



CloudCompare

3D ARCH 2017

Daniel Girardeau-Montaut



www.cloudcompare.org



[@CloudCompareGPL](https://twitter.com/CloudCompareGPL)



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3D-ARCH 2017

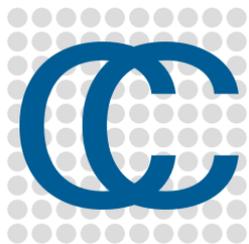
March 1-3, 2017, Nafplio, Greece



Outline

- About the project
- Quick overview of the software capabilities
- Some success stories
- Future

● ● ● The project



2003: PhD for **EDF R&D**



o **EDF**

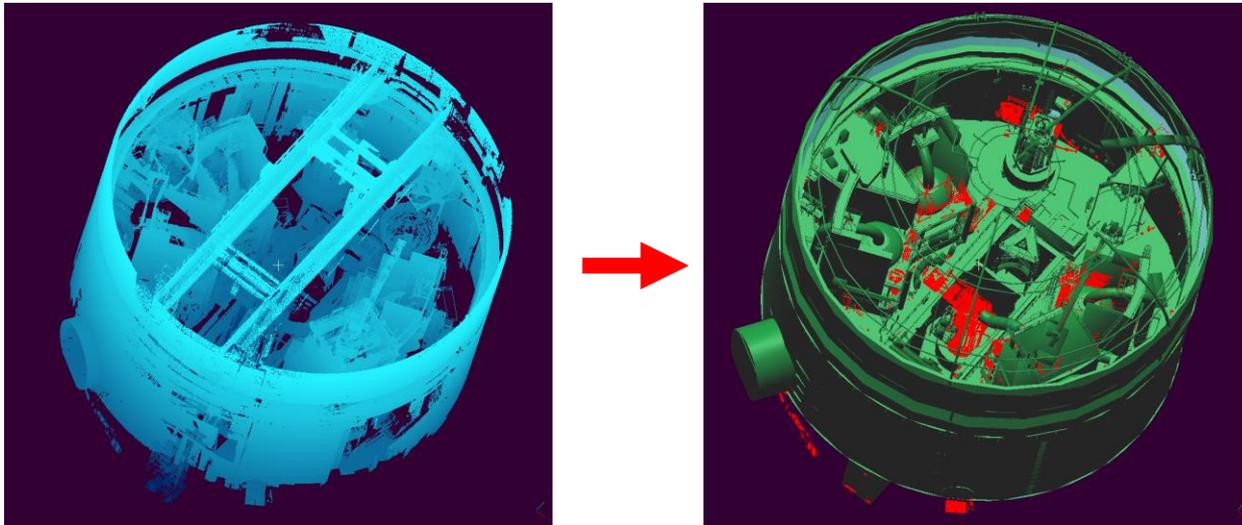
- Main French power utility
- More than 150 000 employees worldwide
2 000 @ R&D (< 2%)
200 know about CloudCompare (< 0.2%)
- Sales >75 B€
- > 200 dams + 58 nuclear reactors (19 plants)





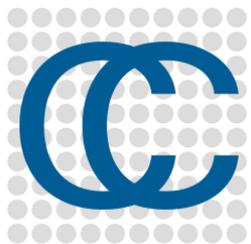
EDF and Laser Scanning

- **EDF** = former owner of **Mensi** (*now Trimble Laser Scanning*)
- Main scanning activity: *as-built* documentation



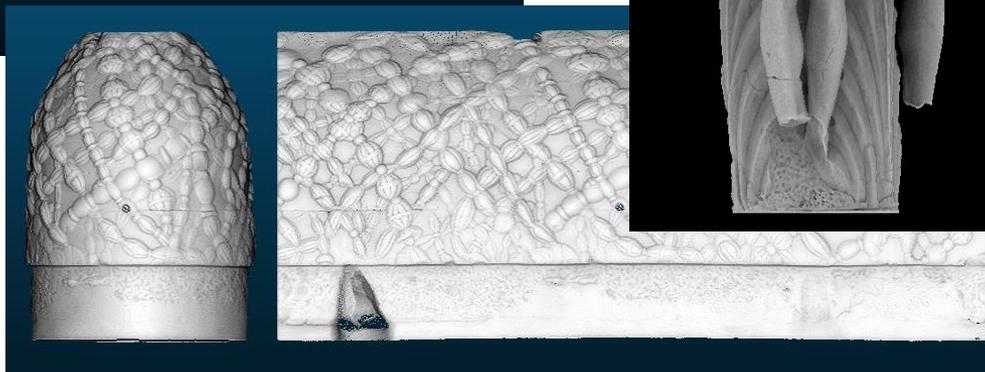
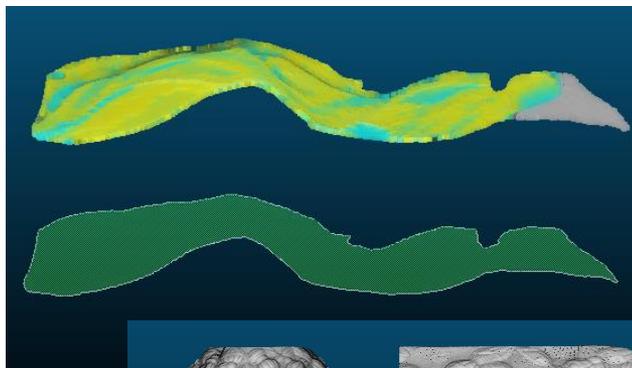
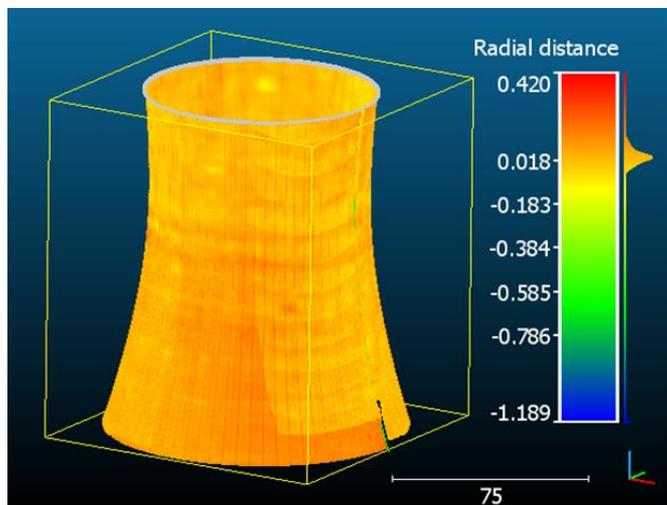
Scanning a single nuclear reactor building

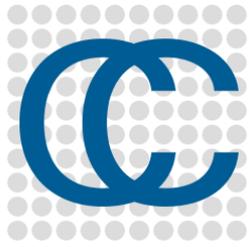
- 2002: 3 days, 50 M. points
- 2014: 1.5 days, **50 Bn** points (+ high res. photos)



EDF and Laser Scanning

- Other scanning activities:
 - Building monitoring (dams, cooling towers, etc.)
 - Landslide monitoring
 - Hydrology
 - Historical preservation (EDF Foundation)

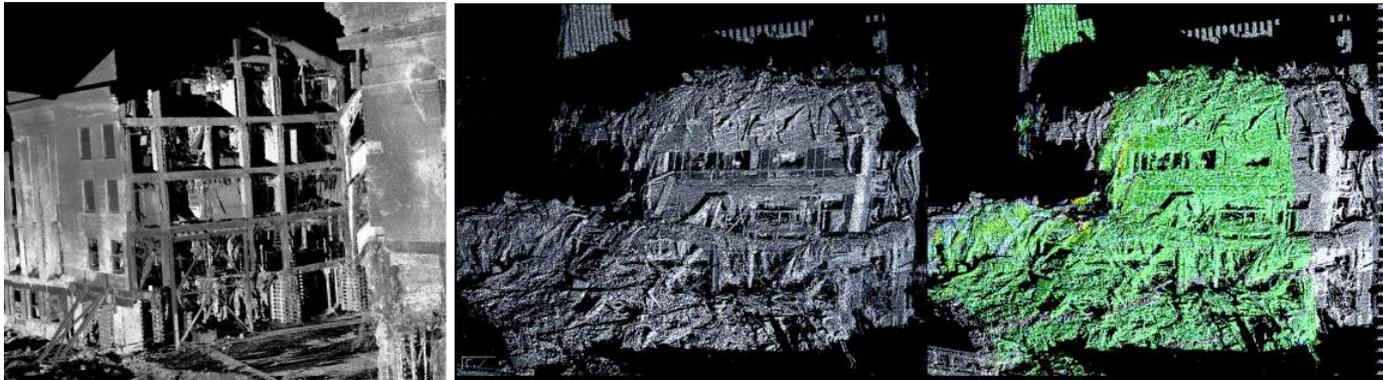




PhD



- *Change detection on 3D geometric data*
 - Application to Emergency Mapping
- Inspired by 9/11 post-attacks recovery efforts
(see “Mapping Ground Zero” by J. Kern, Optech, Nov. 2001)



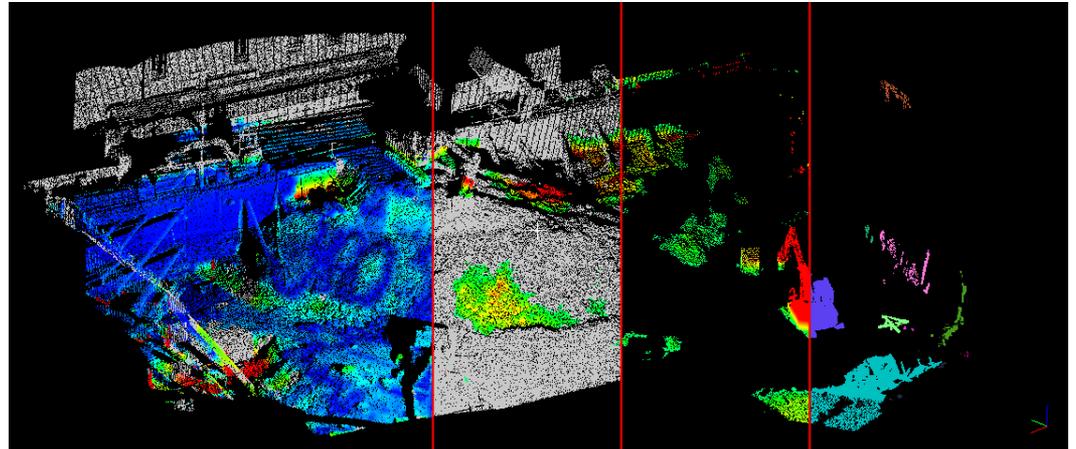
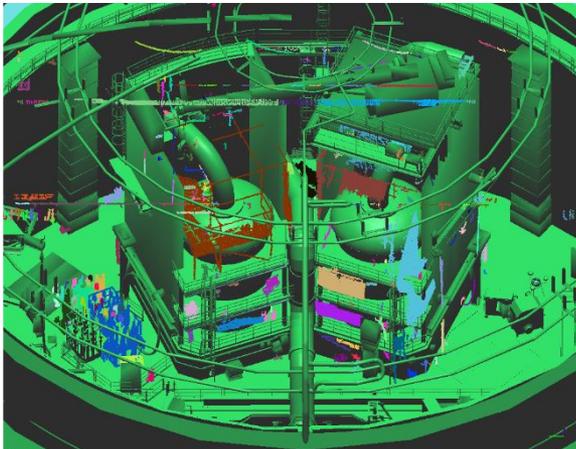
TLS was used for: visualization, optimal crane placement, measurements, monitoring the subsidence of the wreckage pile, slurry wall monitoring, etc.



CloudCompare V1



- 2004-2006
- Aim: quickly detecting changes by comparing TLS point clouds...
 - with a CAD mesh
 - or with another (high density) cloud

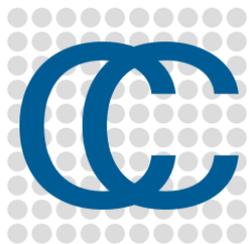




CloudCompare V2

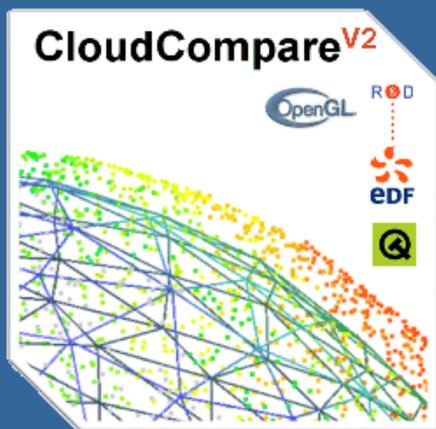
- 2007: “Industrialization” of CloudCompare
... for internal use only!
- Rationale:
 - *idle reactor = 6 M€ / day*
 - acquired data can be checked on-site → less missing or erroneous data → no need to come back later
 - checking the work of sub-contractors in charge of modeling became fast and accurate
 - the algorithms are also used for clash detection during virtual simulation of tricky maintenance operations → highly reduces the risk of issues or *bad surprises* during the actual maintenance operation

+ *EDF is not a software company*



The *open-source* path

- 2009/2010: CloudCompare **V2.1**
 - Already a multi-purpose point cloud editing and processing software
- 2017: CloudCompare **V2.8**



Runs on:

Windows (XP / 7 / 8 / 10)

Mac OS (*Andy Maloney*)

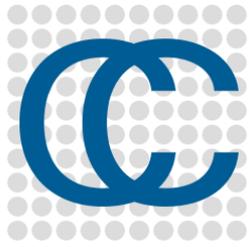
Linux (*Romain Janvier*)

Support for 3D mouse and NVidia Stereo glasses
(*Windows only*)



Open Source!

