University of Reading and Met Office

This document provides stimulus ideas and suggestions for further research for EPQs based on themes relating to climate change. These could take the form of dissertations based on secondary literature, investigation / field study in which a learner accesses sources of primary data and carries out their own data analysis in relation to a chosen research question or hypothesis, an artefact in which a learner works on the creation of a product (e.g. a piece of software) that meets a specific need related to climate change, or a performance, where a learner creates performance work that relates the challenge of responding to climate change to a specific audience.

Climate change is affecting the lives of individuals and communities right now, right around the world. For this reason, many people are interested in finding out more about our changing climate but knowing where to go for authoritative information can feel daunting, so we wanted to help.

If you're considering doing an Extended Project Qualification (EPQ) related to climate change, you might find some of the information and links provided below useful in helping you decide on your title and plan your project.

Which ones are most useful for you might depend on what your EPQ outcome is – be it a dissertation, investigation / field study, performance of artefact. For example, if you're someone who wants to develop experience in coding and data analysis as part of your EPQ and are planning to undertake an investigation / field study, then getting to grips with climate data and investigating how climate change is going to impact something that's important to you might be an option. Alternatively, if you are someone who wants to develop a performance for your outcome, then the information below might help you form your creative brief that you then explore.

Making predictions about how a changing climate will affect your community

Climate change caused by humans is unequivocal. While it is important to do everything we can to change behaviours to limit the eventual rise of global temperatures, we all need to prepare for

a future with a different climate. Even with rapid action to limit greenhouse gas emissions, temperature would continue to rise because many parts of the Earth system like the ocean and ice (or cryosphere) are slow to respond to the changing climate. The greenhouse gas pollution already emitted by humans will be around in the atmosphere for a long-time without a costly programme to remove it. This means that all societies will need to develop ways to adapt to a different, warmer climate.

How do we make predictions about what climate will look like in the future?

The main tool that climate scientists use to make predictions about the future are climate models. Climate models use powerful computers to simulate the physical and mathematical equations which tell us how air, water, ice and other parts of the Earth system change and interact. At the Met Office, the same basic model is used to produce both the weather forecasts that you use every day and climate predictions.

To make a prediction about the future with a climate model you need two key ingredients, the model itself and a prediction about how future societies will choose to develop, how large their emissions of greenhouse gases and other pollutants will be and what other changes they will make to the Earth system (for example by changing how land is used). Producing these future scenarios is a complex task that requires a different set of models designed to capture the complexity of links between human society, economies and the environment. Typically, a set of climate predictions might involve asking your climate model to simulate the recent climate past (to test which parts of the climate system it simulates well and which parts it doesn't) and then making several predictions about the future with different emissions scenarios.

Building a climate model involves making lots of different choices. Since the amount of computer time available to anyone making climate predictions is limited, the choices are about how best to make use of the computer time available to the group of scientists making the predictions. Each different climate modelling team will have made different choices about how complicated to make their climate model, how many times they choose to repeat their experiments and in how much detail they want to simulate the globe. This final choice, the resolution of the climate model, is like the difference between the resolution of your TV or smartphone. A higher resolution, simulating the climate with smaller grid squares (pixels) can lead to more detailed information for society but comes at a significant cost in computer time.

Why are these predictions uncertain?

When making a climate prediction, unlike making a weather forecast, climate scientists are not seeking to say exactly what the weather will be like on a particular day in the future. Instead, climate predictions give us a picture of what day to day weather will be like for, say, a thirty-year period from 2050 to 2080. This is useful because it gives you and other climate scientists many ways to analyse climate predictions. You can focus on the mean or average climate over the same period or you can choose to calculate, for example, how many times the temperature exceeds an important threshold. By repeating experiments with the same climate model, a climate model ensemble, climate scientists can explore how natural year to year variability in the climate system affects climate predictions for a particular parameter, location and time. Most climate predictions you might use contain at least a few repeated experiments that will allow you to estimate this effect. Sometimes, even larger ensembles are used to explore natural climate variability in more detail.

Another source of uncertainty is between different climate models. All climate models are approximations of the real, complex Earth system. To understand the differences between models there have been a series of international experiments that ask climate modelling teams to run the same experiment in their models (the Coupled Model Intercomparison Project, or CMIP). A key part of these experiments has been the open and free sharing of data with each other and with the wider world. Anyone can access CMIP data over the internet. This has proved to be extremely useful, both by allowing modelling teams to see how well their models performed against others and for climate scientists trying to assess how their predictions about the future might depend on the model used. As you make your own climate predictions, you should bear in mind the need to use multiple different climate models to take this key uncertainty into account.

