

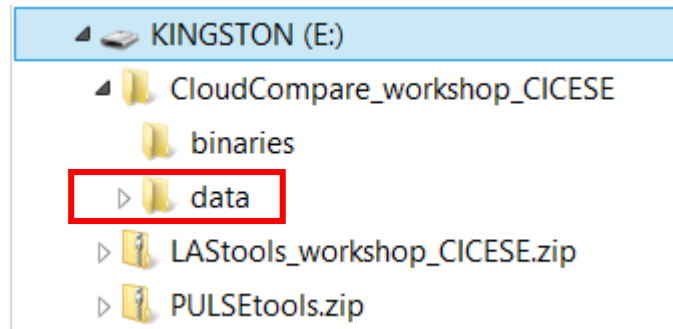


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Workshop

- Interactive!
- Copy the sample files from the USB thumb drive:



- You can install CloudCompare 2.6.1 with the Windows or Mac OS X 10.9+ installers (“*binaries*”). Otherwise go to:

www.cloudcompare.org



Outline

- About the project
- Generalities
 - Level 1: GUI, display, manual editing, etc.
- Advanced stuff
 - Level 2: registration, distances, scalar fields, etc.
- And everything else...



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



o **EDF**

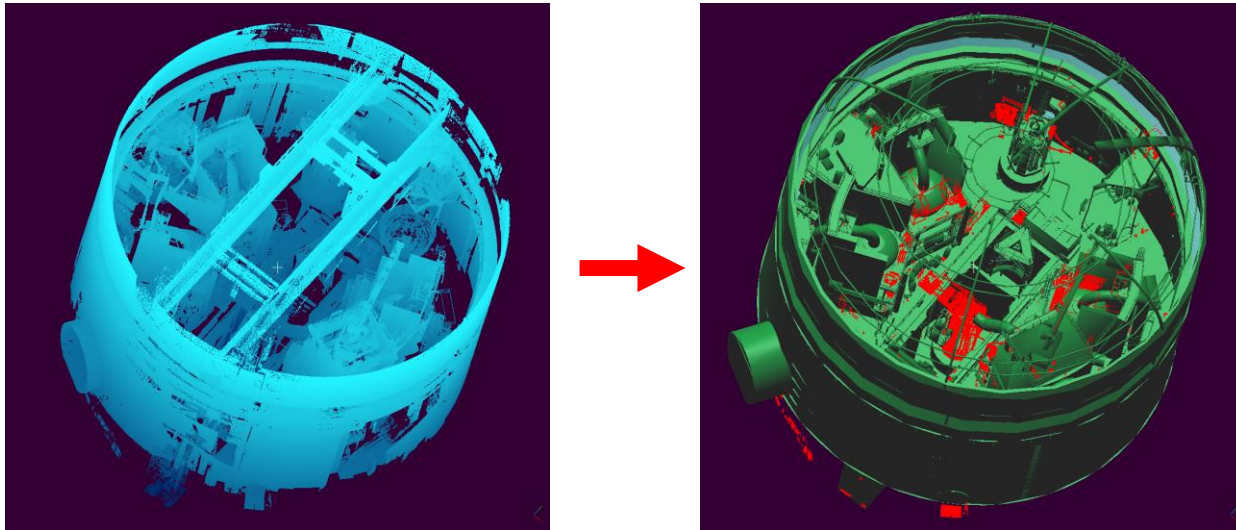
- main French power utility
- Over 150 000 employees worldwide
2 000 @ R&D (< 2%)
200 know about CloudCompare (< 0.2%)
- Sales >75 Bn € (90 Bn \$)
- Over 200 dams
- 58 nuclear reactors (19 plants)





EDF and Laser Scanning

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



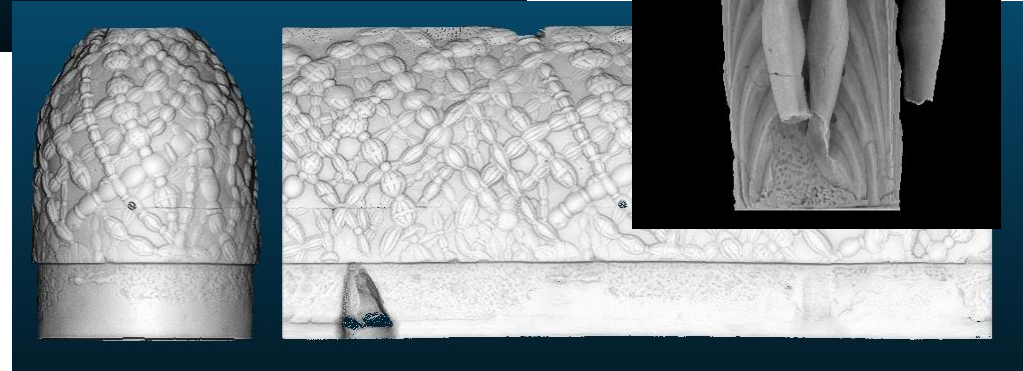
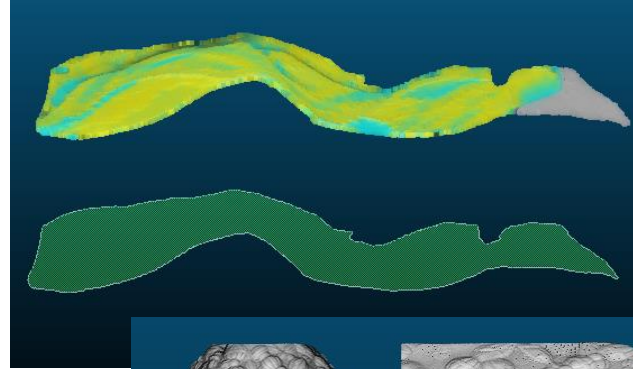
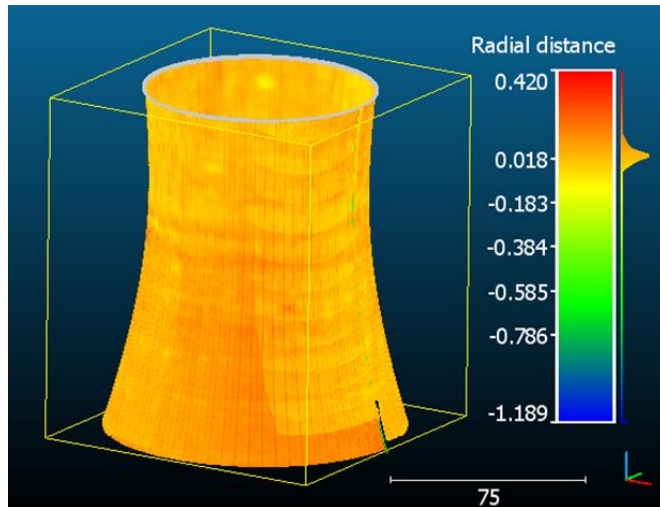
Scanning a single nuclear reactor building

- 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)



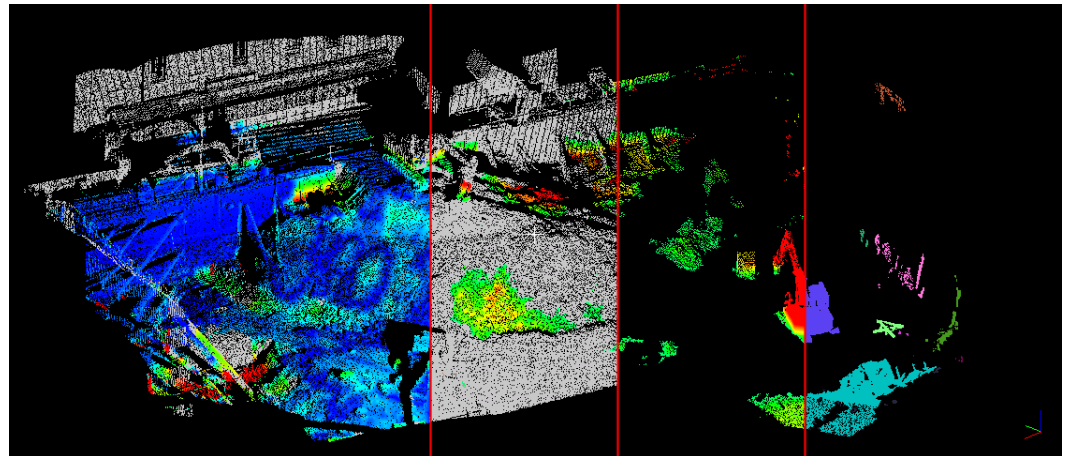
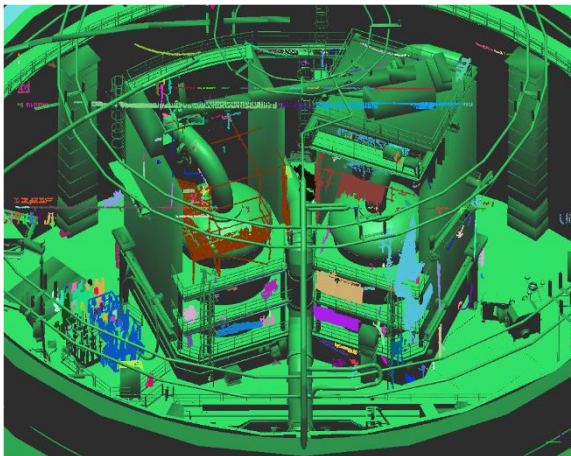
TLS was used for: visualization, optimal crane placement, measurements, monitoring the subsidence of the wreckage pile, slurry wall monitoring, etc.



CloudCompare V1



- 2004-2006
- Initial goals: to compare freshly (*and big*) acquired point clouds to quickly assess for changes
 - either between a cloud and a mesh/CAD
 - or directly between two clouds (→ *the high density of TLS clouds is the key*)





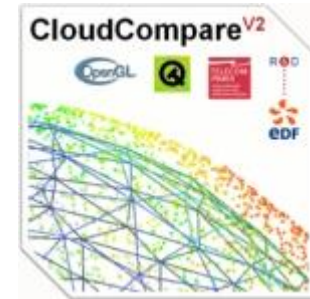
CloudCompare V2

- 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
- Moreover 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
- 2014: CloudCompare **V2.6**
- Works on:
 - Windows (XP / 7 / 8)
 - Mac OS (*thanks to Andy Maloney*)
 - Linux (*thanks to Romain Janvier*)
- Supports 3D mice (*Windows only*)





Open-source!

- Quickly evolving
- Goes where the users want...
... goes there faster if the users are able to actively participate!
- Remains under strict supervision of the administrator ;-)
- Independent on any manufacturer
- Meant to survive: backed by strong companies and institutions (EDF, BRGM, CNRS, etc.)



Open-source!

- Free...



