CLIM-111/PHYS-111 : Tentative Syllabus

Introduction to the Fundamentals of Atmospheric Science

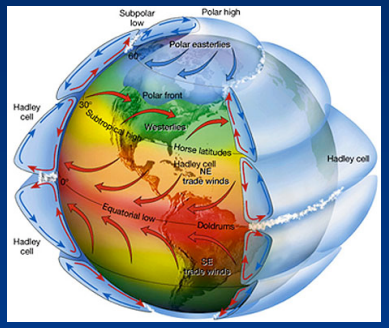
Lectures - Tuesday & Thursday, 1:30-2:45pm

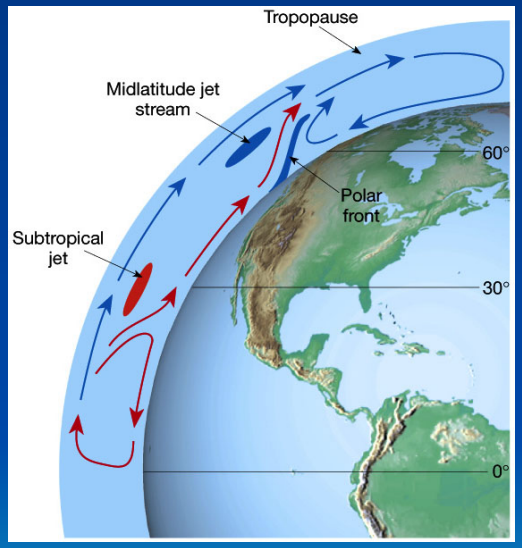
Laboratory - Friday: 10:30am-1:15pm

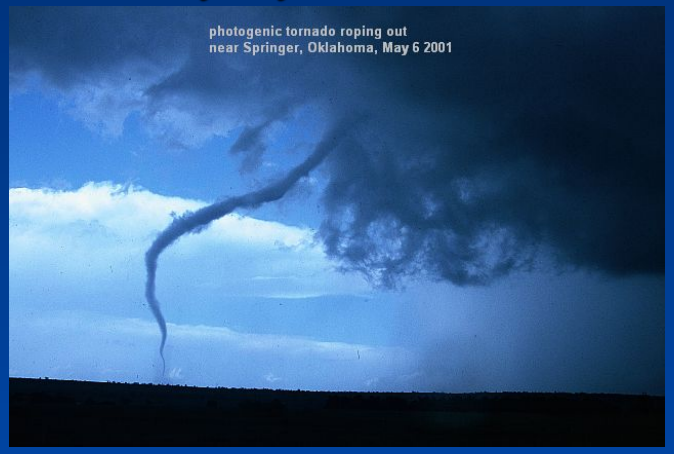
Spring Semester, 2010

Lectures: Research I, Room 201

Profs. Zafer Boybeyi and Michael E. Summers







CLIM-111/PHYS-111
Introduction to the Fundamentals of Atmospheric Science
CLIM-112/PHYS-112 Lab

An overview of the Earth's atmosphere, its history, and the fundamental physical and chemical processes which determine its characteristics. The focus is on key concepts from thermodynamics, radiation, chemistry, and dynamics that are essential for understanding the state, variability, and long term evolution of the atmosphere, especially in the context of comparisons with other planetary atmospheres.

Instructors and Contact information

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FAX: (703) 993-9229

Course Website: http://camp.cos.gmu.edu/CLIM-111.html

CLIM-111/PHYS-111 Course Goals:

The overarching goal of this course is to provide the student with a "big-picture" view of the field of atmospheric science as it relates to understanding the Earth's atmosphere, its complex history, its expected future evolution, and human influences.

This course is designed to ensure that students develop the essential skills of analytical and quantitative reasoning, information gathering, and communication related to issues in natural sciences.

CLIM-111/PHYS-111 Course Goals:

This general goal will be achieved by

(a) a focus on the planetary context of the Earth's atmosphere, i.e., what we have learned by the study of other planetary atmospheres,

(b) an emphasis on quantitative physical principles that control the atmosphere, and

(c) a heavy reliance on computer simulations for visualizing the complex interactions that occur in the atmosphere.

CLIM-111/PHYS-111

Introduction to the Fundamentals of Atmospheric Science

Specific Course Goals:

(1) an overview of the important physical and chemical processes which control the state, variability, and evolution of the Earth's atmosphere in the context of what we have learned from exploration of other planetary atmospheres,

(2) an understanding of the key scientific discoveries and remaining unanswered questions in atmospheric science,

(3) an overview of the primary scientific principles and analytical tools used in atmospheric science studies, including both remote sensing and *in-situ* techniques, with special emphasis on model simulations to visualize the complex feedbacks involved in atmospheric processes, and

(4) an understanding of the application of the scientific method to analyze and interpret observations of components of the atmospheric system.

CLIM-111/PHYS-111

This combined lecture and lab course is designed with a dual-purpose:

The first purpose is to provide a stand-alone course for students needing an introduction to scientific methods and critical reasoning as it relates to the environment. As such it will provide the necessary background information for understanding the many emerging societal problems that are consequences of human influences on the atmosphere.

The second purpose is to provide an introductory course for those students that are beginning their degrees in atmospheric science or related scientific fields. For those students this course will provide a solid foundation for future more specialized courses in atmospheric science.

The course is designed as the first course in the atmospheric science concentration (under development), but would be useful for any student wanting a one-semester overview of atmospheric science.

CLIM-112/PHYS-112 - Lab

Introduction to the Fundamentals of Atmospheric Science

The laboratory section is designed to enhance learning by applying the information acquired in the lecture portion of the course with practical applications covered in the student's lab books.

The student will engage in activities that are designed to expand and enrich the learning process through the use of state-of-the-art computer simulations that illustrate the complex phenomena that occur in the atmospheres of the Earth and other planets.

