Water in the Atmosphere
AOSC 200

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Class Web Site: http://www.atmos.umd.edu/~tcanty/aosc200

Topics for today:

The Water Cycle
Latent Heat
Evaporation & Saturation
Relative Humidity
Dew Point

Lecture 10
Sep 26 2019

Air temperature data

- **Daily mean temperature determined two ways**
  1. **average of max. and min. temperatures for the day**
  2. **average of 24 hourly temperatures**
- **Daily temperature range – difference between max. and min. temperatures**
- **Monthly mean temperature – average of daily mean for the month**
- **Annual mean temperature – average of monthly means**
- **Annual temperature range – difference between coldest monthly mean and warmest monthly mean**

Daytime Temperatures

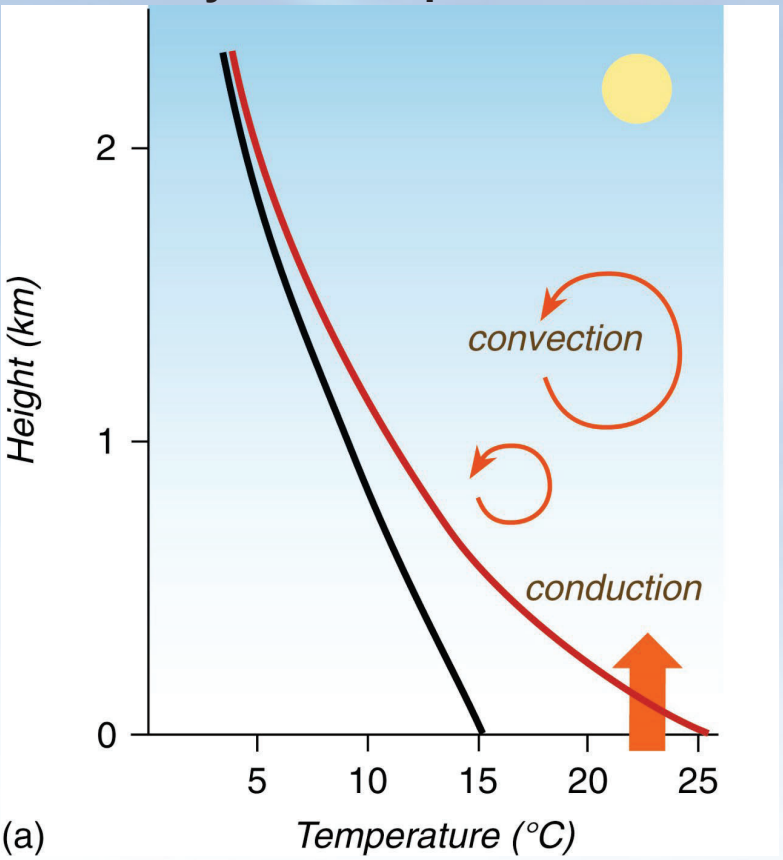
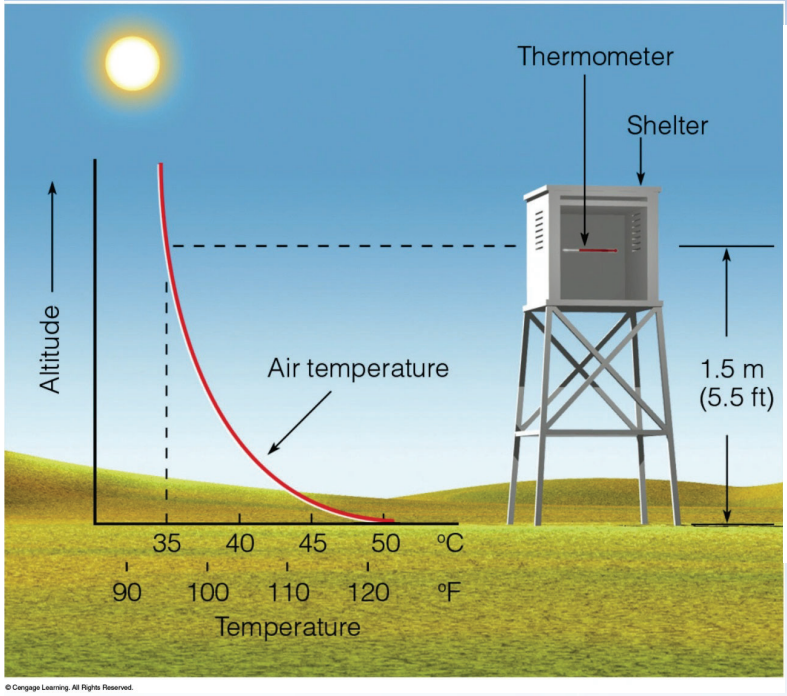


Fig 4.14: ***Weather: A Concise Introduction***

Daytime Temperatures



As the sun rises, the ground warms.

Air in contact with ground warms, too.

On calm days, air above the surface is cooler

On windy days, the air is mixed so the difference in temperature between the surface and air above is smaller

Fig 3.1: ***Essentials of Meteorology***

Nighttime Temperatures

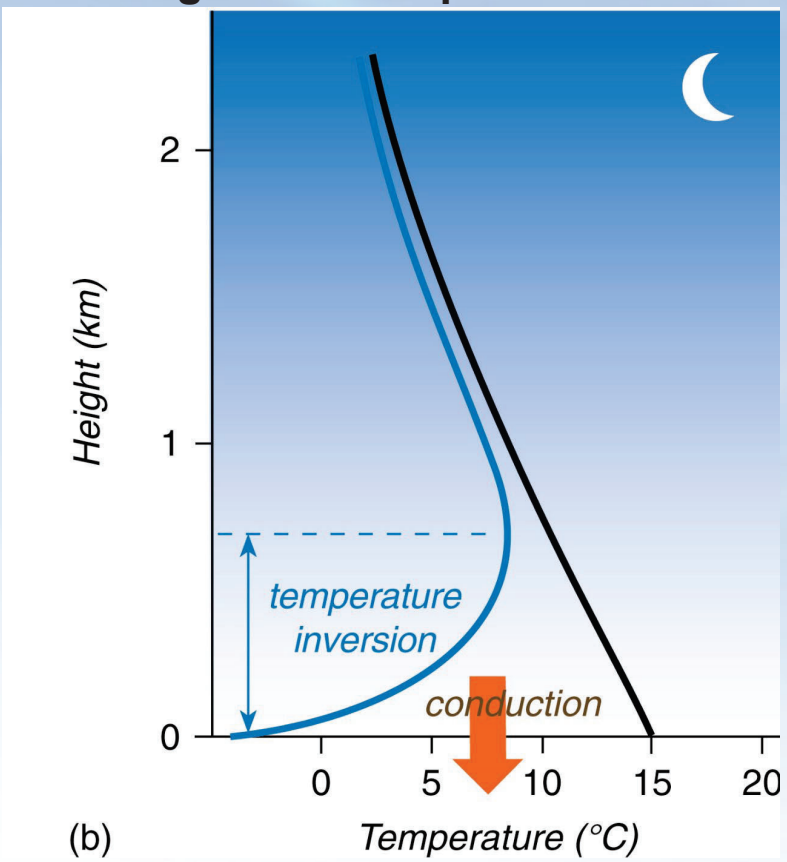
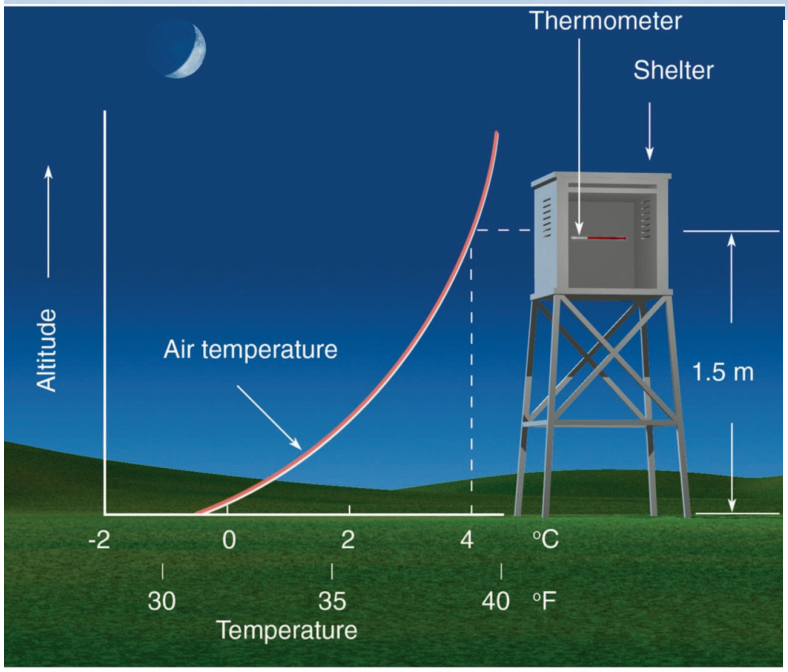


