UNEXMIN

AN AUTONOMOUS UNDERWATER EXPLORER FOR FLOODED MINES

DATA POST-PROCESSING

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NEMO 33, UNEXMIN FINAL CONFERENCE

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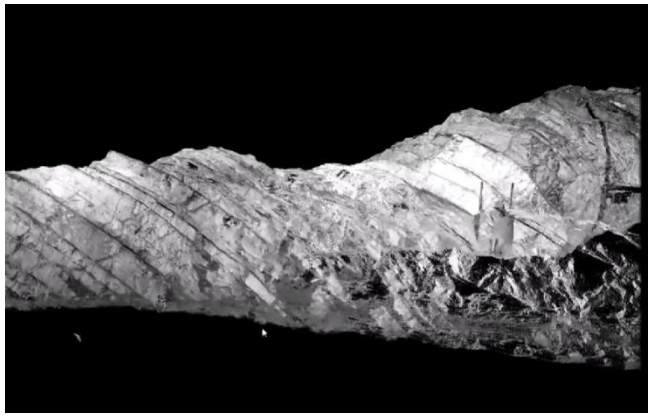
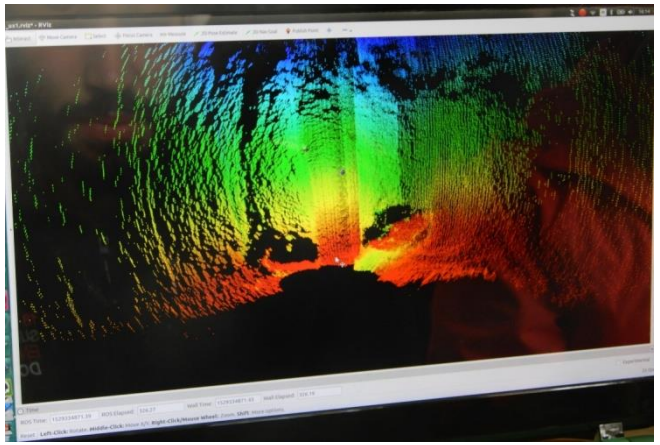
This project has received funding from the European Union's Horizon 2020research and innovation programme under grant agreement No 690008.

POST-PROCESSING SUMMARY

- Data standards agreed
- Data conversion requirements for navigation and sensor systems agreed
- Database management: SQLite
- Post-processing applications
- Point-cloud modelling
- Visualisation applications





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DATA TRANSFER AND STORAGE

- Data from UX-1 in ROS bag format converted to CSV, JPG, and AVI formats
- Large data volumes held in robust (military-spec) disk drives kept in separate locations (as required by DMP)

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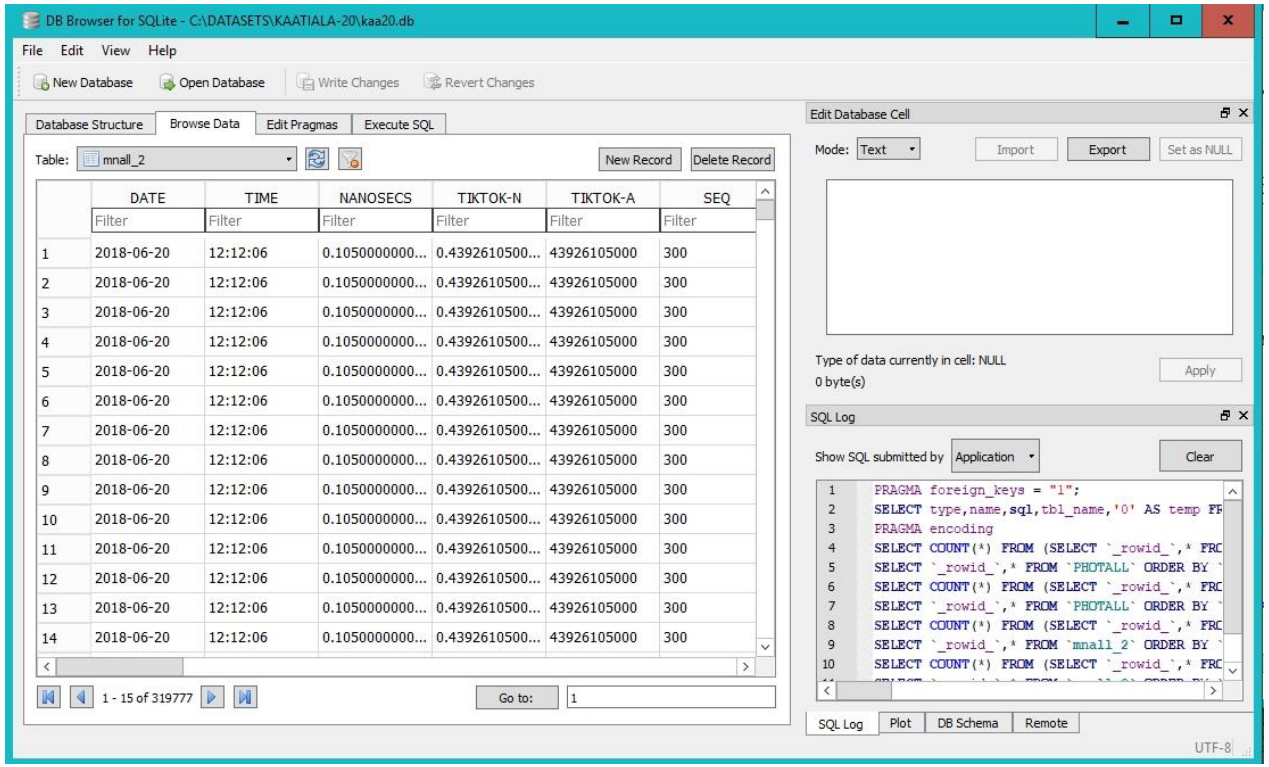
SQLITE DATABASE MANAGEMENT SYSTEM

- Relational database management - full SQL support
- No server; no database administrator
- Open-source, free of charge
- Very large (5 million+) installed base; active user community
- API for multiple programming languages (including C++ and Fortran)
- Simple data typing: REAL, INTEGER, TEXT, BLOB, NULL



