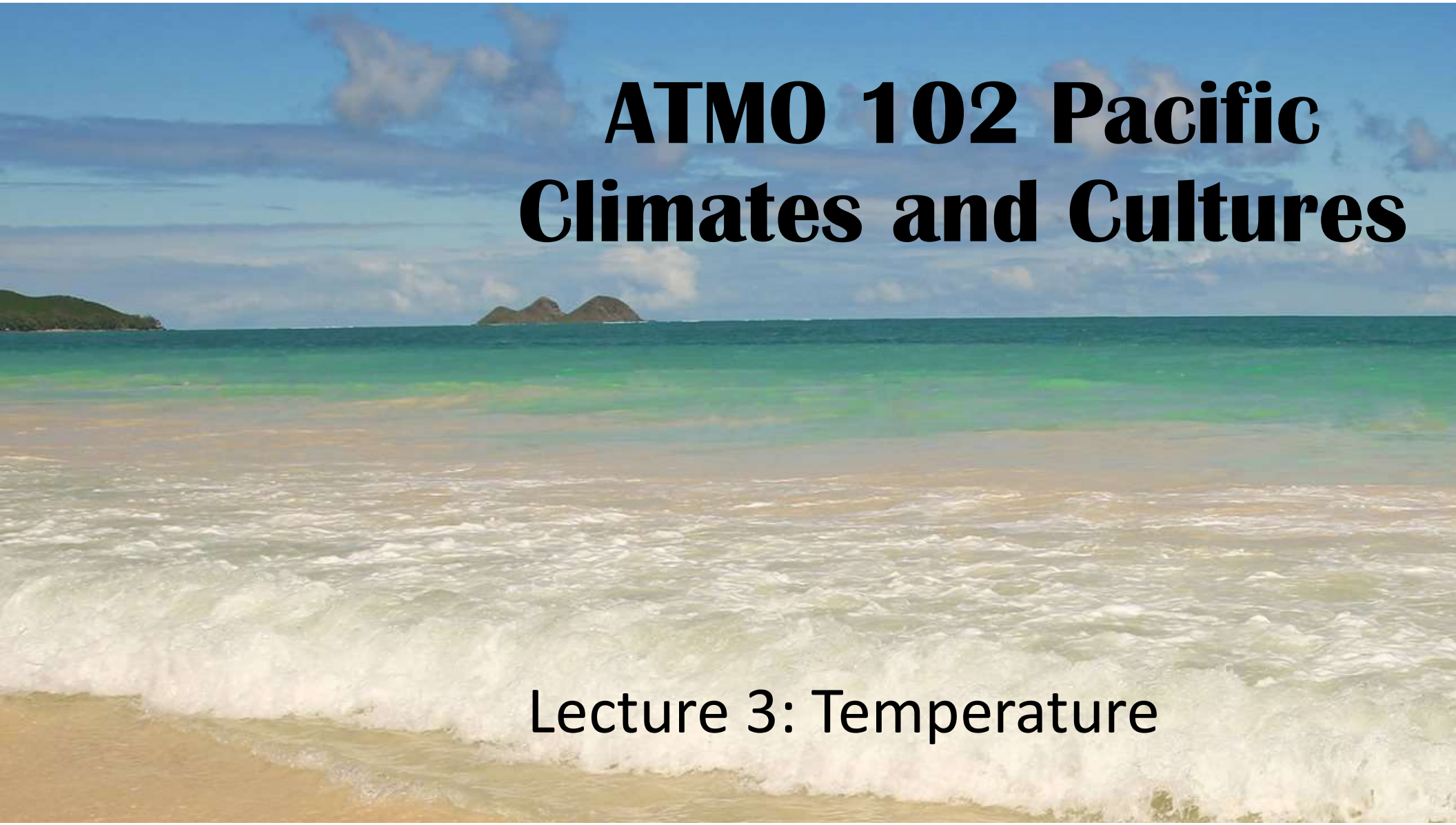
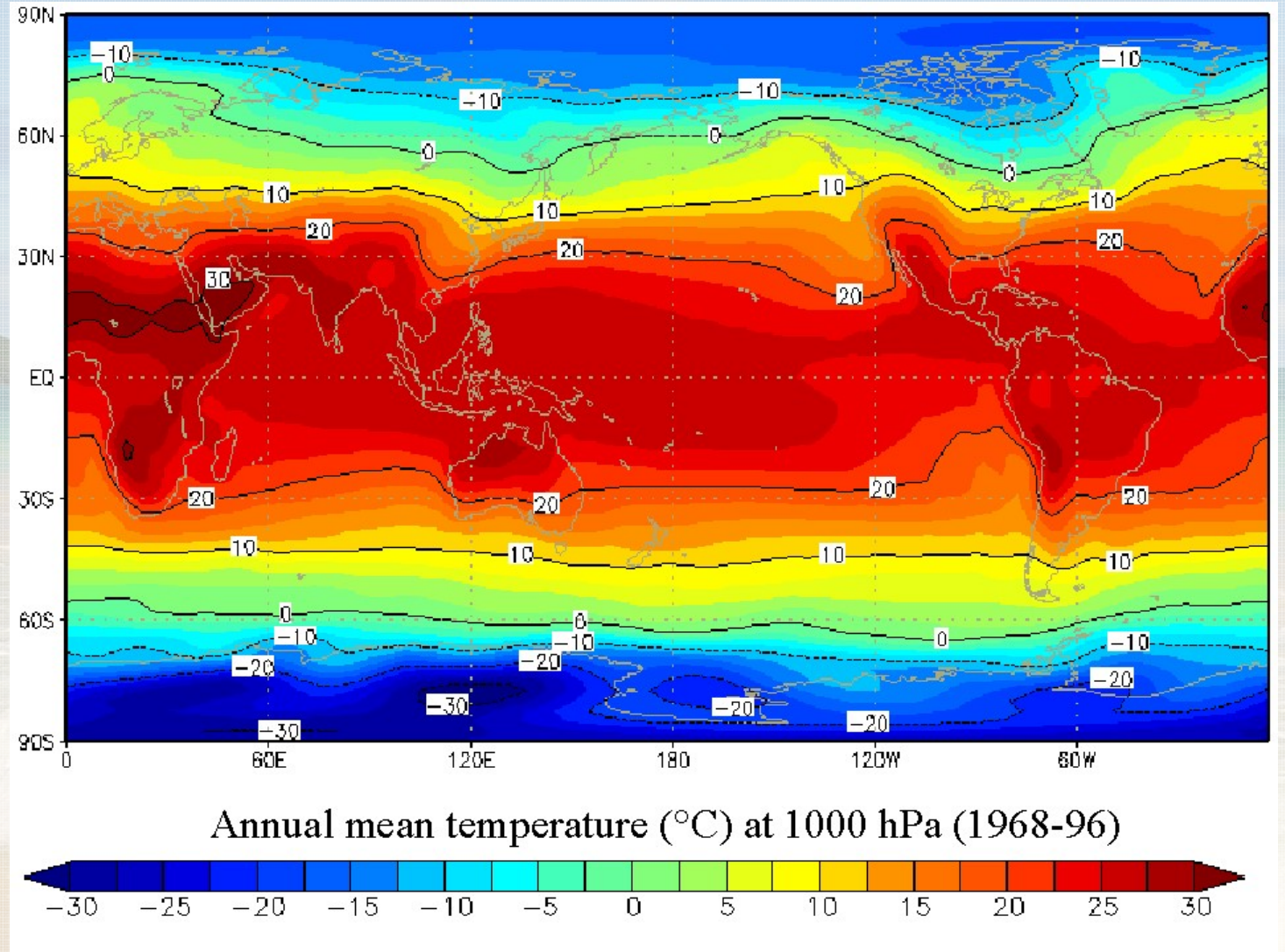


ATMO 102 Pacific Climates and Cultures

Lecture 3: Temperature

Horizontal Temperatures



- Warmer at the equator than at the poles
- Continents warmer than ocean at same latitude
- An island will be slightly warmer than the surrounding ocean

