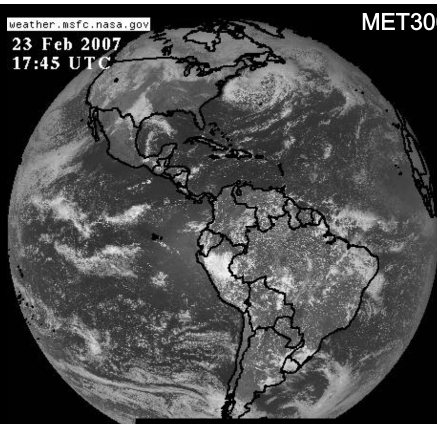
MET3003



Lecture 14: Atmospheric Circulations 05MAR07

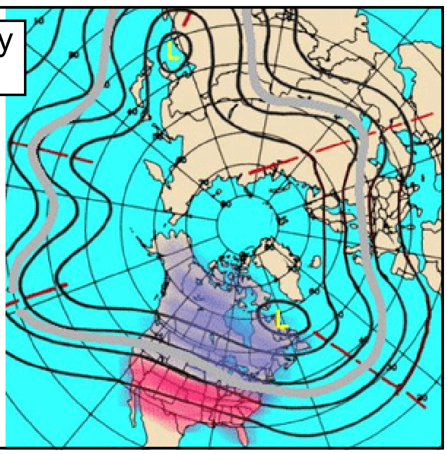
What the book says about scales of atmospheric motion:

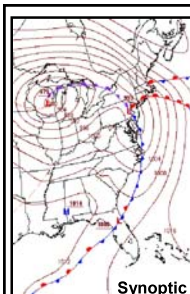
Scale	Time scale	Distance scale	Examples
Macroscale			
Planetary	Weeks or longer	1000–40,000 km	Westerlies and trade winds
Synoptic	Days to weeks	100–5000 km	Mid-latitude cyclones, anticyclones, and hurricanes
Mesoscale	Minutes to hours	1–100 km	Thunderstorms, tornadoes, and land–sea breeze
Microscale	Seconds to minutes	<1 km	Turbulence, dust devils, and gusts

What you should learn about scales of atmospheric motion:

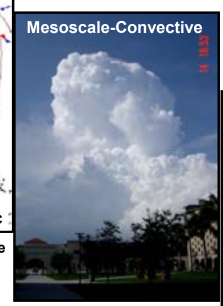
Scale	Length	Duration
Planetary	> 6000 km	Weeks
Synoptic	> 2000 km	Days
Mesoscale	20-2000 km	Hours
Convective	500 m – 20 km	Minutes
Microscale	< 1 km	Seconds