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SOFTWARE DEVELOPMENT

Data analysis methods

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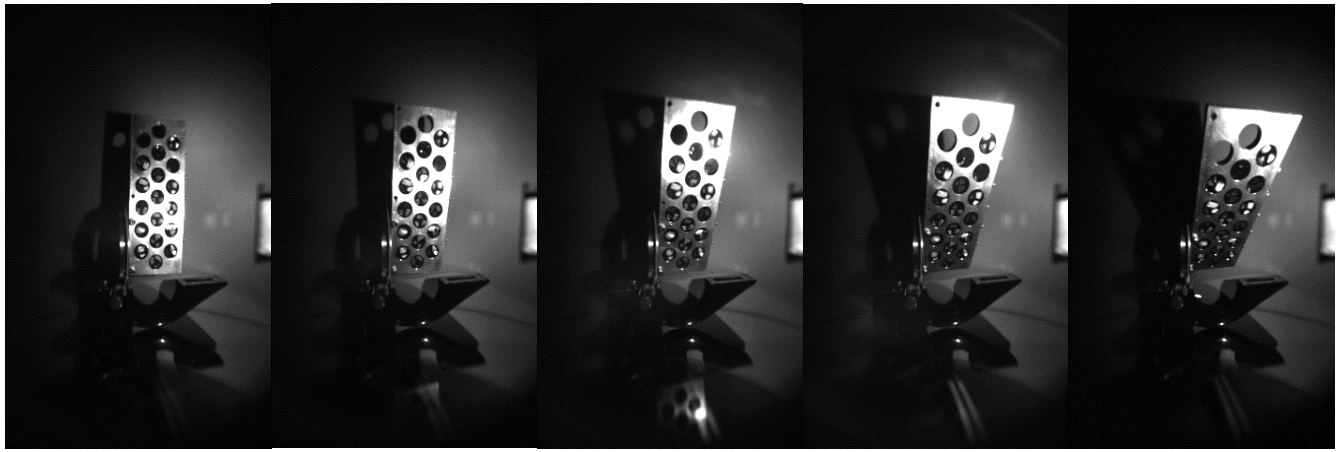
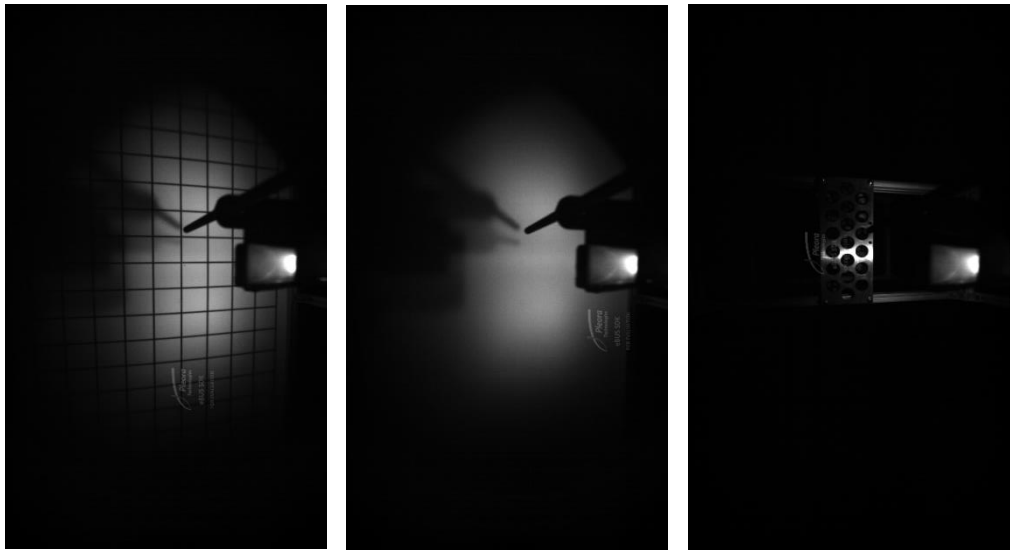
MULTI-SPECTRAL DATA - CALIBRATION



Polished surface mineral samples at 25 cm distance with 90°, 80°, 70°, 60° and 50°tilt



Calibration measurements at Porto with the checkerboard, white board and mineral samples

- Using sets of reference minerals, polished and rough
- Illumination tested at different distances and angles
- Illumination dependence on lighting/camera geometry

Further tests in 'real' conditions at Kaatiala and Idrija, using mineral samples from Ecton

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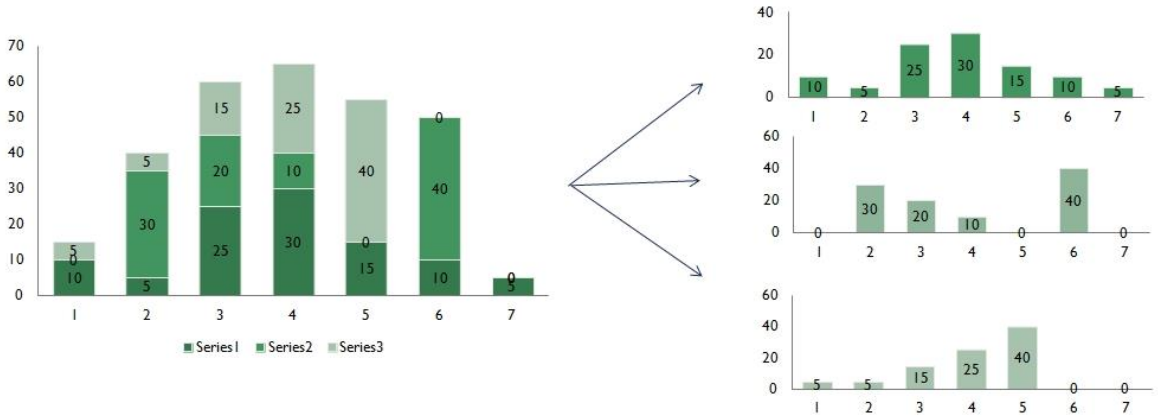
MULTI-SPECTRAL DATA - PROCESSING OPTIONS

Any spectrum can represent a mixture of spectra of different pure minerals



1. Linear programming end-member identification
2. Principal components and factor analysis
3. Multiple discriminant analysis
4. Matching coefficients
5. Neural networks for classification. Calcite detection application

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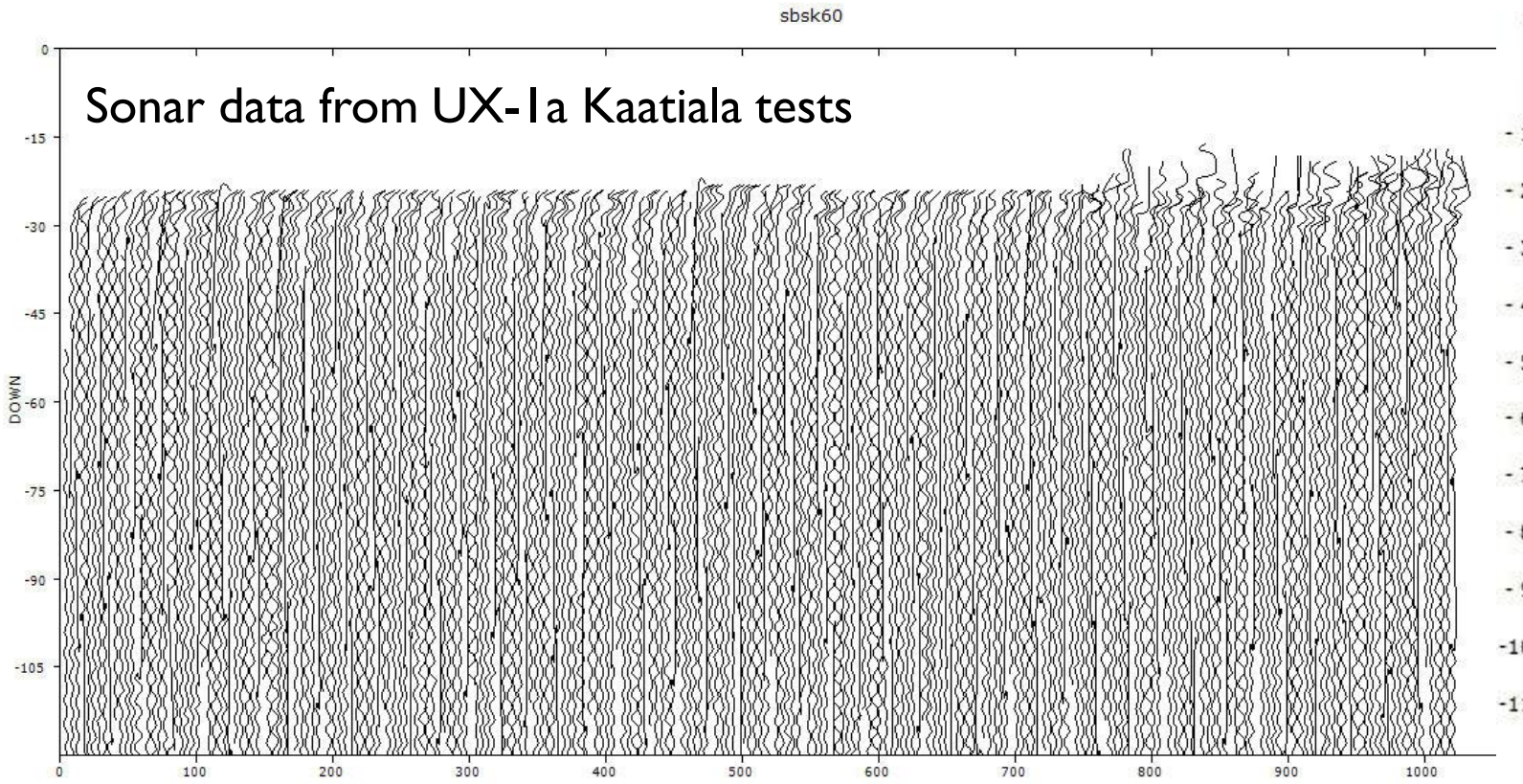
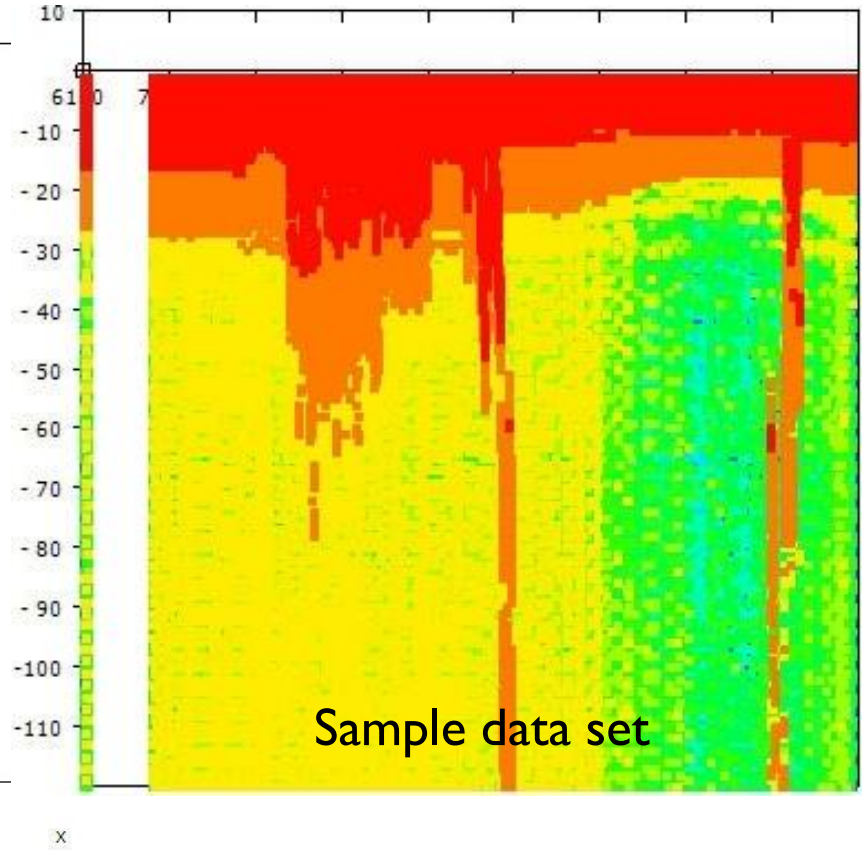
SUB-BOTTOM SONAR DATA (30CM TO 2.5M DEPTH) WIGGLY LINE OR COLOUR-CODED PLOTS





