Introductory Material

(Christopherson Cha 1)

I. Brief History Of Geography:

Three driving forces: TRADE, MILITARY, and CURIOSITY

- HOW to get to a place
- WHAT that place was like.
- WHY that place was different

Pre-geography: Geography has probably been practiced since humans first were able to use tools and communicate.

II. Definitions of Geography

A. <u>Geography</u> (from *geo*, "Earth," and *graphein*, "to write,") is the science that studies the relationship among geographic areas, natural systems, society, cultural activities, and the interdependence of all these *over space* (<u>spatial analysis</u>). CHRISTOPHERSON IN *GEOSYSTEMS*

B. <u>Physical Geography</u> centers on spatial analysis of all the physical elements and processes that make up the environment: energy, air, water, weather, climate, landforms, soils, animals, plants, and the Earth itself.

III. Why Geography?

A. Important to understand the world around us; the way it works.

B. Human-environment interrelationships are increasingly important.

1. Humans are affected by the environment
2. Humans can greatly affect the environment.
3. Technology will not save us; only help us...

IV. What do geographers do? Careers: Outstanding foundation to many career choices!

Looks at the broad perspective. Trend in business to hire students from other backgrounds.

A. <u>Teaching</u>: All levels…

B. <u>Environmental and Resource Planning</u>:

- **Meteorologist (Weather Forecaster)**
- **Field Biologist (Environmental Impact Reports, Ecological Restoration)**
- **Forest Ranger, Park Ranger**
- **City Planner (Where to build? Water? Stable Foundations? Natural Hazards?)**
- **Hydrologist (Water managers, flood control)**
- **Farmer (Crop choice)**

C. <u>Site Location</u>: Location, Location, Location. Area known as locational analysis. Locate a business, what's important? Customers, energy, supplies, workers, transportation routes.

D. <u>Cartography ("the art and science of making maps")</u>: Accurate maps are very important today, just as in the past. However, today Geographic Information Systems (GIS) have supplanted static maps for much of what used to be just cartographic maps. There are many GIS/cartography applications today, as businesses, science institutions, and governments begin to see the utility of spatial databases linked to new mapping and display technologies, including satellite imagery, aerial photography, GPS navigation, etc. This is a very cutting edge and well paid career field, both now and into the foreseeable future.

Environmental Systems

System = A distinct and interrelated set of components (living and non-living) which is linked by movements of matter and energy. Systems can be large or small, depending on how one wishes to study them.

**Instead of studying the environment piecemeal, we now try to look at all the elements as they interrelate.

I. Types of Systems

A. Closed Systems: Closed with respect to transfer of matter, but not energy. Rare in nature. Biosphere Project.

B. Open Systems: Includes the flow of both energy and matter. All environmental systems are open systems. Examples: Automobile, Lake, Forest, The Earth??

II. System Concepts

A. Feedback: When one portion of a system affects another.

- Negative Feedback: Feedback which discourages change in the system. (human respiration)
- Positive Feedback: Feedback which encourages change in the system. (??)

B. Equilibrium : The tendency of a system to maintain structure and character over time.

1. **Steady-state equilibrium:** Remains extremely constant (Cave)
2. **Dynamic-equilibrium:** Fluctuates around an average. (Prairie and fires)
3. **Metastable equilibrium:** Occasionally changes drastically. (Mt. St. Helen's)

C. Inputs and Outputs: These are terms which refer to energy or matter entering a system (inputs) and exiting a system (outputs).

III. Models of Systems:

Models are attempts by humans to simplify and display the functions of a system. They are only our best-guess and they are never perfect. Examples include Black Box (not descriptive, only recognizes a system as such), Grey Box (intermediate level of description), and White Box, (An attempt at the highest level of description of components, structures, and processes of a system.).

IV. The Earth as a System: Major Components

A. Atmosphere: Gaseous envelope surrounding Earth.

B. Hydrosphere: Water, including ice (cryosphere)

C. Lithosphere: Solid part of the Earth (rocks, minerals, soil)

Biosphere: The living portion of the Earth, made possible by the other three.

Units of Measure

I. Length Examples

A. **1 inch is about 2.5 centimeters (cm)**
B. **6 feet is about 1.8 meters (m)**
C. **1 foot is about 30 centimeters (cm)**
D. **L.A. to Sac. is about 400 miles or 660 kilometers (km)**
E. **1 yard is about 1 meter (m)**

II. Weight Examples

A. **100 pounds is about 45 kilograms (kg)**
B. **1 pound is about 450 grams (g)**

III. Volume Examples

A. **1 quart is about 1 liter (L)**
B. **1 gallon is about 4 liters (L)**

IV. Temperature Comparisons

- **Coldest Day on Record: Antarctica** **(-89°C = -129°F)**
- **Freezing Point of Water:** **(0°C = 32°F)**
- **Chilly Day:** **(10°C = 50°F)**
- **Room Temp:** **(20°C = 68°F)**
- **Hot Day:** **(40°C = 105°F)**
- **Hottest Day on Record:** **(58°C = 136°F)**
- **Boiling Point of Water:** **(100°C = 212°F)**

V. Conversion Example

How many kilometers is 3000 feet?

$$\frac{3000\ \text{feet}}{} \times \frac{1\ \text{mile}}{5280\ \text{feet}} \times \frac{1.6\ \text{kilometers}}{1\ \text{mile}}$$

= 0.91 kilometers

Geographic Information Sciences

I. Cartography: Cartography is the art and science of making maps.

A. Map: A map is a flat representation of the spherical Earth. The only truly correct representation of the shapes of the Earth's land masses is a globe.

B. Projections (see web site on class page): A map is actually a projection of a spherical surface to a flat surface.

1. **Types of Projections:**
   a) **Cylindrical:** True-shape, true-direction; distorted area. Areas of land mass at high latitudes appear much larger than they actually are. (Mercator Projection)
   b) **Planar:** see text

   c) **Conic:** see text

2. **Projections cause distortion of:**
   a) **Shape**
   b) **Area (or Size):** Mercator Projection
   c) **Distance**
   d) **Direction**

C. Scale: A map is a reduced picture of the true Earth. Scale indicates the amount of reduction.

1. **Written Scale:** Expressed in words. Ex: "one inch equals one mile"

2. **Graphic Scale:** A line with divisions

3. **Representative Fraction:** Expressed as a fraction, (Ex. 1:24,000) Indicates the amount of reduction.

Self Study
Which is larger scale, a road map of San Diego or a world map? Understand large and small scale.

Hint: Think “small scale -> large area” and vice versa...

II. Geographic Information Technologies: (Expanding Technologies)

A. Remote Sensing: Air and satellite imagery; mostly passive imaging (except radar)

B. Global Positioning System (GPS): ground receiver which communicates with satellites and calculates/displays exact locational data.

C. Geographic Information System (GIS) (see Appendix II): A computer system for entering, storing, manipulating, analyzing, and displaying spatial data. All data is digital!!!

1. **Database of Information:** (Rows and Columns) Data with spatial components and metadata.

2. **Digital "Georeferenced" Map:** Map information is stored in real world coordinates like latitude/longitude.

