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FIG WORKING WEEK 2017
Surveying the world of tomorrow - Helsinki Finland 29 May - 2 June 2017
From digitalisation to augmented reality

Noise Reduction Algorithm for Mobile LiDAR Data of Sand Ripples in Intertidal Zones of Beaches

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3D data acquisition group, Belgium

200 YEARS GHENT UNIVERSITY
FACULTY OF SCIENCES
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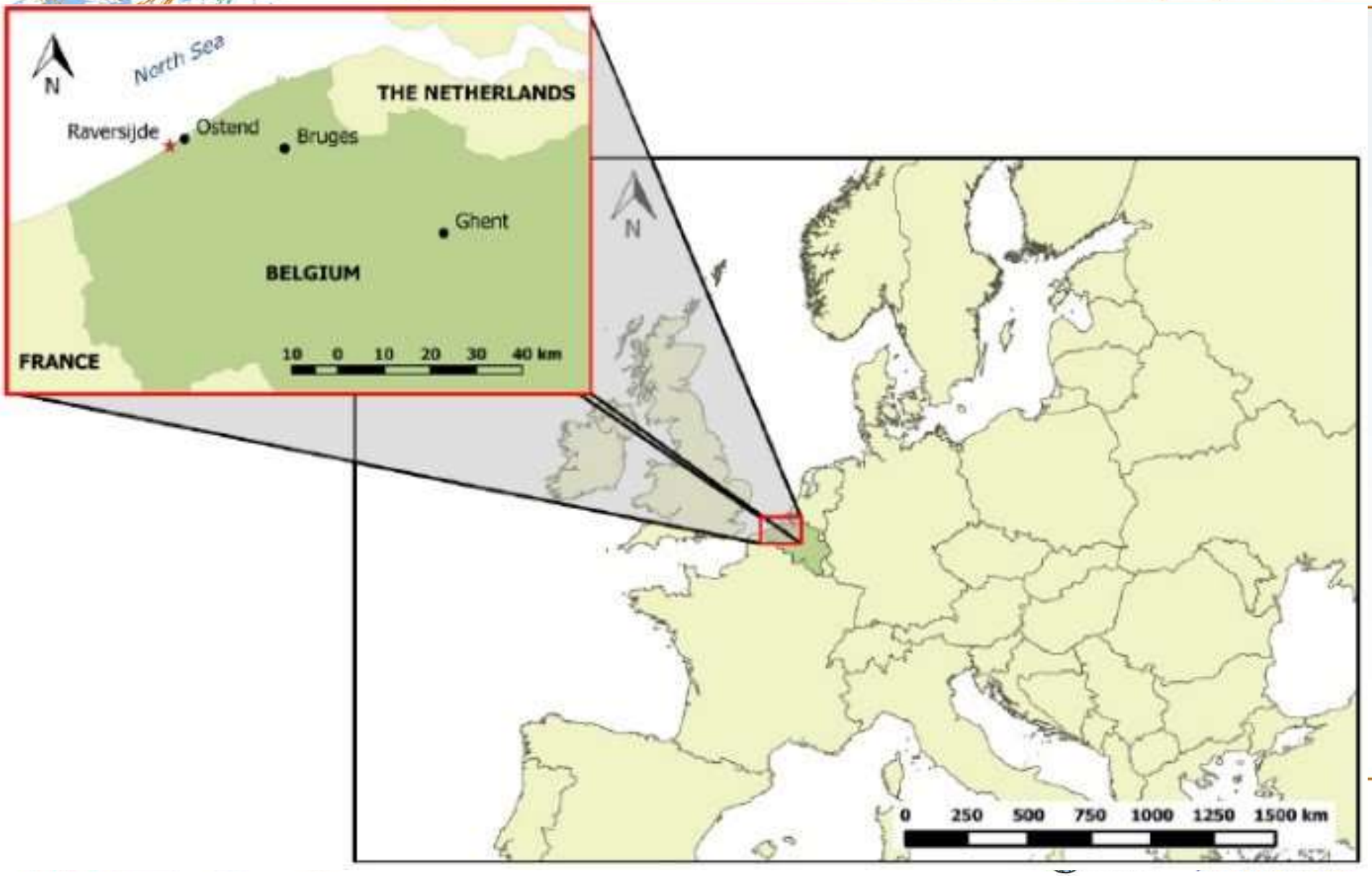
N
North Sea
THE NETHERLANDS
Raversijde
Ostend
Bruges
Ghent
BELGIUM
FRANCE
10 0 10 20 30 40 km
N
0 250 500 750 1000 1250 1500 km

Outline

1. Data acquisition research group projects
2. Mobile LIDAR beach vehicle
3. Classical grid filtering
4. Advanced noise reduction algorithm
5. Conclusion

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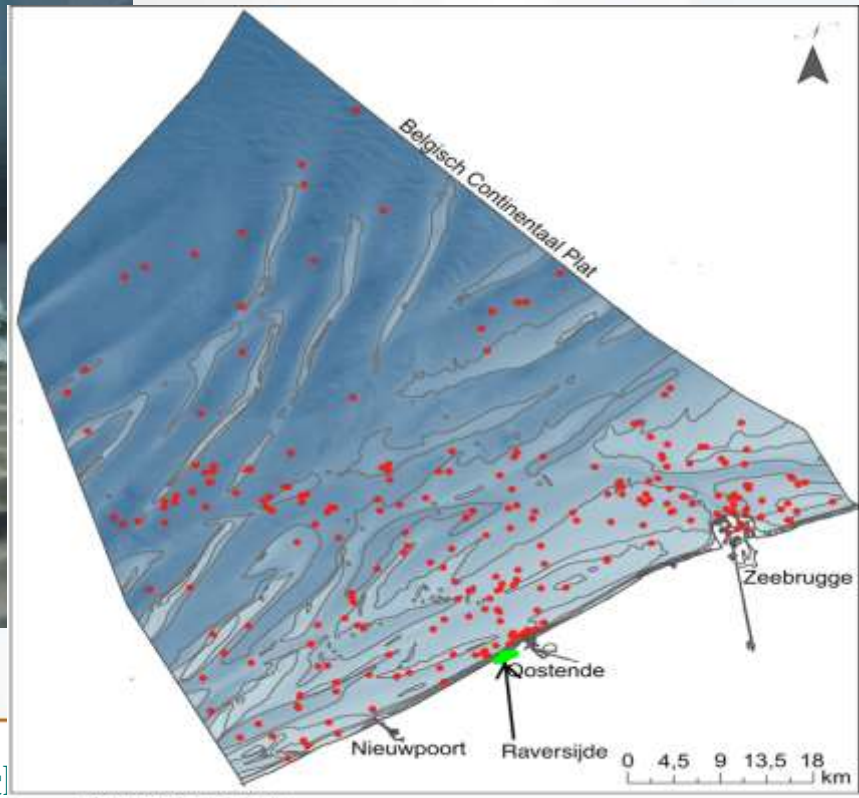
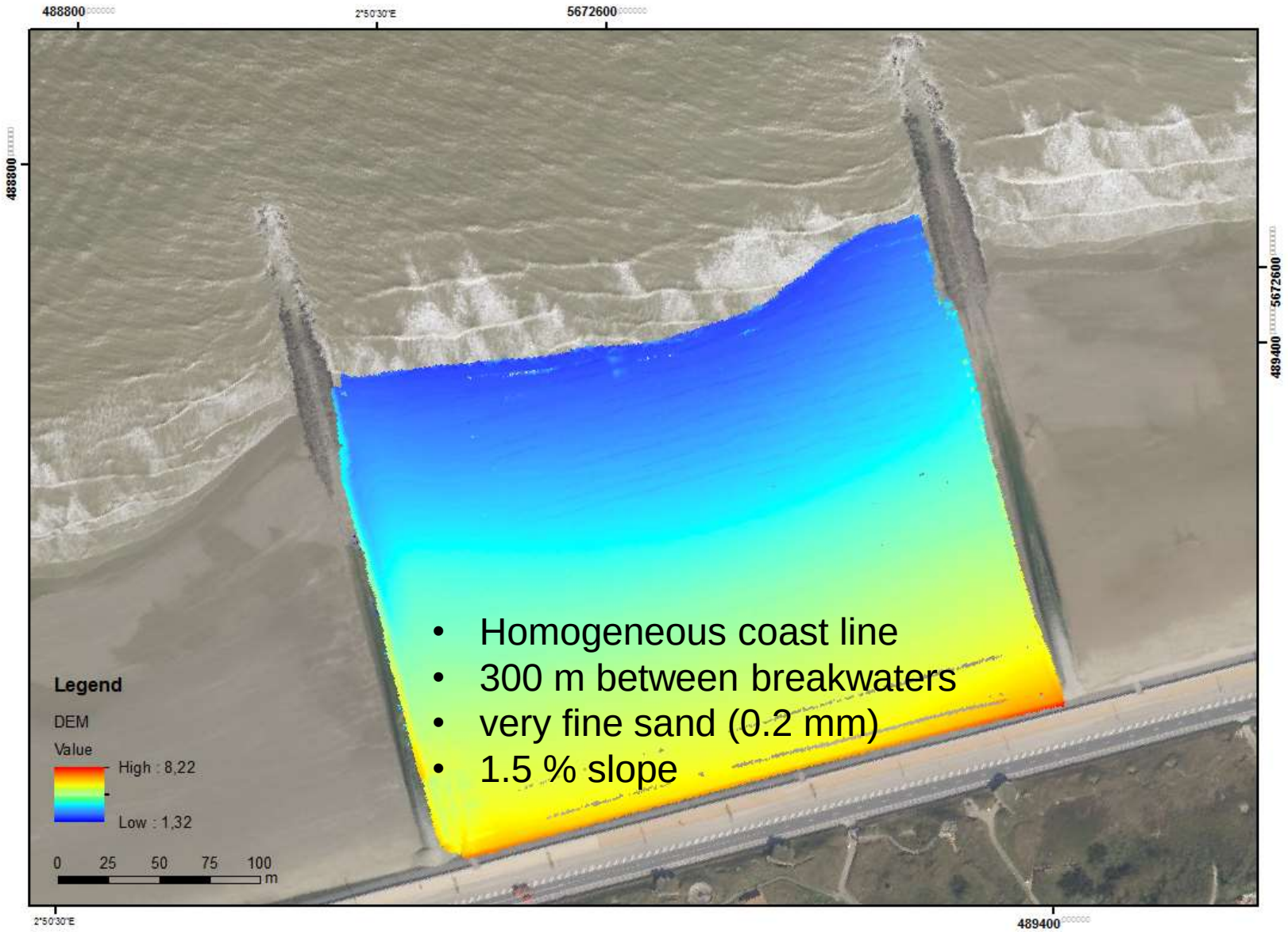
Archaeological heritage in the North Sea