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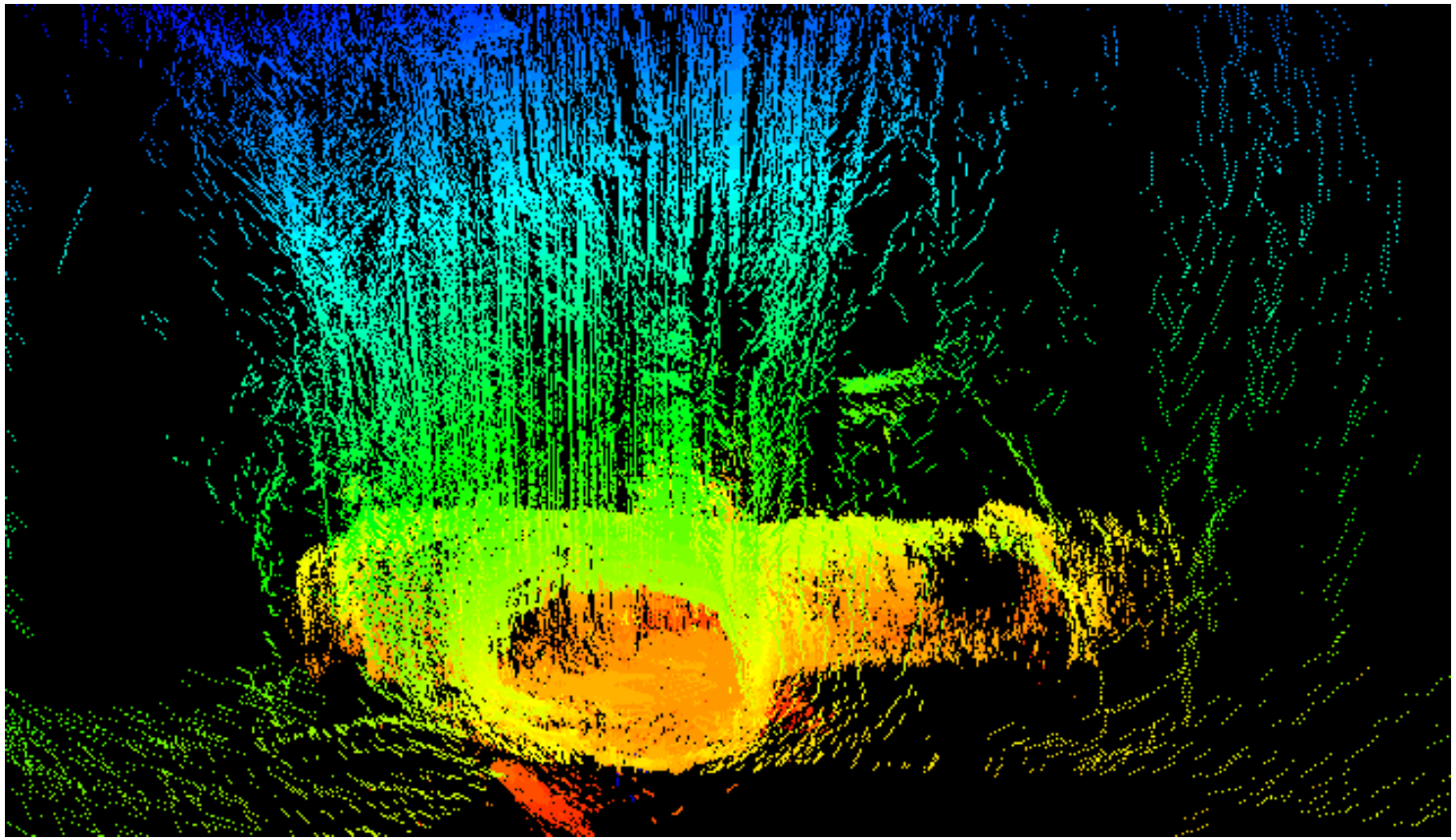
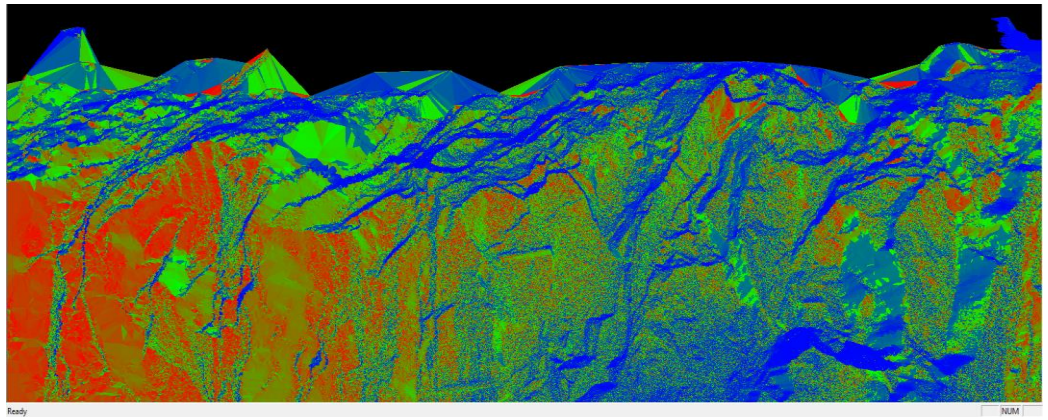
M3 MULTI-BEAM SONAR DATA



