



United Nations
Educational, Scientific and
Cultural Organization



UNIVERSITÀ
DEGLI STUDI
FIRENZE

- UNESCO Chair on the Prevention and
- Sustainable Management of Geo-Hydrological Hazards,
- University of Florence, Italy

Monitoraggio e allertamento per il rischio di frana

Nicola Casagli



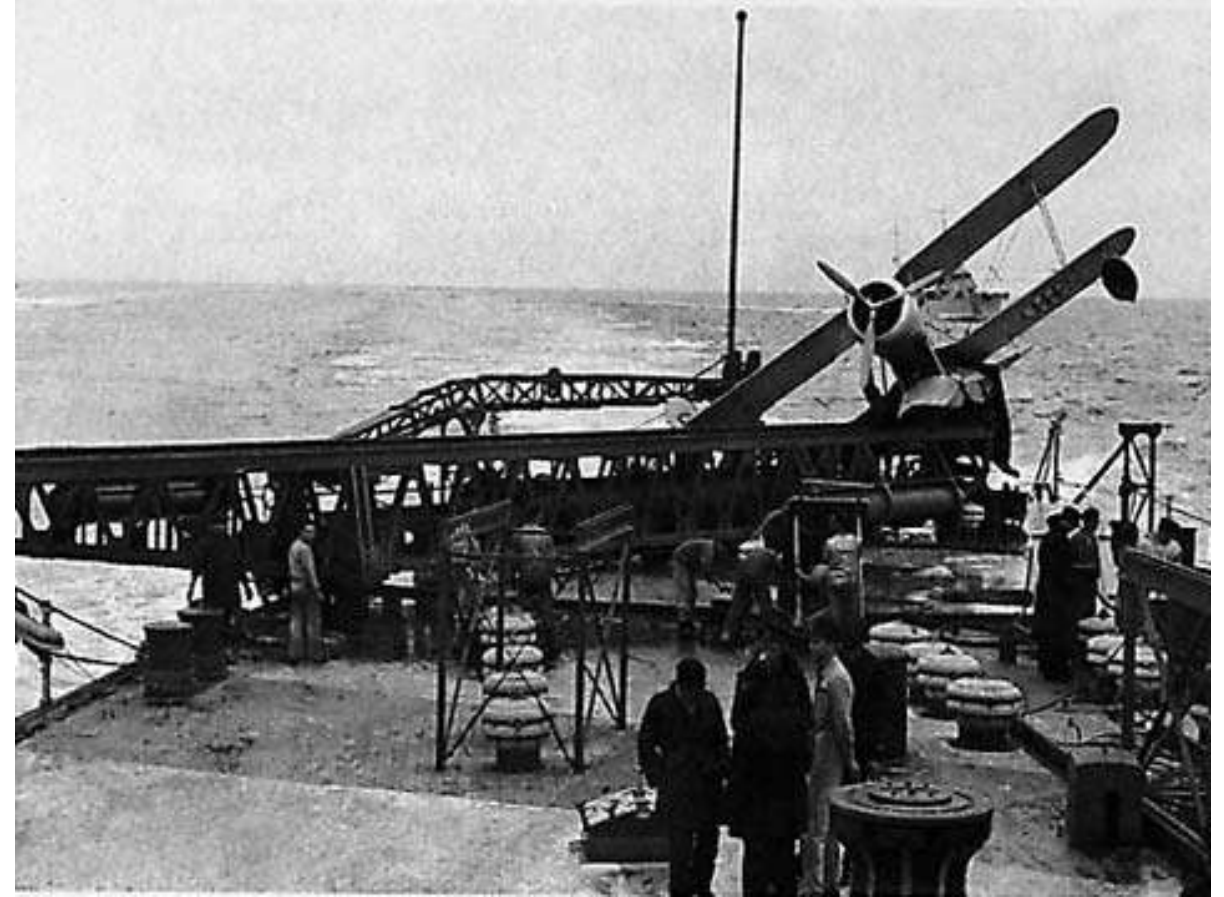
1874-1937

Non vi è distanza
sulla terra che le
radiocomunicazioni
non possono
superare

Guglielmo Marconi



Ugo Tiberio (1904-1980)



Capo Matapan (28-29 marzo 1941)

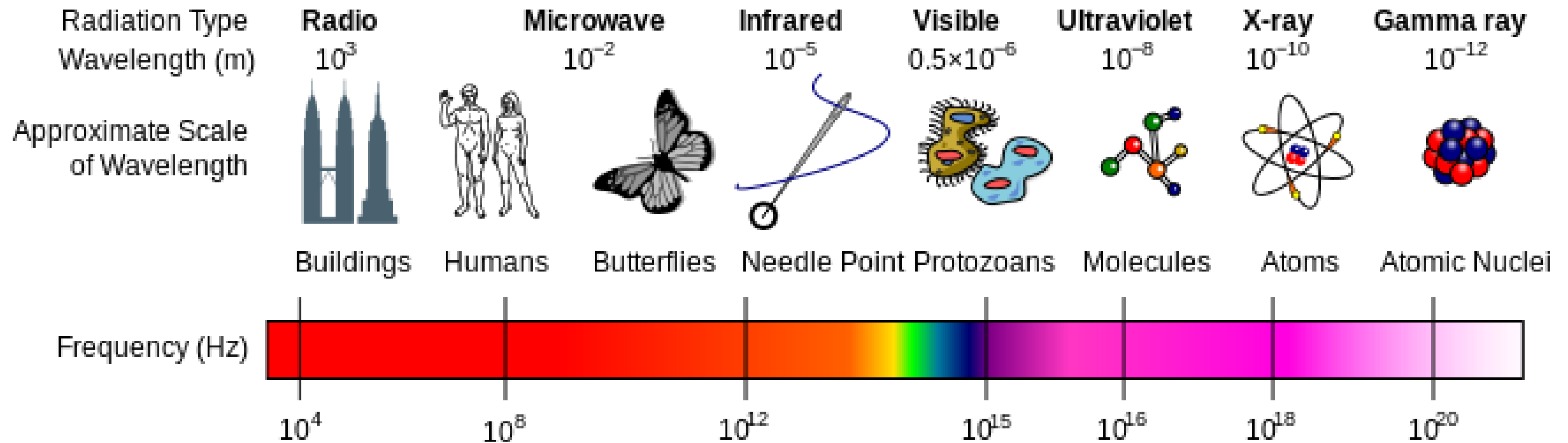
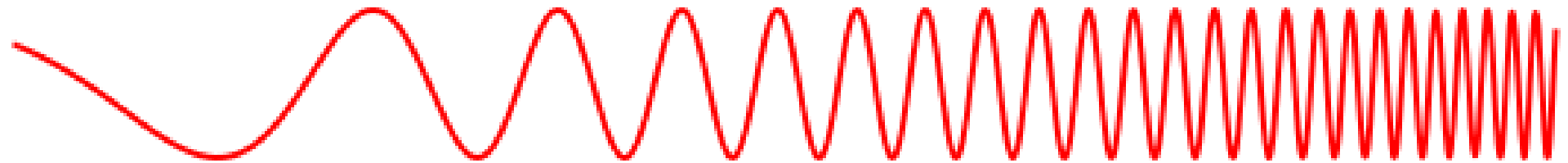


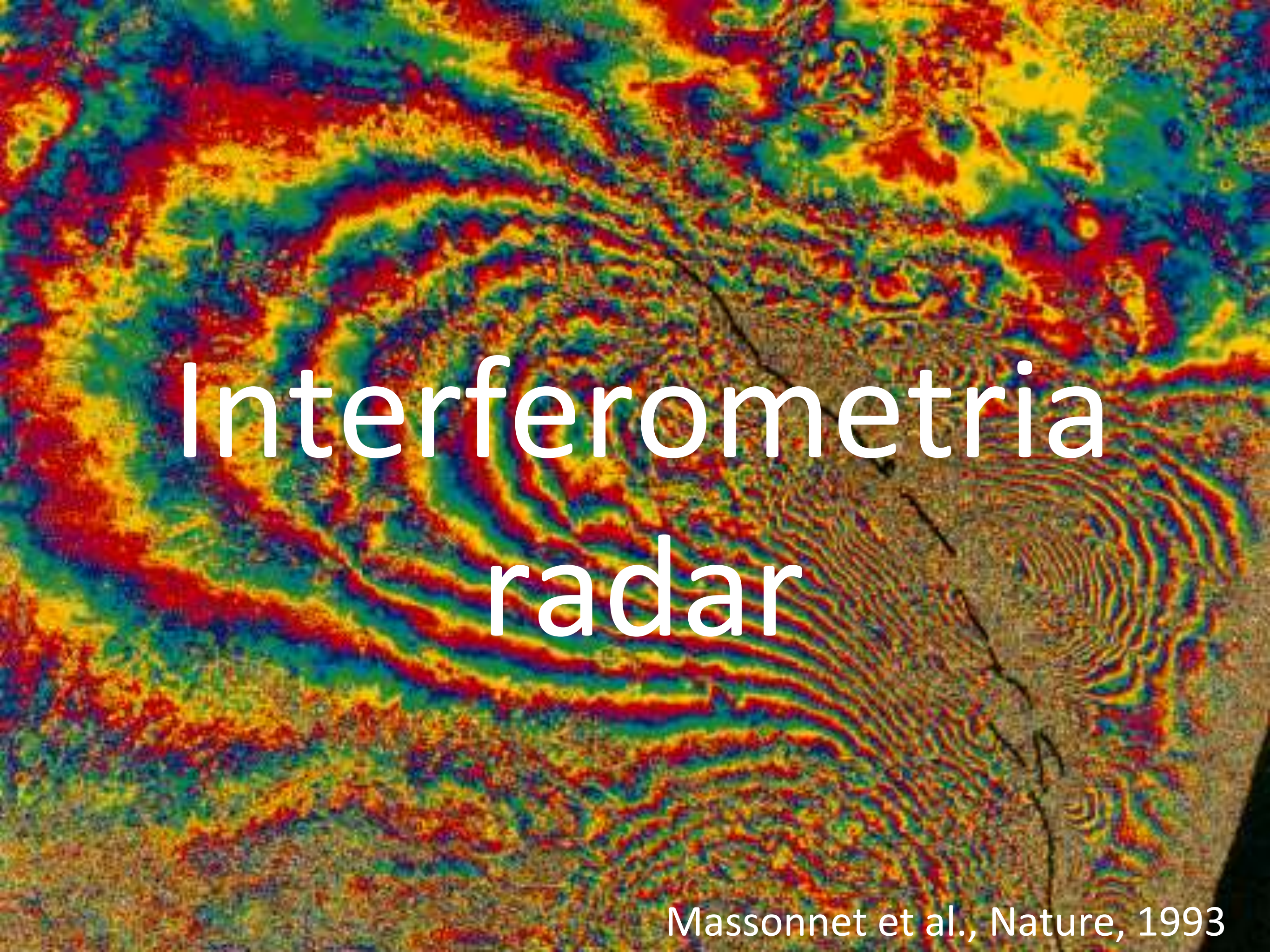
**Il radar italiano
sulla corazzata
Roma**

Spettro elettromagnetico



RADAR





Interferometria radar

Massonnet et al., Nature, 1993

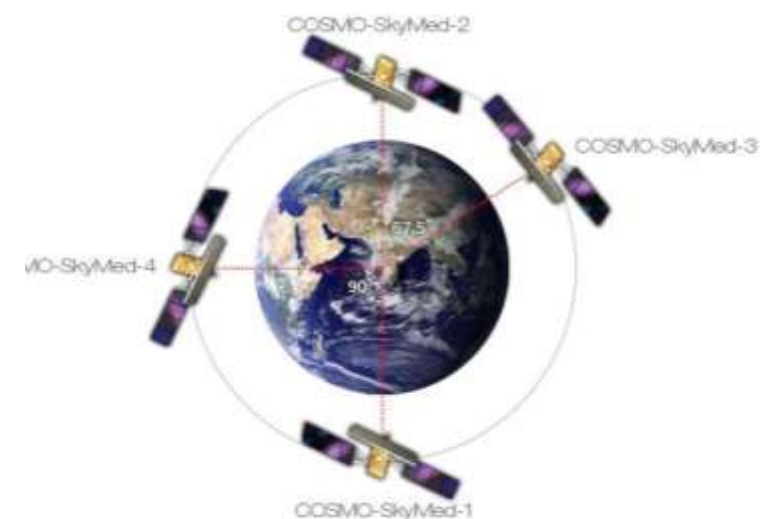
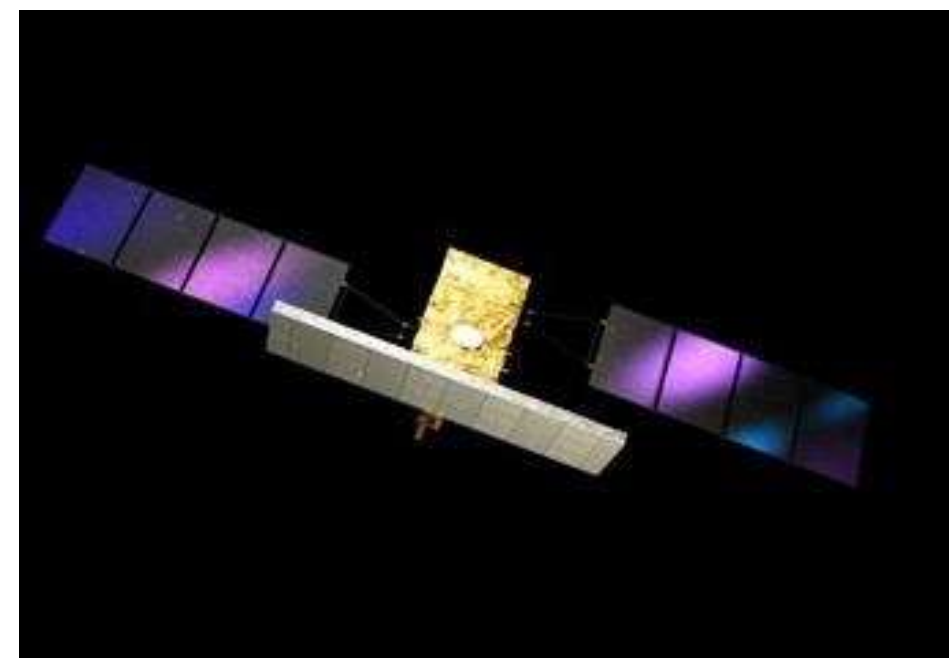
Radar e frane



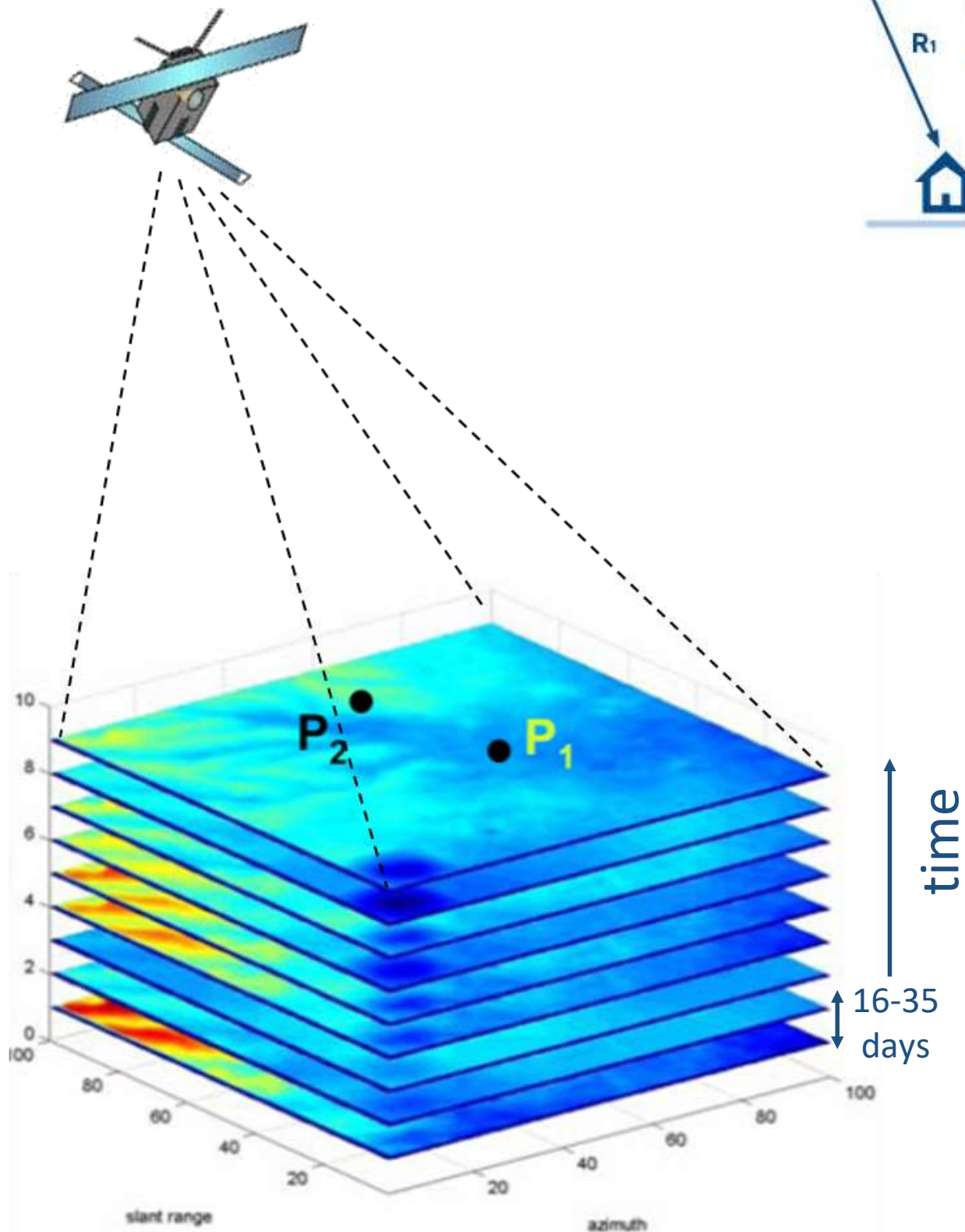
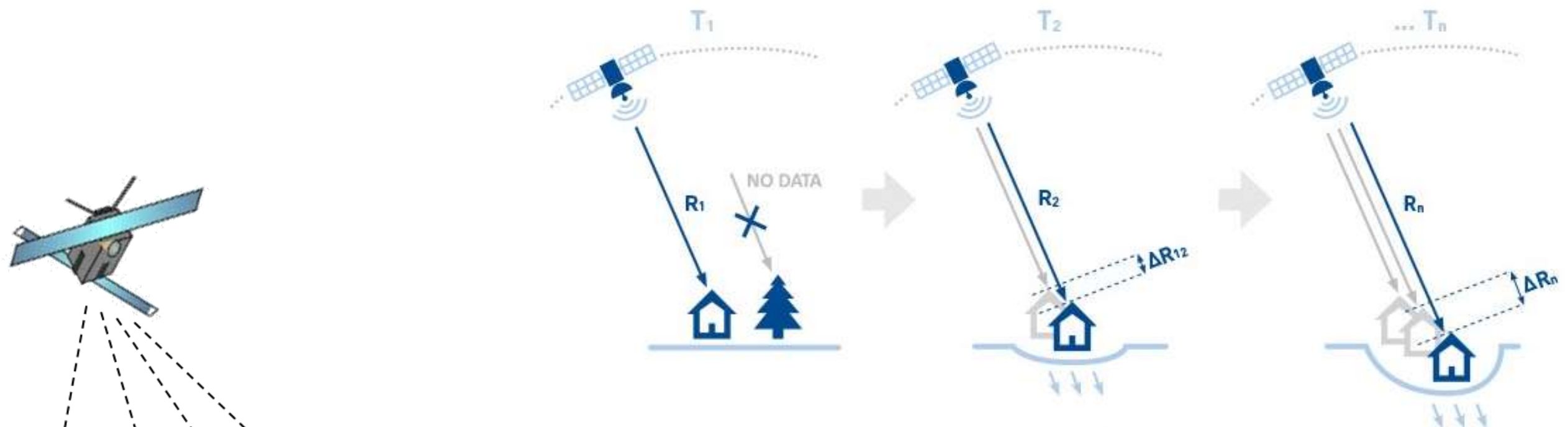
Velocità della frana

