

Name: _____

Date: _____

Student worksheet for interactive lecture on: System diagrams.

Activity Slide 3: From a previous lesson. Your prediction: If rising CO₂ increases temperature, how will this change evaporation and atmospheric H₂O ? How do you think earth's temperature will respond? *Take a minute to jot down your ideas in the space below, compare with your neighbor and revise as appropriate, and then be prepared to share with the class.*

Systems Diagrams* and Feedback Structure

Systems thinkers use systems diagrams to help them describe and understand dynamic feedback structures in a variety of complex systems. In this interactive lecture activity you will learn how to create and interpret systems diagrams as a step towards being a more accomplished systems thinker.

Learning goals: students will:

1. Identify causal connection polarities between system components with a focus on Earth's energy balance and the Earth system.
2. Analyze system diagrams related to the Earth system.
3. Create systems diagrams of feedback processes within the Earth system.
4. Build a system diagram to describe the interconnections and feedbacks between climate change mitigation policy, science education, public awareness, and the media.

Activity Slide 6: What do you know?

Have you ever learned how to create and use systems (or causal loop) diagrams?

___ Yes ___ No

If yes, how would you rate your understanding of creating and using them?


Very poor 1 2 3 4 5 Expert

With the guidance of your instructor, work through the Interactive Lecture in class.

Rubric for this activity. This is a self-assessment activity and may or may not be collected at the end of class. If it is collected the rubric for your score is shown below.

Score	12	9	6	0
	All answers to questions clearly identified and legible.	Most answers to questions clearly identified and legible.	Over half of the questions answered clearly identified and legible.	Less than half of the questions answered clearly identified and legible.

Activity Slide 9: Connections

Connections (+ or - ??)** 

put a + or – near the tip of the arrow to indicate whether the connection between the two climate system variables is positive or negative.

Absorbed Sunlight → Earth’s Mean Temperature

Planetary albedo → Earth’s Mean Temperature

Emitted Infrared → Earth’s Mean Temperature

CO₂ → Earth’s Mean Temperature

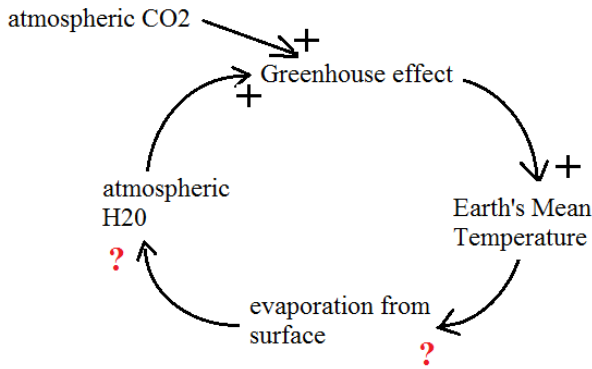
Water Vapor → Earth’s Mean Temperature

Cloud cover → Earth’s Mean Temperature

System variables should be nouns (Earth’s Temperature rather than warming.)

**** A connection is positive if when the first increases the second also increases, and a connection is negative (opposite) if when the first increases the second decreases.**

Activity Slide 11.



What are the missing connections? + or -

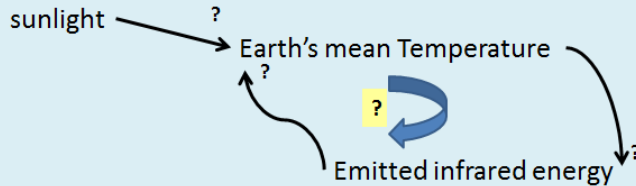
Activity Slide 14: A diagram challenge. The sun becomes brighter, causing Earth to warm. As Earth warms, it gives off more longwave radiation until it settles into a new equilibrium temperature. Your diagram should have the Sun's brightness as an external driver to Earth's temperature and Earth's Temperature connected with emitted longwave (infrared*) radiation.

Think for a minute on your own and then share your thoughts with your neighbors. Revise your idea as appropriate.

Activity Slide 15:

A first Challenge: diagram structure

- Draw a systems diagram to describe the following:
- The sun becomes brighter causing Earth to warm to a new equilibrium temperature.



Notice that the sun is not within the feedback loop structure.

What are the missing connections? + or –
and is the loop a positive or negative feedback loop

Pencil in your answers above, compare with your neighbor(s) and be prepared to share with class.

Activity Slide 18 and 19: Ice albedo feedback process. The ice albedo feedback process is described by the system diagram below.

As Earth's temperature increases from an increase in solar intensity, there will be less snow and ice cover globally. This decreases the planetary albedo causing even more sunlight to be absorbed by the climate system resulting in amplified warming. A systems diagram capturing the essence of the feedback process is shown below.

<p>What is the polarity of each connection?</p> <p>1. ____</p> <p>2. ____</p> <p>3. ____</p> <p>4. ____</p> <p>5. ____</p> <p>Is this feedback loop positive or negative?</p> <p>6. ____</p>	
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Pencil in your answers above, compare with your neighbor(s) and be prepared to share with class.

Activity Slide 23:

<p>Population informed of climate change science</p> <p>Media coverage of human induced climate change</p> <p>Climate Change science education</p>	<p>Pressure on policy makers to create climate change mitigation policy</p> <p>Climate Change mitigation policy. Including carbon emission reduction, research and development, and science education</p>	<p>This figure shows 5 components of a systems diagram intended to show the interconnections between key factors driving climate change policy.</p>
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- Take a minute to think about the possible connections between these components and whether the connections are positive or negative. Pencil in your answers on the figure above.
- Pair up with a neighbor or two and exchange your ideas.

Be prepared to share your ideas with the class.

