Seismic structure of the North American lithosphere and upper mantle imaged using Surface and S waveform tomography

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The evolution, stability, and dynamics of continental lithosphere remain a central focus of Earth Science research. The continued deployment of the US Array is producing a massive new dataset that samples North America at scales from tectonic units to continent-wide domains and enables resolution of structure and deformation of the lithosphere previously possible only at regional scales. With this resolving power come new challenges relating to efficient management and processing of such large data volumes. In this study, we have assembled a dataset comprising over 3.5 million three-component broadband seismic waveforms from more than 3000 stations. We augment available US Array stations with 600 additional North American stations of the GSN and affiliates, Canadian National Seismograph Network, regional arrays, past PASSCAL experiments, and other stations from Iceland, Greenland, Central and South America, the Caribbean, and several Mid-Atlantic Islands. We exploit the resolving power of this unprecedentedly large dataset using the Automated Multimode Inversion of surface- and S-wave forms. The waveforms are inverted for path-averaged linear constraints on elastic structure along the source-receiver paths. The linear equations are then simultaneously solved for a high-resolution 3D upper mantle shear velocity model of the continent.

We present a model of the North American continent's and the surrounding Ocean's (Pacific, Atlantic, Gulf of Mexico) upper mantle structure down to the 660 km discontinuity. Clearly identifiable boundaries between different tectonic features such as basins and relic mountain ranges are readily observable. For example, a strong correlation between the Hudson Bay geoid anomaly can be identified with an underlying domain of particularily cold cratonic lithosphere. Our model also includes the 3D distribution of azimuthal anisotropy within these structures, which provides new insight into past and present dynamics of the lithosphere and asthenosphere.