SEISMIC MONITORING SYSTEM CALIBRATION USING GROUND TRUTH DATABASE

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ABSTRACT

Calibration of a seismic monitoring system remains a major issue due to the lack of ground truth information and uncertainties in the regional geological parameters. Rapid and accurate identification of seismic events is currently not feasible due to the absence of a fundamental framework allowing immediate access to ground truth information for many parts of the world. Precise location and high-confidence identification of regional seismic events are the primary objectives of monitoring research in seismology. In the Department of Energy Knowledge Base (KB), ground truth information addresses these objectives and will play a critical role for event relocation and identification using advanced seismic analysis tools. Maintaining the KB with systematic compilation and analysis of comprehensive sets of geophysical data from various parts of the world is vital.

The goal of this project is to identify a comprehensive database for China using digital seismic waveform data that are currently unavailable. These data may be analyzed along with ground truth information that becomes available. To date, arrival times for all regional phases are determined on all events above Mb 4.5 that occurred in China in 2000 and 2001. Travel-time models are constructed to compare with existing models. Seismic attenuation models may be constructed to provide better understanding of regional wave propagation in China with spatial resolution that has not previously been obtained.

OBJECTIVE

Introduction

Calibration of a seismic monitoring system remains a major issue due to the lack of ground truth information and uncertainties in the regional geological parameters. Rapid and accurate identification of suspicious events is currently not feasible due to the absence of a fundamental framework regarding the thorough and comprehensive knowledge of ground truth information for many parts of the world.

In this project, we identify a comprehensive database for all of China. Digital seismic waveform data from the newly operational China National Digital Seismic Network (CNSDN) may be analyzed along with the seismic bulletins prepared from this network. Tomographic inversion may be performed to obtain regional three-dimensional velocity models for calculation of travel-time correction surfaces.

RESEARCH ACCOMPLISHED

Data Collection and Processing

We have been successful in extending our collaborative research with the Chinese scientists on seismic data exchange. In the initial phase of the study, we focus on the collection of seismic waveform data that have recently come online from the China National Digital Seismic Network (CNDSN). This network comprises 48 three-component seismic stations utilizing the latest broadband sensors developed by the Chinese seismologists and engineers. All data are transmitted via satellite to the principal receiving center in Beijing for archive and distribution. All data are archived in the SEED format either as event data or as continuous data in time segments. The event data archive all significant events that occur within China and its vicinity. The continuous data archive in two-hour segments can be retrieved through query.

All the stations in the CNSDN are plotted in Figure 1 along with the events that are recorded in 2000 and 2001. These 48 stations replace the original CDSN stations that were installed by the USGS in the 1980's. The coverage of the CNSDN expands the original CDSN coverage by almost 5 times and has a broader distribution that is best suited for regional studies. The network started its formal operation in September 2000. These data have not been widely distributed and have not been used for any notable research as yet. There remains ambiguity in the official data exchange of these data, especially on the station coordinates of all the 48 stations.

Instrument response is critical to obtaining the true ground motion. The seismometers employed in the Chinese National Digital Seismic Networks prior to late 2001 were of KJ-3 type manufactured by the China Seismological Bureau. This type of instrument has proved successful in obtaining high-quality and reliable digital seismic data from permanent deployments in various parts of China for the last several years. These instruments are three-component mid-band sensors with high dynamic range of greater than 120 dB and low power consumption (250mW). Since late 2001, these sensors have been upgraded to the DFD-V/H high sensitive broadband feedback seismometers. These force-balance instruments have a high dynamic range of over 140 dB. The sensitivity of the broadband output to ground velocity is 2,000 volts-sec/meter with a critical damping of 0.707. A shielding against variations in temperature, air pressure and magnetic field is also provided. These instruments have the ideal response for regional seismic recording ranging from 50 seconds to 20 Hz, as shown in Fig. 2.

The data acquisition system consists of a PC and the associated data acquisition, graphics, local area network (LAN), and storage devices. The system is characterized by:

1. 24-bit (140 dB) A/D converter;
2. A sampling rate up to 100 Hz per channel;
3. A digital oscilloscope capable of displaying any 32 pre-selected channels;
4. The ability to record data either continuously or by event triggering;
5. An automatic event locator based on automatic P phase picking;
6. A 2 mega-baud LAN to link the data acquisition and processing/archiving systems;
7. A processing/archiving system capable of performing real-time interactive analysis;
8. An effective archiving sub-system to store the digital waveform and associated data.

There are a total of 116 events above Mb 4.1 for a 12-month period. The locations of these events are shown in Figure 1 along with the stations. The overall quality of the data is quite good and the azimuthal coverage of these events is unprecedented. This is the first time that seismic events are recorded digitally with such a dense regional coverage using that many broadband stations in China. Sample waveforms of two of these events are shown in Figures 3 through 4.

CONCLUSIONS AND RECOMMENDATIONS

The study has exhibited the expansiveness of the Chinese National Seismic Data Network, whose data are of relatively good quality. A comprehensive database for China using digital seismic waveform data will provide important input to the NNSA Knowledge Base of ground truth information in event relocation and identification using advanced seismic analysis tools. The analysis of these data will yield important parameters to provide better understanding of regional wave propagation in China with resolution that was previously not achievable.

