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Spatial and temporal variation of b-value off northeastern Japan

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1.Introduction

Hirose et al. (2002, 2006) estimated the spatial distribution of the b-value beneath the subduction zone in the Pacific off northeastern Japan. They reported that asperities estimated by Yamanaka and Kikuchi (2004, JGR) are distributed to avoid high b-value areas. Furthermore, they also reported that b-value in and around asperities decreases before a mainshock occurs. In this study, we extended the period of seismic data and thus improved the spatial resolution of b-value. Then we compared the spatial distribution of b-value with the slip distribution of the mainshock of Mw9.0, and investigated the temporal variation of b-value just before the mainshock in the area foreshock activity was eminent.

2.Data and Method

Spatial variation

We used the JMA catalogue in the period from January 1, 1990 to February 28, 2011 (M?3.0, Depth?90 km), and extracted earthquakes which occurred in the Pacific interplate region and the upper part of double-planed deep seismic zone in the Pacific plate from the catalogue taking into consideration the tectonic conditions by using REASA (Aketagawa et al., 2007).

We estimated the spatial distribution of b-value by using the computer program ZMAP (Wiemer, 1996).

We set grids with a spacing of 0.05 degrees in latitude and longitude over the northeastern Japan in the Pacific and selected the nearest 200 events from each grid. Then lower limit magnitude Mc in each grid was estimated by the method of Wiemer and Wyss (2000, BSSA). We estimated the b-value for events larger than Mc by the maximum likelihood method (Utsu, 1965, Hokkaido Univ.). Note that when there are less than 50 events over Mc, b-value is also not estimated.

Temporal variation

We used the JMA catalogue in the period from January 1, 1990 to April 20, 2011 (M?2.0, Depth?90 km). We estimated the temporal variation of b-value by using REASA (Aketagawa et al., 2007). We set 300 events as the calculation unit in order to estimate the temporal variation of b-value and shifted them at every 50 events. Note that we divided a period into two on March 11, 2011 when the mainshock occurred. Mc in the calculation unit was estimated by the method of Wiemer and Wyss (2000, BSSA), and we estimated the b-value for events larger than Mc by the maximum likelihood method (Utsu, 1965, Hokkaido Univ.). Mc was estimated as 2.0-2.1.

3.Result and Discussion

The following results are obtained, which is almost the same as Hirose et al. (2002, 2006) in spite of the difference of the data period.

1)Estimated b-value increases with the increase of depth.

2)Areas with anomalously high b-values are not intruded by asperities.

3)Temporal variation of b-value shows a remarkable decrease just before the mainshock and increase after it.

These observations suggest that b-value reflects the stress change occurring in the vicinity of the asperities (Scholz, 1968, BSSA).

The main cause that b-value became small just before the mainshock was due to the foreshock activity. Seismic activity including an event of M5.5 started one month before the mainshock, and it continued for two weeks at northeastern adjacent area of 50 km away from the epicenter of the mainshock. Furthermore, the foreshock activity with the largest event of M7.3 (Mar. 11, 2011 11:45 JST) started at the same area two days before the mainshock and the aftershock area spread around the epicenter of the mainshock. It was pointed out that foreshock activity is remarkable in this region (Maeda, 1996, BSSA). In 1981 there occurred a mainshock of M7.0 which was preceded by foreshock activity with the largest event of M6.1 about eight and half an hour before the mainshock. Unfortunately, we were not able to estimate b-value for this activity because the detection ability of the earthquakes in that time was low.

Keywords: The 2011 off the Pacific Coast Tohoku Earthquake, b value, Spatial and temporal variation, Subduction zone, Asperity,

Stress