Seismic structure in central Mexico: Possible fragmentation of the subducted South Cocos plate

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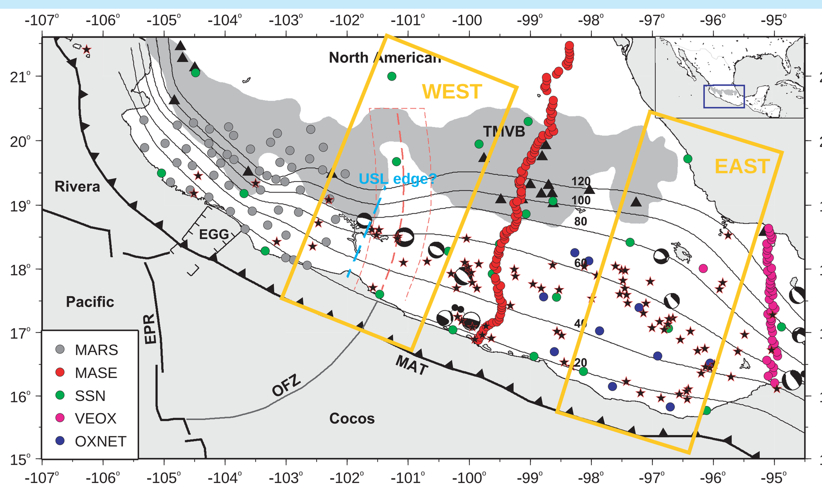
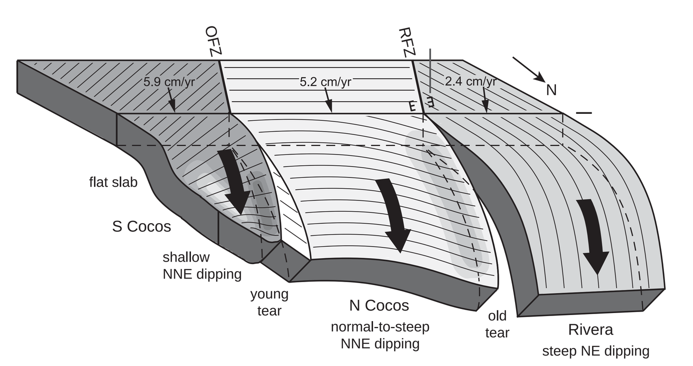
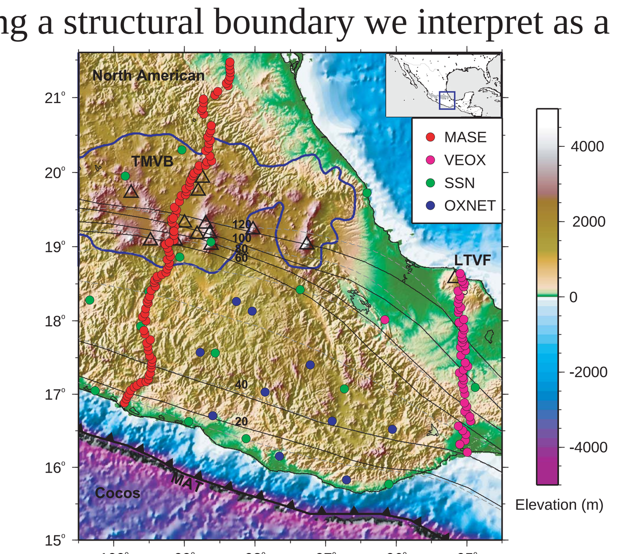
I. Background



The fine-scale seismic structure of the subducted plate along the transitions from flat to normal subduction (orange boxes) is studied using moderate-sized (M4-6) intraslab earthquakes recorded by these arrays: MARS, MASE, VEOX, SSN, and OXNET. Our previous structural modeling found an edge to the ultra-slow velocity layer (USL) that is approximately coincident with the western margin of the projected Orozco Fracture Zone (OFZ) region, indicating a structural boundary we interpret as a plate tear.