3. **Example:** Trivial Example Task: Finding the perfect residence in San Diego

• Potential Home data
ID # Price Bedrooms Bathrooms Square Feet Garage
Pool Yard

• Query the Database to select only the houses you are interested in

• All other homes eliminated on the map...

• Compare with other maps (Overlay): This is possible because all of the data is georeferenced.
Schools, Libraries, Parks, Malls (Shopping), Emergency Medical Facilities
Police Station, Incidents of violent crime, Freeway access points, Bus Stops

• Buffer and include or exclude

Flood Danger Zones
Earthquake Faults

The Earth: Space, Location, and Time

I. The Earth in Space

A. Milky Way Galaxy: Group of over 100 billion stars arranged in a flat, swirling disk like collection. (120,000 light years across) Our sun is a medium sized, rather ordinary star in the Milky Way Galaxy.

Light year: The distance light travels in one year.

- 300,000 kilometers per second (186,000 miles).
- Light could travel around the Earth 71/2 times in one second. (Circumference of Earth = 40,000km or 25,000 miles)
- Over a million years on a jet plane

How much is one billion? Fill up 30 average size classrooms with jelly beans…

B. Solar System: There are nine planets orbiting around the sun, forming what we call the solar system.

C. The Earth -Basic Facts:

The third planet from the sun
Averages 150 million km (or 93 million miles).
Light from the sun actually takes about 8 minutes to reach the Earth
The shape is an oblate spheroid (or ellipsoid), meaning that it is essentially a round sphere which is slightly bulging at the equator. This is caused by the outward force of the earth's rotation.

D. The Revolving Earth: The earth takes an elliptical path around the sun, which it completes once every 3651/4 days. We account for this quarter day by adding an extra day once every four years. We add Feb. 29 every four years (leap year).

Self Study

What is Perihelion and when does it happen?

What is Aphelion and when does it happen?

Do these events cause seasons to occur? (The answer is no; you should understand why.)

E. The Rotating Earth: The earth rotates on its axis, which is an imaginary line passing through the earth from the north pole to the south pole. If one is looking at the earth from the side, with the north pole at the top and the south pole at the bottom, then the direction of rotation will be from left to right.

- Rotating reference frame (the surface of the earth) introduces new apparent forces (eg, the Coriolis Force).

II. Location - The Geographic Grid:

II. Location - The Geographic Grid: In order to better measure the earth and evaluate global environmental phenomena, humans have imposed a grid system over the entire globe (graticule). (The actual shape of the globe is called an oblate spheroid, meaning flattened sphere.) These are the parallels of latitude and the meridians of longitude.

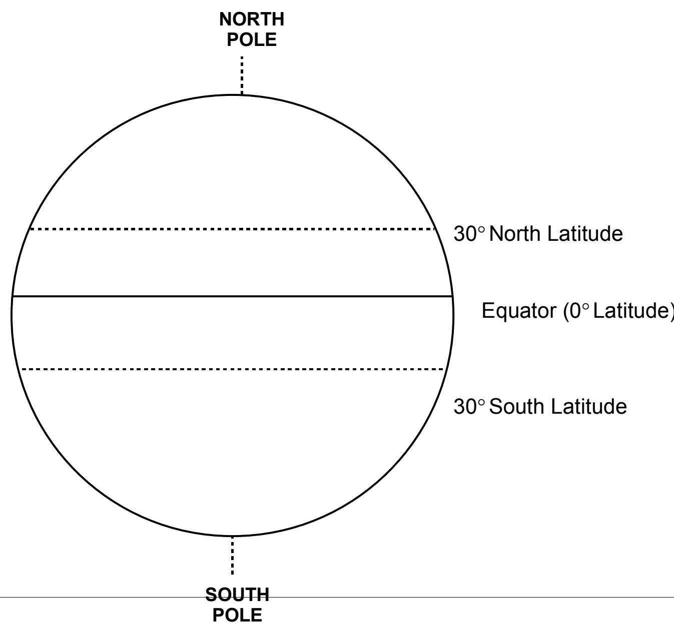
A. Parallels of Latitude (Figure 1.10):

Imaginary Circles drawn on the globe perpendicular to the axis. Lat = Flat

1. **Equator:** The one which perfectly bisects the globe is called the Equator, and it is designated as 0° Latitude. Define great circles and small circles…

2. **Angular Distance:** Measured in degrees north or south of the Equator
   There are 90 degrees from the Equator to both the North and South Poles.
   Each degree of latitude represents approx. 110 km (70 miles).
   Sacramento, CA lies at approx. 39° North Latitude.

Parallels of Latitude
(examples)



B. Meridians of Longitude (Figure 1.12):

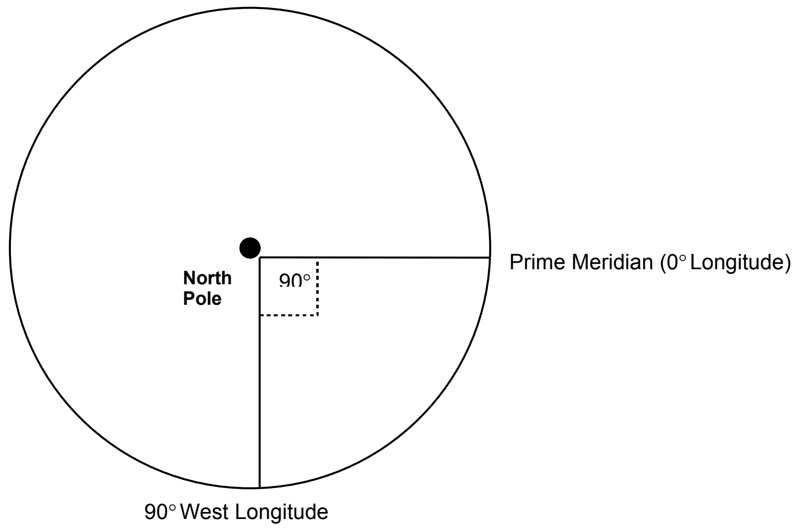
Imaginary Circles. Each circle intersects both the North and South Poles. They cross all parallels of latitude at right angles.

1. **Prime Meridian:** This is the meridian designated as 0° Longitude. Decided arbitrarily. Passes through the old Royal Observatory at Greenwich, England.

2. **Angular Distance:** Measured in degrees east or west of the Prime Meridian.

   From the Prime Meridian, there are 180 degrees to the East and 180 degrees to the West. (360 degrees total)
   Sacramento, CA lies at approx. 121° West Longitude.
   Each degree of longitude is approx. 110 km (70 miles), but only at the Equator.
   They converge toward the Poles.

Meridians of Longitude (examples)



Note: A correct location on the geographic grid must give Latitude (North OR South) AND Longitude (East or West). Sacramento, California is located at approx. 39° North Latitude and 121° West Longitude.

III. Time

A. One Full Rotation: approx. 24 hrs; 15 degrees per hour.

B. Solar Noon: Technically, noon is when the sun is at its highest point in the sky. But this is different depending on exactly what your longitude is.

