COSMO-SkyMed
Earthquakes in Haiti and L'Aquila

Laura Candela
Romeo Pernice
Italian Space Agency
National on-going activities

- COSMO-SkyMed and the ASI Applications’ program
  - Pilot Projects to prove whether EO data could be used to better manage natural and man induced disasters;
  - COSMO-SkyMed as main resource in managing Emergency Response;
- ASI is Centre of Competence for the Earth Observation in the National Civil Protection System
- ASI is supporting Italian Civil Protection Department in managing events
  - Earthquake in L’Aquila
  - Earthquake in Haiti
DEVELOPMENT OF DEMO SERVICES FOR ENVIRONMENTAL RISK MONITORING

- Floods
- Landslides
- Fires
- Oil Spill
- Coasts
- Earthquakes
- Volcanoes
- Now-casting
- Air pollution
ASI main target is to improve utilization of existing and planned EO satellite data in order to support Civil Protection community in every phase of risk management cycle and in the environmental monitoring

→ pre-operational application

Players of this process:

- Users
- Scientists
- Industries

The partnership between Earth Observation (EO) Community and Users is aimed to enforce the role of satellite data in the National System of Civil Protection, developing EO-based systems and new operational procedures.
The national early warning system
(DPCM 27/02/2004)

...is able to share and exchange information, through common standards and procedures and it is targeted the general real time forecast and assessment of the risk scenarios...

is provided by DCP and Regions by the “Centri Funzionali” National Network, along with the “Centri di Competenza” involved in hazard assessment and surveillance activities....

“Centro Funzionale” = Centre for Forecasting and Surveillance of Effects to support the civil protection Authority decisions (CFSE)

ASI - Centro di Competenza per l’Osservazione della Terra (Centre of excellence for Earth Observation) in the Italian Civil Protection System
Use of EO data for Hazard & Risk assessment and Civil Protection actions

There have been research and operational demonstrations that illustrate the potential usefulness of EO satellite data for a broader range of hazards, and DPC has started to use EO data in several activities, even if “… the operational application of these data is still quite limited.”

PC target is to foster improved utilization of existing and planned Earth Observation (EO) satellite data to support users in every phase of risk management cycle (Pre-disaster, Emergency response, Post-disaster).

(*) CEOS Report on Disaster Management
## Needs and EO products in Emergency Response

### Information Needs
- **Reference maps**
  - Place names, human and economical assets, infrastructures
  - Updated background (especially outside EU)
  - Available **within 6 hours**
  - Scale 1:100,000 (overview) – 1:25,000 (tactical)
  - TAKING ADVANTAGE OF EXISTING GIS AND MODELS

- **Assessment maps**
  - Destroyed / flooded areas, landslides…
  - In Europe & Mediterranean basin, available **within 24 hours**, daily update before 17:00 UTC
  - **GARANTEED SERVICE**
  - TAKING ADVANTAGE OF AVAILABLE FORECASTS
  - Scale 1:50,000 (overview) – 1:10,000 (tactical)

### Product content

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population: location and density</th>
<th>Available <strong>within 6 hours</strong> Scale: 1:100,000 (overview) and 1:10,000 to 1:25,000 (detailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Critical infrastructures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(communication, transportation, energy, health &amp; sanitation).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Topography</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Major Rivers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Place names</td>
<td></td>
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<tr>
<td></td>
<td>Vulnerability maps where available</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Location &amp; extent of damage (at local, country and regional scales).</th>
<th>Available <strong>within 12-24 hours</strong>, Scale: 1:50,000 (overview) and 1:10,000 (detailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type and severity of damage (at local, country and regional scales)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temporal situation assessment of disasters such as oil spills, floods, fires, etc</td>
<td></td>
</tr>
</tbody>
</table>
ASI National Focal Point in emergency response
L’Aquila earthquake

ASI and DPC activate National Focal Point
(pre-operational)

