Monday; March19, 2012

Time	Item	
15	Introduction … Welcome back , new ground rules	2:15
10	News	2.25
20	Picking our projects	2:45
15	Break	3:00
60	Weather	4:00
30	Build a Barometer … design thoughts	4:30
20	Review test answers … Close … Give back tests Want to discuss I will be here 60 min. before tomorrows class	

Tuesday; March20, 2012

Time	Item	
	Introduction	
	Build the Barometer	
	Break	
	Create an algorithm for a weather forecast	
	Test the algorithm	
	Reflection	

Weather

- Climate and Biodiversity
- Factors Influencing Climate
- Instrumentation
- Effects on Society

“Climate is what we expect, weather is what we get” … Mark Twain

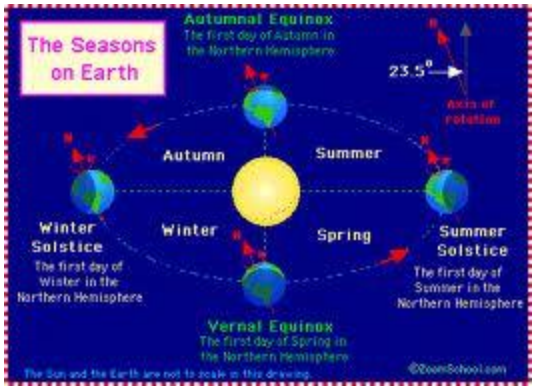
Questions

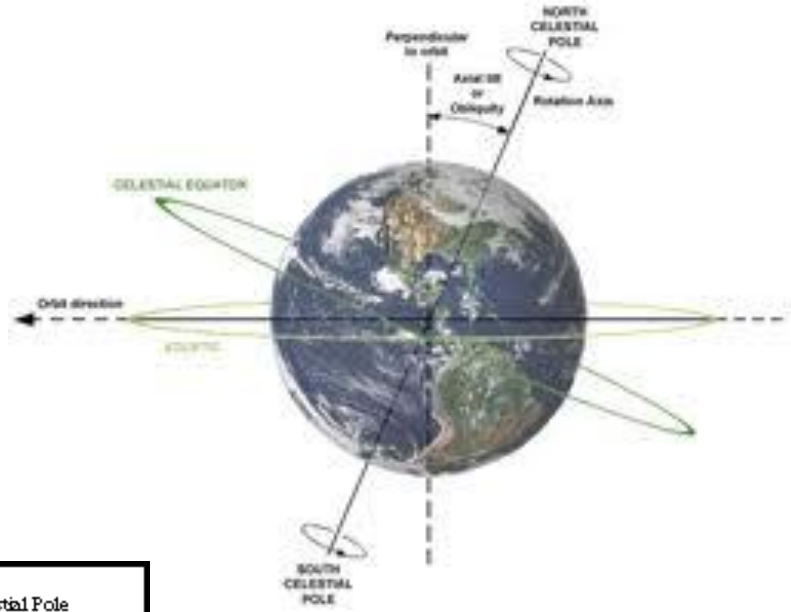
- What kinds of weather does a rising barometer indicate?
- Why does the wind blow?
- What does relative humidity really mean?
- Why are weather predictions wrong so often?

Weather Drivers?
Where does the energy come from?

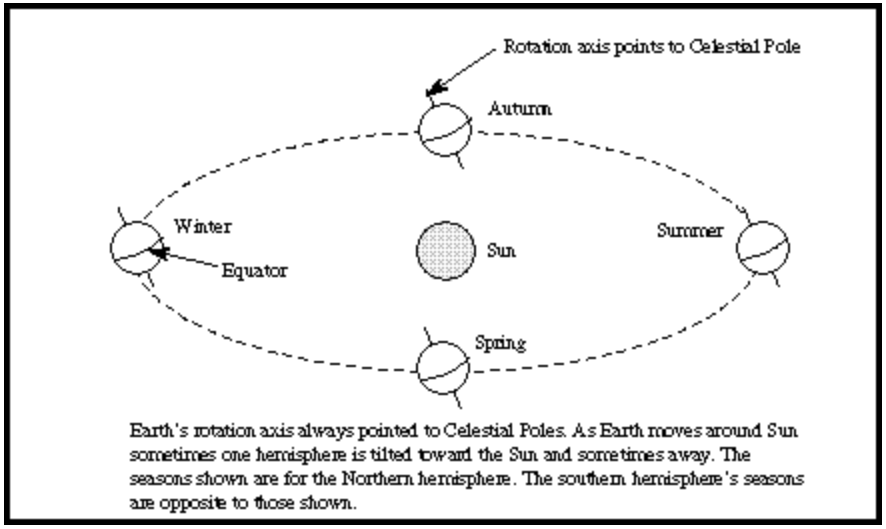
- Sun
- Earths orbit (eccentricity changes over 100,000 years)
- Earths rotation
- Earths Tilt … 23.5 degrees (21^{o} to 24^{o} every 40,000 years)

Relationship of the tilt, Sun





Energy from the Sun



Can we predict the weather?

- I can predict the weather that's happening right now.
- As I go ahead in time it becomes more difficult and to what degree of accuracy.

Predicting the weather is not a single problem but a range of problems. It is easy to predict the weather perfectly in the current moment - just look outside. Predicting what the weather will be in the future depends on how far in the future you want to predict - predicting the weather an hour from now is very easy compared to predicting the weather a week from now. There is also the issue of precision. Predicting the high for the day for Chicago next January 8th is hard if your acceptable margin of error is 3 degrees, but is easy if it is 30 degrees. The weather is also not a monolithic issue, as well. So predicting the temperature a week from now, how cloudy it will be a week from now, and how humid it will be a week from now are all related but separate issues, some of which are harder to predict than others. And because weather prediction is a complex calculation process that involves statistics, pattern recognition, and physical system simulations, our ability to predict the weather is changing about as rapidly as computers are getting faster. An appreciation for all this complexity can help us use the weather predictions we get as effectively as possible.

Dr. Astro Teller Director of New Projects, Google

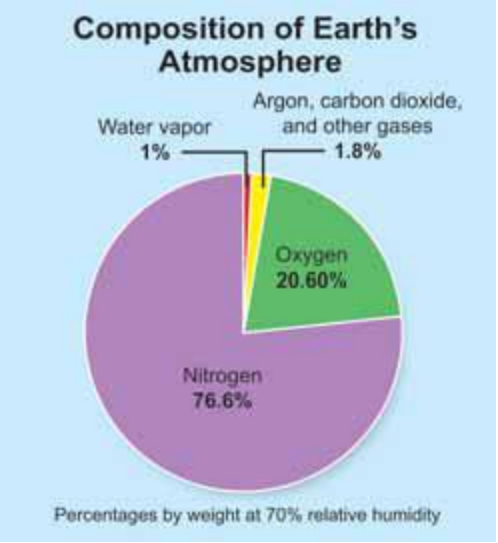
What are the drivers of the weather?

- Temperature
- Pressure
- Humidity
- Density
- Air Speed & Direction
- Water vapor, clouds, and other heat-trapping gases create a natural greenhouse effect by holding heat in the atmosphere and preventing its release back to space.

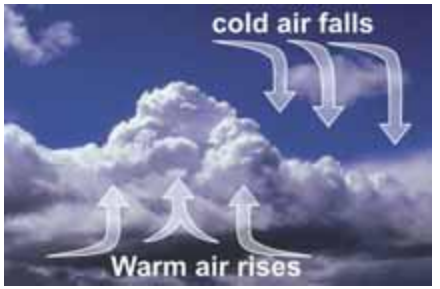
Lets Discuss these items

The atmosphere of Earth

- **Air is not “nothing”**
- **Air is a mixture of gases**
- **Atmospheric pressure …** Has weight with a height of 80Km



Earth’s weather is created by gigantic convection currents in the atmosphere. Energy from the sun mostly passes through the atmosphere to warm the ground. Air near the ground becomes warm and expands. Warmer air is less dense than cold air and therefore the warm air near the ground rises.



