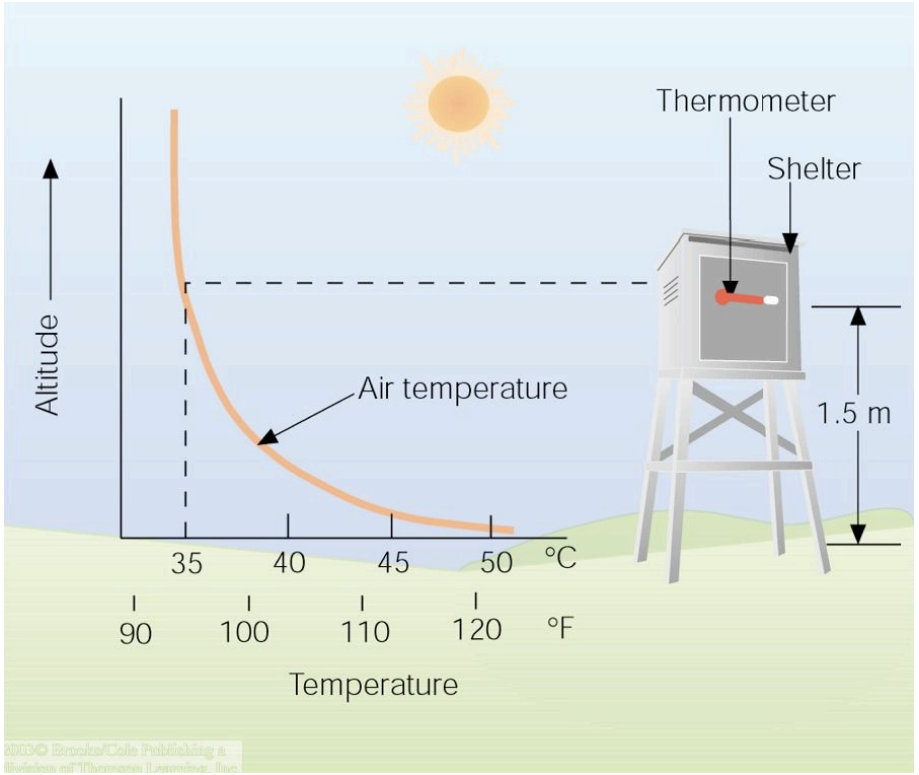

Air Temperature
GEOL 1350: Introduction To Meteorology

Overview

- Daily Temperature Variation
- Controls of Temperature
- Air Temperature Data
- Measuring Air Temperature

Daytime Warming

- Sunlight warms the ground, and the ground warms the air in contact with it by conduction.
- Air is a poor heat conduction.
- Near surface, convection can also help to redistribute the heat. In calm weather, the thermal convection effect is small and do not effectively mix the air near the surface.
- Thus, there is a substantial temperature difference above the ground on windless day.



Heat conductivity of common substances

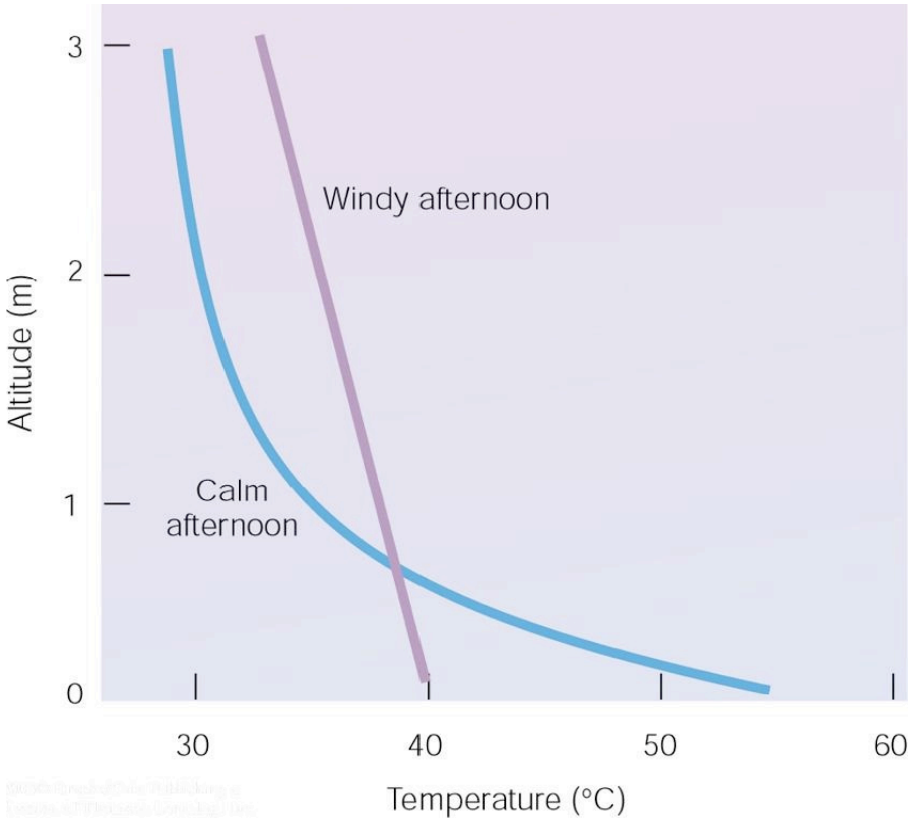
Substance	Heat conductivity (W/m/^{o}C)
still air	0.023
wood	0.08
dry soil	0.25
water	0.60
snow	0.63
ice	2.1
iron	80

