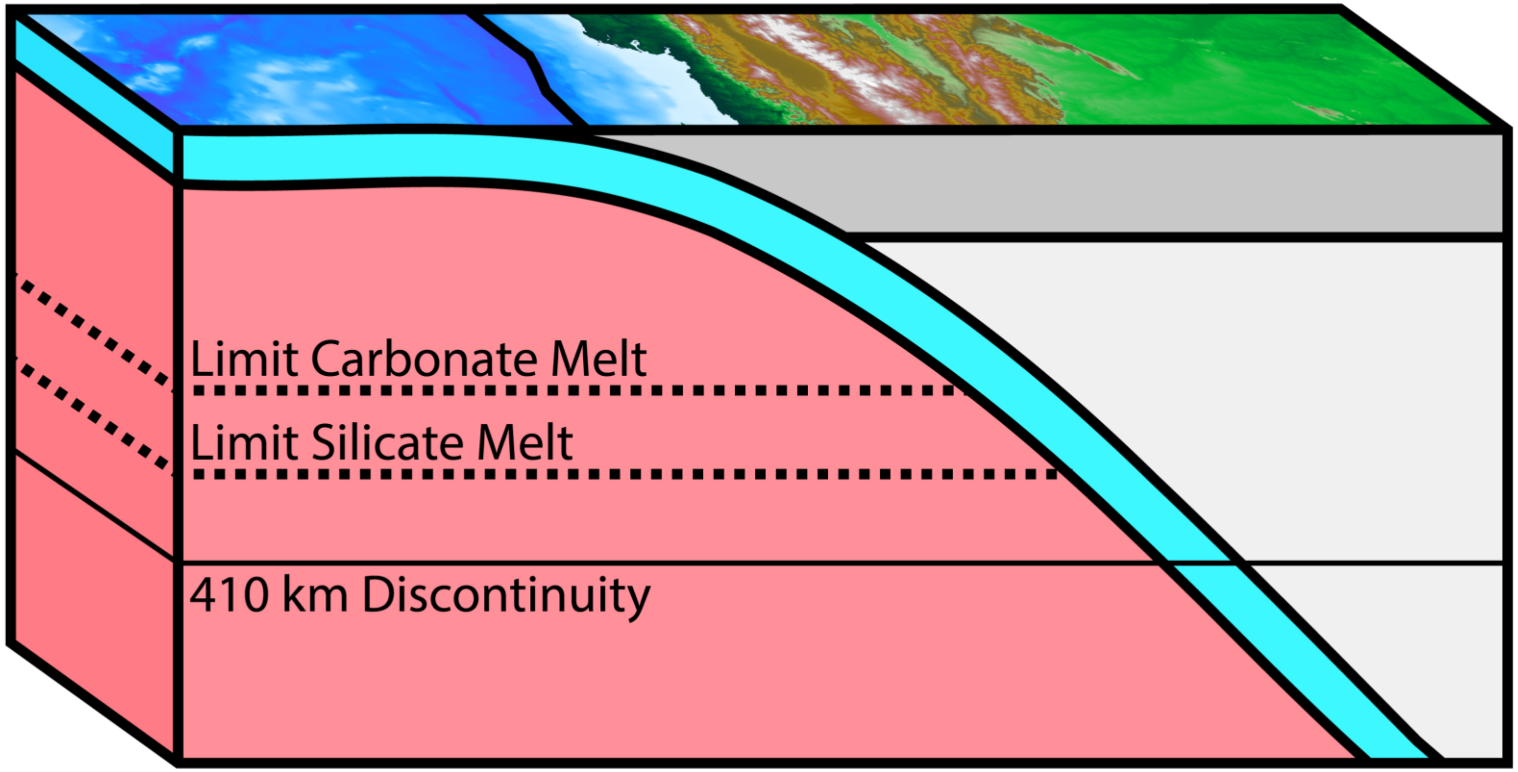
A Thick, Sheared Zone at the Base of an Oceanic Plate:

The Lithosphere-Asthenosphere Boundary of the Subducting Nazca Plate in Colombia as Revealed through P-to-S Receiver Functions



Schematic slab model (after Slab2) through southern Colombia with key depths.

Brandon Bishop[1*], Ademar Fernandez[1], Linda M. Warren[1], Patricia Pedraza[2], Germán A. Prieto[3], and Viviana Dionicio[2]

[1]Saint Louis University, Saint Louis, MO, United States
[2]Servicio Geológico Colombiano, Bogotá, Red Sismológica Nacional de Colombia, Bogotá D.C., Colombia
[3]Universidad Nacional de Colombia, Departamento de Geociencias, Bogotá D.C., Colombia

*brandon.t.bishop@slu.edu

Funding provided by
NSF EAR-2041631

AGU Fall Meeting 2022
#DI16A-08

Are Plates Coupled to the Asthenosphere?

No!

