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Ten years of civil protection support activities in landslide areas of Basilicata (southern Italy)

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Landslide risk management

- ✓ Civil protection system (CPS) is initially activated to response to the emergency
- ✓ CPS involves: 1) Civil Protection Departments at national (DPC) and regional (DRPC) levels, 2) scientific institutions (namely Competence Centres – CdCs), 3) local admministration personnel and technicians.
- ✓ Institute of Methodologies for Environmental Analysis (IMAA) of Italian National Research Council (CNR) is one of the CdCs that collaborates with DPC and DRPC in landslide emergency

Information needed in the emergency phase

Main questions

- What was the trigger factor?
- How extensive the landslide body is?
- What is the displacement velocity?
- How deep the sliding surface is?
- How much material was involved in the movement?
- Are there any areas that could be affected by future instability phenomena?
- ……?
- .....?

The cooperation of **Competence Centres** allows DPC or DRPC to exploit all the scientific skills and the state-of-art of investigation technologies to **answer** these questions in order to plan the first interventions and to size the safety measures

The support activity of IMAA-CNR to the Basilicata DPC in the landslide emergencies of the last ten years

Date of event	Kind of event	Territory involved	Ordinance or deliberation	Date of ordinace or delibaration
From 18/02/2011 to 01/03/2011	Flood	Jonian coast	Ordinance of the President of the Council of Ministers n.3984	25/11/2011
26/10/2012	Earthquake	Pollino area (southern of Basilicata)	Ordinance of the Head of the Civil Protection Department n.25	20/11/2012
From 7/10/2013 to 8/10/2013	Flood	Bernalda, Montescaglioso, Pisticci, Scanzano Jonico (all towns are located in Matera territory)	Ordinance of the Head of the Civil Protection Department n.145	8/02/2014
From 01/12/2013 to 03/12/2013	Flood and **landslide**	Territory of Potenza and Matera Province; Montescaglioso area	Ordinance of the Head of the Civil Protection Department n.151	21/02/2014
From 05/01/2017 to 18/01/2017	Heavy snow	Different portion of Basilicata region	Deliberation of the Council of Ministers	16/06/2017
- First activation: February 2014 - Worsening of conditions: December 2017	**Landslide**	Urban area of Stigliano (Matera)	Deliberation of the Council of Ministers	29/12/2017
- First activation: 25/01/2019 - Second activation: 29/01/2019	**Landslide**	Urban area of Pomarico (Matera)	Deliberation of the Council of Ministers	14/02/2019

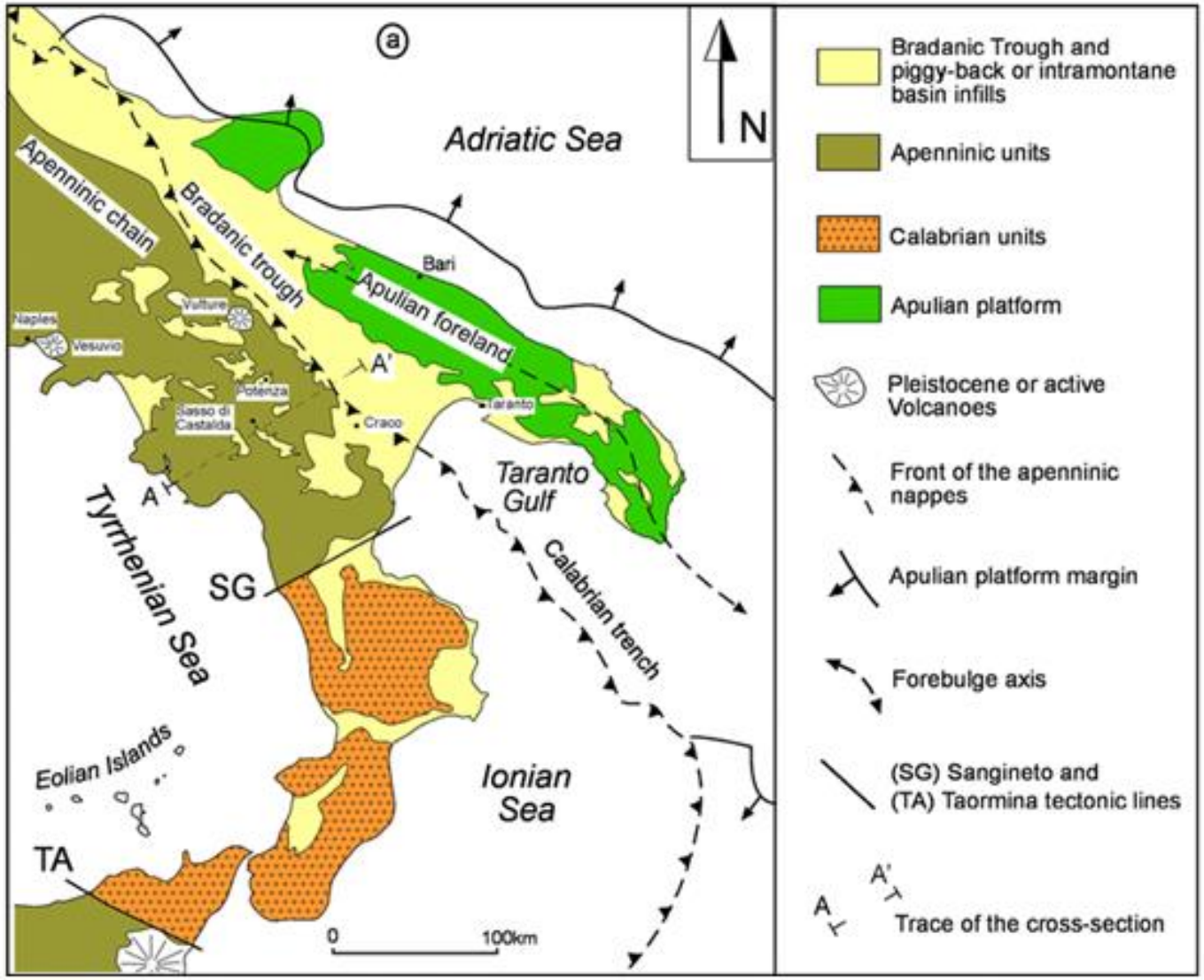
In the last ten years Basilicata region has been affected by significative landslide phenomena, occurring after extreme rain events.