- Evolves quickly...
- ... in the direction users want (*faster if users actively participate to the developments* 😊)
- Remains under close supervision of its administrator
- Manufacturer independent
- Supported by various companies and public institutions (EDF, BRGM, CNRS, etc.)



Open Source!

- o Free...



- o ...however, someone still needs to pay ;)
 - either by developing new functionalities
 - or by paying someone else to do it
- o Plugins are not necessarily open source or free



Users

- Too many ;)
 - Academics:
 - remote sensing
 - geology
 - archeology
 - etc.
 - Surveyors
 - Forensic experts
 - Architects
 - MDs, dentists
 - 3D designers
 - Artist?!

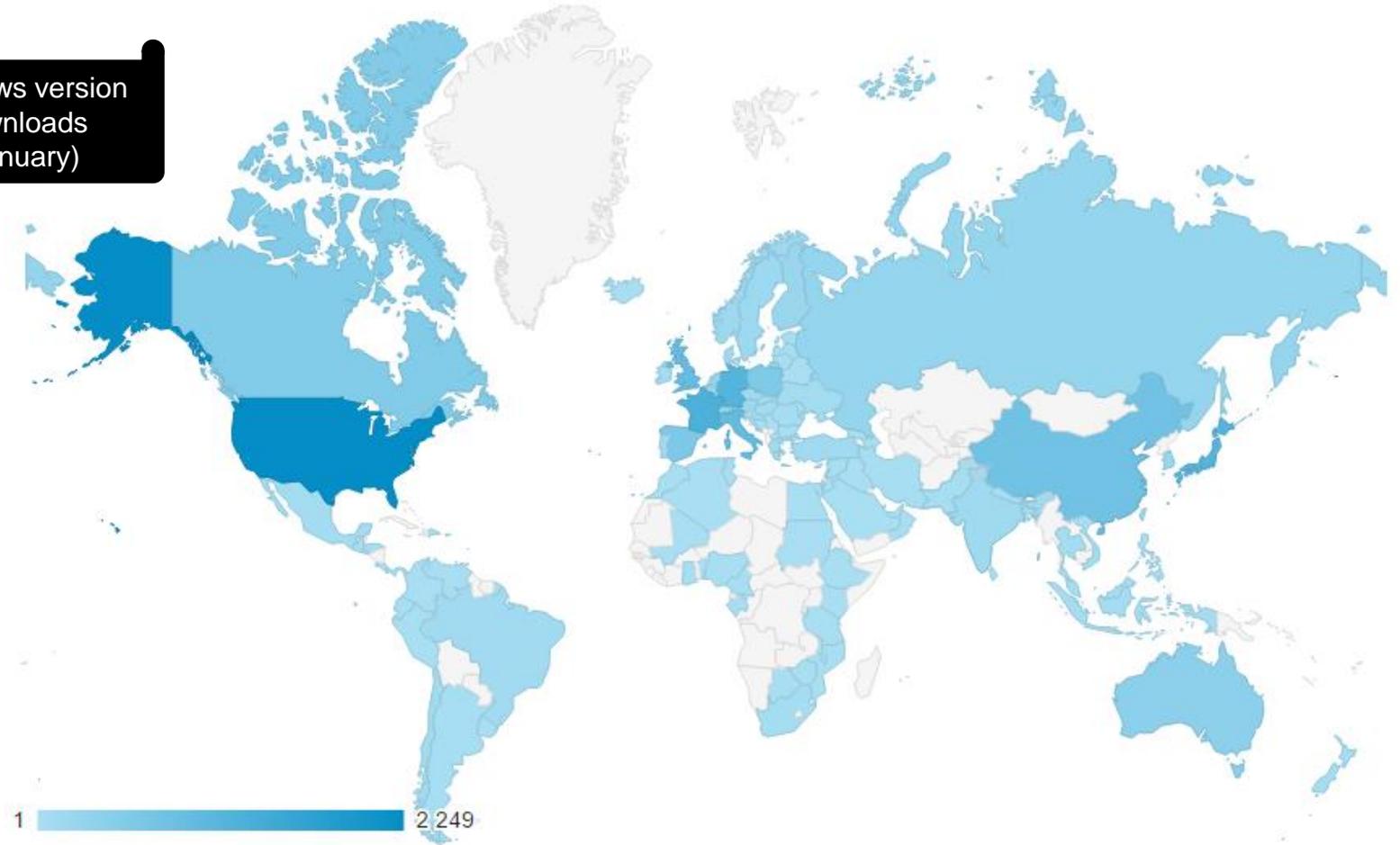
Developers

- Barely enough
 - a few PhD students and research engineers
 - none
 - 1
 - none
 - none
 - none
 - none
 - none



Worldwide

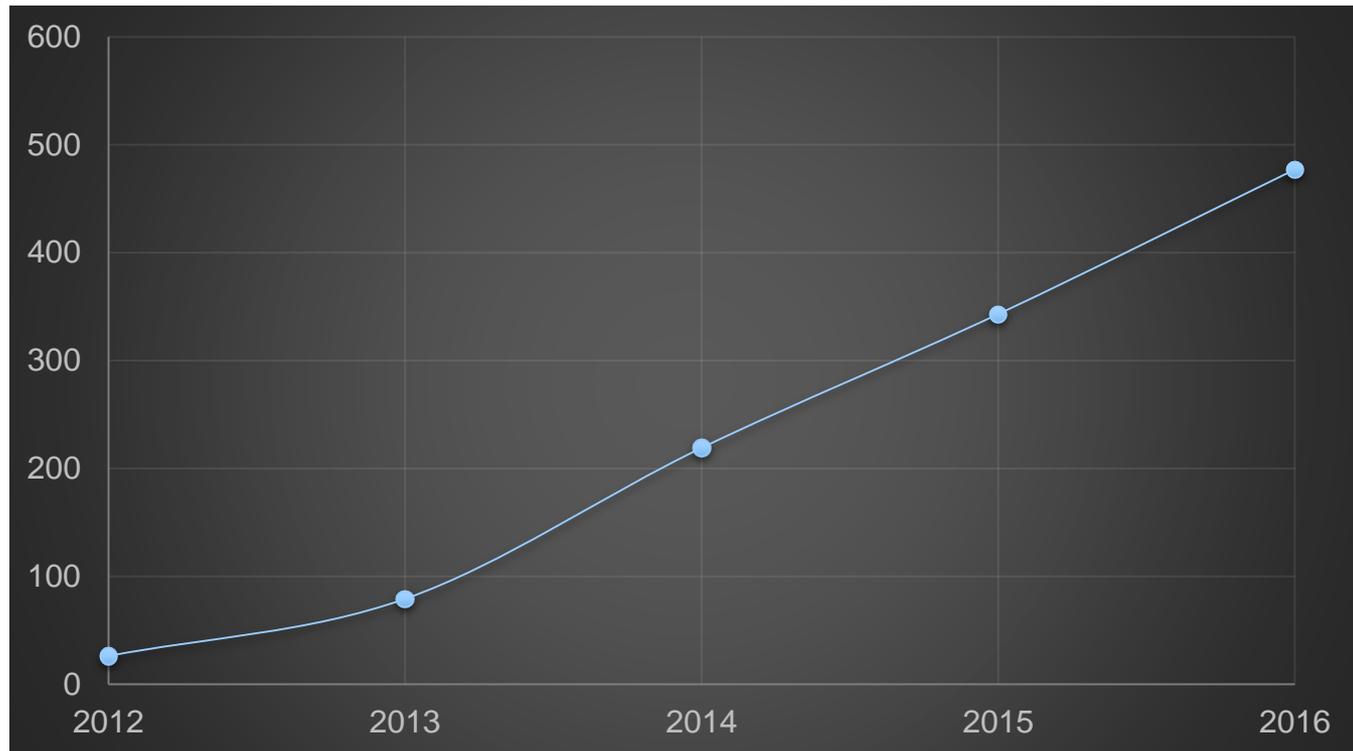
Windows version
downloads
(January)



> 2400 users registered to the newsletter



Citations in scientific articles



source: Google scholar

● ● ● Quick overview



Interface

CloudCompare v2.9.alpha [64-bit] - [3D View 1]

File Edit Tools Display Plugins 3D Views Help

Remove filter Blur (shader) [GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

DB Tree

- [-] Polytech_Tour_exterieur - Cloud.remaining
 - [x] Octree
 - [x] 2D label: Vector #406822 - #426786
- [+] Polytech_Tour_exterieur - Cloud.segmented
 - [x] Dip: 000 deg. - Dip direction: 025 deg.
 - [x] vertices
 - [x] Compressed normals
 - [x] Octree
 - [x] 2D label: Point #50853
 - [x] 2D label: Point #1736
 - [x] 2D area label: arcade

Properties

Property	State/Value
Scalar Fields	
Count	2
Active	Distances (m.)
Color Scale	
Current	Blue>Green>Yellow>Red
Steps	256
Visible	<input checked="" type="checkbox"/>
SF display params	
Display ranges	Parameters
	-0.10656691 displayed 0.10399435
	0.00000000 abs. sat. 0.05000000

Distances (m.) = 0.03

X	8572.85	R	170
Y	8473.87	G	158
Z	77.46	B	123

Distances (m.) = 0.02

X	8551.90	R	153
Y	8473.33	G	153
Z	77.49	B	153

Distances (m.) = 22.20

ΔX	-14.27	ΔXY	22.20
ΔY	17.01	ΔXZ	14.27
ΔZ	0.03	ΔZY	17.01

Distances (m.)

Console

```
[18:33:14] [Picked] - P#1736: (8572.85;8473.87;77.46)
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[18:33:14] [Picked] - C2M signed distances = 0.03
[18:34:29] [I/O] File 'E:/These/Donnees/3DArch2017/chambord.bin' saved successfully
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[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

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Distances (m.)

0.11
0.09
0.08
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.07
-0.08
-0.11

Console

```
[18:33:14] [Picked] - P#1736: (8572.85;8473.87;77.46)
[18:33:14] [Picked] - Color: (170;158;123)
[18:33:14] [Picked] - C2M signed distances = 0.03
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One or several 3D views



Interface

DB Tree

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- ▼ Polytech_Tour_exterieur - Cloud.segmented
 - ☑ Dip: 000 deg. - Dip direction: 025 deg.
 - ☐ vertices
 - ☑ Compressed normals
 - ☐ Octree
 - ☑ 2D label: Point #50853
 - ☑ 2D label: Point #1736
 - ☑ 2D area label: arcade

Properties

Data-base

Property

Scalar Fields

Count: 2

Active: Distances (m.)

