

Natural Disasters

Lecture 4

Ch 9 – External Energy Fuels Weather and Climate

Text Source Today:
Chapter 9 (p. 229-235)

9.1: Ch. 9 – External Energy Fuels Weather and Climate

♦ **Weather** studies the variations in the atmosphere on short, tangible time scales, generally for a specific location.

♦ **Climate** looks at the long-term trend in weather conditions for a given location or region.

- An **air parcel** is a self-contained “blob” of air that can move around the atmosphere; generally, they are assumed to be about the size of **this classroom**.

- An **air mass** is a much larger blob of air, on the scale of the **United States** or even larger.

- Most of the **motions** we deal with in weather are caused by differences between the **density of air and water vapor** in air masses or parcels. Warm air is **less dense** than cold air.

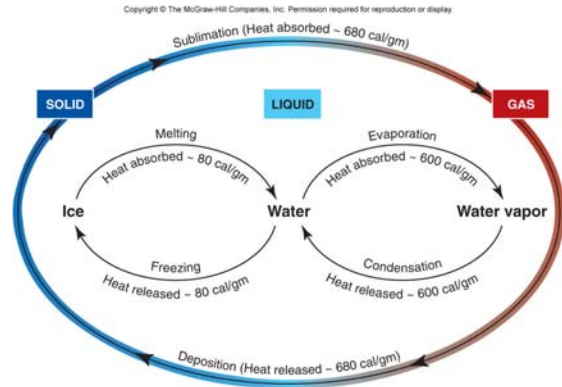
♦ **Dry air** has an average molecular weight of about **29 g/mol**, while **water vapor** is only **18 g/mol**. Thus, for a given amount of molecules in a parcel of air, moist air will be **less dense** than dry air. Warm air can also hold **more water vapor** than cold air. This means **warm, moist air** would be **far less dense** than **cool, dry air**.

- The **specific heat** of any material is the amount of heat energy that must be added to a unit of material to raise the temperature a certain amount. A substance that requires a lot of heat energy to warm up a certain amount has a **high heat capacity**.

- **Water, H_2O** , has the second-highest **heat capacity** of all solids or liquids (only **ammonia, NH_3** , is greater).
- **1 calorie** is the amount of heat required to raise **1 gram of water $1^\circ C$** .

Fig 9.9

♦ **Phases of water and changes in state:** **H_2O absorbs** heat to move from ice to liquid to gas; **H_2O releases** heat to move from gas to liquid to ice.



♦ Heat lost/gained in changing 1 gram of water from one state to another at constant temperature is called **latent heat**; it varies with temperature.

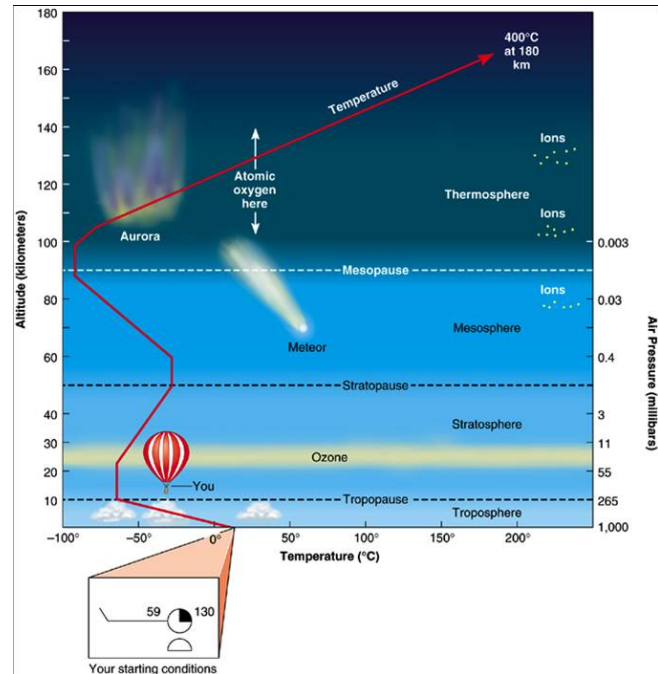
♦ **Condensation** in an air parcel causes **warming** (since water vapor releases latent heat to become liquid), which **increases the temperature** of the parcel.