The phenomena mainly affected the hilly area of Matera and in particular the towns of Montescaglioso, Stigliano and Pomarico.

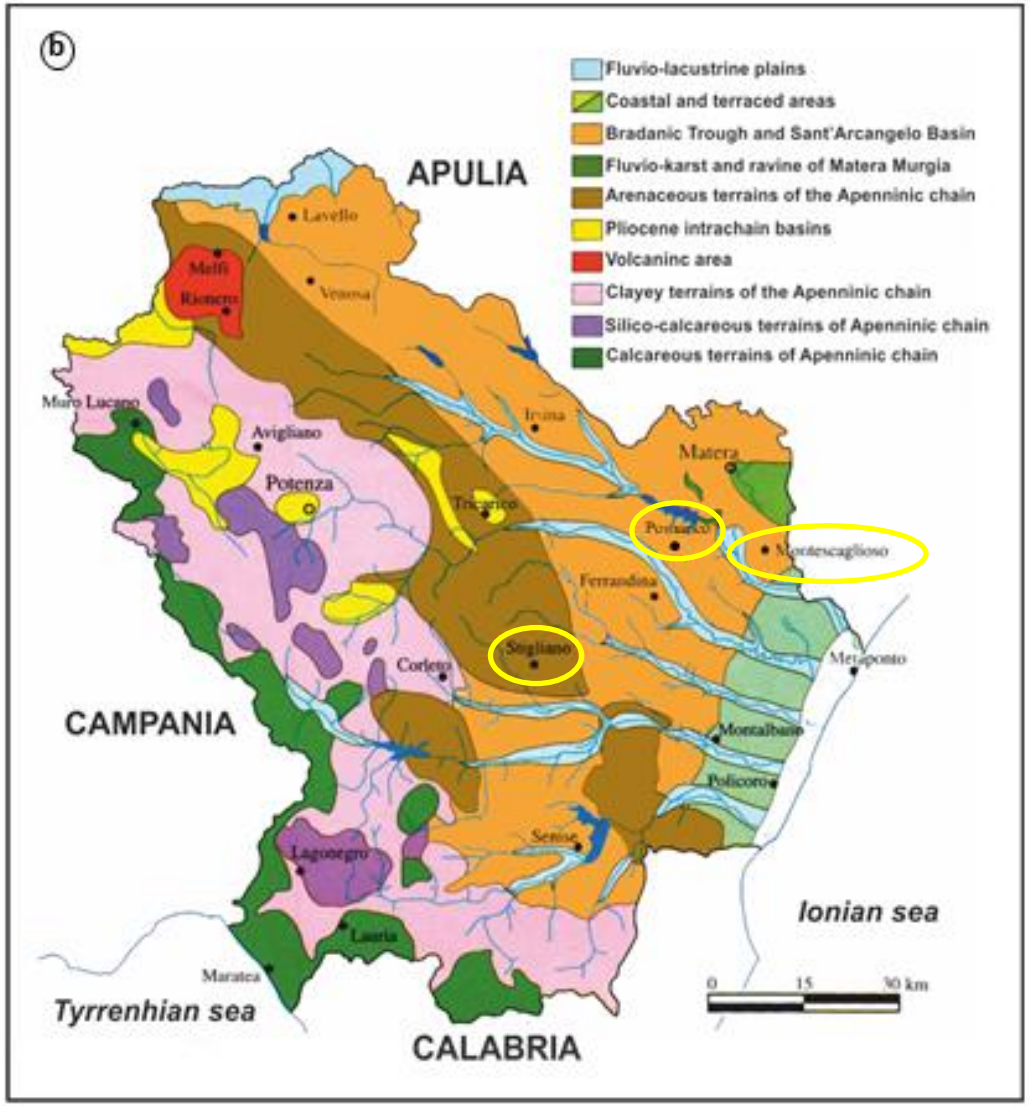
The emergency state was declared after each of these events has occurred.

