S14A-05

Constraints on radial anisotropy in the central Pacific upper mantle from the NoMelt OBS array

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OBSIP
OCEAN BOTTOM SEISMOGRAPH INSTRUMENT POOL

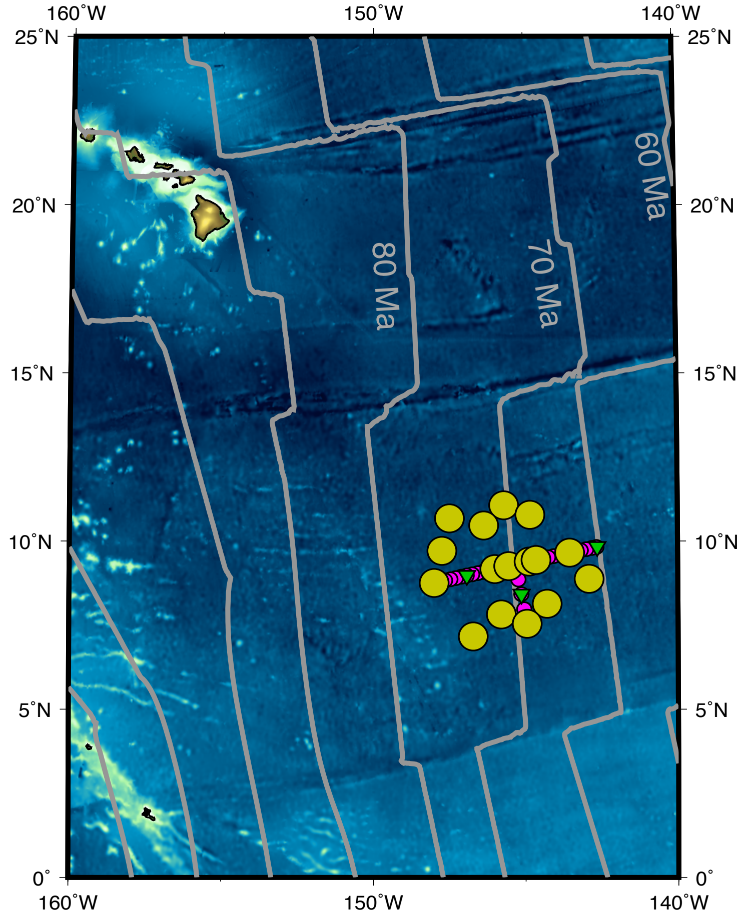
NoMelt Experiment

Situated on relatively pristine oceanic lithosphere (~70 Ma)

One year of continuous data collected in 2012

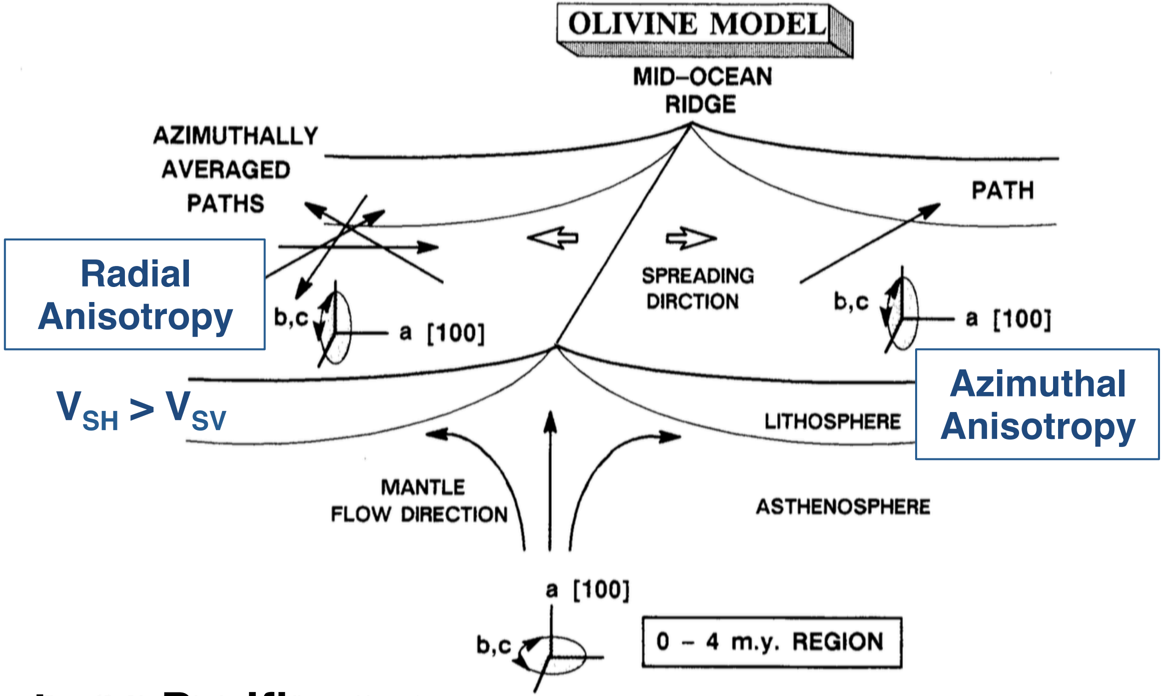
600x400 km footprint

- – 16 broad-band OBS
- – Short-period OBS
- – Magnetotelluric array



Motivation

- Azimuthal and radial anisotropy constrain flow patterns within the mantle
- Previous observations of anisotropy in the lithosphere beneath ocean basins are consistent with horizontally aligned olivine fabric associated with seafloor spreading
- Inconsistencies remain between recent regional and global models of radial anisotropy in the lithosphere



NoMelt provides new constraints on Pacific mantle anisotropy, measured at a local scale.

