AOS 630: Introduction to Atmospheric and Oceanic Physics
Lecture 1 Fall 2021
Introduction

Ángel F. Adames-Corraliza
angel.adamescorraliza@wisc.edu

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This course

Course name

AOS 630: Introduction to Atmospheric and Oceanic Physics

What this course *really* is

Graduate Level Thermodynamics

Canvas and lecture time

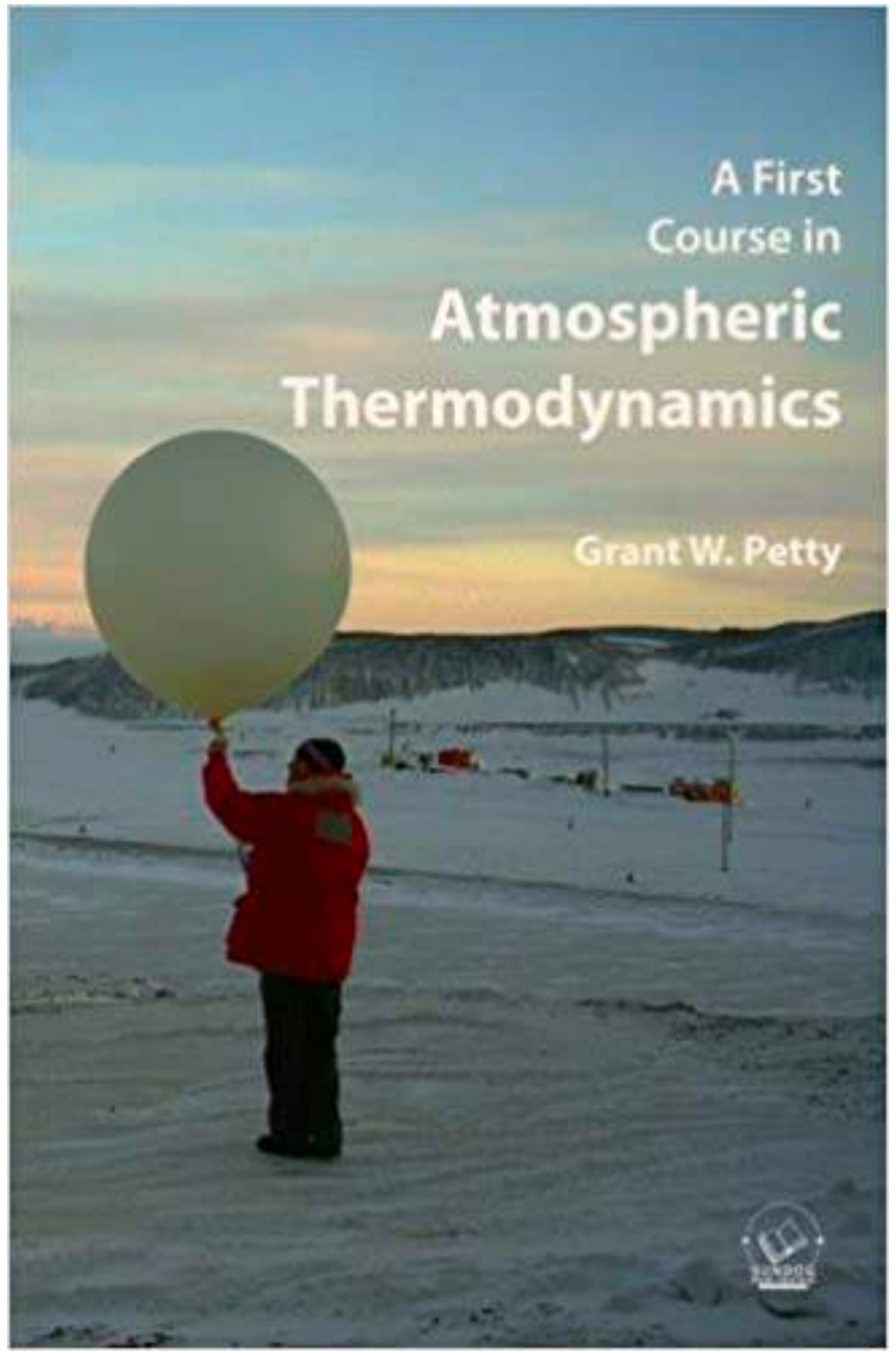
Canvas site
https://canvas.wisc.edu/courses/264500

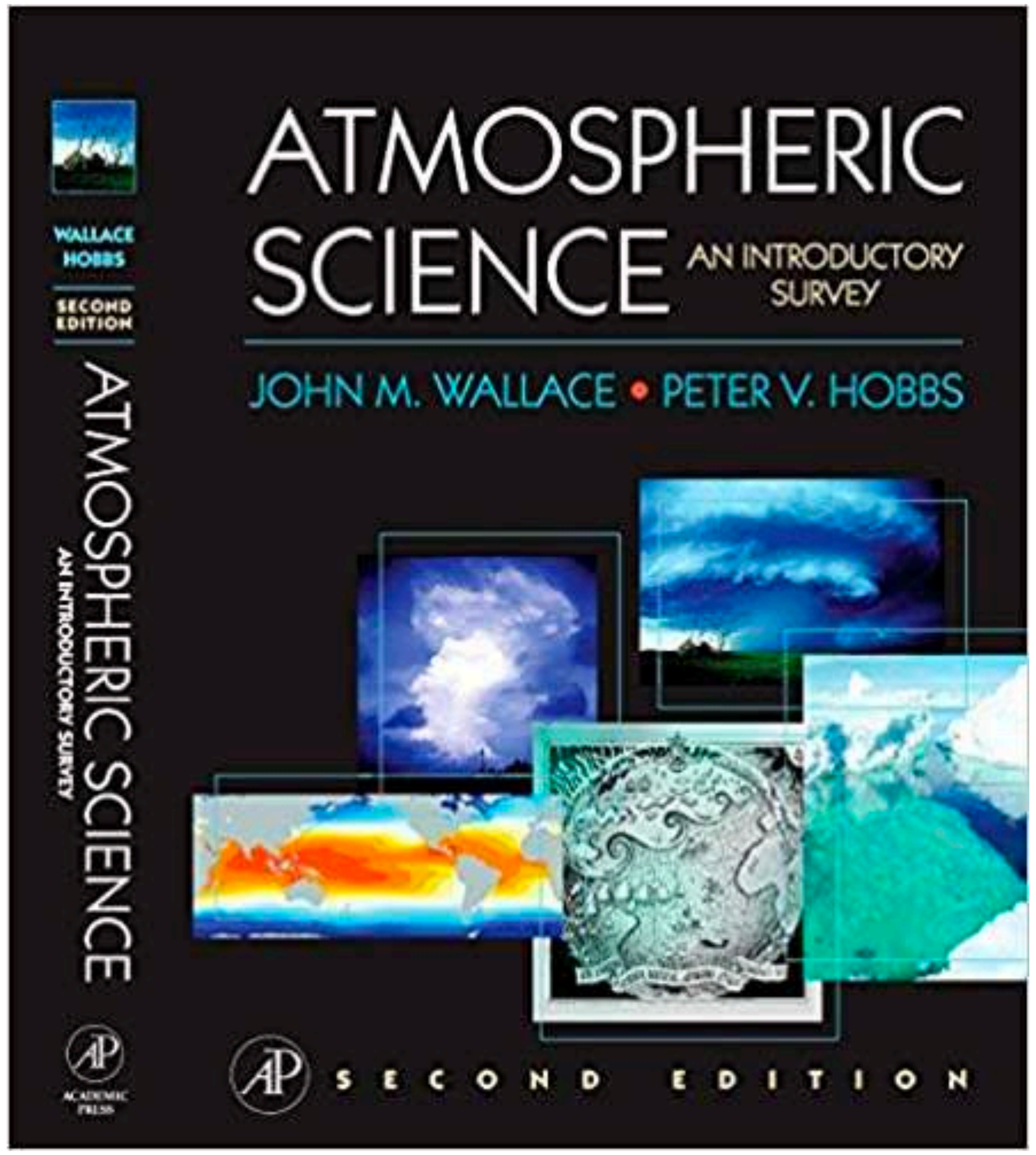
- Syllabus
- Lectures
- Homework
- Reference materials and readings
- Instructions for final project

Lecture Tuesdays and Thursdays 2:30-3:45 pm

Useful Books

There will be no required text for class. However, the following books could be useful if you're not familiar with atmospheric thermodynamics





Office hours

Which times work best for you all?

My preference:
Tuesdays after class.

Due to covid, I will restrict the number of students that can be at office hours to 3 (5 including grader and myself). Please wait outside if you see that the office is full.

Grader

Stephanie Bradshaw will be the grader for the course.

If she is unavailable to assist during office hours, we will have a special hour for questions about grades.

