



UNIVERSITY OF THE ARCTIC

Module 1

Concepts of Nordicity

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Key Terms and Concepts

- nordicity
- parallels of latitude
- meridians of longitude
- obliquity of the ecliptic
- climate classification systems
- evapotranspiration
- soil moisture deficit
- permafrost
- biome
- ecosystem
- polar units
- Nordic Index

Learning Objectives/Outcomes

Upon completion of this module you should be able to

1. develop an understanding of the various criteria employed to distinguish between Subarctic and Arctic environments.
2. provide concise definitions for the key terms and concepts.
3. describe the components of the coordinate grid system used on maps of the Earth's surface.
4. describe the effects of the Earth's seasonal positions in relation to the Sun.
5. list the different climate classification systems and explain the measurements and notation they use to classify regional climates.



Reading Assignments

Hamelin (1978), *Canadian Nordicity: It's Your North, Too*.

Young (1989), chapter 1: "Bears, Boreas and Celestial Mechanics," in *To the Arctic: An Introduction to the Far Northern World*, 1–24.

Overview

The concept of what constitutes the North has proven difficult to define precisely. The vast region of the circumpolar North includes portions of three continents—North America, Europe, and Asia—as well as the Arctic Ocean basin and its marginal seas, and the world's largest non-continent island, Greenland. Various classification schemes have been promoted to define the boundaries of the North. Several of these classification schemes will be examined in this module with a view to developing an appreciation of the various approaches adopted by researchers to define the North.

Lecture

Latitude and Longitude

Earth scientists examine phenomena that occur over a wide range of spatial scales, above, on, and beneath the Earth's surface. In order to describe these phenomena, it is important to know where they occur in relation to the Earth's surface: a coordinate grid system is needed. Earth scientists use a coordinate grid system consisting of *parallels of latitude* and *meridians of longitude* to fix the position of phenomena on the surface of the Earth. This coordinate grid system uses two fundamental reference lines for measuring the position of points on the Earth's surface: the *equator* (a parallel of latitude) and the *prime meridian* (a meridian of longitude).

Latitude measures the position of a given point north or south of the equator. With respect to latitude, the coordinate grid system is divided into broad latitude zones:

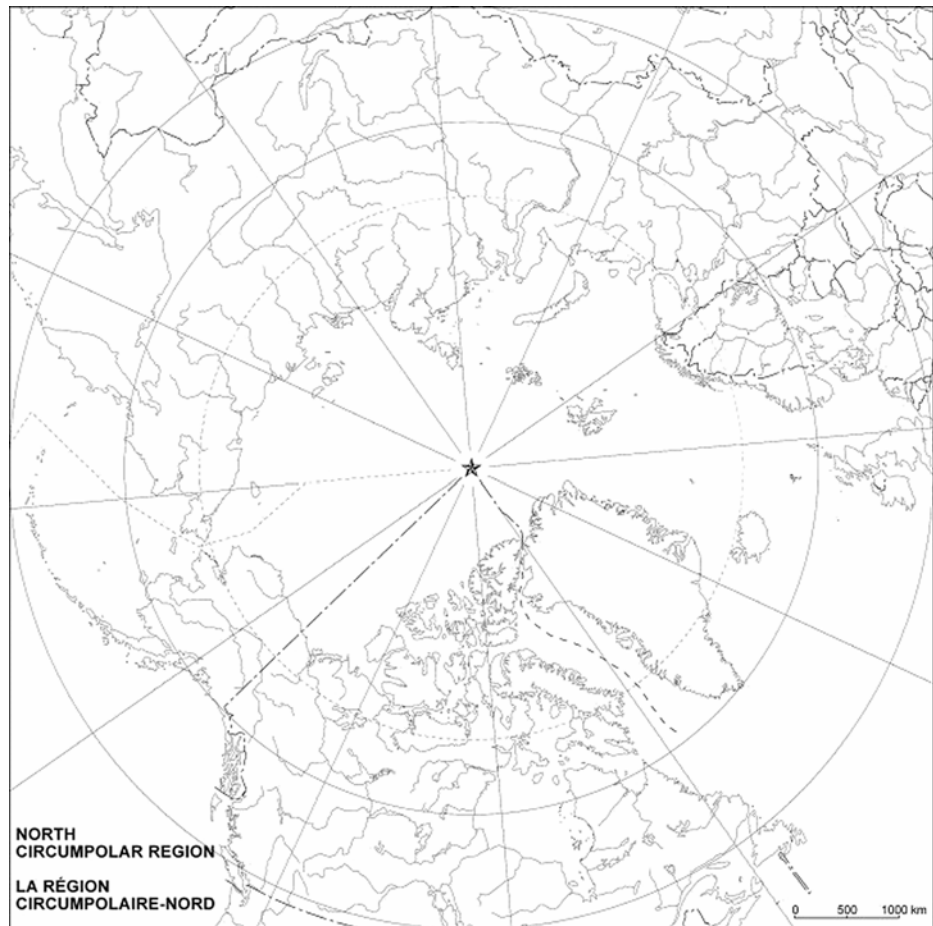
- the Equatorial zone (lat 10° N to 10° S)
- the Tropical zones (10–25° north and 10–25° south)
- the Subtropical zones (25–35° north and 25–35° south)



