

MEA 443

**Synoptic Weather Analysis and Forecasting**

Fall 2009

**Schedule:**

M: 2:30 – 3:20; Tu, W, Th: 2:30 – 4:20

1220 Jordan

**Instructor:**

Dr. Gary Lackmann

Office: 1145 Jordan Hall

E-mail: [gary@ncsu.edu](mailto:gary@ncsu.edu)

Office hours: Thu 4:30-5:30 or by appointment

**Teaching Assistant:**

Ms. Briana Gordon

Office: 1144 Jordan Hall

E-mail: [bjgordon@ncsu.edu](mailto:bjgordon@ncsu.edu)

Office hours: Mon 3:30-4:30 or by appointment

**Course Organization:**

There will be no formal distinction between lecture and lab on Tu, W, and Th, although Mondays will be more lecture-oriented. I will strive to maintain an interactive lecture style, and I will introduce short group exercises and activities. Lab activities will include case study analyses, computing exercises, weather forecasting activities, and more.

**What is Synoptic-Dynamic Meteorology?**

Synoptic-Dynamic Meteorology is the study of the structure and evolution of weather systems typically associated with significant weather, such as extratropical high and low pressure systems, jet streams, fronts, and even organized convective storms. The philosophy behind this class is to integrate theory, observations, and models in a way that enables understanding of why the atmosphere behaves the way it does, and application of class concepts to practical situations. In addition to facilitating physically based weather forecasts, this understanding is helpful for general problem solving in research.

A starting point for synoptic meteorology is to utilize the quasigeostrophic equations, which are a simplified but less accurate version of the full primitive equations. Note that a prerequisite for this class is MEA 422 (and 421), meaning that I assume you have all had a full year of dynamics. *Scale analysis*, as undertaken in your dynamics courses, is of fundamental importance to synoptic meteorology. Characteristic scales for basic meteorological parameters can be identified, and this knowledge is used to reduce the complexity of the governing equations. Weather systems can be classified either in terms of horizontal length scales or time scales, but these are often related to each other. The following are typically used to define different scale regimes in the atmospheric sciences:

Scale	length	time	course
Microscale	< 1 km	< 1 h	MEA 455
Mesoscale	1 – 1000 km	1 h – 1 d	MEA 444
Synoptic scale	1000 – 6000 km	1d – 2 weeks	MEA 443
Planetary scale	> 6000 km	> 1 week	MEA 311

**Course Objectives:**

The overall goals of this course are to (i) reinforce conceptual models and understanding of atmospheric dynamics and physical processes as applied to the structure and life cycles of synoptic-scale weather systems, (ii) develop weather analysis skills including both manual and computerized techniques, (iii) understand how operational weather forecasts are made, and develop a systematic approach to making weather forecasts utilizing state-of-the-art technology and numerical forecast models, (iv) increase student awareness of career opportunities in the atmospheric sciences, and (v) build experience with applied research. *Specifically, by semester's end, I expect that every student in this course will:*

- 1) *possess a conceptual understanding of quasigeostrophic theory as applied to the midlatitude atmosphere,*
- 2) *have a solid understanding of physical processes important to synoptic-scale weather phenomena, including jet streams, midlatitude cyclones, winter storms, cold-air damming, fronts, Rossby waves, etc.*
- 3) *develop working knowledge of interactions between mesoscale systems, topography, diabatic processes, and synoptic-scale systems,*
- 4) *be able to construct and defend a respectable manual surface or upper-air map analysis given a set of meteorological observations,*
- 5) *understand the basic workings of numerical weather prediction models,*
- 6) *be able to produce and defend a well-reasoned weather forecast,*
- 7) *understand the importance of observational analysis, and numerical and conceptual models in weather analysis and forecasting,*
- 8) *possess sufficient computing skills to undertake routine meteorological data analysis using current or archived data sets, and*
- 9) *demonstrate competence and familiarity with scientific writing for a synoptic or mesoscale case study.*

After an initial review of material from earlier courses, including the quasigeostrophic (QG) system of equations, we will undertake a systematic application of both new and previously studied concepts to the atmosphere. Once we have solidified our understanding of QG dynamics, it will form the basis of our weather analysis and forecasting methodology. Some emphasis in this course will be placed on the development of computer skills. Through assignments and labs, students will gain experience with UNIX & scripting, GEMPAK, NMAP, and other display software.