Geophysical Laboratory of IMAA-CNR has supported the DRPC by applying in situ geophysical techniques with the aim to provide a geophysical model useful to reconstruct the geological setting of the subsoil, to identify the sliding surface and to locate high water content areas.

Lithology and landslides distribution in Basilicata region

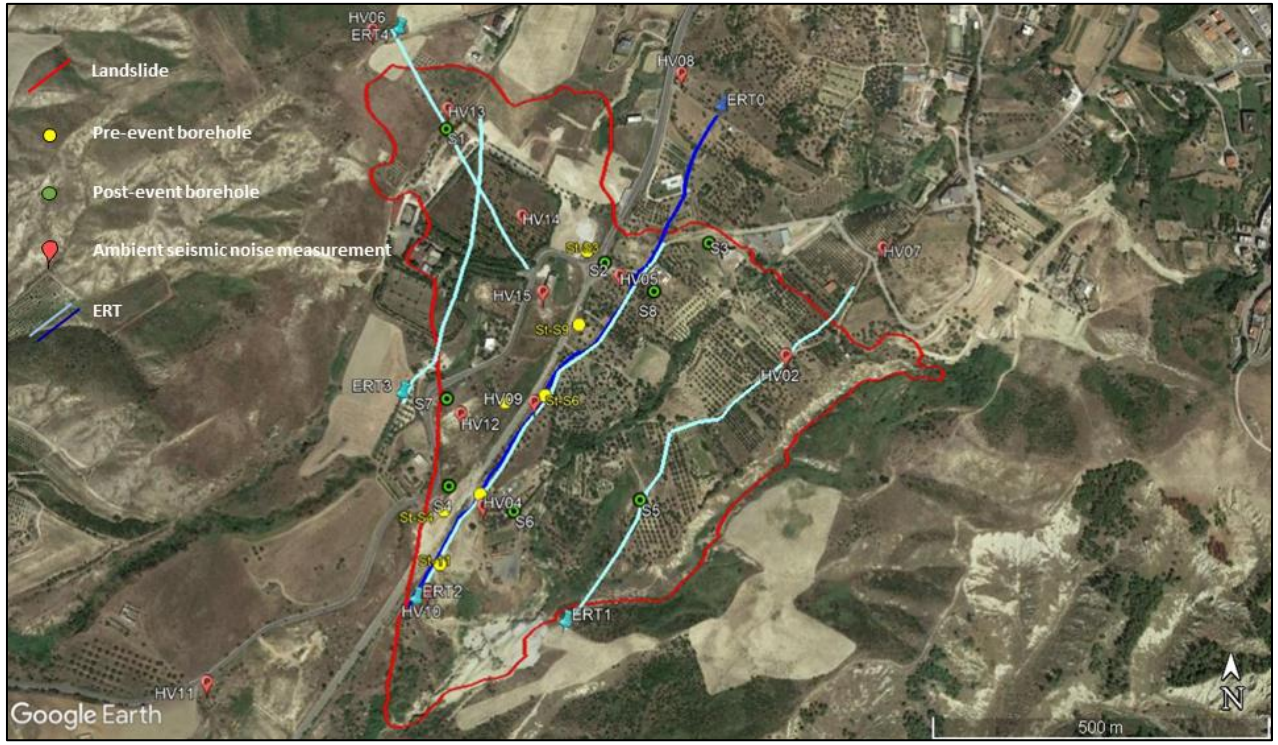


Modified by Bentivenga et al., 2017



Modified by Lavecchia et al., 2003

Montescaglioso landslide: December 2013

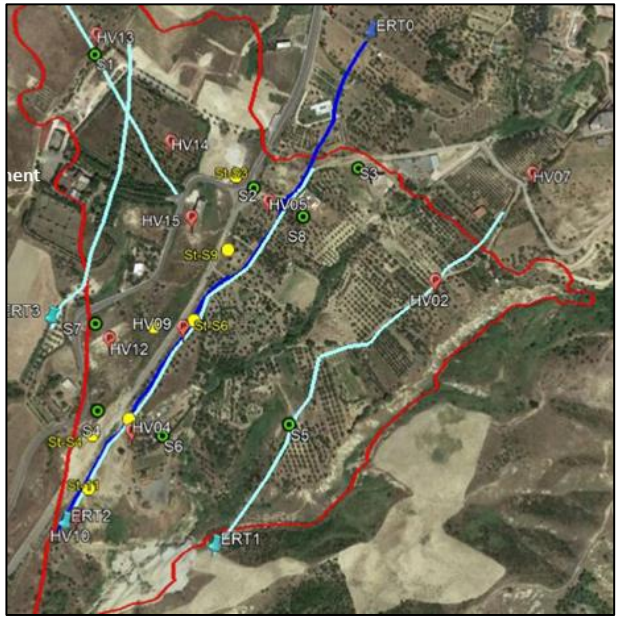


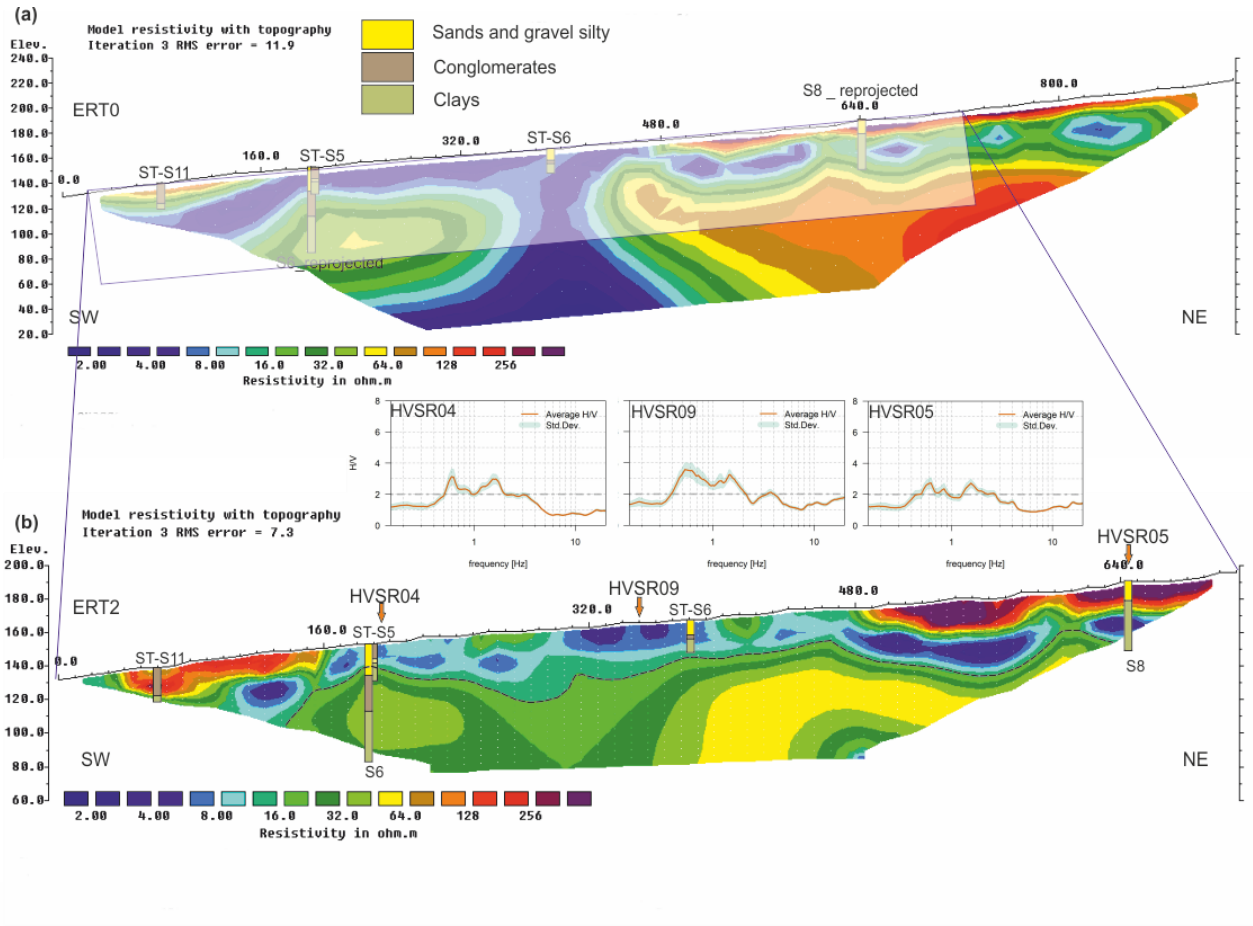
Trigger factor: rainfall (rain gauge station of Ginosa 8 km east)

