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A survey of deconvolution approaches in teleseismic receiver function analysis

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Receiver function analysis is frequently used to image the Earth's crustal and upper mantle structure. The essential processing step in this analysis is the source normalization, which can be accomplished through deconvolution. Though a variety of deconvolution approaches have been employed over the years to solve this problem, no systematic comparison of these approaches has yet been done. Here, we present the results of such a comparison with the aim of evaluating the various deconvolution approaches and providing some guidelines as to which approach may be better suited for specific applications. The following deconvolution approaches are systematically compared: frequency-domain spectral division using both water-level and damping-factor regularization, multi-taper cross-correlation in the frequency domain, time-domain least squares filtering, and iterative time-domain deconvolution. We carry out benchmark tests on synthetic and real data to assess how the various approaches perform for different input conditions – e.g., data quality (including noise content), data volume based on number of stations and events, and the complexity of the target structure. Our results show that the different approaches produce receiver functions that are equally robust provided that a suitable regularization parameter is found – a task that is usually more easily accomplished in the time domain. However, in the case of noisy data, we find that the iterative time-domain deconvolution can generate as much ringing in the resulting receiver function as poorly regularized frequency-domain spectral division. If computational speed is sought, for example when dealing with large data sets, then the use of frequency-domain approaches might be more attractive. We also find that some deconvolution approaches may be better adapted than others to address specific imaging goals. For example, iterative time-domain deconvolution can be used to quickly construct profiles of first-order discontinuities (e.g., Moho and its multiples) by restricting the number of iterations (n=10-20) and thus filtering out higher-order converted signals.