CloudCompare

3D ARCH 2017

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Outline

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

The project

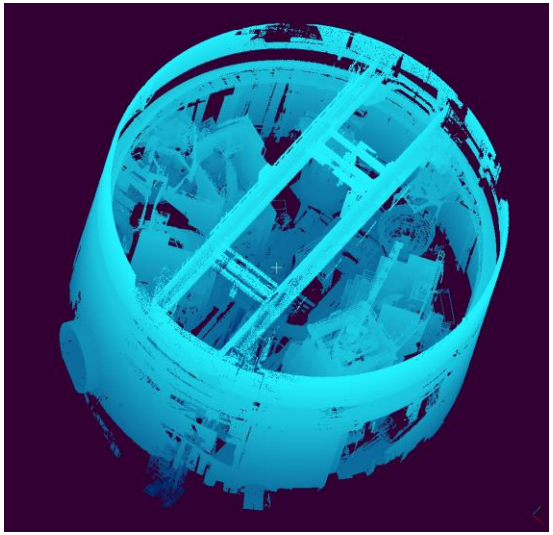
2003: PhD for **EDF R&D**

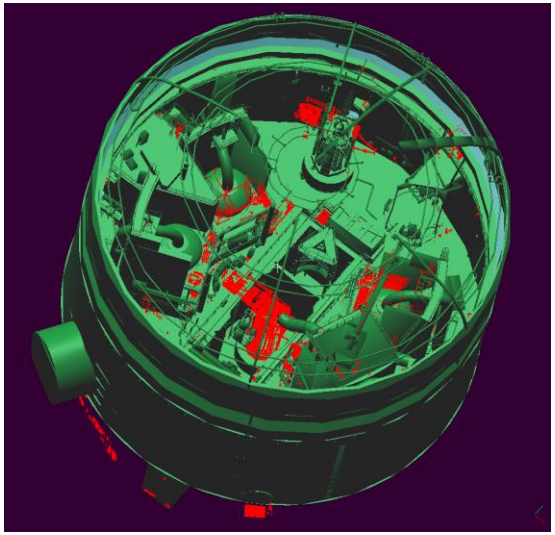
- **EDF**
  - Main French power utility
  - More than 150 000 employees worldwide
    - 2 000 @ R&D (< 2%)
      - 200 know about CloudCompare (< 0.2%)
  - Sales >75 B€
  - > 200 dams + 58 nuclear reactors (19 plants)

EDF and Laser Scanning

- **EDF** = former owner of **Mensi** (*now Trimble Laser Scanning*)

- Main scanning activity: *as-built* documentation



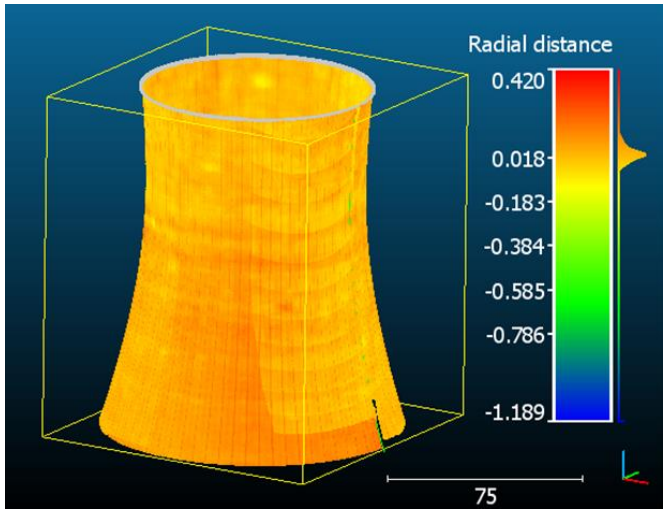


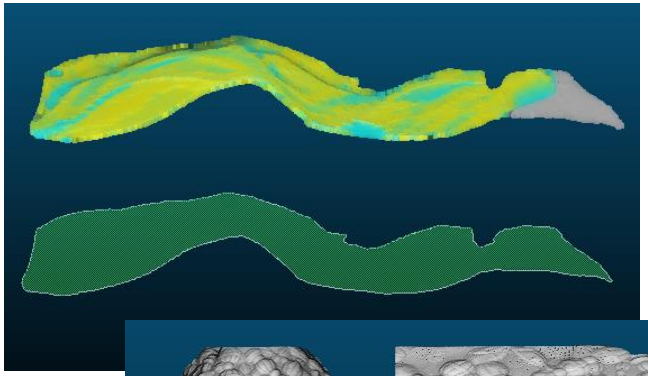
Scanning a single nuclear reactor building

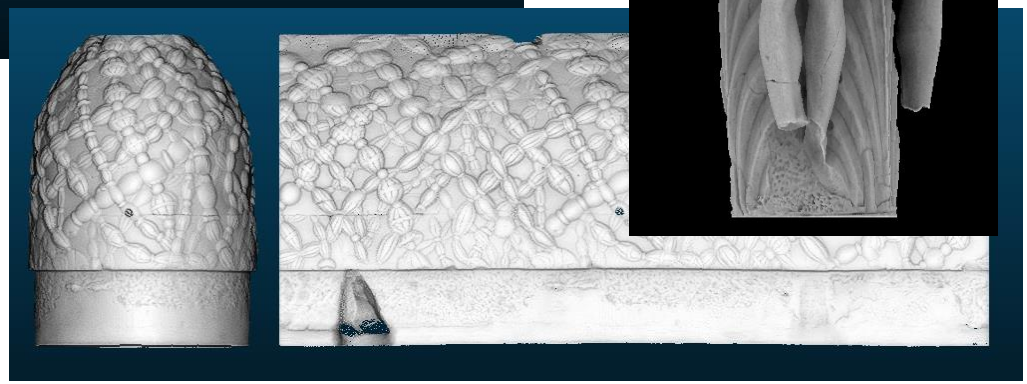
- 2002: 3 days, 50 M. points
- 2014: 1.5 days, **50 Bn** points (+ high res. photos)

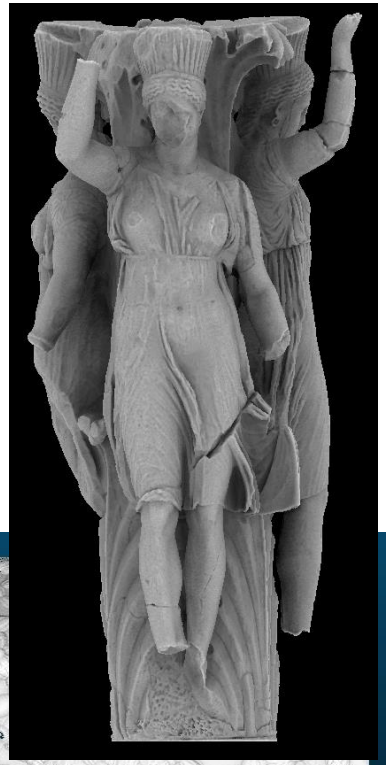
EDF and Laser Scanning

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





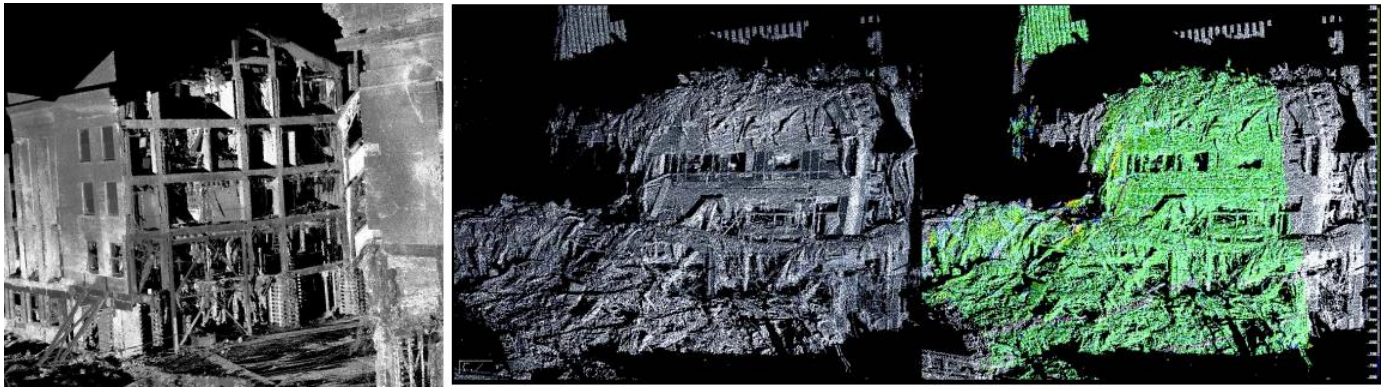




PhD

- *Change detection on 3D geometric data*
  - Application to Emergency Mapping

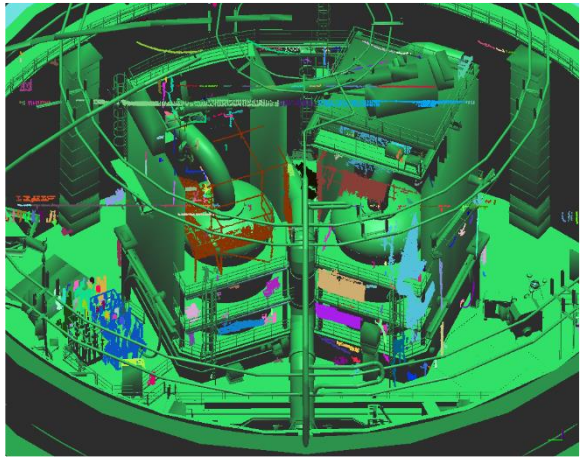
- Inspired by 9/11 post-attacks recovery efforts
  (*see "Mapping Ground Zero" by J. Kern, Optech, Nov. 2001*)

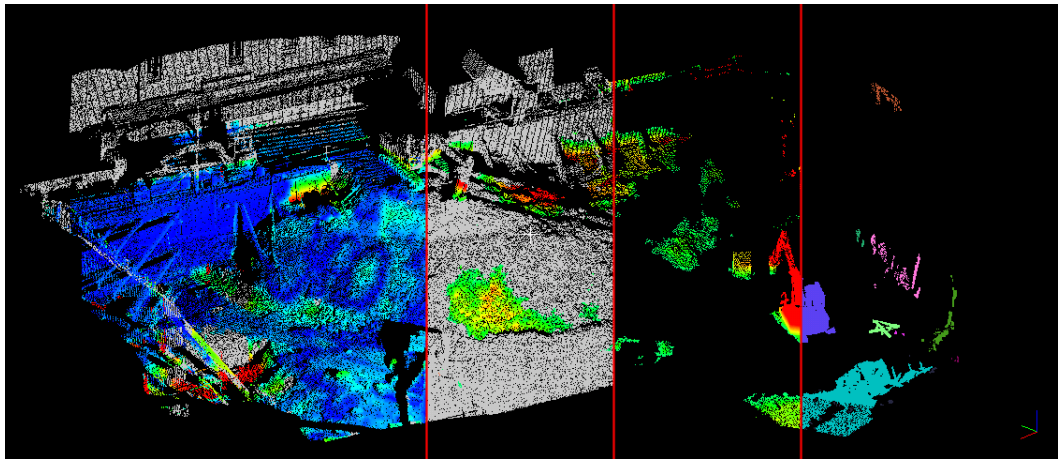


TLS was used for: visualization, optimal crane placement, measurements, monitoring the subsidence of the wreckage pile, slurry wall monitoring, etc.

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

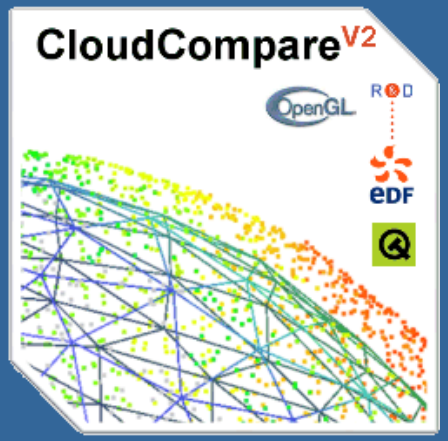
- 2007: “Industrialization” of CloudCompare
  … for internal use only!

- 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!

- Free…
- …however, someone still needs to pay ;)
  - either by developping new functionnalities
  - or by paying someone else to do it
- Plugins are not necessarily open source or free

Users

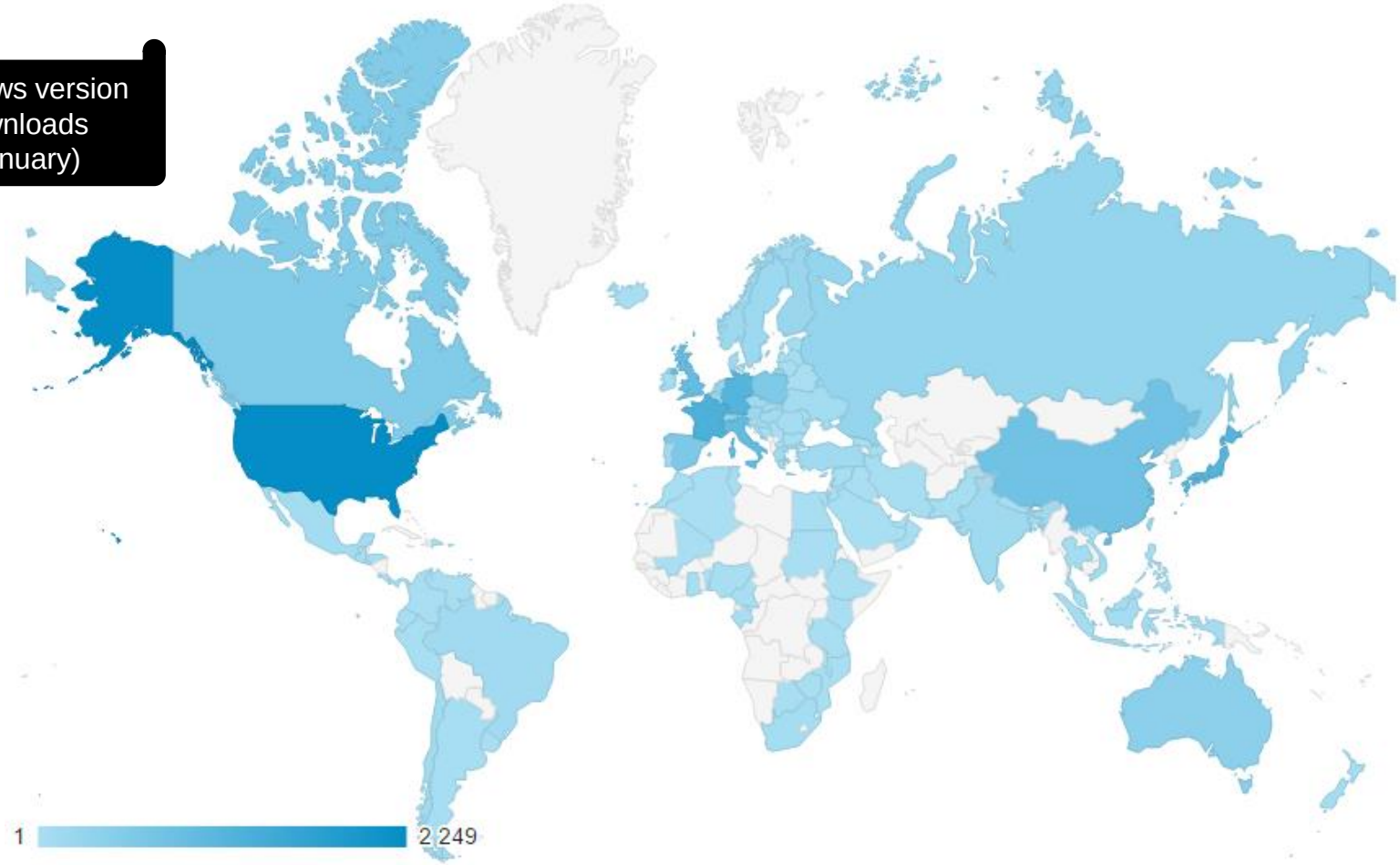
- Too many ;)
  - Academics:
    - remote sensing
    - geology
    - archeology
    - etc.
  - Surveyors
  - Forensic experts
  - Architects
  - MDs, dentists
  - 3D designers
  - Artist?!