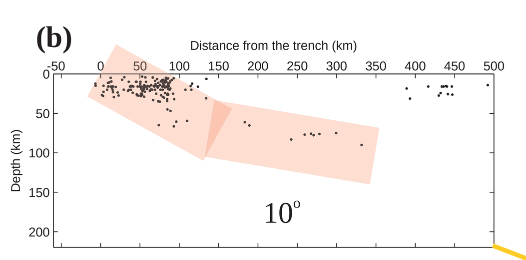


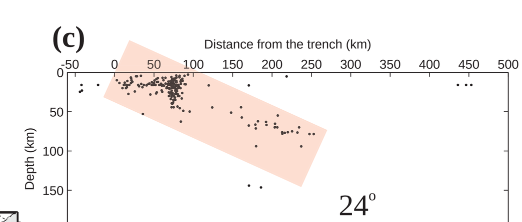
3D schematic of our two-tear model wherein the Cocos slab is currently fragmenting into a North Cocos plate and a South Cocos plate along the eastern projection of the OFZ (*Dougherty et al., JGR, 2012*).

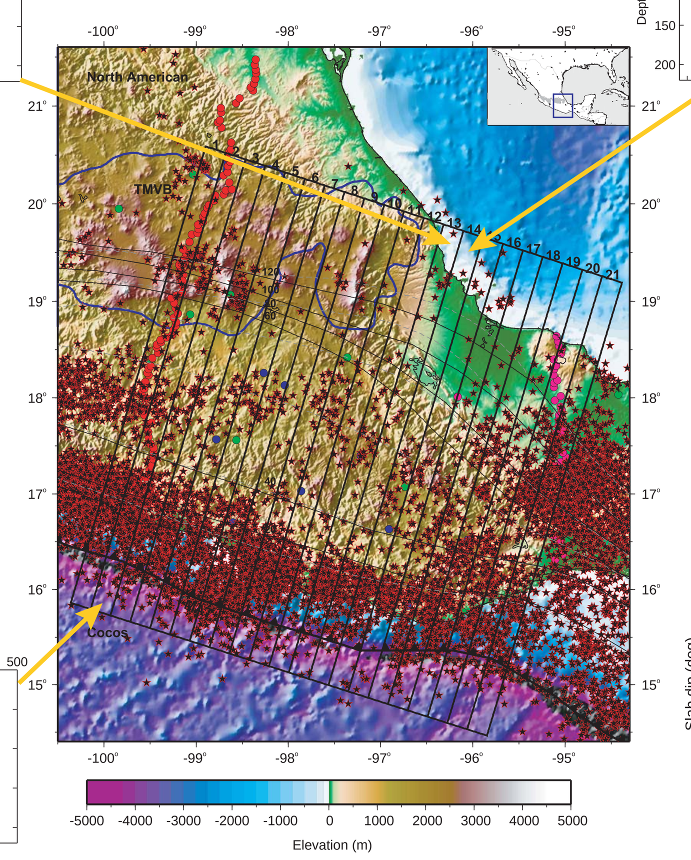


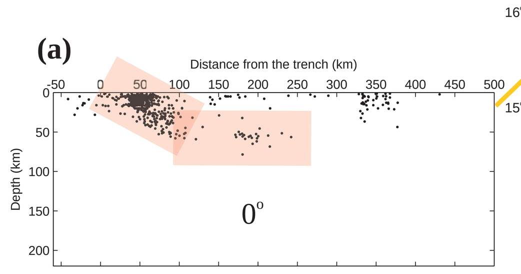
In the east, the abrupt end of the TMVB and the interruption of arc volcanism suggest a second possible slab tear located within the South Cocos plate.