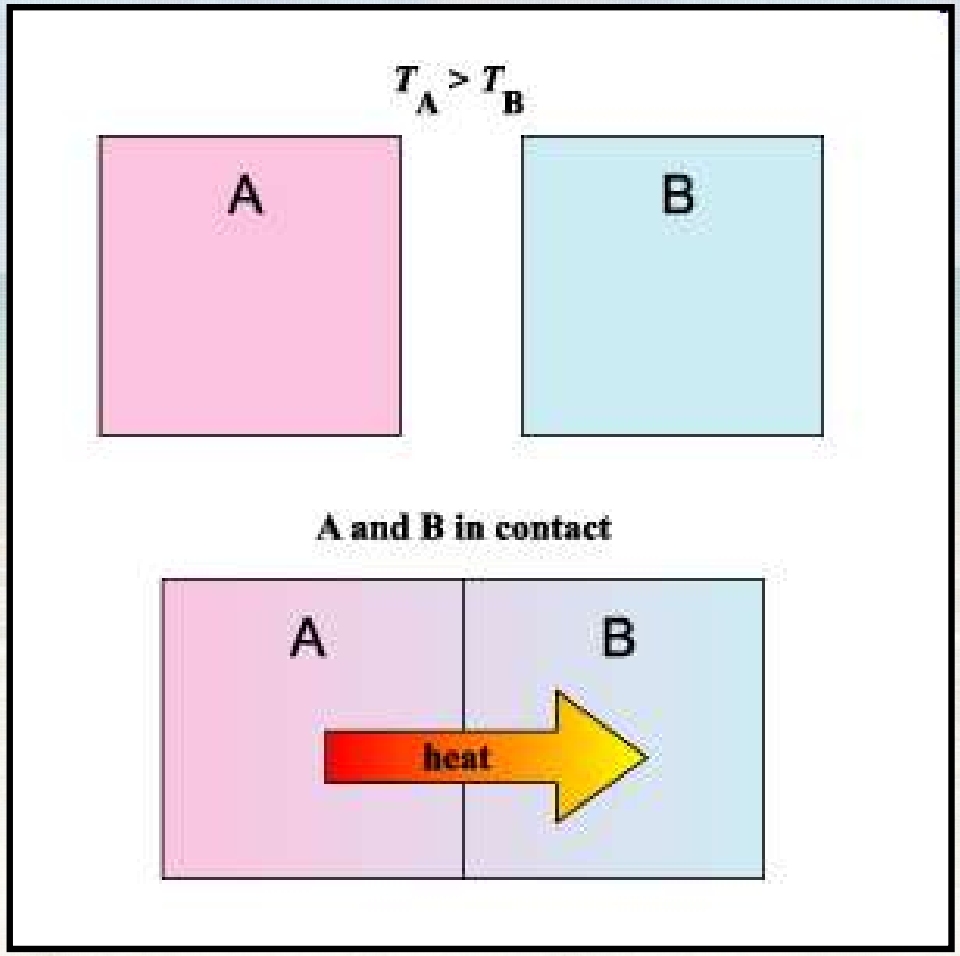
Heat vs. Temperature

- **HEAT** - The **TRANSFER** of energy into or out of an object because of **TEMPERATURE DIFFERENCES**

- It is the **FLOW** of energy!

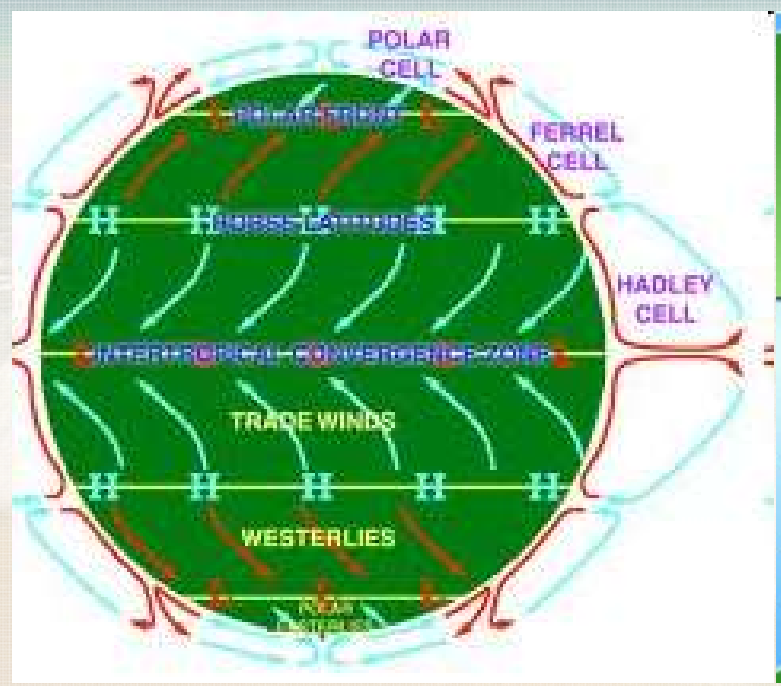
- After heat is transferred it is stored as **internal energy** in the molecules of the air and water (any type of matter).

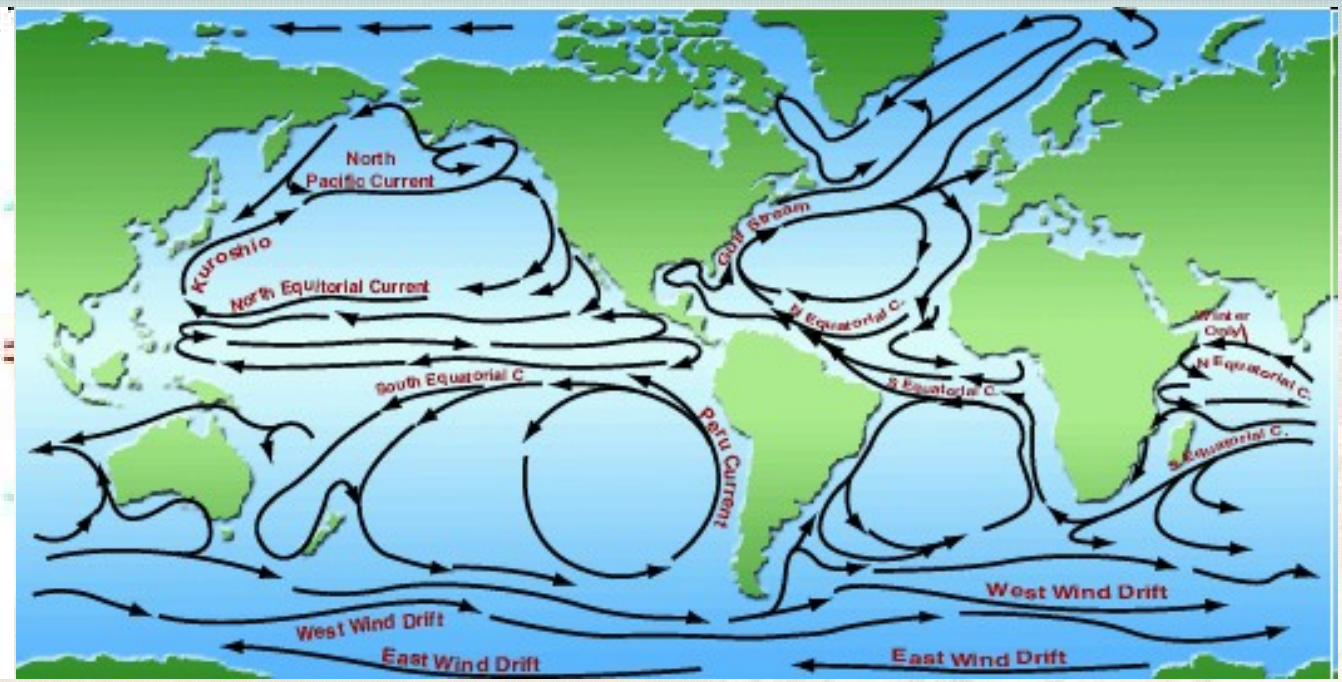
- **Why do we care for PCC?**
  - Movement of heat from the equator to the poles will play a role in both winds and ocean currents!



Winds and Ocean Currents

- Why and where the wind blows is related to the heat transfer from the Equator to the Poles
- The wind drives the ocean currents due to friction.

