A Global 3D P-Velocity Model of the Earth's Crust and Mantle for Improved Event Location

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Using high-quality 3D Earth models should result in more accurate seismic event locations compared to locations computed with 1D models. To test this hypothesis, we have developed a global P wave velocity model of the Earth's crust and mantle using seismic tomography.

Our model is derived from the latest version of the Ground Truth (GT) catalog of P and Pn travel time picks assembled by Los Alamos National Laboratory. To prevent over-weighting due to ray path redundancy and to reduce the computional burden, we cluster rays to produce representative rays. Reduction in the total number of ray paths is > 30%.

The model is represented using the variable resolution tessellation developed by Ballard et al. (2009), with a modification to allow much higher resolution crustal information. For our starting model, we use a simplified 2 layer crustal model derived from the Crust 2.0 model over a uniform AK135 mantle. Sufficient damping is used to reduce velocity adjustments so that ray path changes between iterations are small. We regularize using progressive grid refinement, refining the grid only around areas with significant velocity changes from the starting model. Our approach produces a smooth, multi-resolution model with node density appropriate to both ray coverage and the velocity gradients required by the data. This scheme is computationally expensive, so we use a distributed computing framework developed by Sandia National Laboratories, providing us with 300+ processors.

We evaluate the effectiveness of our model by analyzing travel time residual variance reduction globally, by station, by region, and for a set of 42 very well-characterized events. We also use our model to relocate those same 42 events to assess improvement in location capability compared to the locations computed with a 1D model. Resolution of our model is determined using standard techniques, and we compare it with a model we derived using the openly-available EHB catalog data.