Department of Physics Dr. Yuh-Lang Lin
http://mesolab.org ylin@ncat.edu

Lecture 1 Introduction

1.1 Overview

In general, meteorology may be categorized into three disciplines:

- Physical meteorology
- Dynamic meteorology
- Synoptic meteorology

In physical meteorology, it can be further categorized into

- Cloud physics
- Radiation
- Thermodynamics

Thermodynamics plays important roles in our quantitative understanding of atmospheric phenomena, ranging from the cloud physical processes to the general circulation of the atmosphere.

For example, let us consider the system of the sun and earth. Remember, the ultimate energy source of the atmospheric motion is the sun.

- The sun radiates its energy to earth at short wavelengths.
- Most of them can penetrate the atmosphere and reach the earth surface.
- Part of the energy associated with this short wave radiation are absorbed by the earth, while the rest of it are radiated back to the lower atmosphere at longer wavelength.

How do these radiation processes proceed are taught in the radiation part of the physical meteorology.

Our concern in thermodynamics is on how this longwave radiation influences the structure and motion of the atmosphere.

1.2 Brief review of fundamental properties of the atmosphere

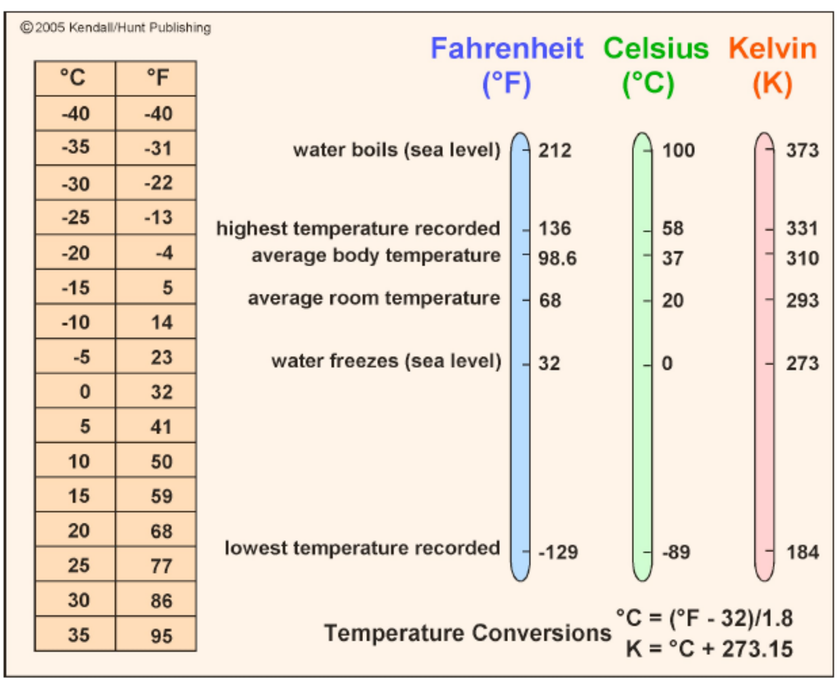
Most of the material in this subsection has been taught in basic meteorology courses.

As atmospheric scientists what properties of the atmosphere do we care about?

How do these properties vary in space and time?

A key goal of this class is to explain why these properties vary in this manner.

Temperature



Let us consider an air parcel near the earth surface.

Once it is heated by the longwave radiation, the temperature of this air parcel increases. Therefore, it will rise since it is warmer than its environment due to the density difference between the air parcel and its environment.

Now, questions arise:

Is the air parcel going to keep rising to higher levels or to sink back to lower levels?

In other words, is the air parcel unstable or stable?

If it keeps rising to new levels, are there any clouds going to form?

If it does, then which level will the cloud form?

If the cloud forms, will it be a shallow or deep cloud? In other words, what is its cloud top?