Other questions should be emailed to the instructor or be brought to office hours.

Weekend Policy

I will try to be prompt in responding to your emails (likely the same day)

However, I will not respond to emails sent during the weekend until the following Monday.

Your classmates may also follow a similar policy.

Be mindful of other people's time.

Class Modality

This will be an in-person class, so most classes (>75%) are likely to be held in person.

Some lectures may be done remotely if I'm sick or if many students cannot attend in person lecture.

However, the class will be live streamed via *Zoom* for those that cannot attend. Accommodations will be made for class exercises.

Mask wearing is currently mandatory. Improper mask wearing will not be tolerated.

Extra masks and hand sanitizer will be available during class.

Feeling Sick?

In the case that you feel sick, please **stay home.** Lectures will be live-streamed and much of the material will be uploaded to Canvas.

If your illness compromises your ability to complete homework, let me know so I can make proper accommodations.

You may also choose to attend the class virtually for other reasons. If you will attend many of these this way please let me know.

Mental Health

Your wellbeing is more important than the course.

If you are going through difficult times because of the course or other circumstances let me know so that you can get professional help.

The goal of the course is to **learn** and **appreciate.** It is not a hazing ritual nor a test of endurance.

Resources

Please let me know asap if you do not have a laptop and/or smartphone. I want everyone to have the resources to do well in this class and do the work efficiently.

Final Grade

There will be no midterms.

Instead, much of your grade will be based on **5 homework** assignments.

You are encouraged discuss the problems with colleagues but final answers are yours. You may be able to redo these problem sets to obtain up to half of your lost credit.

Class work:

In-class discussions and think-pair-share exercises will be 5% of the final grade.

Weekly Skew-T

Final Presentation

Final Project

Homework

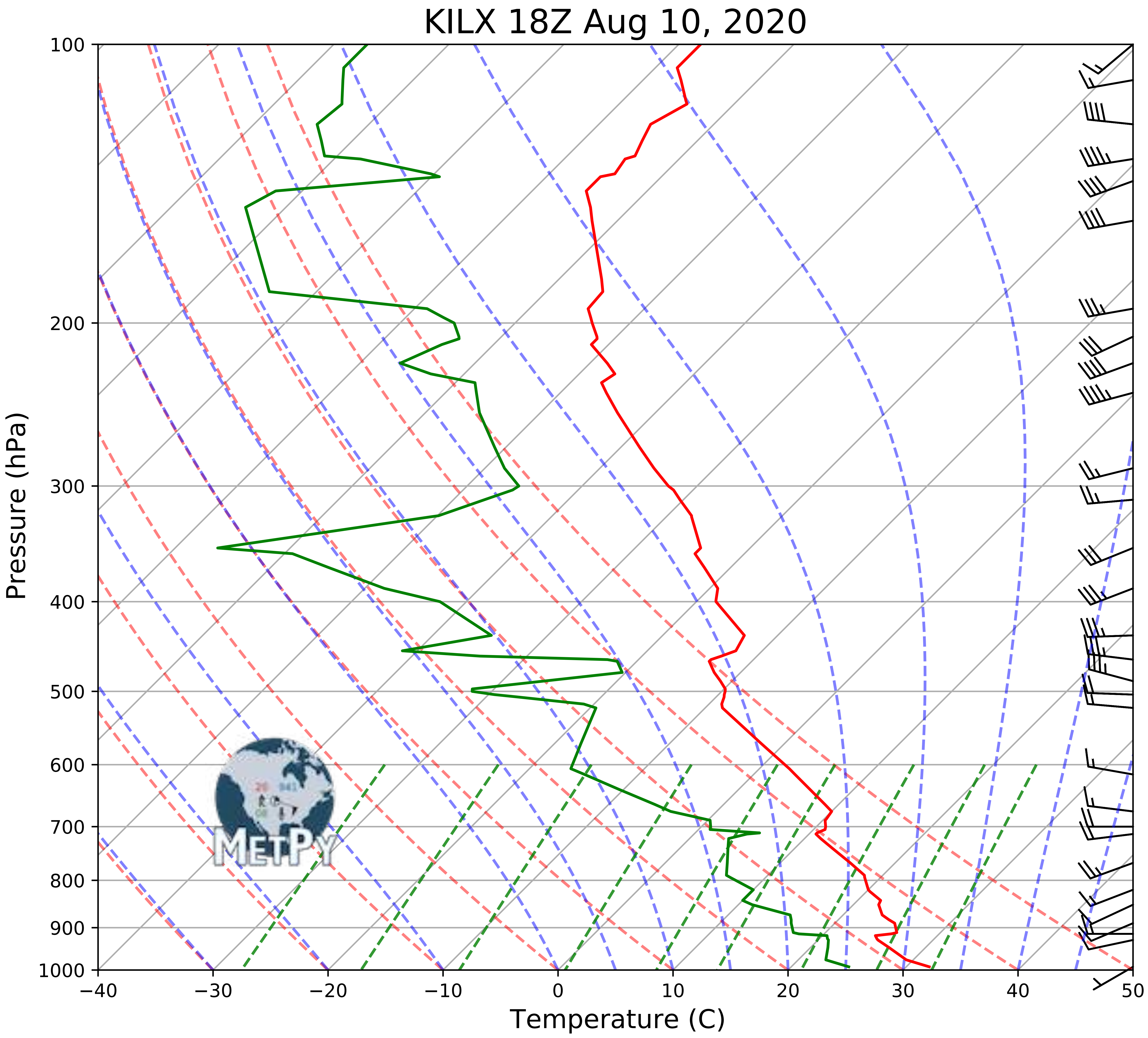
Will be a combination of derivation and application.

Some HW sets will include the reading and discussion of papers.

Weekly Skew-T

Once we begin our discussion on Skew-Ts, you will turn in a weekly assignment answering a question regarding these.

Full credit will be given for completing the problem.



Useful links

Soundings

https://www.aos.wisc.edu/weather/wx_obs/Soundings.html

http://weather.uwyo.edu/upperair/sounding.html

Some Links:

https://www.star.nesdis.noaa.gov/GOES/

www.windy.com

http://mag.ncep.noaa.gov/

earth.nullschool.net

https://www.tropicaltidbits.com/

http://weather.rap.ucar.edu/

http://rammb-slider.cira.colostate.edu/

Some homework problems will require you to look at weather maps or satellite data

More links

afadames.com/links

Links will also be posted on Canvas

Exams and Homework

Homework: 50%

Final Presentation: 15%

Final Project: 20%

Weekly Skew-T: 10%

Class discussions: 5%
Full credit for participation

Final grades will be given based on a standard curve:

A: > 92
AB: [88-92)
B: [82-88)
BC: [78-82)
C: [70-78)
D: [60-68)
F: < 60

Class Topics

Introduction

composition of the atmosphere and ocean, hydrostatic balance, equation of state, and applications

Dry thermodynamics

The first law of thermodynamics, potential temperature, entropy and the Carnot Cycle

Moist thermodynamics

Effects of condensation/freezing on the thermodynamics of air, the Clausius-Clapeyron Equation and moist adiabatic processes

Stability

Stability, buoyancy, convective available potential energy and convective inhibition

