Atmospheric Circulations

GEOG/ENST 2331 – Lecture 12
Ahrens: Chapter 9

Recent lectures

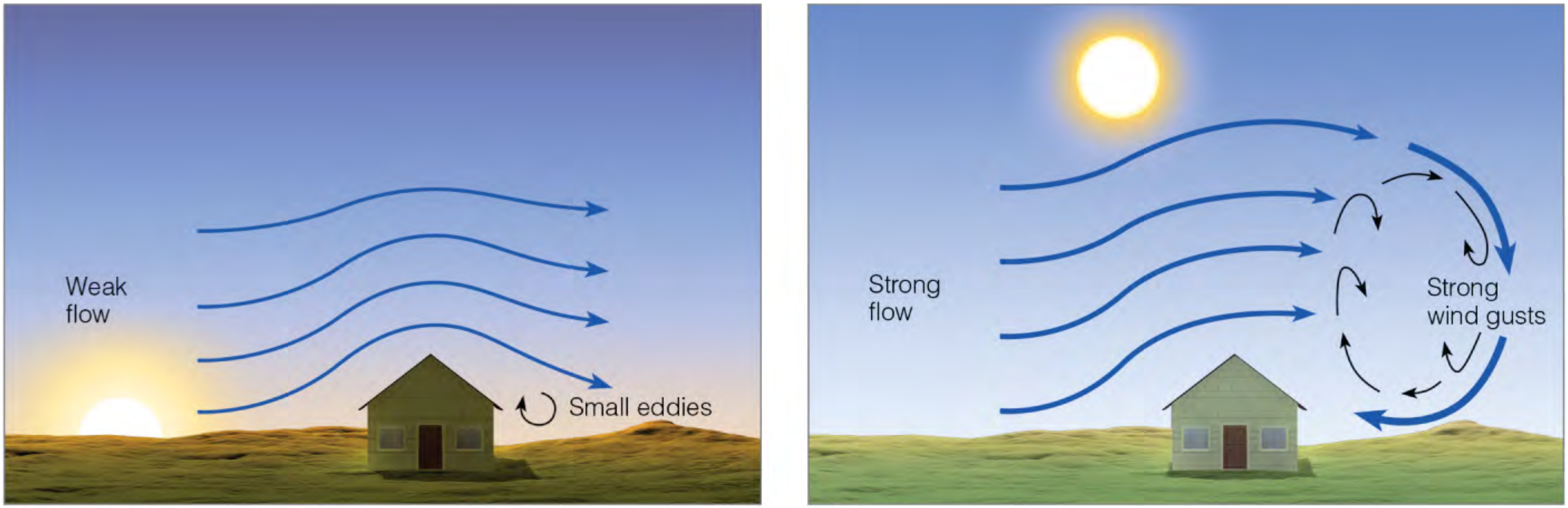
- Adiabatic processes
- Lifting Mechanisms and Stability
- Clouds and precipitation

Scales of analysis

Scale	Size	Example
Microscale	metres	Turbulent eddies
Mesoscale	10 to 100s km	Land/sea breeze
Synoptic scale	1 000 km	Cyclones
Global scale	5 000 km	Planetary waves

- Synoptic and global scales are sometimes grouped together as ‘Macroscale’

Microscale winds



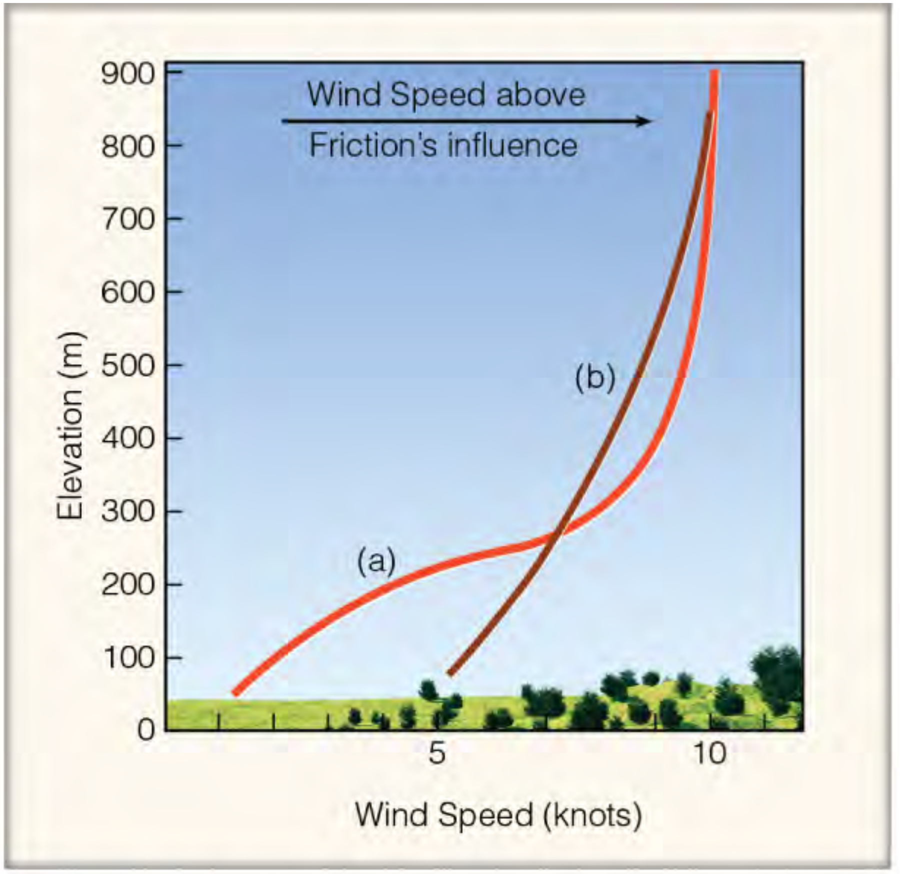
Ahrens: Fig. 9.3

- Light winds in stable air produce small eddies
- Stronger winds in unstable air produce strong eddies
- Wind may even come from unexpected direction