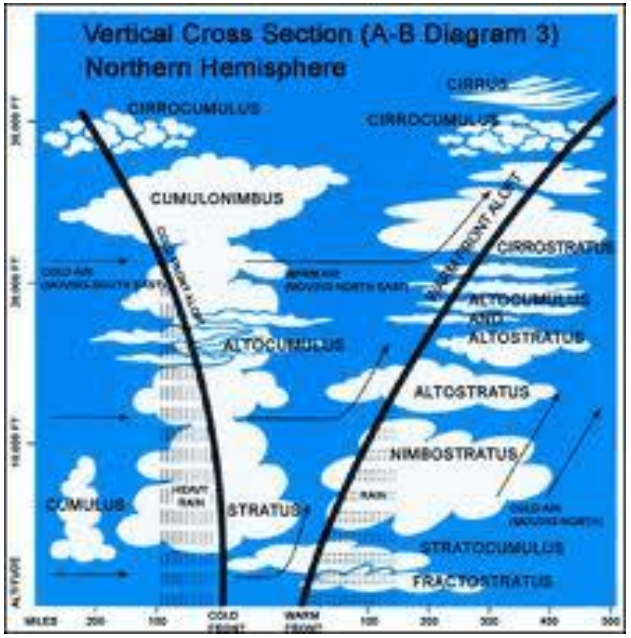
Heating … background

- Adiabatic Process .. Air compress generates heat, air expanding results in a decrease in temperature. Think about a pump
- Warm air is less dense that cool air and rises.
- Rises and expanding unsaturated air will drop in temperature at a constant rate of $1^{o}F$ / 183 ft ($1^{o}C$/100m) … ***Adiabatic lapse rate***.
- The adiabatic process often creates clouds

Clouds

Clouds are generally formed by a combinations of processes:

- Density lifting by warm, low density air rising
- Frontal lifting warm air meeting cold
- Orographic lifting … warm air forced over high natural features like mountains.



- Cumuliform clouds
- Stratiform clouds

Clouds

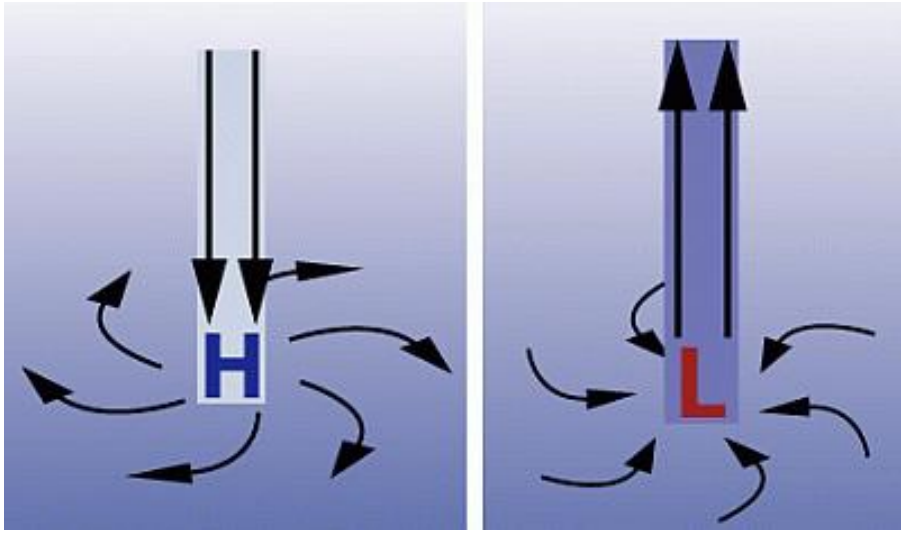
Plankton are active players in the formation of marine clouds; they generate dimethyl sulfide (DMS) which is converted in the atmosphere to sulfates particles that act as condensation nuclei for clouds.

If Clouds exert a net cooling effort , than an increase in clouds formation in a warmer world will constitute a negative feedback on global warming. But will skies be more cloudy?

Pressure

Balloons

Pressure varies from day-to-day at the Earth's surface - the bottom of the atmosphere. This is, in part, because the Earth is not equally heated by the Sun. Areas where air is warmed often have lower pressure because the warm air rises and are called low pressure systems.



Air near the surface flows down and away in a high pressure system (left) and air flows up and together at a low pressure system (right).

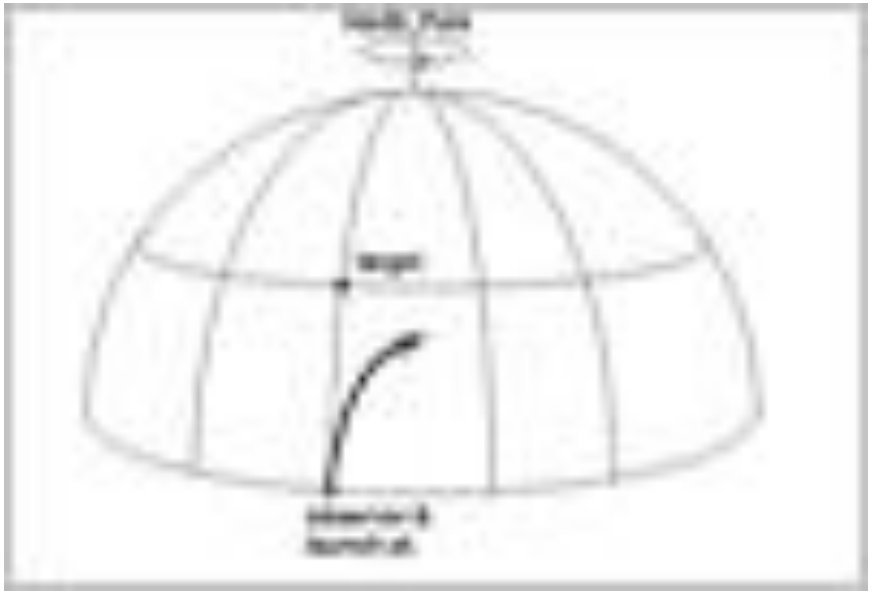
A tower of air that is 1 inch square and goes from the bottom of the atmosphere is 14.7 pounds. **= 14.7 psi**

A **low pressure system**

has lower pressure at its center then the areas around it. Winds blow towards the low pressure, and the air rises in the atmosphere where they meet**. As the air rises, the water vapor within it condenses forming clouds and often precipitation too.** Because of Earth's spin and the Coriolis Effect, winds of a low pressure system swirl counterclockwise north of the equator and clockwise south of the equator. This is called cyclonic flow. On weather maps a low pressure system is labeled with red L.

Coriolis Force

The Coriolis force is created by Earth's rotation, which deflects air masses as they move over long distances. It is strongest near the poles and nonexistent at the equator.



A **high pressure system**

has higher pressure at its center then the areas around it. Wind blows away from high pressure. Winds of a high pressure system swirl in the opposite direction as a low pressure system - clockwise north of the equator and counterclockwise south of the equator. This is called anti-cyclonic flow. Air from higher in the atmosphere sinks down to fill the space left as air blew outward. On a weather map the location of a high pressure system is labeled with a blue H.

Wind … Blow a balloon

Wind is air moving from a place that has higher pressure to one that has lower pressure.

There are steady winds that always blow in the same direction because of the pattern of how air moves through the atmosphere over the entire planet. For centuries sailors have depending on these predictable winds know as the Trade Winds, Westerlies, and Polar Easterlies.

These winds turn to the right in the Northern Hemisphere and to the left in the Southern Hemisphere because of Earth's spin, a phenomenon known as the Coriolis Effect.

Air Speed & Direction

- Even with disruptions like weather fronts and storms, there is a consistent pattern to how air moves around our planet's atmosphere. This pattern, called atmospheric circulation, is caused because the Sun heats the Earth more at the equator than at the poles. It's also affected by the spin of the Earth.

- In the tropics, near the equator, warm air rises. When it gets about 10-15 km (6-9 miles) above the Earth surface it starts to flow away from the equator and towards the poles. Air that rose just north of the equator flows north. Air that rose just south of the equator flows south. When the air cools, it drops back to the ground, flows back towards the Equator, and warm again. The, now, warmed air rises again, and the pattern repeats. This pattern, known as **convection**, happens on a global scale. It also happens on a small scale within individual storms.

