Greenhouse effect

Lesson on global warming and its impact on biodiversity

DynaLearn level 2 | Version 1.0

Summary
In this lesson, the student discovers what happens if a change takes place in one of the causes that influence global warming. The student is challenged to think about other causes as well. Finally, in the extra chapters, the student investigates consequences of global warming.

Given name	
Surname	
Class	
Date	
Comments by teacher	

1. Introduction

Especially in complex systems, such as global warming, it is difficult to oversee what happens when a factor changes. With modelling software such as DynaLearn, we can create an overview and predict what may happen. We also get a better picture of the factors that play a role in a 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 'log in 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:
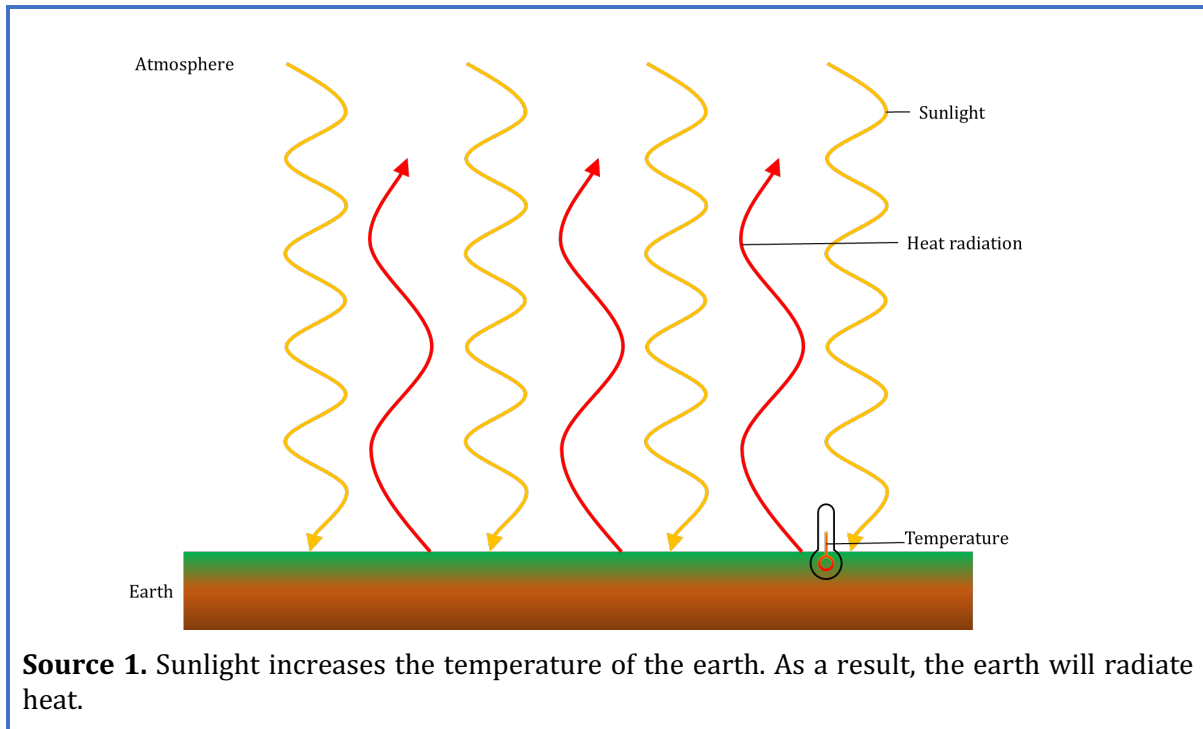
- In DynaLearn, click . Click on 'Select norm model'.
- Choose 'Greenhouse effect' and press 'Load'.

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' and 'Earth'. **Later** on you will add the entity atmosphere.

3. Create the entity *Sun* (see 🎥 → ⬤).

4. Create the entity *Earth.*

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 *Surface temperature* of the entity *Earth*.

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)

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9. Create the cause-and-effect relationship ((+) or (−)) between the quantities *Sunlight* and *Surface temperature* (see ◼️ → 🏔️).

10. Read Box 4.

Box 4. Change of a quantity.

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

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11. There are three possible initial situations. The amount of *Sunlight* may decrease, remain the same or increase. Set as 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 this example 1.
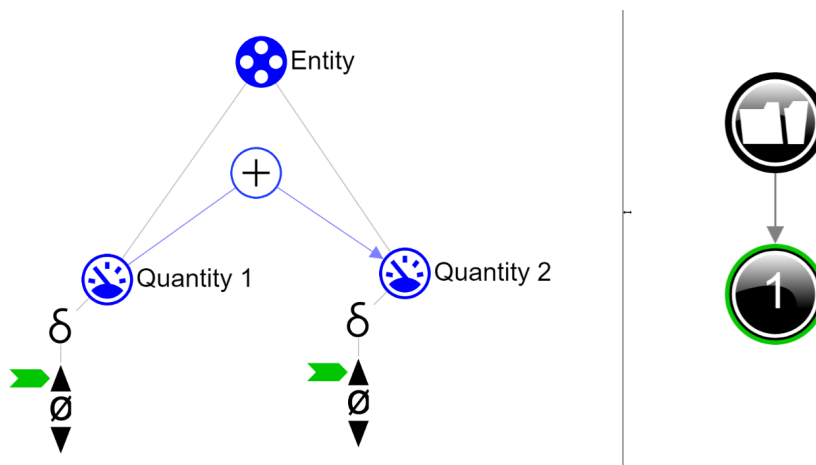
You can click on the state to view the outcome. The state icon then gets a green circle. In the model, the change for this state is indicated by green arrows ➤. The model shows that in state ① *Quantity 1* increases and that therefore *Quantity 2* also increases.

