



Kinematics of the Slumgullion Landslide revealed by Ground based InSAR Survey

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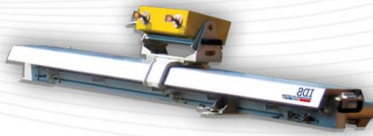
Landslide kinematics

Traditional approaches for characterizing landslide kinematics:

- Often require centimeters-meters of landslide movement to be effective
- Are labor intensive
- Costly
- Time consuming
- Dangerous on inaccessible landslide.



We tested the IBIS-L, which is a ground-based, interferometric, synthetic aperture radar to determine whether it could rapidly acquire kinematic data for a complex and large landslide like the Slumgullion.




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Slumgullion Landslide - Colorado USA


- 3.9 km long,
- 300 m wide
- Average thickness of 13 m
- Mean inclination 8°
- Sporadical Vegetation
- Moves persistently



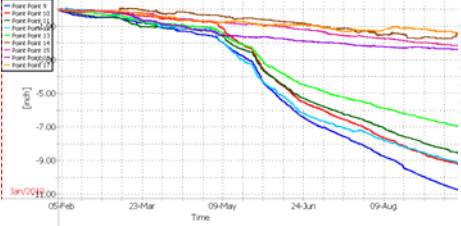
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IBIS-L capabilities

- **Continuously measure (24x7) landslide movements with sub-millimetric accuracy at long distance (up to 4 Km)**
- All weather acquisition
- High spacial resolution



- Map the **long term evolution** of slow moving slopes to get a better knowledge of the rock mass strength



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Techniques behind GBInSAR systems

GBInSAR sensors are based on three well-known radar techniques:

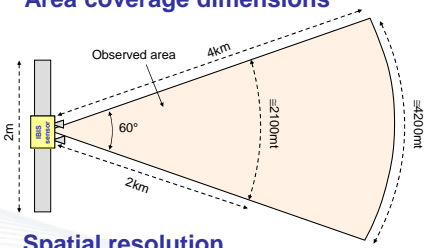
1. **Stepped-Frequency Continuous Wave (SF-CW)** technique resolves the scenario in the range direction, detecting the position in range of different targets placed along the radar's line of sight;
2. **Synthetic Aperture Radar (SAR)** allows to obtain 2D high-resolution radar images by adding to the range resolution (from the SF-CW), the cross-range angular resolution
3. **Interferometric technique**, computes the displacement of each pixels by comparing the phase information of the radar signal collected at different times.

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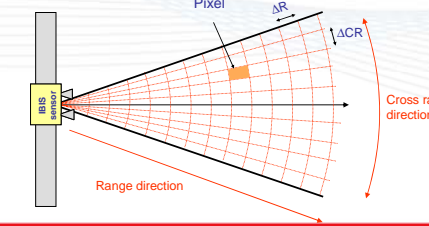
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SAR 2-dimension

Area coverage dimensions



Spatial resolution



Pixel
ΔR
ΔCR
Cross range direction
Range direction

Typical spatial resolutions:

- range: 0.5 m
- cross-range: 4.3 m at 1000 m

High spatial resolution enables the identification within a single bench of several pixels, allowing the detection of small failures.

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Interferometric capability

The interferometric analysis provides data on object displacement by comparing phase information, collected in different time periods, of reflected waves from the object, providing a measure of the displacement with an accuracy of less than 0.01mm.

$$d = -\frac{\lambda}{4\pi} (\varphi_2 - \varphi_1)$$

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SAR 2-dimension

The combination of SAR and SF-CW techniques allows the system to resolve the scenario into two dimensional pixels

Optical Image

Power Map su DTM

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IBIS-L: configurations

Photograph of the IBIS-L monitoring station configuration. The setup includes a Piercing Siren, Ethernet Camera, Photovoltaic Panels, Control PC, Power Supply, Weather Station, Wi-Fi antenna, Generator Set, Sensor Module, and Linear Scanner. Red arrows point from the labels to the corresponding components in the photograph.

