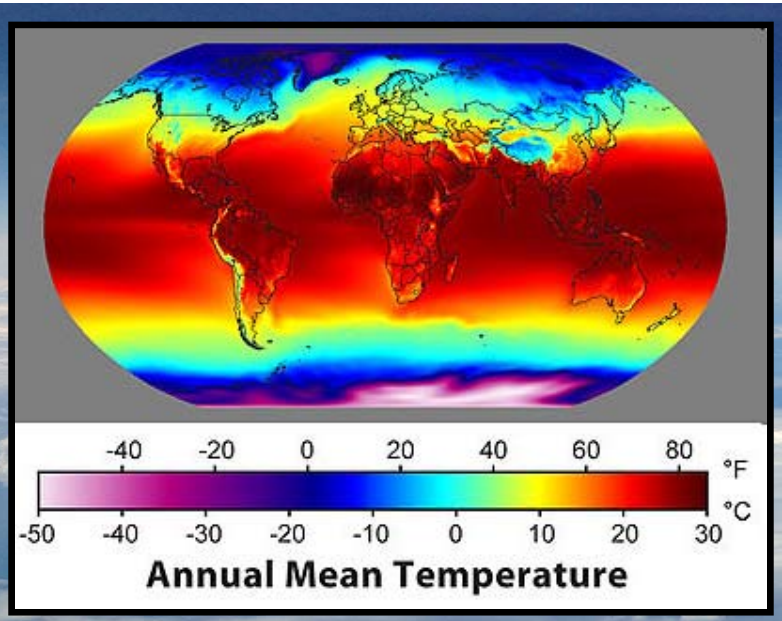
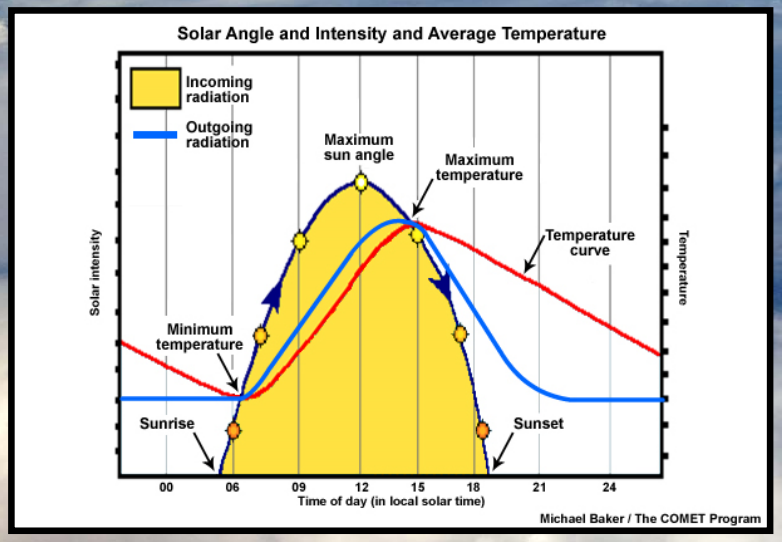
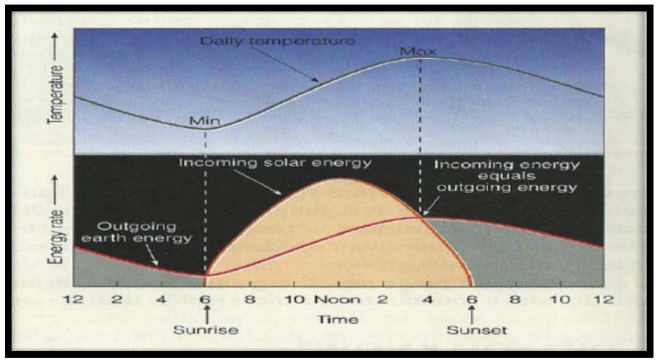


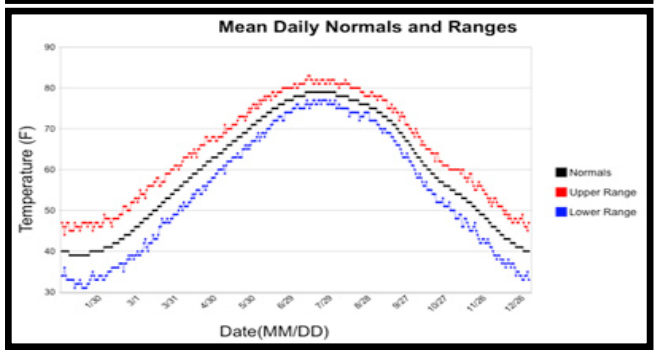


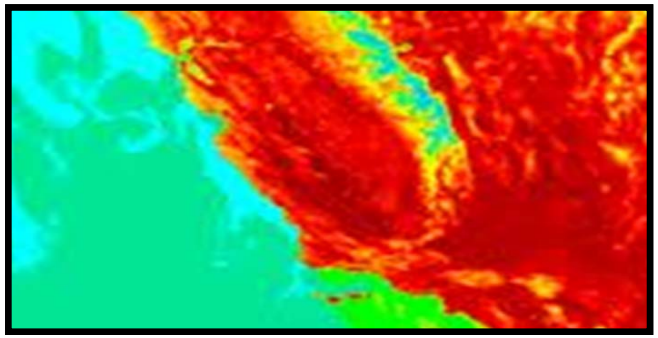
Lecture 5

Air Temperature

Learning Goals for Part 1 of Chapter 3







1. Understand why and how temperature changes over a **24 HOUR PERIOD**.

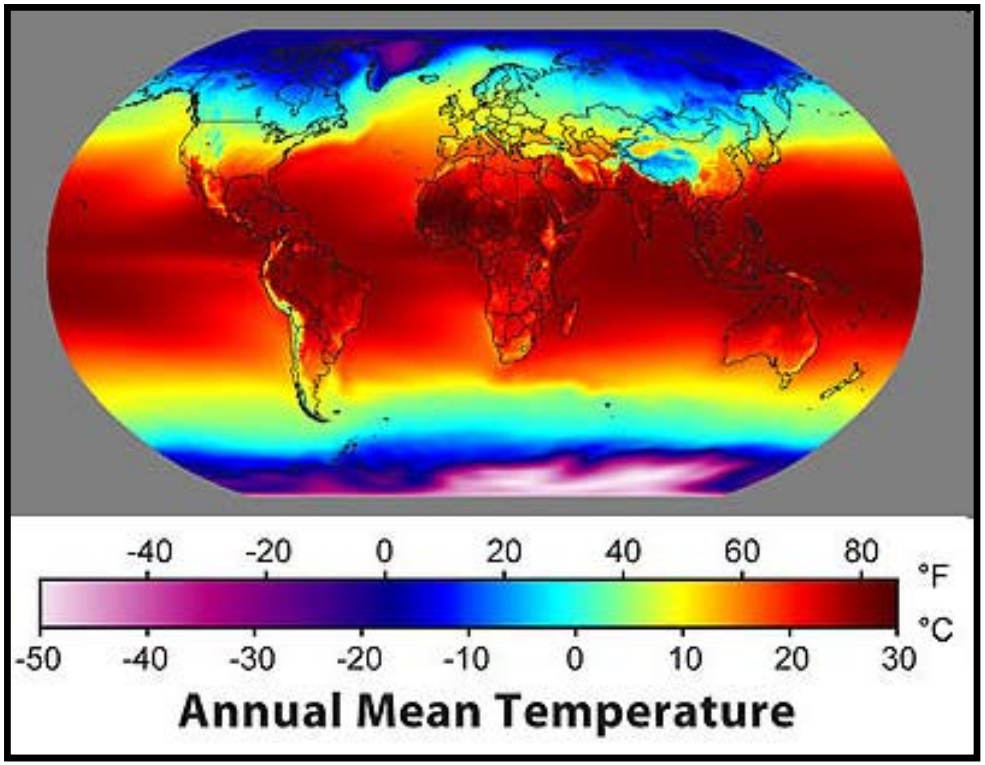
2. Know the different ways we average **TEMPERATURE** data and what they are used for.