Air is a extremely poor conductor ! Inefficient for heat transfer in the atmosphere

Daytime Warming

- On windy days, turbulence eddies are able to mix hot, surface air with cooler air above.

- This form of mechanical stirring, called forced convection, helps the thermals to transfer heat away from the surface more efficiently.



Temperature gradient is smaller in windy day than calm day.

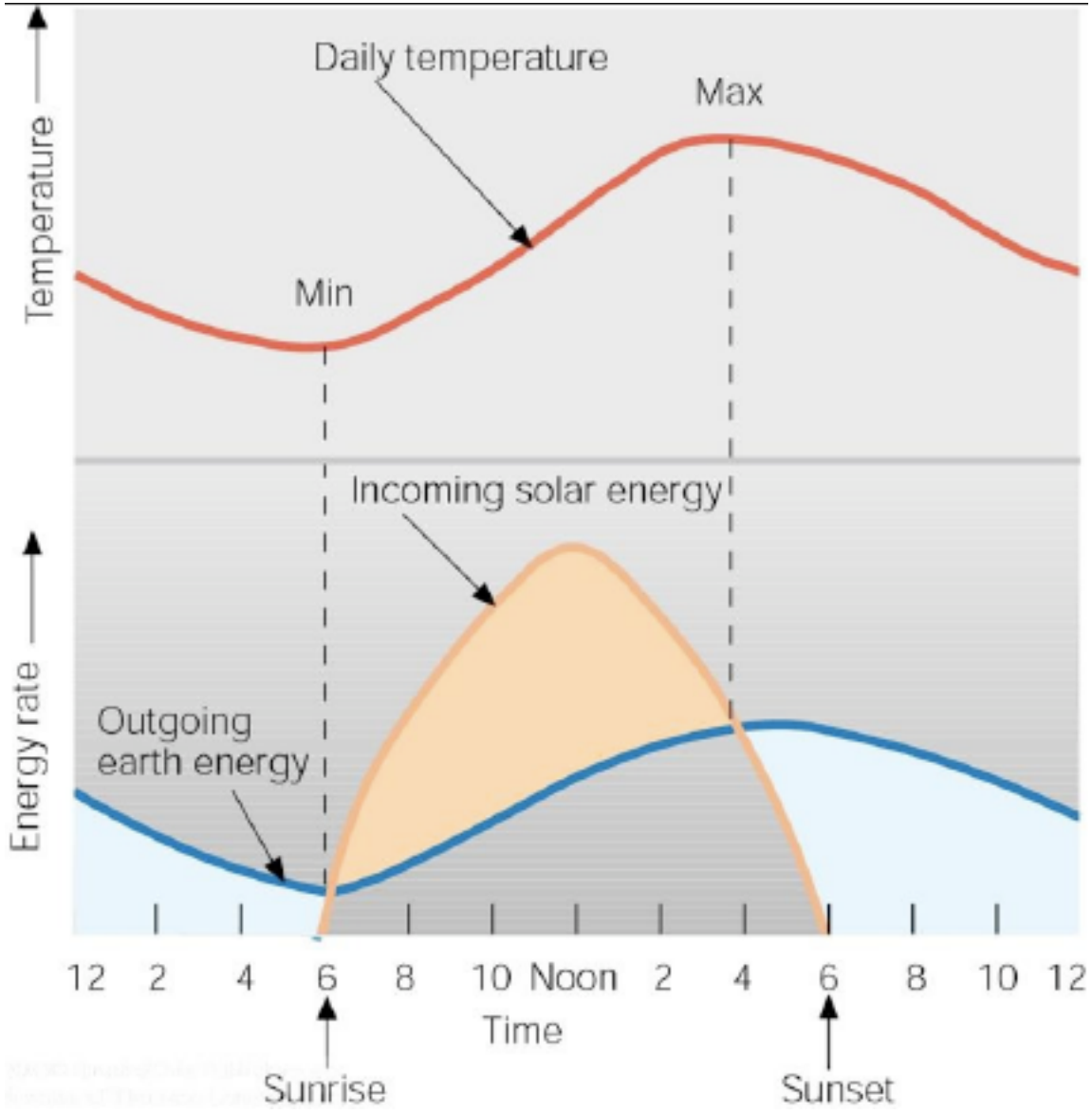
Daily Temperature Variations

- **Each sunny day is like a tiny season as the air goes through a daily cycle of warming and cooling.**
- **Air warms during morning hours, as the sun rises higher in the sky.**
- **It is around noon when the earth's surface receives the most intense solar rays.**
- ***However, noontime is not the warmest part of the day. Why?***

