North Carolina Agricultural and Technical State University

Spring 23 Course Syllabus

College of Science & Technology   Applied Sci&Tech Ph.D. Program

NOTE: Students are responsible for reading, understanding and following the syllabus.

COURSE INFORMATION

- Course Name: Numerical Weather Prediction
- Course Number/Section: AST 853-001   Credit Hours: 3
- Times and Days: 2:00 – 3:15 TR   Class Location: Gibbs 302

INSTRUCTOR CONTACT INFORMATION

- Instructor: Dr. Yuh-Lang Lin
- Office Location: 302H Gibbs Hall
- Office Phone: 336-285-2127
- Email Address: ylin@ncat.edu
- TA: Justin Riley jgriley@aggies.ncat.edu

- *Student's questions will be answered within 48 hours; if not, send an email reminder*

STUDENT HOURS

2:00 – 3:15 PM, TR or by 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. 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)

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:

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

REQUIRED MATERIALS: NA

SUGGESTED COURSE MATERIALS

SUGGESTED READINGS/TEXTS:

(1) Lecture Note (based on Lin 2007): Will be posted on the class blackboard or 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: NA

GRADING POLICY

Course Grading Scale (graduate level courses)

Grade	A	A-	B+	B	B-	C+	C	F
Scores	94-100	90-93	87-89	83-86	80-82	75-79	70-74	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

Lecture notes (based on Lin 2007) will be posted on the Mesolab website: http://mesolab.org or on the class Blackboard. Lectures will be conducted in zoom meetings.

MAKE-UP EXAMS: A penalty may be applied to make-up exams unless there is a special permission

EXTRA CREDIT: NA

LATE WORK: A penalty may be applied

SPECIAL ASSIGNMENTS: NA

Class Schedule [See here for a complete S23 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
1/10 (T)	1	Introduction to the course and modeling projects (FORTRAN programs and the advection model)	Sec. 1.1-1.3
1/12	2	Introduction to NWP, Historical review of NWP	Sec. 1.4 – 1.6
1/17	3	Governing equations for atmospheric motions	Sec. 2.1 – 2.3
1/19	4	Approximation to the governing equations	Sec. 2.3
1/24	5	Shallow water equations	Sec. 2.4
1/26	6	Intro. to numerical methods	Sec. 3.1
1/31	7	Finite difference approx. of derivatives	Sec. 3.2
2/2	8	Finite difference approx. of advection equation	Sec. 3.3.1
2/7	9	Numerical stability and forward-in-time & centered-in-space scheme	Sec. 3.3.2
2/9	10	Forward in time & upstream in space scheme and numerical dispersion	Sec. 3.3.3
2/14	11	Numerical damping, Lax-Wendroff scheme, and WKL Scheme	Sec. 3.3.4 – 3.3.6
2/16	12	Multi-stage schemes, Implicit schemes	Sec. 3.3.7, Sec. 3.4
2/21	13	Semi-Lagrangian methods	Sec. 3.5
2/23		Wellness Day	
2/28	14	Grid systems	Sec. 4.4.1
3/2	15	Vertical coordinates	Sec. 4.1.2
3/6-3/10		Spring Break	
3/14	16	Boundary conditions	Sec. 4.2
		Midterm grades due 3/15 (Mon)	
3/16	17	Boundary conditions and initial conditions	
3/21	18	Initialization	Sec. 4.3.1
3/23	19	Data assimilation	Sec. 4.3.2
3/28	20	Data assimilation	Sec. 4.3.2
3/30	21	Nonlinear aliasing and nonlinear instability	Sec. 4.4.1
4/4	22	Numerical smoothing	Sec. 4.4.2
4/6	23	Modeling of a stratified fluid flow system	Sec. 4.5
4/11		Wellness Day (4/11-4/12)	
4/13	24	Predictability and ensemble forecasting	Sec. 4.6
4/18	25	Reynolds averaging, Parameterization of PBL	Sec. 5.1-5.2
4/20	26	Parameterization of cumulus convection	Sec. 5.3.1
4/25	27	Parameterization of cloud microphysics	Sec. 5.3.2
4/27	28	Parameterization of radiative processes	Sec. 5.4
5/2	29	Introduction to operational NWP models	Ch.6
5/4		Review	
5/8-12		Final Exam (Grades due May 15, Monday)	

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