Interferometria radar satellitare

Satellite InSAR monitoring

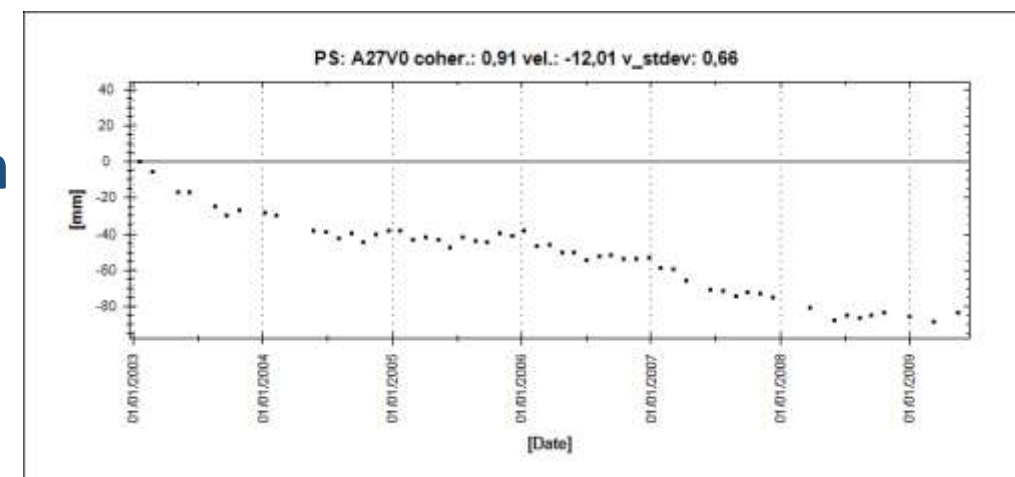
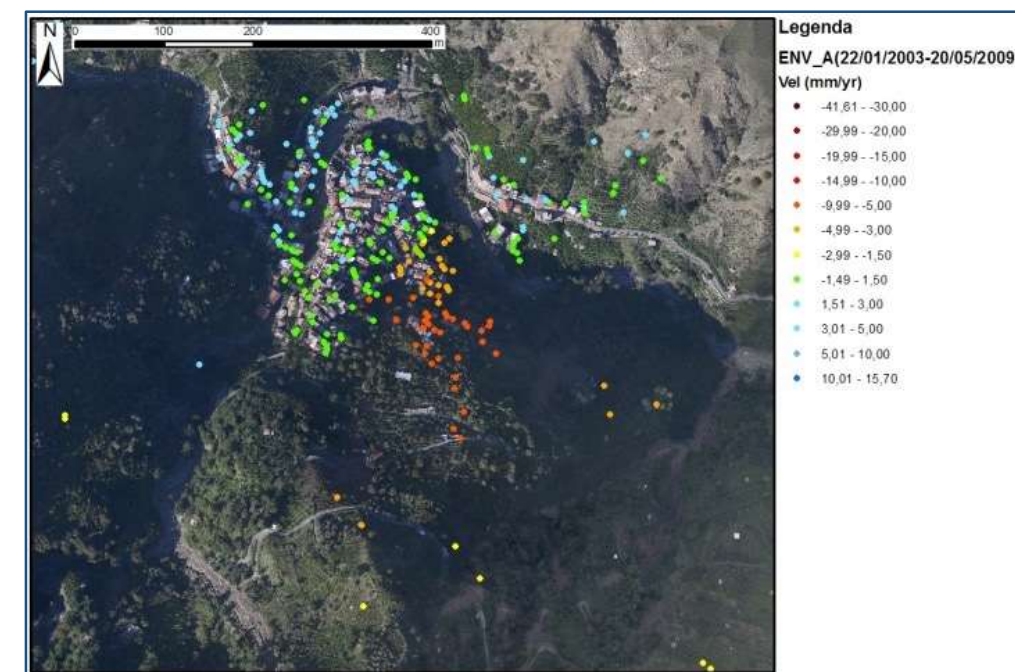


