Air Temperature

(called "sensible" heat; air molecules get excited and vibrate faster as temp increases!)

I. What causes the air to heat or cool? (review net radiation - surpluses and deficits)

II. 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*** pattern or temperature. The highest ***annual*** temperatures will follow the highest sun angles by a month or more.

III. Measuring Air Temperature – not at the ground for gosh sakes!!! (see text)

IV. Main Factors Affecting Temperature (called "Temperature Controls")

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

B. Altitude: Recall that air temperature drops with increasing altitude. Called normal lapse rate. Basically, mountains stick up into the cold air of the atmosphere.

C. Prevailing (Average) Wind Direction: Temperature in one place is commonly affected by air coming from another place. For example, a strong north wind here in the winter usually brings extremely cold temperatures.

D. Cloud Cover

1. Daily Temperature Range: Difference between the maximum and minimum.

2. Cloudy Skies: Sun (shortwave) blocked during day; clouds emit radiation toward Earth at night. Results in lower daily temperature range. ie Days aren't as hot, nights aren't as cold.

3. Clear Skies: Earth receives high shortwave during day; longwave emitted toward space at night (no counterradiation). Results in higher daily temperature range. i.e. Days are hot and nights are cold.

E. Land/Water Heating Differences

Maritime (on or near water)	**Continental (on land)**
•Location is cooler in the summer and warmer in the winter compared to land. •Highs and lows are NOT extreme. •Annual temp. range is low. •Heating and cooling occurs slowly	•Location is warmer in the summer and cooler in the winter compared to land. •Highs and lows are EXTREME. •Annual temp. range is high. •Heating and cooling occurs rapidly
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. **Movement (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.

Oceans are massive energy storage systems! 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.**

V. Air Temperature and the Human Body

A. Wind Chill: Wind chill is a measurement of apparent temperature on exposed skin. Under still conditions, your exposed skin has a thin, protective layer of warm air; wind will break this layer down and bring a constant supply of cold air. Your body cools down as it constantly tries to replace the layer of warm air.

B. Heat Index: The heat index provides an estimate of apparent temperature for the human body. When the air is warm and dry, the human body cools through perspiration and evaporation. When the air is warm and humid, evaporation slows down significantly, thus slowing down your body's cooling system.

VI. Global Temperature Maps

A. Map Terms

1. Isotherm: A line on a map connecting points of equal temperatures.

2. Gradient: Change in temperature over distance.

B. January/July Global Mean Temperature Maps

SELF STUDY – SEE BOTH MAPS

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

Look at either map. Where are the coldest temperatures? (High or low latitude; over oceans or land surfaces?)

Compare coastal and continental (inland) locations at 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.)

C. Global Annual Temperature Range

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?

Climate Change

Natural and Anthropogenic Factors

I. Mechanisms of Climate Change

A. Natural Factors

1. Changes in Orbital Relationships (has been RULED OUT as a factor in current warming)

a) Changing Orbital Shape (100,000 yr cycle)

b) Changing Direction of Tilt (26,000 yr cycle)

c) Changing Degree of Tilt (40,000 yr cycle): Tilt, currently at 23.5° and decreasing, varies between 24° and 22°

2. Solar Variability: The amount of energy given off by the sun changes (solar flares, sun spots, etc), though this has been RULED OUT as a factor in our current warming trend.

3. Tectonics: Air temperature is affected by positions of continents and oceans. Again, this is NOT a factor in our current warming trend.

4. Volcanic Activity: Volcanic ash can block solar radiation and cause cooling; was observed after St Helens, Pinatubo, and others. This is the basis for the Nuclear Winter Hypothesis, which suggests that a nuclear war would create enough smoke and particulates to plunge us into a long cold period.

B. Anthropogenic Factors - Radiatively Active Gasses (called greenhouse gasses, which are good absorbers of longwave energy)

Increases of these gasses cause heating!!!

1. Carbon Dioxide (CO_2):

- Biggest problem, currently increasing at 0.4% per year
- Concentrations are at highest level in 800,000 yr record
- Rate of increase is at highest level in 800,000 yr record
- Increases ***primarily*** caused by burning of fossil fuels
- Also caused by logging and burning in tropical forests
  - Loss of forests means loss of global CO2 consumer (in other words, loss of a CO2 "scrubber"). Thus, there is more CO2 left in the atmosphere
  - Also, logging is always accompanied by burning, which produces more CO2

2. Methane (CH_4):

- Functions like CO2. Increasing at 1% per year – WAAAYYY faster than CO2!!!
- Concentrations are now double compared to previous high in 800,000 yr record.
- Rate of increase is at highest level in 800,000 yr record
- Comes from things that rot or digest where oxygen isn't present. (Livestock Intestines, Rice Fields, and Vegetation Burning)

3. Nitrous Oxide (N_2O) and Chloro Flouro Carbons (see text):

II. Current temperature trends

- Earth's average temperature has increased approximately 1C° (2F°) in the last 140 years.
- 2016 AND 2019 were the two hottest years on record (1880-2019).
- The ten hottest years on record (1880-2019) have occurred since the year 2005.
- Current rates of warming higher now compared to any time in the last 800,000yrs.
- According to the Intergovernmental Panel on Climate Change (IPCC 2013), increases during this century are projected between 0.5 to 4.1C° (1.5 – 7.3F°). This varies with our potential responses and actions.