Daily Temperature Variations

- Around noon, the sun's rays are most intense.
- However, even though incoming solar radiation decreases in intensity after noon, it still exceeds outgoing heat energy from the surface for a time.
- This situation leads to energy surplus for 2-4 hours after noon.
- It leads to a lag between the time of maximum solar heating and the time of maximum air temperature.

Daily Temperature Variations



Daily Temperature Variations

- **The exact time of the maximum temperature varies.**
- **T_{max} is about 3-5pm during summer cloud-free days.**
- **T_{max} also depends on surface type and cover**

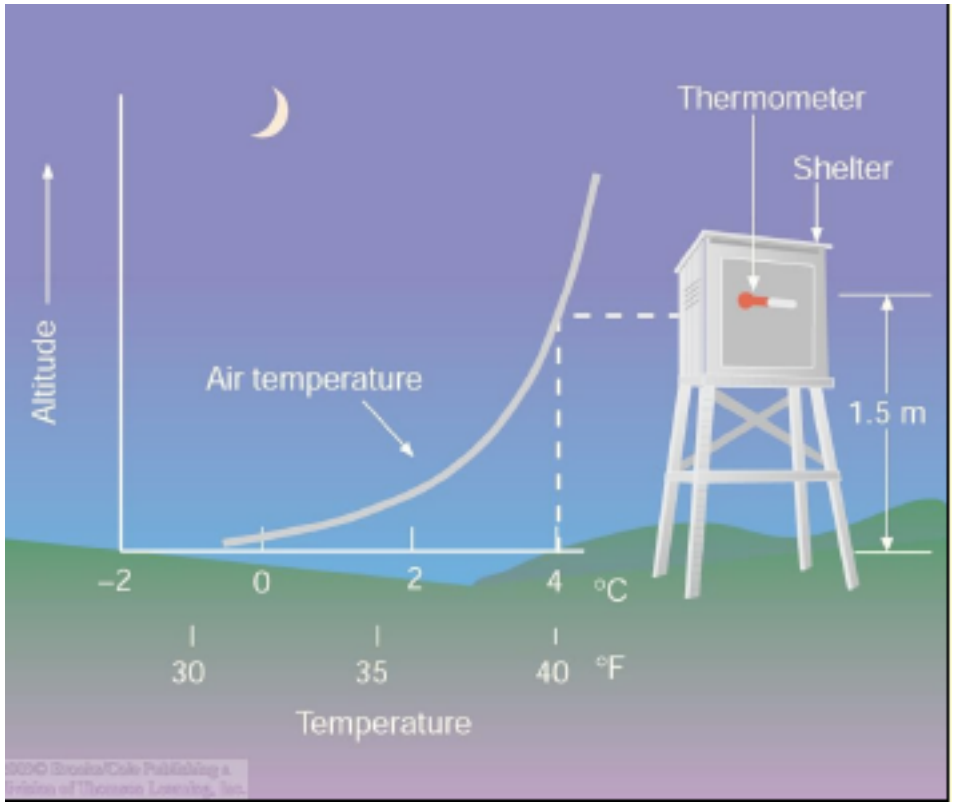
1. Absorption characteristics (Strong absorbers enhance surface heating)

2. Vegetation/moisture (Available energy partially used to evaporate water)

- **T_{max} also depends on wind. Strong mixing by wind will mix heated air near ground to higher altitudes.**

