

# High precision LiDAR mapping for complex mountain topography



**Julien Vallet**  
*Helimap System SA*



# Summary

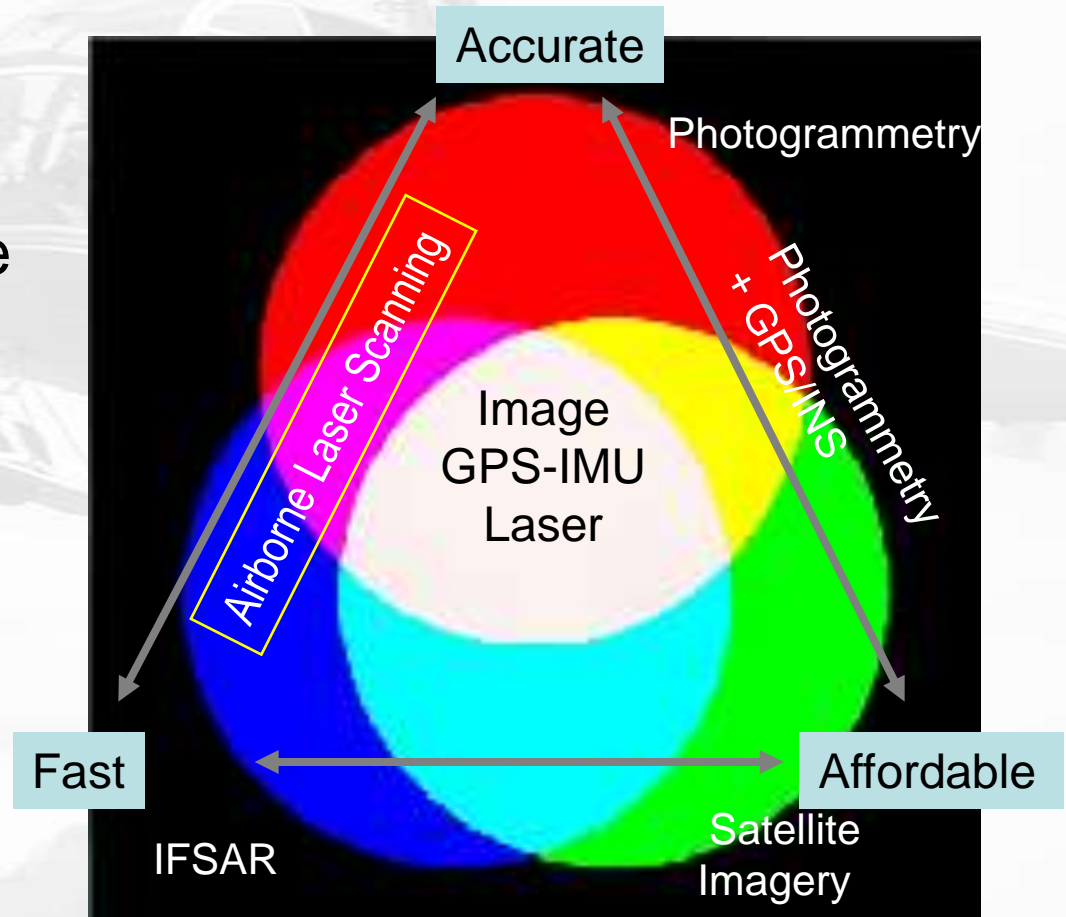
- + Introduction
- + Helimap System<sup>®</sup>
  - + Concept and design
  - + Component and output data
  - + Data processing
  - + Calibration
- + Practical experiences
  - + Application field
  - + Data quality and system performance
- + Conclusions

# Introduction

- + Arrival of new technologies during the 90's
  - + Photogrammetry + GPS (>1990)
  - + Direct georeferencing (GPS-IMU) (>1995)
  - + Airborne laser scanner (end 90's)
  - + High Res. Digital camera (>2000)


# Introduction

- + The Trend: All in one mapping
  - + Imagery
  - + Direct georeference
  - + LiDAR
  - + Multispectral
  - + .....



# Introduction

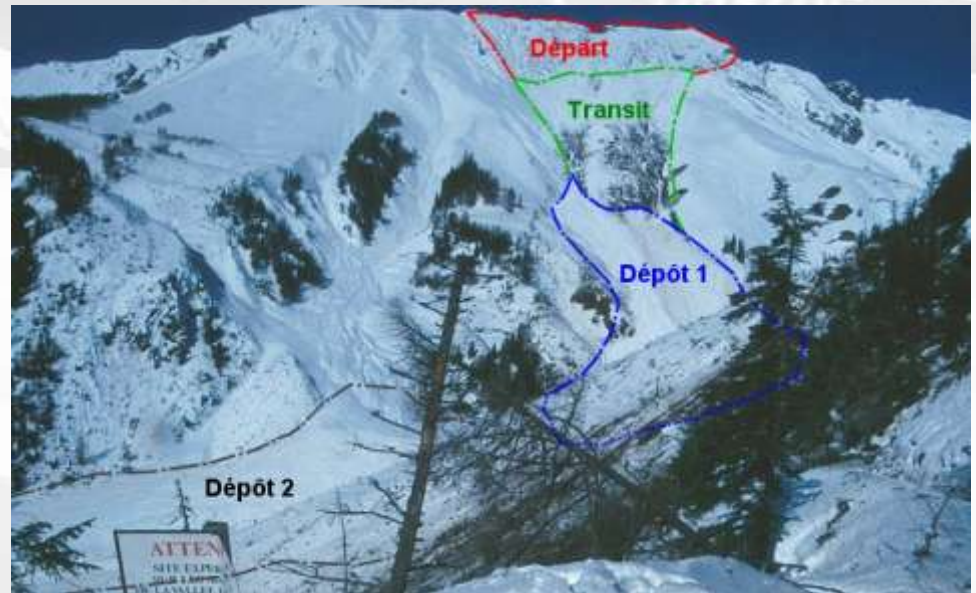
## + Consequences:

- 
- + Automation of data acquisition
  - + Fast delivery of results
  - + Widening of application fields
  
  - + More complex systems
  - + Black box processing

→ New way of working

# Helimap System®

- ➕ Issued from research in the Photogrammetric and Geodetic labs of EPFL, in collaboration with SLF-Davos, and UW+R SA



# Alpine environment Problematics

- ⊕ Limitation of usual airborne technique (ground control, contrast) in harsh winter environment



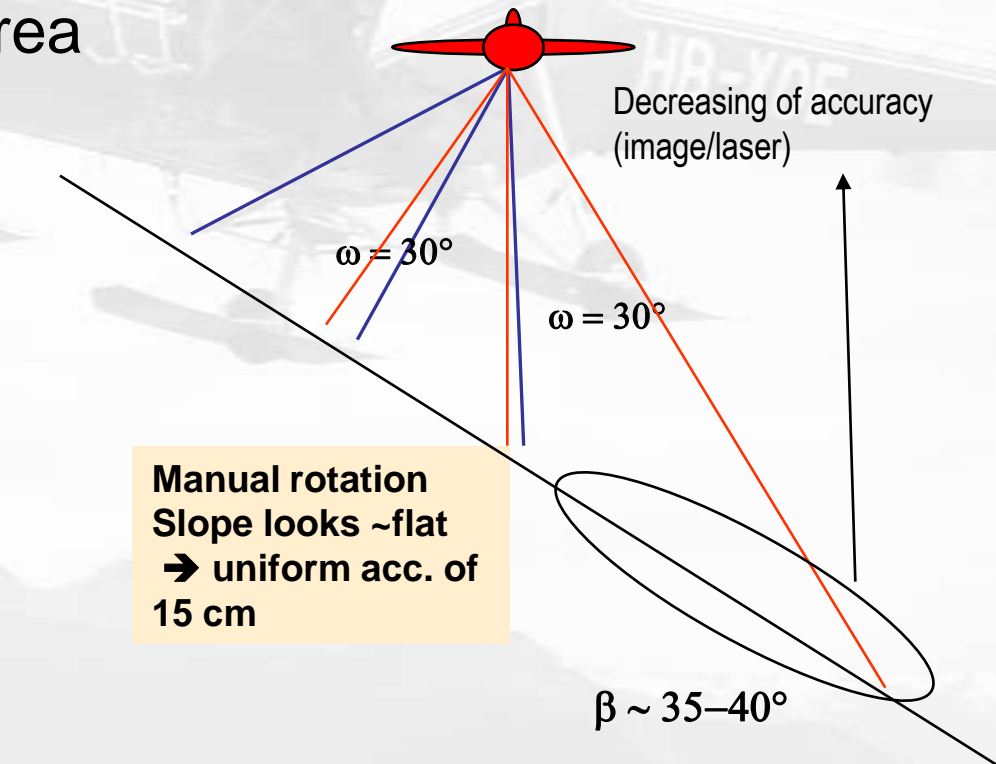
# Concept

## + Needs

- + Precision of  $\sim 10\text{cm}$
- + Inaccessible area and complex terrain
- + Fast setup
- + Affordable for small area

## + Original concept

- + Avoid slope effect
- + Handheld
- + Helicopter based
- + Direct georeferencing



# Helimap System® History

1997                      1999                      2001                      2002                      2003                      2004                      2005                      2006

Helimap System®

Production



Camera

Camera+GPS

Cam +GPS-INS

CCD+GPS-INS

+Laser

CCD-GPS-INS-LASER

# Helimap System®

## Helicopter based mapping system

- ⊕ Especially designed for small area (10 to 2000 ha)
- ⊕ Suits perfectly for complex terrain
- ⊕ Original and unique concept worldwide



# Flexibility and fast intervention

Handheld system is very flexible

- + <1 hour setup, Carrier independent
- + Either Vertical or Oblique acquisition within the same flight



Terrestrial



vertical



oblique

# Components

## + Sensors

- + Digital camera (22/39Mpix, 35mm, FOV=57°)
- + Laser scanner (10kHz,FOV=60°, max. 400m)
- + GPS L1/L2
- + INS iMAR

