Arctic and alpine environments

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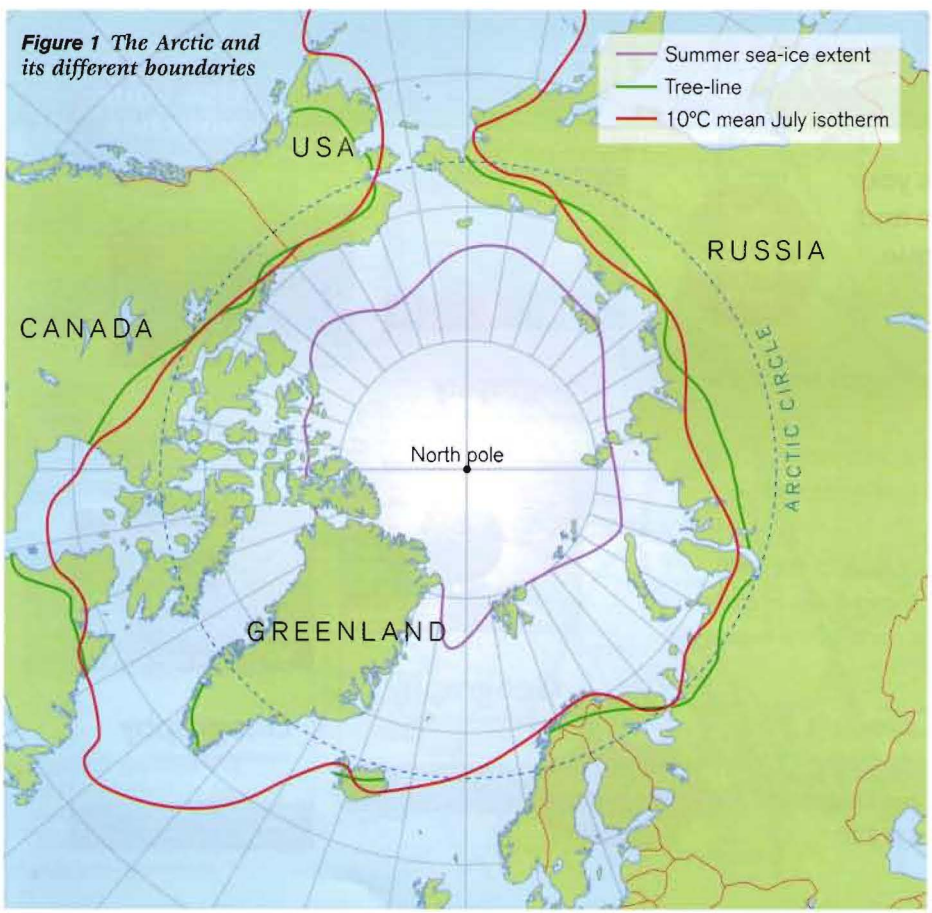

***Figure 1** The Arctic and its different boundaries*

With the world to pick from, why do some geographers choose to study cold places? Arctic and alpine regions have a certain fascination, and contain true wilderness areas and awe-inspiring landscapes. Cold environments are covered by all A-level courses and this article is relevant to options on cold environments, extreme environments and glacial environments. It considers arctic and alpine environments in terms of their climate, geomorphology and biogeography.

What and where are arctic and alpine environments, and what are their similarities and differences? It is common to use lower-case letters for the adjectives artic and alpine, and capital letters for the names of the locations: the Arctic and the Alps. Both types of locality are associated with low average temperatures, and may be mapped together, for example the tundra

▲ *Northern Finland is north of the Arctic Circle*

▶ *The spring gentian,* Gentiana verna, *is a typical alpine plant*

◀ *The Italian Alps*

climate in Köppen's classification, regularly used in atlases. They also have similarities in geomorphology and biogeography, but it is more convenient to define, describe and explain them separately. This article concentrates on the northern hemisphere.

