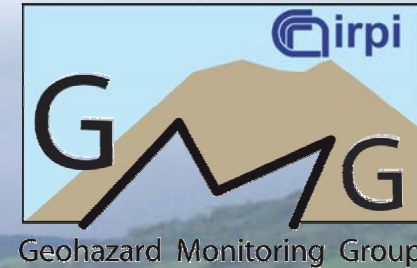




*Consiglio Nazionale delle Ricerche*

ISTITUTO DI RICERCA PER LA PROTEZIONE  
IDROGEOLOGICA

GEOHAZARD MONITORING GROUP - TORINO



# LIDAR AND ROBOTIZED TOTAL STATIONS DATA INTEGRATED FOR A 3-D REPRESENTATION: THE MONTAGUTO EARTHFLOW CASE-STUDY

**Giorgio Lollino**

**Andrea Manconi**

**Daniele Giordan**

**Marco Baldo**

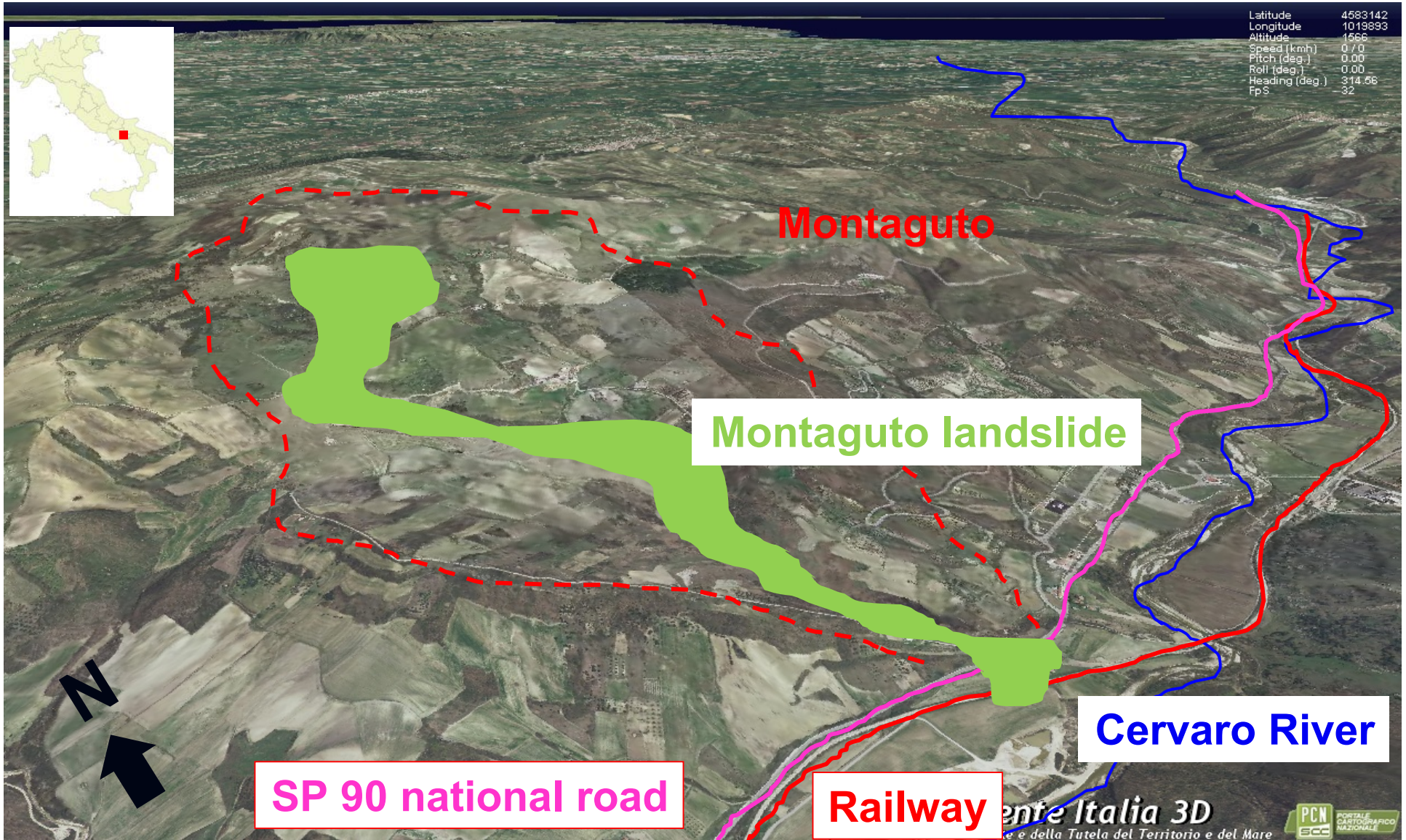
**Paolo Allasia**

**Franco Godone**





# LANDSLIDE OVERVIEW



**Earth flow landslide**

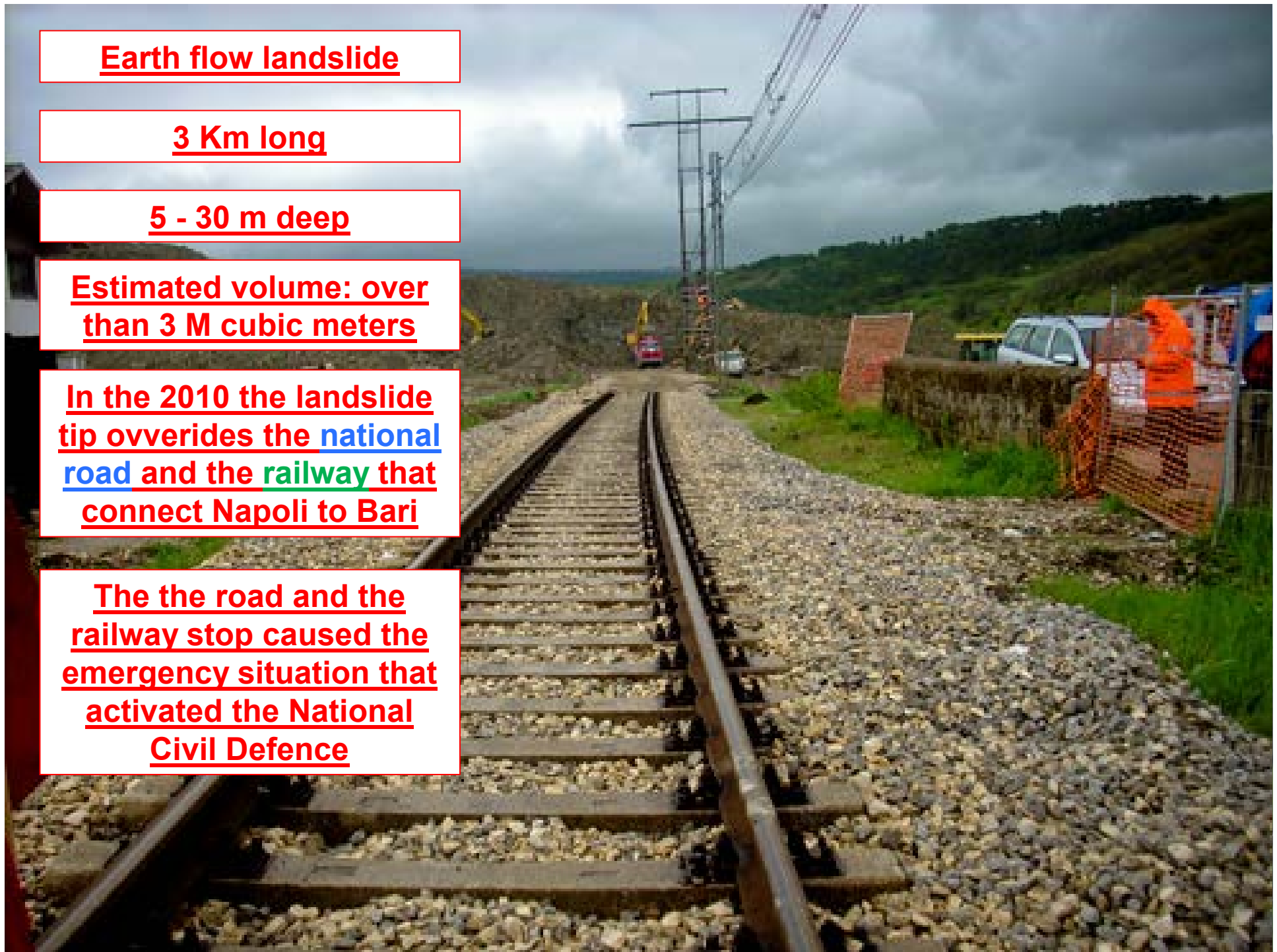
**3 Km long**

**5 - 30 m deep**

**Estimated volume: over  
than 3 M cubic meters**

**In the 2010 the landslide  
tip overrides the [national  
road](#) and the [railway](#) that  
connect Napoli to Bari**

