BASIC WEATHER CONCEPTS
PART ONE
LIFELONG LEARNING INSTITUTE
OCTOBER 24, 2019

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S/V Valhalla

Weather

FUTURE LLI WEATHER COURSES

- **Spring 2020 LLI Feb. 20, 2020**
  - **Water, Humidity, Fog, Atmospheric Stability, Clouds, Precipitation**
- **Future Classes to cover these topics**
  - **Thunderstorms, Tornadoes, Lightning, Optical Effects**
  - **Mid-latitude weather and storms**
  - **Tropical Weather and Storms, Hurricanes**
  - **Weather forecasting processes and resources**

NWS WEATHER BALLOON LAUNCH

Weather

- **DATE: WEDNESDAY OCTOBER 30, 2019**
- **TIME: 2400 GMT (6 pm DST). Be at NWS Office at 5:45 pm.**
- **LOCATION: NATIONAL WEATHER SERVICE OFFICE**
- **2485 SOUTH POINT ROAD**
- **GREEN BAY, WI**
- **The NWS Weather Office is immediately across the street from Austin Straubel Airport. Park in the visitor parking lot and enter building front entrance. The Balloon Launch will take place outdoors, rain or shine, and this will be followed by a tour of the NWS facilities.**

Credit Where Credit Is Due

- **CREDITS TO THE UNITED STATES POWER SQUADRON NOW KNOWN AS AMERICA'S BOATING CLUB**
- **8 week course of Weather with an accompanying textbook.**
- **Modified extensively by me with added videos, additional materials and removal of slides related to boating more appropriate for the LLI Audience**

Chapter 1
General Objectives

Weather

- Understand the Sun is the source of all weather in the Earth
- Understand heat energy and how it is transferred.
- Know that insolation heats the Earth's surface unevenly, creating different air masses.

Chapter 1
Specific Objectives

Weather

- **Atmosphere: Temperature and Heat**
  - This course focuses on the weather that exists in the lowest level of the atmosphere.
  - The first chapter, however, begins with a big picture look at the entire atmosphere – the mixture of gases that surround the Earth.
- Be familiar with the atmospheric layers.
- Recognize lapse rates and inversions.
- Appreciate the importance of water vapor in the air.
- Understand the difference between temperature and heat.
- Convert the Fahrenheit and Celsius Scales.

Origins of Meteorology

- Aristotle 340 BC wrote *Meteorlogica* a natural philosophy text summarizing what was known about weather and climate
- Meteoros-meaning "high in the air"
- Milestones in development of meteorology as a genuine natural science:
  - Invention of hygrometer in 1400s measures humidity
  - Invention of thermometer 1500s measures temperature
  - Invention of telegraph, allowed real time transmission of weather observations
  - 1920s Norwegian scientists postulate air masses and weather fronts
  - 1940's daily upper air weather balloon observations of temp., pressure, humidity----3 dimensional view of weather
  - Other Developments: weather satellites, numerical (computational) weather forecasting, the internet allows widespread distribution of weather forecasting, etc. etc.

Weather

Weather and Climate

Weather

- Weather
  - State of atmosphere at any given time and place
- Climate
  - Average weather over a period of years, usually decades, in same place
- Atmospheric Science
  - Study of weather and climate (meteorology)

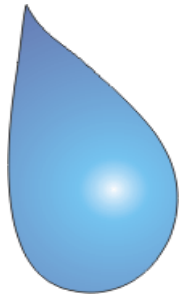
- Climate is what we expect, Weather is what we get!

What causes “Weather?”

- The source of all weather on Earth is unequal heating of the Earth’s surface by the Sun.

What Causes Weather?

- It's all about the sun
  - Heat from the sun is absorbed:
    - by the air
    - by the water
    - by the land
- and, Water vapor…

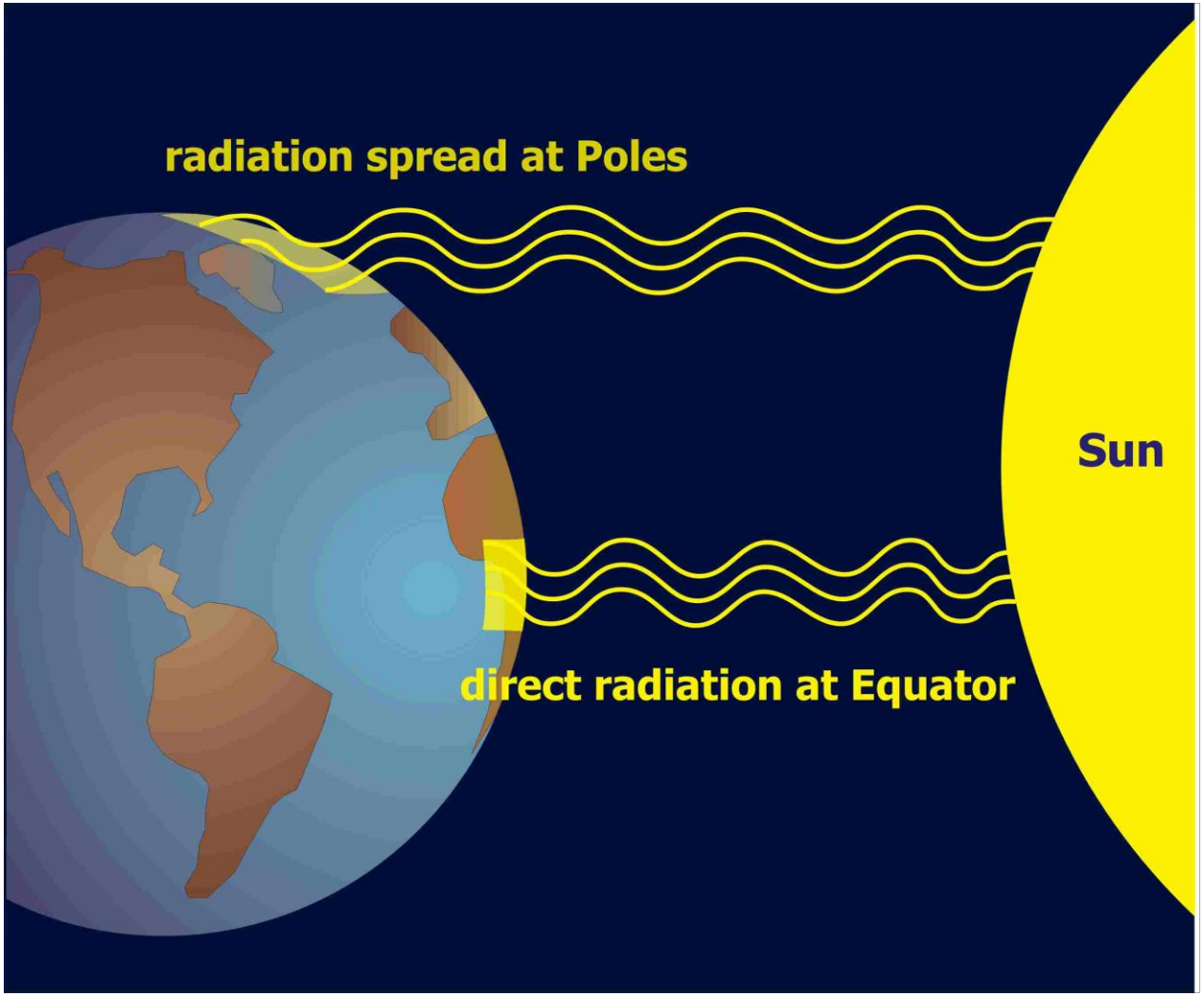


Heating happens unevenly

- Absorption of Heat differs with air, ice, water, and land
- Amount of heating at the poles is far lower than at the equator
- This causes differing temperatures
- This, in turn, causes air to migrate

