LAB 2 SUPPLEMENT: THE JULES VERNE VOYAGER, JR.

For this section of the lab we will be using a very cool web-based map tool that provides access to an amazing suite of state-of-the-art scientific observations about the world around us. It combines satellite imagery, high-resolution topography, a variety of earthquake & volcano data bases, and a really unique set of data on global plate velocities. This exercise is intended to be completed on your own time, mostly outside of lab, but should be turned in, together with their lab exercise, at next week's lab.

We're going to use a new, web-based map tool called the "Jules Verne Voyager, Jr.". Any browser should work, but Internet Explorer seems to work best. Go to:

http://jules.unavco.org/VoyagerJr/Earth

or follow the link from the G141 website ("Links" page).

There is a lot of background information on the map tool available by just clicking on the "JV Voyager, Jr" button at the upper left of the control panel. But you'll find that it's pretty self-explanatory and you should be able to figure out the tool by just playing around with it. Note that you can zoom in on any area of the globe, simply by clicking on it.

The map tool includes three main components:

(1) Base maps: The tool includes a series of map and satellite imagery data bases that can be used to provide a base map for your plots. Check out a few of them, but the most useful will probably be the "Face of the Earth" (satellite mosaic of the Earth), and "Color Topography" (color-coded elevations of the whole Earth. Be sure to check out "Earth at Night" (a night-time satellite-image of the Earth).

(2) Features: A variety of geological and geophysical overlays for your map. Of particular use will be the "political, lat-long" (showing country boundaries and latitude and longitude lines), "plate boundaries" (showing location and types of plate boundaries), "Earthquakes", and "Volcanoes". Choose whatever overlays you like (use the control or apple key to select multiple overlays), and then simply click on "Make Changes" to see the new map.

(3) Add Velocities: This tool allows you to overlay 'vector arrows' indicating the rate and direction of motion of each of the plates. You can use a radio button to choose either "Obs. (observed) motions, which consist of precise Global Positioning System (GPS) measurements from several thousand sites around the globe, or "Model", which are estimated motions for points anywhere on the globe. An important component of this tool is that you can select from one of about a dozen "frames of reference", which show the velocities with respect to each of the Earth's major plates. Thus the "N. America" reference frame shows how all the plates are moving with respect to North America. There is also an important "absolute" reference frame, referred to by the top entry in the panel "No-net-rotation" (or NNR). NNR is the motion of each plate with respect to the average of all of the world's plate velocities. It's sometimes referred to as 'absolute plate motion', since it appears to approximately represent the motions of the surface plates with respect to the Earth's deep interior. It also closely resembles the apparent motion of the world's plates with respect to hot spot volcanoes.

The map tool also features an easy-to-follow legend that shows what each of the symbols on the map represent, and where the data come from. If you find the legend annoying, you can turn it off (and back on) with a key in the upper left of the control panel. Although in principle you can make printouts by using the "Print/Save" key in the upper left, right now there's an error in the system that won't allow you to save maps. The only way you can make prints of the maps is by a rather cumbersome procedure, using the regular 'Jules Verne Voyager' tool. Here's how:

1. When you get a map and overlays that you want to copy, click the "See in JVV" button
2. A new "Jules Verne Voyager: Earth" window will open. Wait a moment for the map to come up in the window.
3. Click on the right-most menu (labeled URL:). Pull down the menu and select "Save".
4. A new page will come up ("Jules Verne Voyager: Save Image")
5. Select GIF
6. Your map will appear (as a GIF image) on a new page. From there you can either print directly, or copy to another document (e.g., Word file)

The exercise we'll be doing as part of this lab makes use of the JVV, Jr. map tool to investigate a number of aspects of plate tectonic processes using real-world geophysical data.

Activity 1

The first exercise uses JVV to examine some of the first-order characteristics of the world's major plates. With the JVV Jr. open, create a world map according to the specifications below. You'll be adding a tectonic plate boundary overlay to the Face of the Earth & Relief map, and then adding estimates of plate velocities from a global model of plate motions.

Clear all previous settings:	Click on the World Map button. Then select the Face of the Earth & Relief map, No Features, and No Plate Velocities. Click on Make Changes.
Base map:	Be sure that Face of the Earth & Relief is selected.
Feature(s):	Select Tectonic Plates to add the detailed plate boundary classification to the map.
Velocities:	Select No-Net-Rotation, then the Model velocity field. (The Model button may not appear until you've selected No-Net-Rotation.) Click on Make Changes.

Looking at your new map, trace your way along the global system of plate boundaries. Then, using observations from your map, fill in the entries in Table 1 (last page). This table asks you to look carefully at the plate tectonic map of the world, and make some direct observations and estimates. Use the 'zoom' tool as necessary to blow up maps of a particular area. A useful resource for this exercise is the NASA "Tectonic Activity Map of the Earth", at

http://denali.gsfc.nasa.gov/dtam/images/schematic_map.jpg).

This map shows all of the world's major plates and the types of plate boundaries that surround them. You may want to make a printout of this map and save it for your records.

For each of the plates listed in col.1, identify

- (col.2) the major plates surrounding it,
- (col. 3) the principal types of boundaries associated with each of the plates described in (1),
- (col. 4 & 5) a rough estimate (i.e., use your eyeballs!) of the make-up of the plate—in terms of the % continental and oceanic crust; and
- (col. 6 & 7) a rough estimate (i.e., use your eyeballs again!) of the average motion of the plate.

In order to fill out the info for columns 6 & 7, you'll need to add a plate velocity overlay. Be sure you select the "No-Net-Rotation" (or 'absolute') frame of reference from the "Add Velocities" tool of the JVV, and then select "Model" velocities for display (Don't forget to hit the "Make Changes" button to display what you've just chosen).

