AdOc 4060 / 5060

Seawater Temperature

Dr Chris Jenkins

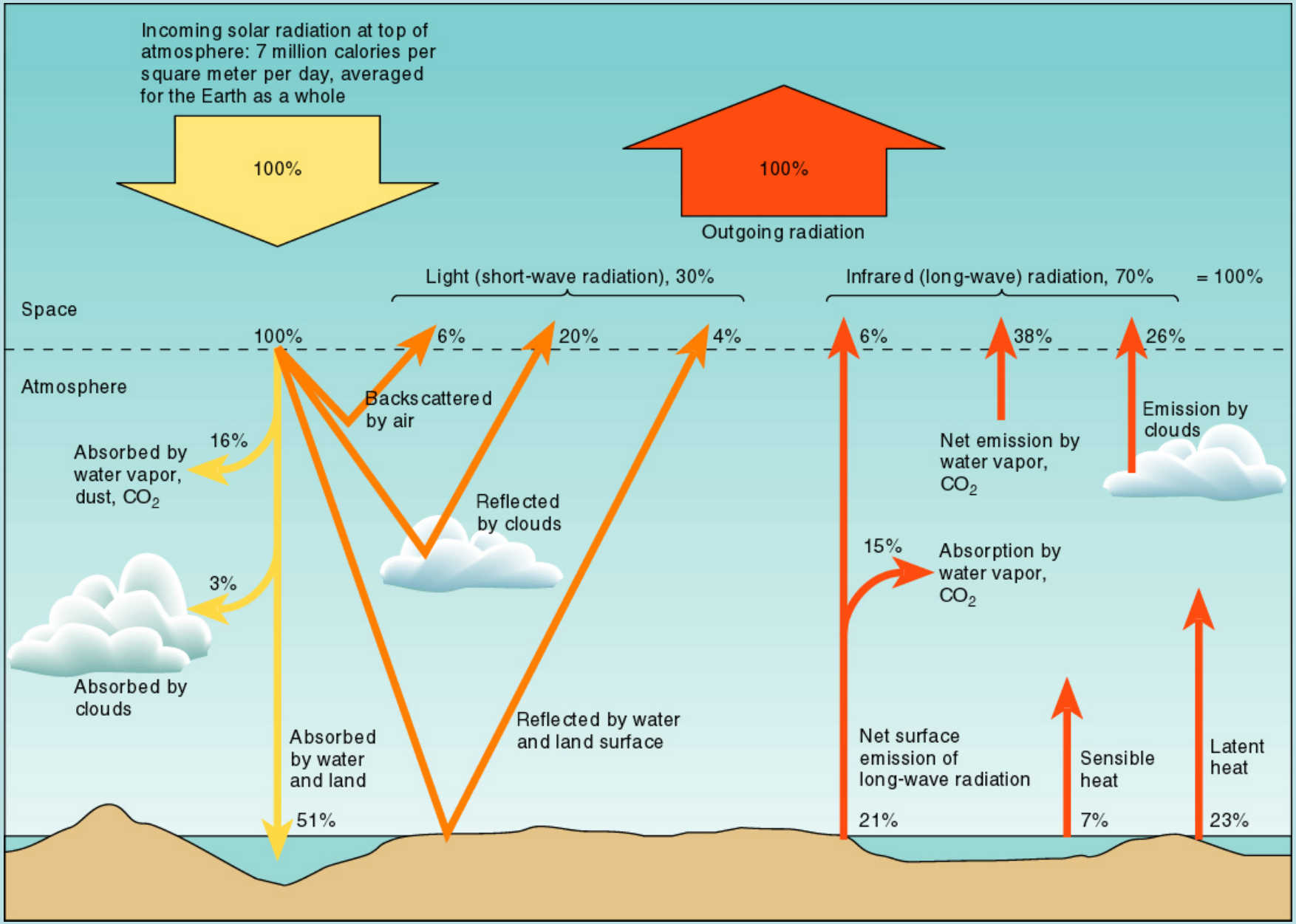
Spring 2013

Albedo

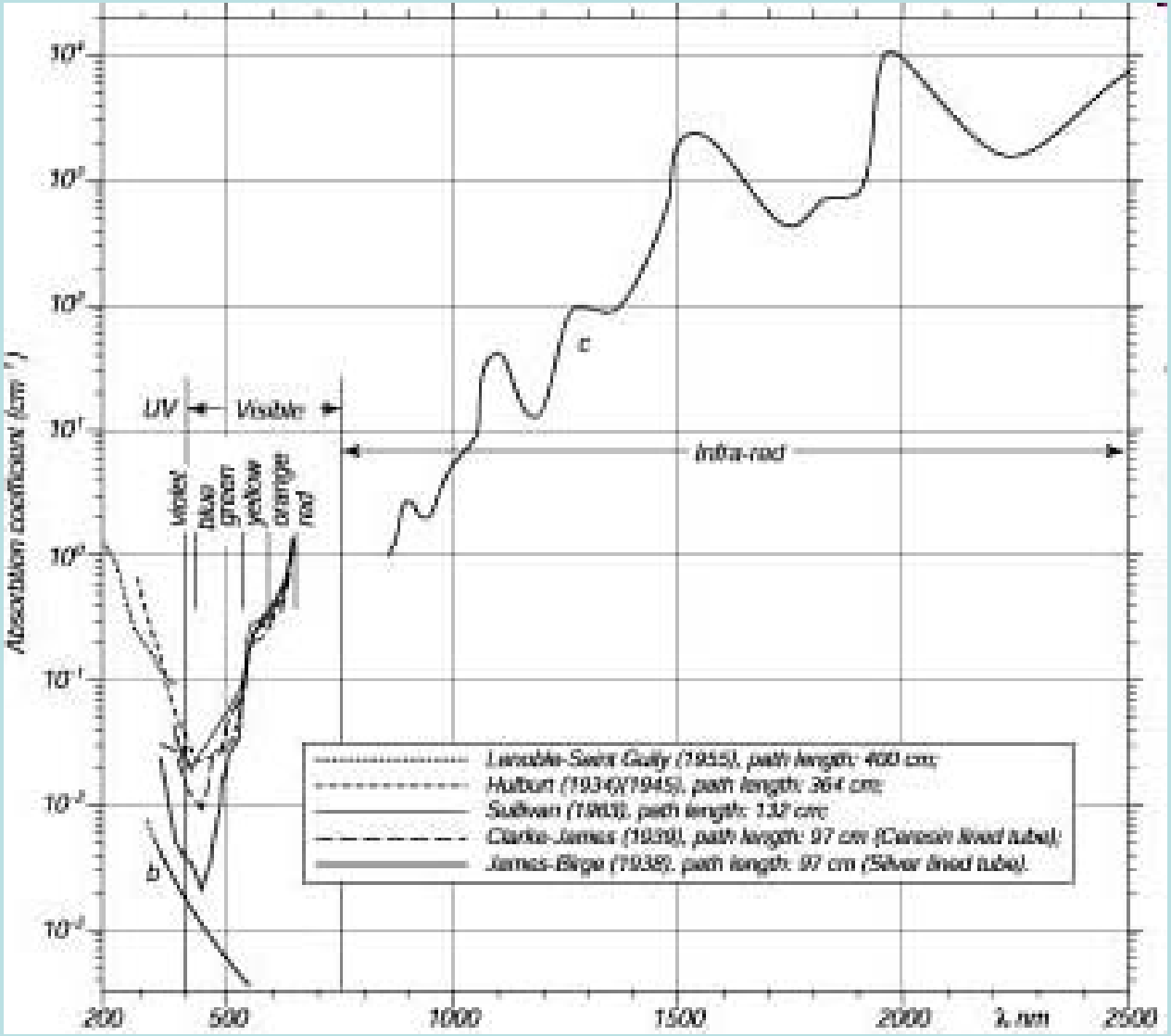
Of the 30% that reaches the Earth's surface — the insolation — not all is absorbed, some is reflected depending on the albedo

- snow: up to 90%
- desert sand: 35%
- vegetation: 10-25%
- bare soil/rock: 10-20%
- built-up areas: 12-18%
- calm water: 2%

The heating of Earth's atmosphere



Absorbtion-scattering



http://oceanworld.tamu.edu/resources/ocng_textbook/chapter06/chapter06_10.htm

Uneven solar heating on Earth

- Solar energy in high latitudes:
  - Has a larger “footprint”
  - Is reflected to a greater extent
  - Passes through more atmosphere
  - Is less than that received in low latitudes