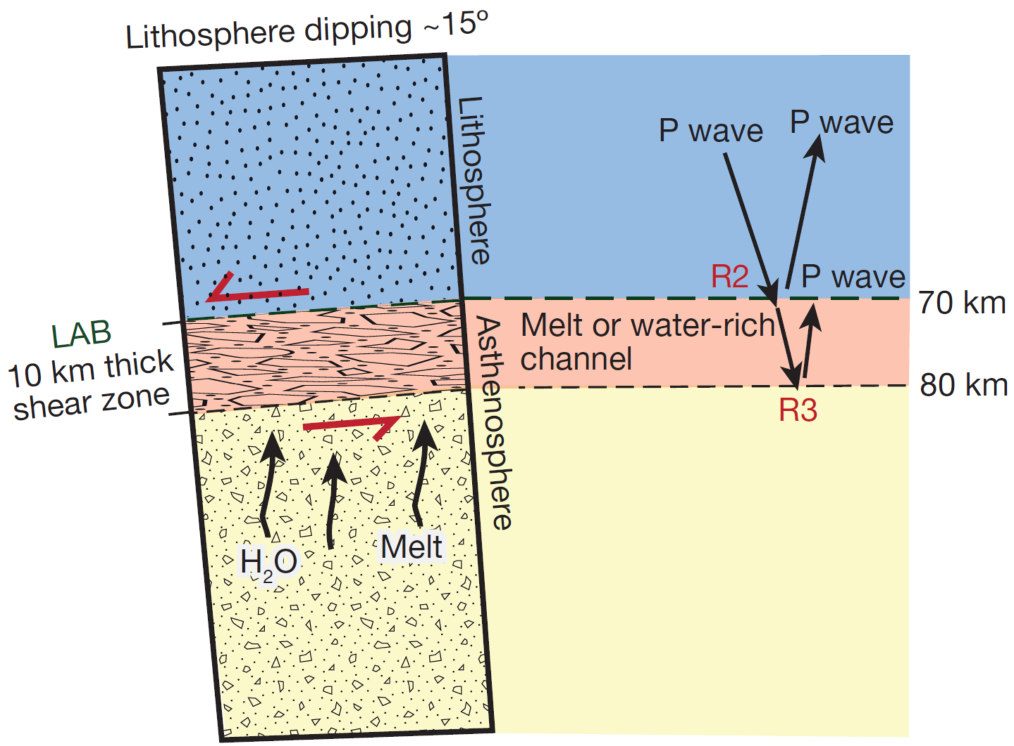


Figure from Stern et al. (2015)

Sees LAB as thin (~10 km) **channel of melt**, strongly sheared, allowing for separate motion.

Yes!

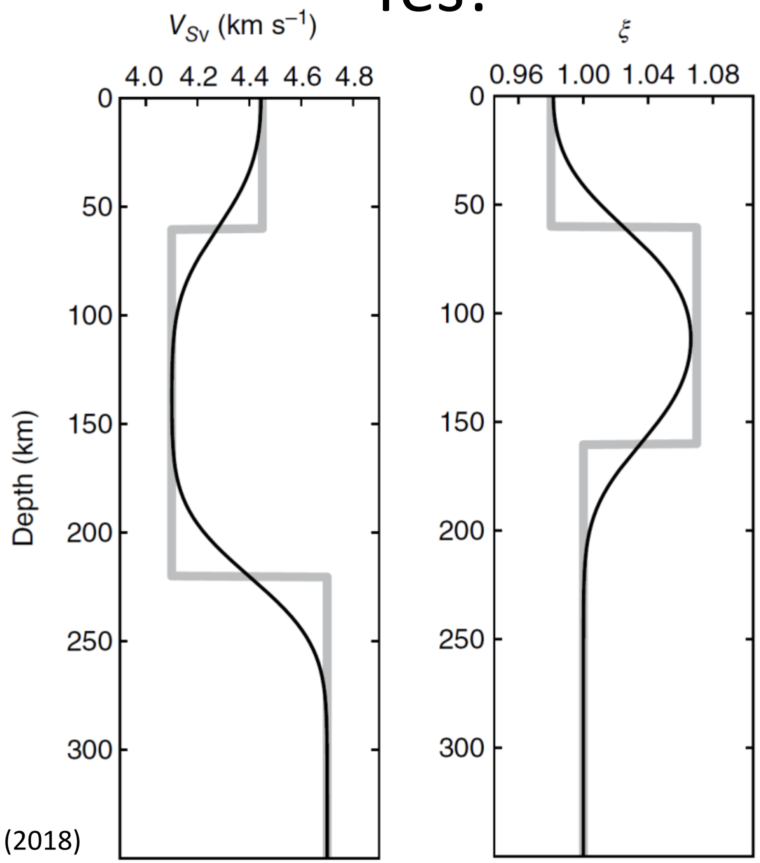
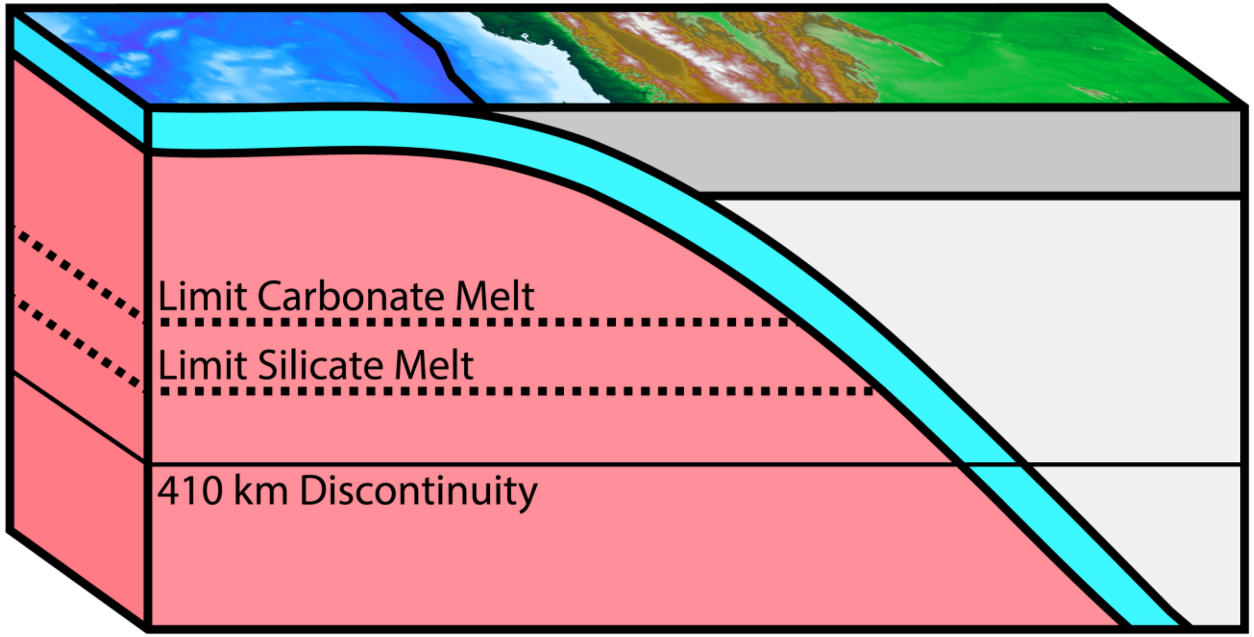