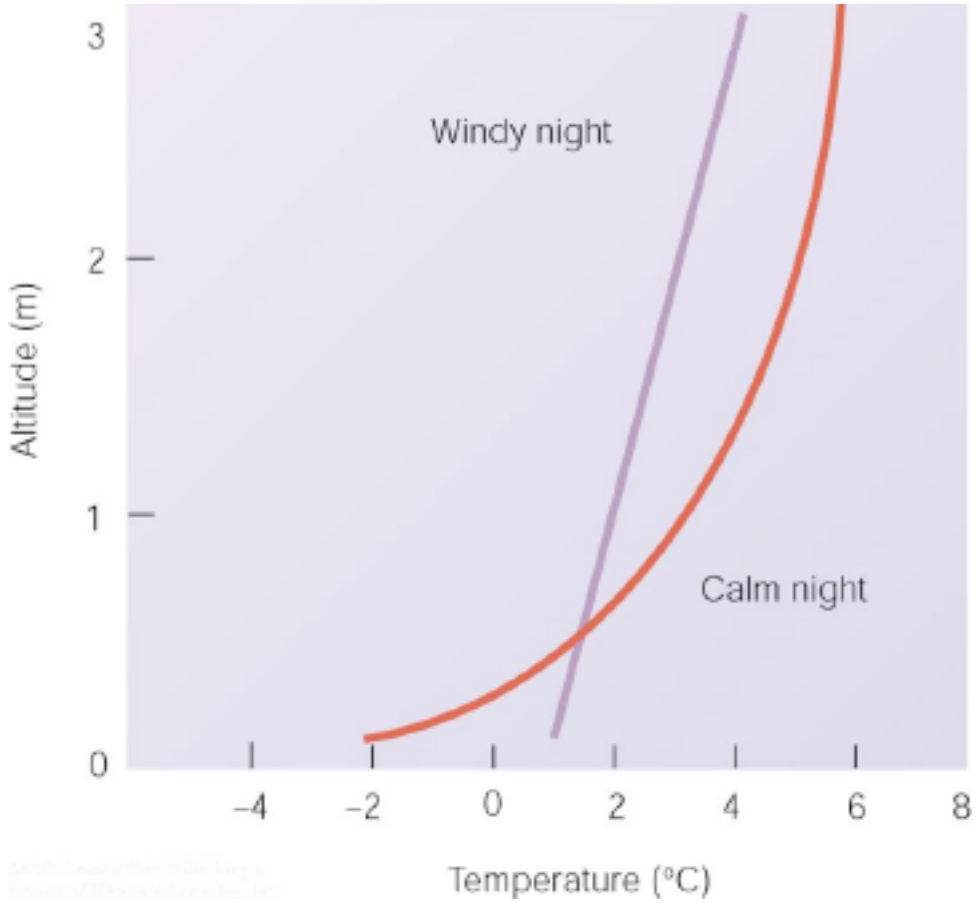
Nighttime Cooling

- At night, both ground and air above cool by radiating infrared energy, a process called radiational cooling.
- Ground, a better radiator than air, is able to cool more quickly.
- After sunset, surface is cooler than the air above it.



Measured increase in air temperature above the ground is known as radiation inversion or nocturnal inversion.