Color Scale

Current: Blue>Green>Yellow>Red

Steps: 256

Visible:

SF display params

Display ranges: Parameters

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0.00000000 abs. sat. 0.05000000

Distance: 22.20

ΔX	-14.27	ΔXY	22.20
ΔY	17.01	ΔXZ	14.27
ΔZ	0.03	ΔZY	17.01

Distances (m.) = 0.03

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0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.10
-0.11

Console

```
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Interface

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Distances (m.)

Distance: 22.20
ΔX -14.27 ΔXY 22.20
ΔY 17.01 ΔXZ 14.27
ΔZ 0.03 ΔZY 17.01

Distances (m.) = 0.02

X 8551.90 R 153
Y 8473.33 G 153
Z 77.49 B 153

Distances (m.) = 0.03

X 8572.85 R 170
Y 8473.87 G 158
Z 77.46 B 123

Console

```
[18:33:14] [Picked] ... (46)  
[18:33:14] [Picked] ... (176, 135, 124)  
[18:33:14] [Picked] ... (2M) ... distances = 0.0  
... these ... Arch ... bin' saved successfully
```

Properties (colors,
normals, S.F., etc)



Interface

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Remove filter Blur (shader) ... N+C ... Kd FM ... SF

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 - 2D label: Point #50853
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Active	Distances (m.)
Color Scale	Blue>Green>Yellow>Red
Current	256
Steps	256
Visible	<input checked="" type="checkbox"/>

SF display params

Display ranges Parameters

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0.05
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0.02
0.01
-0.01
-0.04
-0.07
-0.08
-0.11

Console

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[18:33:14] [Picked] - Color: (170;158;123)
[18:33:14] [Picked] - C2M signed distances = 0.03
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```

Lots of icons tools and plugins



Interface

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 - vertices
 - ✓ Compressed normals
 - Octree
 - ✓ 2D label: Point #50853
 - ✓ 2D label: Point #1736
 - ✓ 2D area label: arcade

Properties

Property	State/Value
Scalar Fields	
Count	2
Active	Distances (m.)
Color Scale	
Current	Blue>Green>Yellow>Red
Steps	256
Visible	✓
SF display params	
Display ranges	Parameters
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0.00000000	abs. sat. 0.05000000

Distance: 22.20

ΔX	-14.27	ΔXY	22.20
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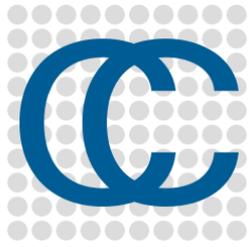
Distances (m.)

0.11
0.09
0.08
0.06
0.05
0.04
0.03
0.02
0.01
-0.01
-0.02
-0.03
-0.04
-0.05
-0.07
-0.08
-0.11

A antiquated good old console

Console

```
[18:33:14] [Picked] - P#1736: (8572.85;8473.87;77.46)
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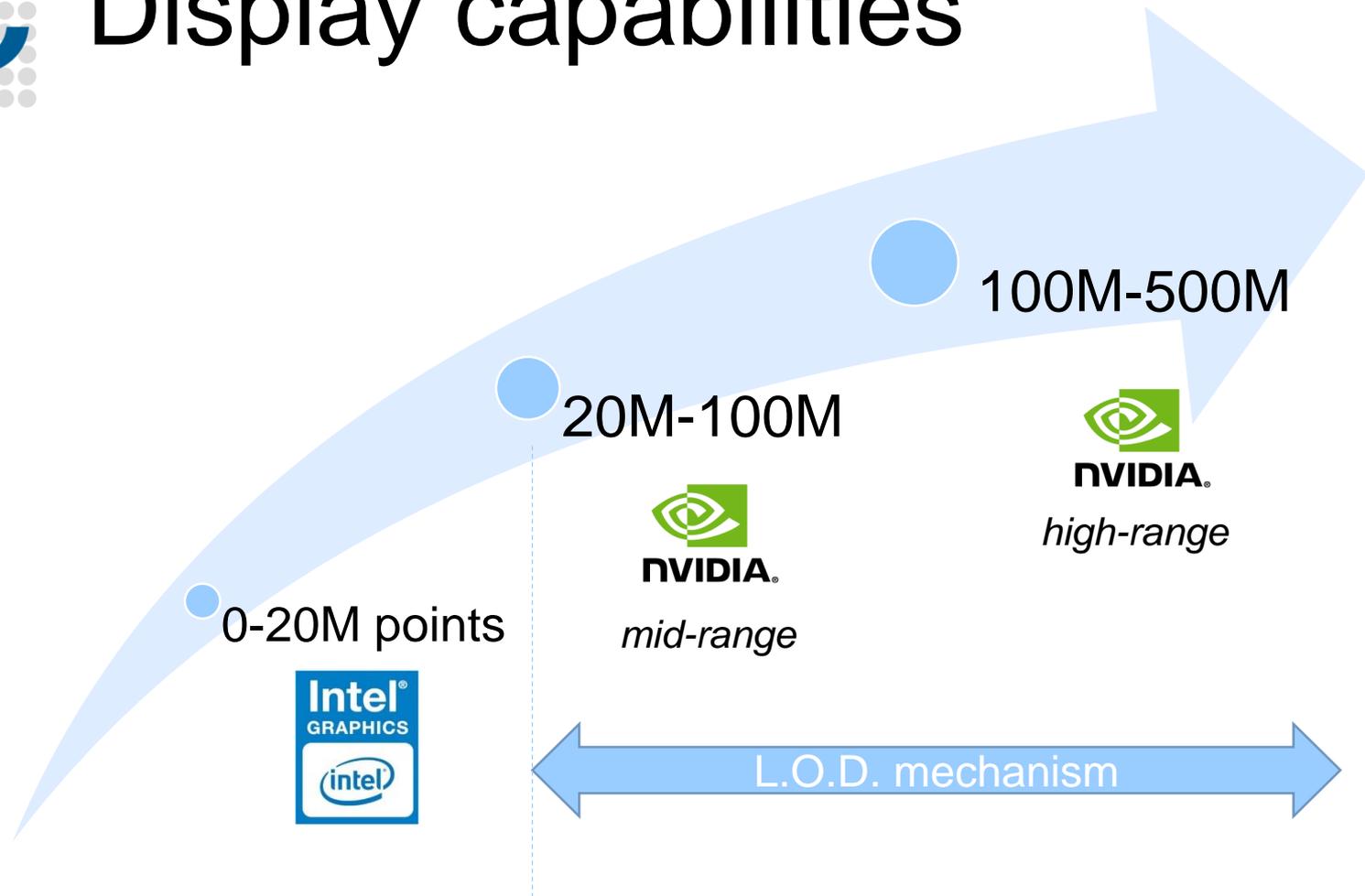
Inputs / outputs

- point clouds 
 - ASCII, PLY, LAS, E57, PTX, PCD... + Faro, Riegl, DotProduct
- triangular meshes 
 - OBJ, PLY, STL, OFF, FBX
- polylines 
 - SHP, DXF, etc.
- rasters 
 - geotiff, etc. (*thanks to GDAL*)
- calibrated pictures 
 - Bunder OUT, Photoscan PSZ (+ *PSX to come*)
- sensors
 - TLS  or projective cameras 

+ dedicated format: **BIN** (for projects)



Display capabilities



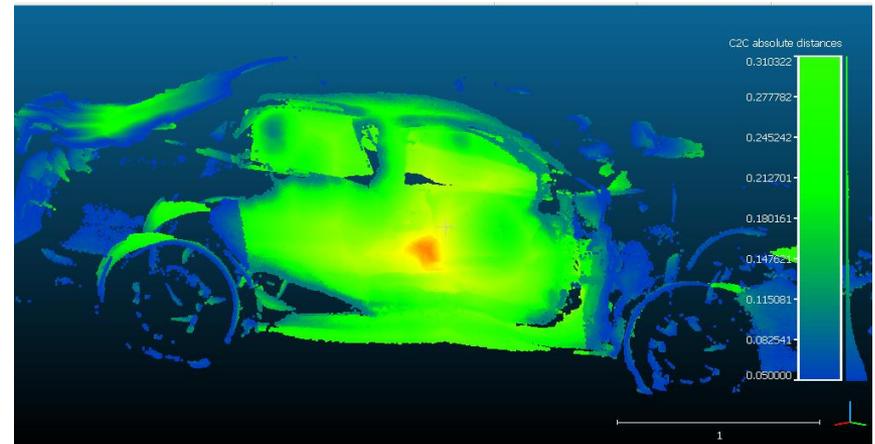
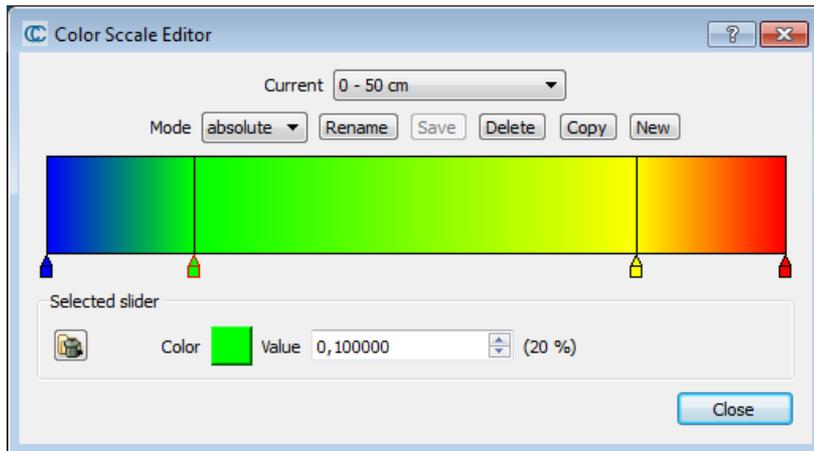
> 500 M. points?

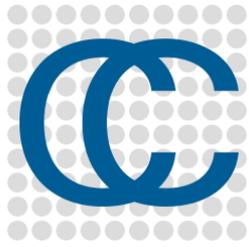
- for now, use the command line mode ;)
- later: *out-of-core* support



Scalar fields

- One value per point
- The value can be anything (distance, intensity, density, roughness, confidence, curvature, temperature, time, etc.)
- Values can be (dynamically) color-coded





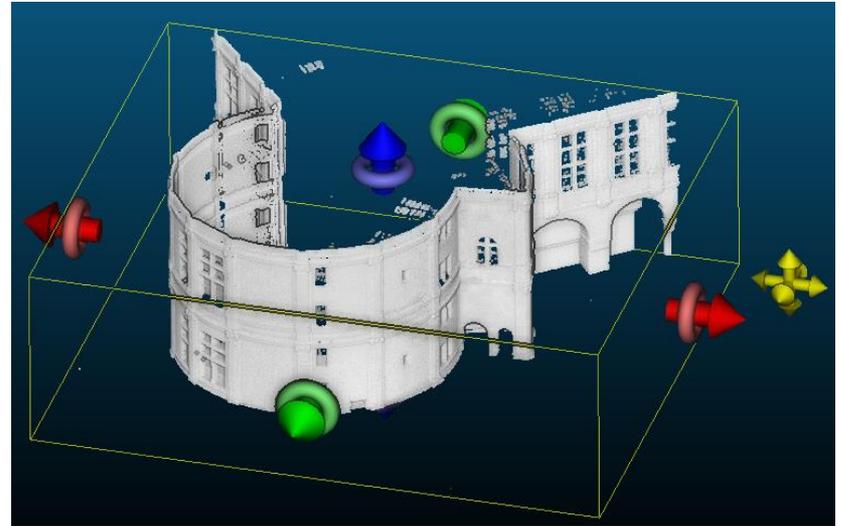
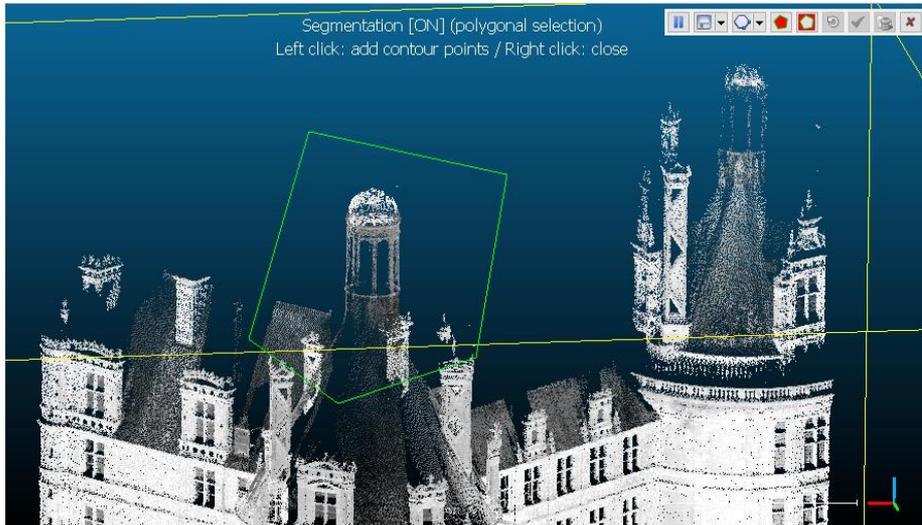
Scalar fields

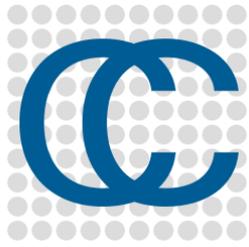
- Values can be
 - mixed (+,-,/,x)
 - transformed (cos, log, etc.)
 - filtered (spatial smoothing, spatial gradient, etc.)
 - imported or exported as a coordinate dimension
 - merged with colors
- Statistics can be computed
- Clouds can be processed based on those values
 - Segmentation (*Filter by value*)
 - Subsampling