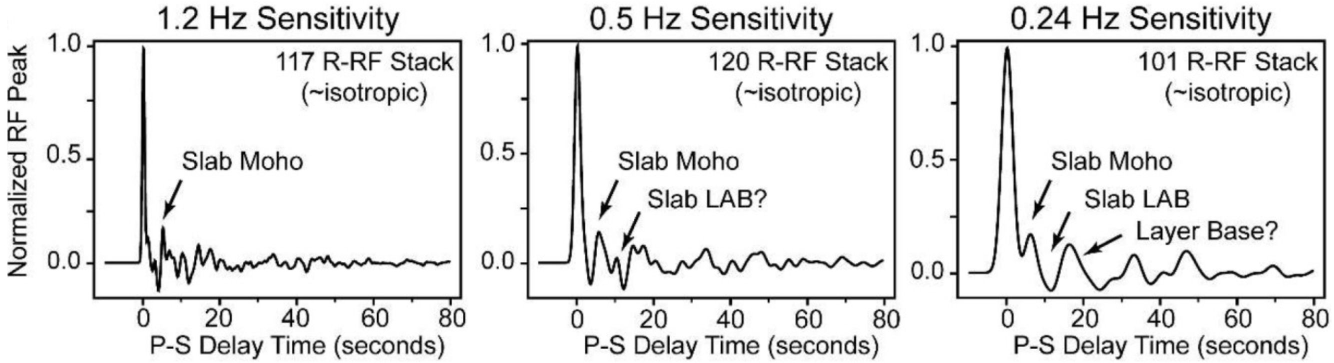
Figure from
Montagner & Burgos (2018)

Sees LAB as thick (>10 km) zone marked by **differences in anisotropy**, in part produced by joint motion.

Testing These Models at Subduction Zones



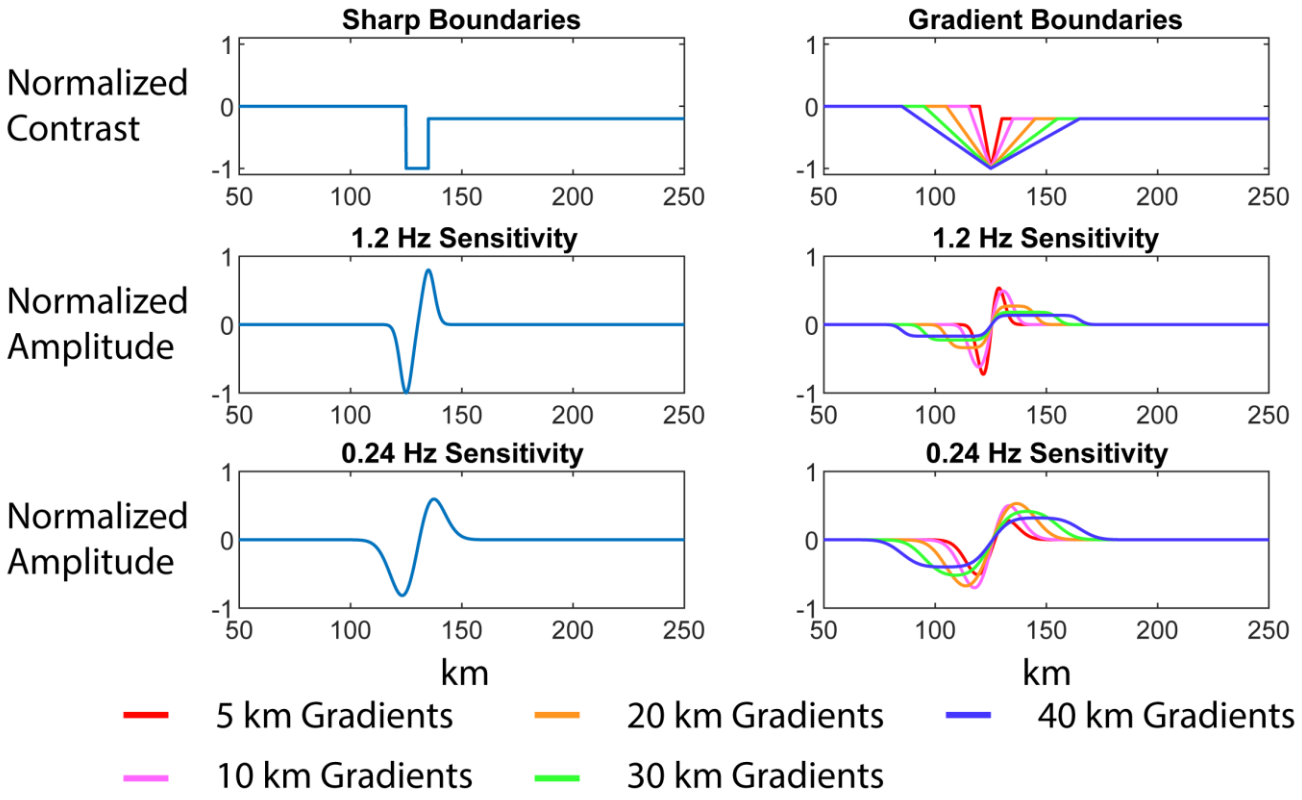
Slab after Slab2 (Hayes et al., 2018), melt limit from Stagno et al. (2013), Dasgupta et al. (2013), Kawamoto (2004)