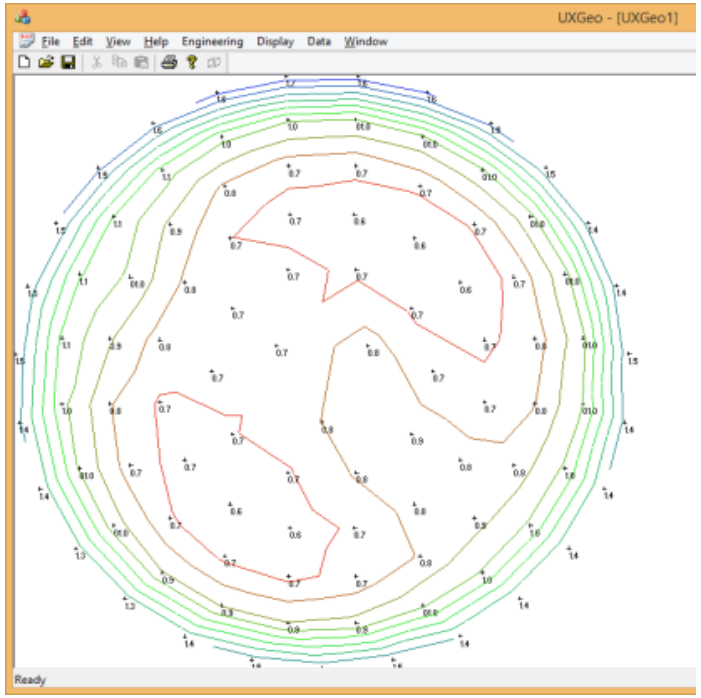
M3 multi-beam sonar data:
the entrance to the tunnels at Kaatiala.
(point-cloud; colour coding by depth or other data fields)

STRUCTURAL GEOLOGY

- Triangulated model from point cloud, colour-coded to show significant fracture orientations in roof of tunnel at **Ecton Mine**



Denness B-type contoured stereographic projection plot of the roof orientations



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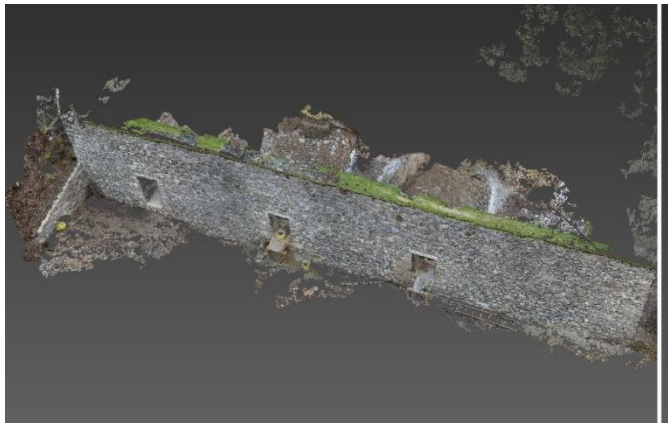
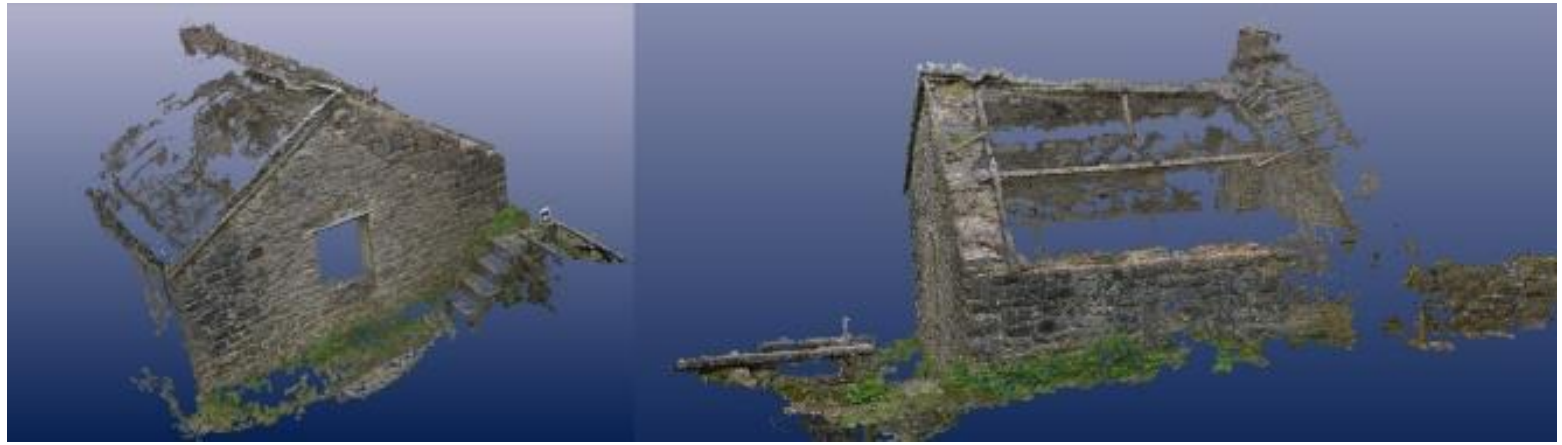
PHOTOGRAMMETRY - POINT-CLOUD CREATION TO CONSTRUCT 3D MODELS

Ecton Mine:

- dressing-floor wall
- building to be demolished
- Deep Ecton adit





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PILOTS

Handling large data volumes

- Kaatiala 477 Gb
- Idrija 671 Gb
- Urgeirica 1661 Gb
- Ecton 5200 Gb
- Molnar Janos 938 Gb

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DATA EXTRACTION

- Point Cloud data
  - Needed to be converted to world coordinates -> transformations
  - Highly-optimized Python scripts for rapid extraction
    - SDD drives are your friend!
    - From hours to minutes

- Images
  - Image data in ROS bagfile format
  - (1) Simple extraction into image files. Correction of lens distortion (‘fish-eye’ effect). Compilation of videos
  - (2) Rapid extraction from a merged bag file, and correction, direct to videos, with time, location, orientation data in captions