→ No ground signalization required

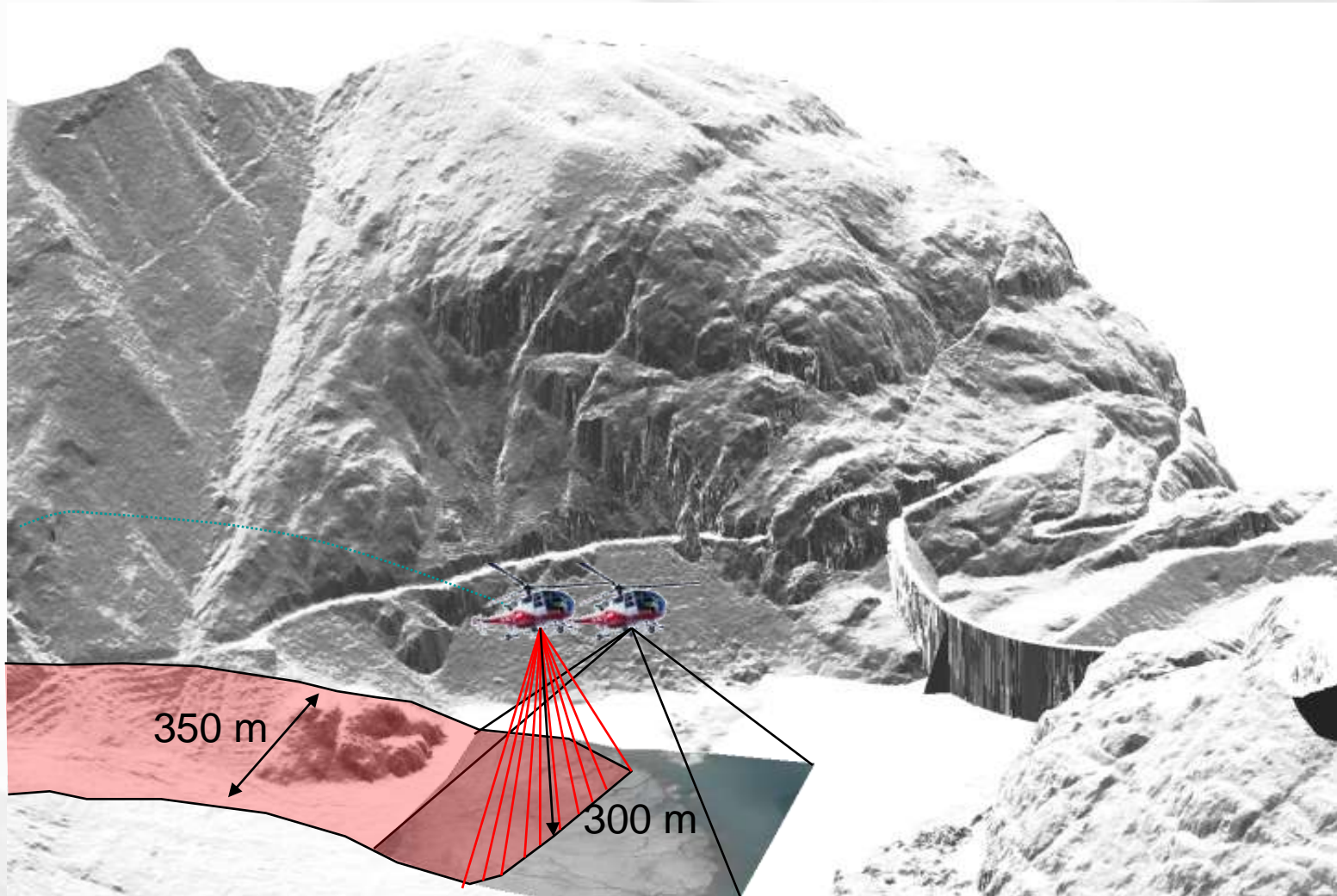
→ High mapping accuracy (~10cm)



# Avantages/Contraints

- + No access requires to ground (no GCP)
- + Automation of surface modeling (laser)
- + Corridor and complex terrain mapping
- + Orthophoto without AT or with highly automated AT (stereo plotting)
  
- + Rigorous calibration phase
- + Stability of camera inner parameters

# Measurements basics



# Derive products

- + Volume, profile, slope, orientation, drainage
- + Obstacles mapping, landcover
- + Object Classification (orthoimage)
- + 3D models for virtual reality
- + Evolution of data (Time based analysis)

# Output data

## Basic product

- + High density Digital terrain/surface model (DTM/DSM) (1-10 pts/m<sup>2</sup>)
- + High resolution Orthophoto (pixel 3-10cm)
- + Feature extraction