The final major uncertainty in climate prediction is related to the future scenario for greenhouse gas emissions and other human induced changes. In most climate modelling experiments this is represented by running a series of experiments with different future scenarios. It is important to remember though that each of these scenarios represents one set of choices that governments and individuals make. As you make your own climate predictions, bear in mind that it is very unlikely that the world will follow any of these particular scenarios precisely and that the scenarios themselves are not equally likely.

How can I access predictions about the future of the UK?

For predictions about climate in the UK, the best place to start is with the UK Climate Projections (UKCP18) produced by the Met Office. These predictions use a combination of different climate

models and modelling approaches to produce climate predictions specifically tailored to the UK. The predictions are designed to be used with the set of observations of climate held by the Met Office and collected together in an easy to access gridded format, HadUK-Grid. You can get access to HadUK-Grid data here.

One extremely simple way to access predictions for different parts of the UK is through the UK Climate Risk Indicators website. This interactive website is built from the UKCP18 projections and allows you to produce plots and download data for different regions of the UK, different prediction scenarios and many different indicators of climate-related risk.

If you would like to go deeper the UK Climate Projections User Interface which allows you to download data and produce plots from all of the models and scenarios within UKCP18.

For those looking to develop their coding and analysis skills even further, a large amount of further data from UKCP18 is available via the Centre for Environmental Data Analysis.

To analyse data from all of these different sources we recommend using the open-source python programming language. This is the standard programming language for data analysis used in climate science. If you haven't used python before, there are lots of helpful tutorials available on the internet. The Institute of Mathematics & its Applications runs online workshops for A-Level mathematics students for a small fee which should give you the basics you need.

If you are an experienced python programmer but haven't worked with climate data before, a great starting point is to us the packages which are part of the pangeo ecosystem which are designed to make climate data analysis as simple as possible. In particular, the xarray and iris packages make loading and analysing files in the climate-standard netCDF format as simple as a few lines of code.

What other information is there?

Lots of work on different climate risks to the UK is already available from various research organisations and programmes. It's a good idea to start by thinking about the work you can draw on which has already been completed. The State of the UK Climate annual reports give a great introduction to how our climate has already changed. The UK Climate Resilience Programme has a large number of reports discussing climate risks across many different sectors of society.

Furthermore, every five years the UK Government is required, under the 2008 Climate Change Act, to publish a Climate Change Risk Assessment (CCRA). The most recent one was published in 2021, and you can read all about it and access the different resources on the CCRA websitehttps://www.ukclimaterisk.org/. There is also a useful factsheet which summarises the findings of the third CCRA for young people.https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Young-Persons-Factsheet.pdf

What can I do with the data and information above?

There are a wide variety of questions and ideas you can start with to think about an EPQ project that makes use of the freely available climate data and information in this guide. A good starting point is to think about something in your life or your local community that you care about and then to think about how it depends on weather and climate.

For example, you might be a keen cricket player. How might periods of high temperatures affect how you play cricket in the future? Will it mean that there are times in which games are cancelled or the pitches you use are too dry for play?

Or if you're someone who is keen to help others understand climate change and its impacts, perhaps you could create a brief for a performance that inspires your local community to take action to reduce the negative impacts of climate change based on authoritative information and data.

Once you have identified a problem that you want to investigate, you need to then think about which climate variables affect your problem and by how much, or which climate information or data might be most powerful to communicate to others to inspire change. Is this as simple as looking at temperature or precipitation or do you need to consider more complex combinations of variables? Are there critical physical thresholds which affect your problem? For example, your school may need to shut down for the day if the inside temperature exceeds forty degrees centigrade. In this part of your analysis, you will need to do some further research about how the climate impacts your chosen activity. You may even need to do some experiments of your own, measuring the impact of local weather and climate on your problem or analysing data from your school, local council or community group.

Once this phase of your work is complete, you should have a good idea about the climate information you need to understand your problem. The next step is looking at the climate data and information available to you (see the previous section) to understand how best to quantify

how much the key climate variables for your problem will change in the future. There is good high-level information about how to make best use of climate projections and where you should be careful on the Met Office website. To get some advice from a real-life climate scientist, ask your teacher to contact a Climate Ambassador who can work with your school to provide help, ideas and advice.