NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

Course Syllabus

Course Information

Course Number/Section	AST 853
Course Title	Numerical Weather Prediction (NWP)
Term	Fall 2018
Days & Times	TR 11:00 – 12:15 AM, 302 Gibbs Hall

Professor Contact Information

Professor	Dr. Yuh-Lang Lin
Office Phone	(336) 285-2127
Email Address	ylin@ncat.edu
Office Location	302H Gibbs Hall
Office Hours	TR 4:00-6:00 or by appointment
Teaching Assistant	William Agyakwah
Other Information	MesoLab website: http://mesolab.org

Course Pre-requisites, Co-requisites, and/or Other Restrictions

(1) Dynamic Meteorology/Atmospheric Dynamics or equivalent
(2) FORTRAN/C++ programming and Linux/UNIX experiences

Course Description

This course surveys the numerical methods for solving the governing equations of mesoscale stratified fluid flow. Focus will be on finite difference approximations with explicit, implicit, and semi-Lagrangian methods. These methods will then be applied to solving geophysical fluid systems with focus on the Earth's atmosphere. In doing so, grid systems, vertical coordinates, boundary conditions, nonlinear aliasing and instability, and predictability will be discussed. In order to apply the above methods to atmosphere, the parameterizations of physical processes, such as planetary boundary layer, cumulus convection, cloud microphysical processes, and radiative transfer will be discussed. Finally, operational NWP models will be introduced. In addition to the regular lectures and homework, a set of hands-on projects is designed to help students develop from an advection model, to one- and two-dimensional shallow water models, and then finally to an atmospheric numerical model.

Student Learning Objectives/Outcomes

1. **Objective**: Understand the governing equations of shallow water and atmosphere systems, basic numerical approximations of these equations, and related instability problems.
   Outcome: Students will demonstrate the ability to answer conceptual questions as well as apply the approximation techniques to problems on examinations.
2. **Objective**: Effectively relate basic ideas and concepts to more sophisticated numerical weather prediction models.

Outcome: Students will demonstrate the ability to employ critical thinking in answering short questions as well as solving problems on examinations.

3. **Objective** Apply numerical modeling skills learned from the class to real fluid systems
   Outcome: Student will develop the advection model to shallow water models, and an atmospheric model.

Required Textbooks and Materials

Required Texts

No textbooks are required.

Lecture notes will be mainly based on Y.-L. Lin, 2007: Mesoscale Dynamics, Cambridge University Press, and will be posted on MesoLab website: http://mesolab.ncat.edu (No requirement for purchasing the book.)

Required Materials

None

Suggested Course Materials

Required Textbook

Mesoscale Dynamics (Ch. 1-3 and 12-14), Y.-L. Lin, Cambridge Univ. Press, 2007 [Ch.1: Overview; Ch.2: Governing equations for mesoscale motions; Ch.3: Basic wave Dynamics; Ch. 12: Basic numerical methods; Ch. 13: Numerical modeling of geophysical fluid systems; Ch. 14: Parameterization of physical processes.]

Suggested Readings

(1) UCAR COMET Distance Learning Course:
   (i) Numerical Weather Prediction (Modeling)
   http://www.meted.ucar.edu/topics_nwp.php
   (ii) Understanding NWP Models and Their Processes
   http://www.meted.ucar.edu/nwp/course/modules.php

(3) Mesoscale Meteorological Modeling
   R. A. Pielke, Academic Press, 2nd Ed., 2002.

(4) Atmospheric Modeling, Data Assimilation and Predictability, E. Kalnay, 2003, Cambridge Press.

(5) Numerical Prediction and Dynamic Meteorology
   G. J. Haltiner and R. T. Williams, 1980, Wiley.

(6) Numerical Methods for Wave Equations in Geophysical Fluid Dynamics, D. R. Durran 1999, Springer.

Suggested Materials

None

Grading Policy

(1) Exams	40%
(2) Modeling projects	60%

Assignments & Academic Calendar (Subjected to change)

Topics, Reading Assignments, Due Dates, Exam Dates (optional: withdrawal dates, holidays, etc.)

