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Visualization and Graphical User Interface for a new, experimental Mimetic Code for Pathway 3 in the SCEC ITR collaboration.

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This summer as a SCEC SURE Intern I worked at the Institute of Geophysics and Planetary Physics at Scripps Institute of Oceanography under Bernard Minster. My summer work was focused on Geoff Ely's new Support Operator Rupture Dynamics code (SORD), designed to model earthquake rupture in nonplanar geometries.

SORD was developed and is being tested and validated in rapid-prototype form using MATLAB. It will ultimately be ported to a very large scale multi-processor environment at the San Diego SuperComputer Center (SDSC). SORD implements a so-called "mimetic" finite-difference discretization of the equations of motion of continuum mechanics, on a noncartesian, yet logically rectangular, three-dimensional mesh. This allows modeling of surface topography as well as rupture on nonplanar faults, capabilities that have previously been the exclusive domain of finite element models using unstructured meshes.

My projects over the course of the summer dealt with the development and testing of visualizations of the code output in MATLAB. I experimented with small-scale runs using different visualization parameters in order to highlight various aspects of the output wave fields. When I felt confident with MATLAB and SORD, I started to experiment with creating different run types and parameters. I worked with the camera angles in MATLAB to zoom in and out to highlight the rupture front and crack tip along the fault. In particular, I worked on a depth plane model showing a plane at half the height of the model with the camera panning along the fault line. I also experimented with adding some stress glyphs. (See Figure 2, 3, 6, 7.)

I also ran larger scale models to help test the code, to verify that the visualization was displaying correctly in the limit of high resolution, and to ferret out possible anomalies in the simulations. I ran simulations with upwards of 100 timesteps and on grid sizes of 100 by 100.

I created some stereo pairs by creating two models and then rotating one of them by a few degrees. The model can be seen in 3-D with stereo glasses, or by merely crossing one's eyes. I also set up the SIO Geowall and projected the stereo pairs in large size to be viewed in 3-D with the special glasses. (See Figure 5.)

A challenging coding aspect of my project, and the most rewarding part, was to create a graphical user interface (GUI) for SORD in order to facilitate the running of the code for users. Now, instead of having to change the variables in the code, users can now choose their parameters from drop down menus and check boxes on the GUI frame. The user can either select a combination of parameters, or choose from a list of preset "run types." (See Figure 4.)

I created some movies to capture ground motions associated with spontaneous earthquake rupture, and adapted the GUI to display and control the resulting movies. I also experimented in a very preliminary way with exporting visualization clips to other movie-development environments.

My poster at the SCEC Annual Meeting in Palm Springs will show examples of various visualization, as well as interactive demonstrations of the GUI and the movie capture capability, including several different views of SORD output. This will include a view in spherical coordinates, a depth plane view, and a stereo view of spherical coordinates, which can be viewed in stereo.

At Yale, I am a senior studying applied math with concentrations in physics and geology/geophysics. Overall, I thoroughly enjoyed my summer experience at IGPP and with SCEC. The SCEC Intern activities enhanced my summer and helped with my work expertise. My knowledge of earthquakes greatly increased, as well as my programming skills. The SCEC SURE Summer Internship was extremely fun and educational.

Equations of Motion

Linearized Conservation of Momentum

$$\sigma_{ij,j} = \rho \ddot{u}_i$$

Viscoelastic Solid

$$\sigma_{ij} = \lambda(u_{k,k} + \gamma \dot{u}_{k,k})\delta_{ij} + \mu(u_{i,j} + \gamma \dot{u}_{i,j} + u_{j,i} + \gamma \dot{u}_{j,i})$$

Fault Boundary Condition

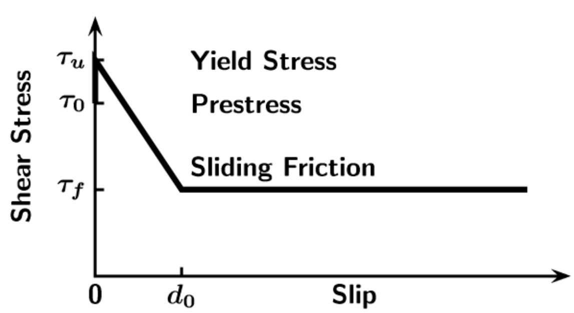

Figure 1. Equations of Motion and Fault Boundary Condition. The equations of motion and the fault boundary condition governing the Support Operator Rupture Dynamics Code.

