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REDUCTION OF EARTHQUAKE LOSSES IN THE NORTHEAST ASIA REGION - RELNAR -

International Workshop on Earthquake Risk Reduction in the Northeast Asia Region

Workshop Report

Beijing, China

30 November – 3 December 2009

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Foreword

In many Asian countries, disasters caused by natural and environmental hazards continue to exact a heavy toll in terms of the loss of human lives and the destruction of economic and social infrastructure. With population growth in the coastal areas of countries concerned, expanding public and private infrastructure, and continuing trends towards urbanization and industrialization, the risks from great disasters are expected to increase in the coming years and decades.

Among the numerous natural disasters that the countries of Asia have experienced, earthquakes have historically had great impacts. It is necessary to mobilize scientific knowledge and technological know-how to assess earthquake hazards and to strengthen disaster mitigation measures. To this end, regional collaboration needs to be encouraged. Since 1999, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the U.S. Geological Survey (USGS) have been cooperating with scientific and engineering organizations in the South Asia region under the Reduction of Earthquake Losses in the South Asia Region (RELSAR) program. The purpose of the program is to provide a platform for examining regional approaches to improve seismic data and earthquake risk mitigation. A number of collaborative activities have taken place under this initiative; these activities include eight workshops that have been held since the start of the Programme in 1999.

In the interest of initiating cooperation on earthquake data analysis in the Northeast Asia Region, UNESCO is exploring the timeliness, possibility and opportunity of pursuing a cooperative activity on earthquake data analysis which will be jointly promoted by UNESCO and the USGS in the sub-region of North East Asia comprising the Democratic People's Republic of Korea, Japan, Mongolia, People's Republic of China, the Republic of Korea, and the Russian Federation.

Beyond their scientific value and merit, these programmes offer a forum for scientists and engineers from various countries presenting a diversity of contexts to work together under UNESCO's umbrella and discuss regional approaches to improve collaboration in earthquake data exchange and analysis. The first step in this planned effort was to hold an international workshop in China, hosted by the China Earthquake Administration, under the aegis of UNESCO, in cooperation with the USGS. This report presents the results of the first meeting of the Northeast Asia sub-regional workshop.

UNESCO thanks the USGS for its cooperation in the Northeast Asia Region and for the production of this report. The commitment and hospitality of the China Earthquake Administration (CEA) and their management and staff have made the meeting a successful event. UNESCO thanks the CEA. UNESCO wishes to express its gratitude all those who have contributed to the success of the workshop and is especially grateful to Dr. Zhao Ming, Deputy Director, Department of International Cooperation, for his support of the workshop. UNESCO would also like to convey its appreciation to the Permanent Delegations to UNESCO of the countries involved in this effort, for their commitment and for identifing specialists from institutions in their country concerned with earthquake risk reduction.

April 2010

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*The content of this report does not necessarily reflect the views of UNESCO.

Earthquake Risk Reduction in the Northeast Asia Region

Beijing, China
30 November – 3 December 2009

Executive Summary

Asia has one of the highest levels of seismicity on the planet; it is also the setting for many of the largest earthquakes. A recently published catalogue for earthquakes with more than 1000 deaths since 1900 lists 125 earthquakes worldwide, of which thirty-two occurred in the region represented by participants at this workshop. In addition, in a compilation of historic World Earthquakes, China had 48 entries, Japan had 42, Russia had 18, and Mongolia had 2. The high seismic risk in the region was recently emphasized by the 12 May 2008 magnitude 7.9 earthquake in eastern Sichaun Province, China, that caused more than 87,000 deaths and billions of U.S. dollars in damage**.** The majority of earthquakes in the Asia region are related to regions of plate convergence where one tectonic plate slides beneath another plate (subduction zones). In addition to generating large earthquakes, plate subduction often gives rise to volcanism. However, large earthquakes are not always associated with subduction zones. Faults where horizontal motion takes place (strike-slip faults) also generate devastating earthquakes. Strike-slip faults in China and Mongolia are responsible for numerous destructive earthquakes, often with magnitudes between 6.0 and 7.5 and occasionally greater than 8.0.

In response to this risk, most nations have increased the number and quality of seismic stations used to monitor earthquake activity. The optimal use of these data for regional earthquake monitoring is a major challenge that will require the exchange of data, software, and expertise among the interested nations.

The Northeast Asia 2009 Workshop

To focus on the high risk in the northeast Asia region, UNESCO, USGS, and the China Earthquake Administration, organized a workshop in Beijing, China, 30 November – 3 December 2009 Earthquake Risk Reduction in the Northeast Asia Region.

The keynote addresses were presented by Dr. Ren Jinwei, CEA: *Seismicity and Active Tectonics of the Northeast Asian Region* and by Koichi Kajiwara, Hyogo Earthquake Engineering Research Center: *Earthquake hazard mitigation and research efforts.*

In the technical sessions, each country summarized their seismic networks and their earthquake hazard research efforts. Participants also presented thirteen papers on topics including: tectonics and seismotectonics, great earthquakes and tsunamis, regional and local seismic activity, the seismic hazard and risk assessments, earthquake forecast and early warning systems, E-Defense Facility, seismic bulletins in northeast Asia, long-term slip-rate of the segmented major active-faults, and 3-D velocity tomography. Videos were presented on the L'Aquila, Italy, earthquake of 2009 and on an introduction to earthquake early warning.

Discussions were held on the future of UNESCO-sponsored northeast Asia multi-lateral meetings. All of the participants agreed that multi-lateral meetings in the northeast Asia region are worthwhile and that UNESCO and the USGS should attempt to find funds for a second meeting during September-October 2010. Mongolia offered to host the next meeting and this was accepted by the participants. A list of topics was suggested for the next meeting, but no decision was made on whether to limit the number of topics or which topics should be given preference.

Introduction

Seismicity of the Asia region

The Asia region has one of the highest levels of seismicity on the planet; it is also the setting for many of the largest earthquakes. A recently published catalogue for earthquakes with more than 1000 deaths since 1900 lists 125 earthquakes worldwide, of which thirty-two occurred in the region represented by participants at this workshop. In addition, in a compilation of historic World Earthquakes, China had 48 entries, Japan had 42, Russia had 18, and Mongolia had 2. The high seismic risk in the region was recently emphasized by the 12 May 2008 magnitude 7.9 earthquake in eastern Sichaun Province, China, that caused more than 87,000 deaths and billions of U.S. dollars in damage**.**

The majority of earthquakes in the Asia region are related to regions of plate convergence where one tectonic plate slides beneath another plate (subduction zones). In addition to generating large earthquakes, plate subduction often gives rise to volcanism. However, large earthquakes are not always associated with subduction zones. Faults where horizontal motion takes place (strike-slip faults) also generate devastating earthquakes. A well-known example in the United States is the San Andreas Fault, where the Pacific plate slides northward with respect to the North American plate. Strike-slip faults in China and Mongolia are responsible for numerous destructive earthquakes, often with magnitudes between 6.0 and 7.5 and occasionally greater than 8.0.

Large earthquakes in the Asian region have proved to be very devastating. The Tangshan, China, earthquake of July 1976, occurred on a strike-slip fault and resulted in over 240,000 deaths according to the China Earthquake Administration (CEA). In 1896 in Sanriku, Japan, a magnitude 8.5 earthquake resulted in 27,000 fatalities and in 1923 in Kanto (Kwanto), Japan, a magnitude 7.9 earthquake resulted in the loss of 143,000 lives. Mongolia suffered two earthquakes with magnitudes greater than 8.0 in 1905 and 1957 while Russia, since 1923, suffered six earthquakes with magnitudes greater than 6.0, five earthquakes with magnitudes greater than 7.0, and six earthquakes with magnitudes greater than 8.0.

Tectonic Setting

Northeast Asia has one of the most interesting and diverse geological settings on East. The range of tectonic features includes: (1) the Western Pacific subduction system; (2) the Japanese and Russian island arc system; (3) the region of active backarc spreading located between Japan and China; (4) the Precambrian through Paleozoic continental crust on the NE Asian mainland that includes Korea, China, Mongolia, and the Russian Far East.

Northeast Asia is a tectonically active region, with earthquakes occurring within the island arc cruist, the subduction zone, and in the intraplate setting of the continental region. Earthquakes occur at depths in excess of 300 km within the subducting slab. Intraplate and arc crustal seismicity is well documented including the great Mongolian earthquake of 1957 and the deadly Tangshan earthquake of 1976 that resulted in over 200,000 deaths.

A wide range of geophysical techniques have been used to investigate the deep structure of the crust and mantle beneath this region. The technique that has provided the most complete picture is seismic tomography that employs passive earthquake sources recorded on the numerous seismographic stations that are operated in the region. This technique are resolved several significant features: (1) the geometry of the subducted Pacific oceanic slab; (2) a region of hot, mobile asthenospheric mantle above the subducting slab that is associated with the backarc spreading; and (3) a large region in NE China with Precambrian crust but without the typical thick lithospheric root. The latter is a highly unusual feature for Precambrian regions, which usually display a thick, cold lithospheric root in seismic tomographic images. The lack of such a root beneath NE China is an important discovery, and may explain why this region has many large intraplate earthquakes. Precambrian region that do have a thick lithospheric root, such as portions of the Russian Far East and north-central North America, do not have a history of significant intraplte seismicity. The seismicity and tectonics of Northeast Asia was expertly described during the meeting by several of the speakers, leading to a very lively discussion and debate.