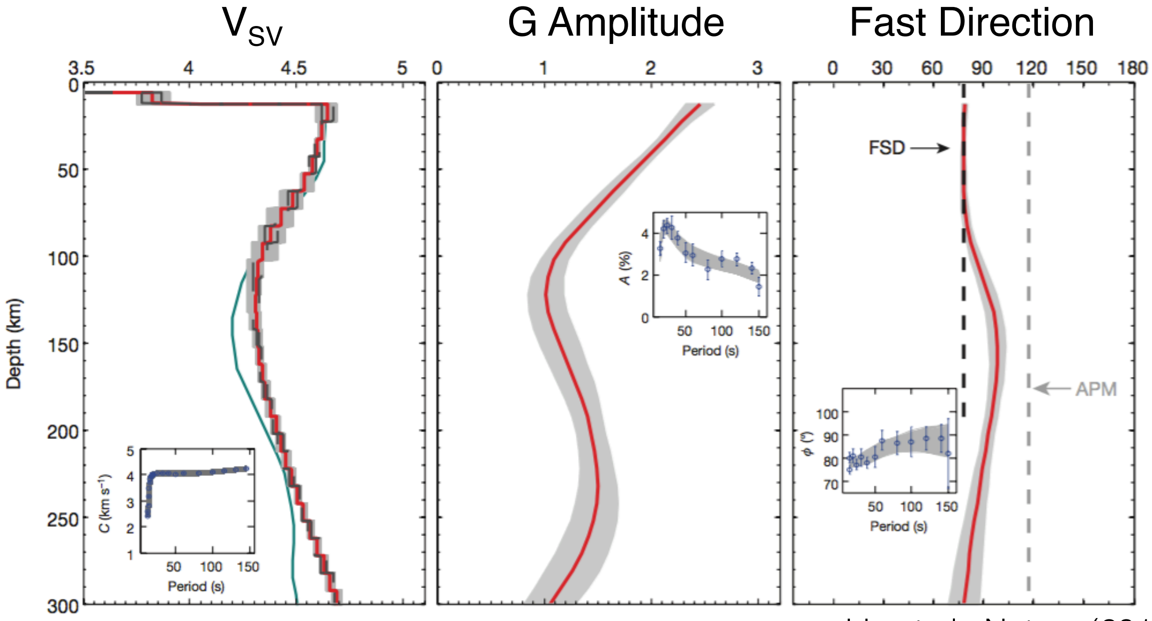
Nishimura & Forsyth, 1989

NoMelt azimuthal anisotropy

Azimuthal variation of Rayleigh wave phase velocities oriented parallel to the fossil spreading direction (~78º) in the lithosphere

- Strong anisotropy in lid oriented parallel to FSD
- Weak anisotropy in the low velocity zone (100-150 km)
- Stronger anisotropy below the LVZ associated with asthenospheric flow

How does strength of radial anisotropy beneath the central Pacific compare with azimuthal anisotropy?

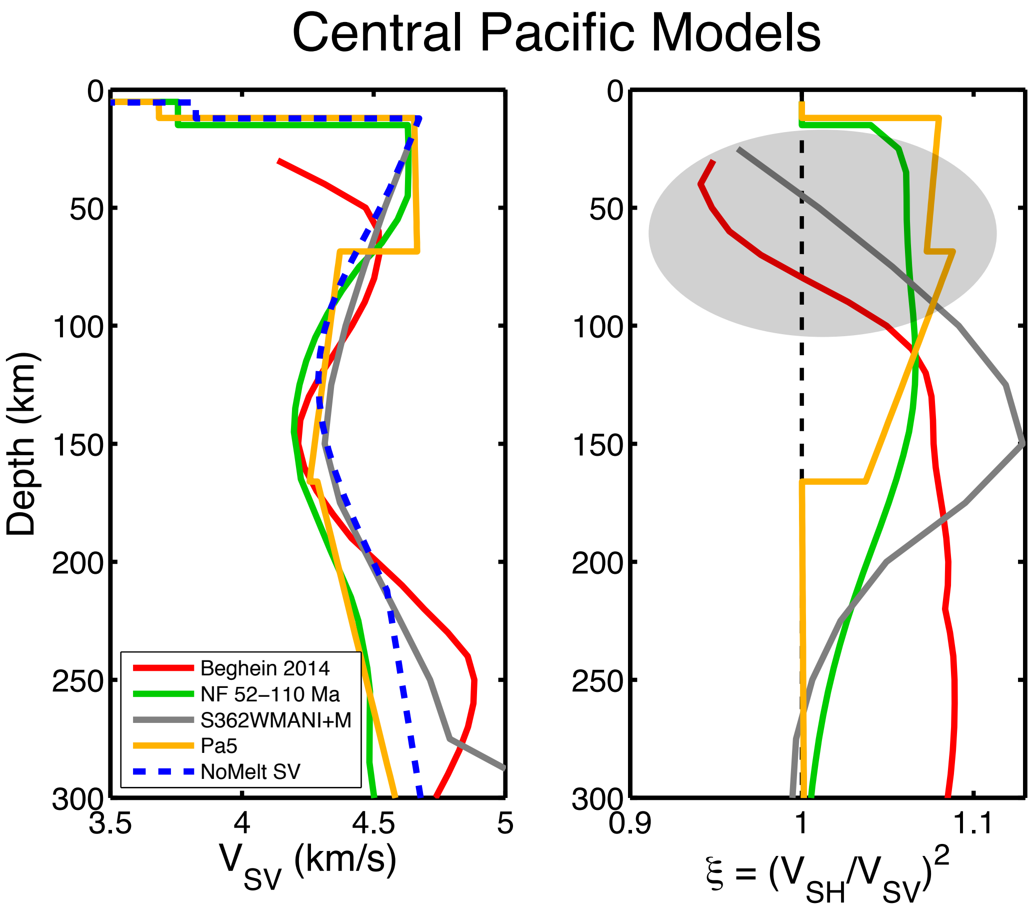


Lin et al., Nature (2016)

PeiYing (Patty) Lin: [S21C-05] Tues. 9-9:15 Room 307

Motivation: Radial anisotropy

- Radial anisotropy ξ is also important for constraining upper-mantle circulation and evolution of the lithosphere-asthenosphere system
- Radial anisotropy may reflect processes controlling the G discontinuity
- Discrepancies exist between current models of radial anisotropy in the central Pacific upper-mantle
- Requires constraints from both Love and Rayleigh waves



