Remote Sensing for Disaster Management

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German Aerospace Center (DLR)
Earth Observation Center (EOC)

Geospatial World Forum 2012
Earthquake Turkey, October 2010
Famine East Africa, July 2011
Tsunami Japan, March 2011
Center for Satellite Based Crisis Information

ZKI
Responsibilities and tasks of ZKI

- **Acquisition and provision** of satellite based crisis information
  - Rapid generation of user-driven information products in case of a disasters → Maps

- **24 hours / 7 days** on-call duty

- Established contact points in Germany and Europe as well as in international institutions
Linking space and technology

Technical Expertise

Data Reception
Data Archiving
Data Management

Applications Competence

Environment & Geoinformation
Crisis Information

Political Decision Makers
Situation Centers
Relief Organisations
Public
Networks and Partnerships

Space Agencies and Industry

Projects, Services

Users

Research Partners
Disaster cycle

Preparation/Prevention

Risk Analysis

Reconstruction

Alertness

Disaster

Transition Phase Relief and Reconstruction

Emergency Relief
Satellite Based Crisis Mapping

Crisis or Disaster

1. **Mobilization**
   - triggering process
   - situation briefing

2. **Data acquisition**
   - satellite tasking
   - archive search
   - auxiliary data

3. **Pre-Processing**
   - geometric correction
   - image enhancement

4. **Analysis**
   - data fusion
   - information generation

5. **Map Production**
   - quality control
   - maps (printed; online)
   - GIS-ready geodata
   - information dossiers

6. **Dissemination**
   - Cooperation with national/local authorities
   - Relief organisations, NGOs
   - Public,...

Integration of auxiliary data
Integration in collaborative platform

Planning and Decision Support

Cooperation with national/local authorities
Relief organisations, NGOs
Public,...
Flood Mozambique, January 2012
In this area about 11.7 hectares of natural grassland burnt down.

<table>
<thead>
<tr>
<th>Land cover class</th>
<th>Burnt area (ha)</th>
<th>Burnt area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed forest</td>
<td>1.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Natural grassland</td>
<td>24.8</td>
<td>60.5</td>
</tr>
<tr>
<td>Moors and heathland</td>
<td>14.7</td>
<td>35.8</td>
</tr>
<tr>
<td><strong>Total (map extent)</strong></td>
<td><strong>41</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Earthquake Turkey, October 2011

Pre-disaster WorldView-2 satellite imagery, acquired on June 27, 2011

Post-disaster QuickBird-2 satellite imagery, acquired on October 26, 2011
Flood Pakistan, September 2011
Famine Ethiopia, August 2011

August 31, 2011:
Within the camp about 10 buildings and more than 2600 tents are visible. Due to cloud cover only parts of the camp could be analyzed.

August 03, 2011:
In the camp 4 buildings and more than 400 tents are visible. Due to cloud cover only parts of the camp could be analyzed.
Earthquake – Tsunami Japan, March 2011
Tsunami Japan, March 2011

Radar data
Satellite data
Flood mask

Population data

Administrative Boundaries
GIS data

Analysis of the affected population

<table>
<thead>
<tr>
<th>District (N → S)</th>
<th>Area [km²]</th>
<th>Inhabitants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>entire</td>
<td>tsunami</td>
</tr>
<tr>
<td></td>
<td>district</td>
<td>affected</td>
</tr>
<tr>
<td>Tagajo</td>
<td>18.70</td>
<td>5.04 (26.94%)</td>
</tr>
<tr>
<td>Ishinomaki</td>
<td>553.27</td>
<td>19.18 (3.47%)</td>
</tr>
<tr>
<td>Higashimatsushima</td>
<td>107.48</td>
<td>51.45 (47.87%)</td>
</tr>
<tr>
<td>Matsushima</td>
<td>51.95</td>
<td>2.63 (5.06%)</td>
</tr>
<tr>
<td>Shiogama</td>
<td>15.51</td>
<td>0.07 (0.46%)</td>
</tr>
<tr>
<td>Shichigahama</td>
<td>16.11</td>
<td>15.49 (96.15%)</td>
</tr>
<tr>
<td>Sendai</td>
<td>787.95</td>
<td>48.39 (6.14%)</td>
</tr>
<tr>
<td>Natori</td>
<td>96.03</td>
<td>29.47 (30.06%)</td>
</tr>
<tr>
<td>Iwanuma</td>
<td>55.67</td>
<td>23.66 (42.51%)</td>
</tr>
<tr>
<td>Watari</td>
<td>63.74</td>
<td>33.67 (52.82%)</td>
</tr>
<tr>
<td>Yamamoto</td>
<td>69.28</td>
<td>12.69 (18.31%)</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>1837.69</strong></td>
<td><strong>241.74 (13.15%)</strong></td>
</tr>
</tbody>
</table>

