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Koppen's Classification

Koppen's Classification

Lesson 1 • Mar 11, 2020 • Mandeep Kumar

Koppen's climate classification

GeoGuruMandeep Sir

Very little rainfall survive.

Koeppen used five major vegetation zones of the world as identified by Candolle in 1874 (e.g., megatherms, xerophytes, mesotherms, microtherms, and hekistotherms) as the basis of classification of world climates on the belief that the distribution of natural vegetation was the best indicator of the total picture of climate of a region concerned.

Meg

Empirical → Data

- He revised his scheme in the year 1918 wherein he paid more attention to monthly and annual averages of temperature and precipitation and their seasonal distribution. He again modified his scheme in 1931 and 1936.
- Koeppen's original scheme was modified in 1953 by Geigger-Pohi and the revised scheme known as Koeppen-Geigger-Pohl's scheme of classification of world climates was publishe

- It may be pointed out that the classification of Koeppen is more popular because it is quantitative in nature as numerical values of temperature and precipitation have been used in delineation of boundaries of different climatic types.

Climograph

∴ Delhi ① March - 36°C ... 32°C.

② Annual Average Temp.

③ Annual Average Rainfall

11 - 2 - 70 cm.

- **Based on these five vegetation zones he divided the world climates into 5 principal types and designated them by capital letters A, B, C, D, and E:**
- **(1) A Climate:**
- Represents humid tropical climates characterized by **winterless** season**, warm and moist c**onditions throughout the year and **mean temperature always above 18°C.**

A → Af
Am/Aw
As

Evaporation & precipitation
water deficit
BSk
BSh
BWh
Steppe
Grass

- **2) B Climate:**
- Represents **dry** climates where **evaporation exceeds precipitation** and there is constant water deficit throughout the year.

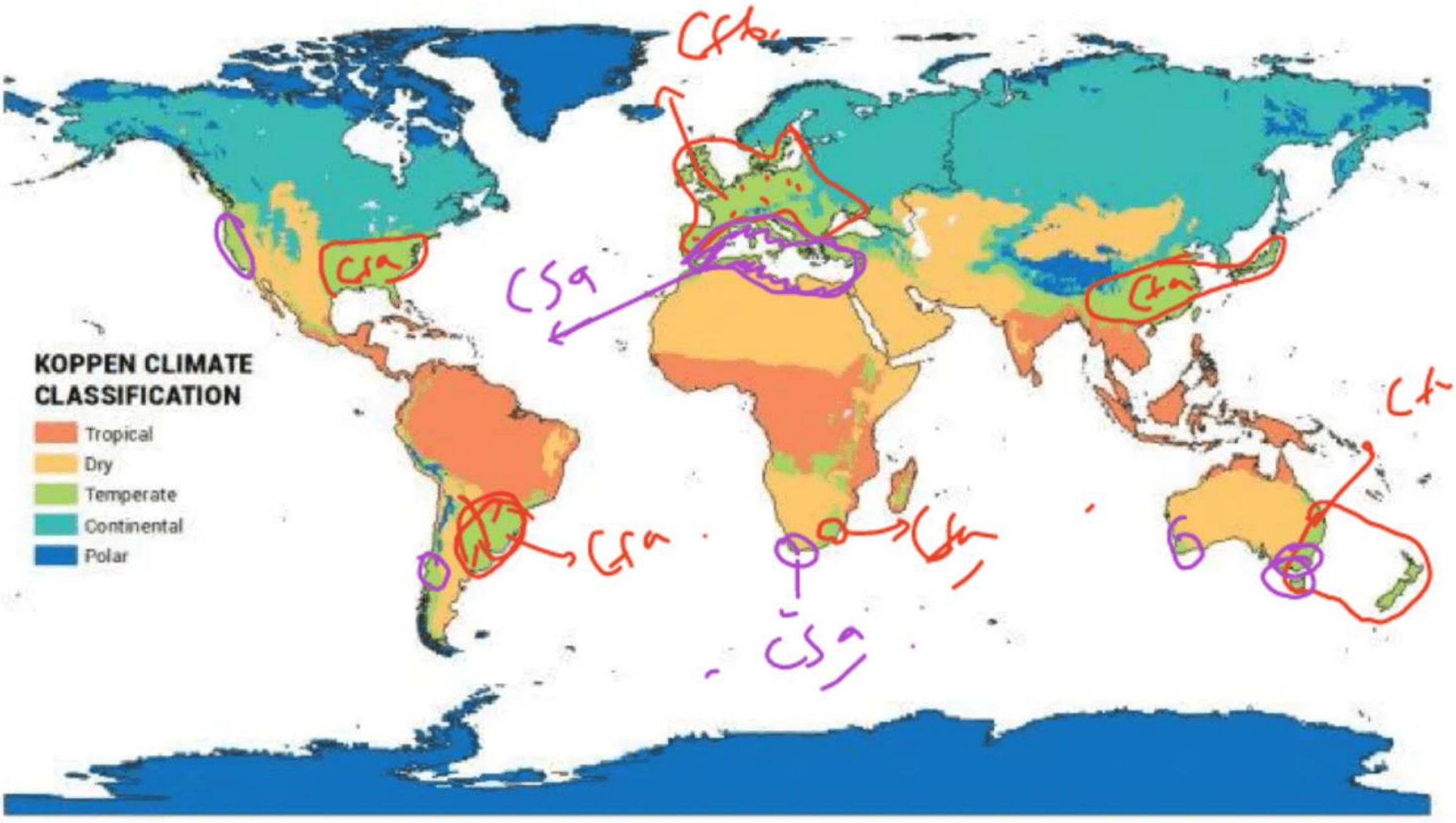
C → Temp. warm month > 10°C
coldest

- **(3) C Climate:**

Represents humid mesotherm-mal or **middle latitudes warm tempe**rate climates having **mild winter**s, average temperature of the **coldest** and warmest months between **8° and 18°**, and below 18°C respectively.

Cf@
Cfb. Csa.
Cfa
Csa
S = Summer
D = ...
f = feucht, whole year Rainfall

- **4) D Climate:**
- Includes humid micro-thermal or **cold forest climates** characterized by **severe** wi**nters,** average temperatures of coldest and warmest months being 3°C and above 10°C respectively.
- **(5) E Climate:**
- Includes **polar climates** characterized by **summer less season**, average temperature of the warmest month below 10°C.


KOPPEN CLIMATE CLASSIFICATION
Tropical
Dry
Temperate
Continental
Polar

World Map of Köppen–Geiger Climate Classification

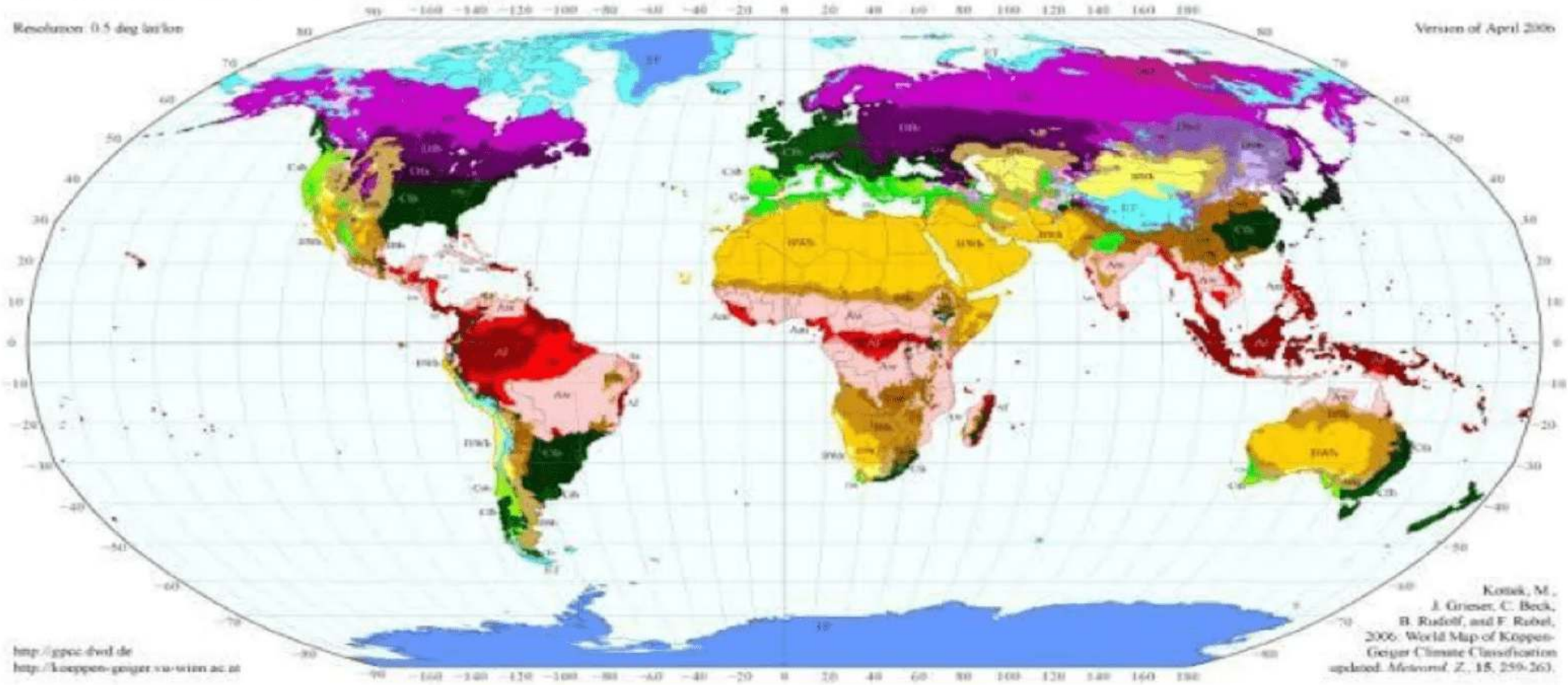
updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000

Af	Am	As	Aw	BWk	BWh	BSk	BSh	Cfa	Cfb	Cfc	Csa	Csb	Csc	Cwa
Cwb	Cwc	Dfa	Dfb	Dfc	Dfd	Dsa	Dsb	Dsc	Dsd	Dwa	Dwb	Dwc	Dwd	EF	ET

Main climates	Precipitation	Temperature	
A: equatorial	W: desert	h: hot arid	F: polar frost
B: arid	S: steppe	k: cold arid	T: polar tundra
C: warm temperate	f: fully humid	a: hot summer	
D: snow	s: summer dry	b: warm summer	
E: polar	w: winter dry	c: cool summer	
	m: monsoonal	d: extremely continental	