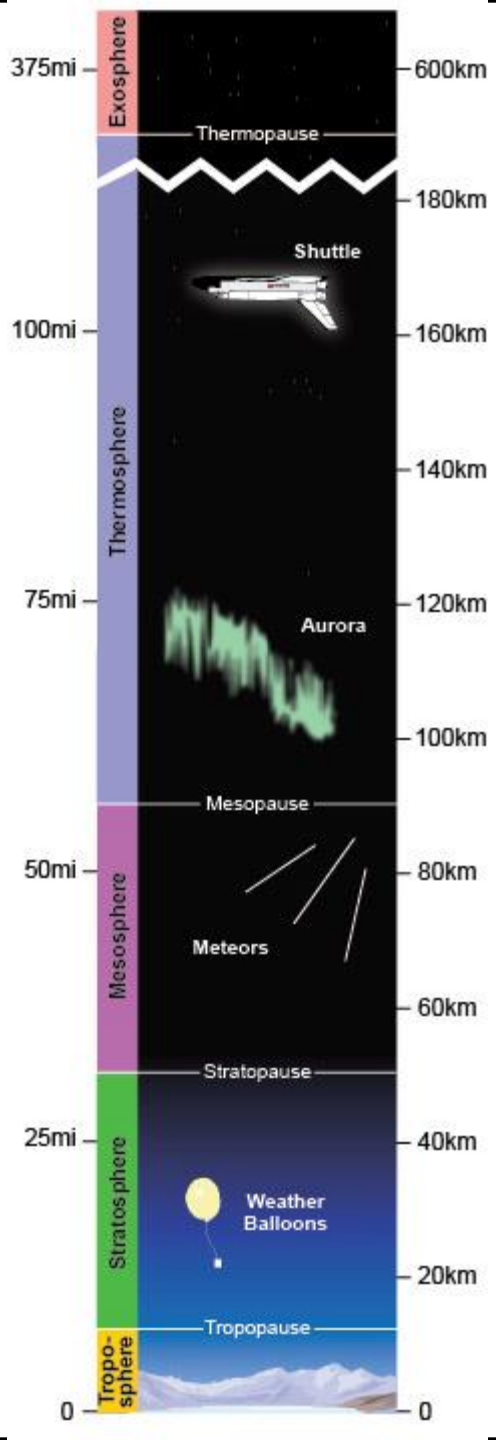
Heating at Poles & Equator

Weather



Events in Layers of the Atmosphere

Weather



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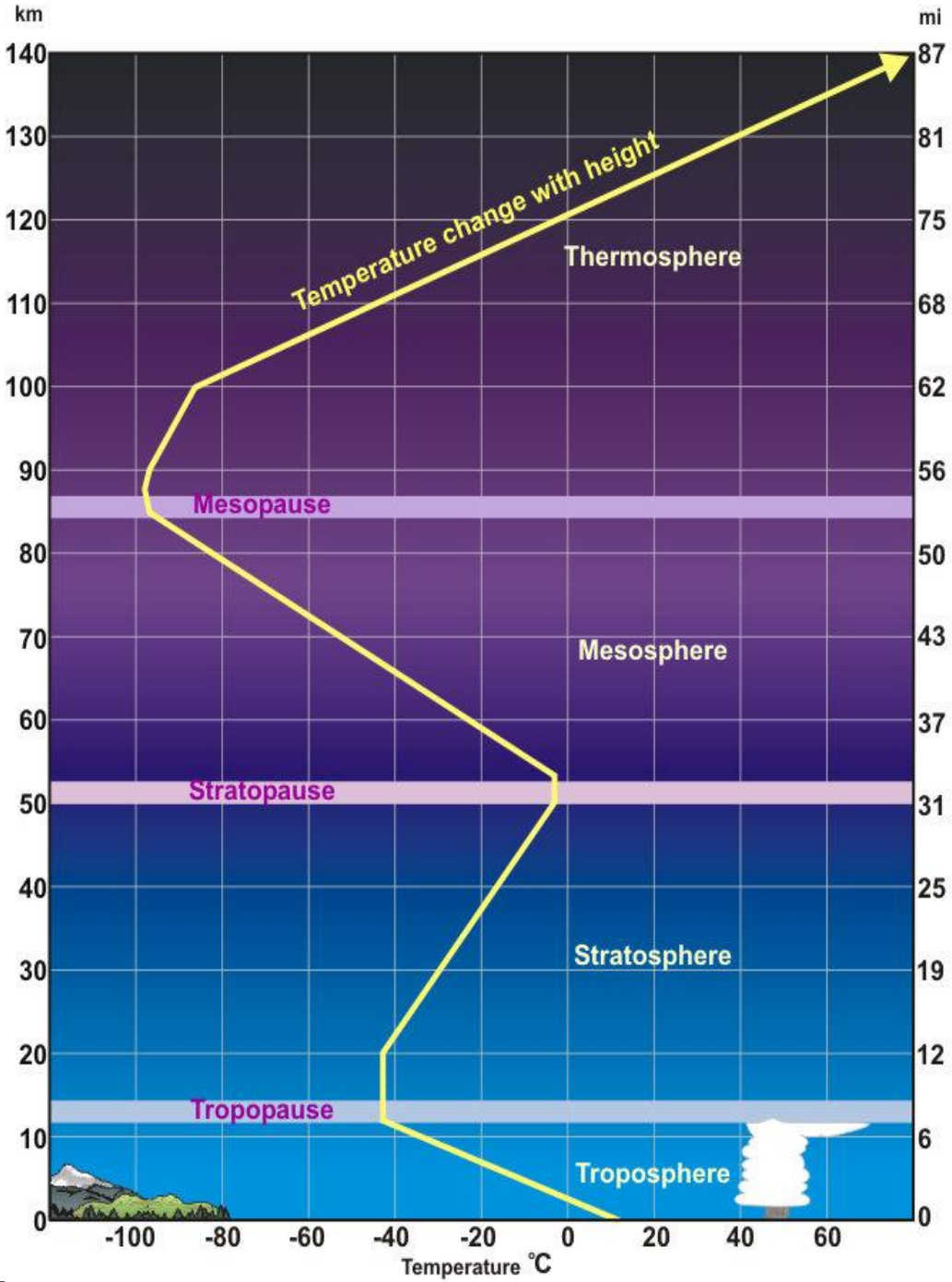
km
mi
140
130
120
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50
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10
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87
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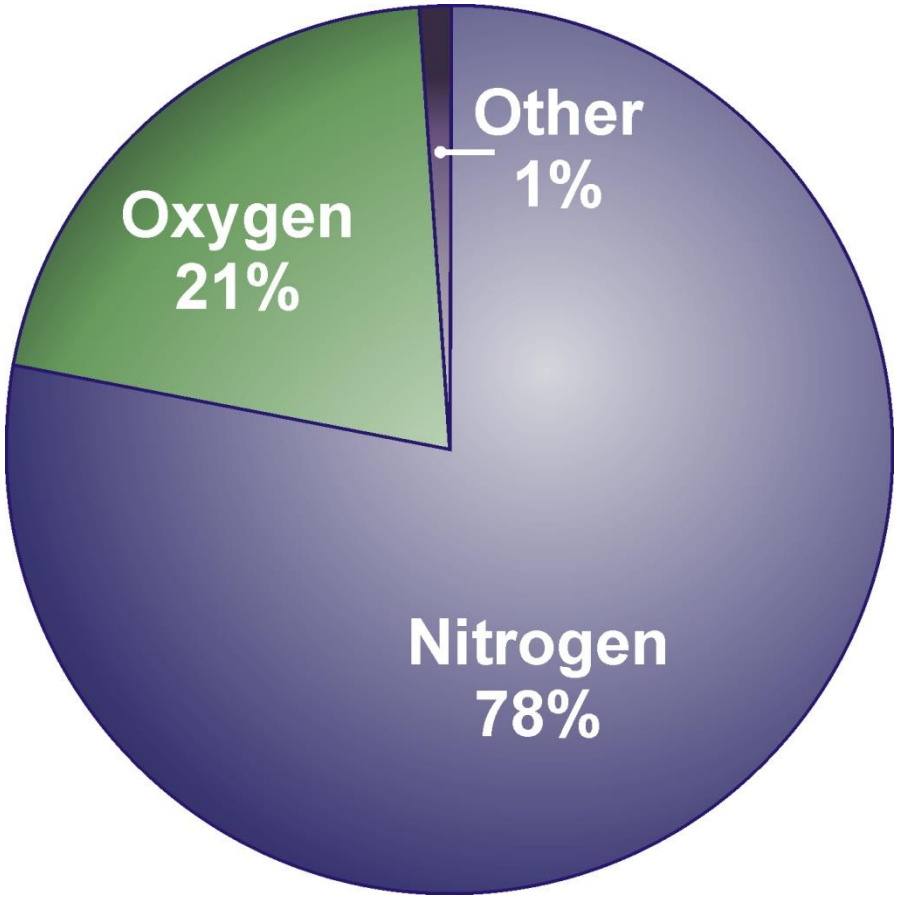
68
62
56
50
43
37
31
25
19
12
6
0
Temperature change with height
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
-100
-80
-60
-40
-20
0
20
40
60
Temperature °C