C. Time Zone (Figure 1-15): Political (human) designations which divide rough longitudinal zones into units which all follow the same time. There are 24 time zones, each being 15 of longitude wide (many countries modify this system). Each time zone has a controlling meridian (the place where solar noon and clock noon are the same)

D. Coordinated Universal Time (UTC): Special accurate atomic clocks which provide an official reference time for the whole world. UTC time always refers to the time at the Prime Meridian. This used to be called Greenwich Mean Time.

E. International Date Line (Figure 1-16): At approx. 180 deg Longitude.

Travel eastward across it and lose a day.
Travel westward across it and gain a day.

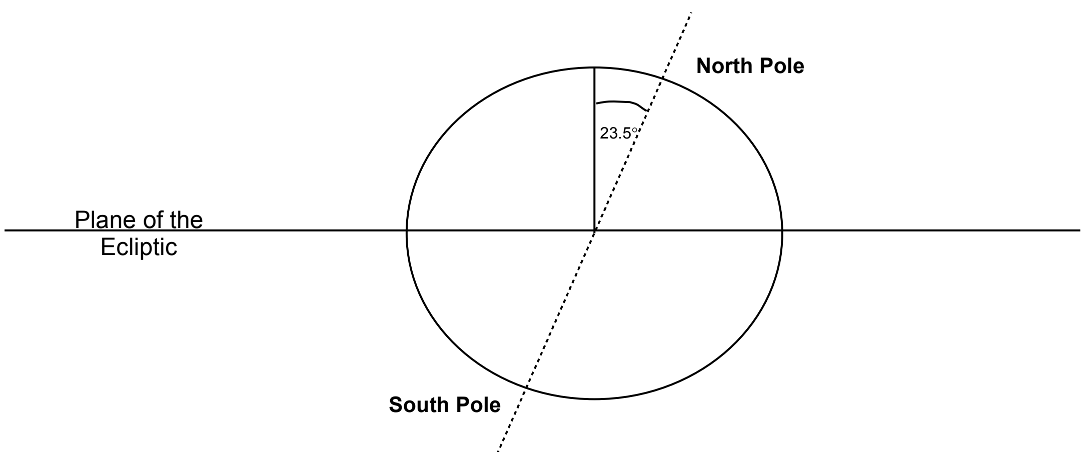
F. Daylight Savings Time: In the summer months, this policy moves our waking/working hours into the actual daylight hours. So, if the sun normally goes down at around 7:00pm during the summer, people will begin turning lights on. But, with daylight savings time we move the clocks ahead so that the sun goes down around 8:00pm. This way we save an hour's worth of energy by not turning on lights.

Reasons for the Seasons

(Christopherson Cha 2)

I. The Tilted Earth (Inclination): The earth's axis is tilted 23.5 ° from a right angle with the plane of the ecliptic; the axis is always directed to a fixed point in space (Polaris, same as the North Star).

The Tilted Earth



II. <u>In</u>coming <u>Sol</u>ar Radi<u>ation</u> (also called <u>Insolation</u>): The Earth intercepts Solar Radiation.

A. Solar Constant: The average amount of energy received at the top of Earth's atmosphere, before it actually enters. The value is 1372 Watts/m2. Generally, this value doesn't change.

B. Distribution of Radiation: Depending on latitude and time of year, the amount of insolation received at the Earth differs!

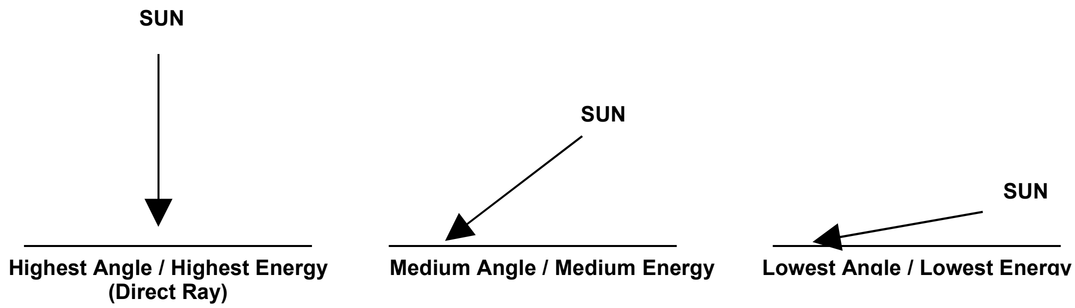
1. **Hours of Insolation:** Less hours of insolation mean less total insolation.

2. **Angle of Incidence (or Sun Angle):** This is the angle at which the sun's rays hit the earth. It is critical is in determining seasons.

<u>Direct Ray (or Vertical Ray):</u> When the sun rays come from directly overhead at a 90 degree angle. These are the <u>strongest</u> rays!!!

<u>Lower Angle Rays</u>
When sun rays come to earth at a lower angle; in other words, when the rays come from lower in the sky.
Rays become progressively weaker when the angle becomes less.
These rays also pass through more atmosphere, resulting in more filtering.

Sun Angles



C. Seasonality of Insolation (Reasons for seasons)

1. **Subsolar Point:** The point on the Earth where the sun is perfectly overhead, or the point where the sun's rays hit the earth's surface absolutely perpendicular.

2. **Declination:** The latitude of the sub-solar point. It changes throughout the year.

3. **Circle of Illumination:** The half of the globe which is receiving the sun's rays. It is always exactly one half of the globe.

4. **The Key Factor:**

The axis always points to the same point in space. This means that as the earth orbits the sun, the declination (see definition) migrates north and south between the Tropics of Cancer and Capricorn. This means that the suns most powerful rays move back and forth between the Northern and Southern Hemispheres during the course of the year.

Summary of Seasonal Changes in Earth / Sun Relationships

December Solstice (around December 21)	***Declination** - 23.5° South Lat. (This latitude is referred to as the Tropic of Capricorn. This is the highest latitude in the Southern Hemisphere which receives the Sun's direct ray on at least one day of the year.)
	*24 hrs. darkness north of 66.5° North Lat. (This latitude, referred to as the Arctic Circle, represents the lowest latitude in the Northern Hemisphere which experiences at least one day with 24 hrs of continuous darkness.)
	*24 hrs. light south of 66.5° South Lat. (This latitude, referred to as the Antarctic Circle, represents the lowest latitude in the Southern Hemisphere which experiences at least one day of 24 hrs of continuous sunlight.)
	*Called Winter Solstice in N. Hem.
	*Hours AND angles of insolation highest throughout Southern Hem., causing Summer!
	*Hours AND angles of insolation lowest throughout Northern Hem., causing Winter!
March Equinox (around March 21)	***Declination** - Equator at 0°Lat
	*All points on Earth receive 12 hrs. light / 12 hrs. dark
	*Called Vernal Equinox in N. Hem.
June Solstice (around June 21)	***Declination** - 23.5° North Lat. (This latitude is referred to as the Tropic of Cancer. This is the highest latitude in the Northern Hemisphere which receives the Sun's direct ray on at least one day of the year.)
	*24 hrs. light north of 66.5° North Lat. (This latitude, referred to as the Arctic Circle, represents the lowest latitude in the Northern Hemisphere which experiences at least one day of 24 hrs of continuous sunlight.)
	*24 hrs. dark south of 66.5° South Lat. (This latitude, referred to as the Antarctic Circle, represents the lowest latitude in the Southern Hemisphere which experiences at least one day of 24 hrs of continuous darkness.)
	*Called Summer Solstice in N. Hem.
	*Hours AND angles of insolation lowest throughout Southern Hem., causing Winter!
	*Hours AND angles of insolation highest throughout Northern Hem., causing Summer!
September Equinox (around September 21)	*Declination - Equator at 0°Lat
	*All points on Earth receive 12 hrs. light / 12 hrs. dark
	*Called Autumnal Equinox in N. Hem.

