Nonlinear inverse problems and model space search

Malcolm Sambridge

Research School of Earth Sciences, ANU

Science is driven by the feedback between predictions and observations. In the Earth Sciences observations are nearly always indirect, since measurements are often made on or above the surface, and an 'inverse' problem exists in extracting information about structure and processes at depth. For more than 35 years inverse problems have been studied within the geosciences. Linear inverse problems arise when the mathematical relationship between data and unknowns is linear, and these were well understood by the mid 1970s. Unfortunately many areas of the geosciences give rise to nonlinear inverse problems, and in this case approximations must be introduced in order to use linear methods. As computational resources have increased fully nonlinear techniques have become viable in many cases. Interestingly enough the origins of fully nonlinear inversion techniques can be traced back to the very earliest days of geophysical inversion in the late 1960s.

This tutorial will provide an introduction to inverse problems and trace some of the major developments. Particular attention will be paid to fully nonlinear model space search techniques that are becoming increasingly popular today. One aspect of direct search algorithms is that they lend themselves naturally to parallel computing, which itself is becoming widely available. The lecture will conclude with a description of some recent computational tools that make model space search algorithms relative easy to use in parallel computing environments.