Learning Outcomes

Course Outcomes: By the end of the semester this course student will have developed a basic understanding of the following:

- Characterization of temperature and it variation in the atmosphere.
- Solar influences and heating which drive atmospheric thermodynamics and motions
- Earth's energy budget.
- Atmospheric moisture and the role of water in stability considerations.
- Cloud formation, precipitation and the range of cloud occurrences on other planets
- Atmospheric motions and the general circulation.
- The ability to read and interpret earth maps
- The climate system, variability, and climate controls.
- The properties and processes that control planetary habitability
- The atmospheric issues related to global change

CLIM-111/PHYS-111
Introduction to the Fundamentals of Atmospheric Science

FORMAT:

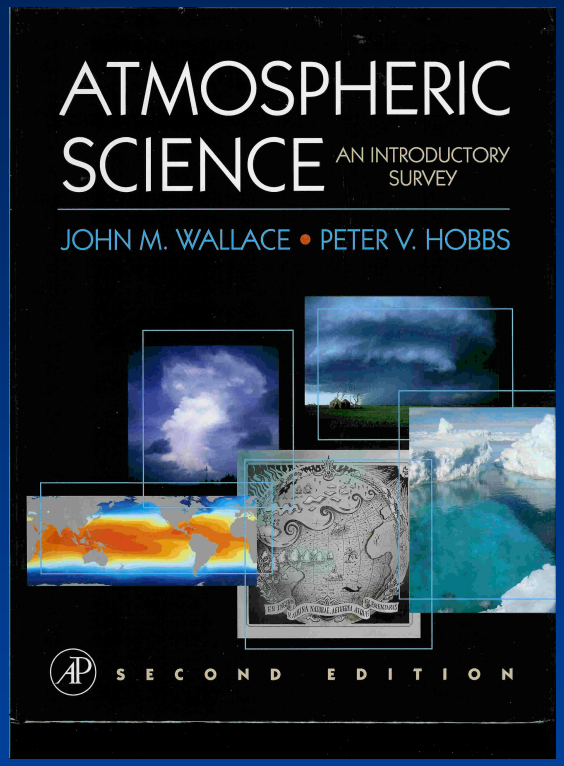
Lecture Section (3 credits): There will be approximately one lecture topic covered per week. These lectures will include class discussion of topical issues.

Selections from the Textbook of Wallace and Hobbs, and its order of presentation, will provide the basic framework of the course and most of the qualitative discussions, while the John Frederick text will provide supplemental quantitative material.

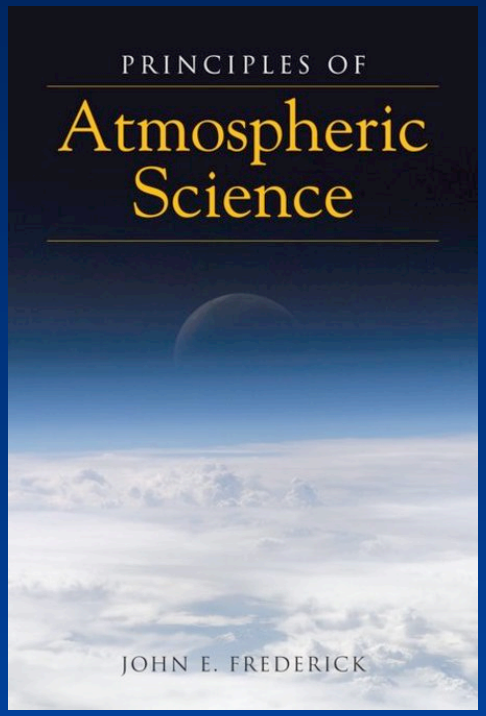
Laboratory Section (1 credit): The Laboratory Section will provide insight into atmospheric processes via web-based simulations that can be manipulated by the student. The Laboratory simulations are chosen to parallel the lecture topics and discussions.

There are no stupid questions!!

Texts:



- Atmospheric Science: An Introductory Survey (Required)
  John M. Wallace & Peter V. Hobbs, (WH)
  Academic Press, Elsevier, 2006
  ISBN 13:978-0-12-732951-2



- Principles of Atmospheric Science (Recommended)
  John E. Frederick
  Jones and Bartlett (2008)
  ISBN 0763740896

CLIM-111/PHYS-111
Introduction to the Fundamentals of Atmospheric Science

Tentative Grading Policy:

- ***Homework: 20%**
- **Two in-semester exams: 40%**
- **Final exam (comprehensive): 30%**
- **Participation: 10%**

**Homework mainly from end-of-chapter questions.*

You are responsible for all material from the texts, and any additional assigned readings.

CLIM-111/PHYS-111

Introduction to the Fundamentals of Atmospheric Science

Tentative Exam Dates:

Two in-semester exams:

Exam 1 – Thursday, February 25

Exam 2 – Thursday, April 22

Final Exam:

Thursday, May 6; 1:30-4:15 pm

Wallace & Hobbs: Tentative Reading Schedule

Lecture numbers correspond to chapters in W&H:

(1) Introduction to the Atmosphere (Summers)
(2) State and Evolution of the Atmosphere (S)
(3) Atmospheric Thermodynamics (S)
(4) Atmospheric Radiation (S)
(5) Atmospheric Chemistry (S)
(6) Clouds and Precipitation (S)
(7) Atmospheric Motions (Boybeyi)

Spring Break

(8) Weather Systems (B)
(9) The Planetary Boundary Layer (B)
(10) The Earth's Climate System (B)
(11) Human Influences on the Atmosphere (B)
(12) Atmospheric Modeling (B)

Frederick - Tentative Reading Schedule

Chapter 1: Chemical Composition and Structure

Parallel reading with WH chapter 1

Chapter 2: Solar and Terrestrial Radiation: Atmospheric Energy Balance

Parallel reading with WH chapters 2 and 3

Chapter 3: Atmospheric Water

Parallel reading with WH chapters 3 and 6

Chapter 4: Winds – The Global Circulation and Weather Systems

Parallel reading with WH chapters 7, 8, and 9

Chapter 5: Chemical Processes and Atmospheric Ozone

Parallel reading with WH chapter 5

Chapter 6: The Earth's Climate

Parallel reading with WH chapter 10, 11, and 12

1. Introduction to the Atmosphere (Summers)

What is atmospheric science?