Fig 4.14: ***Weather: A Concise Introduction***

Nighttime Temperatures



As the sun sets, the ground cools by radiating it's heat to space

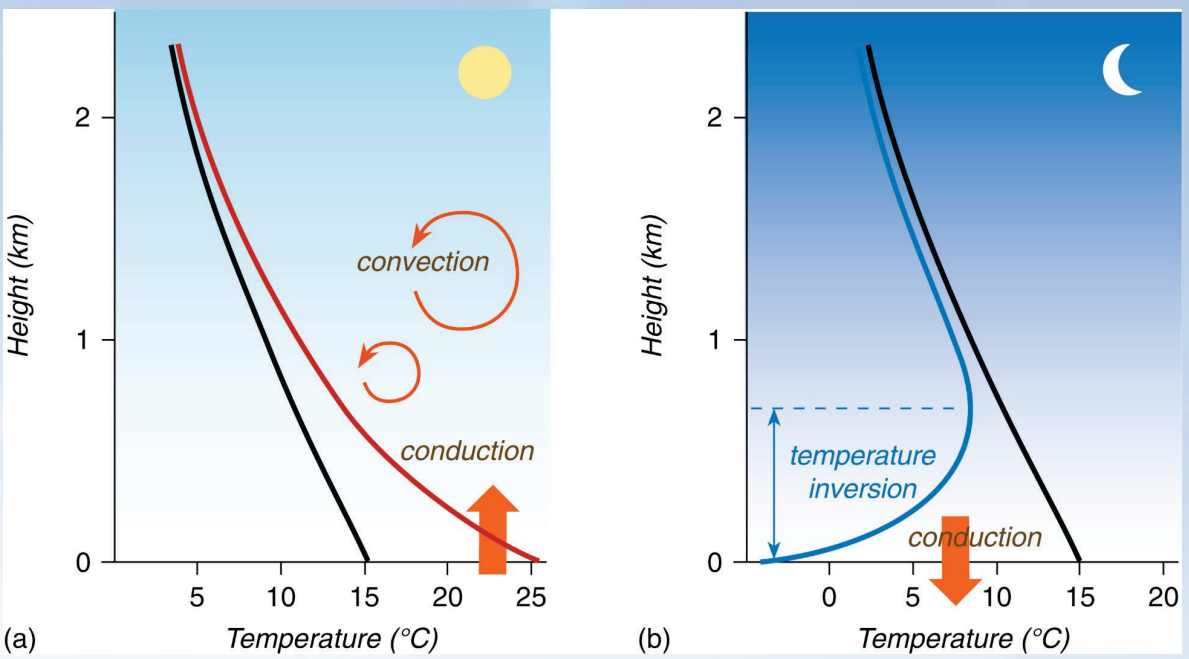
Air radiates some heat to the ground and the ground radiates this heat away, too.

As the night progresses, the ground and the air just above the surface cool more rapidly than the air above.

Increase in temperature above the ground is called a "radiation inversion"

Fig 3.5: ***Essentials of Meteorology***

Daily Temperatures



Daily temperature changes are largest near the surface

Fig 4.14: *Weather: A Concise Introduction*

Role of Clouds

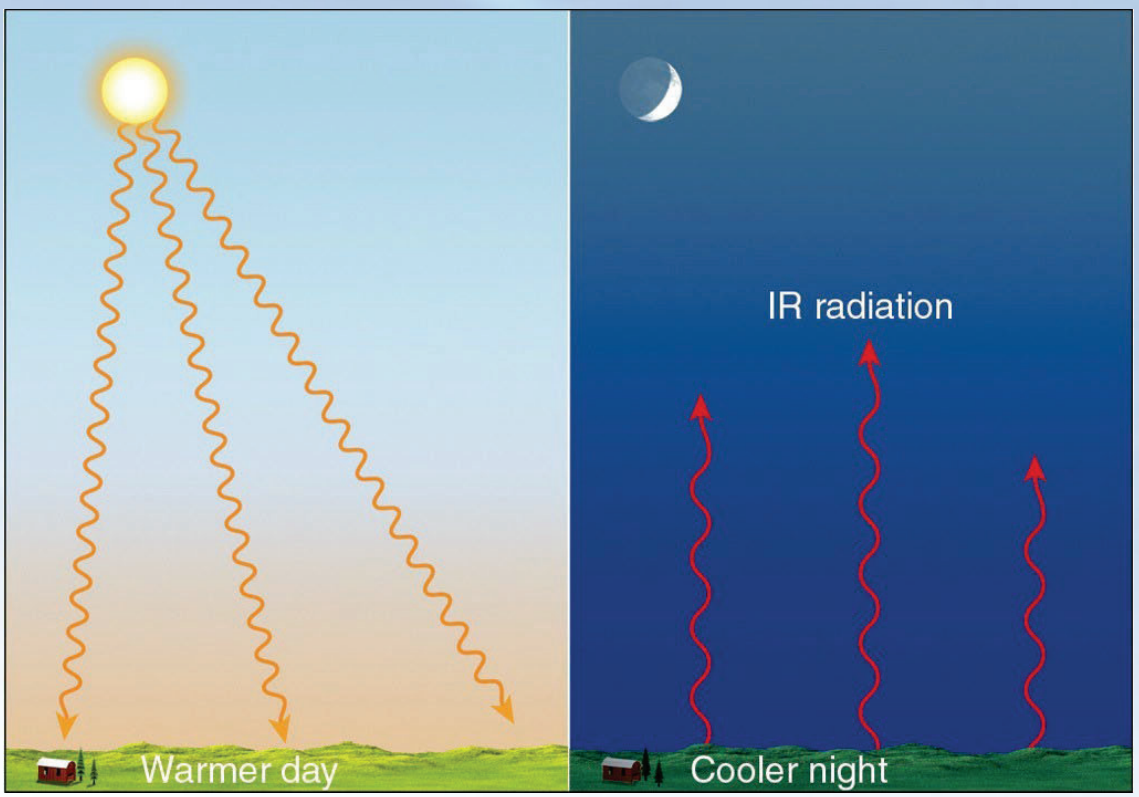
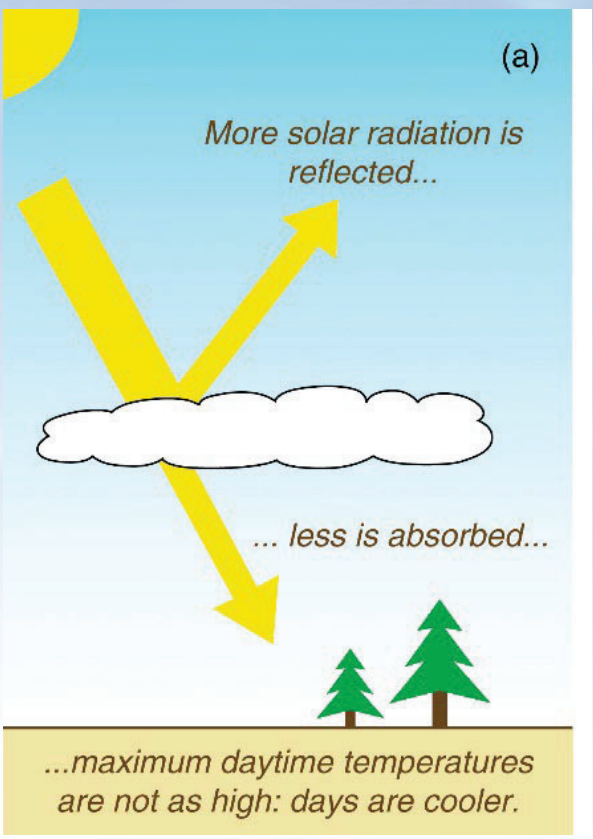


