Crustal Structure between Minnesota and the Gulf Coast from Joint Inversion of Surface-wave Dispersion and Receiver Functions

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Introduction

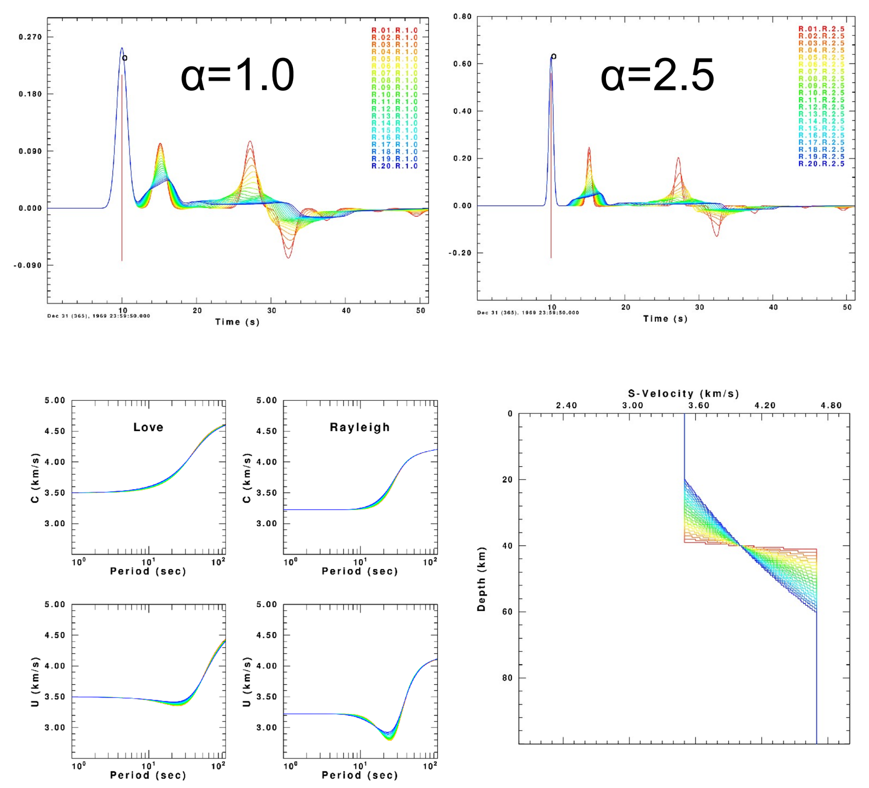
The Transportable Array provides a foundation for integrated studies of continental lithosphere and deep Earth structure over a wide range of scales. With station spacing of about 70 km, Transportable Array data are extremely useful for mapping the structure of Earth's interior. (http://www.usarray.org/researchers/obs/transportable)

We apply joint inversion to study the crustal structure. A well determined velocity structure model is necessary for regional moment tensor inversion and helps to obtain accurate source inversion of earthquakes. Maps of crustal seismic velocities delineate the vertical dimension of platforms, shields, sedimentary basins, and exotic accreted terrains. It can complement maps of the magnetic and gravity anomalies. (Chulick and Mooney, 2002)

Joint Inversion Procedure

We start with the modified AK135 continental model whose lower part is not permitted to change. We use receiver function data, which are sensitive to velocity transitions and vertical travel times, together with surface-wave dispersion measurements, which are sensitive to the average velocity but relatively insensitive to sharp velocity contrast, to estimate the variations of crustal structure and the character of Moho discontinuity of the mid-continent between the Canadian/US border and the Gulf of Mexico. (procedure used in Yoo et al., 2007)

