Non-linear global shear wave traveltime tomography by 3-D ray tracing and iterative inversion

S. Widiyantoro[1], A. Gorbatov[2], B. L. N. Kennett[2], and Y. Fukao[3]

[1] **Department of Geophysics and Meteorology, Bandung Institute of Technology, Indonesia**
[2] **Research School of Earth Sciences, Australian National University, Australia**
[3] **Earthquake Research Institute, University of Tokyo, Japan**

A fully non-linear approach to global tomography using S-wave arrival times has been implemented using 3-D ray tracing with an iterative linearised inversion scheme. The starting model for the 3-D inversion was the long-wavelength SAW12D model derived from inversion of global waveforms (Li & Romanowicz 1996). The travel-time tomography leads to the introduction of smaller scale structure and a final model in which small scale detail exists where it can be resolved with a smooth interconnection through long-wavelength structure. The two-point ray tracing was implemented using a "pseudo-bending" approach for a full spherical 3-D model of the mantle (Koketsu & Sekine 1998). Generally the ray paths in the full 3-D model and 1-D reference model are quite close, but the inclusion of a more accurate treatment of the rays improves the resolution of wavespeed gradients and the positioning of heterogeneity, particularly near strong variations in wavespeed e.g. subduction zones. A further advantage of the use of 3-D ray tracing is that it is possible to undertake resolution tests with fewer approximations.

With the aid of the non-linear inversion a number of different global S models have been constructed with different assumptions about the character of the model, for example solutions can be produced designed to introduce minimum differences from a 1-D reference model (Widiyantoro *et al.* 2000). The new global S models retain the general features of models derived by one-pass linearised inversion with 1-D ray tracing but provide more focused images with a higher perturbation level for the same damping parameters (see Fig. 1). The new models are able to provide a good definition of features revealed by regional tomography using arrival time and waveform data, for example the complex slab morphology beneath the Tonga and Kermadec regions (Van der Hilst 1995), the Mesozoic subducted slabs under Siberia (Van der Voo *et al.* 1999) and the sharp boundary between slow and fast uppermost mantle regions beneath western and eastern Europe (Zielhuis & Nolet 1994).

Furthermore, the use of 3-D ray tracing provides an important tool for tomographic investigations on regional and local scales in which rather small cell sizes are usually used and so it is even more important to take ray bending into account. Some new results of the application of these ray tracing and inversion codes to regional studies (the Sunda and Aegean arcs) will also be presented.

Reference

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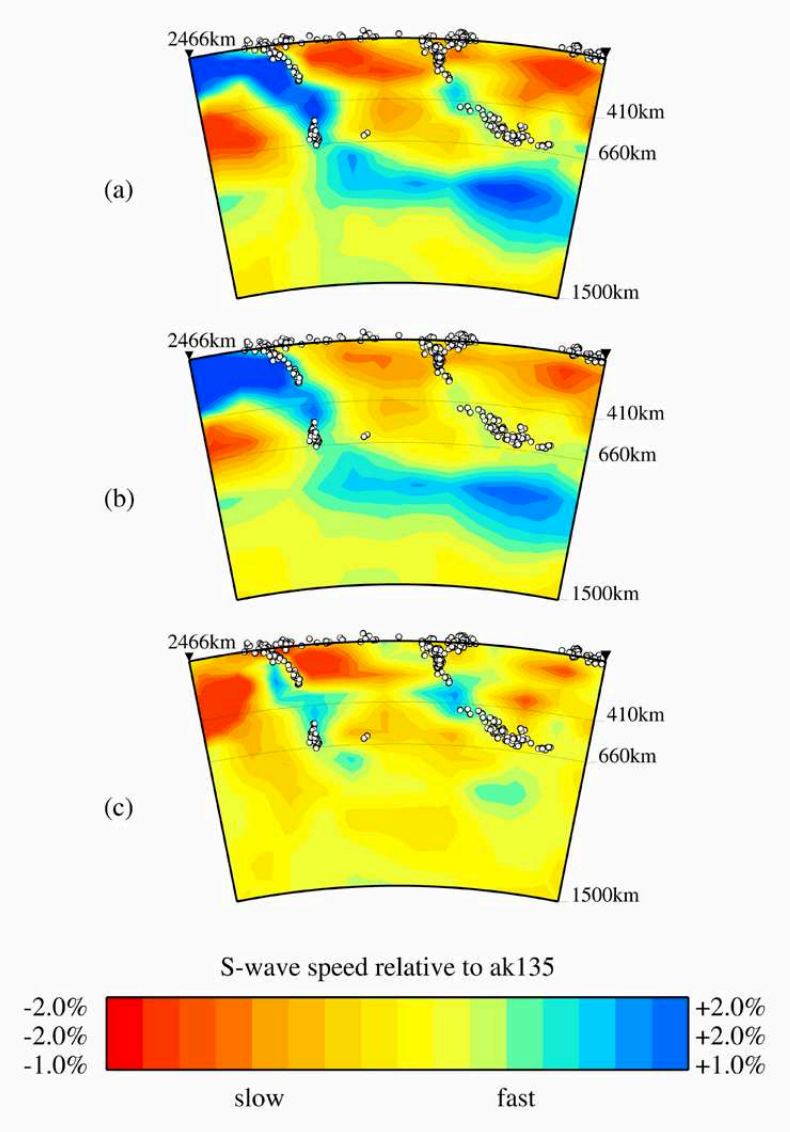

Fig. 1. Vertical mantle sections across the Banda arc through the S models (Widiyantoro *et al.* 2000). **(a)** The solution obtained by employing the non-linear approach. **(b)** The linear solution. **(c)** the increment (difference between the two solutions). The cross sections were plotted from the outer-arc region in the south (left) to the inner-arc region in the north (right). Open dots superimposed in the cross sections depict earthquake hypocentres of magnitude > 5.5 on the Richter scale, projected from a distance of up to 55 km on both sides of the plane of section. Contour scales for wave speed perturbations are in per cent relative to ak135 (Kennett *et al.* 1995). Notice the significantly thinner slab structure in the uppermost mantle shown in the non-linear solution.