Planetary Waves





Middle-Latitude Cyclone

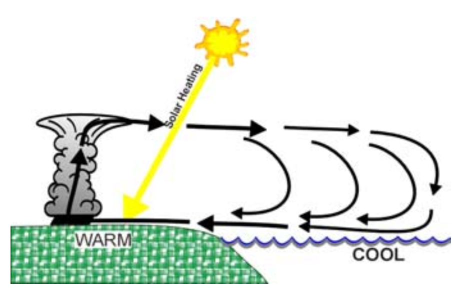


Group of Thunderstorms

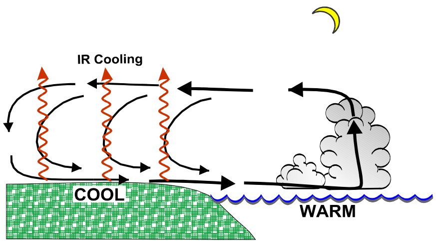
Wind Gusts

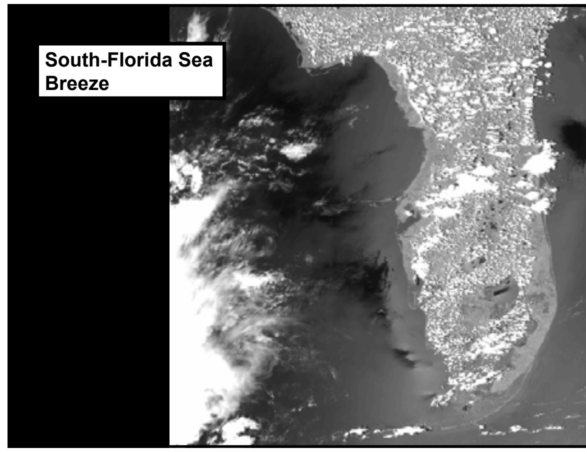
Dust Devil: Another Microscale Motion

Daytime Sea Breeze

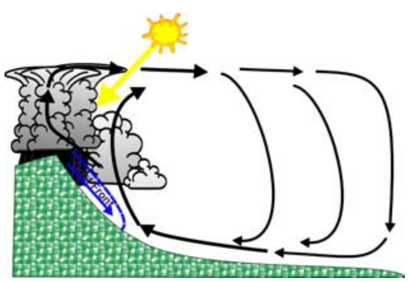


Nighttime Land Breeze

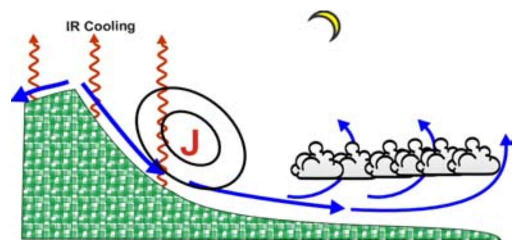




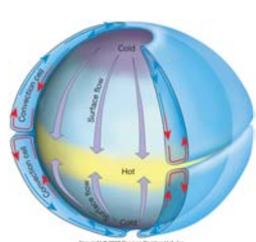
Orographic Convection



Valley Flows at Night



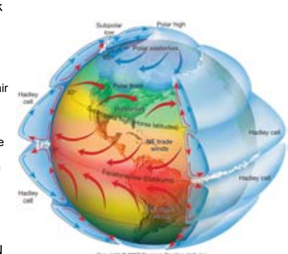
Heating-Induced Single-Cell Circulation



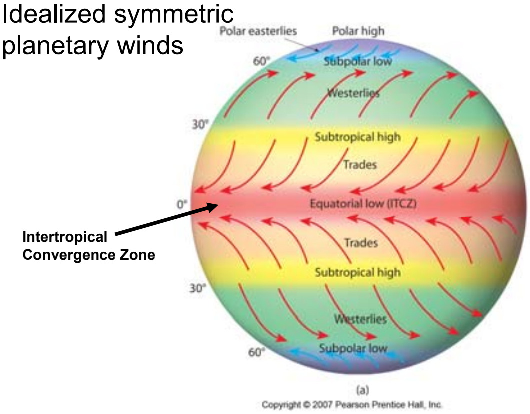
- Proposed by George Hadley in 1735
- Solar heating causes rising motion near the equator
- Air turns poleward and sinks in high latitudes
- To be replaced by low level winds converging toward the equator.
- Does not take into acount Earth's rotation

Effect of Earth's Rotation

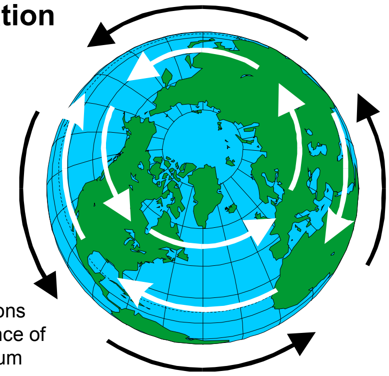
- Causes the idealized single cell to break down into 3 cells
- Equatorial ***Hadley Cell***
  - Caused by strong solar heating
  - Prevailing ***Trade Winds*** blow from the east
  - ***Thermally Direct***: Warm air rises; cool air sinks
- Middle latitude ***Ferrell Cell***
  - Forced by wavelike motions
  - Prevailing ***Westerlies*** wind blow from the west
  - ***Thermally Indirect***: Cool air rises; warm air sinks
- High Latitude ***Polar Cell***
  - Forced by cooling due to IR radiation
  - Easterly winds
  - Thermally direct
- **Doldrums** (calms) separate Trades in N & S Hemispheres
- ***Horse Latitudes*** separate the Trades from the Westerlies



