HIRES3D

HIGH RESOLUTION REMOTE SENSING FOR 3D GROUND MODELING AND CLASSIFICATION

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Research project in ITC's research spearhead "Multiple use of Space"

Application of Lidar

Lidar = LIght Detection And Ranging

Laser scanning techniques give:

- geometry
- intensity
- phase of reflected wave train
- colour (if multiple different frequency lasers are used)

At present geometry and intensity used

Geometry:
spatial relation between all scanned reflection points

Intensity:
amount of laser energy that is reflected

Lidar can be done from a moving or stationary system

Moving: scanning a swath; up to about 5000 reflections per second

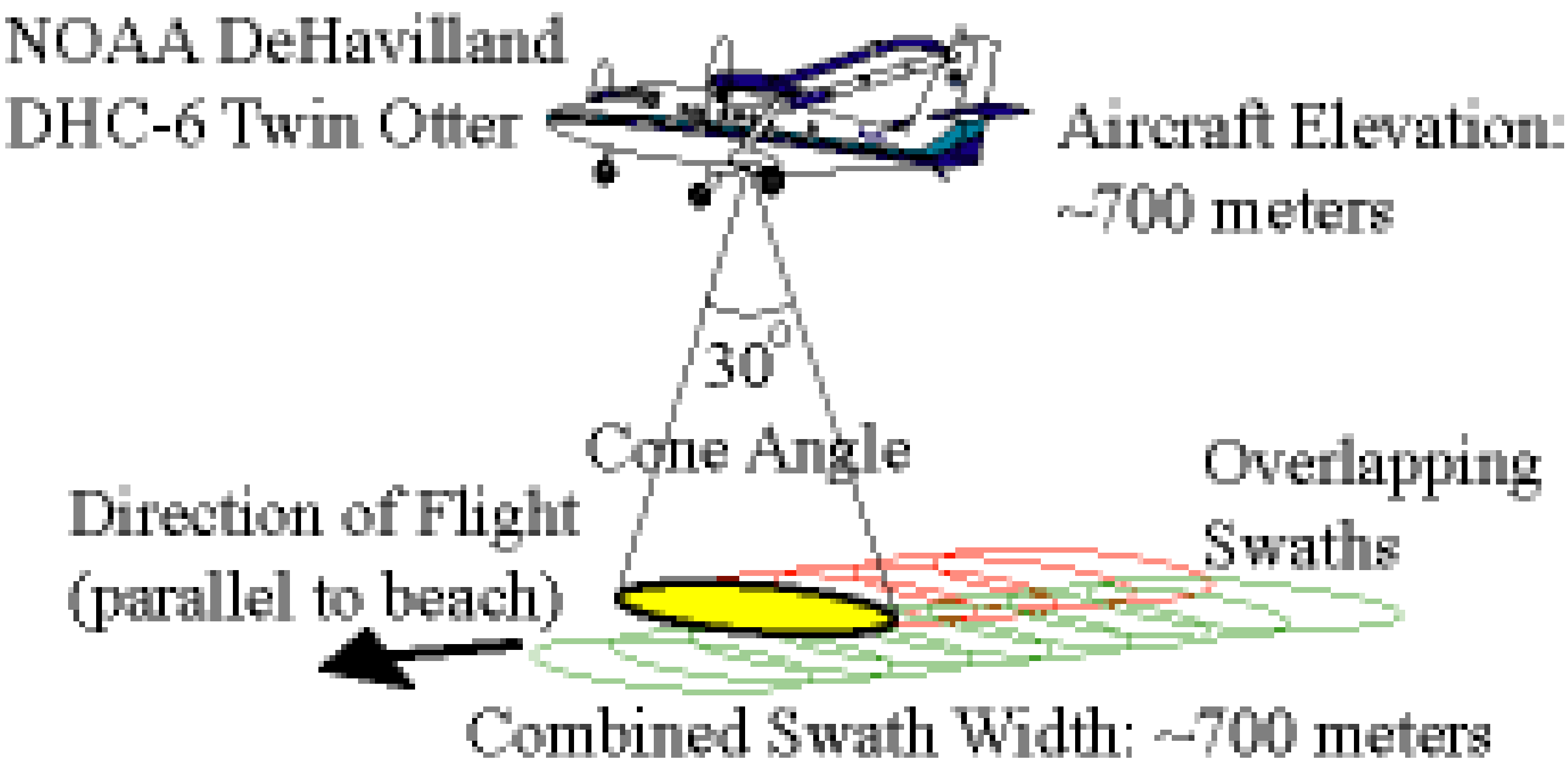
From space:
until now only Space Shuttle (and weather – cloud - satellites)
vertical accuracy: metres

