JCT Maths Team

Mathematical Modelling for the Real World

STE(A)M 2019

Activity 1 – Funding Distribution

Glennbay is a coastal town in the west of Ireland.

The Glennbay town council has made a fund of €3,500 available for applicants to use to help tackle the issue of plastic waste on their coastline.

Four applications are made.

Applicant A: Claims €500

Applicant B: Claims €1000

Applicant C: Claims €2500

Applicant D: Claims €3000

Task: Devise a fair system for the fund administrator to distribute the total amount of the fund to the applicants

Mathematical Modelling

Modelling is a process that uses mathematics to represent, analyse, make predictions or otherwise provide insight into real world phenomena.

The following extract is from an EEA Article 'Signals 2018 – Water is Life'

Climate change and water — Warmer oceans, flooding and droughts

Climate change is increasing the pressure on water bodies. From floods and droughts to ocean acidification and rising sea levels, the impacts of climate change on water are expected to intensify in the years ahead. These changes are prompting action across Europe. Cities and regions are already adapting, using more sustainable, nature-based solutions to lessen the impact of floods and using water in smarter, more sustainable ways to enable us to live with droughts.

Europe is affected by climate change and the impacts are not only felt on land. Europe's water bodies — lakes, rivers and the oceans and seas around the continent — are also affected. As there is more water than land covering the Earth's surface, it is no surprise that the warming of the oceans has accounted for around 93 % of the warming of the planet since the 1950s. This warming is happening as a result of increasing emissions of greenhouse gases, most importantly carbon dioxide, which in turn has increasingly trapped more solar energy within the atmosphere. Most of this trapped heat is eventually stored in the oceans, affecting water temperature and circulation. Increasing temperatures are also melting polar ice caps. As the total area of the global ice and snow cover shrinks, it reflects less solar energy back into space, further warming the planet. This in turn results in more freshwater entering the oceans, changing the currents further.

The sea surface temperatures off Europe's coastlines are rising faster than those in global oceans. Water temperatures are one of the strongest regulators of marine life and increases in temperature are already causing big changes under water, including significant shifts in the distribution of marine species, according to the EEA report Climate change, impacts and vulnerability in Europe 2016. For instance, cod, mackerel and herring in the North Sea are migrating from their historical zones northwards to cooler waters following their food source — copepods. These changes, including the migration of commercial fish stocks, can clearly impact the economic sectors and communities dependent on fishing. Rising water temperatures can also increase the risk of water-borne diseases, for example vibriosis infections in the Baltic Sea region.

From salinity levels to acidification, more change on the way

Climate change is also affecting other aspects of seawater. Recent news reports of dramatic widespread coral reef bleaching, mainly due to warmer temperatures in the Pacific and Indian Oceans, have drawn attention to the effects that 'ocean heatwaves' have on local marine ecosystems. Even a small change in any key aspect, such as water temperature and salinity or oxygen levels, can have negative effects on these sensitive ecosystems.

For example, marine life in the Baltic Sea — a semi-enclosed sea — is closely linked to local salinity and oxygen levels. More than 1 000 marine species live in the Kattegatt, with relatively high salinity and oxygen levels, but this declines to only 50 species in the northern parts of the Gulf of Bothnia and in the Gulf of Finland, where freshwater species begin to dominate. Many climate projections suggest that higher precipitation in the Baltic Sea region could lead to a decrease in the salinity of the water in parts of the Baltic Sea, affecting where different species can live.

A rise in water temperatures due to climate change in the Baltic Sea is also contributing to a further expansion in oxygen-depleted 'dead zones', which are uninhabitable for marine life. The Mediterranean Sea is expected to see an increase in temperature and also in salinity, triggered by higher evaporation and lower rainfall.

Oceans — the largest carbon sink on our planet — are estimated to have absorbed around 40 % of all the carbon dioxide emitted by humans since the Industrial Revolution. A study published in Nature found that changes in ocean circulation patterns is affecting how much carbon dioxide oceans take up. Any reduction in the oceans' capacity to capture carbon dioxide from the atmosphere is likely to increase its overall concentration in the atmosphere and therefore contribute further to climate change.

Acidification — whereby more carbon dioxide is absorbed into the ocean and carbonic acid is produced — is also a growing threat. Mussels, corals and oysters, which build shells from calcium carbonate, have a more difficult time constructing their shells or skeletal materials as the pH of seawater decreases, making them more fragile and vulnerable. Acidification can also affect photosynthesis in aquatic plants.