Learning goals

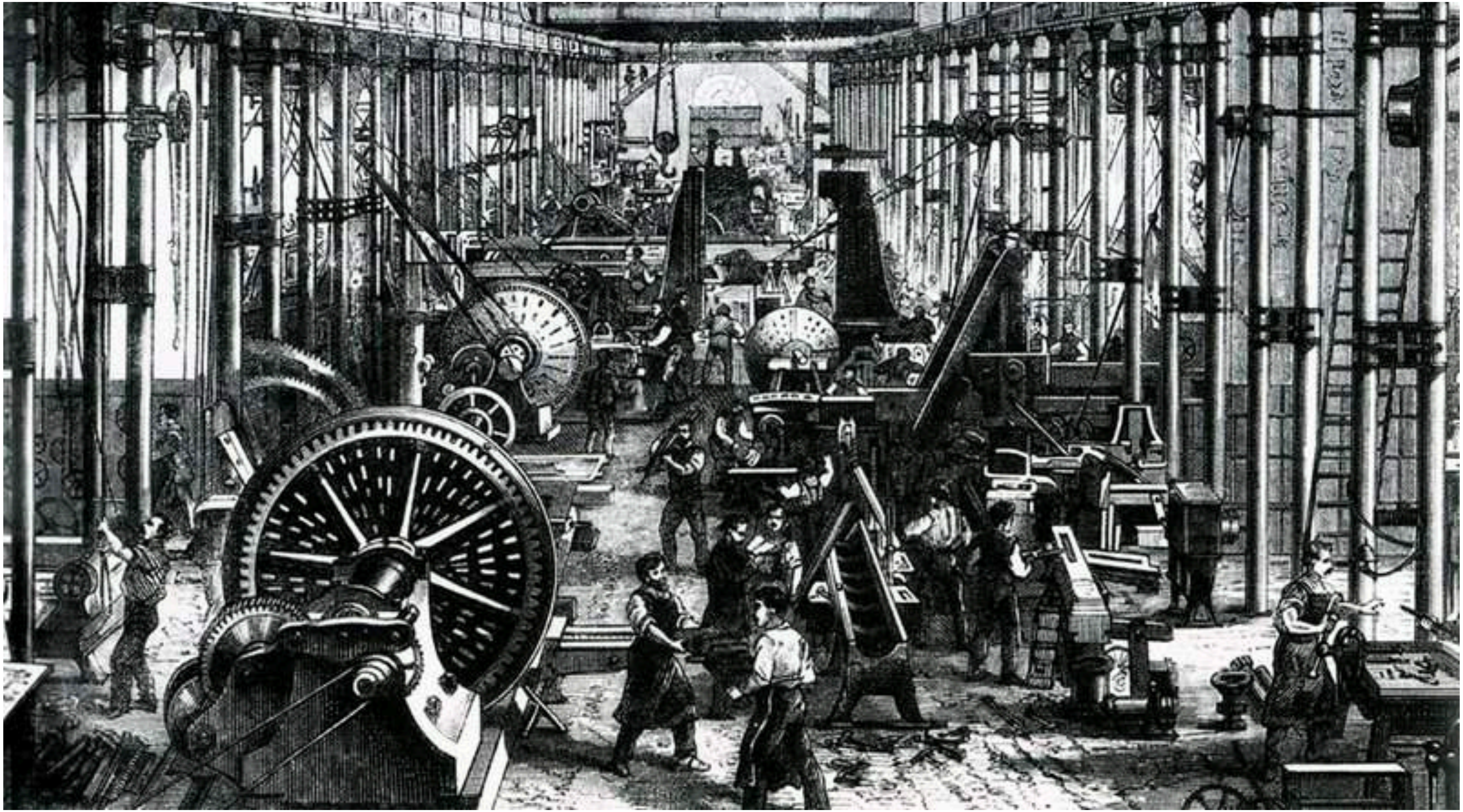
- Have a robust understanding of the basic principles behind atmospheric and oceanic thermodynamics.
- Recognize the importance of water vapor in the thermodynamics of the atmosphere.
- Understand the importance of the Clausius-Clapeyron equation in weather and climate.
- Be able to understand and interpret Skew-T diagrams
- Have the fundamental tools to tackle more advanced courses in atmospheric and oceanic sciences.

Let’s Get Started!

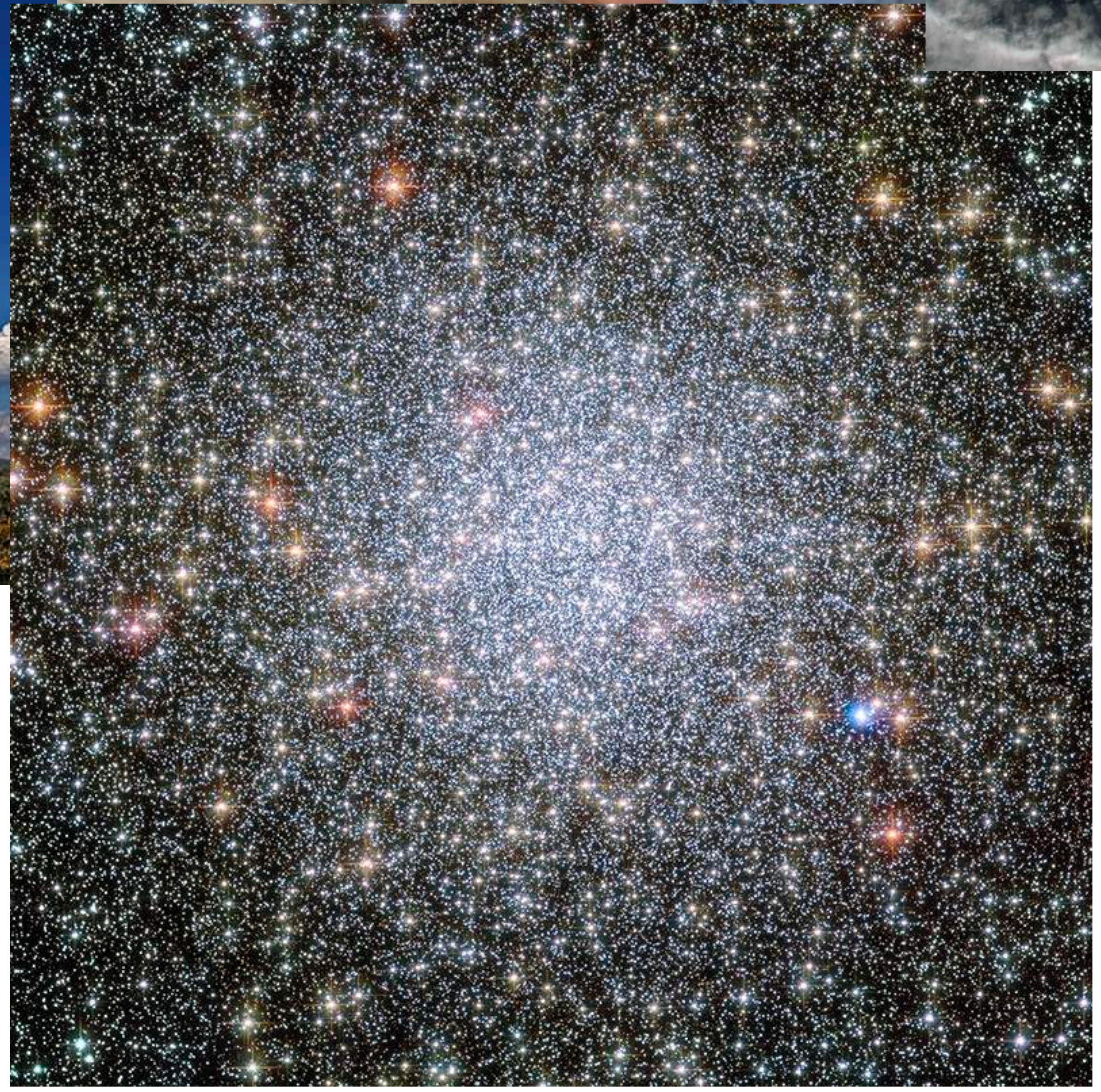
Thermodynamics

The branch of physical science that deals with the relations between heat and other forms of energy …

The industrial revolution



Thermodynamics is important for



Introduction

What’s your name and preferred pronoun?

What did you major in college?

Are you a Professional M.S., research M.S. or Ph.D. student?

What topic you are specially interested to see covered in class?

Tell me something boring or uninteresting about yourself.