**Text:** There is no textbook that is ideally suited to cover the material in this course, however, there are 3 texts of sufficient relevance to qualify as “recommended”:

Martin, *Mid-latitude Atmospheric Dynamics: A First Course* (Wiley)

Bluestein, *Synoptic-Dynamic Meteorology in Mid-latitudes: Volumes I and II*

Carlson, *Mid-Latitude Weather Systems* (Available through the AMS, \$32)

Other recently-updated texts that contain some relevant material include:

Holton, *An Introduction to Dynamic Meteorology*

Wallace & Hobbs, *Atmospheric Science, An Introductory Survey*

**Web Page:** <http://www4.ncsu.edu/~gary/mea443/mea443.html>

**Weather Forecasting:**

Within the realm of forecasting, we will utilize many different tools, including observational data and numerical model output. However, we will seek to avoid the dangers of becoming overly dependent on numerical models. General forecasting techniques will be presented, including the interpretation of various observational data platforms, numerical forecast model output and statistical products.

Experience is a critical element in weather forecasting. Therefore, students will participate in “The Wx Challenge”, run by the University of Oklahoma (see link on class web page). MEA 443 students will be required to submit forecasts for this contest beginning on 28 September. There will be no required forecasting activity on Fridays. There is a small fee (\$3.00 per semester, or \$5 for the whole year) to help defray the cost of trophies (which are awarded to winners in the various forecasting categories for each city and for overall performance).

Your forecasting grade will reflect both your performance in semester forecasting activities and the preparation of and justification for your weather forecasts. Students will conduct oral *weather briefings* on a rotating basis once forecasting exercises have started. Students will participate in grading of the briefings and will be expected to participate in the discussion. Each student briefing team will prepare a written forecast discussion before class on their briefing day, and students will be expected to have read it ahead of time. It requires several hours to prepare briefings; every effort will be made to accommodate those who have classes immediately prior to MEA 443 in these instances.

**Term Paper:**

A term paper, approximately 10 pages in length, is required for this course. The purpose of this assignment is to provide students with experience reading the scientific literature, working with the scientific method, manipulating meteorological data, and with the scientific writing process. Students will select a *case study* event on which to focus their research. The term-paper writing process will be designed to follow that used for publication in professional journals, including peer-review and an editorial decision. Final drafts will be turned in on the last day of class (Thursday, 3 December). Grades for the paper will reflect originality and creativity, rigor of scientific presentation, degree of difficulty, and quality of writing and graphics.

For the term paper project, you will be required to download and manipulate some meteorological data sets. Given the limited storage available with the basic university account, it is suggested that you purchase a USB storage drive with at least 2-4 Gb capacity. These should be available for less than \$15.

**Lab Assignments:**

The class will manually analyze some current as well as historical case study data. Surface analyses as well as upper-air analyses for specific weather events will allow students to integrate different data sources to construct useful, physically consistent analyses.

**Grading:**

Your grade in this class will be determined by your performance on a midterm exam, weekly quizzes, laboratory exercises (including both in- and out-of-class forecasting exercises), a comprehensive final exam, and the term paper according to the following:

Midterm exam	15 %
Weekly quizzes (drop lowest 2)	15 %
Laboratory exercises + forecasting	40 %
Term paper	15 %
Final Exam	15 %

Approximate grading guidelines are as follows:

<b>A+</b> (97 - 100)	<b>A</b> (96 - 93)	<b>A-</b> (92 - 90)
<b>B+</b> (89 - 87)	<b>B</b> (86 - 83)	<b>B-</b> (82 - 80)
<b>C+</b> (79 - 77)	<b>C</b> (76 - 73)	<b>C-</b> (72 - 70)
<b>D+</b> (69 - 67)	<b>D</b> (66 - 63)	<b>D-</b> (62 - 60)
	<b>E</b> ( $\leq$ 59)	

Laboratory exercises must be completed promptly. Therefore, late submission will be discounted 20% per day up to the day the assignment is discussed in class. Once laboratory keys have been posted or discussed in class, credit will not be possible.

**Tentative Exam Dates:**

Midterm	Wednesday, 7 October
Final Exam	Wednesday, 9 December (1–4 p.m.)

Students who must miss an examination must notify the instructor at the earliest possible date *prior* to the examination. If you anticipate a conflict with either of the dates listed above, inform the instructor immediately. There will be a short quiz each week, with a total of about 15 for the semester. Students will be allowed to drop their 2 lowest quiz scores. The quizzes will be administered at either the start of class or at the end of the lecture portion of the class prior to weather briefing on Thursdays.

