Climate and Earth Systems

Introduction

Suppose you want to understand why Earth is habitable to life as we know it, while Venus and Mars are not. The answer is much more complex than simply distance to the sun. To answer this question, you need to consider each planet as a system. A **system** comprises interrelated parts, called **components**, that function as a whole. The links between components are called **couplings**. Scientists construct models as a way to describe and understand complex systems. While system models must leave out many details, they are a useful way to communicate and understand critical concepts.

In this activity, you will construct a model of the inorganic carbon cycle to understand how it regulates Earth's climate over geologic timescales.

Instructions

Read the following text describing the interaction of geology and the carbon cycle. Then use the model components and couplings to design your model. Use your model to explain how Earth's climate system works and how it differs from other nearby planets.

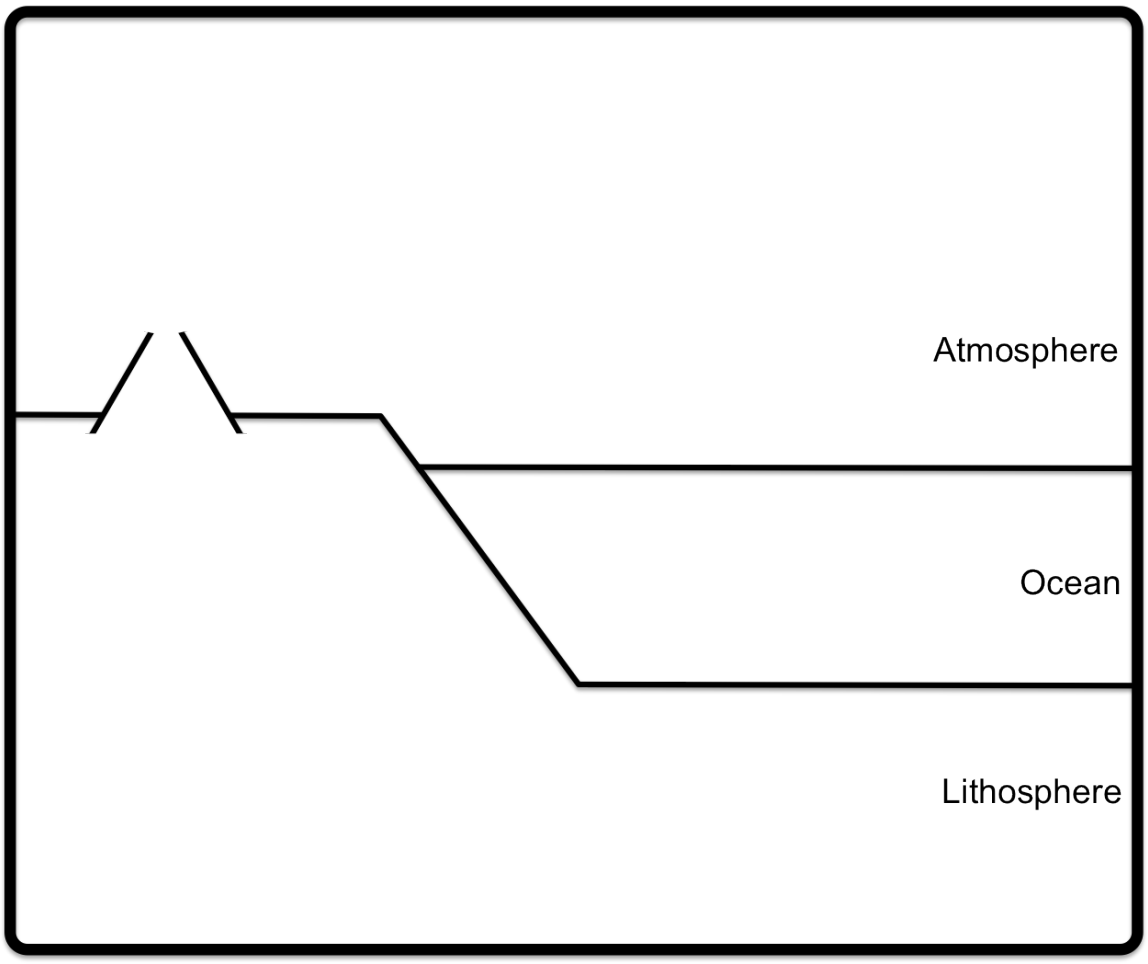
> Carbon dioxide is a gaseous form of inorganic carbon that is an important greenhouse gas. The inorganic carbon cycle is controlled by geologic processes and is critical to the stability of Earth's climate over long timescales. Volcanoes release carbon dioxide from the lithosphere into the atmosphere. Carbon dioxide can dissolve into water droplets in clouds and undergoes a reaction to form a weak acid. Slightly acidic rain falls on continents and contributes to rock weathering –the breaking down of rocks and minerals. This process releases calcium, bicarbonate, and other ions that are transported to the oceans by rivers. Marine organisms use these ions to make calcium carbonate, which is deposited in marine sediments. As the sea floor is recycled by plate tectonics, carbonate sediments are subducted and carbon dioxide is released through volcanoes, completing the cycle.

Components: these parts of system models are often nouns and are commonly represented in boxes. In this example the components are:

Couplings: these are the processes or mechanisms within the system. Couplings are commonly verbs that explain the relationship between the components and are represented with arrows. In this example the couplings are:

Use the components and couplings to draw a model in the space below. You can add components or couplings to make your model more complete.

Bonus: In some cases you can indicate if a coupling is positive (+) or negative (-) by thinking about how one component affects another component or coupling. In a positive coupling a change in one component causes a change in a coupling or component in the same direction. In a negative coupling, the change is in the opposite direction.



Use your model to answer the following questions:

1. Knowing that CO_2 is a critical greenhouse gas that controls temperature over long timescales, how would a long period of excessive volcanism affect the Earth's temperature?

2. The rate of rock weathering increases with increasing temperature. Describe the relationship between temperature and the rate of removal of CO_2 from the atmosphere.

3. If all the continents were covered with ice and weathering reactions stopped, what would be the long-term effect on temperature after reactions ceased?

4. Mars has no active plate tectonics and therefore no volcanism. If there were no plate tectonics, how would CO_2 and temperature in your model be affected?

5. The temperature on Venus is above the boiling point of water. What would happen to CO_2 and temperature in your model if you boiled the oceans away?

6. How does the chemistry of the ocean change in response to high levels of CO_2 in the atmosphere?