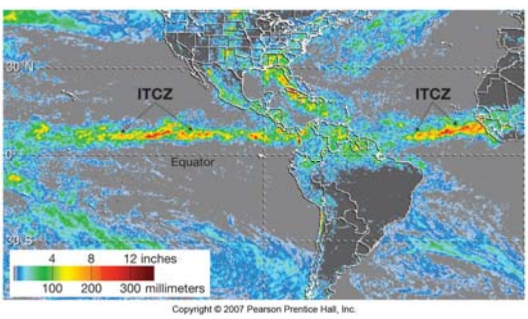
Idealized symmetric planetary winds



Prevailing winds and the Earth's rotation

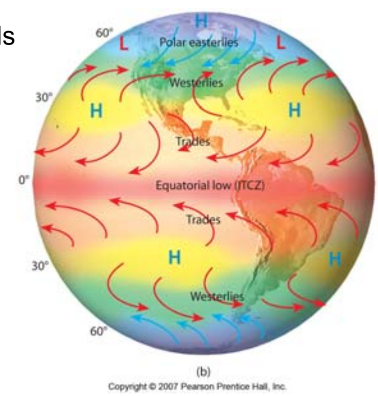


Atmospheric motions maintain the balance of heat and momentum

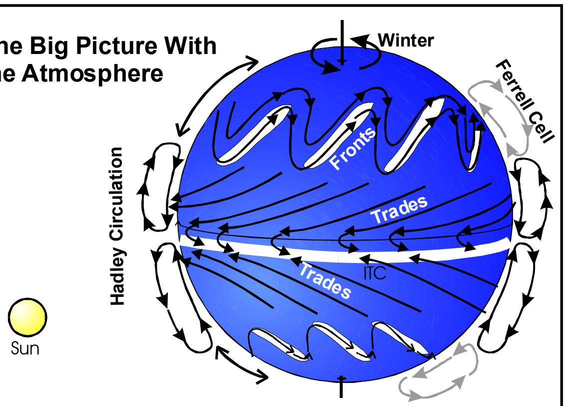


Intertropical Convergence Zone (ITCZ)

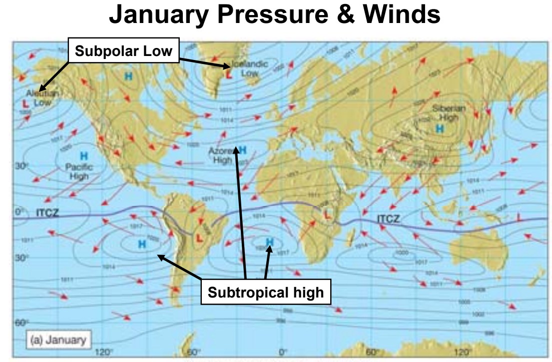
More realistic planetary winds



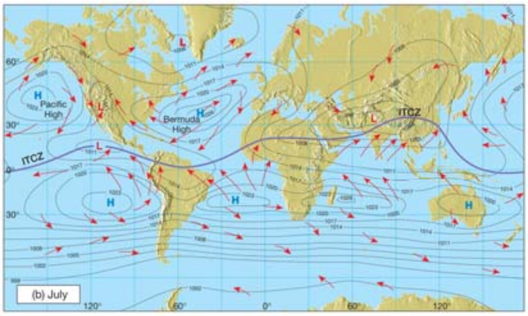
The Big Picture With the Atmosphere



January Pressure & Winds

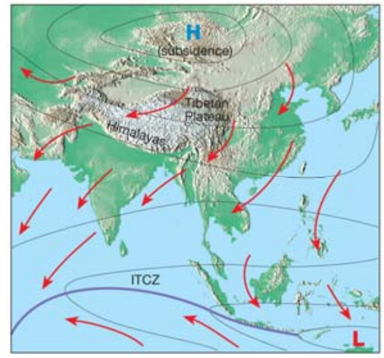


July Pressure & Winds

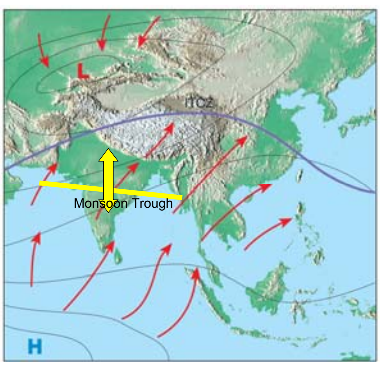


Atmosphere, 10th Ed.
Figure 07-10

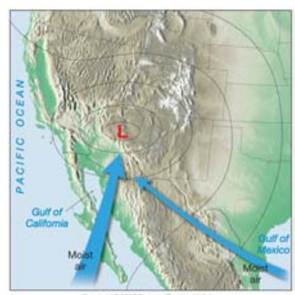
Asian Winter Monsoon

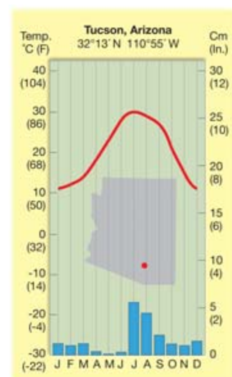


Asian Summer Monsoon

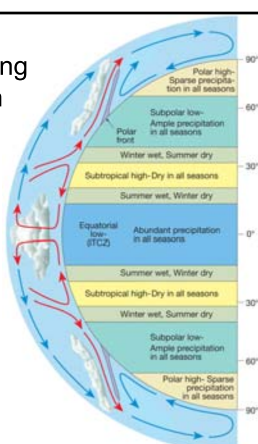


North American
"Monsoon"

