The Prediction Equation of Japanese Instrumental Seismic Intensity and JMA Intensities of Historical Earthquakes in the Early Modern

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Tanaka et al. (2017) derived a set of new prediction equations of Japanese Instrumental Seismic Intensity (JISI), which requires M_w of an earthquake, a hypocentral distance to a site, a depth of the subducting plates under a site, and AVS30 at a site, and is applicable to distance of 10-1000km, M_w>=5 (Ishibe et al., 2017). From the simultaneous inversion of 30,510 JISI data at 1,794 K-NET and KiK-net stations for 73 earthquakes, 17 parameters in a set of four equations according to source types were obtained. The surface ground effect at each station is common for four source types. We also used the intensity data of the M7.9 deep earthquake near Ogasawara Islands in 2015 to obtain one more parameter for the magnitude dependency of AVS30 term.

Here we applied the equations to about 8,700 intensity data of 134 historical earthquakes, which occurred from 1585 to 1872, and whose hypocenters and M_{JMA} were estimated (Fig. 1; e.g. Matsu'ura, 2017). Since our intensity sites were located pinpoint (e.g. Matsu'ura and Nakamura, 2016), 250m-mesh nationwide AVS30 data in J-SHIS (NIED, www.j-shis.bosai.go.jp) was used to determine AVS30 value at each point. M of Japanese historical earthquakes are M_{JMA}. M_w=M_{JMA}-0.2 was assumed this time.

In Fig. 1, residuals of historical intensities from predicted JISI by our equations are shown. Even for earthquakes of M_w>7.5, we just used hypocentral distances here. For intensities originally estimated as numerical values, the standard deviation is 0.89, while that for intensities converted from felt descriptions is 1.1. When we excluded Inter-PHS-type earthquakes, in which some large earthquakes such as the 1707 Hoei (M8.6), and the 1703 Genroku (M8.1) are included, the error due to the ignorance of the closest distances becomes small. The standard deviations for those data are 0.78 for estimated values, and 1.1 for converted one. The standard deviations of O-C for the modern K-NET and KiK-net data for well-known sources of M_w>=6.5 are 0.46-0.76. The standard deviation of 0.78 for historical intensities, which are estimated 0.5-precision or worse, suggests that our prediction equations of JISI are applicable even for the historical earthquakes.

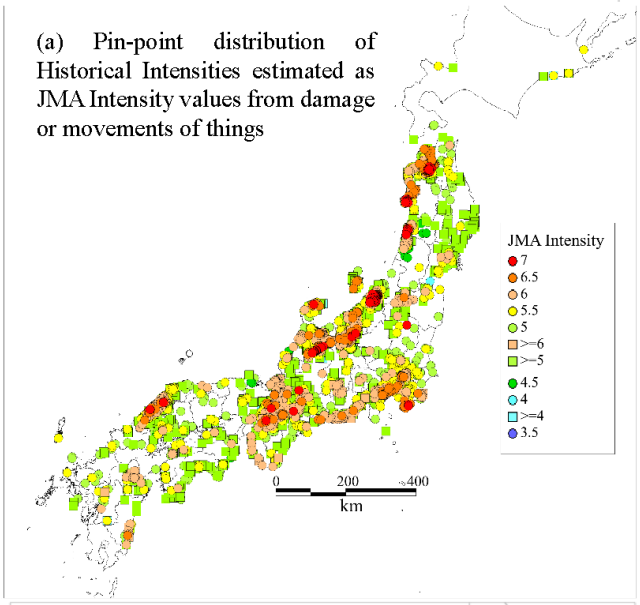
The large standard deviation for converted intensities supports that the mechanical conversions of felt descriptions in various historical materials to some fixed numerical values are harmful. It also suggests that historical intensities of converted type can easily contaminate “Strong Motion Generation Area” (SMGA), which are often obtained for old earthquakes only from intensities without excluding the surface ground site effect from each intensity data properly.

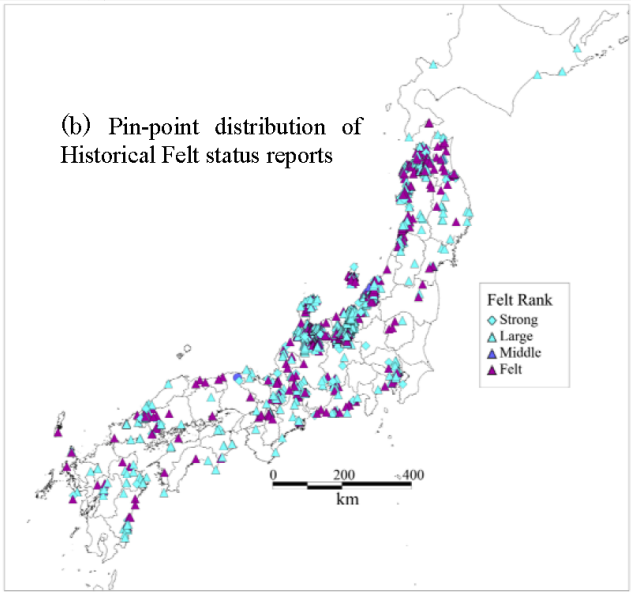
We applied our new set of prediction equations of JISI derived from modern data to intensity data of historical earthquakes. It was revealed that our equations fit well even with historical intensity data of precision of 0.5 at most. It was also shown that hypocenters and M in our systematically analyzed historical earthquake catalogue are reliable. The present result strongly suggests that SMGAs of historical earthquakes are nothing but illusion produced from intensity errors and the ignorance of the shallow effect under sites.

