Energy Transfer in the Atmosphere

Setting Up the Game:

This is a game for 3 players where each section of the model can exchange energy (chips) with the other sections. One player represents each of the following: Earth's surface, the lower atmosphere, and the upper atmosphere. The three people sit in a row, in order just as the different segments appear in relation to each other.

Start by filling the board with chips starting at the bottom of each layer. Fill in only the squares with dark outlines. The surface and lower atmosphere should each have 19 chips, while the upper atmosphere should start with 8 chips.

How to Play the Game:

During the day, the sun shines on the Earth. The energy from the sun goes straight through the atmosphere and warms the surface. To represent this, the sun will take 3 chips and put them in the transfer arrow to give to the surface. Do not move the chips to Earth's surface yet! All transfers will occur at the end of the turn.

The surface and atmosphere layers will radiate depending on how much energy they have at the beginning of the turn. Look just to the right of your **topmost** chip, and it will tell you how much energy you will radiate for your entire turn. The upper and lower atmosphere should use the left number and *ignore the right number for now*. The surface will transfer 4 chips to the lower atmosphere. Place the 4 chips in the energy transfer arrow between the surface and lower atmosphere.

The lower atmosphere will transfer 3 chips each to the surface and upper atmosphere. Place three chips in each transfer arrow. The upper atmosphere will transfer 1 chip each to the lower atmosphere and out to space. Place one chip in the appropriate transfer arrow and one back in your chip cup. Now you can move the chips from the transfer arrows to the appropriate layers of the atmosphere! Make sure to place chips starting from the bottom.

Once you have moved your chips, record the energy data in your data table.

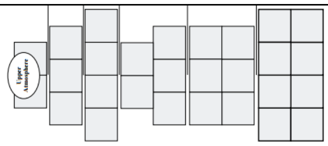
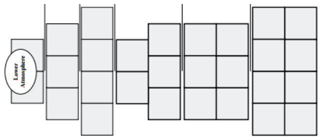
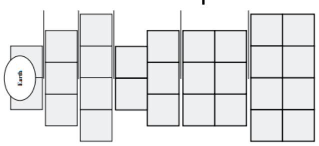
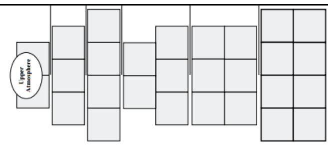
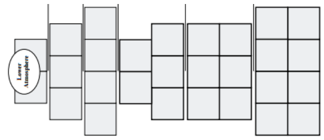
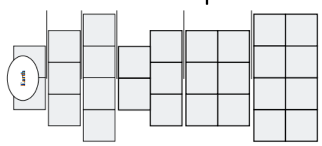
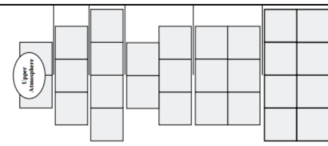
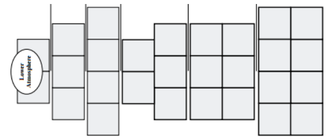
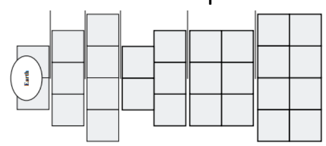
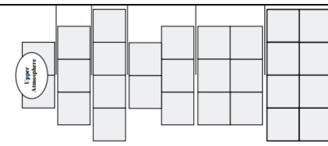
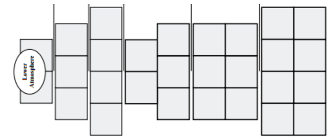
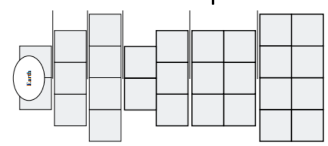
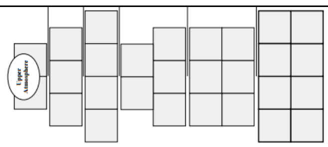
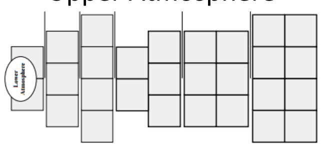
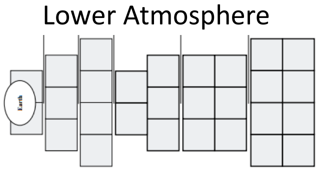
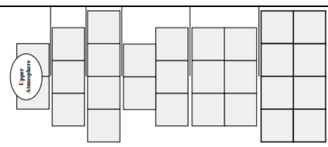
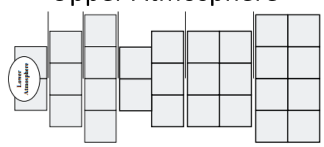
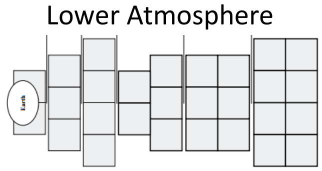
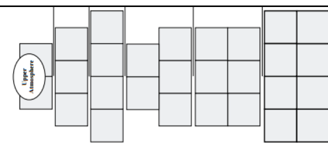
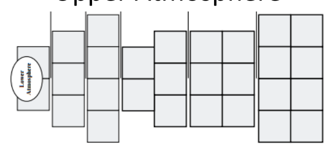
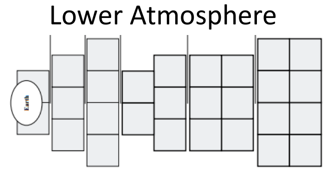
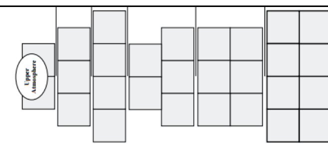
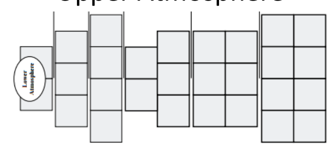
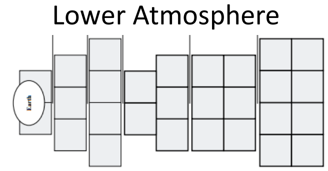
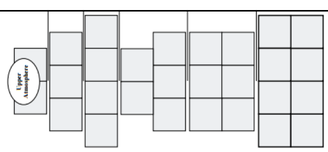
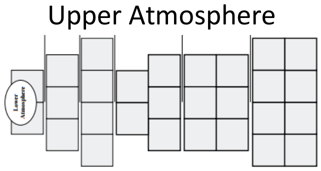
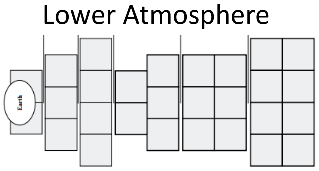
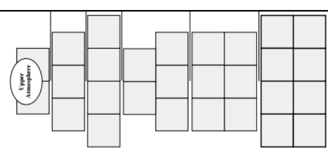
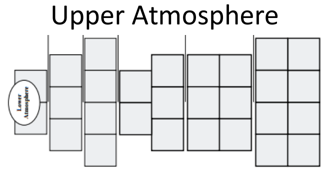
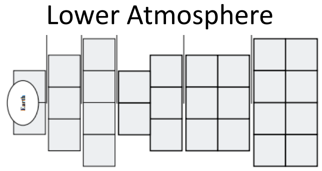
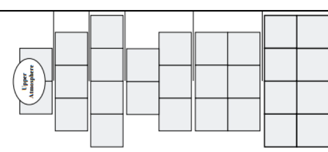
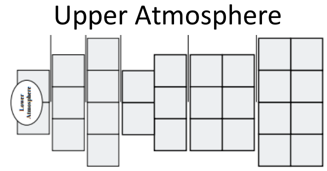
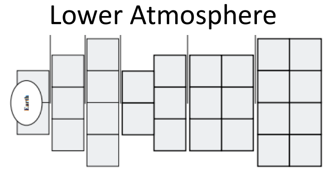
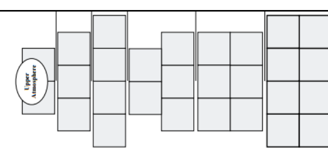
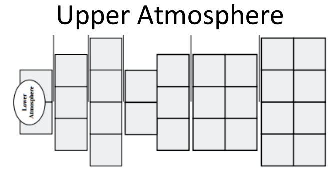
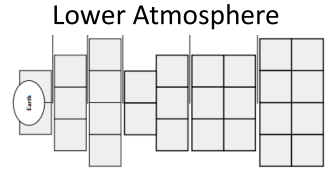
Time to Play:

As you take turns, make observations about the energy and temperature in each section, how energy transfers between the sections, and how energy enters the atmosphere. Additionally, consider the limitations of this model; which parts of the model are different from the Earth's actual atmosphere?

Observations	Limitations of the model

Energy Transfer Data Table

Record the number of tokens filling each layer of the atmosphere by shading in the squares in each layer. Make sure to mark which of the sections below represent day turns and which represent night turns.

 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth
 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth
 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth	 Upper Atmosphere  Lower Atmosphere  Earth

Once you have completed all your *day time turns*, answer the following questions.

1. Where is the most energy located in the model?
2. Where is the least energy located in the model?
3. How did the amounts of energy in each section change over the course of 12 turns?

4. Draw arrows in one of the squares in your data collection table above to show how energy moved between layers.
5. Describe how energy (chips) moved through the model.

6. What types of energy transfer were present? Consider your answer to the previous question and specific which sections (Earth, lower atmosphere, upper atmosphere)

Once you have completed your *night time turns*, answer the following questions.

7. ***What*** is the difference between the daytime turns and the nighttime turns?

8. ***Why*** is there a difference between the daytime turns and the nighttime turns?

9. Where is the most energy located in the model during the night turns?
10. Where is the least energy located in the model during the night turns?
11. How did the amounts of energy in each section differ between the day turns and the night turns over the course of 12 turns?

12. Draw arrows in one of the night squares in your data collection table above to show how energy moved between layers.

Conclusion Questions: Answer the following questions in complete sentences.

1. If a massive volcano, like Krakatoa in 1883, erupted and spewed out ash and debris that blocked out the Sun, how could you represent this with the model?

    a. Describe whether energy would be entering Earth from space and if so, how many chips worth of energy.

    b. Describe the movement of chips between the layers.

    c. Describe which sections (Earth, lower atmosphere, upper atmosphere), would have the most or least energy and why.

2. This model only represents the troposphere, the lowest layer of the atmosphere. If you were to add the stratosphere to this model…

    a. How much energy would come into the stratosphere from space during the day time?

    b. How many chips would you start with in the stratosphere and why?

    c. How many chips would you move from the stratosphere to the upper troposphere and to space and why?

3. Diagram the daytime and nighttime flow of energy with arrows below.

	Daytime	Nighttime
Upper Atmosphere		
Lower Atmosphere		
Earth		