Introduction & Overview

What is atmospheric dynamics?

Goal of the class

- Understand how atmosphere moves
- Thus, how to predict future state of the atmosphere
- Understand the atmospheric structure (distribution of temperature, wind, …)

Today's class

- How do we describe the atmosphere?
- Some examples
- What drives atmospheric motions?
- Some example
- Some models of the atmosphere in motion
- Building blocks to describe atmospheric motions

Quantities?

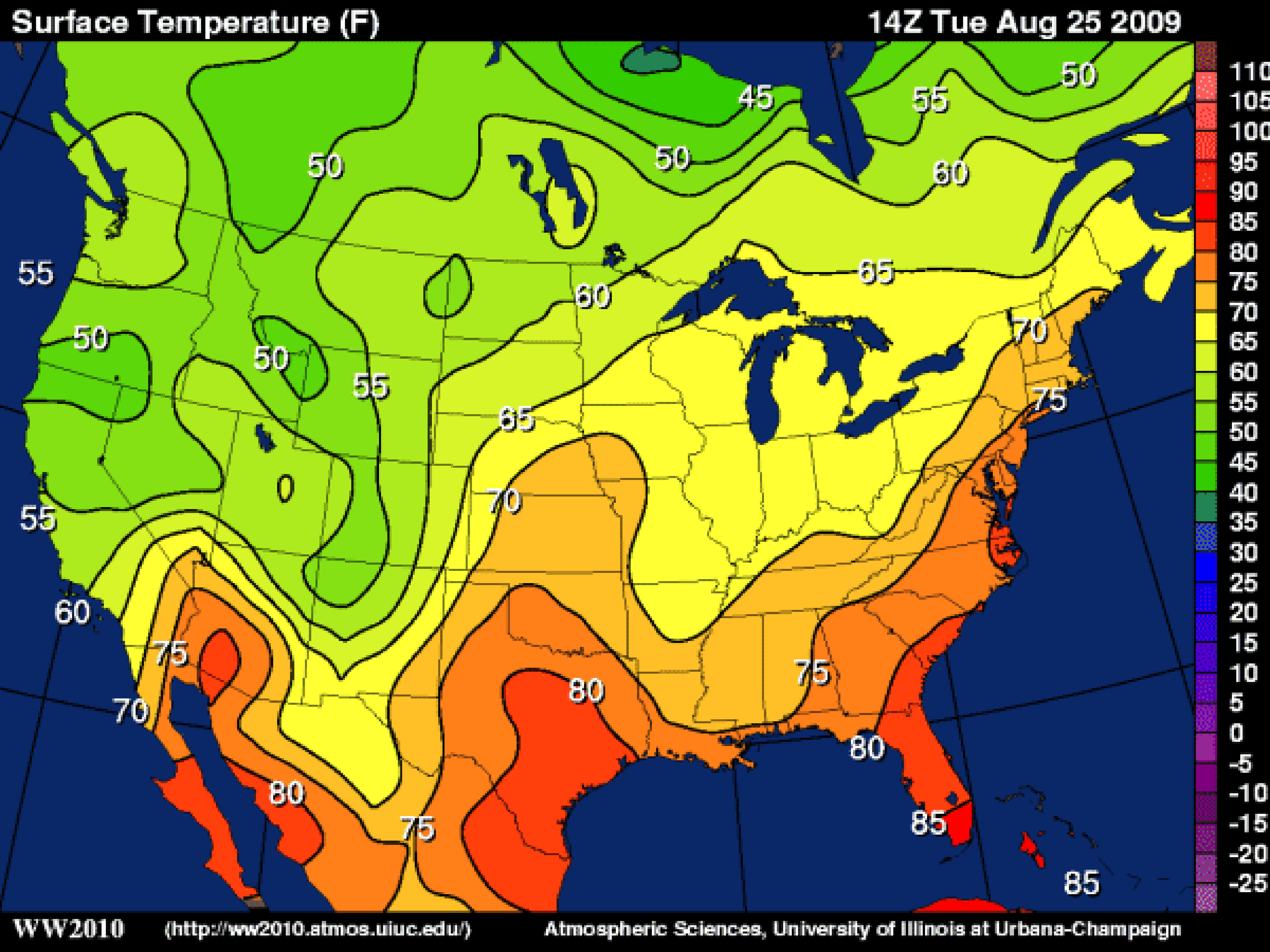
- How to we describe the atmosphere?

