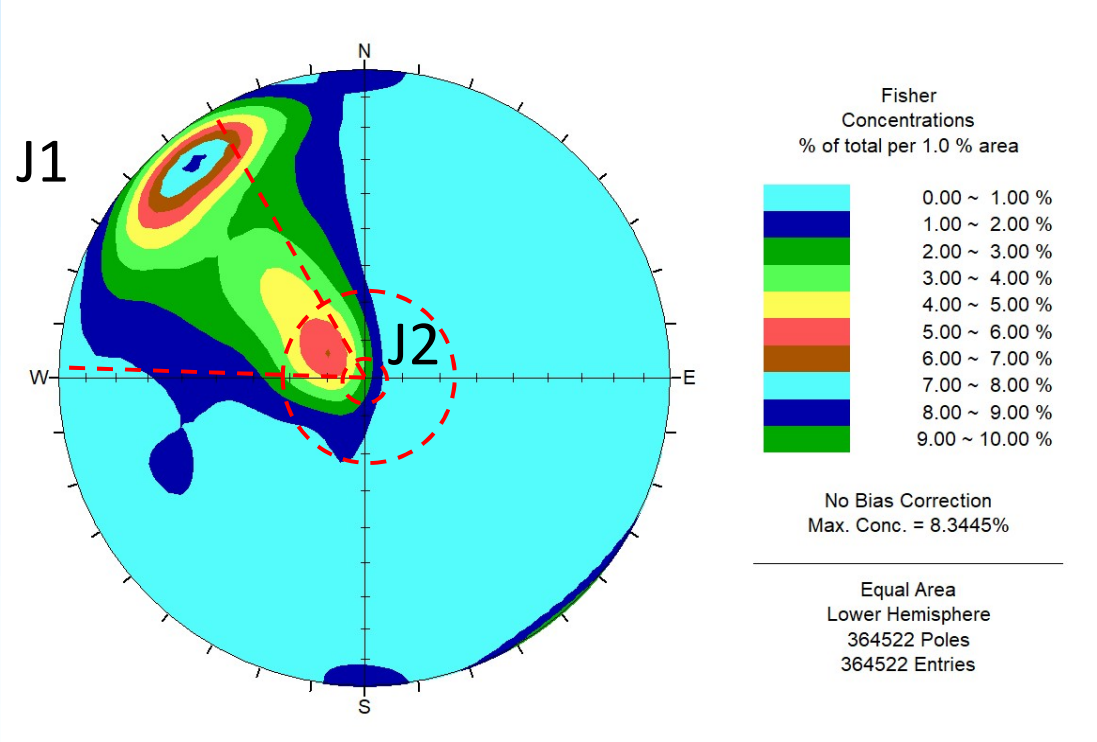


Sub-vertical Joints J1 and Sub-horizontal Joints J2



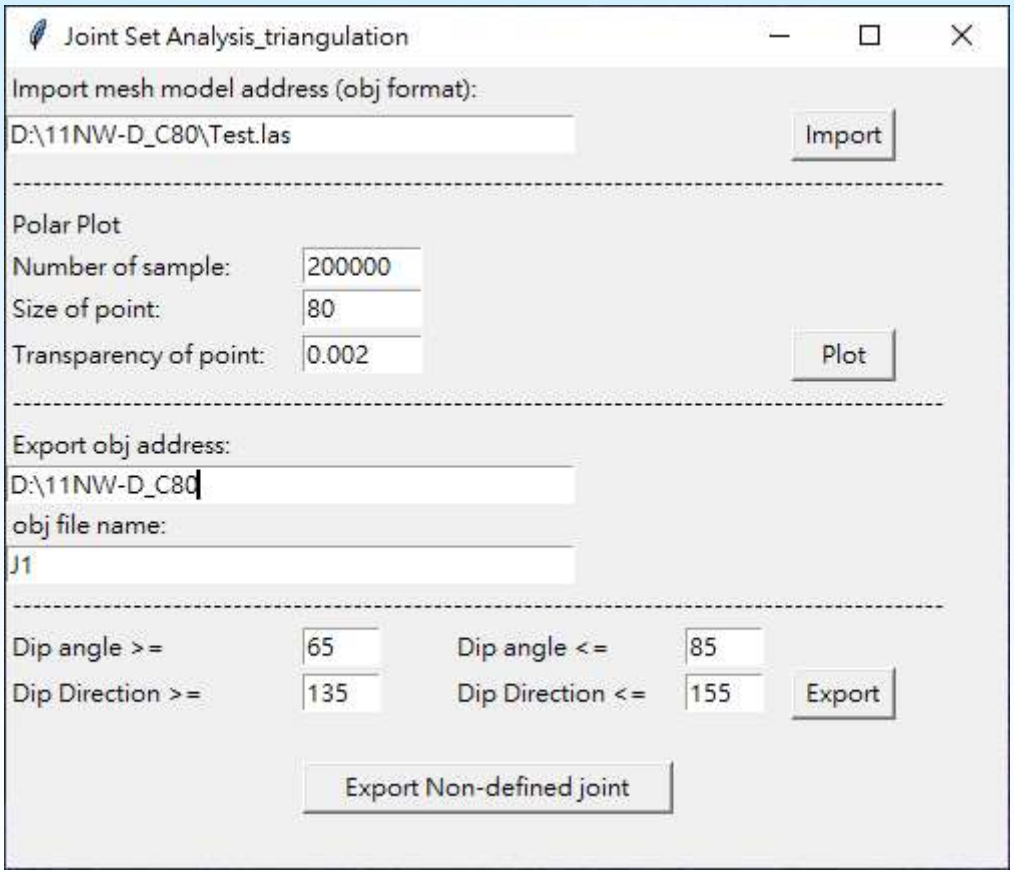
Extraction of facets within the intersecting envelope (5% contour)

Sub-vertical Joints J1 and Sub-horizontal Joints J2

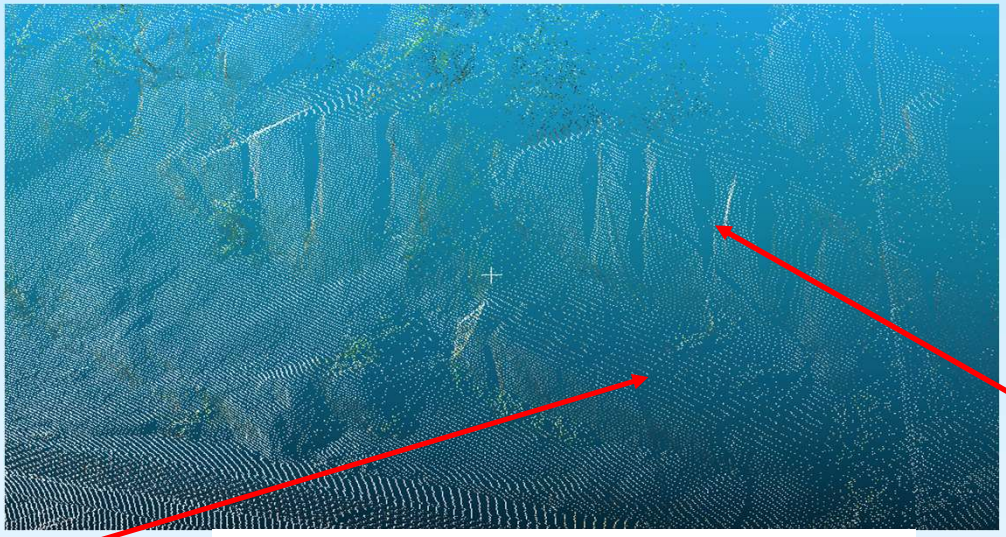


Extraction of facets within the intersecting envelope (5% contour)

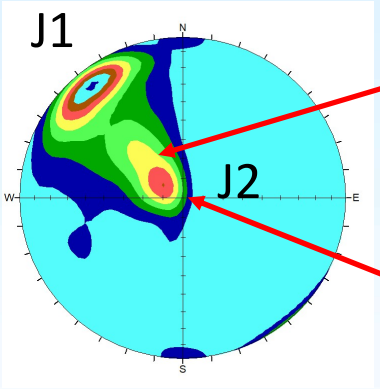
Extraction of Facets within the Intersecting Envelope – J1

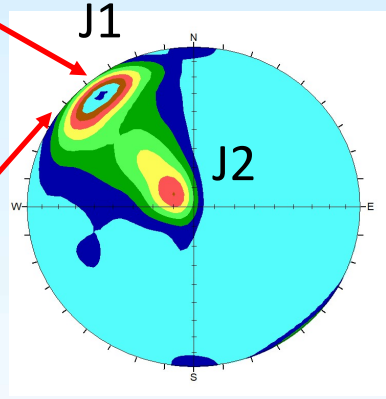


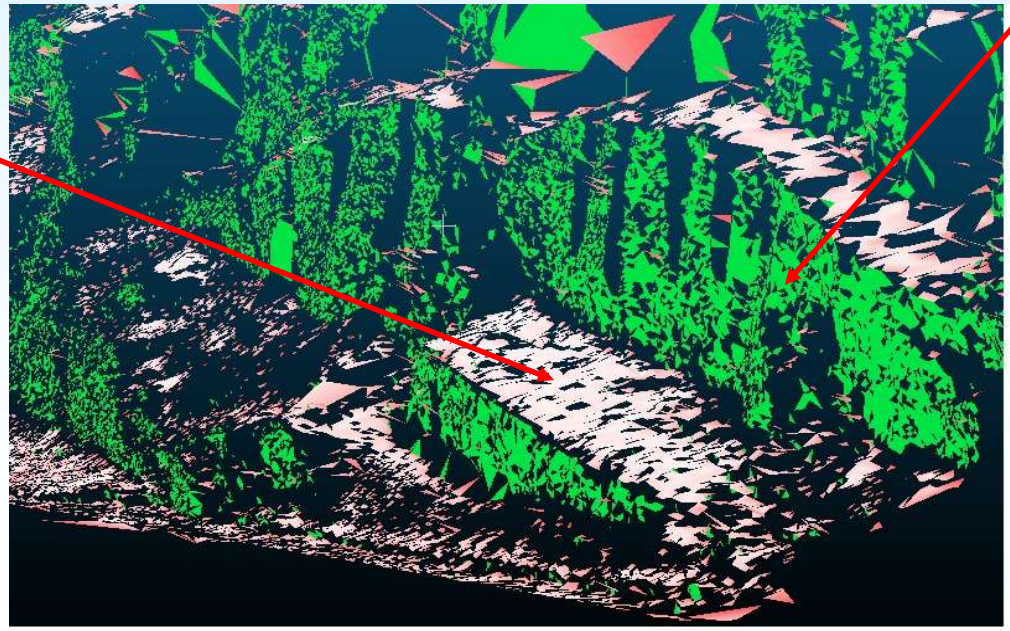
Verification of Results



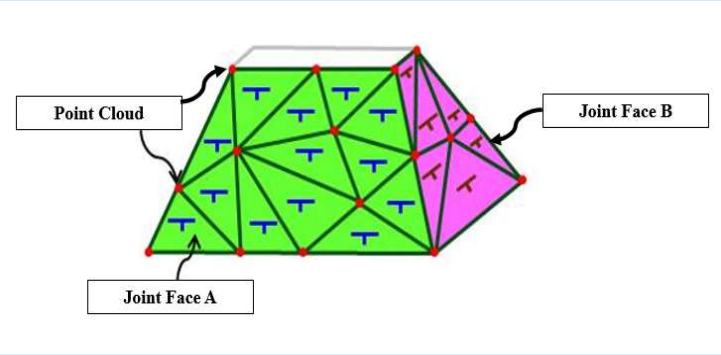
Coloured Laser Point Cloud







Joint planes formed by amalgamation of facets



Removal of Noise

Vegetation and artificial objects shall be removed prior to assessment.

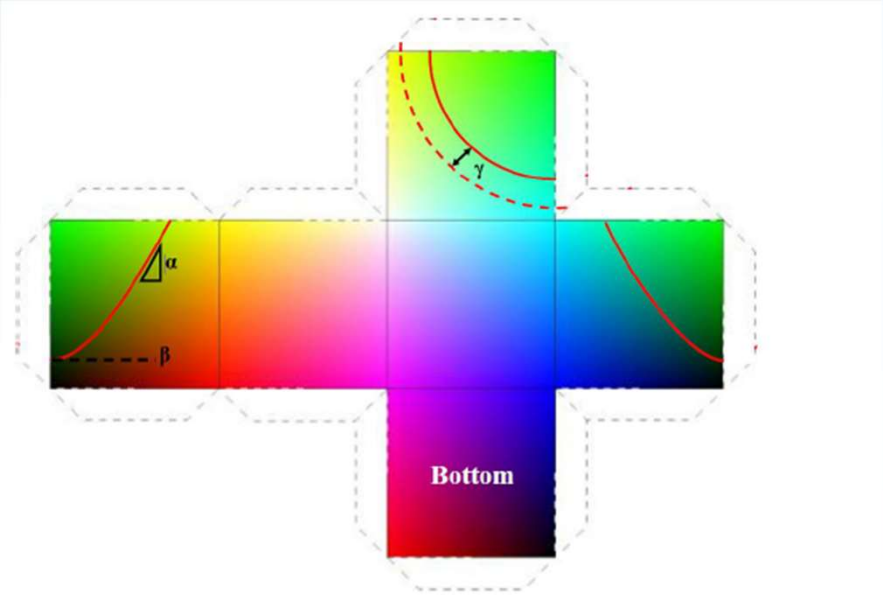
Other noise such as random noise along edges is expected but should not affect the overall result.

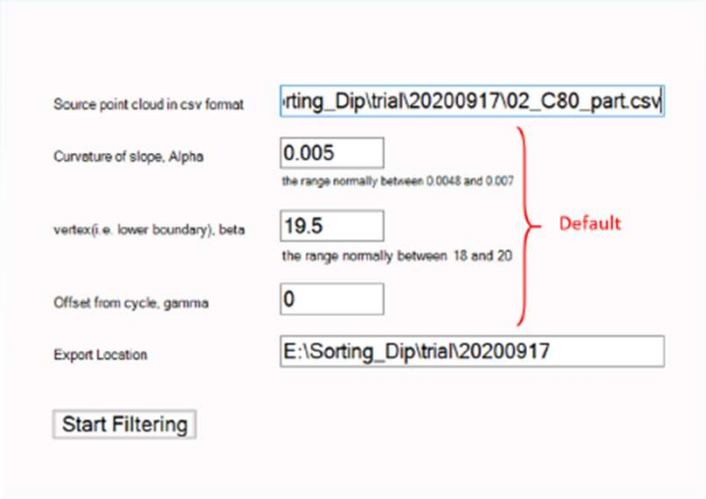
Removal of Vegetation and Above Ground Objects by Colour Filter

Make use of RGB values

p.s. The Default values of Alpha(α), beta(β) and gamma(γ) can be adjusted if necessary.

p.s.2 the variables α, β and γ are given below,





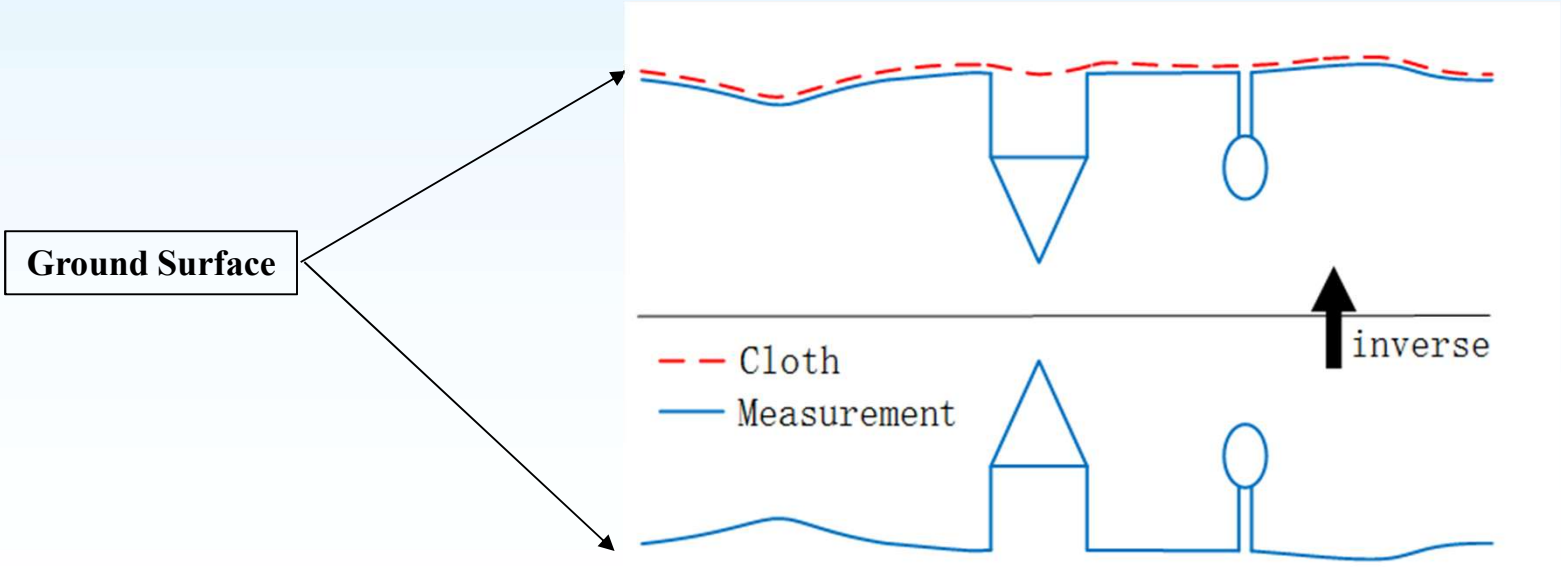
Cloth Simulation Filter (CSF) for Point Clouds