3. Understand how and why **LAND** surfaces and **OCEAN** surfaces heat up and cool down differently.

Air Temperature –why it's important

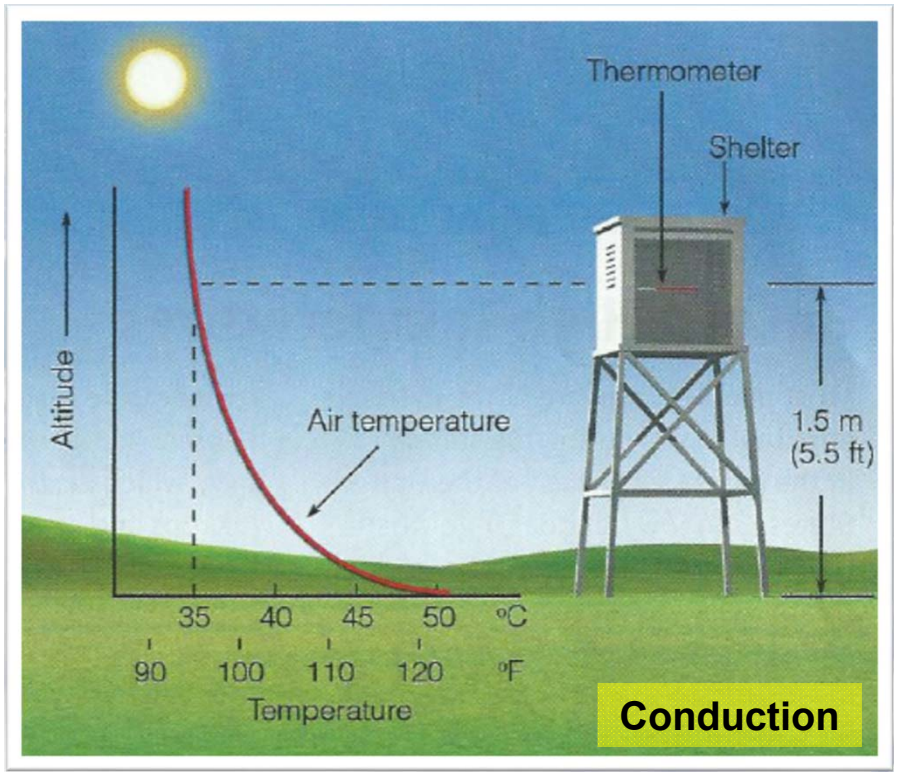
- It's the **first thing** we usually think about when we talk about "weather"

- **Temperatures vary on different time scales**
  - Seasonally, daily and even hourly

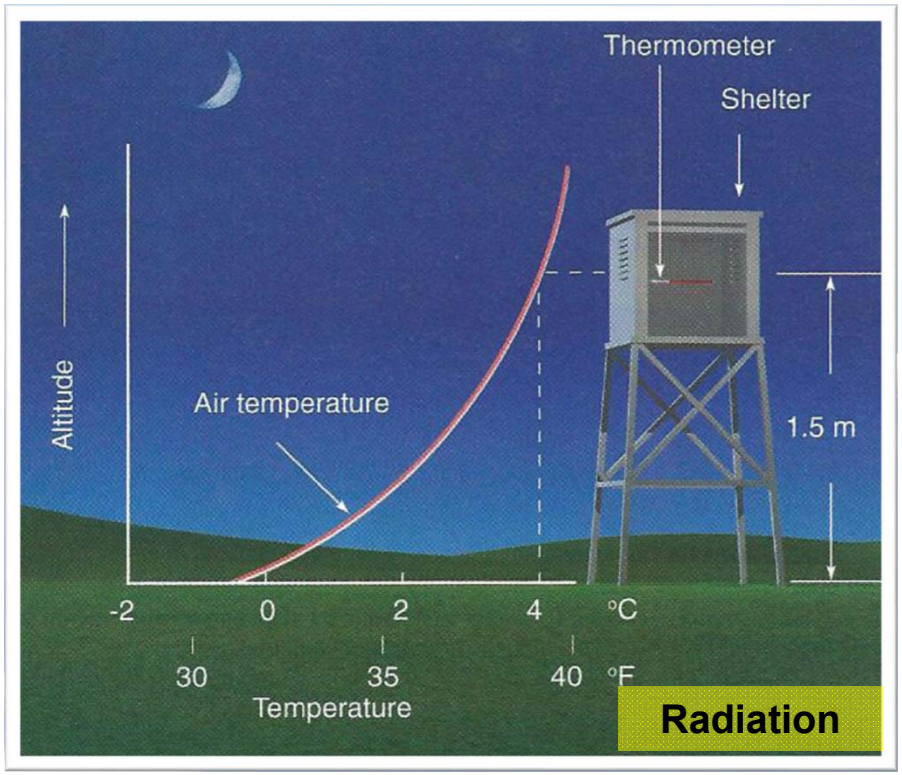


- Temperatures vary all over the globe, by quite a bit.

Air Temperature – Day vs. Night



- On a sunny calm day, the air near the **surface can be substantially warmer** than air a meter or so above the surface.



- On a clear, calm night, the air near the **surface is much colder** than the air above. This is called a **temperature inversion**.