Estimated directly affected inhabitants by city district (Miyagi Prefecture)
Earthquake Haiti, January 2010
Responsibilities and tasks of ZKI

- Preparation/Prevention
- Alertness
- Risk Analysis
- Emergency Relief
- Transition Phase Relief and Reconstruction
- Reconstruction
- Disaster
Risk- and vulnerability analysis, Indonesia
Responsibilities and tasks of ZKI

- Preparation/Prevention
- Alertness
- Risk Analysis
- Disaster
- Emergency Relief
- Transition Phase Relief and Reconstruction
- Reconstruction
- ZKI 24 / 7 Service
Limitations of satellite remote sensing

- Limited number of available satellite imagery within a certain time frame
- Weather constraints for optical data (clouds, haze, etc.)
- Spatial resolution versus large scale coverage
- Response time (new acquisitions)
- Costs
Limited number of available satellite images
Weather constraints
Spatial resolution versus large scale coverage

- **LANDSAT**: 160 x 160 km coverage 30 m resolution
- **SPOT**: 60 x 60 km coverage 15 m spatial resolution
- **IKONOS**: 13 x 13 km coverage 1 m spatial resolution

Bangladesh
Response time

Data acquisition

Pre-processing

Data interpretation

Analysis

Dissemination

ZKI

www.DLR.de • Folie 27  > Zentrum für Satellitengestützte Kriseninformation > März 2012
Airborne real-time monitoring system

**Platform**
- 3K Kamera System
- F-SAR

**Data downlink**
- Microwave data link 20 MBit/sec
- Optical data link 1.25 GBit/sec

**Mobile ground station**
- EmerT-Portal
- ZKI Portal
- DMT

Traffic data
Images
Infrastructure
Images
Images
System for Mass Events and Desasters
3K Camera System

- 3 Canon EOS Mark III, 21MPix
- Max. framerate: 5Hz
- Realtime INS / D-GPS onboard
- Oblique angle max 35°

-Traffic modus:
  - 3x bursts with pause
-Mapping modus
  - Continuous acquisition

-Direct georeferencing
  - Position accuracy < 1 meter

<table>
<thead>
<tr>
<th>Coverage</th>
<th>GSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>@ 3000 m</td>
<td>0.40 m (1:60,000)</td>
</tr>
<tr>
<td>8.5 km</td>
<td></td>
</tr>
<tr>
<td>@ 1000 m</td>
<td>0.13 m (1:20,000)</td>
</tr>
<tr>
<td>2.8 km</td>
<td></td>
</tr>
</tbody>
</table>
Image processing and downlink onboard

Airplane

- Process 1: Read image
- Process 2: Ortho rectify
- Process 3: Tile image for downlink

Camera
- Canon EOS Mark III
- 21 MPix

Middleware
- Data synch + watchdog
- IEEE 1394a 400M/Bit

PC 1
- Process 1
- Process 2
- Process n
- Camera

PC 2
- Process 1
- Process 2
- Process n
- Camera

PC 3
- Process 1
- Process 2
- Process n
- Camera

Gigabit/Ethernet

PC 4
- GPS/IMU
- Watchdog
- Traffic data
- Mosaiking
- Transfer

Ground station

DLR
Three flight strips 1000m a. g.