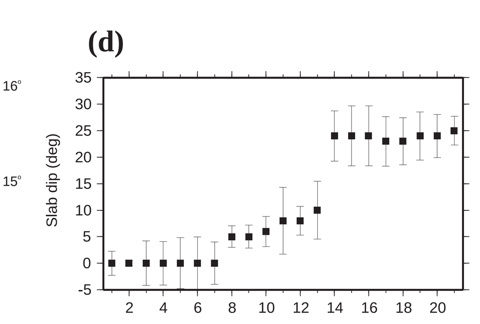
II. Slab Dip









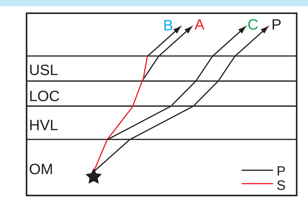


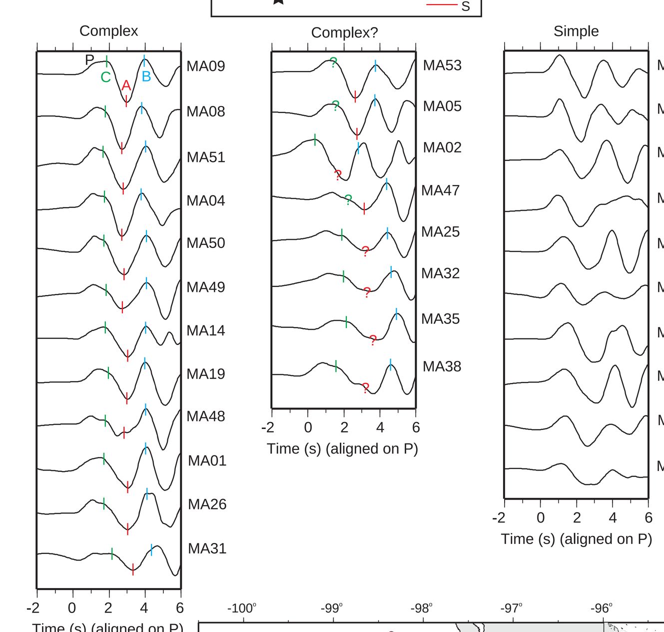
Examination of lateral variations in slab dip across the transition from flat to normal subduction located to the east of the MASE array. Seismicity from the 2001-2011 SSN event catalog is divided into twenty-one 25 km wide bins roughly perpendicular to the trench. Cross-sections of seismicity in bins (a) 2, (b) 13, and (c) 14 are shown. The slab is flat beneath the MASE array, with it's dip gradually increasing to 10° by bin 13. Between bins 13 and 14 there is a sharp increase in slab dip of 14°, which may indicate a possible slab tear in the South Cocos plate. (d) Plot of slab dip across the data bins. Error bars are weighted by the number of events in each bin.

Acknowledgements

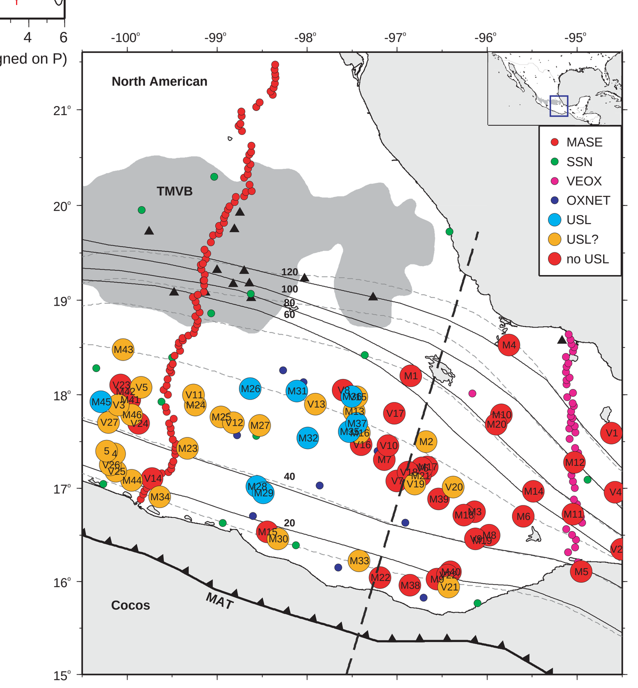
Special thanks to the Gordon and Betty Moore Foundation for their support.