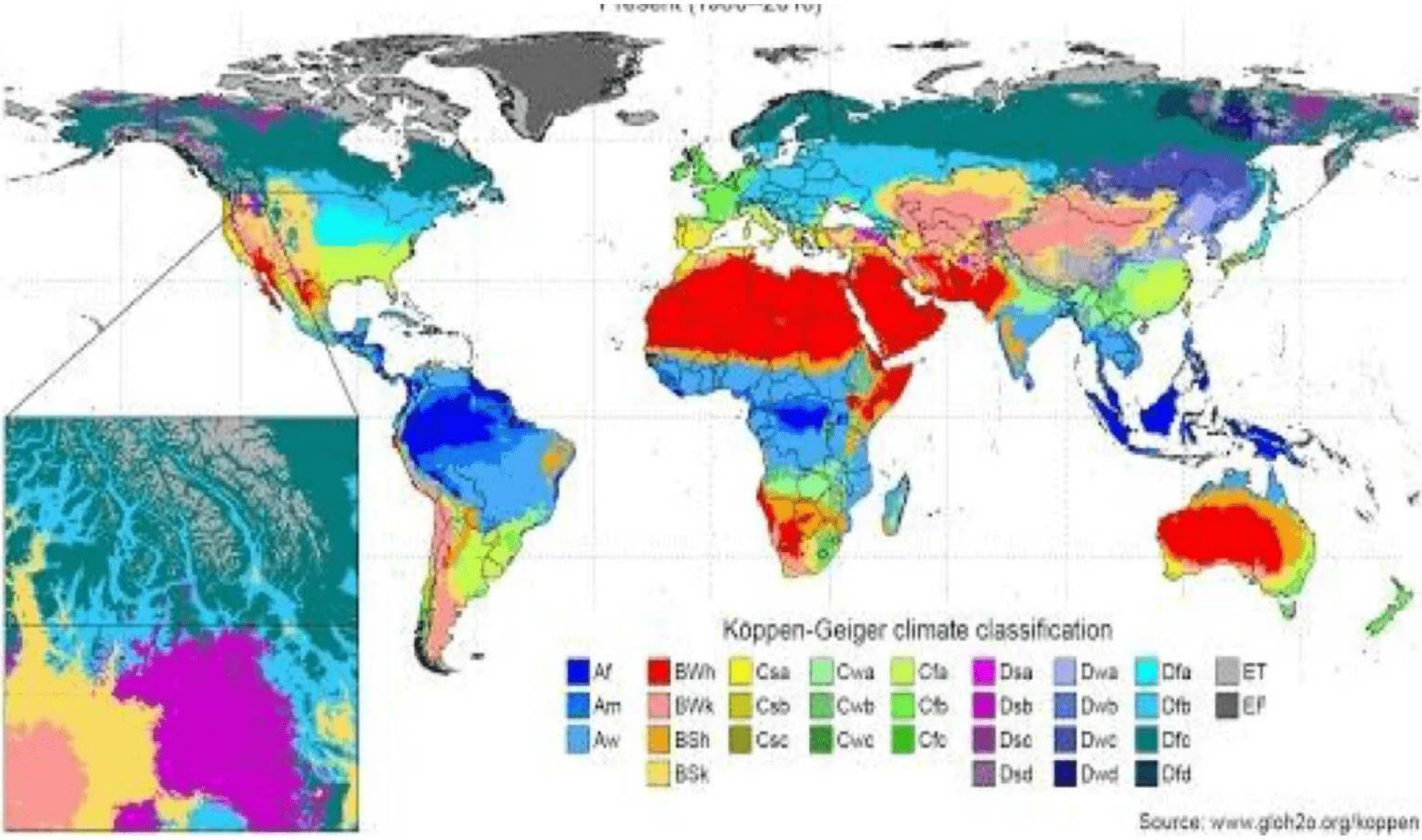
Resolution: 0.5 deg lat/lon

Version of April 2006



http://gpcc.dwd.de
http://koeppen-geiger.vu-wien.ac.at

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: World Map of Köppen-Geiger Climate Classification updated. *Meteorol. Z.*, 15, 259-263.


Köppen-Geiger climate classification
Af
Am
Aw
BWh
BWk
BSh
BSk
Csa
Csb
Csc
Cwa
Cwb
Cwc
Cfa
Cfb
Cfc
Dsa
Dsb
Dsc
Dsd
Dwa
Dwb
Dwc
Dwd
Dfa
Dfb
Dfc
Dfd
ET
EF
Source: www.gloh2o.org/koppen

- **Besides these capital letters, Koeppen has used the following small (lower) letters in his scheme for specific meaning:**

- f = precipitation throughout the year, average temperatures of the coldest month being more than 18°C, minimum precipitation of 6cm in every month of a year.

- M = monsoon climate, short dry season, average precipitation in driest month less than 6cm.
- W = winter dry season
- S = well defined summer dry season.

- Koeppen has divided 5 major climatic types into 11 subtypes on the basis of seasonal regimes of precipitation and nature of aridity and coldness.
- **(1) Tropical Rainy Climates (A Climates):**
- A or tropical rainy climate is that where the temperature of the coldest month is above 18°C.

On the basis of periodicity and regime of precipitation this type has been further divided into 4 types:



- **(ii) Aw climate:**
- tropical humid and dry climate, winter dry season (w), precipitation of at least one month less than 6cm, high temperature throughout the year.
- **(iii) Am climate:**
- monsoon climate, one short dry season but sufficient annual precipitation and thus wet ground throughout the year, dense forest, precipitation of at least one month less than 6cm.
- Iv) As climate-dry summers, rarely found:

- **The boundary between Aw and Am climates is demarcated on the basis of annual precipitation and the precipitation of the driest moth as per formula given below:**
- a = 3.94-r/25
- where a = precipitation of driest month
- r = annual precipitation

- If the precipitation of the driest month of a place is less than the value of a, it will be Aw climate, if it is more than the value of a, it will be Am climate.
- Example = If the annual precipitation of a place is 50 inches, then Am/Aw boundary would be = 3.94 – 50/25 = 1.94 inches. If the precipitation of the driest month of that place is 2 inches (this should be always less than 2.4 inches, otherwise it would be Af climate), it would be Am climate. On the other hand, if the precipitation of the driest month of that place is 1.8 inches, it would be Aw climate.
-

- **Koeppen has further identified finer details in A climates and has used the following lower letters to indicate them**:
  - w' maximum precipitation in autumn
  - w" two seasons of maximum precipitation separated by two dry seasons

- S dry summers
- I difference of temperature of the warmest and the coldest month less than 5°C.
- g hottest season preceding precipitation
-

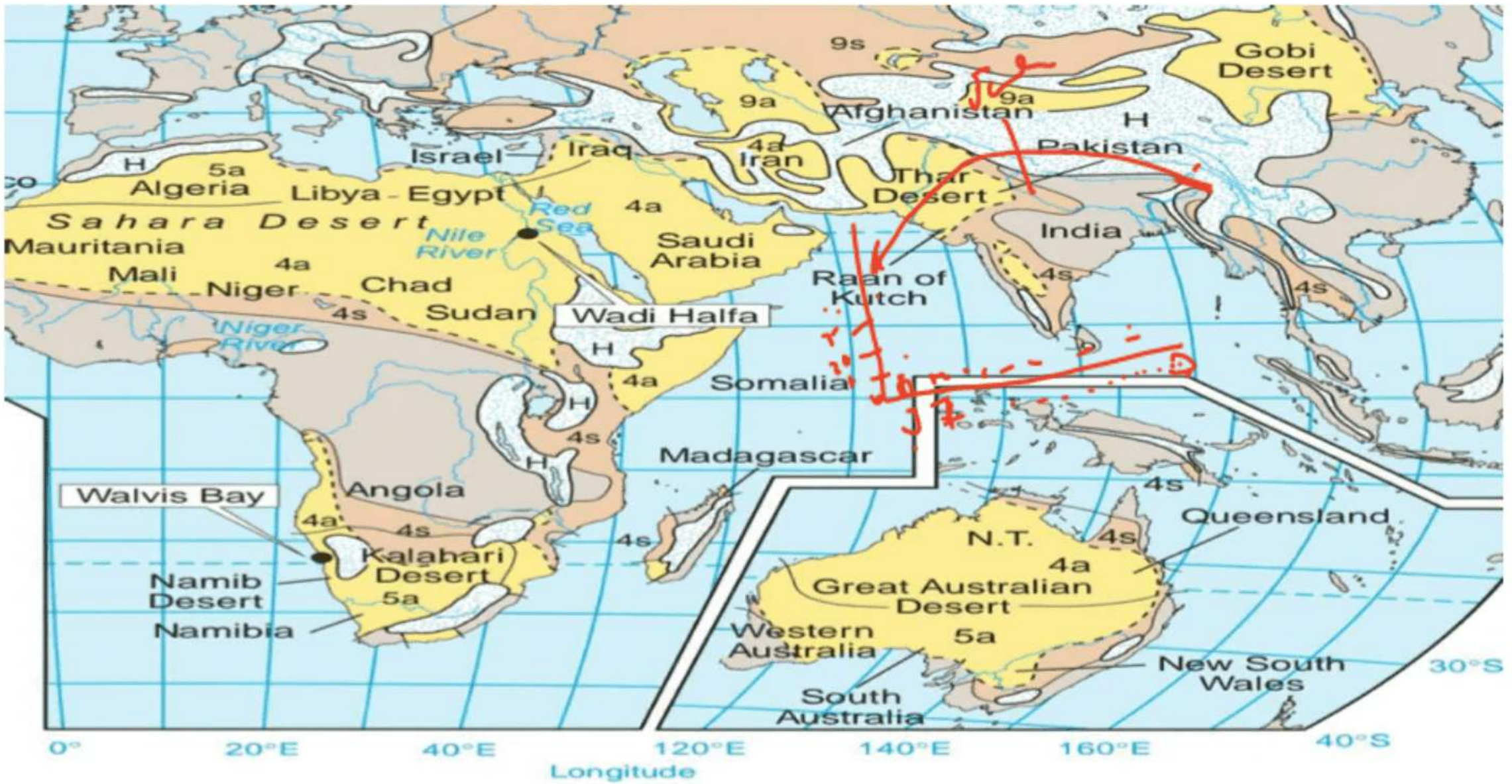
- **(2) Dry climates (B climates):**
- Evaporation exceeds precipitation, precipitation not sufficient to maintain permanent stable water table of ground water.
- **B climates are divided into two types on the basis of annual temperature and the rainiest month of the year e.g.:**
- (i) Dry desert climate (BW), and
- (ii) Semi-arid or steppe climate (BS).

- **The boundary between BW and BS climates is determined on the basis of the following formula:**
- r =0.44t – 8.5 /2
- Where
- r = annual precipitation (inches)
- t = temperature (O°F)

- If the annual precipitation of a given place is more than the value of r, the climate of that place will be BS but if it is less then r, the climate will be B W.
- For example, if the temperature of a place is 80°F, the annual value of precipitation for dividing boundary between BS and BW climates will be 13.3 inches as given below:
- $r = 0.44 \times 80 - 8.5/2 = 13.3$ inches
-

- B climates are further differentiated on the basis of annual temperature. When the mean annual temperature is more than 18°C (64.4°F), the climate is indicated by h letter but if the mean annual temperature is less than 18°C, it is indicated by k letter.

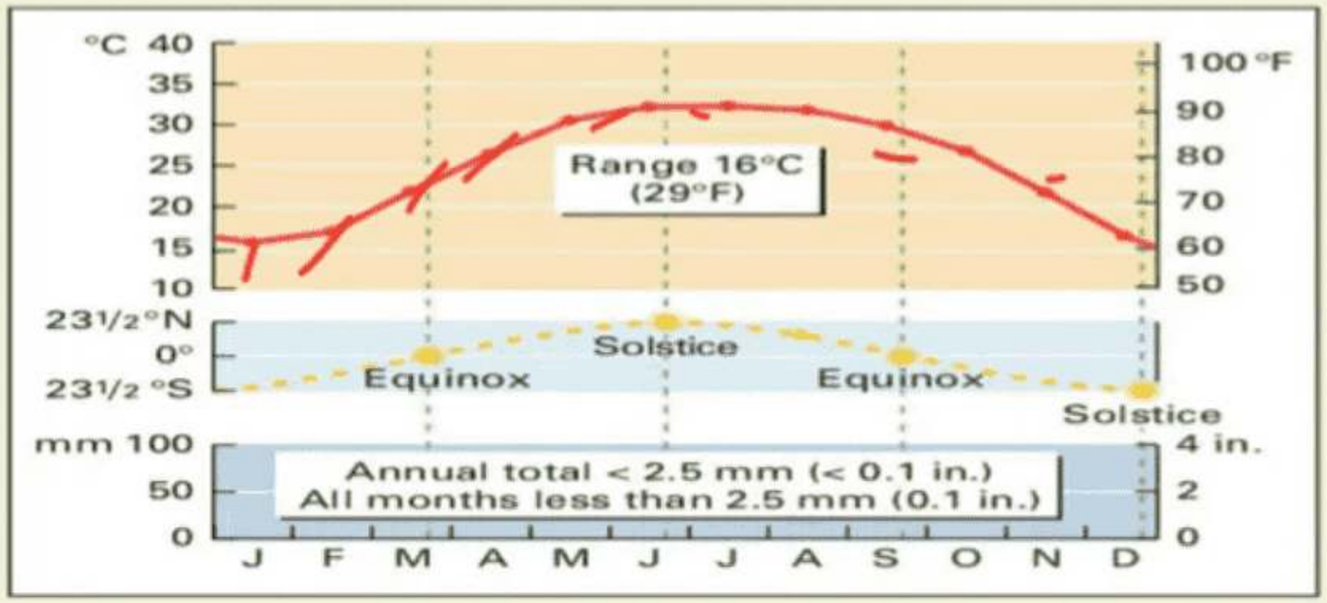
- Thus, B climates are divided into the following four types:
- (i) BWh tropical desert climate, average annual temperature more than 18°C (64.4°F)
- (ii) BSh tropical steppe climate, mean annual temperature above 18°C
- (iii) BWk middle latitude cold desert climate, mean annual temperature below 18°C
- (iv) BSk middle latitude cold steppe climate, mean annual temperature below 18°C
-