**The the road and the  
railway stop caused the  
emergency situation that  
activated the National  
Civil Defence**





# THE MONTAGUTO EMERGENCY TEAM

**National Civil Defence**

**Italian Army**

**University of Florence -  
Earth Department**

**CNR IRPI**

**University of Sannio -  
Earth Department**



# THE MONTAGUTO EMERGENCY ACTIVITIES

**geological and geomorphological  
landslide analysis**

**study of recent (2004-2011)  
landslide evolution**

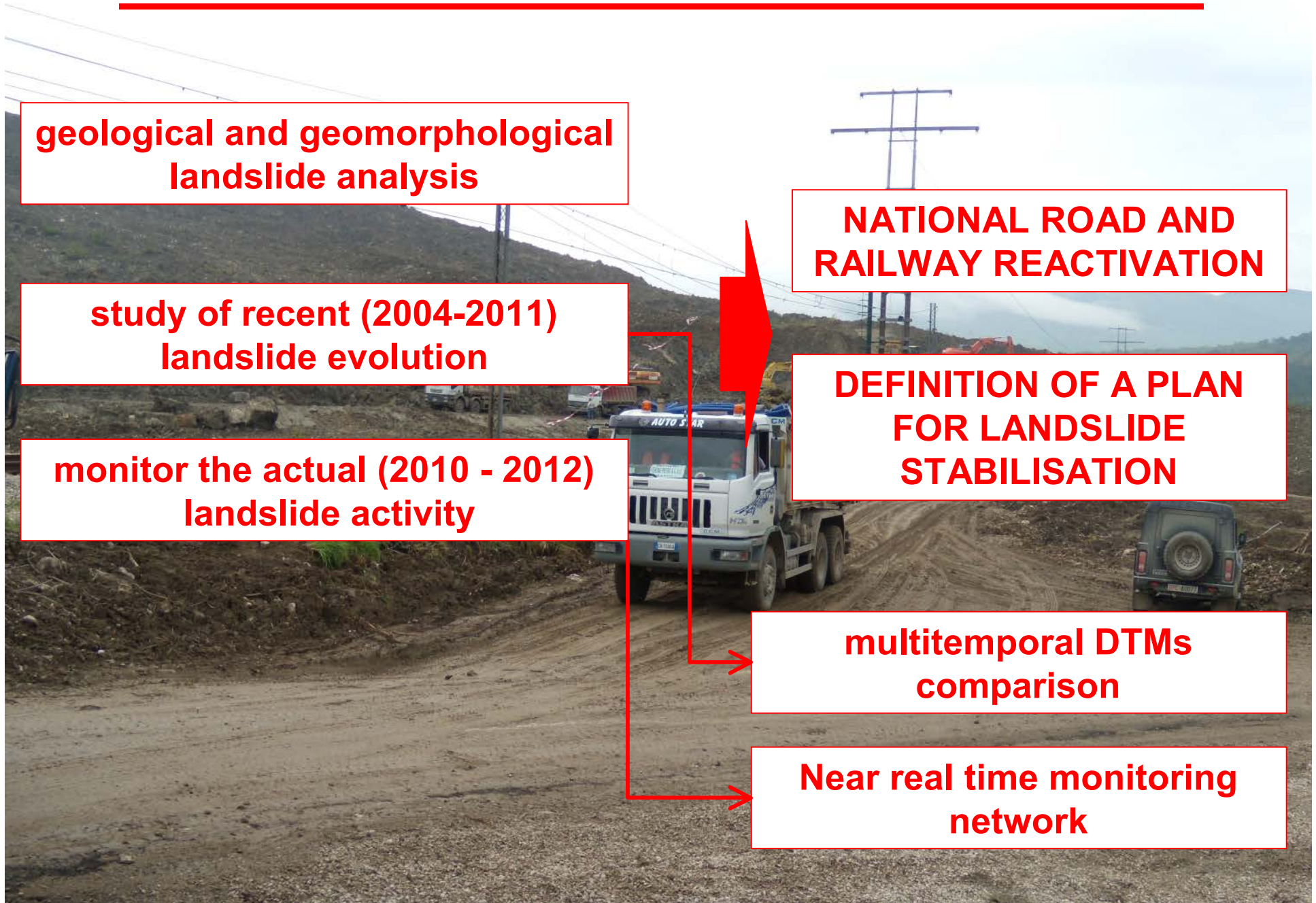
**monitor the actual (2010 - 2012)  
landslide activity**

**NATIONAL ROAD AND  
RAILWAY REACTIVATION**

**DEFINITION OF A PLAN  
FOR LANDSLIDE  
STABILISATION**

**multitemporal DTMs  
comparison**

**Near real time monitoring  
network**





# RECENT AND ACTUAL MONTAGUTO LANDSLIDE MORPHOLOGICAL CHANGES DETECTION

**multitemporal DTMs  
comparison**

- Low frequency
- Long time period
- Morphological and volumetric change detection

**Near real time  
monitoring network  
(RTS)**

- High frequency
- Short time period
- 3D near real time punctual displacement data (available on line)