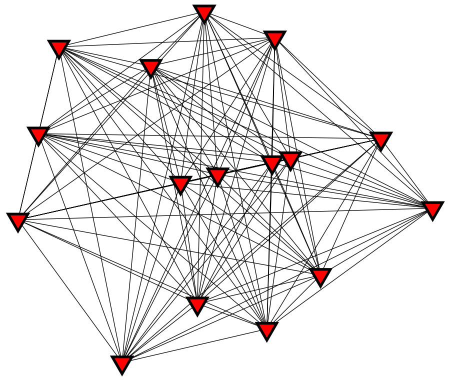
Method

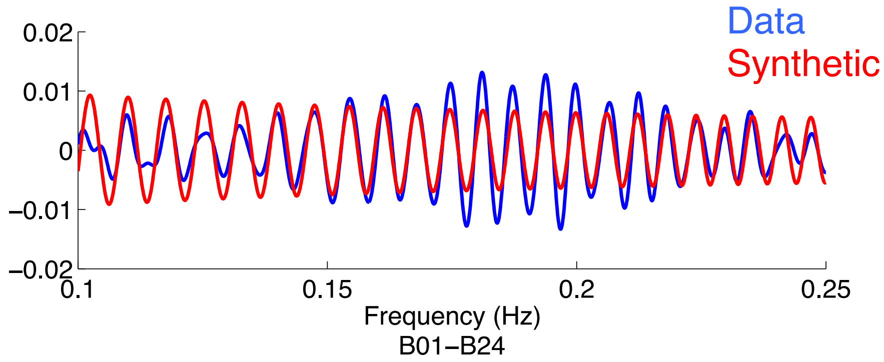
Ambient noise provides constraints from both Rayleigh and Love wave fields

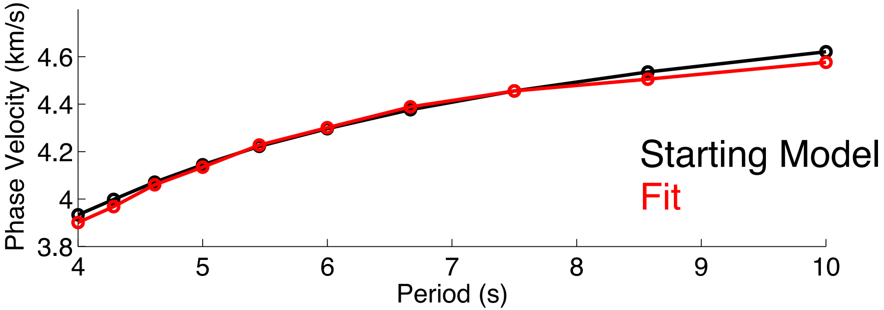
Phase velocities derived from waveform fitting of ambient-noise cross spectra [*Menke & Jin, BSSA 2015*]

cross spectra: $\rho(\omega, r) = AJ_0\left(\frac{\omega r}{c(\omega)}\right)$

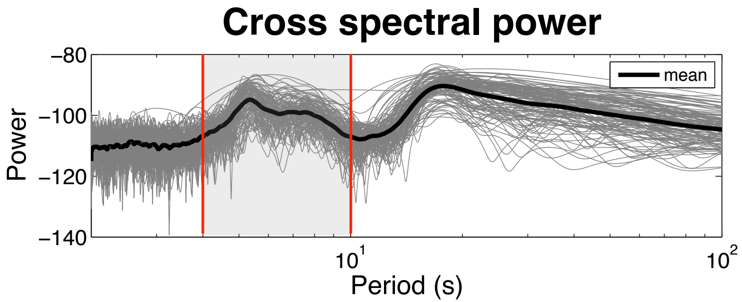
240 cross-correlation functions

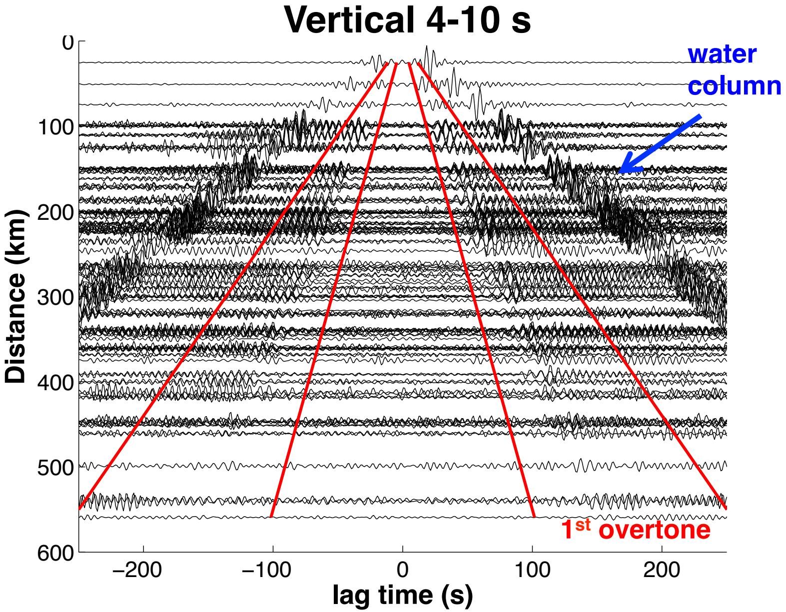




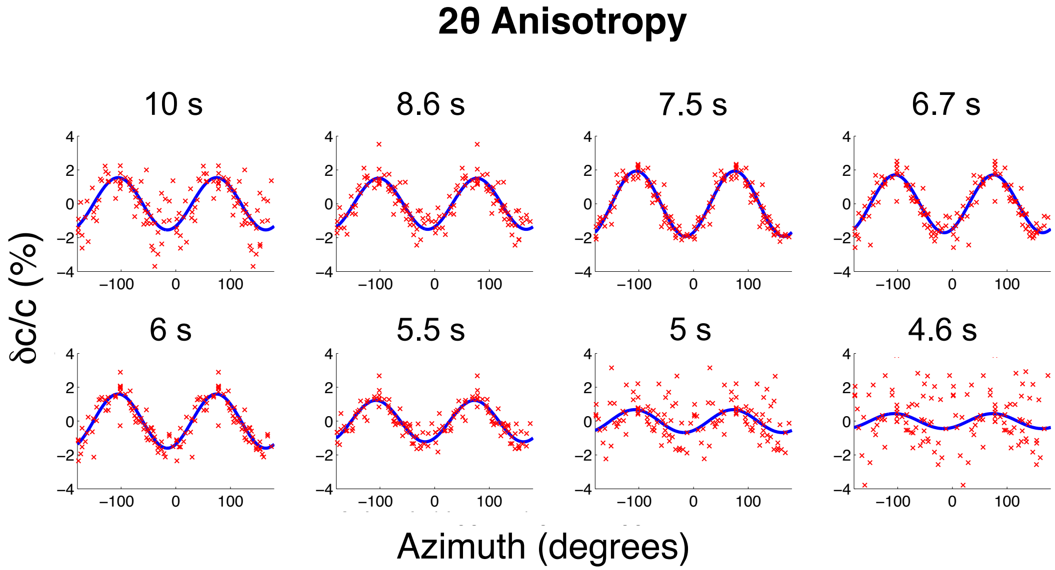


1st overtone Rayleigh waves (4-10 s)