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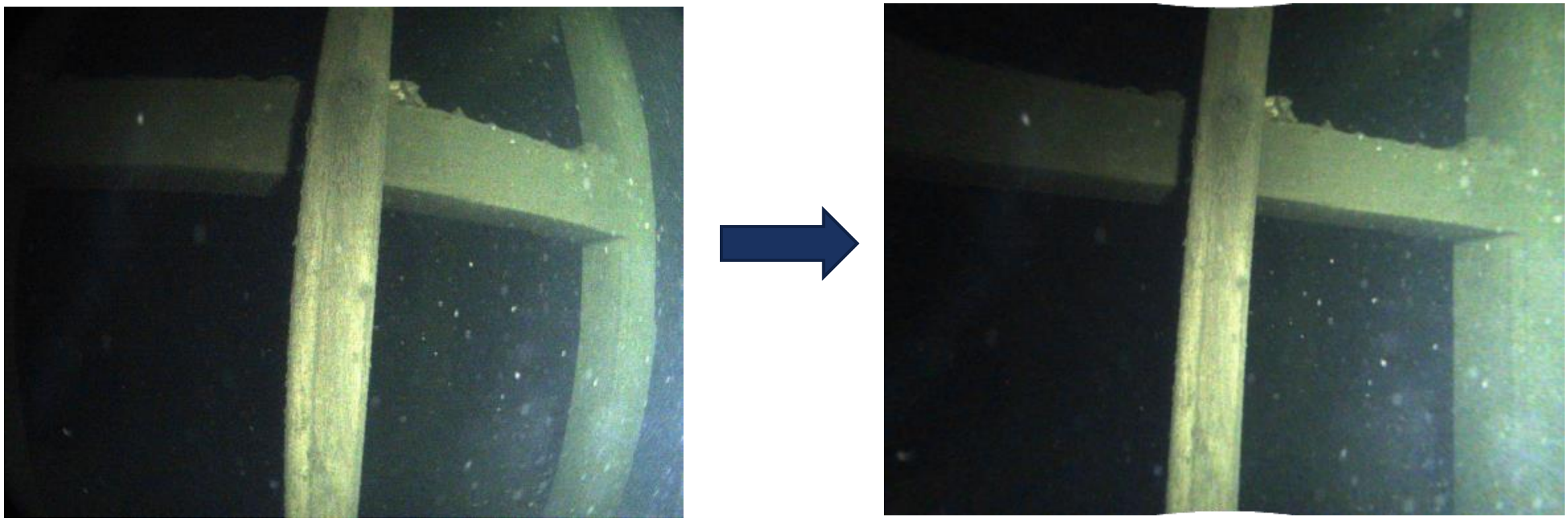
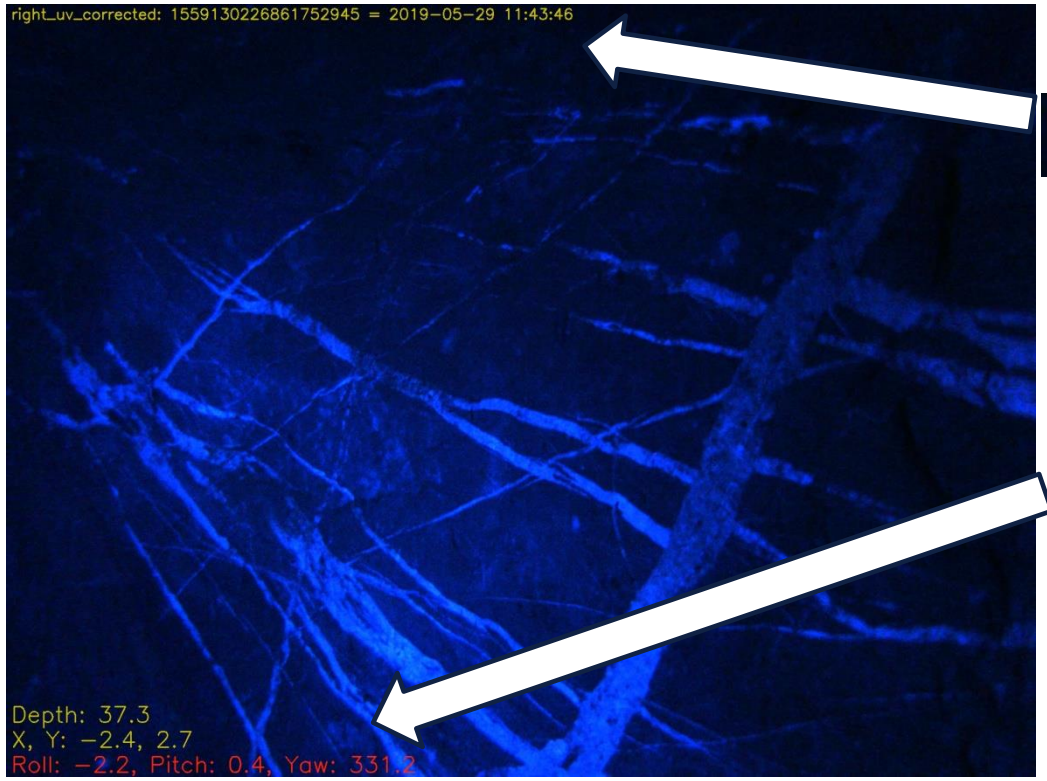
FIRST METHOD – PUBLIC DOMAIN IMAGE PROCESSING SOFTWARE (PHOTODEMON, VIRTUALDUB)

Fish-eye distortion correction, one image at a time

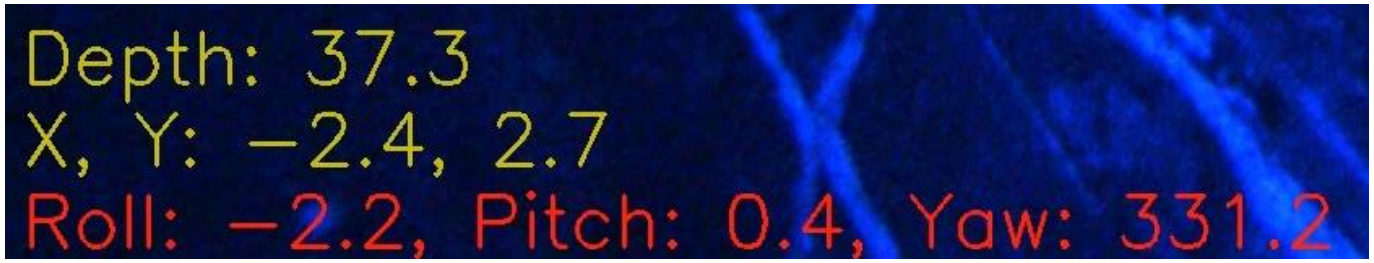


SECOND METHOD – FAST PYTHON SCRIPTS FOR RAPID EXTRACTION OF UN-DISTORTED IMAGES & VIDEOS



Time caption

Location caption



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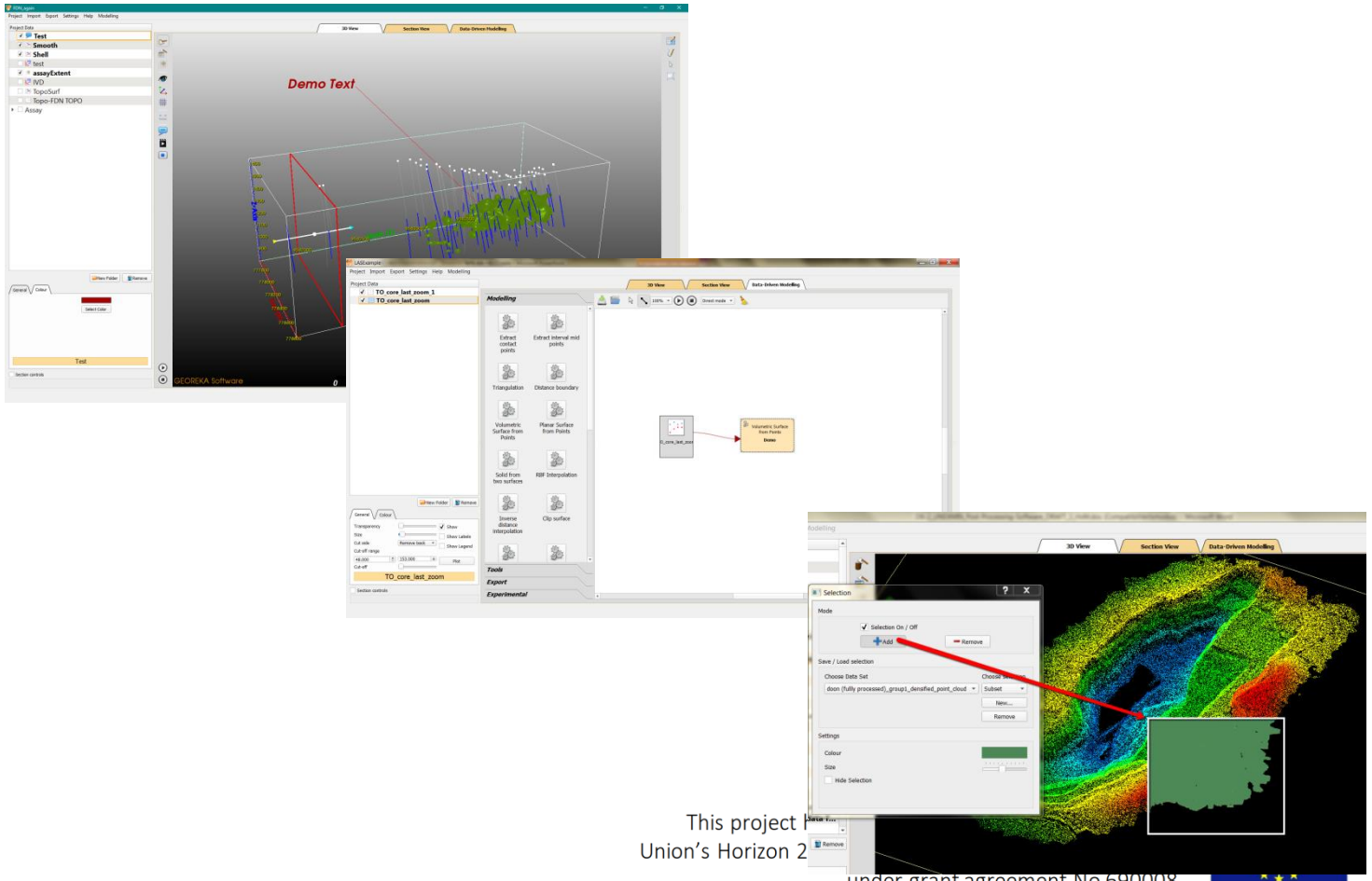
SIMPLE EXAMPLE

