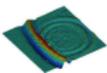


Surface wave isolation with the interferometric Green tensor

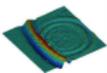
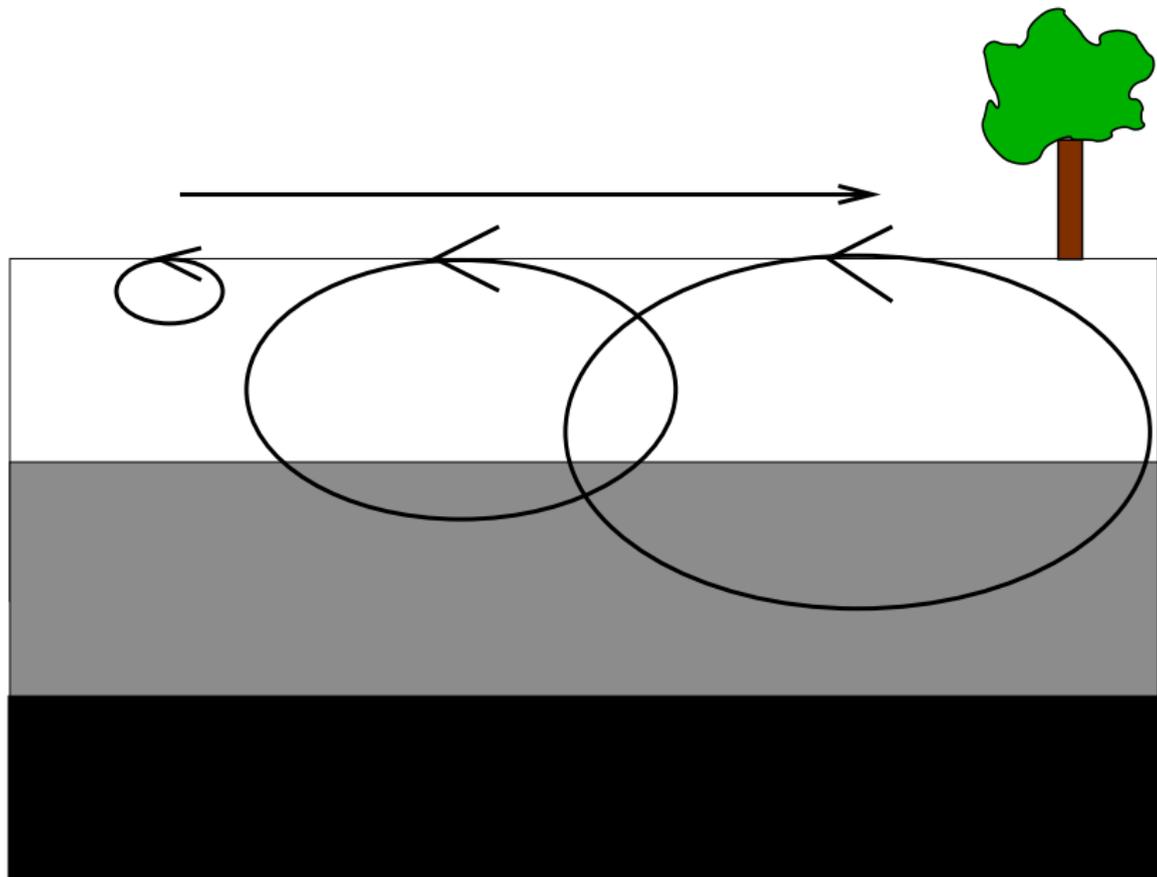
Kasper van Wijk, Dylan Mikesell, Thomas Blum, Matt Haney,
and Alex Calvert[†]