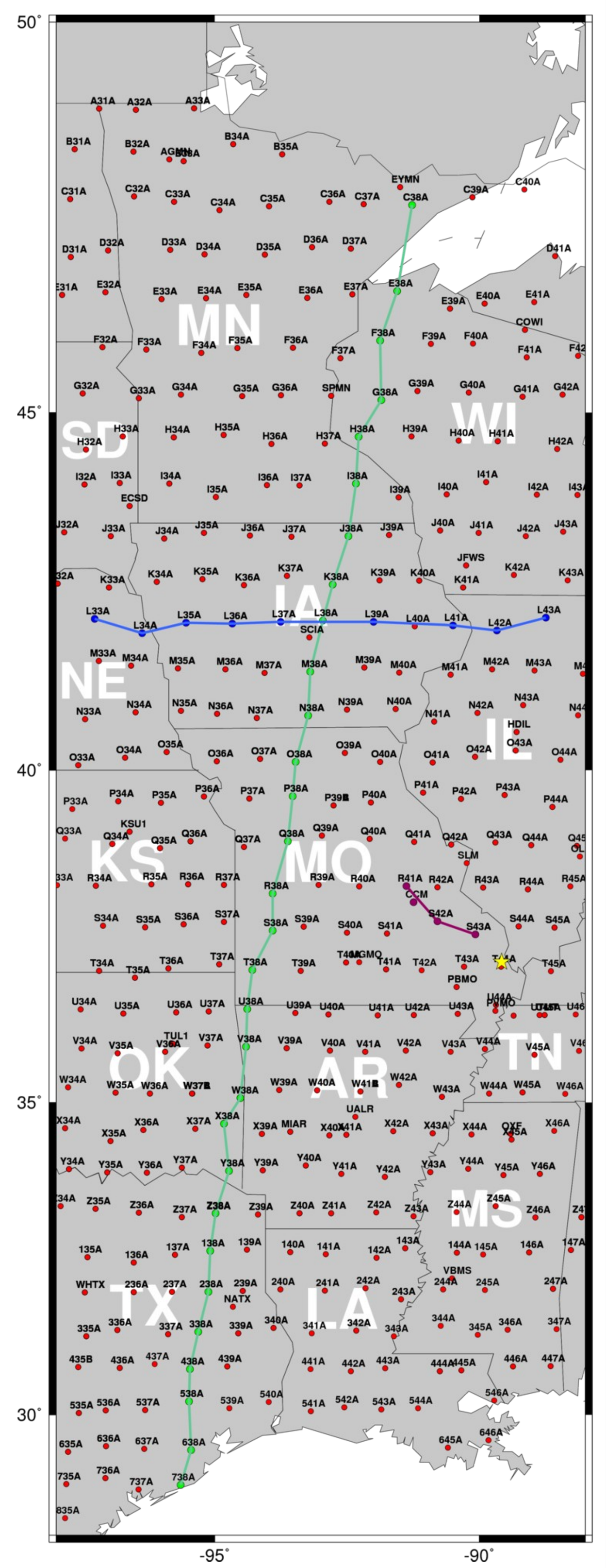
Sensitivity study of Moho sharpness



Velocity models with different Moho transitions, receiver functions with α= 1.0,2.5 and the surface-wave dispersion.

From the theoretical surface wave dispersion, we see that the dispersion is not sensitive to details of the Moho transition; to invert dispersion data, we only need to use a simple model. To model Receiver function (RFTN), the velocity model must have many thin layers to detect a transitional Moho. The RFTN is very sensitive to nature of Moho transition.

This simple study permits us to look at RFTNs and quickly characterize the nature of the Moho.

