Can AI predict the future of climate change?

This resource was developed by teachers within the Royal Society Schools Network

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KS4

Lesson time: 1 hour

Introduction

Predicting the effects of climate change is hugely complex due to the number of variables at play. Scientists are using Artificial Intelligence (AI) to simulate consequences of climate change, factoring in things like temperature changes, rate of deforestation and changing weather patterns.

To access this lesson, students need a reasonable foundation of knowledge in climate change. This lesson includes an excellent opportunity for students to practice exam-style questions, including 'level of response' questions. Mark schemes are provided.

Learning objectives:

- Identify factors affecting climate change.
- Describe the effects of climate change.
- Explain why AI is necessary when dealing with complex issues such as climate change.
- Apply your understanding of climate change to interpret the results of AI predictions.

Curriculum key words

Acids	Climate change
Carbon dioxide	Human activities
pH	Simulations
Uncertainties	

Curriculum links

GCSE science:

- AQA 5.9.2.2
- AQA 5.9.2.3
- Edexcel 8.25
- Edexcel 8.26
- OCR C6.2d
- OCR C6.2e

Equipment needed

– Students need to be able to see the data either by projecting the images or with colour prints.

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Starter activity: AI and climate change

(Approximately 15 minutes)

Watch a short clip from the recorded live stream of the lecture You and AI - The Practical Applications of AI (start 55:43 mins, end 57:05 mins) to introduce the topic. The clip describes the analysis of European summer temperatures.

Discuss with the class what is meant by the term "what the world would have been" used in the clip (green area on the graph) and why the observed (black line) is different to prompt conversation around the role of greenhouse gases.

Key points that should be elicited from the students should include:

- combustion of fossil fuels produces carbon dioxide;
- combustion of fossil fuels is a human activity; and
- use of fossil fuels is continuing to increase.

This is a good opportunity to discuss why predictions have a degree of uncertainty whereas the observations are fixed in value. Predictions are made with ranges of values around the most likely, actual data should fit within this prediction if the models are suitable. Data collected will have a value with a much smaller uncertainty value based upon the resolution of the apparatus. At the scale of this graph, this uncertainty is neglible.

Watch a second short clip from the same video You and AI - The Practical Applications of AI (start 57:16 mins, end 57:58 mins) and discuss what risks the students are most concerned with and why. This introduces the main part of the lesson (analysing models of ocean acidification in a small region of the Pacific Ocean).

Activity A: analyse AI models of ocean acidification

(Approximately 35 minutes)

Discuss the effect of increasing atmospheric carbon dioxide and how it will dissolve in the oceans.

When CO_2 dissolves in water it forms carbonic acid (H_2CO_3). This partially ionizes in solution to form bicarbonate ions (HCO_3^-) and H^+.

$$CO_{2\,(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)} \rightarrow H^+_{(aq)} + HCO_{3\,(aq)}^-$$

This provides an opportunity to practice symbol equations and links to ideas of pH and strong/weak concentrated/dilute acids.

There are good photos / images online showing the effects of ocean acidification on shells. The effects of acids on metal carbonates can be revised at this point to highlight the impact lower pH values of oceans will have on coral reefs.

Optional demonstrations:

- Make sure students understand still/fizzy water is without/with CO2 respectively. Use universal indicator to show the different pHs of still/fizzy water. Discuss that as more CO2 dissolves in the oceans, the pH drops. Refer to equation above.

- Put shells in a beaker of normal 'sea' water and a beaker of hydrochloric acid 'acidified sea water'. Discuss the effects of ocean acification on marine life.

Provide the students with three different models of ocean acidification based upon low, medium and high carbon dioxide emission scenarios to analyse (see Fig1).