Problem: **It is valuable to know what the <u>maximum angle of the sun</u> will be on a given day at any location. Higher maximum sun angles produce high insolation; conversely, lower maximum sun angles produce low insolation. This important angle can be calculated for any location by first calculating the total difference (in degrees) between the latitude of your chosen location and the declination for that day. Then, subtract this number from 90°. Calculate the maximum angle of the sun in Sacramento on the following dates:**

	Sacramento's Latitude	**Declination**	**Difference (see Hints below*)**	**Maximum Sun Angle**
June Solstice?	**39° North**			
September Equinox?	**39° North**			
December Solstice?	**39° North**			
March Equinox?	**39° North**			

***HINTS: This difference is in degrees only; it is not a latitude! Also, you will need to be <u>careful</u> when the declination is in the Southern Hemisphere. Under this circumstance, you may NOT subtract to find the difference. THINK!**

The Atmosphere

(Christopherson Cha 2)

Atmosphere: The collection of gases surrounding the Earth. Held in place by gravity. Different parts can be categorized in different ways.

I. **Heterosphere (80km and higher):** Where gases are not evenly mixed. Filters out damaging radiation.

II. **Homosphere (0-80km):** Where gases are evenly mixed.

A. **Composition**

1. **Nitrogen (78%):** generally inert; does not readily react with other gases or elements
2. **Oxygen (21%):** highly active, involved in oxidation reactions, important for biological activity.
3. **Argon (approx. 1%):** inert
4. **Carbon dioxide (0.033%):** very important as an absorber of longwave energy in the atmosphere. Called a radiatively active gas.
5. **Water vapor (approx. 1%):** varies, also important as an absorber of longwave energy in the atmosphere. Called a radiatively active gas.
6. **Ozone (< .001%)**
   a) **Ozonosphere (15-55km):** Layer where ozone is found.

   b) **Function:** Important in absorbing dangerous ultraviolet (UV) rays.

   c) **Problems**
   - Levels dropping
   - Losses high over poles
   - Incidences of cancer and sunburn increasing
   - Reasons are Chlorofluorocarbons (CFCs); used in industry.

B. **Divided into three temperature layers**

1. **Mesosphere (80-50km)**
2. **Stratosphere (approx. 14-50km)**
3. ****Troposphere** (0-approx. 14km):**
   - Contains 90% of all atmosphere.
   - Where our weather takes place.
   - Warmest at surface, cooling toward space.
   - The top is called the "tropopause."

C. Pollution in the Troposphere

1. Sources

a) **Natural:** Forest fires, volcanoes, dust storms. Most "pollution" is naturally occurring.

b) **Anthropogenic:** Major sources are automobile exhaust and coal burning.

2. Specific Pollutants

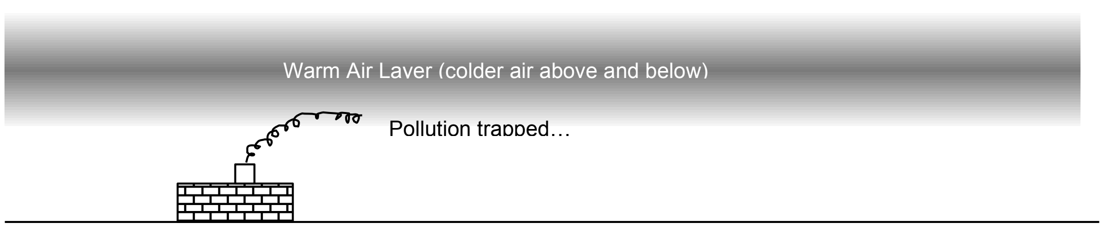
a) **Ozone:** Created when smog is broken down by sunlight. Dangerous at the surface of the earth

b) **Acid Rain:** Rain which mixes with industrial smoke to create a slightly acidic solution. Can be especially damaging to plants, amphibians, and invertebrates.

3. Complicating Factor – The Temperature Inversion:

In this situation, a layer of warm air sits over a layer of cold air. This traps pollution. Caused by cold air drainage and/or radiation cooling.

Temperature Inversion



Energy Budgets

(Christopherson Cha 3)

Electromagnetic Radiation: **To understand energy relationships in the Earth/Atmosphere system, one must first understand the nature of electromagnetic radiation. Electromagnetic radiation (also called radiant energy or just radiation) is emitted in the form of waves which travel quickly away from the surface of ALL objects (the sun, rocks, ice, trees, soil, etc).**

I. Radiation Wavelength Review:
Wavelength decreases with increasing temperature. Hotter objects emit shorter wavelengths. We lump radiation into two types.

A. Shortwave (Solar)

1. **Wavelengths < 3 µm (peaks at 0.5 µm)** (µm stands for micrometers)
2. **Also called "insolation":** (short for incoming solar radiation)

B. Longwave (Terrestrial)

1. **Wavelengths > 3 µm (peaks at 10 µm)**
2. **Also called "thermal infrared"**

II. Important Radiation Terms

- **A. Emitted:** Given off.
- **B. Transmitted:** Allowed to pass; unchanged by atmosphere or water
- **C. Reflected**: Bounded in the opposite direction by atmosphere or water
- **D. Absorbed:** Changed into heat energy.

III. Radiation Budget for the Earth/Atmosphere System: Averaged over many years, incoming radiation EQUALS outgoing radiation for the earth/atmosphere system. (Bank account example!!!) In other words, INPUT equals OUTPUT; the earth/atmosphere system balances!!!

