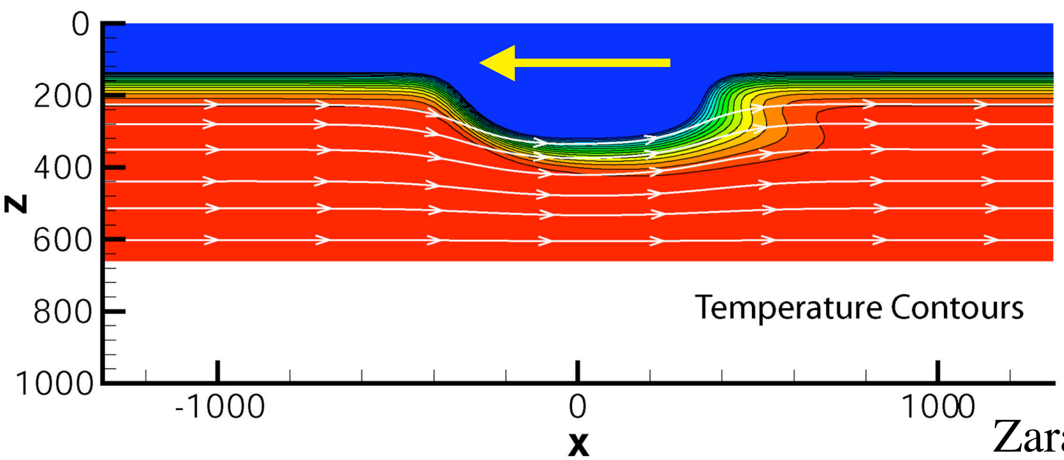
Understanding the lithosphere: Challenges for the future

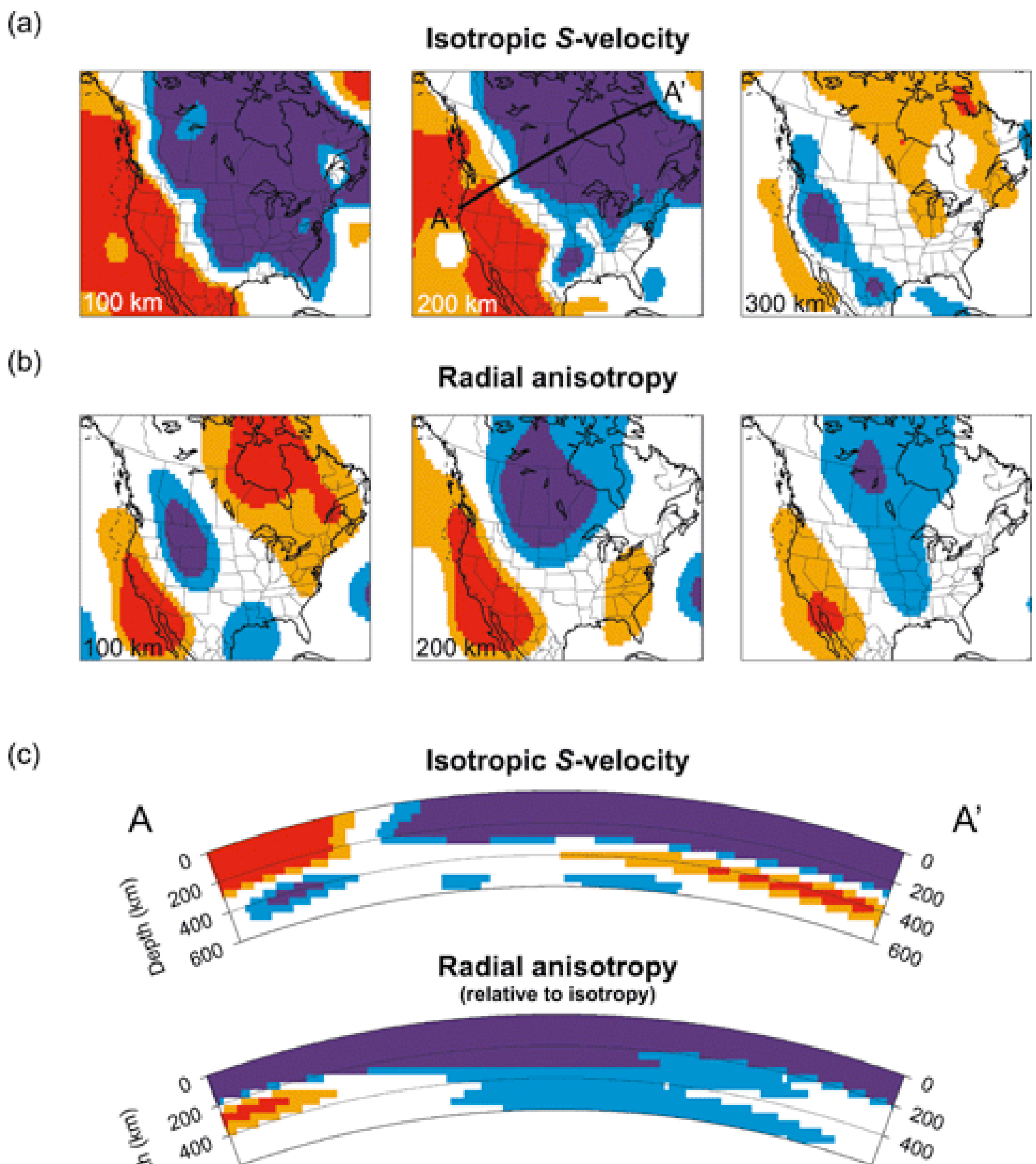
Karen M. Fischer, Brown University

1) **What controls the lithosphere-asthenosphere boundary - temperature, composition, or melt?**

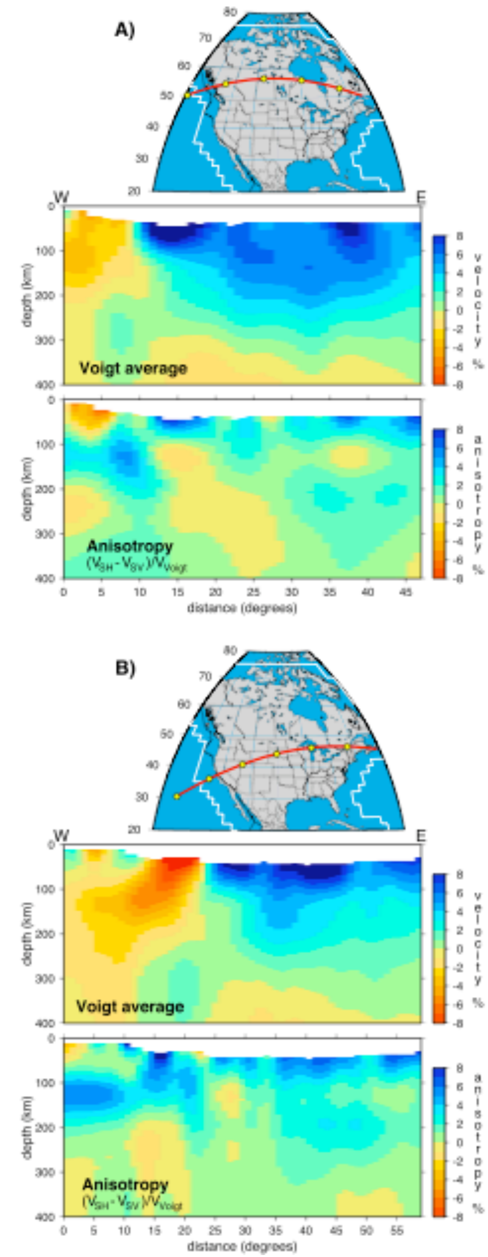
2) **How does plate motion couple to deeper mantle flow?**



Zaranek (2006)