From airplane:
vertical accuracy 15 – 30 cm

From helicopter:
vertical accuracy: order of centimetres

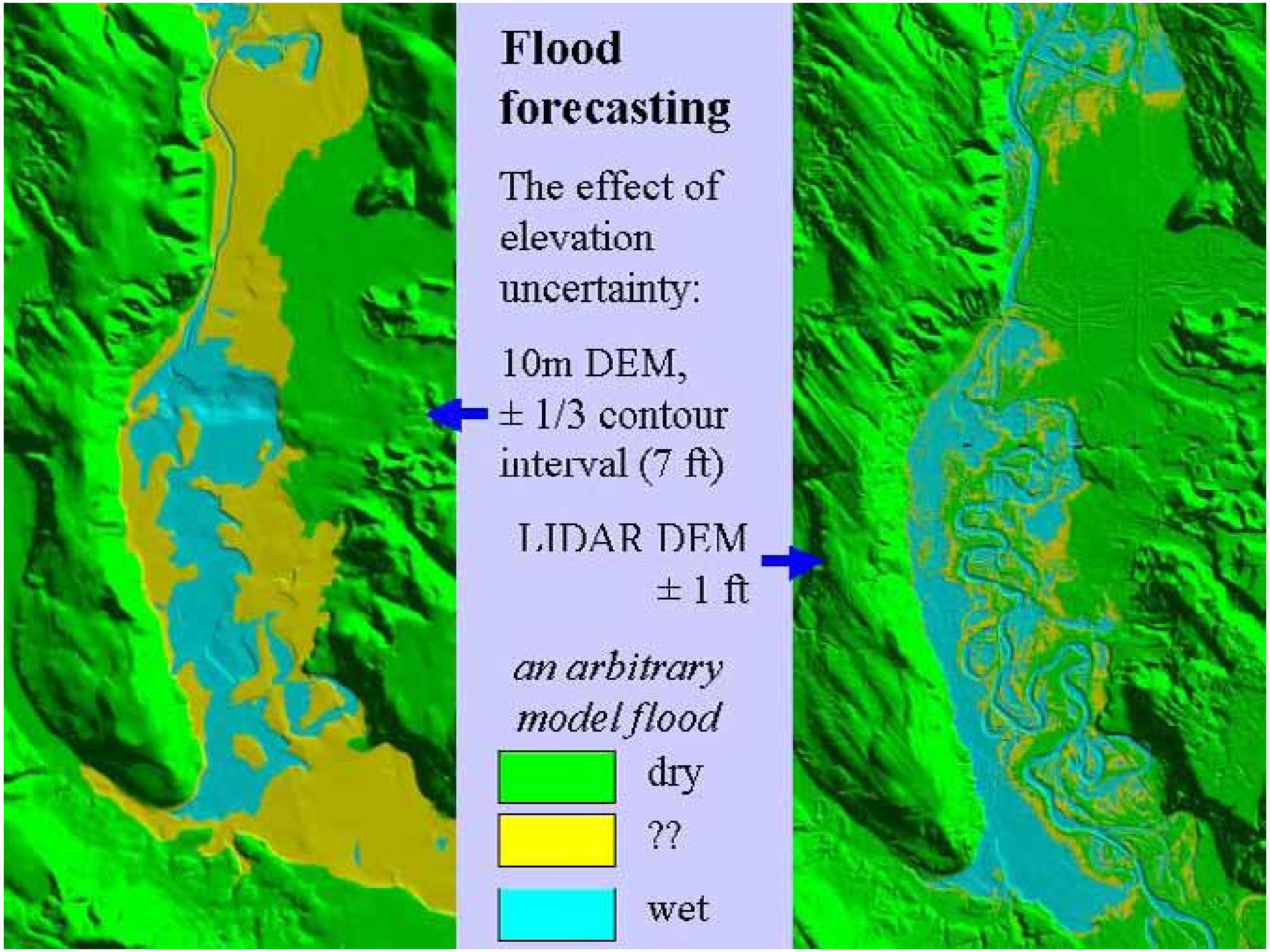
Stationary on distance of 10's of metres:
accuracy: millimetres

