Preliminary modeling of the seismic structure of the central Mexico subduction zone

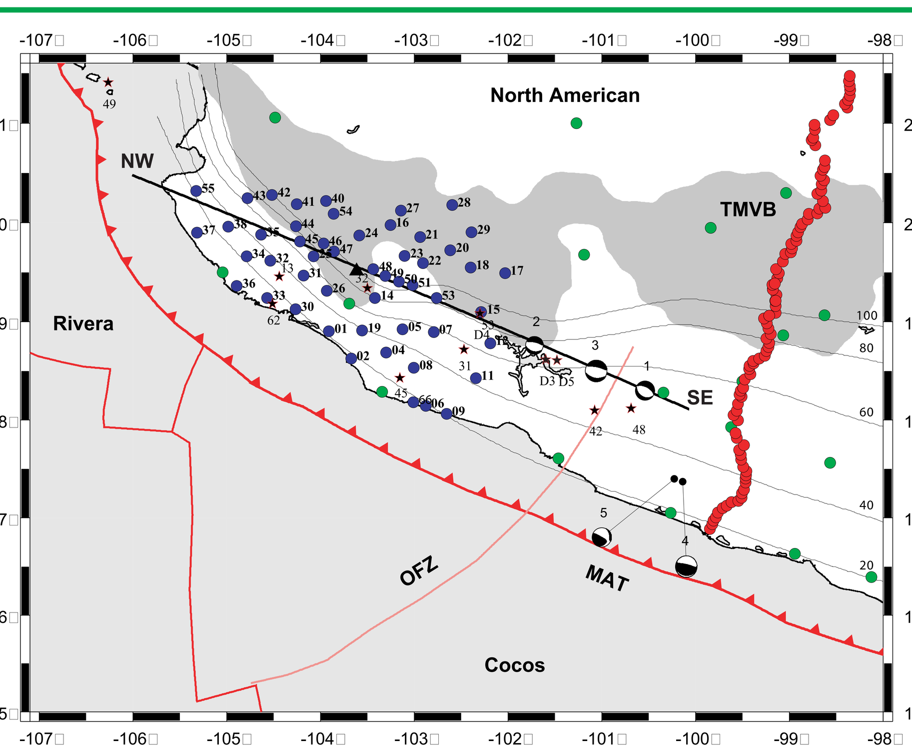
Sara L. Dougherty*, Rob W. Clayton, and Don V. Helmberger

Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125

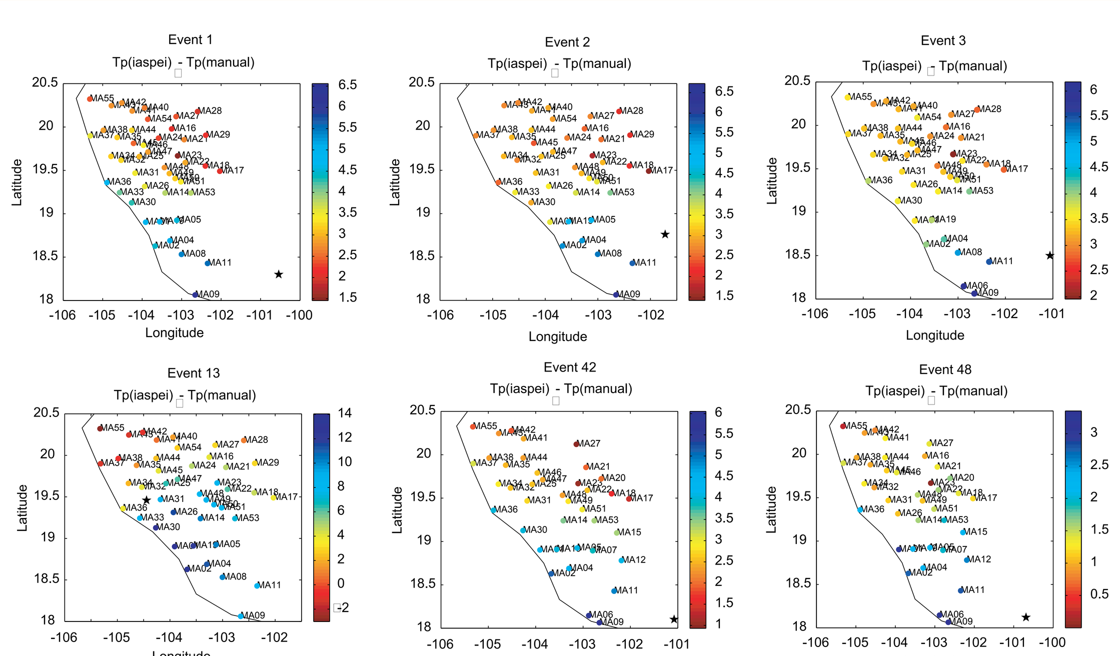
***Corresponding author: sarad@gps.caltech.edu**