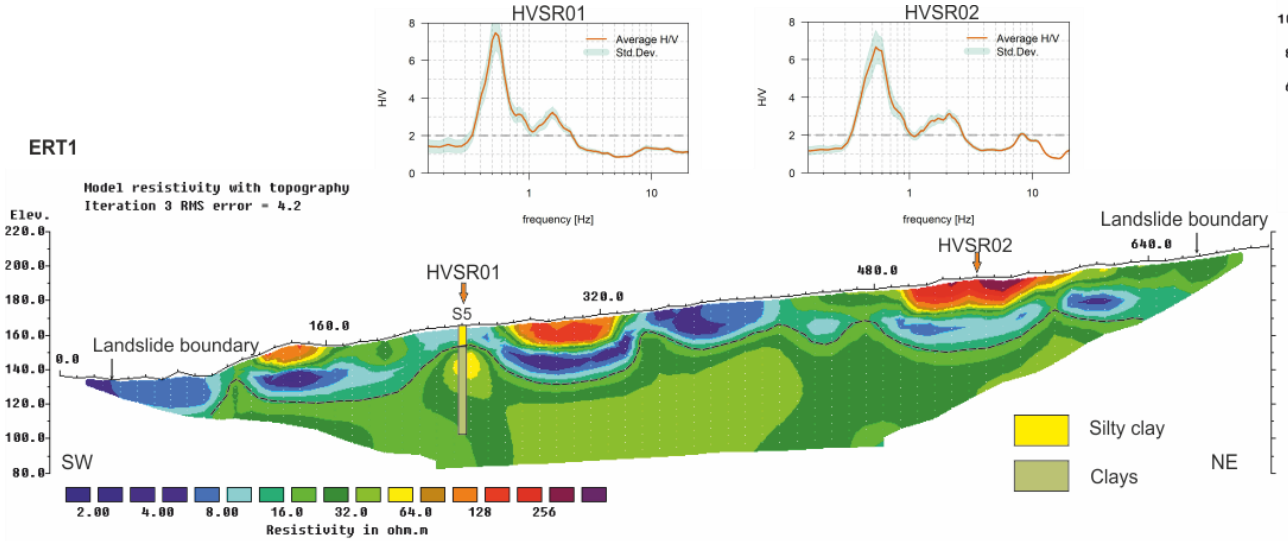
Cumulative rain (mm)	Starting date and local time	Ending date and local time
246.4	6th of October 2013 at 00:00	9th of October 2013 at 11:00
157.6	30th of November 2013 at 13:00	3rd of December 2013 at 2:00

Kind of measure	Action	Number of action	Date
Ordinance	Interdiction to access in landslide area	2	3th December 2013
Ordinance	Evacuation of buildings in landslide area	17	3th December 2013
Ordinance	Evacuation of residential units and annexes (deposits, garages, etc.)	16	3th December 2013
Ordinance	Evacuation of commercial units and annexes (offices, yards, parking, etc.)	8	3th December 2013
Ordinance	Evacuation of residential units (13 people)	4	3th December 2013
Inspection	Technical and structural checks of buildings and infrastructures: n.17 eviction orders n.16 under observation	33	Starting from the 3th of December 2013

Montescaglioso landslide: comparison between ERT, HVSR and stratigraphical data







Geophysical measurements

n. 5 Electrical resistivity tomographies (ERT)

n. 15 Ambient seismic noise measurements (HVSR)

Stigliano landslide: February 2014

Kind of measure	Action	Date
Ordinance n.3	Partial eviction of things and people from the Social Center	20th January 2015
Ordinance n.4	Total eviction of things and people from the Social Center	26th January 2015
Ordinance n.68/74	N.6 families were evacuated from the buildings located in Via Cilento from n.1 to n.17	6th July 2017