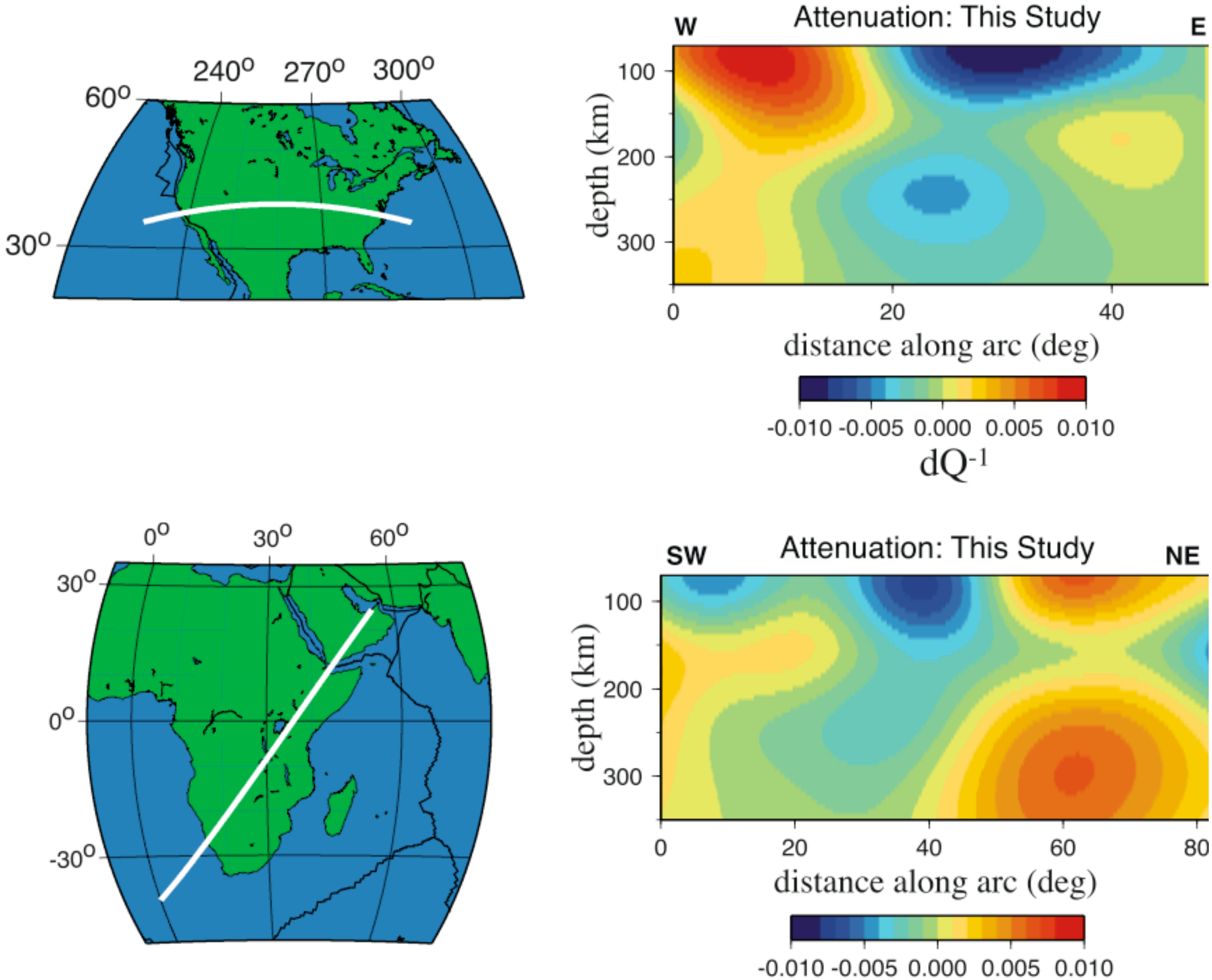


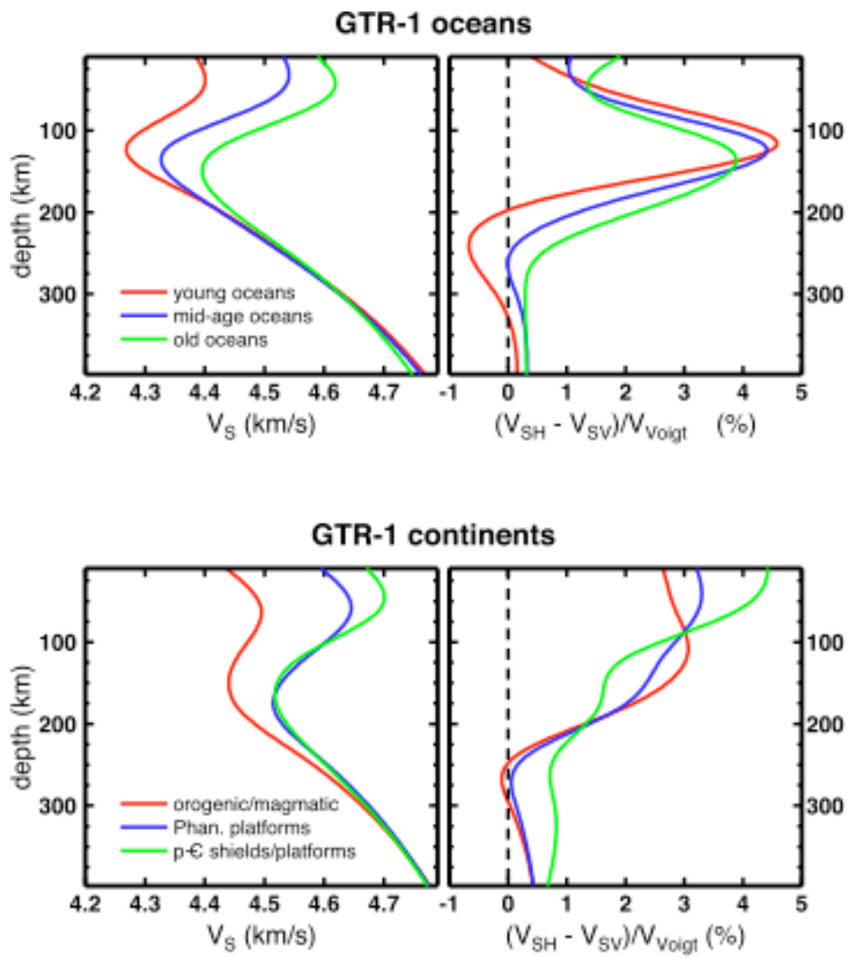
Marone et al. (2007)

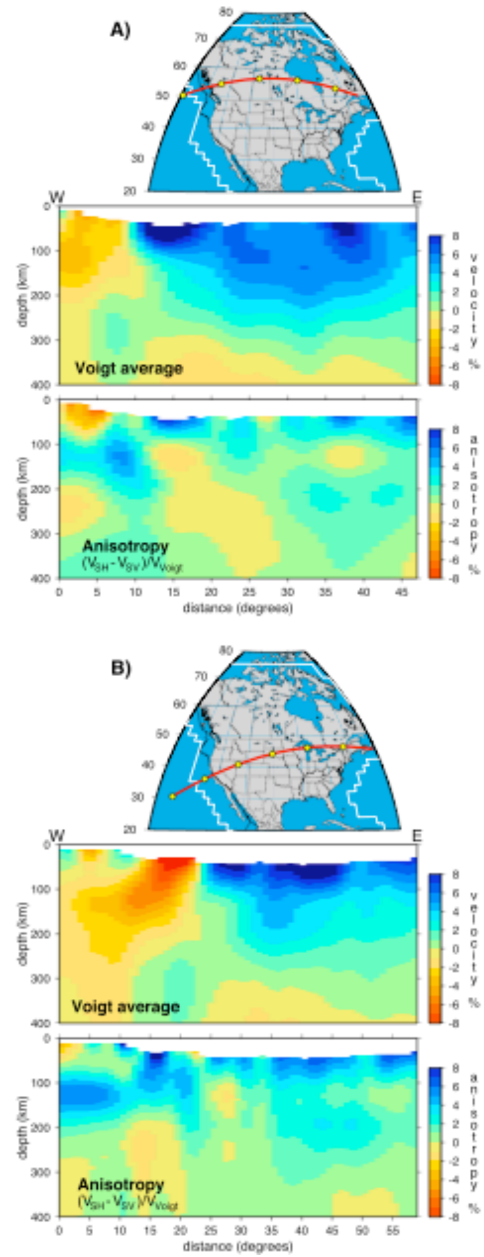


Nettles and Dziewonski (2008)

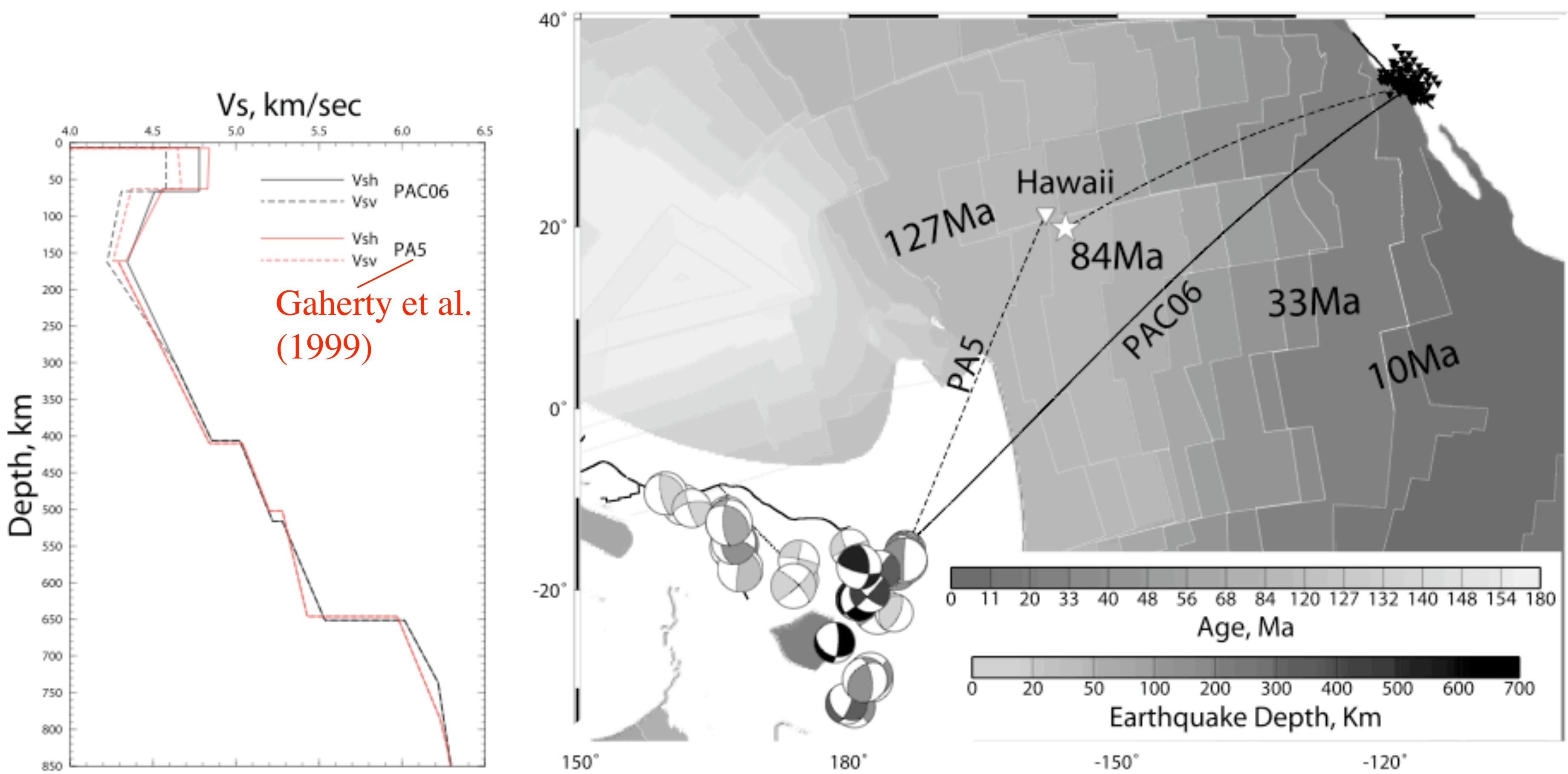
Dalton et al. (2008)





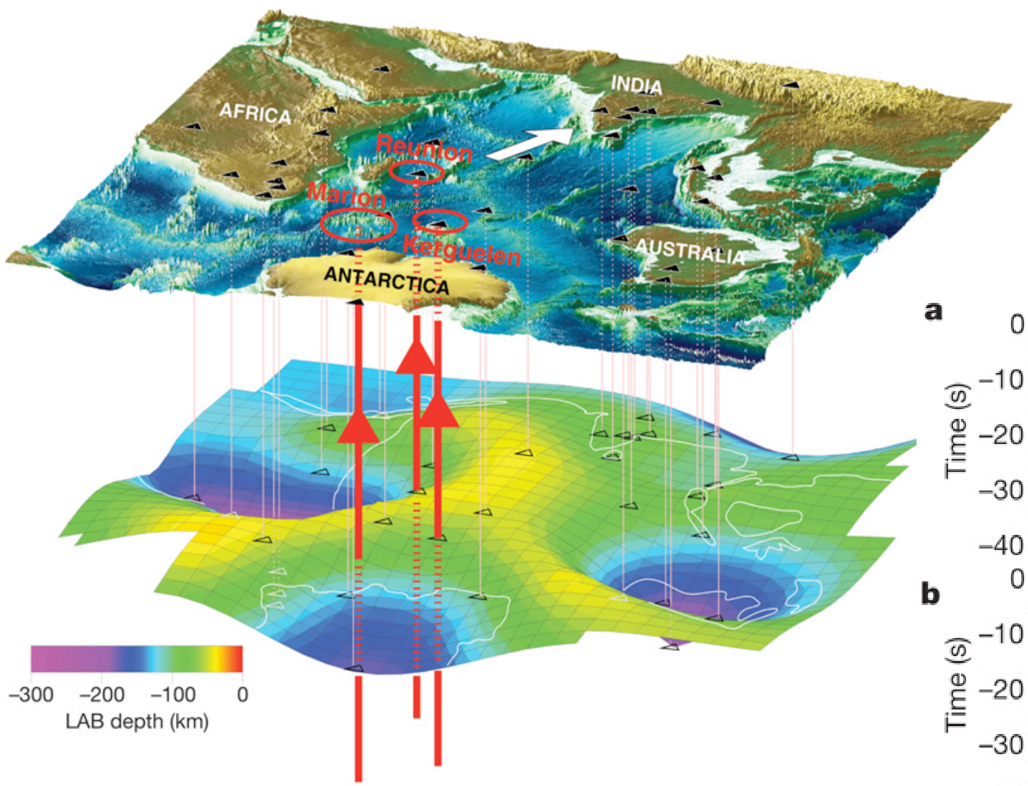


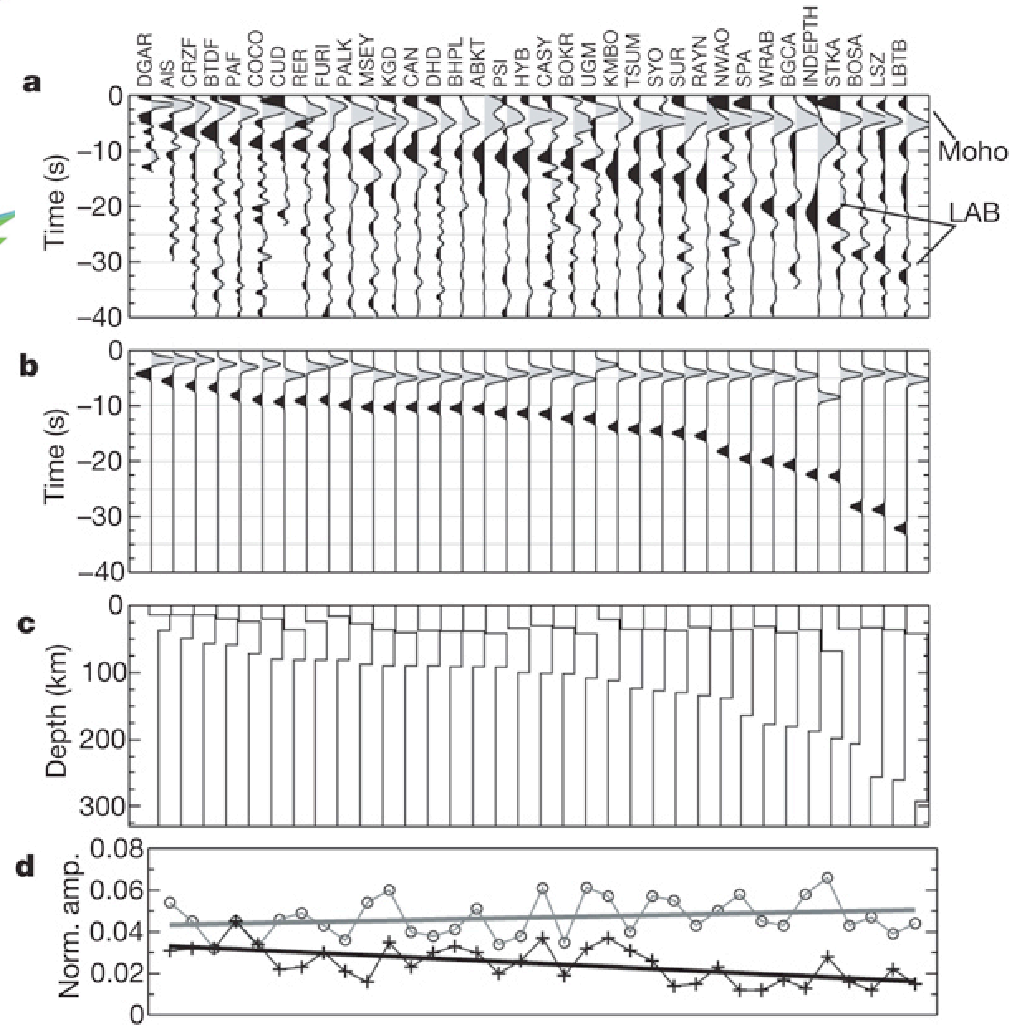
Nettles and Dziewonski (2008)



