Enhanced Imaging of the Mantle Transition Zone with Generalized Iterative Deconvolution and 3D Plane Wave Migration

Yinzhi Wang and Gary Pavlis, Indiana University

We processed Earthscope TA data with a new deconvolution method we call the generalized iterative technique. We then used these data as input to our 3D plane wave migration method to produce an image volume of P to S scattering surfaces under all of the lower 48 states. The result is arguably the highest resolution image ever produce of the mantle transition zone. Generalized iterative deconvolution improves the resolution of receiver function estimation by using an inverse operator instead of the conventional cross-correlation operator. It also provides better control of the signal-to-noise ratio on the result by applying a different convergence criterion. More importantly, new insight gained from generalized iterative deconvolution has shown that profound improvements in resolution were achieved by using a different shaping wavelet than the more widely used Gaussian wavelet. We show the improvement in resolution can be readily explain by an application of the concept of migration impulse response. Applications to the latest USArray data show dramatic improvements in the resolution of plane wave migration images produced using Ricker wavelet in comparison to a Gaussian wavelet with a comparable peak width (Fig. 1). The 410 and 660 discontinuities are resolved to high precision indicating both discontinuities are sharp but rough at the scale of teleseismic P wave frequencies. We present evidence for pervasive negative scatterers found throughout the mantle transition zone under all of the area covered by the TA. A mineral physics explanation for this phenomenon is currently lacking.

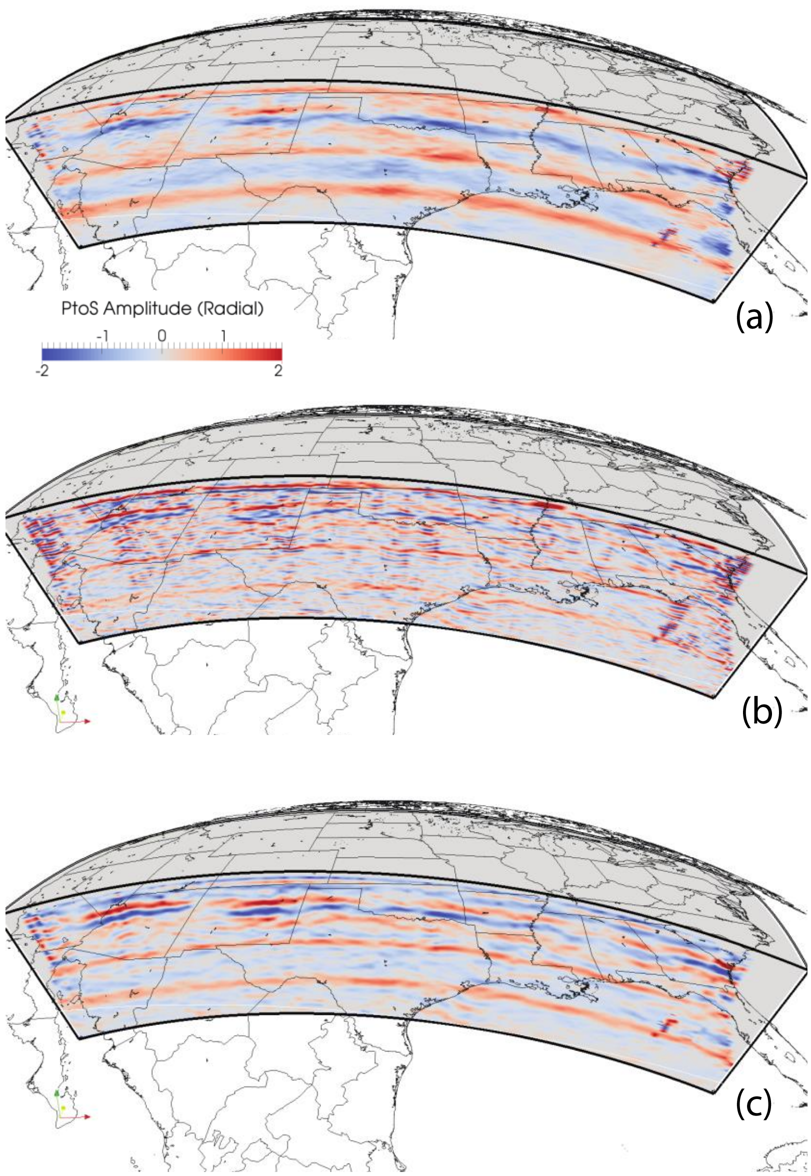

Figure 1. Plane-wave migration result with EARS data using different shaping wavelets. All three parts of the figure are a common slice through the same image volume processed using three different shaping wavelets: (a) Gaussian wavelet used in the original EARS data, (b) 2.5 Hz center frequency Ricker wavelet, and (c) a 0.125 Hz center frequency Ricker wavelet. The slice is a great circle path section with true three-dimensional geometry viewed from the south and at a position above the Earth's surface. The images are displayed as a blue to red color map with blue showing negative and red positive P to S scattering potential on the radial component. Data are shown true amplitude with a $z^{1.4}$ gain function used to provide a more uniform amplitude scaling with depth.