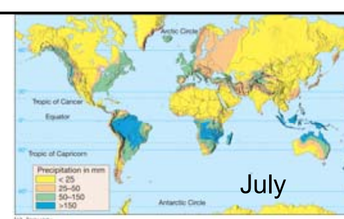




Pressure Belts, Prevailing
Winds and Precipitation



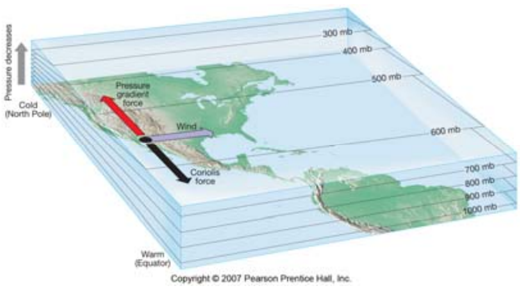
Seasonality of
precipitation

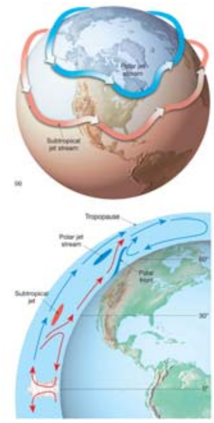


(c) January

(b) July

Pressure and the Westerlies



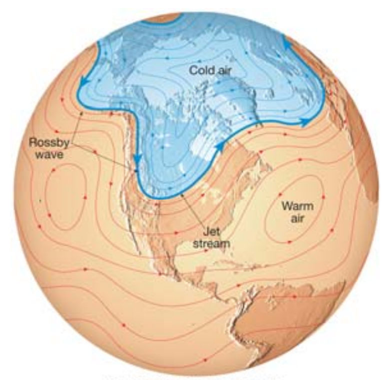


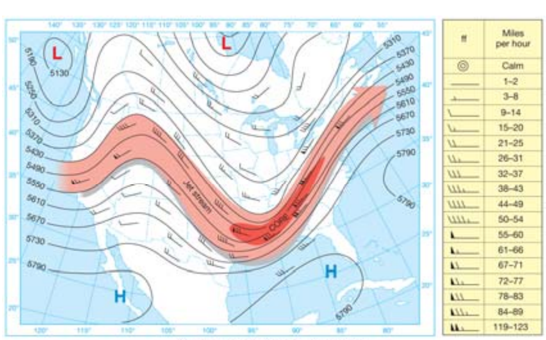
Jet Streams

- Narrow bands of strong westerly winds, generally at high altitudes
- Hypsometric equation predicts strong geostrophic winds above strong horizontal temperature gradients
- ***Subtropical Jet***: Above the sinking branch of the Hadley Cell
- ***Polar Front Jet***: Caused by the strong temperature gradient along the polar front

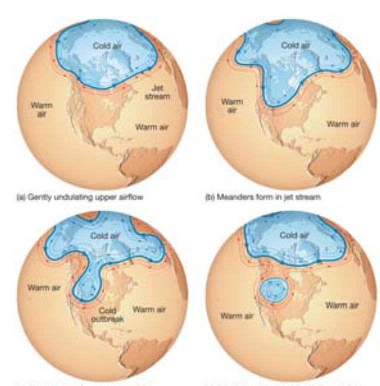
Changes in the Polar Front Jet With Season

