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Escript: Open Source Environment For Solving Large-Scale Geophysical Joint Inversion Problems in Python

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The program package escript has been designed for solving mathematical modeling problems using python, see Gross et al. (2013). Its development and maintenance has been funded by the Australian Commonwealth to provide open source software infrastructure for the Australian Earth Science community (recent funding by the Australian Geophysical Observing System EIF (AGOS) and the AuScope Collaborative Research Infrastructure Scheme (CRIS)).

The key concepts of escript are based on the terminology of spatial functions and partial differential equations (PDEs) – an approach providing abstraction from the underlying spatial discretization method (i.e. the finite element method (FEM)). This feature presents a programming environment to the user which is easy to use even for complex models. Due to the fact that implementations are independent from data structures simulations are easily portable across desktop computers and scalable compute clusters without modifications to the program code. escript has been successfully applied in a variety of applications including modeling mantel convection, melting processes, volcanic flow, earthquakes, faulting, multi-phase flow, block caving and mineralization (see Poulet et al. 2013).

The recent escript release (see Gross et al. (2013)) provides an open framework for solving joint inversion problems for geophysical data sets (potential field, seismic and electro-magnetic). The strategy bases on the idea to formulate the inversion problem as an optimization problem with PDE constraints where the cost function is defined by the data defect and the regularization term for the rock properties, see Gross & Kemp (2013). This approach of first-optimize-then-discretize avoids the assemblage of the - in general- dense sensitivity matrix as used in conventional approaches where discrete programming techniques are applied to the discretized problem (first-discretize-then-optimize).

In this paper we will discuss the mathematical framework for inversion and appropriate solution schemes in escript. We will also give a brief introduction into escript's open framework for defining and solving geophysical inversion problems. Finally we will show some benchmark results to demonstrate the computational scalability of the inversion method across a large number of cores and compute nodes in a parallel computing environment.

References:

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