Near real-time landslides monitoring networks: problems and possible solutions

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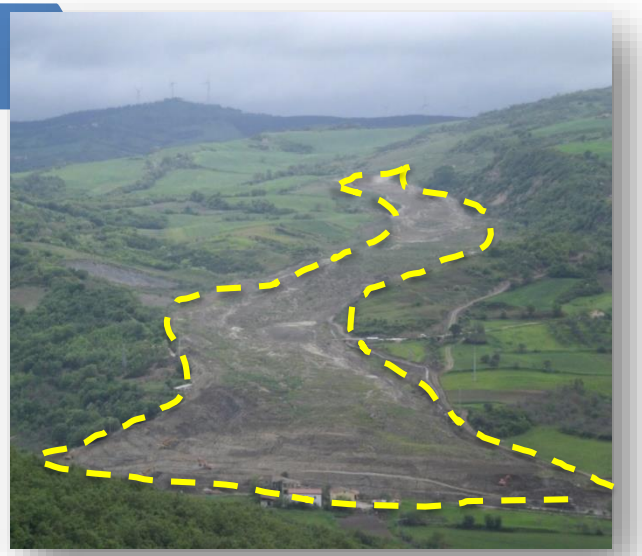
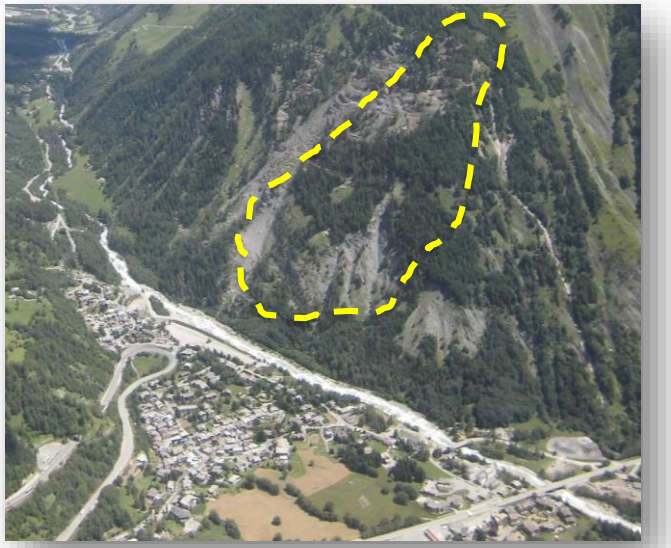
GMG monitoring activities

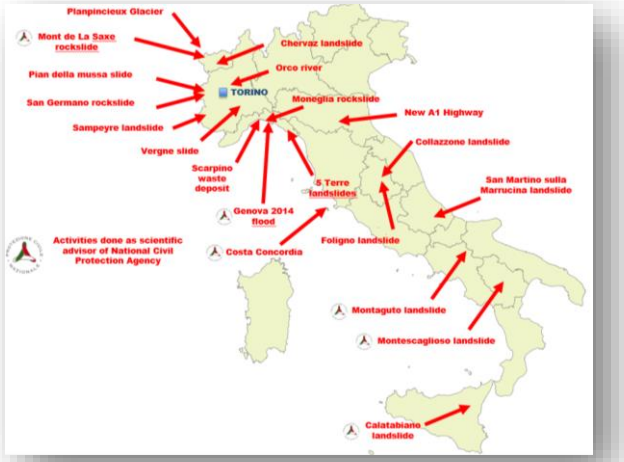


Montaguto earthflow (6 M m³)

Monesi slide (10 M m³)



Mt de La Saxe rockslide (8 M m³)



Not only large landslides…….

Costa Concordia

Paganica active fault

LANDSLIDES MONITORING - THREE MAIN PHASES:

1: On site data acquisition

The design of the monitoring network and the identification of the best technological solutions should consider the early indications of the geological model

2: Data collection and processing

The management in near real time of a complex monitoring network requires a dedicated (hardware software) infrastructure

3: Monitoring results dissemination

Often underestimated, in particular during emergencies, the proper communication is fundamental!