- ...but someone has to “pay” ;)
 - either by working on the project
 - or by paying someone to do so
- plugins are not necessarily public or free



Users

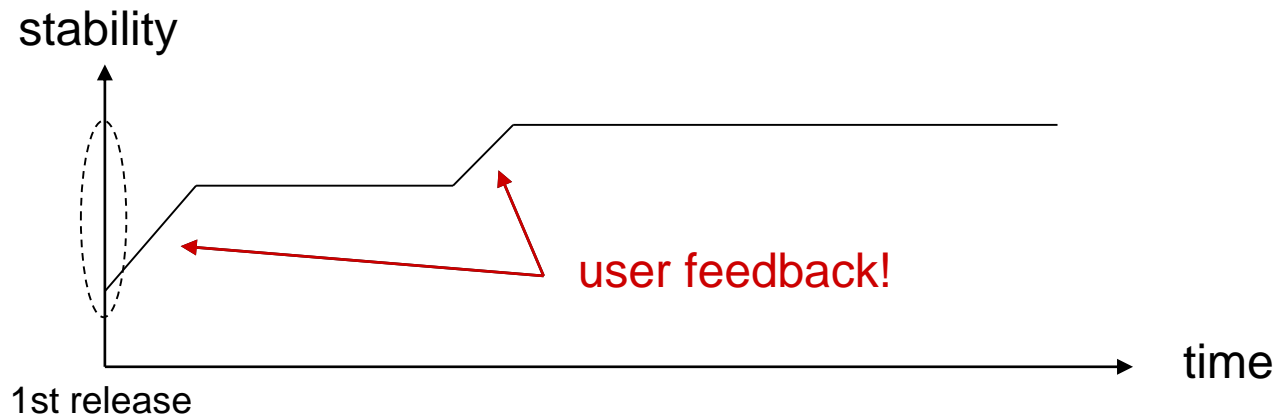
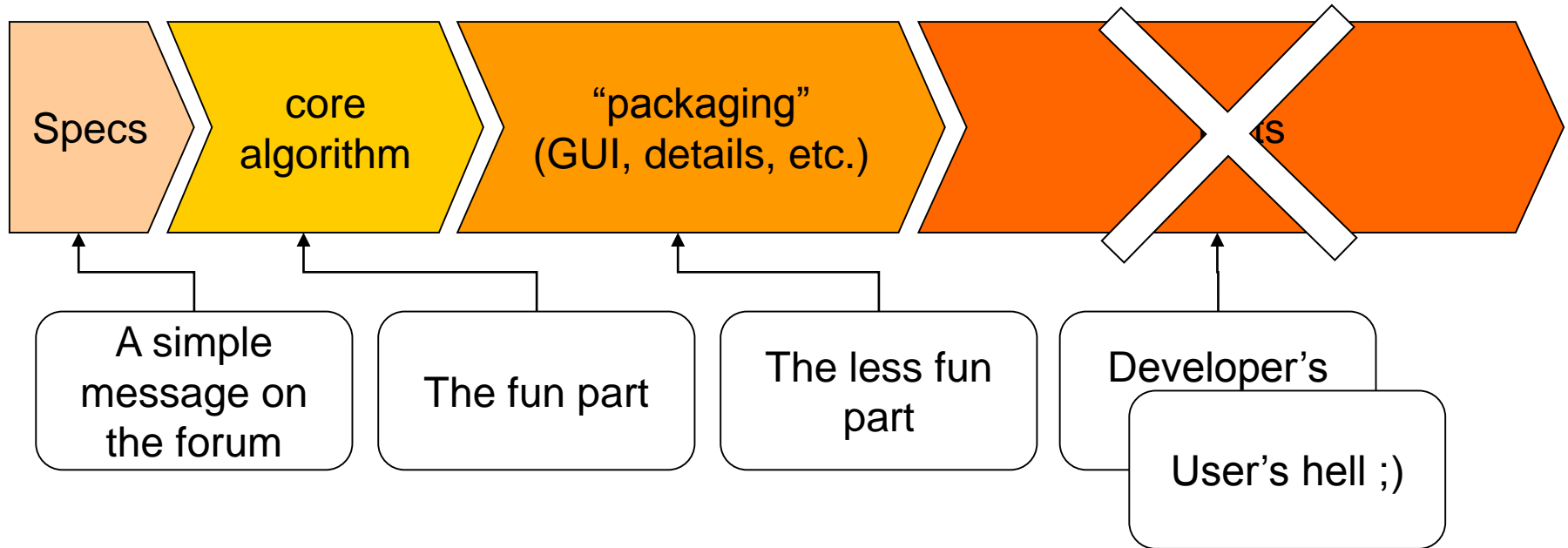
- Too many ;)
 - Academics:
 - remote sensing
 - geology
 - archeology
 - etc.
 - Surveyors
 - Forensic experts
 - Architects
 - MDs, dentists
 - 3D designers
 - Artist?!

