

# **Scheme of work: Glacial systems and landscapes**

## **Introduction**

This scheme of work offers a route through the A-level Geography (7037) specification with a core focus on Physical Geography, optional topic Glacial systems and landscapes.

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 resource section indicates 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 suggest 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.

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## 3.1 Physical geography

### Optional topic: 3.1.4 Glacial systems and landscapes

#### Global distribution of cold environments

##### Specification content

##### 3.1.4.2 The nature and distribution of cold environments

The global distribution of cold environments.

##### Learning outcomes

This lesson will help students to understand:

- The different types of cold environments – Polar, Tundra and Alpine.
- Where these cold environments are situated in the present day.
- Reasons why these cold environments are situated in these locations.
- The concept of 'landscape' as a combination of related landforms.

##### Suggested timing

2 hours

##### Possible teaching and learning activities

- Students could do a mix and match exercise using key terminology to recap K3/4 knowledge and introduce new key terms e.g. glacier, tundra, periglacial, fluvio-glacial, Ice-Age, ice-cap, ice sheet and permafrost.
- Show a map of present day location of Polar, Tundra and Alpine environments and ask students to memorise locations and recreate it on a blank world map.
- Group discussion of reasons for these locations, linking back to knowledge from GCSE.
- Annotate a map of locations to show reasons why these environments are located here considering, latitude, altitude, aspect, relief and distance from moisture source.
- Introduce nature of cold environments by studying a range of images and asking students to identify key characteristics of Polar, Tundra and Alpine environments.

##### Resources

- [View the National Snow and Ice Data Center's guide to the location of the World's glaciers.](#)
- [View the useful map of cold environments \(Physics and Maths Tutor\).](#)

## The nature of cold environments

### Specification content

#### 3.1.4.2 The nature and distribution of cold environments

- Physical characteristics of cold environments.
- Climate, soils and vegetation (and their interaction).

### Links with other units

#### 3.2.1 Global systems and global governance

##### 3.2.1.5.1 Antarctica as a global common

An outline of the contemporary geography, including climate, of Antarctica.

### Learning outcomes

This lesson will help students to understand:

- The physical characteristics of Polar, Tundra and Alpine environments.
- The climate of cold environments and how to use climate graphs to interpret climate.
- The soils of cold environments.
- The characteristics of the vegetation in cold environments.
- How the interactions of climate, soil and vegetation interact to give characteristic landscapes in Polar, Tundra and Alpine regions.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Student discussion about learning from previous lesson and how the locations might determine physical characteristics of cold environments.
- Research the characteristics of each cold environment and produce fact cards to show the key differences.
- Draw climate graphs and/or annotate climate graphs to show the key characteristics. Use the data to show understanding of central tendency as a comparison tool. You can also use this opportunity to apply range and interquartile range and consider their usefulness.
- Discuss the factors affecting Polar and Tundra climates and how these give differences in the climates of these regions; low levels of insolation, albedo, high pressure systems, katabatic winds etc.
- Annotate soil profiles of cold environments to explain differences. Compare to brown earth profile from the UK.
- Study images and/or watch a video of the Tundra ecosystem and discuss the characteristics of the vegetation. Class discussion of why Polar areas do not have vegetation apart from lichens and mosses. Introduce concepts of environmental fragility and low biodiversity.
- Students could research cold environment plant types and their adaptation to soil and climates. Summarise key adaptations and relative importance of climate and soils in these climates.

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- Recap knowledge of nutrient cycling and consider nutrient cycling in Tundra areas and how this is different to tropical rainforests (link with Water and carbon unit). How does this link with low biodiversity and environmental fragility?

### Resources

- View useful [climate data, information and images on the Tundra \(NASA Earth\)](#).
- View [information on the Tundra Biome \(UCMP\)](#).
- Watch the [Frozen Planet video clip Polar Seasons \(BBC\) \(2 minutes\)](#).
- Watch the [Met Office video explaining pressure systems How does atmospheric pressure affect weather? \(YouTube\) \(2 minutes\)](#).
- View the useful [website for climate data for cities worldwide \(Climate Data\)](#).
- Watch the [Frozen Planet video clip about Tundra vegetation, The tundra comes to life \(BBC\) \(1 minute\)](#).