Survey of the Earth's atmosphere: composition, vertical structure, winds, precipitation, etc;

Brief History of the Earth and its atmosphere

Why study the atmosphere?

Science and societal issues – the changing atmosphere

Survey of other planets' atmospheres, similarities and differences

How the study of other atmospheres helps us understand the Earth.

Reading: WH Ch. 1 & F Ch. 1

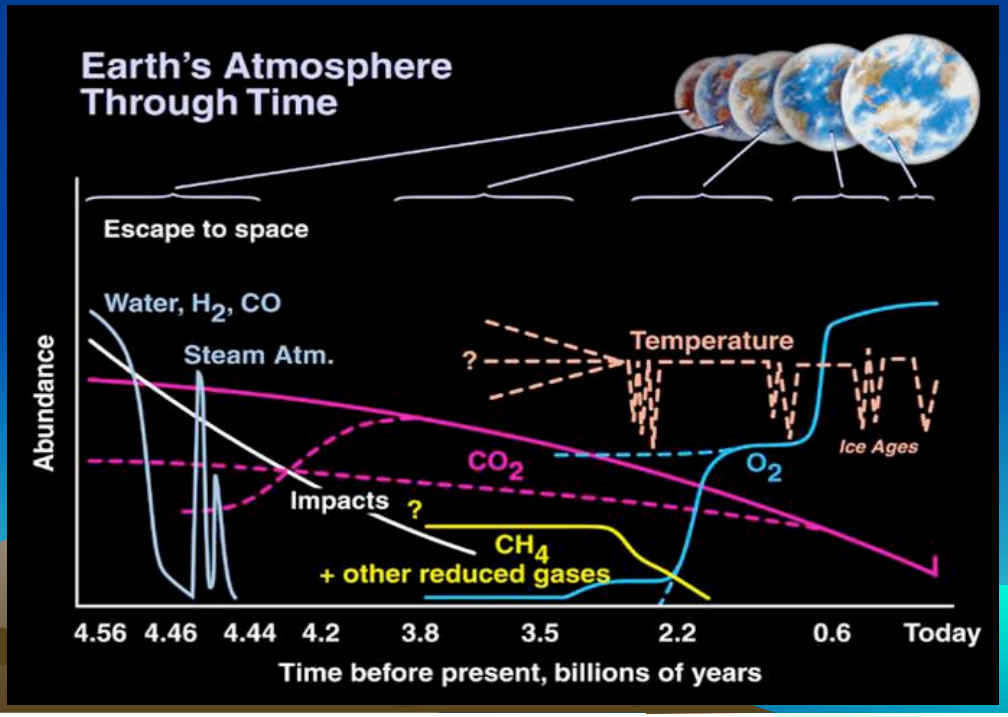
Laboratory Simulation: UI Hands-on Meteorology - Weather Map Contour

2. State and Evolution of the Atmosphere (Summers)

- The Earth system: oceans, cryosphere, biosphere, surface
- The hydrological system
- The oxygen and carbon cycles
- Overview of the formation and evolution of the Earth's atmosphere
- Equilibrium temperature of the Earth: influence of the atmosphere

Reading: WH Ch. 2 & F Ch. 1

Laboratory Simulation: UI Hands-on Meteorology - Evaporation

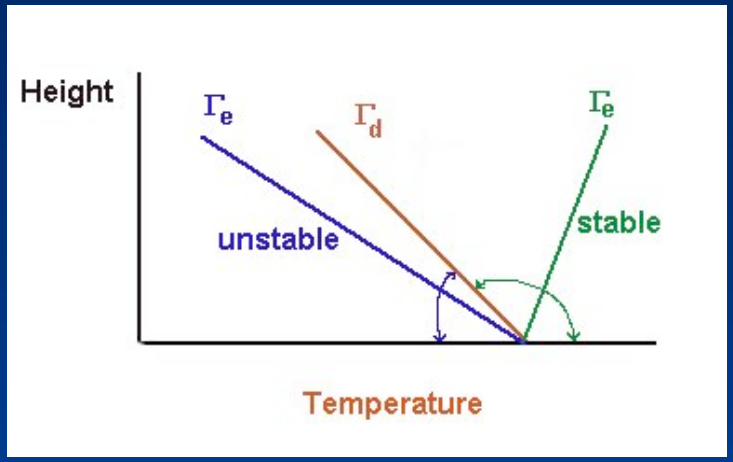


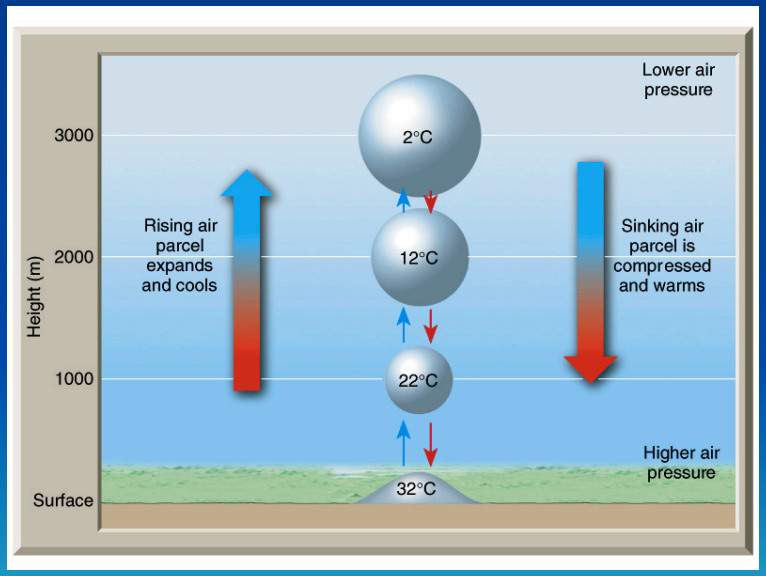
3. Atmospheric Thermodynamics and Stability (Summers)