- But because Earth is spinning, the air that moves north and south from the equator also turns with the spin of the Earth. Air going north turns to the northwest. Air travelling south turns to the southwest. The power of Earth's spin to turn flowing air is known as the Coriolis Effect. I

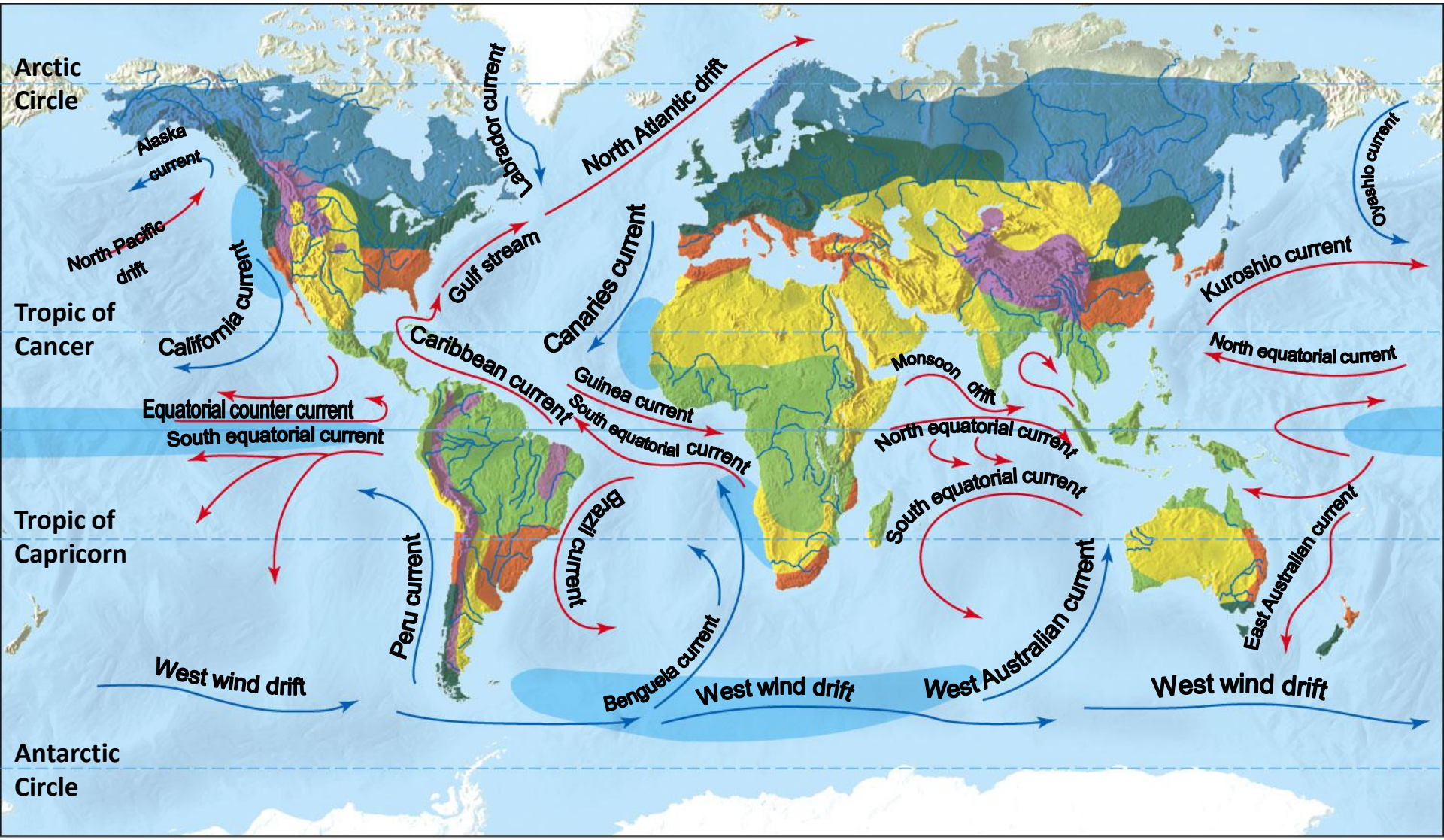

Arctic Circle
Tropic of Cancer
Tropic of Capricorn
Antarctic Circle
Alaska current
North Pacific drift
California current
Labrador current
North Atlantic drift
Gulf stream
Canaries current
Oyashio current
Kuroshio current
North equatorial current
Caribbean current
Guinea current
Monsoon drift
Equatorial counter current
South equatorial current
South equatorial current
North equatorial current
South equatorial current
Brazil current
Peru current
Benguela current
West Australian current
East Australian current
West wind drift
West wind drift
West wind drift
Polar (ice)
Subarctic (snow)
Cool temperate
Highland
Warm ocean current
River
Warm temperate
Dry
Tropical
Major upwelling zones
Cold ocean current

Fig. 7-2, p. 149

Global Air Circulation

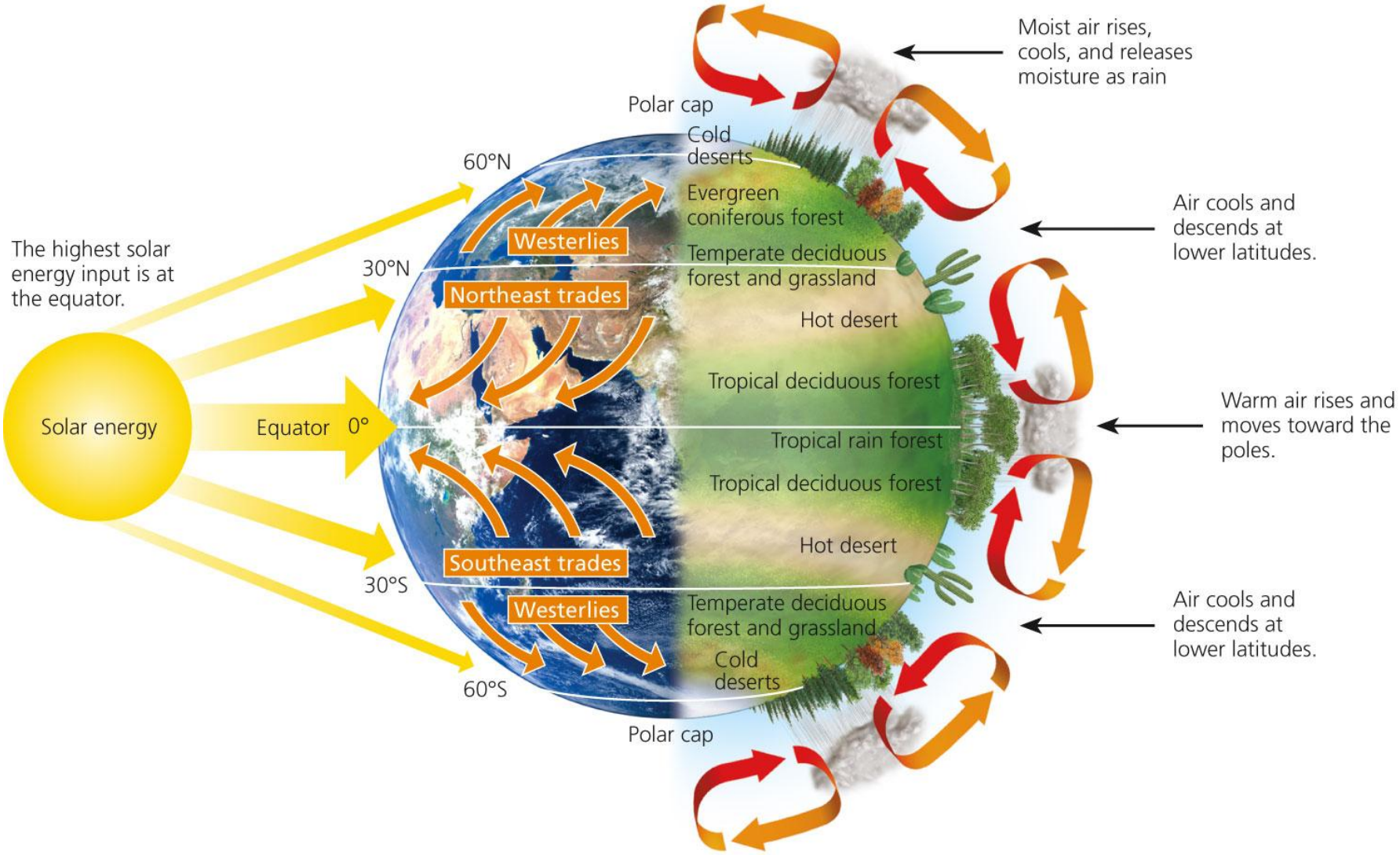


Fig. 7-3, p. 149

Humidity

- The maximum amount of water vapor that can be in the air depends on the air temperature. Warmer air can hold more water vapor within it.

- The amount of water vapor in the air is called absolute humidity. The amount of water vapor in the air as compared with the amount of water that the air could hold is called relative humidity.

