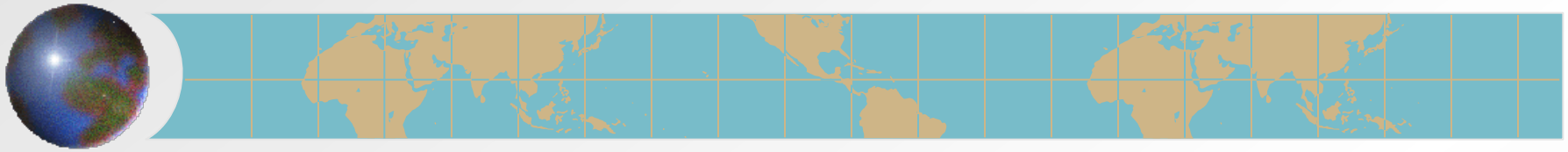


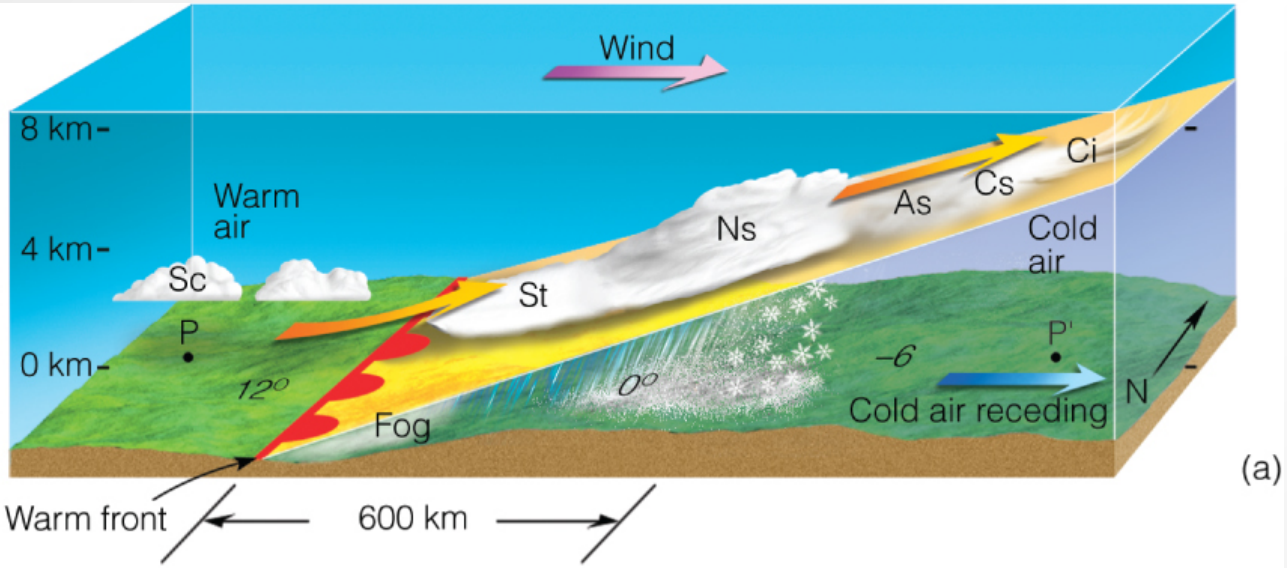
Lecture outline

- **Weather forecasting: Colour in the daytime sky**
  - **Haloes, sundogs and rainbows**
- **Polar cyclones**
  - **Dynamics**
  - **Climatology**

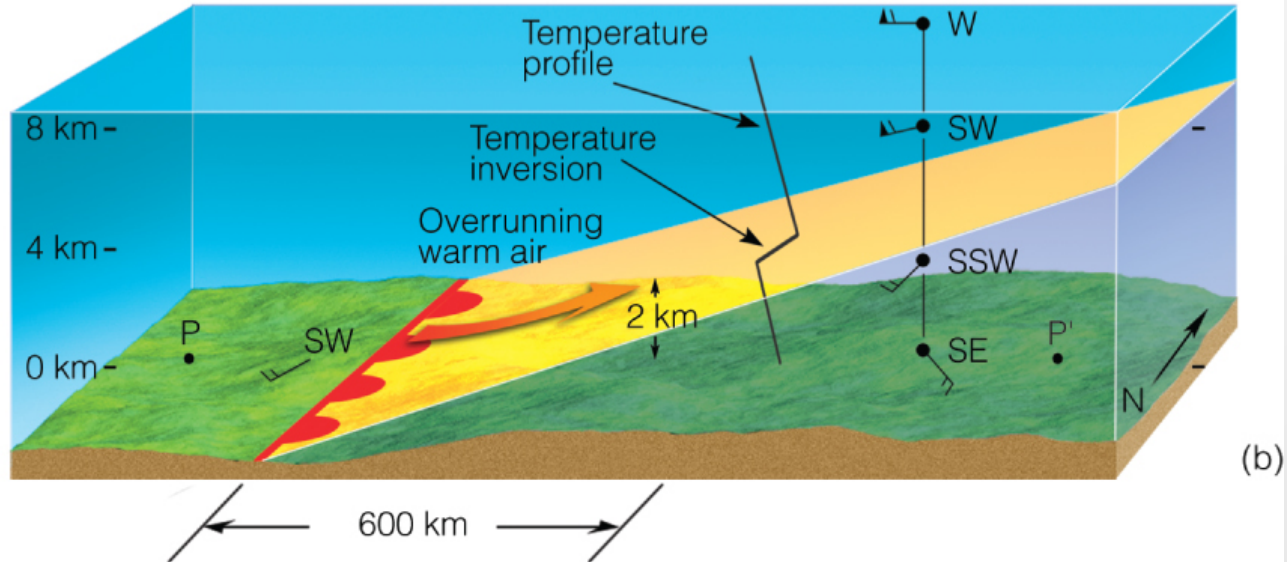
● FIGURE 19.20 A halo with an upper tangent arc.

FIGURE 19.23 The bright areas on each side of the sun are sundogs.

clouds, precipitation,
gure 11.18 along the



(a)

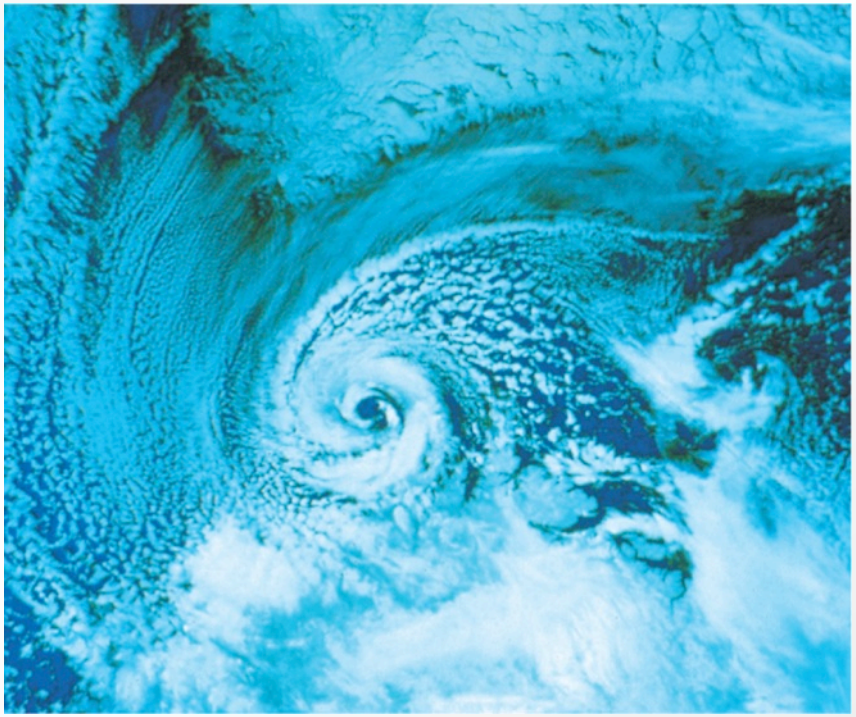


(b)

FIGURE 19.29 A primary and a secondary rainbow.

Polar Lows

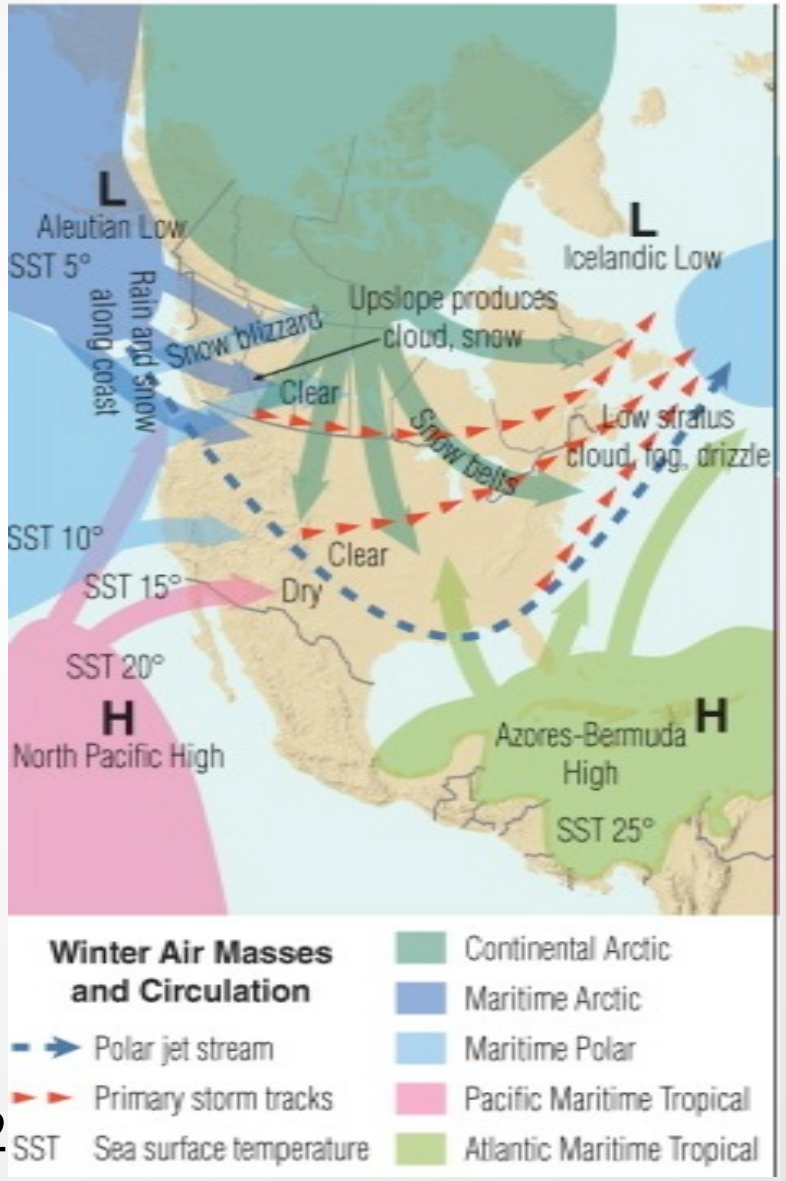
- Cyclones forming over the open sea in polar regions
- Winds must be *gale force*
  - >60 km/h
- Several hundred kilometres in diameter
- Last up to two days



Barents Sea Feb 27 1987
Ahrens: Fig. 12.28

Polar low formation

- cA air mass moves over open sea water
- *Arctic front* forms between cA and mP air masses
- Relative warmth of the open sea fuels the storm

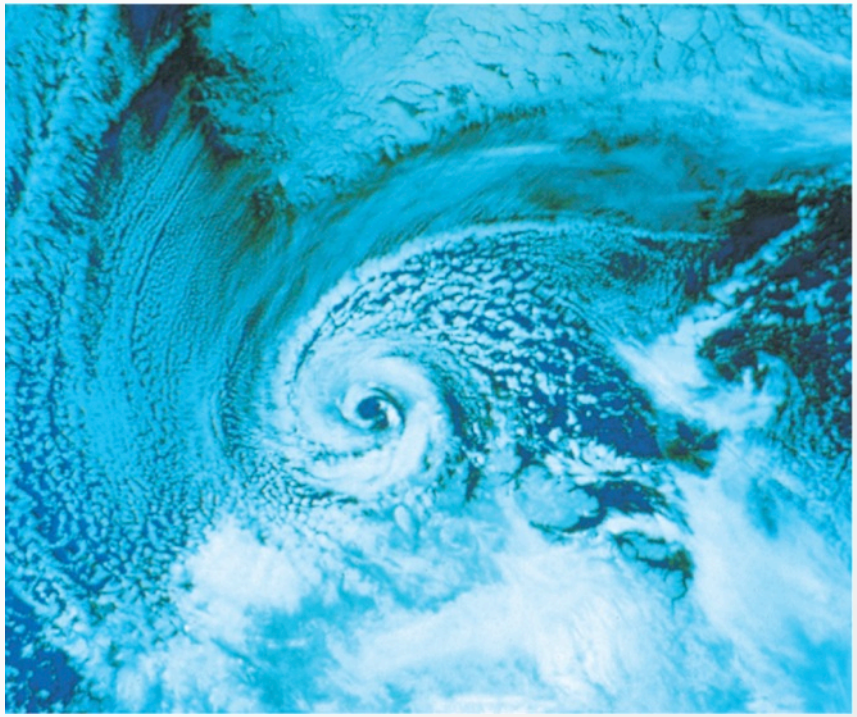


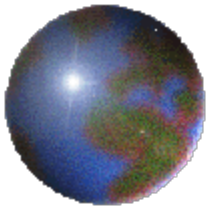
Ahrens: Fig. 11.2

Similarity to tropical cyclones

- Sea surface temperatures (SSTs) as energy source
- Eye formation
- Warm core
- Dissipate over land (or ice)

- Differences:
  - Much weaker winds
  - Heavy snow instead of rain



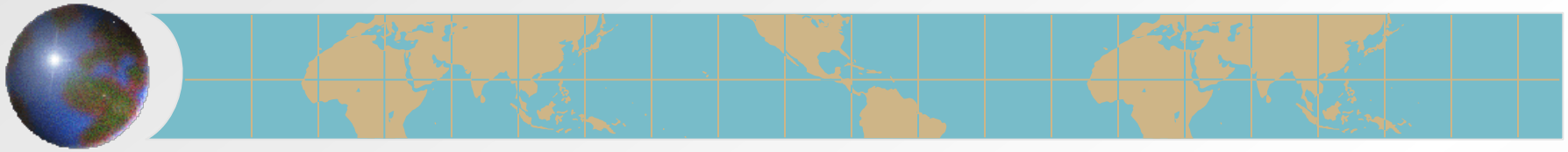


Climate Classification

GEOG/ENST 2331 – Lecture 21

Lab 7

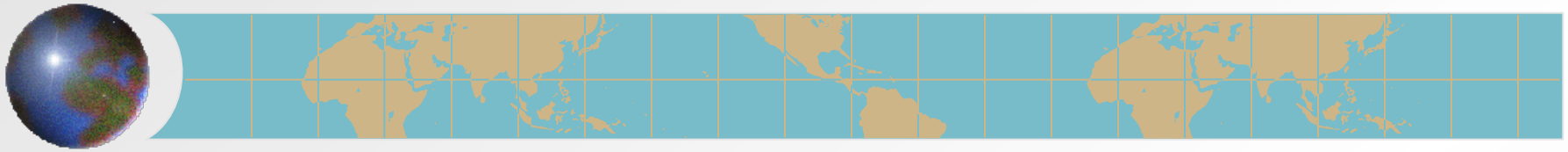
Ahrens: Chapter 17



Defining climate

- The statistical properties of the atmosphere over the long-term constitute the climate of a particular area

