JOANNEUM RESEARCH

Natural Risks
-
Terrestrial Laser Scanning for Georisk Monitoring: Methods and Practice

Institute *for*
Digital Image Processing

DI Arnold Bauer

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Graz / Austria

DI Heiner Kontrus

DIBIT Measurement Systems
Mils / Austria

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RESEARCH

Georisk Monitoring

Overview

Rock Slide
Monitoring

Snow Cover
Monitoring

Glacier Change
Monitoring

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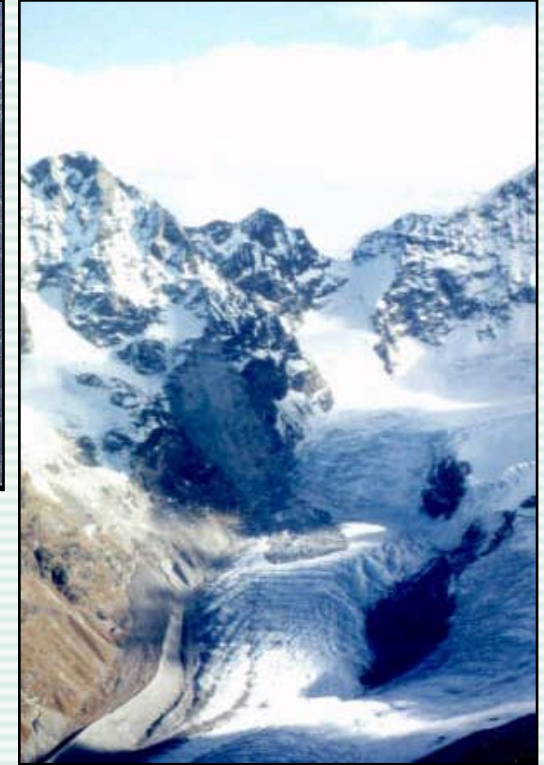a TRADITION of INNOVATION

Rock Slide Monitoring
Danger of a Rock Fall

Vorarlberg, 2002

Eiblschrofen, Schwaz, Tyrol, 1999

Piz Morteratsch, Switzerland, 1988

Reasons: ➤ Climate change: global warming

➤ Extreme weather conditions

➤ Removal of protection forest

➤ Dense settlement

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Rock Slide Monitoring

Appropriate Measures

➢ Evacuation of buildings

➢ Road closure

➢ Disaster alert plans

➢ Protection buildings:
protective barrier, retaining wall,
retention capacity, rock anchor

➢ Restoration of protection forests

➢ Observation of potentially insecure
regions

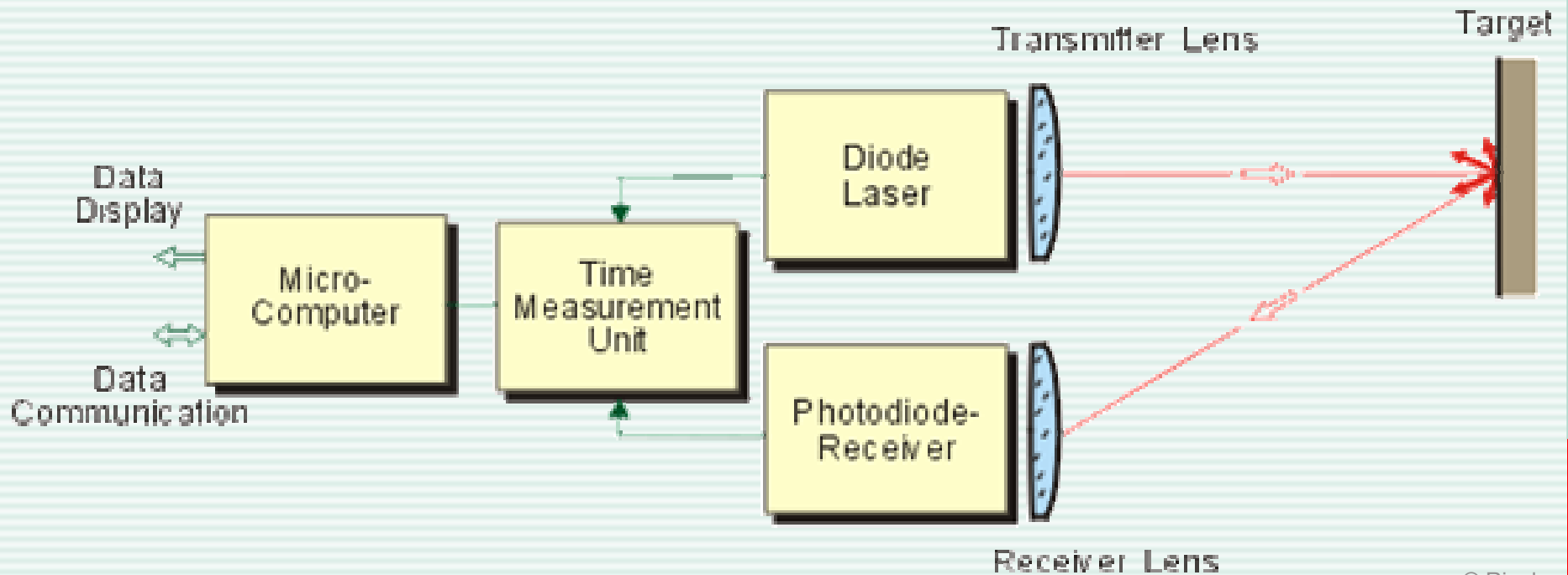ISO 9001 certified
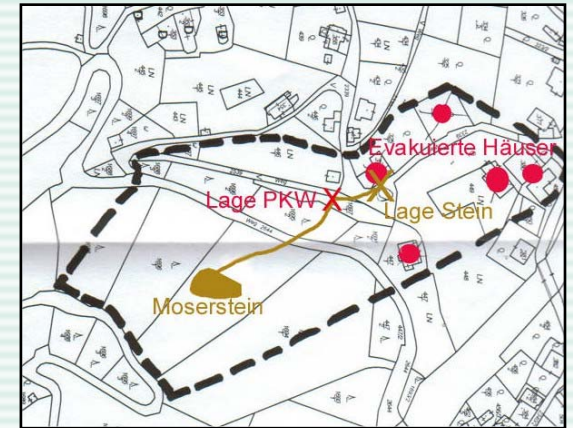
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Laserscanner

DIBIT Geoscanner

Riegl LPM98-2k

➢ Terrestrial
long range laser scanner (up to 2km)