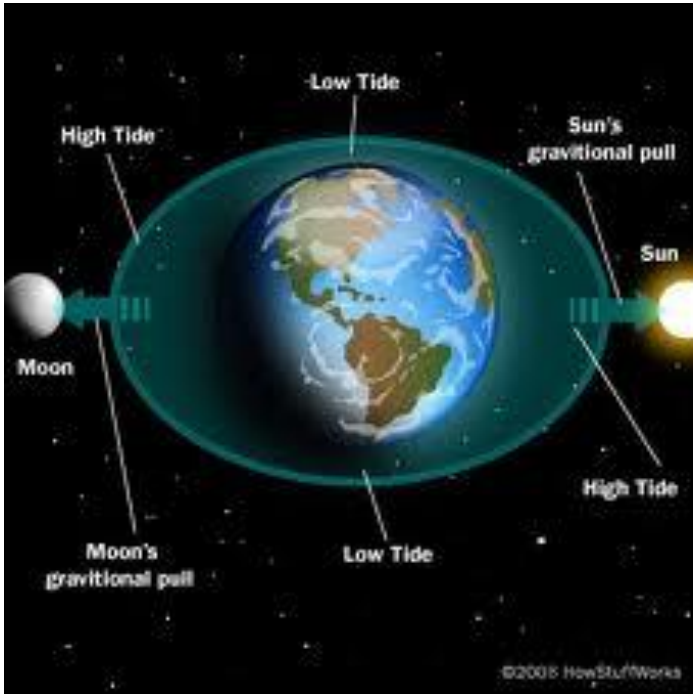
- When air is saturated as much as possible with water vapor it is at the dew point.

What the Past Tells Us

- **Mineral deposits in deep sea beds.** Over time, dissolved shells of microscopic marine organisms create layers of chalk and limestone on sea beds. Analyzing the ratio of oxygen-18 (a rare isotope) to oxygen-16 (the common form) indicates whether the shells were formed during glacial periods, when more of the light isotope evaporated and rained down, or during warm periods.
- **Pollen grains trapped in terrestrial soils.** Scientists use radiocarbon dating to determine what types of plants lived in the sampled region at the time each layer was formed. Changes in vegetation reflect surface temperature changes.
- **Chemical variations in coral reefs.** Coral reefs grow very slowly over hundreds or thousands of years. Analyzing their chemical composition and determining the time at which variations in corals' makeup occurred allows scientists to create records of past ocean temperatures and climate cycles.
- **Core samples from polar ice fields and high-altitude glaciers.** The layers created in ice cores by individual years of snowfall, which alternate with dry-season deposits of pollen and dust, provide physical timelines of glacial cycles. Air bubbles in the ice can be analyzed to measure atmospheric CO_2 levels at the time the ice was laid down.

Tides and Gravity force cause by the Moon and Sun

Moon bigger force because of its being closer to the Earth



Pressure Changes

The change in air pressure over time has important forecasting implications. As pressure lowers over time, especially if it is rapid, that is an indication that a low pressure system or front is approaching. This lowering pressure indicates an increasing likeliness of precipitation. If the air pressure rises significantly or stays well above average for a long period of time, that is an indication precipitation is less likely.

Much of the general public does not understand how air pressure is used in forecasting. Thus it is important to point out when appropriate the importance of air pressure changes over time and the relationship between air pressure and whether a high pressure or a low pressure system is influencing the area. The general public does have a good handle of understanding that low pressure systems tend to bring in precipitation and high pressure systems tend to bring fair weather. Thus, if you can relate the air pressure value to a pressure system then the general public may grasp the significance of the air pressure value especially if they have an understanding of benchmark values.

Core Case Study: Different Climates Support Different Life Forms

- Climate -- long-term temperature and precipitation patterns – determines which plants and animals can live where
- Tropical: equator, intense sunlight
- Polar: poles, little sunlight
- Temperate: in-between tropical and polar

Climate and Biodiversity

When we try to pick out anything by itself, we find it hitched to everything else in the universe…. John Muir

7-1 What Factors Influence Climate?

- ***Concept 7-1*** *Key factors that determine an area's climate are incoming solar energy, the earth's rotation, global patterns of air and water movement, gases in the atmosphere, and the earth's surface features.*

The Earth Has Many Different Climates (1)

- **Weather**
  - Temperature, precipitation, wind speed, cloud cover
  - Hours to days
- **Climate**
  - Area's general pattern of atmospheric conditions over decades and longer

The Earth Has Many Different Climates (2)

- Air circulation in lower atmosphere due to
  1. Uneven heating of the earth's surface by sun
  2. Rotation of the earth on its axis
  3. Properties of air, water, and land

- **Ocean currents**
  - Prevailing winds
  - Earth's rotation
  - Redistribution of heat from the sun
  - Surface currents and deep currents

7-2 How Does Climate Affect the Nature and Locations of Biomes?

- ***Concept 7-2*** *Differences in average annual precipitation and temperature lead to the formation of tropical, temperate, and cold deserts, grasslands, and forests, and largely determine their locations.*

Climate Helps Determine Where Organisms Can Live

- Major **biomes**: large land regions with certain types of climate and dominant plant life:
  - Not uniform
  - Mosaic of patches
- Latitude and elevation
- Annual precipitation
- Temperature

Three Major Climate Zones

Fig. 7-1, p. 147

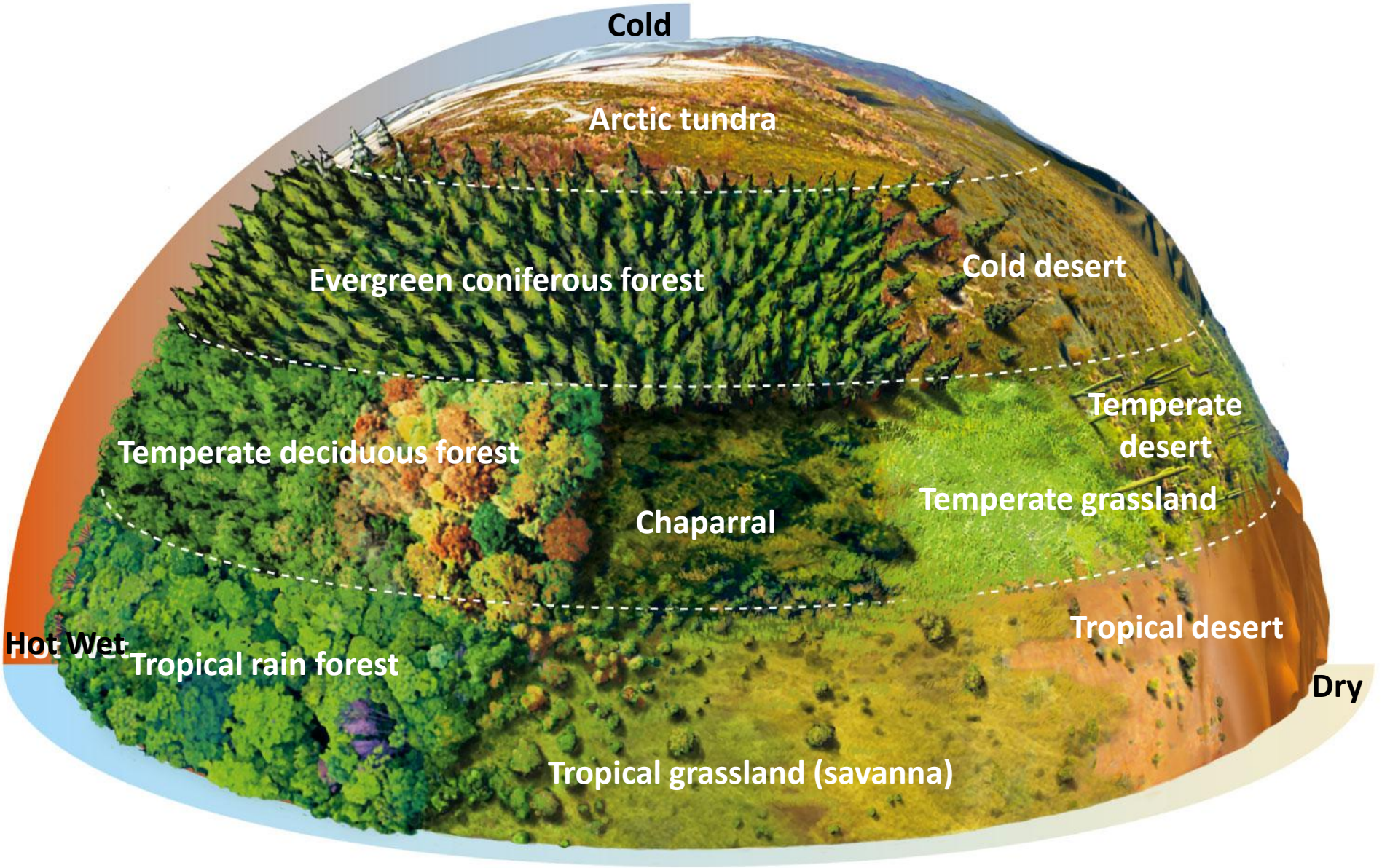
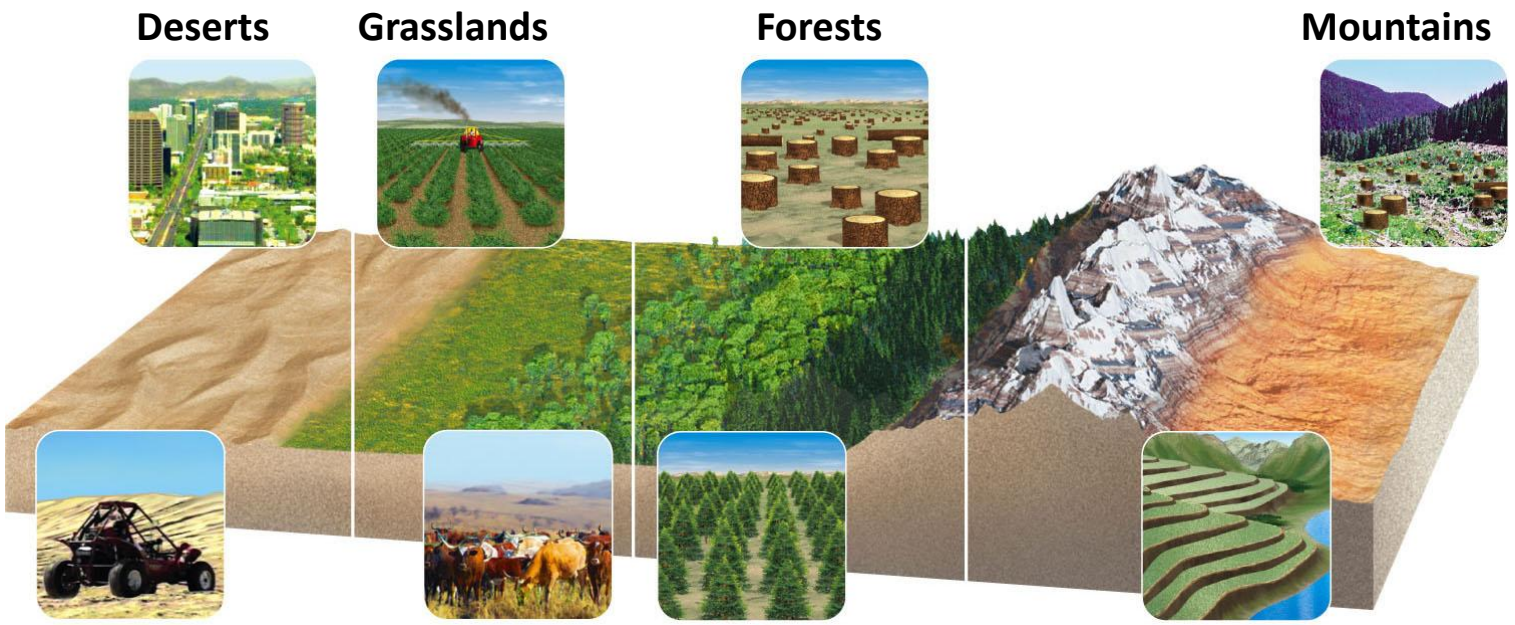