In response to the historic losses and the seismic risk, most nations have increased the number and quality of seismic stations used to monitor earthquake activity. The optimal use of these data for regional monitoring is a major challenge that will require the exchange of data, software, and expertise among the interested nations.

RELEMR and RELSAR Workshops

The first RELEMR (Reduction of Earthquake Losses in the Extended Mediterranean Region) meeting was held in Cairo in 1993 and was hosted by the National Research Institute for Astronomy and Geophysics and the Egyptian Geological Survey. It was sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the U.S. Geological Survey (USGS). Since 1993, twenty-nine RELEMR meetings have been held with up to 85 scientists and engineers from Morocco to Iran in attendance. The thirtieth RELEMR meeting is planned for Ankara, Turkey, (hosted by the Middle East Technical University) in May 2010 and the thirty-first meeting will be held in the Fall of 2010 at a venue yet to be determined.

In December, 1999, UNESCO and the USGS sponsored a planning meeting that was held in the Philippines where the RELEMR concept was presented. This meeting gave rise to RELSAR (Reduction of Earthquake Losses in the South Asia Region) and in September 2001, UNESCO and the USGS, in cooperation with the Nepal Department of Mines and Geology, held the *First International Workshop on Seismic Analysis in the South Asia Region* in Kathmandu. The China Earthquake Administration (CEA) hosted the *Second International Workshop on Seismic Analysis in the South Asia Region* in Kunming, China, 13-16 May 2002 and the third workshop in the series was held in Columbo, Sri Lanka, 30 September – 3 October 2003. The Geological Survey of

Bangladesh and the Bangladesh Atomic Energy Commission co-hosted the *Fourth International Workshop on Seismic Analysis in the South Asia Region*. The *Fifth International Workshop on Seismic Analysis in the South Asia Region* was co-hosted by the China Earthquake Administration and the Earthquake Administration of Shaanxi Province and was held in Xi'an, China, 13 – 16 November 2005. The *Sixth International Workshop on Seismic Analysis in the South Asia Region* was co-hosted by the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP), the Thai Department of Mineral Resources, and the Thai Department of Meteorology in Chiang Mai, Thailand, 4 – 7 December 2006. The Bhutan Department of Geology and Mines hosted the *Seventh International Workshop on Seismic Analysis in the South Asia Region* in Thimphu, Bhutan, 2-5 June 2008. Approximately 40 scientists and engineers from Afghanistan, Bhutan, Bangladesh, China, France, India, Iran, Nepal, Pakistan, Sri Lanka, Thailand, the United Kingdom, and the United States have attended each of these workshops. The next RELSAR meeting is planned for Tehran, Iran, in May 2010 and will be hosted by the International Institute for Earthquake Engineering and Seismology.

The Northeast Asia Workshop

Workshop Proceedings

Opening session

The Welcoming Address was presented by Dr. Liu Yuchen, Vice Administrator, CEA, Additional welcoming remarks were made by Dr. Abhimanyu Singh, Director and Country Representative, UNESCO Beijing Office, Dr. Walter Mooney, Seismologist, USGS), Dr. Ren Jinwei, Director, Institute of Earthquake Science, CEA, and Dr. Badaoui Rouhban, Director Section for Disaster Reduction, UNESCO, Paris.

Keynote Addresses

The keynote addresses were presented by Dr. Ren Jinwei, CEA: *Seismicity and Active Tectonics of the Northeast Asian Region* and by Dr. Koichi Kajiwara, Hyogo Earthquake Engineering Research Center: *Earthquake hazard mitigation and research efforts.*

Ren Jinwei, Institute of Earthquake Science, CEA: *Seismicity and Active Tectonics of the Northeast Asian Region*

Northeast Asia is controlled by the west Pacific Island Arc System. It is the first-order division for lithospheric dynamics. Although the major earthquakes are located along the subduction zone, the earthquakes in northeast Asia are obviously affected by the dynamic process of the subduction between Pacific plate and Eurasian plate.

Northern China is characterized by intense activity of lithospheric dynamics. Upwelling of a mantle convection cell caused plastic flow of the lower crust and brittle extension of upper crust, and hence led to the region to form a series of taphrogenic basins. Northeast China is a unique region for deep earthquakes in China. The lithosphere in this region can be divided into four layers with their total thickness of 63-150 km. and can be separated into three areas with different crustal structures. In eastern China, the distribution of historic earthquakes is similar to those recorded by the instruments, but seismological regionalization and degree of seismicity are remarkably different. Nevertheless, one characteristic is the same, almost of all the earthquakes are generated in the middle and upper crust, and the epicenters are along the major faults in the direction of NE-NNE and NW-NWW. Focal mechanism solutions show that the principal compressive stress axis is in nearly EW in eastern China, ENE north of the Yangtze River, and ESE south of the Yangtze River.

Koichi Kajiwara, Hyogo Earthquake Engineering Research Center: *Earthquake hazard mitigation and research efforts*

Earthquake hazards in Japan are generally well known. The predicted damage from a major earthquake in Tokyo Bay is estimated to be 11,000 casualties and more than $1.2 trillion in economic losses. The goal of the Central Disaster Management Council is to reduce the death toll by fifty percent (50%) and reduce the economic loss by forty percent (40%). Continued operation and immediate recovery is critical, considering the concentration of population and businesses in the Tokyo area.

Seismic design codes in Japan have evolved mainly as a result of major earthquakes. The First Building Law, passed in 1920, required a height limit of 31 m and had no earthquake design load. After the M 7.9 1923 Tokyo earthquake, the building laws were updated in 1924 to provide a design earthquake load equal to 0.1g with a safety factor of three. The M 7.1 1948 Fukui earthquake led to the development of the *Building Code of Japan* (BCJ) that had a design earthquake load of 0.2g with a safety factor equal to 1.5. Again, in 1968, the M 7.9 Tokachi-Oki earthquake resulted in the BCJ being updated to provide for the shear strength of R/C columns. The 1978 M 7.4 Miyagi-Oki earthquake resulted in a revision in that provided a "New Seismic Design" and following the 1983 Nihonkai-Chubu (M7.4) and 1995 Kobe (M7.4) earthquakes, the BCJ was again revised in the year 2000.

The lessons learned from 1995 Kobe earthquake are:

- Need to develop reliable techniques to retrofit existing buildings
- Need to develop improved design and construction technologies for new buildings
- Need to prepare our living environment against future earthquakes.

The National Research Institute for Earth Science and Disaster Prevention (NIED) developed and operates *E-Defense* at an approximate cost of US$450 million. *E-Defense* is the world's largest shaking table and is located in Miki City, near Kobe.

Future plans include improving hospital equipment for immediate post-earthquake functionality, improving the inside conditions of high-rise buildings under long-period motion, improving the survivability of buried facilities and lifelines, soil-structure interaction, advanced base-isolation systems, low-cost seismic designs and upgrades, and human behavior and evacuation response.

Technical Sessions

This is the first meeting organized by UNESCO in the northeast Asia region. For this reason, each country was asked to summarize their seismic networks and their earthquake hazard research efforts. These *Country Reports* are summarized below; additional information may be found in the Abstracts (Annex C) and in the PowerPoint© presentations on the DVD.

Additional presentations on technical subjects are not summarized and readers are referred to the Abstracts and the PowerPoint© presentations on the DVD.

Country Reports

Zhang Xiaodong: *Earthquake Monitoring and Seismicity Characteristics in China*

Earthquakes in China are characterized by high frequencies, large magnitudes, shallow hypocenters, are broadly distributed within China, and frequently inflict serious damage. Each year, on average, the China mainland experiences 20 earthquakes with magnitudes greater than 5.0, 3.8 earthquakes with magnitudes greater than 6.0, and 0.6 earthquake with a magnitude greater than 7.0. Worldwide in the twenty-first century, there were twelve earthquakes with magnitudes greater than 8.0; the only two continental earthquakes with a magnitude greater than 8.0 both occurred on the China mainland. Every province in China has experienced M≥5.0 earthquakes, thirty provinces have experienced M≥6.0 earthquakes, 19 provinces have experienced M≥7.0 earthquakes, and 12 provinces have experienced M≥8.0 earthquakes.

Earthquake monitoring in China consists of three monitoring networks and a communications network:

- Earthquake monitoring network
- Earthquake precursor observatory network
- The GPS crustal movement observation network
- The national system for earthquake information communication

The density of seismometers in China is:

Region	Seismometers/$10^4 km^2$
China mainland:	1.35
East China:	1.53
West China:	0.22
Capital region:	7.2

The system is capable of monitoring M≥4.0 earthquakes nationwide, M≥2.5 earthquakes over 50 percent of the land area, M≥1.5 earthquakes in the provincial capitals and their adjacent areas in the eastern part of China, and M≥1.0 in the capital area. The reporting time of an earthquake in the capital city and the eastern region is 10-15 minutes and 20-25 minutes in other regions.

Currently, there are 4858 instruments operating as part of the China Earthquake Network, including seismometers (1500), deformation monitors (808), electromagnetic detectors (861), and fluid monitors (1626).

The crustal movement observation network of China has 260 continuously observing stations, a regional network consisting of 2000 regular and mobile stations, one data center and four sub-centers.