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Monitoring instruments

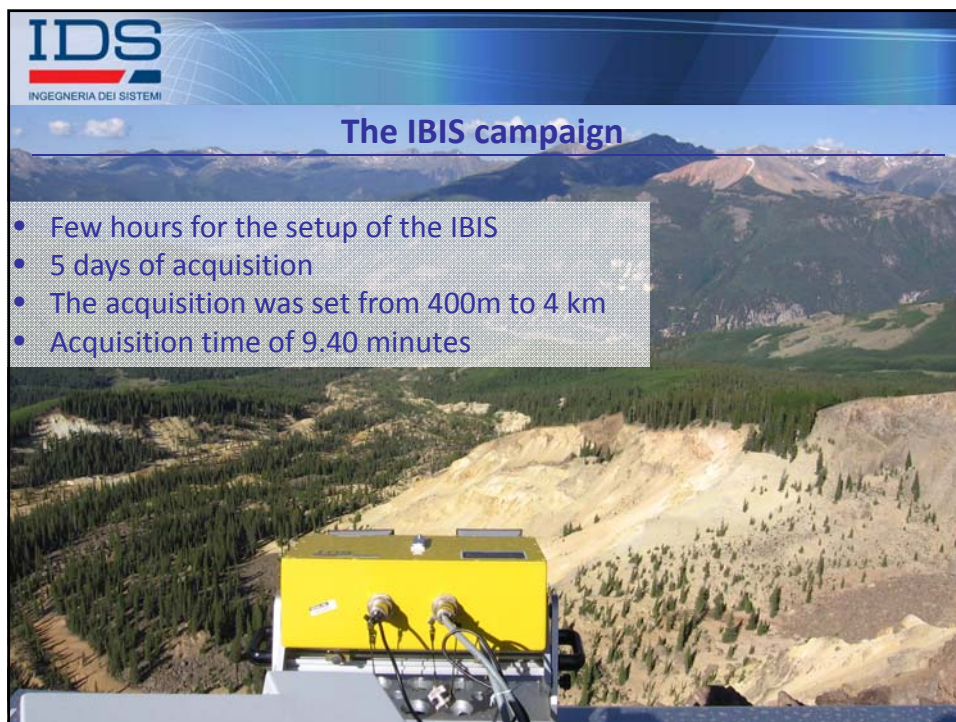
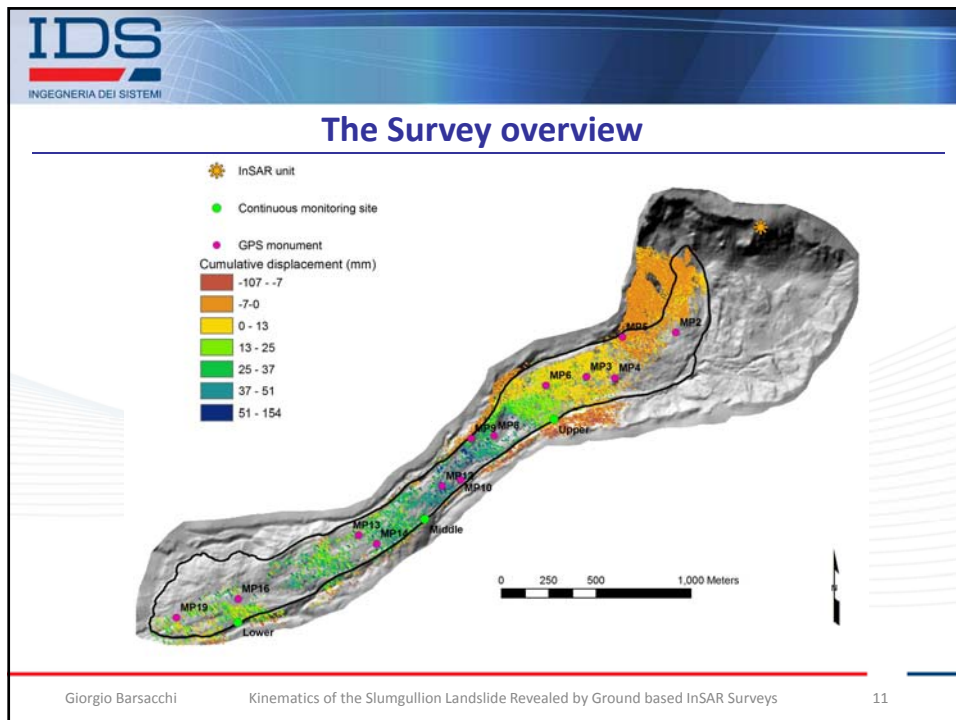
Ground Based InSAR

