RESOURCE

Modelling the Climate in Your Class

This resource is designed as a comprehensive guide for facilitating a professional development workshop on Earth system modelling, specifically tailored for secondary school teachers trainers.

In the workshop, teachers participate in a board game and use a multimedia animation on the Urban Heat Island (UHI) effect to understand the Earth system and how models are built and used, with a particular focus on the concepts of scenarios, projections, and uncertainty.

Summary

3 OVERVIEW AND REQUIRED MATERIAL

4 GENERAL OVERVIEW

- **Activity #1:** Overview
Modelling the Climate Using a Board Game
- **Activity #2:** Overview
Using Climate Models to Predict the Future

8 PART 1: HOW TO COMBINE THESE TWO ACTIVITIES DURING A TEACHER TRAINING SESSION?

- **Activity #1:** Short Procedure Overview
Modelling the Climate Using a Board Game
- **Activity #2:** Short Procedure Overview
Using Climate Models to Predict the Future

12 PART 2: HOW ARE THESE TWO ACTIVITIES CONSIDERED AS MODELS?

14 CONCLUSION

15 TO GO FURTHER

ACTIVITY #1

This icon refers to the **lesson "Modeling the Climate Using a Board Game".**

ACTIVITY #2

This icon refers to the **lesson "Urban Heat Island (UHI)".**

This resource is based on two lessons from the guidebook *The Climate in Our Hands - Climate Models* published by the Office for Climate Education.

Resource
Secondary school teachers
Duration: 3H

Subjects
Physics, Chemistry, Natural Science, Geography

Pedagogical Approach
Serious game and multimedia animation

OFFICE FOR CLIMATE EDUCATION
unesco Centre Under the auspices of UNESCO

Date of publication

June 2025

Photos

Page 1 (cover) – Harsh Kumar

Layout

Léa Chénot

AUTHORS
Adeline Aroskay (OCE), Natalie Chong (OCE), Amina Maroini (OCE), Nicolas Vogt (OCE)

MODELLING THE CLIMATE IN YOUR CLASS
Professional development resource

TARGET AUDIENCE
Secondary school teachers

DURATION
3 hours (1.5 hour for each activity)

SUBJECTS
Physics, Chemistry, Natural Sciences, Geography

KEYWORDS
Models, climate system, climate change, urban heat island effect, mitigation, adaptation, scenario, projection, Paris agreement target, sustainable development goals (SDGs)

KEY COMPETENCE
Systems thinking

PEDAGOGICAL APPROACH
Serious game and multimedia animation

UNDERSTANDING

- Urban Heat Island (UHI) effect
- Climate models
- Mitigation
- Adaptation
- Scenario
- Projection
- Climate feedback
- Scientific consensus

SKILL GOALS

- Understand what a model is and how to use different types of models in the classroom
- Use a board game to explore the complexity of the climate system
- Cooperate to build a model and explore the different interactions between environments
- Explore the concepts of climate projections and scenarios
- Become familiar with some mitigation and adaptation solutions to tackle climate change and the UHI effect

REQUIRED MATERIAL

FOR EACH GROUP OF 6 FOR ACTIVITY #1 (I.E., THE BOARD GAME)

- 1 board game per group of 6 participants, laminated, and in A2 format if possible (see WORKSHEET 3.1)
- Elements and fluxes to be placed on the board game (cut out beforehand and placed in an envelope if possible) (see WORKSHEET 3.2)
- 1 set of booklets (either keep the whole sheet or cut out the cards to make a small booklet) (see WORKSHEET 3.3)
- Correction elements (see WORKSHEET 3.5)

FOR EACH GROUP OF 2 TO 3 PARTICIPANTS FOR ACTIVITY #2 (I.E., THE MULTIMEDIA ANIMATION)

- 1 computer with an internet connection or with the multimedia animation on the UHI effect installed on the computer
- 1 table to be filled in, summarising the different implemented solutions (see WORKSHEET 8.1)
- 1 sheet with the list of the 17 Sustainable Development Goals (SDGs) (see WORKSHEET 8.2)

Download the material for Activity #1:

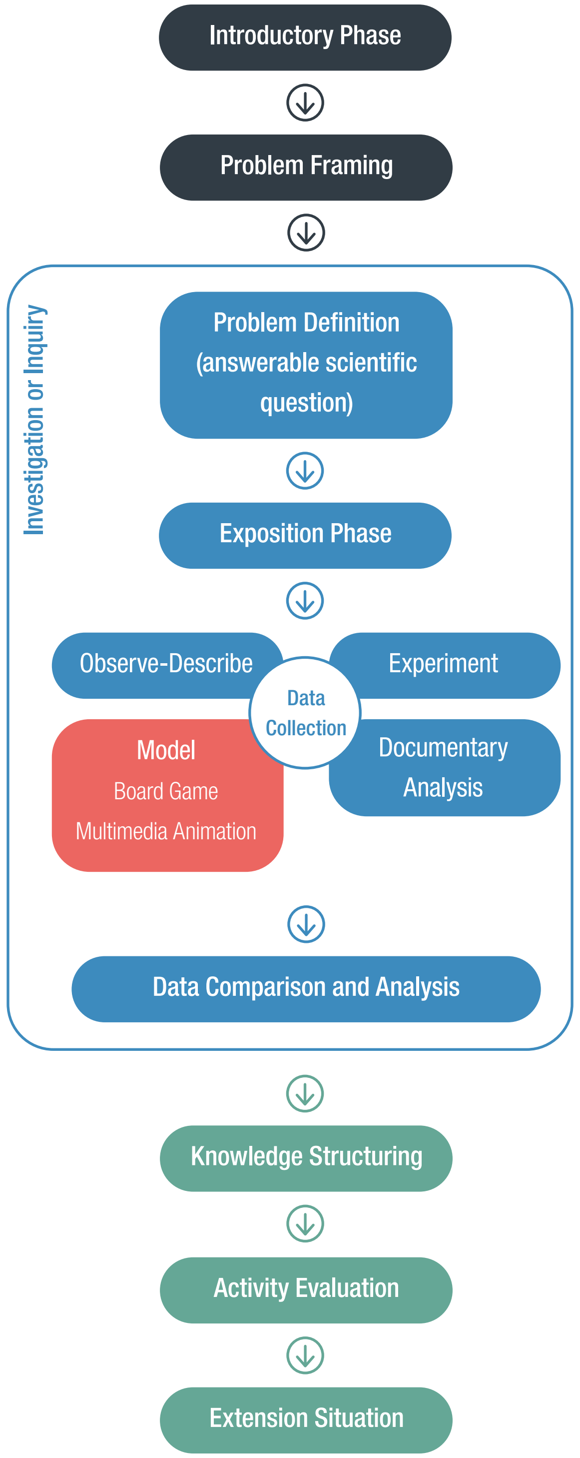
Download the material for Activity #2:

General Overview

Two resources from different lessons of the handbook Climate Models are combined in this professional development resource. Both are based on active pedagogies tools, either in the form of a board game or as a multimedia animation. The corresponding lessons are structured to enable students to **actively engage** in the activities. Learners are indeed involved: they move elements on the board game, read aloud, click to choose solutions, receive numbers of feedbacks, and participate in other interactive tasks. They are also **cognitively engaged**, as they debate, answer questions, and make comparisons between different scenarios. It is also entirely possible to use models as part of an inquiry-based approach to test hypotheses or answer questions (e.g., Why is it warmer in the city than in the surrounding area?).

This professional development resource aims to highlight the use of different types of activities to understand:

— what a model is, how it is built and used,
— how climate models can be used to predict future climate conditions depending on different scenarios.



Potential steps of an explicit inquiry-based approach. Using scientific model is one of the modality that can be applied during this approach, when students investigate to find solutions to the problem raised. During all these stages, it is important to give feedback to the students: This may take the form of guided work or regular feedback in any form possible.

ACTIVITY #1: OVERVIEW
Modelling the Climate Using a Board Game

Through this activity, participants will understand that models are simplified representations of reality—in this case, Earth's climate system—enabling us to simulate and analyse interactions between different components of the Earth's climate system, such as the atmosphere, oceans, and ice sheets. However, it is important to note that models cannot fully capture the complexity of reality.

This activity is divided into three rounds:

Round 1 involves **building a model** of the Earth's climate system with its main components for **an unperturbed climate situation**. Following the instructions on the cards, participants reassemble the different environments and processes within the system by placing the items on the board. They understand that **the board game is, in fact, a model**—a simplified representation of reality.

At this stage, the model represents the Earth's climate system as it was before the Industrial Revolution.

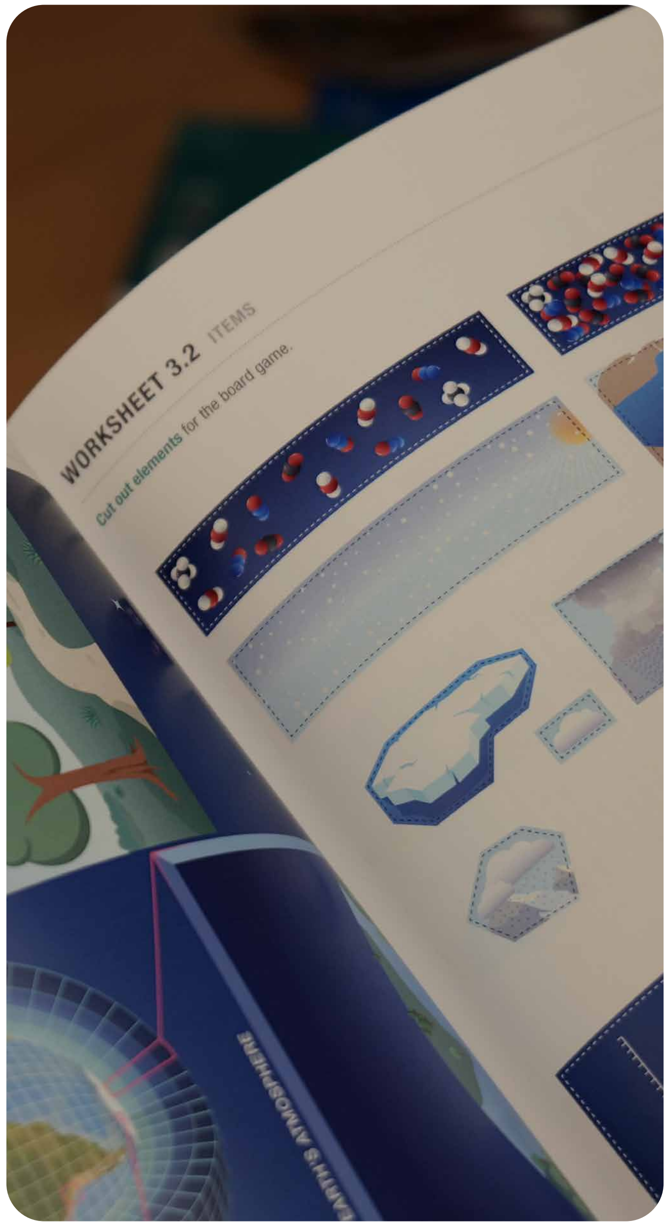
Round 2 is about **using the model to run an experiment in a perturbed climate situation** (i.e., the Earth is facing climate change). Participants modify the different environments according to the changes driven by human activities. Through this experiment, they understand: i) the consequences of climate change on the different components of the Earth's climate system, and ii) that a model can be used to simulate and analyse changing interactions between the different environments they built in Round 1 (unperturbed climate situation).

