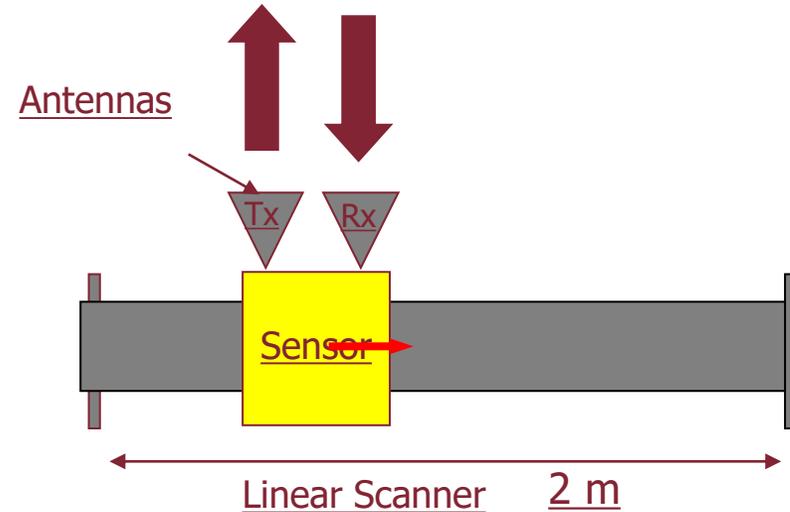


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



RADAR
SF-CW
Bande
~17 GHz

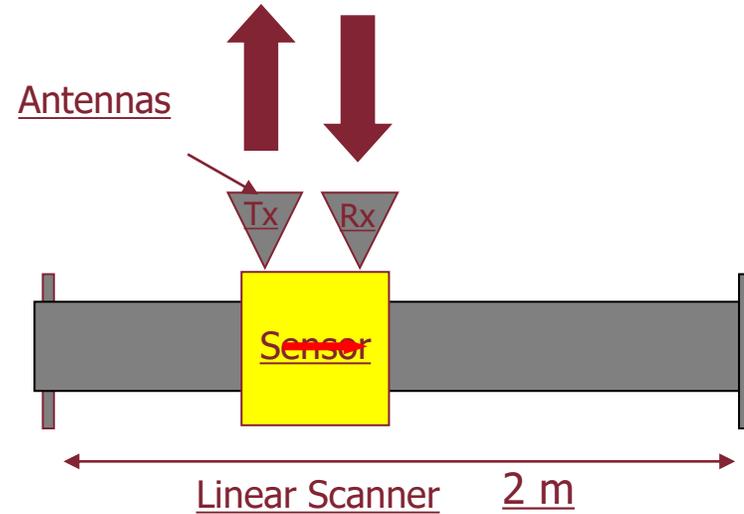


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



RADAR
SF-CW
Bande
~17 GHz

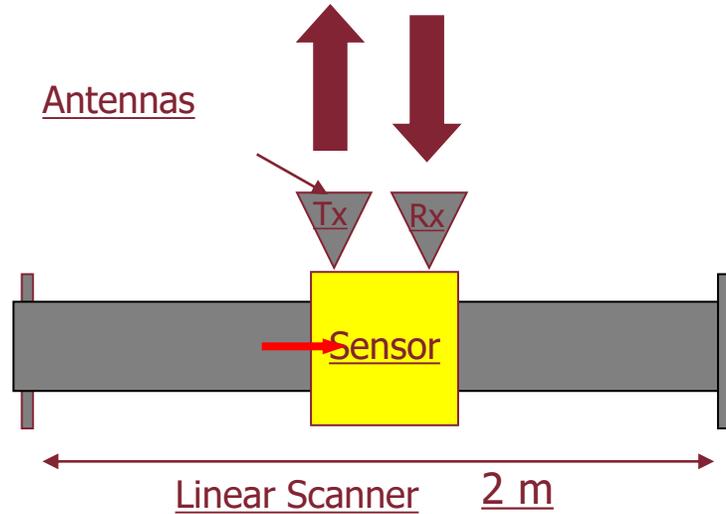


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



RADAR
SF-CW
Bande
~17 GHz

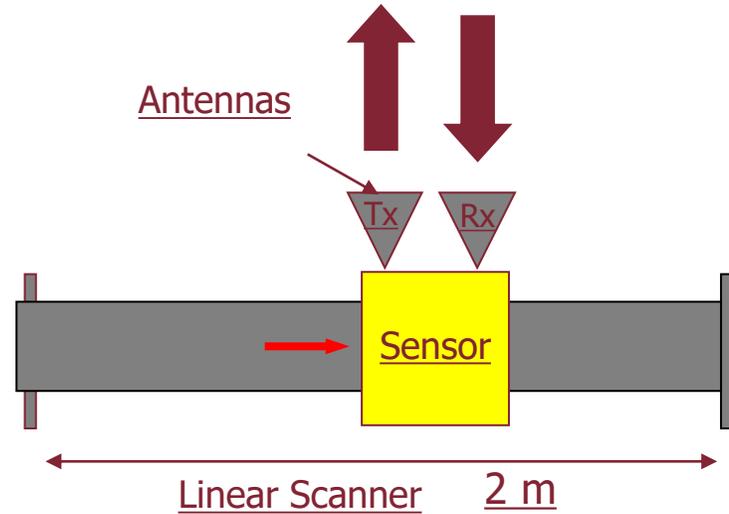


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



RADAR
SF-CW
Bande
~17 GHz

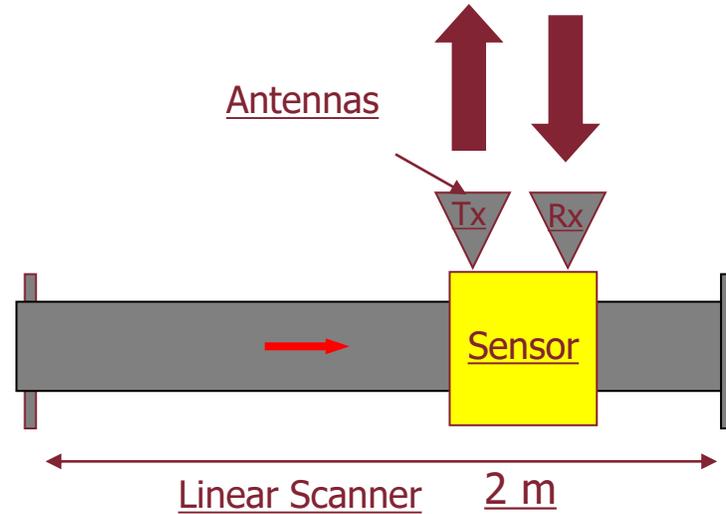


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



RADAR
SF-CW
Bande
~17 GHz

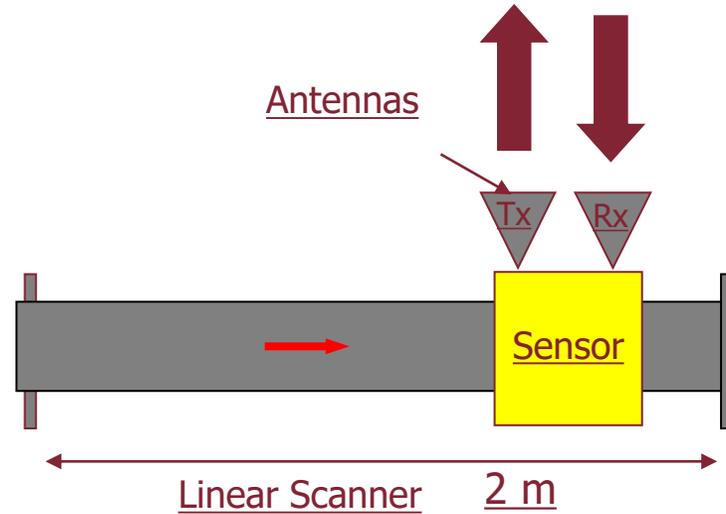


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



RADAR
SF-CW
Bande
~17 GHz

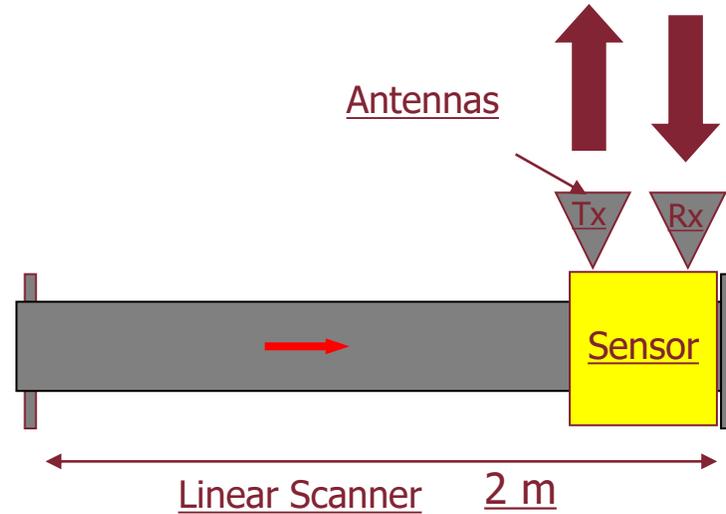


TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)

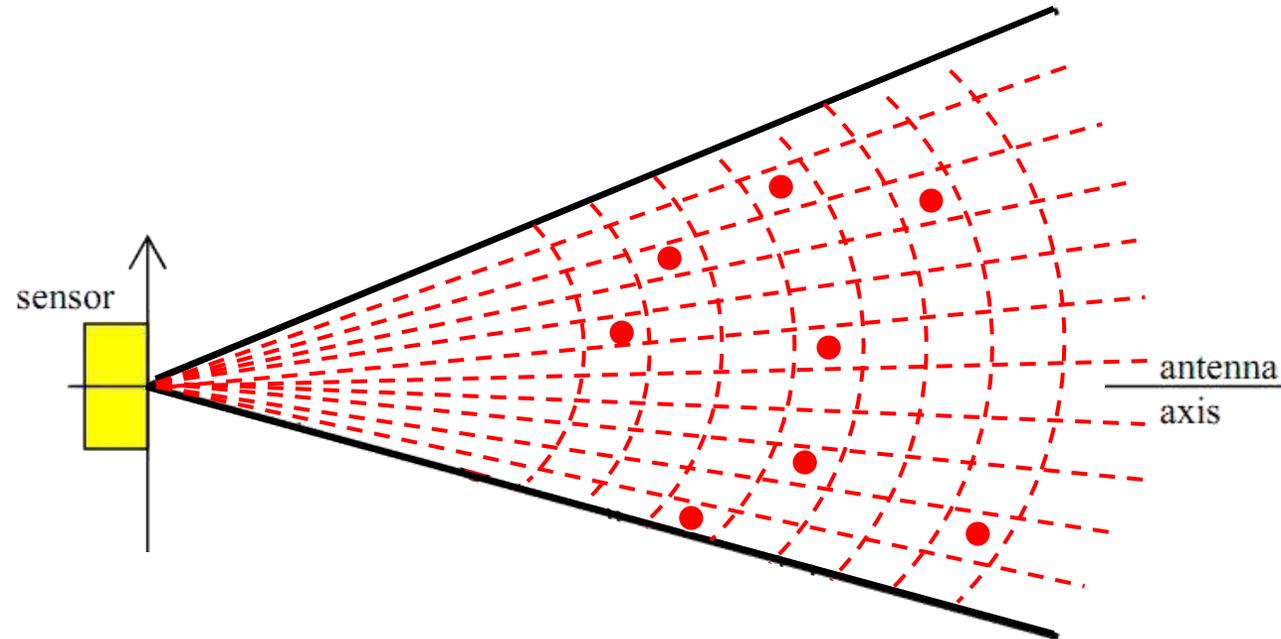


RADAR
SF-CW
Bande
~17 GHz



TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



TERRESTRIAL InSAR

Radar d'immagine ad apertura sintetica (Synthetic Aperture Radar - SAR)



TERRESTRIAL InSAR

Caratteristiche tecniche operative dei sistemi Radar terrestri

Caratteristiche tecniche	SAR Image
Massima frequenza di acquisizione	Alcuni secondi
Accuratezza nella misura degli spostamenti	Fino ad alcuni decimi di mm
Direzioni di risoluzione	2 direzioni
Massima portata strumentale	Alcuni km
Efficacia in qualunque condizione meteo	Totale

TERRESTRIAL InSAR

Esempi applicativi



Photographic archive of Mr. Pietro Zangheri



First activation: 03/25/1914 rock wedge slide

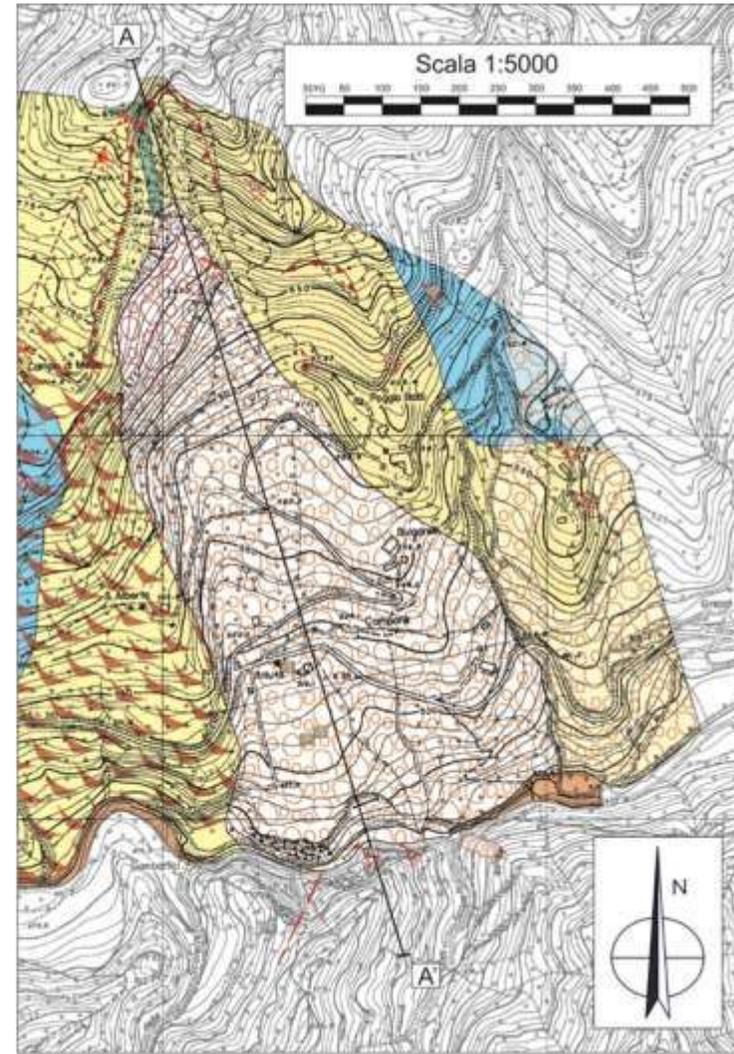
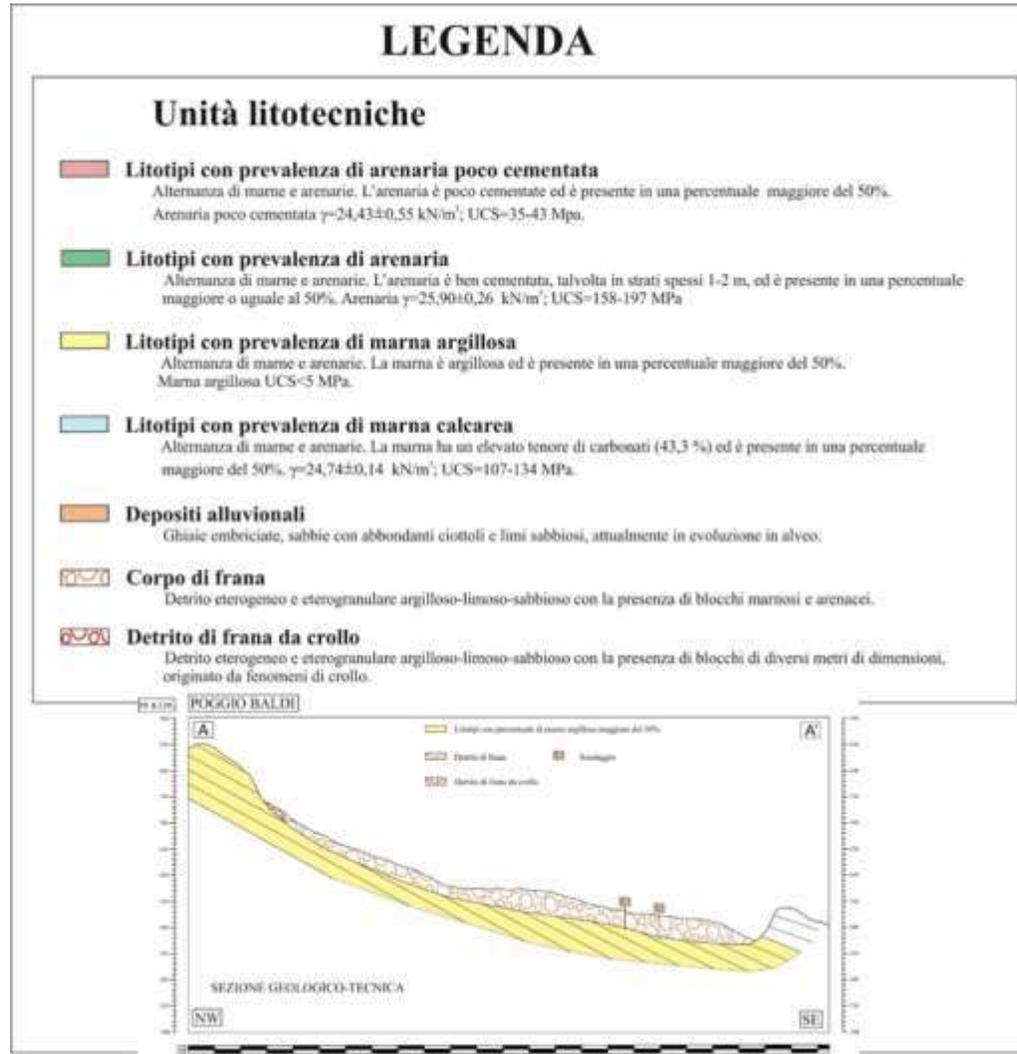
Last activation: 03/19/2010 earthflow

Volume: $4 \times 10^6 \text{ m}^3$

Complex movement started as a rotational
rockslide, then evolved into an earthflow and rock-
falls in head scarp.

TERRESTRIAL InSAR

Esempi applicativi



TERRESTRIAL InSAR

Esempi applicativi



First activation: 03/25/1914 rock wedge slide

Last activation: 03/19/2010 earthflow

Volume: $4 \times 10^6 \text{ m}^3$

Triggered by water pressure increase due to snow-melting, after long rain-snow-fall period.

TERRESTRIAL InSAR

Esempi applicativi



First activation: 03/25/1914 rock wedge slide

Last activation: 03/19/2010 earthflow

Volume: $4 \times 10^6 \text{ m}^3$

2 days of "warning signals" (such as opening of cracks), then the landslide moved downslope in 3 hours.