Weather

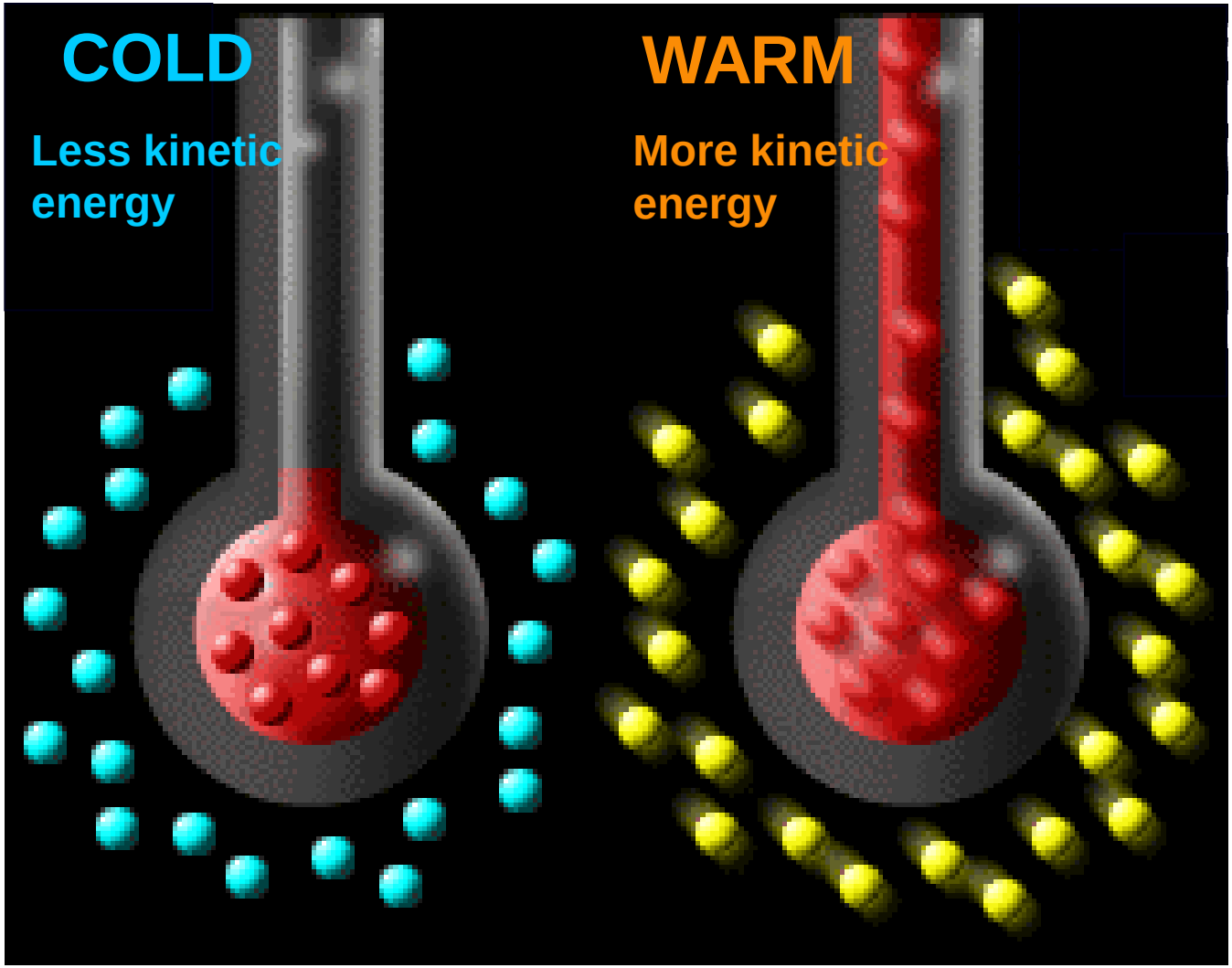


Water Vapor

- Water exists in the atmosphere in three different states:
  - a solid (e.g. ice crystals);
  - a liquid (e.g. water droplets); and
  - a gas - water vapor.
- The amount of water vapor in the air varies from about 1% (very dry) to 4% (very moist).
- Water vapor is the source of:
  - clouds and precipitation;
  - an absorber and transporter of heat;
  - a source of energy for powering storms.

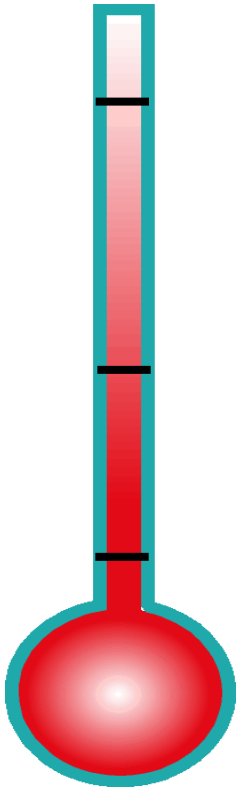
Temperature

Weather

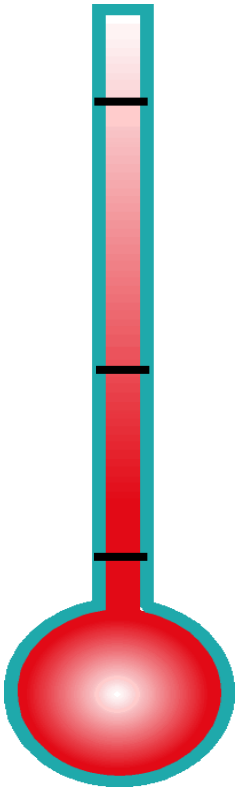


Temperature Scales

Weather



Degrees
Farhenheit



Degrees
Celsius

Temperature Conversion

Weather

- **<u>Temperature Conversion Equations</u>**:
- These are the equations for converting temperatures from one scale to the other.
  - $^\circ F = (\,^\circ C \times 9/5\,) + 32$
  - $^\circ C = (\,^\circ F - 32\,) \times 5/9$
- The 32 accounts for Fahrenheit freezing being 32^0 higher than Celsius freezing.
- The fractions – 9/5 and 5/9 – account for there being 180 degrees between freezing and boiling on the Fahrenheit scale but only 100 degrees on the Celsius scale.

Temperature and Heat

Weather

- Temperature is the measure of the average kinetic energy of molecules in an object
- Thermal energy is the total kinetic energy of molecules in an object
- Heat is the thermal energy being transferred from one object to another
- Heat always flows from the the **hotter object to the colder** one
- **Heat is what we FEEL, Temperature is what we MEASURE**

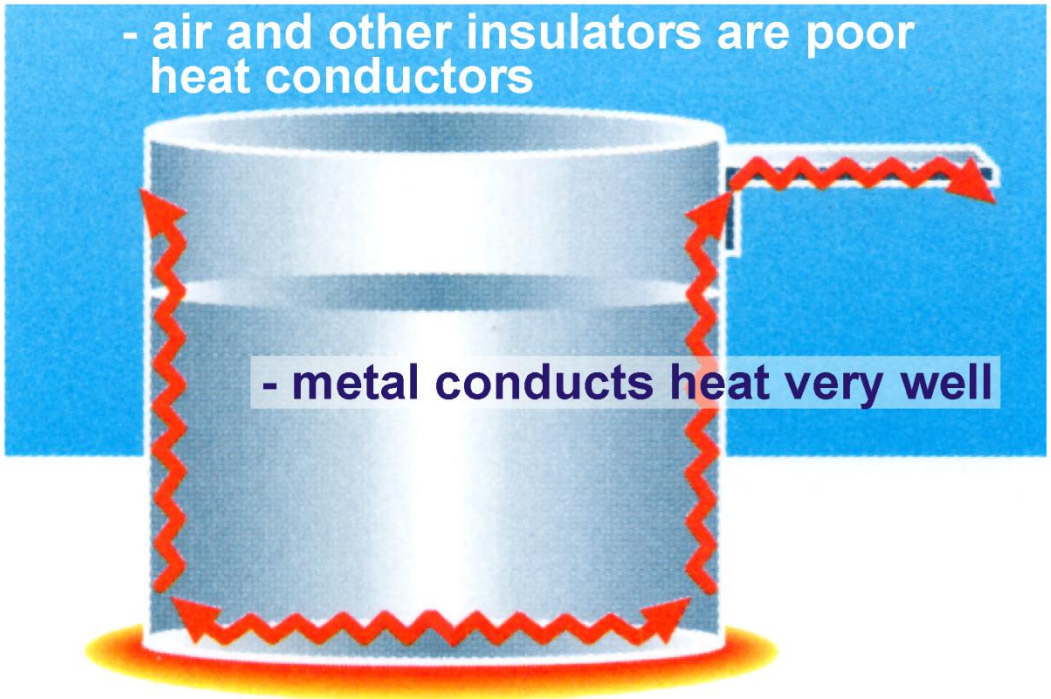
Mechanisms for Heat Transfer

Weather

- CONDUCTION: transfer of heat by molecular activity from one substance to another. ALWAYS from hotter to colder.
- CONVECTION: transfer of heat by actual movement of fluids (liquids and gases). In Meteorology **vertical** movement of heat.
- ADVECTION: is **horizontal** movement of heat.
- RADIATION: transfer of heat, light, other kinds of electromagnetic waves through space.

Conduction - transfer of heat by collisions of molecules

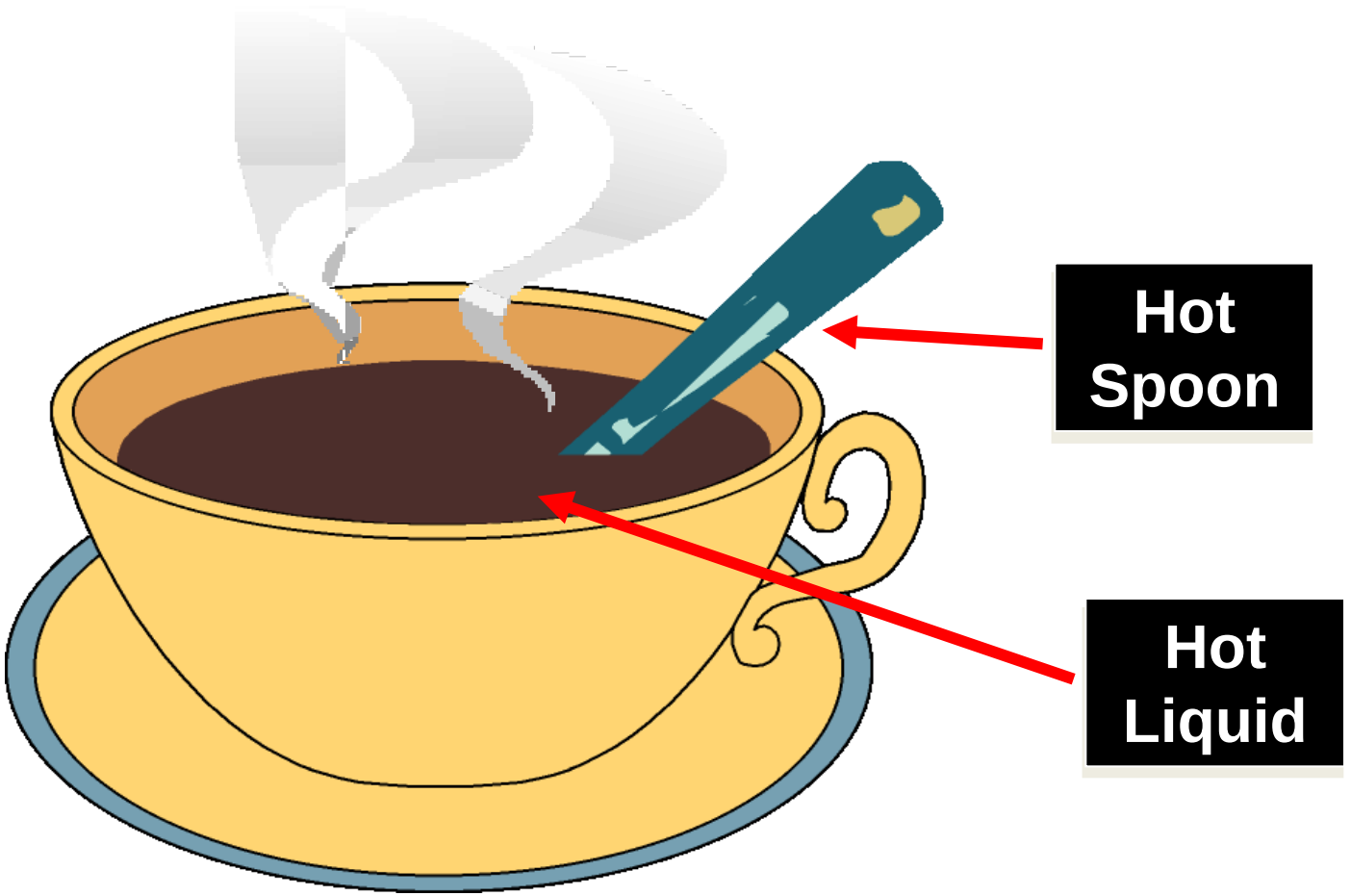
Weather



The stove's heat causes molecules in the pan's bottom to vibrate faster, making it hotter. These vibrating molecules collide with their neighboring molecules, making them vibrate faster too. Eventually, the handle becomes hot too.

