Greenhouse effect

Lesson on global warming and its impact on biodiversity

DynaLearn level 2 | Version 1.1

Summary	
In this lesson, you discover what happens if a change takes place in one of the causes that influence global warming. You are also challenged to think about other causes as well.	
Given name	
Last name	
Class	
Date	
Comments by teacher	

1. Introduction

Especially in complex systems, such as global warming, it is difficult to foresee what happens when a factor changes. With software such as DynaLearn, we can create a model and predict what may happen. We also get a better picture of the factors that play a role in this complex system.

2. Starting DynaLearn

There are several ways to log in. Use one of the two options below. Then check whether the login was successful (see 'Let's check').

Via a code:

1. Go to DynaLearn (https://create.dynalearn.nl/).
2. Click on 'Login with code', at the bottom left.
3. Enter the project code and your (school) email address.
4. Copy the code from the confirmation email received from *dynalearn.nl* (see spam folder if needed) and fill in the other details.
5. Log in to DynaLearn.

By email invitation:

1. Copy the login details from the invitation email received from *dynalearn.nl*.
2. Go to DynaLearn (https://create.dynalearn.nl/).
3. Log in to DynaLearn.

Let's check!
After logging in, you will automatically enter in the white workspace of the assignment. You can recognize it by the question mark on the right side of the screen  . Is the question mark missing? Then first do the following:

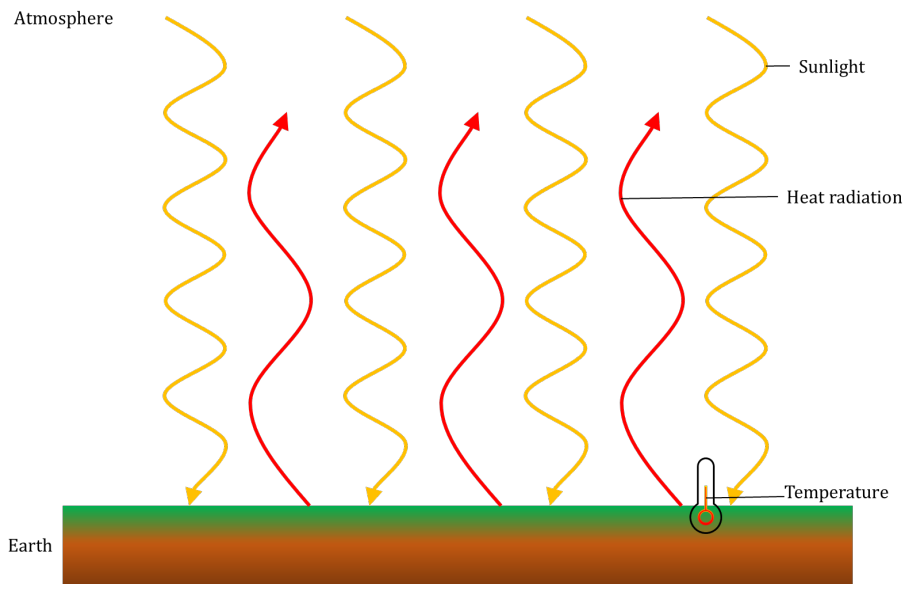
- In DynaLearn, click  . Click on 'Select norm model'.
- Choose 'Greenhouse effect' and press 'Load'.

Save model file and start:

1. Click on  top left. Change the name to 'Greenhouse effect' and click 'Save'.
2. How do you proceed? Just follow the steps in this workbook. Note! You can't skip steps. Ask for help if you do not understand a certain step. The video function  in DynaLearn shows how a model ingredient can be created. The sources contain information about the greenhouse effect and the boxes contain a brief explanation about the model ingredient. Put a check mark √ next to the step you completed. This way you keep track of where you are in the assignment.

3. The earth is warmed up by the sun and emits heat

1. Read Source 1.



Source 1. Sunlight increases the temperature of the earth. As a result, the earth will radiate heat.

2. Read Box 1 about the model parts.

Box 1. Entity and quantity.

An entity is usually a physical thing in a system (e.g., car, human).

A quantity is a measurable property of an entity (e.g., temperature, length).

You will first make a simple model with the entities *Sun, Land* and *Earth*. Later on, you will add the entity *Atmosphere*.