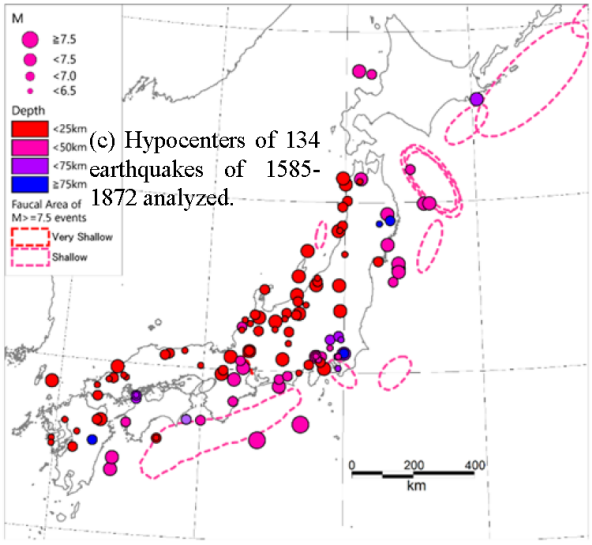
This study was done by the commissioned research of MEXT. We used NIED open data.

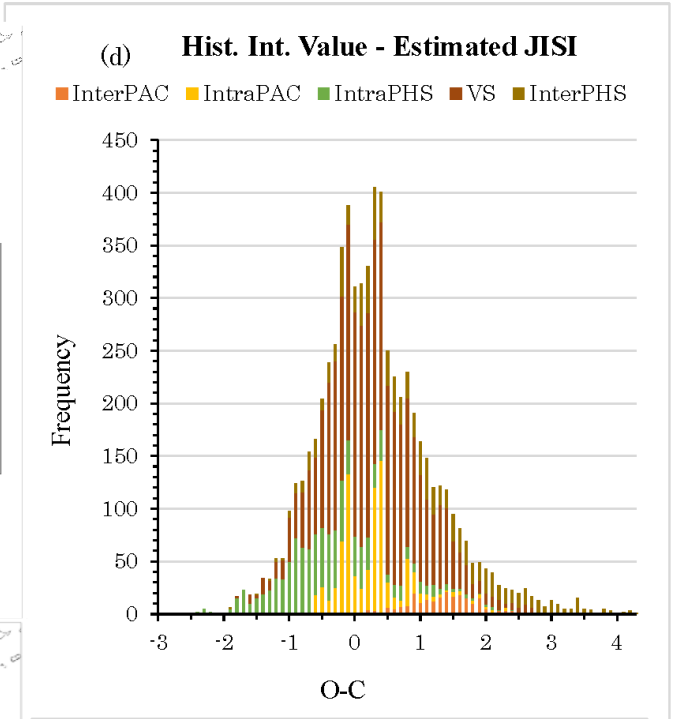
Ishibe et al., 2017, Proceedings of Japan Seis. Soc. Fall Meeting, S15-13.
Matsu'ura, R. S., 2017, https://doi.org/10.1186/s40562-017-0069-4.
Matsu'ura, R. S., and M. Nakamura, 2016, Historical Earthquakes, 33, 9-16.
Tanaka et al., 2017, Abstracts of JAEE annual meeting 2017, JAEE, P4-5.

Keywords: Japanese Instrumental Seismic Intensity, Prediction Equation of Seismic Intensity on the ground surface, Historical Earthquake, Historical Intensities located pin-point









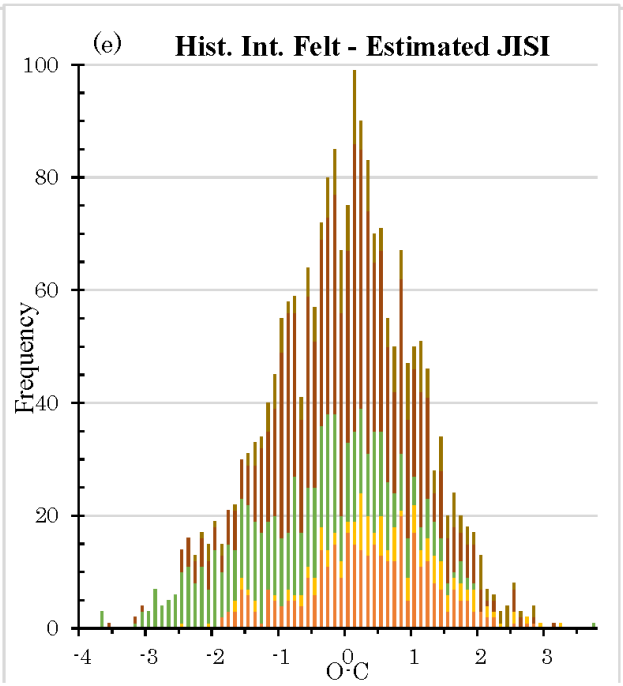


Fig. 1. Maps of JMA Intensities estimated for 134 historical earthquakes of the early modern, and residuals to our prediction equations of Japanese Instrumental Seismic Intensity. (d) Frequency of residuals for data shown in (a). (e) Frequency of residuals for data shown in (b). Strong, Large, Middle, and Felt are substituted to 3.9, 3.5, 3.0, and 2.5, respectively.

The larger variance in (e) shows the danger of replacing felt expressions in historical documents with numerical intensity-values mechanically, which have been done so frequently.