Fig 3.14: *Essentials of Meteorology*

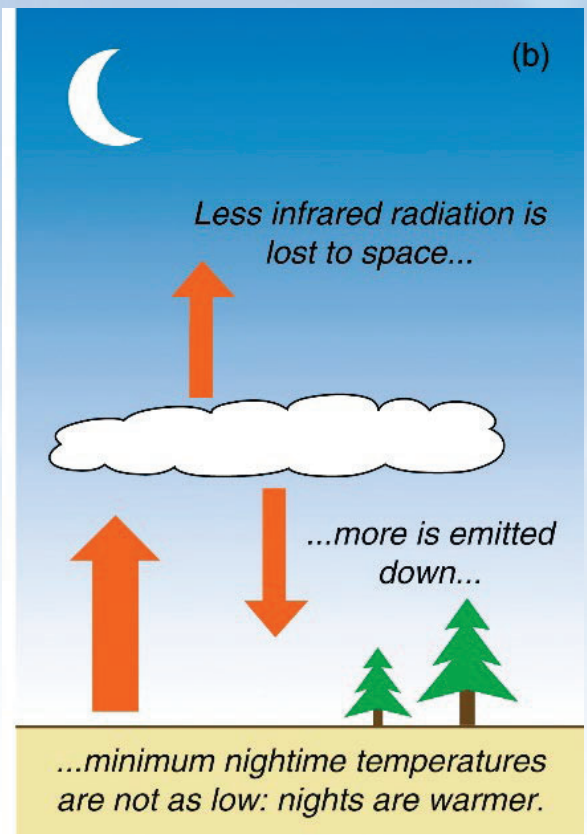
Daytime Temperatures: Clouds



Clouds have a high albedo and will reflect incoming solar radiation

Fig 4.15: *Weather: A Concise Introduction*

Nighttime Temperatures: Clouds



Clouds prevent heat from surface from going out to space

Fig 4.15: *Weather: A Concise Introduction*