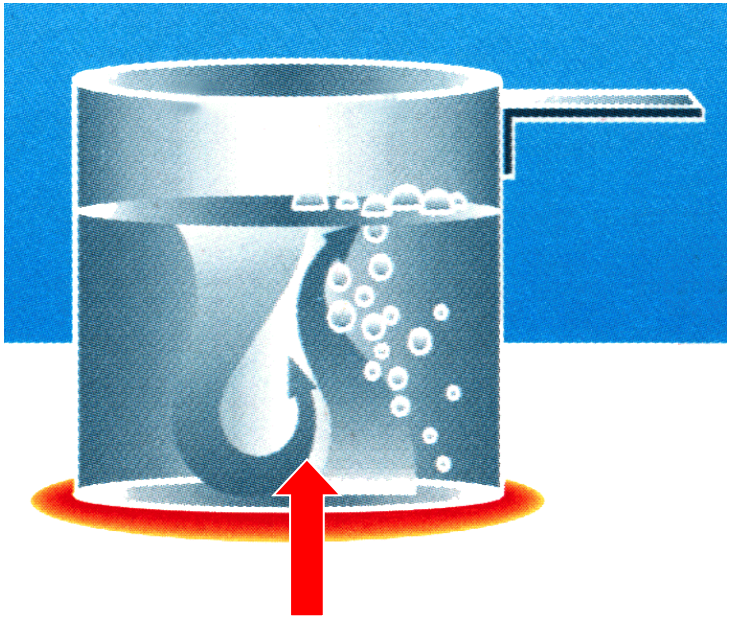
Heat Transfer - Conduction

Weather



Heat Transfer - Convection

Weather



As water in the bottom of the pan heats up, it rises.

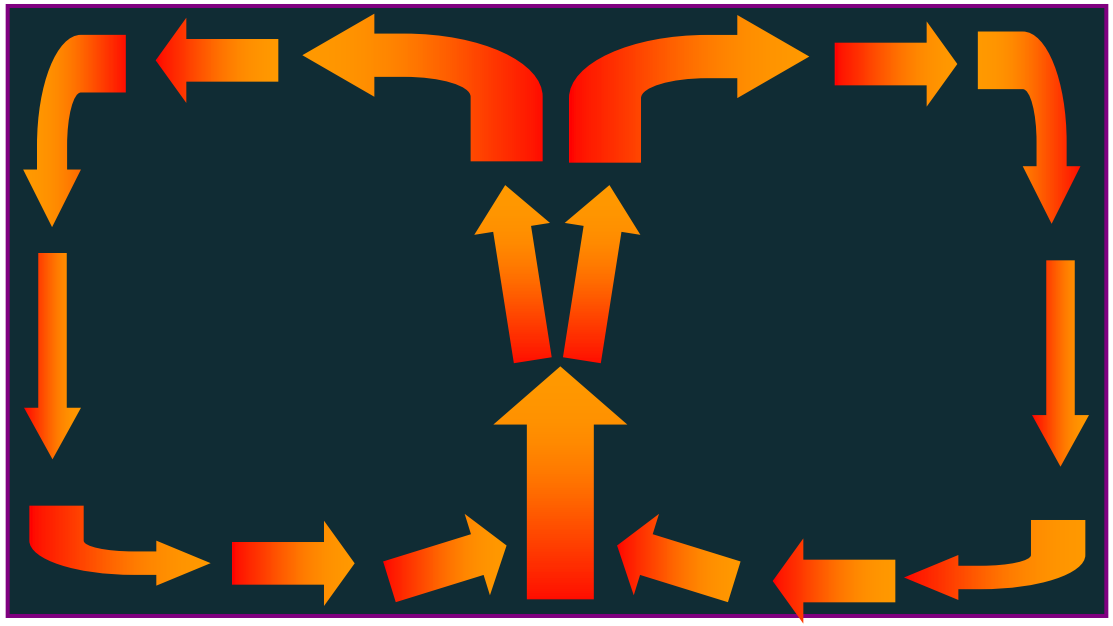
If the water gets hot enough, some of it also vaporizes forming bubbles that rise.

Cooler water sinks from the top to replace the rising water and bubbles.

This up and down movement eventually heats all the water.

Heat Transfer - Convection

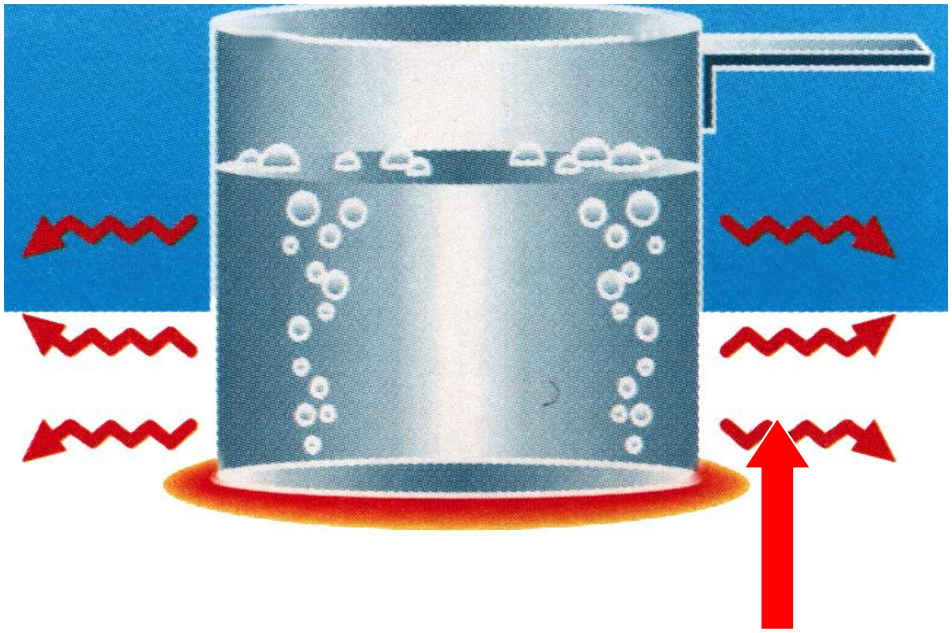
Weather



Heat  **Source**

Heat Transfer - Radiation

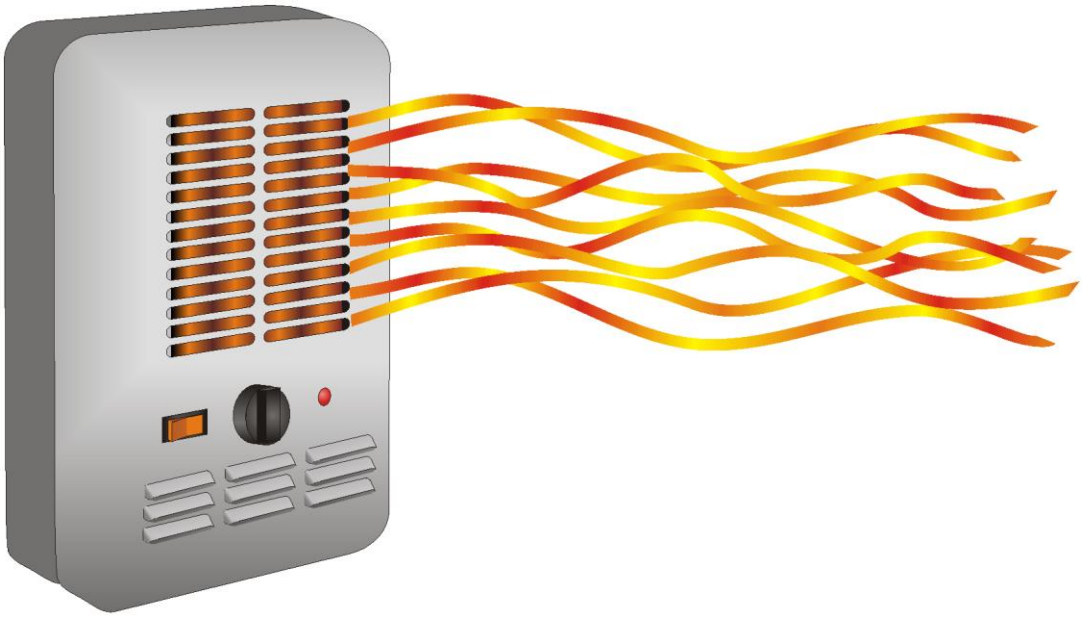
Weather



Even though air conducts very little heat, you can feel the heat coming from the hot stove and the pan. It's radiating through the air.