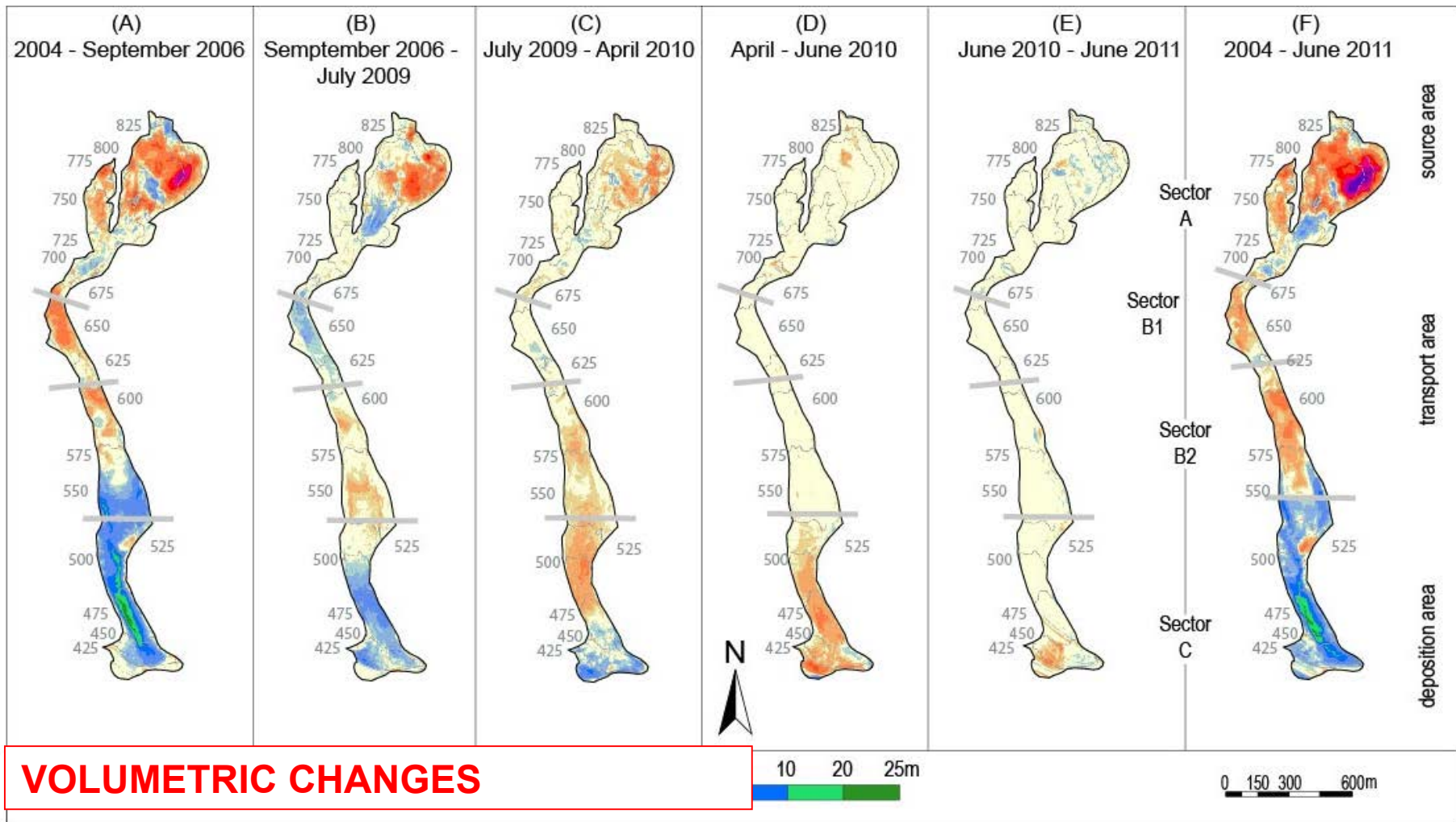


**2004 2005 2006 2007 2008 2009 2010 2011 2012**

# RECENT (2004-2011) LANDSLIDE EVOLUTION

FOR THE COMPREHENSION OF THE ACTUAL LANDSLIDE ASSET IT IS IMPORTANT TO DEFINE THE RECENT EVOLUTION

THE AVAILABILITY OF FIVE LIDAR SURVEYS HAS BEEN USEFUL FOR THE APPLICATION OF A TRIDIMENSIONAL MULTITEMPORAL ANALYSIS





# **RECENT (2004-2011) LANDSLIDE EVOLUTION**

## **AVAILABLE DTMs**

**2004 DTM (vector topography)**

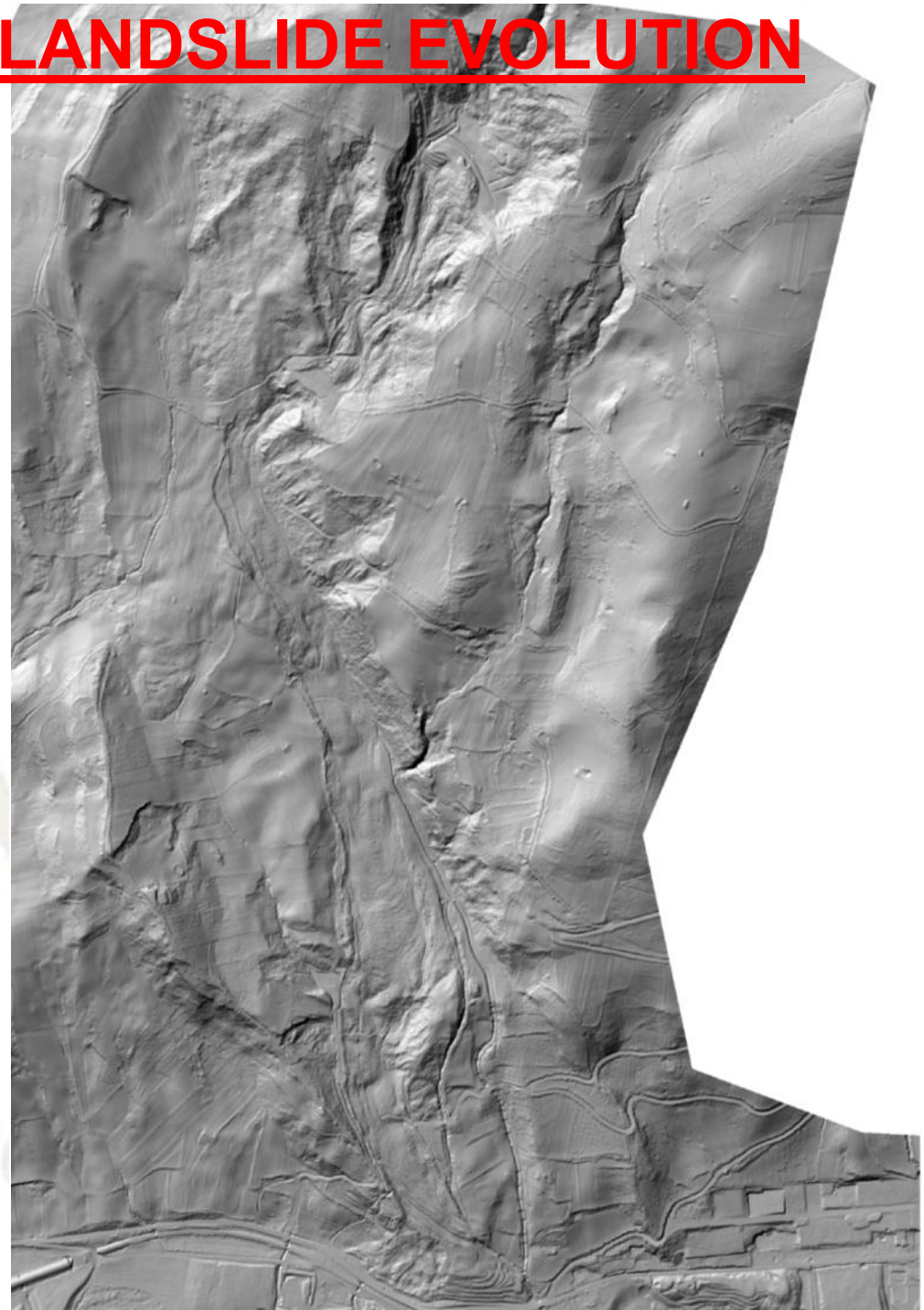
**2006 DTM (LIDAR)**

**2009 DTM (LIDAR)**

**2010 (april) DTM (LIDAR)**

**2010 (july) DTM (LIDAR)**

**2011 (may) DTM (LIDAR)**





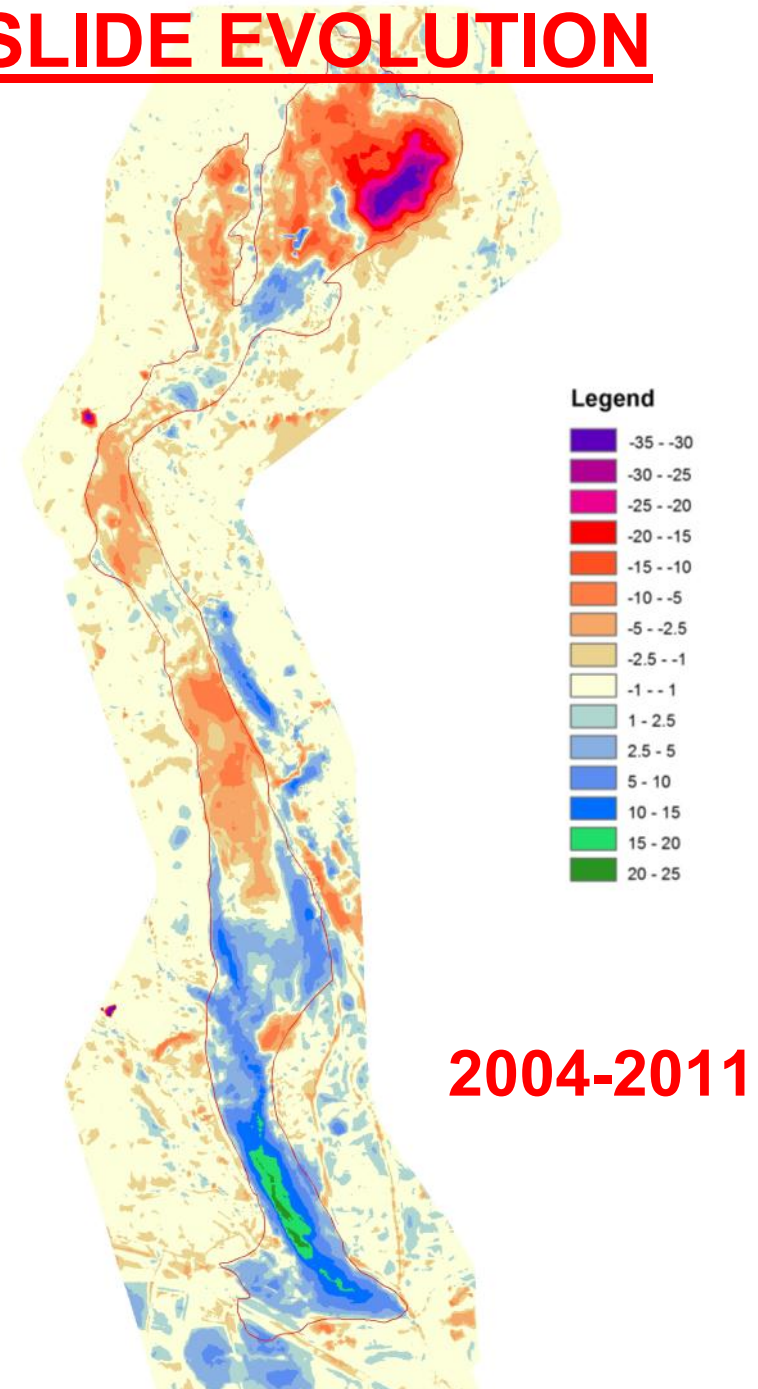
# RECENT (2004-2011) LANDSLIDE EVOLUTION

**DTM MULTITEMPORAL  
ANALYSIS CAN BE USED TO:**

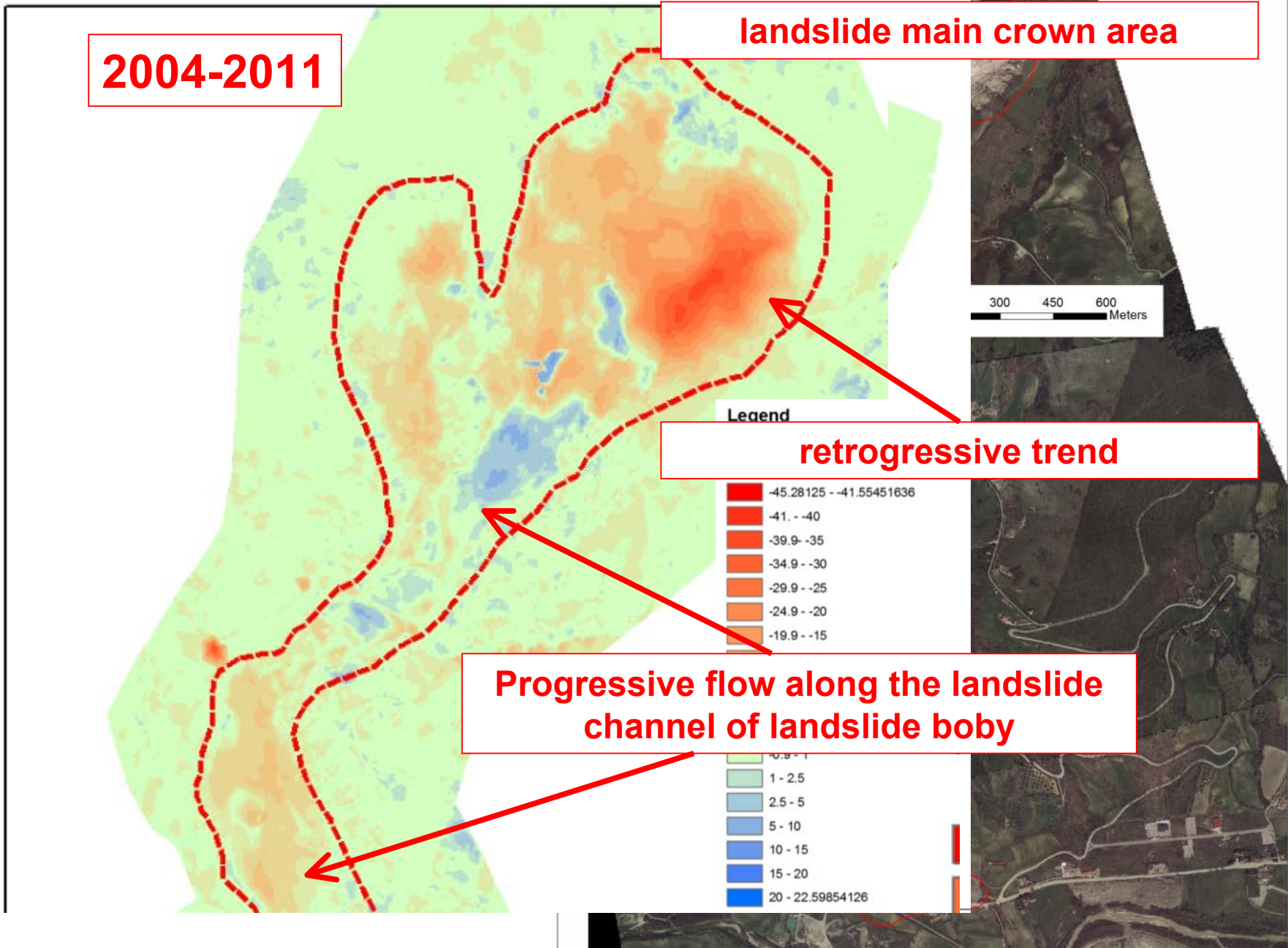
**DETECT THE LANDSLIDE BODY  
EVOLUTION**

