THE UNIVERSITY OF UTAH

# ATMOS 5130

## Lecture 2

- Atmospheric Composition : Chapter 1
  - Water
  - Carbon Dioxide
  - Ozone
- Thermodynamic System and Variables: Chapter2
  - State vs. Process

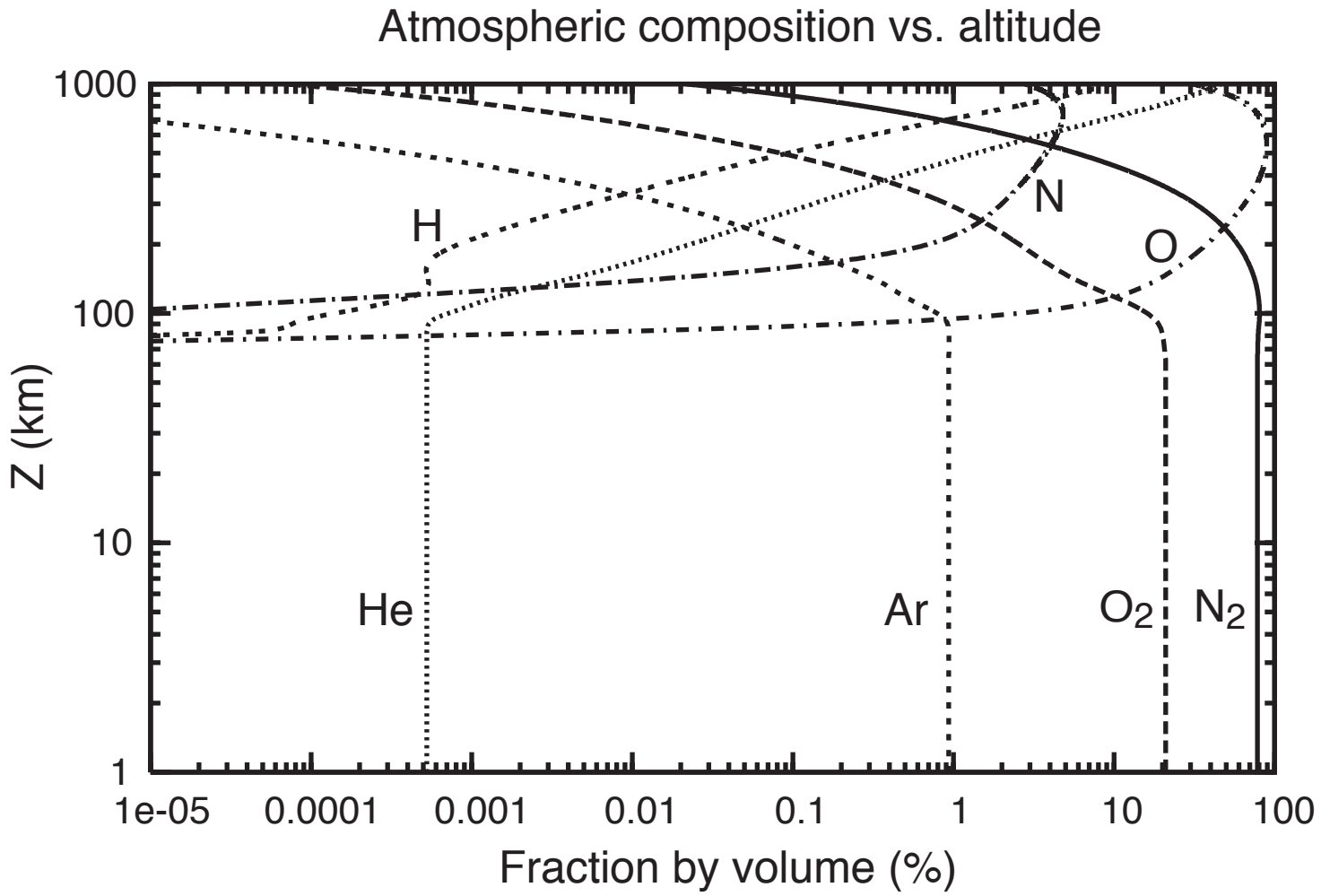
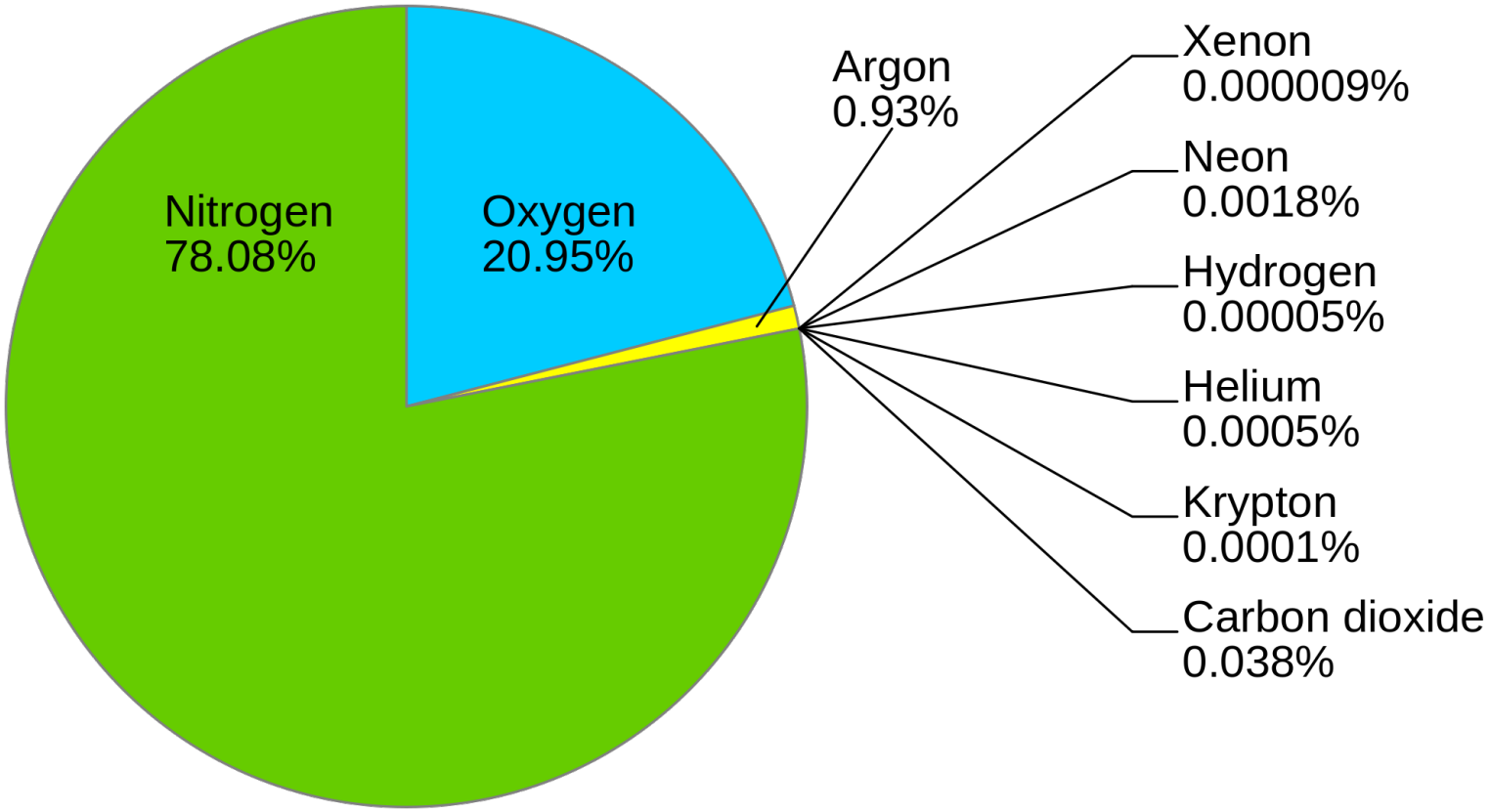

