Atm Sci 460 – Mesoscale Meteorology
TR 9:30-10:45a, CHM 195
Spring 2017 (Dates and project details updated 28 March 2017.)

Instructor:	Prof. Clark Evans
Contact:	(414) 229-4469, evans36@uwm.edu, EMS W401
Office Hours:	TR 12:30-1:45p or by appointment. Feel free to stop in whenever my door is open for short questions, or set up an appointment for longer ones.
Prerequisites:	Passing grade in Atm Sci 360 or instructor consent
Course Website:	http://derecho.math.uwm.edu/classes/AtmSci460.html
Required Text:	*Mesoscale Meteorology in Midlatitudes* by Paul Markowski and Yvette Richardson (available from the UWM Bookstore and elsewhere). I will provide supplementary lecture notes throughout the semester. I expect that you will read the relevant course material *prior* to the class when it is covered. Wrestle with the material and come to class prepared to ask questions and participate in discussions!

Course Overview

How to define the mesoscale? The AMS Glossary defines mesoscale as, "Pertaining to atmospheric phenomena having horizontal scales ranging from a few to several hundred kilometers." Relevant phenomena are said to include thunderstorms, squall lines, fronts, banded precipitation, mountain waves, and sea/lake/land breezes.

Closely related to this definition, the mesoscale is characterized by features with vertical scale approaching, but not exceeding, their horizontal scale; the synoptic-scale is characterized by vertical scale much less than horizontal scale, while the microscale is characterized by vertical scale equaling or exceeding horizontal scale.

Neglecting friction, there are three relevant forces governing horizontal parcel motions: centrifugal force, such as with curved flow; pressure gradient force; and Coriolis force. On the synoptic-scale, the latter two are in approximate (geostrophic) balance. On the microscale, the former two are of primary importance. On the mesoscale, however, all three forces may be important, each to varying degrees depending upon the physical phenomenon being considered.

Finally, the mesoscale may also be defined based upon the length of time that it takes an air parcel to flow through a given feature, or the Lagrangian (flow-following) timescale. Mesoscale phenomena have Lagrangian timescales ranging from that of a gravity wave (with a restoring force of buoyancy; t ~ minutes), where the Coriolis force is relatively unimportant, to that of diurnally-driven phenomena (t ~ a day), where the Coriolis force is comparatively important.

In this class, we will first develop the mesoscale meteorologist's analysis toolbox, including radar and sounding analysis techniques. As mesoscale phenomena evolve in the background synoptic-scale environment, we will next review important synoptic meteorology concepts, particularly as it relates to identifying areas in and features along which ascent may occur. This will allow us to complete the semester with investigations of a diverse range of mesoscale phenomena, starting with dry lines and the low-level jet and ending with terrain-induced flows.

Grading

For undergraduate students, your grade will be based on your performance on the following:

20% Mid-Term Exam
20% Final Exam
40% Labs/Assignments (eight in total, 5% each)
20% Project

For graduate students, your grade will be based on your performance on the following:

20% Mid-Term Exam
20% Final Exam
25% Labs/Assignments (eight in total, 3.125% each)
35% Project

This class uses out-of-class readings to convey the *what* and in-class lectures and demonstrations to convey the *why* and *how* for mesoscale meteorological phenomena. Lab assignments are given to provide practice in *applying* this information to advance your own understanding. While you are welcome to discuss lab assignments with other students, *your actual completed assignments must reflect your own work*! Copying answers, in whole or in part, will result in no credit. Late assignments will only be accepted if late due to an excused absence. In some cases, assignments will be started in-class (likely in EMS W434); others will be completed entirely out of class. In both cases, assignments are due by the start of class one week after being assigned. Typically, assignments will be given on a Thursday and due the following Thursday.

Both mid-term and final exams focus more on application than on memorization. My exams tend to ask questions that build on your understanding and experience in applying that understanding. Exam questions may draw from assigned readings, lectures, or assignments. The final exam is not cumulative and covers only material discussed in class after spring break. Make-up exams are only permissible in the event of an excused absence from class, including absences for university-recognized personal matters. If you are in doubt about whether your absence will qualify, please ask me ahead of time for clarification.

A key component of this course is the successful completion of a short project on an approved topic related to the course. A full description, including the different expectations on the scope of this project for undergraduate and graduate students, is provided at the end of this syllabus.

