

MEA 443

Synoptic Weather Analysis and Forecasting

Fall 2011

Schedule:

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

1220 Jordan

Instructor:

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Course Organization:

There will be no formal distinction between lecture and lab on Tu, W, and Th, although Mondays will be more lecture-oriented. Lab activities will include case study analyses, group projects, computing and data-analysis exercises, weather forecasting activities, and more.

What is Synoptic Meteorology?

Synoptic meteorology is the study of the structure and evolution of weather systems that operate on spatial scales on the order of 1000 km and temporal scales on the order of one to several days. These scales are often associated with weather systems that are accompanied by significant weather, including extratropical cyclones and anticyclones, jet streams, and fronts. Temporal and spatial scales for a given weather system are not generally independent of one another. The following approximate values can be 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

Note that prerequisites for this class include MEA 421 and 422, meaning that you have completed a full year of dynamics, and we will build on this knowledge in this course. *Scale analysis*, as introduced in your dynamics courses, can be used to develop equations relevant to synoptic-scale motions.

Characteristic scales for basic meteorological parameters are identified, and the complexity of the governing equations can be reduced using this information. A starting point for synoptic meteorology is the quasigeostrophic (QG) equations, which are a simplified but less accurate version of the full primitive equations. The QG equations, which were introduced in MEA 422, will form the basis of our approach to weather analysis and forecasting, and will be applied in labs, in-class exercises, and forecasting activities.

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 knowledge of interactions between mesoscale systems, topography, diabatic processes, and the synoptic-scale flow,*
- 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 case study.*

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: I have spent considerable time over the past two years developing a textbook for this class. The final form won't be available until December, unfortunately, but a draft is available and is recommended for the class as a course pack available through the bookstore. By January 2012 it will be in print, published by the AMS. Additionally, there are several texts that are useful references but that are not required; you may have some of these already from earlier classes:

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:

To make a weather forecast is to make a scientific hypothesis. Conveniently, Mother Nature will provide an automatic test of the hypothesis as the weather unfolds! We will utilize several forecasting tools and methods, including observational data analysis and numerical model output. We must avoid the dangers of becoming overly dependent on numerical models, however. 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 26 September. There will be no required forecasting activity on Fridays. There is a small fee (\$3 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.

OU Weather Challenge schedule, Fall 2011 Semester. See <http://www.wxchallenge.com/challenge/schedule.php>

City	Identifier	Dates
Miami, FL	KMIA	September 26 - October 6
Riverton, WY	KRIW	October 10 - October 20
Dayton, OH	KDAY	October 24 - November 3
Juneau, AK	PAJN	November 7 - November 17
Erie, PA	KERI	November 28 - December 8

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.

For some lab exercises, 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.

Grading:

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

Midterm exam	17 %
Weekly quizzes (drop lowest 2)	25 %
Laboratory exercises + homework	30 %
Forecasting activities	10 %
Final Exam	18 %

Approximate grading guidelines are as follows:

A+ (97 - 100)	A (96 - 93)	A- (92 - 90)
B+ (89 - 87)	B (86 - 83)	B- (82 - 80)
C+ (79 - 77)	C (76 - 73)	C- (72 - 70)
D+ (69 - 67)	D (66 - 63)	D- (62 - 60)
	E (≤ 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, 5 October
Final Exam	Friday, 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 on Thursdays.

Tentative Lecture Topics

- Week 1:** (8/17–8/18) Course overview, survey, review of basic units, equations.
Lab: Review map analysis, computer systems. (Chapter 1)
- Week 2:** (8/22–8/25) Review of basic equations, dynamics, vorticity, Rossby waves
Lab: GARP, NMAP, data exercise, map analysis. (Chapters 1, 12)
- Week 3:** (8/29–9/1) QG applications, interpretation of QG ω , Q-vectors, height-tend. Eq.
Lab: Analysis exercises. (Chapters 2, 12)
- Week 4:** (9/5–9/8) Finish QG theory, introduce isentropic analysis. [**Labor Day, 9/5**]
Lab: Isentropic analysis, plotting and interpolation. (Chapters 2, 3)
- Week 5:** (9/12–9/15) Potential vorticity, begin midlatitude cyclones; cyclone climatology, life cycle
Lab: NWP model overview, prep for forecasting (Chapters 4, 5, parts of 10,11)
- Week 6:** (9/19–9/22) Forecast process, area-forecast discussion exercise. History of meteorology.
Lab: Forecast exercises, read historical paper. Chapters 5, 11)
- Week 7:** (9/26–9/29) Continue cyclone dynamics, cyclogenesis, roles of friction, diabatic processes.
Lab: Case study analysis, weather briefings, forecasting. (Chapters 5, 11).
- Week 8:** (10/3–10/6) Continue cyclones, review for midterm exam. [**Fall Break 10/6, 7**]
(Finish Chapter 5) [**Midterm Exam 10/5**]
- Week 9:** (10/10–10/13) Explosive cyclogenesis, mesoscale modeling of cyclones
Lab: Forecasting activities, upper-air analysis (Chapters 5, 11)
- Week 10:** (10/17–10/20) Fronts and frontal weather, frontal kinematics, frontal analysis.
Lab: Forecasting and surface frontal analysis. (Chapter 6)
- Week 11:** (10/24–10/27) Types of fronts, dynamic frontogenesis, upper-level fronts.
Lab: Upper-front cross-section analysis. (Chapter 6)
- Week 12:** (10/31–11/3) Cold-air damming, topographically forced flows.
Lab: Cold-air damming case analysis (Chapter 8)
- Week 13:** (11/7–11/10) Winter weather forecasting, snow, sleet, freezing rain, p-type forecasting
Lab: Winter weather case study (Chapter 9)
- Week 14:** (11/14–11/17) Numerical models, model physics parameterizations
Lab: Post-mortem analysis of model error. (Chapter 10)
- Week 15:** (11/21–11/24) Model physics, MOS (Chapter 10)
[**Thanksgiving Break, no class Wed 11/23, Th 11/24**]
- Week 16:** (11/28–12/1) Data assimilation and ensemble prediction, course overview/review.
(Chapter 10) [**last day of class 12/1**]

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

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/ and also http://www.ncsu.edu/provost/hat/current/appendix/appen_k.html”