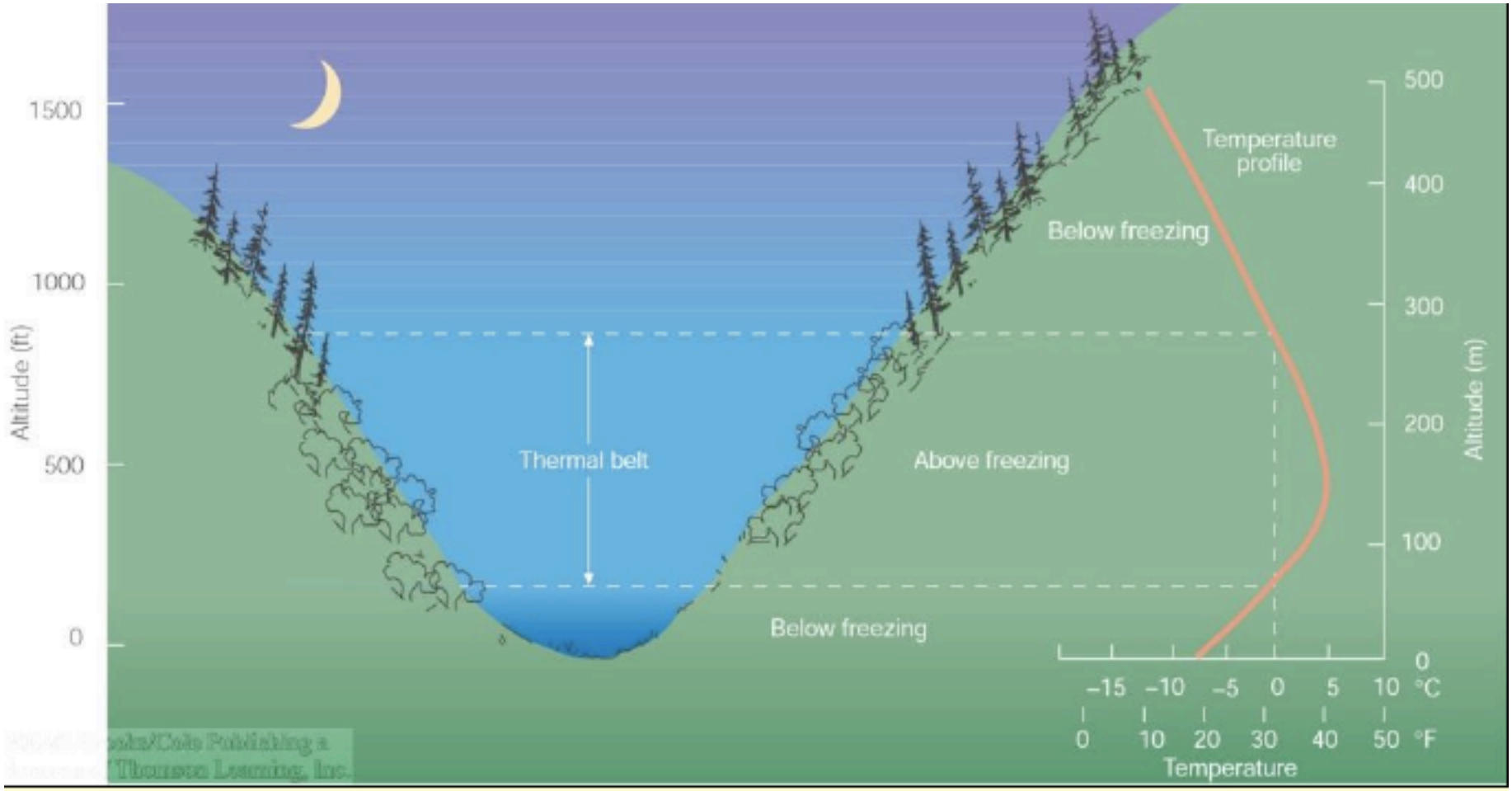
Nighttime Cooling



Temperature gradient is smaller in windy night than calm night.

Evening length, water vapor, clouds, and vegetation affect earth's nighttime cooling.