From Airplane



(After: USGS; http://coastal.er.usgs.gov/lidar/)

Importance of accurate DEM:



(After: Puget Sound Lidar Consortium; http://duff.geology.washington.edu/data/raster/lidar/uses.htm)

In HIRES3D three applications defined for research:

- **Spatial variation of rock and soil mass properties**
- **Monitoring of topography in mountainous terrain for stability determination of man-made slopes or man-influenced natural slopes**
- **Detection of variation in subsoil properties and monitoring of surface subsidence in coastal areas for land use and water management**

Spatial variation of rock and soil mass properties

Objectives

Extract rock mass discontinuity information (joints, bedding planes, fractures) from high resolution “point-cloud” data derived from laser scan measurements:

- Orientations
- Spacings
- Roughness

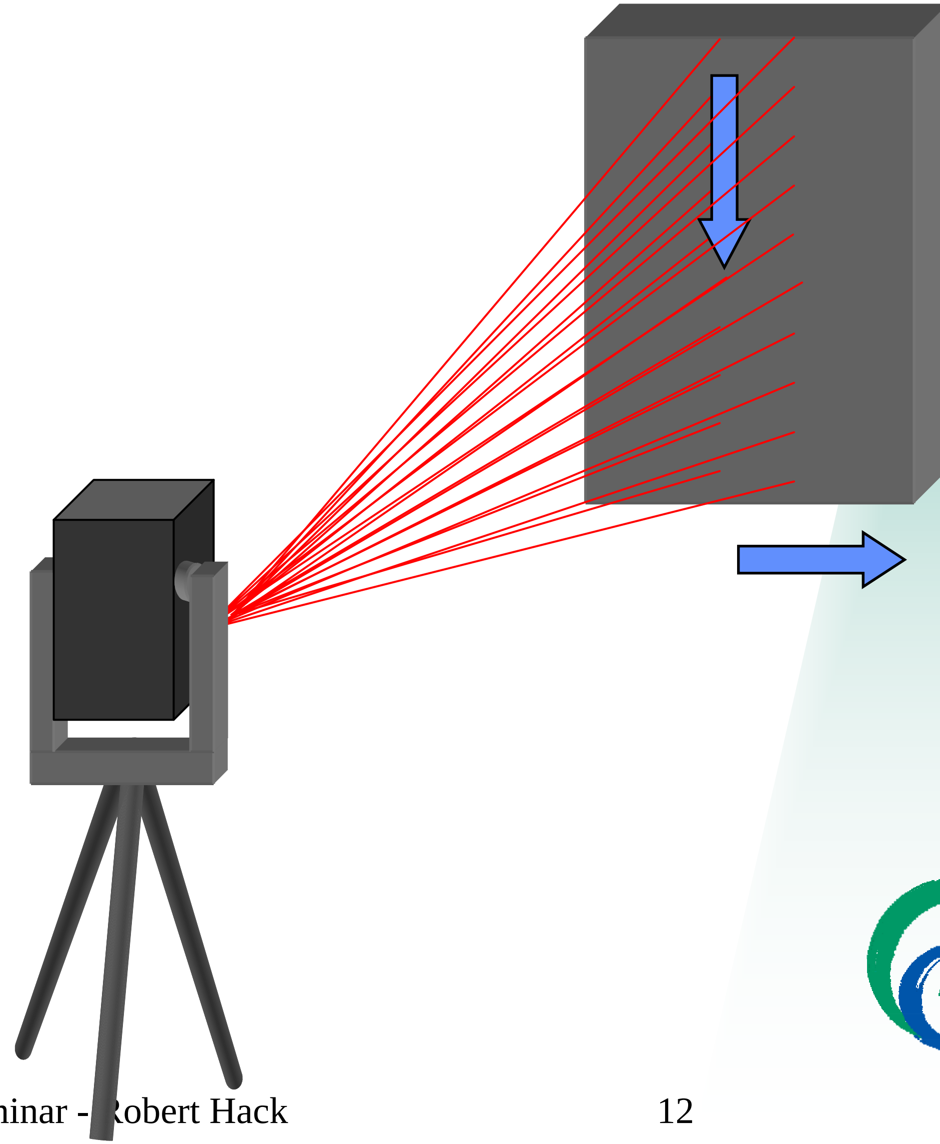
Why ?