Near real-time landslide monitoring: many possible solutions

Inclinometers

GNSS

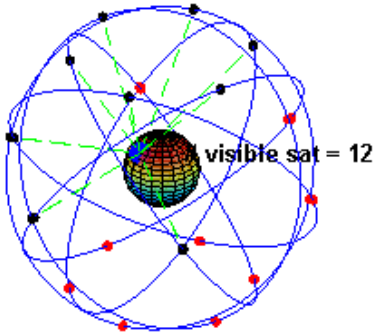
GB SAR

Optical Sensors

RTS

Near real time on site data acquisition

GNSS



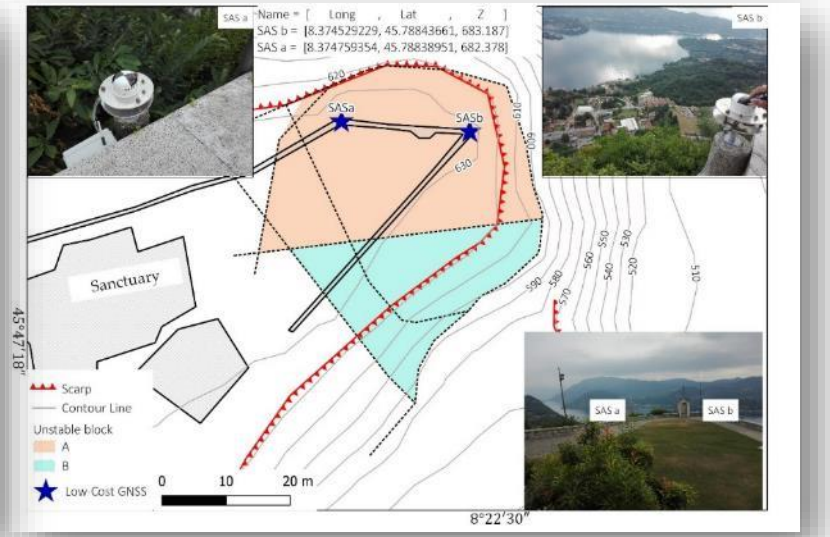
MAIN FEATURES

- Network composed by different active receivers without a physic/optic link
- Punctual 3D monitoring
- Low-cost solutions available

CRITICAL POINTS

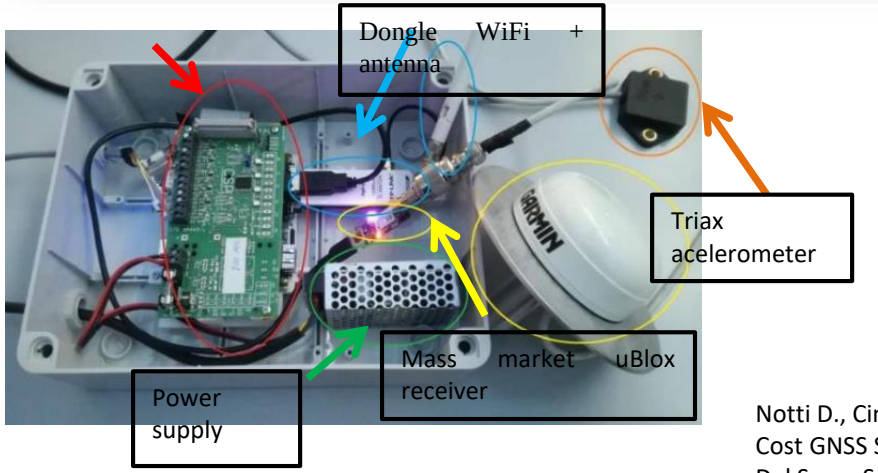
- The high performance GNSS monitoring station is expensive
- The accuracy of the position is related to the adopted time-window and the performance of the receiver
- Monitoring stations require an expensive hardware that could be lost due to the activity of the slide
- Low cost solutions require long time windows or RTK acquisition

GNSS

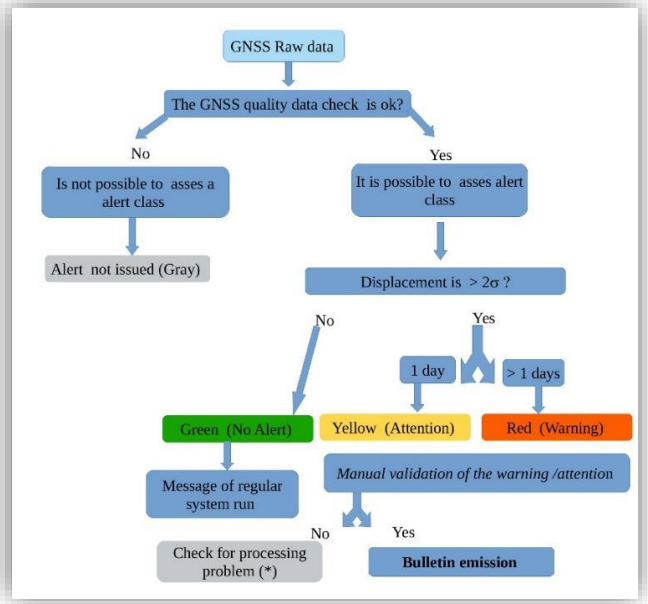


Case study: Madonna del Sasso Sanctuary GNSS low cost monitoring solution

The developed system is aimed to control the position of the frontal part of the Sanctuary yard and identify possible anomalies; then, a more accurate monitoring system will be activated