Radiation Budget for the Earth/Atmosphere System	
RADIATION INPUTS	**RADIATION OUTPUTS**
100 units solar radiation received at top of atmosphere (shortwave)	**30 units solar reflected back to space - called albedo (shortwave)** •6 units (reflected by atmosphere) •20 units (reflected by clouds) •4 units (reflected by the land-sea surface) review the concept of albedo below… **64 units emitted by atmosphere to space (longwave)** **6 units emitted by the earth directly to space (longwave)**
100 units of Input	**30+64+6=100 units of Output**
Input = Output **Radiation Budget for the Earth/Atmosphere System Balances!!!**	

Albedo = shortwave reflected divided by total shortwave received

Average for the Earth:	**30%**
Asphalt:	**5-10%**
Forest:	**10-20%**
Dry concrete	**17-27%**
Water:	**10-60%**
Fresh Snow:	**80-95%**

IV. Radiation Budget for the <u>Surface of the Earth</u>: Radiation budget at the surface of the Earth does not balance:

Radiation Budget for the <u>Surface of the Earth</u>	
RADIATION INPUTS	**RADIATION OUTPUTS**
55 units shortwave received at Earth's surface **95 units longwave (from the atmosphere) absorbed at surface**	**4 units shortwave reflected back to space** **116 units longwave emitted by the surface toward space**
55+95=150 units of Input	**4 + 116 = 120 units of Output**
Input exceeds Output by 30 units!!! **Radiation Budget for the <u>Surface of the Earth</u> does not balance!!!** **There is a 30 unit surplus of radiation at the Earth's surface!!!**	

Important Points:

When the Earth is heated by insolation (solar), it begins to emit longwave radiation back toward the atmosphere.
Longwave from the Earth is then absorbed by the atmosphere (CO_2 and H_2O vapor) and re-radiated back toward earth (called counterradiation).
Because of this, it is correct to say that the atmosphere is actually heated from below. It is heated by the longwave radiation emitted by the earth.
This is similar to a car on a hot day where the shortwave can enter through the windows, but the longwave cannot escape; thus, the car heats up. Greenhouse effect.

V. Energy Budget (includes heat <u>and</u> radiation) for the <u>Surface of the Earth</u> Balances! The Energy Budget includes both heat energy and radiation energy……

Total Energy Budget for the <u>Surface of the Earth</u> (includes heat <u>AND</u> radiation)	
ENERGY INPUTS	**ENERGY OUTPUTS**
30 units surplus radiation (see previous calculations)	**23 units Latent Heat:** The heat energy trapped in evaporated water (water vapor). We do not feel it. **7 units Sensible Heat:** Sensible heat is the heat we feel and the heat measured by thermometers.
30 units (net) Input	**23 + 7 = 30 units of Output**
Input = Output **Energy Budget for the <u>Surface of the Earth</u> balances!!!**	

VI. Poleward Heat Transport:

Radiation surpluses occur globally at low latitudes (between 36° North and South Latitude)

Sensible and latent heat is subsequently produced at low latitudes
This heat flows poleward (toward the high latitude radiation deficit areas)

VII. Energy Budget for Specific Locations

A. Net Radiation

1. **Net Surplus of Radiation:** INPUTS OF RADIATION greater than OUTPUTS OF RADIATION (results in heating at the surface)

2. **Net Deficit of Radiation:** OUTPUTS OF RADIATION greater than INPUTS OF RADIATION (results in cooling at the surface - called RADIATION COOLING)

B. Latent vs. sensible heat:

Net surplus of radiation will produce some form of heat
If there is water available, evaporation will occur and latent heat will be produced.
Sensible heat will be produced if there is no water available
That is why dry environments can be hot.

Problem: Assume you measure the following for an unknown surface:

80 units shortwave received at surface (input) **40 units shortwave reflected by surface (output)** **110 units longwave received and absorbed (input)** **120 units longwave emitted (output)**	**QUESTIONS:** **Is this a surplus or deficit?** **How many units of surplus or deficit?** **Is the surface heating or cooling?** **Is this in the daytime or nighttime?** **What is the albedo?**

Radiation Diagram

Air Temperature
(sensible heat)
(Christopherson Cha 3)

I. What determines surface air temperature?

A. The Process:
Surface temperature determines air temperature
Surface temperature determined by radiation surplus or deficit.
Cold surface will cool the air through conduction
Warm surface will heat the air through conduction

B. Air Temperature Lag: Because it takes time to heat the air, the warmest time of the day will follow the maximum period of surplus of radiation by several hours. This is also true for the annual monthly pattern. The highest annual temperatures will follow the highest sun angles by a couple of months.

C. Normal Lapse Rate: On average, temp drops at an average rate of 6.4°C / 1000 meters. Called the normal lapse rate.

II. Measuring Air Temperature:
Air Temperature is a measurement of sensible heat, the motion of the individual molecules of atmosphere.

A. Thermometer: Generally measures temperatures by the expansion and contraction of a liquid or solid.

B. Thermistor: An electric thermometer. Measures electrical resistance at different temperatures

III. Factors Affecting Surface Air Temperature

A. Latitude: High latitudes receive lower sun angles; thus they have less total insolation than low latitudes. Less insolation means lower temperatures.

B. Altitude: On average temperature decreases with increasing altitude. Called normal lapse rate.

1. **Thin Atmosphere:** Emits less longwave, so the mountain receives less.

2. **Normal Lapse Rate:** Recall that air temperature drops with increasing altitude

C. Cloud Cover

1. **Day Clouds:** Insolation blocked; results in lower maximum temperatures. i.e., It doesn't get as hot as a clear day.

2. **Night Clouds:** Clouds radiate increased longwave toward Earth; results in higher minimum temperatures. i.e. It doesn't get as cold as a clear night.

3. **Daily Temperature Range:** Difference between the maximum and minimum is low in a cloudy situation.

D. Land/Water Heating Differences: Water has certain properties as compared to land. It heats and cools more slowly than land!!!!!!

Water (Maritime) Heats and cools more slowly **and** to lesser extremes. Generally is cooler in the summer and warmer in the winter compared to land.	**Land (Continental)** Heats and cools rapidly slowly **and** to greater extremes. Generally is hotter in the summer and colder in the winter.
1. Specific Heat: Water has a high specific heat, which means that it takes more energy to heat water than land the same number of degrees. So it takes longer to heat. It also takes longer to cool off because it takes time to lose all of the stored heat.	Land has a lower specific heat, so it takes less energy to heat it. Thus, it heats faster…. It also cools faster because there is very little stored heat.
2. Transparency: Since insolation penetrates and is absorbed at depth, the heat is dispersed widely. For this reason, it takes a long time to dissipate in winter.	Since insolation is absorbed entirely at surface, all heat is concentrated there. For this reason, it can also escape quickly in winter.
3. Mixing: Water heats slowly because it mixes with cooler, deeper water. Thus, the whole ocean is heating, not just the surface layer.	Once the land surface heats up, the energy travels very slowly into the deeper ground. Thus, the surface stays hot…
4. Evaporation: Evaporative cooling constantly keeps ocean water cool in the summer.	Land usually has little water to evaporate, so all surplus energy goes to sensible heat. The air gets hot.

Special Note: Oceans are like an energy storage bank. During the summer, they absorb the surplus of energy, keeping maritime locations cooler than continental locations. During winter, they emit that stored energy, so the same maritime locations are kept slightly warmer than continental locations.

MARITIME:
- **Located by the ocean**
- **Cooler in summer and warmer in winter.**
- **Low annual temperature range.**

CONTINENTAL:
- **Located far from the ocean**
- **Hotter in summer and colder in winter.**
- **High annual temperature range.**

****Look at Figure 3.23. Does this graph seem to make sense in light of the information presented here?**

IV. Global Temperature Maps

- **Isotherm:** A line on a map connecting points of equal temperatures.
- **Transect and Gradient (Intro to these terms)**
- **Temperature Gradient:** Change in temperature over distance.