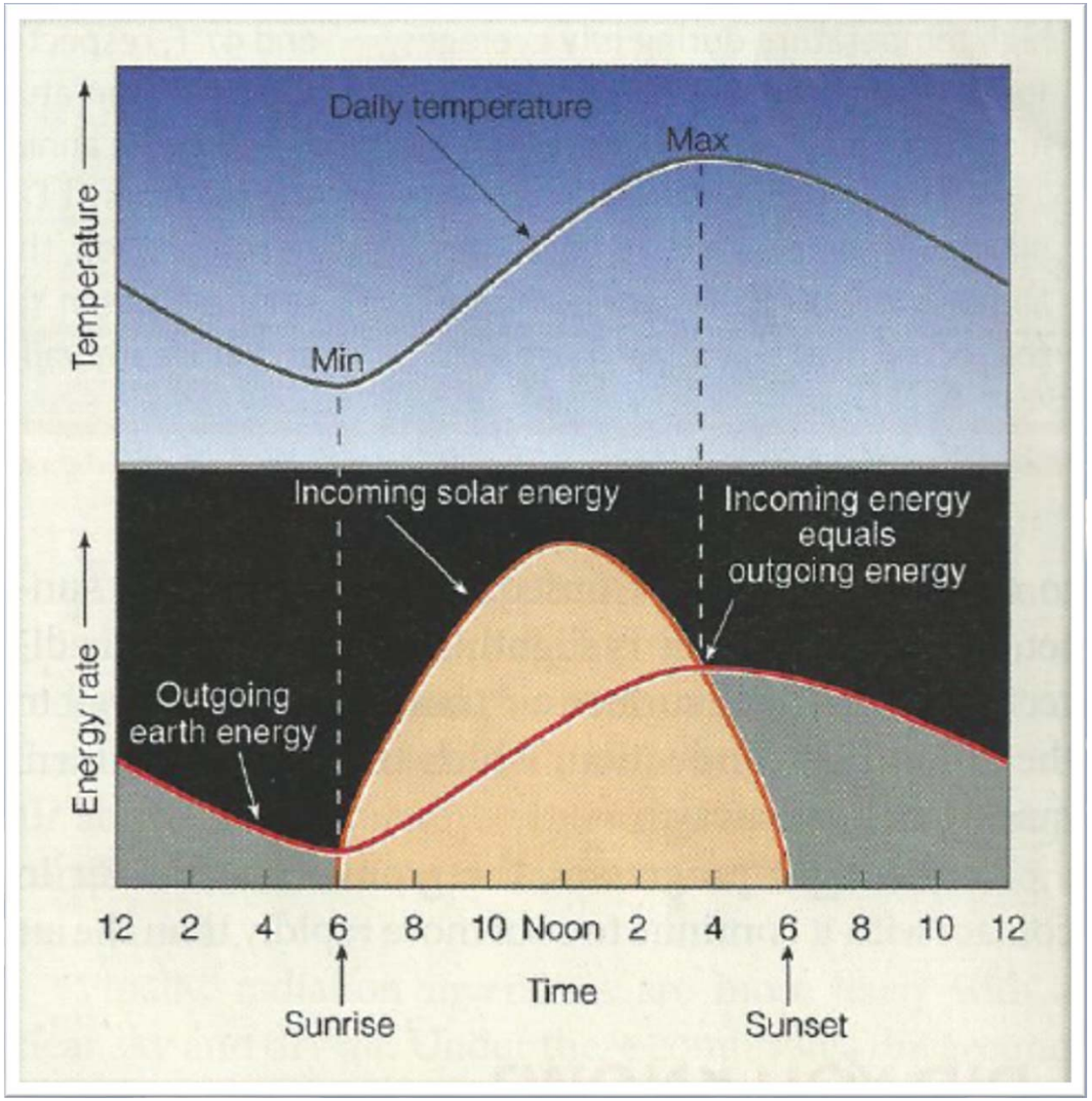
Daily Variations in Temperature

- **Minimum right before sunrise**

No heat from sun, lots of IR energy radiated during night

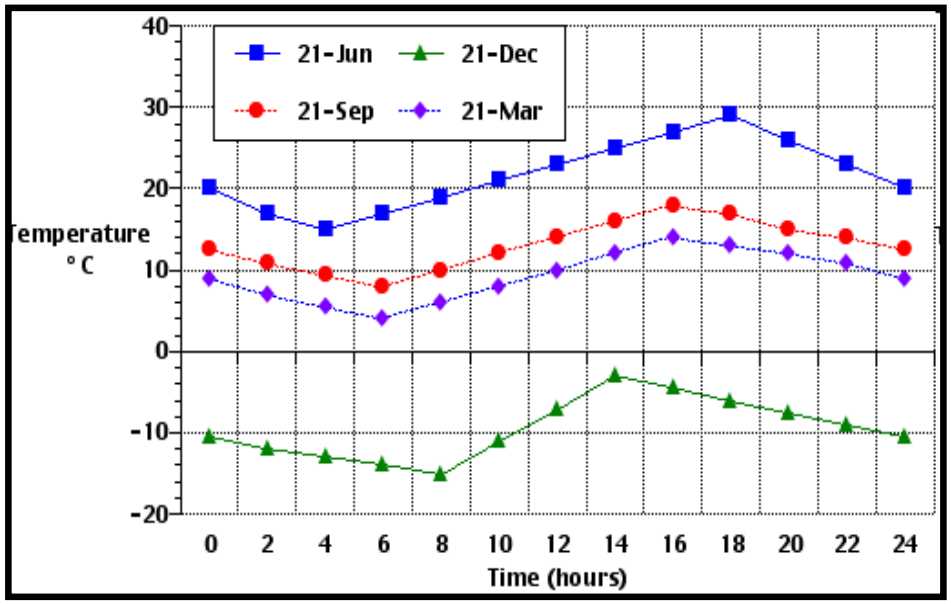
- **Maximum after noon (peak)**
  - In = Out

Heat from sun + IR radiated up from the surface



Air Temperature

- **Daily Mean Temperature**
  - Average of 24 hourly readings
  - Adding maximum and minimum and dividing by two.



- **Example**

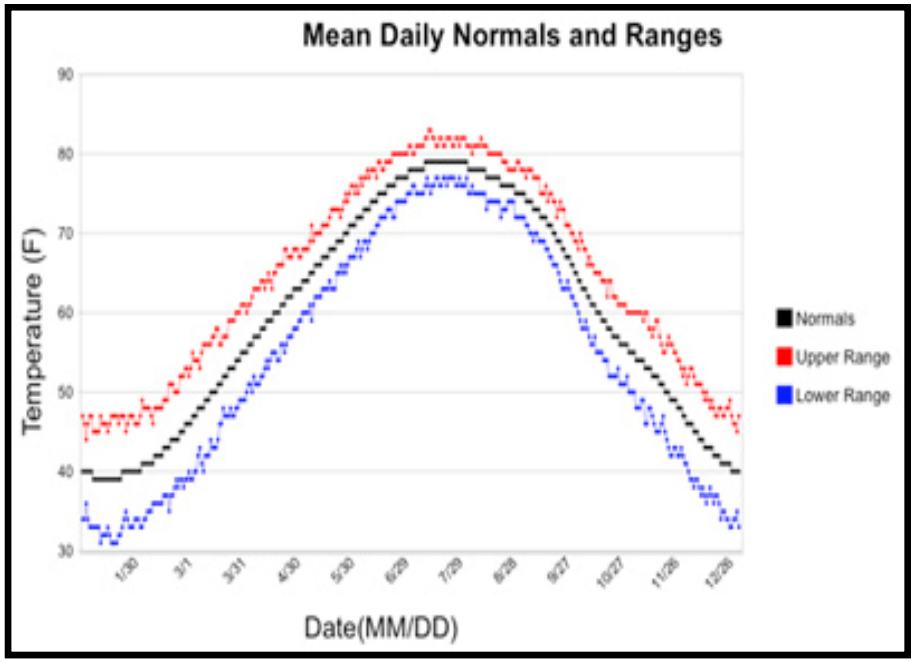
Maximum Temperature: **96**

Minimum Temperature: **42**

Daily Mean Temperature: (**96** + **42**)/2 = **69**

Air Temperature

- **Daily Temperature Range**
  - The difference between the maximum and minimum daily temperatures



