ATMOSPHERIC MOTION I (ATM S 441/503)
INSTRUCTOR

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CLASS MEETS

- MWF 10:30-11:20am
- @ ATG 610
TEXTBOOK

I. Introduction: Fundamental forces, rotating coordinates, Coriolis force, atmospheric statics.

II. Basic conservation laws: Momentum equation, continuity equation, thermodynamic energy equation, scale analysis.

III. Elementary applications of the basic equations: Isobaric coordinates, geostrophic flow, inertial flow, cyclostrophic flow, gradient wind, thermal wind, vertical motion.

IV. Circulation, vorticity, and potential vorticity: Circulation theorem, vorticity, potential vorticity, barotropic vorticity equation.

V. Atmospheric oscillations: Linear perturbation theory, basic properties of waves, linear waves.
PURPOSE OF THE COURSE

- To develop understanding of why large-scale (synoptic scale) midlatitude weather systems behave as they do
ATMOSPHERIC MOTION IN REALTIME (AND FORECAST)

- http://earth.nullschool.net/
- https://www.windyty.com
What information/knowledge do we need to fully describe the behavior of the atmosphere?

What are the forces that move the air parcel around? Among them, what are of primary importance in the midlatitude synoptic scale motion?

Why does the wind blow almost parallel to the height contours on a 500-mb map?

Why is there the jet stream in the mid-latitude?

Why do we need math to answer these questions?
GENERAL CIRCULATION MODEL
WHAT IS THE GCM?

COMPUTER CODE THAT NUMERICALLY SOLVES EQUATIONS THAT GOVERN THE STATE OF THE ATMOSPHERE, OCEAN, LAND SURFACE AND SEA ICE

- EX) ATMOSPHERIC STATE: WIND, TEMPERATURE, HUMIDITY, PRESSURE
- RULES THAT THE ATMOSPHERIC STATES FOLLOW
  - NEWTON’S SECOND LAW OF MOTION
  - FIRST LAW OF THERMODYNAMICS
  - MASS CONSERVATION
WHAT IS THE GCM?

COMPUTER CODE THAT NUMERICALLY SOLVES EQUATIONS

“SOLVING EQUATIONS”

LAW THAT GOVERNS THE MOTION OF THE CAR

DISTANCE = SPEED X TIME

POSITION OF THE CAR AT INITIAL TIME

POSITION OF THE CAR AT FUTURE TIME
WHAT IS THE GCM?

COMPUTER CODE THAT NUMERICALLY SOLVES EQUATIONS

"SOLVING EQUATIONS"
= CALCULATING EVOLUTION OF STATES
= CLIMATE SIMULATION

LAW THAT GOVERNS TEMPERATURE OF THE ATMOSPHERE

TEMPERATURE CHANGE
= SUM OF HEATING
MINUS SUM OF COOLING

TEMPERATURE OF THE AIR AT INITIAL TIME

TEMPERATURE OF THE AIR AT FUTURE TIME
WHAT IS THE GCM?

COMPUTER CODE THAT NUMERICALLY SOLVES EQUATIONS IN THE GLOBAL DOMAIN

• SHOULD SOLVE THE EQUATIONS IN EVERY “BOX”

• THERE IS NO WALL - EVERY BOX AFFECT ADJACENT BOXES AND THE EFFECTS QUICKLY SPREAD OUT

• BY SOLVING A SAME EQUATION SET IN EVERY BOX INTERACTING WITH OTHERS, WE GET..
BY SOLVING EQUATIONS IN EVERY BOX, WE GET..

THE EMERGING PATTERNS (WEATHER/CLIMATE) AND THEIR EVOLUTION
YOU’LL HAVE ANSWERS TO THESE QUESTIONS AT THE END OF THE CLASS.

- What information/knowledge do we need to fully describe the behavior of the atmosphere?
- What are the forces that move the air parcel around? Among them, what are of primary importance in the midlatitude synoptic scale motion?
- Why does the wind blow almost parallel to the height contours on a 500-mb map?
- Why is there the jet stream in the mid-latitude?
- Why do we need math to answer these questions?
ZONAL MEAN RADIATION BALANCE

Surplus Heat Energy Transferred
By Atmosphere And Oceans
To Higher Latitudes

SOURCE: HTTP://WWW.PHYSICALGEOGRAPHY.NET/FUNDAMENTALS/7J.HTML
ERA40 (ZONAL MEAN FIELD)

POTENTIAL TEMPERATURE (ANN)

SOURCE: HTTP://193.63.95.1/RESEARCH/ERA/ERA-40_ATLAS/
ERA40 (ZONAL MEAN FIELD)

ZONAL WIND (ANN)

SOURCE: HTTP://193.63.95.1/RESEARCH/ERA/ERA-40_ATLAS/
WHAT INFORMATION/KNOWLEDGE DO WE NEED TO FULLY DESCRIBE THE BEHAVIOR OF THE ATMOSPHERE?

WHAT ARE THE FORCES THAT MOVE THE AIR PARCEL AROUND? AMONG THEM, WHAT ARE OF PRIMARY IMPORTANCE IN THE MIDLATTITUDE SYNOPTIC SCALE MOTION?

WHY DOES THE WIND BLOW ALMOST PARALLEL TO THE HEIGHT CONTOURS ON A 500-MB MAP?

WHY IS THERE THE JET STREAM IN THE MID-LATITUDE?

WHY DO WE NEED MATH TO ANSWER THESE QUESTIONS?
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Wind speed in east-west direction

\[ \frac{\partial T}{\partial x} \]  

Temperature change (°C) per unit distance (m) in east-west direction

\[ u \frac{\partial T}{\partial x} \]  

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GRADING

- Final exam: 40%
- Homework: 20%
- Quiz: 20%
- In-class presentation and participation: 20%
LECTURES

- Handouts will be used in most lectures
  - Handouts will make it easy to follow the derivations, and will enable us to take more time understanding the equations
  - You should pay attention to keep the handouts in an organized fashion
  - You need to write what you learned on it (otherwise, you will forget it)
COURSE WEBSITE

http://www.atmos.washington.edu/~daehyun/class/441/home.html