南極・昭和基地における遠地地震の検知能力の年周変化：気温による影響を考慮した統計的解析

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The annual variation in teleseismic detection capability at Syowa Station, Antarctica: a statistical analysis including the effect of air temperature

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In this study, we evaluate the annual variation in teleseismic detection capability at Syowa Station, Antarctica. Kanao [2010] and Kanao et al. [2012] have already reported the annual variation in the detection capability through the time history of the minimum magnitude of the detected events at the station; as a general tendency, conspicuous deficits of relatively detected small events are observed in summer, suggesting that the detection capability is worse in summer and better in winter. The main cause of the variation is thought to be the increase in the thickness and spreading area of sea ice in the Antarctica Ocean in winter. The increase restrains the generation of sea waves in the ocean, and makes the noise level in seismic records in winter lower than in summer. The quantification of the relationship between the annual variation and some considerable environmental/climate factors would contribute to deepen our understanding of the atmosphere-ocean-cryosphere system, and therefore we conduct the statistical analysis as described below.

The earthquake dataset analyzed in this study is the same as the examined one in Kanao [2010] and Kanao et al. [2012]. It is taken from the hypocentral catalogue compiled by the National Institute of Polar Research, Japan. The data period ranges from January 1987 to December 2007. The magnitude scale of the catalogue is given as the body-wave magnitude (*Mb*) scale. Because the main interest of this study is the annual variation in the detection capability, the data were divided into periods of 1 year and then these 1-year sequences were stacked. Then, the stacked sequence was analyzed to quantify the annual variation.

The annual variation in detection capability is modeled using a statistical approach similar to the approach developed in Iwata [2008, 2012, 2013a, 2013b, 2014]. In this approach, the model representing the magnitude-frequency distribution of all detected earthquake [Ogata and Katsura, 1993] is introduced. The distribution is assumed to be the product of the Gutenberg-Richter law [Gutenberg and Richter, 1946] and the detection probability of earthquakes at magnitude M. Following the suggestion of Ringdal [1975], the cumulative distribution of a normal distribution is frequently used as the detection probability. Then, the temporal variation in the parameters contained in the above model was estimated by adopting a Bayesian approach with a piecewise linear approximation [e.g., Powell, 1981]. One of the model parameters is μ, the magnitude at which the probability of detecting an earthquake equals 50%, and this parameter quantifies the quality of the earthquake detection capability; the value of μ becomes higher as the detection capability becomes lower.

In this study, two models were considered. In the first model it was assumed that the annual variation has no correlation with any environmental/climate parameters whereas the existence of the correlation was assumed in the second model. Because the thickness and spreading area of sea ice have a solid relationship with the air temperature, the air temperature at Syowa Station was introduced as a climate parameter correlated with the detection capability in the second model. For simplicity of modeling, we supposed that a change in the temperature affects the variation in μ proportionally, and the remaining variation in μ was estimated by the aforementioned Bayesian approach. The goodness-of-fit of the two models was examined by Akaike's Bayesian Information Criterion (ABIC) [Akaike, 1980].

The ABIC value of the second model is smaller than that of the first model, and the difference of the two values are 3.2, which reveals the significance of the correlation between the detection capability and the air temperature. Fig. 1 shows the estimated annual variation in μ in the second model. The total variation (rec curve) is decomposed into the two components corresponding to the variation attributed to the air temperature variation (blue curve) and that to some causes other than the air temperature variation (green curve). The air temperature variation contributes toward a large portion of the annual variation, and this also supports the significance of the effect of the temperature on the annual variation in the detection capability.

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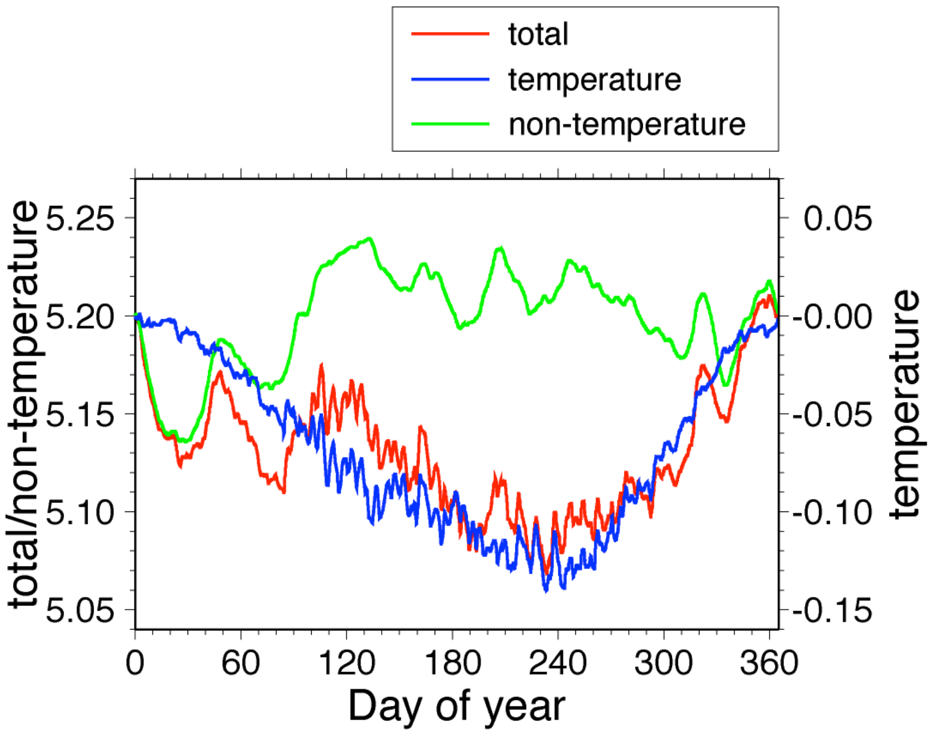

Figure 1. Estimated total variation in μ (red curve, left axis), and the variation attributed to the air temperature variation (blue curve, right axis) and to some causes other than the air temperature variation (green curve, left axis).