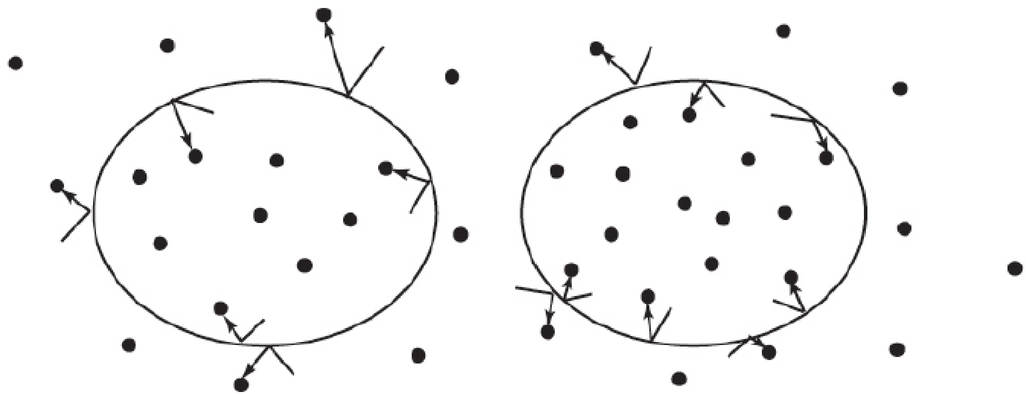
How can one determine the cloud top?

Atmospheric Pressure

Horizontal and vertical variations in pressure give rise to atmospheric motions, which are the focus of ATOC 5050.

What is atmospheric pressure?

A molecular perspective…



SI Units for pressure

Pressure is a force per unit area exerted by a fluid

From Newton's second law: F=ma

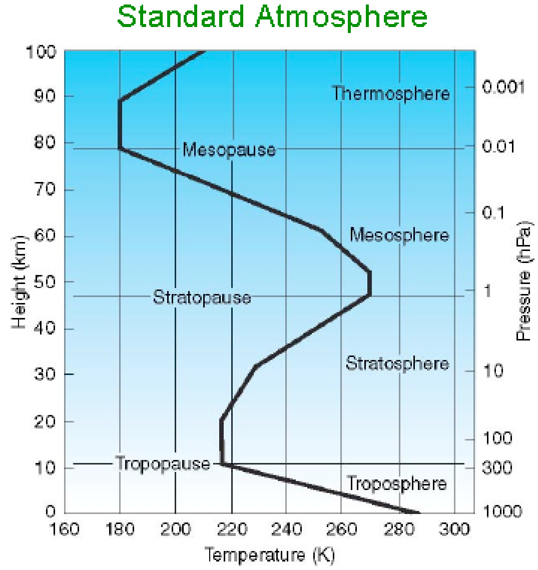
Force has units of kg m s^{-2} (or Netwons – N)

Force per unit area has units of: kg m^{-1} s^{-2} = N m^{-2} (or Pascals – Pa)

Other commonly used units of pressure:

1 hPa = 100 Pa
1 millibar (mb) = 1 hPa

Vertical Variations in Temperature



What features of the standard atmosphere temperature profile are notable?

Lapse rate – rate of *decrease* of temperature with increasing height

$$\Gamma \equiv -\frac{\partial T}{\partial z}$$

What is the lapse rate in the troposphere?

What is the lapse rate in the stratosphere?

Inversion – a layer in which temperature increases with height

What is the significance of a temperature inversion?

Sea level pressure

Decoding sea level pressure reported on station models

If coded SLP is greater than 500:
Put a 9 in front of the 3 digit coded SLP
Insert a decimal point between the last two digits
Add units of mb
Example: coded SLP = 956
Decoded SLP = 995.6 mb

If coded SLP is less than 500:
Put a 10 in front of the 3 digit coded SLP
Insert a decimal point between the last two digits
Add units of mb
Example: coded SLP = 052
Decoded SLP = 1005.2 mb

The normal range of sea level pressure is 950 to 1050 mb.

Record high sea level pressure: 1086 mb (Tosontsengel, Mongolia)
Record low sea level pressure: 870 mb (Typhoon Tip, western Pacific)

The mean sea-level pressure (MSLP) is about 1013.25 mb.