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Imaging the lithosphere and underlying mantle of the South Atlantic, South America and Africa using waveform tomography with massive datasets

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Recent growth in seismic station coverage has facilitated dense data sampling of the previously poorly-sampled lithosphere and underlying mantle within the South Atlantic, South America and Africa. This enables us to image the region at a new level of detail capable of addressing important open questions regarding its lithospheric architecture and mantle dynamics. In order to fully exploit the data sampling, we use an efficient, multimode waveform tomography scheme that allows extraction of structural information from millions of seismograms and uses data redundancy to minimize the effects of data errors on the models. Our tomographic model is constrained by waveform fits of over 1.2 million vertical-component seismograms, computed using the Automated Multimode Inversion of surface, S- and multiple S- waves. Each seismogram fit provides a set of linear equations describing 1D average velocity perturbations within approximate sensitivity volumes, with respect to a 3D reference model. We then combine all equations into a large linear system and invert jointly for a model of S- and P-wave speeds and azimuthal anisotropy within the lithosphere and underlying mantle. In West Africa, two clearly separate high-velocity units underlay the Reguibat and Man-Léo Shields; in the Congo area, a single high-velocity body, formed by three main units underlying the Gabon-Cameroon, Bomu-Kibali and Kasai Shields, is present. We interpret these bodies as the fine-scale structure of the West African and Congo Cratons, respectively. Strong low-velocity anomalies underlay the Afar Hotspot and the East African Rift; pronounced low velocities are also seen beneath parts of the Sahara Desert. We discuss the shape of the deep Afar anomaly and its possible relationships with the Saharan volcanism and the neighboring Tanzania Craton. In the South Atlantic, we retrieve fine-scale velocity structure along the Mid-Atlantic Ridge (MAR), indicative of hotspot-ridge interactions. Major hotspots show low-velocity anomalies extending substantially deeper than those beneath the MAR, with the Vema Hotspot showing especially pronounced low-velocity anomalies under the thick, cold lithosphere of the Cape Basin. The offshore segment of the Cameroon line shows strong low-velocity anomalies that extend from the Sahara volcanic province to the MAR.