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- the Middle Latitude (or Midlatitude) zones (35–55° north and 35–55° south)
- the Subarctic and Subantarctic zones (55–60° north and 55–60° south)
- the Arctic and Antarctic zones (60–75° north and 60–75° south)
- the Polar zones (75–90° north and 75–90° south)

Using this information, we can define the circumpolar North as that portion of the northern hemisphere lying north of the 55th parallel of latitude (see fig. 1.1). Throughout the course we will be making frequent reference to physical phenomena that occur within the Subarctic, Arctic, and Polar zones in the North.



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Fig. 1.1 View of the circumpolar North illustrating the parallel of latitude at 55° north and the Arctic Circle at 66°33' north



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Longitude measures the position of a point east or west of the prime meridian. The prime meridian is a reference point that is recognized internationally as the line extending from the North Pole to the South Pole that passes through the Royal Observatory at Greenwich, England. Meridians of longitude, unlike parallels of latitude, are not parallel to one another; they converge at the poles. The meridians are labelled from 0° to 180° east of the prime meridian and from 0° to 180° west of the prime meridian. The International Date Line, the imaginary line on the Earth that separates two consecutive days, lies mostly on the 180° meridian and makes up the other half of the prime meridian.

Student Activity

1. What are the differences between parallels of latitude and meridians of longitude?
 2. What northern city is nearest the International Date Line? (Use a map.)
 3. How were the zero degrees parallel of latitude and the zero degrees meridian of longitude established, and what are they called?
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Earth-Sun Relations

From the perspective of an astronomer, it is the orientation of the Earth relative to the Sun and the Sun's influence on the input of solar radiation to the Earth's atmosphere that is of greatest interest. Northern environments share these important characteristics:

- They experience extreme seasonal variations in the receipt of solar radiation.
- Only small quantities of energy are available at the surface of the Earth to do the work of melting snow and ice, thawing permafrost, warming the atmosphere in contact with the ground surface, evaporating water, and facilitating the processes of photosynthesis and transpiration within plants.

The tilt of Earth's rotational axis, known as the *obliquity of the ecliptic*, causes the seasonal variations in day length and in the quantity of solar radiation that reaches Earth's atmosphere. It also provides the basis for the location of the Arctic Circle at $66^{\circ}33'$ N (see fig. 1.2). The Arctic Circle is defined as



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- the point where the Sun's rays are tangent to the Earth's surface at midnight at the summer solstice (the longest day of the year: around June 21)
- the point where the Sun's rays are tangent to the Earth's surface at noon at the winter solstice (the shortest day of the year: around December 21)

Fig. 1.2 Animation of the influence of obliquity on the seasonal variation in the receipt of solar radiation at Earth's surface (See online version of course.)

Using the Arctic Circle as a reference point, we can define the circumpolar North as that portion of the northern hemisphere lying north of the Arctic Circle.