Persistent scatterers



LOS average
displacement
rate

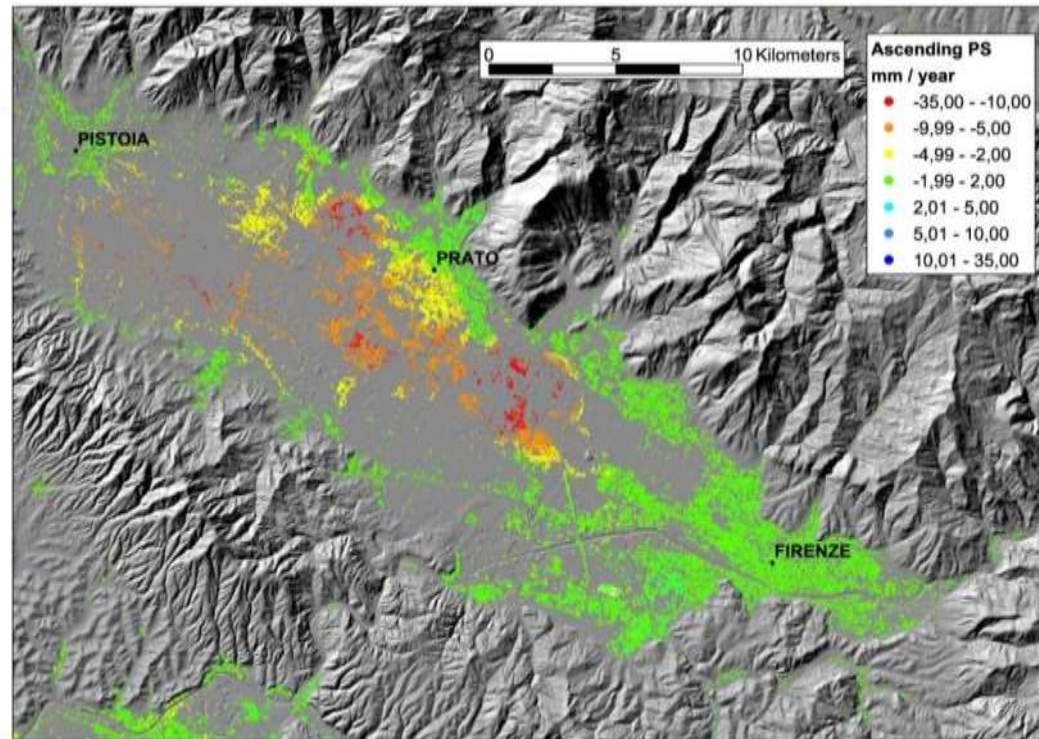
Deformation
time series



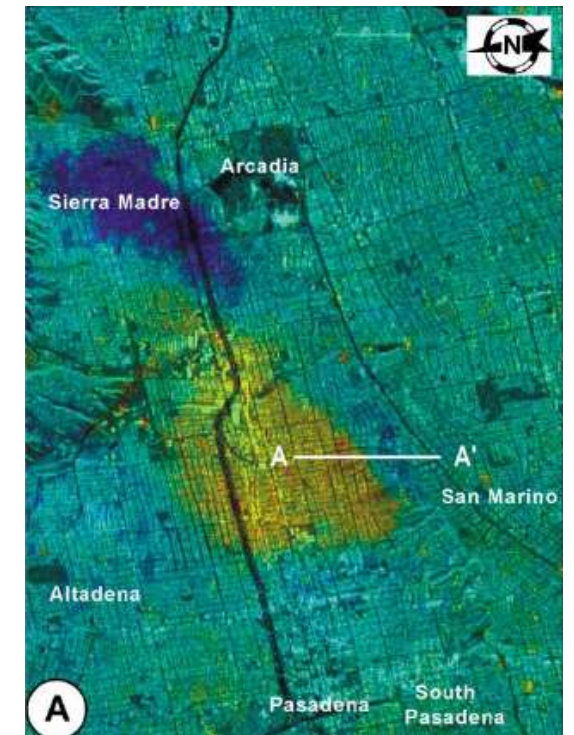
Campi di applicazione



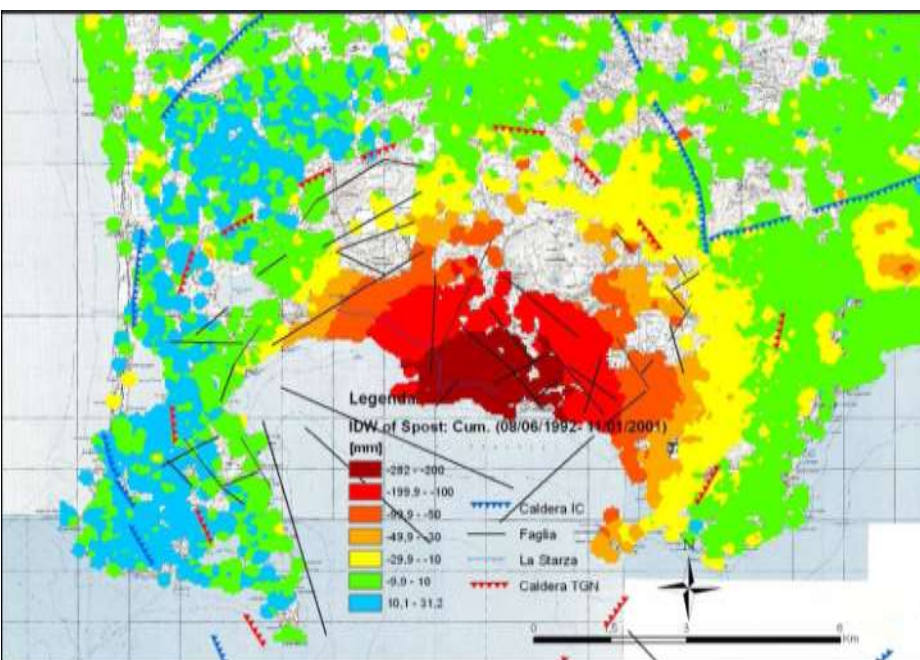
Frane a cinematica lenta



Subsidenza



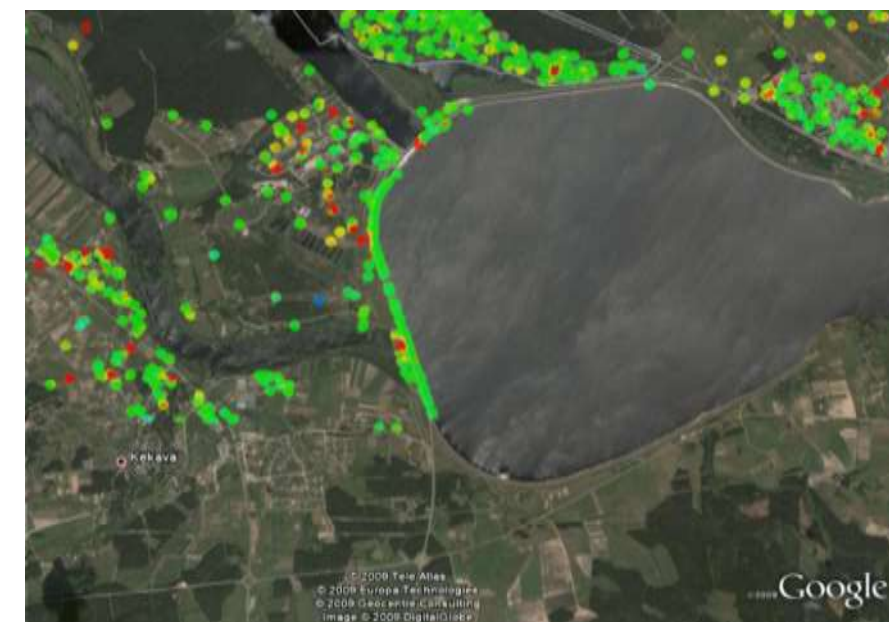
Movimento tettonici



Attività vulcanica



Analisi sul singolo edificio

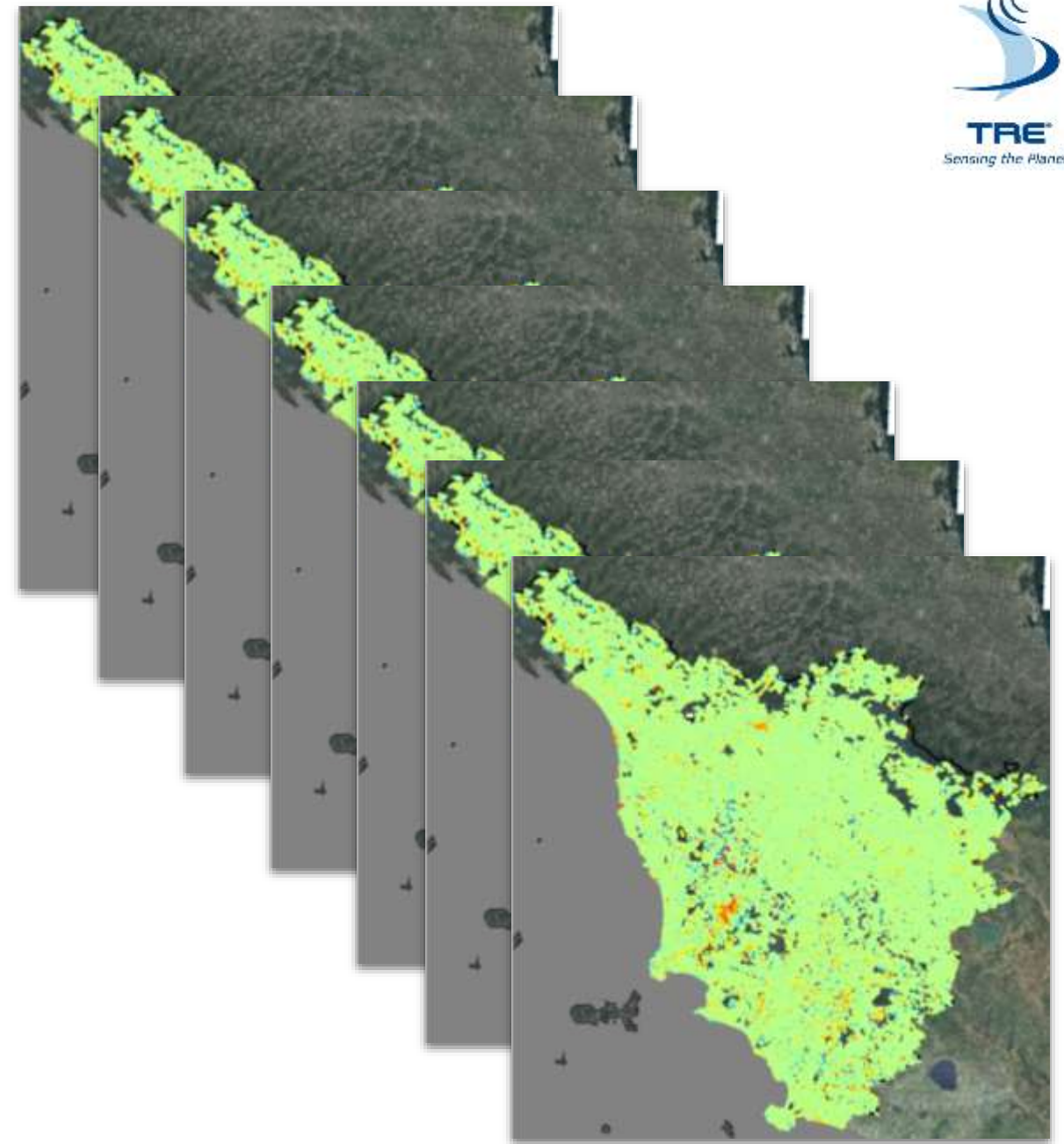


Monitoraggio di strutture arginali

PS Continuous Streaming



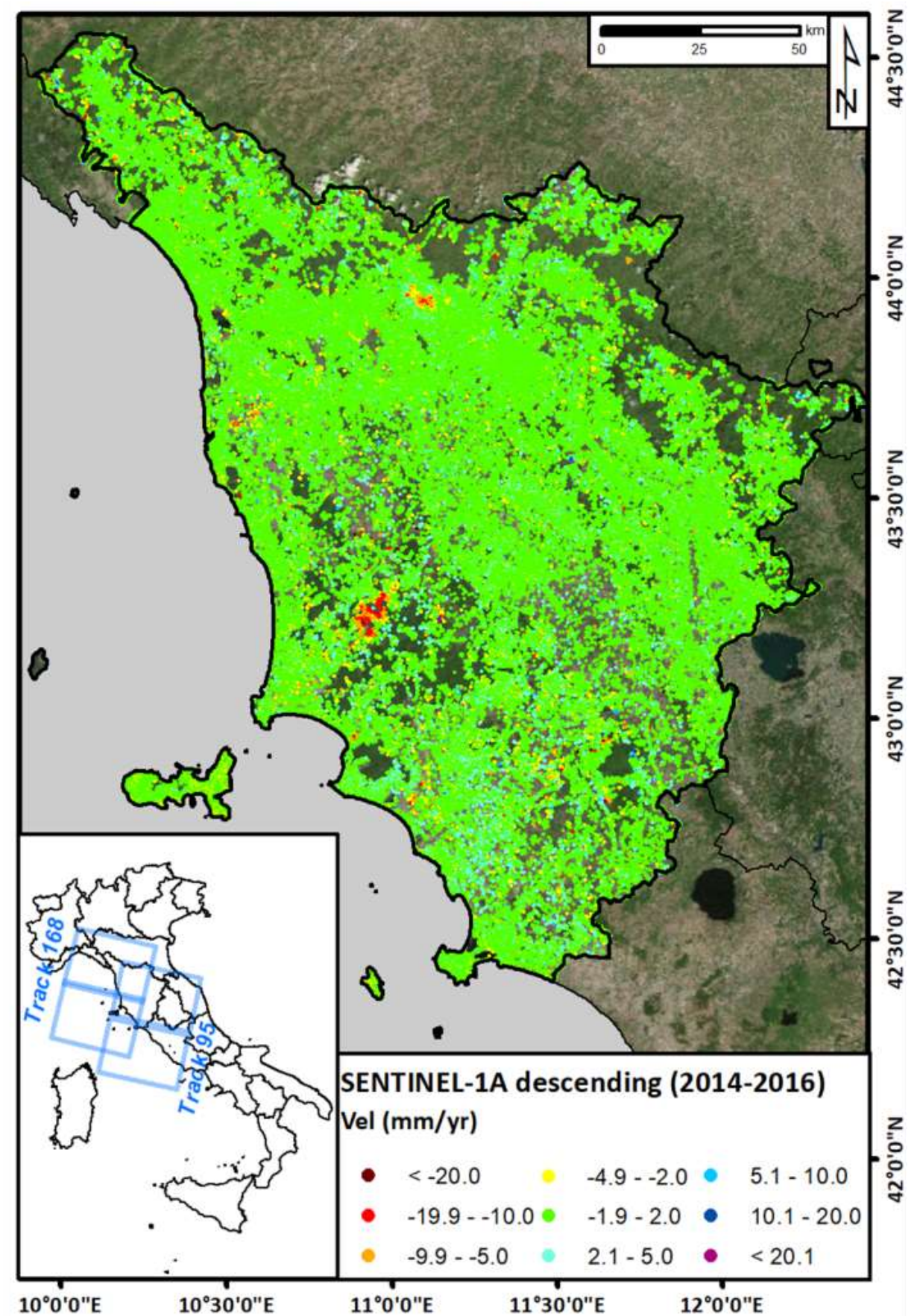
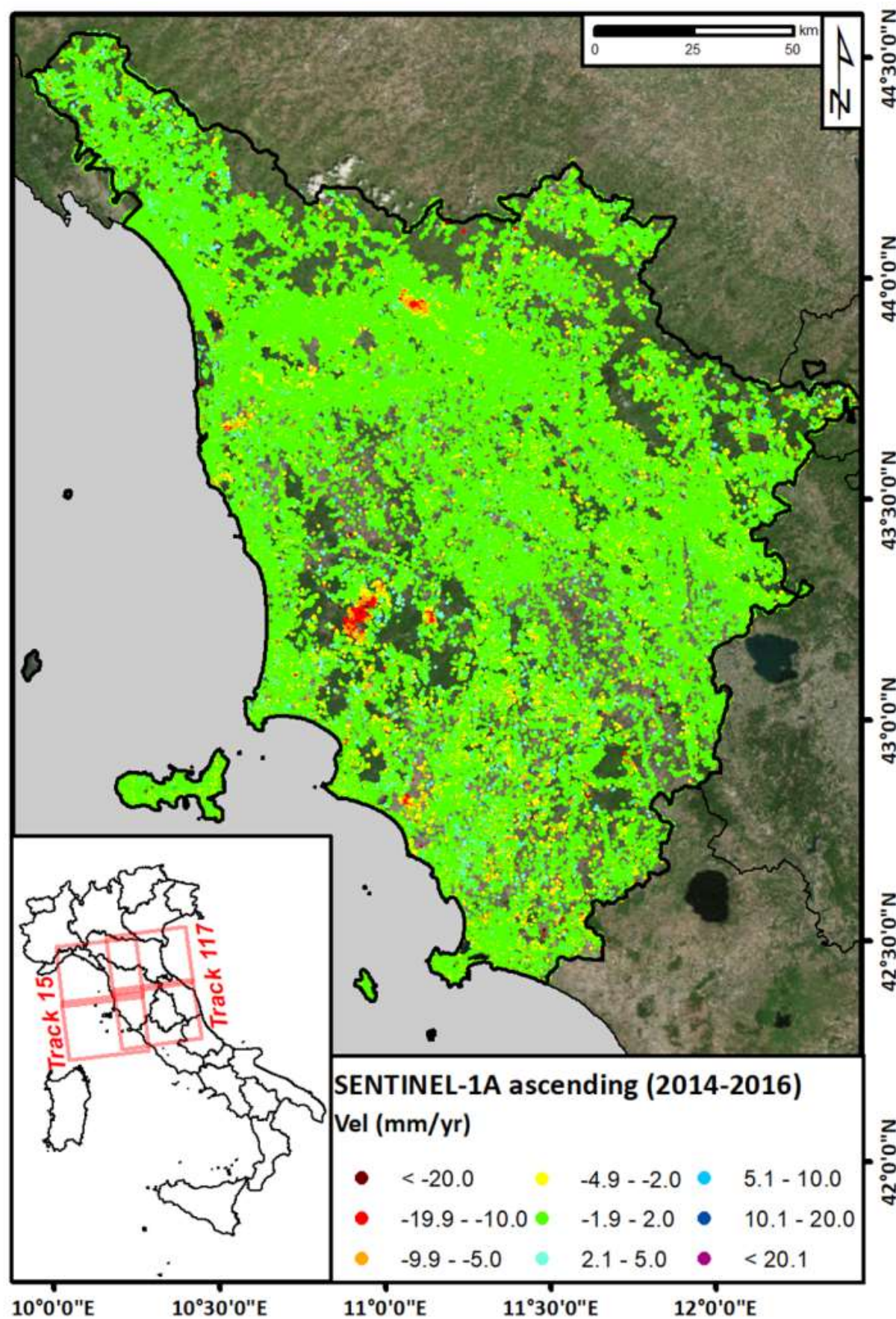
European Space Agency



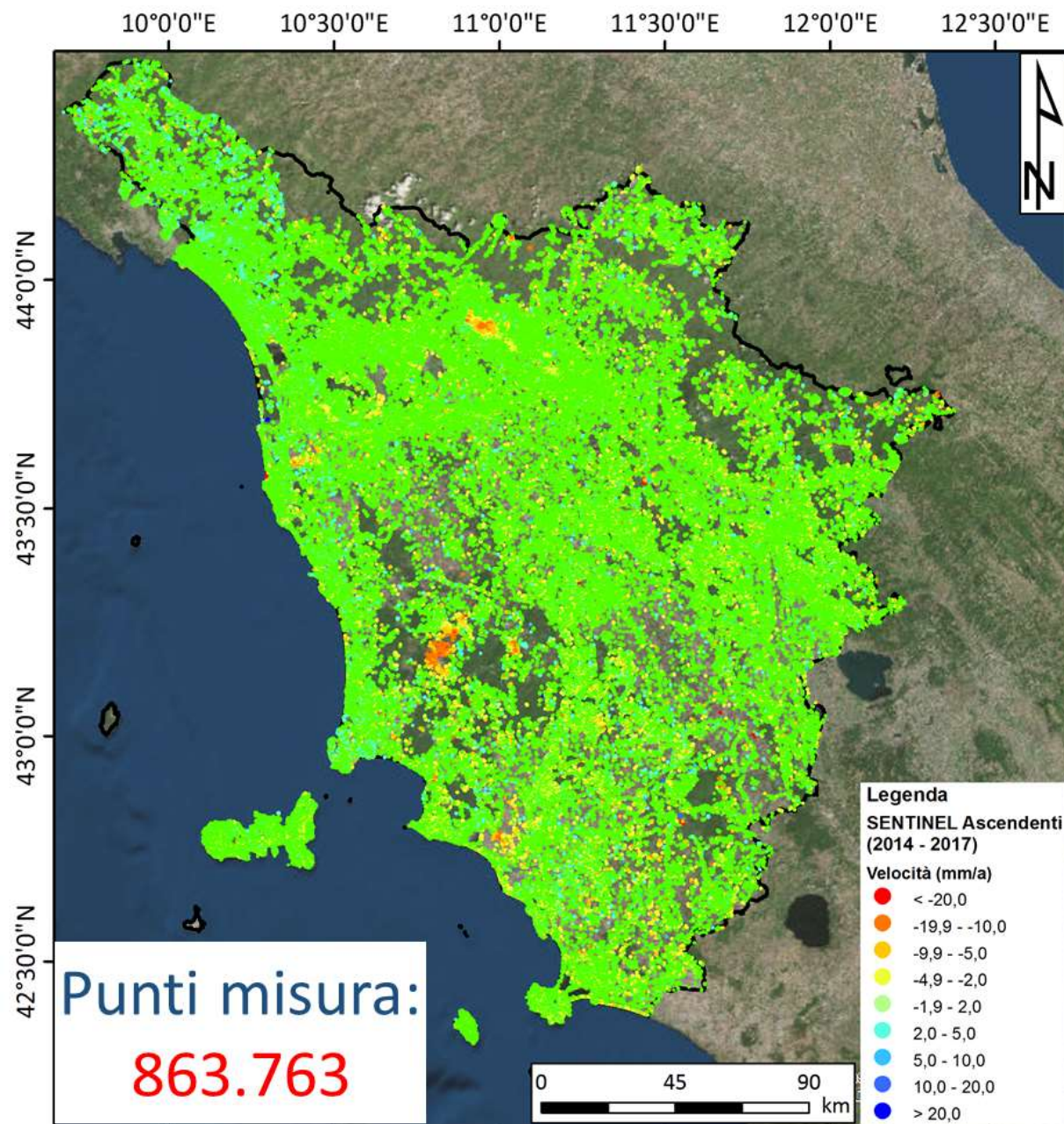
Revisiting time: 6 days

First application of PS-InSAR Continuous Streaming at regional scale (2016)

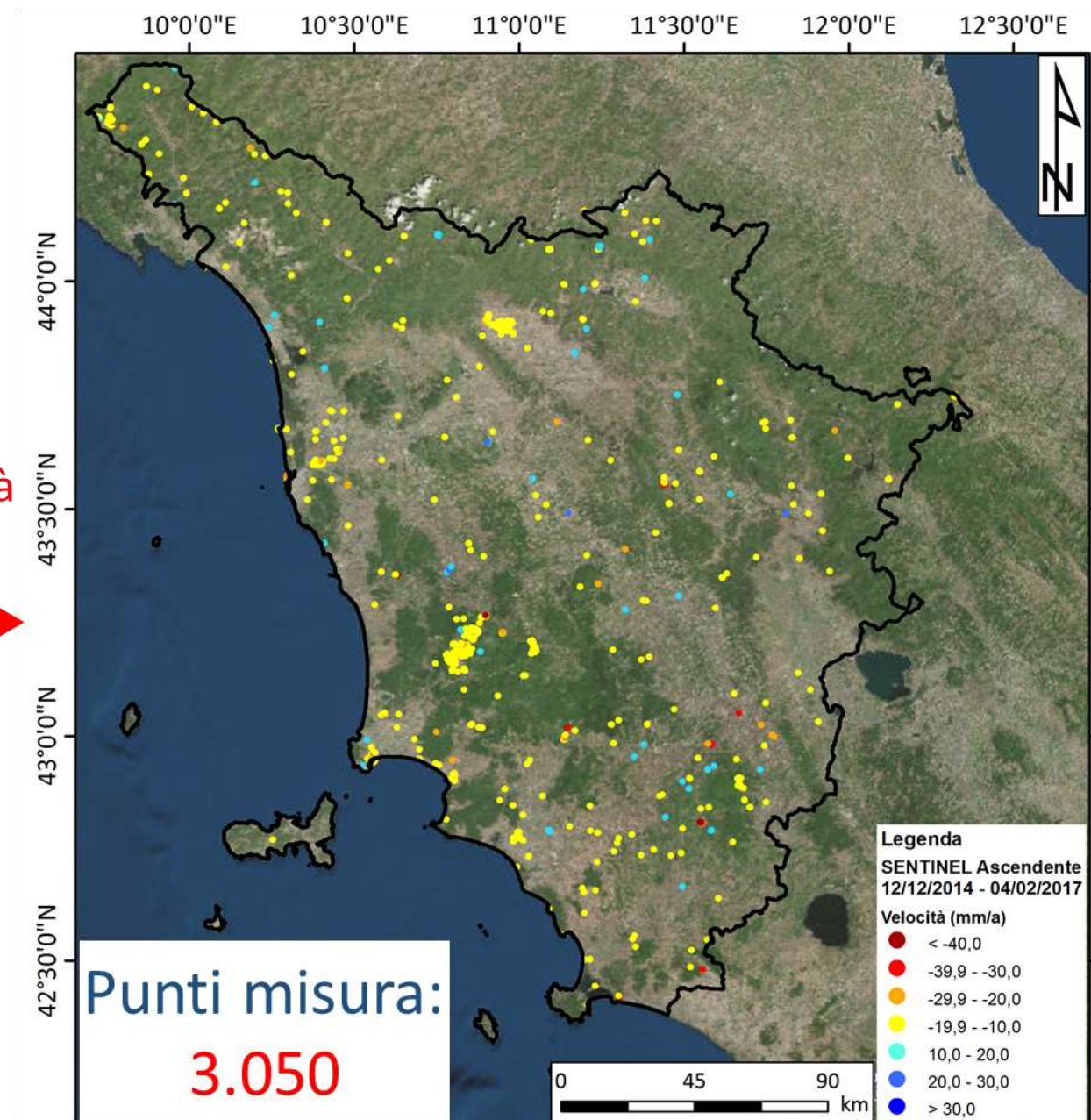
Copertura SAR Sentinel-1



PS mapping: mappatura in tempo differito (Dir. PCM 27/02/2004)

