Scheme of work: Water and carbon

Introduction

This scheme of work (SOW) offers a route through the AS and A-level Geography (7036 and 7037) specifications with a core focus on Physical Geography, core topic Water and carbon cycles.

It covers the specification in a logical order and suggests possible teaching and learning activities for each section of the specification.

The specification content is shown at the start of each section, some suggested activities will target multiple specification points. The learning outcomes indicate what most students should be able to achieve after the work is completed.

Timings have been suggested but are approximate. Teachers should select activities appropriate to their students and the curriculum time available.

The order is by no means prescriptive and there are many alternative ways in which the content could be organised.

The resources indicate those resources commonly available to schools, and other references that may be helpful. Resources are only given in brief and risk assessments should be carried out.

Resources exemplify case studies in this scheme of work, but that it not an endorsement of these case studies and schools are free to choose case studies that are relevant for their students.

Version 2.0
September 2024

Contents

You can use the title links to jump directly to the different sections of this scheme of work. (Use Ctrl and click to follow the link.)

3.1 Physical geography

Core topic: 3.1.1 Water and carbon cycles

Systems in physical geography

Specification content

3.1.1.1 Water and carbon as natural systems

Systems in physical geography: systems concepts and their application to the water and carbon cycles inputs – outputs, energy, stores/components, flows/transfers, positive/negative feedback, dynamic equilibrium.

Learning outcomes

This lesson will help students to understand:

- The concept and use of 'models' by geographers as simplifications of a complex world.
- The concept of 'systems frameworks' as a type of model fundamental to most areas of geographical understanding.
- Classification of systems and common characteristics of systems.
- How the four major subsystems of the Earth are interlinked.

Suggested timing

1 hour

Possible teaching and learning activities

- Introduce the concept of systems using the Geography Education Online slides.
- Small group discussions followed by feedback - what models used in geography do students know?
- Students to draw and annotate a model system to show the key elements of a system. Examples could be used from beyond Geography.
- Students to draw and annotate a diagram of an example of a positive feedback system and a negative feedback system.
- Repeat group discussion to see if students can now think of any more examples of systems in geography.
- Sorting activities; terminology and definitions of open & closed systems, inputs, flows/transfers, stores, outputs etc.
- Identify the four spheres that make up Earth systems, and that will be fundamental to the study of Physical (and Human) Geography.
- Notes on the spheres - understand what they constitute. Students could then make links between them from what they know already. This could be as a poster or mind map (this could be a piece of work they repeat at the end of the topic, or add to as they go along, which could aid integrating water and carbon cycles).

Resources

The following websites identify the key characteristics of the major spheres:

- The hydrosphere (National Geographic)
- The lithosphere (National Geographic)
- The atmosphere (National Geographic)
- The biosphere (National Geographic)
- The cryosphere (NOAA)

Major stores of water

Specification content

3.1.1.2 The water cycle

Global distribution and size of major stores of water – lithosphere, hydrosphere, cryosphere and atmosphere.

Learning outcomes

This lesson will help students to understand:

- That the Earth's water is distributed between: oceanic water, cryospheric water, terrestrial water and atmospheric water.
- Where water is stored globally, the volume of water in each of these stores, and how long water might remain in each of these stores.
- Students will be able to describe and explain the characteristics of each of these stores.
- The limited amount of freshwater economically and physically accessible for human use.

Suggested timing

1.5 hours

Possible teaching and learning activities

- Students could recap the basic water cycle (likely to be prior knowledge from KS3/4) to get them thinking about what they already know/remember and set the scene for this topic.
- This could be backed up with studying a basic diagram identifying the main water stores.
- Students could start by attempting to match percentages of global water to the correct store, and then identify which stores are larger/smaller in volume.
- Opportunity for skills practice; students could create pie charts by hand or using IT, or proportional circles if volumes are available, especially for fresh water sources.
- Practice data manipulation skills when analysing data on the global distribution.
- Identify areas where crysopheric stores are located. These may be less familiar than the water stored in liquid form.
- Global distribution of fresh surface water and groundwater; link to human topics where water demand is a sustainability issue (urban sustainability, population and environment; agricultural use, and resource security - water). This will support their understanding that water may not be available equally everywhere.
- Students could create a fact file or mind map for each store.
- Identify links to other physical topics (Deserts, Coasts, Glaciation etc) in terms of stored water that they will learn about/have learned about in these environments.

Resources

- Read: Where is Earth's water? (USGS) - guide to major stores.
- Read: Ice, snow, glaciers and the water cycle (USGS) - cryospheric stores.
- Read: Permafrost (National Geographic)
- Read: Groundwater (Geological Society) - introduction which can also be useful in subsequent lessons when looking at abstraction.

The movement of water

Specification content

3.1.1.2 The water cycle

Processes driving change in the magnitude of these stores over time and space, including flows and transfers: evaporation, condensation, cloud formation, causes of precipitation and cryospheric processes - at hill slope, drainage basin and global scales with reference to varying timescales involved.

Learning outcomes

This lesson will help students to understand:

- That on Earth water exists in three forms: solid ice, liquid water and gaseous water vapor, and identify the factors that move water between these different states and stores.
- The idea of latent heat and energy in the context of evaporation and condensation, and how they relate to major atmospheric processes like cloud formation and precipitation.
- Different forms of precipitation in the UK and other areas of the world, such as the tropics.
- Cryospheric processes: concept of glacial and interglacial periods and the impact on the cryosphere.
- That the water cycle operates at different scales.

Suggested timing

2 hours

Possible teaching and learning activities

- Students should consider the different states that water is found in; liquid, solid and vapour/gas.
- Students could construct a diagram to illustrate water changing states, identifying energy changes including latent heat.
- They could use a basic water cycle diagram to identify where these changes occur at a global scale, and then at a more local scale, linking to latitude and local climates.
- This will link to learning the key facts about precipitation and atmospheric conditions, specifically the role of atmospheric temperature. UK students are likely to have an awareness of dew and frost but may not have identified it as a state change of water in the water cycle (condensation and deposition) or considered the reversal of these processes causing them to disappear (evaporation and sublimation). This could be done as a sorting activity referencing a typical UK garden at different times of year/day.
- Students could explore different types of precipitation (eg dew, rain, drizzle, sleet, snow, hail, and deposition; frost), plus different causes of rain (frontal, convection and relief/orographic) and identify the dominant causes of rain in the area where they live/in the catchment used for their upcoming case study. Convectional rainfall could additionally be linked to the rainforest case study, or any other tropical regions they have studied in other topics.
- There is a fieldwork opportunity to investigate changes at hill-slop scale, this can be delivered as a simple classroom activity.

