Joint Inversion —
The Way Forward to a
Comprehensive Earth Model

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**Joint Inversion – The Way Forward to a Comprehensive Earth Model**

**Abstract**

Exploration of the subsurface requires the derivation of an Earth model. This is commonly done by acquiring a geophysical data set on the surface, such as seismics, electromagnetic, and/or gravimetric data, which are then converted to a velocity, electrical resistivity, or density model. The conversion of data into an Earth model is termed inversion and is, in principle, a statistical search of a model for which the predicted data fits the observed data. There is, for any geophysical method, always a large number of models with responses that fit measured data, because a) any data set is scarce and associated with errors; b) any modeling routine is hampered by assumptions; c) sheer physics of the chosen methodology might make it impossible to resolve certain structures in question.

Acquiring more than one geophysical data set and gaining additional constraints and complementary information on the Earth model is an obvious way to narrow the possible solutions. Multicomponent geophysical data acquisition has become routine, especially because exploration is forced nowadays to move into geologically more complex regions where single-method exploration is insufficient (i.e. subsalt and sub-basalt exploration).

The question then arises of how to combine complementary content of data sets and identify a reduced subset of models required to fit all data sets. Current practice is to compare final or intermediate results from single data-type inversions. However, given ambiguities in single-method inversion, this is often a difficult process and cumbersome even for experienced interpreters. An obviously more efficient path is to define a new inversion process which combines single inversion streams to a common one and searches right from the start only for models which fit all data sets simultaneously. This type of inversion, called joint inversion, seems a promising path toward a comprehensive Earth model, which is actively researched in academia and industry.

In this presentation, I will give an overview of how joint-inversion problems are formulated and solved. The concepts are obviously target- and method-dependent. For some problems, a safe guess at the physical rock parameter relationship between f.ex. electrical resistivity, seismic velocity, and/or density can be made, which allows a direct and strong coupling of the different methods. For other problems, such a relationship is not known or might change significantly over the structure (f.ex. in subsalt exploration). A better approach seems to be then a structural coupling, requiring that all models considered in the search have a similar structure.

The application and benefit of joint inversion is illustrated through case studies in subsalt/sub-basalt exploration and quantification of gas hydrate and gas in marine sediments.

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**Biography**

Marion D. Jegen has worked at Geomar/Helmholtz Centre for Ocean Research in Kiel, Germany, since 2005. She is the research group leader in Marine Electromagnetics responsible for development of marine CSEM and natural source EM equipment and for development of 3D joint inversion algorithms for EM, seismic, and gravimetric data. She previously worked as a research scientist at ETH Zürich, the University of Cambridge Bullard Laboratories, was a postdoc at Institute Universitaire Europeenne de la Mer (IUEM) in France and the Department of Applied Mathematics and Theoretical Physics at Cambridge. Prior to this she worked in industry as a senior research geophysicist at Aerodat in Canada.

She received her bachelor’s and master’s degrees in geophysics from the University of Cologne and her doctorate, in 1996, from the University of Toronto.

Her awards include selection as an Emmy Noether Fellow (2006-2011), a program of the German Science Foundation for outstanding young scientists. In 2010, she was selected to participate in a panel meeting with German Chancellor Angela Merkel and Nobel Laureate Christian Nusslein-Volhard and in 2012 as panelist in a discussion with members of the European Parliament on marine mineral resources. She has been an associate editor of First Break since 2010.