On the sensitivity kernels for Rayleigh wave azimuthal anisotropy

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For the investigation of the oceanic lithosphere-asthenosphere system employing regional OBS array data, it is essential to resolve azimuthal anisotropy as well as radial anisotropy (e.g., Takeo et al., 2018). Considering the presence of strong sub-Moho anisotropy both in P_n and S_n, it is important to analyze both P and S anisotropy for Rayleigh waves as the phase velocity is quite sensitive to the shallow-most P-wave structure. It is well established that, in the case of weak anisotropy, the sensitivity kernels of azimuthal anisotropy have the same form as those for the corresponding VTI parameters (Montagner and Nataf, 1986). This may be understood as that, within the framework of the first order perturbation theory, the eigenfunction is unchanged and thus the phase velocity change is expressed in terms of the equivalent VTI parameters within the plane of the wave propagation. Recently, Russell (2021, Ph.D. Thesis, Appendix E, F) discussed how parameterizations using Love parameters (δA(B), δL(G), δN(E), δF(H)) due to (Montagner and Nataf, 1986) and those using velocity perturbation ($\delta\alpha_H$, $\delta\beta_V$, $\delta\beta_H$, $\delta\eta$) due to (Takeuchi and Saito, 1972) might be related for azimuthal anisotropy. After pointing out that solving for $\delta\beta_V/\beta_V$ (or $\delta\alpha_H/\alpha_H$) on its own is not equivalent to solving for G/L (or B/A) because of the presence of the δF-term, they suggest assuming $\delta\eta/\eta$ ˜0 for inversion. However, the assumption $\delta\eta/\eta$=0 is exactly the reason why the usage of the conventional η introduces the unpreferable behavior of P-wave kernels that is contaminated by the S-wave sensitivities (Kawakatsu, 2016) and unjustifiable; also existing mantle fabrics show a strong azimuthal dependence for $\delta\eta/\eta$. Instead, we suggest using the parameterization involving the new fifth parameter η_κ, i.e, ($\delta\alpha_H$, $\delta\beta_V$, $\delta\beta_H$, $\delta\eta_\kappa$). Because the fifth parameter is difficult to constrain, it might be more practical to omit the corresponding term in the inversion, which is equivalent to assume $\delta\eta_\kappa/\eta_\kappa$˜0, meaning azimuthal independency of the "ellipticity" parameter η_κ that offers a physical background of the modeling. Also, the aforementioned fabrics show a much weaker azimuthal dependency for $\delta\eta_\kappa/\eta_\kappa$ compared to that for $\delta\eta/\eta$. This approach may be useful for the scaling of S- and P-wave azimuthal anisotropy to reduce the number of parameters in the Rayleigh wave inversion.