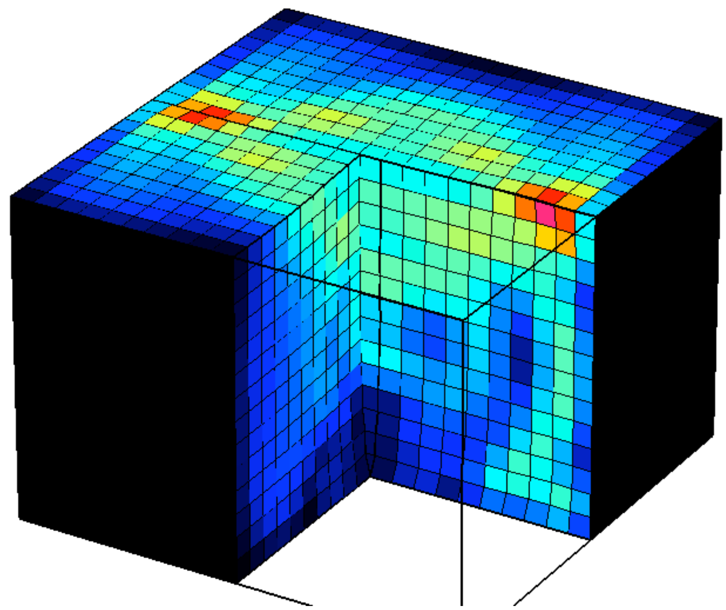

Figure 2. Rectangular Cutout Total Velocity Model. This is a view in rectangular coordinates, with the plot style "Cutout" so as to see into the center of the fault. The fault plane runs from left to right across the model. The right side of the model is slipping to the right, and the left side up to the left. The red colors refer to faster velocity, and the blues are slower. The bottom of the model is locked, and the sides are turned off in this view.

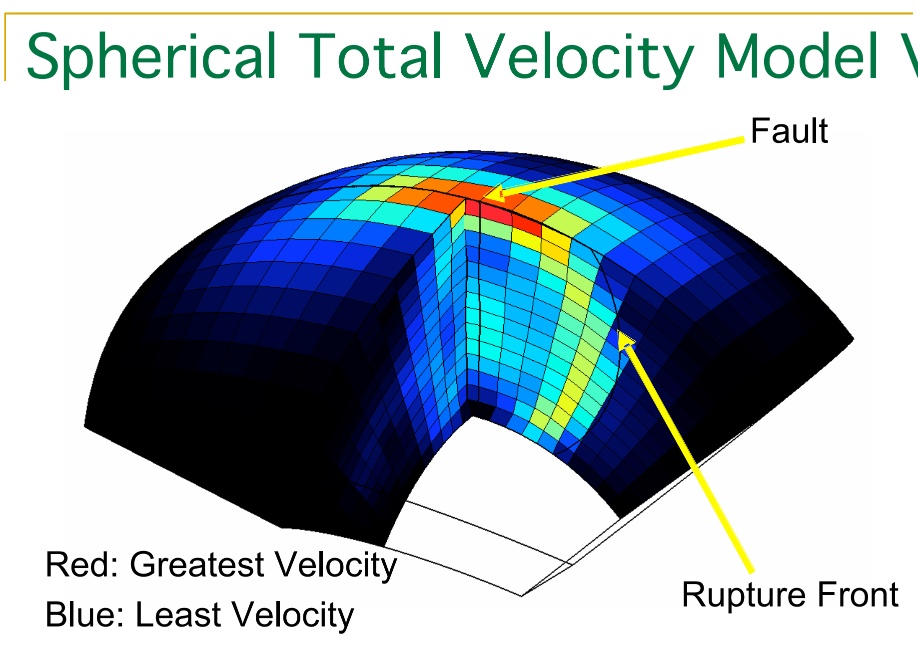

Figure 3. Spherical Total Velocity View. This model is in spherical view, also with the "cutout" style to see into the model. This figure illustrates the rupture front and fault.