- Students could read articles and study graphs about glacial and interglacial periods to introduce the idea of longer-term changes in water stores linked to global climate.

Resources

- Read: The water cycle (GEO) - slides introducing the movement of water.
- Read: The water cycle (Met Office) - straightforward introduction to the water cycle.

Additional Met Office links to support learning about movement of water:

- Watch: What is precipitation? (YouTube) (6 minutes) - causes of precipitation, plus additional information about types of precipitation in the UK.
- Read: Frost and ice (Met Office)
- Read: Dew (Met Office)

Both of the following links support learning about long term cryospheric changes:

- Read: Glacial-interglacial cycles (NOAA)
- Read: Glacial and interglacial periods (Energy Education)

River drainage basin stores and processes

Specification content

3.1.1.2 The water cycle

Drainage basins as open systems – inputs and outputs, to include precipitation, evapotranspiration and runoff; stores and flows, to include interception, surface, soil water, groundwater and channel storage; stemflow, infiltration overland flow, and channel flow.

Learning outcomes

This lesson will help students to describe and explain:

- The characteristics and inputs, stores, transfers and outputs of a drainage basin system: precipitation, interception store, throughfall, stemflow, infiltration, soil storage, vegetation storage, transpiration, infiltration, surface storage, evapotranspiration, overland flow/sheet flow, throughflow, percolation, groundwater store and flow, channel flow, and run off.
- The difference in scale between the global water cycle, drainage basin and hill slope, and that drainage basins vary hugely in scale.

Suggested timing

1 hour

Possible teaching and learning activities

- Define the drainage basin and key terminology, catchment, watershed etc.
- Watch the Time for Geography: Anatomy of a Drainage Basin video (6 minutes).
- Students could draw a simple diagram to identify the main features.
- Opportunity for analysis of Ordnance survey (OS) maps or similar, identifying where watersheds might fall. Students could look for areas where surface storage, interception storage, channel flow etc might occur.
- Recap concept of an open system and use colour coding to identify theses parts of a drainage basin on a diagram.
- Depending on the time of year, and view from classroom window, students might be able to suggest where water is moving and being stored in the immediate vicinity.
- Students could practise differentiating between transfers, eg infiltration and percolation, throughflow and groundwater flow, identifying where each flow occurs, and how the water moves. Students could practise describing transfers, and a partner/group could name the transfer from the description.
- There is a fieldwork opportunity to investigate infiltration on different surfaces, this can be delivered as a simple classroom activity.
- Introduce the idea of where the drainage basin fits in terms of scale, between global water cycle and drainage basin and hill slope scales. Students could make brief summaries, identifying drainage basin and hill slope areas with reference to a local scale catchment (or any river basin) using an appropriate map.

Resources

- Read: The drainage basin system (Time for Geography) – transfers of water within the drainage basin.
- Read: Drainage basins at varying scales (The British Geographer) – this supports the concept of drainage basin and the water cycle operating at different scales.

The water balance

Specification content

3.1.1.2 The water cycle

Concept of water balance.

Learning outcomes

This lesson will help students to understand:

- The concept of water balance
- Inputs, outputs and stores, and the soil moisture budget.
- How evapotranspiration, precipitation, vegetation and soil storage are linked.
- That local and regional climate characteristics will influence the soil moisture budget.

Suggested timing

1 hour

Possible teaching and learning activities

- Construct and annotate a model of the soil moisture budget (SMB) – opportunity to stretch students with thinking skills to identify and analyse factors affecting the SMB through links to previous learning by annotating diagrams to show the soil water store changes throughout the year using water cycle terminology.
- At a basic level, consider their local area through the year; gardens, parks, green spaces etc in terms of vegetation and surfaces to attribute context to the stages of the SMB. Students could apply the SMB terminology to what they see at different times of year, potentially creating a 'living graph' to show how changes through the year affect people's lives, in terms of leisure activities, and local areas such as gardens (muddy footpaths, flooded fields, vibrant green countryside, needing to mow the lawn etc).
- Opportunity to use climate graphs to study the seasonal pattern of rainfall in the local area (data opportunity) and suggest likely impact on the SMB. Refer to recent year/months to understand that the SMB is a model, and the stages will not be the same every year. Suggest why this might increasingly be the case.
- Link to river catchment case study; annual precipitation and temperature patterns, flood events etc.
- If integrating the case study throughout, students could explore the soils and vegetation cover in the river catchment that forms their case study. Are local characteristics likely to change the SMB?
- Opportunity to study climate graphs from different regions and suggest likely impact on the soil moisture budget and implications for communities in contrasting locations in terms of water supply, agriculture etc.
- Look at SMB for different climates (eg tropical rainforest). Understand that months do not relate to the same seasons around the world; southern hemisphere and tropical differences where 'winter, spring, summer and autumn' do not have the same meaning as they would in the UK. Students could consider the impact of different soil SMBs on people's lives. This could directly link to optional human units: Soils in People and the

environment, SUDS and urban drainage in Contemporary urban environments, and Water security in Resource security.

Resources

- Read: The water balance by David Redfern (A Level of Geography) - a summary of the water balance in the UK, linked to water cycle processes.
- Read: Royal Geographical Society skills lessons for the water cycle – skills and data analysis: Lesson 1 relates to the global water balance.
- Read: The UK Soil Observatory map viewer is a good website for further research investigating soil characteristics in the UK.

River regimes and flood hydrographs

Specification content

3.1.1.2 The water cycle

Runoff variation and the flood hydrograph.

Learning outcomes

- Students to understand how river flow rates are measured and how data can be used.
- Students will be able to describe and explain the characteristics of a storm and flood hydrograph. Rising limb, peak discharge, lag time and receding limb.
- Students to understand human and physical factors affecting a storm and flood hydrograph.
- Students to understand the relative speeds of water transfers identified in the drainage basin lesson.