- Certain areas have similar annual and multi-annual ranges in weather properties
  - Temperature
  - Precipitation
  - Air Mass Types
  - Energy Budget
  - Seasonal Water Budget

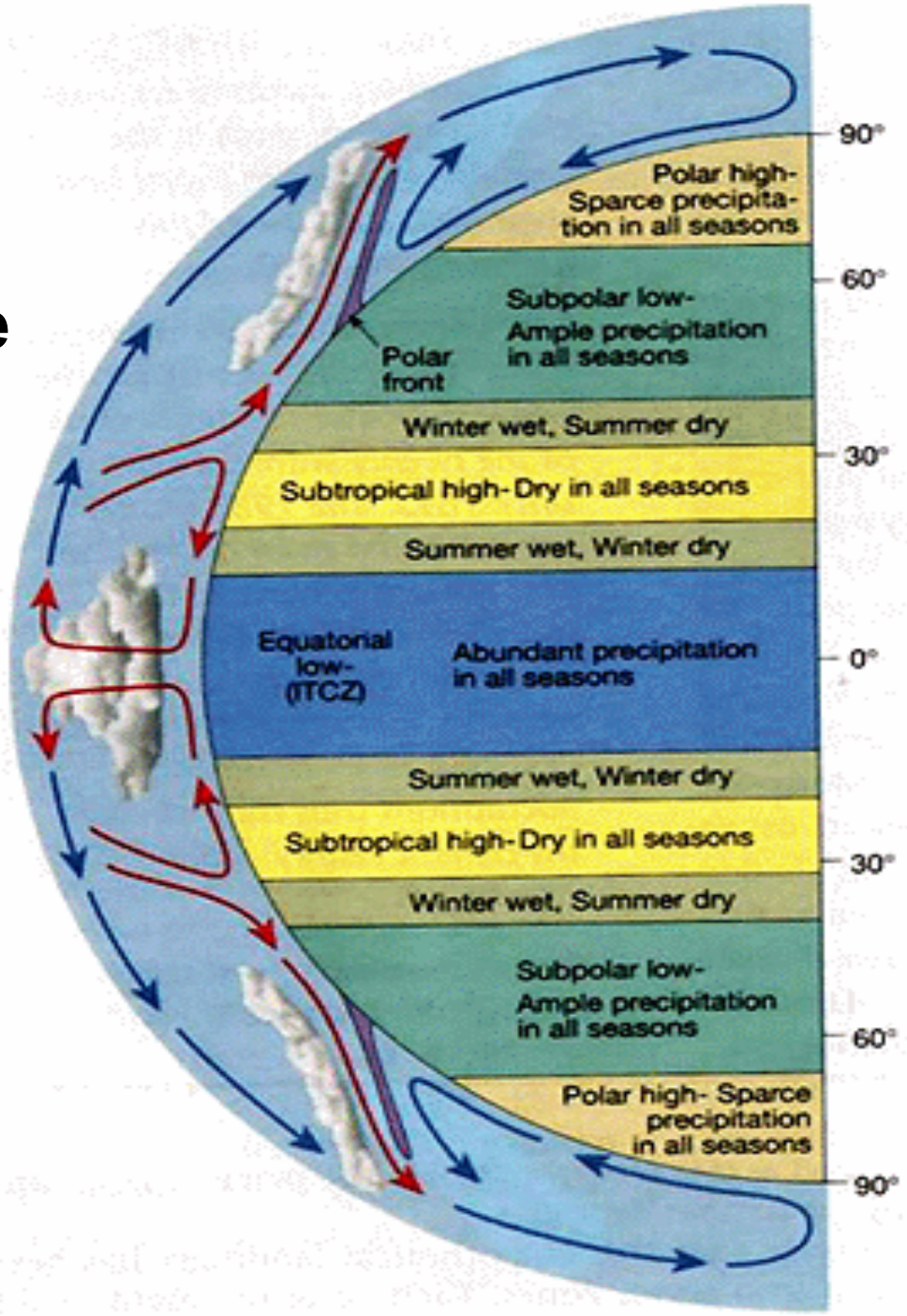


Climate classification

- Variables aren't independent
  - Similar regions can be grouped together
  - Generalizations can be useful

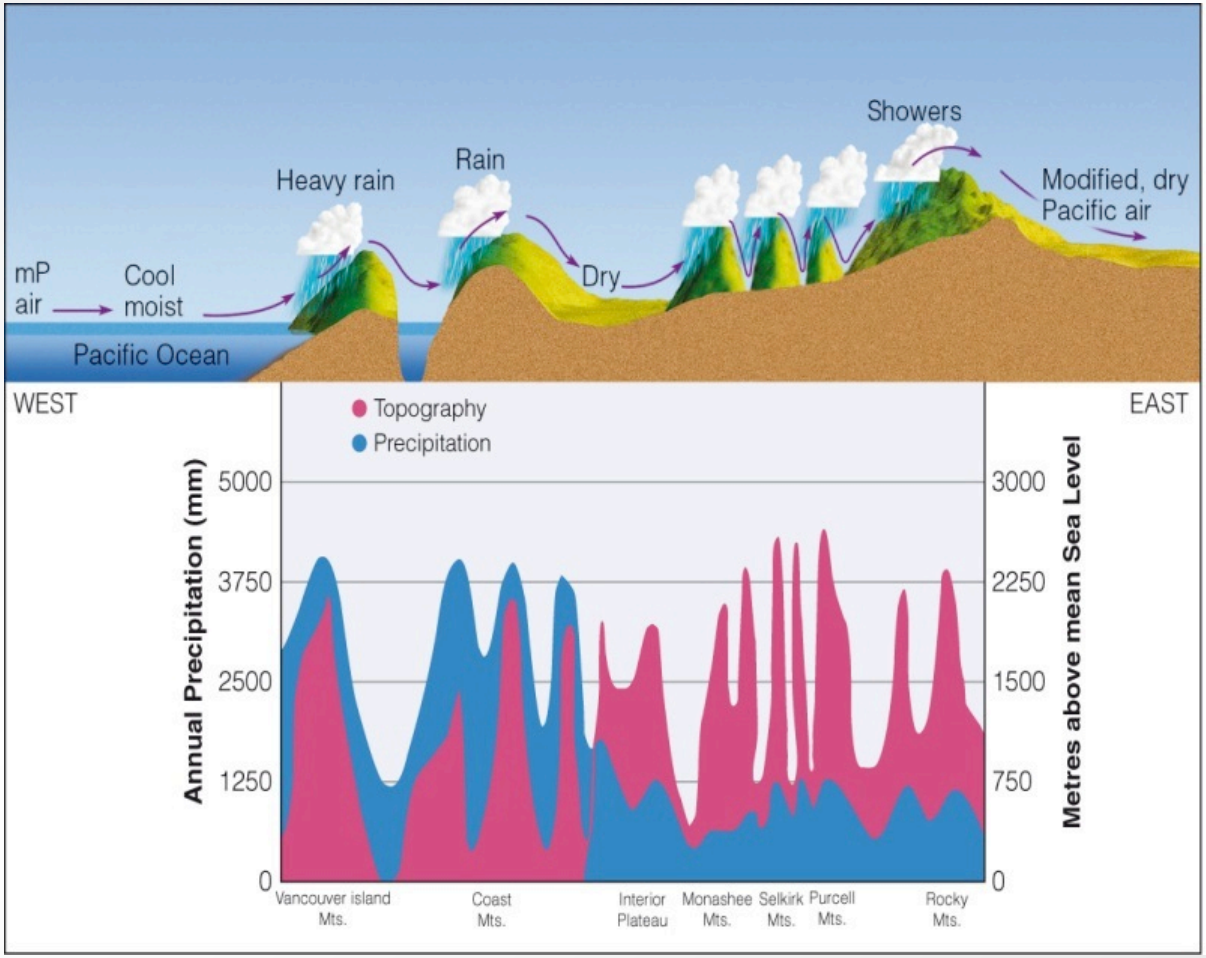
- Ancient Greeks
  - Tropical, temperate and polar
  - Classification based on latitude

Global precipitation pattern predicted by the general circulation



Mountains

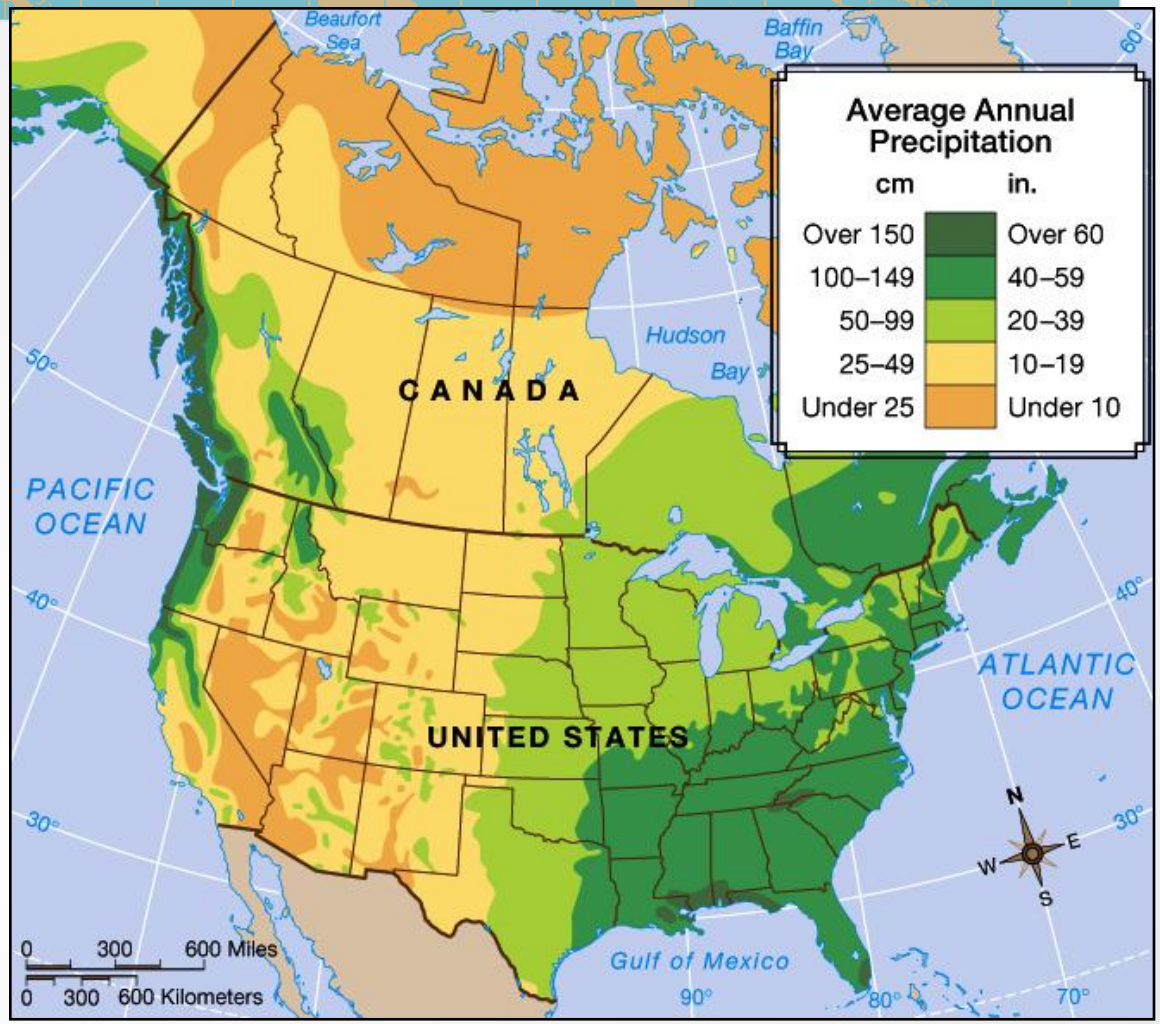
- Temperature decreases with altitude
- Rain shadows form downwind



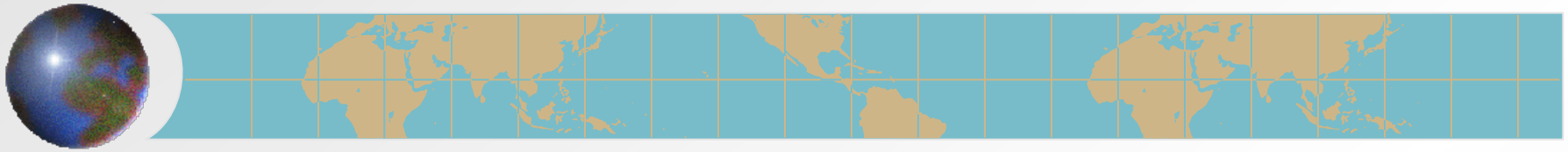
Ahrens: Fig. 17.5

Oceans

- Moderate temperature
- Provide moisture

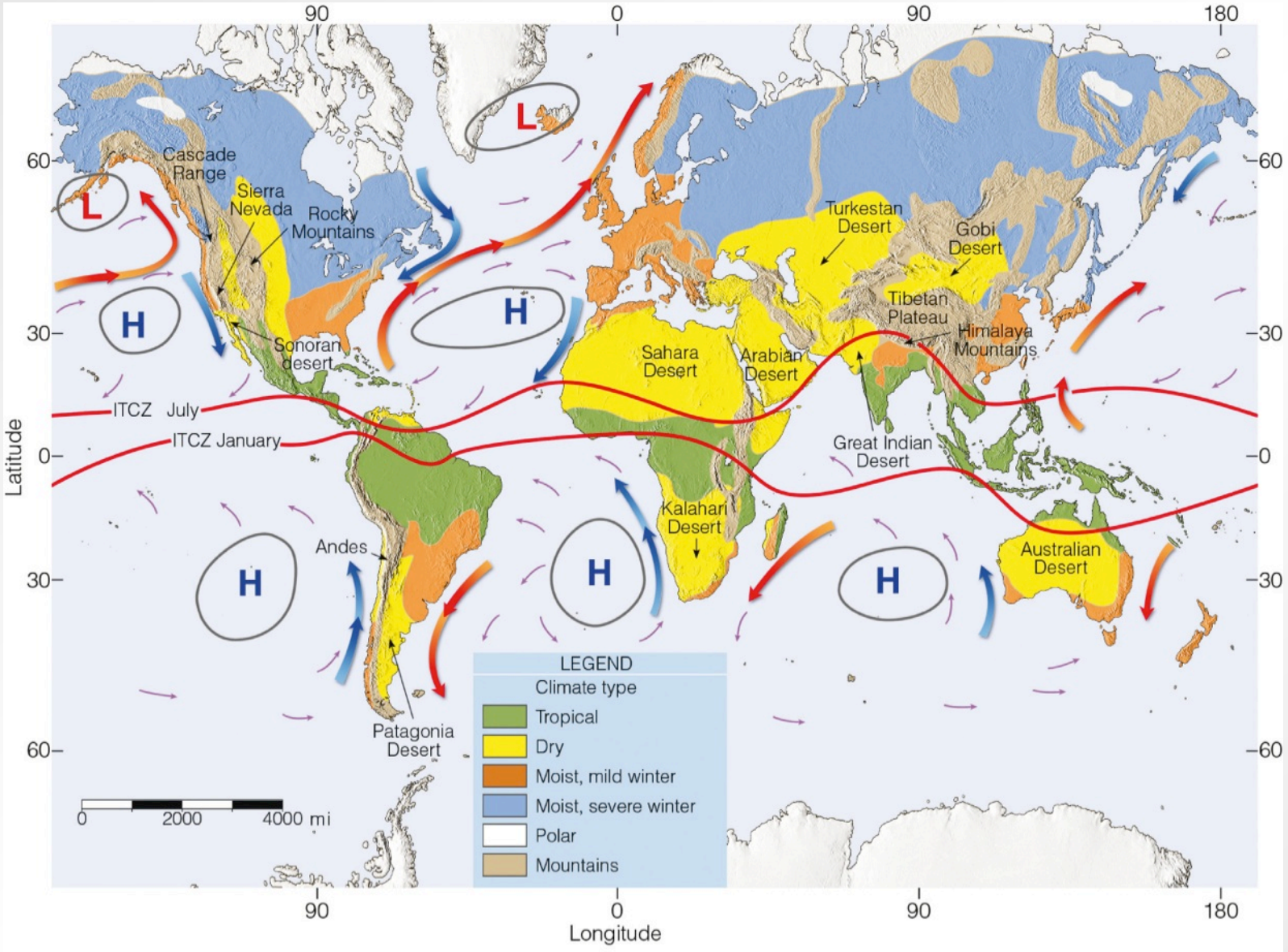


A&B: Figure 7-10



Climate classification

- Ancient Greeks
  - Latitude (temperature)
- The Köppen System (1918)
  - Vegetation used as an indicator because of sparseness of direct observations
- Thornthwaite's System
  - P/E index (1930)
  - Potential evapotranspiration (1948)

