Detection Capability Estimation of the 2014 Integrated Field Exercise SAMS Network

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Overview

- Station network of the Seismic Aftershock Monitoring System (SAMS)
- Seismic events within Inspection Area of Integrated Field Exercise 2014 (IFE14)
- Estimation of station quality using noise
- Detection capability of SAMS network
- Conclusions
SAMS Station Network

16 seismic stations
12 Tripartite mini arrays
4 3-component stations

Inspection Area: ≈1000 km²

Task of SAMS

- Detection of micro seismicity related to aftershocks of the triggering event
- Narrow down the search area
Challenges during network deployment

- Unsafe areas
- Unclear property access
- Significant part of the IA was not navigable due to a lack of paved roads
- Mountainous terrain with significant differences in elevation, up to 1400 m
- Difficult conditions for array deployment
- Time consuming for driving (maintenance and deployment)
Theoretical Network Capability

Joswig (2005)
Seismic Events within Inspection Area

- 3 local tectonic events
- 2 quarry blasts
- 3 scenario events (blasts)

<table>
<thead>
<tr>
<th>#</th>
<th>Date 2014</th>
<th>Origin time (UTC)</th>
<th>Latitude North</th>
<th>Longitude East</th>
<th>Depth km</th>
<th>M_L</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.11.</td>
<td>13:44:11.1</td>
<td>31.6836</td>
<td>35.7173</td>
<td>10f</td>
<td>2.1</td>
<td>Local tectonic event</td>
</tr>
<tr>
<td>2</td>
<td>16.11.</td>
<td>14:15:08.7</td>
<td>31.6564</td>
<td>35.6490</td>
<td>0f</td>
<td>0.0</td>
<td>Blast 1 (aftershock)</td>
</tr>
<tr>
<td>3</td>
<td>17.11.</td>
<td>02:39:46.0</td>
<td>31.66</td>
<td>35.70</td>
<td>-</td>
<td>-</td>
<td>Possible blast at Q1</td>
</tr>
<tr>
<td>4</td>
<td>17.11.</td>
<td>07:30:15.0</td>
<td>31.5867</td>
<td>35.5611</td>
<td>15f</td>
<td>0.5</td>
<td>Local tectonic event</td>
</tr>
<tr>
<td>5</td>
<td>17.11.</td>
<td>10:20:48.1</td>
<td>31.6682</td>
<td>35.6528</td>
<td>0f</td>
<td>0.5</td>
<td>Blast 2 (aftershock)</td>
</tr>
<tr>
<td>6</td>
<td>17.11.</td>
<td>12:10:55.8</td>
<td>31.6616</td>
<td>35.6729</td>
<td>0f</td>
<td>-0.1</td>
<td>Blast 3 (aftershock)</td>
</tr>
<tr>
<td>7</td>
<td>25.11.</td>
<td>10:37:06.9</td>
<td>31.6598</td>
<td>35.7026</td>
<td>0f</td>
<td>2.4</td>
<td>Quarry blast at Q1</td>
</tr>
<tr>
<td>8</td>
<td>27.11.</td>
<td>23:52:47.8</td>
<td>31.5353</td>
<td>35.5470</td>
<td>8f</td>
<td>-0.1</td>
<td>Local tectonic event</td>
</tr>
</tbody>
</table>
Seismic Events of Scenario

Three small blasts were conducted in boreholes within the Inspection Area
Depth: 12 m
Explosive charges: 10 kg, 5 kg and 3 kg
These scenario events were treated as aftershocks

<table>
<thead>
<tr>
<th>#</th>
<th>Date 2014</th>
<th>Origin time (UTC)</th>
<th>Yield kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.11.</td>
<td>14:15:00</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>17.11.</td>
<td>10:20:00</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>17.11.</td>
<td>12:10:00</td>
<td>3</td>
</tr>
</tbody>
</table>
Seismic Events of Scenario

First blast (10 kg) generated acoustic signals
Clear indication of insufficiently tamped borehole
lower efficiency

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Origin time (UTC)</th>
<th>Yield</th>
<th>M_L reproc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event 1</td>
<td>16.11.</td>
<td>14:15:00</td>
<td>10</td>
<td>0.0</td>
</tr>
<tr>
<td>Event 2</td>
<td>17.11.</td>
<td>10:20:00</td>
<td>5</td>
<td>-0.2</td>
</tr>
<tr>
<td>Event 3</td>
<td>17.11.</td>
<td>12:10:00</td>
<td>3</td>
<td>-0.6</td>
</tr>
</tbody>
</table>
Completeness of SAMS Station Network

Duration: 11. - 30. Nov. 2014  20 days
Seismic Signals from Blast

Seismogram
Vertical-component of center station

Blast 3  3 kg
Magnitude  -0.6 $M_L$
17.11.2014
12:10:00 OT UTC

Super-sonogram compilation from the 4 sonograms of the vertical traces of a tripartite mini-array
Estimation of Noise Level

Station SJ12-C

Station SJ01-C

Automatic procedure
- $Amp_{mean}$
- $Amp_{STD}$
- Different frequency ranges
- Time-dependent values
Magnitude Calibration Function

Local Magnitude $M_L$

Different calibration functions for small magnitudes

$$M_L = \log_{10}(A_{\text{max}}) + \sigma$$

$\sigma$ calibration function
Location Capability of Tripartite Arrays

Seismic Source

Tripartite array with 100m radius

North

3C Center

1C West

1C East

Parameter for hypocenter determination

$\beta_{\text{baz}}$

$V_S, V_p$

$T_S, T_P$

back-azimuth

apparent velocities

arrival times of phases
Detection Capability of SAMS Network

**Rule:** 3 stations

**Rule:** 2 stations

**Rule:** 1 station

Detection threshold (magnitude $M_L$)

$M_L = [ -0.8 , -0.2 ]$

$M_L = [ -1.1 , -0.3 ]$

$M_L = [ -2.6 , -0.4 ]$

| Event 1 (0.0) | -0.5 | -0.6 | -1.3 |
| Event 2 (-0.2) | -0.5 | -0.5 | -1.8 |
| Event 3 (-0.6) | -0.5 | -0.7 | -1.2 |
Detection Capability of SAMS Network

Rule: 3 stations

Rule: 2 stations

Rule: 1 station

Detection threshold (magnitude $M_L$) of inspection area

$M_L = [-0.8, -0.1]$  $M_L = [-1.7, -0.2]$  $M_L = [-3.0, -0.3]$
Conclusions

• The number of deployed SAMS stations was less then planned and the objective of a -2.0 magnitude ($M_L$) threshold could not be reached for the entire inspection area.

• Substantial parts of the IA could not be reached by vehicles. Many challenges from high elevation differences, unclear property access and unsafe areas complicated the station deployment significantly.

• Nevertheless all three events of the scenario could be clearly detected. The calculated epicenters were in good agreement with the locations of the blasts.

• The applied algorithm works well but underestimates the detection threshold of the area of the three small blasts. The threshold varies with time.

• For a two station rule the estimated detection threshold covers the range from approximately -1.7 to -0.2 $M_L$ for the inspection area. The effective threshold seems to be much lower.