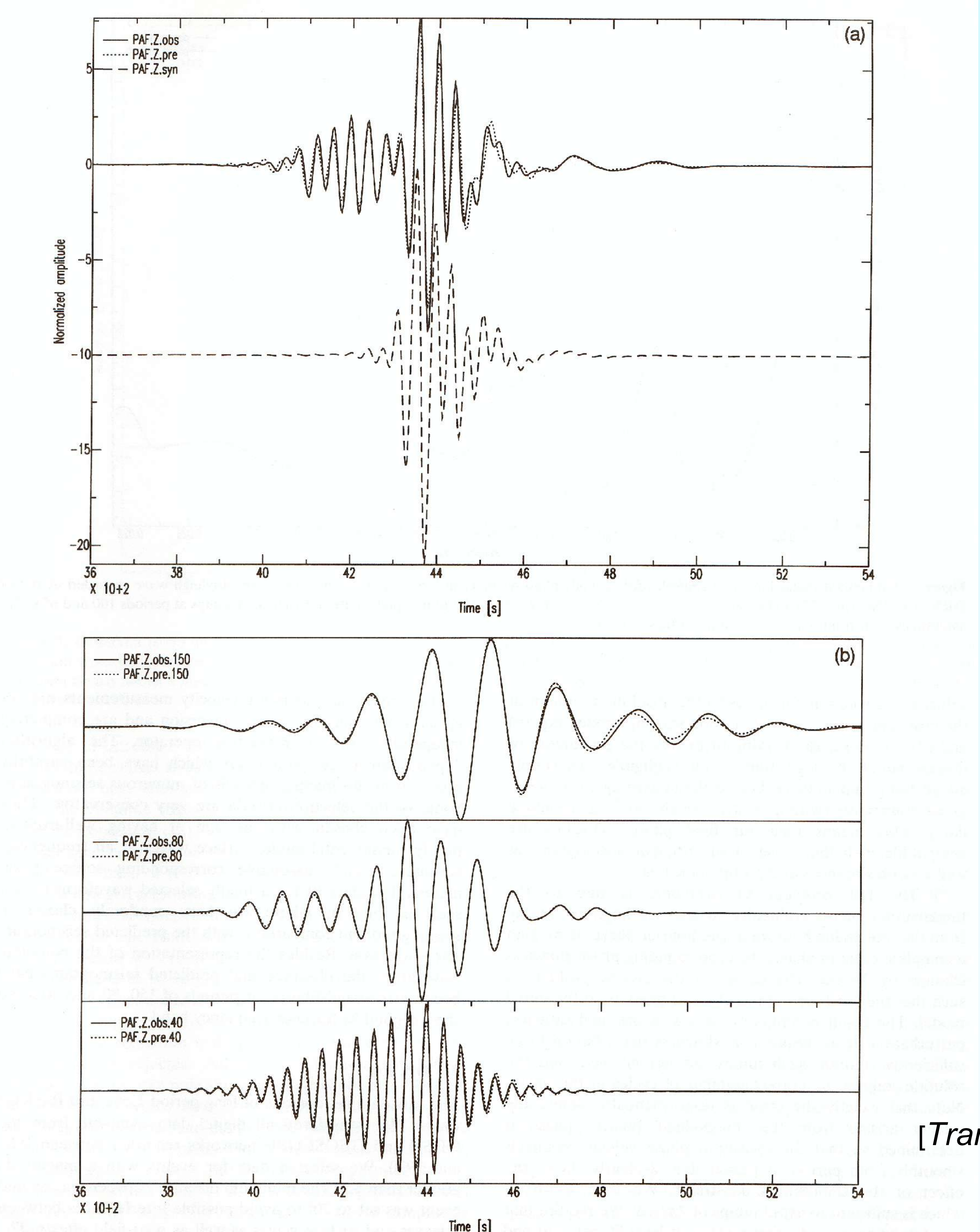
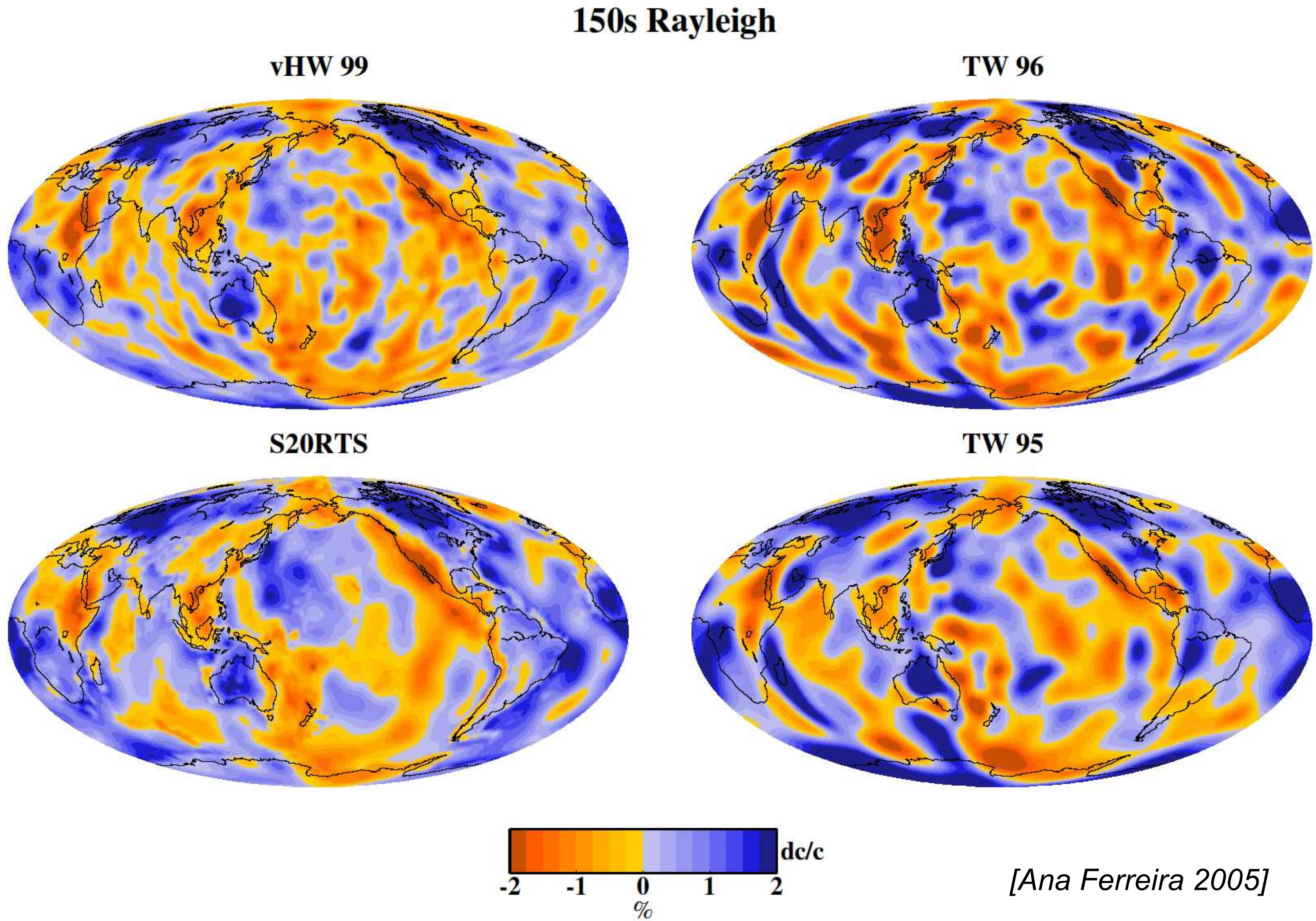
Seismic Tomography and Fully Numerical Wave Field Calculations – Prospects and Perspectives