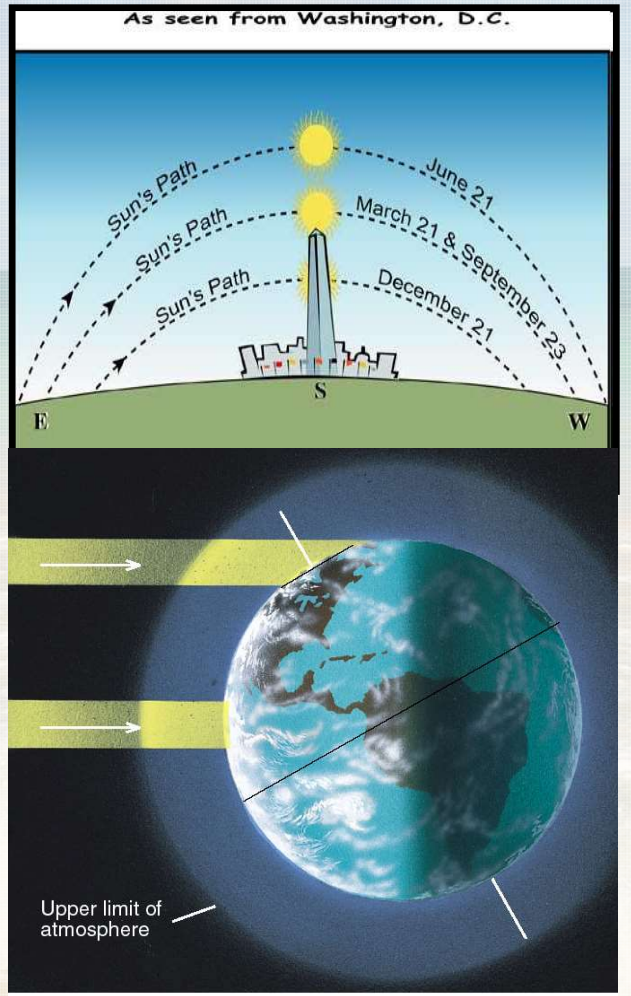




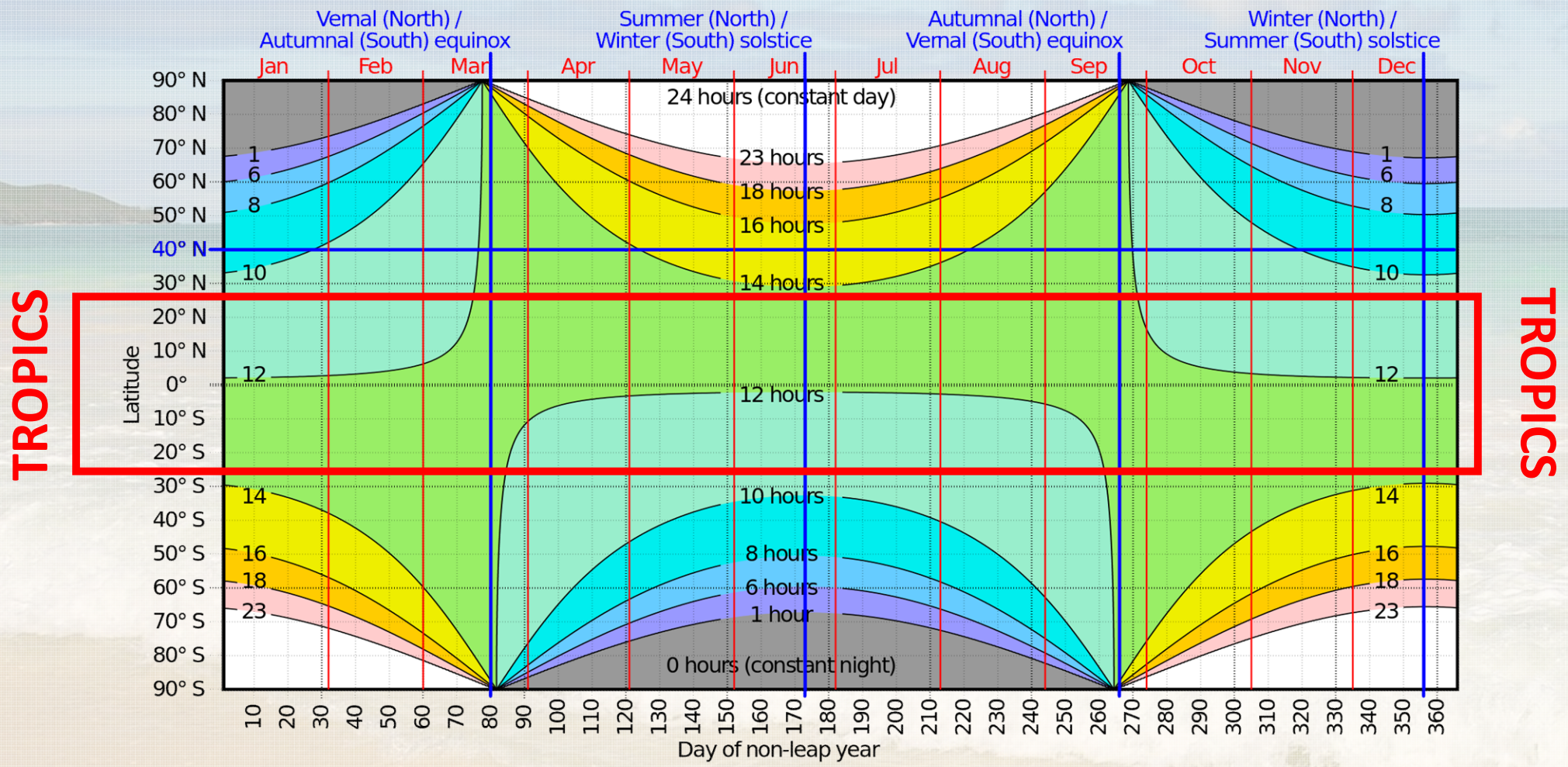
Seasons

- What are seasons? Why do some locations on earth have “stronger” seasons and others “weaker?”

- Seasons are primarily due to:
  - Change in the length of day accounts for some.
  - **Gradual change in the angle of the sun at noon.**
  - Affects the amount of energy received at Earth’s surface
    - When overhead → strongest
    - Lower angle → less intense

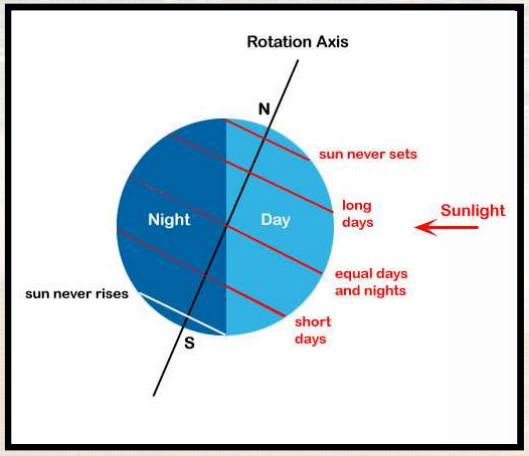


Hours of Sunlight



Length of Day, Sun angle and Seasons

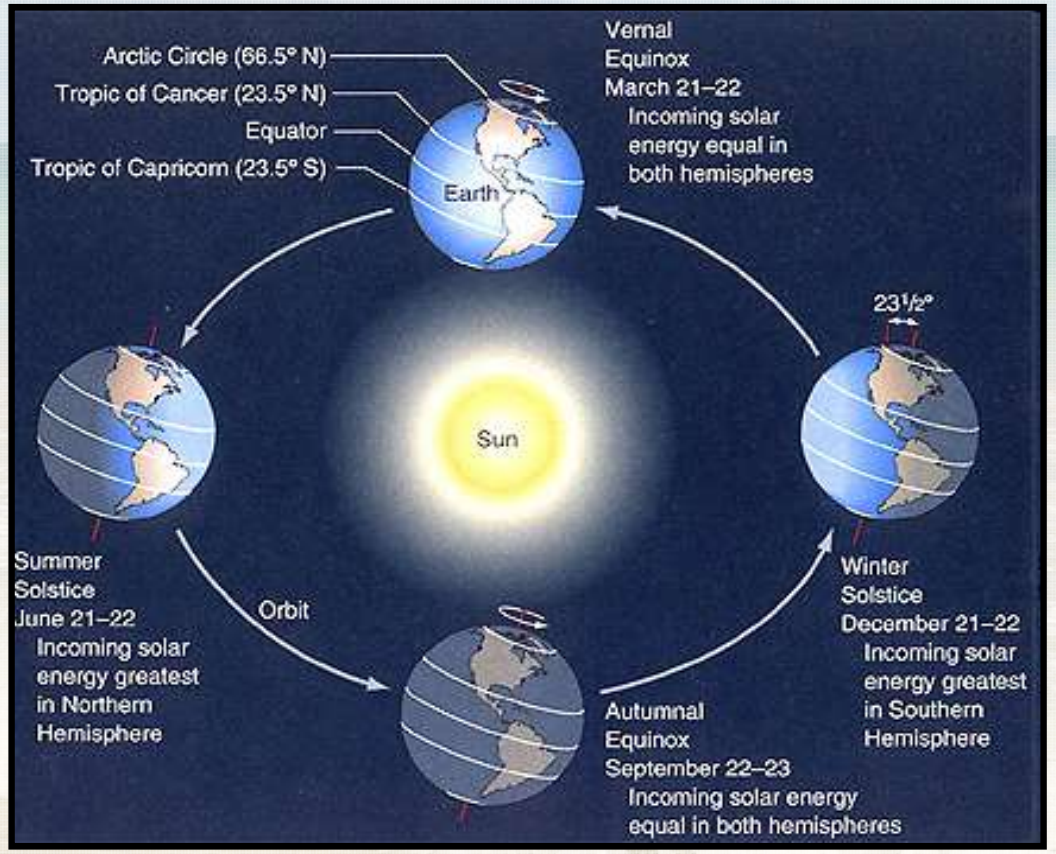
- Why does length of day and sun angle change?
  - Earth's orientation to the sun is constantly changing
- **The TILT of the Earth!!!**
  - 23.5 degrees
  - Without the tilt we wouldn't have seasons



