Scotland's Climate

These workshop notes are designed for use along with the accompanying slides which contain explanatory images etc

Year Group: S3-S6

Length: ~50 minutes [10 minutes introduction, 40 minutes activities]

Set-up Time: 30 minutes

Room requirements: A classroom space with desks for up to 30 students.

Summary: Climate is a fundamental part of the Earth's system and impacts everyone on the planet – from making (or breaking!) the perfect holiday to threatening entire species. Through a series of practical experiments and demonstrations, students will be introduced to the physical aspects of Earth's climate system and how Scotland's climate has changed over geological time. The rock record will then be investigated to yield clues about Scotland's past and why it has changed.

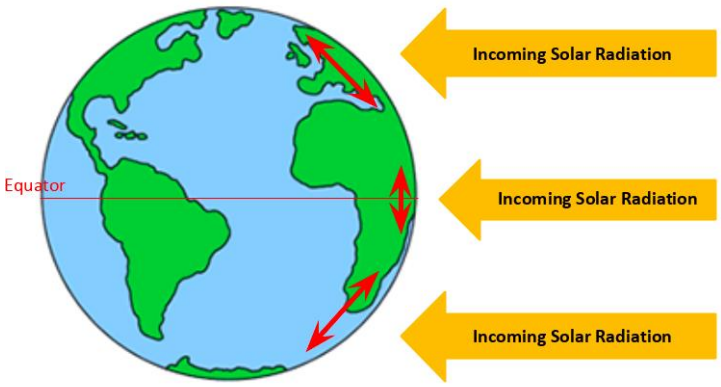
Equipment:

- Large shallow dish (with tepid water)
- Bottle of hot water + red colouring
- Gloves to handle bottle of hot water
- Bottle of ice-cold water + blue colour
- Rock samples:
  - red sandstone
  - limestone (ideally with coral or ammonite fossils)
  - plant fossil (and/or coal)
  - shale/fish fossil
- Large bottle (e.g. 2l drinks bottle)
- Oil
- Jug of water + red food colouring
- Effervescent tablets (e.g. vitamin C)

Content:

Earth's climate is controlled by a number of different factors – some are large scale and some are more local but they all have an influence on the climate we experience.

<u>Solar output + Earth-Sun geometry:</u> the amount of heat and light energy received from the sun varies at different latitudes due to the curvature of the earth (this can be quickly demonstrated using a globe and a torch, the beam spreads out more at higher latitudes).



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Reflectivity: Light coloured areas (e.g. ice cover) reflect more of the energy from the sun back to space, whereas dark areas absorb it and cause the planet to warm up. This is known as the albedo effect. As the planet warms, more ice is melting, reducing the light-coloured areas – meaning less energy is reflected and more is absorbed which further contributes to the warming effect.

Atmospheric chemistry: Once energy is reflected back from the Earth's surface, some of it is trapped in the atmosphere and re-emitted back to the Earth. The concentrations of different gases in the atmosphere (particularly CO_2 and H_2O) influence how much is trapped. Volcanic emissions can have an effect on the gases in the atmosphere, as well as containing small particles which can influence the formation of clouds.

Why is Scotland's climate so different from Canada even though we are on similar latitudes?

DEMO: Ocean Circulation

Place the large shallow dish (roughly 3/4 full of lukewarm water) on a table at the front of the room so that pupils can gather round (the demonstration is best viewed with the dish at eye level so pupils may wish to crouch down. Gently pour cold, blue-coloured, water in one end of the dish at the same time as pouring hot, red-coloured water in at the other end (useful to have a volunteer to help by pouring the cold water)

Observe the cold blue water begin to sink towards the bottom of the glass dish, while the warm red water will (hopefully!) spread out in a layer across the top. Eventually, the red water will cool down and start to sink at the other side of the dish.