Boise State University, Department of Geosciences
[†] Formerly ION, now Maersk

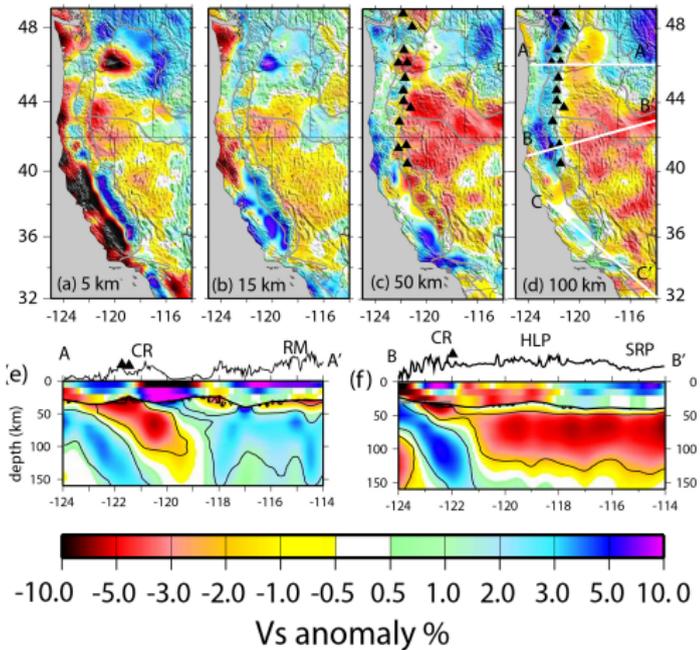
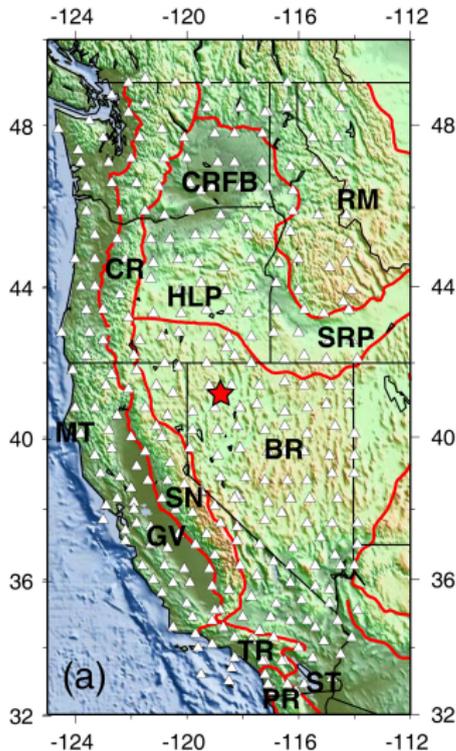
November 2, 2010