More TILT = Strong seasons

Less TILT = Weaker seasons

No TILT = No Seasons

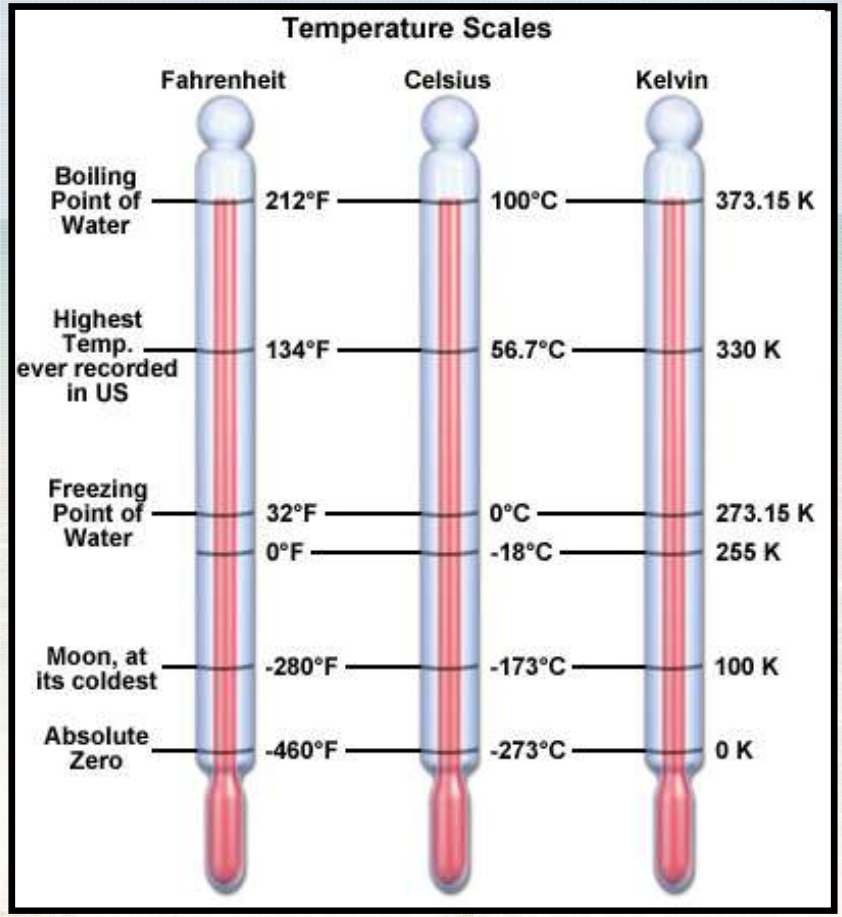


Measuring Temperature

- **Fahrenheit (°F)**
  - **Freezing is at 32** and **Boiling is a 212**.
  - 180 Divisions between Freezing and Boiling
  - We use this temperature scale here in the USA.

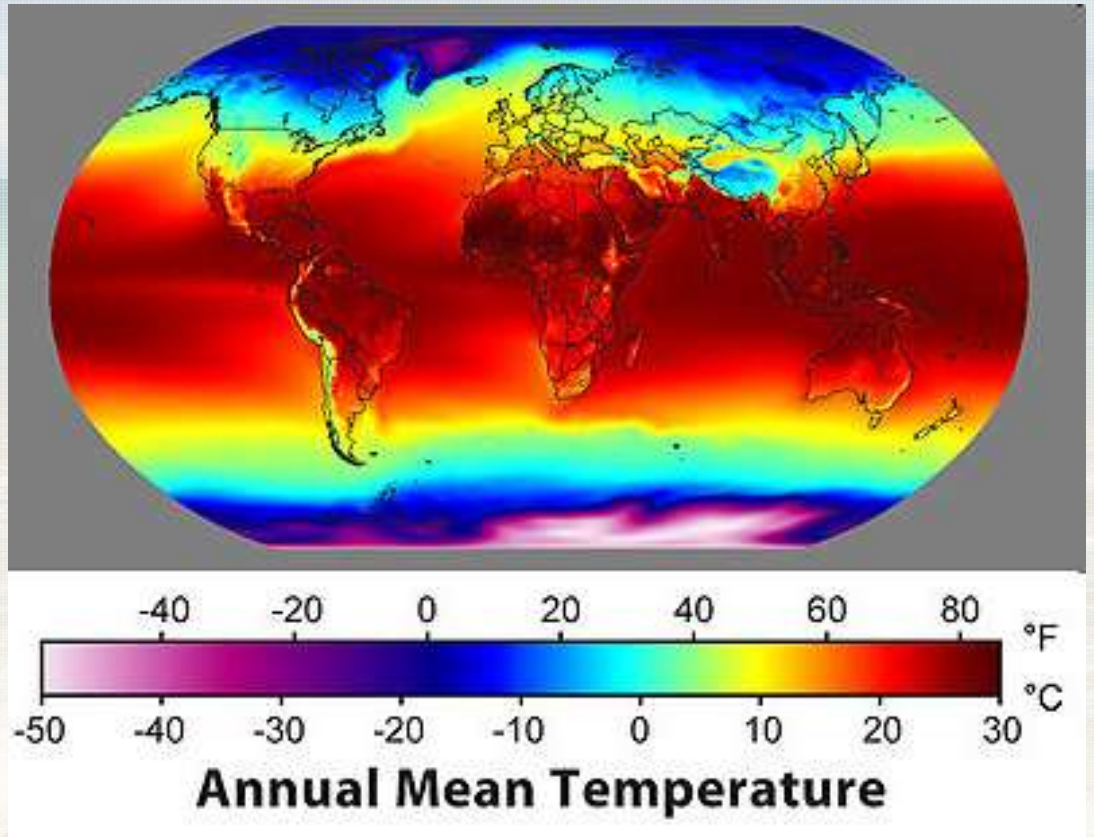
- **Celsius (°C)**
  - Decimal Scale (powers of 10)
  - **0 degrees = Freezing** and **100 degrees = Boiling**
  - 100 between Freezing and Boiling
  - Scientists use this.

- **Kelvin (K)**
  - Called the "**Absolute Scale**"
  - **Same Spacing as Celsius**
    - 100 divisions between boiling and freezing
  - 0 K = the temperature at which all molecular motion is presumed to cease
  - **Absolute Zero** = molecules stop moving, no thermal motion.

