Preface

Research into early warning for geological disasters covers all geological phenomena: volcanic crises, landslides, earthquakes and tsunamis. The past few years have seen new technologies developed that could be utilised in these fields for early warning, real-time loss estimations and rapid disaster response. They include self-organising sensor networks, new satellite imagery with high resolution, multi-sensor observational capacities and crowd sourcing for rapid information provision. From these and improved physical models, data processing and communication methodologies, a significant step towards better early warning capabilities has been achieved. At the same time, early warning systems have started to become part of the disaster risk management practice. For example, the Japanese earthquake early warning system was made public in 2007 by the Japanese Meteorological Agency (JMA). The efforts to establish a tsunami warning system for the Indian Ocean following the tragic mega-tsunami of 2004 are being co-ordinated by the UNESCO Intergovernmental Oceanographic Commission—and have resulted so far in three national systems (Australia, India and Indonesia) that provide warnings. Thus, apart from new research, more experience was built up in the application of early warning methodologies and the integration of its recipients ('last mile') in the early warning process. This book therefore marks an important point where (1) research activities continue to grow—supported by a number of national and trans-national research programmes such as the European Commission FP7 program and (2) experience with applications is expanding so that more feedback from experience and practice to the research community is becoming available. Therefore, for this stage in the development of early warning systems for geological disasters it is timely to produce a volume that documents the state of the art, provides an overview on recent developments and serves as a knowledge resource for researchers and practitioners.

We utilise the UNISDR definition of early warning (UNISDR 2009). This definition encompasses the range of factors necessary to achieve effective responses to warnings. A people-centred early warning system by necessity comprises four key elements: Knowledge of the risks; monitoring, analysis and forecasting of the hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received.

The chapters contained in this book on Early Warning Systems (EWS) cover all geological disasters, however, with a focus on earthquakes and tsunamis, as these have caused significant death tolls and losses to property, infrastructure and the environment in recent years. They cover many aspects of early warning, beginning with scientific and technological issues (instrumentation, algorithms, data management) but also addressing issues related to the dissemination of warnings and decision making.

The most advanced and best tested earthquake early warning system that also includes tsunami warnings has been operated by the Japanese Meteorological Agency (JMA) since 2007. A critical performance test of the system is involved in the Tohoku earthquake of March 11, 2011 with a magnitude of 9.0 that cost the lives of almost 20,000 people, nearly 100 % of them due to the tsunami waves. The chapter of Hoshiba and Ozaki outlines the performance of the system in detail and reports on the quality of the earthquake and the tsunami warnings and advisories, including lessons learned and a discussion on how to improve the system. One deficiency of the system turned out to be the inherent assumption that an earthquakes rupture can be treated as a point source for seismic waves. This is an acceptable assumption for many earthquakes below magnitude 7, but is no longer valid for large earthquakes with magnitudes in the range of 8 and greater, where fault lengths are in the range of hundreds of kilometres. The chapter of Yamada discusses a methodology that allows for the estimation of the fault rupture extent in real-time. It naturally relies on a dense seismic network, which is available in Japan, and allows the identification of a fault rupture by classifying stations in near source and far source. The methodology has been validated by a number of earthquakes and is planned to be introduced into the JMA warning system soon.

A successful early warning system that has experienced several tests is the Mexican one, discussed and described in the chapter of Cuéllar et al. The early warning for the recent earthquake on March 20, 2012, with a magnitude of 7.4 (Ometepec earthquake) was able to demonstrate the value of the system to the general public.

Another promising development is the Californian early warning system which is currently being tested. It combines three different methodologies: Onsite early warning with one or at the utmost two stations, which is very fast but exhibits a high error range, ELARMS which relies on four stations and allows a higher precision but reduced speed, and the virtual seismologist approach with an increasing number of stations being used during the earthquake, which is rather slow in terms of early warning but shows very good performance in determining the magnitude and location of the event. The chapter of Böse et al. presents details of the system and demonstrates its performance in a number of examples. A large number of scientists, also end users from industry, emergency response and infrastructure operators are involved in its testing, and stakeholders provide valuable knowledge to improve the performance of the system.

Utilisation of earthquake early warning systems in Europe is lacking significantly behind the pioneer applications in Japan, California, Taiwan and Mexico. However, efforts have been made over more than a decade to protect the cities of

Istanbul and Bucharest, and the territory of Campania in Southern Italy. In addition to these regional advances, two European research projects (FP6 SAFER—Seismic Early Warning for Europe and FP7 REAKT—Strategies and Tools for Real Time Earthquake Reduction) have advanced our knowledge and the level of application in Europe significantly. The chapter of Gasparini and Manfredi outlines the history of earthquake early warning in Europe, its current status and its future prospects.

Some applications in Europe—without being comprehensive—are discussed in three chapters. The chapter of Wenzel et al. presents results from a project focusing on a warning system for Istanbul. Which involves a broader approach than earthquake early warning in a strict sense, with modern information technologies being combined with seismology and instrumental methodologies to develop an earthquake disaster information system for the Marmara region. The chapter by Zollo et al. presents an approach to early warning for Southern Italy that integrates regional and on-site systems. The system is described and demonstrated by several cases, which show the benefits of a robust methodology with respect to the early warning performance. The chapter of Bonn et al. focuses on earthquake early warning for transport lines. The aim is to enable the issuing of alert maps before the strong motion phase of seismic waves can endanger trains. Although the system has so far only been developed as a concept, it could demonstrate that a service-oriented system architecture can provide various users with rapid information, relevant for warning, rescue and repair.

