North Carolina Agricultural and Technical State University

Fall 2024 Course Syllabus

College of Science & Technology

Applied Science & Technology Ph.D. Program

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

Graduate Course Information

Course Name: Orographic Precipitating Systems
Course Number/Section: AST 885-005 Credit Hours: 3
Days and Times: 2:00 – 3:15 pm TR Class Location: 302 Gibbs Hall

Instructor Contact Information

Instructor: Dr. Yuh-Lang Lin
Office Location: Gibbs 302H Email Address: ylin@ncat.edu Office Phone: 336-285-2127

Communication

Students will receive an answer to all communications by email within 48 hour excluding holidays. The secondary point of contact will be Dr. Shak Karim. See below for his email address.

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

Student Hours

1530-1630 TR. For a longer discussion, email me at ylin@ncat.edu to make an appointment.

Monday ☐ Tuesday ☒ Wednesday ☐ Thursday ☒ Friday ☐

Course Prerequisites

Dynamic Meteorology; Atmospheric Dynamics I & II or equivalent

Course Description

Many well-known weather phenomena are directly related to flow over orography, such as mountain waves, lee waves and clouds, rotors and rotor clouds, severe downslope windstorms, lee vortices, lee cyclogenesis, frontal distortion across mountains, cold-air damming, track deflection of midlatitude and tropical cyclones, coastally trapped disturbances, orographically induced precipitation and flash flooding, and orographically influenced storm tracks. This course can be approximately divided into four parts, namely (I) basic dynamics of stratified fluid flow, (II) orographically forced flows, (III) thermally forced flow over orography, and (IV) moist convection and precipitation. In Part I, governing equations and linearization of them for basic dynamics of stratified fluid flow will be discussed. In Part II, linear and nonlinear dynamics associated with two-dimensional and three-dimensional stratified fluid flow over sinusoidal and/or isolated mountains will be studied. Applications of the mountain-wave theories included trapped lee waves, severe downslope winds, lee vortices, lee cyclogenesis, track deflection of cyclones and fronts by mountains, coastally trapped disturbances, cold-air damming, and gap flow. In part III, combined thermally and orographically forced flows will be discussed. Applications included heat island circulations, sea and land breezes, mountain-plain solenoidal circulations, density current generation and propagation, formation of thunderstorm cloud tops, as well as circulations and gravity waves that are generated by diabatic heating associated with coastal frontogenesis, moist convection, and orographic precipitation systems. In part IV, the dynamics of moist convection and precipitation for moist airflow over mountains will be studied. Topics in this part include orographic influence on climatological distribution of precipitation, orographic modification of pre-existing disturbances (e.g., troughs, midlatitude cyclones and fronts, tropical cyclones), common ingredients of orographic precipitation, formation and enhancement mechanisms, and control parameters for moist flow over mountains and their associated flow regimes. In addition to the problems, several short projects, which involve idealized and real-case modeling, will be assigned to enhance the understanding of dry and moist flow theories and dynamics.

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

Any course-level subscriptions and tools linked in Blackboard Learn learning management system (LMS) should be listed here. The Blackboard LMS must have links to their student data privacy statement.

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

Required Materials: N/A

Suggested Course Materials

Suggested Readings/Texts:

(1) Mesoscale Dynamics (Ch. 1-9 & 11) by Y.-L. Lin, Cambridge Univ. Press, 2007
(2) Mountain Meteorology, by C. David Whiteman, Oxford University Press, 2000
(3) Mountain Weather Distance Learning Course, UCAR, MetEd (online)

Suggested Materials: N/A

Grading Policy

Course Grade Scale *[Graduate Level Courses]*

94% and above	A	83% - 80%	B-
93% - 90%	A-	79% - 75%	C+

89% - 87%	B+	74% - 70%	C
86% - 84%	B	69% - 0%	F

Grading Allocation

Describe how grades are determined in a thorough manner.

(1) Homework 20%
(2) Midterm and Final Exams 50%
(3) Projects 30%

Course Policies

Use Of Blackboard as The Learning Management System

MesoLab website and Blackboard are the primary online instructional and course communications platforms. Students can access the course syllabus, assignments, grades, and learner support resources. 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 will be applied for late submission of assignments. For an assignment, a penalty of 10% per day will be applied.

Special Assignments N/A

Class Schedule [Click here for a complete calendar]

Presentation Schedule

Date	Pres. No.	Presentation Title	Remarks (Sec.)
		Part I: Basic Wave Dynamics	
8/22	1	Introduction of definitions of atmospheric scales	Ch. 1
8/27	2	Governing equations for mesoscale motions and their approximations	Ch. 2
8/29	3	Basic wave properties & shallow-water waves	Sec. 3.4
9/3	4	Pure gravity waves – I	Sec. 3.5
9/5	5	Pure gravity waves – II	Sec. 3.5
9/10	6	Inertia-gravity waves	Sec. 3.6
9/12	7	Reflection and critical levels	Sec. 3.7-3.8
9/17	8	Wave Generation & Maintenance Mechanisms; Energy propagation & momentum flux	Sec. 4.1-4.4
		Part II: Orographically Forced Flow	
9/19	9	Flow over 2D sinusoidal mountains	Sec. 5.1
9/24	10	Flow over 2D isolated mountains	Sec. 5.2
9/26	11	Nonlinear flow over 2D mountains (nonlinear flow regimes, generation of severe downslope winds)	Sec. 5.3
10/1	12	Flow over 3D mountains (linear theory & generation of lee vortices)	Sec. 5.4
10/3	13	Flow over large-scale mountains (rotational effects, lee cyclogenesis, orographic effects on cyclone tracks)	Sec. 5.5
10/8	14	Other orographic effects [effects on frontal passage, coastal trapped disturbances, cold-air damming, gap flow]	Sec. 5.6

		Part III: Thermally Forced Flow	
10/10	15	Thermally Forced Flow – I (steady state flow)	Sec. 6.1
10/15	16	Thermally Forced Flow – II (transient flow)	Sec. 6.2
10/17 (R)		Midterm	
10/21-22		Spring Break (M-T)	
10/24	17	Application of thermally forced flow theories to mesoscale circulations	Sec. 6.3
10/29	18	Effects of shear, 3D, and rotation on thermally forced flows	Sec. 6.4
10/31	19	Dynamics of sea and land breeze	Sec. 6.5
11/5	20	Dynamics of mountain-solenoidal circulations	Sec. 6.6
11/7	21	Mesoscale instabilities (static, conditional, potential instabilities & K-H instabilities)	Sec. 7.3
		Part IV: Moist Convection and Precipitation	
11/12	22	Isolated convective storms (single-cell storms, multi-cell storms)	Sec. 8.1-8.3
11/14	23	Supercell storms & tornadogenesis	Sec. 8.4-8.5
11/19	24	Mesoscale convective systems (squall lines, rainbands)	Sec. 9.1-9.2
11/21	25	Mesoscale convective systems (MCC, tropical cyclones)	Sec. 9.3
11/26	26	Orographic influence on the climatological distribution of precipitation and preexisting disturbances	Sec. 11.1-11.2
11/27-29		Thanksgiving holiday (W-F)	
12/3	27	Common ingredients of orographic precipitation	Sec. 11.2
12/5	28	Orographic precipitation mechanisms & Control parameters	Sec. 11.3-11.4
12/9-13		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.*