Planetary Boundary Layer

Depth depends on roughness and stability

a) Stable air
b) Unstable air

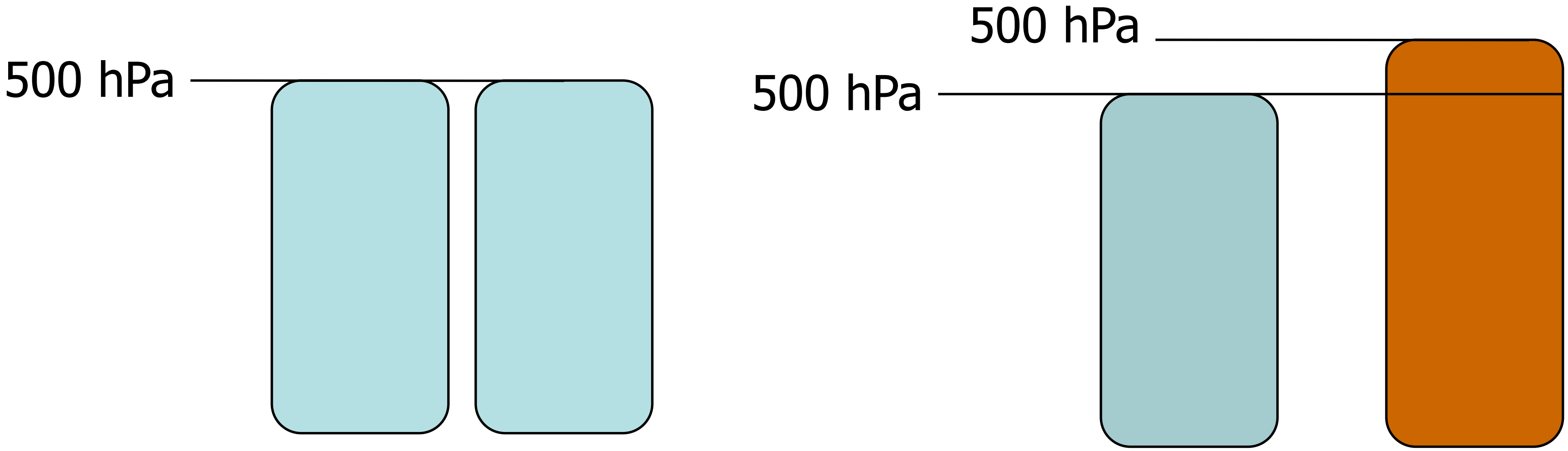


Ahrens: Fig. 9.4

Mesoscale winds

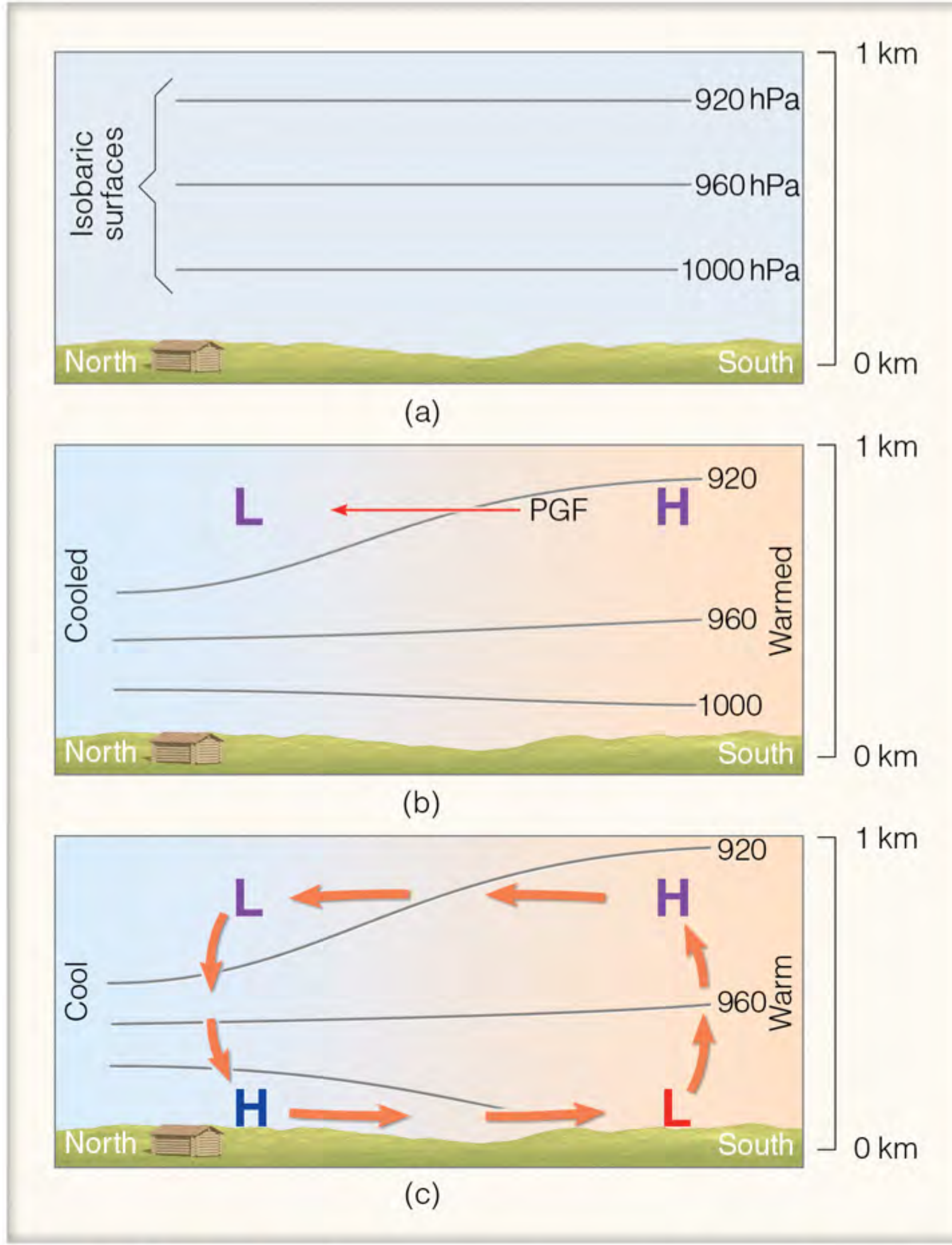
- ‘Local’ winds
  - Land/sea breeze
  - Mountain/valley breeze
  - Katabatic winds
  - “Wreckhouse” wind warning

Heating and Expansion



Thermal Wind

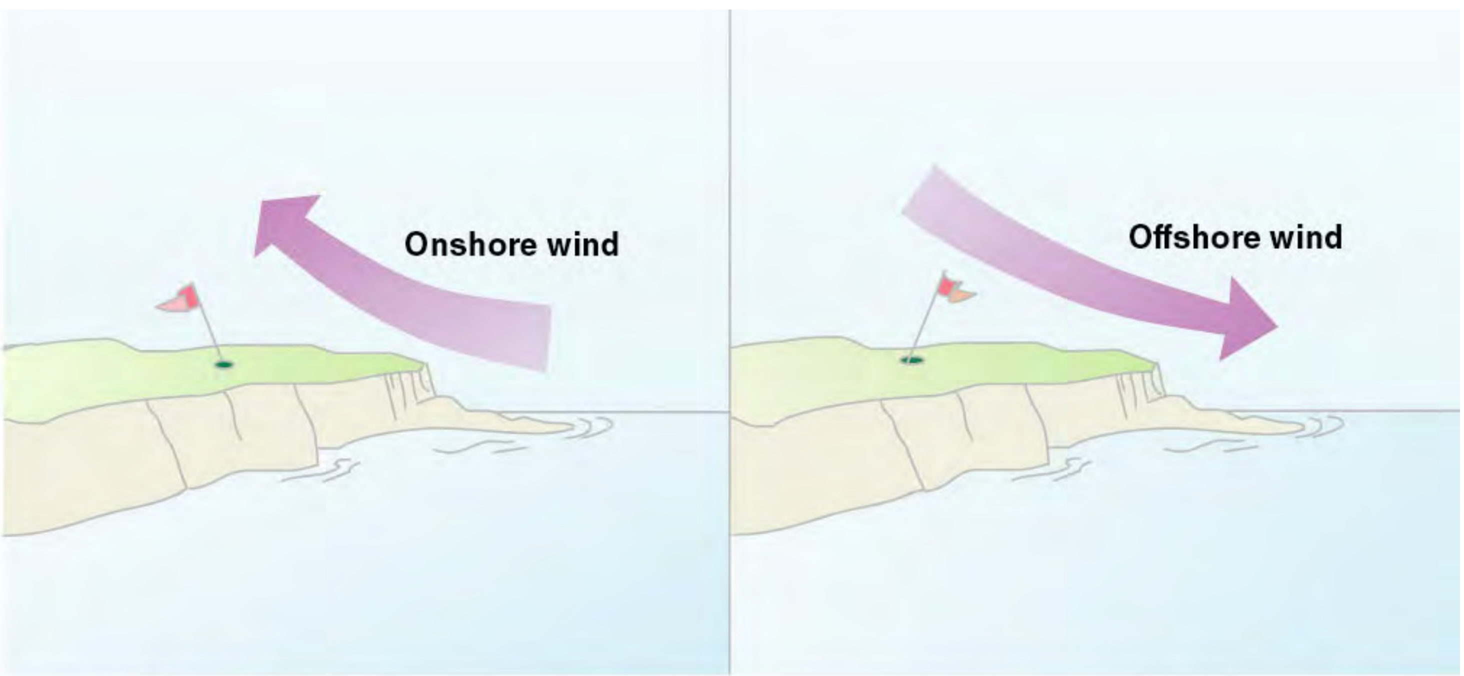
Ahrens: Fig. 9.12



Land/Sea Breeze

Land heats up and cools down faster than water

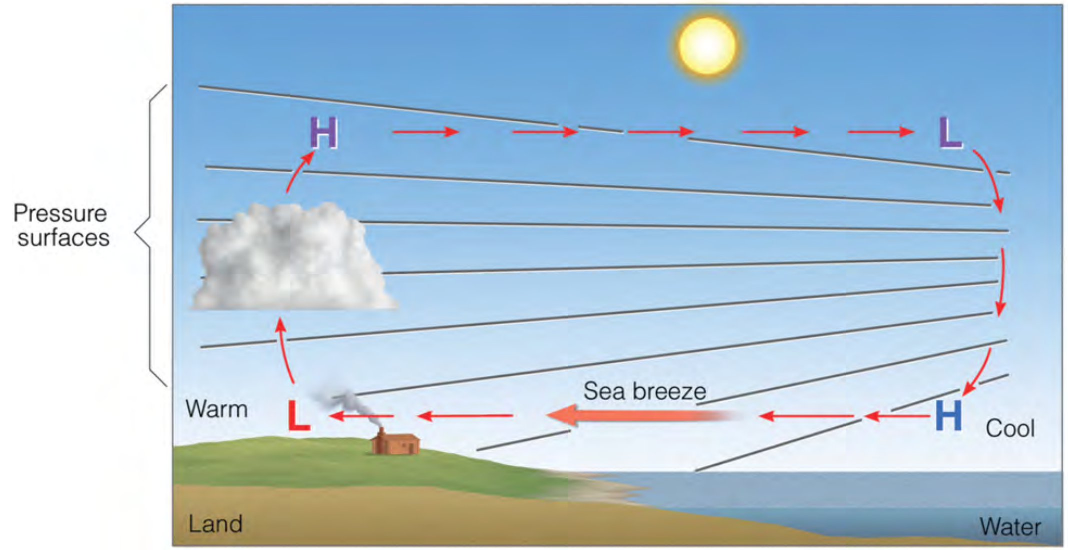
- daytime warming causes air over land to rise and air over ocean to sink, this inducing an *onshore* or *sea* breeze.
- opposite occurs at night (*offshore* or *land* breeze)