- Temperature and Gas laws
- Hydrostatic equation
- First Law of thermodynamics, heat capacities, energy transport
- Adiabatic processes
- Influence of water vapor in the atmosphere
- Humidity, saturation vapor pressure, relative humidity, dew point;
- Static stability
- Second law of thermodynamics

Reading: WH Ch. 3 & F Chs. 1&3

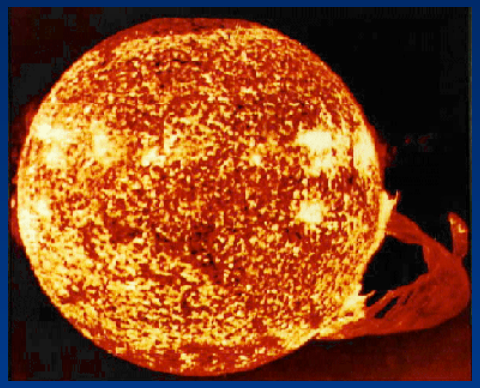
Laboratory Simulation: UI Hands-on Meteorology - Temperature

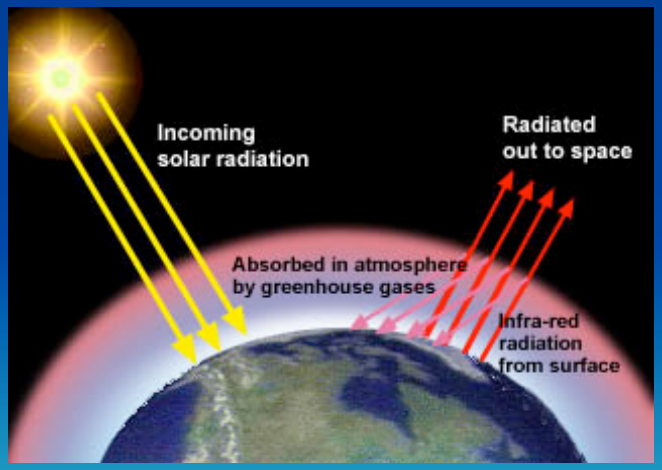




4. Atmospheric Radiation; Solar & Terrestrial (Summers)

- Solar and terrestrial radiation
- Scattering and absorption
- Transfer of radiation in a planetary atmosphere
- The greenhouse effect
- The greenhouse effect on other planets





Reading: WH Ch. 4 & F Ch. 2

Laboratory simulation: UI Hands-on Meteorology – Controls of Temperature

5. Atmospheric Chemistry (Summers)

Controls: sources, transport, and sinks

Photochemistry

Biological effects on composition

C, N, O cycles; Aerosols

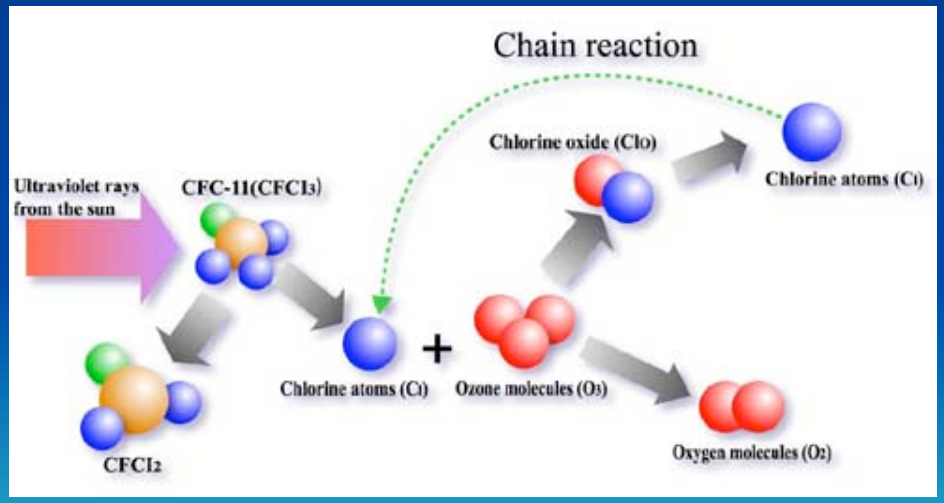
Tropospheric and Stratospheric chemistry

Anthropogenic effects

Atmospheric chemistry on other planets

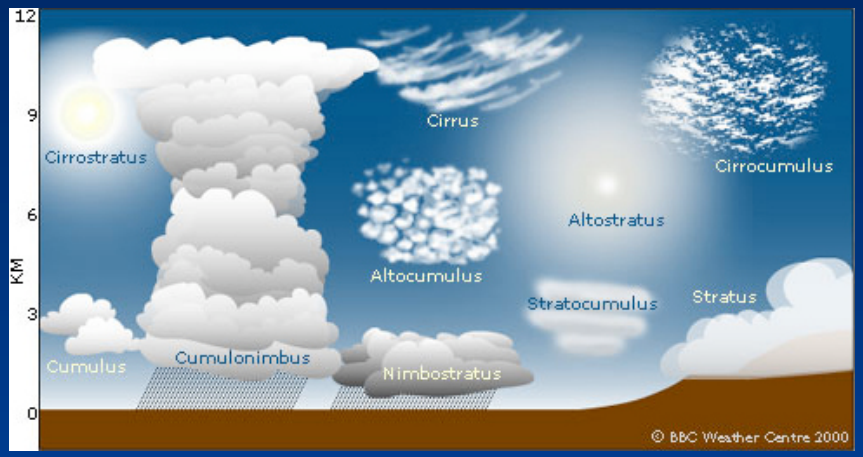
Reading: WH Ch. 5 & F Ch. 5

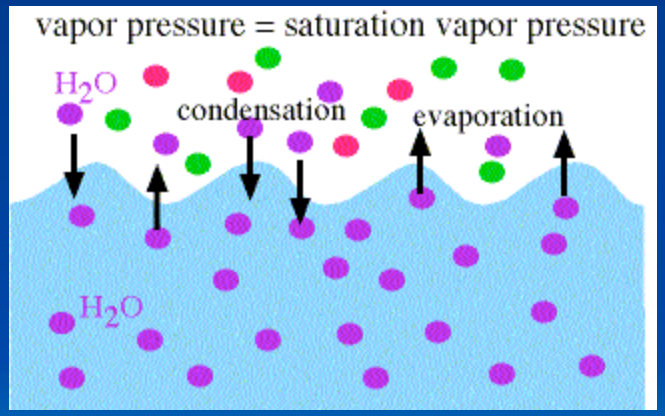
Laboratory simulation: UI Hands-on Meteorology TBD