Temperature: Cloud Influence

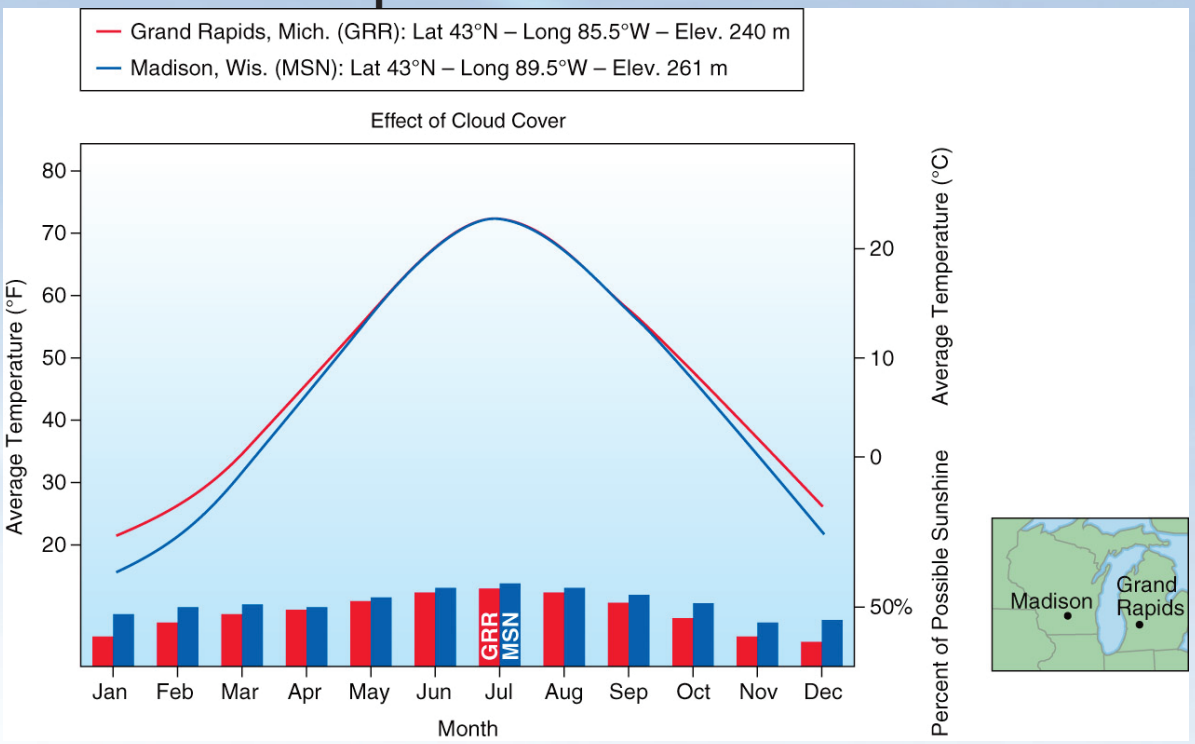


Fig 3-14 *Meteorology: Understanding the Atmosphere*

Temperature: Latitude Variations

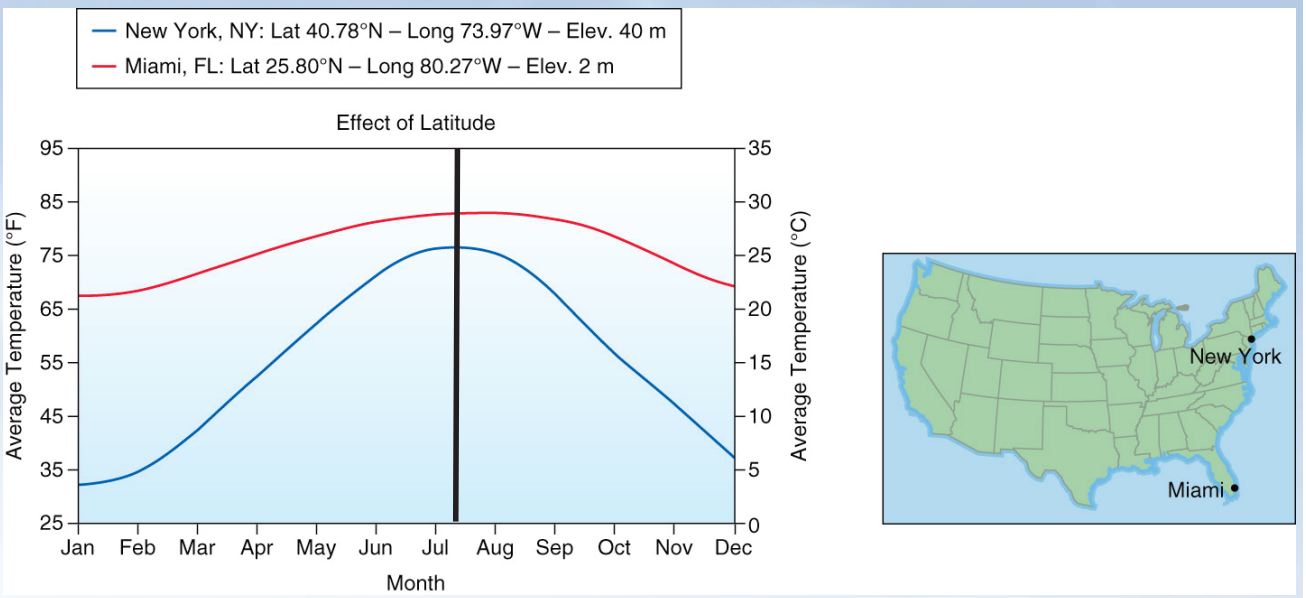


Fig 3-6 *Meteorology: Understanding the Atmosphere*

Temperature: Latitude Variations

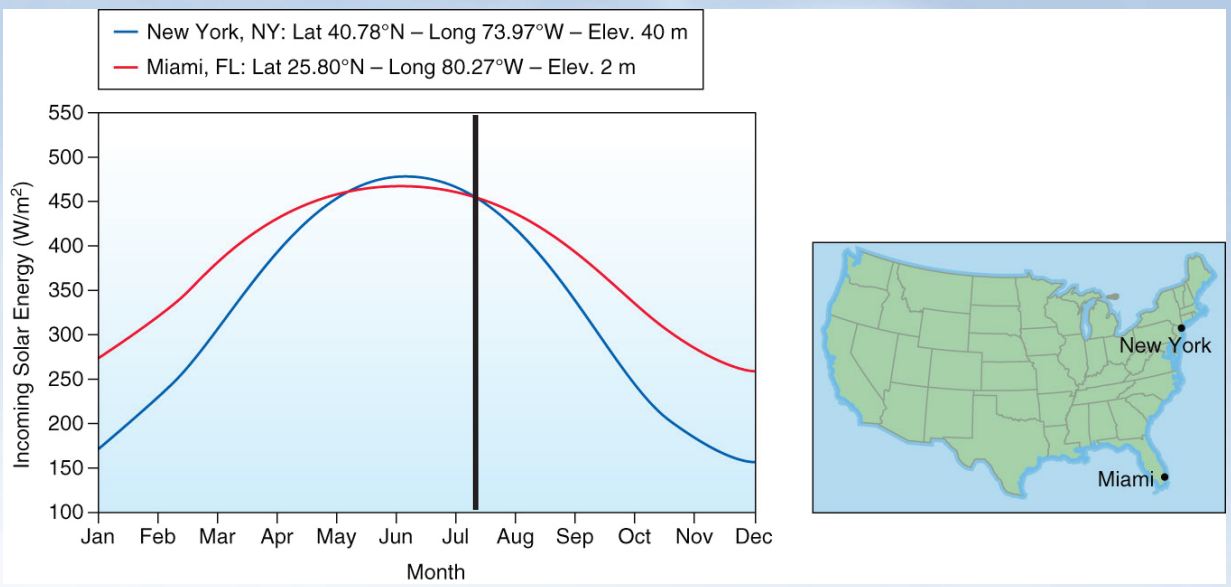
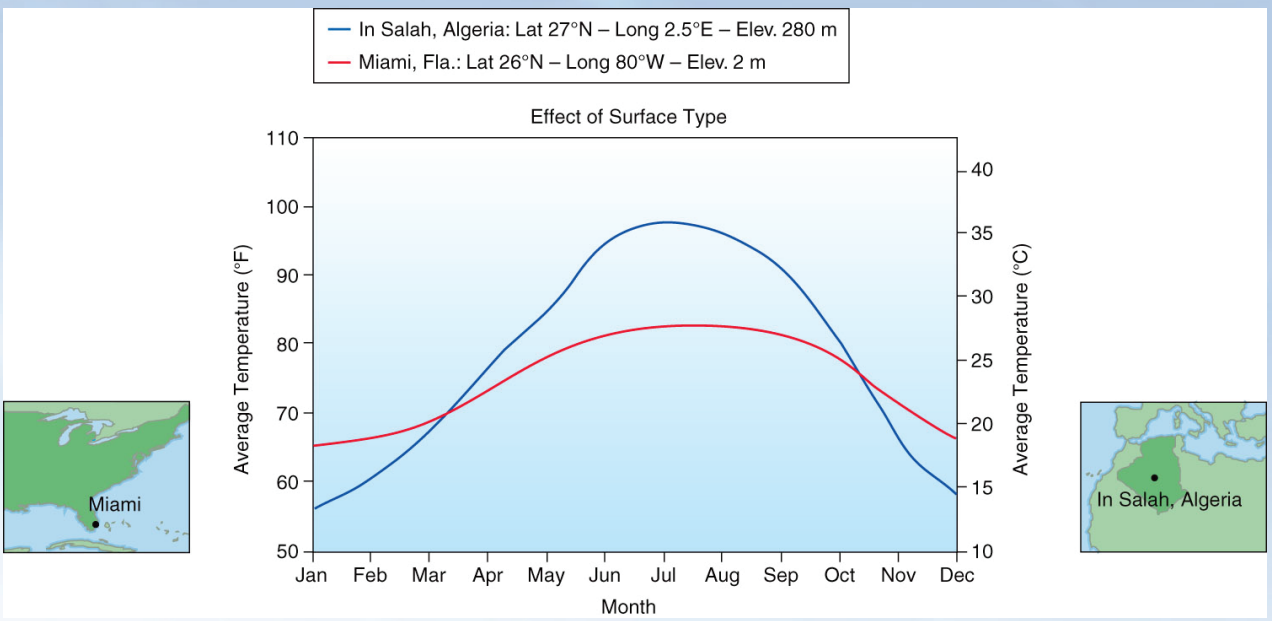


