SEATREE tutorial

CIDER program 2016 – Geodynamics Tutorial

Thorsten Becker, May 2016

The *Solid Earth Research and Teaching Environment* (SEATREE) is a set of python scripts that are intended to make working with a range of solid Earth research software easier. There's a short article by Milner et al. (2009) describing the philosophy of the approach which I've uploaded to Bspace.
The general idea is to have a consistent user interface for different *modules*, which deal with various geophysical problems, such as *hc* which is for global mantle flow, *larry* which is for phase velocity tomography, or *ConMan* which is for thermal convection. The use of these tools is simplified by means of a graphical user interface which embeds visualization of output files. However, all original software is provided with the package, along with various python/shell script wrappers, so that you can look under the hood and reuse code, for example for running numerous, automated forward models.
It's important to note that the underlying software and data was created and kindly shared by a number of researchers, including Lapo Boschi, Goran Ekstrom, and Scott King.

The SEATREE web site at http://geosys.usc.edu/projects/seatree/ has more detailed references and documentation; all source code is provided their by means of SVN repository access or archive download. At CIDER, we will provide access to SEATREE on our servers using NX, for those who can circumvent the KITP wireless Firewall. Else, we will also have a VirtualBox Linux install available, and we'll try to install the software directly on Mac OS-X or Linux systems.

SEATREE usage

There is documentation for some modules on the SEATREE web site, and I will demo the major features in session. Also, most selection boxes and buttons of the GUI have “tool tips” where a little help window will pop up when the mouse is hovering over them for a long time.

SEATREE exercises

The following tutorial exercises are meant to show you some of the capabilities of SEATREE and explore a few scientifically interesting implications, some of which already showed up in the previous geodynamics and seismology lectures and tutorials. All items are meant as suggestions for what effects to explore and I encourage you to discuss your findings in groups, and perhaps use SEATREE for aspects of the project work.

HC – Global mantle circulation modeling

1. Start up the *hc* module. Use the default settings, but load viscosity structure *visc.D* from the file dialog. Compute mantle flow and plot the geoid.
2. Change the asthenospheric and lower mantle viscosity. Compute the geoid and comment on the changes, for example as expressed in the correlation with the actual geoid.
3. By adding another layer, shift the lower mantle viscosity increase from being at 660 km to ~900 km. Recompute the geoid.
   Reload the original viscosity structure, for example by restarting SEATREE or by navigating to the default input data directory *$SEATREE/seatree/python/data/hc/*viscosity, where $SEATREE is the installation directory. Change to depth-dependent scaling of velocity to density and compare the geoid (and the radial tractions at ~100 km) with constant scaling with that where the upper or the lower 300 km of the mantle are set to zero. How about the lower 500 km of the mantle zeroed out?
4. Using your favorite flow model with free slip surface boundary conditions, plot the velocities at the surface, at 600 km (layer 26 for the default model), at 750 km (in the lower mantle, layer 23), and just above the CMB (layer 2).
5. Change to prescribed plate velocities and replot the velocities, bottom up.
6. Compare the geoid for free-slip and prescribed plate computations.
7. Compute the geoid for free slip and a viscosity structure that follows the 1D shear Q profiles discussed by Colleen Dalton. Compare to the observed geoid.

Larry – Global surface wave phase velocity tomography (you can skip the parts that were dealt with in Guy's tutorial)

1. Load the Larry 2D phase velocity tomography module. Plot sources, receivers and every 10^{th} and every 5^{th} raypath of the default database. What is the expected resolution?
2. Using 5 degree resolution, zero norm damping, explore solutions with 0, 0.1, 0.5, 1, 5, and 10 roughness damping. Write down the variance reduction and model norm for each and plot them. Which solution do you like best? Using lower resolution, do you need any damping?
3. Using roughness damping of 0.5, explore norm damping, noting how amplitudes vary along with variance reduction and imaged patterns.
4. Using your preferred damping and resolution, invert Rayleigh waves at 35, 75, and 150 s.
5. Compare the images for Love and Rayleigh waves at 35 s. Why are there differences?

ConMan – 2D thermal convection

1. Load the Conman module. Using the default parameters, explore the steady state (?), average temperature profile for Rayleigh, *Ra*, numbers of 5.10^3, 10^4, 10^5, 10^6 at zero activation energy. Measure the top boundary layer thickness and plot against *Ra* on a log-log plot.
2. Using $Ra = 10^5$, test activation energies, *E*, of 0, 5, 10, and 15 and note how the top thermal

boundary layer thickness deviates from that of the bottom.

3. Using zero activation energy and internal heating of 10, comment on the steady state (?) temperature profile.
4. Use a Rayleigh number of 10^6 and explore the planform of convection for activation energy 5, and zero, and 20 internal heating.