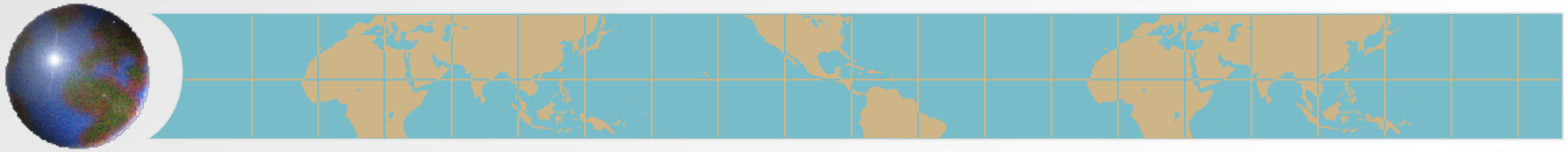


The Köppen System

Ahrens: Fig. 17.6

Table 15–1 Climate Types According to Koeppen

Type	Subtype	Letter Code	Characteristics
A—Tropical	Tropical wet	Af	No dry season
	Tropical monsoonal	Am	Short dry season
	Tropical wet and dry	Aw	Winter dry season
B—Dry	Subtropical desert	BWh	Low-latitude dry
	Subtropical steppe	BSh	Low-latitude semi-dry
	Mid-latitude desert	BWk	Mid-latitude dry
	Mid-latitude steppe	BSk	Mid-latitude semi-dry
C—Mild Mid-latitude	Mediterranean	Csa	Dry, hot summer
		Csb	Dry, warm summer
	Humid subtropical	Cfa	Hot summer, no dry season
		Cwa	Hot summer, brief winter dry season
	Marine west coast	Cfb	Mild throughout year, no dry season, warm summer
		Cfc	Mild throughout year, no dry season, cool summer
D—Severe Mid-latitude	Humid continental	Dfa	Severe winter, no dry season, hot summer
		Dfb	Severe winter, no dry season, warm summer
		Dwa	Severe winter, winter dry season, hot summer
		Dwb	Severe winter, winter dry season, warm summer
	Subarctic	Dfc	Severe winter, no dry season, cool summer
		Dfd	Extremely severe winter, no dry season, cool summer
		Dwc	Severe winter, winter dry season, cool summer
		Dwd	Extremely severe winter, winter dry season, cool summer
E—Polar	Tundra	ET	No true summer
	Polar ice cap	EF	Perennial ice
H—Highland	Highland	H	Highland



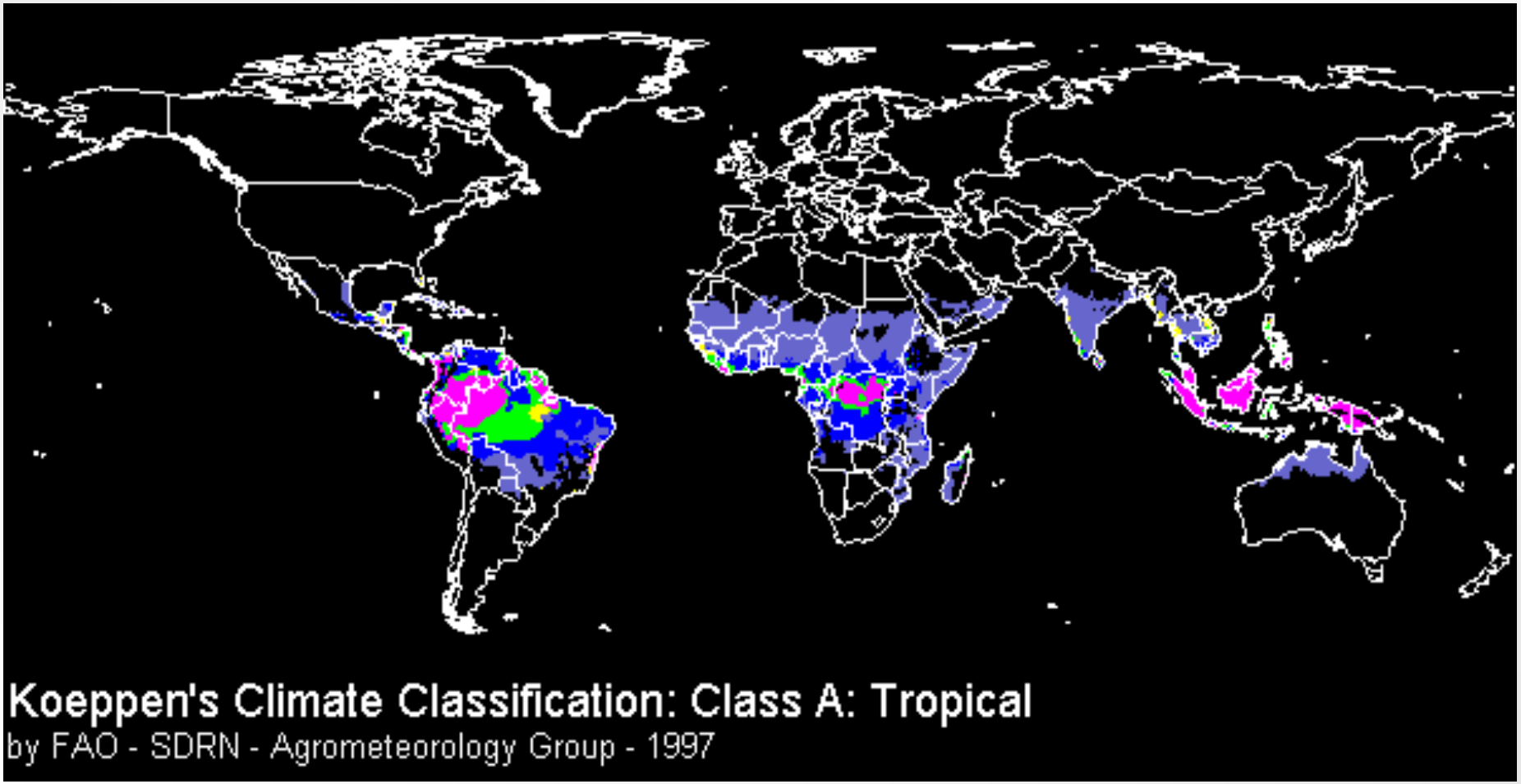
Additional codes for A, C and D

- *f* – full year precipitation
- *s* – driest in summer
- *w* – driest in winter
- *m* – monsoon

- *a* – hottest summers
- *b*
- *c*
- *d* – coldest summers

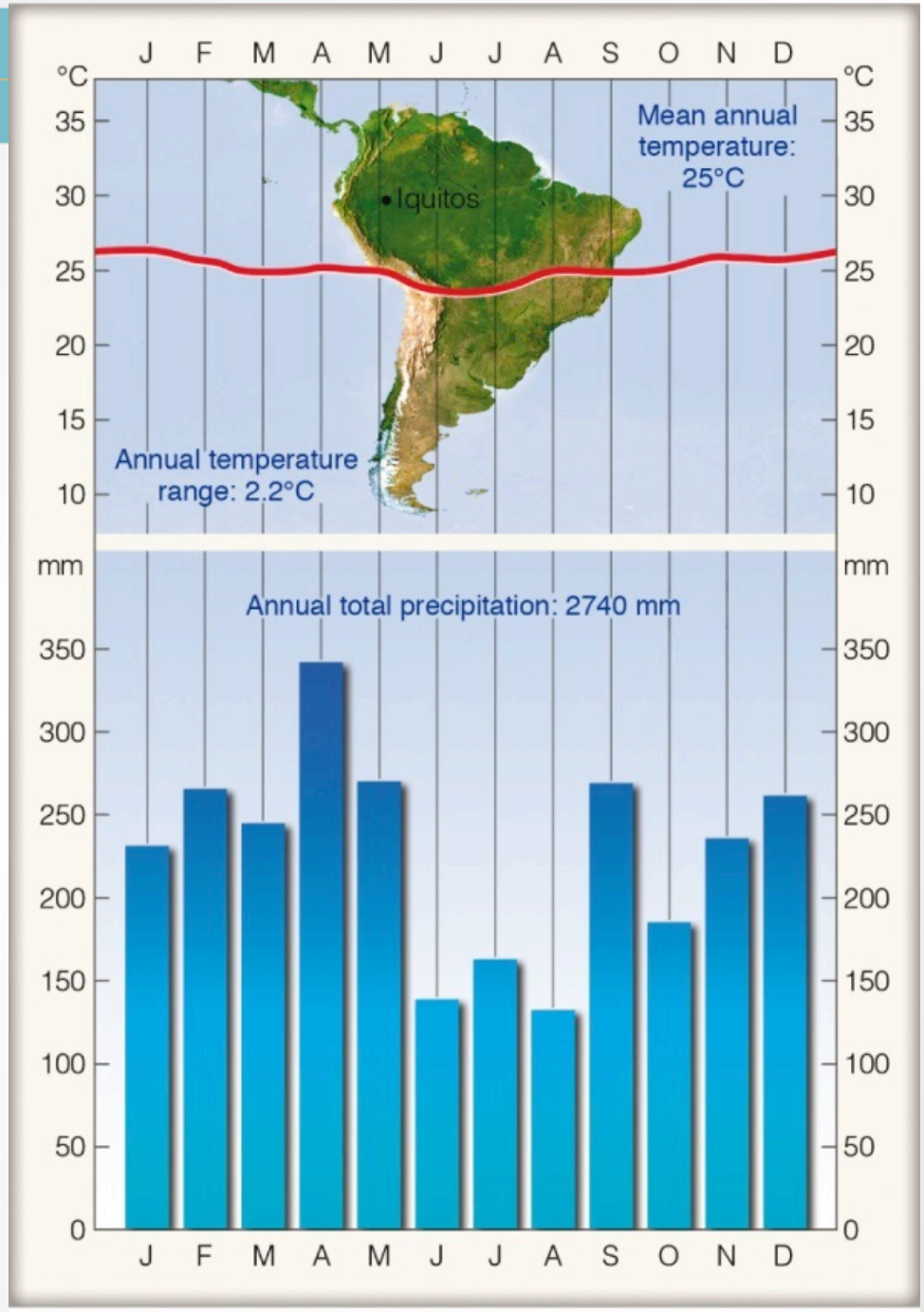
A - Tropical Climates

- Between the Tropics of Cancer and Capricorn
- Exhibit warm temperatures and minimal seasonal temperature



Af – Tropical wet climate

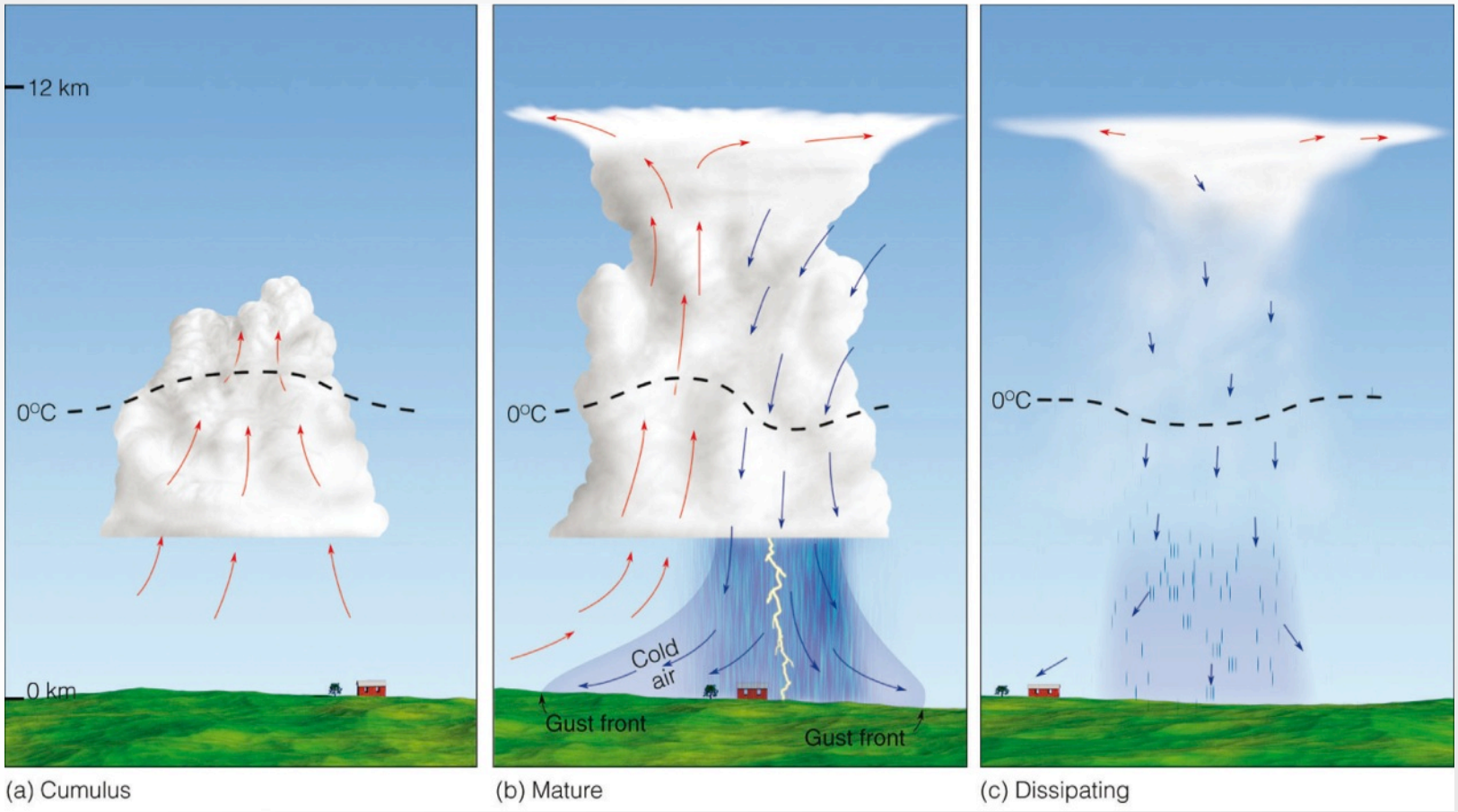
- ***Climograph*** for Iquitos, Peru
- 4°S, 73°W
- 130 m above MSL
- ITCZ is always close
- Windward side of Andes