## Distribution of cold environments in the past

### Specification content

#### 3.1.4.2 The nature and distribution of cold environments

The global distribution of past and present cold environments (polar, alpine, glacial and periglacial) and of areas affected by the Pleistocene glaciations.

#### 3.1.4.3 Systems and processes

Ablation and accumulation – historical patterns of ice advance and retreat.

### Links with other units

#### 3.1.1. Water and carbon cycles

##### 3.1.1.3 Changes in the carbon cycle over time

To include natural variation (including wild fires, volcanic activity) and human impact (including hydrocarbon fuel extraction and burning, farming practices, deforestation, land use changes).

### Learning outcomes

This lesson will help students to understand:

- Global distribution of cold environments in the past.
- The difference between past and present distributions of cold environments.
- The nature and causes of ice-ages.
- Advancing and retreating glaciers today.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Introduce key terminology – ice-ages, glacials, odinterglacial, advance, retreat, ablation and accumulation.
- Study a map from a recent ice-age (e.g. 18000 years ago) and consider the extent of the ice – are there any patterns? How is it different from today's pattern?
- Use a blank map of the UK and draw the extent of the ice in the last ice-age. Discuss what their school/home location would have looked like referring back to last lesson – vegetation, soils, and climate.
- Students research evidence of Britain in the last ice-age – how do we know the extent of the ice?
- Student discussion of what causes ice-ages. Present different graphs and maps to show past ice-ages. Teacher presentation or student research on Milankovitch cycles, solar variation and volcanic activity.
- Consider how global warming might be affecting long-term climate change.

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- Choose a glacier that is retreating (e.g. Columbia or Alaska) and a current advancing glacier (e.g. Hubbard or Alaska) – compare photographic and map evidence. Discuss why some glaciers might be advancing whilst most are retreating.
- Create sketch maps of various snout positions of a retreating and an advancing glacier and add annotation to suggest reasons for the advance and retreat.

### Resources

- Use the [“Ice Age” Visualisation interactive globe app to see view the last glacial maxim \(UTAH Geology\)](#).
- Watch the [Earth: The Power of the Planet video The current ice age by Dr Iain Stewart explaining ice ages \(BBC\) \(3 minutes\)](#).
- View the [British Antarctic Survey webpage showing maps of ice extent in last ice age; ‘MRI’ scan reveals spectacular ice age landscapes beneath the North Sea](#).
- View the [Britice glacial mapping project, an interactive map allowing you to look at glacial landforms across the UK \(University of Sheffield\)](#).
- Watch the [video by Bill Nye No More Ice Ages explaining causes of ice ages \(YouTube\) \(5 minutes\)](#).
- View [mapping and photography of the world’s glaciers; Mapping the World’s Glaciers \(Antarctic Glaciers\)](#).

## Glacial systems

### Specification content

#### 3.1.4.1. Glaciers as natural systems

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

#### 3.1.4.3 Systems and processes

Glacial systems including glacial budgets.

### Links with other units

#### 3.1.1. Water and carbon cycles

##### 3.1.1.1. 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:

- What is the glacial system and how it relates to other Earth systems.
- What are the inputs, outputs, stores and flows/transfers of glacial systems.
- How positive and negative feedback change glacial systems and the concept of dynamic equilibrium.
- The glacial budget – mass balance and equilibrium.
- How to use graph skills to present mass balance data.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Note: this lesson will depend on units already studied. For example, if water and carbon cycles have already been taught then there is no need to cover the basics on systems again.
- Students to think of different Earth systems. Recap what they know about systems. Draw a simple systems diagram based on a simple activity such as making a cup of tea – consider the inputs, stores, processes and outputs.
- Give students a list of glacial system key terms and ask them to sort into inputs, stores, processes and outputs. Compare a glacial system to another Earth system e.g. hydrological cycle.
- Consider how glacial systems interact with other Earth systems.
- Model examples of positive and negative feedback loops in glacial systems. Ask students to come up with their own examples. Good starting points: increased carbon emissions, glacier retreat and melting of permafrost.