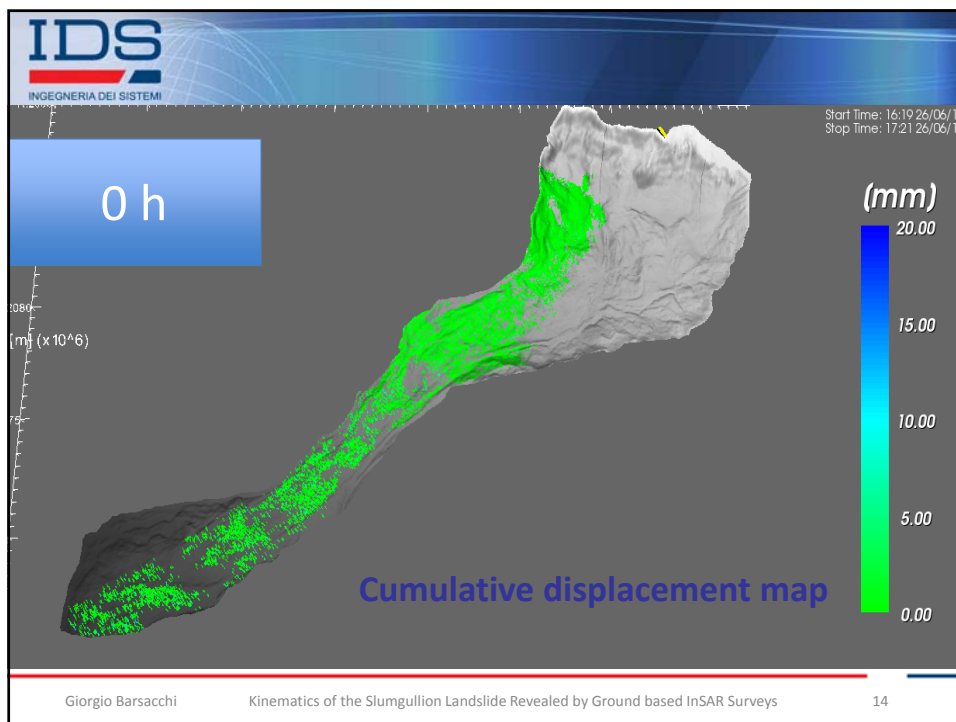
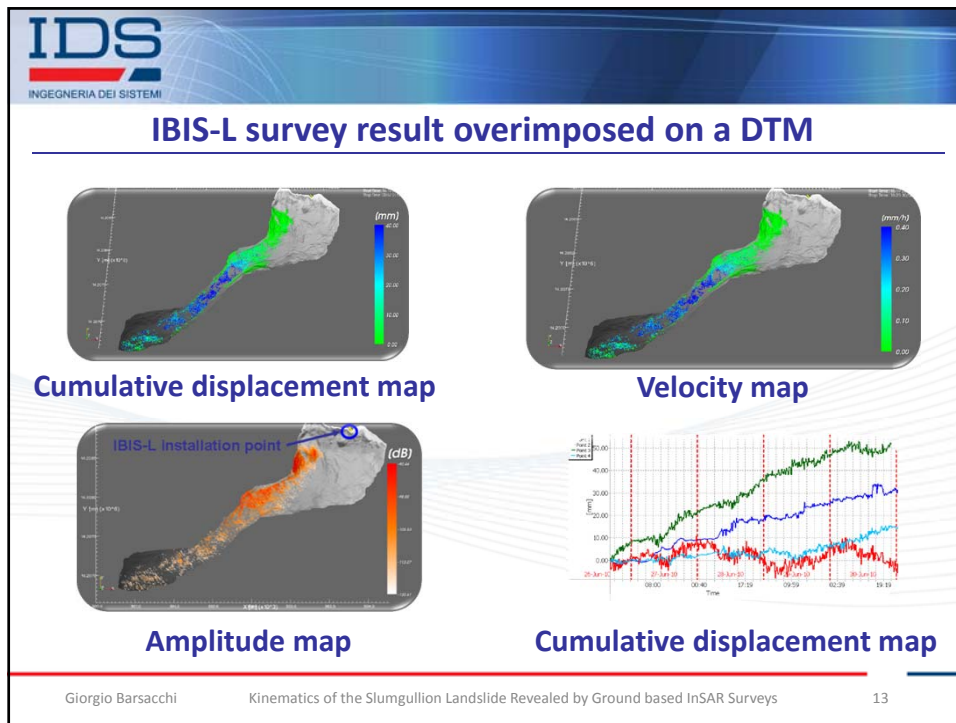
Extensometer