To extract of ground points in discrete return LiDAR point cloud

Point cloud is inverted

A digital cloth cover the inverted surface

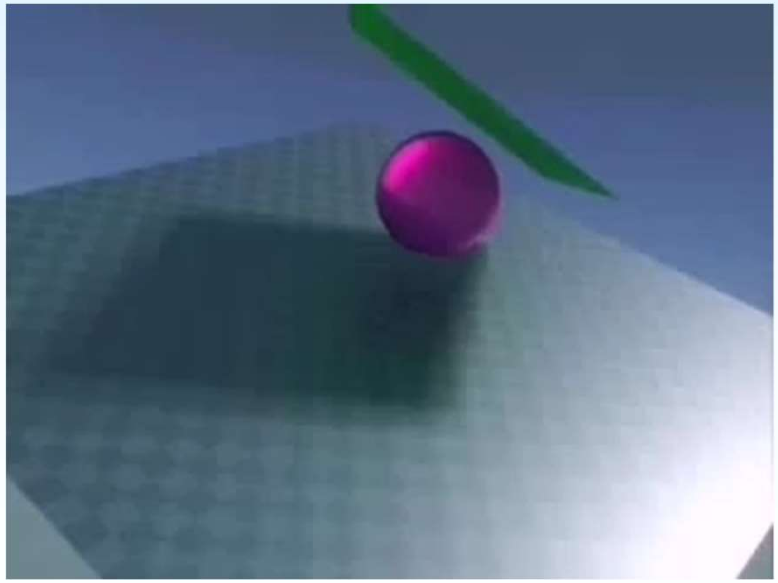
By analyzing the interactions between the cloth nodes and the corresponding points, the locations of the cloth nodes can be determined to generates an approximation of the ground surface



W. Zhang et al (2016)

Cloth Simulation Filter (CSF)

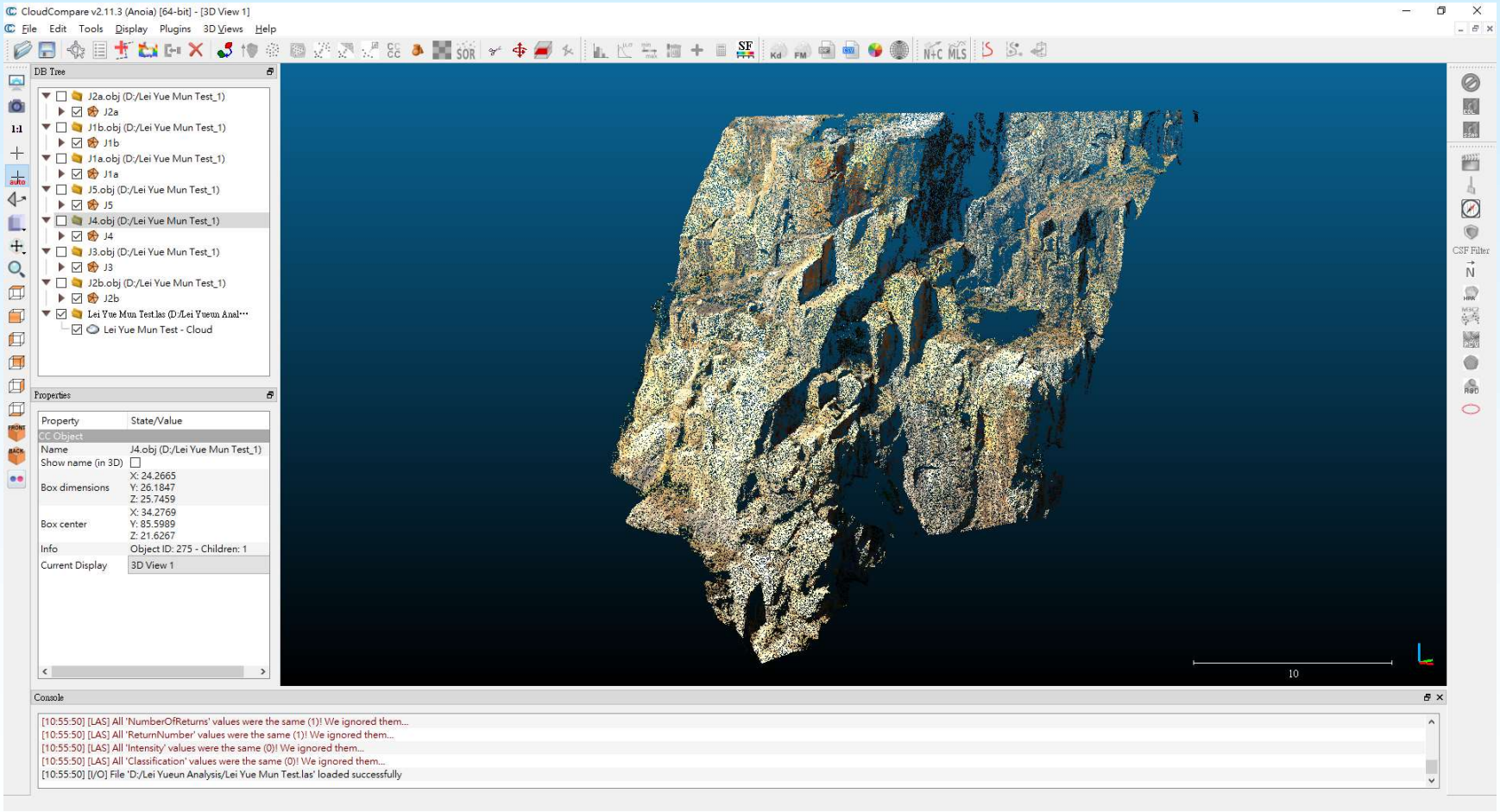
- Remove above ground objects ad vegetation
- An approach to model surfaces for movies, games



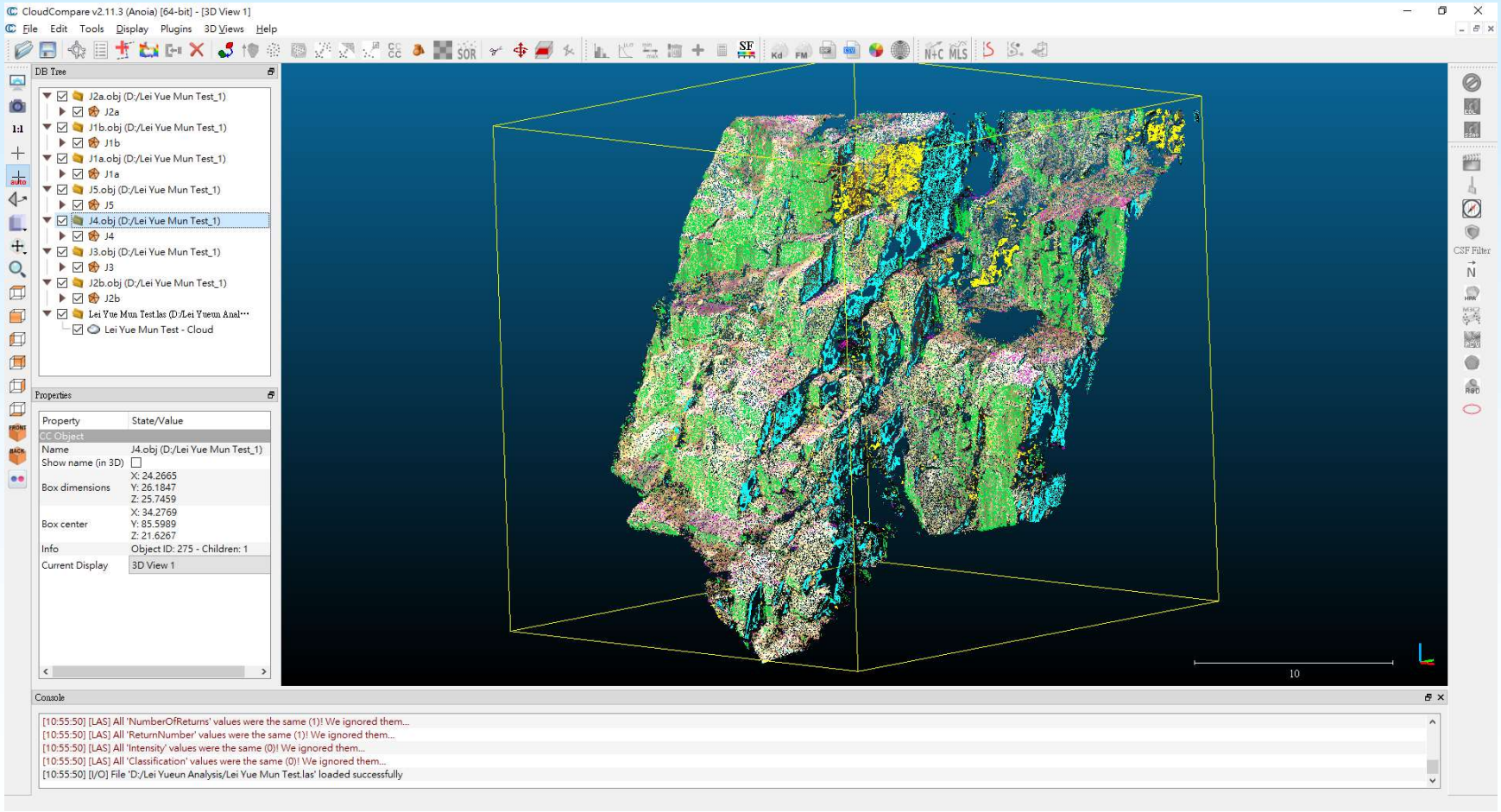
https://www.youtube.com/watch?v=kv5vzFB3sws

Identification of Joint Planes

Lei Yue Mun Quarry



Lei Yue Mun Quarry



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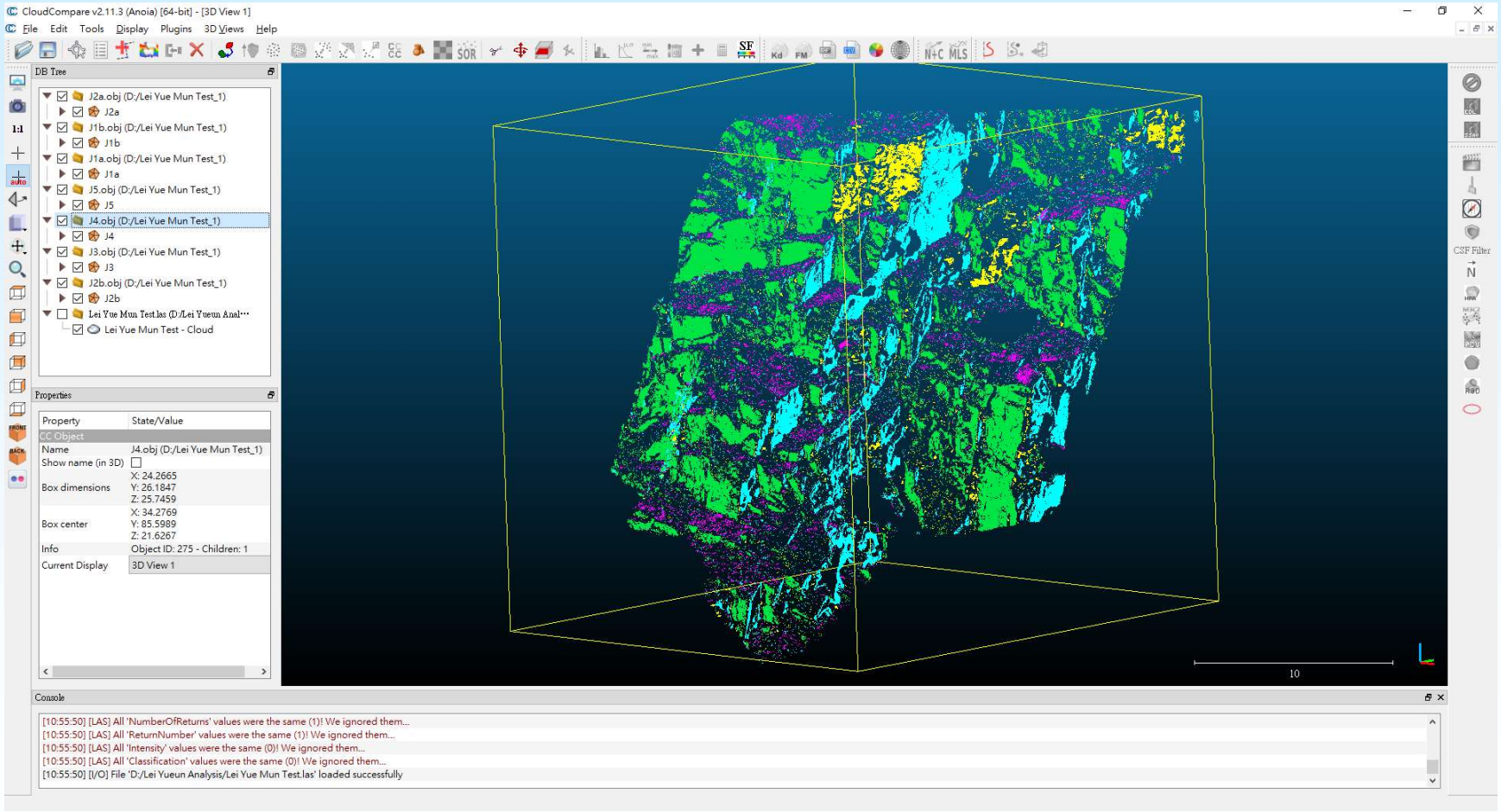
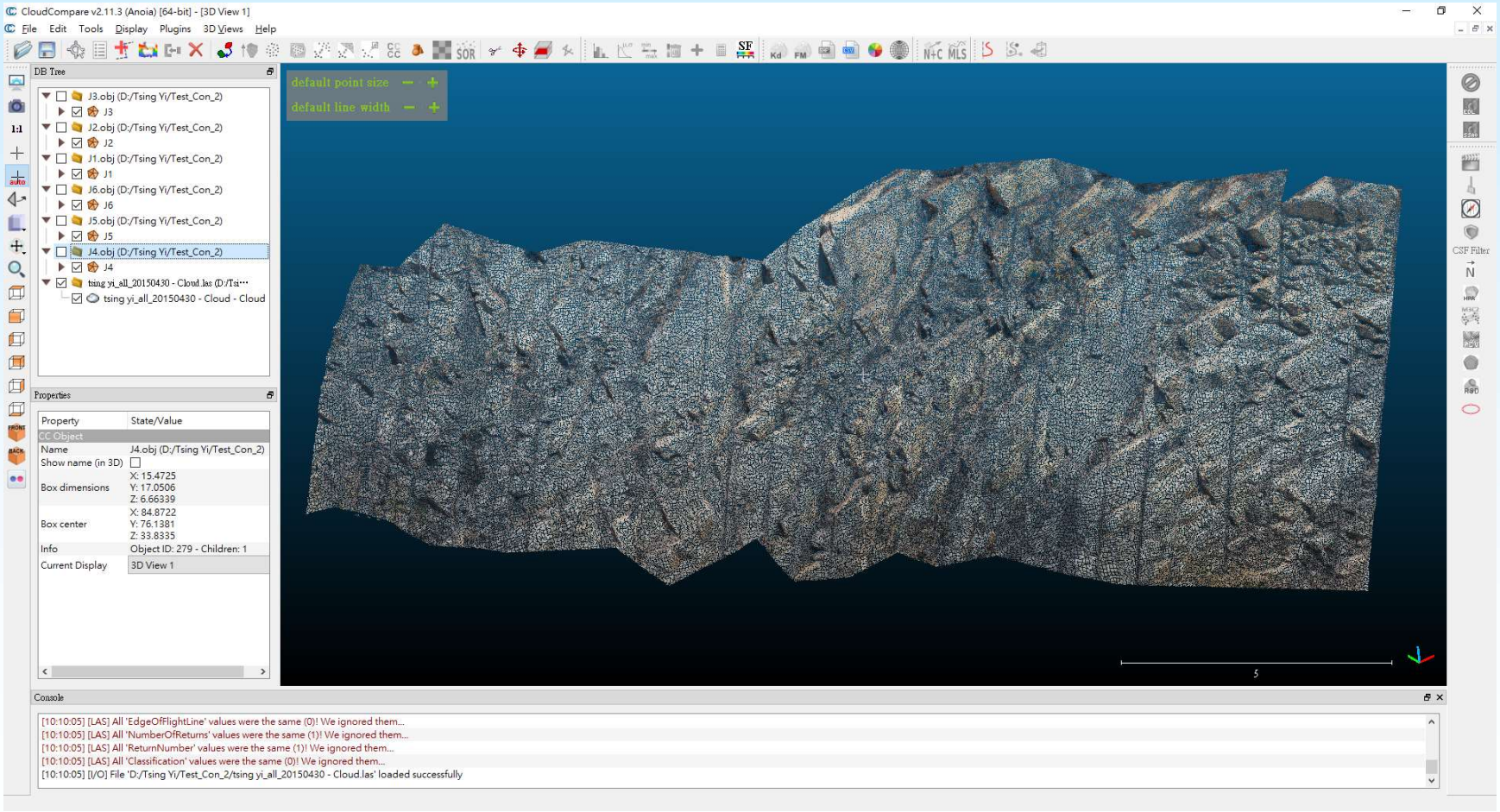
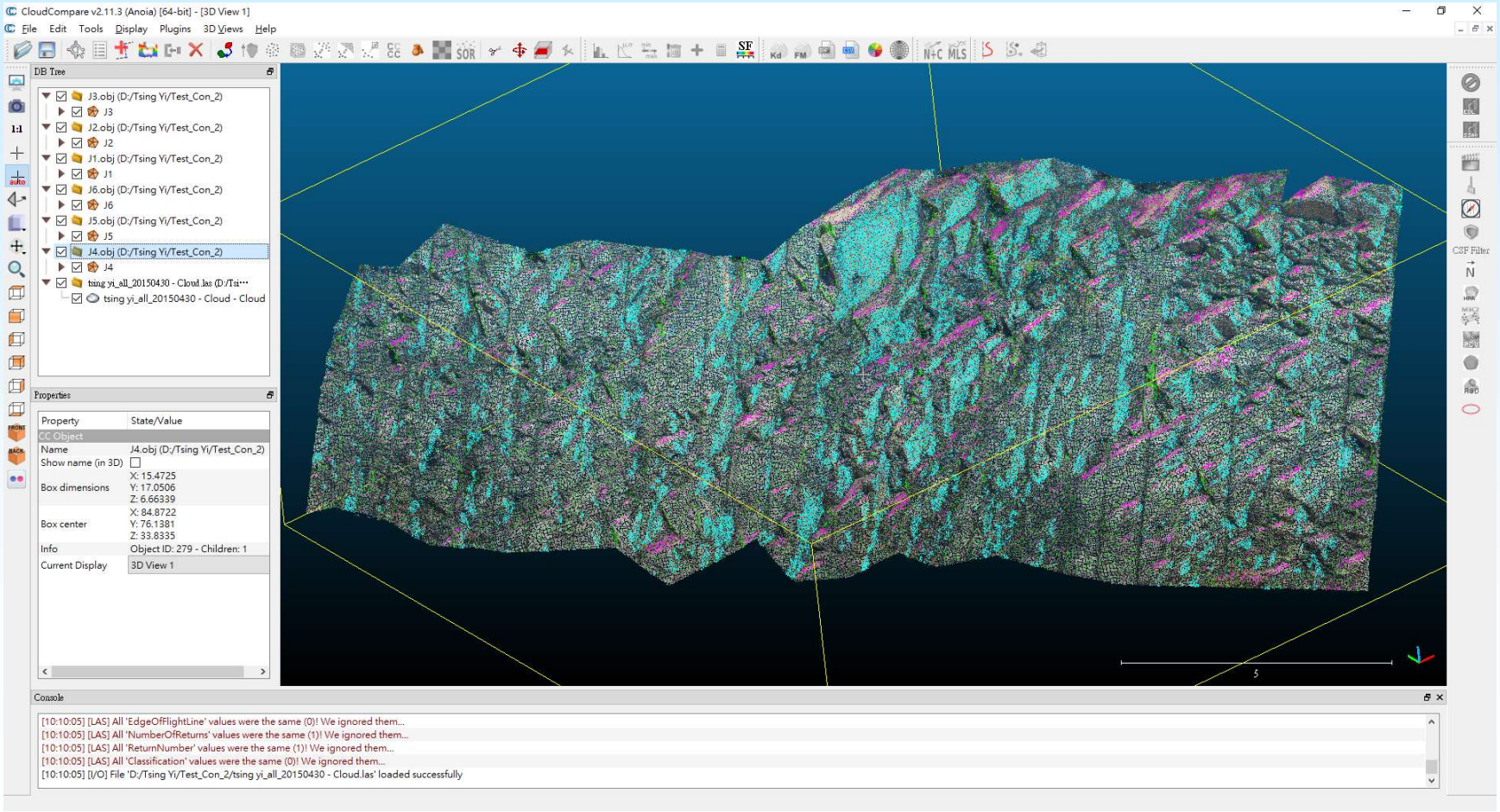


