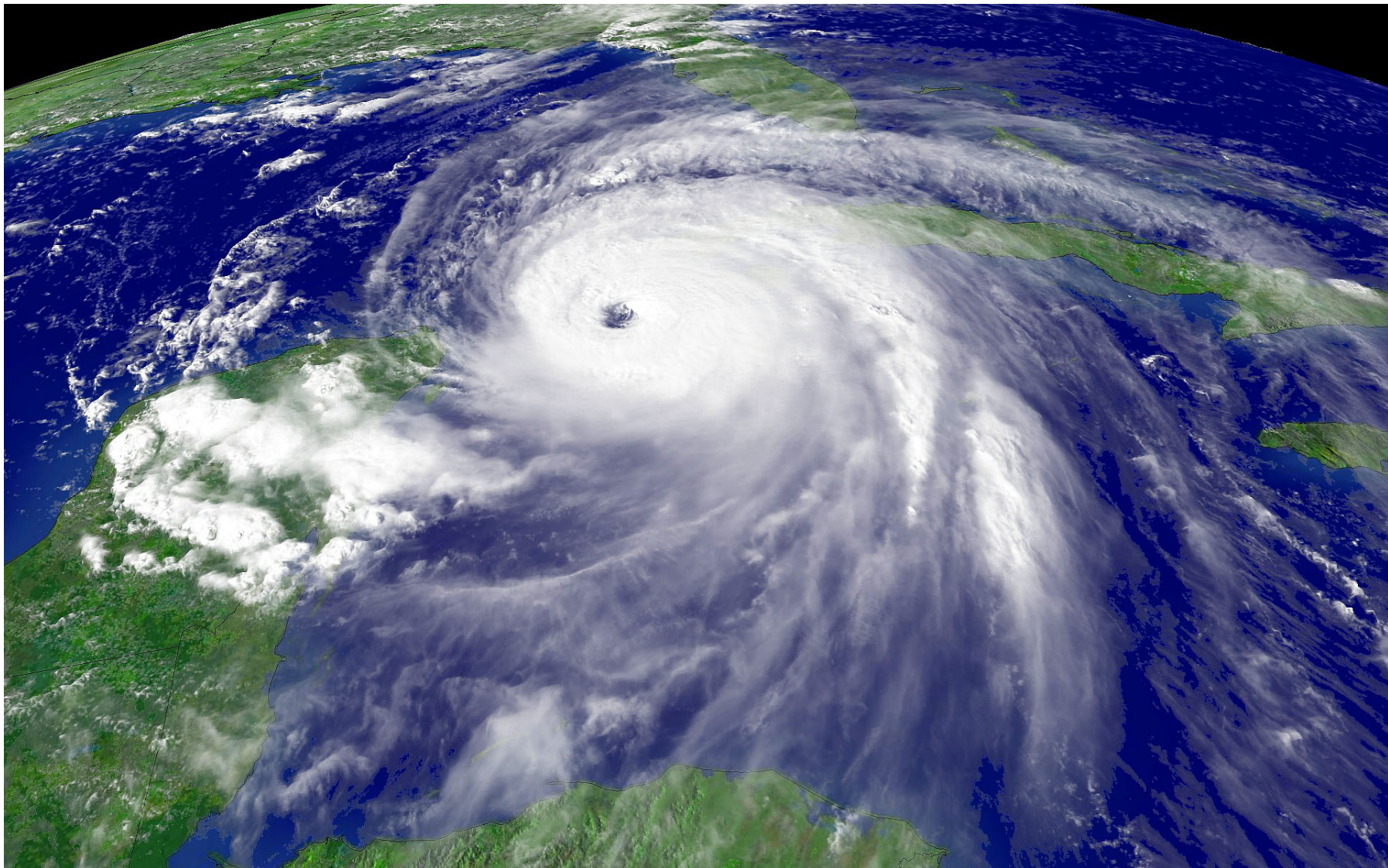
ATM 10 Severe and Unusual Weather

Prof. Richard Grotjahn

http://atm.ucdavis.edu/~grotjahn/course/atm10/index.html



Lecture topics:

- Course overview
- Atmospheric context
- Atmospheric composition
- Vertical structure of atmospheric pressure & temperature

Course Overview - Administration

- Course administration covered in first discussion meeting.
- Lectures & Information to be posted on course website: http://atm.ucdavis.edu/~grotjahn/course/atm10/index.html
- Goals:
- To learn a bit of the scientific method,
- To learn some scientific principles, and
- To learn these in an interesting context

ATM 10 Severe and Unusual Weather

Fall 2004, MW 11:00-11:50, 212 Veihmeyer

G.E. CREDIT: Science and Engineering; Writing

WEBSITE: http://atm.ucdavis.edu/~grotjahn/course/atm10/index.html

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Office Hours: T 2:10-4:00; M 10-10:50; W 4:10-5:00

Location for office hours: 124 Hoagland Hall

DISCUSSION SECTIONS:

2:10-3:00 Thursday	**124 Hoagland**
3:10-4:00 Thursday	**124 Hoagland**
12:10-1:00 Friday	**124 Hoagland**
1:10-2:00 Friday	**124 Hoagland**

TEXT: ***Meteorology Today****: An Introduction to Weather, Climate & the Environm't*

C. D. **Ahrens**, Thomson Brooks/Cole Publishing Company, 2003, **Seventh Edition**

Course Overview - Rules

Some rules:

1. No early or late offerings of midterm
2. Homework is due by the end of lecture on the date indicated in the syllabus. Homework turned in after that time will receive 0% credit.
3. Do your own homework.
4. Exams and quizzes are “closed book”
5. For more info, check online & syllabus
6. Questions? Ask your TA or me.