Heat Transfer - Radiation

Weather



Specific Heat

Weather

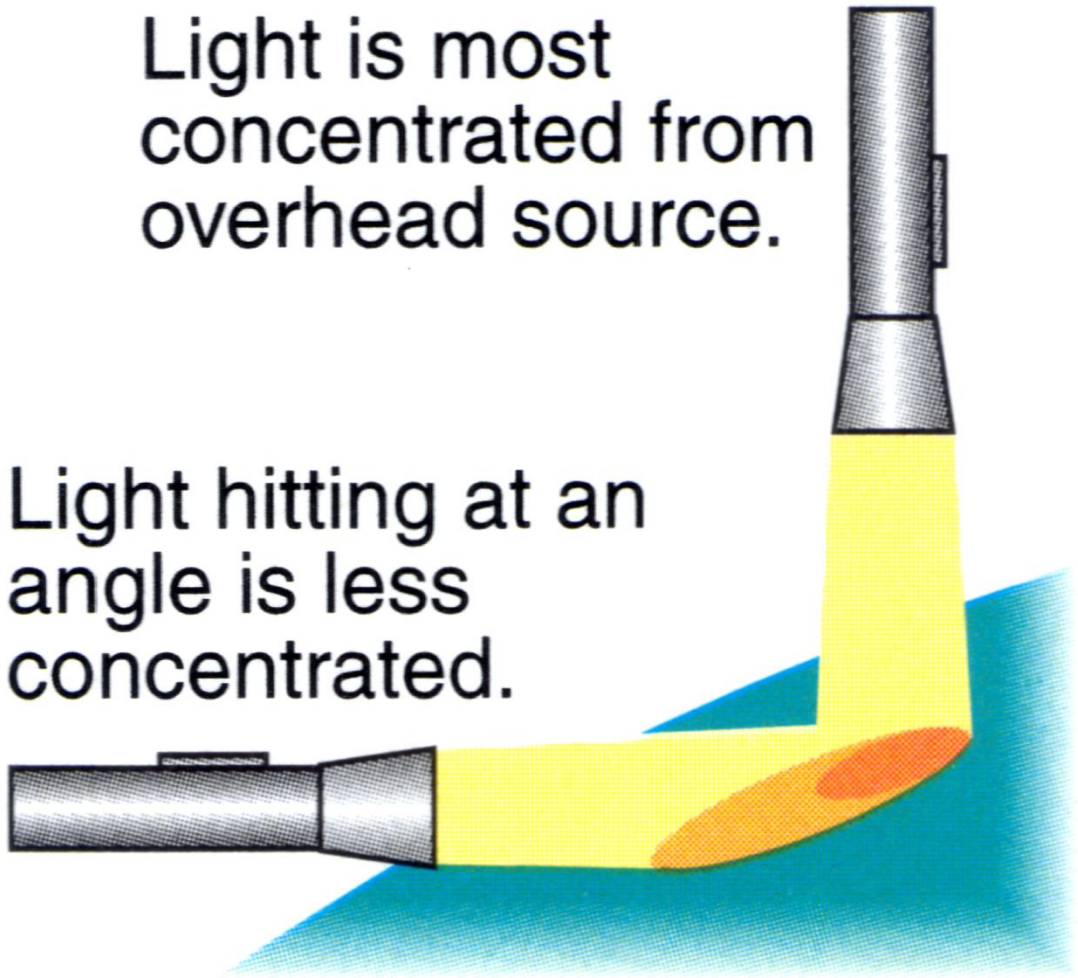
- Specific Heat is the measure of the **amount of heat it takes to change the temperature of a substance.**
  - number of calories it takes to **warm 1 gram of a substance 1^0 C**
  - the specific heat of water is 1 (1cal/g/^{0}C) (by Definition)
- Land has a lower specific heat than water thus, **Land warms up and cools off more quickly than bodies of water. Water "retains heat" longer than land.**

Specific Heats of Common Materials

- **Dry Air 0.24**
- Dry Soil 0.19
- Wet Soil 0.35
- Aluminum 0.21
- **Copper 0.09**
- Iron 0.11
- Ice/Snow 0.50
- **Water 1.00 (by Definition)**
- Note the pattern: **metals conduct heat readily and have a low specific heat. Water is a very poor conductor of heat and has a high specific heat. Air also is poor heat conductor.**