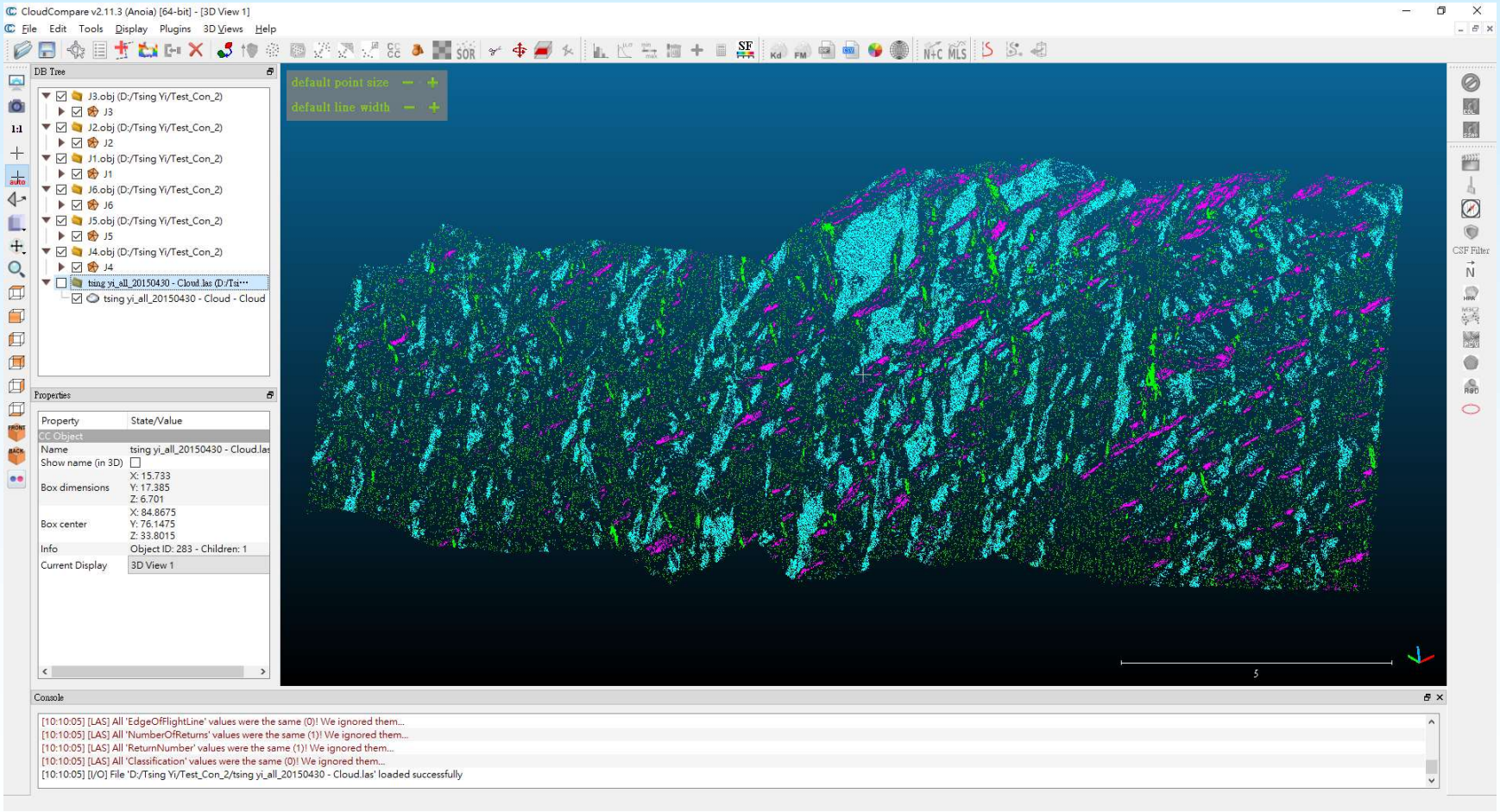
Rock Slope in Tsing Yi



Rock Slope in Tsing Yi

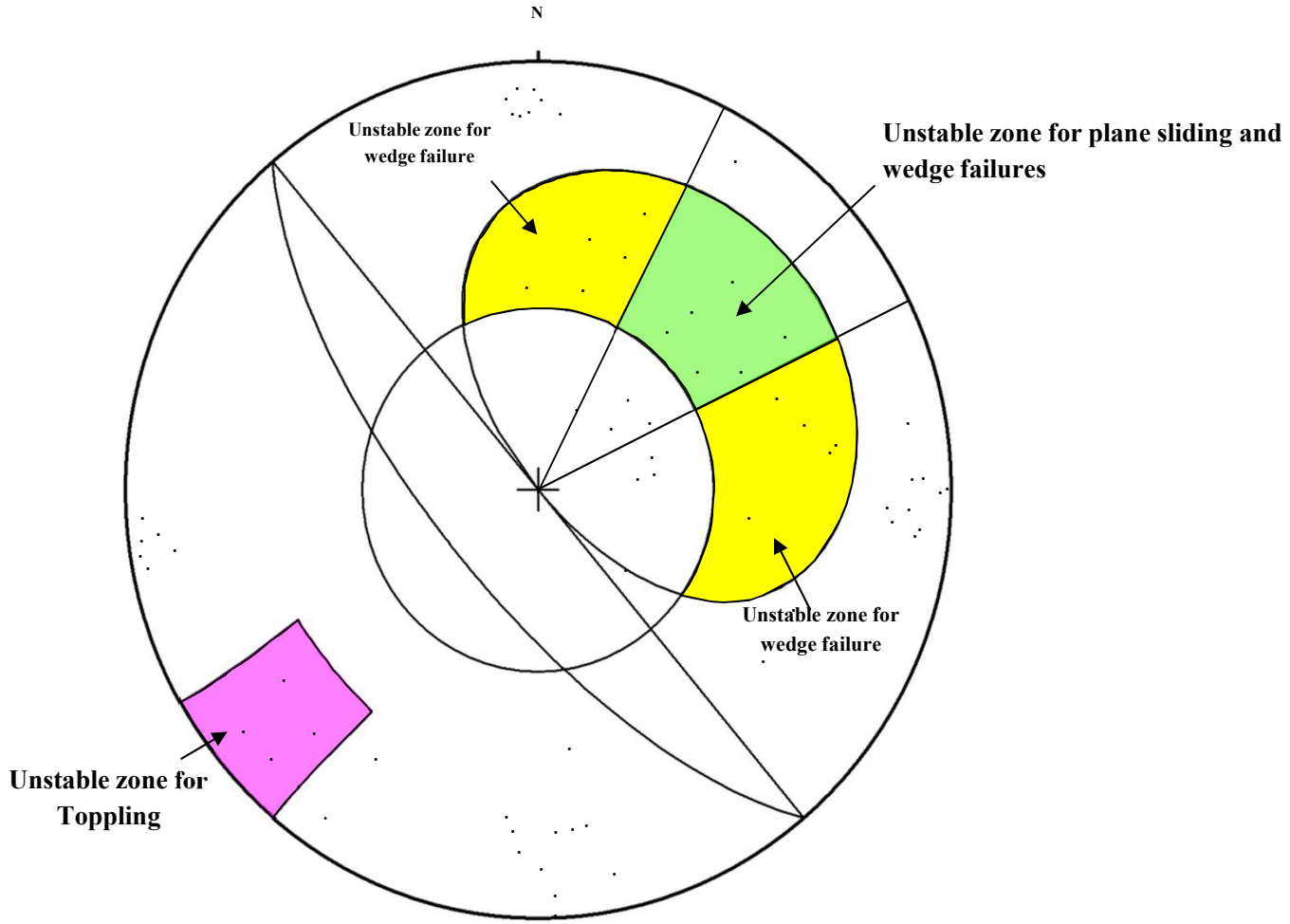


Rock Slope in Tsing Yi

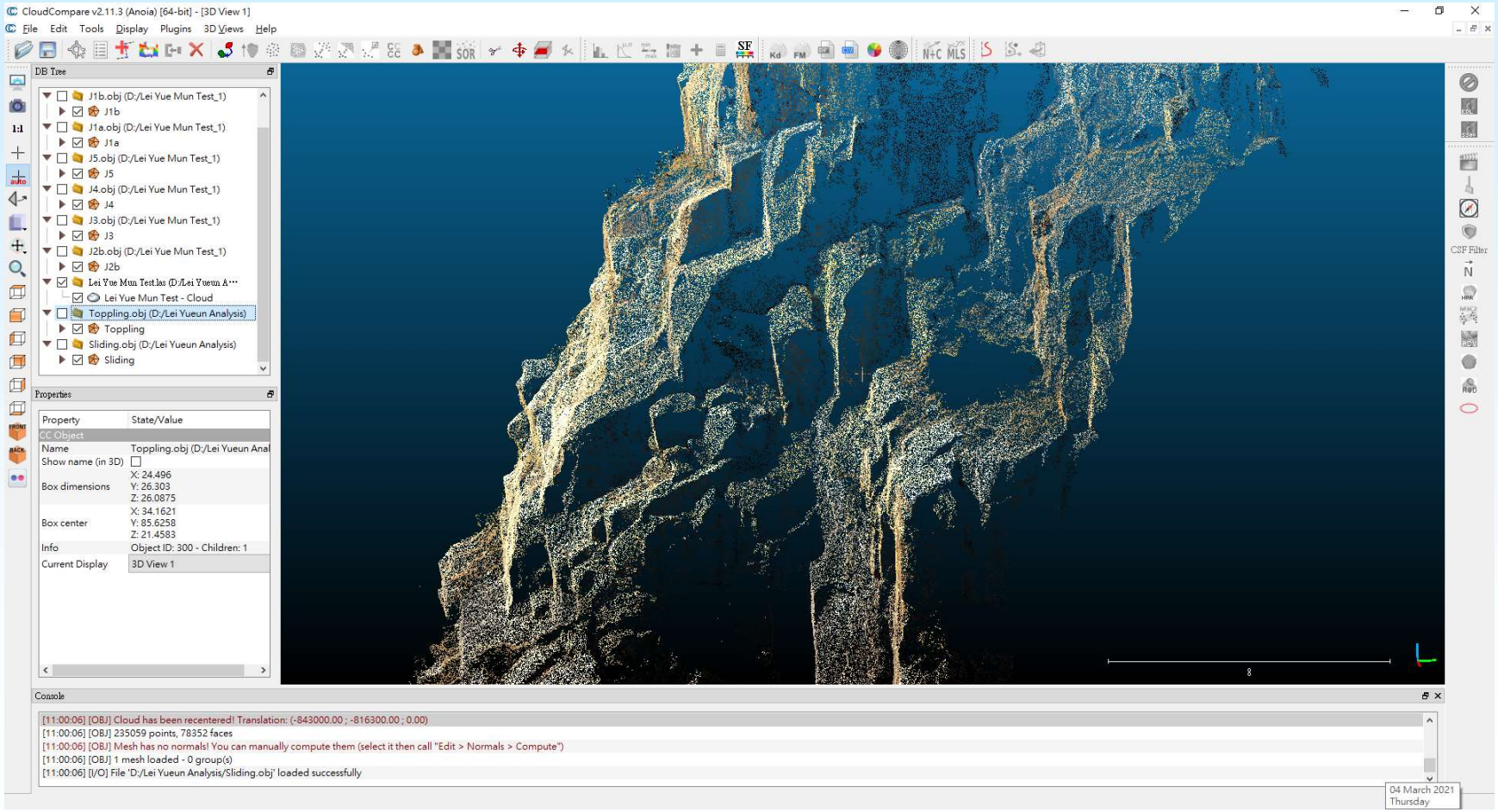


Stability Assessment

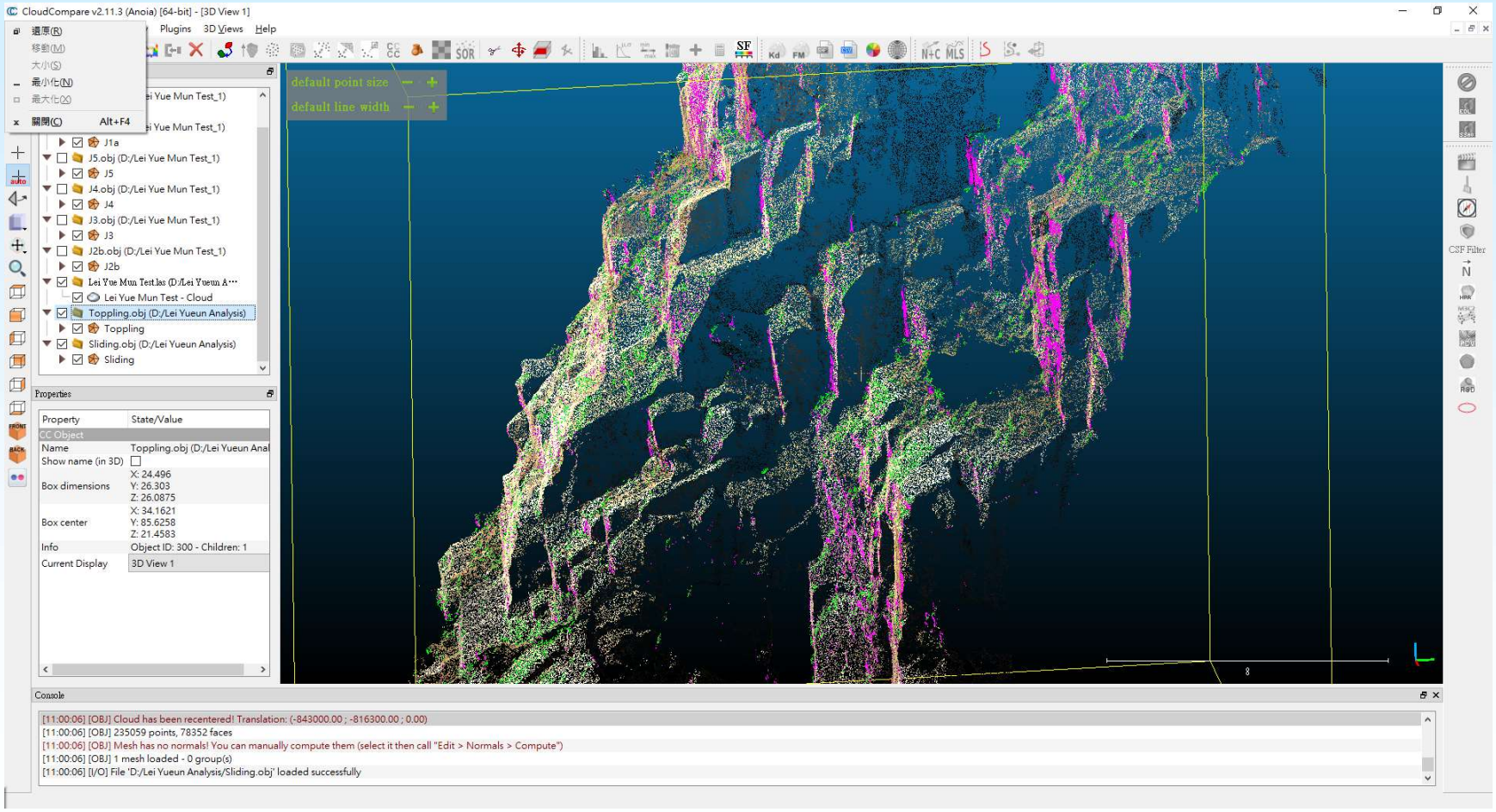
Identification of Facets within Unstable Zones for Plane Sliding and Toppling