During this round, **the board game is used as a model, enabling participants to run simulations with distinct values for some parameters, leading to different future climate projections. This also helps participants understand a complex problem :** how interactions and processes within and between the different environments making up the climate system are evolving with human-induced climate change.

The Earth's climate system is represented in the board game through five distinct environments.

Round 3 focuses on **understanding the interactions between the different environments in a perturbed climate situation,** taking into account the various feedback mechanisms associated with the changes highlighted in Round 2. Participants learn that different environments interact with each other and that the change in parameters (e.g., temperature, humidity) in one environment can lead to subsequent changes in another—this process is known as **climate feedback**.

The board game is used as a model to help participants understand complex phenomena: positive and negative climate feedbacks. Additionally, participants familiarise themselves with the concept of scientific consensus regarding different feedbacks by selecting arrows with varying levels of consensus (medium to strong) to place on the board.



ACTIVITY #2: OVERVIEW
Using Climate Models to Predict the Future

Through this activity, participants will explore how climate models can be used to predict future climate conditions and phenomena such as the Urban Heat Island (UHI) effect. They will also learn the difference between a scenario and a projection and reflect on various adaptation and mitigation strategies to tackle climate change and the UHI effect.

Activity #2 is divided into two parts:

Activity 2.1: Using Models to Predict Future Climate on a Global Scale

This part highlights the role of models in predicting the evolution of climate on a global scale, allowing participants to explore various mitigation strategies to limit climate change by the end of the century. In doing so, participants will understand that: i) **models can be used to predict future climate**, and ii) depending on user-selected options (i.e., the scenario they build), the resulting **projected climate change** by the end of the century may vary.

Like the board game in Activity #1, **the multimedia animation serves as a model** to enable participants to run simulations with **distinct scenarios, leading to different future climate projections.** The animation functions as a black box—participants simply select the options they want to implement. This allows them to appreciate the power of models in predicting future climate without needing to understand the coding or the science behind it.

However, it is important to point out that each option is backed by real **scientific data** from either the Intergovernmental Panel on Climate Change (IPCC) or the French National Meteorological Research Center (CNRM).

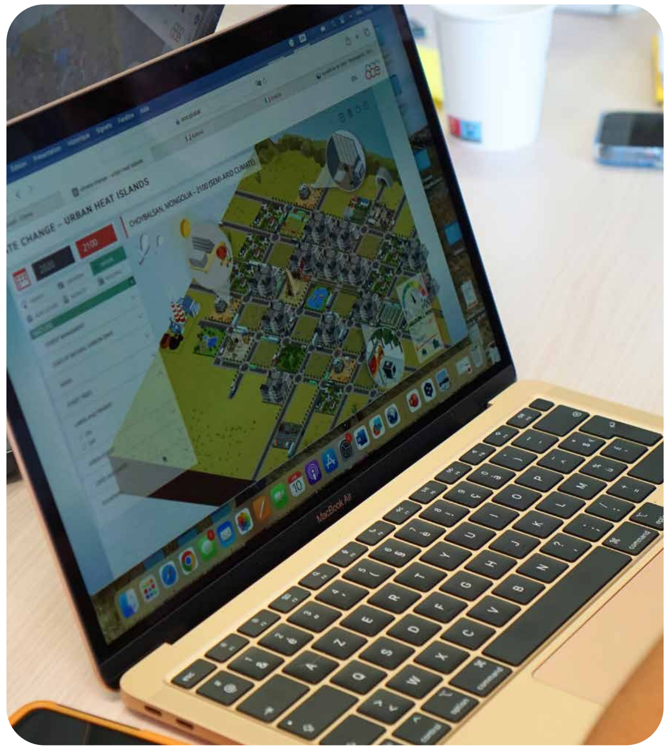
Participants place different elements and fluxes on the board game to recreate the climate in a given environment.
OCE, July 2024, Climate Education Summer University.