The precursor observation network has 1303 seismic stations, 358 deformation observation stations, 294 electromagnetic observation stations, and 619 fluid observation stations.

Kenji Satake: ***Earthquake activities and the seismic networks in Japan***

Japan is one of the most seismically active countries in the world. Each year, more than 100,000 earthquakes, or more than 300 a day, are detected. Thousands of seismic stations with various types of instruments are distributed throughout Japan, including about 800 Hi-net and KiK-net (high-sensitivity and strong-motion instruments in boreholes) stations operated by the National Research Institute for Earth Science and Disaster Prevention (NIED), and about 200 seismic stations operated by Japan Meteorological Agency (JMA). These data are telemetered to JMA for Earthquake Early Warning, tsunami warning and producing an earthquake catalog. In addition, NIED operates about 70 broadband stations (F-net) and about 1,000 strong-motion stations (K-NET). Other agencies, e.g., local governments, operate a few thousand seismic intensity meters. For geodetic monitoring, the Geographical Survey Institute operates about 1200 continuous GPS stations.

The Central Disaster Management Council (CDMC) was established in 1961 in the Cabinet Office. Its duties are:

1. Formulate and promote implementation of the Basic Disaster Management Plan and Earthquake Countermeasures Plans.
2. Formulate and promote implementation of the Urgent Measures Plan for major disasters.
3. Deliberate on important issues on disaster reduction.
4. Offer opinions regarding important issues on disaster reduction.

After the 1995 Kobe earthquake which caused more than 6,000 casualties, the Japanese government established the Headquarters for Earthquake Research Promotion (HERP). Its duties are:

1. Planning comprehensive and basic policies.
2. Coordination of budgets and other administrative works with related governmental organizations.
3. Establishment of comprehensive survey and observation plans.
4. Collection, arrangement, analysis and comprehensive evaluation of survey results by related governmental organizations, universities, etc.
5. Public announcements based on the comprehensive evaluations.

HERP includes a Policy Committee and an Earthquake Research Committee (ERC). The ERC meets every month to evaluate the current seismic activity in and around Japan. The ERC also made and has been updating National Seismic Hazard Maps, which consist of probabilistic seismic hazard maps for the entire Japan, and deterministic seismic hazard maps for specified source faults. These maps were made based on several steps. First, past occurrence of earthquakes were studied by paleoseismological and historical studies, from which the probability of future earthquake occurrence is estimated. Then, strong-motion is calculated based on models of earthquake faults and subsurface seismic velocity structure, following a standardized method.

In October 2007, JMA established an Earthquake Early Warning (EEW) system to provide a quick estimation of hypocenter, magnitude and seismic intensity and broadcast the information before ground shaking. Seismometers used for the EEW system include 200 JMA stations and 800 NEID stations. Tsunami warnings are also provided.

National seismic hazard maps, both deterministic and probabilistic, are made based on paleoseismic surveys, long-term forecasts, and strong-motion prediction.

Demberel Sodnomsambuu: ***Earthquake activities and the seismic networks in Mongolia***

The seismicity of Mongolia is controlled by the deformation process that is caused by the collision and subsequent penetration of the Indian plate with respect to Eurasia and the extensional tectonics related to the active Baykal rift system. The occurrence and distribution of strong earthquakes are the manifestation and result of these widespread and varied styles of deformation. From 1900 to 2000, Mongolia has suffered thirty M≥7 earthquakes including four M≥8 earthquakes.

The Research Center for Astronomy and Geophysics (RCAG) of the Mongolian Academy of Sciences is the national data center for seismology of Mongolia. RCAG currently has 82 employees with 33 employees in the Seismological Section. The development of a Mongolian National Seismic Network (MNSN) began in 1957 with the installation of the first analog seismic station by the Government of Mongolia in Ulaanbaatar. A few months later, the M_w 8.1 earthquake occurred on 4 December 1957 in the Gobi-Altay. Three other $M_w \geq 8$ events occurred earlier in Mongolia and its immediate surroundings: 1905/07/09, 1905/07/23, and 1931/08/10.

Since 1957, the MNSN has been developed and the Ulaanbaatar network now includes one three-component LP+SP station and four SP vertical stations. In 2000, the CTBTO installed a seismic and infrasound array near Ulaanbaatar consisting of one three-component LP+SP seismic station and nine SP vertical seismic stations and an eight-element infrasound stations. This enables the RCAG to detect and locate seismic activity in Mongolia and the surrounding region. In 2007, RCAG renewed all national analog seismic stations and installed a new one-component, short period, digital seismometer.

All seismic data of the MNSN are transmitted and archived in real time to the Mongolian National Data Center (NDC) of RCAG. The detection, interactive data processing, and interpretation are carried out by researchers at the NDC. At present, the MNSN receives data from 50 digital seismic stations including one- and three-component short period, broadband and borehole instruments. In 2009, the Government of Mongolia adopted the National Program on Seismic Risk Mitigation and RCAG has a plan for future development of MNSN that includes the installation of three new, permanent regional seismic stations near the significant seismic source areas in Mongolia.

Since 1994, the RCAG has collaborated with the French Laboratoire de Détection et de Géophysique of the Département Analyse, Surveillance, Environnement (DASE – LDG).

Duk Kee Lee: *Earthquake activities and the seismic networks in the Republic of Korea*

The Korea Meteorological Administration (KMA) is responsible for officially issuing national earthquake and tsunami notifications and disseminating the information to the public. In 1996, the Earthquake Division was established as part of KMA. The earthquake division of KMA currently operates at the bureau level under the leadership of the Director-General for Earthquakes. The following are highlights regarding the KMA history of seismic observation:

1905	Earthquake observation began
1944~1962	Suspension of observation
1963	World-Wide Standardized Seismograph Network was installed in Seoul
1978	Analog seismic network was constructed
1996	Earthquake division was newly established
1999	Digital seismic network was constructed
2005	Earthquake division was divided into two parts • Earthquake Planning Division • Earthquake Detection Division
2006	Ocean Bottom Seismometer was installed
2007	Earthquake division was elevated into Bureau level • Director General for Earthquake was appointed
2009	Current Status • Seismic stations: 48 • Accelerometer stations: 109 • One laboratory

KMA is exchanging seismic data from 83 stations with other related institutions of Korea. KMA also has data-exchange agreements with China (CEA), Japan (JMA and NEID), and the USA (IRIS, Incorporated Research Institutions in Seismology). Three of the other institutions that operate seismic networks in the Republic of Korea are:

Korea Institute of Geoscience and Mineral Resources (KIGAM)	Broadband: 9 Short Period: 15 Borehole: 10
Korea Electric Power Research Institute (KEPRI)	Short Period: 13
Korea Institute of Nuclear Safety (KINS)	Broadband: 4

In late 1990, KMA began strengthening the Korea National Seismographic Network (KNSN) and the tsunami warning system. This system was completed in 2002 and has been continually upgraded. This network is currently composed of 12 broad-band seismometers, 32 short-period seismometers, four borehole seismometers, 109 accelerometers, and a system for the analysis of earthquake data. Many inland type seismometers and accelerometers were installed in 2007 and, in 2008, KMA installed three borehole seismometers and a geomagnetic observatory.

The Republic of Korea has been increasingly aware of the importance of preparedness against earthquake and tsunami hazards and continually supports KMA for earthquake hazard mitigation. By 2012, KMA plans to add 11 seismometers, including two borehole seismometers, and 30 accelerometers. KMA also plans to install three OBSs but the schedule for these is not yet fixed. Recent earthquake activity in China and Japan has stimulated interest in earthquake early warning (EEW) systems. KMA has developed a detailed plan to have an EEW system in place by 2015 with work on an EEW algorithm to start in 2010.

Each year, KMA has been executing simulated tsunami preparedness drills to evaluate the tsunami warning and notification system. KMA also participated in the international tsunami drill titled *Exercise Pacific Wave 08* held under the auspices of ICG/PTWS on 29 October 2008. In order to inform the general public, KMA published a catalogue of earthquakes and related fields in 2008 and has executed many educational programs about earthquakes and tsunamis and how to behave when these disasters occur.

Alexei Malovichko: *Earthquake activities and the seismic networks in the Russian Federation*

The main goals of the Geophysical Survey of the Russian Academy of Sciences are:

- Seismic monitoring of Russia, neighboring countries and the world
- Providing urgent warnings to state authorities (EMERCOM) regarding strong and felt earthquakes including earthquake parameters and the evaluation of their possible consequences
- International seismic data exchange
- Provide researchers and institutions with seismic observations and the results of data processing

Specific goals include:

- Monitoring of tsunamigenic earthquakes in Far East of Russia (in cooperation with Meteorological Agency of Russia)
- Monitoring nuclear explosions (in cooperation with Ministry of Defense of Russia)
- Monitoring volcanoes in the Kamchatka region

The seismic network of the Geophysical Survey has 273 stations (including 253 digital stations) and 1137 employees and provides monitoring at three levels:

- teleseismic;
- regional;
- Local.