6. Clouds and Precipitation (Summers)

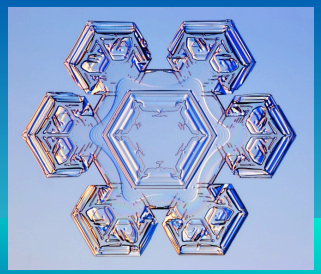
- Cloud taxonomy and Microphysics
- Nucleation and condensation
- Cloud formation conditions
- Influence of Clouds on the state of the atmosphere
- Forms of precipitation
- Weather modification
- Clouds on other planets: Venus, Mars, Jupiter's storms
- Clouds and chemical effects





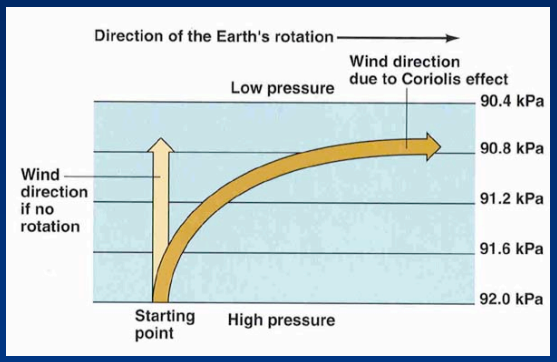
Reading: WH Ch. 6 & F Ch. 3

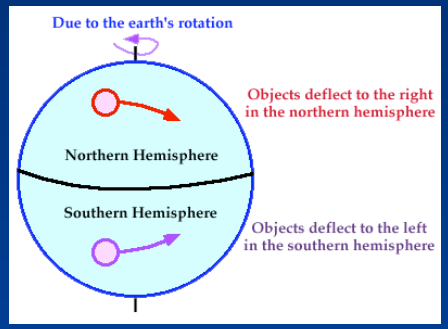
Laboratory Simulation: **UI Hands-on Meteorology – Mountains & Condensation Simulations**

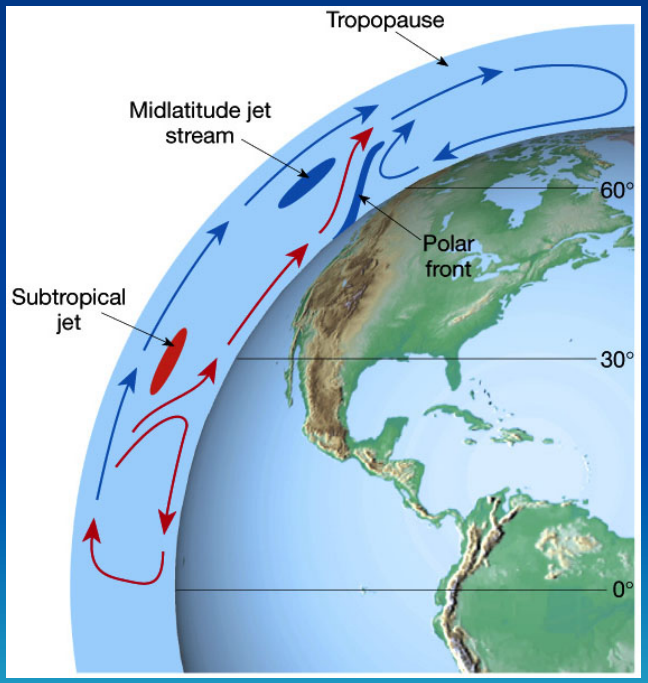


7.Atmospheric Motions (Boybeyi)

- Large scale flow kinematics
- Horizontal flow and the gradient wind
- Real vs. apparent forces
- Geostrophic wind
- Friction
- Equations of motion
- General circulation