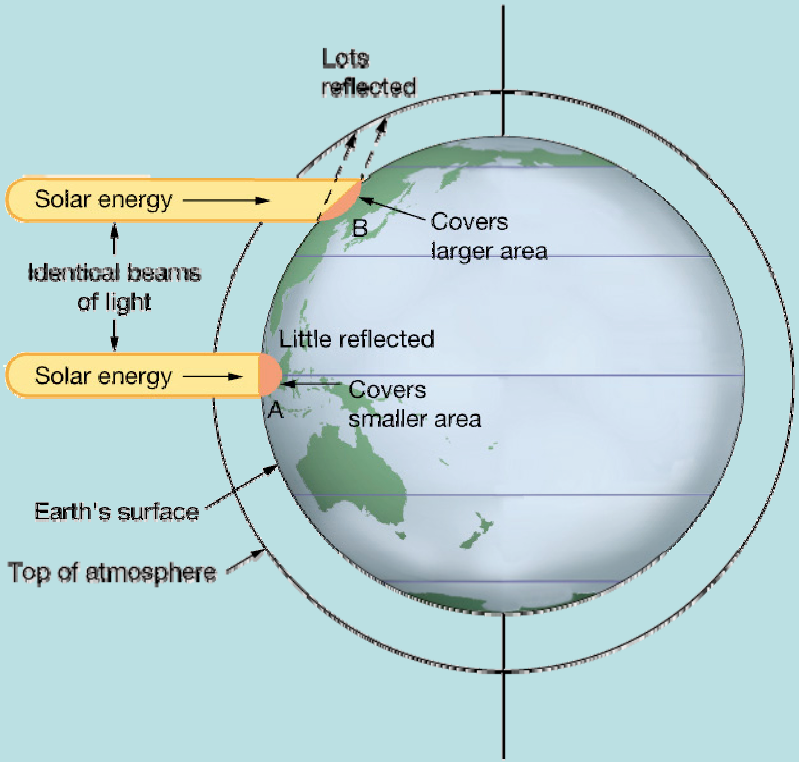
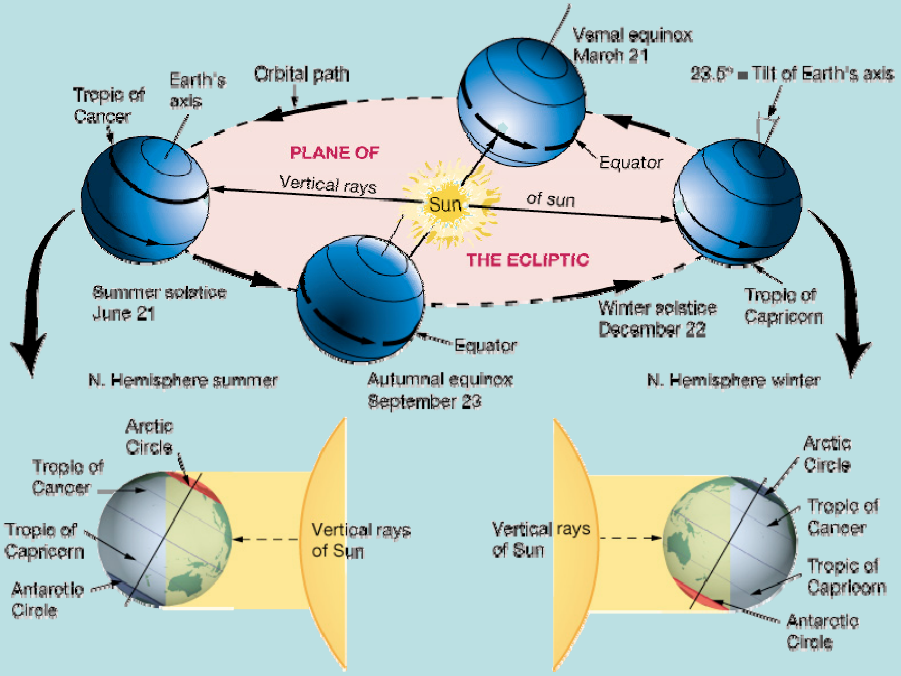


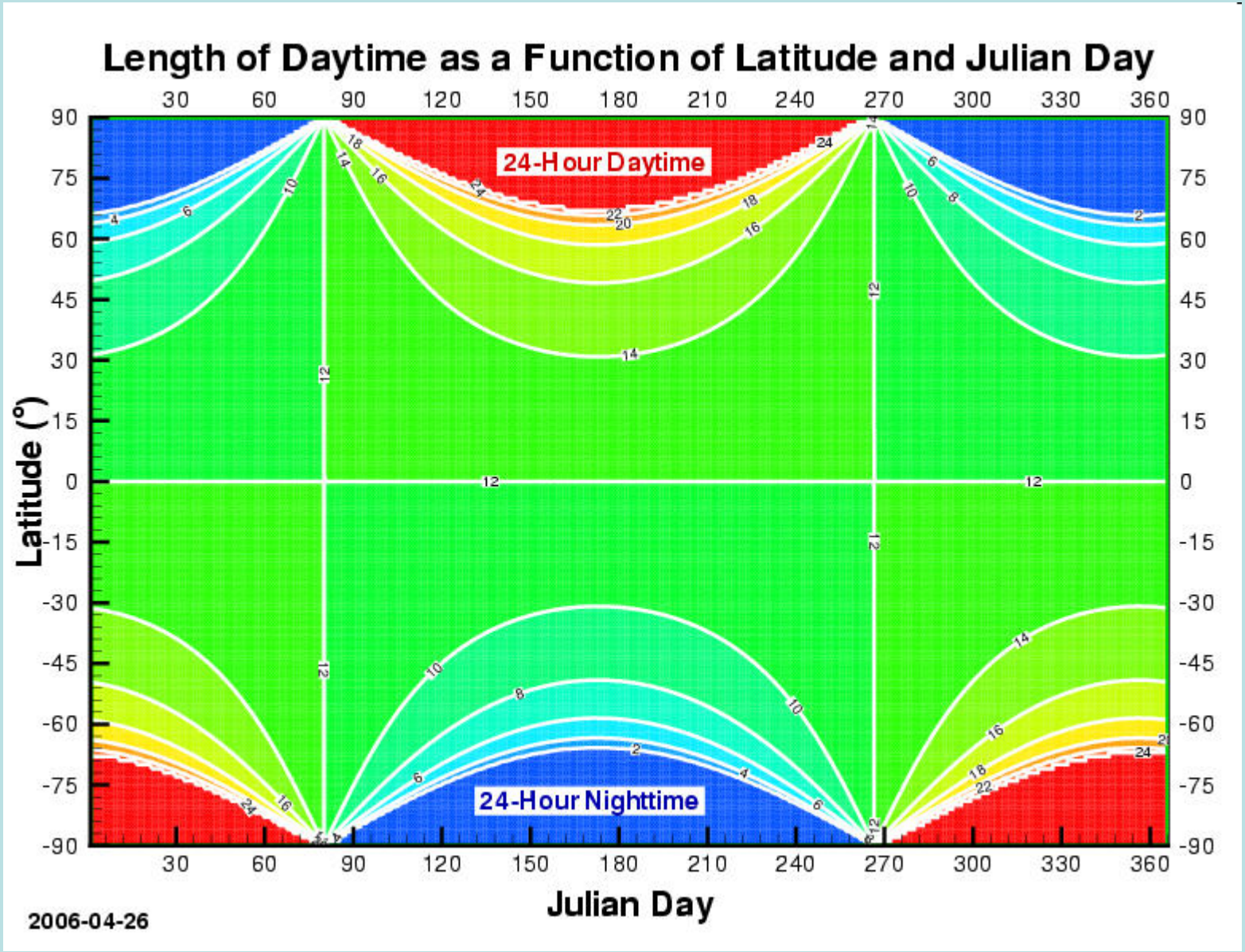
Table 6–1 Reflection and absorption of solar energy relative to the angle of incidence on a flat sea.

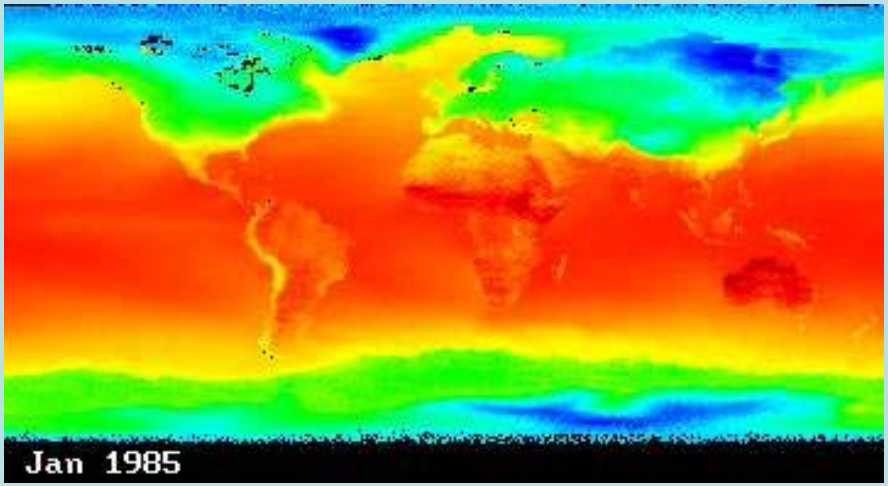
Elevation of Sun above horizon	*90°*	*60°*	*30°*	*15°*	*5°*
Reflected radiation (%)	2	3	6	20	40
Absorbed radiation (%)	98	97	94	80	60