ORTHO



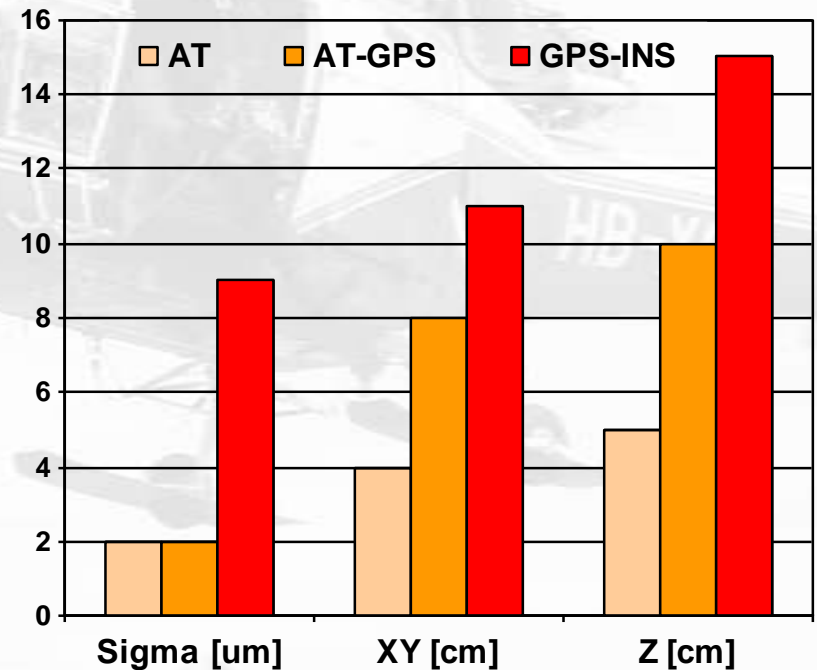
# Laser data processing

- + Huge amount of data: ~150'000 pts/ha/pass
- + Automated filtering:
  - + isolated points (air)
  - + Ground
  - + Wires, power lines
  - + Vegetation
- + Semi-automated filtering:
  - + Ground correction (cliffs, wall, discontinued terrain)
  - + Ground cover classification (buildings, roads, ...)

# Photogrammetric mapping accuracy

- + Scale 1:10'000
- + (340m/sol)

Constraint Method	Tie Points	GCP's
AT	+	+
AT-GPS	+	
GPS-INS		

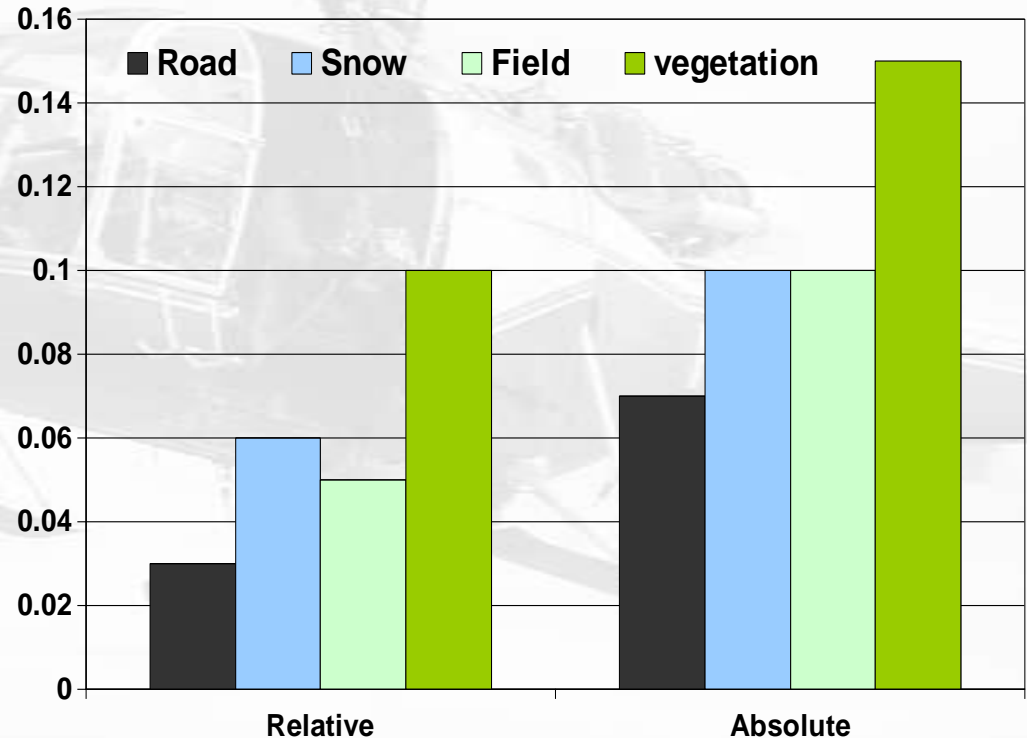


RMS GCP's residuals (XYZ) and image residuals ( $\sigma$ )