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- Refer back to previous lesson on advancing and retreating glaciers. How does the glacial system contribute to this? Why might inputs and outputs change?
- Question and answer task/paired discussion to identify what is meant by a glacial budget and dynamic equilibrium – can they identify the elements of a glacial budget? Refer to terms: ablation, accumulation, mass balance, equilibrium line.
- Use data from glacier measurements to plot a mass balance graph and calculate rate of retreat or advance. The [Norwegian Water resources directorate](#) has lots of data for Norwegian glaciers. Students can use this to draw line graphs and bar graphs or use the graphs to discuss the changes.

### Resources

- View useful [systems diagram and mass balance graphs; \*Glacier accumulation and ablation \(Antarctic Glaciers\)\*](#).
- View [time-lapse photography of a glacier over a year to show how ice is moved in the system; \*Time-lapse footage reveals ice sheet in crisis\* \(New Scientist\)](#).

## Ice formation and different glacier types

### Specification content

#### 3.1.4.3 Systems and processes

- Glacial systems and glacial budgets.
- Warm and cold based glaciers: characteristics and development.

### Learning outcomes

This lesson will help students to understand:

- How ice forms and how this operates as a system with a glacial system.
- The difference between warm based and cold based glaciers.
- The nature of glaciers, ice-sheets and ice-caps.
- The location of different types of glaciers.

### Suggested timing

1 hour

### Possible teaching and learning activities

- Referring back to the previous lesson, consider how the glacial system forms ice. Discuss how snow becomes ice. Students could complete flow diagrams to show the process of ice formation.
- In pairs/groups research cold and warm based glaciers. How are they different? Where do we find them?
- Annotate a diagram showing thermal regimes of warm and cold based glaciers to show the key differences and explain the idea of the pressure melting point.
- Students could research what a polythermal glacier is. These are commonly found in Svalbard. Using knowledge from last two lessons they could try and discuss why this might be the case.
- How else are glaciers classified? – Group presentation of different types of ice masses e.g. ice-sheet, ice-caps, piedmont glaciers, valley glaciers etc.
- Give students photos of different glacier types and ask each pair/group to describe the nature of it, and find a location. These could then be added to a global map. Refer back to lesson one on the [Global distribution of cold environments](#) to discuss reasons for these different types of glacier.

### Resources

- Watch the [Earth: The Power of the Planet video How glaciers form by Dr Iain Stewart showing the formation of glacial ice \(YouTube\) \(3 minutes\)](#).
- View the [Cool Geography webpage showing the thermal regimes of cold and warm based glaciers](#).
- View the useful webpage [Polythermal glaciers, Svalbard \(Aberystwyth University\)](#).
- View the academic webpage [Glacial thermal regime on types of glaciers with useful information and images \(Antarctic Glaciers\)](#).
- View [different types of glaciers and examples \(U.S. National Park Service\)](#).

## Glacial processes

### Specification content

#### 3.1.4.3. Systems and processes

Geomorphological processes:

- weathering: frost action, nivation
- ice movement: internal deformation, rotational, compressional, extensional and basal sliding
- erosion: plucking, abrasion
- transportation and deposition.

### Learning outcomes

This lesson will help students to understand:

- How ice moves in different ways – internal deformation, rotational, compressional, extensional and basal sliding.
- How ice movement is a factor in warm and cold based glaciers.
- The main processes in the formation of glacial landscapes – weathering, nivation, erosion, transport and deposition.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Give pairs/groups of students different types of movement – text and diagrams. Students can then peer-teach their movement.
- Students discuss which movement would be most important in cold based glaciers and explain why and then repeat this for warm based glaciers.
- Use past knowledge of glacial landforms to link movement to glacial landforms e.g. corries.
- Look at images of crevasses and ask students to explain how movement links to crevasse formation.
- Study a picture of a glacial deposit and ask students to describe it. Focus on angularity and lack of sorting. Ask students to consider the processes which may have formed the deposit e.g. frost shattering transport and erosion.
- Students to consider how glacial processes might differ from river or coastal processes. How might this impact on erosion, transport and deposition?
- Students research frost shattering and carbonation in glacial landscapes and explain why these are dominant.
- Teach the process of nivation and ask students if it is an example of weathering, erosion, transport or deposition and to explain their answer.
- Teach the processes of abrasion and plucking and ask students how this will affect what the ice does to the bedrock.
- Show a diagram of three types of transport: subglacial, englacial and supraglacial. Show pictures of different types and ask students to annotate with type of transport and where the material has come from and where it might be deposited.

