Complex shear-wave splitting implies simple anisotropy in the lithosphere and asthenosphere beneath the eastern U.S.

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Decades of shear-wave splitting measurements have provided constraints on deformation in the sub-continental mantle lithosphere and asthenosphere. Yet debate remains regarding the proportion of shear-wave splitting that accrues in the lithosphere versus the asthenosphere and the interpretation of splitting patterns in terms of lithospheric tectonic history and recent asthenospheric flow. To explore the origins of mantle anisotropy beneath eastern North America, we modeled teleseismic shear-wave splitting measurements with anisotropy in the lithosphere and asthenosphere. New observations include 315 SKS/SKKS splitting measurements from the 85 broadband stations of the EarthScope SESAME array in the southeastern U.S. These observations (0.05-0.35 Hz) delineate a strong variation of fast polarization direction with back-azimuth that cannot be explained by lateral variations in anisotropy. We combined these data with the results of nine published studies, including measurements from the stations of the NSF EarthScope Transportable Array. Back-azimuthal variations of fast polarization direction are widespread in the eastern U.S. and are particularly evident when data are combined over sub-regions with dimensions of 200-300 km. Observed splitting parameters were compared to the predictions of two-layer models that describe anisotropy in each layer with olivine a-axis azimuth, a-axis plunge, and anisotropy strength. Layer thicknesses were scaled to the depths of mantle lithosphere and asthenosphere estimated from surface wave tomography. Best-fitting a-axis azimuths in the lower (asthenospheric) layer of anisotropy are typically within 20˚ of absolute North American plate motion in the Pacific hotspot reference frame. This result is consistent with olivine lattice preferred orientation (LPO) caused by shearing of the asthenosphere due to recent plate motion. Best-fitting a-axis azimuths in the upper (lithospheric) layer of anisotropy are more variable and approximately align with the local strike of the Appalachian-Ouachita orogeny, and further west with the strikes of Proterozoic orogens. This finding is consistent with olivine LPO due to compression of the lithospheric mantle as it was accreted to the margin of proto-North America.