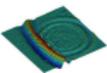
Surface waves



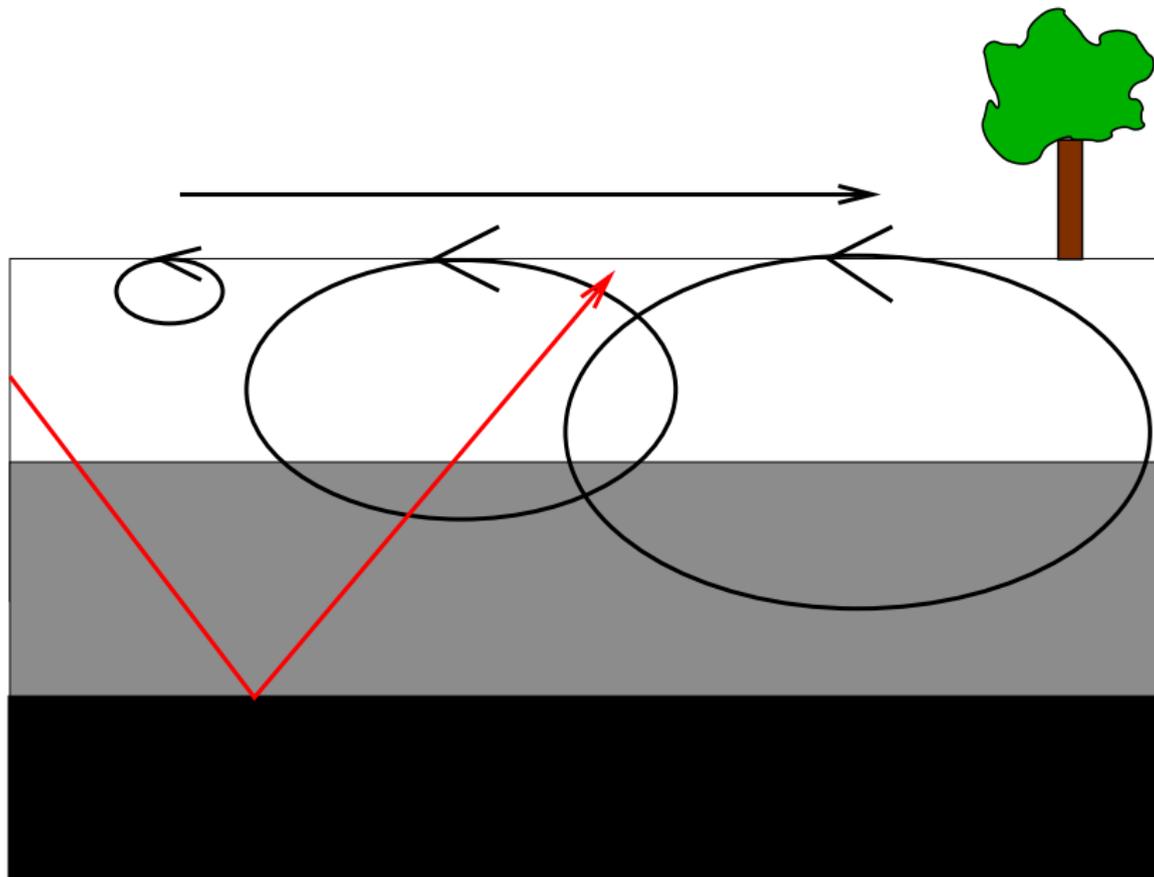
Imaging: Seismic Interferometry



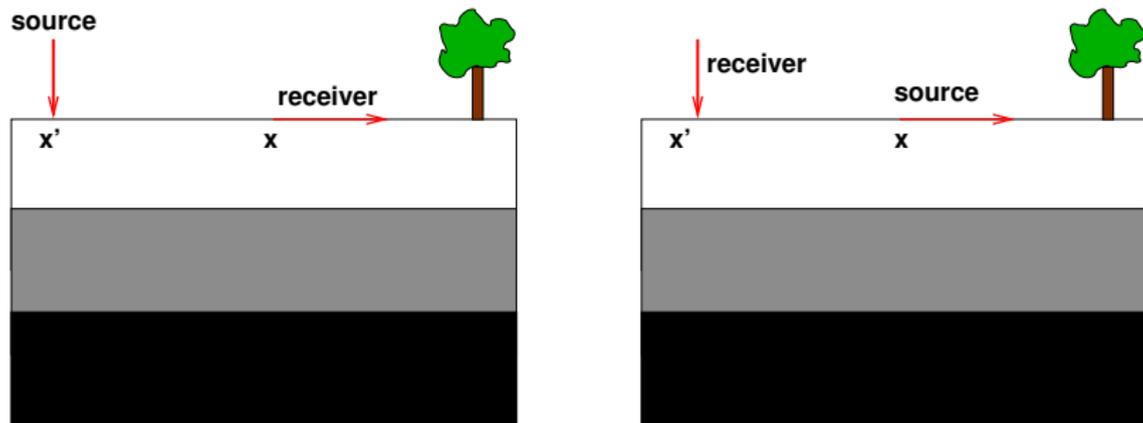
(Yang et al., JGR, 2008)



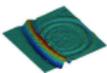
Or "Ground Roll"