3. Create the entity *Sun* (see →), the entity *Earth*, and the entity *Land*.

4. Create the configuration *consists of* between entity *Earth* and entity *Land* (see →).

5. Read Box 2.

Box 2. Help function.

If the question mark or an ingredient in your model turns red, then something is wrong. Click the question mark for a hint. Then click on a number, for example 1, to see where the error is in your model. Only use the question mark if you can't figure it out yourself!

6. Create the quantity *Sunlight* of the entity *Sun* (see →).

7. Create the quantity *Temperature* of the entity *Land*.

8. Read Box 3.

Box 3. Cause-and-effect relationships.

In DynaLearn, there are two types of cause-and-effect relationships:

- Positive relationship ⊕: the quantities change in the same direction (if quantity 1 increases, then quantity 2 increases also)
- Negative relationship ⊖: the quantities change in opposite direction (if quantity 1 increases, then quantity 2 decreases. Or vice versa: if quantity 1 decreases, then quantity 2 increases)

9. Create the cause-and-effect relationship (⊕ or ⊖) between the quantities *Sunlight* and *Temperature* (see →).

10. Read Box 4.

Box 4. Change of a quantity.

A quantity can change. This is indicated by δ. The delta symbol (δ) is the mathematical sign for change (also known as the derivative). The down arrow (▼) is decrease, the zero (Ø) is constant and the up arrow (▲) is increase.

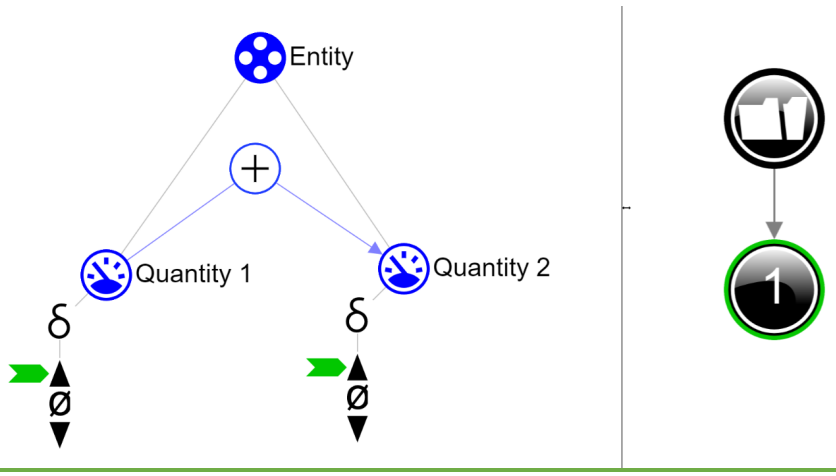
11. There are three possible initial situations. The amount of *Sunlight* may decrease, remain the same or increase. Set the initial change (see →):

    a. *Sunlight* increases (click ▲ and choose . It will look like this:).

12. Read Box 5.

Box 5. Read the outcome of a simulation.

After starting a simulation (with), a window appears on the right in which the possible states of the system are indicated. There is one possible state in the *example* shown below.



You can click on the state to view the outcome. The state icon then gets a green circle. In the model, the change for this state is indicated by green arrows. The model shows that in state 1 *Quantity 1* increases and that therefore *Quantity 2* also increases.

13. Read Box 6.

Box 6. Help function.

If the exclamation mark appears, something went wrong during the simulation. Click on the exclamation mark for a hint. Then click on a number, for example 1, to locate the error in your model.

14. Start the simulation (with), investigate the results, and circle the correct answer in the first row of the table below. Next, vary the the initial setting – one by one – for sunlight to 'stay the same' and then 'decrease' (place a one by one at: ø and ▼) and simulate your model again by clicking on . Give the results in the table below.

Amount of sunlight...	**Temperature of land...**
increases	*decreases/stays the same/increases*
stays the same	*decreases/stays the same/increases*
decreases	*decreases/stays the same/increases*

You are now going to add more earth related details to the model.

15. Create the quantity *Radiated heat* of the entity *Land*.

16. Create the cause-and-effect relationship between *Temperature* and *Radiated heat*. You must decide again whether this is a positive or a negative relationship.

17. Set the initial change (see →):

    a. Let the quantity *Sunlight* of the entity *Sun* remain on increase.