- **Example**

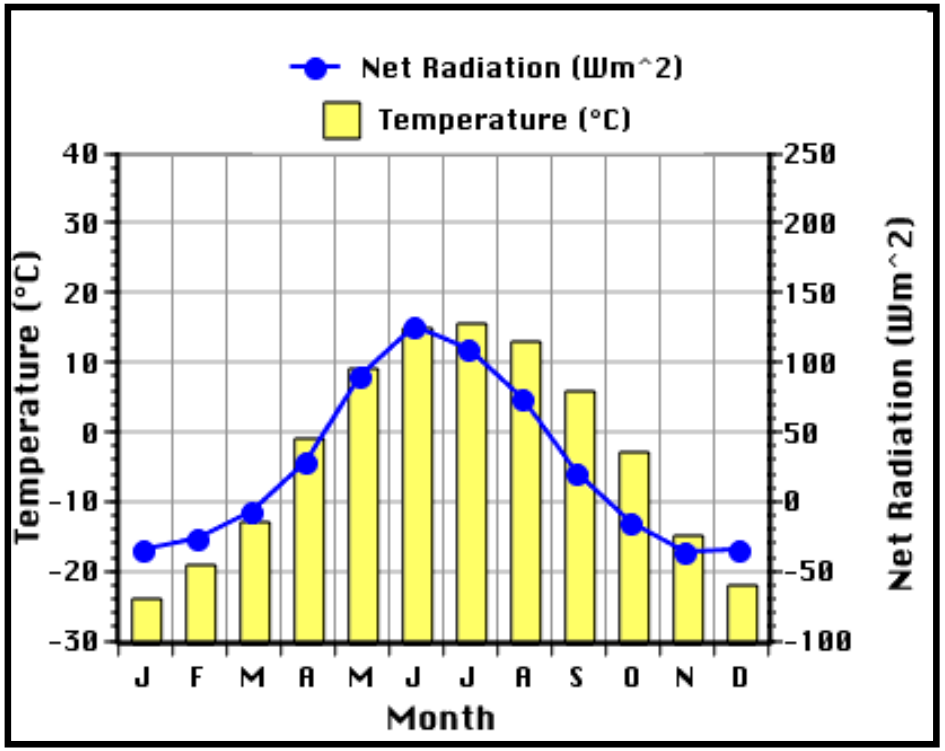
Maximum Temperature: **96**

Minimum Temperature: **42**

Daily Temperature Range: (**96** - **42**) = **54**

Air Temperature

- **Monthly Mean Temperature**
  - Adding together the daily means for each day of a month and then dividing by the number of days in that month



- **Example**

Sum of Daily Means: **1216**

Number of Days: **28**

Monthly Temperature Mean: (**1216/28**) = **43.4**

Air Temperature

- **Annual Mean Temperature**
  - Adding together the monthly means and dividing by 12
- **Example**

Sum of Monthly Means: **766**

Number of Months: **12**

Annual Mean Temperature: (**776**/**12**) = **63.8**

Annual Means
January: 49
February: 47
March: 52
April: 60
May: 69
June: 75
July: 80
August:: 83
September: 76
October: 65
November: 58
December 52

Air Temperature

- **Annual Temperature Range**
  - The difference between the warmest and coldest monthly mean temperatures

- **Example**

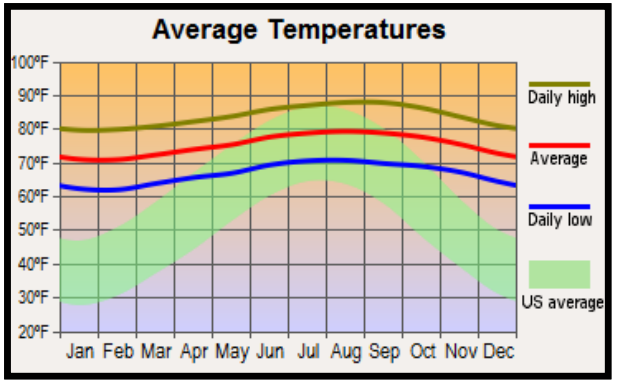
Warmest Monthly Mean Temperature: **95**

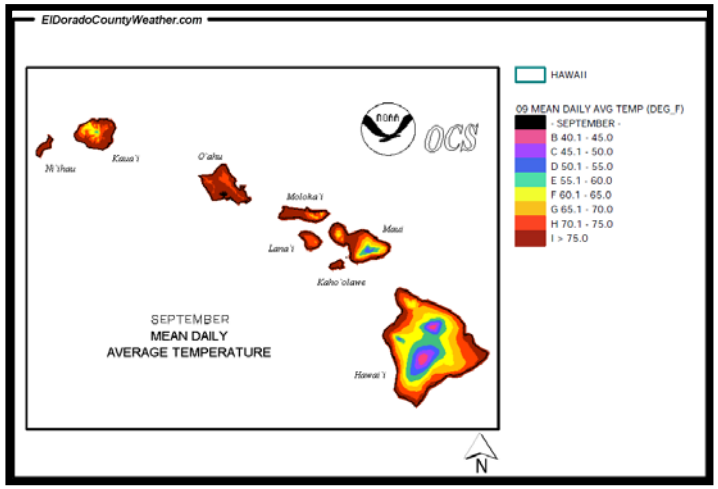
Coldest Monthly Mean Temperature: **25**

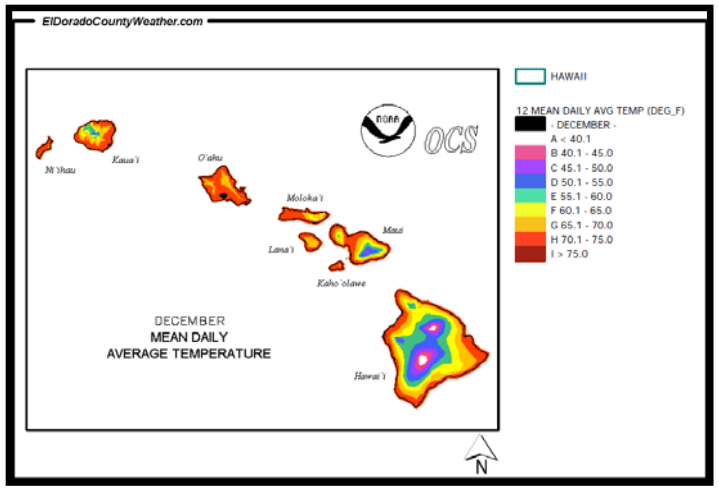
Annual Temperature Range: (**95** - **25**) = **70**

What controls air temperature?

- Differential Heating of Land and Water
- Ocean Currents
- Altitude
- Geographic Position & Prevailing Winds
- Cloud Cover and Albedo

