Landslide Disaster Monitoring using space-based technologies

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October 23rd, 2017
Global Landslide Hazards

Global landslide susceptibility map

Global landslide Catalog - # of Landslides

Stanley and Kirschbaum 2017
Global Landslide Hazards

Committee on Earth Observation Satellites (CEOS)

Virtual Constellations
- AC-VC
  - NASA
  - ESA
- LSI-VC
  - ESA
  - USGS
  - GA
- OCR-VC
  - ESA
  - NOAA
- OSVW-VC
  - NOAA
  - EUMETSAT
  - ISRO
- P-VC
  - NASA
  - JAXA
- OST-VC
  - CNES
  - EUMETSAT
- SST-VC
  - EUMETSAT
  - NOAA

Working Groups
- WGCV
  - Chair: NASA
  - Vice-Chair: CSIRO
- WGCapD
  - Chair: SANSA
  - Vice-Chair: ISRO
- WGClimates
  - Chair: ESA
  - Vice-Chair: EUMETSAT
- WGDisasters
  - Chair: CSA
  - Vice-Chair: ASI
- WGIS
  - Chair: NASA
  - Vice-Chair: ESA

Ad Hoc Teams
- SDCG for GFOI
  - ESA
  - USGS
- GEOGLAM
  - NASA
  - CNES
- Future Data Architectures
  - ESA
  - USGS
  - CSIRO
- Sustainable Development Goals
  - ESA
  - USGS
  - CSIRO

Past Chair
- CSIRO/Australia
- Troika (all 3 chairs) 1-year terms

CEOS Chair
- USGS/United States
- 2-year term

Future Chair
- EC/European Union
- Permanent
Global Landslide Hazards

Plenary endorsed creation of multi-hazard landslide pilot team at the 29th CEOS Plenary in 2016

Main Goals of the landslide pilot:

To demonstrate the effective exploitation of Earth observations (EO) data and technologies to detect, map and monitor landslides, in different physiographic and climatic regions.

To apply satellite EO across the cycle of landslide disaster risk management, including preparedness, situational awareness, response and recovery with a distinct multi-hazard focus on cascading impacts and risks.

View from the ground (Photo credit USGS)

Damage Proxy Map (DPM) from ALOS-2 Data
I. Mapping
• Creating inventories
• Documentation

II. Monitoring
• Routine processing over sample sites

III. EO-based Analysis
• Establishing automatic and standardized methods for landslide hazard analysis.
Main Focus areas:
• Nepal
• Pacific Northwest, US

Experimental areas:
• SE Alaska
• China
• The Caribbean (Cuba, Haiti, Antillas)
• Sri Lanka/India
Landslide Hazards in China

The number of landslide events over past 60 years

Landslide susceptibility map and catastrophic landslide events during 2001-2010 in China (Jusong Shi et al., 2012)
Ms8.0 Earthquake
- Wenchuan, May 12, 2008
  - 48,000 landslides*
  - 70,000 fatalities (20,000 by landslides)

Ms7.0 Earthquake
- Jiuzhaigou, August 8, 2017
  - No. of landslides: unknown
  - 617 deaths, 112 missing.

Ms7.0 Earthquake
- Ya An, April 20, 2013
  - No. of landslides: unknown
  - 196 deaths

Ms6.5 Earthquake
- Ludian, August 3, 2014
  - 1,000+ big landslides
  - Thousands killed in slides

(*) Runqiu Huang et al., 2011

Global Landslide Hazards Distribution
https://databasin.org/datasets/b5c842f4b248464593a7673f5ad7f10f

Credits: Center for Hazards and Risk Research (CHRR); Center for International Earth Science Information Network (CIESIN), Columbia University; Norwegian Geotechnical Institute (NGI)
China Pilot – Study Area and Data

Landslides & Barrier Lake
(water level 58m)

Floods
(10+ towns, 30 km² croplands)

Optical Images Time Series
(332 images with 8-30m Res., 2000-2016)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat TM/ETM+/OLI</td>
<td>2000~</td>
<td>172</td>
<td>16 d</td>
<td>15/30 m</td>
<td>USA</td>
</tr>
<tr>
<td>GF-1 CCD</td>
<td>2013~</td>
<td>68</td>
<td>4 d</td>
<td>2/8/16m</td>
<td>China</td>
</tr>
<tr>
<td>HJ-A/B CCD</td>
<td>2008~</td>
<td>92</td>
<td>4 d</td>
<td>30 m</td>
<td>China</td>
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</tbody>
</table>

Images of Landsat, GF-1/2 and HJ-CCD captured in summers

<table>
<thead>
<tr>
<th>Year</th>
<th>Landslides</th>
<th>Total Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>6</td>
<td>0.24</td>
</tr>
<tr>
<td>2001</td>
<td>6</td>
<td>0.12</td>
</tr>
<tr>
<td>2002</td>
<td>12</td>
<td>0.30</td>
</tr>
<tr>
<td>2003</td>
<td>15</td>
<td>0.60</td>
</tr>
<tr>
<td>2004</td>
<td>16</td>
<td>1.14</td>
</tr>
<tr>
<td>2005</td>
<td>12</td>
<td>0.34</td>
</tr>
<tr>
<td>2006</td>
<td>12</td>
<td>0.95</td>
</tr>
<tr>
<td>2007</td>
<td>10</td>
<td>0.52</td>
</tr>
<tr>
<td>2008</td>
<td>17</td>
<td>1.34</td>
</tr>
<tr>
<td>2009</td>
<td>10</td>
<td>0.84</td>
</tr>
<tr>
<td>2010</td>
<td>14</td>
<td>0.52</td>
</tr>
<tr>
<td>2011</td>
<td>5</td>
<td>0.68</td>
</tr>
<tr>
<td>2012</td>
<td>10</td>
<td>0.64</td>
</tr>
<tr>
<td>2013</td>
<td>7</td>
<td>0.21</td>
</tr>
<tr>
<td>2014</td>
<td>526</td>
<td>6.5</td>
</tr>
<tr>
<td>2015</td>
<td>28</td>
<td>1.10</td>
</tr>
</tbody>
</table>
China Pilot – Map of Landslides (> 0.01km², 2000-2015)

- Landslides occurred every year
- Large amount of huge landslides were induced by earthquake in 2014
China Pilot – Landslide Detection in Multi-temporal Images

Results:

<table>
<thead>
<tr>
<th>Automatic</th>
<th>Visual</th>
<th>True Positive</th>
<th>False Negative</th>
<th>Producer Accuracy</th>
<th>User Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1372</td>
<td>1017</td>
<td>872</td>
<td>145</td>
<td>63.56 %</td>
<td>85.74 %</td>
</tr>
</tbody>
</table>

– Principle to detect landslides
  Vegetation cover changes before and after landslide candidates.

– What are false landslides?
  New roads and quarries.

– What are missing landslides?
  Shallow slopes with little vegetation.

China Pilot – What’s in next two years

- **Objective A:**
  Develop more effective **multi-temporal** methods for merging multi-source satellite images to better detect historical landslides **on a quarterly to monthly basis**.

- **Objective B:**
  Develop machine learning methods to understand **variation patterns** in time series images and to **rapidly detect new landslides** in new available satellite images.
China Pilot – Long-range objectives

- **Objective 1:**
  Improve abilities in monitoring the **process of landslide development** based on integration of space-based remote sensing and geophysical survey technologies.

- **Objective 2:**
  Develop methodologies on **landslide short-term forecast** using big data of space- and air-borne remote sensing as well as geophysical and ground survey.
谢谢！
Thank you!