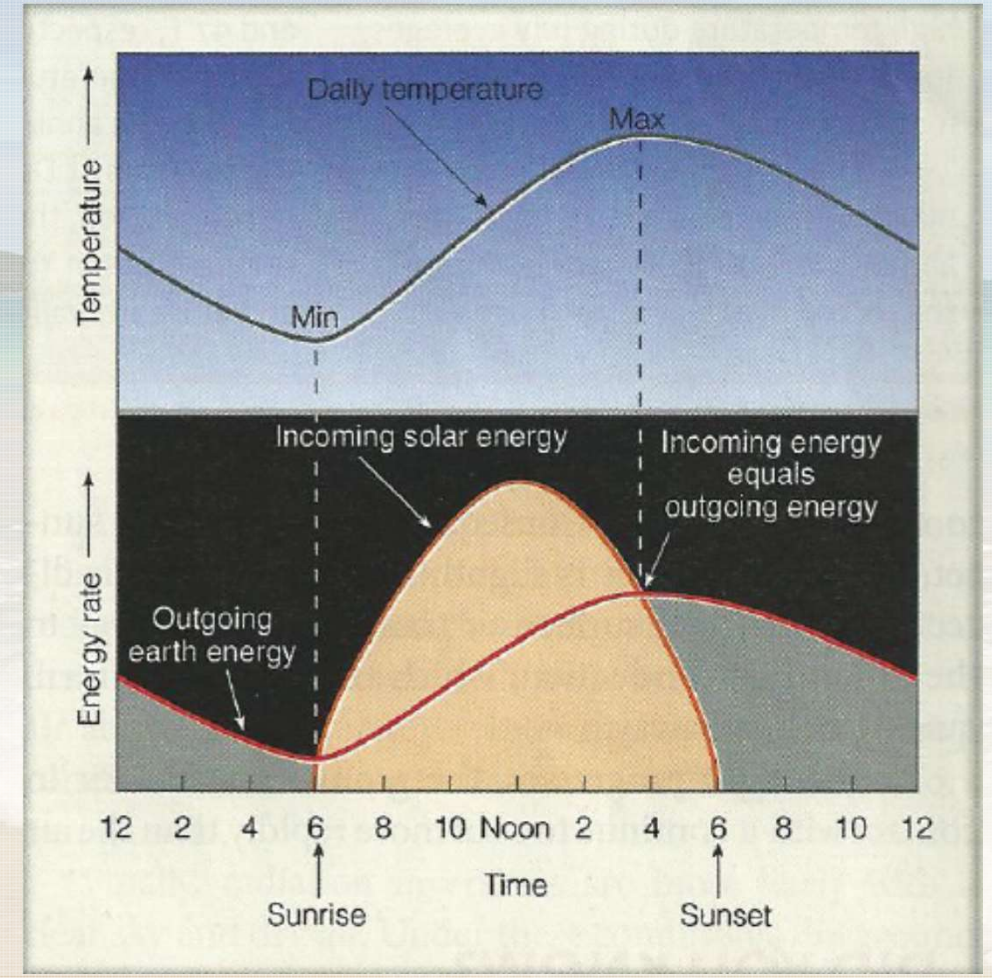


Global Temperatures

- 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



Daily Variations in Temperature



- Minimum right before sunrise

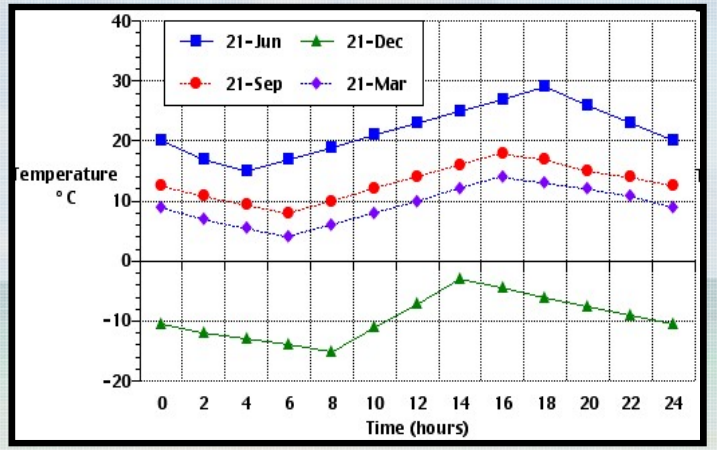
No heat from sun, lots of IR energy radiated during night

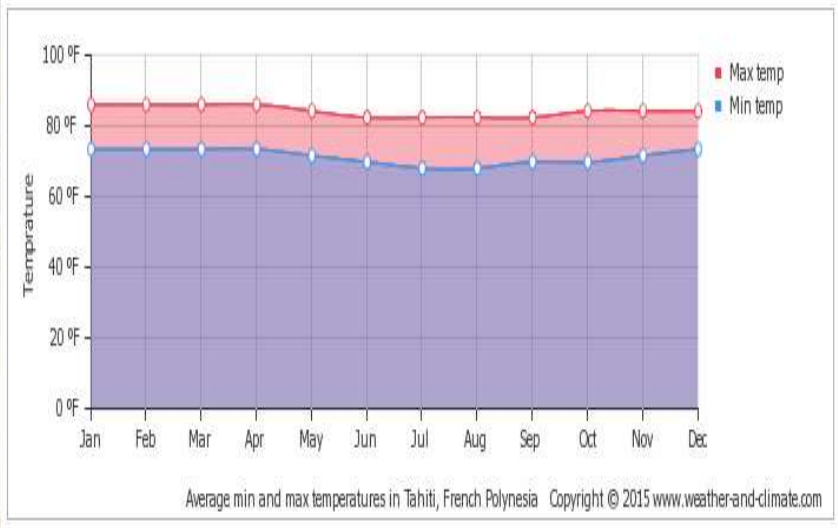
- Maximum after noon (peak)
  - In = out

Heat from sun + IR radiated up from the surface

Ways to average Temperature

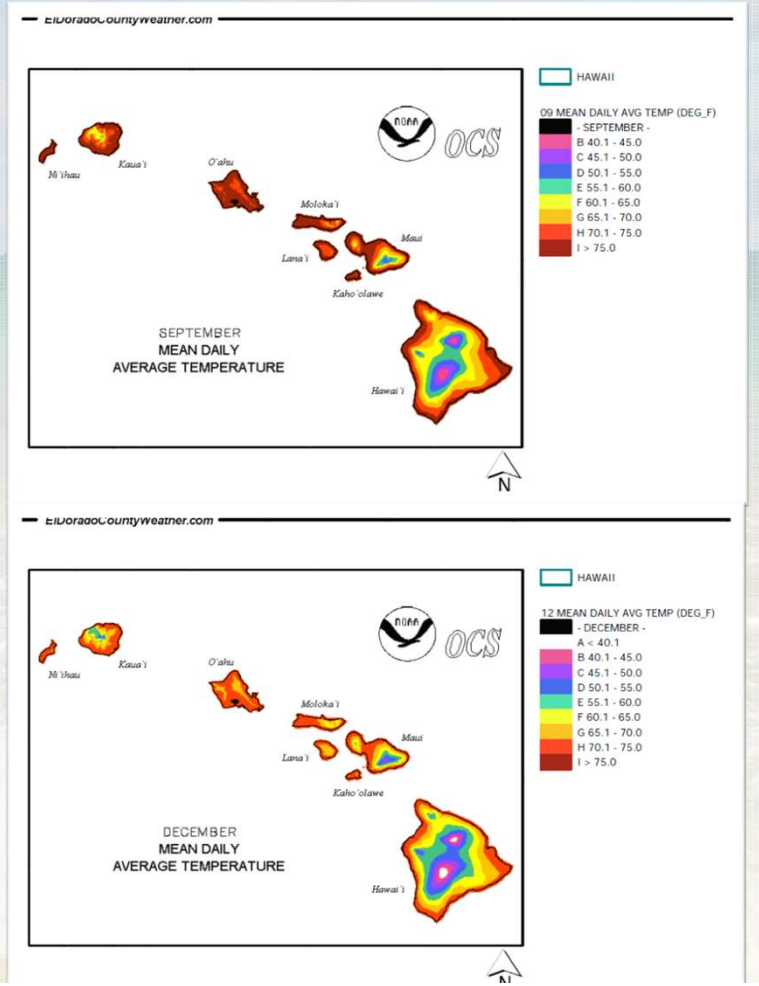
- **Daily mean temperature**
  - Average of 24 hourly readings
  - Adding maximum and minimum and dividing by two.
- **Daily Temperature Range**
  - The difference between the maximum and minimum daily temperatures
- **Monthly mean temperature**
  - Adding together the daily means for each day of a month and then dividing by the number of days in that month
- **Annual Mean Temperature**
  - Adding together the monthly means and dividing by 12
- **Annual Temperature Range**
  - The difference between the warmest and coldest monthly mean temperatures