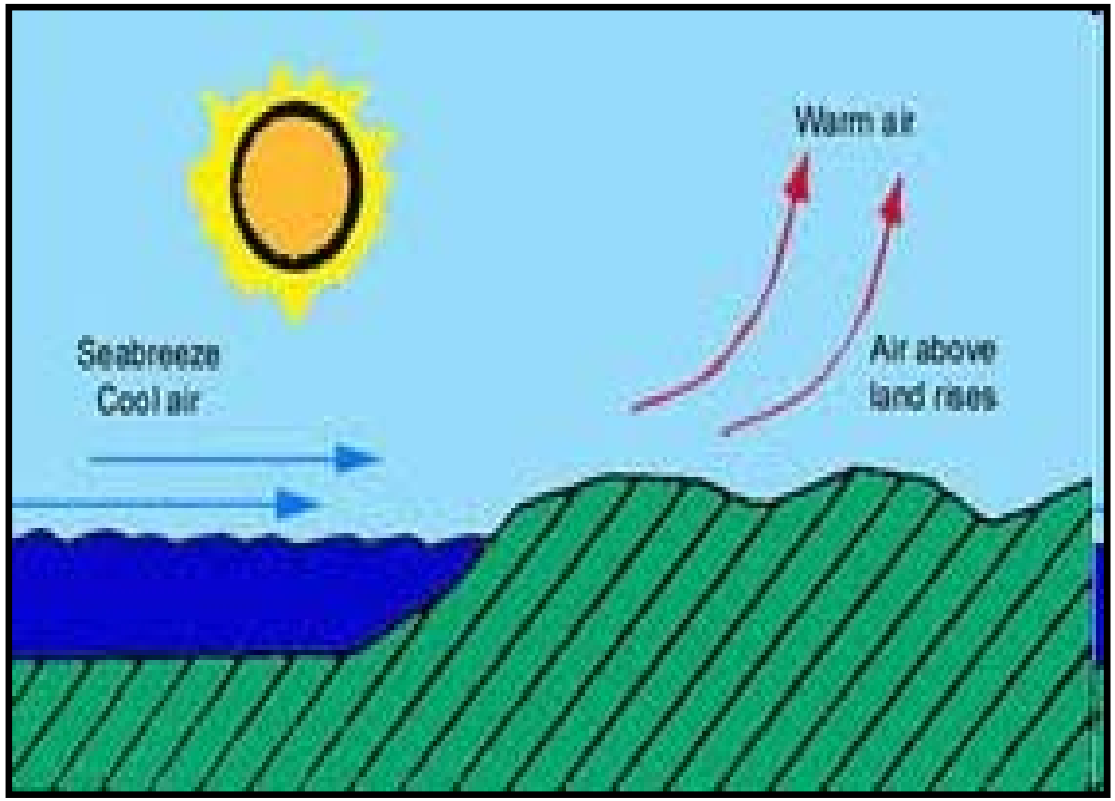


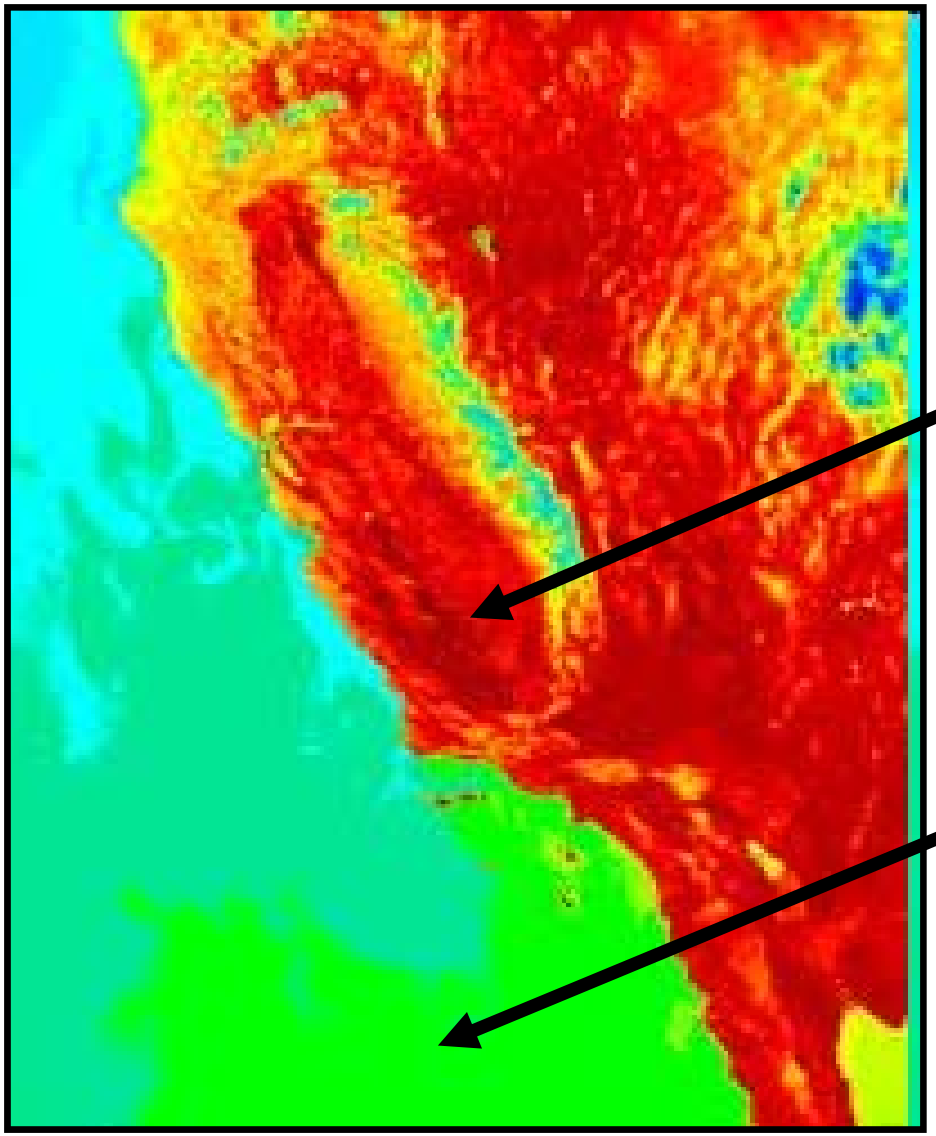




Land and Ocean – Differential Heating

- **Different surfaces absorb, emit and reflect different amounts of energy.**
  - Things like asphalt get warmer than grass
  - Things like snow reflect light while black soil absorbs energy
  - This causes variations in air above each surface





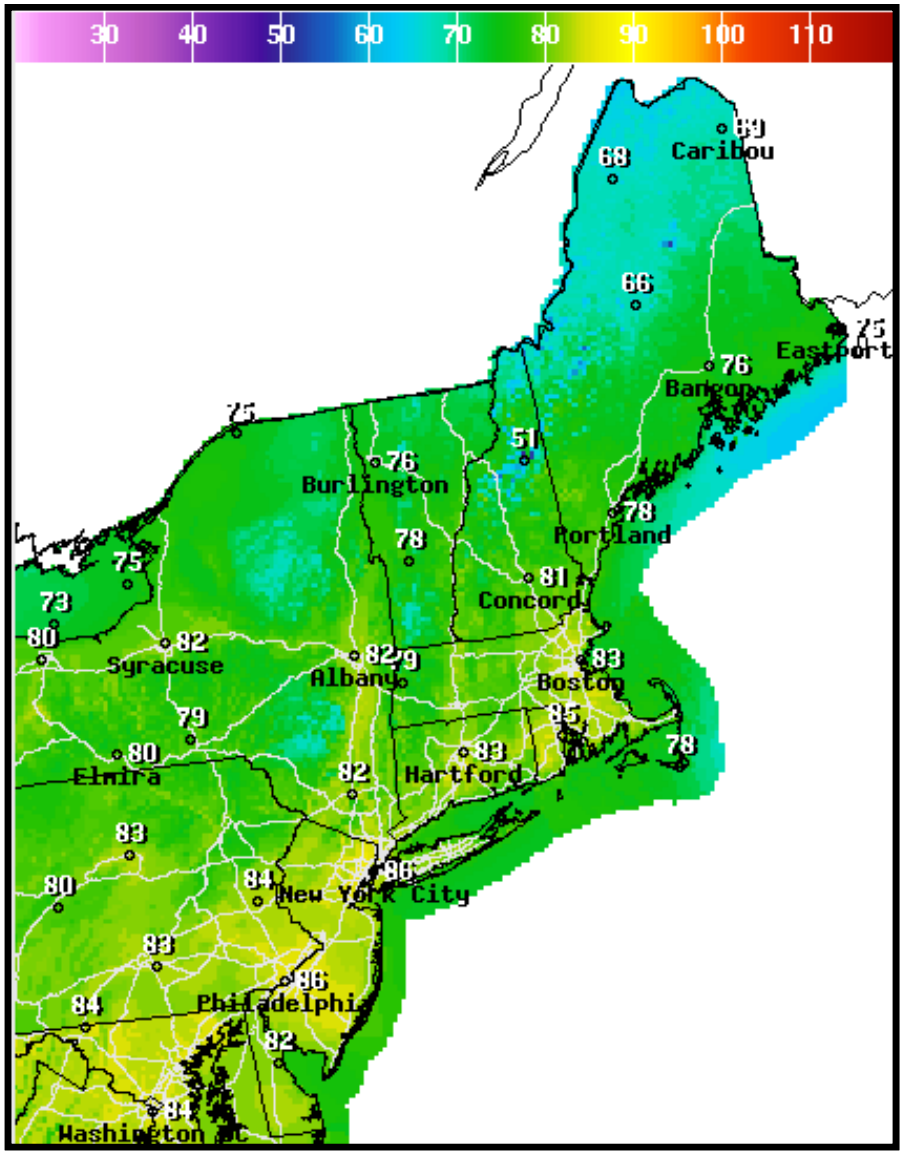
Land and Ocean – Differential Heating

- **In general:** Land **HEATS** more rapidly and to **HIGHER** temperatures than Water.