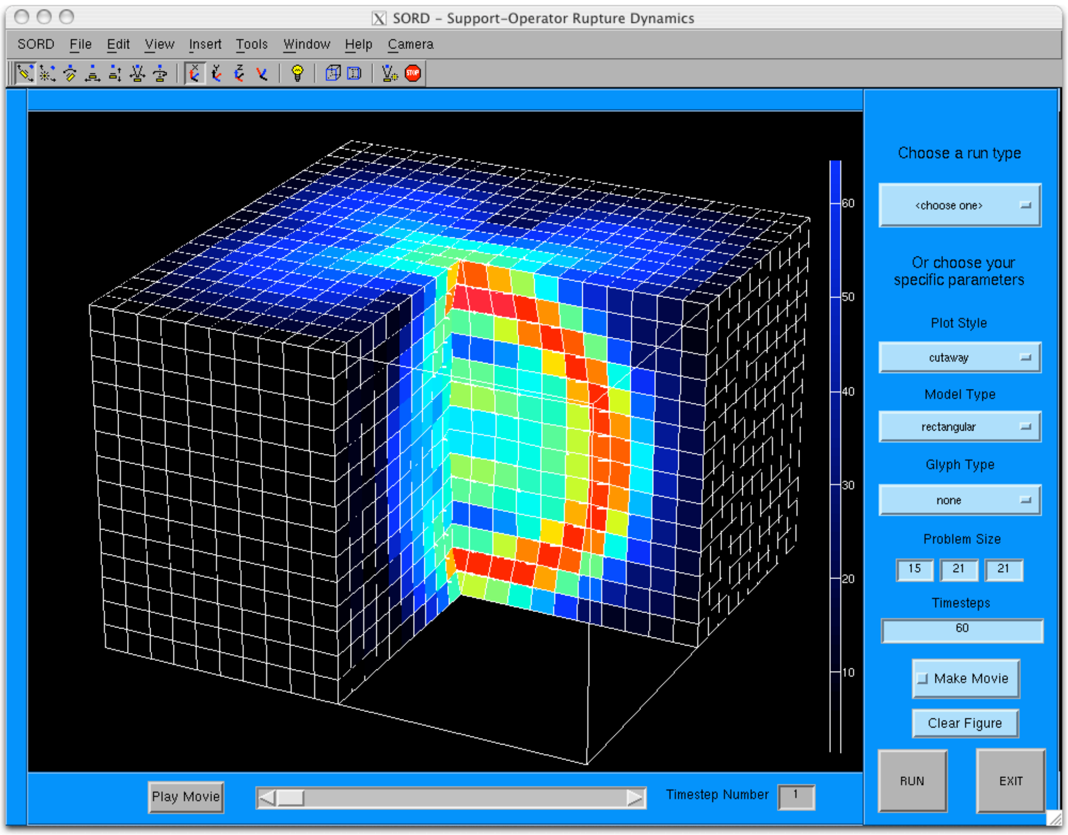

Figure 4. SORD GUI. This is a view of the SORD GUI I developed, with a rectangular cutout total velocity model shown. On the right side of the GUI are the user controls for the input, and along the bottom are the movie playback controls.

Figure 5. Stereo Spherical Model. Views of two spherical total velocity models with a slight "stereo" angle difference. Use stereo viewers, or cross your eyes, to see the 3-D model.