Fig 3-6 *Meteorology: Understanding the Atmosphere*

Temperature: Surface Variations



Both cities are around the same latitude

Fig 3-8 *Meteorology: Understanding the Atmosphere*

Temperature: Surface Variations

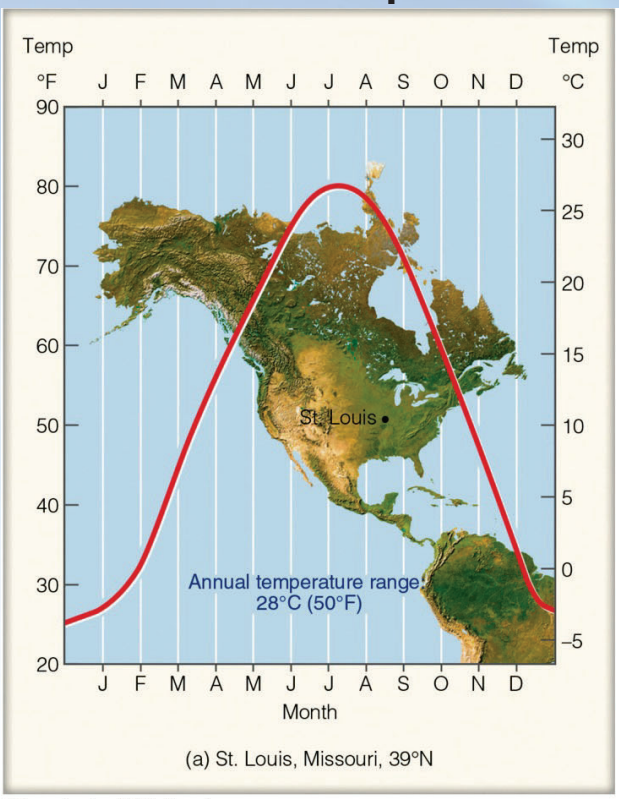


Fig 3.17: ***Essentials of Meteorology***

Average Temperature

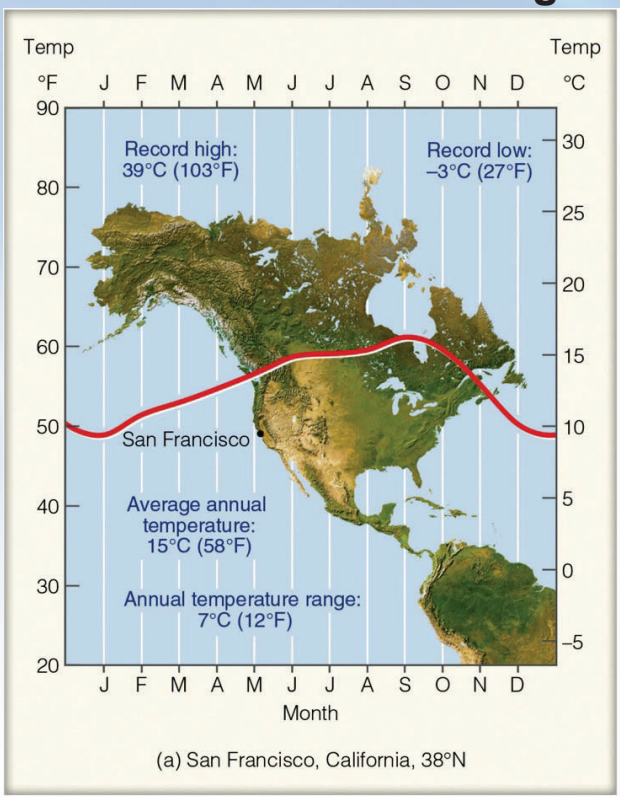


Fig 3.17: ***Essentials of Meteorology***

The Water Cycle

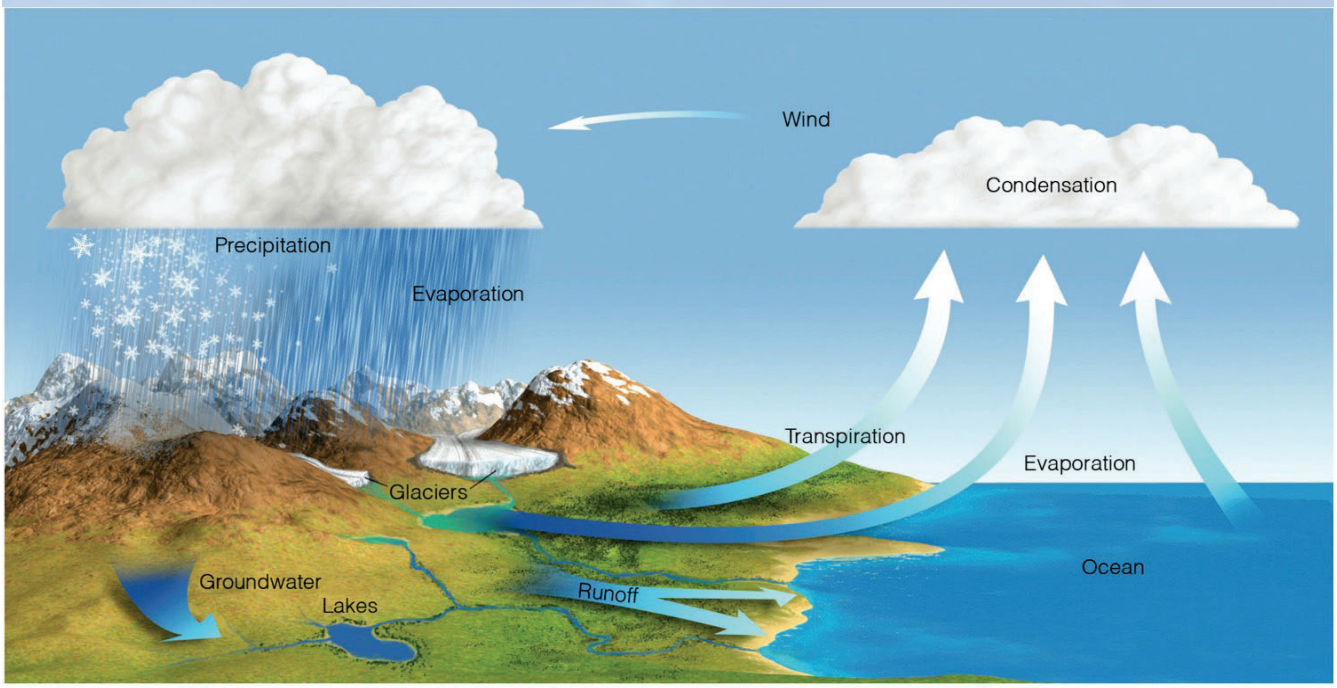


Fig 4.1: *Essentials of Meteorology*

Energy Transfer

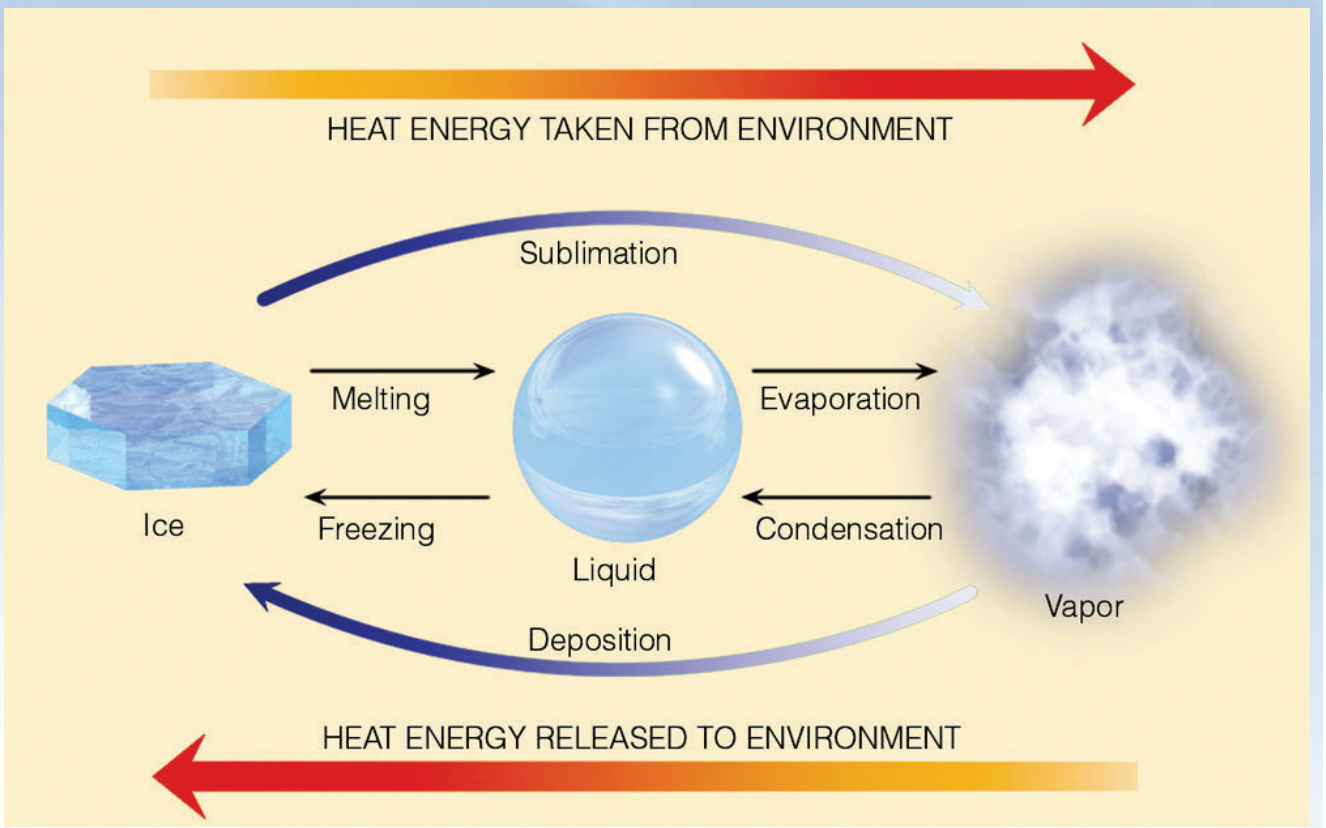


Fig 2.3: *Essentials of Meteorology*