John Woodhouse, University of Oxford

- A discussion of research directions and prospects for employing fully numerical wavefield calculations in global tomography



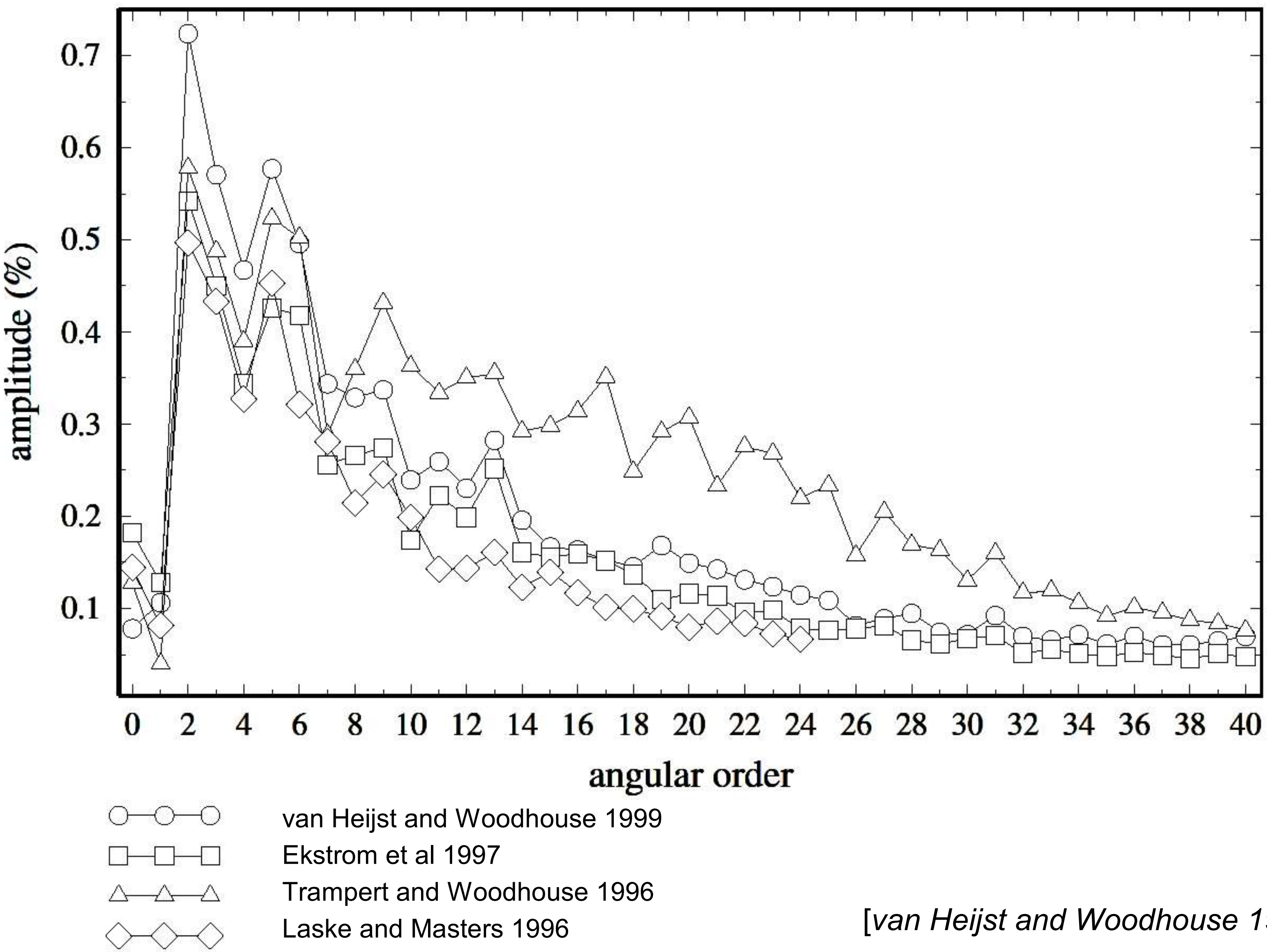
[*Trampert & Woodhouse 1995*]



[Ana Ferreira 2005]

Surface wave phase velocity distributions in several studies. Data are potentially able to resolve features comparable to the wavelength at very long periods. Ray theory is reaching the limit of its validity in such models.

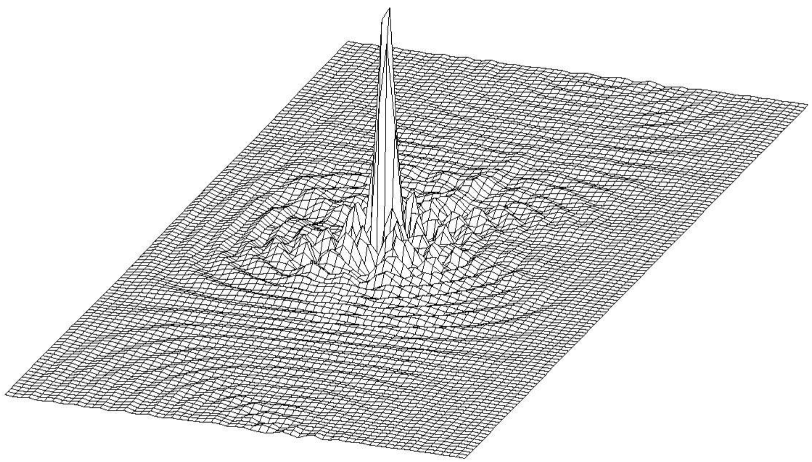
Amplitude spectra for 150s Rayleigh wave phase velocity distributions for several models

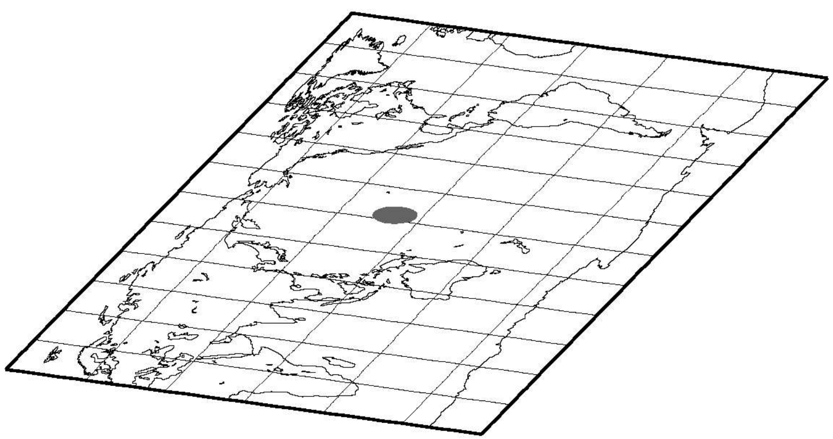


[*van Heijst and Woodhouse 1999*]

