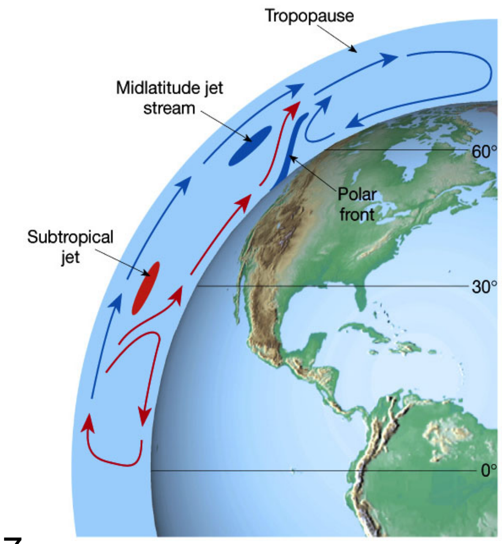
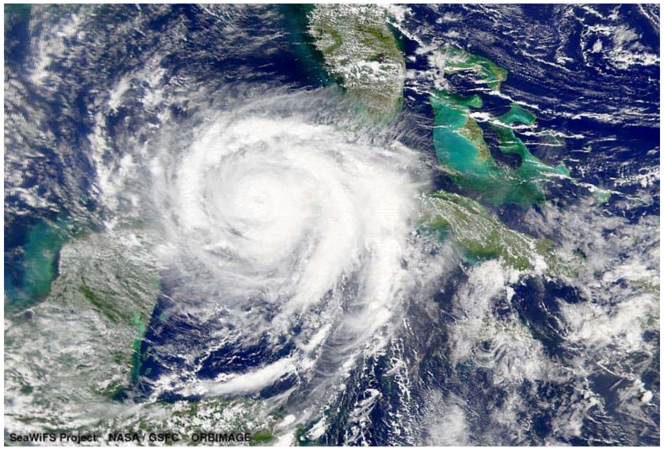
# CLIM-715
# Numerical Methods for Climate Modeling

# (Syllabus)



# Instructor and Contact Information

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Course Website: http://camp.cos.gmu.edu/CLIM-715.html

Tentative Travel: N/A

# Goal

- Goals
  - Understanding of numerical methods for the solution of PDEs as are used in weather/climate/ocean models
  - Understanding of modern weather/climate models
  - Experience with using modern weather/climate models

# Text

- Required Text
  - A First Course in Atmospheric Numerical Modeling

    Alex J. DeCaria & Glenn E. Van Knowe

    ISBN 978-0-9729033-4-9
  - Class notes

- You are responsible for all material from the required text, and any additional assigned readings

# Text

- Additional Text
  - Numerical Prediction & Dynamic Meteorology (George J. Haltiner & Roger T. Williams)
  - Numerical Methods for wave Equations in Geophysical Fluid Dynamics (Dale R. Duran)
  - Mesoscale Meteorological Modeling (Roger A. Pielke)

# Useful Outline Notes

- ECMWF Training Manuals

http://www.ecmwf.int/newsevents/training/rcourse_notes/index.html

- Documentation of ECMWF Forecast Model

http://www.ecmwf.int/research/ifsdocs/

- Documentation of NCAR Climate Models (CAM 3.0)

http://www.ccsm.ucar.edu/models/atm-cam/docs/description/

# Course Outline

- Weekly lectures
- Problem sets (homeworks)
- Final project - with bi-weekly status sections
- Midterm exam
- Final exam

# Weekly Lectures
## (General Topics)

- Introduction,
- Basic Tools,
- Model Equations, Simplifying Assumptions & Waves,
- Finite Difference Methods,
- Dynamical Frameworks,
- Nonlinear Computational Instability,
- Spectral Methods,
- Finite Volume Methods,
- Flux Corrected/Limited Methods,
- Sub-grid Scale Processes,
- ICs & BCs,
- Model Uncertainty & Evaluation Methods

# Final Project
## (Modeling as Experimental Science)

- Identify a question of interest
- Question whether the problem is testable
- Formulate your hypothesis and identify your prediction
- Choose a model that is suitable to conduct your experiment
- Run your experiment
- Analyze & present the results

# Some Global Scale Examples
## (Climate Modeling)

- Why is there an Aleutian Low? Is it caused by the continents, land-sea contrast, or surface heat flux?
- Why are there deserts? Why is the Sahara a large desert but China is not, even though they are located at the same latitude?
- What aspects of the land-sea contrast are important for monsoon climates?
- Can the variability of midlatitude SSTs be reproduced by a AGCM coupled to a mixed layer?

# Some Mesoscale Examples
## (Weather Modeling)

- What aspects of terrain inhomogeneities are important for convection and convective cloud systems?
- What aspects of land/water discontinuities are important for sea- and land-breeze circulations?
- What aspects of atmospheric variables are important for tropical cyclone intensity and track?

# Project
## (Modeling as Experimental Science)

- If you change something in the model, what happens?
- You can perform numerical sensitivity runs to find your answer!

# Project & Exam Timeline

- Jan 23 –
- Jan 30 - Problem chosen
- Feb 6 –
- Feb 13 - Present hypothesis
- Feb 20 -
- Feb 27 – Obtain, get access, and describe model that you choose
- March 6 – (Midterm exam)
- March 13 – (Spring Break)
- March 20 – Preliminary demonstration runs
- March 27 -
- Apr 3 - Configure your final runs
- Apr 10 - Runs complete
- Apr 17 - (Thanksgiving recess, no class this week)
- Apr 24 -
- May 1 – Present results (Dec 12 – last day of classes)
- May 10 - (Final Exam, 1:30 pm – 4:10 pm)

# Requirements & Suggestions

- Knowledge of primitive equations
- Knowledge of concepts such as hydrostatic vs. nonhydrostatic, vorticity, conservation…
- Programming in Fortran, C or C++ (Fortran 95 preferred)
- GrADS, Matlab, or IDL for plotting, analysis

# Tentative Grading Policy

- Homework: 20%
- Final Project 20%
- Midterm exam: 20%
- Final exam (comprehensive & possibly take home exam): 40%

# GMU Honor Code

✓ GMU is an Honor Code university; The principle of academic integrity is taken very seriously and violations are treated gravely.

**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://catalog.gmu.edu/content.php?catoid=5&navoid=410#Honor

# Academic Integrity

- ✓ What does academic integrity mean in this class?
  - ✓ Essentially when you are responsible for a task, you will perform that task.
  - ✓ When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form.
  - ✓ Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions.
  - ✓ When in doubt (of any kind) please ask for guidance and clarification.

# Important Dates

- ✓ January 30 – 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 13 – Drop Deadline: This is the last day a student may drop a course. Students will receive a 67% tuition refund. After this date, students may withdraw from a course, but only according to strict guidelines.

- ✓ February 24– 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.