Developers

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

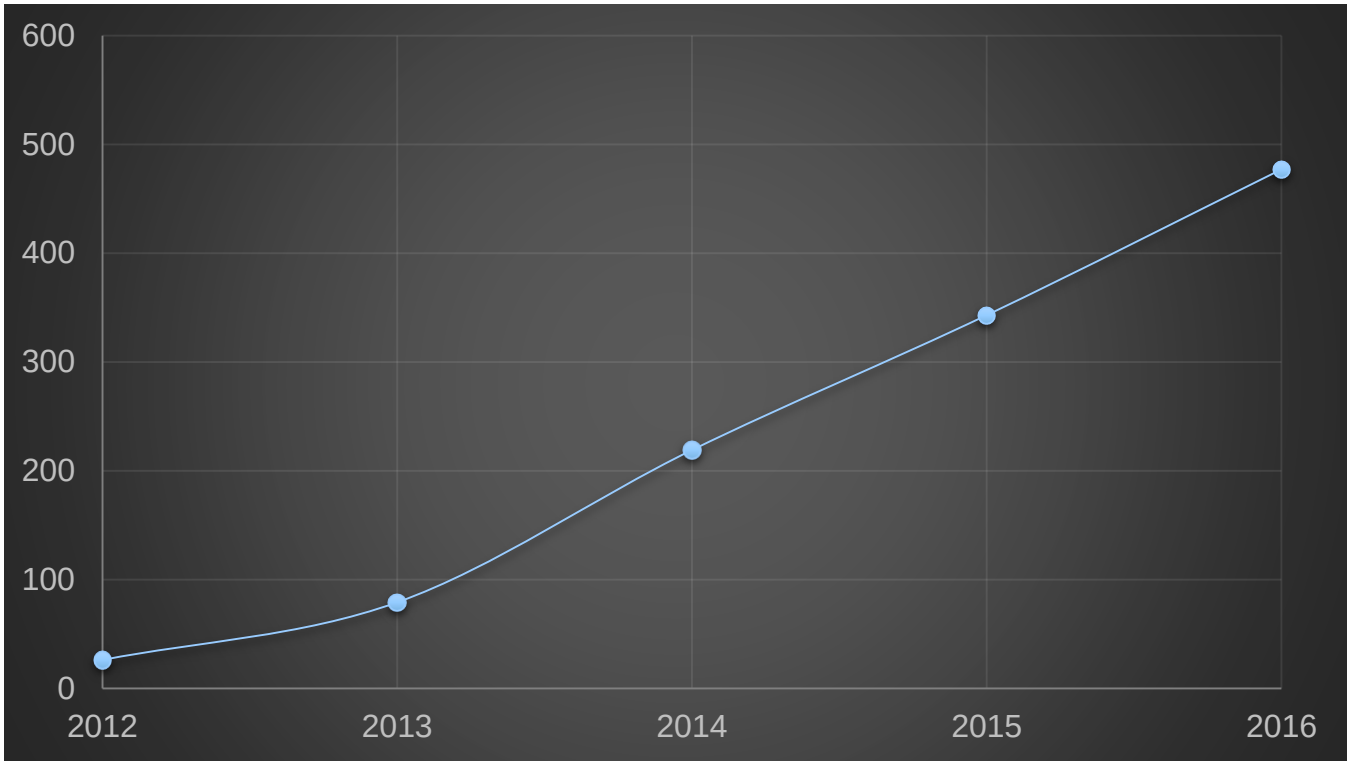
Worldwide

Windows version downloads (January)