Abstract

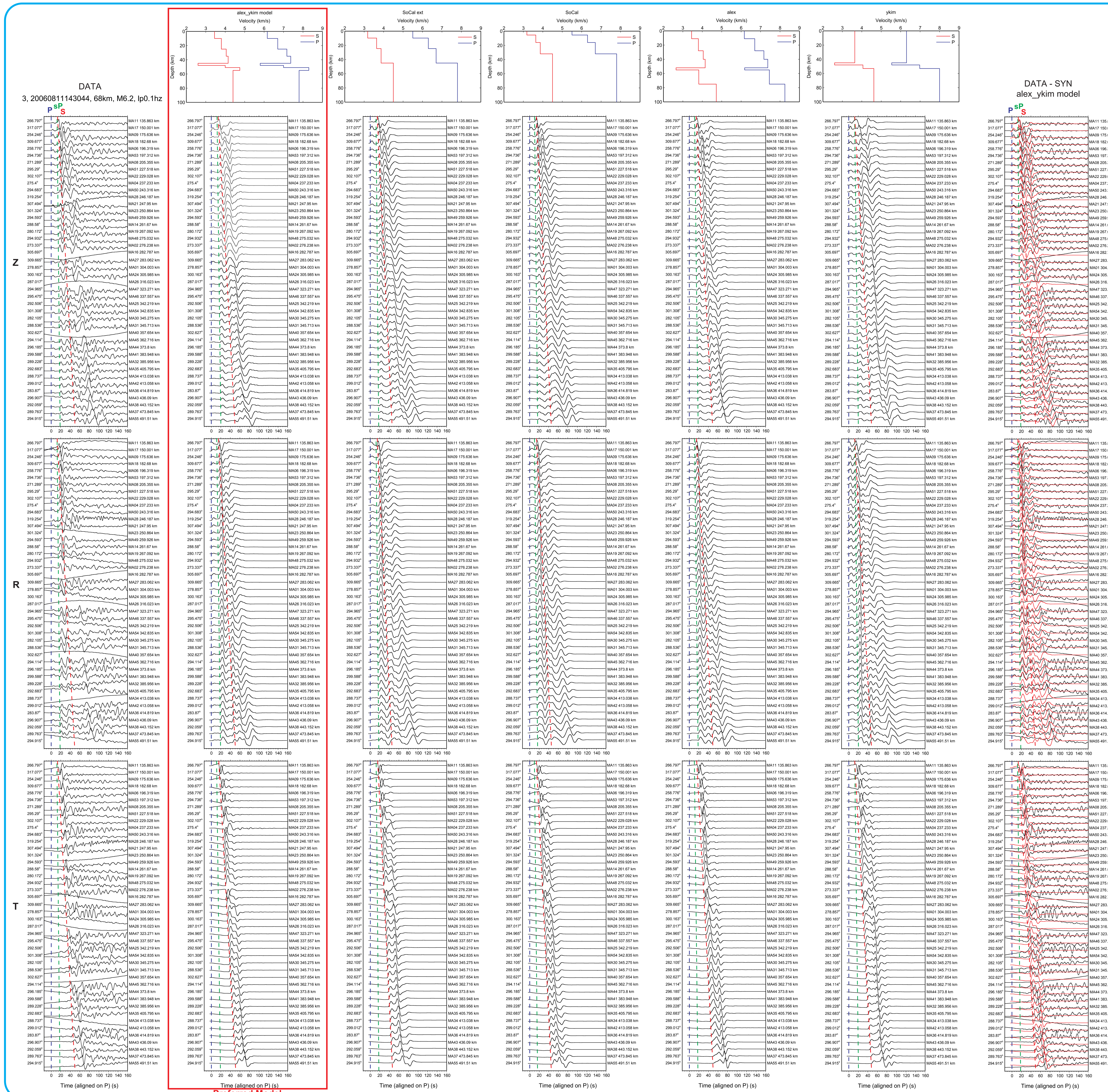
The seismic structure of the central Mexico subduction zone, particularly the interface between the slab and overriding plate, is studied using shallow (~40-90 km) intraslab earthquakes of moderate magnitude (M4-7). Regional waveforms from the Mapping the Rivera Subduction Zone (MARS) seismic array are complicated and contain detailed information about the subduction zone structure. Identification of seismic phases, their arrival times, and any possible complexities in their waveshapes provide evidence of lateral variations in structure. The detailed waveform information obtained is used to model the structure of the subducted plates, particularly in the Rivera-Cocos plate boundary region, where recent studies have shown evidence for possible slab tearing. Initial 1D modeling is conducted in order to learn more about the origin of seismic phases present in the data. A sensitivity test is performed in which synthetic waveforms produced using five different 1D models are compared to observed waveforms. The results of this test show that no single model can accurately predict all of the major seismic phases at all distances, but individual models fit the data well in particular distance ranges. These 1D models will be combined and fine-tuned in 2D forward modeling in order to provide a more accurate representation of the lateral variations in the subduction zone structure.