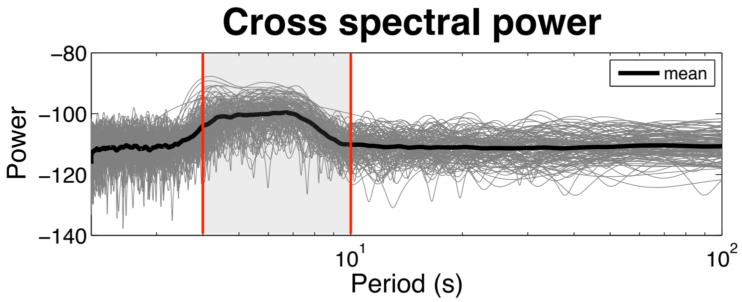


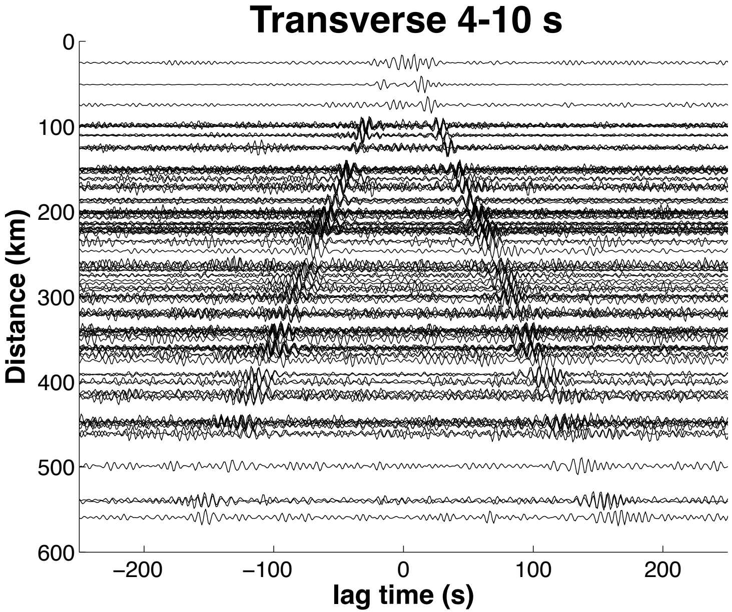


- Sensitivity of 1st overtone Rayleigh comparable to fundamental mode Love wave
- Strong 2θ azimuthal signal
  - Rayleigh fast direction parallel to fossil spreading (78°)

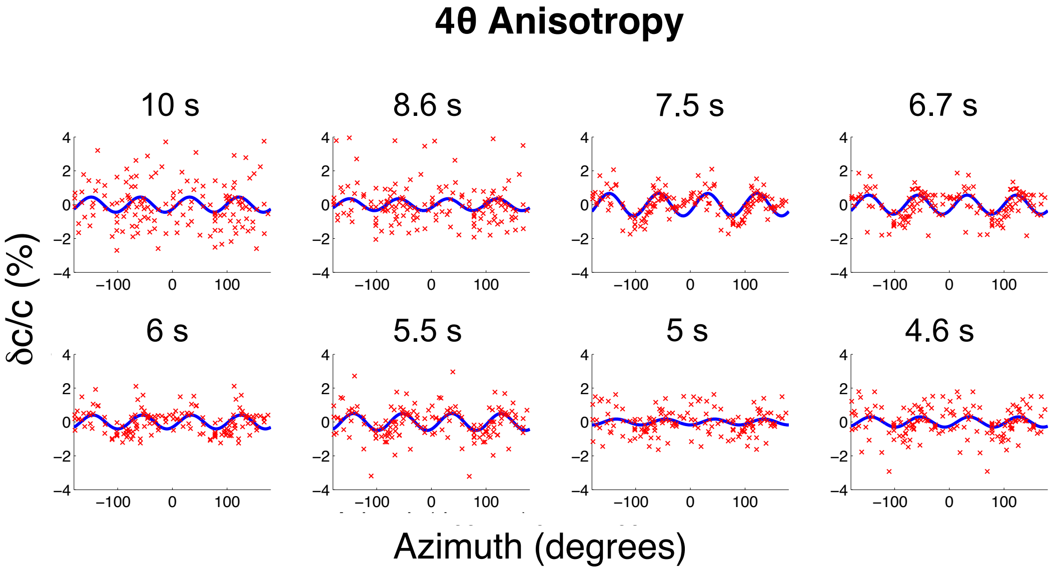


Fundamental mode Love waves (4-10 s)





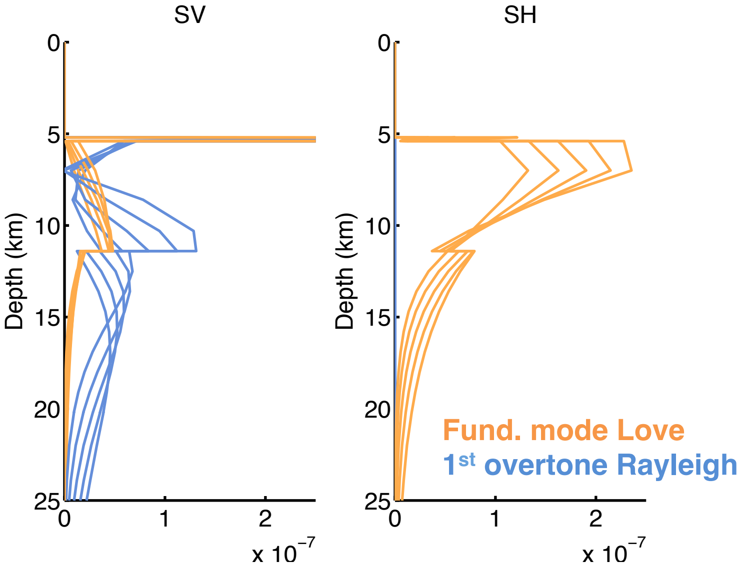
- Clear 4θ azimuthal signal
  - Love slow direction parallel to fossil spreading (78º)
  - Consistent with predictions of olivine fabric

