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Whole-mantle structure under the Reunion hotspot in the western Indian Ocean from multifrequency P-wave tomography

Maria Tsekhmistrenko, Karin Sigloch, and Kasra Hosseini
University of Oxford, Department of Earth Science, Oxford, United Kingdom (maria.tsekhmistrenko@seh.ox.ac.uk)

We present a high resolution body-wave tomography of the whole mantle column beneath the western Indian Ocean, with a focus on the volcanic hotspot of La Reunion, the presumed location of a deep mantle plume.

From 2011 to 2016, the RHUM-RUM (www.rhum-rum.net/en/) project instrumented a 2000 km x 2000 km area of the seafloor and islands surrounding the hotspot with broadband seismometers. The central component was a 13-month deployment of 57 German and French ocean bottom seismometers (OBS) at 2300-5600 m depth. This was supplemented by 37 island stations on Reunion, Mauritius, Rodrigues, the southern Seychelles, the Iles Eparses and southern Madagascar, which ran for 2-3 years. Two partner projects contributed 30 more stations on Madagascar. This large deployment vastly improved the seismological illumination of a previously sparsely instrumented oceanic region.

More than 200 teleseismic events during the 13-month long OBS deployment yielded usable measurements, supplemented by another 400 events recorded by the land stations before and after the OBS deployment. Multi-frequency traveltime measurements are obtained by cross-correlation of observed with predicted waveforms, which are computed by full waveform propagation and careful deconvolution of source time functions.

We obtained ∼50,000 cross-correlations measurements for our multifrequency tomography, in passbands between 30 and 2.7 seconds dominant period. For the final inversion, we combined regional multifrequency measurements with ISC data (1970-2013) in order to regularize the tomography on the margins of the region of interest.

The new P-wave model shows a lowermost mantle source for the plume beneath La Reunion, rooted in the African LLSVP. The model is consistent previous studies in terms of 'fat' plumes in the lower mantle, but reveals much more detail and considerable complexity in the transition zone and upper mantle beneath the Reunion hotspot. Rather than being near-vertical, the upwelling show considerable tilt in the lower mantle (consistent with geodynamic predictions) and splits into branches closer to the surface.