



North Carolina Agricultural and Technical State University

College of Science & Technology

Applied Science & Technology PhD Program

**Numerical Weather Prediction**

## Course Syllabus

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### Course Information

<i>Course Number/ Section:</i>	<i>AST 853</i>
<i>Term:</i>	<i>Spring 2020</i>
<i>Semester Credit Hours:</i>	<i>3</i>
<i>Times and Days:</i>	<i>2:00-3:15 TR</i>
<i>Class Location:</i>	<i>Gibbs 302</i>

### Instructor Contact Information

<i>Instructor</i>	<i>Dr. Yuh-Lang Lin</i>
<i>Office Location</i>	<i>302H Gibbs Hall</i>
<i>Office Phone</i>	<i>336-285-2127</i>
<i>Email Address</i>	<i><a href="mailto:ylin@ncat.edu">ylin@ncat.edu</a></i>
<i>Teaching Assistant</i>	<i>William Agyakwah &lt;<a href="mailto:william.agyakwah@gmail.com">william.agyakwah@gmail.com</a>&gt;</i>
<i>Other Information</i>	<i>Mesolab Website: <a href="http://mesolab.org">http://mesolab.org</a></i>

**Student Hours:** 12:30-3:00 MWF, stop by for short discussion, or by appointment

**Note:** Students are responsible for reading, understanding, and following their syllabi.

Course Pre-requisites: (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

- 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.
- 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 Text and Manual*

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

**Useful Reading/reference (not required)**

- (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](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, 2<sup>nd</sup> 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.

**Grading Scale**

Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	F
Scores	94-100	90-93	87-89	83-86	80-82	77-79	73-76	70-73	67-69	60-66	0-59

**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%

**Assignments & Academic Calendar (Subjected to change)**

*Presentation Schedule*

Date	Pres. #	Presentation Title	Remarks
1/14	1	Introduction to the course and modeling projects (FORTRAN programs and the advection model)	Lecture notes will be provided
1/16	2	Introduction to NWP	Sec. 1.1 – 1.3
1/21	3	Historical review of NWP	Sec. 1.4 – 1.6
1/23	4	Governing equations for atmospheric motions	Sec. 2.1 – 2.3
1/28	5	Approx. to the governing equations	Sec. 2.3
1/30	6	Shallow water equations	Sec. 2.4
2/4	7	Intro. to numerical methods	Sec. 3.1
2/6	8	Finite difference approx. of derivatives	Sec. 3.2
2/11	9	Finite difference approx. of advec. equation	Sec. 3.3.1

2/13	10	Numerical stability and forward-in-time & centered-in-space scheme	Sec. 3.3.2
2/18	11	Forward in time & upstream in space scheme and numerical dispersion	Sec. 3.3.3
2/20	12	Numerical damping, Lax-Wendroff scheme, and WKL Scheme	Sec. 3.3.4 – 3.3.6
2/25	13	Multi-stage schemes	Sec. 3.3.7
2/27		Midterm	
3/2-6		Spring Break	
3/10	14	Implicit schemes	Sec. 3.4
3/12	15	Semi-Lagrangian methods	
3/17	16	Grid systems	Sec. 4.4.1
3/19	17	Vertical coordinates	Sec. 4.1.2
3/24	18	Boundary conditions	Sec. 4.2
3/26	19	Initial conditions and initialization	Sec. 4.3.1
3/31	20	Data assimilation	Sec. 4.3.2
4/2	21	Nonlinear aliasing and nonlinear instability	Sec. 4.4.1
4/7	22	Numerical smoothing	Sec. 4.4.2
4/9	23	Modeling of a stratified fluid flow system	Sec. 4.5
4/14	24	Predictability and ensemble forecasting	Sec. 4.6
4/16	25	Reynolds averaging	Sec. 5.1
4/21	26	Parameterization of PBL	Sec. 5.2
4/23	27	Parameterization of cumulus convection	Sec. 5.3.1
4/28	28	Parameterization of cloud microphysics (5.3.2); radiative processes (5.4)	Sec. 5.3.2 & 5.4
4/30	29	Intro. to operational NWP models (Ch. 6)	Ch. 6
5/4-8		Final Exam	

## Course Policies

### *Make-up exams*

No make-up mid exams are allowed. With advanced & excused absences with evidence, the homework and final exam with appropriate weights will be used to evaluate the overall grade.

### *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*

### **Class Attendance is Strongly Encouraged**

As there is a strong correlation between class attendance and performance in the course, class attendance in Physics 241 is strongly encouraged. As attendance will be taken in the first 20 minutes of the class, any student not in class by 20 minutes after the class starts will be considered absent. Absence without excuse for more than 9 days may result in a grade of F for the course. Dishonesty in recording attendance by signing in for someone else, or other means, will be considered cheating and will result in a grade of F for the course. Make-up examinations will be given in accordance with University policy (2017-2018 Undergraduate Bulletin).