Lei Yue Mun Quarry



Lei Yue Mun Quarry



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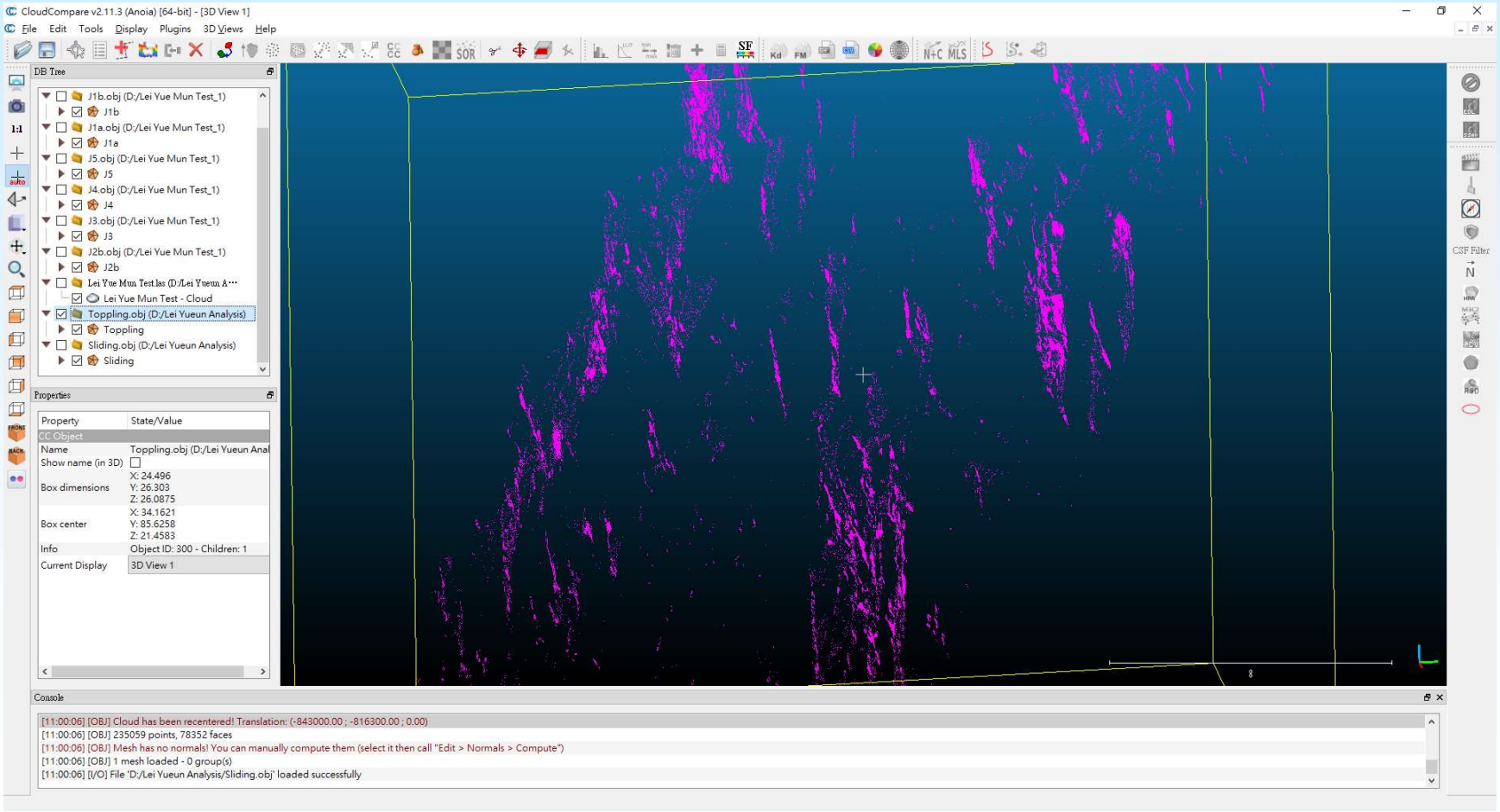

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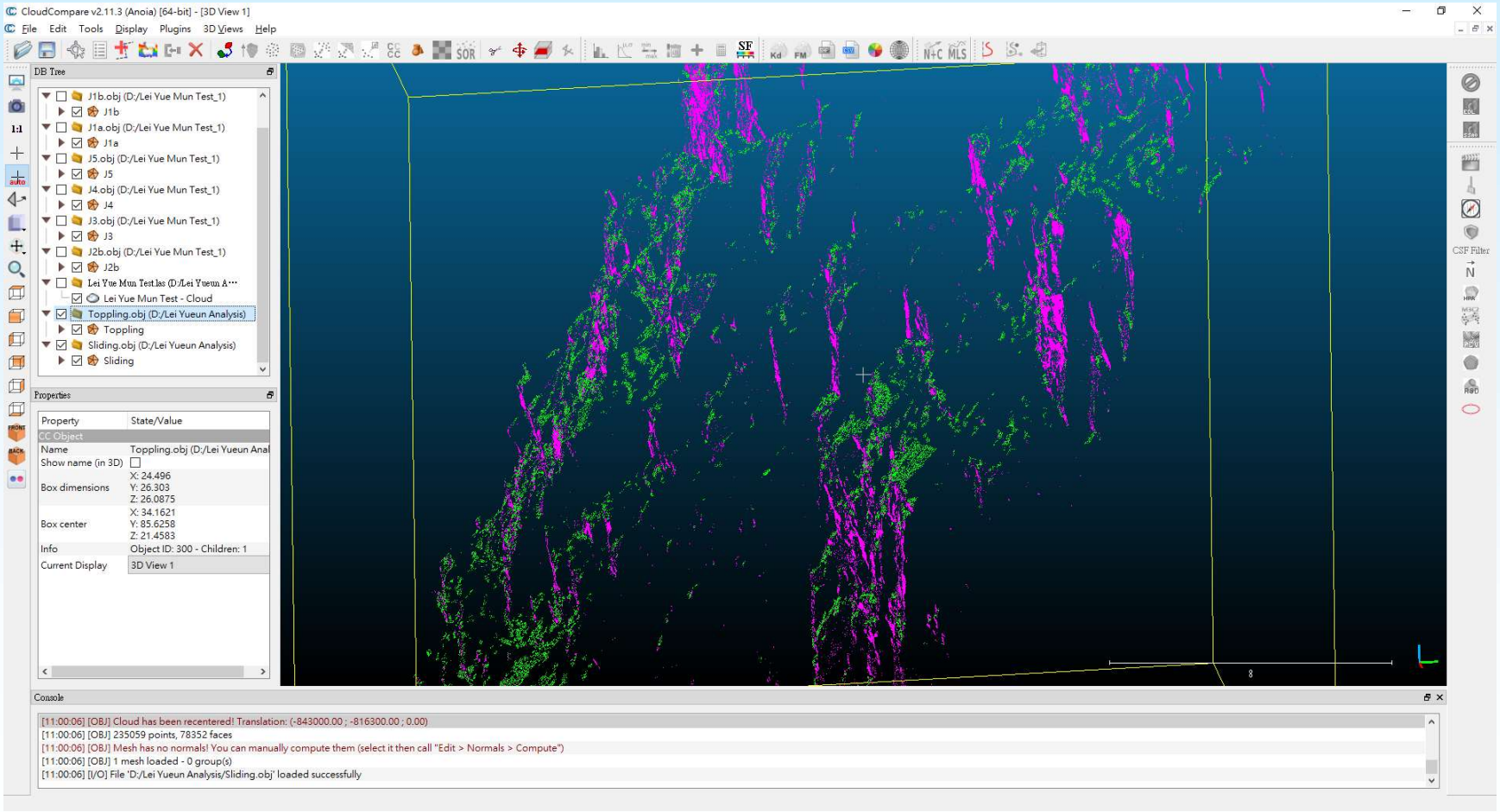
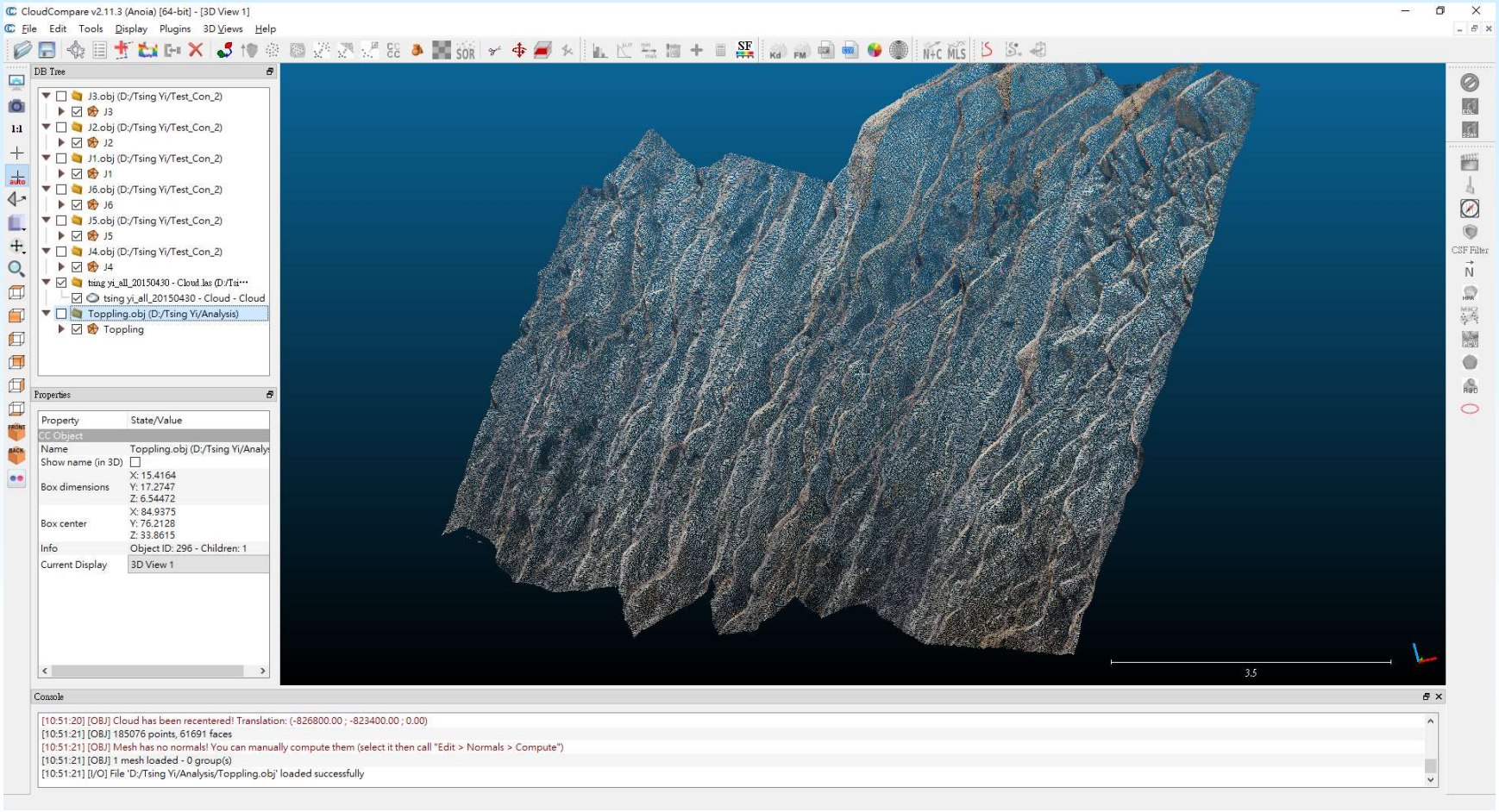
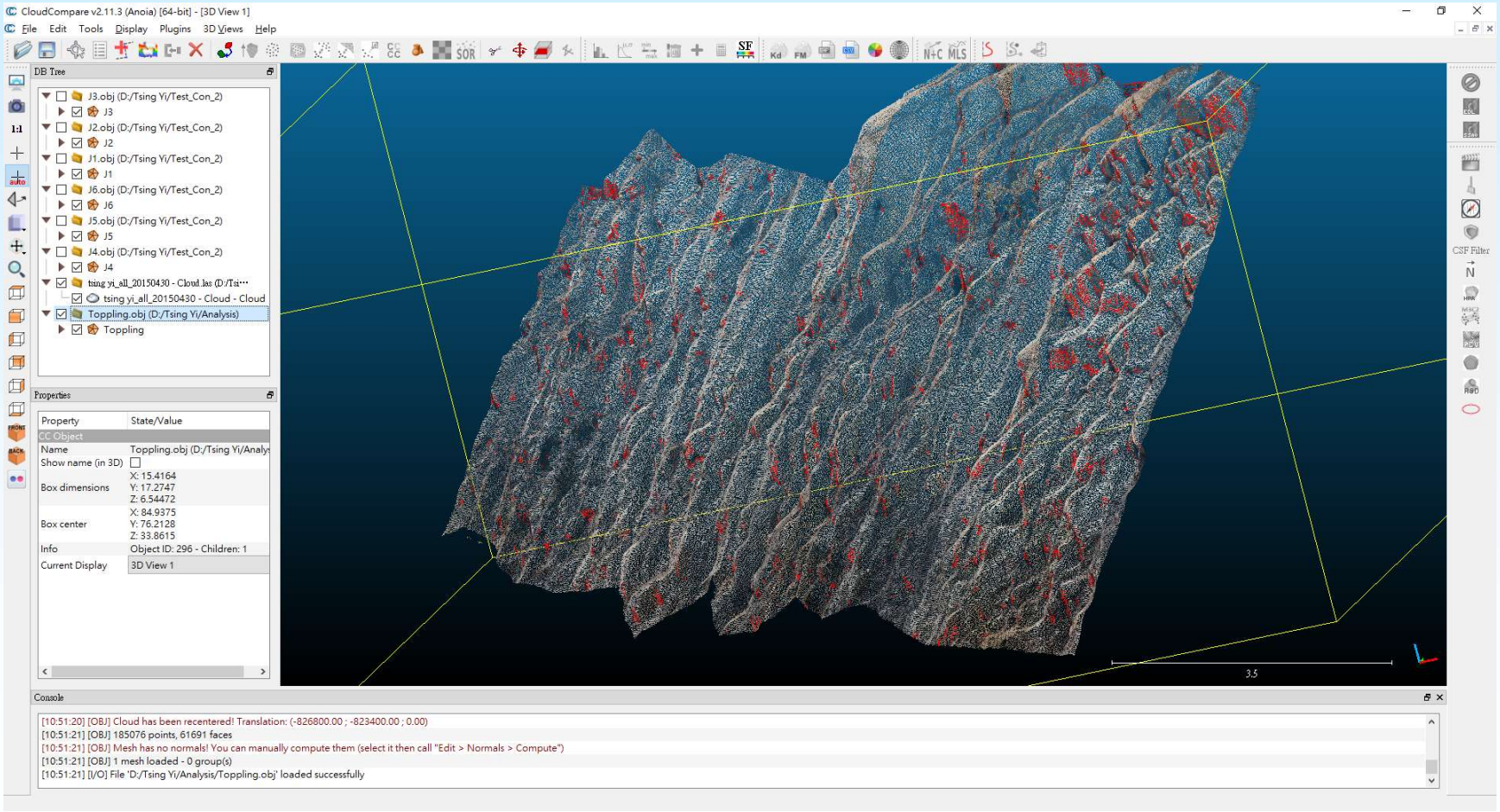