In summer, the northern hemisphere is tilted towards the Sun, thus shortening the travel path for solar radiation to Earth's atmosphere (see fig. 1.2 in online version of course). This season corresponds to the period of maximum day length in the North: the period of the midnight Sun above the Arctic Circle (see fig. 1.3). This combination of factors results in the maximum receipt of solar radiation in Subarctic, Arctic, and Polar zones during the northern hemisphere summer (see fig. 1.4).

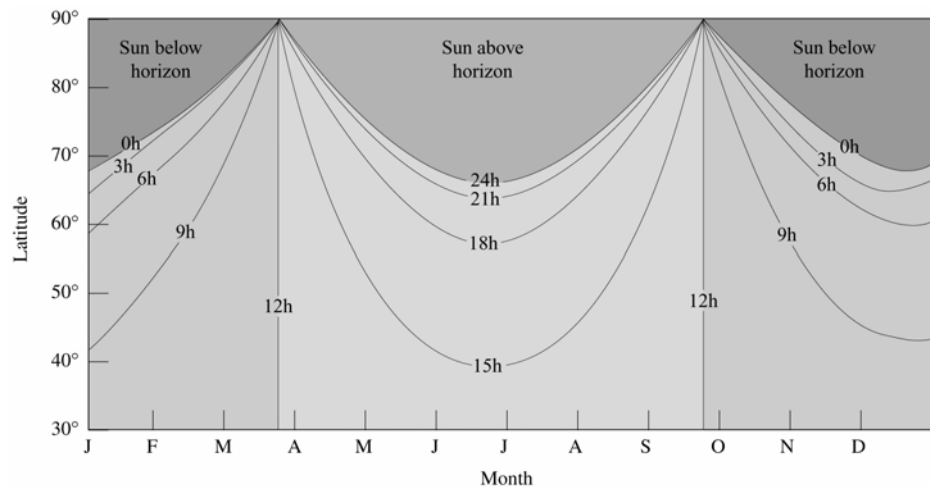


Fig. 1.3 The influence of obliquity on the seasonal variation in day length, measured in hours, at various latitudes in the northern hemisphere

In winter, the northern hemisphere is tilted away from the Sun, thus lengthening the travel path for solar radiation to the Earth's atmosphere (see fig. 1.2). This season also corresponds to the period of minimum day length in the North: the period of polar night above the Arctic Circle (see fig. 1.3). This combination of factors results in the minimum receipt of solar radiation in Subarctic, Arctic, and Polar zones during the northern hemisphere winter (see fig. 1.4).



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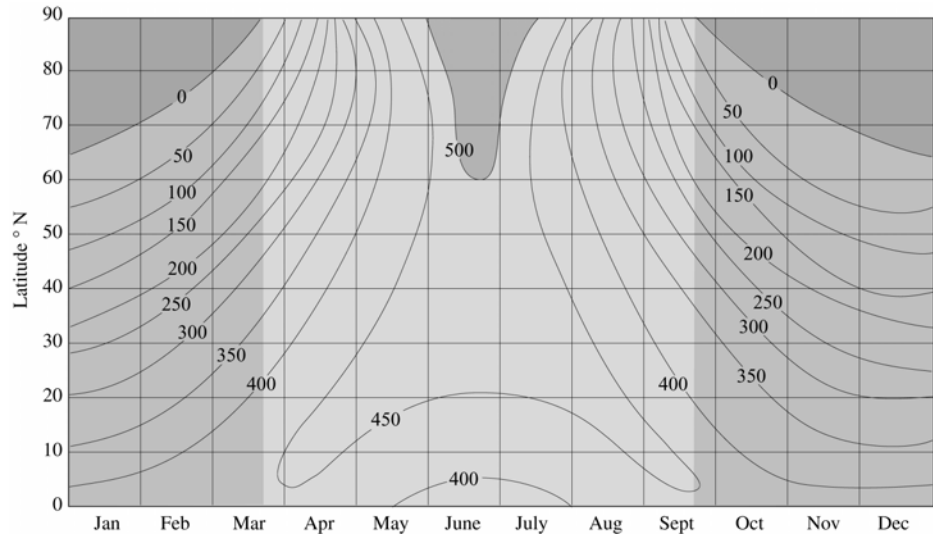