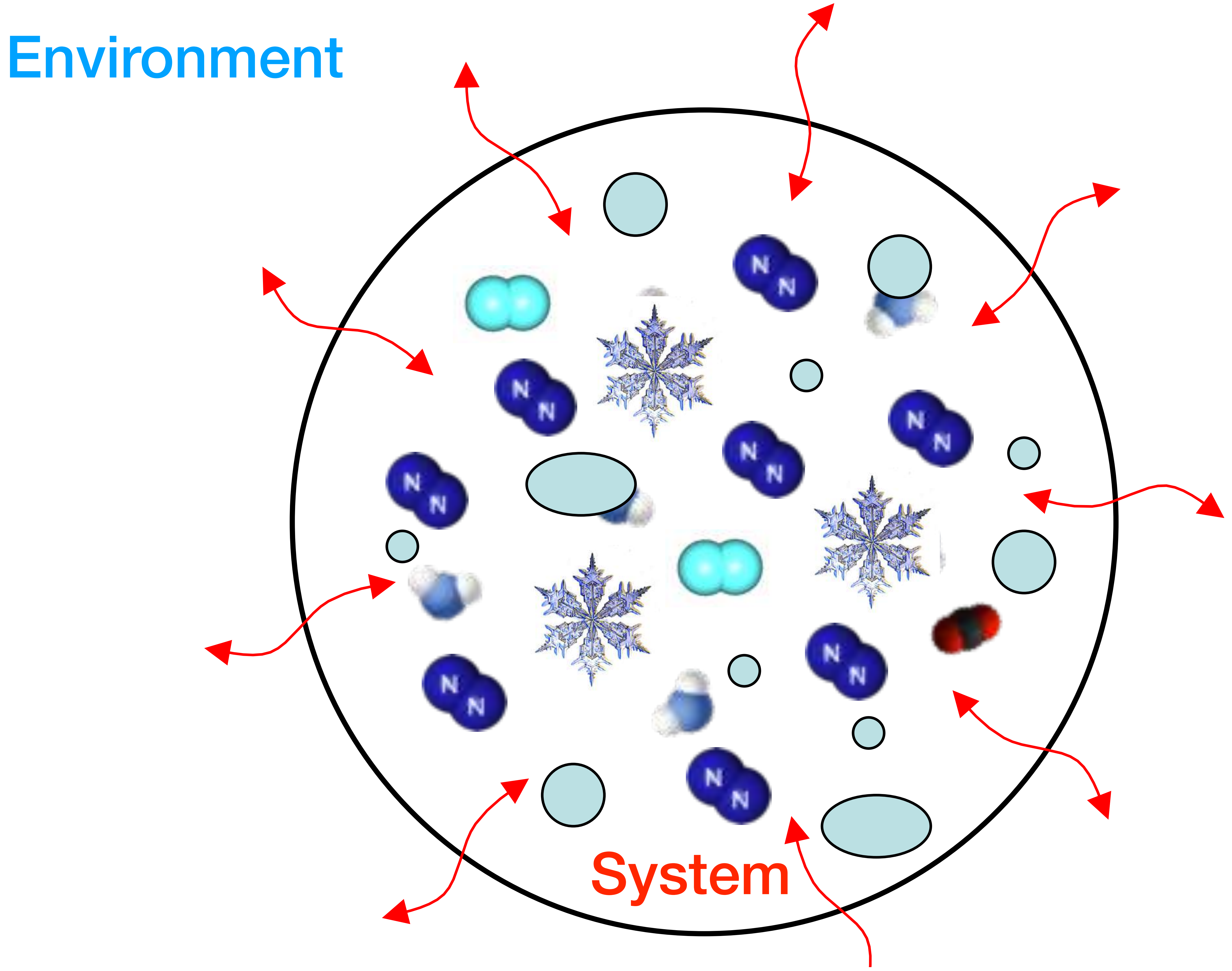
Defining our system

Concept of a “**parcel**”: a volume of air

Large enough to make continuum assumptions (length scale large compared to the molecular mean free path).

Small enough to neglect the effects of (and feedback to) dynamics (e.g., advection).

For the purposes of thermodynamics, we consider this a “closed system” (for now).



Defining our system

Definitions:

Open system: freely exchanges mass and energy with its surroundings

Closed system: freely exchanges energy with surroundings, but does not exchange mass

Isolated system: no mass or energy exchange with surroundings

What are air parcels made of? Atmospheric composition

~99% of the atmosphere is composed of Nitrogen and Oxygen.

We will refer to the sum of these two as “dry” air.

Constituent[a]	Molecular weight	Fractional concentration by volume
Nitrogen (N_2)	28.013	78.08%
Oxygen (O_2)	32.000	20.95%
Argon (Ar)	39.95	0.93%
Water vapor (H_2O)	18.02	0–5%
Carbon dioxide (CO_2)	44.01	380 ppm
Neon (Ne)	20.18	18 ppm
Helium (He)	4.00	5 ppm
Methane (CH_4)	16.04	1.75 ppm
Krypton (Kr)	83.80	1 ppm
Hydrogen (H_2)	2.02	0.5 ppm
Nitrous oxide (N_2O)	56.03	0.3 ppm
Ozone (O_3)	48.00	0–0.1 ppm

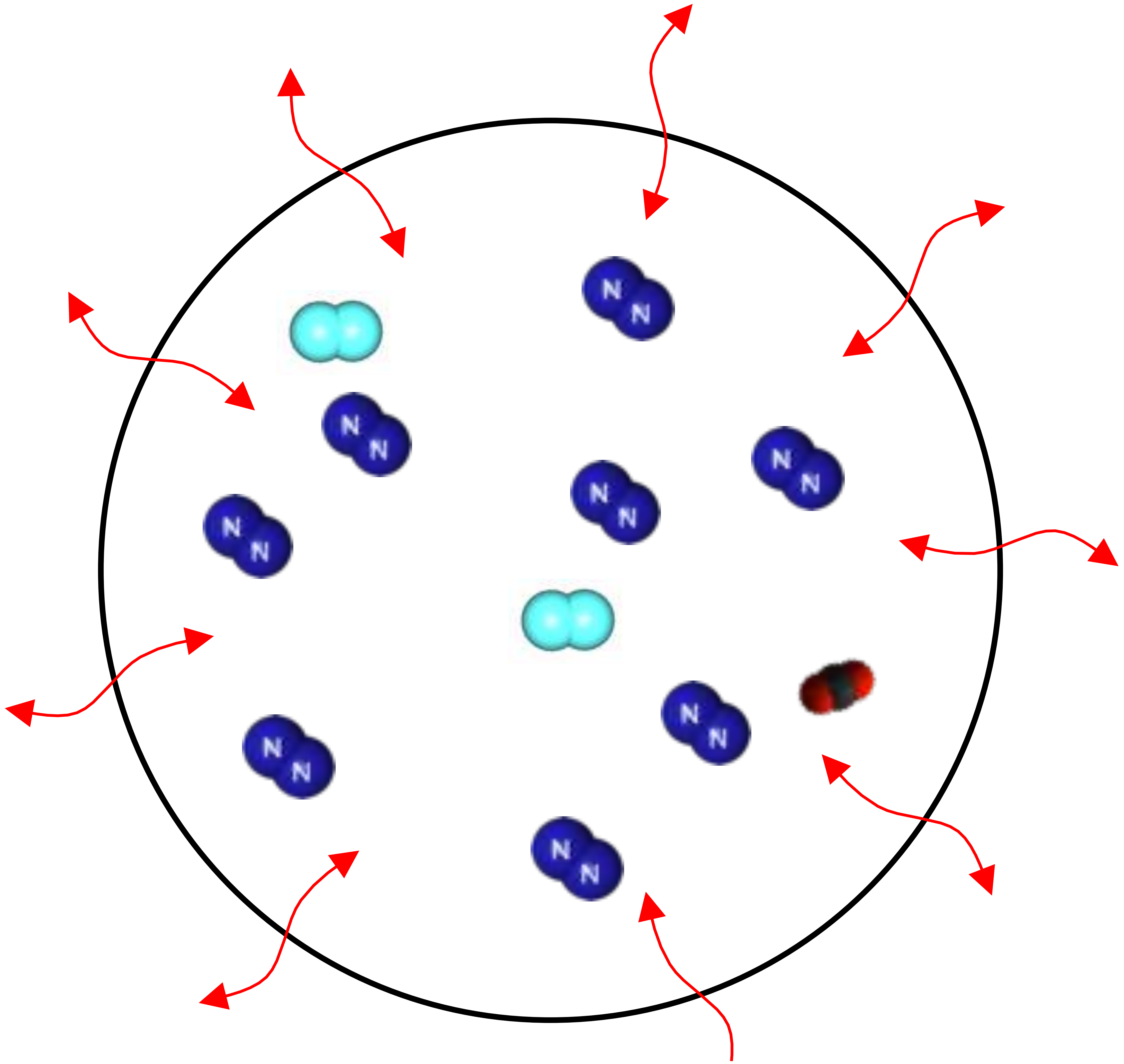
[a] So called *greenhouse gases* are indicated by bold-faced type. For more detailed information on minor constituents, see Table 5.1.

Wallace & Hobbs (2006)

Defining our system: Dry air

~99% of the atmosphere is composed of Nitrogen and Oxygen.

We will refer to the sum of these two as “dry” air.