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- Show pictures of odd objects that have been transported in ice and then deposited. Students to discuss why these are preserved and how this makes ice deposition different to that of river or coastal deposition (for example mummified people, shoes etc).
- Draw a table with three column headings: Glacial, Fluvioglacial and Periglacial. Include at least three rows headed: Processes, Landforms and Notes on landscape. As students progress through the next few lessons they can add to this table to produce a summary the three landscapes.

### Resources

- Read and watch videos about [different types of movement, Deformation and sliding \(Antarctic Glaciers\)](#).
- Watch the video of [Mont Blanc, Underneath a glacier time lapse \(YouTube\) \(1 minute\)](#).
- Watch the video from the [Smithsonian Institute about a 5300 year old body revealed by a retreating glacier This 5,300-Year-Old Corpse Was Found by Accident \(YouTube\) \(3 minutes\)](#).

## Glacial landscapes: Landforms of erosion

### Specification content

#### 3.1.4.3 Systems and processes

Geomorphological processes:

- weathering: frost action, nivation
- ice movement: internal deformation, rotational, compressional, extensional and basal sliding
- erosion: plucking, abrasion
- transportation and deposition.

#### 3.1.4.4 Glaciated landscape development

- Origin and development of glaciated landscapes.
- Erosional and depositional landforms: corries, arêtes, glacial troughs, hanging valleys, truncated spurs, roches moutonnées.
- Characteristic glaciated landscapes.

#### 3.1.4.6 Quantitative and qualitative skills

Students must engage with a range of quantitative and relevant qualitative skills, within the theme landscape systems. These should include observation skills, measurement and geospatial mapping skills and data manipulation and statistical skills applied to field measurements.

### Learning outcomes

- This lesson will help students to understand:
  - How processes of nivation, glacial erosion, transport and deposition form glacial landforms.
  - How ice movement contributes to the formation of glacial landforms such as corries and roches moutonnées.
  - The connection between different glacial landforms and glaciated landscapes.
- Practice statistical skills to consider the orientation of corries.

### Suggested timing

3 hours

### Possible teaching and learning activities

- Questions and answers activity to establish that landscapes that are currently glaciated may once have been fluvial landscapes with different characteristics. Opportunity to draw a diagram of a model upland fluvial landscape compared to a model glaciated valley landscape.
- Introduce an image of a current glaciated landscape and a UK glaciated landscape and ask students to identify landforms and features of the landscapes.
- Watch the video [Evidence of UK glaciation and deglaciation \(Time for Geography\) \(8 minutes\)](#) and ask students if they can now identify more landforms from the images.

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- Discuss alternative names for landforms found in different resources e.g. cirques, u-shaped valleys, horns etc.
- Give students a table with images of different landforms. Around the classroom place notes on formation and ask students to match these up with their images and complete the table showing an image with notes on formation.
- Group presentations on different landforms – students teach the rest of the class how their landforms are formed, considering erosion, transport, deposition and ice-movement where applicable.
- Give students sentences about formation of corries and ask them to sequence the sentences in the correct order. Ask them to do this for another landform and peer test.
- Give each student an image or sketch of a landform – as a group construct a 'map' on a large sheet of paper to show where these might be found in a glaciated landscape. Note, this could be added to in subsequent lessons to show depositional and fluvio-glacial landforms.
- Fieldwork opportunity – visit a glaciated landscape and ask students to sketch and identify landforms. Students could measure direction and assess direction of ice-flow using corries, striations, roches moutonees etc.
- Use secondary data to compile a table to show the orientation of corries in two areas e.g. Glyders and Arran. Use statistical tests such as central tendency, interquartile range and standard deviation to consider if there is any difference in the orientation for two areas.
- Use an OS map to identify glacial landforms e.g. Lake District, Snowdonia etc.

### Resources

- View the [Britice glacial mapping project, an interactive map allowing you to look at glacial landforms across the UK \(University of Sheffield\)](#).
- View the [Antarctic Glaciers webpage with lots of images from across the globe Introduction to glacial landforms \(Antarctic Glaciers\)](#).
- View the [Cool Geography webpage with links to lots of glacial landforms](#).
- View the [Field Studies Council's useful skills page and data for corrie orientation](#).
- Read about [Upland glacial landscapes in North Wales \(Alexander Kay\)](#).

