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ESSEMOD - Electroseismic and Seismoelectric Flux-Normalized Modeling for Horizontally Layered, Radially Symmetric Configurations

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We present a numerical code (ESSEMOD) for modeling electroseismic and seismoelectric wave propagation in horizontally layered configurations. As the basis for the code, we have first split the SH-TE mode from the P-SV-TM mode and used an energy flux-normalized system of two-way equations decomposed into upgoing and downgoing fields. Using this flux-normalized system enables the usage of the transpose of the composition matrix as the inverse of the composition matrix (being the decomposition matrix). This leads to a faster and computationally less expensive numerical code. Furthermore, flux-normalization leads to a more stable numerical scheme due to the fact that the numerical inverse of the composition matrices can be avoided. The mode splitting is achieved by decoupling the coupled system of 12 governing equations into a coupled system of 8 equations, describing the P-SV-TM propagation mode, and an independently coupled system of 4 equations, describing the SH-TE propagation mode. At the source level, the two-way wavefields are decomposed into upgoing and downgoing wavefields, which are extrapolated via one-way wavefield extrapolation operators in the horizontal wavenumber-frequency domain. The code makes use of global reflection coefficients, leading to an efficient numerical scheme due to the fact that explicit calculation of the scattering matrices is not required. The recursive scheme requires a one-way trip from the bottom interface up to the source level and a similar one-way trip from the top interface down to the source level, where the two are connected by satisfying the pertaining boundary conditions. Because the receiver is known when the computations start, the field at the receiver level is updated when the recursive scheme passes the receiver level and moves on to the source level. The upgoing and downgoing wavefields generated at the source level, are extrapolated to the receiver layer. Here, the wavefields are multiplied with the corresponding global reflection matrices to obtain the full upgoing and downgoing wavefields at the receiver level. The two seismoelectric propagation modes are modeled independently. Before the inverse Fourier-Bessel transformation can be carried out at the receiver level, wavefield composition takes place and here the SH-TE and P-SV-TM propagation modes are combined, resulting in two-way wavefields due to two-way sources. The resulting Fourier-Bessel transformation is then computed. The sources and receivers can be placed anywhere in the model, even on interfaces. Furthermore, modeling of all existing seismoelectric (electroseismic) two-way source-receiver combinations is possible. Several modeling results will be presented, placing the sources and receivers at different depth levels. Placing the sources and/or receivers in the near-fields, enables us to study the interface waves. Acknowledgements: This research was funded as a Shell-FOM (Foundation for Fundamental Research on Matter) project within the research program 'Innovative physics for oil and gas'.