Activity Slide 24:

	<p>As a start, think about <i>whether the connections shown at left are positive or negative, and whether the loop structure is a positive or negative feedback loop</i>. Pencil in your answers on the figure.</p> <p>Compare your answers with those of your nearest neighbors</p> <p>and</p> <p>be prepared to share your results with the class.</p>
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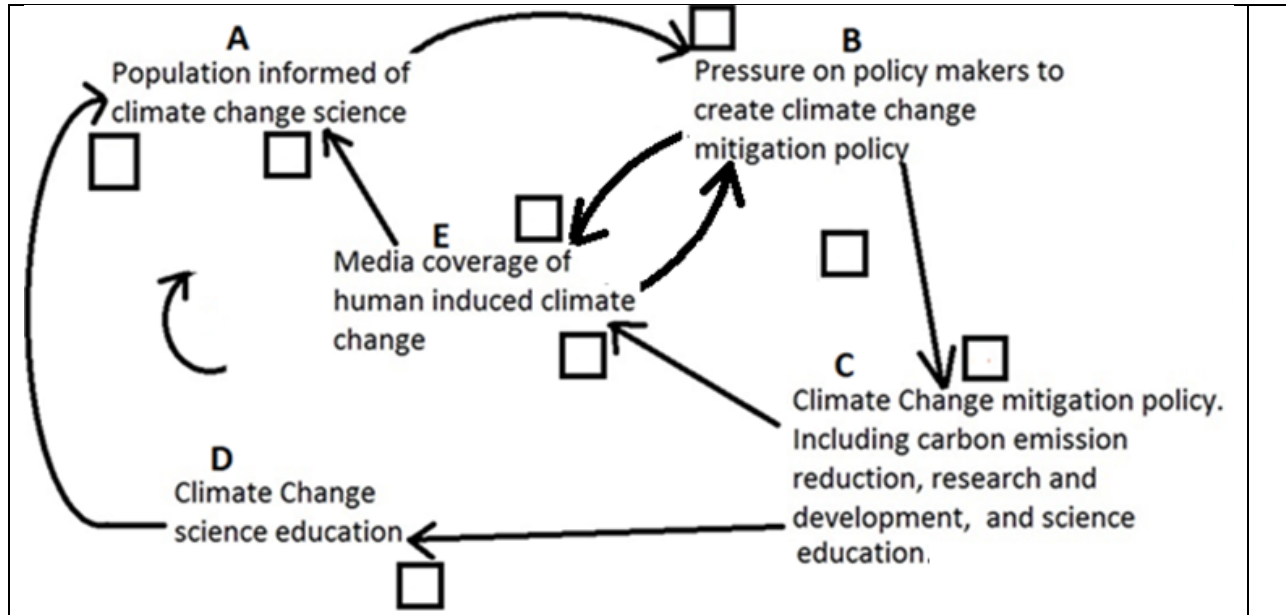
Activity slide 26:

	<p>Add the connections shown (CE and EA).</p>
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Think about *whether the connections shown above are positive or negative, and whether the additional loop structure is a positive or negative feedback loop*. Pencil in your answers above.

Compare your answers with those of your nearest neighbors and be prepared to share your results with the class.

Activity Slide 28:



Finally add the connections (BE and EB) shown above. Think about:

- How pressure on policy makers influences the media? + or -
- How the media influences pressure on policy makers? + or -
- *Whether these are positive or negative connections, and whether the additional loop structures are positive or negative feedback loops.*
- In this diagram how many feedback loops are there?

Pencil in answers above.

Compare your answers with those of your nearest neighbors and be prepared to share your results with the class.

Activity Slide 30:

How would you rate your understanding of creating and using systems diagrams now?

Very poor 1 2 3 4 5 Expert

What about today's lesson has been most helpful?

What suggestions do you have for improvements in today's lesson?

Rubric for this activity. This is a self-assessment activity and may or may not be collected at the end of class. If it is collected the rubric for your score is shown below.

Use the Rubric below to rate yourself.

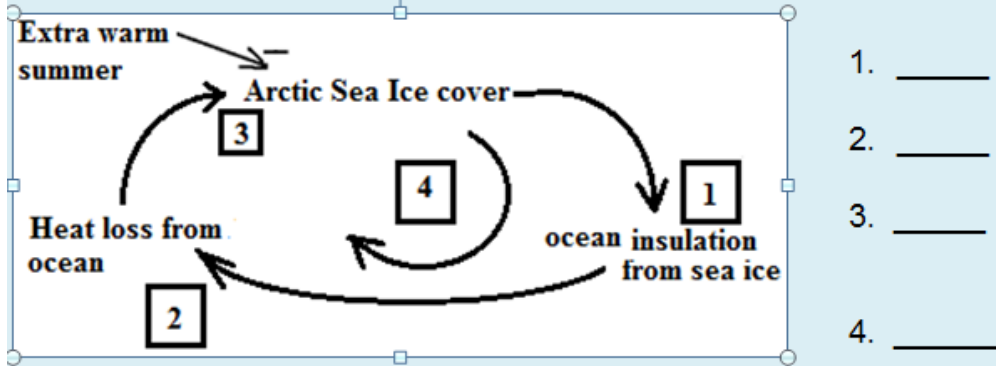
Rubric

score	12	9	6	0
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Slide 31:

Quiz Question

- Arctic sea ice grows in the winter as the ocean loses heat energy to the atmosphere, and retreats in the summer as the ocean gains heat energy from the sun and atmosphere.
- For this question we focus on the winter months where heat loss from the ocean is slowed by sea ice cover which provides insulation for the ocean.
- A system diagram showing the connections between Arctic sea ice cover, insulation provided for the ocean by the sea ice, and ocean heat loss is given below.
- What is the polarity of each connection in the diagram below? Is this feedback loop positive or negative?



How confident are you about your answers?

Not sure at all 1 2 3 4 5 Extremely confident