Atmospheric composition vs. altitude
1000
100
10
1
Z (km)
H
N
O
He
Ar
O2
N2
1e-05
0.0001
0.001
0.01
0.1
1
10
100
Fraction by volume (%)

Fig. 1.3

# Composition of a DRY Atmosphere: Troposphere

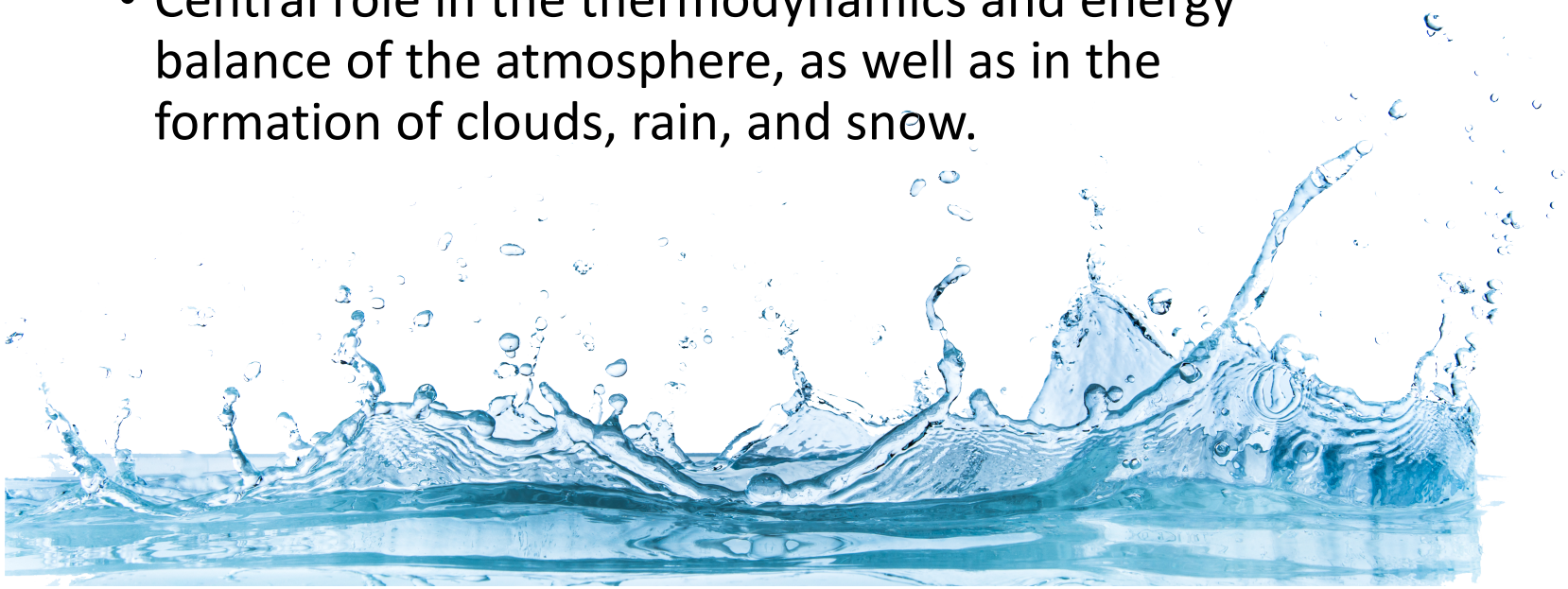
Water Vapor Varies 0 – 5%



# Water

- Despite its relatively small fractional contribution, water in all of its phases is by far the most important constituent from a meteorological point of view.