## Glacial landscapes: Landforms of deposition

### Specification content

#### 3.1.4.3 Systems and processes

Geomorphological processes:

- weathering: frost action, nivation
- ice movement: internal deformation, rotational, compressional, extensional and basal sliding
- erosion: plucking, abrasion
- transportation and deposition.

#### 3.1.4.4 Glaciated landscape development

- Origin and development of glaciated landscapes.
- Erosional and depositional landforms: corries, arêtes, glacial troughs, hanging valleys, truncated spurs, roches moutonnées.
- Characteristic glaciated landscapes.

### Learning outcomes

This lesson will help students to understand:

- The link between erosion and deposition and how this forms glaciated landscapes.
- The characteristics and formation of landforms of deposition.
- Where depositional landforms can be located in a glaciated landscape.

### Suggested timing

1 hour

### Possible teaching and learning activities

- Discuss where and why we might find landforms of deposition.
- Show an image of glacial till – discuss how it is different from a river deposit and the reasons for this.
- Show images of different types of moraine – students suggest reasons for their different locations. Draw a sketch map to show these and annotate to show characteristics and reason for deposition.
- Show images of erratics and discuss where these might have come from and why they are useful in studying movement of ice.
- Students research different theories on the formation of drumlins and present their ideas to the class. Debate the different theories. Class discussion about why there are different theories.
- Students place sketches and/or labels of landforms onto the large landscape 'map' from the last lesson.
- Add all the information from these past lessons onto the overall table to show processes and landforms.

## Resources

- View the [Antarctic Glaciers webpage on different types of moraine with useful images.](#)
- View the [Britice glacial mapping project, an interactive map allowing you to look at glacial landforms across the UK \(University of Sheffield\).](#)
- View the [Yorkshire Dales useful webpage showing drumlins in Yorkshire and other landforms.](#)

## Fluvioglacial landscapes

### Specification content

#### 3.1.4.3 Systems and processes

Fluvioglacial processes: meltwater, erosion transportation and deposition.

#### 3.1.4.4 Glaciated landscape development

- Fluvioglacial landforms of erosion and deposition: meltwater channels, kames, eskers, outwash plains.
- Characteristic fluvioglacial landscapes.

### Learning outcomes

This lesson will help students to understand:

- The fluvioglacial processes that occur in glaciated landscapes.
- The relative importance of erosion and deposition in fluvioglacial landscapes.
- How fluvioglacial deposits are different from glacial and fluvial deposits.
- The characteristics and formation of different fluvioglacial landforms.
- Where fluvioglacial landforms are located in glaciated landscapes.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Show images of glacial till, fluvial deposit and a fluvio-glacial deposit. Students annotate them to show how they are similar and different. Discuss reasons for these differences.
- Give a list of words associated with deposits and ask students which ones they would use with different images e.g. angular, sub-rounded, rounded, stratified, sorted etc. Describe fluvioglacial deposit and ask students to explain characteristics such as sub-rounded, sorted, stratified and sand/gravel.
- 'Fluvioglacial erosion is powerful!' Ask students to discuss in groups why this statement is true.
- Refer back to lesson on transport – ask students to recap three types of glacial transport and explain why these are all places where fluvioglacial transport can occur, along with outwash. Students sketch a diagram to show this.
- Students research fluvioglacial landforms. Produce a fact card on one and compile in groups to produce a revision booklet.
- Give students a range of images and ask them to identify the landform and annotate to show its formation.
- Research examples of different types of fluvioglacial landforms finding an example of each one from the UK and beyond the UK. Discuss whether some are more common than others.
- Discuss how you know whether a landform is fluvioglacial – what factors would you need to look at before identifying?
- Add images of landforms to the large class landscape 'map' produced in previous lessons and complete summary table of processes and landforms.

## Resources

- Watch the [video explaining the formation of kames and eskers \(YouTube\) \(1 minute\)](#).
- View the [useful summary of fluvio-glacial processes and landforms \(Cook Geography\)](#).
- Read the [introduction to fluvio-glacial landforms \(Antarctic Glaciers\)](#).
- View [examples of fluvio-glacial landforms in Svalbard \(Antarctic Glaciers\)](#).