Sea breeze development

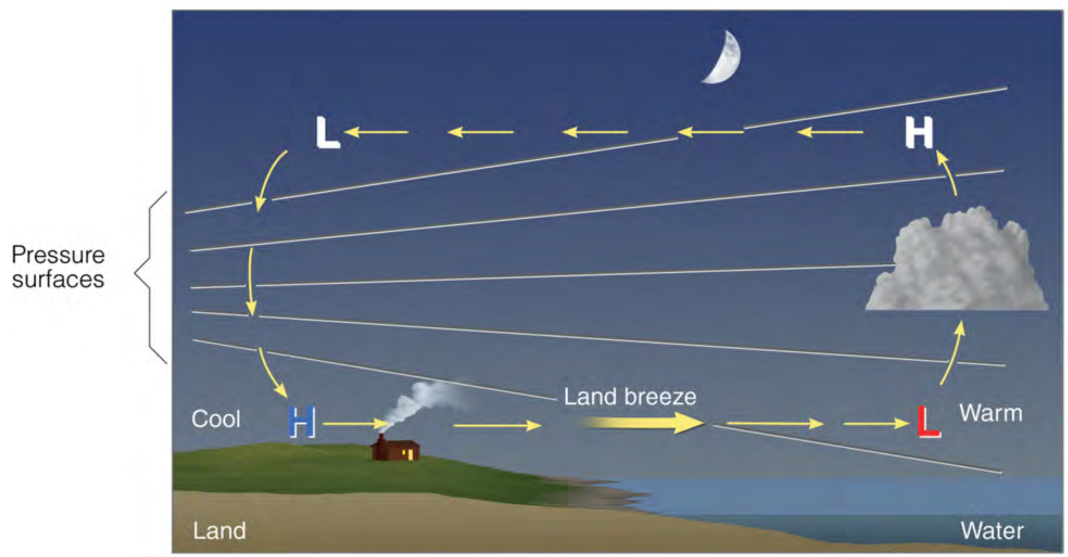
Ahrens: Fig. 9.14

Sea breeze begins with air expanding upward over the land surface



(a) Sea breeze

Land breeze at night begins with air shrinking downward over the land surface



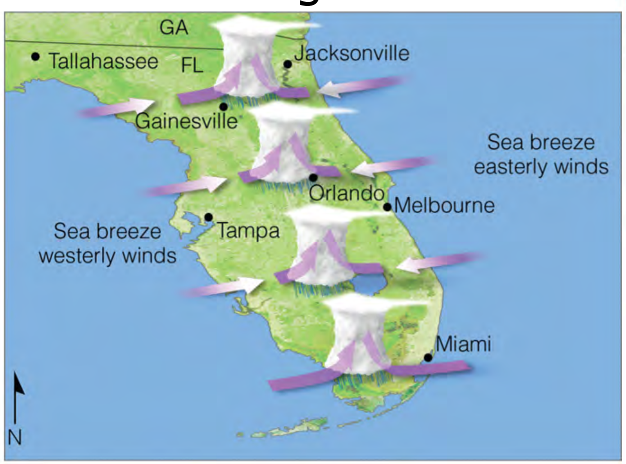
(b) Land breeze

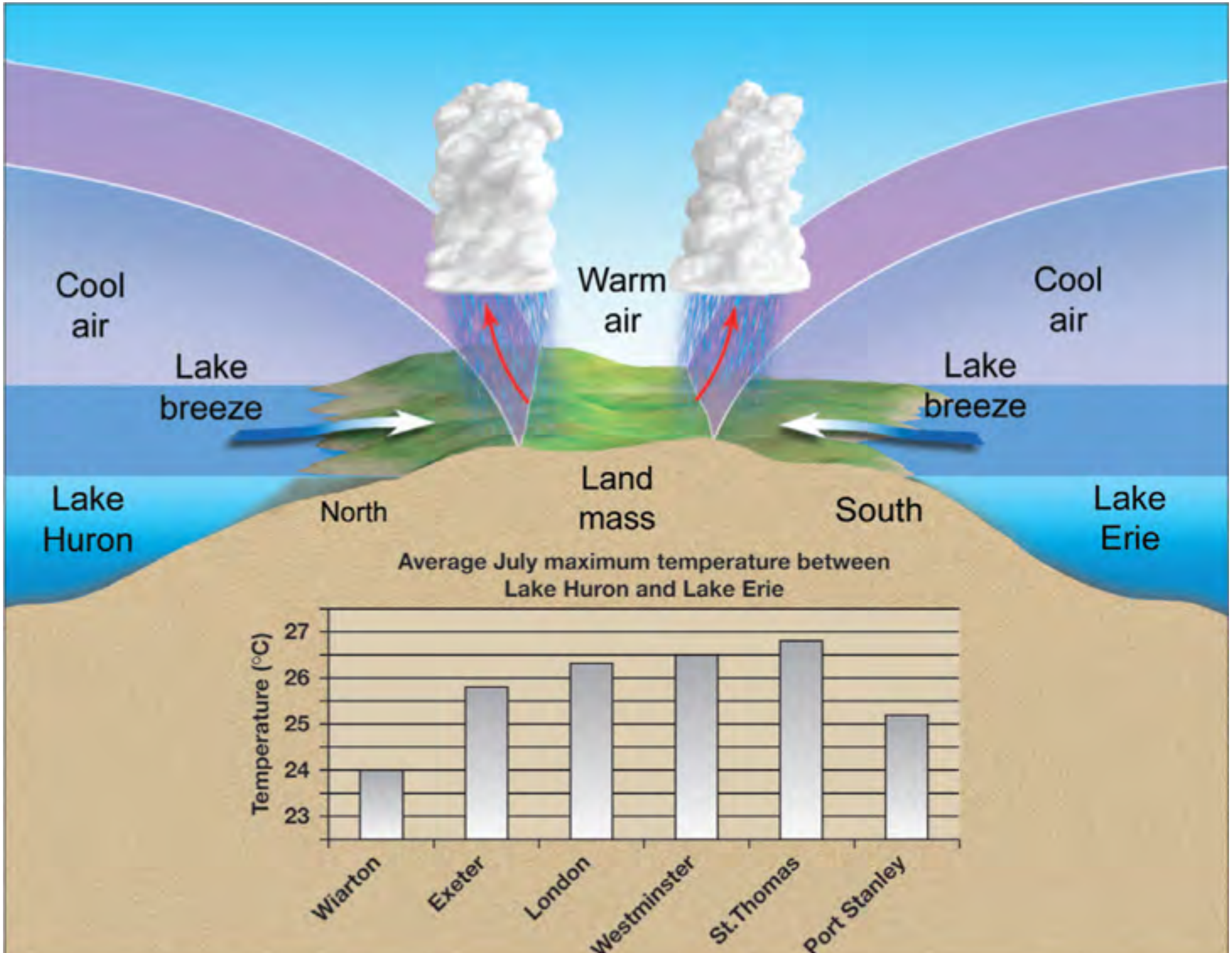
Sea breezes

Clouds and precipitation over the island of Hawaii

A&B: Figure 8-25

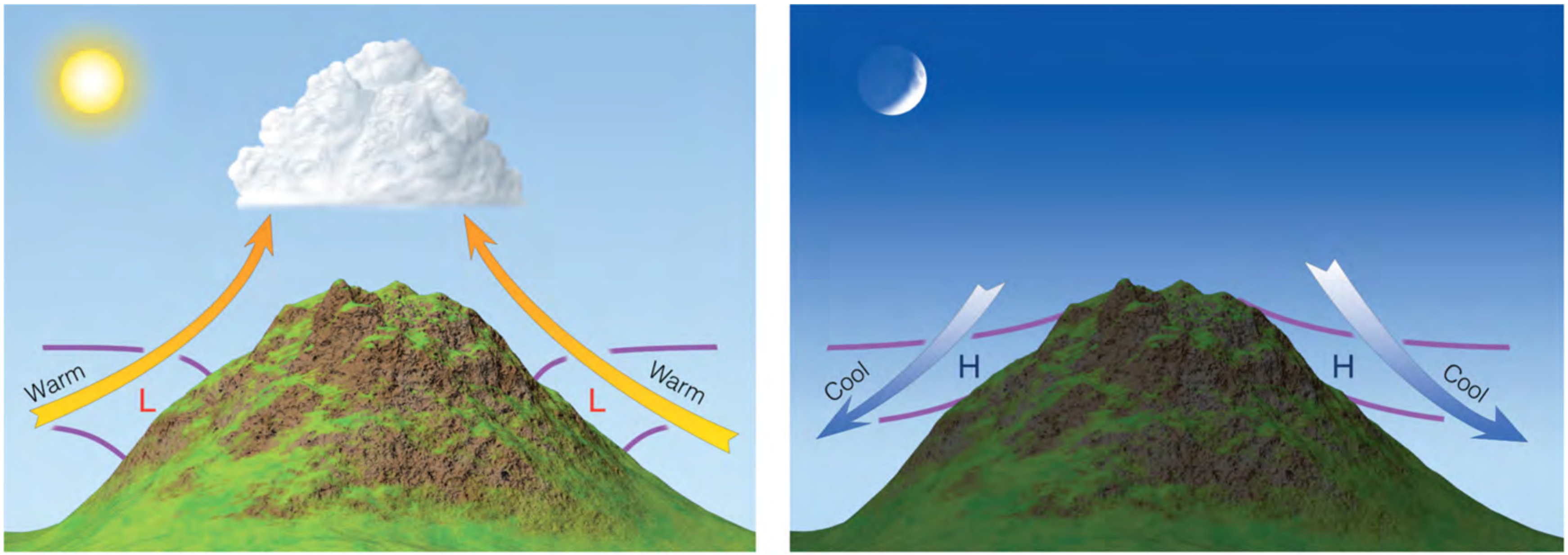
Ahrens: Fig. 9.16





Thermal breezes from the Great Lakes Region (Ahrens: Fig. 9.15)