Suggested timing

2 hours

Possible teaching and learning activities

- Students could use the National River Flow archive website to identify the reasons for monitoring river flow, how flow is measured and the concept of a river regime.
- Opportunity to research and analyse the regime of the river studied in the river catchment case study, or a local river known to the students.
- Explain the concept of a flood hydrograph and how it can 'tell the story' of a flood event.
- Students could sketch an outline of a hydrograph and annotate the key terminology.
- Students could construct (by hand or using IT) a hydrograph from real data (links below), potentially relating to the local scale river catchment case study, a river local to the school/college, or a flood event that students are aware of.
- Opportunities for practising data skills and manipulation by calculating lag times etc and comparing hydrographs in the same location.
- Identify the factors that affect movement through a drainage basin, and therefore lag time. Students could use OS maps to identify different catchment characteristics and how they might affect lag time etc. Identify 'at risk' communities in a catchment.
- Construct a table showing relative speeds of water transfers identified in the drainage basin lesson, and link these to land cover and soil information for a chosen catchment.
- Students could use the National River Flow archive website to identify the reasons for monitoring river flow, how flow is measured and explore a range of gauging stations to see how river flow varies.

Resources

- Read: UK river and flow regimes (National River Flow Archive) - introduction to flow regimes in the UK

The following websites contain data for UK rivers which can be used to construct hydrographs:

- View: National River Flow Archive - search for gauging stations.
- View: Gaugemap for UK rivers - flow and river levels with live data.
- Read: Flood hydrographs explained (tutor2u) - this is a summary of hydrograph terminology and the concept.
- Read: Physical factors affecting flood hydrograph dynamics (tutor2u) - a summary of factors that affect hydrographs.

Natural changes to the water cycle

Specification content

3.1.1.2 The water cycle

Changes in the water cycle over time to include natural variation including storm events, seasonal changes and human impact including farming practices, land use change and water abstraction.

Learning outcomes

This lesson will help students to understand:

- How seasonal changes in different regions impact the inputs, stores, transfers and outputs in the water cycle.
- How floods and droughts affect water stores and transfers.

Suggested timing

1 hour

Possible teaching and learning activities

- Draw on students' knowledge of seasons, linking to water balance and river flow data they have looked at to summarise the changes that are likely in the study area across the course of a typical year.
- Opportunity to identify and consider that seasons are different around the world, and how this might impact availability of water for both vegetation and human activities, plus the hazards associated with flooding and how this impacts people. Examples of drought or flood events could be studied to add context and depth to student understanding.
- Students could investigate and then write definitions for storm events and droughts.
- Students could breakdown the drainage basin model (each store and transfer) and annotate versions to identify and explain the changes that might occur during and following a drought.
- This could be repeated for a flood event.
- This activity could be extended to identify the frequency and impacts of these extreme events on different areas of the world and communities that might be affected.

Resources

- Read: Spring, summer, autumn and winter - why do we have seasons? (ABC News) - introduction to seasons.
- View: Climate maps showing rainfall patterns from IPCC data - this website helps to identify different seasonal patterns around the world.
- Read: Extreme weather - include Flooding and Drought (Met Office) - information about floods and droughts in the UK and beyond
- Read: UK and Global Extreme events - drought (Met Office)

The impact of farming and land use change on the water cycle

Specification content

3.1.1.2 The water cycle

Changes in the water cycle over time to include natural variation including storm events, seasonal changes and human impact including farming practices, land use change and water abstraction.

Learning outcomes

This lesson will help students to understand:

- How human activities of deforestation, agriculture and soil drainage affect the water cycle.
- The reasons for these human activities.
- How each one affects stores and transfers within the water cycle at different scales.

Suggested timing

2 hours

Possible teaching and learning activities

- Students could refer to earlier sections within this topic; recap the stores and transfers that are associated with trees, soils and bedrock before beginning this lesson.
- Define each of the human activities and research how each of these affects human welfare and supports life in different areas, to understand the socioeconomic reasons behind different uses of water and land.
- Students could research the impacts of each of the following human activities and changes to the natural water cycle. This could be done as flow diagrams or fact files that identify the 'before' and 'after' for these human activities.
- Deforestation (land use change) has a clear link to Tropical Rainforests and the case study at the end of this unit, but it could be identified at a local scale and applied to local environments, including the local scale River Catchment case study (either, or theoretically, depending on the catchment chosen).
- Students could read the David Redfern article *Farming and water cycle* and produce a poster of the impacts of agriculture on the water cycle.
- Students could learn the basic principle of soil drainage for agriculture and identify how it changes the stores and transfers in the areas where it is used. This could be annotated onto a flow diagram or onto a hill slope diagram. They could construct a table identifying the positive and negative impacts of this human intervention.

Resources

- Read: How deforestation affects the water cycle (Earth Day)
- Watch: MetLink video about deforestation and the tropical rainforest water cycle (YouTube) (2 minutes)
- Watch: Farm basics video introduction to soil drainage for agriculture (YouTube) (5 minutes) - this is a video promoting the use of soil drainage in the USA from an agricultural point of view.
- Watch: Soil drainage lecture, including artificial drainage by Dr Denise DeBusk (YouTube) (13 minutes). Identifies some of the issues associated with soil drainage (7 minutes to 10 minutes).

The impact of water abstraction on the water cycle

Specification content

3.1.1.2 The water cycle

Changes in the water cycle over time to include natural variation including storm events, seasonal changes and human impact including farming practices, land use change and water abstraction.

Learning outcomes

This lesson will help students to understand:

- How water abstraction affects the water cycle.
- The reasons for water abstraction in different areas.
- How water abstraction affects stores and transfers within the water cycle at different scales.

Suggested timing

1 hour

Possible teaching and learning activities

- Define water abstraction and identify how this affects human welfare and supports life in different areas.
- Recap groundwater stores in terms of volume and distribution. Reference could be made to the local area/local scale case study of a river catchment.
- Abstraction (link to water supplies in Resource Security, Population and the Environment, and Contemporary Urban Environments): students should consider the reasons for abstraction, linked to human welfare. Recap the size of the available surface freshwater store in the context of human needs.
- Students could read about the basic methods of groundwater and surface water abstraction, with reference to named locations, potentially the river catchment case study.
- Students research the impacts of water abstraction and changes to the natural water cycle. This could be done as flow diagrams or fact files that identify the ‘before’ and ‘after’.
- Students should identify the impacts on water stores, and the wider impacts on local ecosystems and communities. This could include saltwater intrusion.
- Students could investigate the example of the Thames Basin and explain how abstraction can be used to keep a water table in balance.

Resources

- Read: Groundwater basics (UK Groundwater Forum) - introduces groundwater and links to abstraction.
- Read: Rising groundwater in Central London (UK Groundwater Forum) - impacts of historic abstraction.
- Read: Water abstraction statistics: England, 2000 to 2018 (GOV.UK) - government data on abstraction in the UK.
- Read: WWF-UK case study: the impact of over-abstraction on the River Kennet

- Watch: What is seawater intrusion? (YouTube) (2 minutes) - Southern California video explanation with clear visuals.
- Groundwater our hidden asset (groundwateruk.org) - UK sea water intrusion linked to abstraction for water supply.