Course Overview - Subjects

- Physical Concepts
- Pressure, Density, Temperature, moisture variables

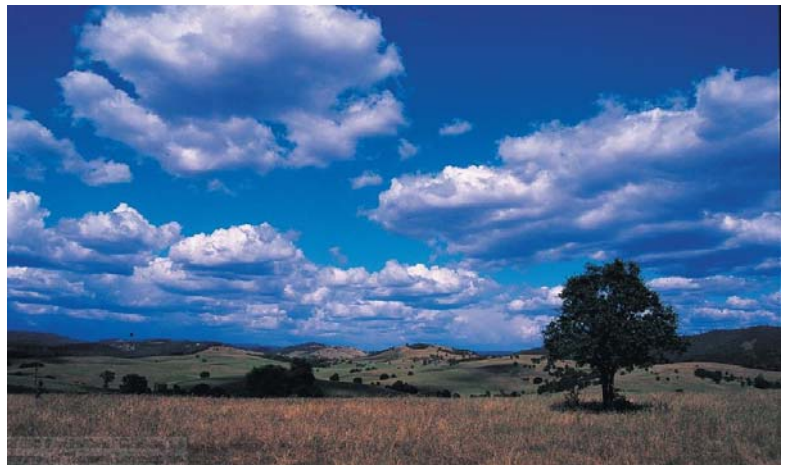
- Equations
  - Necessary, math is the “language” of science
  - Kept to a minimum and simplified
  - See summary in Appendix A