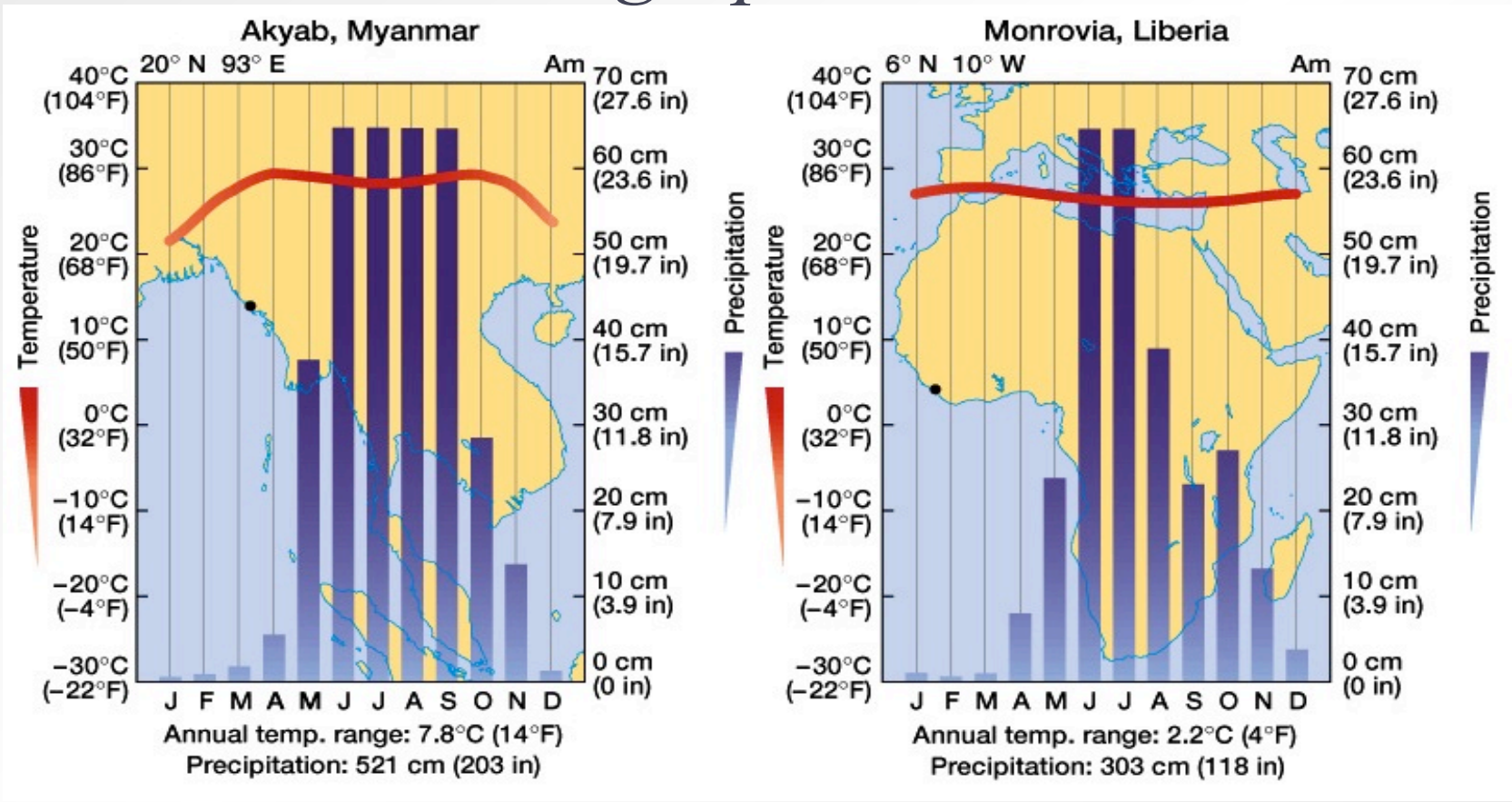
Ahrens: Fig. 17.11

Tropical wet climates (Af)

Brief but heavy afternoon thundershowers



Am *climographs – Monsoonal*



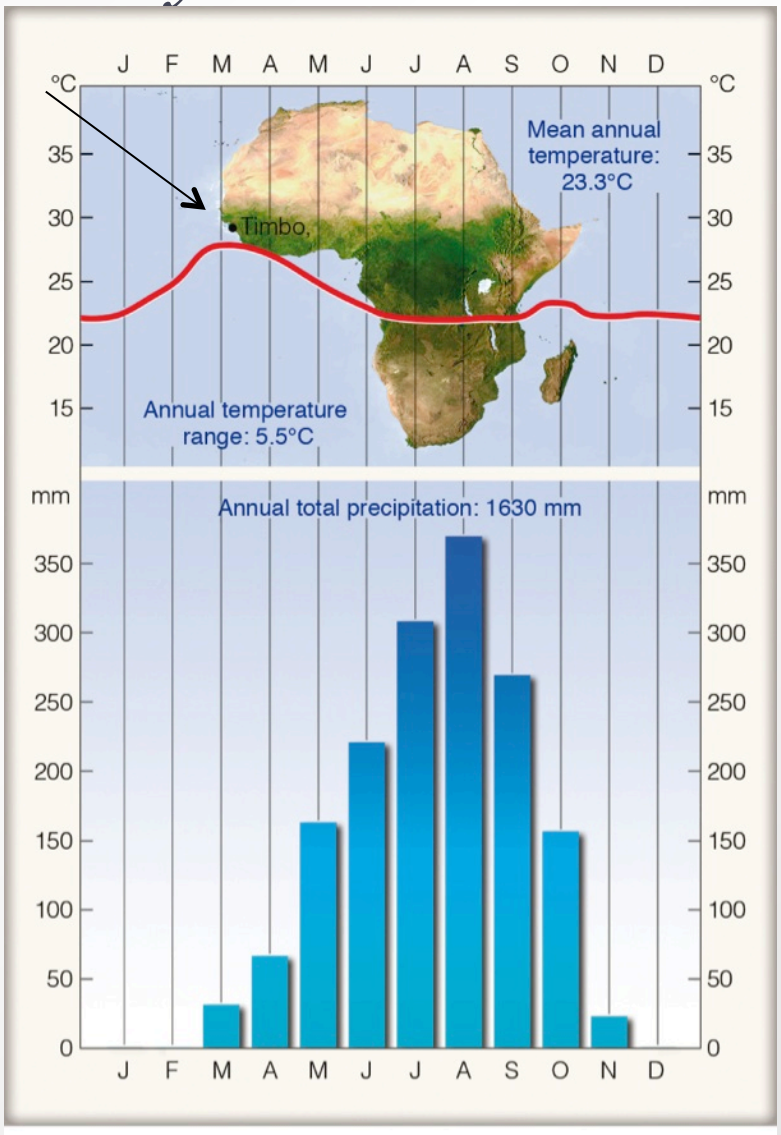
Occur near tropical coastal areas receiving onshore winds through much of the year

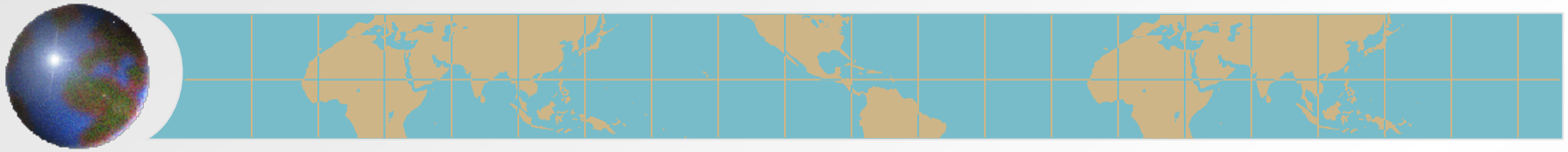
Pronounced seasonal variations of precipitation

Aw – Tropical wet-and-dry climate

- Timbo, Guinea
- 10°N, 12°W
- ITCZ in summer
- Subtropical high in winter
  - Higher *T* from sunny skies

- Ahrens: Fig. 17.13



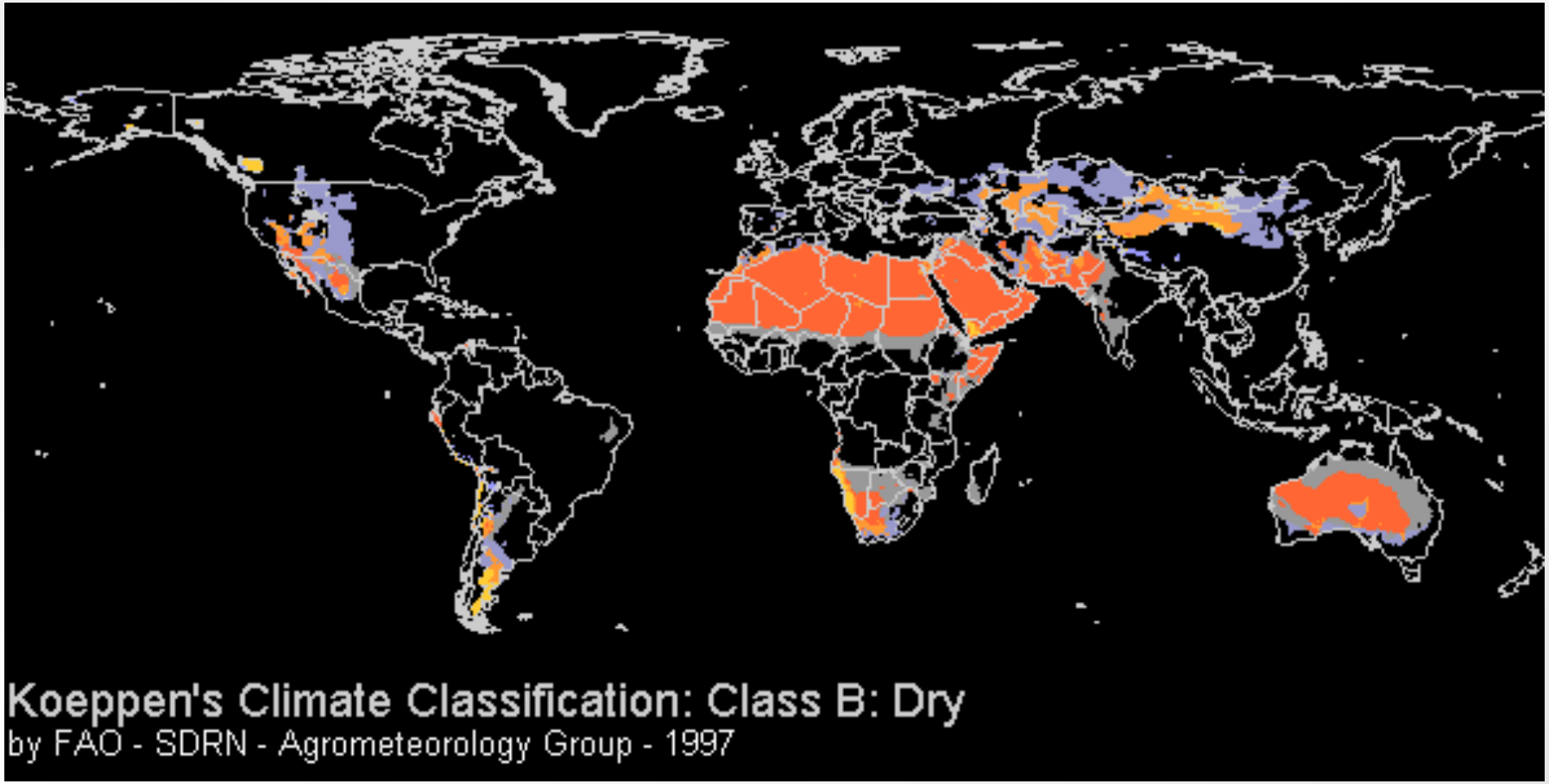


Aw climates

- Rainfall may be unreliable
  - E.g. Sahel region
- Savanna vegetation regimes dominate due to a lack of precipitation and frequent fires in the dry months
- Diurnal temperature variations are pronounced in dry season when ranges may be as high as 15 C°
  - Few clouds
  - Closer to arid than tropical

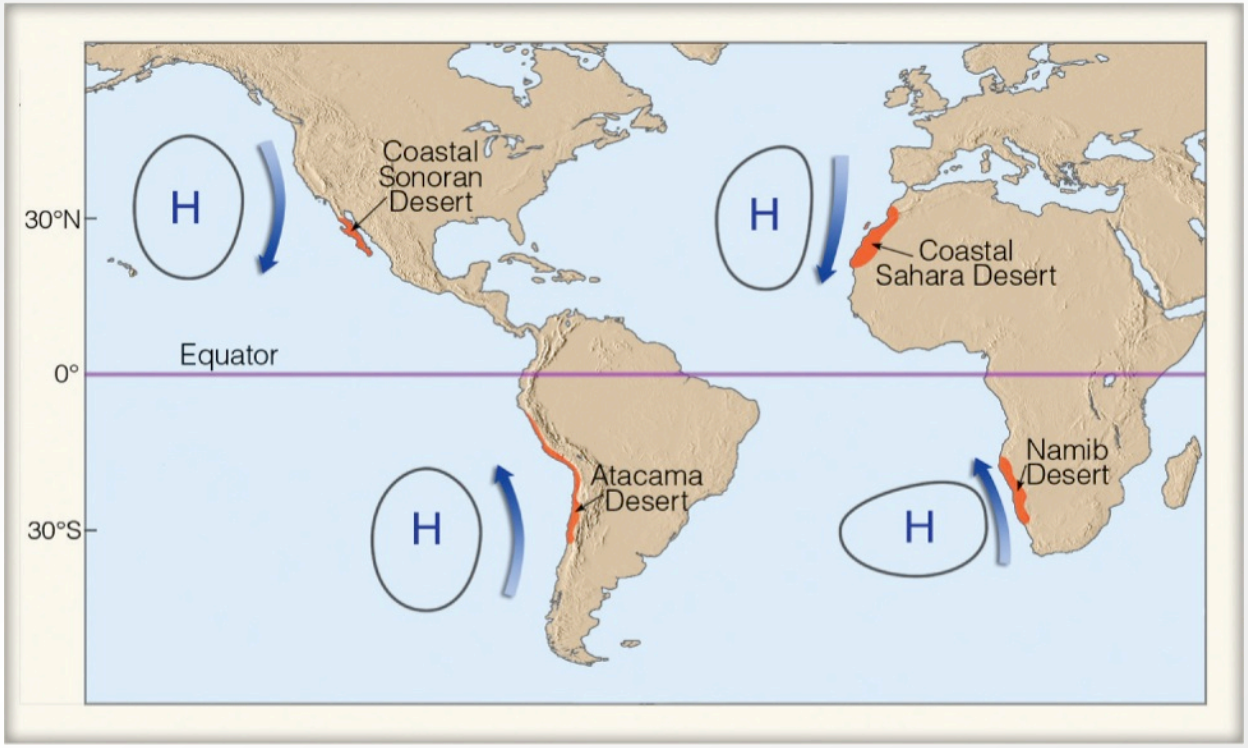
B – Dry Climates

- Potential evapotranspiration exceeds precipitation
- Regions sub-classified as either semi-desert (steppe) or desert



