Interferometric analysis of geohazards with synthetic aperture radars : Landslides

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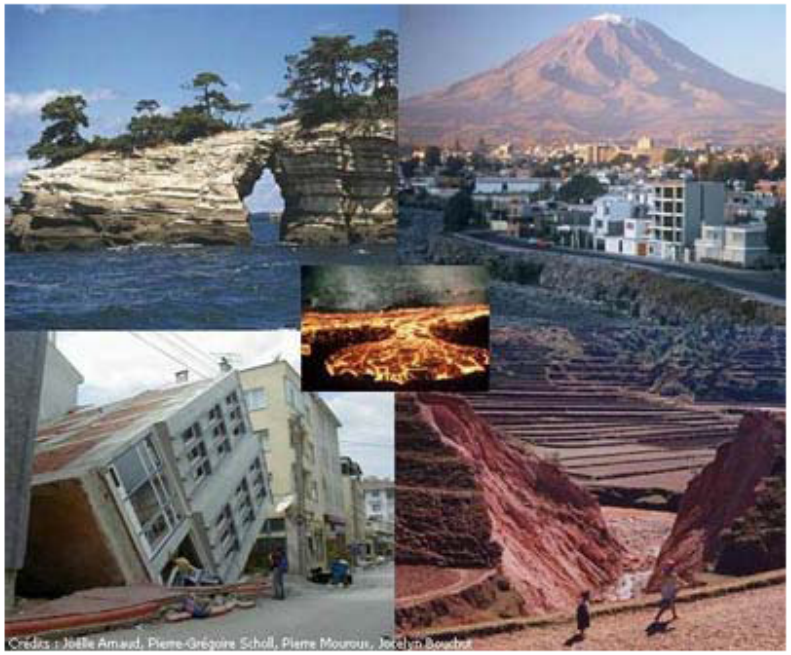
IGOS Geohazards
Theme Reports 2004 and 2007



The IGOS Geohazards Initiative

intends to respond to the scientific and operational geospatial information needs for the prediction and monitoring of geological hazards, namely earthquakes, tsunamis, volcanoes and land instability.

Other participating organisations :

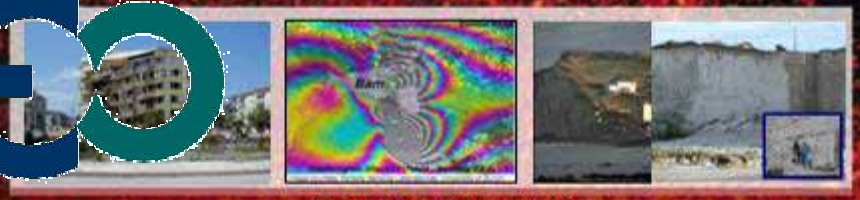
BGS 1835 · CEOS · ICSU · IUGS · UNESCO · USGS · NASA · ICL · GGOS http://www.ggos.org · FDSN · JAXA · cnes · IASPEI · GDV

3rd International Geohazards Workshop

6th 8th November 2007

European Space Agency, ESRIN, Frascati

Since their inception, the European Space Agency supports the international efforts to coordinate a community concerned with Geohazards observations. In 2007, ESA will host the 3rd International Geohazards Workshop, in order to facilitate establishing an International Geohazards Programme. This event will immediately follow the GGOS Workshop 2007, whose conclusions will be a useful input for the workshop participants.



Workshop Objectives

- To review the achievements of the Geohazards Theme during the 2004 – 2007 timeframe
- To review undergoing projects such as Globvolcano, Daphne, Sentinel Asia, Earthscope, Multi Andean Initiative...
- To identify the need for information on Geological hazards, and thus for observation networks and instruments
- To review the undergoing regional and international initiatives on Geohazards
- To define a 3 year strategy for 2007 – 2010 to promote a multi-hazards approach for coordinated observations on Geohazards.

Expected impact

- To establish a Coordinated International Geohazards Programme
- To initiate fund rising for new projects

as Villeneuve

Organising committee :

WOVO

http://www.ggos.org

FDSN

International Consortium on Landslides

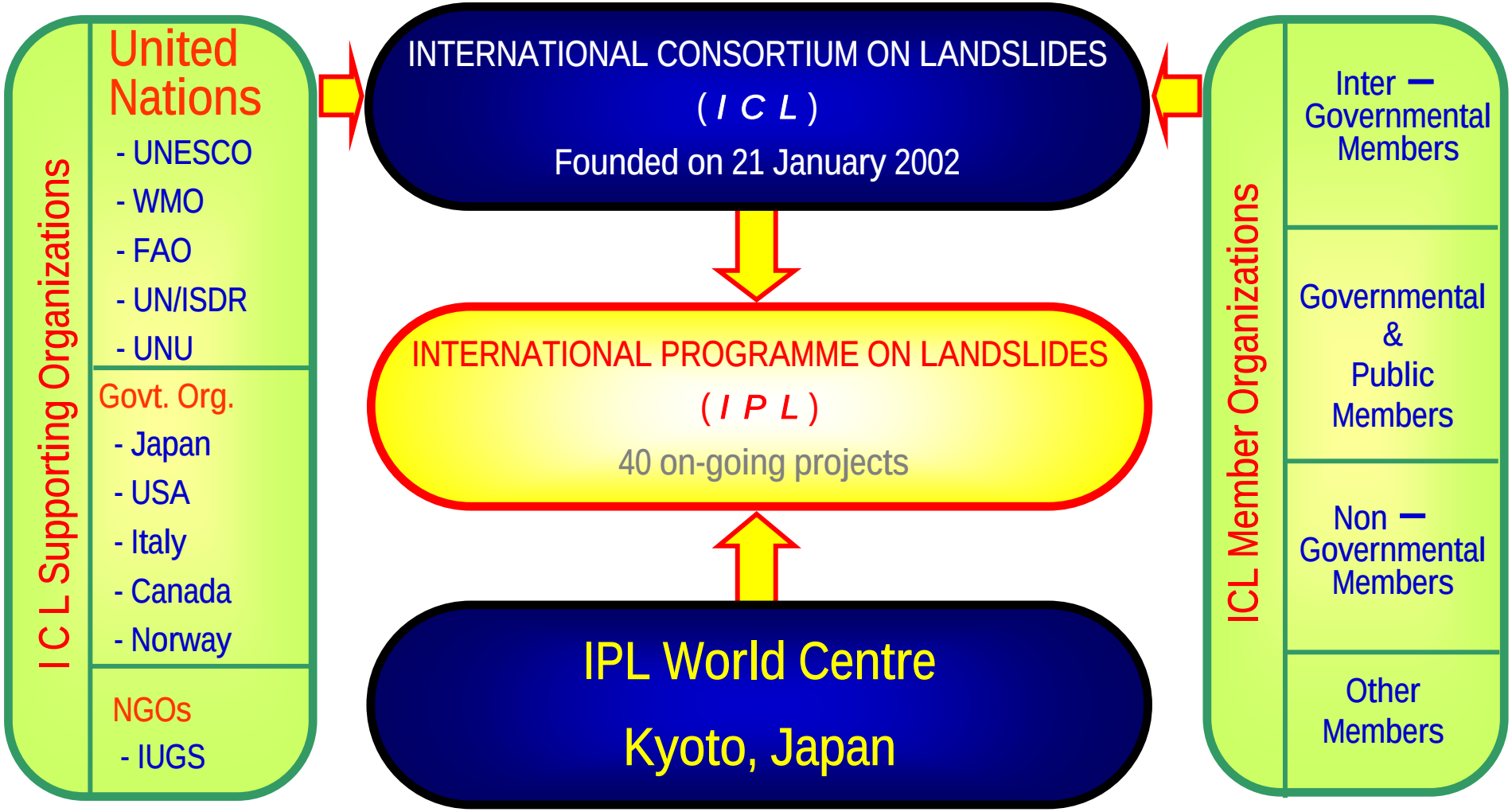
Global landslide observing strategy

Coordinators: Kaoru Takara & Nicola Casagli

Objectives

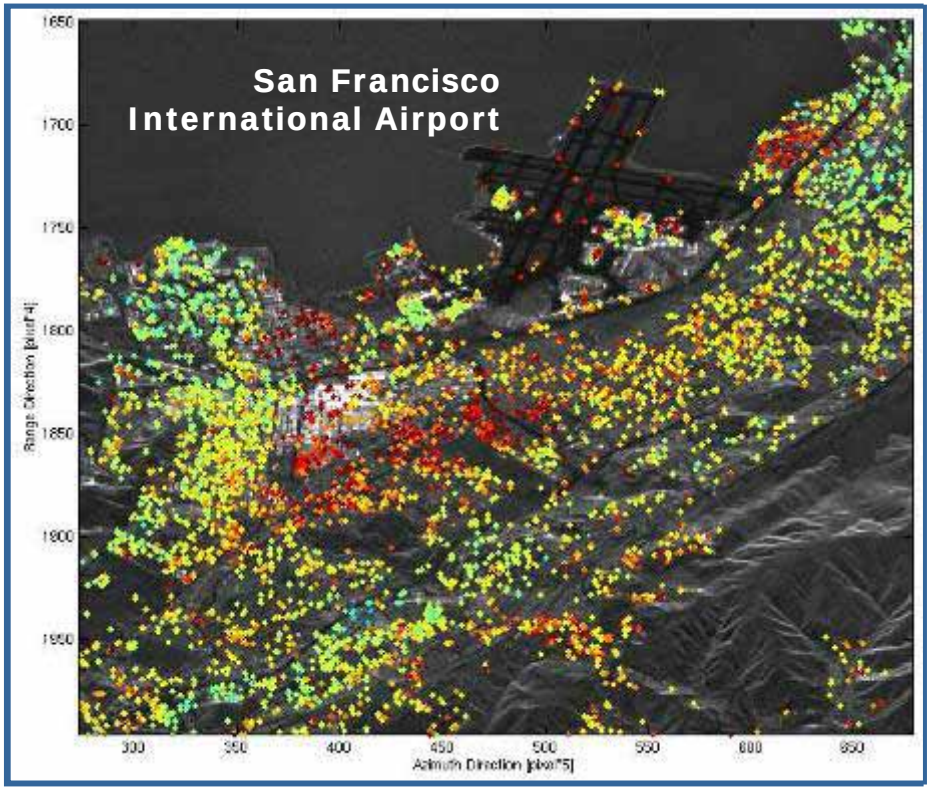
- This project seeks better methodologies for monitoring and forecasting landslides in many hazardous areas in the world by using earth observation systems including satellite, airborne and ground-based remote sensing techniques, and facilitate focused pilot studies by providing new in situ instrumental and mapping support

Framework for ICL and IPL

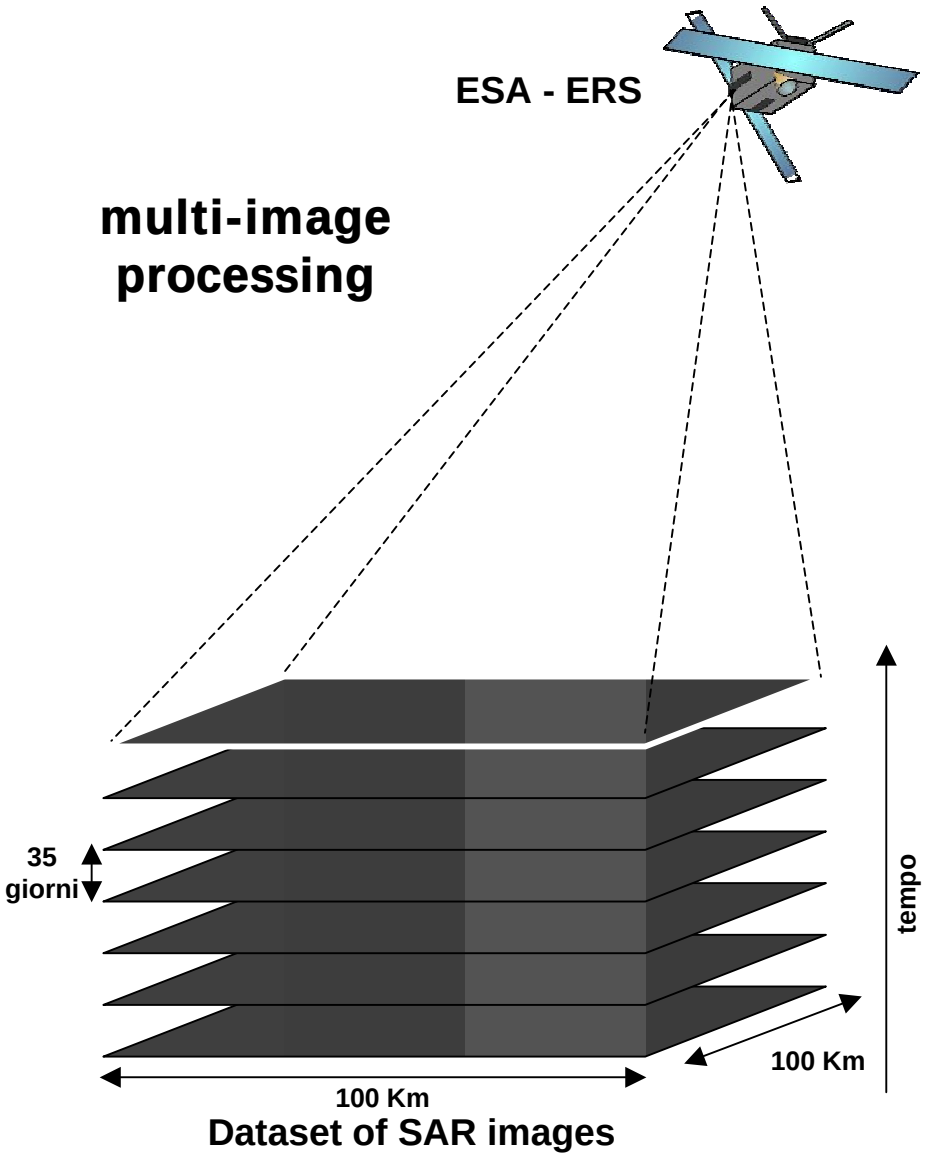


Persistent Scatterers Interferometry (PSI)

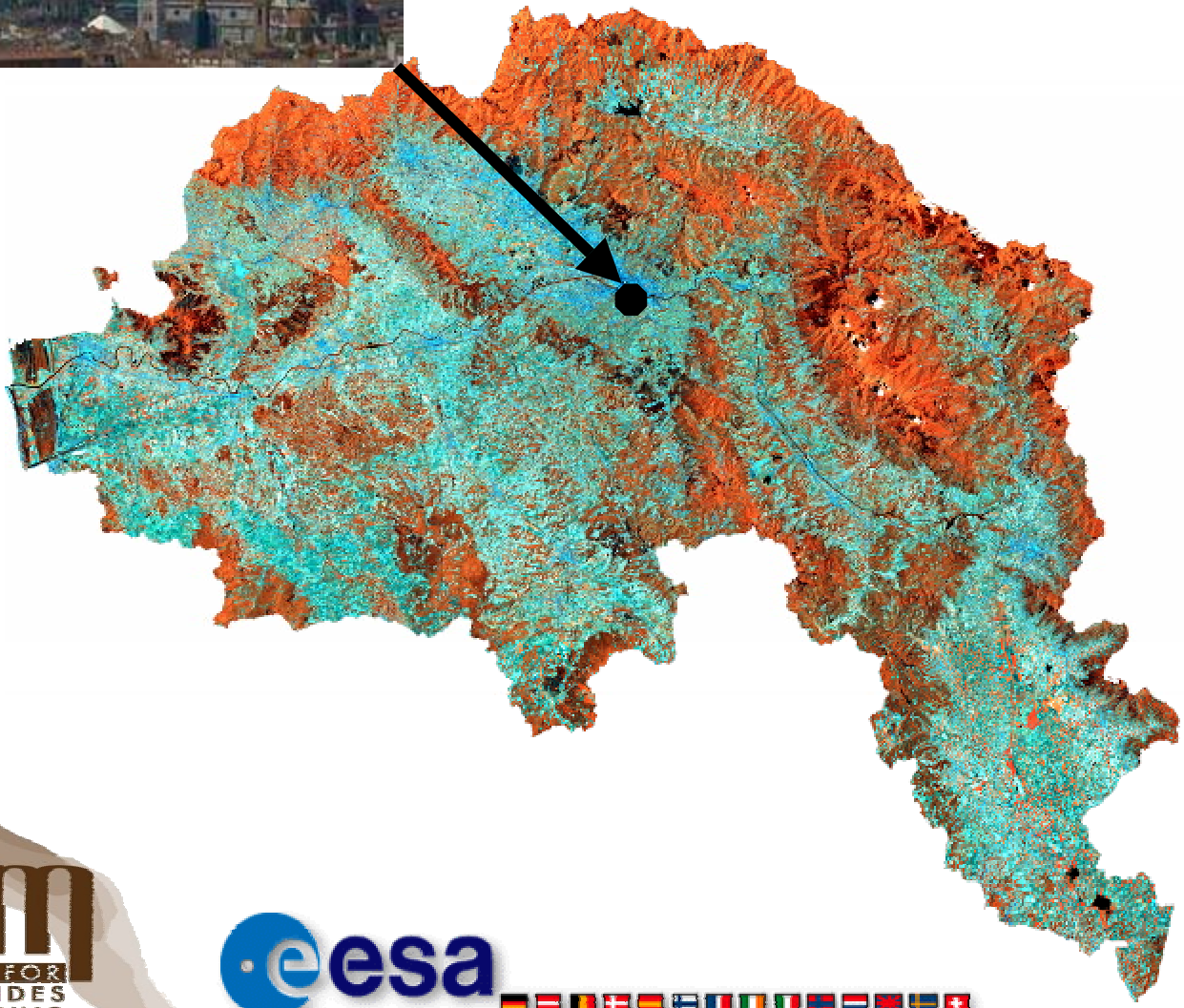
pixel by pixel analysis



Processing technique of SAR images for measurement of ground deformations with millimetric accuracy



