USING RECEIVER FUNCTIONS TO ESTIMATE THE CRUSTAL THICKNESS AND THE BULK CRUSTAL VP/VS RATIO IN THE PRESENCE OF CRUSTAL ANISOTROPY

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To account for the presence of seismic anisotropy within the crust and to estimate the relevant parameters, we first discuss a robust technique for the analysis of shear-wave splitting in layered anisotropic media by using converted shear phases. In (weakly) anisotropic media, the P-to-S converted phases (Ps) exhibit a distinct variation in arrival time (cosine moveout) as function of back-azimuth. This variation can be exploited by time-shifting and stacking radial receiver functions to constrain a range of possible splitting parameters (i.e. the fast-polarization direction and the delay time) for an anisotropic layer (Rumpker et al., 2014) (Figure 1).

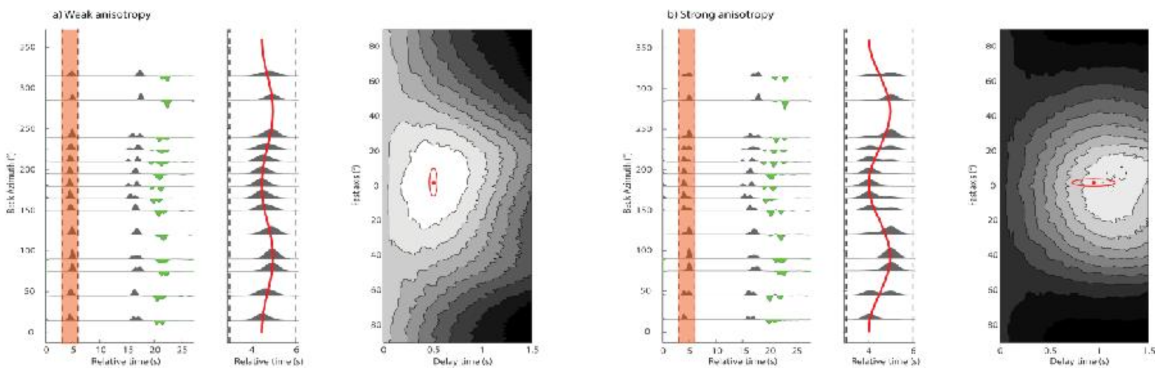

Figure 1. Azimuthal variation in Ps arrival time and the stacking procedure to estimate splitting parameters, a) A case of weak anisotropy, b) A case of strong anisotropy

Then, the minimization of the transverse-component energy is used to select the pair of splitting parameters that best describes the anisotropic properties of the layer. This two-step approach stabilizes the inversion process and significantly reduces the time for computing the best splitting parameters. In multi-layered anisotropic media, the splitting parameters for the individual layers can be inferred by a layer-stripping approach, where the splitting effect due shallower layers on converted phases from deeper discontinuities is successively corrected. The method represents a computationally-efficient extension to multiple anisotropic layers. We further investigate the influences of noise and of gaps in the azimuthal distribution of events.

The effect of anisotropy on the estimate of crustal thickness and average bulk Vp/Vs ratio can be significant. Here, we present a stacking scheme that extends the approach of Zhu and Kanamori (2000) to include P-to-S converted waves and their crustal reverberations generated in the anisotropic case. A ray-based algorithm (Frederiksen and Bostock, 2000) is used to calculate amplitudes and arrival times of all phases generated in an anisotropic medium with hexagonal symmetry and a horizontal symmetry axis. The anisotropic parameters of the medium are first estimated using the splitting analysis of the Ps-phase as described above. Then, a grid-search is performed over layer thickness and Vp/Vs ratio, while accounting for all relevant arrivals in the anisotropic medium. Synthetic examples show the robustness of the stacking approach in the anisotropic case (Figure 2). Further applications of the stacking approach to real data illustrate the feasibility of the approach. For a complete description of the method, refer to Kaviani and Rumpke (2015).

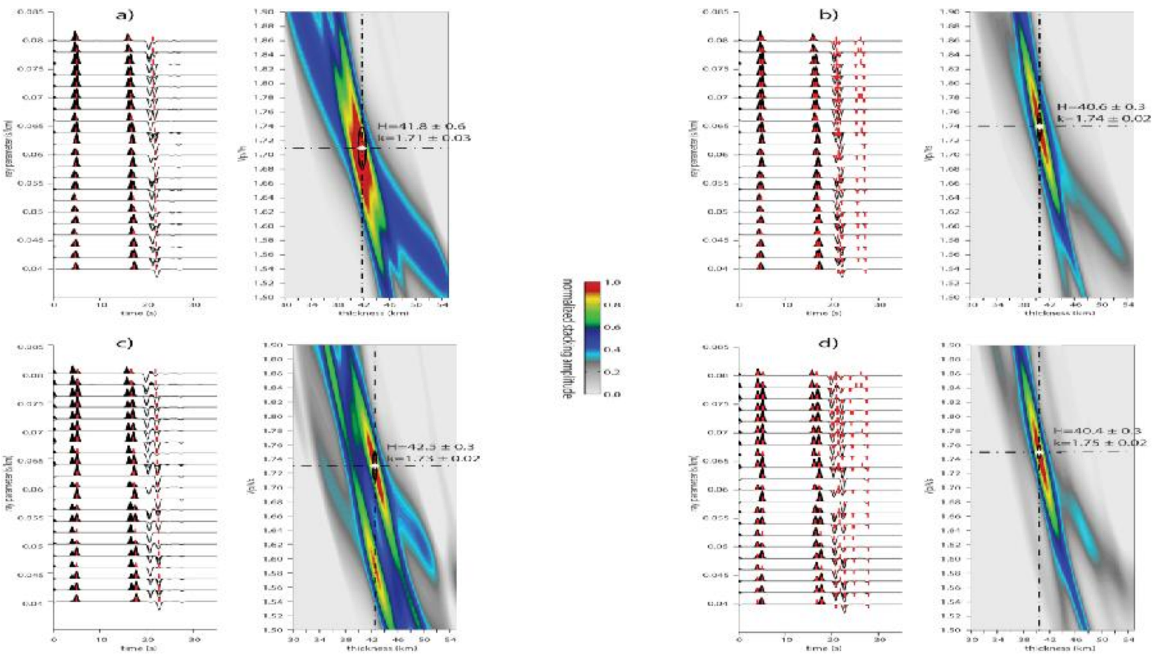

Figure 2. The isotropic and anisotropic stacking and grid-search are applied on receiver functions (RRF) generated for a model with an anisotropic crustal layer overlying an isotropic half-space. The layer is 40 km thick and exhibits isotropic velocities Vp=6.30 km/s and Vs=3.64 km/s (κ=1.73). a) Isotropic H-κ grid search on the synthetic RRFs for a case of weak anisotropy (4%). The colored contours represent the normalized stacked amplitudes of RRFs as a function of layer thickness and κ. b) Anisotropic H-κ grid search applied on the RRFs from the model of weak anisotropy. c) and d) represent the same analysis as shown in a) and b), respectively, but for a case of strong anisotropy (8%).

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