Photo by Civil Protection Basilicata region


Photo by Civil Protection Basilicata region

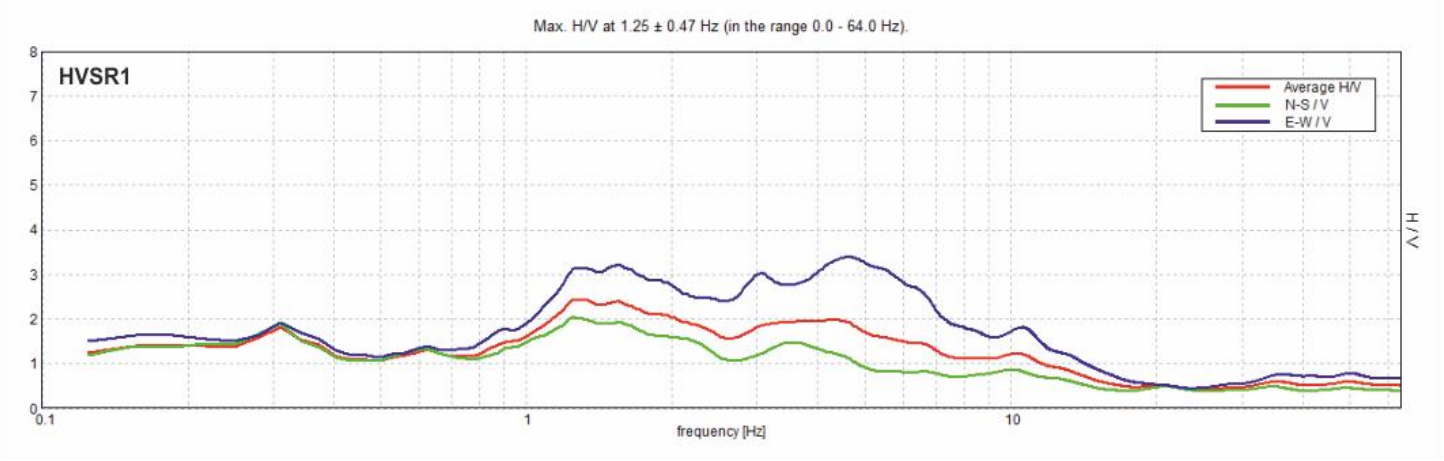
Trigger factor: rainfall

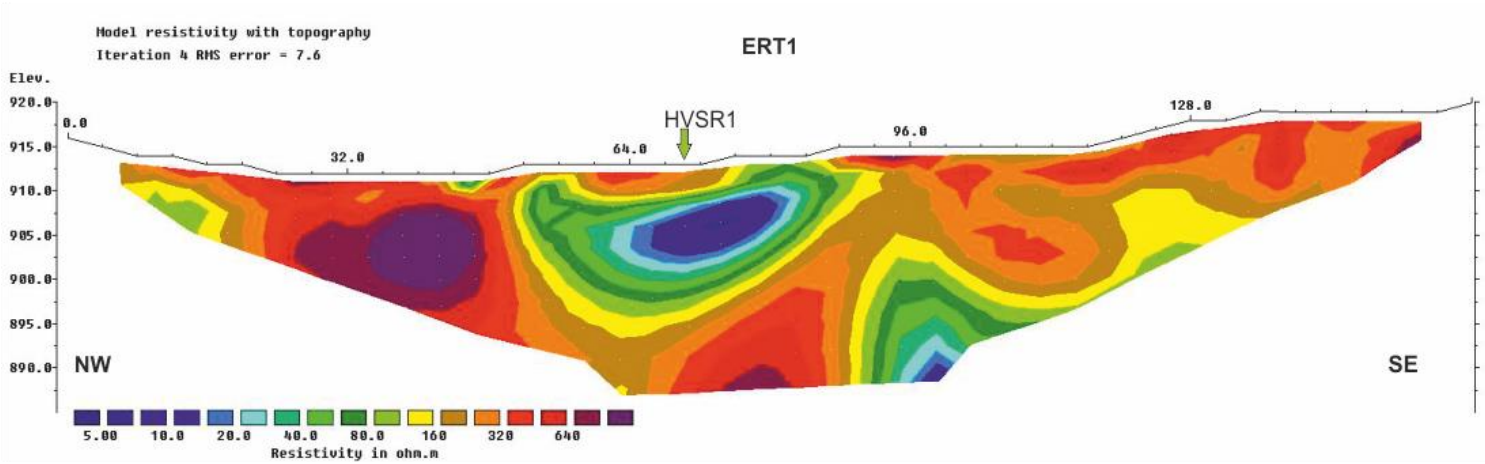
Date	Rain gauge station	Cumulative rain (mm)	Time (h)
5th – 7th October 2013	Gorgoglione	50.60	72
5th – 7th October 2013	San Mauro Forte	26.60	72
11th – 13th November 2013	Gorgoglione	98.40	72
11th – 13th November 2013	San Mauro Forte	107.60	72
30th November – 2nd December 2013	Gorgoglione	164.40	72
30th November – 2nd December 2013	San Mauro Forte	191.20	72
1st – 3rd February 2014	Gorgoglione	124.40	72
1st – 3rd February 2014	San Mauro Forte	97.20	72