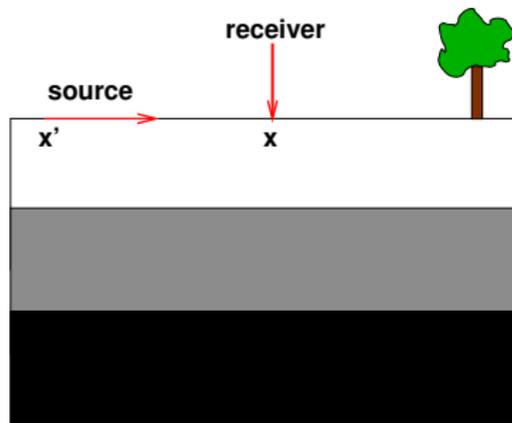
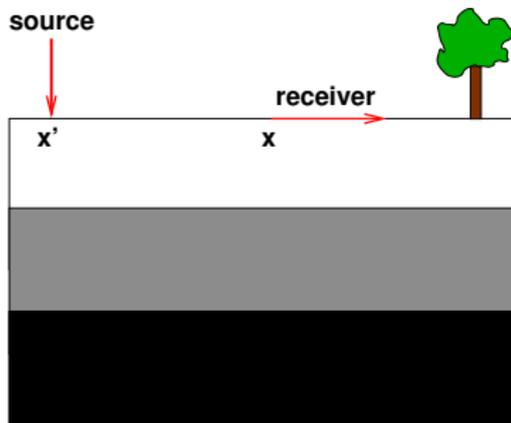
Reciprocity



$$G_{xz}(\mathbf{x}, \mathbf{x}', \omega) = G_{zx}(\mathbf{x}', \mathbf{x}, \omega)$$

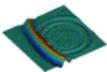


Rayleigh wave in a vertically heterogeneous Earth

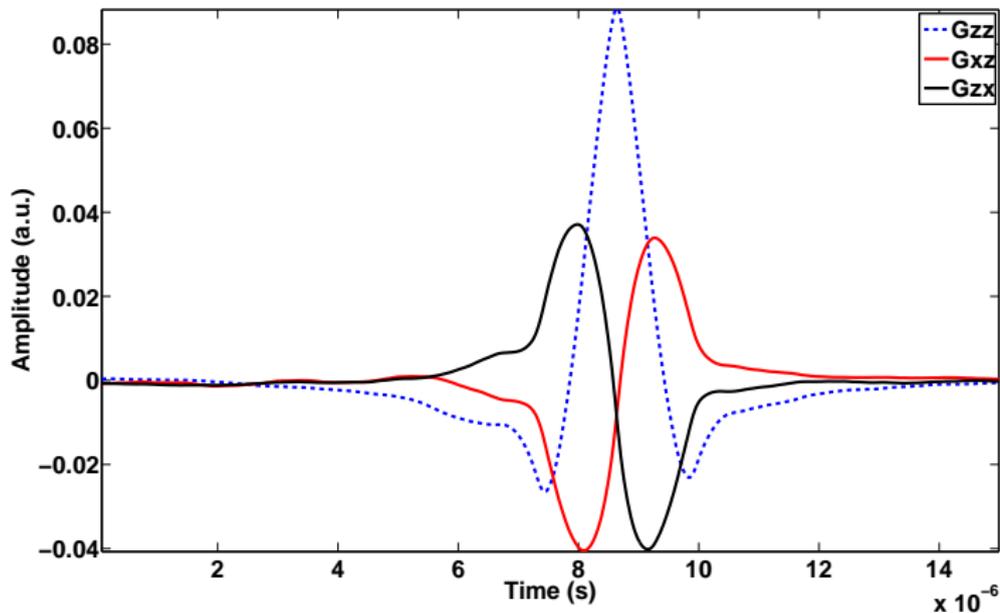


$$G_{xz}(\mathbf{x}, \mathbf{x}', \omega) + G_{zx}(\mathbf{x}, \mathbf{x}', \omega) = 0$$

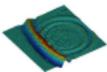
(Aki and Richards, equation 7.147)



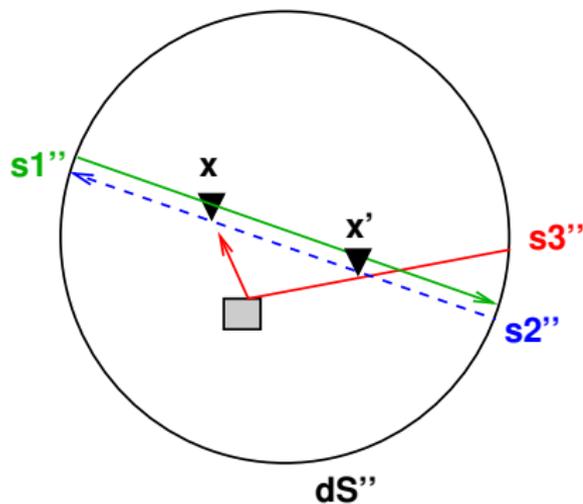
Impulse response components



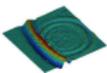
$$G_{xz}(\mathbf{x}, \mathbf{x}', \omega) + G_{zx}(\mathbf{x}, \mathbf{x}', \omega) = 0$$