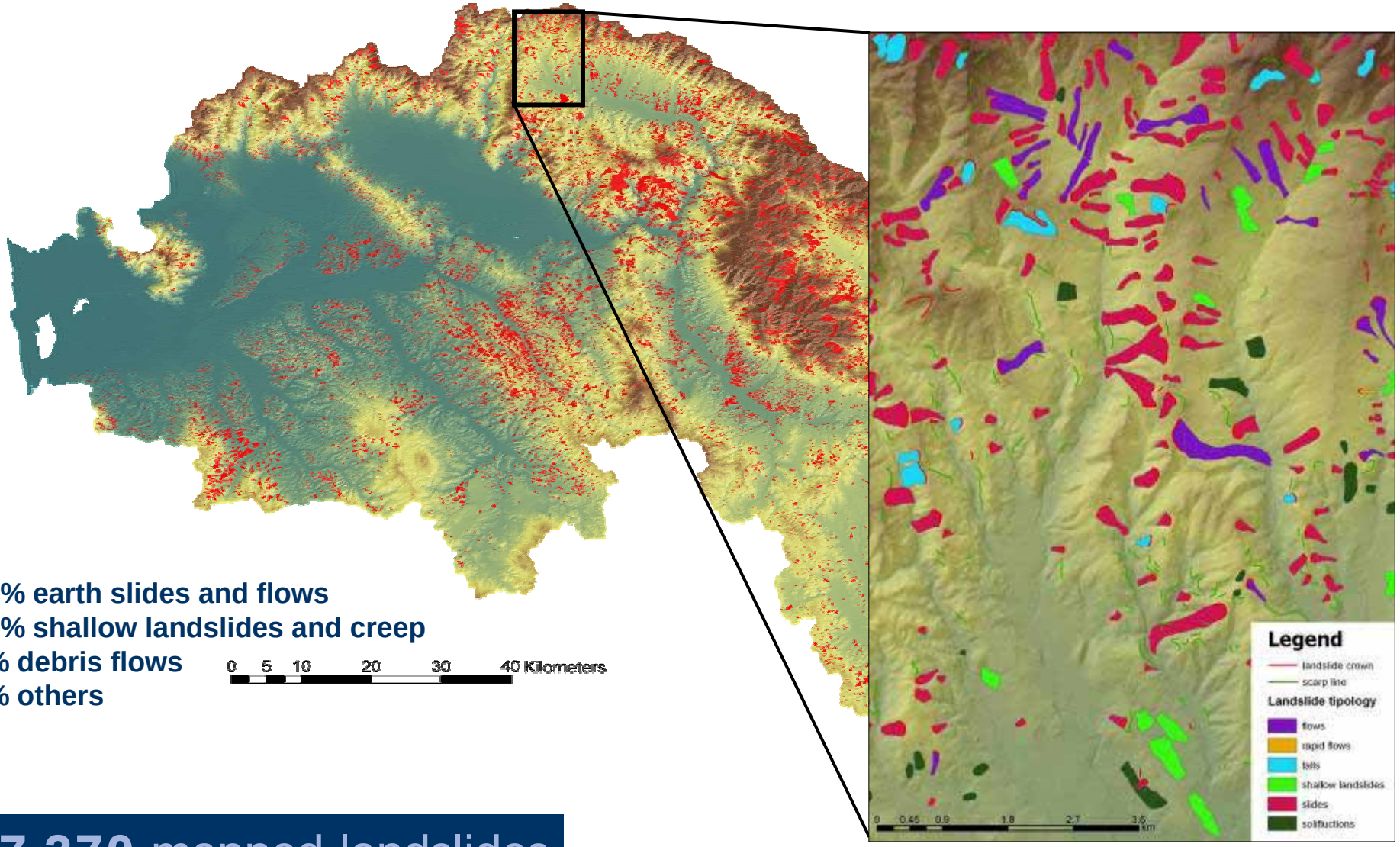
Landslides in the Arno River Basin



SLAM SERVICE FOR LANDSLIDES MONITORING

esa

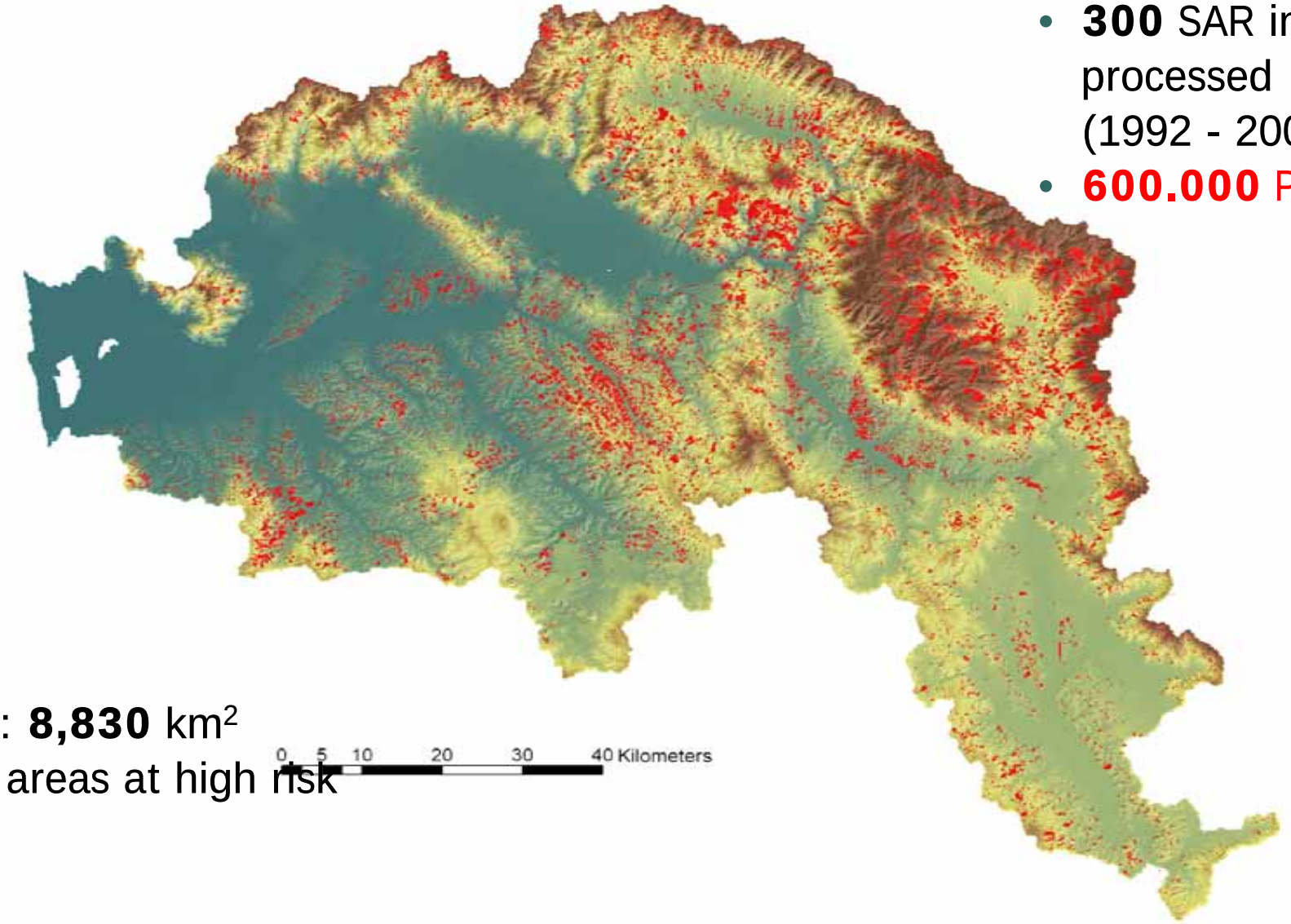
Rapid landslide mapping



74% earth slides and flows
19% shallow landslides and creep
5% debris flows
2% others

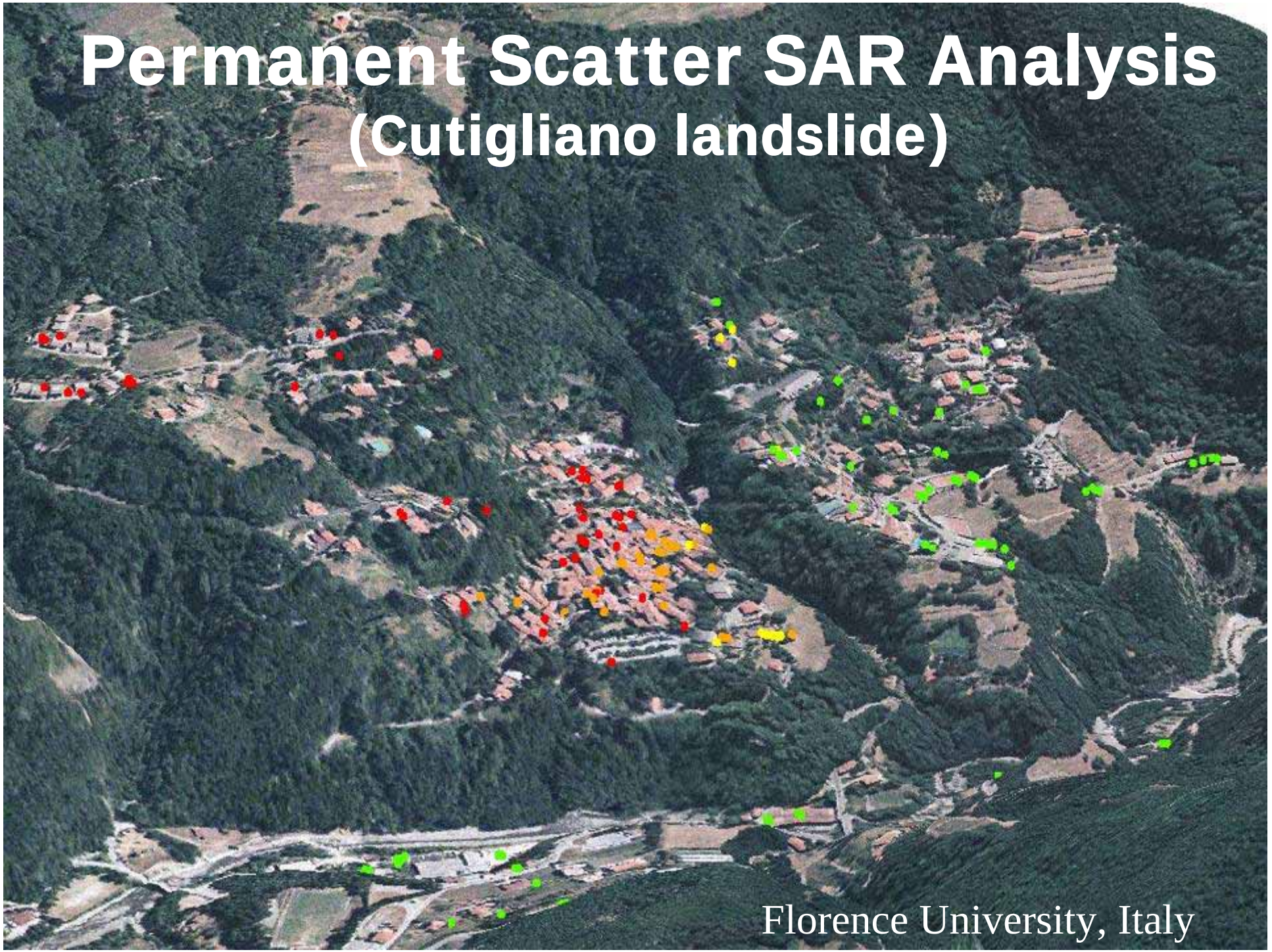
27 270 mapped landslides
8.8 % landslide density

Landslide inventory map

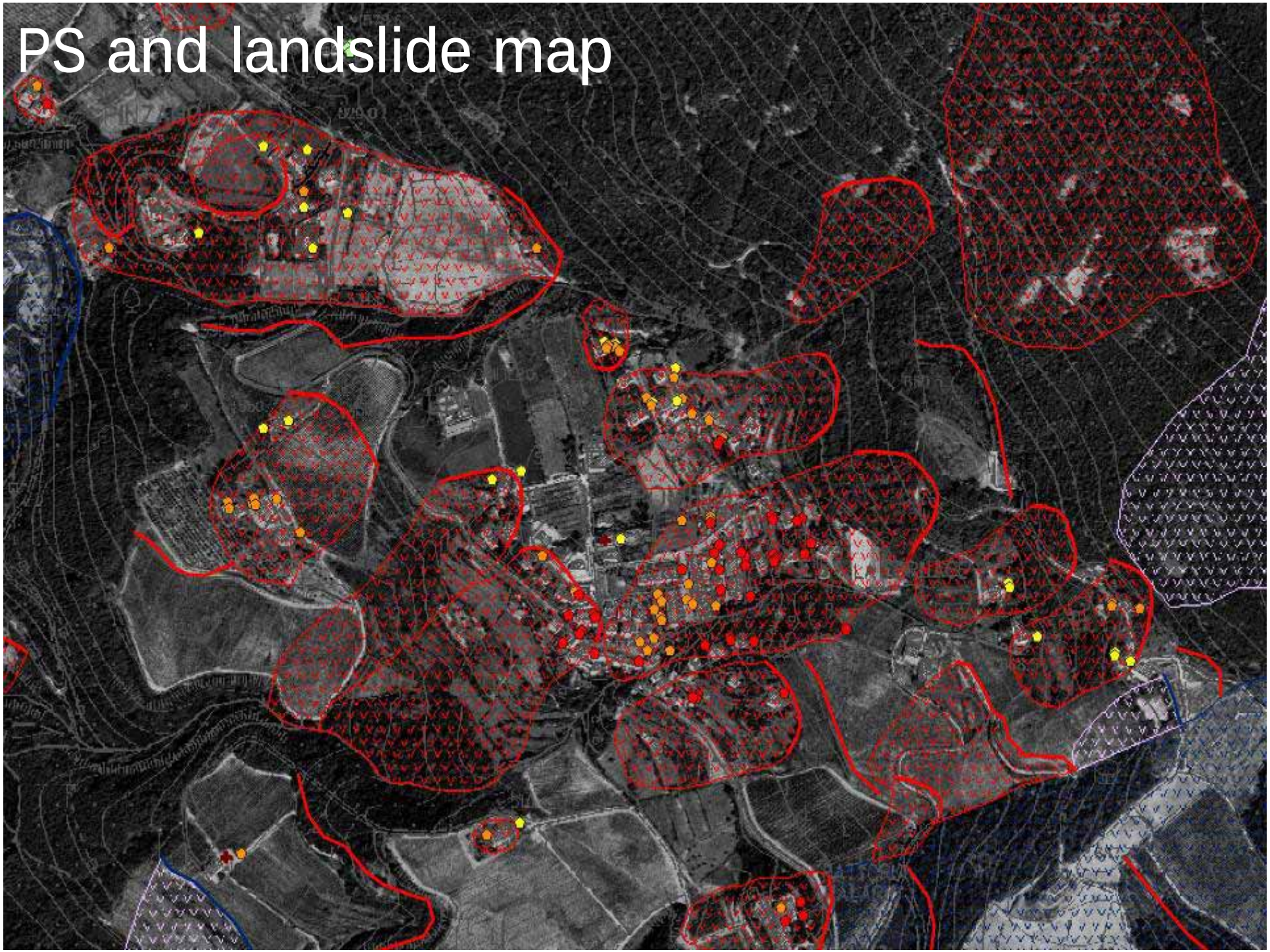


- **300** SAR images processed (1992 - 2000)
- **600.000** PS

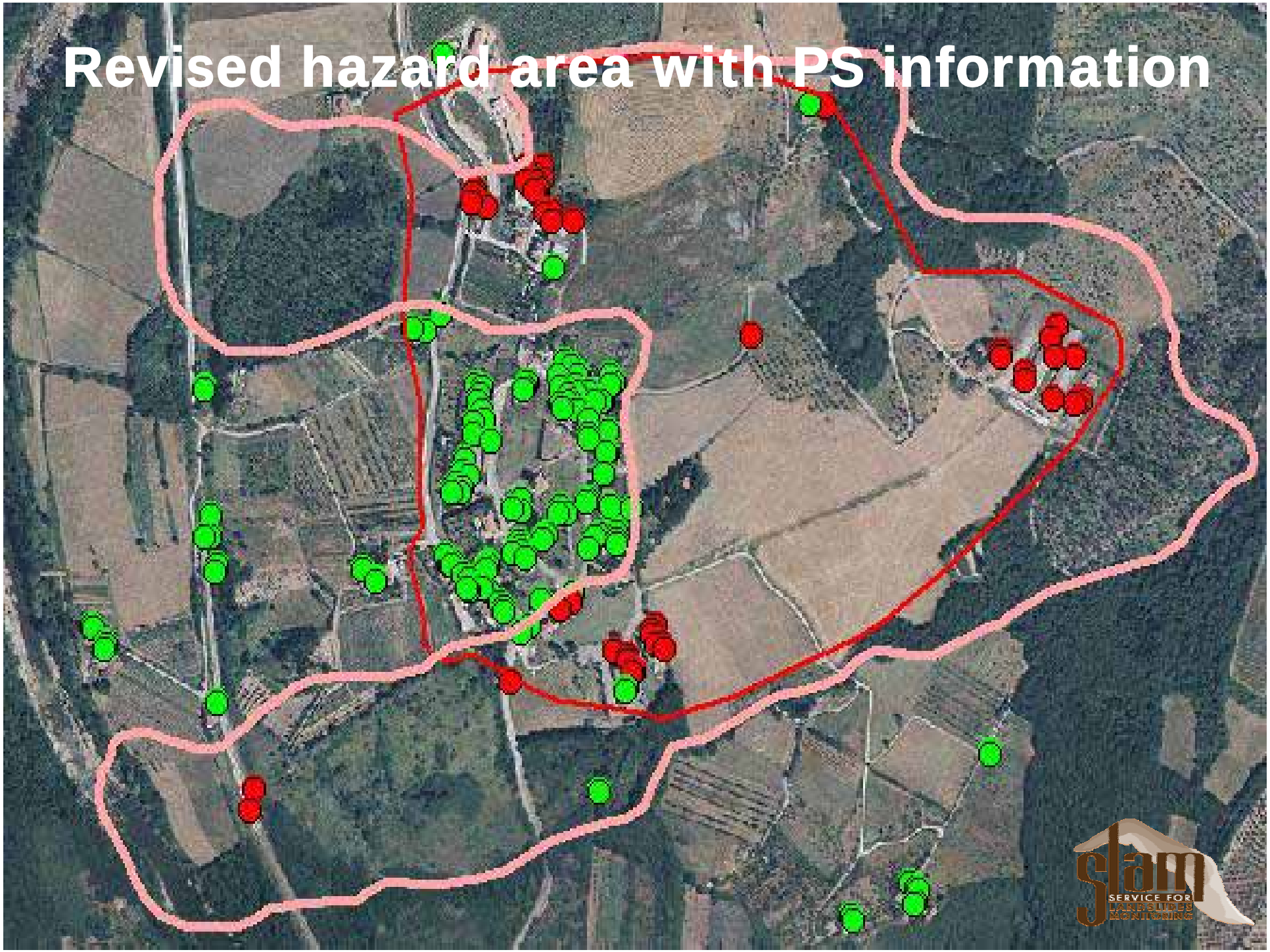
- Area: **8,830** km^2
- **300** areas at high risk