III. Is the Current Warming Anthropogenic?:

- There is NO EVIDENCE that any known natural mechanism of climate change is causing current increases in temperature.
- Conversely, the timing and amount of human sources of carbon dioxide correlates ***incredibly strongly*** with the global increase in carbon dioxide.
- Further, the pattern of global carbon dioxide increases correlates ***incredibly strongly*** with the increase in global atmospheric temperature.
- In short, there is no evidence that warming is occurring naturally and substantial evidence that the warming is caused by humans.

IV. Major Consequences of Global Warming

A. Major Changes in Natural Plant and Animal Distributions – extinctions!
B. Agricultural Crop Failures
C. Human Health Issues
D. Significant Impact on Water Resources (California especially!)
E. Coastal flooding and erosion due to sea level rise

V. Understanding Sea Level and Climate Change

A. Causes of Sea Level Fluctuation

1. Caused by Glacier and Ice Sheet (shrinking or expanding) Glaciers melt, sea level rises; glaciers expand, sea level lowers.

2. Caused by Ocean Temperature Changes: Warm water expands, sea level rises; cold water contracts, sea level lowers.

B. Current Sea Level Trends

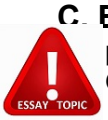
- Sea level during the last century rose between 10-20cm (4-8in).
- Intergovernmental Panel on Climate Change (IPCC 2013) predicts sea level increases between 30cm (12in) and 120cm (47in) by 2100. Some estimates are even higher.

VI. What can be done?- **(First international meeting was in Kyoto, Japan, December 1997. Many since.)**

A. Countries Pledge to Reduce Emissions: Based on population and levels of industrialization.

B. Emission Reducing Technology Developed and Shared: Countries "with" provide clean technology to countries "without" – reduced price or free.

1. **Cleaner burning fossil fuel technologies**
2. **Renewable (non-fossil fuel) energy technologies**
3. **Carbon sequestration technologies (taking carbon out of the atmosphere!)**



C. Emissions Trading ("cap and trade") Promoted: Treaty allows countries who undercut their polluting goals to "sell the right to pollute" to other countries. This creates an incentive to reduce pollution. Overall pollution levels continue to drop.

D. Ultimately, it is time to adapt to a warmer world…

VII. The "No Regrets" Philosophy: Without even considering the benefits of slowing global warming, many of the emission reduction strategies referred to above will have substantial benefits to society and the environment. In other words, even if the efforts don't slow global warming, the air and water will be cleaner, energy use will be reduced, energy efficiency will be increased, etc.

Sample Questions: Questions similar to these will be on your exam. As you study you should anticipate how I might use these questions to create new questions on the same concepts.

1	As a general rule, which locations have the lower average temperatures? A. high longitudes B. low longitudes C. high latitudes D. low latitudes
2	Which location is likely to have the lowest annual temperature ranges? A. 5° latitude and near an ocean B. 5° latitude and far from an ocean C. 70° latitude and near an ocean D. 75° latitude and far from an ocean
3	According to the heat index, humans will perceive the air temperature to feel <_____> than it actually is when the relative humidity is extremely <_____>. A. <lower>…<low> B. <higher>…<low> C. <lower>…<high> D. <higher>…<high>
4	Generally speaking, cloudy skies during a 24 hour period (compared to clear skies) will result in: A. low temperatures B. high temperatures C. low temperature ranges D. high temperature ranges
5	Generally speaking, maritime locations have <_____> summers and <_____> winters when compared to continental locations at the same latitude. A. <cooler>…<warmer> B. <warmer>…<cooler> C. <warmer>…<warmer> D. <cooler>…<cooler>
6	During warm periods sea level rises due to <_____> of glaciers and <_____> of ocean water. A. <melting>…<contraction> B. <melting>…<expansion> C. <growth>…< contraction > D. < growth >…< expansion >
7	Over the last 120 years, approximately how much has the global average temperature changed? A. –1.0C° B. -0.5C° C. no change D. +0.5C° E. +1.0C°
8	***Possible Essay Question:*** Explain how emissions trading (or "cap and trade") works and why it is seen by many as a useful strategy to reduce carbon dioxide emissions.
9	***Possible Essay Question:*** Explain why large scale logging of tropical rainforests results in an increase of carbon dioxide in the atmosphere.
10	***Possible Essay Question:*** Why does an ocean surface heat more slowly than a land surface when exposed to the same amount of solar radiation?
11	***Possible Essay Question:*** Many people argue that since Earth has heated and cooled naturally in the past, the current warming we are experiencing must be natural and not due to human influence… Provide a succinct argument ***against*** this statement and in support of the fact that humans are in fact largely responsible for current global warming.

GOOD NEWS!!! The practice questions above - plus *many*, *many* more – can be found in the online practice quizzes discussed in your syllabus and in class. You can take each quiz multiple times, and each time you will get some new questions. Once submitted, the quizzes are graded automatically, with the correct answers provided immediately. ***This is a great way to prepare for the exams!!!***

SERIOUSLY, TAKE THE ONLINE PRACTICE QUIZZES!!!