Cold
Arctic tundra
Evergreen coniferous forest
Cold desert
Temperate deciduous forest
Temperate desert
Temperate grassland
Chaparral
Tropical desert
Hot Wet
Tropical rain forest
Dry
Tropical grassland (savanna)

Fig. 7-9, p. 154

Natural Capital Degradation

Major Human Impacts on Terrestrial Ecosystems



Deserts

- Large desert cities
- Destruction of soil and underground habitat by off-road vehicles
- Soil salinization from irrigation
- Depletion of groundwater
- Land disturbance and pollution from mineral extraction

Grasslands

- Conversion to cropland
- Release of CO_2 to atmosphere from burning grassland
- Overgrazing by livestock
- Oil production and off-road vehicles in arctic tundra

Forests

- Clearing for agriculture, livestock grazing, timber, and urban development
- Conversion of diverse forests to tree plantations
- Damage from off-road vehicles
- Pollution of forest streams

Mountains

- Agriculture
- Timber and mineral extraction
- Hydroelectric dams and reservoirs
- Increasing tourism
- Air pollution blowing in from urban areas and power plants
- Soil damage from off-road vehicles
- Water supplies threatened by glacial melting

Fig. 7-18, p. 165

Energy Transfer by Convection in the Atmosphere

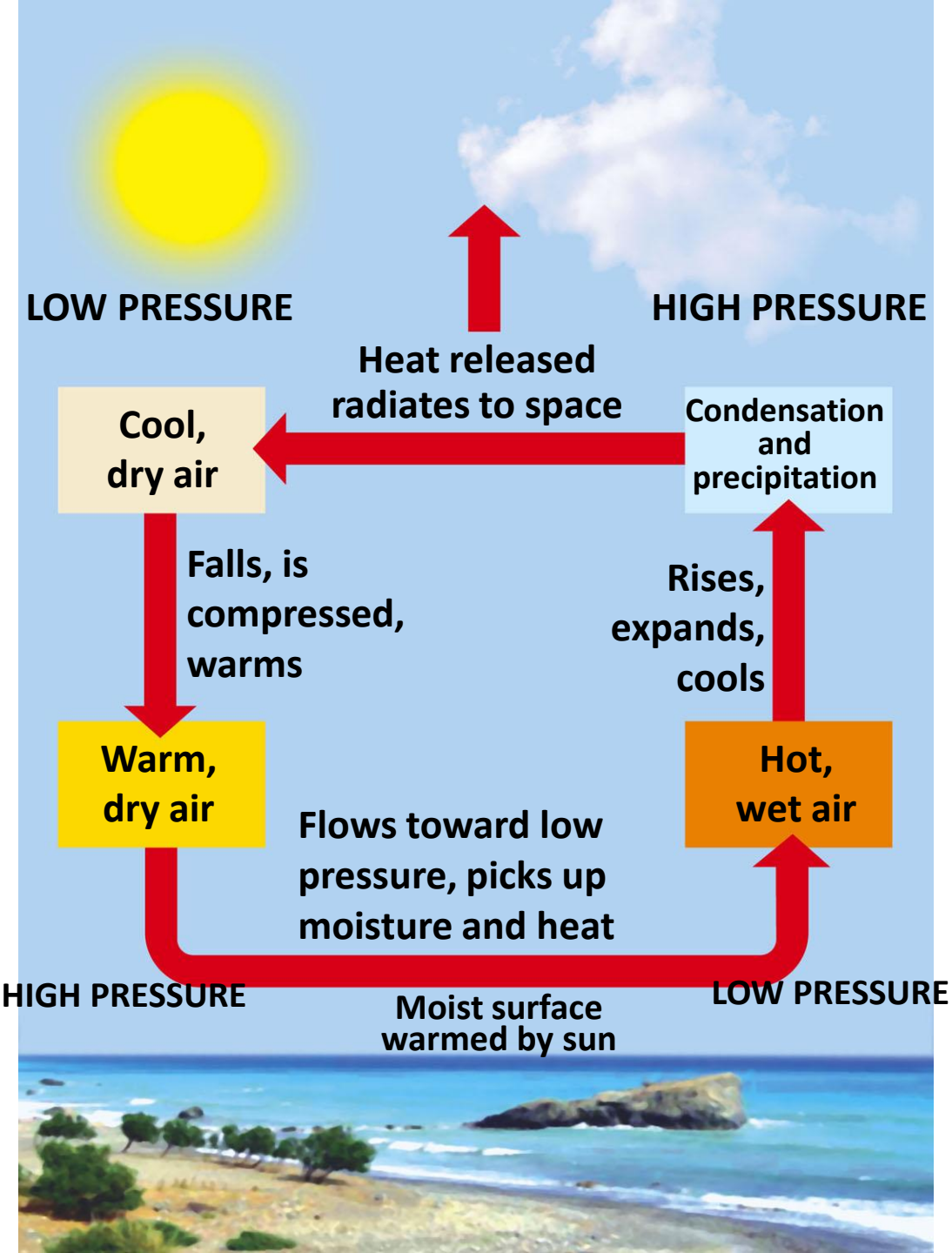
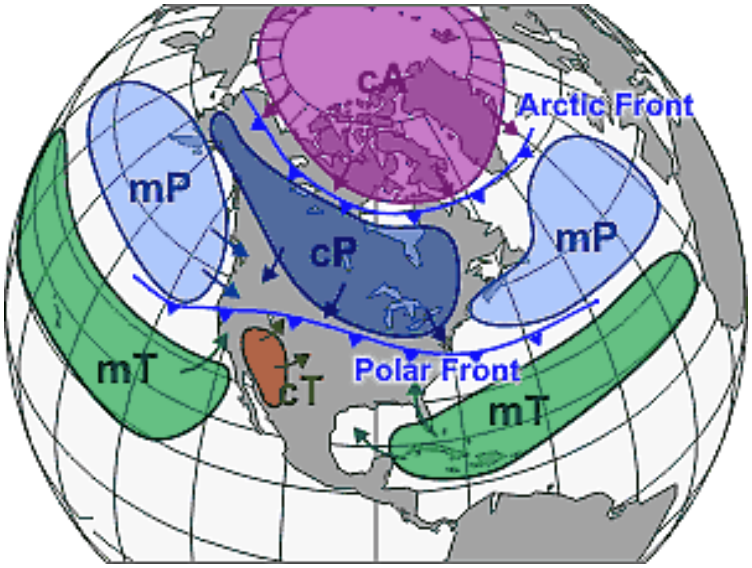


