

1 ☐ Global Environments:
The Atmosphere

2 ☐ Global Environments:
The Atmosphere

- The Atmosphere
 - Composition
 - Vertical structure
 - Heat transfer
 - Atmospheric moisture
 - Atmospheric circulation
 - Weather and climate

3 ☐ Global Environments:
The Atmosphere

- The earth's atmosphere
 - is unique
 - in our solar system
 - in the universe, as far as we know at this time
 - a relatively thin, life-giving blanket of air surrounding the earth
 - influences everything we see and hear
 - is intimately connected to life as we know it
 - its presence contributes to the physical characteristics of the earth
 - which in turn determines scope of life

4 ☐ Global Environments:
The Atmosphere

- The earth's atmosphere
 - is central in physical geography because of its roles in
 - Heat transfer throughout the globe
 - Water vapor transport
 - Determination of weather and climate

5 ☐ Global Environments:
The Atmosphere

- Composition of the atmosphere
 - Gaseous envelope
 - Comprised of a mixture of
 - Various gases

- Water vapor and ice crystals
- aerosols
 - tiny suspended particles of solid or liquid

6 ☐ Global Environments:

The Atmosphere

- Composition of the atmosphere
 - a mixture of various gases
 - two gases make up 99% of the total volume of the atmosphere
 - nitrogen (N_2) = 78%
 - oxygen (O_2) = 21%
 - percentages of these two gases are fairly constant up to about 80km
 - water vapor (H_2O) concentrations vary greatly
 - vertically and horizontally

7 ☐ Global Environments:

The Atmosphere

- Composition of the atmosphere
 - a mixture of various gases
 - carbon dioxide (CO_2)
 - occupies a small percent of volume of atmosphere
 - ~0.036%
 - varies vertically and horizontally
 - has been increasing since industrial revolution

8 ☐ Global Environments:

The Atmosphere

- Composition of the atmosphere
 - a mixture of various gases
 - others, in small amounts
 - methane
 - nitrous oxide
 - chloroflourocarbons
 - sulfur dioxide
 - ozone

9 ☐ Global Environments:

The Atmosphere

- Vertical structure of the atmosphere
 - several atmospheric characteristics vary with changes in altitude
 - air density and air pressure
 - temperature

- gaseous composition
- electrical properties

10 ☐ Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air density and air pressure
 - air density
 - is determined by the masses of the component atoms and molecules and the amount of space between them
 - density is a measure of the amount of matter in a given volume
 - is greatest near earth's surface
 - because there are more atoms and molecules in a given volume of air

11 ☐ Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air density and air pressure
 - air pressure or atmospheric pressure
 - results from the force exerted by constantly moving air molecules as they bump against objects
 - since air molecules are matter, they occupy space and have mass
 - pressure at any level in the atmosphere can be measured in terms of
 - the total mass of air above any point

12 ☐ Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air pressure and air density
 - air pressure or atmospheric pressure
 - average or standard atmospheric pressure at sea level is ~14.7 pounds/in²
 - 1013.25 mb (millibars)
 - 29.92 in. Hg (inches of mercury)
 - if more air molecules packed into the same column, air would be more dense & pressure would increase
 - fewer air molecules would result in lower pressure

13 ☐ Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air pressure and air density
 - air pressure or atmospheric pressure
 - the number of air molecules present in atmosphere decreases with increases in altitude
 - density decreases with increased altitude
 - pressure decreases with increased altitude

14  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air density and air pressure
 - initially decrease rapidly with altitude
 - because air near earth's surface is compressed
 - about 10 mb/100 m increase in altitude
 - decrease more slowly with altitude
 - 1013 mb at 0 km
 - 500 mb at ~ 5.5 km
 - 100 mb at ~17.0 km
 - 50 mb at ~22.0 km
 - 10 mb at ~32.0 km

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16  Global Environments:
The Atmosphere


- Vertical structure of the atmosphere
 - several atmospheric characteristics vary with changes in altitude
 - air density and air pressure
 - temperature
 - gaseous composition
 - electrical properties

17  Global Environments:
The Atmosphere


- Vertical structure of the atmosphere
 - air temperature
 - has a more complicated vertical profile than density and pressure
 - which decrease with altitude
 - is a measure of the "heat" of the air
 - which is a measure of the average speed of movement of the air molecules


18  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air temperature
 - normally decreases from earth's surface up to altitude of ~11 km
 - because atmosphere is heated primarily from below by the transfer of heat energy from the surface
 - lapse rate
 - rate at which air temperature decreases with height
 - average or standard in lower region of atmosphere is ~6.5°C per 1000 m


- 19  Global Environments:
The Atmosphere
- Vertical structure of the atmosphere
 - air temperature
 - lapse rate
 - average or standard in lower region of atmosphere is $\sim 6.5^{\circ}\text{C}$ per 1000 m increase in altitude or elevation
 - occasionally, temperature may increase with increases in height in lower region of atmosphere, a condition called a
 - temperature inversion