Rock Slope in Tsing Yi

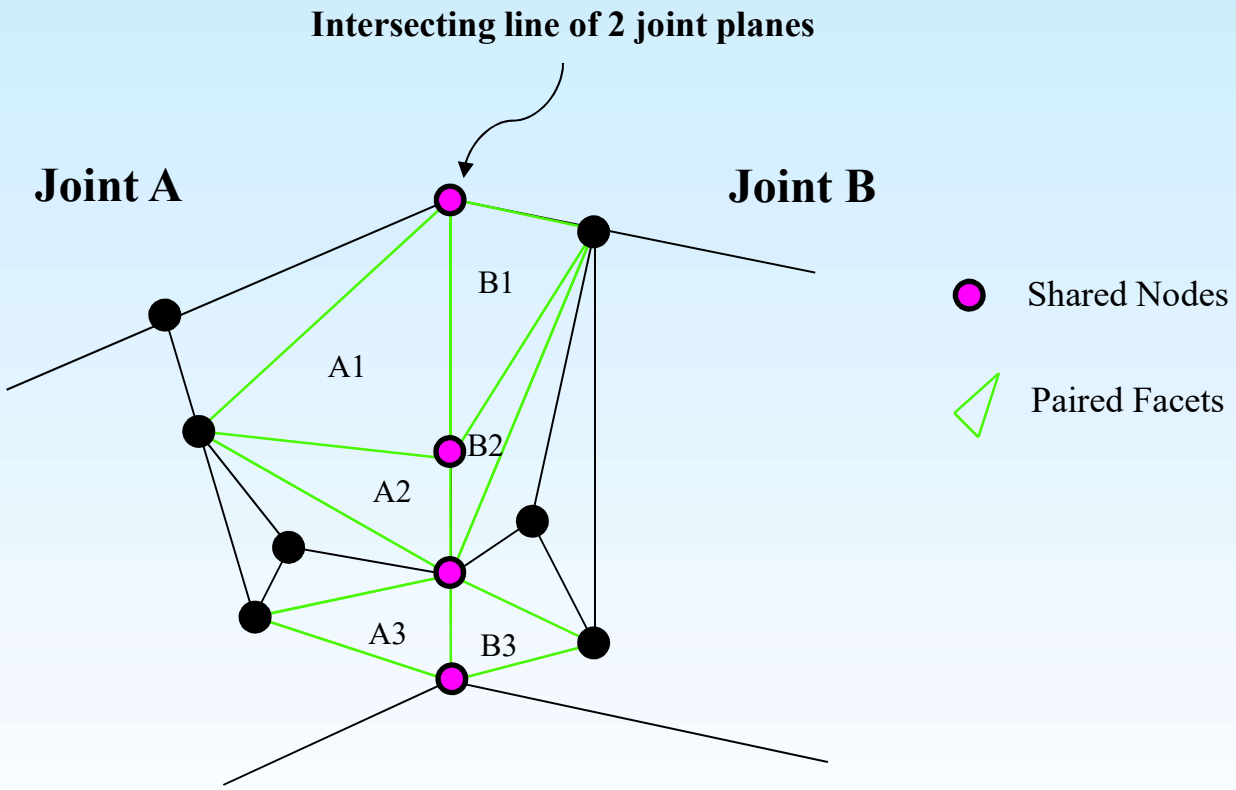


Rock Slope in Tsing Yi

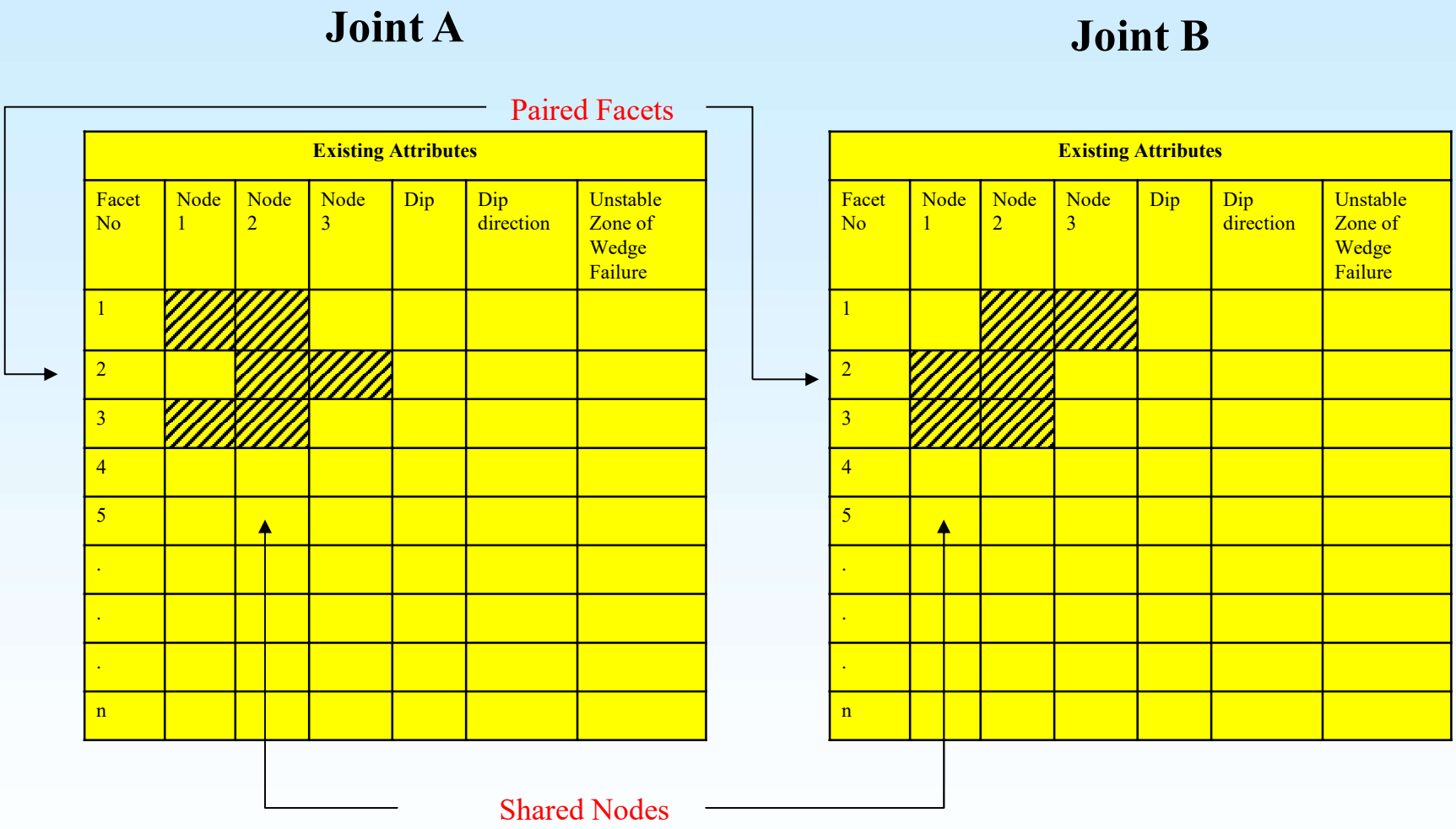


Assessment of Wedge Failure by Facet Amalgamation Approach

Assessment of Wedge Failure

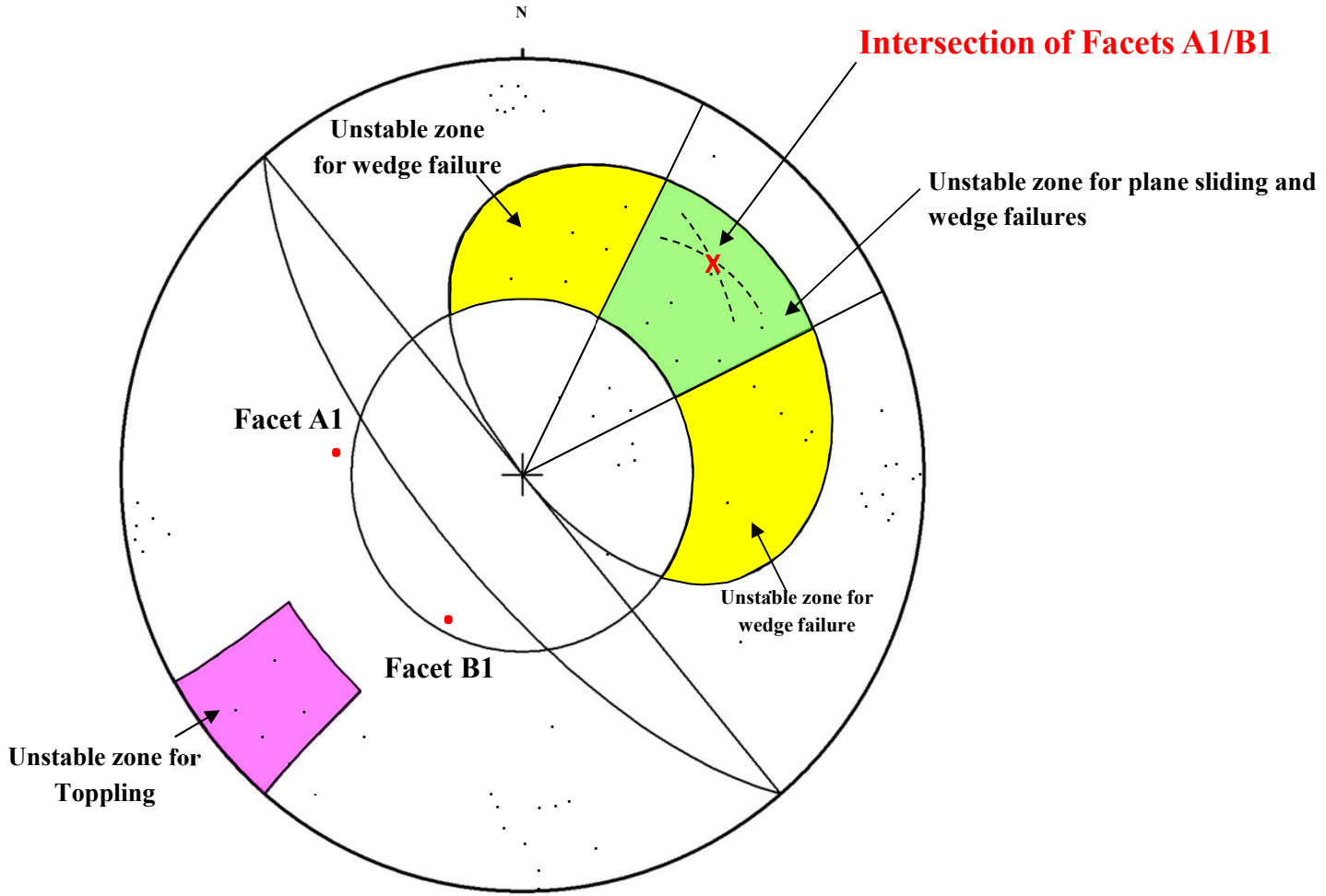


1. Identify the facets belonging to different joint planes sharing two nodes of the facets of other joint planes (**Shared Nodes**)
2. Those facets with Shared Nodes are **Paired Facets** e.g. A1, B1

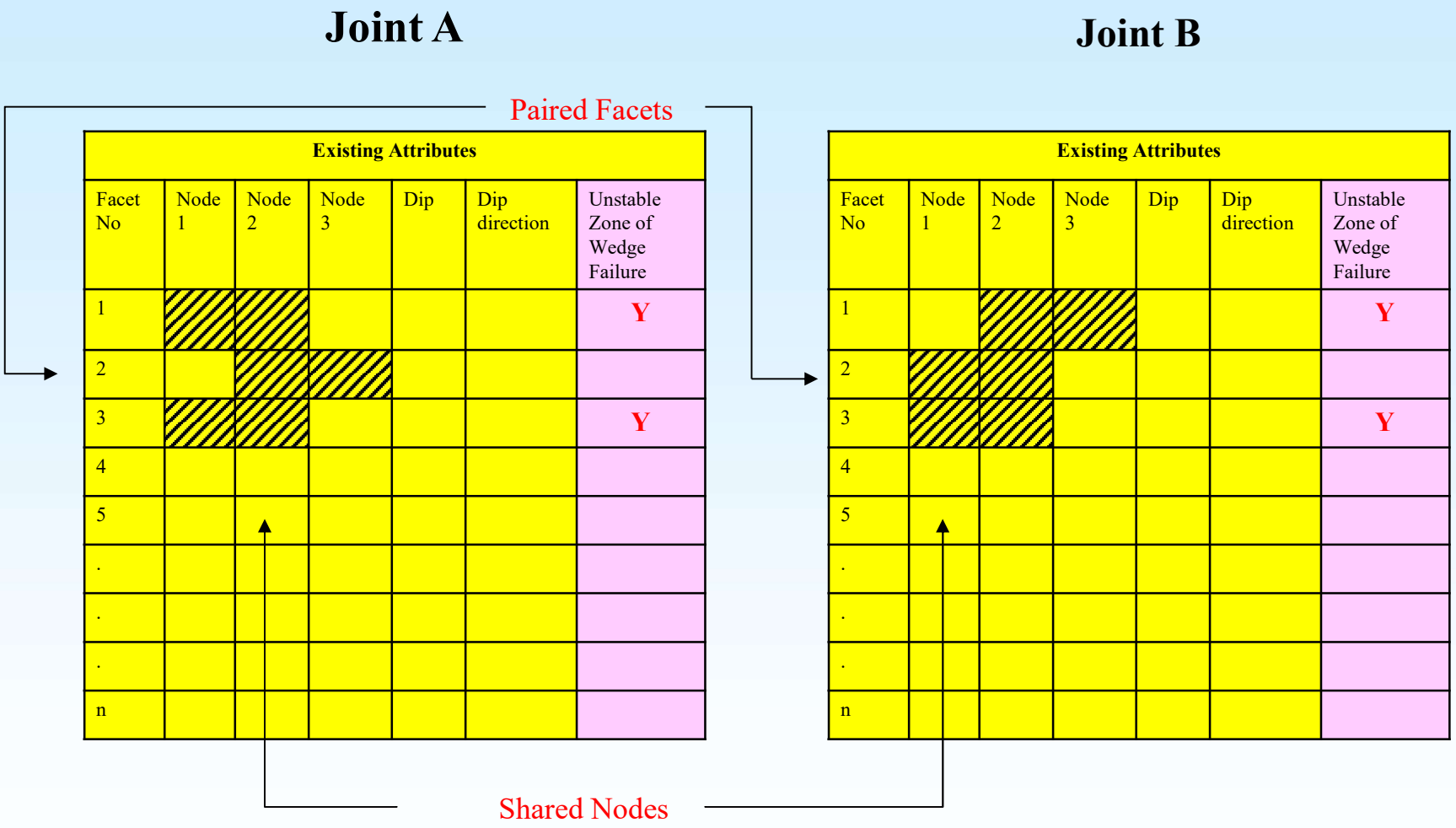


Identify and extract all **Paired Facets** from the attribute tables

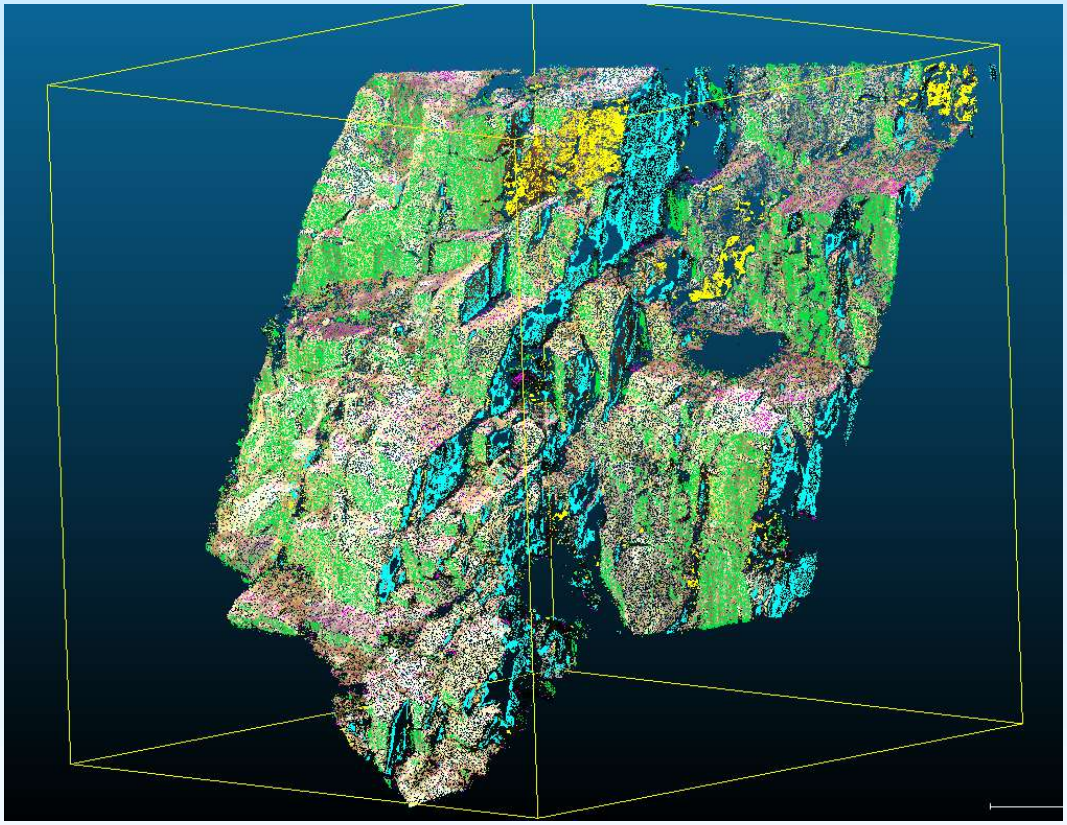
Identification of Facets within Unstable Zones for Wedge Failure



Draw great circles of each Paired Facets and find out whether the intersecting point falls within the unstable zones of wedge failure



Identify and Extract Paired Facets which fall within the unstable zones of wedge failure



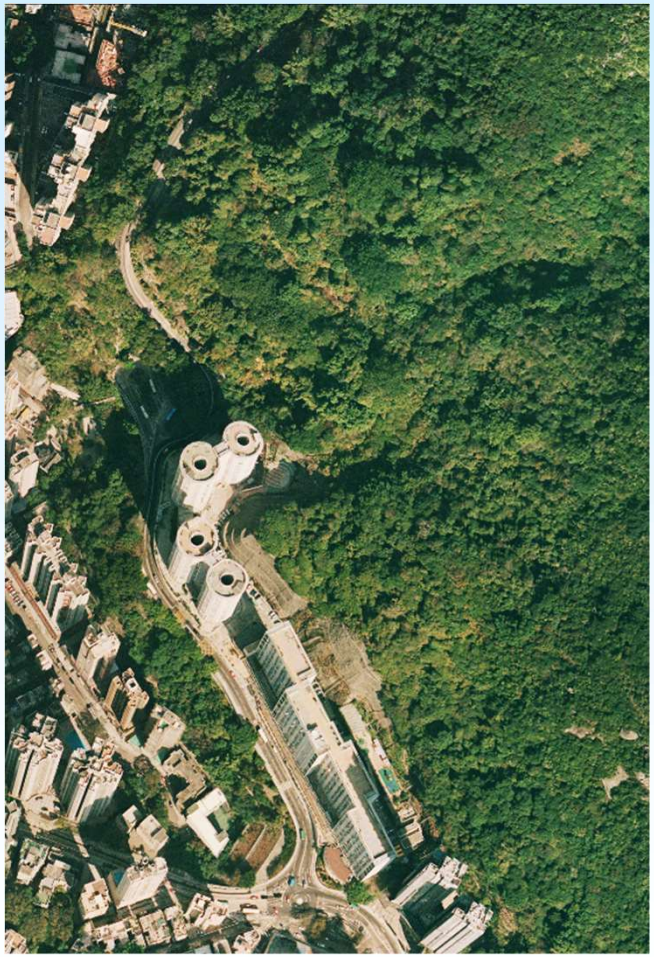
1. Amalgamate all those Paired Facets within the unstable zones of wedge failure
2. Superimpose those facets on photos or point clouds
3. Add the joint planes already identified to find out the locations of the joint planes which are subjected to wedge failure