Arctic environments

The ancient Greeks, who could be said to have invented geography, used the word *Arktikos* for the northern constellation of the Great Bear. The simplest way to define arctic environments is to say that they are inside the Arctic Circle (66°33′39″ North with the Earth's present orbital inclination). Figure 1 shows a polar projection with the Arctic Circle indicated. A bit of thought will suggest that this line on its own is unlikely to be a satisfactory definition in detail – there will not be a sudden change in climate on either side of it. However, it does provide a precisely defined boundary. North of the Arctic Circle the sun fails to set on the summer solstice and fails to rise at the winter solstice. The further north you travel, the longer the summer daylight and winter night.

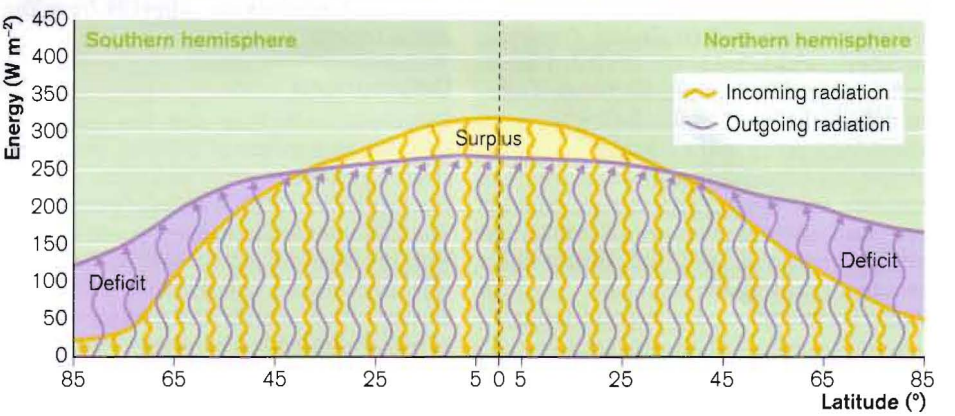

Figure 2 *Annual radiation budget around the world*

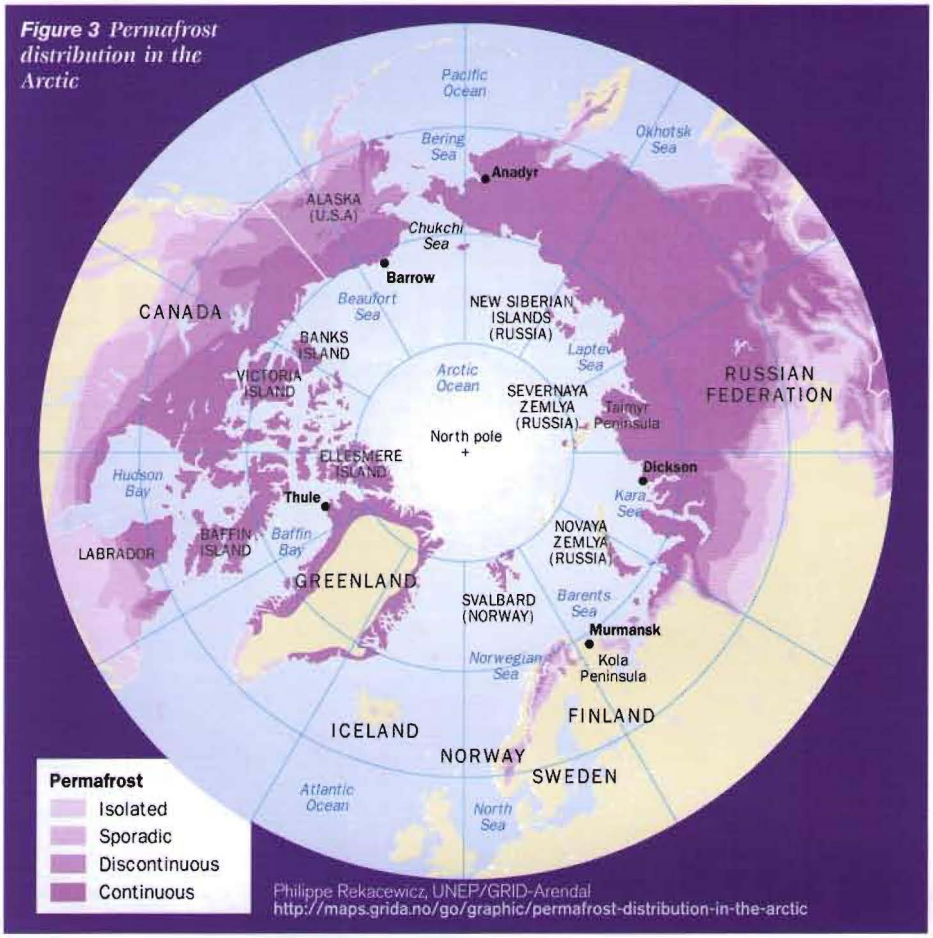

***Figure 3** Permafrost distribution in the Arctic*

The sun's maximum inclination at the Arctic Circle at the summer solstice will only be about 47°, so its angle in the sky will be low, providing limited heat (insolation). Twenty-four hour daylight is not enough to compensate for the low solar angle. In fact, this is a distinguishing characteristic of arctic cold environments: the input of solar energy is limited. They are regions of net negative radiation balance (Figure 2) and rely on heat imported from lower latitudes.

Climate

The climate of arctic regions is varied, but the 10°C mean July isotherm (Figure 1) is a possible boundary line. Geographers have considered changing this boundary, particularly because many locations experiencing extreme winter cold (including Omyakon in Siberia which holds the northern hemisphere record for a minimum temperature) lie outside the line. Despite the low temperatures, snow cover in the Arctic is limited, as almost any photograph of an arctic region in summer will show. Precipitation amounts are small, snow is often drifted into gullies and depressions, and the spring thaw removes nearly all the remainder. The high Arctic is often referred to as polar desert.