Italy
L’Aquila (Abruzzo)
Earthquake
06 April 09
Time: 3:32 a.m.
6.3 magnitude

ASI was activated at 7:00 a.m.
<table>
<thead>
<tr>
<th>Time</th>
<th>Date</th>
<th>Acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.30</td>
<td>06/04/09</td>
<td>Request acquisitions</td>
</tr>
<tr>
<td>17.29</td>
<td>06/04/09</td>
<td>1st usefull passage</td>
</tr>
<tr>
<td>4.24</td>
<td>07/04/09</td>
<td>Sar 3 (spot)</td>
</tr>
<tr>
<td>4.54</td>
<td>07/04/09</td>
<td>Sar 1 (strip)</td>
</tr>
<tr>
<td>05.12</td>
<td>08/04/2009</td>
<td>strip</td>
</tr>
<tr>
<td>16.59</td>
<td>08/04/2009</td>
<td>strip</td>
</tr>
<tr>
<td>17.1</td>
<td>08/04/2009</td>
<td>strip</td>
</tr>
<tr>
<td>18.05</td>
<td>08/04/2009</td>
<td>spot</td>
</tr>
</tbody>
</table>
COSMO-SkyMed
L’Aquila ABRUZZO April 6°, 2009

Response time 12.5 h

April 6, 2009
Interferometric analysis IREA-CNR

COSMO-SkyMED

ENVISAT (DESCENDING)

L’ Aquila Earthquake
Mw = 6.3

Timeline
06.04 08.04 10.04 12.04 15.04 16.04

ENVISAT (ASCENDING)

TerraSAR-X (ASCENDING)

IREA
Co-seismic displacements: 4/4/09 - 12/4/09
Post-seismic monitoring

8 cm/yr

-8 cm/yr
Test Site: Abruzzo – Beam: H4-09
Post-seismic SPINUA analysis
Test Site: L’Aquila – Beam: H4-09
Post-seismic SPINUA analysis
La massima dislocazione sul piano di faglia (in rosso) corrisponde al massimo abbassamento del suolo (-25 cm) misurato dal satellite COSMO-SkyMed.
<table>
<thead>
<tr>
<th>Date/ time</th>
<th>Mode</th>
<th>Orbit</th>
<th>Pol.</th>
<th>Look</th>
<th>Angle</th>
<th>Sat.</th>
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</thead>
<tbody>
<tr>
<td>06/04/09 17.29.29</td>
<td>Strip</td>
<td>Desc</td>
<td>VV</td>
<td>Right</td>
<td>21.8</td>
<td>SAR1</td>
</tr>
<tr>
<td>07/04/09 04.24:36</td>
<td>Strip</td>
<td>Asc</td>
<td>HH</td>
<td>Left</td>
<td>30.6</td>
<td>SAR1</td>
</tr>
<tr>
<td>07/04/09 04.54:39</td>
<td>Spot</td>
<td>Asc</td>
<td>HH</td>
<td>Right</td>
<td>19</td>
<td>SAR3</td>
</tr>
<tr>
<td>08/04/09 05.12:41</td>
<td>Strip</td>
<td>Asc</td>
<td>HH</td>
<td>Right</td>
<td>41</td>
<td>SAR3</td>
</tr>
<tr>
<td>08/04/09 16.59:20</td>
<td>Strip</td>
<td>Desc</td>
<td>VV</td>
<td>Right</td>
<td>51.6</td>
<td>SAR3</td>
</tr>
<tr>
<td>08/04/09 17.17:25</td>
<td>Strip</td>
<td>Desc</td>
<td>HH</td>
<td>Right</td>
<td>36</td>
<td>SAR2</td>
</tr>
<tr>
<td>08/04/09 18.05:28</td>
<td>Spot</td>
<td>Desc</td>
<td>HH</td>
<td>Left</td>
<td>37.5</td>
<td>SAR1</td>
</tr>
</tbody>
</table>

Acquiring up to 6 images per days, using all possible modes and viewing geometries.
During the following month over 100 images were acquired, ~3 per day on average.
Dense coverage allowed by the high flexibility of the system (right and left looking side capability on the orbit passes, using variable incidence angles)
For six months, COSMO perform sistematic interferometric acquisitions over the whole area of interest (6 acquisitions every 16 days)
Earthquake in HAITI
First COSMO-SkyMed acquisition