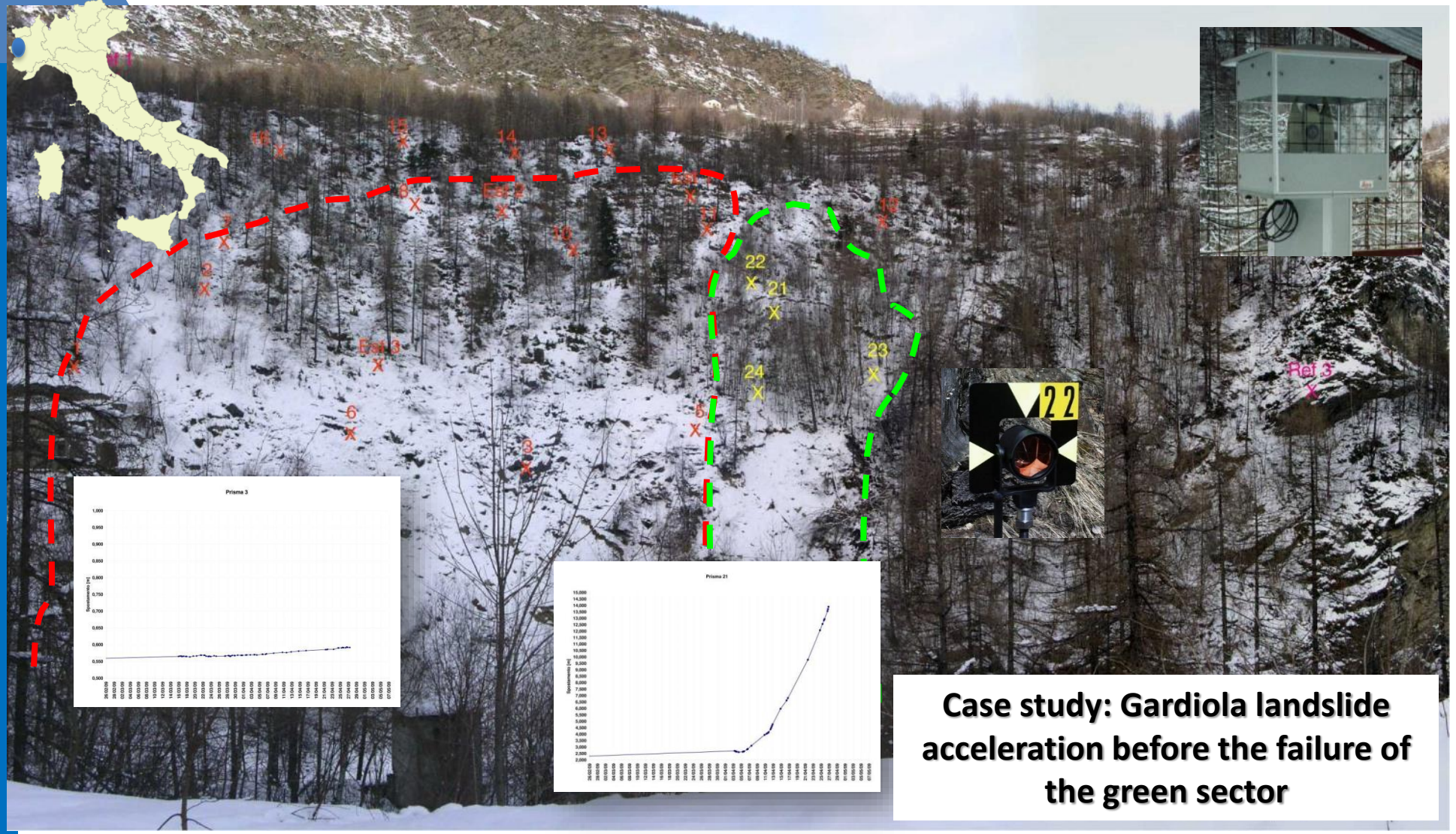


Instrument	Unit Cost
GNSS uBlox L1	70 €
Garmin antenna	50 €
Tri-axial accelerometer + temperature sensor	150 €
Micro PC mainboard, plastic box and dongle Wi-Fi	200 €
batch procedure RTKlib per RT e PP from NRTK SPIN	free



Notti D., Cina A., Manzino A., Colombo A., Bendea I.H., Mollo P., Giordan D. 2020. Low-Cost GNSS Solution for Continuous Monitoring of Slope Instabilities Applied to Madonna Del Sasso Sanctuary (NW Italy). Sensors, 20(1), 289.