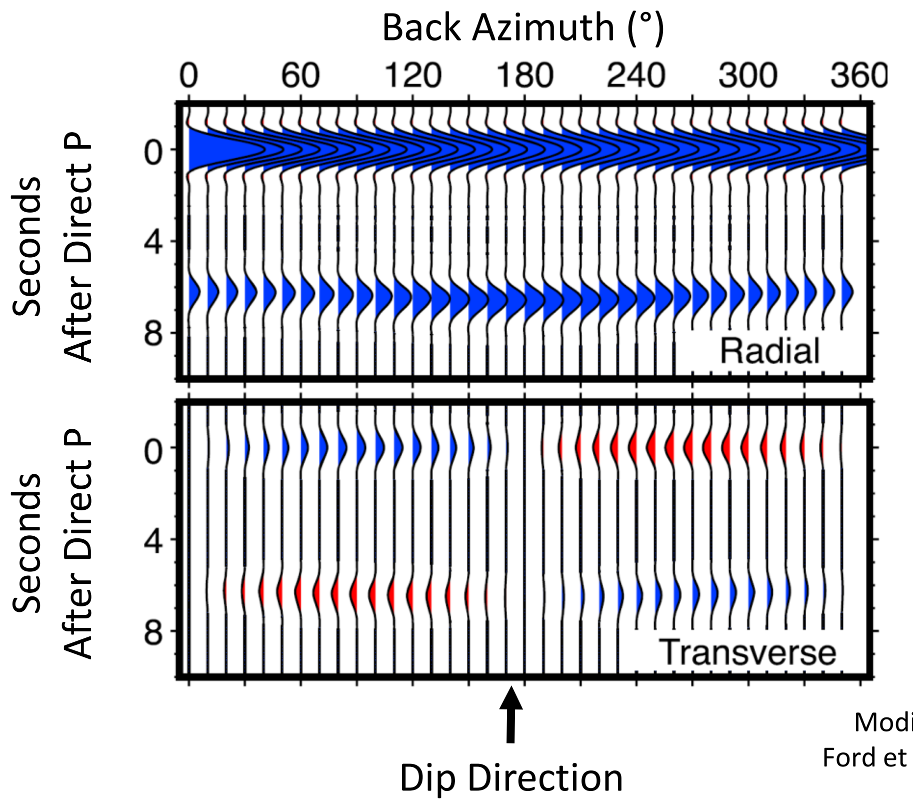


- Decoupled Models:
  - Melt solidifies by ~250 or ~330 km
- Strongly Coupled Models:
  - Anisotropy contrast should shift in transition zone
  - Ductile mechanisms change ~250 km

- Receiver functions sensitive to a seismic discontinuity's abruptness, and P-to-S RFs detect anisotropy

Detection Alone Can Tell Us Enough to Test LAB Models





Modified from
Ford et al. (2016)

All frequency bands sensitive to sharp boundaries of a channel.
1.2 Hz band only sensitive to <10 km gradient boundaries.
0.24 Hz band most sensitive to 10-30 km gradient boundaries.

Anisotropy effects are complicated!
But as the slab dips in a known direction, departures from dipping layer patterns must be due to anisotropy.

Nazca Slab in Colombia is an Excellent Test Case

- Broadband seismic network stretching from coast to back-arc
- Regional and Global tomography shows continuous slab from trench through mantle transition zone
- Young Oceanic Plate Endmember
- Contrasting anisotropy in lithosphere and in asthenosphere likely

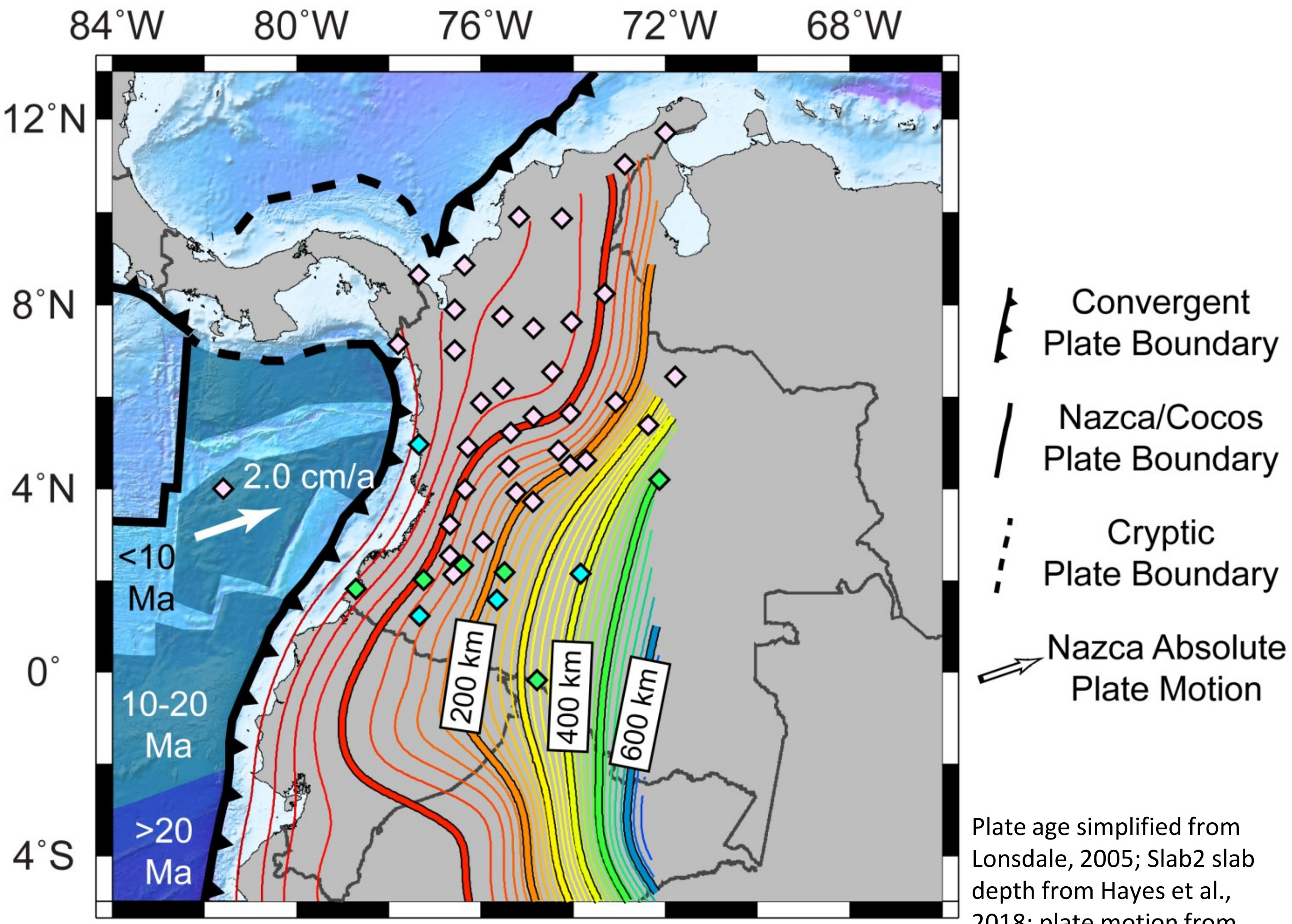
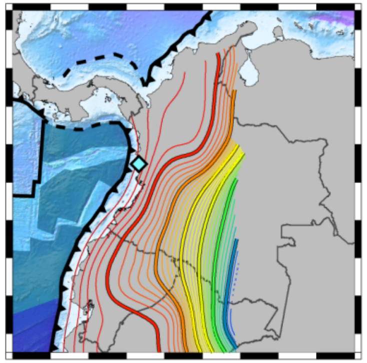


