Royal Holloway Geography for Schools Lecture Series

Carbon Cycle Activities
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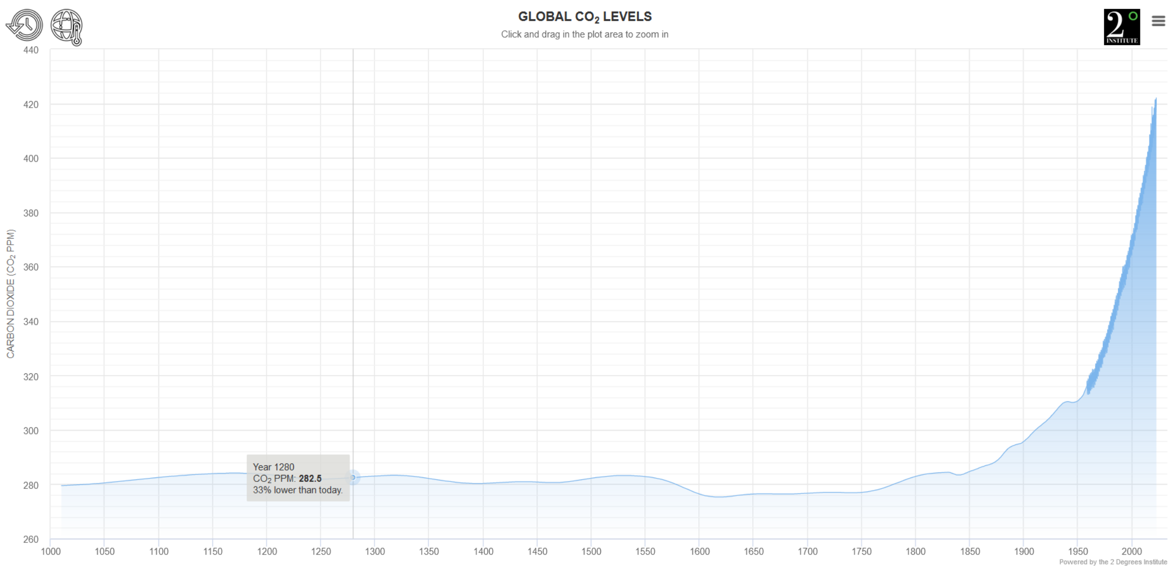
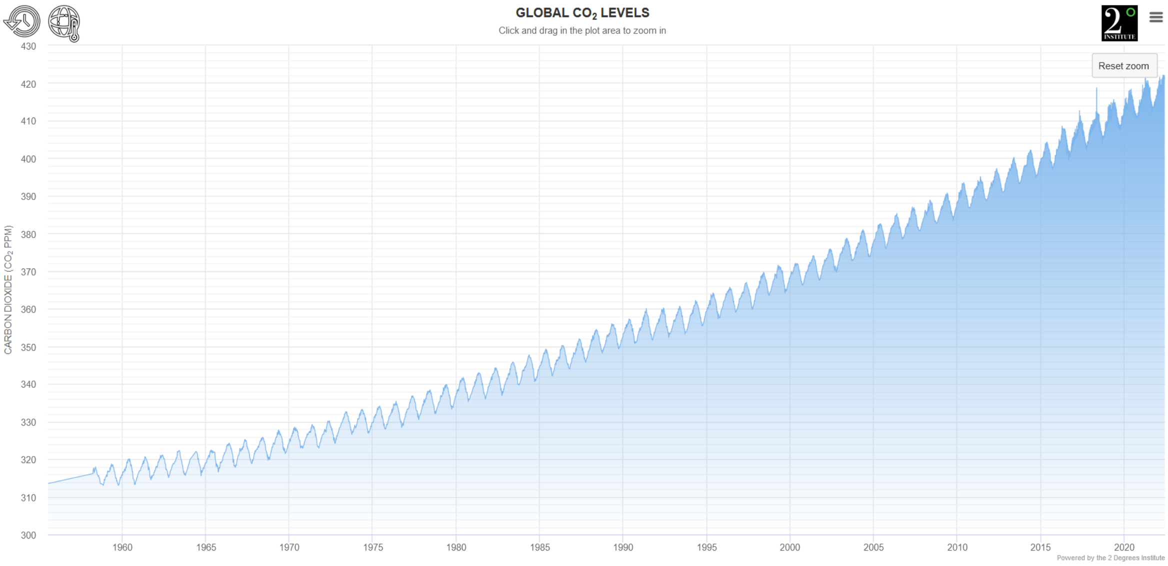
For this activity we are going to interrogate the Keeling curve and use a computer model to understand how future carbon values in the atmosphere might impact global temperatures.