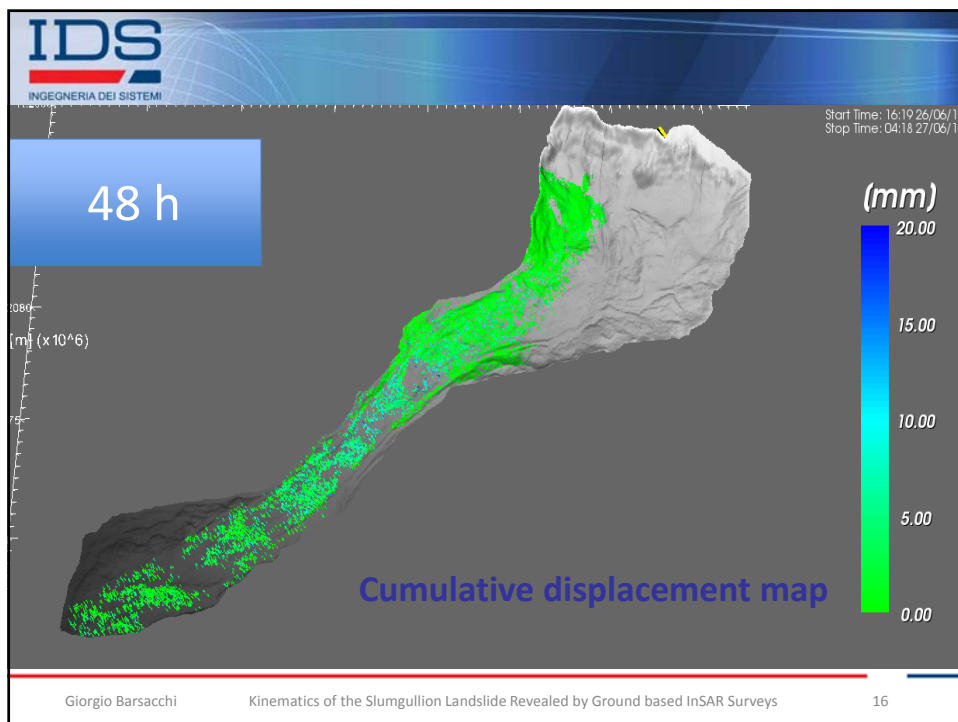
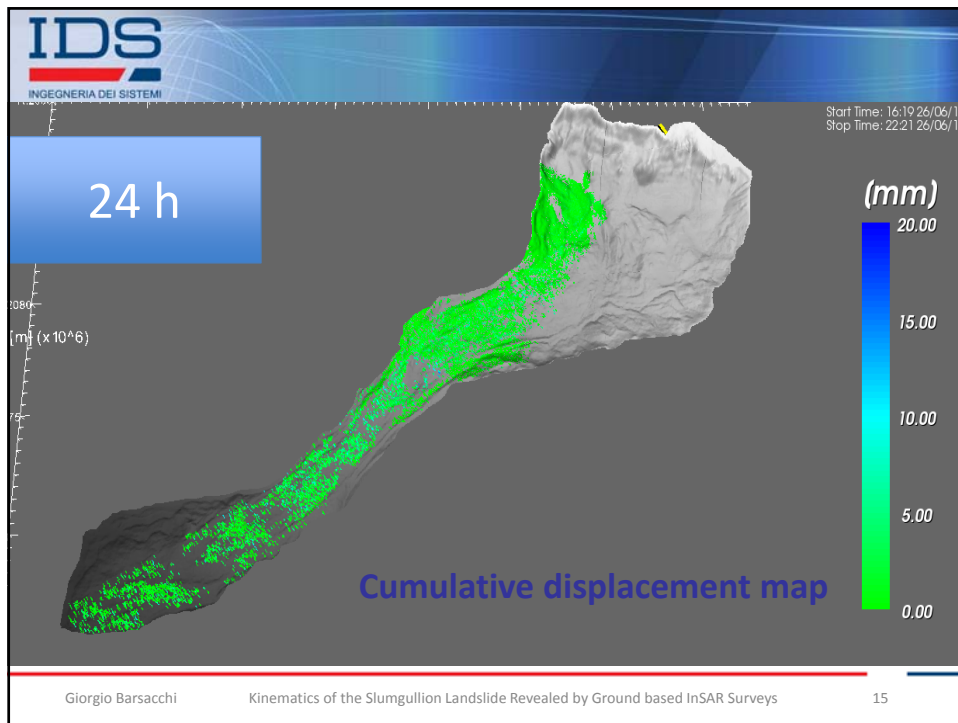
GPS