If we only had multi-component sources: interferometry



$$G_{ij}(\mathbf{x}, \mathbf{x}', \omega) + G_{ij}^*(\mathbf{x}, \mathbf{x}', \omega) \propto \oint_S \frac{U_{ik}^*(\mathbf{x}, \mathbf{x}'', \omega) U_{jk}(\mathbf{x}', \mathbf{x}'', \omega)}{\rho(\mathbf{x}'') c(\mathbf{x}'')} dS''$$

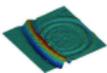


Interferometry for surface wave removal recipe

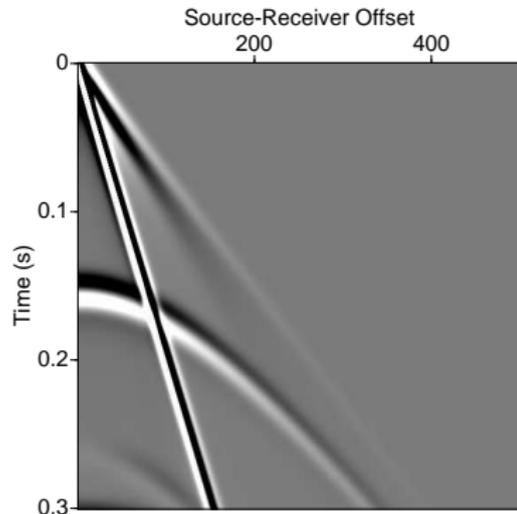
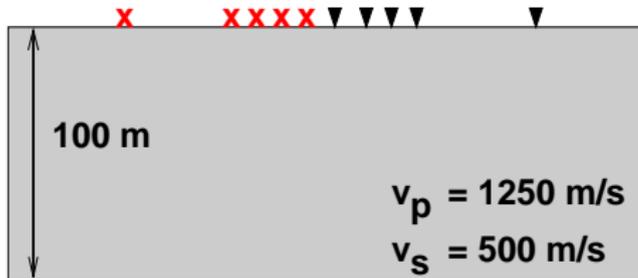
Xue, Dong and Schuster (2008) and Haliday and Curtis (2009):

- predict surface waves from interferometry
- subtract from real records

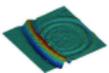
Unlike f-k techniques, there are no aliasing issues



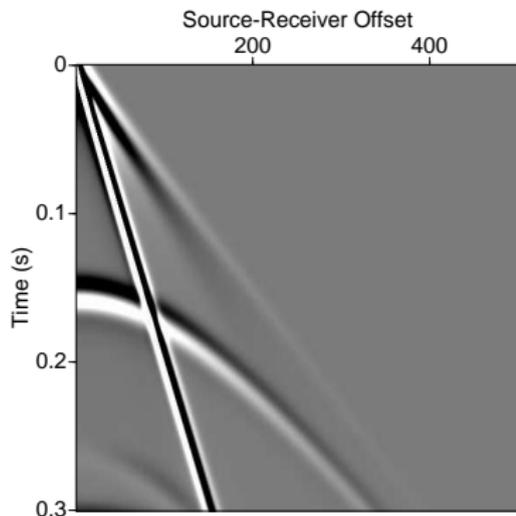
Numerical example



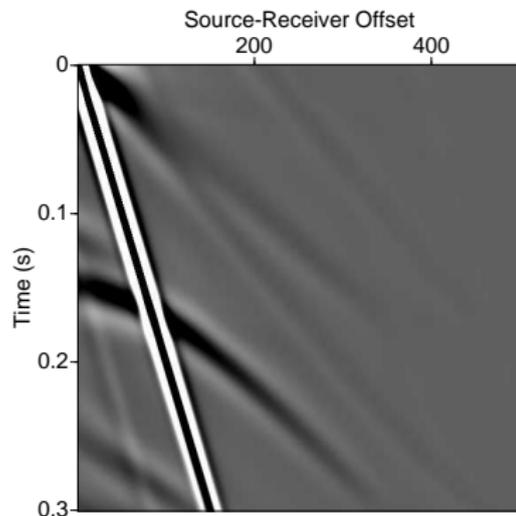
shot record (U_{zz})



