Multimode Phase Velocity Measurements using a Model Space Search Approach

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Introduction

Surface wave tomography generally suffers from limited depth resolution because most information is obtained from fundamental mode phase velocities. By including higher mode phase velocity measurements the depth resolution can be significantly improved. We have automated the fully non-linear waveform inversion technique of Yoshizawa and Kennett (2002) to make multimode path average dispersion measurements including robust uncertainties. We measure both the fundamental and higher mode phase velocities with similar coverage.

Data

We measured over ninety thousand minor arc seismograms of the IRIS database. The networks used were mainly GDSN and Geoscope of the years 1994 to 2002.

Method

The automatic procedure is based on a combination of the Automated Multimode Inversion method (Lebedev et al, 2004) and the neighbourhood algorithm (Sambridge 1999). AMI provides us with a 1-D average depth profile for the shear wave velocity. From a linearized model space search around the reference model we obtain a full collection of shear velocity models which are compatible with the data. From this collection of models we construct phase velocity models with uncertainties.

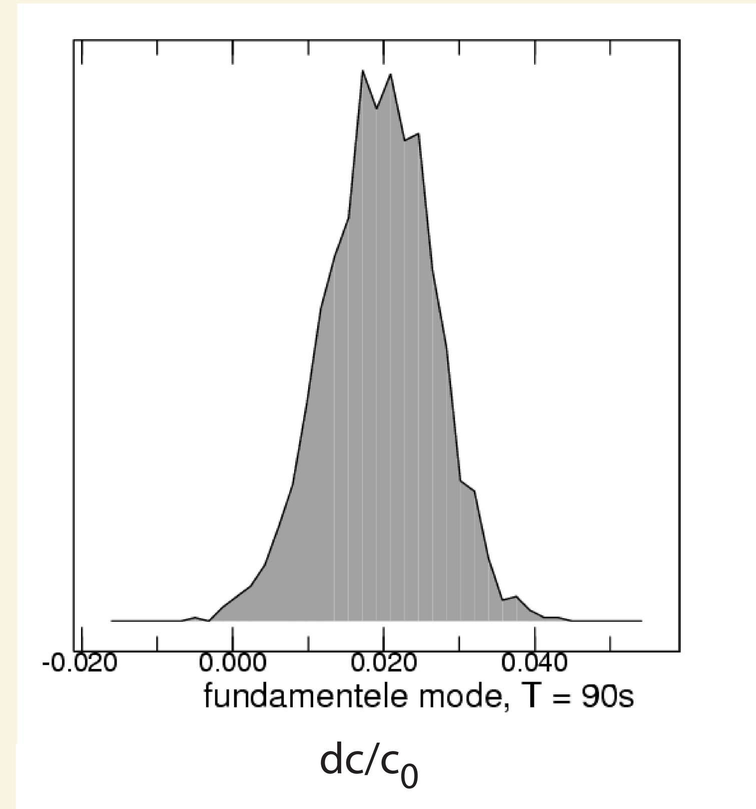


Figure 1
Phase velocity marginal of the fundamental mode at a period of ninety seconds with respect to anisotropic PREM.