Although not explicitly listed above, I expect that you will actively participate in class by coming prepared, asking questions for clarification, and answering questions when asked. Implicit to this is attending class. You are permitted up to three unexcused absences without penalty; the fourth and each subsequent absence will result in a three-point deduction on your final grade.

Grades will be assigned based on the following scale:

A	92.5-100%	**A-**	90-92.49%	**B+**	87.5-89.99%	**B**	82.5-87.49%
B-	80-82.49%	**C+**	77.5-79.99%	**C**	72.5-77.49%	**C-**	70-72.49%
D+	67.5-69.99%	**D**	62.5-67.49%	**D-**	60-62.49%	**F**	0-59.99%

A grade of an "A" is intended to reflect *mastery* of the presented material. Grades of "B" and "C" are intended to reflect minor and major deficiencies, respectively, in your mastery of the presented material. Grades of "D" and "F" reflect no mastery of the presented material. Minor deficiencies include incomplete attribution while major deficiencies include incorrect attribution.

Course Outline

The following outline is tentative and subject to change. Please note, and review in advance, the text references for each topic. Dates listed for labs are their tentative assignment dates.

Week	Dates	Topic(s) To Be Covered
1	Jan. 24, 26	**No Class – AMS Annual Meeting**
2	Jan. 31, Feb. 2	Introduction (Ch. 1); Radar Overview (Appendix A)
3	Feb. 7, 9	Sounding and Stability Analysis (Secs. 2.1, 2.3.3, 2.6, 2.7, 3.1)
4	Feb. 14, 16	Quasi-Geostrophic Theory
5	Feb. 21, 23	Fronts and Frontogenesis (Secs. 5.1.1-5.1.5)
6	Feb. 28, Mar. 2	Drylines and the Low-Level Jet (Secs. 4.7, 5.2)
7	Mar. 7, 9	Seabreezes and Related Phenomena (Sec. 5.4)
8	Mar. 14, 16	Boundary Layer Processes (Secs. 4.1-4.3); **Mid-Term Exam**
9	Mar. 21, 23	**Spring Break – No Class**
10	Mar. 28, 30	Mid-Term Review and Boundary Layer Processes (Secs 4.1-4.4)
11	Apr. 4, 6	Lake Effect Precipitation (Sec. 4.5)
12	Apr. 11, 13	Density Currents (Sec. 5.3) and Gravity Waves (Ch. 6)
13	Apr. 18, 20	Convective Cells (Ch. 7 and Secs. 8.1-8.3)
14	Apr. 25, 27	Supercell Dynamics (Sec. 8.4)
15	May 2, 4	Mesoscale Convective Systems (Ch. 9)
16	May 9, 11	Terrain-Induced Flows (Chs. 11-13); Evaluations and Project Presentations

Mid-Term: 16 March, in class **Final:** 18 May, 10:00-noon

Lab 1: Radar Analysis (2 February)
Lab 2: Sounding and Stability Analysis (9 February)
Lab 3: Quasi-Geostrophic Theory (16 February)
Lab 4: Frontal Analysis and Frontogenesis (23 February)
Lab 5: Sea/Lake Breezes (9 March)
Lab 6: Lake Effect Precipitation (6 April)
Lab 7: Supercell Dynamics and Forecasting (27 April)
Lab 8: Organized Mesoscale Convective Phenomena (4 May)

Apart from the first week of the semester, I may be absent for one class during the middle of the semester due to research travel. I will let you know as soon as possible if this will be the case. If needed, we will make up that class at a mutually agreed-upon date and time.

Course Credit Hour Statement

This course is a three credit course. This means that this class represents an investment of time of at least 144 hours by the average student. Of these 144 hours, 45 are associated with in-class instruction, 32 with the completion of course assignments, 25 with the completion of the course project, and 42 with each student's study of course materials.

Departmental Regulations

Any room changes and/or course cancellations will be posted on departmental letterhead only.

University Regulations

University-Wide Rights and Regulations

The University of Wisconsin-Milwaukee has established a series of policies relating to student rights and regulations in this and all UWM-offered courses. You are encouraged to read through these policies at http://www4.uwm.edu/secu/news_events/upload/Syllabus-Links.pdf at your earliest convenience. Please notify me if you need special accommodations in order to meet any course requirements.

Statement of Academic Misconduct

The university has a responsibility to promote academic honesty and integrity and to develop procedures to deal effectively with instances of academic dishonestly. Students are responsible for the honest completion and representation of their work, for the appropriate citation of sources, and for respect of others' academic endeavors. Further information can be found at http://uwm.edu/academicaffairs/facultystaff/policies/academic-misconduct/.