o of the dry tropical ④, dry subtropical ⑤, and dry midlatitude ⑨ clim

tes are poleward and eastward extensions of the dry tropical climate ④ with

7.22 Dry tropical climate ④, dry desert subtype

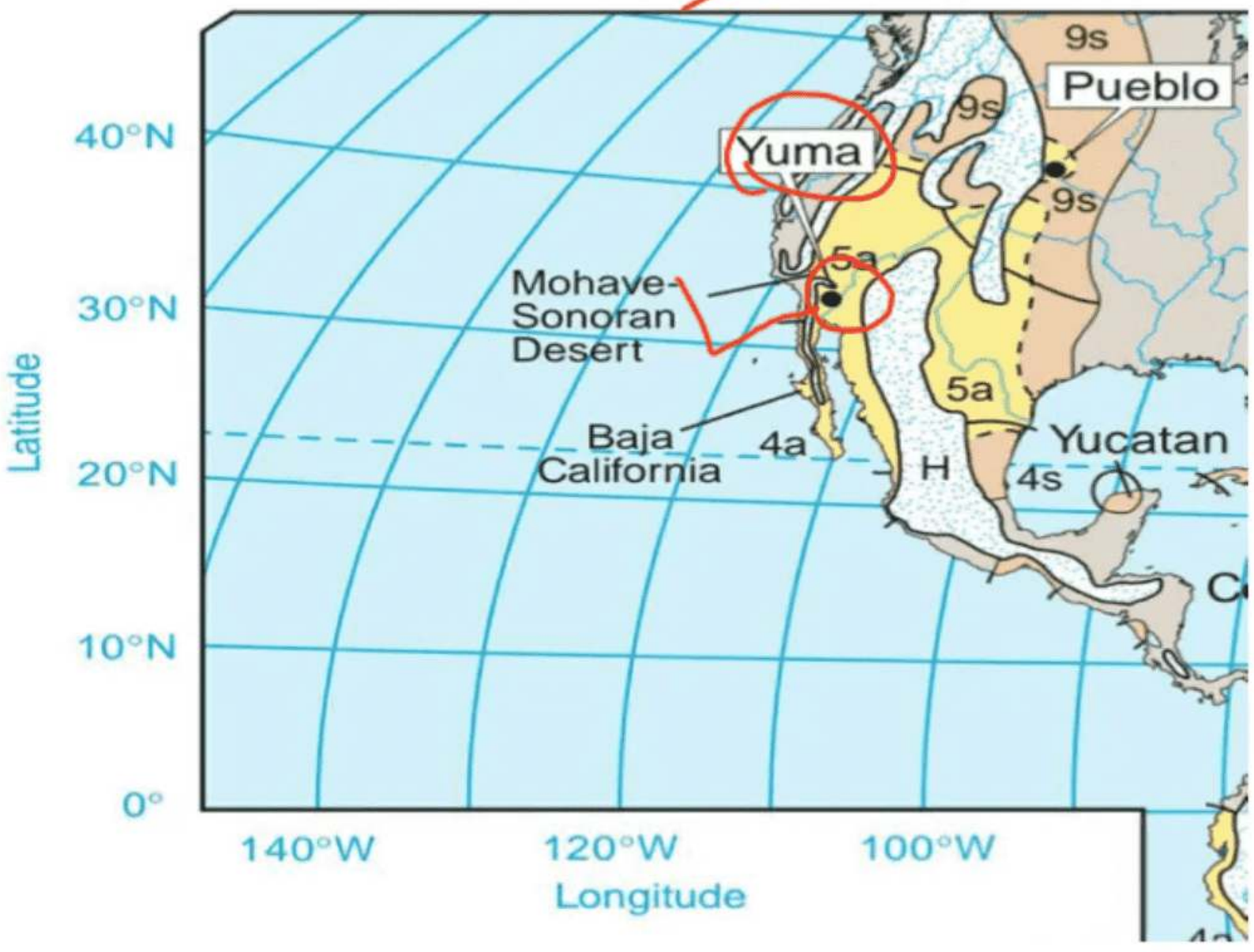


▲ **Wadi Halfa climograph** Wadi Halfa is on the Nile River in Sudan at lat. 22° N, almost on the Tropic of Cancer. There is a strong annual temperature cycle with a very hot period at the time of high Sun. Daytime maximum air temperatures are frequently between 43° and 48°C (about 110° to 120°F) in the warmer months. There is a comparatively cool season at the time of low Sun. There is too little rainfall to show on the climograph. Over a 39-year period, the maximum rainfall recorded in a 24-hour period at Wadi Halfa was only 7.5 mm (0.3 in.).

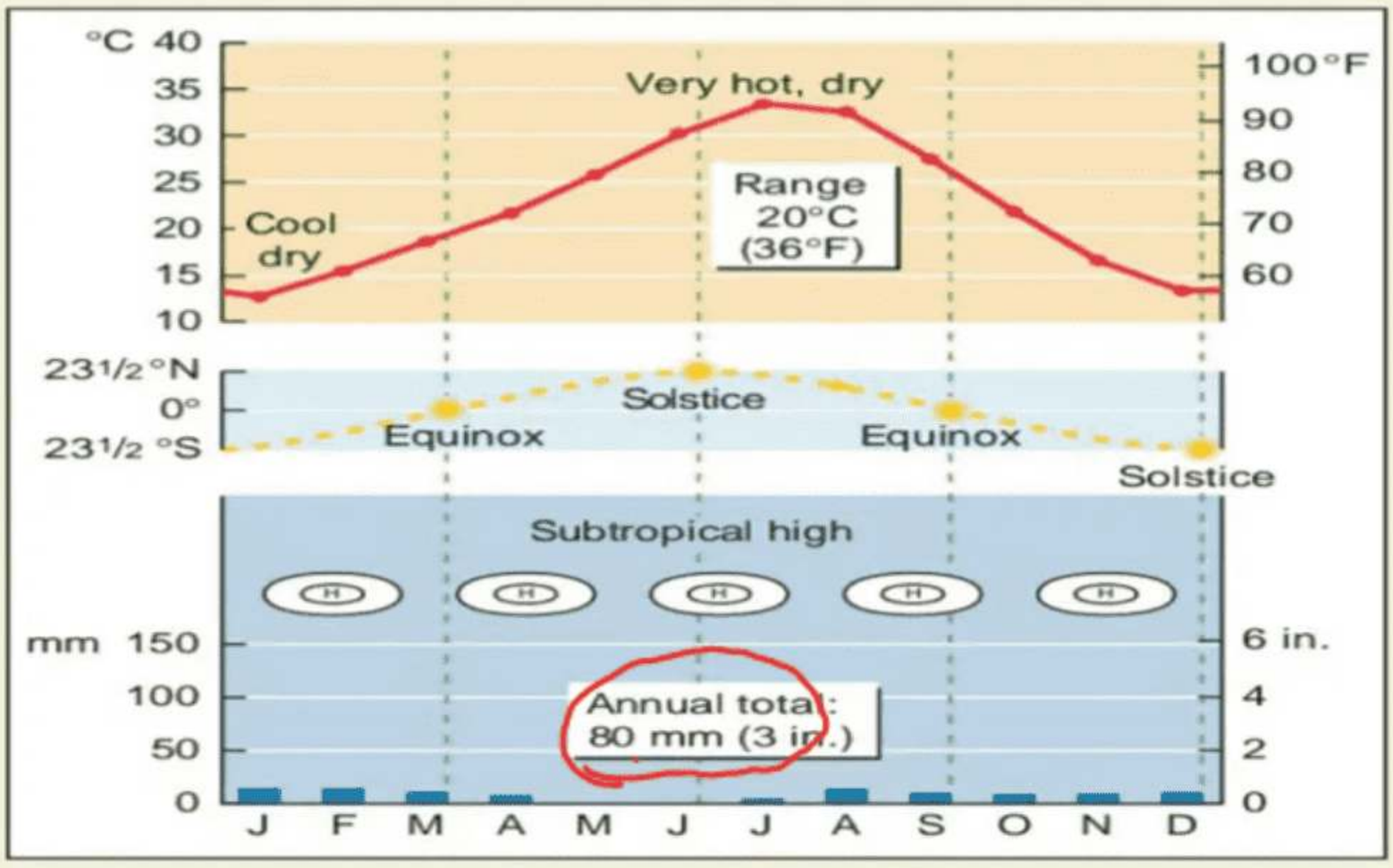


- **Koeppen has identified further details in B climates and has used the following letters to indicate them:**
- **k mean annual temperature below 18°C**
- **h mean annual temperature above 18°C**

BSh


9s
Pueblo
9s
Yuma
9s
5a
Mohave-
Sonoran
Desert
5a
Baja
California
4a
H
Yucatan
4s
40°N
30°N
20°N
10°N
0°
140°W
120°W
100°W
Latitude
Longitude

7.25 Dry subtropical climate ⑤

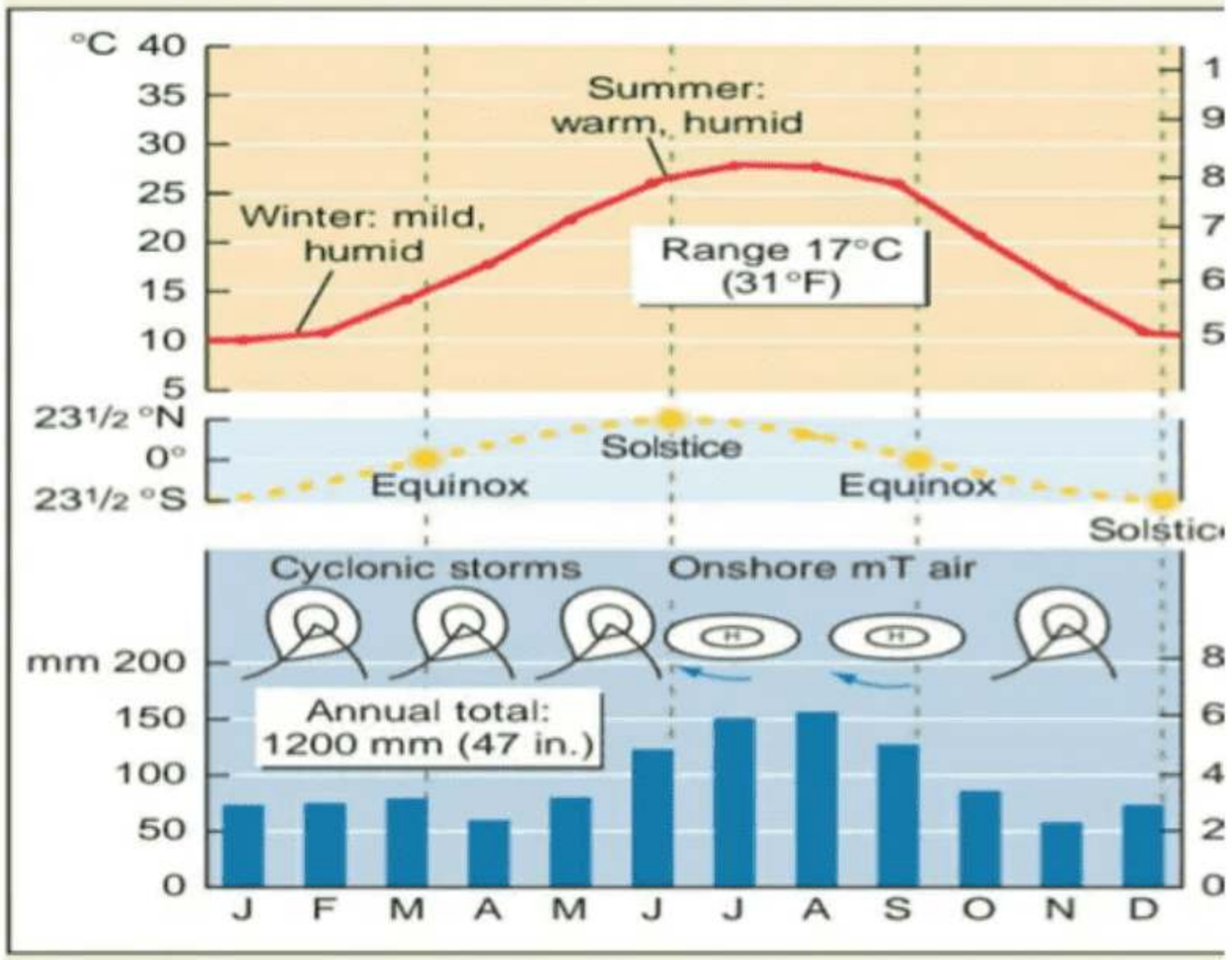


▲ **Yuma climograph** Yuma, Arizona (lat. 33° N), has a strong seasonal temperature cycle, with a dry hot summer, and freezing temperatures in December and January