Earth's seasons

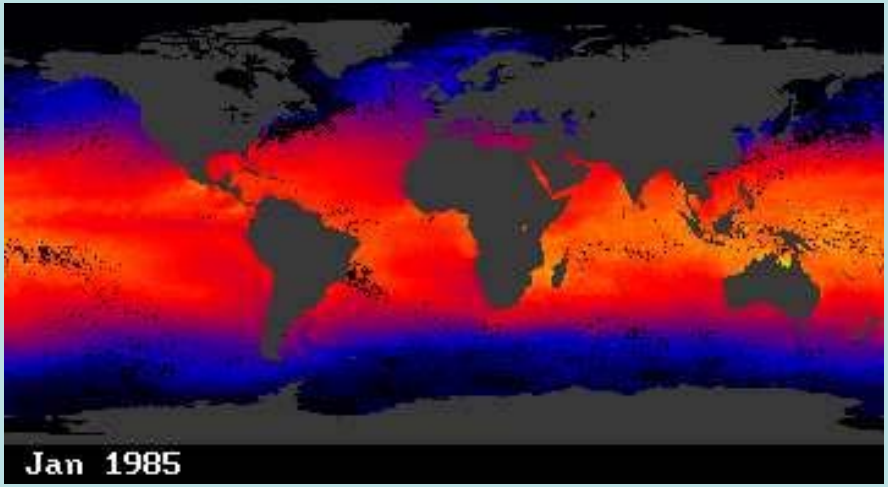
- Earth's axis is tilted 23½º from vertical
- Northern and Southern Hemispheres are alternately tilted toward and away from the Sun
- Causes longer days and more intense solar radiation during summer



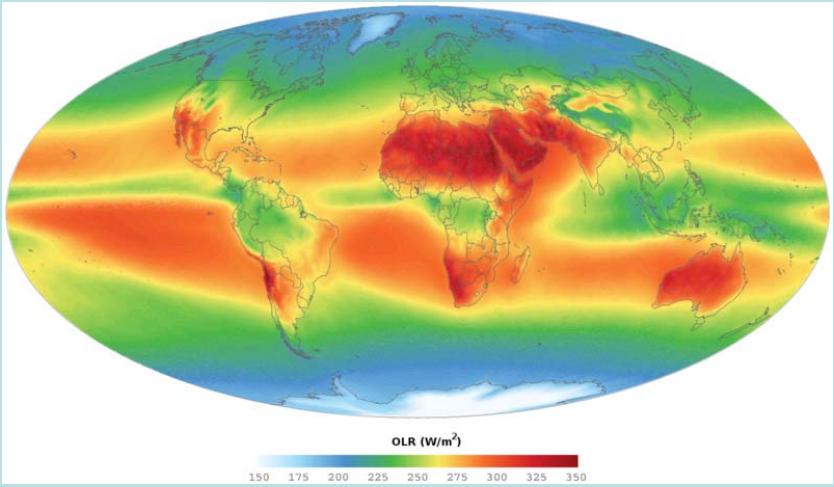

Length of Daytime as a Function of Latitude and Julian Day
24-Hour Daytime
24-Hour Nighttime
Latitude (°)
Julian Day
2006-04-26



