Combining asynchronous data sets in regional body-wave tomography

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Body-wave tomography with data from regional networks, also called ACH tomography, has provided a lot of information on the upper mantle structure, especially in continental settings. A key factor in this technique is the usage of relative residuals, not absolute ones. It is based on the assumption that travel times at stations in a regional network are affected in a similar way by errors in source location and origin time, as well as by large-scale heterogeneities in the lower mantle, and that demeaning the residuals strongly reduces the influence of these factors on the inverse regional model. This results in the well-known fact that the final velocity model is relative to an unknown vertically varying reference model. This also prevents combining data obtained with networks in the vicinity of each other but operating at different times, even though we may have stations, for example permanent stations, which are common to these networks. This is because the residuals at the two networks are measured with respect to different unknown averages and cannot be inverted together. This is very unfortunate as we have numerous examples of asynchronous network deployments which together would provide a much more useful station coverage and model than independently.

I will analyse how a simple change in the formulation of the direct problem allows to take into account that the residuals are demeaned, and, most importantly, how this can be used to remedy the limitations of regional body-wave tomographic methods in terms of asynchronous station deployment. I will first illustrate this with a very simple example and then present the results of a more realistic synthetic test combining data from two neighboring asynchronous networks in a single inversion.