Activity 2.2: Using Models to Investigate Solutions to Limit the UHI Effect on a Local Scale

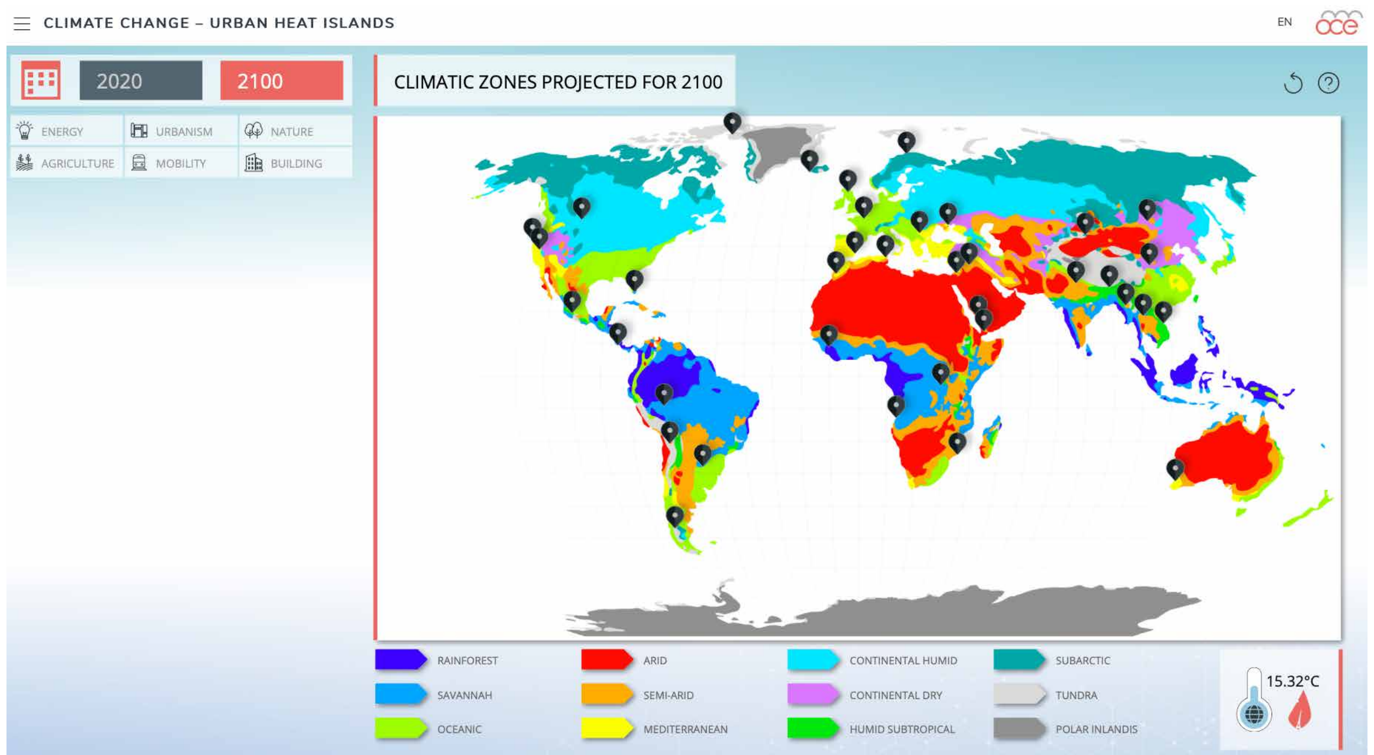
This part emphasizes the importance of models when thinking about efficient solutions to limit the UHI effect, both in the short term and over the longer term (by the end of the century). After observing the positive temperature anomaly between the city and the countryside, participants can choose from a range of actions across various sectors to help limit temperature increases in urban areas.

They understand how important models are for proposing adaptation strategies to address the UHI effect—both in the present and in the future, especially within the broader context of global warming.

Similar to Activity #1, **the multimedia animation serves as a model for running simulations with distinct scenarios, resulting in different projections of temperature anomalies** between cities and the countryside (i.e., a more or less pronounced UHI effect). This allows participants to appreciate the power of models in predicting future temperature trends in cities and their role in supporting decision-making for adaptation strategies to limit the UHI effect in the coming decades.



The multimedia animation on the UHI effect can be used to explore the difference between a scenario and a projection.
OCE, July 2024, Climate Education Summer University.



Screenshot of the multimedia animation on Urban Heat Islands (UHI) exploring the global distribution of climate zones and the global mean temperature in 2100 (shown on the right, below).

PART 1

How to Combine These Two Activities During a Teacher Training Session?

The activities described above can be carried out during the same teacher training session in a complementary way.

The training session should begin with Activity #1 (i.e., the board game) to help participants understand how a model is built and how it can be used. Divided into three rounds, Activity #1 allows participants to gain a deeper understanding of what lies behind a model (e.g., different parameters involved, various environments, chemicals, processes, etc.). Round 3 specifically focuses on how the different components of the modelled climate system interact and respond to a perturbation, often leading to climate feedback mechanisms. Activity #1 focuses on system thinking competence, which is relevant for quality climate education. Activity #2 then continues to explore the role and strengths of models, particularly how they can help societies make informed, science-based decisions and adapt to future changes. In this sense, Activity #2 focuses more on addressing solutions, which are known to be highly effective in quality climate education.