Course Overview - Subjects

Unusual & common optical events

1. Why is the sky blue?
2. Why are there rainbows?
3. What causes mirages?
4. What causes halos and related phenomena?

Course Overview - Subjects



Clouds, lots of clouds

1. Common clouds
2. Unusual clouds
3. How they develop and what they tell us about the weather

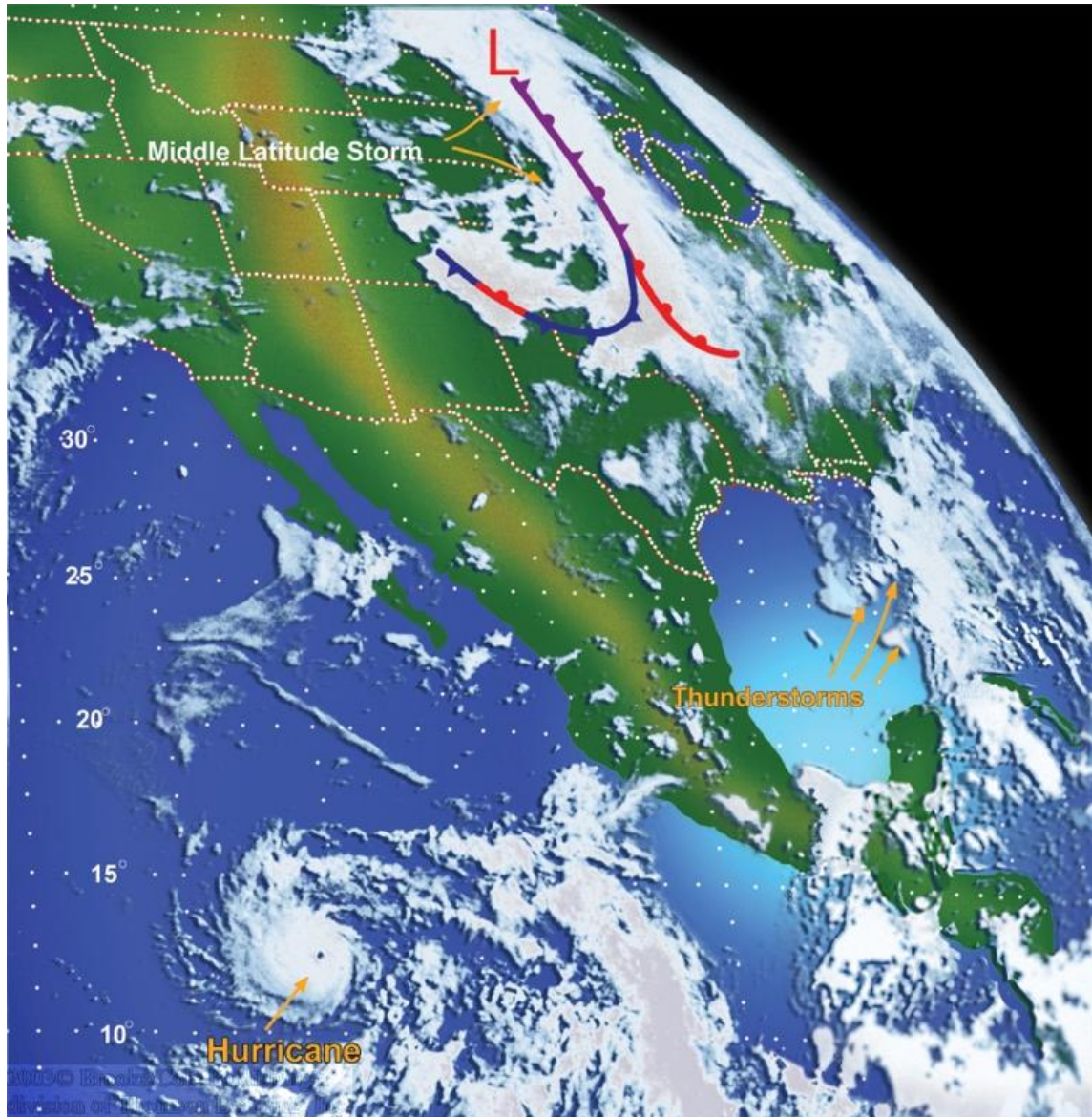
Course Overview - Subjects

Basic weather events

Large Scale:
-general circulation
-mid-lat. Cyclones

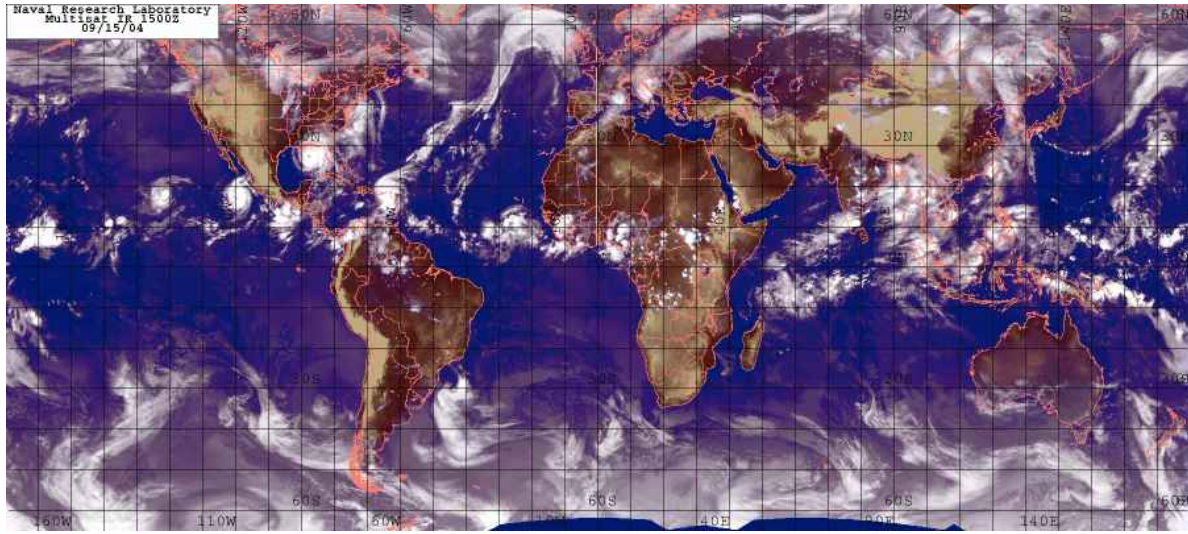
Medium Scale:
-hurricanes
-floods
-windstorms

Small Scale
-thunderstorms
-hail, lightning, tornados



Course Overview – Large Scale Subjects

Basic weather events



Large Scale:
-general circulation
-mid-lat. Cyclones

Medium Scale:
-hurricanes
-floods
-windstorms

Small Scale
-thunderstorms
-hail, lightning, tornados

Course Overview – Medium Scale Subjects

Basic weather events

Large Scale:
-general circulation
-mid-lat. Cyclones

Medium Scale:
-hurricanes
-floods
-windstorms

Small Scale
-thunderstorms
-hail, lightning, tornados

Course Overview – Small Scale Subjects

Basic weather events

Large Scale:
-general circulation
-mid-lat. Cyclones

Medium Scale:
-hurricanes
-floods
-windstorms

Small Scale
-thunderstorms
-hail, lightning, tornados

Course Overview – Severe Weather Subjects

- Severe weather

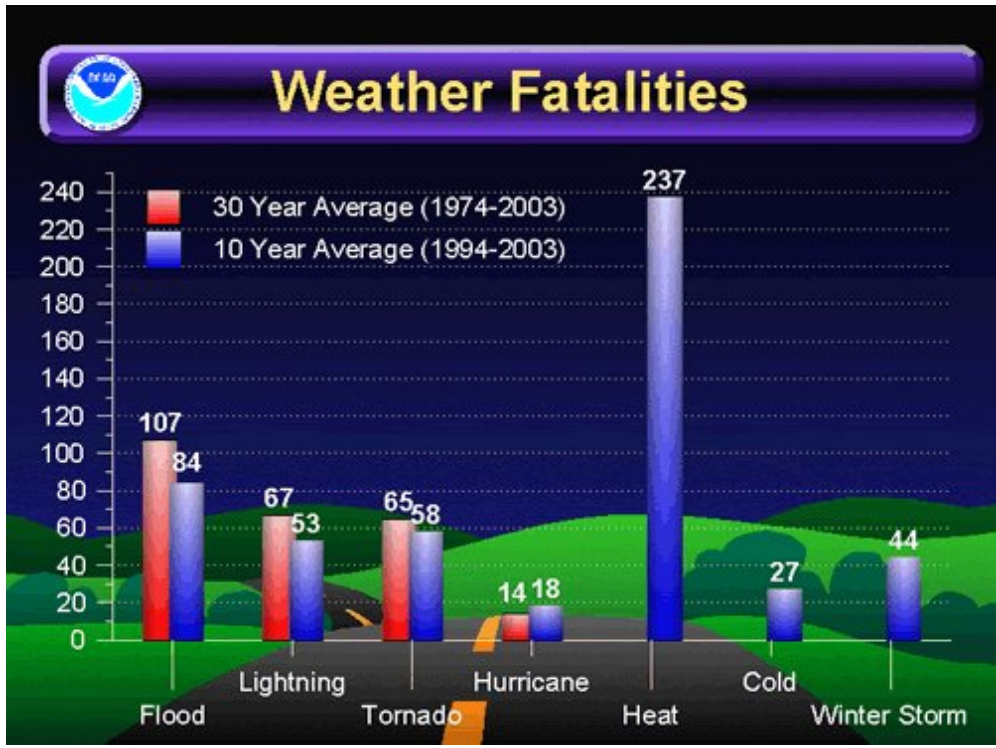
Question: Which is more dangerous?

Course Overview

Answer: It depends on the measure.

Heat waves are the most dangerous to people.