This interaction between two bodies of water at different temperatures demonstrates the effects of the Gulf Stream, which is responsible for Scotland's temperate climate. For an interesting summary on the Gulf Stream and what changing ocean currents could mean for future climates, check out the BBC article https://www.bbc.co.uk/news/science-environment-44875508 (available as a pdf from the GeoBus website).

How has Scotland's climate changed over time?

Scotland's climate has changed, sometimes dramatically, over geological time but how do we investigate this? Geologists use sedimentary rocks to understand past environments.

Sedimentary rocks are formed from pre-existing rocks or pieces of once-living organisms. They form from deposits that accumulate on the Earth's surface. The sediments are buried deep and water is squeezed out to create a cement which combines the sediments. The size, shape and colour of these pieces are what give clues to our past environments.

ACTIVTY: Describing Sedimentary Rocks

Colour of rocks – oxidisation of iron in sandstone gives red colour and may represent hot dry environments, dark/black can be from organic material or represent anoxic conditions.

Grain size – represents the energy of the environment the sediment was deposited in. Big grains require lots of energy for transport, for example a large river system or glacier. Small grains indicate little energy, for instance a lake, deep ocean or swamp environment.

Grain Shape – the more rounded the grains are the further they have travelled. In particular if you have grains which are almost perfectly spherical this is indicative of wind-blown sediment.

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Pupils should spend some time examining the rock samples, writing down their observations. Walk around each group helping them with observations. After they have had a chance to do this, gather their attention and go through which rock type matches each environment in the booklet:

Warm swamp – plant fossil/coal. Much of Scotland's coal was formed around 330 million years ago by Lepidodendron plants, which required lots of water and heat but grew fast in conditions similar to an equatorial rain forest.

Drought – red sandstone with very well rounded grains are similar to grains of sand we find in today's deserts.

Lake – fish fossil within a fine grained mudstone/shale – fresh water fish and low energy environment, therefore lake deposit.

Warm Ocean – fossilised coral and/or limestone (made of lots of dead shelly animals). The best-know example of a modern coral reef is the Great Barrier reef in Australia – indicative of warm waters.

[British Geological Survey map - http://mapapps.bgs.ac.uk/geologyofbritain/home.html - has details of bedrock, geological period and the past environment of the area you select.]

What has caused the dramatic changes in climate that were deduced from the rocks?

DEMO: Plate Tectonics

Fill the large bottle 1/3 full with red-coloured water and carefully pour in a layer of oil on top (roughly the same thickness). The best way to get an un-mixed layer is to tilt the bottle and slowly pour the oil down the inside of the bottle. The water represents the core of the Earth and the oil is the mantle (not to scale!). The air left at the top of the bottle is the atmosphere.

Drop an effervescent tablet into the bottle.

Bubbles will start to rise through the oil to the surface, release CO_2 and fall back down. As the demonstration continues, foam should begin to form on the surface of the oil – this can be described as the crust. The foam will start to move around, representing the movement of the continents over time as a result of the movement in the mantle below. This model is similar to the mechanisms inside the planet – movement in the mantle is controlled by density but in the mantle, the change in density is produced by heat (from the core) rather than gas.

The slides contain an animation of this process occurring in the mantle – it is useful to have this playing in the background and point out what is happening. The slides also contain a model of the movement of the continents across the surface of the globe from the supercontinent Pangaea (175 million years ago) to the present day and forwards to the predicted supercontinent named Amasia (75 million years in the future) – tracking the movement of Scotland through different climate conditions.

The changes in Scotland's climate over time are mainly due to its location on the planet – tropical rainforests require a location near the equator, deserts are predominantly found in areas remote from the sea (where most of the moisture has already precipitated from the prevailing winds).

Climate Change today – these variations in Scotland's climate are natural and have occurred over time as a result of geological processes, this is in contrast to the rapid changes that are occurring as a result of changes to the global climate system as a result of human-controlled addition of CO_2 to the atmosphere, causing a warming effect (for more, see the 'Climate Change' workshop).