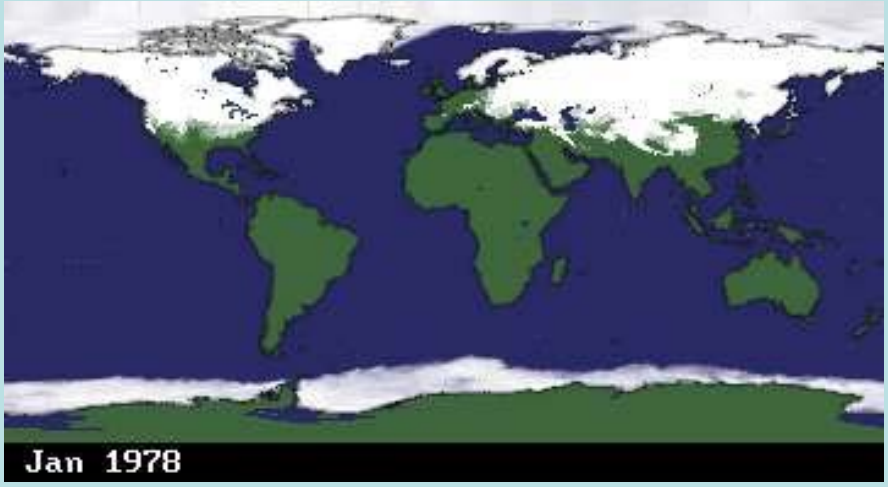
Surface Temperature



Sea Surface Temperature



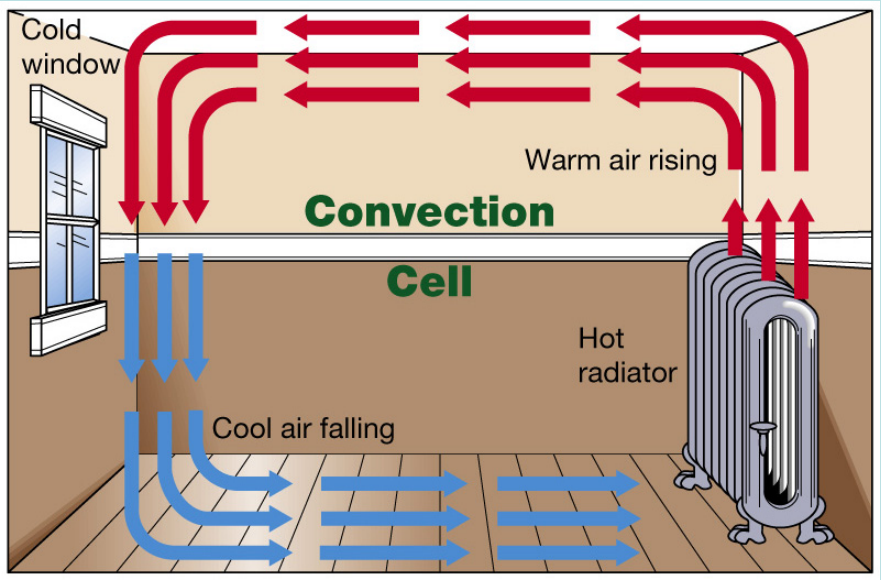
Outgoing Long Radiation



Snow & Sea Ice

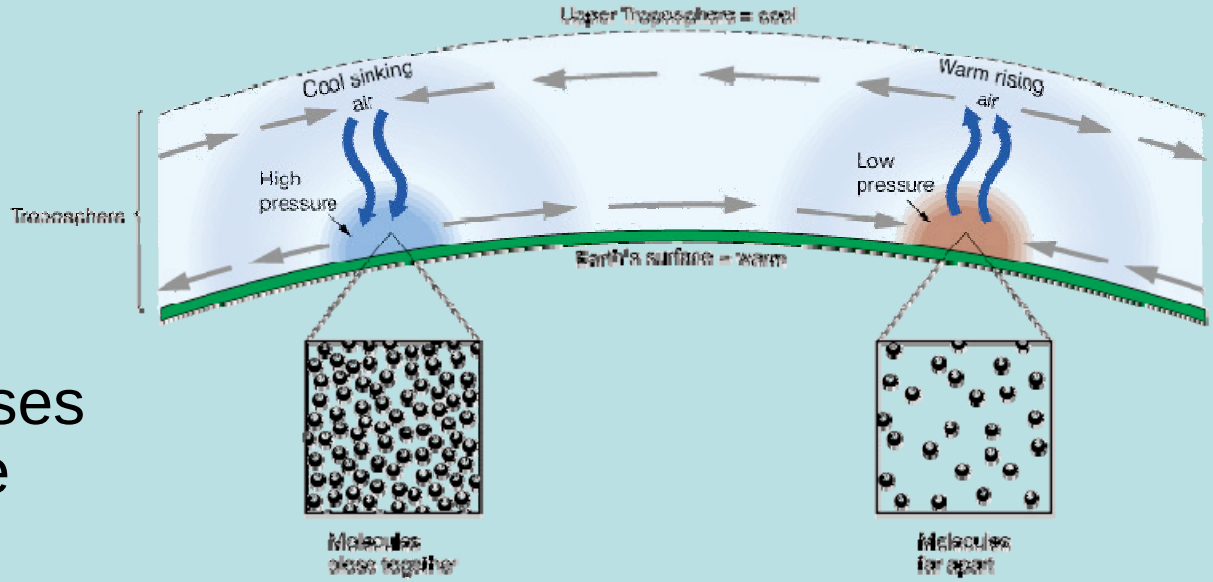
Atmospheric Density

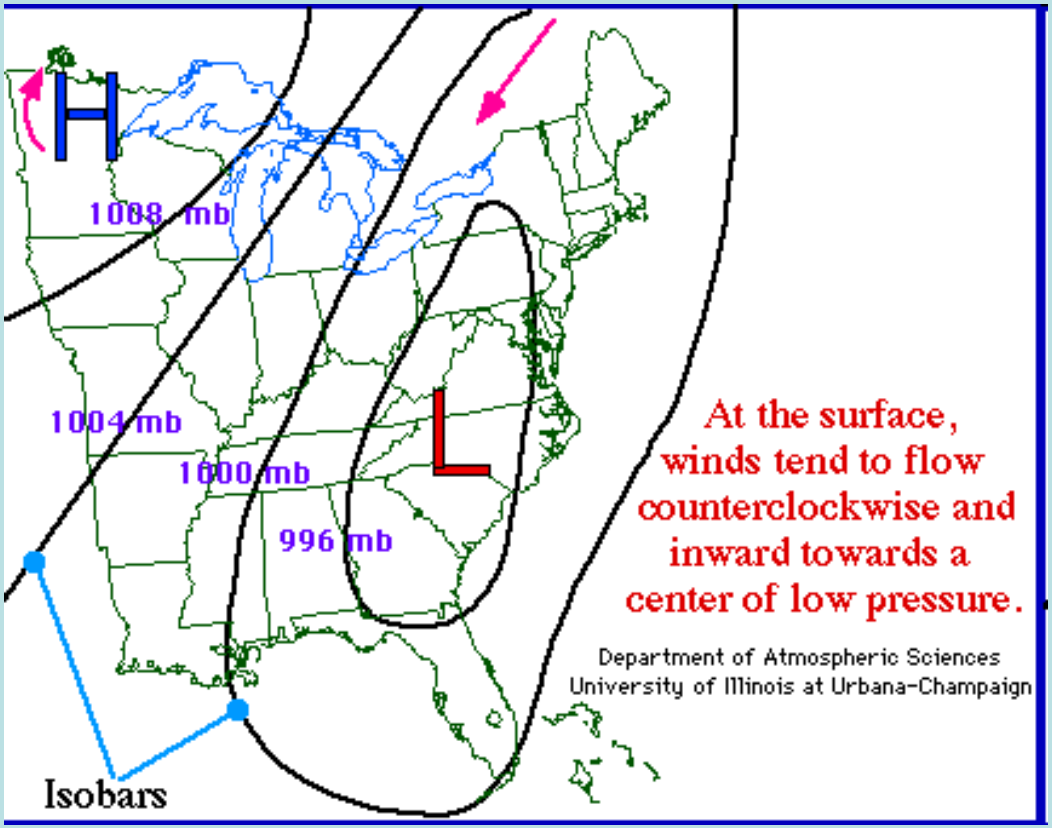
- Warm, low density air rises
- Cool, high density air sinks
- Creates circular-moving loop of air (convection cell)



Atmospheric Pressure

- A column of cool, dense air causes high pressure at the surface, which will lead to sinking air
- A column of warm, less dense air causes low pressure at the surface, which will lead to rising air





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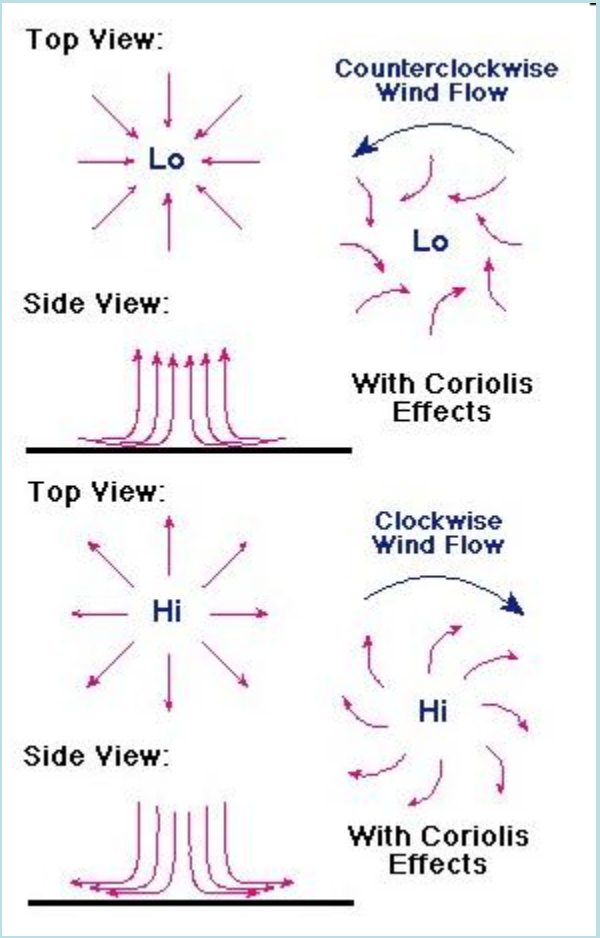

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Atmospheric Water vapor

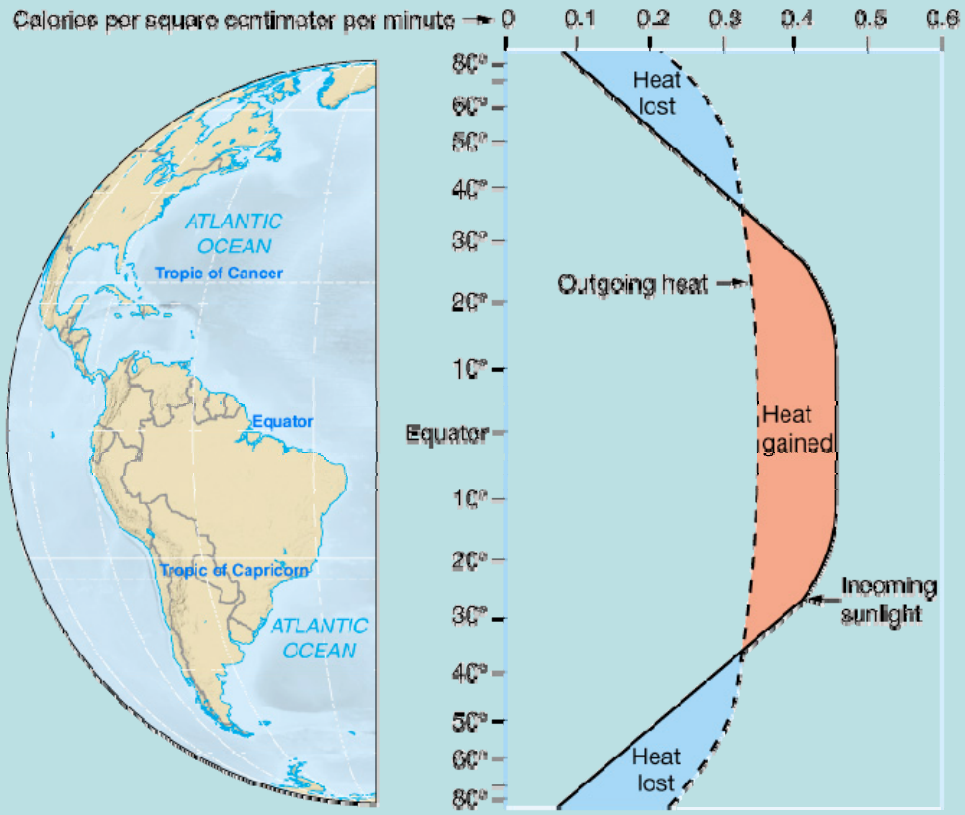
- Cool air cannot hold much water vapor, so is typically dry
- Warm air can hold more water vapor, so is typically moist
- Water vapor decreases the density of air

http://www.youtube.com/watch?v=Mpyr6QWKEq4

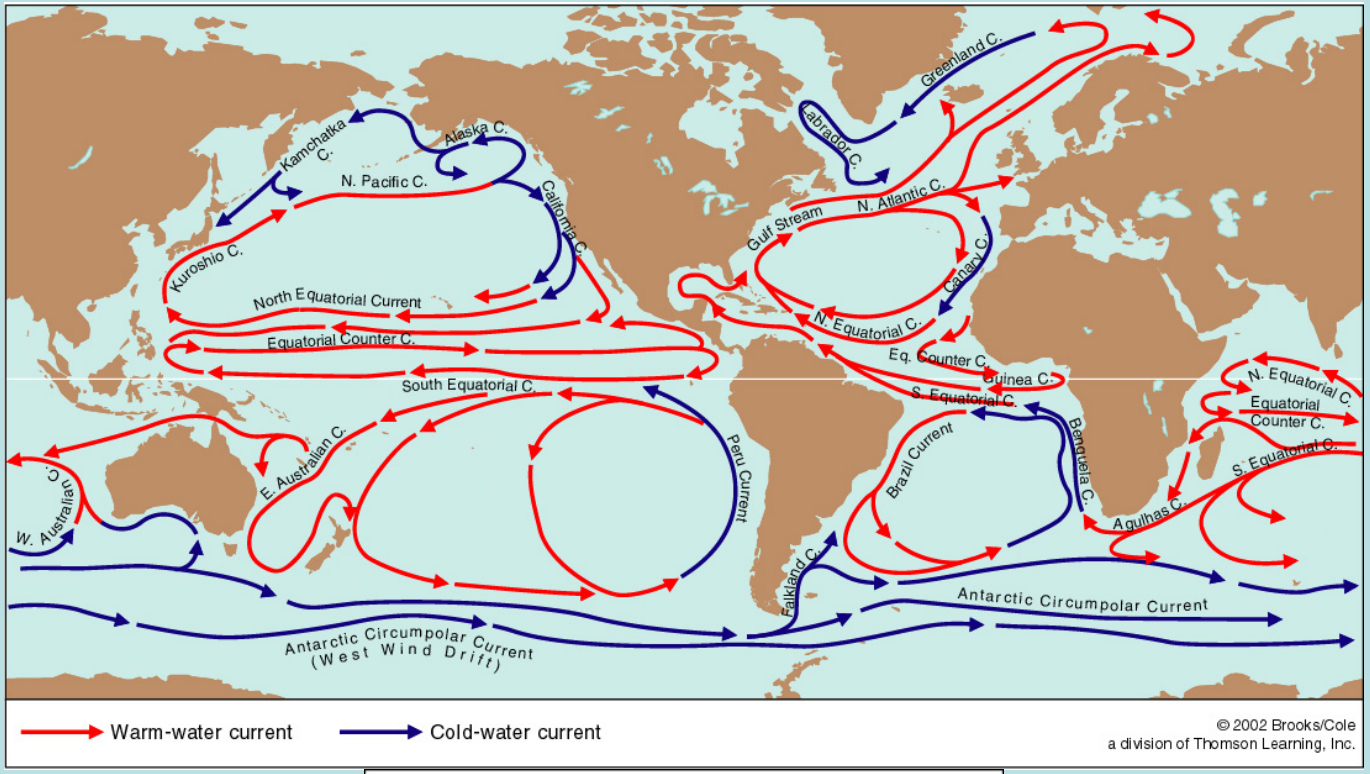
http://www.youtube.com/watch?v=MzL65Qgh2qU&feature=related