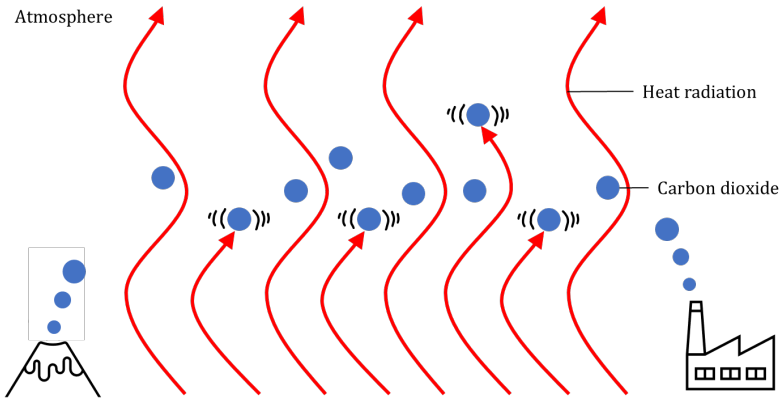
18. Is your screen content a bit messy? Click to align everything neatly. Click to fit your model on your screen.

19. Start the simulation .
    a. Circle the correct answers in the sentences below.

If the amount of sunlight that reaches the earth increases, the temperature of the land will *decrease/remain the same/increase.* As a result, the amount of radiated heat from the land will *decrease/remain the same/increase.*

4. Enhanced greenhouse effect

1. Read Source 2.



Source 2. The earth's heat radiation is partly absorbed by greenhouse gases such as carbon dioxide in the atmosphere, which increases the atmosphere's temperature. Note that, carbon dioxide is just one of several greenhouse gases. Other significant greenhouse gases include methane, nitrous oxide, and water vapor.

The atmosphere is also an entity and has three quantities that play a role.

2. Create the Entity *Atmosphere*.

3. Create the configuration *consists of* between the entity *Atmosphere* and the entity *Earth*.

4. Create the three quantities of the atmosphere (based on source 2).

5. Is your screen content a bit messy? Click to align everything neatly. Click to fit your model on your screen.

6. Read Box 7 to determine if your model is complete.

Box 7. Progress bar.

The *progress bar* is at bottom of the screen. An example is shown below. In this example, entity shows: 4/4/0, meaning: 4 created, 4 needed, 0 error. For quantity it shows: 5/17/1, this means: 5 made, 17 needed, 1 error. If all the numbers are green, that ingredient type is completed.

7. Add three cause-and-effect relationships in the model (based on source 2).
   a. Pay attention to the right direction (from what quantity to what other quantity?)
   b. Is it a negative or a positive relationship?

You can check your model by running the simulation. Follow the steps below.

8. In addition to the initial change of sunlight, the initial situation of the amount of greenhouse gas can now also vary. It is not difficult to predict what will happen if sunlight and the amount of greenhouse gas both increase. And it is also not difficult to predict will happen if both decrease. But what if one increases and the other decreases?

   Set the initial change:
   a. Let's assume that the *Sunlight* is decreasing.
   b. And, that the *Greenhouse gas* is increasing.

9. Simulate the model. If all goes well, there are three possible end states. We call this **ambiguity**. This is because the size of the effects of sunlight and greenhouse gas are undetermined. When both quantities have an opposite effect on a third quantity, the resulting change in this quantity becomes indeterminate and all possible states are represented.

10. Make the table below correct (cross out). Give a brief explanation of each outcome.

Results	**Temperature of the atmosphere**	**Your explanation**
State 1	*decreases/stays the same/increases*	
State 2	*decreases/stays the same/increases*	
State 3	*decreases/stays the same/increases*	

When people influence global warming, we are talking about the *anthropogenic greenhouse effect*. The amount of greenhouse gas (such as carbon dioxide) also increases (and decreases) due to natural causes. We could extend the model by making this part more detailed.

11. Name at least 3 human causes that influence the amount of greenhouse gas in the atmosphere.

1.
2.
3.

5. Biodiversity crisis

Biodiversity and temperature

For now, we leave deeper causes of anthropogenic global warming outside the model. Instead, we will look at one of the many consequences, namely the consequences for biodiversity.