Tan and Helmberger (2007)

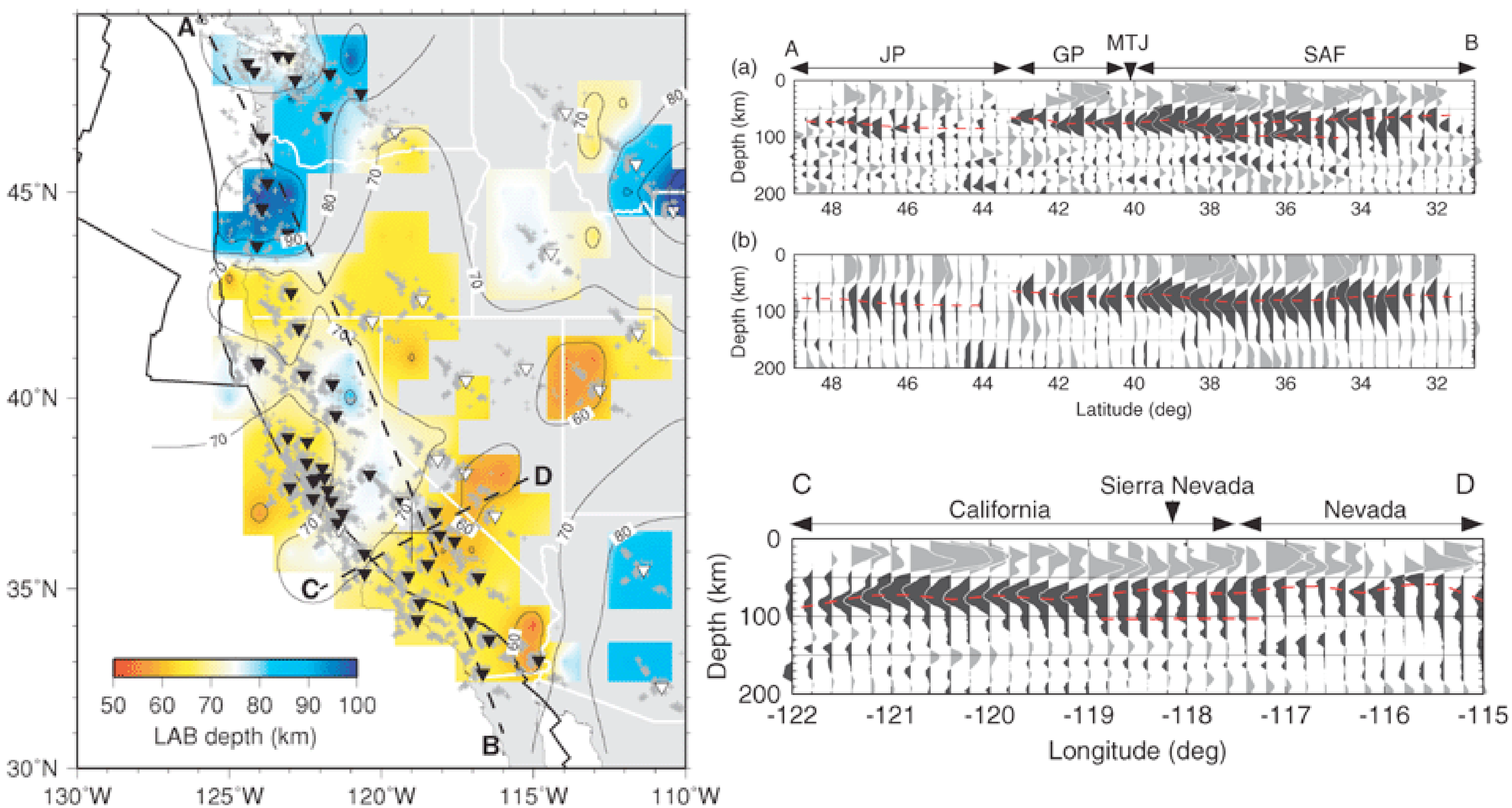
Sp receiver functions



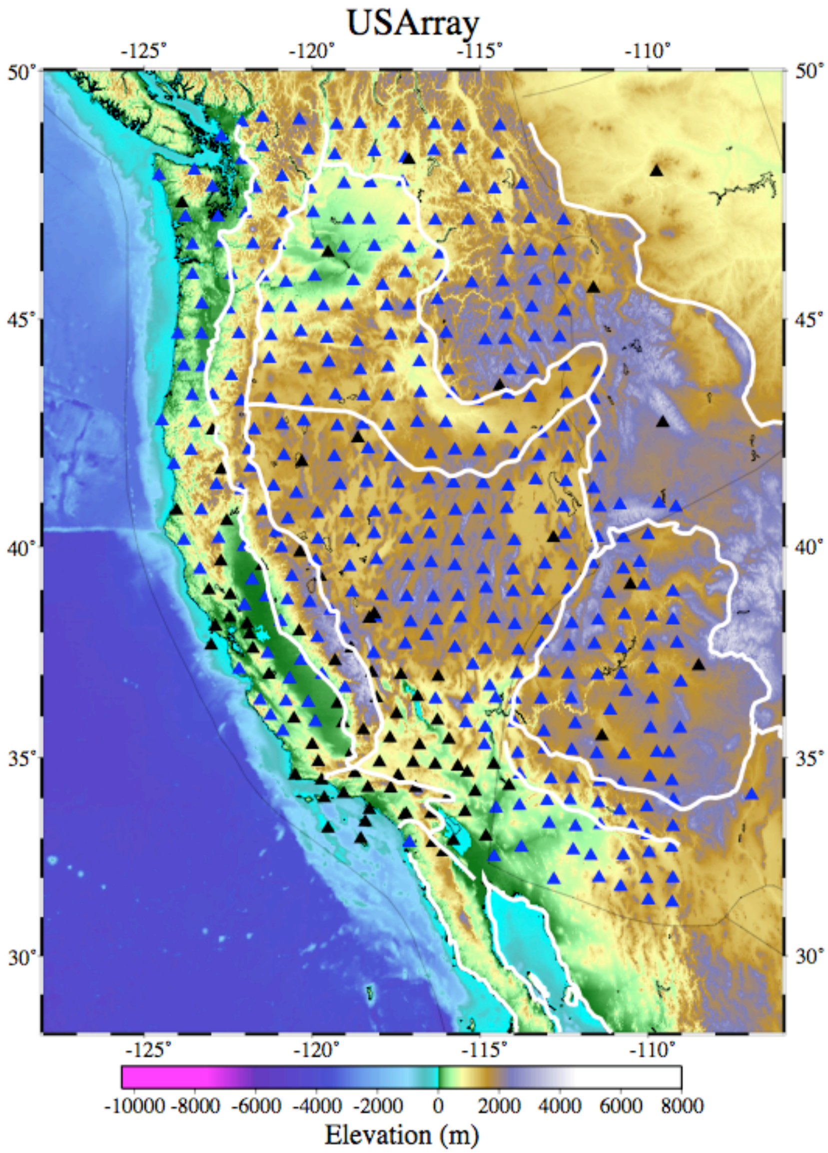


Kumar et al. (2007)

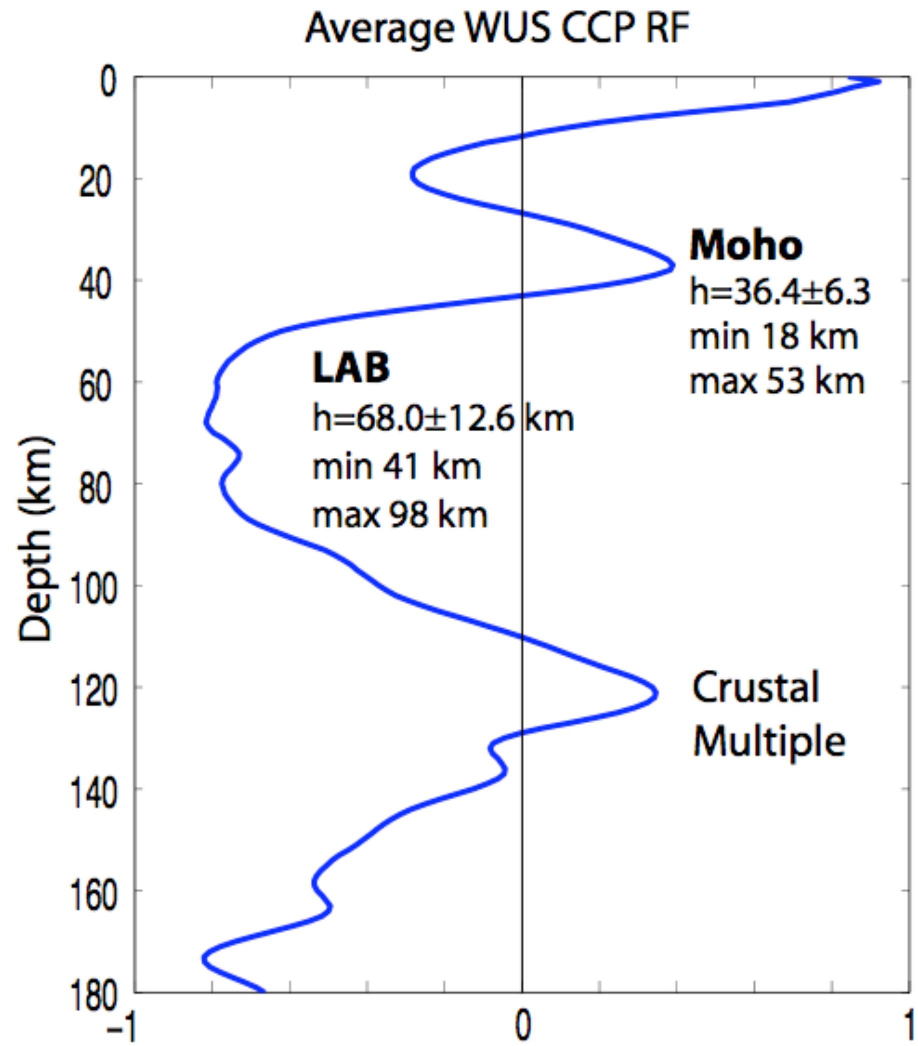
Sp receiver functions



Li et al. (2007)