Mountain/valley breeze



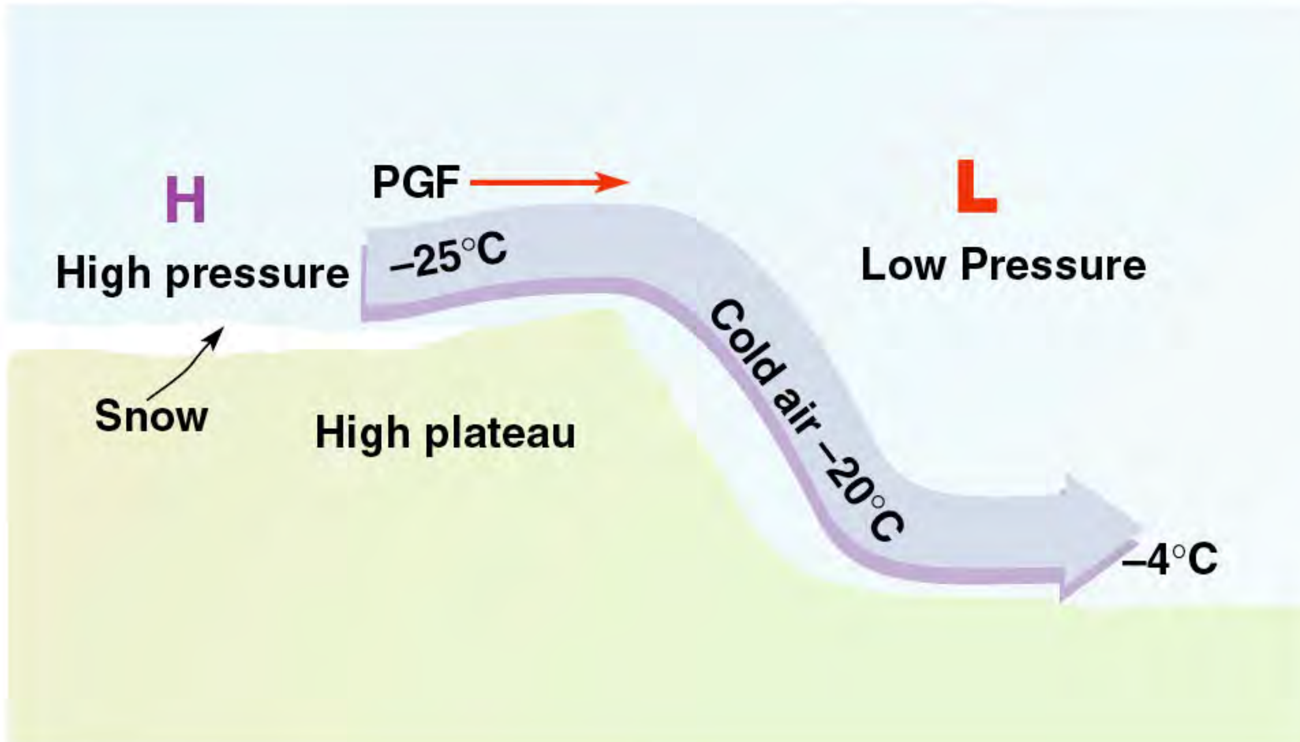
Valley breeze

Mountain breeze

- Solid mountain heats and cools faster than surrounding air.
- Differential heating produces horizontal pressure gradients.
- Flow is upslope in the afternoon, and downslope at night.

Ahrens: Fig. 9.19

Katabatic Wind



- Another mountain wind
- Air passing over a glacier or ice sheet becomes very cold and dense
- Cold air funnels into valleys producing cold strong winds