Hurricanes and Floods cause the most economic loss



Chapter 1 – Atmospheric Context

Solar Energy as Radiation

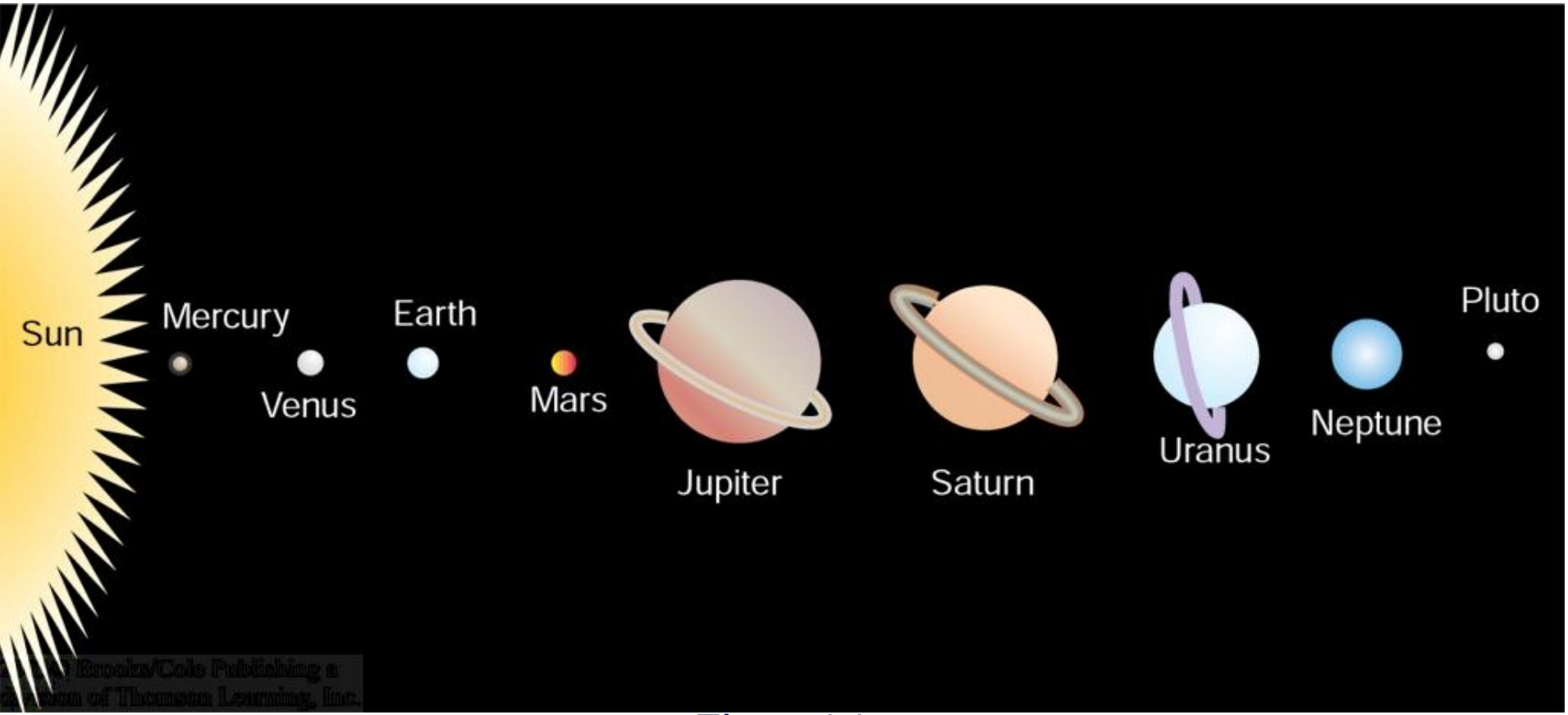


Figure 1.1

Nearly 150 million kilometers separate the sun and earth, yet solar radiation drives earth's weather.

Figure 1.2

- **99% of atmospheric gases, including water vapor, extend only 30 kilometer (km) above earth's surface.**
- **Most of our weather occurs within the lowest 10 to 15 km.**

Weather & Climate

Weather is comprised of measured *variables*:

- **a) air temperature**
- **b) air pressure**
- **c) humidity**
- **d) clouds**
- **e) precipitation**
- **f) visibility**
- **g) wind**

Organized into distinct weather *events*.

Weather events have many scales, but

Climate indicates long-term (e.g. 30 yr) averages of weather.

Grey area: "short term" climate such as "el nino".

Chapter 1 – Atmospheric Composition

Atmospheric Gases

Figure 1.3

Nitrogen, oxygen, argon, water vapor, carbon dioxide, and most other gases are invisible.

Clouds are not gas, but condensed vapor in the form of liquid droplets.

Ground based smog, which is visible, contains reactants of nitrogen and ozone.

Chapter 1 – Atmospheric Composition
Atmospheric Gases

Table 1.1 Composition of the Atmosphere Near the Earth's Surface

PERMANENT GASES			VARIABLE GASES			
Gas	Symbol	Percent (by Volume) Dry Air	Gas (and Particles)	Symbol	Percent (by Volume)	Parts per Million (ppm)*
Nitrogen	N_2	78.08	Water vapor	H_2O	0 to 4	
Oxygen	O_2	20.95	Carbon dioxide	CO_2	0.037	374*
Argon	Ar	0.93	Methane	CH_4	0.00017	1.7
Neon	Ne	0.0018	Nitrous oxide	N_2O	0.00003	0.3
Helium	He	0.0005	Ozone	O_3	0.000004	0.04†
Hydrogen	H_2	0.00006	Particles (dust, soot, etc.)		0.000001	0.01–0.15
Xenon	Xe	0.000009	Chlorofluorocarbons (CFCs)		0.00000002	0.0002

*For CO_2, 374 parts per million means that out of every million air molecules, 374 are CO_2 molecules.

†Stratospheric values at altitudes between 11 km and 50 km are about 5 to 12 ppm.

