Energy at the Earth surface

Three primary sources of energy driving processes at the Earth surface

Heat from the core
Solar radiation
Gravity
Energy from the Sun

Drives the hydrologic cycle

Provides chemical energy to sustain almost all life on the planet

Produces differential heating of the oceans and atmosphere that drives circulation and creates weather
Concepts of energy and heat

**Force** – pushing or pulling, mass x acceleration

**Work** – force applied over a distance

**Power** – the rate of work being done

*example of different batteries driving a fan*
Types of energy

**Kinetic energy**
energy of a mass in motion

*Newton’s First Law of Motion*

An object at rest will remain at rest ...  
An object in motion will remain in motion ...

UNLESS _________________
Types of energy

**Potential energy**
stored energy
available to be converted to kinetic energy

Types of potential energy
(How can energy be stored?)

- gravitational
- chemical
- electrical
- elastic
Heat

Fundamentally, what is heat?

The kinetic energy of molecules vibrating and moving (colliding)

A balloon as a physical model forces pushing out forces pushing in
Heat

Ways of transferring heat

Conduction

Convection – convection cells

Radiation – electromagnetic energy
Transfer of heat

Figure 8.3

Latent heat

Convection

Conduction

Radiation
Density and buoyancy

In a *FLUID*, materials will rise or sink according to density

*What is the driving force for buoyancy?*
Density & Buoyancy

Composition: He H
Density & Buoyancy

Composition: $\text{SF}_6 \ \text{CO}_2 \ \text{O}_2 \ \text{N}_2$
Atmospheric physics

Atmospheric pressure

Static at sea level
High pressure
Low pressure

Humidity, relative humidity, and dewpoint

Compressing and expanding air
Energy balance for the Earth

Figure 8.4

This is the key to the greenhouse effect

Heat reabsorbed by Earth (CO₂, CH₄, etc.)
Spectra of incoming vs. outgoing radiation
Structure of the atmosphere

- Ionosphere (100-1000 km)
- Thermosphere (part of ionosphere)
- Mesosphere
- Stratosphere
- Troposphere

Figure 8.7
The Earth’s magnetosphere

10 Earth radii to 1000 Earth radii
The Earth’s ozone layer

Ozone is produced in the stratosphere and absorbs incoming UV from the Sun.
CFCs and ozone depletion

CFC = chloro fluoro carbon
The Earth’s ozone layer

The ozone hole over Antarctica
The Earth’s ozone layer

The ozone hole splits and moves
The Earth’s ozone layer

Projected chlorine in the atmosphere

Projected reduction of ozone
The Earth’s ozone layer

Projected ozone depletion with no action

Projected ozone recovery because of restrictions
The year is 2065.
Two-thirds of Earth’s ozone is gone – not just over the poles, but everywhere.
The ozone hole over Antarctica has a twin over the North Pole.
The UV radiation on mid-latitude cities like Columbus is strong enough to cause sunburn in 5 minutes.
DNA-mutating UV radiation is up more than 500 percent, with harmful effects on plants, animals, and human skin cancer rates.
Atmospheric pressure

About 90% of the mass is in the troposphere

Figure 8.10
Low pressure      High pressure

(a) HEATING OF AIR  (b) COOLING OF AIR
Atmospheric high and low pressure

In the Northern Hemisphere:

Low pressure – rising air, moving inward, condenses to produce clouds and precipitation, counter-clockwise circulation, these are the storms hurricanes & extratropical storms
In the Northern Hemisphere:

High pressure – sinking air, moving outward, compresses and heats, clockwise circulation, associated with clear skies, dry conditions
Rising air, low pressure, precipitation

Figure 8.8
Rising air, low pressure, precipitation

Concepts and processes:

- Absolute humidity
- Relative humidity
- Dewpoint

Sensible heat

Latent heat
- of vaporization – from liquid to vapor: 540 cal
- of melting – from solid to liquid: 80 cal

Compression and expansion of a gas
Coriolis effect – deflection of moving objects

Deflection to right in Northern Hemisphere

(b) Rotating Earth

Figure 8.12
Global distribution of heat
Hadley cell

Atmospheric pressure at surface

Polar cell

Ferrel cell

"Horse latitudes"

High

Low

Hadley cell

Doldrums

Subpolar lows

Equatorial lows
Atmospheric circulation
Tropical convection cells
Global atmospheric pressure

- Arrows indicate wind direction.
- Lines represent lines of equal atmospheric pressure.
- High pressure areas are marked with 'H' and low pressure areas with 'L'.
Outgoing radiation

- Shortwave radiation
- Longwave radiation
Heat loss and gain from the oceans
Weather fronts

Figure 8.13

- Cold air mass moving quickly
- Warm air mass moving slowly

(a) Cold front

- Warm air mass moving quickly
- Cold air mass moving slowly

(b) Warm front
A developing thunderstorm

Figure 8.16
Producing a tornado

Figure 8.19