**MEASURE THE ALTIMETRIC AND  
VOLUMETRIC VARIATION  
DURING THE TIME**

**DEFINE THE ACTUAL  
LANDSLIDE BODY THICKNESS**



# 2004-2011 LANDSLIDE EVOLUTION



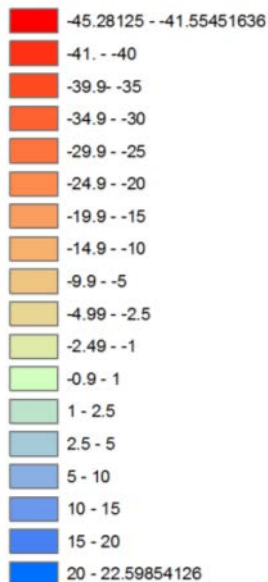


# 2004-2011 LANDSLIDE EVOLUTION

**2004-2011**

Legend

DTM\_04\_10B\_1m



**landslide toe**

**The DTM analysis evidenced the progressive landslide mass increasing and the creation of lobes connected to the transfer of the landslide body to the Cervaro river plain**

**The last DTM comparison define the actual landslide body thickness of the most active landslide part**

# MONITORING SYSTEMS FOR THE ACTUAL LANDSLIDE ACTIVITY

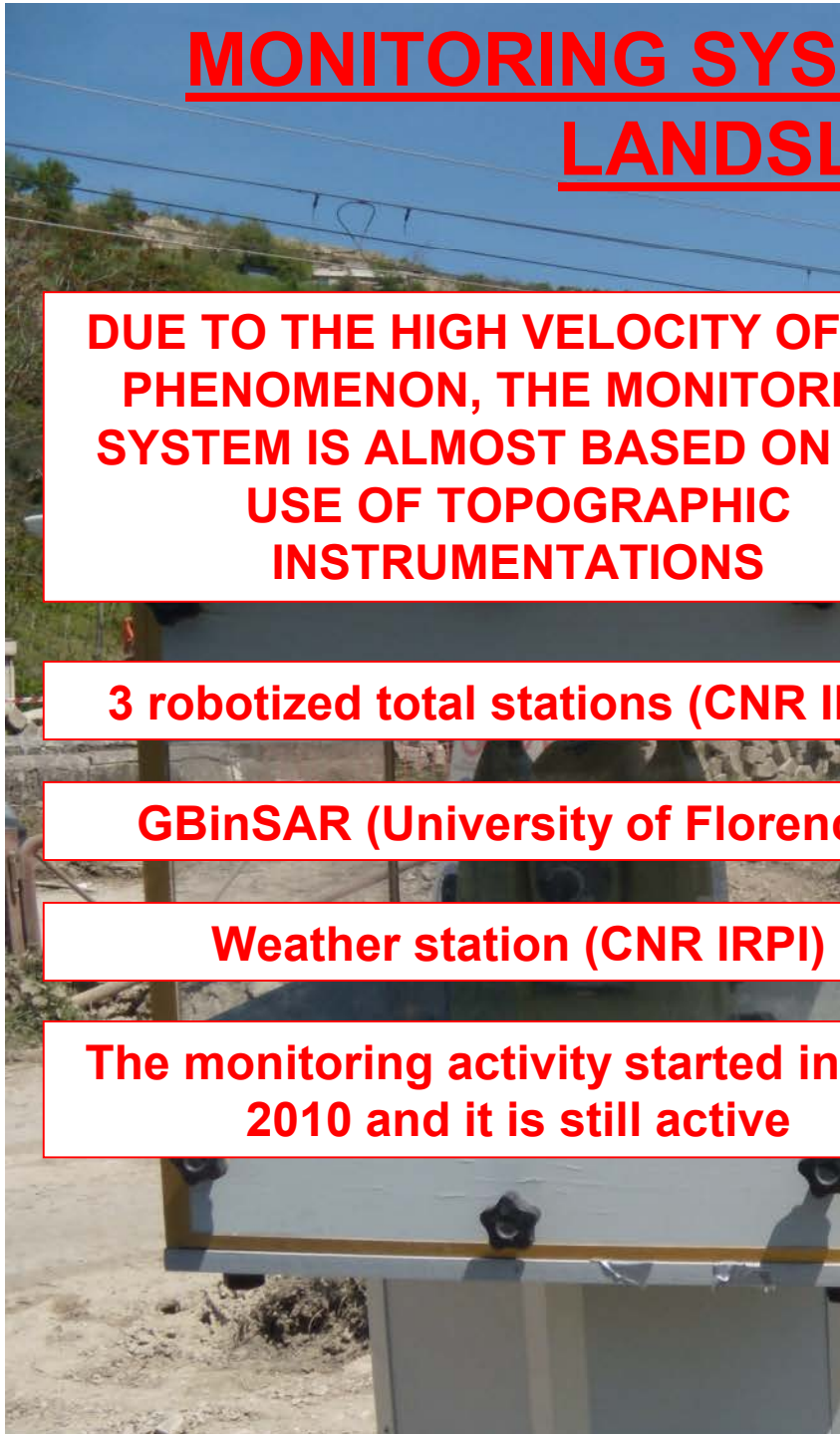
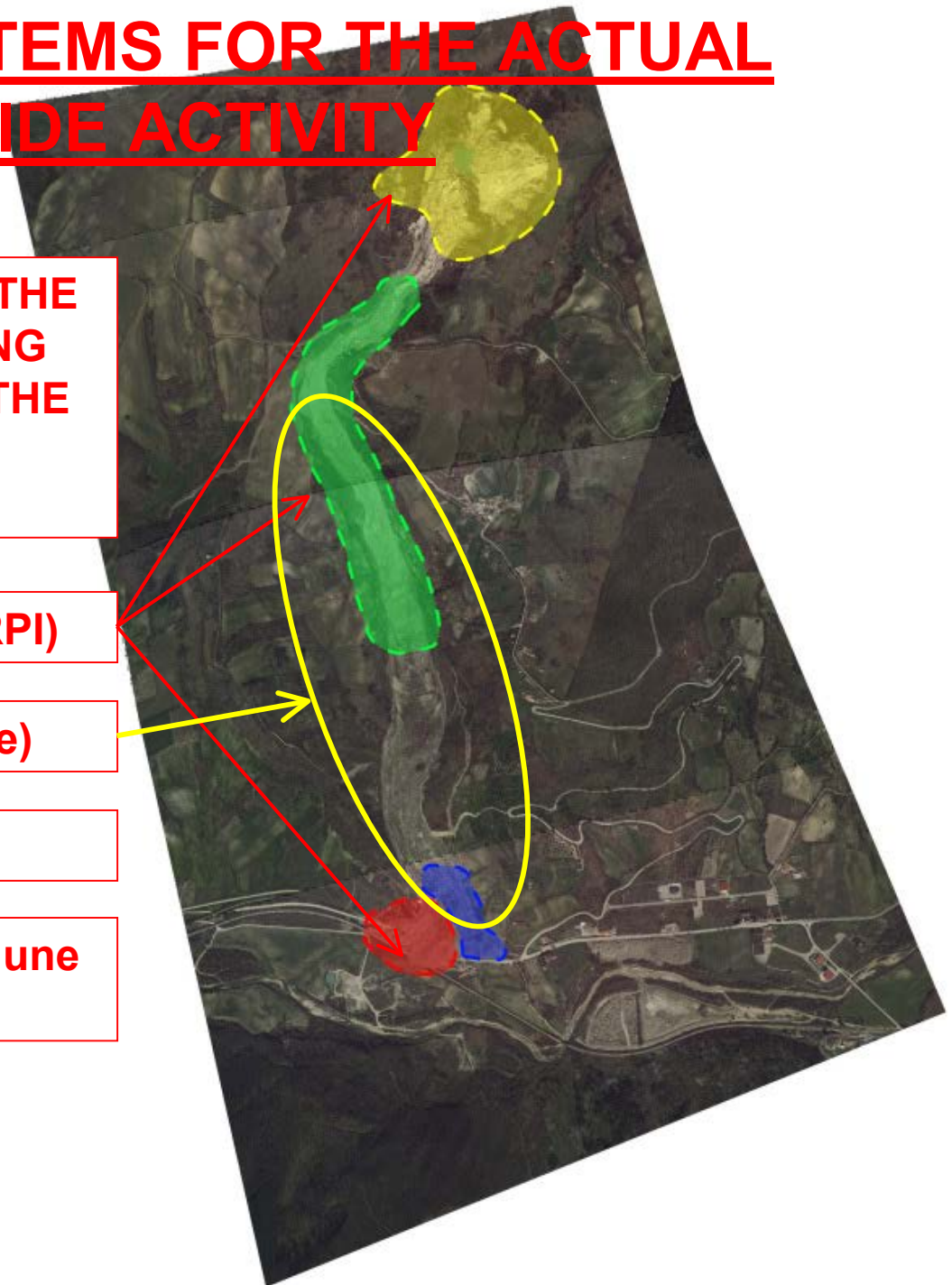
**DUE TO THE HIGH VELOCITY OF THE  
PHENOMENON, THE MONITORING  
SYSTEM IS ALMOST BASED ON THE  
USE OF TOPOGRAPHIC  
INSTRUMENTATIONS**

**3 robotized total stations (CNR IRPI)**

**GBinSAR (University of Florence)**

**Weather station (CNR IRPI)**

**The monitoring activity started in June  
2010 and it is still active**





# CNR IRPI MONITORING SYSTEMS

All the systems are automatized and work h 24

The robotized total stations made the measurement sessions

A GSM/UMTS connection transfer all the raw data to the Geo-monitoring Group CNR IRPI (Turin) server

A CNR IRPI software suite collects all the data and transforms the raw measures in graphics in few minutes