Case Study of a river catchment at a local scale

Specification content

3.1.1.6 Case studies

Case study of a river catchment(s) at a local scale to illustrate and analyse the key themes above, engage with field data and consider the impact of precipitation upon drainage basin stores and transfers and implications for sustainable water supply and/or flooding.

Learning outcomes

These lessons will help students to:

- Illustrate how the hydrological system affects channel flow, by identifying the stores and transfers in the catchment.
- Analyse the relationships between inputs and outputs in a local river; be able to link the catchment characteristics to flows of water.
- To understand implications for flooding on a local river, and how this can be managed, **and/or** explain how water is abstracted, and how this can be managed sustainably.

Suggested timing

2 hours

Possible teaching and learning activities

- The teaching of this case study can be integrated into previous lessons or taught separately as detailed below.
- Introduce the river and identify the aims and purpose of the case study.
- **Background to the catchment:** students should identify the characteristics of the drainage basin in terms of bedrock, relief, soils and land use/land cover. For each of these, students can identify the impact on stores and transfers of water.
- **Climate of the catchment area:** specifically annual precipitation as an input. Basic analysis skills: students can look at rainfall data and summarise the typical rainfall across a year. Data can be found via the Met Office website.
- **River regime and flow data:** students can analyse the flow data from the National River Flow Archive for the chosen river at a particular location. An assessment of the relationship between precipitation and river flow/regime can be made and summarised.
- **Sustainable water supply:** if applicable to the chosen river, investigate abstraction via the water company, or regional CAMS website. Reports may be available that provide information on drought resilience for a particular catchment.
- Students could focus on one specific abstraction site and investigate this in detail.
- **Flooding:** it might be useful to identify one specific flood, although if a river experiences frequent flooding, then this could form the basis of this section. Qualitative information is likely to be readily available via local or national media. This could focus on one or two specific locations (depending on catchment, and flood extent)
- Students could compare the flood events to typical flow/regime. This might include obtaining data on the precipitation patterns and antecedent conditions that might have contribute to flooding. The National River Flow Archive has data going back several decades, so specific dates can be found.

- Local flood management plans are likely to identify the risks, and management in place for specific areas within the catchment study area.

Resources

- Read: UK water resources portal (UK Centre for Ecology & Hydfrology) - rainfall, river flow, soil moisture and groundwater level data in one place; useful for creating a case study.
- Read: Met Office climate data – includes precipitation data (will locate closest station to a chosen location within a catchment).
- Read: Hydrology data explorer (Department for Environment Food & Rural Affairs)
- Visit: Gauge map
- Read: The recent storms and floods in the UK (Centre for Ecology Hydrology) - includes maps showing rainfall for Dec 2013 and Jan 2014.
- View: UK actual and anomaly maps (Met Office) - searchable maps to show climate data (eg rainfall) for specific months, with anomaly information.

Example resources for the River Wey near Guildford, Surrey

- Read: Wey Catchment Portal (StoryMaps) - example of general river catchment information for the River Wey (Surrey/Hampshire).
- An introduction to the Wey Valley (Wey River)
- Read: Section 19 Flood Investigation Report: Guildford Borough (Surrey County Council) - this includes specific reference to the floods of 2013-2014.
- Read: Guildford flood alleviation scheme (GOV.UK) - flood management plan, with reference to 2013 to 2014 winter floods.
- Read: Final Drought Plan: April 2017: Main Report (Thames Water) - reference to River Wey abstraction at Shalford, near Guildford. This includes data on abstraction and sustainability.
- Read: Section 19 Flood Investigation Report: Guildford Borough (Surrey County Council) - page 11 of this report gives some clear background to the flooding on the Wey from 2013 to 2014, with reference to weather conditions and rainfall data.

Example resources for the River Greta near Keswick

- Read: Our area (West Cumbria Rivers Trust) - information of general river catchment information for the River Greta and West Cumbria.
- Visit the West Cumbria Catchment Partnership website.
- View: Derwent North West catchment area (River Levels) – information about current river levels.
- Read: Keswick flood investigation report (Cumbria County Council) - this includes specific reference to the floods of 2015.
- Read: Cumbria flood action plan - reducing flood risk from source to sea (Environment Agency) - management plan, with reference to Derwent catchment.
- Read: Derwent and West Cumbria abstraction strategy (Environment Agency) - this includes data on abstraction and sustainability.

Introduction to carbon

Specification content

3.1.1.3 The carbon cycle

Global distribution, and size of major stores of carbon – lithosphere, hydrosphere, cryosphere biosphere and atmosphere.

Learning outcomes

- Students to understand the features of carbon as an element, its versatility and importance as a component of organic and inorganic compounds.
- Students to understand the origins of the carbon that we study in the carbon cycle.
- Students to be able to describe and explain the global stores of carbon, including: lithosphere, hydrosphere, cryosphere, biosphere, atmosphere, identifying organic and inorganic carbon.
- Students to understand that organic and inorganic carbon is moved between stores at different rates via a range of processes.

Suggested timing

1 hour

Possible teaching and learning activities

- Get students to think about where they know carbon is present in different forms.
- Students could complete the carbon cycle quiz (Visionlearning) to establish prior knowledge.
- Students could research key facts about carbon, including where it is found, origin of carbon, presence in compounds, organic and inorganic carbon.
- Introduce the basic carbon cycle via a diagram and/or descriptive text resource. Students could produce their own diagram which can be added to in subsequent lessons (when they focus on each of the transfers).
- Opportunity for data/skills work; produce compound bar graphs or divided bars pie charts showing the distribution of carbon or proportional circles on a simple diagram showing land, sea, atmosphere etc.
- Students can look at data on carbon in different stores and produce mini fact files on each store. Globally significant stores such as boreal forests and tropical rainforest can be identified, as these will link forward to future learning (and the case study).
- Students may be less aware of the pedosphere and peatlands, so this could be highlighted or modelled as a fact file to aid their understanding.