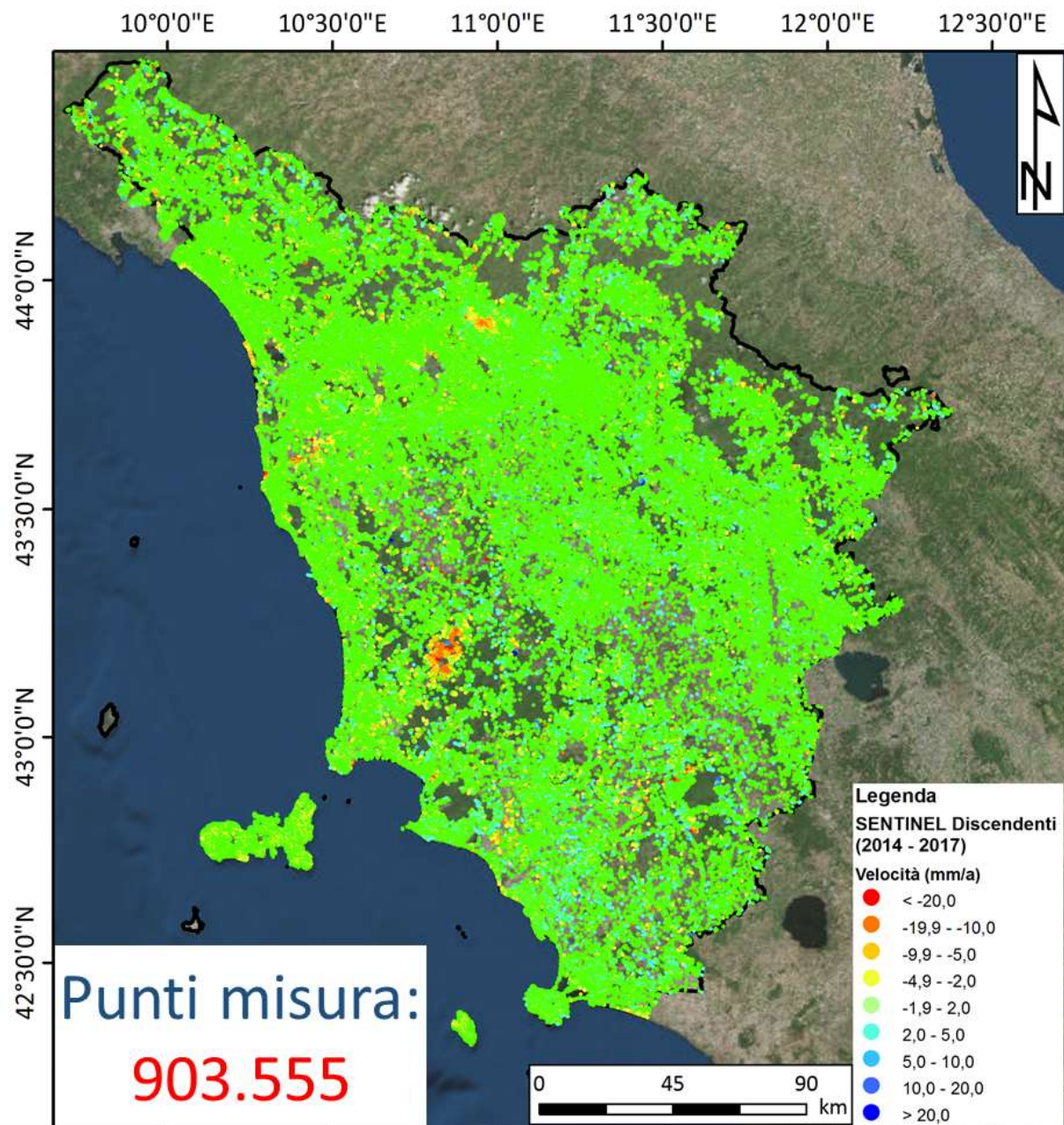


Soglia
velocità

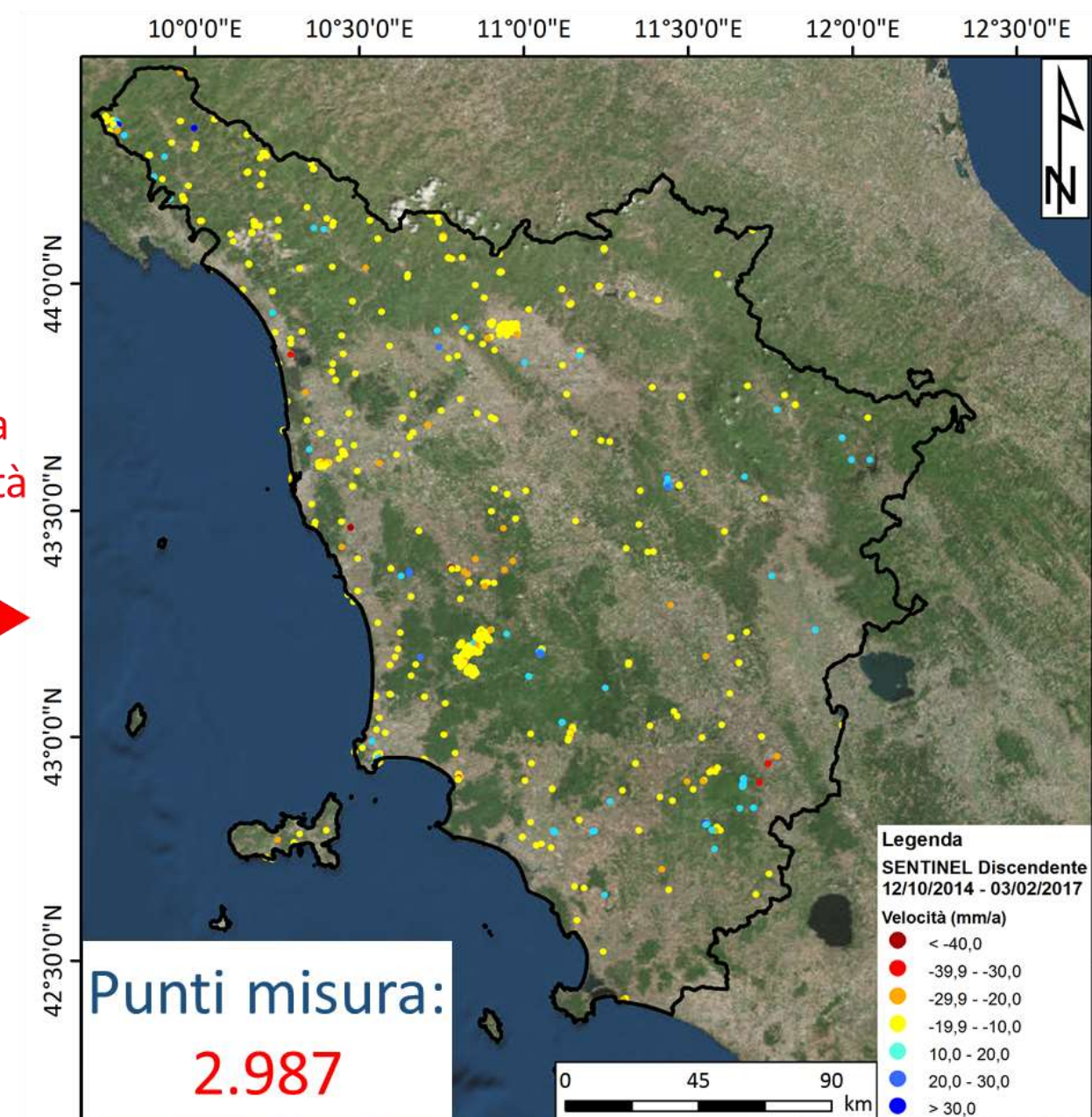


Geometria ascendente

PS mapping: mappatura in tempo differito (Dir. PCM 27/02/2004)



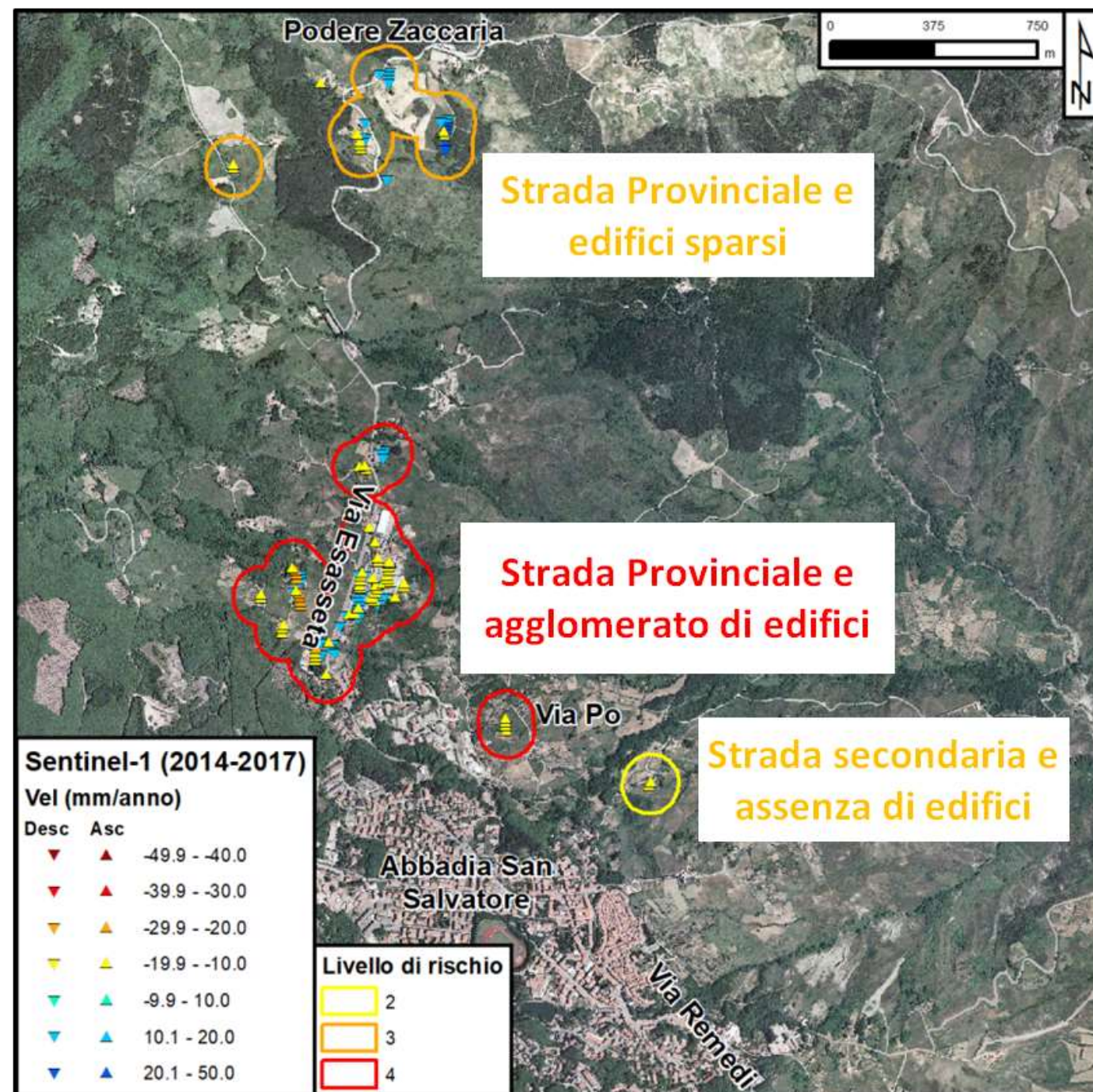
Soglia
velocità



Geometria discendente

Valutazione speditiva del rischio

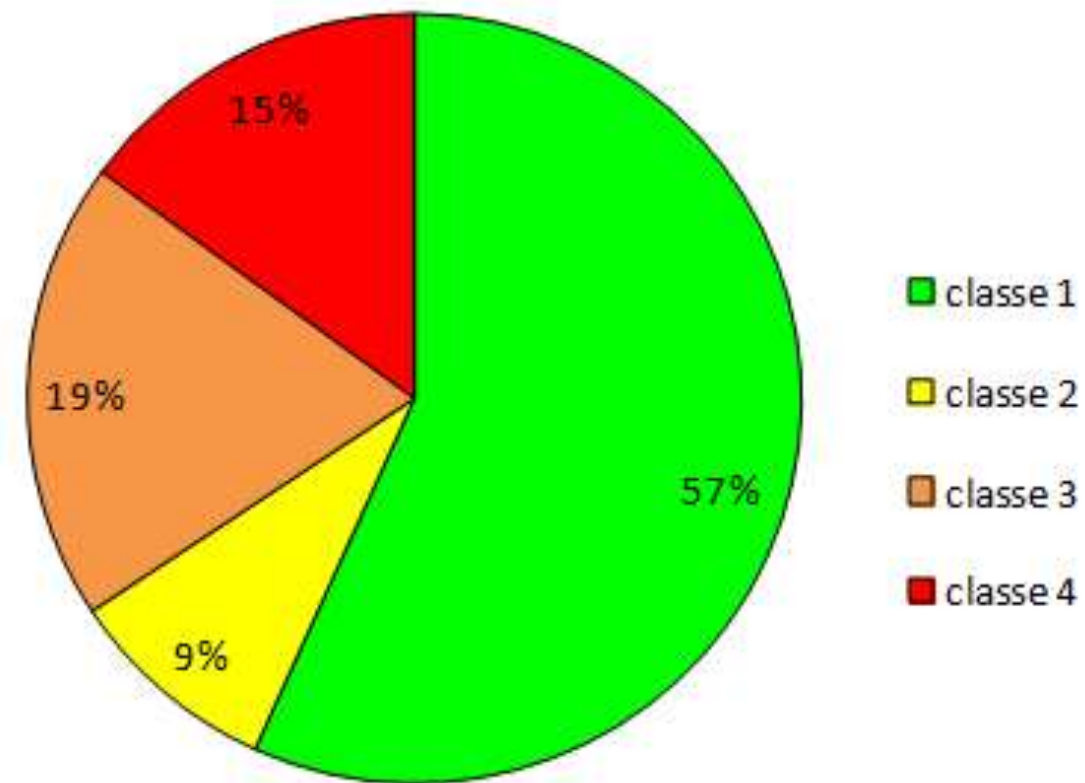
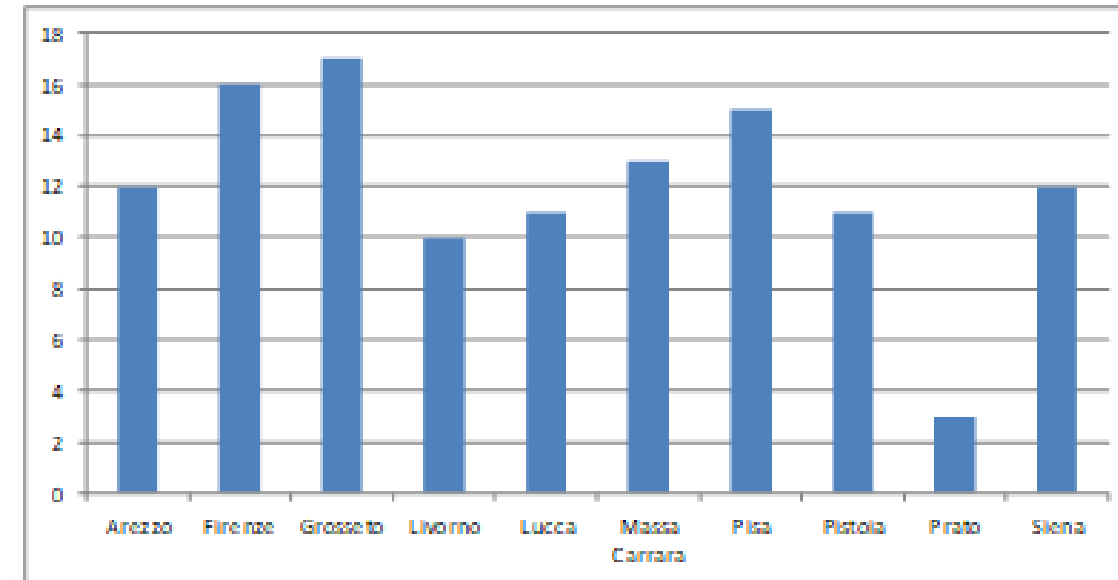
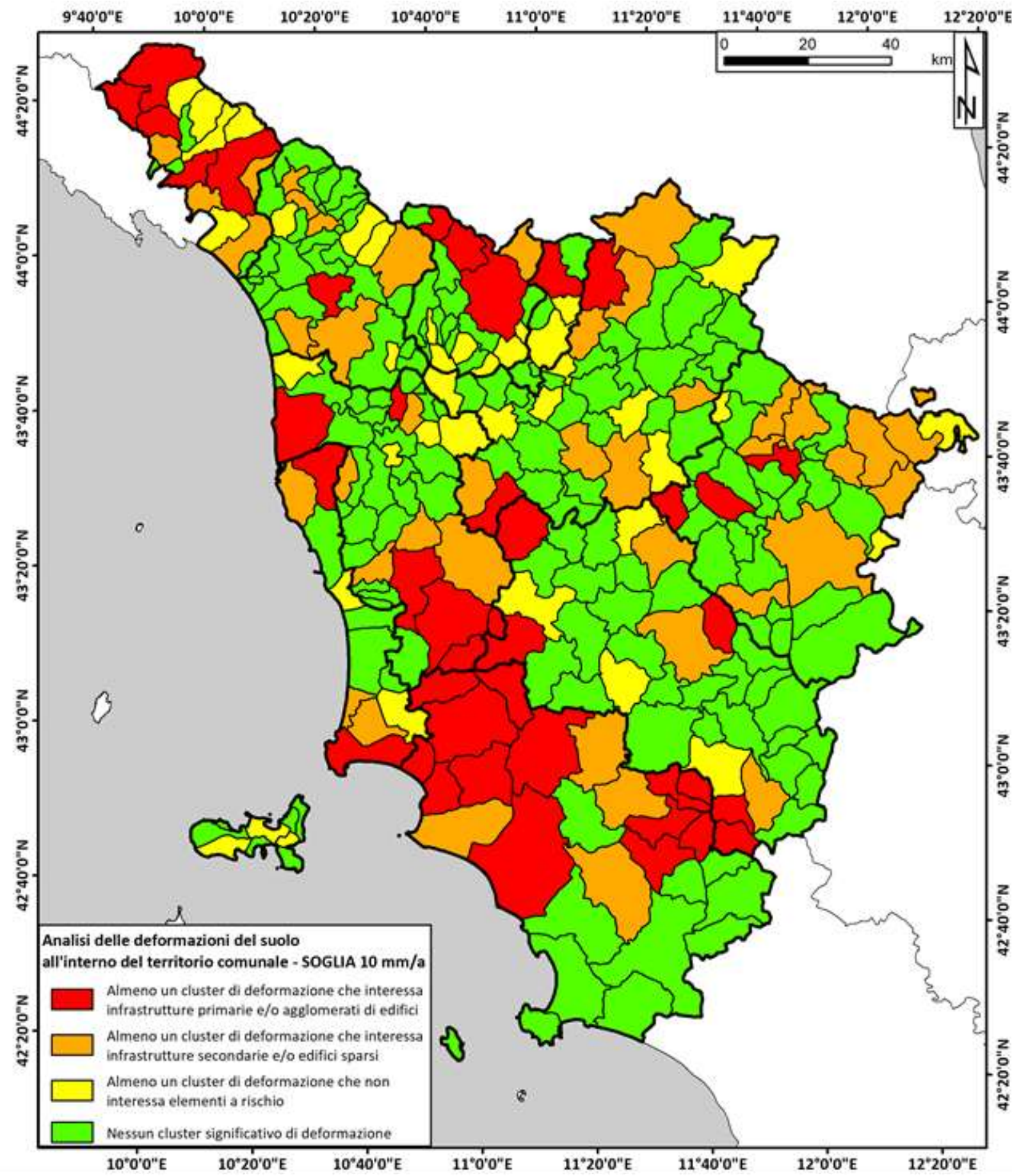
PS Clusters di rilevanza statistica + Elementi a rischio



Abbadia San Salvatore (SI)

Classe	Descrizione
1	Nessun cluster significativo di deformazione
2	Presenza di elementi a rischio isolati (viabilità secondaria, edifici isolati) all'interno del cluster
3	Presenza di elementi a rischio distribuiti (viabilità principale, edifici sparsi) all'interno del cluster
4	Presenza di numerosi elementi a rischio (viabilità principale, centri abitati) all'interno del cluster