Discontinuities govern stability of most rock and many soil slopes, tunnels, and foundations

Variation in discontinuity properties are, thus, important to design proper slopes, tunnels, and foundations

Principle 3D laser scanning

- **Rapid scanning of objects using pulsating laser**
- **Reflection time (distance to surface from laser) & orientation of laser beam gives position in 3D space**
- **Dense scanning (mm to cm resolution) yield highly accurate 3D models**
- **Intensity of reflected pulse is measured.**
- **New generation of laser scanners detect colour information as well**



(After Slob et al., 2002)

1st Approach and results

- **Acquisition of point cloud data of rock face (x,y,z,intensity)**
- **3D triangulation of points into a real 3D digital surface**
- **Statistic analysis of triangulated surface to obtain the orientation of each individual triangle (dip direction/dip angle)**
- **Plot orientations in a polar plot and create kernel density contours to determine orientation trends**

(After Slob et al., 2002)

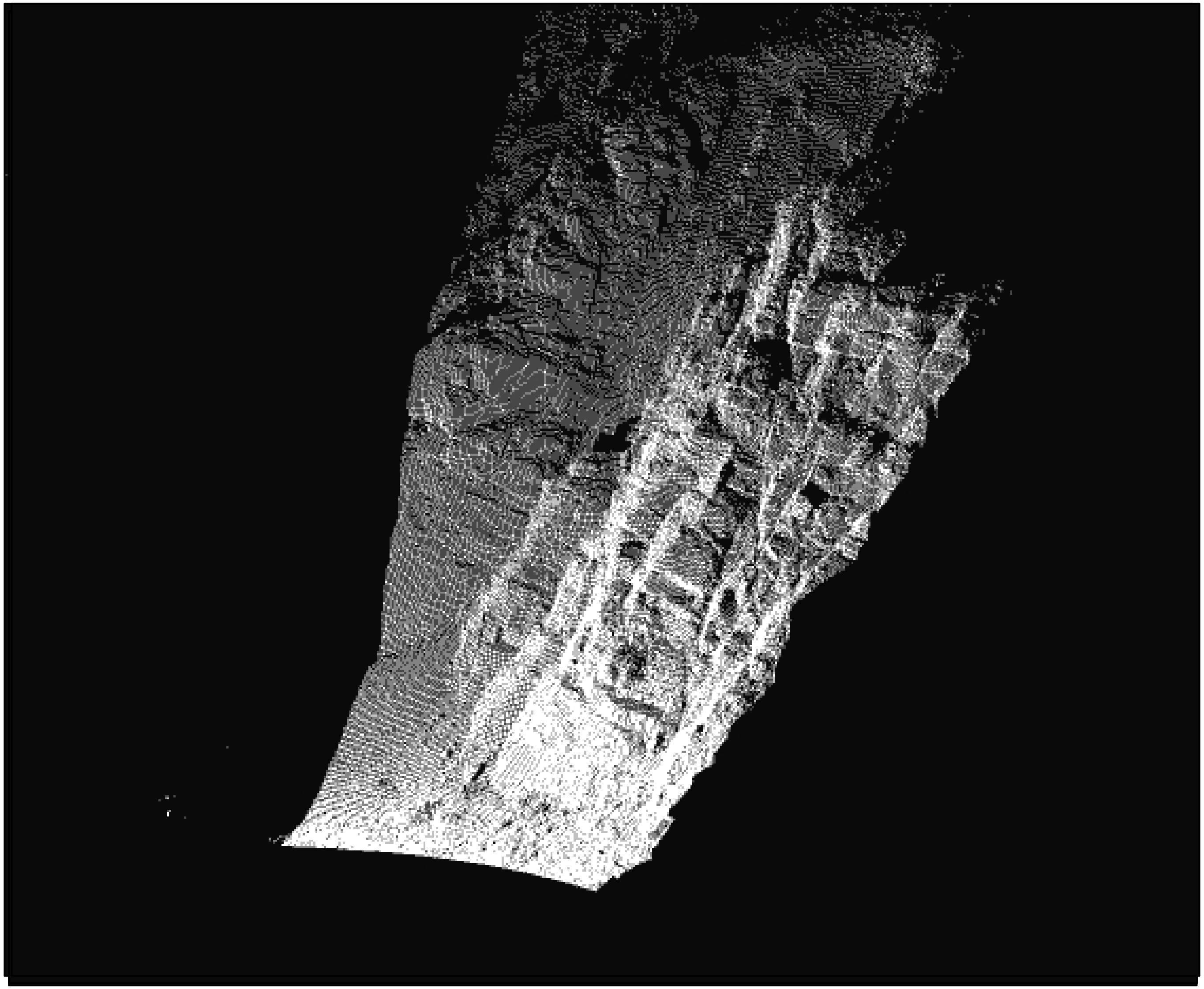
Rock face - Mt. Vernon (Co.), USA

(After Slob et al., 2002)

Rock surface scan (using a Cyrax scanner

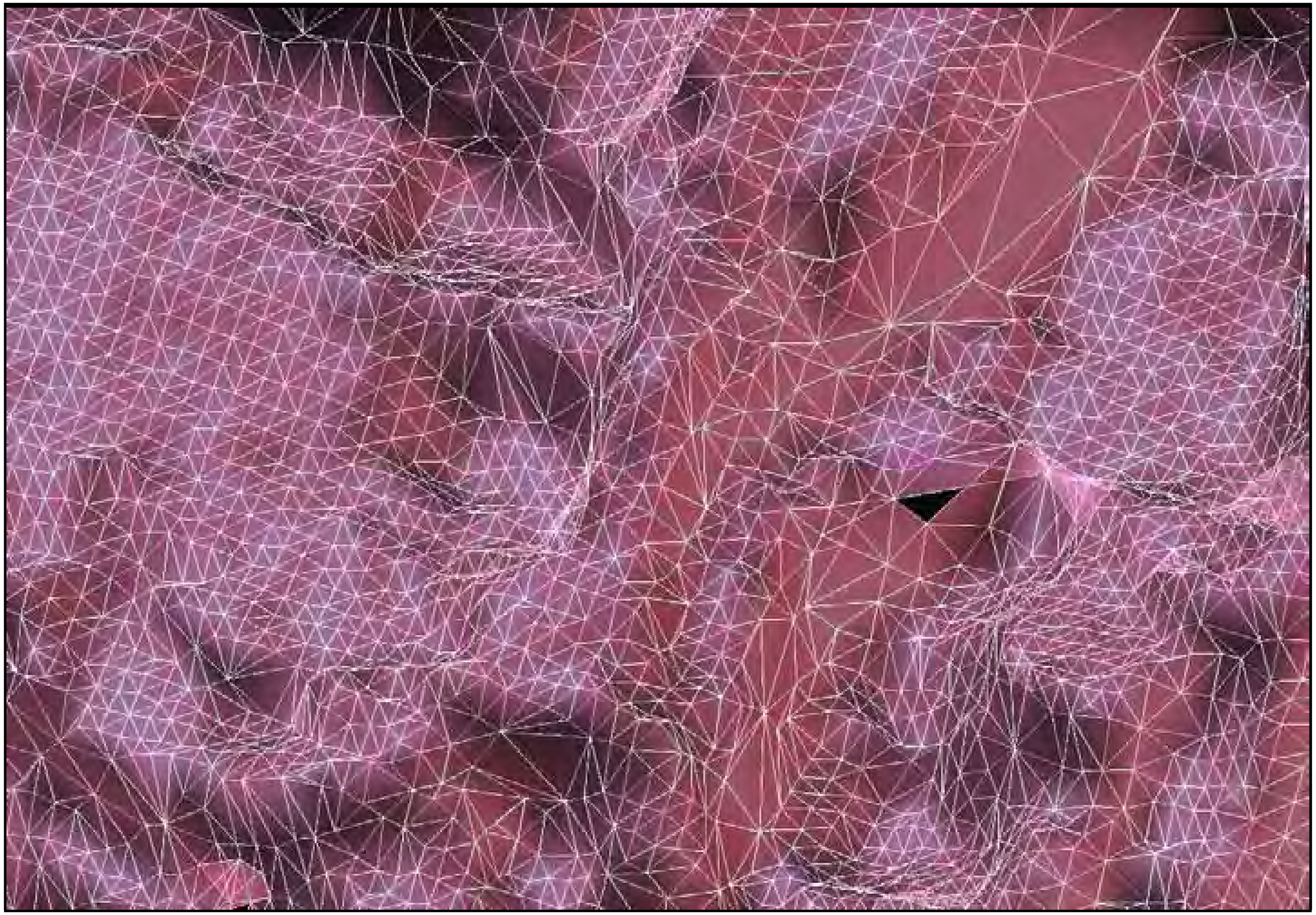
(After Slob et al., 2002)