Dry climates (B)

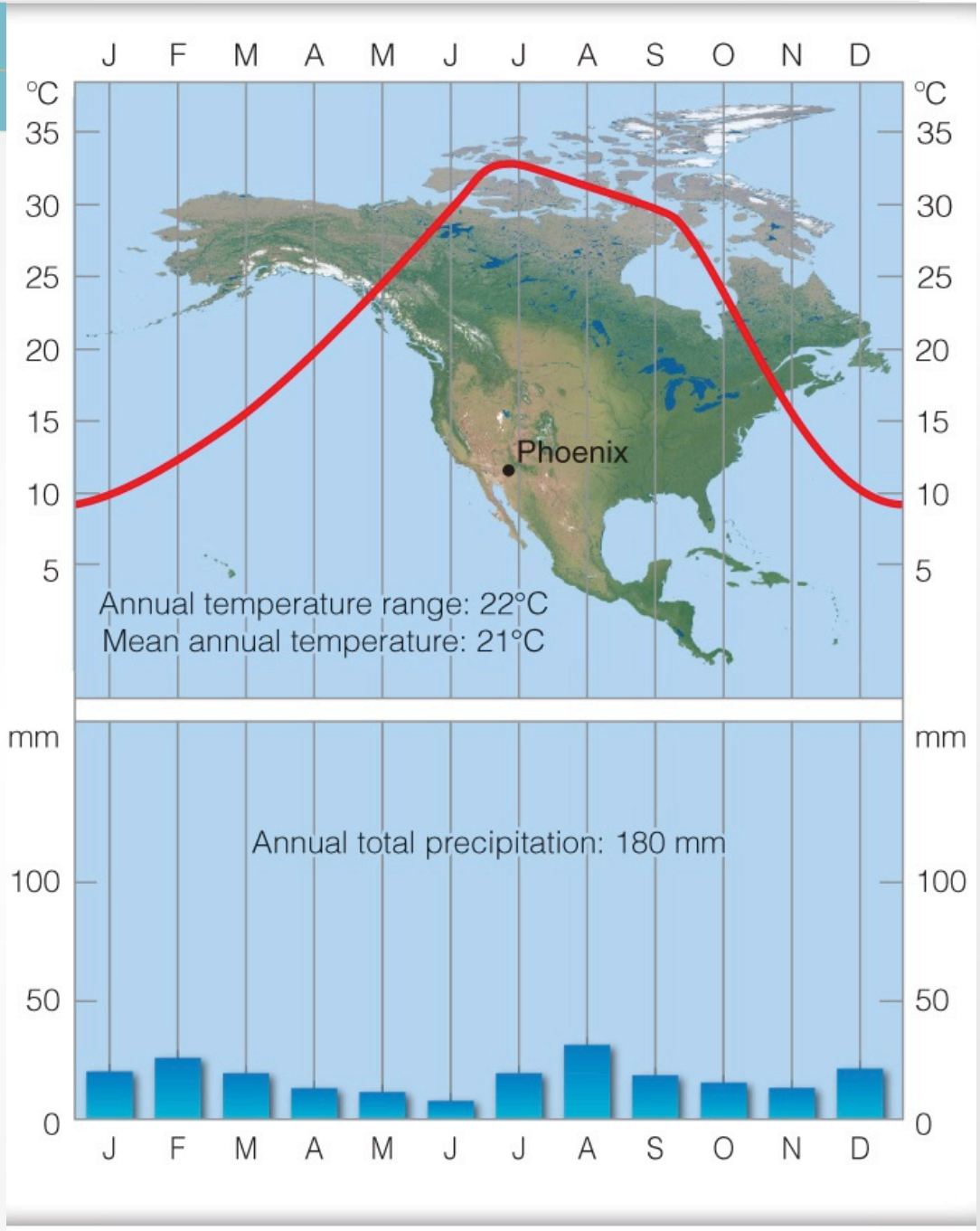
- Subtropical highs
- Rain shadows and continentality
- Cold air
  - Can bring dry climates even to coastal areas



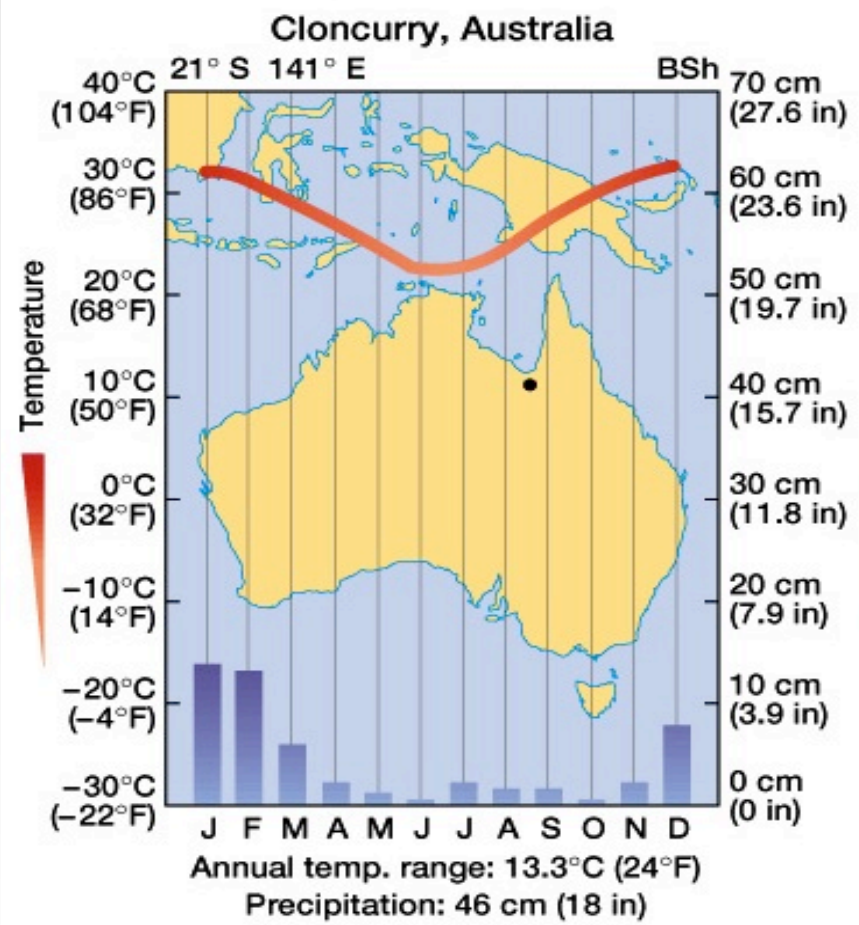
BWh – Arid hot climates

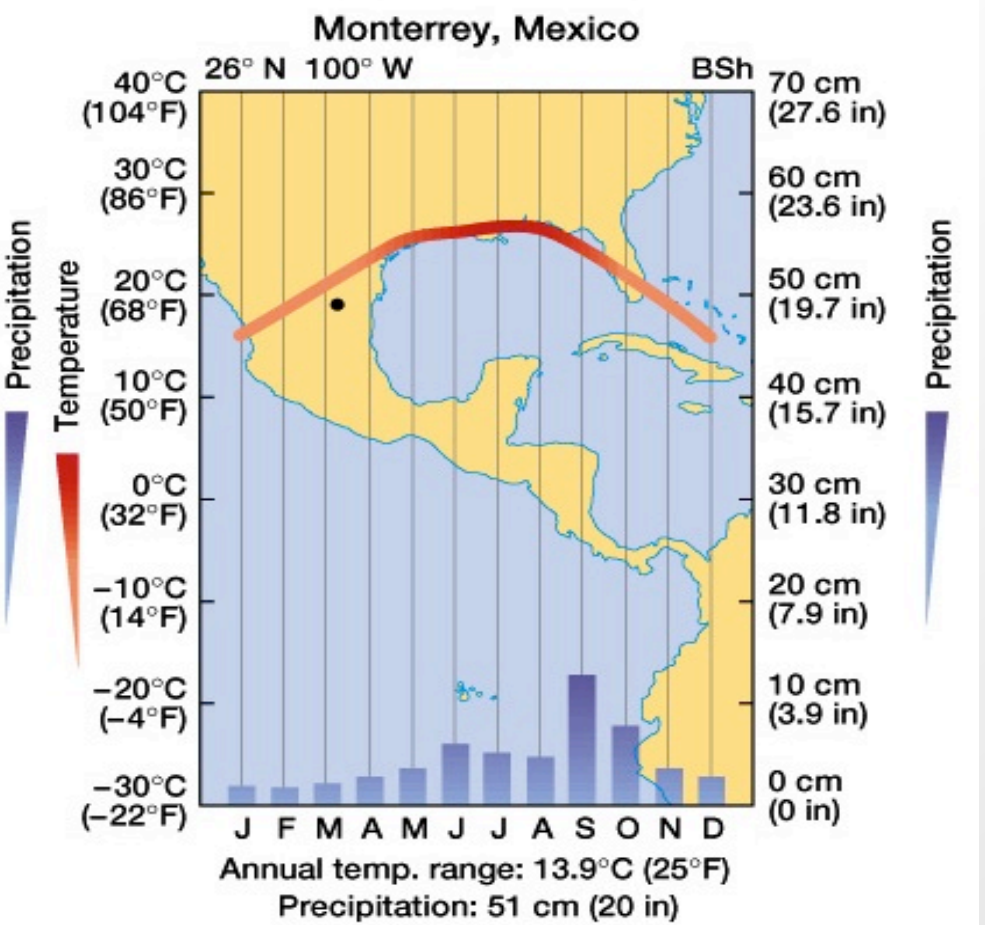
- Phoenix, Arizona
- 33°N, 102°W
- Subtropical highs
  - Band from 10°-30°
- Hot days, cold nights