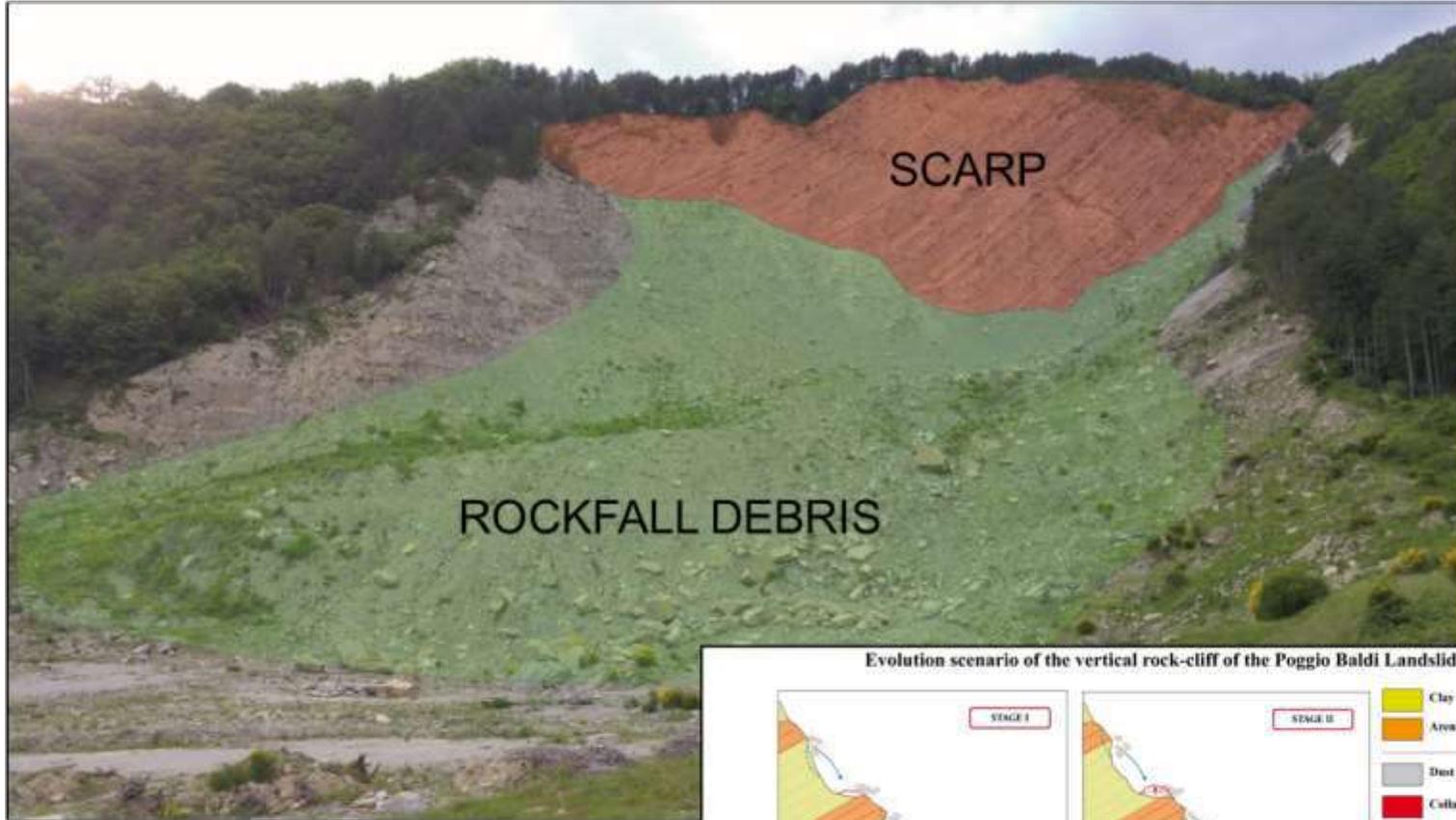
TERRESTRIAL InSAR

Esempi applicativi

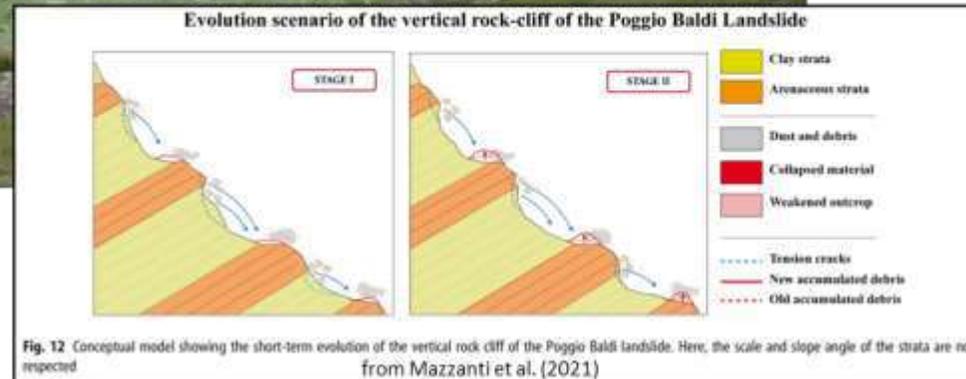


TERRESTRIAL InSAR

Esempi applicativi



height-range 480 – 800 m asl, max
width 200 m, max length 850 m

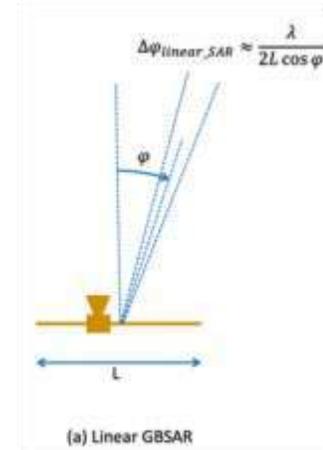
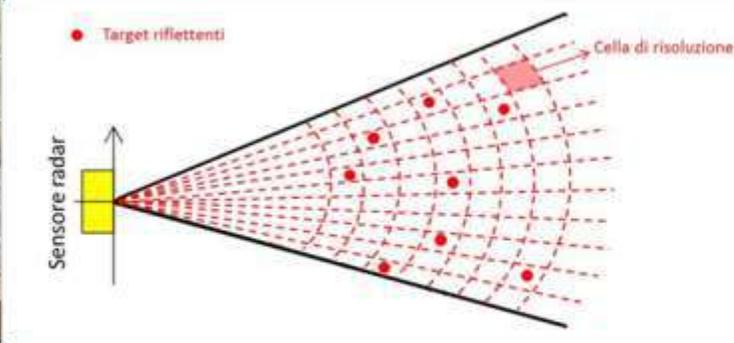


TERRESTRIAL InSAR

Esempi applicativi



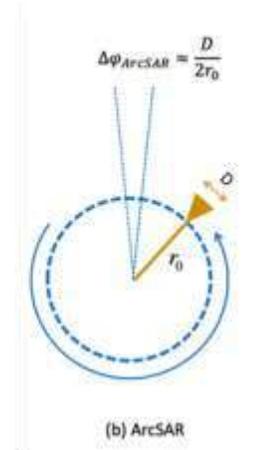
IBIS-FL (by IdS Georadar S.r.l.)



Angular resolution of GBSAR
(modified from Pieraccini & Miccinesi, 2019)

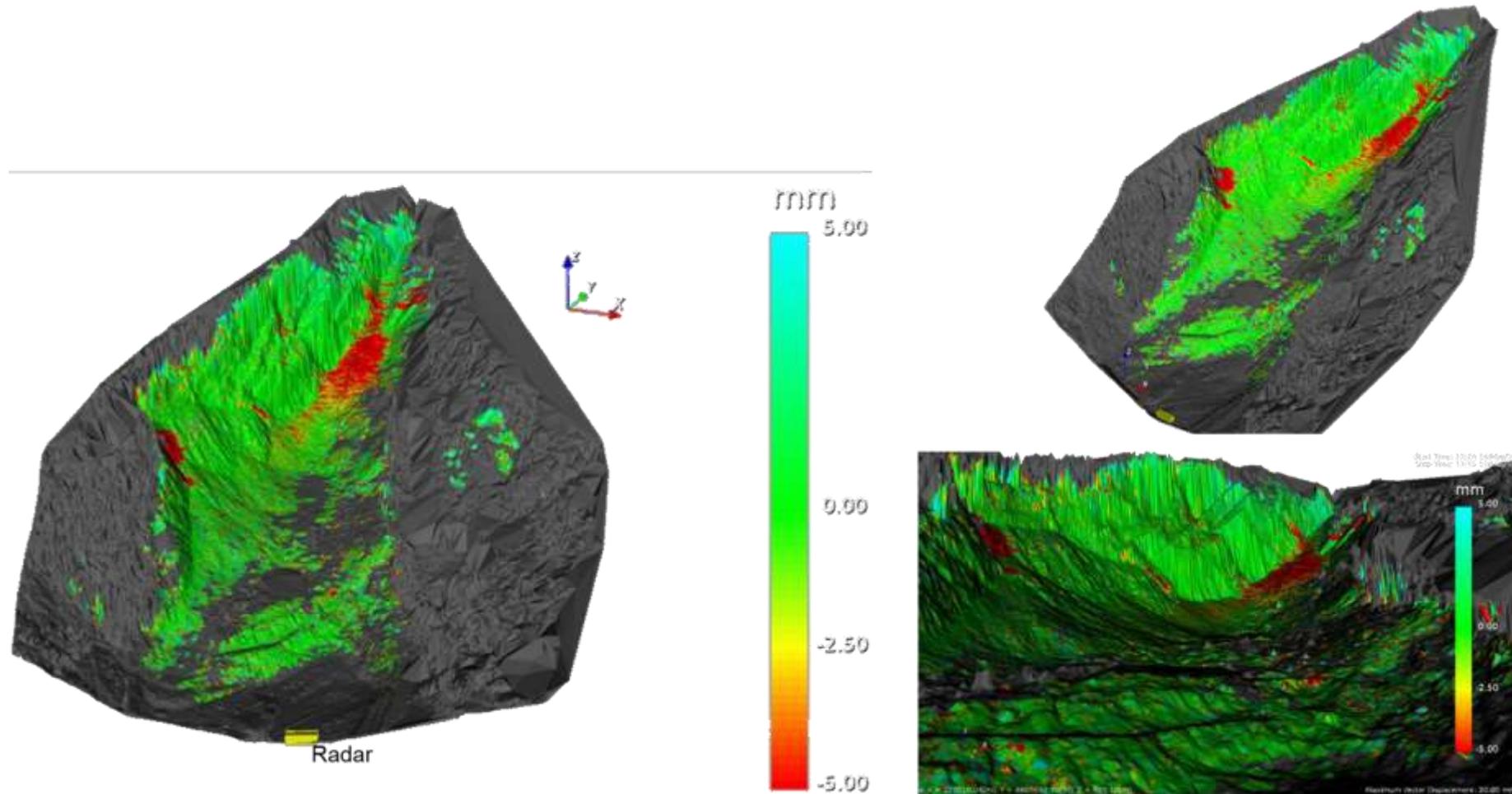


Hydra-G (by IdS Georadar S.r.l.)



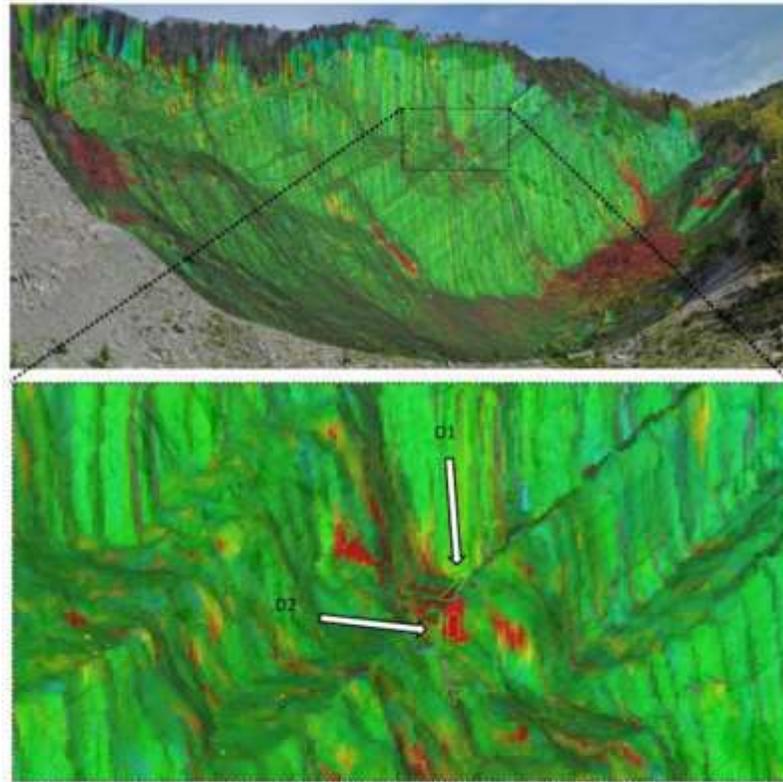
TERRESTRIAL InSAR

Esempi applicativi

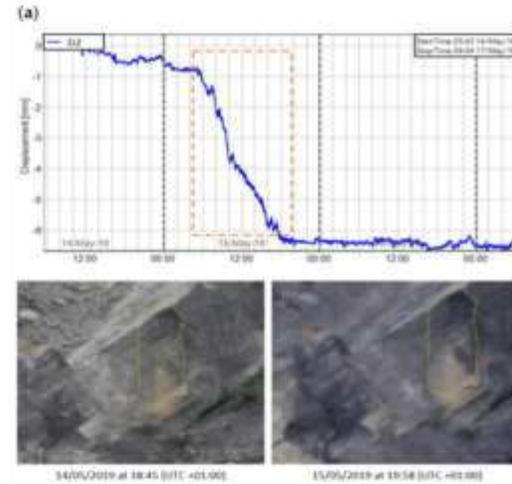
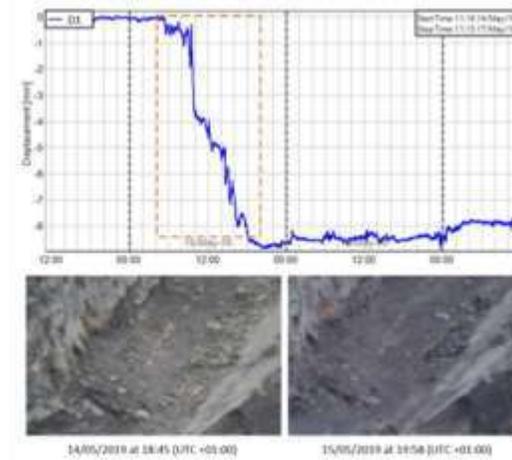


TERRESTRIAL InSAR

Esempi applicativi



Central sector of the slope with correspondence between changes detected by radar measurements (green-red pixels) and GigaPan image analysis (yellow polygons)



(a) Displacement time series of D1 area measured by radar (above) and pre/post event images taken by GigaPan (below); (b) Displacement time series of D2 area measured by radar (above) and pre/post event images by GigaPan (below).

TERRESTRIAL InSAR

Esempi applicativi

LA NUOVA
Xtra Sardegna

Sassari | Alghero | Cagliari | Nuoro | Olbia | Oristano | Tutti i...

Regione

Il monte spaventa Bonorva la frana si avvicina alle case

DI GIOVANNI BUA
19 GENNAIO 2021



Crollato un primo edificio, gli smottamenti sono a 500 metri di distanza

ANSA.it - Sardegna - **Pericolo frane a Bonorva, sindaco chiude zona a rischio**

Pericolo frane a Bonorva, sindaco chiude zona a rischio

Smottamenti nei pressi area dove si è creata voragine sulla 131

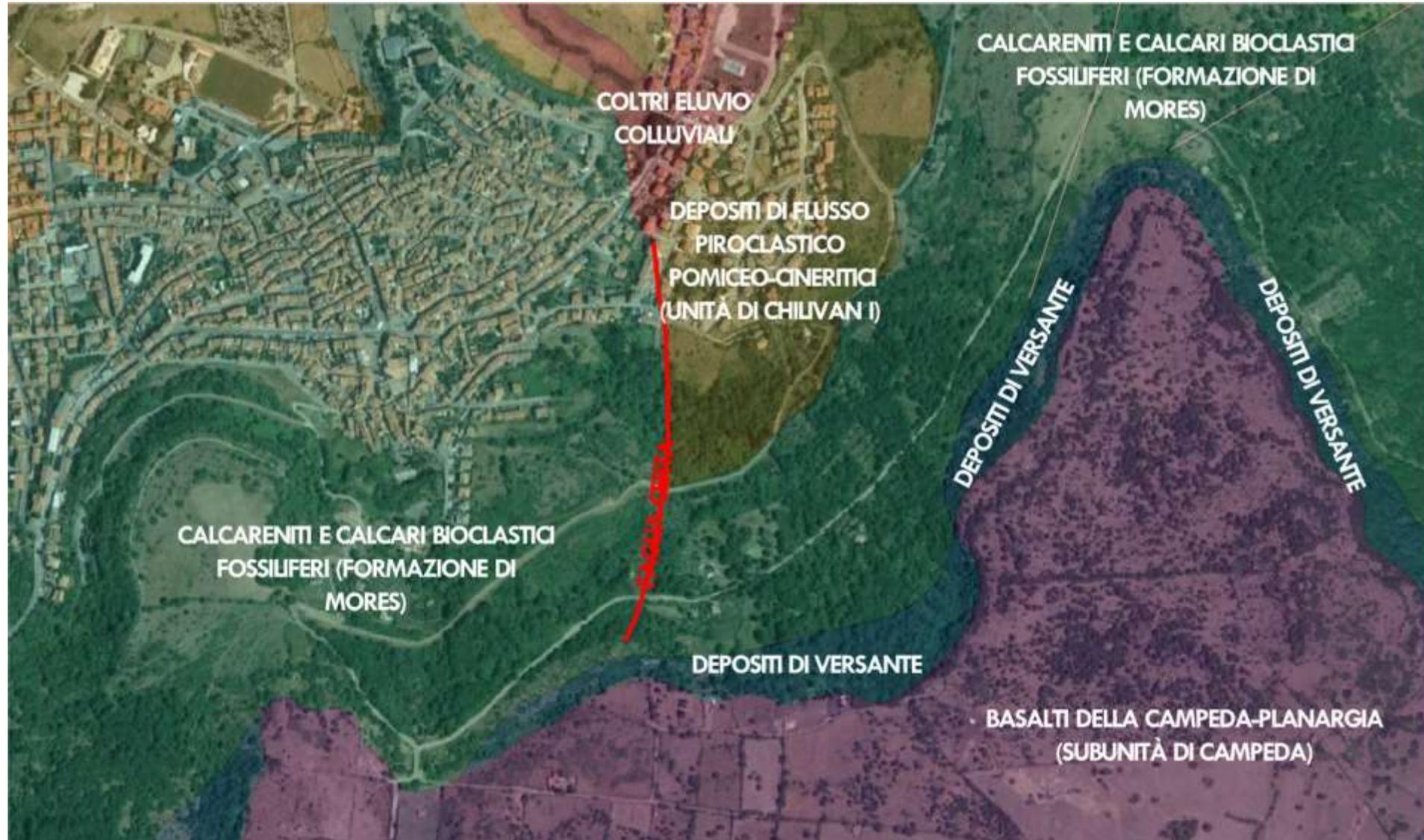
Redazione ANSA
SASSARI
15 gennaio 2021
20:17
NEWS

Suggerisci
Facebook
Twitter



TERRESTRIAL InSAR

Esempi applicativi



TERRESTRIAL InSAR

Esempi applicativi

ATTIVITA' SVOLTE (Sopralluoghi in frana)



Venerdì 22/01/2021- Sabato 23/01/2021 – Domenica 24/01/2021

TERRESTRIAL InSAR

Esempi applicativi

ATTIVITA' SVOLTE (Installazione Interferometro SAR Terrestre)

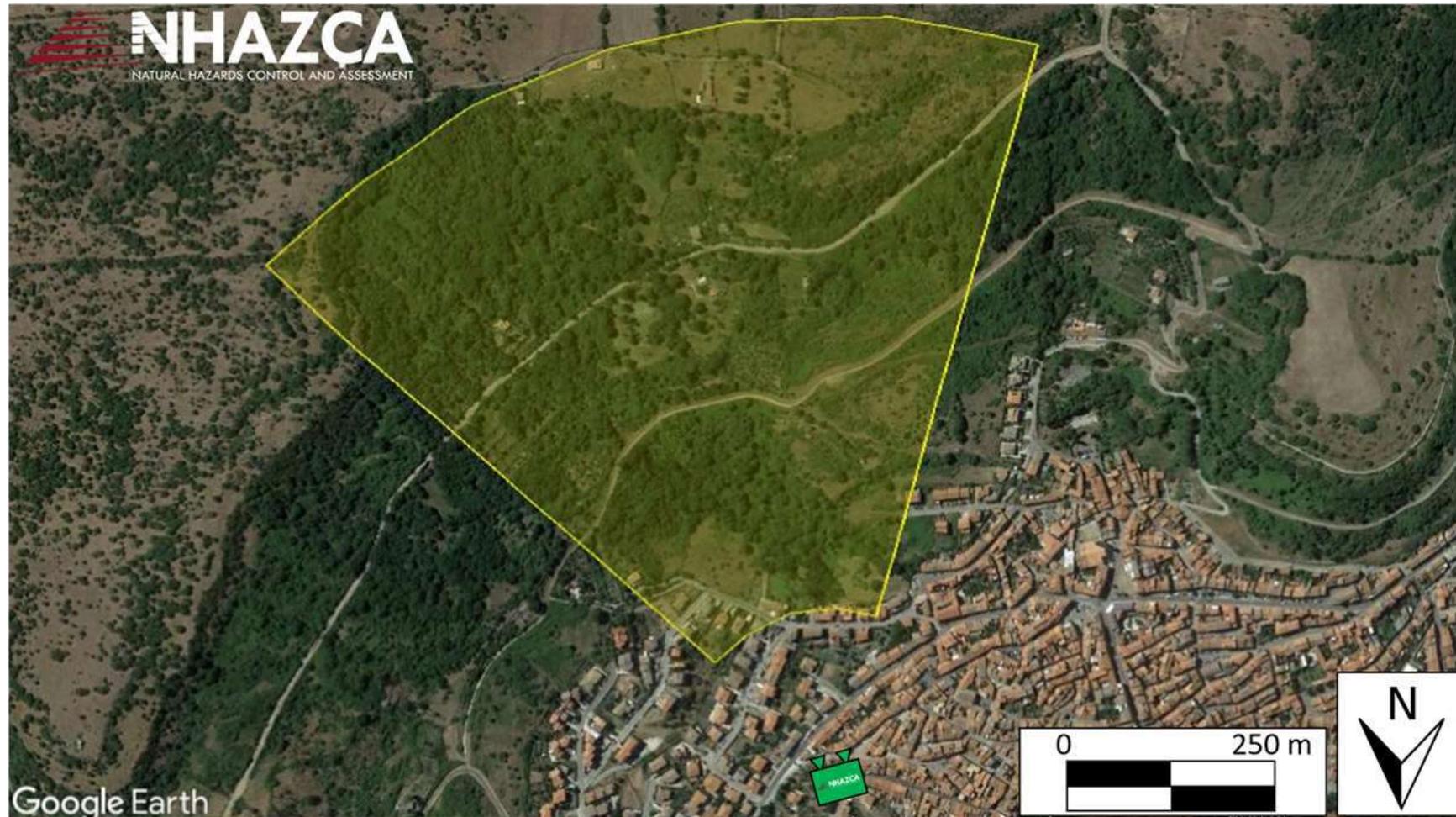


Venerdì 22/01/2021

TERRESTRIAL InSAR

Esempi applicativi

ATTIVITA' SVOLTE (Installazione Interferometro SAR Terrestre)



Google Earth

Venerdì 22/01/2021

TERRESTRIAL InSAR

Esempi applicativi

ATTIVITA' SVOLTE (Installazione Corner Reflector)