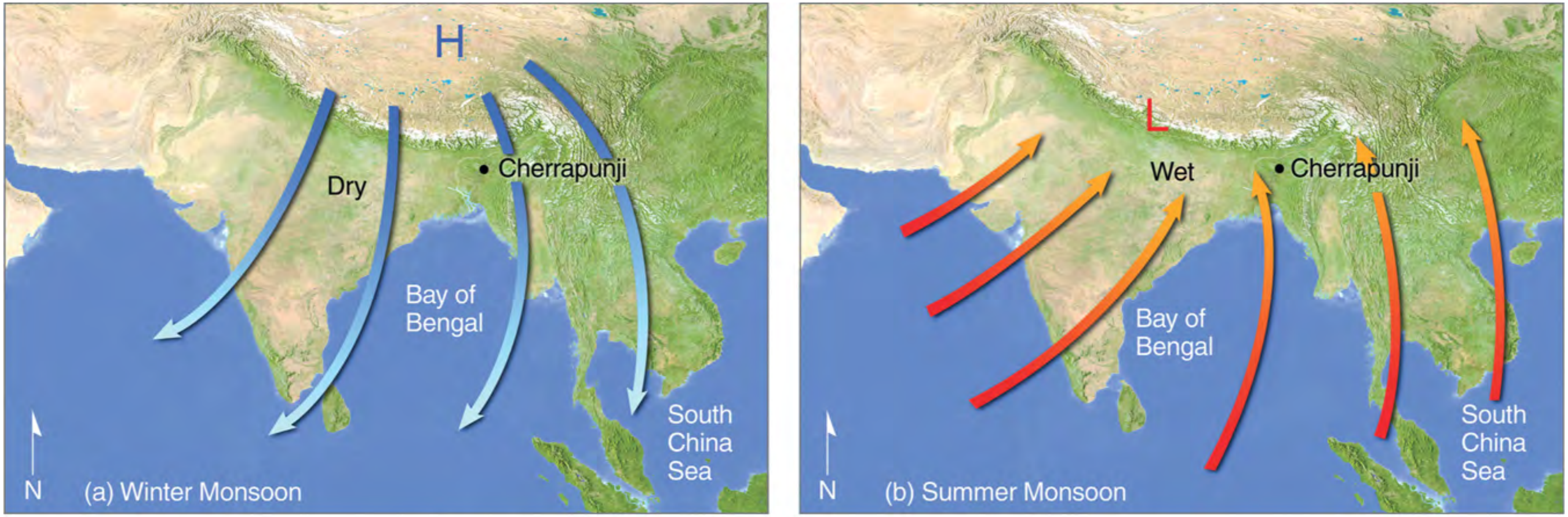
Synoptic winds

- Continental winds
  - Monsoons

Monsoons

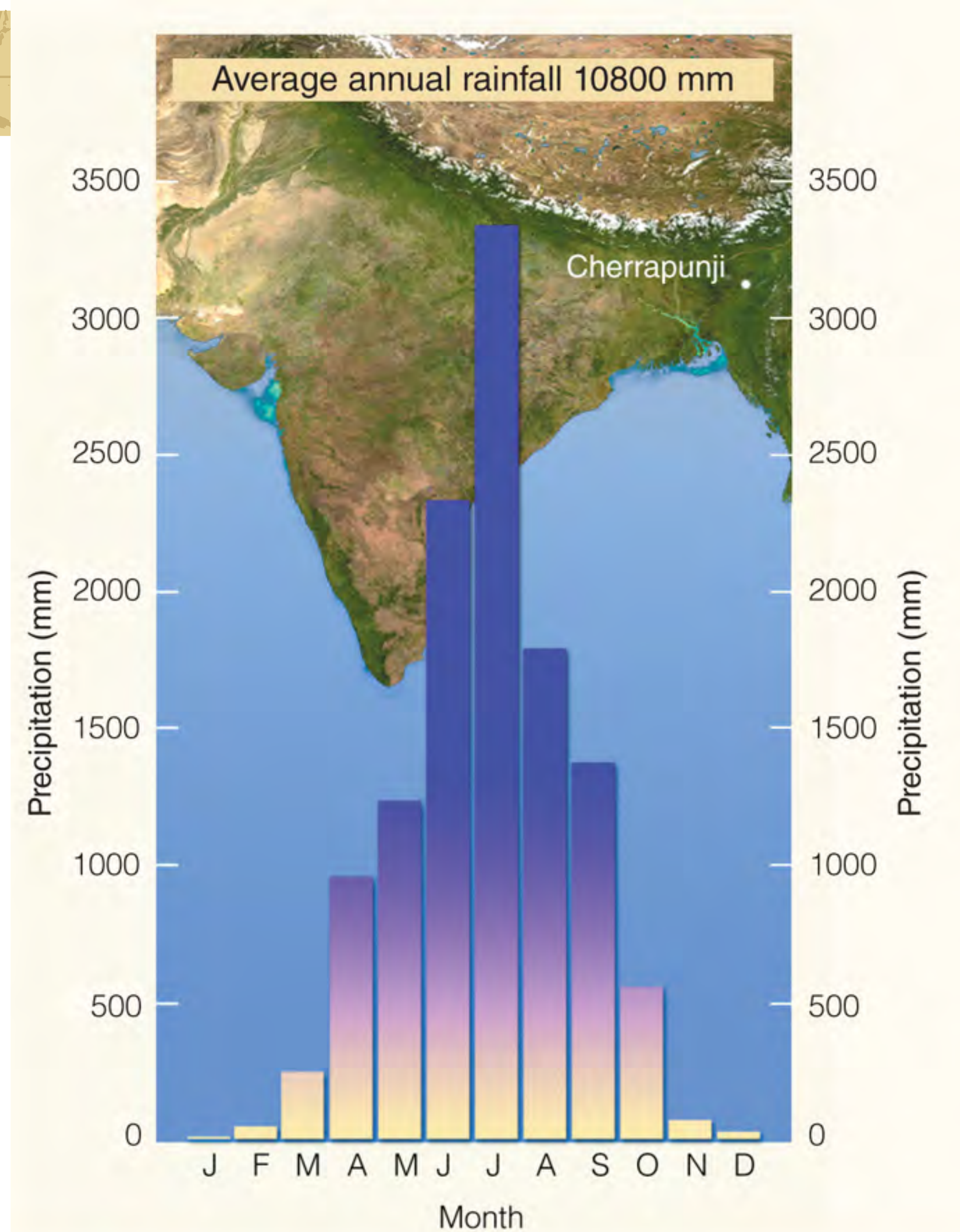
- A seasonal reversal of wind due to thermal differences between land masses and large water bodies
  - Dry, offshore flow conditions during cool months
  - Wet, onshore flow conditions during warm months
- Saturation and orographic lifting assures large precipitation

Monsoon: Seasonal winds



Climograph for Cherrapunji, India

Ahrens: Fig. 9.30

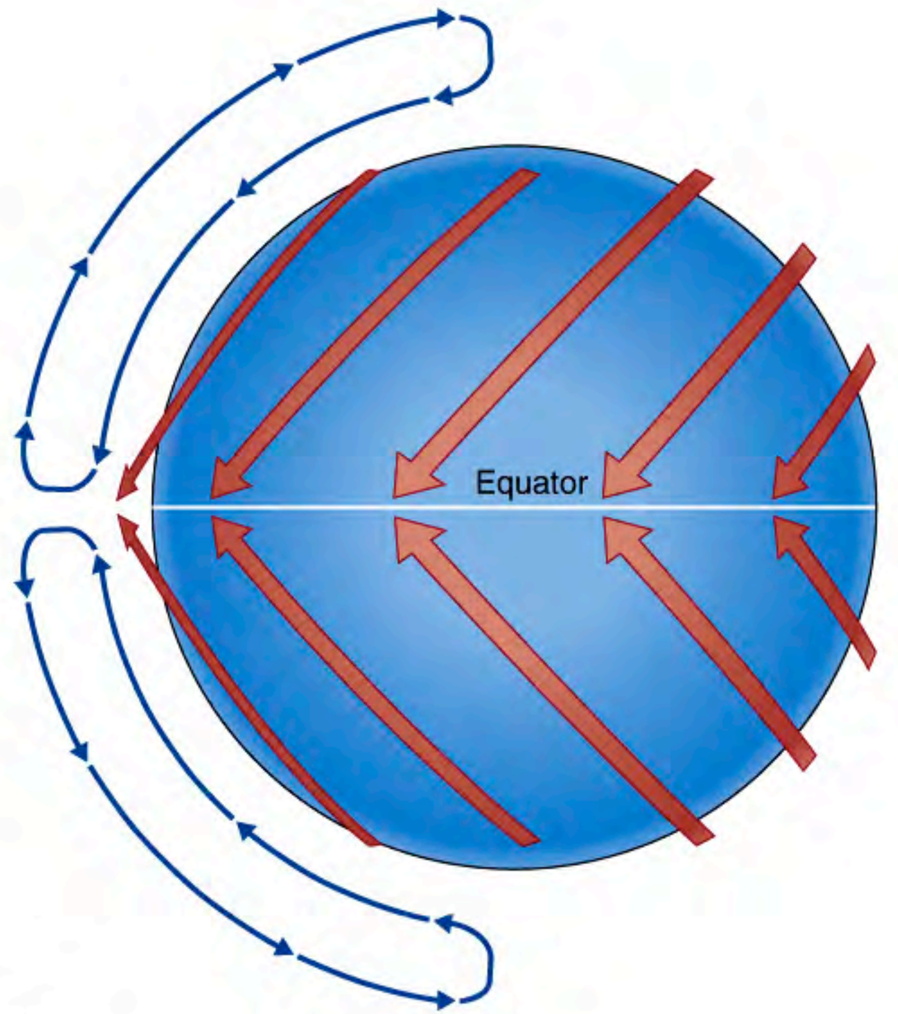


Monsoon

- In SE Asia, rain lasts for weeks at a time
  - Can be critical for crops, drinking water
- Other monsoons occur in Africa, Australia, South America, North America
  - Not as dramatic as the South Asian monsoon

One cell model

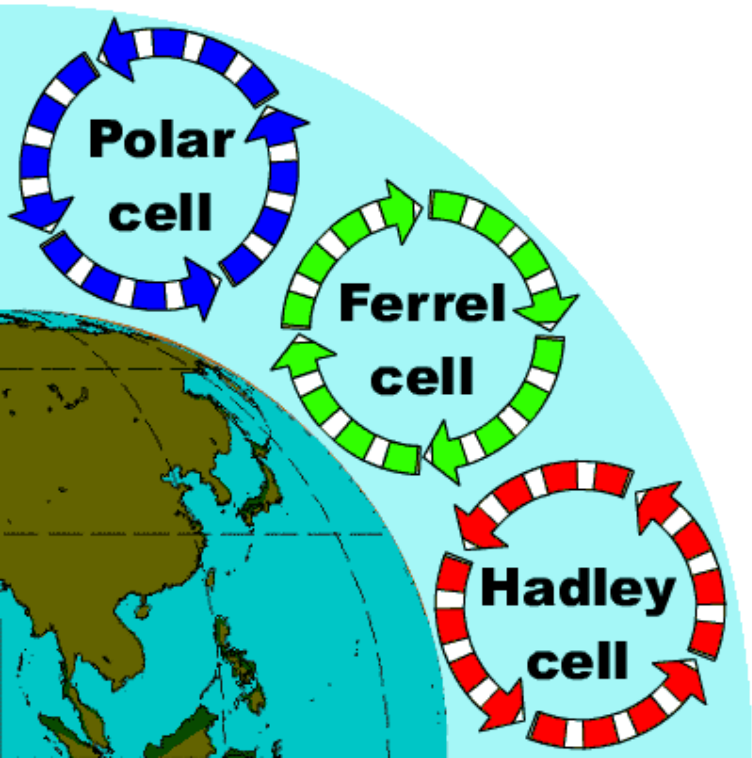
- George Hadley (1685-1768)
- Consider:
  - Ocean-only planet
  - Fixed solar declination
- The result:
  - Thermally driven circulation
  - Coriolis deflection would cause surface winds to be primarily easterly



