The cause of Mj overestimates (Mj > Mw) for the shallow earthquakes in western Japan

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In Japan, the Japan Meteorological Agency (JMA) magnitude (Mj) is officially used for the magnitude estimates of the earthquakes occurring in the area around Japan. However, it is well recognized that the estimated Mj sometimes shows large discrepancies between the moment magnitude (Mw)and momentum magnitude(Mw). Typical examples are the Western Tottori earthquake in 2000 (Mj=7.3; Mw=6.8) and Northern Yamaguchi earthquake in 1997 (Mj=6.6; Mw=5.9), all are strike-slip fault events occurred in the inland of western Japan. Since the Mj of shallow (h < 60 km) earthquakes are estimated by using the maximum amplitude of horizontal displacement motions recorded by long-period seismometers with a natural period of T=5 s, it is expecting that the propagation and attenuation properties of the long-period ground motions in this period range might be different in western Japan. In this study we examined the cause of such discrepancy between Mj and Mw occurring in western Japan based on the analysis of the K-NET and KiK-net strong ground motion data for recent shallow earthquakes.

We analyzed 47 inland earthquakes of shallow (h < 40 km) and large (Mj > 5.5) event occurred during between Sep. 1994 to Nov. 2016 in which the K-NET and KiK-net data is available. We made a regression analysis of relation between Mj and Mw, which are obtained from the JMA and the GCMT catalog, respectively. The result shows that the Mj is proportional to the Mw with a bias of 0.16 (Mj=Mw+0.16). After substituting this bias (0.16) from the Mj we selected the events having large discrepancy between Mj and Mw. We confirmed such peculiar events are mostly located in some area such as in Chugoku-Kinki and from South-Fukushima to South-Niigata (Fig).

To study the cause of larger Mj than Mw in western Japan we examined the strong motion record of the K-NET and KiK-net for the 2000 Western Tottori (Mj=7.3; Mw=6.8) and the 2004 Mid Niigata (Mj=6.8; Mw=6.8) earthquakes. The accelerograms of the K-NET and KiK-net are integral twice to obtain the ground displacement after applying a band pass filter (f=0.20 to 40 Hz) to match to the response of the JMA seismograph. Obtained waveform shows that the attenuation of the long-period ground displacement motion from the Mid Niigata earthquake is very strong with propagation in northern Japan, but it is rather weak for the Western Tottori earthquake in western Japan. It is also confirmed that the large ground displacement of the Western Tottori earthquake has strong directional dependency with larger tangential motion in the direction of fault strike and its perpendicular directions where the radiation of the SH wave from the strike-slip fault source develops large Love waves. The seismogram demonstrated that the Love wave traveling longer distances in western Japan without showing strong dispersion properties, while the development of the surface wave from the Mid Niigata earthquake is very weak in all directions.
The results of this study demonstrated that the earthquakes of larger Mj, which occurred in western japan, might be due to larger radiation of the Love wave from the source as well as efficient propagation of the short-period (T=5 s) Love wave in regional distances without causing significant dispersion. Such efficient Love wave propagation in western Japan might indicates the peculiarity of the crustal structure beneath western Japan compared with that of northern Japan. Such propagation and dispersion properties of the fundamental-mode, short-period (T=5 s) Love wave might occur due to the difference in the shallow structure such as sedimentary layers between western and northern Japan.