Fig. 1.4 The influence of obliquity on the seasonal variation in the receipt of solar radiation, measured in watts per square metre (W/m^2), at various latitudes in the northern hemisphere

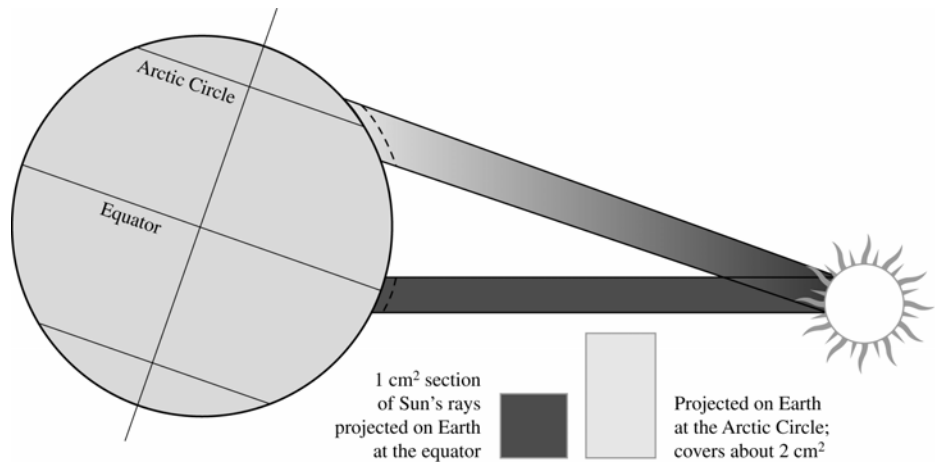


Fig. 1.5 The influence of obliquity on the travel path of solar radiation through space and the intensity of solar radiation received at the equator and at the Arctic Circle

The Subarctic, Arctic, and Polar zones of the North receive much less energy from the Sun than do the regions in the midlatitude and low-latitude zones. Several factors contribute to the low level of available energy at high latitudes. First, solar radiation must travel through a greater thickness of the Earth's atmosphere to reach the surface at high latitudes (see fig. 1.5). This longer travel path for solar radiation results in the loss of energy via absorption and scattering within the atmosphere. Approximately 50 per cent of the solar radiation that arrives at the Earth's atmosphere is actually received at Earth's surface. Second,



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any given quantity of solar radiation received at the Earth's surface is dispersed over a greater surface area at high latitudes than at low latitudes (see fig. 1.5).

Student Activity

1. What is the primary cause of seasonal variations in the receipt of solar energy at the surface of the Earth?
 2. How is the Arctic defined?
 3. Which part of the Earth is tilted towards the Sun in January? In June?
 4. When do the Sun's rays pass through less atmosphere to reach the Arctic surface?
 5. What is the significance of the angle of the Sun's rays to the dispersal of solar radiation over the Earth's surface?
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Weather and Climate

From the perspective of geographers, variations in weather and climate are of great interest in defining northern environments. Regional climates represent the average, long-term (i.e., more than 30 years) weather patterns over the surface of the Earth. Several environmental variables are employed to describe regional climates:

- variations in temperature
- variations in precipitation and evaporation
- the nature of winds

Annual variations in temperature are influenced by latitude. The changes in the input of solar radiation owing to latitude, as discussed, affects the seasonal patterns of temperature. The distribution of land and water also influences the precipitation regime through its control of atmospheric humidity: oceans are associated with moist air masses, while continents are associated with dry air masses. The precipitation regime is related to the source region of the various air masses and their interaction under the influence of prevailing wind patterns at Earth's surface.



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Köppen-Geiger Climate System

A system for defining regional climates that is widely used among geographers is the Köppen-Geiger Climate System. This system of climate classification was originally developed to explain the distribution of plants over the surface of the Earth. The system is based on the following information: monthly mean temperature, annual mean temperature, and total annual precipitation. In this system, regional climates are represented by a series of letters.