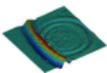
Interferometry with the vertical components



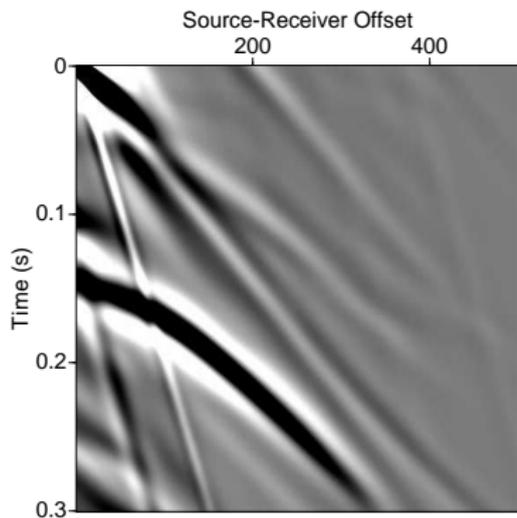
shot record (U_{zz})



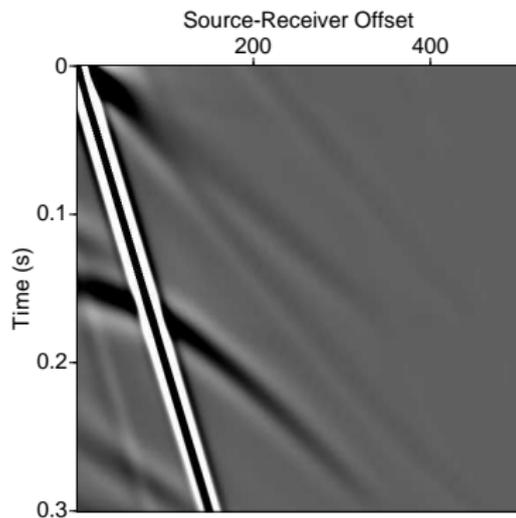
virtual shot record (G_{zz})



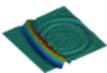
surface-wave removal



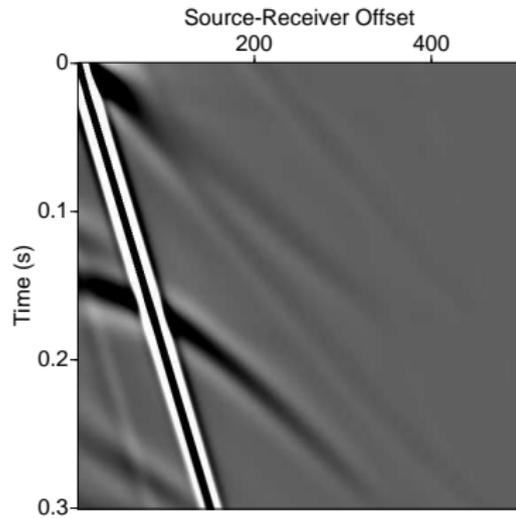
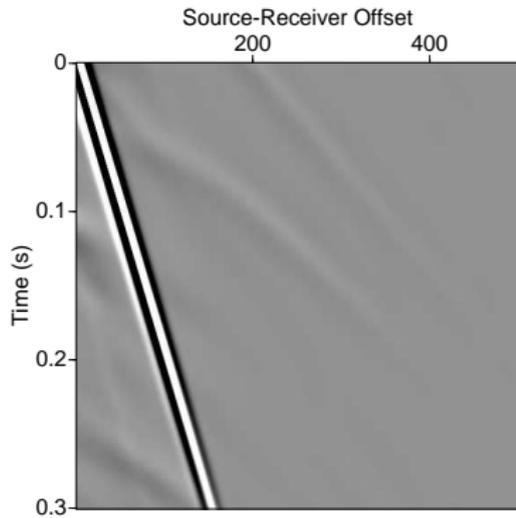
$G_{zx} + G_{xz}$