PS mapping – Classificazione comuni



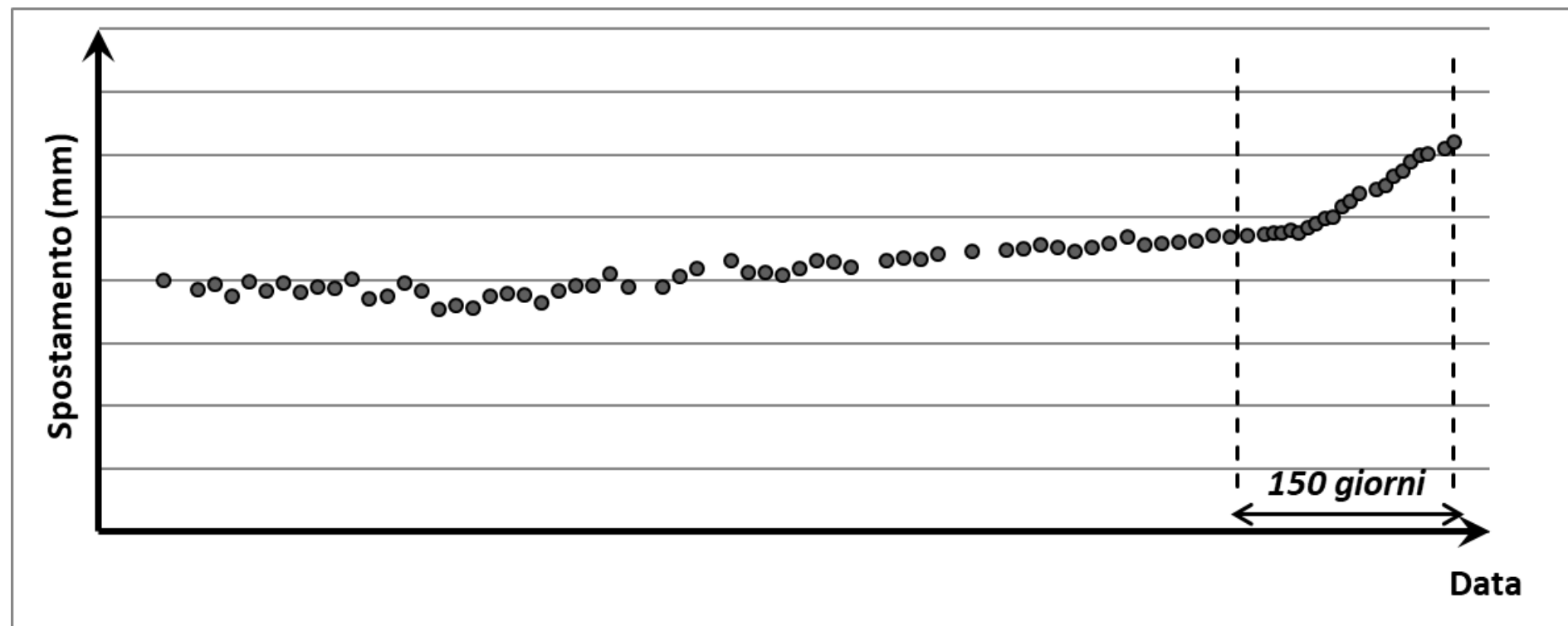
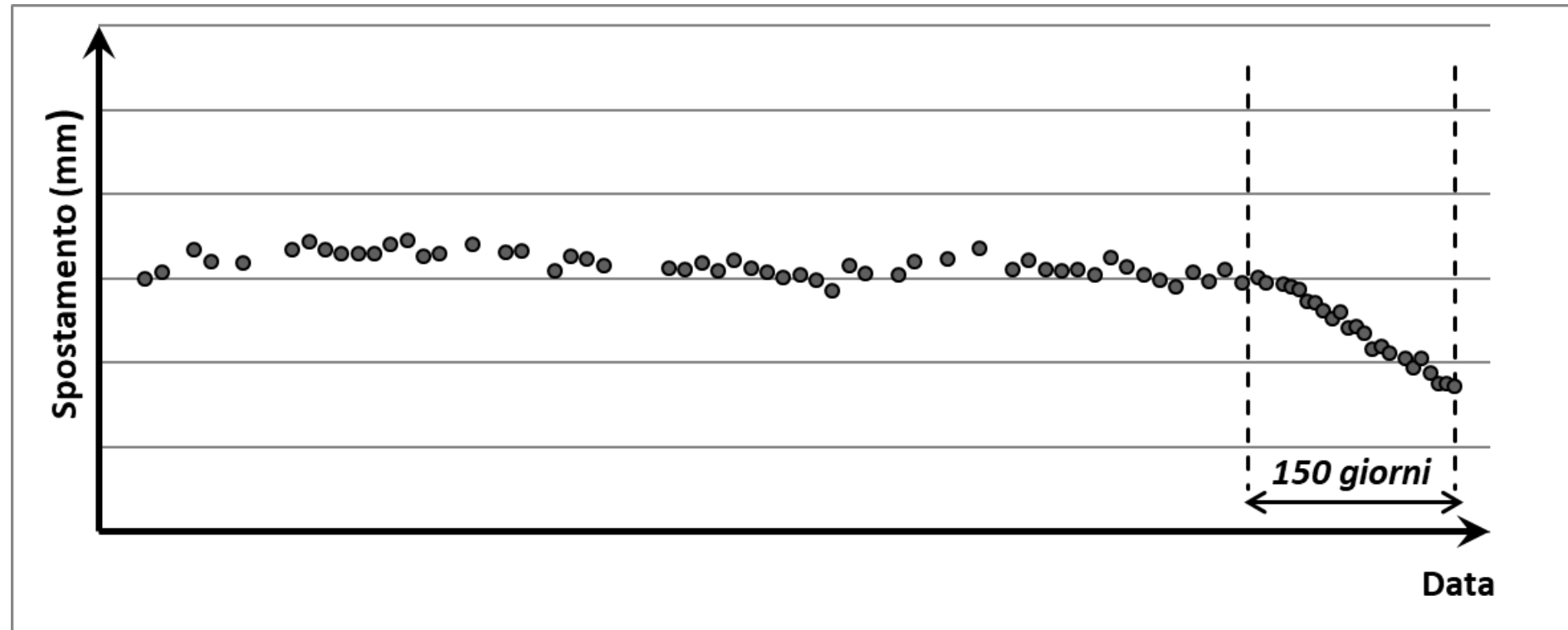
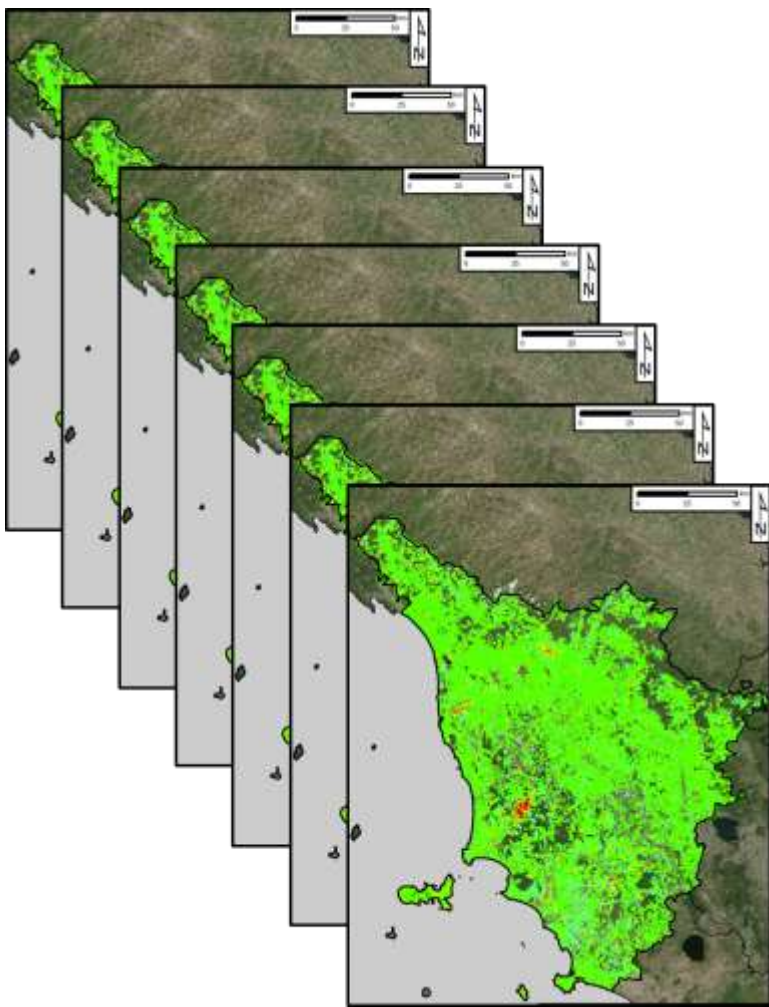
Sopralluoghi di validazione – Abbazia (SI)



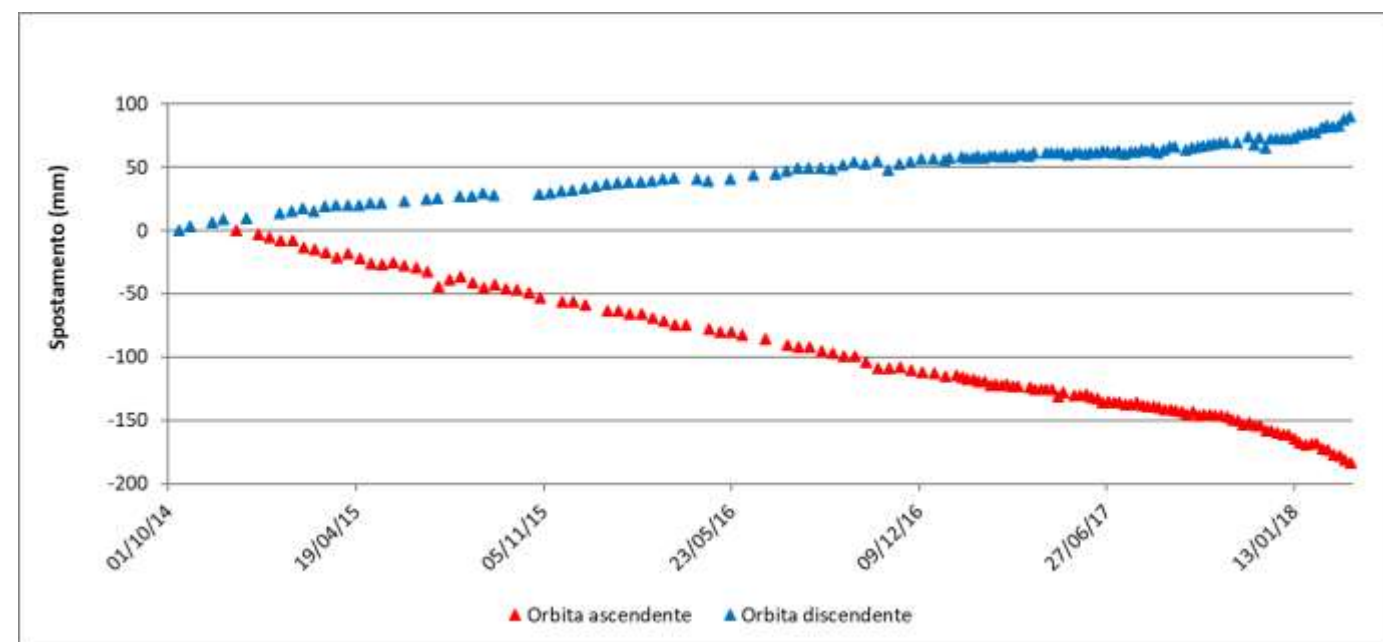
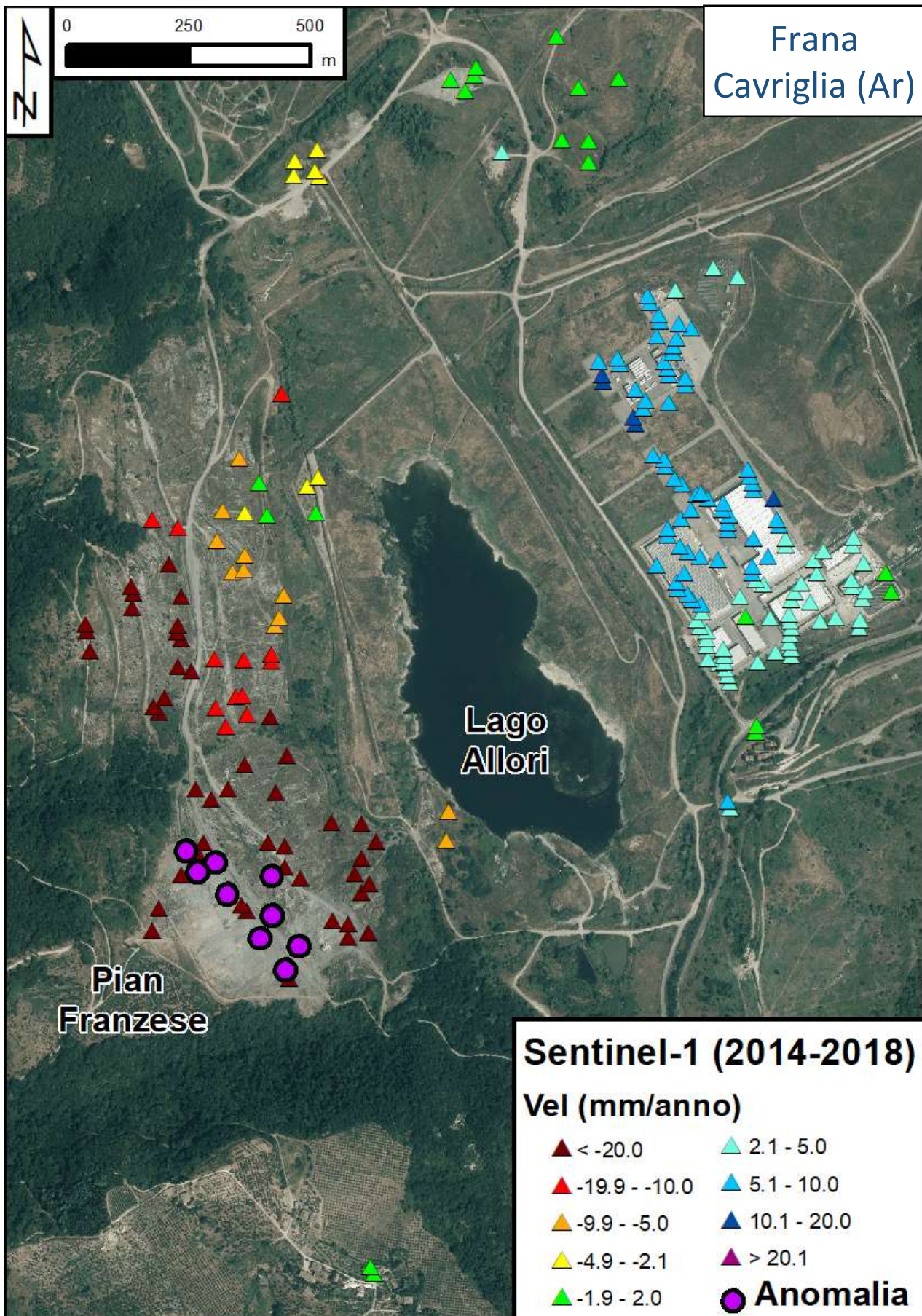
Sopralluoghi di validazione – Abbadia (SI)