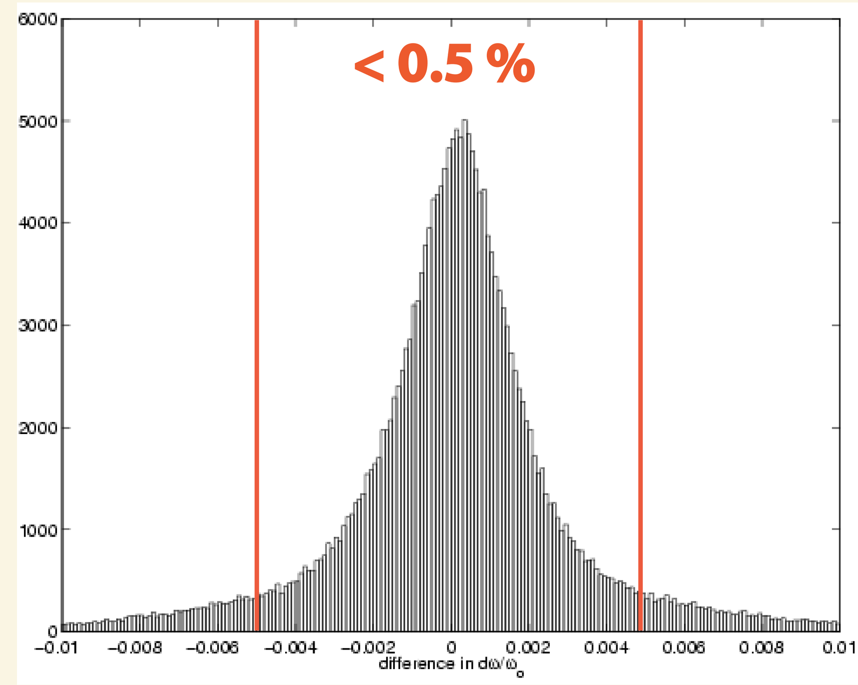


Figure 3. Comparison with van Heijst and Woodhouse (2002) phase velocity measurements. Shown is a histogram of the differences for all phase velocity measurements (fundamental and higher mode phase velocities). Most of our measurements fall within 0.5 percent of van Heijst and Woodhouse (2002) measurements.

