



Structural joint inversion of SRT and SWA data

Nathalie Roser¹, Florian Wagner², Matthias Steiner¹, and Adrian Flores Orozco¹

¹TU Wien, Department of Geodesy and Geoinformation, Vienna, Austria (nathalie.rosen@geo.tuwien.ac.at)

²Geophysical Imaging and Monitoring (GIM), RWTH Aachen University, Aachen, Germany

Seismic refraction tomography (SRT) and surface wave analysis (SWA) are two geophysical methods frequently used in near-surface investigations. SRT provides models of the subsurface 2D/3D P-wave velocity distribution, whereas the classical SWA approach solves for the 1D or pseudo 2D S-wave velocity variation with depth. Optimized acquisition schemes allow for the joint collection of SRT and SWA data sets, improving data consistency and reducing resource requirements. Processing and inversion of the data sets are commonly carried out in separate workflows, and only the results are subjected to a joint interpretation. This can lead to inconsistencies between the resolved models, due to different intrinsic limitations, resolutions, as well as solution non-uniqueness of the inversion, potentially misleading the interpretation. Since both methods are sensitive to the properties of the soil or rock matrix, a suitable joint inversion scheme can exploit the existing synergies to improve the coherency and interpretation of the resolved subsurface models.

Accordingly, we developed a structural joint inversion (SJI) scheme and explore its application to SRT and SWA data. Structural similarity is established through the popular cross-gradient constraint to enhance the geometrical consistency between the resolved P-wave and S-wave velocity models. To solve for the pseudo 2D S-wave velocity structure from 1D SWA data, we incorporate lateral constraints to enforce spatial continuity and consistency between adjacent profiles. The SJI is realized using quadrilateral 2D grids with flat topography, because (1) SWA field data is typically collected over flat surfaces, allowing us to neglect topographical effects during data processing, and (2) model gradients and cross-gradient are computed based on finite differences. The SWA forward modeling and the SJI scheme are developed using the open-source library pyGIMLi (Rücker et al., 2017). As a first step, we conduct a numerical study to test the SJI on simple synthetic models with blocky piecewise-constant structures. Our investigations demonstrate that the SJI is superior to the individual inversion approach in delineating subsurface features and reconstructing true model properties. In a second step, we used seismic field data collected in a shallow aquifer, where an initial independent analysis revealed structural similarity between the SRT and SWA data sets. The effects of the cross-gradient constraint on the field data are less pronounced, but the resolved models correspond well to the local geology and a complementary electrical data set. Results obtained through our SJI scheme highlight the improved structural coherency between the resolved P- and S-wave velocity models, which is critical for the localization of subsurface units and the reliability of derived parameters (e.g.,

porosity) in near-surface investigations.

References: Rücker, C., Günther, T., Wagner, F.M., 2017. pyGIMLi: An open-source library for modelling and inversion in geophysics, *Computers and Geosciences*, 109, 106-123, doi: 10.1016/j.cageo.2017.07.011.