The Solid Earth Research and Teaching Environment: a new software framework to share research tools in the classroom and across disciplines

Kevin Milner[1], Thorsten W. Becker[1], Lapo Boschi[2], Jared Sain[1], Danijel Schorlemmer[1], Hannah Waterhouse[3]

(1) University of Southern California, Los Angeles, CA 90089[{kmilner, twb, sain, ds}@usc.edu]
(2) Institute of Geophysics, ETH Zurich, Zurich, Switzerland [larryboschi@gmail.com]
(3) Bryn Mawr College, Bryn Mawr, PA 19010 [hwaterhous@gmail.com]

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The 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. SEATREE provides a fully contained, yet transparent package that lets users operate in a graphic, "black box" mode, but also allows "looking under the hood" to dig deeper. Top-level, graphical user interfaces (GUIs) are written in the Python programming language, using an object-oriented, modern design. Lower-level programs can be written in any computer programming language, for example C or Fortran. In the long run, SEATREE may contribute to new ways of sharing scientific research, making published (numerical) experiments truly reproducible again.

SEATREE is open source and community developed. It is distributed under the GNU General Public License, and uses management systems such as Subversion and Trac to assist in web-based, collaborative development, documentation, and feature tracking. While users do not need to study the source code, they are welcome and encouraged to get involved at a detailed level and share their changes. SEATREE is written such that its components are both easy to understand and reuse. For example, the included Generic Mapping Tools (GMT) Python wrapper could be employed by anyone wishing to make geographic plots from within Python code.

Another important part of the SEATREE is the modular architecture. The SEATREE framework handles the main GUI, plotting, and dynamic module loading independently. This hides much of the implementation details from programmers in order to facilitate development. A module in SEATREE follows a specified application programming interface, and supplies its own GUI widget and SEATREE plotting facility; several examples are already given. Currently implemented graphic displays are a GMT plotter for geographic data, a MatPlotLib plotter for displaying both static and interactive Matlab-like plots, and an image plotter for displaying image files. SEATREE also handles the details of the GUI interactions, running programs on the command line, writing script for later reuse, and many other operations.

There are currently three fully developed science modules for SEATREE that were assembled by a team of undergraduate and graduate researchers: (1) HC is a geodynamics tool which wraps a semi-analytical mantle-flow modeling program based on work by B. Steinberger, Becker, and C. O'Neill; it accounts for radially varying viscosity, and provides modeled values of mantle

velocities, tractions, and the geoid. Results from HC can be visualized on the fly via SEATREE's GMT wrapper (Figure 1), while MatPlotLib can be used to interactively edit inputs such as the viscosity structure. A second seismology module, (2) Larry, wraps a global, surface wave phase-velocity inversion tool by Boschi. The latest SEATREE release also contains a synthetic Cartesian tomography teaching tool, (3) Syn2D, based on code also contributed by Boschi. Syn2D supports both GMT and MatPlotLib plotting and deals with ray-theory inversion for synthetic, arbitrary velocity structure in the presence of noise (Figure 2). The goal of all the implemented modules is to aid in teaching research techniques, while remaining flexible enough for use in true research applications, such as computing numerous flow models for nonlinear (e.g., Monte-Carlo algorithms) geoid inversions.

Other modules are currently under development, e.g., NonLinLoc, a wrapper for the nonlinear earthquake relocation tools by Anthony Lomax. Another development module is Larry3D, a three-dimensional mantle, P-wave tomography tool by Boschi whose output could be used directly as input for the HC mantle flow module. A two-dimensional convection module with continuously updating plotting is also planned based on Scott King's ConMan convection code. We hope that other developers will try out SEATREE and implement their own modules.

Version 1.0 of SEATREE was released on August 21, 2008. It can be downloaded as a package from http://geosys.usc.edu/projects/seatree/wiki/, and users can also subscribe to our Subversion project page. The software is designed to run on GNU/Linux based platforms and has also been successfully run on Mac OS-X. Future goals include embedded, Python-based three-dimensional visualization, and a web interface for performing server side calculations.