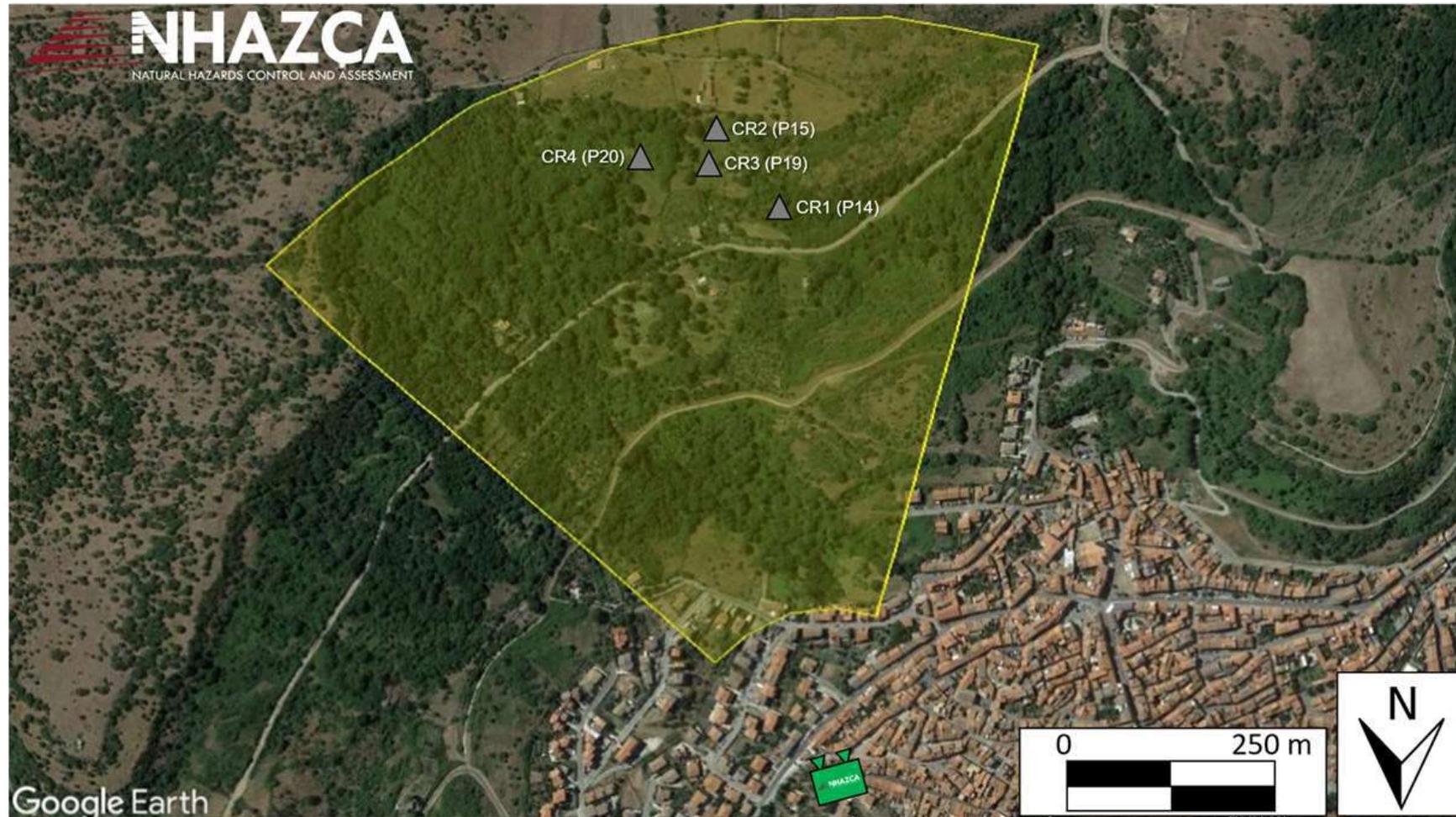


Sabato 23/01/2021 – Domenica 24/01/2021

TERRESTRIAL InSAR

Esempi applicativi

ATTIVITA' SVOLTE (Installazione Corner Reflector)

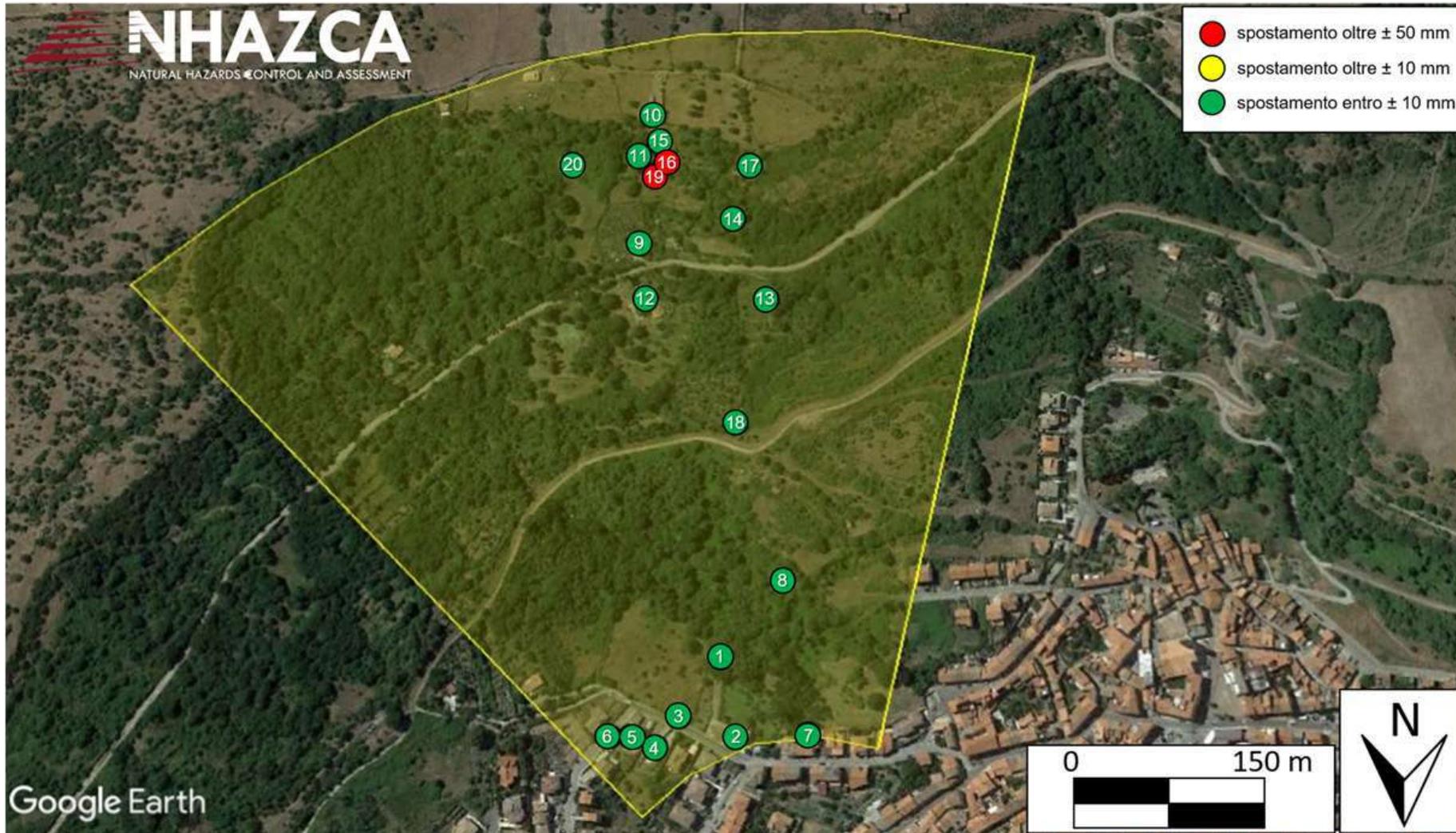


Sabato 23/01/2021 – Domenica 24/01/2021

TERRESTRIAL InSAR

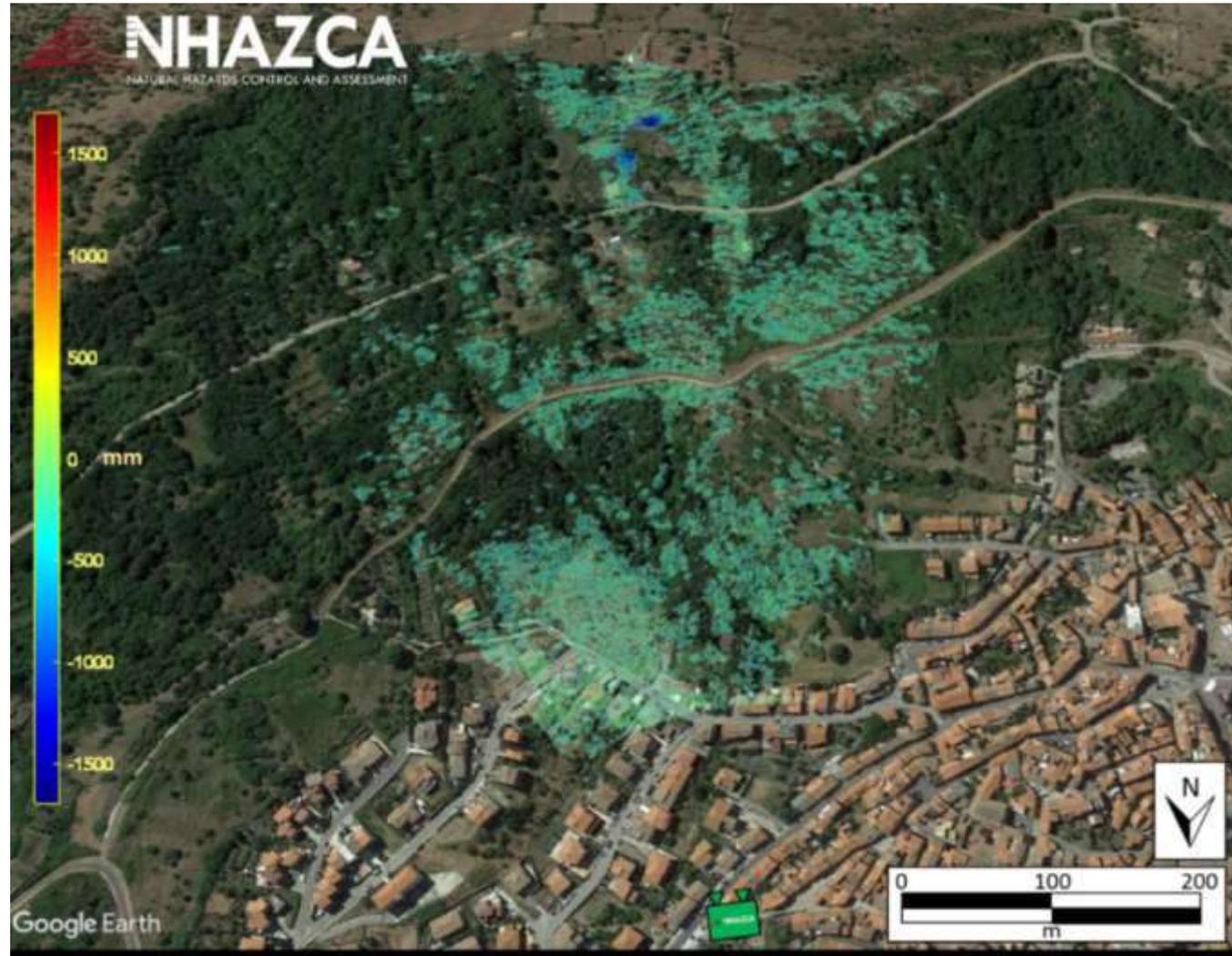
Esempi applicativi

RISULTATI (PRIME 48h)