Developers

- Barely enough
 - few
 - none
 - none
 - none
 - none
 - none
 - none

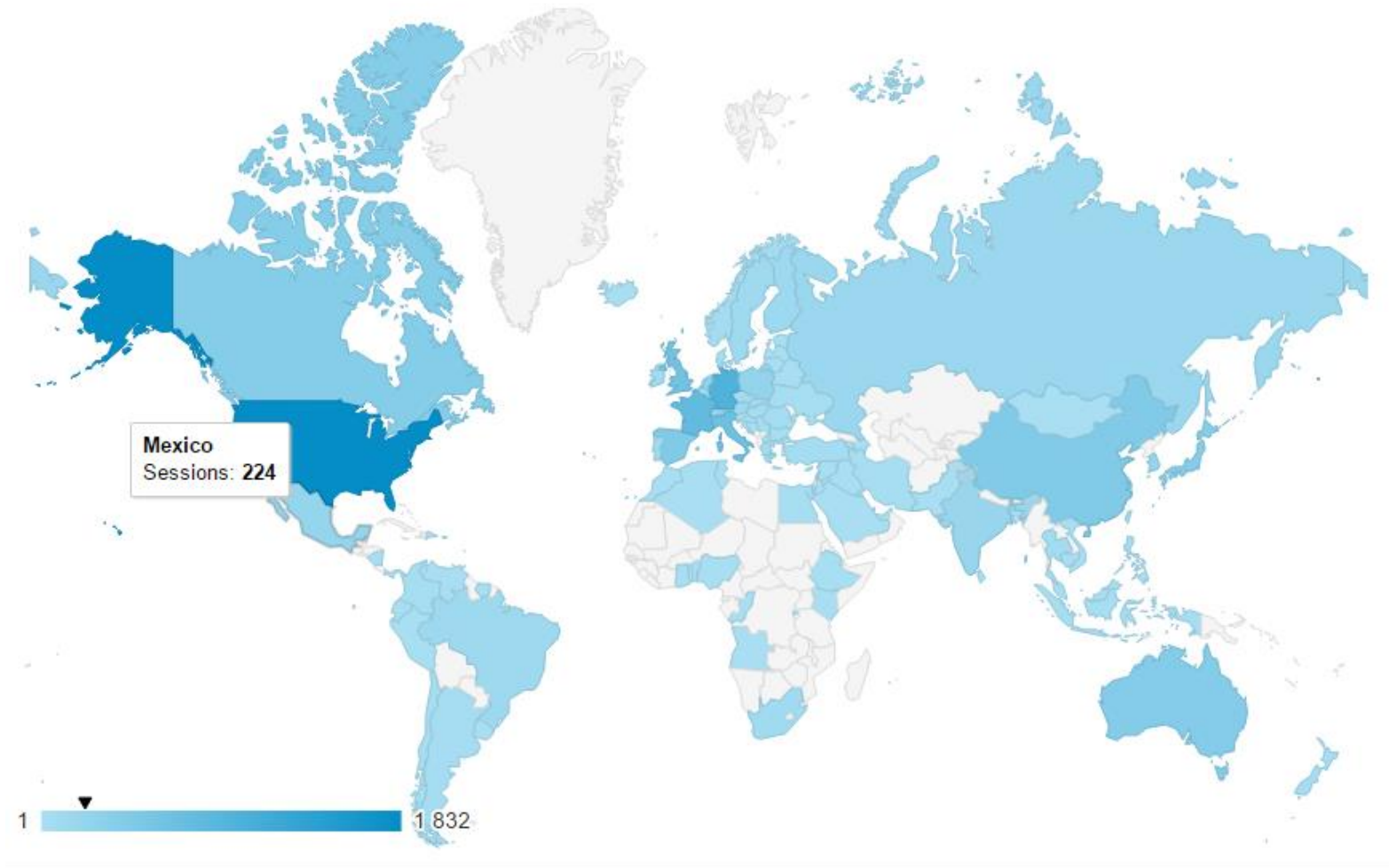


Development cycle





Worldwide users



> 1300 subscribers to the news letter

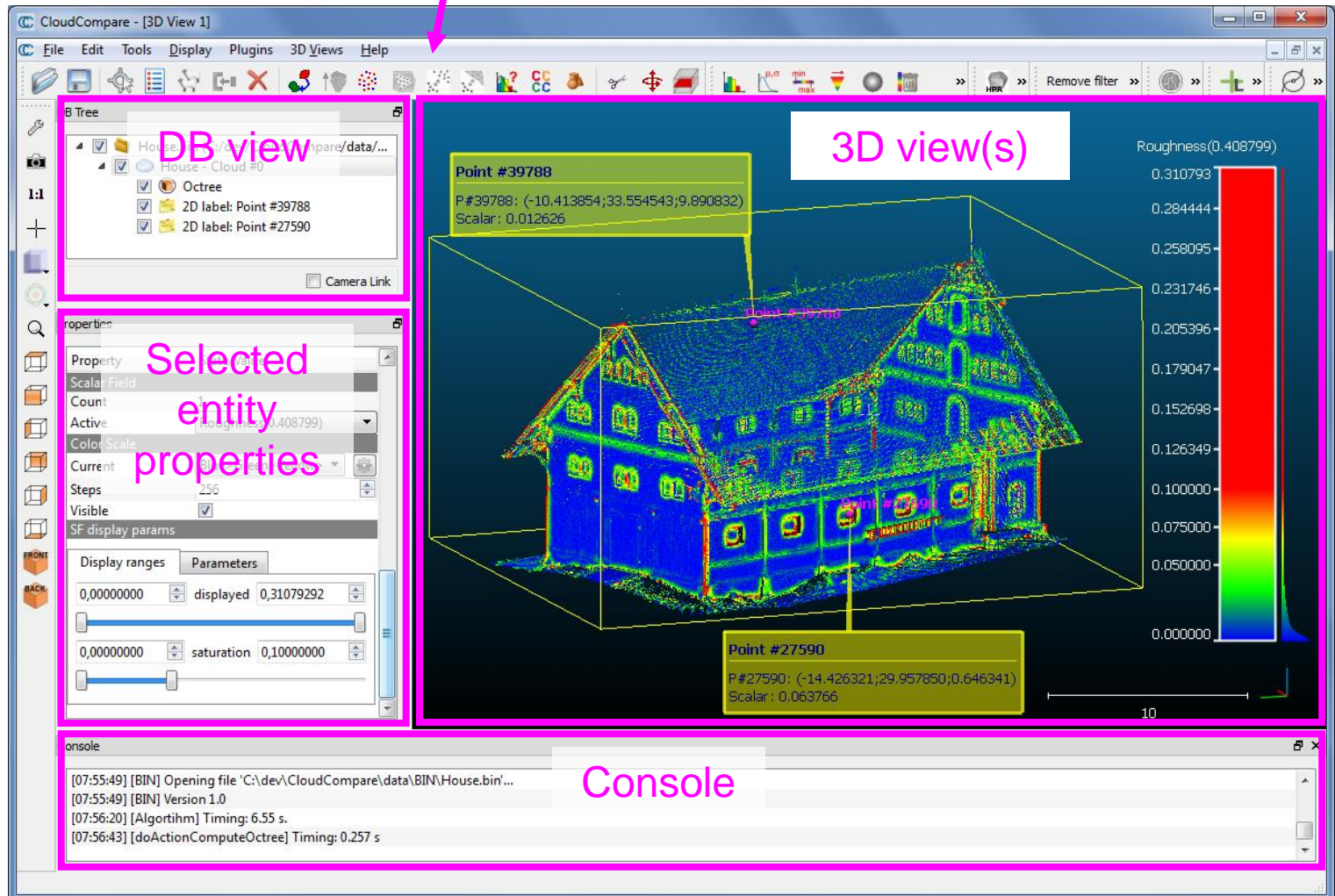
● ● ● Generalities



User interface overview

Menus + main toolbars

View
toolbar



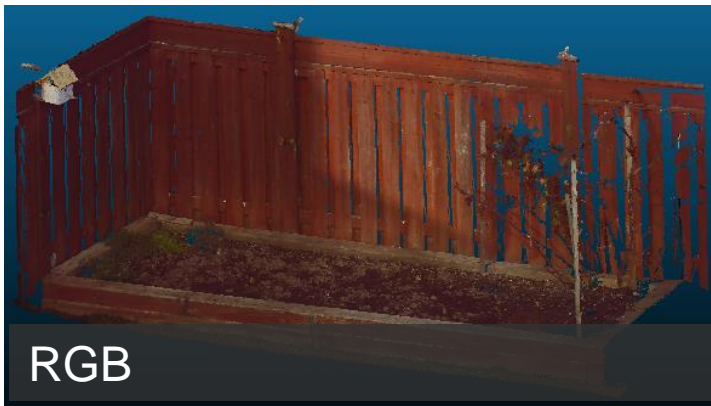
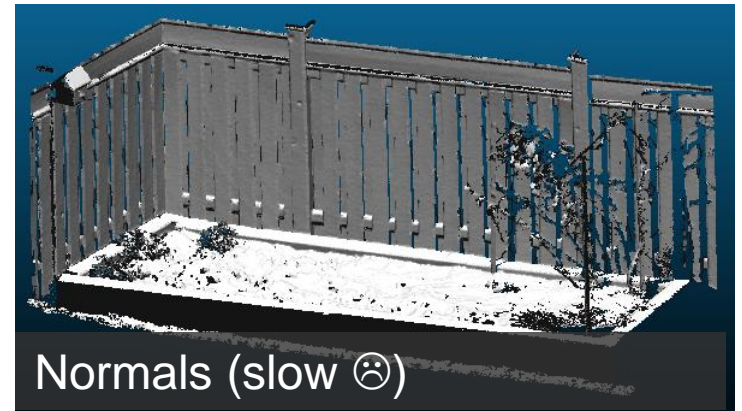
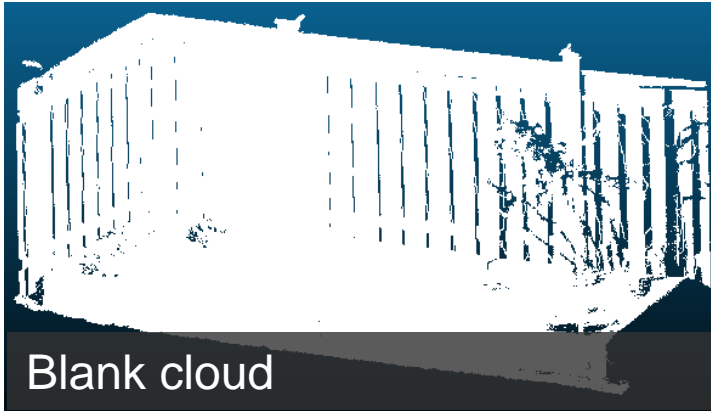


Input/Output

- Mainly point clouds (ASC/PTS, LAS/LAZ, E57, PTX, FLS/FWS, DP, etc.) and triangular meshes (PLY, OBJ, STL, OFF, FBX)
- Dedicated format: “BIN” (for projects)
- Other formats: calibrated photos (Bundler .OUT), CAD (Autocad DXF drawings, Aveva .PDMS scripts), GIS shapefiles
- To come:
 - RIEGL files
 - more manufacturer formats?



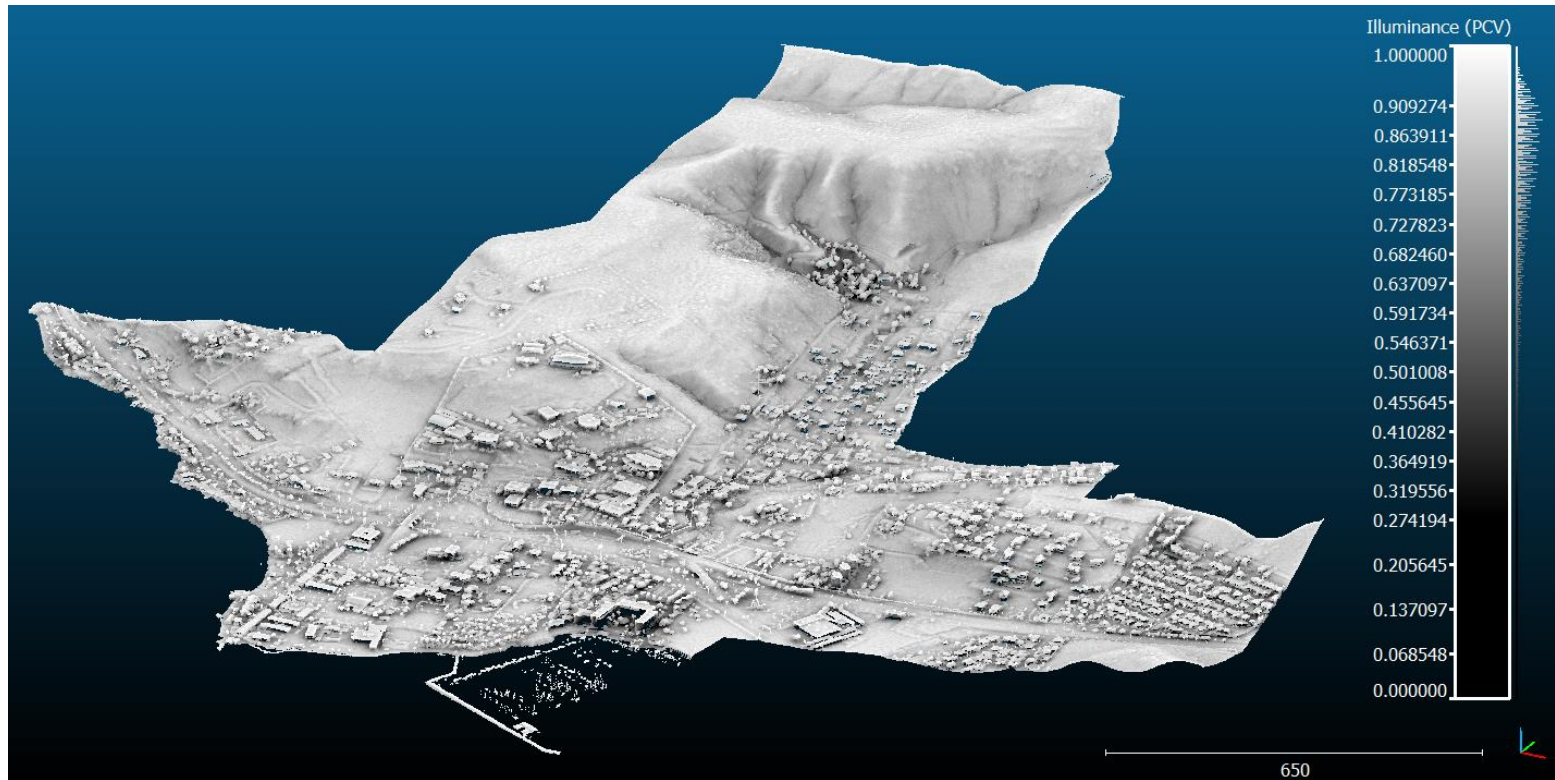
Clouds display





PCV

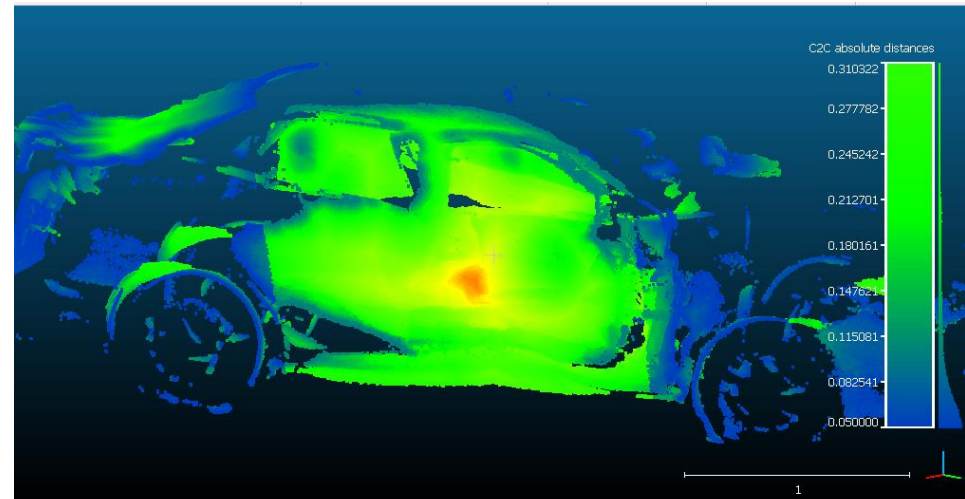
- Global illumination / ambient occlusion





