Geophysical Research Abstracts
Vol. 17, EGU2015-6202, 2015
EGU General Assembly 2015

Strategies for joint geophysical survey design

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In recent years, the use of multiple geophysical techniques to image the subsurface has become a popular option. Joint inversions of geophysical datasets are based on the assumption that the spatial variations of the different physical subsurface parameters exhibit structural similarities. In this work, we combine the benefits of joint inversions of geophysical datasets with recent innovations in optimized experimental design. These techniques maximize the data information content while minimizing the data acquisition costs. Experimental design has been used in geophysics over the last twenty years, but it has never been attempted to combine various geophysical imaging methods. We combine direct current geoelectrics, magnetotellurics and seismic refraction travel time tomography data to resolve synthetic 1D layered Earth models. An initial model for the subsurface structure can be taken from a priori geological information and an optimal joint geophysical survey can be designed around the initial model. Another typical scenario includes an existing data set from a past survey and a subsequent survey that is planned to optimally complement the existing data. Our results demonstrate that the joint design methodology provides optimized combinations of data sets that include only a few data points. Nevertheless, they allow constraining the subsurface models equally well as data from a densely sampled survey. Furthermore, we examine the dependency of optimized survey design on the a priori model assumptions. Finally, we apply the methodology to geoelectric and seismic field data collected along 2D profiles.