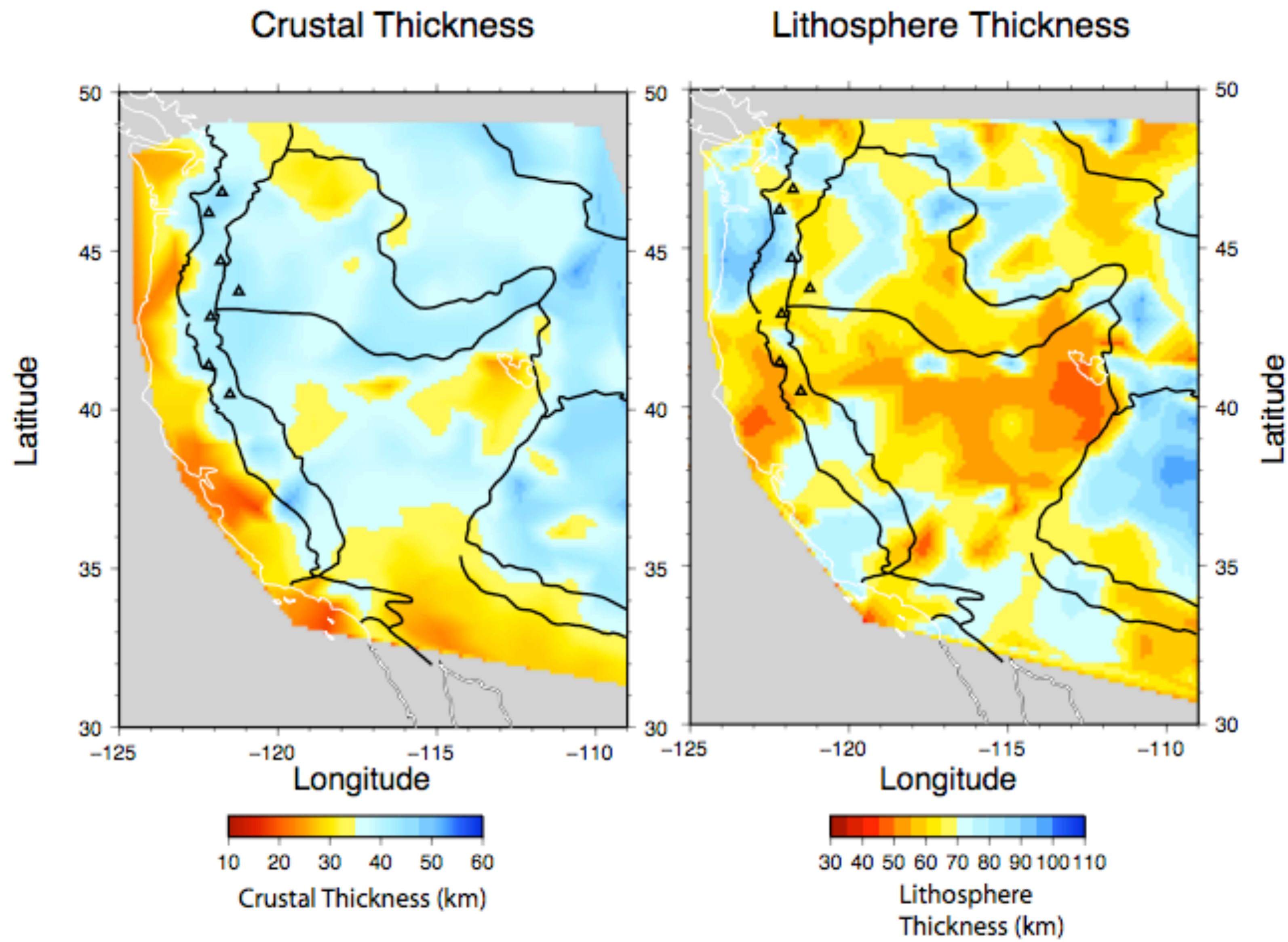


Levander (2008)



Ps

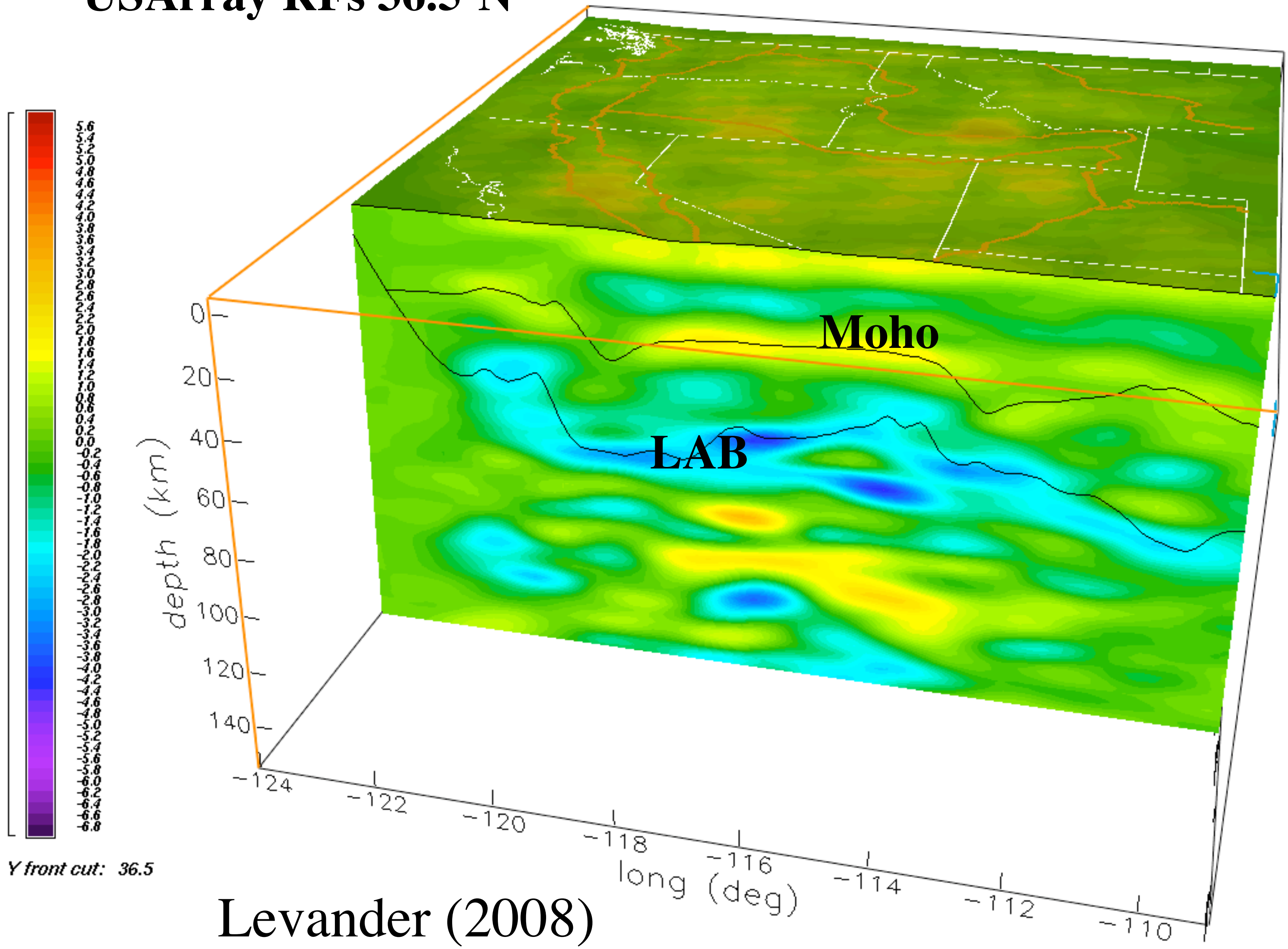
10,000 RFs
61earthquakes
520 stations



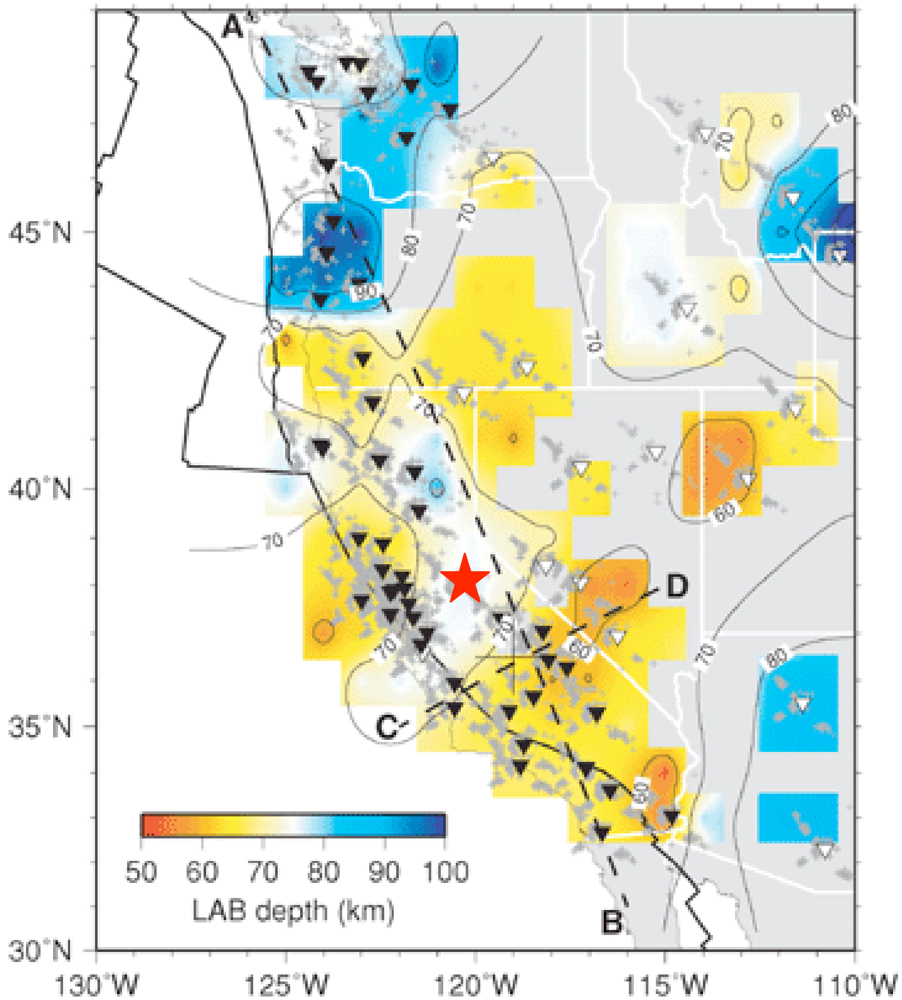
RFs calculated with Crust2.0 (Bassin et al., 2000)
and NA04 (van der Lee and Frederiksen, 2005)

Levander (2008)