A&B: Figure 8-2

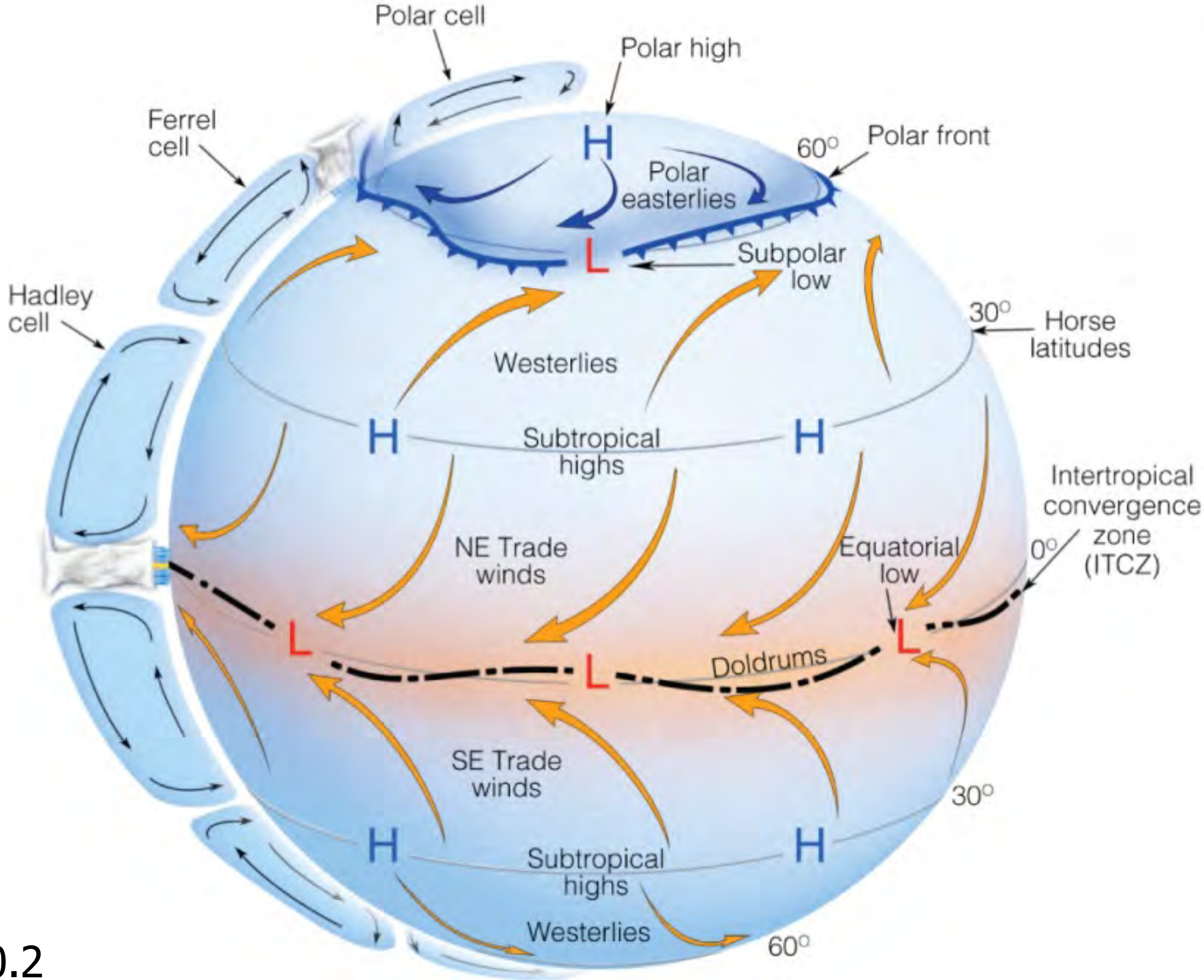
Three Cell Model

- Hadley and Polar cells
  - Thermally driven
- Ferrel cell
  - Thermally indirect

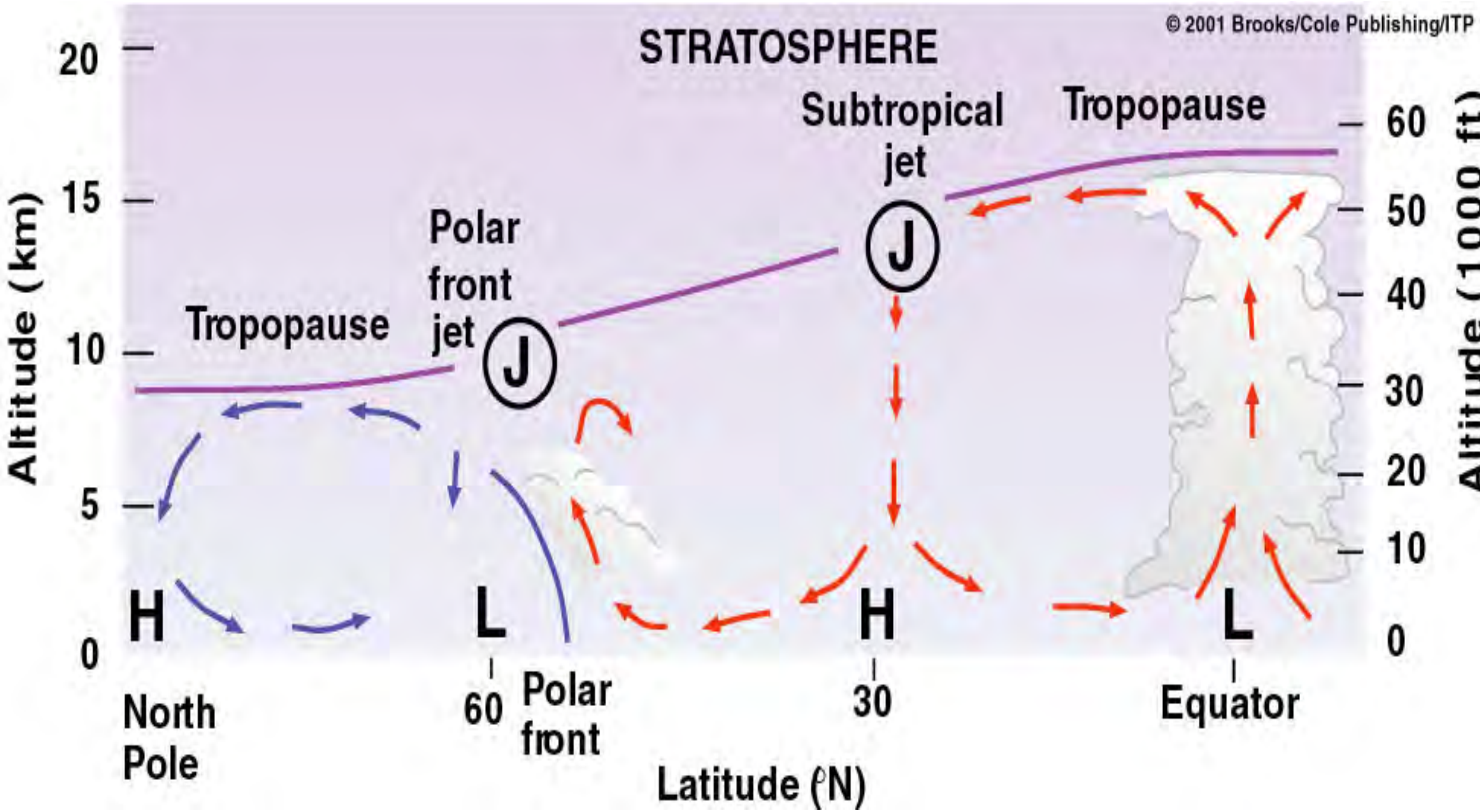


Ahrens: Fig. 10.2

Three Cell Model



Ahrens: Fig. 10.2



Ahrens: Figure 10-9

Three-Cell Model vs. Reality

- This is a simple model: an approximation of how global circulation works
- Cells shift with the seasons
- Circulation distorted by continents
- Ferrel and Polar cells are imperfect
  - Oversimplification

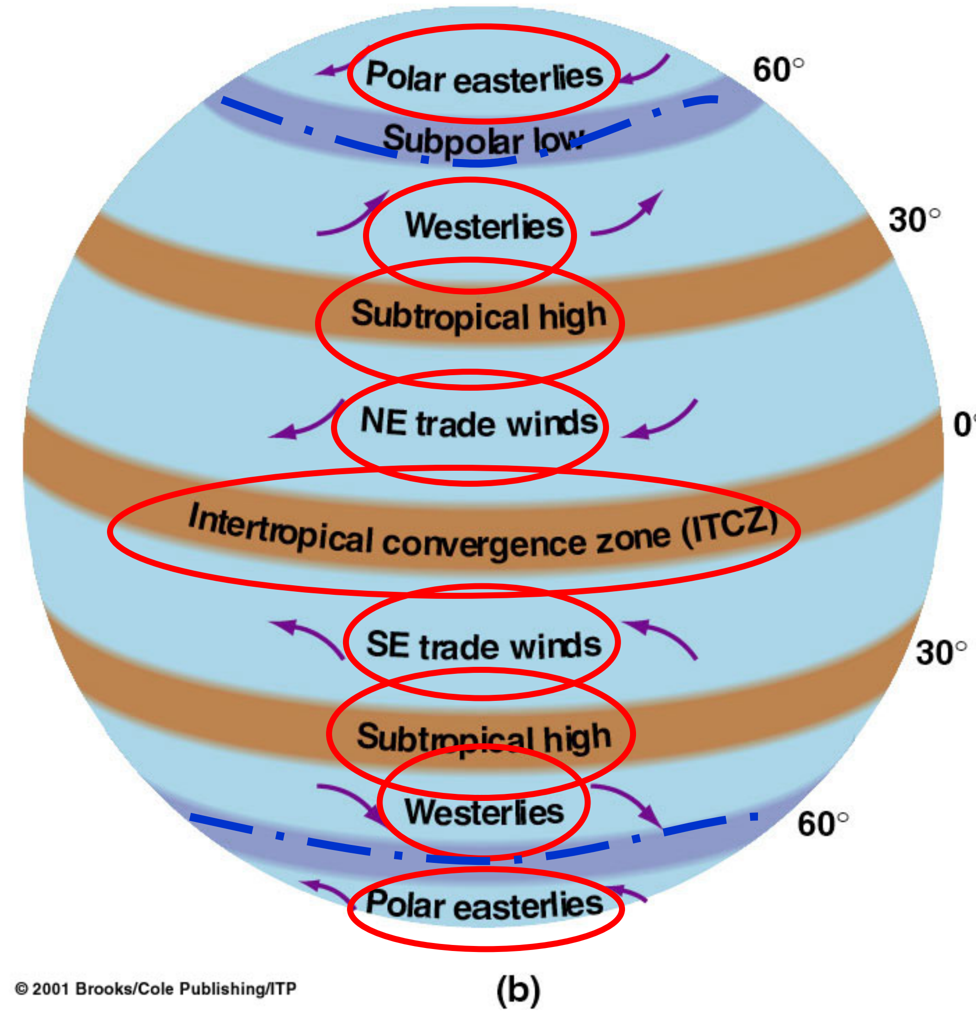
Intertropical Convergence Zone

The ITCZ is observable in this photo as a band of clouds extending from northern South America into the Pacific