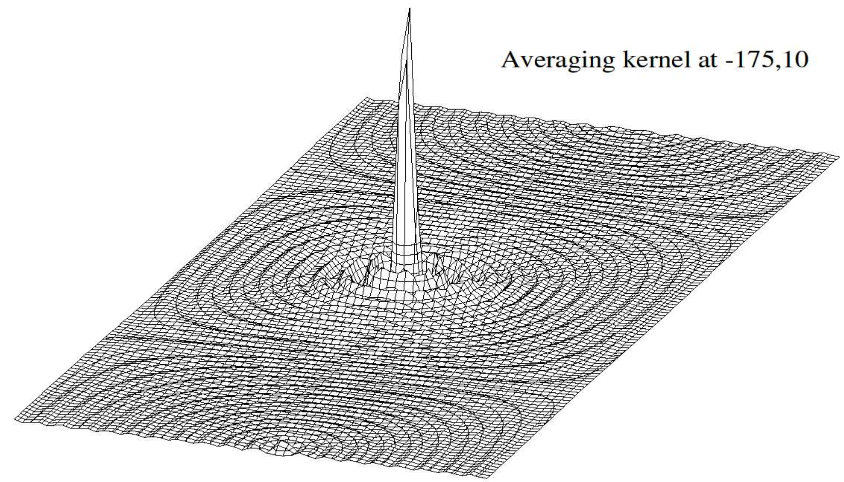
Resolution in surface wave tomography

Averaging kernel for 150s Rayleigh waves



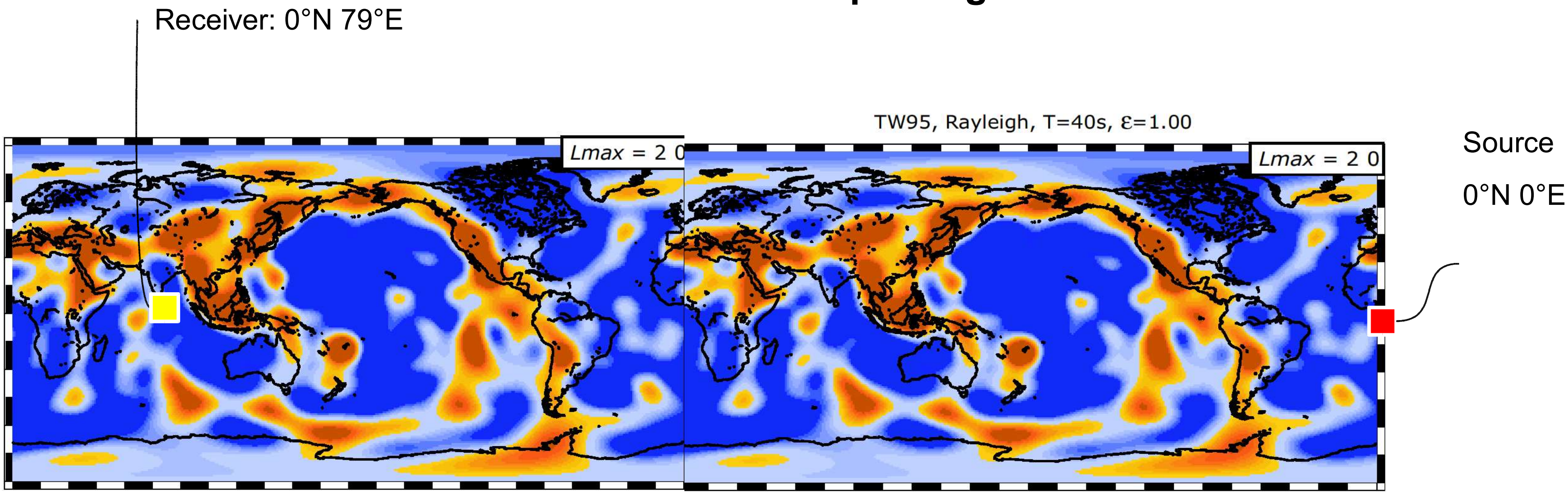


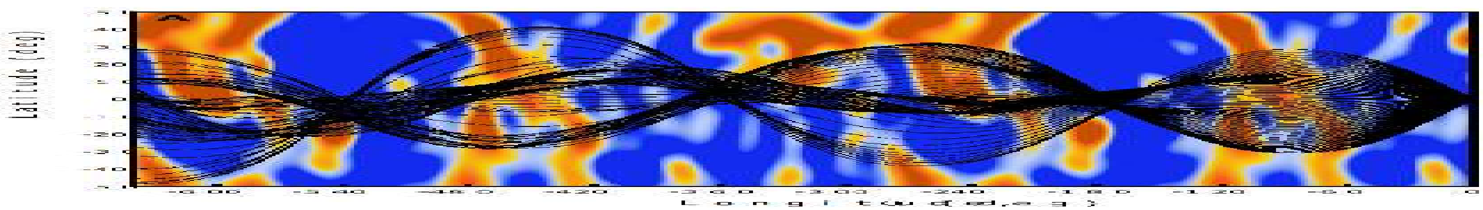
δ-function expanded to degree 40 in spherical harmonics



[van Heijst and Woodhouse 1999]

