Atmospheric Motions I, ATM S 441/503

Instructor: Professor Cecilia Bitz, PhD in UW atmospheric sciences 1997

Course Objective: To introduce you to fluid dynamics of large-scale, midlatitude weather systems

Lecture notes will be available on the web 0-7 days prior to class. I’ll hand them out at the beginning of the week.

This ppt is posted already

Lecture notes will not contain everything I write on the board.

If I have something to add, I will provide lecture notes on a topic.

I won’t lecture on every page in the text, you should still read everything unless I tell you to skip it.

Course web site
http://www.atmos.washington.edu/academics/classes/2010Q4/441

Reading Assignment for Friday Holton 1.1 -- 1.5.2

First Assignment Due **Friday**, Oct 8 (normally due on Wednesdays)

Group “projects” assigned later will coincide with shorter homework assignments

Projects and exercises will occasionally require running MATLAB scripts with very minor code changes. I’ll give instructions in class.

Why does Earth have an atmosphere?

Why is it in motion?

Why study atmospheric dynamics?

Is it needed to take observations or run models?
Is it needed to fly an airplane?

To transcend mere description

No meteorologist is qualified without it

“Without understanding atmospheric dynamics, if the weather outside disagrees with your forecast model, all you can do is hope it changes.”

Approximate quote from Dr. Brad Coleman, NWS chief meteorologist for western Washington.

Early weather observers

"Northeaster" By
Winslow Homer

"Fisherman upon a lee-shore in squally weather" by J.M.W Turner

"Sunlight and Shadow: The Newbury Marshes" by Martin Heade

Early forecasters

Bergeron, Solberg, V. Bjerknes, Sverdrup, J. Bjerknes, Pettersen, Godske

1.1 Definitions

Continuum - continuous fluid medium

Point or Air Parcel - small compared to the scale of interest but very large compared to a molecule

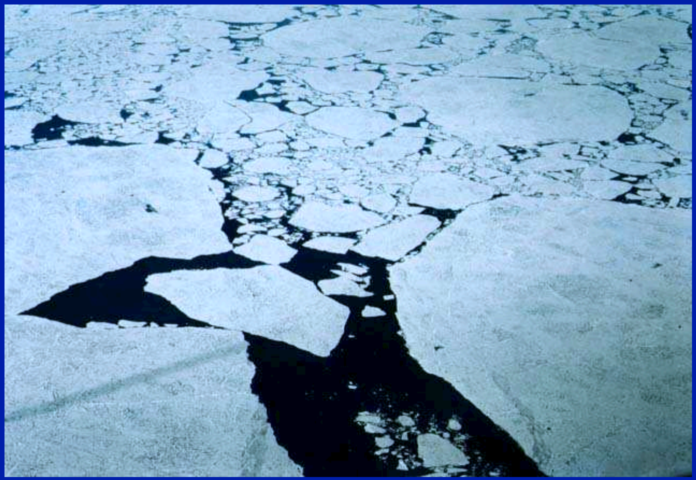
State Variable - necessary to describe a system

Field Variable - continuous in space and time, so is its derivative

Field variables can be described with p.d.e.'s

What might be better treated as discrete

(non-continuum)?



Read 1.2 on units on your own

1.3 Scale Analysis

Identify expected values of the following:

1) Magnitude of field variables
2) Magnitude of fluctuations in these fields
3) Characteristics length, depth, time-scale etc

Excerpt from Table 1.4

Type of motion	Horizontal Scale (m)
Dust Devil	1-10
Tornadoes	10^2
Hurricanes	10^5
Synoptic cyclones	10^6

"Order of magnitude" means within a factor of 10
Hence we round to 10^0, 10, 10^2, etc

The symbol for order of magnitude is $\mathcal{O}$,
The symbol for horizontal length scale is L,