> 2400 users registered to the newsletter

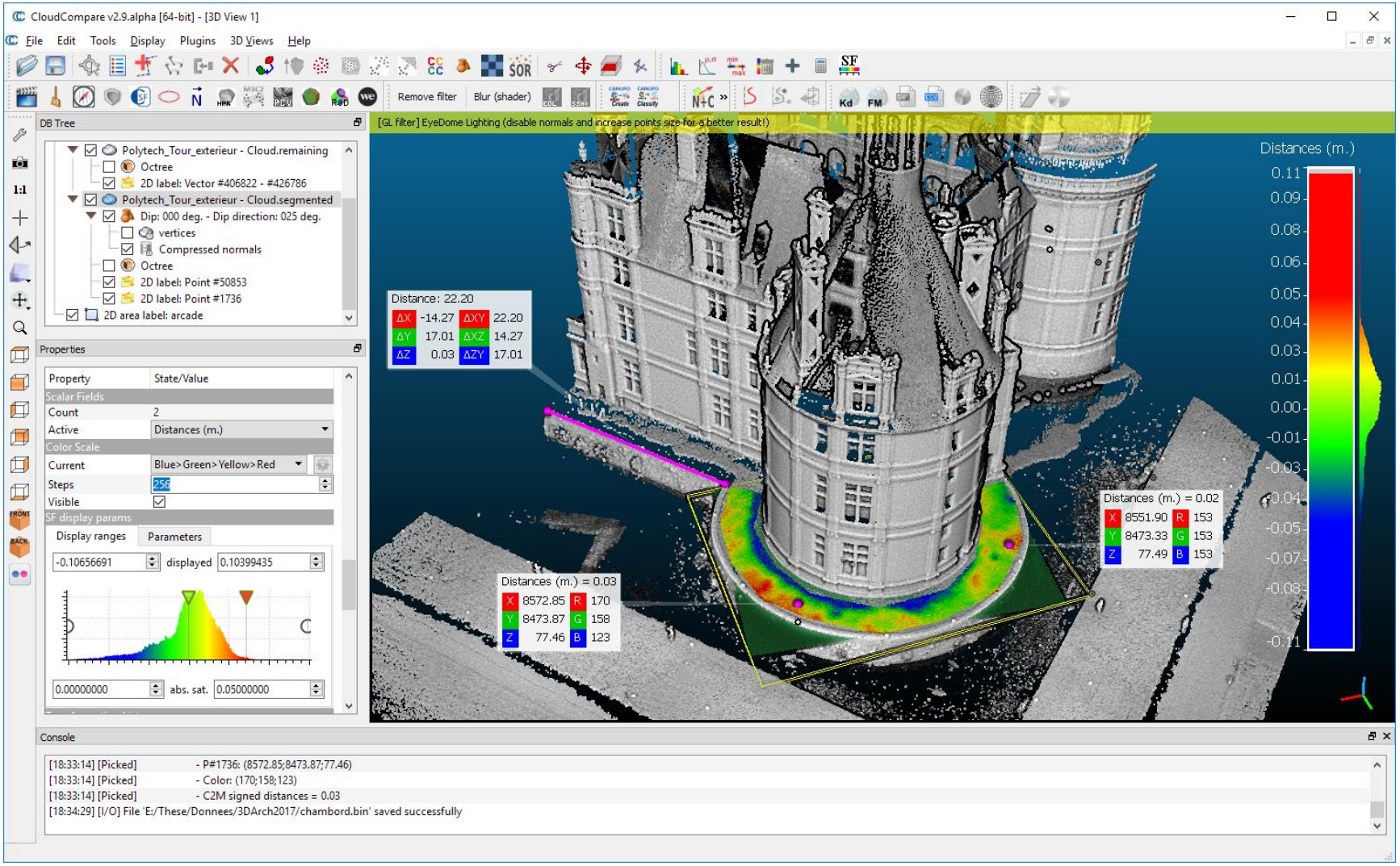
Citations in scientific articles



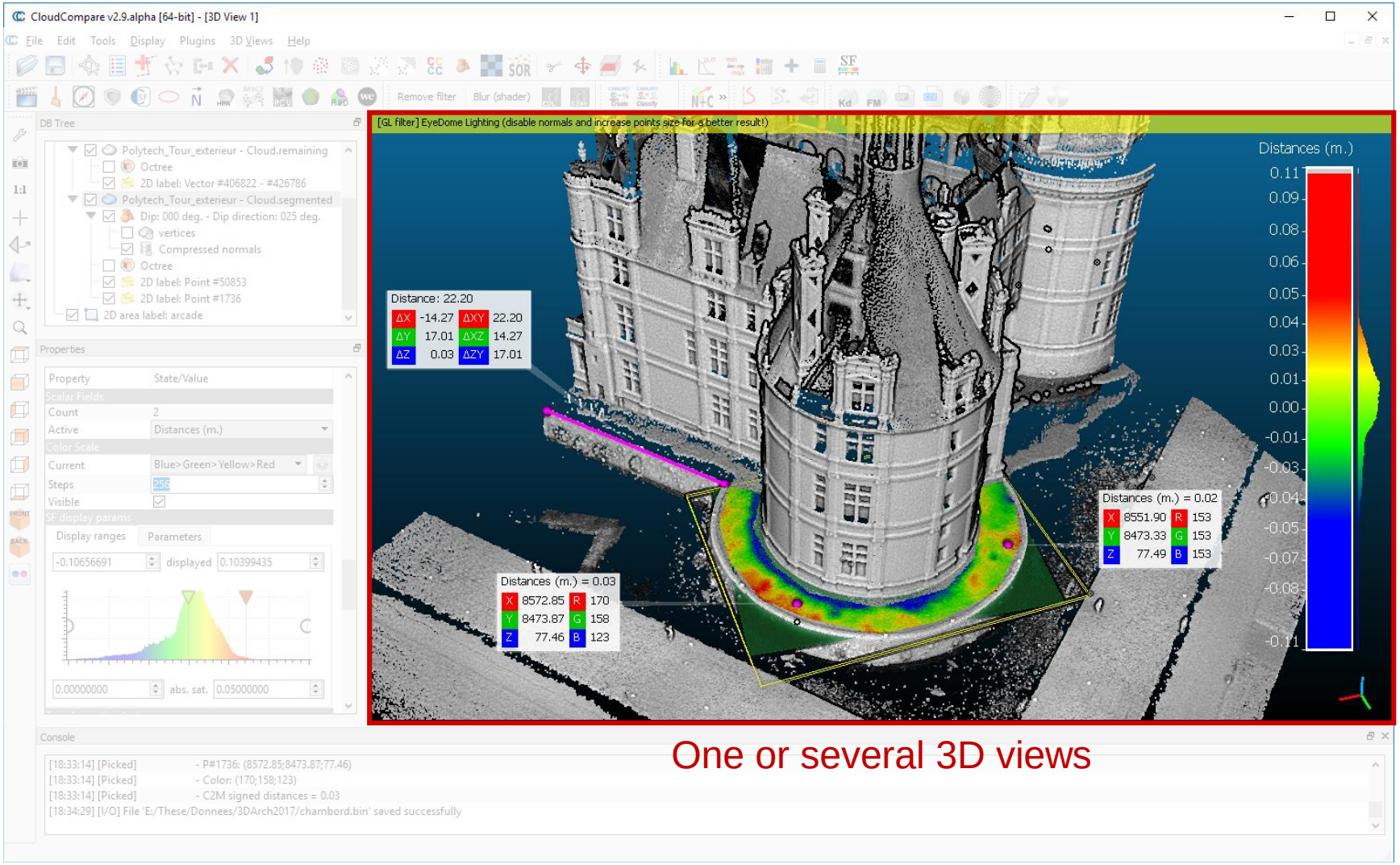
source: Google scholar

Quick overview

Interface

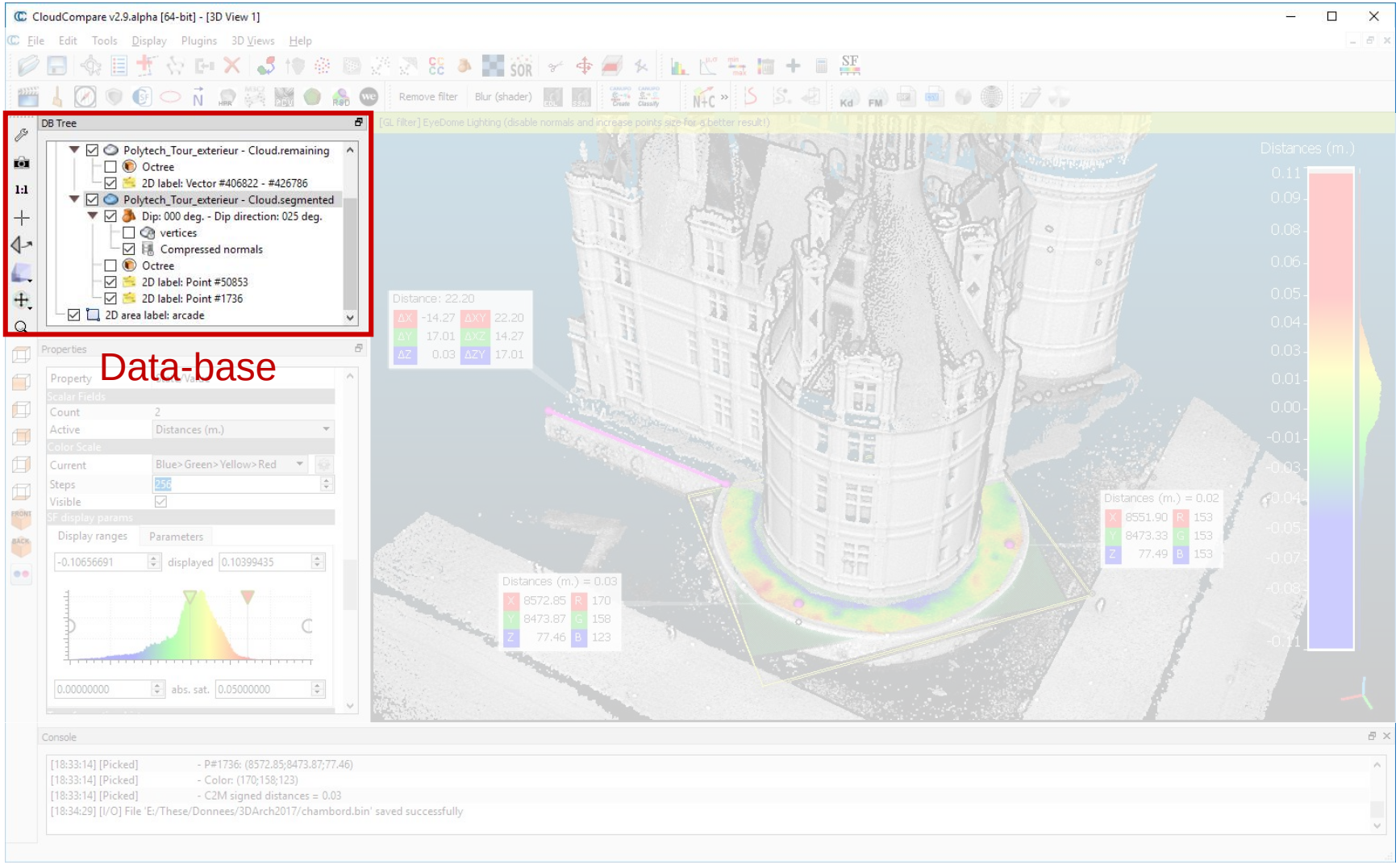

CloudCompare v2.9.alpha [64-bit] - [3D View 1]
File Edit Tools Display Plugins 3D Views Help
Remove filter
Blur (shader)
DB Tree
Polytech_Tour_exterieur - Cloud.remaining
Octree
2D label: Vector #406822 - #426786
Polytech_Tour_exterieur - Cloud.segmented
Dip: 000 deg. - Dip direction: 025 deg.
vertices
Compressed normals
Octree
2D label: Point #50853
2D label: Point #1736
2D area label: arcade
Properties
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
-0.10656691
displayed
0.10399435
0.00000000
abs. sat.
0.05000000
[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)
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
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.)
0.11
0.09
0.08
0.06
0.05
0.04
0.03
0.01
0.00
-0.01
-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
[18:34:29] [I/O] File 'E:/These/Donnees/3DArch2017/chambord.bin' saved successfully

Interface



One or several 3D views

Interface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vertices
Compressed normals
Octree
2D label: Point #50853
2D label: Point #1736
2D area label: arcade
Data-base
Properties
Count 2
Active Distances (m.)
Current Blue>Green>Yellow>Red
Steps 256
Visible
Display ranges
Parameters
-0.10656691
displayed
0.10399435
0.00000000
abs. sat.
0.05000000
Distance: 22.20
Distances (m.)
Distances (m.) = 0.02
Distances (m.) = 0.03
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
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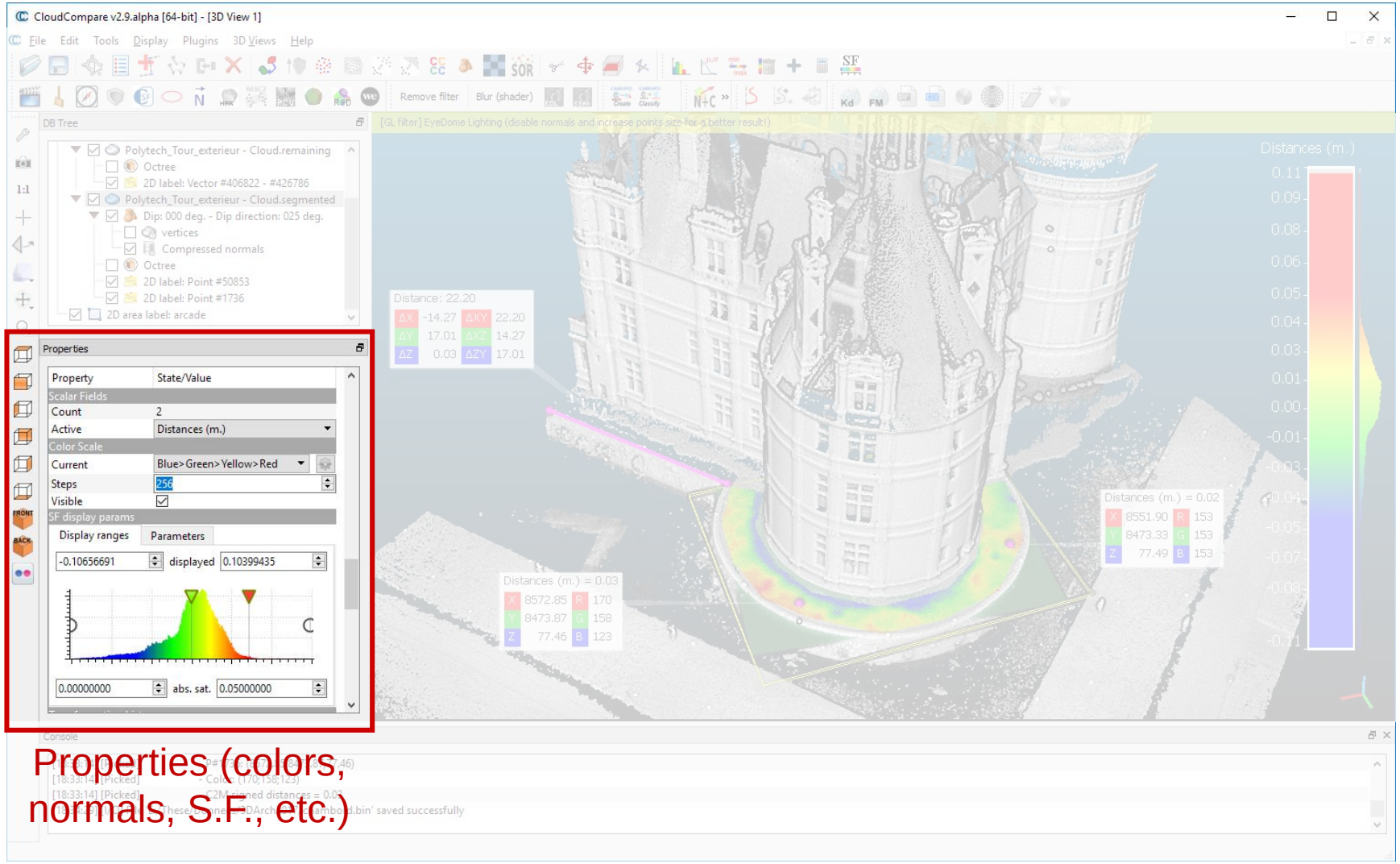
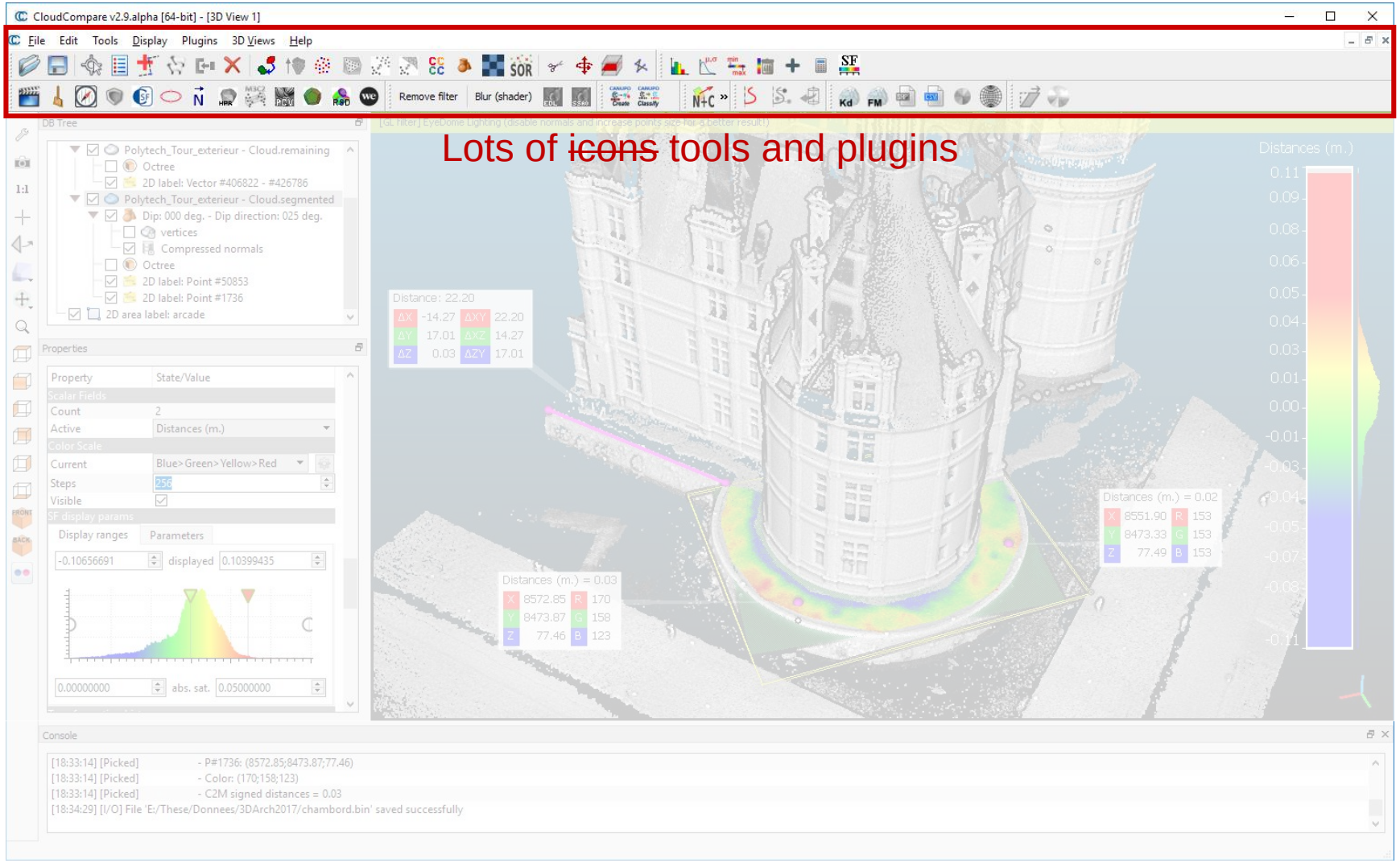


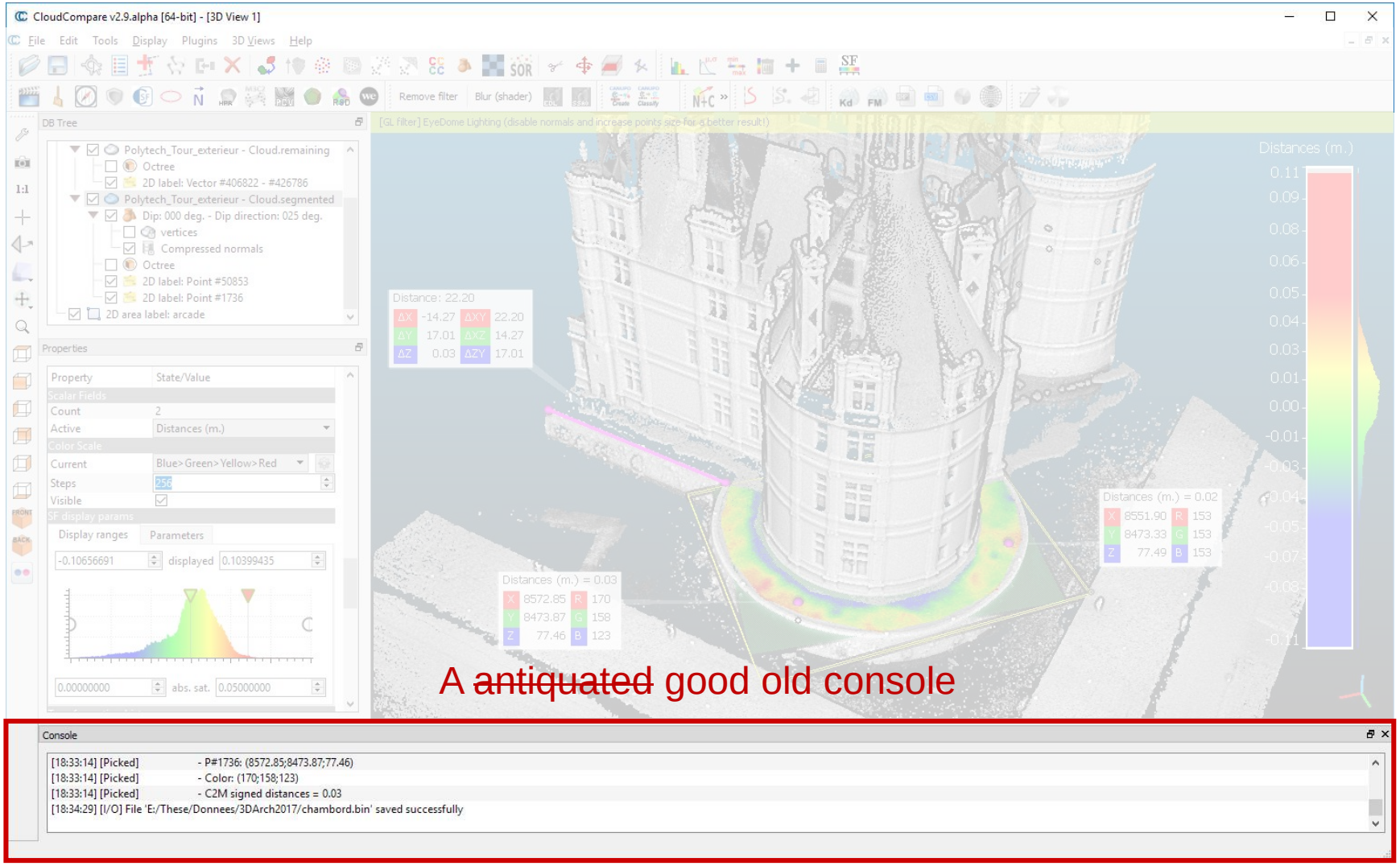
Properties (colors, normals, S.F., etc.)