The breakdown by region is:

Altai Sayan Department SB RAS	52 digital stations
Baikal Department SB RAS	23 digital stations
Buryatiya Department SB RAS	8 digital stations
Yakutia Department SB RAS	19 digital stations

Kamchatka Department	45 stations, (including 3 local telemetric systems)
Magadan Department	15 digital stations
Sakhalin-Kurily Department	31 stations, including 24 digital stations
Northern Osetiya Department	12 digital stations
Dagestan Department	17 stations, including 5 digital stations
Kola Department	5 digital stations (1 array)
European part of Russia (Obninsk)	46 stations, including 45 digital stations

Other seismic networks in Russia include the Special Seismic Control Survey of Ministry of Defense (11 stations), the provincial networks (Krasnoyarsk kray – 10 stations and Permian kray – 7 stations), and the Seismic Network of Ministry of Natural Resources (8 stations).

The magnitude levels for teleseismic monitoring are Russia≥3.5, Northern Eurasia≥4.0, other regions of Eurasia≥4.5, and other regions of the earth≥5.0.

The largest earthquakes on the territory of Russia from 1999 to 2009 include:

Central Kuril Islands:	10 earthquakes with the largest having Ms=8.2
Koryak area:	6 earthquakes with Ms>5.5 and the largest with Ms=7.8
Altay area	3 earthquakes with Ms>6.5 and the largest with Ms=7.3
Okhotsk Sea area	4 earthquakes with m_b>6.5 and the largest with m_b=7.2
Kamchatka area	6 earthquakes with Ms>6.0 and the largest with Ms=7.1
Primorskiy kray	3 earthquakes with m_b>6.0 and the largest with m_b=7.0
Sakhalin	4 earthquakes with Ms>5.5 and the largest with m_b=6.3
Yakutia area	3 earthquakes with Ms≥5.0 and the largest with m_b=6.2
Baikal area	4 earthquakes with Ms≥6.0 and the largest with Ms=6.1

In the past decade, the Geophysical Survey implemented several scientific and technical projects with the aim of developing a significant seismic network in the Far East of Russia. The most important project is *Upgrading of the Russian Tsunami Warning System*. Eight new digital seismic stations were installed in Kamchatka, the Kuril Islands, Sakhalin Island and Primorye regions. All stations were equipped with CMG-3ESPC broadband seismometers and CMG-5 accelerometers.

In the framework of the cooperative project *Research on Seismo-Tectonics around the Okhotsk plate* between Japanese Universities and the Geophysical Survey of RAS, 11 digital stations were installed. They were equipped with STS-2 broadband seismometers. In addition, a local network of nine short-period seismic stations was installed in cooperation with the Hokkaido University in the south part of Sakhalin Island. In order to provide real-time data transmission from the stations to the processing centers, 23 communication channels were installed through the Russian geostationary satellite *Express AM-3*.

Advanced observational facilities will provide new opportunities to study the space-time pattern of earthquake occurrence, the initiation and rupture sequence of earthquakes, the three-dimensional structure of Earth's interior, and many other fundamental aspects of modern seismology. The improved understanding of seismic processes and continental structure and dynamics is an important step for the development strategy for solving earthquake risk reduction problems in region.

Other Presentations

Technical Presentations

There were thirteen technical presentations on a wide variety of subjects related to the northeast Asia region, including:

- Tectonics
- Seismotectonics
- Great earthquakes and tsunamis
- Regional and local seismic activity
- The 12 May 2008 M=8.0 Wenchuan (China) earthquake
- The 30 September 2009 M=7.6 Padang, Sumatra (Indonesia) earthquake
- Seismic hazard and risk assessments
- Earthquake forecast systems
- Earthquake early warning systems
- E-Defense Facility
- Seismic bulletins in northeast Asia
- Long-term slip-rate of the segmented major active-faults
- 3-D velocity tomography

Two videos produced by Walter Mooney were also presented. The first video (6 minutes) was on the L'Aquila, Italy, earthquake of 2009 and the second video (10 minutes) was an introduction to earthquake early warning. Both videos are available on the DVD.

Initiating cooperation on earthquake data analysis in the Northeast Asia Region

UNESCO is exploring the timeliness and opportunity of pursuing a cooperative activity on earthquake hazards that will be jointly promoted by UNESCO and the USGS in the sub-region of North East Asia comprising the Democratic Peoples' Republic of Korea, Japan, Mongolia, Peoples' Republic of China, the Republic of Korea and the Russian Federation. The first step in this effort is this international workshop, hosted by the China Earthquake Administration, under the aegis of UNESCO, and in cooperation with the USGS.

At the end of the first day, a session on other UNESCO regional programs and the future of a UNESCO program in the northeast Asia region was chaired by Badaoui Rouhban, Director, Section on Natural Disasters, UNESCO/Paris. The session was opened by a presentation on RELEMR (Reduction of Earthquake Losses in the Extended Mediterranean Region) and RELSAR (Reduction of Earthquake Losses in the South Asia Region).

Frederick Simon: ***Summary of RELEMR and RELSAR*.**

RELEMR and RELSAR have their roots in another UNESCO program: PAMERAR – Program for Assessment and Mitigation of Earthquake Risk in the Arab Region – that was started in 1983 following the M_s = 7.3 10 October 1980 El-Asnam, Algeria, earthquake. PAMERAR was funded by Arab Fund for Economic and Social Development and the Islamic Development Bank and involved Algeria, Egypt, Iraq, Jordan, Lebanon, Morocco, Syria, Tunisia, and Yemen. RELEMR, funded by the U.S. Geological Survey and UNESCO, was initiated in Cairo in 1993. Since the first meeting in Cairo, a total of 29 meetings were held with participation of scientists and engineers from Morocco to Iran. Countries that have participated in RELEMR meetings are:

Armenia	Algeria	Belgium	Cyprus (GCC)
Cyprus (TCC)	Denmark	Ecuador	Egypt
France	Germany	Greece	Iran
Israel	Italy	Jordan	Kuwait
Lebanon	Libya	Mauritania	Morocco
Netherlands	Norway	Oman	Palestinian Authority
Portugal	Saudi Arabia	Slovenia	Spain
Sudan	Sweden	Syria	Tunisia
Turkey	UAE	U.K.	U.S.
Yemen			

RELSAR was initiated with a planning meeting in Pampanga, Philippines, in 1999 that was similar to this 2009 meeting in Beijing. Eight additional meetings have been held since the first meeting in 1999. Countries that have participated in RELSAR meetings are:

Afghanistan	Bangladesh	Bhutan	China
France	India	Indonesia	Iran
Nepal	Pakistan	Sri Lanka	Thailand
United Kingdom	United States		

The goals of RELEMR and RELSAR meetings are:

- Seismology
  - ➢ Data exchange
  - ➢ Improve data
    - ✓ Improve earthquake locations
    - ✓ Improve magnitude estimates
  - ➢ Regional seismicity map
- Geology
  - ➢ Improved understanding of regional tectonics
- Earthquake Engineering
  - ➢ Regional ground-shaking map
  - ➢ Probabilistic Seismic Hazard Assessments
  - ➢ Earthquake provisions included in building codes

Both programs are on-going and meetings are planned for 2010.

A decision on a future northeast Asia meeting was deferred to the Closing Session.

Fieldtrip

A field excursion was conducted to examine the *China National Training Base for Urban Search and Rescue (CNSART)* and the *China Earthquake Networks Center*. Both centers are operated by the China Earthquake Administration (CEA).

CNSART is operated by the National Earthquake Response Support Service (NERSS) of CEA and was created to strengthen the emergency response to major earthquake disasters and to improve the competence of first responders. Its facilities cover an area of approximately 130,000 m^2 with a building area of approximately 17,000 m^2 and include an indoor physical training area, administrative area, trainees' dormitories, trainers' apartments, a VR-based simulation hall, and a rescue training area. The rescue training area includes: a lifting and shoring zone, a drilling and cutting zone, a narrow space zone, a smoke generating zone, fire fighting zone, K-9 houses, and high-angle and vertical shaft training zones. CNSART has extensive cooperation with national and international institutions.

The CEA China Earthquake Networks Center is a newly constructed facility that operates 24 hours per day/7 days per week. It has extensive communication and earthquake monitoring capabilities. Seismic data from all over China is received on a real-time or near real-time basis. In the event of an earthquake disaster, it functions as a command and control center for disaster response.

Closing Session

All of the participants agreed that multi-lateral meetings in the northeast Asia region are constructive and that UNESCO and the USGS should attempt to find funds for a second meeting during September-October 2010. Mongolia offered to host the next meeting and this was accepted by the participants.

Walter Mooney offered the following list of topics for the next meeting:

- Seismic network data: locations, focal mechanisms, depths, magnitudes
  (Example: seismicity of Mongolia, Russia, and North China)
- Analysis of Active Fault Maps
  (Example: are there active faults in South Korea? Longmenshan fault, China)
- Exchange of information regarding recent damaging earthquakes
  (Examples: recent earthquakes in Russia, Japan and China)
- Advances in Earthquake Engineering
  (Examples: E-Defense in Japan; hazards in Ulaanbaator)
- Earthquake Early Warning
  (Examples: Japanese system and the new systems for the Republic of Korea and China)
- Probabilistic Earthquake Aftershock Forecasting
  (Examples: systems in China and Japan)

- Medium- and Long-term Earthquake Forecasting
  (Examples: CSEP programs in China, Japan, Russia)
- Public Education, Building Construction, Earthquake Preparedness
  (Examples: education programs in Japan and China)
- Tsunami Hazards and Preparedness
  (Examples: Japan, Russia, and Korea)
- GPS data, Geodynamics, and Active Tectonics
  (Examples: China, Mongolia, Japan, Russia)
- Earthquake Hazards Maps
  (Examples: China, Russia, Japan)
- Earthquake Notifications
  (Example: ShakeMap and other technologies)

The participants discussed many of the points in the list but no decision was made on whether to limit the number of topics for the next meeting.

