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Feasibility test of joint maximum likelihood earthquake location with arrived and not-yet arrived data for early warning

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Successful operation of earthquake early warning (EEW) significantly depends on the prompt identification and the reliable quantification of an event. In particular, to maximize the warning time and, consequently, to minimize the blind zone, an event should be reliably identified with a minimum number of P arrivals. However, during the very early stage of an earthquake, a few arrivals are only available, leading to an ill-posed inverse problem for earthquake location. Therefore, use of the not-yet-arrived data (NYAD) [1] can greatly contribute to provide reliable location estimates as early as possible.

Sheen [2] proposed a robust maximum likelihood earthquake location method for early warning (MAXEL), which could reliably locate an event with a small number of P arrivals. MAXEL is based on the maximum likelihood method using the concepts of equal differential times of P arrivals and Student's t-distribution. Recently, Sheen et al. [3] implemented the event identification criteria into the MAXEL and showed its application to the EEW system in South Korea, which confirmed the robustness of the MAXEL to outliers conceal within a small number of P arrivals and its superior capability for discriminating local events from regional or teleseismic events.

In this study, the NYAD is incorporated into the MAXEL by introducing the likelihood function to the NYAD. The difference between the residual of the P arrival and the current times and the residual of travel times to triggered and non-triggered stations is used for the parameter of the probability distribution. It is assumed for the probability of the region where the difference is greater than or equal to zero to be 1, because this region can be thought of the probable event location. On the other hand, the region with negative value of the difference of the residuals is assumed to have less probability of being event location and, thus, to follow a given probability distribution. Synthetic tests and tests for historical events in California show that the joint maximum likelihood earthquake location method has great potential for earthquake early warning.

References:

[1] Horiuchi et al. (2005) Bull. Seismol. Soc. Am. 95(2): 708-718

[2] Sheen D-H (2015) Bull. Seismol. Soc. Am. 105(3): 1301-1313

[3] Sheen et al. (2016) Bull. Seismol. Soc. Am. 106(3): in press