- **In general:** Land **COOLS** more rapidly and to **LOWER** temperatures than Water.

Land and Ocean – Differential Heating

- Variations over **Land** are **GREATER** than variations over the **Ocean**!!!
  - The land surface has more variety….
    - Trees
    - Streets
    - Buildings
    - Fields
    - Houses….



Ocean

Why is it less variable?

1. Surface temperature of water **rises and falls slower** than land

2. Water is highly **mobile and mixes easily** (think mixing red and blue dye… turns purple)

3. **Daily** changes are about **6 meters deep**

4. **Yearly** ocean and deep lakes experience variations through a layer between **200-660 m thick**!

Land

Why is it more variable?

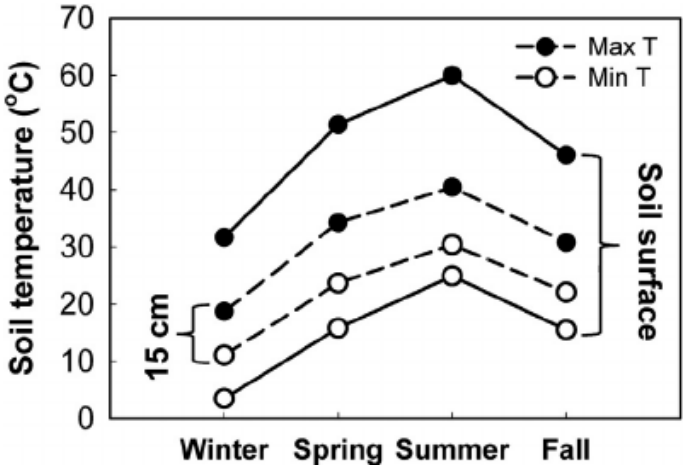
1. **Heat** does not penetrate deeply into soil or rock; it **remains near the surface**.

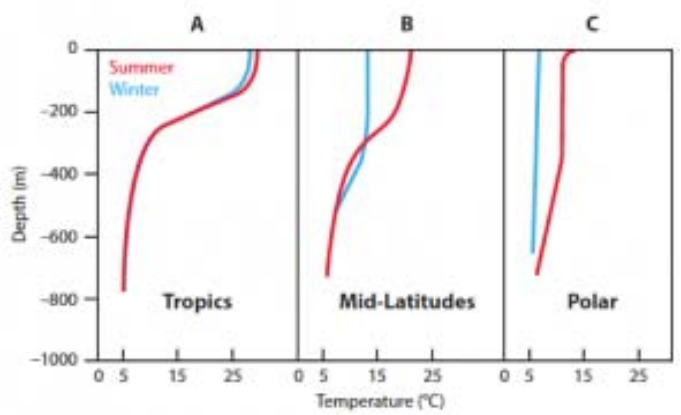
2. Rocks are not fluid… so **no mixing**

3. **Daily** temperature changes are seen only **10 cm down**

4. **Yearly** temperature changes reach only **15 meters or less**

Land and Ocean – Summer vs. Winter



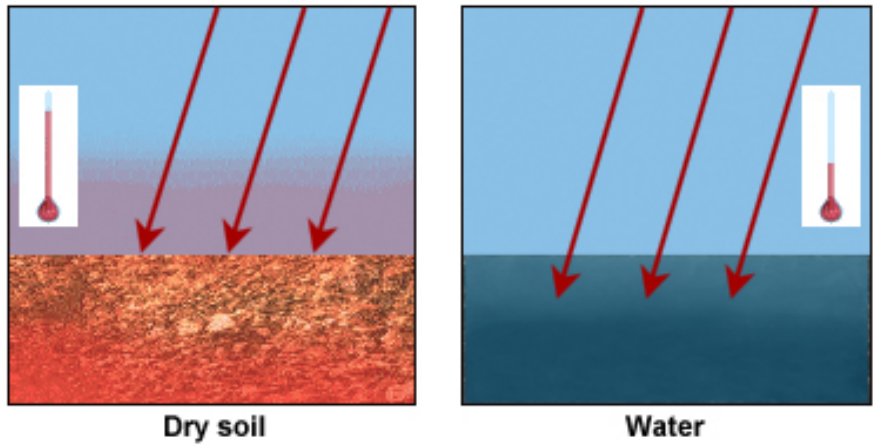


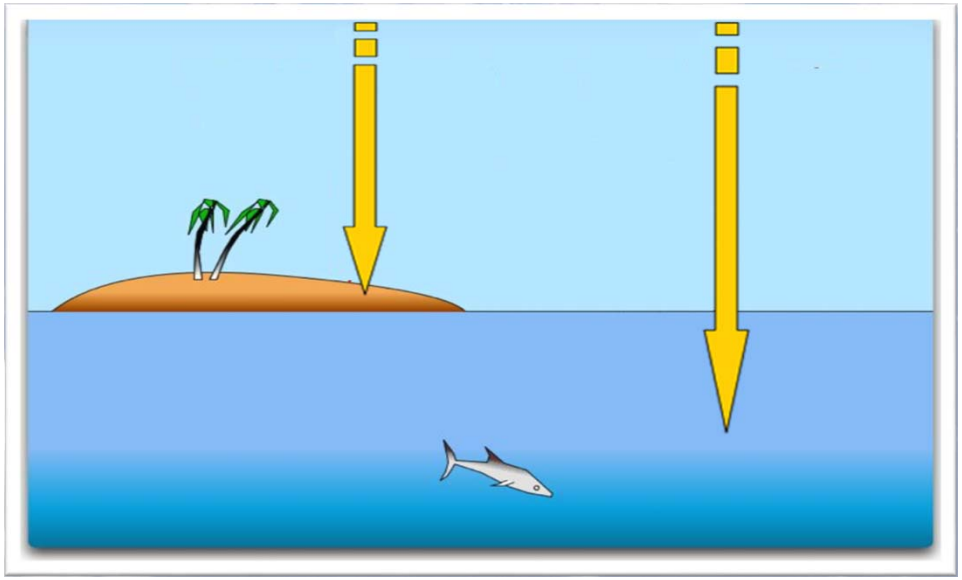
- During summer a **thick** layer of **water** is heated while only a **thin** layer of **land** is heated.
- During winter the **shallow** layer of **rock** cools rapidly while the **deeply** heated **water** takes a longer time to cool.
  - as surface water cools it becomes **heavier and sinks**, replaced with warmer less dense water from below….
    - **This means the surface temperature of water doesn't appear to change much**

