SOFTWARE REVIEW

New Software Framework to Share Research Tools

PAGE 104

Solid Earth Teaching and Research Environment (SEATREE) is a modular and user-friendly software to facilitate the use of solid Earth research tools in the classroom and for interdisciplinary research collaboration. The software provides a stand-alone open-source package that allows users to operate in a "black box" mode, which hides implementation details, while also allowing them to dig deeper into the underlying source code. The overlying user interfaces are written in the Python programming language using a modern, object-oriented design, including graphical user interactions. SEATREE, which provides an interface to a range of new and existing lower level programs that can be written in any computer programming language, may in the long run contribute to new ways of sharing scientific research. By sharing both data and modeling tools in a consistent framework, published (numerical) experiments can be made truly reproducible again.

SEATREE is a community-developed software distributed under the GNU General Public License using Web-based software management systems to assist in collaborative development, documentation, and feature tracking. While users do not need to study SEATREE's source code, they are welcome to and are encouraged to become involved and add new modules and functionality. SEATREE is written in a manner that makes its components easy to understand and reuse. For example, the Generic Mapping Tools (GMT) "wrappers," as included in the software, provide easy access to underlying GMT command-line tools from within a higher abstraction programming language. These wrappers can be used by anyone who wants to make geographic plots using Python, independent of SEATREE. Another design aspect is the modular architecture that handles dynamic module loading and provides a flexible interface, for example, for switching quickly between different visualization tools such as GMT and MATLAB-like plotting.

Currently Implemented Scientific Modules

A collaboration of undergraduate and graduate researchers has assembled three fully developed science modules for SEATREE. The first module, known as HC, for the Hager and O'Connell approach, is a global geodynamics tool based on a semi-analytical mantle-circulation program by Bernhard Steinberger, of Deutsches GeoForschungsZentrum (GFZ; Potsdam, Germany), rewritten in the C programming language by Thorsten Becker (coauthor of this article), and Craig O'Neill, of Macquarie University (Sydney, Australia). HC can compute velocities and tractions for global spherical mantle flow and purely radial viscosity variations. Results from HC can be visualized via SEATREE's GMT wrapper (see Figure S1, in the electronic supplement to this *Eos* issue (http://www.agu.org/eos_elec/)), while the user can also interactively edit input parameters such as the viscosity structure of the mantle. With computations typically taking just a few seconds, HC is fast enough to be used for interactive classroom instruction, for example, to allow students to explore the role of radial viscosity variations for global geopotential (geoid) anomalies. Likewise, seismologists can use HC to investigate flow predictions corresponding to a range of seismic tomography models and assumptions about velocity to density scaling.

SEATREE includes two seismology modules: Larry, a global, surface wave phase-velocity inversion tool, and Syn2D, a Cartesian tomography teaching tool for ray-theory wave propagation in synthetic, arbitrary-velocity structure in the presence of noise (see Figure S2, in the electronic supplement to this *Eos* issue). Both seismology modules were contributed by Lapo Boschi (coauthor of this article). Using Syn2D, students can explore, for example, how well a given input structure (e.g., a checkerboard pattern) will be resolved by data for different types of earthquake-receiver geometries; those geometries can be edited interactively or generated for different random distributions. As is the case for the Larry module, different inversion damping approaches can be chosen to examine effects such as the trade-off between variance reduction and model complexity.

The goal of all three modules is to aid in teaching research techniques while remaining flexible enough for use in true research applications. For instance, HC already has been used to perform numerous computations for Monte Carlo–type inversions for a best fit to the geoid for different flow model scenarios.

Other modules are currently under development, for example, NonLinLoc, which provides an interface to nonlinear earthquake relocation tools developed by Anthony Lomax, of Lomax Software. Another development module is Larry3D, a three-dimensional (3-D) mantle body-wave seismic tomography tool by Boschi, whose output could then be used directly as input for the HC mantle flow module. Also in development is a 2-D convection module with continuously updating plotting, based on the ConMan convection code by Scott King, of Virginia Polytechnic Institute and State University (Blacksburg).

Version 1.0 of SEATREE, released on 21 August 2008, can be downloaded as a package from http://geosys.usc.edu/projects/seatree/wiki/, and users can also subscribe to the Subversion® repository (http://geosys/.usc.edu/svn/seatree/trunk/) to obtain the latest development version. The software is designed to run on GNU/Linux-based platforms and has also been successfully run on Mac OS X. Future goals include creating embedded, Python-based, 3-D visualization and a Web interface for performing server-side calculations.

—KEVIN MILNER and THORSTEN W. BECKER, University of Southern California, Los Angeles; E-mail: kmilner@usc.edu; LAPO BOSCHI, Institute of Geophysics, Swiss Federal Institute of Technology Zurich (ETH Zurich), Zurich, Switzerland; JARED SAIN and DANIJEL SCHORLEMMER, University of Southern California, Los Angeles; and HANNAH WATERHOUSE, Bryn Mawr College, Bryn Mawr, Pa.