Health and Climate Change – the past, present and future

Reconstructing the Earth's past climate

How do we know what the Earth's climate was like in the past?

Over the past few decades, sophisticated instruments have gathered huge amounts of data about the Earth's climate. For earlier periods, data are sketchier, but some long time-series exist. For example, in 2011, the diaries of Algernon Belfield presented climate scientists with a wealth of new data on weather in New South Wales between 1877 and 1922. The Australian amateur meteorologist had recorded details of the weather at his home every single morning at 9am for 45 years.

Before the 1800s, however, things get trickier, as few reliable measurements were recorded. Instead, scientists may infer what was going on from other sources, such as incidental details in written historical records. One German study published in 2009 drew from a variety of historical documents to construct graphs of average temperature in Central Europe over the last 1,000 years.

Tree rings can also be used for learning about past climates; the size of a ring is an indication of a tree's growth for a particular year, which depends on climate. However, tree rings only indicate the temperature over a few months during the summer.

Perhaps the most widely used method for exploring Earth's past climate is analysis of ice cores – columns of ice extracted from Greenland and Antarctic ice sheets. The ice at particular depths can be dated precisely and analysed chemically to provide clues about the climate prevailing at that time. The deepest continuous ice cores go down more than 2.7 km, equivalent to around 800,000 years of Earth history. However, in 2019, European scientists announced plans to go even deeper, drilling down into 1.5 million years of climate history in Antarctica.

Remarkably, it is even possible to infer what the ancient climate was like from analysis of cave stalagmites. For older periods still, chemical analysis of rocks can provide clues about the climate millions of years ago.

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Evidence-based climate projections

How do we know what is going to happen next to the Earth – and to humans?

One crucial feature of science is that it makes evidence-based predictions.

This evidence comes from several sources. Data can be collected to characterise the current state of the planet, and recordings over time can reveal short-term trends. Controlled experiments can tell us how different factors interact with one another (how chemicals react, how organisms respond, etc.).

In addition, various techniques can be used to reveal what Earth was like in the past, and how and why it has changed. Then, principally through the use of computer models, we can simulate what may happen next. Models have been used to map out possible futures for the planet.

We can also learn from the past by looking for examples of the effects of climate on people. The French Revolution of 1789 followed several years of harsh weather and food shortages, possibly linked to the eruption of the Laki volcanic system in Iceland in 1784, suggesting that rapid climate change could significantly increase the risk of social unrest. In the same way, we may be able to predict how climate change could impact on our health.

How do climate scientists predict the future?

We can measure things now, and infer what the past was like, but how do we predict what will happen next?

Early humans may have noticed annual cycles, spotting that spring invariably follows winter. Until very recently in our history, this was pretty much the limit of our predictive abilities. Today, though, meteorologists are able to accurately predict the weather, at least in the short-term, and climate scientists make projections about the climate decades into the future. How do they do it?

In recent years, weather forecasting has moved from being reasonably dependable over 24 hours to being accurate over a five-day period, in part thanks to the application of chaos theory to forecasting. Weather forecasters now use the insight that small differences in the initial conditions of the atmosphere can lead to big differences a few days later.

To predict the weather, forecasters make use of mathematical models. Programmed into the models are key parameters describing different parts of the weather system and how they interact with one another. Starting conditions are entered – what the weather looks like now – and when the 'on' switch is flipped, the model runs until a predetermined point. The accuracy of a model depends on how well it describes the system.

The models can be rerun time and again with slight modifications. Meteorologists check and the weather throughout the day and update the starting parameters to produce the most up-to-date forecasts. Although weather forecasting has become more accurate over the years, uncertainty is inevitable because no system will ever be understood in perfect detail. Some simplification is always required to make the models.

In the same way, climate scientists must create models that describe the climate in enough detail to make projections about the climate decades into the future. This is a more complex and uncertain business. However, one way to test the accuracy of models is to test whether they can recreate known patterns from the past. Modellers can test whether the predictions of their model match what actually happened.