Geomorphology

The lack of solar energy is an important control on physical systems (e.g. landforms) and biological systems. For the geomorphologist, an important defining characteristic of arctic environments could be the presence of permafrost – perennially frozen ground (Figure 3). The distribution of permafrost around the north pole in the northern hemisphere is obvious, but notice how it extends well to the south of the Arctic Circle in the interiors of continents. Geomorphologists use the term **periglacial** to describe environments and processes associated with, but not necessarily restricted to, regions of permafrost.

Arctic regions have little tectonic activity. They are dominated by large areas of lowland based on Precambrian shields or the sedimentary rock overlying them. There are vast lowlands over much of Siberia and northern Canada, very different from the alpine regions.

Biogeography

Biogeographers may use the northern tree line as a means of defining the Arctic (Figure 1). Conifers grow well to the north of the Arctic Circle and in areas of permafrost. The 10°C July isotherm corresponds roughly with the tree line. Arctic environments are typically treeless, and dominated by dwarf shrubs which include low-growing species of willow and birch. This vegetation cover is generally referred to as **tundra**.

The distribution of the creature most symbolic of the Arctic, the polar bear (*Ursus maritimus*), is more limited than any of the other arctic boundaries already discussed (Figure 4). Note, however, that the bear's range extends well to the south along Hudson Bay and James Bay in Canada.

Sadly, the polar bear's range is likely to become even more reduced as the sea ice melts. For the oceanographer the annual advance and retreat of the pack ice is one of the most striking features of the Arctic. The sea ice reached its lowest minimum recorded extent in 2007. Unlike the Antarctic, which is a continental land mass mostly buried under a vast ice sheet, and surrounded by ocean, the Arctic is centred on an ocean, with the land masses around the edges. Glaciation in the Arctic is relatively limited, apart from the ice sheet on Greenland.