Resources

- Read: Carbon cycle (Met Office)
- Watch: Stores of carbon on planet Earth (Time for Geography) - video that gives a clear introduction to the major stores (7 minutes).
- Read: The carbon cycle (Geography Education Online) - slides 3 to 6 on the linked PowerPoint introduce carbon stores.
- Read: Peatlands and the carbon cycle (Geography Education Online) - more detailed information about peat; relevant to UK, the Arctic and tropical rainforest in Indonesia.
- Read: UK Peatlands (IUCN)
- Read: Global carbon cycle (University of New Hampshire) - useful as an introduction and/or a summary of the topic, in terms of stores, transfers, and carbon budget data.

The movement of carbon: The fast carbon cycle

Specification content

3.1.1.3 The carbon cycle

Factors driving change in the magnitude of these stores over time and space, including flows and transfers at plant, sere and continental scales. Photosynthesis, respiration, decomposition, combustion, carbon sequestration in oceans and sediments, weathering.

Learning outcomes

- Students to understand how carbon moves between stores over short timescales.
- Students to understand the role of living things in the movement of carbon.
- Students to be able to describe and explain the processes involved in these transfers, including: photosynthesis, respiration, decomposition and combustion.
- Students to understand movement of transfer between the carbon stores, studied above, at a range of scales. Including plant, sere and continental.

Suggested timing

1.5 hours

Possible teaching and learning activities

- Students could start by watching the NASA video A year in the life of Earth's CO_2 (YouTube) (3 minutes) without the commentary but identify the key to students so they can 'track' the atmospheric carbon over the course of the year. They could focus on the northern and southern hemispheres separately (could be watched twice) and then suggest reasons for the seasonal changes in global atmospheric carbon (link to boreal forests identified as significant stores, and to seasonality identified in the water cycle content). Start to bring in photosynthesis and respiration etc.
- Students should watch the video about the fast carbon cycle, to get a sense of how carbon moves around the Earth's surface and atmosphere.
- Students can then research the key movements of carbon, describe each movement, and identify the stores between which these occur. This could be added to a working diagram of the carbon cycle.
- Students could draw a sketch of a tree with roots, and then identify the carbon transfers occurring between the tree, soil and atmosphere across the course of a day.
- They could construct a flow diagram of seral succession in an ecosystem and identify the movement of carbon and change in stores, linked to the processes of photosynthesis, respiration and decomposition.
- Students could create a simple diagram of vegetation and atmosphere, summarising photosynthesis, respiration, decomposition and combustion (use Britannica video clip).
- Students could play the Carbon cycle game (Climate Change Live) in this lesson, or the next, to reinforce the timescales involved in the fast and slow carbon cycle.
- There is a fieldwork opportunity to compare carbon stores in different land-uses.

Resources

- Read: The short-term carbon cycle (Time for Geography)
- Read: Carbon and oxygen cycle explained (Britannica) - good for fast carbon cycle processes.
- Watch: NASA: A year in the life of Earth's CO_2 (YouTube) (3 minutes) - shows the changes in carbon dioxide in the atmosphere across a year.
- Play the carbon cycle game (Climate Change Live) - other versions are available; the first 12 pages of this document provide the resources for the basic game, which helps students identify how carbon moves between stores, and the relative time carbon might spend in different stores. Carbon cycle game (RSC Education) is a slightly different version of this game.

The movement of carbon: The slow carbon cycle

Specification content

3.1.1.3 The carbon cycle

Factors driving change in the magnitude of these stores over time and space, including flows and transfers at plant, sere and continental scales. Photosynthesis, respiration, decomposition, combustion, carbon sequestration in oceans and sediments, weathering.

Learning outcomes

- Students to be able to describe and explain the processes involved in these transfers, including: burial, compaction, carbon sequestration and weathering.
- Students to understand how these link to wider geomorphological processes such as fluvial transport (and therefore the water cycle).
- Students to understand how the slow carbon interacts with the fast carbon cycle.

Suggested timing

1 hour

Possible teaching and learning activities

- Each of the movements could be added to a working diagram of the carbon cycle, and colour coded to differentiate from the fast carbon cycle.
- Students can refer to the basic carbon cycle diagram and identify the movement of carbon from the atmosphere to the land via precipitation.
- Weathering; students likely have some understanding of these processes from prior learning, so this can be a recap with an emphasis on rainwater and the reactions with carbonate rocks. This links to transfers in the water cycle.
- Burial, compaction and sequestration; a simple flow diagram could be used to understand the processes occurring on the seabed.
- Students could also consider the longer-term tectonic processes leading to uplift; explaining how chalk and limestone are found at the surface, having been formed under the ocean, thus completing the slow carbon cycle where weathering can begin once more.

Resources

- Read: The long-term carbon cycle (Time for Geography) – clear introduction to the cycle and processes.
- Read: The slow carbon cycle (NASA)
- Read: Burial and compaction (Geological Society) - includes subsequent links to cementation.
- Read: Uplift (Geological Society)

The role of ocean pumps in the movement of carbon

Specification content

3.1.1.3 The carbon cycle

Factors driving change in the magnitude of these stores over time and space, including flows and transfers at plant, sere and continental scales. Photosynthesis, respiration, decomposition, combustion, carbon sequestration in oceans and sediments, weathering.

Learning outcomes

This lesson will help students to understand:

- How the biological carbon pump links the fast and slow carbon cycles via burial and compaction.
- How organic carbon becomes inorganic carbon.
- How carbon moves between the oceans and the atmosphere.
- How atmospheric and ocean temperatures are linked, and how ocean currents move carbon.

Suggested timing

1 hour

Possible teaching and learning activities

- Biological carbon pump - fast and slow carbon interacting. Students could study diagrams to identify the movements and the potential for carbon to move from fast processes into long term storage in the slow carbon cycle. Students could construct their own diagram and annotate these changes.
- Study the map showing carbon concentrations in the oceans (in the resources list), and compare this to an ocean temperatures map (and atmospheric circulation/temperatures)
- Study a diagram of Earth - equator and poles to show physical pump - definition of upwelling and downwelling. Links to atmospheric circulation and climate.
- Links to Global systems and global governance Antarctica - importance of cold Southern Ocean waters for phytoplankton, krill and whales etc. Depending on teaching sequence, this could be identified ahead of teaching GSGG, or as a recap to reinforce learning of the physical geography and food webs in Antarctica.

Resources

- Watch: The marine carbon cycle explained (YouTube) (18 minutes) - covers the biological pump with burial, compaction and uplift. From 13 minutes, the physical carbon pump is explained.
- Read: Ocean currents and the carbon cycle by David Redfern (A Level of Geography)
- Read: Carbon and climate (Galen Mckinley) - section on the oceans has a map showing carbon in the oceans at different latitudes.