Plate velocities can be described in terms of two parameters, the **rate** of motion (or speed), and the **direction** of motion. You can estimate the **rate** of each plate by comparing the size of the velocity arrows within each plate with that of the 'reference velocity arrow' (representing 50 mm/yr speed) that is shown in the upper left of the map (again, a rough "eyeball" estimate is fine.) You can estimate the direction of the plate motion roughly, in terms of geographic direction of the plate motion arrow (e.g., NW, ENE, WSW, etc.) Or, if you'd prefer to be more precise, you can quantify the direction using the 360 degree convention, where 0° = North, 90° = East, 180° = South, 270° = West. Thus NNW = 330º)

Activity 2

Next, using the zoom capability of JVV, Jr., we'll investigate some of the characteristics of the landforms associated with a few of the world's plate boundaries (and one intraplate zone), and their associations with earthquakes and volcanoes. Note that the "Color Topography" basemap we'll be using assigns colors to Earth's surface elevations, from dark blue (deep-sea trenches), to bright orange (high mountains). See legend for details.

Clear all previous settings:	Click on the World Map button. Then select the Color Topography base map, No Features, and No Plate Velocities, and click on Make Changes.
Base map:	Be sure Color Topography is selected
Feature(s):	Select Earthquakes, Volcanoes, and Tectonic Plates. Use "Political/Lat,Long" as needed to identify locations on maps. (To make multiple selections, hold down the CTRL key on PCs and the Command key on Macintoshes). Click on Make Changes

By zooming in on each of the following areas of the world, we can examine the characteristics of earthquakes, volcanoes, and landforms in a seismically active region of the globe:

1. The northern mid-Atlantic Ridge (lat. 60°N lon. 30°W)
2. The Andes mountains (lat. 20°S lon. 70°W)
3. The Himalayas (lat. 30°N lon. 80°E)
4. The Gibbs Fracture Zone, North Atlantic Ocean (lat. 52°N lon. 32°W)
5. The Mississippi River valley, United States (lat. 35°N lon. 90°W)
6. The Tonga Islands (lat. 20°S lon. 175°W)
7. The San Andreas Fault (lat. 36°N lon. 122°W)

By using the zoom utility, look carefully at maps of each of these areas. Then answer the following questions:

1. Which of these areas can be characterized as an "intraplate" seismic zone (i.e., far from a tectonic plate boundary)?

Explain your answer:

2. Which of these areas is associated with intermediate- or deep-focus earthquakes (shown as colored dots)?

Why are these peculiar earthquakes associated with only <u>some</u> of our seismic areas? What tectonic environment (i.e., type of plate boundary) do these areas represent?

3. Which of the areas are associated with active volcanoes?

In what tectonic environment do these volcanoes appear?

4. Turn off the earthquake and volcano overlays. Briefly describe the characteristics of topography associated with each of these zones. In each case, list the tectonic environment that best describes the area (convergent, divergent, transform, intraplate zone):

1. The northern mid-Atlantic Ridge
2. The Andes mountains
3. The Himalayas
4. The Gibbs Fracture Zone
5. The Mississippi River valley,
6. The Tonga Islands
7. The San Andreas Fault

Activity 3

Finally, we'll make use of a remarkable data set represented in the JVV, Jr.: a compilation of predicted (model) and observed motions of points on the Earth's surface from very precise Global Positioning System (GPS) measurements, and we'll use them to investigate relative motions at one of the world's remarkable plate boundaries, the Himalayan mountains.

Feature(s):	Click on No Features, then the Make Changes button.
World map:	Click on the World Map button to return to the global map. Now zoom in on the India by clicking anywhere on the Indian subcontinent.
Velocities:	Select the Eurasian plate reference frame, click the Model radio button, then click on the Make Changes button.

By selecting the "Eurasian reference frame", we are showing the motions of any point on the Earth's surface, with respect to points within the Eurasian plate. Examine the predicted motion of India, shown by the blue arrows.

1. What is the approximate rate and direction of motion of India with respect to Eurasia?

Next, we'll change the 'frame of reference'. Let's see how points in Eurasia are moving with respect to a point within the Indian plate. Select "India" from the Velocities panel, then "Make Changes".

2. What is the approximate rate and direction of motion of Eurasia with respect to India?

3. How do these sets of measurements compare?

4. How might these motions explain the formation of the great Himalayan Mountains?

Next, let's take a look at the observed (actual) motions of points on the Earth's surface from GPS measurements in and around India, by clicking the "Both" radio button (i.e., this shows <u>both</u> predicted measurements (blue arrows) and actual measurements on the ground (purple arrows). Return the frame of reference to "Eurasia".

4. Approximately how many GPS measurements were made in southern India?

5. How well do the observed and the predicted model motions agree (compare size and directions of arrows in India and the mountains to the north)?

6. Which direction is Tibet (the big plateau north of India) moving with respect to Eurasia?

7. [Extra credit challenge!] Can you come up with a simple model to explain the peculiar pattern of motions in the mountainous areas to the north and east of India.

Table 1. Observed characteristics of the world's major plates.

Plate name	Neighboring plates	Plate boundaries (convergent, divergent, or transform)	% Continental	% Oceanic	Estimated average plate motion (NNR)	
					Rate	Direction
Antarctic						
Arabian						
Australian						
Caribbean						
Cocos						
Eurasian						
Indian						
Nazca						
North American						
Nubia (Western African)						
Pacific						
Philippine						
South American						