➢ Pan & tilt mount for positioning
Regular grid of spherical angles

➢ Laser wavelength: near-infrared, 900 nm
Eye safety: class 1M (3B)
Beam divergence: 1.2 mrad

➢ Measures distance, reflectivity, SDev

➢ High accuracy (distance: typ. ± 50 mm)
Measuring time: 0.25 - 1 sec / point

➢ See www.riegl.co.at

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Laserscanner
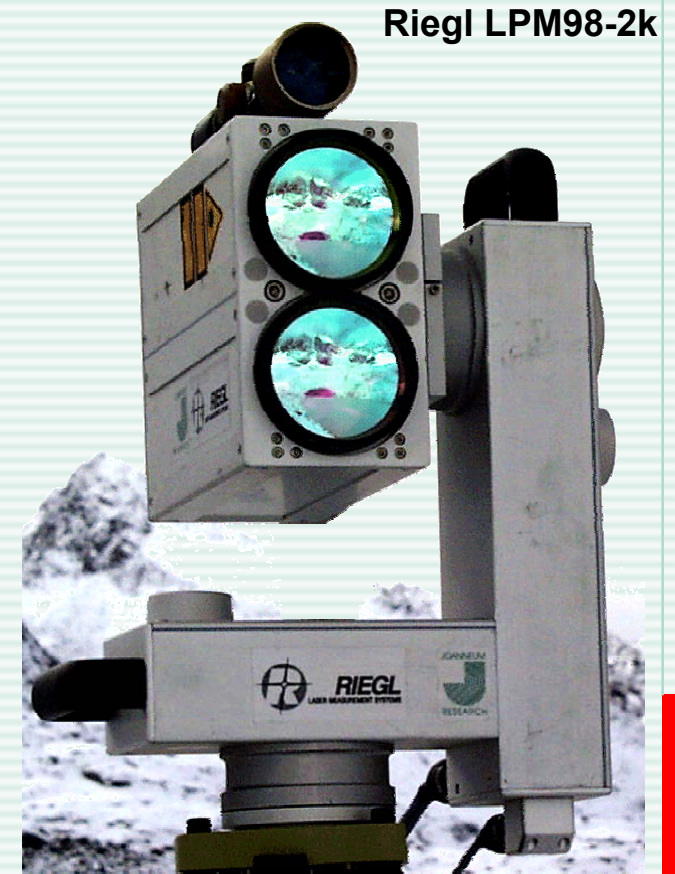
Time-of-flight Measurement

Pulsed laser sensor

© Riegl

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Laserscanner

Reflecitity of Surfaces / Materials

Diffuse reflection

incident beam
diffusely reflecting target surface
target
© Riegl

Mirror-reflection

incident beam
reflected beam
glossy or mirror-like target surface
target
© Riegl

Retro-reflection

incident beam
reflected beam
Retroreflecting foil or cat's eyes reflector
© Riegl
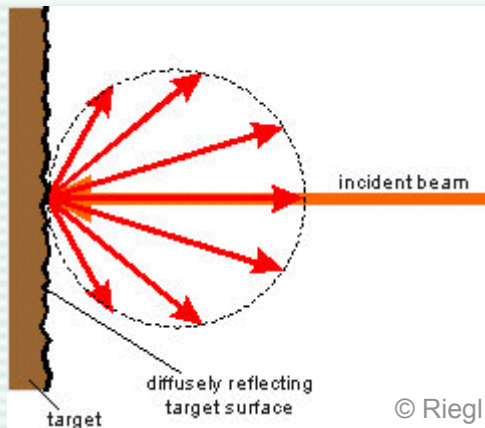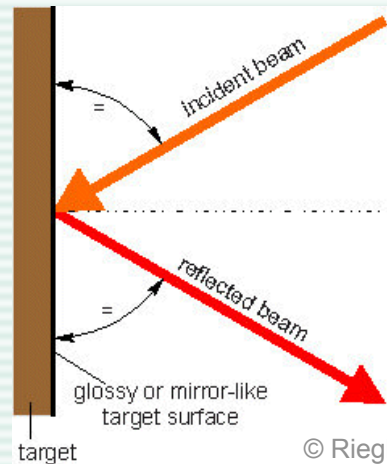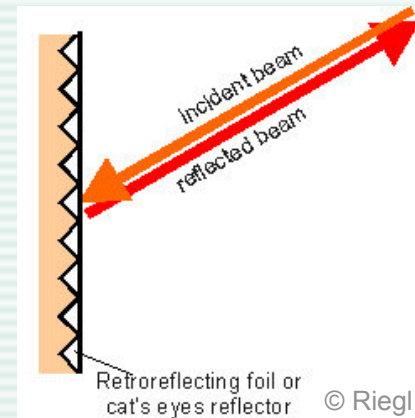
Reflectivity:

Snow: ~ 85 %   Sand: ~ 50 %

Rock: ~ 75 %   Trees: ~ 30 %

Reflecting foil 3M: ~ 1250 %

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Laserscanner

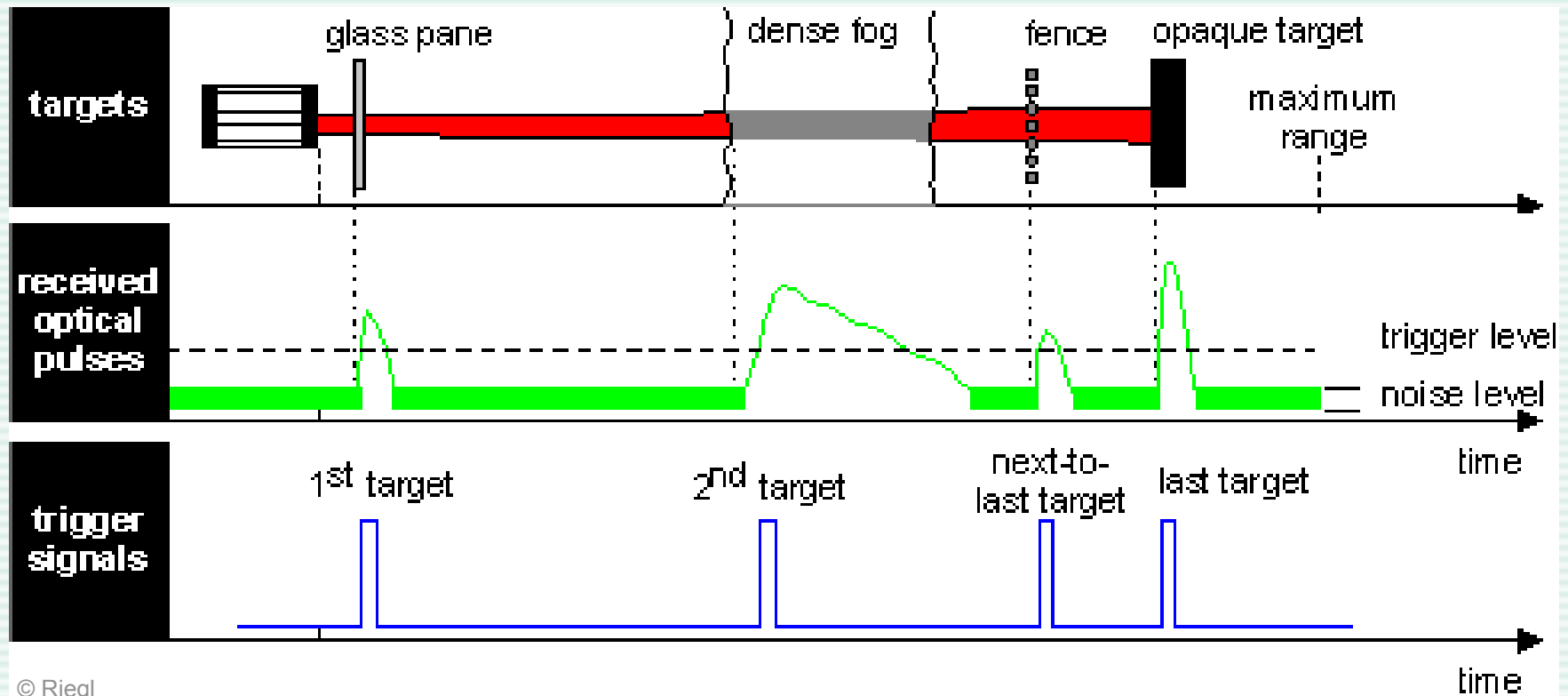# Maximum Range

Depends on:

Visability
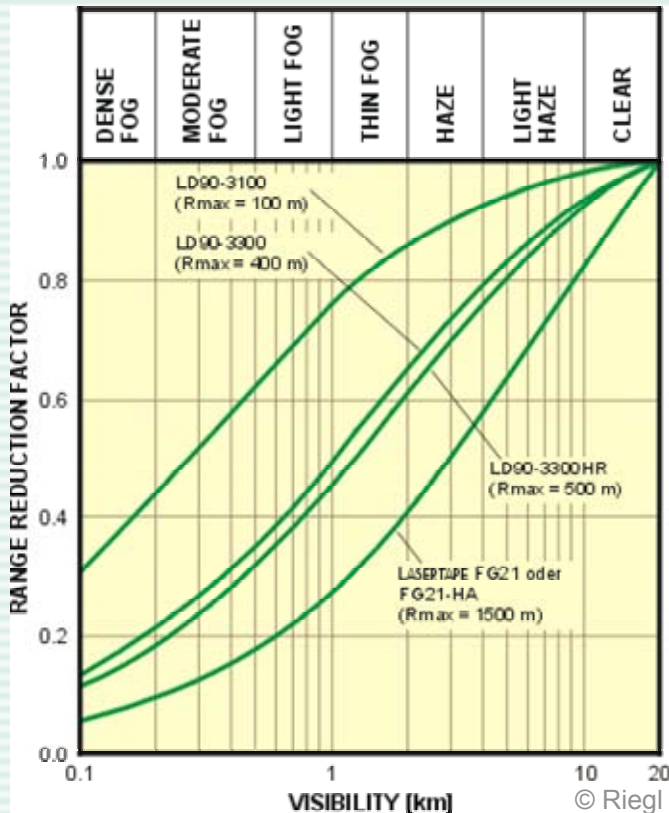
Reflectivity
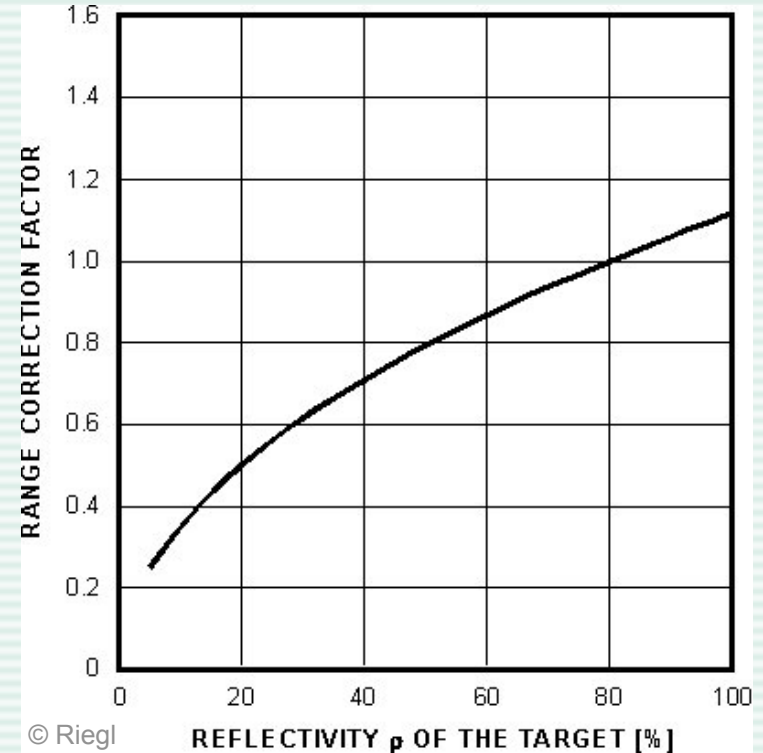
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Laserscanner
First / Last / Strongest Pulse