- A summer dry, three times more precipitation in the wettest month of winter season than the driest month of summer season
- w winter dry, 10 times more precipitation in the wettest month of summer season than the driest month of winter season
- n minimum fog
-

- **(3) Humid mesothermal or warm temperate rainy climates (C climates):**
- Average temperature of the coldest month above 3°C but below 13°C, precipitation in all seasons.
- **Based**

7.28 Moist subtropical climate ⑥



▲ **Charleston climograph** Charleston, South Car (lat. 33° N), located on the eastern seaboard, has a mild winter and a warm summer. Total annual rainfa is abundant—1200 mm (47 in.). There is a strongly

▼ **Charleston, South Carolina** These old homes on the Charleston waterfront display a local architecture well adapted to the climate of the region. The upper porches were used for outdoor living and sleeping in the hot and humid summer weather. (Charleston is located on Figure 7.27.) (National Geographic Image Collection.)



THE MOIST SUBTROPICAL CLIMATE ⑥ (KÖPPEN: Cfa)

The **moist subtropical climate** ⑥ (Figure 7.27) is found on the eastern sides of continents between lat. 20° and 35° N and S. In South America, it includes parts of Uruguay, Brazil, and Argentina. In Australia, it consists of a narrow band between the eastern coastline and the eastern interior ranges. Southern China, Taiwan, and southernmost Japan are included, as is most of the Southeast of the United States, from the Carolinas to east Texas.

Circulation around subtropical high-pressure cells provides a flow of warm, moist air onto the eastern side of continents, as we have discussed. This flow of maritime tropical (mT) air dominates the moist subtropical climate ⑥. There is abundant rainfall in the summer,

- on seasonal distribution of precipitation C climates have been divided in to 3 climatic types:
- (i) Cf climate:
- precipitation throughout the year, precipitation more than 1.2 inches in the driest month of summer season. This climate represents Western Europe type of climate. This is further divided into two second order sub-divisions e.g. Cfa (humid subtropical) and Cfb (marine west coast type)
-

- **ii) Cw climate:**
- Dry winters, 10 times more precipitation in the wettest month of summer season than the driest month of winter season. This represents China type of climate.

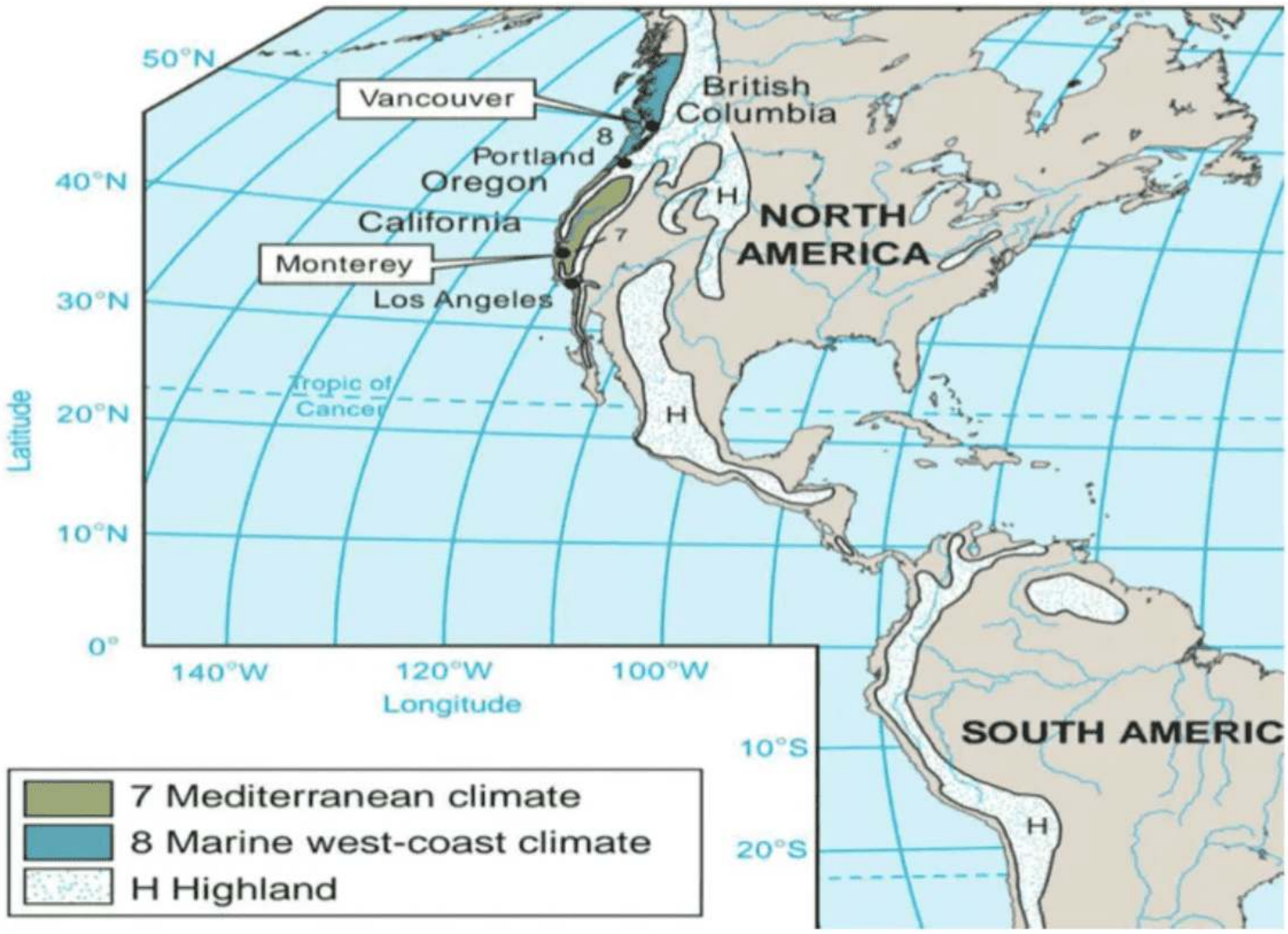
- (iii) Cs climate :
- Dry summers, three times more precipitation in the wettest month of winter season than the driest month of summer season, precipitation of the driest month of summer season less than 1.2 inches. This represents Mediterranean type of climate.
-

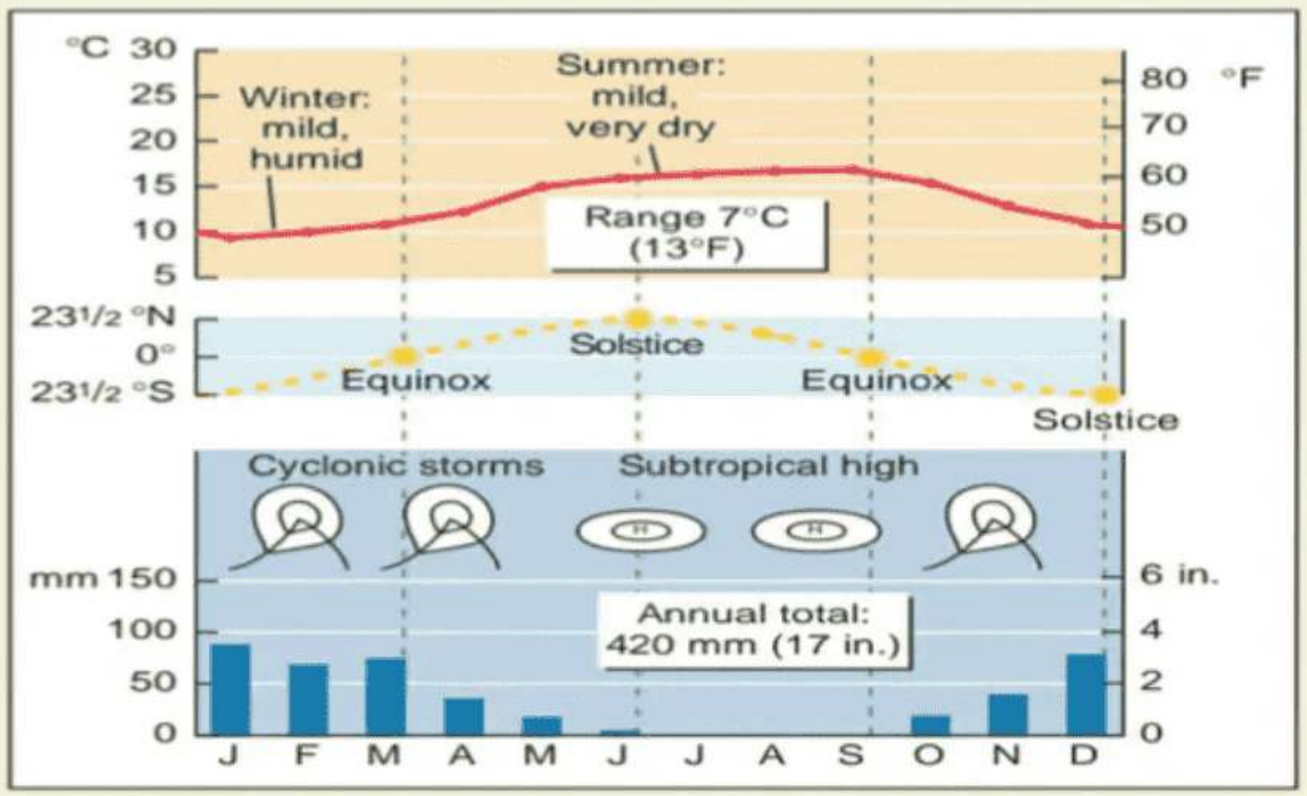
THE MEDITERRANEAN CLIMATE ⑦ (KÖPPEN: Csa, Csb)

The **Mediterranean climate** ⑦ is unique because it has a wet winter and a very dry summer. This is because the climate is located along the west coasts of continents, just poleward of the dry, eastern side of the subtropical high-pressure cells. When the subtropical high-pressure cells move poleward in summer, they enter the Mediterranean climate region. Dry continental tropical (cT) air then dominates, producing the dry summer season. In winter, the moist mP air mass invades with cyclonic storms and generates ample rainfall.

The Mediterranean climate ⑦, found along midlatitude west coasts, is distinguished by its dry summer and wet winter. In summer, dry subtropical high pressure blocks rainfall, while in winter, wave cyclones produce ample precipitation.

A global map of the Mediterranean climate ⑦ is shown in Figure 7.30. It is found between lat. 30° and 45° N and S. In the southern hemisphere, it occurs


50°N
40°N
30°N
20°N
10°N
0°
140°W
120°W
100°W
Longitude
Latitude
Vancouver
British Columbia
Portland
Oregon
California
Monterey
Los Angeles
8
7
H
NORTH AMERICA
Tropic of Cancer
H
H
SOUTH AMERIC
10°S
20°S
7 Mediterranean climate
8 Marine west-coast climate
H Highland



▲ **Monterey climograph** Monterey, California (lat. 36° N), has a very weak annual temperature cycle because of its closeness to the Pacific Ocean. The summer is very dry. Fogs are frequent. Rainfall drops to nearly zero for four consecutive summer months but rises to substantial amounts in the rainy winter season.



