Monitoring major landslides using Global Positioning System- case study Hammana region- Lebanon

Chadi Abdallah * & Francisco Gomez **

Dubai, 16 – 20 January 2011

* Lebanese National Council for Scientific Research -Remote Sensing Center
** Department of Geology, University of Missouri –Columbia- USA
Strategy

Hazard and Risk mapping:

1- Land slides (Mass movement)
2- EQ
3- Floods
4- Soil Erosion
5- Sea level rise
6- Forest Fires
About 100 people are located in these buildings
1. Detection of LS/MM using different types of platforms and processing techniques

2. Establishing correlations between MM occurrence and the influencing factors (preconditioning & triggering) using GIS and statistical methods

3. Mapping the susceptibility & hazard of MM at a scale of 1:50,000 (qualitative)

4. Predictive mapping of block fall volumes (quantitative)

5. Monitoring Mass Movement using GPS, and Radar interferometry
Detecting MM using Remote Sensing techniques

- Satellite imageries:
  * 2 panchromatic stereopairs SPOT 4 images (10 m resolution) (2.3 & 30.3 incident angles)
  * Landsat TM (30 m)
  * IRS-1C (6 m)
  * IKONOS (1 & 4 m)

- Data combination and treatments:

<table>
<thead>
<tr>
<th>Method</th>
<th>Imageries</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCC</td>
<td>Landsat TM (3,5,7 &amp; 4,5,7)</td>
</tr>
<tr>
<td>Panchromatic</td>
<td>SPOT4</td>
</tr>
<tr>
<td>Anaglyph</td>
<td>SPOT4</td>
</tr>
<tr>
<td>Pan Sharpen</td>
<td>Landsat TM-IRS</td>
</tr>
<tr>
<td></td>
<td>IKONOS</td>
</tr>
<tr>
<td>PCA</td>
<td>Landsat TM</td>
</tr>
<tr>
<td></td>
<td>Pan Landsat TM-IRS</td>
</tr>
</tbody>
</table>
d) Pan-Sharp IRS + LANDSAT  

e) PCA (IRS + LANDSAT)  

f) SPOT 4
Correlating terrain parameters with MM occurrence

Figure 6: Organigram showing different steps of the study
**Volumetric mapping of MM**

Decision-tree model explored on all parameters, without applying a pruning cross-validation test (model 1a)
On going work
- Mapping 27 sheets
  Scale 1:50 000
- Mapping 121 sheet
  Scale 1:20 000

Risk mapping on finer scale
Albian Erosion

Previous glacial age conditions

1. Upstanding cliff slopes, and evolved slopes at their bases with various configurations

2. Re-mobilization of alluvial deposits

Albian debris deposition
Monitoring LS/ MM using GPS

Two sets of Trimble 5700 receivers with Zephyr Geodetic antennae

- 13 monuments, 4 Profiles, 3 point/profile
- 15 cm steel pin cemented in the bedrock
- The reference station was mounted on top of the cliff and above the slide in a relatively stable area.
- 2 hours reading.
Monitoring LS/ MM using GPS
Monitoring LS/ MM using GPS

Monuments distribution in Hammana
Monitoring LS/ MM using GPS
What does radar tell us?

- Radar signals consist of:
  - Amplitude
  - Phase
  - Wavelength
  - Polarization

- Different objects will scatter energy and change these properties in the returned signal
Interferometry (InSAR)

- Measuring the **difference** of phase between two radar images
- Phase difference reflects change in Line-of-Site distance between satellite and ground
- Ideally, difference should be ZERO
Image A - 12 August 1999

Image B - 16 September 1999

SAR image
To isolate the contribution of interest, the other phase contributions must be reduced or removed. How?

For deformation, we must mitigate topography and atmosphere (and noise)
**Monitoring mass movement using Radar Interferometry**

### Recent Satellite SAR Missions

<table>
<thead>
<tr>
<th>Mission</th>
<th>Launched</th>
<th>Repeat Cycle</th>
<th>Satellite Altitude</th>
<th>Radar Band</th>
<th>Wavelength (cm)</th>
<th>Center Frequency (GHz)</th>
<th>Bandwidth (MHz)</th>
<th>Look Angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERS-1/2</td>
<td>1991</td>
<td>35</td>
<td>790</td>
<td>C</td>
<td>5.6</td>
<td>5.3</td>
<td>15.55</td>
<td>23</td>
</tr>
<tr>
<td>ERS-2</td>
<td>1995</td>
<td>35</td>
<td>790</td>
<td>C</td>
<td>5.6</td>
<td>5.3</td>
<td>15.55</td>
<td>23</td>
</tr>
<tr>
<td>JERS-1</td>
<td>1992</td>
<td>44</td>
<td>568</td>
<td>L</td>
<td>11.8</td>
<td>1.275</td>
<td>15</td>
<td>39</td>
</tr>
<tr>
<td>Radarsat-1</td>
<td>1995</td>
<td>24</td>
<td>792</td>
<td>C</td>
<td>5.6</td>
<td>5.3</td>
<td>11</td>
<td>20-49</td>
</tr>
<tr>
<td>ENVISAT</td>
<td>2002</td>
<td>35</td>
<td>800</td>
<td>C</td>
<td>5.6</td>
<td>5.3</td>
<td>14</td>
<td>20-50</td>
</tr>
<tr>
<td>ALOS</td>
<td>2005</td>
<td>45</td>
<td>700</td>
<td>L</td>
<td>11.8</td>
<td>1.27</td>
<td>28</td>
<td>8-60</td>
</tr>
<tr>
<td>TerraSAR-X</td>
<td>2007</td>
<td>11</td>
<td>514</td>
<td>X</td>
<td>3.1</td>
<td>9.6</td>
<td>150</td>
<td>35</td>
</tr>
<tr>
<td>Cosmo-Skymed</td>
<td>2007</td>
<td>4</td>
<td>619</td>
<td>X</td>
<td>3.1</td>
<td>9.6</td>
<td>150</td>
<td>45</td>
</tr>
</tbody>
</table>

- **ERS-1/2**: 26 imageries, 75 interferograms
- **ENVISAT**: 29 imageries, 128 interferograms
- **ALOS**: 8 imageries, 23 interferograms
Monitoring mass movement using Radar Interferometry
Monitoring mass movement using Radar Interferometry
Monitoring mass movement using Radar Interferometry

09624-12927: 14/11/07 – 01/07/08

09624-10295: 14/11/07 – 30/12/07
Monitoring mass movement using Radar Interferometry

Abdallah et al., 2009, AGU fall meeting

09624-12927: 14/11/07 – 01/07/08

10295-11637: 30/12/07 – 31/03/08
Monitoring mass movement using Radar Interferometry

08282 – 09624: 29/08/07 – 14/11/07

09624- 10295: 14/11/07 – 30/12/07

08953 – 09624: 29/09/07 – 19/11/08
Future Plans

- Carry on GPS campaigns for the sliding areas
- Establish 2 new permanent GPS stations
- EQ studies
Thank YOU