Visualisation of point cloud data



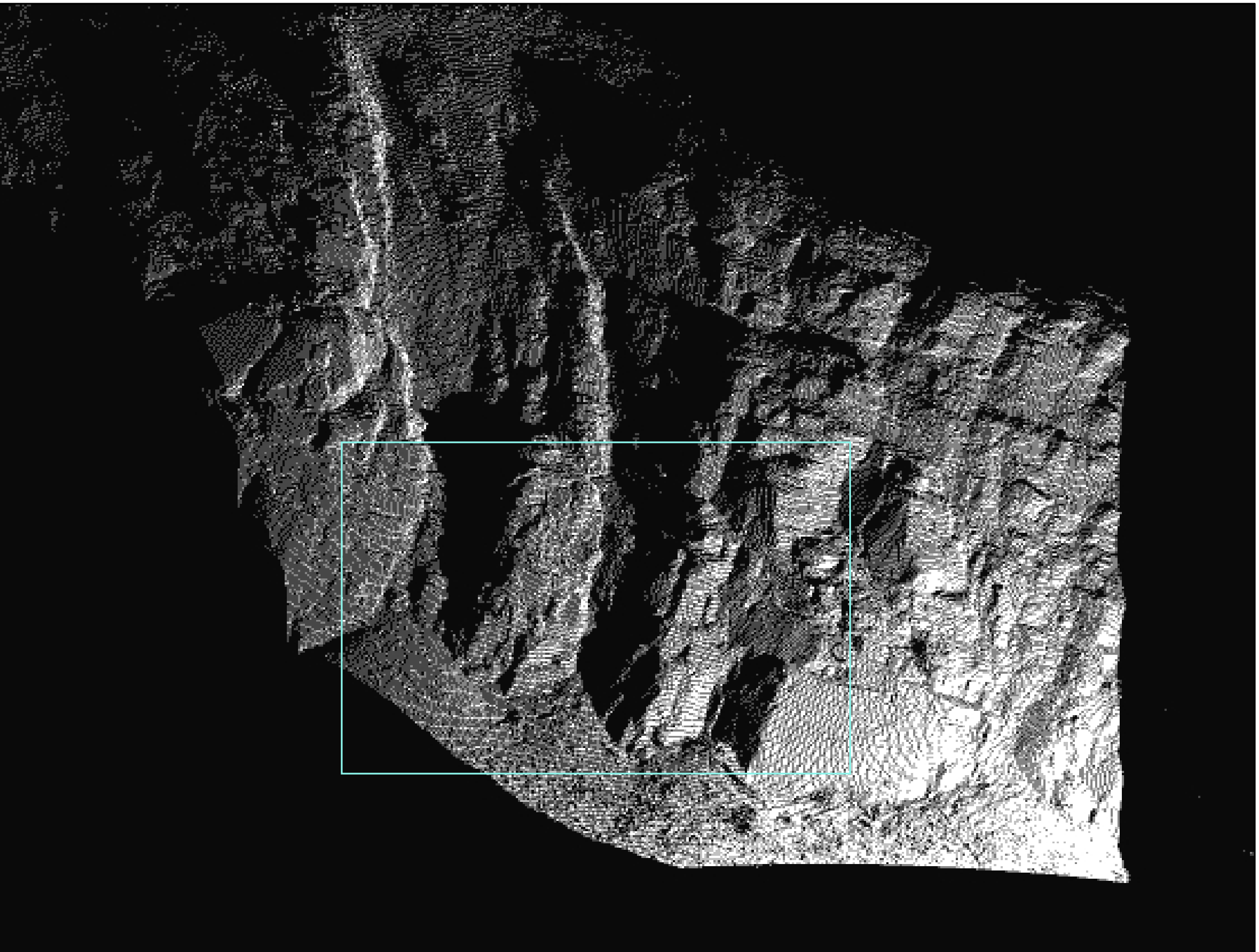
(After Slob et al., 2002)