▲ **Monterey, California** As evident in this photo of Monterey harbor, the west coasts of the Mediterranean climate often support extensive fisheries (National Geographic Image Collection). (Monterey is located on Figure 7.30.)

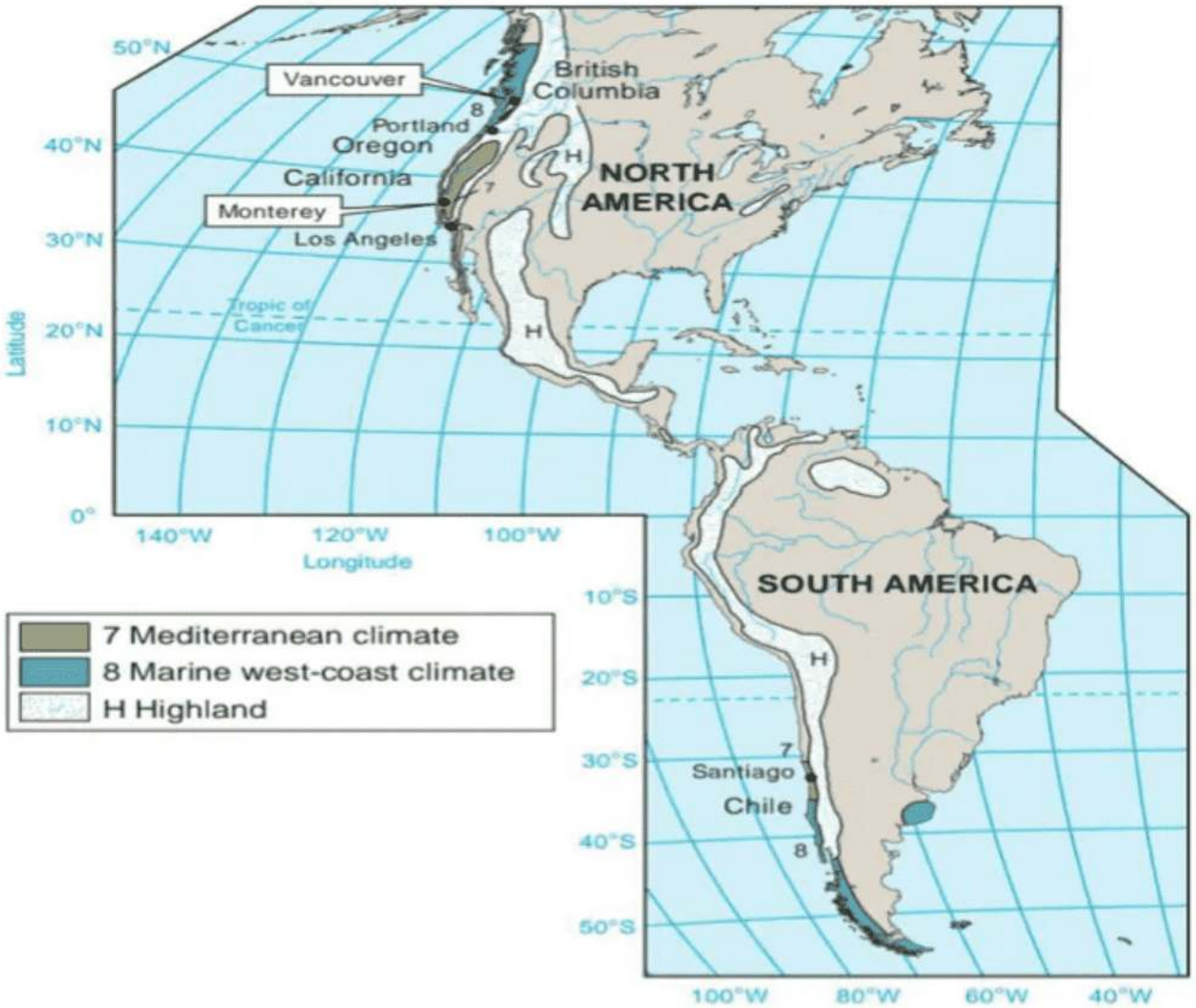
- **Koeppen has identified further minor details in C climates and has used a few explanatory small letters as given below:**
- a warm summers, temperature of the warmest month above 22°C (71.6°F).
- b cold winter, temperature of the warmest month below 22°C.
- c cold short summer season
- i, n, g = as explained above

THE MARINE WEST-COAST CLIMATE ⑧ (KÖPPEN: Cfb, Cfc)

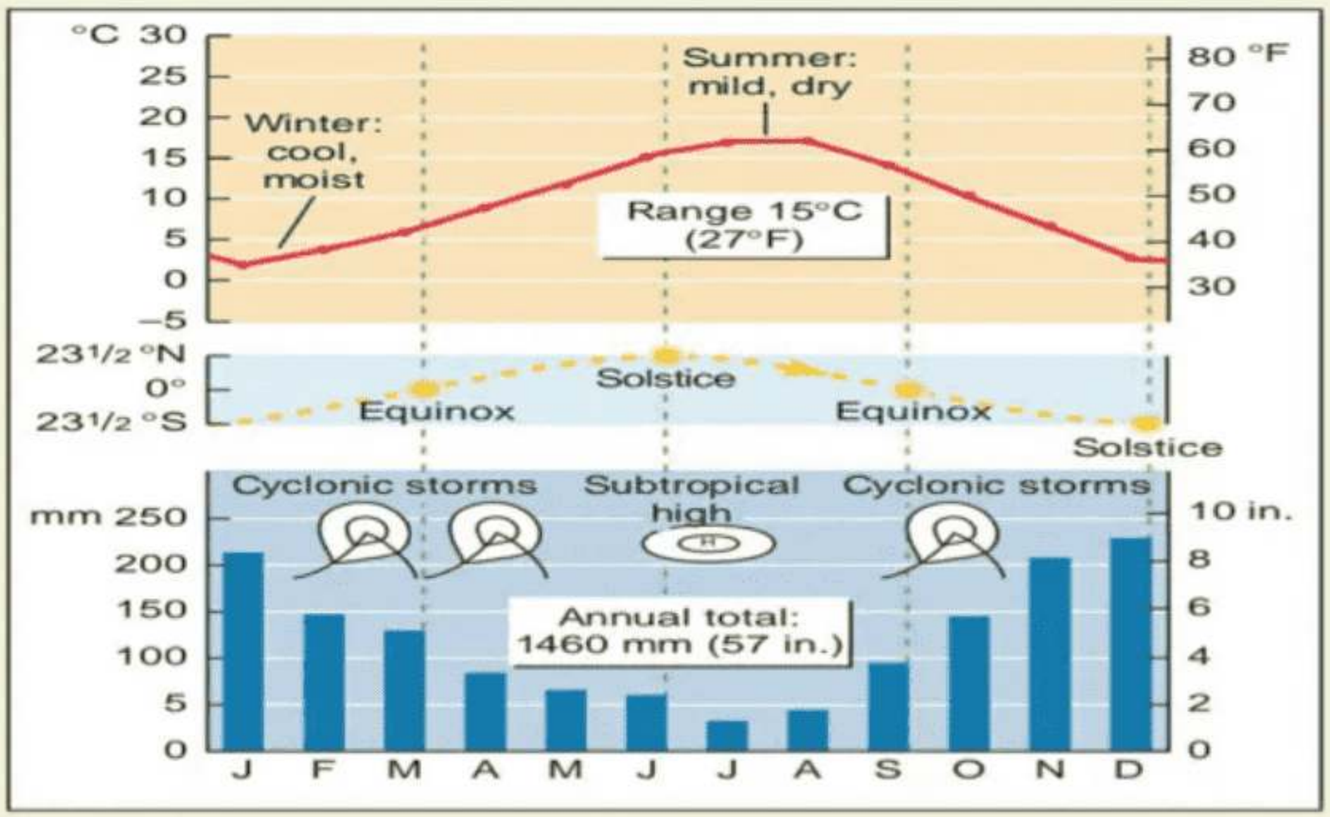
The **marine west-coast climate** ⑧ occupies midlatitude west coasts. These locations receive the prevailing westerlies from a large ocean, and there are frequent cyclonic storms involving cool, moist mP air masses. Where the coast is mountainous, the orographic effect causes large amounts of precipitation annually. Precipitation is plentiful in all months, but there is often a distinct winter maximum. In summer, the rainfall is reduced because subtropical high pressure extends poleward into the region. The annual temperature range is comparatively small for midlatitudes. The marine influence keeps winter temperatures milder than at inland locations at equivalent latitudes.

In North America, the marine west-coast climate ⑧ occupies the western coast from Oregon to northern British Columbia. In Western Europe, the British Isles, Portugal, and much of France fall under this climate. In the southern

The marine west-coast climate ⑧ features frequent cyclonic storms that provide abundant precipitation, especially when enhanced by an orographic effect. Summers are drier as subtropical high pressure moves poleward, blocking storm tracks.


50°N
40°N
30°N
20°N
10°N
0°
Latitude
140°W
120°W
100°W
Longitude
Vancouver
British Columbia
8
Portland
Oregon
California
H
NORTH AMERICA
7
Monterey
Los Angeles
Tropic of Cancer
H
10°S
20°S
30°S
40°S
50°S
SOUTH AMERICA
H
7
Santiago
Chile
8
100°W
80°W
60°W
40°W
7 Mediterranean climate
8 Marine west-coast climate
H Highland


England
Germany
8
Ireland
EUROPE
France
Italy
Portugal
7
Spain
Turkey
Syri
Morocco
Greece
Israe
Tunisia
Algeria
AFRICA



▲ **Vancouver climograph** Vancouver, British Columbia (lat. 49° N), has a large annual total precipitation, with most precipitation falling in winter. The annual temperature range is small, and winters are very mild for this latitude. Evergreen needleleaf forest is typical of this climate (National Gographic Image Collection).

► **Vancouver, British Columbia** Situated on the western coast of Canada, Vancouver is a major deep-water seaport. The nearby Coast Mountains are lined with conifer forests. (Vancouver is located on Figure 7.30.)



- **4) Humid microthermal or cold snow forest climates or humid cold climates (D climates):**
- Temperature of the coldest month below – 3°C (26.6°F) but of the warmest month above 10°C (50°F), ground surface covered with snow for several months of a year.

- This climate has been divided into three types:
- (i) Df Climate:
- Humid cold climate, no dry season.
- This is further divided into:
- (a) Dfa (long warm summers, continental),
- (b) Dfb (long and cool summers), and
- © Dfc (short cool summer-subarctic).
- (

THE MOIST CONTINENTAL CLIMATE ⑩ (KÖPPEN: Dfa, Dfb, Dwa, Dwb)