Permanent Scatter SAR Analysis
(Cutigliano landslide)
Florence University, Italy

PS and landslide map



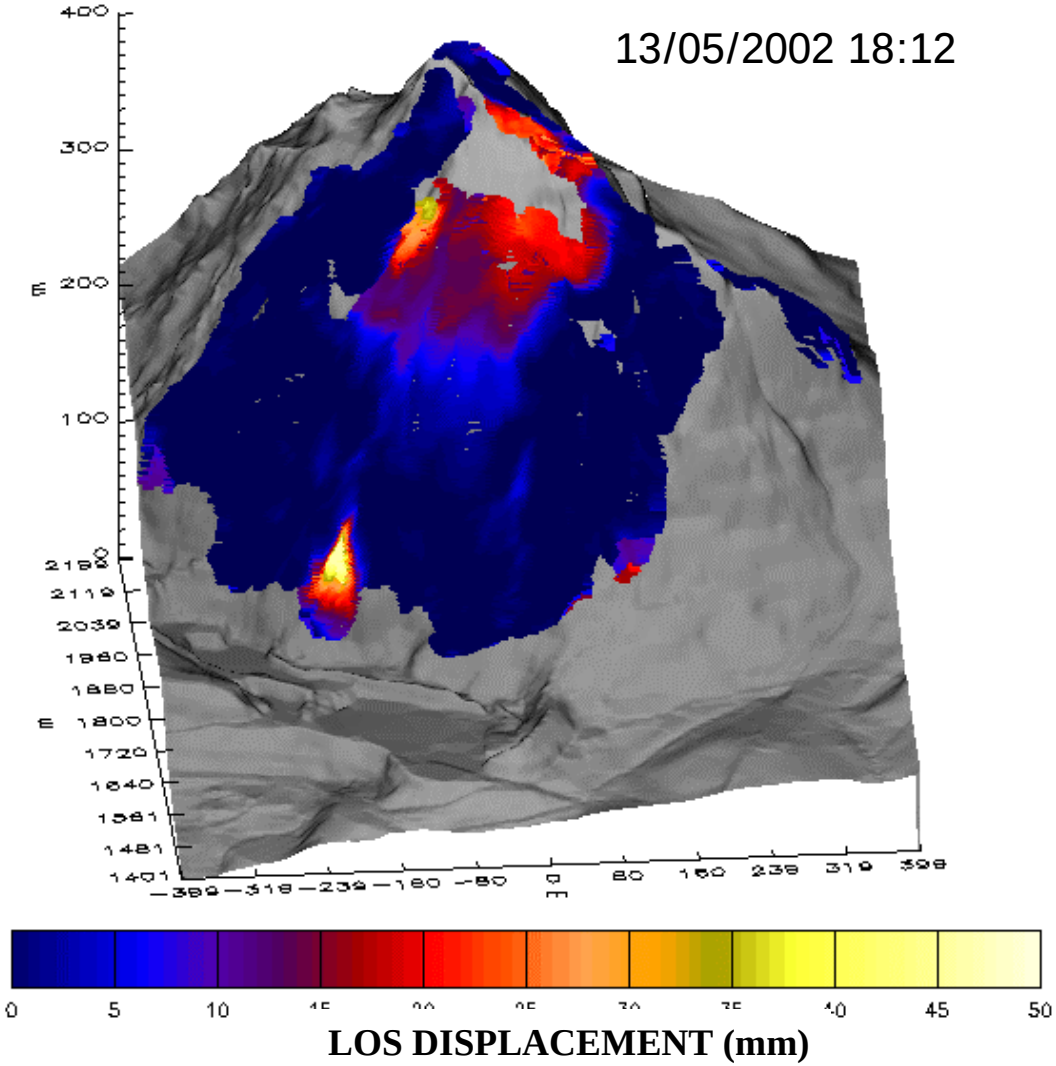
Revised hazard area with PS information



Ground based SAR interferometry

Portable SAR apparatus known as LISA (*Linear Synthetic Aperture Radar*), developed by the Joint Research Centre of the European Commission

Landslide Monitoring by Ground-based Interferometry SAR (Monte Beni landslide, Italy)



Start: 8/5/2002 13:59

End: 13/5/2002 18:12

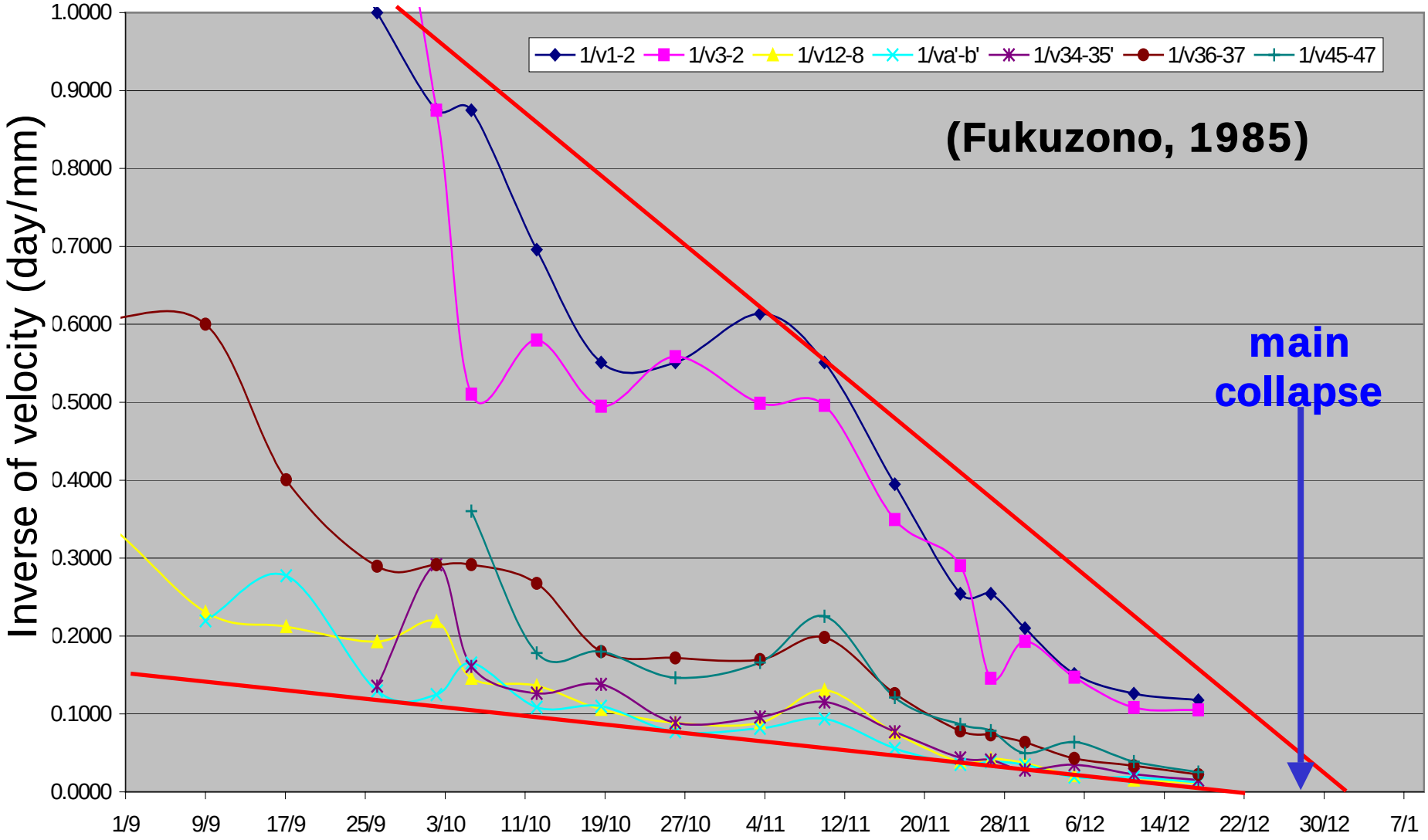
Interval: 124 h

Acquisition time: 40 min

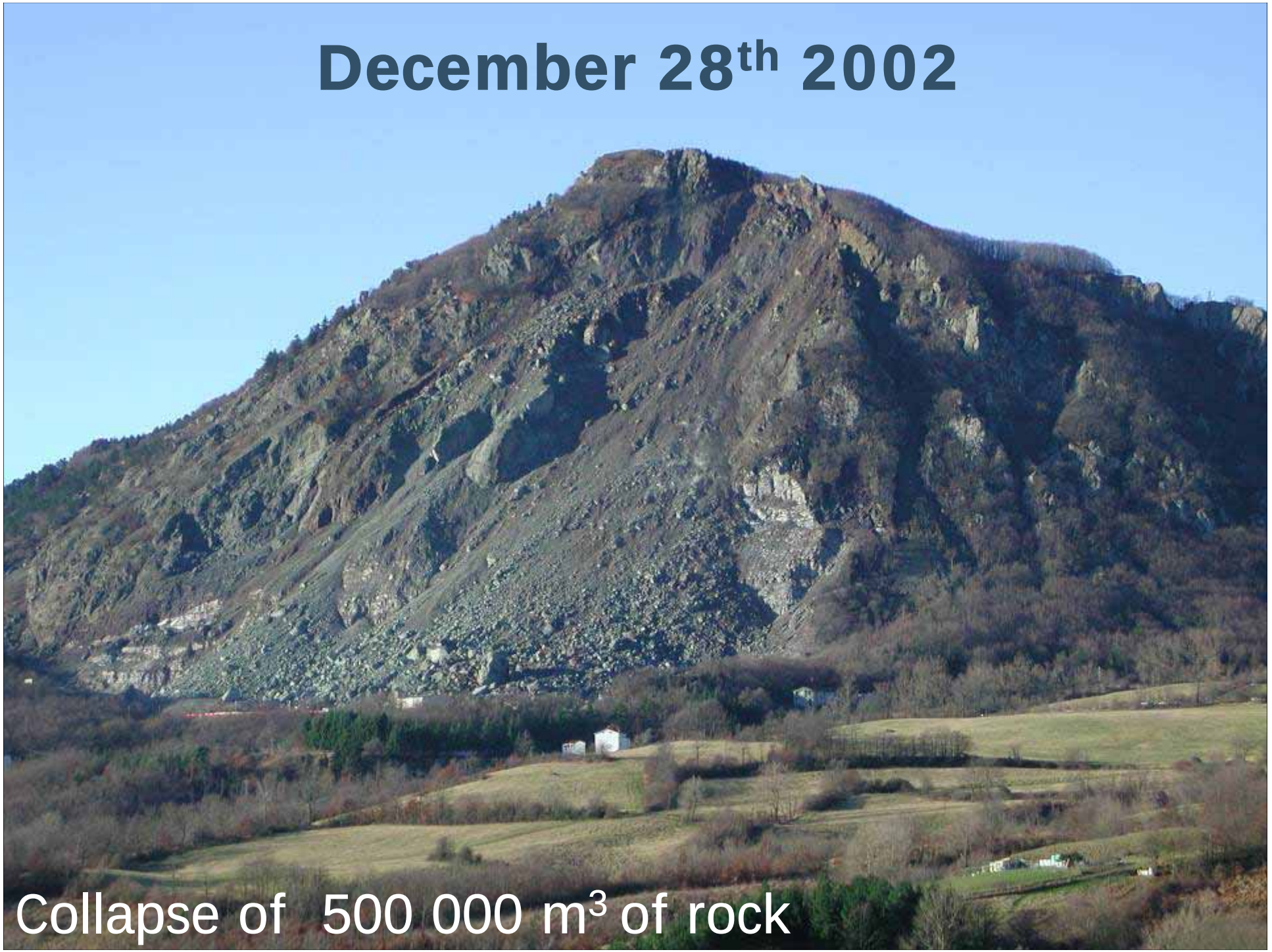
Peak velocity: 0.48 mm/h

Mean Velocity: 0.16 mm/h

Prediction of the time of failure



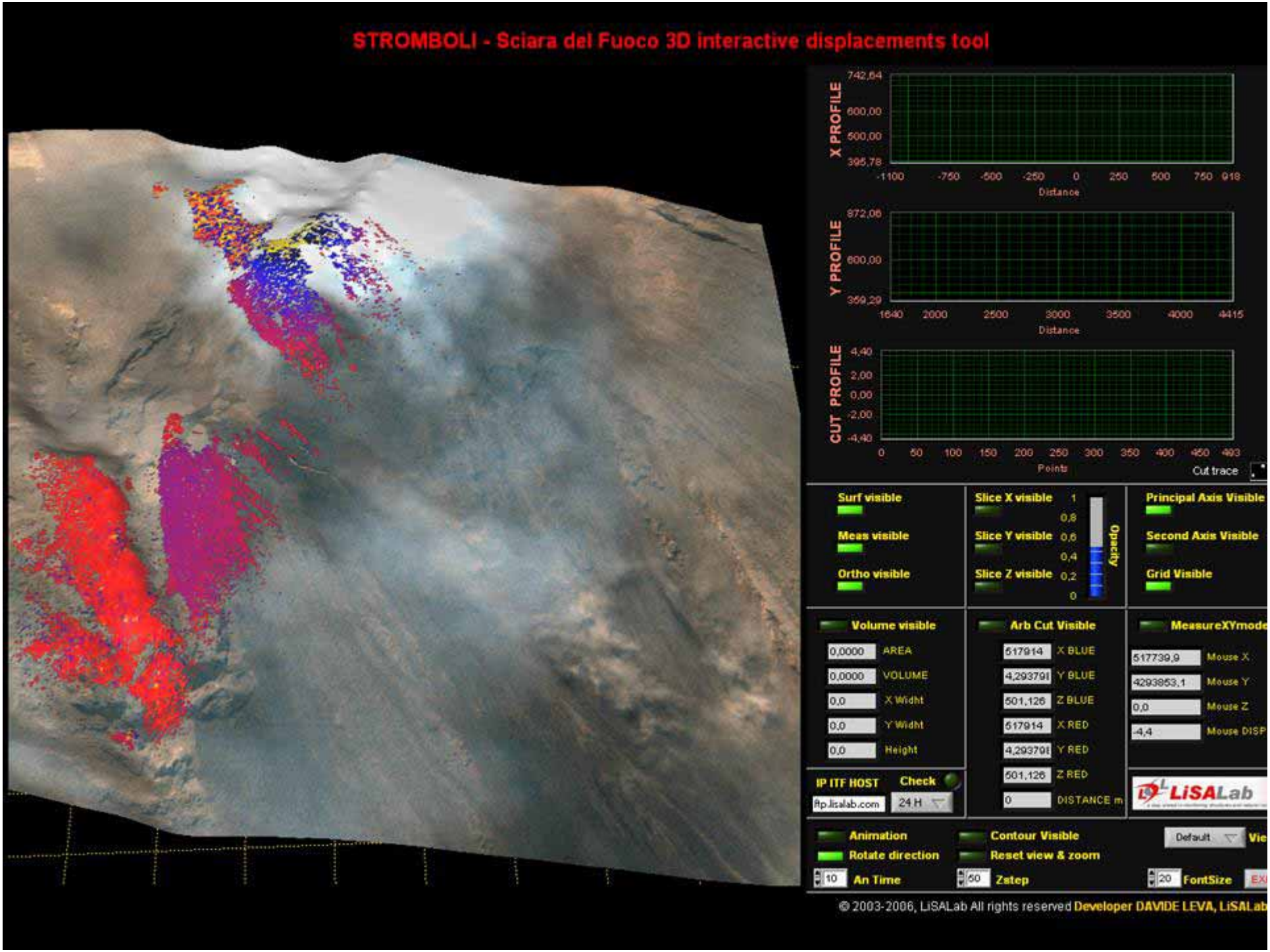
December 28th 2002



Collapse of 500 000 m^3 of rock

Landslide risk evaluation in Machu Picchu World Heritage, Peru

Submarine landslide at Stromboli Volcano


STROMBOLI - Sciara del Fuoco 3D interactive displacements tool
X PROFILE
742,64
600,00
500,00
395,78
-1100 -750 -500 -250 0 250 500 750 918
Distance
Y PROFILE
872,06
600,00
359,29
1640 2000 2500 3000 3500 4000 4415
Distance
CUT PROFILE
4,40
2,00
0,00
-2,00
-4,40
0 50 100 150 200 250 300 350 400 450 493
Points
Cut trace
Surf visible
Meas visible
Ortho visible
Slice X visible
Slice Y visible
Slice Z visible
1
0,8
0,6
0,4
0,2
0
Opacity
Principal Axis Visible
Second Axis Visible
Grid Visible
Volume visible
0,0000 AREA
0,0000 VOLUME
0,0 X Widht
0,0 Y Widht
0,0 Height
Arb Cut Visible
517914 X BLUE
4,293791 Y BLUE
501,126 Z BLUE
517914 X RED
4,293791 Y RED
501,126 Z RED
0 DISTANCE m
MeasureXYmode
517739,9 Mouse X
4293853,1 Mouse Y
0,0 Mouse Z
-4,4 Mouse DISP
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ftp.lisalab.com
24 H
LiSALab
Animation
Rotate direction
Contour Visible
Reset view & zoom
Default
10 An Time
60 Zstep
20 FontSize
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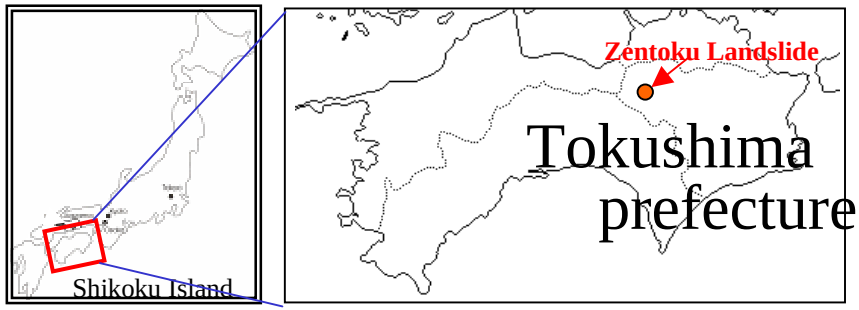
Zentoku landslide, Shikoku Island, Japan – a long-term movement monitoring site

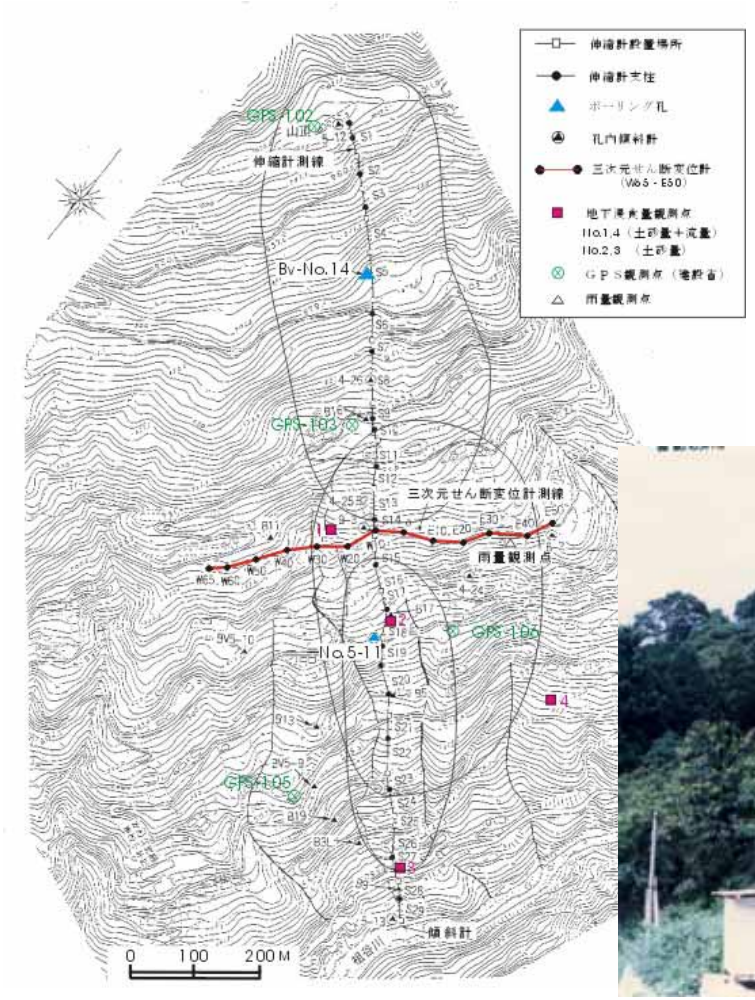


Vine-made bridge which attract millions of tourists

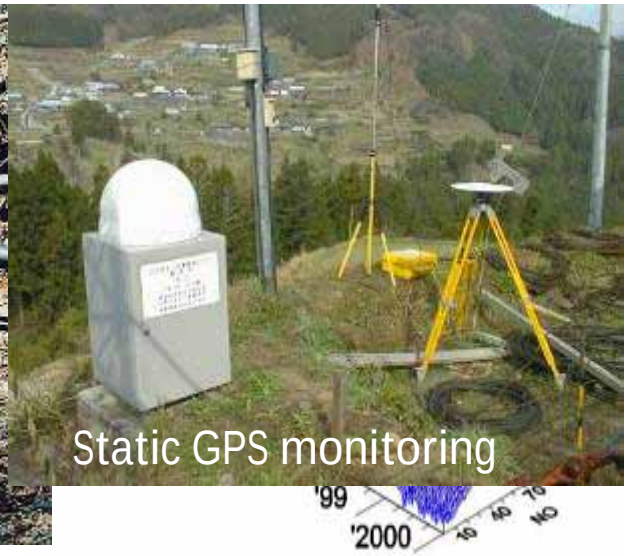
- Geology : crystalline-schist of Sambagawa Zone parallel to MTL (Median Tectonic Line)
- Slope angle : about 28 degrees

