Chapter 2: Solar Energy, Seasons, and the Atmosphere

Figure 2.1

Milky Way Galaxy

Our Solar System

Figure 2.1

Chapter 2: Solar Energy, Seasons, and the Atmosphere
Solar Energy: From Sun to Earth

- Solar Wind
- Electromagnetic Spectrum of Radiant Energy
- Energy at the Top of the Atmosphere
Auroral displays can be monochrome or polychrome: can extend to Lower 48 [Wisconsin].

Images from the Solar Heliospheric Observatory [SOHO] sensor suite.

Solar fusion releases an incredible amount of energy with minimal loss of solar “gas mass” or fuel... potentially, could be a virtually inexhaustible power source here on Earth due to abundant fuels such as Deuterium...

Fusion power on Earth is not science fiction... early stages of production underway.
Contemporary nuclear energy by fission: about 1/8 of world’s electricity

In the not-so-distant future, fusion reactors may supply virtually all electricity, since the fuel for fusion reactions is the various isotopes of hydrogen...

Tokamak: hypothetical design for fusion reactors

[Russian, from toroidal’naya kam(era s) ak(sial’nym magnitnym polem), toroidal chamber with axial magnetic field.]
Overall, there is a balance between the amount of incoming solar radiation and outgoing terrestrial radiation, even though they are different spectra of radiation.
Angle of Incidence

Solar Constant

- The amount of energy received at the thermopause when Earth is at an average distance from the Sun
- 1372 watts per square meter input to Earth’s systems from the Sun
- Net radiation values indicate gains of energy in some locations, and losses of energy in other locations around the planet

Global Net Radiation at the Thermopause

Figure 2.8

Net radiation at top of atmosphere, in Watts/m²
The Seasons

- Seasonality:
  - Altitude: angle between Sun and horizon
  - Declination: latitude of direct insolation
  - Daylength: duration of sunlight

- Factors That Influence Seasonal Change

- Annual March of the Seasons

Revolution and Rotation

- Revolution: one solar year
- Rotation: one solar day

Axial Tilt and Parallelism

- Perpendicular to plane of ecliptic: 23.5°
- North Pole: 66.5°
Seasons occur as the Sun migrates in the sky from Tropic to Tropic, casting varying insolation across the globe.

Camera facing due north during Northern Hemisphere summer

In winter, the Sun may never rise above the horizon...
Pressure decreases as altitude increases, simply because there is less atmosphere at altitude... gravity pulls most of the molecules down towards the surface.

Figure 2.13

This is the condition we expect, wherein temperature decreases as altitude above the Earth’s surface increases:

a "normal lapse rate"

Figure 2.14

Profile of Atmosphere

Heterosphere: layered gases
Homosphere: mixed gases
Thermosphere: inverted lapse rate; lots of molecular motion, little 'heat'
Mesosphere: normal lapse rate
Stratosphere: inverted lapse rate; this is due to ozone creation and destruction
Troposphere: normal lapse rate
Ionosphere: absorbs many harmful wavelengths of insolation
Ozonosphere: absorbs UV rays

Figure 2.15
Composition of the Homosphere

Layer in the atmosphere that typically contains a mixture of these gases. Also, this 'layer' encompasses the stratosphere and troposphere, where most forms of weather occur.

Protective Properties of the Atmosphere

This is why many CFC refrigerants are restricted for use in many countries...
Ozone & UV Rays

- UV radiation is involved in both the creation and destruction of ozone (O3)
- Release heat energy = higher molecular activity = higher temperatures
- Antarctic Ozone Hole: occurs at transition from winter to spring, as returning sunlight activates chemical reactions within Polar Stratospheric Clouds
Ozone Forecasting

ENVISAT: Ozone Forecast for Northern Hemisphere

Most harmful radiation is filtered out by the atmosphere above the Tropopause.

Variable Atmospheric Components (Pollutants)

- Natural Sources
- Natural Factors That Affect Air Pollution
- Anthropogenic Pollution
Volcanics

Vatnajökull eruption in Iceland… sulfur oxides and particulate matter source

Wildfires

Atmospheric pollution from Alaskan wildfires on August 4, 2002

Source of:
- Carbon dioxide
- Carbon monoxide
- Nitrogen oxides
- Particulates

Decaying organic matter in marshes as a source of:
- Methane gas
- Hydrogen sulfide
Natural Factors That Affect Air Pollution

- Winds
- Local and regional landscapes
- Temperature inversion

Formation of the infamous "Asian Brown Cloud", composed of natural and human created air pollutants: desert dust, power plant emissions, industrial soot, etc. Put in motion by local, regional, and global wind patterns.
Puget Sound

Topographic influences: the greater Seattle metropolitan area's air quality can suffer as the Olympics to the west and the Cascades to the east form a natural 'bowl' in which the atmosphere can become trapped and stagnant under the appropriate weather conditions.

Temperature Inversion 1

Normal conditions, with air temperature decreasing as altitude increases, resulting in vertical movement upward from the surface.

Temperature Inversion 2

Descending air creates warm inversion layer
**Anthropogenic Pollution**

- Carbon monoxide
- Photochemical smog
- Industrial smog
- Sulfur oxides
- Particulate matter
- and *et cetera*…

Map of CO during the first week of August, 2003: derived from MOPITT imagery

High concentrations of the gas due to various forest and prairie fires in Washington, Idaho, Montana, British Columbia, and Alberta