Seismic tomography provides the primary information on the three-dimensional variation in physical properties in the mantle of the Earth. The trend has been to combine multiple data sets to obtain models covering as wide a span of scale lengths as possible. Thus free oscillation data, surface waves and the passage times of seismic waves may all be brought together in a single inversion. The advantage is that the various classes of data provide different sampling of the Earth, the downside is that judgements need to be made on the relative importance of the different data sets. Much effort has been expended on extracting passage times for intermediate frequency seismic waves for which simple ray theory is barely adequate. Improved results can be obtained by allowing for finite frequency effects either through complex kernels in a single pass inversion from a fixed reference model or through iterative update of the model in a nonlinear inversion.

A challenge remains to interpret the patterns of variation, since we see the imprint of the sampling of the Earth and the impact of regularisation required to produce stable inversions. We can expect that tomographic images will underestimate the true variation in seismic properties. Where joint inversions are undertaken with suitably controlled datasets ratios of properties can be reliably determined even though the absolute variations are not. Interpretations of patterns of seismic heterogeneity need to take account of the nonlinear dependence of seismic wavespeeds on temperatures and a simple derivative assigned to a reference model is not adequate. Indeed the influence of reference models is significant and can influence physical interpretation.