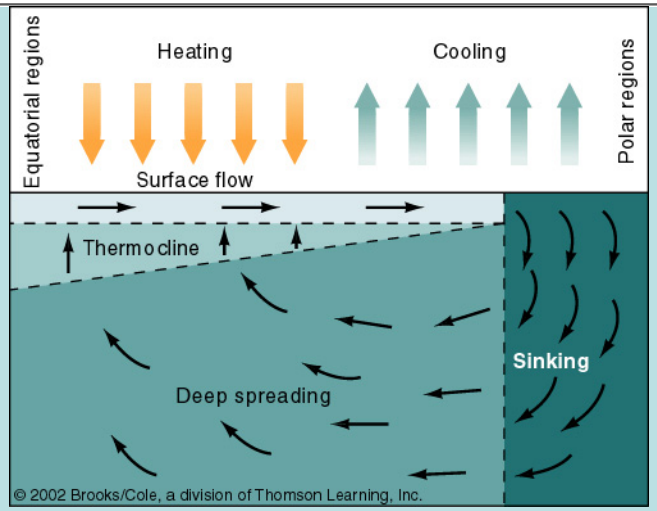
Oceanic heat flow

- A net heat gain is experienced in low latitudes
- A net heat loss is experienced in high latitudes
- Heat gain and loss are balanced by oceanic and atmospheric circulation



Temperature Redistribution





II. Heat and temperature (cf. CC4)

- heat is the *energy* of vibrating molecules (calories or joules)
- temperature is the *speed* of those molecules (°C)

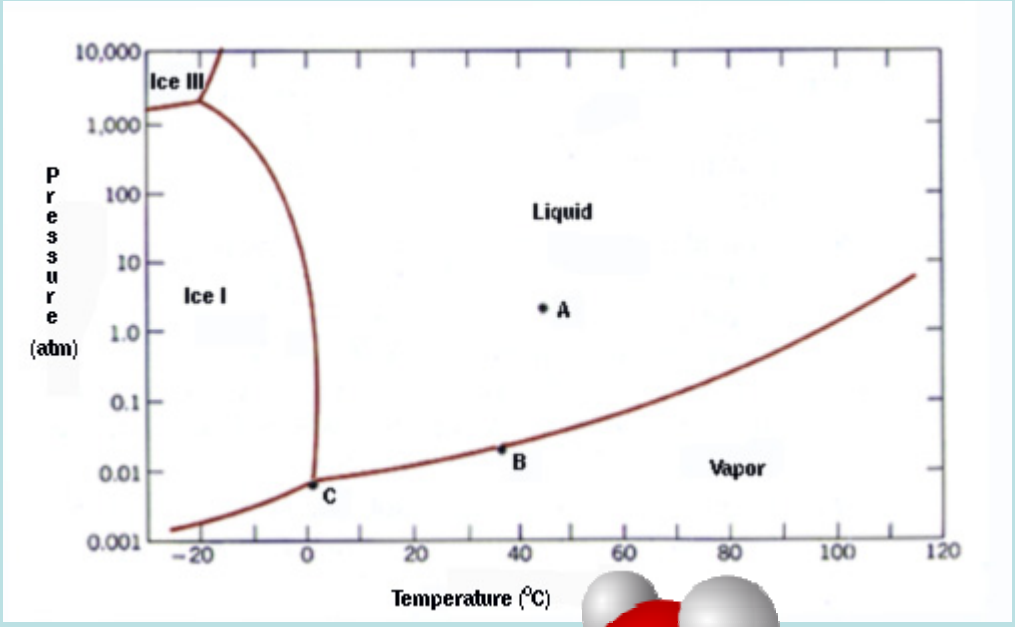
- adiabatic temperature change is due to pressure change without the addition or removal of heat

- if adding/removing heat from a substance changes its temperature, it is called sensible heat

- if adding/removing heat results only in a phase change (solid-liquid-gas) with no temperature change, it is called latent heat

Phase changes & latent heat

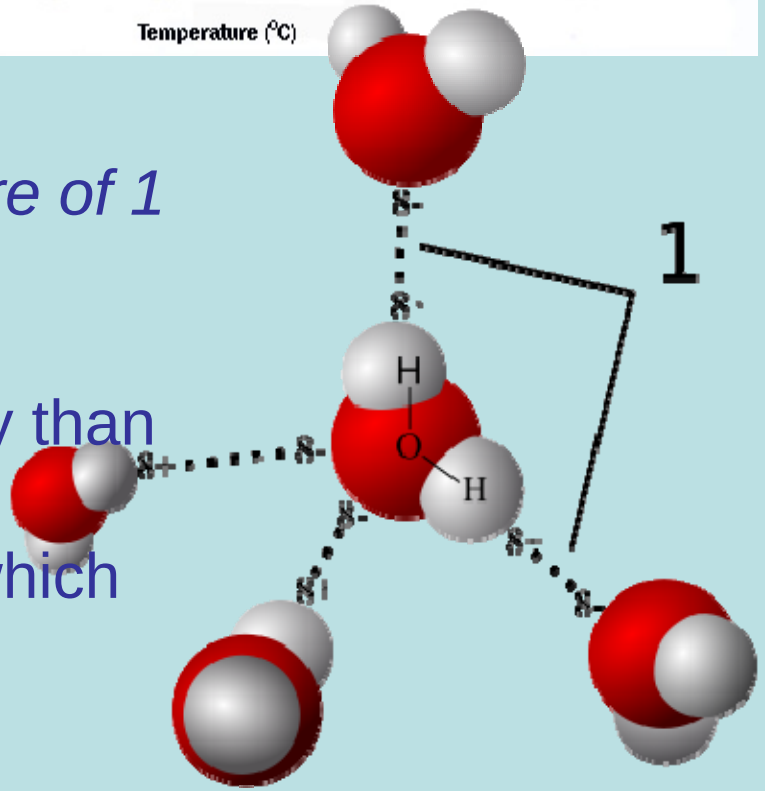
•Water is *very* unusual in that it occurs as solid, liquid, and gas at Earth's surface



Heat capacity

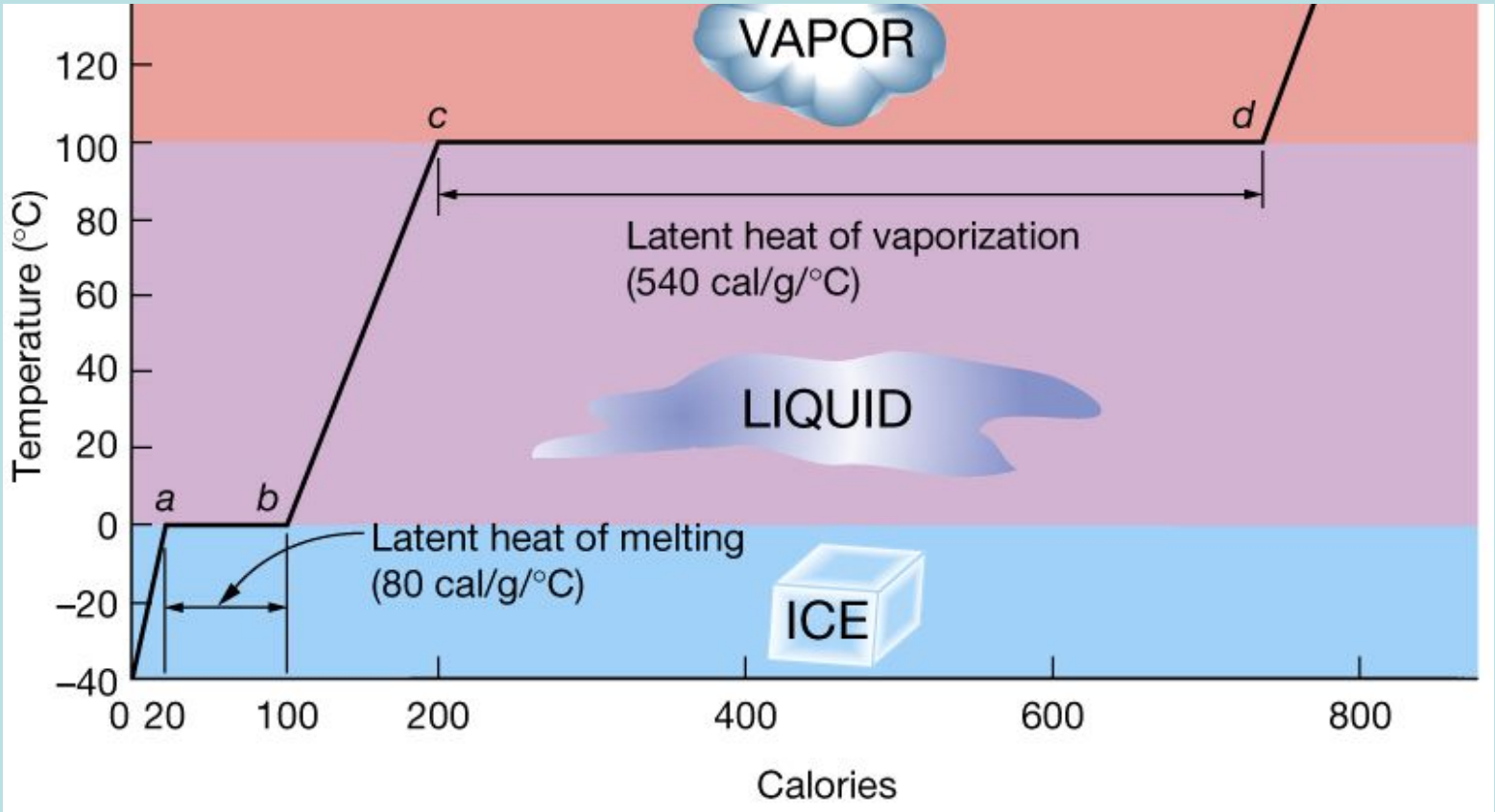
Heat required to change the temperature of 1 g of a substance by 1 ℃