Instrumentation in Zentoku landslide

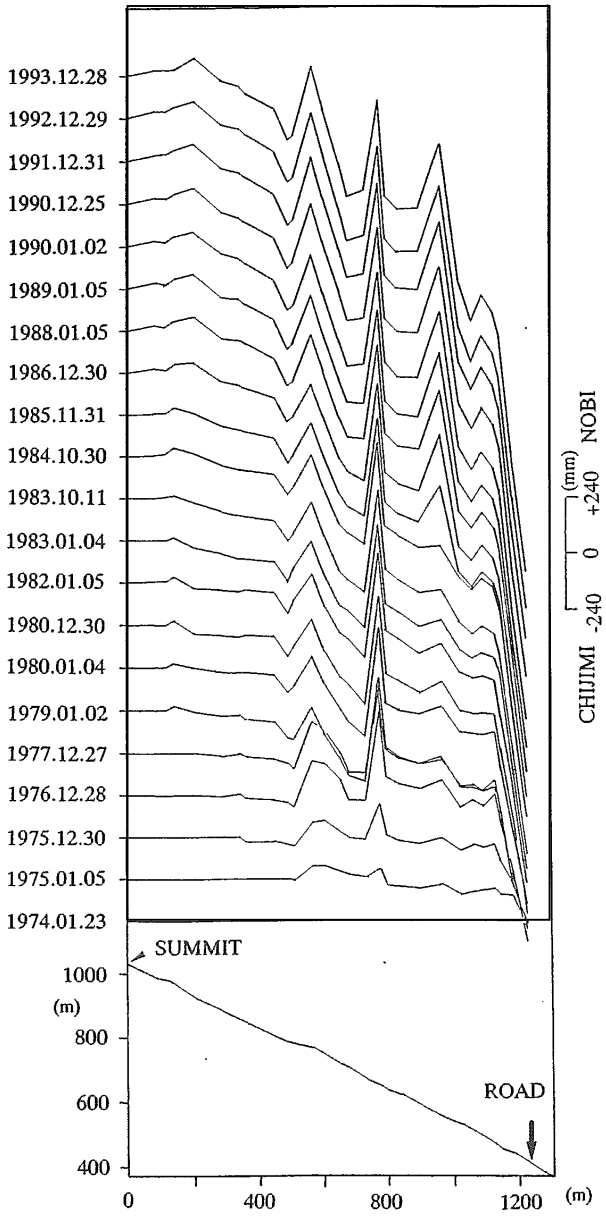
A typical large-scale crystalline schist landslide, which is creeping. Movement as been monitored by extensometers, GPS and others since1972 .



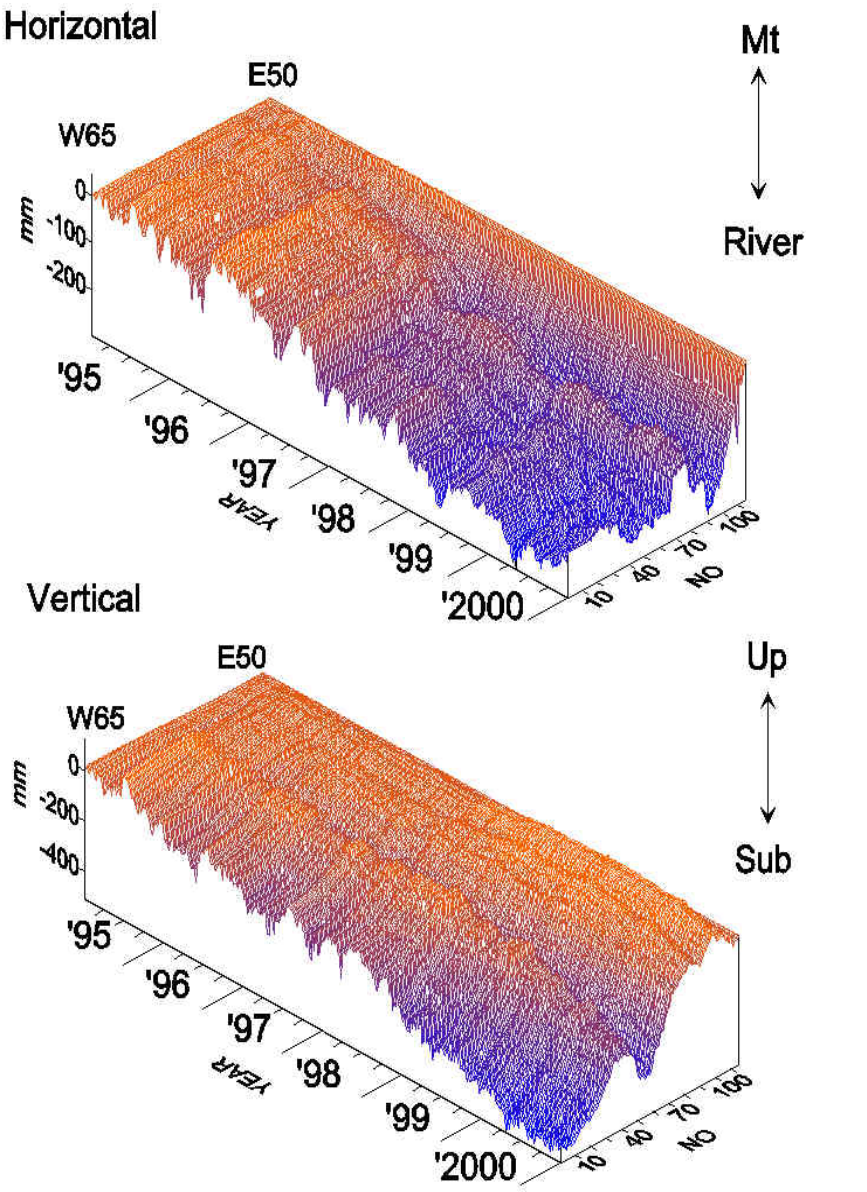
Extensometers



3-D shear displacement meters

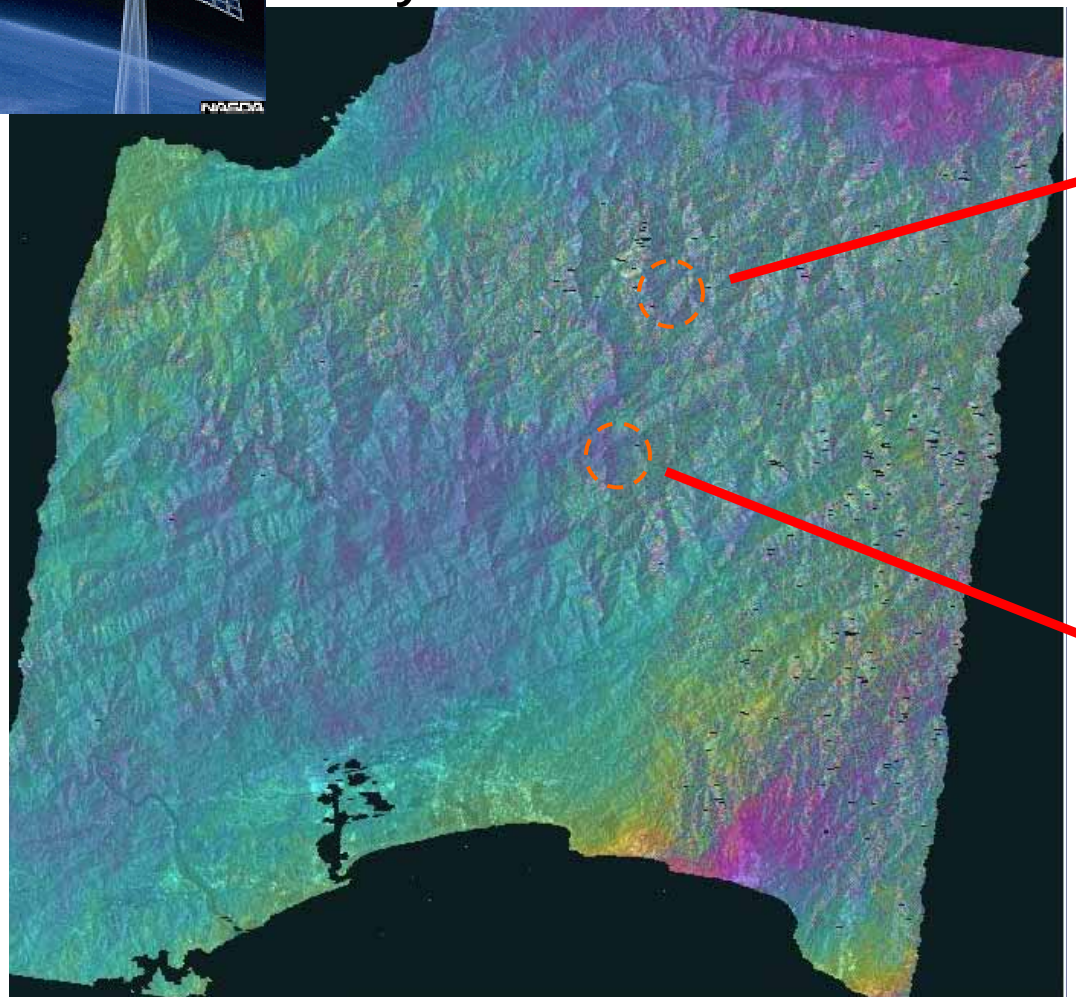


山頂から谷底近くまでの超長期観測結果の一部

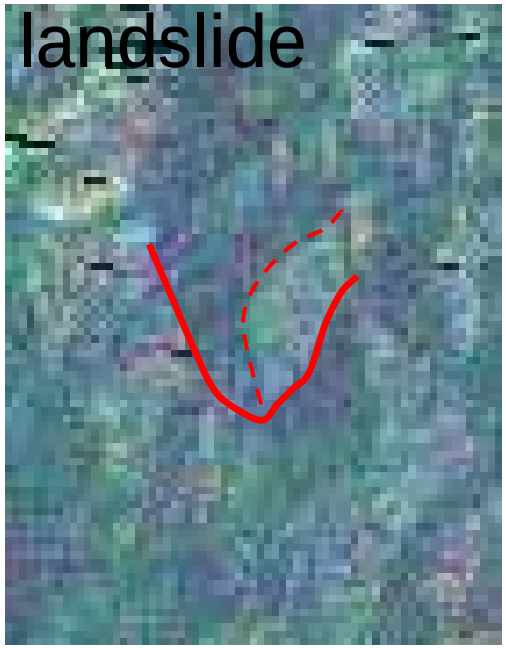


三次元せん断変位計の計測結果より、水平変動量（上）と鉛直変動量（下）の立体表示.

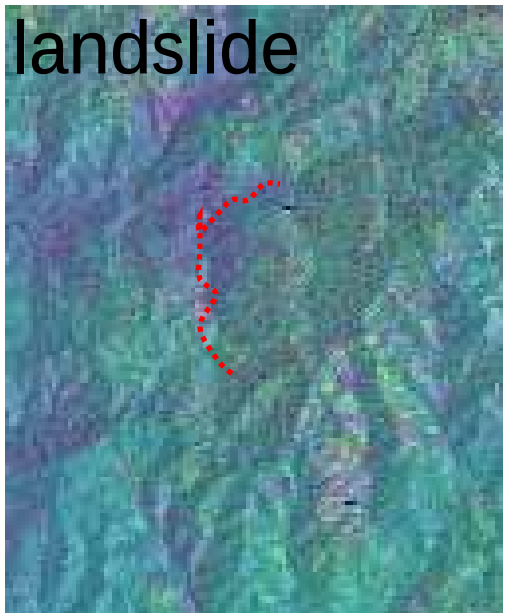
Preliminary Interferometric analysis of JERS-1 **08/02/95-12/02/98**