http://www.sea-arch

The CREST project aims to increase the **knowledge of coastal processes** near the coast and on land. This project with primarily a social finality is part of the Strategic Basic Research (SBO) programme of the Flanders Innovation & Entrepreneurship and runs from **1 November 2015 to 31 October 2019**. There are ten partner institutions involved coming from the academic world, the Flemish government and the private sector.

http://www.crestproject.be/en


488800
2°5'0"E
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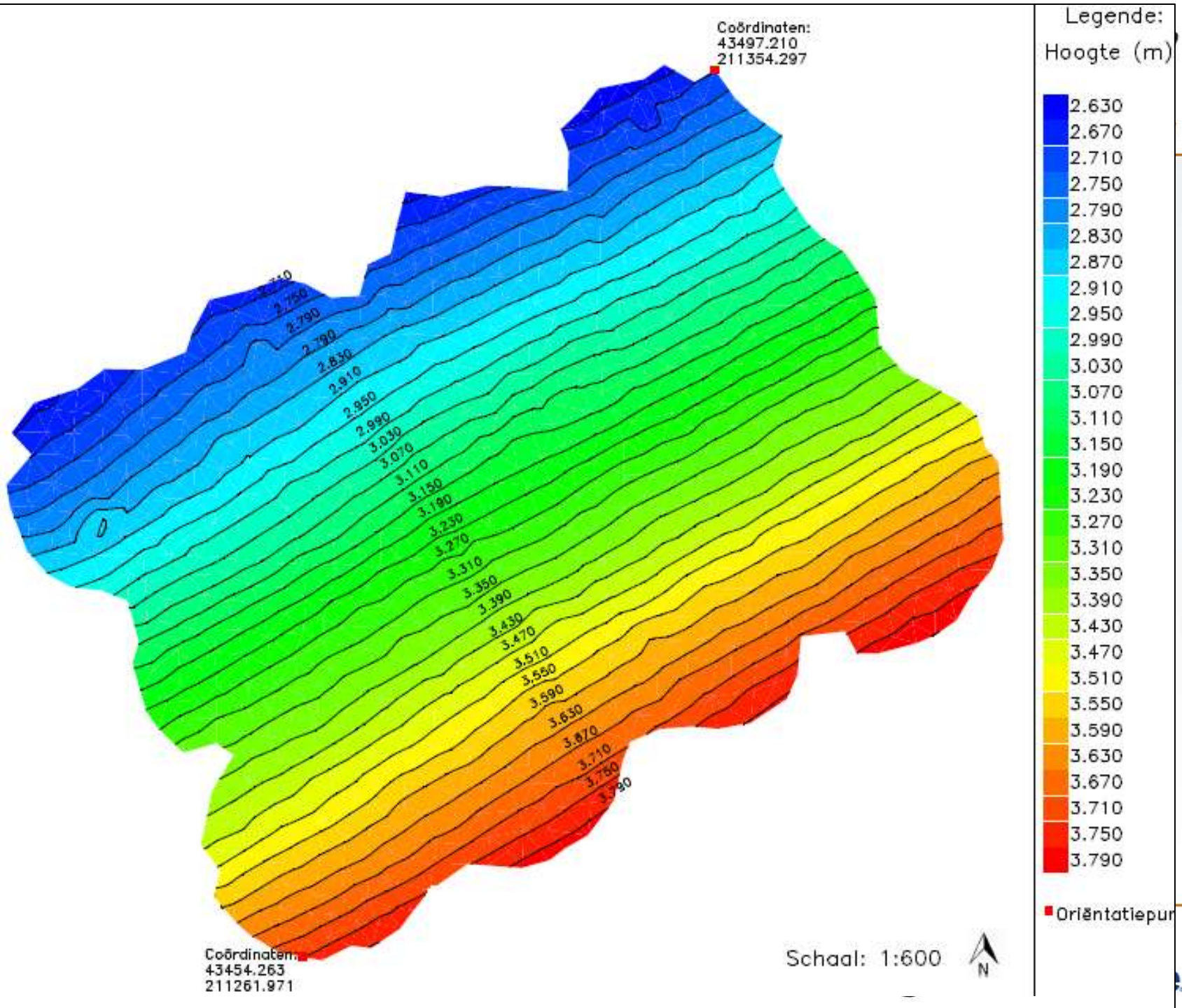
Legend
DEM
Value
High : 8,22
Low : 1,32
0 25 50 75 100
m
• Homogeneous coast line
• 300 m between breakwaters
• very fine sand (0.2 mm)
• 1.5 % slope


Coördinaten:
43497.210
211354.297
Coördinaten:
43454.263
211261.971
Legende:
Hoogte (m)
2.630
2.670
2.710
2.750
2.790
2.830
2.870
2.910
2.950
2.990
3.030
3.070
3.110
3.150
3.190
3.230
3.270
3.310
3.350
3.390
3.430
3.470
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3.550
3.590
3.630
3.670
3.710
3.750
3.790
Schaal: 1:600
N

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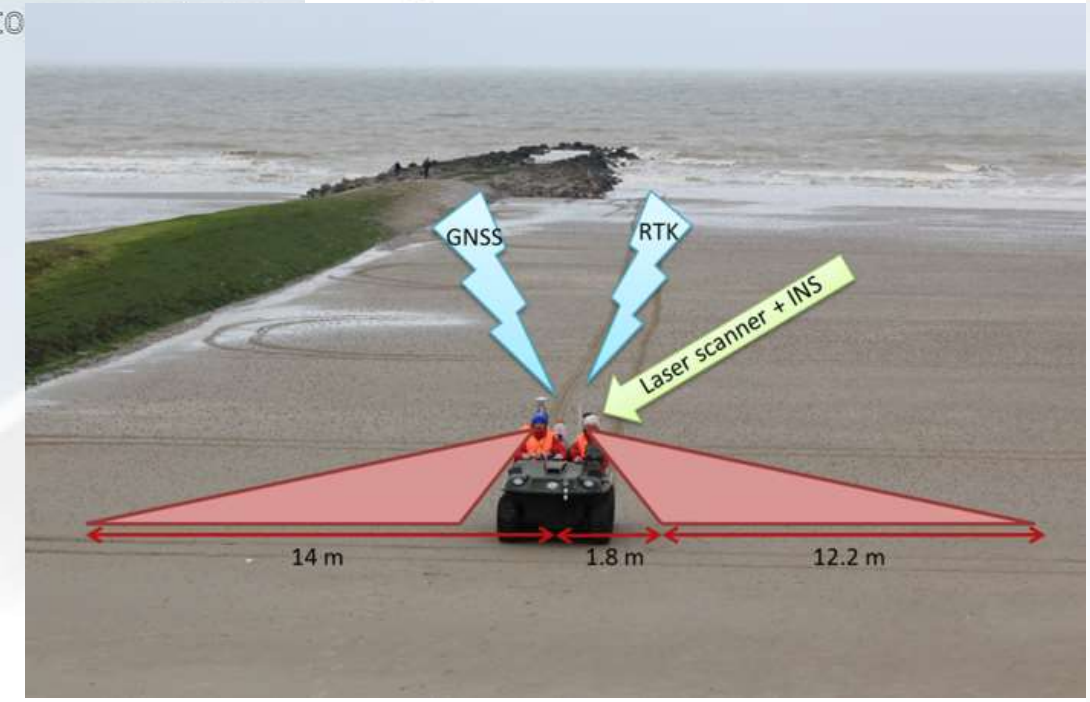
Comparison of several beach data-acquisition techniques