Robotized total station



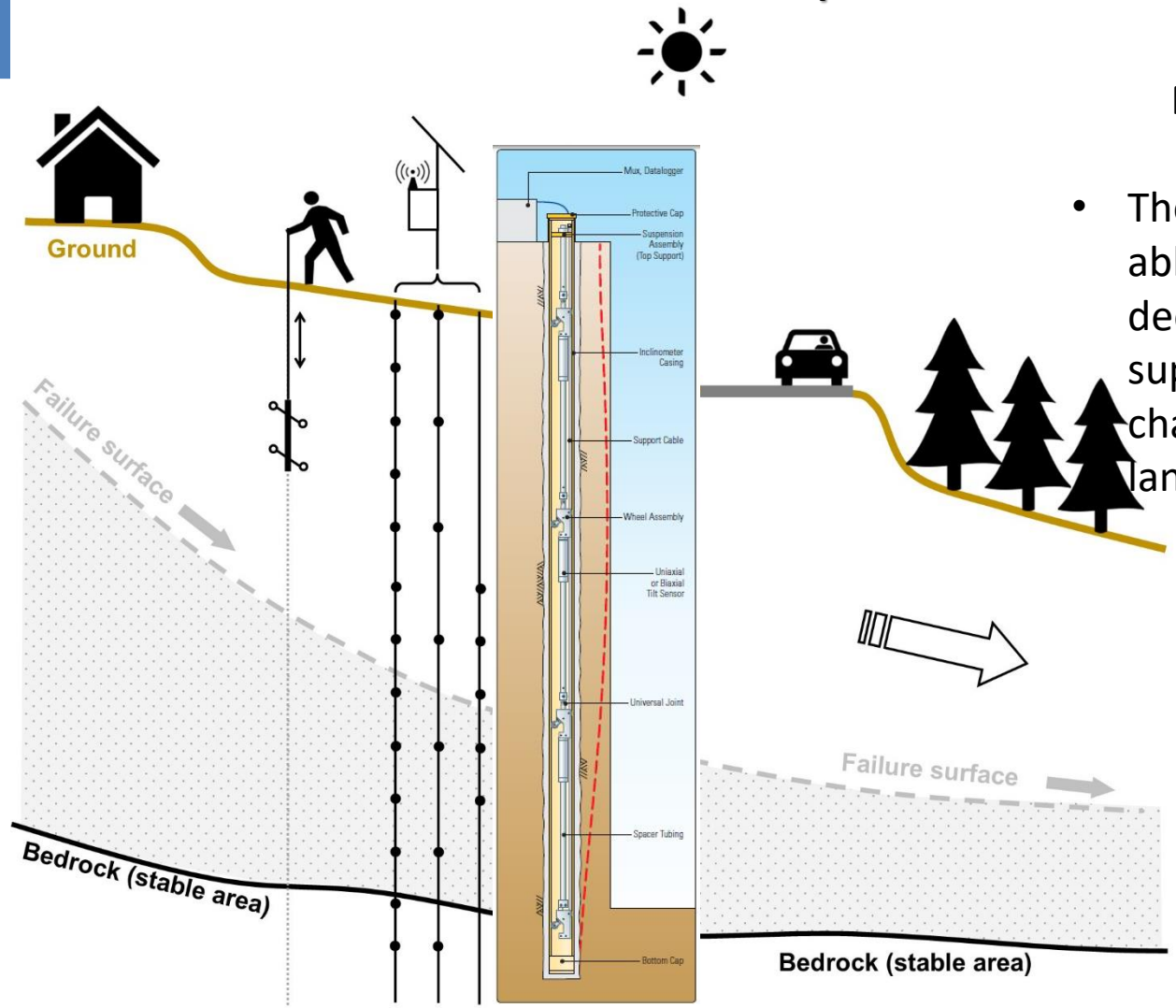
MAIN FEATURES

- Network composed by different target and a single active instrument
- Punctual 3D monitoring
- High accuracy and frequency

CRITICAL POINTS

- visual connection between station and target is mandatory
- Problems with bad atmospheric conditions

In place inclinometric columns



MAIN FEATURES

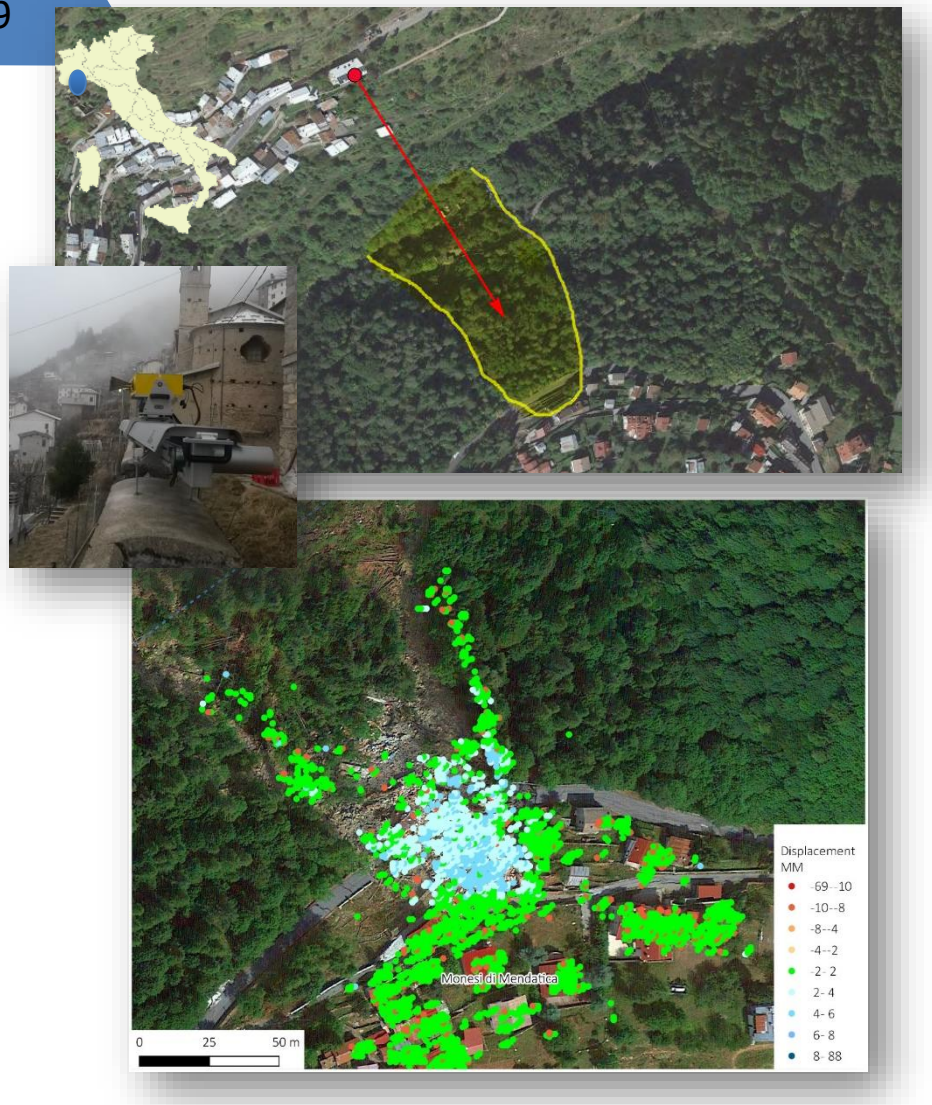
- The single installation is able to monitor the deep displacement and support the 3D characterization of the landslide