Zentoku landslide

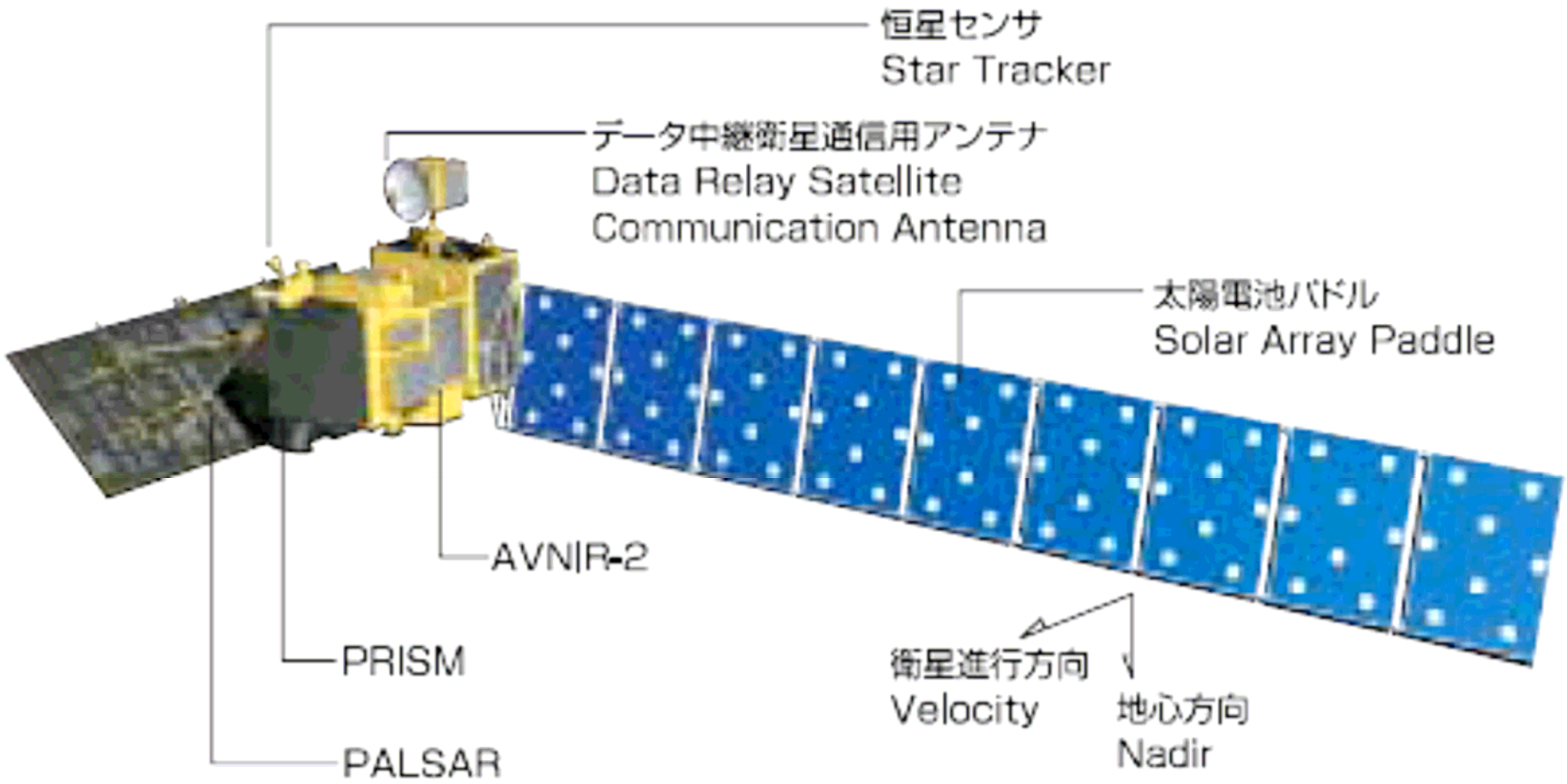


Nuta landslide

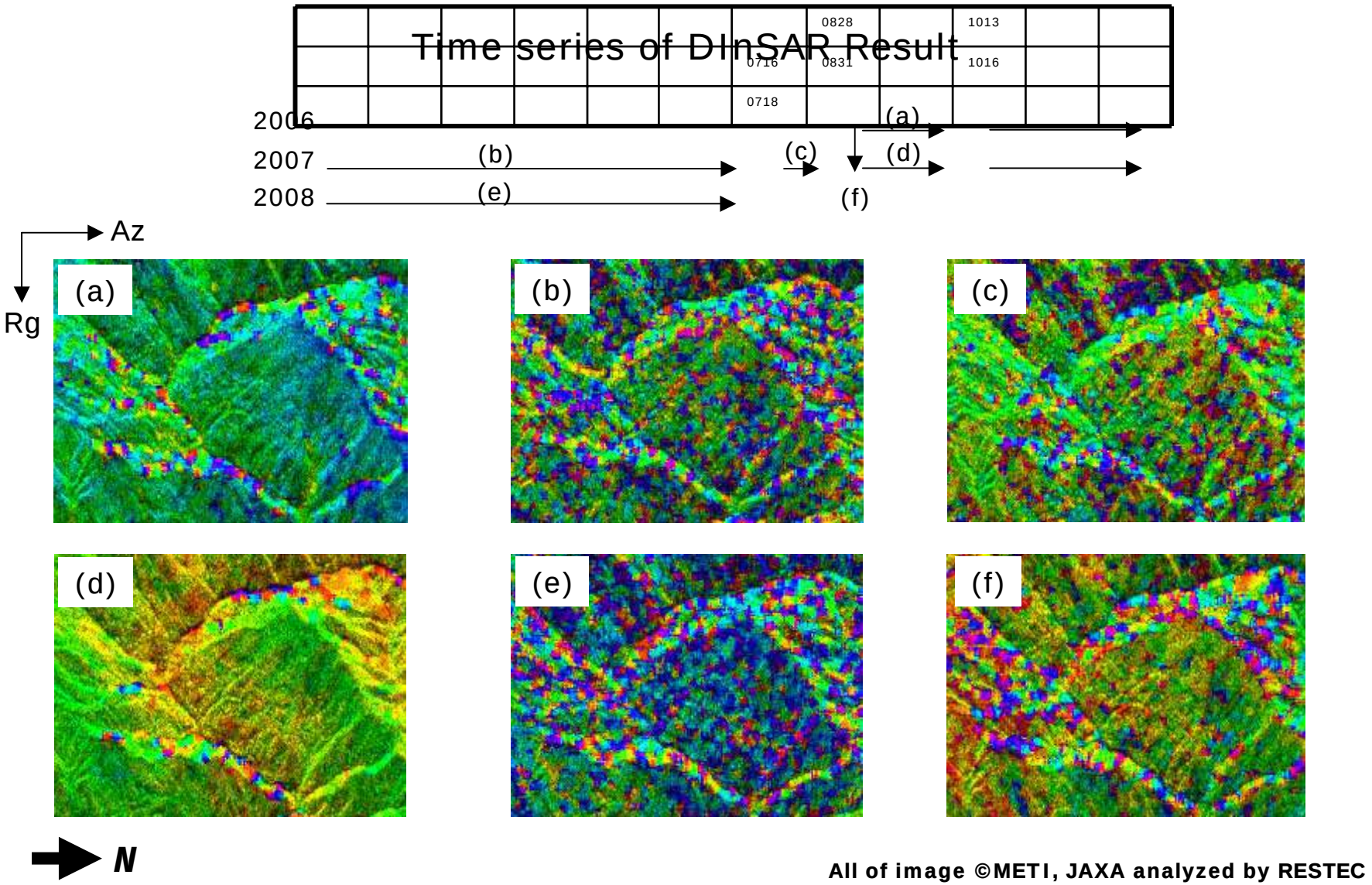


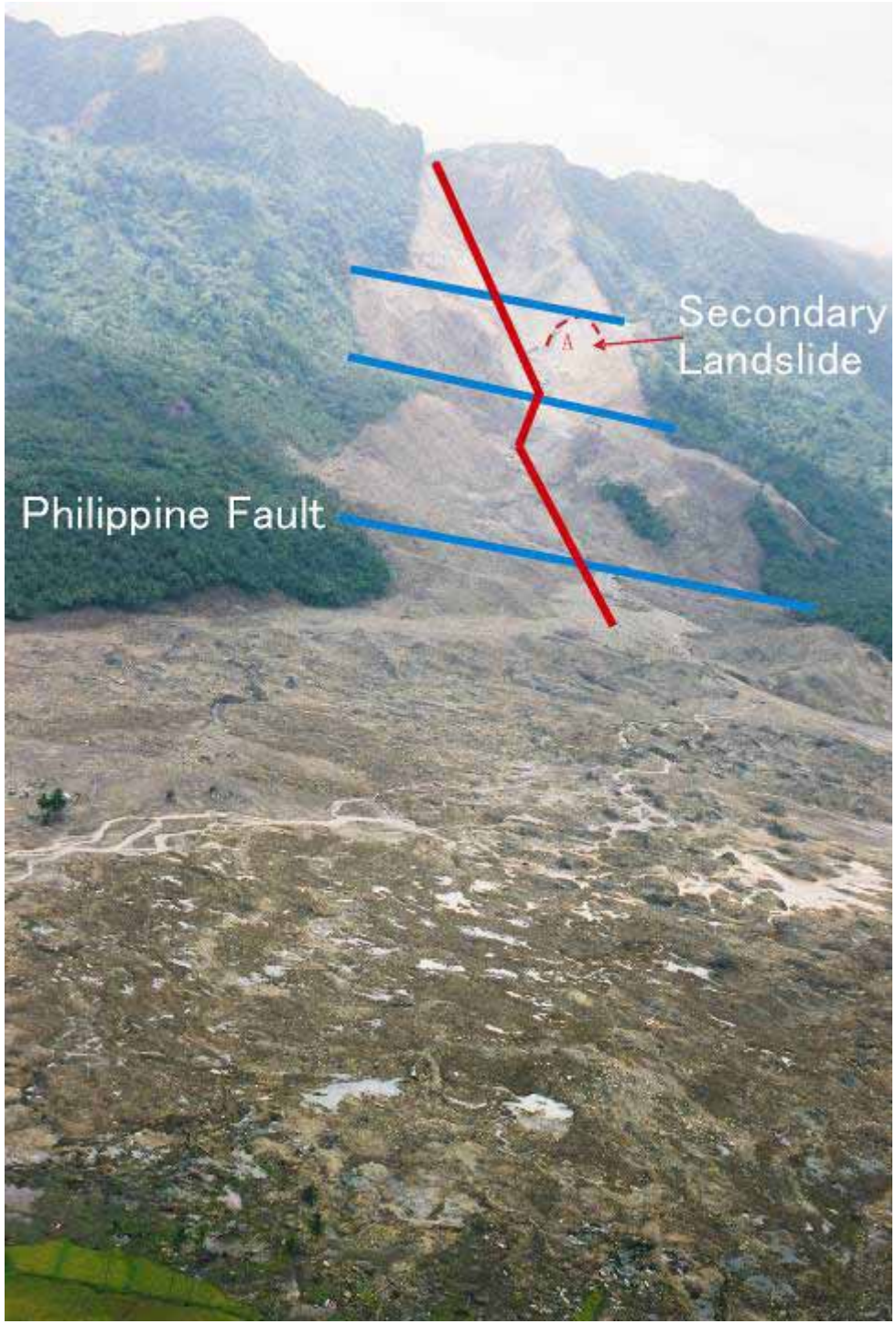
陸域観測技術衛星「だいち」

ALOS : Advanced Land Observing Satellite DAICHI



Analysis of DInSAR of Zentoku Landslide analyzed by Dr. Furuta, RESETC



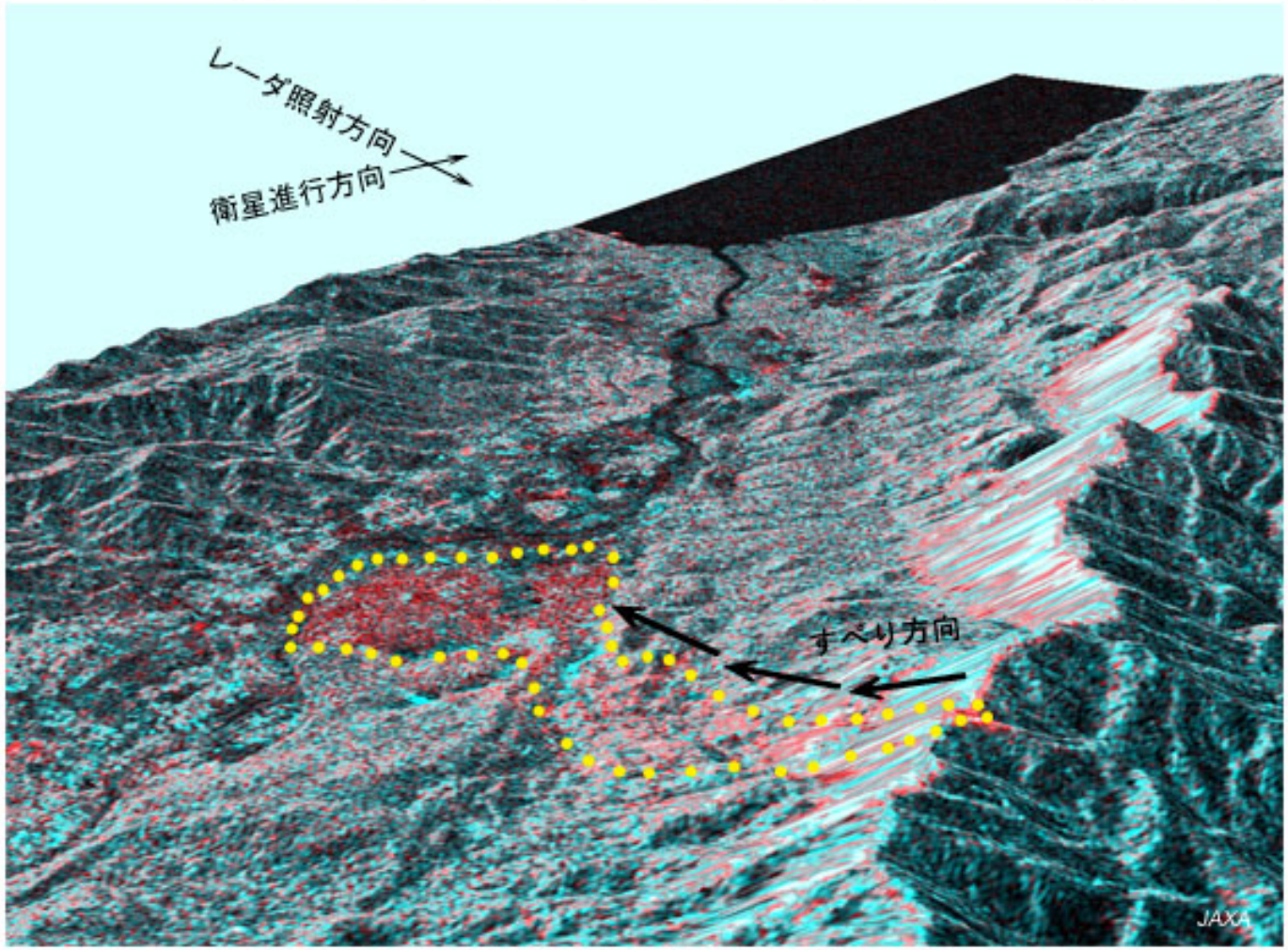


Feb 2006 Guinsaugon landslide, Philippines, which buried two villages and killed about 1,100 residents.

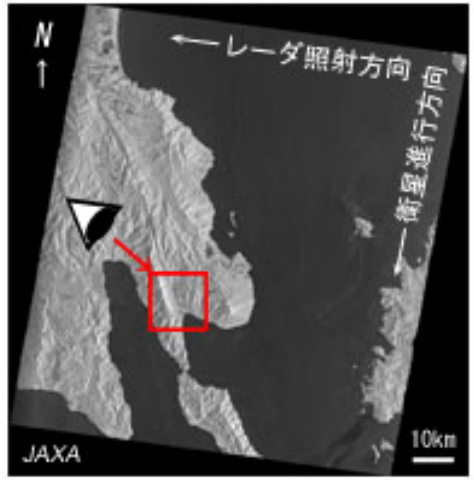
This landslide was triggered jointly by heavy precedent rainfall and a small scale earthquake. Estimated debris volume is 22 million m^3.

北西方向から見たフィリピン・レイテ島の地すべり被災地

North-west view of landslide area in Leyte Island, Philippines



地すべり被災地周辺の鳥瞰図
ALOS/PALSARとJERS-1/SARのカラー合成画像(R:PALSAR, G & B:JERS-1/SAR)
黄色点線枠内がカラー合成画像より推定された地すべり被災領域



