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Precursory seismicity changes associated with the M_w 7.4 1999 August 17 Izmit (Turkey) earthquake

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SUMMARY

We investigated precursory seismicity in and around the epicentral zone of the M 7.4 1999 August 17 Izmit (Turkey) earthquake, by applying a statistical method—the RTL (Region–Time–Length) algorithm—to earthquake catalogues derived from that for the period 1981–1999 of Kandilli Observatory and Earthquake Research Institute (KOERI). The derived catalogues are complete for events M_D 3 in most of western Turkey. After declustering aftershocks, we investigated the seismicity patterns preceding the Izmit event at local (Izmit tectonic zone) and national (Turkey) scales. The RTL parameter indicates that a period of seismic quiescence started at the end of 1995 and reached a minimum in December 1996. An activation phase lasting about three months followed. The main shock in Izmit and vicinity did not occur when the seismicity returned to its background level, but occurred with a delay of nearly 2.5 yr. We present a new parameter to quantify the spatial distribution of seismic quiescence. The results from both catalogues indicate that a significant quiescence anomaly appeared in 1996 around the epicenter of the Izmit earthquake. The primary characteristics of the seismicity patterns prior to the Izmit earthquake are similar to those obtained for large events in Russia and Japan. The variations of seismicity patterns revealed by the RTL algorithm may offer better understanding of the physical nature of seismo-tectonics and provide useful information for seismic hazard estimation. The varying characteristics of the Izmit and other events may reflect the difference between seismo-tectonics in Turkey and in other regions such as Russia and Japan.

Key words: Izmit earthquake, quiescence, seismicity, seismo-tectonics, statistical method.

1 INTRODUCTION

In August 1999, a strong earthquake with M 7.4 struck Izmit, an industrial city 100 km east of Istanbul, the biggest city of Turkey. More than 15 000 people died and 24 000 people were injured during this event, which has been named the 'Izmit earthquake' (sometimes the 'Kocaeli earthquake'). The epicenter was located on the western part of the North Anatolian fault, an east–west trending strike-slip fault with a length of nearly 1,200 km.

The seismo-tectonics of Turkey are determined by the configuration of the Arabian and the Anatolian plates in eastern Turkey as shown in Fig. 1 (McKenzie 1972; Alptekin 1973; Sengor 1979; Sengor et al. 1985; Taymaz et al. 1990, 1991; Jackson 1994; Jackson & McKenzie 1988; Papazachos 1990; Oncel et al. 1998). The ongoing collision between these plates forces the Anatolian block to move toward the west, causing a tensional stress regime and the formation of horsts in southwestern Turkey, although some authors regard that backarc tension mechanisms associated with the Cretan arc are a principal driver of the tectonic regime of the Aegean and western Turkey. The northern boundary of Anatolian plate is known as the North Anatolian Fault Zone (NAFZ).

The NAFZ is well defined morphologically from about 31 E to 41 E, where a sequence of migrating major earthquakes occurred on the NAFZ since 1939 (Allen 1969). Dextral strike-slip faulting along the NAFZ appears to continue eastward, beyond the triple junction (41 E, labelled by K in Fig. 1) along the East Anatolian Fault Zone (EAFZ), but is not as continuous as it is along the NAFZ (Jackson 1992). Oncel et al. (1995, 1996a,b) have examined seismicity rate changes in time and space along the NAFZ and have interpreted these results as a potential precursor of the Izmit earthquake (Oncel & Wilson 2002).

West of 31 E, the NAFZ breaks into two strands extending towards the northern Aegean Sea region (Fig. 2). Based on long-term historical data (Ambraseys & Jackson 2000), GPS data (McClusky et al. 2000), and variation of frequency-magnitude parameters (see Fig. 4 of Oncel & Wyss 2000), the northern strand is a more active