A new model of P ans S wave attenuation structure for the Tokyo Metropolitan area using the MeSO-net station network

*Yannis Panayotopoulos[1], Naoshi Hirata[1], Shin'ichi Sakai[1], Shigeki Nakagawa[1], Ryoichi Nakamura[1]

1.Earthquake Research Institute, University of Tokyo

In recent years the development of dense seismic networks in Japan has enabled high quality observations of instrumental intensities. The seismic intensity generally decays linearly with distance. This approximation is not always accurate, since the amplitude of short period ground motion decays with focal distance and is affected by the 3D attenuation structure along the path and in addition displays frequency dependence. In order to accurately simulate the seismic intensity distribution, we need to account for the non linear attenuation of seismic waves along the path. The instrumental seismic intensities inside the Kanto basin observed at the Tokyo Metropolitan Seismic Observation network (MeSO-net) and Hi-net stations display unusual distribution patterns, with peak intensities observed several km away from the epicenter rather than at the stations closer to it. In order to understand the source of this intensity distribution, we estimated the theoretical instrumental intensities using a 3D attenuation structure and compare it to the observed intensity distribution. We first estimated a 3D attenuation structure using the spectral decay of seismic waves, by fitting the observed seismic wave spectrum to a theoretical spectrum using an ω^2 model. The obtained model suggests Q values of 50~100 inside the Kanto basin and low Q values < 300 in the area where the Philippine Sea plate meets the upper part of the Pacific plate. In addition, we find that there is little attenuation of seismic waves in the middle crust area of the Honshu island bellow the northern Chiba and Ibaragi prefectures, with Q values greater than 600.
We then use an ω^2 model in order to estimate the source acceleration spectrum of several earthquakes occurring below the Kanto basin at depths ranging 30~80 km and to derive the PGA for P and S waves. We compared the observed PGA at the MeSO-net stations to the calculated PGA by our model. In order to estimate the observed PGA, we took a 4 sec window starting from the P or S wave arrival, and looked for the highest acceleration inside this window. The PGA values are moderately low west of the epicenter and highest in an area 20 km to the east of it for earthquakes occurring below the northern edge of Tokyo bay on the Pacific plate. These earthquakes are located exactly below the area were our model displayed significantly low Q values. Seismic waves passing through that area should be highly attenuated. This could be a possible explanation for the observed pattern of the intensity distribution. Although we are able to simulate the general trend in the PGA distribution, our model failed to exactly match the observed amplitudes. On the other hand the PGA distribution of shallow earthquakes does not exhibit a similar anomalous pattern. The distribution for both the observed and estimated PGA, for shallower earthquakes that probably occurred in the upper part of the Philippine sea plate, is characterized by amplitudes that drop almost concentric with increasing distance from the epicenter. Our attenuation tomography results suggest high Q values for the upper part of the crust. As a result, seismic waves passing through this area are very little attenuated. We also achieved better match of the observed and calculated PGA amplitudes in this case.

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