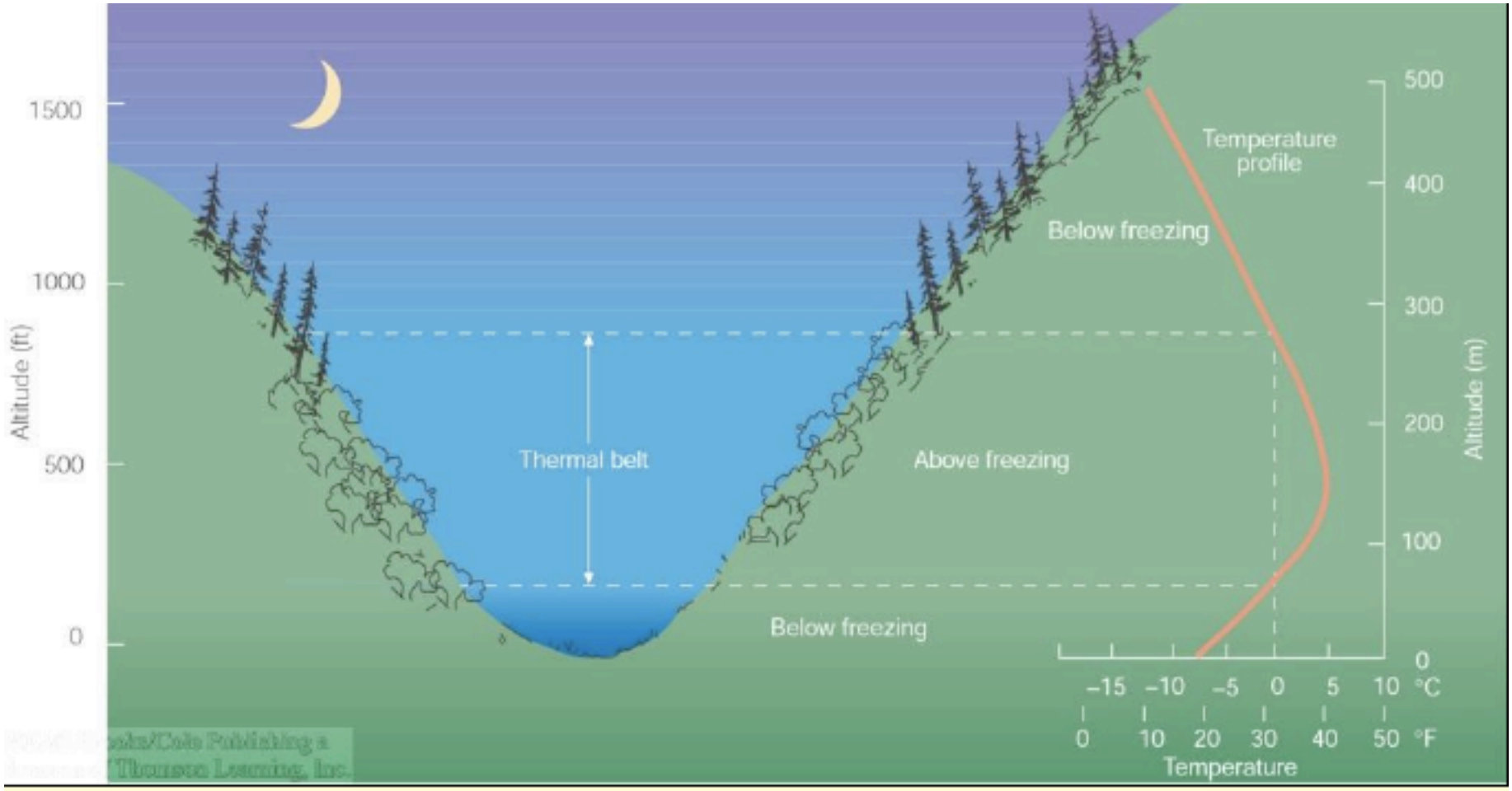
Cold Air Near the Surface



Night time radiational cooling increases air density.

Cold, heavier air settles to the valley bottom. It leads to a thermal belt of warmer air between lower and upper cooler air.

Cold Air Near the Surface



On the valley floor, cold and dense air cannot rise. Smoke and other pollutants are trapped. Thus, valley bottom is colder and more frequently polluted than nearby hillsides.

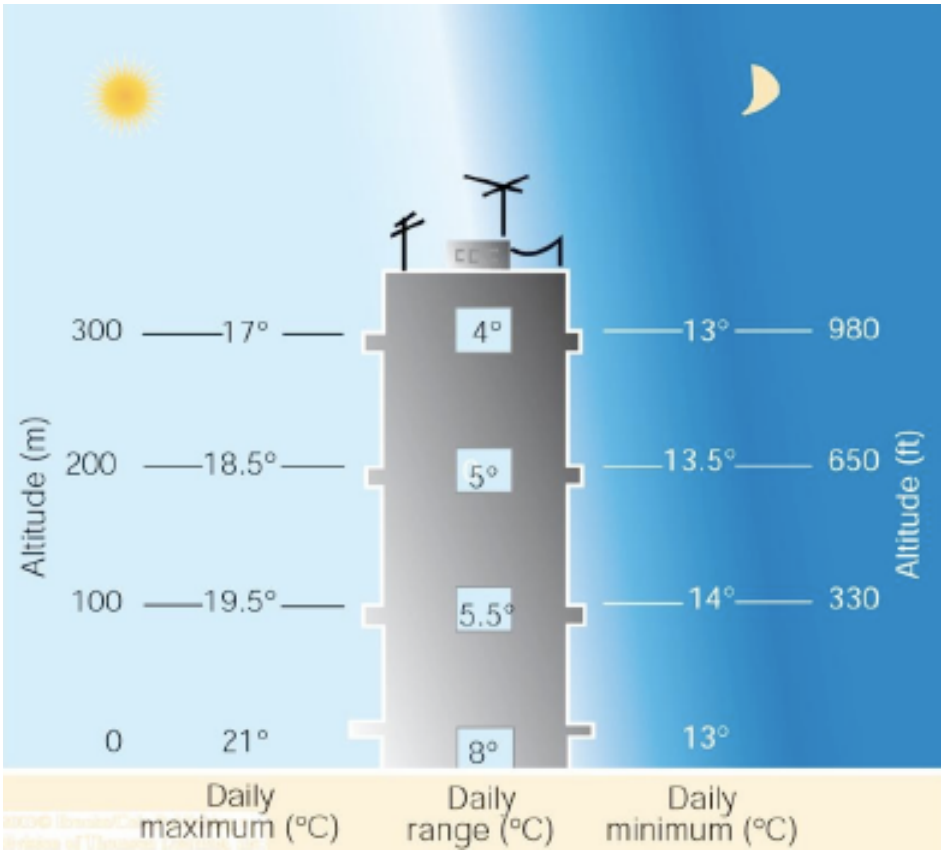
Protecting Crops from the Cold Night Air

- On cold nights, many plants may be damaged by low temperatures.
- To protect small plants or shrubs, cover them with straw, cloth, or plastic sheeting. This prevents ground heat from being radiated away to the colder surroundings.
- The lower branches of fruit trees are the most susceptible to damage. Increasing the air temperature close to the ground may prevent damage. We can increase near-ground temperature by using orchard heaters. It can warm the air around the trees by setting up convection currents close to the ground.

Protecting Crops from the Cold Night Air

- Another way to protect trees is to mix the cold air at the ground with the warmer air above, thus raising the temperature of air next to the ground. This can be accomplished by using wind machines.