Natural changes to the carbon cycle

Specification content

3.1.1.3 The carbon cycle

Changes in the carbon cycle over time, to include natural variation (including wildfires, volcanic activity) and human impact (including hydrocarbon fuel extraction and burning, farming practices, deforestation and land use changes).

Learning outcomes

This lesson will help students to understand:

- How natural events, such as wildfires and volcanic eruptions, alter the carbon cycle.
- The relative impact of natural events and human activity on the carbon cycle.

Suggested timing

1 hour

Possible teaching and learning activities

- Refer to the movement of carbon and identify seasonal changes to the carbon stores and transfers linked to photosynthesis
- Students could recap the carbon movements and identify where fires and combustion occur within the carbon cycle.
- Engage with data on volume released by individual events (potential link to Hazards topic).
- Identify areas globally where fires are more common/more likely. This may link to the tropical rainforest case study (and to human causes). Students could begin to make links between latitude, climate and vegetation types.
- Students could practise graphical/data skills by creating graphs to show carbon emitted by fires in recent years.
- Research opportunity: students could search for information about the role of volcanic eruptions in the carbon cycle. This will link to a comparison with the impact of human activity (covered in the next lesson).
- Students could then discuss the relative impact of fires and volcanic activity in carbon emissions (this could be done at the end of the topic, incorporating climate change and human activity into the discussion as well).

Resources

- Read: Natural causes of Quaternary climate change (Time for Geography) - identifies long term changes in carbon and global climate.
- Watch: Seasonal changes in carbon dioxide (YouTube) (1 minute) - identifies the seasonal variation in carbon due to photosynthesis.
- Read: Wildfires turn Canada's vast forests from carbon sink into super-emitter (The Guardian) – article from 2023.
- Read: Which emits more carbon dioxide: volcanoes or human activities? (Climate.gov)

Impact of human activity on the carbon cycle

Specification content

3.1.1.3 The carbon cycle

Changes in the carbon cycle over time, to include natural variation (including wildfires and volcanic activity) and human impact (including hydrocarbon fuel extraction and burning, farming practices, deforestation and land use changes).

Learning outcomes

This lesson will help students to understand:

- How human activities have affected major stores of carbon.
- The reasons behind human activities that move carbon between stores.
- Where the most significant changes are occurring.

Suggested timing

2 hours

Possible teaching and learning activities

- Students could be encouraged to suggest human activities that they think/know cause changes to the carbon cycle.
- View the land use change timelapse (Google Earth Engine) – students could look through various sets of images showing land use change, including deforestation, urban growth etc. (This could also be used to support the water cycle sections, and the rainforest case study). Students could identify and suggest indirect impacts on the carbon cycle of specific examples of their choice or allocated by the teacher.
- Research: students research below topics individually or in groups: what, why, where, change in time, data, identifying the stores and transfers being altered by each activity. Opportunities for presentations or posters to summarise:
    - hydrocarbon fuel extraction and burning
    - farming practices (arable and livestock)
    - deforestation
    - land use change (urban growth and cement manufacture).
- Students can then identify the links between these human activities and wider links to GSGG themes, population, urbanisation, resource use etc (all human topics).
- Consider the implications of these activities for communities in terms of economic growth and development.

Resources

- Read: Human causes of climate change (Time for Geography) - introduces the main human activities that affect the carbon cycle.
- Read: How livestock affect the carbon cycle (New Zealand Agricultural Greenhouse Gas Research Centre)
- Read: Impact of agriculture on climate change (Future Learn)
- Read: Climate change: The massive CO_2 emitter you may not know about (BBC News) - information about cement, which links to land use changes and industrial processes.

The impacts of the changing carbon budget on the atmosphere

Specification content

3.1.1.3 The carbon cycle

The carbon budget and the impact of the carbon cycle upon land, ocean and atmosphere, including global climate.

Learning outcomes

This lesson will help students to understand:

- The concept of the carbon budget and how the Earth balances carbon transfers under natural conditions.
- How the carbon budget has been altered by human activities, leading to the enhanced greenhouse effect and climate change.
- How the changing carbon budget is impacting the atmosphere in terms of climate change and weather patterns.
- How climate change has different characteristics/outcomes in a range of locations around the world.

Suggested timing

1 hour

Possible teaching and learning activities

- Students could study the diagram of the Earth's carbon budget from the GEO diagram on slide 6 (Geography Education Online) and calculate the net stores and sources of carbon based on the transfers between land, ocean and atmosphere.
- Read the David Redfern article about the changing carbon budget (A level of Geography) and identify how these sources and stores are changing.
- Students will have previously studied the greenhouse effect. They could sketch what they know/remember and add explanations of what is happening.
- Read the University of Bergen article about the causes of climate change (futurelearn.com), which explains the concept of radiative forcing.
- Students could then add additional notes to a more comprehensive diagram to identify the energy imbalance linked to emissions.
- Students could then explore the main examples of climate change, identifying changes in temperatures and rainfall patterns. This could be an annotated world map, and students could use examples they have/are likely to study in other topics or select specific regions to exemplify. The more detailed impacts on land (and therefore communities) will be explored in the next lesson.

Resources

- Read: The carbon cycle (Geography Education Online) - slide 6 on the linked PowerPoint has a carbon budget diagram.
- Watch: The carbon cycle is key to understanding climate change (YouTube) (8 minutes)
- Read: Effects of changing the carbon cycle (NASA) – introduces impacts on atmosphere, land and ocean.
- Read: Introduction to man-made radiative forcing (Future Learn)
- Read: Mapped: How climate change affects extreme weather around the world (Carbon Brief) - useful tool for identifying examples of atmospheric changes linked to climate change.

The impacts of the changing carbon budget on the land

Specification content

3.1.1.3 The carbon cycle

The carbon budget and the impact of the carbon cycle upon land, ocean and atmosphere, including global climate.

Learning outcomes

This lesson will help students to understand:

- How the changing carbon budget is impacting the atmosphere in terms of climate change and weather patterns.
- How climate change is impacting the land and the lives of communities in different areas of the world.

Suggested timing

1.5 hours

Possible teaching and learning activities

- Students could start by recapping the previous lesson, specifically identifying the changes to the carbon levels in the atmosphere and the ocean.
- Students could explore how the increased carbon in the atmosphere affects agriculture in different regions; explain how theoretically increased carbon should increase vegetation and growth in many regions, and how photosynthesis should increase.
- Identify why this may not be the case in combination with deforestation and changing precipitation patterns.
- Explore areas of the world that may see increases in agricultural productivity, and those that might see decreases. This can include climate related impacts such as pests and diseases. Students can identify contrasting impacts in the UK and other regions.
- Students could then watch the video below identifying the impact of a warmer atmosphere on Arctic regions and permafrost.