Chapter 1 – Atmospheric Composition **Variable & Increasing Gases**

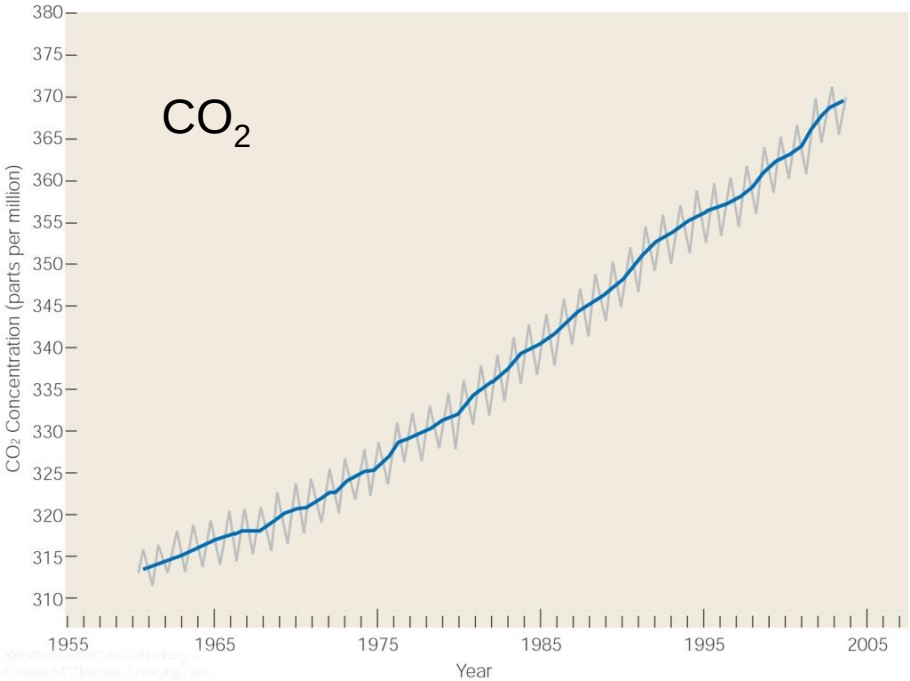


Figure 1.4

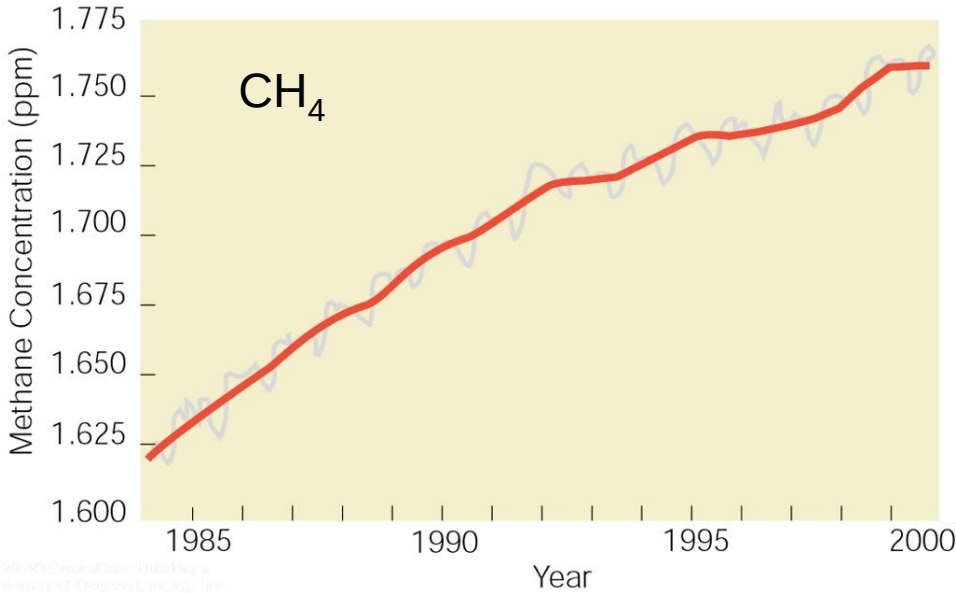


Figure 1.5

Nitrogen and oxygen concentrations experience little change, but carbon dioxide, methane, nitrous oxides, and chlorofluorocarbons are greenhouse gases experiencing discernable increases in concentration.

Interested in more on climate change? Consider ATM 5 ***also***

Aerosols & Pollutants

Human and natural activities displace tiny soil, salt, and ash particles as suspended aerosols, as well as sulfur and nitrogen oxides, and hydrocarbons as pollutants.