# Laser mapping accuracy

## + Comparison

- + Absolute: GCP's + stereo plotting
- + Relative: inter-strip, noise level

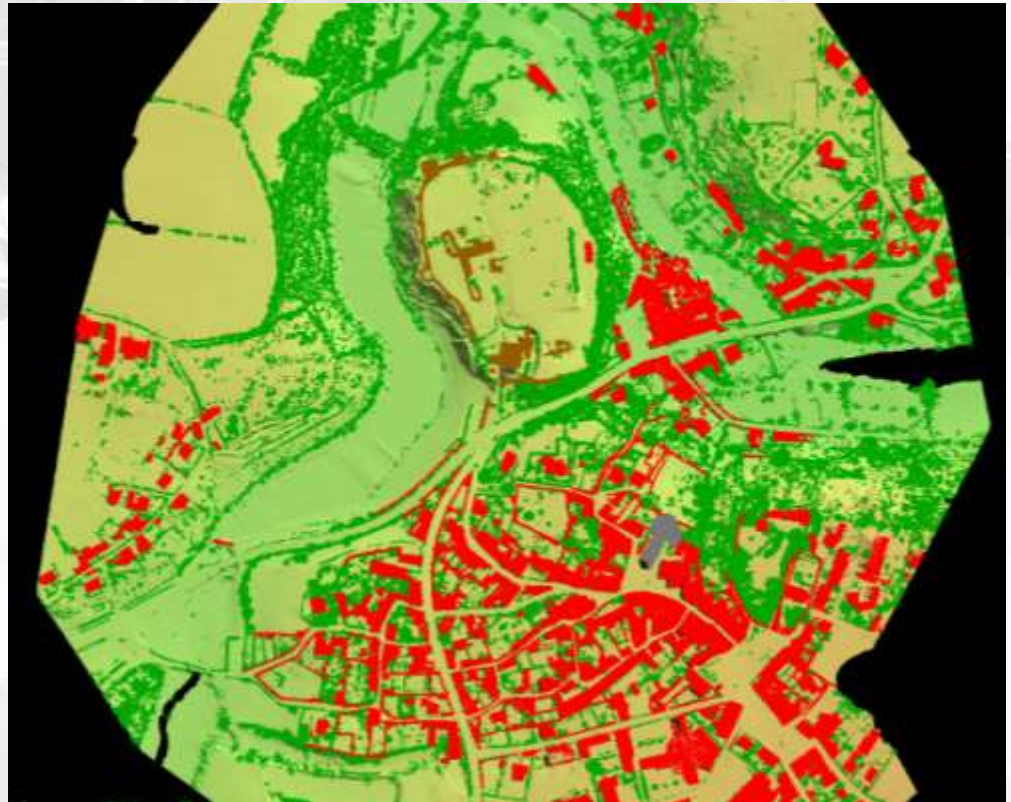


Precision [m] of laser points  
Distance of 250m/ground  
(G. Vessyère, EPFL/INSA)

# Land management

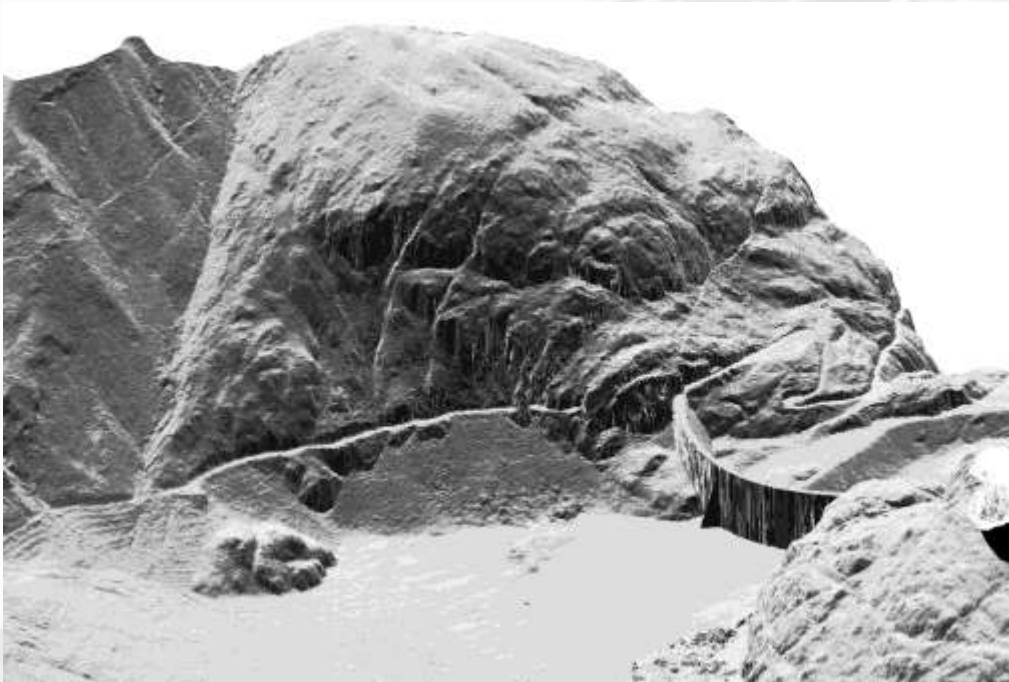
## + Urbanism, constructions, land registre...

- Data Classification
- Land cover identification (Forest area)
- Topography, Fill/Cut control