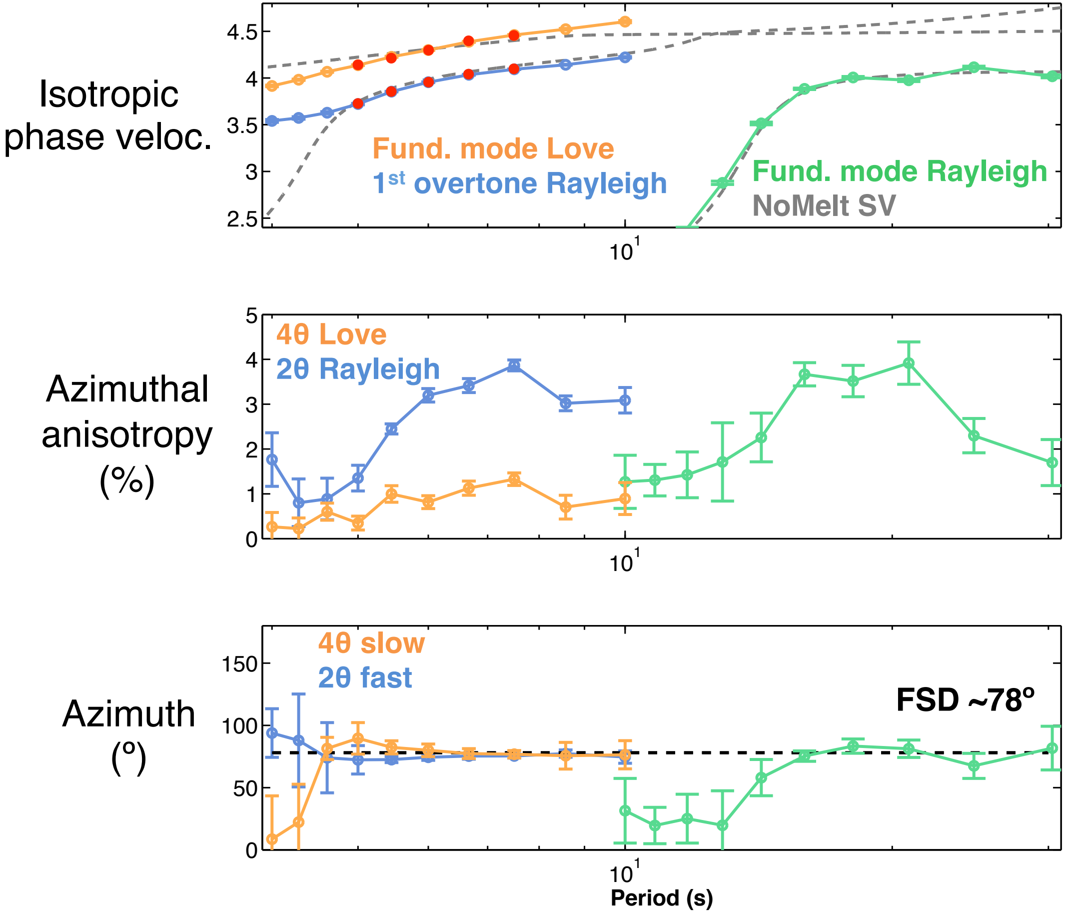


Measurements

Strong azimuthal anisotropy suggests significant mantle sensitivity

Fréchet Kernels (5-7.5 s)





Inversion

Solving for horizontal and vertical V_P & V_S

Starting model

V_P

0-35km: NoMelt refraction model accounting for ~8% P-azimuthal anisotropy in the mantle
(D. Lizarralde personal communications)

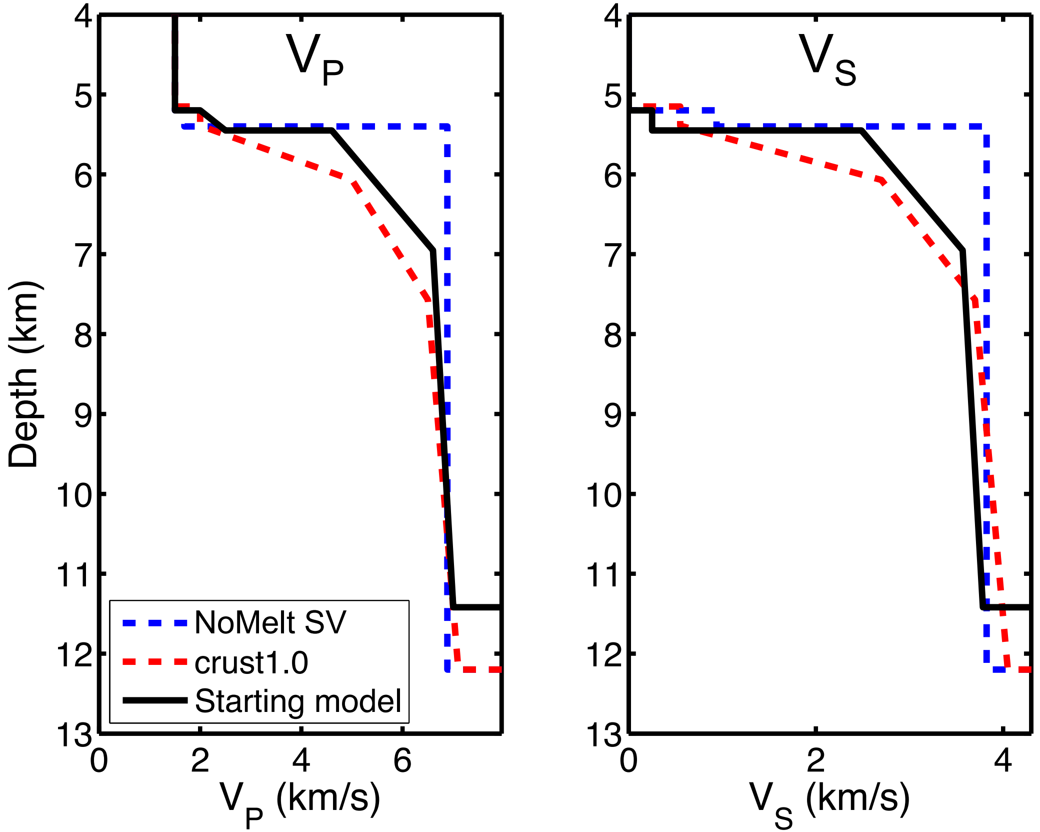
V_S

Sediments: Seafloor compliance
[*Ruan et al., JGR 2014*]

Crust: V_P/V_S = ~1.85 [*Brocher, BSSA 2005*]

