Continuous measurements of S-wave splitting parameters for monitoring of seismic anisotropy

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In this study, we approach an unsolved question with respect to mechanisms of triggering and synchronization among members of a family of slow earthquakes using seismic anisotropy. The study area is the Nankai trough subduction zone, southwest Japan. In this presentation, we mainly focus on a tremor activity from 2015/12/26 to 2016/01/05 beneath eastern Shikoku.
Features of seismic anisotropy are attributed to characteristics of stress state, structure, and physical properties of the medium. A study of seismic anisotropy using slow earthquakes can, therefore, provide physicochemical, geometrical and mineralogical information in their source regions and along the ray paths. In our previous study, we focused on one of a slow earthquake, deep low frequency earthquakes (DLFEs), reported by JMA. Ishise & Nishida (2015 JpGU) investigated S-wave polarization anisotropy using DFLEs and tried to detect temporal variation of seismic anisotropy in the source region of DLFEs in the Nankai trough subduction zone: S-wave splitting analysis (Ando et al., 1983 JGR) was applied to S-phases of DFLEs picked by JMA. However, the seismicity of DLFEs was too low to show the temporal variation of anisotropy. Ishise & Nishida (2015 SSJ), then, applied S-wave splitting analysis continuously to continuous waveform data including DLFEs analyzed in our previous study and continuously measured S-wave splitting parameters in order to detect temporal variations of seismic anisotropy during the tremor activities. Since tremor signals are inferred to be composed of S-waves primarily, we can obtain S-wave anisotropy during the tremor activity. A similar analysis provided crustal anisotropy beneath northern Cascadia (Bostock and Christensen, 2012 JGR).
In this study, we applied the S-wave splitting analysis to filtered seismograms (2-8 Hz) and determined the polarization direction of fast S-wave and the delay time between fast and slow S-waves. The time window and time step of the continuous analysis were 60 and 30 seconds, respectively. Together with the anisotropy monitoring, we performed polarization analysis to estimate the incoming wave. Following Bostock and Christensen (2012 JGR), assuming S-wave incidence, we estimate back azimuths and incident angles.
The continuous measurements of splitting parameters showed the relatively smaller variability of the parameters and high reliability of the estimated anisotropic parameters when strong tremors were recorded. In a similar manner to splitting analysis, polarization analysis provides reliable estimation when strong tremors are recorded because it assumes S-wave incident during the polarization analysis. Actually, we found a number of clear temporal variations of back azimuth of the incoming waves that were synchronized between more than one stations. Judging from the intensity of the tremor signals, the temporal variations suggest processes of tremor migration.
As for characteristics of anisotropy, we found that polarization directions of fast S-wave tend to fluctuate around the strike directions of geological lineaments (from SW–NE to NW–SE). It suggests that the surface anisotropy would prevent from detection of deeper anisotropy. At the same time, we observed clear temporal variations of anisotropic parameters at stations near the center of tremor activities. The temporal variations of anisotropy tended to synchronize with those of parameters of incoming waves. The temporal variation of anisotropic parameters can, therefore, be explained by spatial variations of seismic anisotropy. In order to achieve our purpose to detect temporal variation of seismic anisotropy in tremor source region, we need more case studies through retrospective analyses.

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