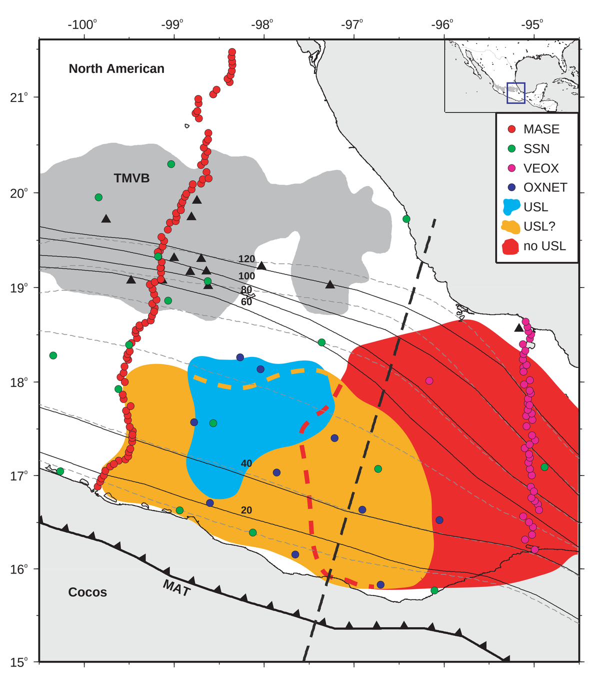
III. Ultra-slow Velocity Layer





(Top) Schematic illustrating the ray paths of the P-wave and the three S-to-P phases (A, B, C) that comprise the complex P waveform, which is used to identify the presence of the USL. (Bottom) Examples of complex (left), possibly complex (middle), and simple (right) P waveforms from the MARS array. All three S-to-P phases are visible in the complex waveforms within 4 sec of the P-wave. Questions marks on the possibly complex waveforms indicate a phase that is not easily identified. Simple waveforms lack the shoulder in the direct P pulse indicative of the C phase and also have uncharacteristic A and B phases, indicating there is no USL present.

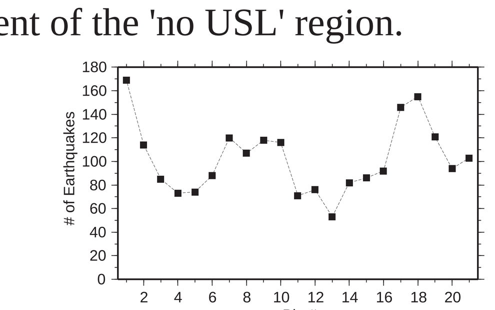


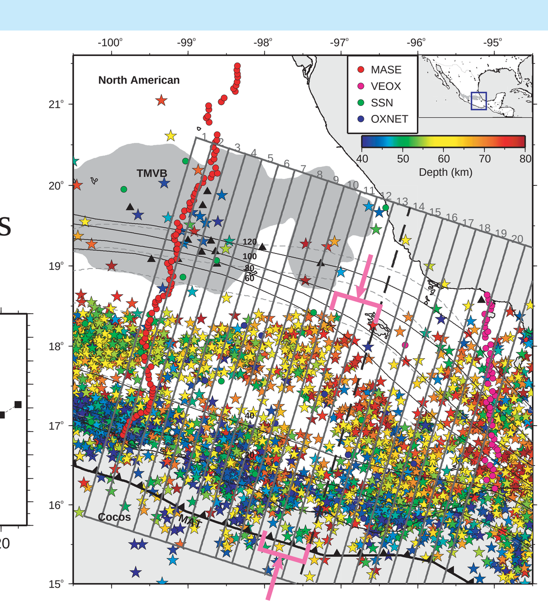


(Left) Mapping the eastern lateral extent of the USL using MASE, VEOX, and SSN waveforms to test if the USL ends along a lineament related to the potential slab tear. Events which indicate the presence of the USL are shown in cyan. Those which possibly indicate the USL is present are shown in orange. Red events indicate no USL is present. (Right) Shaded contours of USL, possible USL, and no USL zones.

