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How resolving are teleseismic forward and backscattered teleseismic P to S converted waves?

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The Receiver Function (RF) technique, that aims to isolate P to S teleseismic converted waves, is largely used to image seismic discontinuities at depth. In particular, in subduction zones, the subducting crust has often be identified on RF as a Low Velocity Layer (LVL) embedded between the mantle of the overriding plate and the mantle of the subducting lithosphere.

The arrival times and polarities of the forward Ps and backscattered Pps and Pss converted waves at the top and bottom of a LVL are sensitive to the backazimuth and ray parameter of the teleseismic events. We first demonstrate on a synthetic study that the thickness, the Vp/Vs ratio and the dip of a LVL can be retrieved by inverting the arrival times and polarities of these converted waves for a good azimuthal coverage. The Bayesian formalism allows us to also quantify the uncertainties associated to these inverted parameters.

In several subduction zones, a high Vp/Vs ratio inside the oceanic crust has been estimated from the arrival times of the forward and backscattered P to S converted waves at the top and bottom of the LVL. In order to check if the signal periods associated to common filters could lead to an overestimation of the Vp/Vs ratio, we compute the wavelet response in conversion for a LVL typical of an oceanic crust. This multiscale analysis allows to illustrate that the LVL characteristics can be misinterpreted for the common frequency range due to interferences between the converted waves at the top and at the base of the LVL. For example, for a common dominant period of about 3s, the Vp/Vs of a typical oceanic crust will be largely overestimated and its thickness underestimated since a period smaller than 1s is required for a reliable interpretation. Indeed the true characteristics of a layer can be retrieved only if the ratio between the dominant period and the time delay (between the converted waves at the top and bottom of the LVL) is smaller than 1. This allows us to quantify, for the three kind of waves (Ps, Pps and Pss), the resolvable thickness of a LVL with respect to the Vp/Vs ratio and to the Vp velocity for a given signal period.

The approach is finally applied to a real data example of teleseismic events recorded at a 3-component seismometer in order to reliably constrain the dip, the Vp/Vs ratio and the thickness of the oceanic crust at the top of the Hellenic subduction.