The Keeling curve.

We are going to use the CO2 levels website to look at the Keeling curve. Navigate to https://www.co2levels.org/, and you will see the following screen.



This shows the last 1000 years of CO_2 data. However, we are just going to look at the period of instrumental data. This can be selected by clicking and dragging across the area of interest. It will provide a graph that looks like this.



Now we are going to use this information to look at the impacts of human activities on CO_2 concentrations. Use the cursor to address the following points:

1. What is the most recent level of CO_2 reported (date and value)?
2. What were atmospheric CO_2 levels when you were born (find the nearest measurement to your birth date)
3. How much has this value changed in measured amounts (ppm) and percentage terms (hover the cursor over the birth date and this can be recorded).
4. What were CO_2 levels when the first report by the Intergovernmental panel of climate change was published (1990)? (use the nearest date to the start of this year).
5. Find the CO_2 values for January 1990, January 2000, January 2010 and January 2020, then calculate the rate of CO_2 change between the decades. (This can be calculated using the difference between two dates and then dividing by 10 to get an annual rate for each decade).
6. Look at the year 2020. This period covered the initial COVID pandemic and saw widespread reductions in the level of transport and industry across the globe. How does this year compare with the one preceding and following? Can you observe a change in carbon transfer to the atmosphere?

Future CO_2 and climate

Once this is complete, we are going to observe the potential changes to the globe if we do not restrict the transfer of carbon to the atmosphere. To do this we are going to use a model visualisation hosted as a web app. We will use https://climatearchive.org/nextMillion.html produced by the University of Bristol. Click through to the app (works best on Google Chrome). Look at the temperature data prior to the present day and run the animation to see what happens to global temperatures if carbon transfers to the atmosphere are not restricted.

Look at the polar areas and CO_2 values in the future. What is the maximum values obtained for CO_2 and global temperature, and look at what this does the Greenland and Antarctic ice sheets.

Answer sheet

The Keeling curve.

1. What is the most recent level of CO_2 reported (date and value)?
   This will be continuously updated
2. What were atmospheric CO_2 levels when you were born (find the nearest measurement to your birth date)
   This is individual
3. How much has this value changed in measured amounts (ppm) and percentage terms (hover the cursor over the birth date and this can be recorded).
   This can be calculated by hovering the cursor over the date selected at point 2 and reading of the pop up box displayed
4. What were CO_2 levels when the first report by the Intergovernmental panel of climate change was published (1990)? (use the nearest date to the start of this year).
   This can be used a start point for a discussion over human awareness of climate change but relatively ineffectual efforts to change things.
5. Find the CO_2 values for January 1990, January 2000, January 2010 and January 2020, then calculate the rate of CO_2 change between the decades. (This can be calculated using the difference between two dates and then dividing by 10 to get an annual rate for each decade).
   This is a good way for looking at differences between decades which are less susceptible to noise than individual years. It shows that the rate of CO2 increase is not slowing down but accelerating.

year	CO2 ppm	difference	per year increase
1990	353.47		
2000	368.74	15.27	1.527
2010	388.41	19.67	1.967
2020	413.2	24.79	2.479

6. Look at the year 2020. This period covered the initial COVID pandemic and saw widespread reductions in the level of transport and industry across the globe. How does this year compare with the one preceding and following? Can you observe a change in carbon transfer to the atmosphere?
   While there are some periods of reduced CO2 values in early 2020 there is no clear impact of the pandemic on CO2 values. Stopping many hundreds of millions of people from travelling and closing down parts of industry had no real effect on carbon release. This could be the start of a discussion on decarbonisation and mitigation strategies.

Future CO_2 and climate

Under the 8.5 RCP scenario (no efforts to curb emissions) CO_2 levels reach 1182ppm after 1000 years and a global temperature rise of 8.9°C. This leads to a severe reduction in ice cover in Greenland, the loss of the West Antarctic ice sheet, and a reduction in the size of the East Antarctic ice sheet. These do not begin to recover for nearly 200,000 years. If CO2 emissions are curbed relatively rapidly after the initial spike.

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In terms of carbon cycle its worth thinking about the mechanisms which are drawing carbon from the atmospheric store and transferring it elsewhere into wetlands, ocean sediments and biomass, and eventually the geological record. If students understand it is quite quick to transfer carbon to the atmosphere but much more difficult to remove it that is a good outcome. Ideally getting students to realise that the best policy is likely to be not transferring the carbon to the atmosphere in the first place.

A last point could be to consider the knock on effects on other systems e.g. ocean acidification and the weakening of any marine creature using $CaCO_3$ to build their shell.