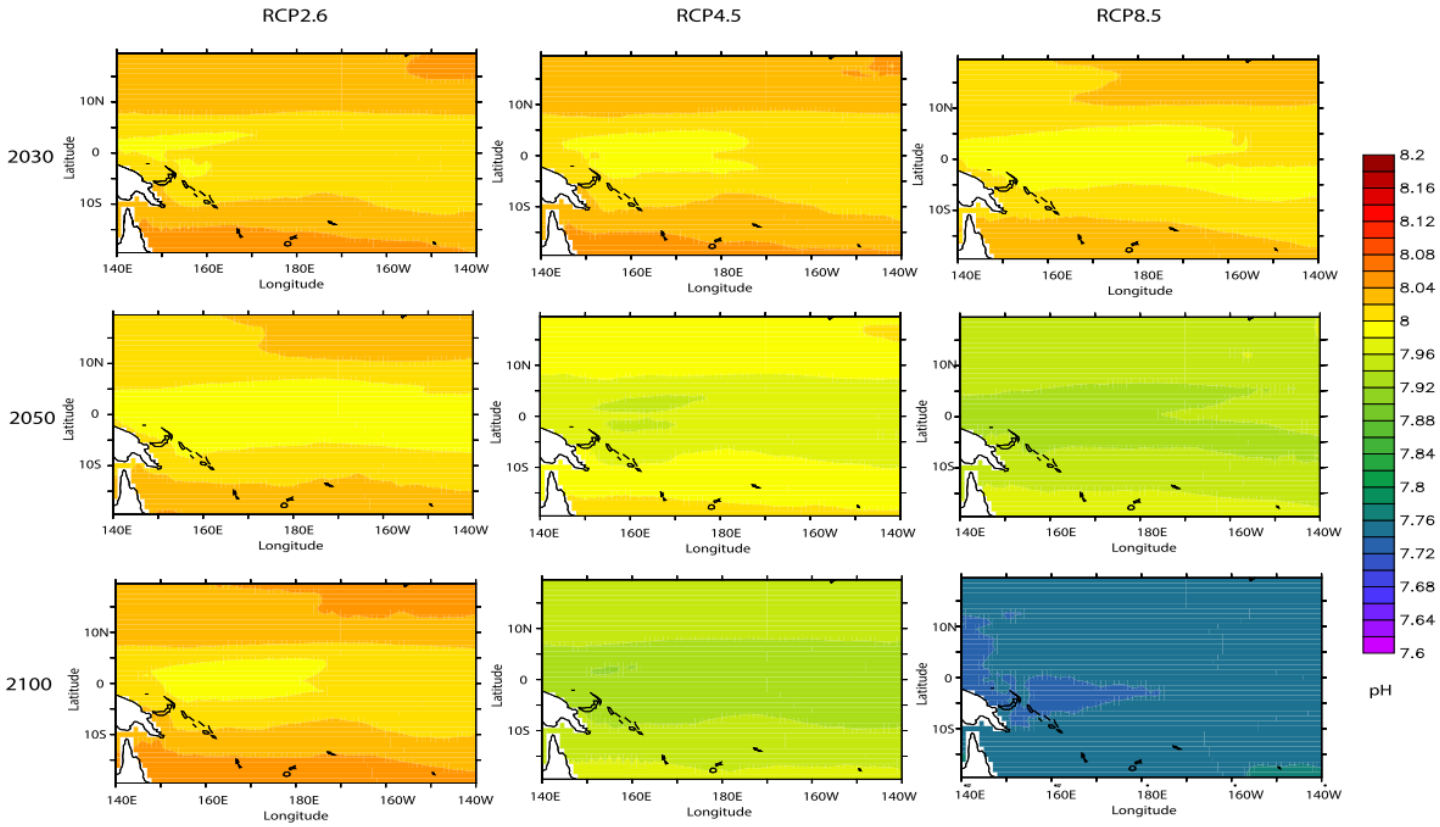

Fig 1. Lenton, Andrew & Matear, Richard & Mongin, Mathieu. (2018). Effects of Climate Change on Ocean Acidification Relevant to Pacific Islands.

You will need to either project this image or provide printed copies for the students to work form to enable them to identify the trends in pH changes over time. It is reproduced from Lenton et al. (2018).

Ask students to answer the following questions. An example marking scheme has been suggested under each:

1. What are the scientists using artificial intelligence to model?

   The pH of the oceans (1); over time (1); in different carbon dioxide emission scenarios (1).