Statement of Sexual Harassment

Sexual harassment is reprehensible and will not be tolerated by the University. It subverts the mission of the University and threatens the careers, educational experience, and well-being of students, faculty and staff. The University will not tolerate behavior between or among members of the University community which creates an unacceptable working environment. The policy on discriminatory conduct, including sexual harassment, can be found at http://www4.uwm.edu/secu/docs/faculty/2847_S_47_Discr_olicy_clean.pdf.

Project Description

Both undergraduate and graduate students must complete a project on an approved topic related to the course. Sample project ideas, particularly aimed at graduate students, are provided below.

For undergraduate students, you are to conduct a case study analysis of an observed mesoscale meteorological event of your choosing. This will require both synoptic- and mesoscale analysis conducted using appropriate observational datasets. The primary emphasis of this project is to be the correct *application* of key concepts covered in this class to an observed mesoscale event.

For graduate students, you are to conduct some form of data analysis on a topic of interest to you that is related to the material covered within the course. While you may choose to conduct a case study analysis of an observed event using only observations, your project need not necessarily be a case study analysis, nor need it only use observations. (For instance, numerical data from either operational models or simulations you conduct may be used.) Your project must be motivated by an appropriate hypothesis and include a literature review to place results into the appropriate context provided by earlier studies.

There exists a single deliverable from this project: a poster presentation given (using the classroom projector) on the last day of classes in the style of an American Meteorological Society conference. If you desire, UWM provides students with one free poster printout per year (http://uwm.edu/universityrelations/for-students/). For undergraduate students, the poster should introduce the case that you studied, the data used to study that case, and the key findings from your analysis. For graduate students, the poster should describe the key question motivating your analysis, the chosen analysis methods, key findings, and how those findings relate to previous research. You should also cite all references using the AMS reference convention. All information should be clearly explained, both orally and in print, and legible to someone with average eyesight. Large blocks of text are not recommended. There are examples of conference posters on display in the west wing EMS 4th floor hallway, and I recommend that you look at these to get ideas as to how you should structure your poster.

Given the relatively limited contribution of the course project to your course grade, the project should be of appropriately limited scope. In other words, I do not expect publishable research to result from this project. To ensure that your project is of appropriately limited scope, and to help guide you to appropriate resources (data, references, etc.) for your project, please schedule a meeting with me prior to 28 February to discuss your project idea.

Your project will be graded according to the following rubric:

- **Presentation quality (25%):** Was the poster presented well? Did the poster adhere to the provided guidelines? Does it contain sufficient information for an outside observer to be able to understand the methods and results? Is it legible? Were questions handled well?

- **Experimental design (25%):** For undergraduate students, is the case studied introduced well? For graduate students, is the hypothesis clearly stated and well-posed? For both, what data and analysis methods are used? Are they appropriate for the study?

- **Data analysis (50%):** Are the chosen data analysis methods applied appropriately? What are the key findings that result from the analysis? Is physically- and/or dynamically-based insight provided to connect the results of the analysis to theory? For graduate students, are connections drawn between the results and those obtained by previous investigators?

Sample project ideas include, but are by no means limited to, the following:

- Why do some mid-latitude cyclones have notable embedded precipitation bands while others do not?

- How sensitive is dryline eastward propagation to underlying soil moisture conditions?

- Why is the seabreeze a preferred focus for thunderstorms along the Gulf of Mexico coastline, but thunderstorms rarely occur in the Great Lakes along the lakebreeze?

- How sensitive is lake effect-induced precipitation accumulation to lake temperature?

- What is the contribution to total lake effect-induced precipitation accumulation from air passing over multiple lakes rather than a single lake?

- Why do some thunderstorms weaken while others maintain their intensity as they cross over the Great Lakes?

- How do the thermodynamic environments differ between left-moving and right-moving supercell thunderstorms?

- What environmental differences exist between cases with large hail and accumulating small hail?

- How predictable is the formation, evolution, structure, etc. of a mesoscale phenomenon?

- How accurate are 4-8 day Storm Prediction Center convective outlooks?

- How does nocturnal valley inversion strength vary as a function of terrain prominence?

- How well are numerical models able to represent the southward extent and persistence of cold air damming events along the Appalachian Mountains?