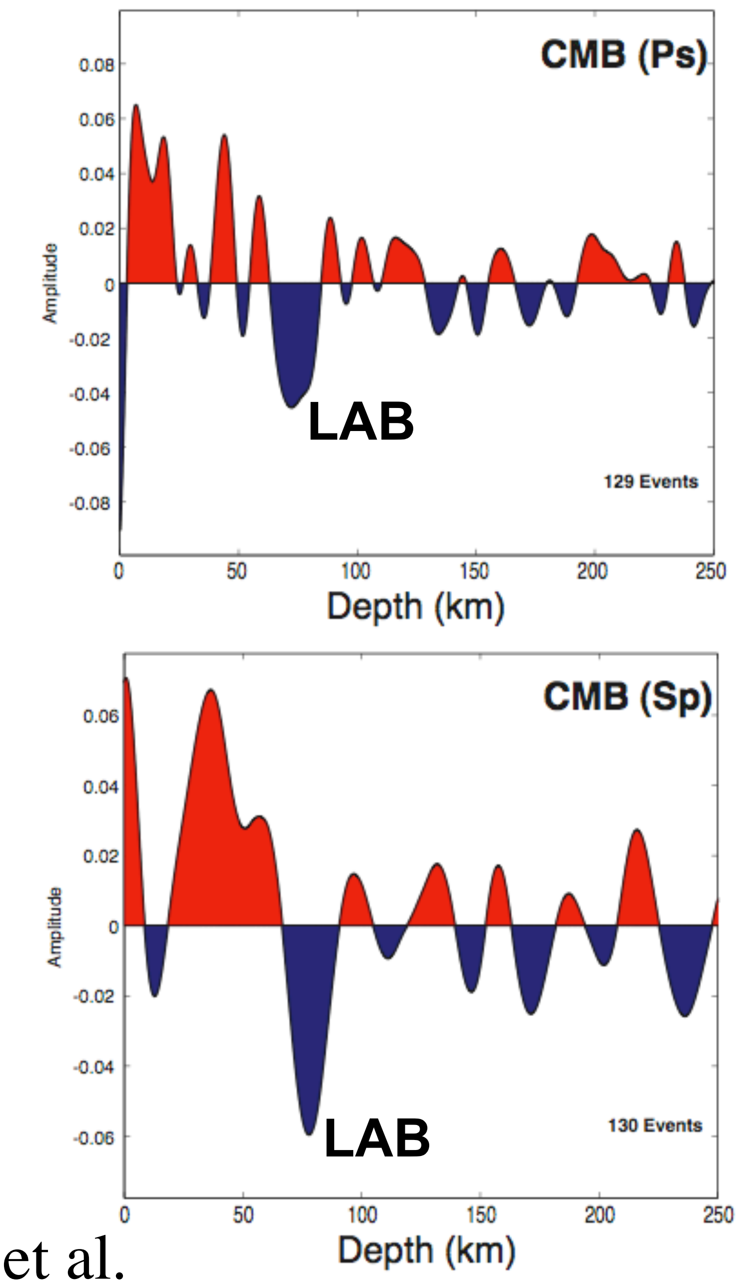
USArray RFs 36.5°N



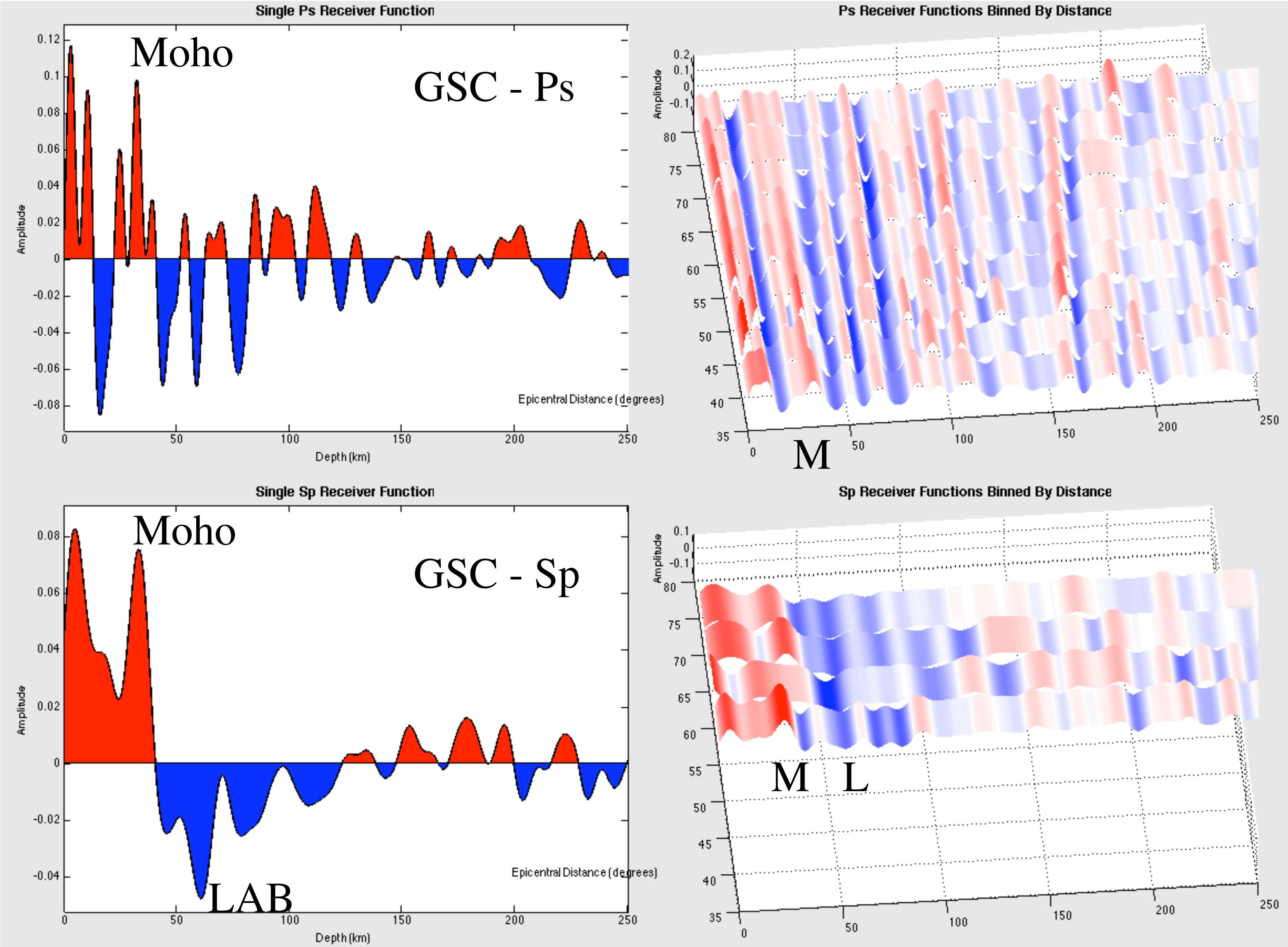
Levander (2008)

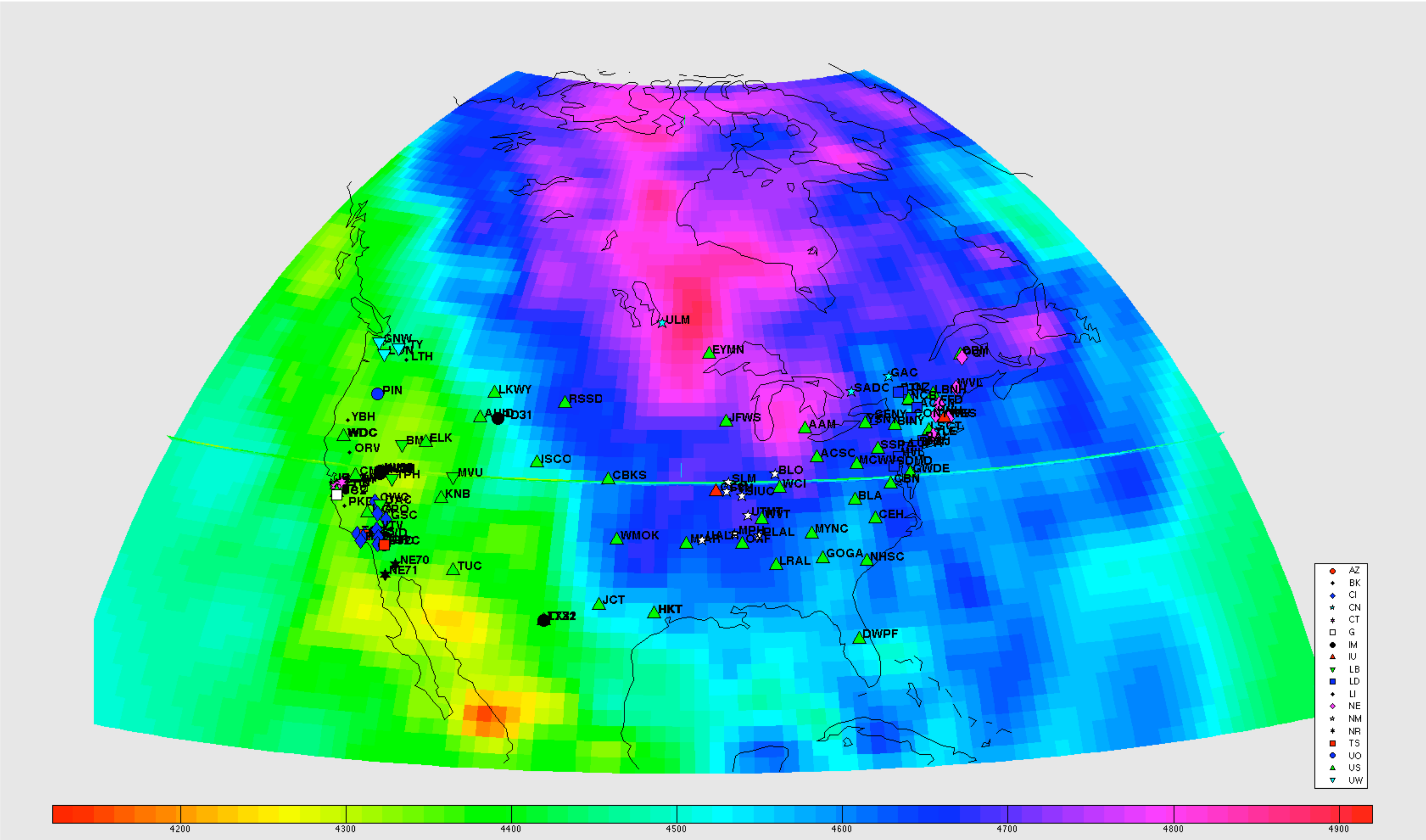


Li et al. (2007)



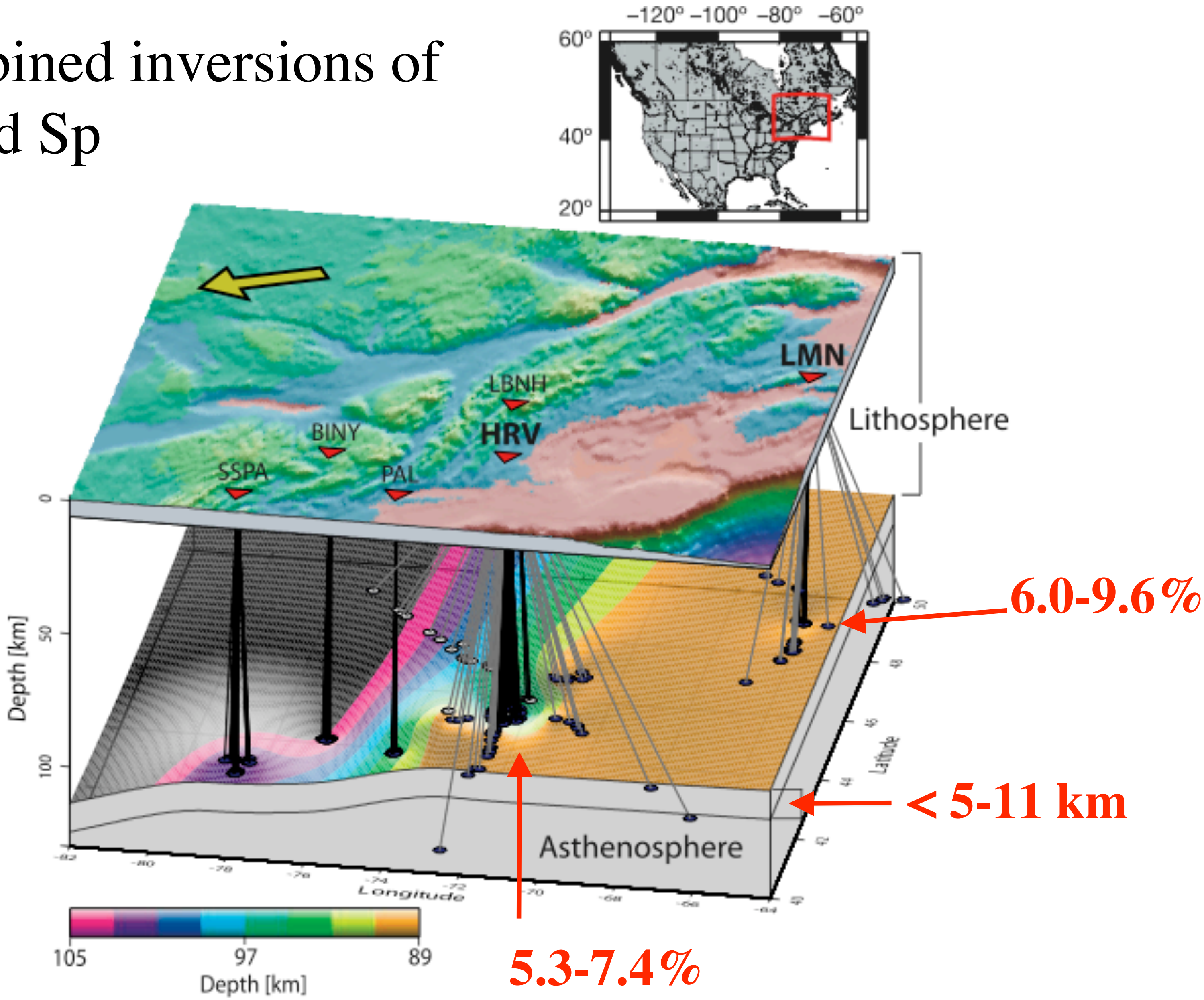
Abt et al.