If the temperature changes quickly as I travel from one place to the next, we say that this is a high temperature gradient.

High temperature gradients are indicated by closely spaced isotherms on the map.

If the temperature doesn't change as I travel from one place to the next, we say that this is a low temperature gradient.

Low temperature gradients are indicated by widely spaced isotherms on the map.

A. June/July World Air Temperature Patterns

SELF STUDY

In general, how does the Equator compare to the Poles?

Where are the coldest winter temperatures? (High or low latitude; over oceans or land surfaces?)

Compare coastal and continental (inland) locations with the same latitude; which one is colder in winter? Which is colder in summer?

Which seems to have the warmer summers, Northern or Southern Hemispheres? Why? (HINT: See maritime vs. continental discussion.)

B. Annual Temperature Range (difference between yearly high and low)

SELF STUDY

What happened to the range as latitude increases?

Where are the highest ranges? (High or low latitude?; over oceans or land surfaces?)

Where are the lowest ranges? (High or low latitude?; over oceans or land surfaces?)

How do ranges compare between coastal and inland locations of the same latitude?

Atmospheric and Oceanic Circulation

(Christopherson Cha 4)

I. Atmospheric Pressure:

Atmospheric pressure is the force exerted by air molecules. Since the atmosphere is fluid, this force acts in all directions. It is approx. 1kg/cm2. Theoretically, if we were to take a perfectly vertical column 1cm2 at the base and rising to space, the collective weight would be 1kg.

A. Relationship Between Molecular Density and Atmospheric Pressure:

High density means high pressure; low density means low pressure.
Atmospheric pressure is highest at sea level and decreases rapidly toward space.
This is because gravity is holding the molecules in place.

B. Relationship Between Temperature and Atmospheric Pressure:

Heated air becomes less dense: Molecules move faster and spread outward. Results in LOW pressure.

Cooled air becomes more dense: Molecules move slowly and stay compact. Results in HIGH pressure.

These are called THERMAL high and low pressures.

C. Measurement of Pressure

1. **<u>Average Sea-Level Atmospheric Pressure Values</u>**
   a) **29.92 inches Hg**
   b) **760 millimeters Hg**
   c) **1013.2 millibars (mb) (this is the one we will use)**

2. **Mercurial Barometer:** This method involves the fluctuations in the level of mercury in a test tube. The fluctuations are caused by changes in air pressure.

3. **Aneroid Barometer:** This method involves the expansion or contraction of a small, sealed metal chamber. The chamber expands with lowered external pressure and contracts when external pressure increases.

II. Wind:

The horizontal motion of the air with respect to the Earth's surface.

- The atmosphere has a consistently irregular pattern of air pressure.
- Since any flowing fluid strives to reach a uniform pressure, the atmosphere is constantly in motion (wind).
- Movement is from high to low pressure (soda can)

A. The Pressure Gradient Force: The force generated by the pressure differences between two points.

1. **Isobars:** On a map, these are lines of equal pressure.

2. **Closely spaced isobars:** Indicate a high pressure gradient and high wind speeds

3. **Widely spaced isobars:** Indicate a low pressure gradient and low wind speeds

4. **Direction of Force:** The pressure gradient force acts perpendicular to the isobars.

B. The Coriolis Force: An apparent deflection of wind and ocean currents. (The single hardest thing to understand in Physical Geography. If nothing else, memorize this)

	Northern Hemisphere	**Southern Hemisphere**
Deflection of winds and ocean currents:	**to the RIGHT**	**to the LEFT**

1. **Wind Speed:** The strength of the Coriolis Force increases as wind speed increases.

2. **Latitude:** The strength of the Coriolis Force increases as latitude increases.

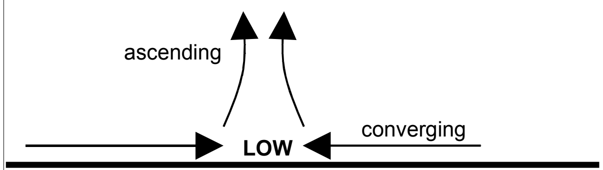
3. **No force at Equator**

This apparent force occurs because, as a wind or ocean current is set in motion in a particular direction, the earth basically rotates out from under it. This makes it seem as though the wind or ocean current takes a left or right turn, depending on the hemisphere. To understand this, you will have to read this section in the text carefully. We may have an in-class demonstration.

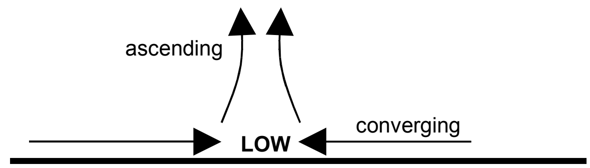
C. Cyclones and Anti-Cyclones: Spiraling wind systems (NOT storms)

1. Cyclones (Low Pressure): Inward spiraling wind systems!

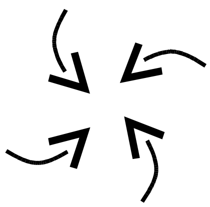
Northern Hemisphere (Side View)



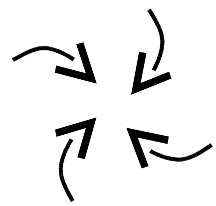
Southern Hemisphere (Side View)



Northern Hemisphere (Top View)

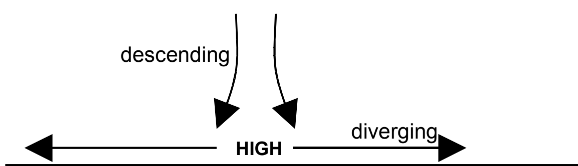


Southern Hemisphere (Top View)

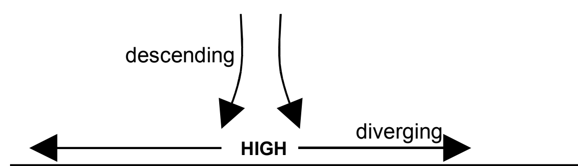


2. Anticyclones (High Pressure): Outward spiraling wind systems!

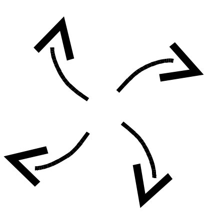
Northern Hemisphere (Side View)



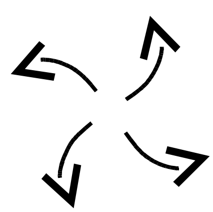
Southern Hemisphere (Side View)



Northern Hemisphere (Top View)



Southern Hemisphere (Top View)



III. General Atmospheric Circulation Model

A. **Inter-Tropical Convergence Zone (ITCZ) or Equatorial Low Pressure Trough:** **High inputs of insolation along the equator cause warming and convectional lifting (THERMAL LOW PRESSURE). Winds are weak here (called Doldrums); pressure is low. Lots of rain!!!**

B. **Hadley Cell: This warm air rises to the troposphere and then turns poleward in both directions. At approx. 30°N & S Latitude these currents descend from the tropopause toward earth. The circulation is called a Hadley Cell.**