♦ **Evaporation** in an air parcel causes **cooling** (since liquid water takes latent heat from the parcel as it vaporizes).

- The amount of **water vapor** in the air is known as **specific or absolute** humidity (usually in units of **g/kg**). The **ratio** of the **specific** humidity to the **maximum specific** humidity possible for a given temperature is called the **relative humidity (RH)**.

- The **dewpoint** temperature is reached when an air parcel reaches **saturation (100% RH)**. Any additional moisture or cooling would lead to **condensation** within the parcel.

- The atmosphere **decreases in density** as one moves away from the Earth. The atmosphere reaches ~1000 km above the Earth's surface. However, about **75%** of the mass of the atmosphere is within the **lowest 10 km** of the atmosphere (known as the **troposphere**). This is due to **gravity** pulling the molecules in the atmosphere toward the ground.

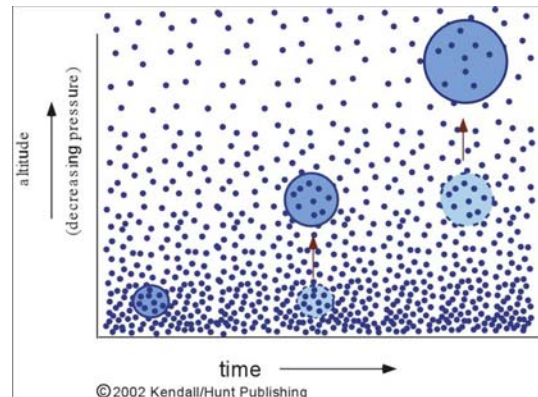


- **Atmospheric pressure** is determined by the amount of air above a point. Thus, pressure **decreases** with increasing height from the surface, and **decreases most rapidly** near the ground.
- ♦♦ Atmospheric motions are driven by **density variations**, **pressure variations**, and **rotational influences** in all directions.
- ♦ **Adiabatic** processes involve a change in temperature without adding or removing heat (thus, we'll refer to it as **warming and cooling**).
- **Adiabatic warming** comes from an **increase** in pressure or a **decrease** in volume (which happens when a parcel is **sinking**).
- **Adiabatic cooling** comes from a **decrease** in pressure or an **increase** in volume (when a parcel is **rising**).

♦ A **lapse rate** measures how much **temperature varies** in the **vertical** over a specific height change.

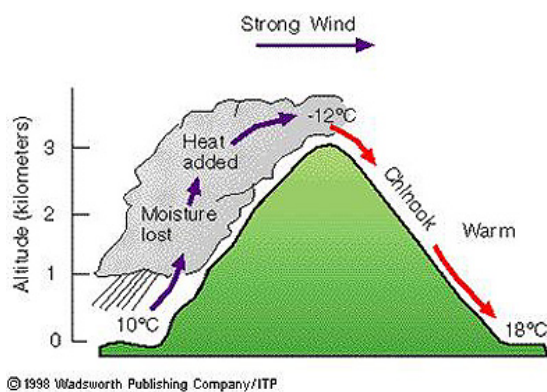
● The **environmental (average) lapse rate** in the troposphere is around **$\sim 6.5^\circ\text{C}/\text{km}$** , meaning that the atmosphere is generally **$\sim 6.5^\circ\text{C}$ colder **1 km**** further up in the troposphere.

♦ A parcel of dry (unsaturated) air lifted in the atmosphere will cool at **$9.8^\circ\text{C}/\text{km}$** (called the **dry adiabatic lapse rate**). When sinking, it will warm at **$9.8^\circ\text{C}/\text{km}$** .



♦ Lifted, **saturated air** will cool at a **slower rate** (**$\sim 5^\circ\text{C}/\text{km}$** , the **moist adiabatic lapse rate**), because latent heating from condensation counteracts some of the cooling due to the adiabatic expansion.

♦ However, **saturated air** sinking will warm at **$9.8^\circ\text{C}/\text{km}$** , since there is no latent heat of vaporization (the relative humidity **decreases** as the parcel sinks, so it's no longer saturated).



● **Example:** air at $+10^\circ\text{C}$ ascends a mountain range, **cools** to saturation, leading to **precipitation** upon further ascent to the summit (-12°C); upon descent to the lee, air **warms** to $+18^\circ\text{C}$ at the foothills. This is an example of a **Chinook wind**.