Making climate projections is also complex because it relies on making assumptions about the starting conditions. For example, we don't know what the level of greenhouse gases in our atmosphere will be 50 years from now – it depends what mitigation actions we take. This is why climate modellers often produce different scenarios based on different sets of assumptions. For example, for the IPCC's 2014 assessment, it used different Representative Concentration Pathways (RCPs) to make projections based on different assumptions about greenhouse gas concentrations. In RCP 4.5, emissions peak in 2040, whereas in RCP 8.5, they keep rising until the end of the century.

The upshot is that no-one can say with absolute certainty what the climate will be like in, say, 20 years' time. But we can plan for a range of different climate scenarios.

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Tick borne-disease and climate change

Modelling of tick ecology can pinpoint areas at risk of tick-borne diseases

Ticks spread a range of diseases, including Lyme disease and a viral infection of the brain, tick-borne encephalitis. Where they live depends on climate factors such as temperature and rainfall.

The life of a tick is complex. The adults feed on animals such as mice, deer and humans and mate before spending the winter in leaf litter or soil, where the female lays eggs in the spring. Larvae hatch from these eggs in the summer, then go in search their own blood meal before dropping off to moult (forming a 'nymph') and spend the winter in the soil as their parents did. Finally, after more feeding and moulting the following year, they become adults and find mates themselves, beginning the cycle again.

Temperature and humidity are just two of the many factors that affect this complicated existence, which involves multiple hosts and life stages. Modelling the impact of climate change on tick-borne disease is therefore a sizeable challenge. As a 2015 study noted, many researchers simplify the task by choosing a limited number of variables on which to base their models.

Factors that are not modelled may have important effects – changes in land use, for instance, which affects the numbers of tick-carrying animals, or in leisure activities that increase human exposure to ticks.

Without a satisfactory model, predicting the effects of climate change is very difficult. Studies often predict increases in tick-borne disease such as Lyme disease under climate change. Only continuous monitoring, however, is likely to give a clearer picture of trends.

Tick-borne encephalitis is seen only in part of the range of ticks, in parts of central and eastern Europe and Scandinavia. These areas support a particular style of tick life cycle, which is associated with a specific type of climate – hot summers, rapid cooling in autumn and reasonable rainfall.

Between 2012-2016, there were no cases of the disease in either the UK or France. Although some spread is possible, the UK government's Parliamentary Office of Science and Technology advises that it is unlikely and that if it does happen, climate change is less likely to be the cause than land use changes affecting wooded areas, which are home to tick hosts such as deer.

How can modelling be applied to human health?

The challenge is to understand how the key factors affecting health will be altered by climate change

One approach is to sift through historical data to look for correlations between a past change in climate and human health. So a change in rainfall might have been linked to an increase in the spread of cholera, or a rise in sun exposure to additional skin cancers.

A related approach is to look for climate variables that show correlations with the incidence of disease – typically infectious disease. A good example is the spread of dengue fever, caused by the world's most common mosquito-borne virus.

Transmission of dengue fever is dependent on temperature. The disease-carrying mosquitoes not only reproduce and hatch quicker at higher temperatures, they survive longer too. Increasing temperatures could also enable the insects to thrive in European countries that were previously too cold, leading to epidemics in parts of Italy, Greece and Spain. Although these have not occurred so far, there have been small outbreaks in France and Spain – the European Centre for Disease Prevention and Control reported nine cases in 2018.