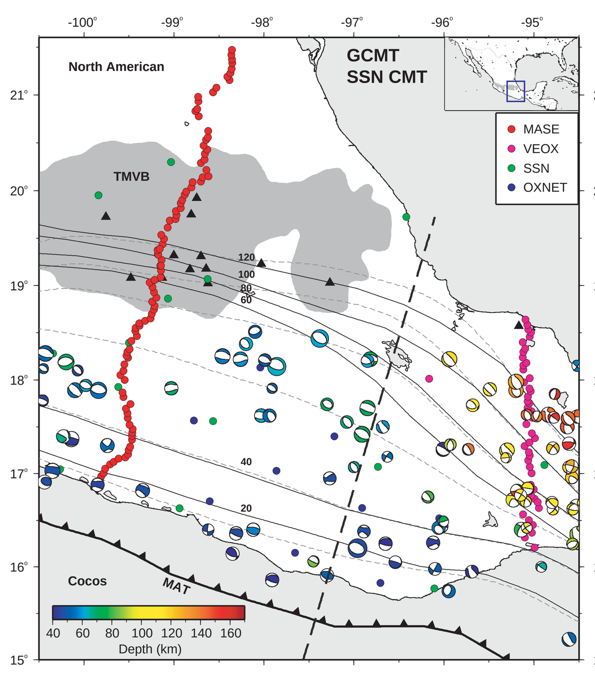
IV. Seismicity

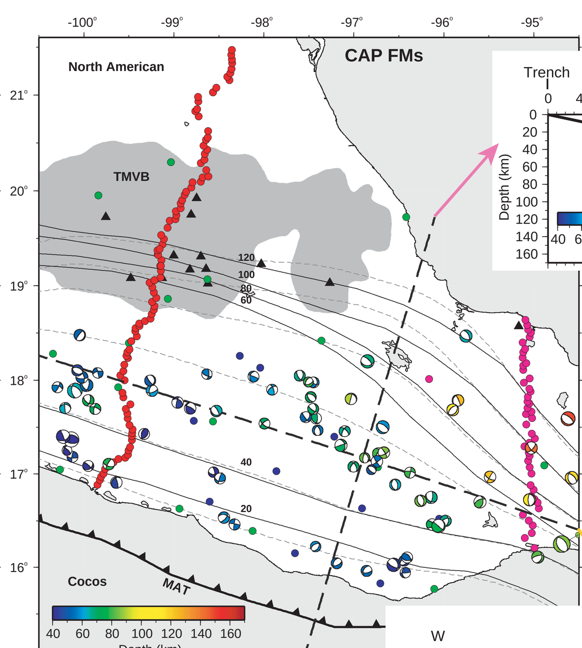
Intraslab seismicity (40-80 km depth) from the 1900-2012 ISC event catalog. A ~50-75 km wide zone of decreased seismicity (pink brackets) is shown along the western side of the sharp transition in slab dip and may indicate a change in structure. This zone coincides with the western extent of the 'no USL' region.

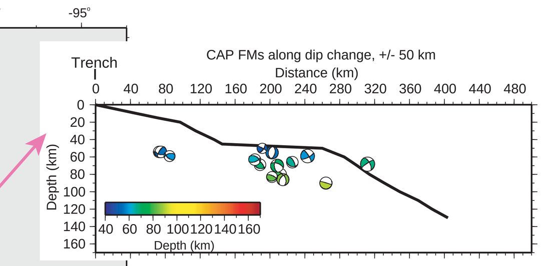




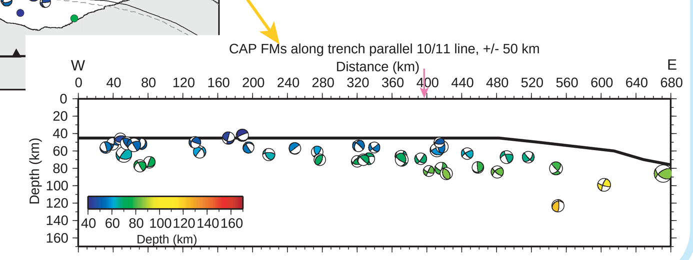
Comparison of GCMT and SSN CMT catalog solutions (left) with focal mechanism results from CAP (right).





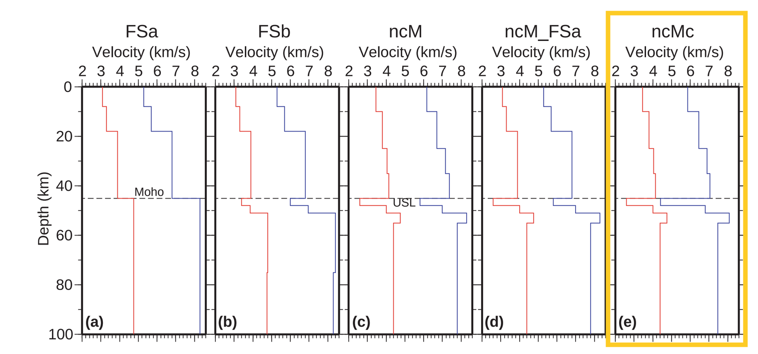


Trench-normal (top) and trench-parallel (bottom) cross-sections showing CAP focal mechanisms for events located within 50 km of the respective profile.