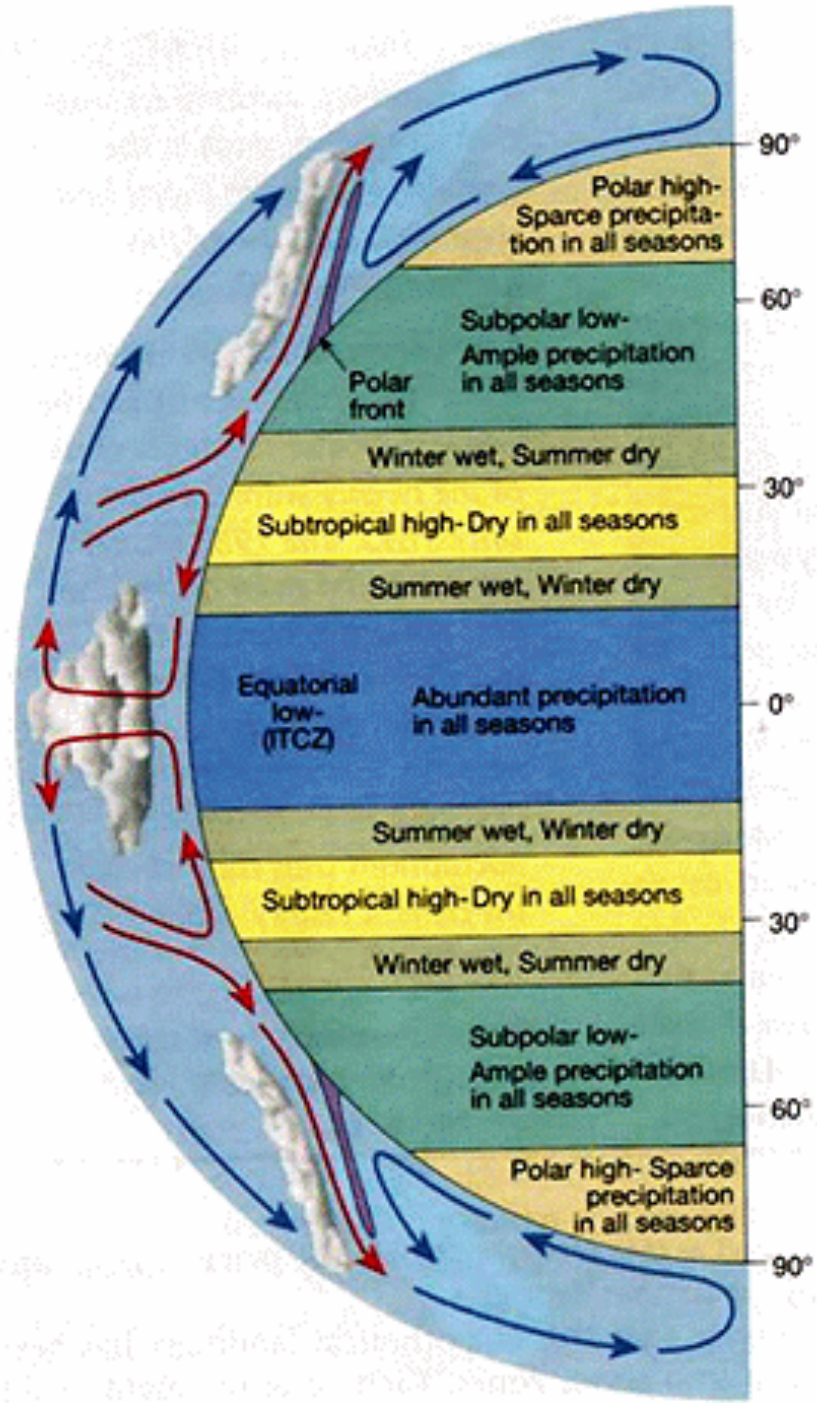
A&B: Figure 8-3

Surface regions

- Intertropical Convergence Zone (ITCZ) (Doldrums)
- Trade Winds
- Subtropical high (Horse latitudes)
- Westerlies
- Polar Front
- Polar easterlies



Global Precipitation Pattern Produced by the General Circulation



The Sahel

Borders the southern Sahara Desert

Green lines: precipitation contours.

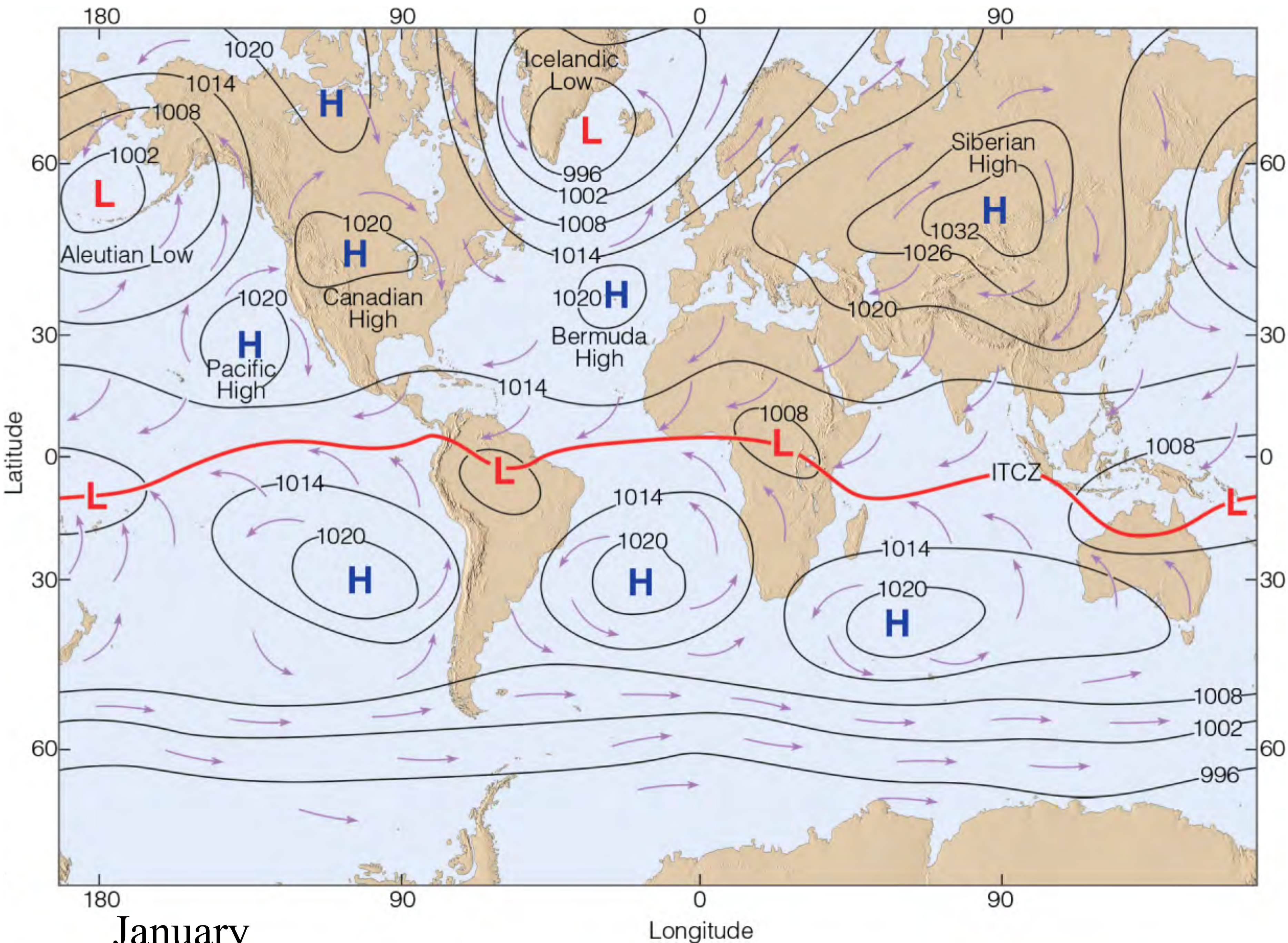
A&B: Figure 8-5 (a)

The Sahel

Shifts in the ITCZ bring rain to the Sahel in summer, dryness in the winter.