Ren Jinwei made a final presentation on recommendations for future northeast Asia activities: **Suggested Topics on Active Tectonic Research.** He proposed the following topics and gave examples of where he thought cooperative research on these topics would be beneficial. Ren Jinwei's presentation is available on the DVD.

- Active fault tracing across national boundaries
- Earthquake hazard assessments across national boundaries
- Comparison studies on unique seismotectonic features
- Deep earthquakes in northeast Asia.

Results and Conclusions

Presentations

1. Two keynote addresses were presented by Ren Jinwei, CEA: *Seismicity and Active Tectonics of the Northeast Asian Region* and by Koichi Kajiwara, Hyogo Earthquake Engineering Research Center: *Earthquake hazard mitigation and research efforts.*

2. This is the first meeting organized by UNESCO in the northeast Asia region. For this reason, each country was asked to summarize their seismic networks and their earthquake hazard research efforts.

3. Participants presented thirteen papers on topics including:
    - Tectonics
    - Seismotectonics
    - Great earthquakes and tsunamis
    - Regional and local seismic activity
    - The 12 May 2008 M=8.0 Wenchuan (China) earthquake
    - The 30 September 2009 M=7.6 Padang, Sumatra (Indonesia) earthquake
    - Seismic hazard and risk assessments
    - Earthquake forecast systems
    - Earthquake early warning systems
    - E-Defense Facility
    - Seismic bulletins in northeast Asia
    - Long-term slip-rate of the segmented major active-faults
    - 3-D velocity tomography

4. Videos were presented on the L'Aquila, Italy, earthquake of 2009 and on an introduction to earthquake early warning.

Discussions

5. Discussions were held on the future of UNESCO-sponsored northeast Asia multi-lateral meetings. All of the participants agreed that multi-lateral meetings in the northeast Asia region are constructive and that UNESCO and the USGS should attempt to find funds for a second meeting during September-October 2010. Mongolia offered to host the next meeting and this was accepted by the participants.

6. The following list of topics was suggested for the next meeting:
    - Active fault tracing across national boundaries
    - Earthquake hazard assessments across national boundaries
    - Comparison studies on unique seismotectonic features
    - Deep earthquakes in northeast Asia
    - Seismic network data: locations, focal mechanisms, depths, magnitudes
    - Analysis of active fault maps

- Exchange of information regarding recent damaging earthquakes
- Advances in earthquake engineering
- Earthquake early warning
- Probabilistic earthquake aftershock forecasting
- Medium- and long-term earthquake forecasting
- Public education, building construction, earthquake preparedness
- Tsunami hazards and preparedness
- GPS data, geodynamics, and active tectonics
- Earthquake hazards maps
- Earthquake notifications.

The participants discussed many of the points in the list but no decision was made on whether to limit the number of topics for the next meeting or which topics should be given preference.

Annex A

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Annex B

Preliminary Program

Sunday, 29 November 2009

Arrive in Beijing, China

Monday, 30 November 2009

09:30 – 10:30 Opening Session
Chairpersons: Liu Yuchen and Ren Jinwei, CEA

Speakers:

- Liu Yuchen, Vice Administrator
  China Earthquake Administration
- Abhimanyu Singh, Director and Country Representative
  UNESCO Beijing Office
- Walter Mooney, Seismologist
  U.S. Geological Survey (USGS)
- Ren Jinwei, Director
  Institute of Earthquake Science, China Earthquake Administration
- Badaoui Rouhban, Director
  Section for Disaster Reduction, UNESCO, Paris

Introductions: Participants introduce themselves giving their country, institution, and scientific/engineering background

10:30 – 11:00 Tea/Coffee Break

11:00 – 12:30 Keynote Addresses:
Chairperson: Walter Mooney, USGS

Ren Jinwei, *China*: *Seismicity and Active Tectonics of the Northeast Asian Region*

Koichi Kajiwara, *Japan*: *Earthquake hazard mitigation and research efforts.*

12:30 – 14:00 Lunch

Session I	Seismic networks in the Northeast Asia Region: Chairperson: Yasuo Awata, Japan [A representative of each country is asked to describe the seismic networks in his/her country]
14:00 – 14:20	Country Report China Zhang Xiaodong: *Earthquake Monitoring and Seismicity Characteristics in China*
14:20 – 14:40	Country Report Japan Kenji Satake: *Earthquake activities and the seismic networks in Japan*
14:40 – 15:00	Country Report Mongolia Demberel Sodnomsambuu: *Earthquake activities and the seismic networks in Mongolia*
15:00 – 15:20	Country Report Republic of Korea Duk Kee Lee: *Earthquake activities and the seismic networks in the Republic of Korea*
15:20 – 15:40	Country Report Russian Federation Alexei Malovichko: *Earthquake activities and the seismic networks in the Russian Federation*
15:40 – 16:00	Tea/Coffee Break

Session II

16:00 – 17:30	Discussion of other regional UNESCO programs – Part I: Chairperson: Badaoui Rouhban, UNESCO Frederick Simon: *Summary of RELEMR and RELSAR* Open discussion focusing on the Northeast Asia Region

Tuesday, 1 December 2009

Session III	Major Earthquakes and Seismic Activity in the Northeast Asian Region Chairperson: Alexei Malovichko, Russian Federation
09:00 – 09:20	Jiang Haikun: *Major earthquakes in northern China and Summary of the M=8.0 Wenchuan, China, Earthquake of May 12, 2008*
09:20 – 09:40	Evgeny Rogozhin: *Seismotectonics and major earthquakes of the Far East region of the Russian Federation*

09:40 – 10:00	Kenji Satake: *Recurrence of Great Earthquakes and Tsunamis*
10:00 – 10:20	Ulziibat Munkhuu: *Recent seismic activity around Ulaanbaatar area, capital of Mongolia*
10:20 – 10:40	Walter Mooney: *The deadly Padang, Sumatra (Indonesia) M=7.6 earthquake of Sept. 30, 2009: Field and Seismological Observations*
10:40 – 11:00	Tea/Coffee Break
Session IV	Seismic Hazard Assessment in the Northeast Asian Region: Chairperson: Duk Kee Lee, Republic of Korea
11:00 – 11:10	Video (6 minutes): *The L'Aquila, Italy, Earthquake of 2009*
11:10 – 11:30	Alexei Malovichko: *The development of Russian seismic station network in the Northeast Asian region*
11:30 – 11:50	Kenji Satake: *CSEP-Japan: A rigorous earthquake forecast system based on seismicity data*
11:50 – 12:10	Mengtan Gao: *The main features of seismic hazard and risk in China*
12:10 – 12:30	Demberel Sodnomsambuu: Development of seismic monitoring system in Mongolia
12:30 – 14:00	Lunch
Session V	Seismology, geology, and earthquake engineering in the Northeast Asia Region: Chairperson: Demberel Sodnomsambuu, Mongolia
14:00 – 14:20	Video (10 min.): *Earthquake Early Warning: An Introduction*
14:20 – 14:40	Koichi Kajiwara: *E-Defense Facility*
14:40 – 15:00	Dmitry A. Storchak, ISC: *Integrating Seismic Bulletins in the North East Asia (1960-2009)*
15:00 – 15:30	Discussion
15:30 – 16:00	Tea/Coffee Break

Session VI

1600 – 1730	Discussion of other regional UNESCO programs – Part II: Chairperson: Badaoui Rouhban, UNESCO Open discussion focusing on the Northeast Asian Region
19:00	Dinner hosted by CEA

Wednesday, 2 December 2009

09:00 – 12:30	Visit to the China National Training Base for Search and Rescue
12:30 – 14:00	Lunch
14:00 – 17:30	Visit to the China Earthquake Networks Center

Thursday, 3 December 2009

Session VII	Seismicity and Tectonics in the Northeast Asian Region: Chairperson: Gao Mengtan, China
09:00 – 09:20	Yasuo Awata: *Characteristics of size and long-term slip-rate of the segmented major active-faults in Japan*
09:20 – 09:40	He Honglin: *Seismicity and Tectonics in northern China*
09:40 – 10:00	Winston Chan: *3-D Velocity tomography of Korean peninsula and surrounding regions*
10:00 – 10:30	Discussion
10:30 – 11:00	Tea/Coffee Break

Session VIII

11:00 – 13:00	Closing Session and Discussion of future activities in the Northeast Asia Region Chairpersons: Walter Mooney, USGS and Frederick Simon, UNESCO
13:00 – 14:30	Lunch
14:30 –	Free time for one-on-one discussions

Friday, 4 December 2009

Participants depart from Beijing

Annex C - Abstracts

Seismicity and Active Tectonics of the Northeast Asian Region

Ren Jinwei
Institute of Earthquake Science, China Earthquake Administration
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Northeast Asia continent is controlled by the west Pacific Island Arc System. It is the first-order division for lithospheric dynamics. Although the major earthquakes are located along the subduction zone, the earthquakes in the northeast Asia continent are obviously affected by the dynamic process of the subduction between Pacific plate and Eurasian plate.