The first letter indicates whether the regional climate is dry (B, E) or moist (A, C, D). This letter relates to the following latitudinal zones:

- A – tropical rainy climates
- B – dry climates
- C – mild, humid climates
- D – snowy forest climates
- E – polar climates

For moist (A, C, D) climates, the second letter represents the temporal distribution of precipitation.

For A, C, and D climates, the second letter will be one of the following:

- f – adequate precipitation for plant growth in each month
- s – dry season (moisture deficit) in the summer
- w – dry season (moisture deficit) in the winter
- m – monsoon wet/dry regime (for A climates only)

For dry (B, E) climates, the second letter is determined by equations. It will be one of the following:

- S – STEPPE
- W – DESERT

The third letter relates to the seasonal variations in mean air temperatures for midlatitude and high-latitude climates.



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For A, C, and D climates, the third letter will be one of the following:

- a – Hot summer: The mean temperature of the warmest month is greater than 22°C .
- b – Warm summer: The mean temperature of the warmest month is less than 22°C ; four months of the year experience mean temperatures greater than 10°C .
- c – Cool, short summer: Between one and four months of the year experience mean temperatures greater than 10°C ; the mean temperature of the coldest month varies from -38°C to -3°C .
- d – Cold winter: Between one and four months of the year experience mean temperatures greater than 10°C ; the mean temperature of the coldest month is less than -38°C .

For B climates, the third letter will be one of the following:

- h – The mean annual temperature is greater than 18°C .
- k – The mean annual temperature is less than 18°C .

For E climates, the third letter will be one of the following:

T – The mean temperature of the warmest month varies from 0°C to 10°C . This classification is further subdivided by the “degree of coldness”:

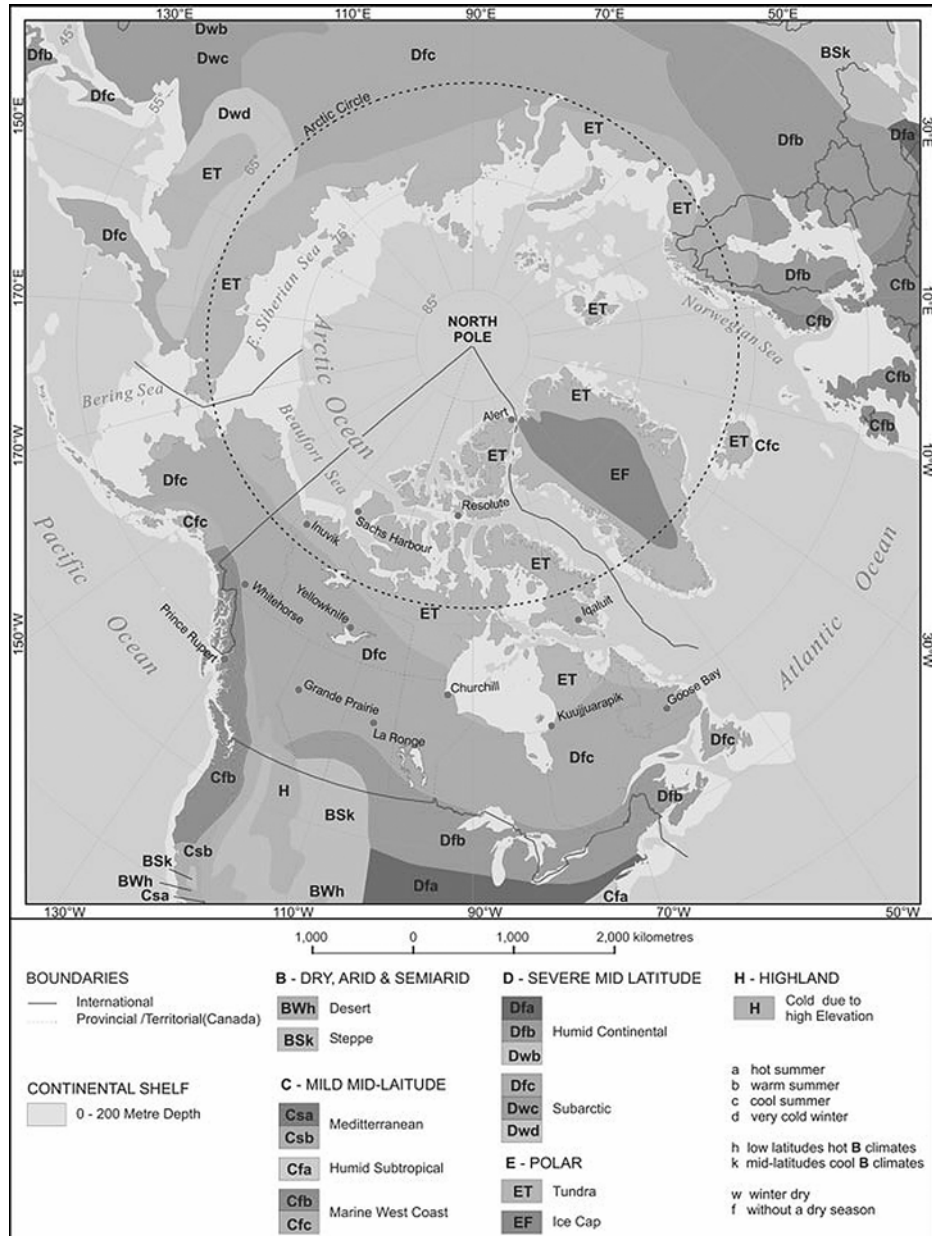
High Arctic – The mean temperature of the warmest month is less than 5°C .