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





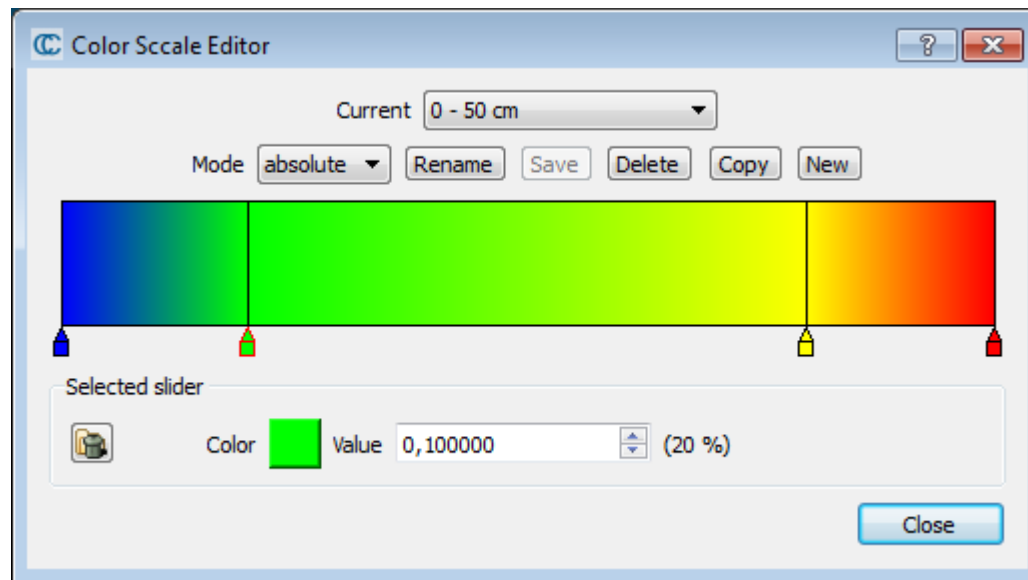
Scalar fields

- 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
- Values can be exported to a CSV file
(→ Excel, Matlab, etc.)



Color scales

- Color Scale Editor : edit and create color scales

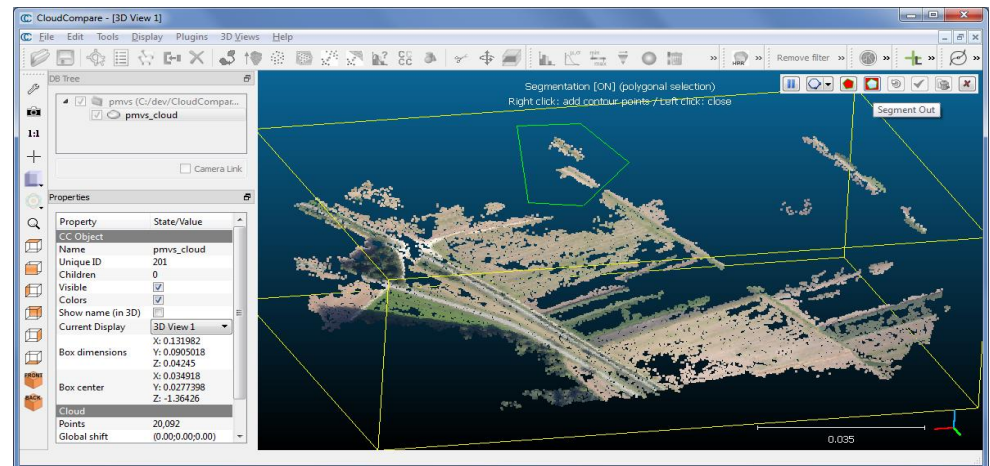


- *Color scales can now be imported/exported as XML files*
- *When saving a « BIN » file, custom scales are automatically exported (and will be automatically imported when opening the file on another PC)*



Manual editing

- Manual transformation
- Manual segmentation
- Cross Section
- Color / Normal editing
- Sub-sampling tool
- Scaling
- Cloning / Merging

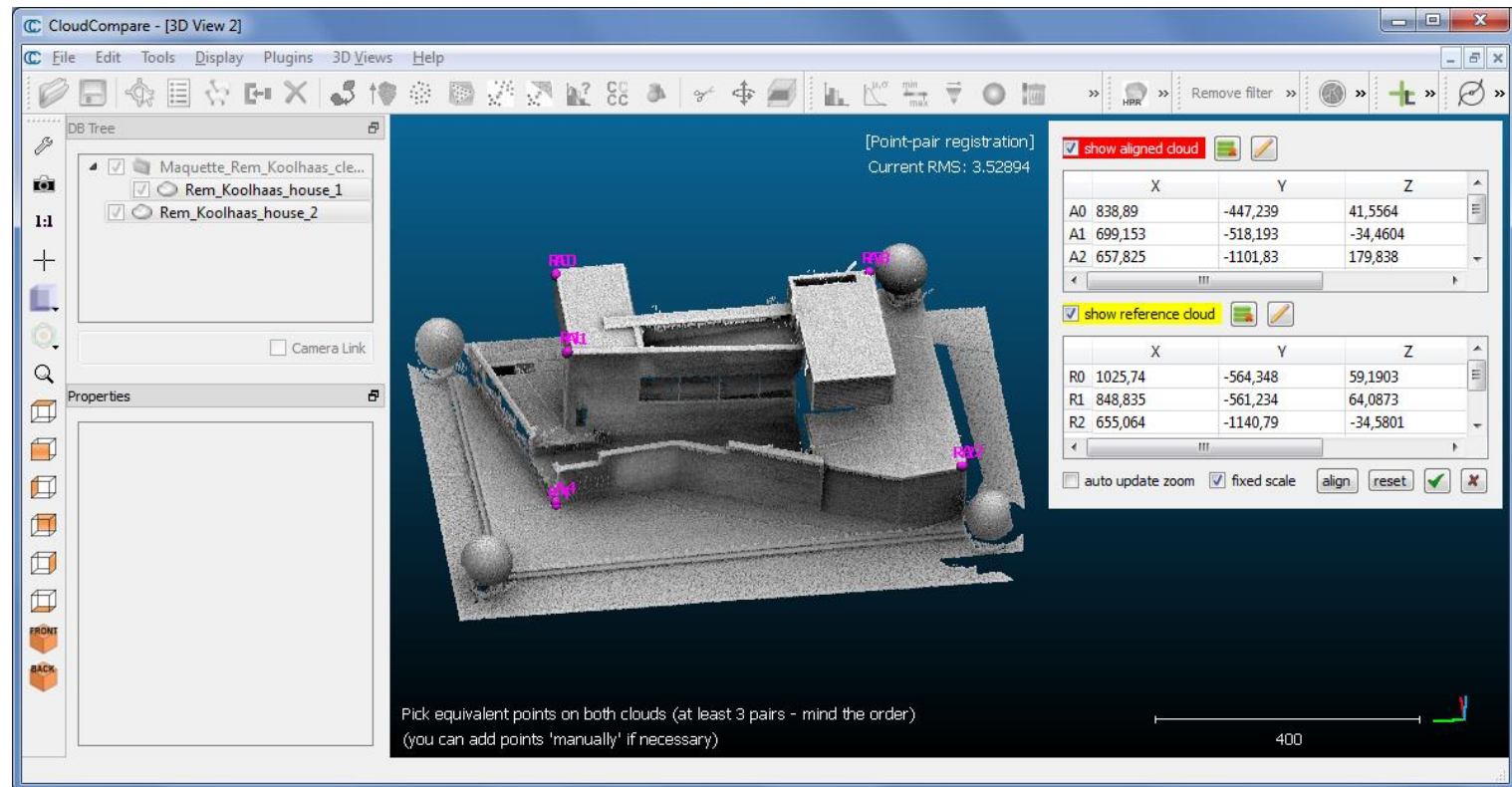


● ● ● Advanced



Registration

- Point-pair based alignment
- Automatic registration (ICP)



+ semi-automatic ball detection



Registration

Some considerations

What if my entities have some “structural differences”?

- Small local differences:
 - ICP: *‘Enable farthest points removal’* checkbox
- Different scales:
 - Point-pairs based alignment: uncheck the *‘Fixed scale’* checkbox
 - ICP: check the *‘Free scale parameters’* checkbox
- Major differences:
 - Prefer the “point-pairs based alignment” tool!

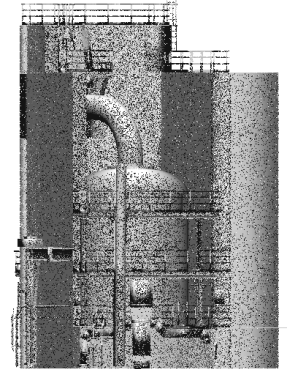
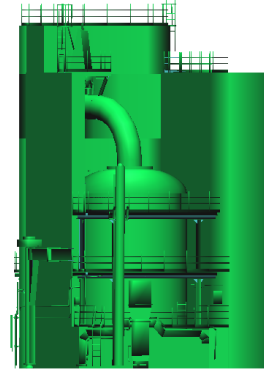


Registration

Some (more) considerations

What if one of the entity is a mesh?

- Almost the same workflow
- Sometimes you may have to
 - sample points on the mesh first (*Edit > Mesh > Sample points*)
 - then apply the resulting transformation on the original mesh (*Edit > Apply Transformation*)
- For the ICP process (*fine registration*) the mesh should always be the 'reference'
 - generally less holes and/or noise

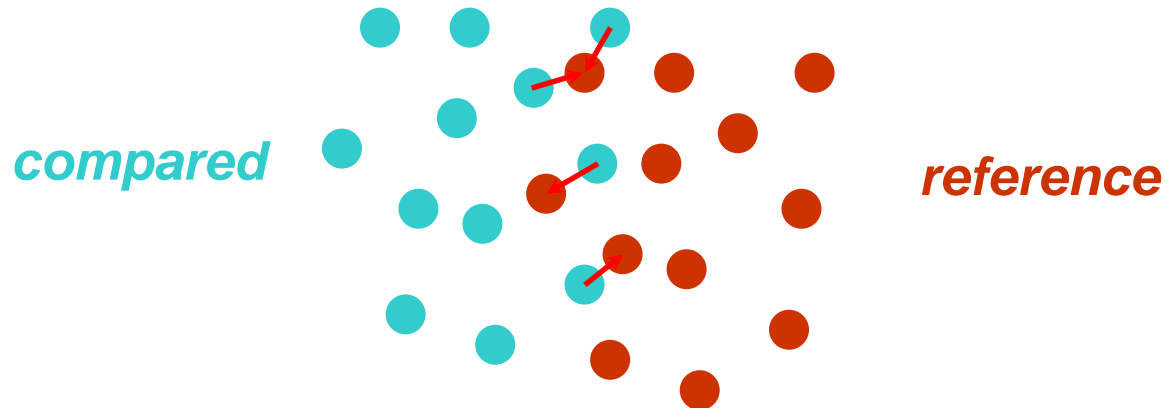


● ● ● Distances computation



Distances computation

- Distances are computed between each point of a 'compared' cloud and its nearest point or triangle in a 'reference' entity





