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Global-scale Joint Body and Surface Wave Tomography with Vertical Transverse Isotropy for Seismic Monitoring Applications

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We continue to develop more advanced models of Earth's global seismic structure with specific focus on improving predictive capabilities for future seismic events. Our most recent version of the model combines high-quality P and S wave body wave travel times and surface-wave group and phase velocities into a joint (simultaneous) inversion process to tomographically image Earth's crust and mantle. The new model adds anisotropy (known as vertical transverse isotropy) to the model, which is necessitated by the addition of surface waves to the tomographic data set. Like previous versions of the model the new model consists of 59 surfaces and ∼1.6 million model nodes from the surface to the core-mantle boundary, overlaying a 1-D outer and inner core model. The model architecture is aspherical and we directly incorporate Earth's expected hydrostatic shape (ellipticity and mantle stretching). We also explicitly honor surface undulations including the Moho, several internal crustal units, and the upper mantle transition zone undulations as predicated by previous studies. The explicit Earth model design allows for accurate travel time computation using our unique 3-D ray tracing algorithms, capable of 3-D ray tracing more than 20 distinct seismic phases including crustal, regional, teleseismic, and core phases. Thus, we can now incorporate certain secondary (and sometimes exotic) phases into source location determination and other analyses. New work on model uncertainty quantification assesses the error covariance of the model, which when completed will enable calculation of path-specific estimates of uncertainty for travel times computed using our previous model (LLNL-G3D-JPS) which is available to the monitoring and broader research community and we encourage external evaluation and validation.
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