The Water Cycle

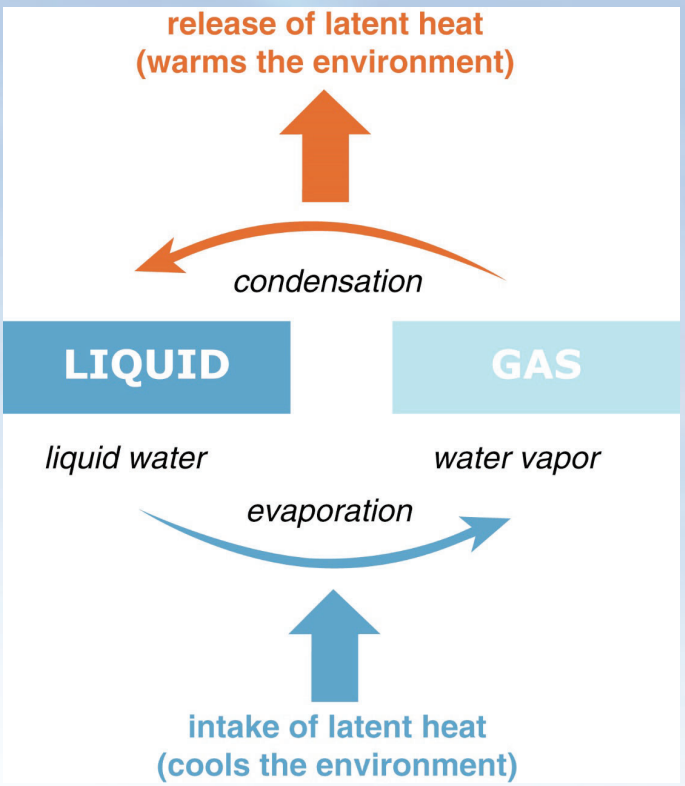


Fig 5.1 *Weather: A Concise Introduction*

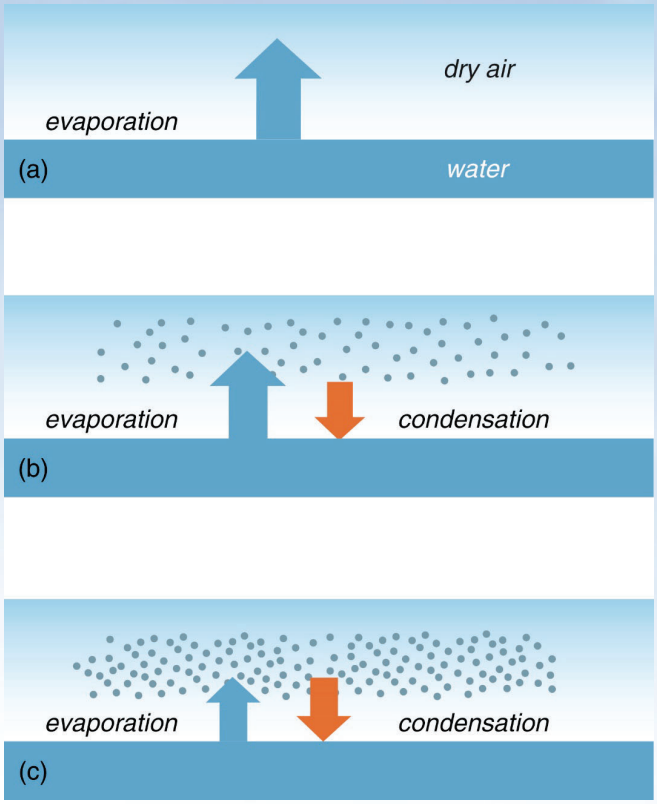
Latent Heat

Latent heat: the heat required to melt or evaporate a substance

Ice in the cooler absorbs heat from the drinks

Result: the ice melts while the drinks stay cold

Saturation



Water evaporates and enters dry air

Eventually, some of the water vapor hits the surface through collisions and random motion (condensation)

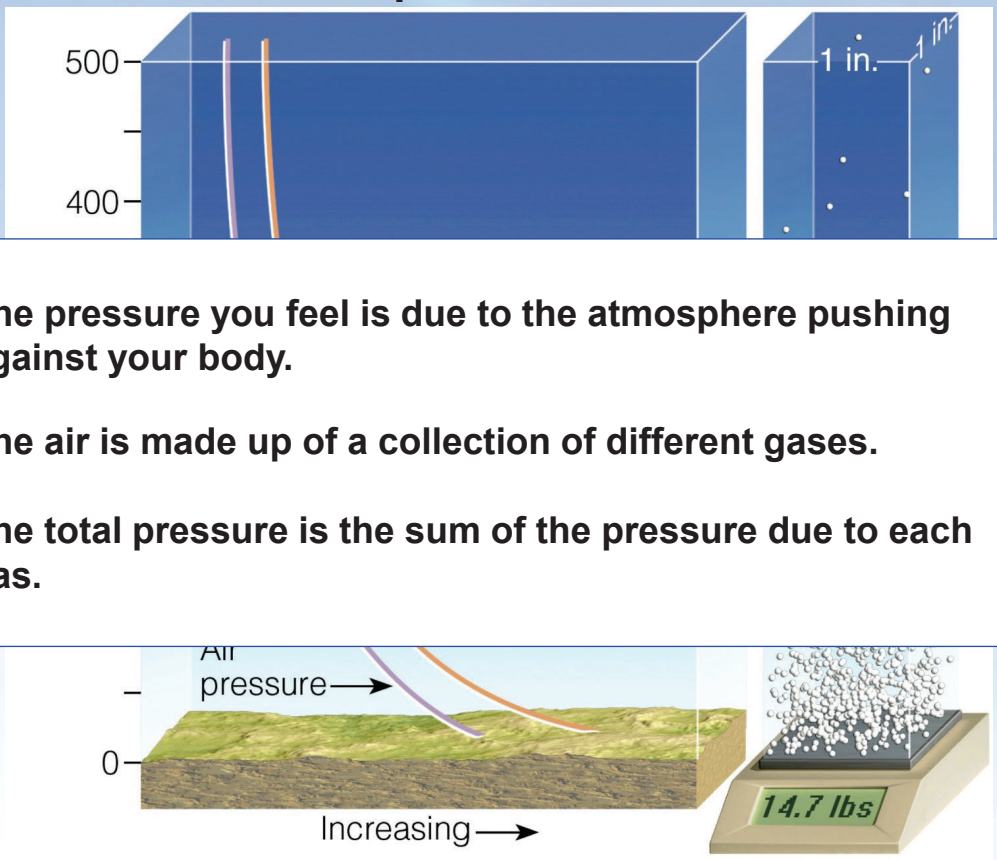
When evaporation and condensation are equal the air is said to be saturated