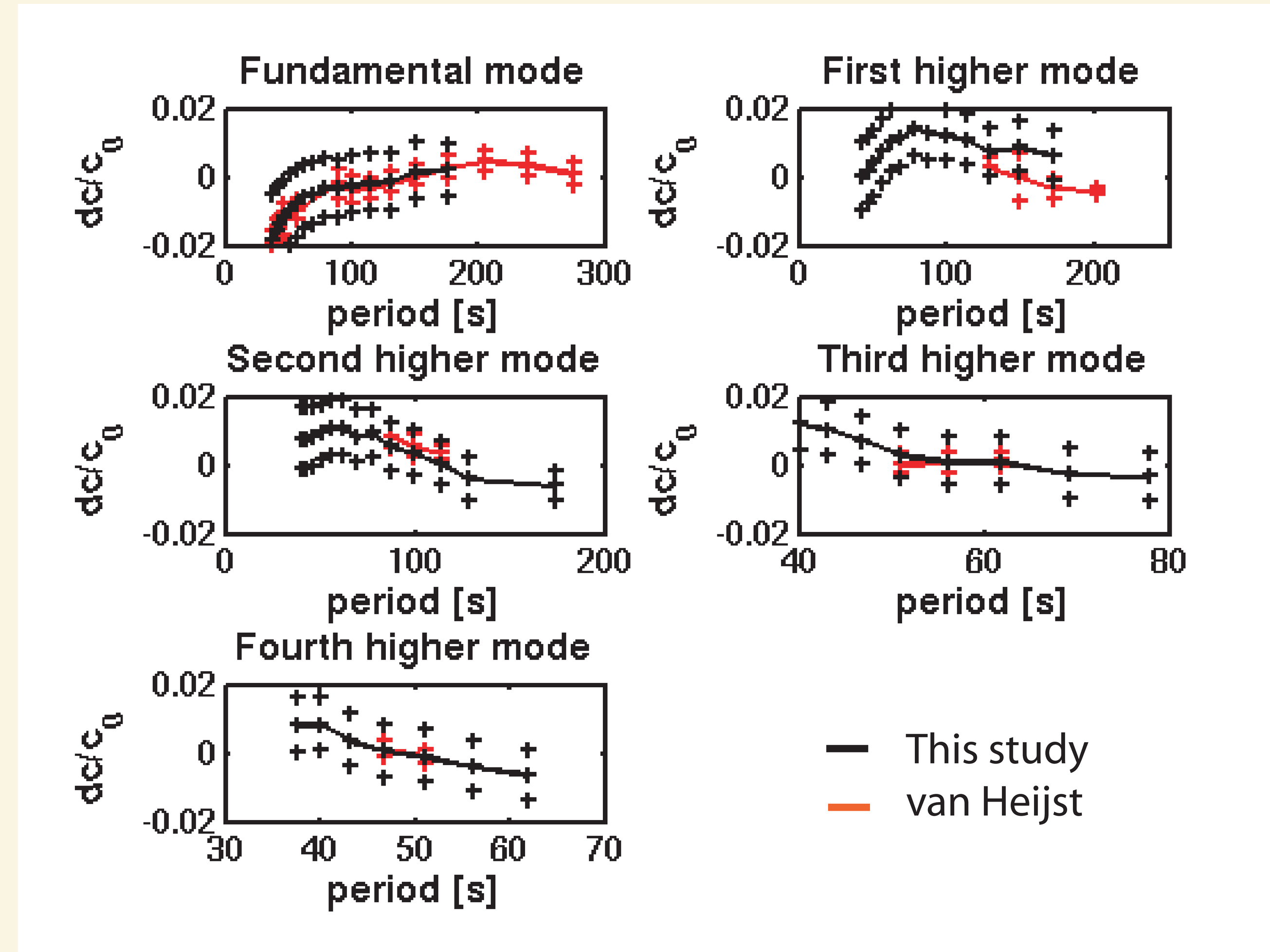
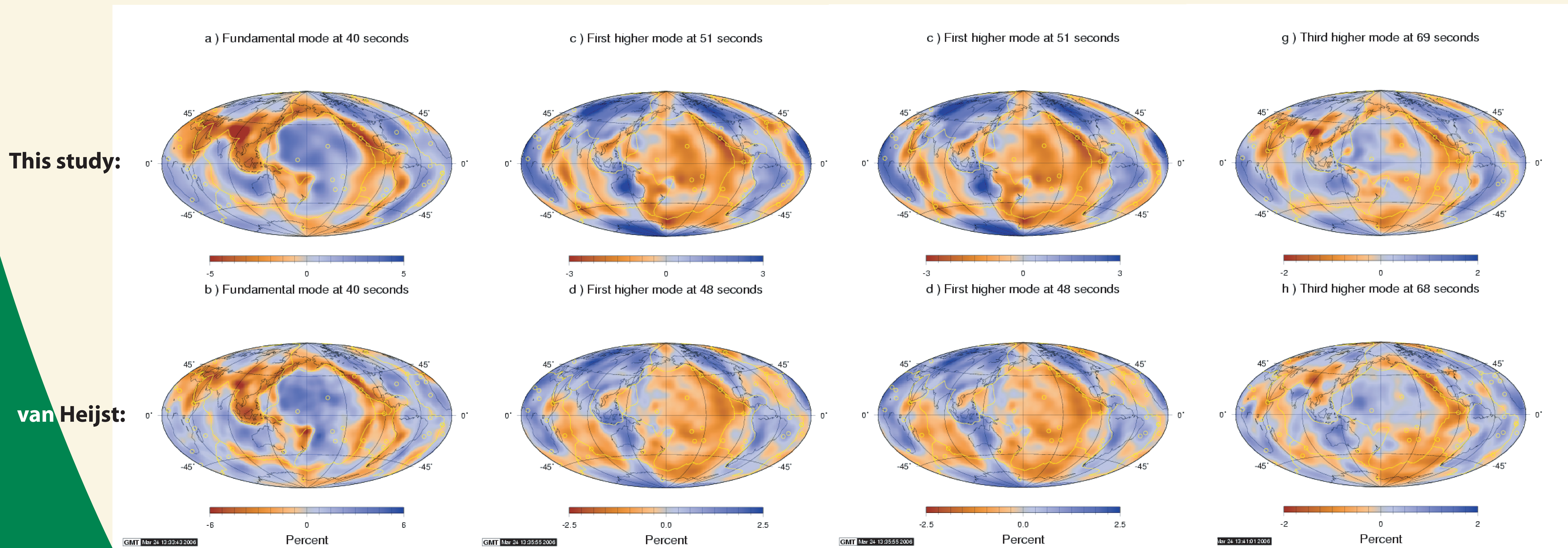


Figure 4. Phase velocity measurements with respect to anisotropic PREM for one seismogram. Also indicated are van Heijst and Woodhouse (2002) measurements for the same seismogram. The standard deviations for van Heijst's measurements were calculated using a cluster analysis.

Figure 2. Comparison of Rayleigh wave phase velocity maps between this study and van Heijst and Woodhouse (2002) at the indicated periods.



Conclusions

We are able to measure fundamental mode and higher mode phase velocities using a fully non-linear automatic method. The use of a model space search does not only provide us with phase velocity measurements but also with corresponding uncertainties. The measured phase velocities agree well with the phase velocities measured by van Heijst and Woodhouse, using a mode branch stripping technique. The advantage of our technique is that we obtain many more overtone measurements with meaningful error bars.

References

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