Case Study

Early Warning and Information System for Geologic Hazards in Iceland

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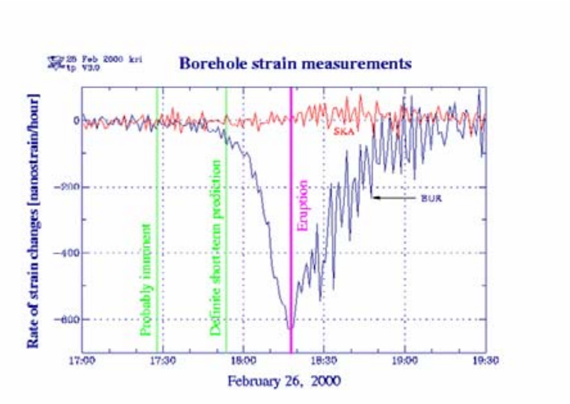

Direct measurements of bedrock strain

Volcanic eruption at Mt Hekla, 2000

Real-time overview of geophysical data enables short- and long-term forecasts of hazard potential

Key words: Internet, earthquake, volcanic eruption, hazard identification, risk mitigation, Iceland

Project description

The Icelandic Meteorological Office (IMO) monitors and maintains an automated network of 43 digital seismic stations, which provides near real-time seismicity measurements for an area encompassing terrestrial and near-shore regions of Iceland (see http://www.vedur.is/ja). Additionally, digital data are received continuously from six borehole strain meters and 17 differential GPS stations. Collectively, these geophysical data allow unique insight into tectonic processes responsible for earthquake and volcanic activity in Iceland. To enable more precise, verifiable short- and long-term forecasts of geologic hazard potential in Iceland, the IMO is currently developing an early warning and information system (EWIS). Such forecasts will be achieved primarily through an Internet-based compilation of geophysical information, which will facilitate rapid visual analysis of historic and real-time geologic data. The main advantage of EWIS is the ease and speed at which multi-parameter historic and real-time geophysical data can be evaluated on-screen (Figure 1). Besides the ability to visualise processed field data, a resource database is accessible from the system interface. This database comprises digital information in the form of scientific publications, customised hazard summaries, pre-processed information for civil defence purposes, and annotated map and image resources.

Although the warning system will be used primarily by the IMO, it is anticipated that allied research institutions, civil defence personnel, and the public will benefit from Internet access to geophysical data and related hazard information. However, to ensure clear and effective information dissemination, varying access levels will be imposed. The warning system also serves as a platform for accessing environmental data from other institutions, and as an interface for public and scientific communication of observations. The IMO digital warning system is a state-of-the-art example of synergy between geophysical data and information technology for the purpose of geologic hazard mitigation.

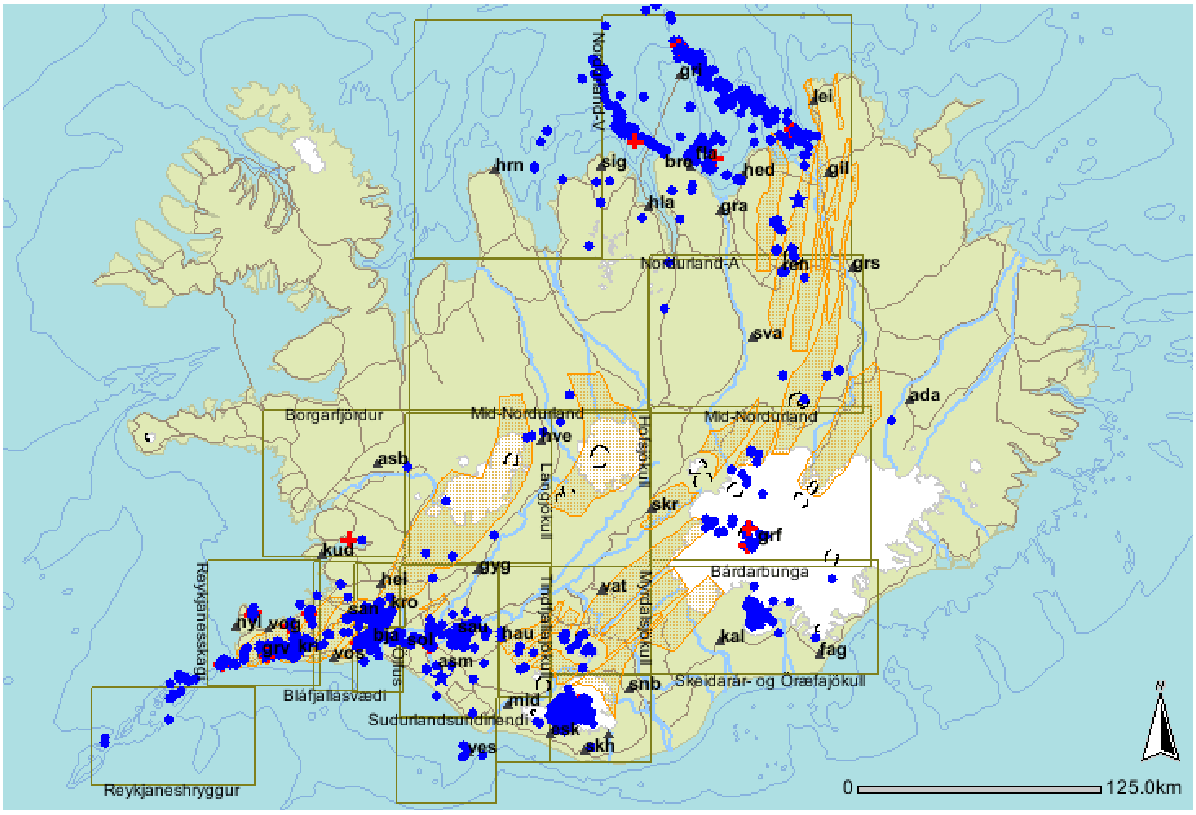

Figure 1. EWIS view of earthquake epicentres (denoted by blue dots) in Iceland between 01 August and 01 November 2003. The rectangular zones on the map represent hazard zones defined by IMO for seismic monitoring.