Alpine environments

The word alpine obviously derives from the Alps. High mountain ranges around the world have been created in geologically recent times by plate collisions. If the mountains are high enough, alpine environments can be found at the equator, above about 4,000 metres. In mid-latitudes they occur over 3,000 metres. In locations on the edge of the Arctic, such as Scandinavia, alpine landforms and processes will be found in lower, more ancient mountain ranges, above 1,000 metres.

Climate

It is difficult to give a simple definition of alpine climates. Permanent snow and glacier ice can be found from the equator (although this is disappearing with global warming), where seasonal effects are largely absent, to high latitudes, where mountain ranges have arctic and alpine characteristics. Alpine environments do not usually have the extreme low minimum temperatures of arctic ones, but the effect of the environmental lapse rate (the higher you go, the colder it gets) is to guarantee low average temperatures.

Aspect is an important factor, with south-facing slopes considerably warmer as they receive more solar radiation. There is a strong correlation between altitude and precipitation, so alpine environments often have heavy snowfall which accumulates and is transformed into glacier ice. Precipitation totals fall off at the top of very high mountain ranges.

Geomorphology

A distinguishing characteristic of alpine environments is the presence of glaciers and the landforms they produce. The low temperatures are also associated with periglacial processes and landforms, including permafrost. The steep slopes make slope processes an important consideration and a source of environmental hazards.

Biogeography

Mountain ranges create very particular niches for alpine species, providing refuges and isolating populations. As in arctic environments there is a tree line, although in alpine environments the extent of tree cover is limited by altitude rather than latitude. The tree line is influenced by local factors, such as aspect and soil depth, not just temperature. Above the tree line smaller shrubs and herbaceous plants are found.

The human dimension

Human beings have occupied alpine and arctic environments for thousands of years, often thriving as nomadic hunters and gatherers. In the last 50 years lifestyles have modernised and traditions have come under pressure. In recent years there have been growing calls for autonomy from arctic peoples, for example in Canada and Greenland. They have formed the Arctic Council as a forum for discussion, lobbying and research. At present research in cold places is more important than ever as the effects of human-induced global warming are felt. The impacts on arctic and alpine environments are likely to be among the most far-reaching, and will have serious consequences for the people living in those regions.

***Figure 4** The normal range of polar bears in the Arctic*

Discussion points and activities

(1) As this article points out, we can map cold environments in many ways. Looking at an atlas will raise questions about some locations. Compare and contrast the environments of Alaska, Iceland and Kamchatka.

(2) Account for the variability in the different criteria used to define arctic regions.

(3) Use Google Earth to explore the arctic and alpine regions, trying to spot the tree line.

Further information

Anderson, D. (2004) *Glacial and Periglacial Environments*, Hodder and Stoughton

Knight, J. (2008) *Glaciation and Periglaciation Advanced Topic Master*, Philip Allan Updates.

Moore, P. D. (2006) *The Tundra*, Chelsea House.

Sale, R. (2008) *The Arctic: the Complete Guide*, Frances Lincoln

Alpine temperature data: www.tutiempo.net/en/Climate/JUNGFRAUJOCH/67300.htm

The Arctic Council: www.arctic-council.org

Grid-Arendal/UNEP, 'Environmental knowledge for change': www.grida.no

US National Oceanographic and Atmospheric Administration: www.arctic.noaa.gov/

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Key words

Cold environments | Arctic | Alpine | Glacial | Periglacial

Key points

- Arctic and alpine cold environments are characterised by low mean annual temperatures and the absence of trees. In the Arctic the cold is related to low levels of solar radiation, whereas in alpine places the chief factor is the environmental lapse rate.
- When we examine different locations, both factors come into play, with reduced insolation becoming more important as we move away from the equator.
- As a consequence of the low temperatures, there are characteristic landforms, flora and fauna.