Single Ps Receiver Function
Moho
GSC - Ps
Amplitude
Depth (km)
Epicentral Distance (degrees)
Ps Receiver Functions Binned By Distance
M
Single Sp Receiver Function
Moho
GSC - Sp
LAB
Sp Receiver Functions Binned By Distance
M
L



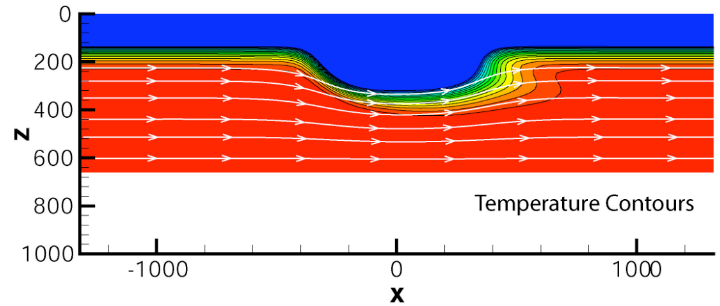
Absolute velocity at 100 km depth (Yuan and Romanowicz, 2008)
Stations from Sp, Ps migration (Rychert et al., 2005, 2007; Abt et al.)

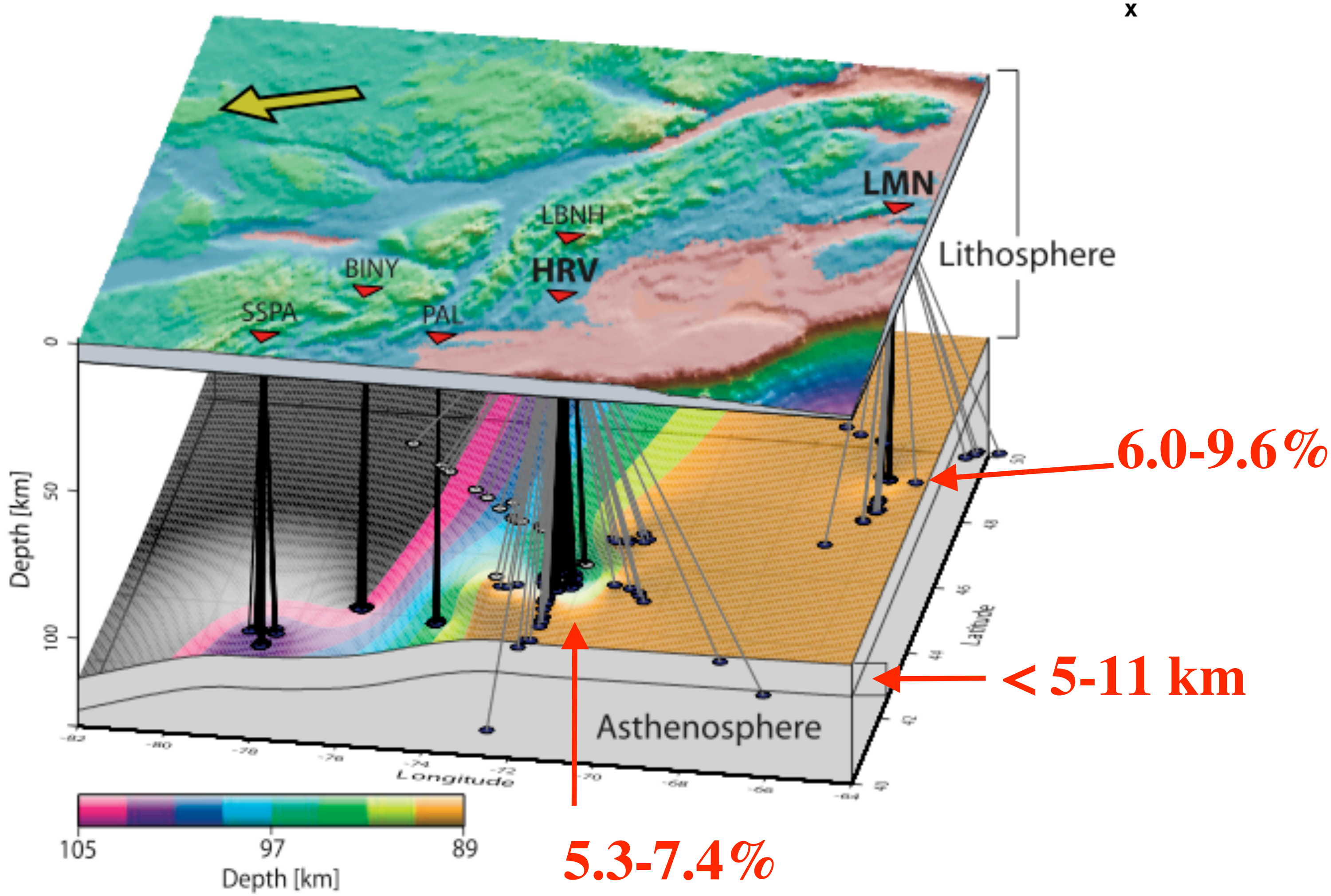
Combined inversions of Ps and Sp



Rychert et al. (2007)

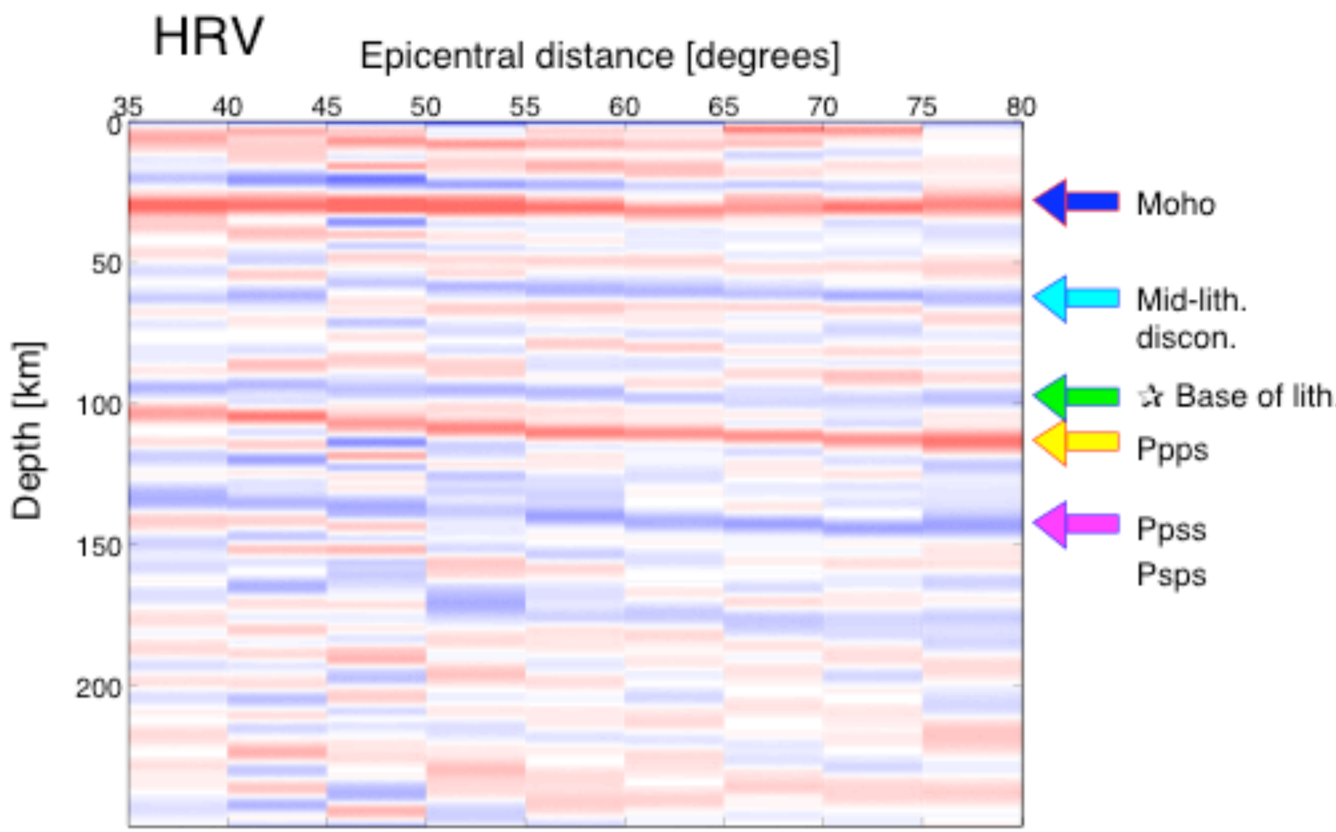
Combined inversions of Ps and Sp



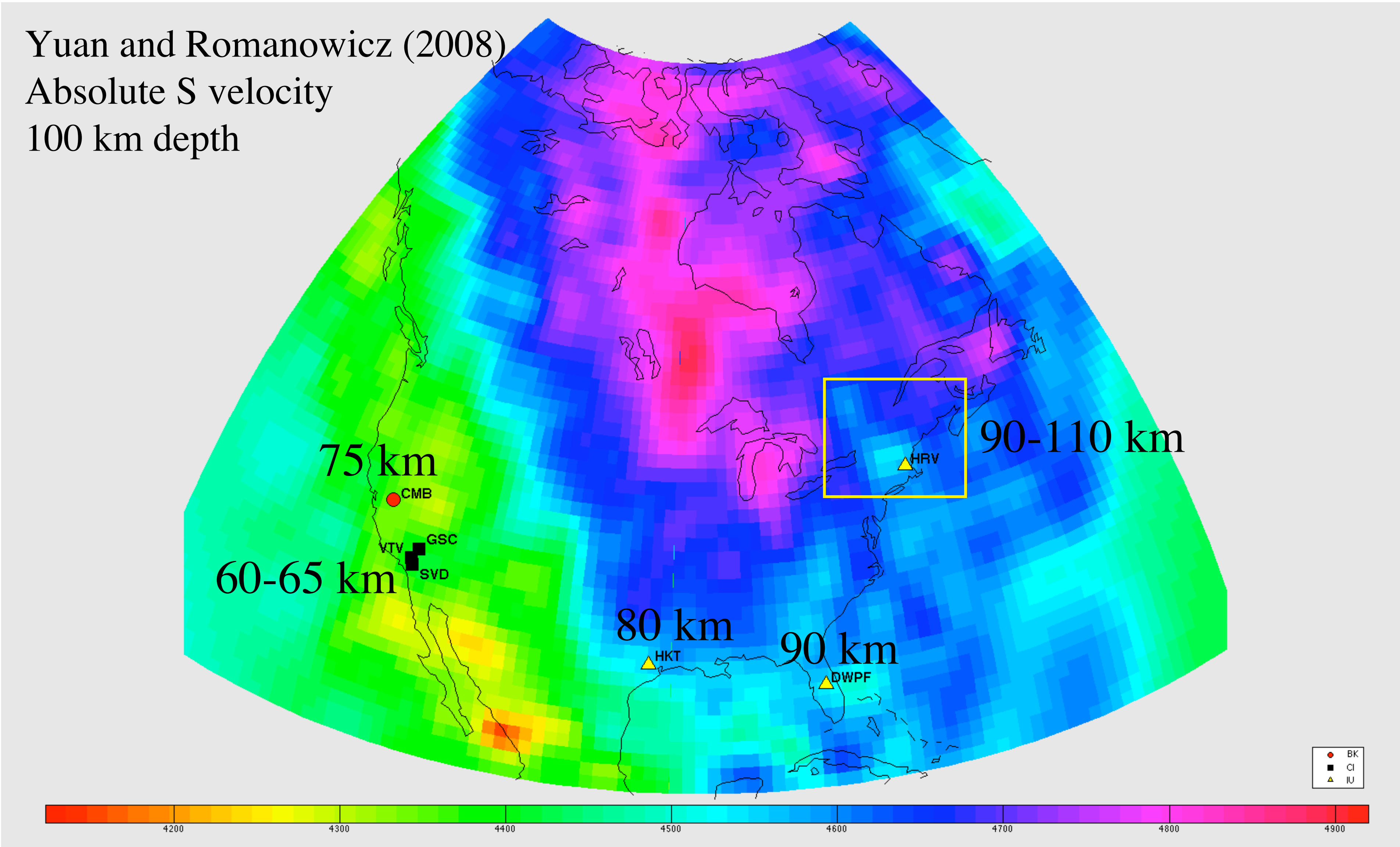


Rychert et al. (2007)