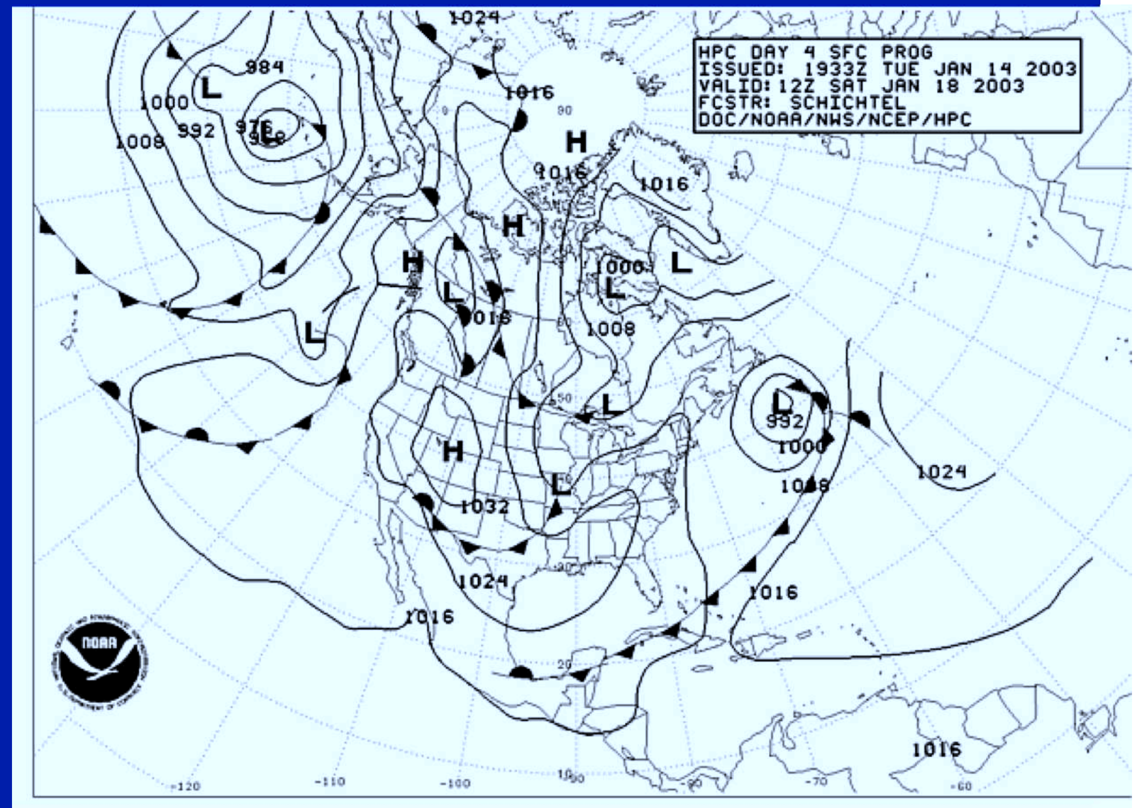
For example a hurricane has $L = \mathcal{O}(10^5)$

What is the scale of the pressure gradient:

$$\frac{\partial p}{\partial x}, \frac{\partial p}{\partial y} \sim \frac{\delta p}{L}$$

$$= \frac{10 \text{ hPa}}{1000 \text{ km}}$$

$$= 10^{-3} \text{ Pa/m}$$



1.4 Fundamental Forces that influence atmospheric motions

$$\left.\frac{d\,\text{momentum}}{dt}\right|_{\text{Inertial coord}} = \sum \text{fundamental forces}$$

Examples of fundamental forces

1. **Pressure gradient force (PGF)**
2. **Gravitation force**
3. **Friction/Viscous force**

Body forces act on center of mass and are proportional to the mass.
Surface forces act across the boundary of a fluid parcel.

If motion is with respect to a rotating coordinate system, then apparent forces,
Centrifugal and Coriolis Forces,
Must be included with the fundamental forces

What are the forces acting on air parcel Jacques?