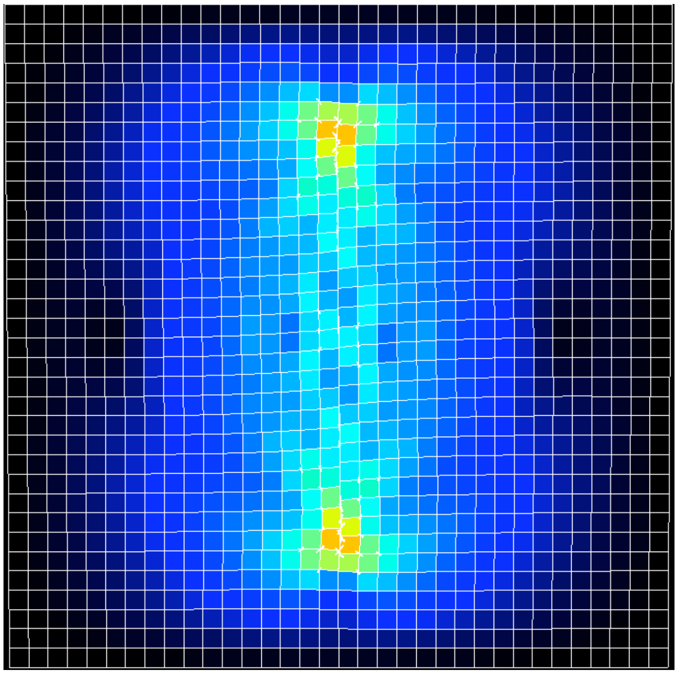

Figure 6. Depth Plane Total Velocity Model. This view is looking down from the earth's surface at a depth place at half the model's height. The fault plane is vertical in the middle of the grid, with the left side moving upward and the right side moving downward. The edges of the model are locked here.

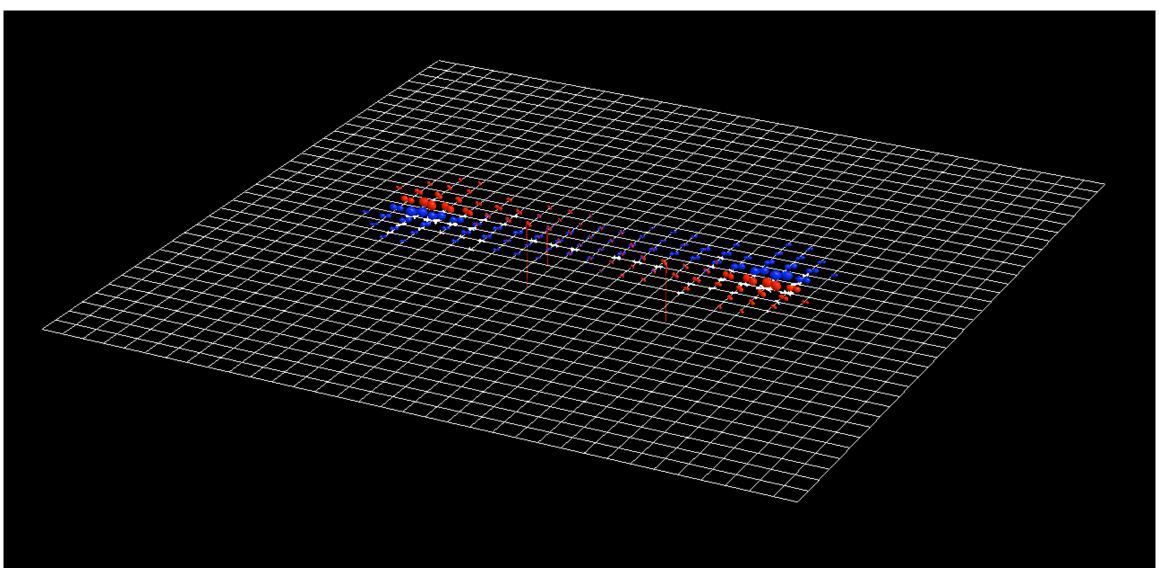

Figure 7. Depth Plant Glyph Model. This model is of Reynolds stress glyphs viewed on a depth plant at half the model's height.