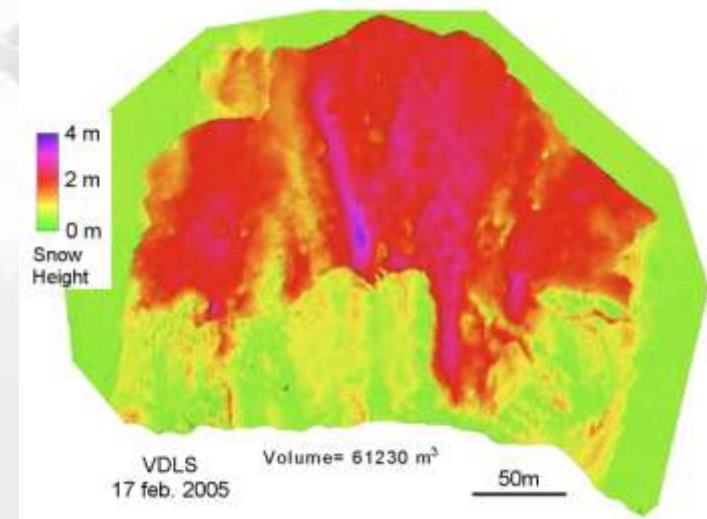
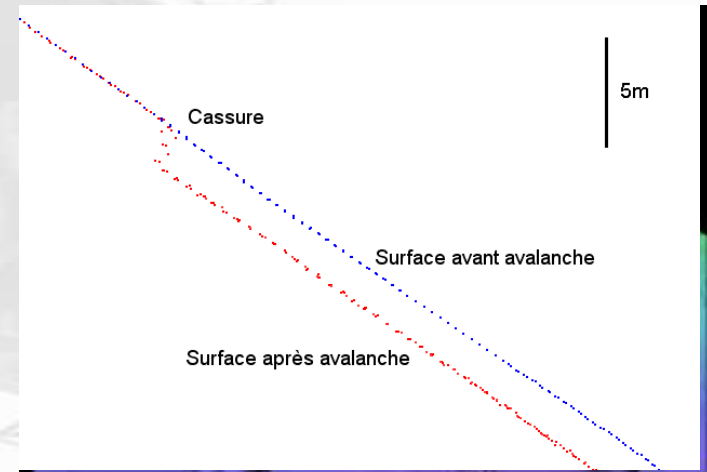


# Inaccessible Areas / natural hazard

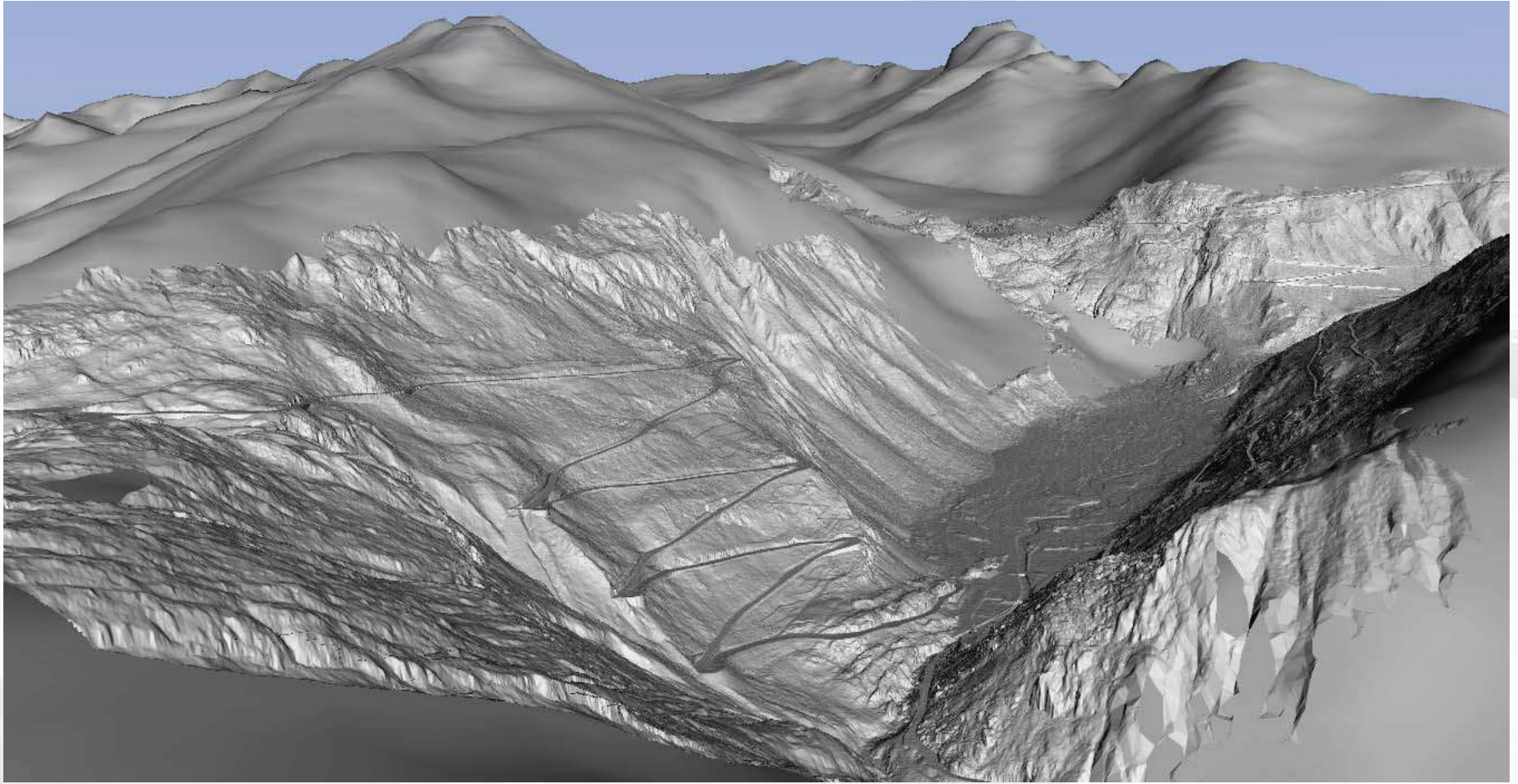
- ⊕ Cliffs, steep slopes, hazardous area, rockfall, landslides, floods, avalanches,...
- ## Avalanche snow volume (SLF)