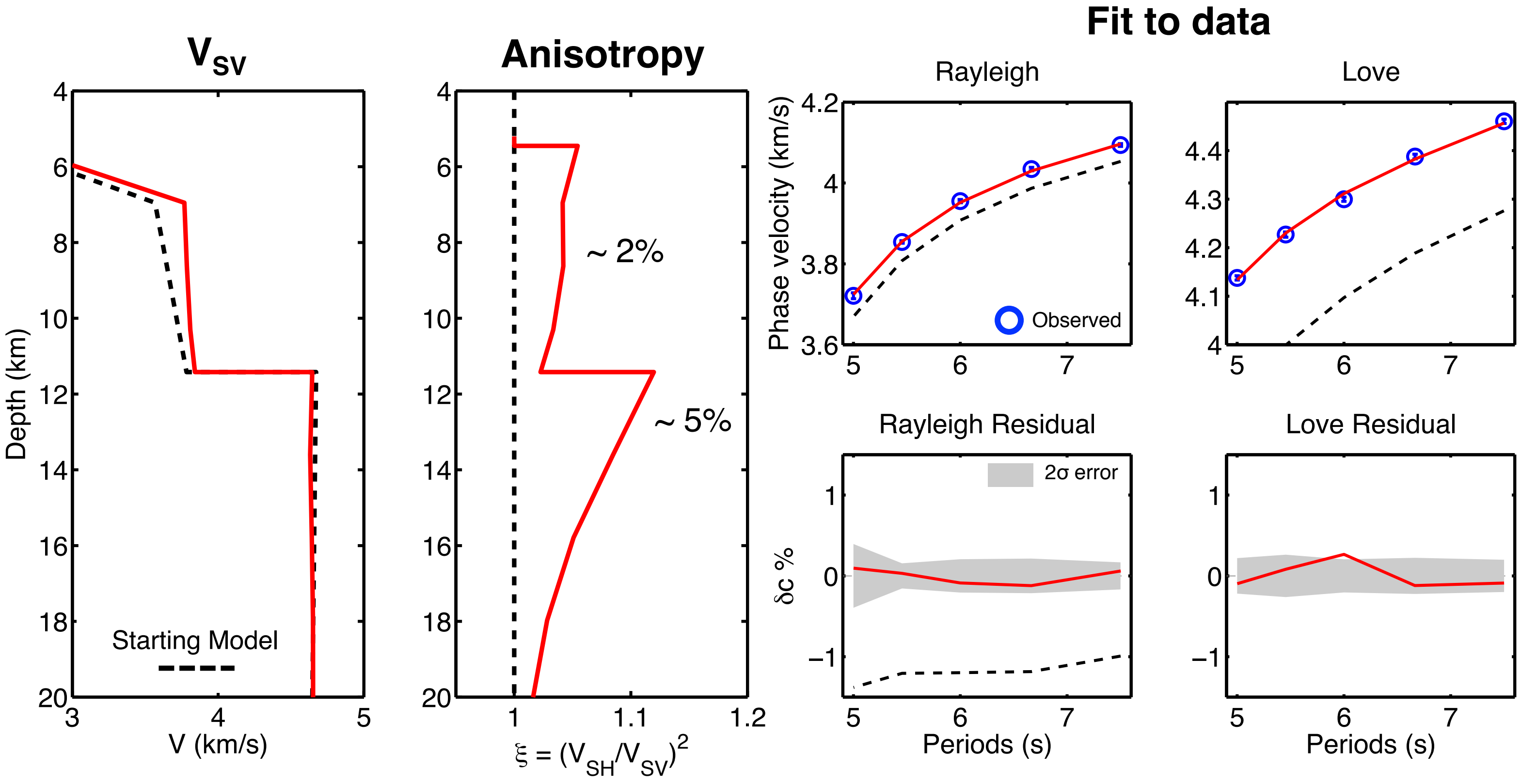
Mantle: NoMelt SV [*Lin et al., Nature 2016*]

Crustal Model



Inversion results

$V_{SH} > V_{SV}$ required in the mantle lithosphere and cannot be ruled out in the crust



Summary & Interpretation

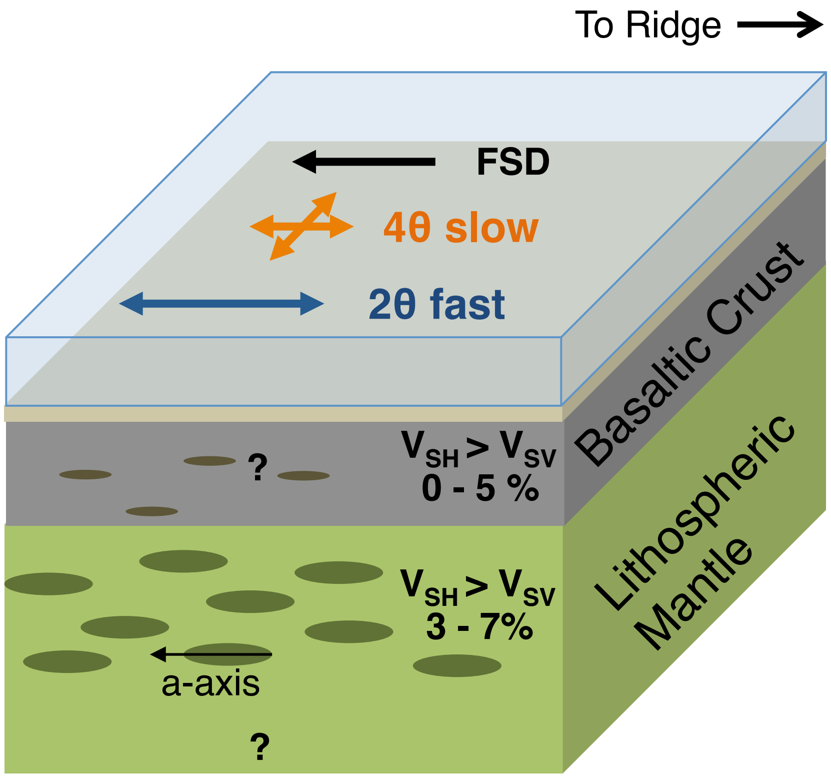
Both azimuthal and radial anisotropy required in the lithospheric mantle

