Synthetic tomography of plume clusters and thermochemical piles

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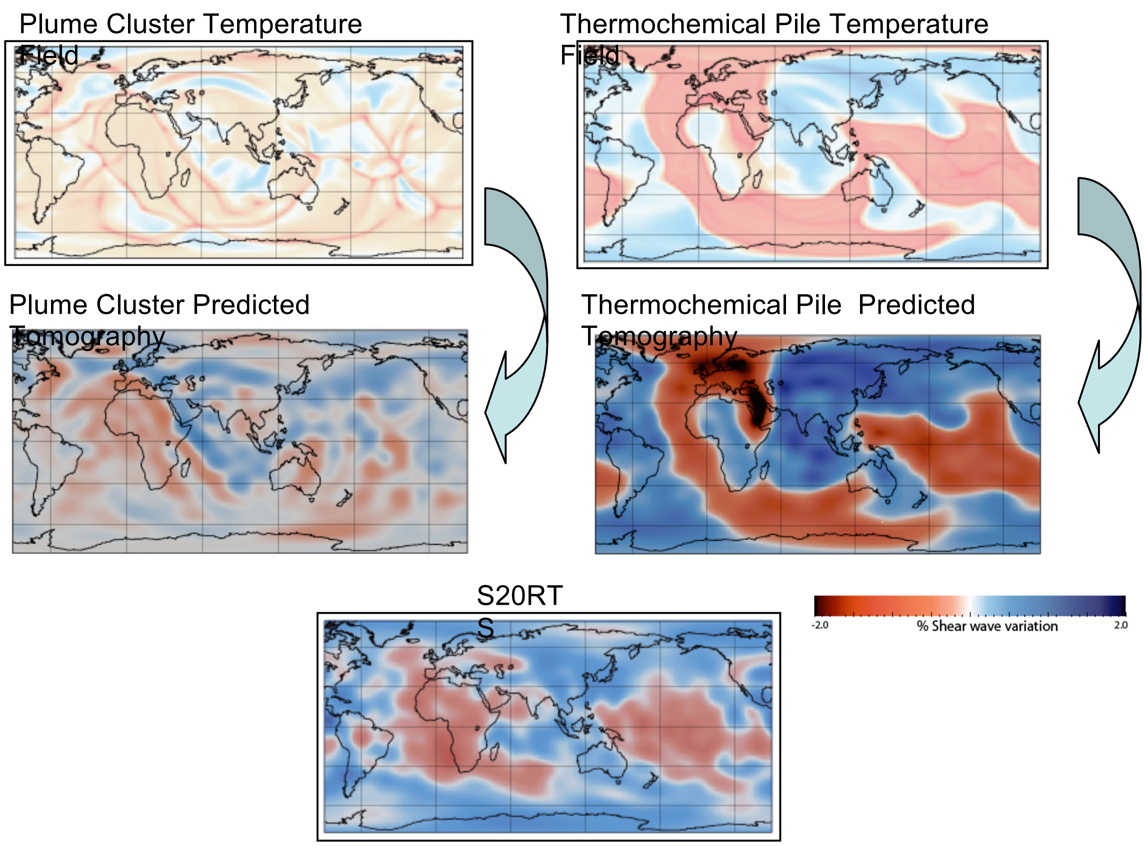
Seismic tomography elucidates broad, low shear-wave velocity structures in the lower mantle beneath Africa and the central Pacific with uncertain physical and compositional origins. One hypothesis suggests that these anomalies are caused by relatively hot and intrinsically dense material that has been swept into large thermochemical piles by mantle flow. An alternative hypothesis suggests that they are instead poorly imaged clusters of narrow thermal plumes. Geodynamical calculations predict fundamentally different characters of the temperature fields of plume clusters and thermochemical piles. However the heterogeneous resolution of tomographic models makes direct comparison between geodynamical temperature fields and tomographic shear-wave anomalies tenuous at best. Here, we compute synthetic tomographic images from 3D spherical mantle convection models using *CitcomS*, and evaluate how well thermal plumes and thermochemical piles can be reconciled with actual seismic tomography images. Geodynamical temperature fields are converted to shear-wave velocity using experimental and theoretical mineral physics constraints. The resultant shear-wave velocity fields are subsequently convolved with the resolution operator from seismic model S20RTS to mimic the damping and distortion associated with heterogeneous seismic sampling of the mantle. We demonstrate that plume clusters are tomographically blurred into two broad, antipodal velocity anomalies in agreement with S20RTS and other global seismic models. Large, thermochemical piles are weakly distorted by the tomographic filter. The power spectrum of velocity heterogeneity peaks at spherical harmonic degree 3, unlike the degree-2 maximum in S20RTS, but decays rapidly similar to S20RTS and many other seismic models. Predicted tomography from thermochemical pile and plume cluster models correlate equally well with S20RTS given the uncertainties in the numerical modeling parameters. However, thermochemical piles match tomography better in visual comparison and in the overall character of the harmonic spectrum.



Reference

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