Landslide monitoring with an integrated platform methodology, design and case study

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Geology and Information Technology - Sezione della Società Geologica Italiana
GIT 2013 – Chiavenna (SO)
Rotolon Web-based platform

Rotolon torrent basin area (5 km²)
- Stretch: N-NW to S-SE
- Elevation range: 1950 m – 590 m
- Average basin slope: 55 %
- Main channel length: 4270 m
- Average main channel slope: 18%

BENCHMARKS

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BUSE SCURE-COL</td>
</tr>
<tr>
<td>2</td>
<td>ROTOLON COL</td>
</tr>
<tr>
<td>3</td>
<td>VAL FRIZZI VALLEY</td>
</tr>
<tr>
<td>4</td>
<td>AGNO DI LORA VALLEY</td>
</tr>
<tr>
<td>5</td>
<td>LENO DI VALLARSA VALLEY</td>
</tr>
<tr>
<td>6</td>
<td>RECOARO TERME</td>
</tr>
</tbody>
</table>

Meters

0 300 600
Col Rotolon - Recoaro Terme, Vicenza (Eastern Italian Alps)

- Debris flow associated to a Deep-Seated Gravitational Slope Deformation
- Significant re-activation on November 2010 (rainfall of 637 mm /12 days)
- Serious damages on the hamlet of Parlati and the town of Recoaro Terme
Col Rotolon - Recoaro Terme, Vicenza (Eastern Italian Alps)
Rotolon Web-based platform

Monitoring System and implementation of an EWS

- 2 rain gauges
- 1 video camera
- 6 wire extensometers
- Automated Total Station (ATS) with 42 benchmarks
- 3 pendulum section
- 1 trip wire
- Sirens system and thresholds
- Master Station
- Modem ADSL and WiFi
- Radio link

1495 m a.s.l
Rotolon Web-based platform

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Why a Web-based platform for disaster management?

- Collecting data, connecting users and sharing information
- Reduce cost of maintenance and simplify the monitoring network
- Aggregate all monitoring system measures on a common DBMS
- Provide a cost-benefit solution for stakeholders actions

Features and rules of a Web-based platform:

- Multi-user access and maintenance (**admin rights**)
- End-user support on prevention and decision-making (**read-only rights**)
- Common platform for a user-friendly interface (report and graphic layout)
- Integration and time-based synchronization of all measurements
- Near-real time and easy-to-use facility
- Automatic communication (Skype, email, SMS) by threshold criteria
- Apple SDK integration
- Remote user-interface for technical maintenance
Sn = REFLECTING SENSORS
Bn = BENCHMARK SENSORS
En = EXTENSOMETERS
Landslide monitoring with an integrated platform methodology, design and case study

Rotolon Web-based platform

Monitoraggio Frana del Rotolon Recoaro Terme (Vicenza)

Commissariato delegato per il superamento dell'emergenza derivante da eventi alluvionali che hanno colpito il territorio della Regione Veneto dal 31 Ottobre al 2 Novembre 2010

CUM = cumulated rainfall
EST = extensometer
TEMP = temperature
RAD = solar radiance
PREC = hourly average rainfall

JavaScript, PHP
Dygraphs
PostGRES
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Monitoring / reflecting sensors

- API selector
- Range selector

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Landslide monitoring with an integrated platform methodology, design and case study

Monitoring / extensometer

- **Range selector**
- **Linear fit**

Dato misurato dall’estensimetro nr. 8

(Media oraria con aree di confidenza ottenute dallo scostamento massimo rispetto al valore medio, aggiornata all’ultima misura utile per l’estensimetro al 2012-11-19 08:25:00)

Velocità: 2.481 [mm/gg]

Clicca il pulsante “Mostra fit lineare” per generare una regressione lineare sui dati rappresentati. Se cambi lo zoom e schiacci nuovamente il pulsante, la regressione lineare verrà ricalcolata sui punti visibili.