© Riegl

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Laserscanner Software

LaserServer

Fully automated data acquisition and analysis

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Project Definition
Define Measuring Process
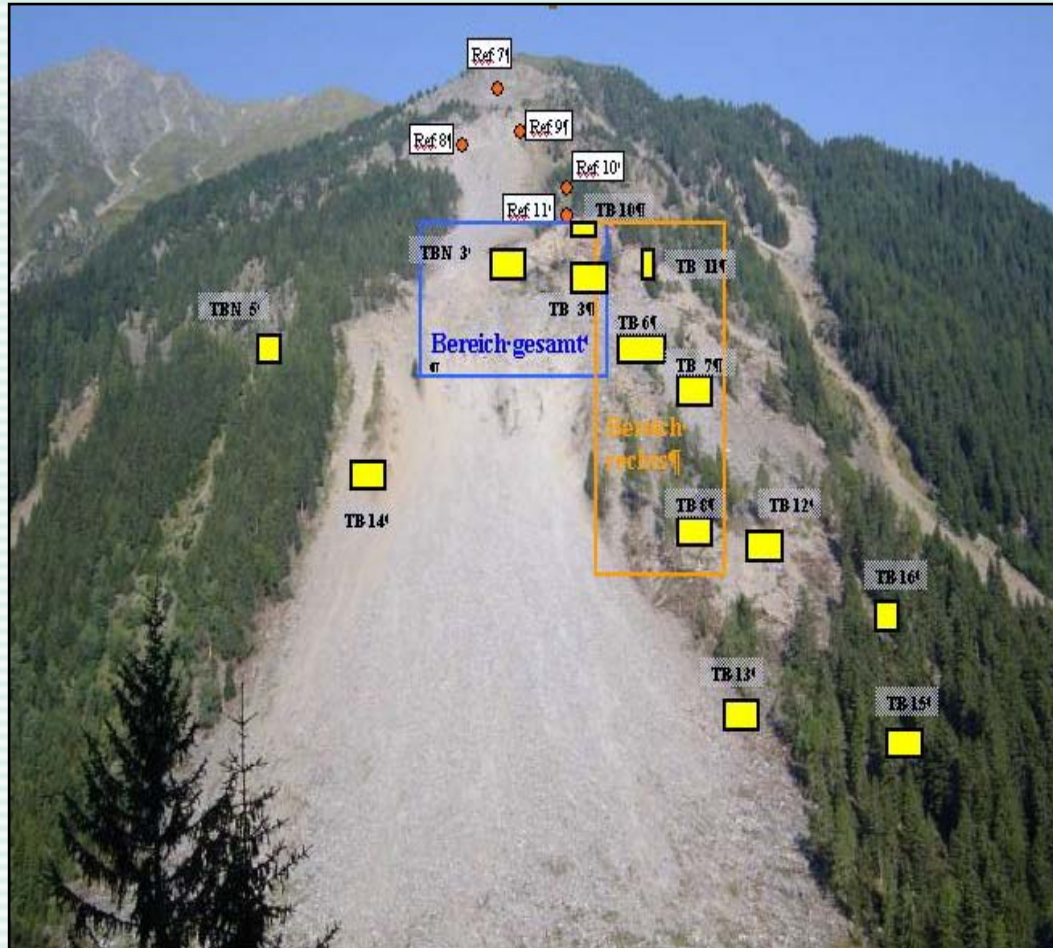
➢ Areas to be surveyed:

    ➢ Area ROI

    ➢ Point ROI

    ➢ Reflective Target

    ➢ Natural Target

➢ Measuring Sequence

➢ Starting time & Repetitions

➢ Strategy for acquisition and evaluation

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Laserscanner Software

Data Acquisition

Hor

Vert

Regular grid of sperical angles
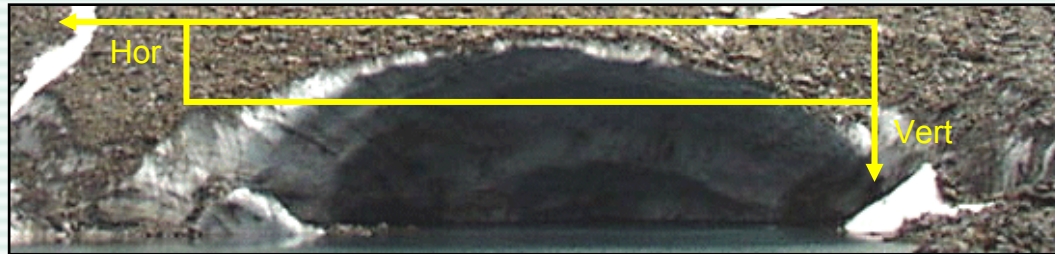
Continuously scan rectangular regions-of-interest with dense grid of distance measurements
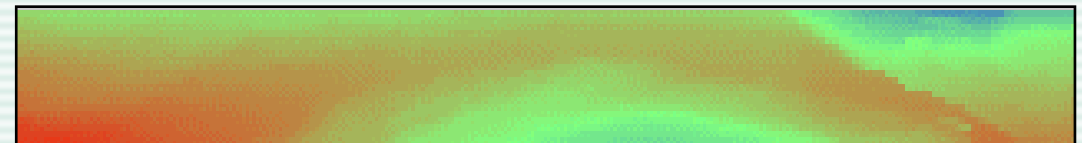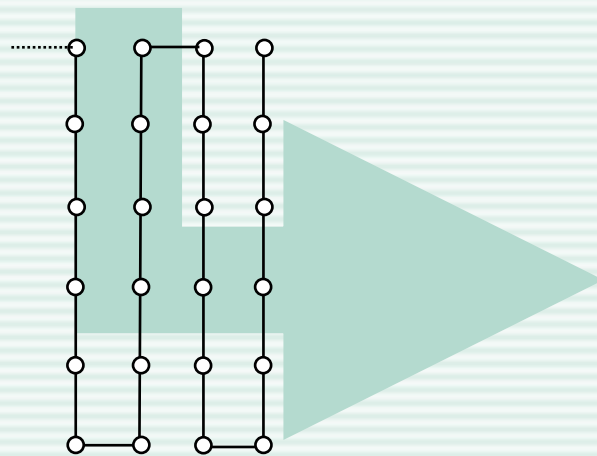
Distance   150m ■■■■ 200m

Reflecitivity   good ■■■ bad

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Laserscanner Software
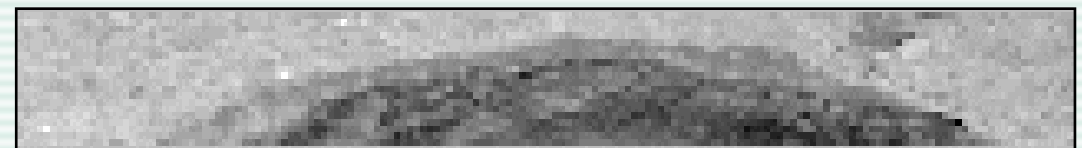
Measurement Compensation

- To guarantee comparability of measurements
  - Compensate orientation (due to misalignment)
  - Compensate distance measures (due to atmospheric influences)
- Use circular reflecting point targets
- Method: Reflectivity-weighted centroid determination