Northern China is characterized by intense activity of lithospheric dynamics. Upwelling of mantle convection cell produced by an undefined mechanism caused plastic flow of lower crust and brittle extension of upper crust, and hence led to the region to form a series of taphrogenesis basins. There is a ductile shear zone between the lower and upper crusts with different dynamic features. In this zone a low velocity layer is found. On the other hand, lateral compression caused by the subduction of west Pacific, marginal sea basin, deep plastic flow and shallow lateral compression caused by the uplifting of Tibet plateau produced a horizontal tectonic stress field with ENE-WSW compression imposed on this region.

Northeast China is a unique region for deep earthquakes in China. The lithosphere in this region may be distinguished into four layers with their total thickness of 63-150 km. In accordance with gravity and magnetic data, the region can be divided into three areas with different crustal structure. Since the Cenozoic time they have undergone differential movement, uplifting and subsidence. The lithospheric structure and seismicity in this region could be resulted from the deformation and tectonic adjustment by heating and pressure under the interaction of Pacific plate, lateral compression of Baikal rift, upwelling magma and gravity isostasy. During the last 1000 years, the seismicity in the region is mainly caused by the lateral compression of the Pacific plate.

In eastern China, distribution of historical earthquakes is similar to those recorded by the instruments, but seismological regionalization and degree of seismicity are remarkably different. Nevertheless, one thing is the same, almost all the earthquakes are generated in the middle and upper crust, and the epicenters are along the major faults in the direction of NE-NNE and NW-NWW. Focal mechanism solutions show that the principal compressive stress axis is in nearly EW direction in eastern China, in ENE direction north of the Yangtze River, and in ESE direction south of it.

The tectonic activity in the last 1000 years in northern China is characterized by uplifting and faulting, which are consistent with the Cenozoic active zones and with the belts of the historic and recent large earthquakes. From the attitude of sedimentary formations, the region was dominated by faulting in the last 10000 years, especially in the last 2000 years the regional uplift is evident. The faulting in this region has dislocated Holocene sediments, cultural relics and layers, controlling the distribution of river system and lakes.

Earthquake Monitoring and Seismicity Characteristics in China

Zhang Xiaodong
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There are existing 1244 seismology monitoring (network) stations and 2263 observation stations, including 191 national stations, 296 provincial stations and 757 county-level stations. There are 4858 current running seismic instrumentations, of which, the Seismic, deformation, electromagnetic, fluid subjects on China Earthquake Network. The numbers of instrumentations are as follows: 1500 sets, 808 sets, 861 sets and 1626 sets. At present, earthquake of magnitude 1-1.5 can be monitored in the metropolitan area, time of rapid earthquake information report is 5-10 minutes; Earthquake of magnitude 1.5-2 can be monitored in capital cities and eastern region, time of rapid earthquake information report is 10-15 minutes; And earthquake of magnitude 4 or above can be monitored in other regions, time of rapid earthquake information report is 20-25 minutes.

There are existing 1303 seismic observation stations, 358 deformation observation stations, 294 electromagnetic observation stations, 619 fluid observation stations. Sum of them precursor observation stations is 1271.

Our country's geotectonic environment brings the frequent seismic activity, so China is the highest earthquake activity area in the world. The seismic activity of China is very frequent due to it located between several tectonic plates and is also located at the intersection part of circum-Pacific seismic belt and Eurasia seismic zone. Earthquakes in Chinese mainland are about one third of the land ruinous earthquakes over the world, however, the land area of China is only 1/14 of the global one. Since 20 century, there are more than 1600 earthquakes in Chinese mainland with magnitude between 5 and 5.9, and the average is 16 times per year; 395 earthquakes with magnitude between 6 and 6.9 and the average is 4 times per year; 70 M7.0-7.9 earthquakes and the average is two times for three years; 8 $M \geq 8.0$ earthquake occurrence.

These seismic activities in space and time are not uniform. There are more earthquakes in west than east in space and have very obvious active and quiet alternative characteristics according to their occurrence time. These earthquake occurrences are intermediate focus earthquakes (with 70-300km depth of focus) in Taiwan and Himalayan areas, are deep-seated earthquakes (with more than 300km depth of focus) along the area from Heilongjiang to Jilin. Others are all shallow focus earthquakes with less than 20km depth of focus.

Every province in China has $M \geq 5.0$ destructive earthquakes. 30 provinces (excluding Zhejiang) have $M \geq 6.0$ earthquakes and 20 have $M \geq 7.0$ ones. Tibet, Xinjiang, Yunnan, Sichuan, Gansu and so on have the higher level of seismic activity. More than 40% national territory and 2/3 big cities with million people are located in the high intensity seismic regions which are above VII intensity.

Earthquake activities and the seismic networks in Japan

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Japan is one of the most active countries in terms of seismicity. Each year more than 100,000 earthquakes, or more than 300 a day, are detected. Thousands of seismic stations with various types of instruments are distributed throughout Japan, including about 800 Hi-net and KiK-net (high-sensitivity and strong-motion instruments in boreholes) stations operated by NIED (National Research Institute for Earth Science and Disaster Prevention), and about 200 seismic stations operated by Japan Meteorological Agency (JMA). These data are telemetered to JMA for Earthquake Early Warning, tsunami warning and making earthquake catalog. In addition, NIED operates about 70 broadband stations (F-net) and about 1,000 strong-motion stations (K-NET), and other agencies such as local governments operate additional a few thousands of seismic intensity meters. For geodetic monitoring, Geographical Survey Institute operates about 1200 continuous GPS stations.

After the 1995 Kobe earthquake which caused more than 6,000 casualties, the Japanese government established Headquarters for Earthquake Research Promotion, which includes Policy Committee and Earthquake Research Committee (ERC). The ERC meets every month to evaluate the current seismic activity in and around Japan. The ERC also made and has been updating National Seismic Hazard Maps, which consist of probabilistic seismic hazard maps for the entire Japan, and deterministic seismic hazard maps for specified source faults. These maps were made based on several steps. First, past occurrence of earthquakes were studied by paleoseismological and historical studies, from which probability of future occurrence of earthquakes is estimated. Then strong-motion is calculated based on models of earthquake faults and subsurface seismic velocity structure, following a standardized method.

Earthquake activities and the seismic networks in the Republic of Korea

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KMA(korea Meteorological Administration) has performed the project for strengthening the Korea National Seismographic Network (KNSN) and the tsunami warning system since later 1990. KMA officially issue national earthquake and Tsunami dissemination and notification to public.

This system was completely constructed in 2002 and has been continuously reinforcing. This network is currently composed of 12 broad-band seismometers, 32 short-period seismometers, 4 borehole seismometers, 109 accelerometers and earthquake analysis system also. Many inland type seismometers and accelerometers were also installed in 2007. Especially, KMA installed 3 borehole seismometer and one geomagnetic observatory in 2008. The one-stop earthquake & tsunami analyzing and broadcasting (warning) system that disseminates warning messages to the relevant organizations has been improved continuously. The Republic of Korea is currently exchanging seismic data with Japan. KMA is keen to share seismic data with other countries. In addition, KMA is exchanging seismic data from 83 stations with other related institutions of Korea.

KMA has been executing simulated tsunami preparedness drills to evaluate the tsunami warning and notification system each year. KMA executed that drill in 2008. KMA also participated in the international tsunami drill titled ‘Exercise Pacific Wave 08’ held in charge of ICG/PTWS on October 29 in 2008.

In order to inform for the general public, KMA published one catalogue on earthquakes and related fields at 2008 and have executed many education programs about the earthquake & tsunami and how to behave against these disaster.
The earthquake division of KMA currently operated as a bureau level under the leadership of Director-General for Earthquake.

Korea has been increasingly aware of the importance of preparedness against earthquake and tsunami hazards and continually support KMA for earthquake hazard mitigation.

Seismotectonics and major earthquakes of the Far East Region of the Russian Federation

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The Far East of Russia is the most seismically hazardous region of the country. For last 15 years 8 major seismic events with intensity of 9-10 degrees (in MSK-64 scale) have occurred in this region. The M=8.2 Shikotan (1994) and M=7.9 Urup (1995) earthquakes in the South Kuril Islands, the M=7.6 Neftegorsk (1995) earthquake in the North of Sakhalin Island, the M=7.9 Kronotsk (1997) earthquake in the East of the Kamchatka peninsula, the M=7.0 Uglegorsk (2000) earthquake in the central part of Sakhalin Island, the M=7.8 Olyutor (2006) earthquake in the Koryak Region of the Kamchatka area, two M=8.3-8.2 Simushir (2006 and 2007) earthquakes in the Central Kuril Islands happened. More than 10 strong earthquakes (M=6.0-6.8; I=7-9) occurred in the Region for the same period. Thus, the seismic activation took place in the Far East region in the late XX and early XXI centuries.

Some of the events were accompanied by human losses, numerous destructions and disasters. For example, due to the 1995 Neftegorsk earthquake, about 2000 people were killed and several hundreds of persons were wounded. The settlement Neftegorsk was completely destroyed. After the Shikotan event the ocean bottom relief changed and 3 m high tsunami wave came.