Main features

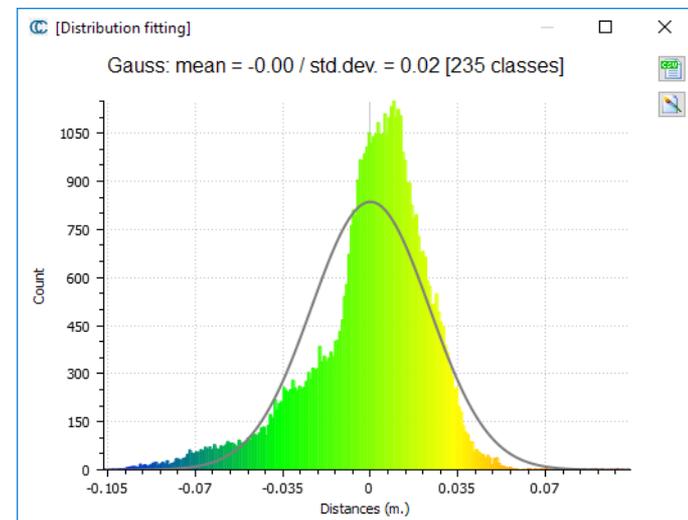
- Interactive tools
 - transformation, segmentation, cross section
- Colors
 - create, convert, level, etc.
- Normals
 - create, convert, orient

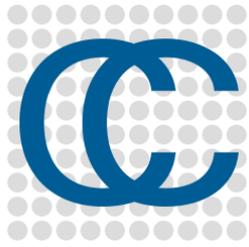




Main features

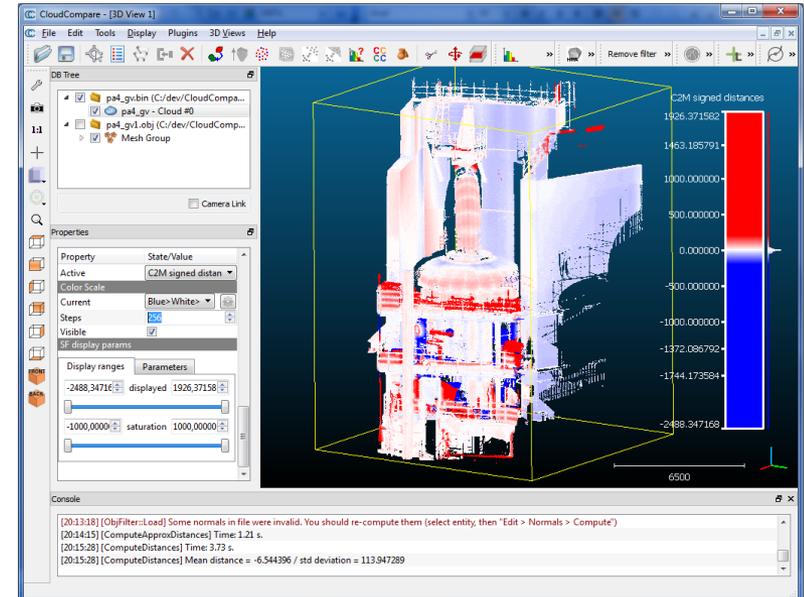
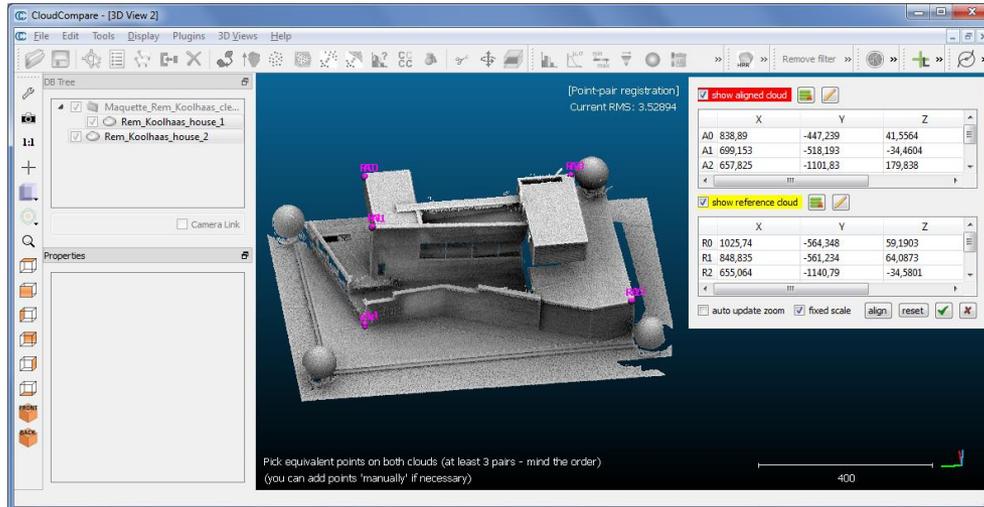
- Mesh operations
 - create (2.5D Delaunay), sample points, smooth, etc.
 - → see *Meshlab* for more
- Scalar fields operations
 - filter points by value, convert, smooth, gradient, etc.
- Point picking,
Distance / angle measurements
- Others
 - Subsample, merge, scale, etc.





Main tools

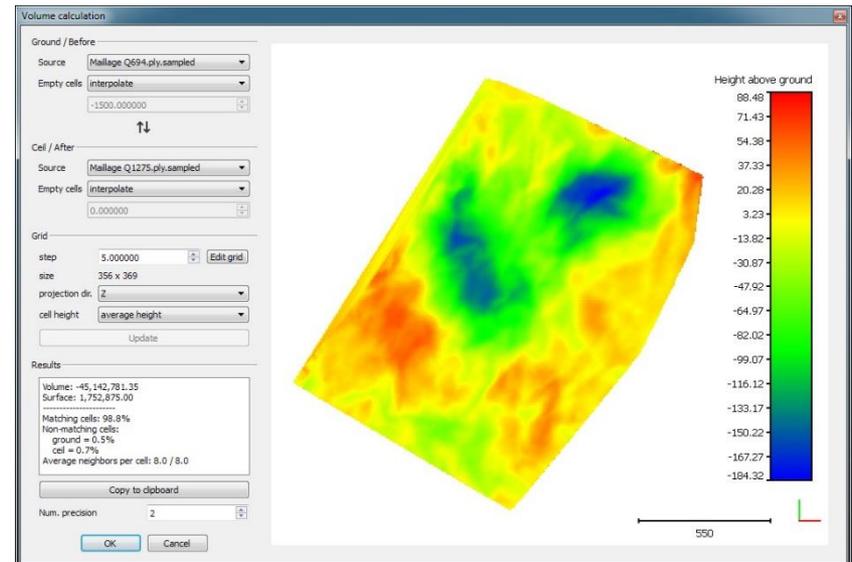
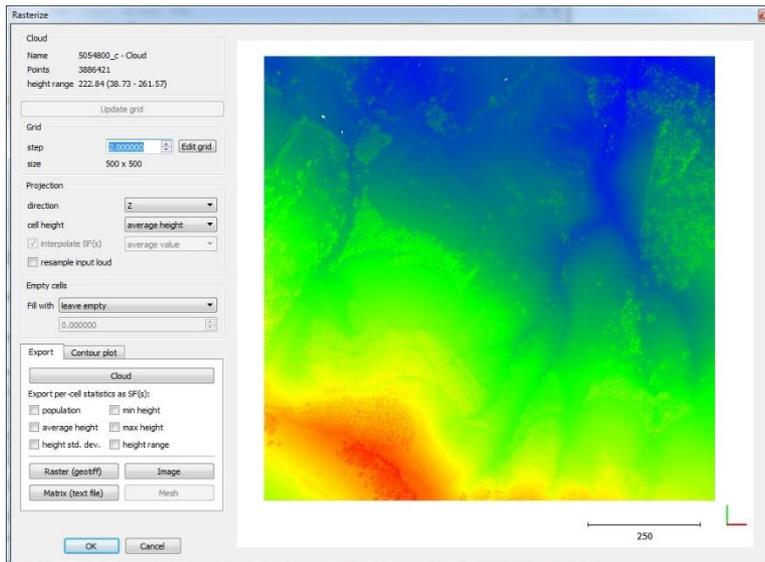
- Registration
 - point-pair-based alignment, ICP
- Distances
 - Cloud-to-cloud (C2C), Cloud-to-mesh (C2M), M3C2 (plugin)





Main tools

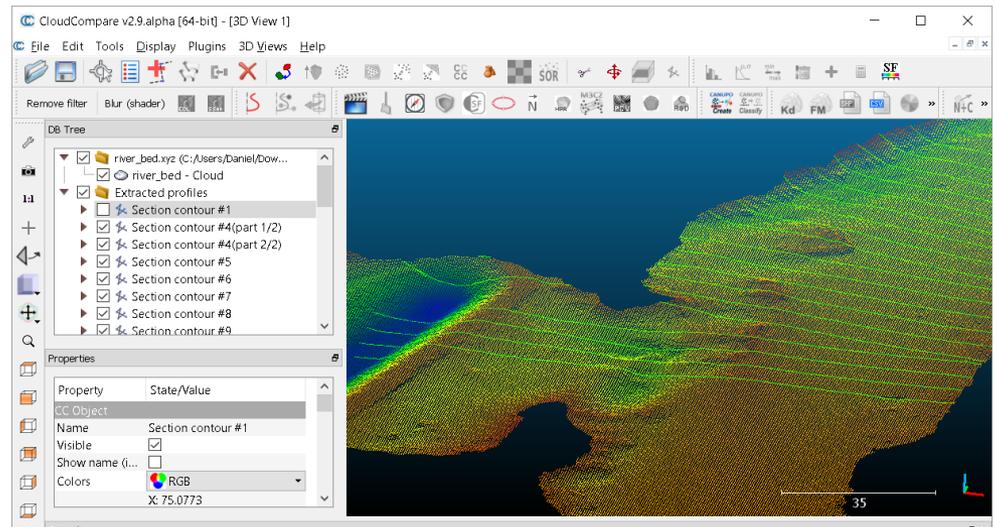
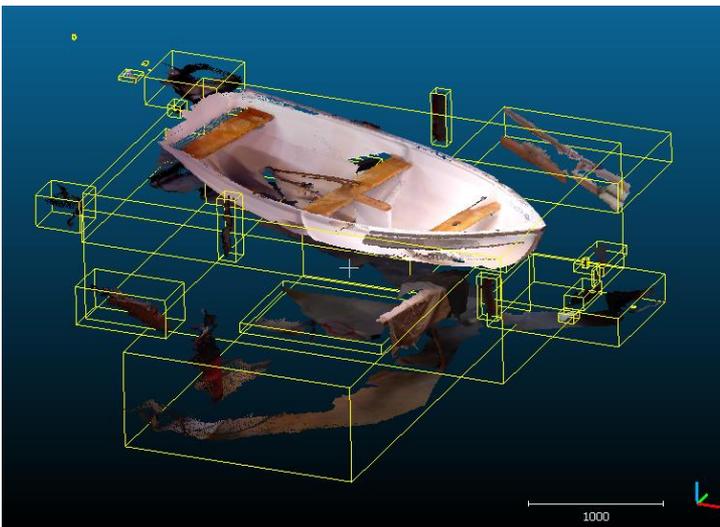
- Cleaning
 - SOR, etc.
- Rasterize
 - + contour plot
- 2.5D volume estimation





Main tools

- Segmentation
 - connected components, profile extraction, etc.
- Fitting
 - plane, sphere, quadric
- Other
 - density, curvature, roughness, etc.

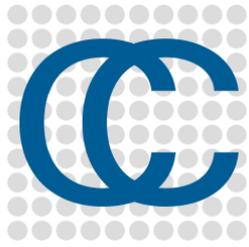




Plugins

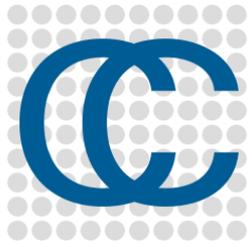
- Robust + signed C2C distances (M3C2)
- Classification (CANUPO)
- Automatic shape detection (RANSAC S.D.)
- Global illumination of clouds and meshes (PCV)
- 3D surface reconstruction (PoissonRecon)
- Animation rendering (Animation)
- Surface of Revolution Analysis (SRA)
- Planar surfaces cleaning (Virtual Broom)
- Geological facet extraction (Facets)
- Hidden Points Removal
- etc.