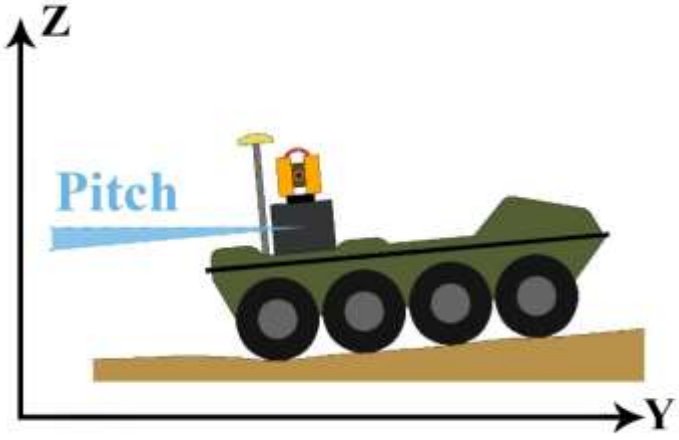
- Aerial LIDAR
- Conventional techniques used for data validation and quality assessment
  - *Global Navigation Satellite System (GNSS) measurements*
  - *Robotic Total Station*
  - *Static Terrestrial Laser Scanning (STLS)*
- Structure from Motion and Multi View Stereo (SfM & MVS) – Kite
- Singlebeam or multibeam echosounding
- Mobile Terrestrial Laser Scanning

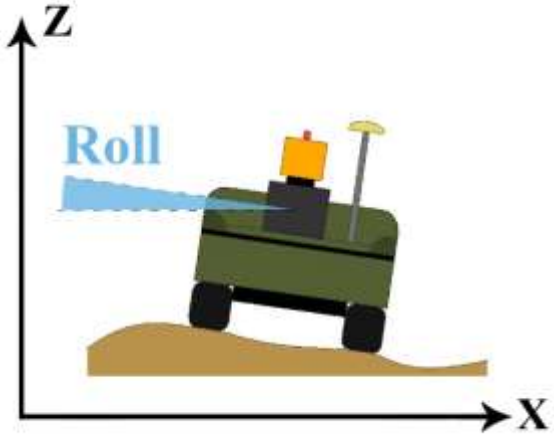
Selected technique:

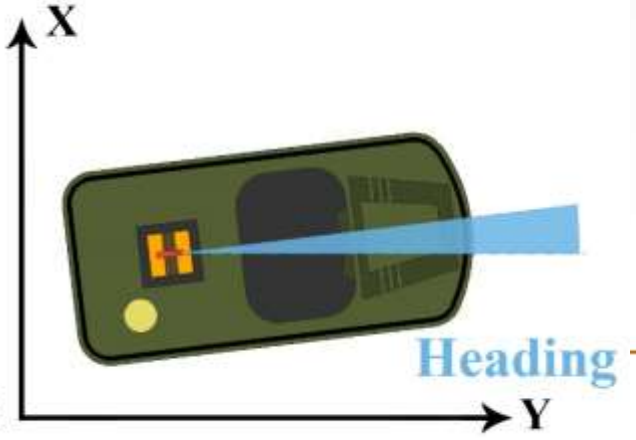
MTLS (LIDAR), several test in cooperation with

Prof. Nicolas SEUBE (formerly ENSTA, Brest, France, now CIDCO, Rimouski, CANADA)









Special Service Vehicle (SSV) Kymco UXV 450

Leica HDS 6100 (similar to Z&F 5006)

GPS antenna – heading

TLS – HDS6100

GPS RTK Septentrio - AlterXu

GPS antenna – position

IMU – Octans 3000

Laptop QINSy software

GSM antenna

Modem GSM
172.20.100.103

COM1 : GGA,GST,ZDA

GGA,GST,VTG,ZDA

Septentrio AsterXu
172.20.100.104

ETH
172.20.100.101

COM2

ETH Switch

COM1

PPS/TTL

IXSEA TAH

OCTANS3000
Out A: TAH
In A: GPS

HDS6100
172.20.100.100
port 6100

RS232/USB
(FTDI)

FIG WORKING WEEK 2017

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From digitalisation to augmented reality

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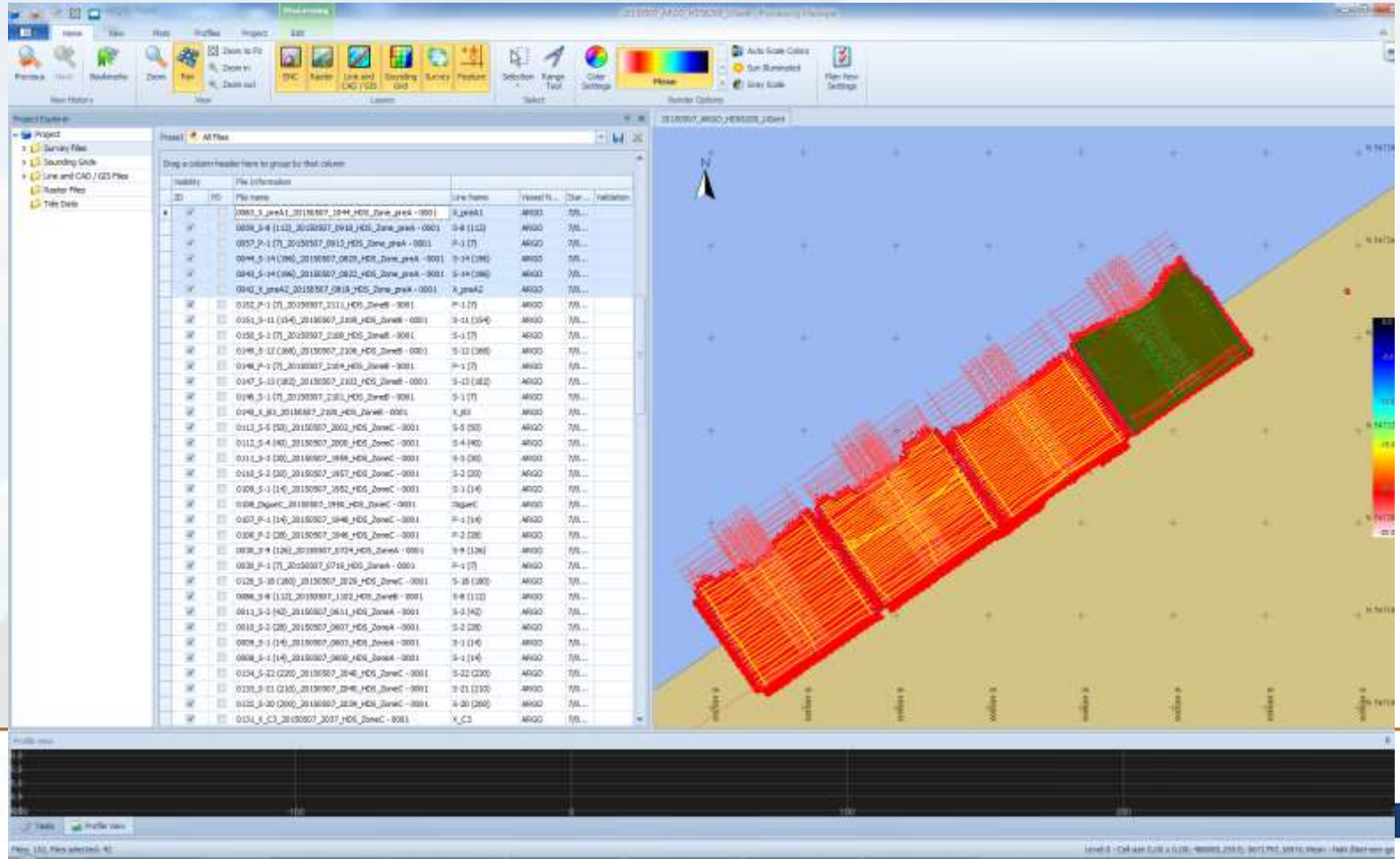
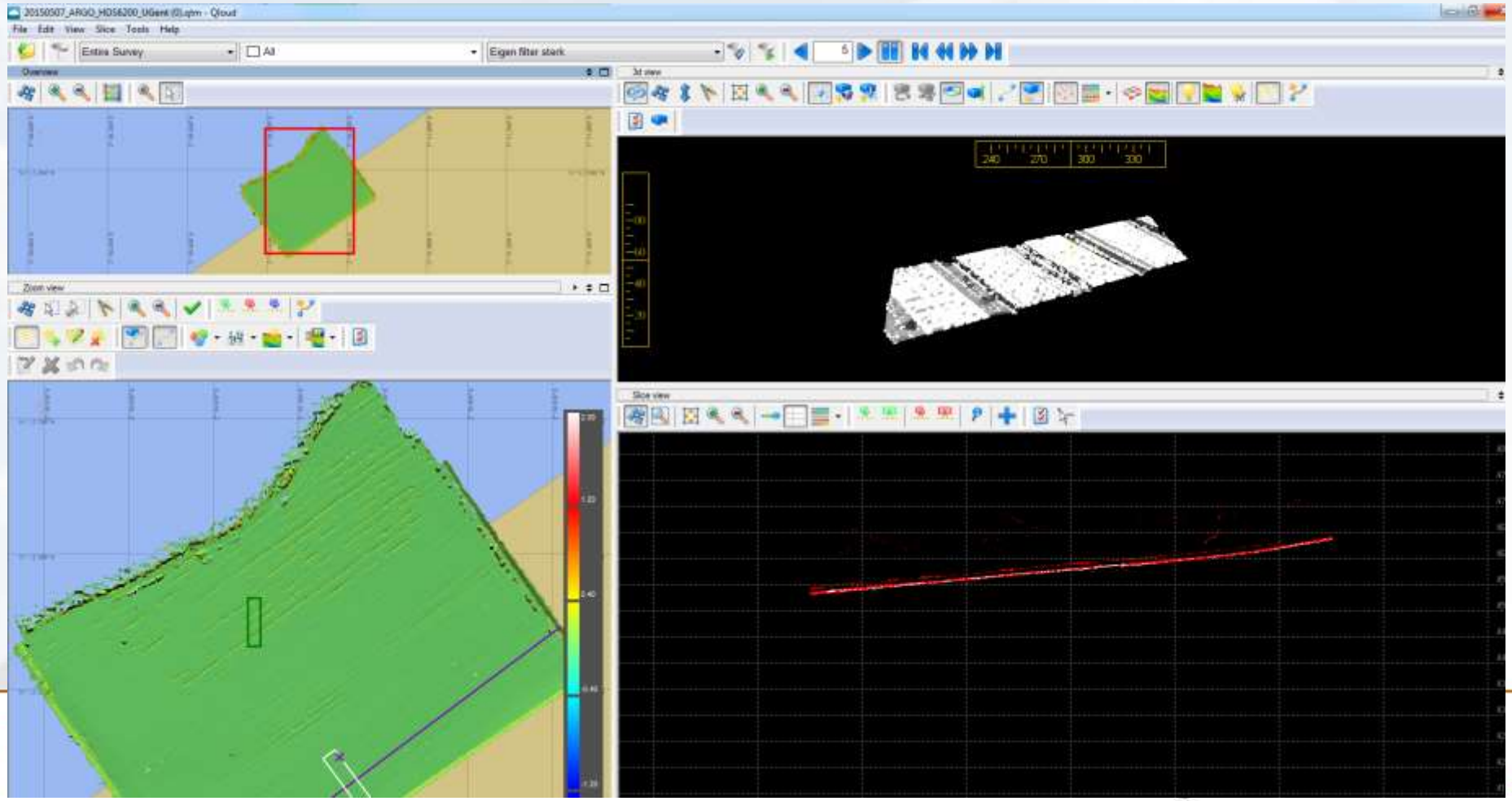
- Mobile Terrestrial Laser scanning using MTLS
  - Real-time acquisition and processing in QPS Qinsy spftware