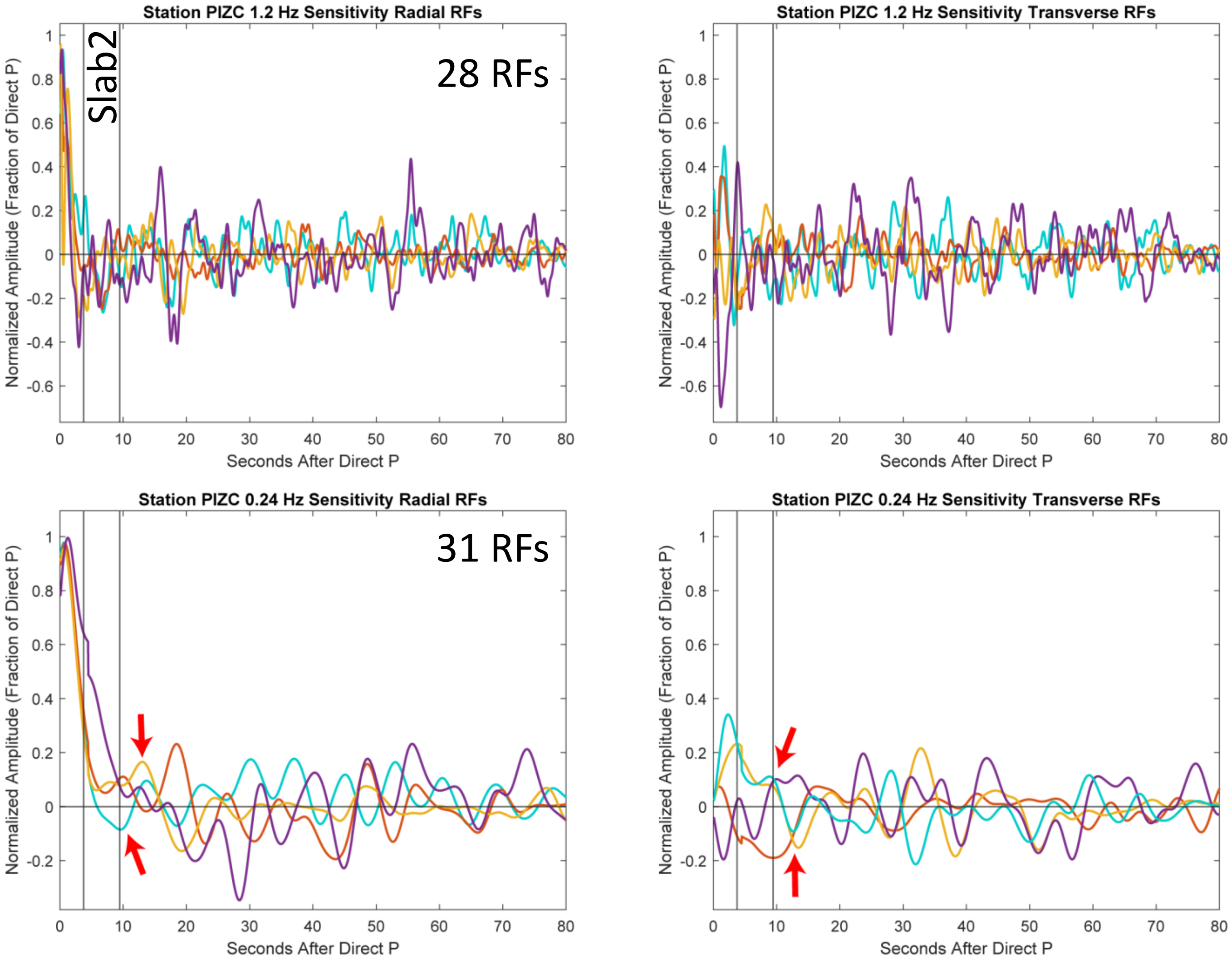
Plate age simplified from Lonsdale, 2005; Slab2 slab depth from Hayes et al., 2018; plate motion from Gripp and Gordon, 2002.