CRITICAL POINTS

- High performance solutions are very expensive
- Low cost solutions are often not very accurate
- Problem of sensor drift without the possibility of a compensation procedure
- Due to the high cost of the single module, not all the column is monitored

Allasia P., Lollino G., Godone D., Girdan D. 2018 Deep displacements measured with a robotized inclinometer system. Proceedings of 10th International Symposium on Field Measurements in Geomechanics – FMGM2018

Ground based SAR



MAIN FEATURES

- A single instruments that is able to cover a large area
- High frequency of acquisition
- Only LOS component monitored

CRITICAL POINTS

- Expensive
- Complex installation
- The total displacement could be underestimated

Case study: Monesi landslide SAR monitoring

Notti D., Wrzesniak A., Dematteis N., Lollino P., Nuzio LF, Zucca F., Giordan D. 2020 A multidisciplinary investigation of deep-seated landslide reactivation triggered by an extreme rainfall event: a case study of the Monesi di Mendatica landslide, Ligurian Alps. Landslides, 18, 2341-2365

Smart networks

MAIN FEATURES

- geotechnical instrumentations can be very useful in particular if they are managed by a smart network
- The frequency of acquisition is very high and they can be adopted even in real time
- Smart networks can collect a large number of different parameters and sesnors on the landslide and infrastructures

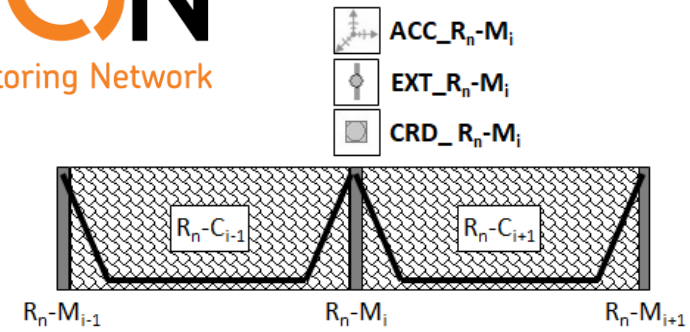
CRITICAL POINTS

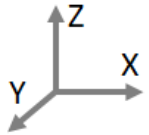
- The number of false alarms can be very high, only a strong post processing can balance this problem

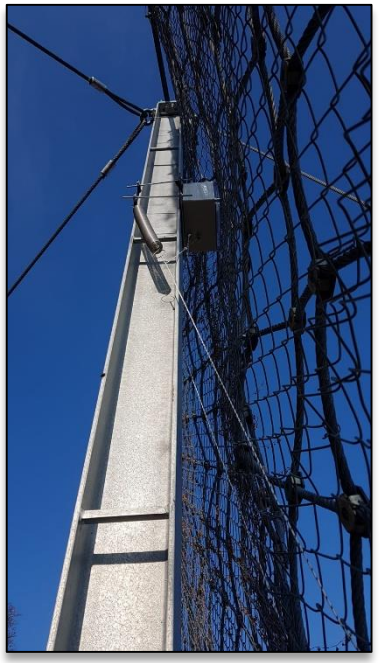
Smart network applied to rockfalls barriers monitoring

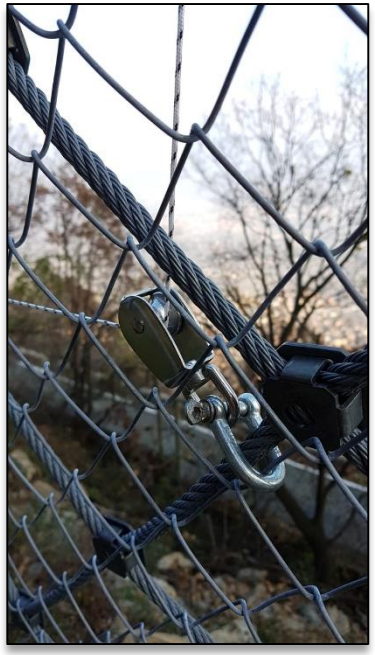
LASMON
Landslide Smart Monitoring Network

Smart network applied to rockfalls barriers monitoring









Case study: Val Pelline test field

COMPLEX LANDSLIDES MONITORING NETWORKS ARE A GOOD SOLUTION BUT….

