Practices to enable the geophysical research spectrum: from fundamentals to applications

Seogi Kang, Lindsey Heagy, Rowan Cockett, Dominique Fournier, Michael Mitchell, Brendan Smithyman, Thibaut Astic, Guðni Karl Rosenkjær et al.

In a geophysical survey, a source injects energy into the earth and a response is measured. These physical systems are governed by partial differential equations and their numerical solutions are obtained by discretizing the earth. Geophysical simulations and inversions are tools for understanding physical responses and constructing models of the subsurface given a finite amount of data. SimPEG (http://simpeg.xyz) is our effort to synthesize geophysical forward and inverse methodologies into a consistent framework. The primary focus of our initial development has been on the electromagnetics (EM) package, with recent extensions to magnetotelluric, direct current (DC), and induced polarization.

Across these methods, and applied geophysics in general, we require tools to explore and build an understanding of the physics (behaviour of fields, fluxes), and work with data to produce models through reproducible inversions. If we consider DC or EM experiments, with the aim of understanding responses from subsurface conductors, we require resources that provide multiple “entry points” into the geophysical problem. To understand the physical responses and measured data, we must simulate the physical system and visualize electric fields, currents, and charges. Performing an inversion requires that many moving pieces be brought together: simulation, physics, linear algebra, data processing, optimization, etc. Each component must be trusted, accessible to interrogation and manipulation, and readily combined in order to enable investigation into inversion methodologies. To support such research, we not only require “entry points” into the software, but also extensibility to new situations.

In our development of SimPEG, we have sought to use leading practices in software development with the aim of supporting and promoting collaborations across a spectrum of geophysical research: from fundamentals to applications. Designing software to enable this spectrum puts unique constraints on both the architecture of the codebase as well as the development practices that are employed. In this presentation, we will share some lessons learned and, in particular, how our prioritization of testing, documentation, and refactoring has impacted our own research and fostered collaborations.