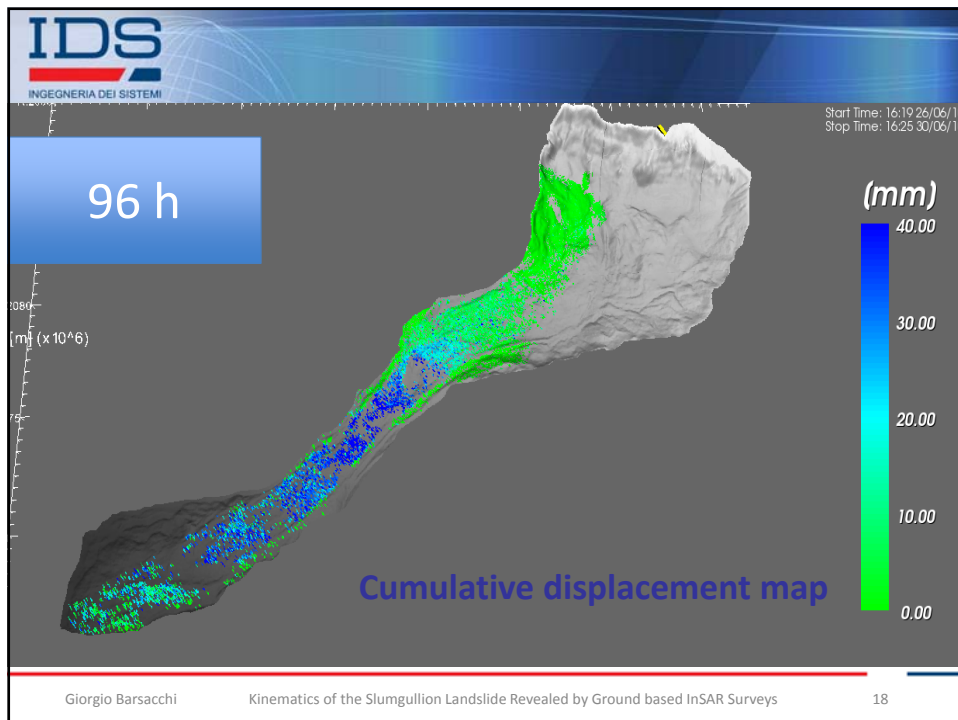
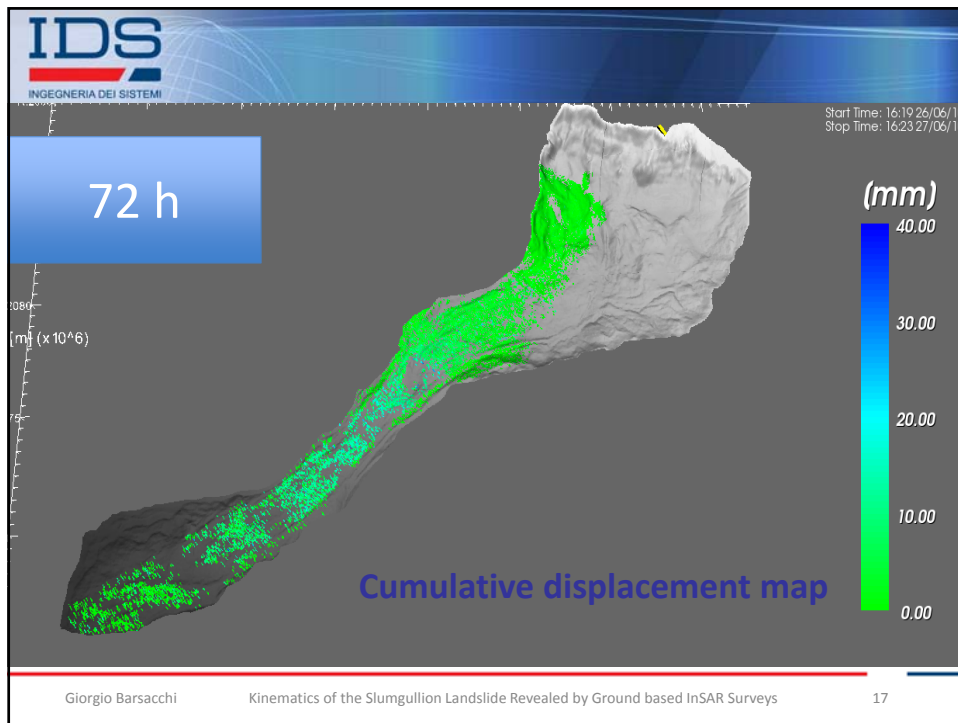
IBIS-L from Ingengeria dei sistemi