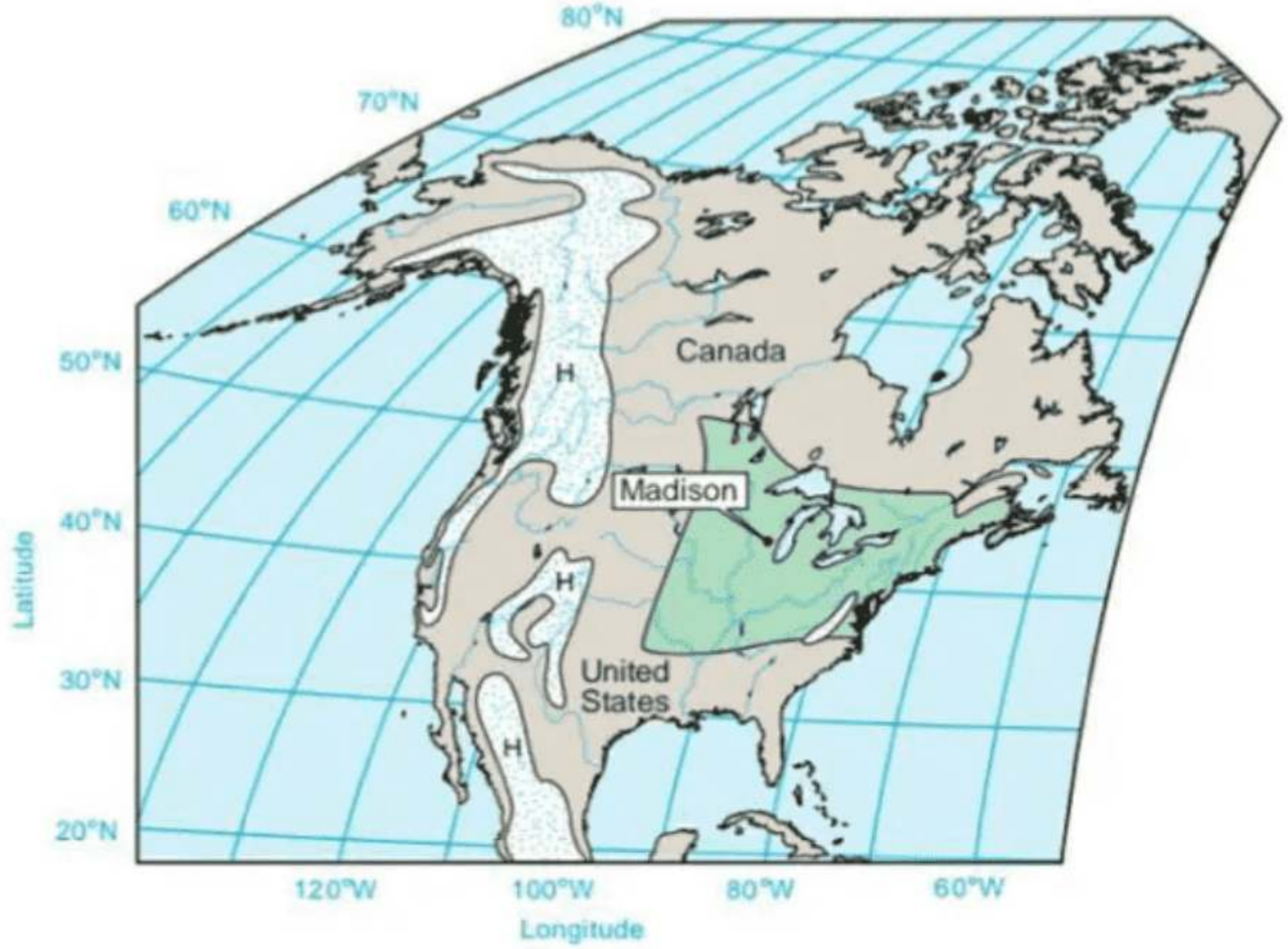
The **moist continental climate** ⑩ is located in central and eastern parts of North America and Eurasia in the midlatitudes. It lies in the polar-front zone—the battleground of polar and tropical air masses. Seasonal temperature

very commonly invade the region. The annual range of temperature is greater than that of any other climate and is greatest in Siberia, in Russia.

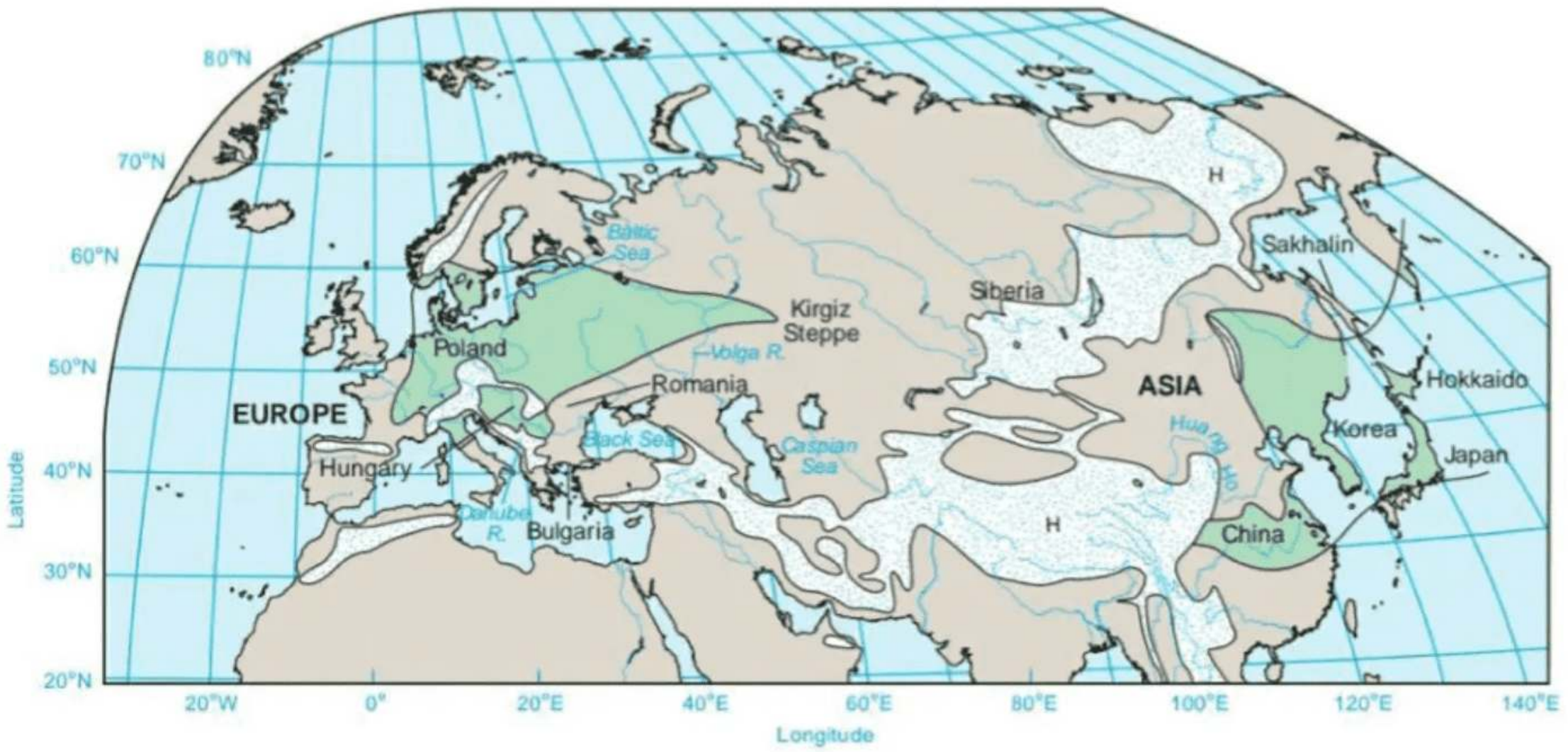
Precipitation increases substantially in summer, when maritime air masses penetrate the continent with traveling cyclones, but the total annual precipitation is small. Although much of the boreal forest climate is moist, large areas in western Canada and Siberia have low annual precipitation and are therefore cold and dry.

The boreal forest climate ⑪ has long, bitterly cold winters and short, cool summers. For most of the year, cold, dry continental arctic and polar air masses dominate. In summer, occasional maritime air masses provide moisture for precipitation.

Figure 7.37 shows the global extent of the boreal forest climate ⑪, ranging from 50° to 70° N latitude.

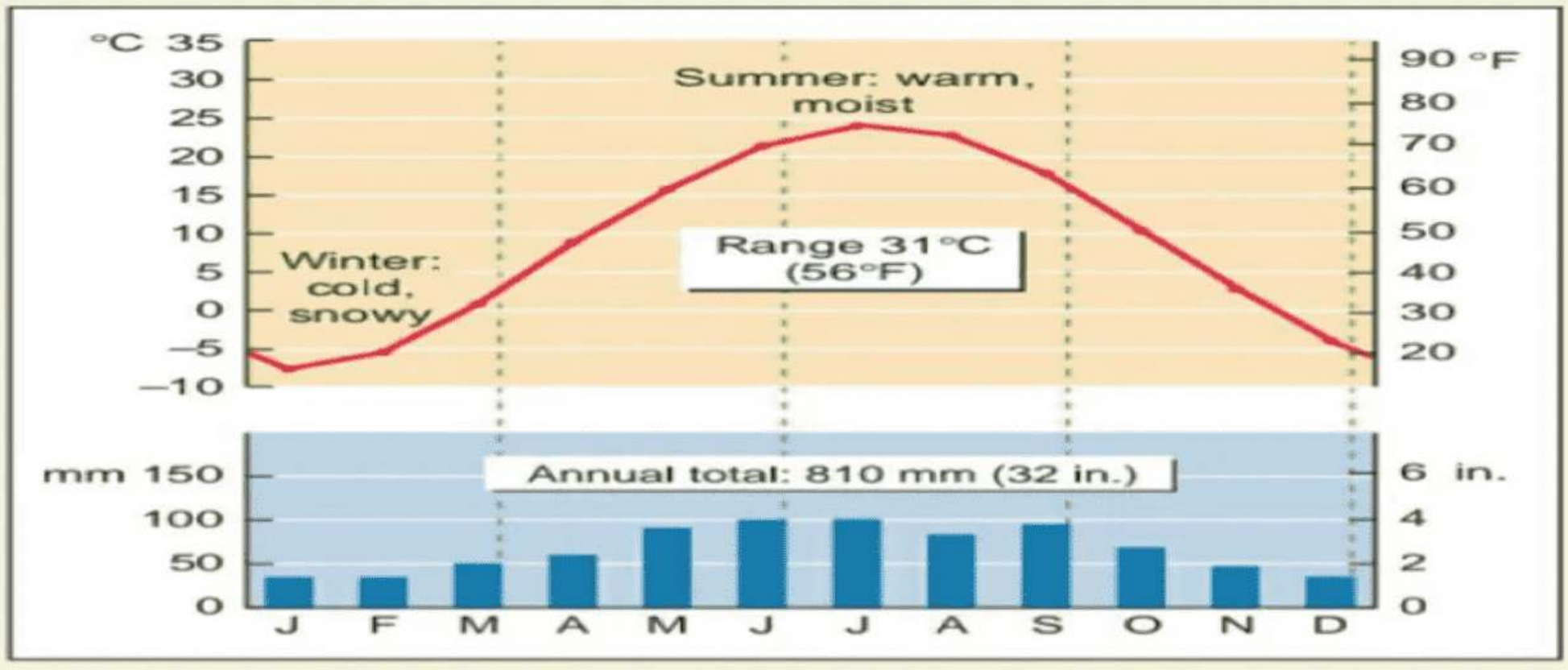


10 Moist continental climate
H Highland



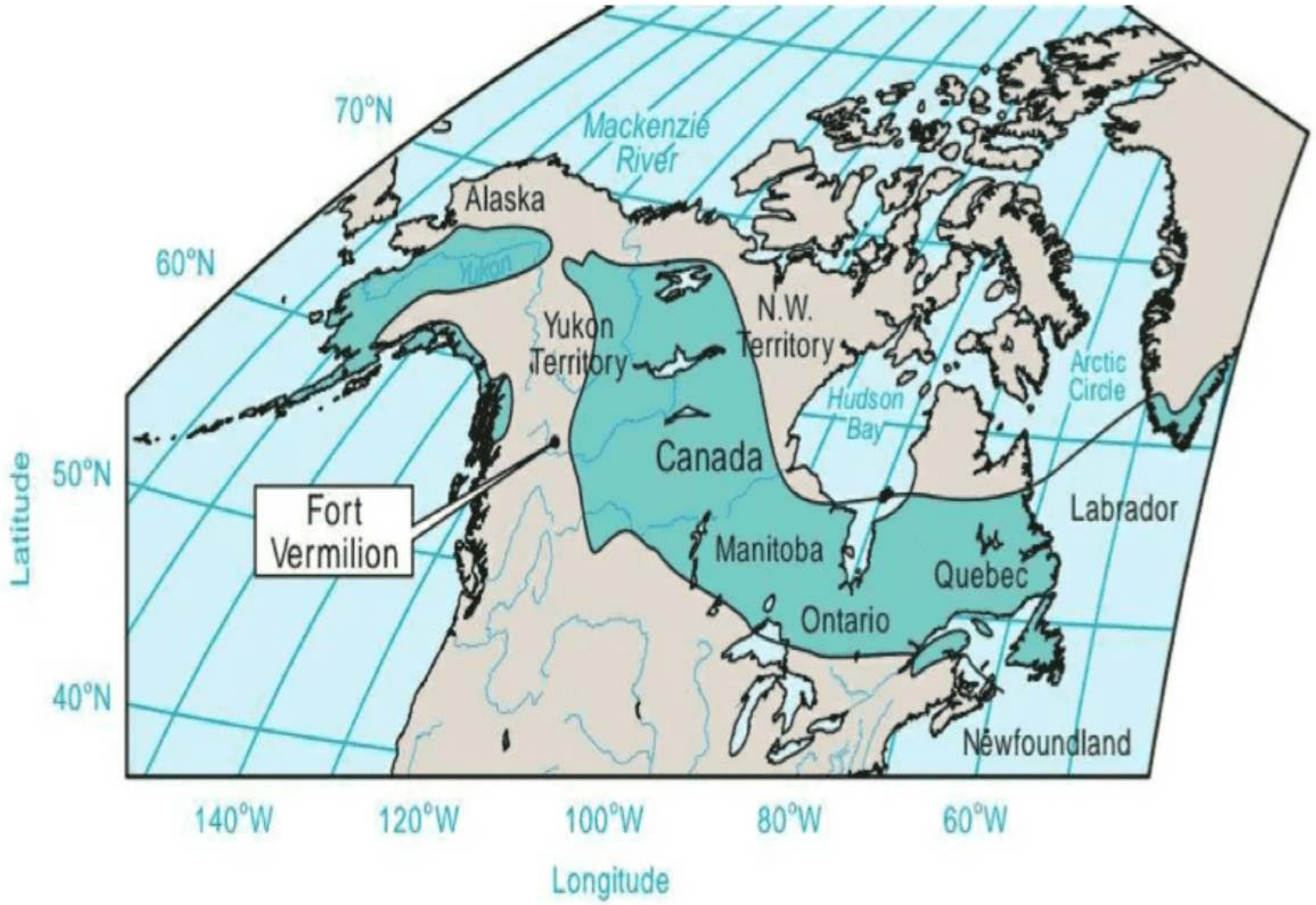
7.35 World map of the moist continental climate ⑩