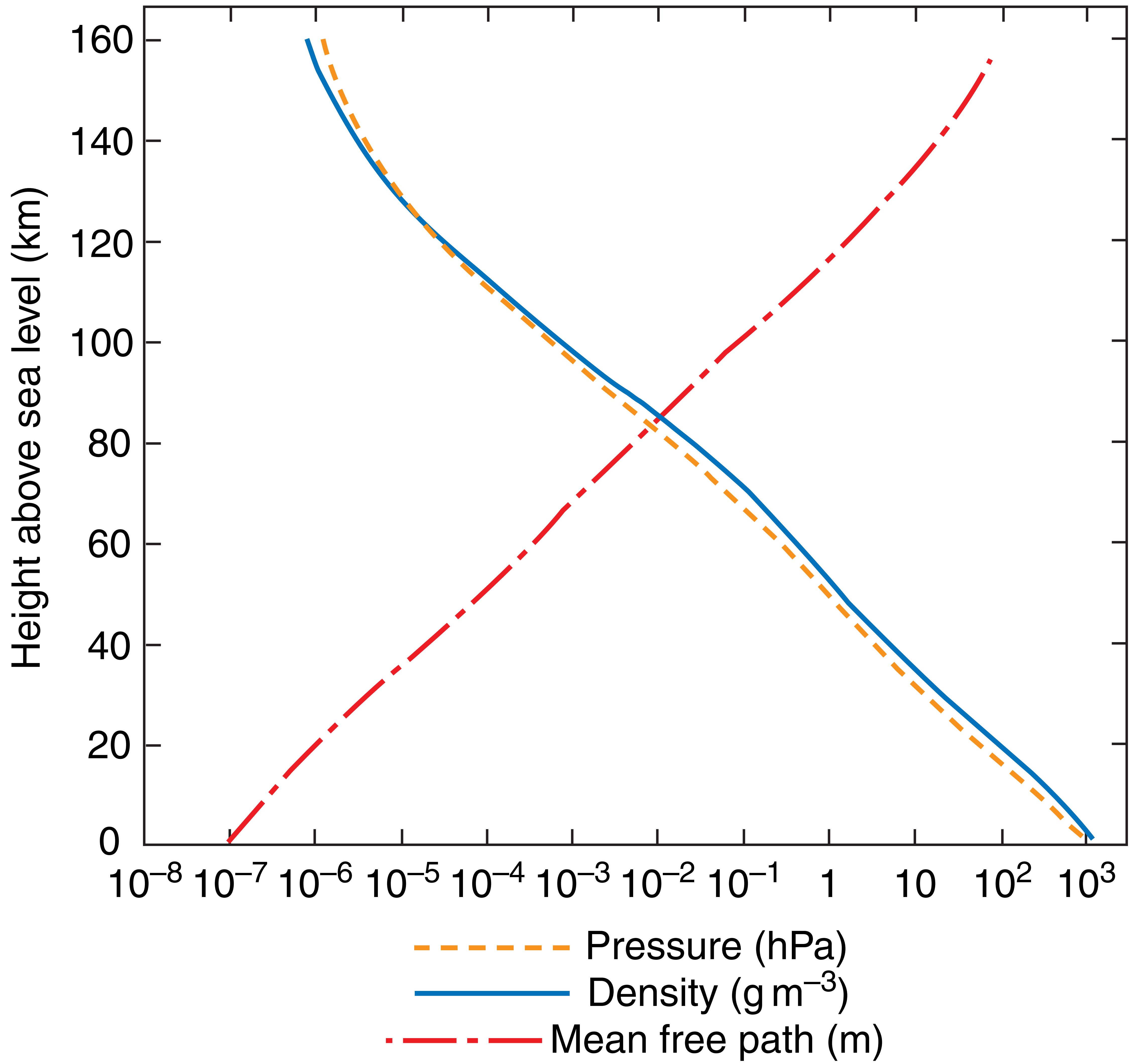


Parcel of dry air

Atmospheric profile of density and pressure

Density and pressure decrease exponentially with height

(Note the log scale in the figure)



Wallace & Hobbs (2006)

Layers of the atmosphere

Our atmosphere is divided into layers.

Troposphere: *tropos* (rotating) and sphere. The tropos comes from the rotation from overturning circulations and turbulence

Stratosphere: *the stratified (layered) sphere*

Mesosphere: *the middle sphere*

Thermosphere: *the "heat" sphere*

Exosphere: *the "external" sphere*

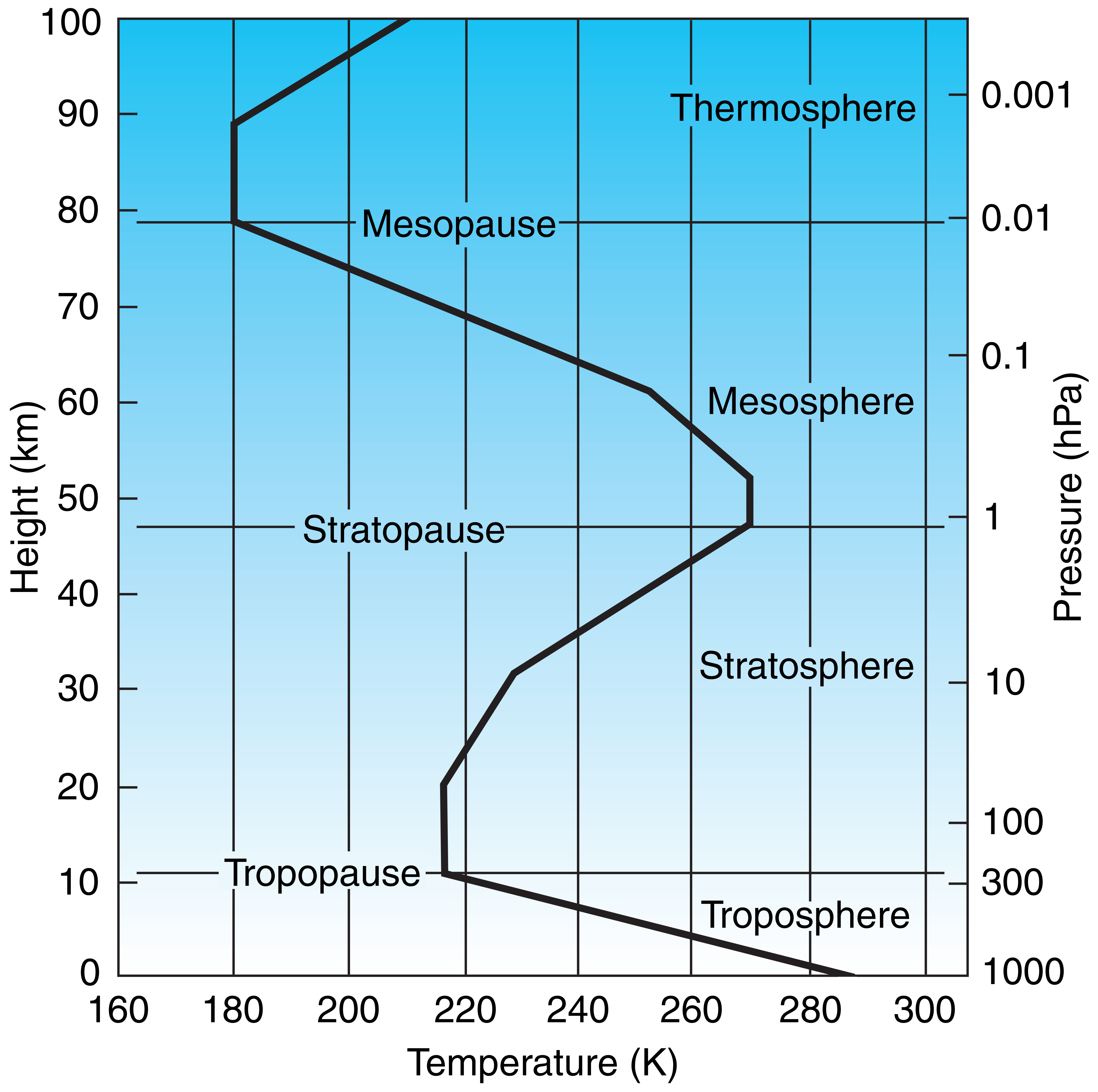


Fig. 1.9 A typical midlatitude vertical temperature profile, as represented by the U.S. Standard Atmosphere.

Wallace & Hobbs (2006)