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 ❶, to locate the error in your model.

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

Amount of sunlight...	Surface temperature earth...
decreases	*decreases/stays the same/increases*
stays the same	*decreases/stays the same/increases*
increases	*decreases/stays the same/increases*

You are now going to finish the model of the earth.

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

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

17. Set as initial change (see 🎥 → ➤):
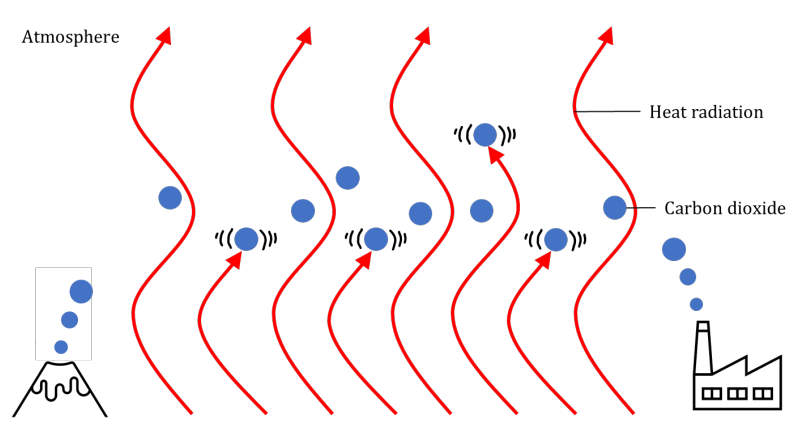
    a. The *Sunlight* of entity *Sun* increases ➤▲ø▼.

18. Start the simulation ⊙.
    a. Circle the correct answers in the sentences below.

If the amount of sunlight that reaches the earth increases, the surface temperature of the earth will *decrease/remain the same/increase.* As a result, the amount of radiated heat from the earth 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. The atmosphere retains the radiated heat, which increases the 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. Add Entity *Atmosphere*.

3. Add the three quantities of the atmosphere.

4. Is your screen content a bit messy? Click [⚡] to align everything neatly. Click [⤢] to fit your model on your screen.

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

> **Box 7.** Progress bar.
>
> At the bottom of the screen is the *progress bar* (see example below).
>
> Entity shows: ⚙ 4/4/0, this means: 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.
>
> ⚙ 4/4/0   ⚙⚙ 3/3/0   ⌚ 5/17/1   ⚙ 0/26/0   # 12/24
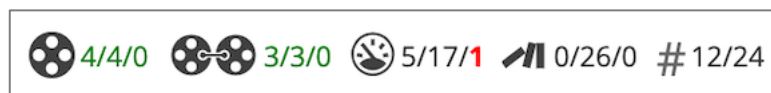
6. There are now three cause-and-effect relationships missing. Add the missing cause-and-effect relationships to the model.
    a. Pay attention to the right direction (from what quantity to what other quantity?)
    b. Is it a negative ⊖ or a positive ⊕ relationship?

You can check your model by running the simulation.

7. 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?

8. Set as initial change:
    a. *Sunlight* is decreasing.
    b. *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 extent the model by making this part more precise.

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 *Earth*.

Note the quantity *Biodiversity* of the entity *Earth* 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. Add the entity *Ocean*. For this entity, create the quantities *Biodiversity* and *Temperature*.

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

5. Set as initial change:
   a. *Sunlight* is decreasing.
   b. *Greenhouse gas* is increasing.

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

7. 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, 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 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. Recent research shows that sunspots have only a small influence on the climate.

Source 3. The number of sunspots in the last 400 years.
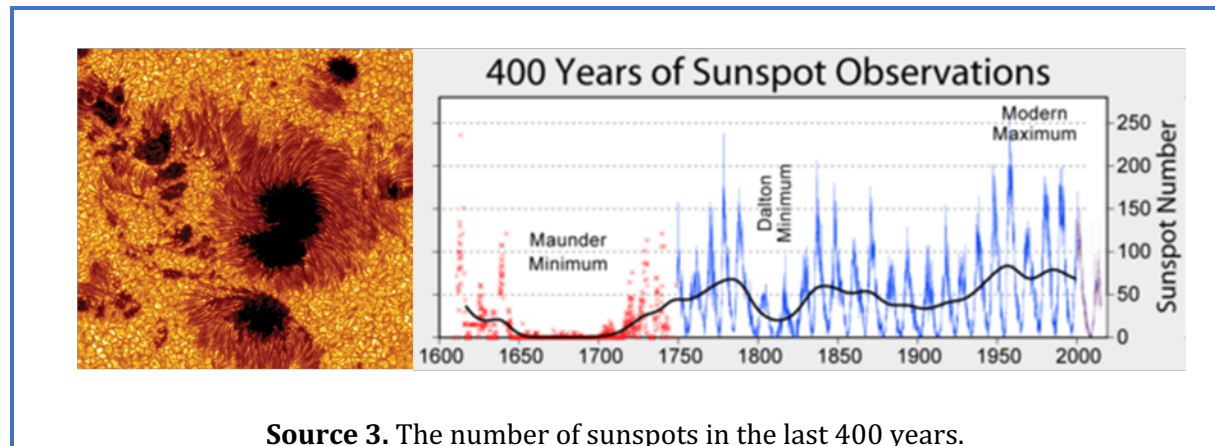
6. Set as initial change:
    a. *Sunlight* is decreasing (period with few sunspots).
    b. *Greenhouse gas* is increasing.

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 earth and in the ocean.	
The drop in temperature of the oceans perfectly compensates for the effects of acidification on the earth'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.	