Interface



Lots of ~~icons~~ tools and plugins

Interface



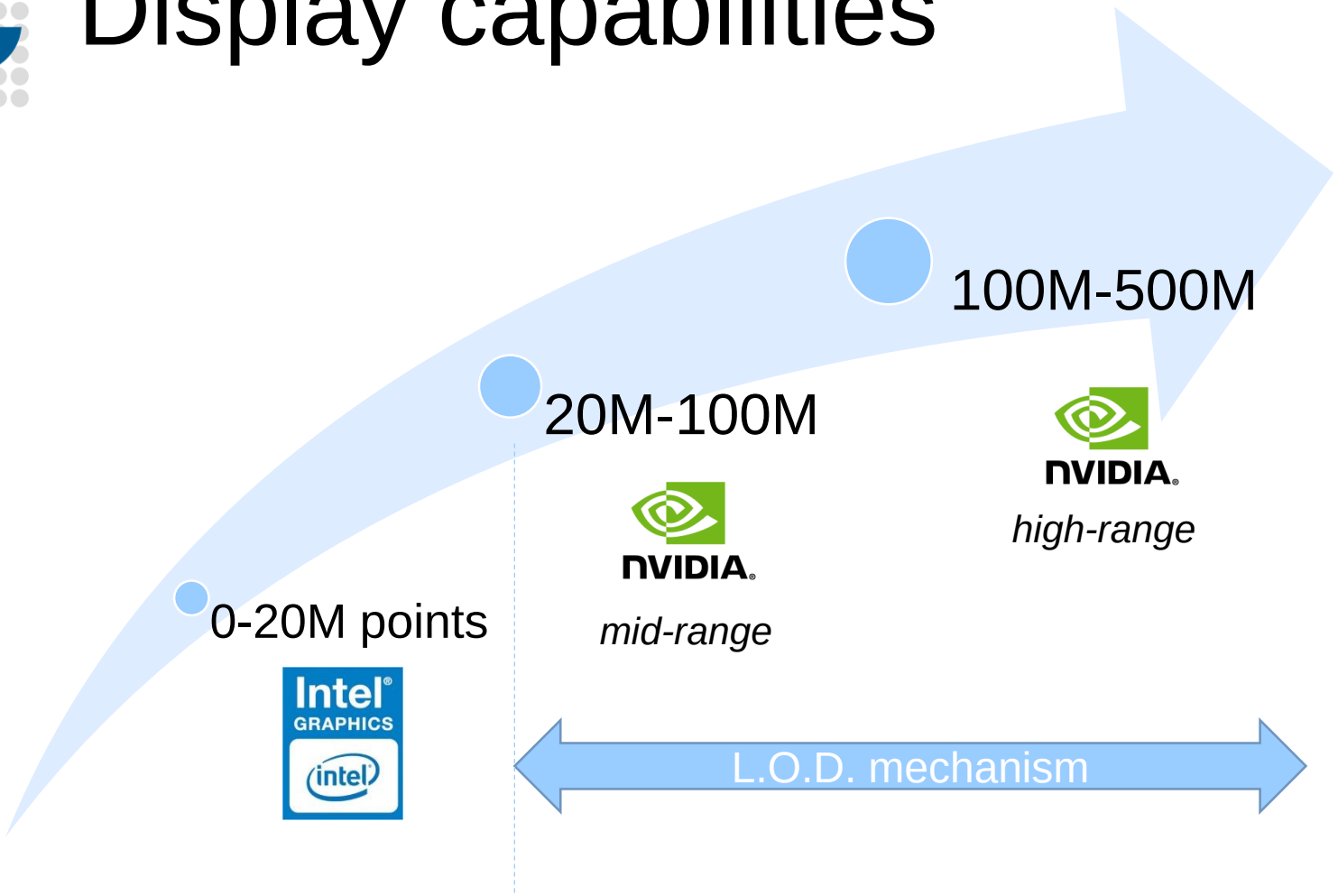
A ~~antiquated~~ good old console

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

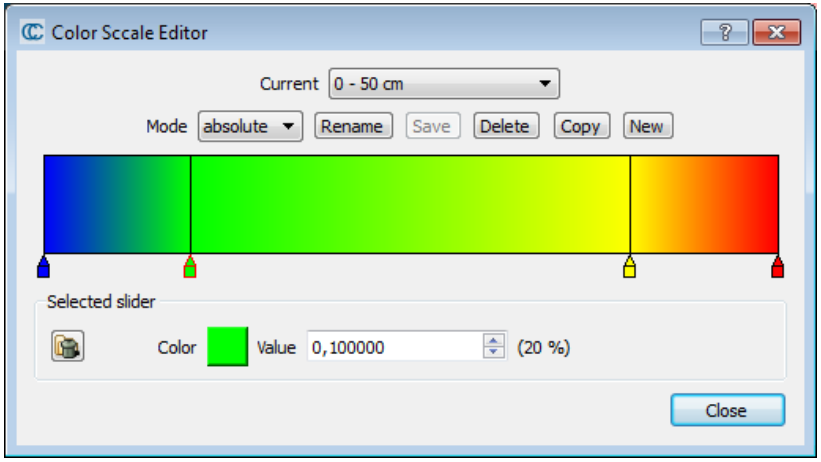


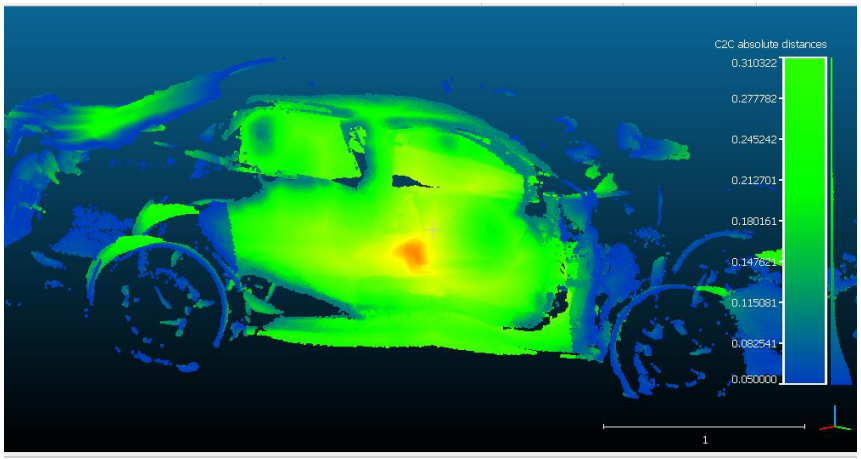
> 500 M. points?

- 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

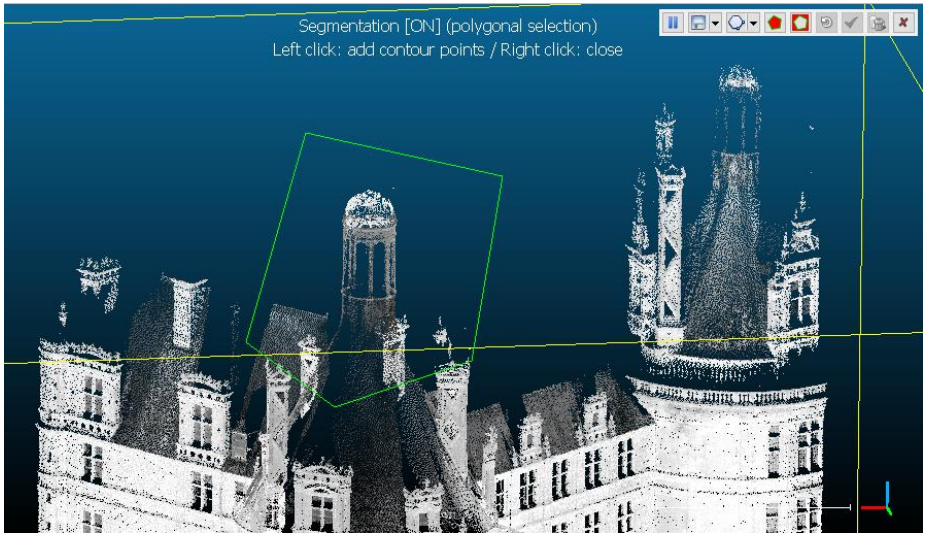
- Values can be
  - mixed (+,-,/,x)
  - transformed (cos, log, etc.)
  - filtered (spatial smoothing, spatial gradient, etc.)
  - imported or exported as a coordinate dimension
  - merged with colors

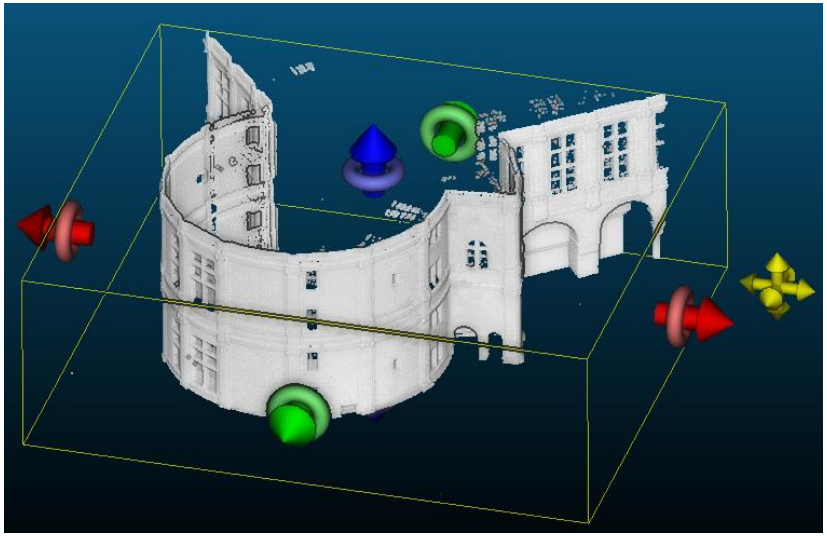
- Statistics can be computed

- Clouds can be processed based on those values
  - Segmentation (*Filter by value*)
  - Subsampling

Main features

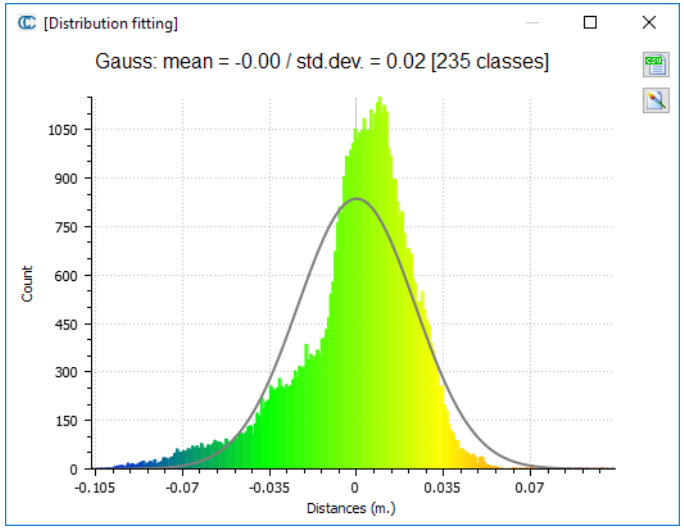
- Interactive tools
  - transformation, segmentation, cross section
- Colors
  - create, convert, level, etc.
- Normals
  - create, convert, orient





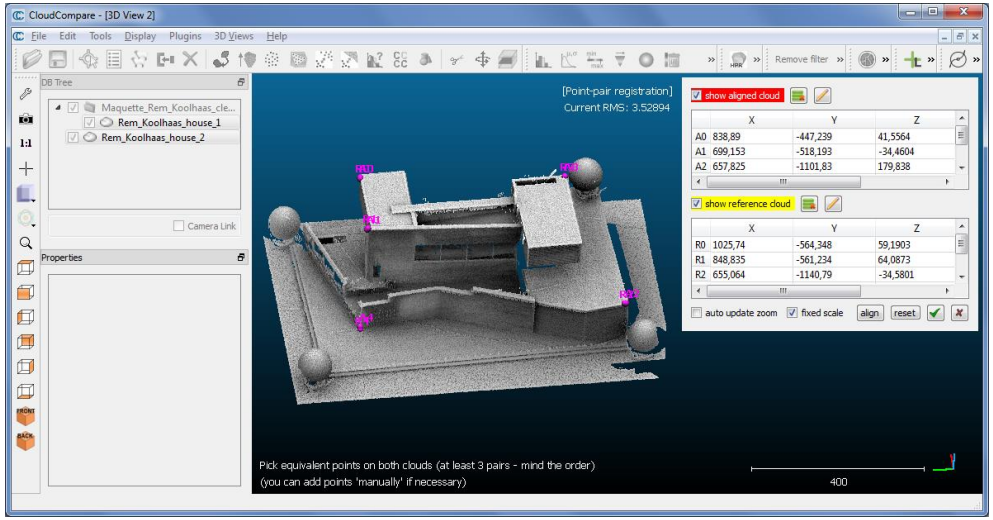
Main features

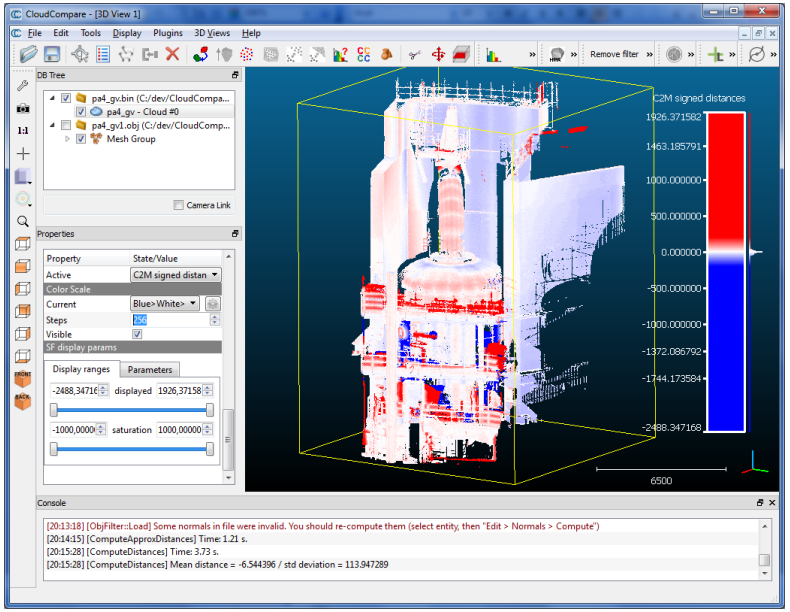
- Mesh operations
  - create (2.5D Delaunay), sample points, smooth, etc.
  - → *see Meshlab for more*
- Scalar fields operations
  - filter points by value, convert, smooth, gradient, etc.
- Point picking,
  Distance / angle measurements
- Others
  - Subsample, merge, scale, etc.



