Traveltime estimation from the data observed by ACROSS

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ACROSS is a subsurface exploring / monitoring system which uses accurately controlled sinusoidal waves to measure frequency-domain transfer functions of the subjects. We have developed a method to extract 'events' localized in time domain from frequency-domain data, which is called the Sompi event analysis. We present some techniques for practical application and show the examples of analysis.

In the Sompi event analysis we assume that the complex frequency sequence to be analyzed is a transfer function between the source input and the receiver output sampled at discrete frequencies. Through a kind of auto-regressive modeling in frequency domain, we obtain a set of 'events' characterized by complex travel time and complex amplitude, where the former expresses traveltime and attenuation, and the latter amplitude and phase angle.

Wave propagation in non-elastic media necessarily involves dispersion or frequency dependence of velocity and attenuation, so that a transfer function does not fit a simple auto-regressive model. The Sompi method has the advantage in analyzing relatively short data sequence. Band-limited analysis enables us to estimate frequency-dependent travel times.

Now we measure transfer functions with their errors by ACROSS observation. Introducing weighted least-square method to the Sompi event analysis enables us to estimate parameters in consideration of observation errors. This method requires linearization of model about small variation of parameters.

We are also trying to analyze data set acquired by a sensor array as application of the Sompi event analysis. In analysis method we present in 2002, we analyze data for each sensor respectively to determine the traveltime, then we estimate the slowness through least-square fitting of traveltimes at all sensors. We have designed more simple method using weighted least-square method for linearized model, though slowness estimation is not very accurate. Further investigation is required to practical application.

To evaluate uncertainty of the result is important subject. Bootstrap error analysis enables us to estimate errors of determined parameters only from observed data. In the case of introducing least-square method for linearized model, errors of parameters are estimated by error propagation. Resultant errors estimated by this method are confirmed to agree with those obtained by bootstrap method approximately.