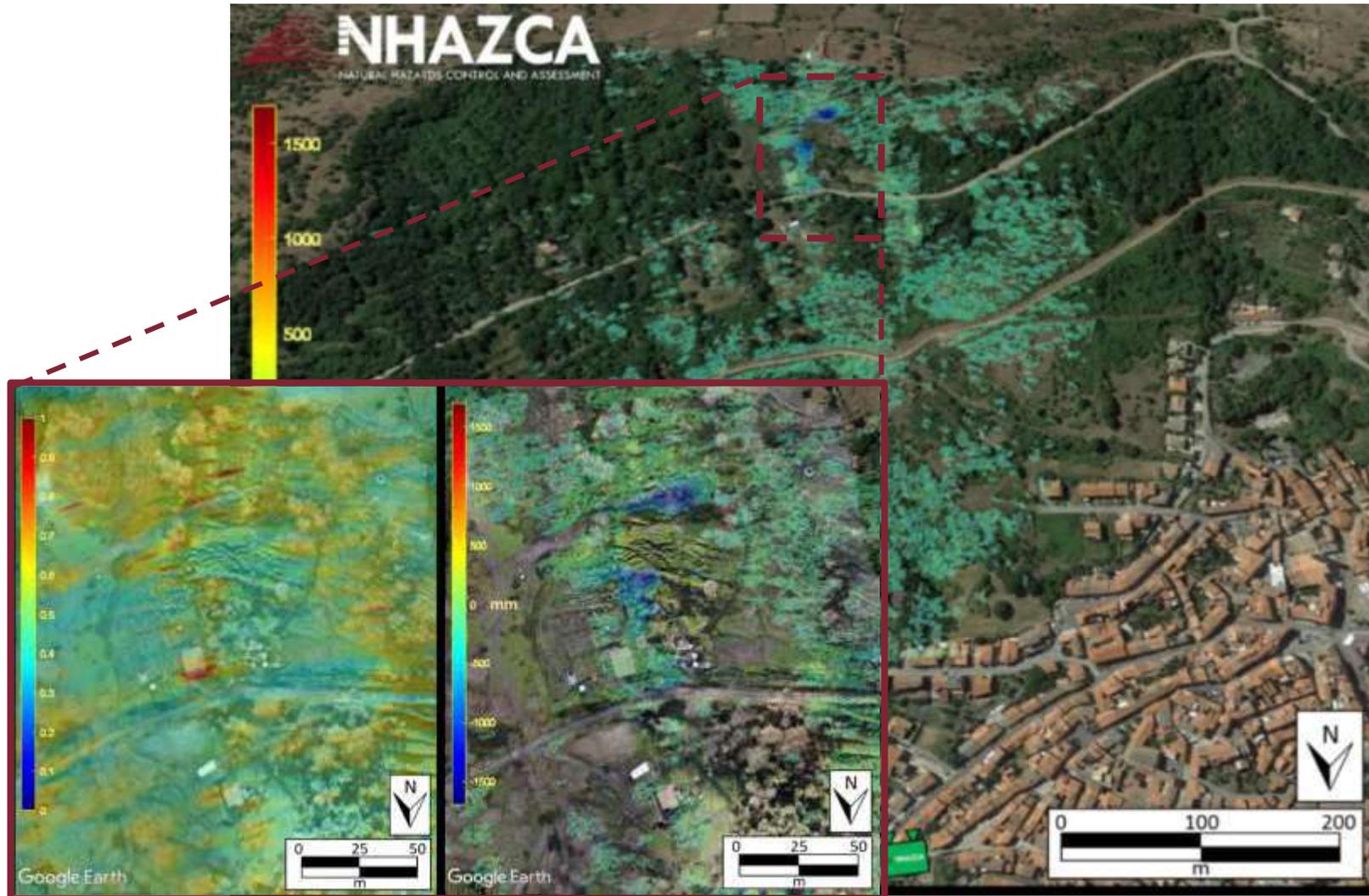
TERRESTRIAL InSAR

Esempi applicativi

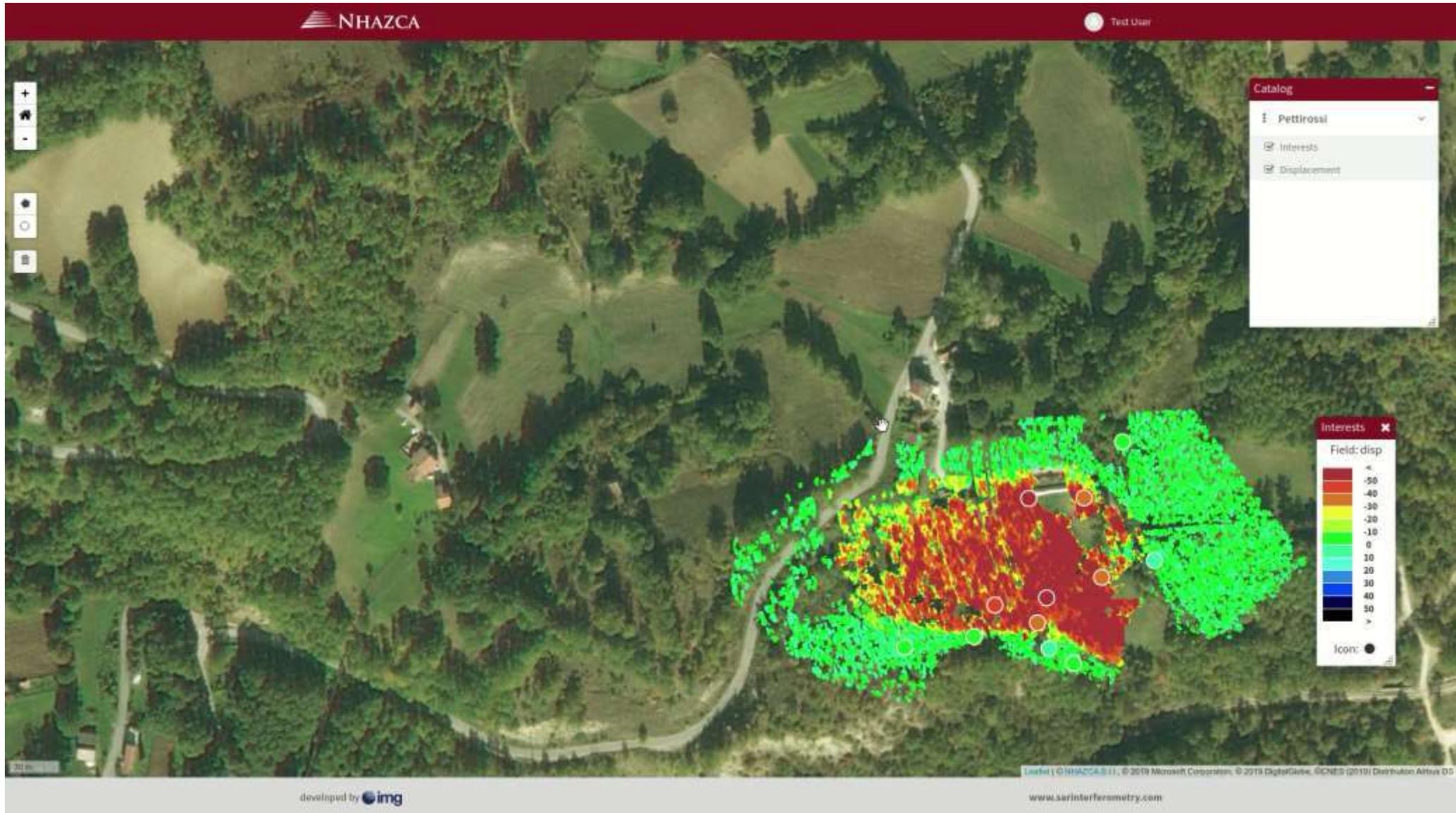


TERRESTRIAL InSAR

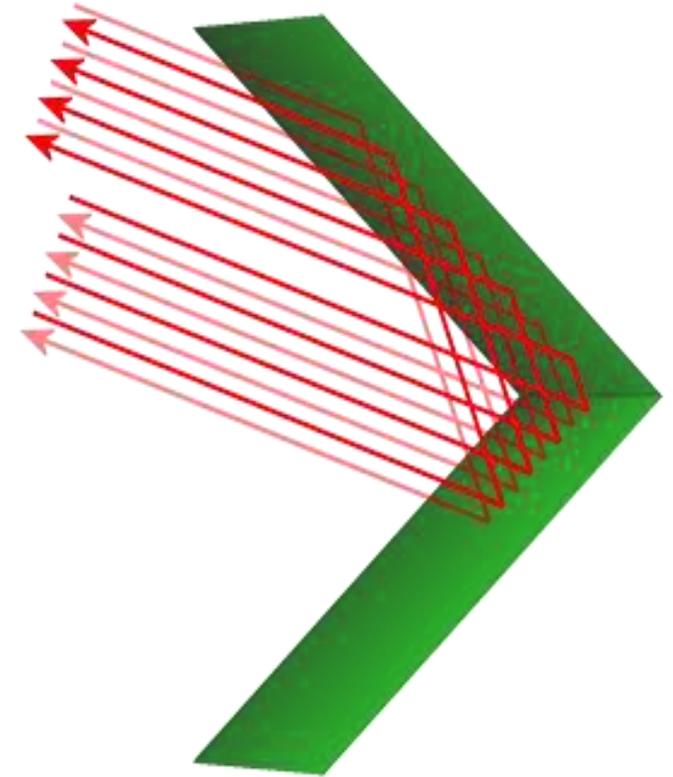
Esempi applicativi



TERRESTRIAL InSAR



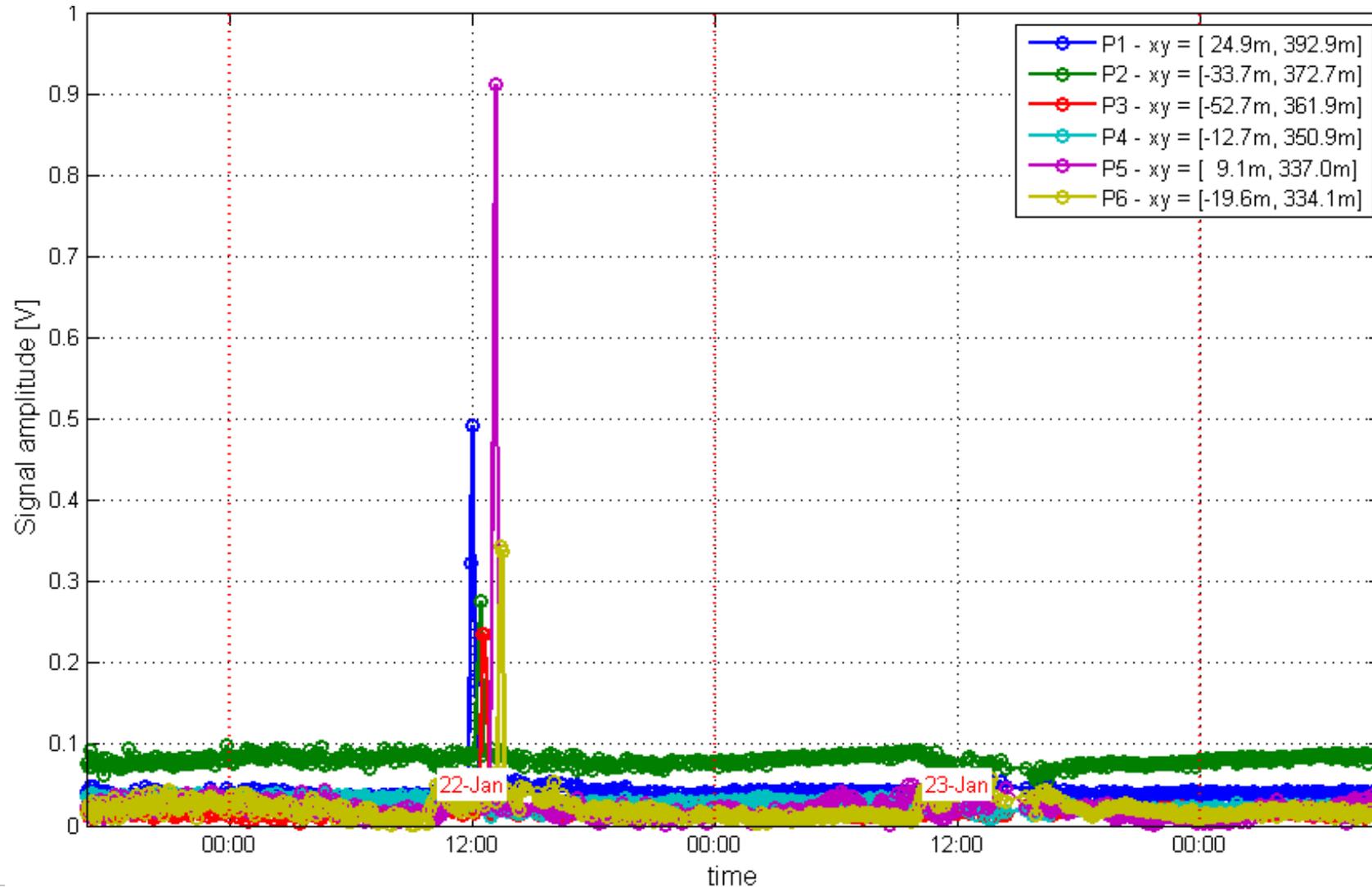
TERRESTRIAL InSAR & Satellite InSAR – Corner Reflector



TERRESTRIAL InSAR & Satellite InSAR – Corner Reflector



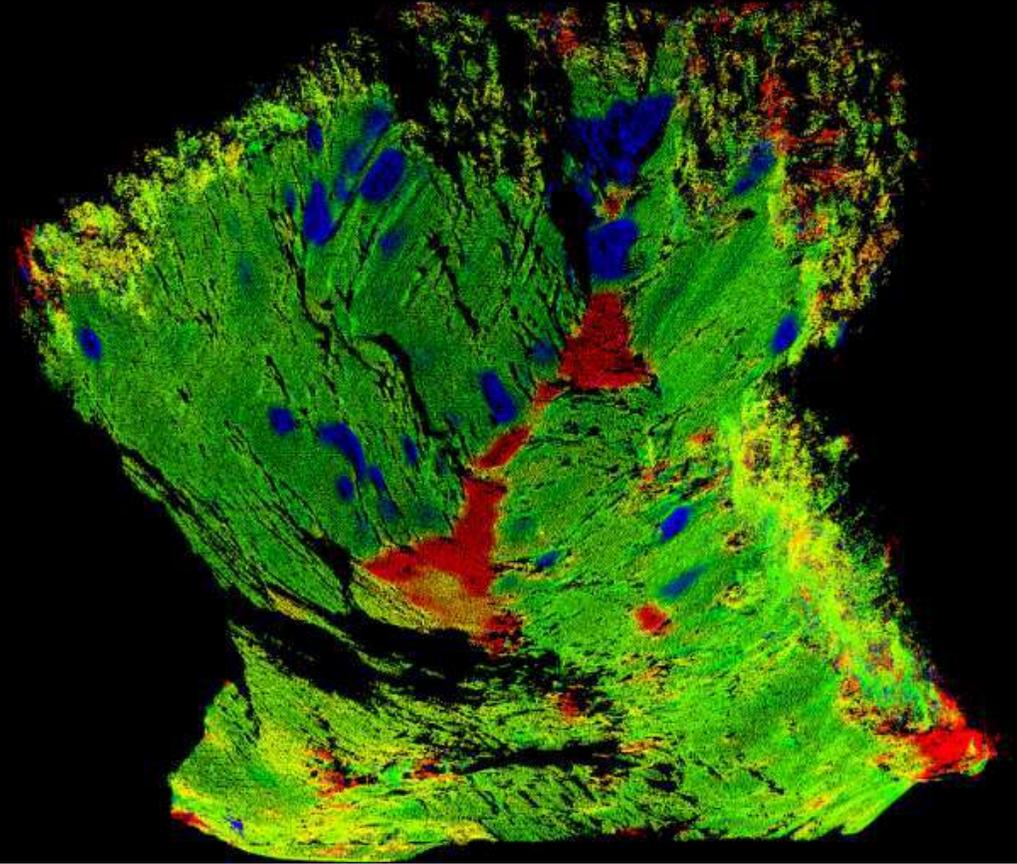
TERRESTRIAL InSAR & Satellite InSAR – Corner Reflector



TERRESTRIAL LASER SCANNING



3D model in real colors retrieved by a Terrestrial Laser Scanner survey of a rock scarp.



Volumetric change estimation derived by multi-temporal surveys of the rock scarp. The blue color identifies the detachment areas of rockfalls, while red color is referred to the accumulation zones.

LASER SCANNER

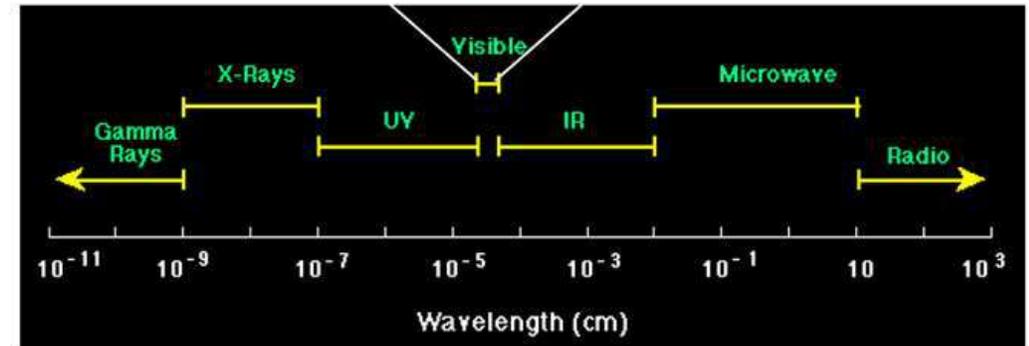
LIDAR

Light Detection And Ranging = Identificazione e misura tramite la luce

Tecnica di telerilevamento che permette di determinare la distanza d da un oggetto con un impulso laser.

La strumentazione utilizza una lunghezza d'onda del visibile e dell'infrarosso vicino (solitamente tra 0,3 e 1,6 μm).

Sistema attivo che attraverso sistemi meccanici e specchi ruotanti ed oscillanti è in grado di emettere raggi *LASER* e di indirizzare gli stessi in diverse posizioni dello spazio, eseguendo in questo modo una “scansione” degli oggetti che ha nel proprio campo di azione.



LASER SCANNER PIATTAFORME



LASER SCANNER

Categorie di Laser Scanner

I laser scanner possono essere definiti come dei distanziometri a scansione.

I distanziometri usati nei Laser Scanner possono essere distinti in **due categorie principali**:

- strumenti che prevedono la **misura di tempi** trascorsi tra due impulsi o tra due treni d'onda (distanziometri ad impulsi);
- strumenti che prevedono la **misura dello sfasamento** tra l'onda emessa e quella ricevuta (distanziometri a misura di fase), detti anche interferometrici.

LASER SCANNER

Confronto della precisione strumentale delle tecnologie disponibili

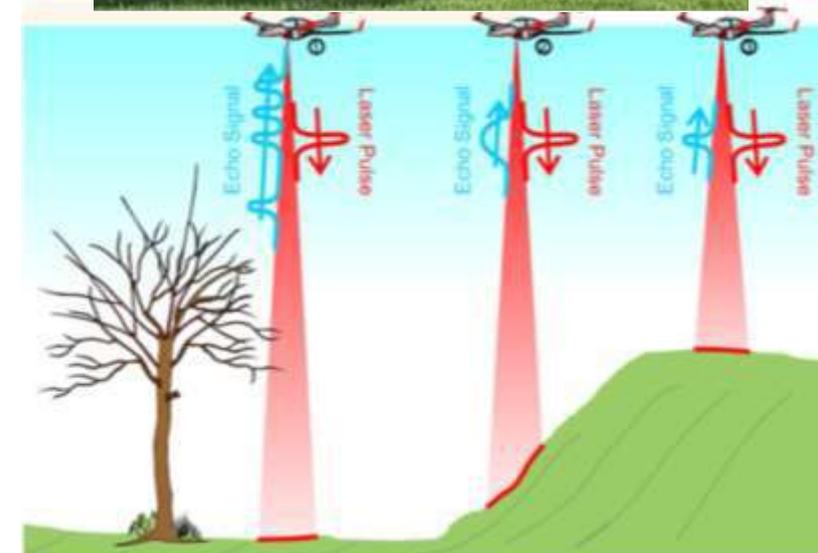
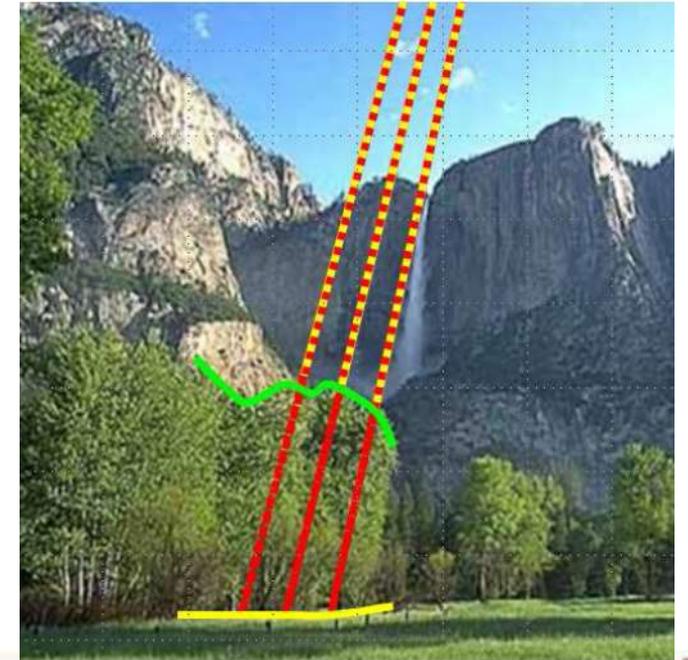
I Laser Scanner a tempo di volo garantiscono una **precisione** sul punto **minore** (5-15 mm) ma **portate elevate** (fino ad alcuni km), con una velocità di acquisizione che può arrivare da diverse decina fino a diverse migliaia di punti al secondo.

I Laser Scanner a differenza di fase raggiungono invece una **precisione maggiore** (2-4 mm) ma con **portate inferiore** a 100 m.

LASER SCANNER

"multiple targets" (solo specifici modelli)

Nel momento in cui il raggio laser incontra degli ostacoli una parte di esso viene riflessa e ritorna allo strumento mentre l'altra parte supera l'ostacolo raggiungendo l'oggetto di interesse. In base all'analisi dei ritorni multipli del segnale ("**Echoes**") è così possibile acquisire informazioni anche in zone parzialmente coperte dalla vegetazione.



LASER SCANNER



LASER SCANNER



LASER SCANNER



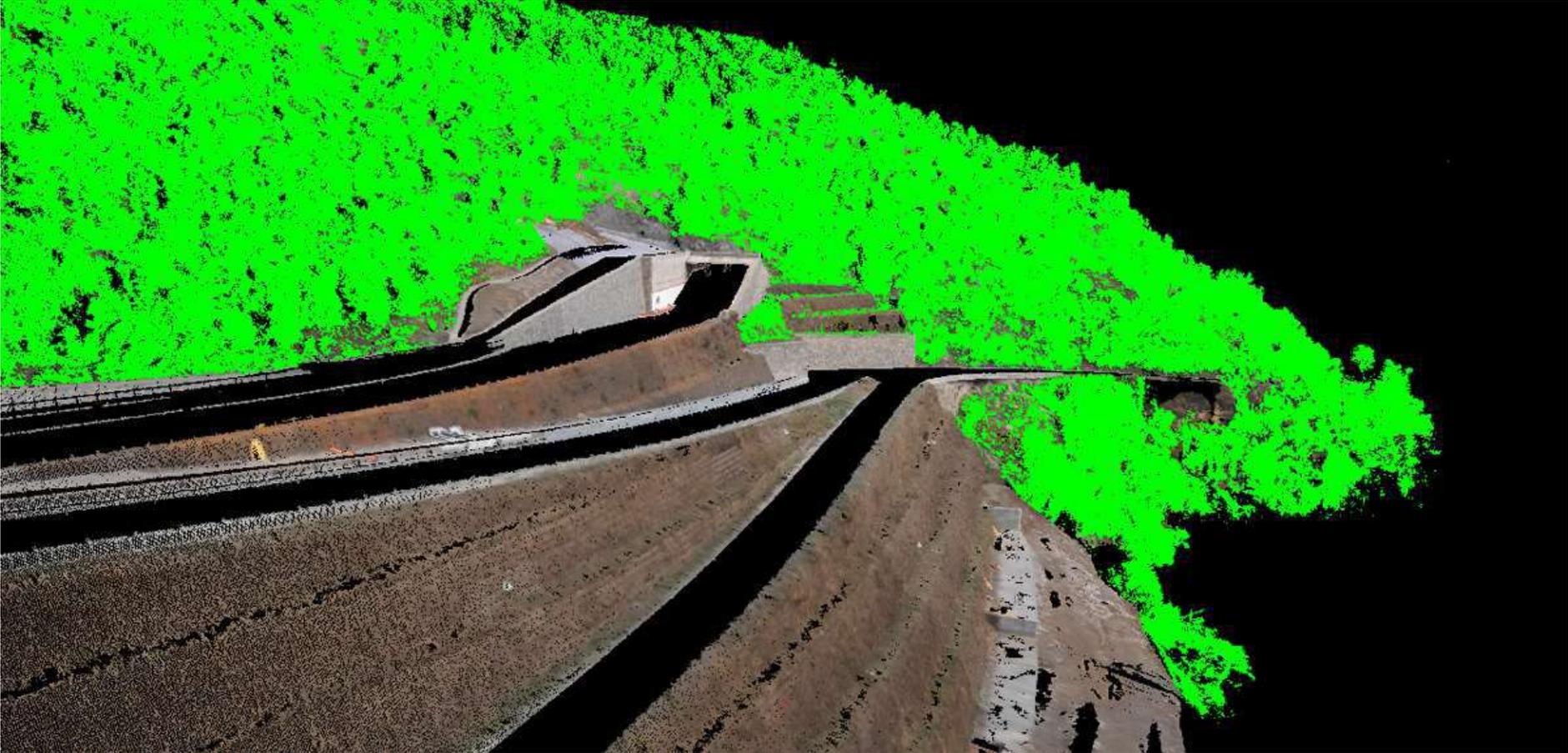
LASER SCANNER



LASER SCANNER



LASER SCANNER



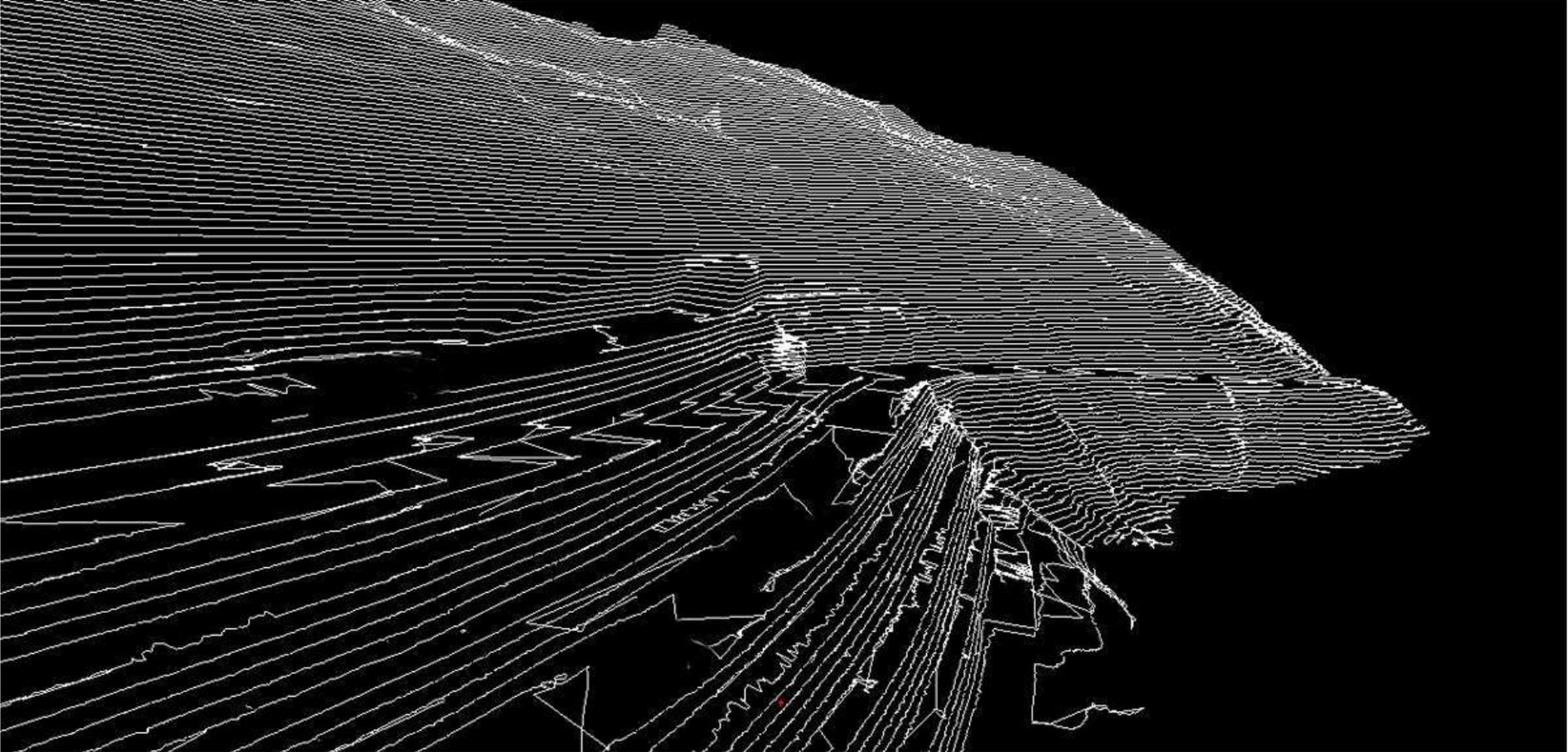
LASER SCANNER



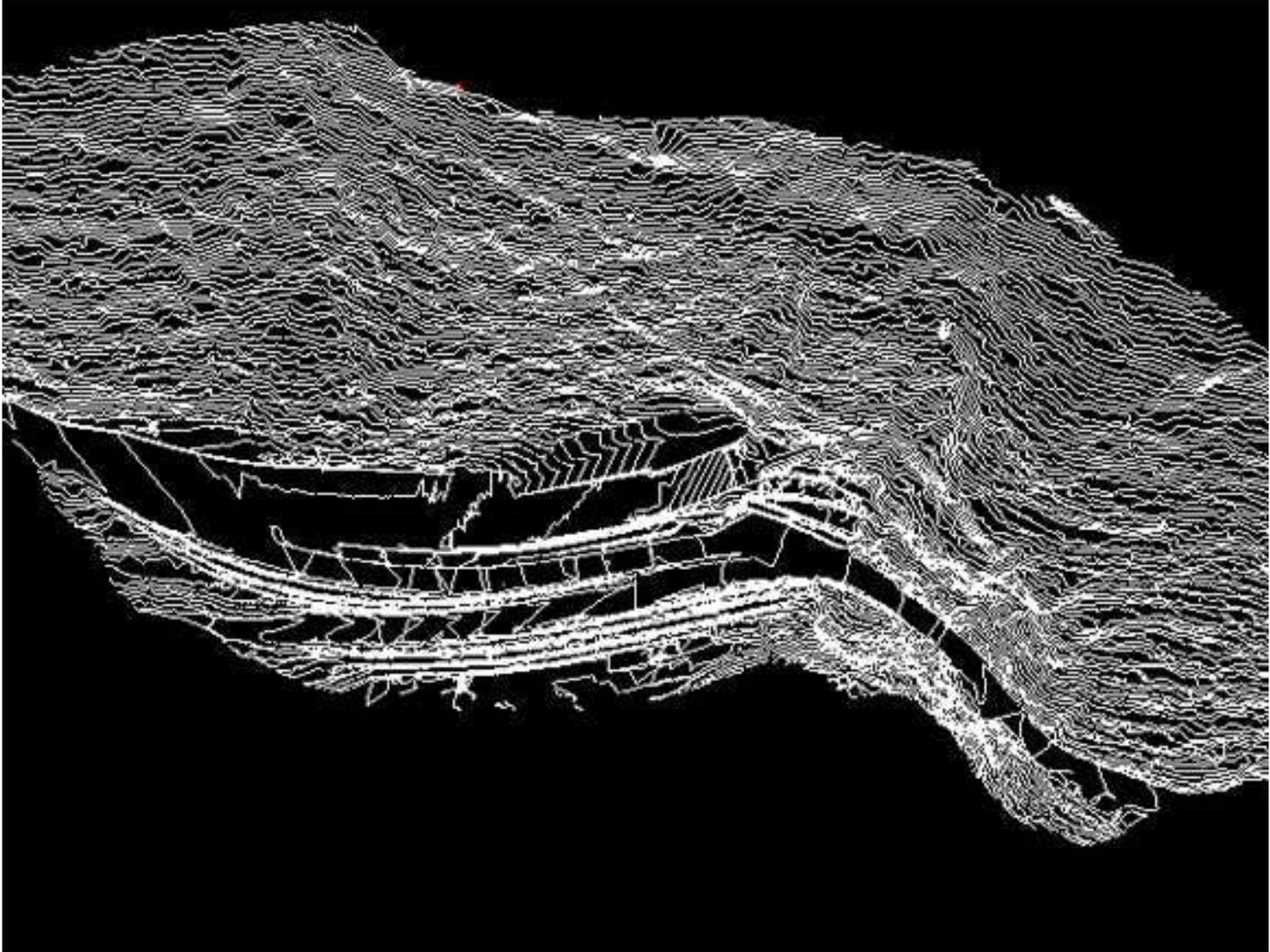
LASER SCANNER



LASER SCANNER



LASER SCANNER



LASER SCANNER



Esempio parete rocciosa



Utilizzo dei dati

- Per generazione sezioni, profili,

Equazione
 $0.984508 \cdot x + -0.173648 \cdot y + 0.000000 \cdot z + -123.009768 = 0$

Punto (m)

	Normale
x: 127.202437	x: 0.984508
y: 13.021521	y: -0.173648
z: 90.359630	z: 0.000000

COP e COP direction

Punto (m)	COP (deg)	COP direction (deg)
x: 127.202437	90.000000	100.000000
y: 13.021521		
z: 90.359630		

Disegna profilo sulla sezione: Sezione?