## Periglacial landscapes

### Specification content

#### 3.1.4.3 Systems and processes

Periglacial features and processes: permafrost, active layer and mass movement.

#### 3.1.4.4 Glaciated landscape development

- Periglacial landforms: patterned ground, ice wedges, pingos, blockfields, solifluction, lobes, terracettes, thermokarst.
- Characteristic periglacial landscapes.
- The relationship between process, time, landforms and landscapes in glaciated settings: characteristic glaciated and periglacial landscapes.

### Learning outcomes

This lesson will help students to understand:

- The periglacial processes that occur in glaciated landscapes.
- The characteristics and importance of permafrost.
- How different periglacial landforms are formed by periglacial processes.
- Where periglacial landforms are located globally.
- The link between processes and landforms found in glacial, fluviglacial and periglacial landscapes.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Recap and review previous learning on Tundra environments – characteristics. Discuss feedback loops involving permafrost melting – students discuss the importance of periglacial landscapes.
- Students map location of different types of permafrost – continuous, discontinuous and sporadic. Annotate map to explain location – what factors are the most important?
- Student discussion about how the Tundra climate will influence periglacial processes.
- Recall process of nivation – discuss how this process might operate in Periglacial landscapes. Teach processes of frost-heave and solifluction. Students can then use these processes to identify how they might affect landforms.
- Group work to investigate different landforms and peer teaching to rest of the class.
- Give students images of periglacial landforms and ask them to describe how they were formed.
- Students investigate examples of periglacial landforms across the globe. Show examples from the UK and ask students to explain their location. Student research a case study of a periglacial landscape.
- Fieldwork opportunity – investigate a periglacial landscape (good examples on South Devon coast and Dartmoor). Conduct field sketches, measure solifluction lobes and direction of sediment in deposits.

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- Add images/sketches of periglacial landforms to the overall landscape sheet from glacial landscapes lesson. Complete summary table of processes and landforms.
- Student discussion about the links between the three landscapes and how these might change over time. Give students images of different glaciated landscapes and ask what they might look like in 100 years given current predictions of global warming.
- Hand students images from across all three glaciated landscapes and ask them to identify the landscape, describe the characteristics and explain formation using processes.

### Resources

- View the [Antarctic Glaciers webpage showing different periglacial landforms.](#)
- View [secondary data on evidence for glaciation in the Drakensburg mountains, South Africa \(Royal Geographical Society\).](#)
- View the [Cool Geography webpage with climate graphs and landforms for periglacial areas.](#)
- View the [University of Regina's useful webpage for research with processes and landforms, with wide range of images and locations.](#)

## Case study of a glaciated landscape at a local scale

Please note: lesson content will very much depend on the chosen location and landforms present. Local scale means a small area and it could be a location in the UK or elsewhere.

### Specification content

#### 3.1.4.6 Quantitative and qualitative skills

Students must engage with a range of quantitative and relevant qualitative skills, within the theme landscape systems. These should include observation skills, measurement and geospatial mapping skills and data manipulation and statistical skills applied to field measurements.

#### 3.1.4.7 Case studies

Case study(ies) of glaciated environment(s) at a local scale to illustrate and analyse fundamental glacial processes, their landscape outcomes as set out above and engage with field data.

### Learning outcomes

This lesson will help students to understand:

- How different landform and processes interact to form a glaciated landscape at a small scale.
- The interaction between processes and formation of landforms in a small scale setting.
- How landscapes change over time.

### Suggested timing

1 hour

### Possible teaching and learning activities

- Use an OS map or satellite image of a small scale area to identify glacial landforms present.
- Students research a small scale area to identify glacial landforms to produce a 'guide to the area'. Investigate factors affecting the glaciation e.g. geology, topography, relief and aspect.
- Investigate the direction a glacier flowed within a glaciated valley.
- Map features that are present on a base map and annotate to show different characteristics and links between landforms. Locate images of different landforms.
- Fieldwork opportunity – visit the chosen location and conduct fieldwork activities. For example sketch maps, orientation of landforms, orientation of striations and recording height of landforms.