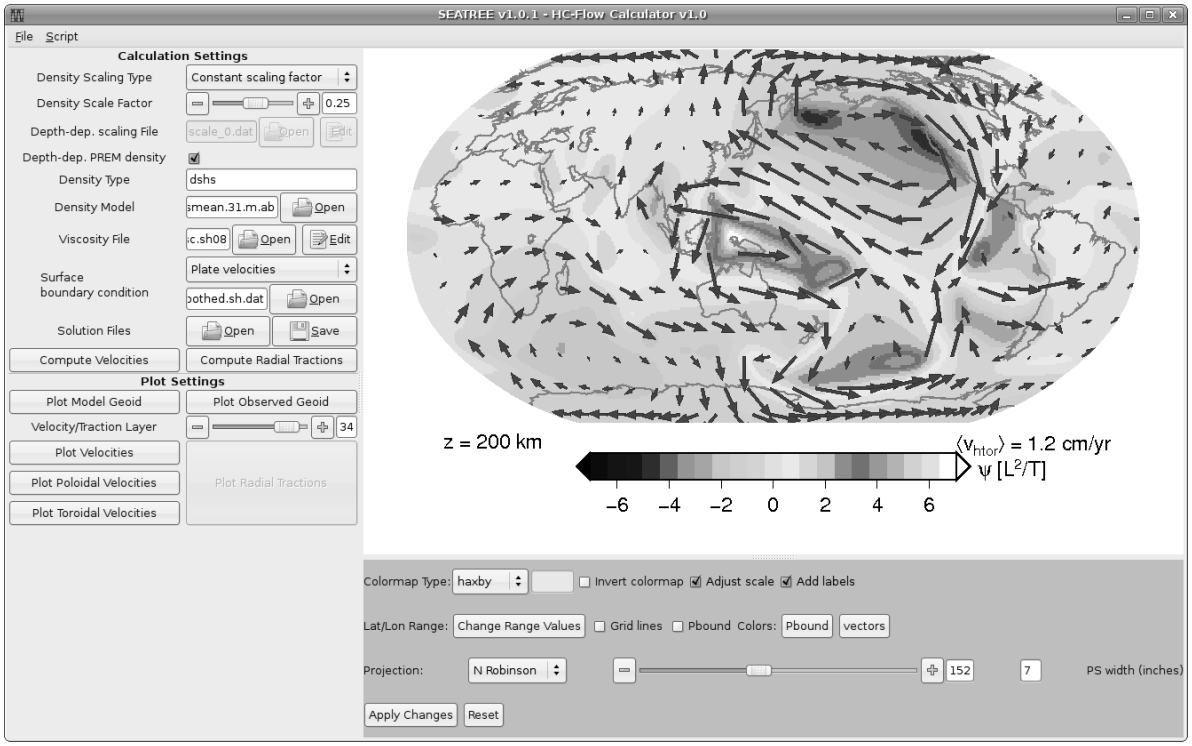

Figure 1: The HC module in the SEATREE GUI with GMT plotting

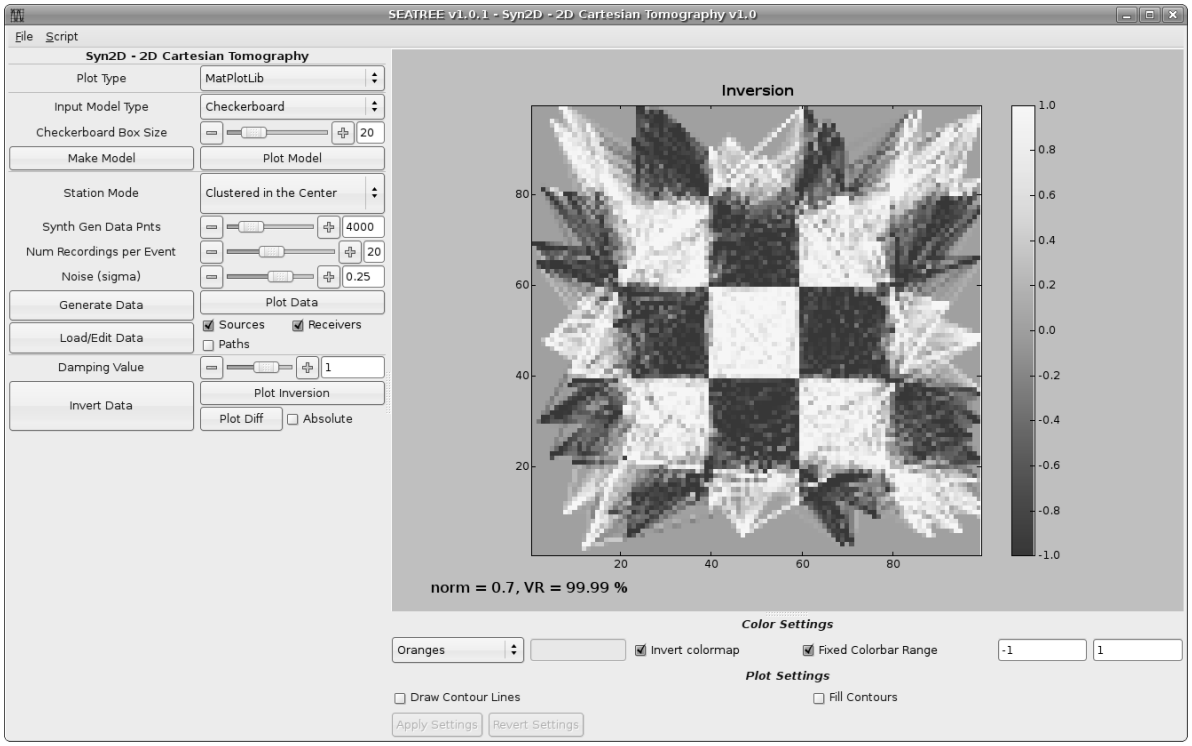

Figure 2: The Syn2d module in the SEATREE GUI with MatPlotLib plotting