Mantle

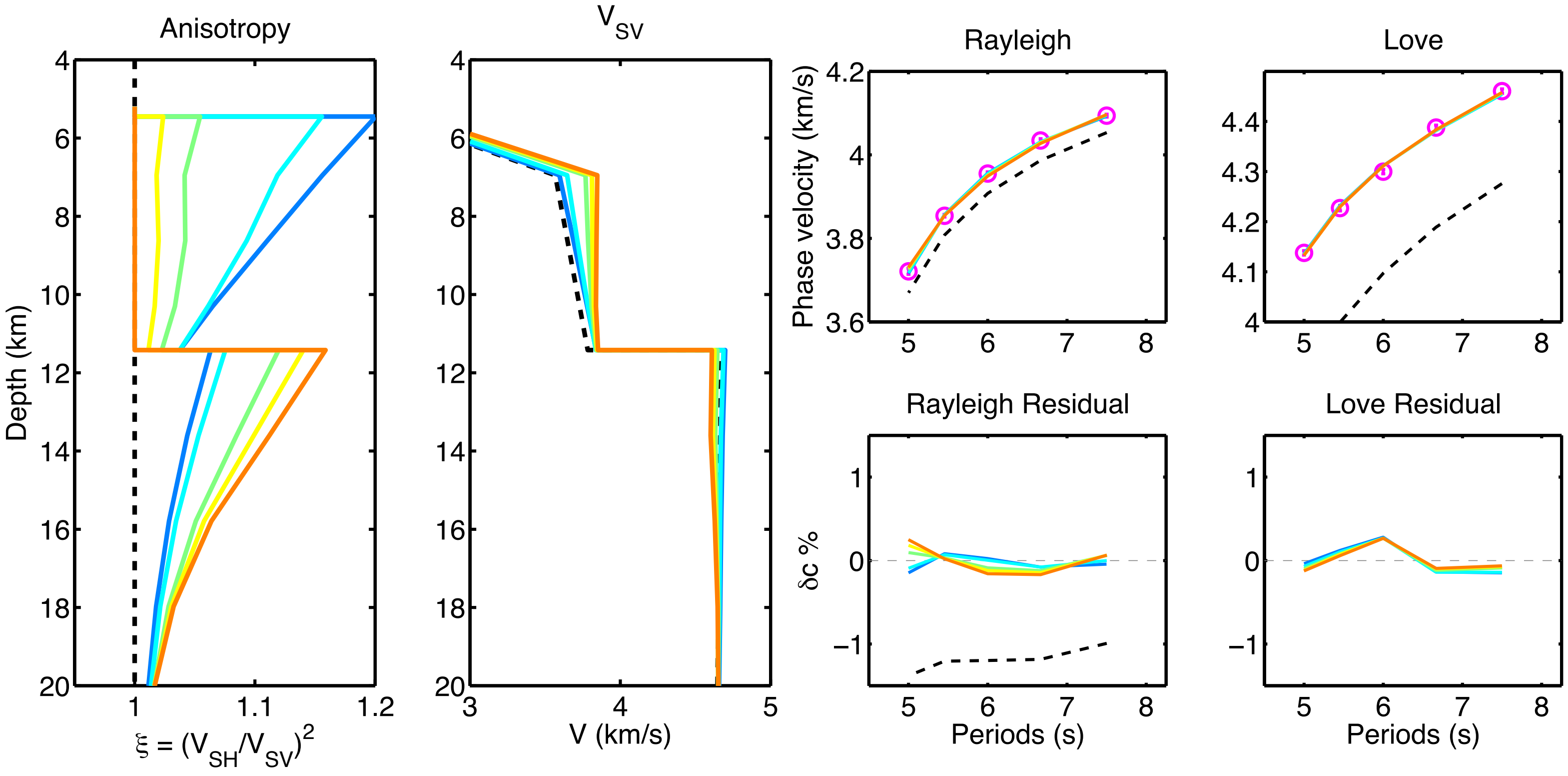
- **Radial anisotropy: $V_{SH} > V_{SV}$ (~ 3-7%)**
- **Clear 2θ and 4θ azimuthal anisotropy**
- Consistent with petrologic models of olivine with orthorhombic or hexagonal symmetry
- Horizontal preferred alignment of olivine a-axis associated with fossil spreading

Crust

- $V_{SH} > V_{SV}$ (0-5%)
- Horizontal crustal fabric?
  - Layering processes? Cracks? Fluids?