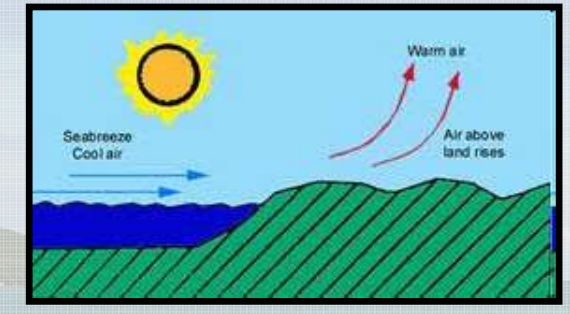


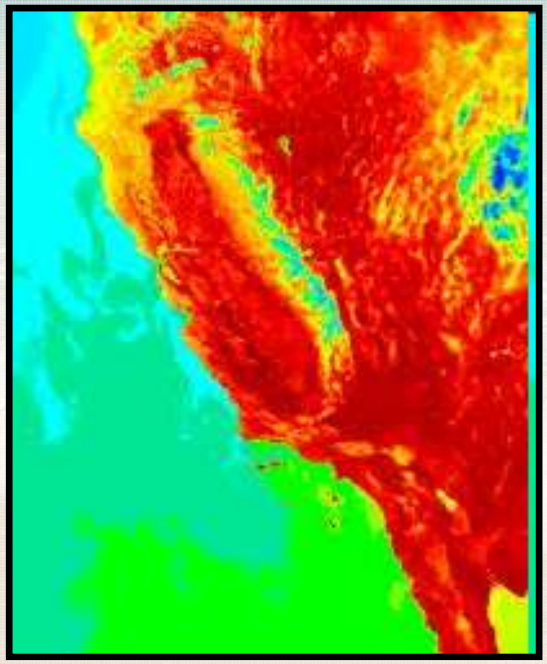
Other Controls of Temperature

- **Differential Heating of Land and Water**
- Ocean Currents
- Altitude
- Geographic Position
- Cloud Cover and Albedo



Differential Heating of Land and Water





- Different surfaces absorb, emit and reflect different amounts of energy.
  - This causes variations in air above each surface
- **In general:** Land **HEATS** more rapidly and to **HIGHER** temperatures than Water.
- **In general:** Land **COOLS** more rapidly and to **LOWER** temperatures than Water.
- Variations over **Land** are **GREATER** than variations over the **Ocean**!!!

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

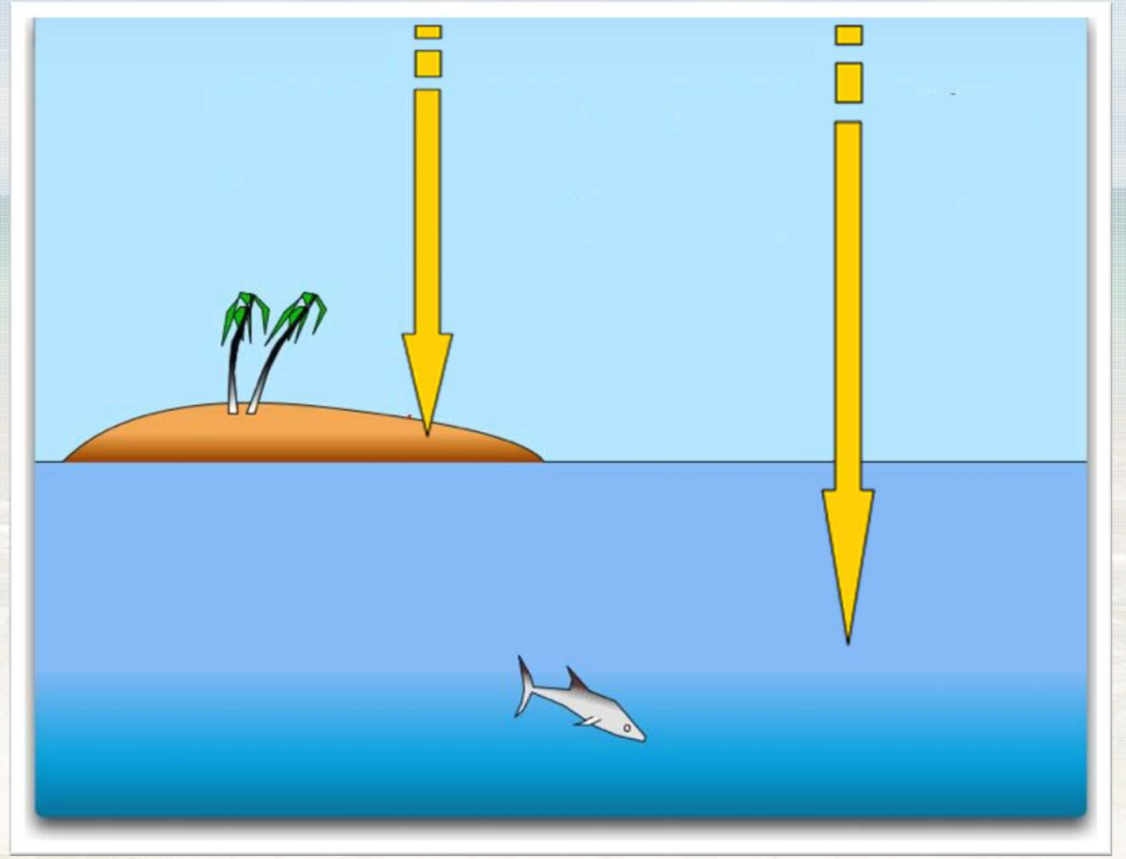
3. Daily temperature changes are seen only 10 cm down

4. Yearly temperature changes reach only 15 meters or less

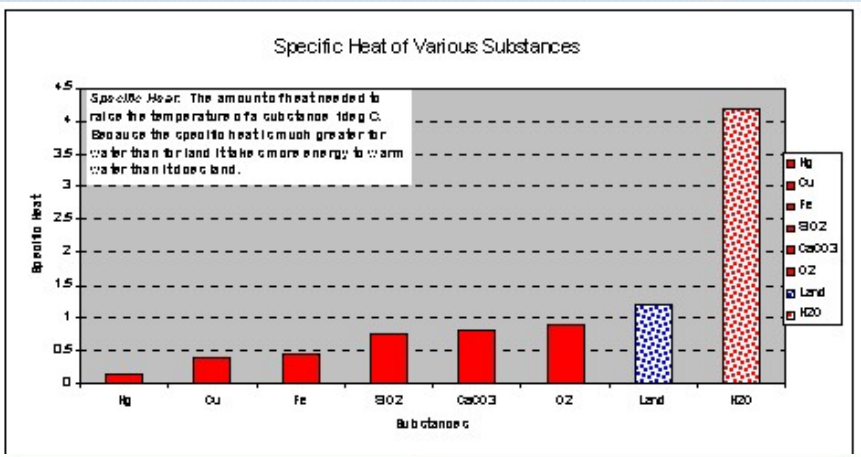
Opaque vs. Transparent

- 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



Specific Heat



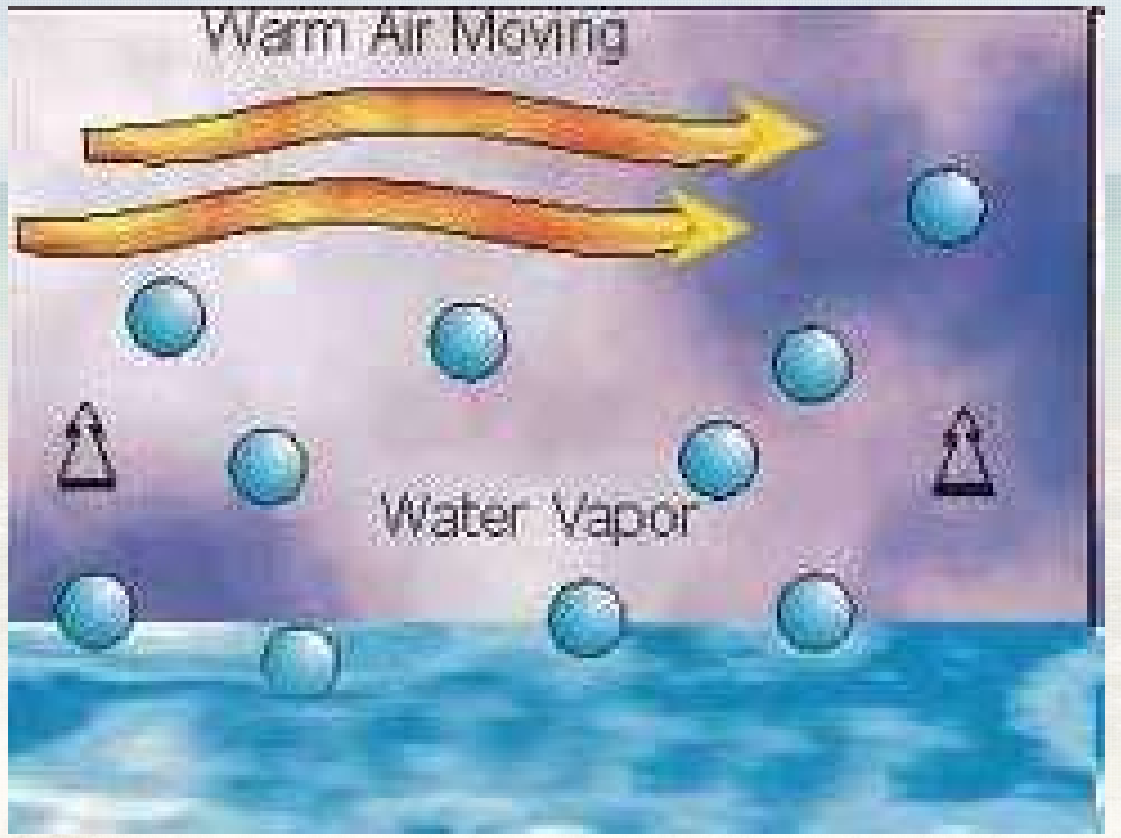
MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

- The **specific heat**
  - the amount of heat needed to raise the temperature of 1 gram of water by 1 degree Celsius is **greater** (~3 times) 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.