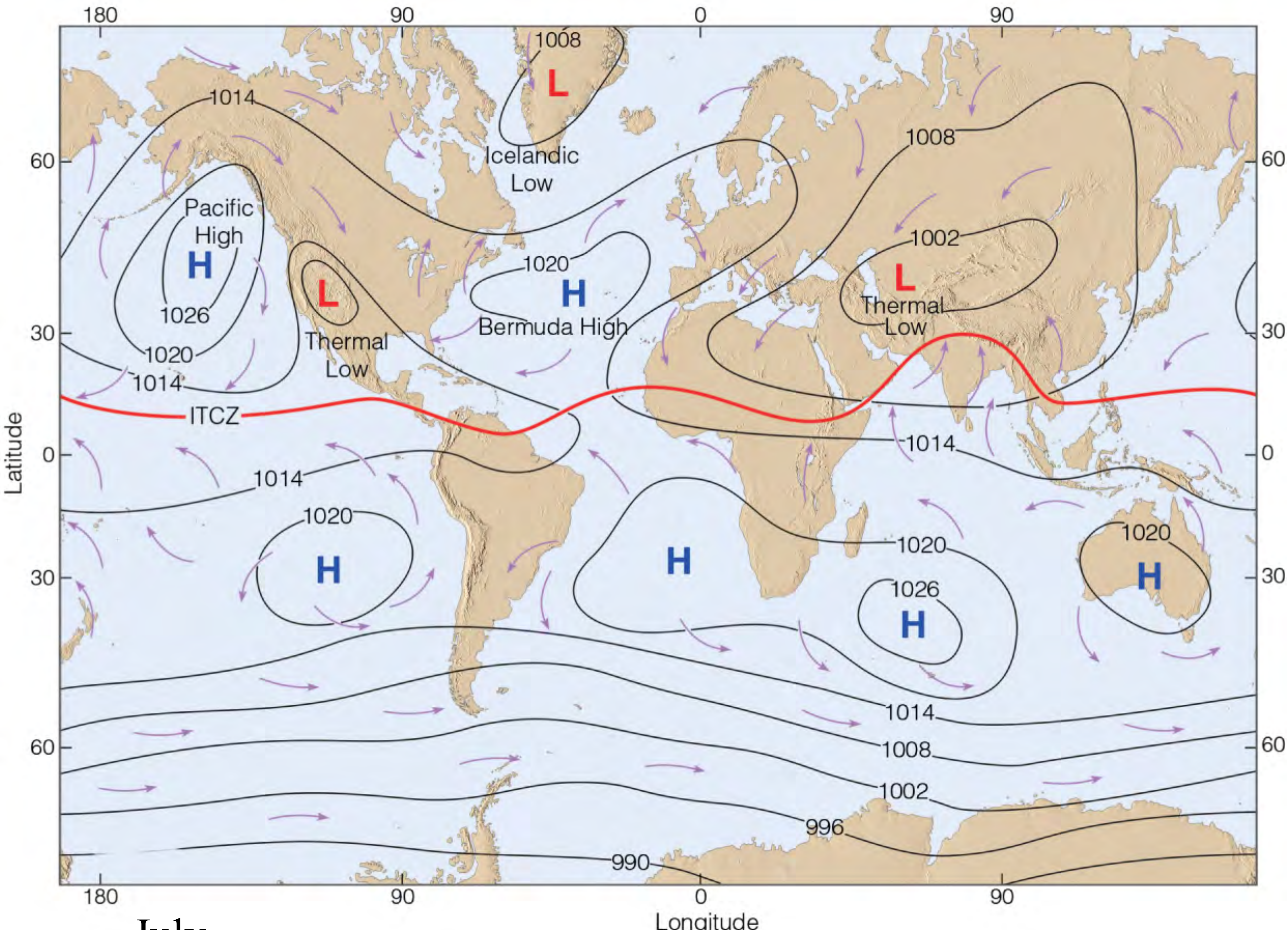
During most of the year the ITCZ and the rain is located south of the region

A&B: Figure 8-5 (b) and (c)



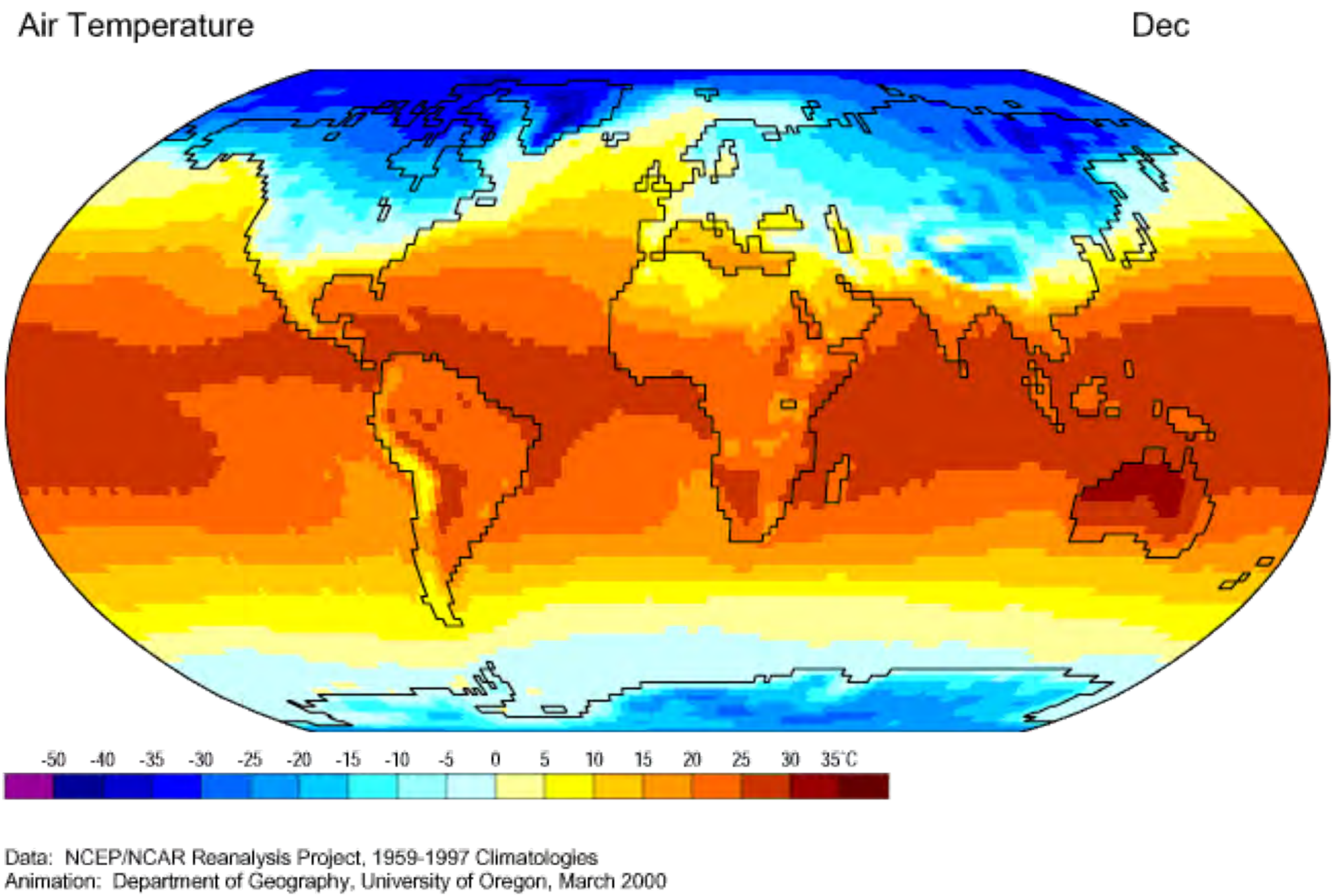
180
90
0
90
Icelandic
Low
1020
1014
1008
1002
Aleutian Low
996
1002
1008
1014
Siberian
High
1032
1026
1020
Canadian
High
1020
1020
Bermuda
High
Pacific
High
1014
1008
1014
1020
1014
1020
ITCZ
1014
1020
1008
1002
996
Latitude
60
30
0
30
60
Longitude

January



180
90
0
90
60
30
0
30
60
Latitude
Longitude
1008
L
Icelandic
Low
1014
Pacific
High
H
1026
1020
1014
L
Thermal
Low
1020
H
Bermuda High
1008
1002
L
Thermal
Low
ITCZ
1014
1014
1020
H
H
1020
1026
H
1020
H
1014
1008
1002
996
990

July



Animation: University of Oregon

Next lecture

- Upper troposphere winds
- Ocean currents
- Oscillations