C. **Subtropical High Pressure Cells: Created where the Hadley Cell descends to Earth. Centers with generally fair, warm weather. Wind is weak here; (called Horse Latitudes). These are anticyclones. (Since they are NOT directly caused by heating or cooling, they are considered DYNAMIC HIGH PRESSURE.)**

D. **Trade Winds: Northeast and Southeast trade winds created as air spirals toward Equator away from Subtropical High Pressure and into the Equatorial Low Pressure Trough. Found between 5° - 25° N & S Latitude (roughly)**

E. **Westerlies: Created as air spirals away from Subtropical High Pressure toward the Poles. Found between 40° - 60° N & S Latitude (roughly)**

F. **Sub-Polar Low Pressure Cells: Usually synonymous with the Polar Front, which is a distinct boundary between warm and cold air at about 60°N & S Latitude. Associated with stormy weather. Steep temperature gradient exists here. Important zone of mixing. (Since they are NOT directly caused by heating or cooling, they are considered DYNAMIC LOW PRESSURE.)**

G. **Polar High Pressure Cells: Bitter cold, dense air descends at the poles, creating high pressure (THERMAL HIGH PRESSURE).**

H. **Polar Easterlies: Cold, dry wind at high latitudes (70°+ North and South.). Spirals out of the Polar High Pressure**

Atmospheric Circulation – A Closer Look:

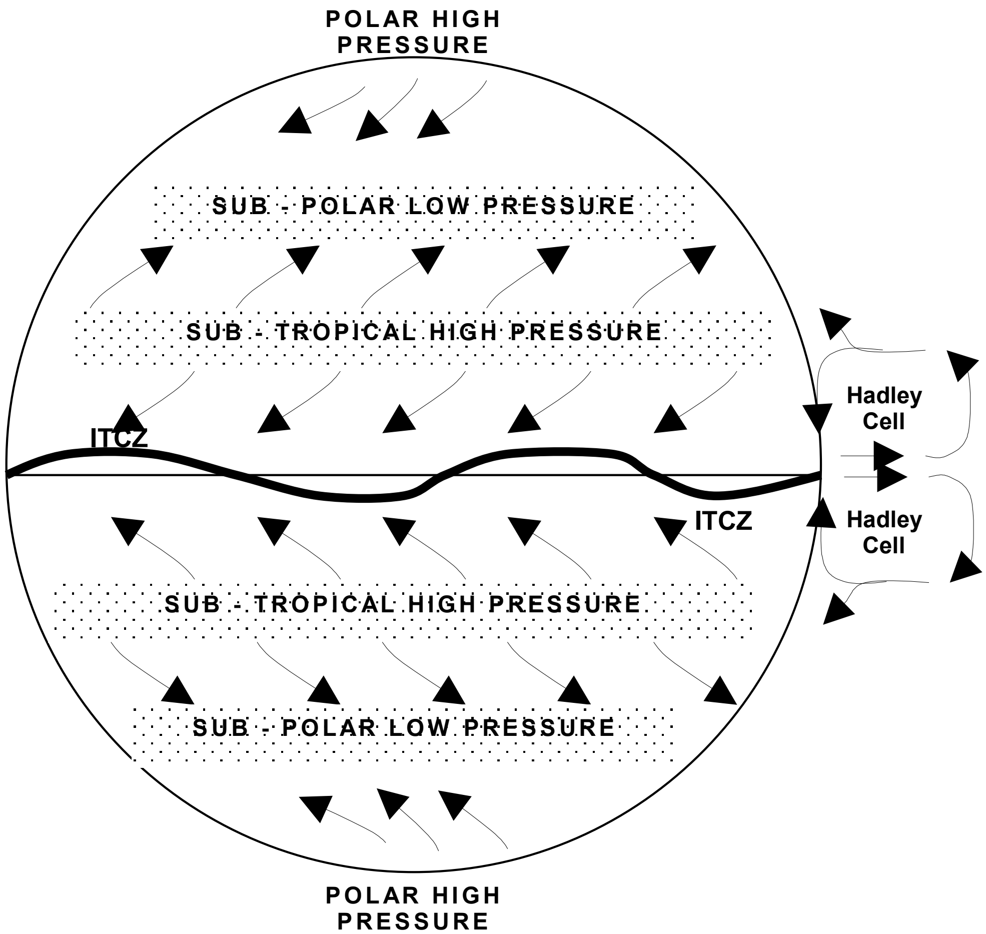
These patterns are complicated by the different surfaces of the earth.
The pressure systems usually take the form of CELLS (a concentration of pressure).

Pressure and Wind Systems Migrate: Pressure and Wind Systems Migrate North and South During the Year, roughly following the north and south migration of the Sub-Solar Point

1. **ITCZ Example:** Note the movement of the ITCZ between July and January.

2. **Subtropical High Examples**
   a) **Pacific Sub-Tropical High:** Centered near Hawaii. Farthest north in July and then heads south.

   b) **Azores Sub-Tropical High:** Centered near Azores (off the coast of Portugal). Has the same effect as the Pacific Sub-tropical High.



Dynamic vs. Thermal Pressure Systems: Thermal pressure systems will develop over hot or cold land masses. They are driven by extreme temperatures. The HIGHS are cold, descending air over land masses in the winter hemisphere, while the LOWS are warm, ascending air over land masses in the summer hemisphere. Pressure systems which develop without temperature extremes are called dynamic pressure systems.

Pressure System Review Table

	Subtropical Highs (also called Dynamic Highs)	**Sub-Polar Lows** (also called Dynamic Lows)	**Thermal Highs** (usually on land)	**Thermal Lows** (usually on land)
Associated Temperature	Warm	Cool to Cold	Very Cold	Warm
Cyclone or Anticyc.	Anticyclone	Cyclone	Anticyclone	Cyclone
Direction of Spiral (N.Hem)	Clockwise	Counter Clockwise	Clockwise	Counter Clockwise
Basic Cause	General Circ. of Atmosphere		Surface Cooling	Surface Heating
Movement of Air	Descending and Diverging	Ascending and Converging	Descending and Diverging	Ascending and Converging
Associated Weather	Clear and Warm	Cloudy, Rain or Snow	Clear and Freezing	Warm and Thundershowers
Where Found	Over Oceans at **approx**. 30°N or S Lat (always present, migrate some north or south)	Over Oceans at **approx**. 60°N or S Lat (generally travel west to east)	At Poles and Over Continents in Winter - Low Sun Season	Over Continents in Summer - High Sun Season and Along the **I**nter **T**ropical **Convergence** zone **(ITC)**
Stability	Stable	Unstable	Stable	Unstable
Examples in N. Hem.	Pacific Subtropical High, Azores High	Aleutian Low, Icelandic Low	Polar Highs Siberian High, Canadian High	Asian Low, Equatorial Low Pressure Trough

IV. Upper Atmospheric Circulation Features

A. Geostrophic Winds:

Extremely high speeds reached above the surface (lack of friction)

The Coriolis Force acts strongly on high speed winds. They move so fast that the Coriolis Force actually causes them to flow parallel to the isobars.

They don't flow from high to low; they flow between high and low.