PIZC: Initial Subduction

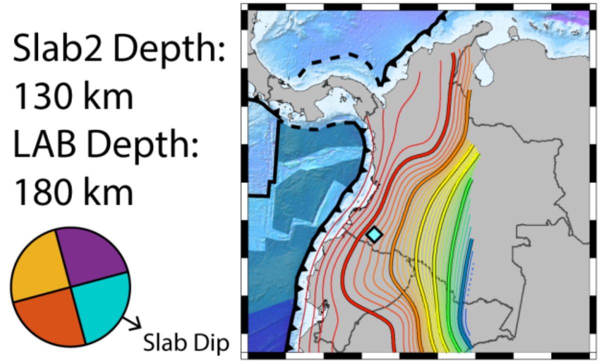
Slab2 Depth:
30 km
LAB Depth:
80 km



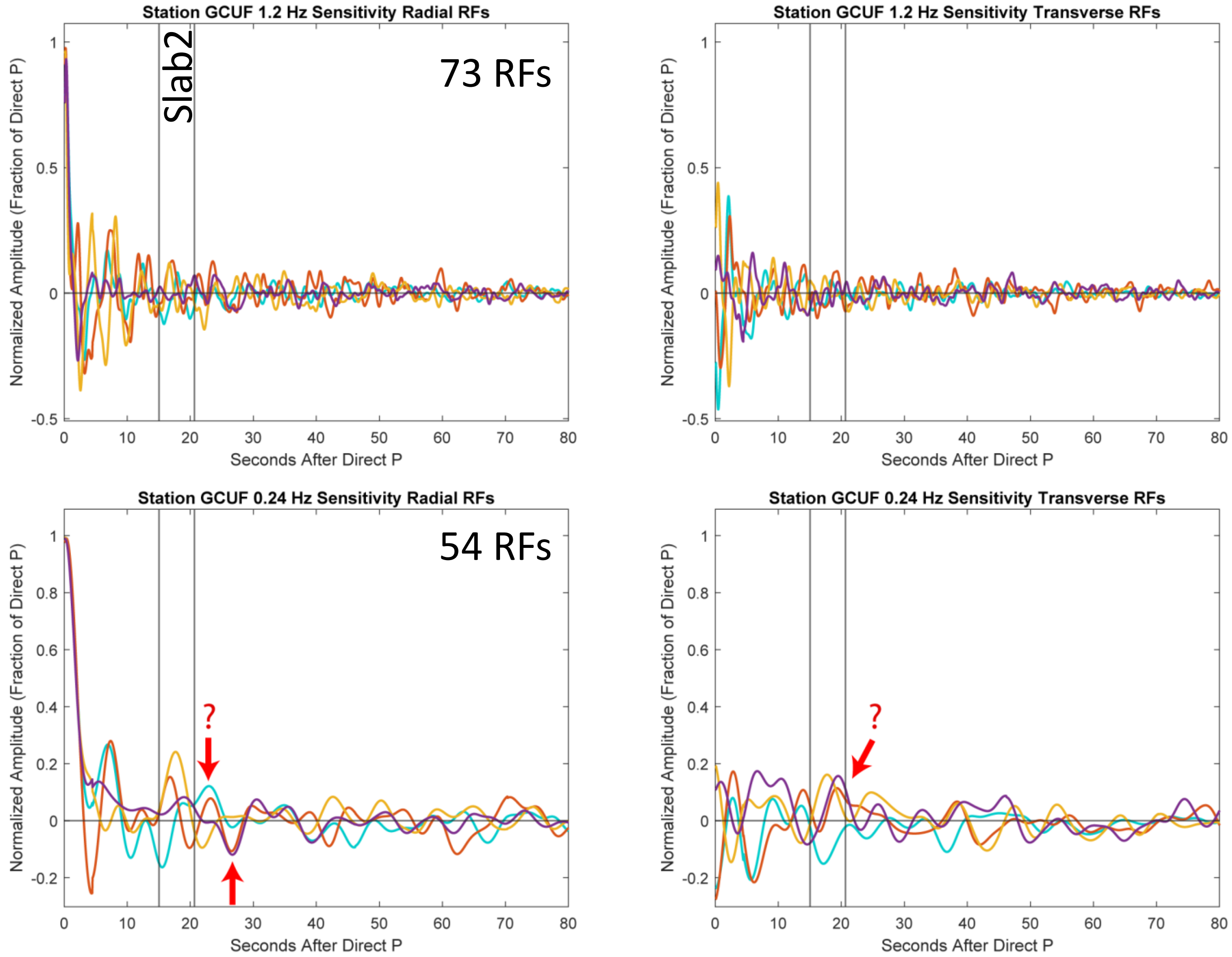
- Moveout Corrected, Quadrant Stacked RFs
- Slab Top clear on 1.2 Hz band Slab LAB clear on 0.24 Hz band
- Slab top matches known depth from active source, LAB ~50 km below that
- Transverse in up, down dip not explainable by dipping layer alone
- Additional arrival ~4 seconds later may be bottom of sheared material



GCUF: Volcanic Arc

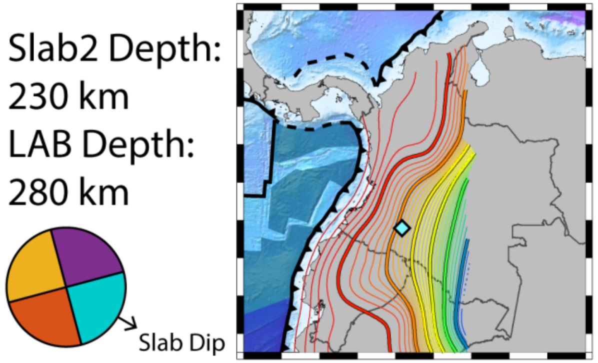


- Slab LAB on 0.24 Hz Band, but may be complicated by artifacts?
- Energy on 0.24 Hz Band not significantly present ~4 seconds beyond expected LAB depth
- Transverse difficult to interpret, but not a match for simple dipping model