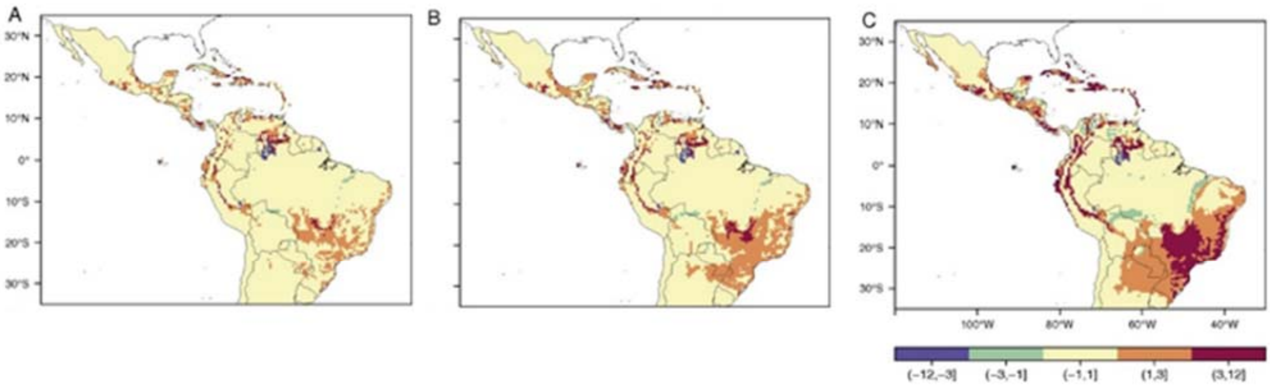

Figure: Changes in the length of the dengue transmission season by 2100 compared to 1961-1990 in Central and South American under (A) 1.5ºC of warming, (B) 2.0ºC of warming and (C) 3.7ºC of warming. Source: Colón-Gonzalez et al (2018).

Dengue fever is already a much bigger issue in Latin America and the Caribbean, where there are 54 million cases a year. A 2018 study used modelling to project the number of dengue fever cases in the coming century under three different climate scenarios – a “business-as-usual” scenario, resulting in 3.7ºC of warming by 2100 and mitigation scenarios where global temperature rises by 1.5ºC and 2.0ºC. The figure above shows how a greater temperature increase leads to an increase in possible transmissions – the hotter colours represent longer transmission seasons. The researchers projected the biggest increases in cases would occur between now and 2050. Under their 3.7ºC of warming scenario, there would be an extra 7.5 million cases per year, whilst limiting warming to 2ºC would still lead to an additional 6.7 million additional cases, and keeping it below 1ºC, a further 6.4 million.

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Dealing with uncertainty in climate change

How can we decide what to do when the future is unclear?

It is now widely accepted that climate change is happening and will affect human health. Action must be taken, but with limited resources and time to mitigate the worst impacts, difficult decisions have to be taken. Policymakers must determine the level of risk in order to make these decisions:

- How certain are we about what the impact will be and its severity?

- How soon will it occur?
- What are the options for preventing it?
- How effective are these approaches likely to be?
- What side-effects might they have?

Unfortunately, none of these questions is easy to answer and these actions are not without cost – reducing carbon emissions, for example, will impose an economic cost. The latest evidence from the IPCC suggests limiting global warming to 2ºC would mean reductions in global spending of between 1-4% in 2030 and 2-6% in 2050. However, one 2017 study suggested that the health gains associated with improved air pollution alone – as a result of reducing carbon emissions – would offset the cost.

Governments are taking action. The EU, for example, has a target for reduction in greenhouse gases of 40% by 2030. New policies on issues such as renewable energy and vehicle emissions are increasing. In 2015, under the Paris Agreement, 179 nations agreed to "undertake ambitious efforts to combat climate change and adapt to its effects". These efforts take the form of voluntary commitments that must strengthen over time. However, many nations are not on track to meet their targets.

The health benefits of taking action on climate change are often presented as 'co-benefits', which we would gain as an added bonus of reducing greenhouse gas emissions. Certainly, actions such as swapping cars for bikes and public transport could improve public health in the future. However, health impacts can also be viewed as an imperative for action, due to the excess deaths that will occur if climate change continues unabated.

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The psychology of taking action on climate change

Human psychology may also be an obstacle to quick action

Many studies have shown that we have limited willingness to make sacrifices now in order to gain bigger rewards in the future.

The phenomenon of pluralistic ignorance describes a situation where we make wrong assumptions about the opinions of other people. According to one 2016 study, in the case of climate change, we often assume that others do not feel the same way that we do, and so avoid discussing it. Similarly, assuming that others are not as concerned as we are may actually stop us from taking collective action.

We may recognise that something needs to be done about climate change but believe that there is little we can do. We may even stray into the territory of cognitive dissonance, where two competing ideas – 'Because of climate change I should change my lifestyle' and 'I want to protect my quality of life' – come into conflict.

To resolve this tension, we may reject one of these ideas – perhaps that climate change is a major threat. This in turn may lead to confirmation bias – taking note only of evidence that supports a pre-existing belief – or denial. People may end up making further bad choices for the sake of consistency, rather than learning from mistakes.

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