Video with captions

These are attached to each separate frame, so the exact location of each photo image is recorded

POINT CLOUD DATA PROCESSING
GEOREKA SOFTWARE OVERVIEW

- Visualization & Interpretation
- Data-Driven modelling (processing)
- Interactive modelling (e.g. selections)



This project
Union's Horizon 2
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DATA AND MODEL VISUALISATION : TOOLS DEVELOPED

- Visualisation of very large point-cloud data sets
  - Octree encoding based visualization
    - Smart handling of points
    - Caching of octree blocks (remove points from memory if not used)
- Virtual reality viewing
  - **Demonstrated at Bled workshop**
  - Interaction with point clouds in VR. Coding in progress.
    Demonstrated at PDAC 2019, Toronto and **EIG 2018**, Durham

- Fast 3D point selections
  - Structural planes extraction
- Fly-through animations
- Align images to point clouds
  - **Coding done**, but limited testing due to lack of test data
- Output for hardcopy: 3D printer, projector, glass block, and hologram

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SHORT FLY-THROUGH EXAMPLE

- FARO Data scan:
  - 550+ million points
- 6-Core 32GB high-end laptop

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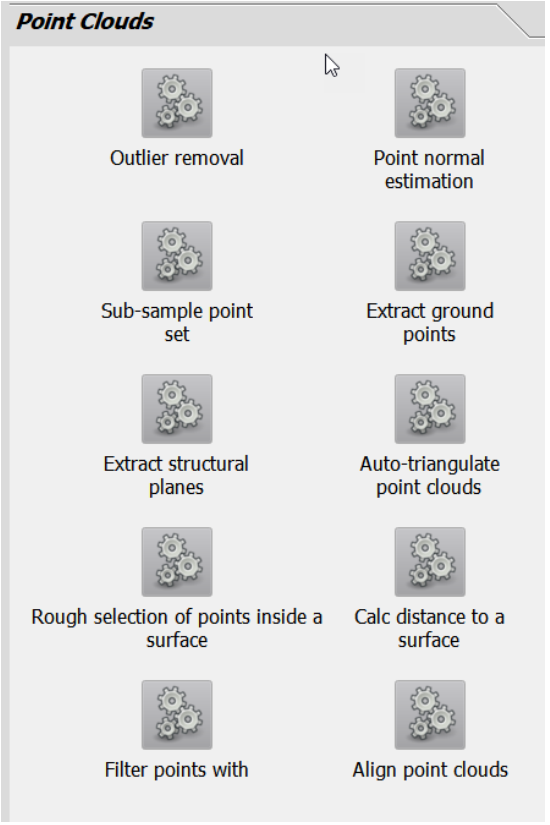
POINT CLOUD DATA PROCESSING

- Efficient data import
- Convert to Octree sub-divisions
- “Throw away” as much data as possible
  - But, keep the important bits
    - Ultra-fast sub-sampling
    - Filters
    - Unique methodology using a low-resolution pre-processing and robust triangulation of noisy data



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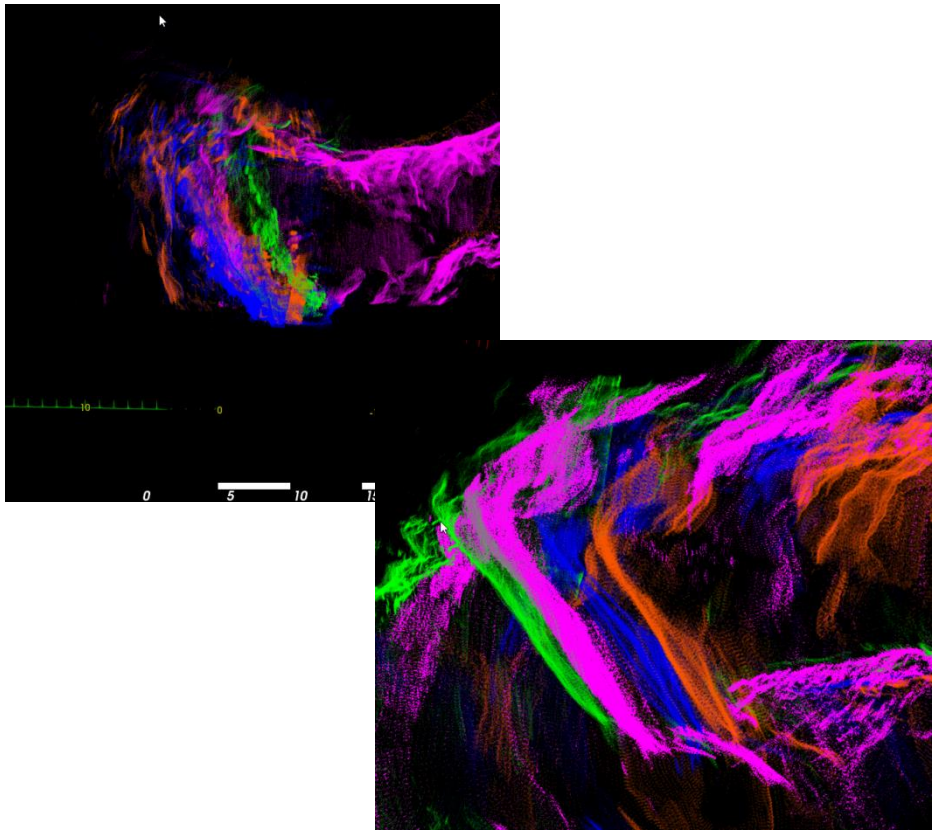
DEALING WITH MISALIGNMENTS I

- Data from 4 missions
  - Nearly same starting points and orientations
  - Points further away show greater misalignment



