

EGU21-926

<https://doi.org/10.5194/egusphere-egu21-926>

EGU General Assembly 2021

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Comparing Higher-dimensional Velocity Models for Seismic Location Accuracy using a Consistent Travel Time Framework

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Historically, location algorithms have relied on simple, one-dimensional (1D, with depth) velocity models for fast, seismic event locations. The speed of these 1D models made them the preferred type of velocity model for operational needs, mainly due to computational requirements. Higher-dimensional (2D-3D) seismic velocity models are becoming more readily available from the scientific community and can provide significantly more accurate event locations over 1D models. The computational requirements of these higher-dimensional models tend to make their operational use prohibitive. The benefit of a 1D model is that it is generally used as travel-time lookup tables, one for each seismic phase, with travel-time predictions pre-calculated for event distance and depth. This simple, lookup structure makes the travel-time computation extremely fast.

Comparing location accuracy for 2D and 3D seismic velocity models tends to be problematic because each model is usually determined using different inversion parameters and ray-tracing algorithms. Attempting to use a different ray-tracing algorithm than used to develop a model almost always results in poor travel-time prediction compared to the algorithm used when developing the model.

We will demonstrate that using an open-source framework (GeoTess, www.sandia.gov/geotess) that can easily store 3D travel-time data can overcome the ray-tracing algorithm hurdle. Travel-time lookup tables (one for each station and phase) can be generated using the exact ray-tracing algorithm that is preferred for a specified model. The lookup surfaces are generally applied as corrections to a simple 1D model and also include variations in event depth, as opposed to legacy source-specific station corrections (SSSCs), as well as estimates of path-specific travel-time uncertainty. Having a common travel-time framework used for a location algorithm allows individual 2D and 3D velocity models to be compared in a fair, consistent manner.