Additional inversions: Good fits



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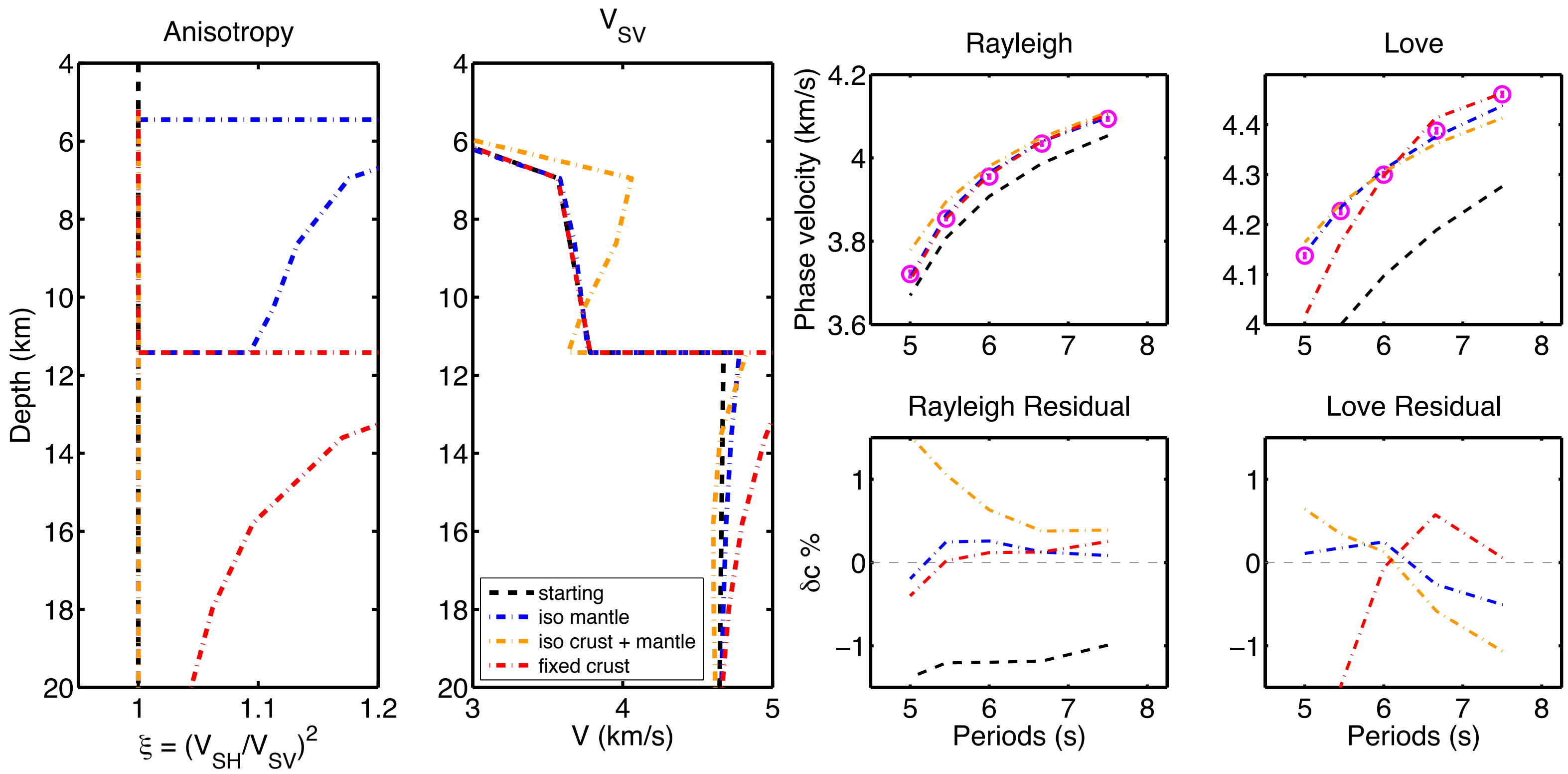
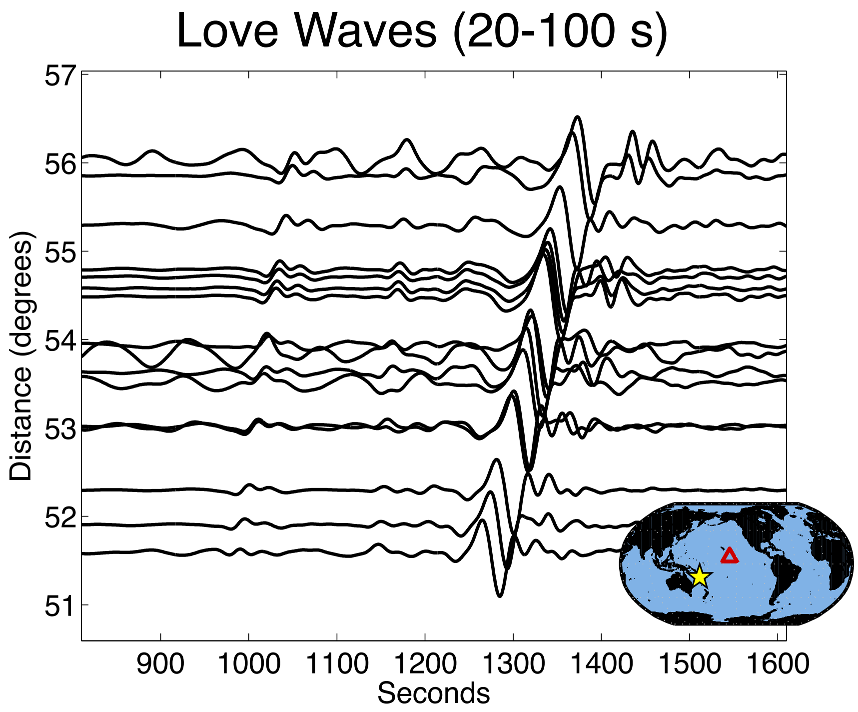
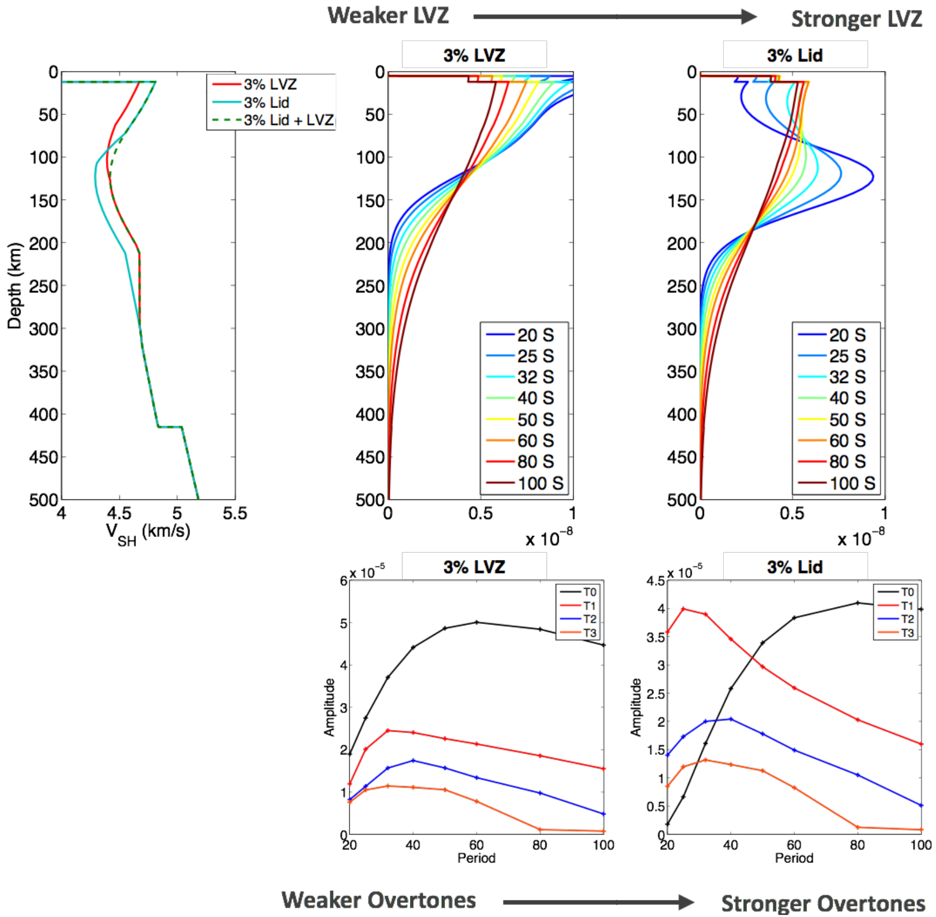


Kernel Nonlinearity: Love waves (20-100 s)





Kernel Nonlinearity: 4-30 s