レイテ島南部のJERS-1/SAR画像
（オルソ補正済み）

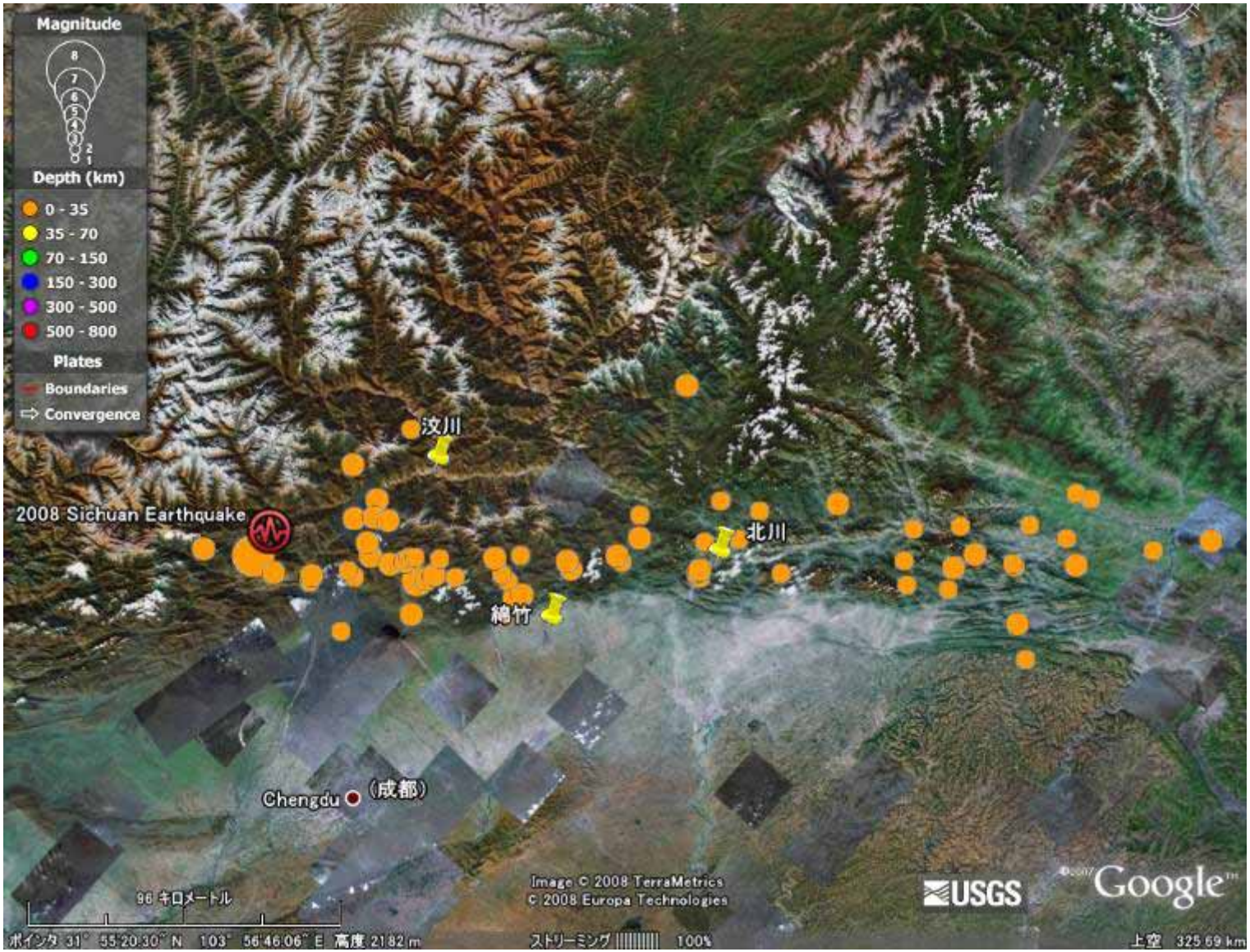
ALOS PALSAR
観測日：2006年2月24日

JERS-1 SAR
観測日：1996年2月2日

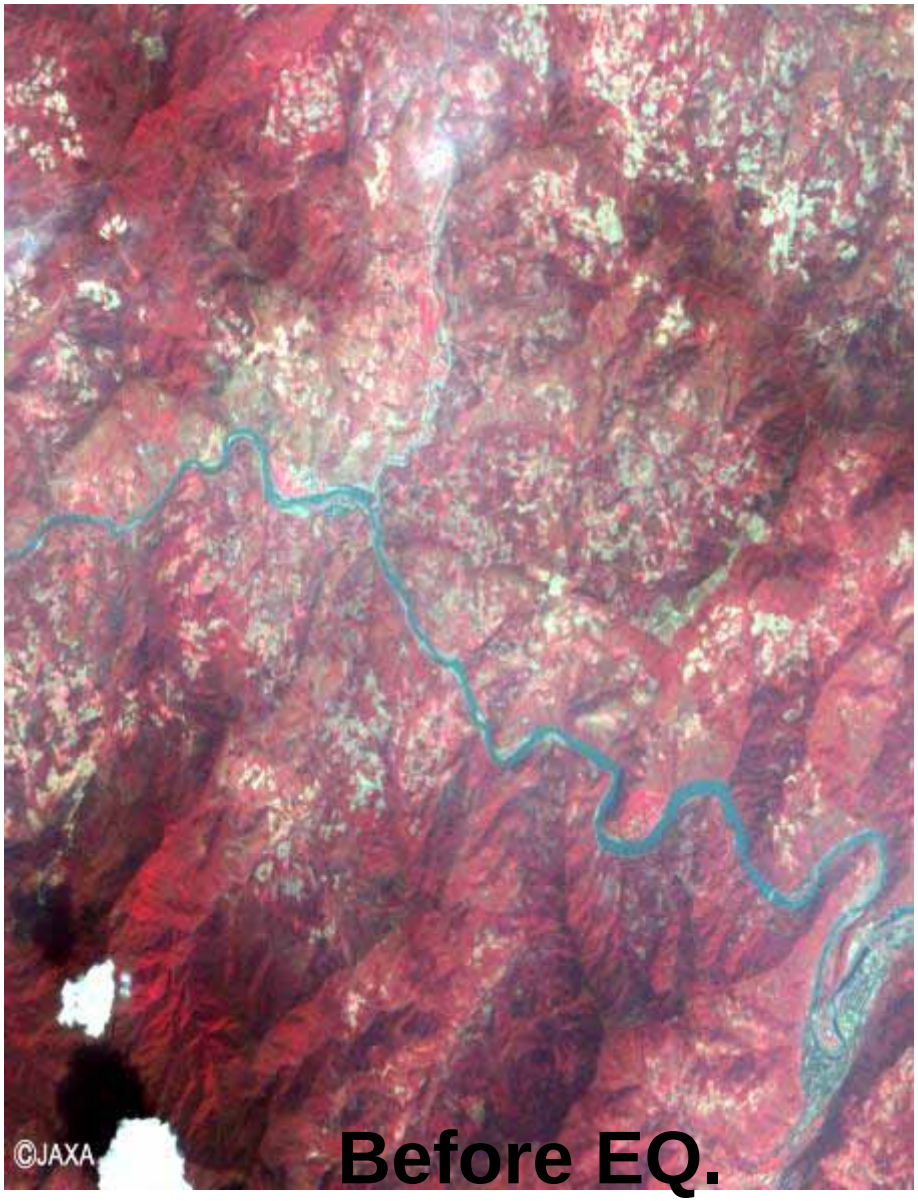
被災地付近の緯度・経度
北緯 10° 20′
東経 125° 05′

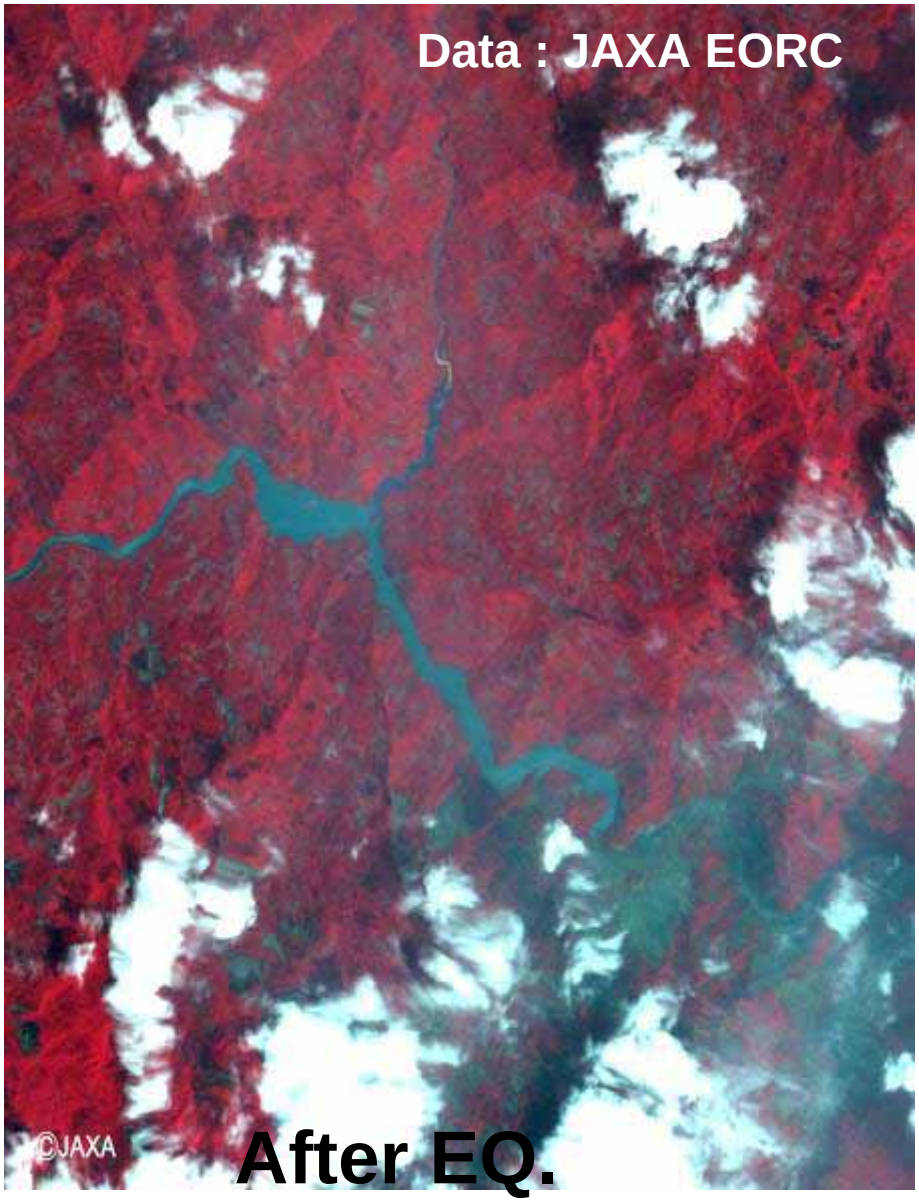
2006年2月17日フィリピン・レイテ島地すべり
PALSAR緊急観測画像

2008 China Wenchuan EQ disaster (epicentral area)

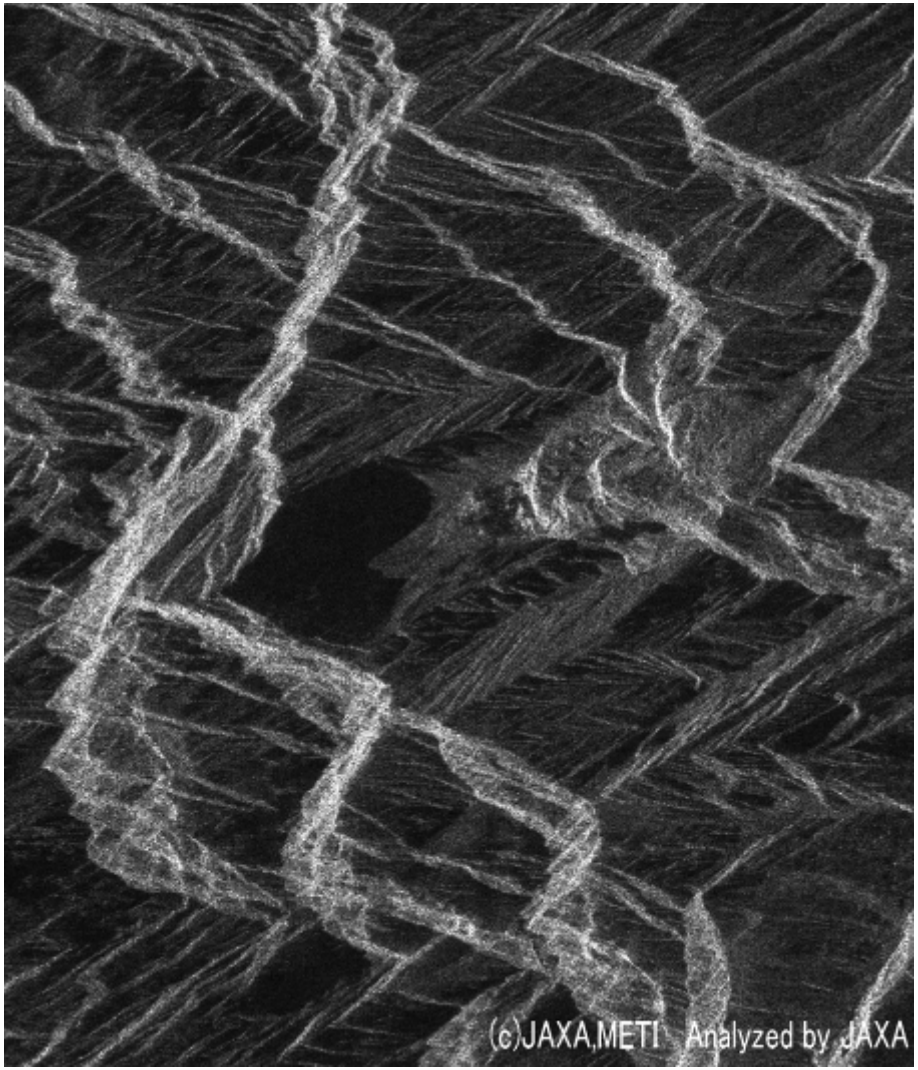


Landslide Dam and reservoir formation obtained by ALOS

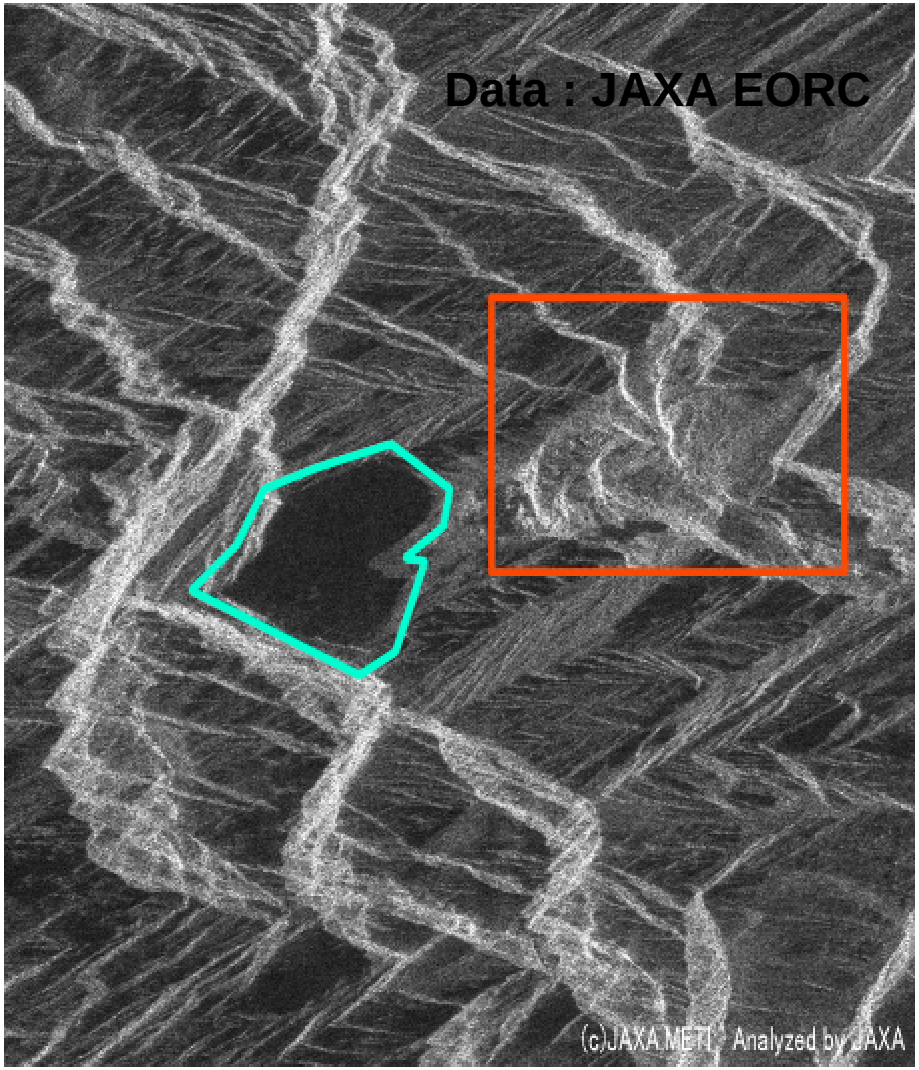




Detection of a landslide dam by ALOS-PALSAR

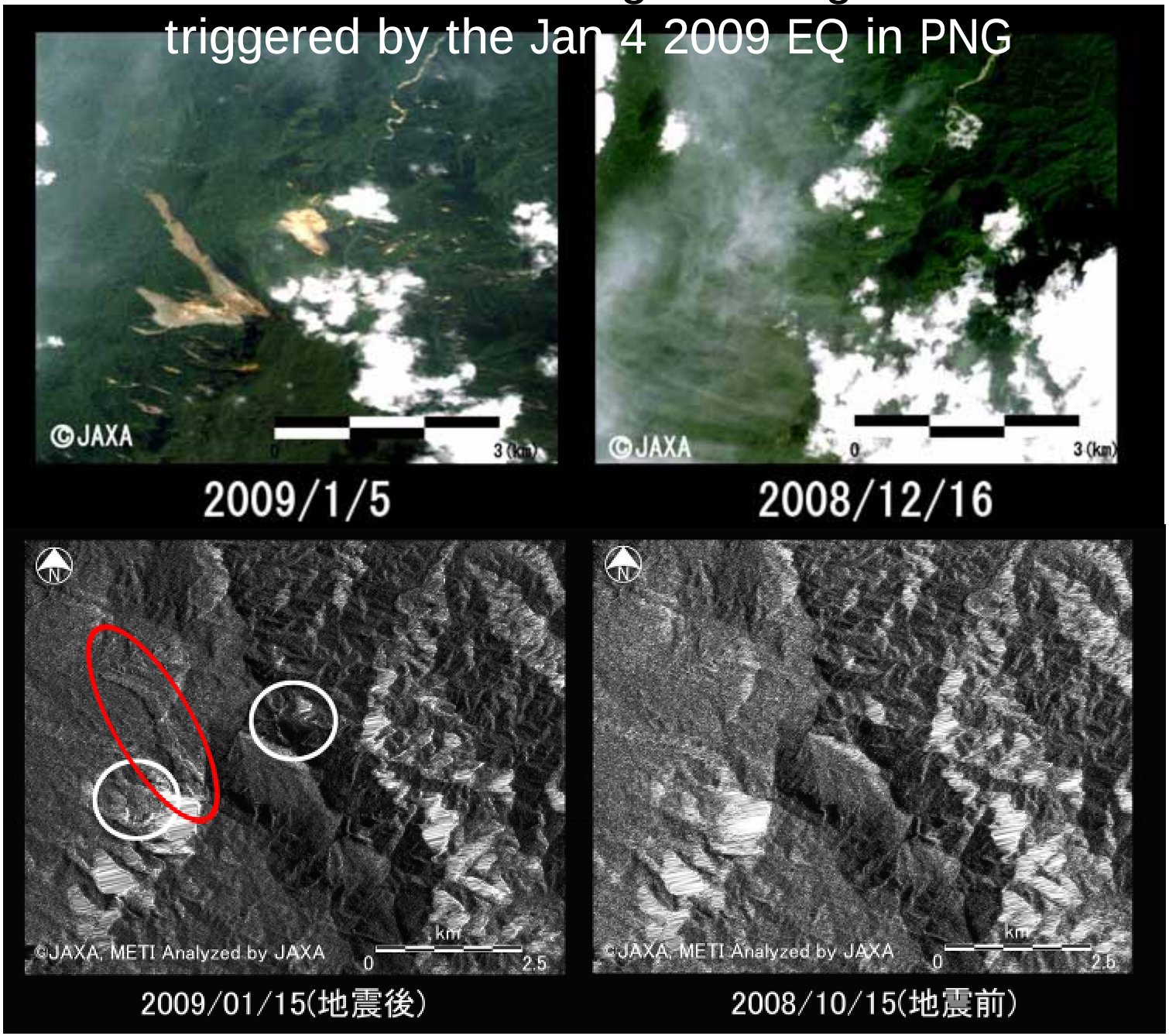


Before EQ.

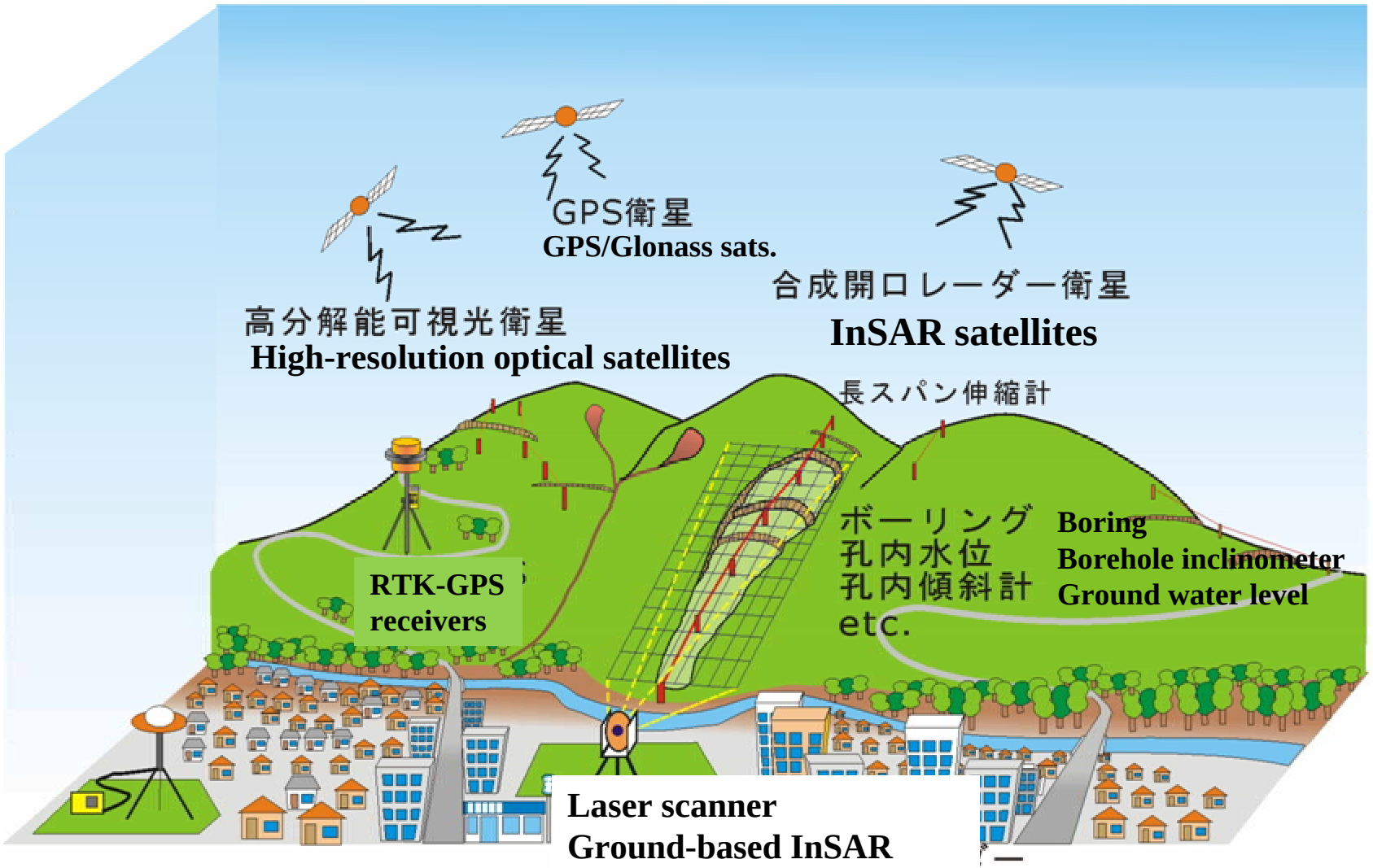


After EQ.

ALOS-AVNIR and PALSAR images of large scale landslide triggered by the Jan 4 2009 EQ in PNG

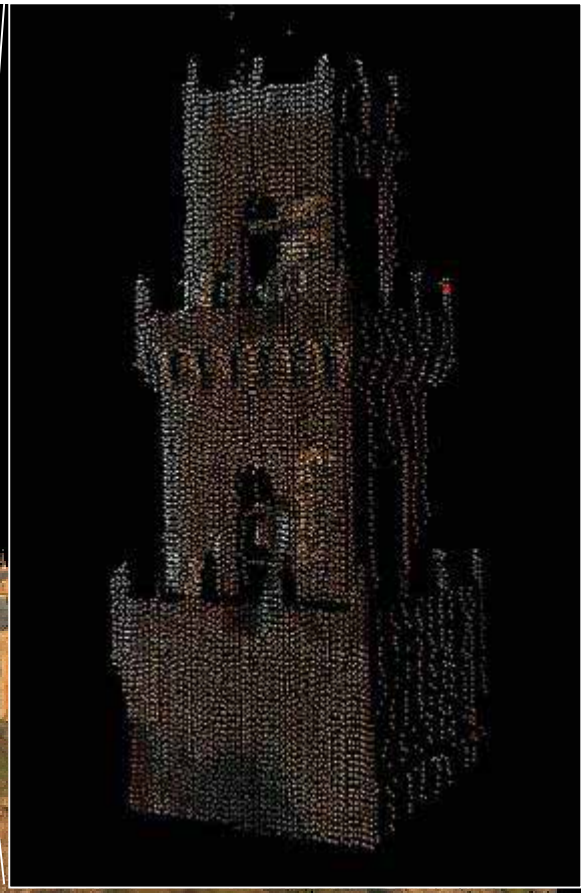


Outline of future integrated landslide monitoring system



Thank you for your attention !

Long range 3D terrestrial laser scanning



160 milion points

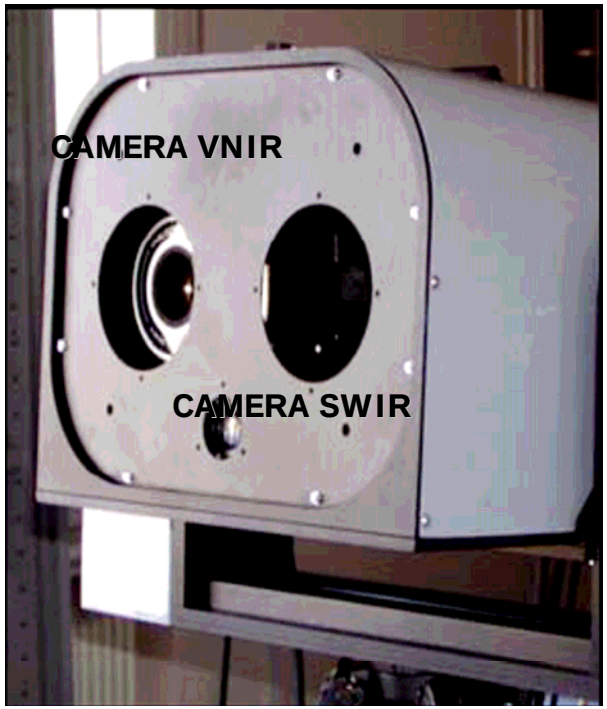
Hyper-spectral

Galileo Avionica

SIM-GA is a new airborne system composed of two hyper-spectral cameras at high spatial and spectral resolution

	VNIR	SWIR
Range Spettrale (nm)	421-1033	965-2574
N.canali	512	256
Ris. spaziale (m) @1500m	1	2
Ris. spettrale (nm)	1.2	6.3

ULM - Folder "*IRON EYE*".