Daily (Diurnal) Range of Temperature



- **Greatest variation in daily temperature occurs at the earth's surface. It becomes smaller as we move away from the surface.**

- **By day, clear summer skies allow the sun's energy to quickly warm the ground. At night, the ground cools rapidly by radiating infrared energy to space.**

Daily (Diurnal) Range of Temperature

- The largest diurnal range of temperature occurs on high deserts, where the air is fairly dry, often cloud-free. There is little water vapor to radiate much infrared energy back to the surface.

- Clouds are good reflectors of incoming solar radiation, and so they prevent much of the sun's energy from reaching the surface during daytime.

- If the clouds persist into the night, they tend to keep nighttime temperatures higher, as clouds are excellent absorbers and emitters of infrared radiation.

Measuring Air Temperature

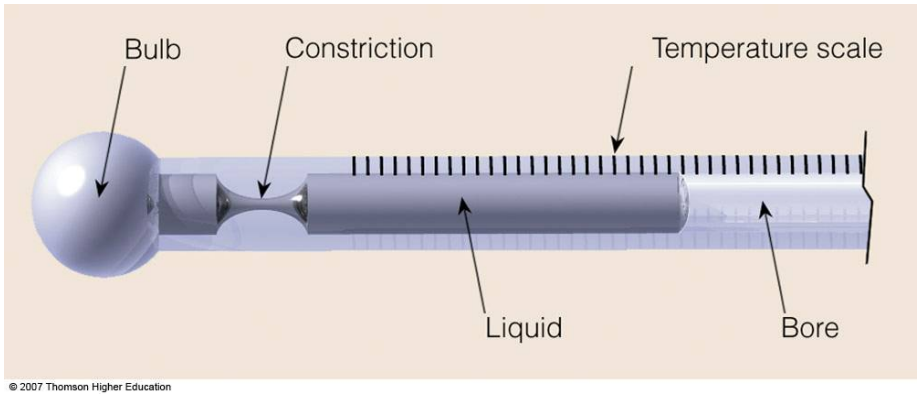
- Thermometers were developed to measure air temperature.

- Liquid-in-glass thermometers are often used for measuring surface air temperature because they are easy to read and inexpensive to construct.

- Thermometers have a glass bulb attached to a sealed tube about 25 cm long. When the temperature rises (decreases), the liquid in the bulb expands (contracts). Hence, the length of the liquid in the tube represents the air temperature.

Maximum Thermometer

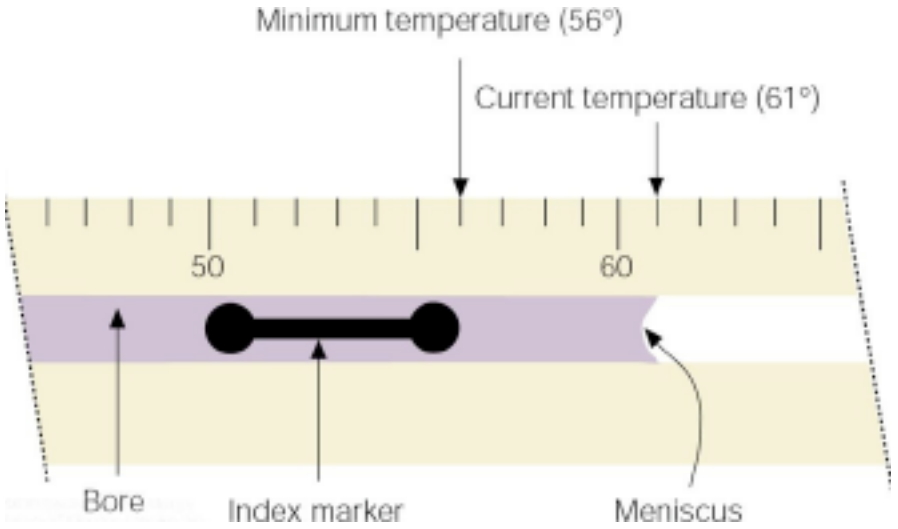
- Maximum thermometer looks like any other liquid-in-glass thermometer with one exception:
- It has a small constriction within the bore just above the bulb.
- As the air temperature increases, the mercury expands and freely moves past the constriction up the tube, until the maximum temperature occurs.
- However, as the air temperature begins to drop, the small constriction prevents the mercury from flowing back into the bulbs.
- Thus, the end of the stationary mercury column indicates the maximum temperature for the day.