Fundamental units

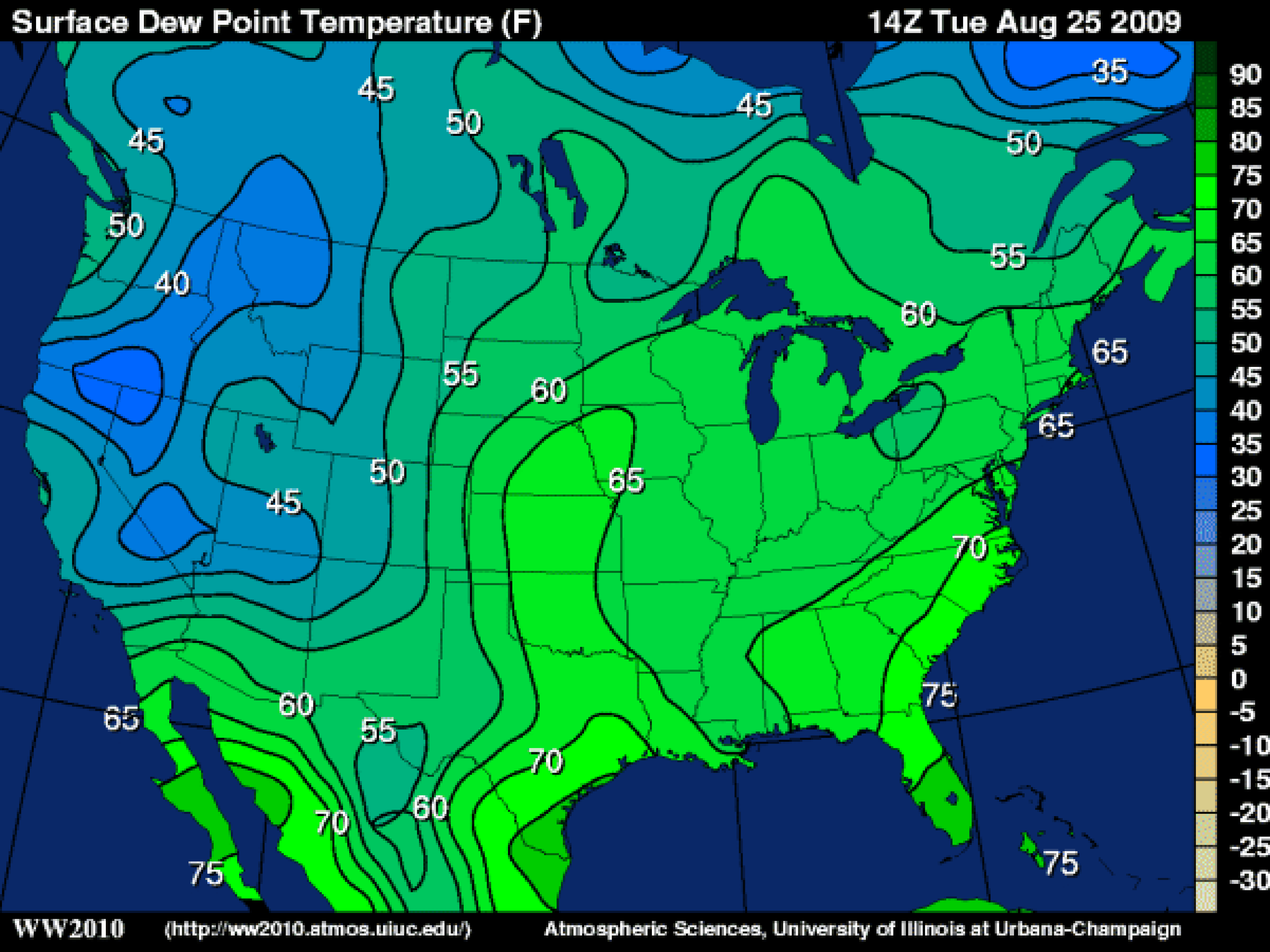
Property	Name	Symbol
Length	Meter (meter)	m
Mass	Kilogram	kg
Time	Second	s
Temperature	Kelvin	K