Ahrens: Fig. 17.16

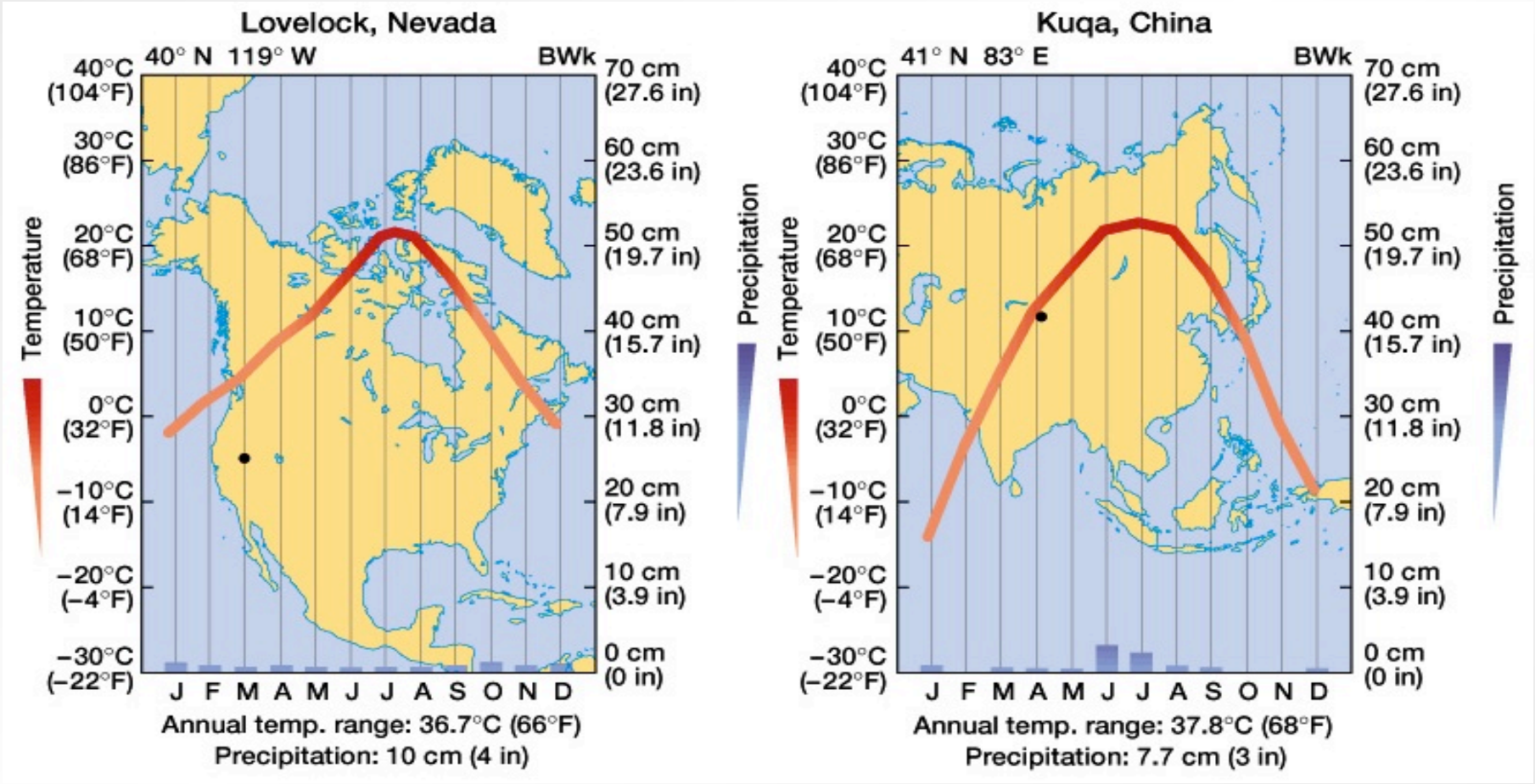


BSh *– Semi-arid hot climates*





BWk *– Arid cool climates*



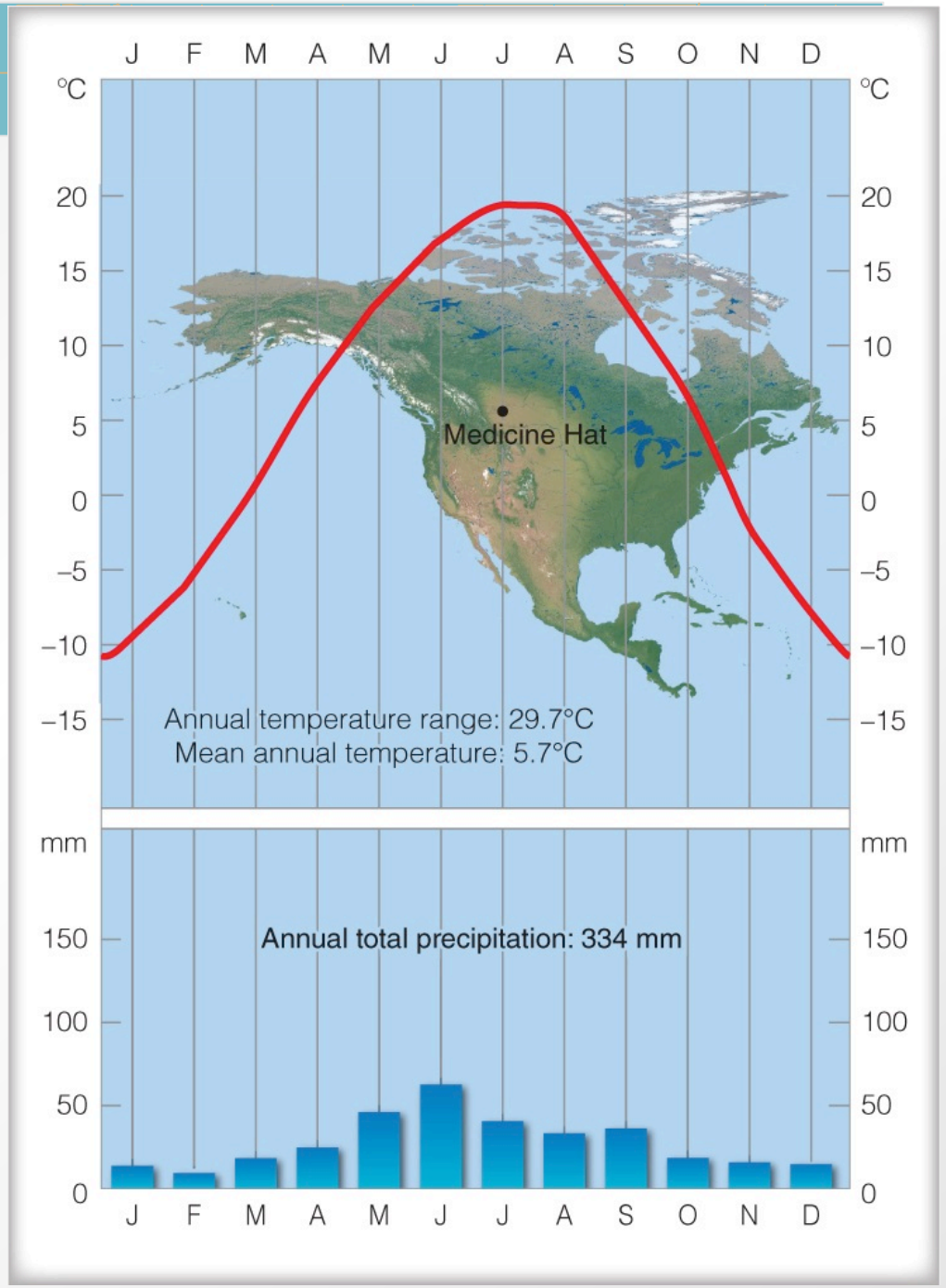
Extreme continentality and/or rain shadows

Very cold winter nights

BSk – Semi-arid cool climates

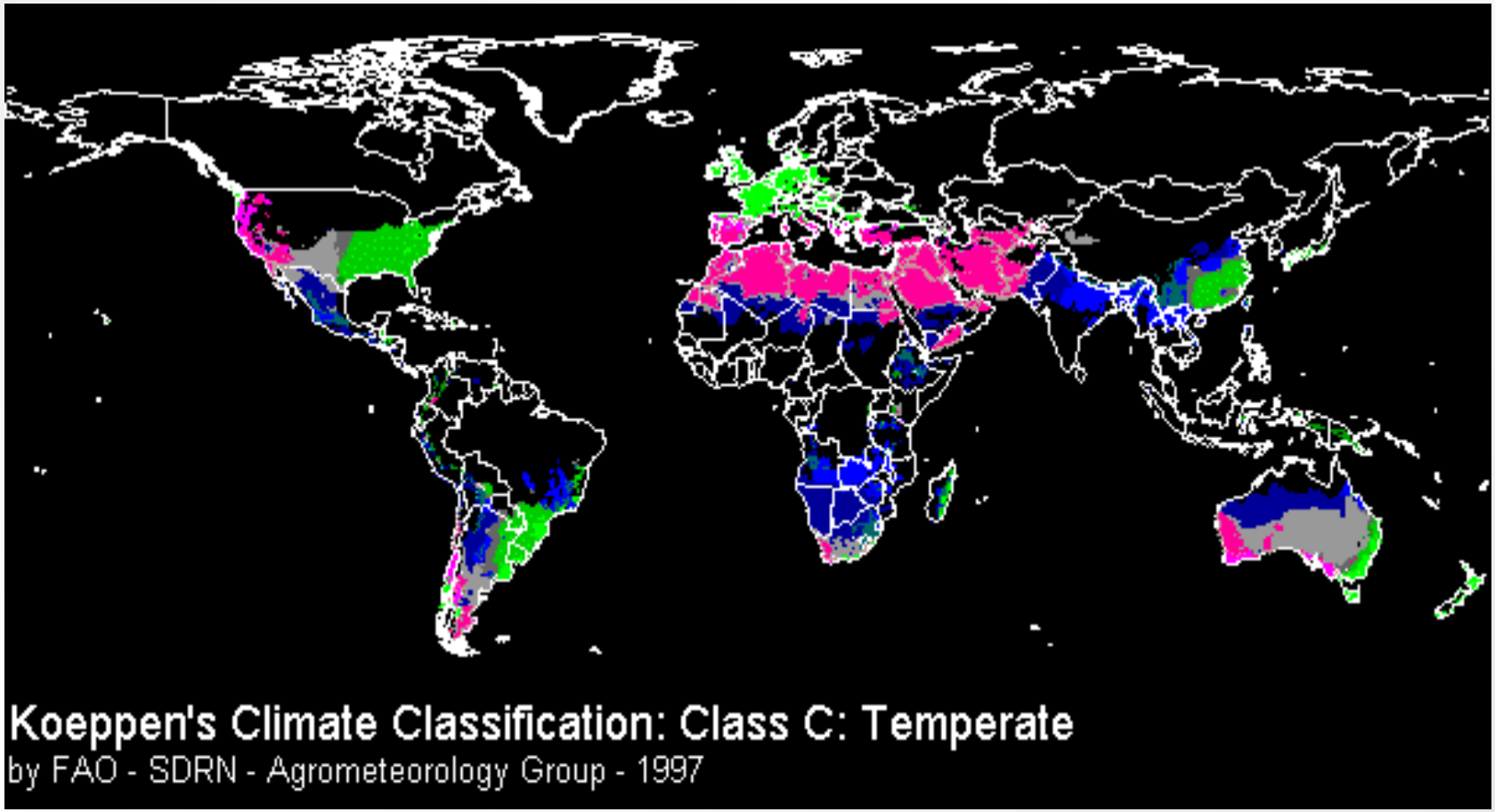
- Medicine Hat, Alberta
- 50°N, 140°W
- Higher annual average precipitation

Ahrens: Fig. 17.18

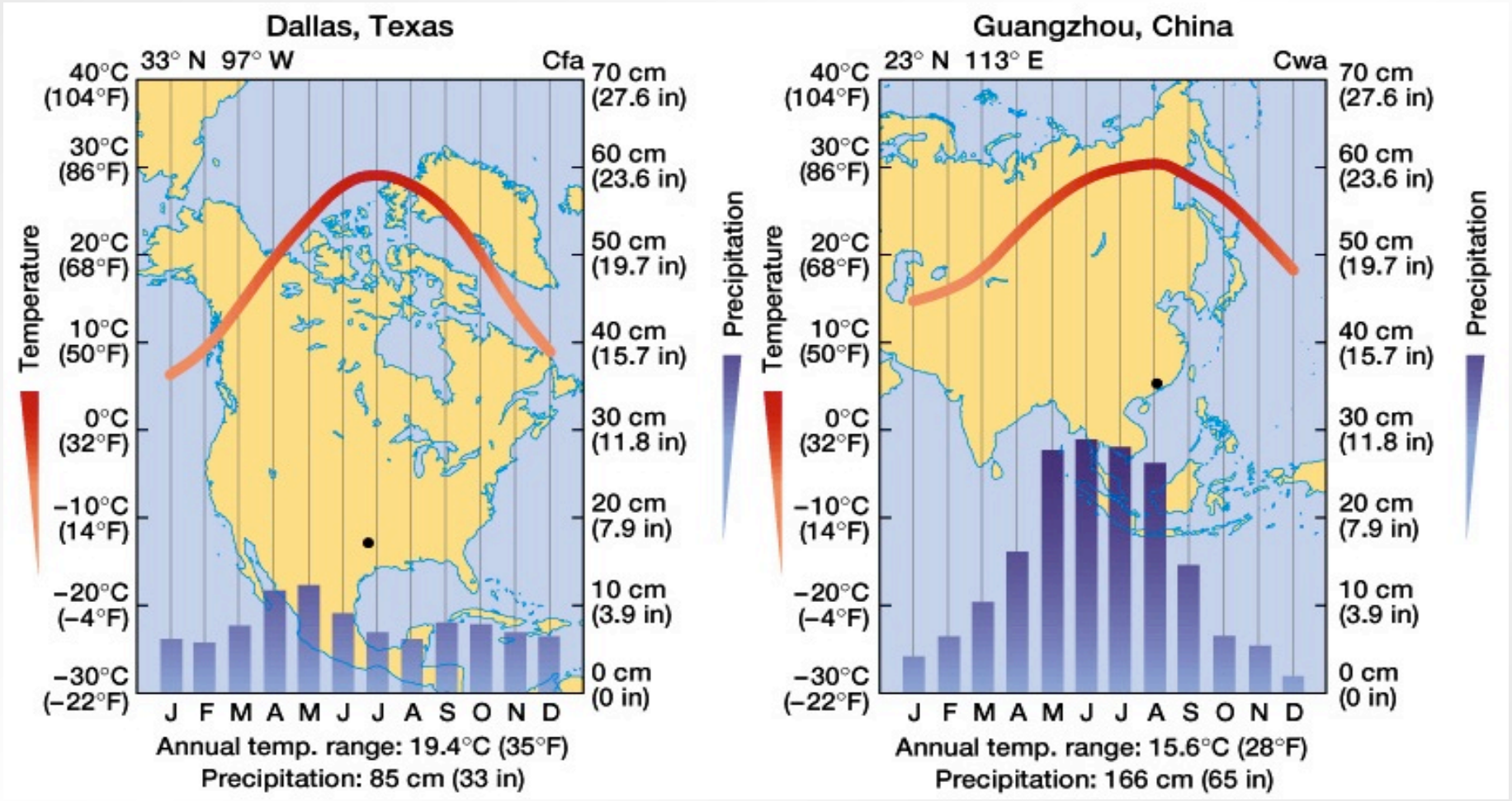


C – Temperate Climates

- Exist between 30° and 60°
- Not cold enough for persistent snow in winter
- Precipitation regimes vary considerably