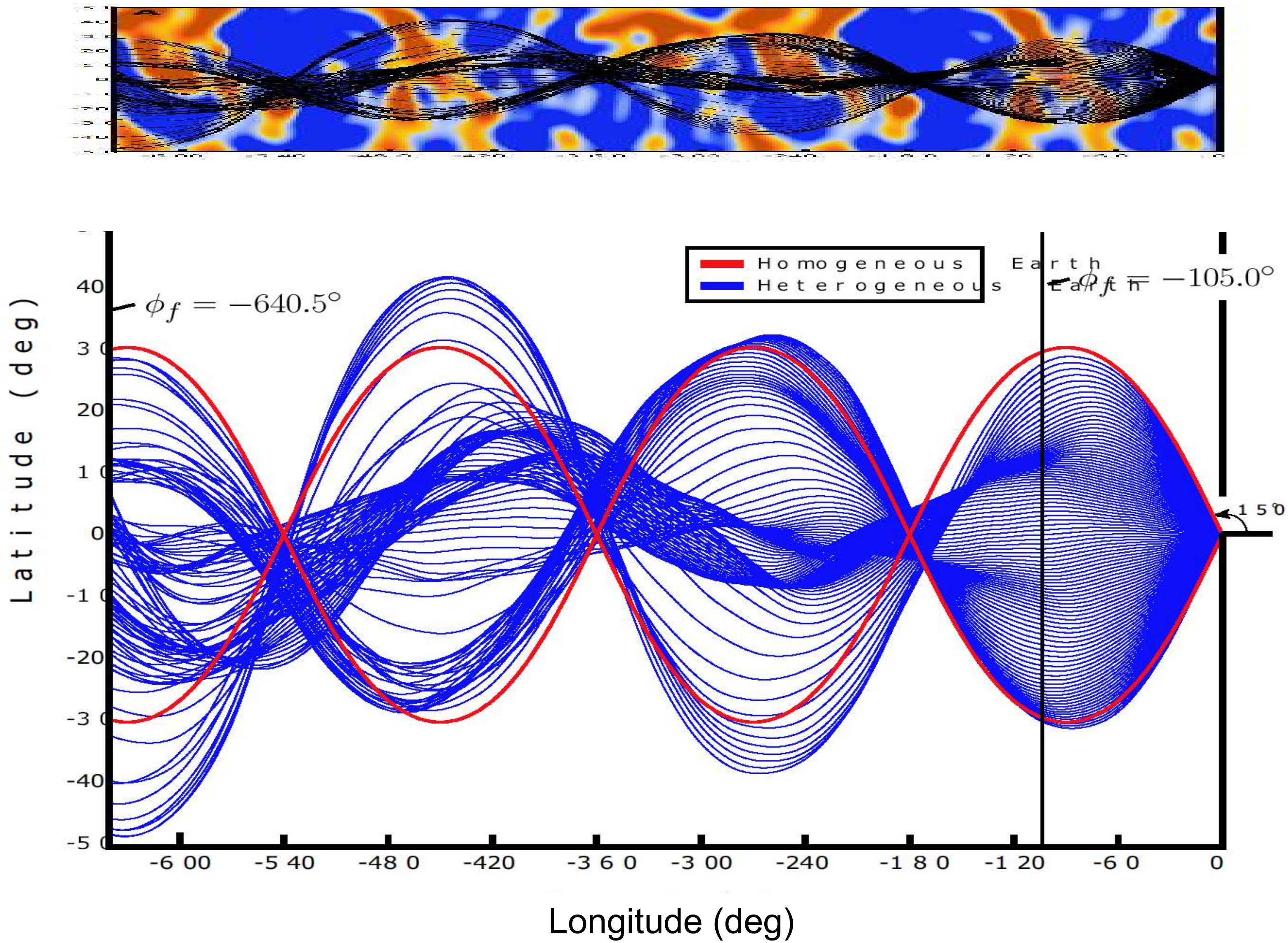
Surface Wave Multipathing





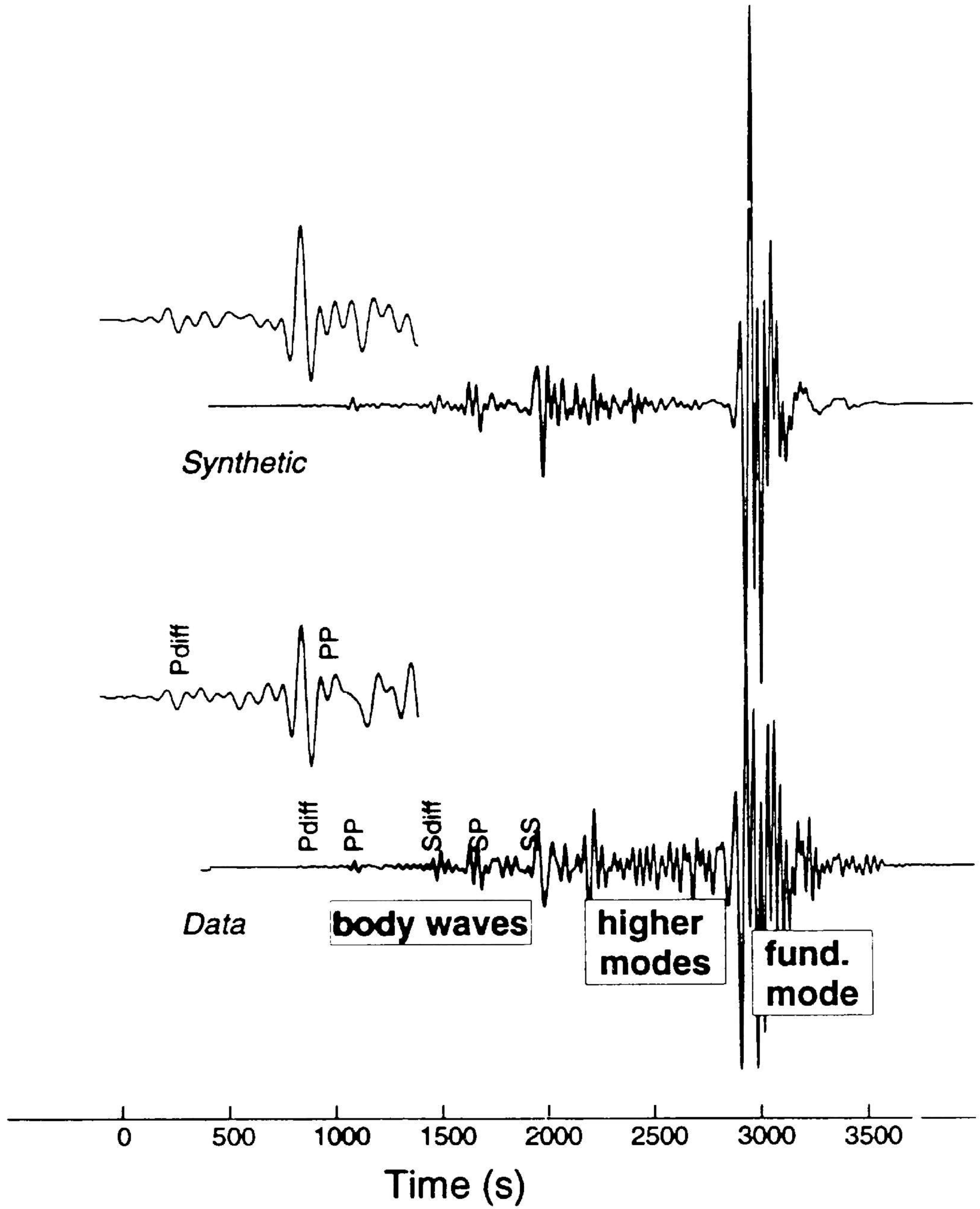
[Carl Tape2003]

Surface Wave Multipathing

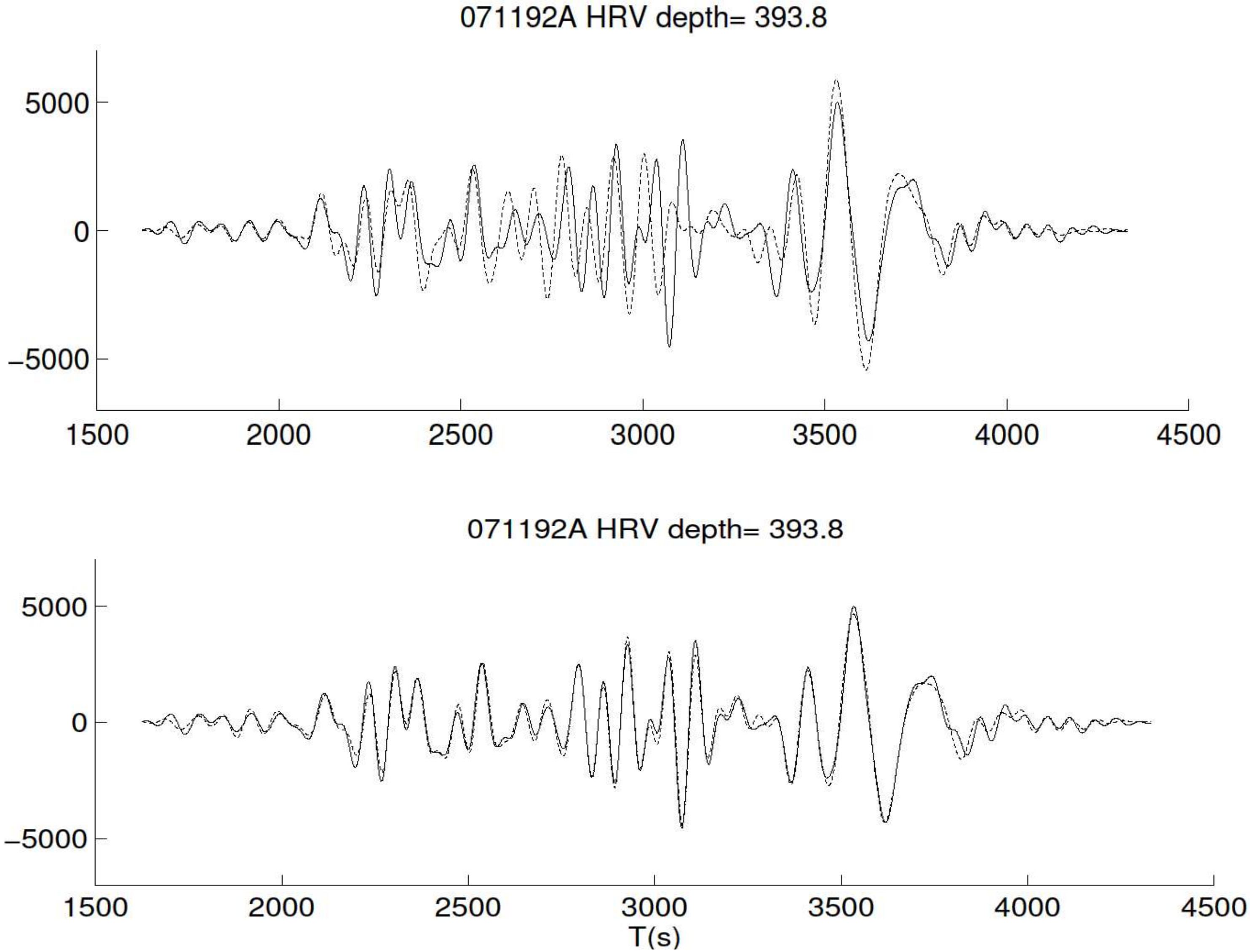


[Carl Tape 2003]