Photo by Civil Protection Basilicata region


Photo by Civil Protection Basilicata region

Stigliano landslide: comparison between ERT and HVSR



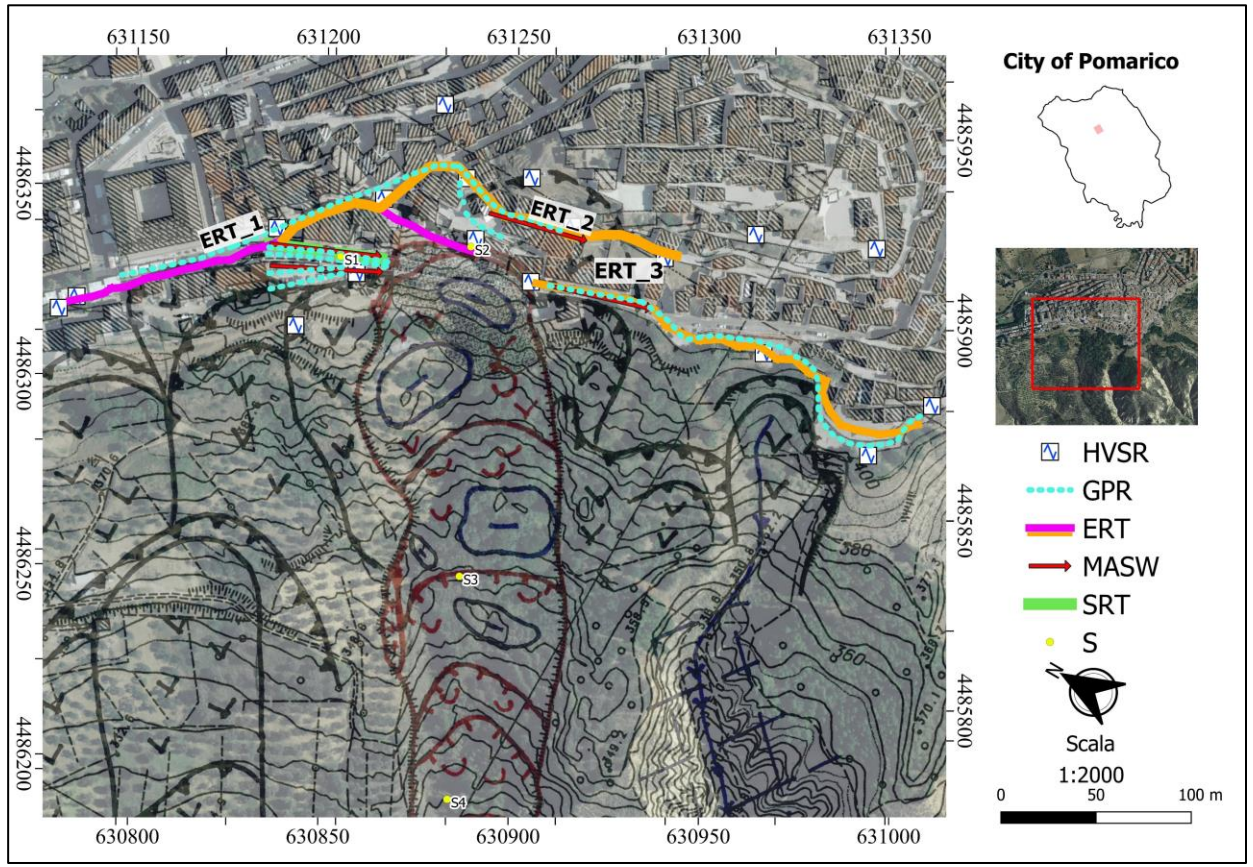


Geophysical measurements

n. 2 Electrical resistivity tomographies (ERT)

n. 2 Ambient seismic noise measurements (HVSR)