Low Arctic – The mean temperature of the warmest month varies from 5°C to 10°C .

F – The mean temperature of the warmest month is less than 0°C .



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Base Map Source: Canada Base Data; Atlas of Canada (www.atlas.gc.ca). Government of Canada. Projection: Azimuthal Equidistant. Latitude of Origin 75° N, Central Meridian 90° W.

Fig. 1.6 Regional climates in the circumpolar North as defined by the Köppen-Geiger Climate System

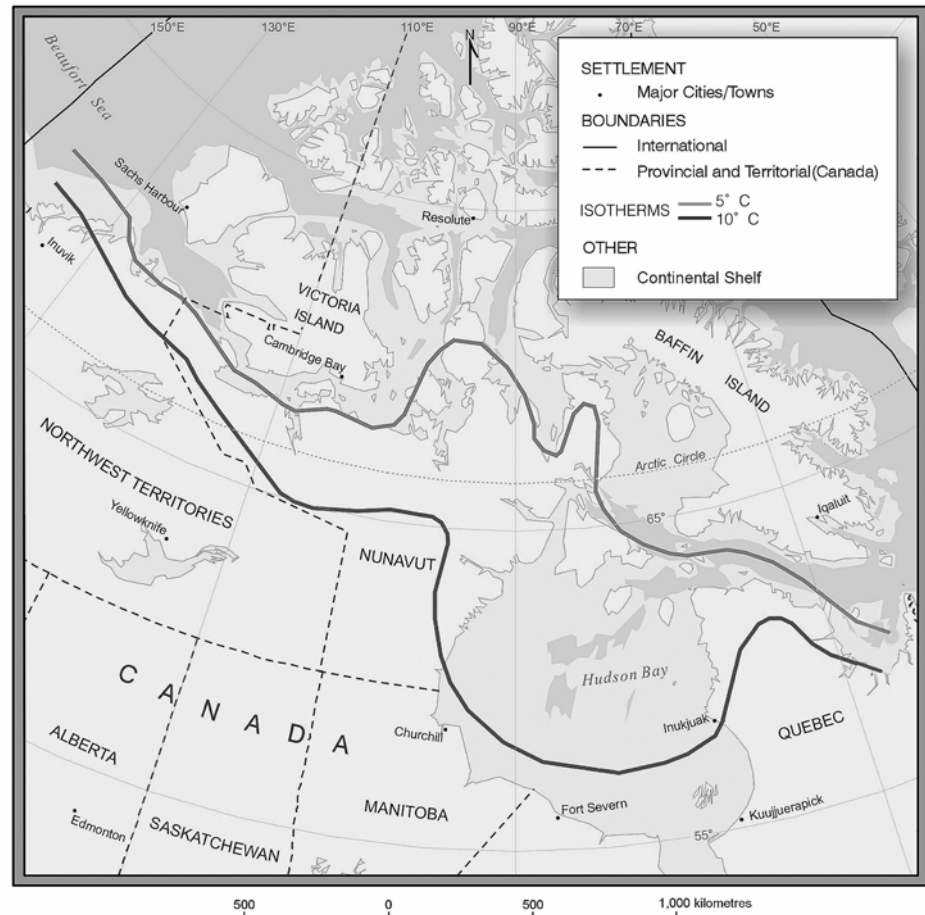
For the purposes of this course, you should be familiar with the regional climates of the Subarctic, Arctic, and north Polar zones as illustrated in figure 1.6 and figure 1.7. These regional climates are referred to as Boreal Forest climates (Dfc, Dfd), Tundra climates (ET), and Ice Sheet climates (EF),