Event 21 May 1998 (Indonesia) at TSUM (Tsumeb, Namibia)
(Depth = 28 km; Mw = 6.6; Mb = 6.3; Δ = 101.5°)



Overtone Signals and Waveform Fitting



[van Heijst and Woodhouse 1999]

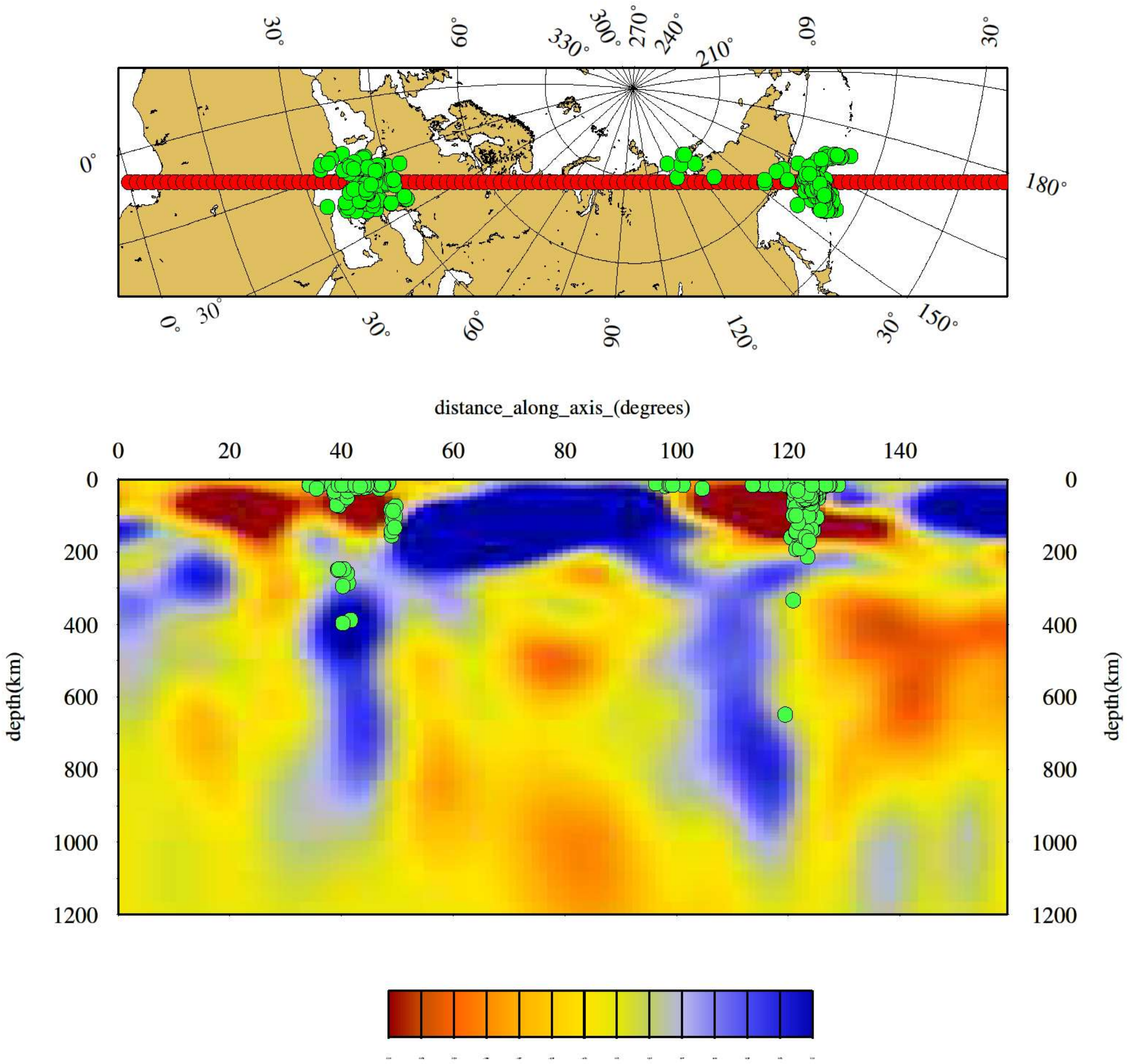


Figure 9.1: Slice through S20RMC14/RD along the (red) great-circle shown in the top two figures. The green circles represent the (CMT) locations of earthquakes. The colour scale ranges from -1.5% to +1.5% . Note the good correlation of the earthquake locations with fast, subduction related, structure.

[van Heijst 1997]

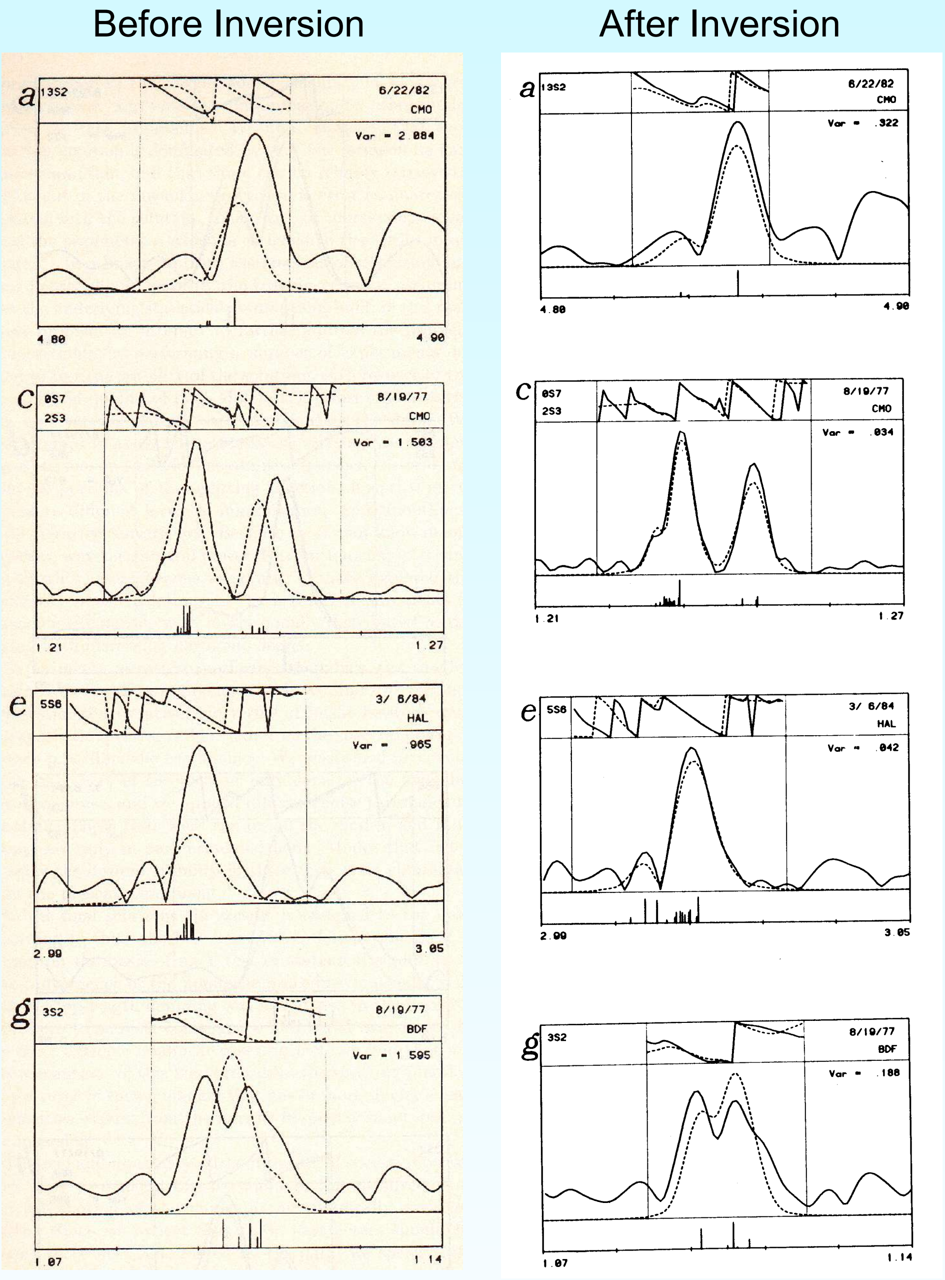
Small spectral segments are studied in order to understand the splitting of normal modes.