Mostra fit lineare  Elimina Fit
Monitoring / rain gauge

- Rainfall cumulated
- Alert level
- Range period
- Total and hourly

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Monitoring / Reflecting sensors cumulated

• Selected benchmarks
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Monitoring / Arrow Map

- Graphic thresholds
- Vector displacement

### Table: Spostamento Totale 3D Accumulato

<table>
<thead>
<tr>
<th>Prisma</th>
<th>Spostamento totale planare [mm]</th>
<th>Spostamento totale verticale [mm]</th>
<th>Spostamento totale 3D [mm]</th>
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<td>-0.6</td>
<td>1.2</td>
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<tr>
<td>2</td>
<td>7.5</td>
<td>5.7</td>
<td>9.4</td>
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<td>20.8</td>
<td>-3.2</td>
<td>24.0</td>
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<td>7</td>
<td>17.3</td>
<td>-13.9</td>
<td>22.2</td>
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<td>8</td>
<td>28.6</td>
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<tr>
<td>11</td>
<td>34.2</td>
<td>12.3</td>
<td>36.4</td>
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Aggiornato a 2012-11-21 08:00:00 con l’ultima misura valida disponibile.
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Monitoring / 3D displacement

- Selected benchmarks
- Cumulated 3D displacements
- Update 2012-12-07 08:00:00
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Rotolon Web-based platform

Monitoring / Arrow Map

- Graphic thresholds
- Update 2012-12-07 08:00:00
- Vector displacement

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Monitoring / Cumulated rainfall + extensometers
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Monitoring / Benchmarks sensors
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Monitoring / Temperature + Extensometers

- Applied for all extensometers
Monitoring / Radiance + Extensometers

- Applied for extensometers 6-7-8
Monitoring / Rainfall + Extensometers

- Applied for extensometers 6-7-8
Monitoring / DTM 2m pre- & post-event (Oct 2010 – Nov 2010)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Raw</th>
<th>Thresholded DoD Estimate:</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>± Error</td>
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<tr>
<td>AREAL:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Area of Erosion (m²)</td>
<td>114,900</td>
<td>91,732</td>
</tr>
<tr>
<td>Total Area of Deposition (m²)</td>
<td>180,276</td>
<td>156,656</td>
</tr>
<tr>
<td>VOLUMETRIC:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Volume of Erosion (m³)</td>
<td>404,048</td>
<td>400,890 ± 25,946</td>
</tr>
<tr>
<td>Total Volume of Deposition (m³)</td>
<td>387,705</td>
<td>384,551 ± 44,309</td>
</tr>
<tr>
<td>Total Volume of Difference (m³)</td>
<td>791,752</td>
<td>785,441 ± 70,255</td>
</tr>
<tr>
<td>Total Net Volume Difference (m³)</td>
<td>-16,343</td>
<td>-16,339 ± 51,347</td>
</tr>
<tr>
<td>PERCENTAGES (BY VOLUME)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Erosion</td>
<td>51%</td>
<td>51%</td>
</tr>
<tr>
<td>Percent Deposition</td>
<td>49%</td>
<td>49%</td>
</tr>
<tr>
<td>Percent Imbalance (departure from</td>
<td>-1%</td>
<td>-1%</td>
</tr>
<tr>
<td>equilibrium)</td>
<td></td>
<td></td>
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Monitoring / Webcam

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Monitoring / 3D view
Challenge

• Parameters for Automated Total Station (ATS). Which thresholds?
• Parameters for extensometers? Which thresholds?
• Upgrade version for Apple SDK and Android SDK
• Integration of offline toolset (local web-clouds)
• Improving “human sensor” capability for data capture and calibration

....
On going….

- DTM 2m pre- and post-event (Oct 2010 – Nov 2010)

  Back-analysis of the 2010 event
  - MassMov
  - Dan3D

  Soil parameters
  - Runout scenarios
    - MassMov
    - Dan3D

HAZARD MAPS
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On going....

- Decision Support System
- Modeling output
- Risk scenarios
- Structures
- Infrastructures
- Human resources
- Technical staff
- Personal data
- Documents
- Workflows
- Rules
- Email
- Alert System
- Modeling output
- Risk scenarios
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- Sistema di Supporto alle Decisioni
  - Scenari di runout
  - Scenari di rischio
  - Email
  - Sistemi di allerta
  - Soglie
  - Dati personali
  - Documenti
  - Workflows
  - Leggi/regole interne

- Strutture
- Infrastrutture
- Risorse umane
- Materiale tecnico
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3D Displacement 16/07/12 - 21/11/2012

3D Displacement 16/07/12 - 21/11/2012
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