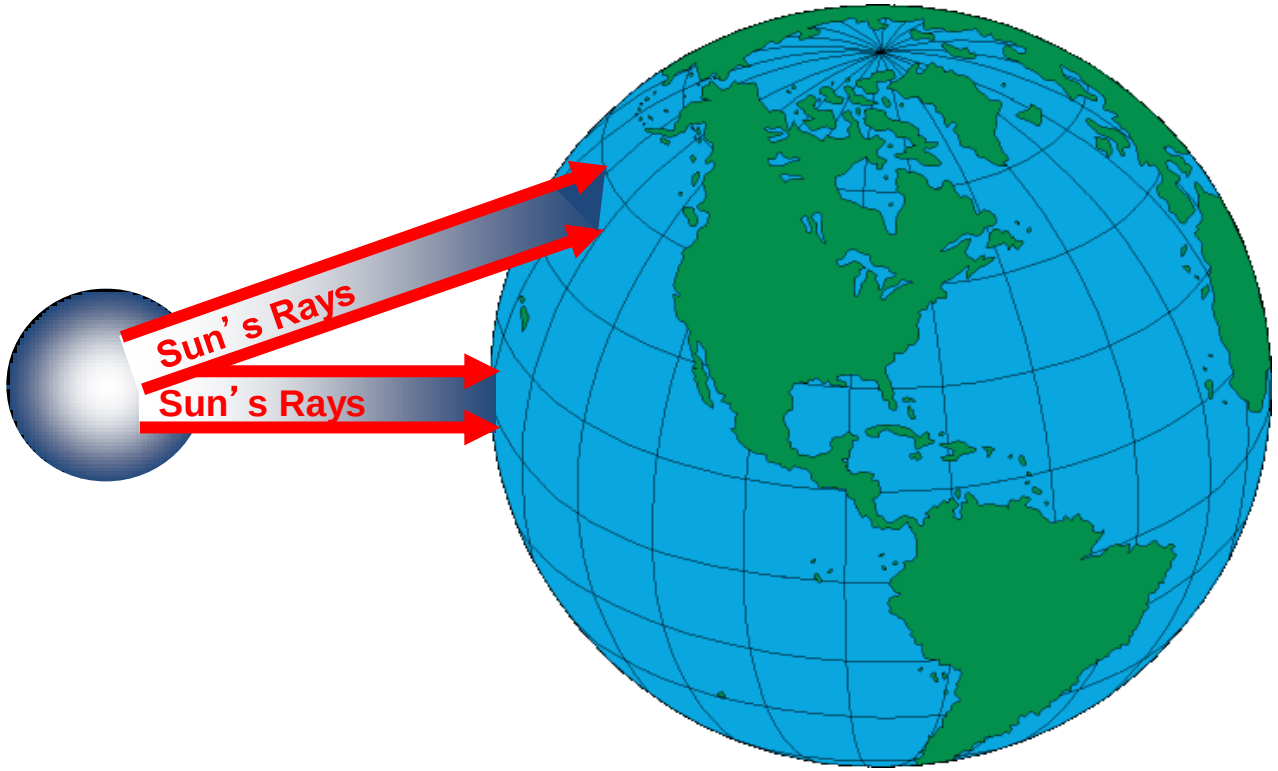
Insolation-Incoming Solar Radiation

Weather



Insolation can lead to unequal heating of Earth's surface

Weather

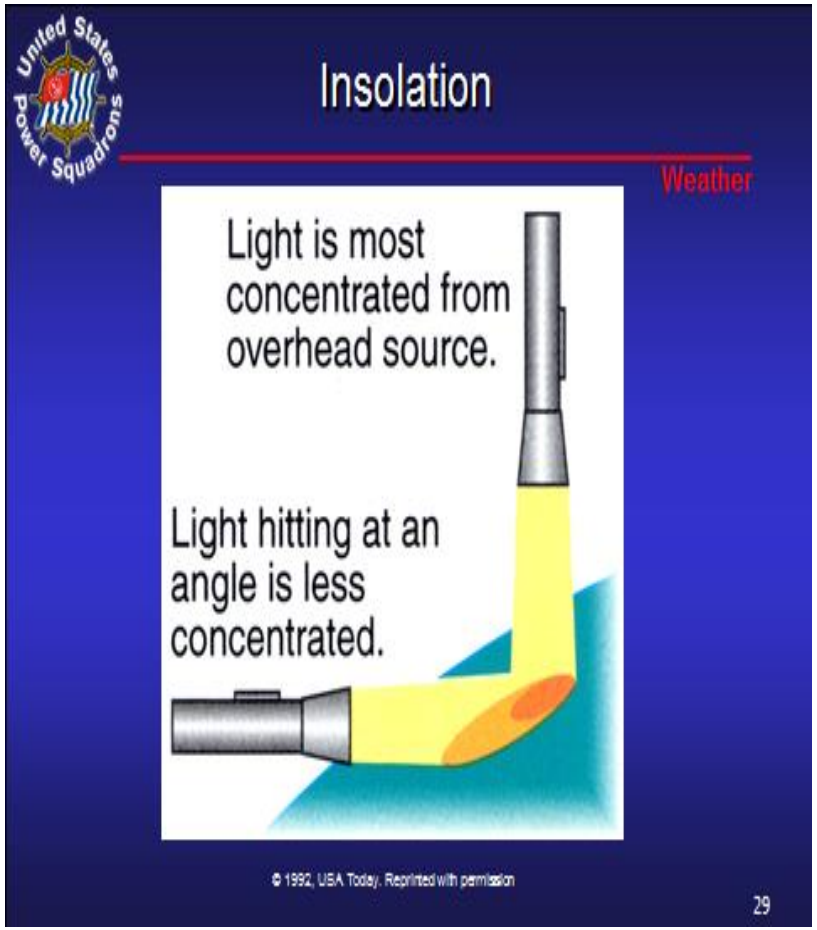


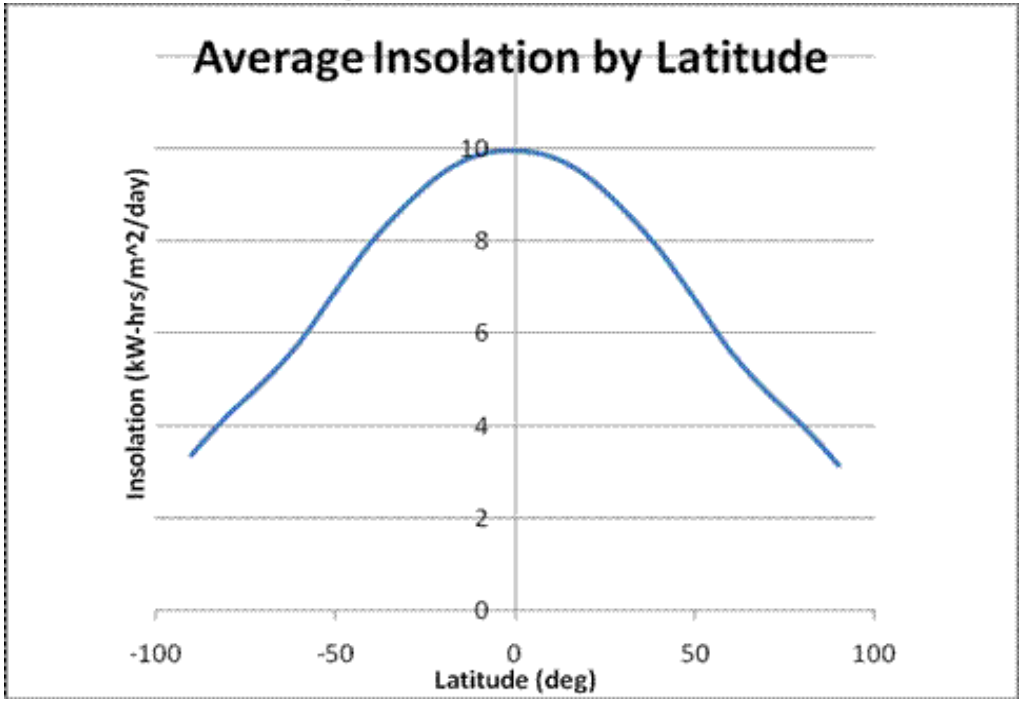
Insolation is "INcoming SOLar radiATION"

Insolation Varies with Latitude and also with Seasons

Weather

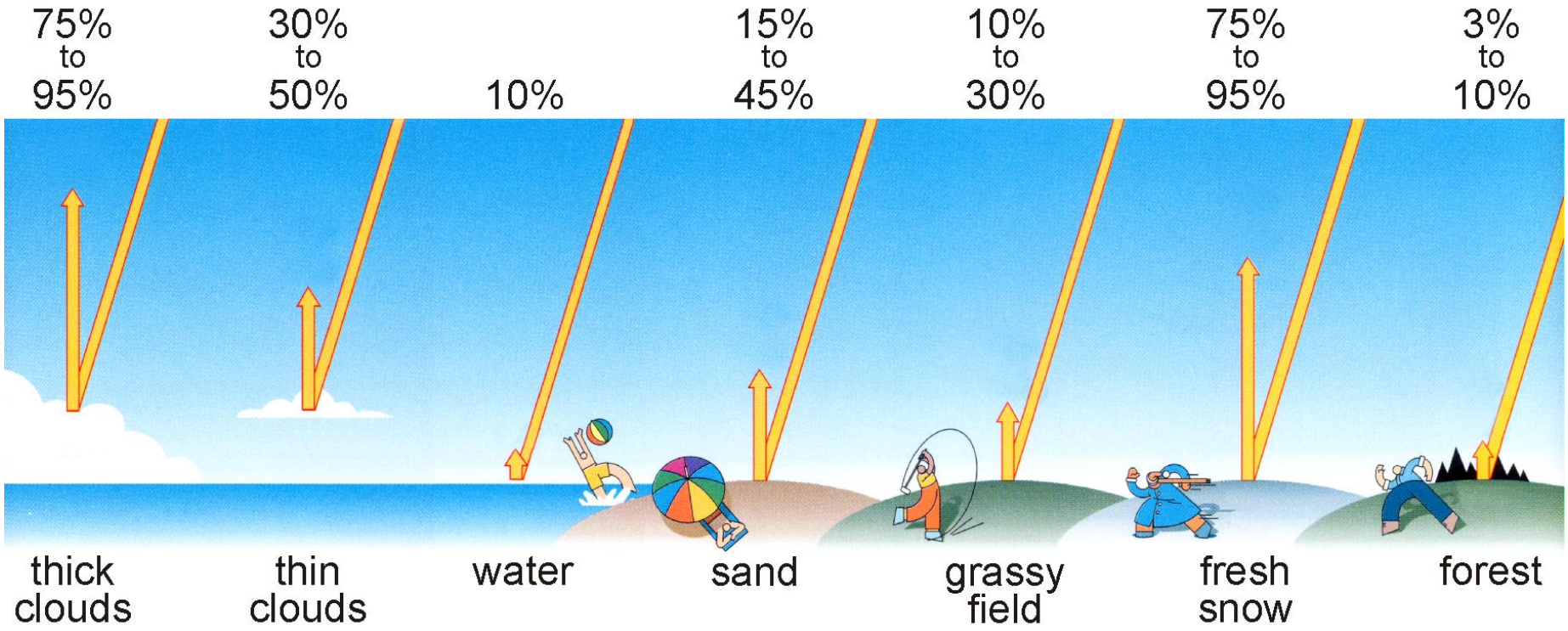
- In kW-hrs/m2/day
- 0 deg Latitude (Equator) = 10
- 60 deg Latitude = 5





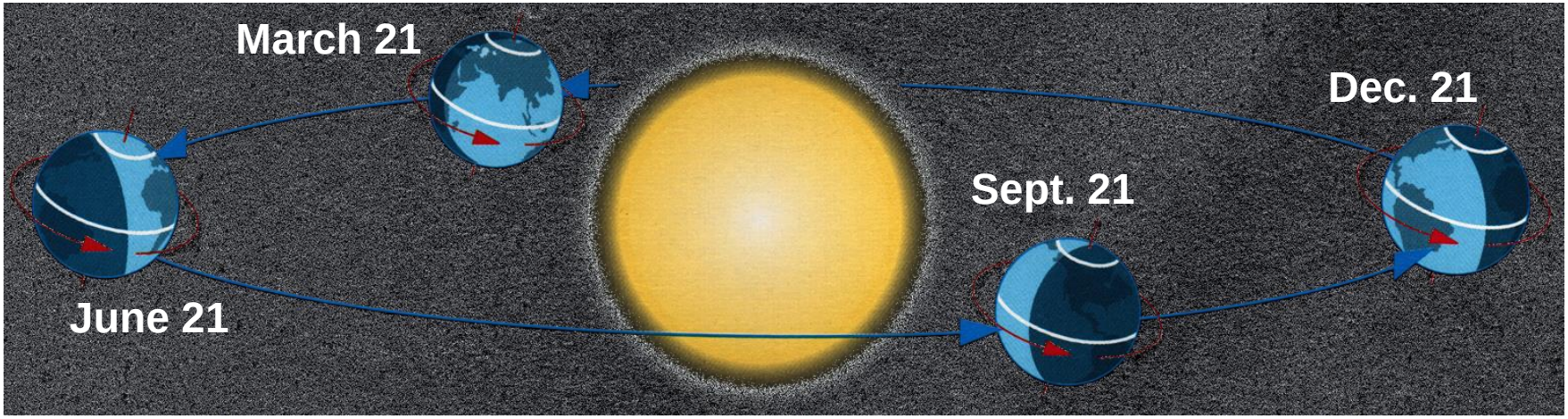
Reflected Solar Energy varies by type of material