- MTLS (Lidar):
  - Processing = mainly noise filtering



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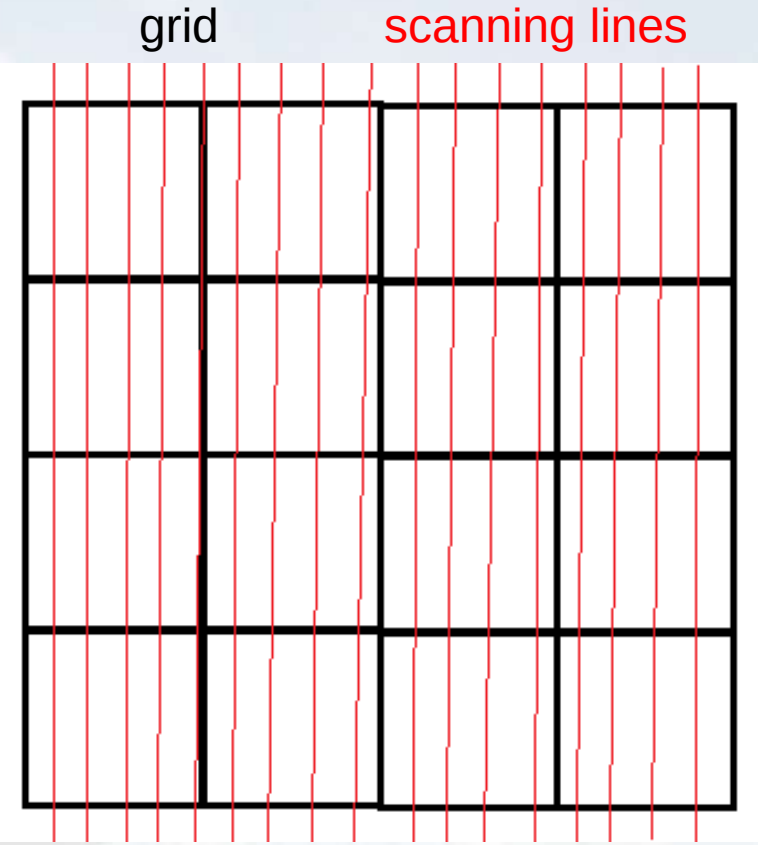
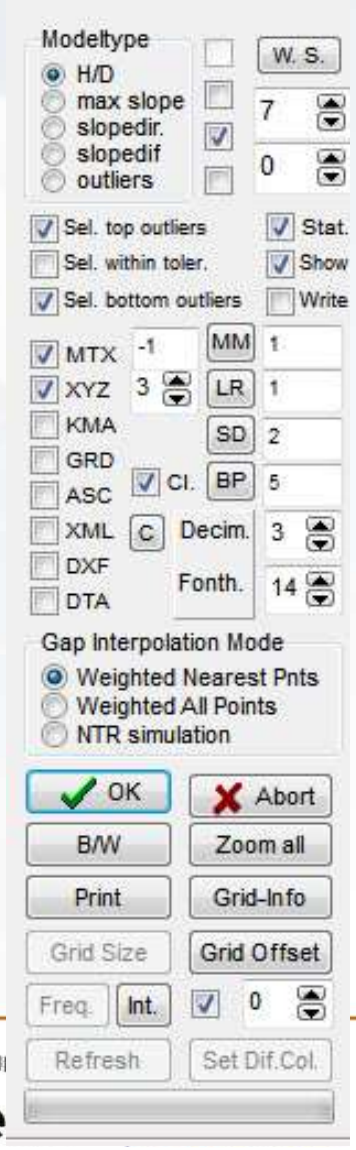
Classical noise removal based on a grid system:

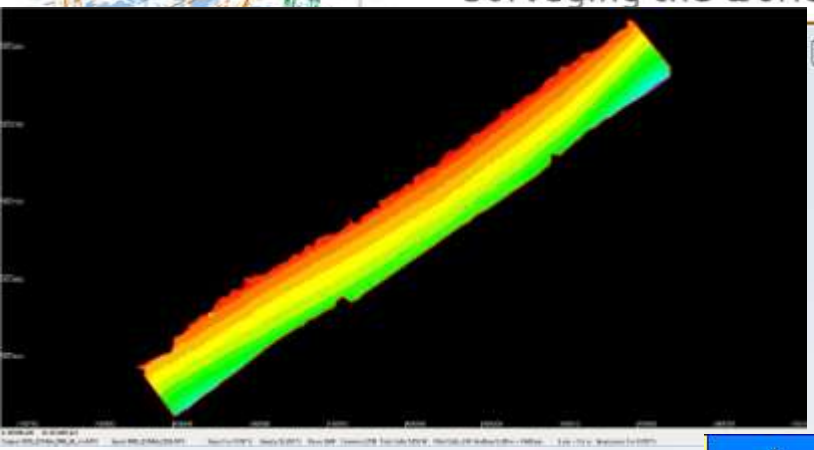


Removal condition is based on statistical outliers in the height/depth or more complex conditions

Own PC software development for grid filtering based on H/D and Backscatter

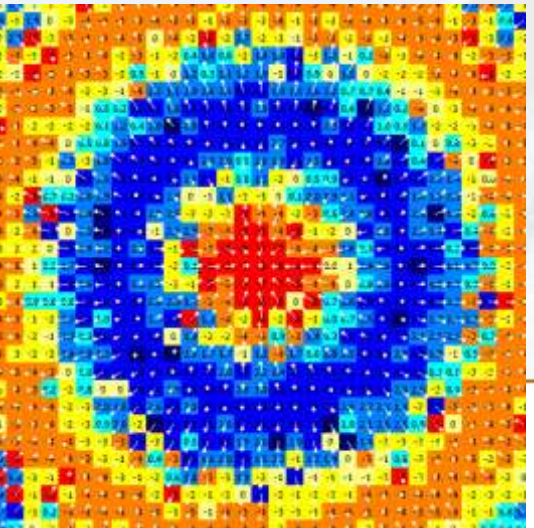
- High precision digital terrain model, up to 8 billion grid cells (or TIN with 50 million points) with 32 Gb RAM.
- Allows:
  - Sub-cm grid intervals (e.g. 300 m by 160 m grid of 2,5 mm cells => ca. 8 billion cells)
  - Visualisation
  - Filtering (outlier removal)
  - Correlation computation