Cliff of Vieux Emosson dam



# High res. DTM in mountains



Grimsel-Furka pass, Switzerland

# Mountain DTM: Glacier Mass balance



ifu  
Institut für  
Umweltingenieur-  
wissenschaften

**ETH**  
Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich

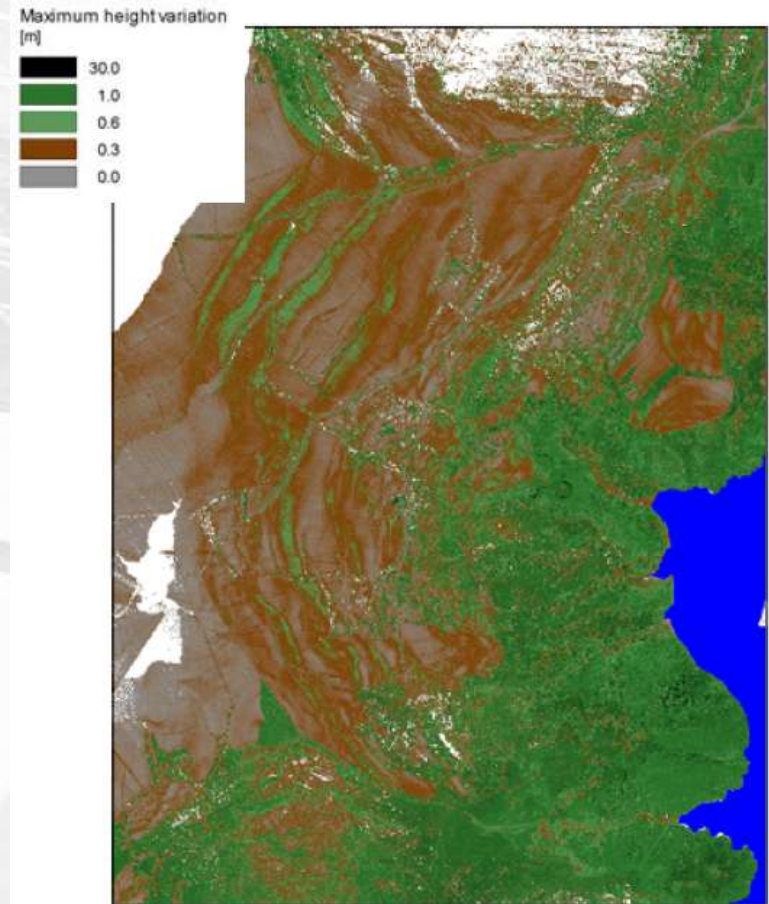
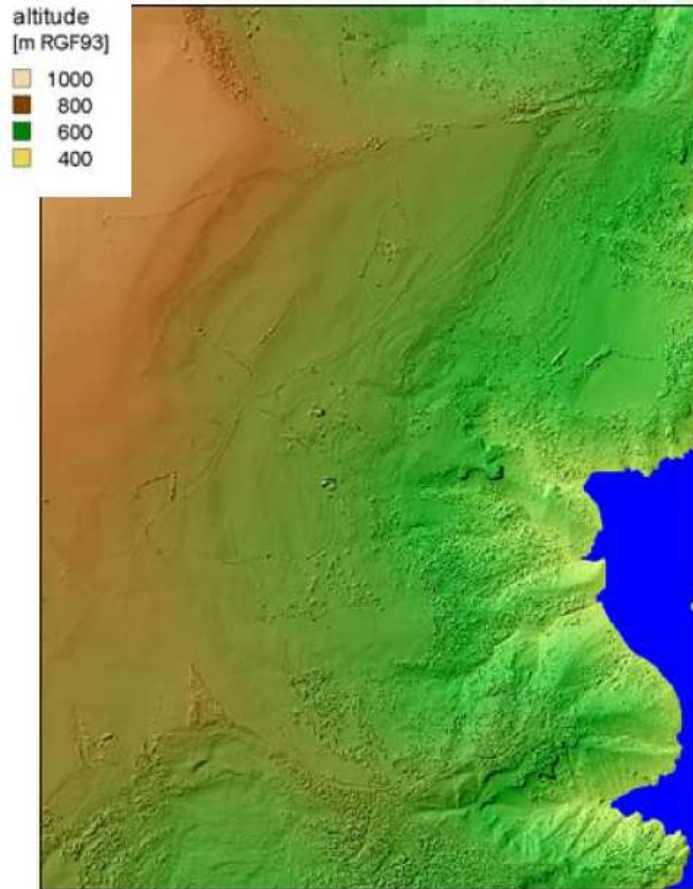
Haut glacier d'Arolla (VS)