3D Delaunay triangulation to create surface through point cloud data

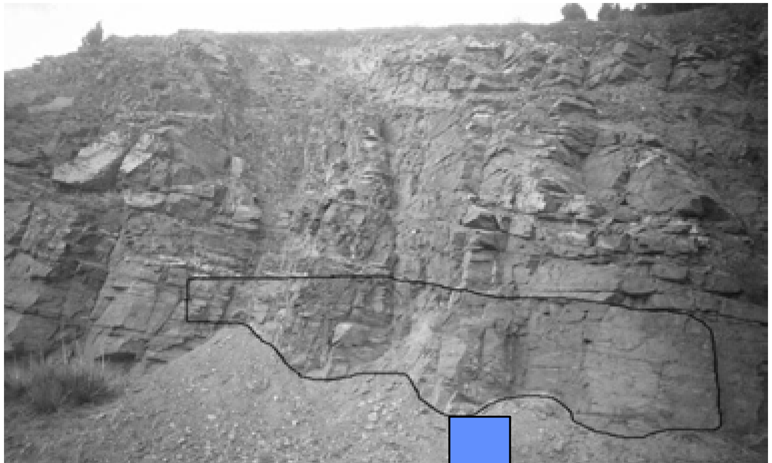


(After Slob et al., 2002)