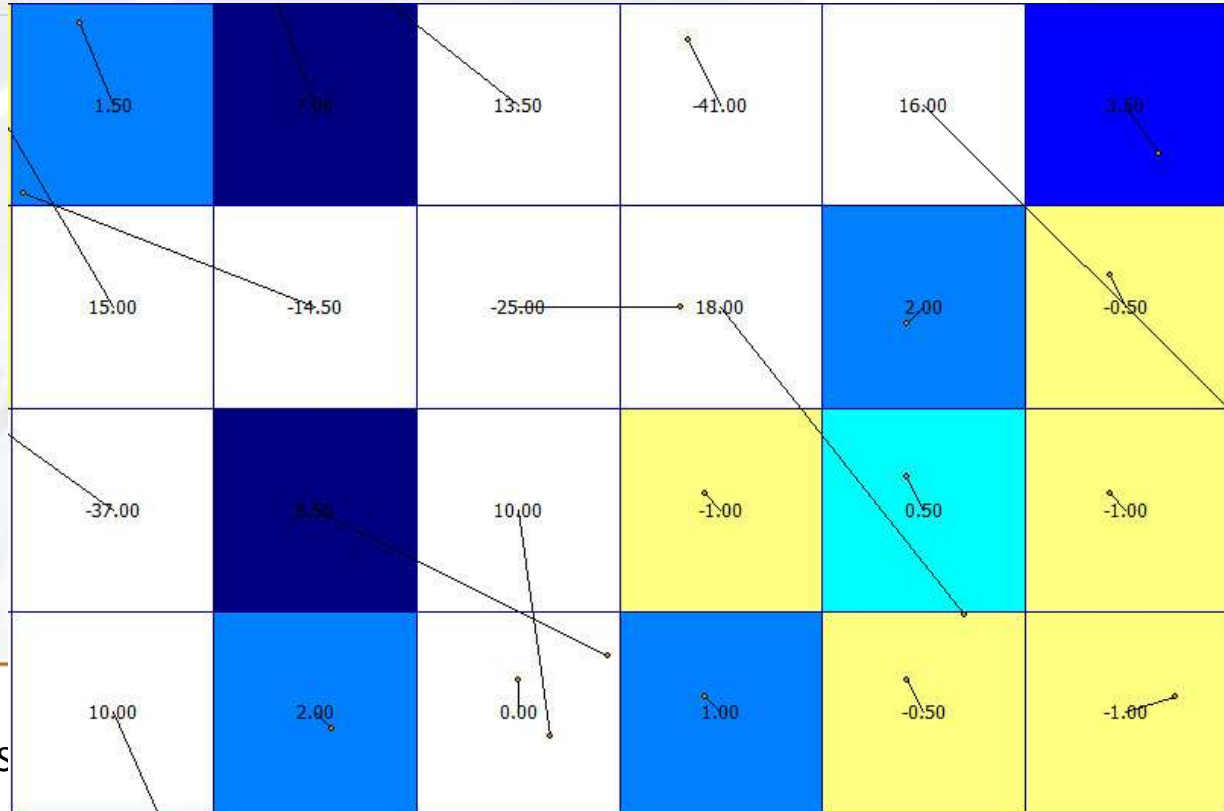


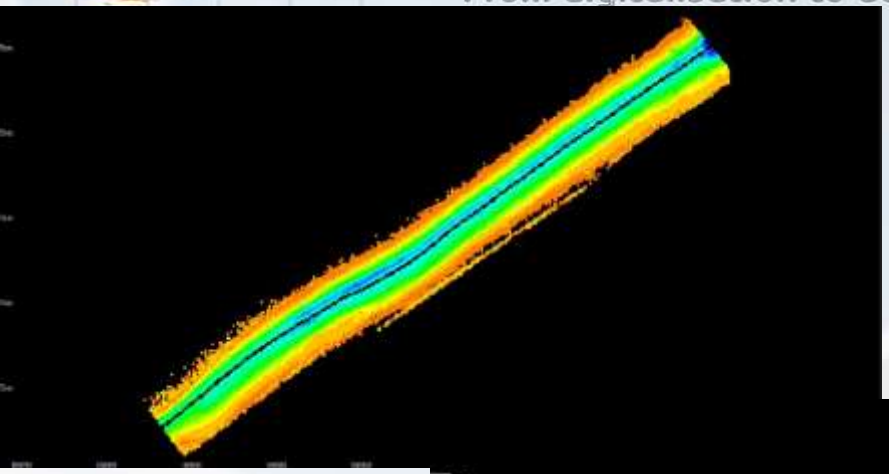


Height/Depth variation Analysis

- Maximal Slope (%)
- Maximal slope direction
- Slope in specified direction
- Slope curvature (second derivative model)

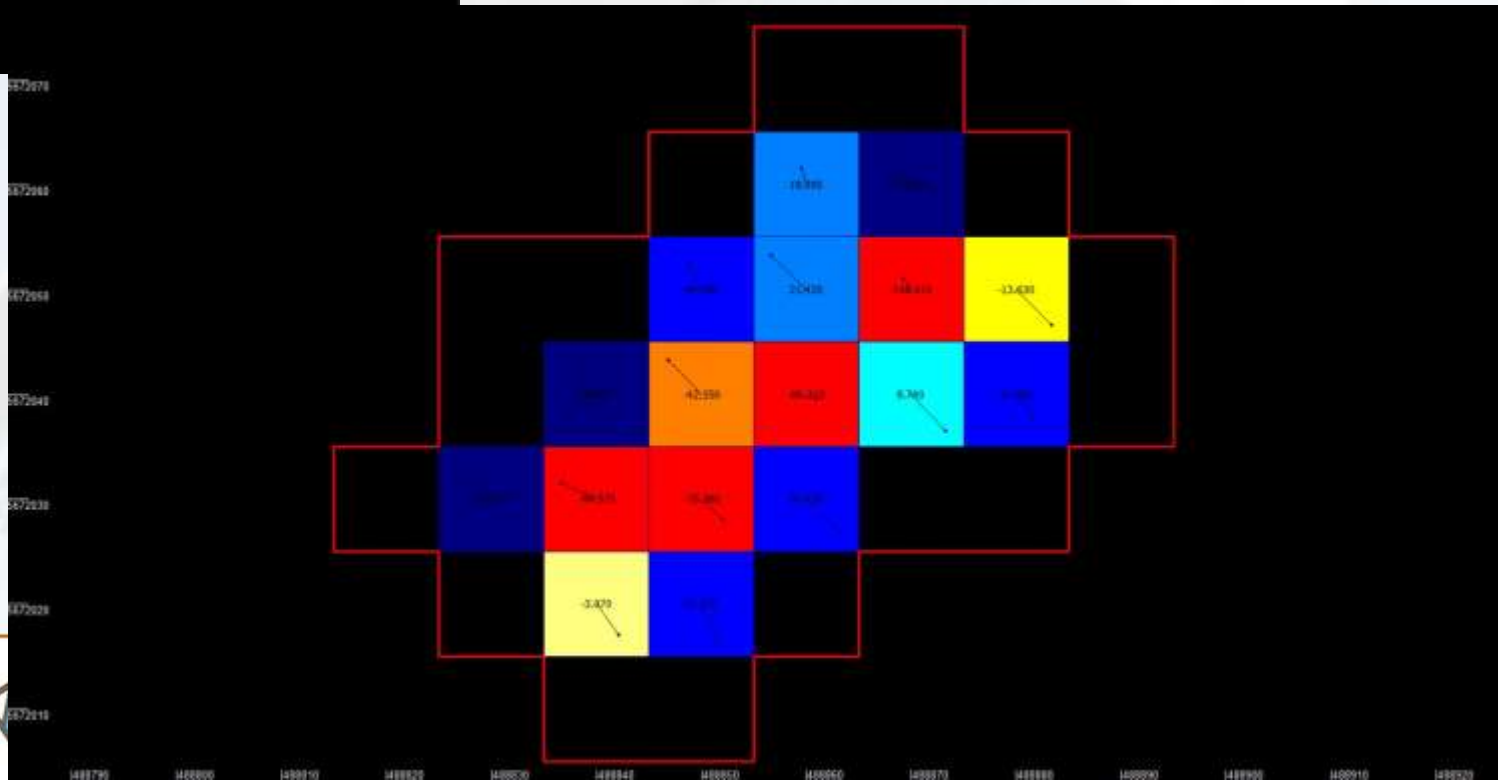


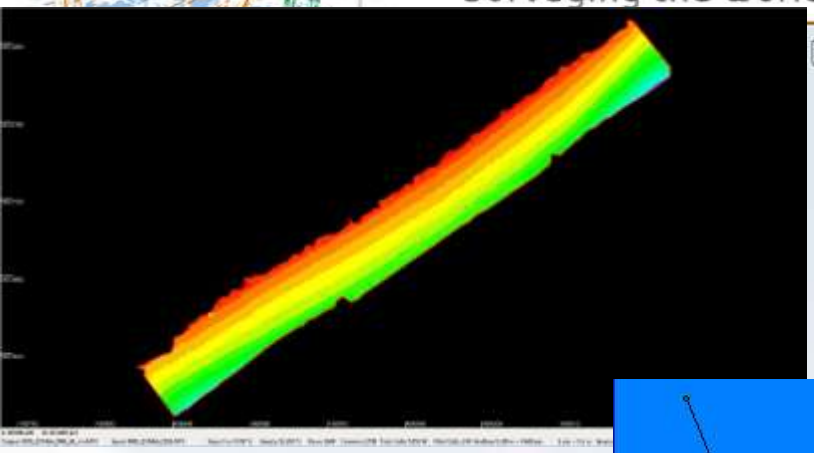




Backscatter Intensity Analysis

- Intensity of the backscatter signal
- Slope direction of maximum intensity
- Slope in specified direction
- Slope curvature (second derivative model)