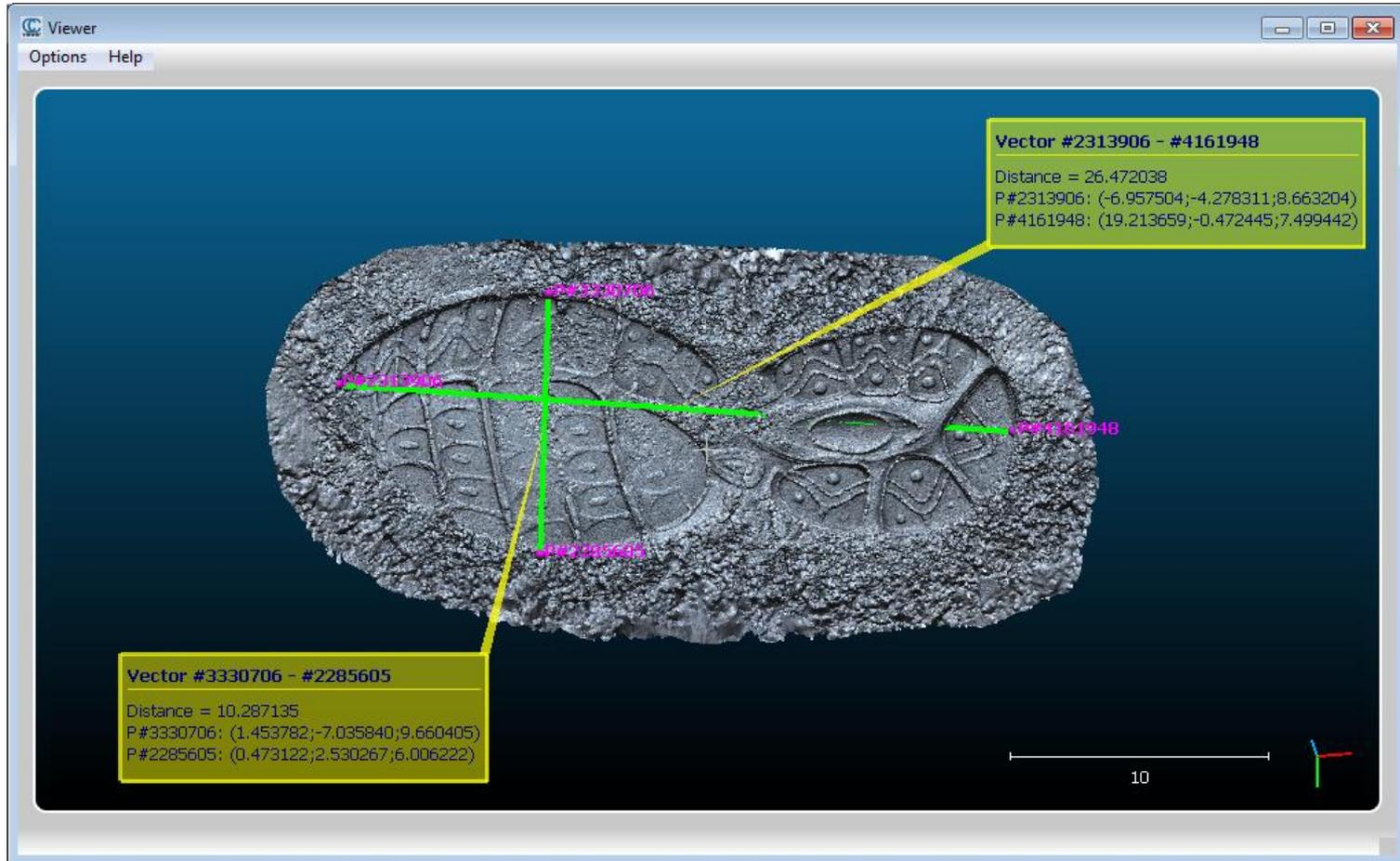


Creating your own plugin...

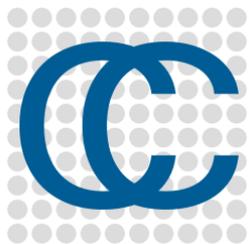
- ... is easy:
 - copy the 'dummy' plugin folder
 - replace the word 'dummy' in all files by your plugin name
 - and add the code for your plugin 'action' at the right place
- Plenty of examples
 - simply mimic another plugin that has the same workflow
- Ask questions on the forum (*or send me an email*)
- **Development in C++**



ccViewer

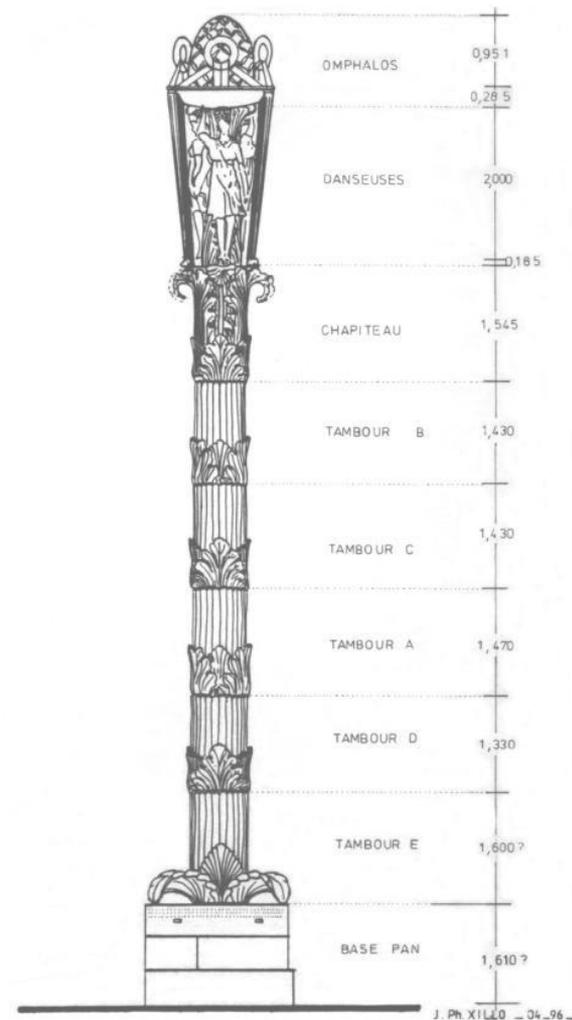


● ● ● Success stories



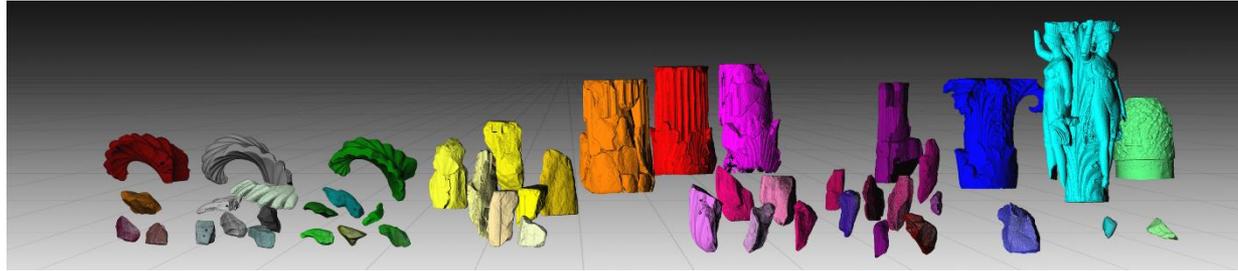
The Dancers column of Delphi

- Virtual reconstruction of the column
 - More than 260 marble fragments
 - More than 14 m. high

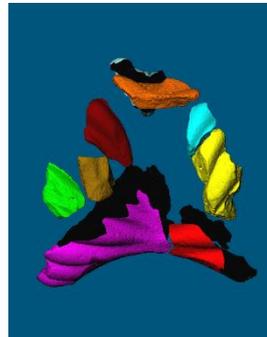
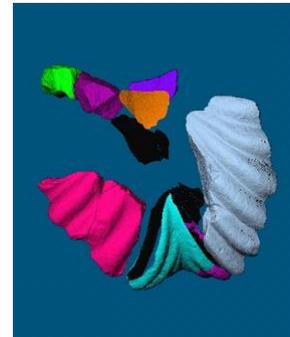
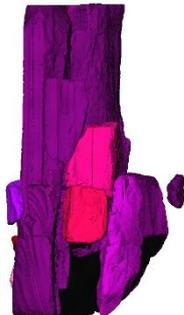


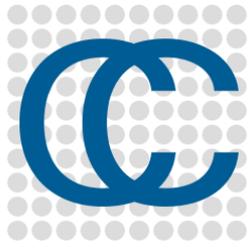


The Dancers column of Delphi



- acquisition: > 1 week, 2200 scans, 600 M. points (in 2004)
- cleaning + segmentation (*removal of plaster parts*) → 220 M. points remaining
- 600h of intensive 2D/3D virtual “puzzling”
- lots of discussion + specific tools development (3 labs)





The Dancers column of Delphi

- CloudCompare part:
 - unrolling
 - mesh quality assessment
 - global illumination of clouds (Shadevis / “PCV”)
 - visualization



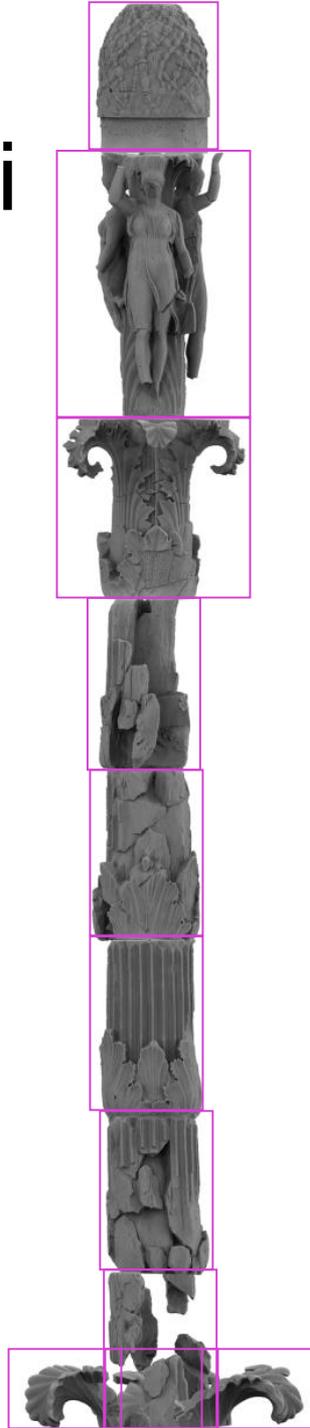
mesh (*normals*)



mesh (*PCV*)



