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GUEST EDITORS' INTRODUCTION

# Inverse problems in geophysics: closing the gap between theory and practice

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Inverse problems play a crucial role in geophysics because one of the main tasks in this field is to probe the Earth's interior both for economic reasons, such as oil prospecting, and for the pursuit of academic knowledge about our planet. A variety of different physical fields are used for this: elastic waves form the basis of seismic prospecting, electromagnetic or magnetic fields are used to make inferences about the electrical conductivity in the Earth and the magnetic properties of the core, the gravity field constrains the mass distribution within the Earth, and many other examples can be given where inverse problem theory is crucial for inferring the properties of the Earth from measurements at its surface. Examples of the theory and practice of geophysical inverse problems are given by Iyer and Hirahara (1993), Lines and Levin (1988) and Parker (1994).

This special section is aimed at presenting the inverse problems community with the theoretical barriers that geophysicists encounter, and providing some unorthodox examples of geophysical inverse problems. Every image obtained from an inverse problem with an incomplete data set gives an incomplete impression of the object under consideration. Trampert shows how limitations in global tomography influence the interpretation and implications of global maps of the seismic velocity in the Earth. In addition he shows how difficult it is to quantify the limitation of the images that are obtained. As shown by Snieder, nonlinearity aggravates this problem. He makes the point that currently there are no satisfactory theoretical tools for the error and resolution analysis of truly nonlinear inverse problems. Mosegaard attacks this problem, not by seeking a single solution to inverse problems, but by constructing many models and making inferences on the likelihood of these models using Bayesian statistics. That such an approach is needed for many practical problems is shown by Sambridge who shows that in practical problems the misfit function (or probability density function) can be extremely complex. In addition he develops tools to characterize this complexity. That inverse problem theory can be applied to problems other than making images of the Earth's interior is shown by Peltier, who makes inferences about the viscosity in the Earth from the measurement of sea-level variations, and by Gallagher, who reconstructs the thermal history of oil reservoirs from measurements at the surface. A major challenge in geophysics is to use different datasets to make inferences about the Earth's interior. Barghazi and Sansó present theoretical tools that can be used for the joint inversion of seismological and gravity data.

It will be clear from this special section that inverse problems is a rich and diverse field of research within geophysics. Despite the success of many of its applications (western

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