Facet Amalgamation Approach for Other Geotechnical Studies

Cut and Fill Terraces

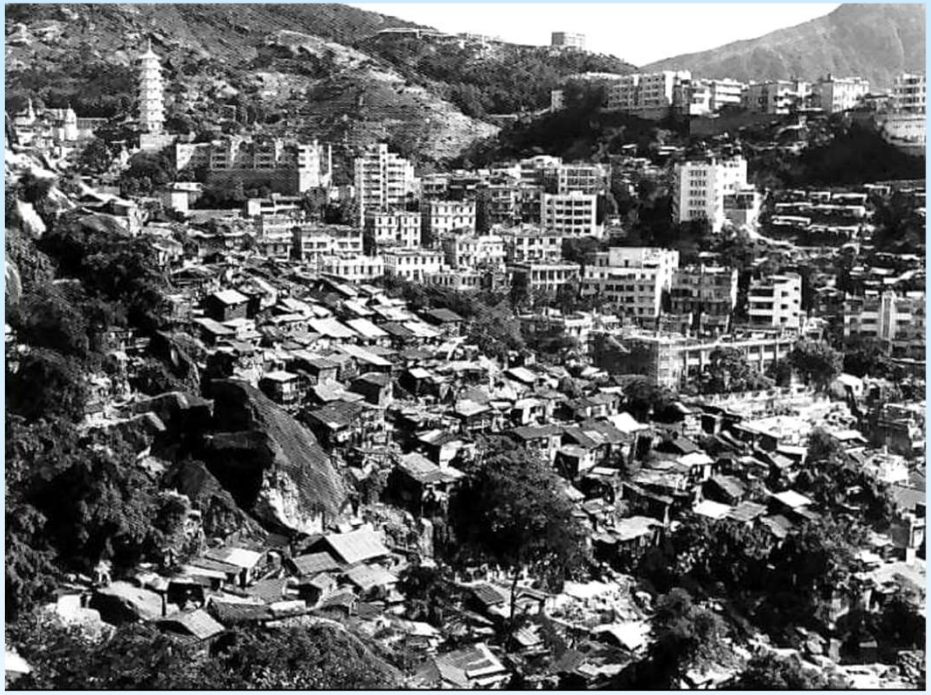
Tai Hang

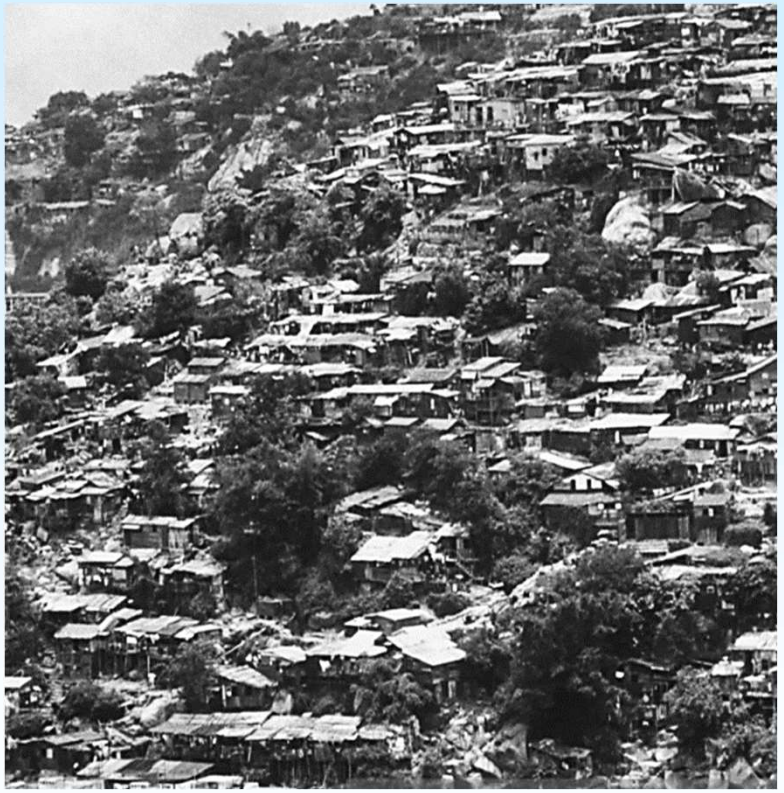
1963

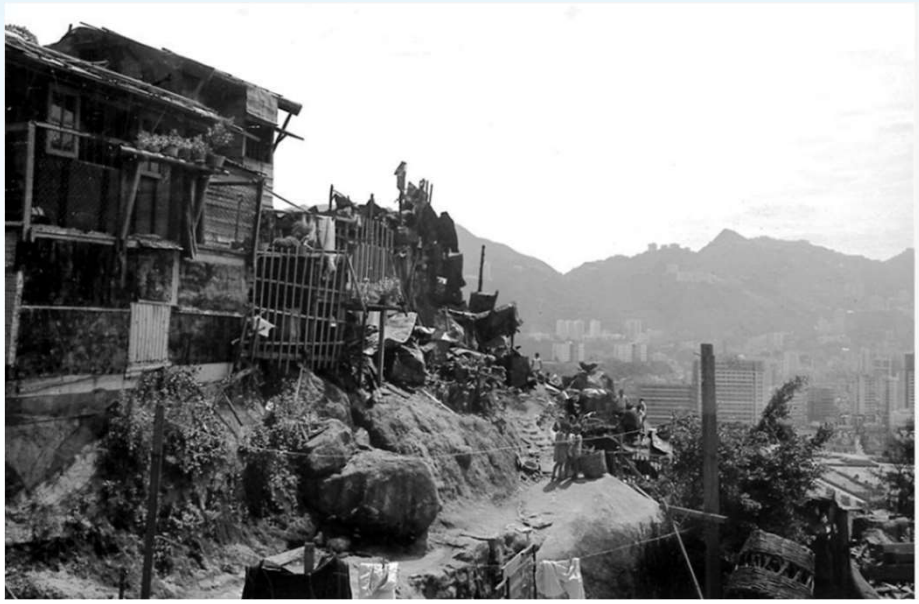


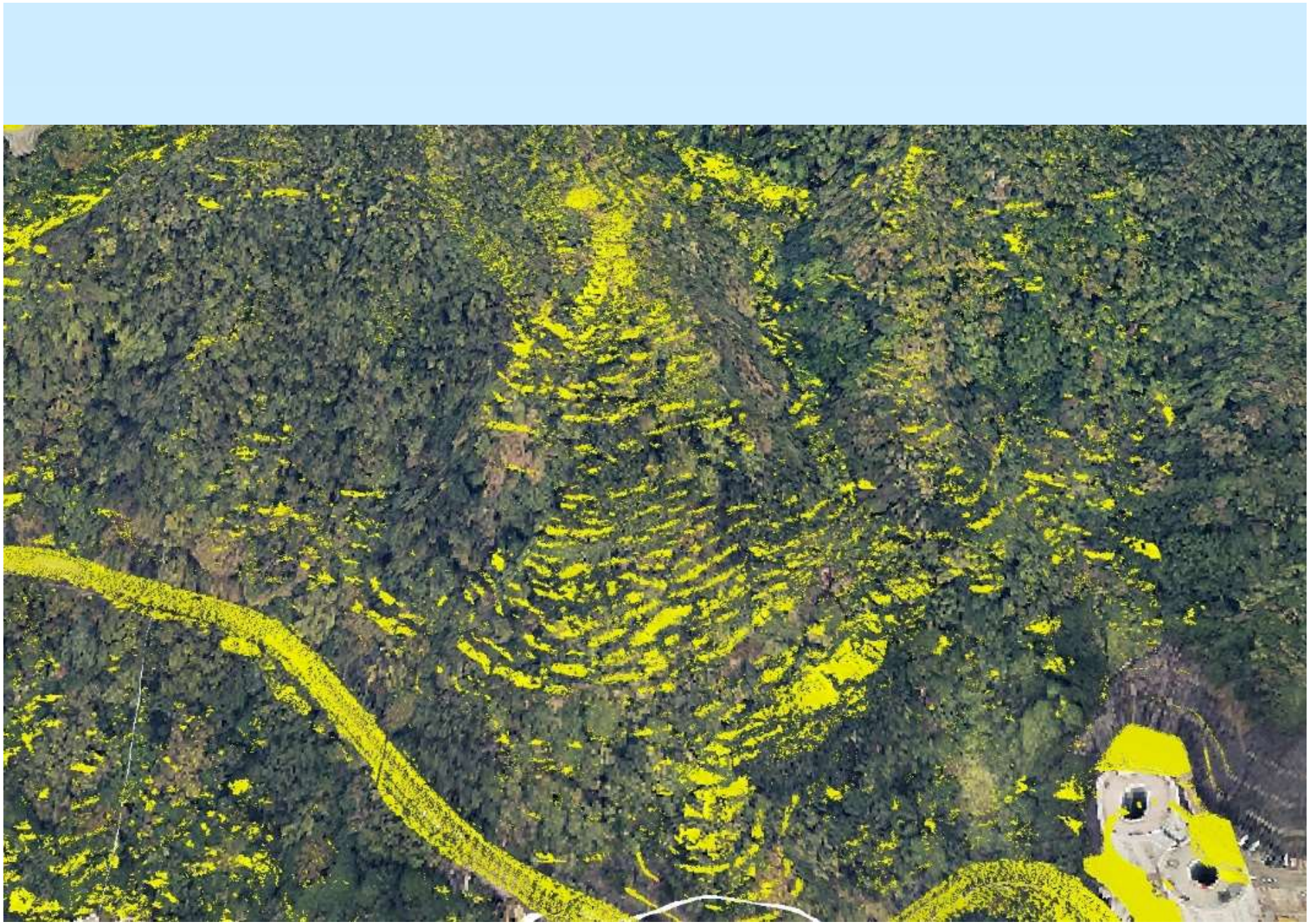
2018

Tai Hang



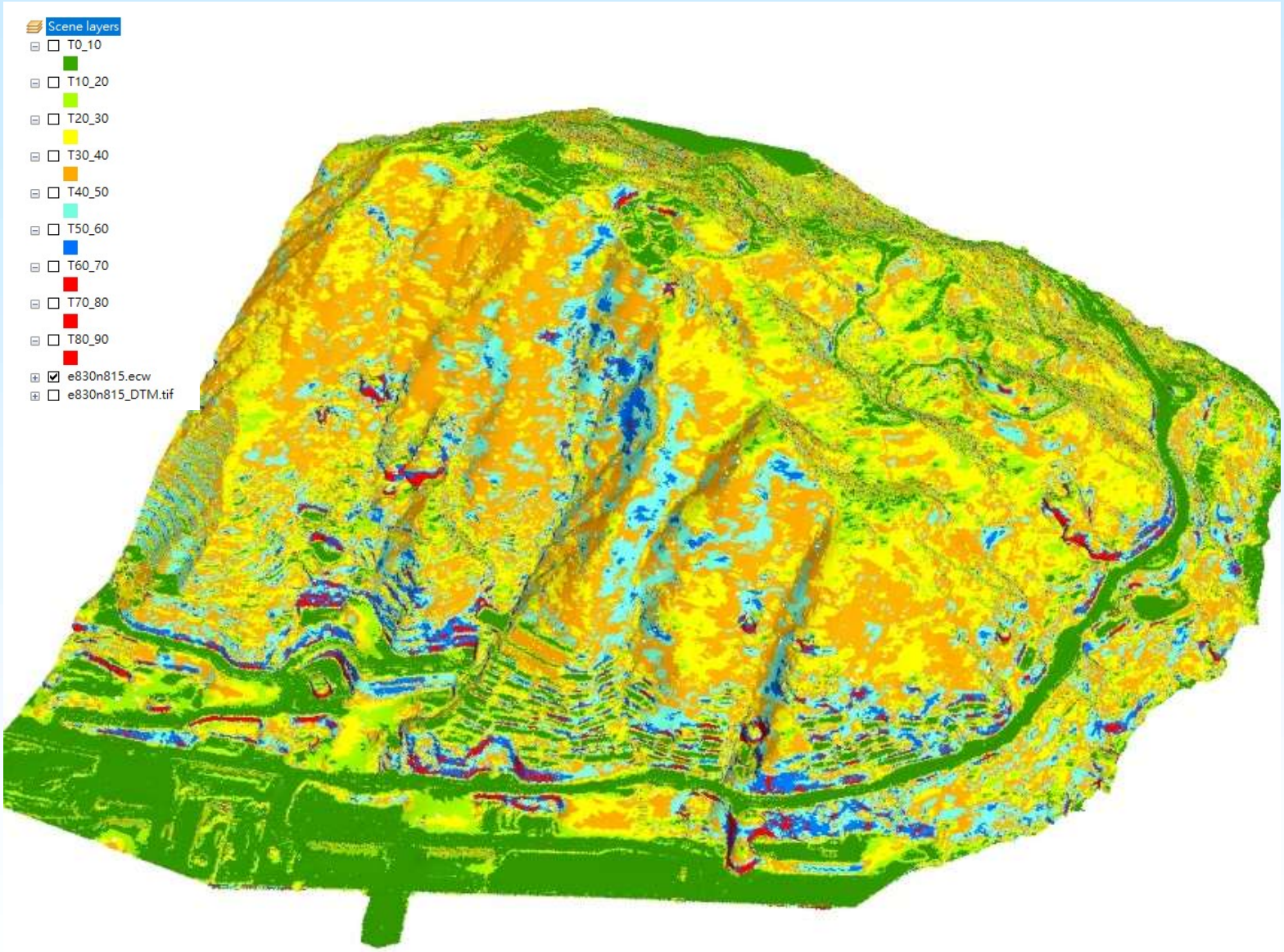






Slope Angle Maps

Mount Davis


Scene layers
T0_10
T10_20
T20_30
T30_40
T40_50
T50_60
T60_70
T70_80
T80_90
e830n815.ecw
e830n815_DTM.tif

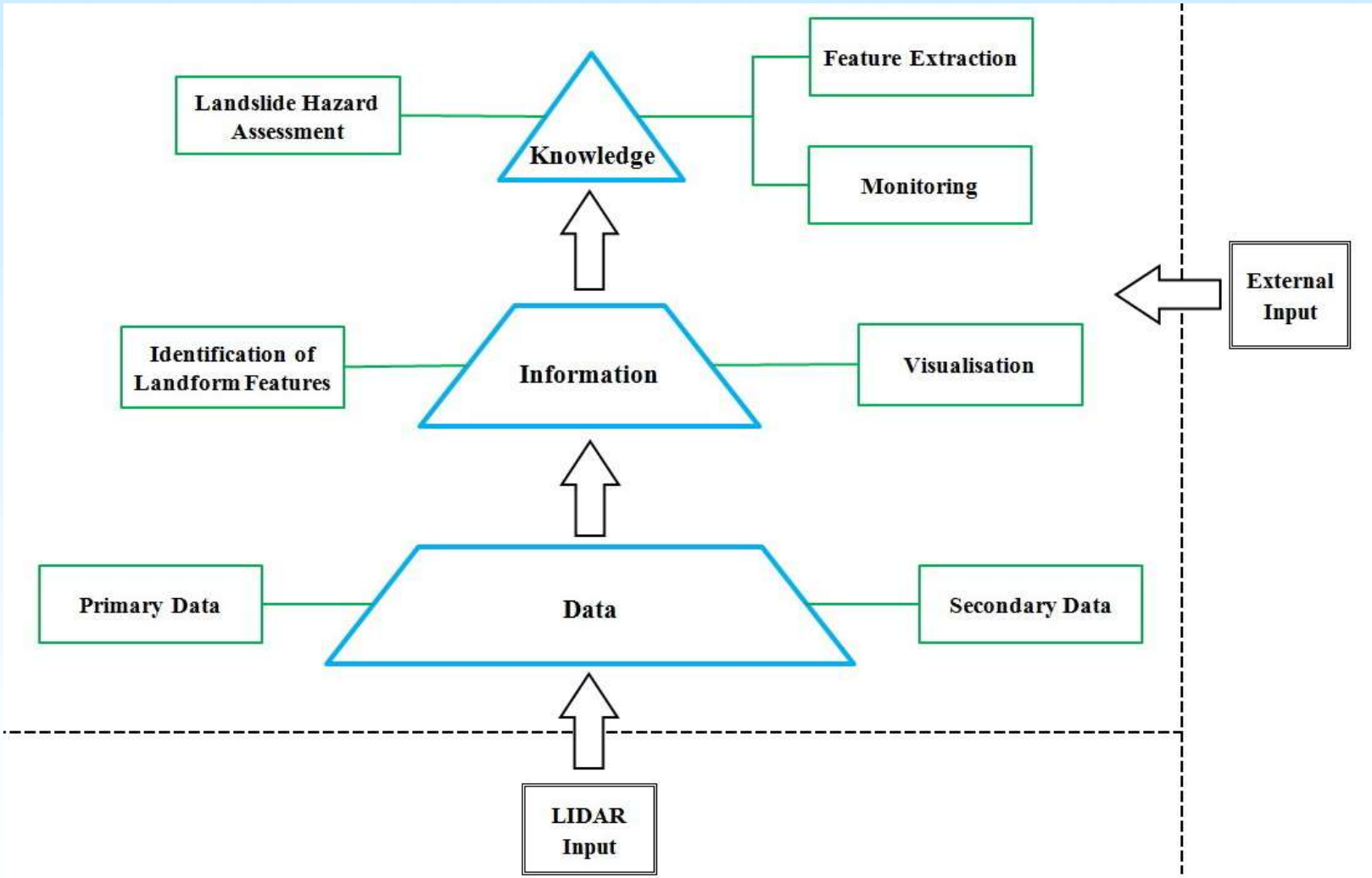
Mount Davis

Applications of Remote Sensing in Geotechnical Studies

Attribute Table

Existing Attributes						LIDAR Data			Other remote sensing data			Other data	
Facet No.	Node 1	Node 2	Node 3	Dip	Dip direction	Classification	Return No.	Intensity	RGB	Infrared Thermography	Hyperspectural	Geology	….
1													
2													
3													
4													
5													
.													
.													
.													
n													

Applications of Remote Sensing in Geotechnical Studies

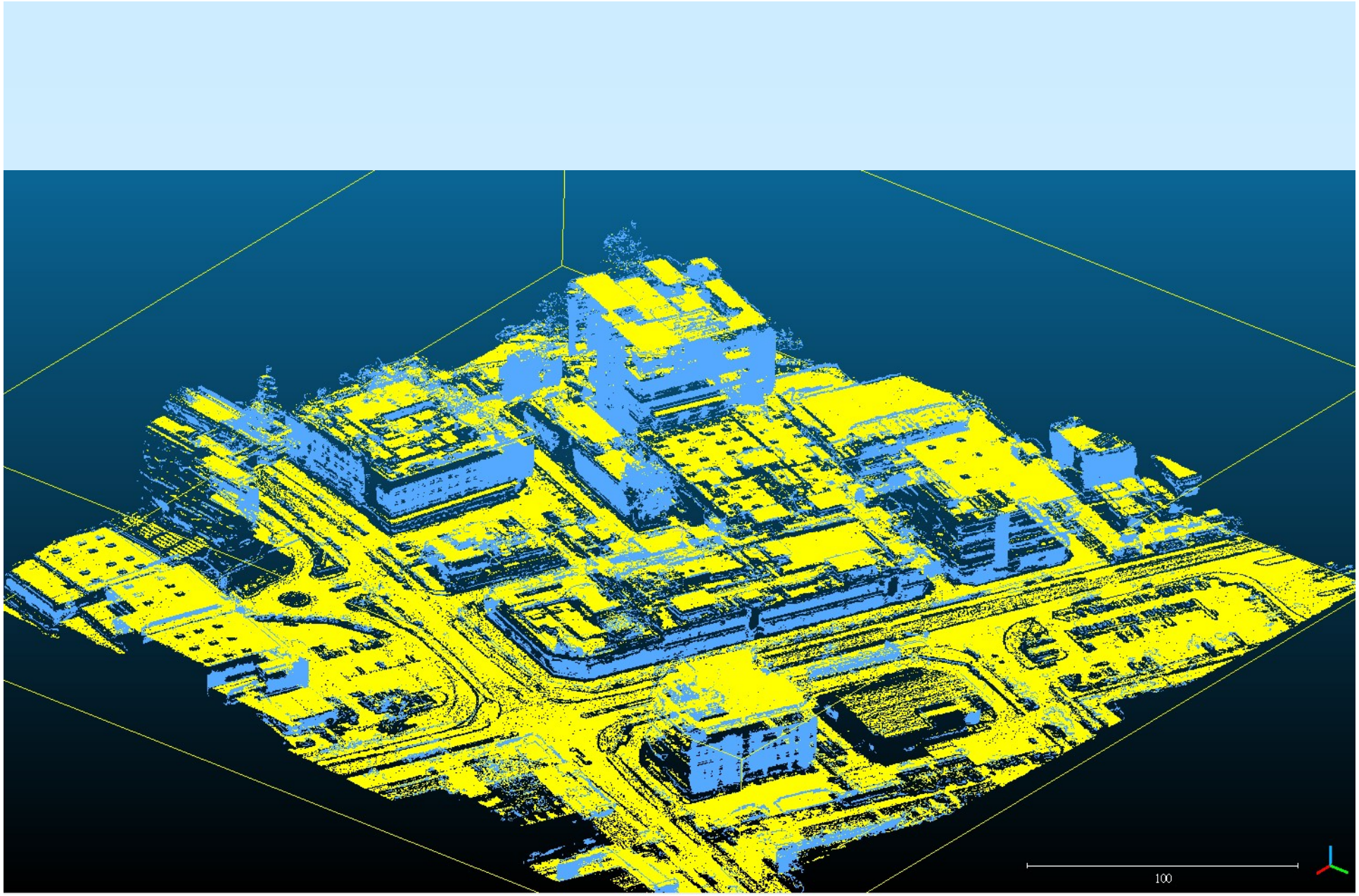


From Lai & So (2014)

