Seismic audification and sonification for data exploration

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Seismograms are basic information for seismology. Seismologists usually check seismograms by visualization, i.e., plotting them on screen or paper. They must have another way: hearing sound made from seismograms, which is getting popular but mainly for outreach activities. We are trying to employ the seismo-sound for research. There are two ways to convert time-series data to sound: audification by interpreting the time-series data as an audio waveform; and sonification by assigning sound according to feature of the data such as instantaneous frequencies or amplitudes. We develop seismic audification and sonification methods to investigate what kind of information can be extracted by hearing the seismo-sound.

The first case study for our group is the 2011 Tohoku-oki earthquake using data from 116 of K-NET and KiK-net surface stations maintained by NIED. Since seismic records are, in general, at too low frequencies to hear, audification needs fast play in order to shift frequencies into the audible range. We synthesized audified seismograms from the 116 stations at 10 times faster than the actual speed. The sound is in an audible but low tone. From the sound we can feel the propagation of seismic waves all over Japan. In order to make the features of seismic waves clearer, we designed a sonification process to assign sounds according to the zero-crossing rate and amplitude in an audible frequency range. We set that the playback rate is 10, so that the length of the sound is around 40 s, enough short to listen. In addition we attempted not to make fearful sound, mainly for the purpose of outreach activity. The all data from 116 stations are played simultaneously with an appropriate time alignment.

The sonified sound allows us again feel the nationwide seismic wave propagation. The sound at the beginning is loud and at high pitch and getting small and at lower pitch. This feature reflects the geometrical spreading and the anelastic attenuation effects. Around 23 s after the onset of the sound, i.e., 230 s after the origin time, a high-pitch sound distinct from the overall propagation-like trend is heard. We searched for the origin of this high-pitch sound by sonifying seismograms from area to area, and found that this is from the Hida area in Gifu prefecture. The timing of the high-pitch sound is consistent with the origin time of a dynamically triggered event already reported [e.g., Uchide, SSA, 2011; Miyazawa, GRL, 2011; Ohmi et al., Zisin2, 2012].

The audification and sonification make it easier to observe changes and differences in frequencies as well as amplitudes for many stations at once. Our approach will be a powerful tool for detecting dynamically triggered events that radiate seismic waves at higher frequencies than those propagating for a long distance from a huge earthquake.

Acknowledgement: We used seismograms from K-NET and KiK-net maintained by NIED.

Keywords: Seismology, Audification, Sonification, The 2011 Tohoku-oki earthquake, Dynamic triggering of earthquakes