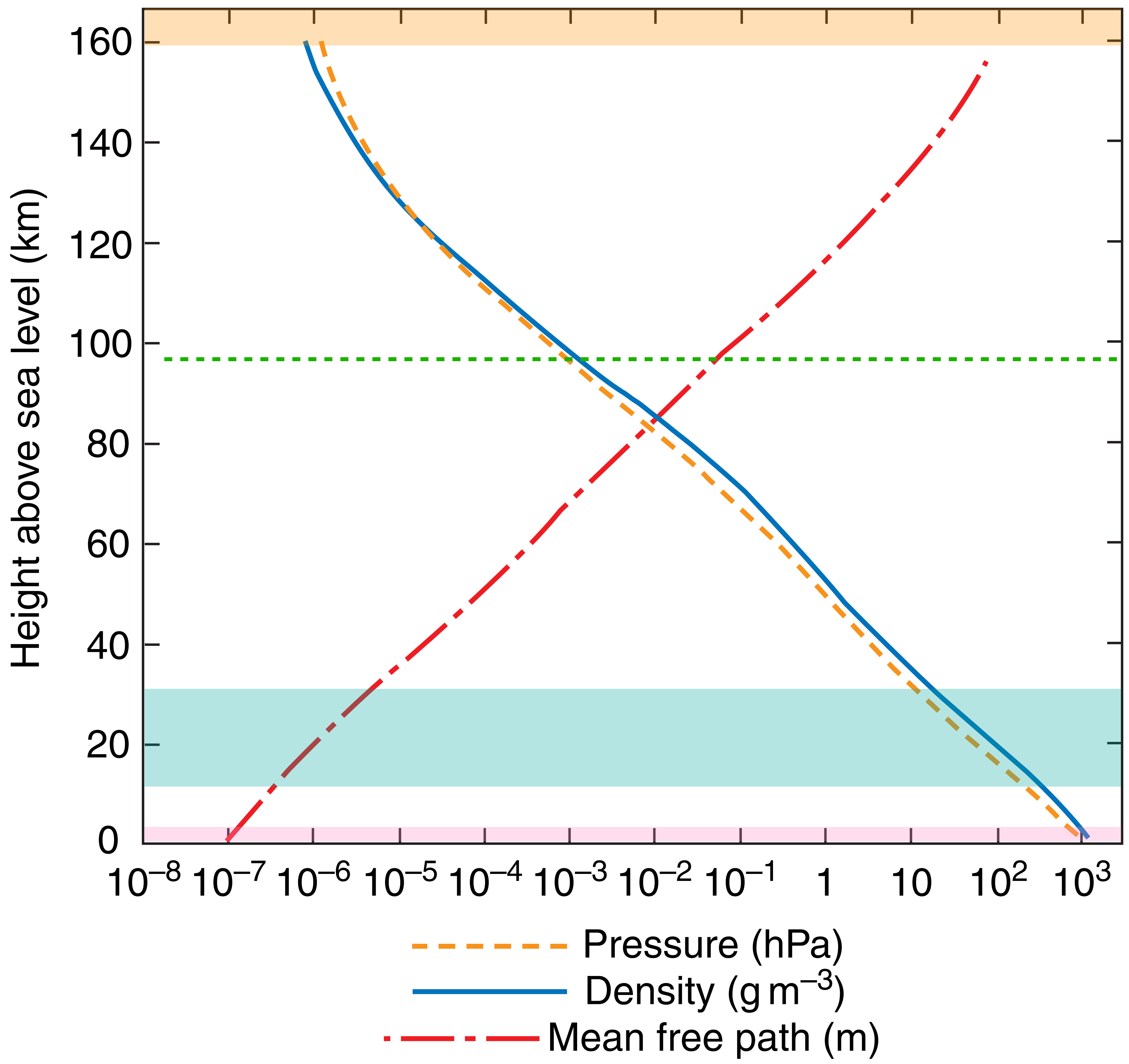
Other important regions of the atmosphere

Planetary boundary layer: Region of the atmosphere that is strongly affected by surface friction and heat exchange.

Ozone layer: Region of the stratosphere were most of the sun's UV radiation is absorbed.

Turbopause: Height in which chemicals in the atmosphere are no longer well-mixed by turbulence. ~ 100 km above sea level.

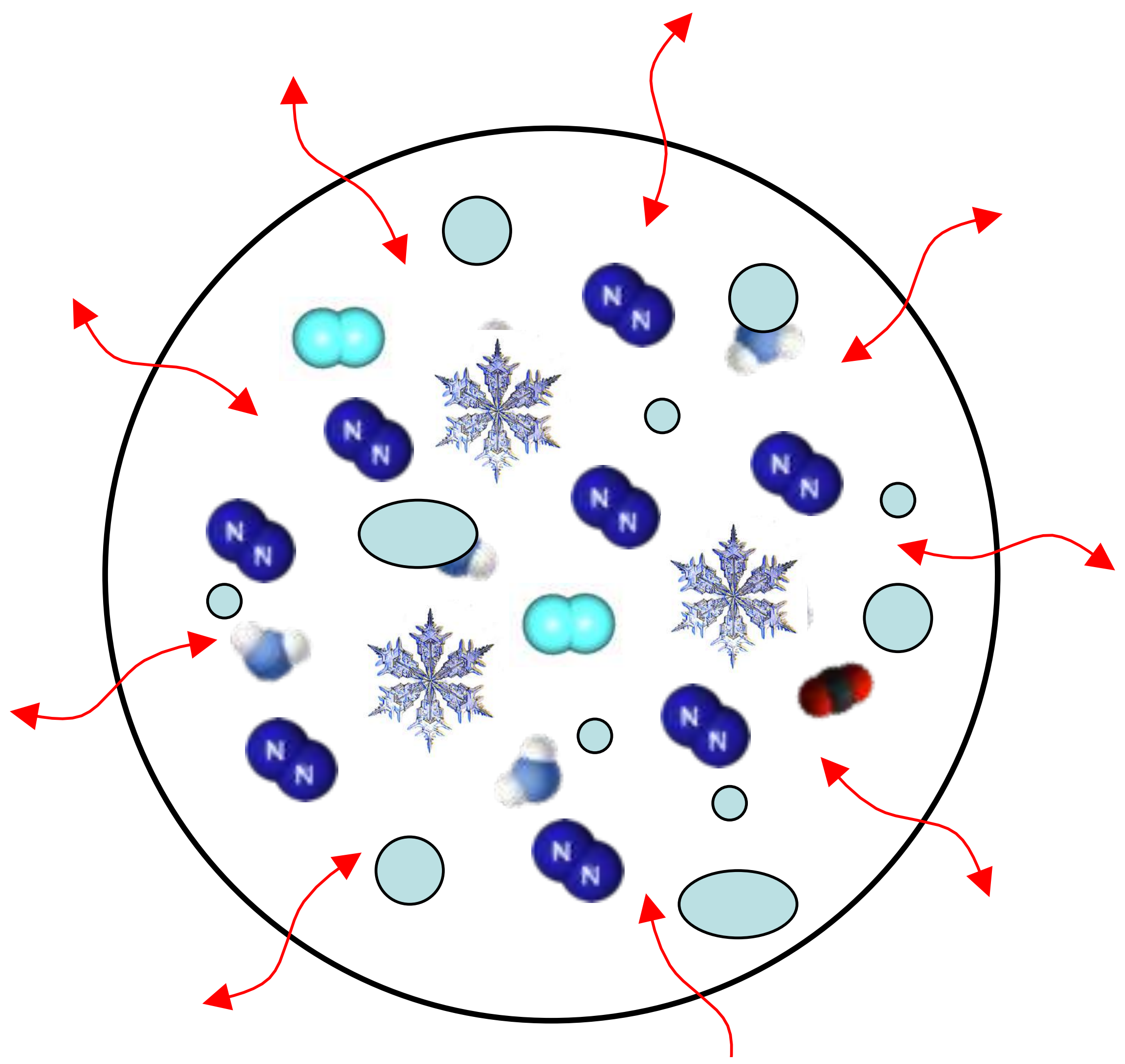
Anacoustic zone: Region where air density is too small to transmit sound. >160 km

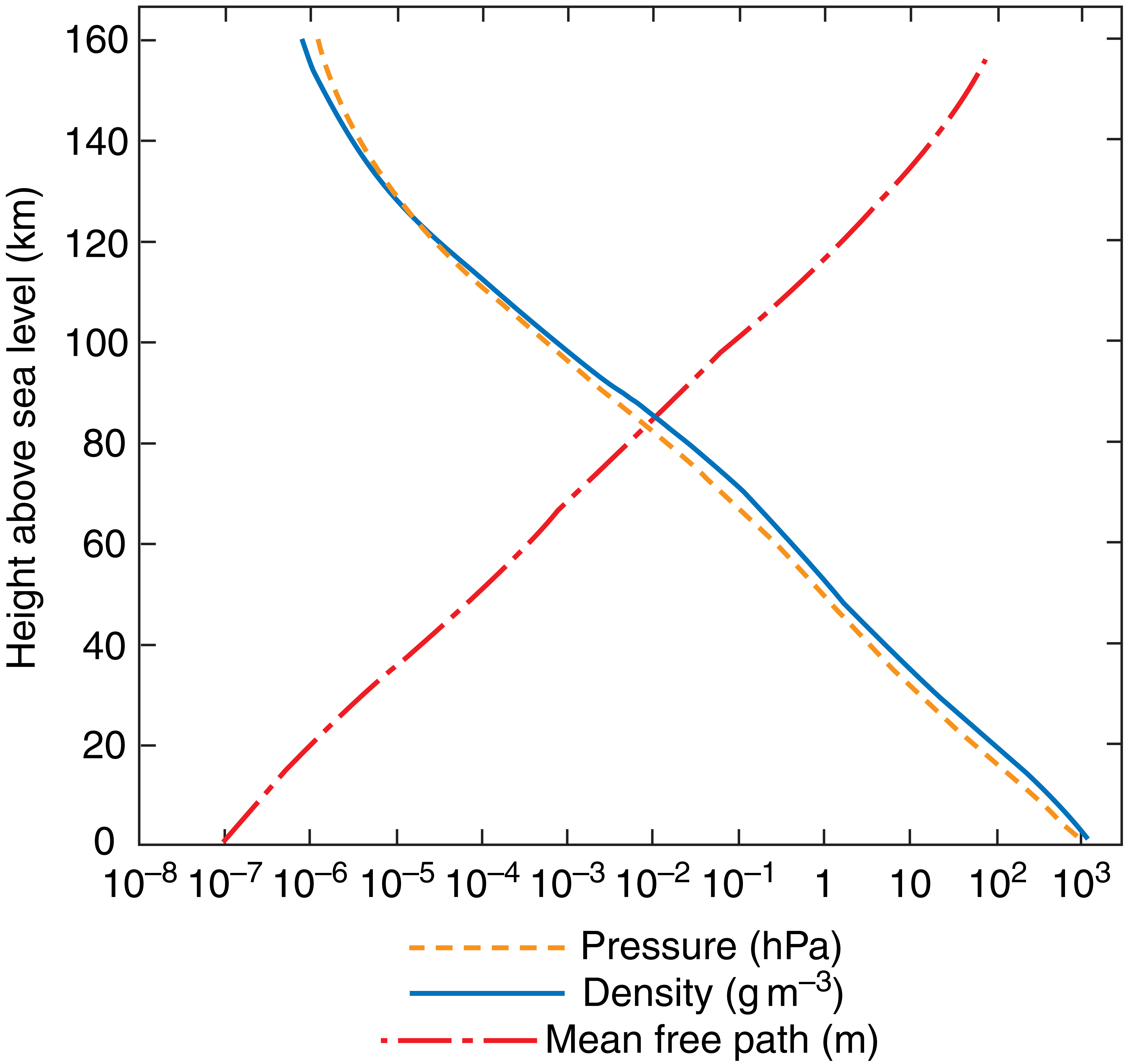


Wallace & Hobbs (2006)