Ps



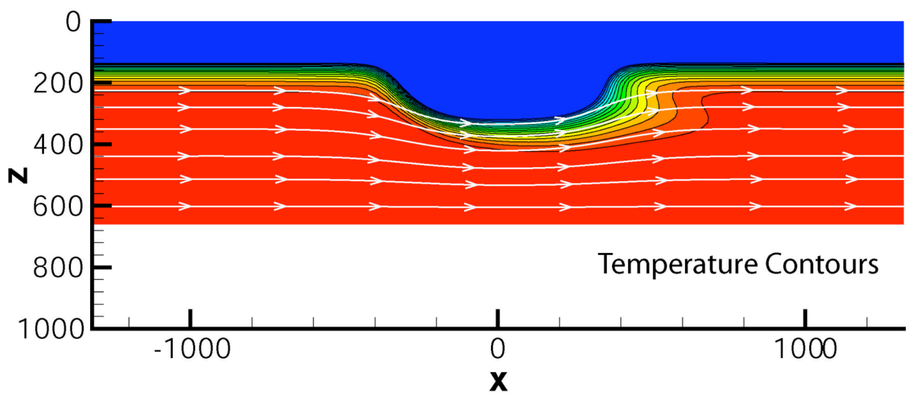
Rychert et al. (2005)



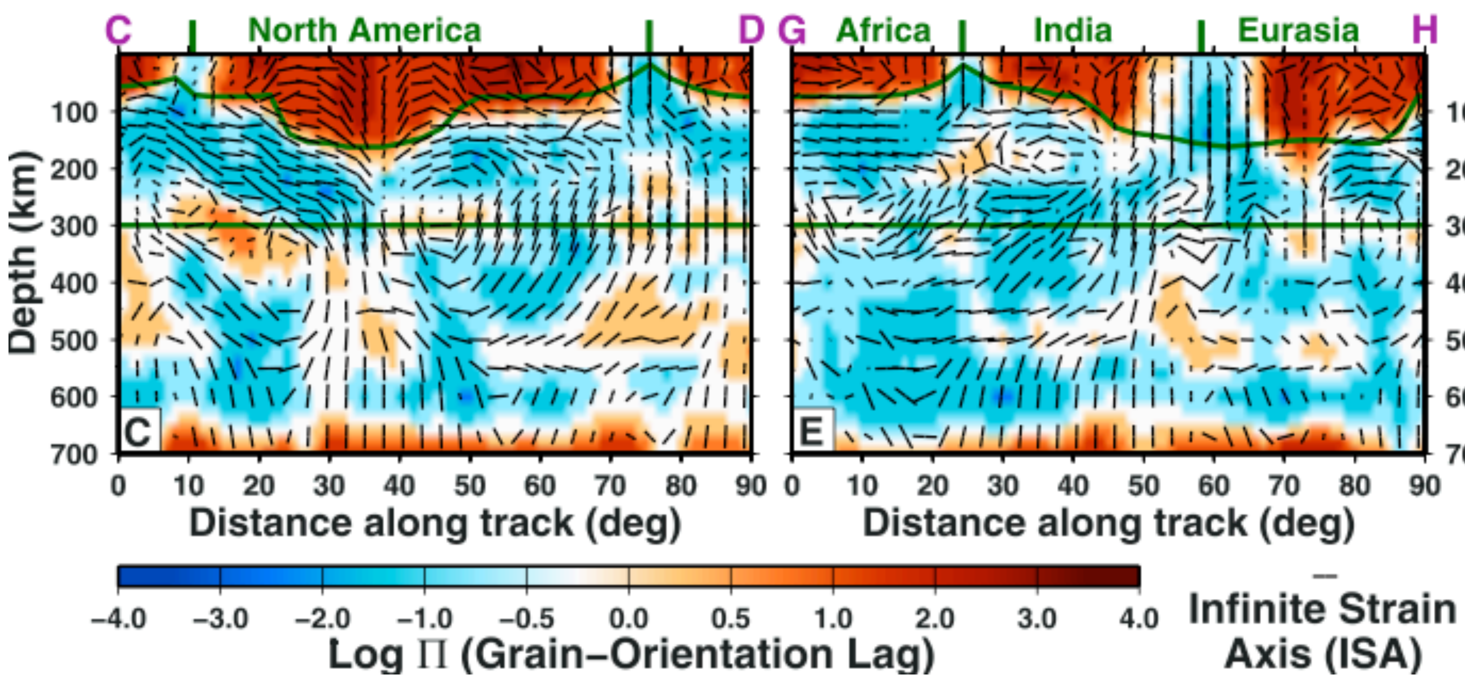
California: LAB 60-80% of Moho amplitude

Eastern U.S.: LAB 30-40% of Moho amplitude

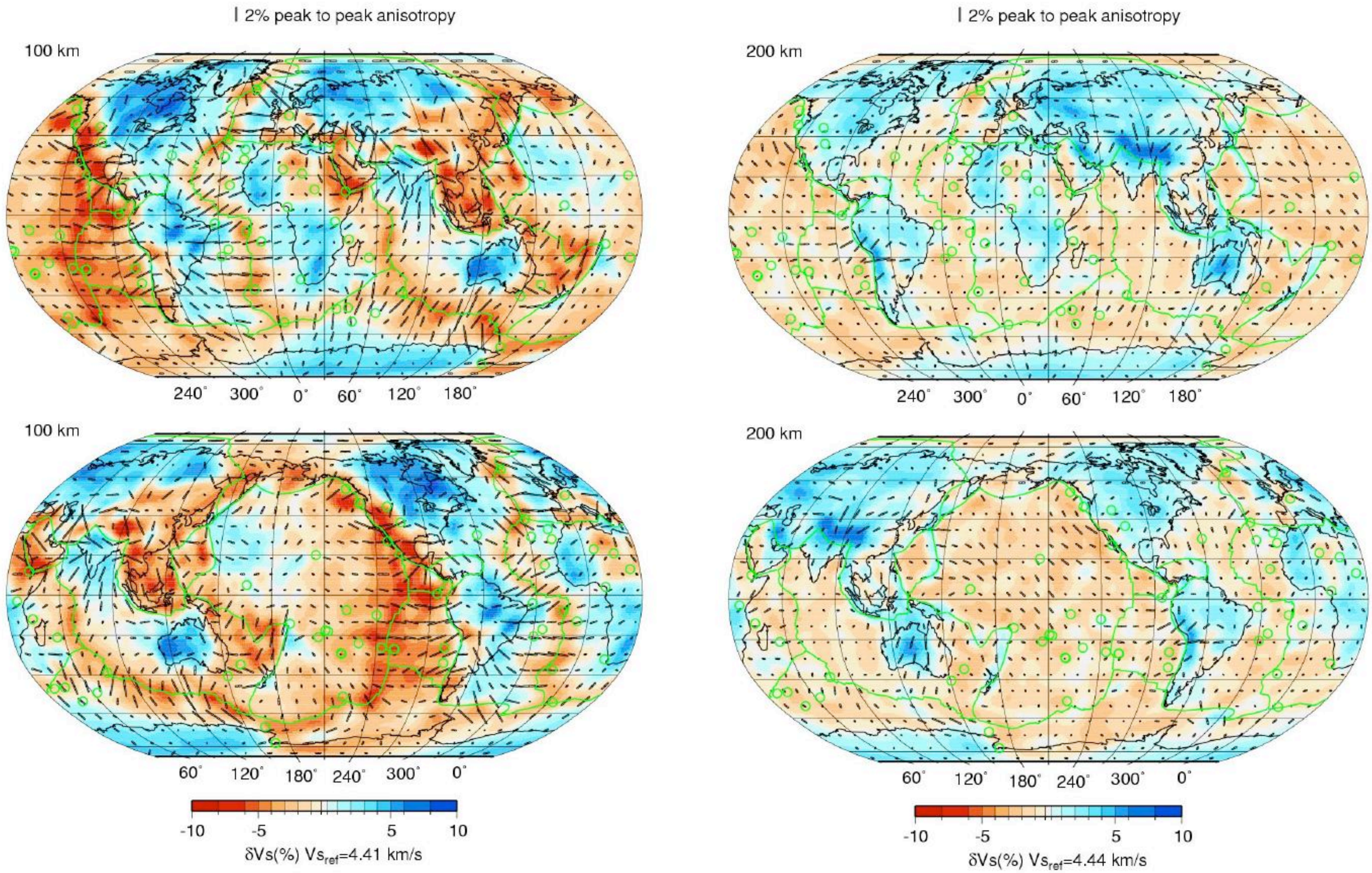
How does plate motion couple to deeper mantle flow?



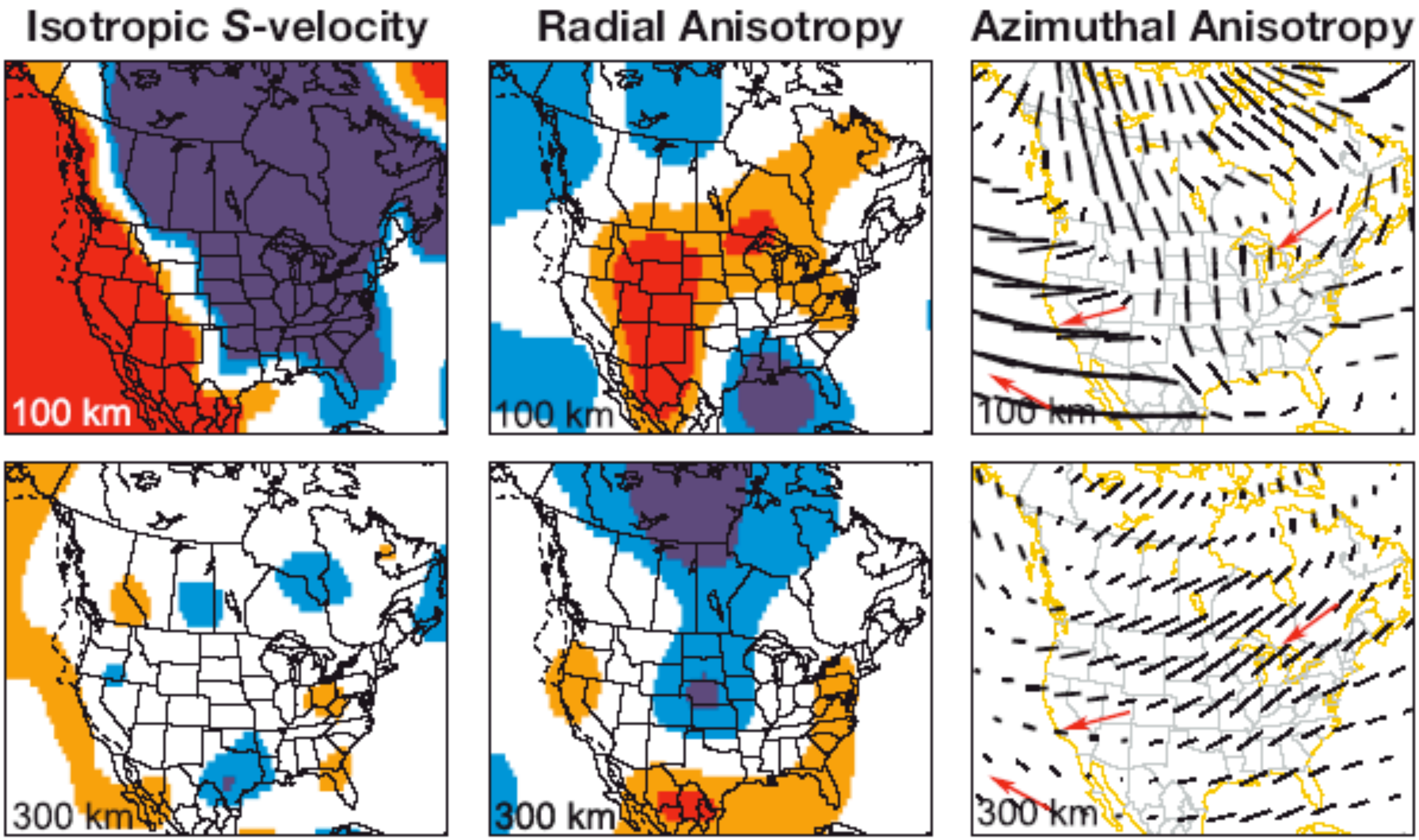
Zaranek (2006)