LASER SCANNER

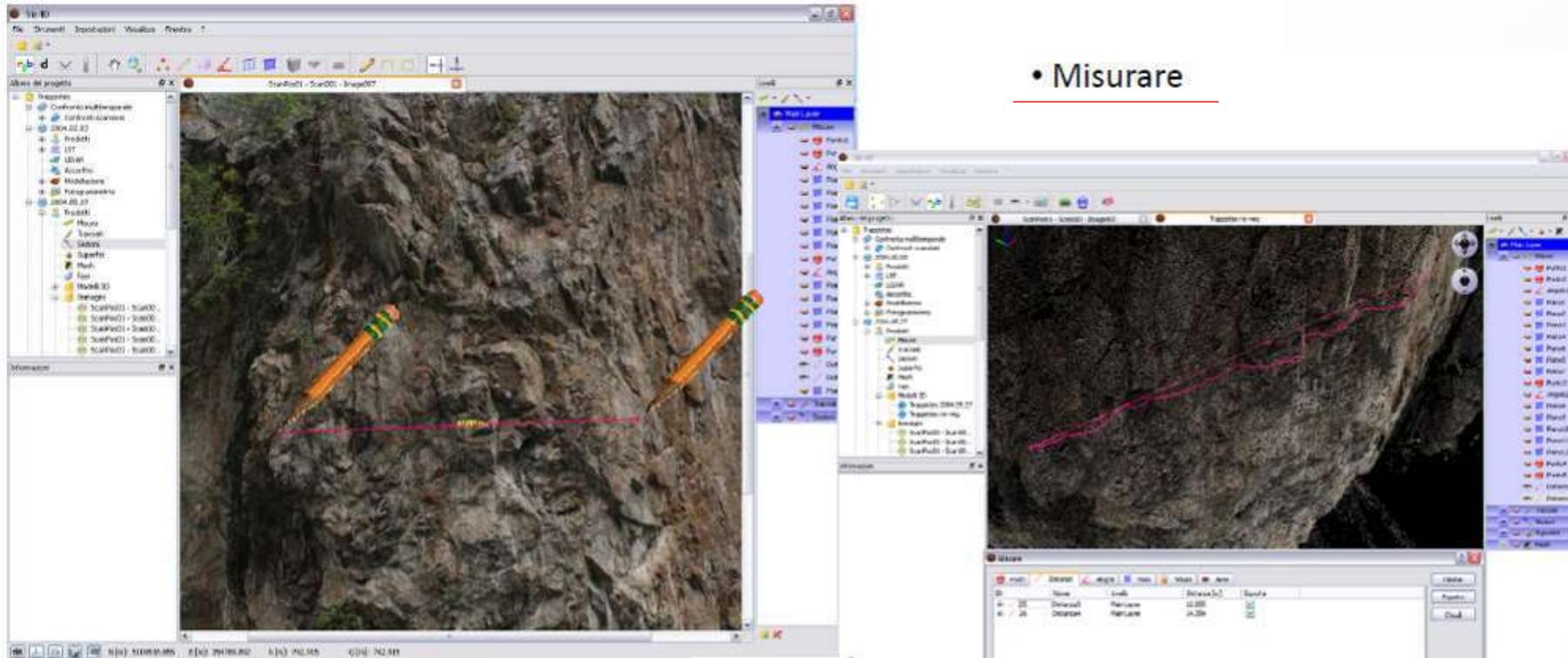


Esempio parete rocciosa



Utilizzo dei dati

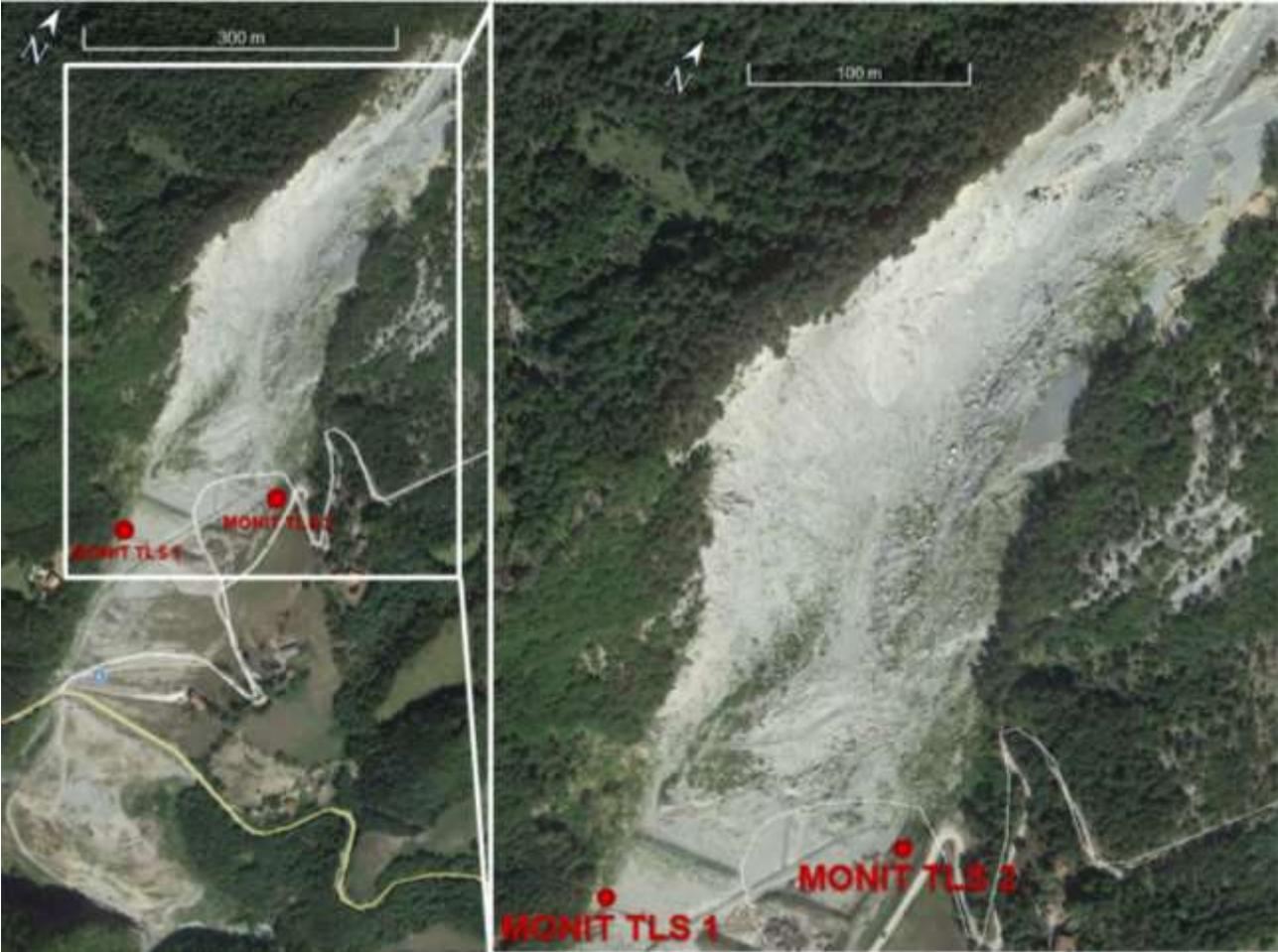
- Misurare



LASER SCANNER



LASER SCANNER



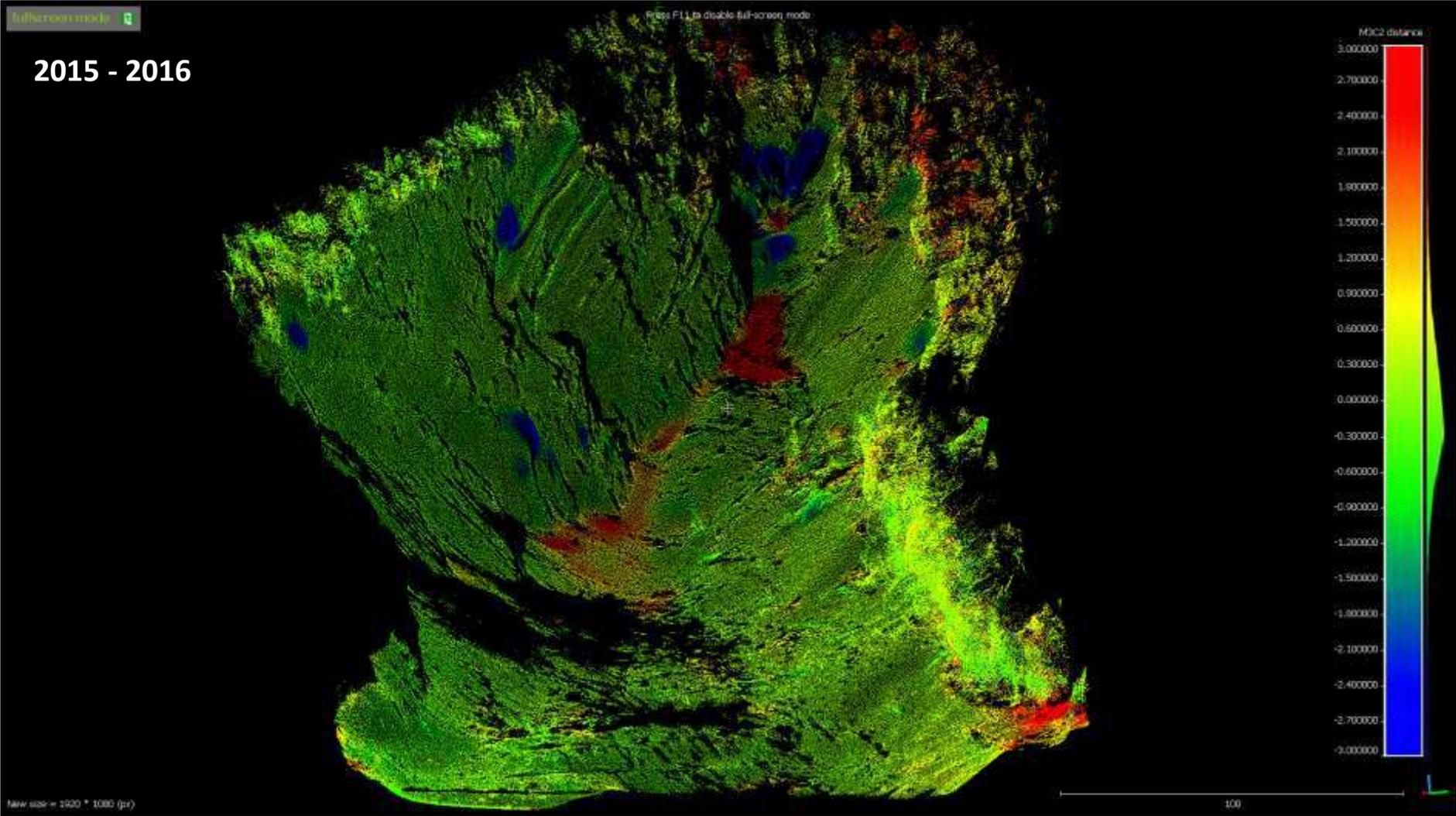
LASER SCANNER



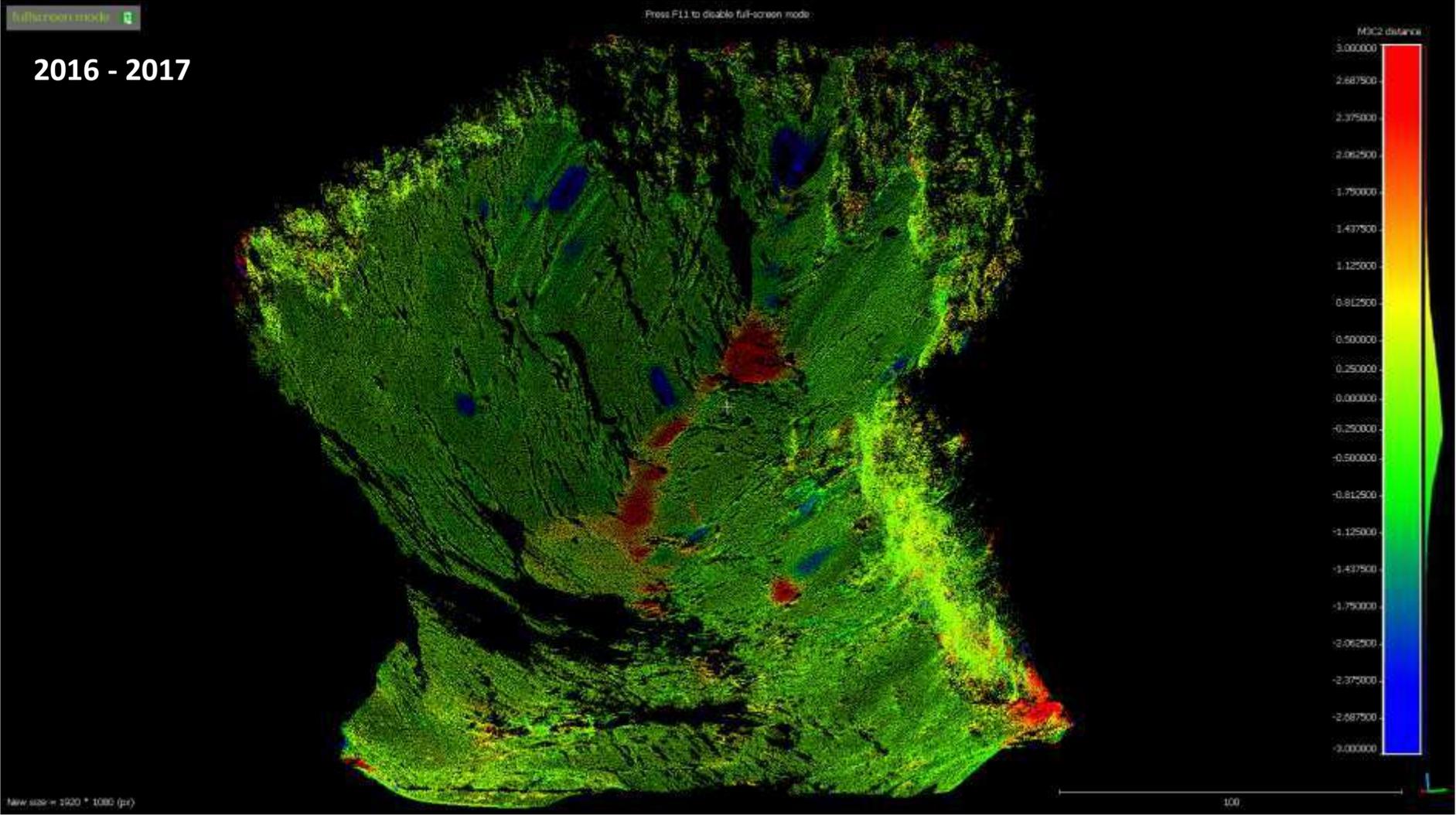
LASER SCANNER



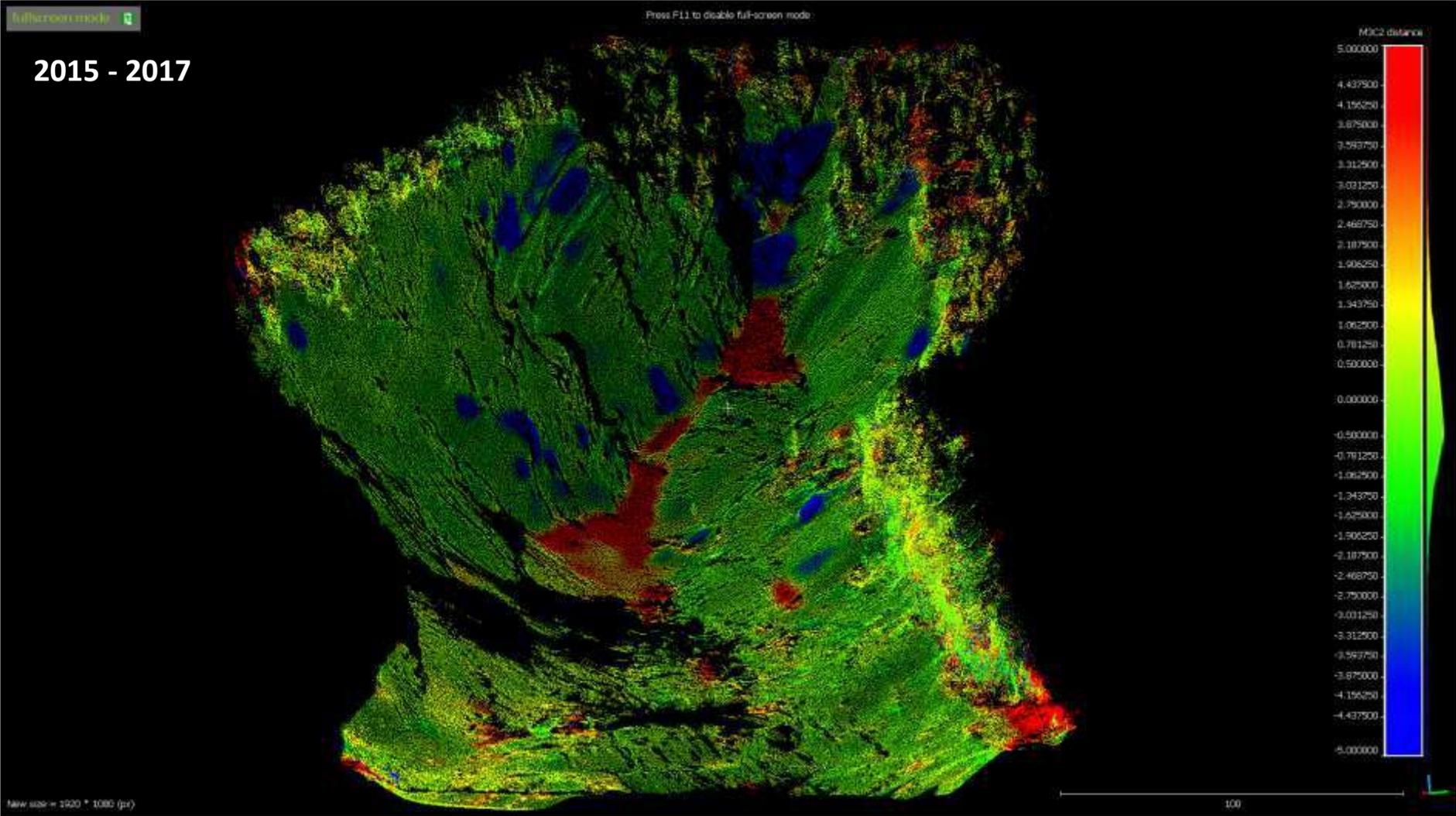
LASER SCANNER



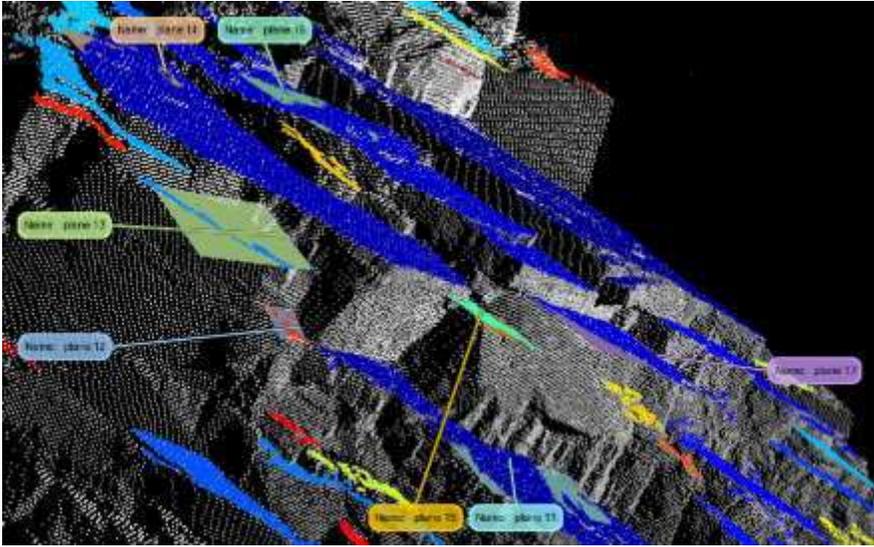
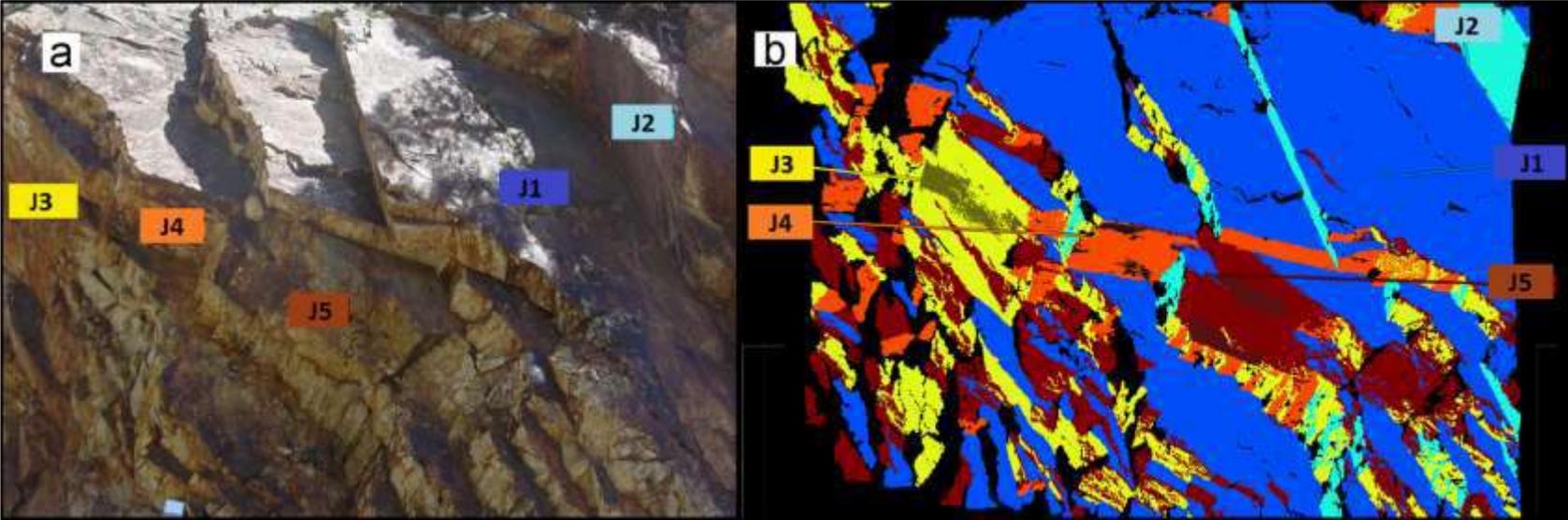
LASER SCANNER



LASER SCANNER

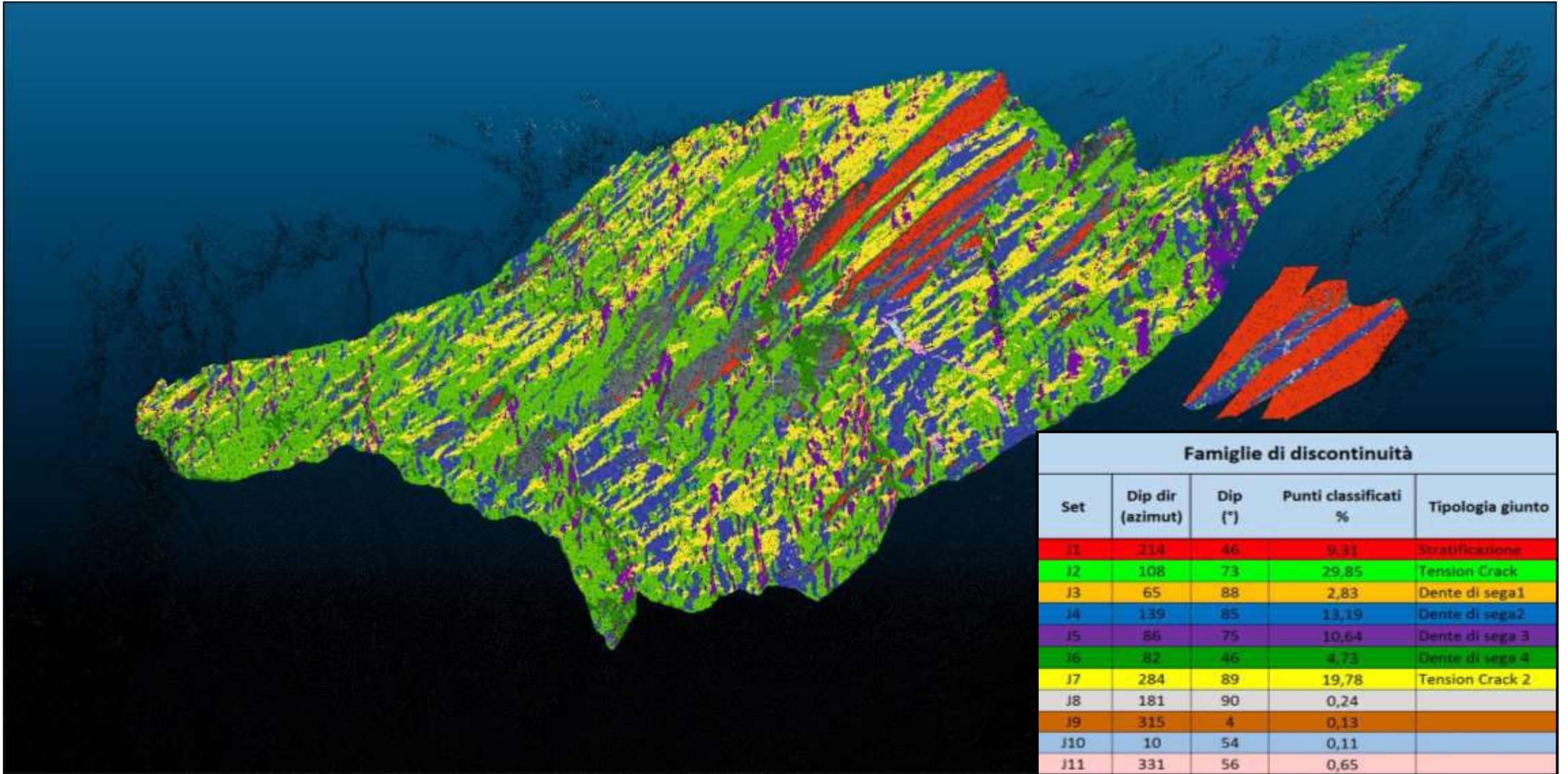


LASER SCANNER



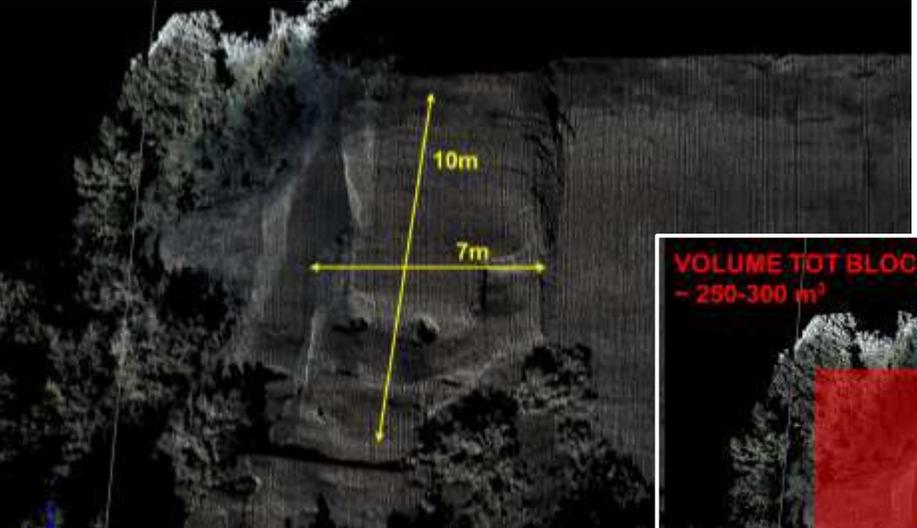
(Requielme et al., 2014)

LASER SCANNER

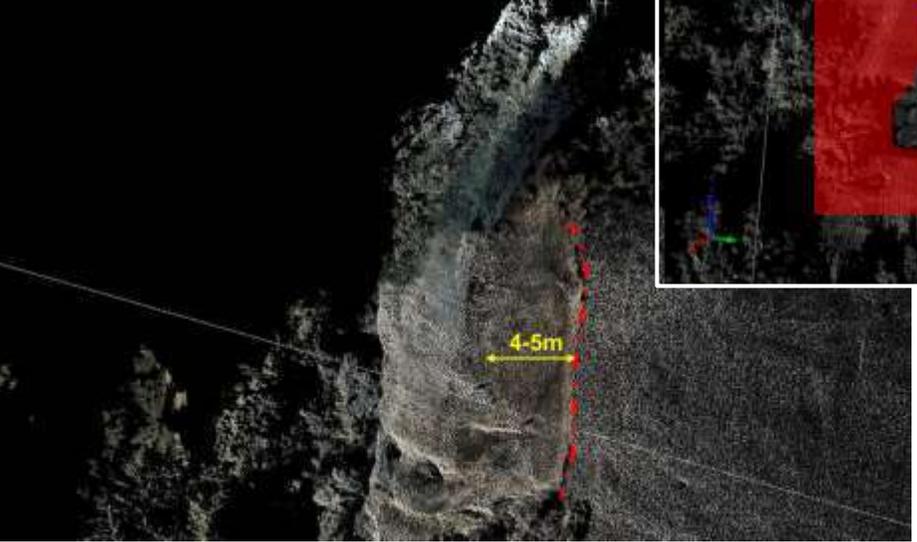
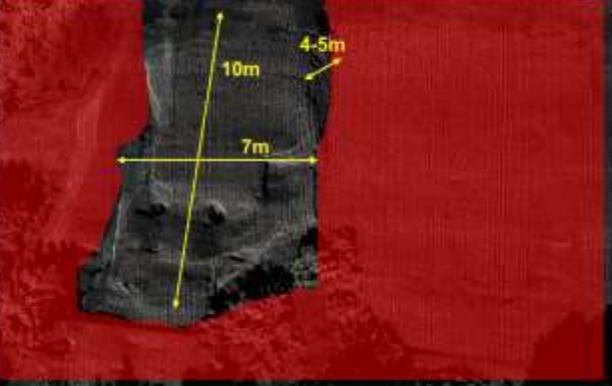


Famiglie di discontinuità				
Set	Dip dir (azimut)	Dip (°)	Punti classificati %	Tipologia giunto
J1	214	46	9,31	Stratificazione
J2	108	73	29,85	Tension Crack
J3	65	88	2,83	Dente di sega1
J4	139	85	13,19	Dente di sega2
J5	86	75	10,64	Dente di sega 3
J6	82	46	4,73	Dente di sega 4
J7	284	89	19,78	Tension Crack 2
J8	181	90	0,24	
J9	315	4	0,13	
J10	10	54	0,11	
J11	331	56	0,65	

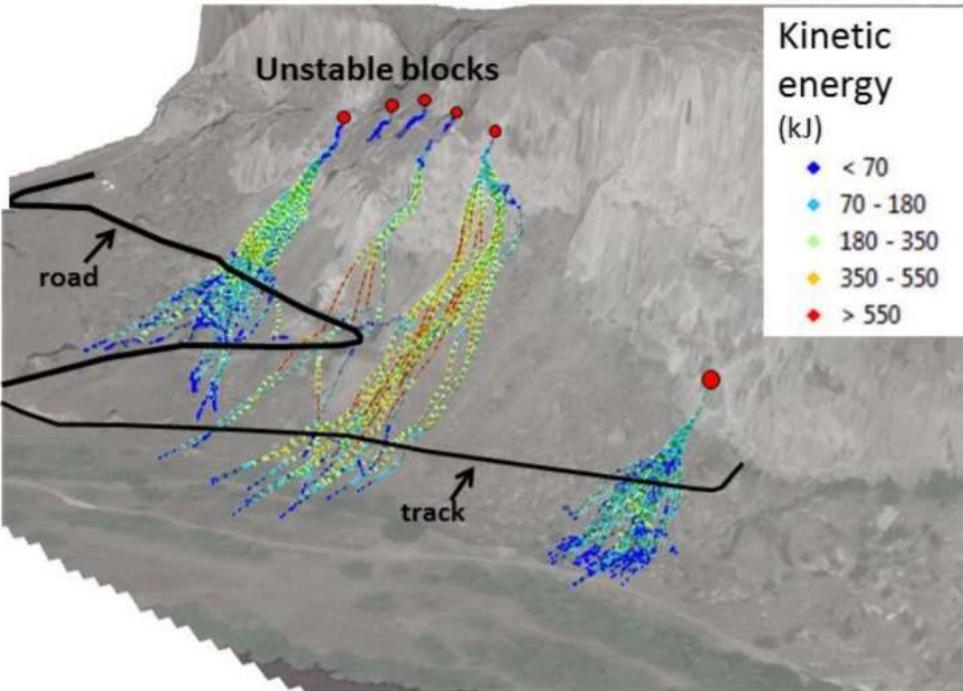
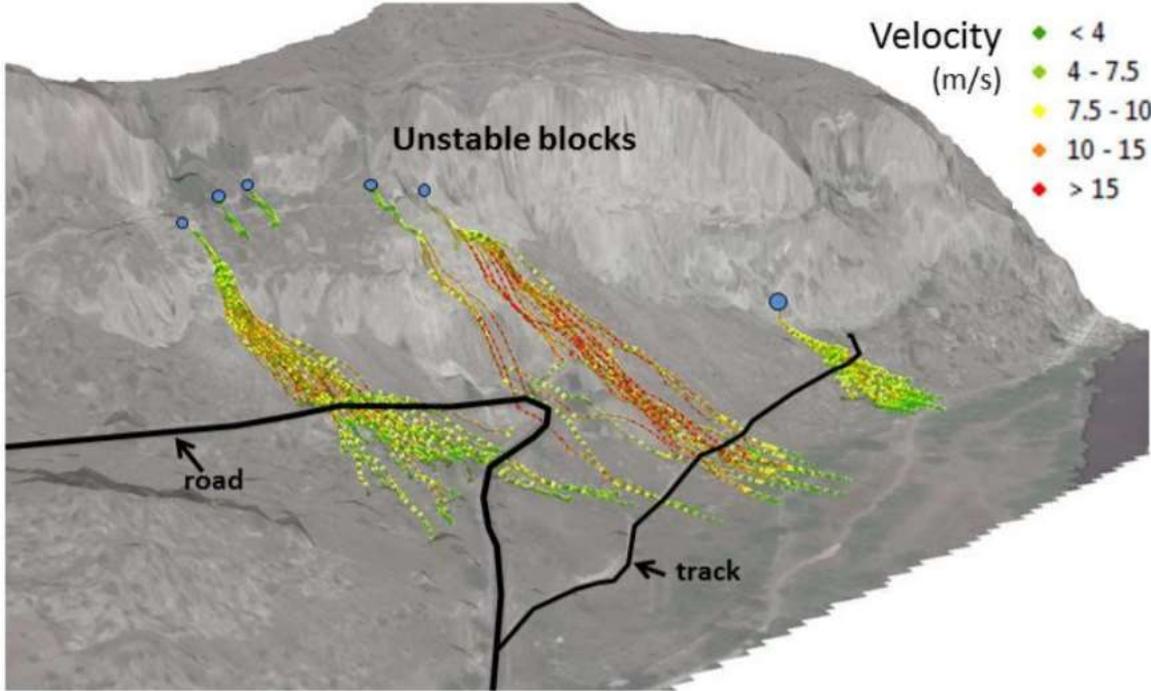
LASER SCANNER



VOLUME TOT BLOCCO:
- 250-300 m³



LASER SCANNER



(Margottini et al., 2015)

PhotoMonitoring

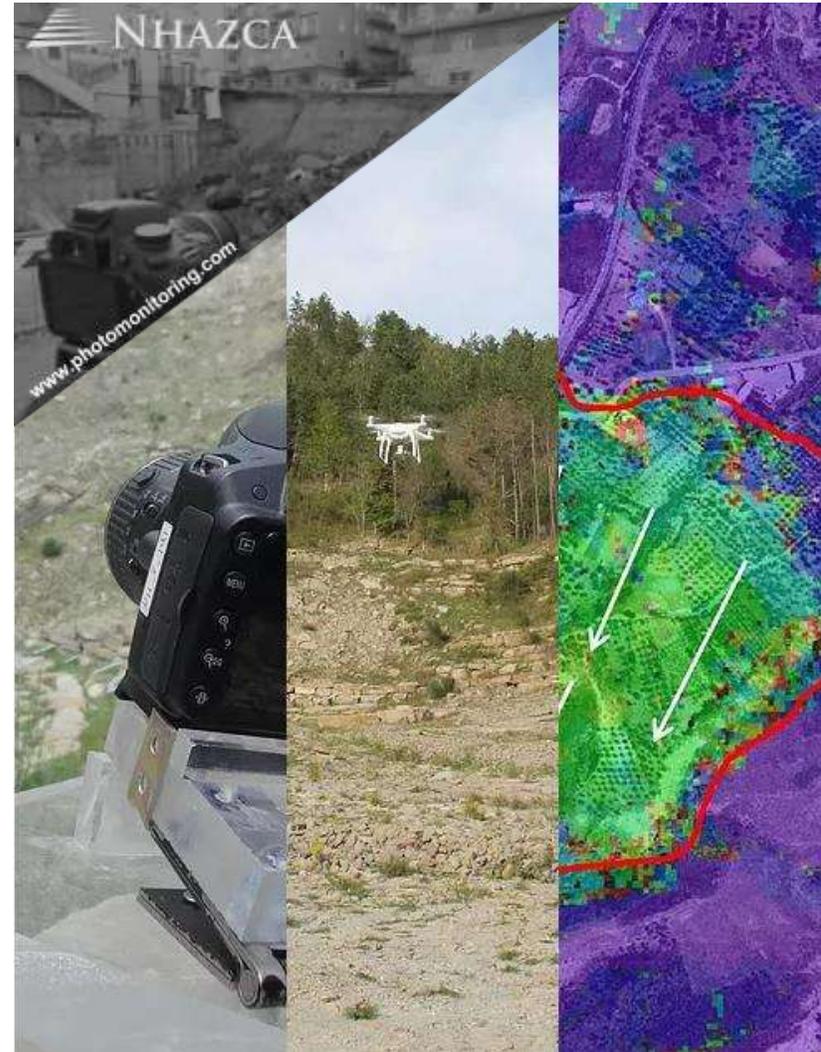
<https://www.photomonitoring.com/>