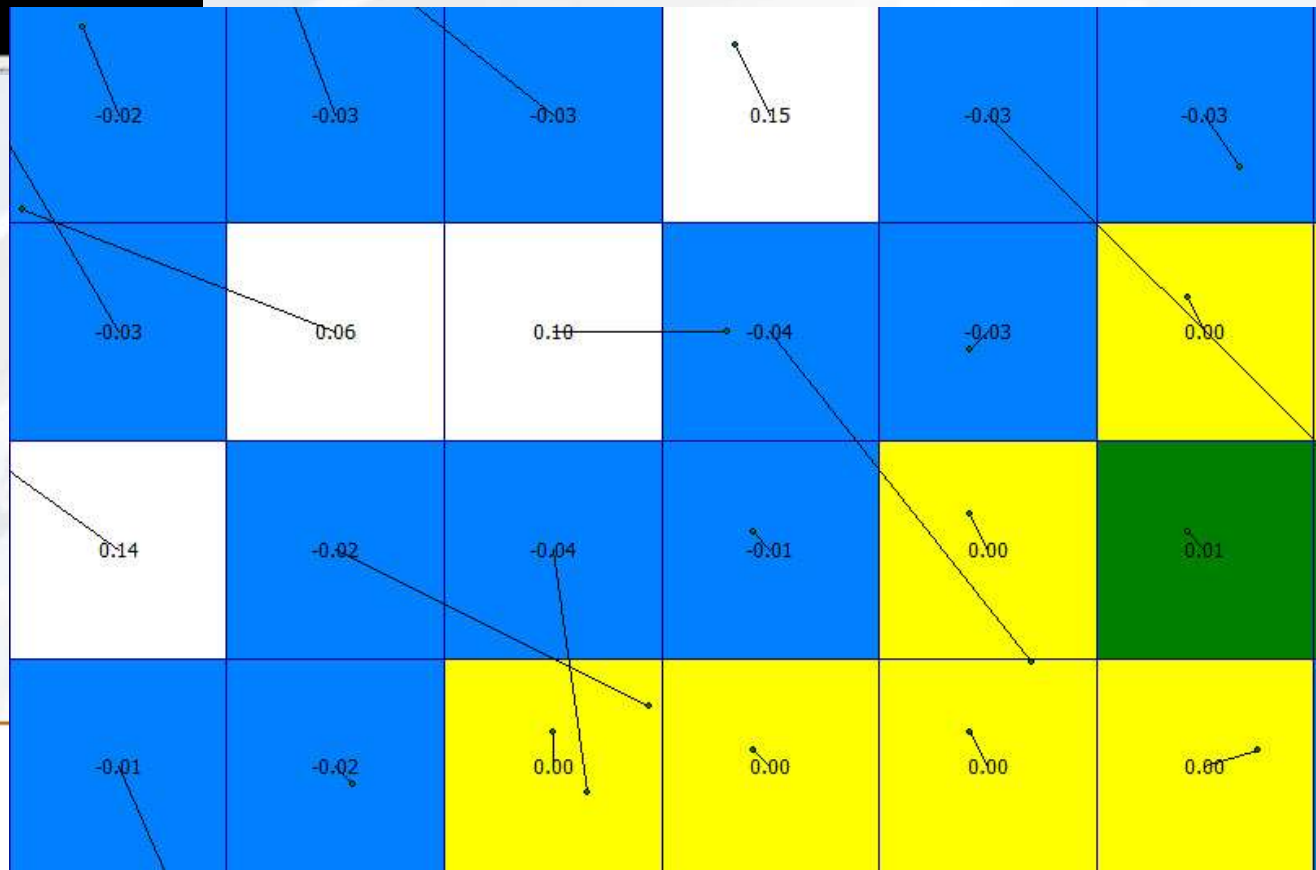
Outlier elimination

- Local Relief (absolute difference value)
- Standard Deviation (n*SD)
- Boxplot (1.5 * (Q3-Q1))

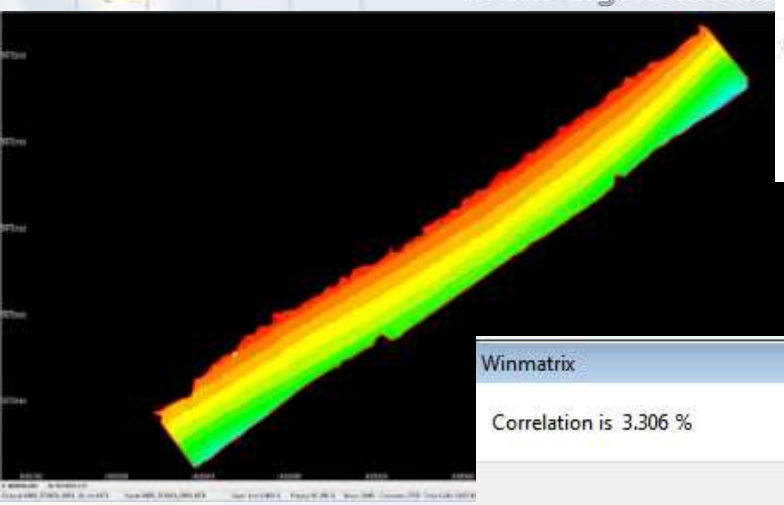
Can be applied to:

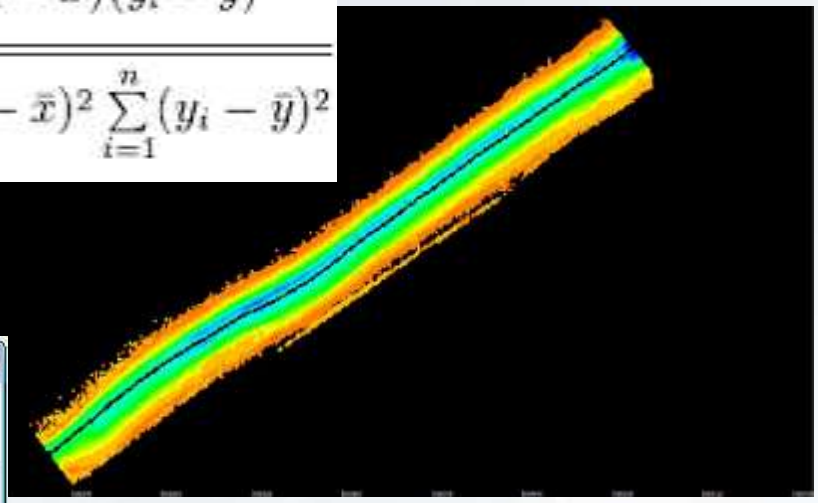
Geometric model
- Depths
- Slopes
- Curvature

Backscatter model
- Intensity
- Slopes
- Curvature



$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$





Correlation Analysis between geometry and backscatter

- Without adequate noise elimination and intensity correction => weak correlation
- Geometric model can be improved by optimal noise filtering
- Backscatter model can be improved by corrections for distance, angle (and humidity ?)

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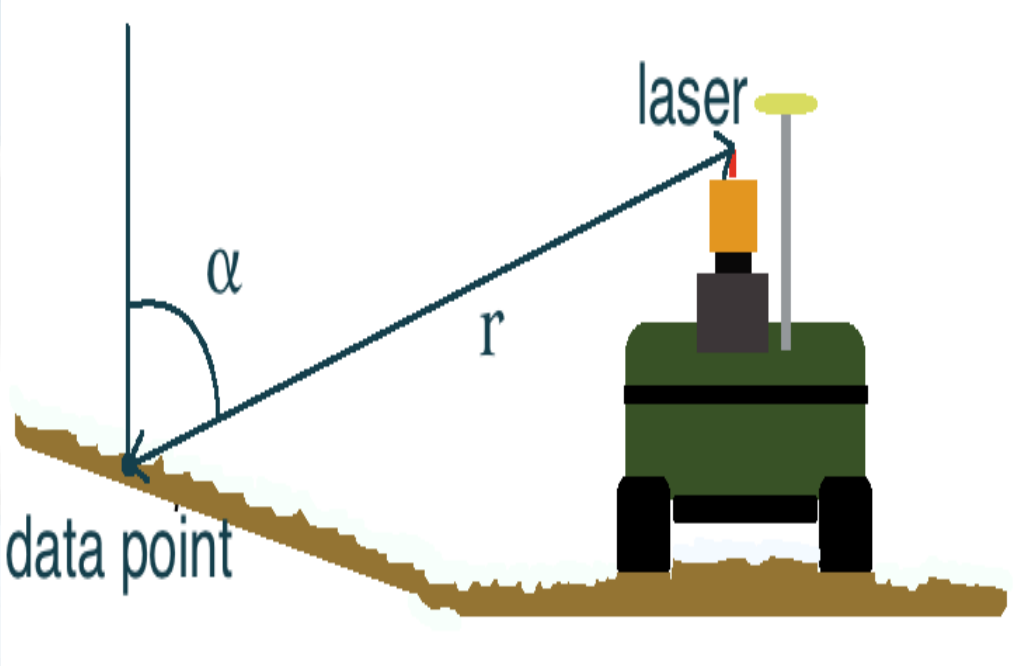
Backscatter adjustment