Derived units

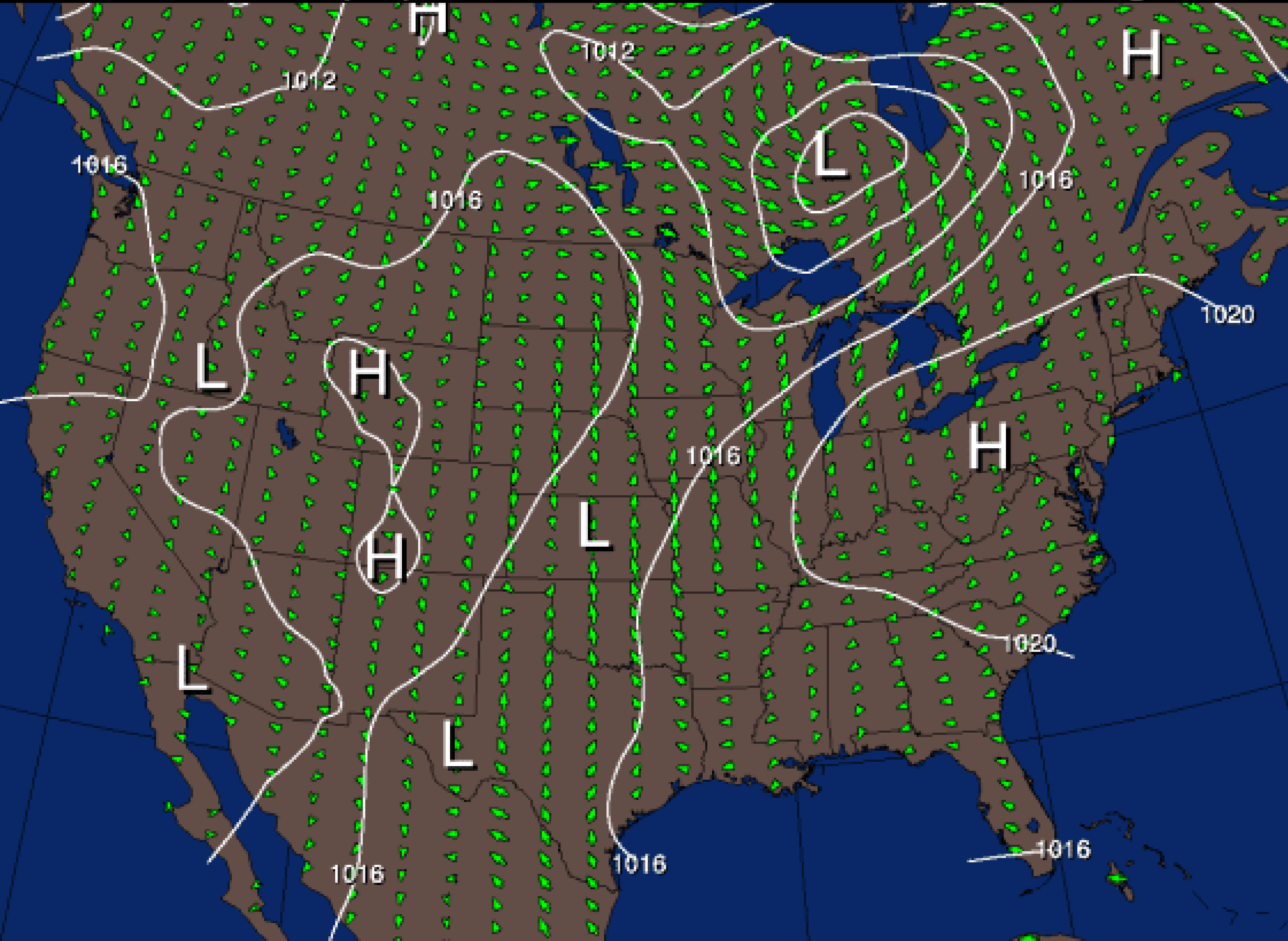
Property	Name	Symbol
Frequency	Hertz	Hz (s^{-1})
Force	Newton	N (kg m s^{-2})
Pressure	Pascal	Pa (N m^{-2})
Energy	Joule	J (N m)
Power	Watt	W (J s^{-1})