Splitting is governed by perturbation theory, in which the eigenvalues and eigenfunctions of the split modes are found by solving a matrix eigenvalue problem.

The matrix governing splitting – the *splitting matrix* - depends upon a certain function on the sphere which is analagous to a phase velocity distribution. This is called the splitting function.

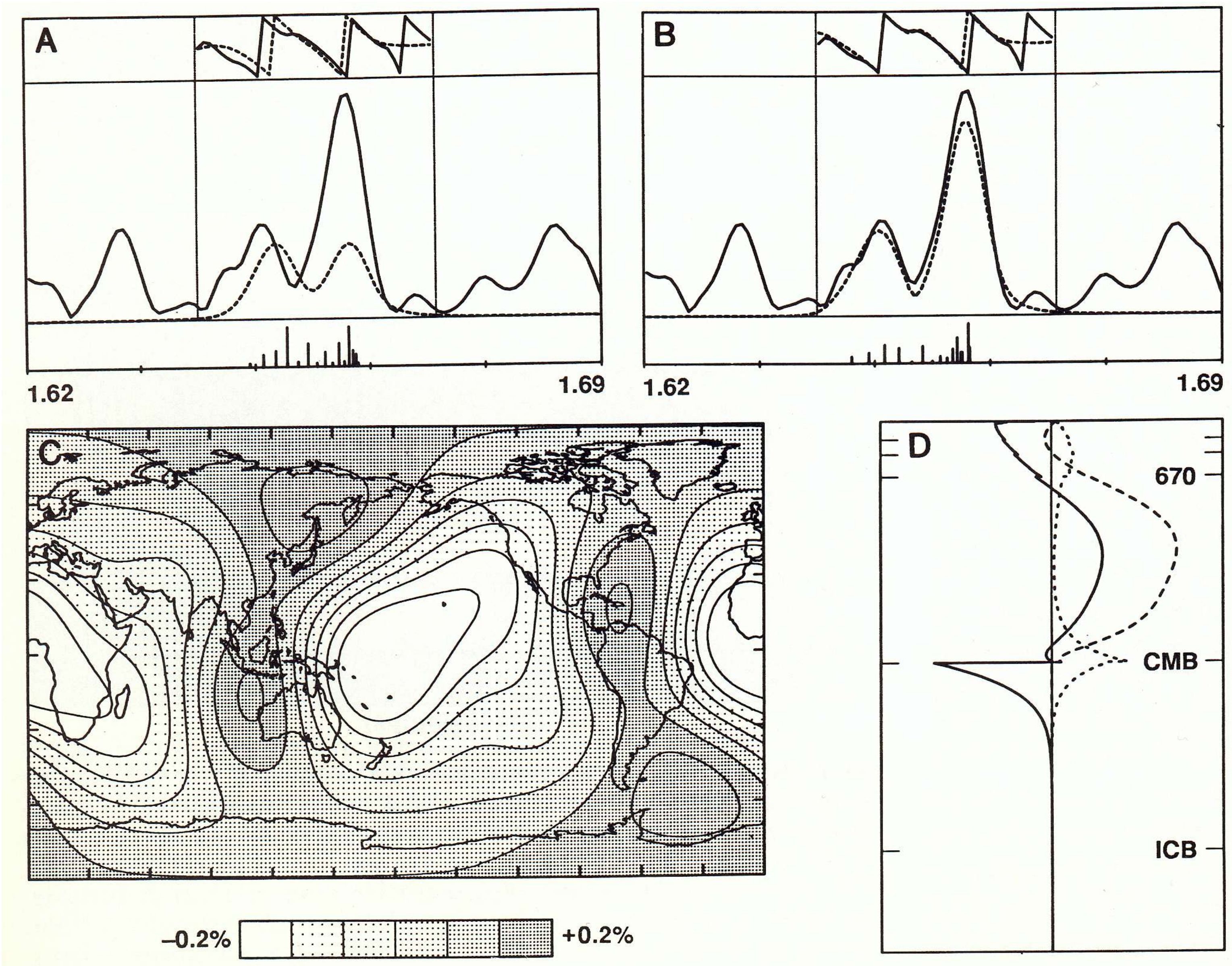
The examples on the right illustrate how the spectral segments corresponding to so-called ‘isolated’ modes can be used to estimate the splitting function and thereby to obtain a model which is much more successful in explaining the amplitude and the phase of the observed spectra.

<u>However</u> many modes are strongly coupled to one-another. Can numerical simulation help us to understand modal spectra better?



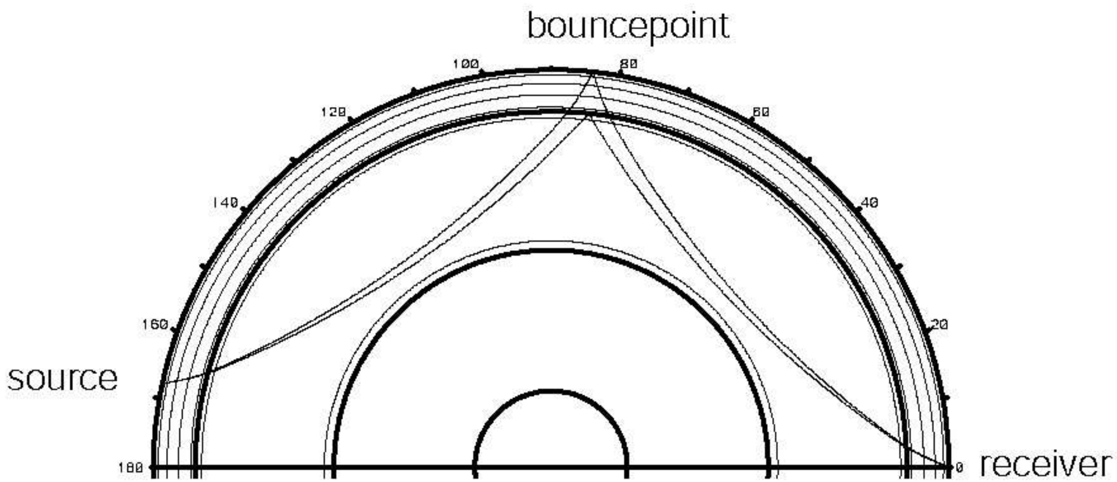
[*Giardini Li & Woodhouse 1988*]