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respectively. The seasonal variations in air temperatures associated with these regional climates are illustrated in figure 1.8.

5°C and 10°C Isotherms; Northern Canada



Base Map Source: Canada Base Data; Atlas of Canada (www.atlas.gc.ca). Government of Canada. Projection: Azimuthal Equidistant. Latitude of Origin 75° N, Central Meridian 90° W.

Fig. 1.7 Map illustrating the 5°C and 10°C mean July isotherms that define the boundaries of Subarctic, Low Arctic, and High Arctic regions in northern Canada



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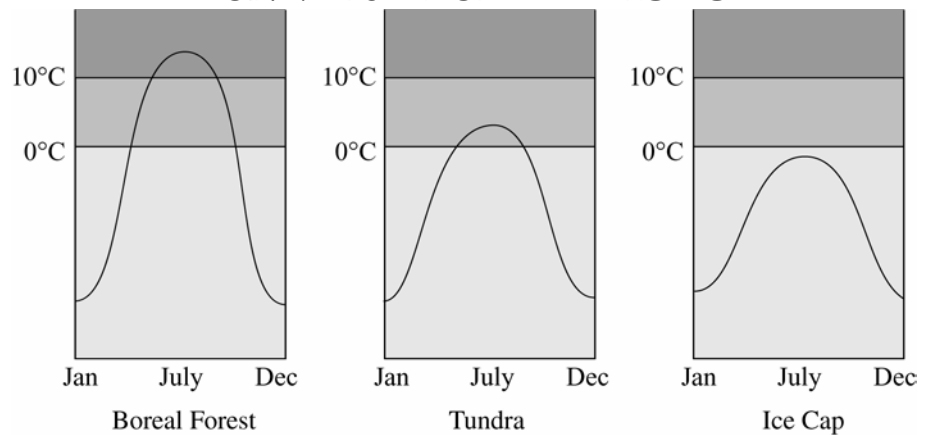


Fig. 1.8 The seasonal variations in surface air temperatures for Boreal Forest, Tundra, and Ice Sheet climate regions as defined by the Köppen-Geiger climate classification system

Thornthwaite System

Another climate classification system that is widely used in North America is the Thornthwaite System. Like the Köppen-Geiger Climate System, the Thornthwaite System examines the relation of climate to plant growth. Unlike the Köppen-Geiger Climate System, which examines climate in relation to monthly and annual variations in temperature and precipitation, the Thornthwaite System employs components of water balance to describe the climate of a region. These components are *potential evapotranspiration* (PE) and *soil moisture deficit* (D). In the Thornthwaite System, the following regional climates are recognized:

- dry climates – D is greater than 15 cm of water.
- moist climates – D is less than 15 cm of water.
- low-latitude climates – PE is greater than 130 cm of water.
- midlatitude climates – PE is greater than 52 cm of water and less than 130 cm of water.
- high-latitude climates:
 - Boreal Forest – PE is greater than 35 cm of water and less than 52 cm of water.

Tundra – PE is less than 35 cm of water.

For the purposes of this course, you should be familiar with the Boreal Forest and Tundra climates that are associated with the Subarctic and Arctic zones, respectively.