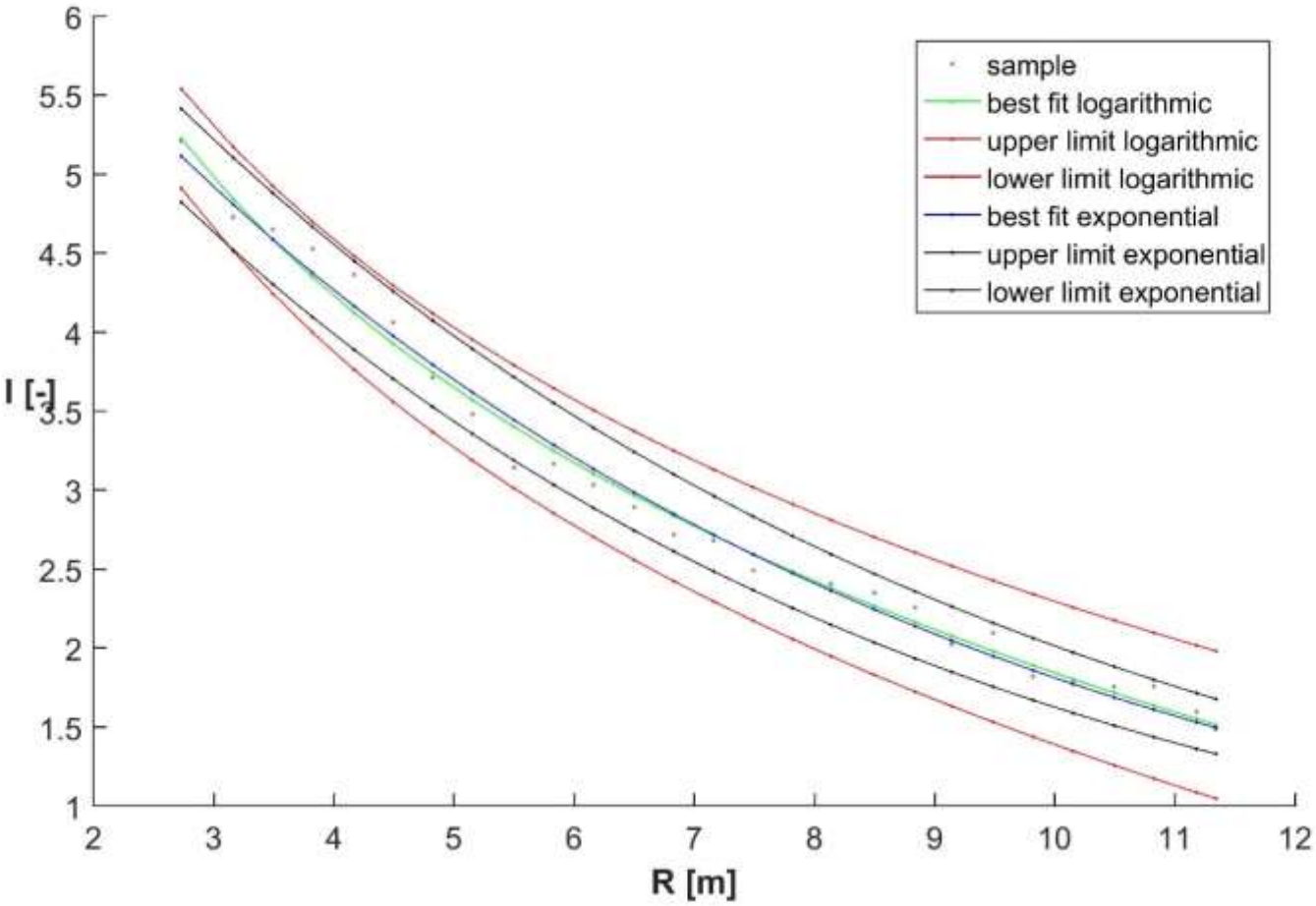
$$I = C\,\rho\,\eta_{sys}\,\frac{\cos\alpha}{r^2} + \varepsilon$$

(Pfeifer *et al.*, 2007)

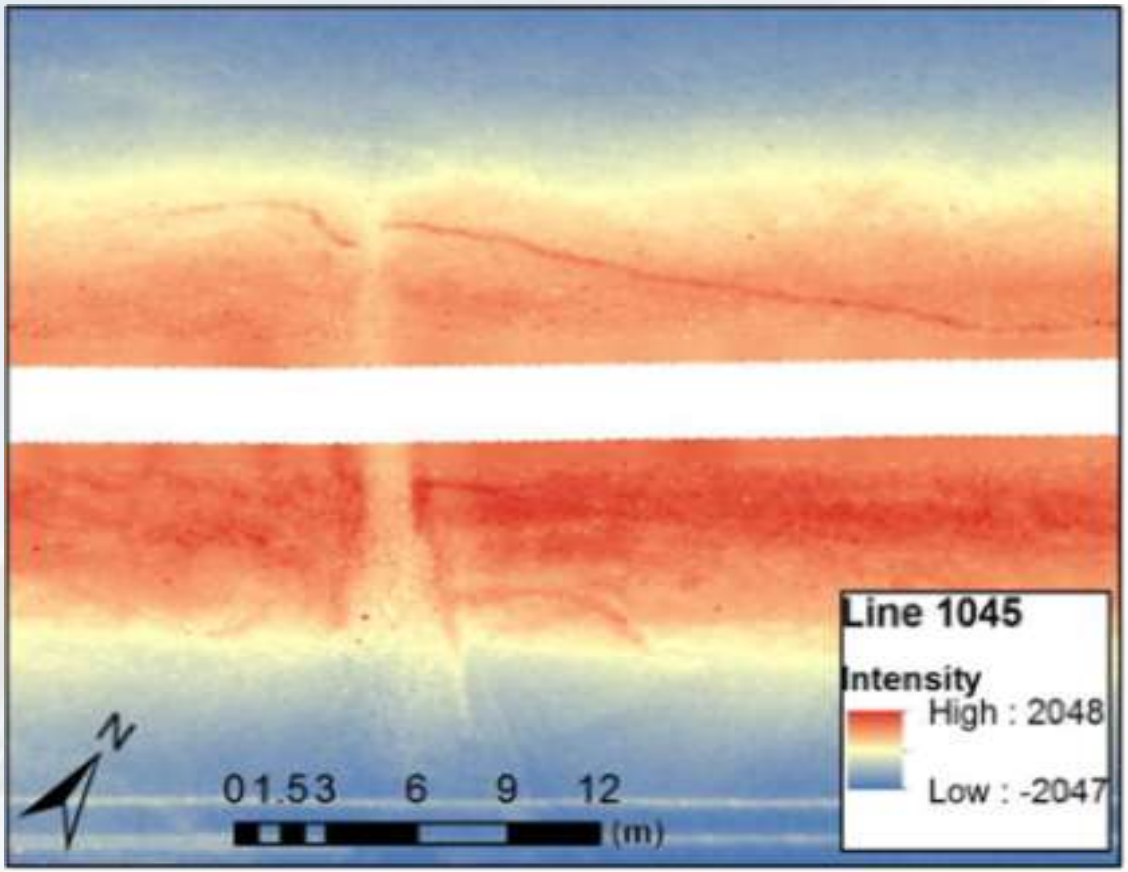
- I = intensity
- C = constant factor
- ρ = surface properties
- η_{sys} = (non-constant) system transmission factor
- α = incidence angle
- r = measured distance



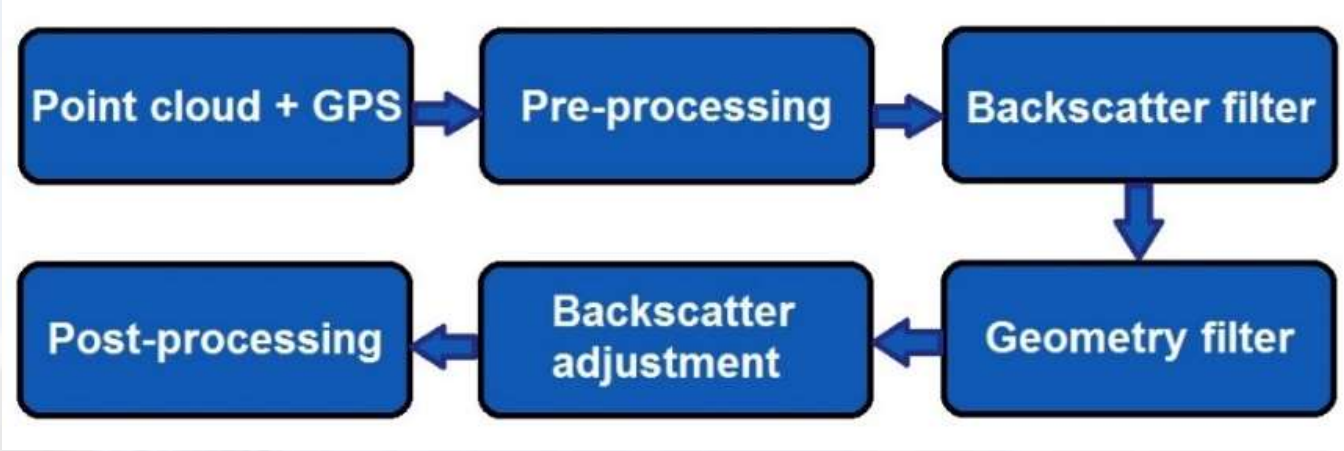
Comparison of the absolute backscatter variability between the exponential and logarithmic models