Europe is not immune. The waters surrounding Europe are expected to experience further acidification over the coming years. Observed reductions in water pH levels are nearly identical across oceans worldwide and across European seas. The pH reductions in the northernmost European seas, the Norwegian Sea and the Greenland Sea are actually larger than the global average.

Hollywood script to become reality?

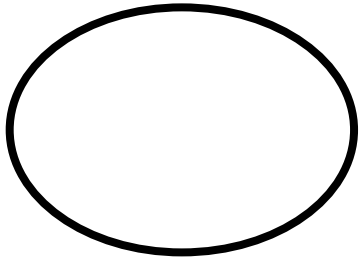
Unusual and extreme weather is often big news and a box office draw. So the combination of water and climate change provides the perfect mix for film-makers. The science fiction film The Day After Tomorrowfrom 2004, which saw northern Europe and North America enter a new ice age as a result of the shutdown of the Atlantic Ocean's Gulf Stream highlighted the dangers of climate change to cinema audiences. New research suggests that while such cataclysmic extremes are unlikely, climate change is actually impacting the Gulf Stream and other currents that are part of a complex circulation system in the Atlantic Ocean, formally known as the Atlantic meridional overturning circulation (or AMOC). Other new studies show that the Atlantic circulation is at its weakest in at least 1 600 years and suggest a weakening or slowing down of the current.

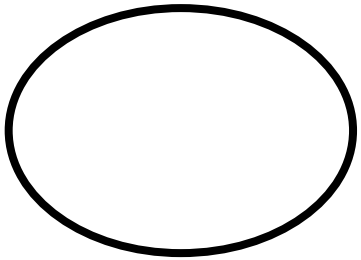
The Atlantic circulation works like a conveyer belt, moving warm water from the Gulf of Mexico and Florida coast to the North Atlantic and Europe. In the north, the warm water current is cooled, becomes denser and sinks to lower depths, bringing cooler water as it returns to the south. The current acts like a thermostat, bringing heat to western Europe.

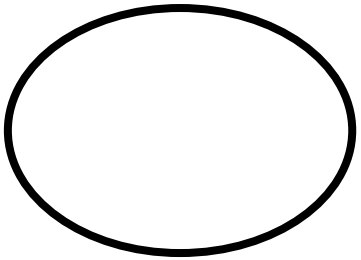
The observed weakening of the Atlantic circulation has led to the cooling of sea surface temperatures in parts of the northern Atlantic, according to the studies. This is probably due to the increased melting of freshwater ice from the Arctic and Greenland and the impact the melted freshwater is having on parts of what is known as the North Atlantic sub-polar gyre — a key component of the Atlantic circulation. Ocean currents are impacted by the way water streams flow through different depths, where they sink, how fast and how deep they sink before moving to upper layers, and so on.

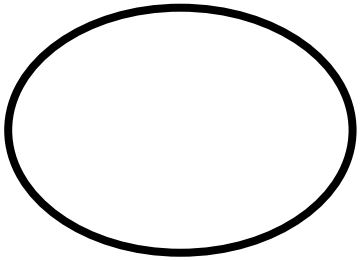
What variables have I identified?

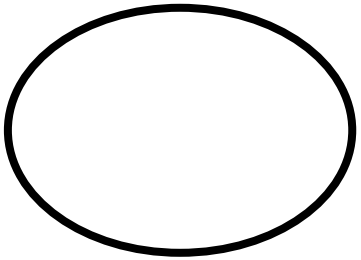
Identifying Relationships between variables

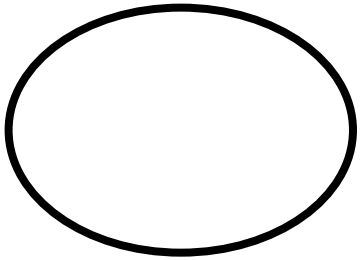


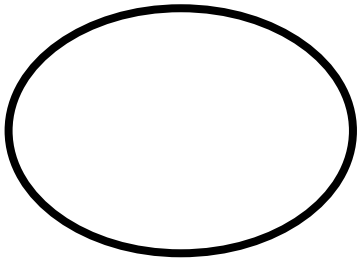












Modelling using Software

You can use the following link or QR code to access the Geogebra file we have prepared for this workshop.

https://bit.ly/2sf3SBJ

JCT Maths Team

For any queries, please contact us on one of the following:

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