Figure 1.6

Chapter 1 – The Atmosphere's Vertical Structure

Pressure & Density

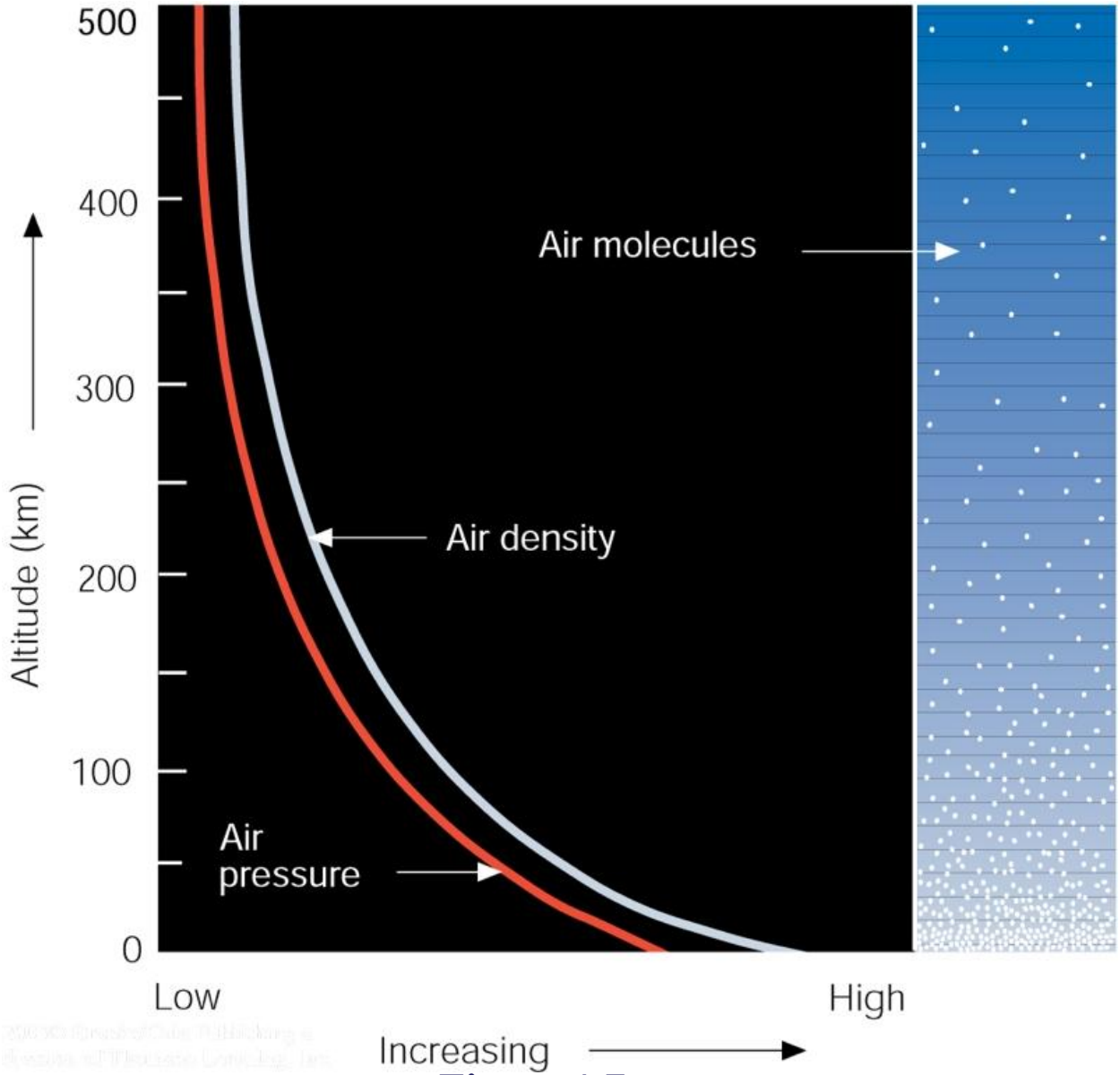


Figure 1.7

Gravity pulls gases toward earth's surface, and the whole column of gases weighs 14.7 psi at sea level, a pressure of 1013.25 mb or 29.92 in.Hg.