### Resources

- View [image/diagrams of Easedale Valley in the Lake District \(Cool Geography\)](#).
- View the [introduction to the Easedale Valley produced by the Field Studies Council \(although aimed at GCSE it is still a useful introduction\) \(Story Maps\)](#).
- Read about [Coppermines Valley in Cumbria, with data and notes on an investigation into glacial landforms \(Routes Journal\)](#).

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- Read the [Field Studies Council document on glacial landforms found in the Ogwen Valley, Snowdonia \(Alexander Kay\)](#).
- Read [information on the Isle of Arran and its glacial landscape \(Arran Geopark\)](#).

## Environmental fragility

### Specification content

#### 3.1.4.5 Human impacts on cold environments

- Concept of environmental fragility.
- Human impacts on fragile cold environments over time and at a variety of scales.
- Recent and prospective impact of climate change.
- Management of cold environments at present and in alternative possible futures.

### Links with other units

#### 3.2.1 Global systems and global governance

##### 3.2.1.5.1 Antarctica as a global common

An outline of the contemporary geography, including climate, of Antarctica (including the Southern Ocean as far north as the Antarctic Convergence) to demonstrate its role as a global common and illustrate its vulnerability to global economic pressures and environmental change.

### Learning outcomes

This lesson will help students to understand:

- The concept of environmental fragility in cold environments.
- How this environmental fragility is impacted by human activities.
- Environmental fragility in two different cold environments.
- How humans can attempt to manage environmental fragility.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Recap Tundra and Alpine environments – class discussion on why these environment might be fragile. Recap feedback loops and nutrient cycling.
- Outline the concept of environmental fragility and ask students to apply this to glaciated environments.
- Group work: give each group a different human threat to cold environments e.g. fishing, mining, oil drilling or tourism. Students research how this threat impacts the cold environments. Groups present these threats back to the others. Each group investigates the management strategies of a different threat and the effectiveness of these.
- Focus on a specific threat to cold environments and how the fragile environment is impacted by this threat. For example tourism in the Alps and the impact on the fragile Alpine ecosystem. Consider alternative futures as the climate gets warmer and how this might impact the ecosystem and physical landscape of the Alps.
- Students investigate an example of a community where the environmental fragility is impacted from human activities. For example the Nenets people of Siberia, impacted by resource extraction.

## Resources

- Read the [National Geographic's article \*Tundra Threats Explained\*](#) – considers the impacts of human activities on indigenous peoples of the Arctic and some of the strategies being employed to manage the threats.
- Watch the [video \*Human Impacts on Alpine Areas\* \(YouTube\) \(3 minutes\)](#).
- Read the [article \*Human Impacts on Antarctica and Threats to the Environment – Overview Threats to Antarctica\* \(Cool Antarctica\)](#).

## Impact of climate change on cold environments

### Specification content

#### 3.1.4.5 Human impacts on cold environments

- Concept of environmental fragility.
- Human impacts on fragile cold environments over time and at a variety of scales.
- Recent and prospective impact of climate change.

### Links with other units

#### 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 particular reference to climate.
- The relationship between the water cycle and carbon cycle in the atmosphere.
- The role of feedbacks within and between cycles and their link to climate change and implications for life on Earth.

#### 3.2.1 Global systems and global governance

##### 3.2.1.5.1 Antarctica as a global common

- An outline of the contemporary geography, including climate, of Antarctica (including the Southern Ocean as far north as the Antarctic Convergence) to demonstrate its role as a global common and illustrate its vulnerability to environmental change.
- Threats to Antarctica arising from climate change.

### Learning outcomes

This lesson will help students to understand:

- The impacts of recent climate change on both the physical and human environment in cold environments.
- Impacts of prospective climate change on cold environments.
- Alternative futures for cold environments at risk from climate change.

### Suggested timing

2 hours

### Possible teaching and learning activities

- Use maps of the Arctic at different time periods, including future projections. Students annotate these to describe the changes and suggest impacts on the physical characteristics, ecosystems and human populations.
- Choose one indigenous population and research the impacts climate change has already had and what might happen in the future.
- Research project to study the threat from climate change for example, on the glaciers of the Himalayas and its impact on people living in Pakistan. Students can use images to show recent change and then predict future change with a variety of scenarios on glaciers.