ACTIVITY #1: SHORT PROCEDURE OVERVIEW
Modelling the Climate Using a Board Game

Participants are divided into groups of six: one Game Master and five scientists (see the booklets). Each group of participants receives a board game representing five distinct environments of the Earth's climate system. The game consists of three rounds.

Round 1 - Unperturbed Climate: Participants must reconstruct the environments and their processes by following the instructions on the cards and placing the corresponding items on the board. In doing so, **they build a model of the natural climate system** by choosing the physical parameters that determine the local climate of each environment and setting their values (e.g., volume of ice, concentration of greenhouse gases, etc.)

Example of a booklet with a scientist profile. Each booklet contains instructions for the different rounds participants need to play.

Round 2 - Climate Perturbed by Human Activities: Participants must modify the environments on the board according to the instructions on the cards. **They use the model they previously built in Round 1 to run an experiment,** modifying the value of a single parameter (for example, the concentration of greenhouse gases in the atmosphere). This follows the principle of a scientific experiment: changing only one parameter between two experiments allows the effect of that parameter to be deduced.

Round 3 - Climate Perturbed by Human Activities: Participants must link two environments with feedback arrows (reinforcement or limitation of climate change) according to the instructions on the cards. The level of scientific consensus regarding the feedback is represented by a colour code. **They use the model to understand the concept of climate feedback and scientific consensus,** which also demonstrates the dependencies between physical parameters in different environments. For example, a change in albedo in the Arctic has a global impact on temperatures, which in turn affects temperatures in tropical zones. These interdependencies can be translated into a set of equations involving all these physical parameters, also called variables. Connecting all the variables through mathematical formulas is the fundamental principle of climate modelling[1]. This round illustrates the interaction between the Earth's different environments. It's a way of developing systems thinking and understanding the interdependencies between Earth's systems.

ACTIVITY #2: SHORT PROCEDURE OVERVIEW
Using Climate Models to Predict the Future

Participants are divided into small groups of 2 or 3, with each group needing a computer to work on. This activity has two main parts, corresponding to two different spatial scales: global and local.

1 For more details on the dependencies between physical quantities, please see: OCE (2024), Lesson "The laws of physics", Lesson plan: teachers' handbook. The Climate in Our Hands – Climate Models. [Online] Available at https://www.oce.global/en/resources/class-activities/law-physics

Activity 2.1: Using Models to Predict Future Climate on a Global Scale

After exploring the animation, participants are asked to find solutions to limit the temperature increase by 2100, keeping it at or below the Paris Agreement objective (around +1.5°C of warming relative to the 1850-1900 era). You can explain the meaning of the colour code on the COP21 logo: red if the Paris Agreement target is not achieved, and green if it is. This exercise will help participants understand that **efforts are required across sectors** to reach the Paris Agreement objective of limiting warming to +1.5°C compared to the pre-industrial period – this is called **systemic transformation**. Here, the model is used as a predictive tool to test various mitigation scenarios on a global scale. You can summarise this section by emphasising the variety and effectiveness of existing solutions to address global warming.

Teacher's tip: Keep in mind that adopting a positive way of thinking is essential to quality climate change education (especially with pupils): constructive hope is a unique predictor of climate-friendly behaviour in regression analyses[1]. Teachers can refer to the resource *The Emotions of Climate Change*[2] to equip themselves with tools for engaging their students in meaningful discussions about climate change and its psychological impacts. This comprehensive professional development guide is designed to help teachers address the complex emotions that students may experience in response to climate change, known as "eco-anxiety".

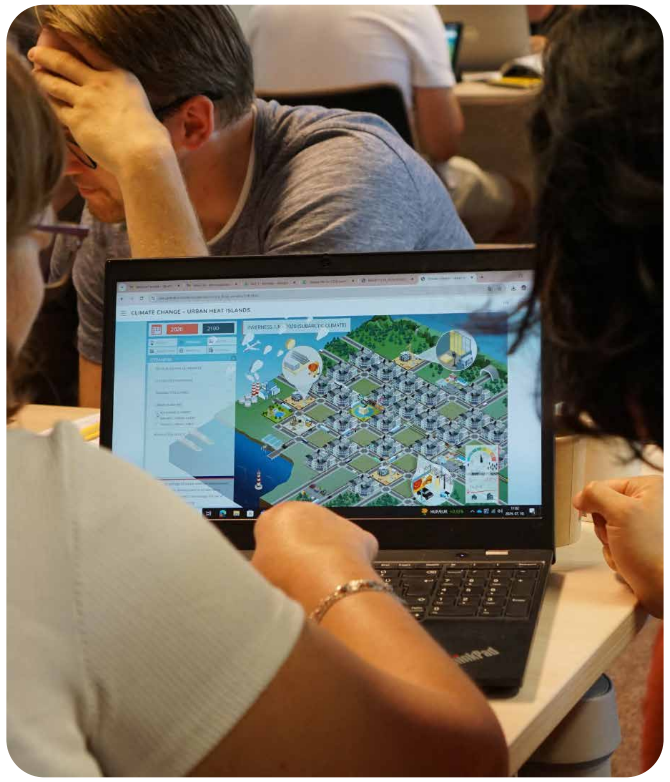
1 Ojala, M. (2012). Hope and climate change : The importance of hope for environmental engagement among young people. Environmental Education Research, 18(5), 625 642. https://doi.org/10.1080/13504622.2011.637157