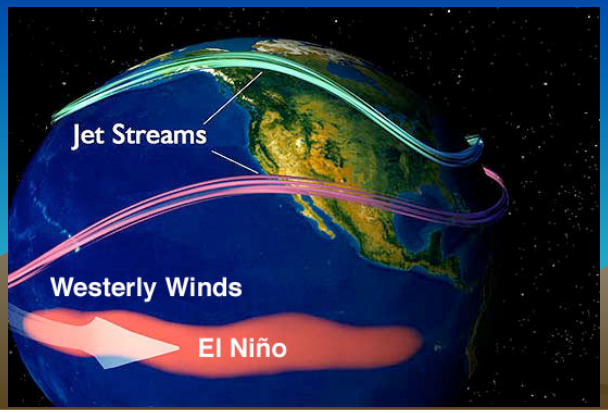






Reading: WH Ch. 7 & F Ch. 4

Laboratory Simulation: UI Hands-on Meteorology – Coriolis & Cyclone

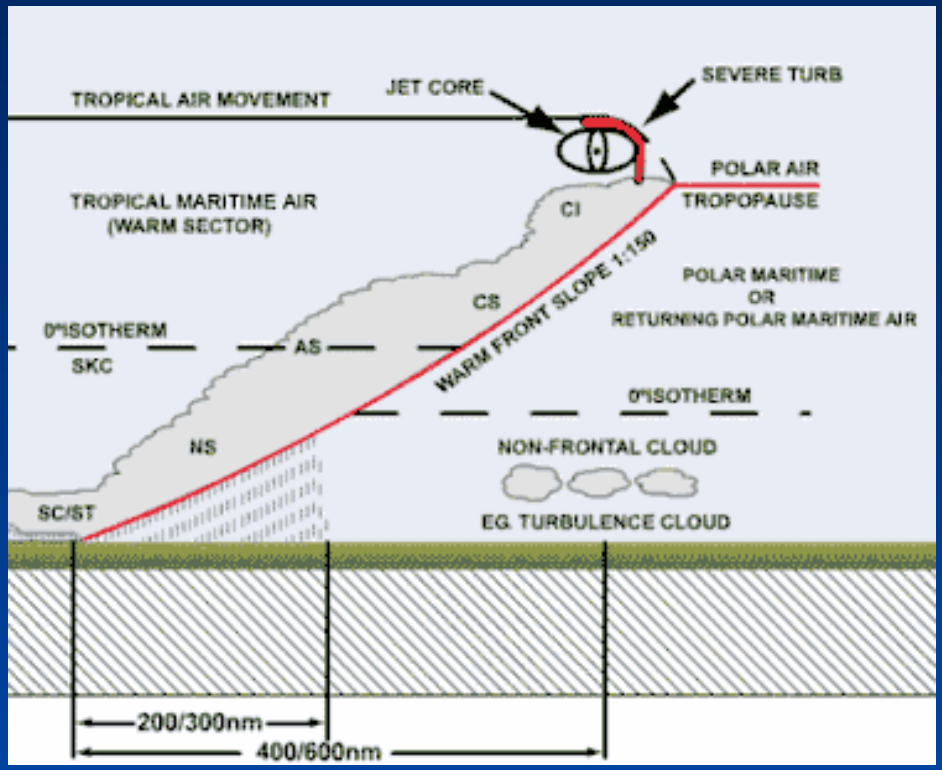


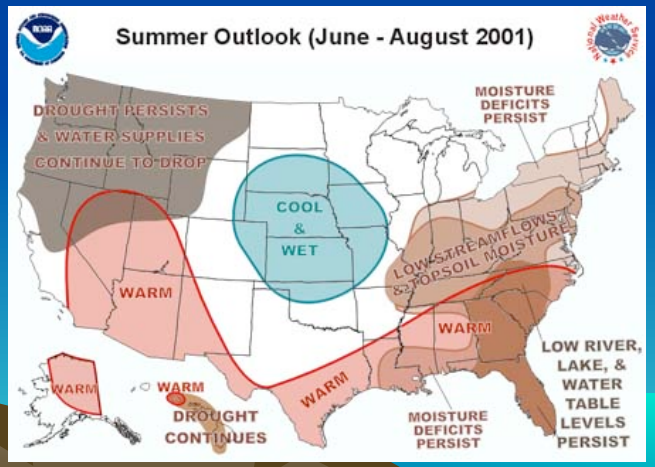
8. Weather Systems (Boybeyi)

Extratropical cyclones
Orographic effects
Deep convection
Tropical cyclones
Weather patterns
Weather analysis and forecasting
The role of weather satellites
Storms, tornados, and hurricanes

Reading: WH Ch. 8 & F Ch. 4

Laboratory Simulation: UI Hands-on Meteorology – Jet Stream & Fronts & Hurricane Tracker



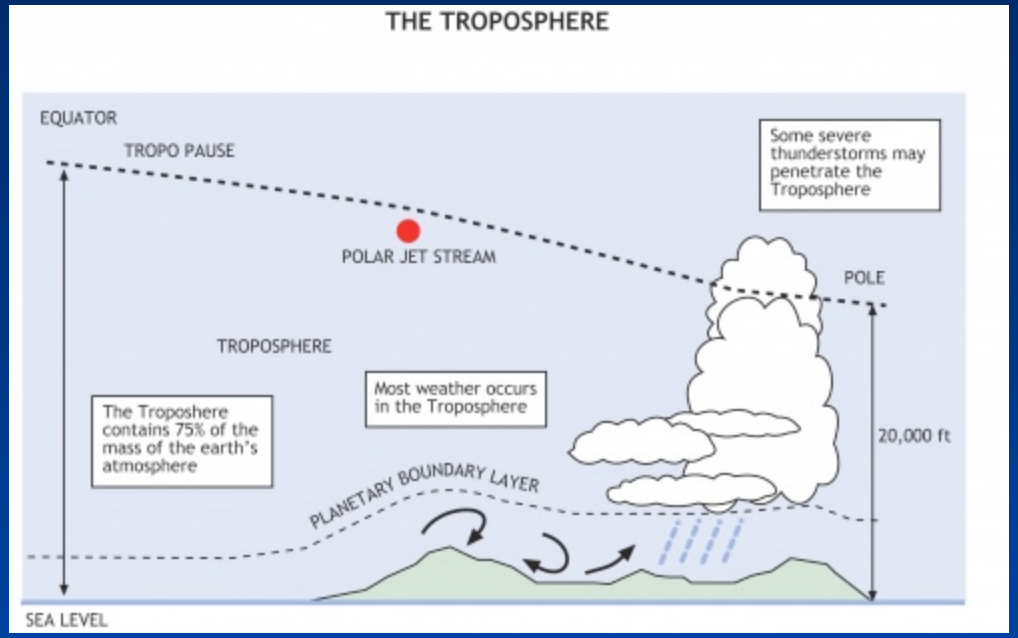


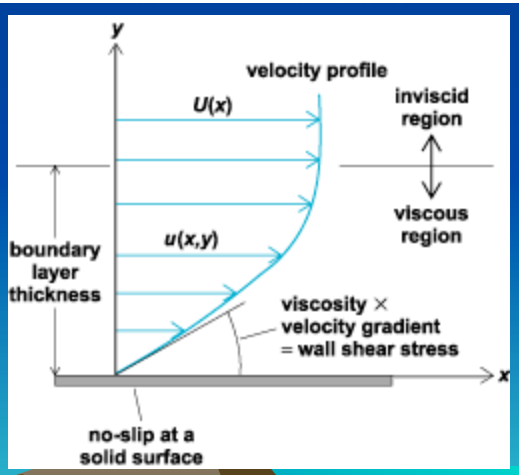
9. The Planetary Boundary Layer (Boybeyi)