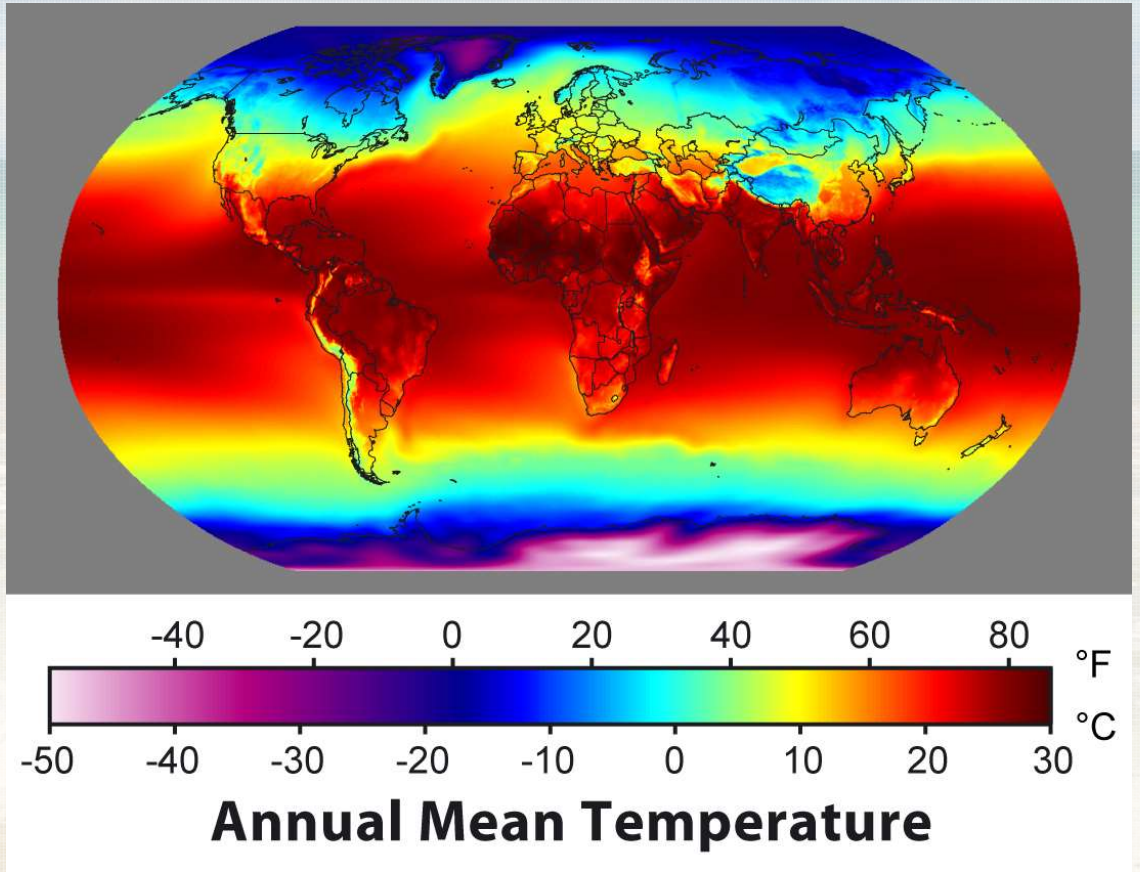
Evaporation over Ocean

- **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.



Other Controls of Temperature

- Ocean Currents
- Altitude
- Geographic Position
- Cloud cover and albedo

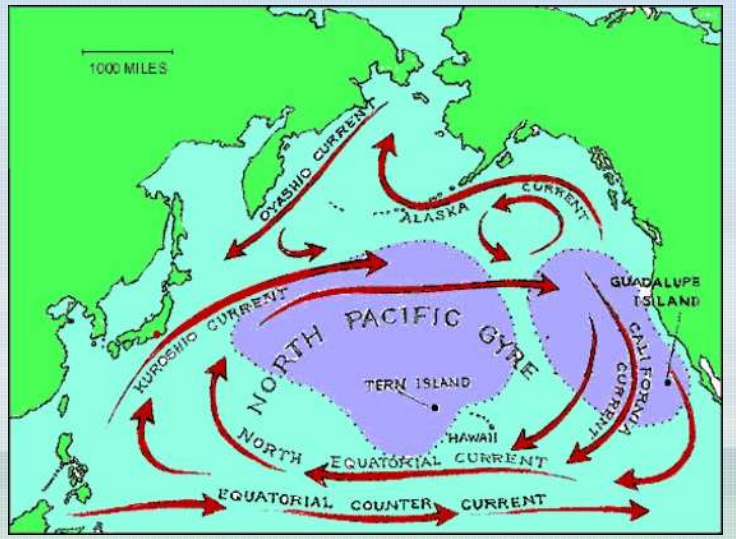


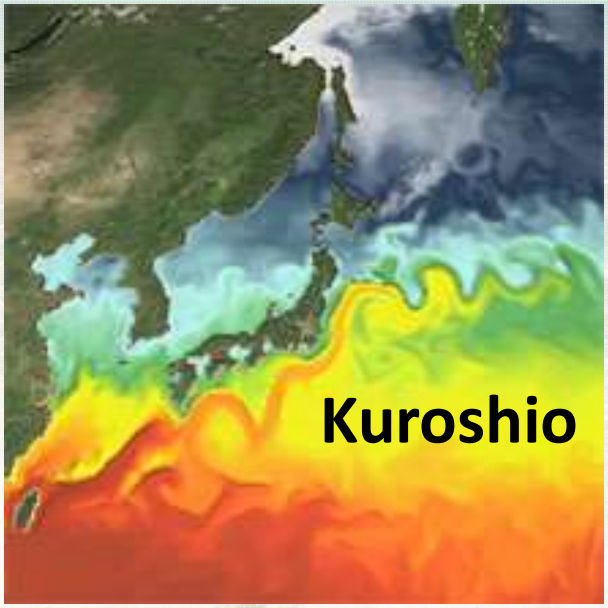
Ocean Currents

- **Ocean currents are caused by wind**
  - interactions between the atmosphere and ocean

- Energy passes from the atmosphere to the ocean via friction.
  - The **DRAG** exerted be the wind causes it to move

- In the Pacific – warm water from the tropics travels up past Indonesia and Southeast Asia toward Japan as the Kuroshio Current.
  - It keeps this region warmer than it would otherwise be.

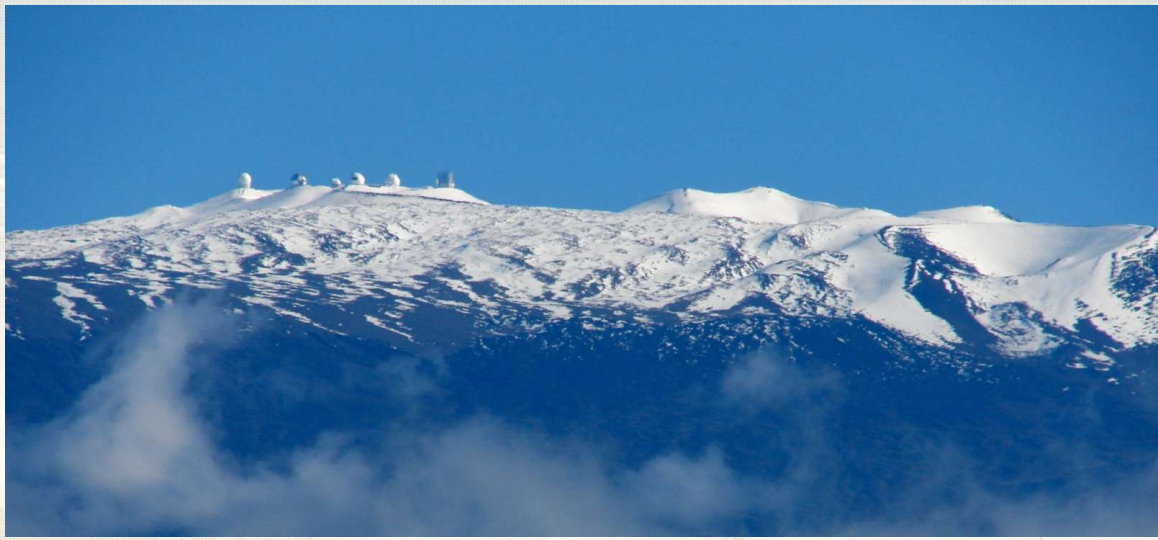




Altitude

- Cooler temperatures at **greater heights**
- Atmospheric **pressure** and **density decreases** so that atmosphere absorbs and reflects less radiation.
- **Mauna Kea** - Stands 4,205 m (13,796 ft) above sea level
  - However, much of the mountain is under water; when measured from its oceanic base, Mauna Kea is over 10,000 m (33,000 ft) tall—significantly taller than Mount Everest.