The principle of the splitting function. Mode 1 S 7

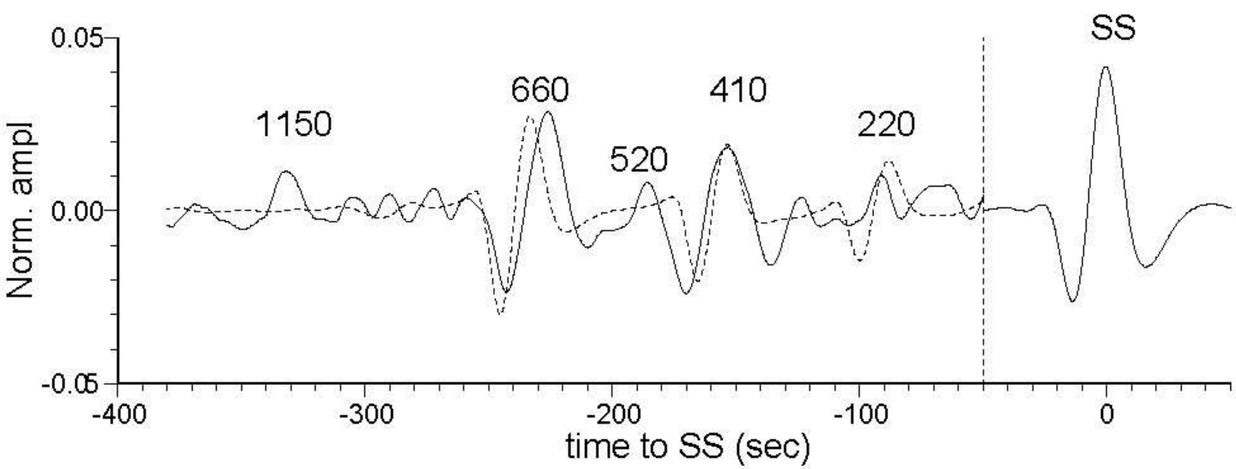


[*Giardini 1987*]