Trial on sub-dataset

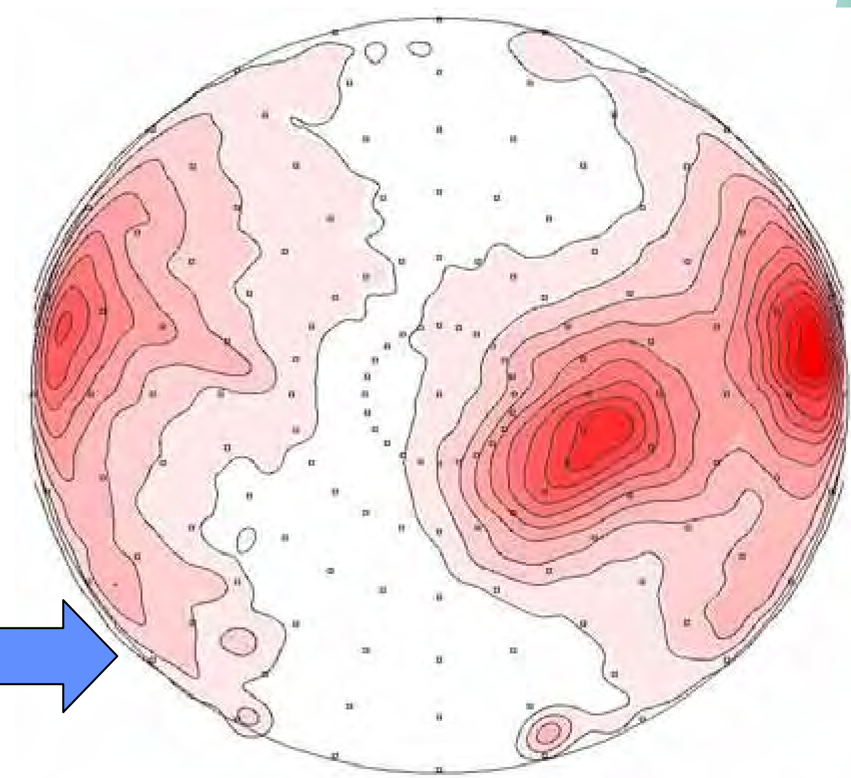


Statistic analysis of triangulated data



Digitally rendered 3d model

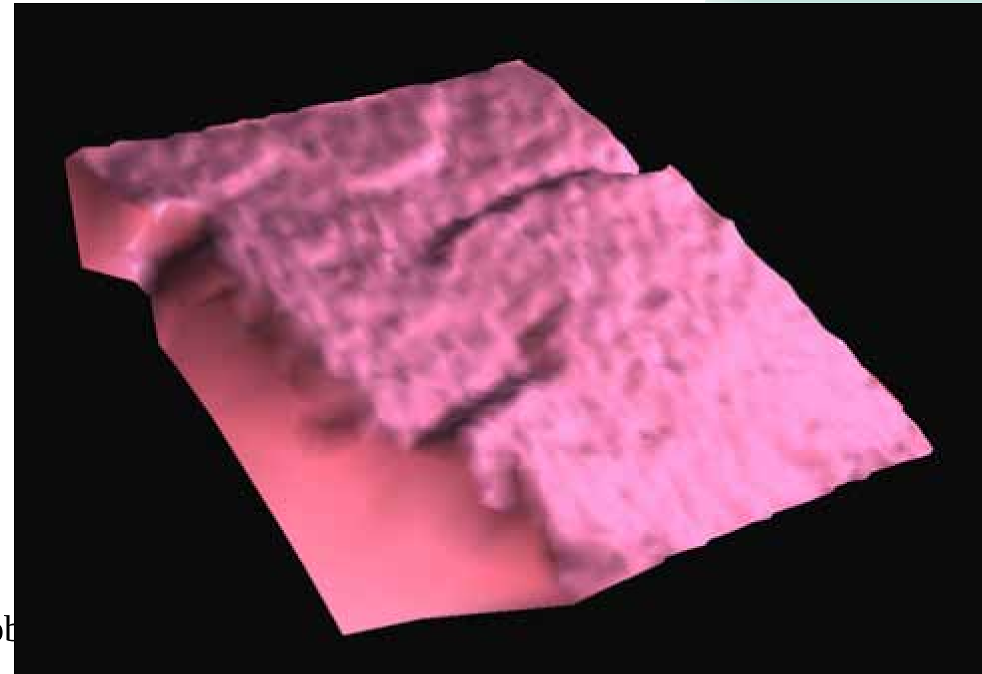
(After Slob et al., 2002)



Kernel density pole plot of all triangle orientations of this part of rock surface

Further research (1)

- **Calculation of discontinuity spacing distributions**
- **Calculation of discontinuity surface roughness (large- vs. small scale)**
  - Intensity (of reflected laser beam)
  - Geometry



Detail of interpolated discontinuity surface (appr. 50x50 cm), clearly visible are the roughness characteristics. Artificial illumination (rendering) applied to enhance relief

(After Slob et al., 2002)

Further research (2)

- **Calculation of persistency of discontinuities**
- **Comparison with discontinuity information gathered with traditional surveying:**
  - Digital stereo photo analysis
  - Scanline surveys
- **Export of rock mass discontinuity model to 3D-GIS or numerical calculation models**

(After Slob et al., 2002)

Detection of variation in subsoil properties and monitoring of surface subsidence in coastal areas for proper land use and water management
(proposal submitted for ICES3/KIS and EU-link research programs)

Why ?

Subsidence (due to peat oxidation, clay compression, weathering, water extraction, tectonic movements, etc.) and impossibility for new sediment deposits (due to, for example, dykes) in combination with (possible) rising sea water levels give more and more problems with land use and water management in coastal zones

Examples ?

Most of Western part of the Netherlands
Sinking cities as Bangkok, Surabaya, Semarang, etc.
Parts of Bangladesh
Mexico City
etc., etc.,

- Lidar monitoring data
- 4D sub-surface model for subsidence (based on existing geology information and Lidar monitoring data for subsidence and material compression properties)
- 4D ground/surface water model
- 4D geotechnical property model
- 4D bearing capacity and settlement model for various engineering applications
- Decision support system for land use and water management

Future:

Expected:
- higher resolution
- cheaper equipment
- space based scanners with high resolution

Lidar is one of the most important developments because until now no (easy and cheap) method existed to measure natural material surfaces with an accuracy anywhere near that obtained by Lidar scans