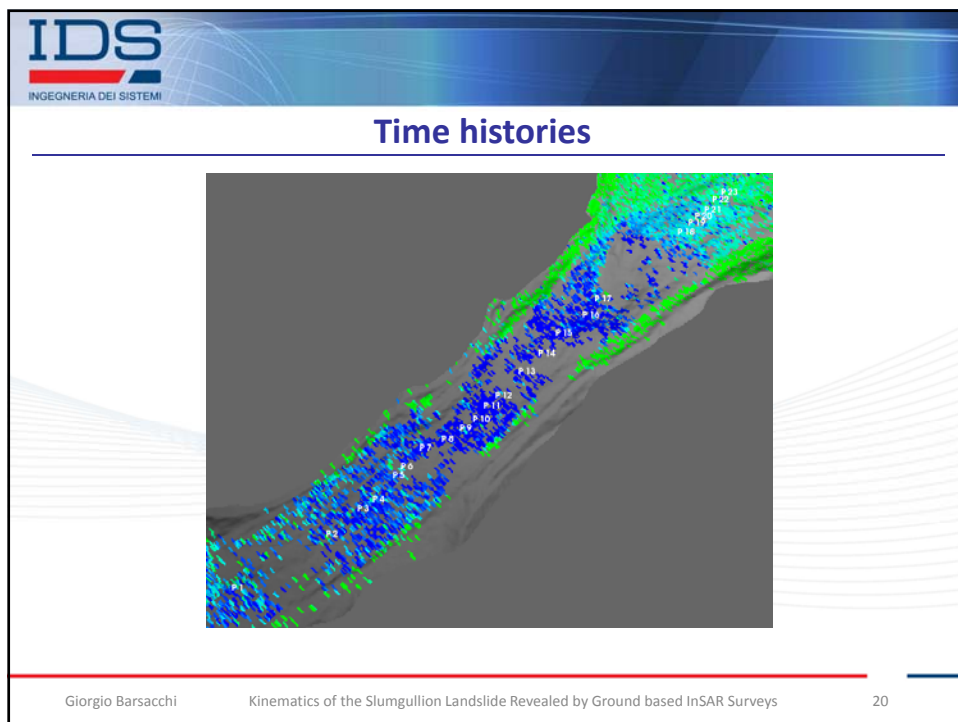
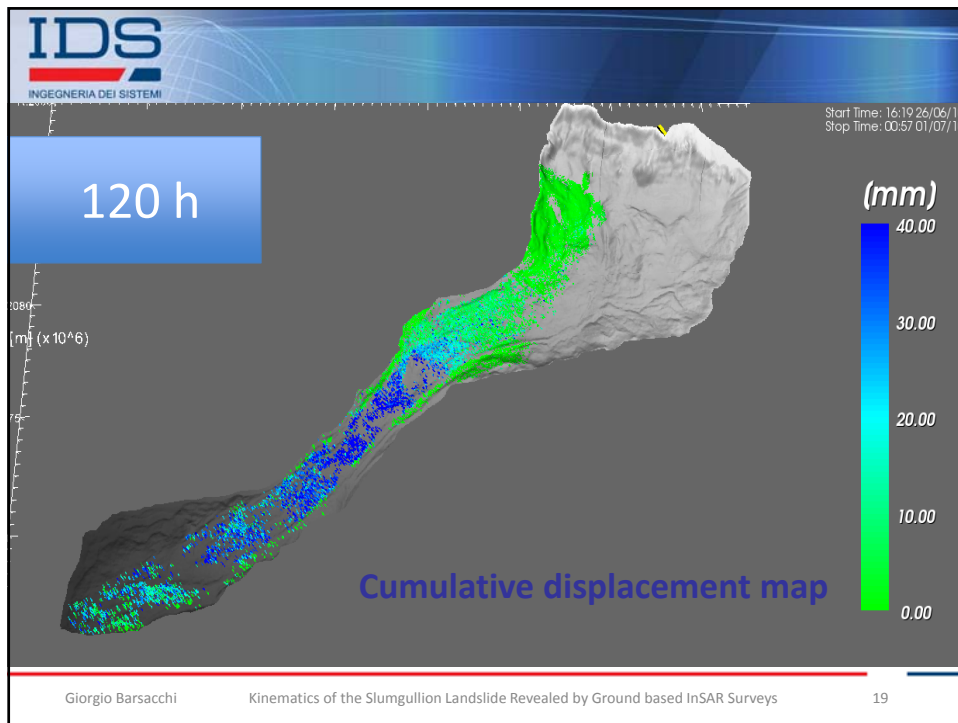
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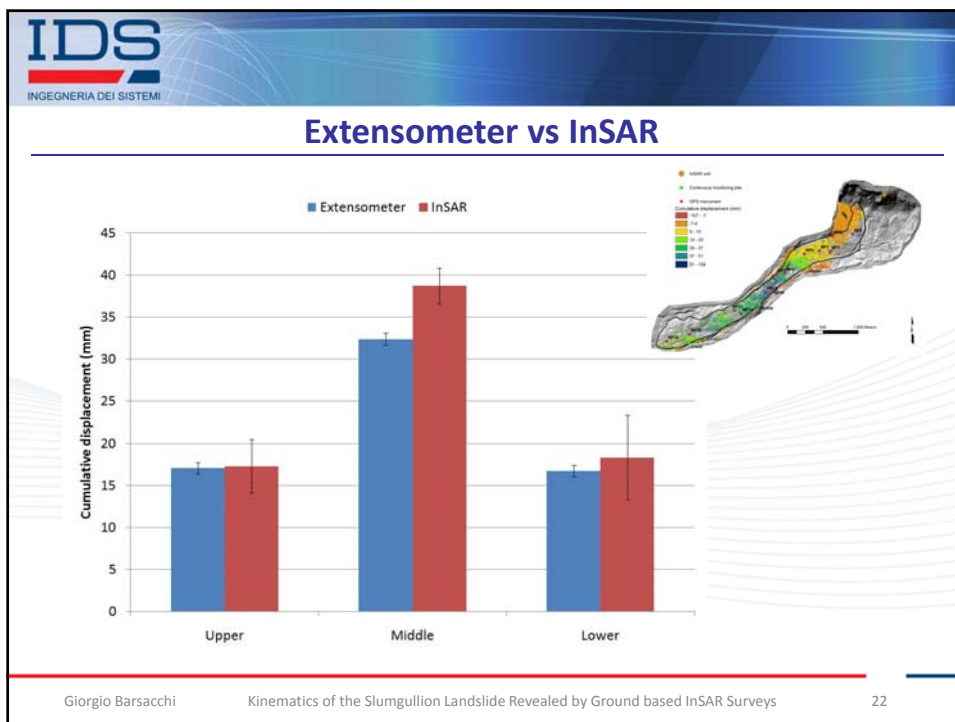
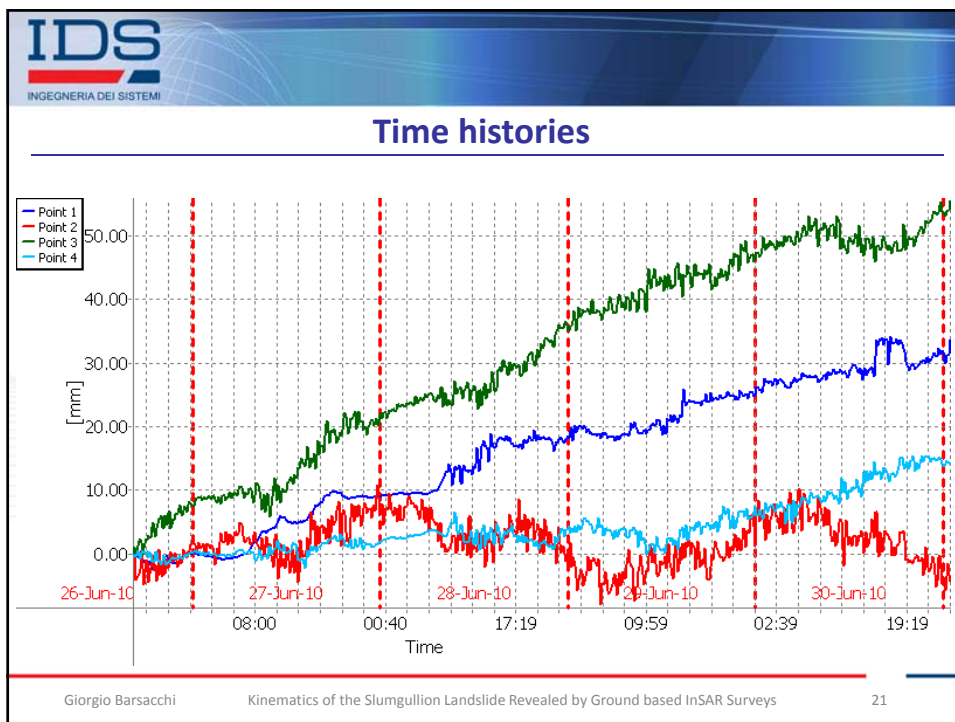


