How to do things in STELLA:

This handout is designed to walk you through the steps of building the box models used in lab 5 to explore concepts of the carbon cycle. We'll start with the basics and then increase in complexity, starting with building a simple reservoir with inputs and outputs, to adding in the necessary connections to get the models to do the math we want them to do.

Build a reservoir (stocks)
Be sure you are in the "model" tab (on left hand side of the window). Select the square icon ("stocks"), and then click on any spot on the workspace. A box representing your reservoir should appear. Let's take use the first part of the lab as practice. Rename it "Ocean" to represent your system. You'll likely see a "?" in the middle of the box. Don't worry about this; you'll take care of that as you build your model.

Add fluxes (flows in STELLA)
Now we need to add some fluxes into and out of our reservoir ("Flows" in STELLA-speak) or this will be a very boring model. Click on the icon that looks like a faucet.
For Inputs: click and hold the cursor somewhere outside the reservoir and drag the icon into the reservoir. Then release the cursor. You should now see a faucet with a cloud on one end and an arrow on the other end that intersects the reservoir.
For Outputs: click and hold the cursor inside the reservoir and drag the icon out of the reservoir. Then release the cursor. You should now see a faucet with a cloud on one end and a tube on the other end, coming out of the reservoir.

Again, let's use the first part of lab as an example. Add one input flux and label it "River Flux" and add two output fluxes, one labeled "Inorganic Carbon" and the other labeled "Organic Carbon."

Defining Initial conditions and simple fluxes for your box model
Double click on the reservoir and a window should pop up. Look for the box in this window that says {insert the right side of the equation here}. Type in values supplied in your lab for the initial ocean reservoir. You'll notice a button that says "unit." Click on this, and you can pick the units for your system (under mass, you'll find moles). Sweet!
Now do the same thing for your input flux: double click on it and a window should appear. Type it the value for your flux in the equation box.

Awesome! If you've done things correctly, there should no longer be any "?" symbols in the reservoir or flux that you edited.

How to make equations in STELLA (action connectors and converters)
You will find in most of the box models that some of the fluxes and the reservoirs are NOT constants, and instead change through time, often as a response to changes in other parts of the system.
For example, in the ocean box model, both of the outputs are equations. The Inorganic burial flux is a function of reservoir size and the Organic Carbon flux is a function of the

Inorganic Carbon flux and the Burial Ratio "R." Therefore, to compute these fluxes accurately in STELLA, you need to "connect" them. To do this, select the arrow icon (called the "action connector"), click and hold the cursor in the flux/reservoir that the other flux is dependent on (for example, the "Ocean" reservoir), and drag the cursor into the dependent flux (the "Inorganic carbon" flux) and then release the cursor. You should now see a red arrow pointing from "Ocean to "Inorganic Carbon." Now, double click on the Inorganic carbon flux, and a window should appear. You'll notice "Ocean" now appears under required inputs. To set up the equation listed in your lab for the Inorganic carbon flux, click on "Ocean" under the required inputs. You'll notice those words appear in the equation box. Good. Now, to finish the equation, type "*(5.05E-6). If you've done this correctly, your equation box should read "Ocean*(5.05E-6)"

Now, do the same for the Organic Carbon flux: Add an action connector from "Inorganic Carbon" to "Organic Carbon." Double click on "Organic Carbon" and click on "Inorganic Carbon" in the required inputs box. You've just added the numerator of your Organic Carbon flux equation. To finish off this equation, we need another box for the value of the denominator.

This is where "converters" come into play. Go back to your model. Click on the circle icon called "converters". Click in the model workspace near the "Organic Carbon" flux. You should see a circle appear. Let's label this "Burial Rate." Double click on the circle and a window should appear. In the equation box, type "4" (which is the burial rate initially defined in the lab). You may change this later as the lab goes on.

Now we can finish off our "Organic Carbon" flux equation. Add another "action connector" going from "Burial Rate" to "Organic Carbon" then double click on the "Organic Carbon" flux. When the window appears, note that "Burial Rate" is now listed in the required inputs box. Type a "/" in the equation box, then click on "Burial_Rate" in the required inputs box. Congrats! If you've done this correctly, your Organic Carbon flux equation should read: "Inorganic_Carbon/Burial_Rate."