2 OCE (2024) Professional development for educators: "The Emotions of Climate Change". [Online] Available at https://www.oce.global/en/resources/teacher-professional-development/emotions-climate-change

Activity 2.2: Using Models to Investigate Solutions to Limit the UHI Effect on a Local Scale

To begin, you can select the year 2020 in the animation to: i) highlight the Urban Heat Island (UHI) effect by asking them to click on different cities around the world to show the evolution of the temperature anomaly between the city centre (urban area) and the countryside (surrounding rural areas), and ii) encourage participants to explore solutions that can be implemented across different sectors to reduce the UHI effect.
Here, the animation serves as a model to predict the evolution of a parameter (the temperature anomaly between the urban centre and the surrounding countryside) based on different adaptation scenarios.

Next, ask the participants to select the year 2100 in the animation and observe the changes associated with global warming and the UHI effect.
The global temperature is the temperature in the countryside, and the UHI effect is the temperature anomaly in urban areas relative to the countryside temperature. In most cases, the countryside temperature is higher compared to 2020 (due to global warming), while the urban temperature anomaly remains the same as in 2020, indicating that the UHI effect is constant.



Participants using a multimedia animation to investigate the different solutions to limit the UHI effect.
OCE, July 2024, Climate Education Summer University.

They can also examine the impact of the various solutions, had they been implemented earlier in the century, by comparing the global temperature and the urban temperature anomaly in 2100. These solutions can lead to:

— a reduction of the UHI effect;
— a reduction of the global temperature without changing the urban temperature anomaly;
— a reduction of both.

This demonstrates that some solutions aimed at limiting the UHI effect also help to mitigate global warming by the end of the century.

Here, the animation serves as a model to predict the evolution of global warming and the UHI effect by the end of the century, depending on different adaptation scenarios. Don't forget to explain to participants that the IPCC reports[1] place a great deal of emphasis on these existing **synergies between mitigation strategies and adaptation strategies.**

Adaptation solutions implemented to face the issue of the UHI effect in cities at a short time scale and at a local level can also limit the temperature increase in surrounding areas by 2100. These adaptation solutions are therefore also considered as mitigation solutions, in this case we can talk about **synergies** between adaptation and mitigation solutions.

1 See figure from the IPCC 6th assessment report to learn more about various synergies between mitigation and adaptation solutions for different systems https://www.ipcc.ch/report/ar6/wg2/downloads/figures/IPCC_AR6_WGII_Figure_18_Cross-Chapter_Box_FEASIB_2.png

BACKGROUND FOR TEACHERS

URBAN HEAT ISLAND EFFECT

The Urban Heat Island (UHI) effect corresponds to a positive temperature anomaly measured in urban areas compared to surrounding rural areas. During the day, in the countryside, solar radiation warms up all natural surfaces, both biological and mineral. Biological surfaces absorb this energy and use it to grow (typically through photosynthesis), while mineral surfaces warm up and emit infrared radiation as a result. In urban areas, most surfaces are mineralised, leaving little vegetation. Most of the energy received is stored in materials and re-emitted as infrared radiation. Thus, the UHI primarily results from soil artificialization, which limits vegetation cover, but also from higher population density, which influences heat production from human activities, and the thermal properties of buildings. The UHI is independent of global warming. However, even though they are not directly related, global warming amplifies the UHI by increasing the global temperature and worsening the heat-related risks in cities. Given that the urban population is expected to double by the end of the century, cooling solutions must be implemented to mitigate the UHI. Due to the extreme complexity of urban geometry at local, meso, and large scales, models are used to simulate the effectiveness of proposed solutions. This can be illustrated by watching the "Urban Heat Islands" CLIM video, in which Aude Lemonsu (CNRM, Météo-France) explains their characteristics.

MITIGATION AND ADAPTATION SOLUTIONS

Mitigation solutions aim to reduce greenhouse gas (GHG) emissions from human activities or to enhance GHG sinks, in order to limit global temperature increase and, consequently, global warming.

Adaptation solutions aim to reduce the impact of the UHI effect on urban populations and to cool cities by reducing heat emissions and/or trapping. Examples of adaptation strategies include planting trees, cool/green roofs, cooling centres, switching to electric transportation, rethinking urban planning and design, and incorporating vegetation or water-based solutions (blue infrastructure).

Screenshot of the multimedia animation on Urban Heat Islands (UHI) exploring the different solutions that can be implemented at a local scale (city of Morelia, Mexico) in various sectors, in 2020.

PART 2

How Are These Two Activities Considered as Models?

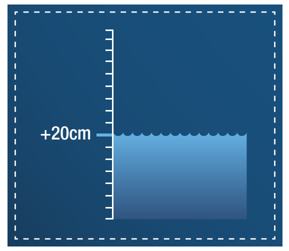
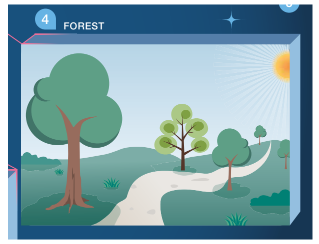
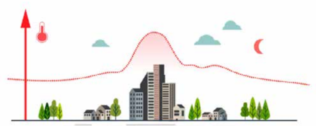
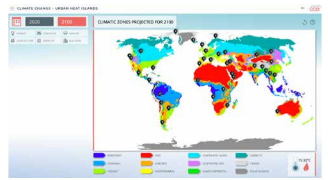
BACKGROUND FOR TEACHERS
MODELS

A model is a simplified representation of reality that can be used to understand complex problems. Using models has many advantages, but they also have their limitations. They cannot capture the full complexity of reality.