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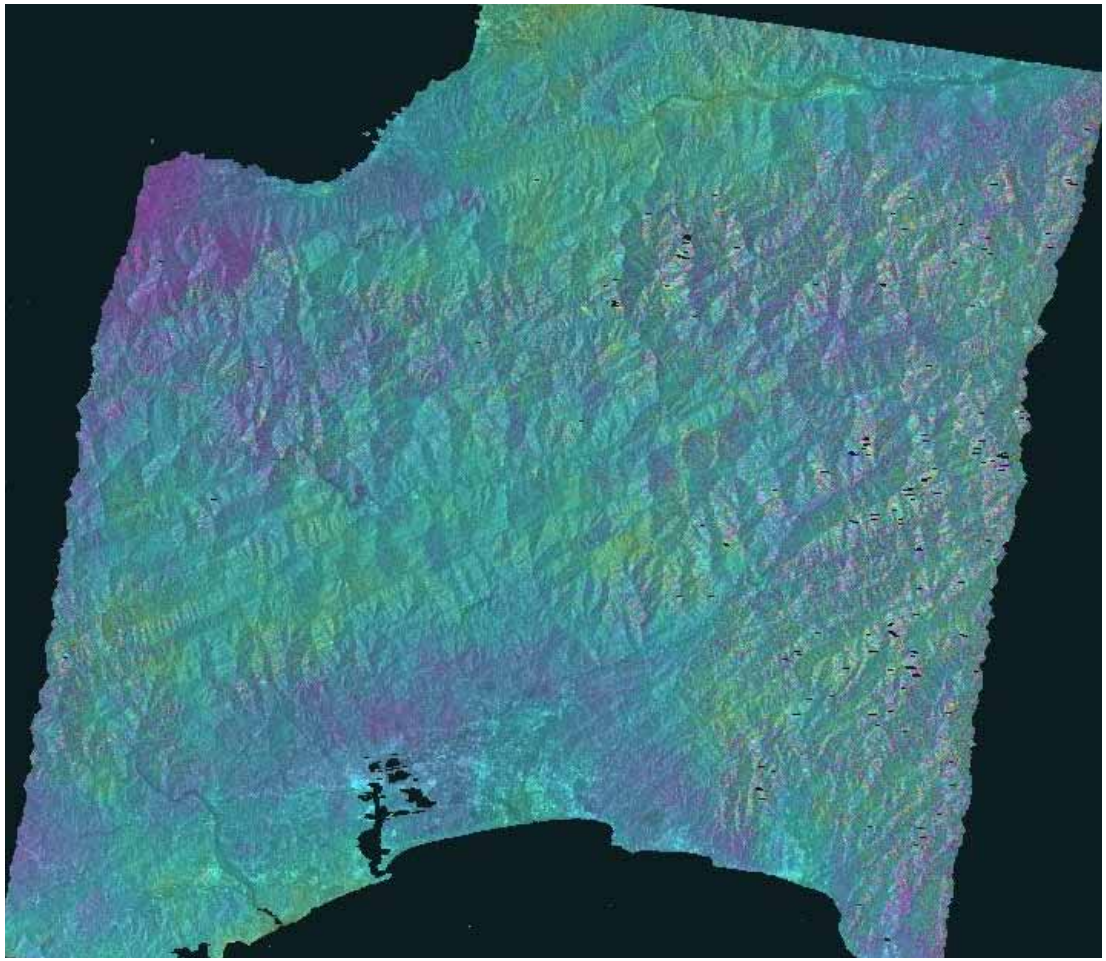
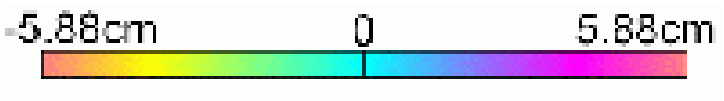
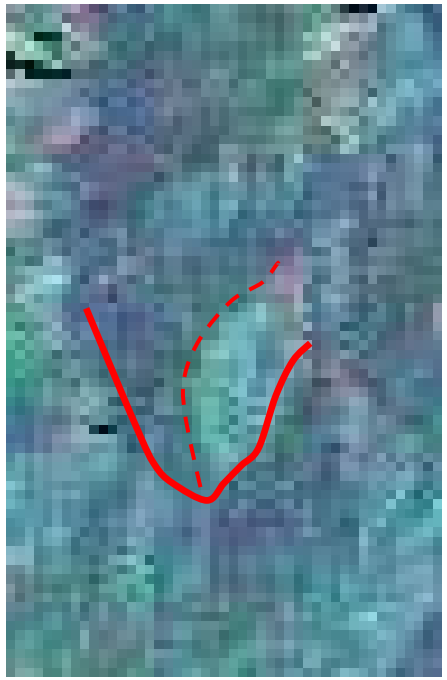
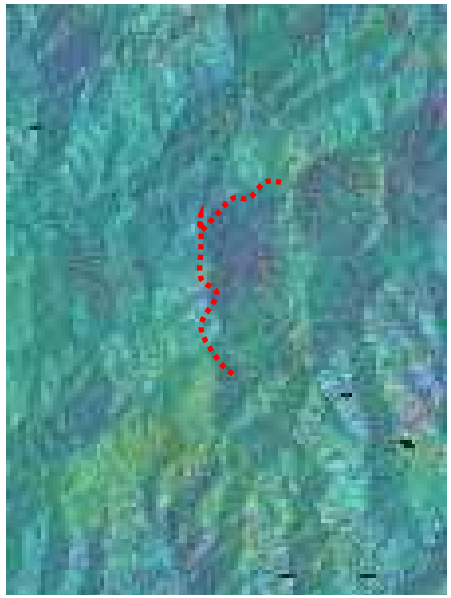




Zentoku



Nuta



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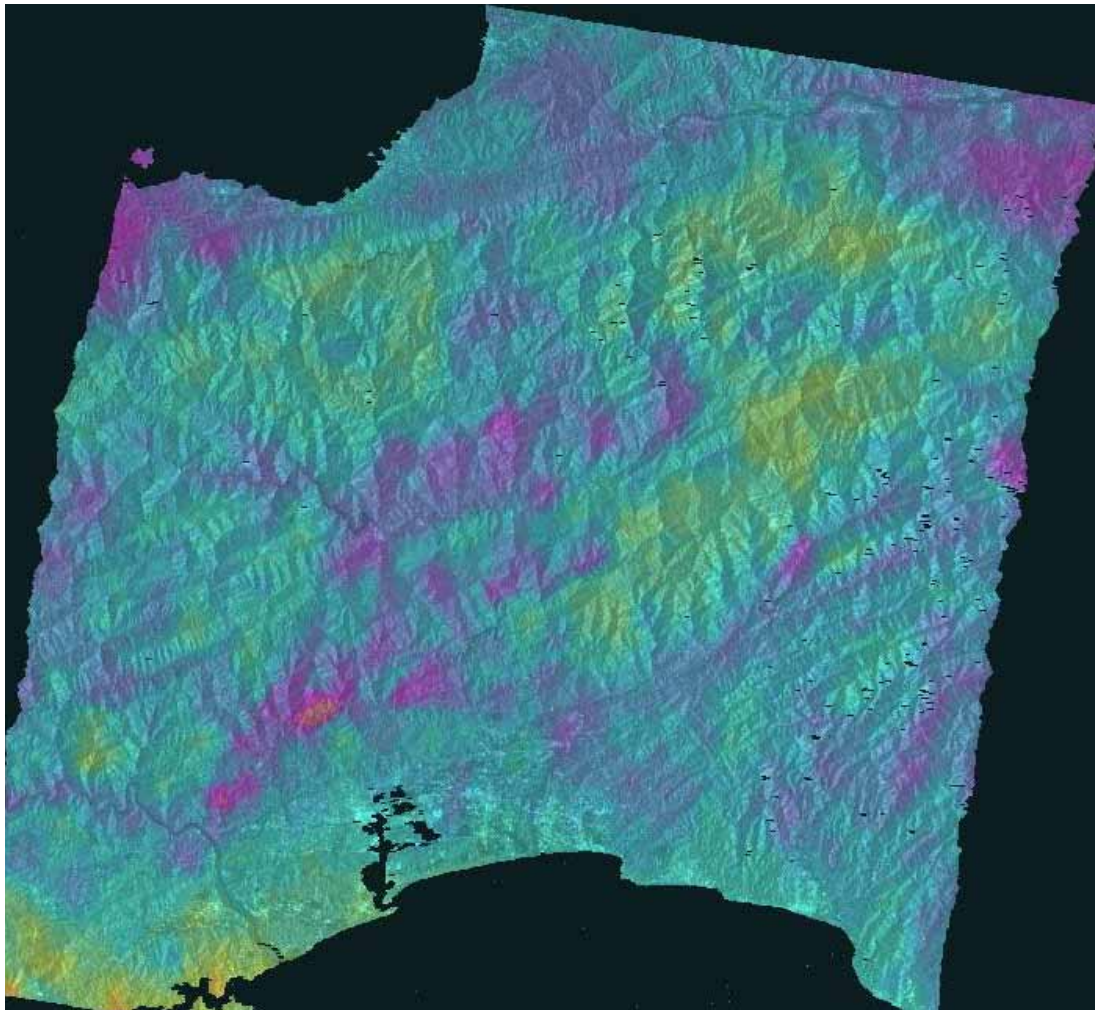
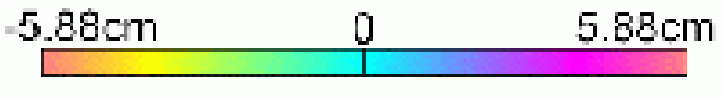
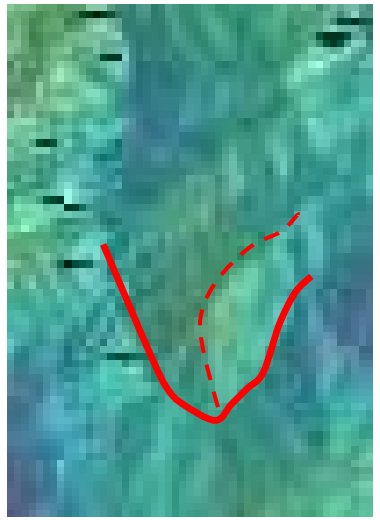
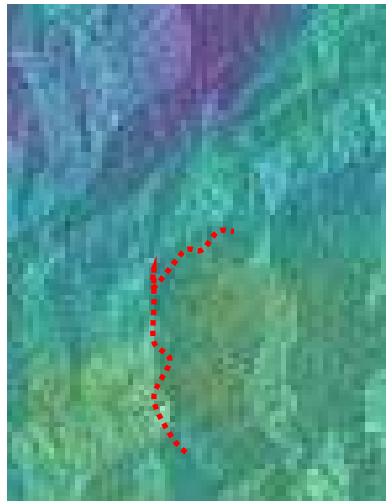




Zentoku



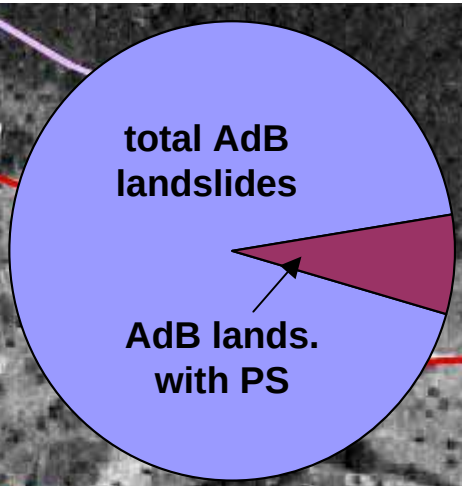
Nuta



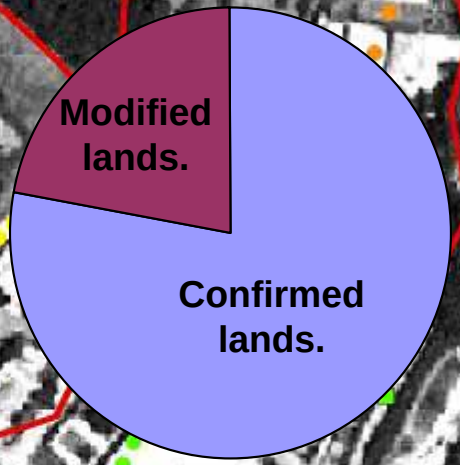
Landslide Inventory Mapping

- AdB lands.: 25.581
- PS: 669.803
- PS density: 73/km^2

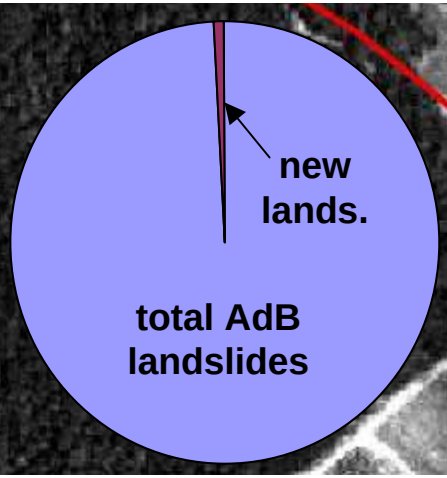
-landslides with PS: 1.728 (6.8%)



-different state of act/boundaries.: 481 (27.8%)



- new landslides: 200 (0.8%)



PS without interpretation: 844

Objectives:

The proposed project will

- (1) Advocate integration of InSAR technology into landslide disaster warning and prediction systems. The ERS (European Remote Sensing) and Envisat missions of the European Space Agency (ESA) have pioneered these applications and shall be continued for global, long-term applications. As part of this effort, facilitate efficient exploitation of data from Japan's upcoming Advanced Land Observation Satellite (ALOS) with PALSAR, an L-band SAR sensor (spatial resolution of 10 m).

Objectives:
The proposed project will

- (2) Utilize other high-resolution optical sensors relevant to landslide monitoring and detection, such as QUICKBIRD and IKONOS (1 m), ALOS's PRISM (2.5 m) and AVNIR-2 (10 m), and terra/ASTER (15 m). A passive-microwave capability would help in determining soil moisture repeatedly over broad areas.

Objectives:

The proposed project will

- (3) Facilitate the development and sharing of critical airborne sensors and capabilities, such as hyper-spectral sensors, high-resolution infrared sensors, synthetic aperture radar (SAR) and LiDAR.

Objectives:

The proposed project will

- (4) Facilitate the development and sharing of remote sensors using ground-based platforms such as SAR, infrared cameras, laser scanners and hyper spectral sensors.

Objectives:

The proposed project will

- (5) Advocate systematic expansion of landslide zonation maps, Geographic Information Systems (GIS) and Global Positioning Systems (GPS) as critical tools for managing spatial information for disaster management, including precision topography, mapping support, and deformation monitoring, as well as geolocation for search and rescue operations.

Objectives:

The proposed project will

- (6) Facilitate ongoing capacity building activities, with a focus on transferring technologies and best practices: dissemination of real-time information and early warnings to end users and the public, in concert with efforts by UNESCO and WMO to expand and improve sediment- and flood-related initiatives.

Global Monitoring for Environment and Security (GMES)

- GMES is a European initiative for the implementation of information services dealing with environment and security
- GMES will be based on observation data received from Earth Observation satellites and ground based information.
- GMES is a set of services for European citizens helping to improve their quality of life regarding environment and security.

ESA GMES: TERRAFIRMA Stage II

ESA - GMES Service Element Programme
Ground motion hazard information service distributed throughout Europe via national geological surveys and other institutions.

Partners:
Coordinator: NPA
Service Providers: UNIFI, TRE, GAMMA, ALTAMIRA, DLR,
Validation Workgroup: BGS, BRGM, TNO, ARUP, CESI
End Users: national and local authorities e.g. DPC, FOWG

Ground motion hazards:

Hazard	Motion magnitude
Swelling and shrinking soils	Millimetres to centimetres
Mass movements (slides, flows, falls, topples and cambers)	Centimetres to 100s metres
Dissolution	Centimetres to 10s metres
Compressible and collapsible soils	Millimetres to centimetres
Running conditions	Millimetres to metres
Earthquakes	Centimetres to 100s metres

EC GMES: PREVIEW

- Prevention Information and Early Warning
  - EC Integrated Project
  - Coordinator: ASTRIUM

- New information services to help risk management
  - Based on Core Users needs - Mature and New Services
  - Dissemination & Training - Pre operational Validation

- Operational platforms
  - Floods
  - Windstorms
  - Fires
  - Earthquake & Volcanoes
  - Landslides
  - Man-made Risks
  - Assets Mapping, Damages

GMES Fast-track services

- Fast Track services are GMES services that have been identified as first candidates for “fast track” treatment, with the objective of being operational by 2008.

- This selection has been performed on the basis of the following criteria: their maturity, uptake by user communities and long term sustainability of demand and supply.