Pressure = Force / Area

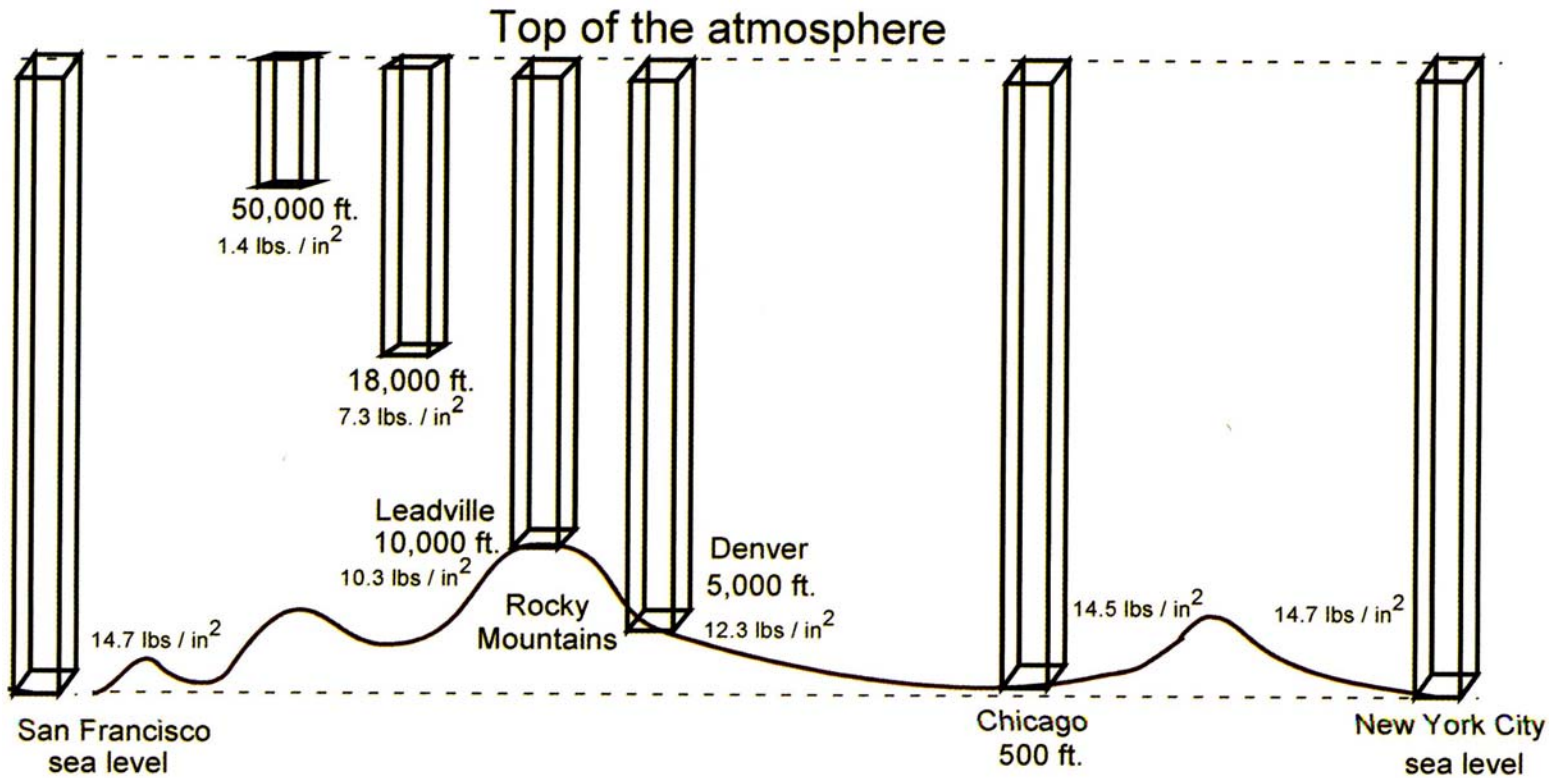
Density = Mass / Volume

Pressure

- Pressure = weight of air above an elevation
- San Francisco Leadville ~5.5 km

Sea level ~10,000 feet ~18,000 feet

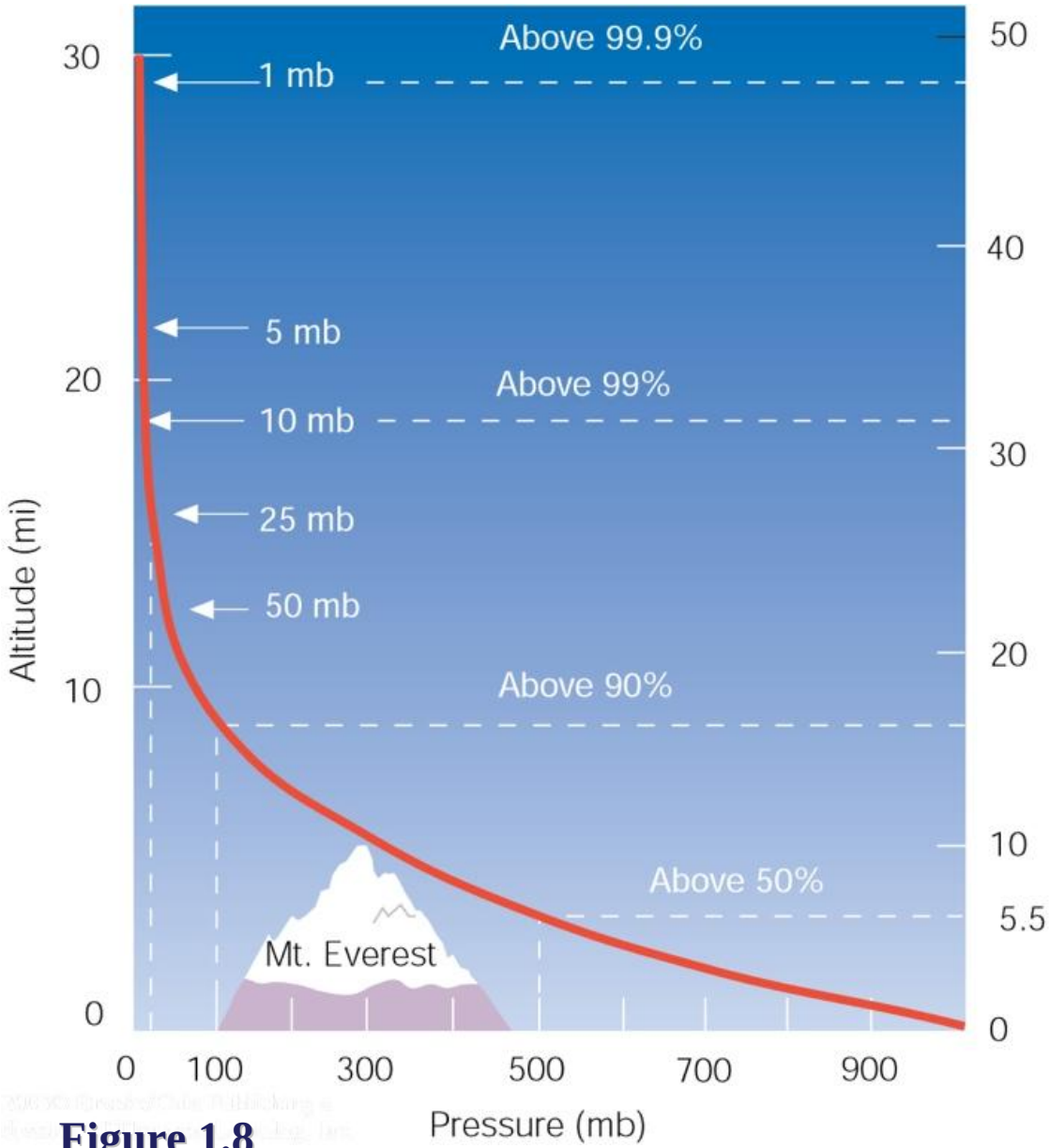
14.7 lbs / in^2 10.3 = 70% of 14.7 7.3 = 50%



Vertical Pressure Profile

Pressure increases at a curved rate* but near the surface a linear estimate of 10 mb per 100 meters works well.

***nearly exponential:**
$P = P_s \exp(-z / 10.)$



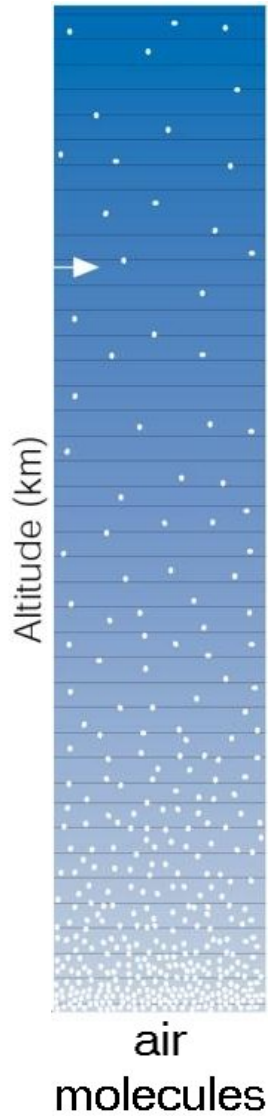
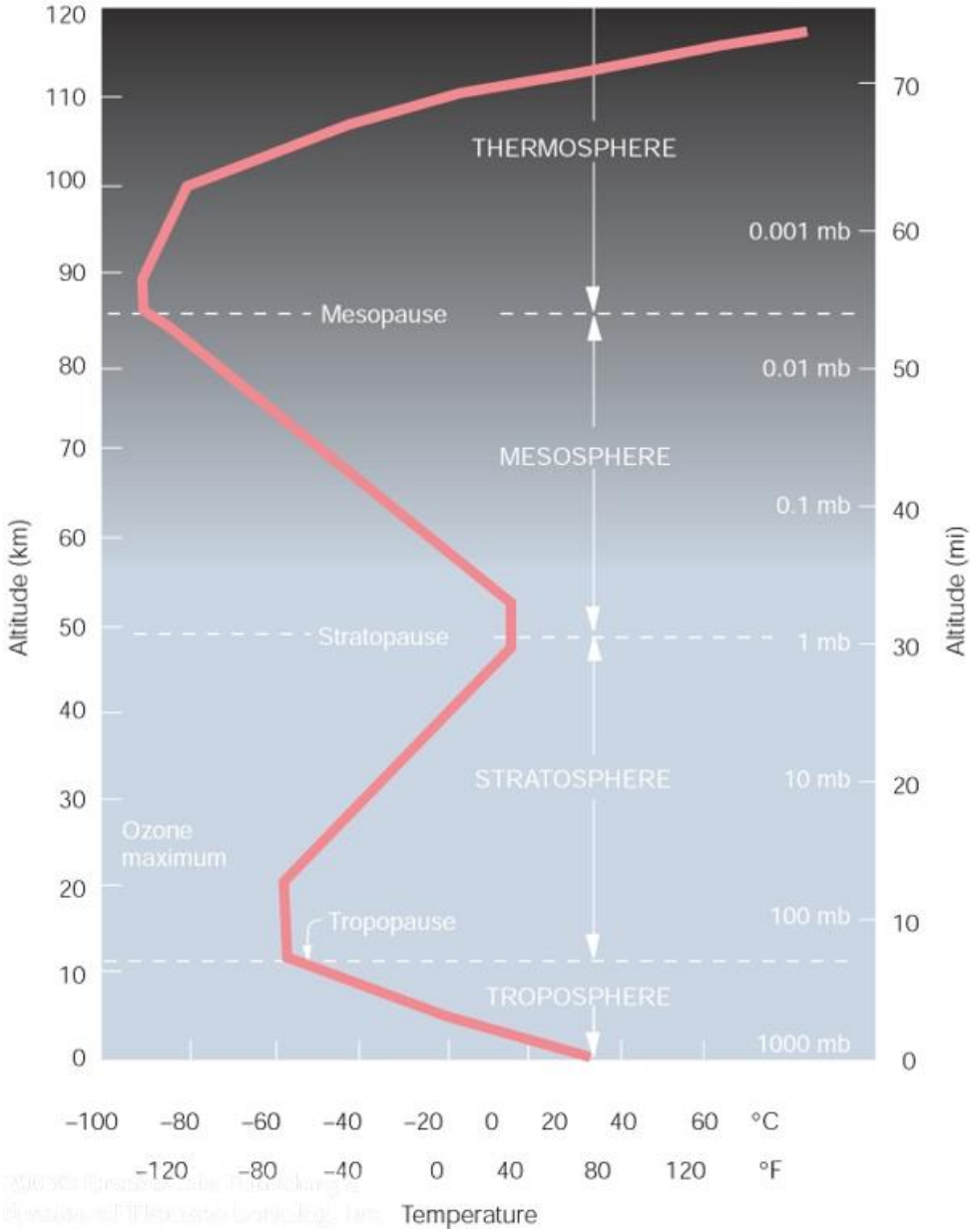