Seismotectonic position of seismic sources for the strongest events was thoroughly studied for which both geological and seismological epicentral investigations were specially organized. As a result two main types of the sources were recognized: intraplate and interplate. Therefore, the Shikotan, Simushir (2007), Neftegorsk and Uglegorsk earthquakes had intraplate nature. They are not correspondent with movement on the margins of lithosphere plates. On the other hand the sources of the Kronots, Simushir (2006) earthquakes were interplate because their offset is well correspondent with displacements on the boundaries between the Pacific and Eurasian plates (subduction zone). The Olyutor earthquake source was interplate, too as it marked the boundary of the North America plate and the Bering microplate.

In some cases the successful prediction of major earthquakes was elaborated. For example, half a year before the Shikotan event the prediction was announced according to the data of specific solution to focal mechanism for deep focused foreshocks. The medium term forecasting of the Simushir 2006 major earthquake was formulated using the result of seismic gap analysis and GPS measurements for the Kuril Islands arc.

Complicated structure of the Neftegorsk and Olyutor seismic sources were reconstructed as a result of seismic and tectonic field study of surface rupture system carried out immediately after the main shock. In the first case the seismic fault of total length up to 40 km with amplitude of vertical offset up to 1 m and right-lateral offset up to 8 m was mapped on the surface of the Earth. The orientation of the fault was NNE and the northern end of the rupture zone looked like some tree branches. It had three additional smaller faults. The Olyutor earthquake system of ruptures looks like three echelon segments of total length up to 140 km, presented by a 75 km overthrust fault with vertical offset amplitude more than 3 m. The central segment 40 km long was presented by pure dextral strike-slip with offset 2.5 m and south-eastern segment had a length of 16 km and pure left-lateral strike-slip offset with amplitude up to 2 m.

The paleoseismic investigations were carried out in the mezoseismal area of the Neftegorsk and Olyutor earthquakes. Two trenches across the fault of the first event demonstrated that at least three seismic events occurred there about 1000, 1400 and 1800 yr BP. Recurrence interval is nearly 400 years. Three trenches were excavated across the fault of the Olyutor earthquake. Reconstructed ancient earthquake took place within 7000-6000, 3700-3500, 2500-2000 and 1500-1000 yr BP. Recurrence interval between 4 last events (including the 2006 Olyutor earthquake) was estimated to be a little bit more than 1000 years.

Recurrence of Great Earthquakes and Tsunamis

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Paleoseismological studies of subduction-zone earthquakes along the Pacific Rim, including those in Chile, Cascadia and Kuril subduction zones, had shown that giant earthquakes occur at 300 to 500 year interval, longer than the recurrence interval of typical subduction-zone earthquakes estimated from historical records. The 2004 Sumatra-Andaman earthquake (M 9.1) and the associated Indian Ocean tsunami demonstrated that such an earthquake occurs in Indian Ocean and cause unpredicted disaster.

Along the southern Kuril trench, the recurrence of earthquakes larger than those in the 200-year written history of Hokkaido has been revealed from coastal geology. Multiple sand layers indicate recurrence of unusually large tsunamis with an average interval of ~500 years with the most recent event in the 17th century. The inferred tsunami inundation area is best modeled by a multi-segment interpolate earthquake (M~8.5), which also triggered deep post-seismic creep that produced decimeters of coastal uplift. Similar unusual earthquakes have been inferred off Sendai along the Japan trench. The AD 869 Jogan tsunami brought tsunami deposits to Sendai and Ishinomaki plains and the deposits suggest that similar earthquakes repeat at a recurrence interval of ~ 1,000 years.

Such great earthquakes and the accompanying tsunamis can affect neighboring countries in Northeast Asia. Great earthquakes along the Kamchatka or Kuril trench can generate tsunami which may cause damage in Japan. Tsunami from an earthquake along the eastern margin of Japan Sea can affect Korean peninsula or Russian coast. Earthquakes in Korean peninsula, eastern China or southwest Japan can be felt in other countries. These indicate that studies of historical documents and paleoseismological evidence in neighboring countries may help to reconstruct history of past earthquakes. International collaboration on past earthquakes, as well as modern seismicity, in Northeast Asia needs to be promoted

Recent seismic activity around Ulaanbaatar area, capital of Mongolia: Results of seismic, geological and geophysical surveys

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A high seismic activity occurs in the western end of Ulaanbaatar basin, at about 20 km to the west from the city center of capital city of Mongolia since 2005. This area, which could be one of most seismic active zone around Ulaanbaatar, dramatically increases the seismic hazard of the capital of Mongolia where is concentrated about of 1/3 of the Mongolia population and the majority of industries of the country.

Since the beginning of this high seismic activity in middle of 2005, more than 2000 earthquakes with magnitude between 0.5 and 4.2 have been observed by our network through this area. Moreover, the analyses of the seismotectonic context is very interesting and challenging as this area is at the junction between high and low active tectonic areas revealing a clear paleoseismic activity . In addition to the complexity of the tectonics context, the lack of large magnitude earthquake in this area conjugated with the recent triggered high seismic, which has been well monitored by local digital seismic network, makes the study of this earthquake activity fundamental for the estimation of Ulaanbaatar seismic hazard. In this presentation, we will discuss results of geological survey and analyze this seismic activity, such as the time evolution of the earthquake swarms.

The Development of Russian Seismic Station Network in Northeast Asian Region

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Few scientific and technical projects were implemented in the past decade with the aim of significant developing a seismic station network in the Far East of Russia. The most important project is “Upgrading of the Russian Tsunami Warning System”. Eight new digital seismic stations were installed in Kamchatka, the Kuril Islands, Sakhalin Island and Primorye region. All stations were equipped with broadband seismometers CMG-3ESPC and accelerometers CMG-5.

In the framework of the cooperation project "Research on Seismo-Tectonics around Okhotsk plate" between Japanese collaboration of Universities and Geophysical Survey of RAS eleven digital stations were installed. They were equipped with broadband seismometers STS-2. A local network of 9 short-period seismic stations was installed in cooperation with the Hokkaido University in the south part of Sakhalin Island.

To organize the real-time data transmission from stations to processing centers the 23 communication channels (through Russian geostationary satellite “Express AM-3") were installed.

Advanced observational facilities will provide new opportunities to study the space-time pattern of earthquake occurrence, the initiation and rupture sequence of earthquakes, three-dimensional structure of Earth’s interior and many other fundamental aspects of modern seismology. Improved understanding of seismic processes and continental structure and dynamics is important step for development strategy for solving earthquake risk reduction problem in region.

CSEP-Japan: A rigorous earthquake forecast system based on seismicity data

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presented by Kenji Satake
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We started CSEP-Japan, a program to quantitatively forecast time, place, and magnitude of future earthquakes in and around Japan, based on seismicity data. Our focus is a rigorous approach based on the following three steps: (1) developing the Testing Center, a framework to quantify the performance of registered earthquake forecast methods; (2) conducting comparative testing experiments within this framework to determine the registered forecast model's accuracy; and (3) aiming at the creation and buildup of sophisticated forecast models, based on results obtained from multiple experiments. To start this new research program, the Earthquake Research Institute (ERI) joined the global project "Collaboratory for the Study of Earthquake Predictability" (CSEP) that promotes rigorous research on earthquake predictability. In collaboration with CSEP, ERI implemented the Japanese Testing Center since summer of 2008 and formally started the 1st earthquake forecast testing experiment on 1 November 2009. In our presentation, we first give a brief introduction of the current national program. We then present our primary scope of the CSEP Testing Center and a short summary of the experiment's recent status. We finally conclude that our approach is becoming a good baseline for model development in order to move toward constructing earthquake forecast systems for Japan.

The main features of seismic hazard and seismic risk in China

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China is an earthquake prone country, and has suffered tremendous losses from earthquakes. In the last one hundred year, nearly 0.7 million people died from earthquakes, nearly hundreds cities and towns ruined by the earthquakes. Earthquake disaster mitigation is vital to the largest developing country in the world.

There are very good database for seismicity analysis. The historical catalogue contains nearly 12 thousands of events. The instrumental catalogue contains 250 thousands of events. The frequency of earthquake in China is very high. There is about one earthquake with magnitude equal or greater than 8 in ten years, and about one earthquake with magnitude equal or greater than 7.5 in 4 years. The distribution of earthquakes in China is inhomogeneous. The annual rate in western china is six time than that of eastern China. The dense epicenters have very well correlation with tectonic frames. The large earthquakes with magnitude greater than 7.5 occur along the block boundary of the tectonics.

The current used national seismic hazard map is published in 2001. This map was made by using probabilistic method. The seismicity model for the hazard map is benefit from the long history of earthquake events recording. The parameters in the hazard map are peak acceleration and the corner period of seismic response spectrum, and the exceeding probability is 0.1 in 50 yeas. The national seismic hazard map is used as the state standard for the seismic design. This presentation shows the seismic hazard map with different exceeding probability levels in China and also the progress of the methodology seismic hazard mapping.

China is in exposure of the highest seismic risk in the world. There are about 15% of the cities and towns in China which might be the epicenter regions of great earthquake with magnitude 7 or above. The seismic hazard and vulnerability are high in western China, but the exposure population is much lower than that in eastern China. There are dense population and economics in eastern China. There is the possibility of more than one hundred thousand people died in a earthquake with magnitude 8 in this region. There is also the possibility of one billion RMB economic losses from a moderate earthquake in this region.

Development of Seismic Monitoring System in Mongolia

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In Mongolia, as well as in all seismic active countries in the world, the seismic monitoring and its study are important scientific and practical measures for their sustainable development.