- **Process is not symmetrical**



Distances computation

Two (or three) cases

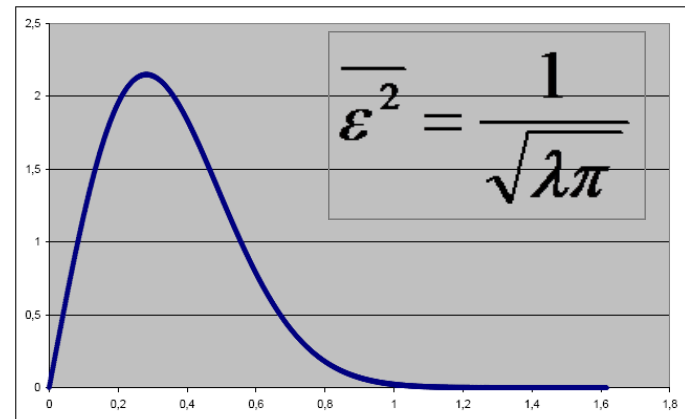
1. Comparison of two clouds 
2. Comparison of a cloud and a mesh 
3. Comparison of two meshes: *the only way to do this in CloudCompare is to sample points on the 'compared' mesh* → back to case 2



Cloud-cloud distances

- **Main idea:** if the 'reference' cloud is dense enough, then the *nearest neighbor* distance will be (almost) as accurate as the *true* distance to the underlying surface

- Error is bounded
- Error depends on the reference cloud density only



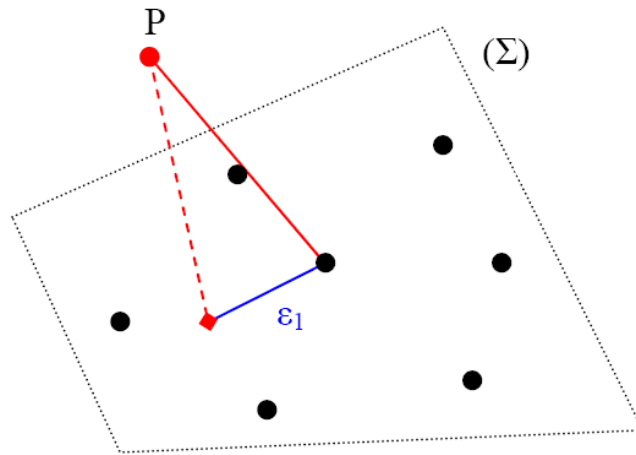
N.N. distances in a random
Poisson process

- Consequences:
 - Use the denser cloud as reference (if possible)
 - The reference cloud extents must be at least as large as the compared ones (*avoid non overlapping areas!*)



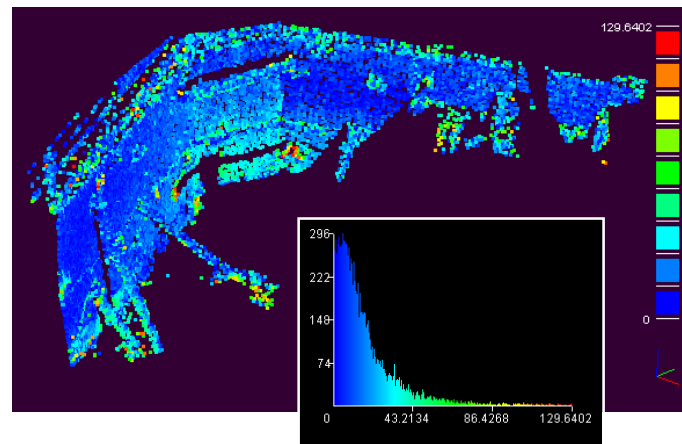
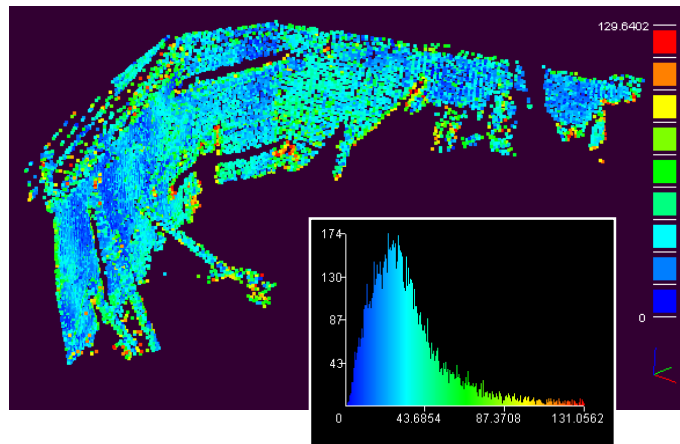
Poor or irregular density?

Local meshing strategy



— measured distance
- - - real distance

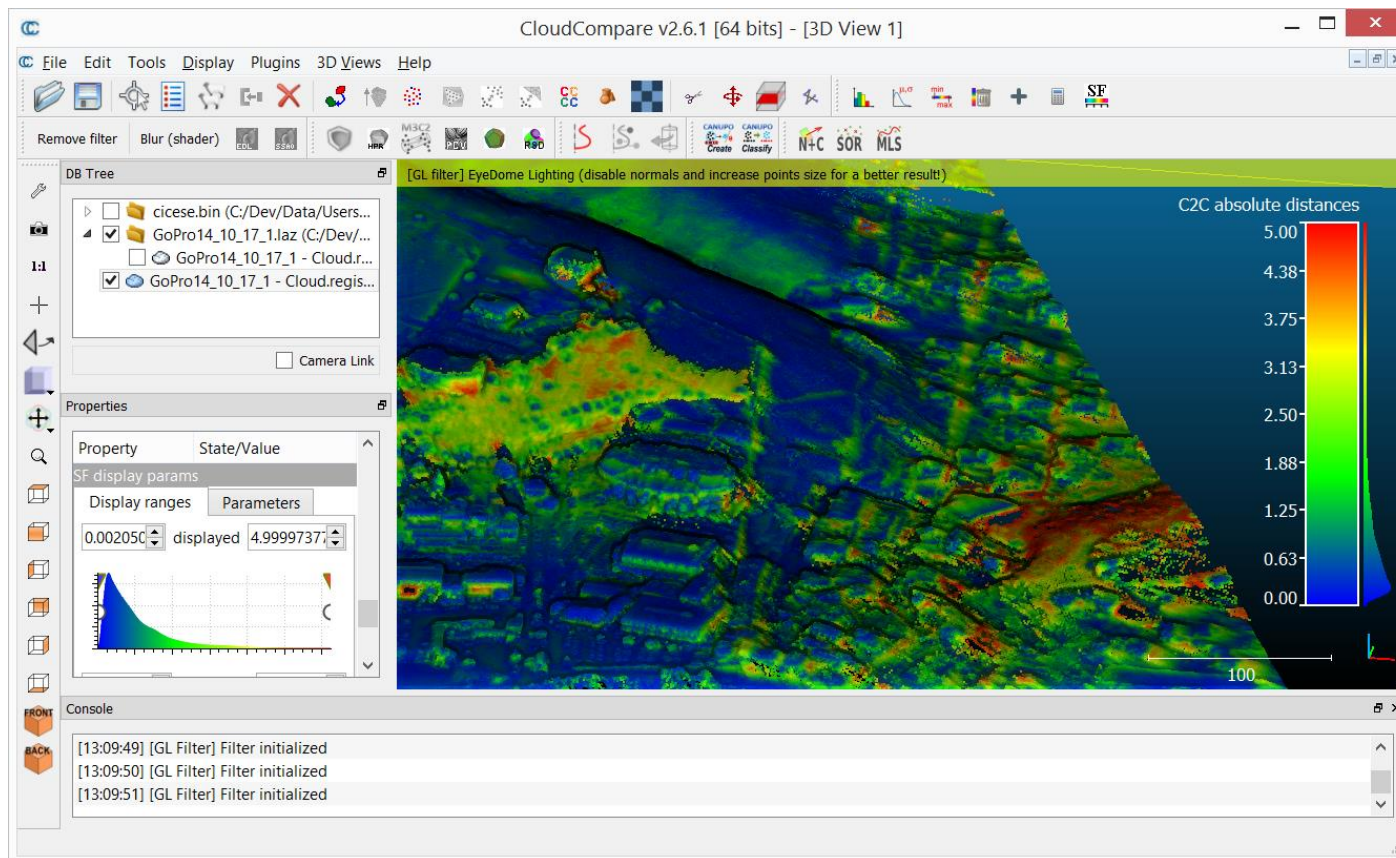
Local modeling: 2 to 5
times slower





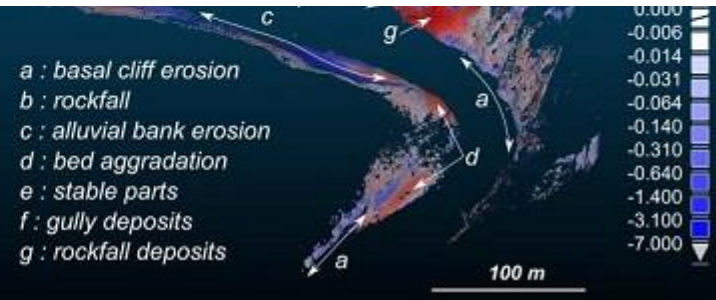
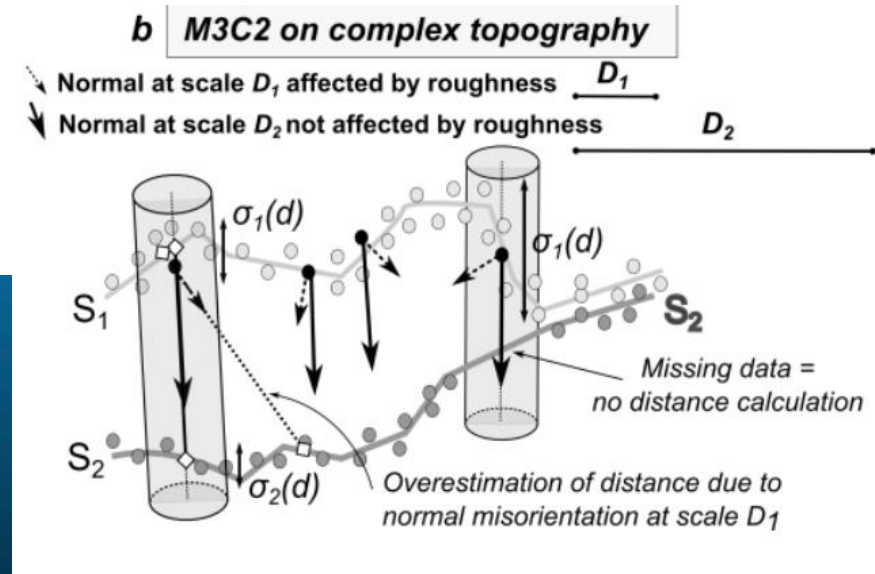
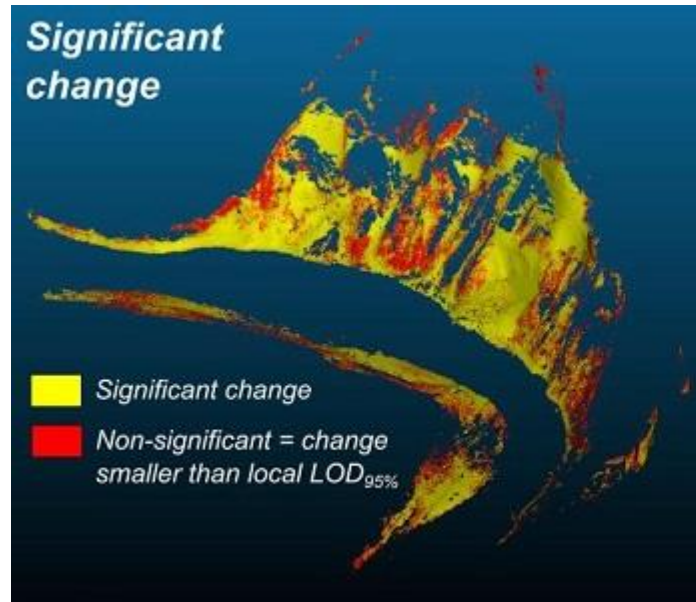
Cloud-cloud distances