Main tools

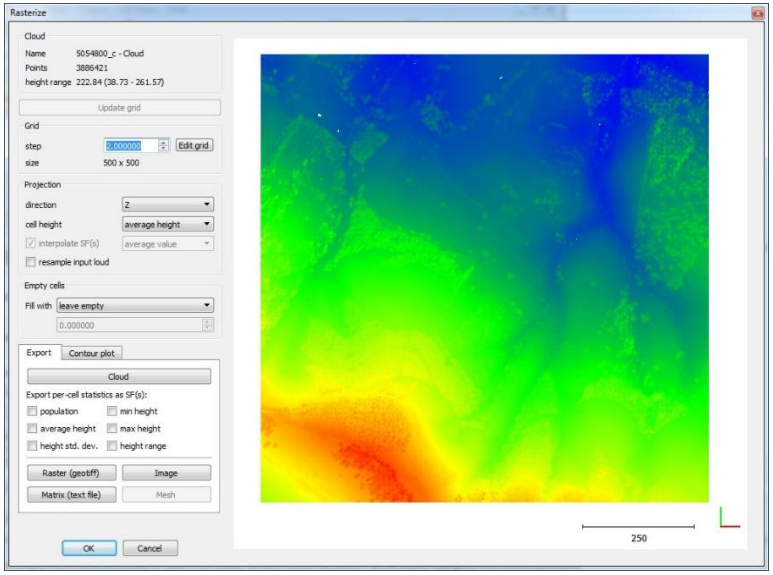
- Registration
  - point-pair-based alignment, ICP
- Distances
  - Cloud-to-cloud (C2C), Cloud-to-mesh (C2M), M3C2 (plugin)

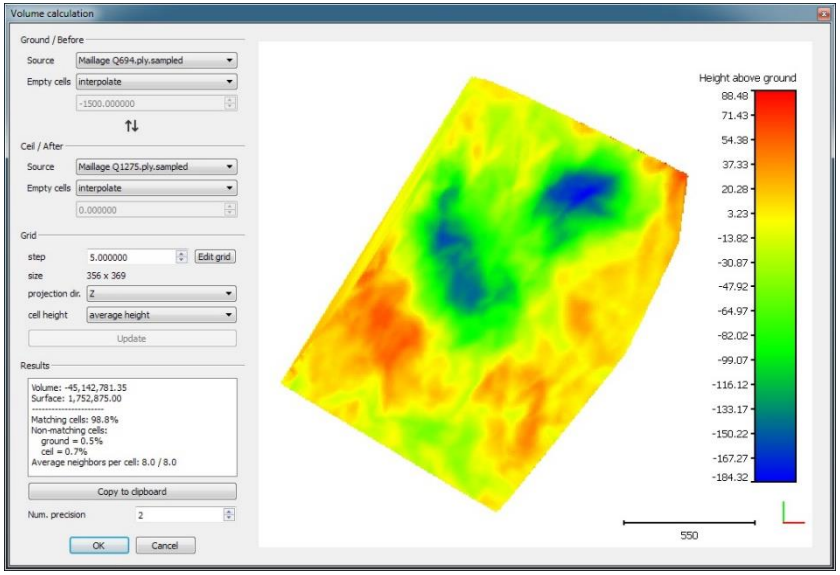




Main tools

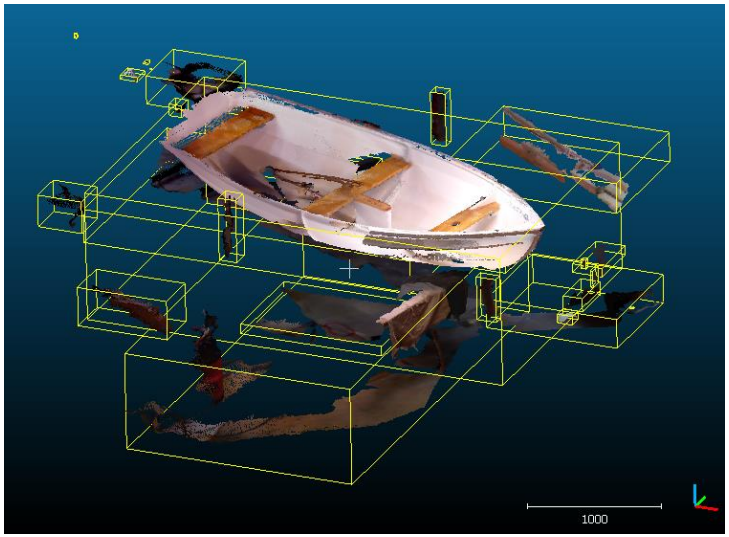
- Cleaning
  - SOR, etc.
- Rasterize
  - + contour plot
- 2.5D volume estimation

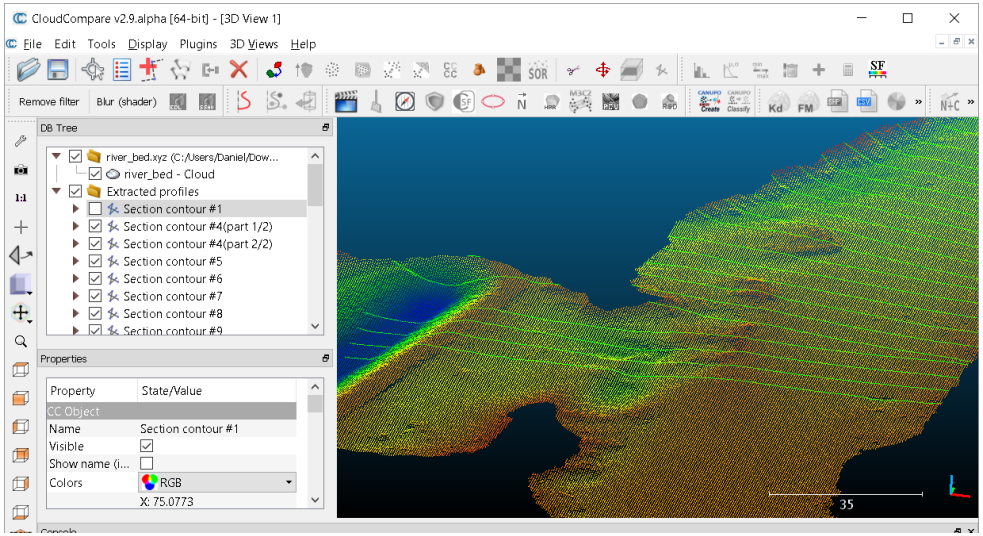




Main tools

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





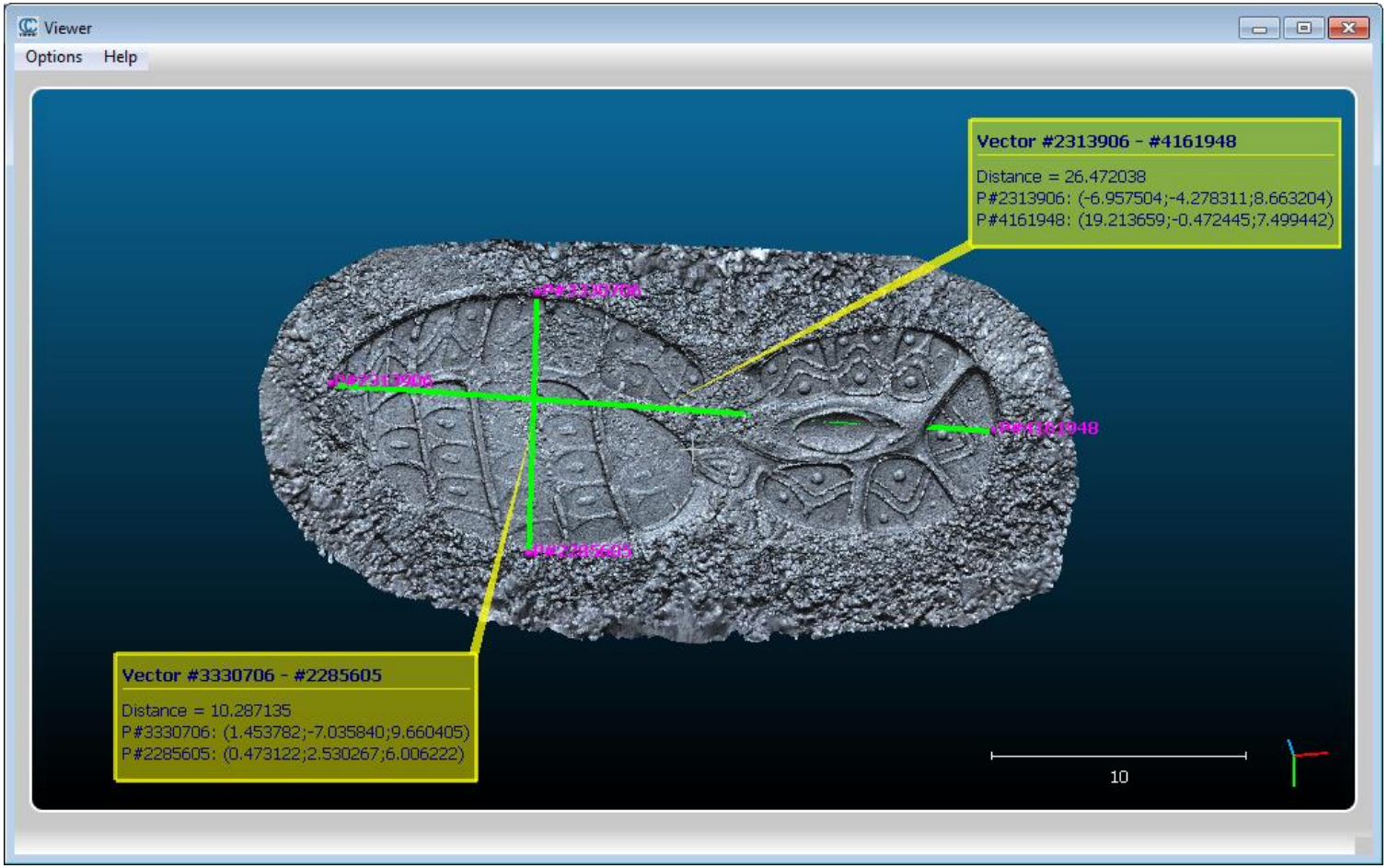
Plugins

- 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++**

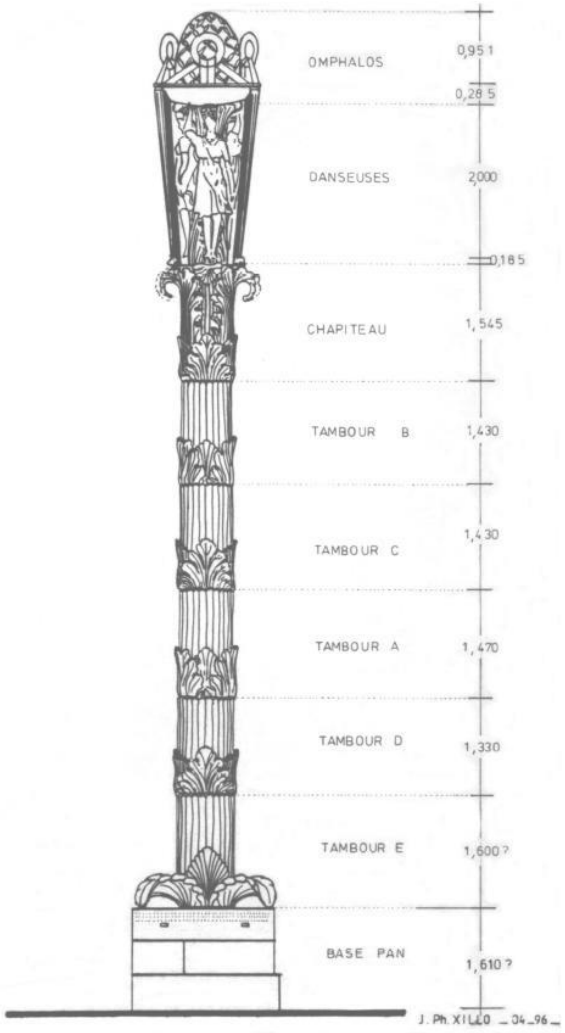
ccViewer


Viewer
Options
Help
Vector #2313906 - #4161948
Distance = 26.472038
P#2313906: (-6.957504;-4.278311;8.663204)
P#4161948: (19.213659;-0.472445;7.499442)
Vector #3330706 - #2285605
Distance = 10.287135
P#3330706: (1.453782;-7.035840;9.660405)
P#2285605: (0.473122;2.530267;6.006222)
10