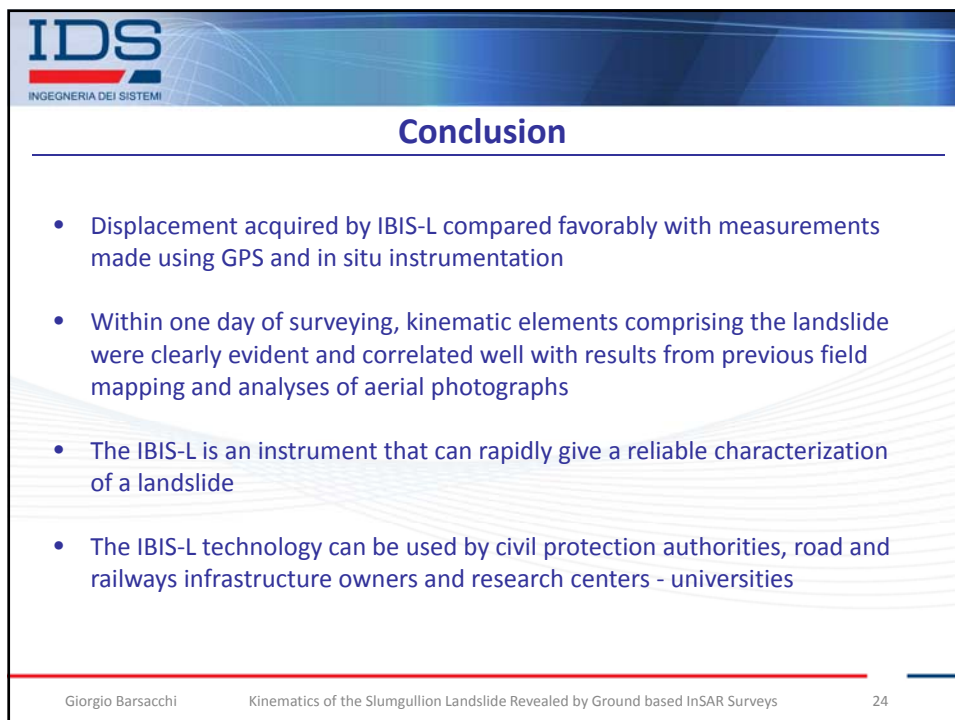
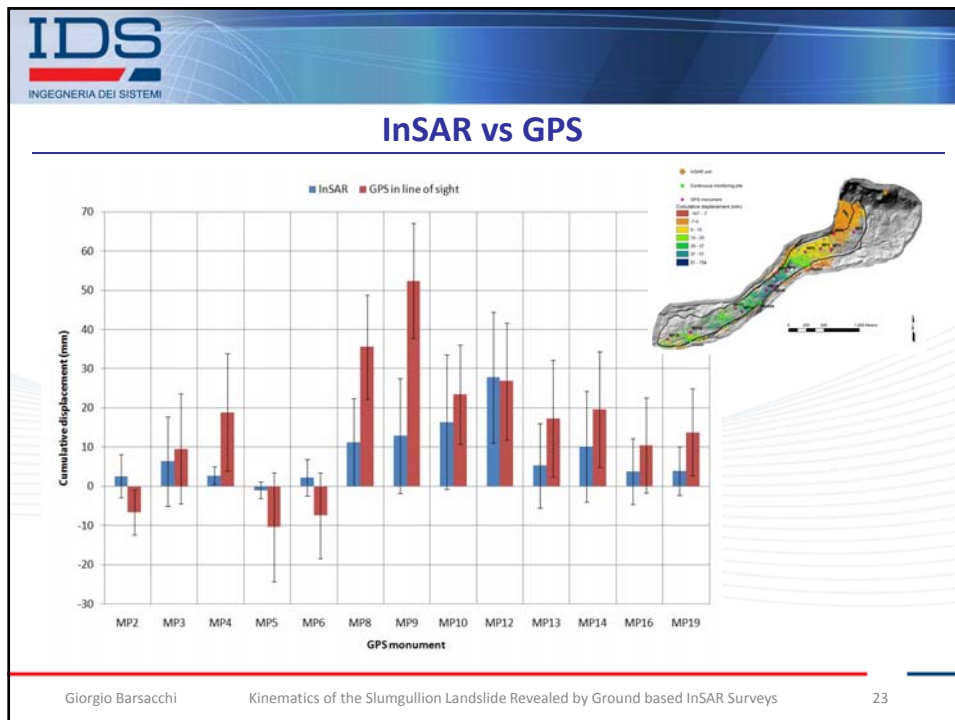