Cfa, Cwa – *Humid subtropical climates*

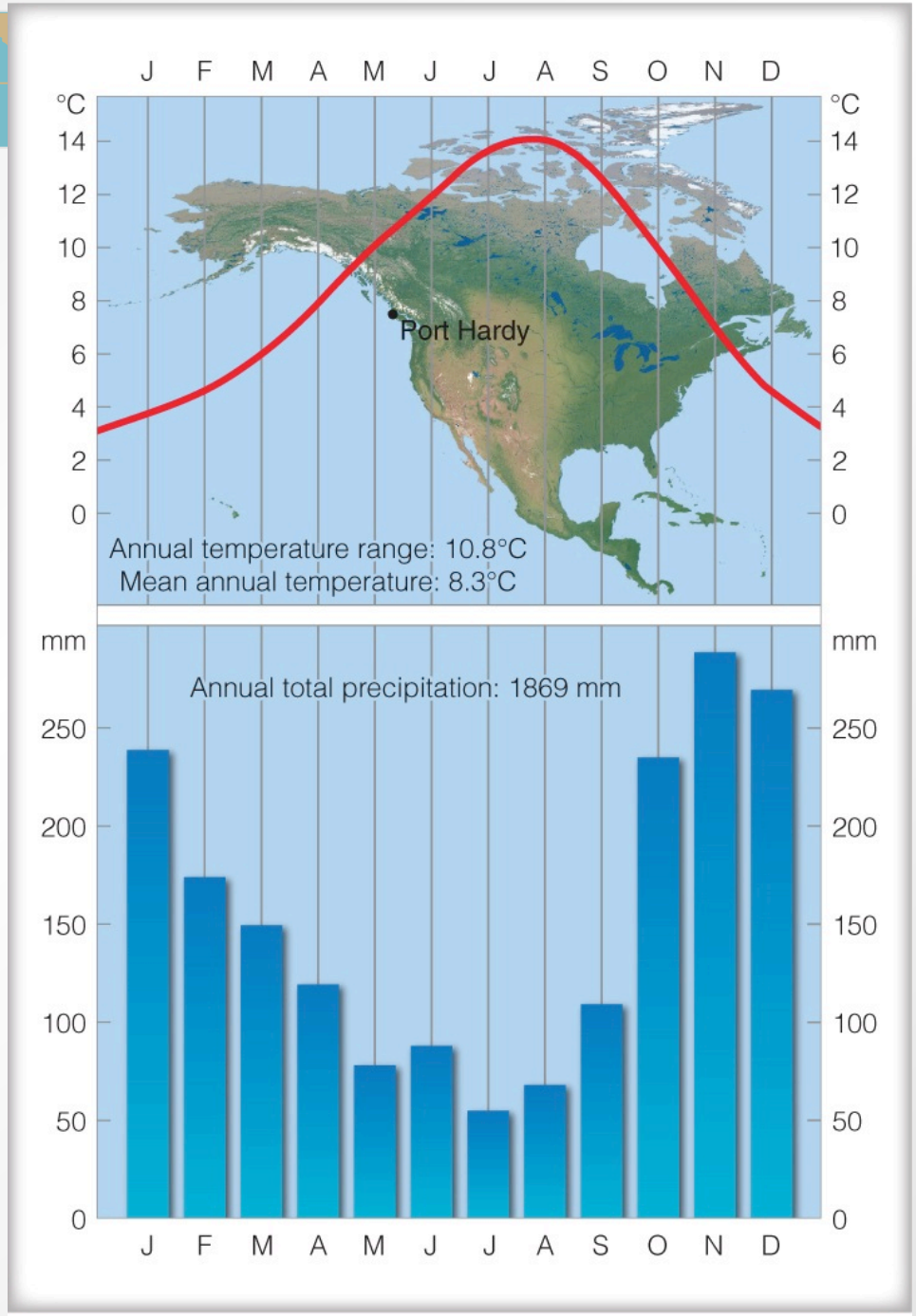


Heat and moisture from on-shore advection due to off-shore subtropical highs

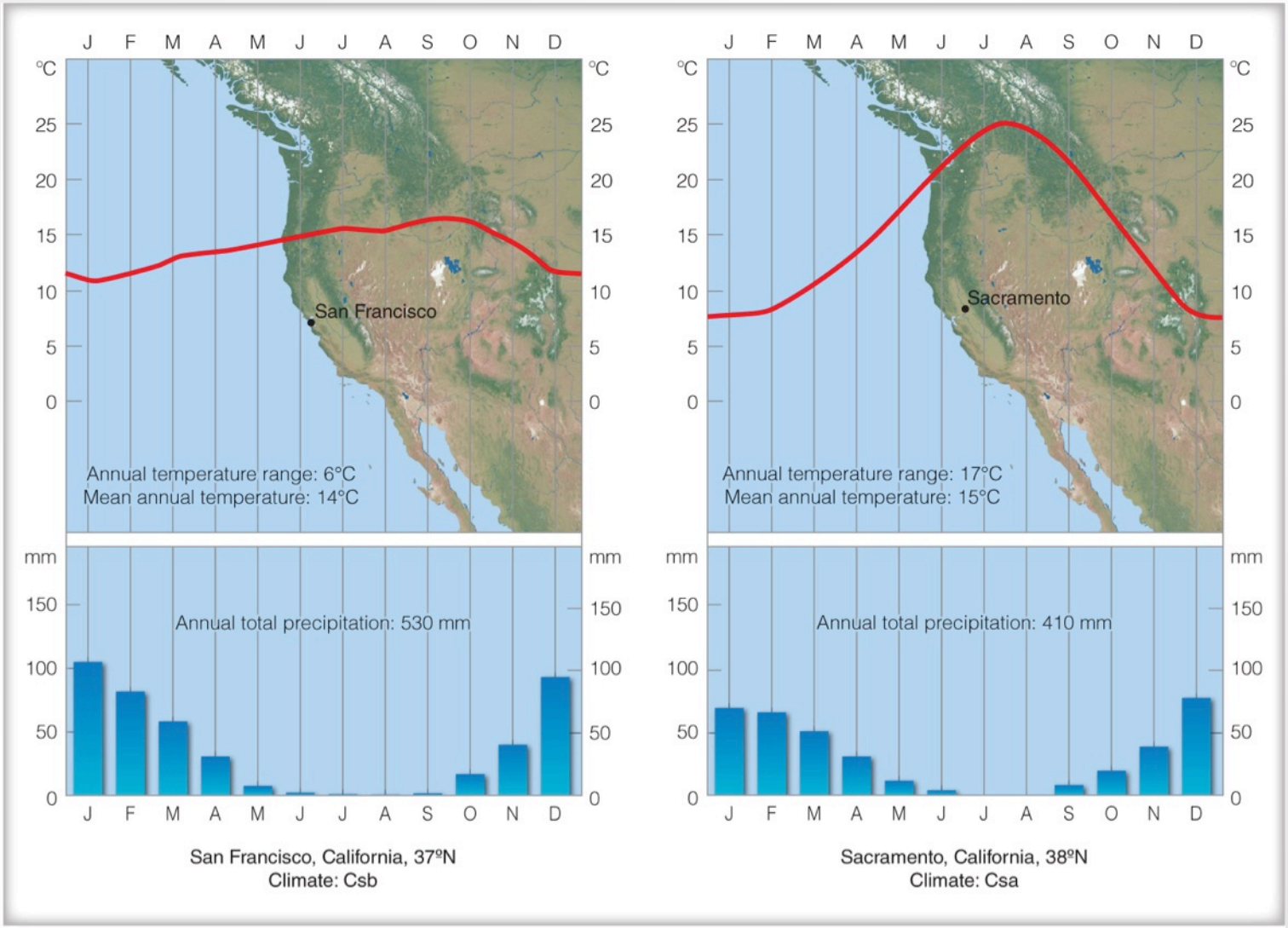
Cfb, Cfc - Marine west coast climates

- Port Hardy, BC (Cfb)
- 50°N, 127°W
- Sea breeze
- Frequent fog and low clouds

Ahrens: Fig. 17.20



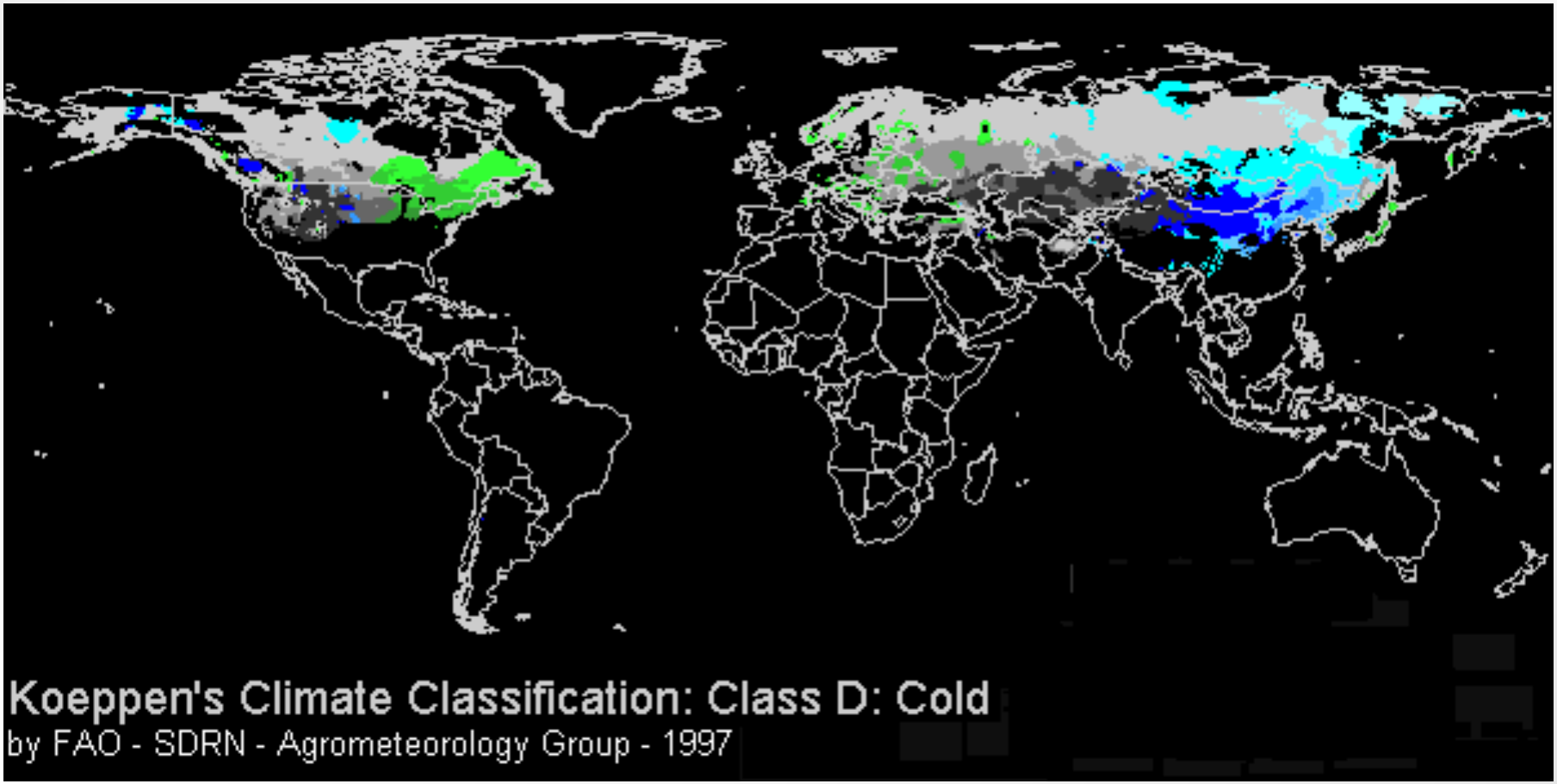
Csb, Csa – *Mediterranean climates*



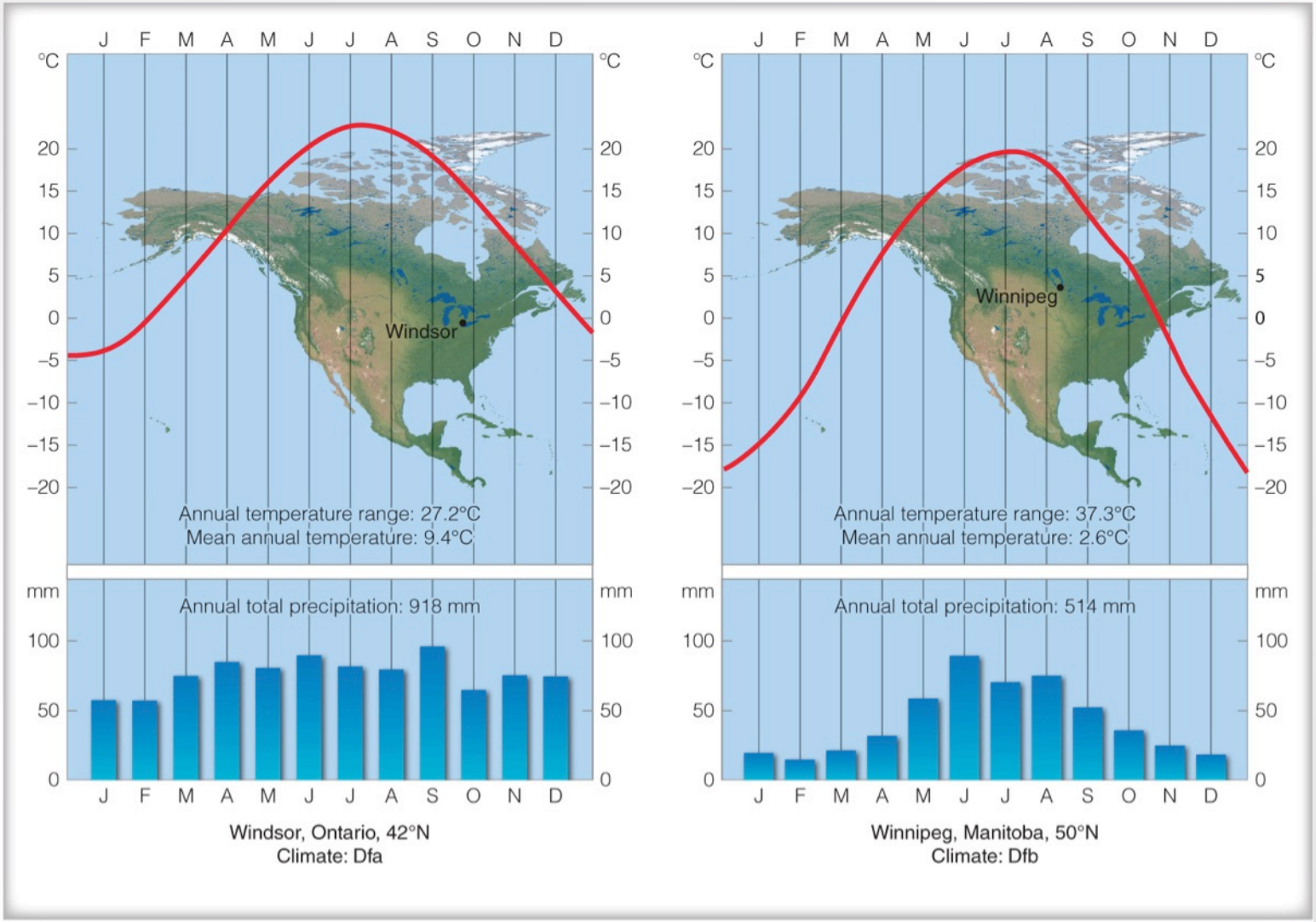
Ahrens:
Fig. 17.21

D – Cold Climates

- Common between 40° and 70°
- Cold enough for snow but warm enough for trees



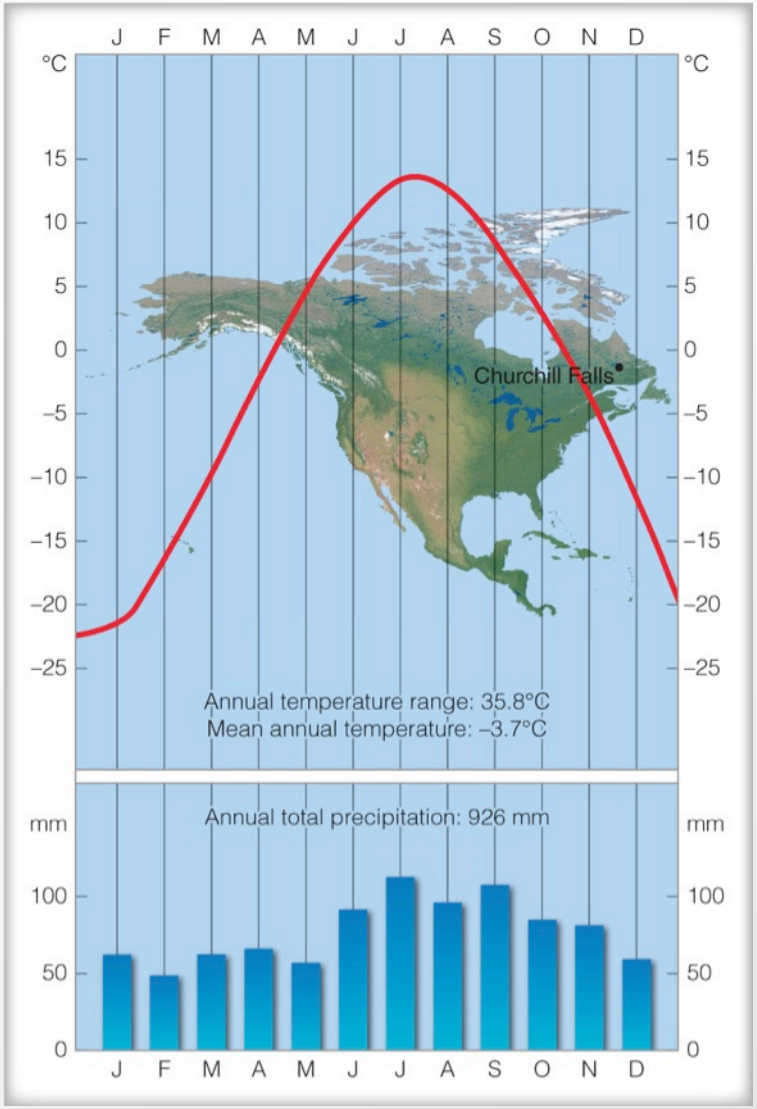
Dfa, Dfb, Dwa, Dwb – *Humid continental climates*