- Turbulence; Vertical structure of the PBL
- Surface energy budget
- Evolution of the PBL
- Interaction between the PBL and the general circulation

Reading: WH Ch. 9 & F Ch. 4

Laboratory Simulation: UI Hands-on Meteorology – Ekman & Thunderstorm





10. The Earth's Climate (Boybeyi)

The present-day climate

The historical record; Ice ages

Climate variability

The role of the greenhouse effect

Climate equilibria and sensitivity

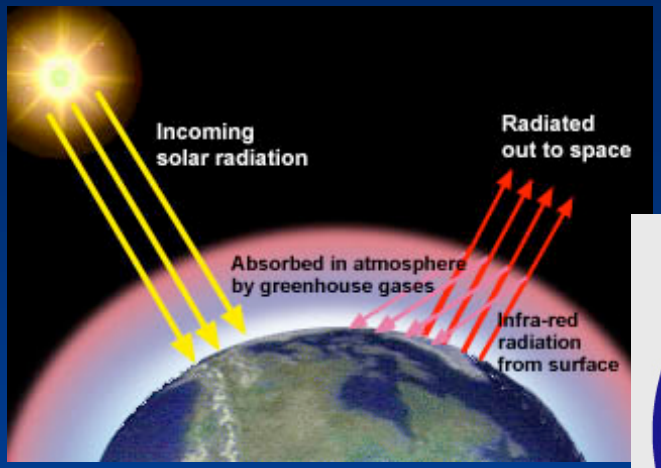
Climate feedbacks

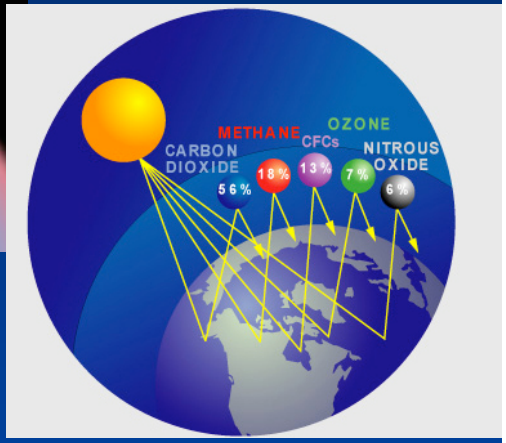
The carbon cycle

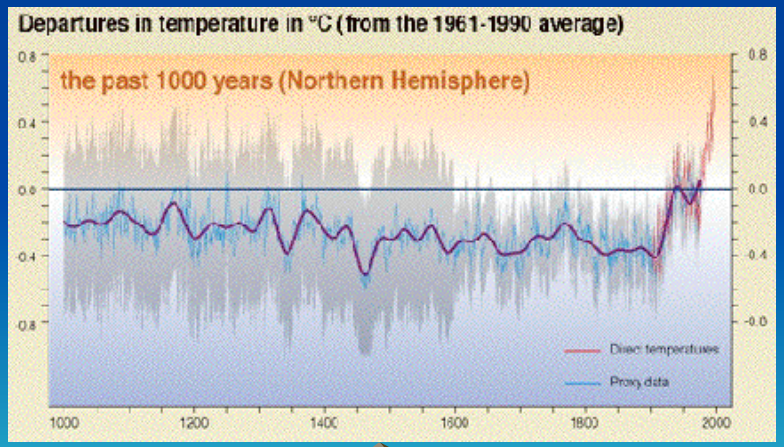
Solar variability

Volcanic and other episodic events

Detection and measurements of climate change.







Reading: WH Ch. 10 & F Ch. 6

Laboratory Simulation: UI Hands-on Meteorology – Growing Seasons

11. Human Influences on the Atmosphere (Boybeyi)

Greenhouse gases: sources and sinks

Buildup of greenhouse gases

Projections of human-induced warming

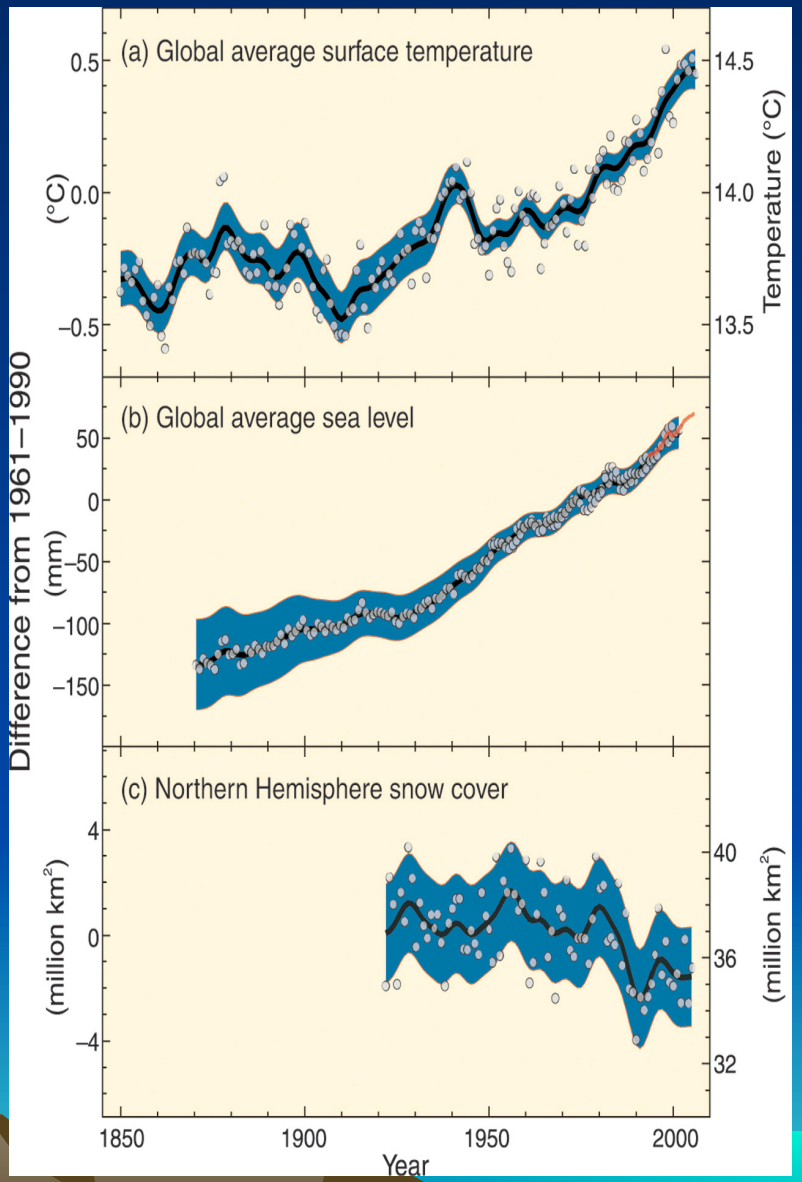
Other types of air pollution, trends, acid rain