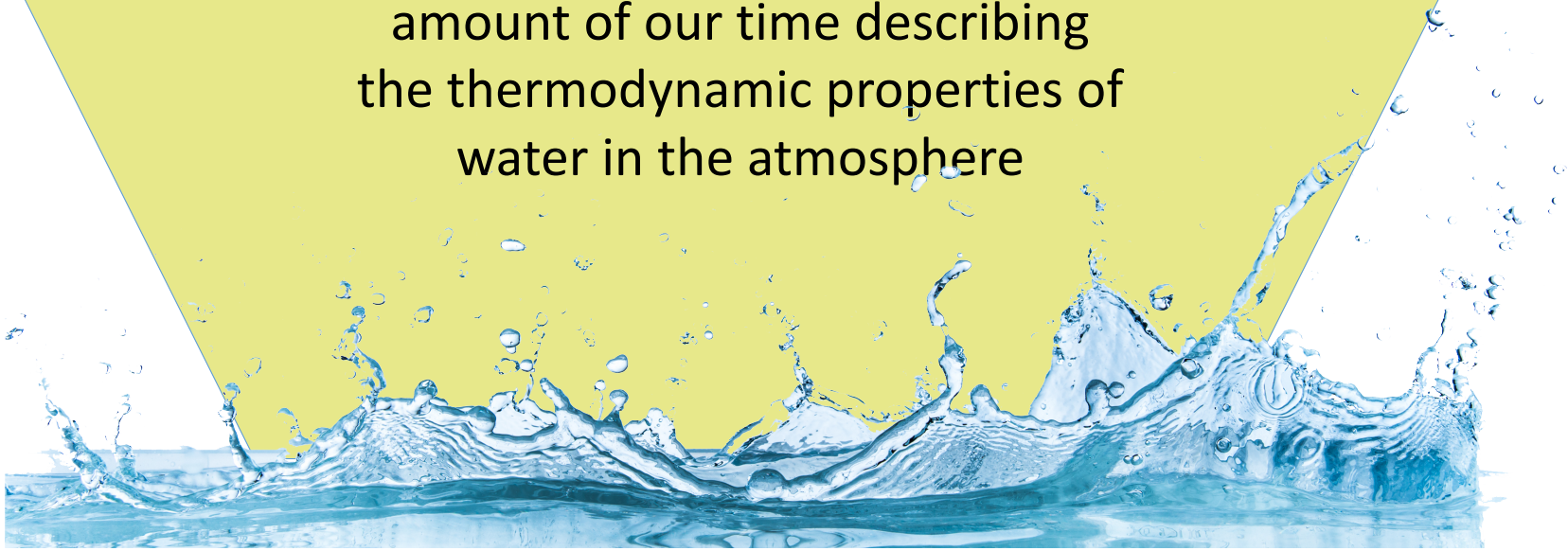
- Central role in the thermodynamics and energy balance of the atmosphere, as well as in the formation of clouds, rain, and snow.