Resources

- Read: Effects of changing the carbon cycle (NASA) - introduces impacts on atmosphere, land and ocean.
- Watch: Lakes of frozen methane are potential disasters | Earth: power of the planet | BBC Earth Science (YouTube) (5 minutes)
- Read: River deltas are threatened by more than climate change – leaving hundreds of millions of people at risk (Geography Directions)
- Read: Extreme UK flood levels are happening much more often than they used to, analysis shows (Geography Directions)
- Read: Impacts of climate change on low-lying coastlines | The Muni coastal lagoon, Ghans (Time for Geography) - impact of climate change on communities. Links atmospheric changes, water cycle and impacts linked to sea level rise.

The impacts of the changing carbon budget on the oceans

Specification content

3.1.1.3 The carbon cycle

The carbon budget and the impact of the carbon cycle upon land, ocean and atmosphere, including global climate.

Learning outcomes

This lesson will help students to understand:

- How climate change is impacting the oceans at different scales and in different regions.
- How climate change is impacting the land and the lives of coastal communities in different areas of the world.

Suggested timing

1 hour

Possible teaching and learning activities

- Students could start by recap the biological carbon pump in the oceans and identify the movement of carbon occurring in the oceans.
- Then watch the videos in Resources identifying how changes to carbon levels in the ocean impacts life in the oceans (shell-building molluscs and coral).
- Students can use a variety of resources to explain the processes and impacts of ocean warming, ocean acidification, coral bleaching, ocean salinity, melting sea ice and sea level rise. It is useful to link back to water cycle to look at interactions and feedback cycles.
- Students can also identify the impact of warmer water/melting ice on ocean currents and the potential impacts beyond the oceans on climate.

Resources

- Read: Effects of changing the carbon cycle (NASA) – introduces impacts on atmosphere, land and ocean.
- Watch: NASA | Earth science week: keeping up with carbon (YouTube) (6 minutes) - carbon cycle, oceans, climate and changing climate impacts - impacts of changing carbon budgets.
- Watch: NASA | Earth science week: the ocean's green machined (YouTube) (6 minutes) - recap oceanic pumps, but then impacts of warming oceans on plankton
- Watch: Demystifying ocean acidification and biodiversity impacts (YouTube) (12 minutes)
- Read: Carbon dioxide, shell building, and ocean acidification (Woods Hole Oceanographic Institution)
- Watch: Impacts of Antarctic ice melt on the oceans (Time for Geography) (9 minutes) – from 3 mins 30, focuses on ice shelves, ice sheet and the impact of melting on sea levels.

The importance of water and carbon for life on Earth, and Interrelationships between the water and carbon cycles

Specification content

3.1.1.4 Water, carbon, climate and life on Earth

The key role of the carbon and water stores and cycles in supporting life on Earth with reference to climate. The relationship between the water cycle and carbon cycle in the atmosphere.

Learning outcomes

This lesson will help students to understand:

- Students to understand the significance of water (water vapour and clouds) and carbon (CO_2) as greenhouse gases.
- Students to understand the dominance of CO_2 in controlling the scale of the greenhouse effect.

Suggested timing

1 hour

Possible teaching and learning activities

- Students could begin by sketching the water cycle diagram again, but then add on the movements and stores of carbon to identify where the two cycles interact and support each other.
- Students could refer to their work on human impacts on the water cycle and on the carbon cycle. They could combine the impacts on both into one diagram, helping to reinforce the links between water and carbon associated with agriculture and with deforestation.
- There is an opportunity to make explicit links between changing carbon cycles and processes such as precipitation and evaporation. Soil moisture also directly links here, so students can further develop the impacts of changing carbon budgets on the atmosphere and the land.

Resources

- Read: UK Extreme weather (Time for Geography) - divided into chapters so specific hazards such as storms, droughts etc.
- Read: The water cycle and climate change (UCAR)
- Read: Steamy relationships: how atmospheric water vapor amplifies Earth's greenhouse effect (NASA Science)

Feedback systems in water and carbon cycles

Specification content

3.1.1.4 Water, carbon, climate and life on Earth

The role of feedbacks within and between cycles and their link to climate change and implications for life on Earth.

Learning outcomes

This lesson will help students to understand:

- Students to understand the positive feedback between CO_2 led warming leading to higher evaporation rates and a wetter atmosphere.
- Students to understand the significance of water (water vapour and clouds) and carbon (CO_2) as greenhouse gases.
- Students to understand the dominance of CO_2 in controlling the scale of the greenhouse effect.
- How the changing carbon budget on the land and oceans can link to different feedback loops.

Suggested timing

1 hour

Possible teaching and learning activities

- This can be used as a consolidation lesson at the end of the topic (potentially after the rainforest case study has been completed).
- Students could begin by recapping the concept of systems thinking.
- Students could construct feedback diagrams to illustrate relationships between water and carbon cycles and climate change.
- This could be completed in groups, with diagrams passed around for other groups to identify the type of feedback. Groups could create sorting cards for each feedback loop, and other student could attempt to place the cards in the correct order (this could be hard copies, or digital versions with drag and drop boxes).
- Examples could include: melting permafrost, reduction in sea ice cover, removal of forest vegetation, increasing vegetation due to higher CO_2 levels, decreasing vegetation cover and climatic CO_2. Many other examples can be identified.

Resources

- Read: Introduction to systems thinking (Geography Education Online) - useful for recap, and some examples of feedback in water and carbon cycles.
- Read: Explainer: Nine 'tipping points' that could be triggered by climate change (Carbon Brief) - identifies examples of systems where tipping points could trigger positive feedback.
- Read: The carbon cycle: Better understanding carbon-climate feedbacks and reducing future risks - first seven pages; chapter 1 and 2.
- Climate Feedbacks -Met Office (YouTube) (10 minutes)

Attempts to manage and mitigate climate change

Specification content

3.1.1.4 Water, carbon, climate and life on Earth

Human interventions in the carbon cycle designed to influence carbon transfers and mitigate the impacts of climate change.