Commercial monitoring systems are often characterized by ‘closed’ software with a limited interoperability with other instruments provided by different companies

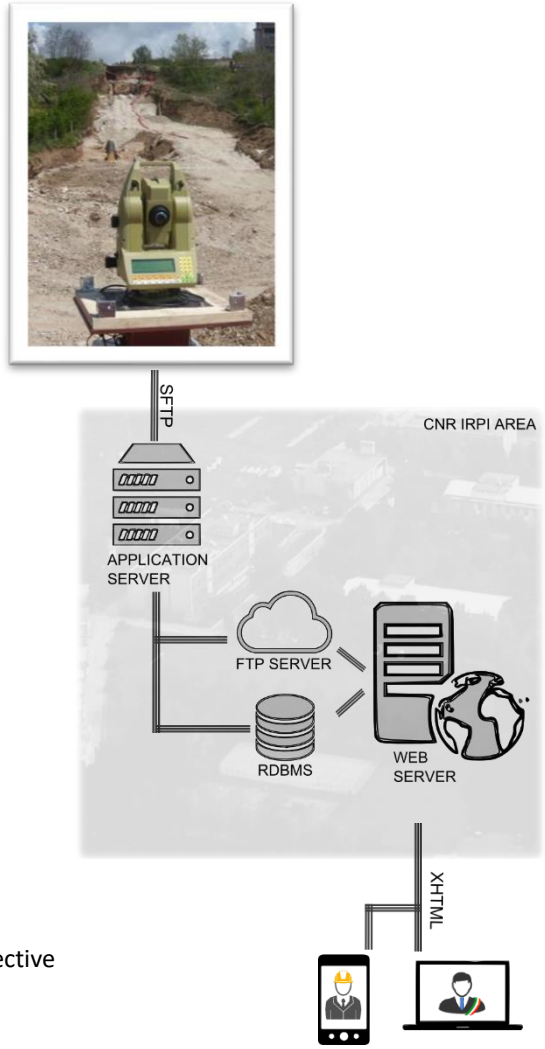
The risk that a complex monitoring network could become a sort of ‘technological Babel’ is real

During emergencies, it is important to have a system able to manage data fusion and comparison between different instruments

The final goal of a monitoring network is not only the acquisition and management of data, but also the DISSEMINATION OF OBTAINED RESULTS

The Geohazard Monitoring Group developed **LANDMON (LANDslides MOnitorng Network)**, a system able to manage landslide monitoring networks in near real time

The system is able to:
acquire data from in situ instrumentations,
transfer to the GMG sever,
process the available dataset using dedicated alghoritms
Publish results on GMG web page



Giordan D., Wrzesniak A., Allasia P. 2019. The importance of a dedicated monitoring solution and communication strategy for an effective management of complex active landslides in urbanized areas. Sustainability, 11(4), 946

Allasia P., Manconi A., Giordan D., Baldo M., Lollino G. 2013. ADVICE: A New Approach for Near-Real-Time Monitoring of Surface Displacements in Landslide Hazard Scenarios. Sensors, 13(7), 8285-8302.

LANDMON MAIN FEATURES

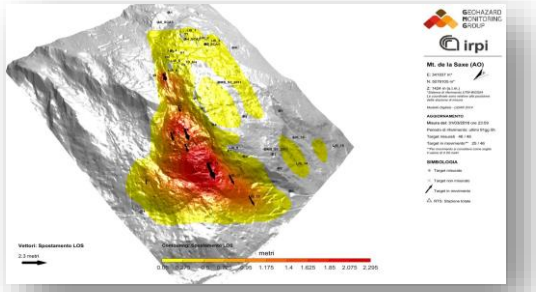
Acquisition, management and merging of different instrumentation datasets

On line publication of monitoring results

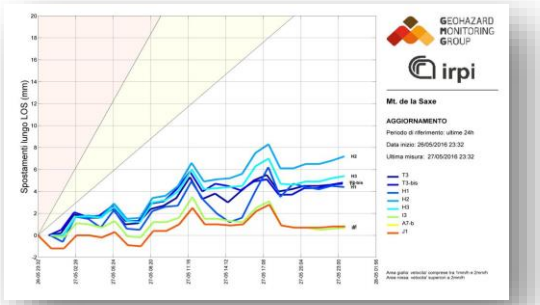
Management of thresholds for early warning applications

Near real time failure forecast

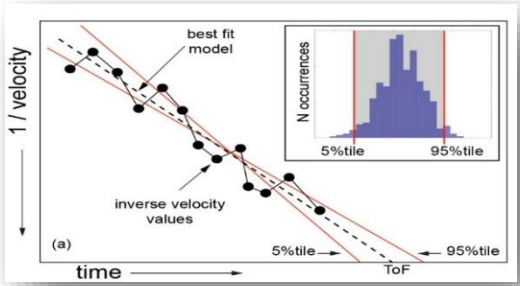
ALL THESE ACTIVITIES SHOULD BE DONE AUTOMATICALLY TO BE AN EFFECTIVE SUPPORT TO DECISION MAKERS



GbinSAR and Robotised total station datasets merged in the same representation



Thresholds management



Time to failure forecasts (inverse velocity)

Manconi A., Giordan D. 2015. Landslide early warning based on failure forecast models: the example of the Mt. de La Saxe rockslide, northern Italy. Nat. Hazards Earth Syst. Sci., 15, 1639–1644.