7.36 Moist continental climate ⑩

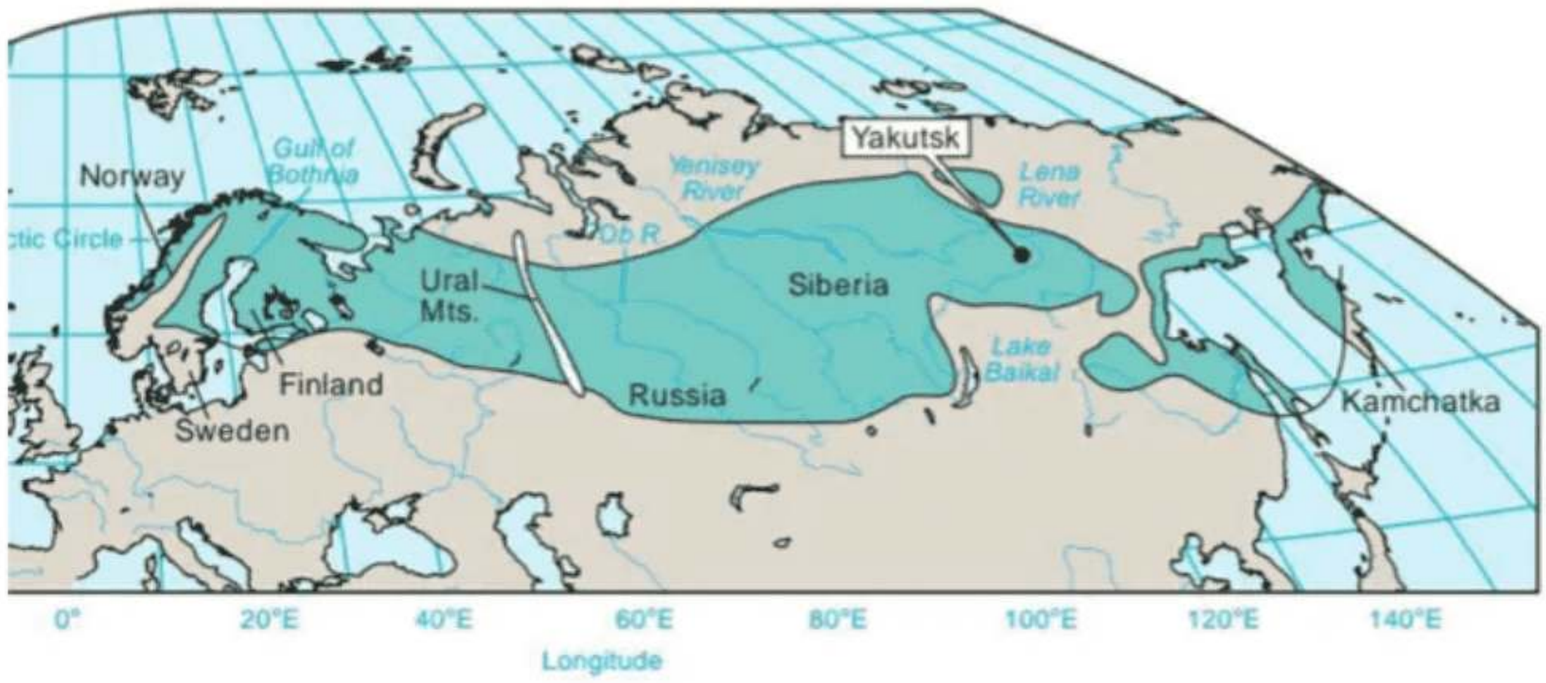


► **Madison, Wisconsin** The snowy winters here offer plenty of opportunity for outdoor recreation. (Madison is located on Figure 7.35.)

- Ii) Dw Climate:
- Humid cold climate, dry winters, further divided into:
- (a) Dwa-continental climate with long cool summer,
- (b) Dwb- cool short summer (sub-arctic type), and
- © Dwc-cold winters, d = temperature of the coldest month below –38°C, f, a, w, b, c as explained above.
-

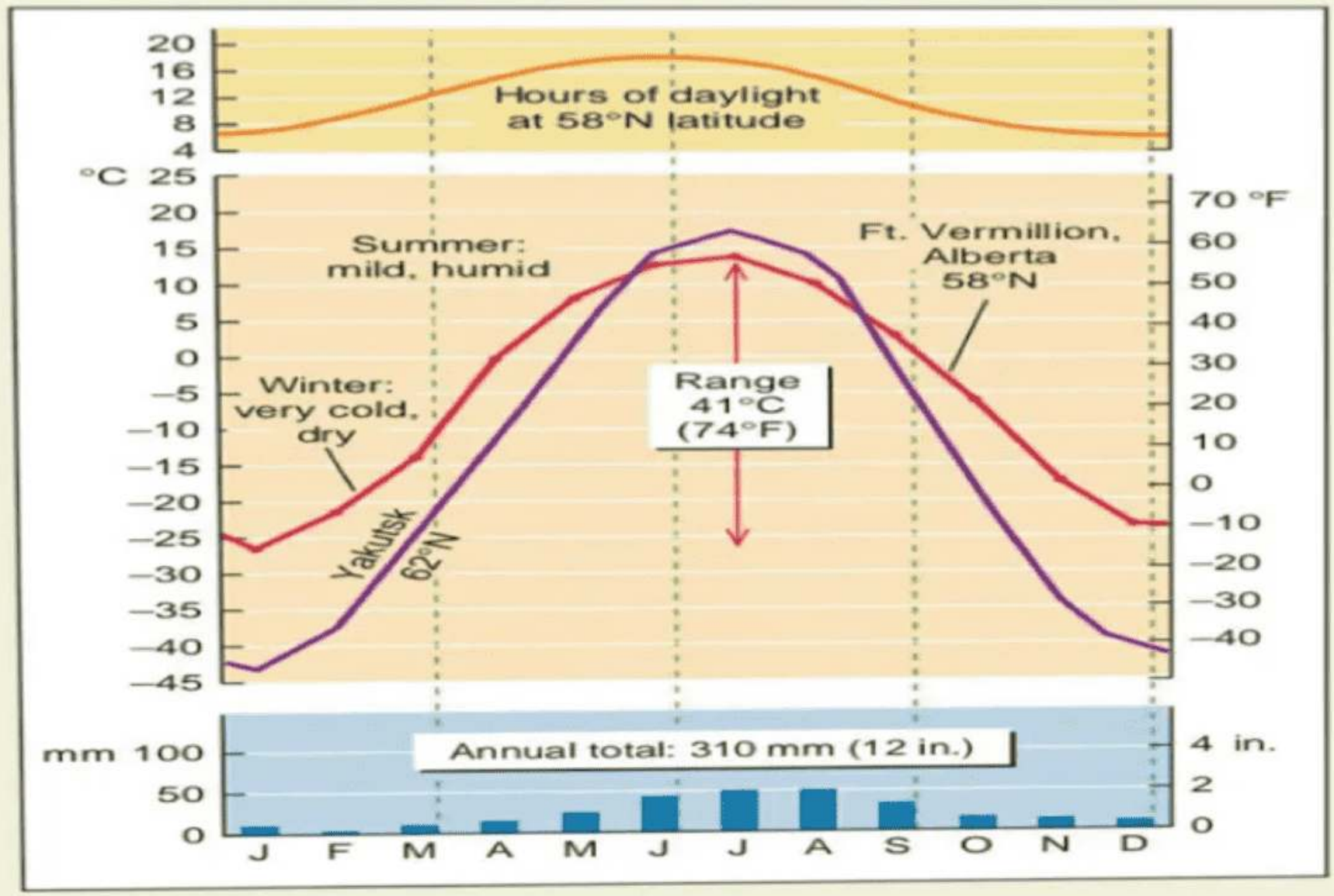

70°N
60°N
50°N
40°N
Latitude
140°W
120°W
100°W
80°W
60°W
Longitude
Mackenzie River
Alaska
Yukon
Yukon Territory
N.W. Territory
Hudson Bay
Arctic Circle
Canada
Fort Vermilion
Manitoba
Quebec
Ontario
Labrador
Newfoundland

e



e boreal forest climate ⑪

d a very great
lberta (lat.
consecutive
ual cycle with
over remains
nperature
range, as well
(–44°F).



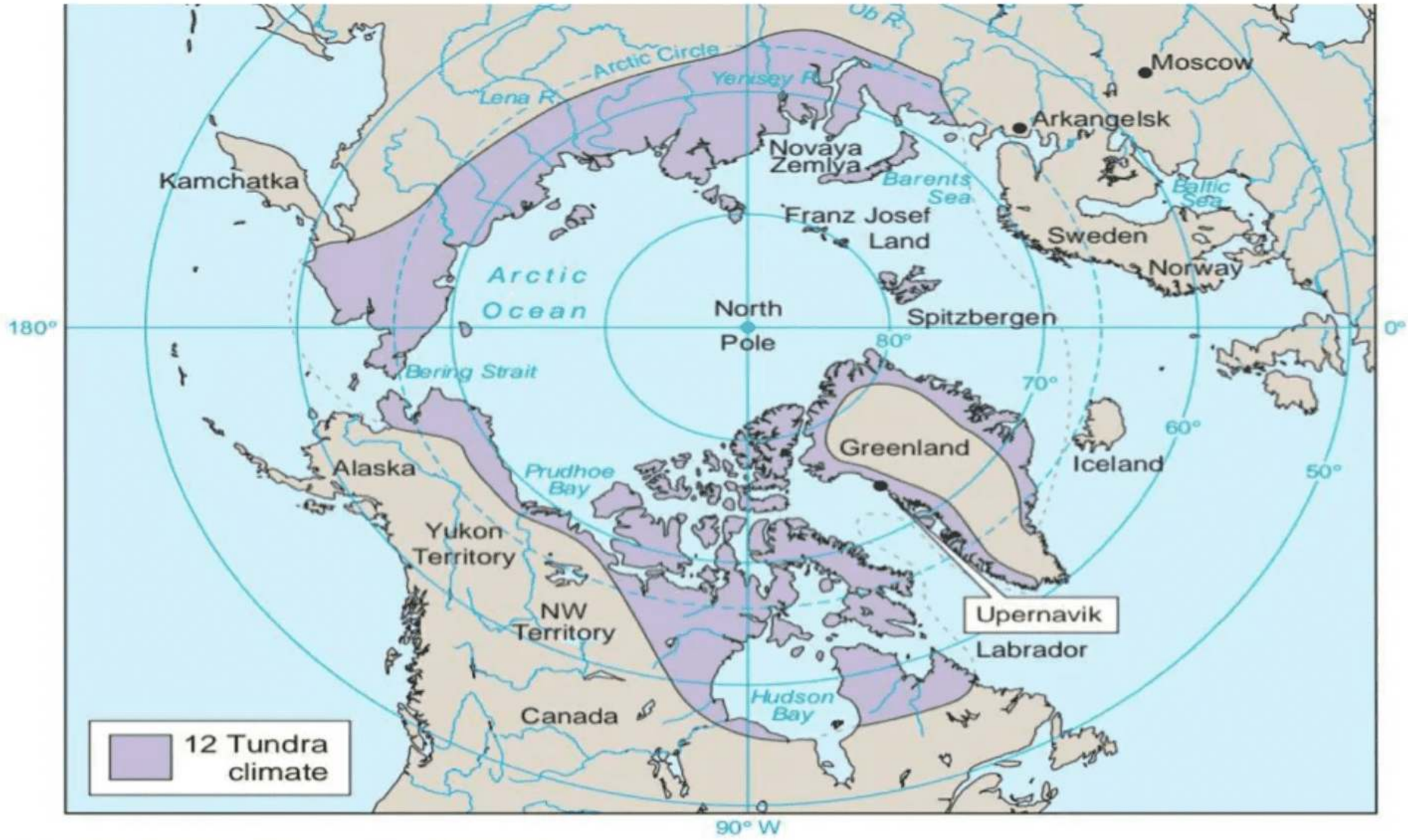


◀ **Yakutsk, Siberia** These well-dressed pedestrians are making their way down a snowy street in winter. (Yakutsk is located on Figure 7.37.) (National Geographic Image Collection.)