Fig 5.3 *Weather: A Concise Introduction*

Two ways to get water to condense

1) Decrease the air temperature
2) Increase the amount of water vapor

Vapor Pressure



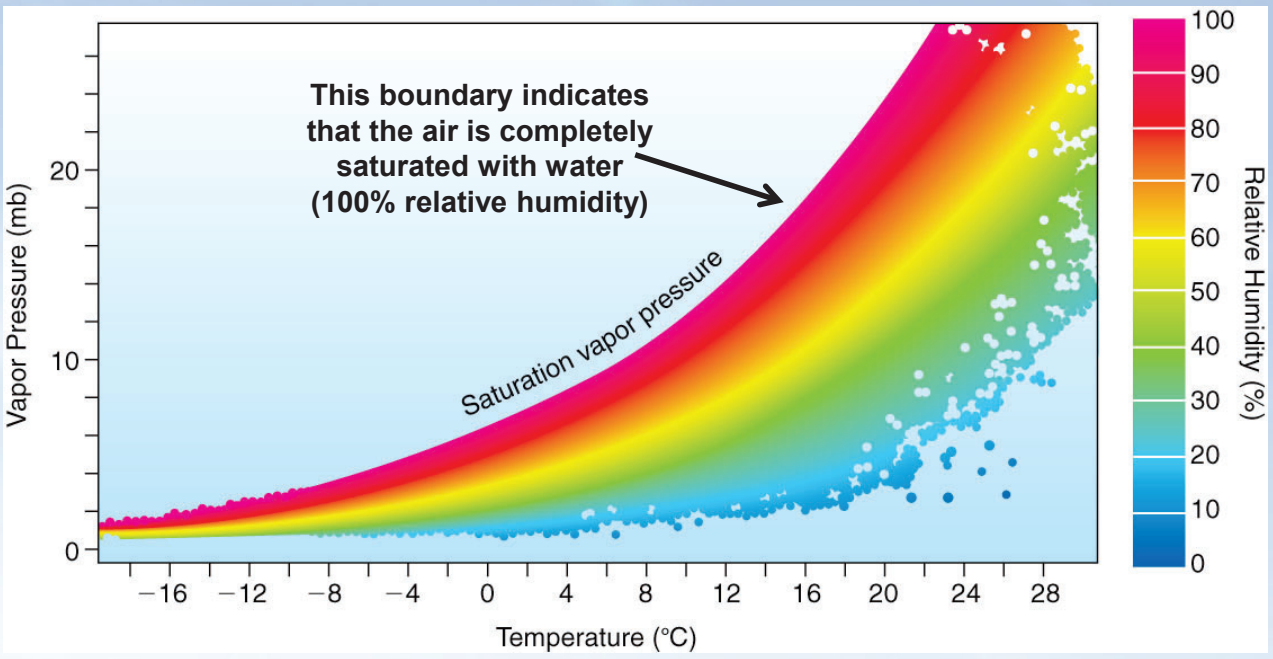
The pressure you feel is due to the atmosphere pushing against your body.

The air is made up of a collection of different gases.

The total pressure is the sum of the pressure due to each gas.

Fig 1.7: ***Essentials of Meteorology***

Vapor Pressure



Actual vapor pressure: the atmospheric pressure due to water
Saturation vapor pressure: the atmospheric pressure if the air was saturated

Fig 4-3 *Meteorology: Understanding the Atmosphere*

Different ways to think about humidity

1. **Absolute humidity: the mass of water vapor per volume**
2. **Specific humidity: the mass of water vapor per mass of dry air**
3. **Relative humidity: percent of water vapor present in air compared to the maximum at saturation; RH= e/e_s**