***Classroom Citizenship:*** Courtesy, civility and respect must be the hallmark of your interactions.

### ***Compliance with the Americans with Disabilities Act***

North Carolina A&T State University is committed to complying with the Americans with Disabilities Act of 1990 and Section 504 of the Rehabilitation Act of 1973 by providing equal access to the programs, services and benefits to qualified students with disabilities. All reasonable efforts must be made to accommodate the needs of students with documented disabilities. **If a student has a disability that qualifies under the American with Disabilities Act Amendments Act (ADAAA) and requires accommodations, he/she should contact or visit the Office of Accessibility Resources (OAR) located in Murphy Hall, Suite 01 or at (336) 334-7765 for information on appropriate policies and procedures. Disabilities covered by ADA may include learning, psychiatric, physical disabilities, or chronic health disorders. Students can contact the Office of Accessibility Resources if they are not certain whether a medical condition/disability qualifies. Please note that approved accommodations must be adhered to by law, but cannot be performed retroactively!**

### ***Title IX***

North Carolina A&T State University is committed to providing a safe learning environment for all students, is free of all forms of discrimination and harassment. Sexual misconduct and relationship violence in any form are inconsistent with the university's mission and core values, violate university policies, and may also violate federal and state law. Faculty members are considered "Responsible Employees" and are required to report incidents of sexual misconduct and relationship violence to the Title IX Coordinator. If you or someone you know has been impacted by sexual harassment, sexual assault, dating or domestic violence, or stalking, please visit the Title IX website to access information about university support and resources. If you would like to speak with someone confidentially, please contact the Counseling Services or Student Health Center.

### ***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 or Client Technology Services: <https://hub.ncat.edu/administration/its/client-technology-services.php>

### ***Field Trip Policies / Off-Campus Instruction and Course Activities***

If Applicable

*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:*

***Student Affairs:*** <https://www.ncat.edu/campus-life/student-affairs/index.php>

**Student Handbook:** <https://www.ncat.edu/campus-life/student-affairs/departments/dean-of-students/student-handbook.php>

**Student Travel Procedures and Student Activity Travel**

**Waiver:** <https://hub.ncat.edu/administration/business-and-finance/comptroller/forms/form-docs/stud-trvl-act-waiv.doc>

*Description of any travel and/or risk-related activity associated with this course.*

**Other Policies (e.g., copyright guidelines, confidentiality, etc.)**

**Student Handbook:** <https://www.ncat.edu/campus-life/student-affairs/departments/dean-of-students/student-handbook.php>

**Sexual misconduct policy:** <https://www.ncat.edu/legal/title-ix/sexual-harassment-and-misconduct-policies/index.php>

**Family Educational Rights and Privacy Act:** <https://www.ncat.edu/registrar/ferpa.php>

**Student complaint form:** <https://www.ncat.edu/current-students/student-complaint-form.php>

**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 bulletin: <https://www.ncat.edu/provost/academic-affairs/bulletins/index.php>, Graduate catalog: <https://www.ncat.edu/tgc/graduate-catalog/index.php>

and Student Handbook <https://www.ncat.edu/campus-life/student-affairs/departments/dean-of-students/student-handbook.php> 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.

**Academic Dishonesty Policy**

Academic dishonesty includes, but is not limited to, the following:

1. Cheating or knowingly assisting another student in committing an act of cheating or other academic dishonesty;
2. Plagiarism (unauthorized use of another's words or ideas, as one's own), which includes, but is not limited to, submitting exams, theses, reports, drawings, laboratory notes, or other materials as one's own work when such work has been prepared by or copied from another person;
3. Unauthorized possession of exams or reserved library materials; destroying or hiding source, library or laboratory materials or experiments or any other similar actions;
4. Unauthorized changing of grades, or marking on an exam or in an instructor's grade book or such change of any grade record;
5. Aiding or abetting in the infraction of any of the provisions anticipated under the general standards of student conduct;
6. Hacking into a computer and gaining access to a test or answer key prior to the test being given. A&T reserves the right to search the emails and computers of any student suspected of such computer hacking if a police report of the suspected hacking was submitted prior to the search; and
7. Assisting another student in violating any of the above rules.

A student who has committed an act of academic dishonesty has failed to meet a basic requirement of satisfactory academic performance. Thus, academic dishonesty is not only a basis for disciplinary action, but may also affect the evaluation of a student's level of performance. Any student who commits an act of academic dishonesty is subject to **disciplinary action**. In instances where a student has clearly been identified as having committed an act of academic dishonesty, *an instructor may take appropriate disciplinary action, including a loss of credit for an assignment, exam or project; or awarding a grade of "F" for the course, subject to review and endorsement by the chairperson and dean.*

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