Surface Temperature (F)
14Z Tue Aug 25 2009
45
50
55
60
65
70
75
80
85
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
WW2010
(http://ww2010.atmos.uiuc.edu/)
Atmospheric Sciences, University of Illinois at Urbana-Champaign

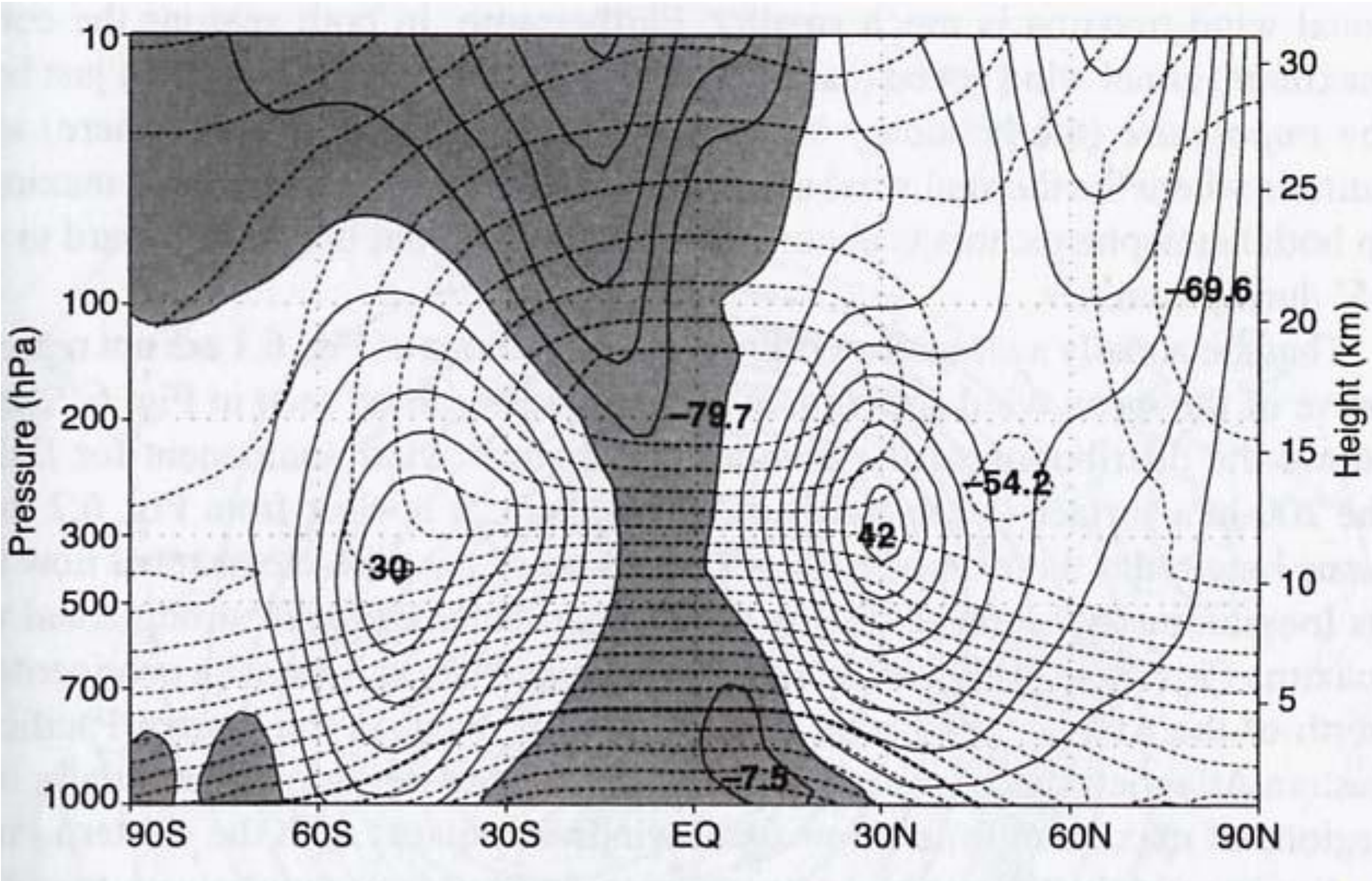

Surface Dew Point Temperature (F)
14Z Tue Aug 25 2009
35
45
45
45
50
50
50
55
55
60
60
65
65
40
50
45
50
55
60
65
70
75
75
60
55
70
60
70
75
65
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
WW2010
(http://ww2010.atmos.uiuc.edu/)
Atmospheric Sciences, University of Illinois at Urbana-Champaign

Sea Level Pressure (mb) / Wind Vectors 14Z Tue Aug 25 2009



WW2010 (http://ww2010.atmos.uiuc.edu/) Atmospheric Sciences, University of Illinois at Urbana-Champaign

Atmospheric structure (July)



Solid lines show westerly wind speed

Dashed contours show temperature

Holton, page, 141

Composition of the atmosphere

- Air is a mixture of various gases
- Particularly, nitrogen, oxygen, water vapor, carbon dioxide
- We can assume air behaves like an ***ideal gas***