Rossby Waves





Vacillation of the upper-level flow



(a) Gently undulating upper airflow

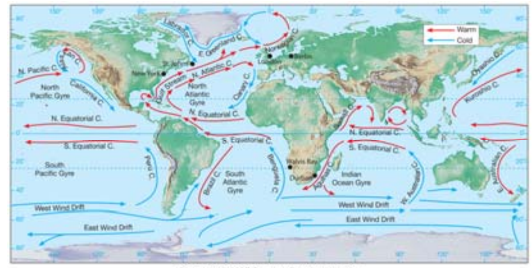
(b) Meanders form in jet stream

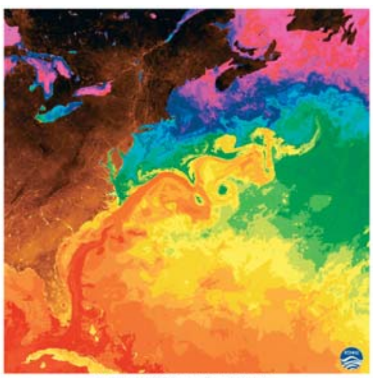
(c) Strong waves form in upper airflow

(d) Return to a period of flatter flow aloft

Modeled in Rotating Dishpan Experiments

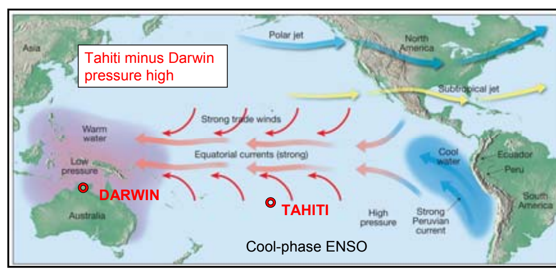
Ocean Currents





Warm water transport by the Gulf Stream

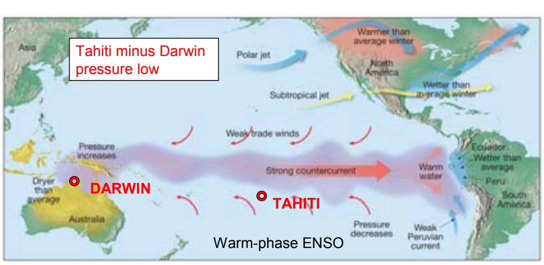
Normal Conditions in the Equatorial Pacific



Cool-phase ENSO

Strong Tradewinds push warm water westward where it piles up against the Maritime Continent
ENSO: El Niño-Southern Oscillation

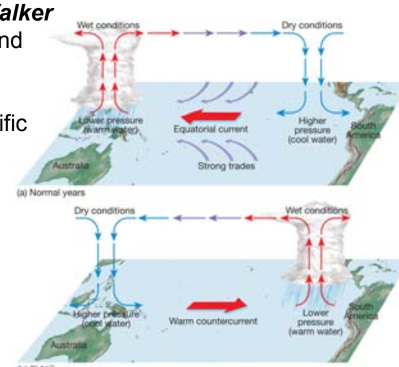
El Niño Conditions in the Equatorial Pacific

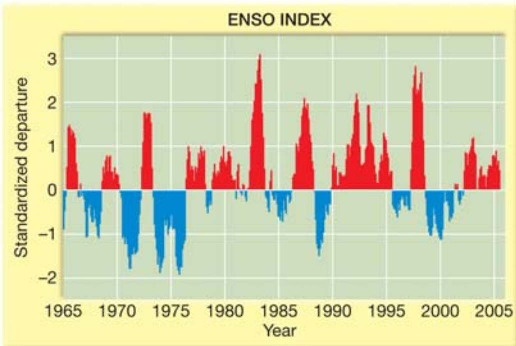


Warm-phase ENSO

Weaker Tradewinds allow warm water to push eastward where it warms the ocean east of the Dateline

El Niño, the ***Walker Circulation***, and their effect on weather in the equatorial Pacific





Summary

- Memorize and be able to identify ***Microscale, Convective, Mesoscale, Synoptic*** and ***Planetary Scales*** of motion
- Be able to draw and explain the ***Sea/Land*** and ***Mountain/Valley Breezes***
- Be able to draw and explain the three cell model of the general circulation
- Be able to define: ***Hadley Cell, Ferrell Cell, Polar Cell, Westerlies, Trade Winds, Doldrums, Horse Latitudes,*** and ***Intertropical Convergence Zone (ITCZ)***
- Be able to draw and explain the Big Picture of the Atmosphere
- Be able to draw and explain the Asian and North Amercian Monsoons
- Understand how prevailing winds and the general circulation control precipitation patterns
- Be able to relate pressure and temperature patterns to the middle latitude westerlies and ***Polar Front*** and ***Subtropical Jet Streams***
- Be able to explain normal conditions in the equatorial Pacific and contrast them with what happens during El Niño.
- Know the definitions of ***Walker Circulation*** and ***Southern Oscillation Index***