Consequences of climate change

The far future: runaway greenhouse effect – The lesson from Venus.

Reading: WH Ch. 10 & F B Ch. 6

Laboratory Simulation: UI Hands-on Meteorology – Pollution



12. Numerical Modeling (Boybeyi)

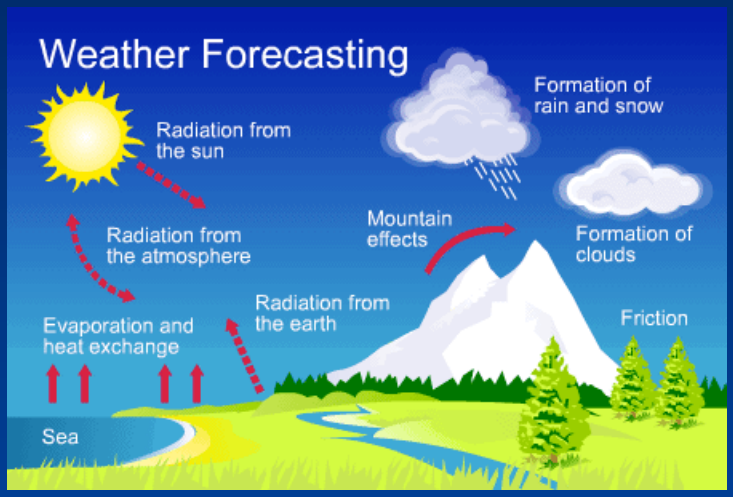
Fundamentals of atmospheric modeling

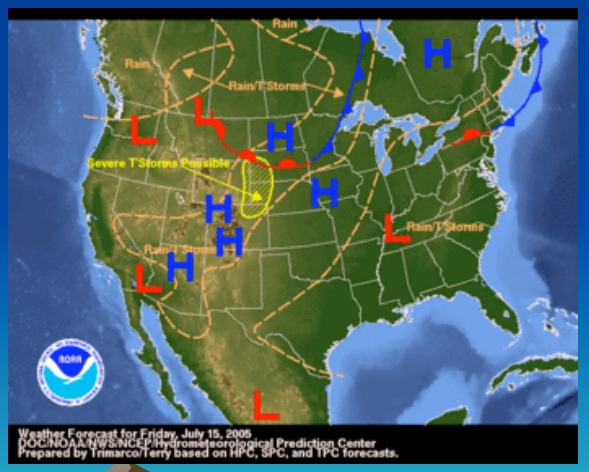
Evaluation of models results

Predictability of models

Reading: Material will be provided

Laboratory Simulation: Results from Numerical Weather Predictions (NWP) will be presented and studied.





Suggested Readings

Basic and Introductory:

Clouds in a Glass of Beer: Simple Experiments in Atmospheric Physics, Craig F. Bohren, Dover Publications, 2001.

What Light Through Yonder Window Breaks: More Experiments in Atmospheric Physics, Craig F. Bohren, Dover Publications, 2006.

The Atmosphere: An Introduction to Meteorology, Frederick K. Lutgens, Edward J. Tarbuck, and Dennis Tasa, Prentice-Hall, 2006.

More Advanced:

An Introduction to Atmospheric Physics, David G. Andrews, Cambridge University Press, 2000.

An Introduction to Dynamic Meteorology, J.R. Holton, 4th Edition, International Geophysics Series, 2004.

Basic Physical Chemistry for the Atmospheric Sciences, Cambridge University Press, 2000.

Useful Websites:

American Meteorological Society:
http://www.ametsoc.org/

National Aeronautics and Space Administration:
http://www.nasa.gov

National Oceanic and Atmospheric Administration:
http://www.noaa.gov/

The Weather Channel:
http://www.weather.com/

The NASA Astrobiology Institute:
http://nai.nasa.gov/

GMU Honor Code

Honor Code *To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University community and with the desire for greater academic and personal achievement, we, the student members of the University Community have set forth this* **Honor Code**

Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work.

http://www.gmu.edu/departments/unilife/pages/honorcode.html

Important Dates:

February 2 – Enrollment Deadline. This is the last day to add into a course. Students may not register into any section after this date. No exceptions. This is also the last day to drop a course without losing tuition money.

February 9 – Drop Deadline. This is the last day a student may drop a course. Students will receive a 33% tuition refund. After this date, students may withdraw from a course, but only according to strict guidelines.

Students with Disabilities

If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Resources at 703/993-2474.

All academic accommodations must be arranged through that office.

Office Hours – Spring, 2010

Prof. Michael E. Summers
Office Hours
Tuesday: 3:00-5:00pm
Additional hours by appointment

Spring 2010: Tentative Travel
January 20-21
February 18-19

Prof. Zafer Boybeyi
Office Hours
Wednesday:
Additional hours by appointment

Spring 2010: Tentative Travel

Homework Assignment #1:

- Read Wallace & Hobbs, Chapter 1
  Chapter 1 Exercises: 1.6 (a through k)

Read Handout:
D. Bodanis article "It's in the air…"

Earth – The Water Planet

Is there anything in this picture that in not influenced by water?

Is there anything in this picture not influenced by life?

Is there anything in this picture not influenced by the atmosphere?