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Questions ?

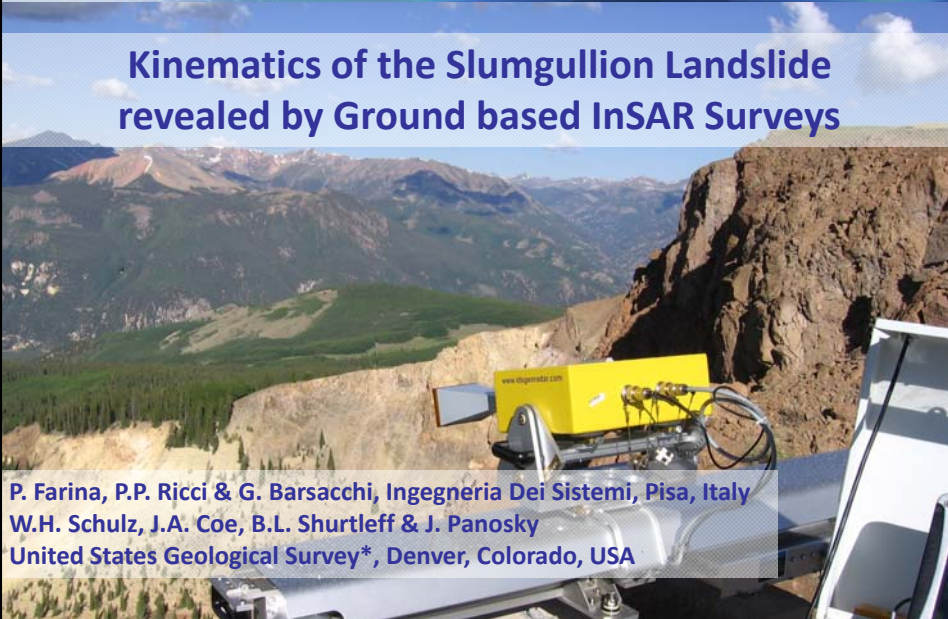
Thanks for your attention

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