Maximum Thermometer

Minimum Thermometer

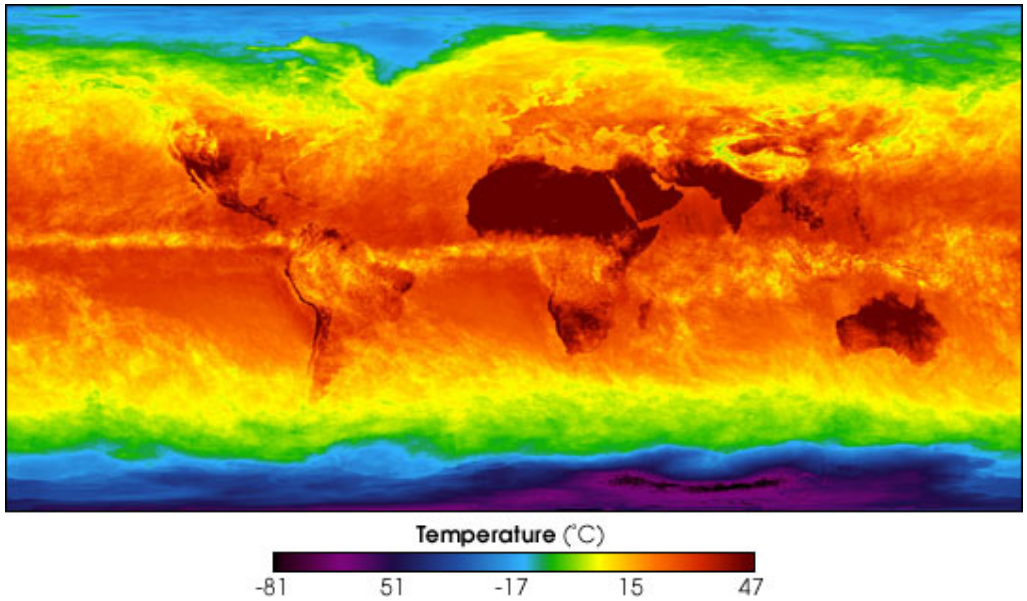
- A minimum thermometer measures the lowest temperature during a given period.
- It is similar to other liquid-in-glass thermometers except that it contains a small barbell-shaped index marker in the bore.
- As the air temperature drops, the contracting liquid moves back into the bulb and brings the index marker down the bore with it.
- When the temperature stops decreasing, the liquid and the index marker stop moving down the bore.
- When the temperature increases, the alcohol expands and moves freely up the tube past the stationary index marker.
- Because the index marker does not move as the air warms, the minimum temperature is read by observing the upper end of the marker.



Other Thermometers

- **Electrical thermometer: Since the resistance of the material chosen for these thermometers changes as the temperature changes, the resistance can be calibrated to represent air temperature.**

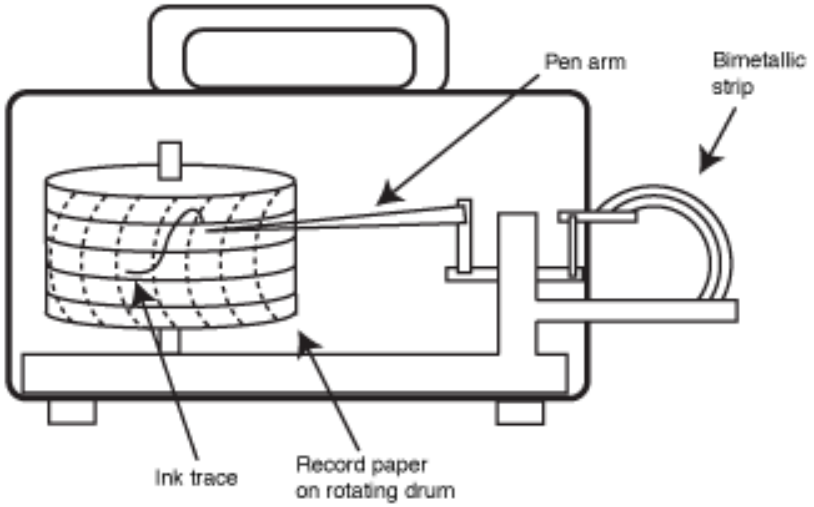
- **Infrared sensors (Radiometers): By measuring both the intensity of radiant energy and wavelength of maximum emission of a particular gas (either H2O or CO2), radiometers in orbiting satellites are able to estimate the air temperature at selected levels in the atmosphere.**



Temperature from Atmospheric Infrared Sounder on Aqua Satellite

Other Thermometers

- **Bimetallic thermometer**: It consists of two different metal (brass and iron) welded together to form a single strip. As the temperature changes, the brass expands more than the iron, causing the strip to bend.The small amount of bending is amplified through a system of levers to a pointer on a calibrated scale.



Summary

1. Daily variation in air temperature near the earth's surface is controlled mainly by the input of energy from the sun and output energy from the surface.
2. On a clear, calm day, surface air warms as long as heat input (sunlight) exceeds heat output (convection and radiated infrared energy).
3. Surface cools at night as long as heat output exceeds input.
4. Coldest air is normally found at the surface, for the ground at night cools more quickly than the air above.
5. Greatest daily variation in air temperature occurs at the earth's surface.