2. Describe the trends of each emission model over time?

   Appropriate comparisons between each model at each time (max 2); Credit discreption of the rate of change for each model (max 3); Low emission: between 2030 - 2100 there is little change in pH/small decrease in pH credit use of numbers (1); Medium emission: between 2030 - 2050 there is a small decrease in pH/increase in acidity (1), but between 2050 - 2100 there is a greater decrease in pH; High emission: between 2030 - 2100 the rate of decrease in pH increase is greatest (1).

3. Explain the trends for each emission model?

   Low emission: low carbon dioxide emission would not increase the atmospheric concentration of carbon dioxide (1), therefore there would be no change in how much carbon dioxide dissolves (1) and no change in the pH of the oceans; Medium emission: more carbon dioxide produced would increase the atmospheric concentration of carbon dioxide proportionally (1) and lead to more carbon dioxide dissolving in the oceans (1) forming more carbonic acid (1) decreasing the pH; High emission: more carbon dioxide produced with increase atmospheric concentration of carbon dioxide exponentially (1) leading to a greater volume of carbon dioxide disolving in the oceans (1) leading to a greater concentration of carbonic acid (1) decreasing the pH the most (1).

4. What impacts of ocean acidification would there be on the distribution of organisms in this region?

   Coral reef ecosystems would be lost (1); all of the organisms that live in the reefs would no longer be present (1); credit suitable examples of flora and fauna.

5. What other variables may the scientists not have factored into their models that would affect the concentration of carbon dioxide within the oceans?

   Credit references to the rate of photosynthesis changing (1); credit references to human activities that increase carbon sequestration e.g. afforestation (1). This study did not consider the role of seagrass and mangroves.

6. Describe the human activities that would lead to a low carbon dioxide emission scenario and a high carbon dioxide emission scenario.

   Low carbon emission strategies: reduced use of fossil fuels (credit named examples) for electricity generation (1); reduced use of petrol cars/named transport (1); increased use of electric cars/named transport (1); increased use of nuclear/solar/wind/tidal/hydroelectric/wave/geothermal electricity generation (1); increased use of energy from biomass/bioethanol/alternative fuels (1); increased use of energy efficient appliances (1); increased use of insulating materials (1).

Questions 3 and 6 may be treated as level of response questions. If this is desired, please see the band descriptors.

Question 3 Level of response bands

Band	Descriptor
5-6	The rate of pH change of each emission model is explained. *Word equations or symbol equations are use to support the formation of carbonic acid.*
3-4	Each model is described but only two are explained. Detail may be missing. *There is an explanation* of how acids form.
1-2	The rate of pH change is generically explained. *There is some mention as to the cause of a decrease in pH.*
0	No creditworthy response

Question 6 level of response bands

Band	Descriptor
5-6	There are at least two named strategies that reduce the use of fossil fuels and two named strategies that use renewable/carbon-neutral fuels. *Scientific language is appropriate throughout the response.*
3-4	The is at least one named strategy that reduces the use of a fossil fuel and one correct suggestion of an alternative energy source. *Scientific language is generally appropriate to the context.*
1-2	There is either a named strategy of reducing the use of a fossil fuel or replacing it with an alternative energy source. *There is use of technical terminology in the response.*
0	No creditworthy response

Plenary

(Approximately 10 minutes)

The high emission model was "business as usual" in terms of carbon dioxide emissions, with the scientists stating a medium level of confidence based upon data from other studies and the number of models that their systems ran. It is worthwhile reviewing that the further into the future predictions are made the greater the uncertainty becomes due to the increasing impact of different and unforeseen variables.

Watch a third and final short clip from the same video You and AI - The Practical Applications of AI (start 58:14 mins, end 1:00:55 mins) to put the use of AI in context in managing risks and disasters that may result from climate change.

Stretch & challenge question: ask students what other complex problems AI could be asked to solve?

Reference

Lenton, A., Matear, R.J., Mongin, M. (2018) Impacts of Climate Change on Ocean Acidification Relevant to the Pacific Islands. Pacific Marine Climate Change Report Card: Science Review 2018, pp 31-42.