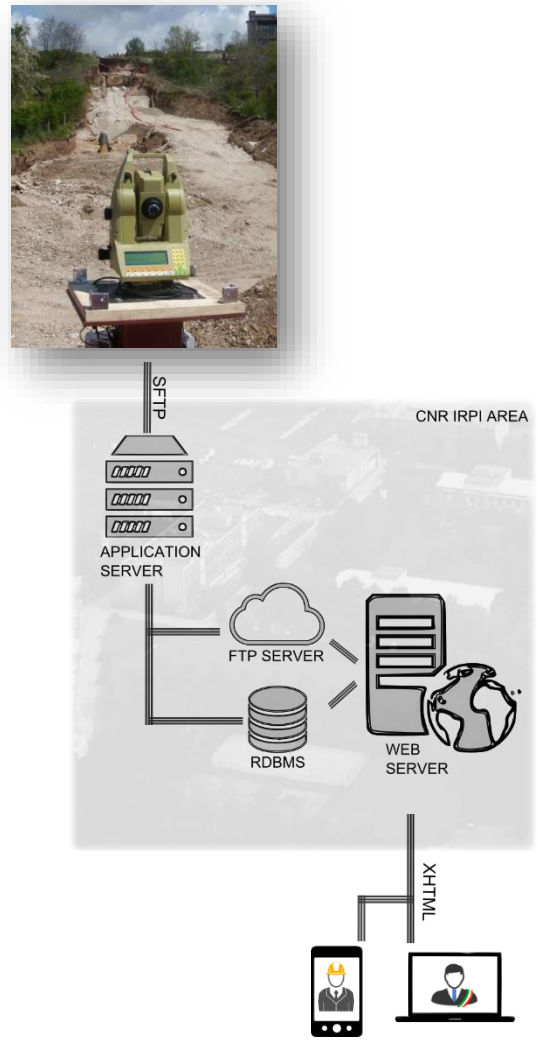
Manconi A., Giordan D. 2016. Landslide failure forecast in near-real-time. Geomatics, Natural Hazards and Risk, 7 (2), 639, 648.

LANDMON communication strategy

LANDMON is also a communication system that supplies different monitoring results representations according to the stakeholders' background

ASSUMPTION

The use of monitoring systems is correct only if ALL THE INVOLVED PEOPLE CAN UNDERSTAND published results



Giordan D., Manconi A., Allasia P., Bertolo D. 2015. Brief Communication: On the rapid and efficient monitoring results dissemination in landslide emergency scenarios: the Mont de La Saxe case study. Nat. Hazards Earth Syst. Sci., 15, 2009–2017

Giordan D., Wrzesniak A., Allasia P. 2019. The importance of a dedicated monitoring solution and communication strategy for an effective management of complex active landslides in urbanized areas. Sustainability, 11(4), 946

LANDMON communication strategy

Near real time website application for the publication of monitoring results

Periodically bulletins with the description of the landslide evolution

Representation of recent landslide evolution with updated plots and infographics

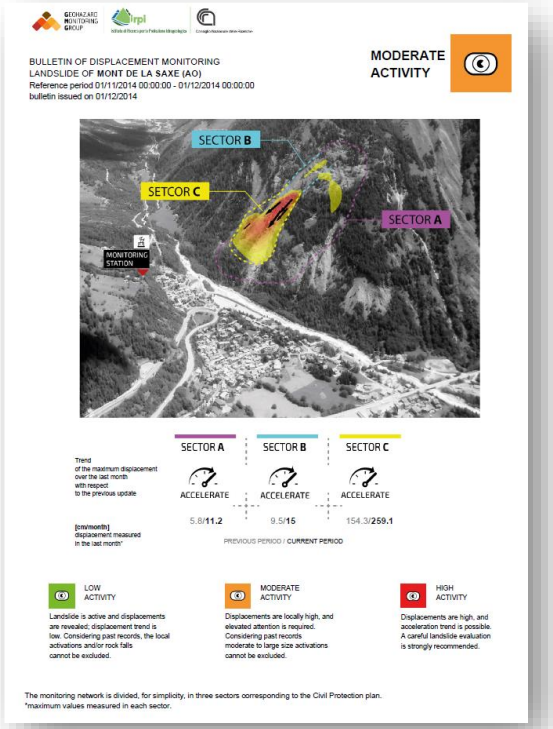
Commented description of recent landslide evolution

N.B. A CORRECT DISSEMINATION OF COMMENTED MONITORING RESULTS MAKES THE DIFFERENCE BETWEEN A 'SIMPLE' LANDSLIDE MONITORING NETWORK AND A DECISION-MAKERS SUPPORT SYSTEM