Fig. 7-4, p. 150

Air Masses

An air mass can change as it moves into different environments. For example, if a continental polar air mass moves into warmer areas and over the ocean the air will warm and moisture may evaporate from the ocean surface into the air, adding humidity.

Cold and warm air masses usually come together in middle latitudes areas such as the United States, where they form weather fronts and can produce massive storms.



The air masses in and around North America include the continental arctic (cA), maritime polar (mP), maritime tropical (mT), continental tropical (cT), and continental polar (cP) air masses.

Greenhouse Gases Warm the Lower Atmosphere

- **Greenhouse gases**
  - H_2O
  - CO_2
  - CH_4
  - N_2O
- **Natural greenhouse effect**
  - Gases keep earth habitable
- Human-enhanced global warming

Flow of Energy to and from the Earth

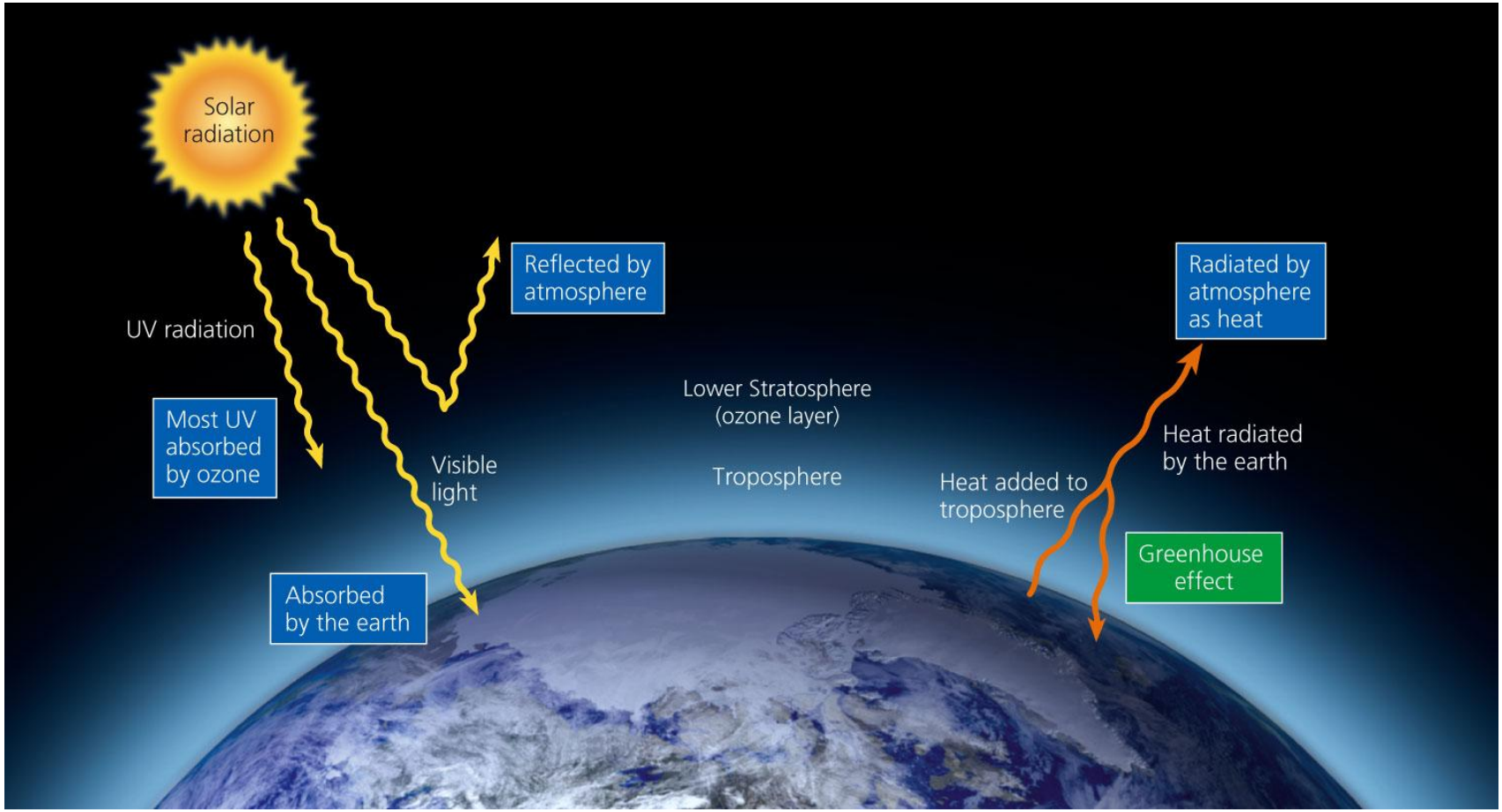


Fig. 3-4, p. 57

Earth's Surface Features Affect Local Climates

- Differential heat absorption by land and water
  - Land and sea breezes
- **Rain shadow effect**
  - Most precipitation falls on the windward side of mountain ranges
  - Deserts leeward
- Cities create microclimates