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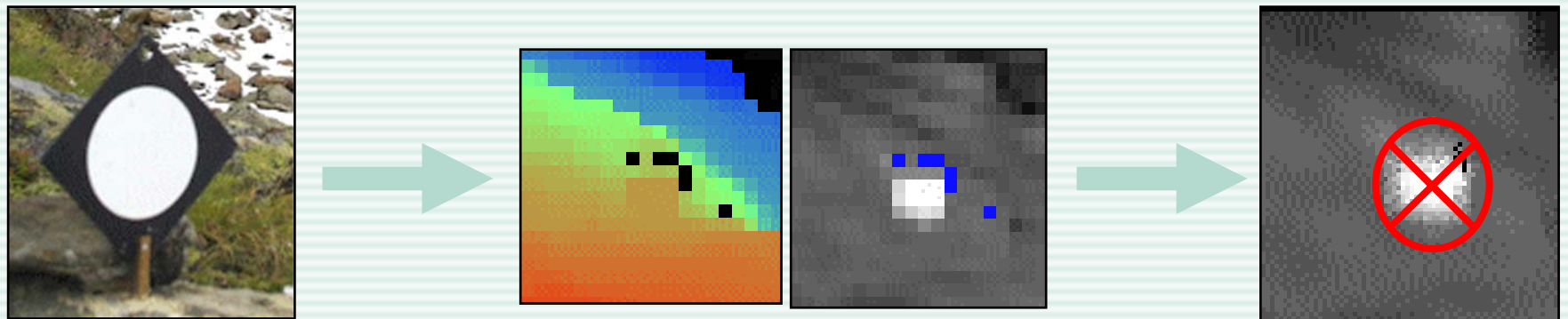
Rock Slide Monitoring

Monitoring of Mass Movements

➢ Objective:

- ➢ Online monitoring of instable slopes and rock faces
- ➢ Detection of instable slopes and movements

- ➢ Low-speed motions of rock surface
- ➢ Lateral distribution of deformations

- ➢ Measure volume loss
- ➢ Global trends

- ➢ Change detection and classification
- ➢ Risk assessment

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Rock Slide Monitoring

Monitoring of Mass Movements

➢ Strategy:

  ➢ Distance measurement

  ➢ Point / ROI tracking

  ➢ Volume / deformation model

➢ Projects:

  ➢ Eiblschrofen, 1999

  ➢ Innertkirchen, 2001

  ➢ Gries, 2003

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Rock Slide Monitoring

Series of Measurements
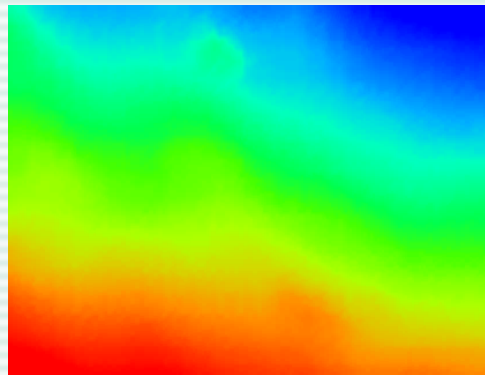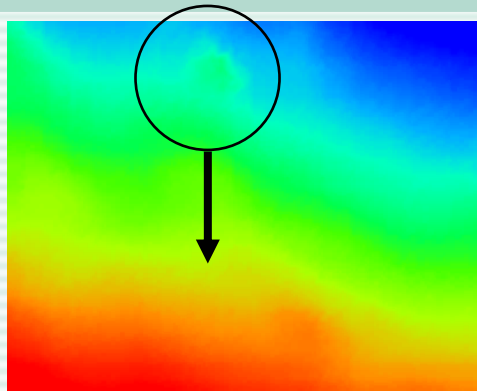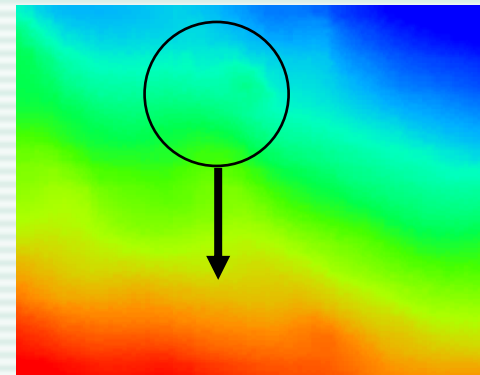
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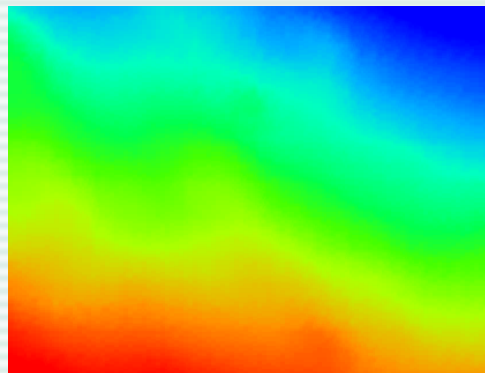
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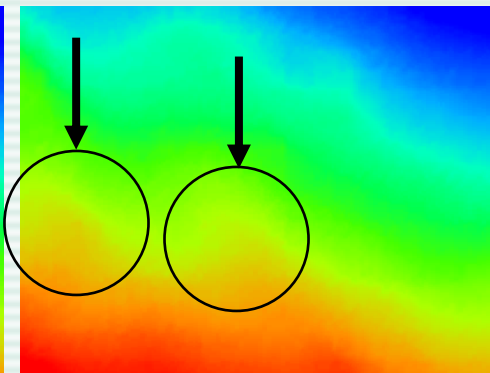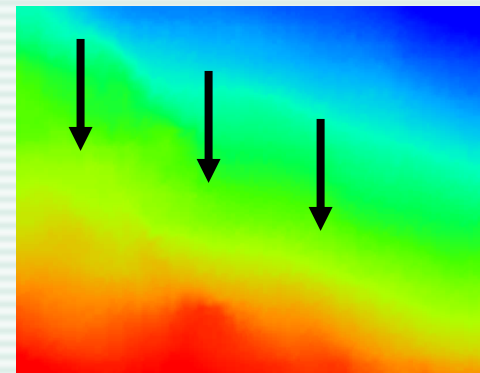
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Rock Slide Monitoring
ROI Tracking