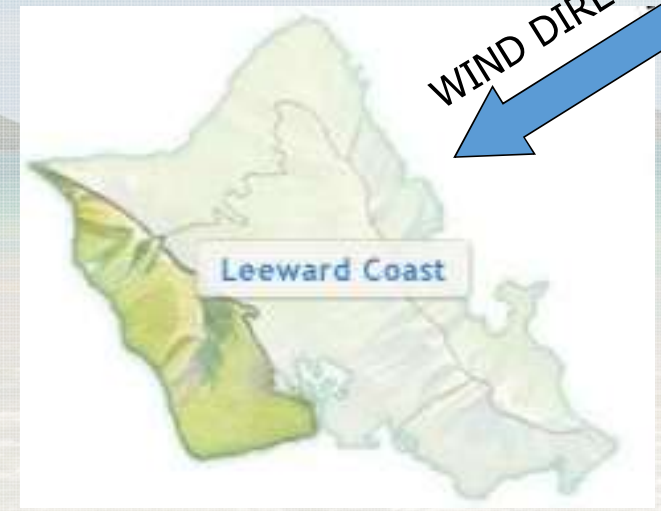
https://upload.wikimedia.org/wikipedia/commons/2/26/Mauna_Kea_Summit_in_Winter.jpg



https://commons.wikimedia.org/wiki/File:Mauna_Kea_from_Kohala_Mountain_Road.JPG

Geographic Position and Winds

- **Leeward:** Prevailing winds blow TOWARDS the Ocean



Lacks Ocean Influence, More like Land Temperatures

MORE VARIABLE TEMPERATURES

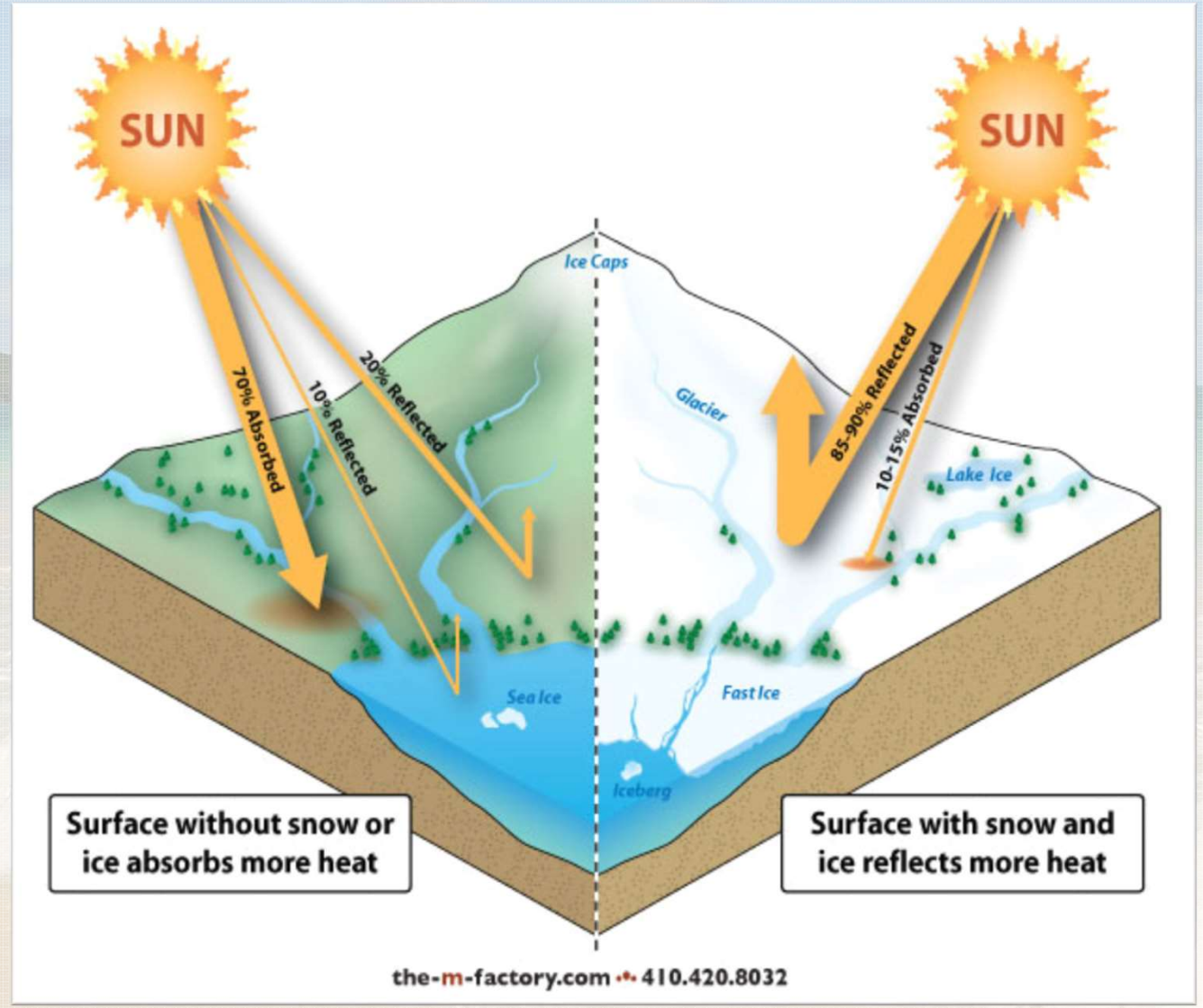
- **Windward:** prevailing winds blow from the Ocean to the SHORE

Moderated by the Ocean air, cool summers-mild winters

LESS VARIABLE TEMPERATURES

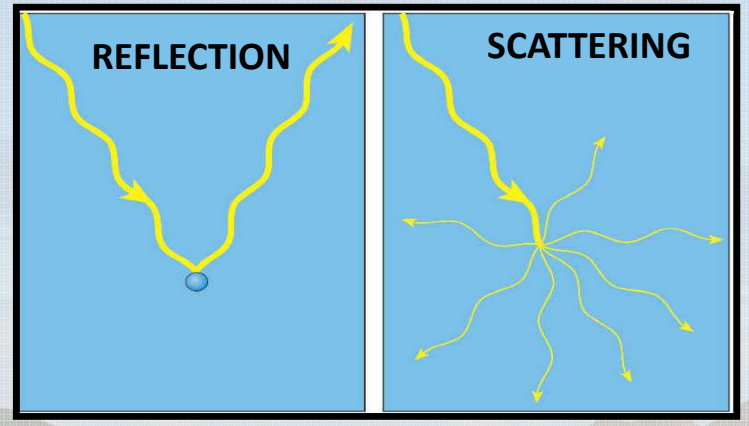
- **Prevailing Winds:** The wind direction most frequently observed during a given period.

Albedo



- Energy is returned to space via **reflection** and **emission**
- **ALBEDO** – The percentage reflected
- About **30%** of incoming solar radiation is reflected by the earth
  - 5% from land and the ocean
  - 25% from clouds and ice!

Cloud Cover



Bouncing back at the same angle and same intensity

Produces a larger number of weaker rays, more forward less backward

- Clouds cool during the day
  - High ALBEDO
  - **Lower Maximum**
- Clouds warm at night
  - Trap OUTGOING Longwave radiation
  - **Higher Minimum**

ON AVERAGE Clouds end up COOLING the Earth!