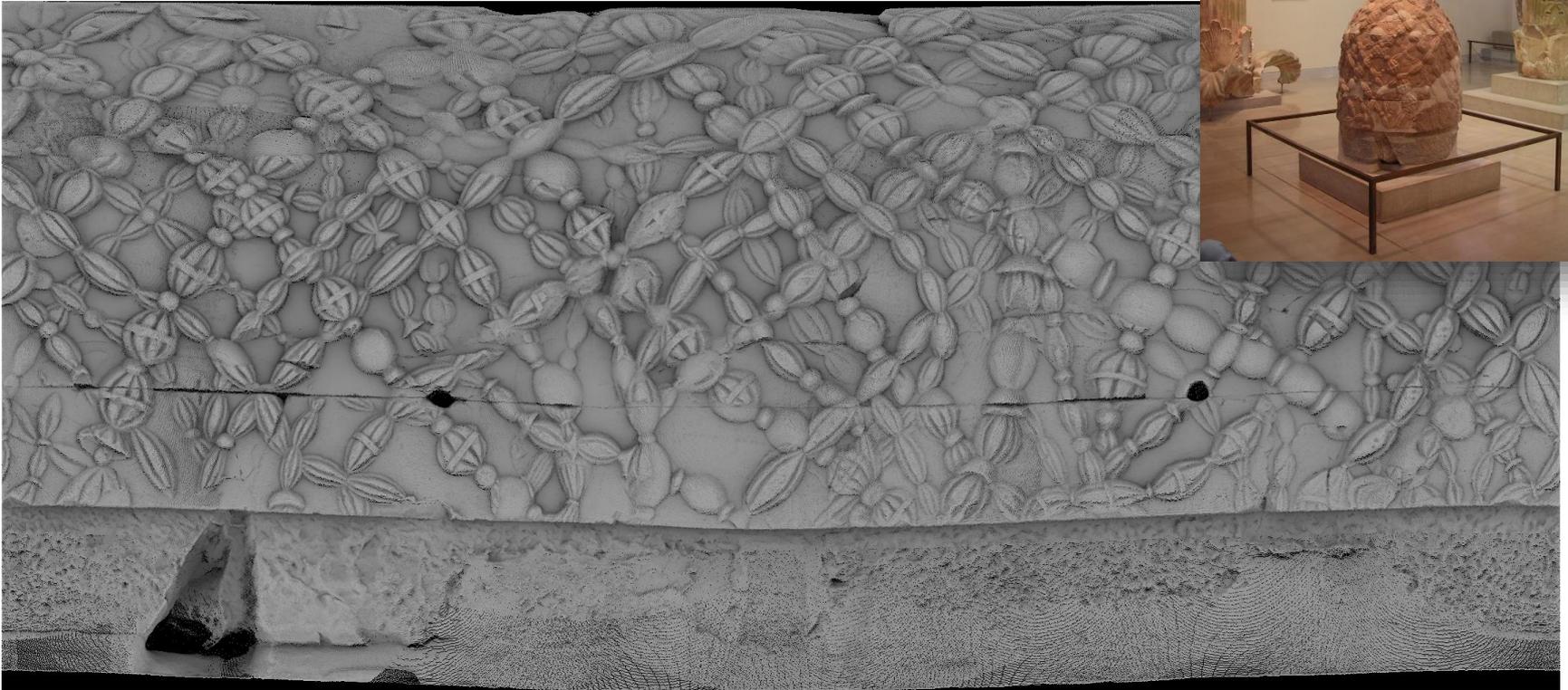
photograph





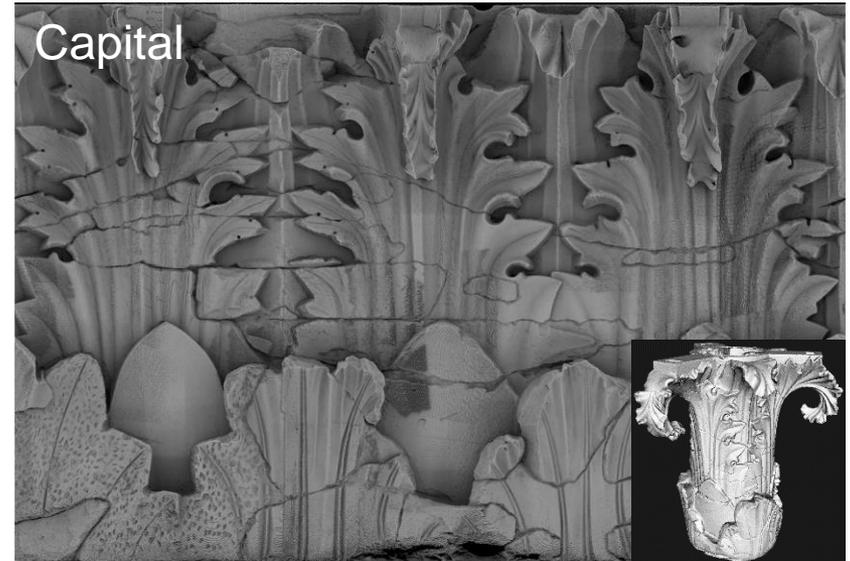
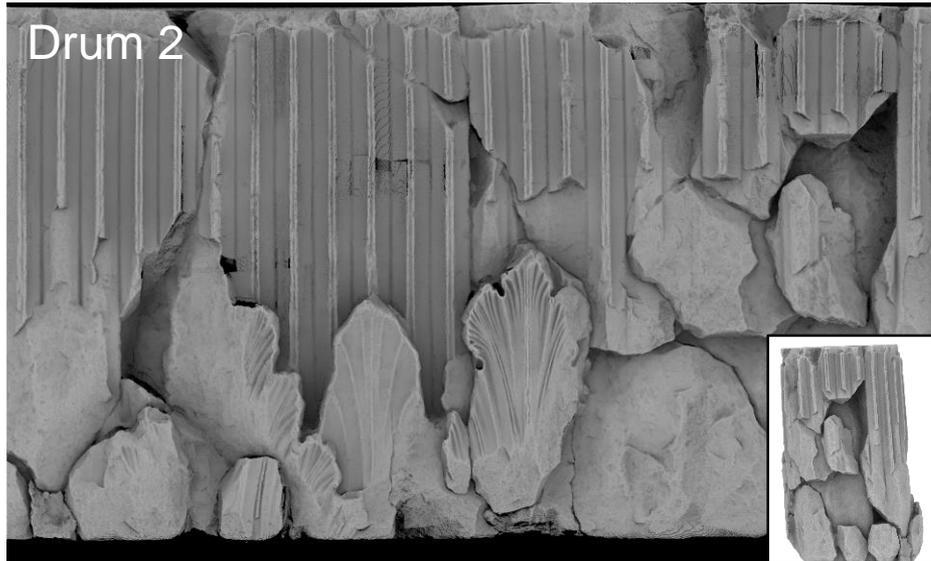
The Dancers column of Delphi

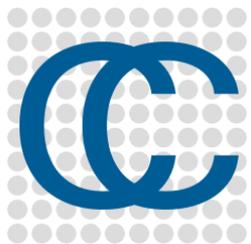
- Unrolling (Omphalos)



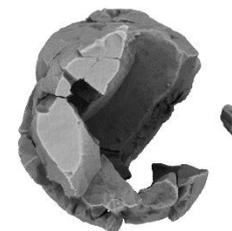
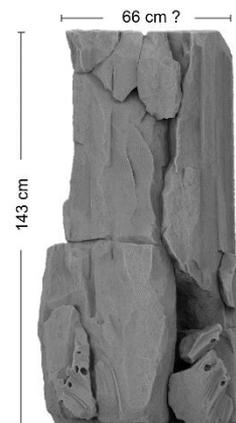


The Dancers column of Delphi





The Dancers column of Delphi





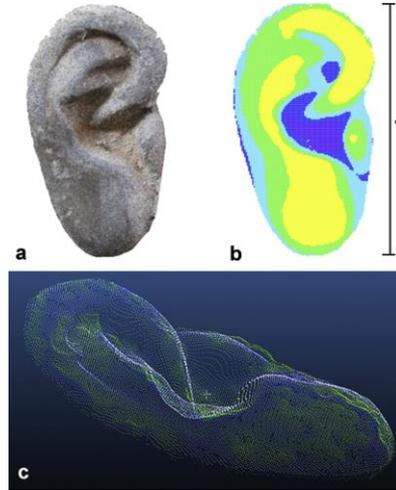
Classification of China's terracotta warriors ears (1)



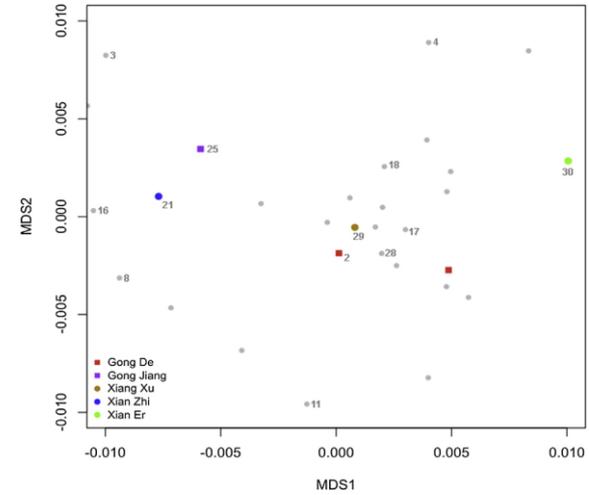
Photogrammetry



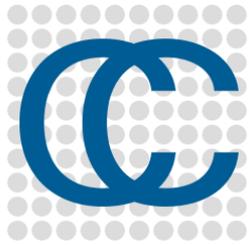
Segmentation



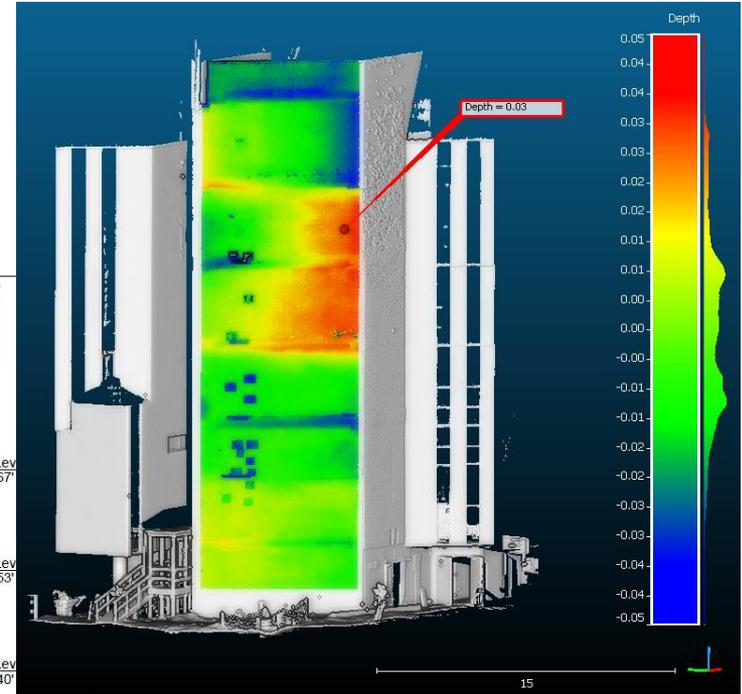
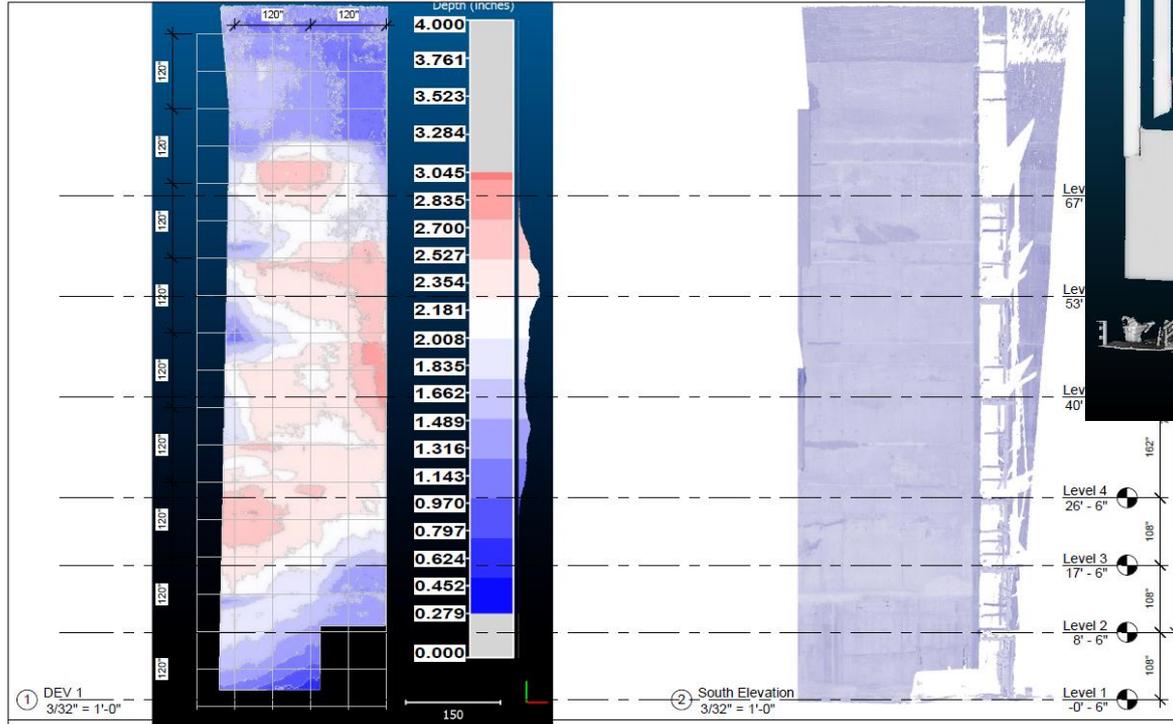
Pair-wise
comparison