B. Polar Jet Stream Example: Geostrophic wind at the Polar Front

West-to-east "pipe" of wind

350-450 km/hr.

The polar front jet stream roughly marks the global boundary between cold polar air and warm tropical air.

It is across this boundary that much global energy transfer occurs.

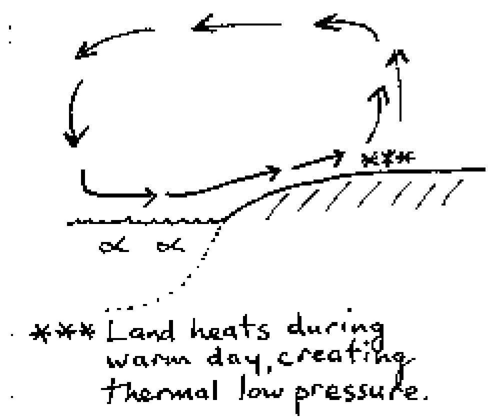
Rossby Waves (Fig. 4-16): Huge undulations in the polar jet stream. Pockets of cold air are brought south while pockets of warm air are brought north.

V. Local Winds (Winds on a smaller scale)

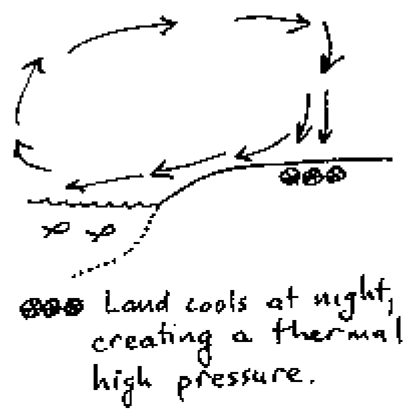
A. Land and Sea Breezes: Winds are always designated by where they are coming from; if you are standing at the beach facing the ocean and the wind is in your face, this is a sea breeze.

- During a warm day the land surface heats more rapidly than the sea surface, generating a thermal low pressure on land.
- As heated air ascends by convection, a vacuum is created and cool marine air converges to fill the void.
- The land breeze occurs at night as the reverse happens (the land cools causing the air above it becomes cooler and denser. This generates a thermal high pressure.) See Fig. 4-18.

Sea Breeze

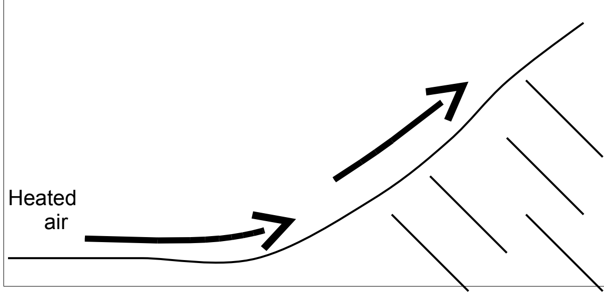


Land Breeze

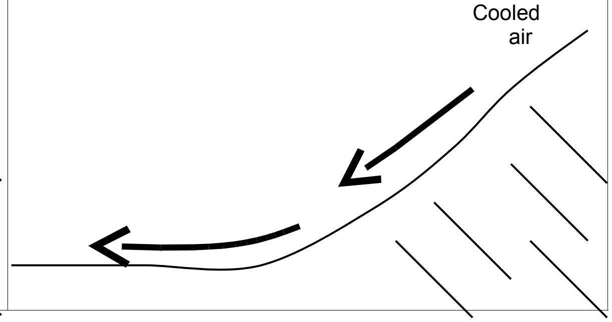


B. Mountain and Valley Breezes: Mountain slopes heat rapidly when heated by the sun. Convection creates up valley breezes. Conversely, the cooling at night creates down valley drainage winds. This is because the cool air is dense and flows downhill. The general term for this cold air flowing downhill under the force of gravity is katabatic wind or cold air drainage..

Valley Breeze



Mountain Breeze (also called Cold Air Drainage or Katabatic Wind)



C. Monsoonal Winds - South Asia Example: Similar to a large scale sea breeze.

1. **December/January:** ......the ITCZ is well south of southeast Asia, and the area is dominated by the Siberian High (thermal high). Wind blows offshore (out to sea)

2. **June/July:** Thermal low pressure develops (the Asian Low). This thermal low merges with the ITCZ. This thermal low pressure serves as a vacuum for warm, moist, tropical air off the Indian Ocean. Precipitation is substantial.

VI. Ocean Currents

A. Factors Determining Direction of Current

1. **Anti-Cyclones (create gyres):** Surface winds actually pull surface currents along through the force of friction between the water and air. The subtropical high pressure centers (anticyclones) form huge circulating ocean currents called **gyres**.

2. **Coriolis Force:** Deflects currents to the right in the Northern Hemisphere.

B. Role in Energy Transfer:

1. Warm waters transferred poleward
2. Cold waters transferred equatorward
3. Global the energy balance maintained

C. Examples

1. **Warm Currents:** Found on eastern sides of continents; can serve to moderate otherwise potentially very cold climates.
   a) **Gulf Stream (or Florida Current):** Eventually becomes the N. Atlantic Current, warms the British Isles and Scandinavia.

   b) **Kuroshio Current:** Warms Japan and East Asia.

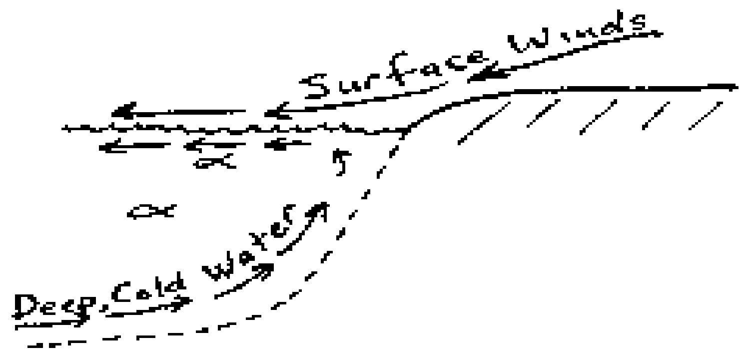
2. **Cold Currents:** Found on western sides of continents; can serve to moderate otherwise potentially very warm climates.

   a) **Peru-Chile Current:** Cold current which travels north up the west coast of South America.

   b) **California Current:** Cold current which travels south down the coast of California.

   c) **"Upwelling" and the California Current Example:**
   Cold water is dense and generally sinks to the ocean bottom.
   With upwelling, the deep, dense cold waters are brought to the surface by the action of winds.

Upwelling



VII. El Niño (see Focus Study, pg 220):

This is not a violent storm or large waves.
In the strictest sense, an El Nino event occurs when the trade winds, which normally push warm Pacific water along the Equator toward Australia and Indonesia, weaken.

This allows the warm water to flow (or "slosh") back toward South America (Coastal Peru). The net result is that a large body of unusually warm water forms off the coast of South America.

This raises the atmospheric water vapor content in this area; some of this gets channeled toward California causing heavy rains. Conversely, Australia and Indonesia experience cooler ocean waters and dryer weather than normal.