Does Supplementing Travel Time Data with Amplitude Data improve Geo-tomographic Determinations of Earth Structure?

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Previously, geo-tomographic imaging of mantle convection has mostly relied on P and S wave travel times. However, errors in travel time measurements can lead to poor images. In this study, a new geo-tomographic method is explored that improves the image quality by expanding the observations to include P and S wave amplitudes. The quantity being imaged is slowness (the reciprocal of wave speed). Travel time is related to the slowness along the ray and amplitude to the second derivative of slowness along the ray. We invert the method of cubic interpolation described by Keys (1981) in order to relate measurements at points along a ray to properties of the slowness grid. An image is then estimated from the combined data sets and is compared to an image produced from travel time data, only. The addition of amplitude data reduces the number of rays required to achieve a high-quality image by 40%. It is found that the combination of travel time and amplitude observations leads to an image that is less sensitive to the presence of noise, especially when the ray paths are sparse. Then, even very noisy amplitude data (signal to noise ratio of 3:1) leads to improved images (95% error reduction). Additionally, the inclusion of amplitude data lowers the error of an image created with a limited angle range of earthquake data (with a median of 62% error reduction). The imaging technique requires observations along fewer rays to achieve a high-quality image. The new method suggests that the addition of amplitude data can substantially improve Earth images in a broad range of studies.

Keys, R. (1981). Cubic convolution interpolation for digital image processing, IEEE Transactions on Acoustics, Speech, and Signal Processing 29, 1153–1160.