Weather



Earth's Year Around Sun

Weather



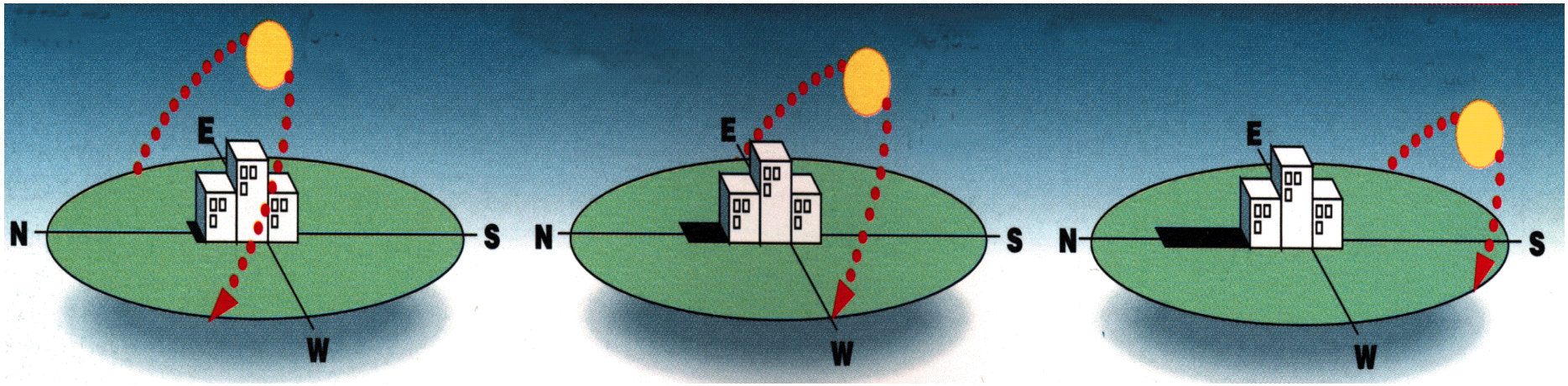
Sun Angles

Weather

Summer Solstice

Spring or Fall Equinox

Winter Solstice



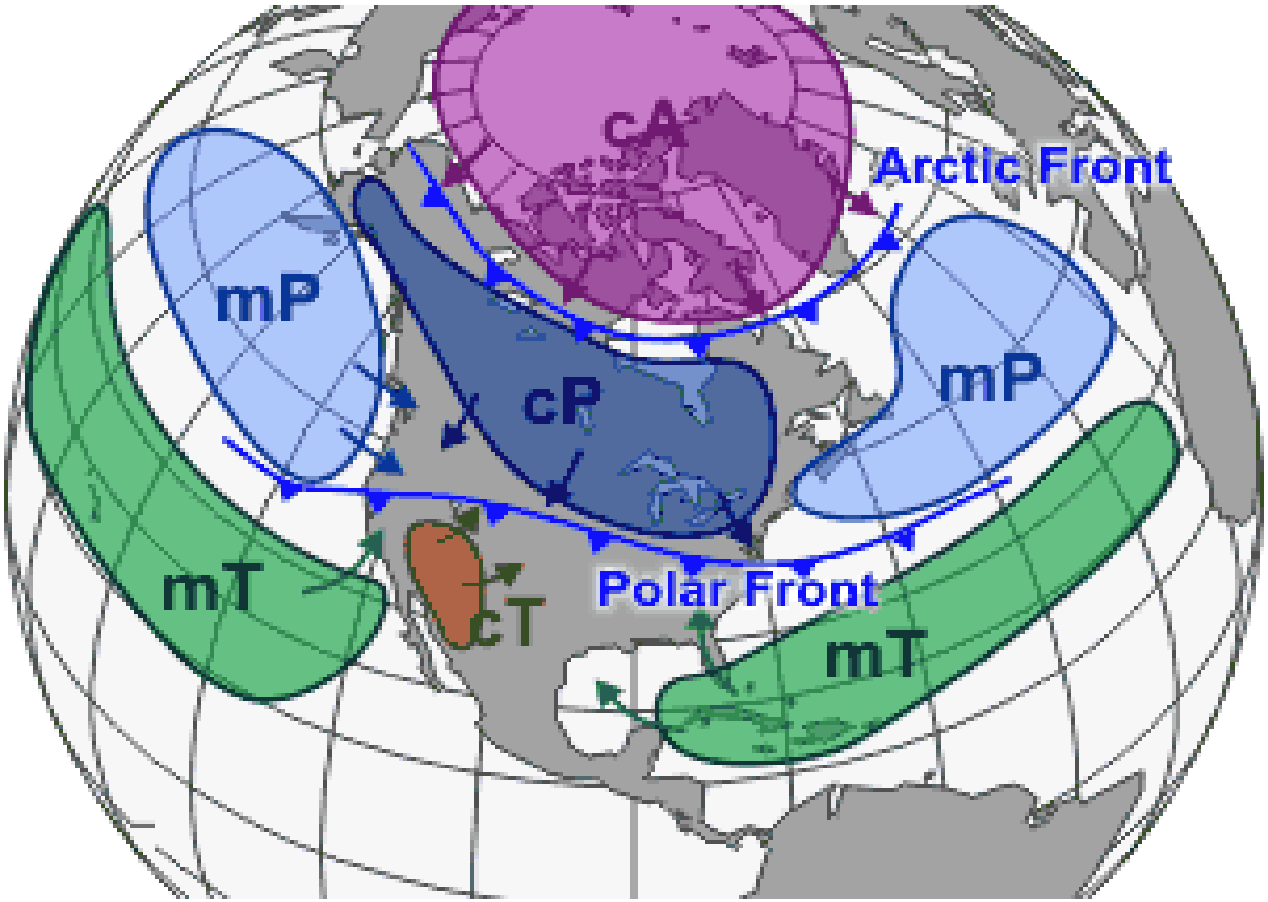
Air Masses-large body of air with **permanent uniform** horizontal **temp** and **humidity**

Weather

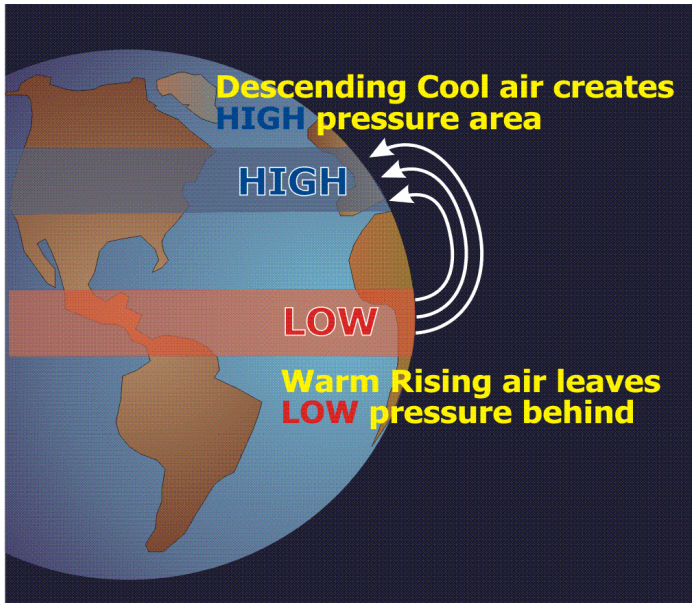
		Temp---Humidity
cP	Continental Polar	cold - dry
mP	Maritime Polar	cool - moist
mT	Maritime Tropical	warm - wet
cT	Continental Tropical	hot - dry
A	Arctic	very cold
E	Equatorial	warm - moist

Major Air Masses

Weather



Uneven temperatures



- Air rises over heated areas
  - Leaves lower pressure behind
- Air falls over cooler areas
  - Creates higher pressure
- Winds develop toward the lower pressure
- Wind moves weather

Key Points to Remember about Heat and Pressure

- Heat: energy (heat) is always transferred from WARM to COLD
- Pressure: pressure always flows from HIGH to LOW

Regions of Cold and Warm

- **Regions form Globally**
  - Cold Air Masses
  - Warm Air Masses
- **Weather systems** form along the **boundaries (fronts)**

Air Masses

Weather

1. Cold air plunging southward in the Northern Hemisphere is often balanced by warm air heading north elsewhere in the hemisphere.

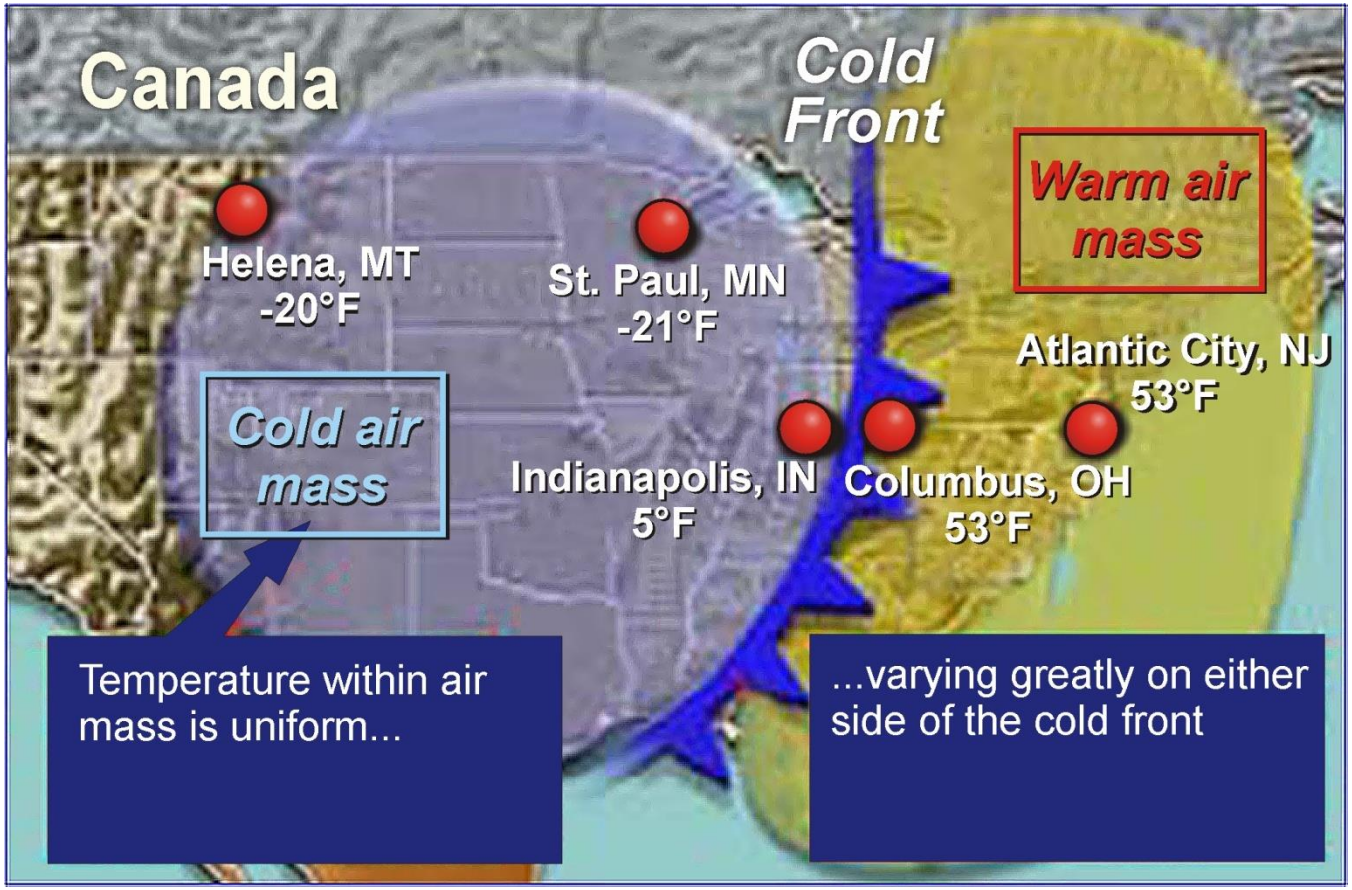
2. A February week that brings record highs in the 60s to the Midwest and East in the United States...