➢ Derive deformation from
   3D surface structure & reflectivity & RGB image

➢ Point tracking on ROIs

➢ Evaluation of the changes

➢ Classification of the changes

➢ Knowledge based system

➢ Automatic selection of ROIs

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Rock Slide Monitoring
Change Analysis

➢ Detect changes and motion

➢ Change classification using expert system

➢ Develop a set of rules to categorize changes:
use statistical parameters of ROI tracking
use expert decisions

➢ Semantic classification of the kind and relevance of the change event

➢ Risk assessment
When exceeding thresholds $\rightarrow$ give an alarm

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Rock Slide Monitoring

Change Analysis

➢ Statistical evaluation of the matching results:
plausibility, estimated accuracy, average displacement

➢ Straightforward set of rules for decisions:

  ➢ Unusable measurement

  ➢ Irrelevant / Significant displacement

 ➢ Structure changed (rock slip, heap)

➢ Prototype software

```
078 TB8_20030721_054935 TB8_20030720_234921 0.86 0.13 0.0013 ROI_M_IrrelevantDisplacement
079 TB8_20030720_234921 TB8_20030720_174926 0.10 0.24 0.1860 ROI_M_StructureChanged
080 TB8_20030720_174926 TB8_20030720_114934 0.61 0.19 0.0200 ROI_M_LargeDisplacement
081 TB8_20030720_114934 TB8_20030720_054929 0.64 0.20 0.0023 ROI_M_IrrelevantDisplacement
082 TB8_20030720_054929 TB8_20030719_234942 0.81 0.16 0.0019 ROI_M_IrrelevantDisplacement
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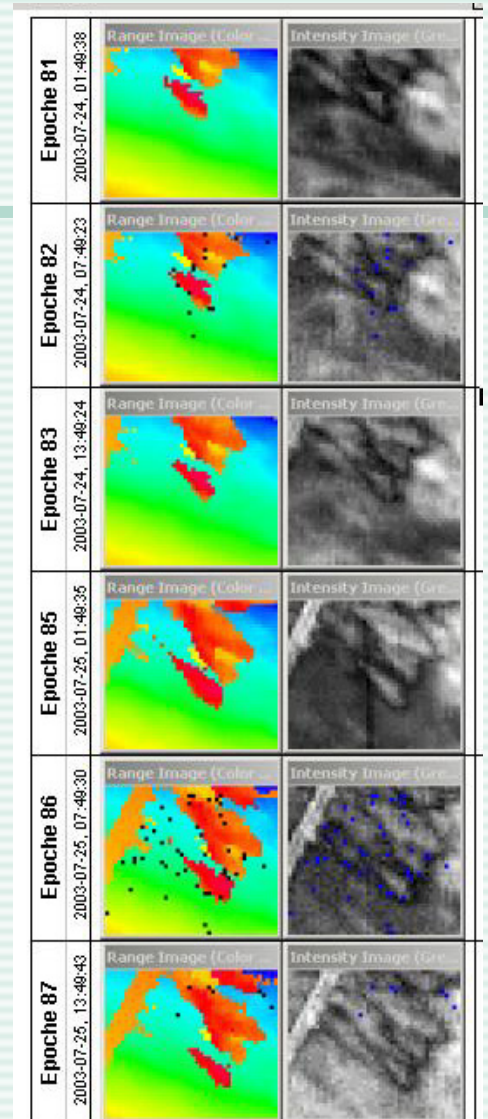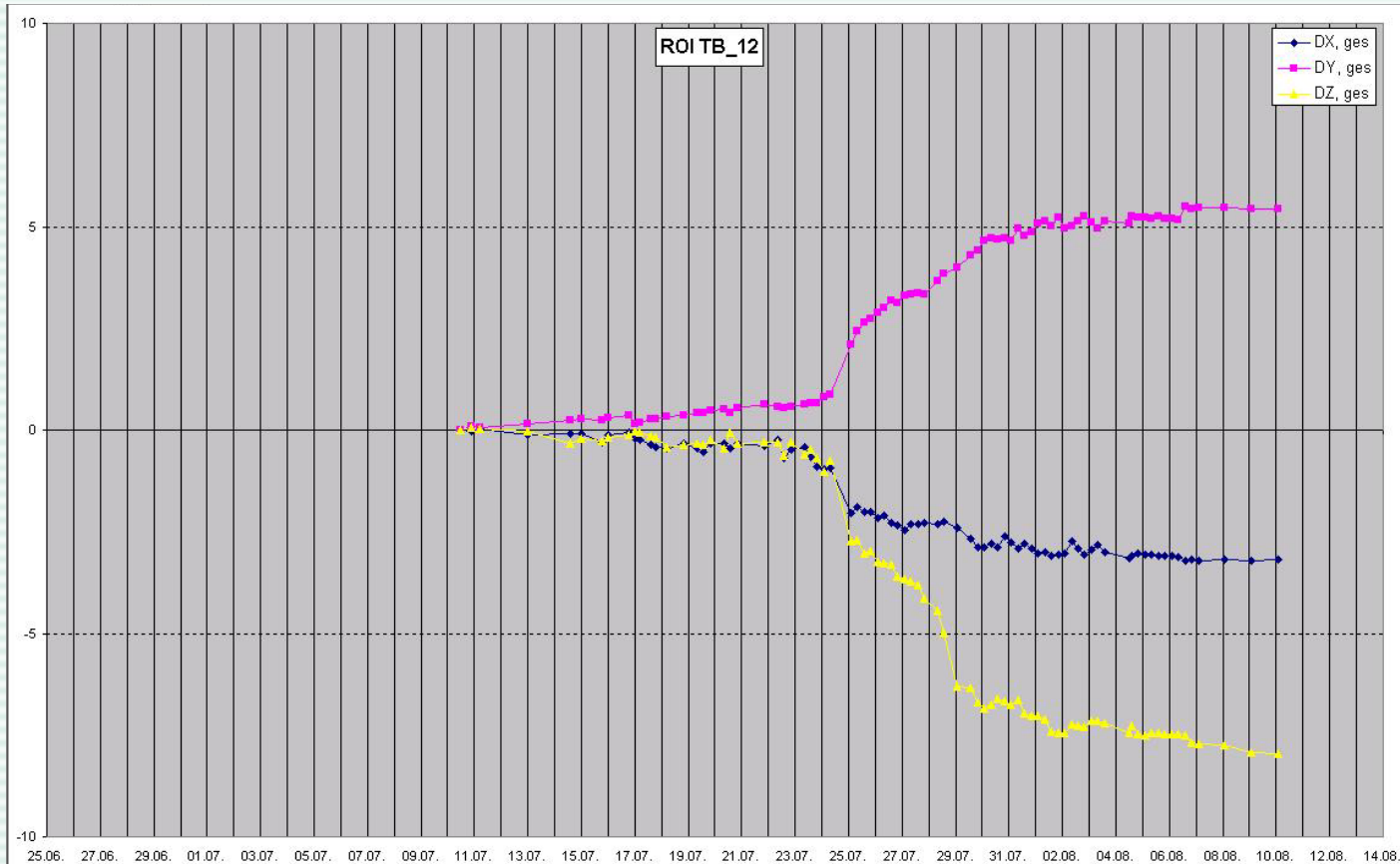
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Rock Slide Monitoring

Volume / Deformation Model
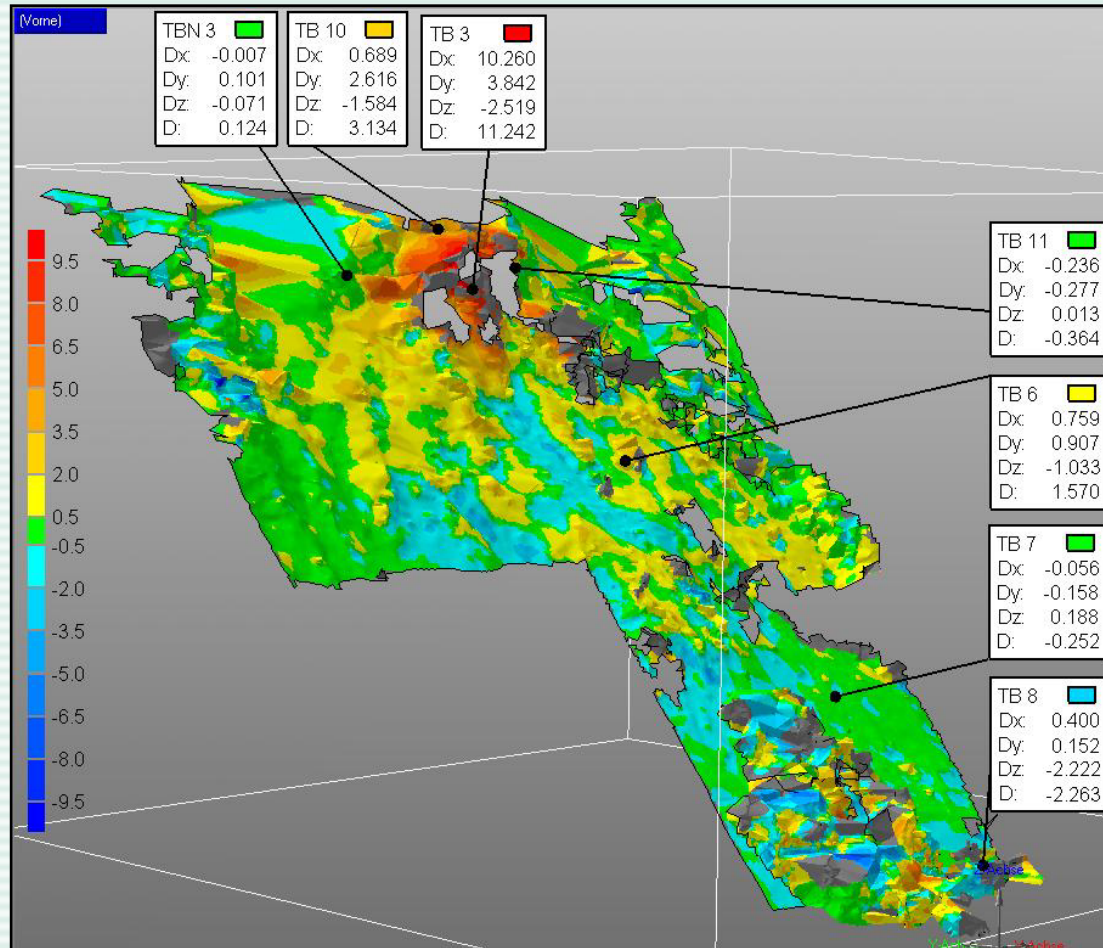
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Rock Slide Monitoring
Point Tracking

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Snow Cover Monitoring
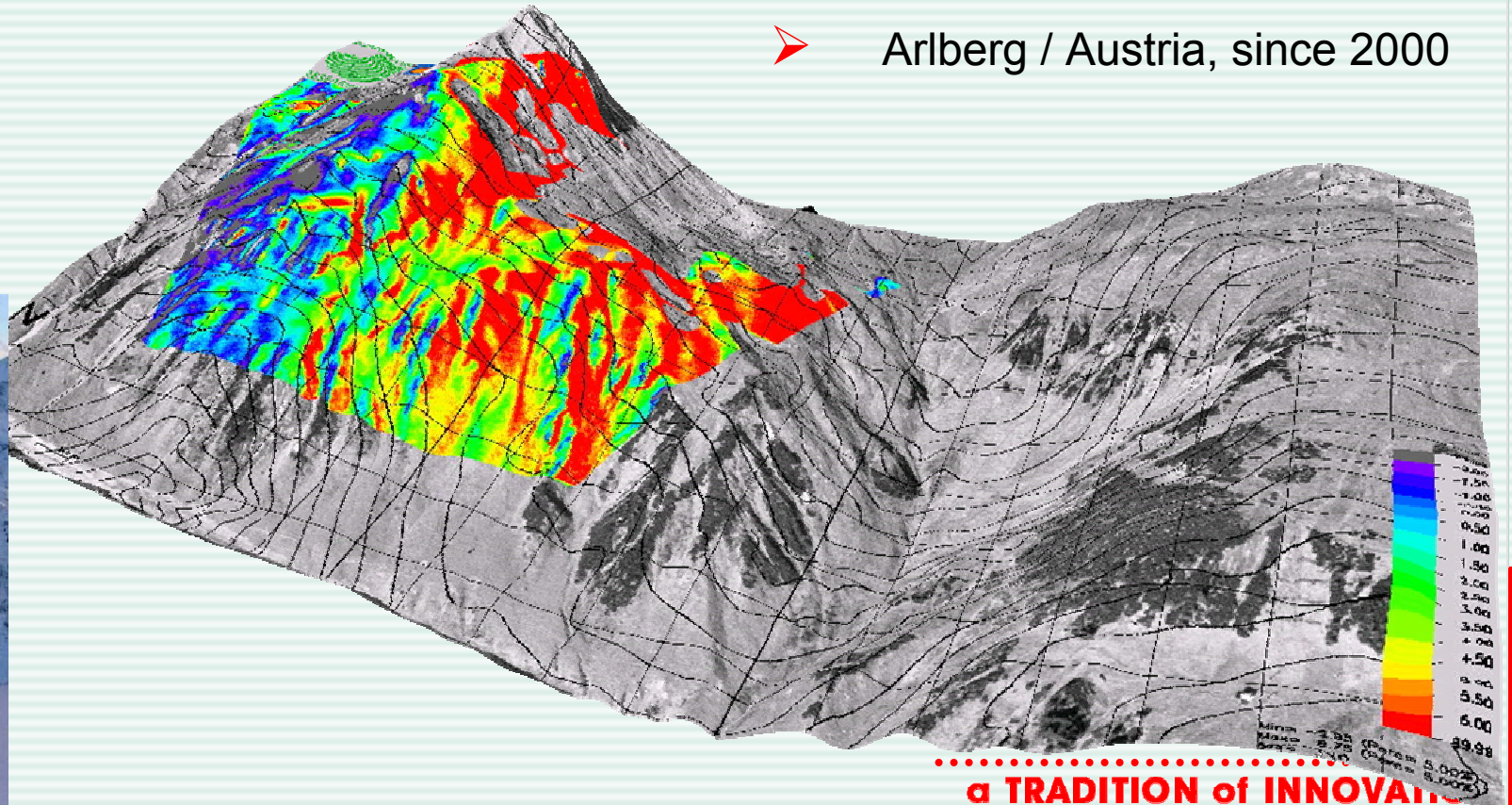
➢ Basics for avalanche prognosis:

  ➢ Meteorological Data: precipitation, atmospheric pressure, atmospheric humidity, temperature, wind speed, ...

  ➢ Digital terrain model

  ➢ Depth of snow

    ➢ not only on few point locations and weekly,
      but on whole area and continuously (several times a day)

    ➢ Redistribution of snow

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Snow Cover Monitoring