Climate models are analogies for reality used to make projections. They are evolving thanks to the integration of new parameters, as well as improvements in climate observations, computing power, and technology, which lead to greater resolution and accuracy.

There are different types of models: an 'analog model' is a simplified representation of reality using physical objects, while a 'digital model' is a simplified representation using numerical data. The accuracy in matching observations—often assessed by evaluating a model's capacity to replicate past climates—and resolution of the model determine its quality.

As the facilitator of this workshop, you have used two different types of learning objects: a board game and a multimedia animation, both of which can be considered as models. The components of these models can be categorised into the following three groups:

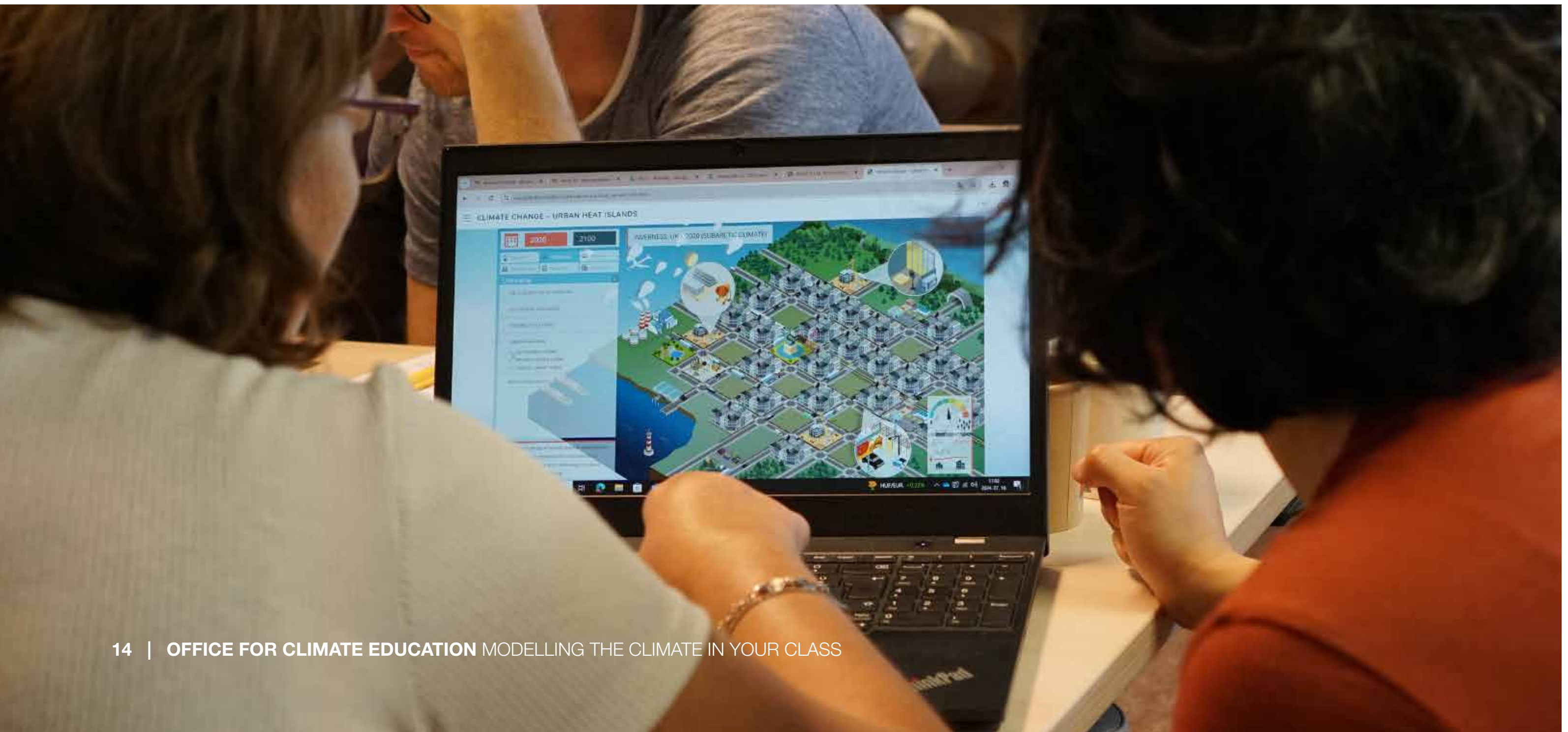
MODEL TYPE	INPUTS = DATA ENTERED IN THE MODEL	OUTPUTS = DATA/RESULT PRODUCED BY A MODEL WHEN RUNNING A SIMULATION	SAMPLING = REDUCTION OF CONTINUOUS INFORMATION TO A FINITE SET OF VALUES
BOARD GAME = ANALOG MODEL	— Infrared radiation (IR), albedo, temperature, solar radiation, greenhouse gas concentration, evaporation, wind, respiration, photosyn- thesis, water (atmosphere, sea ice and continental ice, rain/snowfall), CO_2 (biosphere, atmosphere, lithosphere) — Optional: permafrost, clouds, fires, thermal ocean expansion	— Outgoing IR emission, temperature, rain/snowfall, evaporation rate, sea level rise — Updates of all input values 	— 5 environments (1 atmosphere, 1 Antarctica, 1 Arctic region, 1 forest, 1 hydrosphere) 
MULTIMEDIA ANIMATION = DIGITAL MODEL	— Solutions to face the UHI effect or to limit its impacts — Temperature — Urban classification 	— Global temperature — Urban temperature anomaly — Regional climate — Regional average temperature 	— Cities in the world — Sectors of activity — Periods (2020 and 2100) 