• liquid water has a higher heat capacity than almost any other substance
• hydrogen bonds inhibit the speed at which molecules vibrate



Water in the 3 states of matter

- **Latent (hidden) heat** = energy that is either absorbed or released as water changes state
- Melting & sublimation: absorb heat
- Condensation & freezing: release heat



- Melting

ice may sublimate at temperatures below the melting point (heat of sublimation is much higher)

- Evaporation

water molecules can evaporate from the surface of liquid water without the liquid reaching the boiling point

- Water serves as a “refrigerant”

ice: melting consumes heat in summer and freezing releases heat in winter

vapor: evaporation consumes heat in the tropics and condensation releases heat at higher latitudes

Viral Video ‘Brinicle’:

http://www.bbc.co.uk/nature/15835017

Sea ice formation

- while most icebergs come from land ice (glaciers), sea ice forms from seawater
- sea ice is relatively pure water ice, with only pockets of saline water
- rejection of salt during freezing causes increased density in surrounding water (brine rejection)
- sea ice typically only reaches a few meters thick

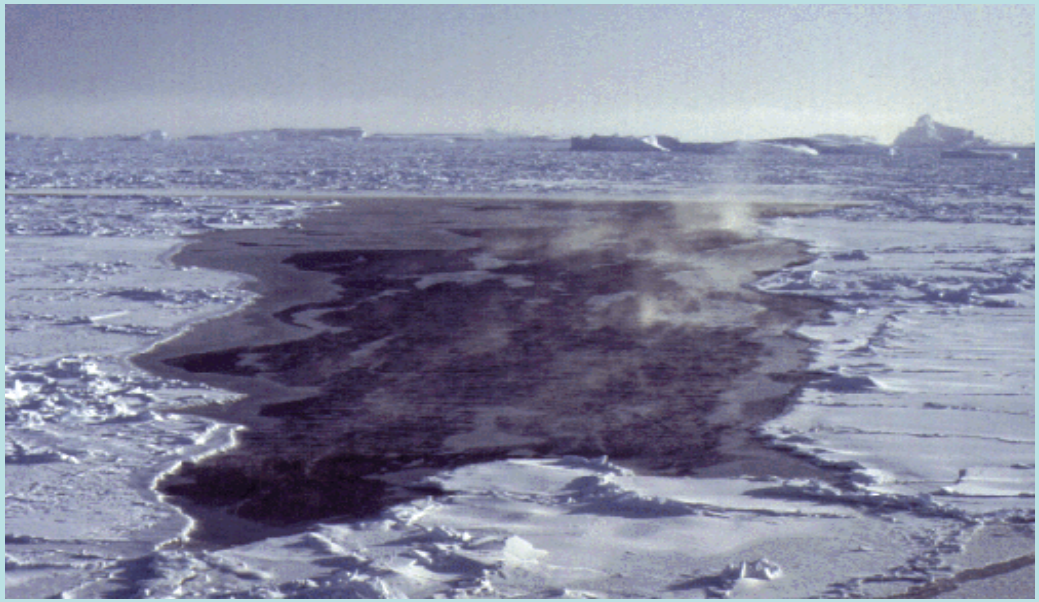
pancake ice

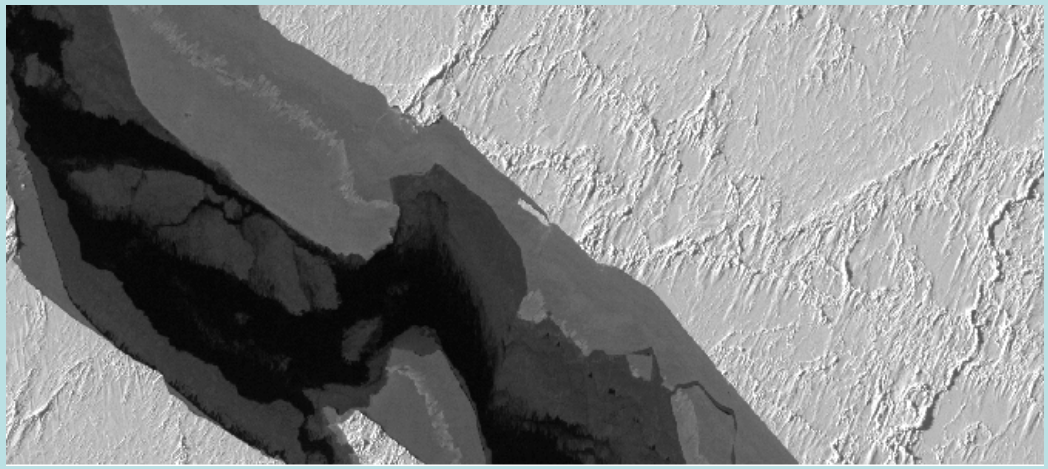
Freeze Up

- affected by air temperature, wind, waves and pack ice conditions, amount of snowfall and the monthly tidal cycle
- air temperature must fall below the **freezing point of sea water** (-1.6° C at a salinity of 29.5°/◦◦ and -1.8° C at 34°/◦◦)
- needle like crystals form **frasil ice**
- when needles are thick, sea surface forms **grease ice.** Thicker, soupy accumulations of frazil ice often herded by wind action

Polynyas & Open Leads

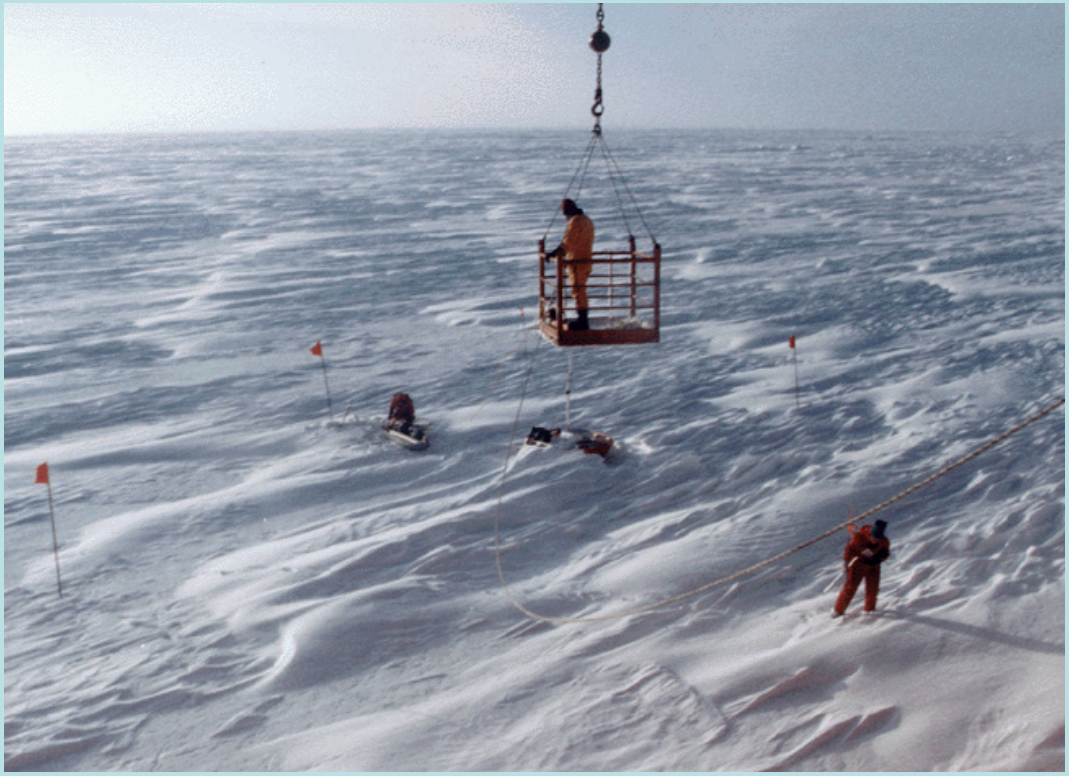
- areas of open water are called polynyas: usually kept open by strong upwelling
- coastal polynyas are 50 to 100 km in diameter and most of the sea ice is formed in these zones (and are then moved away by currents
- open ocean polynyas form in more or less the same part but may not occur every year, can reach 300 by 1000 km in size