Classification



Analysis of construction work for a court case



FIU Stair 3
Deviation

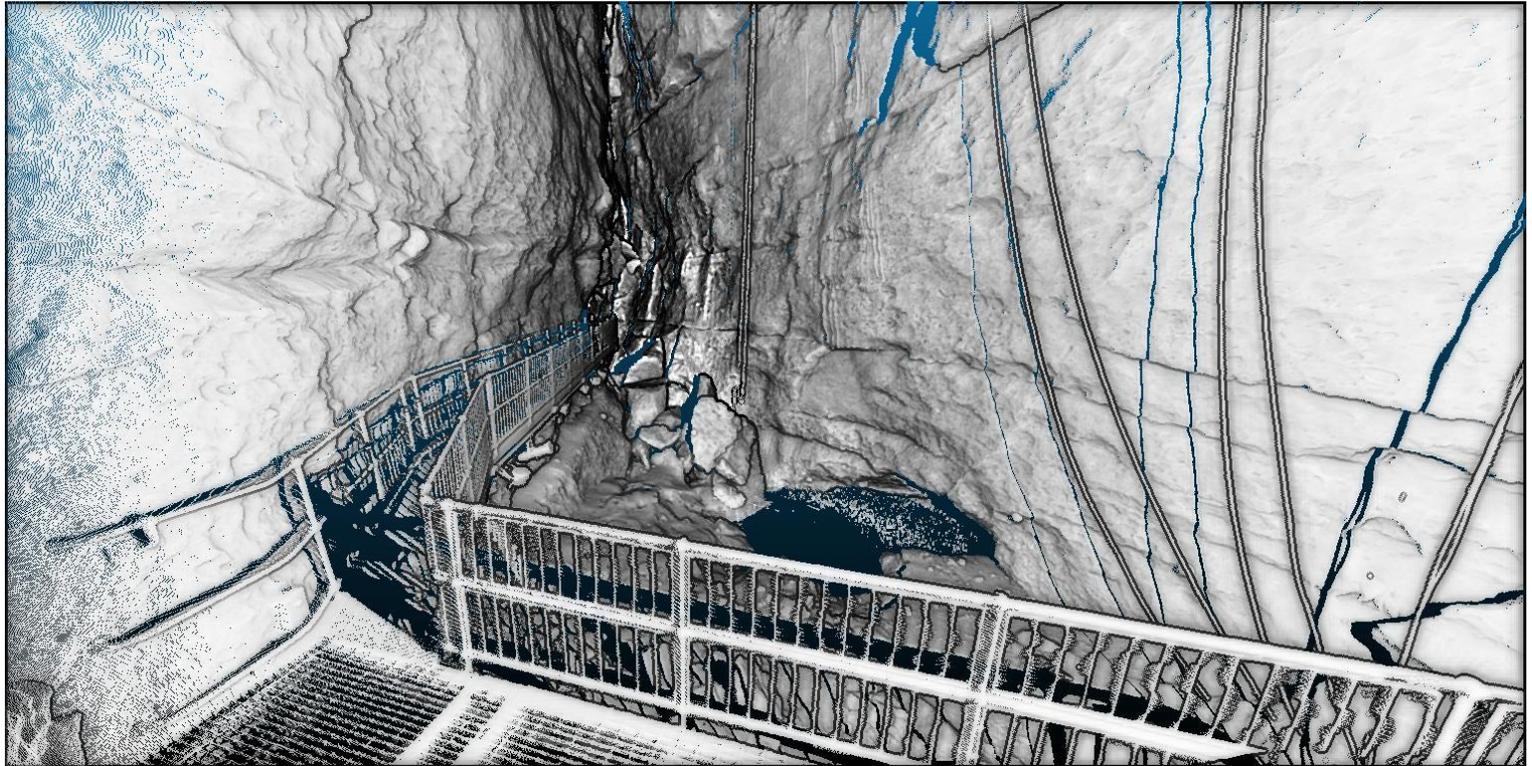
Deviation

Project number	A101
Date	05-05-2015
Drawn by	WS
Checked by	WS Scale 3/32" = 1'-0"



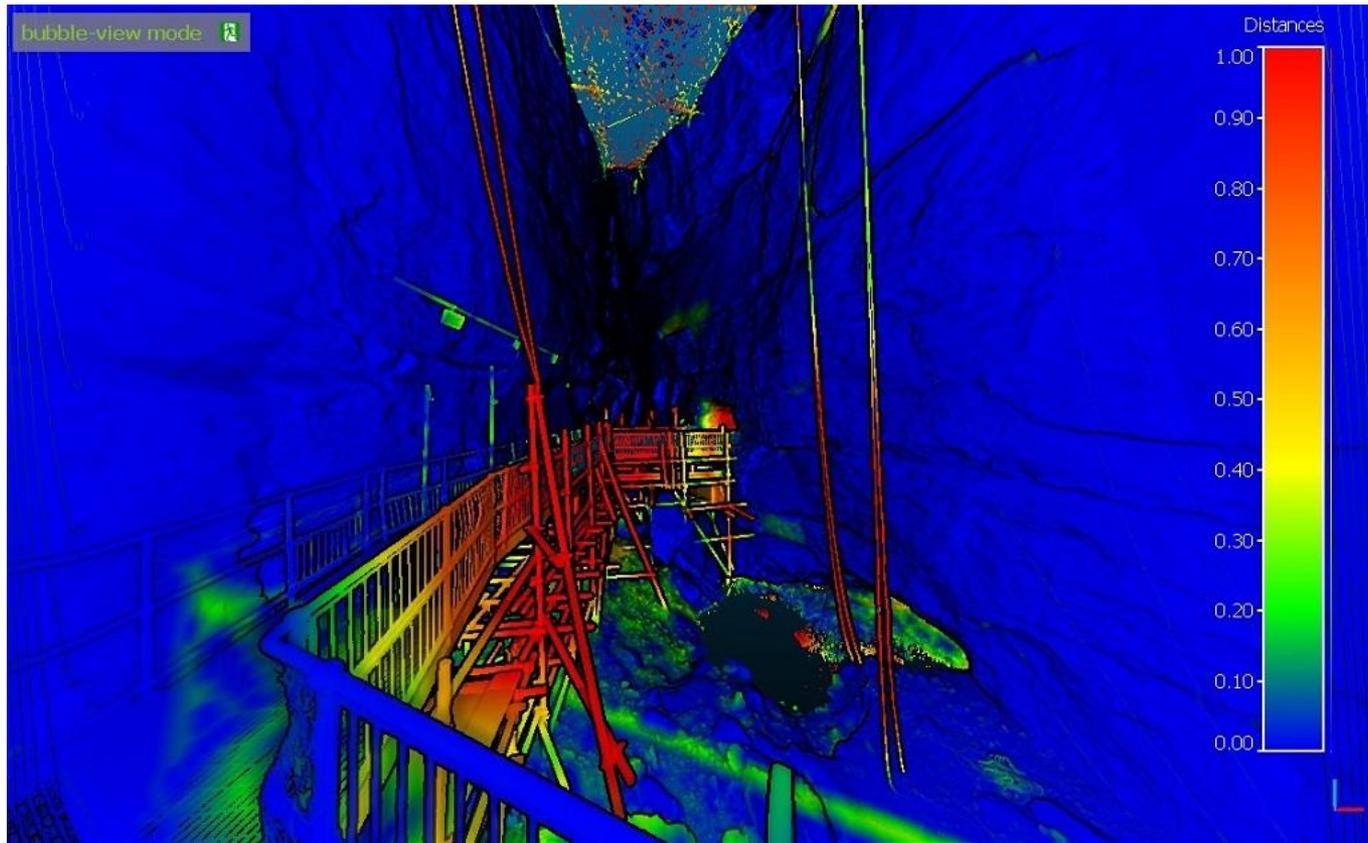
Comparison of scans in a cave

- Cramped environment, few options for positioning the scanner → lots of occlusions