# Water

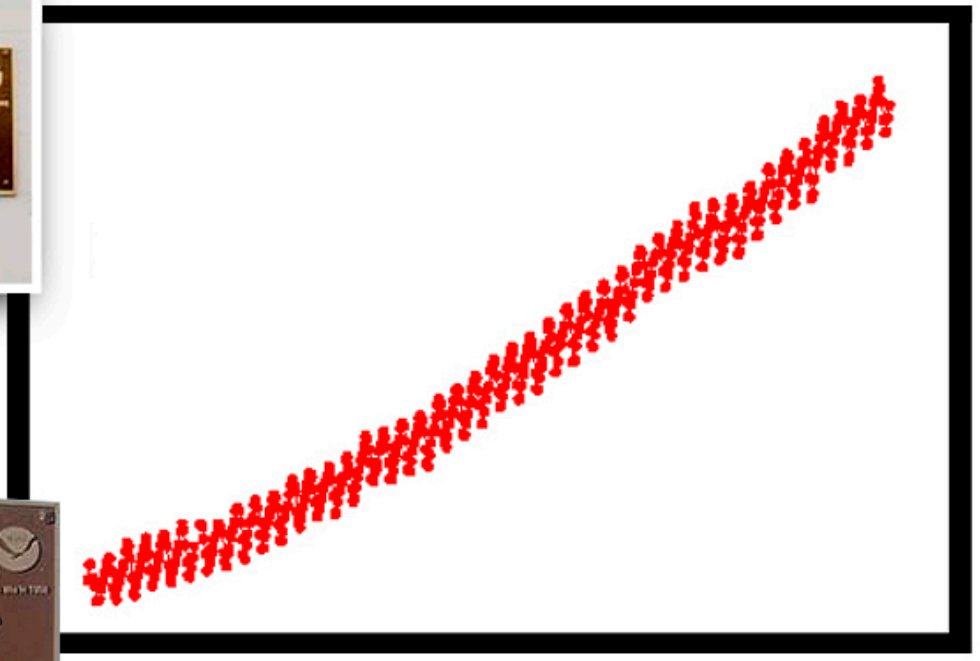
CLASS WILL FOCUS
ON BOTH DRY AND MOIST
THERMODYNAMIC PROCESSES –

We will be spending a significant amount of our time describing the thermodynamic properties of water in the atmosphere