1. Watch this video: https://tinyurl.com/tempandbio (till 9m 25s)

2. Add the quantity *Biodiversity* to the entity *Land*.

Note the quantity *Biodiversity* of the entity *Land* represents all organisms living in soil, on land or in the air (but not those in the oceans). This choice is made because we want to be sparing with the number of ingredients in the representation and in this case do not want to create separate entities for organisms that live in the soil, on land and in the air, each with its own quantity 'Biodiversity' and optionally also 'Temperature'.

3. Create the entity *Ocean* and create the configuration *consists of* between *Earth* and *Ocean*.

4. Add the quantities *Biodiversity* and *Temperature* to the entity *Ocean*.

5. Create the relationships between the *Temperature* of the atmosphere and the 3 new quantities. Three relationships should be added. Two are connected to *Temperature*.

6. Set the initial change:
   a. *Sunlight* is constant.
   b. *Greenhouse gas* is increasing.

7. Start the simulation .
   a. Circle the correct answers in the sentences below.

If the temperature of the atmosphere increases, the temperature of the ocean will *decrease/remain the same/increase.* As a result, the biodiversity in the ocean will *decrease/remain the same/increase.* Increasing atmospheric temperature will lead to a *decrease/increase* in biodiversity on land.

8. The decline in biodiversity is just one of the many consequences of global warming. Name at least 2 other consequences for people and nature.

1.
2.

Biodiversity and acidification

1. Watch this video: tinyurl.com/acidandbio

The increased greenhouse effect has a second effect on ocean biodiversity in addition to an increase in ocean temperature.

2. Create the missing quantity belonging to the entity *Ocean* and make the required cause-and-effect relationships with this quantity (and other quantities).

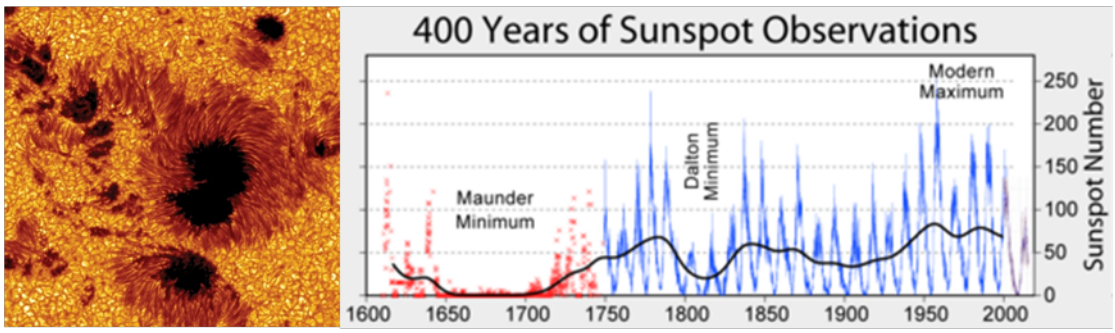
3. Make sure you have created all the required ingredients (check the progress bar, see box 7).

4. Set as initial change:
   a. *Sunlight* is constant.
   b. *Greenhouse gas* is increasing.

5. Simulate the model and check whether the outcomes match your expectations.

6. Natural variation of solar radiation (Sunspots)

In the past, some people claimed that global warming may not be caused by humans, but by natural variations in the sun. These people usually talked about a period in the 17th century when the sun had a low number of sunspots (see Source 3). During this period, the temperature on earth was also lower than normal.



Source 3. The number of sunspots in the last 400 years.

6. Set the initial change:
   a. *Sunlight* is decreasing (period with few sunspots).
   b. *Greenhouse gas* is increasing.

7. Start the simulation. You now get 5 end states. Put the number of the matching end state in the table below.

Description	End state
With less solar radiation, the temperature in the atmosphere drops. However, biodiversity in the ocean is still declining due to acidification.	
The lower temperature in the atmosphere and oceans have a greater influence on biodiversity than the acidification of the oceans.	
The greenhouse effect is so strong that the temperature of the atmosphere is still rising. Even reduced amounts of sunlight cannot stop the loss of biodiversity on land and in the ocean.	
The drop in temperature of the oceans perfectly compensates for the effects of acidification on the land's biodiversity.	
The greenhouse effect compensates for the decrease in solar radiation. The temperature of the atmosphere remains the same and the biodiversity in the ocean is still declining due to acidification.	