PhotoMonitoring è una nuova soluzione di monitoraggio che sfrutta la grande diffusione nel mondo di **sensori ottici/multispettrali** al fine di ottenere **informazioni** circa i **cambiamenti** o gli **spostamenti** del terreno, mediante opportune tecniche di image processing

PhotoMonitoring opera a diverse scale spaziali e temporali, rappresentando uno strumento ideale per lo studio e il monitoraggio di processi deformativi superficiali (**frane, processi di subsidenza, processi vulcanici, terremoti, ecc.**)

PhotoMonitoring si basa sulle seguenti principali tecniche di image processing:

- **Change Detection**
- **Digital Image Correlation**
- **Structure From Motion**
- **Image Classification & feature detection**



PhotoMonitoring



NHAZcam



PhotoMonitoring – Change Detection

Riconoscimento automatico delle variazioni della superficie o del terreno attraverso l'analisi delle variazioni del comportamento radiometrico tra coppie di immagini acquisite a diversi intervalli temporali



PhotoMonitoring – Change Detection



PhotoMonitoring – Change Detection



PhotoMonitoring – Change Detection



PhotoMonitoring – Change Detection



PhotoMonitoring – Change Detection

The screenshot shows the IRIS software interface. The main window displays a photograph of a rocky, eroded slope. The interface is divided into several sections:

- Menu Bar:** File, Settings, Tools, Help
- Parameters Panel (Left):**

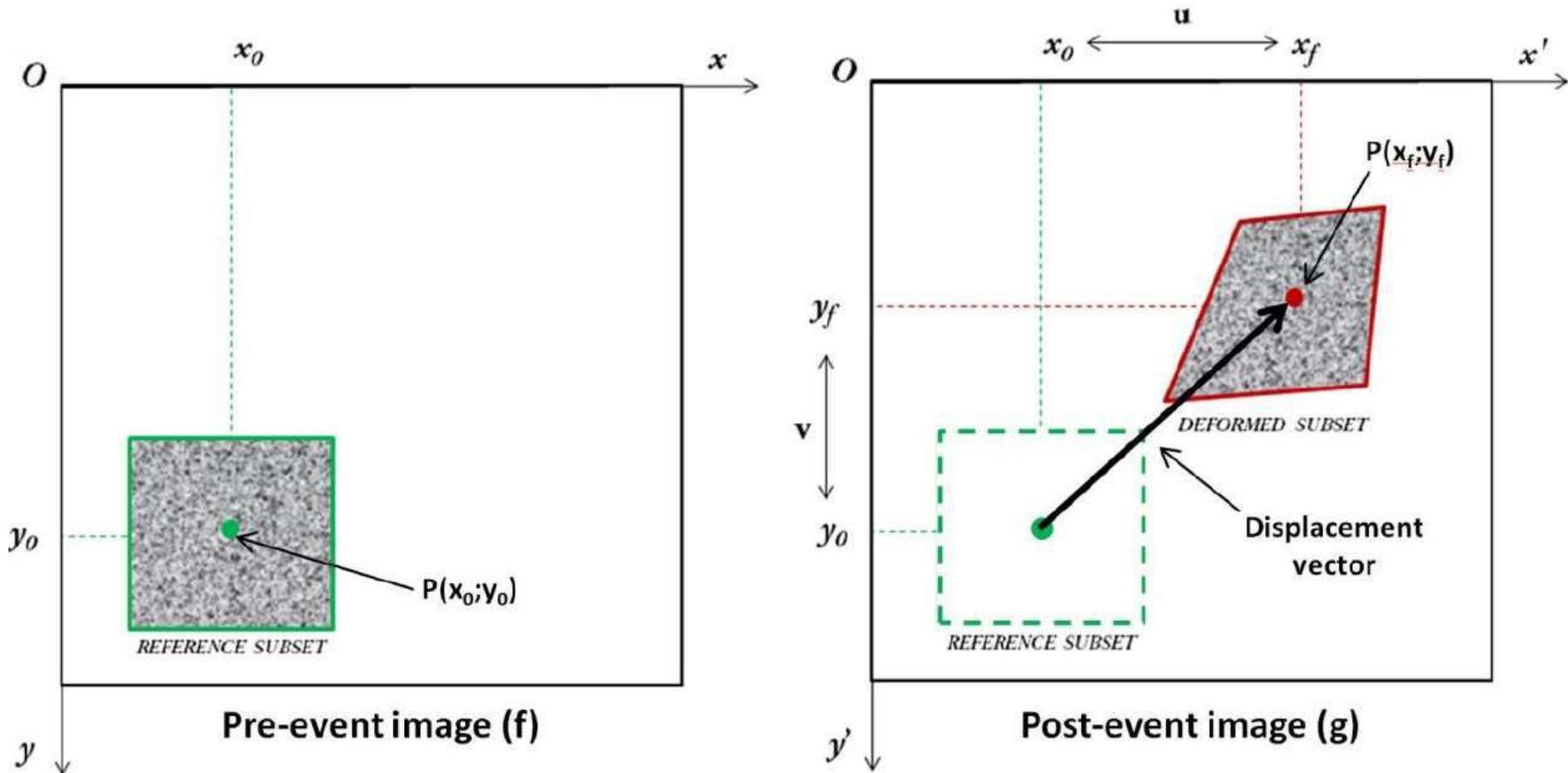
Parameters	Value
Global	
Step size	8
Band(s)	Grayscale
Use mask	False
Coregister	False
Veg. filter	False
Veg. threshold	n.d.
Multicore	True
Multi-master	False
Displacement	
Window size	64
Sub-pix resolution	0.01
Changes	
Window size	32
SSI threshold	0.45
Post-processing	
CC filter	False
CC threshold	n.d.
Colorbar max	5.0
Noise threshold	0.1
Meas. unit	px
Green width	2
Resampling	Nearest
Coregistration	
Affine	False
Projective	True

Value	
Disp E-W	
Disp N-S	
Disp Res	
Change	No
Correl.	
X	167
Y	61
- Image:** A photograph of a rocky, eroded slope with some vegetation. A vertical white line is overlaid on the image.
- Progress Bar:** Change Detection Progress 100%
- Log Window (Bottom):**

```
[13:25:28] - Analysis Started
[13:25:39] - Change Detection started
[13:25:50] - Change Detection finished
[13:25:51] - Saving Change Detection Results
[13:25:51] - Analysis Completed
```



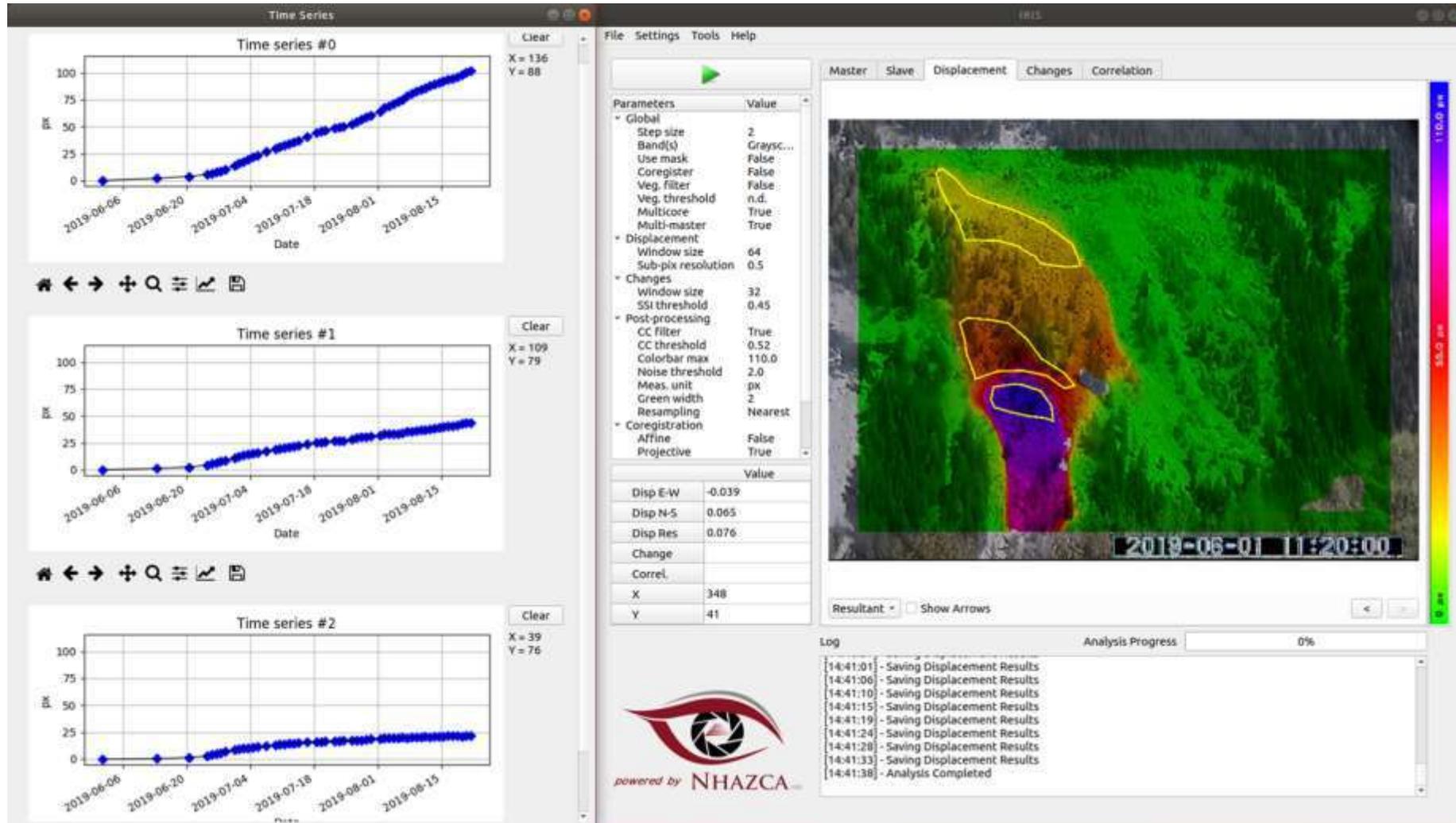
PhotoMonitoring – Digital Image Correlation



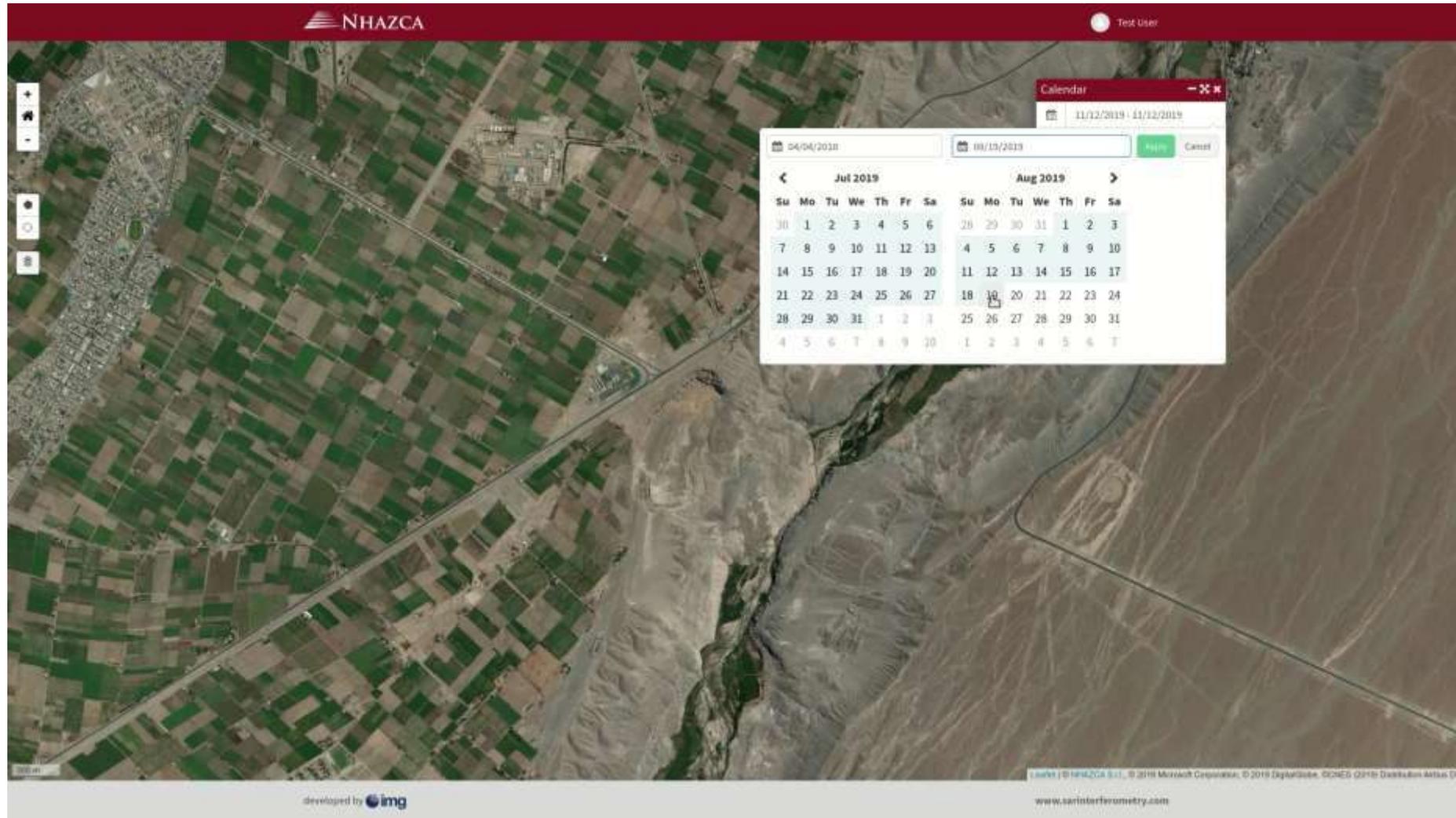
PhotoMonitoring – Digital Image Correlation



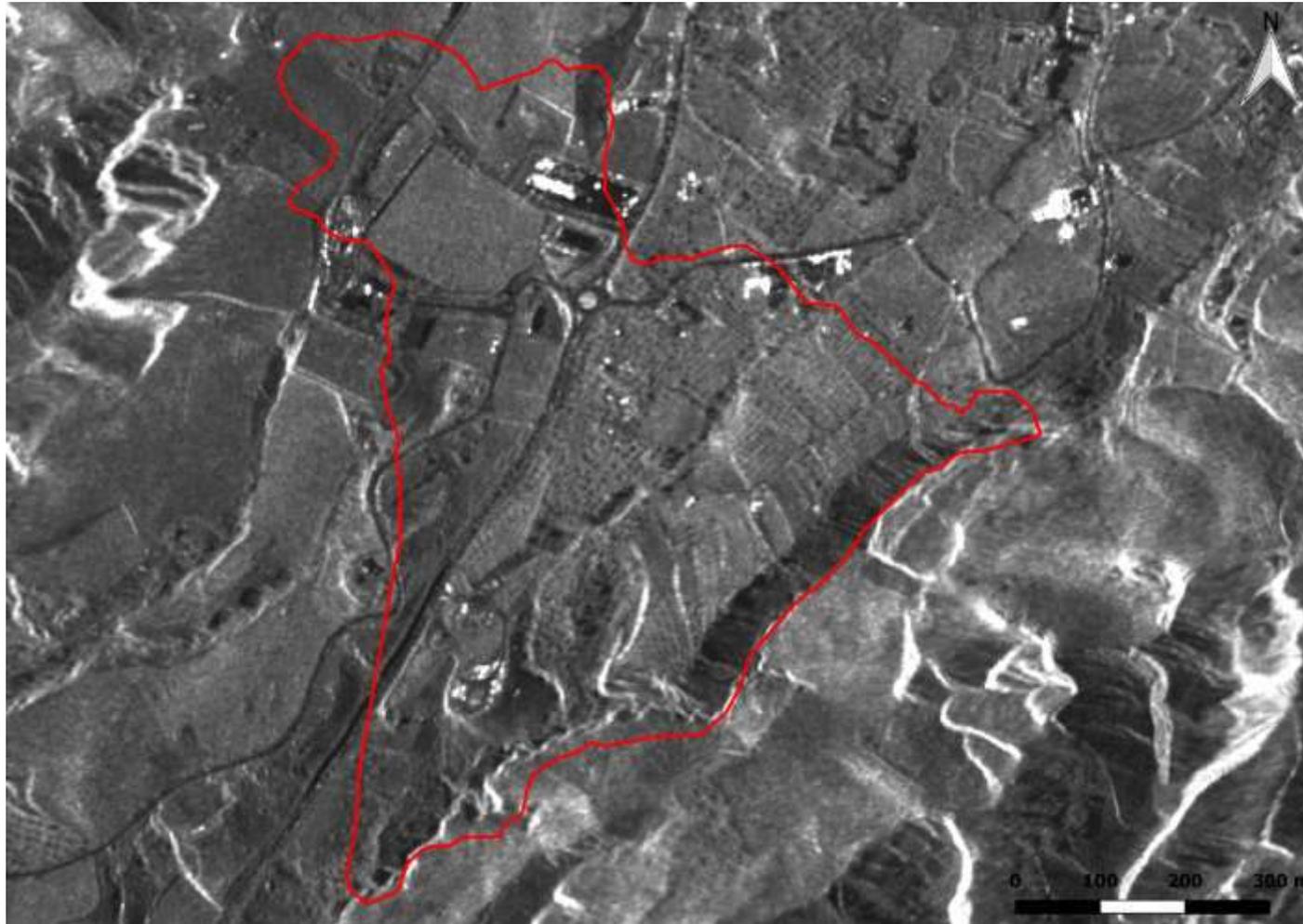
PhotoMonitoring – Digital Image Correlation



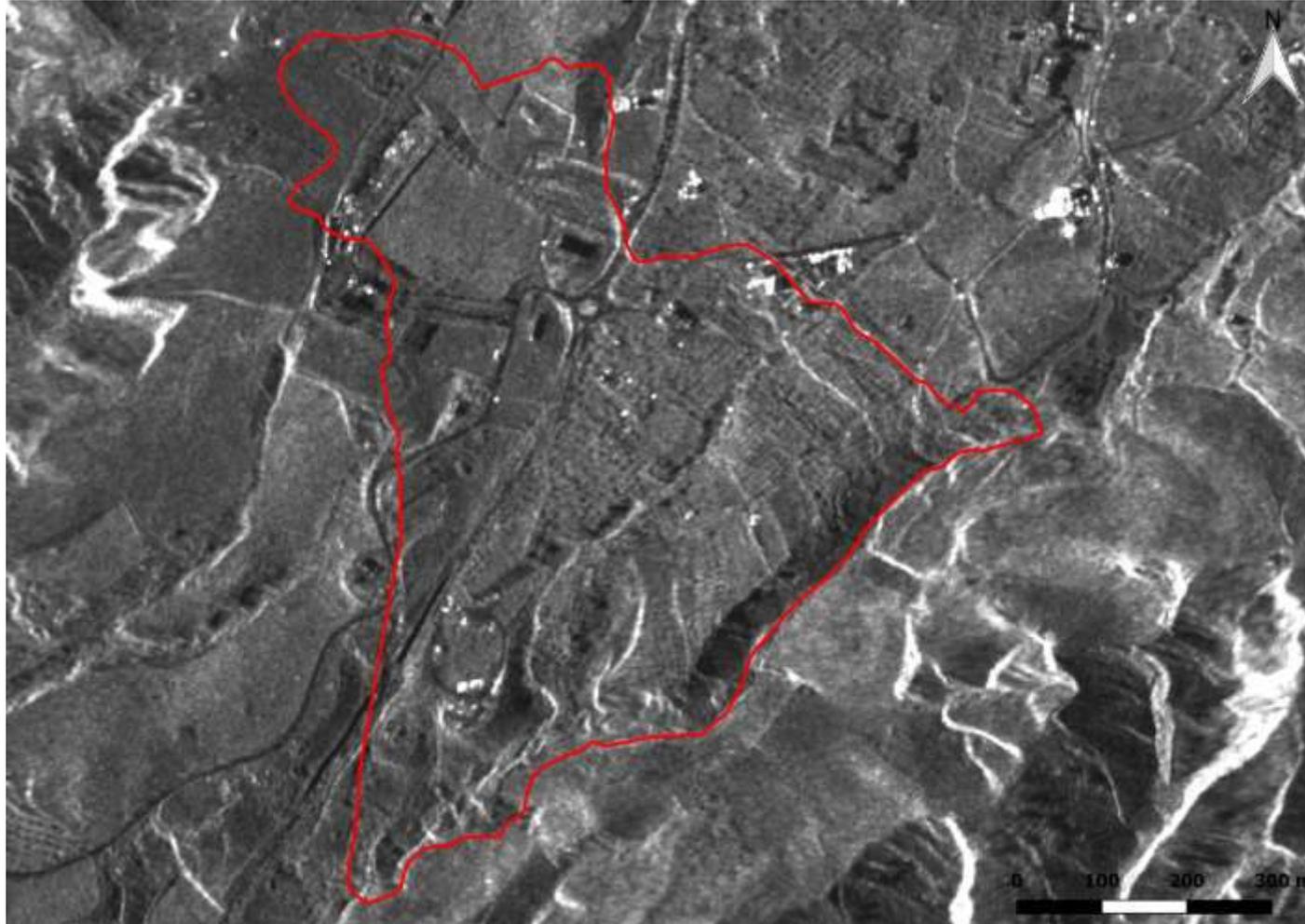
PhotoMonitoring – Digital Image Correlation



