NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

Spring 24 Course Syllabus

COURSE SYLLABUS

College Name: College of Science & Technology

Department Name: Applied Science & Technology (AST) PhD Program

---

Course Information

Course Name: Numerical Weather Prediction

Course Number/Section: AST 853 | Credit Hours: 3

Days and Times: 2:00 – 3:15 TR | Class Location: Gibbs 302

Instructor Contact Information

Instructor: Dr. Yuh-Lang Lin

Office Location: 302H Gibbs Hall | Email Address: ylin@ncat.edu | Office Phone: 336-285-2127

Communication

Students will receive an answer to all communications by email within 48 hours excluding holidays. The secondary point of contact will be Jackson Wiles. See below for his email address.

Teaching Assistant: Jackson Wiles <jtwiles@aggies.ncat.edu>

Student Hours

11:00 -12:00 TR. For a longer discussion, email to make an appointment.

Monday ☐ Tuesday ☒ Wednesday ☐ Thursday ☒ Friday ☐

Course Prerequisites

(1) Dynamic Meteorology 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. The 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 (SLO)

Objective: Use analytical thinking skills to evaluate information critically

Outcome: Students will demonstrate the ability to answer conceptual questions on examination questions.
Objective: Effectively relate basic ideas and concepts to more sophisticated atmospheric systems.
Outcome: Students will demonstrate the ability to employ critical thinking in answering short questions as well as solving problems on examinations.
Objective: Use a wide range of disparate information and knowledge to draw references and summarize various concepts, theories, and observational evidence in the literature.
Outcome: Students will demonstrate the ability to absorb various concepts, theories and observations in assigned references and summarize and present them to the class.

Required Textbooks and Materials

Required Texts:
Mesoscale Dynamics, by Yuh-Lang Lin, Cambridge University Press, 2007

Required Materials: Calculator when taking the Midterm and Final (no cell phone or pc calculators allowed)

Suggested Course Materials

Suggested Readings/Texts:
(1) Lecture Note (based on Lin 2007): Will be posted on the Mesolab website: http://mesolab.org
(2) 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: N/A

Grading Policy

Course Grade Scale

Grade	A	A-	B+	B	B-	C+	C	C-	F
Scores	94-100	90-93	87-89	83-86	80-82	77-79	73-76	70-73	0-69

Grading Allocation
Course grades are based on a weighted grading scale of 100%.
The breakdown for the course is as follows:
(1) Exams 40%
(2) Modeling projects 60%

Course Policies

Use Blackboard as The Learning Management System

Blackboard is the primary online instructional and course communications platform. Students can access the course syllabus, assignments, grades, and learner support resources. Lecture notes will be posted on the MesoLab website. Students are encouraged to protect their login credentials, complete a Blackboard orientation and log in daily to the course.

Make-Up Exams Any request for make-up should follow the University's policies and procedures. A penalty may be applied.

Extra Credit N/A

Late Work Penalty may be applied for late submission of assignments.

Special Assignments N/A

ASSIGNMENTS AND ACADEMIC CALENDAR

Include topics, reading assignments, due dates, exam dates, withdrawal dates, pre-registration and registration dates, all holidays and convocations.*

MONTH /DAY	Lecture Note #	SUBJECT	READING IN TEXT, ACTIVITY, HOMEWORK, EXAM
1/16	1	Introduction to the course and modeling projects (FORTRAN programs and the advection model)	Sec. 1.1-1.3
1/18	2	Introduction to NWP, Historical review of NWP	Sec. 1.4 – 1.6
1/23	3	Governing equations for atmospheric motions	Sec. 2.1 – 2.3
1/25	4	Approximation to the governing equations	Sec. 2.3
1/30	5	Shallow water equations	Sec. 2.4
2/1	6	Intro. to numerical methods	Sec. 3.1
2/6	7	Finite difference approx. of derivatives	Sec. 3.2
2/8	8	Finite difference approx. of advection equation	Sec. 3.3.1
2/13	9	Numerical stability and forward-in-time & centered-in-space scheme	Sec. 3.3.2 (2/13/24) Eq. (12.3.6)
2/15	10	Forward in time & upstream in space scheme and numerical dispersion	Sec. 3.3.3
2/20	11	Numerical damping, Lax-Wendroff scheme, and WKL Scheme	Sec. 3.3.4 – 3.3.6
2/22	12	Multi-stage schemes, Implicit schemes	Sec. 3.3.7, Sec. 3.4
2/27	13	Semi-Lagrangian methods	Sec. 3.5
2/29		Midterm	
3/4-3/8		Spring Break	
3/12	14	Grid systems	Sec. 4.4.1
3/14	15	Vertical coordinates	Sec. 4.1.2
3/19	16	Boundary conditions	Sec. 4.2
3/21	17	Initial conditions and initialization	Sec. 4.3.1
3/26	18	Data assimilation	Sec. 4.3.2
3/28	19	Nonlinear aliasing and nonlinear instability	Sec. 4.4.1
4/2	20	Numerical smoothing	Sec. 4.4.2
4/4	21	Modeling of a stratified fluid flow system	Sec. 4.5
4/8 (M)		Wellness Day	
4/9	22	Predictability and ensemble forecasting	Sec. 4.6
4/11	23	Reynolds averaging & Parameterization	Sec. 5.1-5.2
4/16	24	Parameterization of PBL	Sec. 5.3.1

MONTH /DAY	Lecture Note #	SUBJECT	READING IN TEXT, ACTIVITY, HOMEWORK, EXAM
4/18	25a	Parameterization of cumulus convection	Sec. 5.3.2
4/23	25b	Parameterization of cloud microphysics	
4/25	26	Parameterization of radiative processes	Sec. 5.4
4/30	27	Introduction to operational NWP models	Ch.6
5/2		Review	
5/6-5/9		Final Exam	

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

- Please refer to the Common Policies file for all other University policies, which should also be provided to all students or available in the course Blackboard shell.