G_{zz}



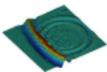
.... or enhancement



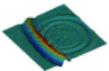
$$G_{zx} - G_{xz}$$

$$G_{zz}$$

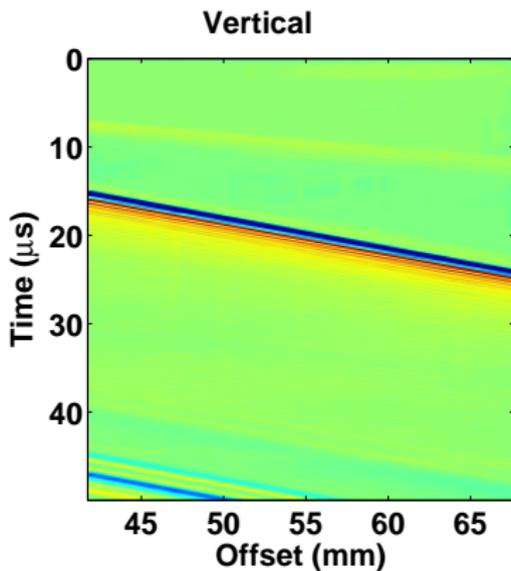
Left panel can go into surface-wave inversion, or into adaptive removal scheme



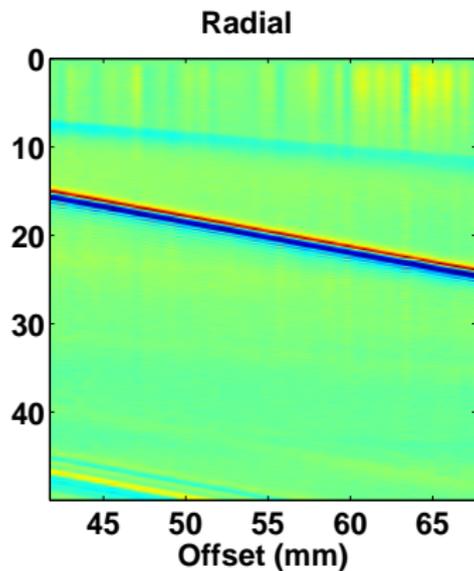
Surface-Wave Isolation (in the PAL)



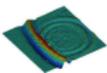
Surface-Wave Isolation (in the PAL)



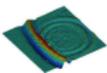
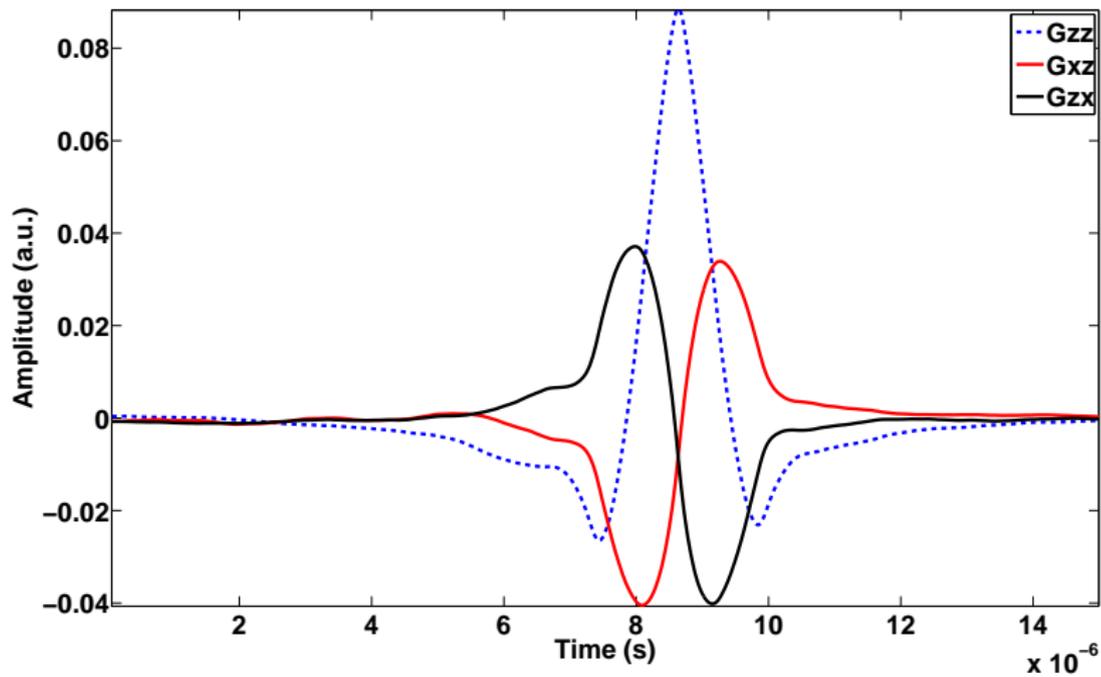
U_{zz}