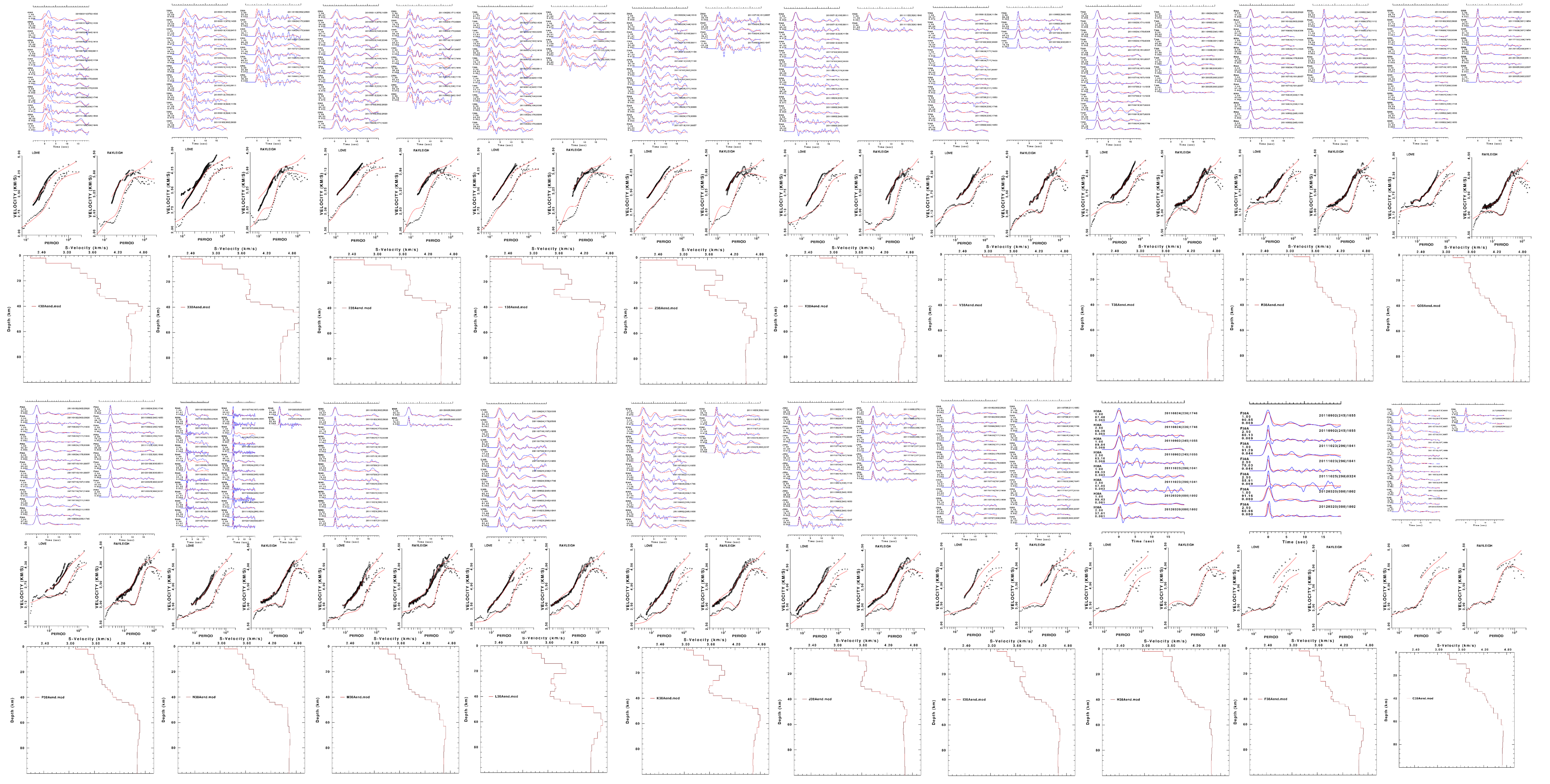


Location of TA stations. Green line is profile 38A. Blue line is L33A-L44A. Purple line is stations for test model. Yellow star is the earthquake.

Surface wave dispersion data:

North American group velocity tomography using > 1,000,000 observations (SLU)
P-omega phase velocities for TA stations (SLU)
Some group velocity from Bensen (U.Colorado) and Harvard (Ekström)

South-North Profile



The profile 38A shows different structure from south to north of the mid-continent between the Gulf Coast and the Canadian/US border. The surface of the Gulf Coast is Paleogene sediment. To north, a large part of the center consists of the continental platform. Here, the Precambrian rocks of the shield are buried beneath sedimentary Phanerozoic strata. The north end of the profile is the shield, consisting of surficial, deeply eroded Precambrian rocks, exhumed by glaciation. A variety of rocks from igneous to ancient sedimentary is well-exposed in the Great Lakes region.