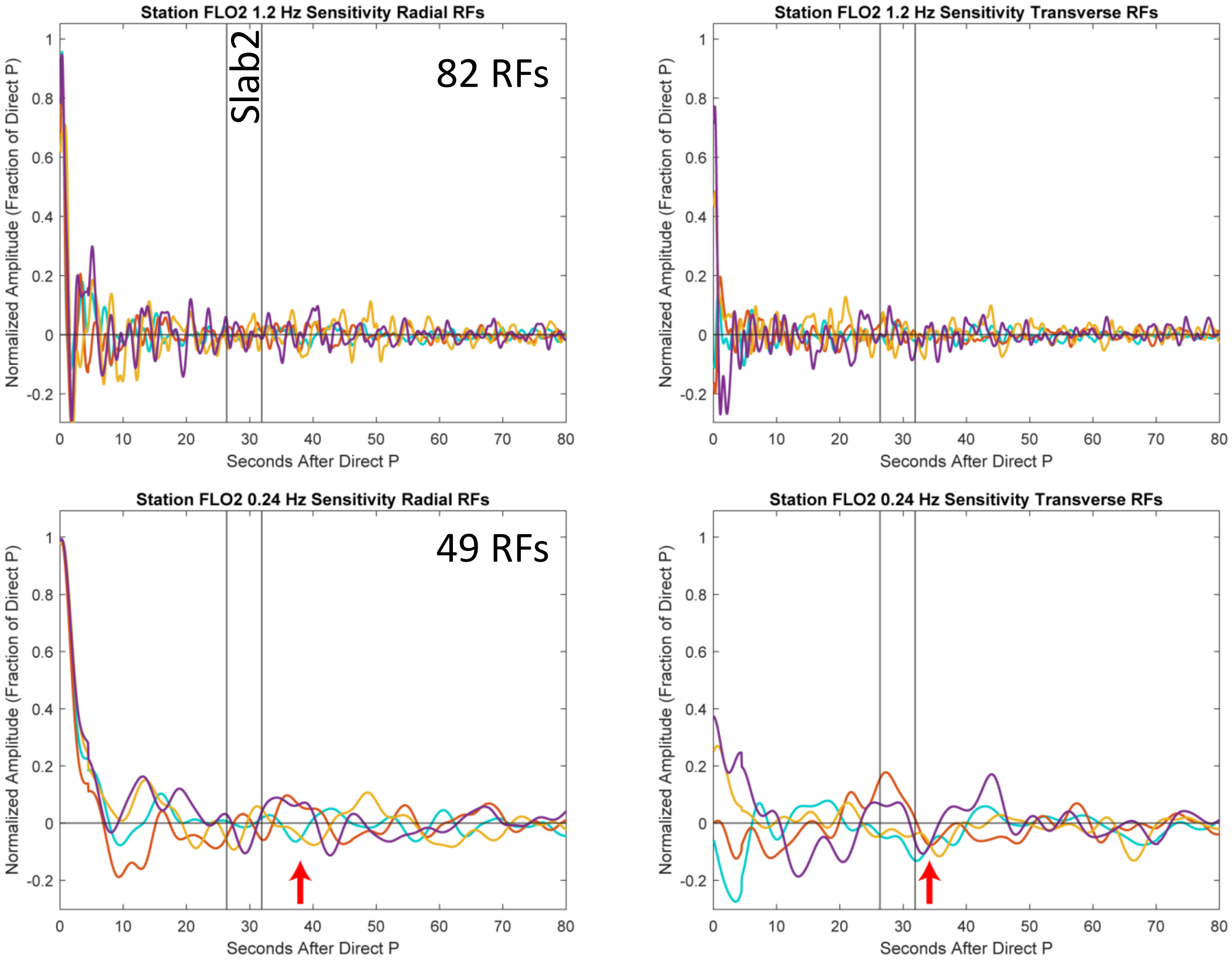


FLO2: Mid-Upper Mantle

Slab2 Depth: 230 km
LAB Depth: 280 km

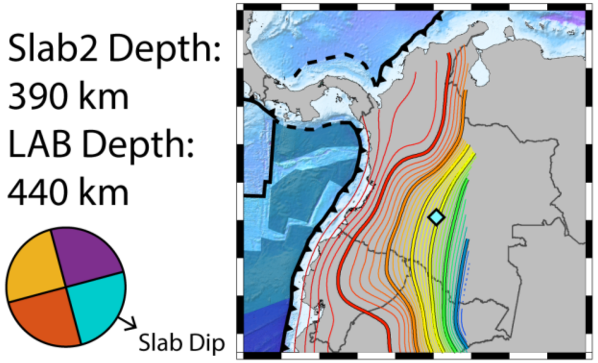


- Supra-slab, immediately sub-slab arrivals on 0.24 Hz Band
- Weak downdip radial, strong transverse expected from prior RF modeling* of steep (~40°) interface
- Uniformly negative transverse not explainable by dipping layer alone