Conclusion

Participants learn that climate models are indispensable tools for studying the climate system due to its complexity. They are used to simulate and analyse interactions between components of the Earth's systems, as demonstrated in the board game, and are also crucial for predicting future climate scenarios, as seen in the multimedia animation.

Through this training, participants will gain important learning outcomes, including:

- **Understanding the role and benefits of climate models:** Understanding what climate models are, their role in representing the Earth's natural climate system, and their function in predicting its evolution under climate change.
- **Understanding scenario development:** Developing and analysing future projections based on different scenarios, and understanding how various pathways could shape our future climate, as well as recognising the difference between a scenario and a projection.
- **Understanding of the Urban Heat Island effect:** Exploring the impacts of urbanisation and climate change on cities.
- **Understanding the difference between mitigation and adaptation:** Learning the difference between climate change mitigation strategies and adaptation strategies.
- **Understanding the concept of Systems Thinking:** Approaching a sustainability problem from multiple perspectives, considering time, space, and context to understand how elements interact within and between systems.



To go further

OCE, Handbook *The Climate in Our Hands: Climate Models*, 2024: https://www.oce.global/en/resources/class-activities/climate-our-hands-climate-models

OCE, Climate models explained by the climatologist Roland Séférian, 2023: https://www.youtube.com/watch?v=6Q3MFEpmnXQ

OCE, Climate projections explained by the scientist Birgit Hassler, 2023: https://www.youtube.com/watch?v=Q7gpDPeArIE

OCE, Webinar by an expert on climate change Robert Vautard on *IPCC reports and climate projections*, 2024: https://www.youtube.com/watch?v=J71A4GIW1qw

OCE, Current climate change – Future projections, 2024: https://www.youtube.com/watch?v=3njDgVs5XZI

OCE, MOOC *Climate change education: from knowledge to action*, 2023: https://www.oce.global/en/resources/teacher-professional-development/mooc-climate-change-education-knowledge-action

European Commission, Joint Research Centre, *GreenComp, the European sustainability competence framework*, Publications Office of the European Union, 2022: https://data.europa.eu/doi/10.2760/13286

Ojala M, *Hope and climate change : the importance of hope for environmental engagement among young people*, Environ Educ Res 18(5): 625–642, 2012: https://doi.org/10.1080/13504622.2011.637157

Ojala M, *Climate-change education and critical emotional awareness (CEA): implications for teacher education*, Educ Philos Theory 55(10): 1109–1120, 2023: https://doi.org/10.1080/00131857.2022.2081150

Rousell D, Cutter-Mackenzie-Knowles A, *A systematic review of climate change education: giving children and young people a 'voice' and a 'hand' in redressing climate change*, Child Geogr 18(2) : 191–208, 2020: https://doi.org/10.1080/14733285.2019.1614532

Xu C, Iyengar R, *Climate change education, an earth institute sustainability primer*, Columbia University Press, 2023: https://cup.columbia.edu/book/climate-change-education/9780231202435/

Zeyer A, Dillon J, *The role of empathy for learning in complex Science|Environment|Health contexts*, Int J Sci Educ 41(3): 297–315, 2019: https://doi.org/10.1080/09500693.2018.1549371

The Office for Climate Education (OCE), created in 2018, is an ambitious response to the Paris Agreement, which emphasizes the importance of climate change education in its Article 12.

A center under the aegis of UNESCO, an observer member of the IPCC, and co-coordinator of the *Greening Education Partnership*, the OCE leverages its dual scientific and educational expertise to support the Sustainable Development Goals. It fosters strong international cooperation among scientific organizations, NGOs, and educational institutions.

The OCE offers teachers worldwide high-quality, interdisciplinary educational tools based on IPCC reports. These tools emphasize active pedagogies (inquiry-based learning, project-based learning, etc.) and are adapted to local contexts. With the help of its partners, it provides professional development opportunities and on-the-ground support.

The OCE also assists education systems globally in implementing high-quality climate change education through expertise and pilot project deployment.

https://www.oce.global
contact@oce.global
Sorbonne Université, Case 100
Campus Pierre et Marie Curie
4, place Jussieu
75005 Paris – France

This resource is published in the framework of the **European project ESM2025**. The project's aim is to develop the next generation of Earth System Models which will provide relevant climate simulations for the deployment of ambitious and realistic mitigation and adaptation strategies.

GRANT AGREEMENT
N° 101003536