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The annual variation in the teleseismic detection capability at Syowa Station, Antarctica

IWATA, Takaki[1*] ; KANAO, Masaki[2]

[1]The Institute of Statistical Mathematics, [2]National Institute of Polar Research

Kanao et al. [2012a, 2012b] have pointed out the annual variation in the teleseismic detection capability at Syowa Station located in Antarctica. The main cause of the variation is considered to be the increase in area and/or thickness of sea ice in winter, which restrains the generation of sea waves around Antarctica; consequently the noise level in seismic records changes annually [Grob et al., 2011; Kanao et al. 2012c].

This implies that environmental parameters relevant to climate, sea ice, and so forth affect the teleseismic detection capability. To investigate the relationship in detail, a quantitative evaluation of the annual variation in the detection capability is dispensable because the aforementioned studies have revealed the annual variation only qualitatively on the basis of the time history of the minimum magnitude of detected teleseismic events at the station. Therefore, we conducted the following analysis in this study.

The dataset analyzed in this study is the same as the examined one in Kanao [2010] and Kanao et al. [2012]. The data period ranges from 1987 to 2007 and the magnitudes of the events are measured with the body-wave magnitude (Mb) scale. The number of analyzed earthquakes of which magnitudes are determined is 19,044. Because the main interest of this study is to quantify the annual variation, the earthquake sequence is divided into periods of one year and these one-year sequences were stacked.

For the quantification of the detection capability, the model representing a magnitude-frequency distribution of earthquake covering the entire range [Ogata & Katsura, 1993] is used with a small modification. In this model, the distribution is assumed to be the product of the Gutenberg-Richter (GR) law [Gutenberg and Richter, 1946] and the detection probability of earthquakes at magnitude M. As mentioned above, the magnitudes in the examined dataset are given as Mb, which saturates at its large value. Therefore, instead of the original GR law, we introduced a modified type of the GR law, which is suggested by Utsu [1974], that contains the maximum magnitude of earthquake potentials as a parameter. The detection probability was represented by the cumulative distribution of a normal distribution, following the suggestion of Ringdal [1975] and its accompanied studies [e.g., Ogata & Katsura, 1993; Iwata, 2008, 2012, 2013a, 2013b, 2013c]. This formulation results in the introduction of a parameter μ, which corresponds to the magnitude at which 50% of earthquakes are expected to be detected, and this parameter quantifies the quality of the earthquake detection capability.

Then, the annual variation in μ was estimated by adopting a Bayesian approach used in Iwata [2013a, 2013b]. In this approach, the annual variation is represented by a piecewise linear approximation of which breaking points were taken at each of the occurrence times of each events. We determined the variation in μ with a smoothness constraint.

The result of the estimation is summarized as follows. The significance of the existence of the annual variation was evaluated with ABIC [Akaike, 1980]; the value of ABIC in the case with the annual variation is 54.9 smaller than that in the case without the annual variation, suggesting high significance of the variation. The maximum (i.e., the worst detection capability) and minimum (i.e., the best) values of μ appear around the end of December and the middle of August, respectively. The difference between the maximum and minimum values is 0.13. Because the maximum and minimum of the average temperature at Syowa Station also appear in those periods, this result reinforces the relationship between the environmental parameter and teleseismic detection capability.

(The references are listed in the abstract written in Japanese.)

Keywords: earthquake detection capability, annual variation, Antarctica, Syowa Station, Bayesian statistics, statistical seismology