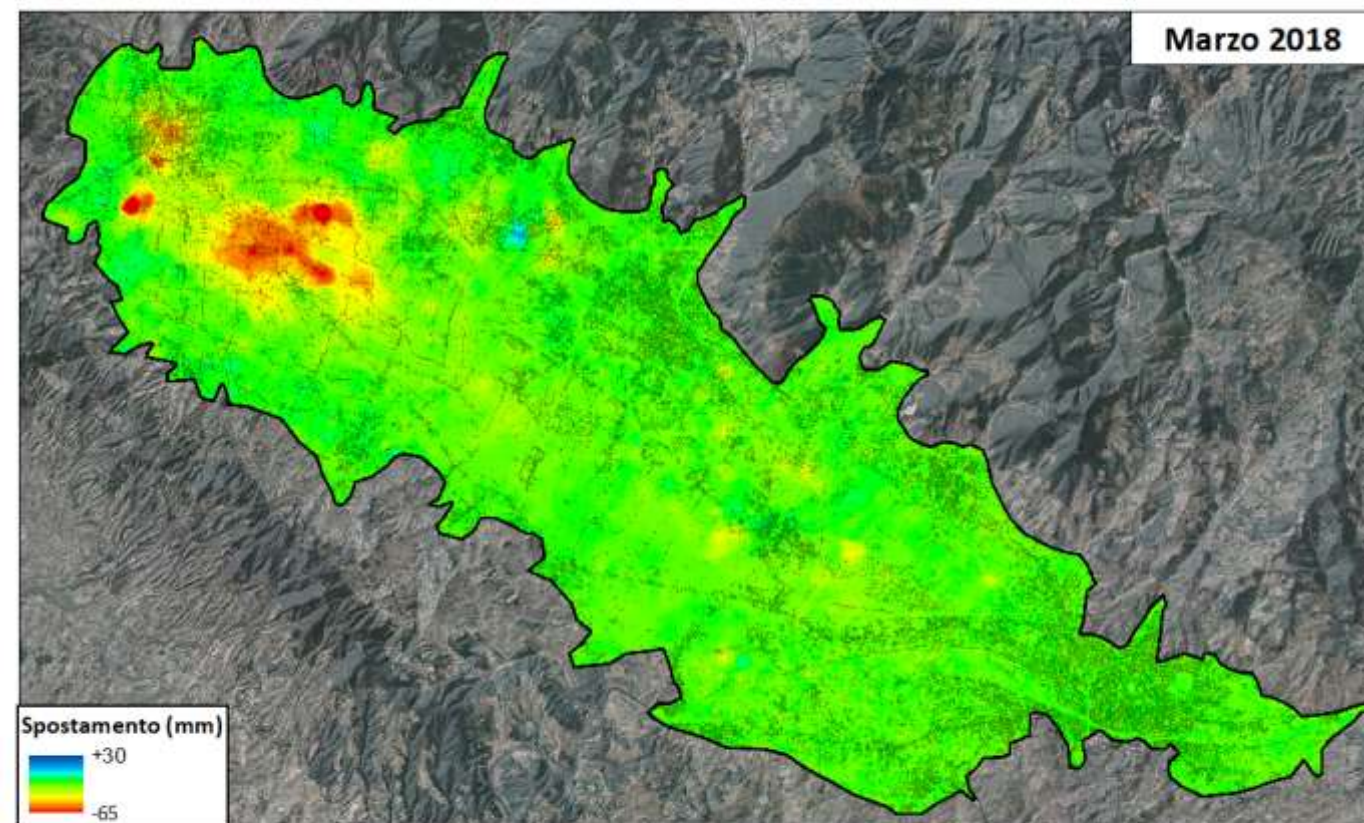
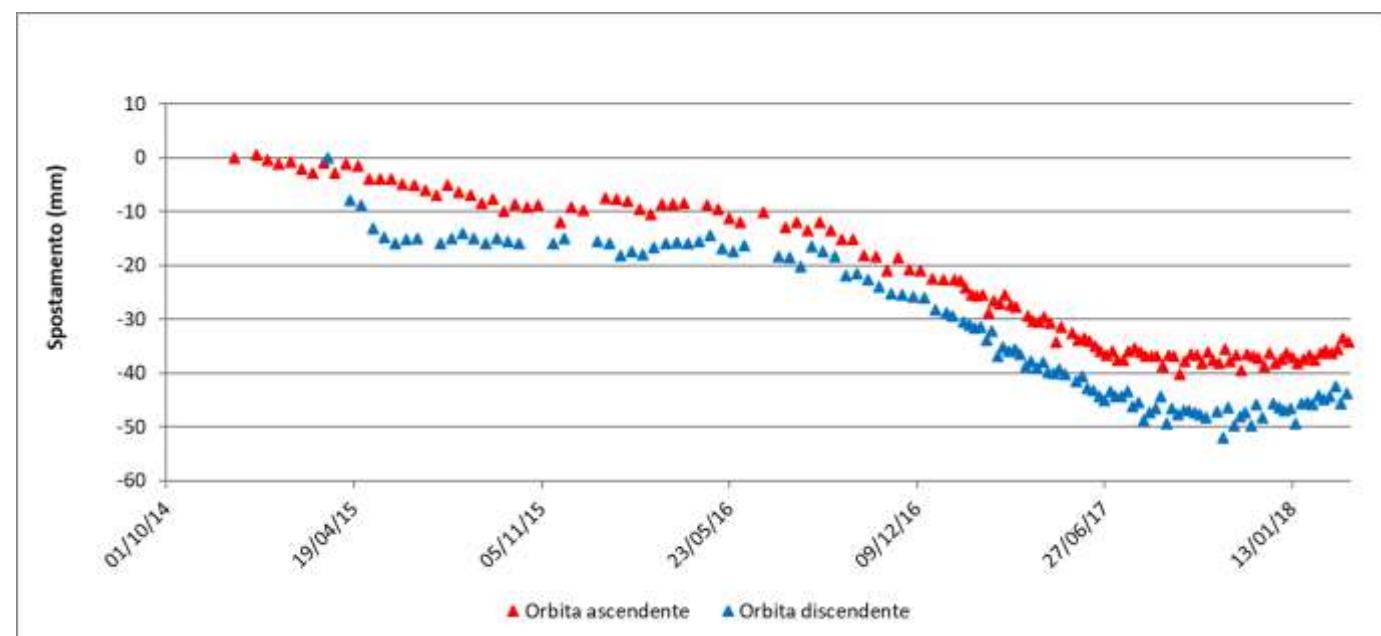
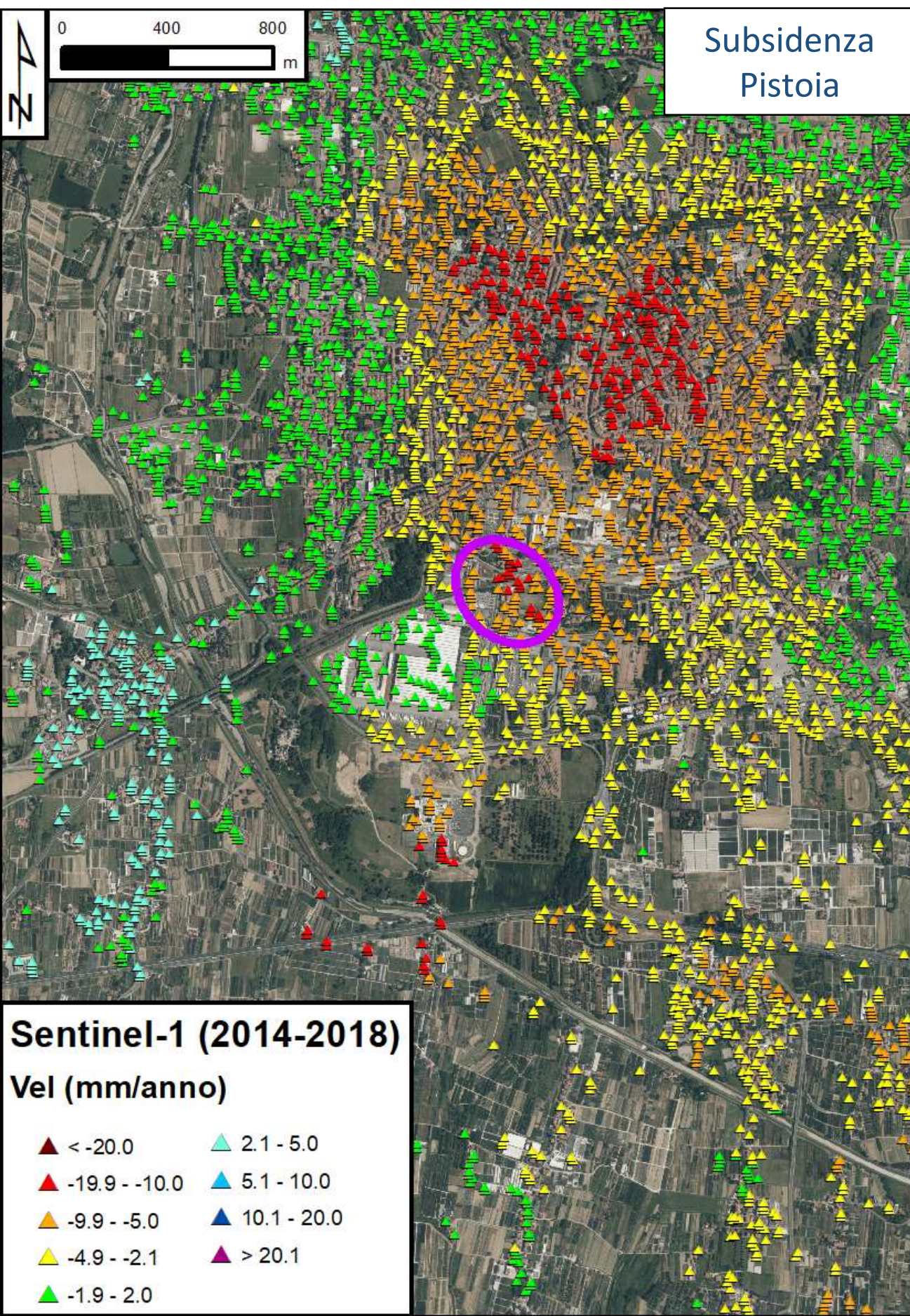
PS monitoring: monitoraggio “in tempo reale” (Dir. PCM27/02/2004)



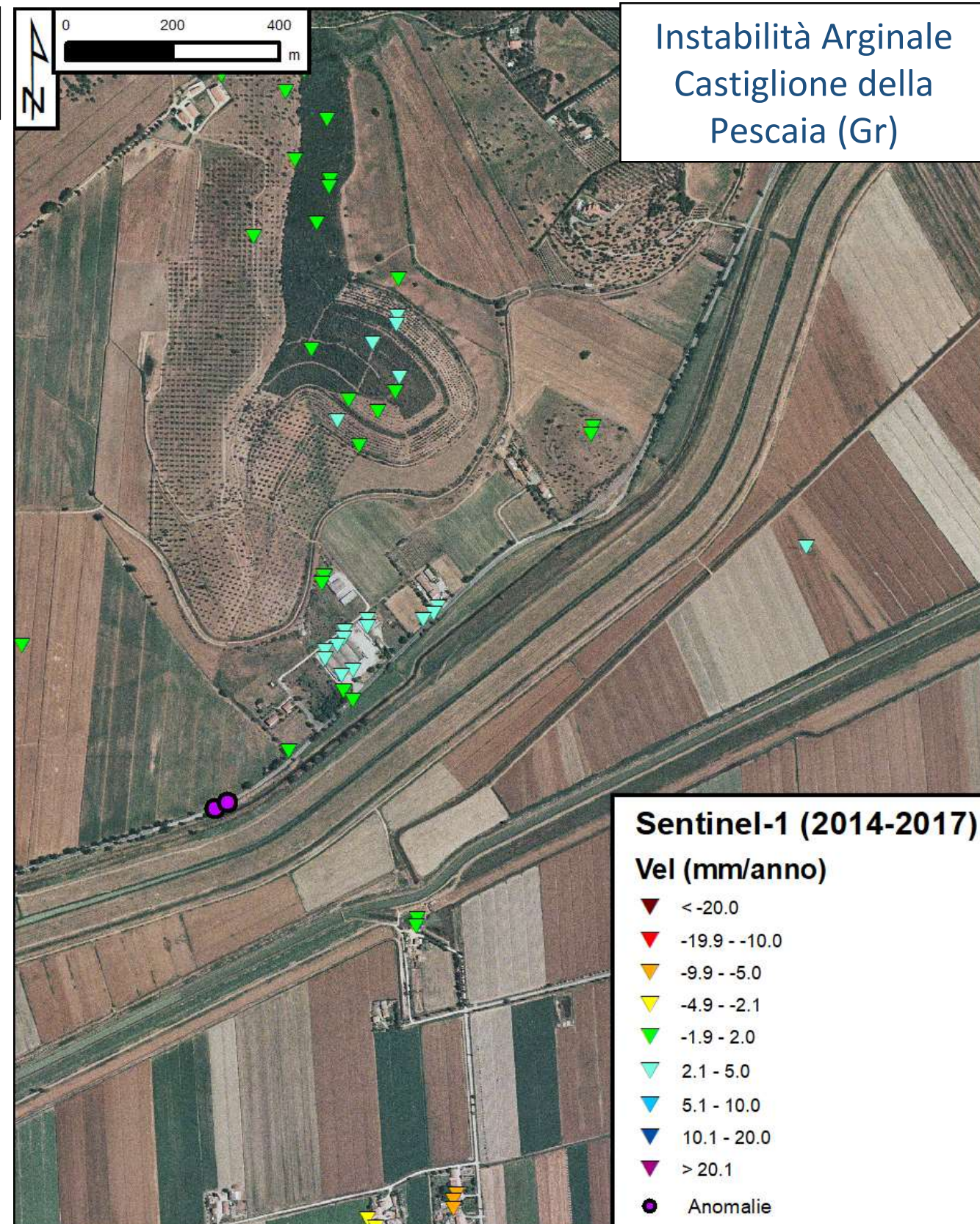
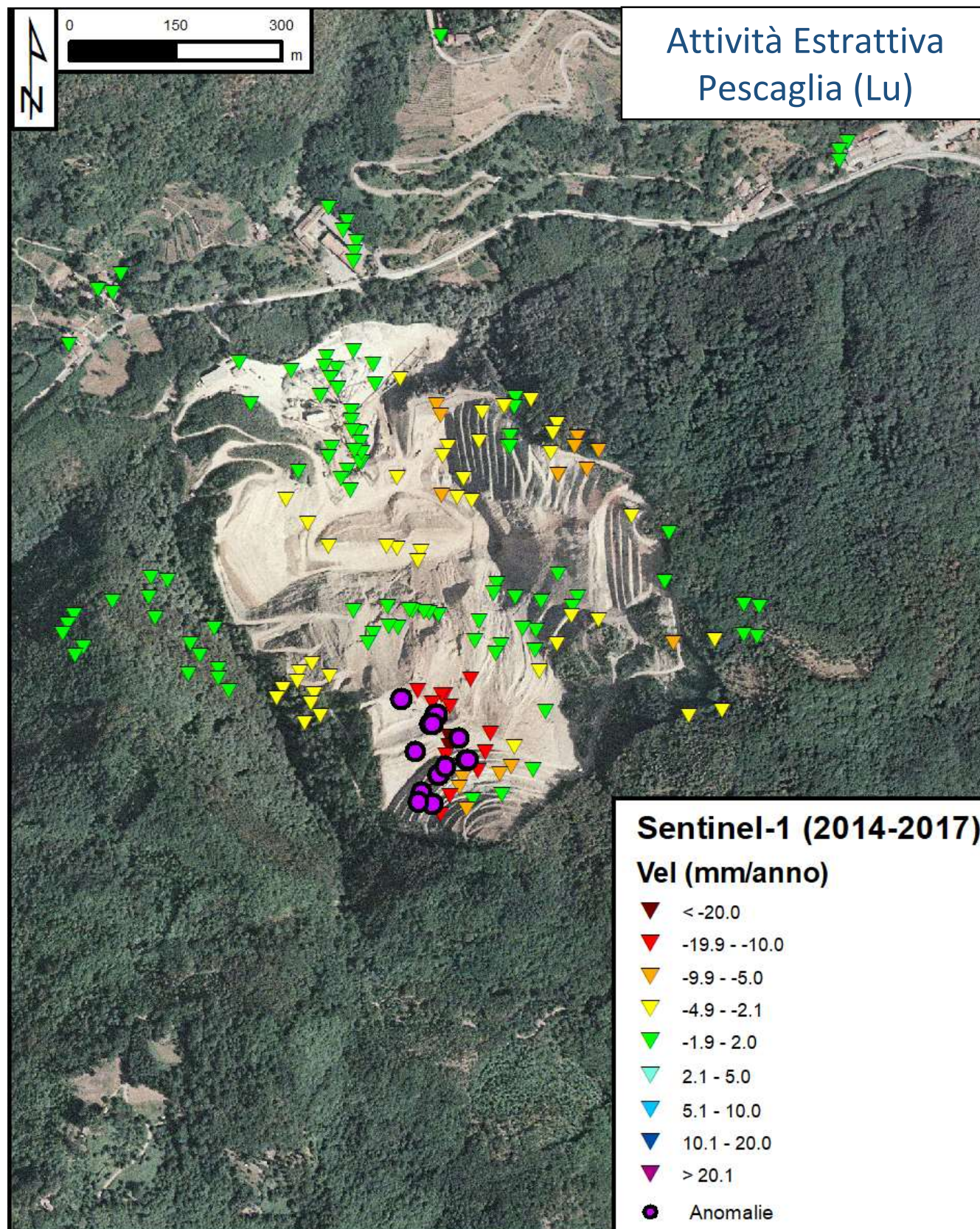
Cause delle Anomalie



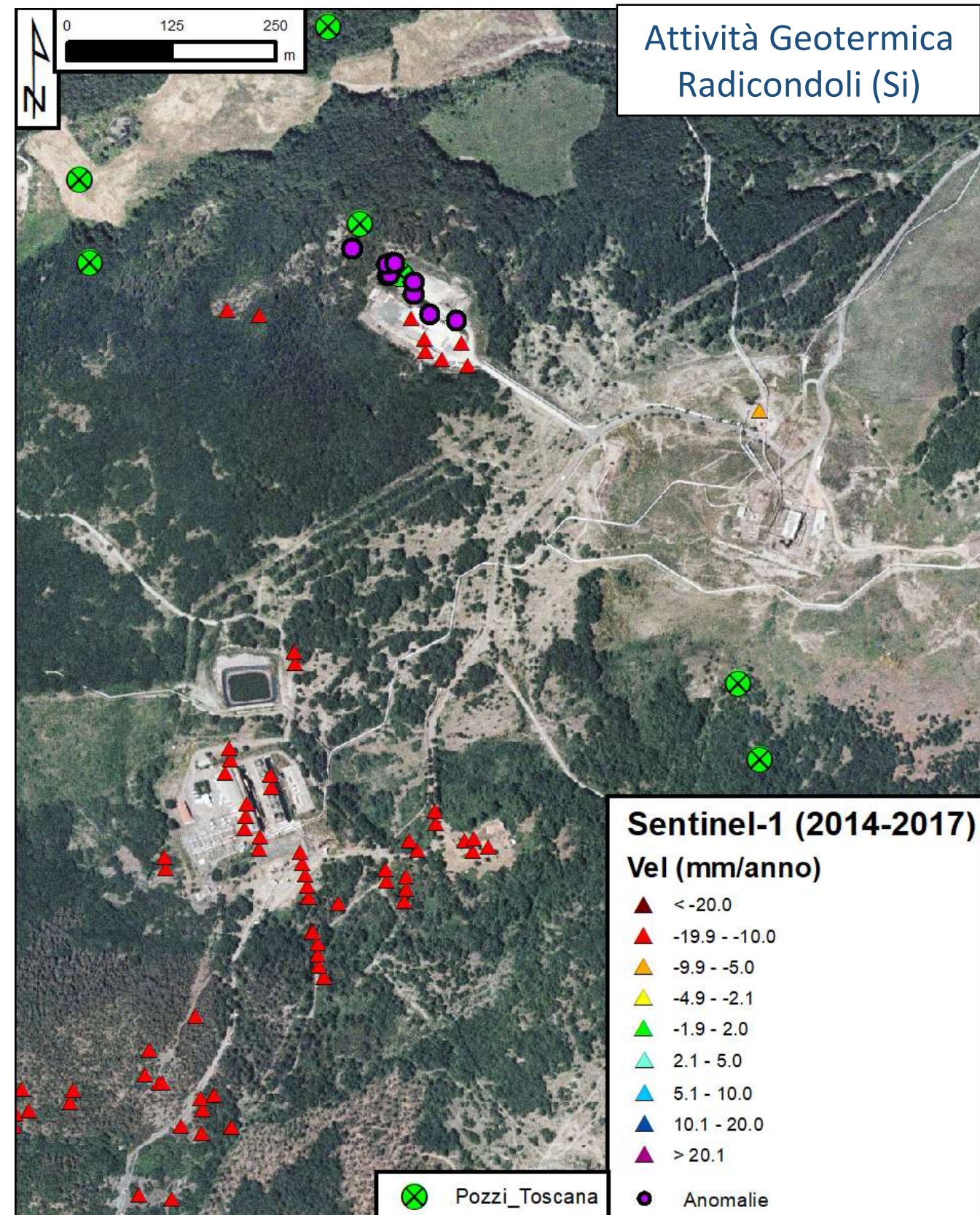
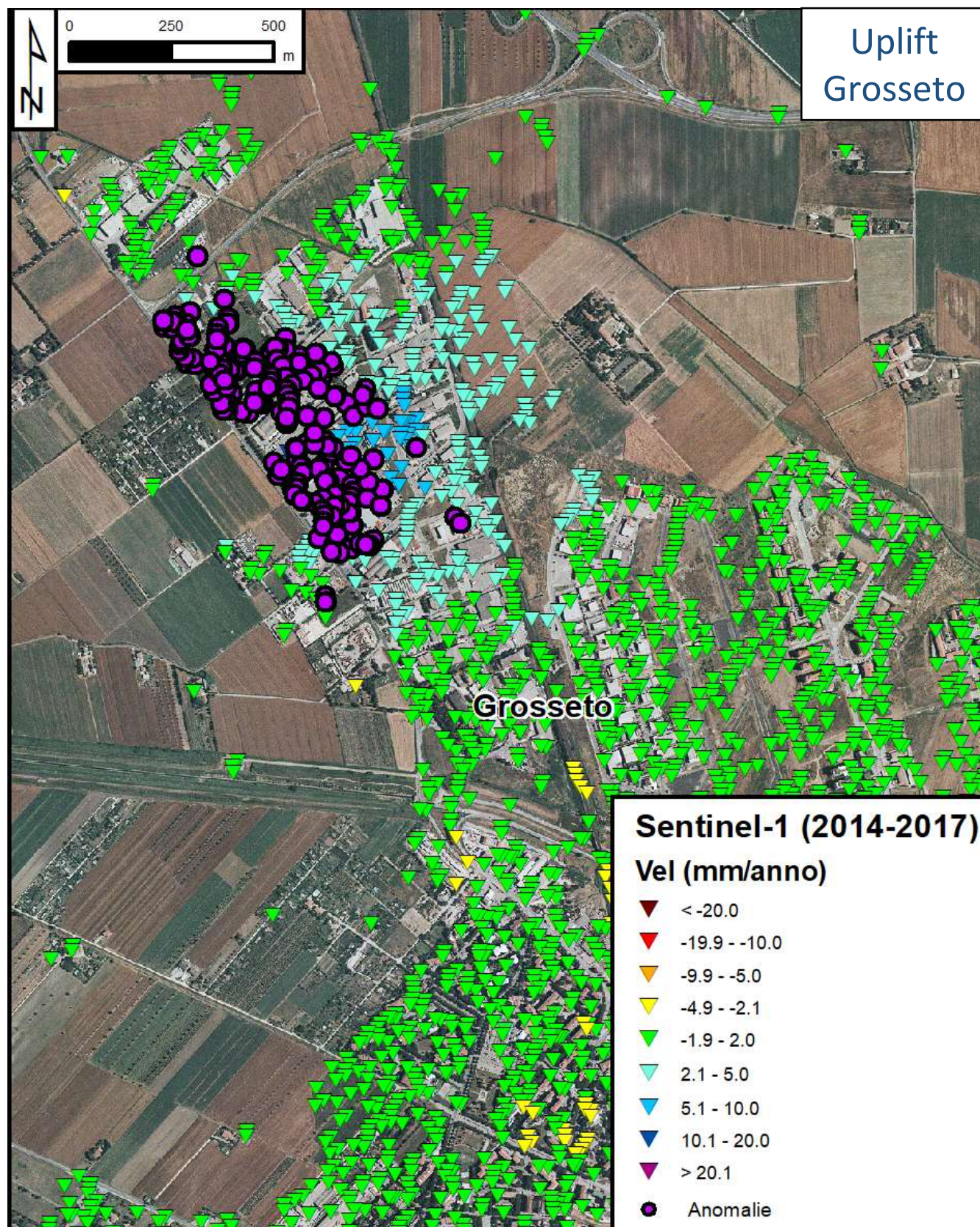
Cause delle Anomalie