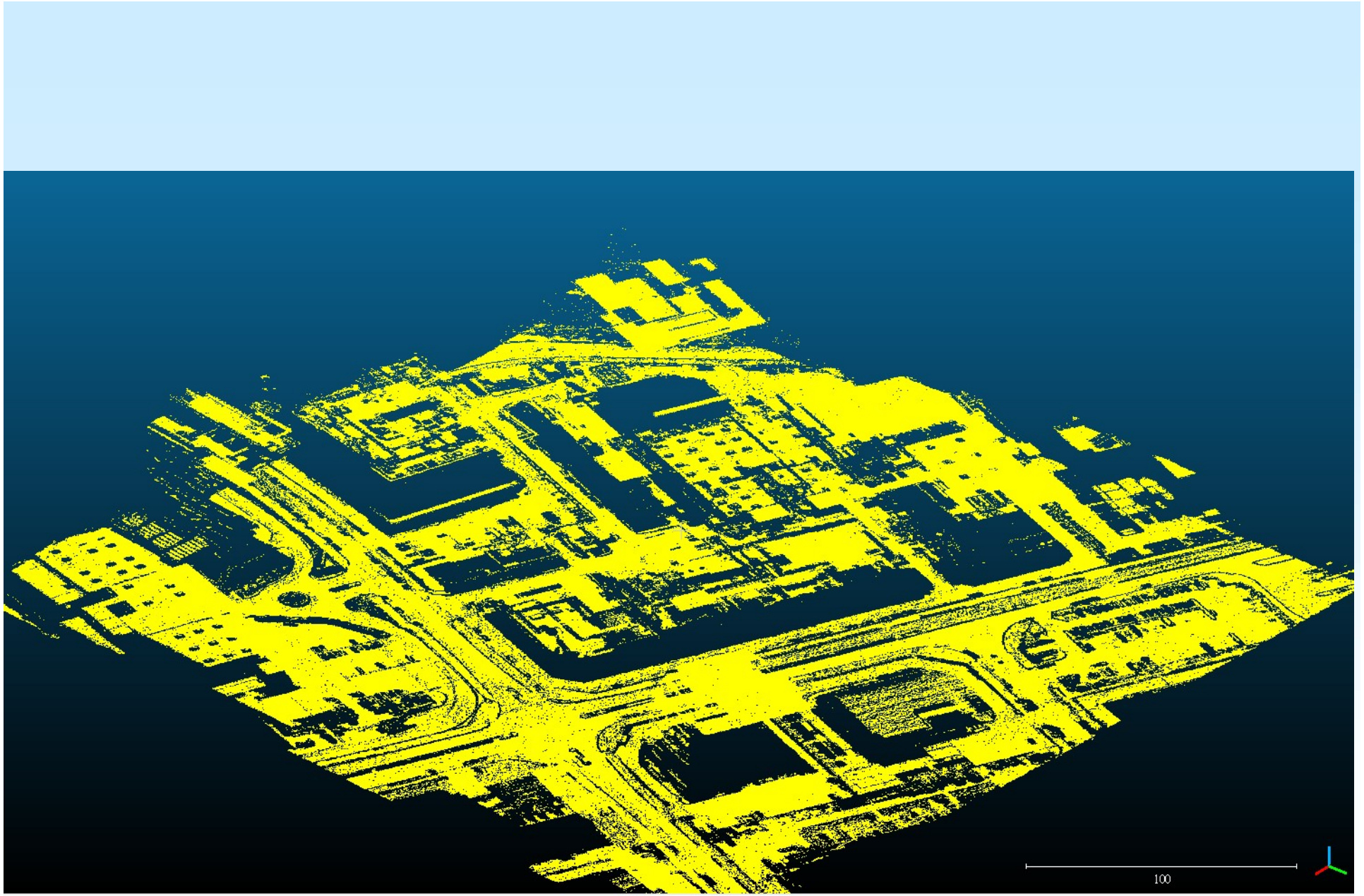
Facet Amalgamation Approach for Potential Non-Geotechnical Applications