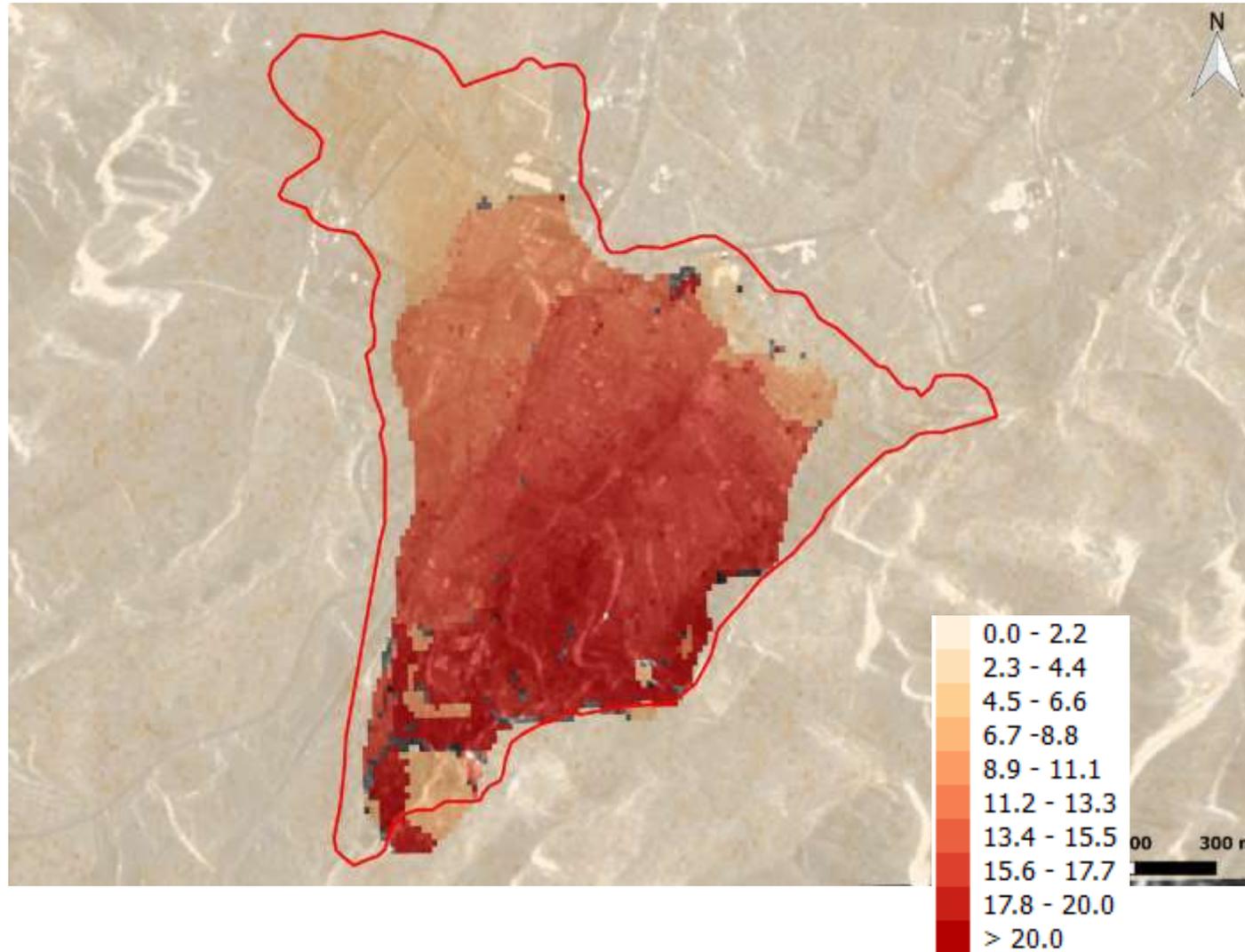
PhotoMonitoring – Digital Image Correlation



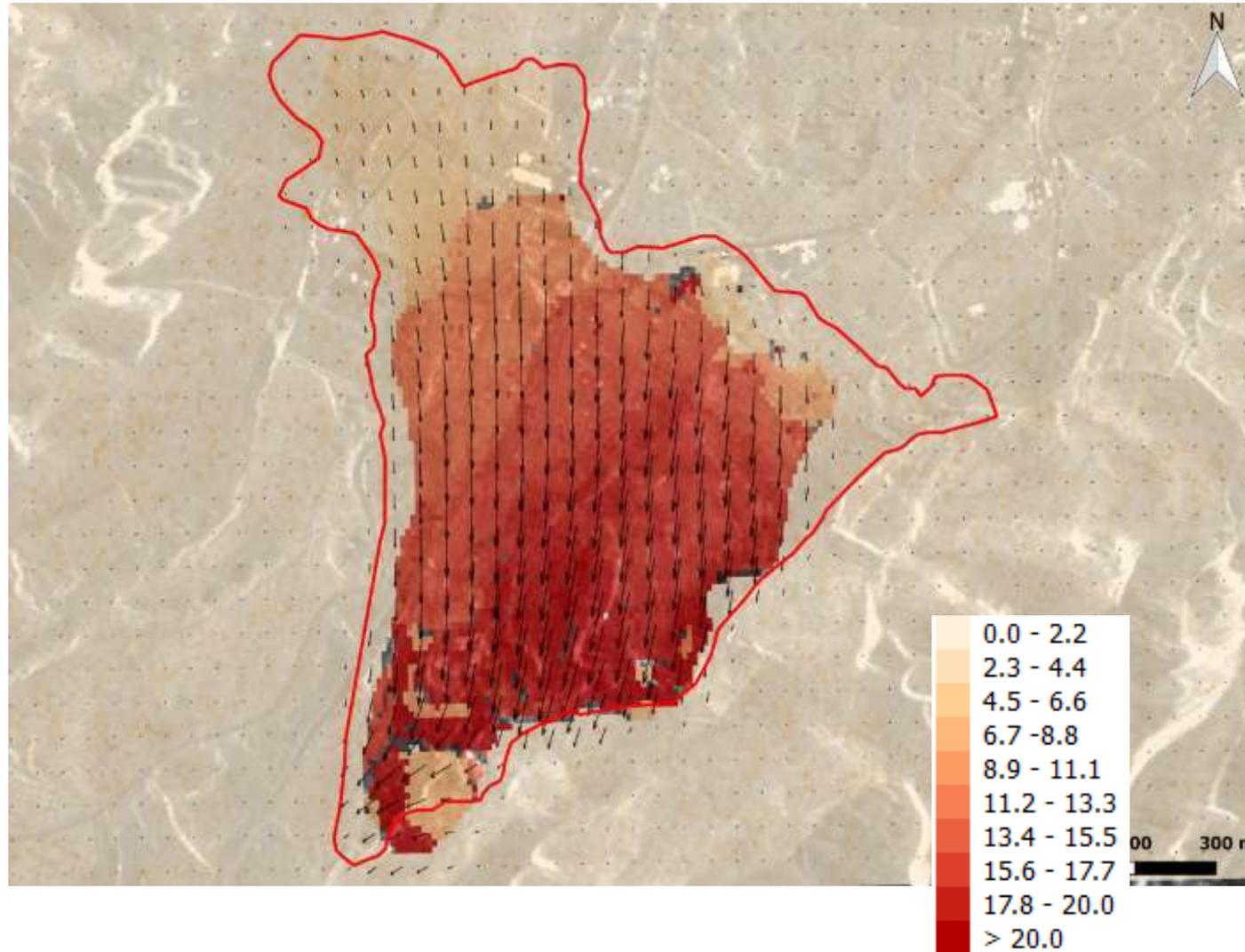
PhotoMonitoring – Digital Image Correlation



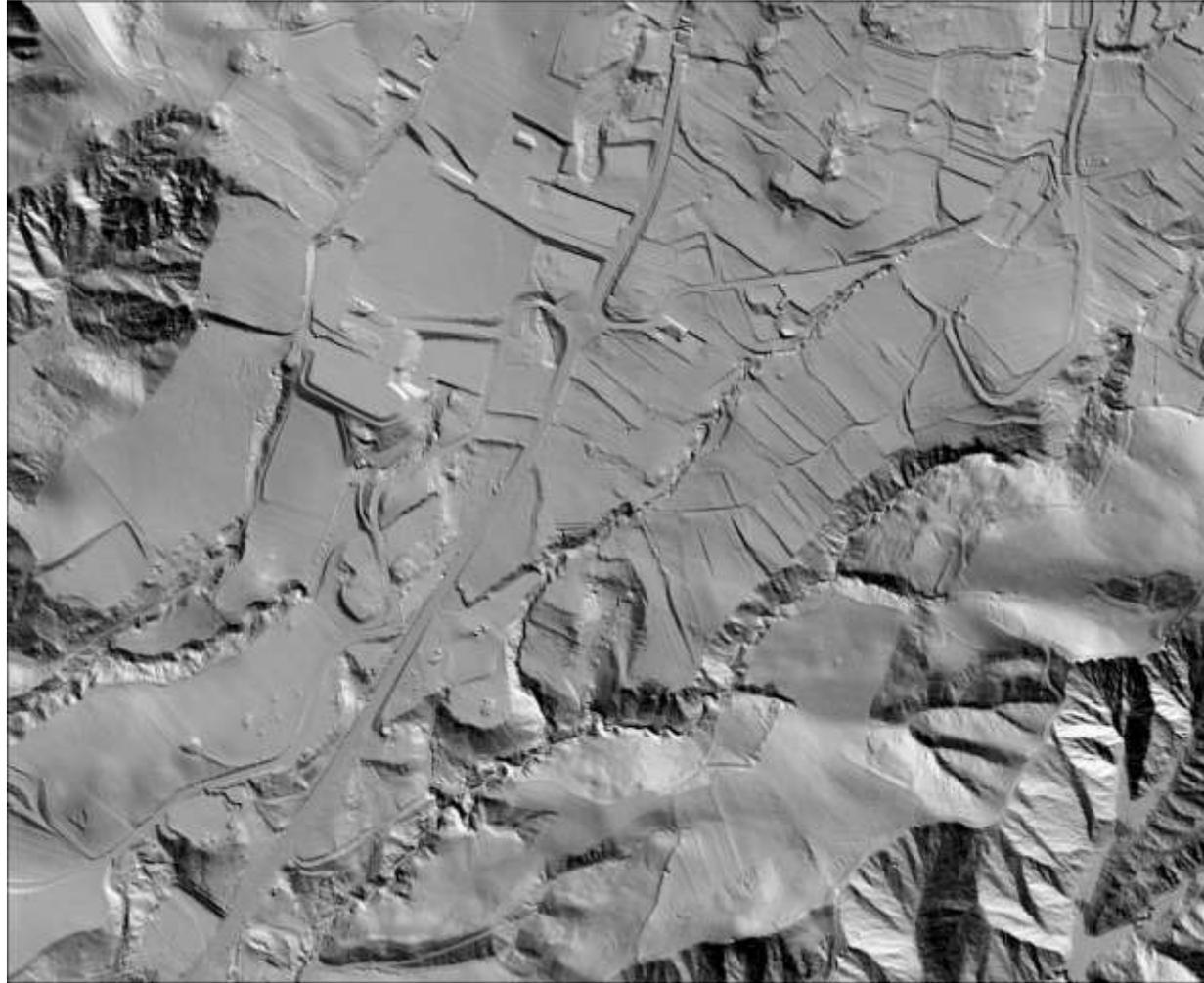
PhotoMonitoring – Digital Image Correlation



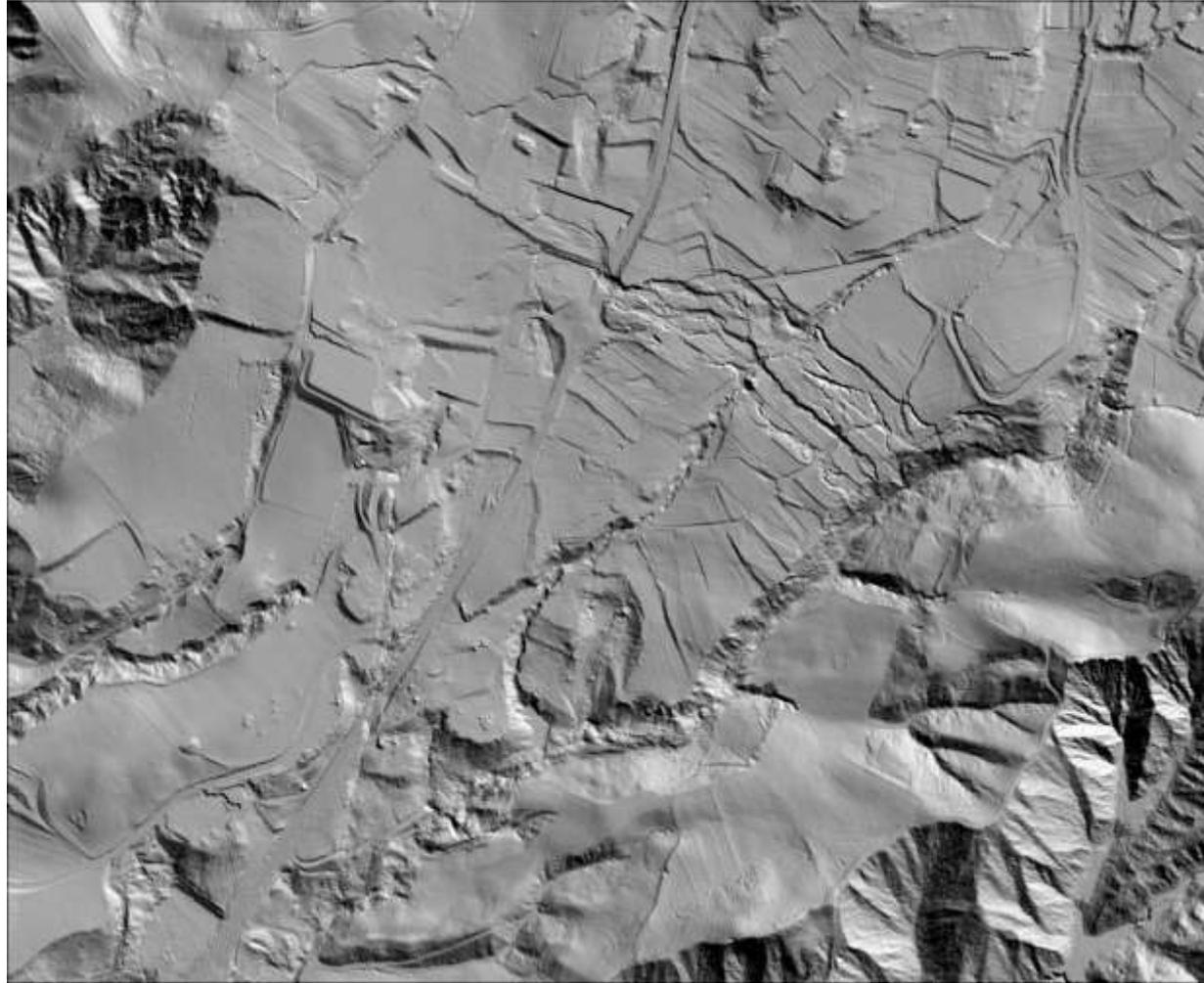
PhotoMonitoring – Digital Image Correlation



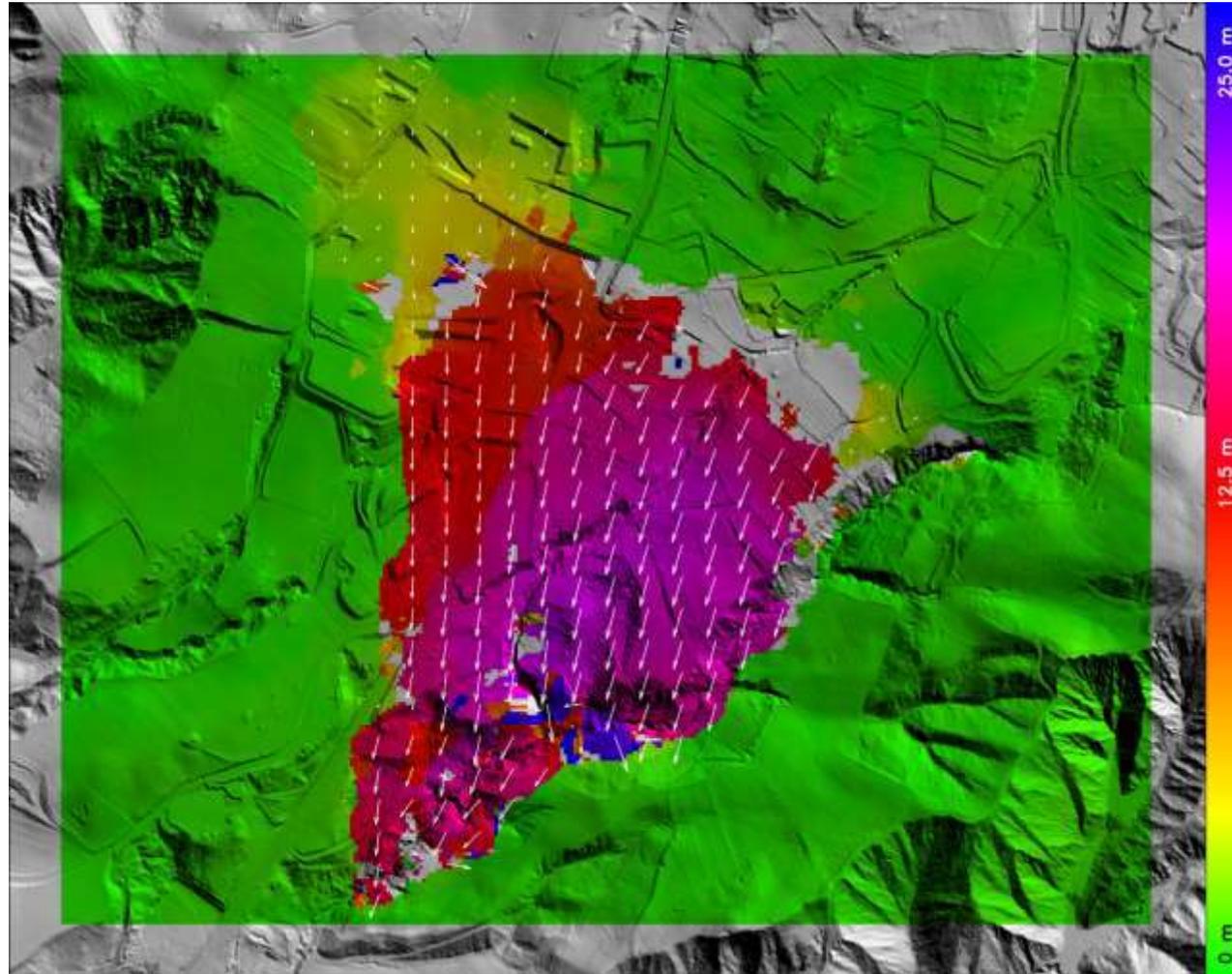
PhotoMonitoring – Digital Image Correlation



PhotoMonitoring – Digital Image Correlation



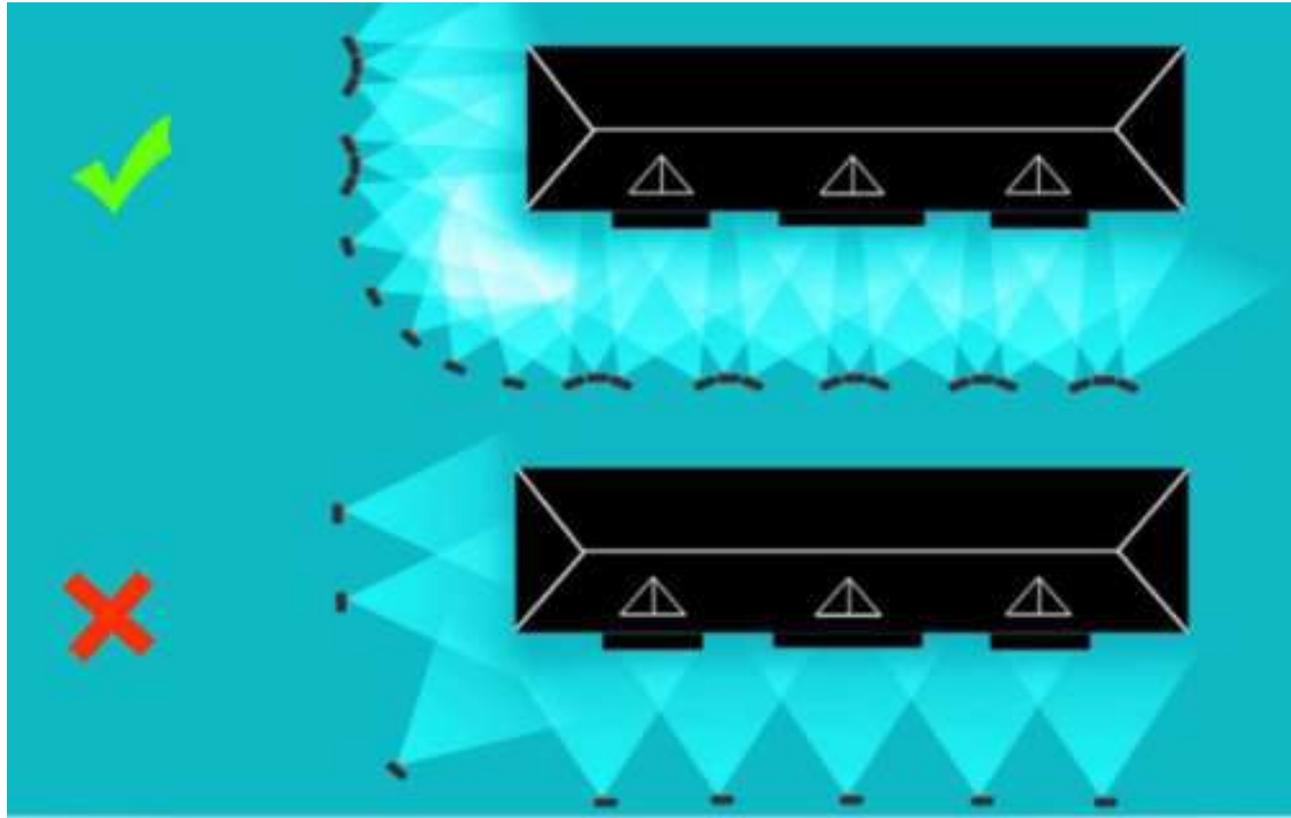
PhotoMonitoring – Digital Image Correlation



PhotoMonitoring – Structure from Motion

Per questo motivo, tale approccio è più adatto per set di immagini caratterizzati da un'elevata percentuale di **sovrapposizione** e acquisiti da quanti più diversi punti di osservazione possibile intorno all'oggetto.

Una volta costruito il dataset, vengono applicati gli algoritmi di SfM



PhotoMonitoring – Structure from Motion



PhotoMonitoring – Structure from Motion



PhotoMonitoring – Structure from Motion



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