- Select both entities
- Tools > Distances > Cloud/Cloud dist. 






Robust C2C distances with M3C2



Lague, D., Brodu, N. and Leroux, J., Accurate 3D comparison of complex topography with terrestrial laser scanner : application to the Rangitikei canyon (N-Z), 2013, [ISPRS journal of Photogrammetry and Remote Sensing](#)

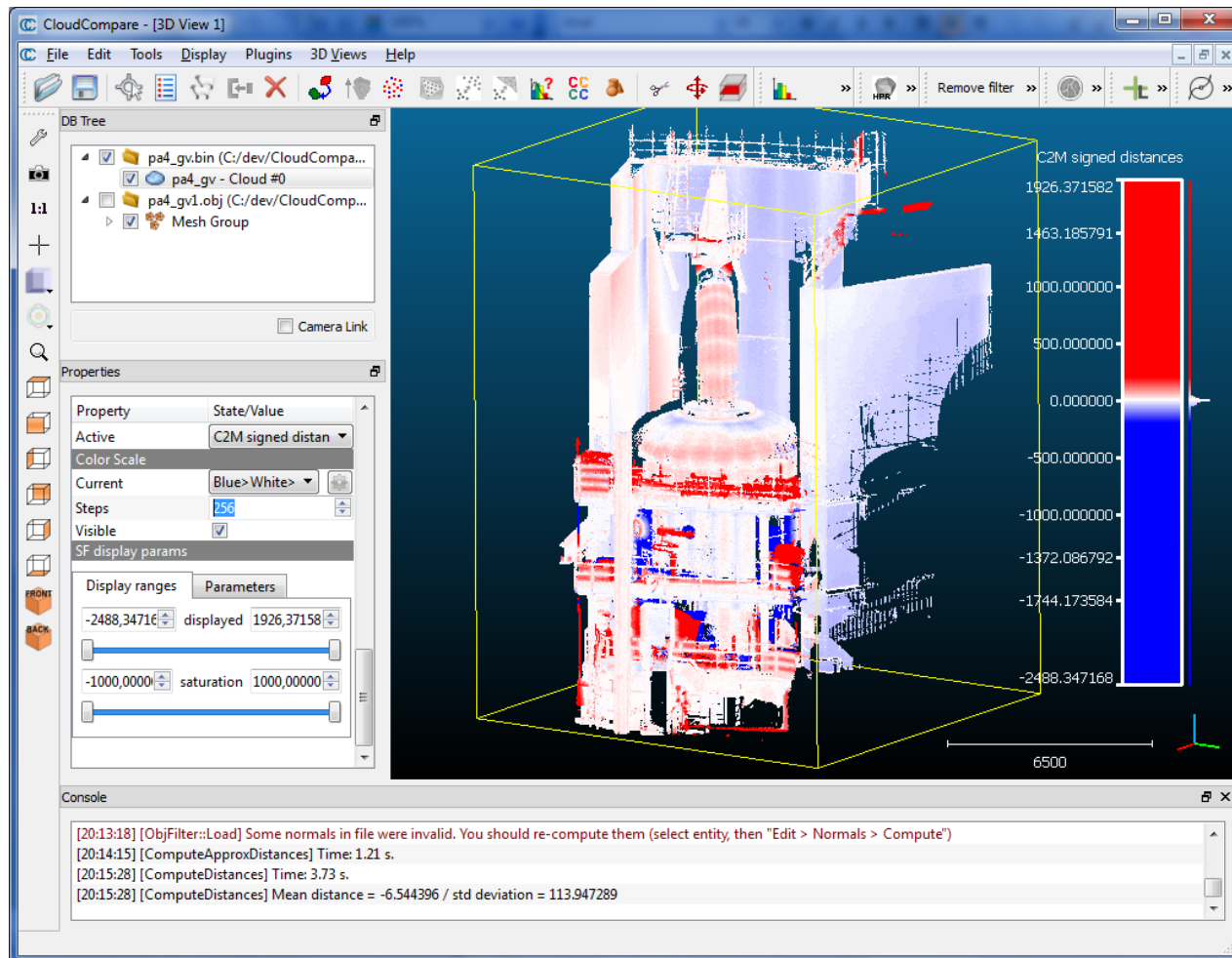


Cloud-mesh distances

- Tools > Distances > Cloud/Mesh dist. 
- In this mode, the distance is computed between each point of the 'compared' cloud and its nearest triangle in the 'reference' mesh
- If the mesh quality is good, this is generally faster and more accurate... but getting a clean mesh can be hard!
- Regarding the output, the only difference with the cloud/cloud case is that the distances are signed (*we use the triangle normal*)



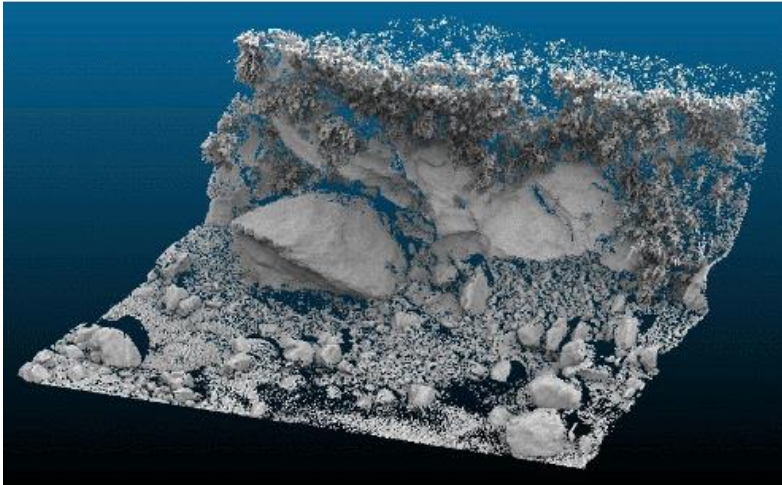
Cloud-mesh distances



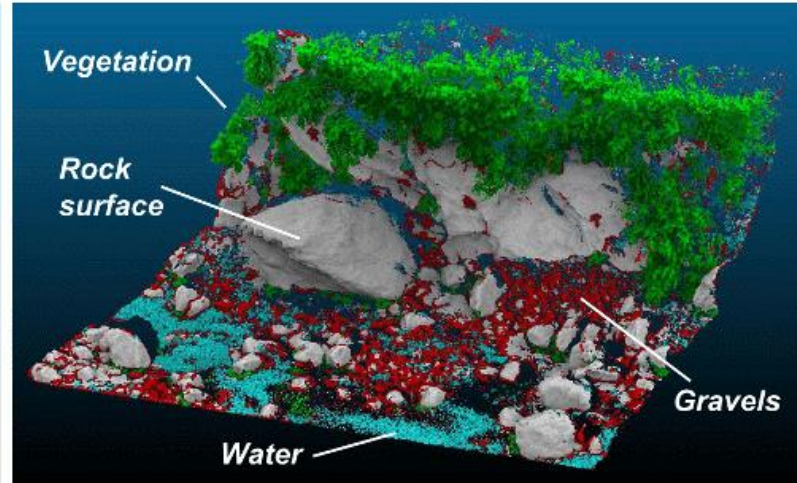


Classification with CANUPO

Raw 3D Point Cloud



Multi-Scale Dimensionality Classification



Brodu, N. and **Lague, D.**, 3D Terrestrial LiDAR data classification of complex natural scenes using a multi-scale dimensionality criterion : applications in geomorphology, *ISPRS journal of Photogrammetry and Remote Sensing*, **2012**



Cleaning

Various methods to remove isolated parts, outliers, non-overlapping areas, etc. :