You now know how to use converters and action connectors to help you define equations in STELLA. Woohoo!

Now that you've constructed your model, you need to set a couple of model parameters before you can tell it to run.

Setting model run parameters (cover time span, DT, sim speed)
Under the "Run" heading, select "run spec" and a window should appear. For this lab, you will only need to adjust "Length of simulation," "Unit of Time" and "Sim Speed." Let's change the parameters for the model you just set up. The lab says to run the model for 5.1 million years and in time intervals of 100,000 years. So, under "length of simulation" type 5100000 into the "To" box, and 100,000 into the "DT" box. Think of "DT" as the time step that the model recalculates the equations in the model. Now, change "Unit of Time" to years. Now look at sim speed. This tells you how long the

model will take. Click in the box and add some zeros right after the decimal point until "Min run length" reads something less than 30 seconds (or you'll be here all night…..).

Now, we need a way to look at the run as it progresses. Let's construct a graph to show us changes in the system as the model runs.

Graphs
Select the Graph icon (green graph with two line graphs on it). Click on the workspace below your model and a blank graph should appear. Now we need to define what we'd like to see in our graph. Double click anywhere on the graph and a window should appear. First, give your graph a title. For your TA's sake, pick something that clearly indicates which model you are working on (for our example, you built an Ocean model) and the question that the graph relates to. Now let's pick what you like to see on the graph. Note all the options under "Allowable." Click on "Ocean" then click the ">>" button. "Ocean" should now appear in the "Selected" box. For this example exercise, select all of the options (for future reference, STELLA allows a maximum of 5 items in the "selected" box). That should do it for now, so hit "OK."

Once you've seen a run in the graph, you may find it helpful to focus more closely on an interval of time in detail. You can do this by adjusting the display range in the "define graph" window. Try it! You can always switch the display range back to the full run time without losing the data.

Model Run:
Let's run this model. Under the heading "Run," select "Run." You should see a single flat line with numbers on it. The numbers correspond to the model parameters you selected. Notice the y-axis. The y-axis has multiple ranges on it, and each corresponds to the different parameters of your model, so be careful that you are looking at the correct scale when you answers questions based on the graph data.

Congrats! Now you have basics down for constructing and running models in STELLA.

Save/Print
You'll want to print these models and graphs according to the lab, so let's save the graph and model you just made. You may print directly from STELLA, but we recommend you save your graphs and models as .pdf files, that way you can print additional paper copies if you lose some of them. You should have a public folder on the campus servers through your ucsc.edu account, and you should save your figures there. Files saved to the computer desktop will likely get erased when you log out of the computer.

[Instructions on saving to .pdf for PC's???]

Build-ins
Build-ins are functions that STELLA recognizes that will help you make equations. They work similarly to built-in functions in EXCEL. For example, question 3a for the Ocean model exercise asks you to double the river flux starting at 1.1 millions years, using a

converter. Let's try this. Add a converter to your model and label it "uplift of Himalayas". Add an action connector that goes from the "river flux" to the "uplift of the Himalayas." Now, double click on the "uplift of Himalayas" converter. When the window appears, click on the "IF" function in the "Builtins" box. "IF()" should appear in the equation box. Inside the parentheses, type "time>=1.1E6" Next, click the "THEN" function, and type "2.0E13" inside the parentheses. Finally, click the "ELSE" function, and type "0" in the parentheses. Your equation box should read:
IF(time>=1.1E6)THEN(2.0E13)ELSE(0)

You have just told the model to input an addition 2 x 10^13 moles/year of carbon, starting at 1.1 millions years!

Ok, now to finish of the question. Double click on "River Flux." Adjust your equation box to add the additional material. If you've done it right, your equation box should read: 2E13+Uplift_of_Himalayas. The model now knows how and when to add material to the river flux!

Builtins you will use in this lab:
IF()
THEN()
ELSE()
*INT() this gives you an integer (helpful for the Extra credit)