## A-LEVEL GEOGRAPHY – 7037 – GLACIAL SYSTEMS AND LANDSCAPES – SCHEME OF WORK

- Present how local people are impacted and research strategies being used to manage these. This could be used to create a large display showing observable changes and ideas of prospective change.
- Students could study the impact of recent climate change on Antarctica and then discuss different models and prediction for future change. Class discussion on mitigation strategies and the impact on changes in the physical environment of Antarctica.
- Student debate to discuss importance of climate action and the consequences of inaction in relation to cold environments.

### Resources

- View [sea ice maps for the Arctic Ocean over time \(Arctic Portal\)](#).
- View the [Yale University webpage on impacts of glacial melting in the Himalayas](#).
- View the [NASA webpage about glacier melting viewed from satellite including a 4 minute video](#).
- View [images of Switzerland's glaciers retreating \(Euro News\)](#).
- Read about the [impacts of climate change in Antarctica \(Discovering Antarctica\)](#).

## sCase study: Impacts of human activities on the Tundra

### Specification content

#### 3.1.4.5 Human impacts on cold environments

- Concept of environmental fragility.
- Human impacts on fragile cold environments over time and at a variety of scales.
- Recent and prospective impact of climate change.
- Management of cold environments at present and in alternative possible futures.

#### 3.1.4.7 Case studies

Case study of a contrasting glaciated landscape from beyond the UK to illustrate and analyse how it presents challenges and opportunities for human occupation and development and evaluate human responses of resilience, mitigation and adaptation.

### Learning outcomes

This section will help students to understand:

- The challenges and opportunities for living in Tundra areas.
- How Tundra areas present opportunities for development and resource security.
- The threats to Tundra area from human developments.
- How humans are able to adapt to these opportunities and challenges.
- Management strategies used to minimise threat of resource development.
- Alternative futures for Tundra case study area.

### Suggested timing

3-4 hours

### Possible teaching and learning activities

- Study maps of indigenous populations in Tundra areas and/or data about occupation of Tundra areas.
- Divide class into two: one half of the class investigates and presents the challenges to living in Tundra areas and the other half investigates opportunities.
- Choose one indigenous group to investigate, e.g. Gwich'in of the Yukon, to form the case study.
- Students research traditional economies of the indigenous group and investigate how these economies have changed over time. For example, Gwich'in are traditionally nomadic but are now more settled, though they are intrinsically linked to caribou hunting.
- Use maps of oil or gas exploration to show how these might threaten the cold environment and human occupation. Recap the previous lesson on threats to cold environments. Apply this to the case study area.
- Consider the opportunities presented by resource development in Tundra areas and apply to case study area. Discuss the benefits at a range of scales.

## A-LEVEL GEOGRAPHY – 7037 – GLACIAL SYSTEMS AND LANDSCAPES – SCHEME OF WORK

- Group work: give each group a different management strategy for protecting the Tundra case study area, both the natural and human environment. For example protected areas such as Arctic National Wildlife Refuge (ANWR), technological advancements to protect the permafrost, employment, cultural and well-being programmes for the Gwich'in. Students research these and present to the class or compile a class resource. They could extend this by completing a SWOT analysis on the effectiveness of each strategy.
- Investigate how an indigenous group has adapted to life in the 21<sup>st</sup> century. Important to consider a variety of viewpoints from different perspectives within the indigenous group e.g. gender, age etc. For example consider access to university education and technological developments.
- Students present arguments for and against resource development in Tundra areas. This could be completed 'café style': place statements for and against around the room on large paper. For example 'Oil is needed for resource self-sufficiency for the US' or 'Oil is endangering the traditional way of life for the Gwich'in'. Students visit each station and add evidence to support these statements.

### Resources

- View [useful information including maps of indigenous populations of the Arctic \(Arctic Centre\)](#).
- Read [information produced by the Gwich'in people \(GTC Department of Cultural Heritage\)](#).
- Watch [videos made by Gwich'in young people interviewing elders in the community about their lived experiences and how life has changed; Gwich'in Elder: Mary Teya \(YouTube\) \(5 minutes\)](#).
- Visit [Alaska's Resource Development Council website looking at different types of resources in Alaska](#).
- Read the [article \*The Long, Long Battle for the Arctic National Wildlife Refuge\* \(NRDC\)](#).
- View the [useful background resource on oil exploration in Alaska, aimed at GCSE level \(Tutor2u\)](#).