- Manual editing



- Remove isolated parts with the “Label Connected Components” tool

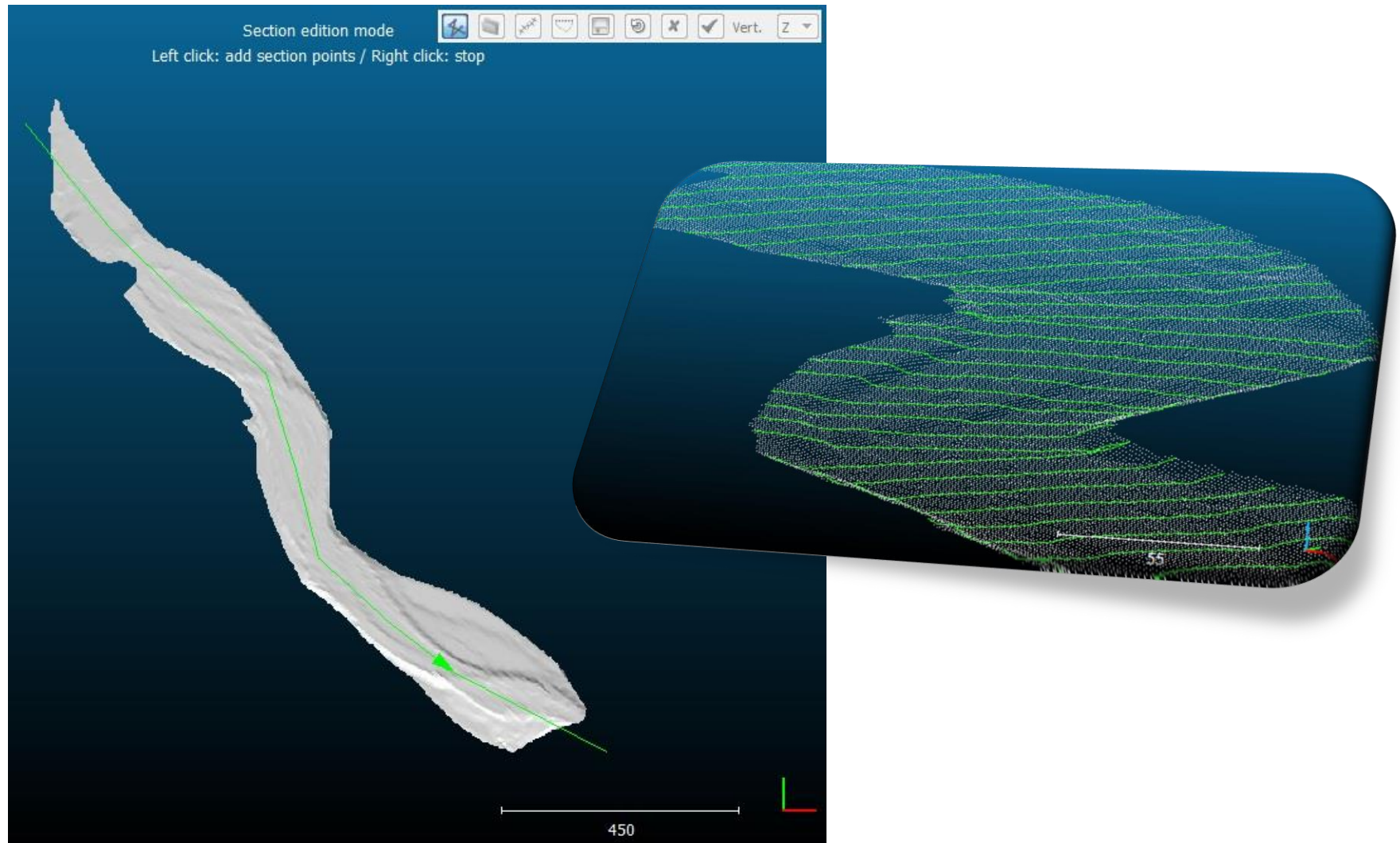
- Remove isolated points / noise with:

- Tools > Clean > Noise filter

- Other option: scalar-field based segmentation

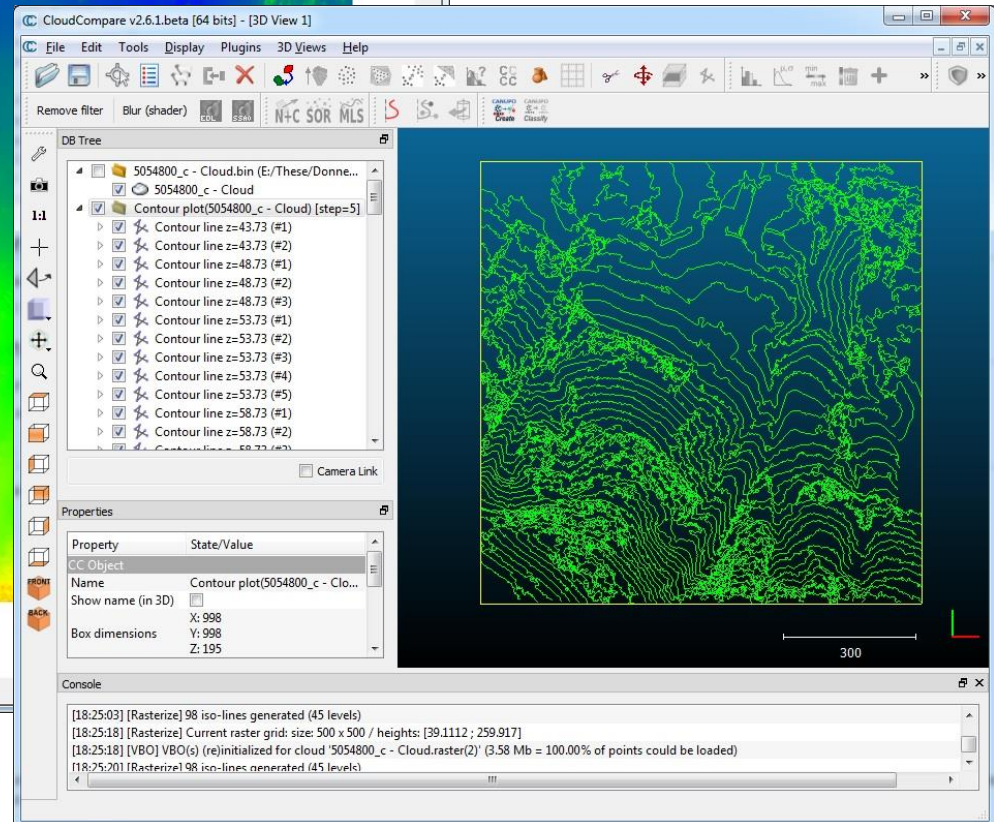
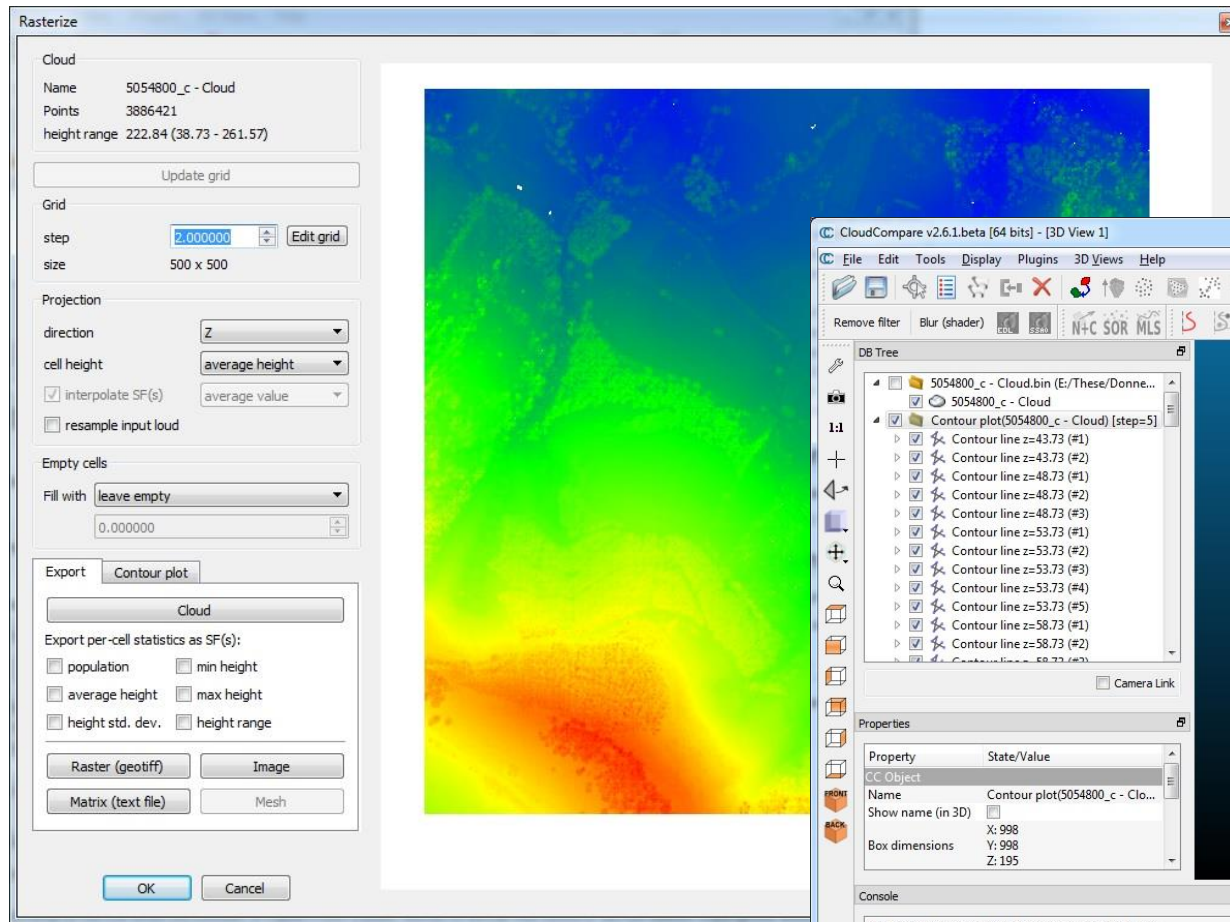