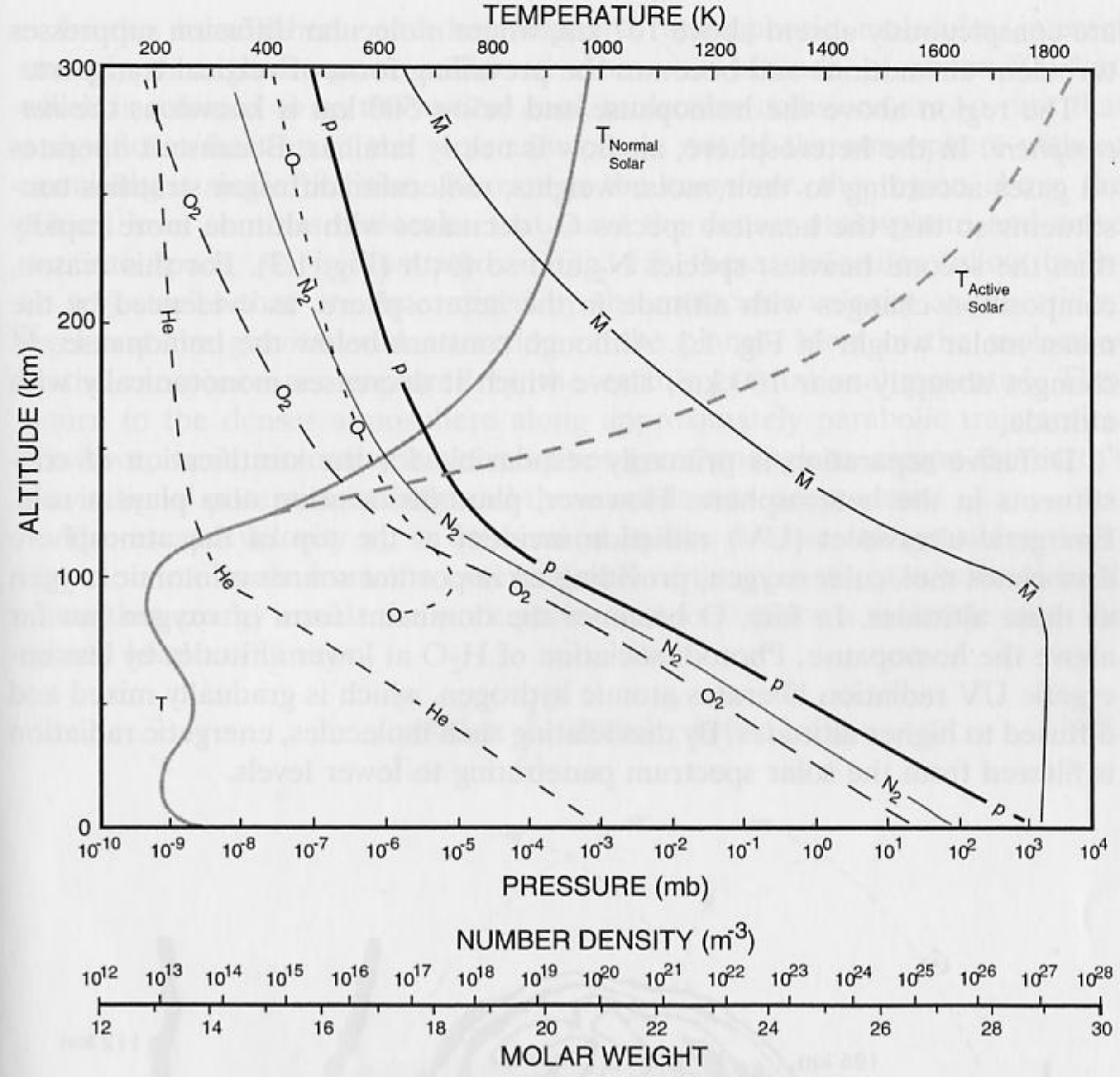