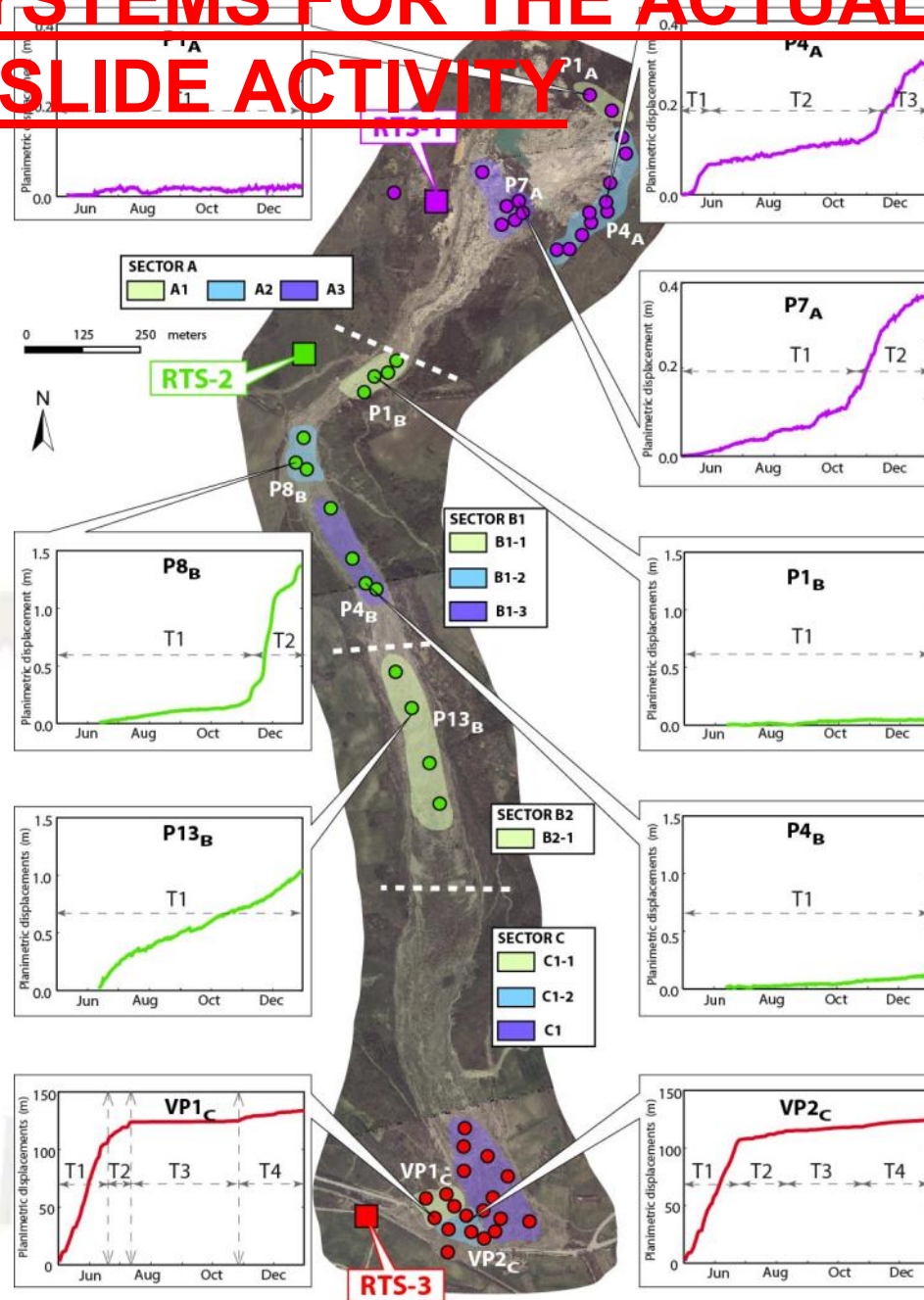
A daily report is sent to the National Civil Defence



# MONITORING SYSTEMS FOR THE ACTUAL LANDSLIDE ACTIVITY

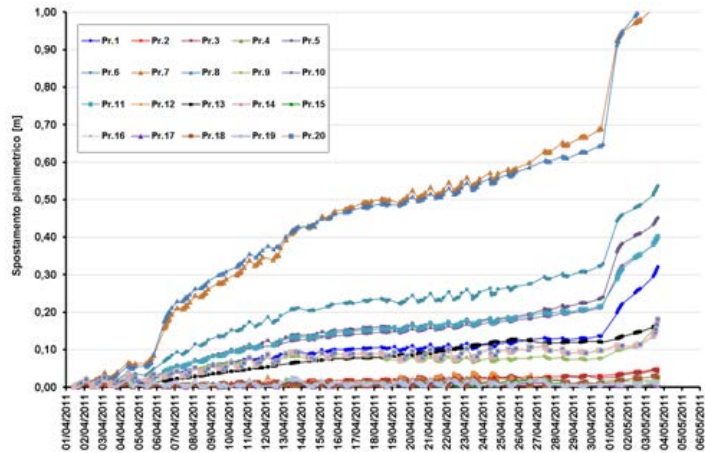
**THE MONTAGUTO LANDSLIDE HAS A COMPLEX EVOLUTION WITH DIFFERENT RATES AND MOVEMENT DIRECTIONS**

**IN 2010 TARGETS CUMULATE DISPLACEMENT RANGED FROM FEW CENTIMETERS IN THE CROW AREA TO 130 M IN THE TOE AREA WHERE SOME TARGET REGISTERED A MAXIMUM VELOCITY OF 5M/DAY**



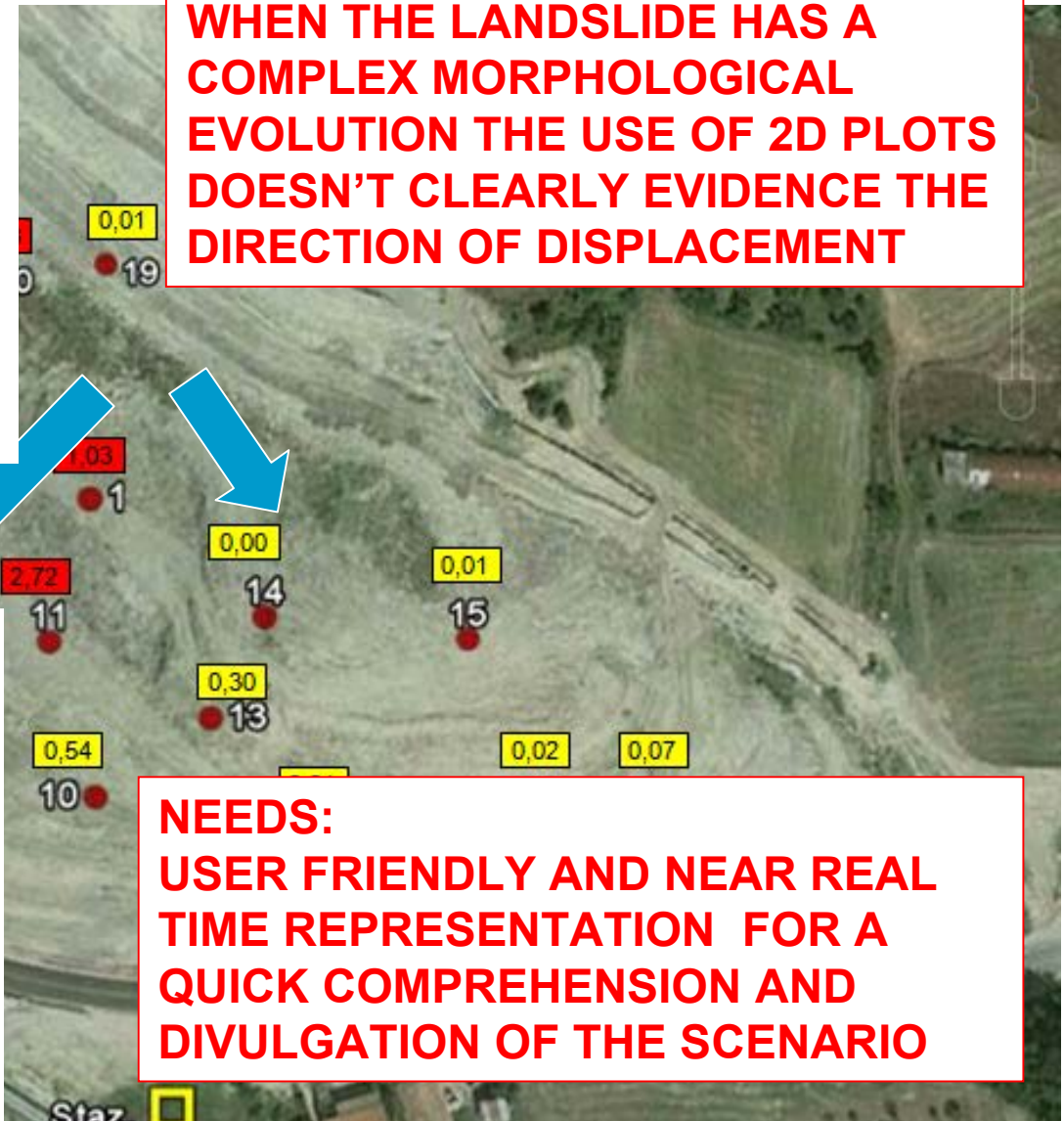
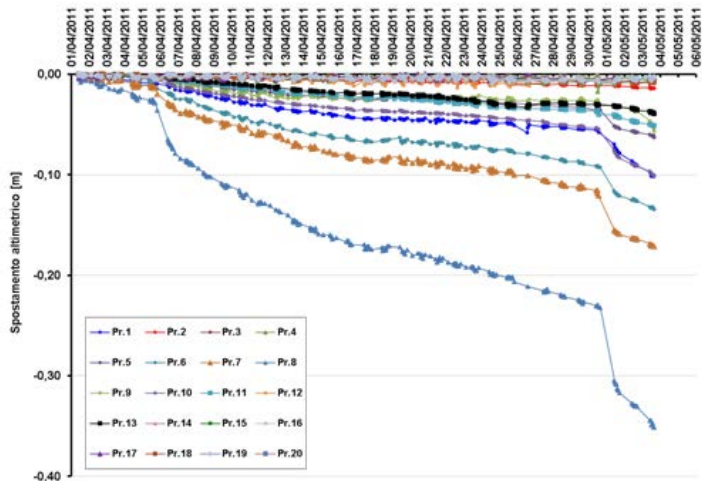


# ROBOTIZED TOTAL STATION APPLICATIONS FOR LANDSLIDES MONITORING – PROBLEMS AND NEEDS



**PROBLEM:**  
WHEN THE LANDSLIDE HAS A COMPLEX MORPHOLOGICAL EVOLUTION THE USE OF 2D PLOTS DOESN'T CLEARLY EVIDENCE THE DIRECTION OF DISPLACEMENT

??????