Thermodynamics is important for

If the parcel must be much larger than molecular mean free path, then how big must it be in the troposphere?





Wallace & Hobbs (2006)

Pressure in the ocean

In contrast, ocean pressure increases linearly with depth.

Parcels of water can also be defined as in air.

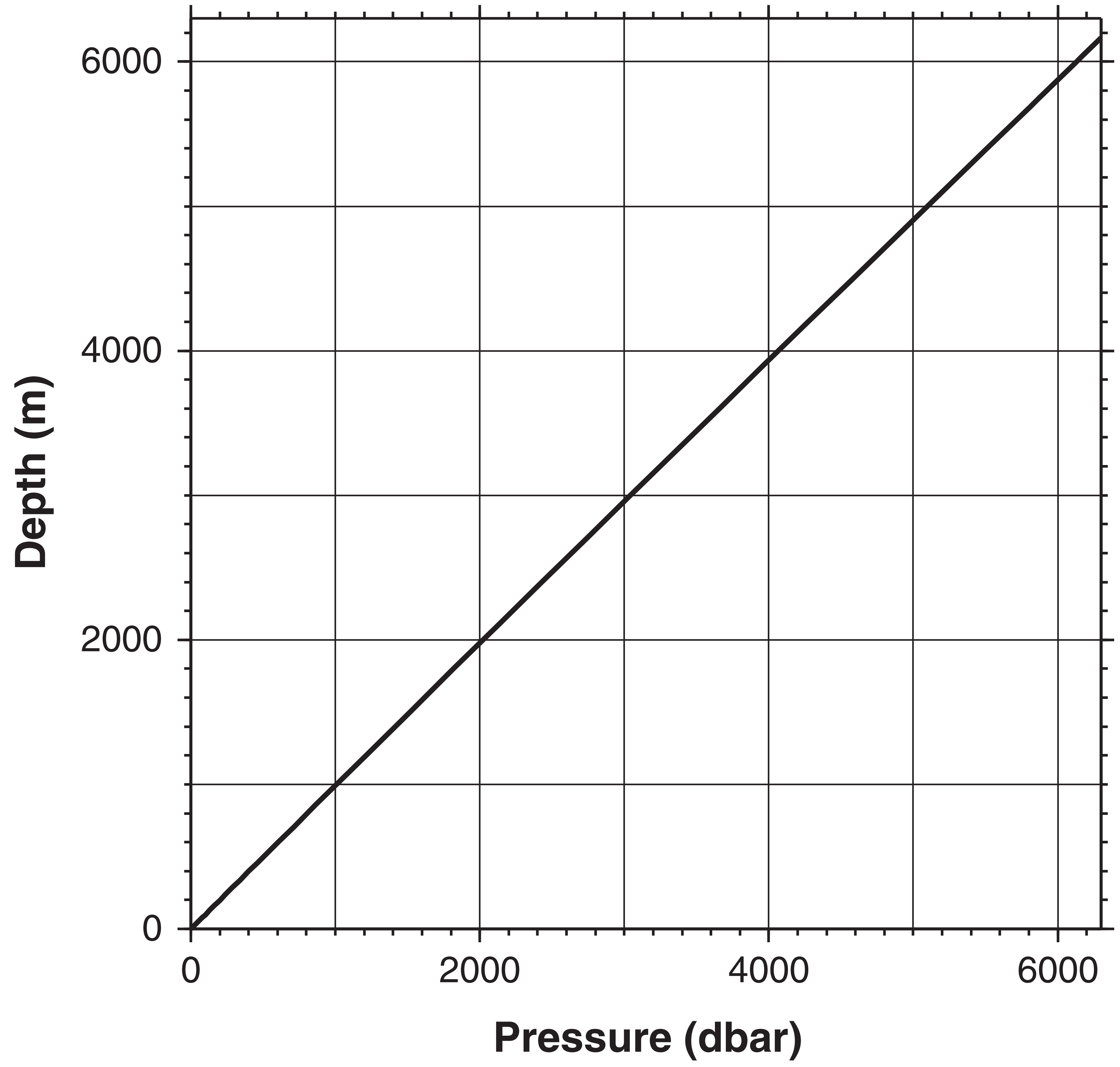


FIGURE 3.2 The relation between depth and pressure, using a station in the northwest Pacific at 41° 53′N, 146° 18′W.

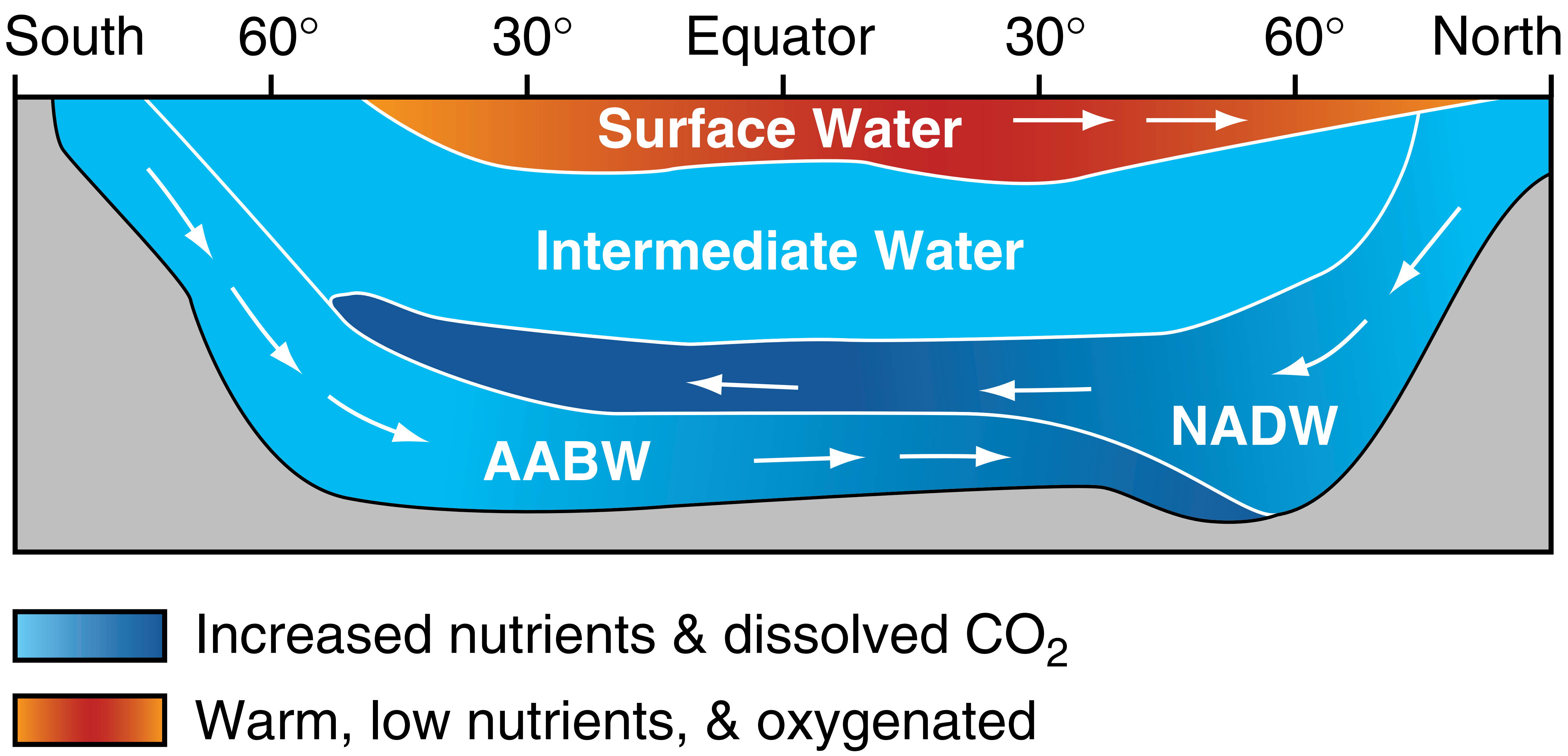
Talley et al. (2008)

Ocean layers

Important layers of ocean water are:

Surface water
Intermediate water
North Atlantic deep water
Antarctic bottom water

These layers of the ocean are important for the **oceanic thermohaline circulation**.