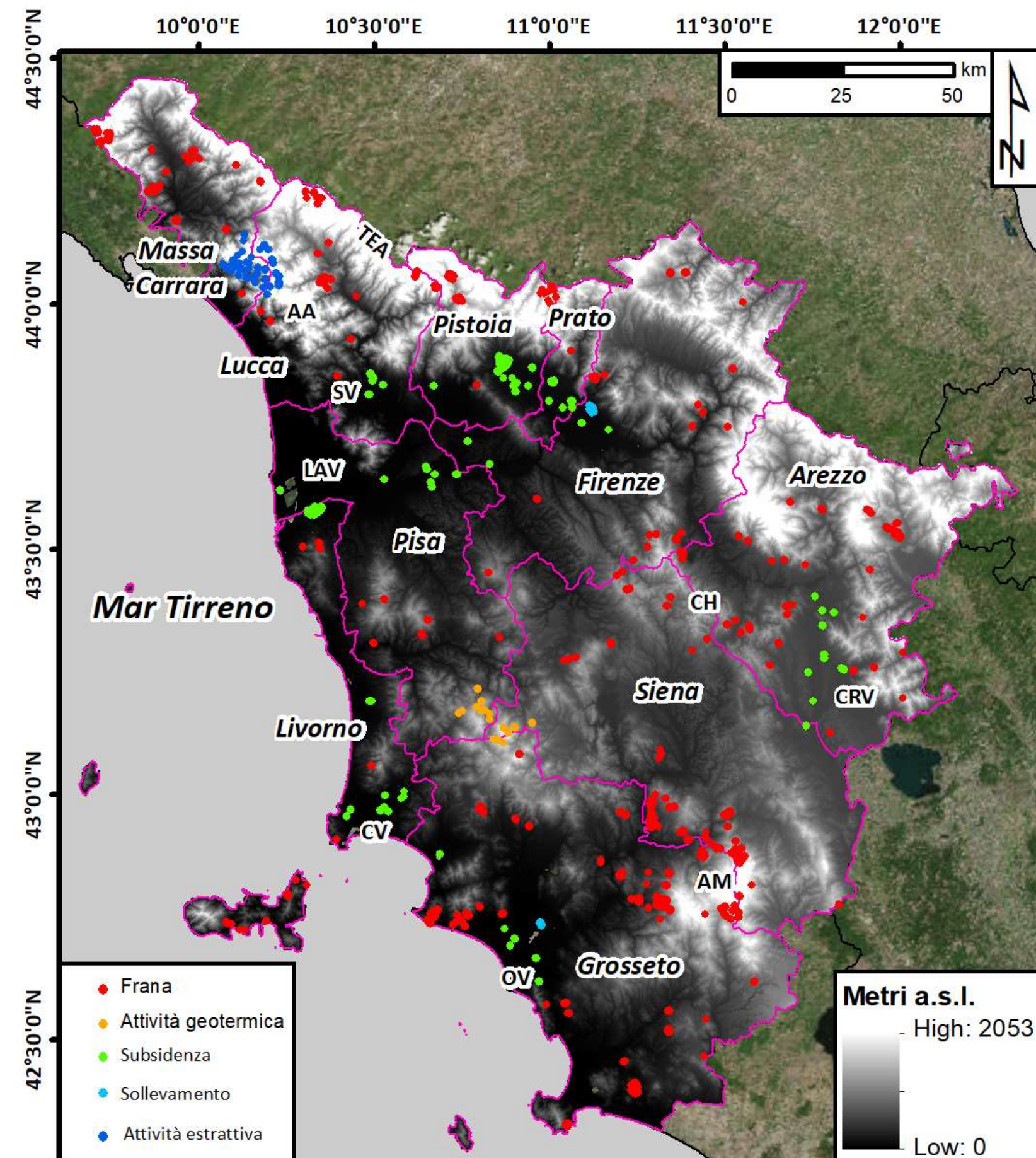
Cause delle Anomalie



Cause delle Anomalie

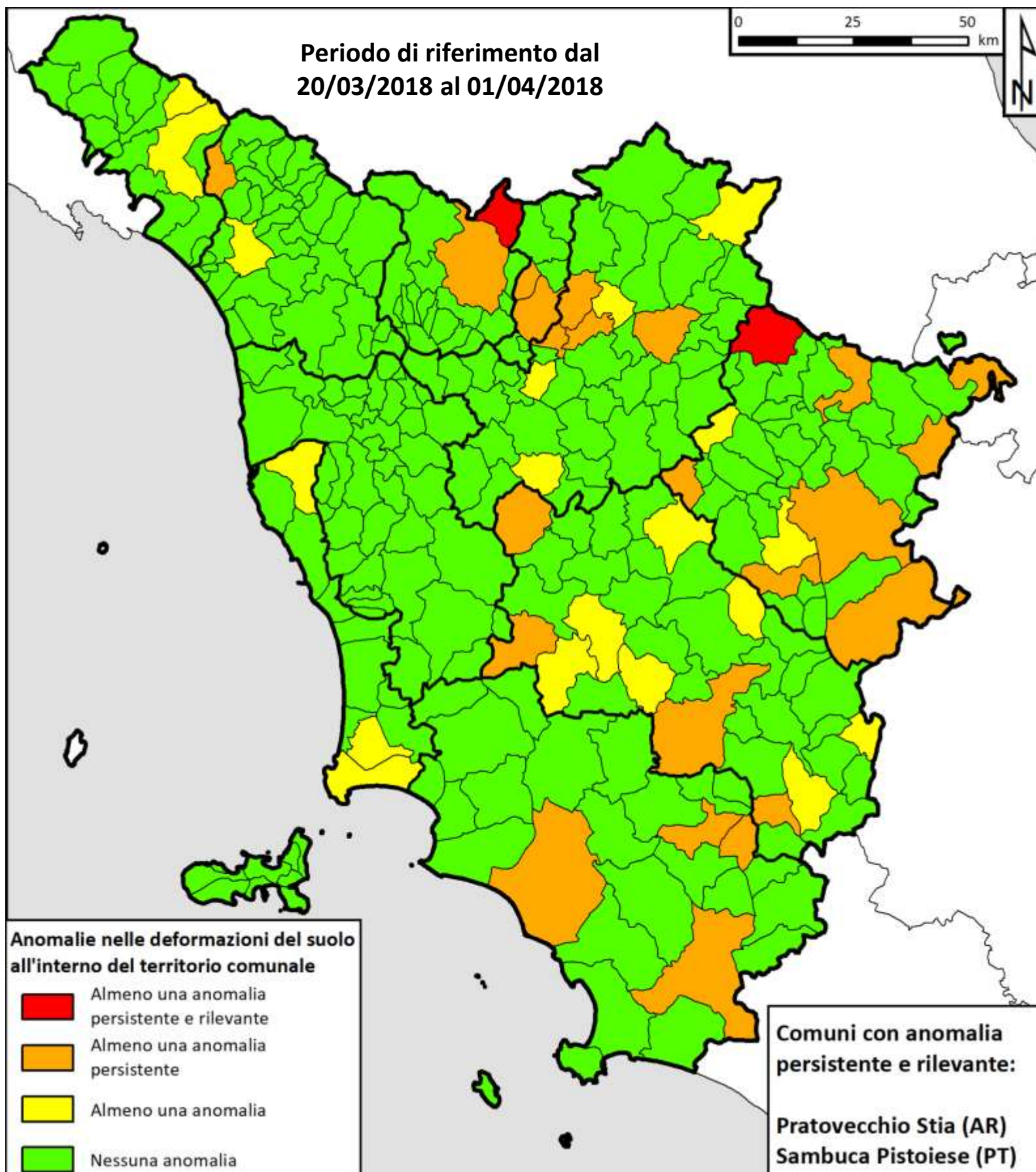


Cause delle Anomalie



Causa	%
Subsidenza (areale e locale)	64.74
Movimento di versante	29.58
Uplift (areale e locale)	3.5
Attività estrattiva	1.63
Attività geotermica	0.48
Instabilità arginale	0.05
Instabilità in discarica	0.02

Bollettino di monitoraggio



Classe	Descrizione
1	Nessuna anomalia all'interno del territorio comunale
2	Almeno una anomalia all'interno del territorio comunale
3	Almeno una anomalia persistente all'interno del territorio comunale
4	Almeno una anomalia persistente e rilevante all'interno del territorio comunale

SCIENTIFIC REPORTS

OPEN

Continuous, semi-automatic monitoring of ground deformation using Sentinel-1 satellites

Federico Raspini¹, Silvia Bianchini¹, Andrea Ciampalini^{1,3}, Matteo Del Soldato¹, Lorenzo Solari¹, Fabrizio Novali², Sara Del Conte², Alessio Rucci², Alessandro Ferretti² & Nicola Casagli¹

We present the continuous monitoring of ground deformation at regional scale using ESA (European Space Agency) Sentinel-1 constellation of satellites. We discuss this operational monitoring service through the case study of the Tuscany Region (Central Italy), selected due to its peculiar geological setting prone to ground instability phenomena. We set up a systematic processing chain of Sentinel-1 acquisitions to create continuously updated ground deformation data to mark the transition from static satellite analysis, based on the analysis of archive images, to dynamic monitoring of ground displacement. Displacement time series, systematically updated with the most recent available Sentinel-1 acquisition, are analysed to identify anomalous points (*i.e.*, points where a change in the dynamic of motion is occurring). The presence of a cluster of persistent anomalies affecting elements at risk determines a significant level of risk, with the necessity of further analysis. Here, we show that the Sentinel-1 constellation can be used for continuous and systematic tracking of ground deformation phenomena at the regional scale. Our results demonstrate how satellite data, acquired with short revisiting times and promptly processed, can contribute to the detection of changes in ground deformation patterns and can act as a key information layer for risk mitigation.

Received: 24 November 2017

Accepted: 17 April 2018

Published online: 08 May 2018



Interferometria radar da terra

A photograph of a GBhSAR radar unit mounted on a linear rail system inside a wooden enclosure. The unit is grey with yellow and black safety markings. A black cable runs from the unit to a power outlet on the wall. A small monitor is also visible on the wall. The enclosure is made of light-colored wood planks.

Tecnologia LiSAmobile™
(Linear Synthetic Aperture Radar)

La frana del 29 gennaio 2019



Scivolamento su sabbie sovrapposte ad argille
Accumulo di acque sul versante S-SO per scarsa
regimazione e perdite della rete idrica sotterranea