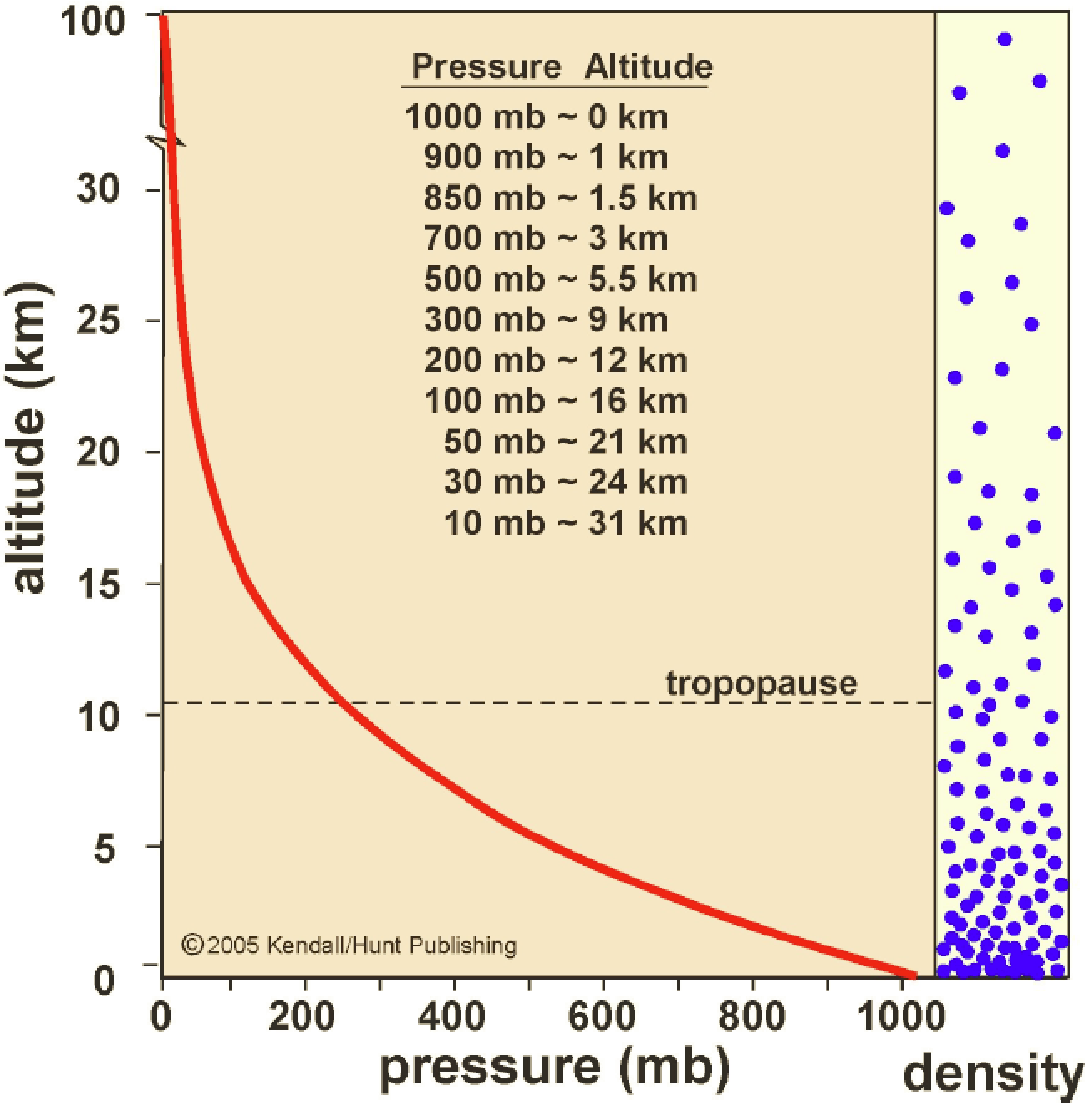