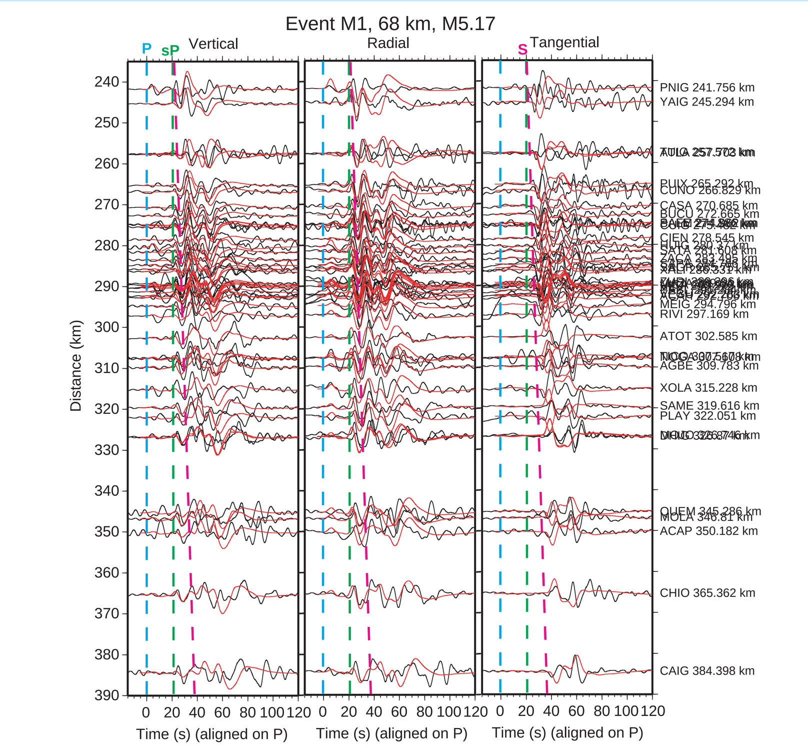


There is no evidence for "tearing events" in the GCMT and SSN CMT catalogs. Analysis of CAP focal mechanisms is ongoing.

V. 1D Velocity Modeling

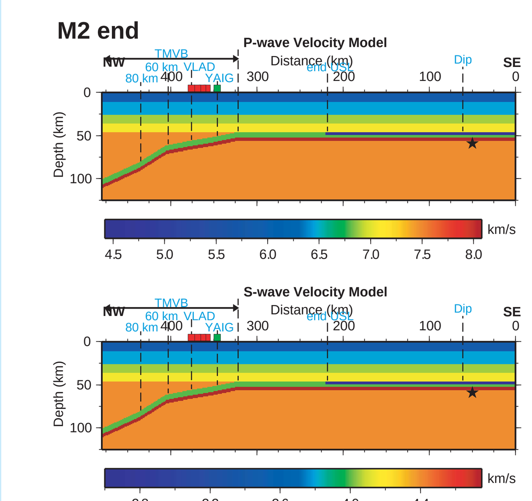


FSa: *Furumura and Singh (2002)*, no slab **(best Z)**
FSb: *Furumura and Singh (2002)*, with slab
ncM: *Dougherty et al. (2012)* **(best R)**
ncM_FSa: FSa overriding plate, ncM slab
ncMc: ncM Vs, Vp calc from FSa Vp/Vs **(best Z & R)**

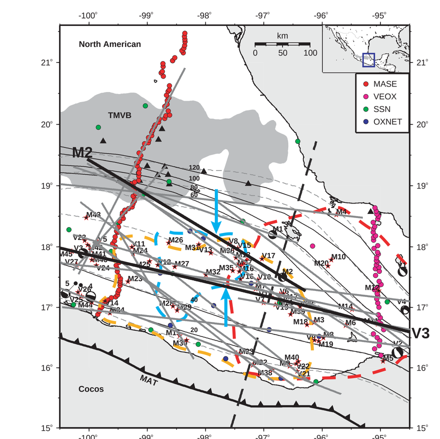


Examples of ncMc modeling results for event M1. Waveform fits are comparable to ncM model results on R and T components, with improved fits on Z. S-wave fits are improved over FSa model, however the predicted SH arrival is slow at many stations.