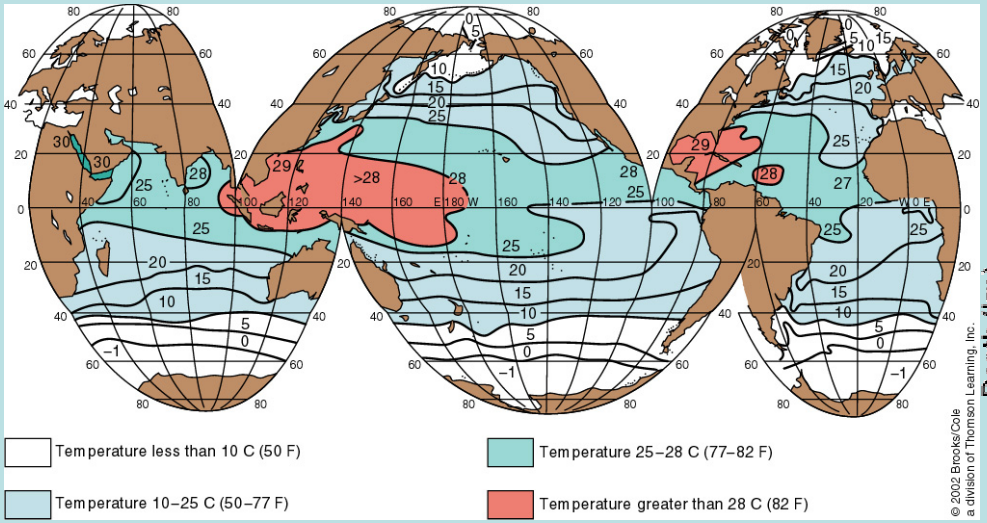


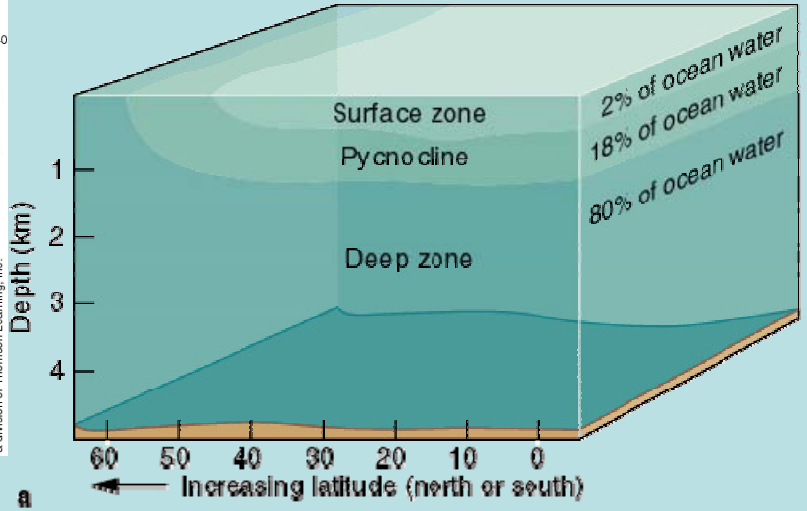
Winter Ice Cover

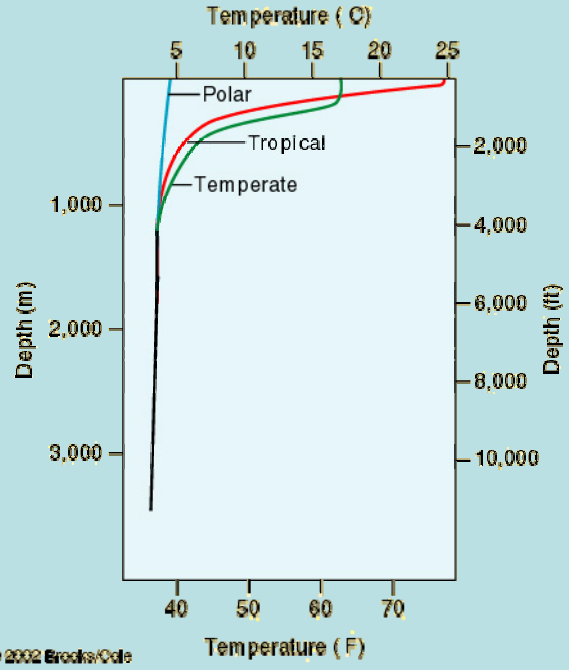
- eliminates wind-induced mixing and waves
- Ice growth mixes the surface layer due to the process of salt rejection whereby salt is released from the freezing ice mass; leaving the sea ice with a salinity between 3 to 10 ppt