Ahrens:
Fig. 17.24

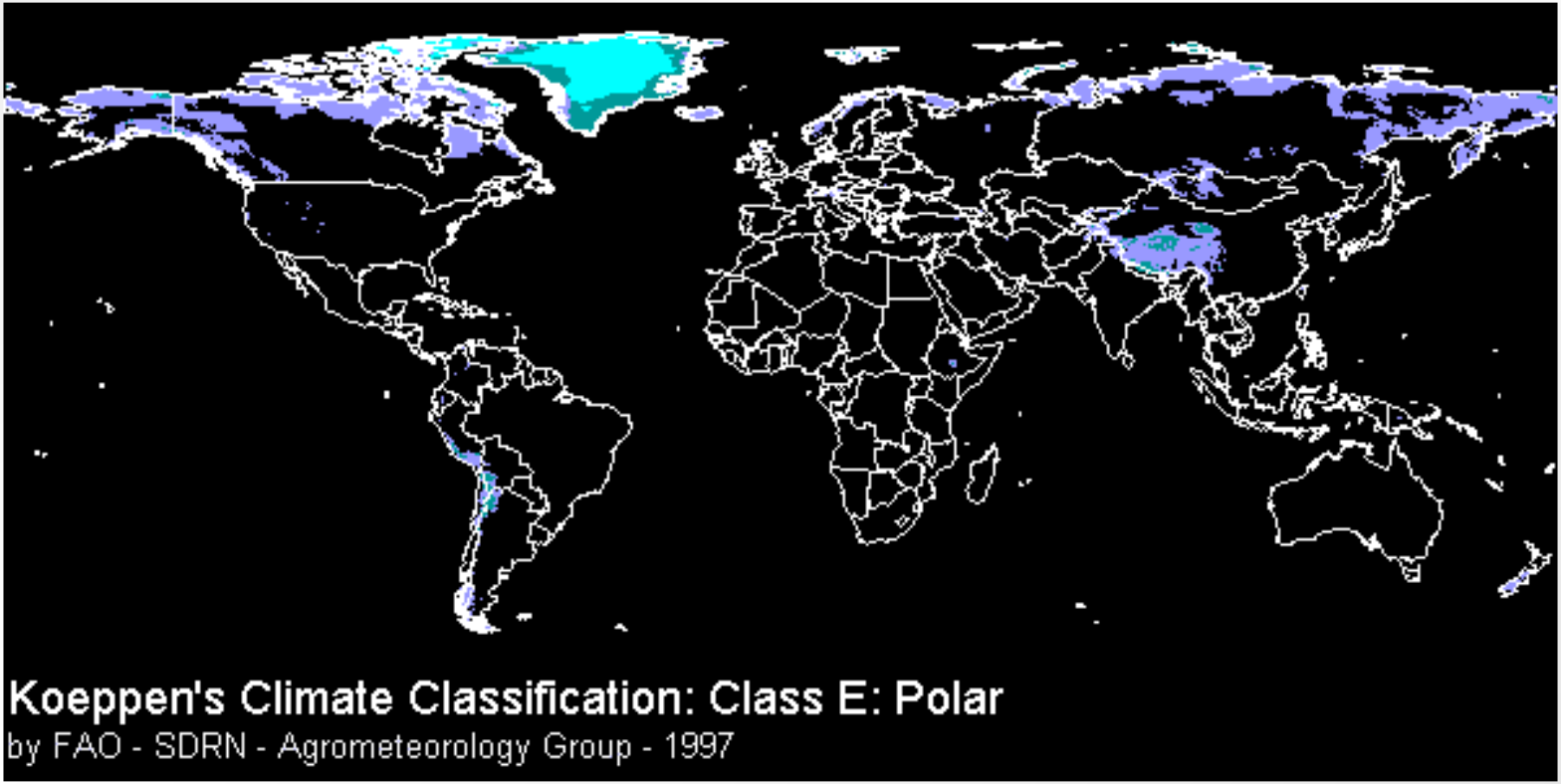
Dfc, Dfd, Dwc, Dwd – *Subpolar climates*

- Churchill Falls, NL (Dfc)
- 47°N, 53°W
- Poleward of humid continental
- Summers warm but short
- Ahrens: Fig. 17.25



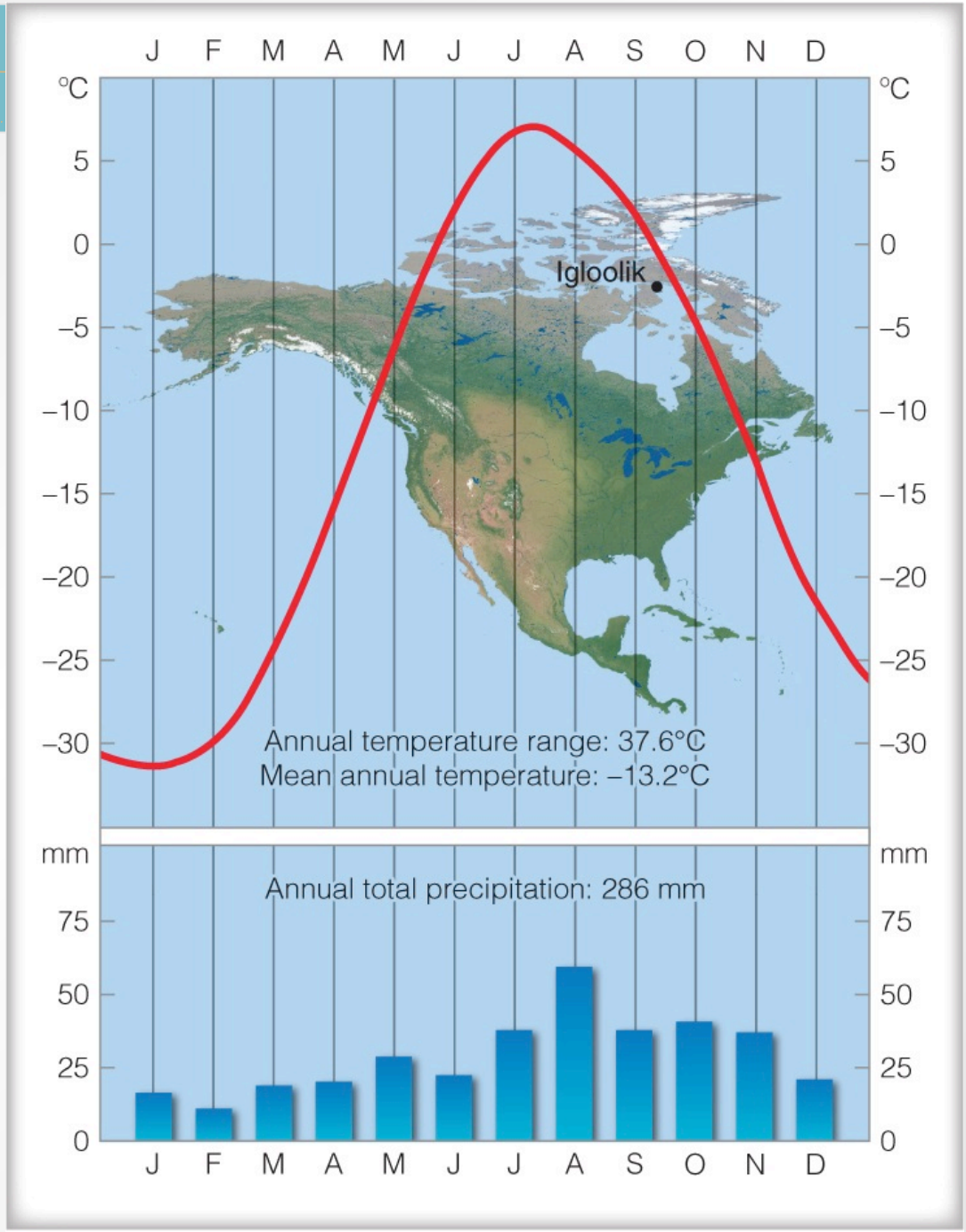
E – Polar Climates

- Typically poleward of 70°
- Treeless terrain and very cold temperatures



ET – Polar tundra climates

- Igloolik, Nunavut
- 69°N, 82°W
- Harsh winters
- High annual *T* range
- Very low precipitation



Ahrens: Fig. 17.27

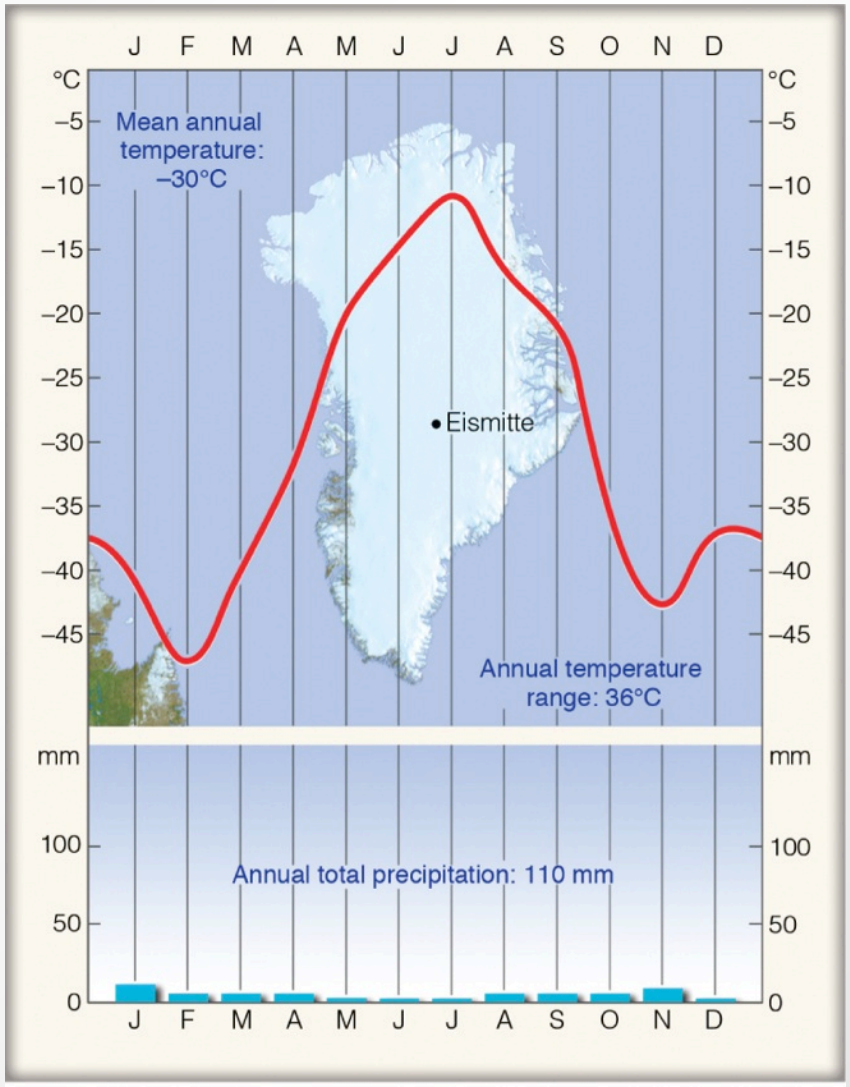
Polar tundra climates

- Named for tundra vegetation: low-growing mosses, lichens, shrubs
- Permafrost is a constant feature

Ahrens: Fig. 17.28

EF – Polar ice cap climates

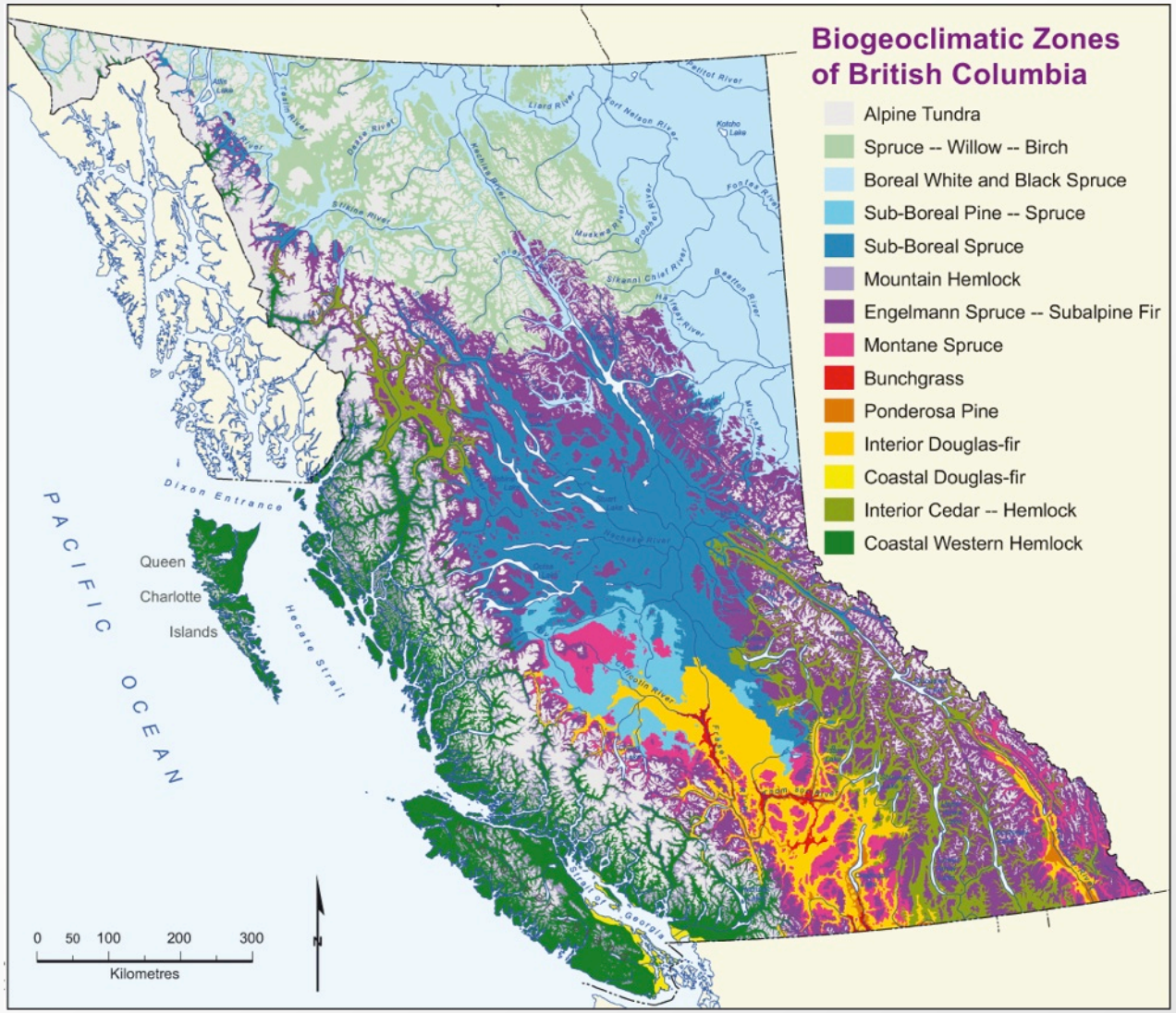
- Eismitte, Greenland
- 71°N, 3000 m above sea level
- Areas of constant ice cover found in Greenland and Antarctica
- Ahrens: Fig. 17.29



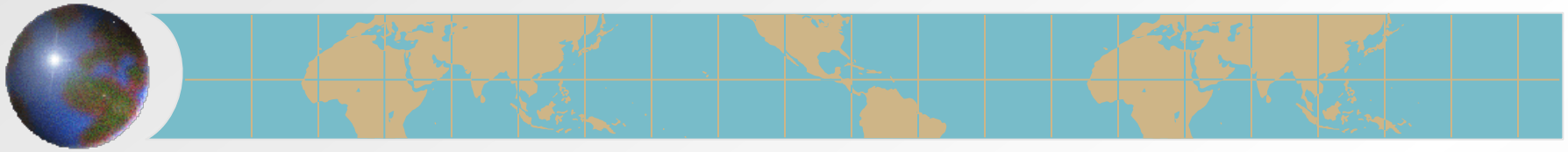
H – Highland Climates

- Mountainous regions experience rapid temperature variations over short distances as a result of elevation changes
- Slope and aspect play a role in energy and water balances
  - Enhanced precipitation versus rain shadows
- Vertical changes become analogous to latitude changes, eventually leading to ice cap conditions in lofty elevation areas
- This ***vertical zonation*** leads to highly variable local climates, all classified within H climate designation

H – British Columbia



Ahrens: Fig. 17.9



Wednesday – Final class

- Global Climatic change
- Review