Source properties, site amplification and crustal attenuation in Japan from spectral analysis of K-and KiK-net data

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Japan is one of the regions with highest seismic activity in the world and, at the same time, one of the most densely instrumented countries. Following the highly destructive Kobe earthquake in 1995, two strong motion networks, K-net and KiK-net, have been deployed, recording earthquakes in and around Japan on a continuous basis. In addition, the KiK-net sites are all equipped with surface and borehole sensors. This wealth of accelerometic data, covering a large range of magnitudes (ranging from about 3 to 8) from both crustal and subcrustal earthquakes, makes the K-net and KiK-net datasets extraordinary valuable for obtaining new insights into highly debated topics in the seismological community, such as the scaling of seismic sources and issues regarding site response estimation.

We analyze a dataset of about 2200 earthquakes recorded at more than 1000 K- and KiK-net stations with the generalized inversion technique (GIT) in order to separate site response, source spectra and attenuation characteristics. The first results from the GIT inversion indicate that the spectral amplitudes at frequencies larger than about 5 Hz, in contrast to general expectation, show a slower decay with distance than the lower frequencies within the first 100-150 km. A comparison of surface and borehole recordings for the KiK-net data shows that this effect can be mainly attributed to the generation of high-frequency surface waves at observation sites with high velocity contrasts at shallow depth. Hence, in order to determine reliable S-wave source spectra, this effect has to be taken into account.

As one of the outcomes from this study, S-wave source spectra can be obtained also for a significant number of large earthquakes in Japan. These will be used to estimate relevant source parameters such as corner frequency or stress drop and spectral fall-off, which in turn have a strong influence on the seismic energy released by an earthquake of given magnitude. The seismic energy release of a large earthquake (and hence an estimate of its energy magnitude M_e) can also be determined quickly after its occurrence using teleseismic data. Our analysis provides a sufficently large set of earthquakes for which source parameters derived from regional data can be compared with teleseismic estimates, allowing us to explore in a next step the capability of rapid teleseismic estimates of M_e to be used as an indicator for shaking severity within the source region. The information provided by such a procedure for large earthquakes would be very important to disaster management organizations especially in areas with lack of strong motion instrumentation, where the rapid evaluation of the damage potential of an earthquake relies mostly on the source parameters obtained from teleseismic signals analysis.