14 Jan 2010
<table>
<thead>
<tr>
<th>Data acquisizione</th>
<th>Sensor mode</th>
<th>Look side</th>
<th>Orbit</th>
<th>Sar</th>
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<tbody>
<tr>
<td>10/09/2008 10.31.05</td>
<td>HI</td>
<td>Left</td>
<td>Ascending</td>
<td>SAR 1</td>
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<tr>
<td>10/09/2008 22.47.54</td>
<td>HI</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 1</td>
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<tr>
<td>26/04/2009 22.51.49*</td>
<td>HI</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 2</td>
</tr>
<tr>
<td>12/12/2009 11.02.04</td>
<td>S2</td>
<td>Right</td>
<td>Ascending</td>
<td>SAR 2</td>
</tr>
<tr>
<td>01/01/2010 22.37.03</td>
<td>HI</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 2</td>
</tr>
<tr>
<td>14/01/2010 22.30.47*</td>
<td>S2</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 1</td>
</tr>
<tr>
<td>14/01/2010 23.18.46*</td>
<td>HI</td>
<td>Left</td>
<td>Descending</td>
<td>SAR 2</td>
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<tr>
<td>15/01/2010 23.48.46*</td>
<td>HI</td>
<td>Right</td>
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<tr>
<td>16/01/2010 23.36.45</td>
<td>HI</td>
<td>Left</td>
<td>Descending</td>
<td>SAR 3</td>
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<tr>
<td>17/01/2010 10.19.29*</td>
<td>S2</td>
<td>Left</td>
<td>Ascending</td>
<td>SAR 3</td>
</tr>
<tr>
<td>17/01/2010 23.24.49</td>
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<td>Left</td>
<td>Descending</td>
<td>SAR 1</td>
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<tr>
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<td>SAR 3</td>
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<tr>
<td>19/01/2010 10.25.39</td>
<td>HI</td>
<td>Left</td>
<td>Ascending</td>
<td>SAR 1</td>
</tr>
<tr>
<td>19/01/2010 10.55.25*</td>
<td>HI</td>
<td>Right</td>
<td>Ascending</td>
<td>SAR 3</td>
</tr>
<tr>
<td>20/01/2010 22.42.24</td>
<td>HI</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 1</td>
</tr>
<tr>
<td>21/01/2010 11.01.27</td>
<td>S2</td>
<td>Right</td>
<td>Ascending</td>
<td>SAR 1</td>
</tr>
<tr>
<td>23/01/2010 22.48.41</td>
<td>HI</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 2</td>
</tr>
<tr>
<td>23/01/2010 23.36.40</td>
<td>S2</td>
<td>Left</td>
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</tr>
<tr>
<td>24/01/2010 22.48.40</td>
<td>HI</td>
<td>Right</td>
<td>Descending</td>
<td>SAR 3</td>
</tr>
<tr>
<td>25/01/2010 23.24.48</td>
<td>S2</td>
<td>Left</td>
<td>Descending</td>
<td>SAR 2</td>
</tr>
<tr>
<td>29/01/2010 11.01.22</td>
<td>S2</td>
<td>Right</td>
<td>Ascending</td>
<td>SAR 2</td>
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<tr>
<td>30/01/2010 11.01.21</td>
<td>S2</td>
<td>Right</td>
<td>Ascending</td>
<td>SAR 2</td>
</tr>
</tbody>
</table>
Eucentre – Damage map (using COSMO-Skymed data)
Spotlight 2 Image

12122009
(pre-event)
21012010
(post-event)
Interferogrammi Spotlight 2
ANALISI BASATA SULL'AMPIEZZA

12122009_21012010
range displacements

large displacements
CIVIL USERS – COSMO-SkyMed

- INSTITUTIONAL Users
  - On demand
  - www.cosmo-skymed.it

- COMMERCIAL Users
  - e-GEOS is supporting data exploitation of commercial users
  - www.e-geos.it

ASI is supporting the data exploitation of Institutional Users
- www.cosmo-skymed.it
What is e-GEOS?

EO Division

COSMO-SkyMed
Mission

To be a leading player in the geo-spatial information business

- *with* an integrated offering of products, application solutions and services

- *based* on radar and optical data from both multi-satellite and aerial platforms,

- *leveraging* COSMO-SkyMed operational capabilities
Multi-Satellite and Aerial Data Provider

- **COSMO-SkyMed**: world-wide Exclusive data distributor
  - Operator of COSMO-SkyMed User Ground Segment in Matera (Italy)

- **GeoEye-1 and IKONOS**: exclusive distribution in Europe and Northern Africa
  - Imaging capability in Neustrelitz, Germany

- **QuickBird-2, WorldView-1/2**: DigitalGlobe European Master Distributor

- **Radarsat 1 - 2**: MDA partner in Europe
  - Direct reception agreement in Matera (Italy)