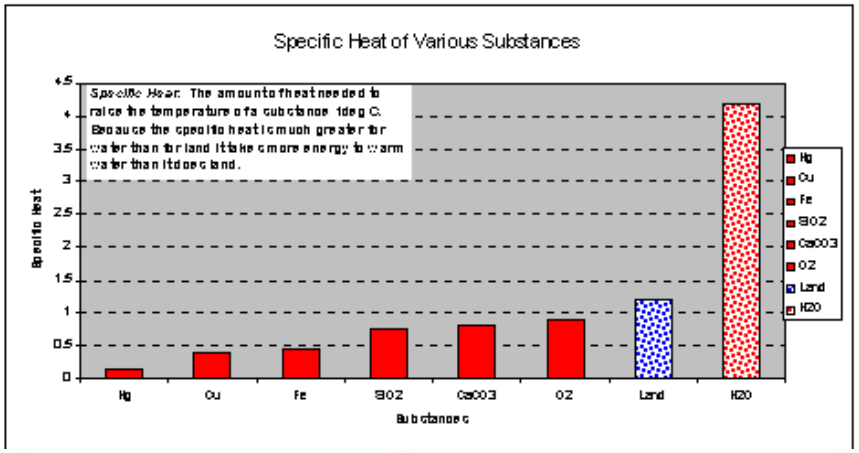
Land and Ocean – opaque vs. transparent

- Because land surfaces are **opaque** **heat is absorbed** only at the **surface**

- Water is **transparent** and lets energy from the sun **penetrate** to a depth of several meters







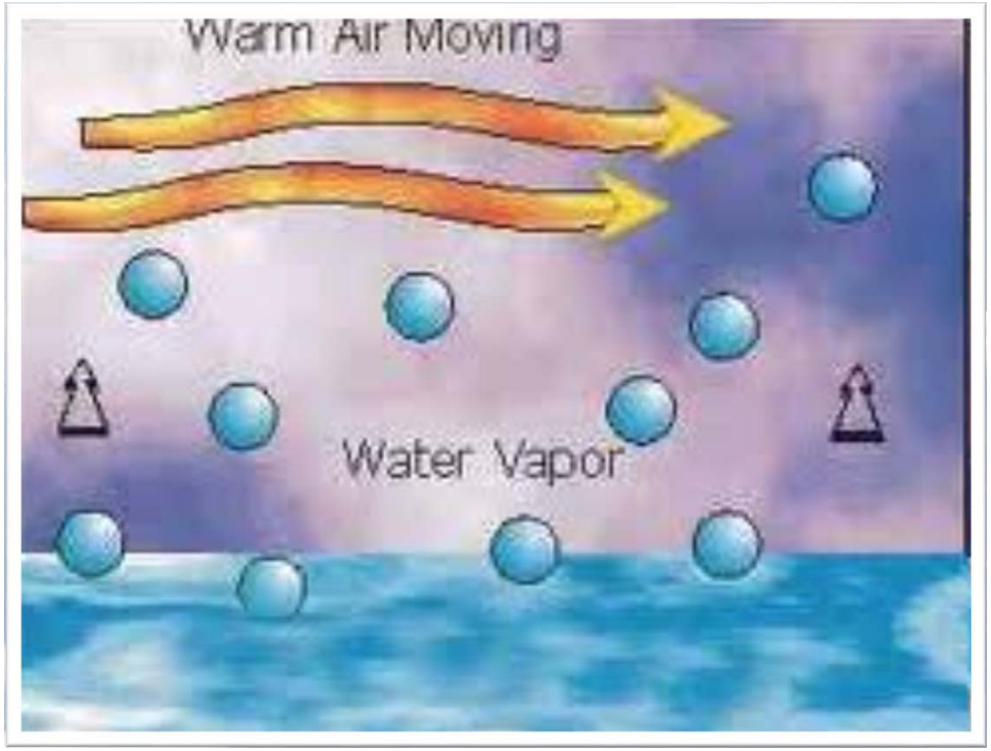
MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

Land and Ocean – Specific Heat

- **Specific heat**
  - Is the amount of heat needed to raise the temperature of 1 gram of a substance by 1 degree Celsius.
  - It is **greater** (~3 times) for water than to do the same for 1 gram of soil/rock.
- The **OCEANS** require **MORE** heat to raise its temperature the same amount as an equal quantity (grams) of land.

Land and Ocean – Evaporation

- **Evaporation** is greater from **Oceans** than from **Land**
  - There's more water molecules ☺
  - Energy is required to evaporate water
  - When energy is used to evaporate water it is not available for heating.



WATER WARMS MORE SLOWLY THAN LAND!!

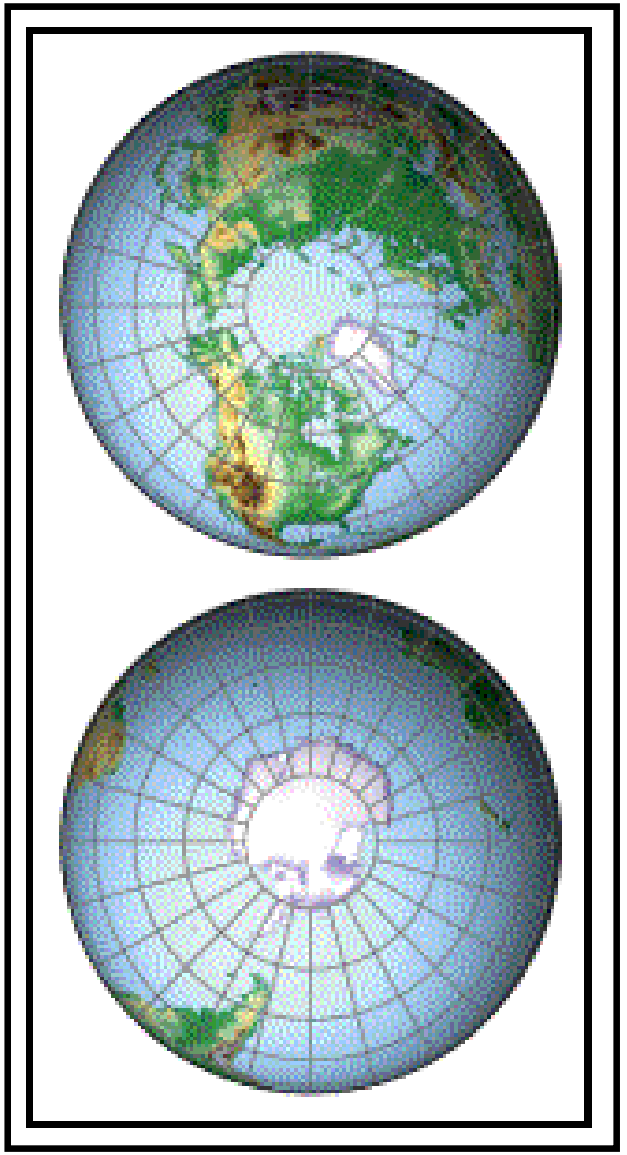
Class Question??

- Which Hemisphere (north or south) has larger temperature variations?