Pomarico landslide: January 2019

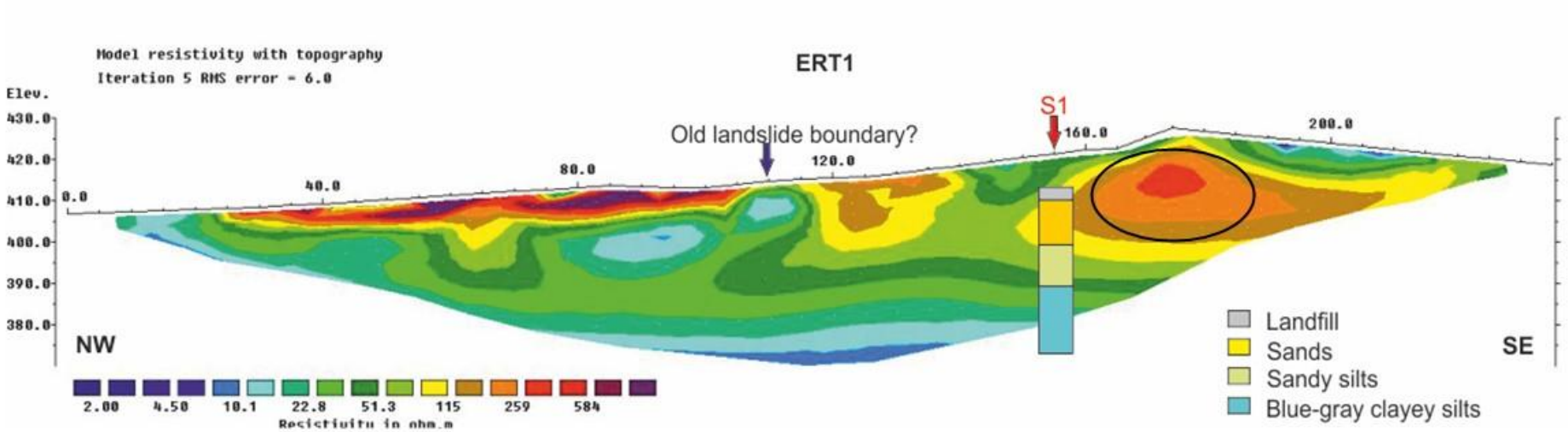


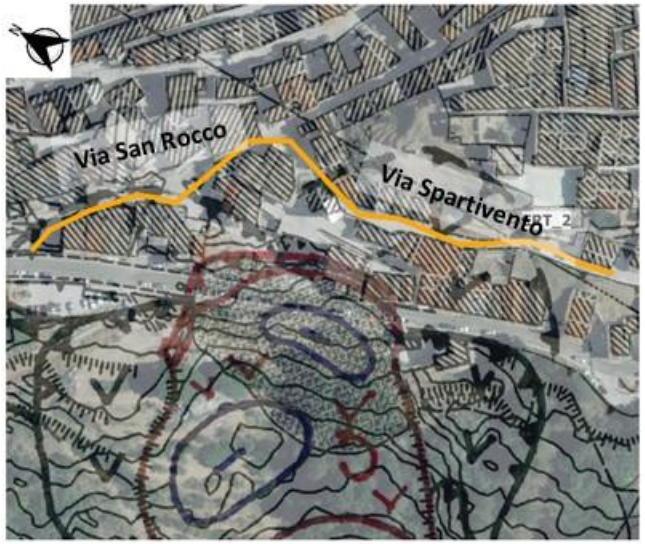
Kind of measure	Action	Date
Ordinance n.1	Eviction of n.14 residential and commercial units; traffic closure of Corso Vittorio Emanuele.	25th January 2019
Ordinance n.2	Eviction of n.11 residential and commercial units.	26th January 2019
Ordinance n.6	Eviction of n.27 residential units; traffic ban in Salita S. Rocco up to the intersection with Spartivento road and Castello Quarter.	30th January 2019

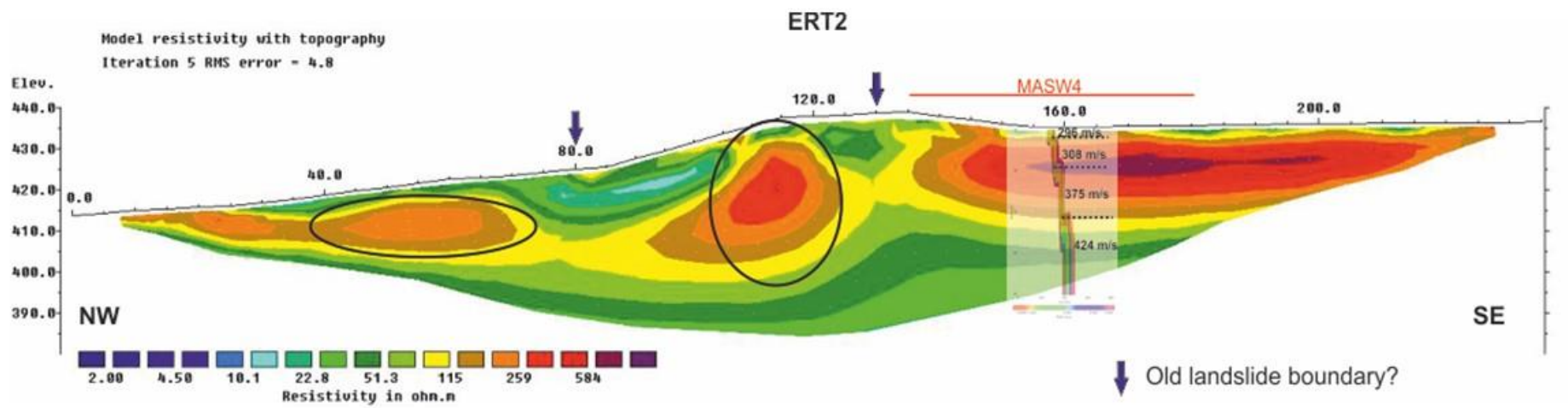
Trigger factor: rainfall

Date	Rain gauge station	Cumulative rain (mm)	Time
24th – 26th January 2019	Matera	42 mm	48 hours
24th – 26th January 2019	Torre Accio – Bernalda	55 mm	48 hours

Pomarico landslide: comparison between ERT, MASW and stratigraphy







Geophysical measurements

n. 3 Electrical resistivity tomographies (ERT); n. 4 Multichannel Analysis of Surface Waves (MASW)

n. 1 Seismic refraction tomography (SRT); n. 20 Ambient seismic noise measurements (HVSR); 810 m georadar profiles (GPR)

Final remarks

- Geophysical techniques, being less invasive and more expeditious than direct techniques (especially geotechnical), prove to be particularly suitable during the landslide emergency phase.

- Geophysical techniques are easily applicable to investigate landslides occurred in rural areas.

- Geophysical techniques can be affected by applicability problems in the study of landslides that affect urban areas.

- In these areas, the integration of different geophysical techniques along the same profiles can help to obtain a large amount of information, improving the interpretation and the significance of the results.