Waveform inversion of source processes using ABIC: Comparison between the results from proper and improper formulation

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Akaike's Bayesian information criterion (ABIC) has been widely used in many geophysical problems since the formulation of Yabuki and Matsu'ura (1992, GJI). ABIC, based on the entropy maximization principle, objectively decides the relative weights of the information from observed data and prior constraints, and enables us to extract unbiased information from limited and noisy data. As we have pointed out in some meetings last year, when there are two different sorts of prior constraints to impose, we have to note the dependence of the two sorts of prior constraints (Fukahata and Matsu'ura, 2002, GJI, submitted).

In many studies to estimate a space-time slip distribution on a fault surface, however, the dependence of the prior constraints has been neglected. Therefore, it is needed that we should examine the appropriateness of the results obtained through the previous formulation. As Fukahata and Matsu'ura (2002, GJI, submitted) have pointed out, the degree of the discrepancy between the results obtained from the new proper and the previous improper formulation would depend on the quality and quantity of the data used for the inversion analysis. If we have satisfactory data, even the previous formulation would give almost proper solutions. In the cases without enough data, however, the results obtained from the previous formulation would be significantly different from the proper ones. Especially, for quite a few data, if we employed the previous formulation, the inversion solution would not be obtained because of the extinction of the local minimum of ABIC.

In order to examine the justice of our prospect in actual data analyses, we applied the new proper formulation to the estimate of a source process of the September 30, 1999 Oaxaca, Mexico, earthquake (Mw = 7.4). The fault plain of the earthquake has been determined by Yagi et al., (2001, JEPSJM). On the basis of the method of Yagi et al., (2001, JEPSJM) we examined the degree of the discrepancy between the results from the new proper and the previous improper formulation in the following three cases of data to analyze: (1) 21 strong-motion records from 7 stations [UNAM] and 15 body wave (P-wave) records from 15 teleseismic stations [IRIS-DCM]; (2) 15 body wave (P-wave) records from 15 teleseismic stations; (3) 9 body wave (P-wave) records from 9 teleseismic stations.

In the case (1), the solutions obtained from the both methods completely coincided, because the information from the observed data was enough to determine the source process. In the case (2), although the solution of the new formulation was similar to the case (1), the solution of the previous formulation was too smoother. This solution was quite different from that of the case (1). This suggests that the results obtained from the previous formulation could be significantly different from the proper ones without enough data. In the case (3), the solution from the new formulation was almost coincident with that of the case (2). On the other hand, we could not obtain any solution from the previous formulation because of the extinction of the local minimum of ABIC.

In conclusion, the previous formulation has given almost proper solutions, when the information from observed data is sufficient. When it is insufficient, however, the results obtained from the previous formulation are likely to be significantly different from the proper ones.