- **IRS (P6, Cartosat-1/2, 1C/1D)**: exclusive distribution in Europe
  - Direct reception agreement in Neustrelitz (Germany)

- **EROS A - EROS B**: agreement with ImageSat

- **Envisat, ERS 1-2, ALOS and Landat**: ESA partner

- **ASTER**: agreement with ERSDAC

- **SPOT, Formosat-2 and Kompsat-2**: agreement with SpotImage

- **Aerial data**: Telaer system
  - Multispectral, radar, lidar
Emergency Response -ER- to Disaster

Haiti Earthquake

L'Aquila Earthquake
ER for Haiti Earthquake

e-GEOS has played an active role at:

- **National level**
  
  a. dedicated WebMapService hosted by e-GEOS serving the very first GeoEye images of Haiti in the Civil Protection crisis room;
  b. COSMO-SkyMed data processing.

- **International level**
  
  (UN-DFS, It. MoD, It. MAE, ES Red Cross, ITHACA/ WFP)
  
  a. G-MOSAIC Rapid Mapping service (damage assessment and roads trafficability over Port-au-Prince, Jacmel and Leogane);
  b. Cooperation with ITHACA to perform damage assessment.
Focus: G-MOSAI C Rapid Geographic Reporting

EC FP7 Pilot Project for GMES Security

activated on January 14th, 2009 by:

UN-DFS, It. MoD, It. MAE, ES Red Cross

- **Products provided** (vector [shp,kml]+ digital maps):
  - Damage assessment (building)
  - Trafficability analysis (GO, Lim. GO, NO GO)
  - Report on harbour and airport conditions

- **Area covered**
  - Port-au-Prince (16.01.2010)
  - Leogane (22.01.2010)
  - Jacmel (22.01.2010)
  - Port-au-Prince → Leogane (on going)
ER for Haiti Earthquake

• Immediate analysis of best available data:
  – GeoEye-1 before the event
  – GeoEye-1 few hours after the terrific event
ER for Haiti Earthquake
Road Status Map (PaP)
Product example: Cosmo-SkyMed
MultiTemporal Coherence analysis

Red: SAR detected amplitude image - 2009, Apr. 26th
Green: SAR detected amplitude image - 2010, Jan 15th
Blue: coherence value

Port-au-Prince metropolitan area
Product example: Cosmo-SkyMed MultiTemporal Coherence analysis

Red : SAR detected amplitude image - 2009, Apr. 26th
Green : SAR detected amplitude image - 2010, Jan 15th
Blue : coherence value

Collapsed port installation
ER for L’Aquila Earthquake

e-GEOS has played an active role at:

- dedicated services via Web by e-GEOS for imageries and assessment data for the Authorities;
- COSMO-SkyMed data acquisitions and processing

Timeline:

- 03:36 GMT+1: Earthquake
- 08:30 GMT+1: Satellite tasking (IKONOS, QB, Geoeye-1)
- 11:06 GMT+1: IKONOS acquisition
- 22:00 GMT+1: IKONOS orthorectified
- 04:30 – 05:00 GMT+1: Layer “Partially/totally collapsed buildings” over the whole AOI (500km²) produced and delivered via WMS to DPC
Cosmo-SkyMed acquisition details

- Images from: Cosmo SkyMed
- Acq. mode: Spotlight-2 / Himage
- Geom. res: 1m / 3m

These images acquired over L’Aquila region have been used for both multitemporal and interferometric analysis.
Cosmo-1
Cosmo-2
Cosmo-3

15 days: 6 - 20 April
Change Detection - Coherent Multitemporal Analysis

Red: SAR detected amplitude image - 2009, april 14th
Green: SAR detected amplitude image - 2009, april 05th
Blue: coherence value
Change Detection: Coherent Multitemporal Analysis

Red: SAR detected amplitude image - 2009, April 14th
Green: SAR detected amplitude image - 2009, April 05th
Blue: coherence value
Post-Event Orthophoto - L’Aquila (Collemaggio)
Coherent Multitemporal Analysis - L’Aquila (Collemaggio)

Red: SAR detected amplitude image - 2009, April 14th
Green: SAR detected amplitude image - 2009, April 05th
Blue: coherence value

Collapsed after the earthquake
Thank you

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