SEISMIC AND TSUNAMI EARLY WARNING ACTIVITIES IN ICELAND

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In Iceland, the Mid-Atlantic ridge is offset by two transform zones: the South Iceland Seismic Zone (SISZ) and the TJörnes Fracture Zone (TFZ), as shown below. Historically, these zones have produced damaging earthquakes. In June 2000, two M6.5 earthquakes hit the SISZ three days apart. Rifting takes place in the volcanic zones (WVZ, EVZ and NVZ).

To monitor seismic and volcanic activity, the Icelandic Meteorological Office (IMO) operates a real-time monitoring digital seismic network (SNIL), and a 30-station continuous GPS network. Southwest Iceland is the focus of IMO's research in the SAFER project (see sections 2-5). In the TRANSFER project, IMO's research is centered on tsunami-related studies in the northern Iceland (see section 6).

Preparations for implementing aftershock hazard forecasting (STEP) are under-way. When completed-time-dependent maps, published on the Web in near-real-time, will forecast in probability terms the risk of site-intensities reaching a given level.

In this initial stage we have derived new relations for attenuation of peak ground velocity (PGV) and acceleration (PGA) with distance, based on data from 46 earthquakes in SW-Iceland (Fig. 5.1). The regression relations take into account both near-effects, that can be seen in Fig. 5.2 and 5.3 as the non-linear part of the curves representing the data. Figure 5.4 shows the different magnitude of the events.

Before curve-fitting, magnitudes were corrected for bias, by relying on events with well-determined magnitude. The resulting PGV-distance relation can be used to correct underestimated event magnitudes.

The attenuation relations and new estimates of modified Mercalli intensity (MMI) vs PGV and PGA (Fig. 5.4) will also be used for the shake-map application.

To provide data for near-real-time generation of shake maps, an algorithm has been instantiated on seismic stations. It inputs peaks for peak ground velocity (PGV) and acceleration (PGA), when these significantly exceed the background level in any of four separate frequency bands. As soon as the first such record arrives at the processing centre, alert maps can be generated displaying the ground motion as a function of the earthquake's location and magnitude (Fig. 2.2 and 2.3).

Once the location and magnitude have been determined for the event, a shake map can be generated. In order to extrapolate the site effects on observed intensity, available information on site-specific soil types has been collected (Fig. 3.1).

An illustrative observation following a large earthquake is that areas experiencing a positive change in Coulomb failure stress (CFS) exhibit increased seismicity. The predictive value of such an observation is limited by the lack of information of CFS values before the earthquake causing the change. However, if absolute CFS values are known, the predictive value of the method is increased. In the SISZ, stress-tensor and water-pressure fields can be estimated using micro-earthquakes. The resulting stress estimates turn the CFS method into a full CFS method. This approach has been applied to the June 2000 earthquakes (Fig. 4.1 and 4.2).

Historically, localised tsunami hazards in Iceland have resulted from: (i) large, offshore earthquakes; (ii) glacial floods into coastal waters (Fig. 6.1), (iii) volcanic eruptions and fissure swarms entering either coastal or inland water bodies; and (iv) snow and ice avalanches into coastal fords. Additionally, coastal deposits show that non-aftershock-induced tsunamis, such as that caused by the early Holocene Storegga submarine slide, have impacted Iceland. In June 1755, an M = 7.7 earthquake triggered a small tsunami in the Tjörnes region (Table 6.1 and location "F" on main map). Selected sources of tsunami are highlighted in Table 6.1.

Our aim is to estimate the source parameters of large, offshore earthquakes in near-real-time; this work will involve adapting the SAFER early-warning algorithms to the TFZ region. Using the relocation method (section 2), we aim to identify faults capable of generating hazardous earthquakes. To further constrain source estimations we will expand the SIL network using real-time data from other seismic networks; additionally, we will also increase the resolution of the continuous GPS network (see main map) via high-rate sampling of crustal deformation.

1. INTRODUCTION

2. NEAR-REAL-TIME FAULT MAPPING

A near-real-time relative relocation (double-difference) procedure is in development for the SAFER region of SW-Iceland (see main map). The method relies on previous pre-historic high-event locations, from which a library of waveforms is built. Each new event is then compared to the library via cross-correlation to obtain a high-precision location in near-real-time. Over 50,000 earthquakes have been located in the SAFER region, of which some have then undergone mapping of focal mechanisms. Using this approach, earthquakes can be associated with already mapped faults in near-real-time; additionally, new faults can be illuminated. If the new events are foreshocks, then the method can map the co-occurring larger earthquake.

Test results from three areas are shown below. At sites H and K extensive fault mapping has been performed, and at site (A) an earthquake swarm is in progress due to magma movements. In all three areas, the relocation procedure significantly improves the original locations.

3. EARTHQUAKE SHAKE MAPS

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Once the location and magnitude have been determined for the event, a shake map can be generated. In order to extrapolate the site effects on observed intensity, available information on site-specific soil types has been collected (Fig. 3.1).

4. CRUSTAL STRESSES AND EARTHQUAKE PREDICTION

A common observation following a large earthquake is that areas experiencing a positive change in Coulomb failure stress (CFS) exhibit increased seismicity. The predictive value of such an observation is limited by the lack of information of CFS values before the earthquake causing the change. However, if absolute CFS values are known, the predictive value of the method is increased. In the SISZ, stress-tensor and water-pressure fields can be estimated using micro-earthquakes. The resulting stress estimates turn the CFS method into a full CFS method. This approach has been applied to the June 2000 earthquakes (Fig. 4.1 and 4.2).

5. REAL-TIME AFTERSHOCK FORECASTING

Preparations for implementing aftershock hazard forecasting (STEP) are under-way. When completed-time-dependent maps, published on the Web in near-real-time, will forecast in probability terms the risk of site-intensities reaching a given level.

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Before curve-fitting, magnitudes were corrected for bias, by relying on events with well-determined magnitude. The resulting PGV-distance relation can be used to correct underestimated event magnitudes.

The attenuation relations and new estimates of modified Mercalli intensity (MMI) vs PGV and PGA (Fig. 5.4) will also be used for the shake-map application.

6. TSUNAMI EARLY WARNING RESEARCH

Historically, localised tsunami hazards in Iceland have resulted from: (i) large, offshore earthquakes; (ii) glacial floods into coastal waters (Fig. 6.1), (iii) volcanic eruptions and fissure swarms entering either coastal or inland water bodies; and (iv) snow and ice avalanches into coastal fords. Additionally, coastal deposits show that non-aftershock-induced tsunamis, such as that caused by the early Holocene Storegga submarine slide, have impacted Iceland. In June 1755, an M = 7.7 earthquake triggered a small tsunami in the Tjörnes region (Table 6.1 and location "F" on main map). Selected sources of tsunami are highlighted in Table 6.1.

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For further details, see sessions: SM1.103001081 and SM1.111123008.

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