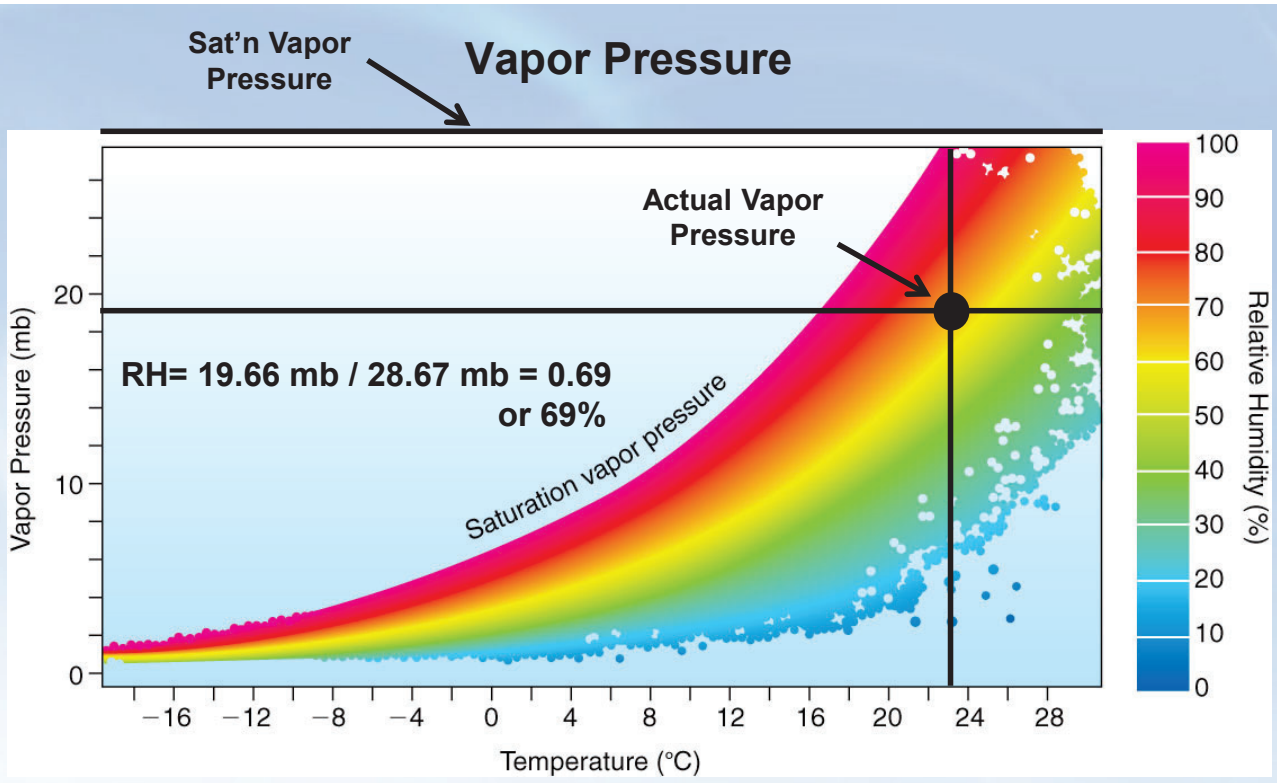


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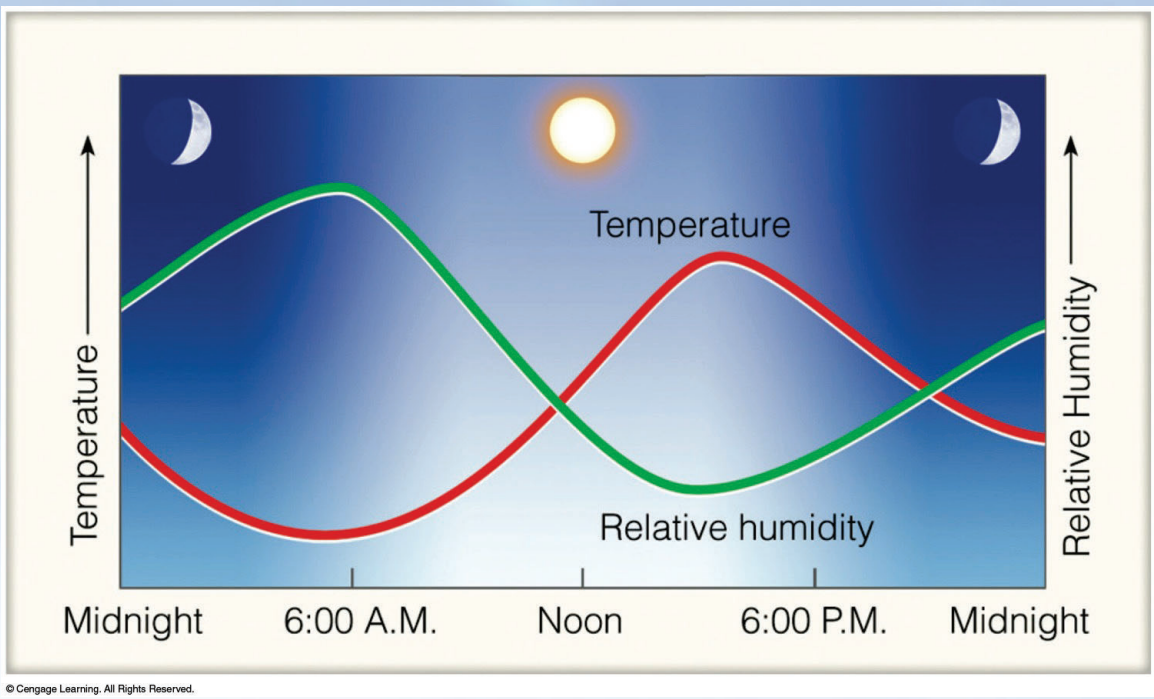
Fig 4-3 *Meteorology: Understanding the Atmosphere*

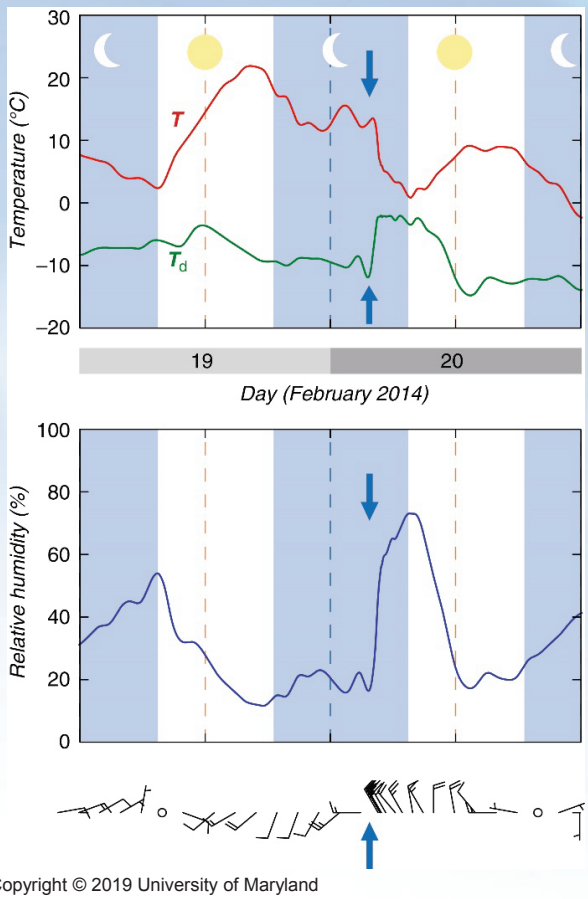
Relative Humidity



Temperature and relative humidity are "anti-correlated"

Fig 4.7: ***Essentials of Meteorology***

Relative Humidity



As T and T_d get closer, relative humidity increases

The blue arrows indicate when a cold front passed through

Fig 5.8 *Weather: A Concise Introduction*

Relative Humidity

T (°C)	e_s (hPa)	e (hPa)	RH (%)
20	23	15	65
19	22	15	68
18	21	15	72
17	19	15	75
16	18	15	83
15	17	15	88
14	16	15	94
13	15	15	100
12	14	14	100
11	13	13	100
10	12	12	100

As T decreases, saturation vapor pressure (e_s) decreases while vapor pressure (e) stays constant

Relative humidity increases

Vapor pressure does start to decrease after RH reaches 100% and e_s continues to drop

Why?

Table 5.1 *Weather: A Concise Introduction*

Vapor Pressure

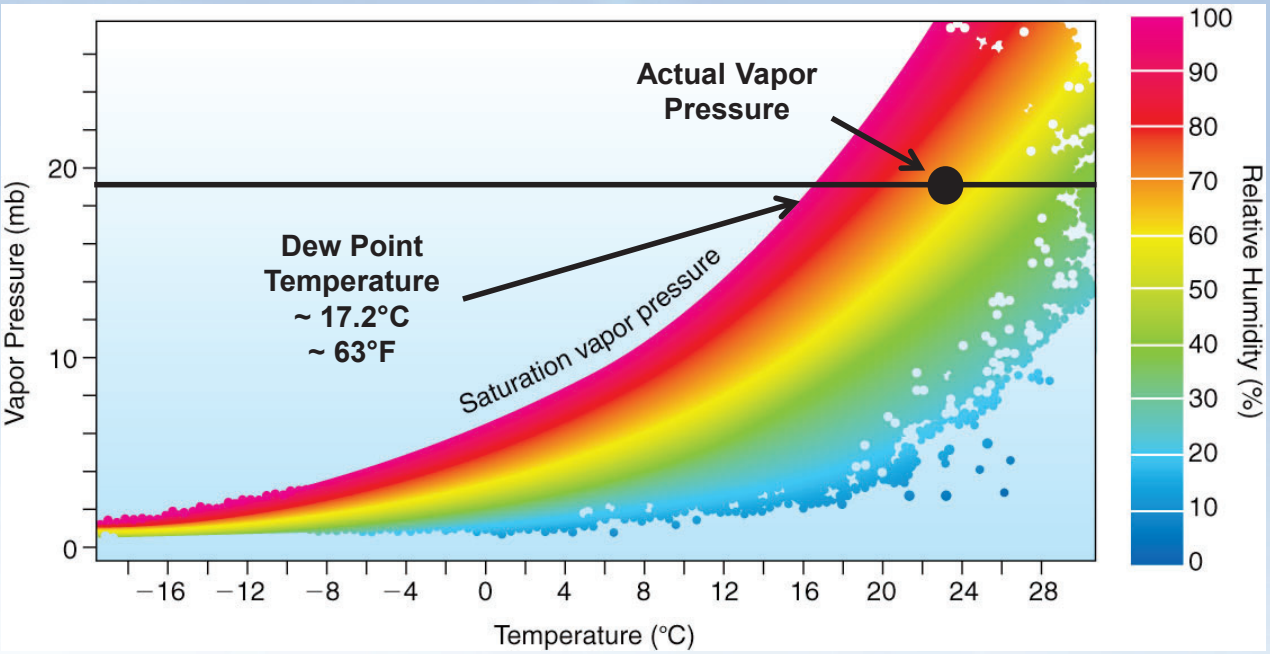


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Fig 4-3 *Meteorology: Understanding the Atmosphere*