Date	Lecture #	Lecture Title	Remarks
8/16	1	Introduction to the course and modeling projects (FORTRAN programs and the advection model)	Lecture notes will be provided
8/21	2	Introduction to NWP	Sec. 1.1 – 1.3
8/23	3	Historical review of NWP	Sec. 1.4 – 1.6
8/28	4	Governing equations for atmospheric motions	Sec. 2.1 – 2.3
8/30	5	Approx. to the governing equations	Sec. 2.3
9/4	6	Shallow water equations	Sec. 2.4
9/6	7	Intro. to numerical methods	Sec. 3.1
9/11	8	Finite difference approx. of derivatives	Sec. 3.2
9/13	9	Finite difference approx. of advec. equation	Sec. 3.3.1
9/18	10	Numerical stability and forward-in-time & centered-in-space scheme	Sec. 3.3.2
9/20	11	Forward in time & upstream in space scheme and numerical dispersion	Sec. 3.3.3
9/25	12	Numerical damping, Lax-Wendroff scheme, and WKL Scheme	Sec. 3.3.4 – 3.3.6
9/27	13	Multi-stage schemes	Sec. 3.3.7
10/2	14	Implicit schemes	Sec. 3.4
10/4		Midterm	
10/8-9		Fall Break	
10/11	15	Semi-Lagrangian methods	Sec. 3.4
10/16	16	Grid systems	Sec. 4.4.1
10/18	17	Vertical coordinates	Sec. 4.1.2
10/23	18	Boundary conditions	Sec. 4.2
10/25	19	Initial conditions and initialization	Sec. 4.3.1
10/30	20	Data assimilation	Sec. 4.3.2
11/1	21	Nonlinear aliasing and nonlinear instability	Sec. 4.4.1
11/6	22	Numerical smoothing	Sec. 4.4.2
11/8	23	Modeling of a stratified fluid flow system	Sec. 4.5
11/13	24	Predictability and ensemble forecasting	Sec. 4.6
11/15	25	Reynolds averaging	Sec. 5.1
11/20	26	Parameterization of PBL	Sec. 5.2
11/21-23		Thanksgiving Holiday (W-F)	
11/27	27	Parameterizations of cumulus convection, cloud microphysics	Sec. 5.3.1, 5.3.2 & 5.4
11/29	28	Intro. to operational NWP models (Ch. 6)	Sec. 5.3.2 & 5.4
12/4-8		Final Exam	

Course Policies

Make-up exams

Make-up for midterm must be done prior to the final examination.

Extra Credit

No Extra Credit

Late Work

Late submission of homework and model projects must be within a reasonable period of time permitted by the instructor.

Special Assignments

Not applicable

Academic Integrity

Enrollment in the class means that you agree to abide by the expectations of North Carolina A&T State University about academic integrity. For specific information refer to your Student Handbook. Also, refer to the most current Undergraduate Bulletin for the academic dishonesty policy. The North Carolina A&T State University's Academic Honor Code will be enforced.

Your responsibilities in the area of honor include, but are not limited to, avoidance of cheating, plagiarism and improper or illegal use of technology. Your presentations, assignments, and quizzes are expected to be your own work. Any questions about these should be directed to the professor. It is permissible to request assistance from a librarian when doing database research as long as the selection and organization of the research for the presentation is in your own work.

Class Attendance

The College of Arts and Sciences requires students to be on time for class and to attend class on a regular basis. If the student has unexcused absences, is late for class or leaves class early, the student's grade may be lowered.
(See attendance policy set forth by the instructor in the course syllabus.)

Excused absences will comply with the following university policy on make up work:
"Sickness (verification needed); death of relative (immediate family); participation in an approved university related activity; acting in the capacity of a university representative (band, choir, sports, related travel, etc.); extraordinary circumstances including court appearances, family emergency~ at the discretion of the professor, etc. require a signed statement.
NOTE: "Other reasons for class absences are not acceptable."

Classroom Citizenship

Normal classroom decorum is expected.

Technical Support

If you experience any problems with your A&T account you may call Aggie Tech Support (formerly Help Desk) at 336.334.7195.

Field Trip Policies / Off-Campus Instruction and Course Activities

Not applicable

Student Affairs website http://www.ncat.edu/~staffair/;
Student Handbook: ***http://www.ncat.edu/~deanofst/Handbook.htm***;
Student Travel Procedures and Student Travel Activity Waiver
http://businessfinance.ncat.edu/policies%20and%20procedures%20index.htm

> *Off-campus, out-of-state, and foreign instruction and activities are subject to state law and University policies and procedures regarding travel and risk-related activities. Information regarding these rules and regulations may be found at the website address:* Student Travel Procedures and Student Travel Activity Waiver http://businessfinance.ncat.edu/policies%20and%20procedures%20index.htm.
> *Additional information is available from the office of Student Affairs, please check the website at http://www.ncat.edu/~staffair/.*
> *Below is a description of any travel and/or risk-related activity associated with this course.*

Other Policies (e.g., copyright guidelines, confidentiality, etc.)
Student Handbook: ***http://www.ncat.edu/~deanofst/Handbook.htm***

Family Educational Rights and Privacy Act
http://www.ncat.edu/~registra/ferpa_info/index.htm

Student Conduct & Discipline
North Carolina A&T State University has rules and regulations that govern student conduct and discipline meant to ensure the orderly and efficient conduct of the educational enterprise. It is the responsibility of each student to be knowledgeable about these rules and regulations. Please consult the undergraduate *http://www.ncat.edu/~acdaffrs/Bulletin_2008-2010/2008-2010_Undergraduate_Bulletin.pdf* and graduate bulletins: 2008-2010 Graduate Catalog.doc http://www.ncat.edu/~gradsch/cstudents.html and student handbook http://www.ncat.edu/~deanofst/Handbook.htm for detailed information about specific policies such as academic dishonesty, cell phones, change of grade, disability services, disruptive behavior, general class attendance, grade appeal, incomplete grades, make up work, student grievance procedures, withdrawal, etc.

These descriptions and timelines are subject to change at the discretion of the Professor.

01.27.09 – Submitted to Faculty Senate by LEW