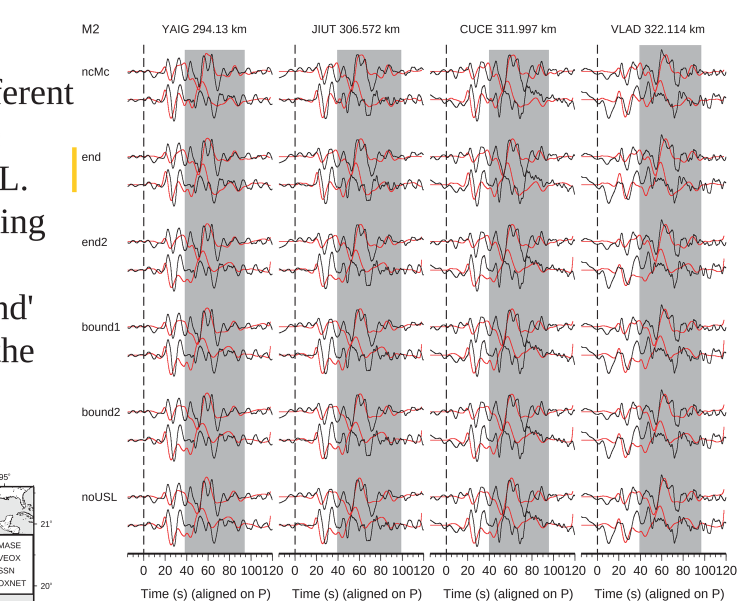
VI. 2D Velocity Modeling



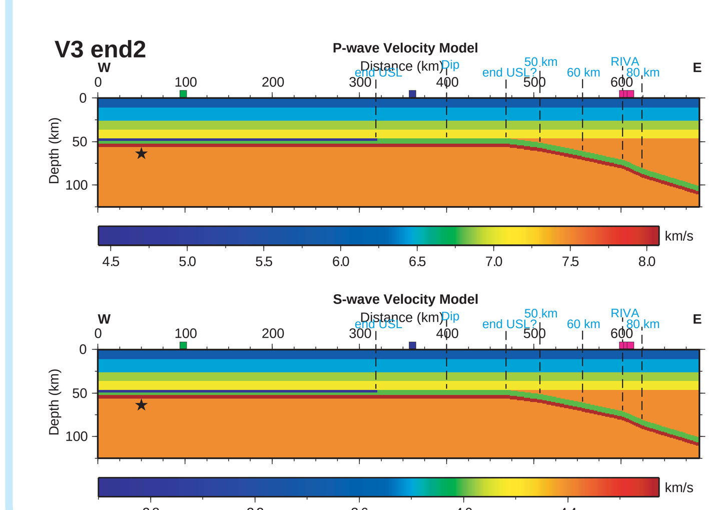
Comparison of 2D modeling results of event M2 for six different models. The primary variance among the models was the USL. Segment of waveform illustrating greatest variance among the models is shaded grey. The 'end' model provides the best fit to the data.

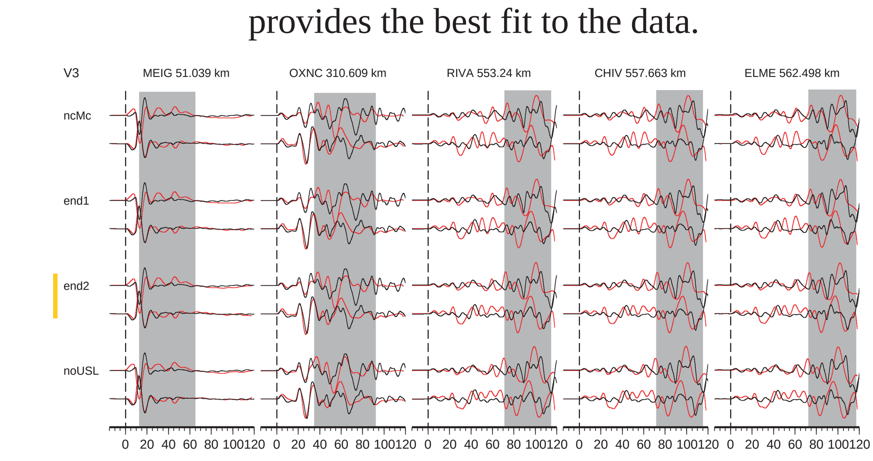


2D velocity models of the upper 125 km subduction zone structure along two different profiles: MASE event M2 (above) and VEOX event V3 (below). *P*- and *S*-wave velocities are from the ncMc model. Subducted slab shape is estimated from isodepth



Comparison of 2D modeling results of event V3 for four different models (below). The primary variance among the models was the USL. The 'end2' model provides the best fit to the data.





VII. Conclusions

-Observations of a sharp transition in slab dip near the abrupt end of the TMVB coupled with a change in waveform complexity across this zone, suggest a second possible slab tear located within the South Cocos plate.

-Mapping of the eastern lateral extent of the USL indicates a boundary between the 'USL' and 'no USL' regions which is coincident with the margin of a zone of decreased seismicity and with the end of the TMVB, suggesting a change in structure and possible slab tear.

-Analysis of 2D modeling results in order to constrain USL location is ongoing.