Building Footprints – BIM

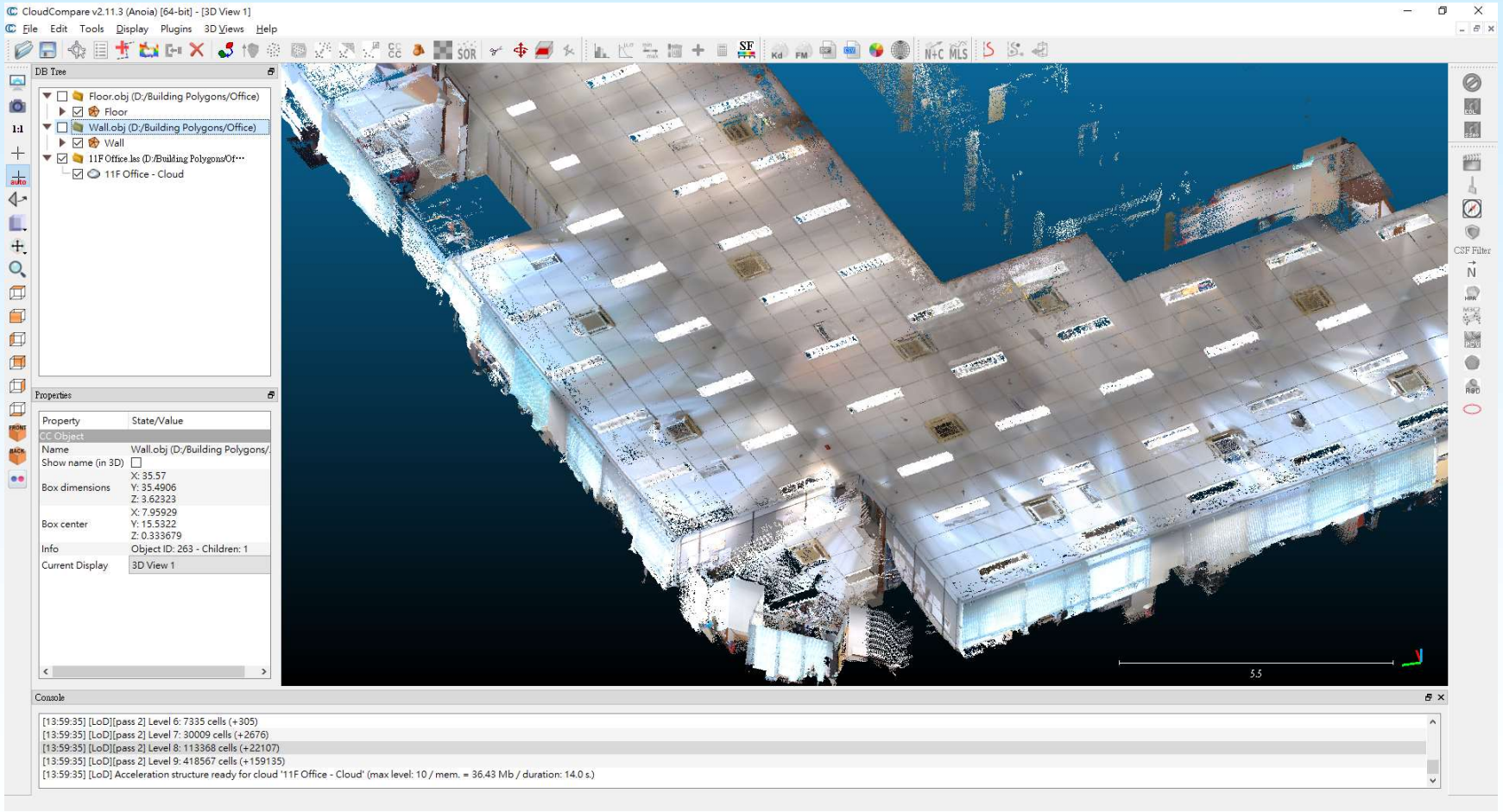
TKO Industrial Estate

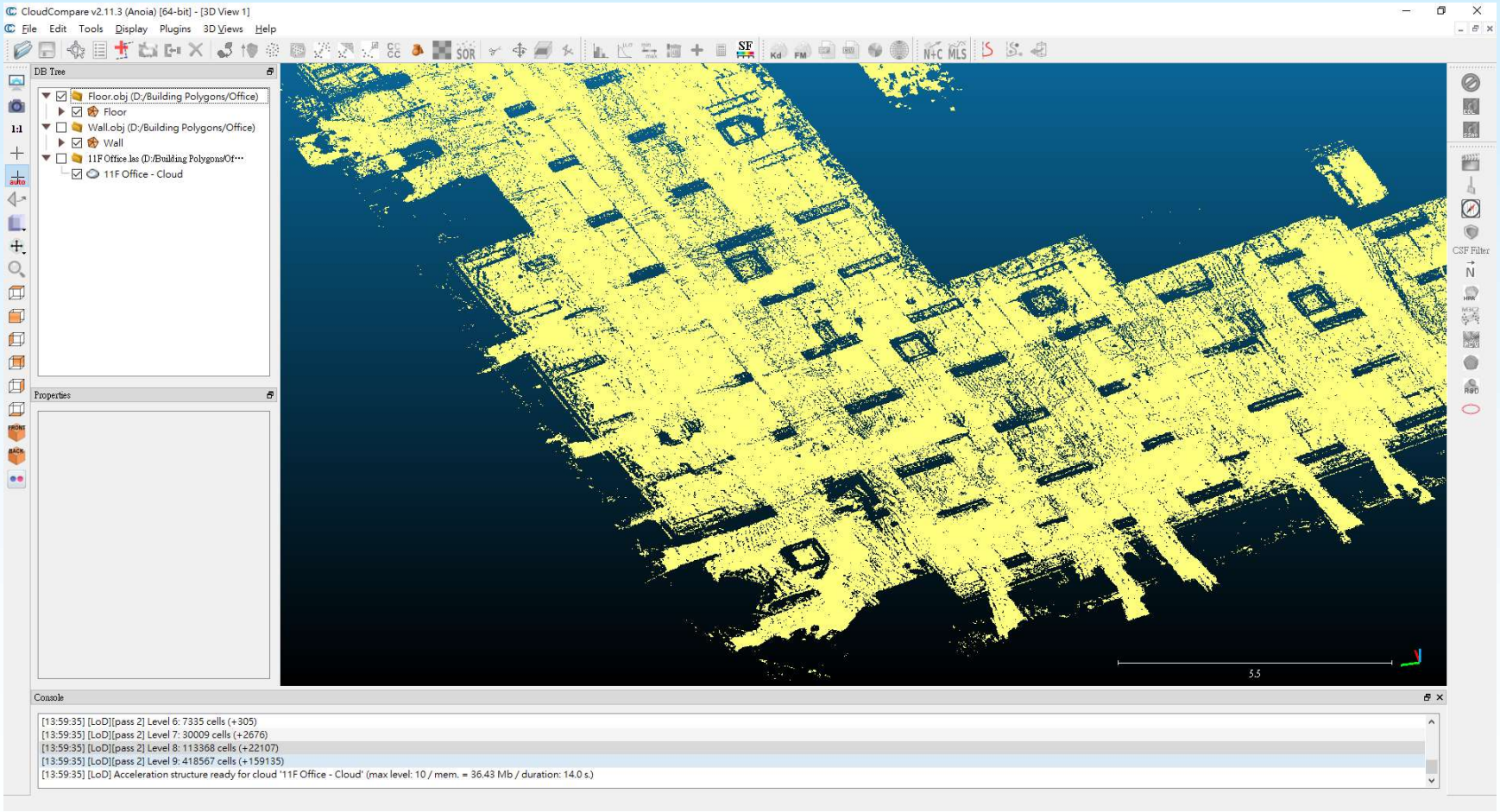

100

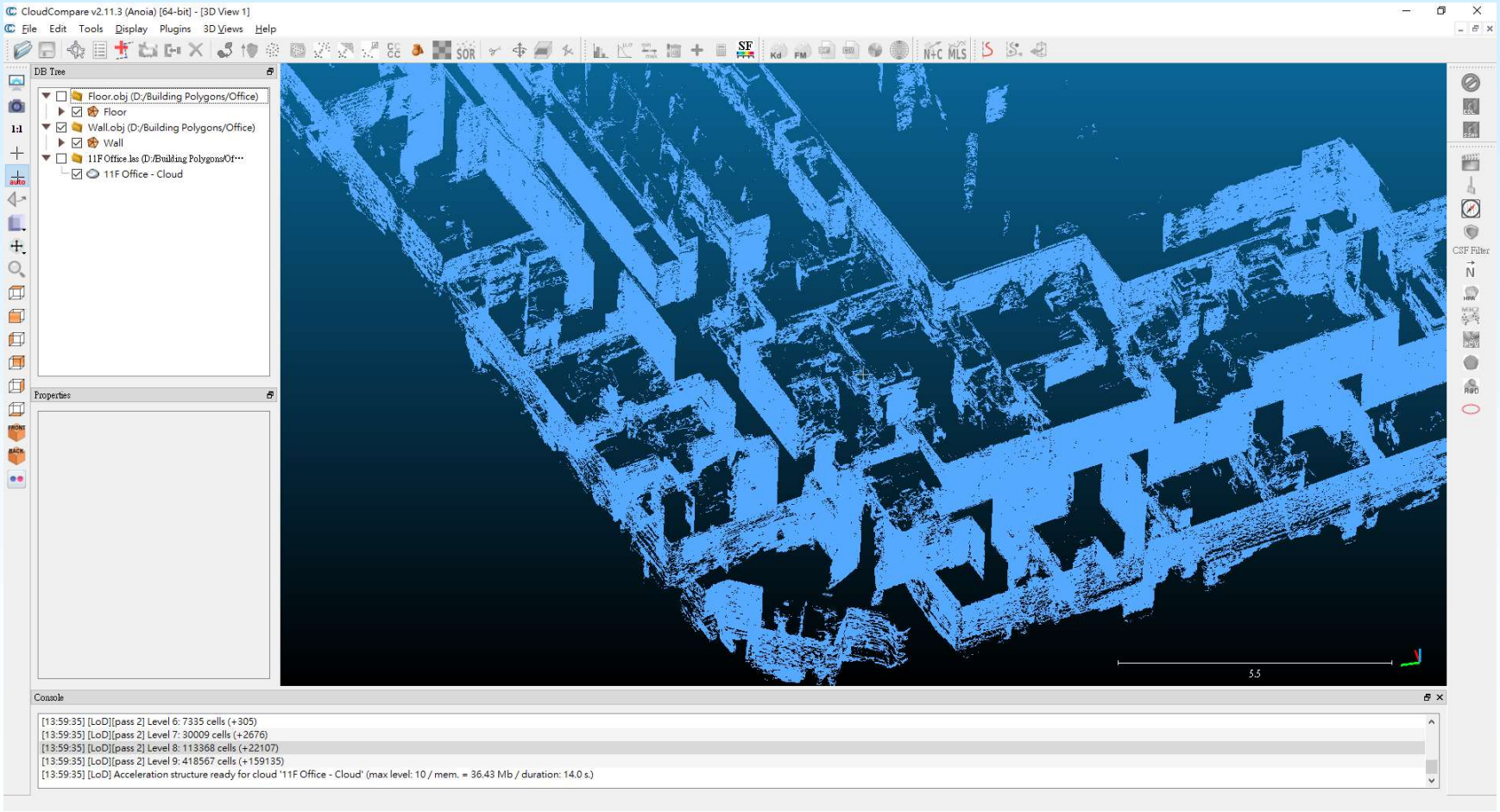

100

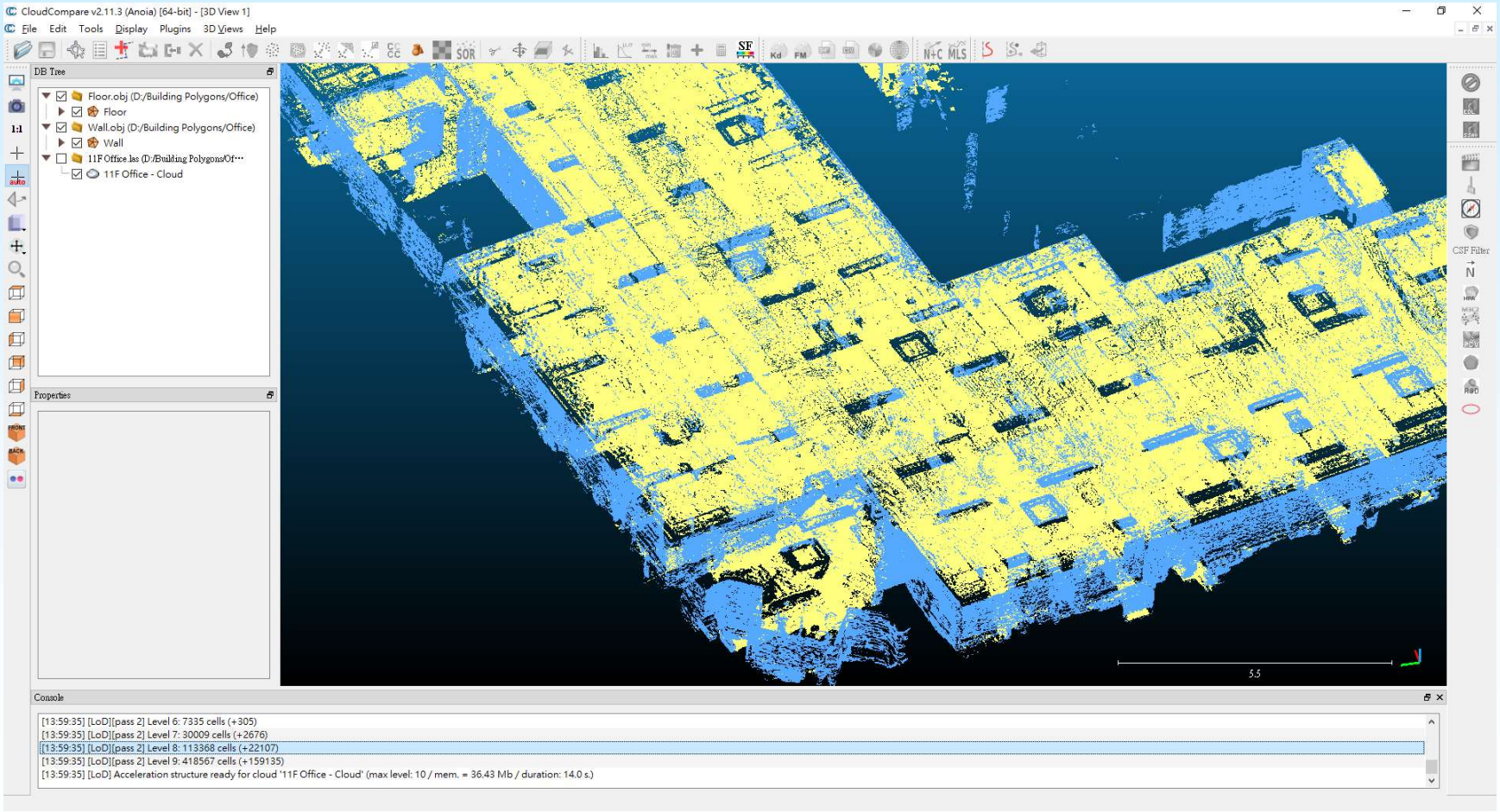

100

Floor Layout


CloudCompare v2.11.3 (Anoia) [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
DB Tree
Floor.obj (D:/Building Polygons/Office)
Floor
Wall.obj (D:/Building Polygons/Office)
Wall
11F Office las (D:/Building Polygons/Of…
11F Office - Cloud
Properties
Property State/Value
CC Object
Name Wall.obj (D:/Building Polygons/
Show name (in 3D)
Box dimensions X: 35.57 Y: 35.4906 Z: 3.62323
Box center X: 7.95929 Y: 15.5322 Z: 0.333679
Info Object ID: 263 - Children: 1
Current Display 3D View 1
5.5
Console
[13:59:35] [LoD][pass 2] Level 6: 7335 cells (+305)
[13:59:35] [LoD][pass 2] Level 7: 30009 cells (+2676)
[13:59:35] [LoD][pass 2] Level 8: 113368 cells (+22107)
[13:59:35] [LoD][pass 2] Level 9: 418567 cells (+159135)
[13:59:35] [LoD] Acceleration structure ready for cloud '11F Office - Cloud' (max level: 10 / mem. = 36.43 Mb / duration: 14.0 s.)


CloudCompare v2.11.3 (Anoia) [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
DB Tree
Floor.obj (D:/Building Polygons/Office)
Floor
Wall.obj (D:/Building Polygons/Office)
Wall
11F Office las (D:/Building Polygons/Of···
11F Office - Cloud
Properties
CSF Filter
5.5
Console
[13:59:35] [LoD][pass 2] Level 6: 7335 cells (+305)
[13:59:35] [LoD][pass 2] Level 7: 30009 cells (+2676)
[13:59:35] [LoD][pass 2] Level 8: 113368 cells (+22107)
[13:59:35] [LoD][pass 2] Level 9: 418567 cells (+159135)
[13:59:35] [LoD] Acceleration structure ready for cloud '11F Office - Cloud' (max level: 10 / mem. = 36.43 Mb / duration: 14.0 s.)


CloudCompare v2.11.3 (Anoia) [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
DB Tree
Floor.obj (D:/Building Polygons/Office)
Floor
Wall.obj (D:/Building Polygons/Office)
Wall
11F Office las (D:/Building Polygons/Of···
11F Office - Cloud
Properties
CSF Filter
5.5
Console
[13:59:35] [LoD][pass 2] Level 6: 7335 cells (+305)
[13:59:35] [LoD][pass 2] Level 7: 30009 cells (+2676)
[13:59:35] [LoD][pass 2] Level 8: 113368 cells (+22107)
[13:59:35] [LoD][pass 2] Level 9: 418567 cells (+159135)
[13:59:35] [LoD] Acceleration structure ready for cloud '11F Office - Cloud' (max level: 10 / mem. = 36.43 Mb / duration: 14.0 s.)


CloudCompare v2.11.3 (Anoia) [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
DB Tree
Floor.obj (D:/Building Polygons/Office)
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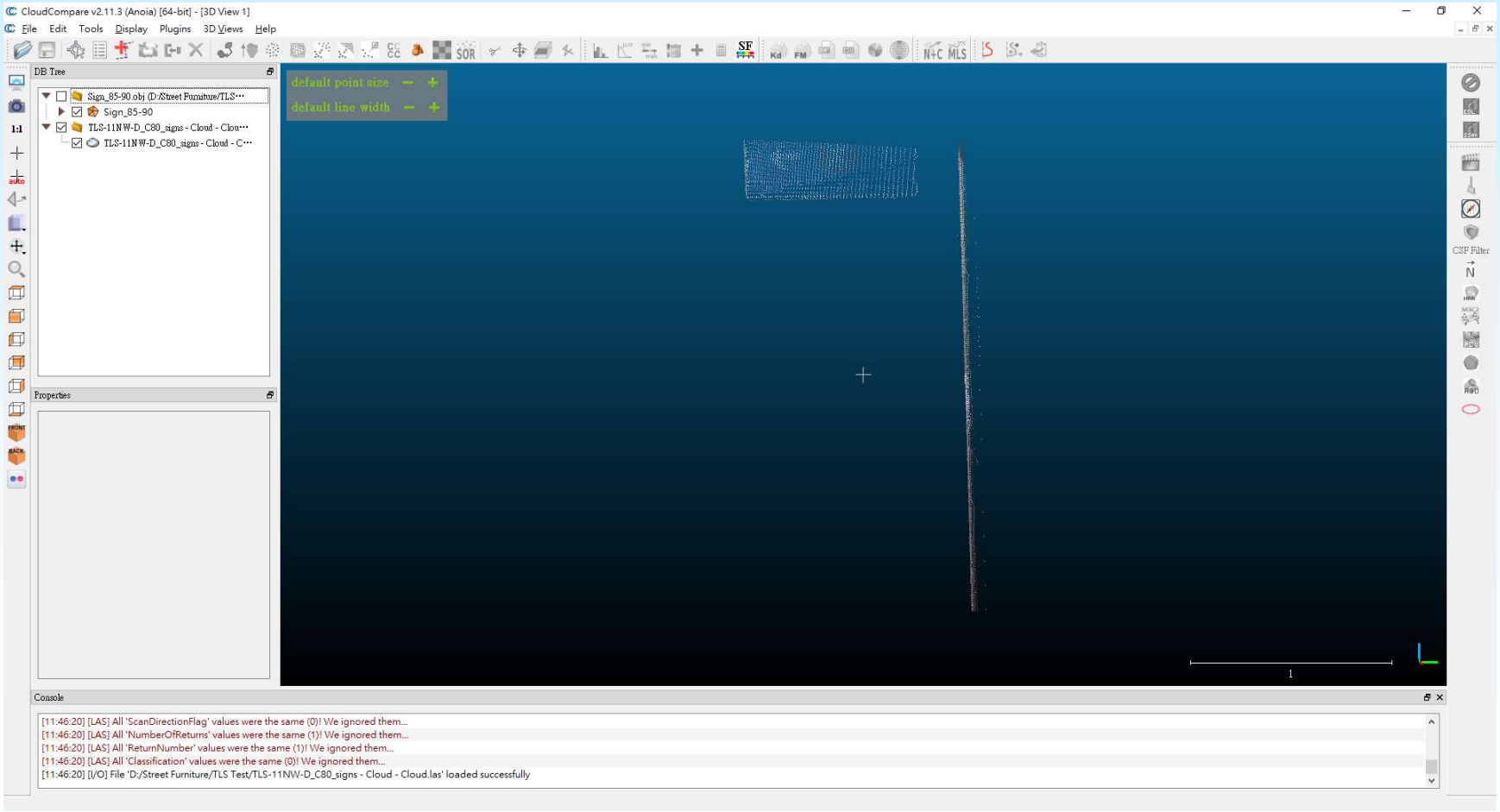
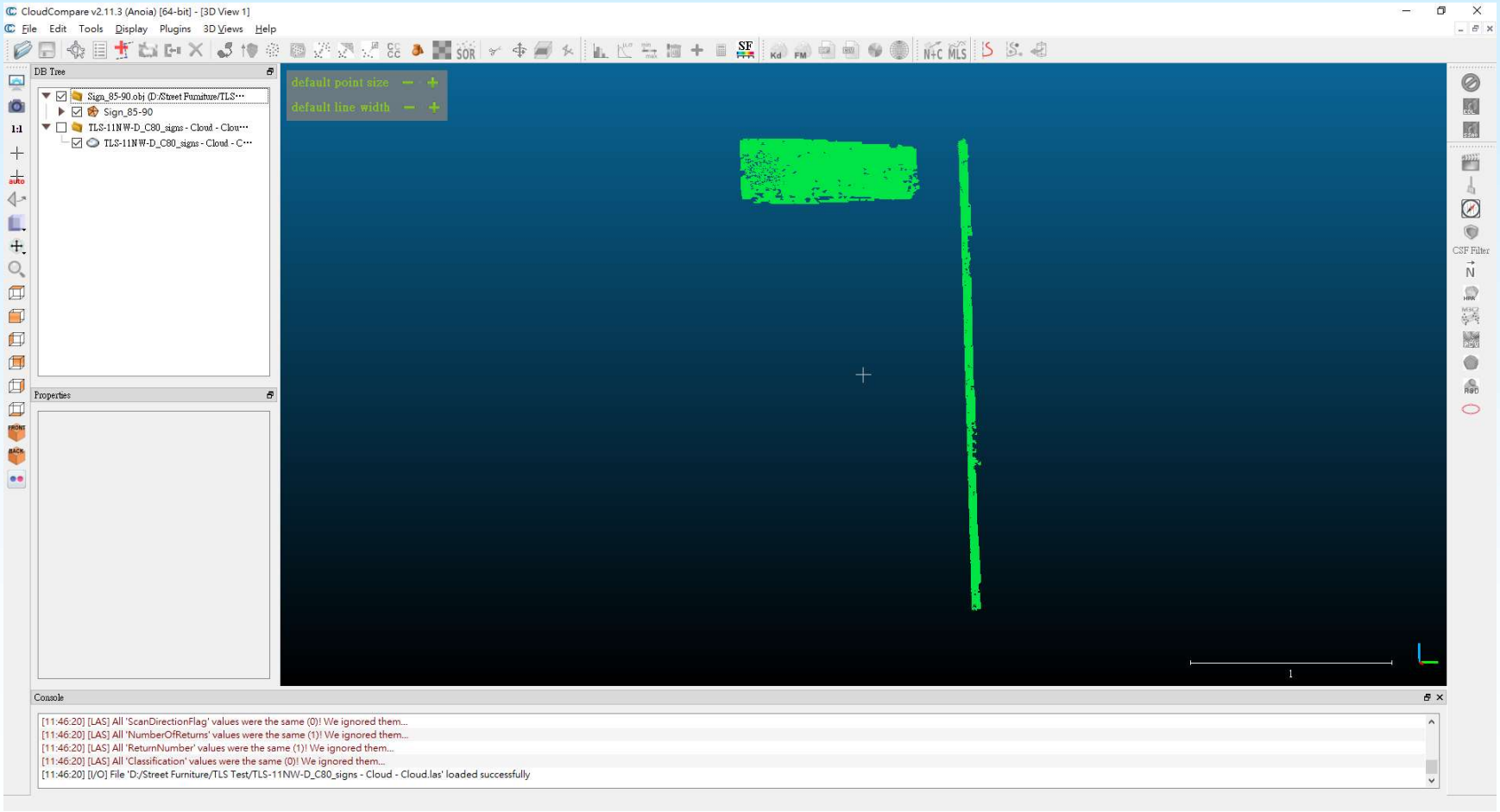
[13:59:35] [LoD] Acceleration structure ready for cloud '11F Office - Cloud' (max level: 10 / mem. = 36.43 Mb / duration: 14.0 s.)

Street Furniture


CloudCompare v2.11.3 (Anoia) [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
DB Tree
Sign_85-90.obj (D:/Street Furniture/TLS···
Sign_85-90
TLS-11NW-D_C80_signs - Cloud - Clou···
TLS-11NW-D_C80_signs - Cloud - C···
Properties
default point size
default line width
CSF Filter
Console
[11:46:20] [LAS] All 'ScanDirectionFlag' values were the same (0)! We ignored them...
[11:46:20] [LAS] All 'NumberOfReturns' values were the same (1)! We ignored them...
[11:46:20] [LAS] All 'ReturnNumber' values were the same (1)! We ignored them...
[11:46:20] [LAS] All 'Classification' values were the same (0)! We ignored them...
[11:46:20] [I/O] File 'D:/Street Furniture/TLS Test/TLS-11NW-D_C80_signs - Cloud - Cloud.las' loaded successfully


CloudCompare v2.11.3 (Anoia) [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
DB Tree
Sign_85-90.obj (D:/Street Furniture/TLS···
Sign_85-90
TLS-11NW-D_C80_signs - Cloud - Clou···
TLS-11NW-D_C80_signs - Cloud - C···
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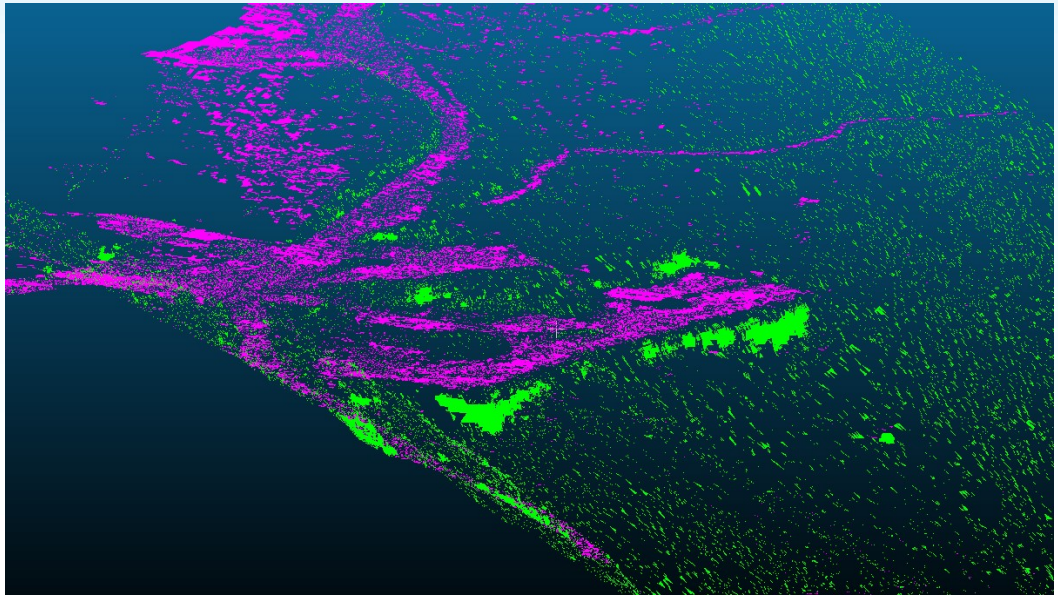
[11:46:20] [I/O] File 'D:/Street Furniture/TLS Test/TLS-11NW-D_C80_signs - Cloud - Cloud.las' loaded successfully

Other Potential Non-Geotechnical Applications

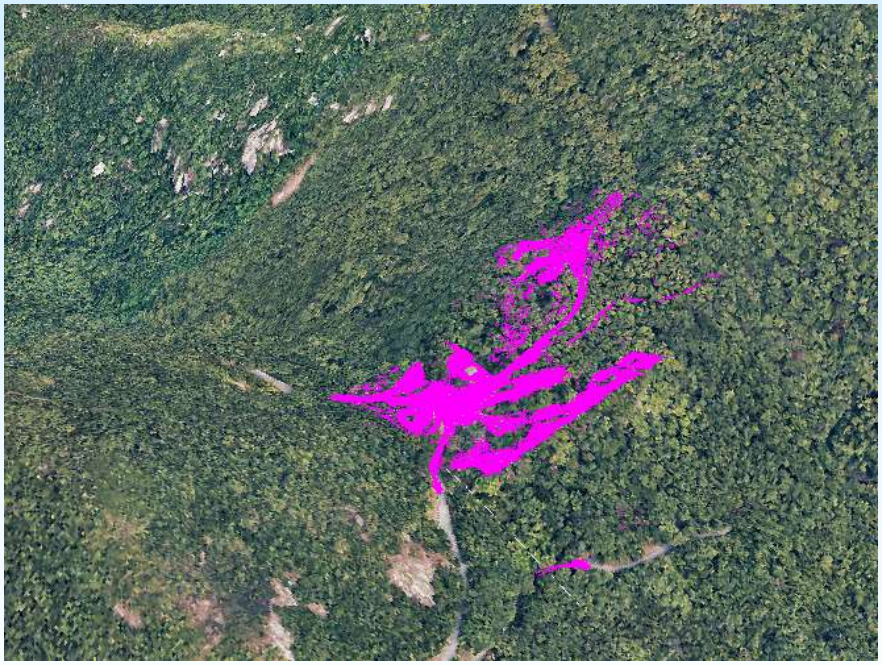
- Products compliance checks – flatness of roofs, verticality of structures such as walls and panels
- Monitoring - tilting of structures
- Quality checks of works and identification of defects – flatness, local anomalies

Historical Sites

Taikoo Sanitarium
(1891 - 1932)



Taikoo Sanitarium Site




潭篤水塘
AM TUK RESERVOIR

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