Success stories

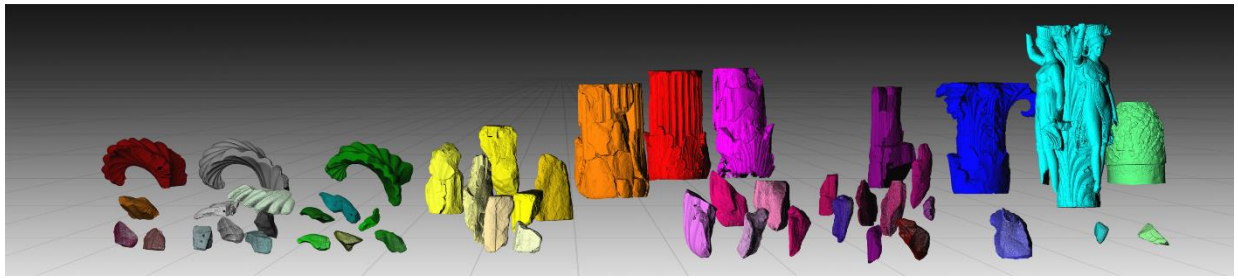
The Dancers column of Delphi

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

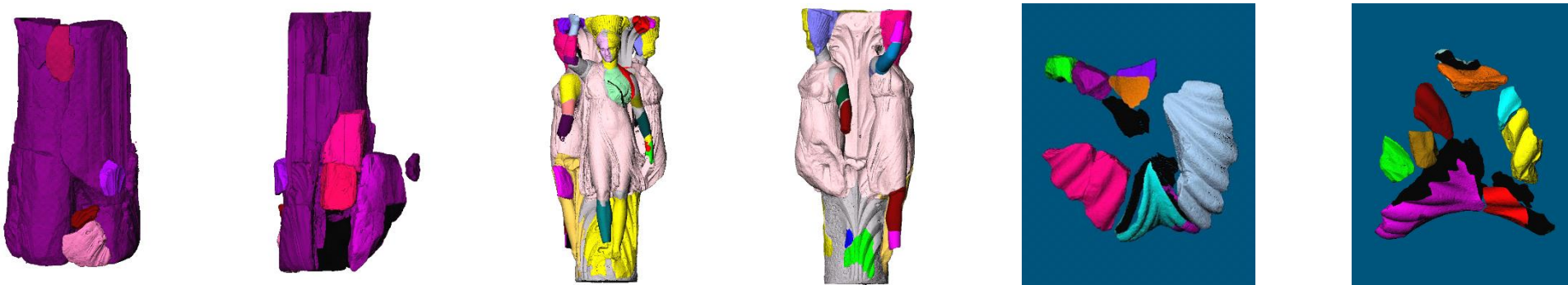


A Point-Based Approach for Capture, Display and Illustration of Very Complex Archeological Artefacts
Florent Duguet, George Drettakis, Daniel Girardeau-Montaut, Jean-Luc Martinez, Francis Schmitt, VAST (2004)

The Dancers column of Delphi



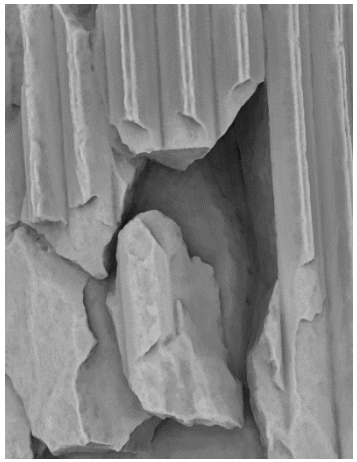
- acquisition: > 1 week, 2200 scans, 600 M. points (**in 2004**)
- cleaning + segmentation (*removal of plaster parts*) → 220 M. points remaining
- 600h of intensive 2D/3D virtual “puzzling”
- lots of discussion + specific tools development (3 labs)



The Dancers column of Delphi

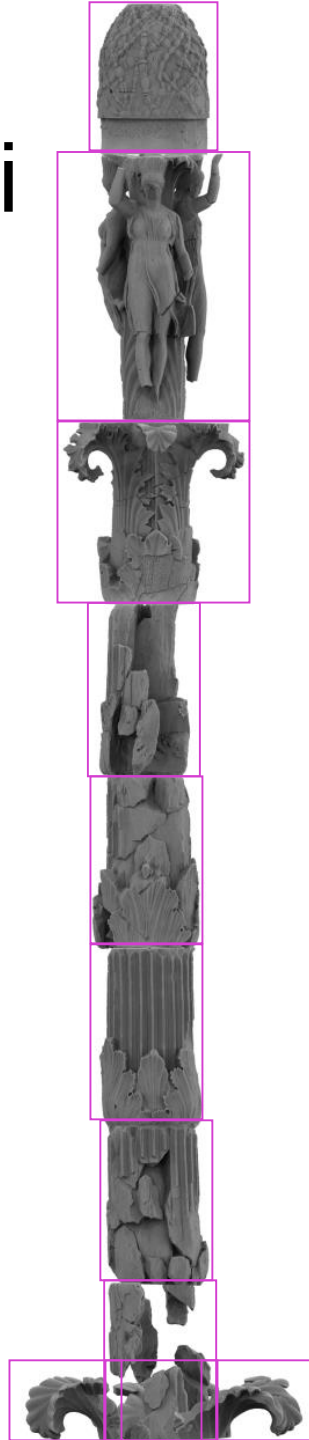
- CloudCompare part:
  - unrolling
  - mesh quality assessment
  - global illumination of clouds (Shadevis / “PCV”)
  - visualization

mesh (*normals*)



mesh (*PCV*)

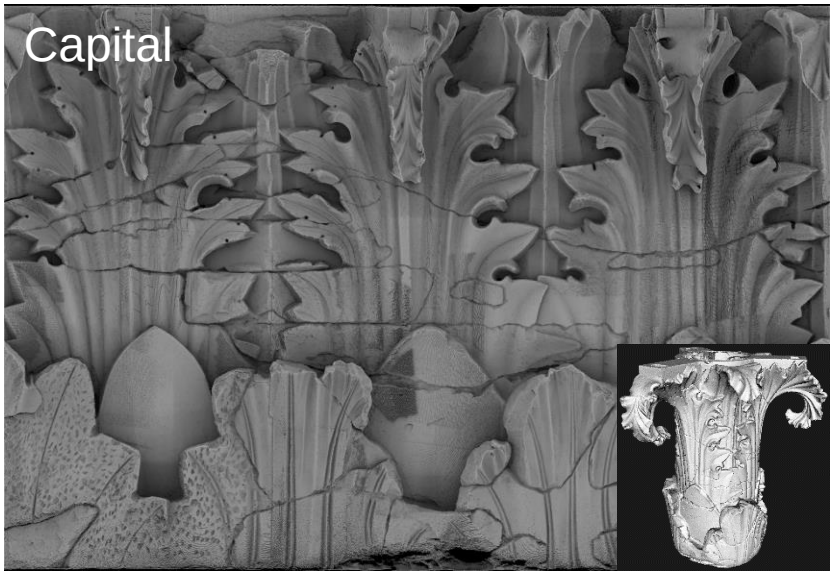
photograph



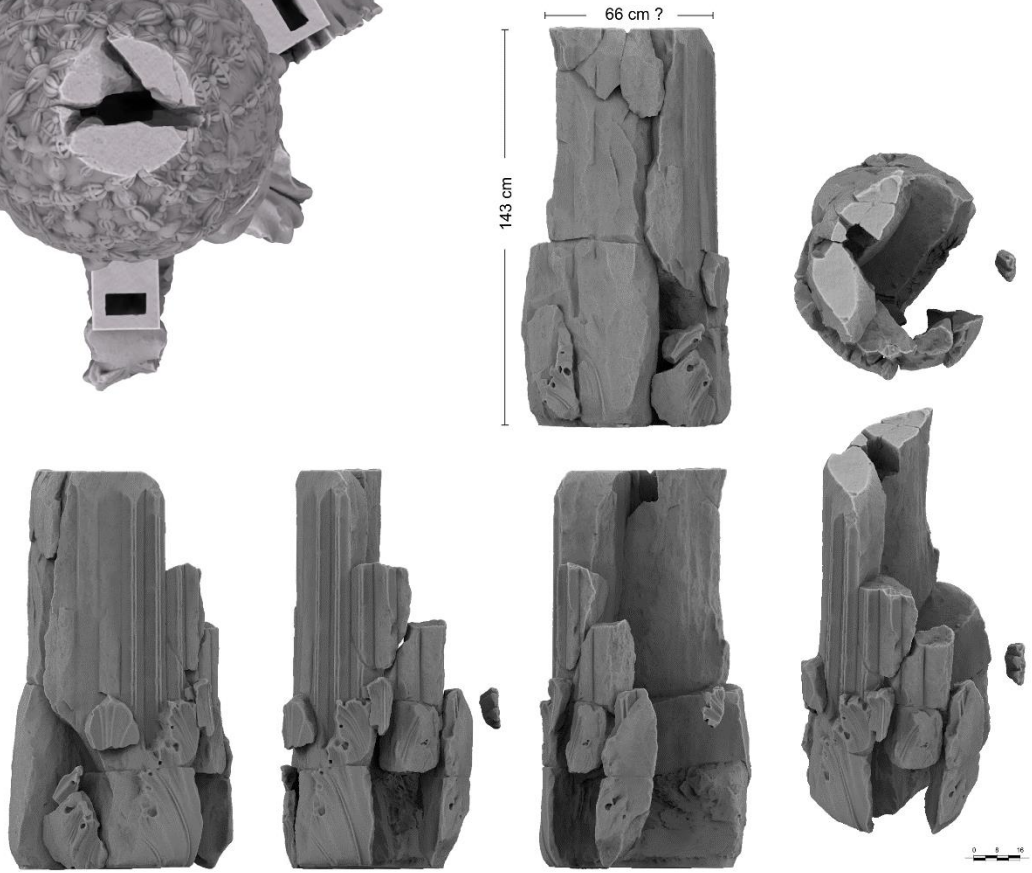
The Dancers column of Delphi

- Unrolling (Omphalos)

The Dancers column of Delphi



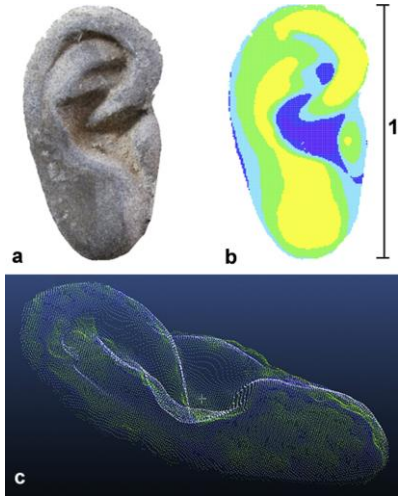
The Dancers column of Delphi



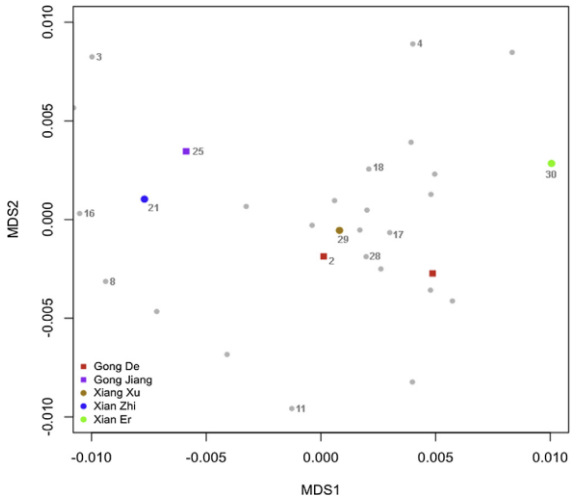
Classification of China's terracotta warriors ears (1)