# Rise in Carbon Dioxide


**David Keeling**

**20% Rise in 50 Years**

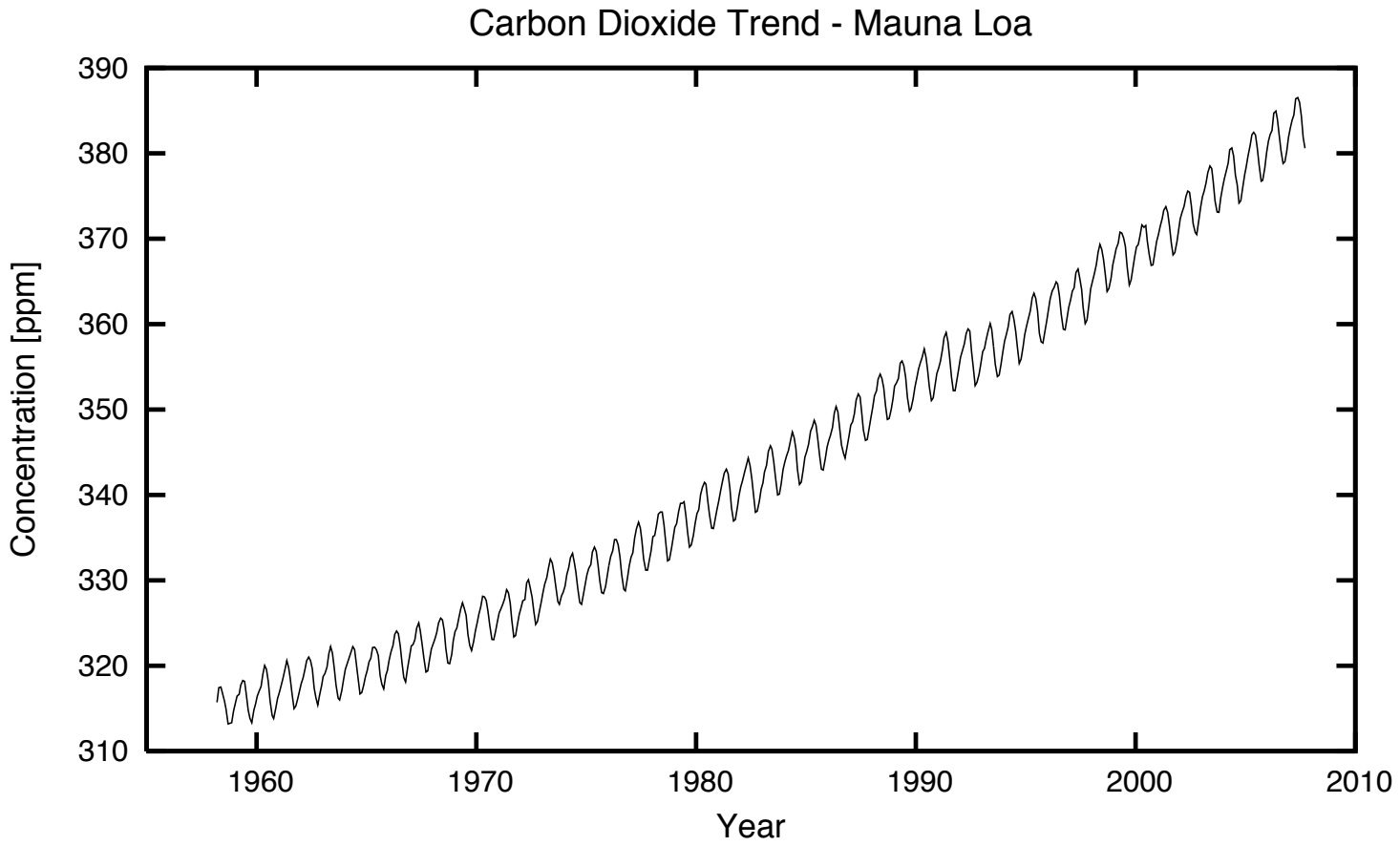