# Rock/Ice fall: Monte Rosa east face



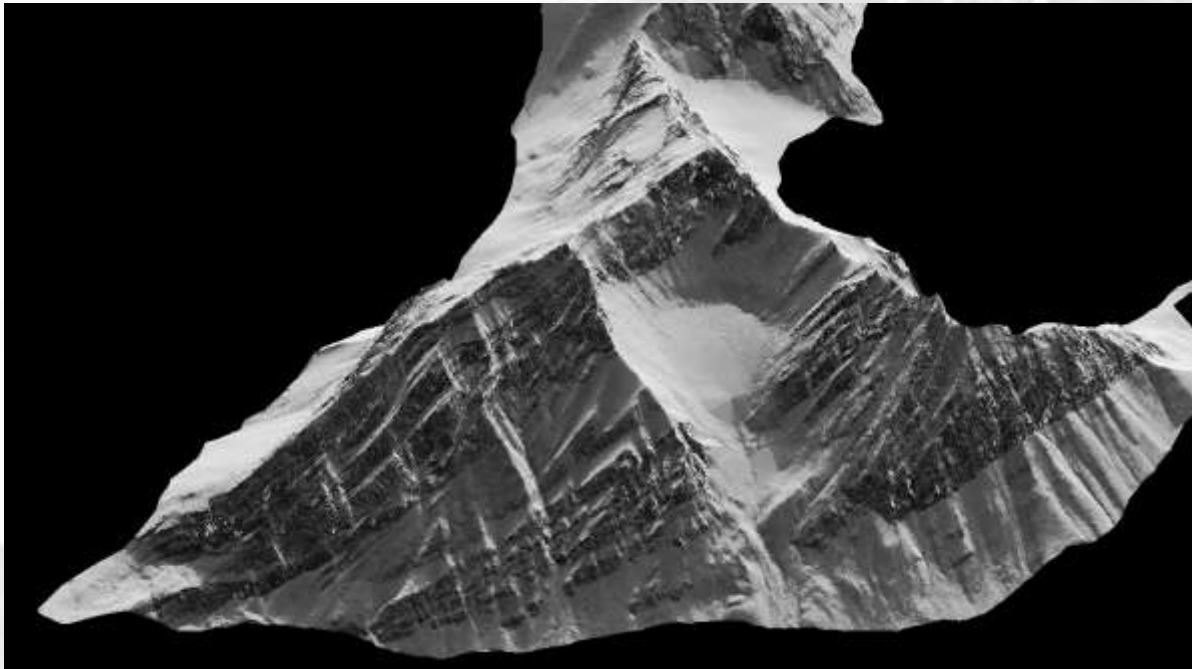
# Landslide

## + Harmalière Landslide (France, LGCA Uni. Chambéry)



# Geological structure analysis

- ⊕ Structural 3D model  
(CIPR-UNI Bergen/UNIS)



# Post-catastrophe mapping

+ EinsideIn june 2007

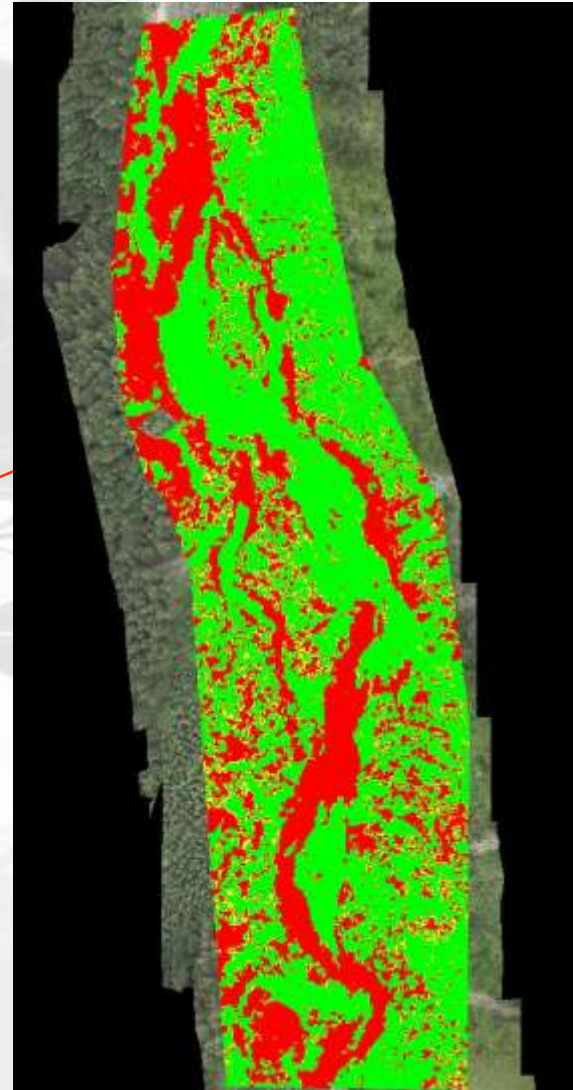


Ortho

DTM

# Erosion/deposition map

+ EinsideIn june 2007



# Rockfall



December 2007



January 2008

# Conclusions

- ⊕ All in one sensor :Helimap System<sup>®</sup>:
  - ⊕ Unique and original tools for mountain mapping
  - ⊕ High automation of all the process
  - ⊕ Remote area and corridor mapping
  - ⊕ Precision ~10-15cm absolute, 5cm relative



Thanks for your attention