Figure 1.8

Chapter 1 – Vertical Structure **Atmospheric Layers**



8 layers are defined by consistent air properties.

4 shown here defined by consistent trends in average air temperature (which changes with pressure and radiation)

Weather and motions are different in these layers.

In between are 3 key levels.

Figure 1.9

Atmospheric Mixture & Charge

Additional layers:

d) The exosphere

c) the electrically charged ionisphere

b) the poorly mixed heterosphere

a) the homosphere with 78% nitrogen and 21% oxygen

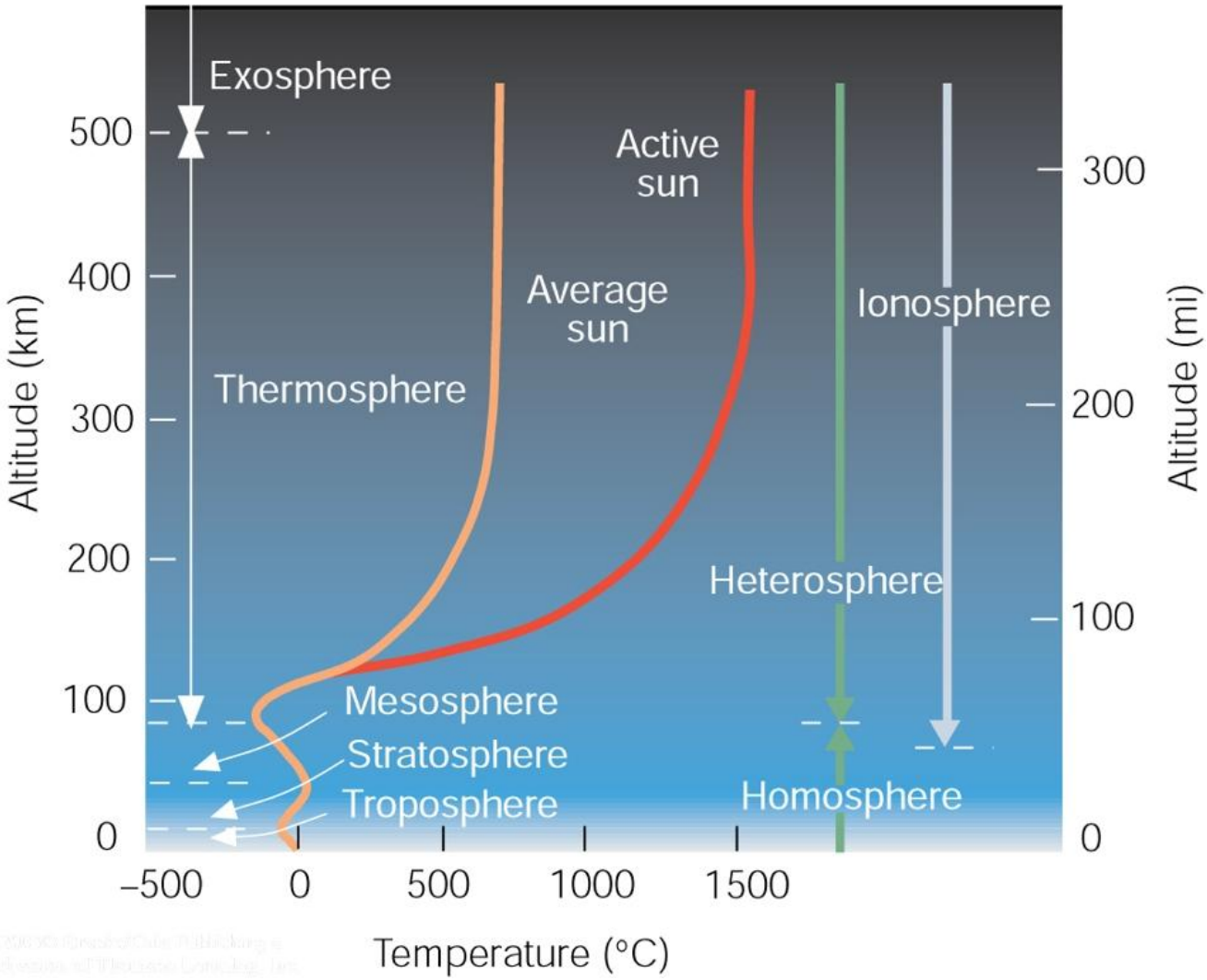


Figure 1.10

End of lecture 1