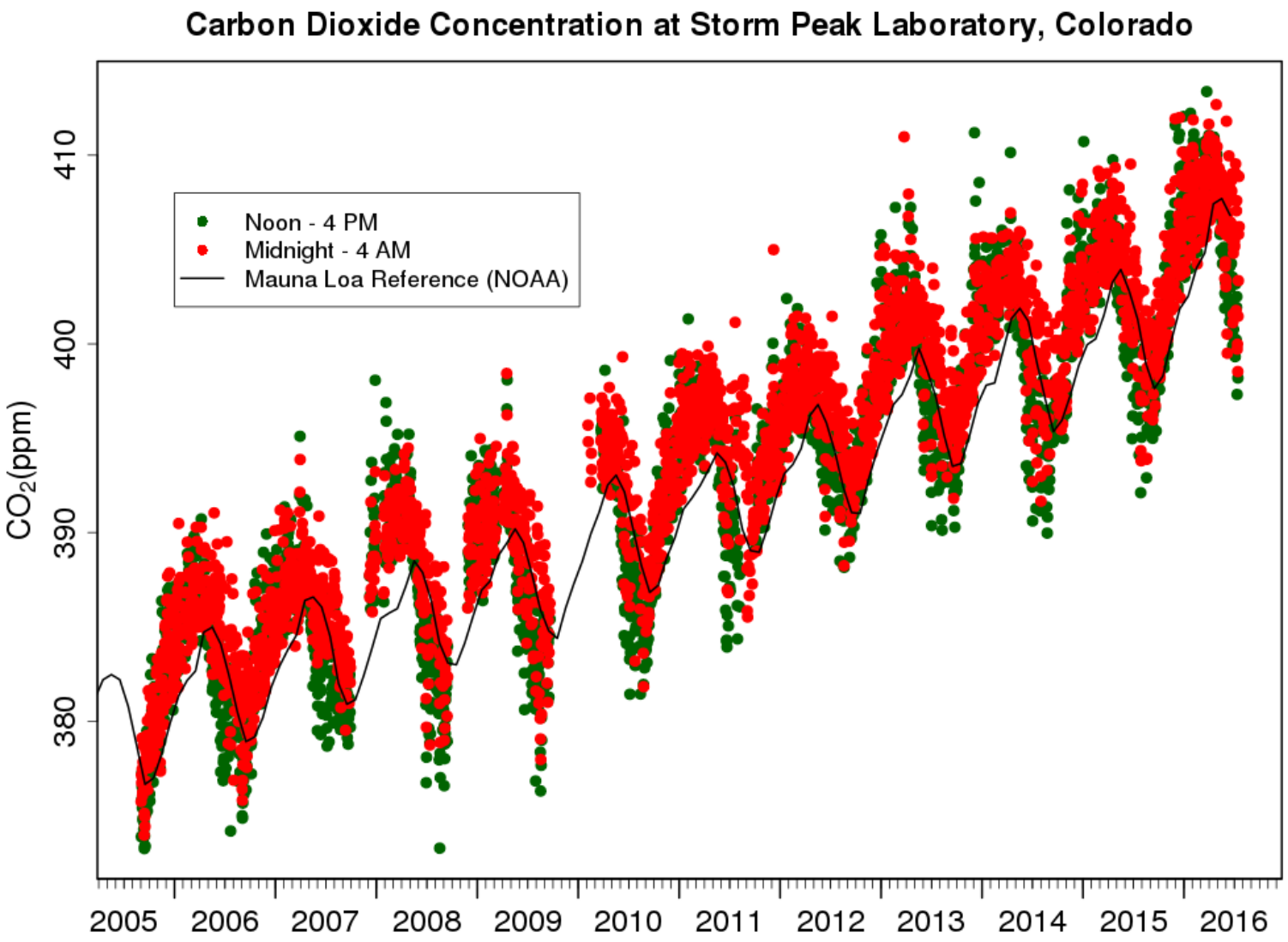
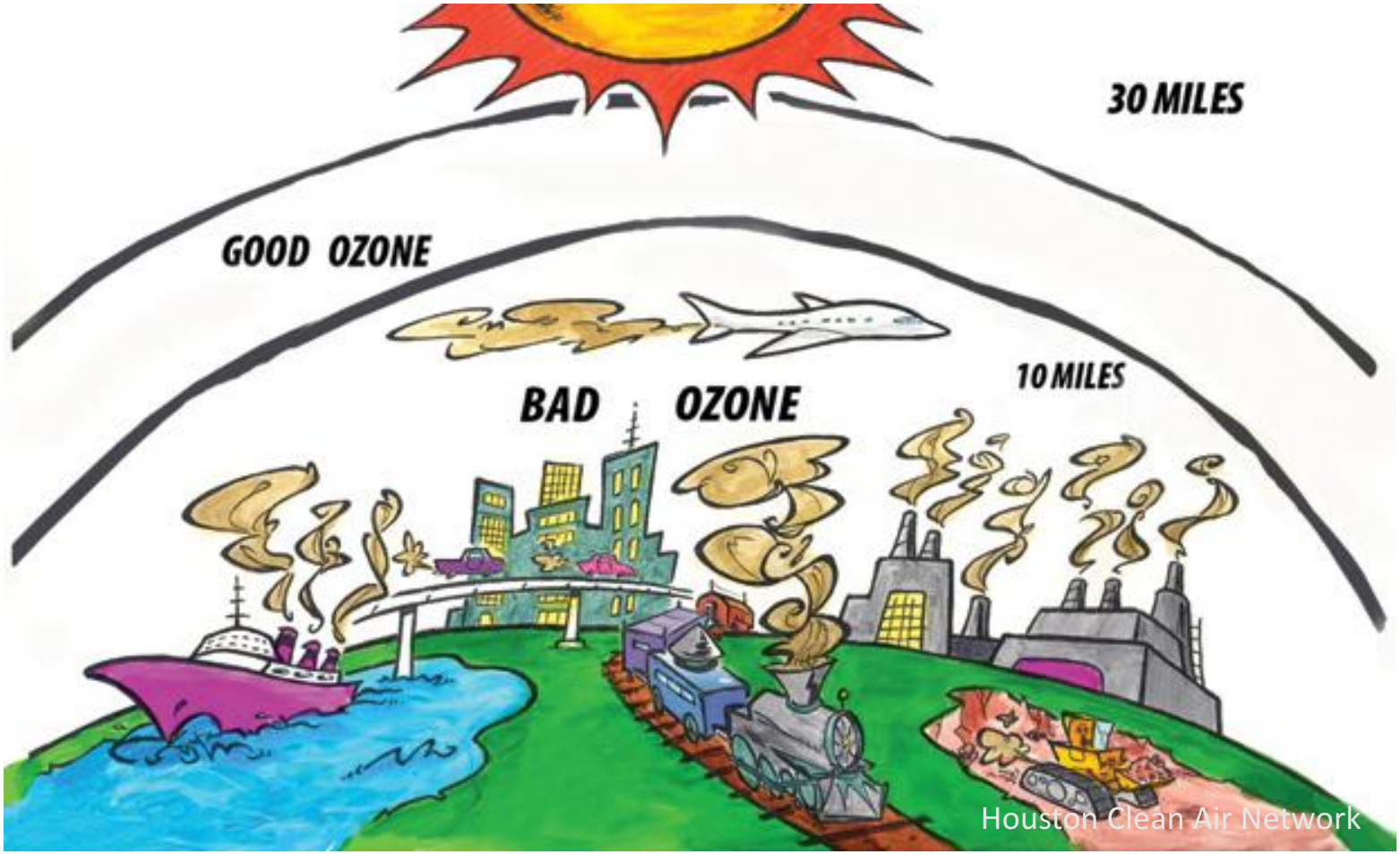