## Tentative Lecture Topics

- Week 1:** (8/19–8/20) Course overview, examples of weather analysis, forecasting, survey, review of basic units, equations, map analysis, computer systems
- Week 2:** (8/24–8/27) Review of basic equations, dynamics, vorticity, QG theory (Bluestein V I, ch 1-4; Carlson ch 1-3)
- Week 3:** (8/31–9/3) Quasigeostrophic theory: Application and interpretation of  $\omega$ ,  $\chi$  eq. Forecasting (Bluestein V I, ch 5; Carlson ch 4)
- Week 4:** (9/7–9/10) **Q**-vectors and applications; midlatitude cyclogenesis, NMAP, GEMPAK analysis exercise (Bluestein VII, ch 1; Carlson ch 10) [**Labor Day, 9/7**]
- Week 5:** (9/14–9/17) Midlatitude cyclogenesis, cyclone life cycles, climatology; forecasting exercises, MOS, NWP model overview (Bluestein VII, ch 1; Carlson ch 10)
- Week 6:** (9/21–9/24) Begin lab case study analysis, weather briefings, forecasting exercises. Begin cyclone energetics and dynamics.
- Week 7:** (9/28–10/1) Cyclone dynamics, roles of friction, terrain, diabatic processes  
Jet dynamics, upper-air analysis (Bluestein VII, ch 2; Carlson ch 5, 12)
- Week 8:** (10/5–10/8) Explosive cyclogenesis, mesoscale modeling of cyclones  
(Bluestein VII, ch 1) [**Midterm Exam 10/7; Fall Break 10/8, 9**]
- Week 9:** (10/12–10/15) Isentropic analysis, relative isentropic flow, airflow in cyclones and forecasting techniques, cold-air damming (handout materials, Carlson ch 13)
- Week 10:** (10/19–10/22) Regional synoptic-scale meteorology and forecasting: Cold-air damming  
Begin precipitation type (handout materials)
- Week 11:** (10/26–10/29) Winter weather forecasting, snow, sleet, freezing rain, precipitation-type forecasting techniques (handout materials, webcast exercises)
- Week 12:** (11/2–11/5) Fronts & frontogenesis, frontal kinematics, coastal fronts, frontal analysis  
anafont/katafront model (Bluestein VII, ch 2; Carlson ch 12, 13, 14)
- Week 13:** (11/9–11/12) Jet dynamics, PV analysis, upper fronts, tropopause dynamics, PV interpretation of dynamics (Bluestein VII, ch 1; Carlson ch 12)
- Week 14:** (11/16–11/19) NWP, statistical forecasting methods, operational model representation of convection. Physical processes and model predictability
- Week 15:** (11/23–11/26) Current operational model configurations (COMET and handout materials)  
[**Thanksgiving Break, no class Wed 11/25, Th 11/26**]
- Week 16:** (11/30–12/3) NWP: data assimilation, extended-range forecasting, ensemble prediction (COMET, handout materials) [**Final term papers due 5:00 p.m. Thu. 12/3**]

Final Examination: Wednesday, 9 December, 1–4 p.m.

OU Weather Challenge schedule, Fall 2009 Semester. See

<http://www.wxchallenge.com/challenge/schedule.php>

City	identifier	Dates
Charleston, SC	KCHS	September 28 - October 8
Denver, CO	KDEN	October 12 - October 22
Stockton, CA	KSCK	October 26 - November 5
Cleveland, OH	KCLE	November 9 - November 19
St. Louis, MO	KSTL	November 30 - December 10

## **Academic Integrity**

It is expected that students will conduct themselves in a manner consistent with the University policy on academic integrity found in the Code of Student Conduct. Plagiarism and cheating are attacks on the very foundation of academic life, and will not be tolerated. Academic dishonesty is the giving, taking, or presenting of information or material by a student that unethically or fraudulently aids oneself or another on any work which is to be considered in the determination of a grade or the completion of academic requirements or the enhancement of that student's record or academic career.

It is suggested that students review the Code of Student Conduct:

<http://www.fis.ncsu.edu/ncsulegal/41.03-codeof.htm>

Cheating and plagiarism take many forms, including assisting others who may initiate dishonest activity. It will be made clear when students are expected to work independently, and it will also be made clear when collaboration is acceptable. Examples of academic dishonesty include:

- representing the work of others as his or her own;
- obtaining assistance in any academic work from another individual in a situation in which the student is expected to perform independently;
- providing assistance to another individual in a situation in which that individual is expected to perform independently;
- offering false data in support of laboratory or field work.

## **DISABILITY STATEMENT**

“Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. For more information on NC State's policy on working with students with disabilities, please see [http://www.ncsu.edu/provost/offices/affirm\\_action/dss/](http://www.ncsu.edu/provost/offices/affirm_action/dss/) and also [http://www.ncsu.edu/provost/hat/current/appendix/appen\\_k.html](http://www.ncsu.edu/provost/hat/current/appendix/appen_k.html)”