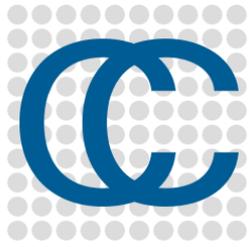




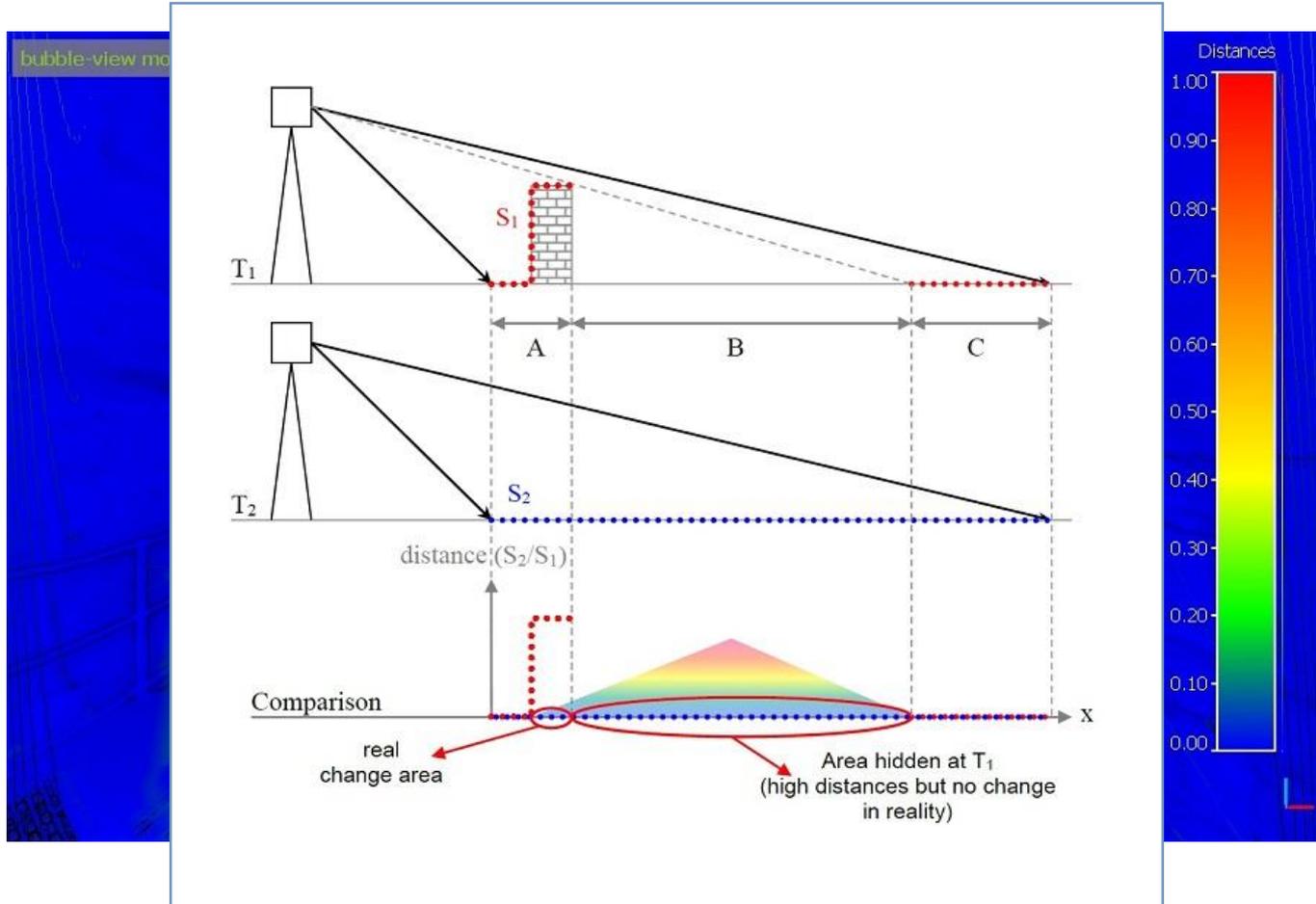
Comparison of scans in a cave



→ lots of false detections

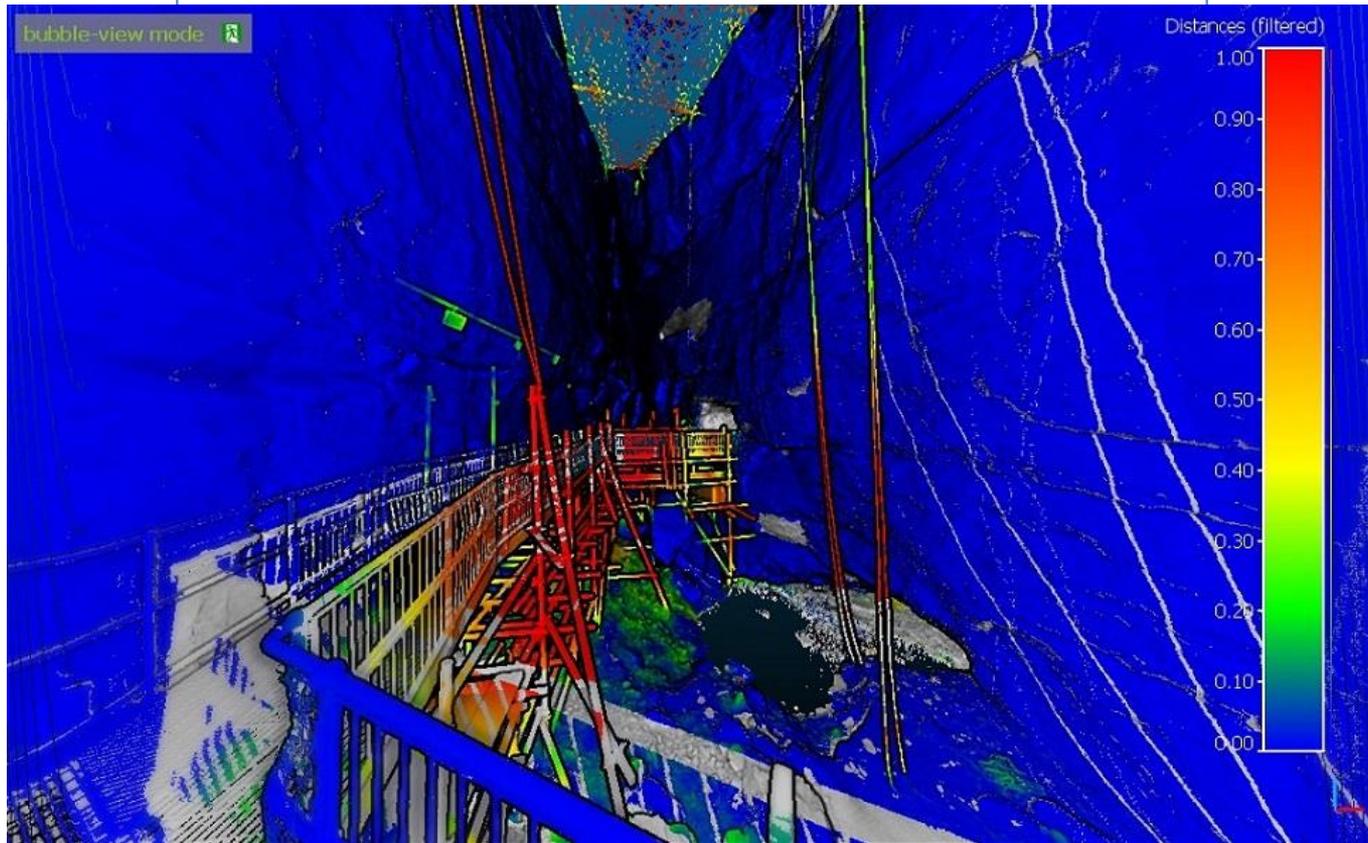


Comparison of scans in a cave



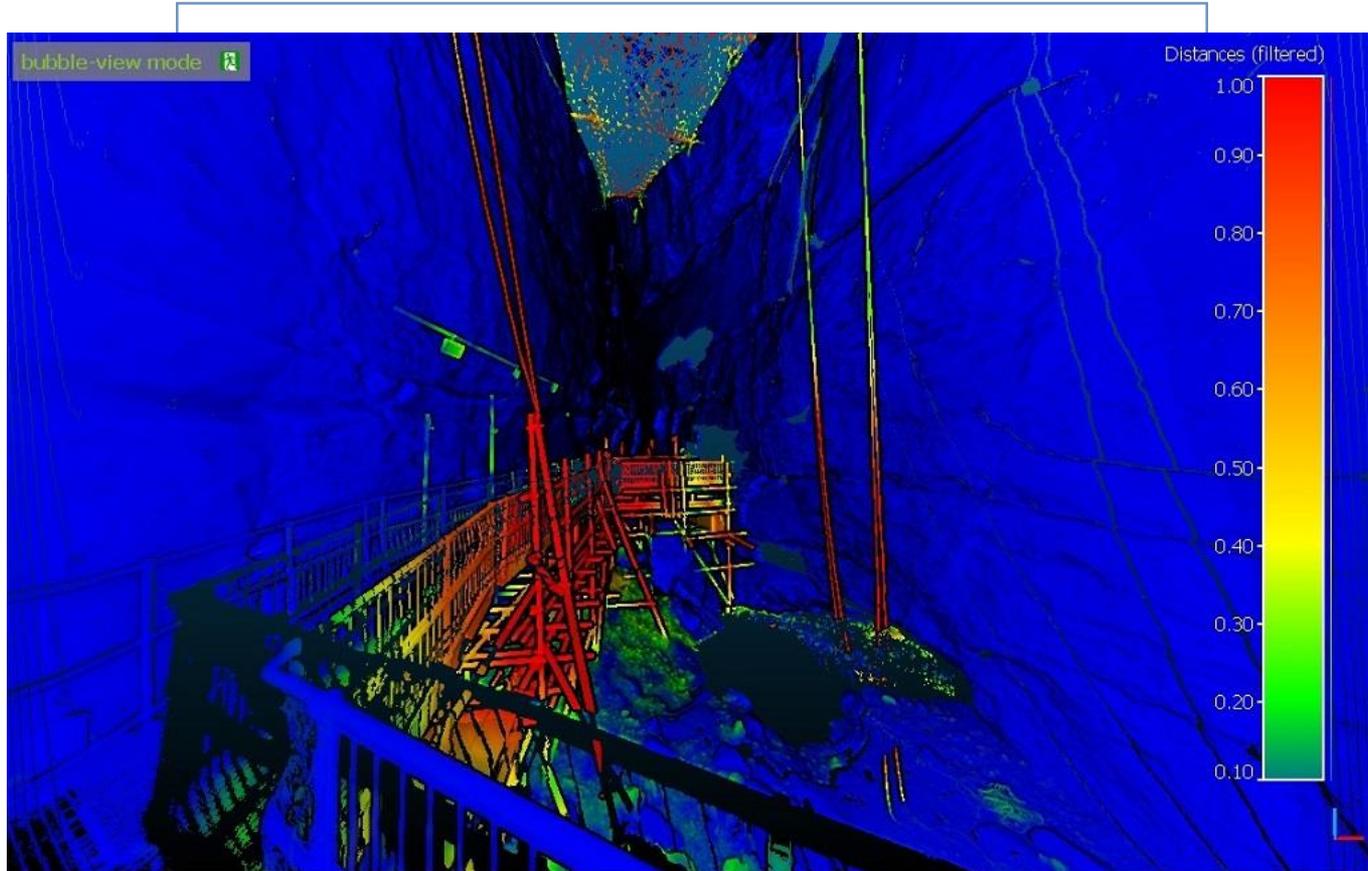


Comparison of scans in a cave



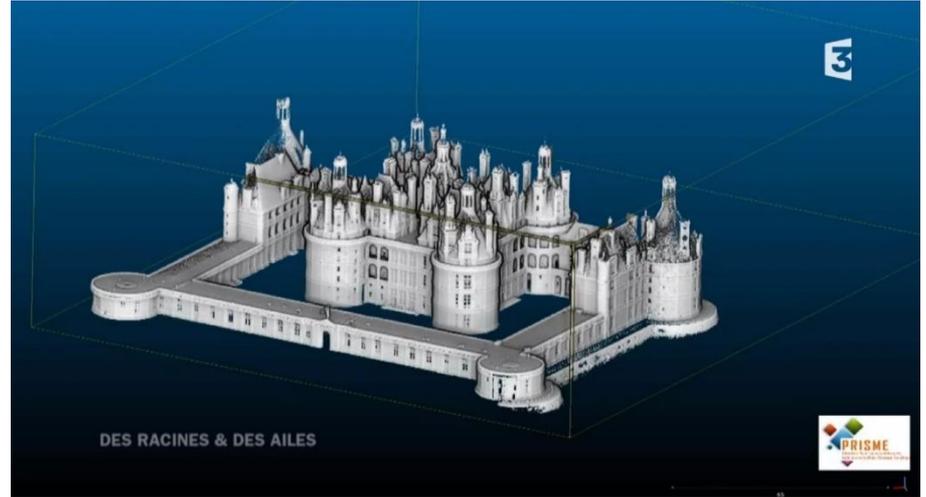


Comparison of scans in a cave





Chambord Castle



ENSG
Géomatique
ÉCOLE NATIONALE
DES SCIENCES
GÉOGRAPHIQUES



domaine national de Chambord

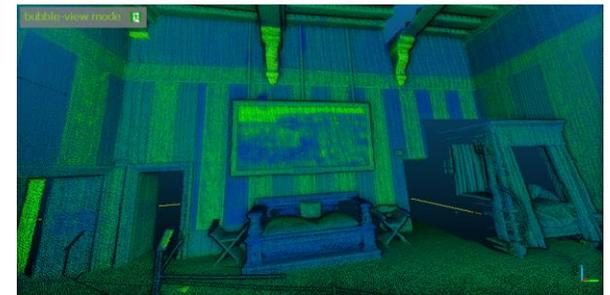
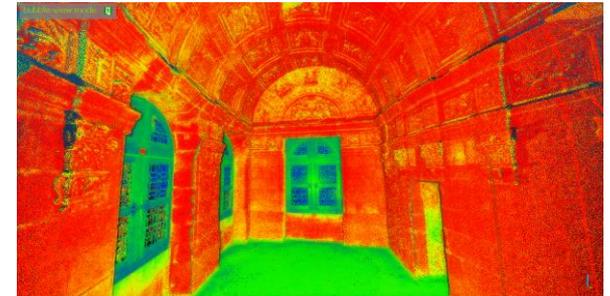
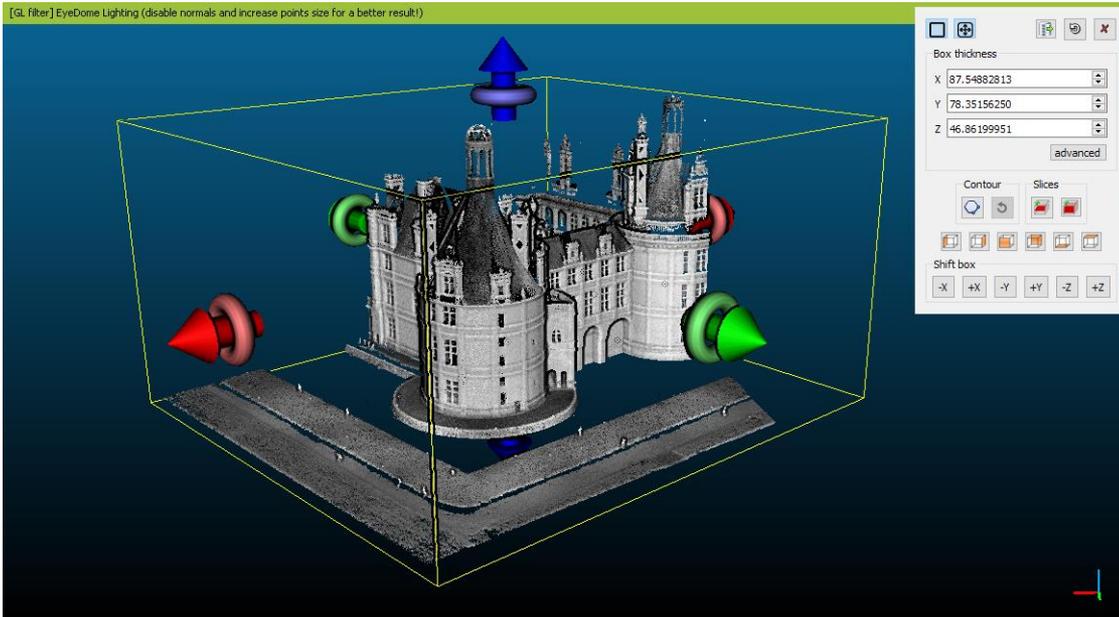


broadcasted on French TV ;)

- Full documentation of the castle with:
 - TLS scans
 - Photogrammetry (ground-based + UAV)
 - Panoramic images
 - Traditional survey points acquisition for georeferencing



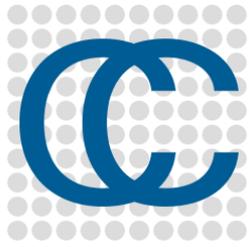
Chambord Castle



- Great communication tool
- Useful for monitoring and maintenance work planning
- Better understanding of the architecture (symmetries, role of some features and rooms, issues during the construction, etc.)

→ *the whole dataset was delivered to the Castle's curators with... CloudCompare!*

● ● ● Future



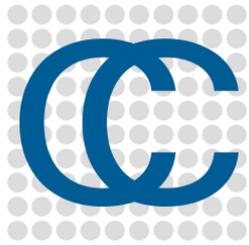
In preparation

- o Next:
 - Out-of-core support
 - 3D VR
 - More plugins



- o And the ever-growing TODO list (*maybe*):

```
1 /***** OC (HDL) TODO LIST *****/
2
3 Methods not yet migrated back to V2:
4 - void MainIndovisionIndicationBase
5 - void MainIndovisionIndicationFormPropagation
6 - void MainIndovisionIndicationIndicationBase
7
8 File I/O:
9 - RTF file
10 - PFD files (RANSAC)
11 - ZED3 Files
12
13 OpenCV format (https://github.com/cloudcompare/track/issue/14)
14 - Visual 3D format (https://www.cloudcompare.org/forum/viewtopic.php?p=12500)
15
16 *** Add from the forum topic or email "request request" ***
17
18 Big ones:
19 [*] Out of core support
20 - scalable
21 - being able to work on portions of very big clouds while only
22 [*] Undo mechanism
23 [*] Command line mode could be extended
24 - use dialog through the command line (HDL, etc - see #88)
25 - extract a cross section from a point cloud using an existing
26 - save the plane orientation as a text file after being plane
27 - option to apply the inverse transformation
28 [*] Change the default output directory (https://www.cloudcompare.org/forum/viewtopic.php?p=12500)
29 - plane files
30 - let the user specify the precise content of an ASCII file if
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Thanks for your attention!

www.cloudcompare.org

CloudCompare v2.8.3 (34-bit) - 3D View

CloudCompare

3D point cloud and mesh processing software
Open Source Project

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Welcome to the official website of the **CloudCompare** project.

Want to know when a new release comes out? Subscribe to the newsletter

You can now follow us on [twitter](#)

CloudCompare (view, edit and process)

ccViewer (light viewer only)

Download the short course presentations of the 2nd Virtual Geoscience Conference [here](#)

Meet us at 3D Arch 2017 (1-3 March 2017)

CloudCompare home - danielgm.net - EDF R&D - [contact](#)