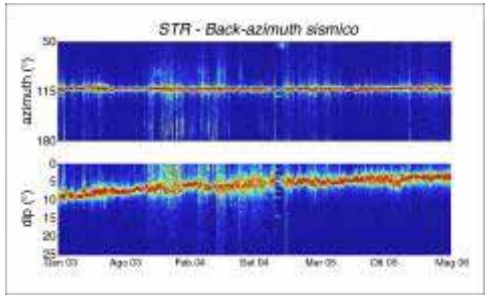
- As a result, three "fast track" services have been identified:
  - A service on emergency response (INSCRIT - Information Service in Response to Crises, Disasters and Emergencies)
  - A service on land monitoring (LMCS - Land Monitoring Core Service)
  - A service on marine (MCS - Marine Core Service)

28 December 2002

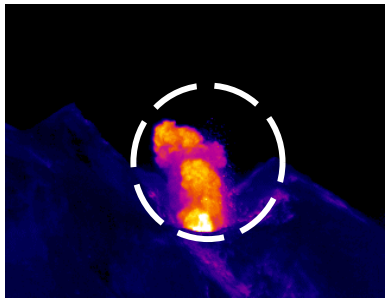
Integrated monitoring networks

Meteo

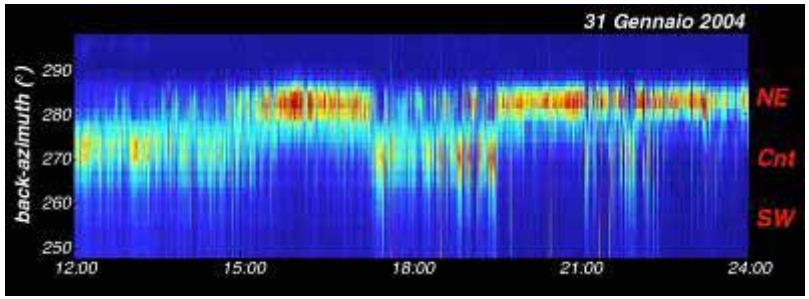
Broadband seismology



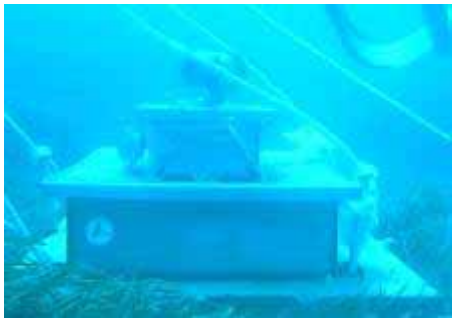
Thermal infrared



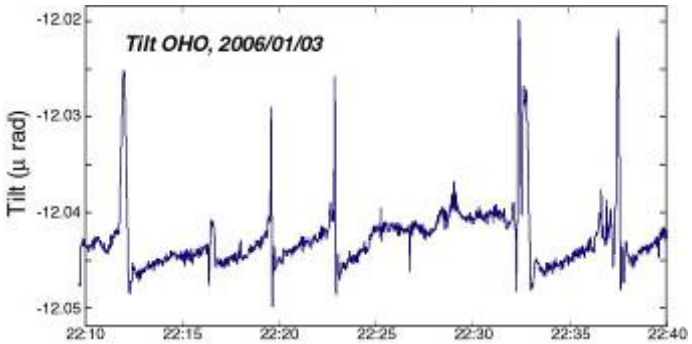
Infrasound acoustics



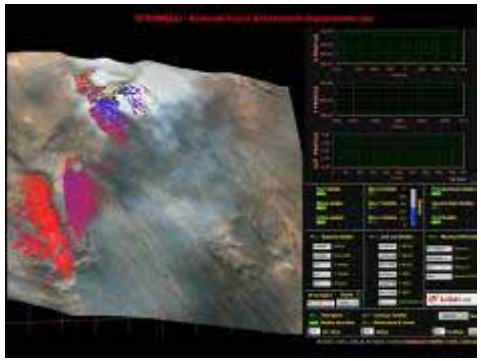
Broadband ondameters



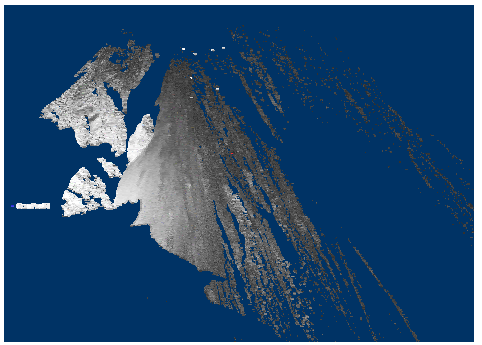
Ground deformation (tiltmeters)



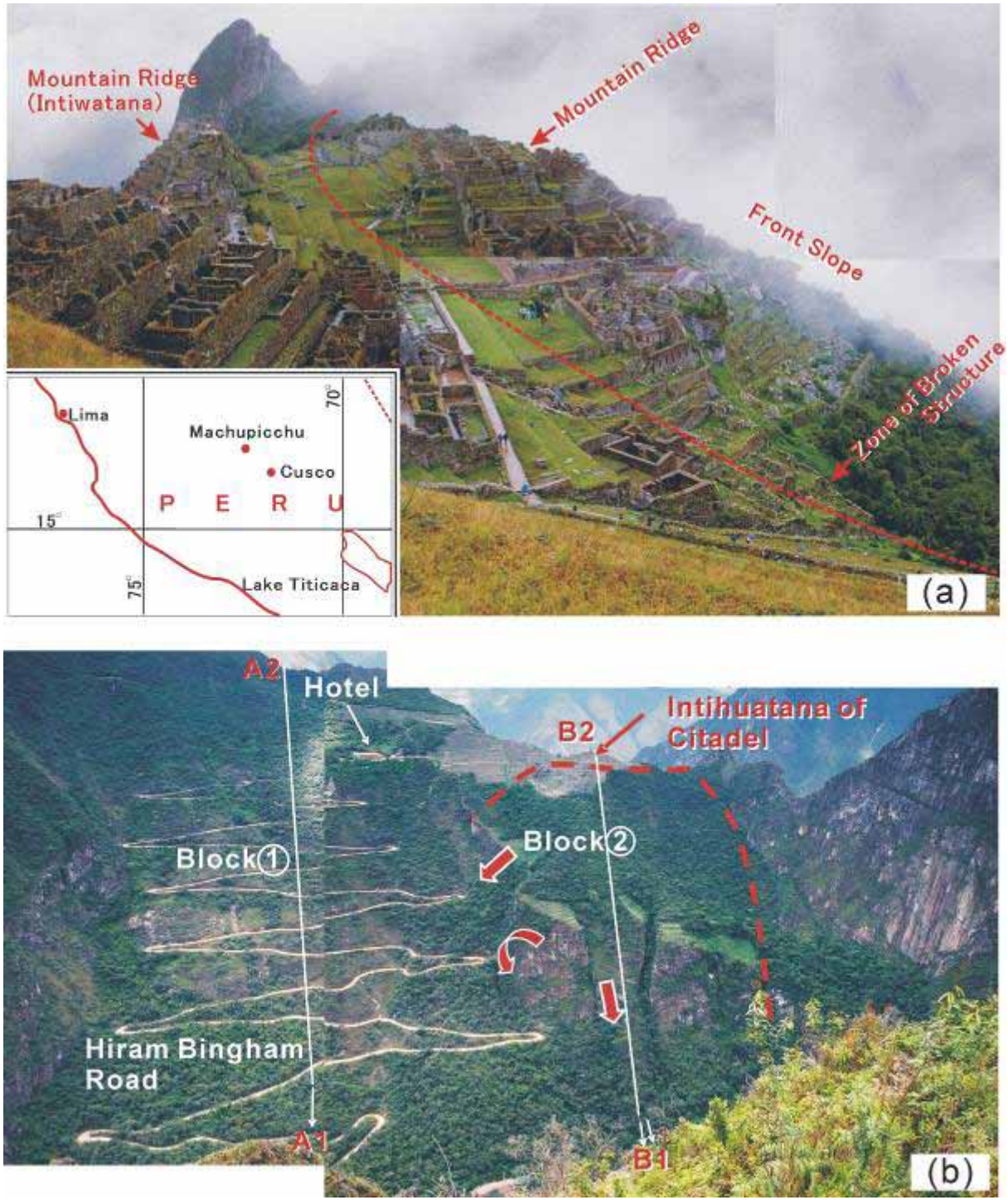
Ground deformation (InSAR da terra)



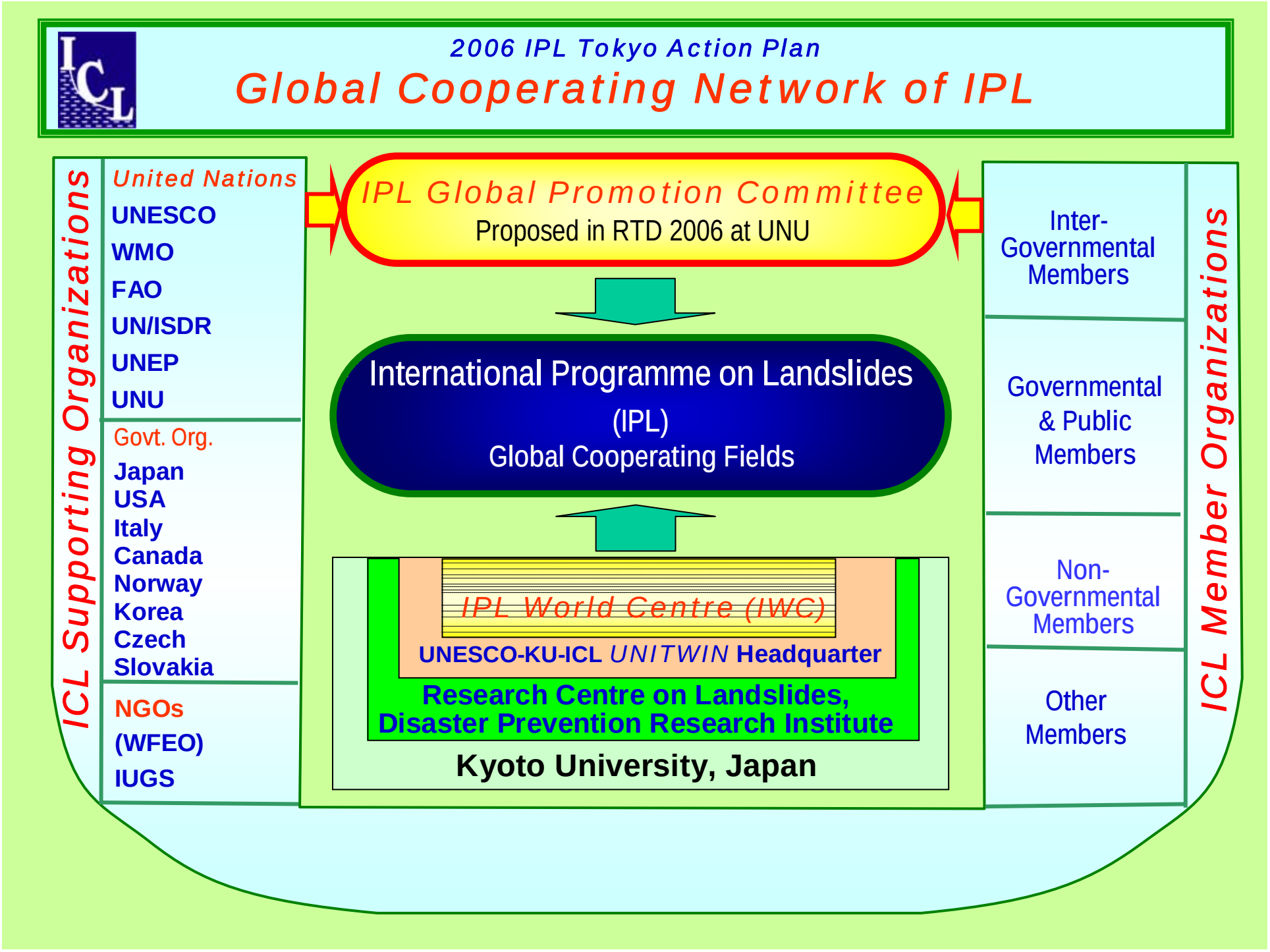
Ground deformation (Laser 3D)



SARによる解析地域



(a) Machu Picchu Citadel and a line crossing the Plaza as noted taken by Sassa (2000); (b) Machu Picchu slope with interpretation of Block No.1 (Hiram Bingham area) and Block No.2 (Citadel area) (from Sassa 2005, UNESCO brochure)

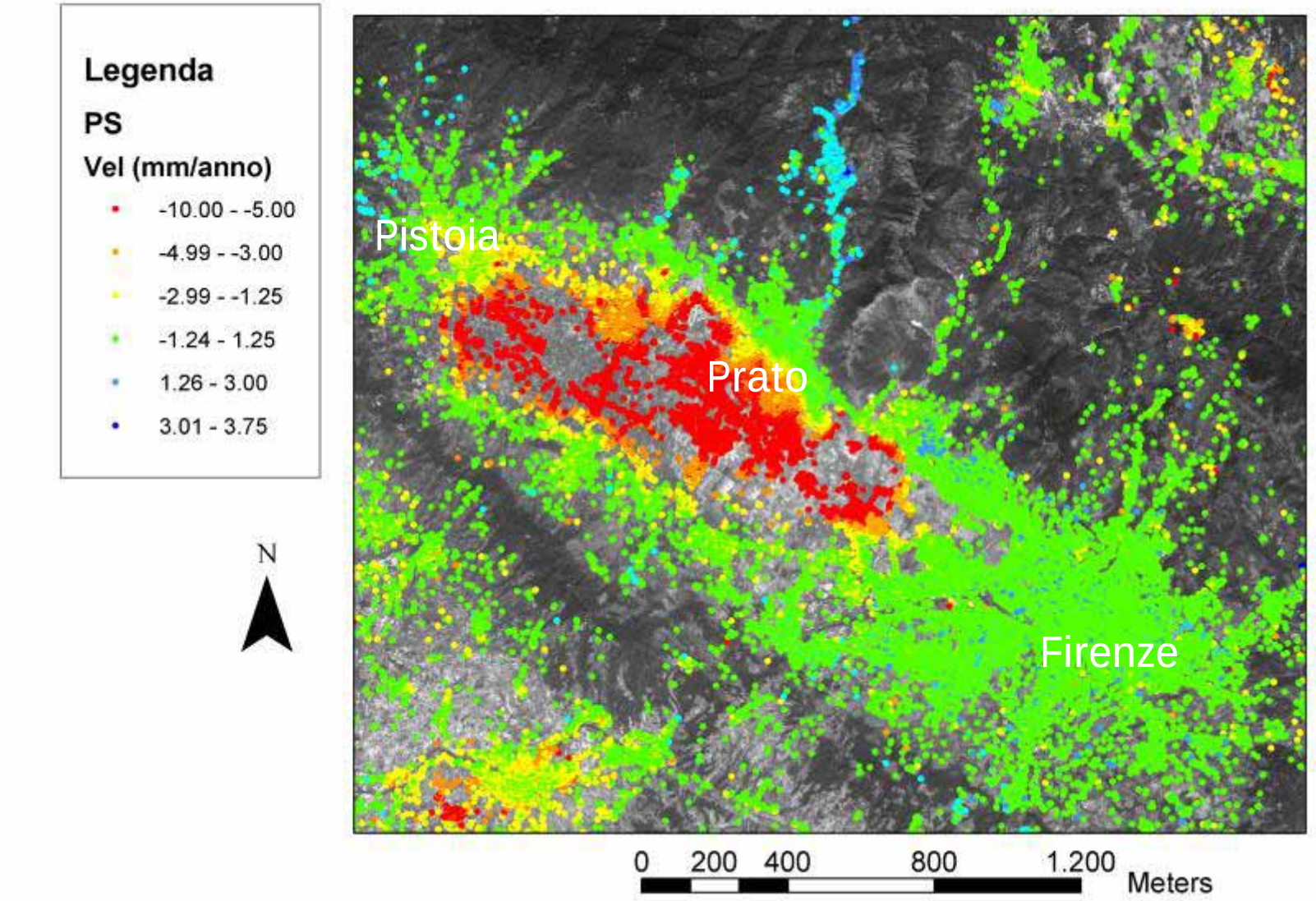

2006 IPL Tokyo Action Plan
Global Cooperating Network of IPL
ICL Supporting Organizations
United Nations
UNESCO
WMO
FAO
UN/ISDR
UNEP
UNU
Govt. Org.
Japan
USA
Italy
Canada
Norway
Korea
Czech
Slovakia
NGOs
(WFEO)
IUGS
IPL Global Promotion Committee
Proposed in RTD 2006 at UNU
International Programme on Landslides
(IPL)
Global Cooperating Fields
IPL World Centre (IWC)
UNESCO-KU-ICL UNITWIN Headquarter
Research Centre on Landslides,
Disaster Prevention Research Institute
Kyoto University, Japan
Inter-Governmental Members
Governmental & Public Members
Non-Governmental Members
Other Members
ICL Member Organizations

(2004 – 2008)

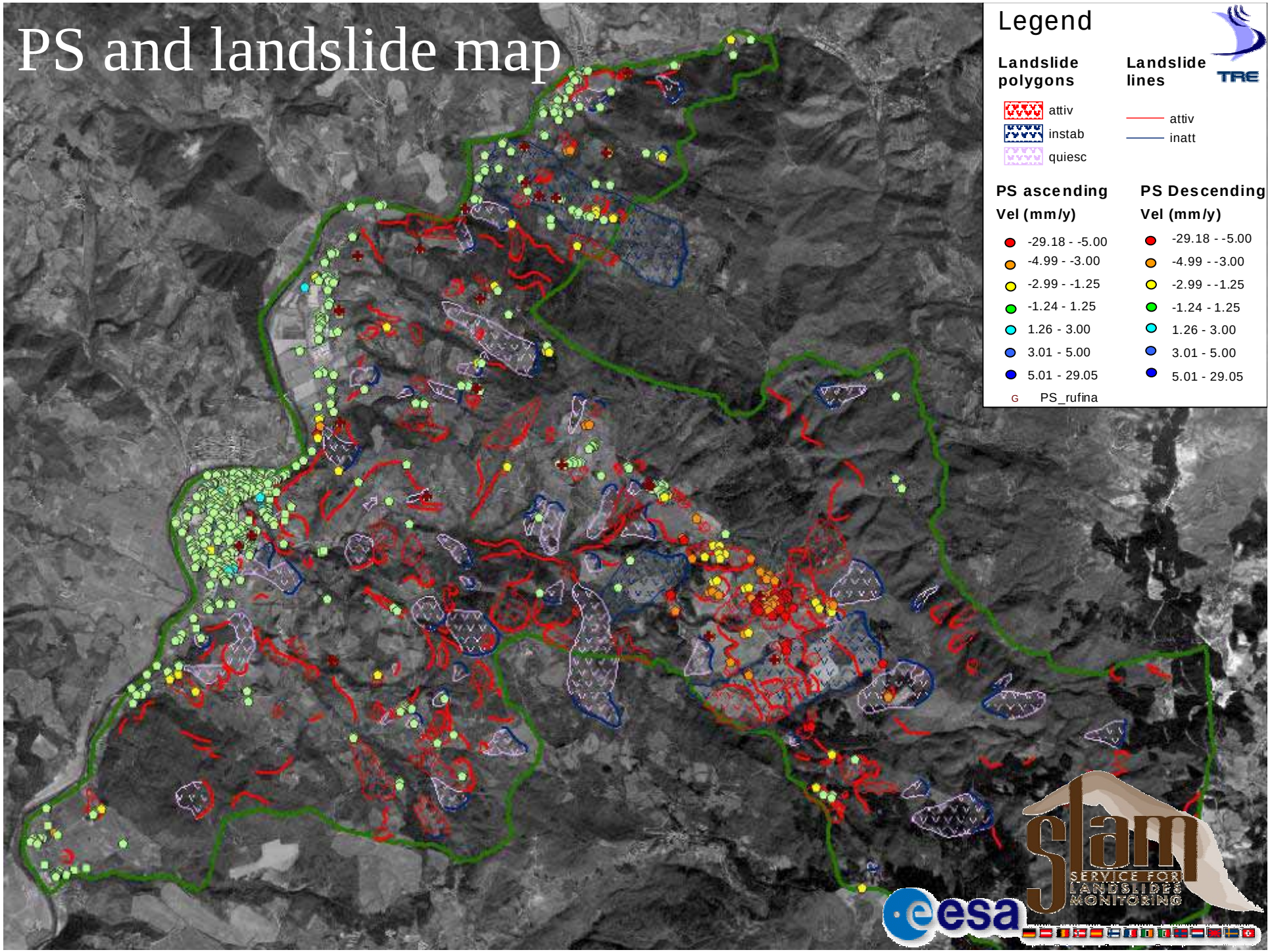
Integrated Global Observing Strategy

The IGOS GeoHazards Initiative intends to respond to the scientific and operational geospatial information needs for the prediction and monitoring of geophysical hazards, namely earthquakes, volcanoes and land instability.

Subsidence map of the Firenze basin



PS and landslide map



Satellite monitoring of single landslides

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION

LiSA

LiSALab © 2003

Portable SAR apparatus used for ground-based interferometry

Installation of LISA system in Machu Picchu, Peru

View from Lisa

Interpretation of the radar image