**NEEDS:**  
USER FRIENDLY AND NEAR REAL TIME REPRESENTATION FOR A QUICK COMPREHENSION AND DIVULGATION OF THE SCENARIO

# PROPOSED SOLUTION: © 3DA

## A NEW SOFTWARE FOR MONITORING DATA MANAGEMENT

RTS RAW DATA UPLOAD TO  
GEOMONITORING GROUP SERVER

CALCULATION OF ENTITY AND  
RATE OF DISPLACEMENT

LOCAL 3D MODEL

GEOREFERENCING TOOL

PHOTO TOOL

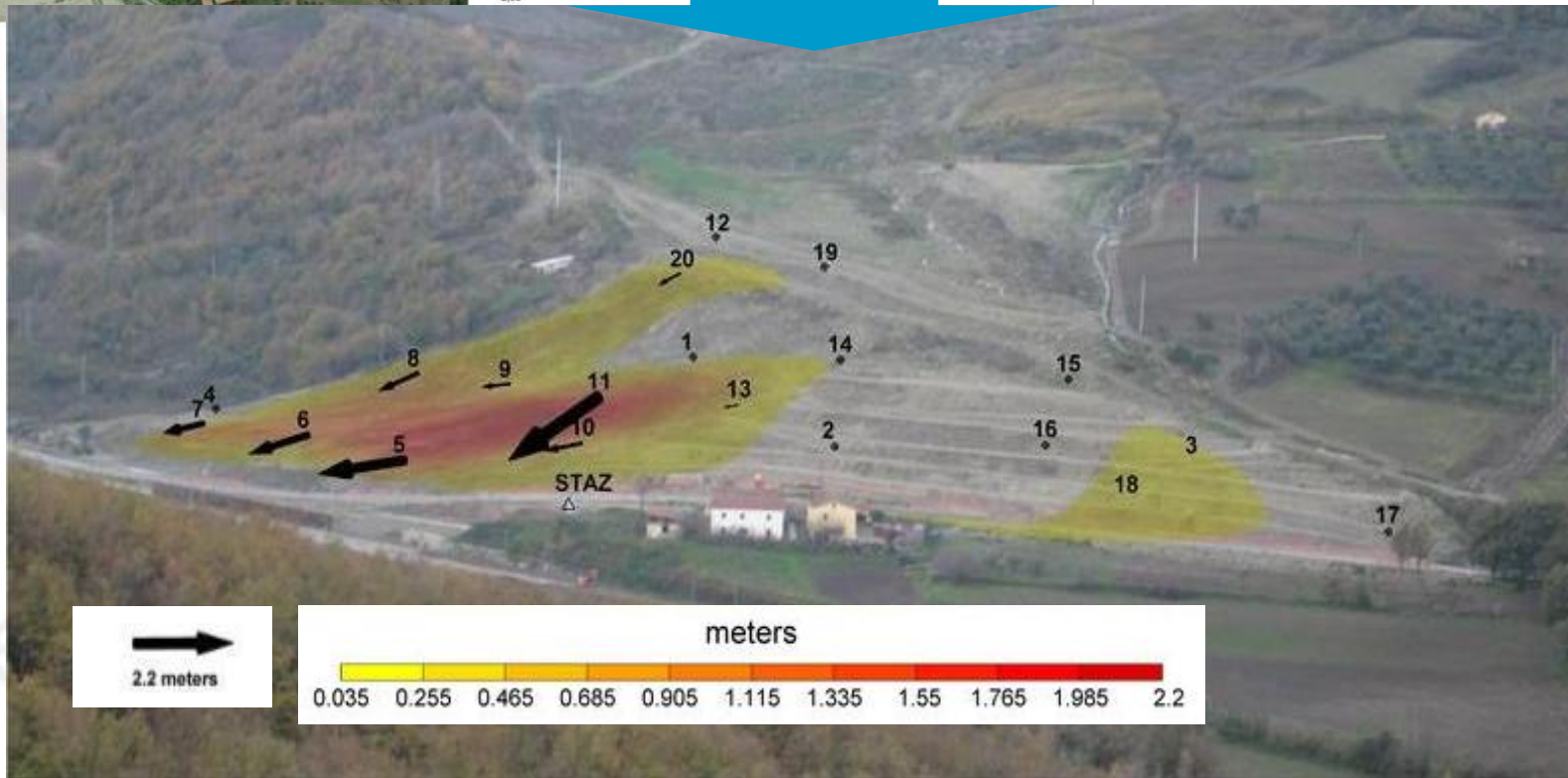
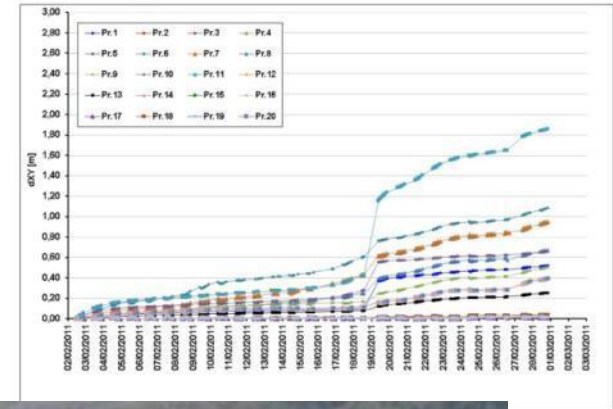
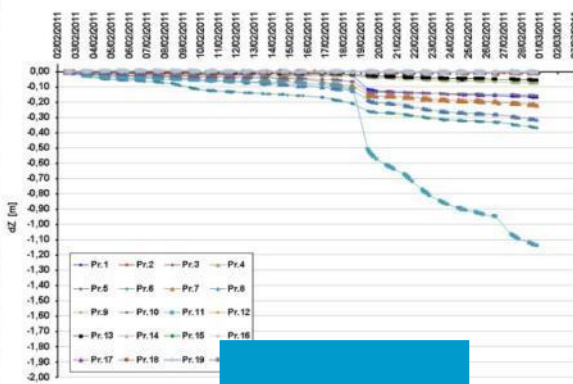
THE RESULT IS A 3D  
MODEL OF MONITORED  
AREA DISPLACEMENT  
OBTAINED FEW MINUTES  
AFTER THE RTS  
MEASURE SESSION



Geohazard



# © 3DA: A SOFTWARE FOR NEAR REAL TIME 3D REPRESENTATION



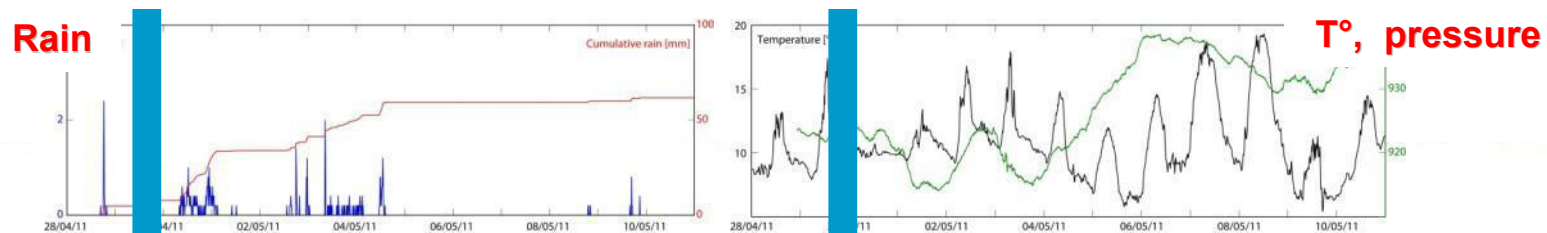
# Velocità media rilevata nelle ultime 24 ore (30/04/2011 15:36:32)



Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio



## 24 HOURS MEAN VELOCITY vs METEO PARAMETERS

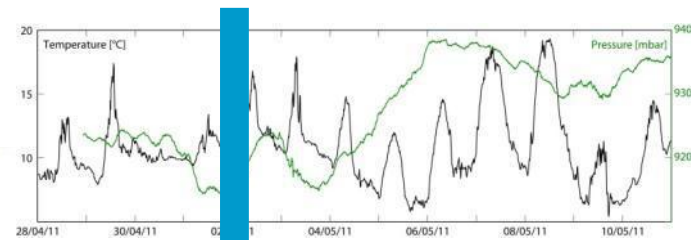
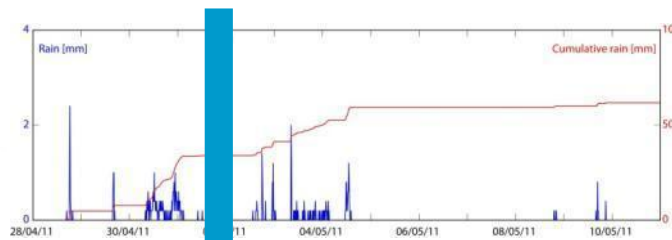
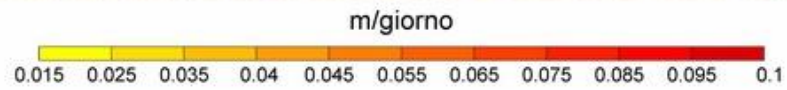