*Eckhardt and Rabbel, 2011

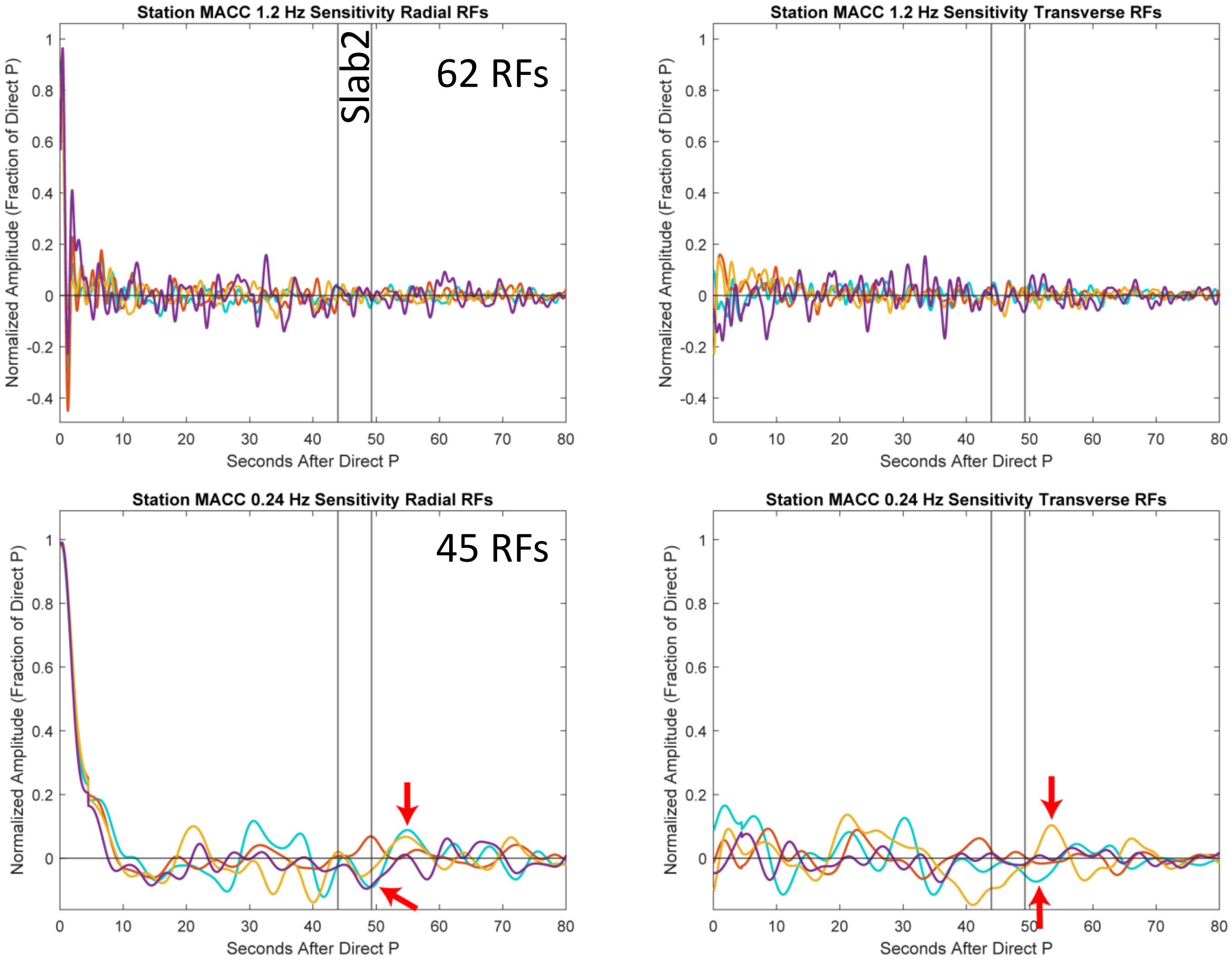
MACC: Mantle Transition Zone

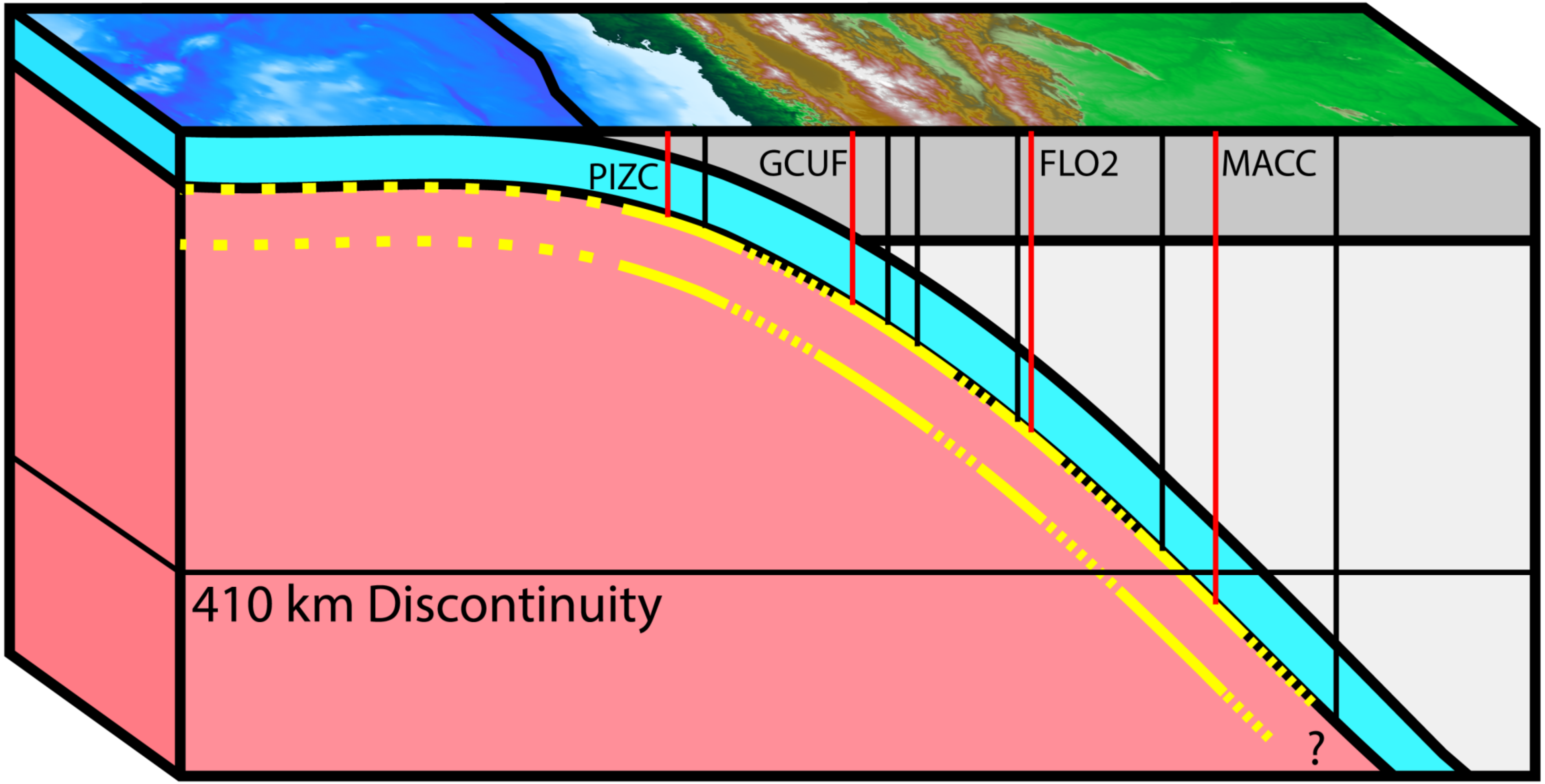


- Negative arrival in 0.24 Hz Band at expected LAB in Radial, including otherwise quiet North/South

- Positive arrival on up-dip, down-dip in 0.24 Hz Band near ~55 seconds should be clear of 410 or 660 interference

- Transverse somewhat noisy





There is no evidence for a melt rich channel beneath the young Nazca Slab. The Nazca Slab's LAB signal is consistently with a pair of signals 4-5 seconds apart, a spatial separation of 40 to 50 km, both may weaken ~550 km depth. This is likely caused by anisotropic contrasts bounding a sheared, coupled zone.