Fig. 1.4 Petty Textbook states: 383 ppm in 2007

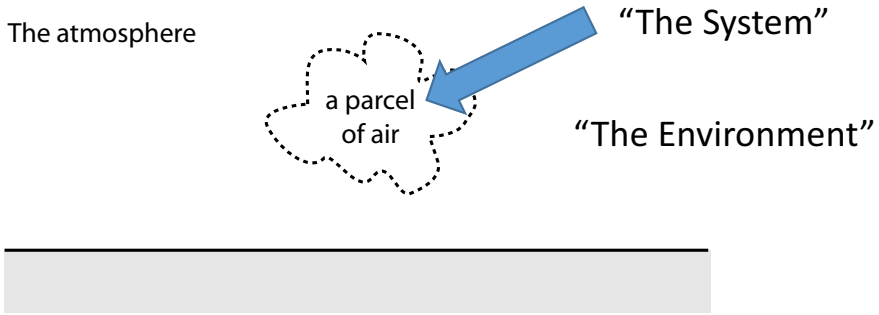
*409.44 ppm on April 9, 2016 at Mauna Loa*


Carbon Dioxide Concentration at Storm Peak Laboratory, Colorado
Noon - 4 PM
Midnight - 4 AM
Mauna Loa Reference (NOAA)
CO2(ppm)
380
390
400
410
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

# OZONE = $O_3$


30 MILES
GOOD OZONE
10 MILES
BAD OZONE
Houston Clean Air Network

# Air Parcel as thermodynamic system




Isolated System – exchanges neither matter nor energy with environment

Closed System – exchanges no matter, but many exchange energy in various forms (timescales)

Open System – exchanges both matter and energy with environment

We normally idealize an air parcel as a closed thermodynamic system

# CHAPTER 2: State vs. Process Variables

## State Variables

Uniquely determined by the current state of the system

Properties of a system are at a point in time, not how it arrived at that state.

- Pressure
- Temperature
- Density

## Process Variables

Associated with a process,

Exchange of energy between system and environment

e..g. heat energy (Q) added to air sample to bring it to current temp

HW problem 2.2

Indicated which of the following variables can be viewed as state variables.

a) your weight
b) The volume of gasoline burned by your car on the way home from college
c) The volume of gasoline remaining in your tank at any particular time
d) The position in space of a weather balloon
e) Distance traveled by weather balloon

HW problem 2.2

Indicated which of the following variables can be viewed as state variables.

a) your weight = state
b) The volume of gasoline burned by your car on the way home from college = not state
c) The volume of gasoline remaining in your tank at any particular time = state
d) The position in space of a weather balloon = state
e) Distance traveled by weather balloon= not state

# Exact and inexact differentials

State Variable: EXACT $\oint dv = 0$

Process Variable: Inexact $\oint \delta q \neq 0$

**Key fact:** If $x$ is a state variable, then its differential is exact and will be written as $dx$. If it is not a state variable, then its differential is inexact and will be written as $\delta x$.

# CHAPTER 2: Extensive vs. Intensive Variables

## Extensive Variables

Depends on the size of the sample or system
e.g. volume

## Intensive Variables

Does not depend on the size of the sample or system
e.g. volume per mass

CONSERVED VARIABLES

IMPORANT CHARACTERISTIC OF ANY STATE VARIABLE IS THE SET OF CONDITIONS UNDER WHICH IT DOES OR DOES NOT REMAIN CONSTANT

**An isothermal process** is one in which temperature is held constant
**An isobaric process** is one in which pressure is held constant
**An isochoric process** is one in which volume is held constant.