# Velocità media rilevata nelle ultime 24 ore (02/05/2011 10:37:05)



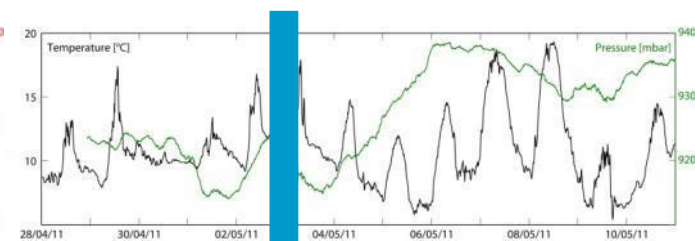
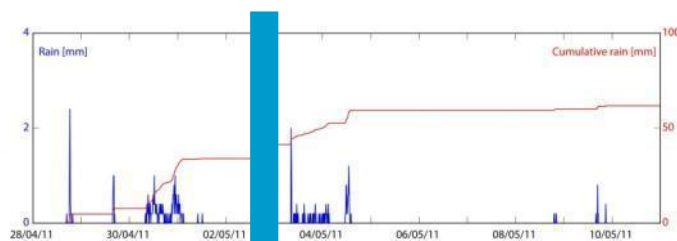
Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio



# Velocità media rilevata nelle ultime 24 ore (03/05/2011 10:37:21)



Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio

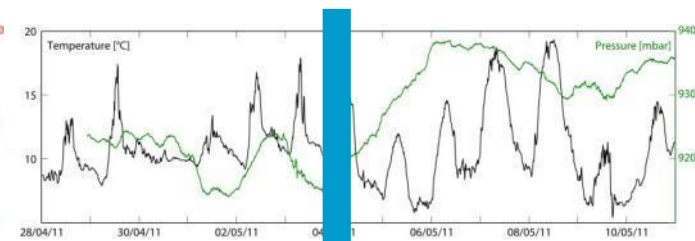
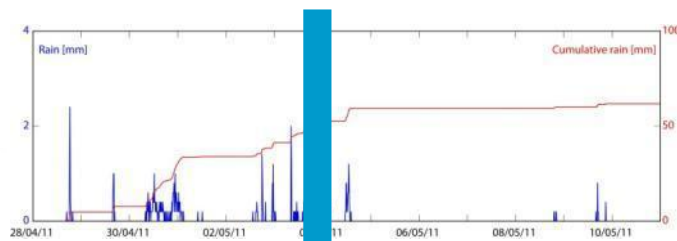




# Velocità media rilevata nelle ultime 24 ore (04/05/2011 17:34:06)



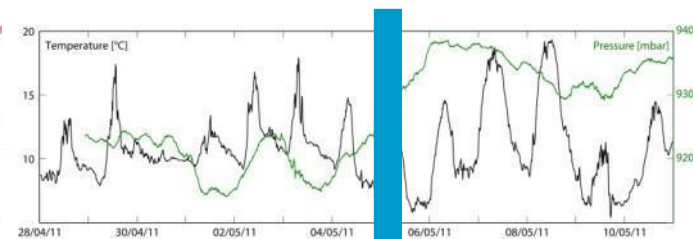
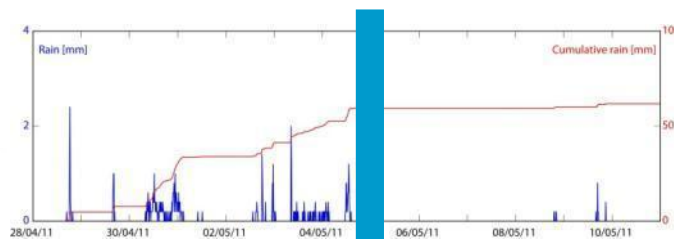
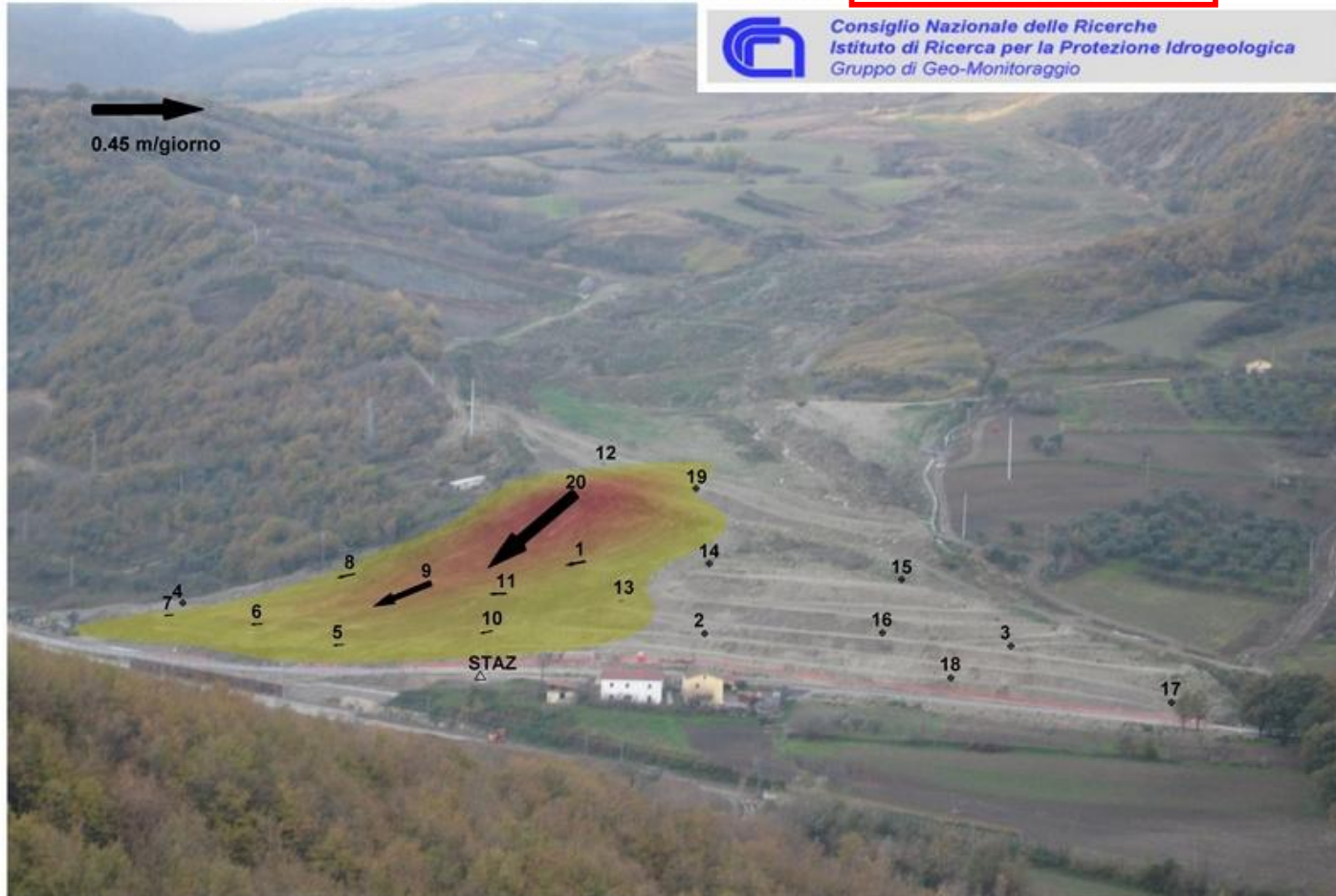
Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio



# Velocità media rilevata nelle ultime 24 ore (05/05/2011 08:37:44)



Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio

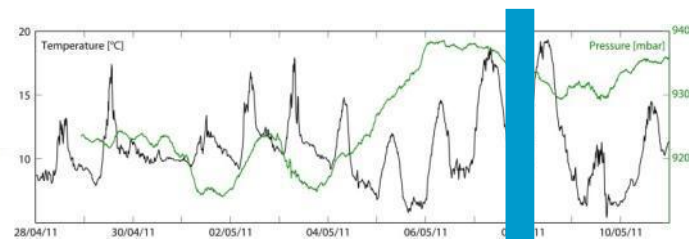
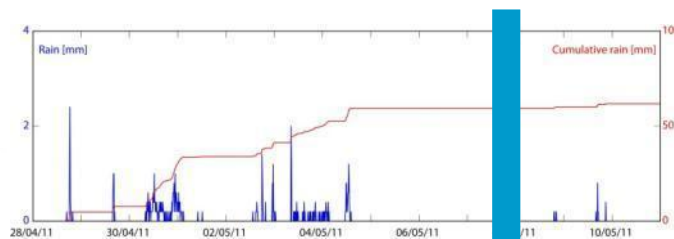
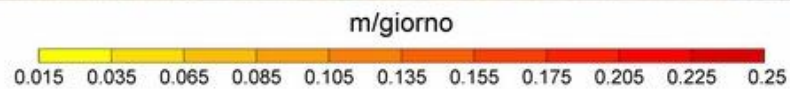




# Velocità media rilevata nelle ultime 24 ore (06/05/2011 09:36:33)



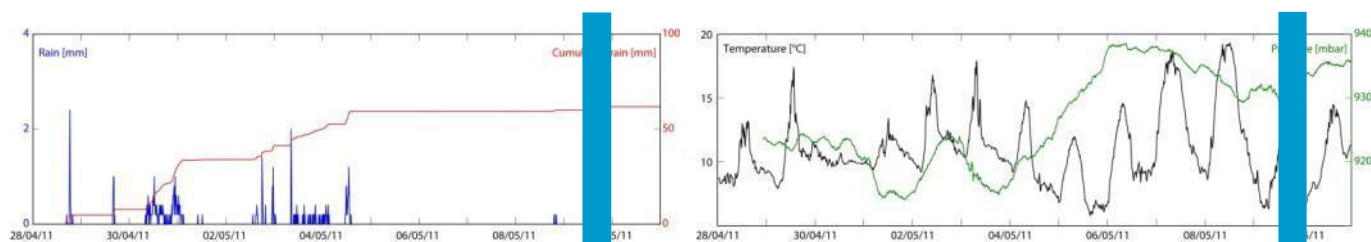
Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio



# Velocità media rilevata nelle ultime 24 ore (10/05/2011 10:07:05)



Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica  
Gruppo di Geo-Monitoraggio





# CONCLUSIONS

**THE MONTAGUTO LANDSLIDE IS AN EXAMPLE WHERE THE JOINT USE OF LIDAR AND RTSs ALLOWED US TO:**

**COLLECT THE INFORMATION THAT CAN BE USEFUL FOR THE LANDSLIDE ANALYSIS AND INTERPRETATION (recent evolution trough DTMs analysis)**