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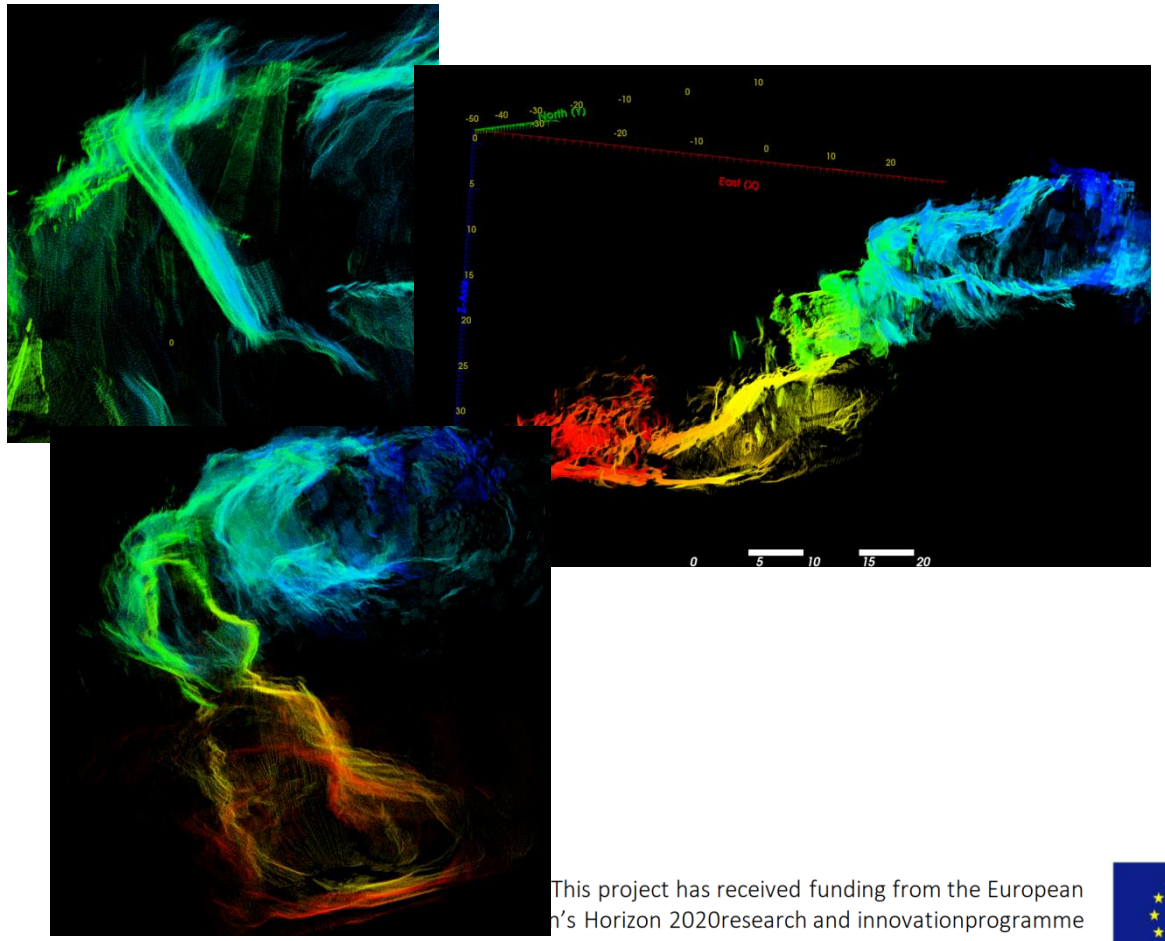
DEALING WITH MISALIGNMENTS 2

- Reducing the error
  - Sub-sample
  - Align point sets
  - Merge
  - Sub-sample again
    - Reduce number of duplicate points



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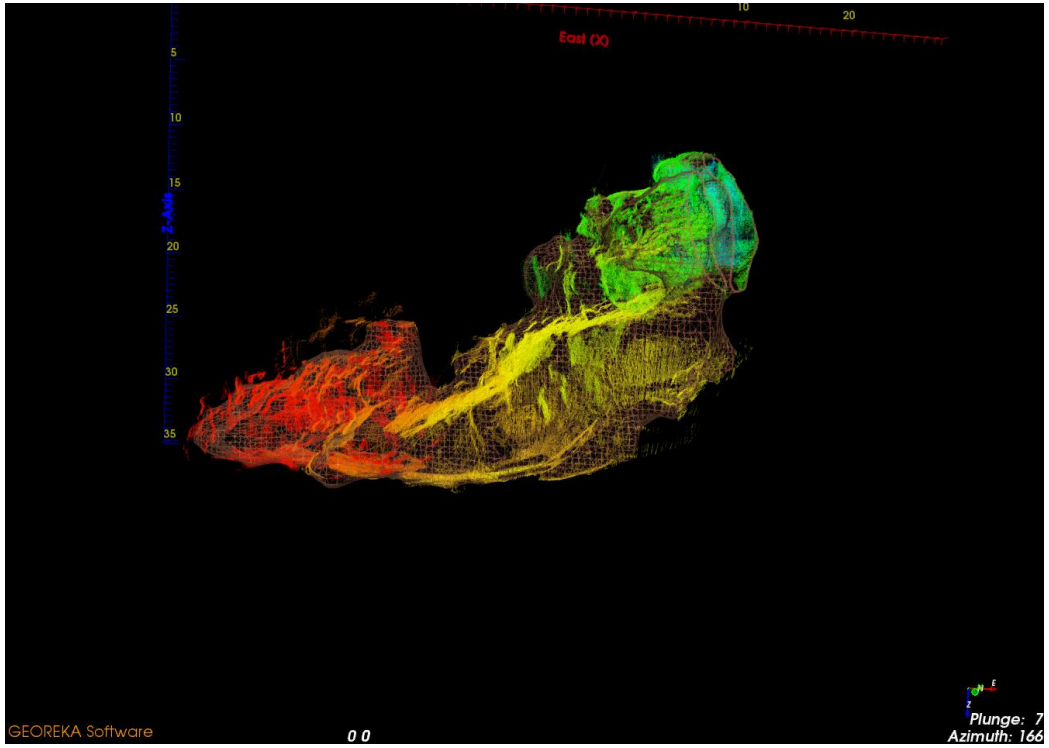
FLY-AROUND

- Result for the Molnar Janos cave data
- Merged data from 4 dives



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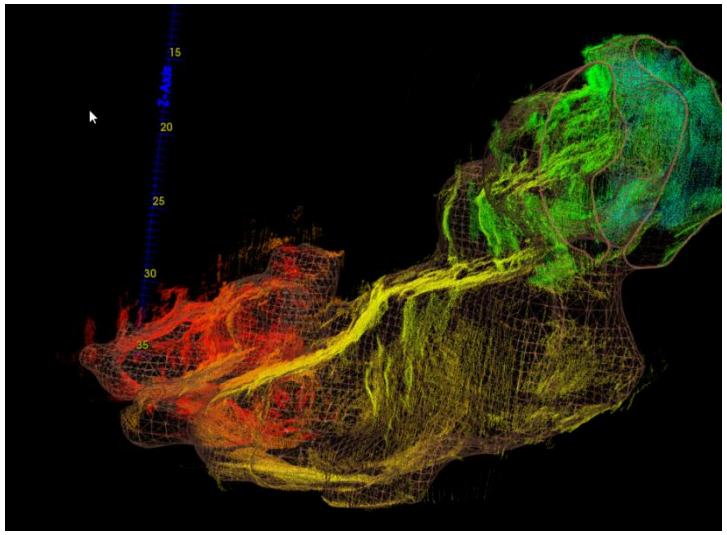
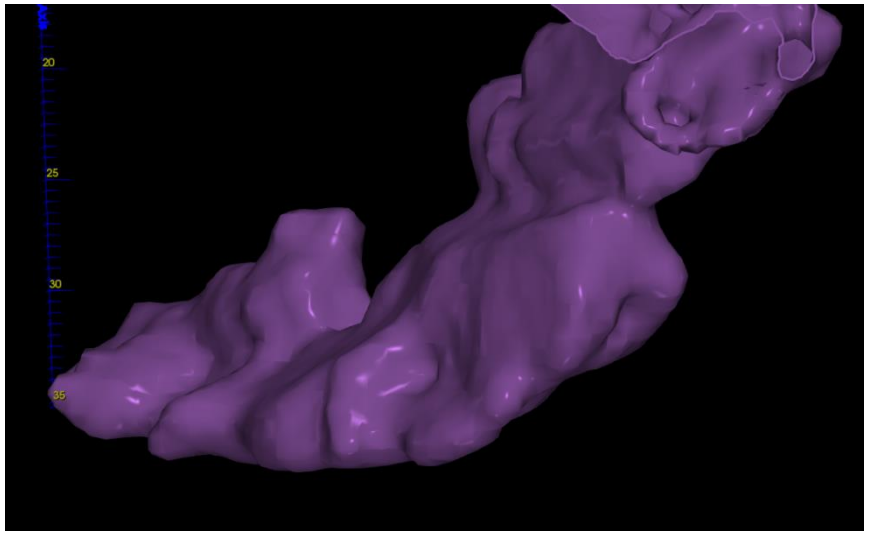
DETECTION AND CORRECTION OF NOISY DATA

Misalignment of point clouds is inevitable with differences in navigation start points.

