Seismicity Analysis Using Felt Reports and Attenuation Relation of Seismic Intensity

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Can felt reports of historical documents be used to estimate the source of large earthquakes or seismicity analysis during the historical period? To explore the possibility of new historical earthquake studies using felt reports, we validated the reproducibility of the spatial distribution of felt report number by using the Japan Meteorological Agency (JMA) seismic intensity database and recently-constructed attenuation relation of seismic intensity. We then established a new methodology to estimate the source area of large earthquakes based on the spatial distribution of felt report number and attenuation relation and applied it to the recent three earthquakes (2004 Niigata-Ken Chuetsu, 2008 Iwate-Miyagi, and 2011 Fukushima-Hamadori earthquakes) in order to investigate the performance of the new method. The method could successfully image the source area of these earthquakes, suggesting the possibility that the source area of historical large earthquakes can be constrained from the distribution of felt reports.

We first validated the reproducibility of felt report number using the JMA seismic intensity database and newly-constructed attenuation relation of seismic intensity by Tanaka *et al*. (2017) for approximately 2,300 shallow crustal earthquakes in 2000-2010 with the maximum intensity >3. As a result, the histogram of residuals between the calculated and observed seismic intensity showed the normal distribution with the center of approximately zero. Furthermore, the attenuation relation successfully reproduced the spatial distribution of felt report number.

We then constructed a new method imaging the source area of large earthquakes and applied it to the recent three large earthquakes. We calculated the normalized residuals between the observed and calculated number of felt reports (seismic intensity >1.5) at each grid uniformly spaced in Tohoku area, by randomly generating the earthquakes in accordance with the Gutenberg-Richter law. As for the two earthquakes (2004 and 2008 events), the source areas were successfully constrained by normalized residuals and the grids with the minimum normalized residual are well matched with the mainshock epicenters. On the other hand, the source area of the 2011 event was less imaged due to the intensive aftershocks following the 2011 Tohoku-oki earthquake. The source areas of these earthquakes were also imaged even after thinning out the observation stations.

In Japan, abundant historical documents spanning over the 1000 years remain and the source area of historical earthquakes have been traditionally estimated from the distribution of damage and casualties recorded in historical literature. However, the damage could be caused by not only a ground shaking but also tsunami, massive fire and/or landslide. In addition, the distribution of building damage is strongly controlled by the population density and elapsed years since constructed.

In some historical literature, earthquakes that were felt without any damage are also reported as well as damage description from major earthquakes, whereas these were not fully utilized except for several previous studies. The number of felt reports are strongly controlled by the elapsed time since the mainshock and distance from the source area, suggesting the possibility that the source area of these earthquakes can be constrained by the spatiotemporal distribution of felt report number. Furthermore, changes in the number of felt reports may suggest the changes in seismic activity including an occurrence

of swarm-like or triggered activity and seismic quiescence. By constructing the methodology imaging the seismicity based on felt reports in historical literature, a new development of historical earthquake studies including small to moderate earthquakes is expected.

Keywords: Felt Report, Attenuation Relation of Seismic Intensity, Seismicity Analysis