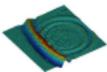
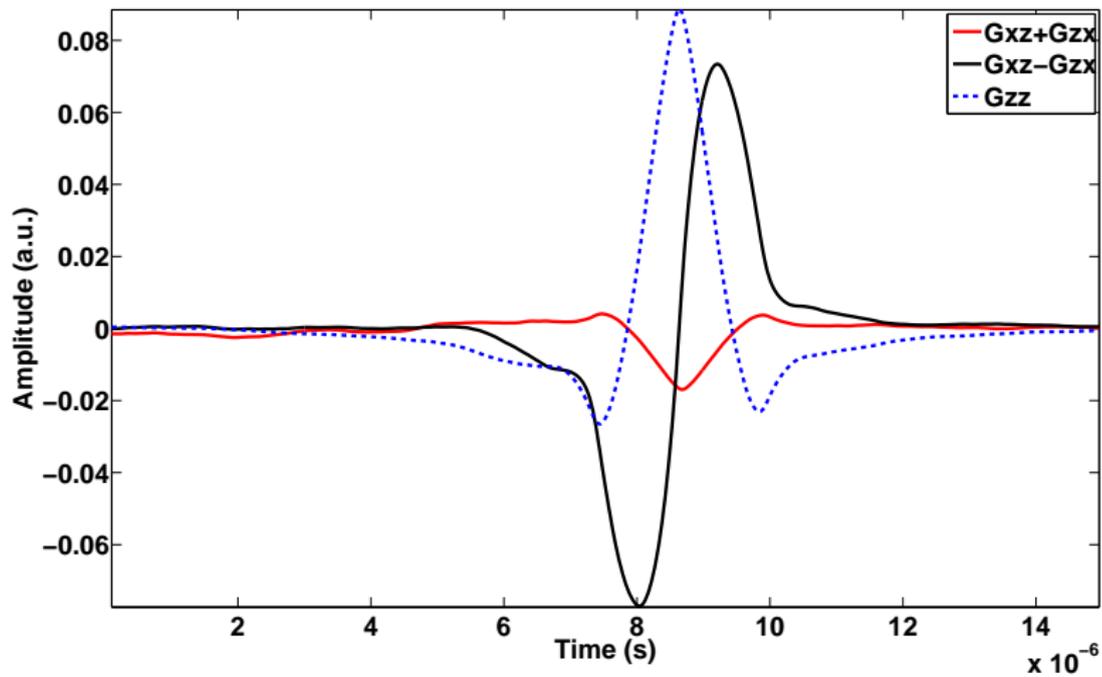
U_{xz}



Estimated Impulse responses

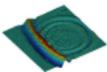


Estimated Impulse responses



multi-component (interferometric) surface-wave removal/enhancement

- has been illustrated for a slab geometry
 - numerically
 - in the lab
- has no spatial aliasing problems
- needs testing on more complicated models:
 - multi-layer
 - lateral variations
 - 3D



Acknowledgments

PALs: Mila Adam, Alison Malcolm, Huub Douma and Roel Snieder