Figure 1.3 Global–mean pressure (bold), temperature (shaded), mean molar weight (solid), and number densities of atmospheric constituents, as functions of altitude. *Source:* U.S. Standard Atmosphere (1976).

Salby, *Fundamentals of Atmospheric Physics*, page 11.

Relationship between temperature, pressure and density



Dynamics occurs on all scales

- Certain types of dynamics occur on global scales (planetary waves, synoptic weather)
- Dynamics on the scale of fronts and thunderstorms - mesoscale
- Smaller scales (e.g., gusts)

- Smaller spatial scales tend to be faster,
  longer spatial scales tend to be slow….
  But not always!

Basis for atmospheric motions

Conservation of momentum

- description of wind in 3 dimensions

Conservation of energy

- change in heat and mechanical energy due to work

Conservation of mass

- total amount of air is known

Conservation of water (and other material)

These all depend on one another – i.e., this is a coupled system

Rules?

- How does the atmosphere change?

Atmosphere conserves

- Energy (mechanical, heat, …)
- Mass (of air, and other gasses)
- Momentum (and angular momentum)

To describe motion, we can make use of:

- Newton's 2nd law ($\sum F = ma$)
- First Law of Thermodynamics
- We need to account for fact that earth is rotating, spherical and there is gravity

Some initial things to remember

- Newton's second law: $\boldsymbol{F} = m\boldsymbol{a}$
  "momentum concerned"
- Ideal gas law: $p = \rho RT$
  expression of mass for air
- First law of thermodynamics
  "energy conserved"

Gravity exists g

Earth is round a

There are days and nights
(Earth is rotating about once per day) Ω

Alphabet soup is better in Greek

ATOC 5050

Class website: http://atoc.colorado.edu/~dcn/ATOC5050

***Who*:** David Noone (dcn@colorado.edu). Ekeley Sciences (CIRES) Building, S234

***When*:** Fall 2009; Tuesday and Thursday 9:30-10:45 am

***Where*:** Duane, E126

***Prerequisites*:** One year of calculus and one year of physics with calculus

***Grading*:** Homework (25%), projects (25%), weekly exercises (10%), mid-term exam (10%) and final exam (30%)

***Office hours*:** Tuesdays, 2-5pm, by email (or other) appointment.

Textbooks

Holton, J. R., *An introduction of Dynamic Meteorology*, Elsevier Academic Press, 4th ed., 2004.
(3rd and 4th editions available in Math-Physics library on reserve)

Rogers, R. R., and M. K. Yau, *A short course in cloud physics*, Butterworth and Heinemann, 3rd ed., 1989.
(On reserve, also ***download and print*** chapters 1-3 on electronic)

Other reading

Many other good books – Wallace and Hobbs, Hartman, Andrews, Salby, Vallis, Gill

Who takes ATOC 5050

- ATOC core class

  ATOC 5050 (Fundamentals, “weather”) ->
  ATOC 5060 (More mathematical)

- Applied math, engineering, geology, geography

- Also special guests from NCAR, NOAA, and other labs around Boulder

Upcoming!

- Field trip – date to be determined.
- What days?