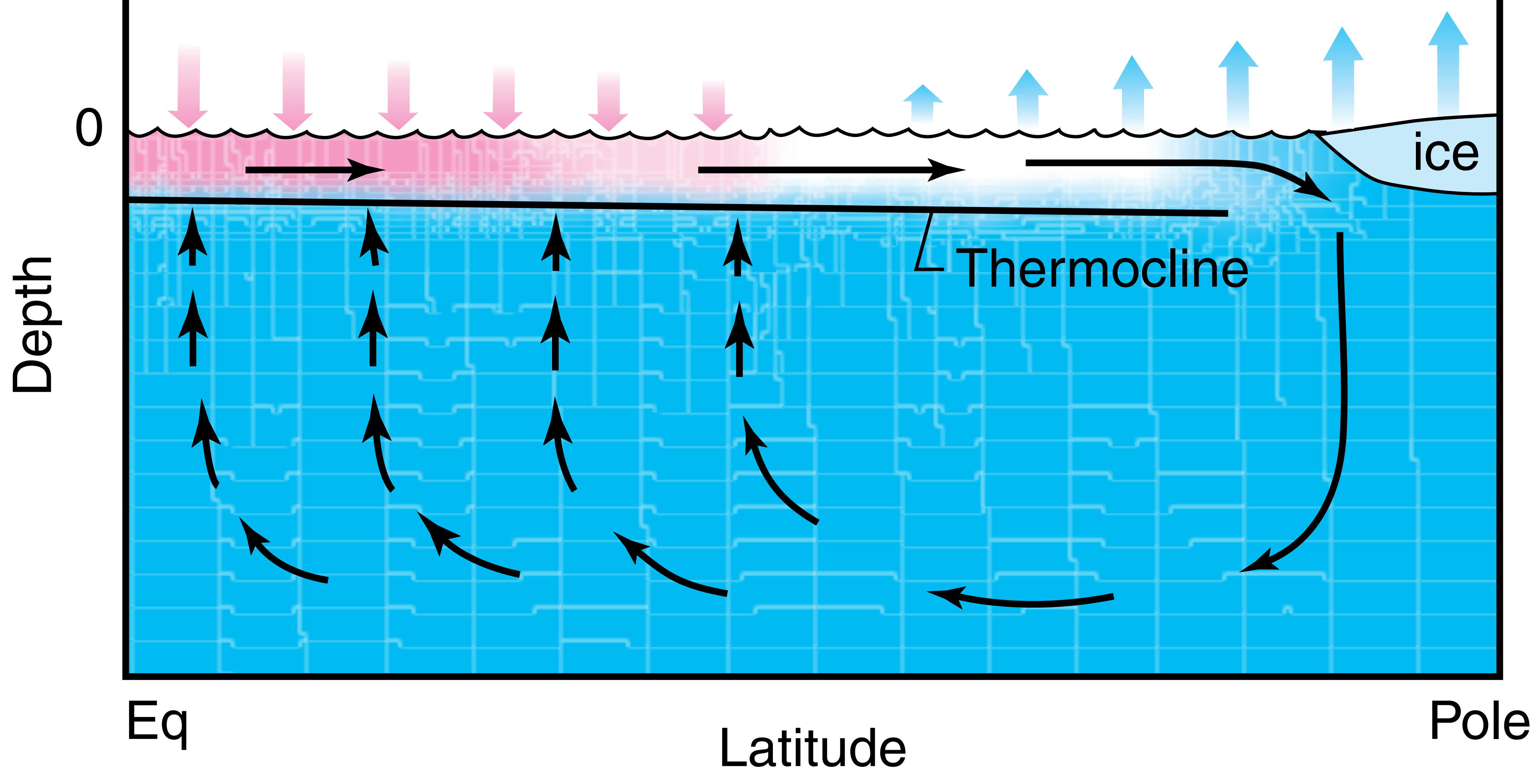
Wallace & Hobbs (2006)

The pycnocline

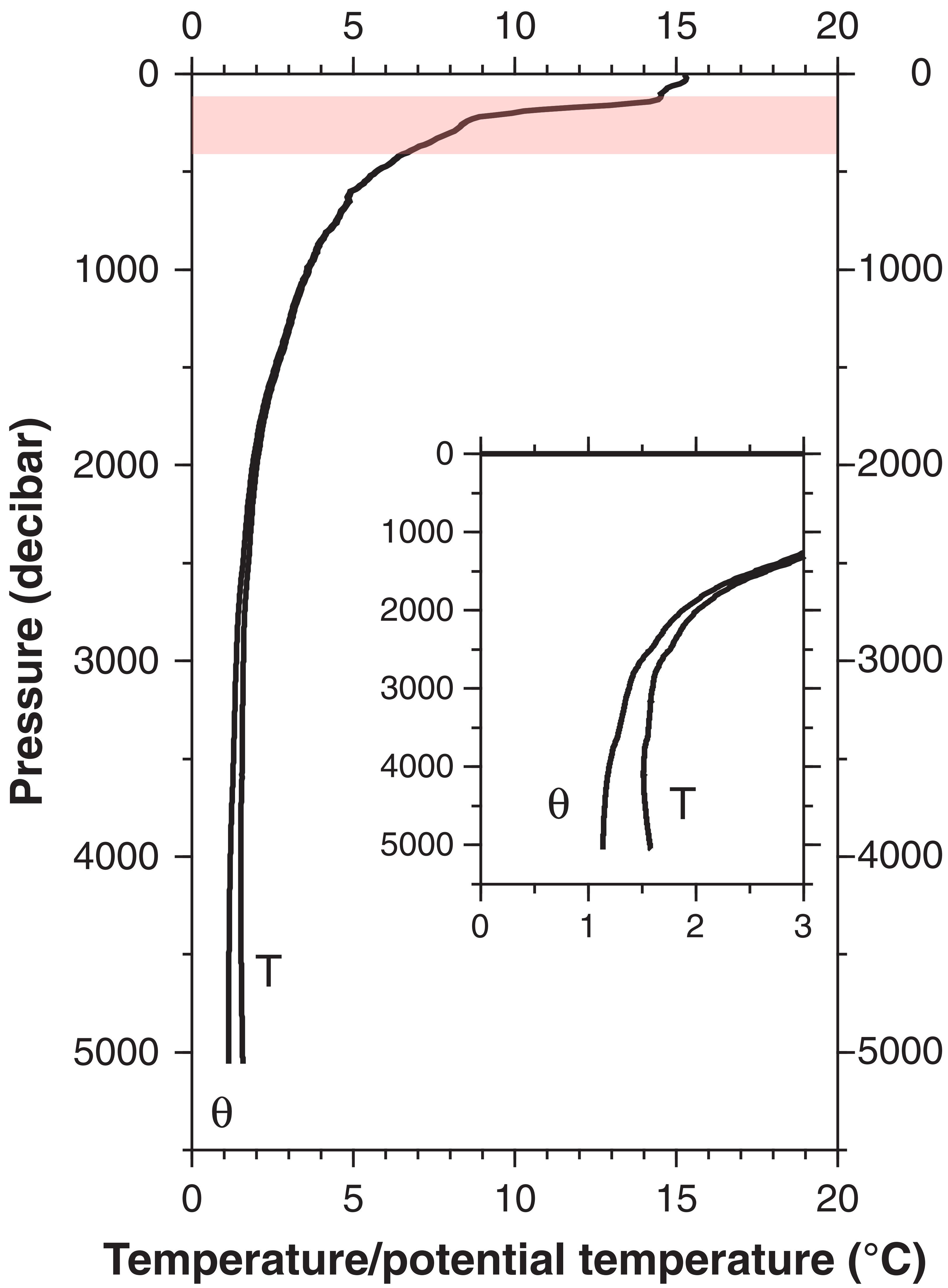
Over the ocean, the **pycnocline** (a region of significant vertical change in density) separates ocean layers.

The pycnocline is a combination of:

- a **thermocline** (temperature change)
- a **halocline** (salinity change)
- The former dominates in the tropics and the latter in the polar regions.



Wallace & Hobbs (2006)



Talley et al. (2008)

See you next class