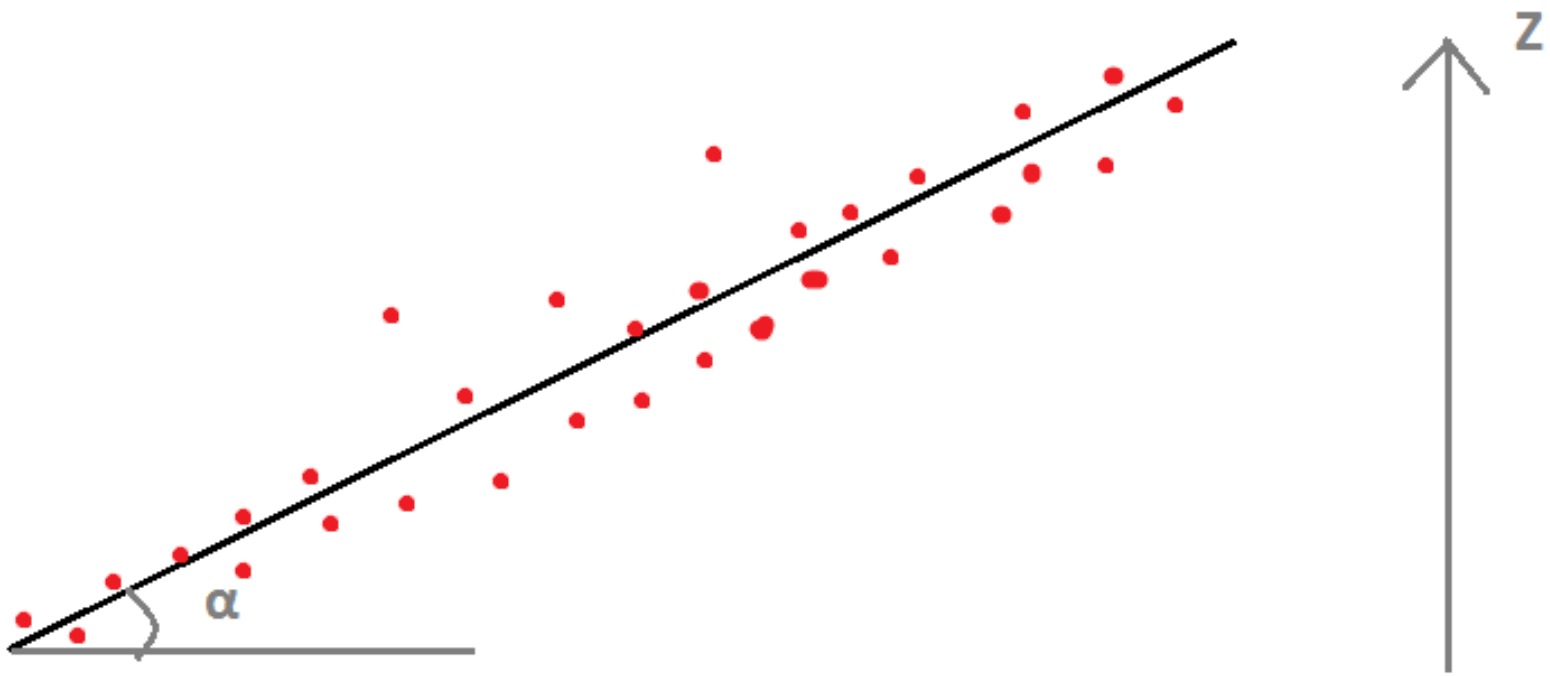
Intensity map for a track line after intensity adjustment



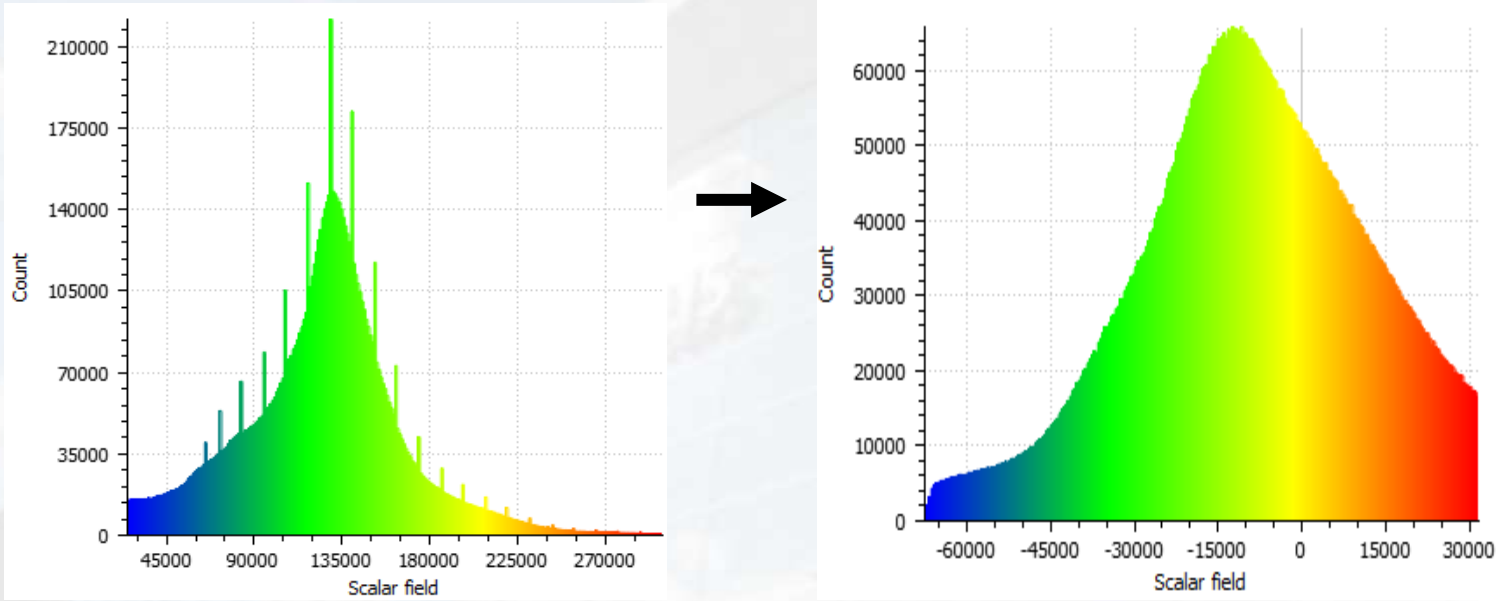
Overview of the filtering algorithm's modules

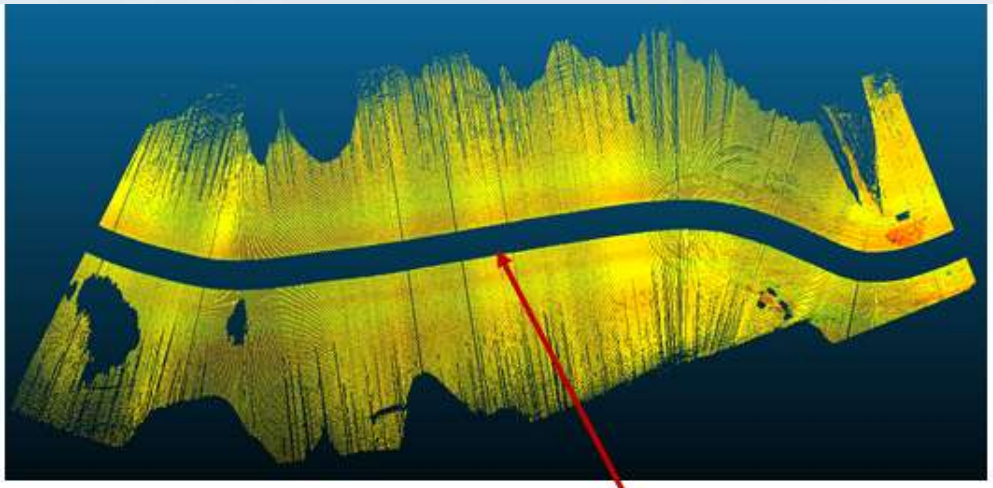


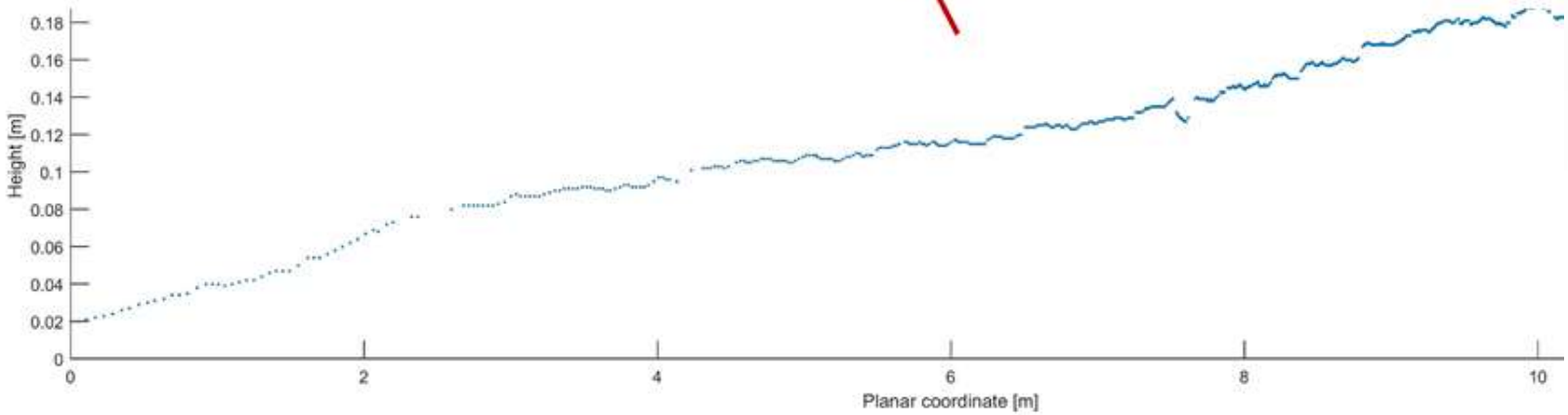
Rotation of strip to eliminate the inclination α of the beach.



- Results:
  - Boxplot-based outlier removal
  - Feature enhancement







Example of a filtered cross-section of the beach

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Conclusion

- Highly accurate intertidal zone modelling of sand beaches requires a specific acquisition technique.
- A SSV equipped with MTLS and a high grade INS and GNSS proved to be the most adequate platform for geomorphological modelling of sand beaches.
- At least equally important is an adequate processing and noise removing filter technique.
- An advanced filtering technique combining the geometry with corrected backscatter values was proposed and proved to yield better results than a classical grid noise filtering technique.

Thank you for your attention

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Questions, Cooperation, Ideas ?