GIS technology

Digital data received from IMO field sensors are stored in a dedicated geo-database, which allows fast and reliable data identification and retrieval from a thirteen-year continuous record of geophysical data. Coupled to the database is a GIS server, which generates user-defined data plots. Users interact with EWIS via a series of webpages. The synergy of GIS and other spatial software with the Internet domain means that geophysical data can be displayed remotely in many different graphical formats, thus allowing rapid dissemination of public and scientific information.

We now use ArcMAP™ GIS applications routinely to collate and transform spatial data into Internet maps. We use these maps for the foundation of the EWIS homepage (Figure 2), thus allowing geophysical data to be overlain dynamically. We are continually gaining access to new spatial data, so several themed maps are in concurrent development. Each map theme fits a specific purpose, ranging from the needs of the novice user to the IMO scientist. Future map versions will include demographic and infrastructure data for selected regions. These data are intended to assist hazard authorities with risk forecasting during geologic crises.

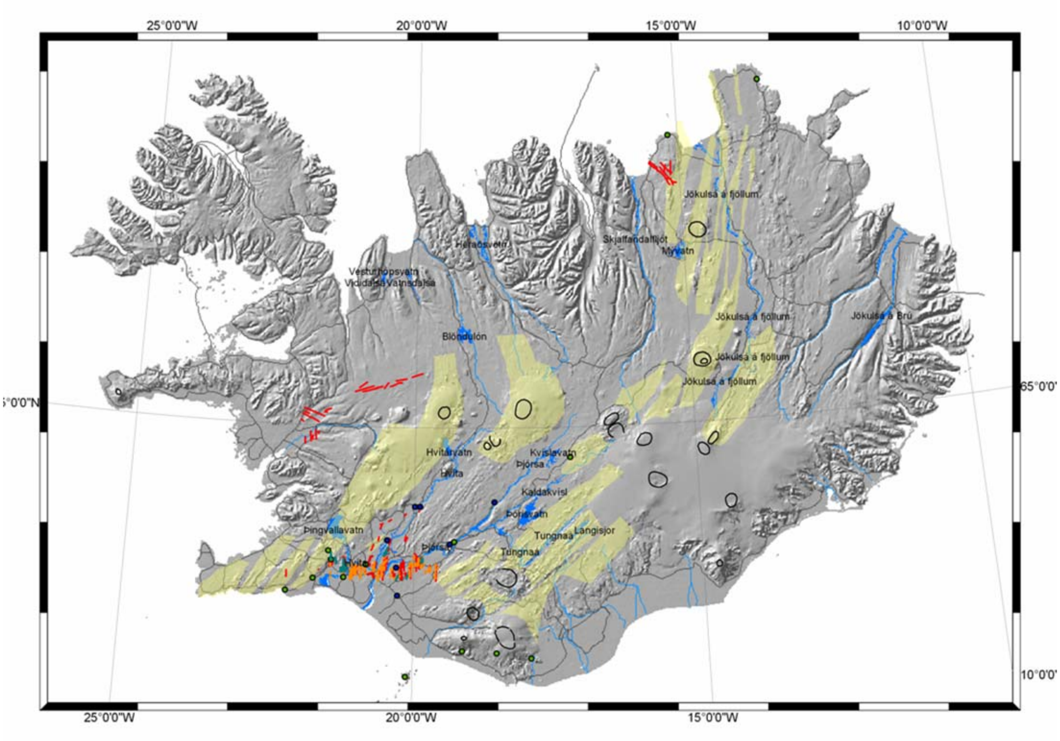

Figure 2. New composite base map for EWIS compiled using GIS techniques. Yellow shading represents the present-day zone of tectonic activity. Red and orange lines signify the location and extent of mapped bedrock faults and fractures exposed at the surface.

Geophysical coupling between seismic events

The exceptional data visualisation potential of EWIS means that temporal interactions between tectonic processes are becoming apparent. By combining time-dependent spatial and graphic data, distinctive, causative changes in tectonic activity are clear. The addition of geologic data to EWIS maps means that tectonic activity can be interpreted in a local context. We observe that comparatively large earthquakes on bedrock faults can transmit stress changes to several fault-lengths distance, thereby mechanically triggering secondary earthquakes. Using real-time GIS technology, we intend to create “event probability” maps for EWIS by dynamically calculating changes in bedrock stress that result from earthquake activity. These maps would serve to identify and quantify precursory active that could precipitate toward a tectonic crisis. In such circumstances, real-time GIS could also supply baseline data for civil defence purposes. Reaching the goal of clickable risk map will require additional development of numerical algorithms, but such achievements are at least in conceptual grasp.

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