SS-precursors

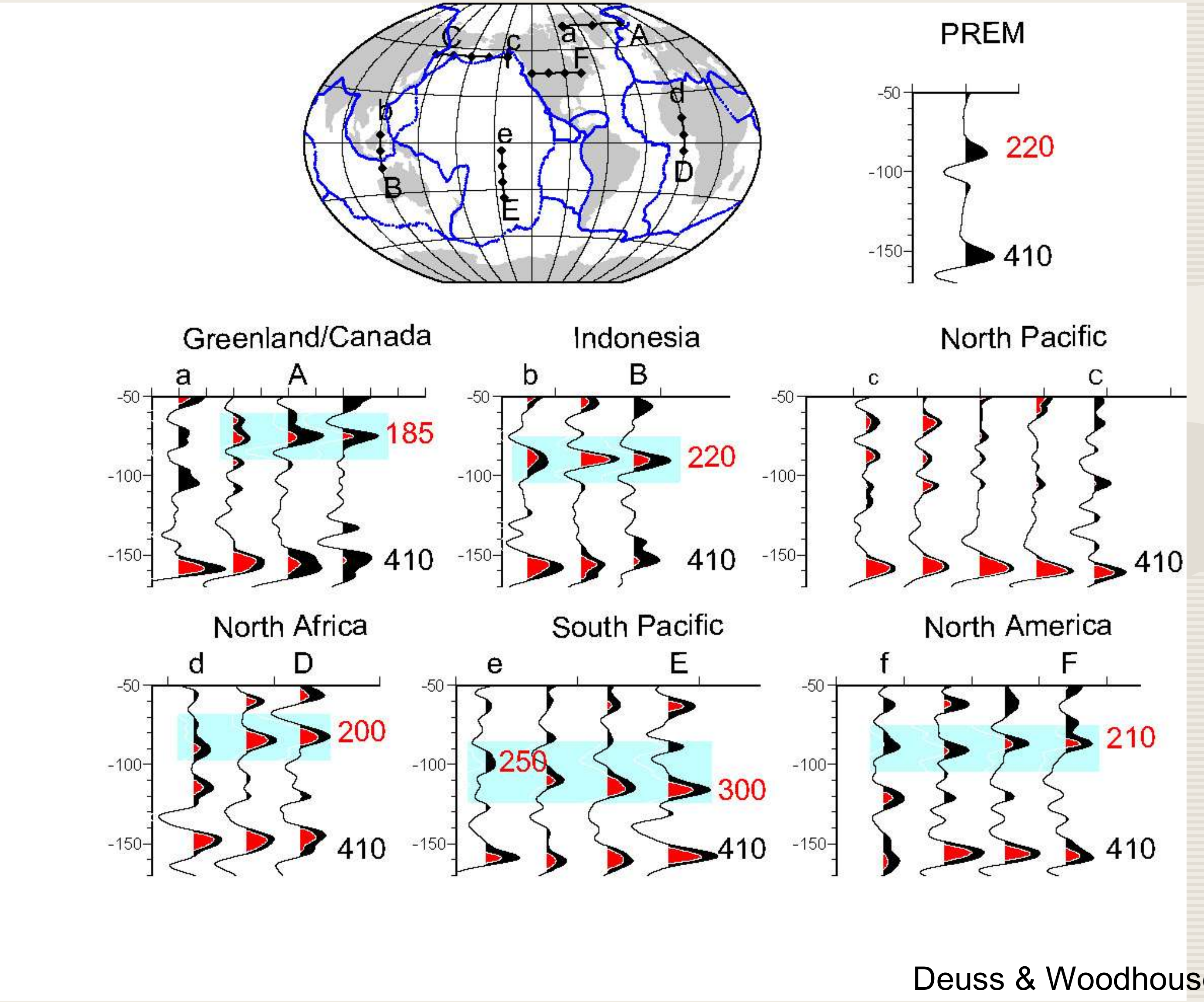


Detection of mantle discontinuities



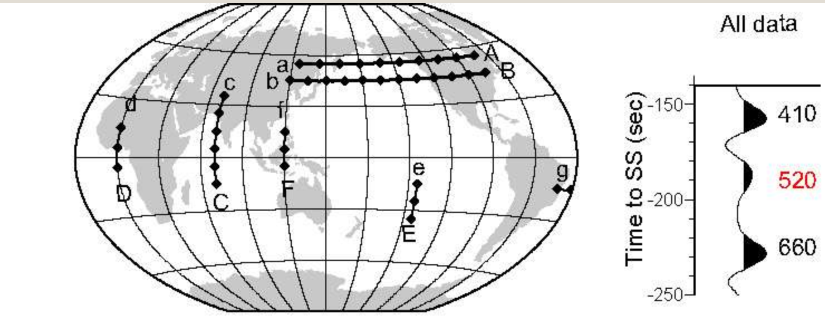
Deuss 2002

Profiles of the Lehmann and X-disccontinuities



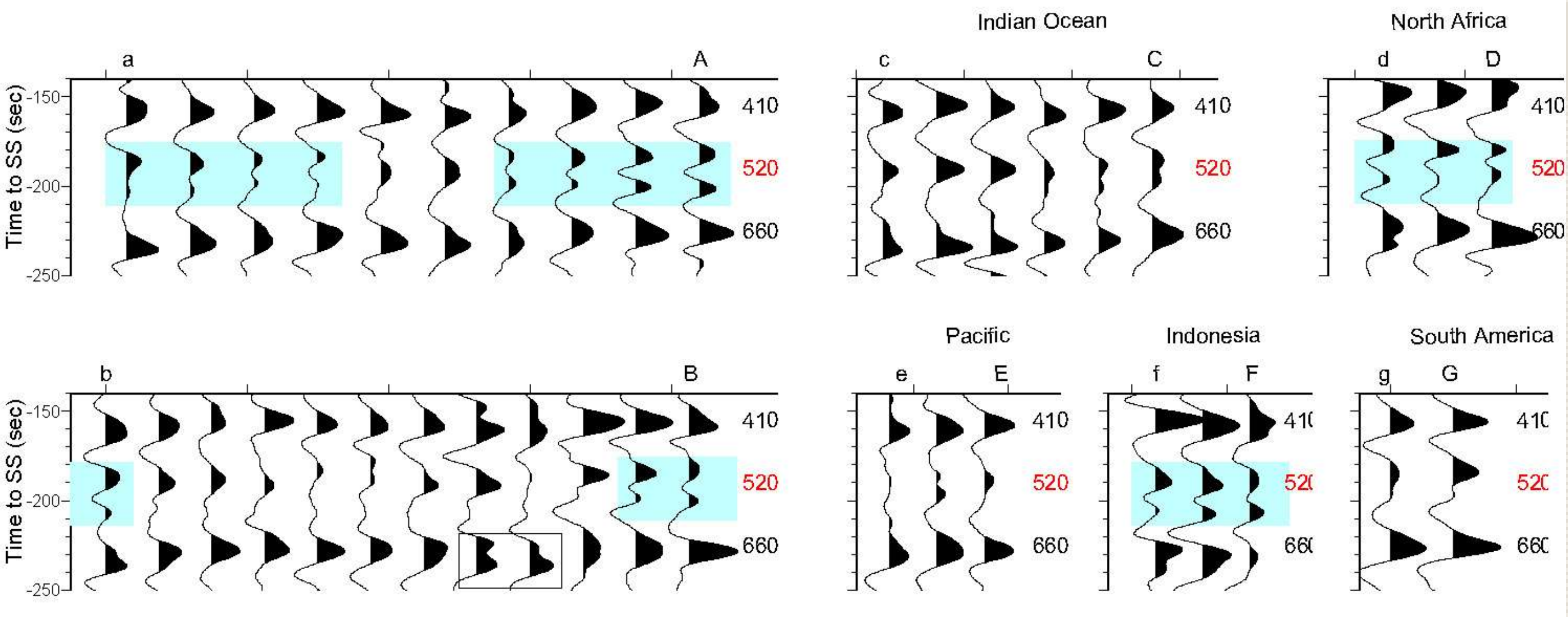
Deuss & Woodhouse 2004

520-km discontinuity   Observations



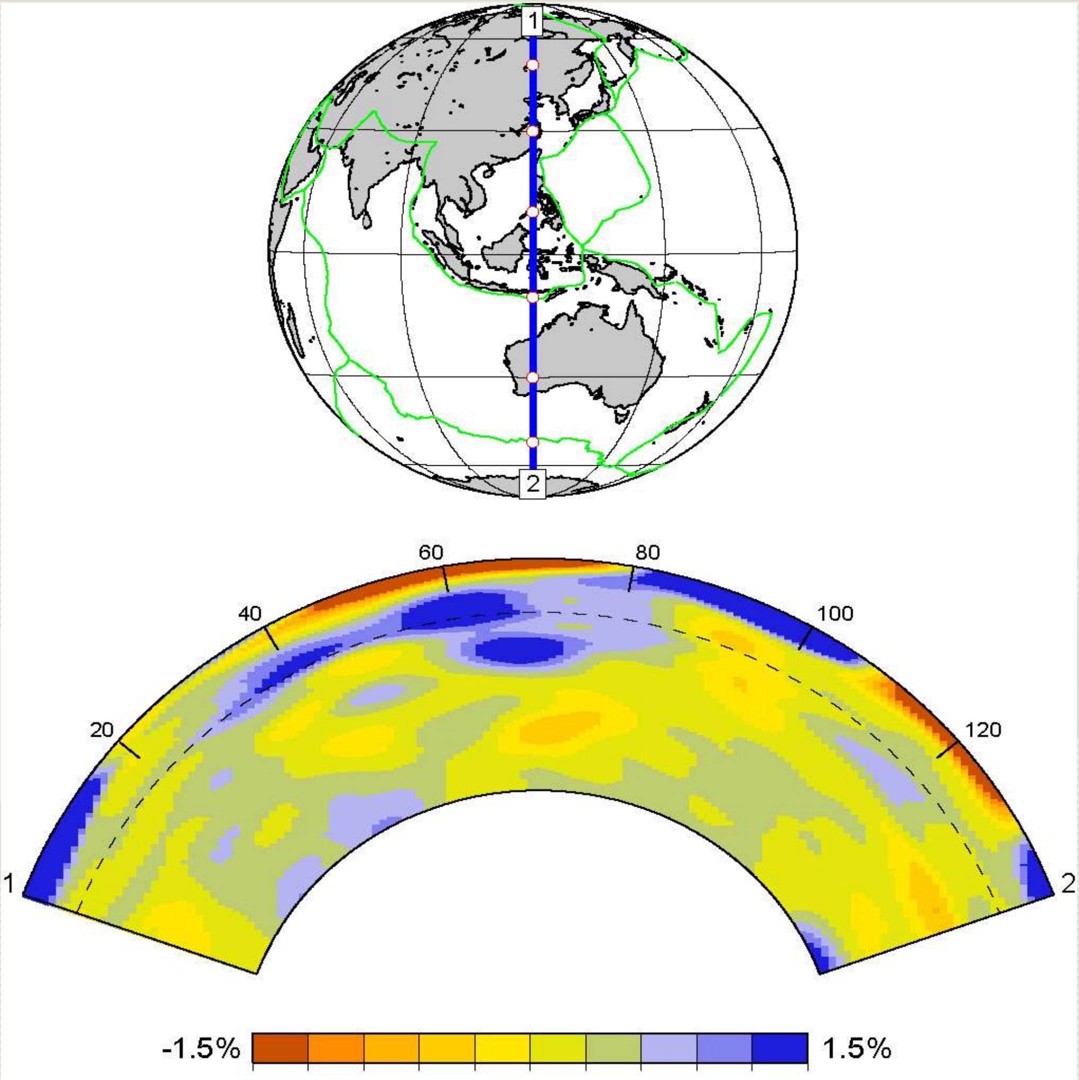
Splitting of 520-km discontinuity

- more complicated than just olivine
- garnet phase change?
  trace elements?

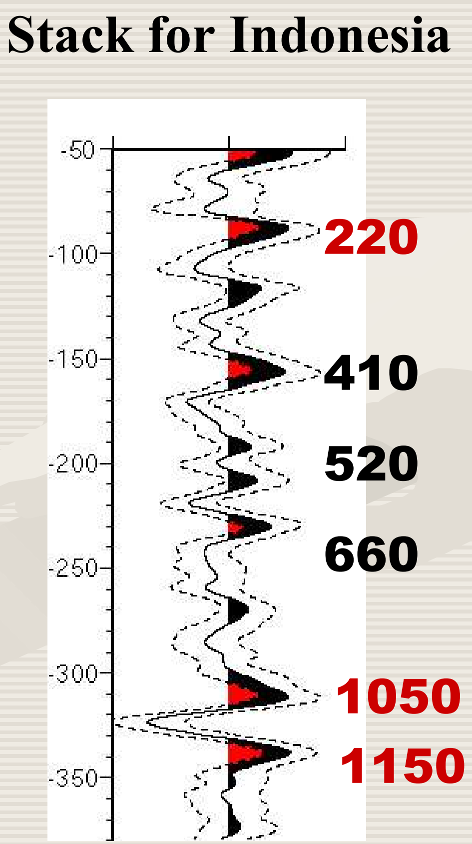


[*Deuss & Woodhouse 2001*]

Robustness of reflections



Deep reflectors in Indonesia



[*Deuss 2002*]