The seismic pattern of Mongolian territory is determined by the deformation process which can be attributed to the collision and subsequent penetration of the Indian plate with respect to Eurasia and the extensional tectonics related to the active Baykal rift system. The occurrence and distribution of strong earthquakes are the manifestation and result of these widespread and varied styles of deformation.

The Research Center for Astronomy and Geophysics of Mongolian Academy of Sciences (RCAG MAS) is the national data center for seismology of Mongolia. First analog seismic station in Mongolia was installed by the Government of Mongolia in Ulaanbaatar in 1957. It was the beginning of the development of Mongolian National Seismic Network (MNSN) in Mongolia. Few months later, the 4 December 1957, a strong earthquake occurred in the Gobi-Altay (Mw=8.1). It confirmed the high seismic activity (three other events occurred earlier with Mw ≥ 8: the 1905/07/09, the 1905/07/23 and the 1931/08/10 in Mongolia and its immediate surroundings).

Since 1957, the MNSN has been developed and enables the RCAG to detect and localize precisely the seismic activity in Mongolia. Since 1994, the RCAG has a very fruitful technical and scientific cooperation with the “Laboratoire de Détection et de Géophysique” of the “Department Analyses Surveillance, Environment” (DASE – LDG) from France.

The seismic mini array PTS-25 of CTBTO was installed near the capital Ulaanbaatar and it allows consistent regional monitoring of UB surroundings. In 2007, we renewed all national regional analog seismic stations and installed a new digital seismic instrument: one component, short period seismometer. All seismic data of MNSN are transmitted and archived in real time to the Mongolian National Data Center (NDC) of RCAG. The detection, interactive processing and data interpretation is carried out by researchers at NDC. At the present, MNSN received the data from 50 digital seismic stations which is equipped by different seismometers like one and three components short period, broadband and borehole instruments.

In 2009 the Government of Mongolia adopted the National Program on Seismic risk mitigation in Mongolia and RCAG, as one of the major executed organization of this program has a plan on future development of MNSN. We are planning to install three new permanent regional seismic stations near the significant seismic source areas in Mongolia.

E-Defense Facility

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Seismologists predict alarmingly high probability that hazardous earthquakes will hit major cities of Japan in the coming years. Among the most notable risks are the subduction zone earthquakes along the Tokai, Tonankai, and Nankai Troughs, which can cause category 7 (the largest in the Japanese seismic intensity scale) ground motion across the greater Tokyo area.

The Japanese citizen and our local and national governments are very aware of the risks, and are therefore, earnestly working to reduce earthquake hazards. The devoting research activities to improve earthquake-resistant construction comprise a part of this larger, national effort.

The Hyogo Earthquake Engineering Research Center, nicknamed E-Defense, is a branch of the National Research Institute for Earth Science and Disaster Prevention (NIED) of Japan. Inaugurated in 2005, E-Defense enables earthquake simulator testing of unprecedented, large-scale specimens. To date, 38 research programs have been completed to advance the state-of-art of earthquake engineering. The scope of research spans from immediate life concerns such as residential wood construction and school buildings, to critical facilities such as power generating stations.

The invaluable information produced at E-Defense has been used for academic research as well as education. Very convincing video images have been aired through the mass media and through the website of E-Defense. These images proved to be a powerful tool for increasing the awareness of earthquake hazards.

E-Defense is intended as a shared-use facility to benefit the international community. For example, a Memorandum of Understanding is in place between NIED and the U.S. National Science Foundation—Network for Earthquake Engineering Simulation. Under this MOU, collaborative research efforts activities are underway between the U.S. and Japan. E-Defense is hopeful that this collaboration will expand to the nations attending this conference to promote research, to promote earthquake risk mitigation, and to promote friendship.

In this presentation I will introduce the E-Defense facility and discuss selected research activities.

ISC: Integrating Seismic Bulletins in the North East Asia (1960-2009)

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The International Seismological Centre (ISC) is a non-governmental, non-profit making organization supported by 55 research and operational institutions around the world, including JMA, RAS, CEA, JAMSTEC, ERI and KMA. The ISC is charged with production of the ISC Bulletin – the definitive summary of world seismicity based on seismic reports from over 120 institutions. Jointly with World Data Center for Seismology (Denver), the ISC runs the International Seismic Station Registry (IR). The ISC updates and distributes the IASPEI Reference Event List (GT) and the EHB data collections.

The ISC plays the unique role in the North East Asia Region by integrating seismic bulletin data from seismic networks in China, Japan, Korea and Russia. This allows ISC to create the most definitive summary of seismicity in the region.

The ISC has a substantial development programme that would ensure that the ISC data will remain an important requirement for geophysical research. An essential part of this programme is a project to re-produce the entire ISC dataset (1960-2009). Consistency and uniformity of the long period data sets is a major requirement. At the ISC we recently started using ak135 velocity model instead of Jeffreys-Bullen. We also are preparing to introduce a more advance location algorithm soon. To make sure that newly produced seismic bulletin data are consistent with those in the past we are planning a massive project of re-producing the entire ISC dataset. We shall:

- Re-compute ISC hypocentres using new standard earthquake locator, ak135 velocity model and uniform thresholding algorithm, set of defining seismic phases (IASPEI) and error estimates;

- Re-compute event magnitudes using consistent treatment of amplitude measurement outliers, removing magnitude estimates based on too few measurements, providing previously unavailable magnitude error estimates and an account of which stations contributed towards the ISC network magnitude in each case;

- Collect, introduce and process essential additional datasets that have not been available at the time of original ISC Bulletin production;

- Fill known gaps in agency's bulletin reports in the past;

- Rectify known errors, inconsistencies and spurious events, identify and mark data from networks with erroneous time stamp, re-assign event type flags to provide consistency between reports of different agencies.

We invite comments, error reports, suggestions and missing bulletin datasets from those institutions in the North East Asia who are interested to help the ISC in this vital development.

Characteristics of size and long-term slip-rate of the segmented major active-faults in Japan

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Size and long-term slip-rate of active faults are fundamental parameters for evaluation of earthquake occurrence from those faults. We analyzed the fault parameters listed in the Active Fault Database of Japan (http://riodb02.ibase.aist.go.jp/activefault/index_e.html) to reveal the characteristics of fault length, slip per event, long-term slip rate and recurrence interval and regional distribution of these parameters.

Major active faults in Japan, which are 10km and longer in length and >= 0.1m/ky in slip-rate, are segmented into ca. 550 behavioral segments, based on geometry of fault strand separated by discontinuities of 2 km larger and bends of 20 degree and larger, and differentiation in faulting behavior, such as timing of paleoearthquake and long-term slip-rate. 550 segments consist of ca. 290 reverse faults, ca. 40 normal faults and ca. 220 strike-slip faults. The length of segmented faults shows a fractal-like structure with fractal dimension: D = ca. 1.6, braking at ca. 20km-long. The maximum value in fault length among those segments is 66. These dimensions of fault show indistinct regional distribution. These characteristic lengths of the segments may be controlled by the thickness of the elastic layer of the crust.

Amount of slip-per-event (mode or frequently-occurring value of net slip) can be estimated from field data on 65 segments. There is linear correlation between segment length (L in km) and the slip per event (D in m); D = 0.12 L. This scaling relation is consistent with the relationship between the length and the maximum displacement of the segmented historical surface ruptures on land of Japan, and suggests constant stress-drop during the rupturing of individual segment The traditional scaling relation between total length and slip of historical ruptures is well depicted by our new scaling relation and characteristic size of segmented active faults.

Long-term slip-rate and recurrence interval of the segments vary between 0.1 and 9.1 mm/yr, and 0.7 and 4.1 ky. These parameters on the fault activity show significant regional distributions. The activities concentrate along the primary active structure, namely the Itoigawa-Shizuoka Tectonic Line and the Median Tectonic Line, back arc margin of the Northeast Honshu Arc and the plate-colliding zone between the Eurasia and Philippine Sea plates. Long-term activities of the faults are consistent with the geodetic measurements during past 10 to 100 years in the back arc regions, where back-slip of the plate subduction earthquakes is negligible.

It is necessary to evaluate the interactions among neighboring fault segments to estimate the size and magnitude of future earthquakes, because an earthquake ruptures one or more contiguous fault segments. To evaluate the long-term rate of earthquake moment release, it makes no difference whether those faulting events are modeled as a single multi-segment earthquake or as separated earthquakes. However, there is a difference for the scenarios of future earthquake hazard.

3-D Velocity Tomography of Korean Peninsula and Surrounding Regions

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Seismic data in the Korean Peninsula were collected, verified, validated, and archived for the time period 1990-2003. Hypocenter locations for over 4500 events were determined and preliminary wave ray-densities examined. On the Korean Peninsula, bulletin data and waveform data from the Korean Meteorological Administration (KMA) of South Korea were collected supplemented by seismic stations in China. The waveform data were analyzed for a total of 207 events, phase arrival times for P- and S-waves determined, and hypocenters estimated. Pn phase information from the KMA waveform data was used to estimate a 3-D image of the Moho topography beneath the Korean Peninsula. The results reveal a slightly undulating interface with depth down to 34 km beneath the southern peninsula and 28 Km beneath the Yellow Sea and Sea of Japan. The structure of the Moho interface can be used to constrain crustal depth in future tomographic studies