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An alternative approach for the Istanbul earthquake early warning system

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ABSTRACT

Two recent catastrophic earthquakes that struck the Marmara Region on 17 August 1999 (M_w=7.4) and 12 November 1999 (M_w=7.2) caused major concern about future earthquake occurrences in Istanbul and the Marmara Region. As a result of the preparations for an expected earthquake may occur around Istanbul region, an earthquake early warning system has been established in 2002 with a simple and robust algorithm, based on the exceedance of specified thresholds of time domain amplitudes and the cumulative absolute velocity (CAV) levels (Erdik et al., 2003 [1]). In order to improve the capability of Istanbul earthquake early warning system (IEEWS) for giving early warning of a damaging earthquake in the Marmara Region, we explored an alternative approach with the use of a period parameter (τ_c) and a high-pass filtered vertical displacement amplitude parameter (*Pd*) from the initial 3 s of the P waveforms as proposed by Kanamori (2005) [2] and Wu and Kanamori (2005) [3,4]. The empirical relationships both between τ_c and moment magnitude (M_w), and between *Pd* and peak ground velocity (PGV) for the Marmara Region are presented. These relationships can be used to detect a damaging earthquake within seconds after the arrival of P waves, and can provide on-site warning in the Marmara Region.

1. Introduction

Present technological advances in seismic instrumentation, in digital communication and in computer technologies enable the implementation of real-time earthquake monitoring systems. Effective early warning systems for natural hazards are now increasingly perceived as an integral component of disaster risk reduction programmes. For this viewpoint, earthquake early warning (EEW) is becoming a practical tool to reduce the losses caused by a damaging earthquake by giving a few seconds to a few tens of seconds warning before the arrival of a damaging ground motion [5,6].

EEW systems, already in operation in several countries around the world, have been using mainly two approaches; regional warning and on-site warning. In the first approach, the traditional seismological method is used to locate an earthquake, and determine the magnitude from stations at close epicentral distances, and estimate the ground motion at other distant sites. This approach has already been used in Japan [7], Mexico [8] and Taiwan [9]. In the second approach, the beginning of the ground motion (mainly P waves) observed at a site is used to predict the ensuing ground motion (mainly by S- and surface waves) at the same site. On-site warning is usually based on individual sensors, while regional warning requires seismic networks. Therefore the regional warning approach is more reliable but requires more time, and cannot be used for the sites at short distances, as is the case for Istanbul. In contrast, the second one is less reliable, but it is very fast and could provide early warning to sites even at very short distances, where an early warning is most necessary. In the second approach, it is necessary to make rapid estimation of the nature of the progressing earthquake or the ground motions at an early stage of its rupture process [2].

In this paper, we explore the use of the second approach, namely τ_c and *Pd* methods [2–4,10,11] for seismic early warning purposes in the Marmara Region using the accelerograms from the strong motion networks operated by three agencies: the Bogazici University Kandilli Observatory and Earthquake Research Institute (BU-KOERI), Istanbul Technical University (ITU) and the Ministry of Public Works and Resettlement-Earthquake Research Institute (ERI). Fig. 1 shows the stations distribution of the networks in the northwestern part of Turkey and the events used in this study.

2. Istanbul earthquake rapid response and early warning system (IERREWS)

Frequent occurrence of historic destructive earthquakes clearly demonstrates the high potential of producing a damaging earthquake and also the high potential of seismic hazard in the

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