Contour/profile extraction





Rasterize & contour plots

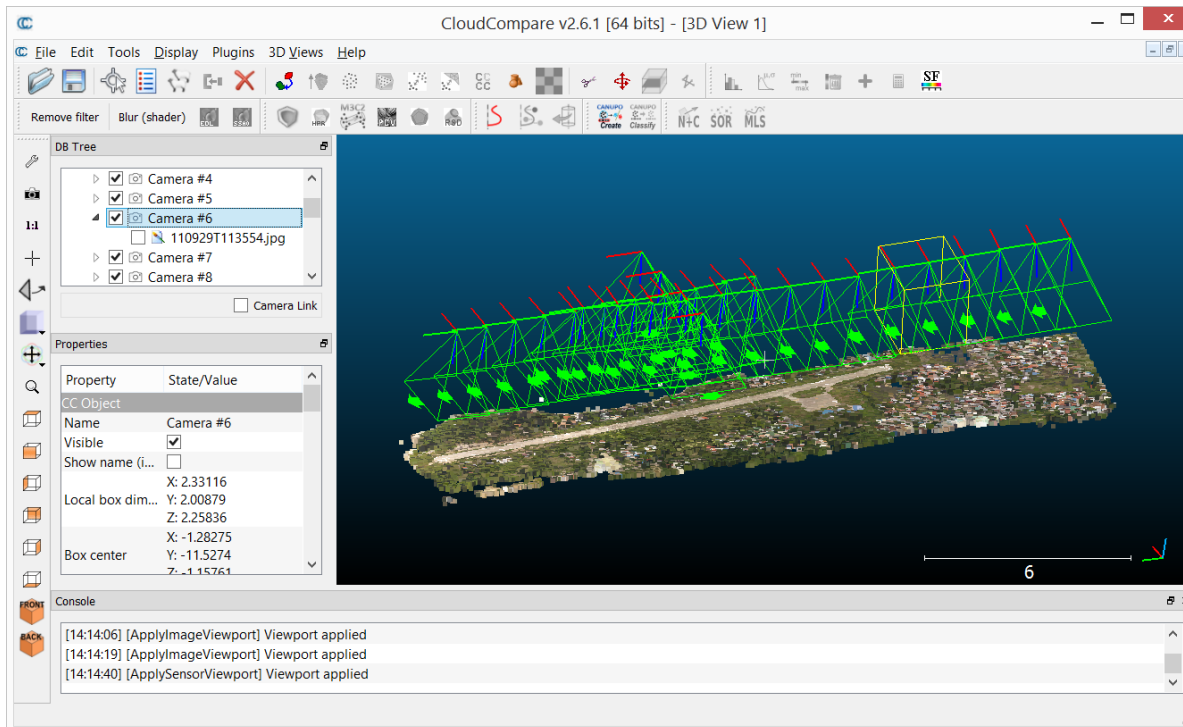


● ● ● Other



Working with SfM data

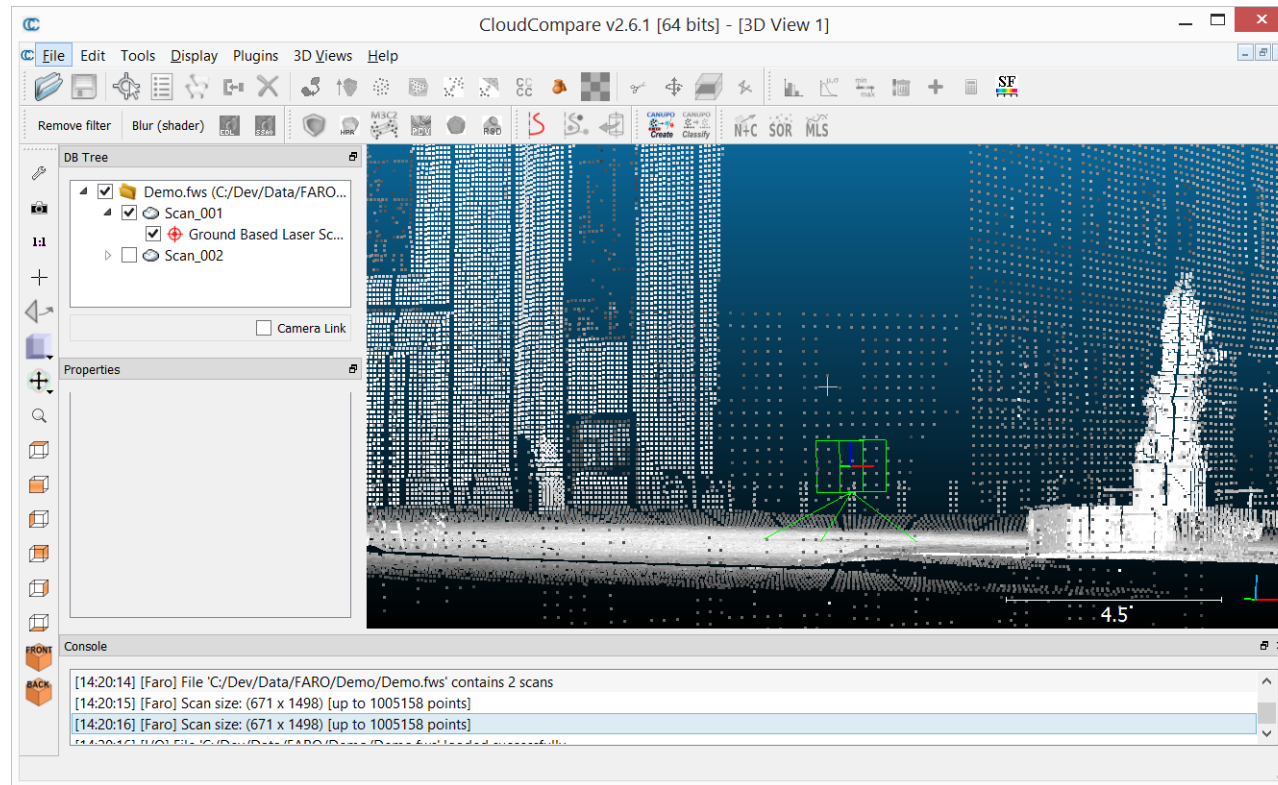
- Support for Bundler files
- Handling of calibrated pictures and camera sensors





Sensors

- TLS (“GBL”) Sensors
- Camera sensors





Meshing

- Meshing tool (to cope with holes mainly)
 - Delaunay 2D for '2D½' clouds
 - Or the [qPoissonRecon plugin](#) for closed shapes

Warning: CloudCompare is not a 'meshing' tool
(remember that the initial aim was to avoid meshes ;-)

It only provides simple approaches for convenience

Consider using “true” meshing tools
(Meshlab, VR mesh, Geomagic, etc.)
If you need accurate meshes

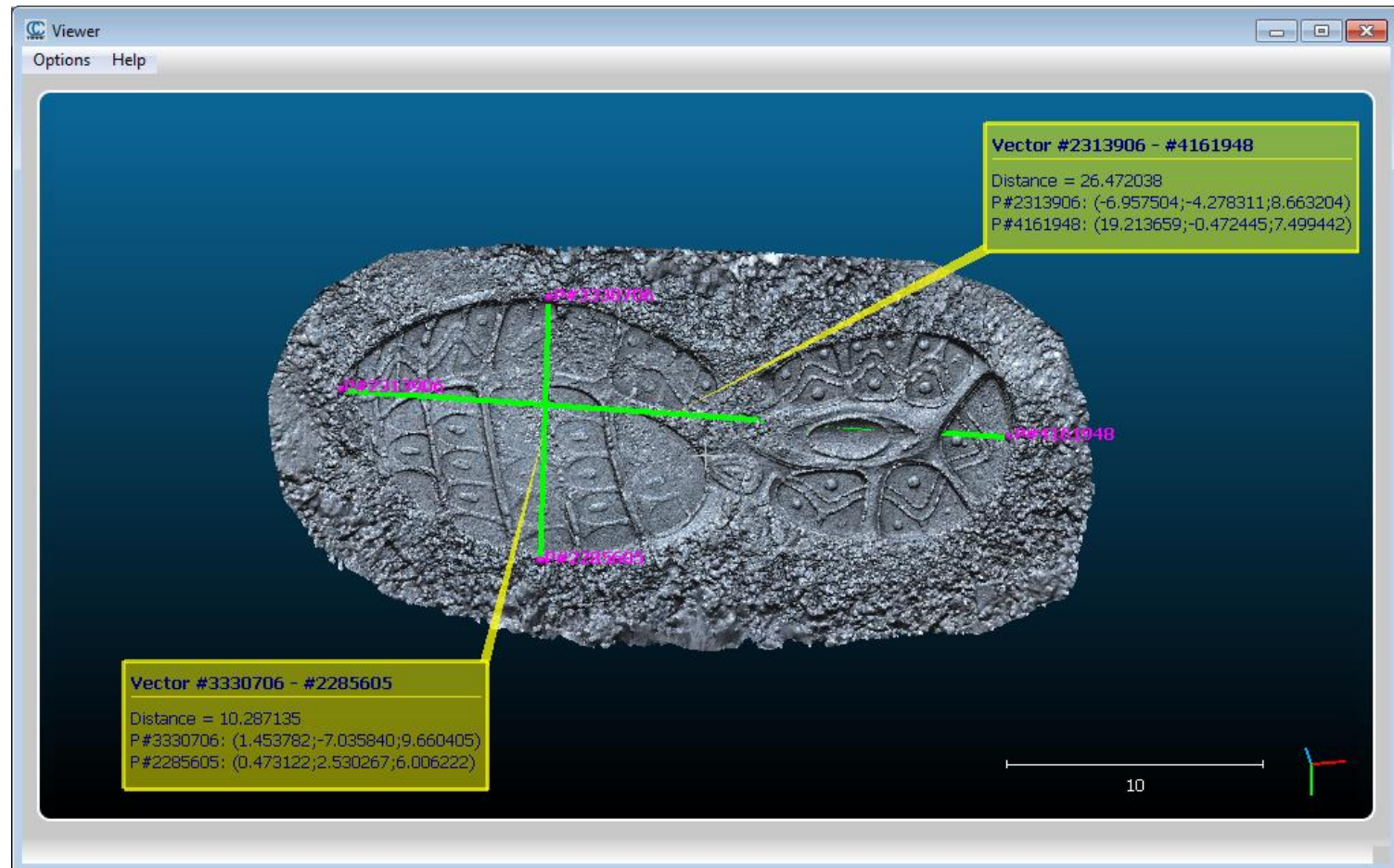


Presenting & sharing results

- Analysis
 - Histogram
 - Local Statistical Testing tool
 - Export to Matlab®/Excel®/etc. (ASCII ~ CSV format)
- Display
 - create labels, save viewports, etc.
 - Save the whole project in a “BIN” file
- Share
 - ccViewer (lightweight, for load & display only)



ccViewer





Misc.

- Plane and sphere fitting
- Unroll feature (on a cylinder or a cone)
- Plugins
- Command line mode
- Wiki (<http://www.cloudcompare.org/doc/wiki>)

● ● ● Next



In preparation

- Near future:
 - Oculus Rift plugin
 - Animation
 - Volume calculation



- TODO list:
 - <https://github.com/cloudcompare/trunk/blob/master/qCC/TODO.txt>



Next workshops

- 2nd international conference of the IAFSM (San Diego, Nov. 2015)



- ISPRS International Conference (Prague, Jul. 2016)





Thanks for your attention!

www.cloudcompare.org

The screenshot shows the CloudCompare website. At the top, there's a browser window with the address bar showing 'www.cloudcompare.org'. The page features a header with the CloudCompare logo, a 'DONATE' button with a progress bar showing '\$1,785.00 Raised!', and a navigation bar with links: Home - Presentation - Download - Github - Tutorials - Documentation - Forum - Declare a bug. Below the navigation bar, a welcome message reads 'Welcome to the official website of the CloudCompare project.' A newsletter sign-up section asks 'Want to know when a new release comes out? Subscribe to the newsletter' with an input field for 'your email address' and a 'JOIN' button. Two software preview windows are displayed: 'CloudCompare v2.11.0 (64-bit)' showing a 3D point cloud of a car with a color-coded distance map, and 'ccViewer v1.33' showing a 3D model of a mechanical part. Below these windows, the text 'CloudCompare (view, edit and process)' and 'ccViewer (light viewer only)' are shown. At the bottom, two red banners announce 'First LAStools / CloudCompare Workshop in Latin America (8-10 Apr.)' and 'New user documentation: version 2.6.1'. The footer contains the text 'CloudCompare home - danielgm.net - EDF R&D - contact'.

CloudCompare v2.11.0 (64-bit)

CloudCompare

3D point cloud and mesh processing software
Open Source Project

Want to support/help us?
DONATE pledgie.com
\$1,785.00 Raised!

Home - Presentation - Download - Github - Tutorials - Documentation - Forum - Declare a bug

Welcome to the official website of the CloudCompare project.

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

CloudCompare (view, edit and process)

ccViewer (light viewer only)

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