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- 21  Global Environments:
The Atmosphere
- Vertical structure of the atmosphere
 - air temperature
 - most common parameter used to define atmospheric layers
 - troposphere
 - stratosphere
 - mesosphere
 - thermosphere

- 22  Global Environments:
The Atmosphere
- Vertical structure of the atmosphere
 - air temperature
 - troposphere
 - from 0 km to ~ 11 km
 - characterized by air temperature decreasing with height
 - region in which “weather” occurs
 - ends at point where temperature stops decreasing with height
 - a boundary called the tropopause

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- 24  Global Environments:
The Atmosphere
- Vertical structure of the atmosphere
 - air temperature

- stratosphere
 - from ~11 km to 20 km
 - air temperature remains constant with altitude
 - from ~20 km to ~50 km
 - air temperature increases with altitude
 - from ~ - 50°C to ~0°C
 - resulting in a temperature inversion

25  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air temperature
 - stratosphere
 - temperature inversion is attributed to ozone
 - reaches its maximum concentrations in stratosphere
 - it absorbs energetic UV solar energy
 - some of the absorbed energy heats the stratosphere

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27  Global Environments:
The Atmosphere


- Vertical structure of the atmosphere
 - air temperature
 - mesosphere
 - separated from stratosphere by boundary called stratopause
 - from ~50 km to ~85km
 - % of N and O about same at this level as at sea level
 - but there is much less air
 - atmospheric pressure is ~1 mb at 50 km

28  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air temperature
 - mesosphere
 - air temperature decreases with height

- partly due to there being so little ozone to absorb solar radiation
- molecules of air lose more energy than they are able to absorb
- cooling continues up to ~ 85 km
 - where temperature reaches its lowest average value, ~ - 90°C

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30  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - air temperature
 - thermosphere
 - separated from mesosphere by boundary called mesopause
 - from ~85 km to several hundred km
 - temperature increases with altitude because oxygen molecules absorb solar radiation
 - actual temperature varies greatly depending on solar activity

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33  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - exosphere
 - upper limit of atmosphere
 - at the top of the thermosphere
 - at an altitude of ~500 km
 - some atoms and molecules from this region
 - escape earth's gravitational pull
 - shoot off into space

34  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - several atmospheric characteristics vary with changes in altitude
 - air density and air pressure

- temperature
- gaseous composition
- electrical properties

35  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - gaseous composition
 - homosphere
 - region below thermosphere where gaseous composition remains fairly constant
 - from 0 km to ~85 km
 - a well-mixed region
 - ~78% N & ~21% O

36  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - gaseous composition
 - heterosphere
 - thermosphere & above (>85km)
 - not well-mixed
 - heavier atoms and molecules, such as N & O, tend to settle to bottom of layer
 - lighter gases, H & He, float to top

37  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - several atmospheric characteristics vary with changes in altitude
 - air density and air pressure
 - temperature
 - gaseous composition
 - electrical properties

38  Global Environments:
The Atmosphere

- Vertical structure of the atmosphere
 - electrical properties
 - ionosphere
 - above ~60 km
 - an electrified region
 - with fairly high concentrations of ions and free electrons
 - atoms lose electrons and become positively charged when they can't absorb all the energy transferred to them by collisions or solar radiation


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- 40 Global Environments:
The Atmosphere
- Heat transfer in the atmosphere
 - occurs via a process called
 - convection
 - transfer of heat by the mass movement of a fluid (such as water and air)
 - takes place because fluids can move freely and it is possible to set up currents within them
 - leads to a cycle of heated air rising and cooled air descending
 - called convective circulation
- 41 Global Environments:
The Atmosphere
- Heat transfer in the atmosphere
 - convective circulation
 - certain areas of earth's surface absorb more heat from the sun than others areas
 - result in uneven heating of the air near the earth's surface
 - heated air expands and becomes less dense
 - expanded , less dense air rises and transfers heat energy upward
- 42 Global Environments:
The Atmosphere
- Heat transfer in the atmosphere
 - convective circulation
 - after warmed, expanded, less dense air rises
 - cooler, heavier, more dense air flows toward surface to replace the rising air
 - upon closer exposure to the warm surface
 - the cool air heats up, expands, becomes less dense and rises
 - and the cycle is repeated
- 43 Global Environments:
The Atmosphere
- Heat transfer in the atmosphere
 - convective circulation
 - this vertical exchange of heat called convection
 - the rising air "bubbles" (or masses of warmed air) are known as thermals
 - as the warmed air rises, its temperature eventually decreases and it sinks to surface where it can replace rising air
 - producing a convective circulation or thermal cell
- 44 Global Environments:
The Atmosphere
- Heat transfer in the atmosphere
 - convective circulation
 - any air that rises will expand and cool