Photogrammetry

Segmentation



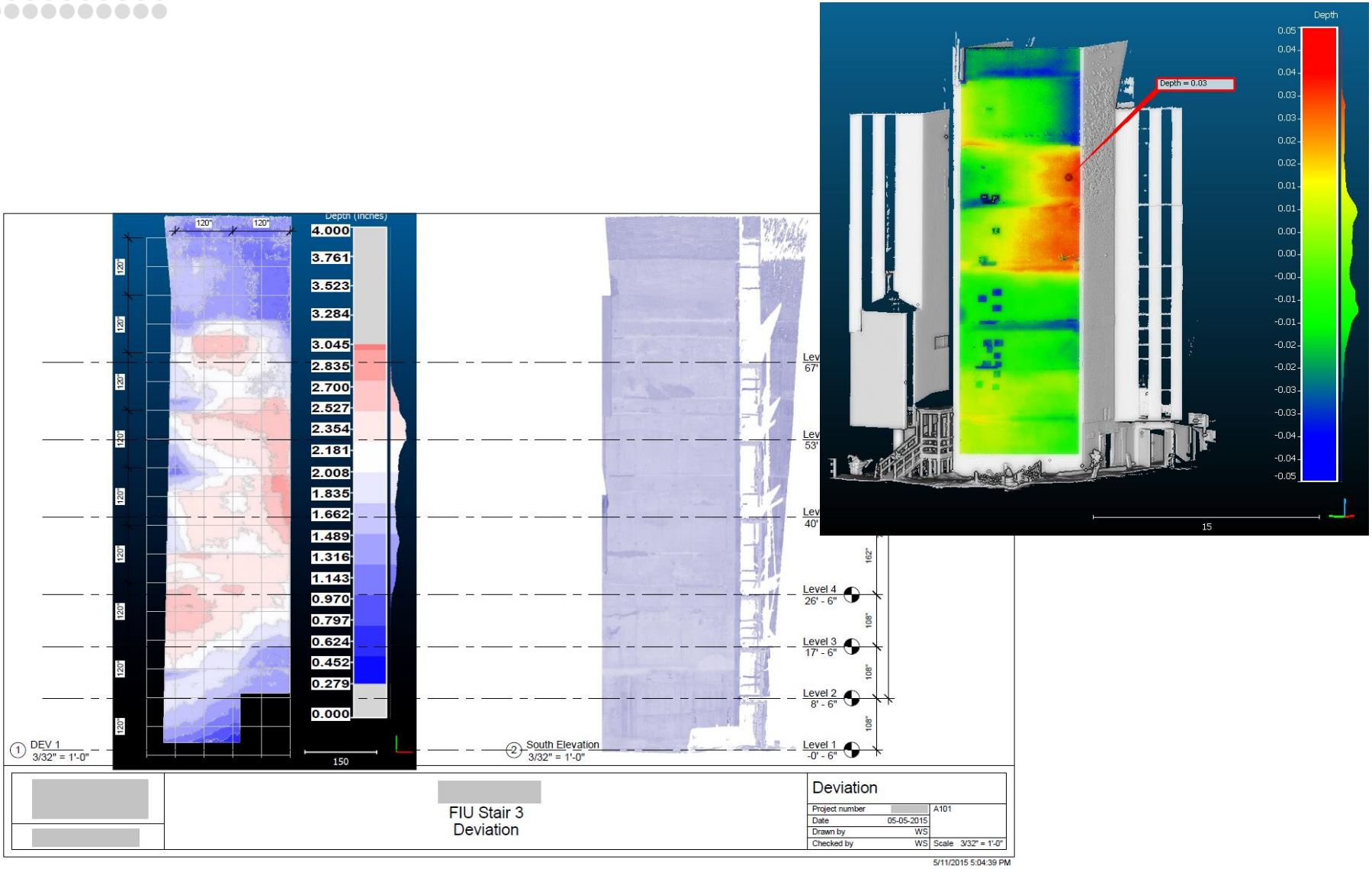
Pair-wise comparison



Classification

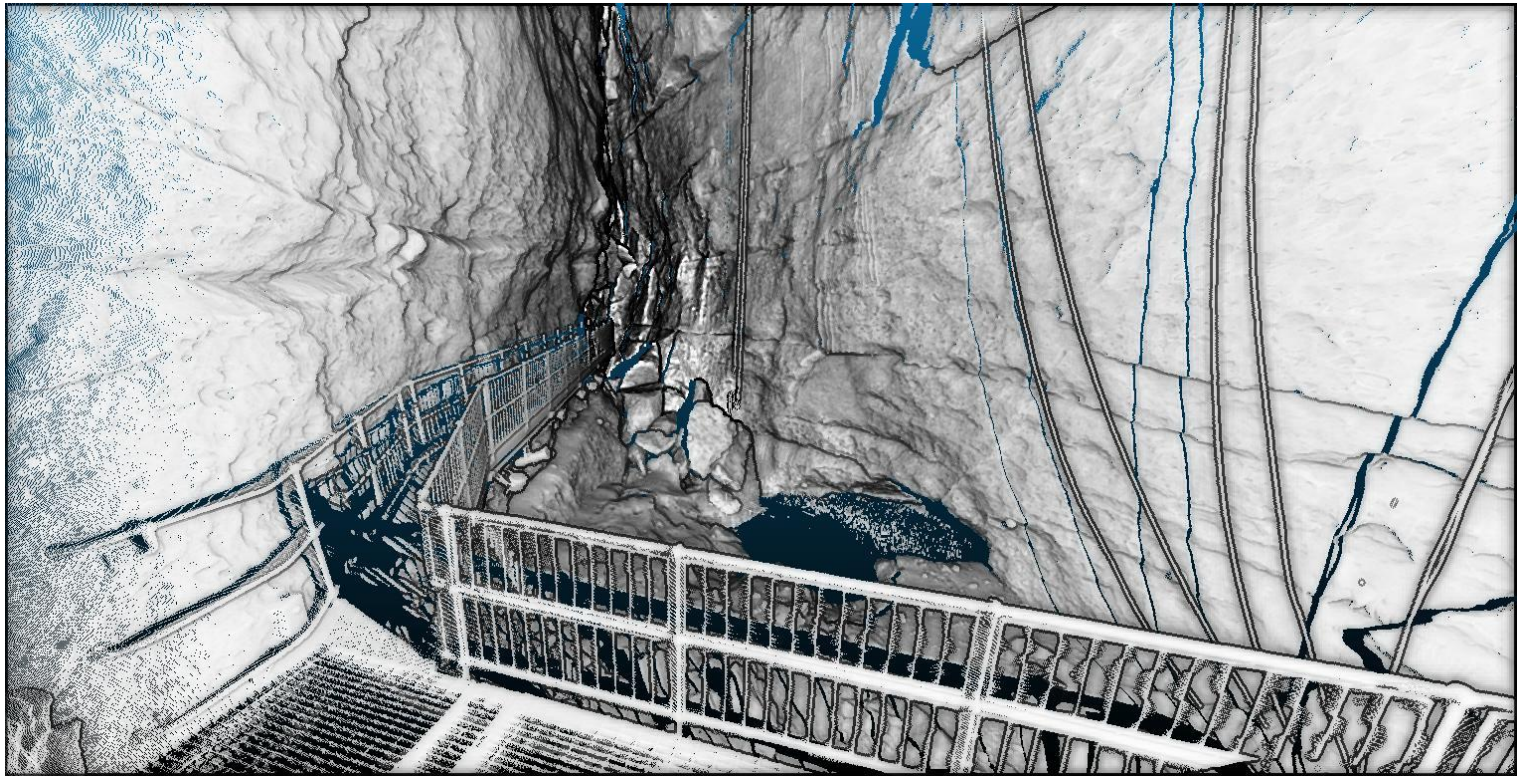
(1) Computer vision, archaeological classification and China's terracotta warriors, A. Bevan et al. 2014