➢ Preprocessing: Measurement usability

➢ Compensate orientation and range measurements

➢ Geo-reference

➢ Digital Elevation Model (DEM)

➢ Difference-DEM:

    ➢ Absolute snow cover

    ➢ Increase of snow cover

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Snow Cover Monitoring

➢ Präbichl / Austria, 1999-2001

➢ Arlberg / Austria, since 2000

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Snow Cover Monitoring

Avalanche
Präbichl / Austria
12.03.2001

Decrease
- 1.8 m

0 m

+ 1.8 m
Increase

14th International Conference on Engineering Surveying, Zürich

Glacier Change Monitoring

- ➢ Area-wide documentation of the dynamic trend of glacier surfaces
- ➢ Increase / decrease of glaciers
- ➢ Measure volume change
- ➢ Cooperation with TU Graz, Institute for Applied Geodesy and Photogrammetry
- ➢ Test site: Gößnitzkees, Langtalsee, Pasterze (Nationalpark Hohe Tauern)

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Glacier Change Monitoring

600 m

160 m

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Georisk Monitoring
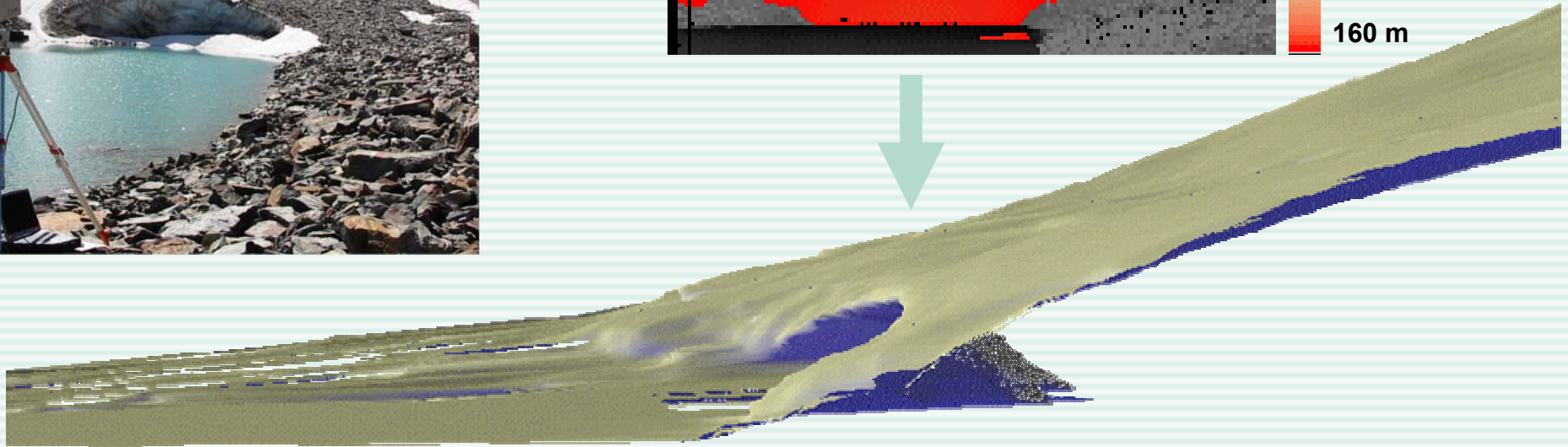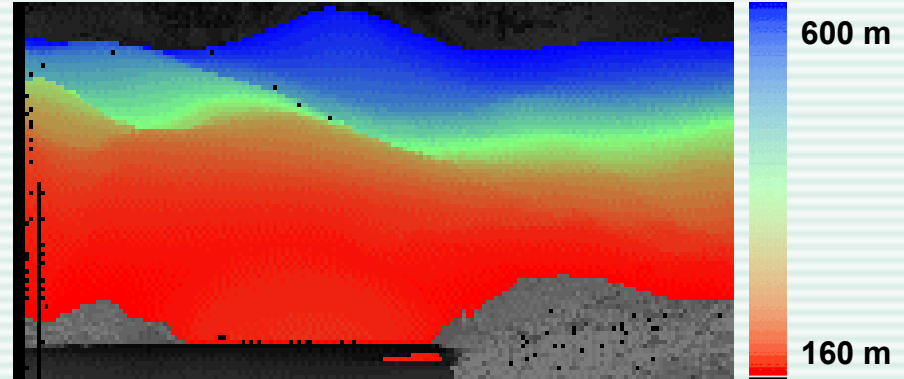
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