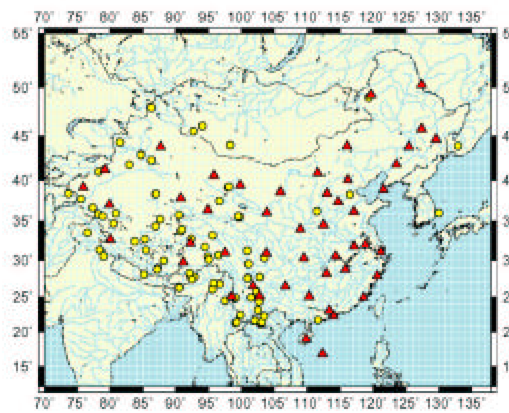

Figure 1. Locations of the China National Digital Seismic Network (triangles) and events recorded (circles).

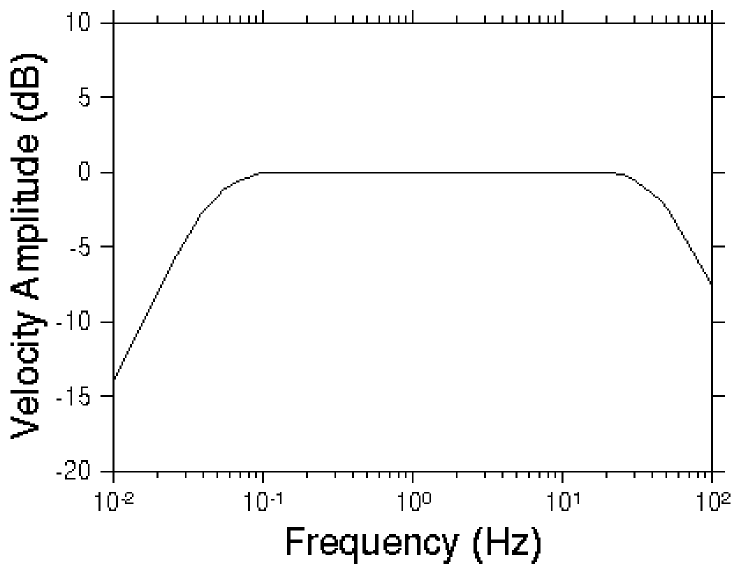

Figure 2. Instrument response for the broadband seismometer in the Chinese digital seismic networks.

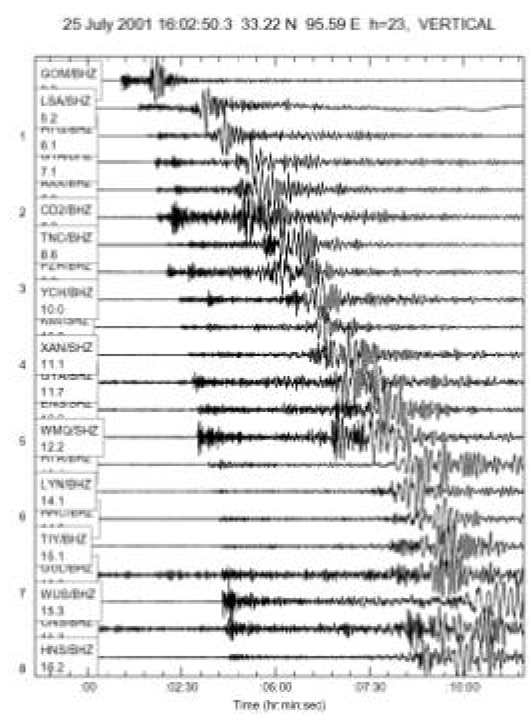

Figure 3. Vertical component seismograms for the July 25, 2001, event near the Tibet-Sichuan border, China.

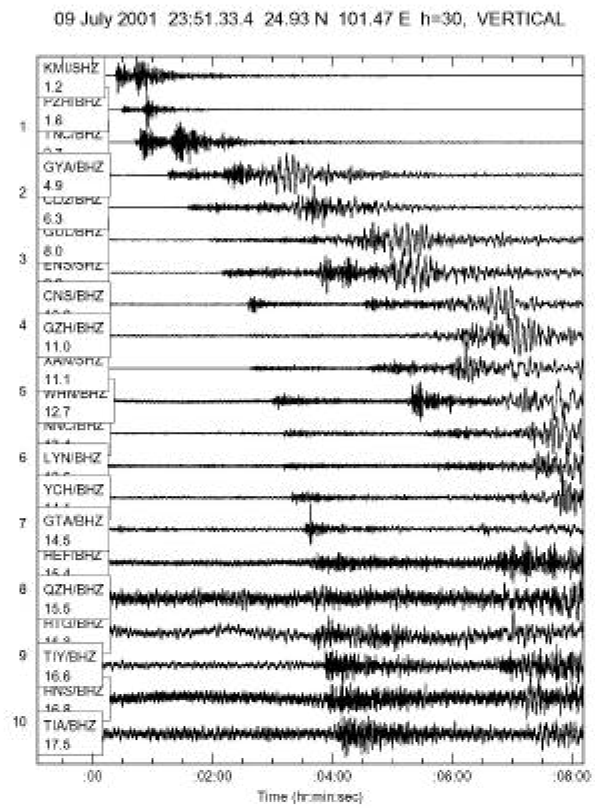

Figure 4. Vertical component seismograms for the July 9, 2001, event in Yunnan Province, China