Water, carbon and climate change

In this section you will learn about:

- the relationship between the water cycle and the carbon cycle in the atmosphere
- how this relationship links to climate change

The role of water and carbon in supporting life

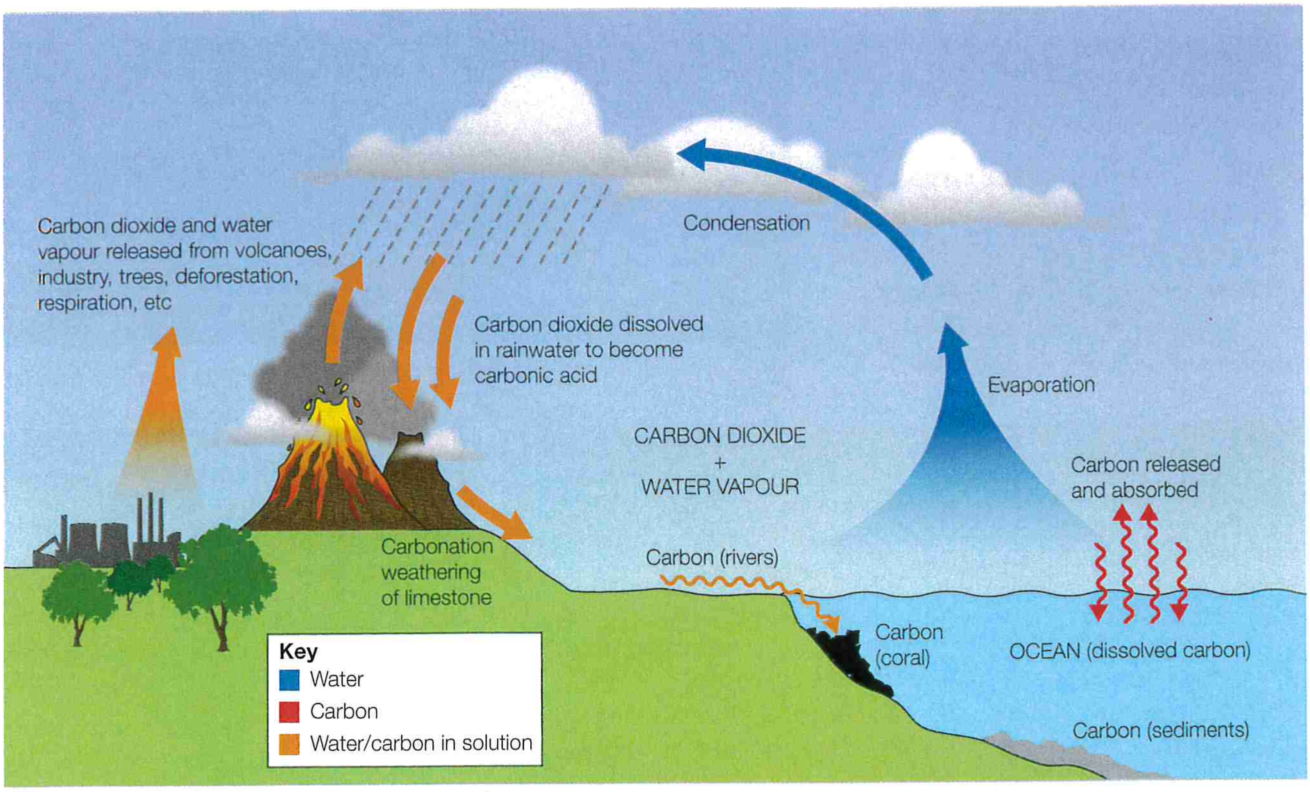
Both water and carbon are critical in supporting life on Earth. Carbon is one of six crucially important elements in humans. Stored in the form of glucose, carbon assists cellular respiration; it makes up 18 per cent of the human body.

In trees, the carbon content of leaves and woody matter (stem, branches and roots) is approximately 50 per cent of their biomass. Through food chains, the carbon stored in plants is passed on to animals, where it provides much needed energy for, among other things, breathing, growing and reproducing. Through respiration and decomposition, carbon is returned to the atmosphere in the form of carbon dioxide.

The atmosphere is an important store of both water and carbon. All living organisms need water to survive, albeit in differing amounts – it is needed for drinking and irrigation. It is also a source of power and energy. Carbon in the atmosphere is essential in photosynthesis to create the carbohydrates needed for plant growth. It is also one of the important greenhouse gases that absorb long-wave radiation emitted from the Earth, providing sufficient atmospheric warmth for life to survive.

The storage and cycling of both water and carbon enable life to flourish on land and in water. Changes in the magnitude of the stores (such as the amount of carbon stored as biomass) can have massive local and global implications for flora and fauna.

What is the relationship between the water cycle and the carbon cycle?



An important link between the water cycle and the carbon cycle is the ability of water to absorb and transfer carbon dioxide. Figure **1** shows the many links and connections between carbon and water, particularly in the way that carbon dioxide is soluble in water.

Figure 1 *The relationship between the water cycle and the carbon cycle in the atmosphere*

The water and carbon cycles do not act completely independently within the atmosphere. One of the key connections involves the absorption of carbon in rainwater, which facilitates key processes and affects the magnitude of both stores and transfers.

The acidity of a solution is measured by its pH value. Pure water has a pH of 7.0 (neutral). However, natural unpolluted rainwater is mildly acidic, with a pH of about 5.6. This acidity comes from the natural presence of three substances, carbon dioxide, nitric acid and sulphur dioxide, found in the troposphere (lowest level of the atmosphere). Carbon dioxide is present in the greatest concentration and is therefore the primary source of acidity in unpolluted rainwater. If air is polluted, say with high concentrations of sulphur dioxide from the combustion of fossil fuels, rainwater can become very acidic with a pH of 4 or even lower. In 1982, the pH of a fog on the west coast of the United States was measured at 1.8!

Acidic rainwater affects weathering. On contact with carbonate rocks, such as limestone and chalk, the acidic rainwater (a mild carbonic acid) converts calcium carbonate into calcium bicarbonate, which is soluble. This process is called *carbonation*. The dissolved carbon is then carried away by rivers to the oceans where it is used for shell growth and ultimately buried to form new limestone deposits. Some carbon is transferred directly back to the atmosphere.

Feedback links to climate change

A **feedback** is a return or 'knock-on' effect that usually leads to a change in the effectiveness of one or more processes. We have seen that positive feedback enhances the outcome driving a system in one direction and leads to instability, whereas a **negative feedback** works against the outcome, leading to stability and a state of equilibrium. It is possible to identify a number of ways in which water and carbon feedbacks are linked to climate change.

Water cycle feedback loop

Ice reflects radiation from the Sun so less heat is absorbed by the surface. The extent of the Arctic ice has been shrinking alarmingly in recent years exposing more water (Figure **2** and 4.13), with subsequently less reflection and more absorption of heat from the Sun. This warms the water and further melts and reduces the ice coverage. This affects the type and magnitude of water transfers between land, ocean and atmosphere. The local and regional impacts of these changes could have profound effects on life on Earth by affecting patterns of precipitation and the availability of freshwater. Political and economic implications are also considerable – for example, no Arctic sea ice will affect trading routes, the exploitation of resources and the development of settlements.

Figure 2 *Melting Arctic sea ice, Greenland*