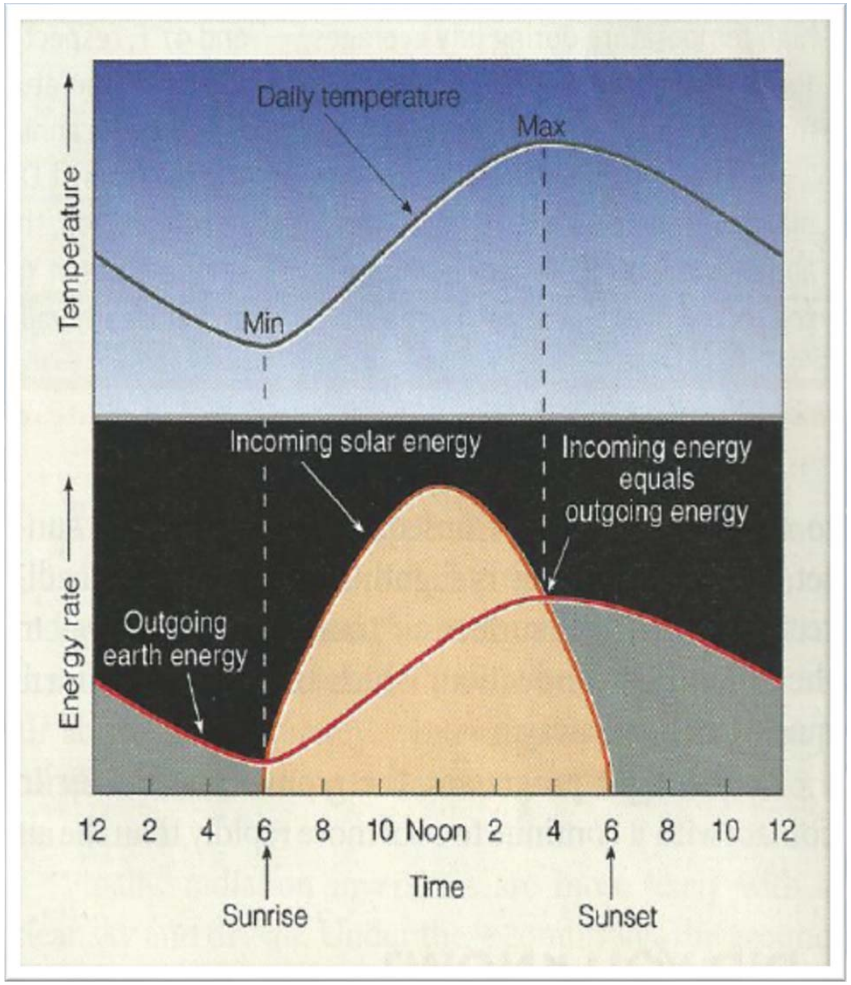
The Northern Hemisphere has greater variations in temperature than the Southern Hemisphere

- Why??

There is more ocean than in the Southern Hemisphere. There is little land to interrupt the oceanic and atmospheric circulation. Thus, the SH has smaller variations in temperature.



Key Information 1



1. Understand why and how temperature changes over a **24 HOUR PERIOD**.

- **Minimum right before sunrise**

No heat from sun, lots of IR energy radiated during night

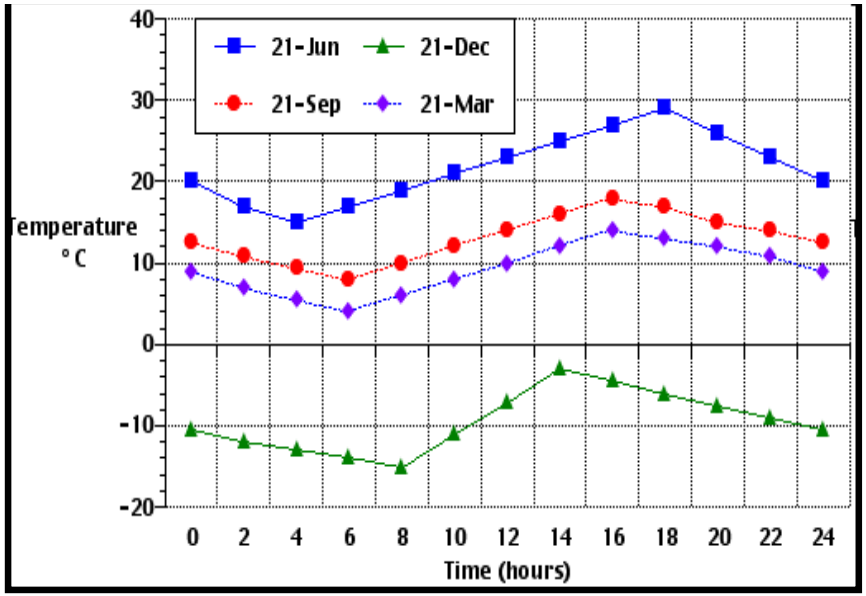
- **Maximum after noon (peak)**
  - In = Out

Heat from sun + IR radiated up from the surface

Key Information 2

2. Know the different ways we average **TEMPERATURE** data and what they are used for.

- Daily Mean Temperature
  - Gives us an idea of the average daily temperature
- Daily Temperature Range
  - Tells us how big a difference there is between the warmest part of the day and coldest part of the day
- Monthly Mean Temperature
  - Give us an idea of the temperature we'd experience in a certain month
- Annual Mean Temperature
  - Gives us an idea what the average temperature (think climate) is of a certain location. This essentially averages all the seasons together.
- Annual Temperature Range
  - Gives us an idea how different the warmest and coldest months are.



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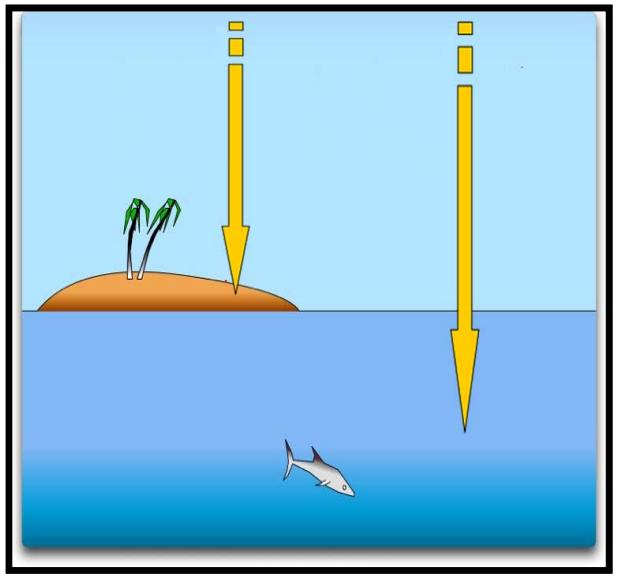

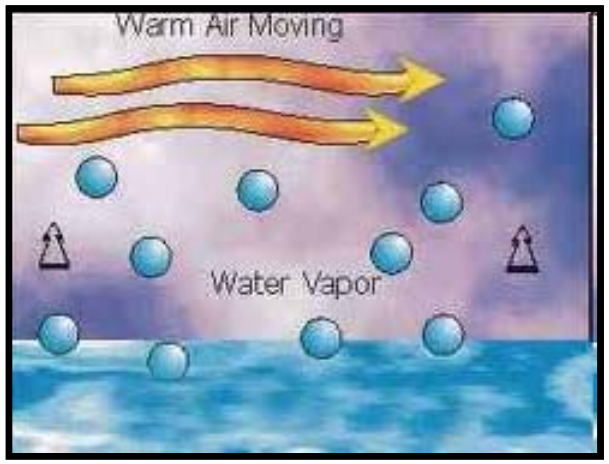

3. Understand how and why **LAND** surfaces and **OCEAN** surfaces heat up and cool down differently.

- **Differential Heating**
  - Land heats up and cools off faster
  - Ocean heats up and cools off slower
  - Variations are greater over land
  - Land is NOT a fluid so there is no mixing
- **Opaque vs. Transparent**
  - Energy can reach deeper in the transparent ocean, spreading out the energy over a larger volume (so the ocean surface looks cooler)
- **Specific Heat of Water**
  - Oceans require more heat to raise its temperature to the same amount as an equal quantity of land
- **Evaporation**
  - Evaporation is greater from oceans than land