Analysis of construction work for a court case

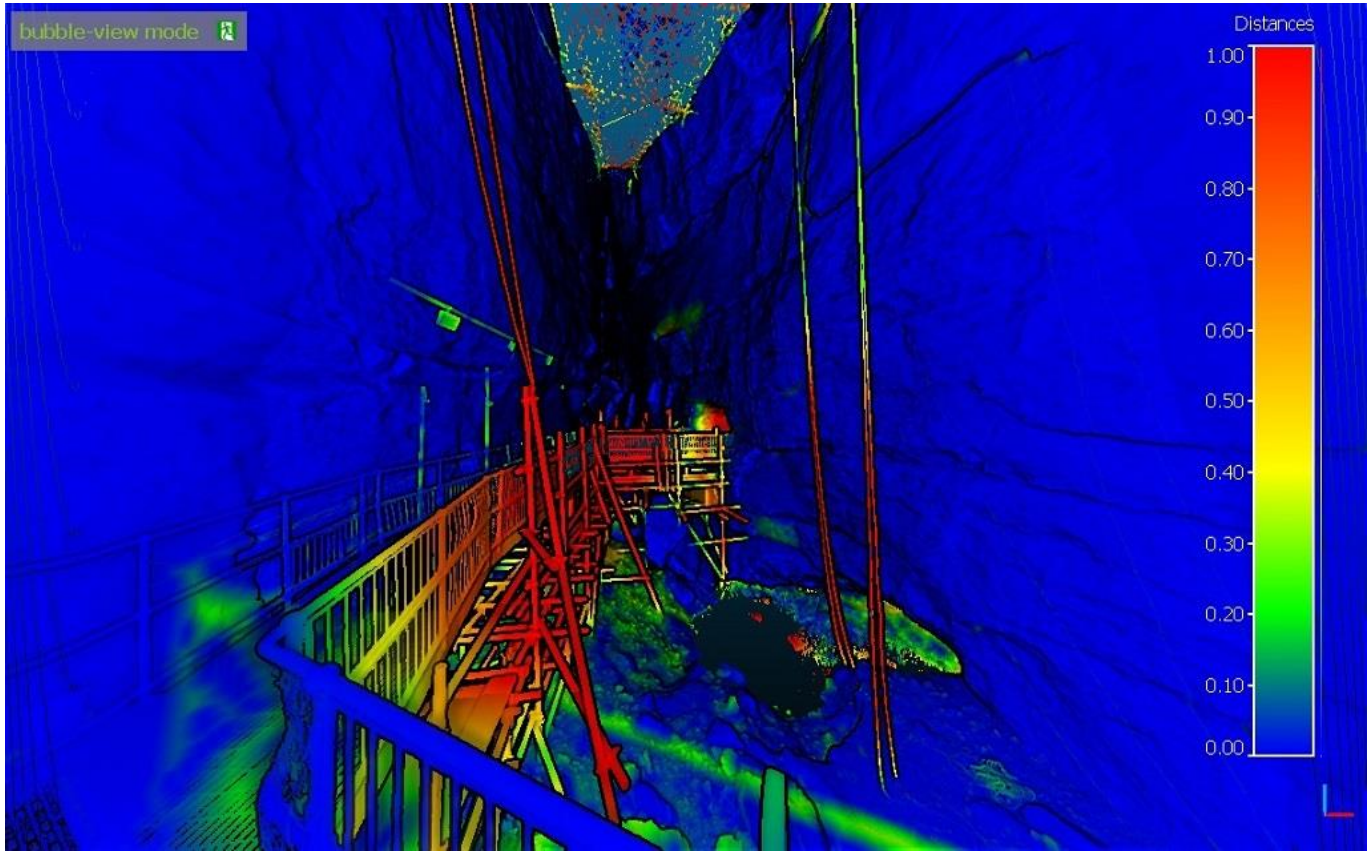


Comparison of scans in a cave

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

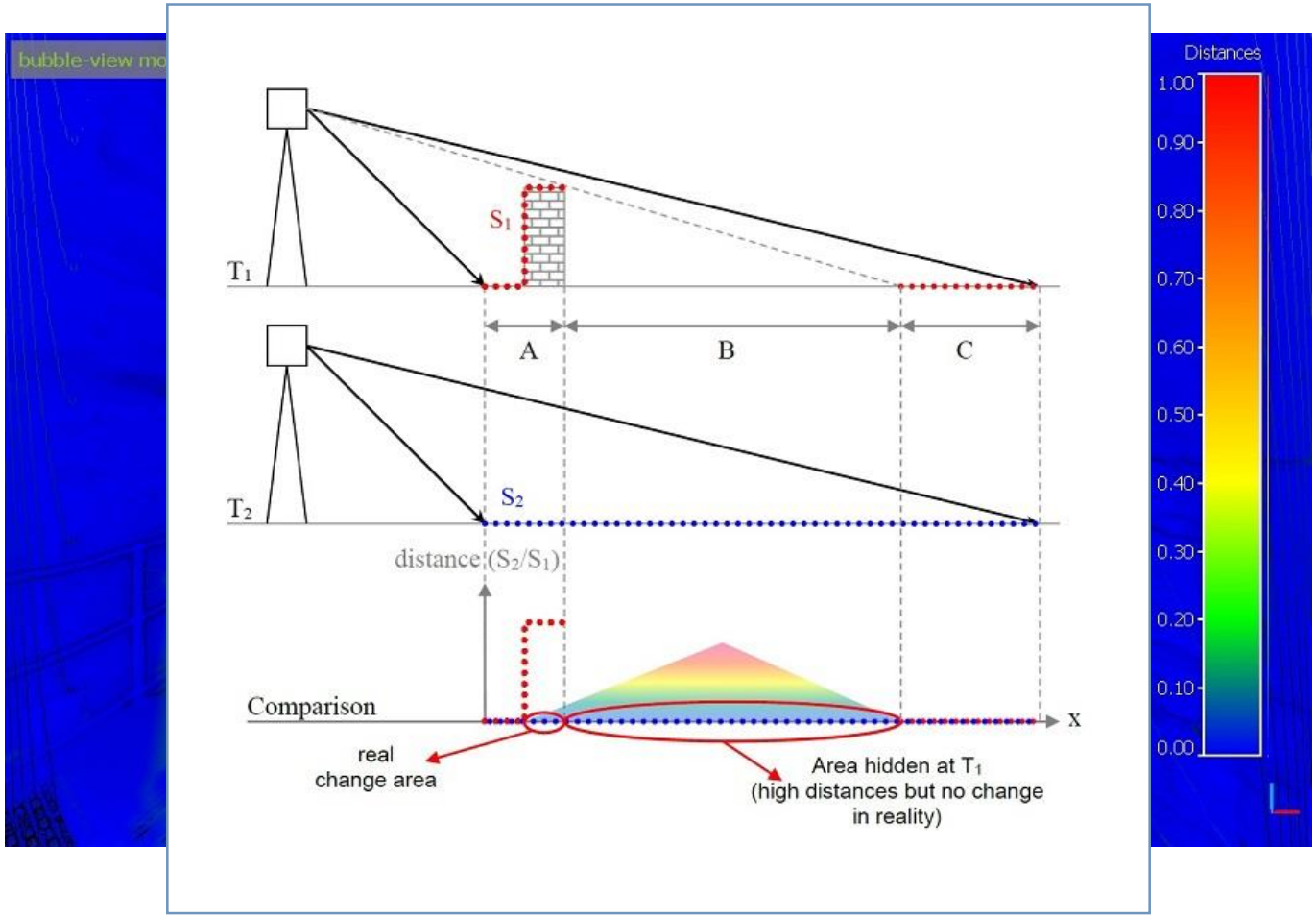


Comparison of scans in a cave

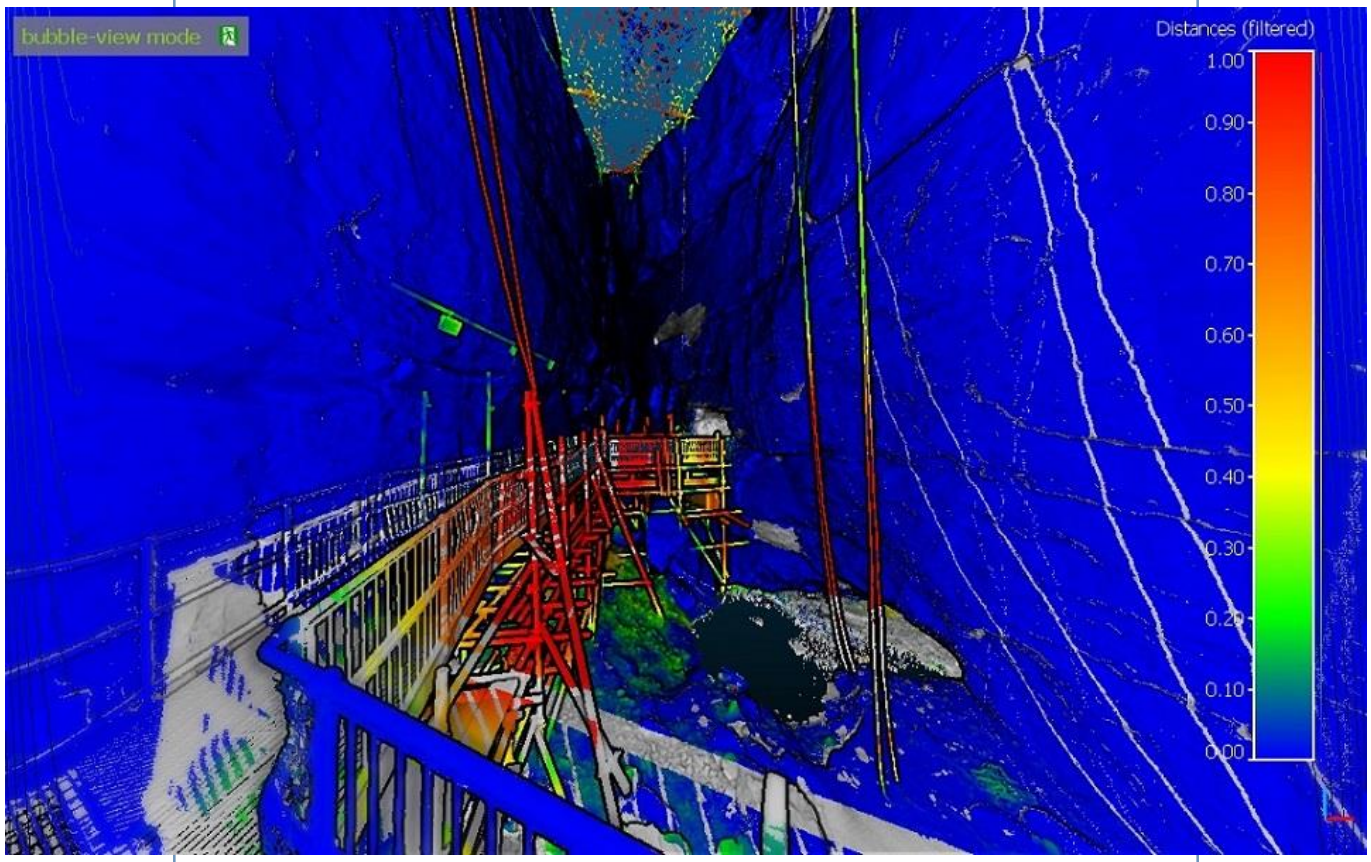


→ lots of false detections

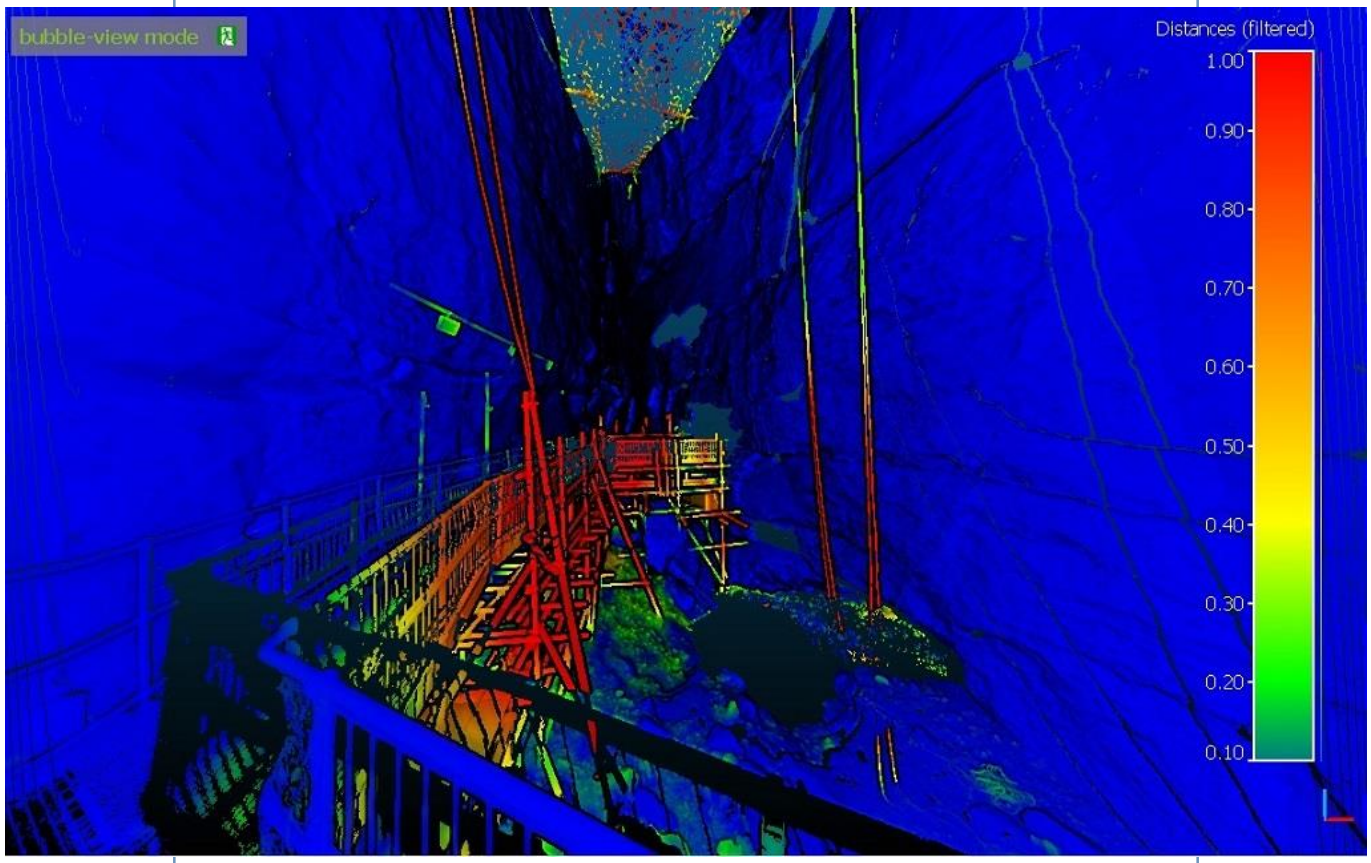
Comparison of scans in a cave



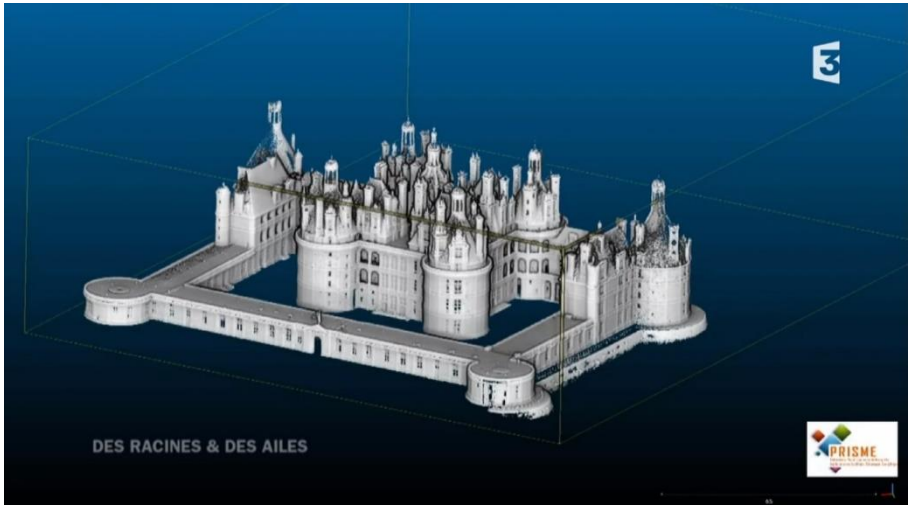
Comparison of scans in a cave



Comparison of scans in a cave



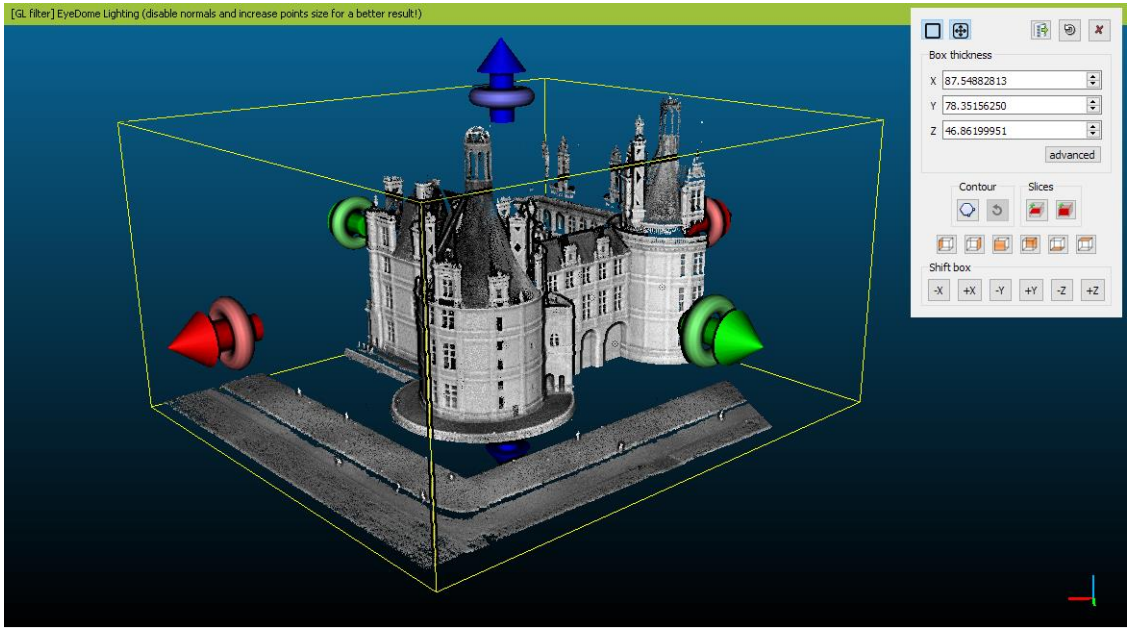
Chambord Castle

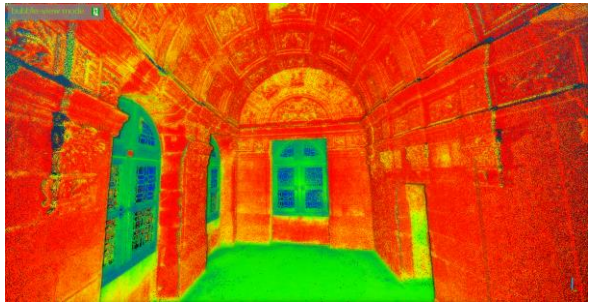


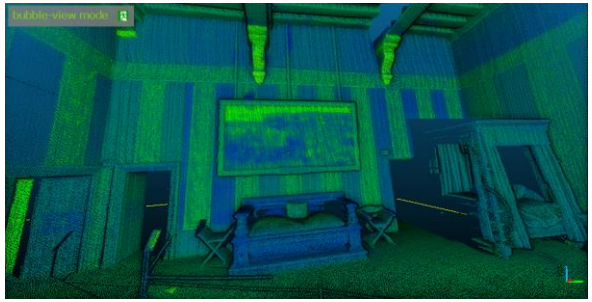
broadcasted on French TV ;)

- 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.)

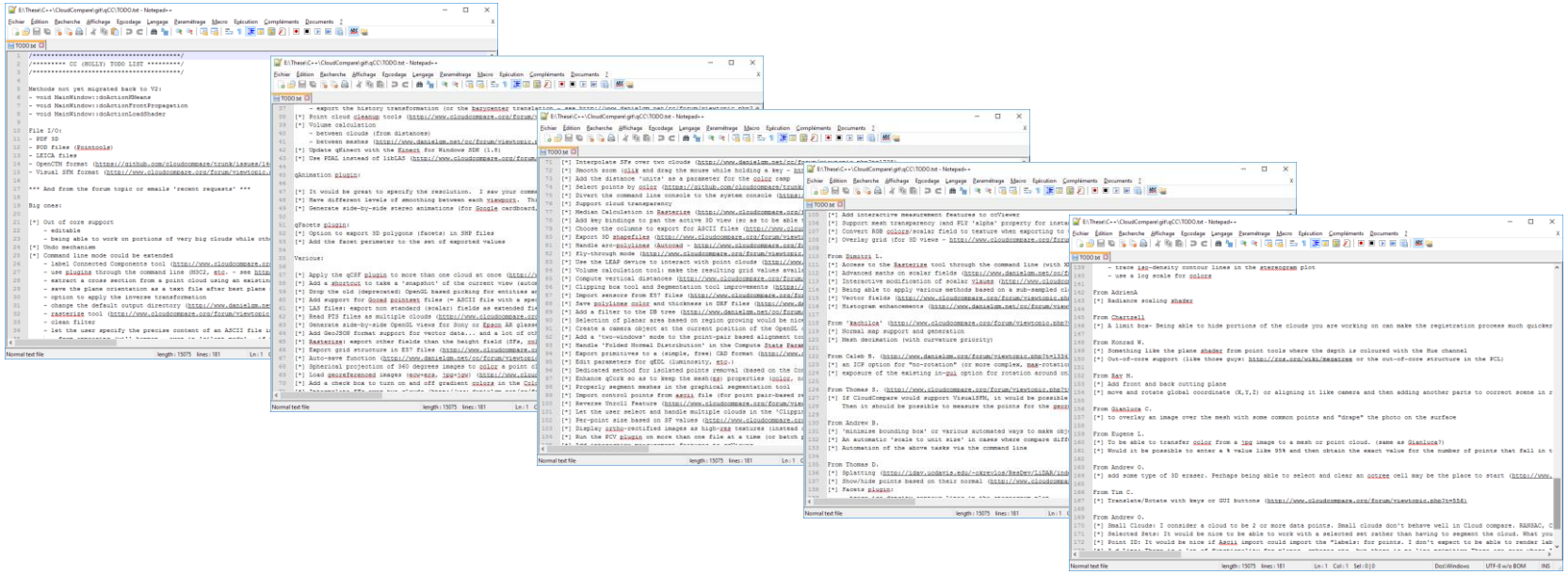
→ the whole dataset was delivered to the Castle's curators with… CloudCompare!

Future

In preparation

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

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



Thanks for your attention!

www.cloudcompare.org