3. ...can send cold into Europe, spreading snow across England and forming ice on the canals of Venice, Italy.

Air Masses at Boundary

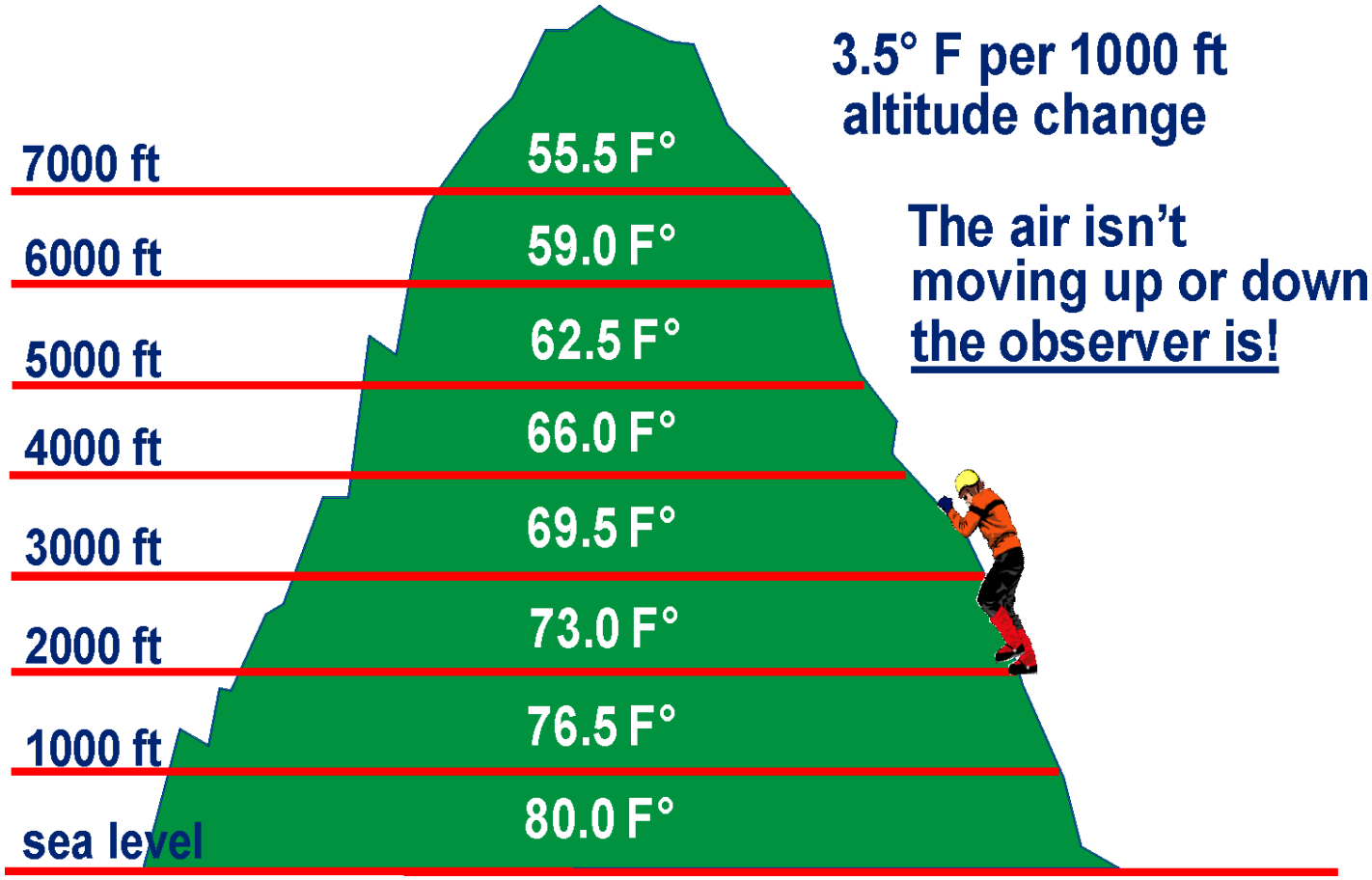
A FRONT is the boundary between two air masses

Weather



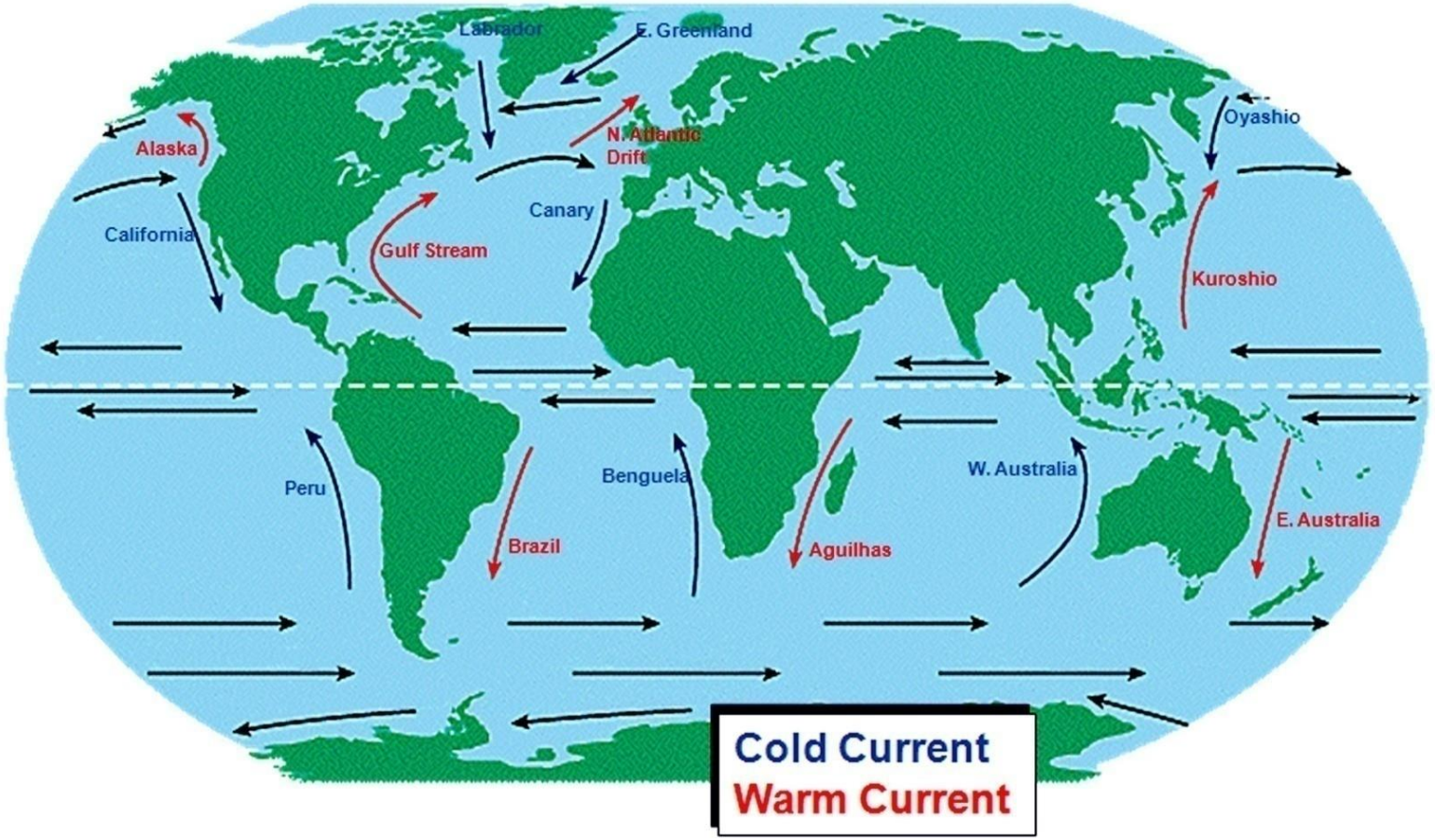
Lapse Rate: the rate at which atmospheric temp decreases with increased altitude

Weather



Ocean Surface Currents

Weather



Chapter 1
Summary pg 1.

Weather

- Temperature generally decreases as altitude increases throughout the lower atmosphere.
- Temperature is a measure of relative hotness or coldness and is a very important factor in weather.
- The equations for converting Fahrenheit and Celsius degrees.
- Heat is energy transferred from a warmer to a cooler body.
- Heat is transferred in three ways: conduction, convection, and radiation.
- The term lapse rate is the observed temperature change as altitude changes in the atmosphere.
- Inversions are important factors in determining atmospheric conditions often contributing to haze and smog.

Chapter 1
Summary pg.2

Weather

- Most weather phenomena result from uneven heating of the Earth's surface and the circulatory processes that transport heat.
- Air masses that remain stationary for a period of time take on the properties of the surface below them (hot or cold; dry or moist).
- Heat is transferred vertically by convection and horizontally by advection as the winds push different air masses.
- The ocean currents and global winds transport heat from the tropics towards the poles.

END of CHAPTER 1

Weather