THE TUNDRA CLIMATE ⑫ (KÖPPEN: ET)

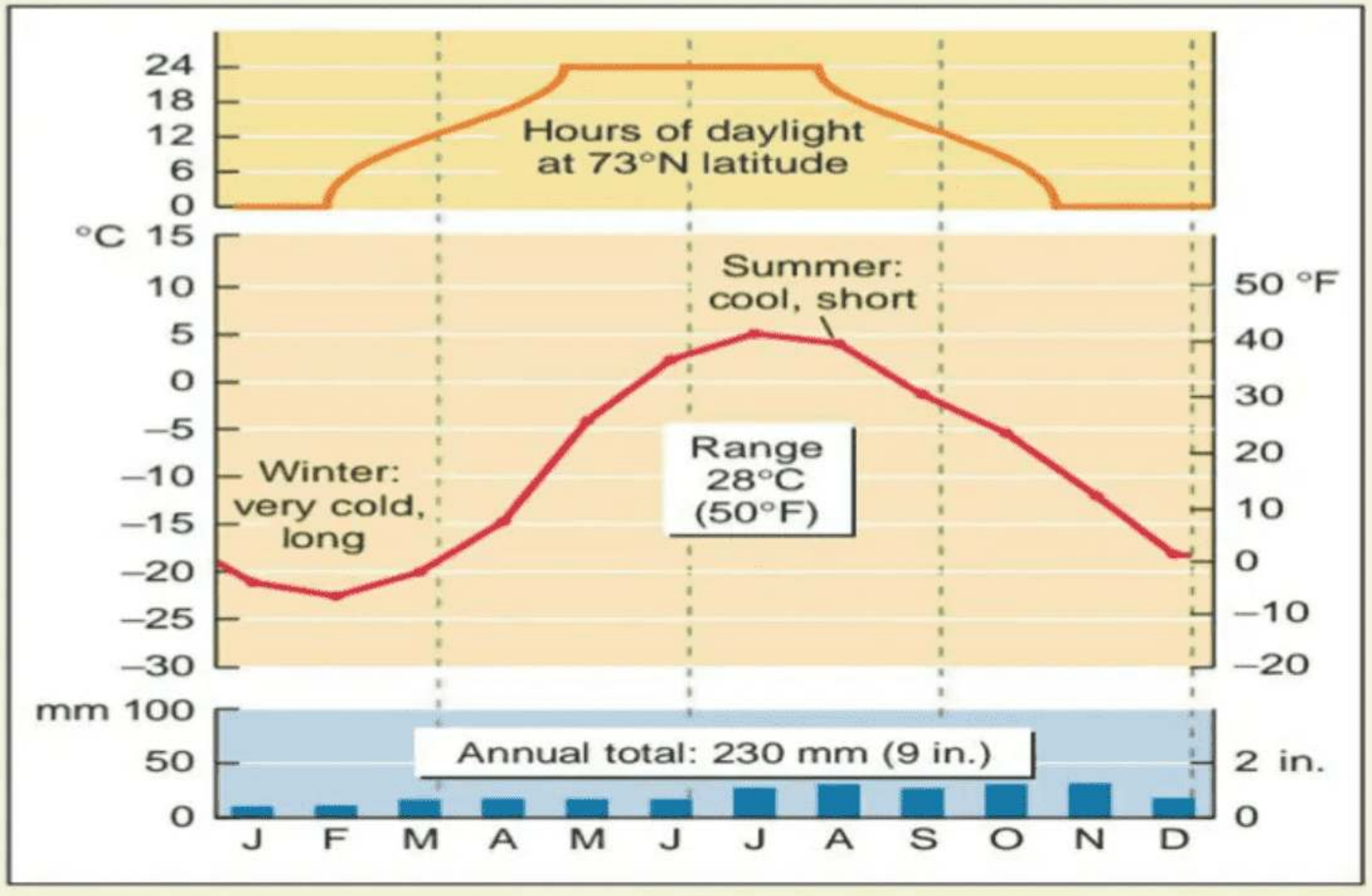
The **tundra climate** ⑫ occupies arctic coastal fringes and is dominated by polar (cP, mP) and arctic (cA) air masses. Winters are long and severe. The nearby ocean water moderates winter temperatures so they don't fall to the extreme lows found in the continental interior. There is a very short mild season, but many climatologists do not recognize this as a true summer.

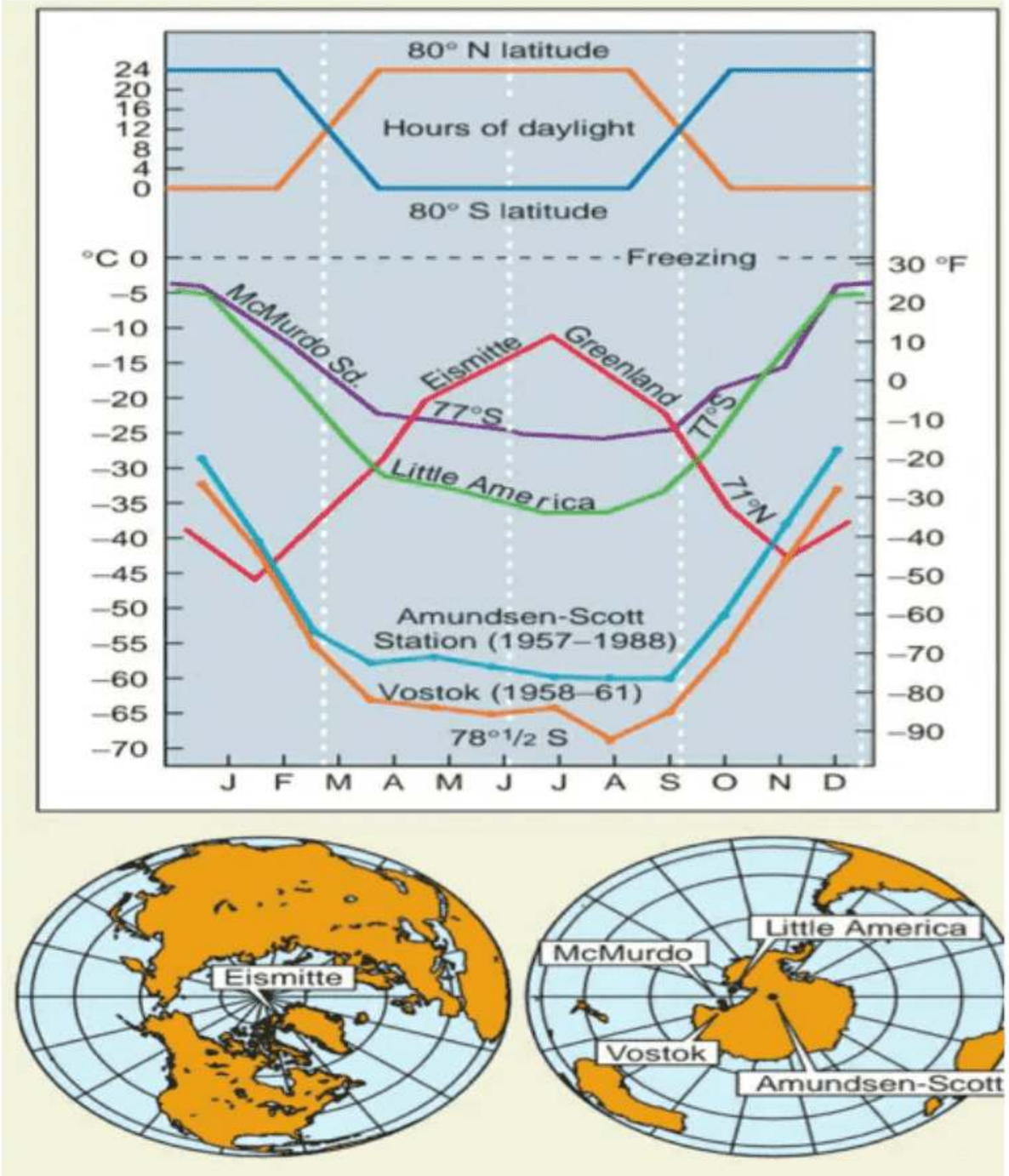
The world map of the tundra climate ⑫ (Figure 7.40) shows this climate type ringing the Arctic Ocean and extending across the island region of northern Canada. It includes the Alaskan north slope, the Hudson Bay region, and the Greenland coast in North America. In Eurasia, this climate type occupies the Siberian coast, although tundra vegetation is also found on northern Iceland and along the arctic coast of Scandinavia. The Antarctic Peninsula (not shown in Figure 7.40) also belongs to this climate. The latitude range for this climate is 60° to 75° N and S, except for the northern coast of Greenland, where tundra occurs at latitudes greater than 80° N.



7.40 World map of the tundra climate ⑫

7.41 Tundra climate ⑫




80° N latitude
24
20
16
12
8
4
0
Hours of daylight
80° S latitude
°C 0
Freezing
30 °F
−5
−10
−15
−20
−25
−30
−35
−40
−45
−50
−55
−60
−65
−70
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
McMurdo Sd.
Eismitte
Greenland
77°S
77°S
71°N
Little America
Amundsen-Scott
Station (1957–1988)
Vostok (1958–61)
78°1/2 S
J F M A M J J A S O N D
Eismitte
McMurdo
Little America
Vostok
Amundsen-Scott

the vast, high ice sheets of Greenland and Antarctica and over polar sea ice of the Arctic Ocean. Annual mean temperature is much lower than any other climate, with no monthly mean above freezing. Strong temperature inversions, caused by radiation loss from the surface, develop over the ice sheets. In Antarctica and Greenland, the high surface altitude of the ice sheets intensifies the cold. Strong cyclones with blizzard winds are frequent. Precipitation, almost all occurring as snow, is very low, but the snow accumulates because of the continuous cold. The latitude range for this climate is 65° to 90° N and S. Figure 7.42 compares temperature graphs for several representative ice sheet stations.

The ice sheet climate ⑬ has the lowest temperatures found on Earth. No month shows mean temperatures above freezing, and winter mean monthly temperatures can fall to 40°C (–40°F) and below.

- **(5) Polar climates (E climates):**
- **Temperature of the warmest month less than 10°C (50°F), further divided into:**
- (i) ET and
- (ii) EF climates.
- **(i)** ET climate-tundra climate, temperature of the warmest month below 10°C but above 0°C.
- **(ii)** EF climate-permanent snow fields, temperature in all months below 0°C.