Rain Shadow Effect

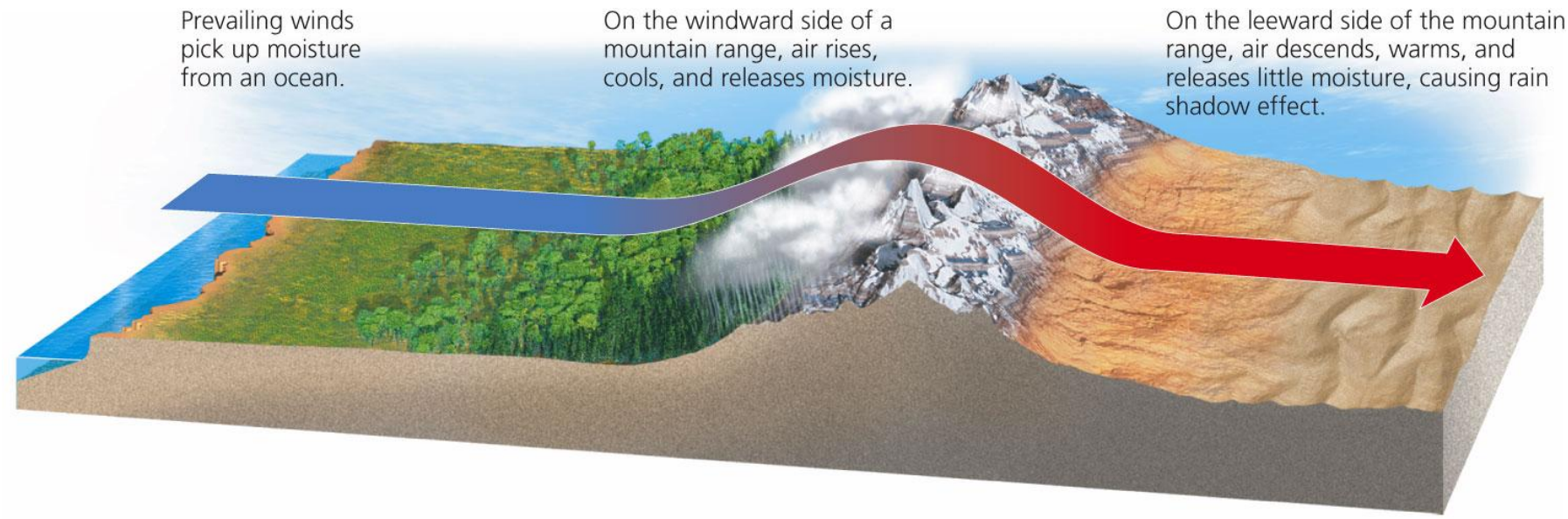


Fig. 7-6, p. 152

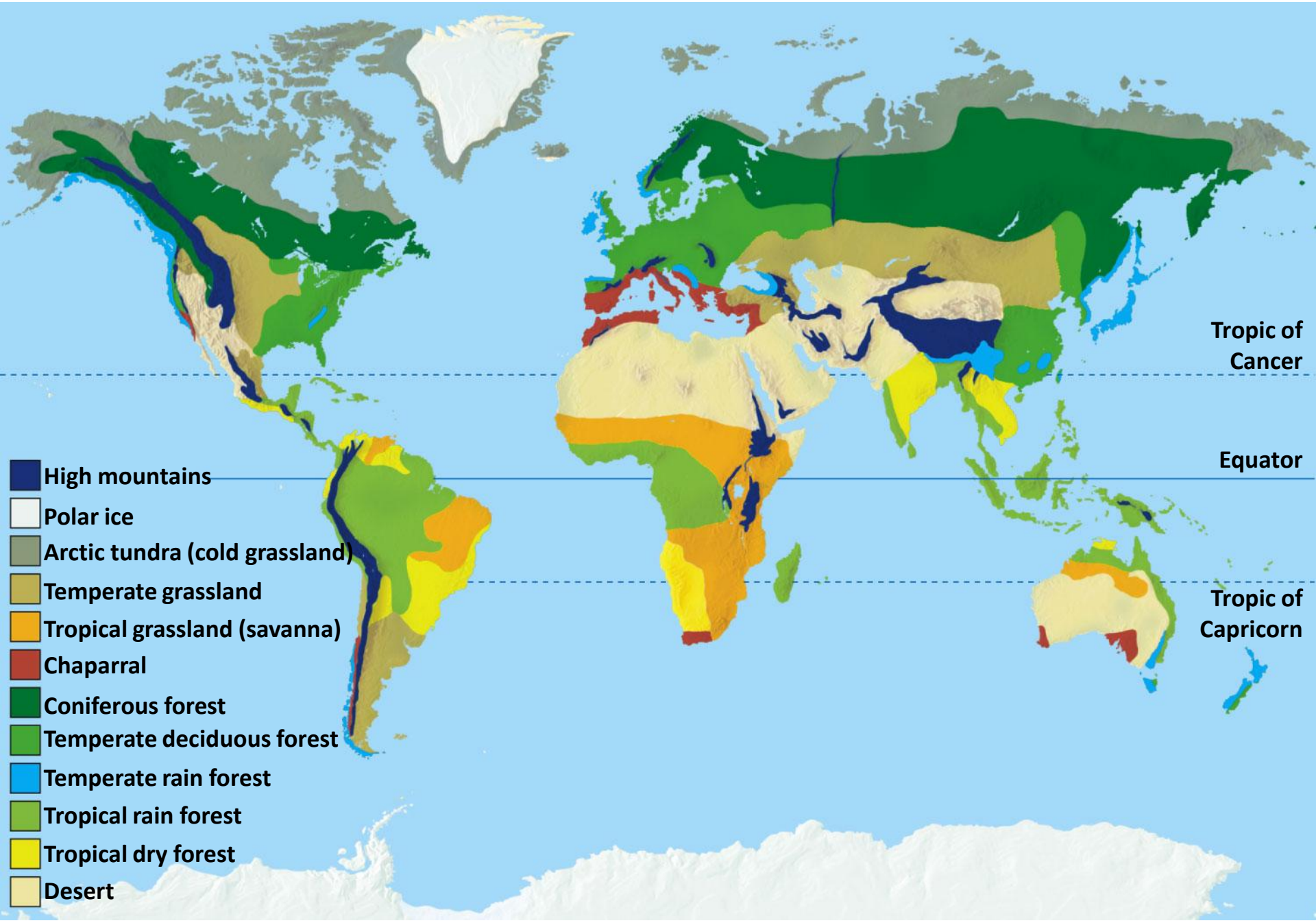

Tropic of Cancer
Equator
Tropic of Capricorn
High mountains
Polar ice
Arctic tundra (cold grassland)
Temperate grassland
Tropical grassland (savanna)
Chaparral
Coniferous forest
Temperate deciduous forest
Temperate rain forest
Tropical rain forest
Tropical dry forest
Desert

Fig. 7-7, p. 153

Three Big Ideas

1. Differences in climate, based mostly on long-term differences in average temperature and precipitation, largely determine the types and locations of the earth's deserts, grasslands, and forests.

2. The earth's terrestrial systems provide important ecological and economic services.

Three Big Ideas

3. Human activities are degrading and disrupting many of the ecological and economic services provided by the earth's terrestrial ecosystems.

Major Happenings

- Sand storms … Sahara desert across the US East Coast … carries Nutrients
- West Indian " Huracan" = Hurricane counter clockwise (Coriolis affect)
- Chinese " Taifun" = Typhoon Clockwise ..Southern oceans
- These storms are initiated from evaporation of sea water warmer than 80F rain water condenses – releases heat (latent heat) starts a region of low pressure
- Storms effect the moving of water from cold to hot and effect the streams of water that circulate around the globe. Professor Kerry Emanual (MIT)

The Earth Has Many Different Climates (3)

- El Niño-Southern Oscillation
  - Every few years
  - Prevailing winds in tropical Pacific Ocean change direction
  - Affects much of earth's weather for 1-2 years