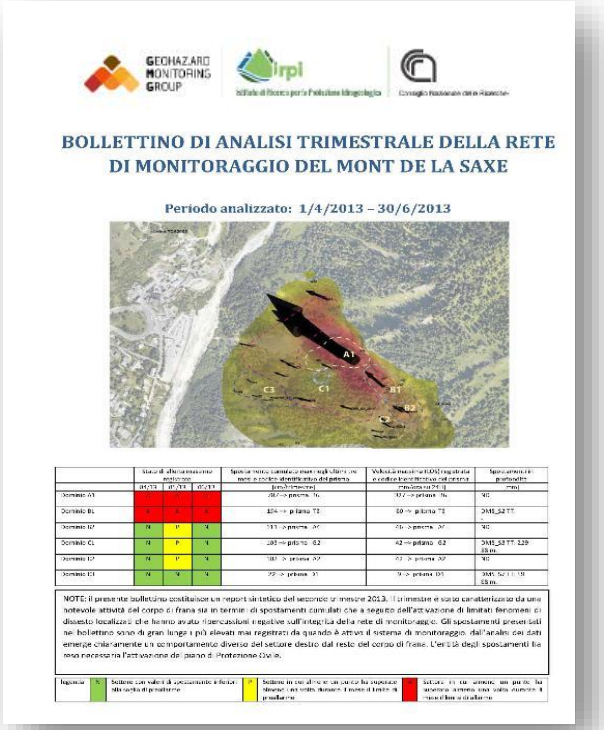
LANDMON communication strategy

BULLETINS

Single page bulletin
For a rapid information

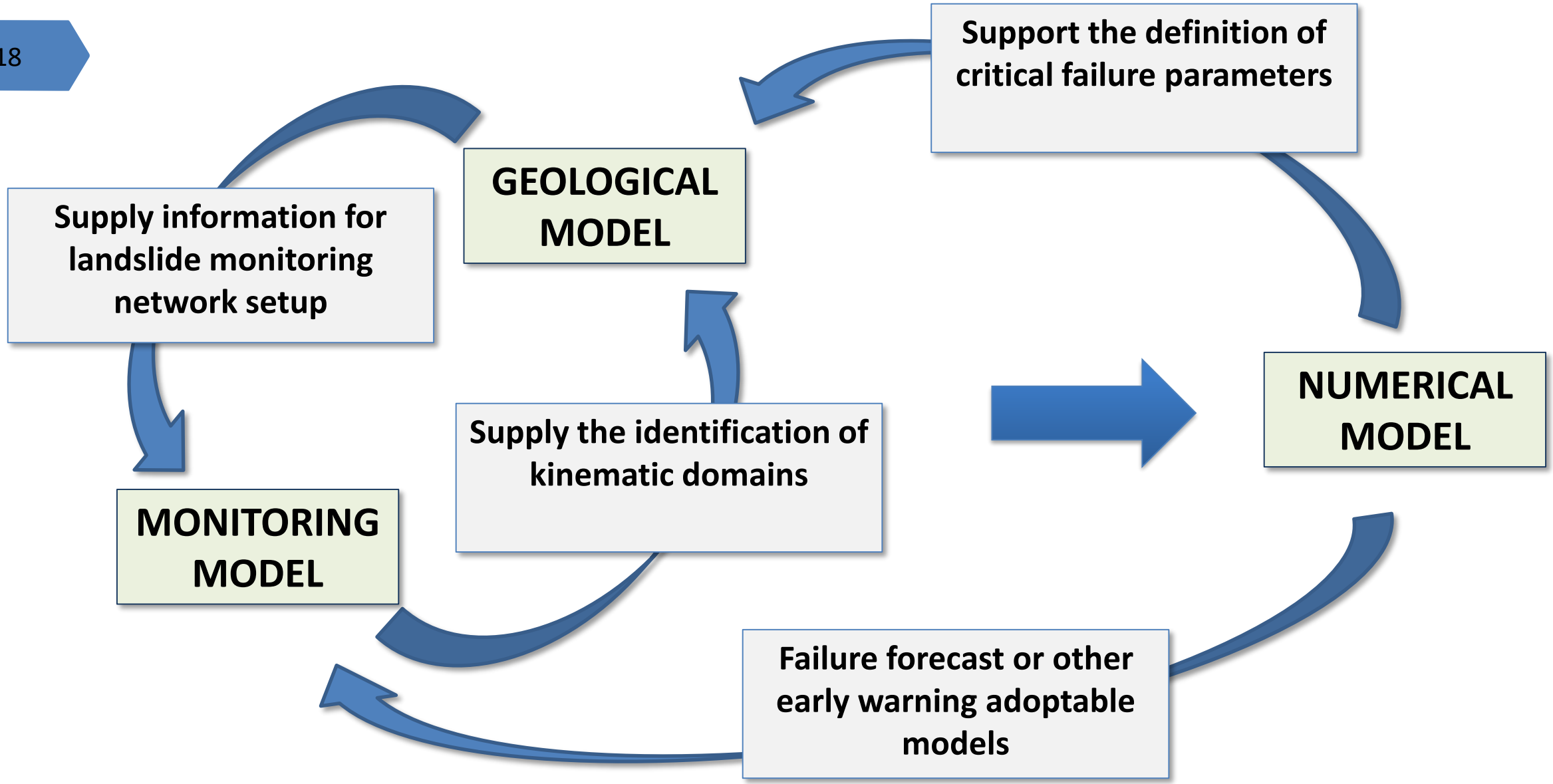


Extended bulletin
For a detailed analysis



Operative Monography
Synthesis of all collected data

Landslide monitoring – What next?




Thank you
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