Another set of chapters is dedicated to earthquake and tsunami early warning for the Indian Ocean, with an emphasis on warnings for Sumatra. This work is based on the significant effort made by German funding agencies and scientific institutions to develop the German-Indonesian Tsunami Early Warning System (GITEWS), which was established after the devastating tsunami in the Indian Ocean on December 26, 2004. The value of this set of chapters is particularly in the combination of technological issues of an early warning system with the communication of warning information, as well as in the aspects of evacuation and early warning implementation in the emergency response structures of the country. Lauterjung et al. discuss the system concept as an ‘end-to-end’ approach aiming at the complete coverage of the warning chain from rapid hazard detection through to decision support to capacity development in communities, and the implementation of disaster risk reduction measures. Spahn et al. focus on the implementation of the system in the day-to-day operations of communities and emergency response agencies. The focus is very much on tsunami preparedness. The time period for the development of sustainable tsunami preparedness at all levels, ranging from the community to the provincial and central government, is significantly longer than the scientific development and technical implementation stages of the system and thus provides major challenges in making the system useful. Goseberg et al. also refer to the ‘last mile’ aspects of tsunami early warning although, with a focus on evacuation planning and risk reduction in tsunami threatened coastal areas. It discusses the generation and compilation of a geo-database that includes remote sensing data, information on social vulnerability related to exposure, risk perception and evacuation behaviour, while also allowing for the simulation of realistic scenarios of inundation. Wächter and Usländer stress the software and hardware aspects of tsunami warning systems in general, based on the experience of the GITEWS project. They show that significant advances in information and communication technology is the basis for making systems such as this workable, provided that protocol interfaces and data exchange are organised in a systematic and standardised way with reference architectures.

The intense seismicity and the dense seismic networks available in Taiwan have promoted work on earthquake early warning for several years. Wu and Lin present a chapter which focuses on the use of MEMS (Micro-Electric Mechanical Systems) types of accelerometer, which are specifically designed for earthquake early warning purposes with the main advantage of being very low cost. An earthquake early warning experiment in the Hualien region (Eastern Taiwan) is discussed in detail. Whereas the chapter of Wu and Lin focuses on MEMS technology for accelerometers Picozzi et al. have developed a system with the same type of accelerometers but as a self-organising seismic early warning information network (SOSEWIN) which allows early warning proper, but can also be used for many other earthquake engineering purposes such as structural health monitoring and aftershock detection. The system in terms of hard- and software is described and analysed, the optimisation procedures explained and test examples with very encouraging results presented.

In addition to earthquakes and tsunamis the book contains one chapter on earthquake early warning for landslides, specifically for instable alpine slopes, by Thuro et al. It discusses a cost-effective landslide monitoring and early warning system based on time domain reflectometry (TDR) for the detection of subsurface displacement in boreholes and reflectorless video tacheometry (VTPS) and GIS information for determining 3D-surface movements.

The chapter by Ferrucci et al. presents the rational and the main achievements of the operational prototype of the first multi-method system for volcanic monitoring in a number of regions. The system was extensively tested in 2011 during major eruptions in Eritrea and the Congo.

Applications of early warning to site-specific engineering systems have not been intensively investigated, thus the chapter of Iervolino is an important contribution that addresses this gap by providing a review of the work done in this field and illustrating a possible performance-based approach for the specific design and application of earthquake early warning systems to engineering structures.

Two more chapters were included as they provide innovative thoughts on early warning which have not been frequently discussed in the literature so far. The chapter of Woo and Marzocchi looks at operational earthquake forecasting and decision making. Operational earthquake forecasting would accommodate the probability of an earthquake's occurrence changing with time, which, although remaining low, according to the authors would still allow a number of appropriate responses. This goes beyond early warning as it does not rely on an already occurred earthquake where seconds or tens of seconds are used for implementing measures, but involves earthquake forecasting in the short term for decision making. The chapter of Wyss et al. refers to classical earthquake early warning, providing only seconds of warning time until intense ground motion arrives. Its innovative part is the suggestion of so-called earthquake protection units (EPUs) that should be incorporated into buildings and would allow the effective protection of residents. The appeal of the suggestion is that it would increase the survival changes of potentially a large segment of the population.

The novel scientific concepts and current practices of early warning for geological disasters described in this book show the increasing potential of early warning methodologies for serving the needs of disaster management, decision makers and the public. We, therefore, hope that this book will contribute to initiating new activities for an effective exploitation of this potential with the ultimate result of reducing the level of risk in areas prone to geological hazards.

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Reference

UNISDR (2009) UNISDR terminology on disaster risk reduction, Geneva, Switzerland.www.preventionweb.net/files/7817_UNISDRTerminologyEnglish.pdf. Accessed May 2009

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