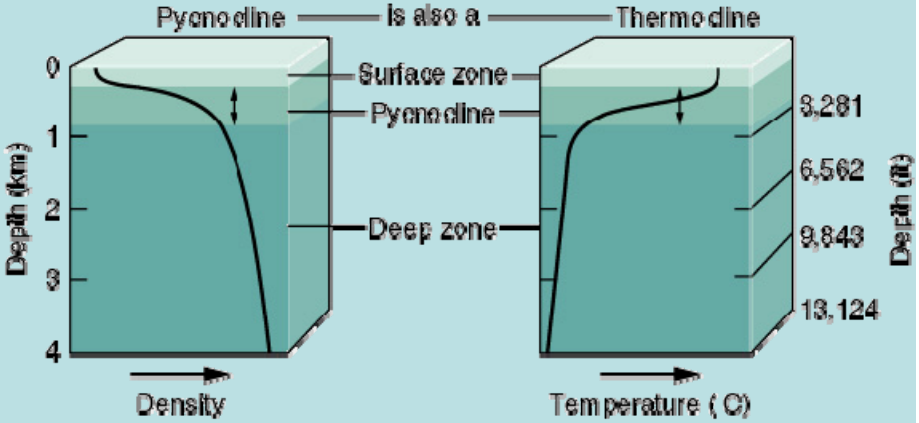


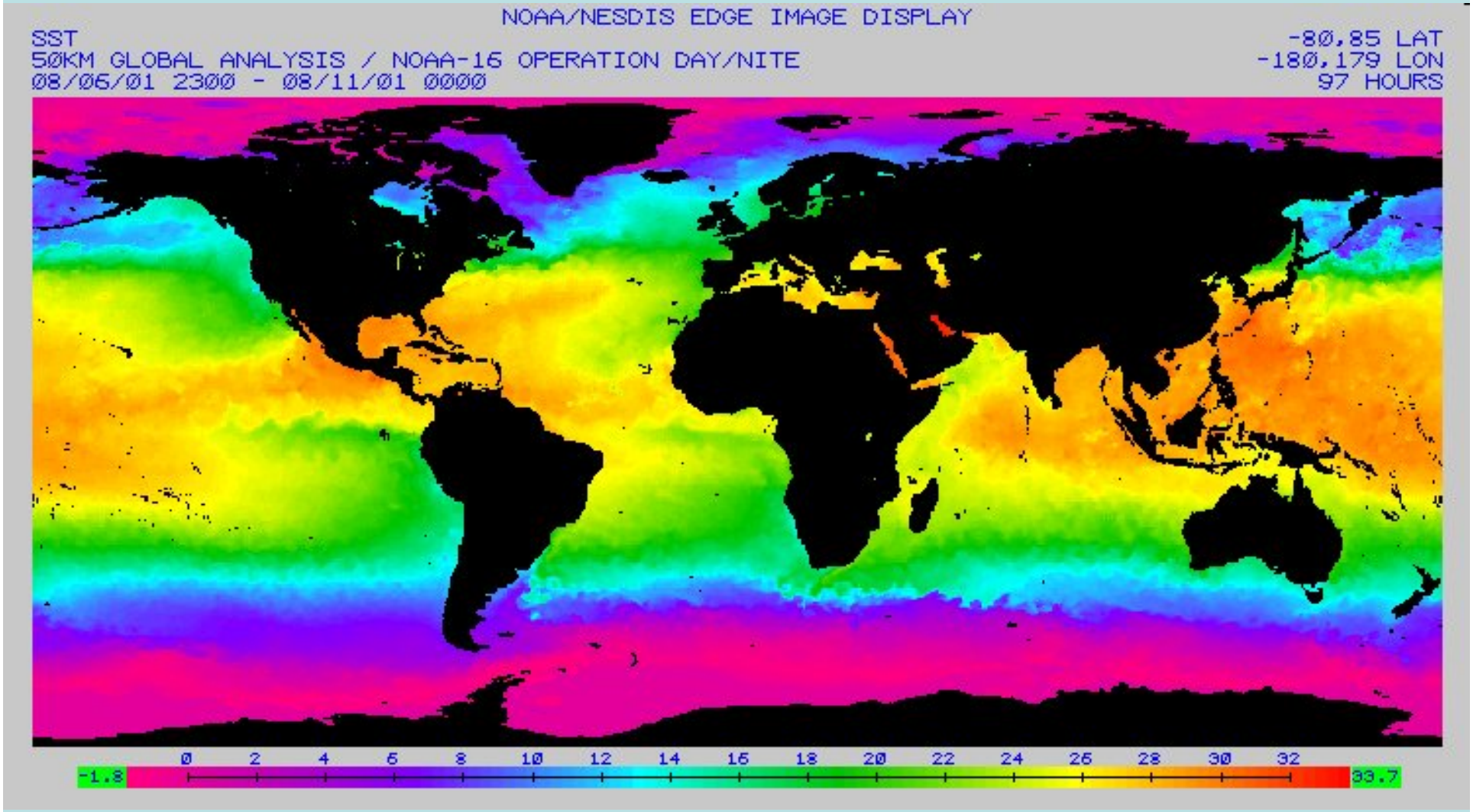
Ocean Temperature







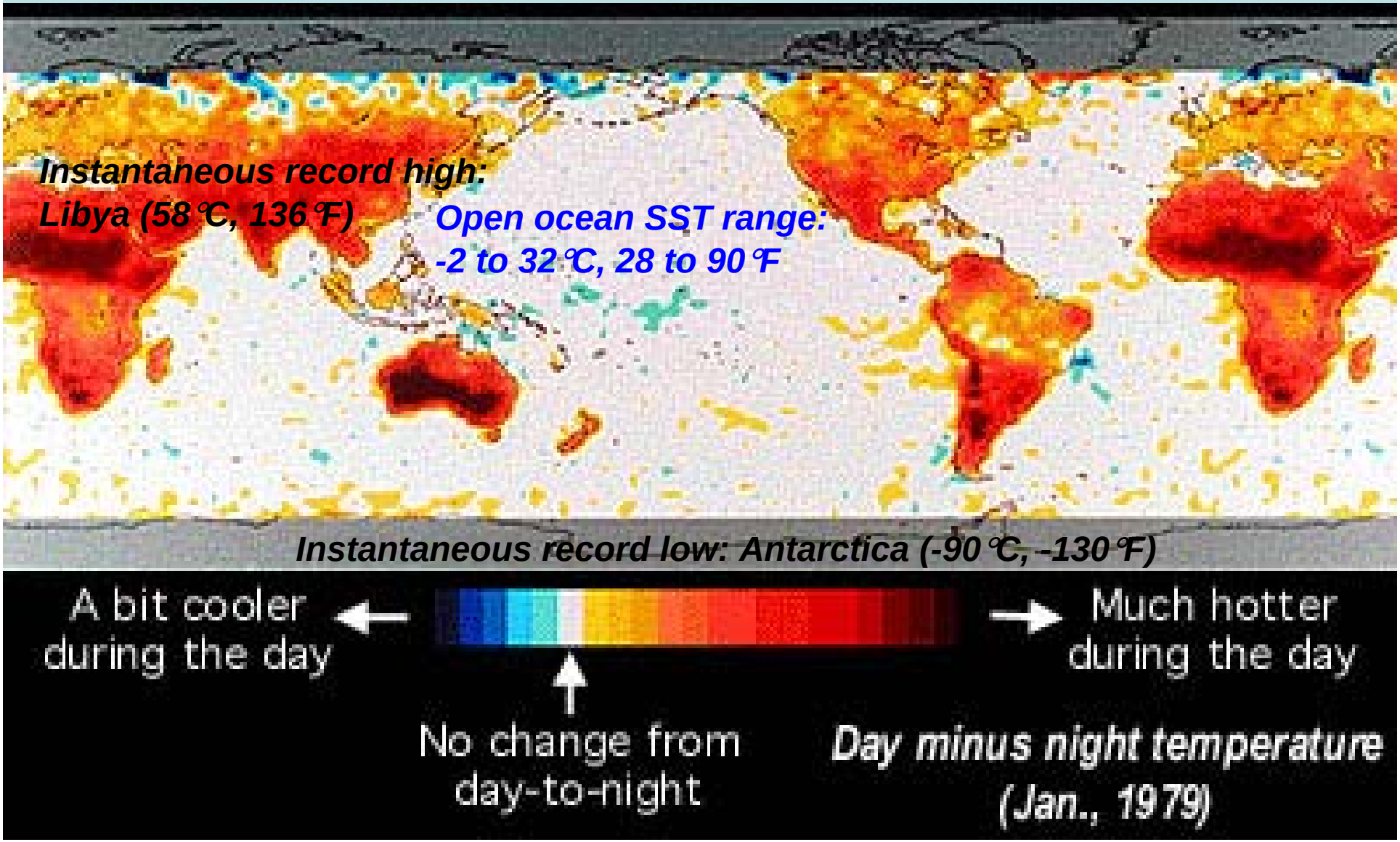




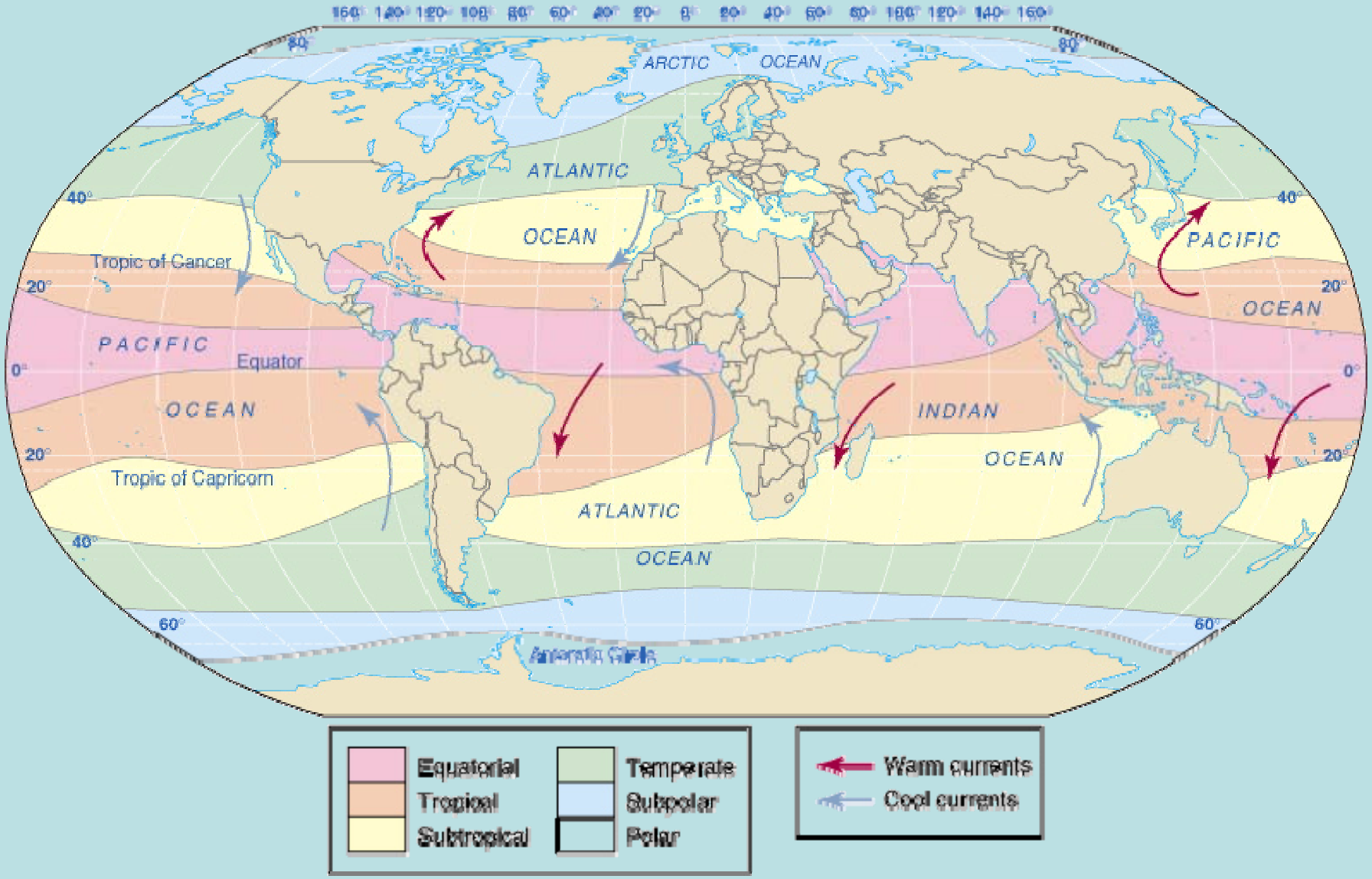
http://www.windows.ucar.edu/tour/link=/earth/Water/images/ocean_temp.html&edu=high

Day – night air temperature change

Land: up to 30°C Ocean: ~1°C



Climate regions of the ocean



Summary

•Solar radiation reaching the earth surface varies with latitude, season, time of day
•Amount absorbed depends on the albedo: insolation is greatest at low latitudes
•Oceans have a large heat capacity: act as a temperature buffer
•Conduction, convection, evaporation/precipitation are the principal means for heat & water exchange between air-sea
•Solar radiation penetrates no more than a few 100's m into the oceans: most is absorbed in top 10 m
•Mixing by wind-waves & currents produces a mixed surface layer 200-300 m thick, below which lies the permanent thermocline where temperatures drop below 5° C
•Air currents & ocean currents redistribute tropical heat to the poles where it is cooled and sinks & returns