- Link between air circulation, ocean currents, and biomes

Normal and El Niño Conditions

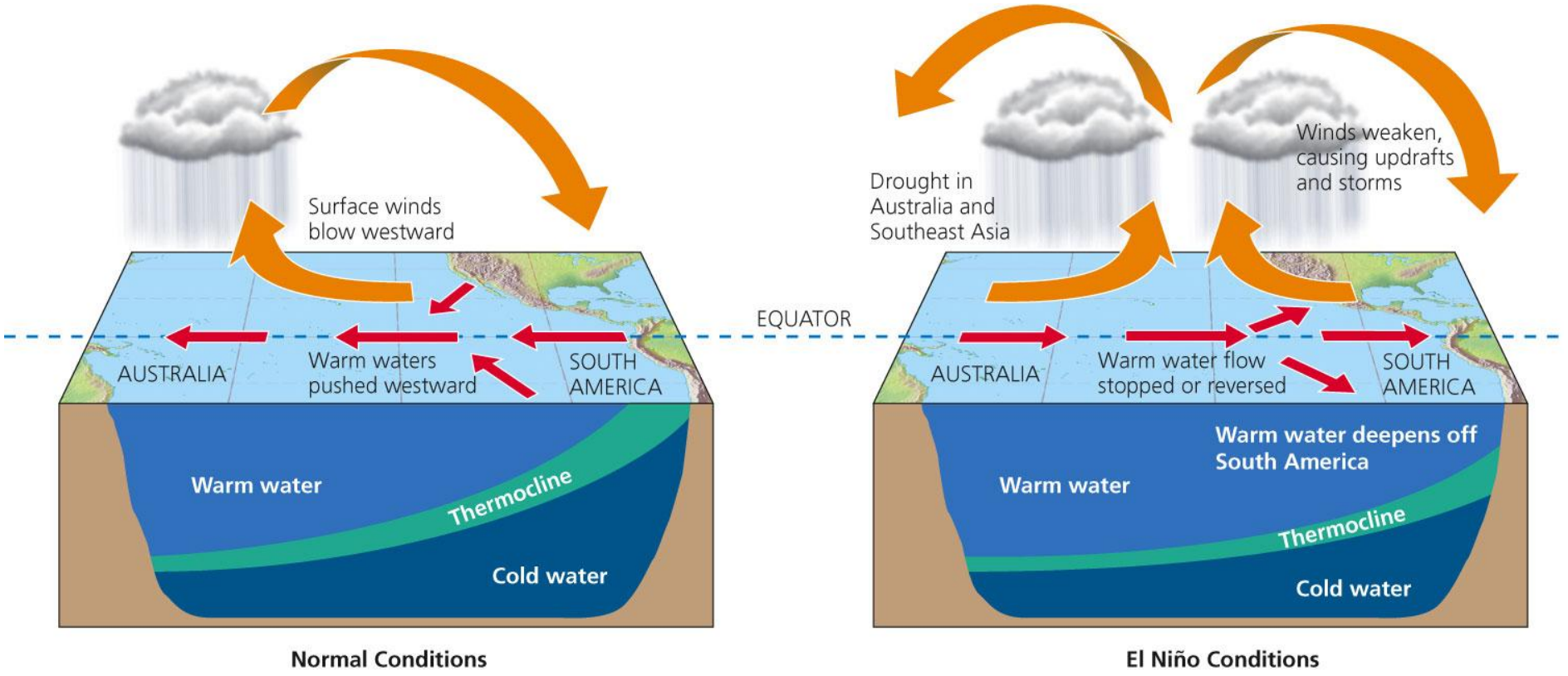


Figure 4, Supplement 7

Impact of El Nino-Southern Oscillation

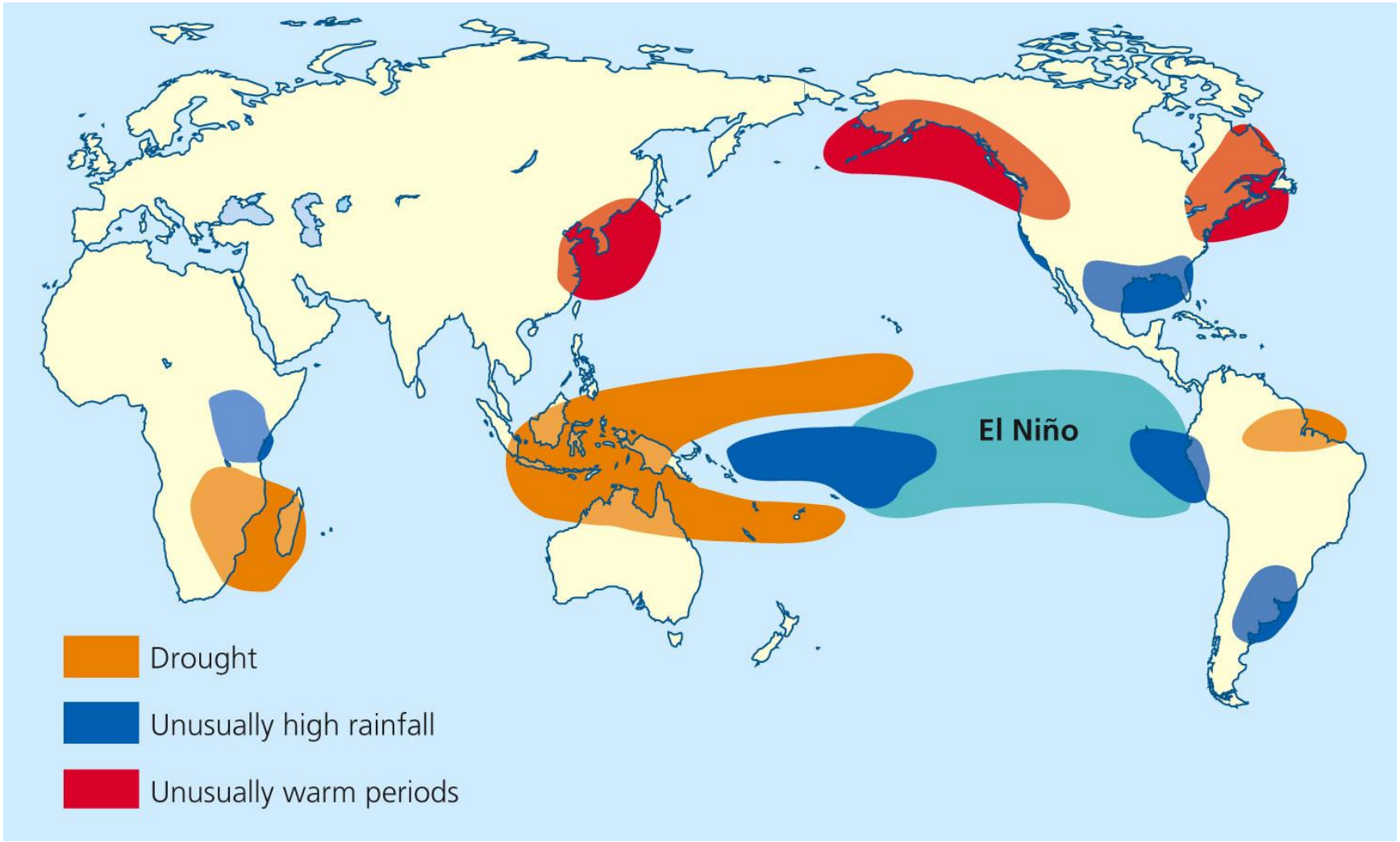


Figure 5, Supplement 7

Oscillations in Nature

- The **Pacific Decadal Oscillation** (PDO) is a pattern of Pacific climate variability that shifts phases on at least inter-decadal time scale, usually about 20 to 30 years. The PDO is detected as warm or cool surface waters in the Pacific Ocean, north of 20° N. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs.
- The Pacific (inter-)decadal oscillation was named by Steven R. Hare, who noticed it while studying salmon production pattern results in 1997.[1]
- The prevailing hypothesis is that the PDO is caused by a "reddening" of the El Niño-Southern Oscillation (ENSO) combined with stochastic atmospheric forcing.[2]
- A PDO signal has been reconstructed to 1661 through tree-ring chronologies in the Baja California area.[3]
- The **interdecadal Pacific oscillation** (IPO or ID) display similar sea-surface temperature (SST) and sea-level pressure (SLP) patterns, with a cycle of 15–30 years, but affects both the north and south Pacific. In the tropical Pacific, maximum SST anomalies are found away from the equator. This is quite different from the quasi-decadal oscillation (QDO) with a period of 8-to-12 years and maximum SST anomalies straddling the equator, thus resembling the ENSO.

Tornadoes

- Tornadoes form when there is a difference in air pressure between the center of the tornado and its outer edge. The center has very low pressure and the outer edge has very high pressure, creating winds that can blow at over 200 miles per hour. Exactly what causes tornadoes to form is a topic of ongoing research.
- NCAR's VORTEX2 field project has been chasing twisters to figure out how they form.

Instrumentation

- Temperature
- Pressure
- Delta Changes

Being your own forecaster

http://www.theweatherprediction.com/philosophy/forecaster

Project … build an instrument to measure pressure

How do we know what the pressure is?

In the past, barometers were used that measured how much air pushed down on a fluid such as mercury. The higher the pressure, the lower the level of mercury.

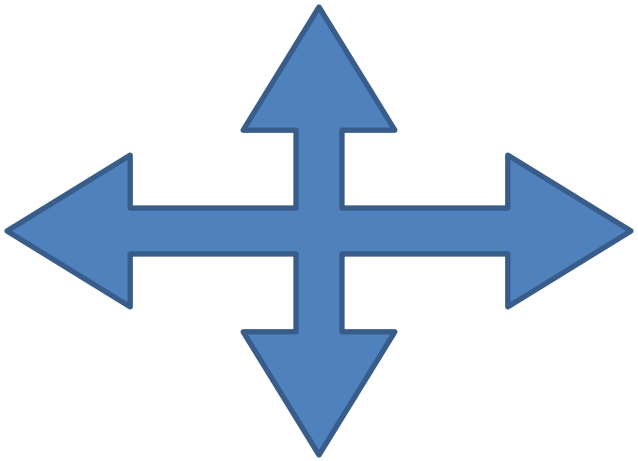
Historically, measurements of air pressure were described as “inches of mercury.” Today, meteorologists use millibars (mb) to describe air pressure.

Parts list: Balloon, straw, glass jar, paper

Build a Barometer

What are we measuring?

What is happening to the air?



Create an algorithm for a weather forecast

Temperature	Pressure rates	Humidity
Temperature & rate of change of temperature	Rate of change of pressure over time	Amount of water in the air
Warm front	Pressure rising = good weather	Little=
Cool front	Pressure falling= bad	Lots = rain

Essentially, a model is a computer program that produces meteorological information for future times at given locations and altitudes. Within any modern model is a set of equations, known as the primitive equations, used to predict the future state of the atmosphere.[30] These equations—along with the ideal gas law—are used to evolve the density, pressure, and potential temperature scalar fields and the velocity vector field of the atmosphere through time.

Remember

- The earth is rotating around its axis
- It’s rotating around the sun
- The moon is rotating around the earth.

- The Sun is providing energy