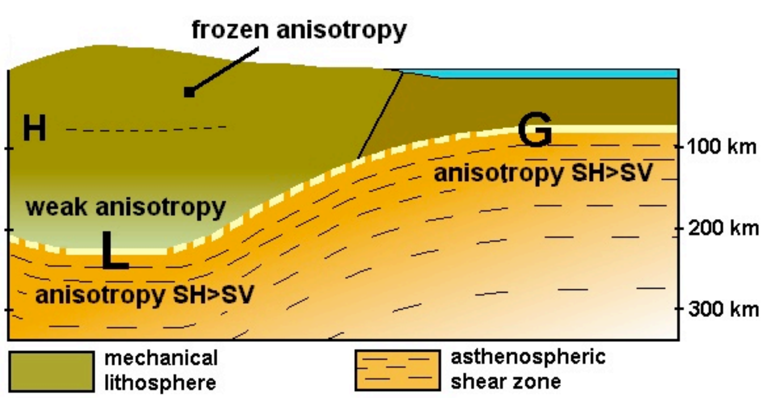


Conrad et al. (2007)



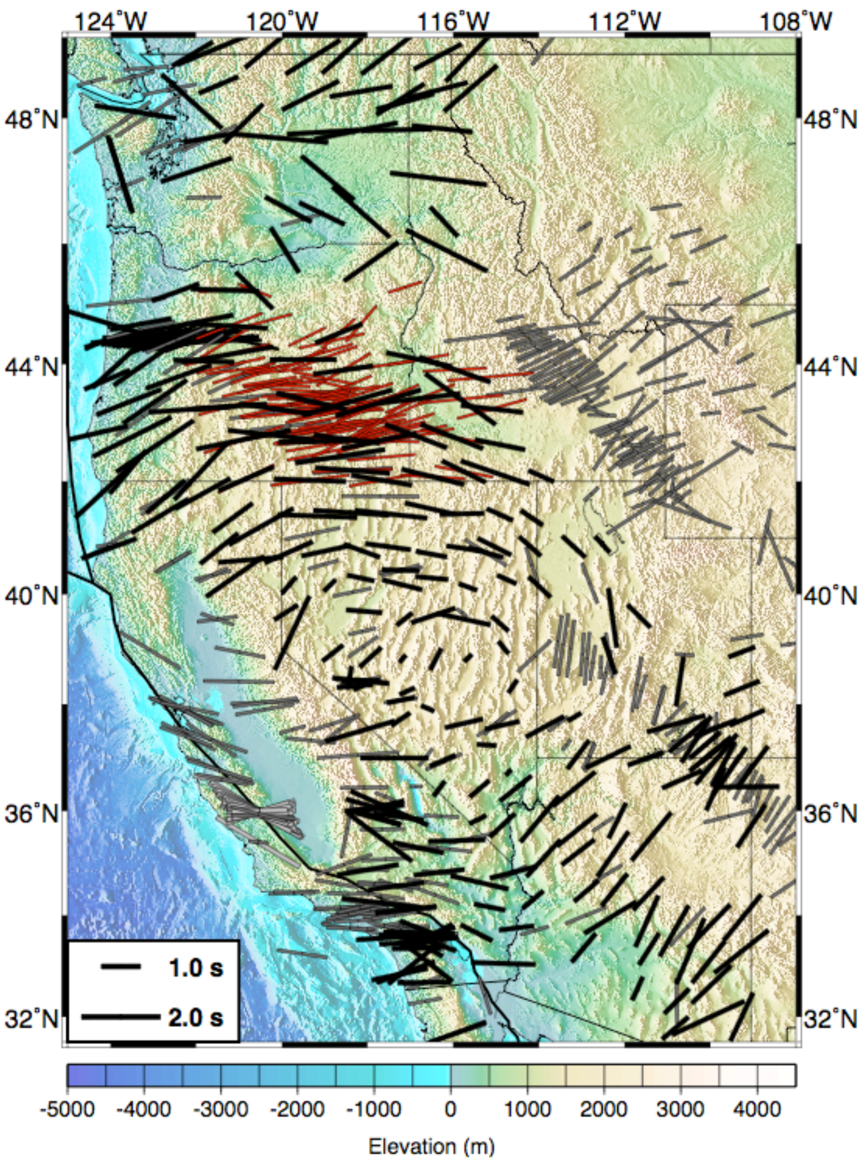
Debayle et al. (2005)





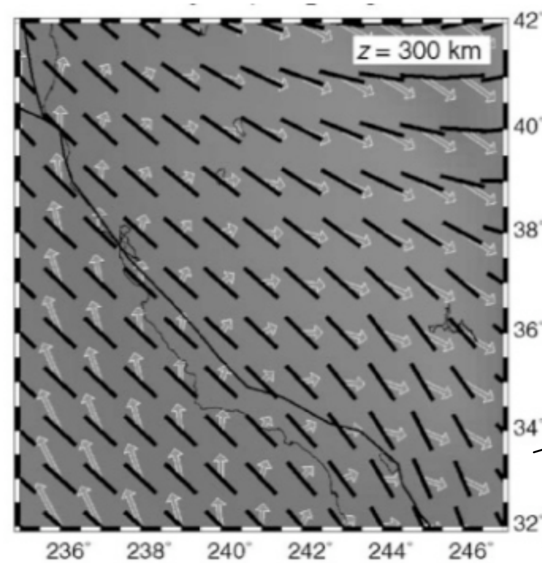
Joint inversion of surface waves and SKS splitting

Marone and Romanowicz (2007)



Fouch et al. (2008)

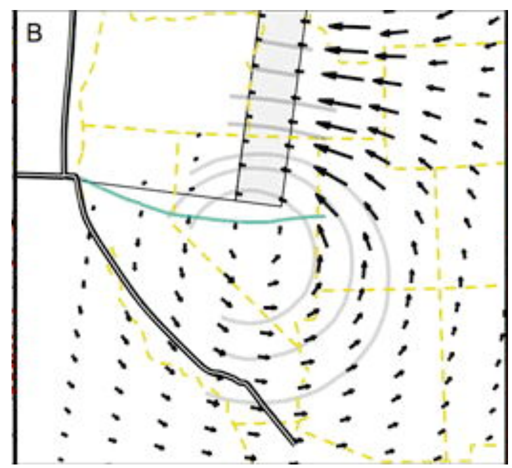
Asthenospheric return flow



Silver and Holt (2002)

Becker et al. (2006)

Toroidal slab flow



Zandt and Humphreys (2008)

Conclusions and Questions for the Future

In certain regions, LAB velocity gradient too strong, sharp to be explained by temperature alone. Implies asthenosphere weakened by volatiles, or melt.

How do LAB properties vary globally? What are the implications for mantle rheology?

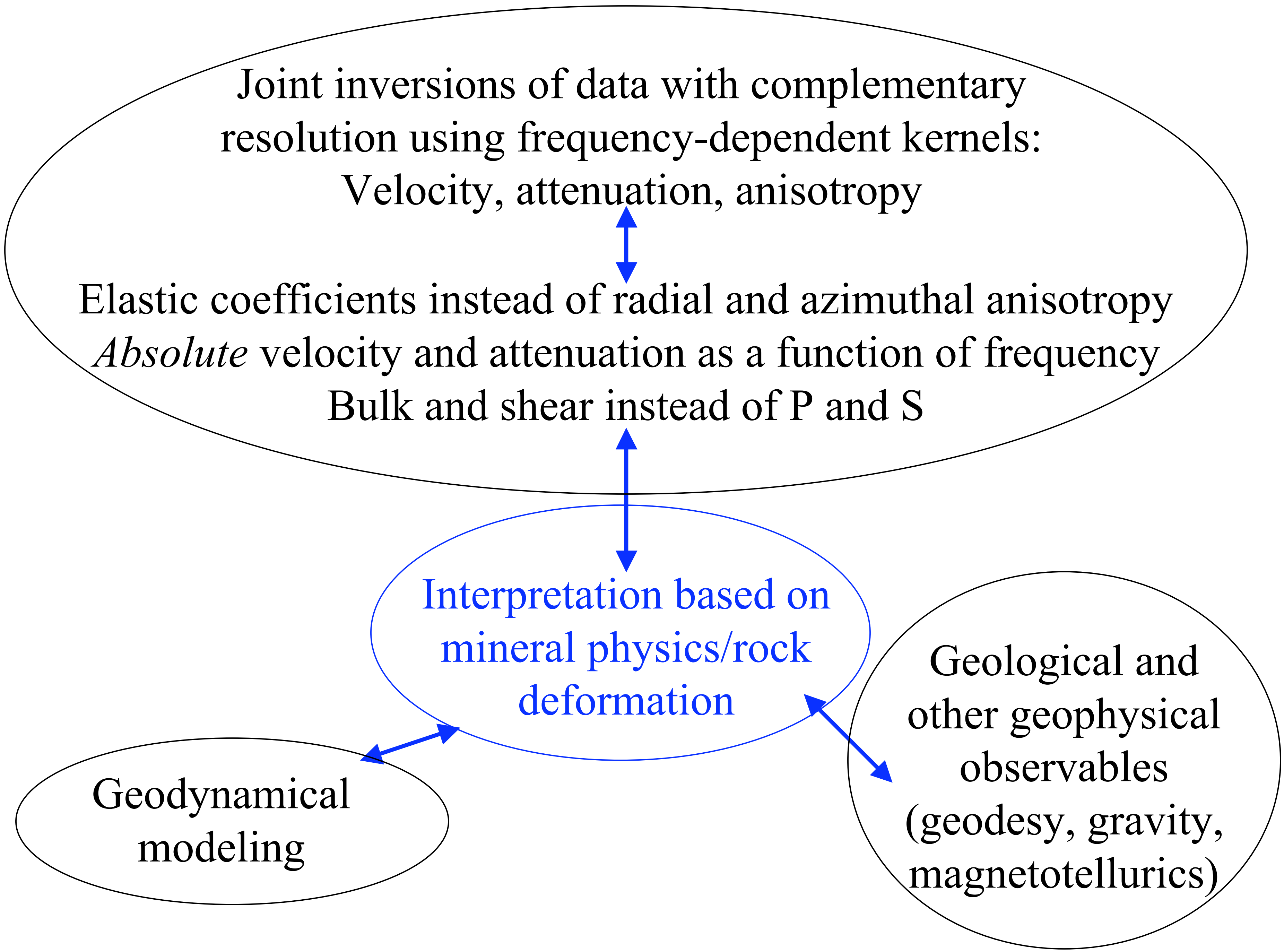
Anisotropy in broad regions of asthenosphere consistent with flow induced by plate motion plus mantle buoyancy. Implies some coupling of plate motion to deeper mantle flow.

How does lithosphere-asthenosphere coupling vary globally?

How does coupling vary at greater depths?

What is the role of small-scale convection, delamination?

Why does simple slab-wedge coupling appear to break down in subduction zones?


Joint inversions of data with complementary resolution using frequency-dependent kernels:
Velocity, attenuation, anisotropy
Elastic coefficients instead of radial and azimuthal anisotropy
Absolute velocity and attenuation as a function of frequency
Bulk and shear instead of P and S
Interpretation based on mineral physics/rock deformation
Geodynamical modeling
Geological and other geophysical observables (geodesy, gravity, magnetotellurics)