Radiometrical adjustment
Octoberfest Munich, 0.5 sec
Automatic real time traffic parameter extraction from optical images

1. Fast geocoding
2. Overlay of geocoded images with road database
3. Vehicle detection
4. Vehicle tracking in image time series
5. Vehicle speed
   \[ v = \frac{\text{driven distance}}{\text{time distance}} \]
Munich, Main roads
Infrastructure- und Situation Monitoring

- Semi-automatic image analysis
  - Algorithm trained by user
    ⇒ Adaptable to different conditions

Possible supply area

Landslide and volume change

Volume: 1,4 Mio m³
Oder Flood: EU-Project SAFER
Flood Map of Frankfurt/Oder 30.05.10
People tracking at Allianz Arena Munich

Flight altitude: 1000 m a.g.
Automatic Crowd Monitoring

We count number of connected FAST features in crowded areas to find number of people in this region.

Performance table indicating number of people in test regions counted by three different students. Automatically detected number of people is given in the last column;

<table>
<thead>
<tr>
<th>Area</th>
<th>Student1</th>
<th>Student2</th>
<th>Student3</th>
<th>Mean of Student Answers</th>
<th>Algorithm Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area1</td>
<td>136</td>
<td>143</td>
<td>116</td>
<td>132</td>
<td>139</td>
</tr>
<tr>
<td>Area2</td>
<td>177</td>
<td>187</td>
<td>175</td>
<td>180</td>
<td>211</td>
</tr>
<tr>
<td>Area3</td>
<td>101</td>
<td>123</td>
<td>119</td>
<td>114</td>
<td>115</td>
</tr>
<tr>
<td>Area4</td>
<td>93</td>
<td>96</td>
<td>106</td>
<td>98</td>
<td>102</td>
</tr>
</tbody>
</table>

Automatically crowd detection result and test regions
Experimental Results:

*Sirmacek, Beril und Reinartz, Peter (2011). Automatic crowd density and motion analysis in airborne image sequences based on a probabilistic framework. ICCV Nov. 11, ARTEMIS-Workshop, Barcelona, Spain
Tracking of persons
3K DEM Munich City (11. August 2008)

- Flight height 1000m a.g.
- Along track imaging
- Two flight strips
- Bundle adjustment for refinement of exterior and interior parameters

RMSE $x,y = 0.19m$, RMSE $z = 0.93m$

DEM was processed using Semi-Global Matching on 20 nadir images

Black areas: not matched pixels
„3D change detection“ (Downtown Munich)
VABENE „Tag der Deutschen Einheit“, Bonn, Germany
Support of traffic police, 3.10.2011

Automatic airborne monitoring of parking areas, traffic situation and crowd density movements
Welcome to the Center for Satellite Based Crisis Information

The Center for Satellite Based Crisis Information (ZKI) presents a service of the German Remote Sensing Data Center (DFD) of DLR. It provides a 24/7 service for the rapid provision, processing and analysis of satellite imagery during natural and environmental disasters, for humanitarian relief activities and civil security issues worldwide. The resulting satellite based information products are provided to relief organisations and public authorities and are also freely available on the ZKI website.

Tropical storm in Mozambique
2 March 2012, 23:59 CET

On March 2, 2012, Tropical storm IRINA struck Madagascar at about 00:00 GMT and is forecasted to strike Mozambique as a tropical cyclone at about 08:00 GMT on March 3.

According to the information supplied by the Joint Typhoon Warning Center (JTWC), the point of landfall will be north the border of Mozambique and South Africa. IRINA is expected to bring 1-minute maximum sustained winds to the region of around 129 km/h (80 mph). The cyclone is expected to cause heavy rain and flash flooding in Mozambique, and storm surges generally between 1.2 and 1.5 metres (4-5 feet).

Full article

Flood in Bulgaria
10 February 2012, 21:55 CET

Due to heavy snow that has covered Bulgaria in the beginning of February 2012, several dams were overflowing. On