K38A L38A RFTN's ring may be due to shallow structure or mid-continental rift.

138A R38A N38A K38A L38A J38A all show sharp Moho.

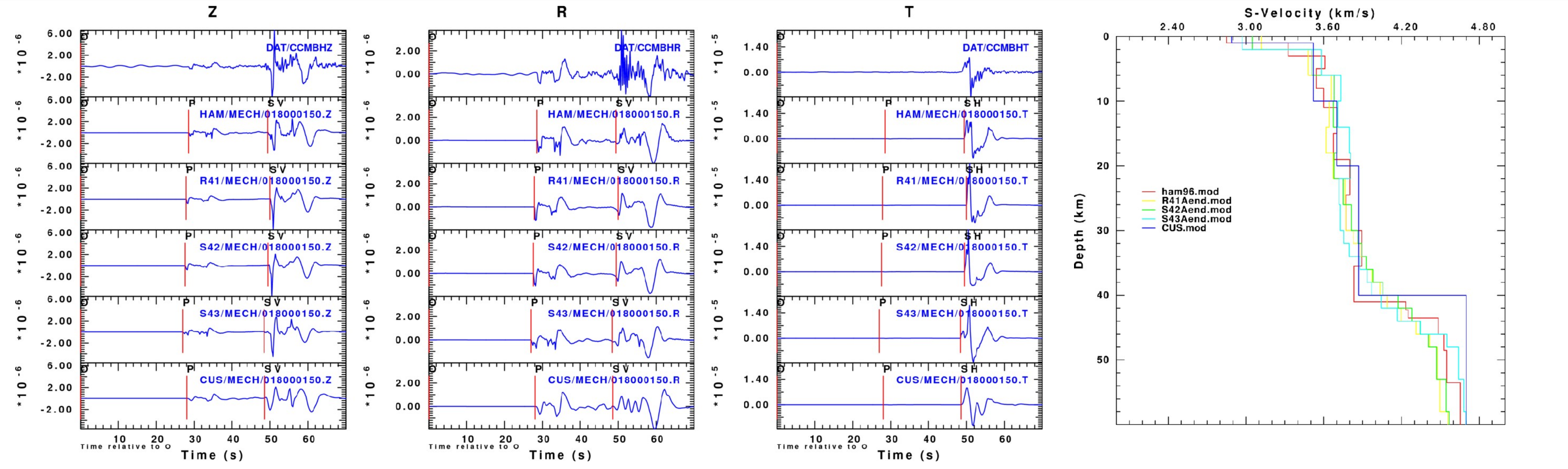
Q38A P38A H38A F38A C38A show gradational Moho.

The models near The Gulf Coast need more data. Their RFTNs show a very complex structure.

Independent Test of Inversion Model

Predict CCM record of the Mw=4.28 1990/09/26 Missouri earthquake to evaluate Joint Inversion models at R41A, S42A and S43A, compared to HAM model derived by direct waveform inversion. Note source parameters are tied to the HAM model.

Conclude that the joint inversion models can be used for regional waveforms.



Comparison of observed and predicted waveforms. All traces show filtered velocity (m/s) using the gsac commands: hp c 0.02 n 2 ; lp c 0.2 n 2. Prominent features on the Z and R are P, sP whose separation is a function of source depth; a sharp S in the Z. All joint inversion models fit the waveforms well. Note the simple CUS model cannot fit the S on the Z – this is why the HAM model has a Moho gradient.

References

Gary S. Chulick and Walter D. Mooney (2002). Seismic Structure of the Crust and Uppermost Mantle of North America and Adjacent Oceanic Basins: A Synthesis, *Bull. Seism. Soc. Am.***92**, 2478–2492.

H. J. Yoo, R. B. Herrmann, K. H. Cho, and K. Lee (2007). Imaging the Three-Dimensional Crust of the Korean Peninsula by Joint Inversion of Surface-Wave Dispersion and Teleseismic Receiver Functions, *Bull. Seism. Soc. Am.* **97**, 1002–1011.