**CREATE A MONITORING SYSTEM FOR THE SAFETY OF THE LANDSLIDE MITIGATION WORKS AND FOR THE CONTROL OF ACTUAL LANDSLIDE EVOLUTION (3 RTSs)**

**TO DEVELOP A NEW SOFTWARE TO PERFORM AN AUTOMATIC SUPPORT FOR THE RTS DATA ANALYSIS AND RESULTS SHARING (© 3DA)**

**THE AVAILABILITY OF NEAR REAL TIME 3D REPRESENTATION OF MONITORING RESULTS CAN EFFICIENTLY SUPPORT THE DECISION MAKERS IN EMERGENCY PHASES**

**OUR FUTURE DEVELOPMENTS ARE AIMED AT INCREASING THE COMPREHENSION OF THE MONITORING DATA IN NEAR REAL TIME AND THEIR DIFFUSION TO AUTHORITIES AND DECISION MAKERS**

# LAST IMPROVEMENT: WEB SERVICE

# <http://gmg.irpi.cnr.it>

← → ↻ gmg.irpi.cnr.it/?q=node/34

Geoportale Nazion... Programmi per cript... Antincendio boschi... ELICOMPANY Helic... SUNIX > PAR5008A ... Accomodation — G... Hotel 4VialeMasini -... MASSA

 Consiglio Nazionale delle Ricerche  
Istituto di Ricerca per la Protezione Idrogeologica

 Geohazard Monitoring Group

Home Chi siamo Dove operiamo Emergenze Personale Strumentazione Brevetti Pubblicazioni Live Data Dove siamo

Nome utente \*

Password \*

- [Richiedi nuova password](#)

Accedi

## Live Data

### Accesso riservato

- [Monitoraggio "Costa Concordia" \(\*Costa Concordia monitoring data\*\)](#)
- [Monitoraggio Frana di Montaguto \(AV\)](#)
- [Monitoraggio Frana di Gardiola \(TO\)](#)

### Accesso pubblico

- [Stazione Metereologica Frana di Montaguto \(AV\)](#)
- [Stazione Metereologica CNR-IRPI, sede Torino](#)

Il GMG è inoltre dotato di stazione permanente GNSS appartenente alla rete nazionale NetGEO. Vai alla pagina della stazione permanente GNSS



# © 3DA WEB SERVICE - MONTAGUTO

Accedi

## Accesso pubblico

- Stazione Metereologica Frana di Montaguto (AV)
- Stazione Metereologica CNR-IRPI, sede Torino

Il GMG è inoltre dotato di stazione permanente GNSS appartenente alla rete nazionale NetGEO. Vai

" [NetGEO](#) " [NetGEO](#) " [NetGEO](#) "



© 3DA Threedimensional Displacement Analysis

### Frana di Montaguto (AV)

E: 518532 m\*

N: 4565133 m\*

Z: 468 m (s.l.m.)

\*Sistema di riferimento UTM-WGS84  
Le coordinate sono relative alla posizione della stazione di misura

Foto del 07/05/2012

#### AGGIORNAMENTO

Misura del: 11/06/2012 ore 11:32

Periodo di riferimento: ultimi 33gg 23h

Target misurati 22 / 22

Target in movimento\*\* 4 / 22

\*\*Per movimento si considera come soglia il valore di 0.03 metri

#### SIMBOLOGIA

⊕ Target misurato

× Target non misurato

↗ Target in movimento

△ RTS: Stazione totale

Vettori spostamento

0.1 metri



Mappa della risultante degli spostamenti

metri



**1 RTS UPDATED  
EVERY 2 HOURS**

# © 3DA WEB SERVICE - MONTAGUTO

Accedi

## Accesso pubblico

- Stazione Metereologica Frana di Montaguto (AV)
- Stazione Metereologica CNR-IRPI, sede Torino

Il GMG è inoltre dotato di stazione permanente GNSS appartenente alla rete nazionale NetGEO. Vai



Vettori spostamento

0.95 metri



**2 RTS UPDATED EVERY 1 HOUR**



© 3DA Three-dimensional Displacement Analysis

### Costa Concordia

E: 858422 m\*

N: 4691432 m\*

Z: 0 m (s.l.m.)

\*Sistema di riferimento UTM-WGS84  
Le coordinate sono relative alla posizione della stazione di misura

Foto di base del 10/02/2012

### AGGIORNAMENTO

Misura del: 13/06/2012 ore 08:07

Periodo di riferimento: ultimi 125gg 20h

Target misurati 10 / 10

Target in movimento\*\* 10 / 10

\*\*Per movimento si considera come soglia il valore di 0.01 metri

### SIMBOLOGIA

⊕ Target misurato

× Target non misurato

↗ Target in movimento

Rappresentazione tridimensionale delle misure RTS relative al periodo di riferimento indicato, proiettate rispetto al punto di presa della foto.



# © 3DA THRESHOLDS - GARDIOLA

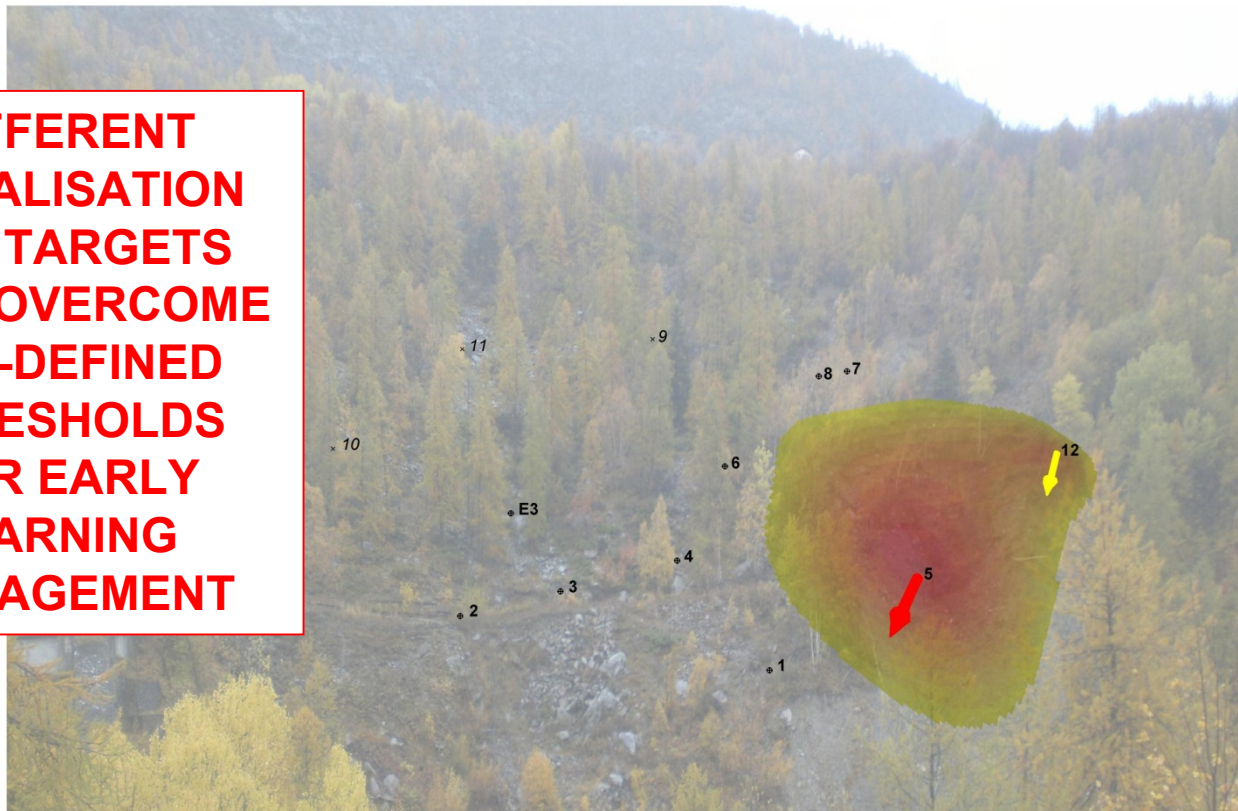
Accedi

## Accesso pubblico

- Stazione Metereologica Frana di Montaguto (AV)
- Stazione Metereologica CNR-IRPI, sede Torino

Il GMG è inoltre dotato di stazione permanente GNSS appartenente alla rete nazionale NetGEO. Vai

**DIFFERENT  
VISUALISATION  
FOR TARGETS  
THAT OVERCOME  
PRE-DEFINED  
THRESHOLDS  
FOR EARLY  
WARNING  
MANAGEMENT**



Scala dei vettori spostamento

2.5 metri



Mappa delle deformazioni (DXYZ)

metri



Geohazard Monitoring Group

### Frana di Gardiola (TO)

E: 347740 m\*

N: 4976526 m\*

Z: 1207 m (s.l.m.)

\*Sistema di riferimento UTM-WGS84  
Le coordinate sono relative alla posizione  
della stazione di misura

Foto di base del 02/11/2011

### AGGIORNAMENTO

Misura del: 17/04/2009 ore 14:00

Periodo di riferimento: ultimi 30gg 0h

Target misurati 10 / 13

Target in movimento\*\* 2 / 13

\*\*Per movimento si considera come soglia  
il valore di 0.5 metri

### SIMBOLOGIA

⊕ Target misurato

× Target non misurato

↗ Target in movimento < 1 metri

↘ Warning, movimento > 1 metri

↙ Alarm, movimento > 2 metri

Note: I prismi 9, 10 e 11 non sono  
collimabili con continuità dal 30 marzo  
2009.



**Consiglio Nazionale delle Ricerche**

**ISTITUTO DI RICERCA PER LA PROTEZIONE  
IDROGEOLOGICA**

**GEOHAZARD MONITORING GROUP - TORINO**

**THANK YOU FOR THE  
ATTENTION**

Giorgio Lollino  
Paolo Allasia  
Andrea Manconi  
Marco Baldo  
Daniele Giordan  
Franco Godone