We have developed a software algorithm to robustly triangulate noisy, even misaligned data.

Example triangulation from 4 surveys at Molnar Janos cave with corrected misalignment.





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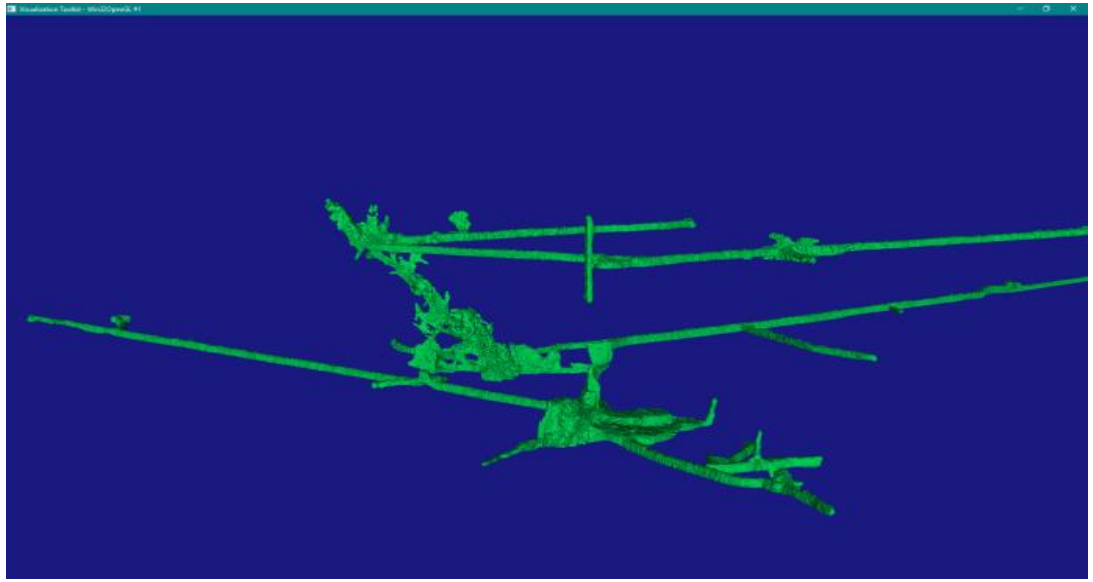
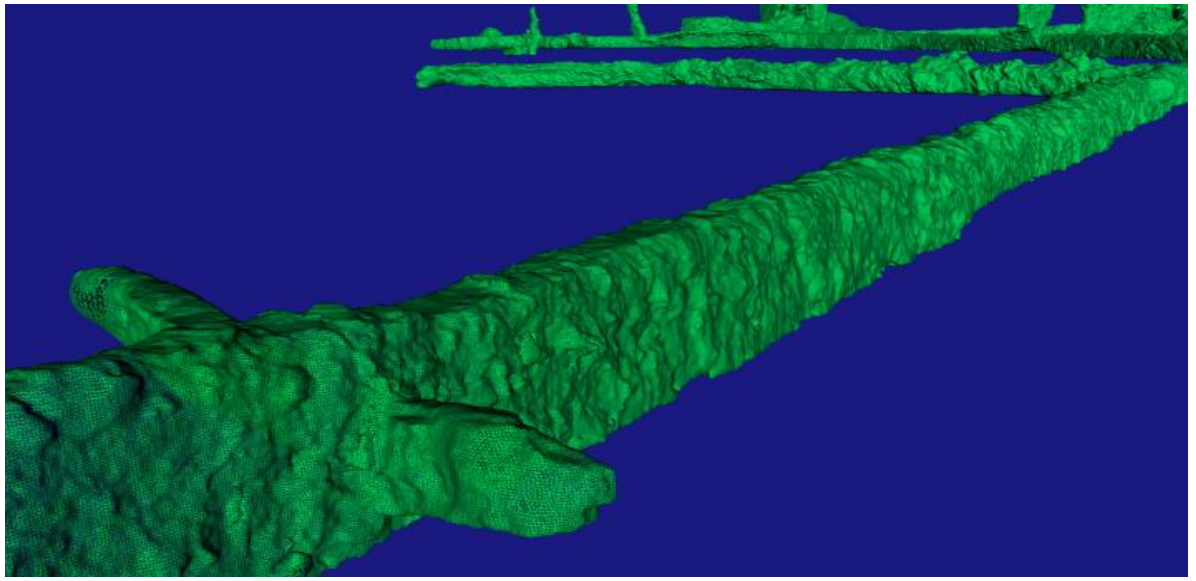
DETECTION AND CORRECTION OF NOISY DATA

Another example with triangulated surface from a GeoSLAM survey at Ecton above water level without corrected misalignment (200+ million points).





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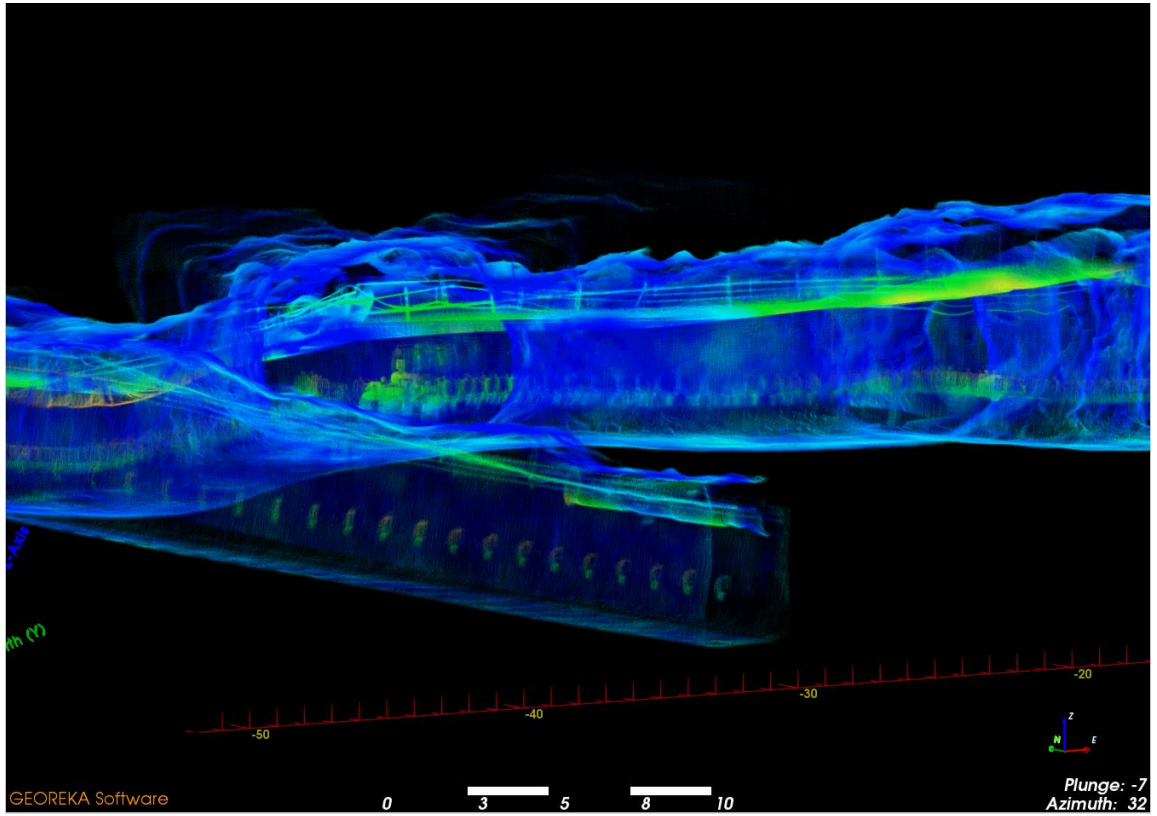
OTHER RELATED TECHNIQUES

Using an initial triangulated surface we can determine objects within the tunnel walls using the distance from that surface. (*Example from unrelated data set*)



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