Regional tectonic map of the central Mexico subduction zone including locations of MARS, Middle America Subduction Experiment (MASE), and Servicio Sismologico Nacional (SSN) seismic stations. The locations of the Orozco Fracture Zone (OFZ), Middle America Trench (MAT), and Trans-Mexican Volcanic Belt (TMVB) are also indicated. Subducted slab isodepth contours from *Pardo and Suarez* (1995).



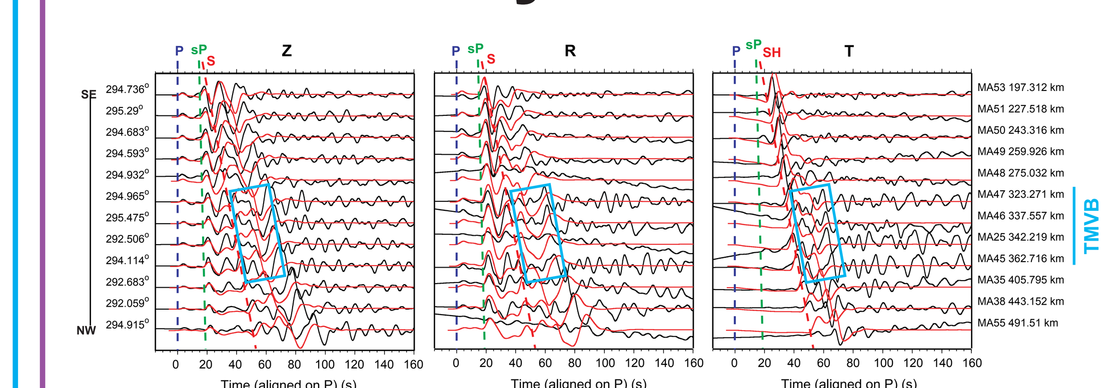
Mapping of residual P-wave arrival times (in sec) relative to the iasp91 model for six events, where blue indicates structure much faster than the model and red indicates structure slower than or approximately the same as the model prediction. Note the strong fast anomaly focused within and east of the Colima graben, south of the TMVB, in the Rivera-Cocos plate boundary region. This fast anomaly may be indicative of the shallow Cocos slab and its termination to the west may represent the Rivera-Cocos plate boundary.



1D Modeling Results

The sensitivity of observed waveforms to subduction zone structure is tested in 1D using five different models. The synthetics produced from each of these models are compared to the data in order to assess how well the model predicts major seismic phases. The model output for all three seismic components are ordered from left to right by decreasing accuracy. While no single model can accurately predict all of the major seismic phases at all distances, individual models fit the data well in particular distance ranges. Overall, the alex_ykim model provides the most accurate prediction of the data, with the best fits to P, sP, and SH phases at all distances, along with an S-wave multiple at large distances. The SoCal model provides a comparable fit to these phases, but fails to predict some of the waveform complexities seen in both the data and the alex_ykim model, such as the "shoulder" following SV. The uppermost slab structure in the alex_ykim model, particularly the ultra-slow velocity layer, is likely responsible for reproducing the observed waveform complexities that the simpler SoCal model fails to predict.

Array Profile



Profile across the MARS array along NW-SE line using the alex_ykim model. Data are in black, synthetics are in red. Model synthetics predict P and sP waveforms reasonably well at all distances, as well as SH arrivals. For stations located within the TMVB, complex waveforms are observed after the arrival of the S-wave in the data (indicated by blue box) and are most prevalent on the transverse component. These complexities are not predicted by the model synthetics and may be indicative of a change in crustal structure within the TMVB region.

Future Work

-Perform backprojection analysis of P-wave travel time residuals in order to locate and identify observed high velocity structure.

-Combine and perturb 1D models in forward modeling of the 2D structure using a finite-difference algorithm in order to provide constraints on the thickness, velocity, and geometry of each slab's shallow seismic structure in this region. Of particular interest is the region where the slab transitions from flat to normal dip angles near the Orozco Fracture Zone, where slab tearing may have occurred.

-Incorporate regional waveforms from the contemporaneous MASE array in all modeling efforts.

References

Kim, Y., R. W. Clayton, and J. M. Jackson (2010), Geometry and seismic properties of the subducting Cocos plate in central Mexico, *J. Geophys. Res.*, **B06310**, doi:10.1029/2009JB006942

Pardo, M., and G. Suarez (1995), Shape of the subducted Rivera and Cocos plates in southern Mexico: Seismic and tectonic implications, *J. Geophys. Res.*, **100** (B7), 12357-12373

Song, T. A., D. V. Helmberger, M. R. Brudzinski, R. W. Clayton, P. Davis, X. Perez-Campos, and S. K. Singh (2009), Subducting slab ultra-slow velocity layer coincident with silent earthquakes in southern Mexico, *Science*, **324**, 502-506

Acknowledgements

The focal mechanism, event depth, and event magnitude used in the 1D modeling were provided by Vanessa Andrews. Special thanks to the Gordon and Betty Moore Foundation for their support.