La frana del 29 gennaio 2019



La frana del 29 gennaio 2019



La frana del 29 gennaio 2019



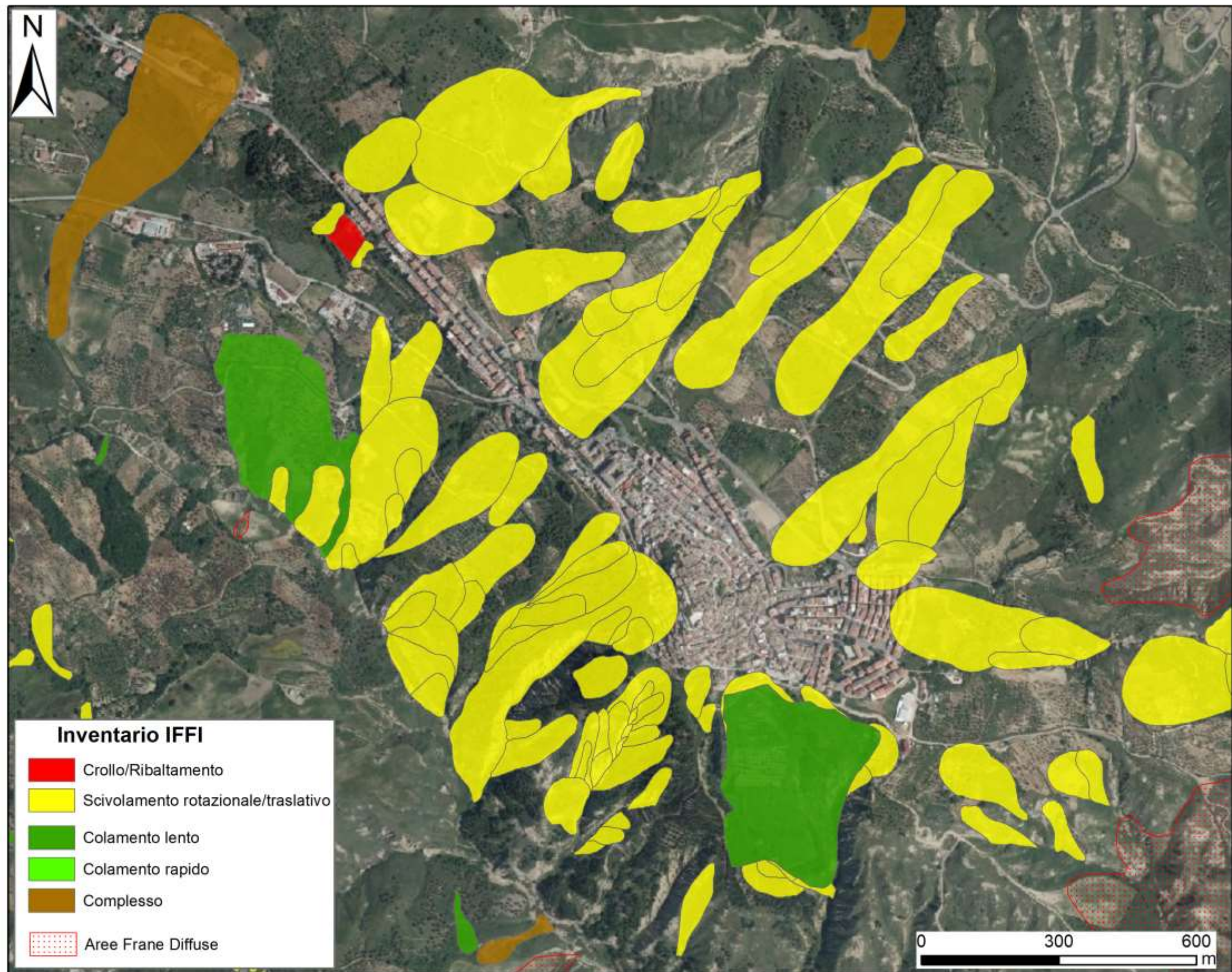
18 case
crollate

12 case
danneggiate

25 edifici
sgomberati

56 persone
evacuate

Inventario delle frane IFFI



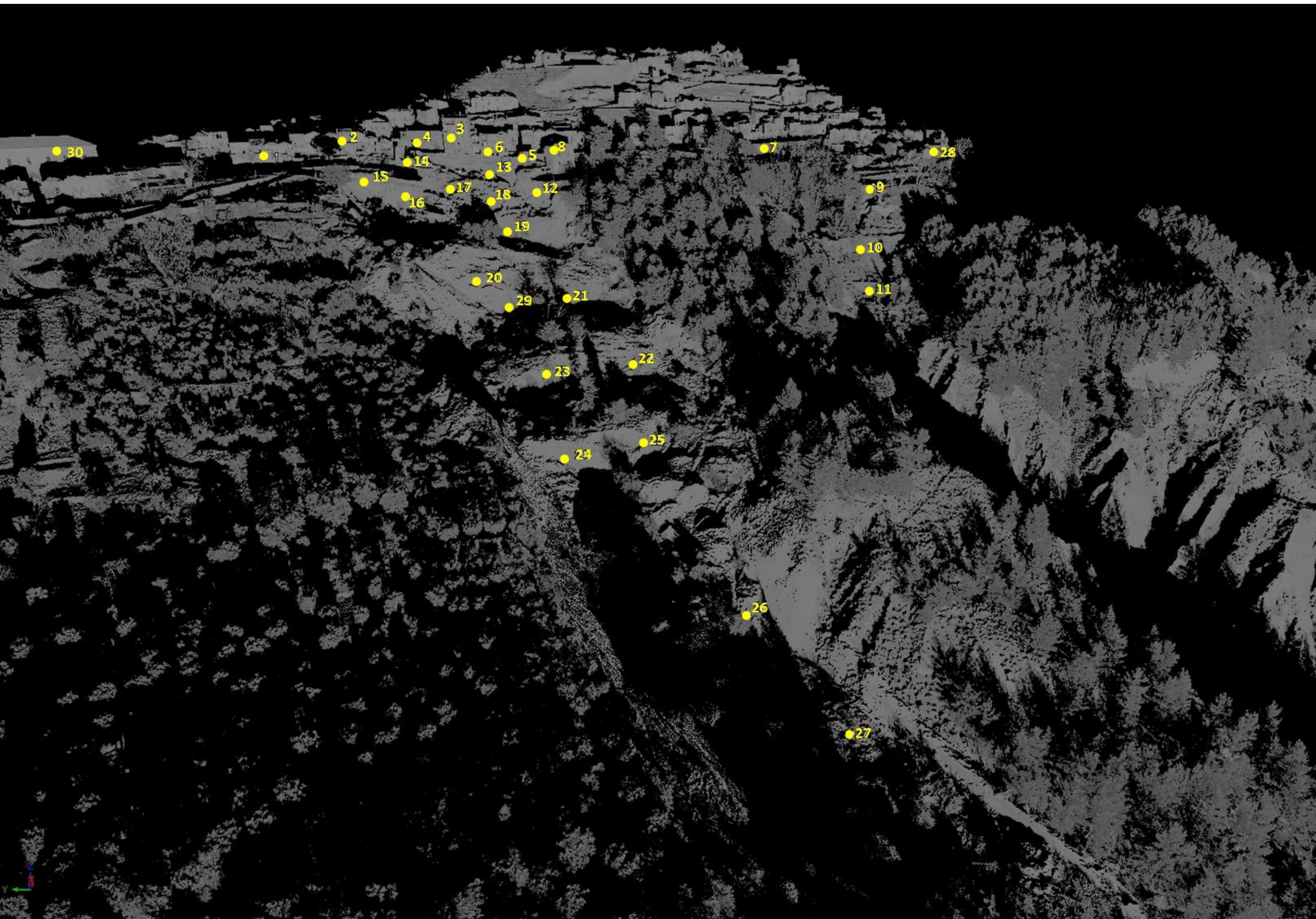






Ubicazione di punti di controllo

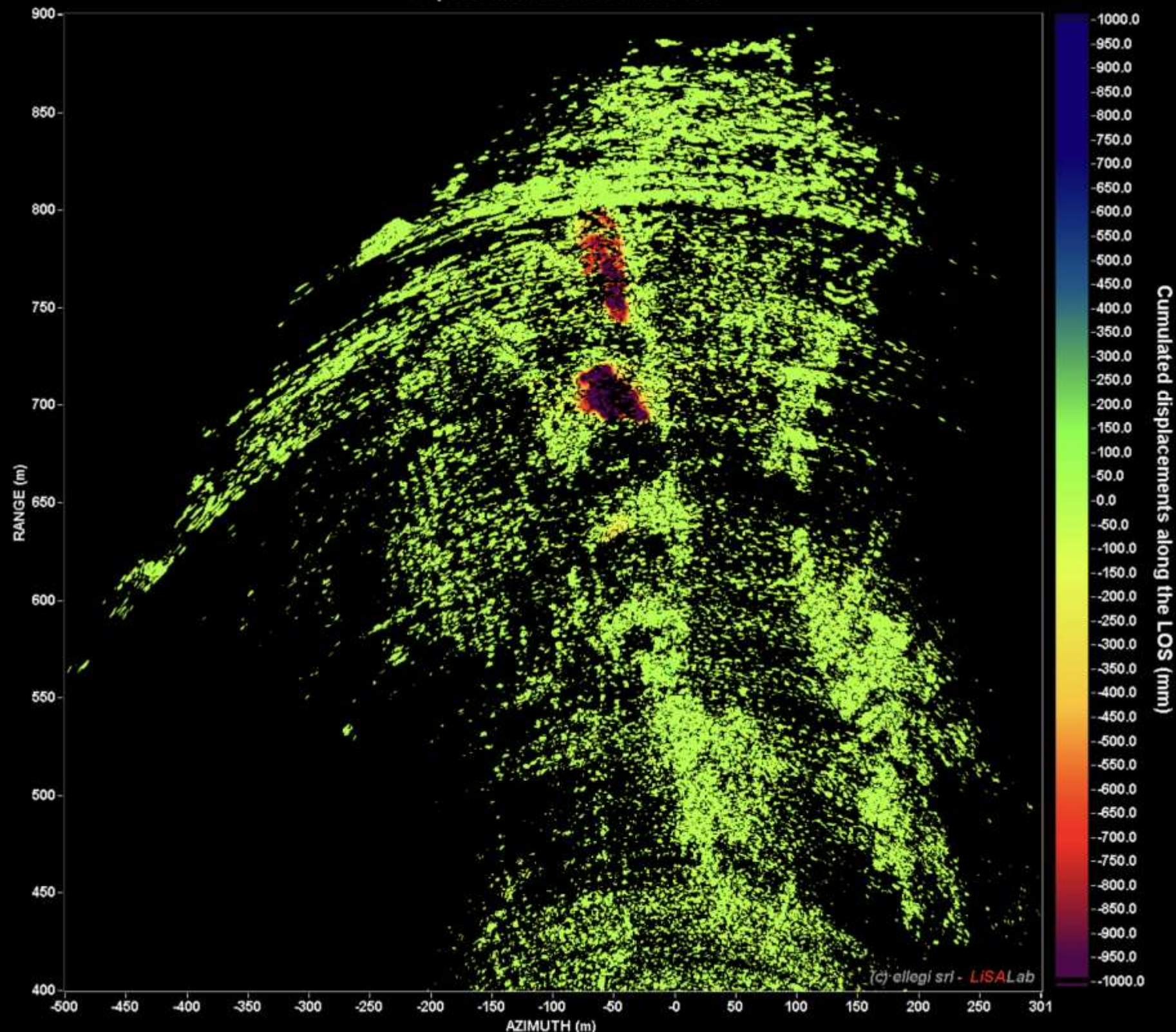




"Pomarico Monitoring [GMT+1]"



Cumulated displacements measured from 13:09:53 2019/02/28 to 07:46:59 2019/03/12
Elapsed time: 11d 18h 37min 6sec

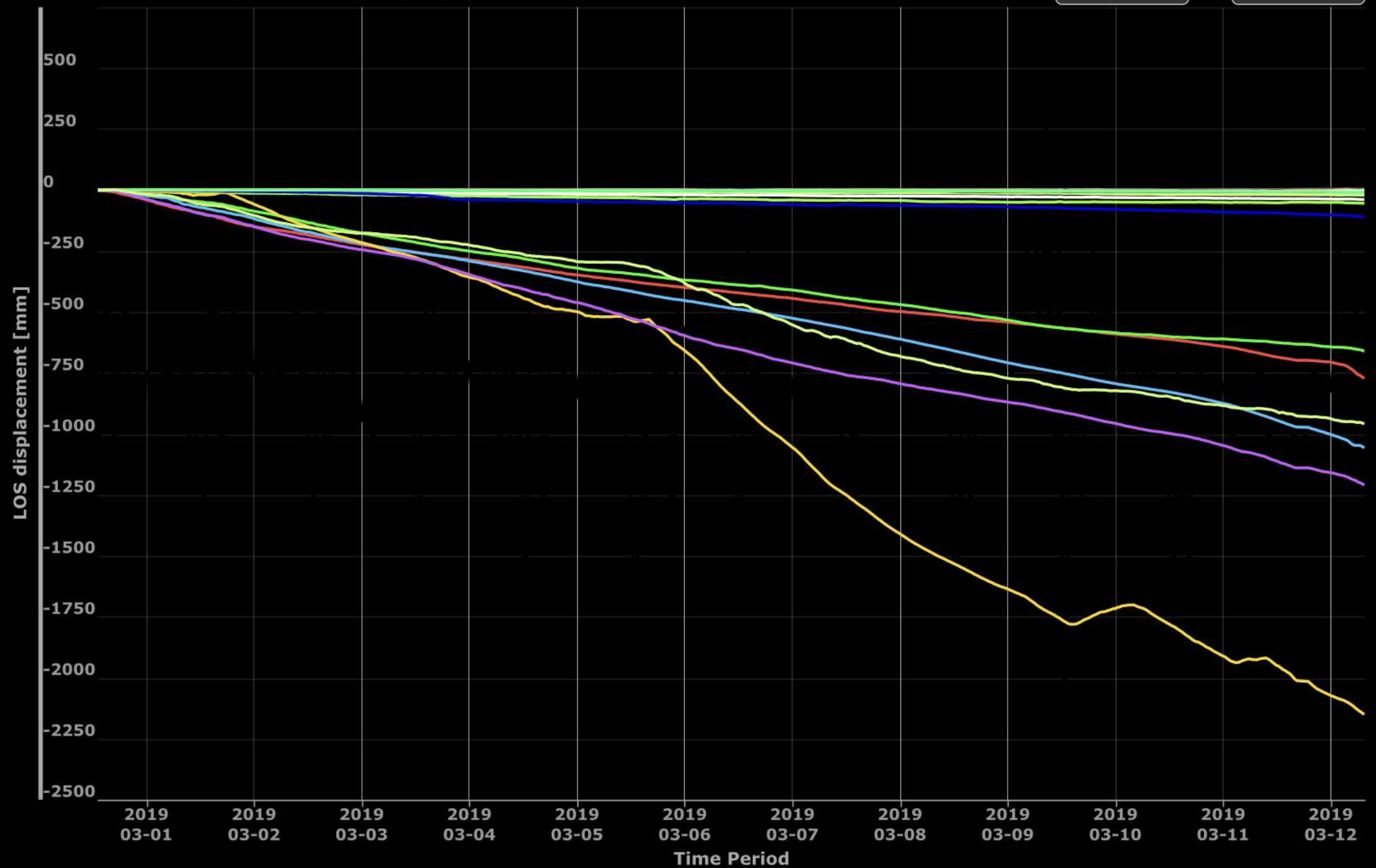


"Pomarico Monitoring [GMT+1]"



Zoom 1d 1w 1m 3m 6m 1y All

From: Feb 28, 2019 To: Mar 12, 2019



©2019, Ellegi srl. Data acquired by LiSALab GBInSAR technology.

☒ ToolTip

Absolute view

Cumulative Rainfall

Velocity

Selection all points

Deselection all point

Mappa degli spostamenti cumulati

Cumulated displacements measured from 13:09:53 2019/02/28 to 13:56:12 2019/03/11
Elapsed time: 11d 0h 46min 19sec



Soglie e livelli di criticità

LIVELLI DI CRITICITÀ	Abitato (A)	Palificate (P)	Frana (CF)	Fianco destro (FD)	Fianco sinistro (FS)	ALLERTA
VERDE	< 1.5 mm/giorno	< 2.5 mm/giorno	< 150 mm/giorno	< 3.0 mm/giorno	< 2.5 mm/giorno	NESSUNA ALLERTA
GIALLO	> 1.5 mm/giorno	> 2.5 mm/giorno	> 150 mm/giorno	> 3.0 mm/giorno	> 2.5 mm/giorno	ATTENZIONE
ARANCIONE	> 3.0 mm/giorno	> 5.0 mm/giorno	> 300 mm/giorno	> 6.0 mm/giorno	> 5.0 mm/giorno	PREALLARME
ROSSO	> 4.0 mm/giorno	> 7.5 mm/giorno	> 400 mm/giorno	> 8.0 mm/giorno	> 7.5 mm/giorno	ALLARME

Modelli previsionali a scala regionale

VMI - 14-05-2014 ore 23:10 UTC



PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

PIOGGIA

assente

debole

moderata

intensa



PROTEZIONE CIVILE

Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile



Sistema di allertamento

Bollettino di
Domenica, 06 Gennaio 2019

Codice Allerta Meteo



Situazione di Domenica, 06 Gennaio 2019

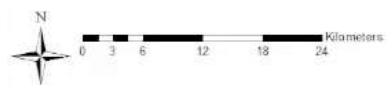


Situazione di Lunedì, 07 Gennaio 2019



<http://www.cfr.toscana.it>

Doppio livello di allerta



Failure probability %

30 ott 01:00-12:00

MEAN



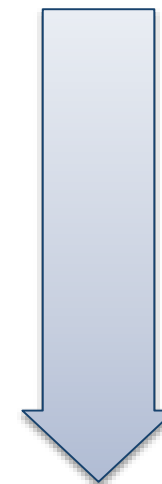
Level 1 – Criticality definition

None

Ordinary

Moderate

High



Level 2

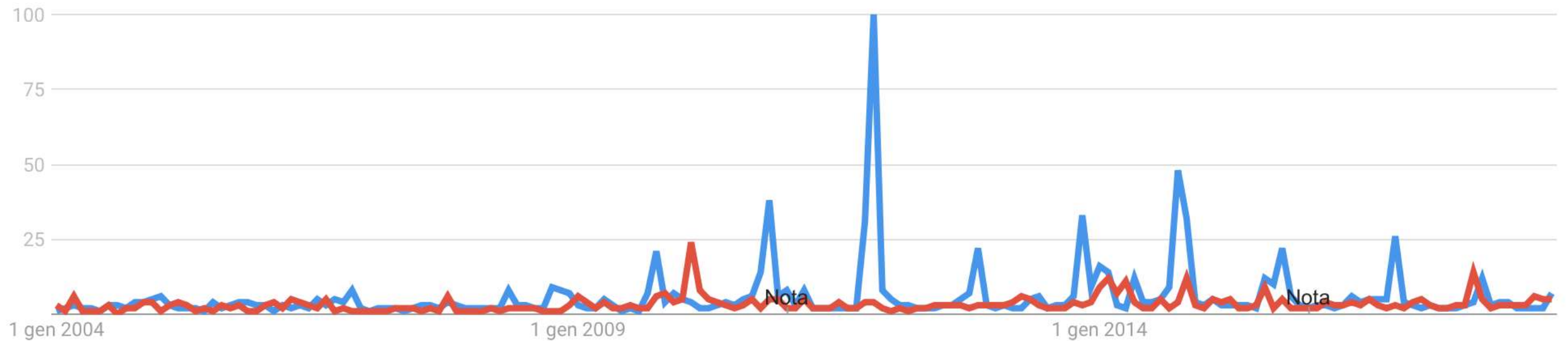
Relative triggering probability



Web news data mining



Google Trends



Frana



Alluvione

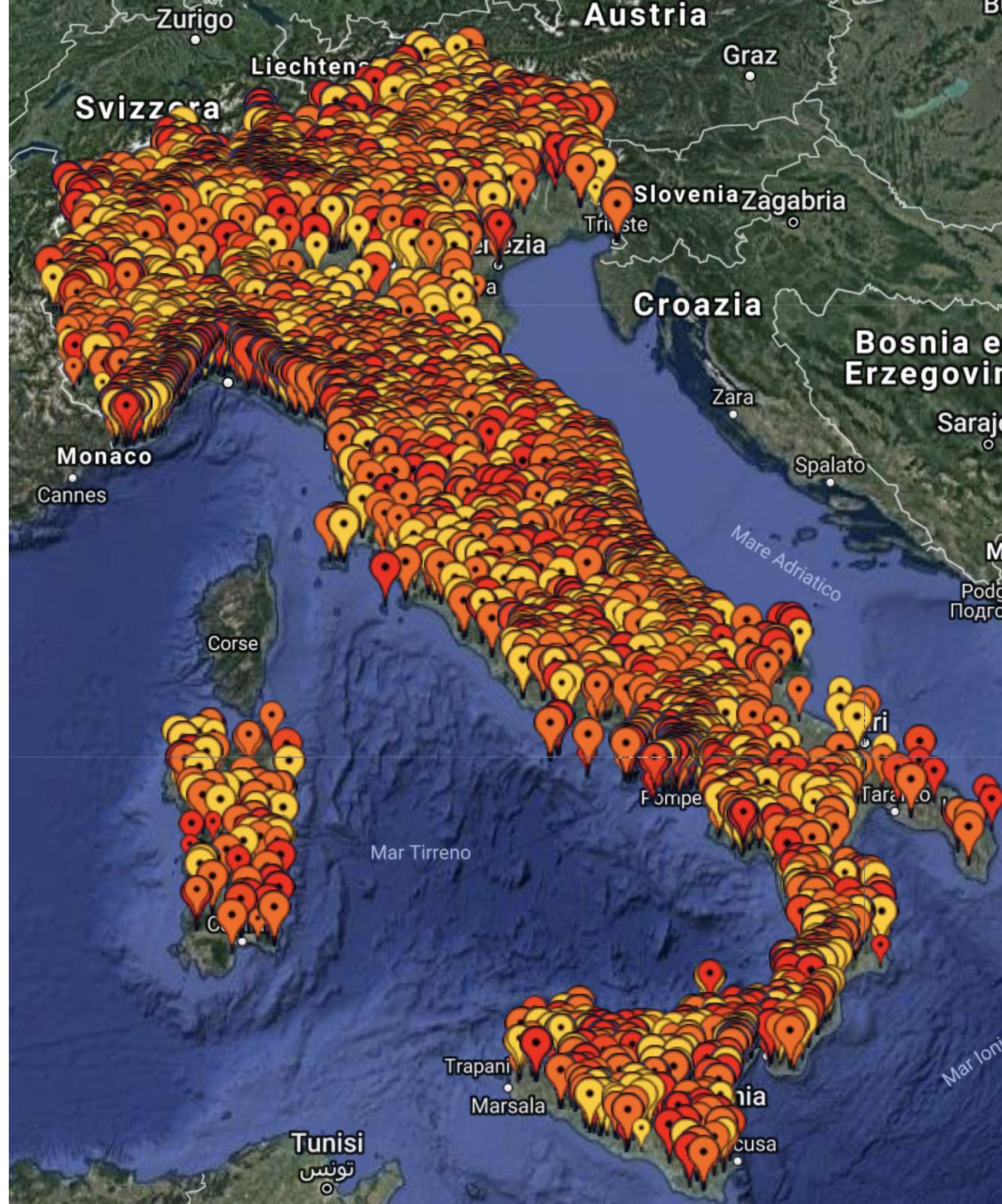


15.084+
frane 2011-
2018

1885 per anno
ca. 5 per giorno

Legenda

	Score < 40	40 ≤ Score < 60	60 ≤ Score < 90	Score ≥ 90
news = 1				
news = 2				
3 ≤ news ≤ 20				
news > 20				



**Gli alti comandi
della Marina non
ebbero il senso del
nuovo**

Ugo Tiberio (1978)

Grazie
nicola.casagli@unifi.it