Learning outcomes

- Students to have a clear understanding of the concepts of mitigation and adaptation.
- Students to be able to describe and explain in detail a range of specific strategies that are employed to mitigate greenhouse gas emissions.
- Students to understand that mitigation can occur at a variety of scales, from individual to global.
- Students will be able to explain how adaptation can be used at a local scale to mitigate the impacts of climate change.
- Students should be able to recognise that strategies to mitigate climate change have implications for development in the area they are applied, and in areas affected by climate change.

Suggested timing

2 hours

Possible teaching and learning activities

- Introduce the concept of mitigation and adaptation.
- Establish what students already know about climate change mitigation at different scales; individual, local, national and international.
- Opportunity for group work for students to identify as many mitigation strategies as possible, and to then categorise. This information once shared could be used to produce a summary mind map.
- Students can explore strategies and identify the carbon transfers being influenced, eg reducing emissions into the atmosphere, increasing potential capture via photosynthesis and increasing geological storage of carbon.
- Suggest mitigation might include; reduction in emissions from transport and energy generation and usage, Carbon Capture and Sequestration (CCS), reducing emissions from agriculture, reducing combustion, increasing biological storage of carbon in different ecosystems and land uses.
- Students should look at a variety of human interventions at different scales. Show examples of effective strategies at a national/local scale – ensuring actions taken by Indigenous Peoples are included. Group work investigating and presenting examples at different scales.
- Students could evaluate these strategies and consider the effectiveness, the challenges of applying this in a range of areas of the world, and the implications of some of these changes for communities around the world at different levels of development.
- Students could make direct connections to Global Governance and evaluate the success of attempts to reduce emissions at a global scale.

- An opportunity to discuss the differing views relating to climate change, and any ethical, moral or socio-political issues arising. Also to be critical of the sources of data.

Resources

- Read: What is climate change mitigation and why is it urgent? (UNDP) – defines the terminology and introduces the concepts.
- Read: What's the difference between climate change mitigation and adaptation? (WWF)
- Read: COP28 agreement on adapting to climate change kicks the real challenge down the road (Geography Directions)
- Read: Understanding carbon capture and storage (British Geological Survey)
- Read: Carbon colonialism must be challenged if we want to make climate progress (Geography Directions) - blog post about UK climate policy.
- Read: Peat bogs: restoring them could slow climate change – and revive a forgotten world (Geography Directions) - natural carbon sequestration – UK.

Case Study of a Tropical Rainforest

Specification content

3.1.1.6 Case Studies

Case study of a tropical rainforest setting to illustrate and analyse key themes in water and carbon cycles and their relationship to environmental change and human activity.

Learning outcomes

Students will be able to describe, explain and evaluate a number of themes relating to water and climate in the Indonesian tropical rainforest, including:

- How changes in the water and carbon cycles have changed the tropical rainforest environment.
- How human activity affects the tropical rainforest.
- How climate change affects the tropical rainforest.
- Students will be able to describe and evaluate a range of strategies employed in the Indonesian tropical rainforest to reduce the effects of climate change.

Suggested timing

3 hours

Possible teaching and learning activities

The teaching of this case study can be integrated into previous lessons or taught separately as detailed below:

- Location background: students could research and create a fact file about the location of selected tropical rainforest (eg Indonesia, specifically Borneo and Sumatra).
- Characteristics of a tropical rainforest water and carbon cycles: general tropical rainforest water and carbon cycle; annotate diagram identifying stores and transfers at a local scale.
- Human activity and impacts on the rainforest: link back to land use change in previous lesson; summarise the specific activities in the chosen rainforest area.
- Explain the links between human activity and economic development at country and community level.
- Identify changes to water and carbon cycle because of the human activities and land use change.
- Impacts of environmental change on the rainforest: identify the changes to the rainforest characteristics, water and carbon cycles that have occurred as a results of climate change (eg fires and flooding in the Indonesian rainforests).
- Identify how human activities and environmental change can combine to create positive feedback loops in the water and carbon cycles (eg loss of peatlands in the Indonesian rainforest).
- Human activities aimed at restoring rainforest and/or mitigating impacts of climate change: identify actions at different scales that attempt to mitigate the threats identified above (eg local scale actions, government strategies and targets). These can be evaluated in the context of impact on water and carbon cycles, mitigation of climate change impacts, impact on rainforest as a whole, in terms of biodiversity.

Resources

- Read: Threats to tropical rainforests (Time for Geography)
- Watch: The tragedy of deforestation | climate change: the facts | BBC Earth (YouTube) - generic, with links to carbon dioxide emissions and deforestation.

Example resources for the Indonesian Rainforest

- Watch: Sumatra, Indonesia: the rainforest's last stand – video (The Guardian) (8 minutes) - shows impact of human activity (paper, pulp, and palm oil) on the Sumatran rainforest, with some link to water cycle impacts and carbon emissions.
- Watch: Indonesia's vanishing forests: too little, too late for Asia's largest rainforest? | Insight (YouTube) (49 minutes) - really good, but long. The first half hour includes clear reference to land use change, and the impact of this and climate change on water and carbon in the area.
- Watch: Deforestation in Indonesia - a waiting world catastrophe? (YouTube) (3 minutes) - trailer for above documentary, which summarises/introduces the key ideas.
- Read: In Indonesia, deforestation is intensifying disasters from severe weather and climate change (AP News) - article linking deforestation, climate change and disasters.
- Read: Deforestation in Indonesia (Earth.Org)
- Read: Peat swamp and lowland forests of Sumatra (Indonesia) (WWF)
- Read: Peatlands and the carbon cycle (Geography Education Online) - slides 8 to 9 reference the peatland degradation in Central Kalimantan.
- Read about the Katingan Mentaya Project - forest and peatland restoration in Central Kalimantan (Indonesian Borneo).

Example resources for the Amazon Rainforest

- Watch: Tropical rainforests: threats and solutions interview by Prof Mark Mulligan (Time for Geography) (49 minutes) - generic, but with examples from the Amazon. Threats from 15.12 minutes; specific threats to the Amazon from 16.30 minutes.
- Watch: The Amazon carbon balance: the rainforest is releasing more carbon than it absorbs (YouTube) (2 minutes) - Sky News report from 2021.
- Watch: The Amazon Rainforest (WWF) (2 minutes) - clear summary with rainforest facts, plus summary of the threats.
- Read: Climate change in the Amazon (WWF) - including links to water cycle and feedback loops.
- Read: Deforestation has big impact on regional temperatures, study of Brazilian Amazon shows (The Guardian) – article from 2023.
- Read: Can investors save the Amazon? (BBC) - article linking to wider causes of deforestation.