- any air that sinks is compressed and warms
- wind
 - refers to the horizontally moving part of the circulation

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47  Global Environments:
The Atmosphere

- Atmospheric moisture
 - several processes and principles interact to determine the manner in which moisture enters, moves about in, and leaves the atmosphere
 - evaporation of water from surface into atmosphere
 - transport of water vapor through the atmosphere
 - precipitation, return of water to surface

48  Global Environments:
The Atmosphere

- Atmospheric moisture
 - in the lower atmosphere, water exists in all three phases of matter
 - liquid - water
 - gas - water vapor
 - solid - ice
 - various atmospheric conditions govern the change of water from one phase to another

49  Global Environments:
The Atmosphere

- Atmospheric moisture
 - water changes phases in the atmosphere
 - sublimation
 - changing from solid (ice) to gas (water vapor) phase without passing through the liquid phase
 - evaporation
 - changing from liquid to vapor phase
 - condensation
 - changing from vapor to liquid phase

50  Global Environments:
The Atmosphere

- Evaporation
 - process by which water molecules escapes surface & enters atmosphere as water vapor
 - energy is required for this to
 - ultimately comes from radiant energy from sun

- escaping molecules carry heat with them
 - evaporation tends to be a cooling process
- rate of evaporation is affected by amount of moisture already present in a mass of air
 - affected by wind, temperature and humidity

51 ☐ Global Environments:
The Atmosphere

- Evaporation
 - rate is affected by amount of moisture in a mass of air
 - amount of water vapor present in a quantity of air can be specified in several ways
 - absolute humidity
 - relative humidity

52 ☐ Global Environments:
The Atmosphere

- Evaporation
 - absolute humidity
 - most direct measure of air's moisture content
 - the weight of water present in a given volume of air
 - is affected by air temperature
 - warm air is able to contain more water vapor per unit volume than cool air

53 ☐ Global Environments:
The Atmosphere

- Evaporation
 - relative humidity
 - ratio of the amount of water actually present in a quantity of air to the amount that could be held by the same air if it were saturated
 - does not by itself indicate actual moisture content of air
 - when temperature of moist air changes, so does its relative humidity
 - temperature at which the relative humidity becomes 100% is called the dew point

54 ☐ Global Environments:
The Atmosphere

- Transport
 - water is transported by the atmosphere in the form of water vapor

55 ☐ Global Environments:
The Atmosphere

- Precipitation
 - water leaves the atmosphere and returns to earth's surface in the form of precipitation
 - which can take the form of any of the phases of water
 - liquid - rain
 - gas - fog
 - solid - ice
 - on average, the amount of water that leaves the atmosphere is equal to the amount that enters the atmosphere

56  Global Environments:
The Atmosphere

- Precipitation
 - several factors govern the process by which water leaves the atmosphere as precipitation
 - temperature
 - humidity
 - dew point
 - presence of condensation nuclei

57  Global Environments:
The Atmosphere

- Precipitation
 - condensation
 - when moist air is cooled to its dew point
 - the water vapor contained in the air is no longer in stable equilibrium and it tends to condense
 - dust particles in the air serve as condensation nuclei
 - collection centers for water molecules
 - promoting the growth of water droplets to a size large enough to be stable

58  Global Environments:
The Atmosphere

- Adiabatic processes
 - combining aspects of vertical structure of atmosphere, heat transfer, moisture content and circulation
 - adiabatic cooling
 - adiabatic heating

59  Global Environments:
The Atmosphere

- adiabatic cooling
 - process by which the temperature of a rising mass of air decreases
 - air mass heated by earth's surface, rises
 - as the warm air mass rises it expands
 - air pressure decreases with altitude
 - as it expands, it does work against surrounding atmosphere

- expenditure of energy causes temperature to decrease

60  Global Environments:
The Atmosphere

- adiabatic heating
 - process by which the temperature of a descending mass of air increases
 - air mass adiabatically cooled, descends
 - as the cool air mass descends it compresses
 - air pressure increases with decrease in altitude
 - as it compresses, surrounding atmosphere does work against it, pushing inward
 - this input of energy causes temperature to increase

61  Global Environments:
The Atmosphere

- lapse rate
 - normally, air temp. decreases with altitude
 - $\sim 6.5^{\circ}\text{C}$ per 1000m increase in altitude
- dry adiabatic lapse rate
 - adiabatic cooling in absence of condensation
 - $\sim 10.0^{\circ}\text{C}$ per 1000m increase in altitude
- moist adiabatic lapse rate
 - adiabatic cooling in presence of condensation
 - varies with moisture content of the air
 - $\sim 5.0^{\circ}\text{C}$ per 1000m

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65  The End